BEFORE A HEARINGS PANEL OF THE GREATER WELLINGTON REGIONAL COUNCIL AND MASTERTON DISTRICT COUNCIL

IN THE MATTER	of resource consent applications to Greater Wellington Regional Council pursuant to section 88 of the Resource Management Act 1991
AND	
IN THE MATTER	of a Notice of Requirement to Masterton District Council pursuant to section 168, 168A and 181 of the Resource Management Act 1991
BY	Masterton District Council
FOR	the proposed upgrade of the Masterton Wastewater Treatment Plant

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SUPPLEMENTARY STATEMENT OF EVIDENCE OF CHRIS HICKEY ON BEHALF OF MASTERTON DISTRICT COUNCIL

FURTHER RESPONSE TO OFFICER'S REPORT AND SUBMITTERS

Subject area: Effects on water quality

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1. INTRODUCTION

1.1 The Officer's Report proposed monitoring and compliance conditions for the pond, Ruamahanga River and Makoura Stream, and groundwater. I raised concerns with some of these in my supplementary evidence. This further supplementary evidence addresses specific detail in relation to compliance monitoring and response to evidence from additional submitters.

2. SITE-SPECIFIC DRP GUIDELINE DERIVATION

2.1 I have presented evidence of the basis of the Ruamahanga River studies and basis for the derivation of the site-specific guideline for dissolved reactive phosphorus (DRP) in my evidence (sections 8.16-8.21). This was based on measured periphyton growth rates, flood 'resetting' and linking with the equations used in the MfE (2000) guideline document. These studies were originally reported in NIWA (2003) and used in subsequent modelling and site-specific guideline derivation (NIWA 2004). Unfortunately, in reviewing this derivation procedure we have now identified an error in the calculation used. The revised calculation results in a higher site-specific guideline value and I provide details below.

2.2 The equations linking maximum algal biomass (measured as chlorophyll *a*) with the accrual period and the DRP concentration (in mg/m^3; termed soluble reactive phosphate (SRP) in the MfE guidelines). The equation to calculate the SRP value for a given maximum Chl *a* and accrual time is a rearrangement of Eqn 2 (from MfE 2000, p43) as given below:

$$\text{Log}_{10}\,(\text{maximum chl. a}) = 4.285 \times (\text{Log}_{10}\,\text{days of accrual}) - 0.929 \times (\text{Log}_{10}\,\text{days of accrual}) + (0.504 \times \text{Log}_{10}\,\text{SIN}) - 2.946 \qquad r^2 = 0.741 \qquad (1)$$

$$\text{Log}_{10}\,(\text{maximum chl. a}) = 4.716 \times (\text{Log}_{10}\,\text{days of accrual}) - 1.076 \times (\text{Log}_{10}\,\text{days of accrual}) + (0.494 \times \text{Log}_{10}\,\text{SRP}) - 2.741 \qquad r^2 = 0.721 \qquad (2)$$

2.3 The original table as used for the site-specific DRP guideline is given below (Table 5.4, NIWA 2003). The calculation error found was the use of an incorrect coefficient in eqn 2 (0.929 from eqn 1 was used instead of 1.076). This resulted in an under-prediction of the DRP corresponding to a given accrual period.

Table 5.4: Predicted algal biomass (as maximum chlorophyll *a*, mg.m^{-2}) as a function of soluble reactive phosphorus (SRP, mg.m^{-3}, summer average from Table 5.2) and days of accrual (duration of stable flow) (calculated from Biggs 2000a, p43, eqn 2). Shaded results are for March sampling growth period (Table 5.3) compared with observed chlorophyll *a* levels (Fig. 5.2).

SRP conc (mg.m^{-3})	Accrual time (d)					Chl *a* Observed	Pred/Obs
	10	13	15	20	30		
2	16	32	47	94	222		
5	25	51	73	147	349	48	1.06
10	35	71	103	207	492		
15	42	87	126	253	601		
20	49	101	146	292	693		
25	55	112	163	326	774		
30	60	123	178	356	847		
40	69	142	205	411	976	102	1.39
50	77	158	229	459	1090		

2.4 A **revised** prediction table using the MfE (2000) equations is provided below. This shows the predicted periphyton Chl *a* concentrations for a range of SRP (or DRP) concentrations and river accrual times. The observed Chl *a* are the maximum periphyton values measured during the summer monitoring period in 2003. These show good agreement with the predicted values relative to the measured river DRP concentrations. The shaded portion indicates the predicted values for the site-specific accrual period of 13 days used in this derivation. The bold highlight (black background) indicates the nominal nuisance threshold of 120 mg Chl *a*/m^2, which corresponds to a DRP of 66 mg/m^3 (or 0.066 g/m^3).

