IN DEFENCE OF

the

AVON-HEATHCOTE ESTUARY

Edited by C.L. Batcheler and K.F. O'Connor
CHRISTCHURCH ESTUARY ASSOCIATION

IN DEFENCE OF THE AVON HEATHCOTE ESTUARY

Collected and revised submissions presented by members and associates of the Christchurch Estuary Association as evidence to the Commission appointed by the Canterbury Regional Council to consider applications by the Christchurch City Council to continue for a further 15 years the discharge of effluent from the Wastewate Treatment Plant at Bromley to the Avon Heathcote Estuary.

Edited by C.L. Batcheler B.Sc. NZ, M.A. Oxon and
K.F. O'Connor, B.A. & B.Sc. NZ, Ph.D. Cornell, USA.
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CHRISTCHURCH ESTUARY ASSOCATION

IN DEFENCE OF THE AVON-HEATHCHOTE ESTUARY

FOREWORD

This is the case of the Christchurch Estuary Association in defence of the Avon-Heathcote Estuary against further sewage effluent discharges from Christchurch's Bromley Wastewater Treatment Plant.

Our forerunner, the Combined Christchurch Estuary Association, was established in 1971 to combat long-continued problems with sea lettuce. The weed then often accumulated in thick mats on the Estuary shores. There it rotted, emitting the rotten egg smell of hydrogen sulphide that caused irritation, discomfort and nuisance to many people. The sulphide blackened silverware and lead-based paint on buildings in the vicinity. Meanwhile, McCormacks Bay had become a convenient trap for silt from the adjacent hillsides, and a dump for all manner of junk. "Reclamation" of the bay became the official city objective.

These events led to formation of the Christchurch Estuary Association to restore the Estuary. Its Constitutional Objects (since 1995) are to:

i. Act on behalf of its Members as a Guardian and Advocate for the Avon-Heathcote Estuary;

ii. Promote protection and enhancement of the Estuary and the landscapes and streams and channels that drain into it so that people and natural biota can enjoy its full benefits in perpetuity;

iii. Monitor the impact of human activity on the Estuary and its environment and seek to eliminate or minimise any adverse impact.

The key of these clauses is our aspiration to conserve and improve the Estuary "so that (both) the people and natural biota can enjoy its benefits in perpetuity". We are proud to acknowledge that, through our affiliations with Residents Associations, Yacht Clubs, Windsurfers, Rowers, Royal Forest and Bird Protection Society, and representatives from two Community Boards and Environment Canterbury, we share this task with some 50,000 Christchurch citizens.

We have campaigned over many issues to persuade those responsible for adverse influences to mend their ways. We want to give the Estuary a chance to function naturally so we may enjoy its birds and restore its fish, shrimp and other organisms to the abundance that made them a treasured food basket from an amazingly productive ecosystem.

The City Council applied in 2001 for Resource Consents to continue discharging treated effluent to the Estuary for a further fifteen years. In effect they applied to expand the

capacity of the Treatment Plant to cope with the increasing population, test sundry methods of improving the quality of effluent, and continue with what it is doing now.

Successive sewage treatment "upgrades" were born of 150 years of Christchurch's history. Much of that was characterised by New Zealand's worst levels of water borne diseases. The contours of Christchurch dictate that the rivers and the Estuary will always function as our natural drain and dump. What we do to it, so it will be. The Estuary is still not healthy. Even now, Christchurch boasts New Zealand's worst statistics for Cryptosporidiosis and Campylobacteriosis, both of these being causes of debilitating diarrhoea".

Conversion of a sewage farm to the Wastewater Treatment Plant and ponds and their commissioning in 1962 relieved the worst influences on health and amenity. Four upgrades of this plant since 1969 increased capacity but they did not reduce the load of nutrients that poured into the Estuary. In fact, because of growth of the city, and extensions of the reticulation system, more and more waste continues to be pumped into and out of Bromley. Inevitably, the increasing nutrient load has altered food chains and built up the potential for masses of sea lettuce and other nutrient-tolerant "sea weeds", and the toxic ammonia in the effluent appears to have poisoned most of the fish.

