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

STATEMENT OF EVIDENCE OF JAMES COOKE
ON BEHALF OF MASTERTON DISTRICT COUNCIL

Subject Area: Hydrology and general water quality

1. INTRODUCTION

1.1 My name is James Grainger Cooke. I hold the degrees of Bachelor of Science (University of Waikato 1973), Diploma in Agricultural Science and Master of Philosophy (Massey University 1974 and 1977) and Doctor of Philosophy (Oxford University 1986). Both my Masters and Doctorate theses were on topics relating to water quality of rivers.

1.2 I have 31 years experience in environmental science, the majority of it (29 years) with the National Institute of Water and Atmospheric Research (NIWA) or its predecessor organisations. At NIWA my career included research into nutrient (nitrogen and phosphorus) runoff from agricultural catchments, nutrient cycling in natural wetlands receiving sewage effluent, and nutrient transformations in freshwater ecosystems.

1.3 I have also managed or led a large number of applied science consultancy projects relating to the environmental effects of anthropogenic activities on aquatic ecosystems, both in New Zealand and Australia. Other roles at NIWA included Business Development Manager, Manager Environmental Research and Services (NIWA Australia), and Leader of the National Centre for Water Resources. From October 2006 to September 2007 I was a Senior Environmental Projects Manager with Beca Infrastructure in Wellington, and worked on projects that included this consent application, managing scientific input to a proposed National Environmental Standard for Ecological Flows (MfE), and advising Auckland Regional Council on improvements to the definition of reasonable mixing for their proposed Auckland Air, Land and Water Plan.

1.4 I am currently a Director of Diffuse Sources Ltd, a company specialising in diffuse water pollution. I am also on the Management Board of the International Water Association's Specialist Group on Diffuse Pollution.

1.5 I have read the Code of Conduct for Expert Witnesses issued as part of the Environment Court Practice Notes. I agree to comply with the code and am satisfied the matters I address in my evidence are within by expertise. I am not aware of any material facts that I have omitted or might alter or detract from the opinions I express in my evidence.

1.6 I have been engaged by Masterton District Council to summarise the key aspects of the proposal as they relate to water quality. In particular, my brief is to discuss:

(a) the hydrological setting of the Ruamahanga River and the influence that hydrology has on water quality in the river and hence the rationale for the river/land discharge regime;

(b) the concepts of reasonable mixing and the methods used to determine the reasonable mixing zone and how this relates to the distance required to achieve full mixing,

(c) how the proposed flow-triggered discharge method will be achieved, and

(d) the monitoring regime proposed to verify the predicted concentrations of contaminants in the Ruamahanga River at the end of the proposed reasonable mixing zone, and at Wardell's Bridge at a range of river stage heights.

1.7 My evidence is structured as follows:

(a) scope of evidence;
(b) executive summary;
(c) the proposal;
(d) mixing and dilution;
(e) trigger flow;
(f) monitoring;
(g) submitters' concerns; and
(h) conclusion.

2. SCOPE OF EVIDENCE

2.1 My evidence will address the key aspects of the proposal as they relate to water quality. I will discuss the hydrology and general water quality of the Ruamahanga River and explain how the new discharge location and inclusion of a diffuser will result in improved mixing of the discharge further upstream of Wardell's Bridge. Others will discuss how this will lead to a significant improvement in aesthetic impacts, and a reduction in health risk.

2.2 I will discuss the concepts of full and reasonable mixing, identify where these occur in the river, and the approach taken to predict future water quality. The effects on water quality will be dealt with in further detail by Dr Chris Hickey and the reduction of health risks will be covered by Mr Andrew Ball.

3. EXECUTIVE SUMMARY

3.1 The hydrology of the Ruamahanga River is characterised by frequent freshes (rapid rises and falls in flow rate) which mobilise faecal and particulate material from diffuse pollution sources, and result in poor water quality both above and below the current point of discharge.

3.2 Diffuse pollution sources account for most of the nutrient load entering Lake Onoke on an annual basis. Less than 8% of the annual load can be attributed to the current Masterton WWTP discharge.

3.3 Under summer low flow conditions, the Masterton WWTP currently contributes a much higher proportion (~43%) of the nutrient load entering Lake Onoke, which may contribute to poor water quality. When the proposed upgrade is complete, however, this contribution will drop from ~43% to <2.5%.

3.4 When the proposed upgrade is complete, a new discharge point together with a diffuser structure will result in greatly improved mixing compared with the current discharge. Dye releases together with modelling demonstrate that full mixing will occur at a distance ~ 800m downstream of the point of dicharge (450m upstream of Wardell's Bridge) and 'reasonable mixing' (where water quality standards are not required to be met) will occur between 300-400m downstream of the point of discharge.

3.5 Reasonable mixing is generally assessed on a continuous discharge at low flow conditions, when flow conditions are relatively stable. When fully operational, however, the proposed discharge for the MWTP upgrade will only be triggered at median flows in summer, which will generally occur when the river is at the onset of fresh/flood conditions – i.e., river flow rising from low to high flow due to a significant rainfall event.

3.6 Thus at less than median flows in summer (when recreational use of the Ruamahanga River is greatest), there will be no direct discharge from the MWTP at all once when the upgrade is complete. At the threshold (just above median flows in summer) water quality may otherwise (except for the discharge) be suitable for recreational use. It is important to realise that this threshold range where there is an elevated health risk occurs only about 4% of the summer time and accordingly exposure risk will be very low. Once the flow rises ~15% above the threshold for discharge, pollution from upstream diffuse sources would render the water quality unsuitable for contact recreation without the MWTP discharge.

3.7 Telemetry of flow measurements at Mt Bruce and Wardell's Bridge will be used to provide reasonable certainty that the river flow will be sustained for more than six hours above the trigger value before discharge commences. A delay of 15 to 30 minutes will ensure that the river flow has comfortably exceeded the trigger value before discharge starts, thus further reducing exposure risk.

3.8 Comprehensive monitoring is proposed in the first year following completion of the upgrade to demonstrate the concurrence between predicted and actual receiving water quality.

4. THE PROPOSAL

4.1 So far as my evidence is concerned, the key elements of the proposed upgrade of the existing wastewater treatment and disposal system are:

(a) Once the new ponds are commissioned, there will be no discharge of treated wastewater to the Ruamahanga River when river flow is below median flow (≤12.3 m^3/s) in summer (1 November-30 April) or below ½ median flow (≤6.2 m^3/s) in winter (1 May-31 October);

(b) The intermittent discharge to the Ruamahanga River will be at a rate to achieve a dilution factor of 30 (i.e. the rate of discharge will not be greater than 1/30th of the instantaneous flow in the river at the point of discharge);

(c) A new discharge location and inclusion of a diffuser will result in improved mixing which, combined with the intermittent nature of the discharge, will result in full mixing of the discharge at least 300m upstream of Wardell's Bridge; and

(d) Together these improvements will result in a significant improvement in aesthetic impacts and reduction in health risk.

5. MIXING AND DILUTION

Hydrology and general water quality of the Ruamahanga River

5.1 The Ruamahanga River flows from its headwaters in the northern part of the Tararua Ranges down to Lake Onoke, which flows into Palliser Bay. Many tributaries join the Ruamahanga River before it enters Lake Onoke, including the Kopuaranga, Waipoua, Whangaehu Waingawa, Taueru, Waiohine and Huangarua Rivers. The Ruamahanga River at Makoura Stream drains a catchment of approximately 63,346 ha.

5.2 The water level recorder at Wardell's Bridge just above the confluence with the Waingawa River has recorded Ruamahanga River water levels since 1954: Figure 1 shows the recorded data for the period January 1997 to October 2005.