SRP conc (mg.m^{-3})	Accrual time (d)					Chl *a* Observed	Pred/Obs
	10	13	15	20	30		
2	11	21	29	53	106		
5	18	33	46	83	167	48	0.69
10	25	47	65	117	235		
15	30	57	79	143	287		
20	35	66	91	164	331		
25	39	74	102	184	370		
30	43	81	111	201	405		
40	49	93	128	232	466	102	0.91
50	55	104	143	259	521		
66	63	**119**	164	297	597		

2.5 This table clearly indicates the very high sensitivity to the accrual period calculation (as was also evident in the earlier derivation). I have noted in my earlier supplementary evidence (section 21) that the detailed methodology for a 'site-specific' guideline derivation is not provided in the MfE (2000) guidelines. The use of a larger 'filter period' will give longer nominal accrual period corresponding to lower DRP concentrations for the filamentous algae nuisance threshold to be reached (eg. 15d accrual = 35 mg/m^3 DRP; 20d accrual = 12 mg/m^3 DRP). I do not consider that the longer filter-period are justified for the Ruamahanga River based on the measured data as described in our reports (NIWA 2003, 2004).

2.6 The above table shows the 'Observed Chlorophyll *a*' which was used to calibrate the river data to the guideline response relationships. These river algal growths were measured after a post-flood accrual period of 16 d and equated to the average summer accrual period (shaded). Extrapolation of this measured downstream growth to 20 d gives a predicted Chlorophyll *a* of 130 mg/m^2, which is markedly less (56%) than the 'predicted' value for a 20 d accrual period. This favoured use of a summer accrual period of 13-15d for establishing the future DRP site-specific guideline.

2.7 The filter period was a specific consideration in deriving the site-specific guideline for DRP (NIWA 2004). The basis for the 1-day filter interval was the observed 'resetting' of growths which occurred for a flow of 3x the summer median (NIWA 2003), and that "*a significant re-growth could occur over a 5-day period*" (at 7 mg Chl*a*/m^2/d, paragraph 4, p9, NIWA 2004). On this basis, it was argued that the use of a longer flood filter period would result in the calculation of an inappropriately long summer accrual period for the site-specific Ruamahanga River guideline.

2.8 We further noted in undertaking our site-specific derivation that: "*The above process is robust and, we judge, moderately conservative for the environment. However readers should recognise that the process for proposing the DRP criteria has, at several steps, borrowed value judgements from elsewhere about what is an appropriate level of protection for the management purpose and what is an appropriate flow band for compliance.*", and that "*The national guidelines can be conservatively restrictive (see page 104, MfE 2000). The RFPWR specifically acknowledges the time and cost elements to achieve water quality improvements (Policies 5.2.10 and 5.2.13).*" (paragraph 7, p10; NIWA 2004).

2.9 Our other field measurements of periphyton proliferations downstream of point-source wastewater discharges has shown the very high nutrients may occur without nuisance growths occurring. In these studies, the absence of nuisance growth exceedance at high DRP concentrations was attributed to the presence of high numbers of macroinvertebrate grazers (Welch et al 1992). Based on our earlier studies (NIWA 2003), grazers are important in the Ruamahanga River and would also contribute to reducing algal abundance.

2.10 Based on this revised analysis, 30 mg DRP/m^3 would result in a maximum of 68% of the nuisance threshold, and site-specific guideline of 66 mg DRP/m^3 would be appropriate for the Ruamahanga River. On the basis that assessments have been made relative to compliance with a 30 mg DRP/m^3 threshold, I would recommend that this should still remain an appropriate assessment benchmark (not a compliance standard, but a trigger for further investigation and possible review if not met).

2.11 I do not agree that 0.012 mg DRP/m^3, as recommended by the Officers' Report, is an appropriate benchmark, let alone a compliance standard.

2.12 I address further issues raised by Dr Olivier Ausseil in relation to site-specific DRP guideline derivation and application later in this supplementary evidence.

3. POND COMPLAINCE MONITORING

3.1 The Officers' Report proposes both median and 95^{th} percentile compliance values for the pond effluent, together with a "rolling" averaging system for compliance assessment (Schedule 1, condition 16).

3.2 Historically a geometric mean was used as the basis for compliance assessment. I consider that geometric mean (or median) values are not good for river protection and should not be recommended or used for consent compliance. They are a robust measure of the pond performance (average and trends) and so should still be measured and reported on this basis.

3.3 I do not recommend using both median and upper percentiles for river protection. There may be some basis for land application in using a median - though it is not obvious to me what this would achieve in terms of mitigation of effects.