From current improvements in the CWTP, the Council expects to discharge next year about one third less ammonia than at present. With increasing volume of wastewaters to treat by 2009, it expects the amount discharged of total nitrogen (including ammonia) to revert to about what it is now. Phosphorus discharges are expected to remain about the same as now, or increase.

The possibility of further treatment of effluents in new experimental wetlands that are proposed in the Council's "Green Edge" scheme is simply that: **a proposal for investigating possible use of wetlands**, yet to be developed, for lowering total N discharge. They might work. They might not. No hard estimates of land actually available or costs were submitted by the Council with its application, but we already know that, even by estimates from the Council's own Engineering advisors, their wetland proposals simply cannot be fitted in to the land available in eastern Christchurch. Council staff gave crude estimates for some investigations during the first half of the applied-for 15-year term. They left the second half as both technical and financial mysteries. This was but one example of what we often discerned in the Council's case: their Witnesses skirted around the tough bits with woolly promises that they would do some experiments in future to find the answers.

In contrast, they lavished nearly $200,000 on "public consultation" to sway the citizens by the prospect of turning the paddocks at Linwood into an ecological wetland wonder that would be the "stunning Hagley Park of the 21st century". Like many other people, we welcome the prospect of tidying up unkempt shores of the Estuary. But the reality is that such pleasurable prospects have nothing whatever to do with effluent treatment and its non-damaging discharge. To us, the "Green Edge" proposal was clearly intended to

buy time to cover the lack of preparation during the last decade to cope with a difficult situation that the City Council knew from 1991 was going to arise in 2001.

As is now widely known, it turned its collective back on a $41.6 million 2 km ocean pipeline into Pegasus Bay that was recommended by its own Wastewater Working Party after three years of study. A Peer Group of distinguished Scientists and Engineers subsequently endorsed the Working Party's recommendation. The Council ignored all this weighty advice with its known price tag. Instead, they favoured a tenuous "green-edged pipe dream" and a "steady-as-she-goes" practice of inshore discharge to the same ultimate Pegasus Bay destination but by a route that destroys the Estuary on the way. The environmental difference is captured by the doggerel: "Dilution is the solution to pollution".

The Estuary Association was not invited to comment on the pipeline option. So, of necessity, we now have no option but to defend the Estuary through the machinery of the RMA (Resource Management Act 1991).

The Council's resource consents case relied on several dubious legalistic premises presented by its Advocate, Mr Anthony Hearn QC. Among them, we were shocked to hear the claims that: "the consent must be given if discharge will not cause degradation ***from the present state***. The natural state is not relevant" and "since consent (to discharge) was given in 1966, it should continue indefinitely". Our legal arguments capably rebut such pleading. Moreover, we argue that "sustainable management" is something more than legalistic "no-further-deterioration of the existing mess". The natural state of the Estuary is highly relevant to the purposes of the RMA. "Safeguarding the life-supporting capacity of air, water, soil and ecosystems" are, in our view, integral parts of sustainable management and the "preservation of the natural character of the coastal environment" is indeed, in our view, of national importance.

We do not know if restoration to "a natural condition" is possible, but we know that the first major step in any ecological salvage is cessation of gross eutrophication, especially from ammonia and other nutrients. We also subscribe to the value judgement that salvage of what remains is necessary for the good of Christchurch **and** the biota that inhabited the Estuary long before people arrived.

Once contamination is discontinued, integrated environmental management through an "Avon-Heathcote Ihutai Estuary Trust", recently launched, will, hopefully, achieve substantial ecological restoration of the Estuary over the next human generation. It will not be achieved overnight.

Our legal, social and scientific arguments on applications CRC 012011 to CRC 012016 are presented here, but we have taken the opportunity to revise the text in the light of all the evidence that eventually came to light. We have rearranged the text to incorporate supplementary information that was made necessary by adjournments and calls from the Commissioners for further evidence. We have altered the grammar from that appropriate in oral submissions to that intended to be read. We have inserted new footnotes where

this has seemed to us appropriate where topics have been further developed or contracted from what was in the formal brief of evidence. But the overall case is as we presented it orally to the Commissioners. We hope we have done our job well.

The original evidence was deposited with the Consents Office of Canterbury Regional Council. Copies will also be lodged in the Christchurch Public Library and the Canterbury and Lincoln University Libraries.