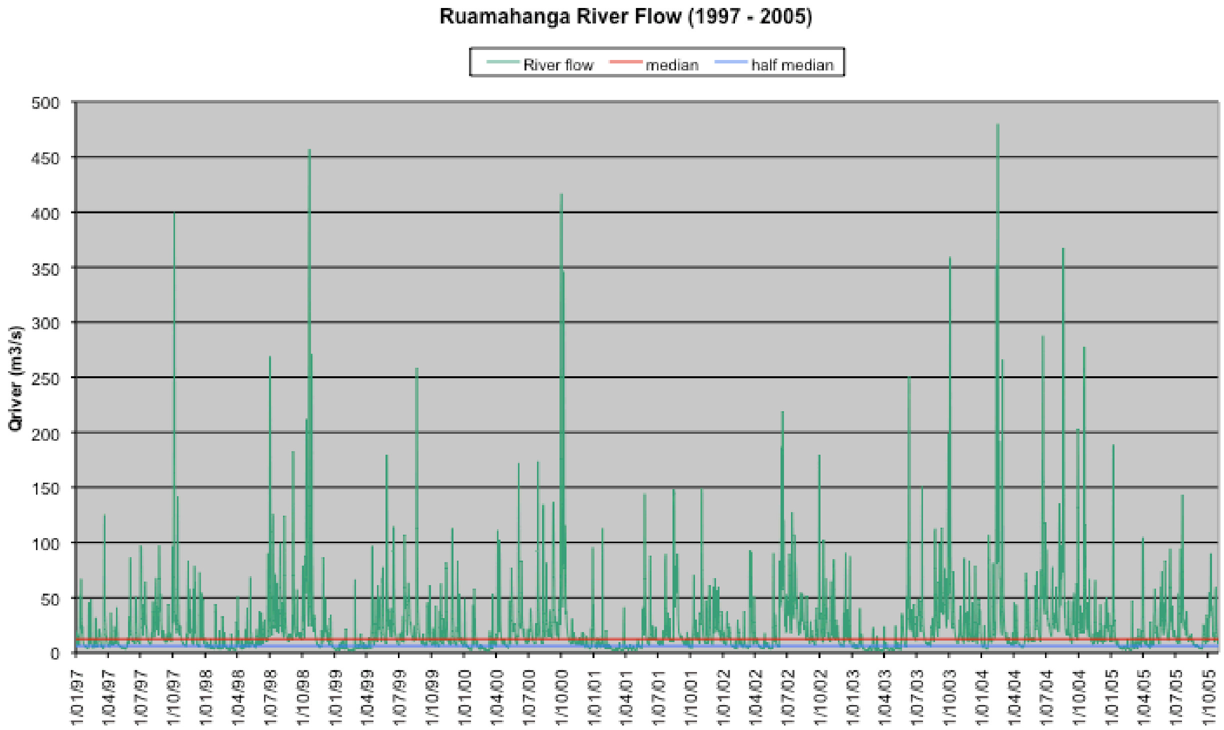

Figure 1 (Figure 10 in the AEE) Ruamahanga River Flow (1997-2005)

5.3 Figures 2 and 3 present example river flow data for summer (November 2001 to April 2002) and winter (May 2002 to October 2002). These figures illustrate the variability of the river flow during both summer and winter. In particular, for the summer river flow record, the record shows that there are frequent minor floods (freshes) where river flow rises rapidly to a peak flow well above the median river flow of 12.3 m^3/s. Similarly in winter, the flow record displays a far greater trend of frequent short, sharp ‘freshes’ in the river. This characteristic of frequent freshes is particularly relevant to the proposed discharge regime.

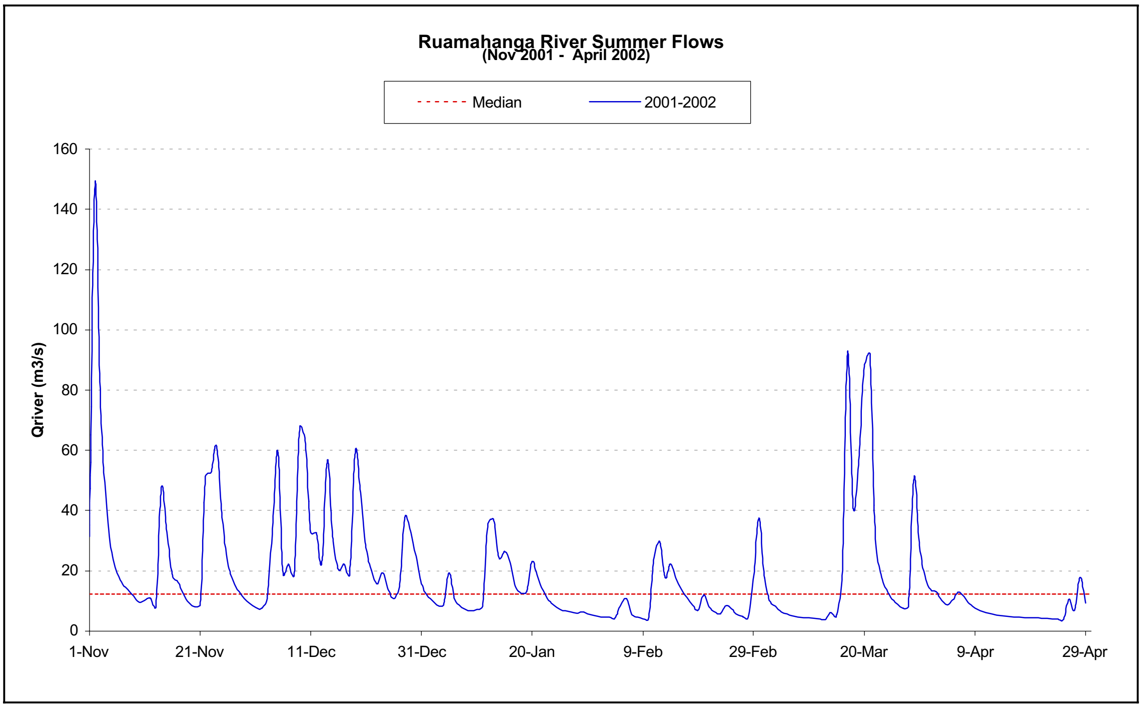

Figure 2 Example of Ruamahanga Summer Flows

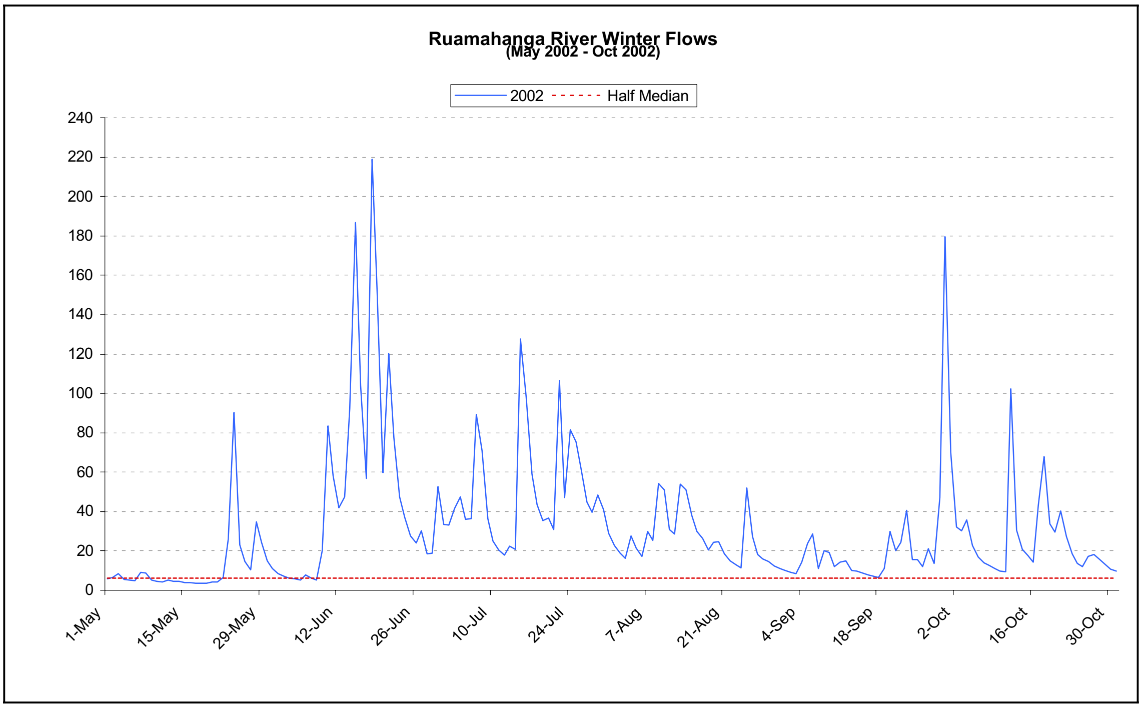

Figure 3 Example of Ruamahanga Winter Flows

5.4 The upper catchment of the Ruamahanga River (and its tributary the Waipoua River) is in the Tararua Ranges, where intense short-term rainfalls in this very steep land generate the sharp flood hydrographs. The eastern tributaries of the Ruamahanga, the Kopuaranga and

Whangaehu Rivers, drain steep pastureland, but channel storage and local ponding reduces their relative flood flows into the Ruamahanga River.