3.4 The upper end of the pond distribution are what can mostly affect receiving waters (eg. high concentrations) - hence the basis of using the upper percentiles (90 or 95%) for compliance assessment. These provide a robust measure for environmental protection. For this reason, percentile values were calculated from the existing pond datasets, at the request of and involving Greater Wellington Regional Council Officers (Mr Ted Turner), for application to the future monitoring programme. The method followed the New Zealand Municipal Wastewater Monitoring Guidelines (NZWWMG 2002) and results were provided in a summary report (NIWA 2006) and incorporated into the AEE. As described in my evidence (section 6.38), the future river effects assessment were based on lower *E.coli* concentrations (geometric mean of 300 cfu/100mL equivalent to a median of 330 cfu/100mL) as a result of treatment improvements, while all other parameters used the existing distributions. These values have been used as the basis for prediction for the new pond systems.

3.5 I have recommended 90%iles for most parameters and 95%ile for *E.coli* as a practical compliance measure given the proposed sampling frequency. I have used the 90%ile pond values for comparison with predicted river concentrations in my assessment of potential effects (my evidence Table 5) to median flow. I have provided further assessment of compliance for the key ammoniacal nitrogen guidelines at half-median flow in my supplementary evidence (section 8).

3.6 I do not recommend a "rolling mean" and know of no advantage for ecological or aesthetic protection. The proposal for use of "rolling" compliance is not justified in the Officers Report. I would recommend that 'adjacent' periods (ie percentile assessment of either summer or annual monitoring period, as appropriate) form the basis of the compliance assessment (NIWA 2006).

4. EFFLUENT COMPLIANCE MEASURES

4.1 The Officer's Report specifies a large number of parameters for compliance assessment. Some of these parameters do not relate to potential adverse effects and so need not be included for compliance, but should be continued for trend monitoring. Some parameters could be discontinued in future if no effects were observed.

4.2 I would recommend that Total nitrogen and Total phosphorus be monitored for trends and not compliance. Potential effects in the receiving water are covered by nitrate/nitrite and dissolved reactive phosphorus.

4.3 I would also recommend that a review clause be incorporated after 3 years. Specifically, I would anticipate that filtered BOD measurement could be discontinued if no undesirable growths were found in the receiving waters

5. FREQUENCY OF MONITORING

5.1 The Officer's Report specifies a high frequency of monitoring for a number of conditions. For some this may be desirable to obtain a baseline condition, however, they should then be critically reviewed after this initial period.

5.2 OR condition 17 (p75) specifies weekly frequency. I do not agree that the proposed high frequency of sampling is required for assessment of potential environmental effects. I would accept that a higher frequency of sampling may be required to assess pond performance during start-up of the new ponds, however, such a high frequency of monitoring is generally not required for a well performing pond with a high residence time. I suggest reducing frequency to coincide with the monthly receiving water monitoring (as is presently the case).

6. RIVER EFFECTS

6.1 The Officers' Report includes receiving water nutrient compliance conditions for both nitrogen and phosphorus (Schedule 1, condition 19, p76).

6.2 I do not agree with the proposal to apply numeric phosphorus and nitrogen standards to the river monitoring for the purpose of compliance monitoring. These are not contaminants of concern for toxic effects, exceedance of which could cause direct adverse effects. Rather they are one of the components affecting algal growth in the river. As such they should be included in a monitoring programme, but not used for compliance assessment.

6.3 I agree with the use of compliance criteria for the nuisance growths of periphyton, which is an appropriate measure of effects in the receiving water. However, these need to be implemented with consideration of the upstream conditions, recognising that if a bloom is occurring upstream then this would not constitute a breach of compliance for that occasion.

7. CYANOBACTERIAL MAT MONITORING

7.1 The Officers' Report includes a requirement for cyanobacterial mat monitoring (schedule 1, condition 21, p77).

7.2 A guideline for the cyanobacterial mat assessment will need to be specified and agreed prior to acceptance of this condition. The significance of cyanobacterial mats which are naturally present both upstream and downstream of the discharge will have to be incorporated into this protocol.

7.3 I would recommend that this condition have a 2 year review clause to critically assess the need for continued monitoring at all of the specified river sites.

8. GROUNDWATER MONITORING

8.1 The Officers' Report includes a requirement for groundwater monitoring to comply with low concentration nutrient conditions (condition 40, p83). I do not consider that the requirement for dissolved inorganic nitrogen or dissolved reactive phosphorus compliance standards for groundwater is required or justified. The reasons for my opinion are as follows.

8.2 The presence of elevated nutrients in soil groundwater does not pose a direct or indirect threat of adverse effects on the ecology or to human health from groundwater exposure. The effects of groundwater load (ie concentration x flow rate) are integrated in the Ruamahanga River and Makoura Stream monitoring. There is no basis for a compliance standard on the groundwater for nutrients. This monitoring may be undertaken to assess the treatment performance but not for compliance monitoring.