EXECUTIVE SUMMARY OF PAPERS PRESENTED AT RESOURCE CONSENT HEARINGS, 2001-2002 IN DEFENCE OF THE ESTUARY

Duncan E.J. Currie L.L.B NZ & L.L.M Oxon, legal advocate for the Estuary Association, presented an analysis of the ways in which effluent discharge into the estuary frustrates the purposes of the Resource Management Act and the Provisional Coastal Environment Plan.

He submitted that, under the Resource Management Act, discharge of effluent into the estuary is a non-complying activity. It is, he submitted, inconsistent with every clause of Section 5 of the Act, the purpose of which is to promote sustainable management of resources for the well-being of the present and future generations of people. Contraventions include the presence of scum, change of colour of the water, unpleasant odours associated with discharges, floatable material in the water, the presence of heavy metals, and adverse effects on natural organisms such as fish that live in the estuary.

He objected to the City Council's application to classify the whole estuary as the effluent mixing zone. The Council wanted that because, faced with fickle winds and tides, the effluent plume may unpredictably go anywhere. But Duncan argued that that is unacceptable. A mixing zone can only be permitted for some definable area downstream of an entry point, and must not jeopardise the purposes for which the water was classified, or jeopardise the life or passage of organisms such as fish etc. that must otherwise pass through it. As applied to the Estuary, where the outfall converges on the channel to Shag Rock and Sumner, it completely blocks the passage of fish. Such a classification would also frustrate the RMA's purpose of classifying the estuary as a "contact recreation" area because it is, among other things, Canterbury's most intensively used natural recreational water body. He supported his case with extensive references to many landmark legal decisions in New Zealand Courts.

Kevin F. O'Connor B.A. & B.Sc. NZ & Ph.D. Cornell, vice Chairman of the Christchurch Estuary Association and Emeritus Professor of Range Management from Lincoln University, showed that drainage development of the city has probably increased the load of nutrients flowing into the Estuary at least 200-fold. With sewage treatment and discharge of wastewater, the total increase in nutrient load has been 2,000-fold. Over 90% of this load of contaminants comes from the CWTP (Christchurch Wastewater Treatment Plant) and is the principal engine that drives growth of sea lettuce, *Gracilaria*

and other nuisance sea-weeds and distorts the life systems of sediments. Rotting sea lettuce generates the "rotten eggs smell" associated with blackened lead-based paint and discoloured household silverware. Ammonia, an important effluent nutrient, is not only a powerful seaweed fertiliser, it also is highly toxic to fish. Kevin demonstrated the uncertainty of the balance sheet of nutrients coming into the Estuary and being in part discharged on the tide. He showed the urgency of determining the role of organic sediments in the balance of nutrients. Accordingly, he proposed that prudence dictates that since we know little about many subtle impacts of the surfeit of nutrients we should observe "precautionary principles", - allow ecological space - for the natural system to survive.

He described the pathway through which proteins in sewage are converted by "ammonification" to ammonia, followed by "nitrification" by specialised oxygen-loving bacteria to form nitrite and nitrate. Finally, nitrate may in certain circumstances be "denitrified" by bacteria that flourish in anaerobic conditions to form nitrogen gas (that comprises 80% of the atmosphere). In a bad-case scenario, denitrification may release nitrous oxide that, as a serious ozone-depleter, is environmentally harmful.

He showed that the City Council proposals to improve the trickling filters, tanks, and ponds at CWTP, and to develop a "polishing wetland" to solve the nitrogen problem, would give a modest degree of relief from present ammonia levels for less than a decade. However, the proposals gave no evidence for any reduction in total nitrogen loading to the Estuary. The proposed wetland simply cannot be fitted into the limited amount of available land in eastern Christchurch. A suggested alternative "biological nutrient removal plant" to remove nitrogen and phosphorus would cost over $100 million - far more than the cost of a pipeline. All this shows, he argued, that if the City will not pump the treated effluent north to irrrigate plantation forests and pastures ($350 million), or to recharge groundwater, then the logical choice is to divert the effluent from the estuary by a pipeline direct to the ocean ($42 million).