5.5 The intensification of land use as the Ruamahanga River flows south from its headwaters in the Tararua Ranges results in increasing inputs of pollutants from diffuse sources (particularly nutrients and faecal material) into the Ruamahanga River, thereby affecting the water quality before the River reaches the Homebush vicinity.

5.6 The relative importance of diffuse sources in the Ruamahanga River catchment is illustrated by calculations of the cumulative annual load of nitrogen and phosphorus from above the MDC discharge (RUA1) to Pukio for the period 2003-2007 (Diffuse Sources, 2009). This information, which was synthesized from monitoring data collected by MDC (RUA1 and effluent) and GWRC (Gladstone and Pukio) is presented in Figure 4, and clearly shows the influence of hydrological regime in controlling diffuse loads. Over the period 2003-2007 annual phosphorus loads at Pukio varied from 157 tonnes in a dry year (2007) to 603 tonnes in a wet year (2003), whereas the phosphorus load from the Masterton WWTP varied from only 13.8 tonnes to 18.9 tonnes over the same period. Overall the Masterton WWTP contributed from 3-8% of the total phosphorus load at Pukio, and 2-3% of the total nitrogen load (Figure 5). Thus the current discharge has only a minor influence on the total load of nutrients entering Lake Onoke.

5.7 Under summer baseflow conditions, however, the Masterton WWTP currently contributes a much higher proportion of the nutrient load. This is particularly the case for phosphorus, as there is a strong relationship between phosphorus concentration and flow rate in the Ruamahanga. Using the period January 1 2007 –March 31 2007 as an example, I estimate (Diffuse Sources, 2009) that when mean daily flows are less than median flow at Wardell's Bridge (12.3 m3/s), the Masterton WWTP contributes 30 kg P/day to the River, compared with an average 69 kg P/day at Pukio (43%). As most of the P (90%) discharged from the Masterton WWTP is in dissolved reactive form, and summer is when high rates of phytoplankton growth can occur in lentic waterbodies, the current discharge may be contributing to poor water quality in Lake Onoke.

5.8 When the proposed Masterton WWTP upgrade is completed, the effluent will be irrigated when flows are less than median in summer and at these lower flows there will be no direct discharge of phosphorus to the Ruamahanga River. The only P entering the river from the Masterton WWTP will be a small amount from irrigation return flow, estimated (PDP, 2008, Table 3) to be <1 kg P/day and pond leakage. Therefore when the upgrade is complete, the contribution from the Masterton WWTP to the P load at Lake Onoke under summer baseflow conditions will drop from 43% to < 2.5%.

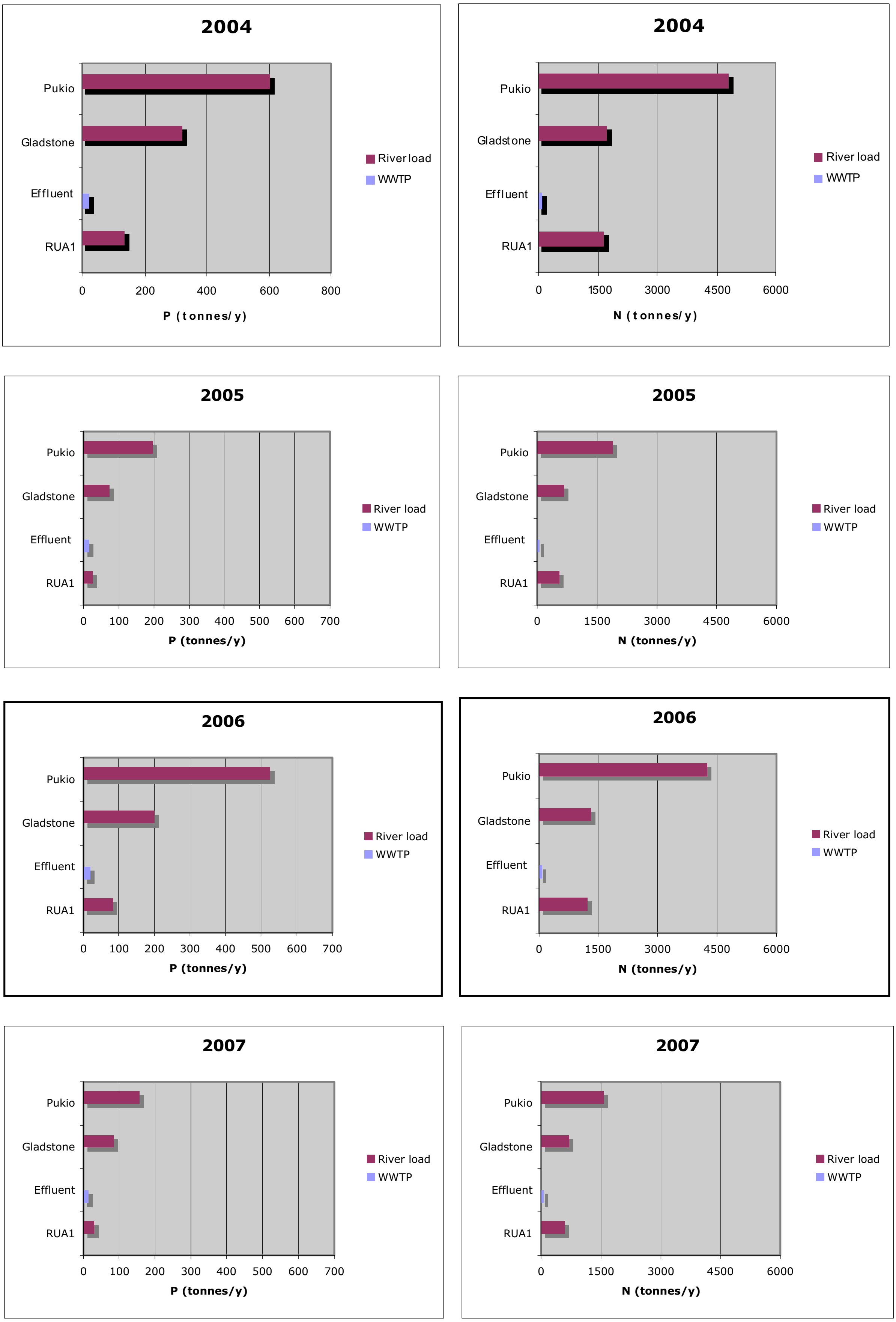

Figure 4 Cumulative annual phophorus (LHS) and nitrogen (RHS) loads in the Ruamahanga River from above the MDC discharge (RUA1) to Pukio.

