IN THE MATTER	of the Resource Management Act 1991
AND	
IN THE MATTER	of applications for consents (**APP-1995014433.02, 2005011178.01, 2016200772.00, 2017201455.00**) by the **TARARUA DISTRICT COUNCIL** to the **HORIZONS REGIONAL COUNCIL** for resource consents associated with the operation of the Pahiatua Wastewater Treatment Plant, including earthworks, a discharge into Town Creek (initially), then to the Mangatainoka River, a discharge to air (principally odour), and discharges to land via seepage, Julia Street, Pahiatua

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STATEMENT OF EVIDENCE OF JOHN MILTON CRAWFORD

WASTEWATER ENGINEER

28 April 2017

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1 INTRODUCTION

1.1 My full name is John Milton Crawford.

1.2 I am currently a self-employed engineering consultant. My technical speciality is in wastewater treatment systems, re-use and disposal schemes.

1.3 Prior to this self-employed role, I was employed by Opus International Consultants Ltd (Opus) for a period of 31 years. At Opus, I held the position of Principal Environmental Engineer based in Hamilton. For a period of 10 years, I was also the Technical Leader for Environmental Engineering at Opus.

1.4 My evidence is given in relation to the application for resource consents for the discharges from the Pahiatua Wastewater Treatment Plant ("PWWTP") lodged by Tararua District Council (TDC).

2 QUALIFICATIONS AND EXPERIENCE

2.1 I hold the degree of Bachelor of Engineering (Hons) in Agriculture from the University of Canterbury (1986).

2.2 I am a Chartered Professional Engineer (NZ) and a UK Chartered Engineer. I am a Fellow of the Institution of Professional Engineers New Zealand. I am a member of Water New Zealand, the Institution of Civil Engineers (UK) and the Chartered Institution of Water and Environmental management (UK).

2.3 I have 31 years' research and practical experience in the investigation, design and implementation of water and environmental engineering facilities including treatment and disposal systems for municipal and industrial wastewater. I have been responsible for the development of options and design of upgrading for many municipal and industrial clients in New Zealand and overseas. Apart from the subject treatment plant, I have been involved in investigations for, resource consenting, implementation or trouble shooting of wastewater treatment and disposal schemes at some 52 wastewater treatment plants in New Zealand, Singapore, England and Fiji.

2.4 I am currently the lead wastewater consultant for Project Shotover, a project transitioning treatment of the wastes from Queenstown, Arrowtown, Frankton and Lake Hayes areas from oxidation ponds to activated sludge based treatment with disinfection. Prior to that, I was lead wastewater consultant on the Thames Coromandel District Council's Eastern Seaboard Project which involved transitioning the coastal resort towns of Pauanui, Tairua, Whitianga and Whangamata from pond based treatment to activated sludge based treatment with tertiary scrubbing and disinfection.

2.5 In recent years, I have advised on troubleshooting of, upgrading of and or consenting of discharges from oxidation pond based treatment plants at Eketahuna, Thames, Porangahau, Porangahau Beach, Ratana, Martin, Leeston, Blenheim, Bulls, Seddon, Havelock, Queenstown, Gore, Kaiapoi, Ashburton, Rangiora and Woodend.

2.6 Because of this experience, I am familiar with very small to very large wastewater schemes and am qualified to comment on issues relevant to the wastewater treatment process currently used in the Pahiatua Wastewater Treatment Plant ("PWWTP") and, in that context, systems and methodologies that could be used for the PWWTP.

2.7 I am familiar with RMA processes and have completed (in 2006) the certification course 'Making Good Decisions' for RMA Decision makers and have completed the 2008 and 2014 recertification modules.

3 EXPERT WITNESS CODE OF CONDUCT

3.1 I have been provided with a copy of the Code of Conduct for Expert Witnesses contained in the Environment Court's Consolidated Practice Note 2014. I have read and agree to comply with that Code. This evidence is within my area of expertise, except where I state that I am relying upon the specified evidence of another person. I have not omitted to consider material facts known to me that might alter or detract from the opinions that I express. The opinions expressed are my own

4 INVOLVEMENT IN THE PROJECT

4.1 I was engaged as Technical Advisor for this project in 2014 as Opus was already assisting TDC with applications for renewal of discharge consents at Woodville and Eketahuna.

4.2 As far as PWWTP is concerned, my role in the project has been limited and has included providing advice to the consent renewal team on the performance improvements that are likely to be gained from the various upgrading works and advising on wastewater characterisation sampling and testing that should be undertaken to better define loading on and performance of the treatment plant.

4.3 I have visited the Pahiatua WWTP on several occasions over the last three years and am familiar with the plant, its' layout and function.

5 PURPOSE AND SCOPE OF EVIDENCE

5.1 The purpose of my evidence is to comment on the proposed effluent standards as they relate to recent upgrading works undertaken at PWWTP. My evidence will cover the following topics:

(a) Description of the existing wastewater treatment system (Section 7).

(b) Current levels of performance (Section 8).

(c) Future flows and loading (Section 9).

(d) Proposed levels of performance (Section 10).

(e) Optimisation of the recent PWWTP upgrading works (Section 11).

(g) Discharges to air (Section 12).

(h) Comment on issues raised in the Horizons Regional Council technical officer's report, and the conditions recommended in that report (Section 13).

5.2 There are a number of technical terms, abbreviations and units used in my evidence. A glossary explaining these is attached as **Appendix 2** to my evidence.

5.3 A summary of my evidence is set out in Section 2 below.

6 SUMMARY OF MY EVIDENCE

6.1 PWWTP consists of 3 oxidation ponds in series, these being 1.3, 1.3 and 1.4 hectares respectively. A fine screen at the inlet provides preliminary treatment. Recently installed chemical dosing, clarification, filtration and

UV disinfection provide tertiary treatment. The operation of these tertiary processes is yet to be optimised. Discharge is via an outfall pipe to 'Town Creek' which subsequently discharges into the Mangatainoka River downstream of the treatment plant.

6.2 PWWTP performance is good in comparison to typical pond based systems in New Zealand with mean $cBOD_{5,}$ Total Nitrogen and TP at 23, 9 and 2.7mg/l respectively and mean E.coli of 600 MPN/100ml.

6.3 Average day inflow is approximately 780 $m^{3/}$d. The dry weather flow is 408 m^3/d and the peak wet weather flow (from one year of data), appears to be approximately 4,300 m^3/d, a multiplier of 10.5 times from dry weather flow or 5.5 times average day flow.

6.4 Considering the treatment plant type and the very limited actual or likely effects of the discharge, I consider the discharge standards proposed herein to be reasonable, sensible and achievable.

6.5 Further works to complete the upgrading necessary to achieve the proposed consent conditions include a formal optimisation programme of the existing tertiary processes, and installation of a wetland system that will assist with policy 5-11 requirements and provide some additional 'polishing' treatment.

6.6 I have reviewed the Horizons Officer's report and make relevant comments, where I felt appropriate, throughout the body of my evidence.

7 DESCRIPTION OF THE EXISTING WASTEWATER TREATMENT SYSTEM

Treatment plant

7.1 The Pahiatua wastewater system includes a reticulation system throughout the town and a wastewater treatment plant based around a three-pond oxidation pond based.

7.2 The treatment plant services a population of approximately 2,500 persons (1,316 total connections). With a reticulated water supply, a typical per capita discharge to the sewer would be approximately 250 l/hd/day, yielding a theoretical dry weather flow of 625m^3/day

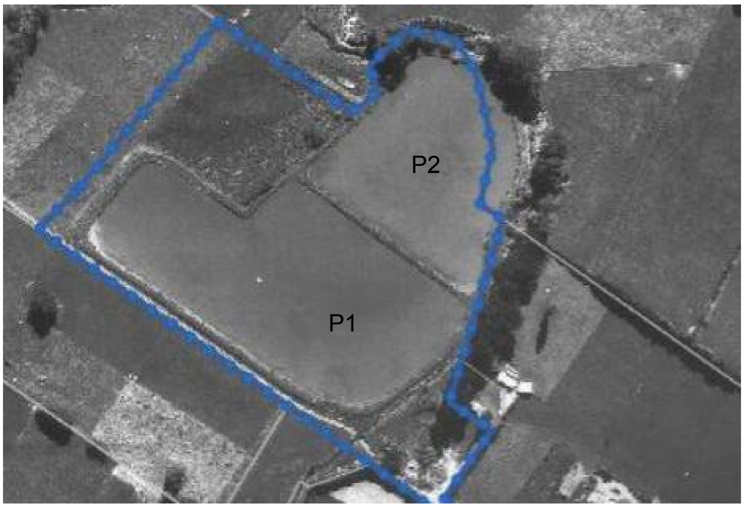
7.3 The PWWTP is at Boundary Road, about 100m north-west of Pahiatua township at coordinate reference 40º26’40” S and 175º50’27”E on Part Lot 2 DP 5239` Blk VIII Managahao SD, Lot1 DP 52391 (WN 44B/616).