Walter C. Clark, B.Sc & M.Sc. NZ, Ph.D. London, Emeritus Professor of Zoology from University of Canterbury, spoke about the ecological complexity of the estuary. He delivered a shock that non-specialist observers find hard to take on board by stating that the added dose of non-saline treated sewage discharge water (which we may euphemistically call fresh-water) is a powerful poison to many invertebrates (animals without back-bones). This is because the unnaturally low salinity pulse of "fresh water" kills the minute free-living sperm and ova of many estuary-adapted animals. As Walter wryly observed, species that cannot reproduce are effectively dead.

He also discussed the effects of ammonia and the well-documented history of eutrophication. Kevin O'Connor (2 above) and Vivienne Burrows and Bernard Hansen (4 and 5 below) had also discussed this topic. Walter emphasised the need to be extremely circumspect with regard to the public health implications of mixing people with even their treated excrement. He also discussed the toxicity of ammonia to fish and other organisms and the difficulties and costs likely to be encountered with ultra violet

irradiation to remove pathogens of different kinds, of which faecal bacteria are only **indicators** of pollution.

Vivienne Burrows B.Sc. NZ & D.Phil. Oxon, a University Teacher, gave a background account of the great biological productivity of the estuary with its day and night succession of saline tidal filling, emptying, and partial fresh water inflows, and its sensitivity to enrichment with nutrients.

She also described the outcomes from the City Council's Wastewater Working Party, its recommendation for an ocean outfall, and the sense of betrayal that accompanied rejection of that recommendation by the Council in favour of continuing discharge to the Estuary.

Bernard R. Hansen, B.A., Dip. Teaching, reviewed his involvement with the Estuary over many years as an unabashed campaigner for environmental protection. Much of his work had been associated with challenging once politically popular intrusions into the Estuary. It was considered to be a wasteland awaiting development by the city. One example was the Estuary Association's fight to protect McCormacks Bay against "reclamation" which was proposed to solve the dual problems of stinking sea lettuce while "developing" the bay. The idea was eventually rejected and, for the first time in Christchurch, this event established the idea in the public mind that the Estuary had value in its own right. He also wrote passionately and skilfully about silt flows from surrounding hill-suburb residential developments, industrial pollutants in the Heathcote River, the downsides of using high-powered racing boats in the estuary, degradation of the river banks and estuary shore line. His was a well-informed and masterly historical traverse of the impacts of the city on its Estuary.

Ian R. Wood, B.E. NZ M.E. & Ph.D, NSW, Emeritus Professor of Engineering of the University of Canterbury, recalled his association with the City Council Wastewater Working Party that recommended that CWTP effluent should be discharged by pipeline to the ocean. He noted that a Peer Group endorsed the Working Party's recommendation, and "having independently read the reports I also agree with the Working Party's conclusion". He gave the opinions that "if the estuary is ever to be returned to something like its natural state .... the ocean outfall is the only long term solution" .... and "well designed outfalls in an open coastline have little effect on the environment".

Peter A. Neal. Plastics Design Engineer, recalled his experiences of fishing in the Estuary from 1970 onwards, when he and his family arrived in NZ from UK. Then, fish were abundant. Now, they are "not worth the trouble of pursuit". He acknowledged that a large part of the change could be due to over-fishing but thought it was more likely to have been due to an environmental change because both keenly sought and unwanted species (like the spiny globe fish or 'puffer', Eds.) have disappeared.

An abrupt decline of numbers of some species, noticeably shrimp, occurred during the early 1970s, at about the time the effluent discharge schedule was changed from continuous to ebb tide only. His statement was one of two anecdotal accounts of the

recent reduction of fish numbers (the other by Mr Dougherty of Salmon Anglers Association) since 1966, the year of the last quantitative survey of fish populations, by University of Canterbury students. These anecdotal accounts were extremely important strands of evidence for the Consent Hearing.

Leo Byatt, New Brighton, had spent all his life in New Brighton and gave interesting anecdotal information on the penetration of effluent from the CWTP, up the Avon, as far as Kerrs Reach. This important matter was not referred to by any other witness except by way of evidence for it in chemical analyses of river samples.