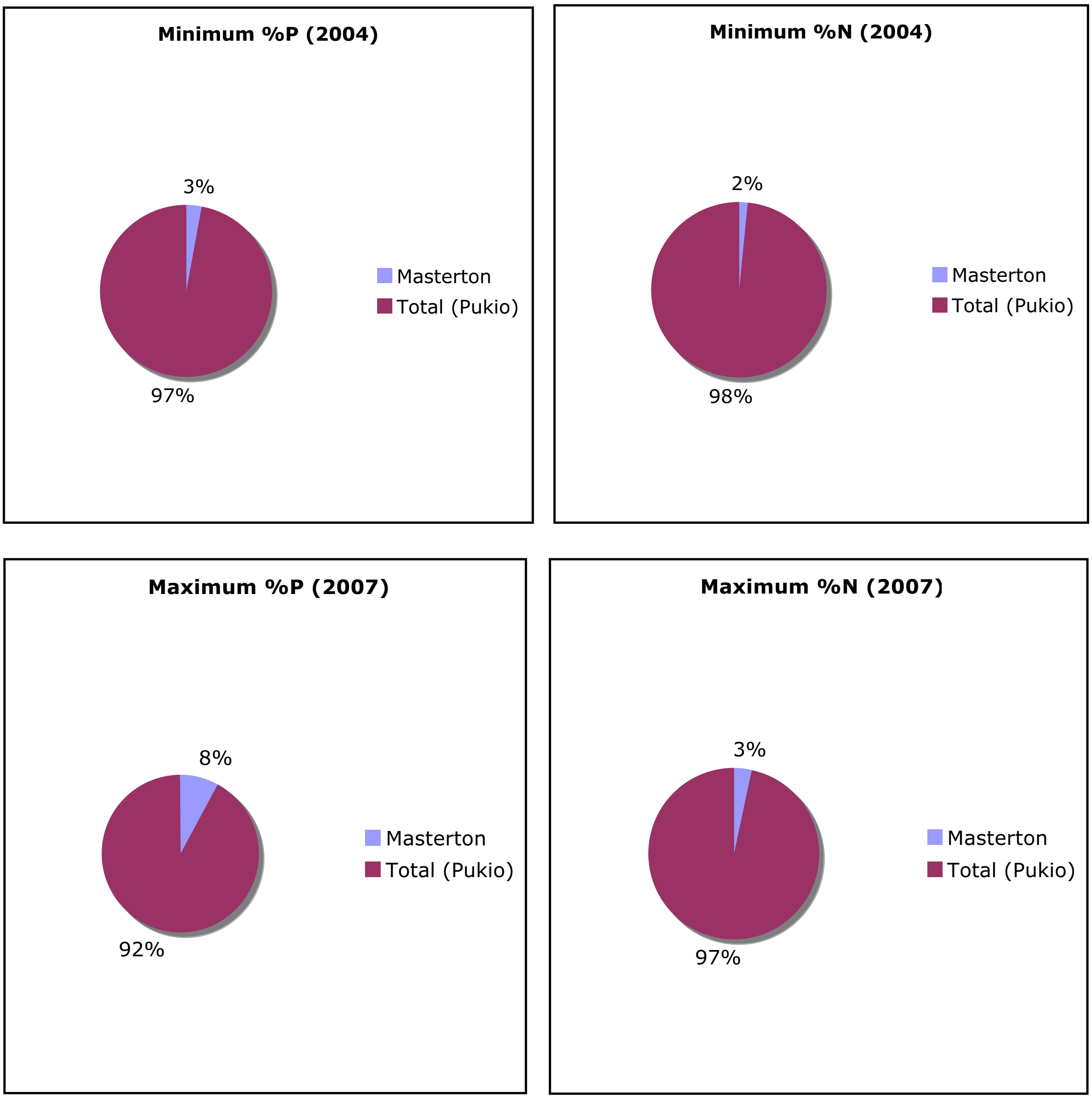

Figure 5 The proportion of the total phosphorus (LHS) and nitrogen (RHS) loads at Pukio currently attributable to the Masterton WWTP.

5.9 The Ruamahanga River in the vicinity of Masterton has a rocky (largely cobble) channel, with a common pool-run-riffle structure associated with such riverbeds. Analysis of the complete flow record at Wardell's Bridge gives an annual median flow of 12.3 m^3/s and summer median of 6.6 m^3/s, with a high flood frequency of 23.6 floods/yr.

5.10 The majority of the load of contaminants from diffuse sources <u>upstream</u> of Masterton is transported during flood events. Thus there is a strong relationship between flow rate and the concentration of contaminants associated with particulate matter as can be seen in Figures 6 and 7 for water clarity and E coli, respectively.

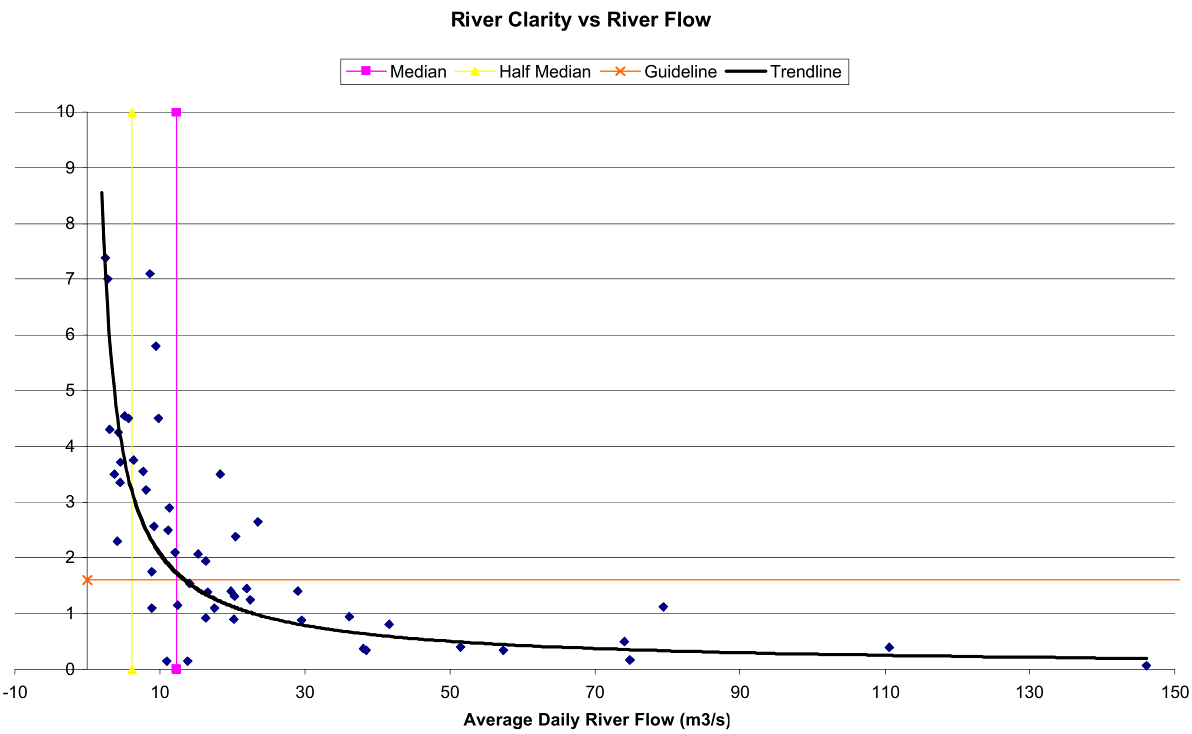

Figure 6 Relationship between river flow rate and water clarity upstream of the Masterton WWTP discharge (RUA1)