8.3 I note that Graeme Proffitt has provided model-predicted DRP compliance values which include a background DRP component in his further supplementary evidence (dated 8 March 2009). I acknowledge that this is an improved approach which targets the limiting nutrient, however, I would consider that these values (potentially termed groundwater targets - GWTs), would be best used in a 'performance monitoring' programme. Exceedance of the GWTs would then trigger an investigative assessment regarding the cause and consequence of the exceedance. A single high core concentration would not necessarily represent a concern for the river in terms of adverse effects.

9. RESPONSE TO DR OLIVIER AUSSEIL

9.1 I respond to the statement of evidence of Dr Ausseil dated 9 March 2009. I respond to his comments on periphyton and nutrient guidelines, monitoring and consent conditions.

9.2 I note that he recommends effects-based consent conditions which are as "enforceable as possible" (section H). I agree with his recommended approach in having nutrient “targets” and monitoring assessment of effects against those targets as the most appropriate approach (section G 90). I also agree that changes in water clarity, periphyton and macroinvertebrate community indices are suitable indictors of effects (section H 98) and his concept of “acceptable degree of change” (section H 101), but do not agree with all of the parameters or frequency recommendations.

9.3 Dr Ausseil provides a list of measures for condition 7 and 19 (section H 103) and change conditions, together with pond monitoring frequency for condition 17 (section H 104), and biomonitoring for condition 20 (section H 105). My specific responses are:

9.4 Clarity change (section 103 g & section D). Including a compliance condition for clarity change of <33% after reasonable mixing is consistent with our proposed compliance guideline (Table 25 of my evidence). Dr Ausseil recommends a 30% change to apply at 175 m downstream, while I would recommend a 33% change (as consistent with the MfE guidelines) to apply after the 300 m reasonable mixing zone. I do not understand the basis for reducing the mixing zone to 175 m for this parameter and do not support that proposal.

9.5 Dr Ausseil raises concerns as to potential effects for trout foraging if clarity changes were to be excessive, particularly for the winter half-median threshold (section D 48). I have summarised the available winter clarity data in my evidence (Table 15, Table 40 of AEE), showing clarity of median 3.6 m and a very high variability (0.3-7.1m for 5-95%ile) for <half-median. This reduces to 3.0m median (0.7-5.2m range) for the threshold flow range data (9 data from 5 to 8 m^3/s), and further to a 0.6m median (0.084-3.6m range) for flows high flows. I estimated the reduction in median clarity of about 17% based on my summer effects modelling. I state in my evidence that the median summer clarity may change in the threshold flow range by 15% at 300m and range from 0-50% (section 6.37). I would add to clarify that the model predicts less than 44% change for 90% of the time after reasonable mixing (ie 20x dilution) for the transition flow range (NIWA 2005b). Given that the transition flow period is also of short duration (about 4% of time), I would expect that a clarity change of less than 33% change after reasonable mixing would be achieved.. I further note that the ponds have lower suspended solids and turbidity in winter, and so may have a lower change after reasonable mixing. I therefore do not consider that the winter change in clarity will result in an adverse affect on trout.

9.6 Periphyton growths. Section 103 h and i recommend filamentous and algal mat covers. These values are consistent with the MfE guidelines and form the basis of the compliance monitoring proposed in the AEE. However, the algal biomass condition (section 103 j) recommends: "*The biomass of periphyton as filamentous growths or mats on the bed to exceed 120 mg/ chlorophyll a /m^2 over a representative reach.*", and further specifies criteria to breach:

a. *The periphyton biomass measured at the site downstream of the discharge is above standard set in conditions 14 (j); and*
b. *the increase between the upstream and downstream concentration (calculated as follows) is equal to or exceeds 20%. Percentage of increase = 100 x [downstream result – upstream result/ upstream result].*

These biomass conditions would apply after reasonable mixing (300 m) and at Wardells Bridge (1250m) downstream. I do not agree with the biomass compliance conditions.

9.7 My concerns regarding this algal biomass compliance condition are two-fold: (i) The proposed compliance conditions do not specify whether the measured algal biomass are the maximum for a cross-section average or average for multiple cross-sections; and (ii) the standard value of 120 mg/ chlorophyll *a* /m^2 is appropriate for filamentous algal growths while a value of 200 mg/ chlorophyll *a* /m^2 is appropriate for mat algal growths (MfE 2000). Our studies of periphyton response to leakage indicate that this condition would not be workable as it stands.