7.4 Chronology:

i) 1930: The Pahiatua town sewerage system was installed around the year 1930.

ii) 1974: In 1974 a two pond oxidation pond system was constructed on the present treatment plant site, discharging the treated wastewater into the Mangatainoka River.

Photo 1: Original PWWTP Pond Layout



iii) 2002: Excess sludge build up removed from the existing two ponds. Pond 1 was enlarged then divided in two to form what are now ponds 1 and 3. Two Baffle walls were added into Pond 1. These use ‘hit and miss’ timbering and it is not clear if a membrane sheet was added to make them impermeable.

Photo 2: Clay Liners & Baffle Walls added 2002

Photo 3: Current PWWTP Pond Layout

iv) 2005: Supplementary aeration has been provided to Pond 1 or Ponds 1 & 2 in various configurations since 2005. 7.5 kW surface mounted ‘cage’ aerators were initially used.

v) 2014: Two ‘Baffle Curtains’ to minimise hydraulic short circuiting have been added to Pond 3 in 2014.

vi) 2014: A Fine screening system has been added to remove gross solids from the incoming raw wastewater and prevent these from causing nuisance and unsightly mess within the treatment plant and downstream of the discharge.

vii) 2014: Two x 3kW Reliant supplementary aeration devices were added in 2015. One each to Ponds 1 and 2. One cage aerator was removed and the other left in place in Pond 1.

viii) 2014: Filtec Lamella Clarifier and associated chemical storage, dosing and coagulation facility installed.

ix) 2015: In-Eko Tertiary Micro-filter installed downstream of Lamella clarifier.

x) 2015: UV disinfection system installed between In-Efo filter and point of discharge.

7.5 The existing (Post 2015) PWWTP consists of:

(a) Influent fine screening.

(b) Facultative pond (1.3ha and approximately 1.5m deep)

(c) 10.5kW of mechanical aeration provided by 2 surface aerators.

(d) Maturation pond (1.4 ha and nominally 1.5 m deep) in series.

(e) 3kW of mechanical aeration provided by 1 surface aerator.

(f) Pond 3 - Maturation (1.4 ha and minimum 1. 5 m deep) in series. As well as being the final treatment pond, Pond 3 is also used as a buffer storage lagoon to provide for long, 24 hr per day, 7 day per week, tertiary plant run times to avoid unnecessary starting and stopping of the tertiary treatment plant.

(g) Transfer pump station

(h) Chemical dosing facility for mixing and dosing coagulating chemical to the Pond 3 effluent prior to tertiary treatment. This includes an elevated plastic coagulation tank of approximately 25m^3 volume. This tank provides the time and space required for large flocs to form from the Pond 3 effluent after the coagulating chemical has been added and flash mixed.

(i) Lamella clarifier which is said to be rated for a flow rate of up to 25 litres per second (l/s) (2,160m^3/day). However, it is not clear if this has yet been tested or an optimised flow rate arrived at. When inspected, it was operating at 16 l/s. The purpose of the clarifier is to remove, by gravity settlement the large floc particles that have formed in the contact tank. In removing these, the clarifier provides tertiary treatment to the effluent by:

- Removing suspended solids – Physically removes TSS from the effluent stream. Removal of TSS aids in reducing the build-up of organic solids on the bed of the receiving water which can contribute to degradation of fish and macro-invertebrate habitat. The other benefit of this is that it makes the effluent clearer and more amenable to UV disinfection.

- Removing phosphorus – Both P which is a component of the organic particles and DRP which has been drawn out of solution and chemically bound with the metal salt (or other coagulant chemical).

- Removing nitrogen – N which is a component of the organic particles. Total nitrogen loading is reduced by an equivalent of 9 to 11% of the effluent solids mass removed. This is organic nitrogen, which, longer term, also contributes to eutrophic effects downstream.

- Removing pathogens – By physically removing those pathogens that are embedded in or adhered to the algal and or floc particles.

- Removing BOD_5 – Physically removes a component of the filterable BOD_5 that is associated with the algal particles and that which may also have complexed with the coagulant chemical.

(j) The clarifier is provided with a sludge storage tank from which batches of sludge are loaded out to Dannevirke. This is an appropriate arrangement, as long as the sludge is appropriately managed at the destination site such that it does not cause additional issues there.

(k) An In-Eko Drum Micro-Filter (Model 4FB0), fitted with 20-micron (μ) filter cloth. The purpose of the micro-filter is to intercept and remove flocs that may have carried over from the tertiary clarifier. The supplier's stated design flow is 20l/s (but up to 50 l/s) assuming a 10 mg/l influent TSS. Filtration area is 6.24m^2.

(l) UV disinfection reactor. This is a Trojan UV3000^{TM}PTP system, model 3400K. It is a 4 Module, 16 lamp system. The clarified effluent is irradiated using ultraviolet light. The UV light radiation, at approximately 254nm wavelength interrupts the DNA of micro-organisms and prevents them from replicating. It does not physically remove the micro-organisms from the effluent flow. The suppliers stated design conditions are that it has a peak design flow of 20 l/s (1,728 m^3/d) at 60% minimum UVT and a 7-day average TSS concentration of less than or equal to 6mg/l.

(m) Outfall pipe directly into 'Town Creek", a small, spring fed stream which eventually discharges into the Mangatainoka River.

Figure 1: Whole of plant schematic

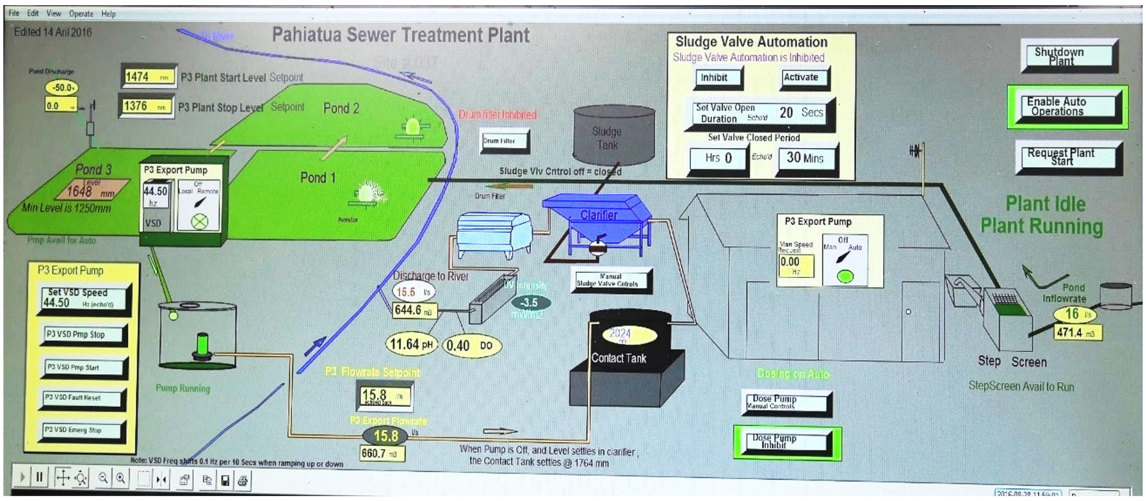
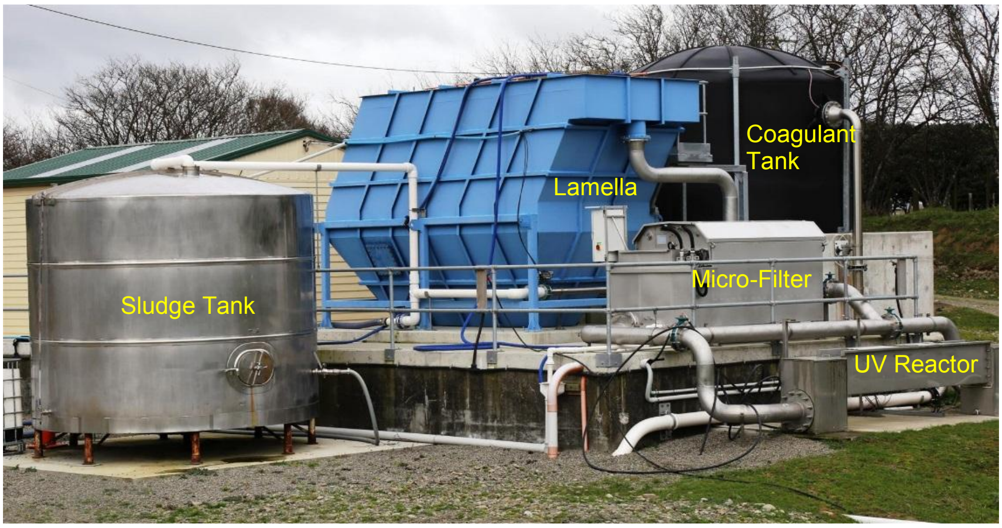