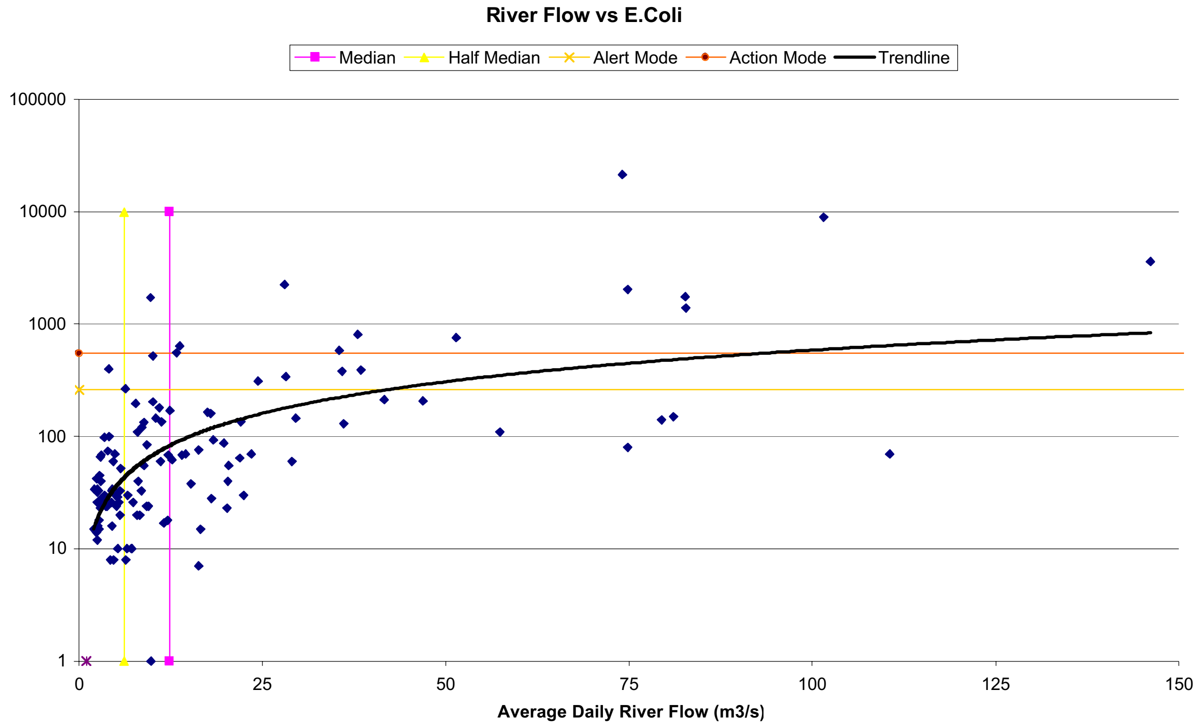

Figure 7 Relationship between river flow rate *E.coli* upstream of the Masterton WWTP discharge (RUA1)

5.11 Figures 6 and 7 show that below the median flow at Wardell's Bridge the water quality upstream of the Masterton WWTP is generally very good, but that with increasing flow rate water clarity is markedly reduced and *E coli* concentrations are more likely to be elevated.

5.12 The hydrology of the Ruamahanga upstream of Masterton and its effects on the concentration of contaminants from diffuse sources provides the setting for this consent application. At below median flows the water quality of the Ruamahanga at Masterton is generally very good, and, during summer, the river is used extensively for contact recreation. The proposal is that in summer at river flows below the median, the treated wastewater will be irrigated to land or stored and none will be directly discharged to the river. At higher flows, however, the water quality upstream is markedly impaired. These flows normally coincide with saturated soils which mean that effective land disposal is also compromised. Under these circumstances the proposal is that treated sewage effluent will be discharged directly to the river at a controlled rate (at least 30 x dilution with river water).

The Concepts of Full and Reasonable Mixing

5.13 In this section of my evidence I will discuss the concept of reasonable mixing and its relationship to the physical mixing processes that occur in a river when an effluent is discharged into it. This provides essential background to later discussion on discharge to the river at just above median flows in summer, or half median flows in winter.

5.14 In a situation such as this, where effluent is discharged to a shallow river, a distinct set of physical mixing processes define the characteristics of the effluent plume as it enters and then mixes into the receiving water. These include jet momentum of the effluent as it leaves the diffuser, river flow depth and riverbed characteristics.

5.15 The effluent plume initially makes contact with the receiving water, with rapid mixing occurring as the jet effect dominates. The area of the river closest to the effluent discharge point is called the “near-field mixing zone”, where the effluent mixes rapidly with the receiving water because of the momentum and/or buoyancy of the effluent and the natural turbulence of the receiving water.

5.16 Once the jet effect dissipates, the rate of mixing slows down, and further mixing depends on the natural currents and turbulence of the river. Gradually, the width of the effluent plume increases across the river until the effluent is fully mixed over the full width of the river flow. ‘Full mixing’ therefore occurs once the effluent is completely dispersed through the receiving water, and all parts of the river flow are mixed with the same proportion of effluent.

5.17 As full mixing does not occur instantaneously, contaminant concentrations close to the point of discharge may exceed the various water quality targets (or standards) for the receiving water. It is only after a period of mixing occurs, as the effluent flows downstream, that the effluent becomes diluted with the receiving water to a point at where compliance with the relevant water quality target is appropriate.

5.18 The RMA recognises that discharges into water cannot be instantaneously fully mixed, and refers to the concept of “reasonable mixing”. The reasonable mixing zone (RMZ) is, in effect a zone where the discharge is not required to meet the relevant guidelines or standards. The downstream end of the reasonable mixing zone for a particular contaminant, may be considered as the point at which that contaminant is *reasonably well mixed* with the receiving water **and** which reflects what will be *reasonable* in terms of the effects in issue. The downstream end of the reasonable mixing zone will accordingly be at some point between the point at which the plume is reasonably well mixed and the point of full mixing. This may vary for different contaminants.

5.19 The different mixing concepts are shown schematically in Figure 8 below.

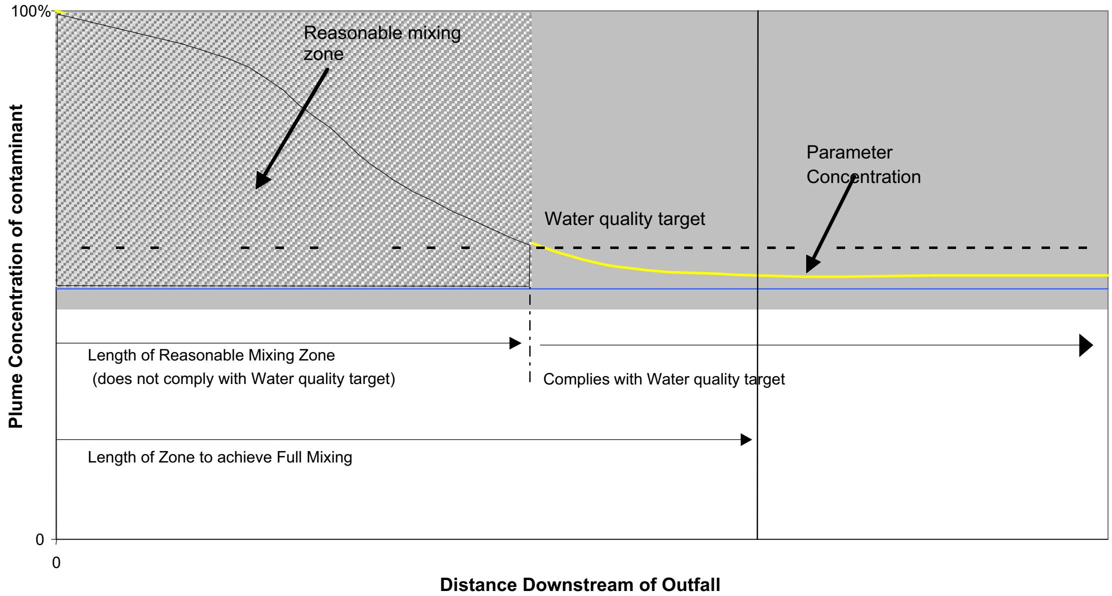

Figure 8 (Figure 31 in the AEE) Conceptual River Mixing of Plume Downstream of Outfall

5.20 Under the Wellington Regional Freshwater Plan (WRFP), the extent of a particular RMZ depends on the effects that non-compliance within the zone will have on the management purpose for the receiving water (which for the Ruamahanga River is for contact recreation). What is a "reasonable degree of mixing" in a specific case is a matter of judgement. It will vary according to the parameter concerned and the sensitivity of the receiving environment. Consideration of the potential for and the nature of possible effects within this zone can also be a key factor in establishing the extent of a RMZ.