9.8 A pond leakage study was undertaken in 2005 to measure river effects in the reach from adjacent to the ponds to upstream of Wardells Bridge, together with an assessment of cover at the distant downstream Gladstone Bridge. This involved extensive river nutrient measurements, faecal bacteria (*E.coli*) and periphyton cross-sections for biomass and abundance (including photographic records) (NIWA 2005a). This study was undertaken on two occasions after a long low-flow period and thus the near-peak communities should have established. The results showed that the algae did respond to the pond leakage DRP increase, but that all of downstream algal biomass increase was mat cover, with no change in abundance of filamentous algae. Regression relationships were developed for individual stones (maximum Chlorophyll *a* = 197 mg/m^2) and with cross-section averages. The cross-section average cover relationship for 6 cross-sections explained 69% of the variance, and showed that about 50% cover occurred when the Chlorophyll *a* was 100 mg/m^2. This indicates that visual assessment of algal cover does provide a good measure of algal biomass and that Chlorophyll *a* measurement would not be required for averaged assessments.

9.9 These data showed: (i) that mat algae are expected to predominate in response to leakage DRP; and (ii) that a numeric algal biomass guideline, if used, should be appropriate to mat algae (ie 200 mg/ chlorophyll *a* /m^2). I do not consider that the monitoring frequency needs to be all year rather than the summer period as recommended in the AEE. I base this opinion on my inspection of the monthly algal monitoring data for winter on 118 occasions at Wardells Bridge since 1989. The maximum filamentous algal cover was 11.9% (14 May 2003) and mat cover 64% (13 September 2005), with the majority of occasions showing no filamentous or mat algae present. This is the situation with the continuous discharge and I expect a further improvement with the intermittent discharge.

9.10 Increase in algal mat cover would be considered less concern for reducing aesthetic and recreational amenity value than proliferation of more conspicuous filamentous algae. I do not consider that the application of more stringent arbitrary guidelines to protect “trout habitat/angling and aquatic ecology values” (section C 20) are required. I have noted above the lack of winter blooms and I consider that my assessment of current macroinvertebrate communities indicate healthy communities as addressed in my supplementary evidence (section 13.1). I also, note, that whilst there will be a winter discharge between half median and median flow, there will be an overall reduction of nutrient loads at flows below median as compared to present. (The current discharge is at all flows.)

9.11 Cyanobacteria monitoring (section 20-23). I have provided further comment in relation to cyanobacterial mat monitoring in section 7 of this further supplementary evidence.

9.12 Nutrient guidelines (section iv). Dr Ausseil raises a number of points in relation to nutrient guideline derivation and application. The difference between generic nationwide guidelines application as addressed in the MfE (2000) guidance and the recent workshop report Wilcock et al 2007) needs to be distinguished from a site-specific application with support from field-collected data. Guidance is not provided in the national document for site-specific derivations, and we provided the justifications for our decisions in our field data and monitoring records of existing nuisance growths (NIWA 2003, 2004). I consider that focusing on the effects-based monitoring programme for compliance monitoring, together with required review periods, provides the best approach to validate the proposed site-specific guideline value for the Ruamahanga River. This agrees with the monitoring proposed by Dr Ausseil as addressed earlier and an "assessment against numerical targets" (section D 66) approach.

9.13 Discharge regime (section E). Dr Ausseil maintains that in "winter" the discharge "will be operating 94 to 95% of the time". I have confirmed that the average percentage of days of discharge during winter is 90%. However, I understand that the proposed discharge protocol would aim to minimise discharges below median flow.

9.14 The discharge will be reduced from the current situation as a result of the land treatment which does continue during winter. In any event, this does not justify or require chemical monitoring at the end of the mixing zone (300m). The concentration of the chemical parameters can be calculated at this location from the measured (monthly) upstream and pond monitoring. The effect observations for periphyton growths (monthly in summer), together with the annual summer invertebrate monitoring, would provide the integrated effects assessment. Therefore, I do not agree that additional water quality monitoring is required at the reasonable mixing boundary. If needs be there could be some initial monitoring of periphyton during winter, however given that there is currently no problem in winter I consider that such monitoring is rather pointless.

9.15 Monitoring frequency for ponds (section F). Dr Ausseil considers that weekly monitoring for 2 years is required after the upgrade is completed (section 104). I have indicated that I consider that this frequency is excessive for ongoing monitoring (section 5), but that some additional monitoring may be required at start-up. The suite of parameters will depend to some extent on the start-up procedure (eg the amount of old pond effluent used to 'seed' the initial filling). Because of the hydraulic residence time many parameters change minimally over weekly periods. Therefore, a small suite of parameters for weekly analysis for 3-6 months could usefully complement the routine monthly monitoring suite for a commissioning period. I do not consider that the full suite for 2 years would be required in order to calibrate pond performance.