Photo 1: Tertiary Treatment Plant



Flows

7.6 Effluent flow data from PWWTP from June 2014 to December 2016 has recently been made available to me. There is a gap in the data from May to and including July 2015. The data from June 2016 onward appears unusable as it appears to be low by a factor of approximately 10. Therefore, I have omitted these two time periods from calculation of the plant flows

7.7 From the useable flow record, the following statistics are drawn:

(a) Average Dry Weather Flow (ADWF): 408 m^3/d

(b) Average Day Flow (ADF): 780 m^3/d

(c) 95^{th} %ile day flow 1,389 m^3/d

(d) Maximum Day Flow (PWWF): 4,300[1] m^3/d

7.8 The per capita average day flow appears to be approximately 300 litres, or 163 l/hd/day on the basis of average dry weather flow.

7.9 From dry to peak wet weather is a multiplier of 13 times. Typically, however, the increase from dry weather to wet weather is approximately 4 times. This is very similar to many reticulated systems around New Zealand in older towns.

[1] Based on a very limited period of data collection.

Loads

7.10 Because there is no influent characterisation of the wastewater stream available and because the flows are so variable, I have based an assessment of the loading onto the PWWTP on per capita waste production figures. I have used a population of 2,500 people. This is understood to be reasonably stable. Table 1 below provides an update of the figures presented in Table 1 of the 2014 Opus memorandum[2] on the subject.

7.11 The following per capita domestic loads, shown in Table 1 below, have been derived from Metcalf & Eddy, 5th Edition, Table 3-13. I have assumed that 50% of homes use a kitchen waste grinder of some form. I have also applied a factor of safety of 15% to allow for loading sources other than just the domestic population.

7.12 Estimated total plant loadings are shown in Table 1 below. The column on the right is a load assessment based on average daily flows and a limited amount of influent 'grab' sample based characterisation. However, the two methods show a high level of agreement.

Table 1: Calculated Plant Loading - Domestic

Pollutant	**Per Capita Load**	**Total Daily Load** (based on per capita loads)	**Total Daily Load** (based on influent grab samples & 2017 inflows)
	g/hd/d	Kg/d (allows 15% FS)	
COD	205	589	
BOD_5	80	230	232
TSS	78.5	226	
NH3-N	7.8	22	
TKN	13.5	39	41
TP	2.2	7	6
FOG	30	86	

[2] 11 Dec 2014, Opus International Consultants Ltd Pahiatua WWTP Upgrades

7.13 The treatment plant will likely have been designed for a nominal loading on the facultative pond of 84 kg BOD_5/ha/day. That was the prevailing Ministry of Works and Development standard at the time and the loading to which most facultative pond systems in New Zealand were designed. Given the area of 1.3ha and estimated loading of 230kg/day, the loading rate on the facultative pond would be approximately 177 kg/ha/d or 85kg/day if we consider Pond 2 as providing further facultative treatment.

7.14 The more recent work of Mara and others has determined that, temperature and hydraulic conditions permitting, normal loads higher than 84kg/ha/day can readily be managed by these pond systems.

7.15 Addition of supplementary aeration systems such as the 10.5kW (Cage plus Reliant aerators) installed on Pahiatua Pond 1 are a viable method of increasing the load carrying capacity of the facultative pond. We do not have specific data on the Reliant aerator. However, if we consider that both machines have a standard oxygen transfer efficiency of 0.9 kgO_2/kw.hr, an actual transfer efficiency in this waste of 0.6 kgO_2/kWhr and that 1.1kg of oxygen is required to oxidise 1kg of BOD_5, then the supplementary aeration, as installed could provide for a further 151kg of oxygen demand per day. This combined with the nominal pond capacity would increase the total BOD processing capacity of Pond 1 to 260 kg BOD_5/day, which exceeds the load on the pond of 230kg $cBOD_5$/day. Therefore, irrespective of whether or not Pond 2 is considered to be providing facultative treatment, I conclude that the treatment plant is operating well within its nominal loading capability. This is particularly important in managing the risk of odour generation – which I understand, has not raised any particular concerns at Pahiatua.

Effluent disposal system

7.16 Effluent from the UV Disinfection system is currently piped out directly to Town Creek, immediately adjacent the treatment plant which subsequently discharges to the Mangatainoka River.

8 CURRENT LEVELS OF PERFORMANCE

8.1 This section describes the recent historical performance of the PWWTP in terms of effluent quality. This is shown in Table 2, which presents the current performance (based on sample analyses) of the PWWTP and the performance required if HRC proposed conditions are adopted for comparison.

Table 2: Historic Effluent Quality Indicators

Analyte	2016 Performance		HRC Proposed conditions (Post July 2018)		
	Mean	95th %ile	Median*	95th %ile**	100%ile
Flow (m^3/day)	780				<3,460
$cBOD_5$ (mg/L)	23	31	<=1	<=3	
Suspended Solids (mg/L)	41	65	<=10	<=30	
Ammonia (mg/L)	2.5	6	<=1	<=3	
Total Nitrogen (mg/l)	9	14			
D.R phosphorus (mg/l)	1.4	2.2	<=0.1	<=0.5	
Pond D.O (mg/l)					>0.5
Microbiological					
E.coli (MPN/100ml)	600	2340	<=50	<=1000	
UV Dose (mJ/cm^2)					>30

* No more than 8 exceedances in 12 samples

** No more than 2 exceedances in 12 samples

8.2 At face value, these current performance figures appear on a par with or better than most two pond systems.

Table 3: Comparison with other NZ pond based WWTPs

Site	Description	$cBOD_5$	TSS	NH_3-N	TKN	DRP	TP	FC	E.coli
Bulls	2 pond + aerator	13		6			7.3		
Ratana	2 pond + aerator	15	48	8		1.9			
Gore	2 pond + aerator	29	56	14	24	3.5	4.8		2301
Leeston	8 pond + aerator	22	63	17	23				
Queenstown	3 pond + aerator	36	65	31	38		6	44100	
Woodend	2 pond + aerator + UV	10	59	15	27		9	430	430
Rangiora	2 pond + aerator	38	78	17		3.8		4350	4285
Pahiatua	3 pond + aerator	23	41	2.5	9	1.4	2.7		600

8.3 In preparing information for this evidence, only flow data pre-June 2016 and from January 2017 onward have been able to be used. The flow data available appears to have come from at least two different sources. However, averaged over a period of months it appears reasonably consistent. Only effluent concentration data from May 2016 and later has been able to be used. Thus, the loading data presented below has had to be derived from a mismatch of flow and concentration days. This is not ideal but should provide a reasonable estimate of the effluent loads. The seasonal loads, particularly autumn and winter should be taken as indicative only as, there was very limited concentration data available for some of the seasons.

Table 4: Year 2016 Daily Effluent Flows and Loads

	Flow	e.coli	TSS	NH_4-N	SIN	TN	DRP	$cBOD_5$
	m^3/d	x 10^8 MPN/d	kg/d	kg/d	kg/d	kg/d	kg/d	kg/d
Annual	780	47	32	2.0	4.1	7.1	1.1	18
Spring	846	60	42	2.6	4.0	8.2	1.3	21
Summer	687	5	17	1.5	1.8	3.5	0.7	11*
Autumn	867	No data	44	1.0	3.2	7.6	1.8	16*
Winter	799	No data	23	2.0	6.0	8.1	0.6	No data

* Based on only one or two samples

8.4 Based on the calculated plant loadings presented in Table 3, the following waste removal performance has been calculated.

Table 5: Pollutant Removal Performance 2016

	TN	DRP	$cBOD_5$
	kg/d	kg/d	kg/d
Influent	39	7	230
Effluent	7	1.3[3]	18
% Removal	82%	81%	92%

[3] Estimated as DRP+(TSS/100) assumes effluent solids are 1% P

Biochemical-parameters

8.5 **Carbon:** The pond system is principally configured to reliably remove carbon-based wastes and provide rudimentary effluent disinfection. The combined tertiary coagulation-clarification-filtration process should remove additional $cBOD_5$ in the form of particulates. From the currently available data, it does not appear that this is the case and that tuning and optimisation of these processes is necessary. Reduction of $cBOD_5$ is approximately 92% on an estimated load basis.