5.21 In defining the RMZ, Policy 5.2.11 of the WRFP sets out as follows:

Mixing Zones

5.2.11 To ensure that any zones allowed on a discharge permit for reasonable mixing of contaminants or water with the receiving water are determined by having regard to:

- *the purpose for which the receiving water is being managed, and any effects of the discharge on that management purpose; and*
- *any tangata whenua values that may be affected; and*
- *the volume of water or concentration of contaminants being discharged, and the area of receiving water that could potentially be affected; and*
- *the physical, hydraulic and hydrological characteristics of the receiving water.*

***Explanation**: Both s107 and the Third Schedule of the Act direct that the effects of discharges are to be considered after reasonable mixing of the contaminants with the* *receiving water. The size of the zone allowed for reasonable mixing depends on the effects that non-compliance within the zone will have on the management of the receiving water as directed by Policies 5.2.1 to 5.2.6 of the Plan and by s 107 of the Act. For example, the size of a zone allowed for reasonable mixing of ammonia may depend on whether the zone impedes fish passage (because of its toxicity). The size of the zone allowed for reasonable mixing of nutrients may depend on whether excessive algal growths will attach to stones on the bed downstream of the discharge (undesirable biological growths are not allowed in waters managed for contact recreation, fish spawning, water supply, or aquatic ecosystems).*

5.22 MDC is not proposing receiving water quality standards that apply after reasonable mixing, but rather effluent (or "end-of-pipe") standards. The proposed effluent standards, in conjunction with the proposed discharge regime, are intended to ensure achievement of the proposed receiving water quality targets after reasonable mixing. The primary relevance of reasonable mixing, is in terms of the applicant satisfying the Regional Council that the section 107 standards will be met after reasonable mixing and that relevant guidelines will be achieved after reasonable mixing.

5.23 In my opinion, reasonable mixing can be regarded as being somewhere between 300m to 500m downstream of the proposed new discharge point for all parameters. Full mixing occurs by about 800m downstream of the discharge point, which is 450 m upstream of the first sensitive site in the river; Wardell's bridge. (Currently the reasonable mixing zone extends to at least Wardell's bridge and full mixing is well downstream of Wardell's Bridge). 300m has been used as the basis of tabulated water quality predictions for the proposed new outfall location because by that point, the discharge is reasonably well mixed.

5.24 It should be noted that it is not proposed that the monitoring location be shifted from Wardell's Bridge. That is still the most appropriate location to monitor the effects of the discharge on receiving water quality since that is the first point at which any significant degree of contact recreation occurs and allows ready access for monitoring. Continuing with monitoring at that point, will also allow comparison of the upgraded water quality with pre upgrade quality.

Methodology for Determining Dilution and Mixing Effects

5.25 An assessment was undertaken to determine the distance downstream from the new outfall at which full mixing will occur. This was based on a combination of fieldwork, involving dye testing in the river, and calculations to determine the dilutions, and hence concentrations, of various effluent parameters at distances downstream from the new outfall.

5.26 Dye release studies were conducted to characterise the transverse mixing characteristics in the Ruamahanga River at potential discharge sites (NIWA 2005b). Figure 9 shows the spread of dye 1010 metres below a single injection point. Subsequent simulations were undertaken using the CORMIX model (Jirka et al 1996) to combine the dye study dispersion results with the initial diffuser mixing performance (NIWA 2007). The CORMIX modelling was used to evaluate options for the configuration of the outfall for an effluent discharge at half-median and median river flows.

Figure 9. NIWA team preparing to measure dye concentration across a river transect. Note dye plume in foreground.

5.27 Once the preferred outfall configuration had been confirmed, this enabled the extent of mixing and dilution at various downstream distances to be determined.

5.28 Analysis was then carried out to determine the concentrations of various parameters at distances downstream of the outfall until the point of full mixing was reached, and also at Wardell's Bridge. These analyses have been carried out for the summer discharge regime at just above and just below median river flow, and also for the winter discharge regime at just above and just below half median river flow.

5.29 The parameters modelled were:

- Filtered BOD
- Ammonia
- Nitrate

- Nitrite
- DRP
- E.coli
- Clarity

Dilution and mixing assessment

5.30 Based on the outcome of the CORMIX modelling, the most effective effluent diffuser was a four-port diffuser (minimally recessed), with a pipe diameter of 0.5 m. For this outfall configuration, the effluent dilutions and corresponding mixing percentage are detailed in Table 1.

Table 1 (Table 31 in the AEE) Effluent Dilutions Downstream for Half-Median and Median River Flows

Distance Downstream from Discharge Point (m)	Half Median River Flow (%mixed)	Median River Flow (%mixed)	Nominal Dilution
200	16.4 (55%)	17.6 (59%)	17
300	19.8 (66%)	21.1 (70%)	20
400	22.5 (75%)	25.0 (83%)	24
600	27.3 (91%)	29.1 (97%)	28
800	30.0 (100%)	30.0 (100%)	30

5.31 As an example, Table 1 shows that at 300m downstream from the point of discharge, and at median river flow, the concentration **of each** parameter in the effluent is 21.1 times less than at the outfall when the effluent first mixed with the river flow. This means, for example, that if a particular parameter has a concentration of 500 units at the outfall, then the concentration at 300m downstream of the outfall will be 24 units as a result of mixing and dilution. This corresponds to the effluent being 70% mixed. Another point to note in terms of Table 1 is that there is little difference between the dilution at half median and median river flows, and accordingly a single 'nominal' dilution is tabulated for each of the downstream distances.

5.32 Full mixing occurs at a distance of approximately 800m downstream from the point of discharge of effluent. This distance is approximately 450m upstream of Wardell's Bridge. Accordingly, the concentrations of parameters in the effluent can be taken as being the same at 800m downstream of the outfall and at Wardell's Bridge (this ignores the effect of the minor flow and load additions from the Makoura Stream).

5.33 Currently, full mixing occurs downstream of Wardell's Bridge and for monitoring purposes Wardell's Bridge has, in effect, become the end of the RMZ. The shifting of the discharge upstream and the addition of a diffuser will ensure that full mixing is upstream of Wardell's Bridge and reasonable mixing will be well upstream. In my view the most appropriate approach is to take reasonable mixing as being between 300m-400m downstream. At 300m the plume will be about 66% mixed at just above the winter trigger flow and in summer it will be about 70% mixed. Subsequent predictions of water quality (evidence of Dr Chris Hickey) have used 300m (i.e., 20-fold dilution) to show the effects of the discharge before it is fully mixed.

5.34 Reasonable mixing is generally assessed on a continuous discharge at low flow conditions, when flow conditions are relatively stable. When fully operational, however, the proposed discharge for the MWTP upgrade will only be initiated at median flows in summer, which will generally occur when the river is at the onset of fresh/flood conditions – i.e., river flow rising from low to high flow due to a significant rainfall event. As noted previously in my evidence, very rapid increases in flow occur in this part of the Ruamahanga River, with low to flood-flow conditions transitioning over only a few hours.

5.35 The Ruamahanga River flow characteristics are summarised in Figure 10 for summer and Figure 11 for winter data from the Wardell's Bridge gauging site. The cumulative frequency presentation indicates the percentage of the time the river will exceed a given value in an average year.

5.36 Figure 10 indicates that flows above median flow (12.3 m^3/s), when the effluent can be discharged, can potentially occur for 33% of the summer period (i.e., 66% of the time the effluent will not be discharging). The winter data (Figure 11) shows that the river is expected to be above half-median (when the effluent can be discharged), for 92% of the winter period.