10. RESPONSE TO CORINA JORDAN

10.1 I respond to the submission of Ms Corina Jordan on behalf of Fish and Game in relation to water quality issues.

10.2 Ms Jordan has raised various issues in relation to water quality. My reponses to Dr Ausseil's submission (section 9) will be relevant to the Fish and Game concerns. I will make additional further comment regarding clarity and ammoniacal-nitrogen concerns.

10.3 I have specifically addressed clarity issues raised by Dr Ausseil (section 9.2 & 9.4) and Mr Stewart (section 10.12) in relation to their concerns. I would recommend that 33% change should apply after reasonable mixing as a basis of the compliance monitoring programme. The 20% clarity reduction condition has been suggested by Ms Jordan on the basis that "*Allowing a change of clarity by 50% would result in 1.5m clarity, which would significantly impact trout foraging ability, and greatly exceeds the 2000 ANZECC which define a maximum clarity reduction of 20% to protect the aesthetic quality of a water body*" (section 37) . The 20% reduction is for Class A waters (where visual clarity is an important characteristic of the waterbody), and a 33-50% reduction for "other waters" (MfE 1994). Furthermore, MfE state (p34): "*There is no evidence in the literature of clarity criteria to protect visual requirements of aquatic fauna".* Thus, though I do not accept that a reduction to 1.5m visibility would constitute a "…*significantly impact trout foraging ability…",* I would consider that a 33% limit would be an appropriate compliance standard for the Ruamahanga, given that the discharge will only occur at elevated flow conditions.

10.4 So far as trout foraging is concerned, in my view a change of up to 33% after reasonable mixing is unlikely to have any more than an insignificant effect on trout foraging within a very small portion of the river. Clarity will be significantly improved from the present situation at summer flows below median. Changes of clarity of between 20 to 33% are only likely to occur during winter flows between half-median and median. The installation of an diffuser will improve the low flow clarity effects close to the point of discharge as compared to present. As a result the mixing zone is much smaller than the current mixing zone and therefore potential effects much more limited. Additionally, the duration of the intermittent discharge during fresh events will be much less than would be theoretically calculated for a given flood size (see supplementary evidence of Humphrey Archer).

10.5 Concern about the potential toxicity of ammoniacal-nitrogen has been raised by Ms Jordan, citing US EPA and my work on native invertebrates (section 39). The following paragraph, however, incorrectly quotes an ANZECC (2000) to "*Maintain concentrations of Ammonia below 10 µg-N/L*….", and other "POP standards", the derivation of which I am not familiar. (section 40). I have responded in my supplementary to the incorrect usage of ANZECC trigger values for nutrient exceedance (section 18), and this is the same case for the cited “ammonia” value. This is merely the 80^{th} percentile value for selected New Zealand rivers, and does not relate to significant adverse effects. The chronic ANZECC (2000) ammoniacal-N trigger values are protective of New Zealand invertebrates, based on the comparison of community and *Deleatidium* effects thresholds with US EPA chronic guidelines (Hickey et al 1999).

10.6 I have made a specific assessment in my supplementary evidence of the potential for ammoniacal-N toxicity for half-median flow discharges (section 8). I concluded that there would not be exceedance of the guideline after reasonable mixing. I would recommend that all Ruamahanga River monitoring data should include a guideline compliance assessment for ammoniacal-N with the current ANZECC guidelines compliance.

10.7 In summary, I disagree with the suggestion that the proposed upgrade with the conditions proposed by the applicant will fail to protect the habitat of salmon and trout. To the contrary, there is likely to be an improvement in habitat quantity, particularly in the summer period, but also in the winter period.

11. RESPONSE TO MR ANDREW STEWART

11.1 I respond to the submission of Mr Andrew Stewart in relation to water quality concerns.

11.2 In section 4.29-4.30 Mr Stewart calculates a assimilative capacity usage based on a DRP concentration “below 0.01 g/m^3 as is the current national standard”. This is not correct as there is no “national standard”, and information probably comes from the incorrect usage of the ANZECC (2000) lowland stream “trigger” value in the Technical Report. I have addressed this in my supplementary evidence (section 18). The mean DRP upstream of the discharge is currently 0.01 g/m^3 and this forms the basis of our downstream predictions.

11.3 In section 4.33 Mr Stewart addresses the need to understand all catchment loadings. As noted, I agree with this approach, however, I have in the introduction to my evidence (sections 5.4-5.5) addressed the effects-based relevance of total and dissolved nutrients for potential receiving water effects. Our concerns for potential excessive river periphyton growths lead to the emphasis on dissolved nutrients. The relative loadings of the discharge to Lake Onoke are addressed in the evidence and further supplementary of Dr Jim Cooke.