8.6 **Nitrogen:** The main forms of nitrogen in domestic wastewater are organic-N (bound in organic substances), ammonia-N, nitrate and nitrite. Organic N and ammonia together make up what is known as TKN (Total Kjeldahl Nitrogen). TKN is of most interest as an influent determinand because it represents almost all of the influent nitrogen to be assimilated or nitrified. Ammonia-N, nitrate and nitrite make up what is known as SIN (soluble organic nitrogen). SIN is an important effluent determinand because it is these forms of soluble nitrogen that contribute most to eutrophic effects in receiving waters. The ammonia-N component is also important because it can contribute to both acute and chronic toxicity effects in the receiving water.

8.7 The PWWTP is not specifically configured to remove nitrogen. Most nitrogen arriving at the plant is in the form of TKN. A high proportion of nitrogen (approximately 80% for 2016 in this case) is removed by one or more of three processes described by Middlebooks[4]. These are i) assimilation into the growing algal biomass as organic-N, ii) biological nitrification (to nitrite and nitrate) and ii) ammonia volatilization due to pH and temperature changes and thence equilibrium shifts between gaseous ammonia and liquid phase ammonium. For the nitrogen assimilation route to have an effect, the algal solids produced need to be removed from the process stream. However, this is not normally the case and, over time some of the organically bound nitrogen is mineralised in the cold digestion process occurring at the bottom of the pond and re-released as ammonia/ammonium.

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[4] Middlebrooks et al 1999.

8.8 The SIN leaving the treatment plant is a reasonably even mix of ammonia-N and nitrate/nitrite. The proportion of nitrate plus nitrite is not normally so high. However, this may be due to a comparatively low effluent ammonia. In his evidence, Dr Ausseil has concluded that the Mangatainoka River is not nitrogen limited and that effluent SIN from PWWTP does not have potential to cause any more than minor increase in in-stream SIN concentrations or loads.

8.9 It is difficult to formalize and formally control the nitrogen removal processes in an oxidation pond system. Measures such as removal of short circuiting, addition of supplementary aeration (and or pond area), addition of tertiary clarification devices and reduction in wet weather flows are some ways in which the level of total nitrogen removal can be enhanced and or made more reliable.

8.10 The main effect of the tertiary treatment processes, once fully optimised, will be to reduce the level of effluent organic N which is associated with the organic solids in the effluent.

8.11 **Phosphorus**: As with nitrogen, a small amount of phosphorus is removed in the generation of active biomass and algae in the ponds. Active biomass is simply a group of living micro-organisms respiring and reproducing on food and oxygen supplied by external sources. As with nitrogen, some of this organically bound phosphorus will eventually be re-released into the water column due to the solids digestion process.

8.12 The coagulation and clarification process however does specifically target the removal of additional phosphorus. Particulate phosphorus is found included in biological cells (bacteria and algae) exiting the ponds. A proportion of this material is removed by coagulation, flocculation and settlement. In addition, dissolved phosphorus reacts chemically with the coagulant chemical (normally a metal salt such as alum), a heavy precipitate forms and this also settles out in the clarifier.

8.13 The amount of phosphorus that can be removed is dependent upon the amount and type of coagulant dosed and the quantity of other materials in the wastewater that will compete with the phosphorus to react chemically with the coagulant. The plant should be able to reliably remove DRP down to 0.5mg/l. Once stable, reliable operation to an acceptable level has been achieved and proven, consideration can be given to experimenting with seasonal increases in DRP.

8.14 I understand, from the evidence of Dr Ausseil, that the Mangatainoka River is phosphorus limited under most flow and seasonal conditions. I also understand that the existing phosphorus discharge from PWWTP is, according to the evidence of Dr. Ausseill, causing a moderate, but statistically significant, increase in DRP concentration in the river. I also understand that there is a measurable but minor effect in terms of periphyton growth when comparing immediate upstream and downstream sites.

Micro-Biological

8.15 Under dry weather flow conditions influent to PWWTP generally contain E-coli (EC) of the order of 4 x 10^6 MPN/100ml (measured grab samples). Mean dry weather effluent EC level is approximately 6 x 10^2 (600) MPN/100ml. This represents roughly a 3.8 x $\log_{10}$ reduction (from raw sewage) which is reasonable (but not outstanding) performance for a plant configured as this one is. The median effluent e.coli is currently 320MPN/100ml. However, this result is the average of only 12 samples, including two outliers. I am confident, with appropriate tertiary plant tuning and optimisation, that a better result, of the order of 260 MPN/100ml can be achieved.

8.16 The current performance would not be adequate to meet the performance E.coli levels anticipated by HRC. To reach the Median[5] <50MPN/100ml level suggested would require a total 4.9 $\log_{10}$ inactivation which is a further 1.1x$\log_{10}$ inactivation better than the existing performance. This is unlikely to happen, with the existing equipment, except on isolated days.

9 FUTURE FLOWS AND LOADING

9.1 The population at Pahiatua is expected to remain reasonably stable, or even to decline slightly over time. Therefore, apart from any flow changes due to changes to the water tightness of the sewer system and or climate

[5] Median is being expressed as 8 out of 12 samples as defined in the NZ Wastewater monitoring Guidelines for a Discharger's risk of no more than 10%.

change effects, the flows and loading to PWWTP are likely to remain reasonably static.

10 PROPOSED LEVELS OF PERFORMANCE

10.1 Target effluent quality figures have been derived from:

(a) Preferred disposal option - continued discharge to the Mangatainoka River.

(b) Allowance for reasonable mixing.

(c) What the river can assimilate with minimal effect.

(d) Fiscal prudence, namely what reasonably affordable technology can achieve based around upgrading of the existing asset.

10.2 The proposed effluent quality standards are presented in the following table:

Table 6: Proposed Effluent Quality Standards

	Following implementation of proposed upgrades	
	Median	95th %ile[1]*
$scBOD_5$ *(g/m³)*[6]	≤5	≤8
Total suspended solids *(g/m³)*	≤15	≤30
Ammoniacal nitrogen *(g/m³)*	≤10	≤15
DRP (g/m³)	≤0.5	≤1.0
	Median	95th%ile.
E.coli (MPN/100*ml*)	260	1,000

10.3 **Soluble Inorganic Nitrogen (SIN) / Ammonia:** The proposed mean effluent target for ammonia is 10 mg/l. This represents a value that the river can assimilate without significant effect. Because this is pond technology, some high results will inevitably appear from time to time.

10.4 **Dissolved Reactive Phosphorus**: An annual mean of 0.5mg/l is proposed. This will be achieved via chemical dosing and use of a tertiary clarifier. The existing coagulation/flocculation / clarification system will need to be tuned and optimised, in conjunction with a reputable chemicals

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6 $scBOD_5$ is Soluble Carbonaceous Biochemical Oxygen Demand.

supplier, to achieve this result. To a certain extent, the amount of DRP removal can be tuned by adjustment of the chemical dose. At Gore for example, the Actiflo ballasted clarification system, with alum dosing, regularly achieves DRP levels down to 0.1 mg/l. However, there are direct implications for operational cost.

10.5 **scBOD5:** There is currently no effluent $scBOD_5$ data available from the plant. The proposed effluent target of 5 mg/l $scBOD_5$ should be achievable as a median with the technology that has been installed. It is unlikely to be achieved as a 95^{th} percentile. Again, tuning and optimising of the tertiary treatment processes will be required. It is not a critical discharge parameter in this case. Using the measure of soluble $cBOD_5$ removes most influence of high summer spikes due to the proliferation of algal blooms. The tertiary plant of a lamella clarifier and micro-filter are unlikely to improve the $scBOD_5$ performance significantly from current performance, whatever that might be. However, the optimisation of coagulant use in the clarifier to amalgamate the particulates may result in some soluble BOD being removed. The likely extent of this, if any, could only be assessed by experimenting with the full-scale installation during the period of optimisation.

TSS

10.6 The existing effluent TSS levels from PWWTP are not good considering the tertiary processes that are installed. This is perhaps the most obvious indication that optimisation of the tertiary processes is necessary.

10.7 There is currently no apparent improvement in DRP or TSS levels observed at Pahiatua across the lamella system. However, we have no information as to the level of design, sizing or process tuning that has been undertaken at Pahiatua or, for that matter whether the clarifier system was actually running at the time samples were taken. We know such systems work in removing algae in water treatment plants so there would not appear to be a good reason why they won't work on wastewater algae. It should be possible to take the existing effluent and consistently reduce TSS to less than 15mg/l.