C.Leslie Batcheler, B.Sc. NZ, M.A Oxon, as Chairman of the Christchurch Estuary Association, dealt with political matters such as validity of public opinion polls among people living at distances from the estuary. Those people are not much interested in any estuary matter other than the cost of it as a destination for their sewage. It was recognised that incorrect comparisons of costs of alternative discharge routes improperly swayed public opinion. The Association believes these polls were invalid. He also reported the results from weekly surveys in which Association volunteers collected samples for determining *Enterococcus* (an indicator bacterium of faecal pollution), ammonia concentration, alkalinity, temperature, as well as general information about the numbers of people, dogs and birds in the vicinity of the estuary and local beaches.

Among other things, these surveys showed: generally low levels of *Enterococcus*, except during rainstorms, most faecal bacteria coming from CWTP rather than the rivers; that ammonia concentration in the water is up to about three times the median lethal concentration for fish (thus easily accounting for - but not ***proving*** - the recent disappearance of fish); the prolific growth of sea lettuce and the geometry of its growth are demonstrably due to the high concentration of mineral N (nitrate and/or ammonia) and that most sea lettuce would probably disappear if the N was removed; world-wide, metropolitan estuaries and harbours which receive a high load of N are renowned for problems with sea lettuce whereas those not so exposed have very little sea lettuce; that the proposals for UV treatment of effluent were not adequately evaluated (incidentally, information produced in a recent meeting indicates that electricity costs for UV treatment would be about $750,000 per year, so that if UV treatment were required for estuary discharge, that route would cost at least 15% ***more*** than by pipeline to the ocean.)

A CHARTER FOR THE AVON HEATHCOTE ESTUARY

Our concern for the environmental health of the Estuary and the people that use it persuaded us to formulate a "Charter" that expresses what can be honourably shared by people of good will as a statement of the whole community's hopes for the Estuary. We present it in this Foreword as the vision behind our Case for the Estuary.

1. *The Estuary is Valued as a Significant Wetland.* The Avon-Heathcote Estuary is recognised and valued as a wetland of local, regional, national and international significance, principally on account of varied and abundant birdlife.

2. *The Estuary requires integrated Management as a Natural Ecosystem.* Its functions and values as a system of such significance require it to be managed as an integrated natural estuarine ecosystem, even though its condition has been greatly modified by human actions.

3. *Integrated Management must transcend Divided Powers and Responsibility.* The Estuary's need for integrated management must dominate and have precedence over conventional or statutory division of powers and responsibilities concerning it among different bodies, such as city council, regional council, ministries or departments of state.

4. *Planning for integrated Management must provide for uses to be Compatible,* Planning for integrated management includes provisions for the management and control of traditional food gathering, drainage, navigation, recreation, and uses for other purposes such that all uses are compatible with the healthy ecological functioning of the estuarine system.

5 *Management involves Enhancement and Protection of Estuary Margins.* The biological integrity of the Estuary requires that integrated management includes the maintenance and enhancement of its margins and safeguarding them from adverse effects on their ecological functions.

6. *Management Involves Quality Control of Estuary Inflows.* Because of river and tidal inflows and exchanges, integrated management requires the monitoring of river and ocean water quality, and appropriate measures to restore, maintain or enhance the natural condition of the water.

7. *Management Involves Reducing Pollution and Restoring Naturalness.* Great changes in the Estuary bed, pollution from sewage effluents and storm water, hillside, stream-bed and bank erosion, and construction of walls and roadways, have adversely affected the appearance, recreational quality, and capability to provide wholesome food for humans and life-supporting capacity and natural biodiversity of the Estuary. These facts demand that pollution of the Estuary is progressively reduced and that all feasible ways of restoring botanical and zoological naturalness are investigated and followed.

8. Management should Foster Native Biodiversity over Naturalised Lifeforms. As a wetland supporting significant populations of aquatic plants, fish and birds, management of the water and margins of the Estuary should favour nationally and internationally important indigenous species over introduced species.

9. Management Involves Active Participation of all interested Parties. The significance of the Estuary to the people of Christchurch warrants that all interests, especially those concerned with the study, restoration, maintenance and enhancement of its functions, and in the industry and commerce of the city, should be represented in any body constituted to plan and provide for its management.

10. Management requires Financial Resources for Research and Planning. Well-being requires that a representative body constituted and empowered to manage the Estuary should undertake or commission appropriate studies, with appropriate scientific and community participation and involvement, as well as to plan its integrated management. For these purposes the representative management body must have appropriate call on City, Regional and other financial support.