11.4 Mr Stewart raises concerns about the supposed “selective nature of some data” as presented in the AEE and evidence. I can assure Mr Stewart that there was no intent for the analysis to be limited or restricted. All MDC, GW and NIWA data was compiled and used at the time the reviews and assessment were undertaken. Table 19 is indicative of the upstream (RUA1) and partially mixed downstream (RUA2) site for levels of change. A more comprehensive table for March 1994 to October 2005 is given in the before and after analysis (Table 43 in AEE, Table 18 in my evidence). This work was done in 2005 prior to the initial consent lodging and was not updated prior to the revised AEE. I do not consider that the addition of new data would have substantively changed the analysis or conclusions.

11.5 Mr Stewart seeks to clarify the basis of the DRP guideline (section 5.15-5.23). As I have noted earlier, there is no “national guideline”. He raises concerns that the DRP concentration greatly exceeds “guideline values” during flood events (section 5.16). The initial field studies (NIWA 2003) showed that a flood of 3x the summer median flow would efficiently scour the river bed and ‘reset’ to very low periphyton biomass levels. This was recorded on multiple occasions and I presented the results figure in my evidence presentation. Growth from this low periphyton level occurs with slow biomass production, which is further reduced by high turbidity (reduced light energy) (see Figure 6 in evidence of Dr Jim Cooke for clarity decline with flow), and the effects of continued scour conditions during the flood decline. Thus I do not consider that the elevated DRP concentrations above median flow are a significant contributor to nuisance growth proliferation. For this reason, I used the term ‘not applicable’ in the summary table 23.

11.6 As noted, we have acknowledged that the high sensitivity of the MfE (2000) guideline equations to the accrual period. This is common to many New Zealand rivers and is a very challenging component of confidently estimating controlling nutrient concentrations for rivers. While flood frequency is critical, we have also found the high numbers of invertebrate grazers may prevent growths in many rivers receiving high DRP concentrations (Welch et al 1992).

11.7 In our development of site-specific guidelines, we also attempted to use a dynamic periphyton growth model calibrated on our 2003 field study (NIWA 2004). The uncertainties which Mr Stewart cites (section 5.23) are from our report and relate to our testing of that mathematical model in the Ruamahanga River.

Unfortunately, we could not use this model to definitively link DRP and maximum algal biomass in the Ruamahanga, but did use it to predict nuisance growth proliferations based on a low maximum Chlorophyll level. Growth rate data is included from the NIWA 2003 study to drive this model, together with scour equations relating to the instantaneous flow rate. Approximate rates of net growth are given in NIWA (2004) and used to predict exceedance of nuisance thresholds (this it the best data that would answer Mr Stewart's 5.29 query). The predictions were for nuisance growths "occurring in 6 of the 15 years, with durations of from 3.5d to 35d, with most being around 5d." This information, together with the currently observed nuisance growth monitoring, led me to conclude that the frequency of nuisance growths downstream of the discharge would be low and the adverse effects minor.

11.8 Mr Stewart requests the growth rate information in relation to DRP concentration (section 5.30). The only field data are those from 2003 which were used with the mathematical model in NIWA (2004) study. The downstream data range from 0.61 mg Chl *a*/m^2/d to 7.3 mg Chl *a*/m^2/d (ie 2.2 to 27.5x upstream net growth rates, NIWA 2003, Table 5.3). A nuisance growth level for a filamentous threshold of 120 mg Chl a/m^2 could therefore take from 16 to 197 days to occur for linear growth. On this basis the occurrence of nuisance growths would be relatively rare.

11.9 Mr Stewart summarises his nutrient and algal growth section (after 5.34). I have noted elsewhere that there is no "national standard" for DRP and why it is not appropriate to use a site-specific DRP guideline for flows above median. I consider that the predicted frequency and duration of nuisance algal proliferations are minor from both an ecological and a recreational use perspective. Based on the available information, the nuisance growth exceedance frequency is currently higher at the upstream Te Ore Ore monitoring site.

11.10 Clarity in relation to flow. Mr Stewart raises concerns about the clarity relationship with flow (section 5.44-5.51). The clarity relationships with flow in the threshold flow range were analysed at an early stage in this project. Sufficient summer data were only available from the NIWA National Water Quality Monitoring Network (NWQMN) for Wardells Bridge, with 19 data in the 10-14 m^3/s restricted flow range (NIWA 2005b). These data were collected from the true right bank and considered by NIWA staff to not be influenced by the Makoura discharge. These data did not show a flow relationship in the 10-14 m^3/s range (as for Mr Stewart's figure in 5.44), but do show a declining relationship over the greater river range (see Figure 6 in Dr Cooke's evidence). The AEE (Figure 18) shows both RUA1 data and NWQN data and indicates a greater frequency of low clarity data in the NWQN dataset. The threshold range clarity data (median 1.3m, range 0.10 to 6.7m, 0.15-4.8m 5-95%ile) was fitted to a log-normal model for Monte-Carlo modelling with the effluent addition. The model-predicted median and confidence range were summarised in AEE Table 34 (median 1.0m, 0.17-4.63) and used as a basis for clarity change predictions. This analysis has not been updated since that time.