10.8 My recommendation is that a formal commissioning and optimisation process is followed to complete the tertiary process additions at Pahiatua as an integrated and optimised system.

Disinfection

10.9 E. coli type bacteria enter the PWWTP in raw sewage at the rate of approximately 4-5 x 10^6 per 100ml. Protozoan cysts may or may not be present. Human enteric viruses of some kind will normally be present in raw sewage, but numbers are typically relatively low unless there is some form of outbreak condition in the community. However, e.coli has been adopted as the key indicator criterion for this site and this discharge consent.

10.10 Current performance (12 samples to date for 2016/17) is a mean EC of 600 MPN /100ml, median 320 and a 95th percentile of 2,340 MPN/100ml. There is no readily apparent seasonal performance difference indicated by this very small amount of data, although there is virtually no summer data available.

10.11 Key parameters in achieving wastewater disinfection targets using UV irradiation are UV transmissivity (%UVT) and TSS. In a pond with relatively low TSS, the UVT can be as high as 40%, while it can get to as low as 15% for ponds with an algal bloom. The effect of a clarifier should be to make UVT more consistent and at a higher range than could be expected from a simple pond system.

10.12 There are currently 26 UVT data points available from PWWTP effluent. These results range from 27 to 75%. Apart from a few discrete days, these do not indicate any significant improvement in UVT from upstream to downstream of the lamella clarifier. The results below about 35%UVT indicate that, without further intervention, the UV system is occasionally likely to struggle to deliver a high rate of e.coli inactivation. This again indicates that performance optimization is required.

10.13 To achieve the HRC suggested limit of 50 MPN is numerically possible if a clarifier and UV reactor are installed. This would, in effect, require a further 1.1x$\log_{10}$ inactivation beyond what the UV system is currently delivering. It is not clear that this would be consistently achievable. Further, I understand that there is no identified effects driver which would require the proposed end of pipe standard of 50MPN/100ml. I would recommend that the target median is revised to 260 MPN/100ml in line with a 1 x $\log_{10}$ further inactivation in a UV reactor and the MfE and MoH

Safe Bathing Guidelines. 1000 MPN/100ml would be a suitable nominal 95^{th}%ile limit (no more than 2 in 12 exceedances[7]) standard to apply.

Summary

10.14 In summary, and with reference to the evidence of Dr Ausseil the proposed effluent quality targets for the PWWTP recommended above represent, in my view a pragmatic standard that will result in no more than minor effects on the receiving water and that is achievable with a level of expenditure that is fiscally prudent for TDC.

11 OPTIMISATION OF THE RECENT UPGRADING WORKS

General

11.1 The levels of treatment required by the effluent targets will require optimisation of the tertiary upgrade works already installed at PWWTP.

11.2 One further upgrade is intended for PWWTP. This will involve addition of a tertiary polishing wetland (this could be of the surface flow or subsurface flow style or a combination). My evidence covers only the optimisation work. The wetland is discussed in the evidence of Mr MacGibbon.

Prior Upgrades

11.3 Several improvement works have already been implemented at PWWTP since this consent renewal process commenced. These include:

(a) Screening of the pond 3 effluent and installation of a transfer pump station.

(b) Installation of a chemical dosing system and associated flocculation tank – refer paragraph 7.5(h)

(c) Installation of a Filtec Lamella Clarifier– refer paragraph 7.5(i)

(d) Installation of an In-Eko micro filter, post lamella – refer paragraph 7.5(k).

[7] NZ Wastewater Monitoring Guidelines 2005, Table 13.2

(e) Installation of a Trojan, in channel, UV disinfection system– refer paragraph 7.5(l)

Optimisation Programme

11.4 As discussed in previous sections of my evidence, initial monitoring of the tertiary processes indicates that they are not performing optimally. It is proposed that a structured optimisation programme is entered into to obtain optimal performance from the existing systems. The objectives of the optimisation process need to be to:

a) ensure that the chemical dosing system, coagulation tank, clarifier, filter and associated and UV disinfection work as an integrated system (not as isolated components of the plant) and

b) within that context, maximise the performance of each unit process.

11.5 It is clear that the pre-cursor conditions required by the micro-filter and UV system suppliers are not being met. A first step in the programme will therefore be to optimise the performance of the lamella clarifier. While it is possible that those pre-cursor conditions may be overly conservative, they are not being met by quite some margin and improvements should be made to get them closer.

11.6 Once the clarifier performance has been optimised, an assessment can be made regarding optimisation works on the micro-filter and the UV system, or whether these need to be augmented with additional capacity.

11.7 Physico-Chemical treatment systems (such as the tertiary processes at PWWTP) tend to work best when set up to run under near constant flow rate and chemical dosing rate conditions. TDC's approach of using Pond 3 for treatment and buffering storage is therefore a sound approach. The objective is to ensure that the processing runs are as long and steady and slow as possible. If it has not been done already and review of the effluent data record will be needed, in conjunction with a pond flow routing exercise to determine an ideal flow rate of range of flow rates to target. The current average flow data suggests that a flow of about 13 – 15 l/s would be appropriate for the majority of the time. However, it is not clear if that and the available storage would cater for prolonged periods of wet weather flow. It is likely that two operating regimes will need to be established. One for dry weather and one for wet weather.

Chemical Dosing

11.8 It will be necessary to work with a reputable chemical supplier to identify a coagulating chemical that produces a very good 'solid 'floc' under a range of conditions and which is cost effective. If TDC's incumbent chemicals supplier is not able to supply such a chemical, then an alternative supplier may need to be approached for this particular application. As well as a coagulant, a floc enhancing polymer may be required. The two key roles of these chemicals are to i) create large, heavy floc particles that settle easily in the clarifier, and ii) precipitate out dissolved phosphorus from solution.

11.9 The 'flash mixing arrangement will need to be checked for effectiveness. This is the process of high energy mixing the coagulant chemical with the incoming flow. The two streams must be fully mixed within a matter of a few seconds to ensure that the effectiveness of the chemical is not lost.

11.10 The flocculating tank, where the flocs are matured and allowed to amalgamate. This is a low energy process. The floc tank must be checked to ensure that it is providing an appropriate hydraulic residence time to optimise the floc formation.

Clarifier

11.11 Unlike conventional wastewater clarifiers, lamella clarifiers contain a 'pack' of inclined (45 – 60^{o} from horizontal) plates that the coagulated water travels through in an upwards direction. Rather than having to fall through the entire clarifier depth, the coagulated solids only need to fall through a depth equal to the vertical distance (60 – 240mm) between adjacent plates. The settled solids then slide, counter-current, down the top of the plate upon which they have 'settled', to a sludge collection system at the base. This greatly enhances the allowable up-flow volume through the clarifier and allows a much greater throughput per unit area compared to a conventional up-flow gravity clarifier. Typical overflow rates are between 5 and 12 m^3/m^2/hr without sand ballasting, whereas conventional circular or rectangular clarifiers have an operating range of 1 and possibly up to 2 m^3/m^2/hr.

11.12 Physical issues, that will require checking in the clarifier are: baffling of the influent channel; the level and location at which the incoming flow is distributed to the lamella packs; the height from the top of the lamella packs to the discharge ‘V-notch’ weirs and the frequency and duration of sludge removal cycles.

Disinfection

11.13 The existing plant is producing an effluent of variable microbiological quality with a median E.coli level of approximately 600 MPN/100ml and 90th%ile of 2,300 MPN/100ml. This will improve as the TSS output from the combined clarifier and filter system improves and stabilises.

11.14 Key parameters in achieving wastewater disinfection targets using UV irradiation are UV transmissivity (%UVT) and suspended solids. If a pond effluent UVT of 40% can be reliably achieved downstream of the clarifier, a 2 x log10 inactivation should be reliably achievable. If the UVT achieved is less than 40 %UVT and or is inconsistent, then a 1 x $\log_{10}$ inactivation is the likely outcome.

11.15 As well as UV transmissivity, effluent suspended solids concentration is also relevant in determining appropriate limits to be achieved by effluent disinfection. The work of various researchers has shown[8] (refer Appendix 3, Figure 2) that for any given residual effluent suspended solids level, there is a practical limit as to the minimum level of disinfection that can be achieved. For example, it is predicted that, if an effluent TSS of 15mg/l can be achieved, the minimum level to which e.coli can be reduced is 50MPN/100ml (i.e this is not a median, but a minimum). This is due to the phenomena of bacterial particles being shielded from the UV light either due to embedment in the solid particle or hidden in its shadow. This was also reported by Gail Sakamoto in her paper on UV Disinfection to the NZWWA annual conference in 1998.