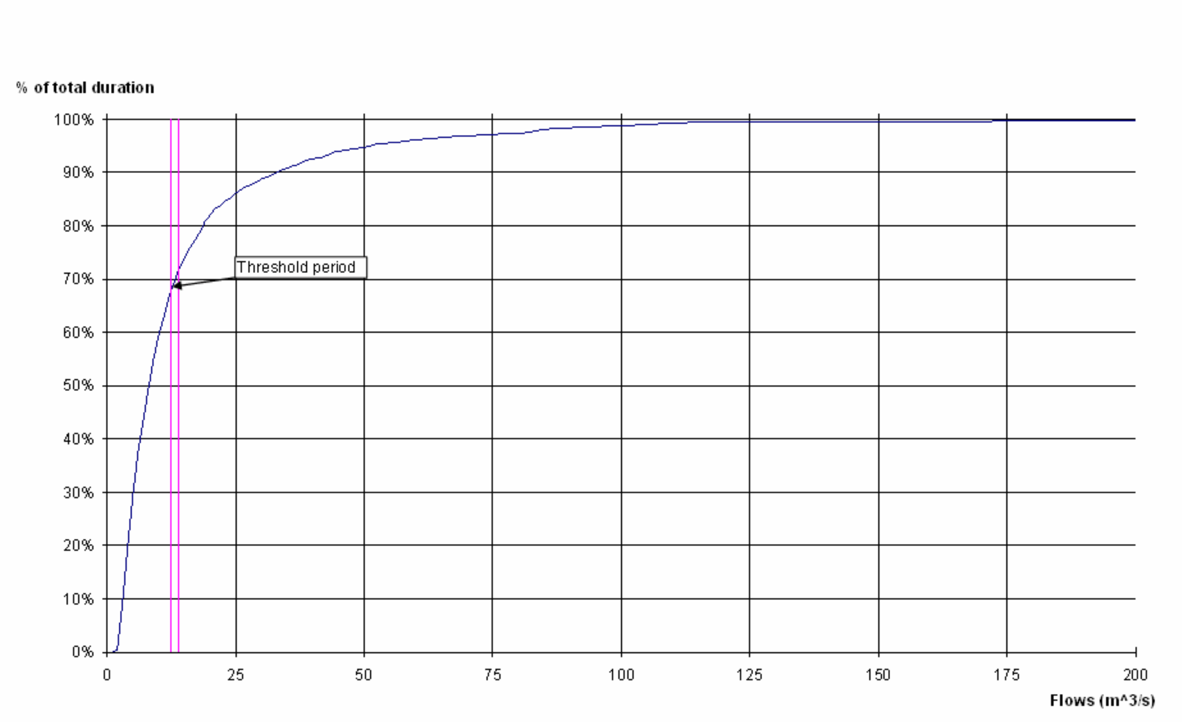

Figure 10 (Figure 33 in the AEE) Cumulative frequency of Ruamahanga River (@Wardell's) summer flows

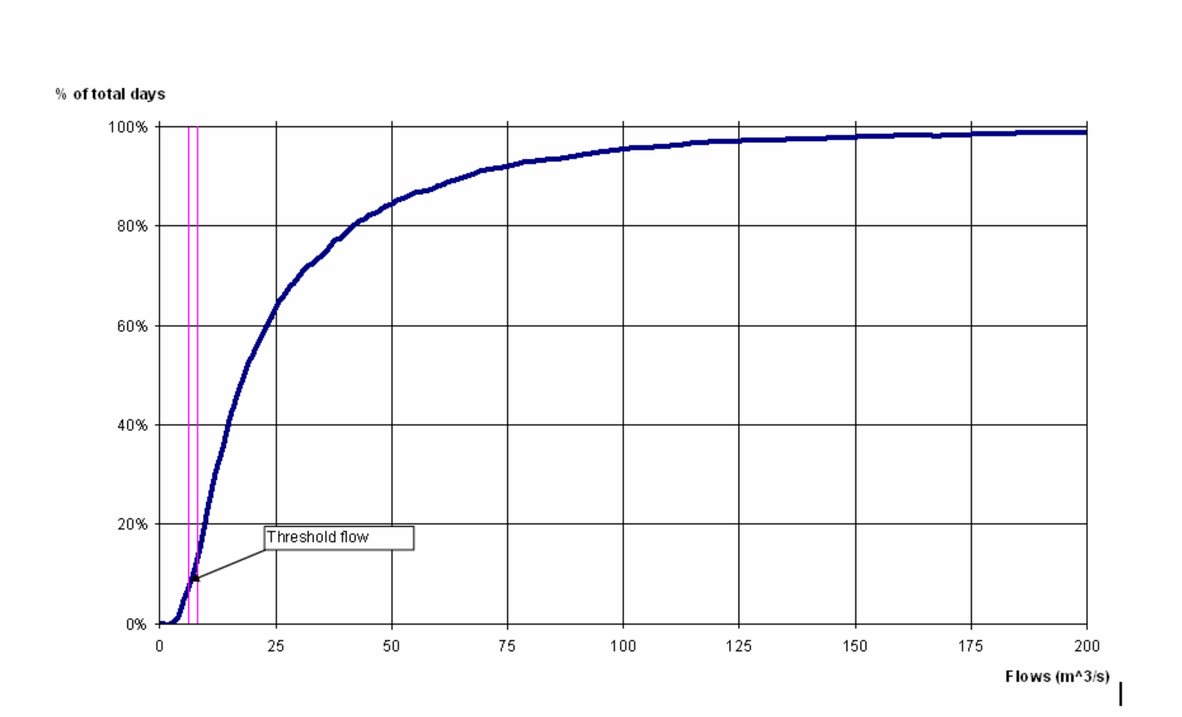

Figure 11 (Figure 34 in the AEE) Cumulative frequency of Ruamahanga River (@Wardell's) winter flows

5.37 A threshold flow range of 30% above the half-median flow (i.e., 6.15 – 8.0 m^3/s) was used for the winter period effects assessment, while a range 15% above the median flow (i.e., 12.3 –

14.0 m^3/s) was used for the summer period. The summer threshold flow range is shown on Figure 10 with the results of the analysis discussed in the following section of my evidence.

5.38 It is important to appreciate that this threshold range only occurs for about 4% of the summer time and 13% of the time that the effluent will be discharging during summer. The winter threshold flow range occurs for 5.5% of the time and 6% of the time the effluent will be discharging (Figure 11). This is relevant to health risk assessment. There is an elevated health risk at flows just above median flows when there may still be some limited contact recreation, however this occurs for a very small amount of time and accordingly exposure risk will be very low.

Water quality effects of pond leakage

5.39 The construction of new clay/silt lined oxidation ponds will significantly reduce leakage. While the leakage from the existing ponds only has a minor effect on water quality, the estimated leakage for new ponds will be reduced to the point where there should be no detectable impact on river water quality.

6. TRIGGER FLOW

6.1 In this section of my evidence I will clarify the flow duration at which the trigger for discharge to the Ruamahanga River in summer is to apply. I will also discuss how the impact of the discharge on the river flow will be accounted for in the trigger flow rates, given that the Wardell's Bridge flow recorder is located downstream of the point of discharge.

6.2 The trigger value of greater than median flows in summer and half-median flows in winter were derived from the NIWA periphyton study (see evidence of Dr Chris Hickey) which indicated that discharge of treated sewage effluent to the river above half median flow at a 30:1 dilution would not cause nuisance growths of periphyton to occur. Once the upgrade is completed, Masterton District Council have decided to use median flow in summer as being more conservative for recreational use (health risk), however, half median flow was retained for winter discharge when there is low light (limiting periphyton growth) and low recreational use.

6.3 In the transitional period, when the decommissioned ponds are converted to an irrigation area, there will be insufficient land to irrigate the volume of effluent required to comply with a summer median flow discharge regime. During this transition period a half-median (6.15 m^3/s) flow trigger is proposed (summer and winter).

6.4 Operationally, a mean daily flow trigger would not work in the Ruamahanga River because of the very peaky nature of the flood hydrographs and the inherent delay before a daily flow value can be obtained. It will be necessary to start to discharge to the river on most occasions when the hourly flow exceeds the trigger value **and** there is a reasonable certainty of the river flow being sustained for more than six hours above the trigger value during daylight hours (when contact recreation will be occurring). Such conditions occur for about 90% of "freshes" during summer.

6.5 A predictive model will be used "to overview" the discharge operation, to give more certainty that the exceedance of median flow will be sustained for a sufficient duration. This will avoid discharging when the river flow exceeds the trigger value for durations of less than about six hours. A similar model for flood warning purposes has been developed by NIWA for the Ruamahanga River, which uses real time monitoring and meteorological forecasting to calculate the predictions.

6.6 The key proposed operating constraints are the minimum 30:1 dilution rule for all discharges, and the discharging at only above median river flows (12.33m^3/s) in the summer period. The hourly flow measurements at Wardell's Bridge and Mt Bruce will be telemetered to the MWTP for discharge control based on the proposed discharge rules for summer of:

(a) no discharge below median river flow,

(b) a minimum dilution of 30:1 to be maintained at all times, and

(c) reasonable certainty that river flow will be sustained for more than 6 hours above trigger value.

6.7 The MWTP contribution to the river flow will be automatically taken into consideration. On all occasions when the river flow drops below the trigger value, the discharge will stop automatically.