11.11 I have not stated that there is a "sudden decrease in water quality once the 12.3 m^3/s flow rate is reached." (section 5.47). Rather, all of the modelling and predictive work seeks to take representative data in this "threshold flow range" just above median flow as the basis for where effects assessments need to be made. I consider that this is a robust approach to a difficult problem of assessing potential effects on a continuum of declining and then improving water quality.

11.12 Visual clarity. Mr Stewart raises concerns about the change in visual clarity (sections 5.56-5.58). The tabulated confidence intervals in the visual clarity (and *E.coli* concentrations) are a function of the upstream or natural water variability. The Monte-Carlo modelling predicts the level of change for median and the distribution of clarity values. I provided an example table of the data output in my evidence for *E.coli* (Table 11), showing the calculated percentage change from upstream. I summarise the data for clarity reduction in my evidence (section 6.37) as a median of 15% and range of 0 to 42%. The analysis shows that 90% of the time the change in the threshold flow region (which occurs 4% of time), would be less than 35% change (NIWA 2005b). I consider that an appropriate compliance condition for upstream / downstream monitoring would be a 33% change in clarity after reasonable mixing, as indicated in Table 25 of the AEE (see my response 9.5 to Dr Ausseil). I consider that the 33% clarity change is an appropriate standard for use in the Ruamahanga River.

12. RESPONSE TO MR IAN GUNN

12.1 I respond to the statement of evidence of Mr Ian Gunn in relation to water quality issues.

12.2 Mr Gunn provides a plot of flow at Wardells, Waihenga Bridge and level in Lake Onoke in 2008 (p29) and states that "no discharges should be allowed into the Ruamahanga river if Lake Onoke is blocked." (section 9.6). I agree that this shows increasing levels for extended summer periods, however, no effects data for degradation of Lake Onoke is provided. As stated in my evidence, I am not aware of data that indicates adverse effects in Lake Onoke which are potentially associated with the discharge from the Masterton treatment ponds. I do not consider that the blockage condition by itself, will necessarily result in adverse effects related to water quality. I also note that as discussed by Dr Cooke, in relation to the discharge of nutrients, Masterton currently contributes only a small proportion of total annual nutrients to the lake (3 to 8%, Figure 5) He estimates that post upgrade the MWTP discharge would contribute no more than 9.4% of the phosphorus load to Lake Onoke during the duration of the blocked lake outlet.

13. RESPONSE TO DEPARTMENT OF CONSERVATION

13.1 I respond to the statement of evidence of Ms Nadine Bott dated 10 March 2009. I respond to her comments on periphyton and nutrient guidelines, monitoring and consent conditions.

13.2 Ms Bott raises a range of specified concerns (section 39) in addition to those addressed by Dr Ausseil, which I have addressed above. A number of these points relating to dewatering and decommissioning of pods and the management of stormwater are addressed in the evidence of Mr Humphrey Archer. I will address the specific points raised in relation to water quality.

13.3 Dissolved oxygen monitoring (section 42). Continuous dissolved oxygen (DO) monitoring is undertaken to measure diurnal changes in temperature and DO in association with photosynthetic activity in the aquatic ecosystem. While there is no current evidence of excessive DO depletion in the Ruamahanga River, a multi-station monitoring of DO during low flow periods would be a useful river characterisation. I do not consider that this should be a compliance condition in relation to this discharge, however, a study could be undertaken by Greater Wellington as part of a wider state of the environment and Ruamahanga catchment characterisation.

13.4 Application of nutrient standards (section 43). I have specifically addressed the basis for my opinion that nutrient standards need not apply all year round in the Ruamahanga as based on periphyton monitoring data (section 9.8). I have previously noted in my supplementary evidence that exceedance of the ANZECC “trigger values” for nutrients constitutes a measure of adverse effect (supplementary section 18). Therefore I do not consider the year-round nutrient standards are required.

13.5 Diffuser impacts during migration (section 45). I accept that there could be potential for increased sediment and near-bank disturbance during the diffuser construction. I would support a condition to restrict the construction period as proposed.

Dr Chris Hickey
Senior Principal Scientist, NIWA
11 March 2009

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