11.16 For these reasons, the greater the level of performance optimisation achieved in the preceding processes, the higher the level of performance that can be achieved from the UV disinfection system.

11.17 The target disinfected water quality is shown in Table 3.

[8] Beltram 2008 & USEPA 1986

Table 7: Current and Target Effluent Disinfection Quality

Raw Sewage	E.coli (MPN/100mL)	3,800,000 ($3.8x10^6$)	Mean
Current performance	E.coli (MPN/100mL)	600	Mean
Current performance	E.coli (MPN/100mL)	320	Median
Current performance	E.coli (MPN/100mL)	2,340	95th %iles
Target - Final	E.coli (MPN/100mL)	1000	
Target - Final	E.coli (MPN/100mL)	260	Median

11.18 All flows (apart from very high flow events bypassed to prevent a pond overflow) would be passed through the UV system. It is not clear yet whether a reactor or channel UV system would be used. Irrespective of which system is chosen, with a pond system upstream, the UV installation can be configured to be shut down for maintenance without undisinfected flows passing to the wetland.

Wetland

11.19 A new wetland is proposed for installation between the existing treatment plant and the new discharge to the Mangatainoka River. This is covered in more detail in the evidence of Mr MacGibbon.

11.20 In general terms, the wetland is likely to: a) reduce effluent total nitrogen through a biological denitrification process and thorough biological cell uptake; b) reduce effluent DRP slightly due to biological cell uptake and c) Reduce effluent TSS by processes of further filtering and settlement.

11.21 The wetland would be installed downstream of the UV disinfection system and therefore the point of compliance, at least for disinfection, should be upstream of the wetland.

11.22 This is because non-human sourced e.coli and e.coli mimics[9] will be reintroduced to the effluent stream within the wetland. These additional e-coli come from the soil, plant material, birds, rats, opossums and the like and disinfection control has effectively been lost. The microbiological quality entering the receiving water will therefore likely be diminished from that leaving the UV disinfection system.

[9] Ishii & Sadowski 2008

11.23 To minimise nutrient and sediment recycling to the effluent, regular maintenance activities will be required.

Dissolved Oxygen Monitoring

11.24 It has been suggested by the HRC Planning officer in proposed conditions 6 & 7 of the air discharge consent, that a permanent continuous dissolved oxygen (DO) monitoring system should be installed in the maturation pond to measure effluent dissolved oxygen.

11.25 There is already a permanently installed DO meter at PWWTP. I would recommend that this is checked and supplemented regularly using a hand-held meter.

Timing

11.26 I estimate that TDC requires approximately 18 months from the date of commencement of the consent (if granted) to complete the proposed optimisation work. This will provide the time necessary to:

(a) Engage an expert operations technician to plan and implement a structured optimisation programme

(b) Undertake stepwise optimisation of the Chemical dosing system, lamella clarifier operation, micro-filter operation and UV disinfection system.

12 DISCHARGES TO AIR

12.1 Four types of discharges to air are potentially produced during wastewater treatment as takes place at the PWWTP. These comprise:

(a) Carbon dioxide produced from the biological breakdown of organic matter in the wastewater.

(b) Nitrogen gas discharged during the denitrification process when nitrates (formed during the oxidation of ammonia and organic N to nitrate) are reduced as heterotrophic bacteria scavenge the bound oxygen during daily cycles of low dissolved oxygen in the water column.

(c) Odour in the form of chemicals such as amines and hydrogen sulphide, which are generated when insufficient oxygen is available to sustain aerobic (oxygen-rich) biological breakdown and anaerobic (lacking oxygen) conditions develop.

(d) Odour produced by decay of natural organisms such as algae that may grow to excess numbers and then die off when nutrients limitations or climatic conditions fail to support their growth (algal blooms).

Carbon dioxide

12.2 Carbon dioxide is a harmless non-toxic gas, which is normally present in the atmosphere. Discharges of carbon dioxide from the PWWTP will not be of such magnitude to result in any detectable changes to the natural carbon dioxide concentration in the air above the site. Some of the carbon dioxide generated will be utilised by the algae in the oxidation pond and converted to oxygen for supply to the bacteria in the pond.

Nitrogen gas

12.3 Nitrogen gas is also a harmless and non-toxic gas which comprises approximately 70% of the atmosphere. Discharges of nitrogen gas from the PWWTP will not be of such magnitude to result in any detectable changes to the natural concentration in the air above the site.

Odour

12.4 Odour generation has not been an issue at the PWWTP in the recent past.

12.5 The screenings facility needs to be managed carefully such that, particularly in summer, organic materials such as faecal matter in the screenings bin do not putrefy and produce an objectionable odour.

12.6 It cannot be guaranteed that an unusual load event will not occur that is larger than the aeration capability in the ponds. In this case, anaerobic conditions and associated odour could occur. The best mitigation for this type of event is strict trade waste control.

12.7 It is not possible to eliminate the risk of an algal bloom occurring in the maturation pond, because algal blooms also occur in natural ponds and estuaries. However, should an algal bloom occur electrically-driven mixers / aerators can be installed in the maturation pond at relatively short notice to provide improved mixing to assist to break up or prevent the formation of algal “mats” and the risk of odour from the “mats” rotting in the sun.

13 COMMENT ON THE OFFICERS REPORTS

13.1 Through my evidence, I have already made comment, at relevant places, on matters raised in the HRC Officer’s report that were directly applicable to issues I was discussing in my evidence.

13.2 The HRC officer has suggested (Proposed Consent Conditions) that a number of the performance parameters for the treatment plant be established as absolutes or 100 percentiles. These include Flow, Dissolved Oxygen and UV Dose.

13.3 When referencing biologically based treatment plants where inflows are influenced by factors over which no person or organisation has direct control, 100 percentile limits are, in my opinion, not helpful and add nothing to the ability to manage the facility. For example, the inflow of 4,300m^3 on 18 February 2017, significantly exceeded the previously expected PWWF by some margin but this did not translate, at all, to any excessive discharge flows. And, even if it had, it would have been within the context of a high flow event in the Mangatainoka River. Similarly, due to circumstances out of the direct control of the owner, the biology in the treatment process can become sick or overwhelmed and a positive DO can be lost for a period of time. Such circumstances could occur, for example, if someone dumps a tanker load of very high strength septage from wine processing without knowledge of the operators. However, such an event is very temporary in nature and unlikely to result in lasting damage, non-compliance or effects. It is however a technical non-compliance that, in theory has to be reported and mitigated.

13.4 In my opinion, the upper compliance standard for flow could be set as a 95th or 99th percentile while biochemical parameters should be established as a combination of Medians (or Means) and 95th percentiles. These are limits that can be effectively managed by designers, equipment suppliers and operators.

13.5 North Island clay soils are generally able to provide a high degree of phosphorus adsorption. My expectation is that the existing low permeability clay liners of the Pahiatua ponds (and subsequent soil lenses) will provide a high level of further treatment to seepage flows in terms of reductions in $cBOD_5$, pathogens and phosphorus. I do not think it likely that significant additional SIN reduction would be achieved.

13.6 In his report, Mr Baker has expressed concern at the possible contamination effects of the partially treated effluent from the ponds on the local groundwater. I do not claim to have expert qualifications in groundwater. However, from experience, I can comment on work that my colleagues and I undertook at Whangamata in 2006 and 2007 where we had to assess likely effects of seepage from a treatment pond, with a low permeability clay liner, adjacent to the Moana Anu Anu Estuary. The following are excerpts from my Environment Court Evidence at the time.

13.7 *"At Whangamata[10], the seepage through the base of the aerated lagoon has been estimated by Opus geotechnical engineers to be 3m³/day but with a possible range of from 0.3 to 30m³/day. The outer water edge of the lagoon is approximately 30m horizontally and 7m vertically from the edge of the Moana Anu Anu Estuary at high tide. Thus, the minimum path length to the estuary water level is 31m"*.

13.8 "*As part of the investigations for this consent, Opus has drilled some observation bores on the down-hill side of the lagoon to intercept and measure the bacteriological quality of any seepage water. These bores are located at approximately 5m from the lagoon edge so there is a further 25m for any seepage to travel through earth to reach the estuary water. Monitoring of these bores has shown that faecal coliforms and E.Coli are at counts of less than 55 cfu/100ml and typically less than 10 cfu/100ml. This indicates that bacterial contamination reaching the estuary is negligible. The estimated FC/E.Coli counts in the lagoon are 1,000,000 cfu/100ml*".

13.9 Mr Baker recommends that the existing liners be tested to see if they conform to a permeability standard of 1×10^{-9} m/s and, if they don't, that remedial action is taken to ensure that they do. It is unclear to me what that would achieve. I understand from Ms Manderson this is a Permitted Activity standard for WWTP treatment and storage facilities.