6.8 The hourly flow data for river flow has been analysed and for virtually all freshes the river flow rate increases very rapidly. A "start to discharge" delay of 15 to 30 minutes will ensure that the river flow has comfortably exceeded the trigger value, thus overcoming any minor errors in the flow measurement data.

6.9 The rate of effluent release to the river (and hence maintenance of the 30:1) dilution rule will be achieved through control over each of the ports of the multiport diffuser (refer Humphrey Archer's evidence).This is needed because it is necessary to maintain velocity through each port in order to achieve the design physical mixing characteristics.

7. MONITORING

7.1 In order to verify that the concentrations of contaminants are as predicted at the end of the reasonable mixing zone and at full mixing, we propose additional monitoring (to that in the current consent conditions, which we propose will continue). This additional monitoring will involve sampling the river upstream and at 300m and 500 m below the discharge as well as at Wardell's Bridge (full mixing).

7.2 Because of the rapidly changing water quality from upstream diffuse sources that occurs on the rising limb of a flood hydrograph, we propose sampling under elevated, but relatively steady flow conditions such as occur on the declining limb of the hydrograph. Samples will be analysed for total phosphorus and nitrogen, E coli, and visual clarity. We propose that 3-5 events be sampled in the first year following the granting of this consent and completion of the upgrade.

7.3 Following this monitoring, a report will be submitted to GWRC documenting the degree of concurrence between predicted and actual receiving water quality.

8. SUBMITTERS' CONCERNS

Submitter 242513 Rangitaane o Wairarapa Inc (Chrystall thesis)

8.1 Rangitaane rely on a thesis by Leila Chrystall (2008). In particular, the following abstract:

"*Significant issues identified in the catchment include; deteriorating water quality in the Ruamahanga River as it flows southwards; a significant increase (~14,000 kg/year) in dissolved reactive phosphorus (DRP) loading in the Ruamahanga River segment between Te Ore Ore and Gladstone, which in most part, is a result of the Masterton Sewage Treatment Plant discharge; unsatisfactory bathing water quality at some sites on the Ruamahanga River; a lower diversity of freshwater species than the rest of the Wellington Region; current and future land use intensification which is leading to increasing demands for water; and fully allocated surface water zones and groundwater aquifers*."

8.2 The principal issue addressed here is the phosphorus load reported by Chrystal and its significance. The 14 tonnes/year DRP from the Masterton WWTP estimated by Chrystal is broadly in agreement with our estimates of 14-18 tonnes/year TP (DRP being ~90% of TP in the effluent) discussed in paragraph 4.6. The method used by Chrystal to estimate phosphorus loads in various parts of the Ruamahanga catchment uses NIWA's River Environment Classification (REC) to estimate accumulated runoff at points in the catchment where flows have not been measured. Accumulated runoff is estimated from accumulated rainfall and a global (catchment-wide) estimate of evaporation. Chrystal (2008) then uses the average nutrient concentration multiplied by the accumulated runoff to estimate the annual nutrient load.

8.3 The method is useful for estimating loads in parts of the catchment where there are no flow records and for making qualitative comparisons between different parts of the catchment. However in my opinion the method is not sufficiently robust to quantify loads in a catchment such as the Ruamahanga where a high proportion of nutrient transport occurs under flood conditions (sections 4.4-4.10). In contrast the method we have used utilises the extensive nutrient monitoring by MDC and GWRC and actual measured flows to synthesise a relationship between flow rate and nutrient concentration. Independent flow versus nutrient concentration relationships were derived at RUA1, Gladstone, and Pukio and excellent relationships were obtained for phosphorus with standard errors of 1.5%, 3% and 4.9%, respectively. Therefore we can have confidence that the estimates of annual phosphorus load obtained by using these relationships and the complete flow record (average daily flows) are robust.

8.4 As was shown in paragraph 4.6 and Figures 4 and 5, the Masterton WWTP currently contributes only a minor proportion of total annual phosphorus load in the Ruamahanga catchment. While the proportion contributed by the Masterton WWTP in the reach Te Ore Ore –Gladstone is much higher (~12% in wet years to 31% in dry years) it should be noted that even under these conditions, instances of periphyton reaching nuisance proportions are rare. The proposed upgrade will eliminate the discharge of treated wastewater to the Ruamahanga River during low summer flows which will result in these rare incidences of nuisance periphyton growths becoming even rarer.

Submitter 242577 Department of Conservation

8.5 DOC is supportive of the application in principle, but seek further information to reassure the aquatic environments of the Ruamahanga River and Makoura Stream are enhanced. DoC are concerned about the cumulative effects on the river and associated environs, particularly as other Wairarapa towns use similar systems – uncertainty over associated effects.

8.6 The principal contaminants of concern in the current discharge are phosphorus (potential for periphyton growth), pathogens (as indicated by E. coli) which can compromise contact recreation, and visual clarity. As discussed in paragraph 4.6, the principal sources of phosphorus in the Ruamahanga River are diffuse (non point) sources, and the contribution from Masterton WWTP is relatively minor in a catchment context. The proposal to irrigate the effluent during summer will almost eliminate the contribution from Masterton WWTP during summer low flow conditions and further reduce the likelihood of periphyton growths, which can degrade the stream habitat for invertebrates. The improvements made to water clarity during summer months will also have a localised beneficial effect on river ecology though this is difficult to quantify.

Submitter 242578 Fish and Game NZ

8.7 Fish & Game is opposed to discharge of treated effluent to water, and has expressed concerns over the effect on river fauna, amenity and recreational values, degraded water quality, stormwater infiltration, sedimentation impacts resulting from upgrade works.

8.8 This submitter supports endeavours to upgrade existing system but wishes the consent authority to only issue consents that result in treated effluent of a quality that is consistent with relevant policies and objectives of the RPS and Freshwater Plan and ensure that aquatic and recreational values are protected.

8.9 As discussed in paragraphs 4.32-4.39 and the evidence of Dr Chris Hickey, the proposed upgrade will result in no discharge to the river at below median flows in summer, and half median flow in winter. The trigger conditions for discharge (section 5) together with a new discharge location and improved diffuser design will ensure compliance with the objectives and policies of the RPS and Freshwater Plan. Masterton District Council supports Fish and Game NZ's request that consents are issued that reflect this requirement.

9. CONCLUSION

9.1 The hydrology of the Ruamahanga River is characterised by frequent freshes where river flow rises rapidly, causing mobilisation of nutrients from diffuse sources and leading to reduced water clarity and impaired bacteriological water quality, both above and below the current point of discharge.

9.2 Phosphorus has been identified as the nutrient limiting pertiphyton growth in the Ruamahanga River, and possibly phytoplankton blooms in Lake Onoke at the mouth of the River. When considered on an annual basis the treated wastewater form the Masterton WWTP is only a minor source of phosphorus compared with diffuse sources. However during extensive periods of low flow conditions, the treated wastewater contributes a significant proportion (~43%) of the phosphorus load at Pukio. The proposed upgrade will remove virtually all treated wastewater from the river at flows < median during summer (when extended periods of low flow are most likely) which will reduce the contribution from Masterton WWTP to the P load at Pukio to <2.5%.

9.3 Currently the reasonable mixing zone (where water quality guidelines or standards are not required to be met) extends to at least Wardell's Bridge and full mixing is well downstream of Wardell's Bridge. The proposed upgrade will result in the reasonable mixing zone being reduced to 300-500m downstream of the new discharge point, and full mixing will be achieved 800m downstream (450m upstream of Wardell's Bridge). At the point of full mixing a dilution of 30:1 will be achieved, which be sufficient to ensure that nuisance growths of periphyton do not occur.

9.4 The proposed 'triggers' for discharge of treated wastewater (> median flow in summer and half-median flow in winter) have been chosen to minimise effects on both recreational and instream (ecological) users. Telemetered flow from Mt Bruce and Wardell's Bridge will be used to ensure that discharge rules at met at all times. Additional monitoring is proposed in the year following the completion of the upgrade to demonstrate concurrence between predicted and measured water quality at the end of the reasonable mixing zone and after full mixing.

Dr James Cooke
Director, Diffuse Sources Ltd
13 February 2009