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[10] Crawford, J.M., 2007. Environment Court Evidence: TCDC & WRC vs Cleanwater Whangamata Inc, Surfbreak Protection Inc, Te Kura Pukeroa Maori Incorporation and Others

13.10 My understanding is that a permeability test, to that level of accuracy (which equates to 0.0864 mm per day in pond water depth) can only be tested on formally prepared samples in a laboratory, normally during construction, under controlled conditions. However, even a laboratory Falling Head Permeameter is only considered accurate down to $k=10^{-7}$m/s (100 times more than the proposed standard)[11]. It is not clear how such tests could or would be extrapolated to account for the heterogeneous nature of a fully saturated field situation that has been operational at PWTTP for some 15 years.

13.11 Removing a series of cores from the 'in service' liners would compromise the liners and require carefully constructed Bentonite plugs to be put back into the exact location the cores have been taken from.

13.12 Permeability to a standard of 1×10^{-9} m/s would equate to seepage of 3.5m^3/day or less from the base of the ponds.

13.13 The associated flow balance exercise which would involve estimates of rainfall, evaporation, inflow and outflow which could not be calculated to that level of accuracy.

13.14 Further, effects such as changes in air pressure and the presence and extent of subsequent soil strata (beneath the liner) would likely have effects[12] of a magnitude which make the permeability standard reasonably meaningless.

13.15 I do agree however, that, if operationally possible, it would be appropriate to undertake a leakage / seepage test on the ponds, within the bounds of possible accuracy to confirm that there is no gross leakage, and to be able to provide some context to measurements made in the proposed monitoring bores.

John M Crawford
Principal Environmental Engineer
April 2017

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[11] Scott, C.R. 1980. Introduction to Soil Mechanics Ch 4 & 5.

[12] The actual rate of flow from the ponds is determined by a 'flow net' using a 3-dimensional integration of effects of water pressure, permeability of individual strata and thickness of individual strata – Scott, 1980, Ch4.

APPENDIX 1: REFERENCES

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APPENDIX 2: GLOSSARY OF TERMS AND ABBREVIATIONS

Term or Abbreviation	Meaning
Activated Sludge	A generic description for a wide range of generally similar treatment processes using vast numbers of specifically selected and cultivated natural microbes to break down particular components of wastewater, normally in a compact, mechanically aerated reactor vessel.
ADWF	Average Dry Weather Flow (Non-peak period) – A measure of the average flow to the treatment plant after dry weather periods of 7 days or more.
ADF	Average Day Flow. The average daily flow taking into account the full yearly flow record.
AEE	Assessment of Environmental Effects
Alum	Aluminium sulphate – an acidic metal salt used in water treatment processes to precipitate out soluble pollutants into a particulate form for settlement or filtration and removal.
aerobic	Containing free oxygen
anaerobic	Devoid of oxygen
anoxic	Devoid of free oxygen but containing molecular oxygen
autotrophic	An autotrophic organism is one "capable of synthesizing its own food from inorganic substances, using light or chemical energy"
BC	Business Case
Beneficial Reuse	Reuse of treated wastewater or biosolids for beneficial purposes
Black noise	Noise created by mechanical sources
BNR	Biological Nutrient Removal – Generic description of a group of wastewater treatment processes that remove nitrogen and or phosphorus biologically.
BOD_5 or $cBOD_5$	Five day carbonaceous biochemical oxygen demand. Used as a measure of carbon based wastes.
$scBOD_5$	Soluble fraction of the five day carbonaceous biochemical oxygen demand. Used as a measure of dissolved carbon based wastes in the effluent.
BNR	Biological Nutrient Removal. The removal of nitrogen and or phosphorus from wastewater using biological methods.
Brownfields	A development site that has been previously been built on
BTF	Biological Trickling Filter
Buffer Zone	Area between point of application (e.g. irrigation) and potentially sensitive location (e.g. house, road, waterway) to avoid adverse effects

Term or Abbreviation	Meaning
CAPEX	Capital cost of a project or product
Caustic	Caustic Soda or Sodium Hydroxide – a strong Base chemical
CCI	Construction Cost Index
CDTCC	Crafted Design and Traditional Construction Contract
CMA	Coastal Marine Area
DBC	Design and Build Contract
DBO	Design, Build, Operate
Denitrification	The separation of nitrate into oxygen and nitrogen gas. The oxygen is scavenged from the molecule by heterotrophic bacteria and the nitrogen is given off to the atmosphere.
DIL	Development Impact Levy
DNA	Deoxyribonucleic acid – Molecular building block for biological tissue.
DS	Dry solids
DWF	Dry weather flow
DWS	Drinking Water Standard (Proposed) 2005. The standard that it is proposed that suppliers of water target for delivery into a Potable water reticulation. The standard is not mandatory and has not been encapsulated in an Act of Parliament.
EBPR	Enhanced biological phosphorus removal
EC or E.coli	Escherichia coli. A bacteria normally found in the gut of warm blooded animals and commonly used as an indicator of the presence of faecal contamination.
PWWTP	Pahiatua Wastewater Treatment Plant
Exogenous	means 'originating externally'
FAST	Fixed Activated Sludge Treatment. Activated sludge process that includes fixed growth media.
floc	A small grouping of (normally visible) particles often attracted by opposite electrical charges or some chemical affiliation
FRP	Fiber Reinforced Plastic (Fiberglass)
HAZNO	Hazardous Substances and New Organisms regulations
Heterotrophic	An organism that, unlike an autotroph, cannot derive energy directly from light or from inorganic chemicals, and so must feed on other life-forms. They obtain chemical energy by breaking down the organic molecules they consume.
HR	High Rate

Term or Abbreviation	Meaning
HRT	Hydraulic Retention Time
IDEA	Intermittently Decanted Extended Aeration. One particular hybrid configuration of Sequencing Batch Reactor
I & I	Inflow and Infiltration – flows of clean water from rainfall and ground water to the sewerage.
LGA	Local Government Act 2002
l/hd/day	Litres per head per day. A measure of the per capita discharge of wastewater to the sewer system.
log	Means '1 exponent of 10' or 1 'order of magnitude'
LTCCP	Long Term Council Community Plan – A requirement of the Local Government Act including 10 year council infrastructure budgetary requirements.
MBR	Membrane Bioreactor
MCI	Macro-invertebrate Community Index
Methylotrophic	A type of heterotrophic organism that can only metabolize on substrate molecules that include a methyl group attached to another atom (usually but not necessarily carbon) e.g methanol.
N	Nitrogen
NH_4-N	Ammoniacal nitrogen
nitrification	Oxidation of ammonia and organic nitrogen to nitrate
nm	nanometer or 10^{-9} meters – used for measuring the size of molecules or the wavelength of different types of light.
NO_3-N	Nitrate
NO_x	Oxidised nitrogen = NO + NO_2 + NO_3
NPV	Net Present Value – The present day value of a series of future costs.
Nitrogen limited	The state of a receiving water in which it is the amount of nitrogen (rather than phosphorus) present that limits the potential macrophyte or periphyton growth in the water body.
OPEX	Operational expenditure
Ozone	O_3 , A toxic and unstable form of oxygen molecule used as a strong oxidising agent for water disinfection.
P	Phosphorus
PCE	Parliamentary Commissioner for the Environment
PDWF	Peak Dry Weather Flow – is the peak flow part of the day (normally early to mid morning) during the peak summer holiday period and during a period of dry weather where I&I are minimal.

Term or Abbreviation	Meaning
Peaking factor	Difference between peak load and off peak load
PET	Proposal Evaluation Team
Phosphorus limited	The state of a receiving water in which it is the amount of phosphorus (rather than nitrogen) present that limits the potential macrophyte or periphyton growth in the water body.
PI	Precipitation Index – provides a relative measure of recent rainfall to the irrigation zones for management of application rates.
PIF	Peak instantaneous flow
Plant	Wastewater treatment plant / facility.
Practical Completion	The point in the Contract at which a treatment plant has been built, commissioned, tested and is ready for compliant operation
Proposal	A tender for work that contains options and alternatives and where the tender rules provide for negotiation of price and conditions of Contract with individual 'Proposers'
PWWF	Peak Wet Weather Flow
PWWTP	Pahiatua Wastewater Treatment Plant
RFT	Request for Tender
RI	Rapid Infiltration
RMA	Resource Management Act 1991 and subsequent amendments.
RNA	Ribonucleic acid
RO	Reverse Osmosis – the finest form of membrane filtration, capable of filtering particles at a molecular scale including aqueous salts.
SBNR	Simultaneous Biological Nutrient Removal
SBR	Sequenced Batch Reactor
SCADA	Supervision, Control and Data Acquisition system.
SDI	Subsurface Drip Irrigation
SH	State Highway
SIN	Soluble inorganic nitrogen. This is a term used to represent the total combine ammonia, nitrite and nitrate in a soluiton.
Specific gravity	The density of a substance relative to the density of fresh, cold water at sea level. e.g, sewage flocs may be around 1.03
SWOT	Strengths Weaknesses Opportunities and Threats
TKN	Total Kjeldahl Nitrogen. Represents the sum of organic nitrogen plus ammonia in a substance.

Term or Abbreviation	Meaning
TN	Total Nitrogen
T/P	Tairua / Pauanui
TP	Total Phosphorous
TPS	Terminal Pump Station: Refers to the last pump station before the treatment plant in a sewage reticulation.
TSS	Total suspended solids
Turn down ratio	Required treatment capacity range to treat high peak load and low off peak load
TWAS	Thickened waste activated sludge
PWWTP	Thames Wastewater Treatment Plant
UAC	Uniform Annual Charges
UF	ultra-filtration in the range 0.004 to 0.1 microns
UV	Ultraviolet: Refers to disinfection by irradiation by ultraviolet light.
UVT	Ultraviolet Transmissivity. A measure of the extent to which a given fluid blocks out or allows transmittance of UV light at a certain wavelength.
VSS	Volatile suspended solids
WAS	Waste Activated Sludge – Surplus biomass that grows in an activated sludge treatment plant due to the provision of food and oxygen.
WCP	Whangamata Community Plan
White noise	Noise created from non-mechanical sources such as water splashing or waves or trees rustling
WSP	Wastewater Stabilisation Pond
WWF	Wet weather flow
WWTP	Wastewater Treatment Plant
pH	a logarithmic measure of hydrogen ion concentration
HRT	Hydraulic retention time
Units	**Meaning**
%	percentage
%ile	Percentile. . 95^{th} percentile is, nominally, the value below which 95% of sample test results will fall.
cfu/100ml	Colony forming units per one hundred millilitres
dBA	the sound level obtained when using a sound level meter having its frequency response A-weighted

Term or Abbreviation	Meaning
g	gram
g/m^3	Grams per cubic metre (equivalent to mg/L)
h	Hour or head
ha	hectare
hd	Per head or per capita
kg	kilogram
kg N/ha.yr	Kilograms of Nitrogen per hectare per year
kg P/ha.yr	Kilograms of Phosphorous per hectare per year
$kgO_2/kw.hr$	Kilograms of Oxygen transferred by an aerator per kilowatt of input electrical energy
kg/d	Kilograms per day
km^2	Square kilometers
kW	kilowatt
kW.hr	Kilowatt hour. A measure of electric power consumption by a machine.
l/hd/d	Litres per head per day. A measure of the per capita discharge of wastewater to the sewer system.
l/s	Litres per second
L_{10}	means the noise level equaled or exceeded 10% of the time during the measuring period
L_{95}	means the noise level equaled or exceeded 95% of the time during the measuring period
L_{max}	means the maximum noise level (dBA) measured with a sound level meter having a “fast” response, or an equivalent method. Fast Response means:The time-weighting characteristic included in sound level meters by convention (See IEC651.)
m	metre
M	Million or Mega
m^3/day	Cubic metres per day
Mg/d	Mega (million) gallons per day
mg NO_3-N/Second/km^2	Milligram Nitrate Nitrogen per second per square kilometre
mg/l	Milligram per litre (equivalent to g/m^3)

Term or Abbreviation	Meaning
micron	One one thousandth of one millimeter (10^{-6}m)
mm/day	Millimetre per day
mm/week	Millimetre per week
MPN/100ml	Most probable number per one hundred millilitres
mJ/cm^2 or mWs/cm^2	Milli-joules (or milli-Watt seconds) per square centimeter. A measure of UV dose rate
pfu	Plate forming unit – one method for enumerating the number of viral organisms in a sample.
UVT	Effluent ultraviolet light transmittance, typically measured at a light wavelength of 254 nanometers
yr	year
l/p/d	Litre/person/day
Organizations	
HBRC	Hawkes Bay Regional Council
HPT	Historic Places Trust
HRC	Horizons Regional Council
MfE	Ministry for the Environment
MoH	Ministry of Health
MOH	Medical Officer of Health
NZWWA	New Zealand Water and Waste Association
Opus	Opus International Consultants Ltd
USEPA	United States Environmental Protection Authority

APPENDIX 3: ACCOMPANYING FIGURES

Figure. 1: Effluent UVT/TSS/Permit Relationships

Process Level	%UVT	TSS mg/L	Permit Level/100mL
Primary	5 – 25	30 – 150	Log reduction or <1,000 to <10,000 TC or FC.
Secondary	40 – 75	10 – 30	<200FC, <240TC <126 E.coli <35 enterococci
Secondary Filtered	60 – 75	5 – 10	<14FC, <23TC
Tertiary Filtered	65 – 80	1 – 5	<1FC, <2.2TC

(FC – fecal coliform, TC – total coliform)

Table 8: Effluent UVT/TSS/Permit Relationships: Sakamoto, NZWWA 1998

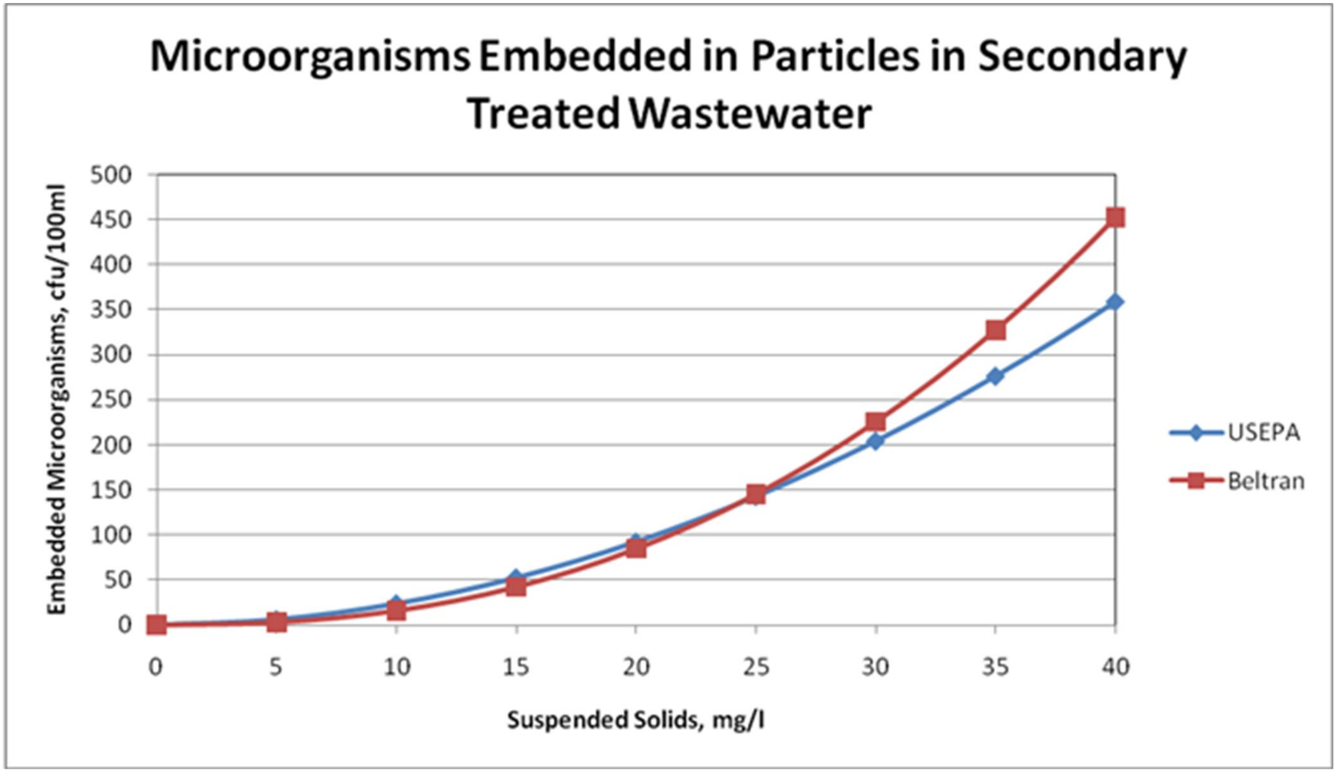

Figure 2: TSS vs Maximum Inactivation: Beltram 2008, USEPA 1986