C.L. Batcheler, Chairman, and
K.F. O'Connor, Vice Chairman.
Thursday, 19 September 2002 {F:\foreword & exec summaries kfo'c & clb 050902.doc}

Duncan E.J. Currie

INTRODUCTION

1. This legal submission first introduces witnesses for the Christchurch Estuary Association (CEA). It then summarises essential aspects of this submission, relevant sections of the Resource Management Act 1991 relevant objectives and policies of the National Coastal Policy Statement, the Regional Policy Statement and the Proposed Regional Coastal Environment Plan (PRCEP).

SUMMARY

2. The Christchurch Estuary Association submits that the consent both cannot and should not be granted.

3. The effects of effluent discharge on aquatic life in the estuary, particularly on sea lettuce and finfish, but also on the benthic communities, invertebrates and shellfish, from eutrophication and ammonia toxicity, reduction of salinity and other causes, are highly significant. The discharge from the sewage outfall must be considered when combined with discharge from the two rivers.[1] It cannot be considered in isolation. If Rule 7.5 or 7.6 of the Proposed RCEP applies and the standard is for a non-complying activity (which we submit is the case because classification standards cannot be complied with), then adverse effects on the environment must only be minor. Granting the consent must not be contrary to the objectives and policies of the proposed plan. Neither criterion is met by the Application. Briefly stated, the case of the CEA is that the contamination, and in particular the nutrient load from the proposed outfall, including ammonia, must be removed from the estuary. That is the only course of action consistent with the Act and the National and Regional Coastal Policy Statements and proposed Plan.

4. S 107 applies in that there are significant adverse effects on aquatic life. The effluent is conspicuously coloured; it is odiforous and; there are effluent scums and floatable matter from the effluent. There are no exceptional circumstances that can support this application and it is not consistent with the purpose of the Resource Management Act to issue consent. This is a jurisdictional provision that overrides the Proposed Plan and thus there is no jurisdiction to grant the requested consent.

5. An ocean outfall must be considered as an alternative under s 104(3). It would be reasonably available and feasible, given the nature and circumstances of the property and the intended operation.

6. The applicant has requested a mixing zone comprising the entire estuary. This in itself shows the estuary, being a shallow and contained area with restricted mixing, is a totally inappropriate receiving environment for the discharge. Such a mixing zone would completely negate the classification standards for the estuary and river mouths, does not comply with the Act's requirement of a reasonable mixing zone, and would be inconsistent with the purpose of the Act since it would negate any controls on the outfall for the estuary. It would not even be a mixing zone as little mixing would take

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[1] S 107, Policy 7.8 RPS, Policy 3.2.4 NPS, Rule 7.2, 7.4 Proposed Plan

place in it. This factor in itself shows that the application is poorly grounded and that ocean outfall is the appropriate alternative.

7. The precautionary principle approach should be applied since there is considerable scientific uncertainty over effects of gross eutrophication on the estuarine ecosystem as a whole, on individual species, on sea lettuce and on the effects of ammonia on fish. There is a paucity of information on the interrelationship of excess concentrations of nutrients and species, on the current state of estuarine bony fish, and very poor evidence on the manifold effects of heavy metals and POPs (persistent organic pollutants) on the estuary system. Nevertheless, notwithstanding uncertainties, there is ample evidence of a positive relationship between high nutrient concentration in the water and the growth of seaweed, and that eutrophication harms most components of natural ecosystems. Exercise of the consent is likely to cause serious harm to the environment. Thus in these circumstances, this uncertainty must be acknowledged in the decision making process when considering this application.
8. The consent should therefore be refused.

WITNESSES

9. CEA will call six witnesses (Our 7th, associated witness, Prof. W.C. Clark, is also listed below, Eds.) who will describe various aspects of the biology, hydrology, history and cultural history of the Estuary.

(a) Emeritus Professor I. Wood. Professor Wood will give evidence as to the Working Party and mixing of the effluent.

(b) Dr V. Burrows. Dr Burrows will give evidence on the nature and sensitivities of the estuarine ecosystem, on the impacts of the discharge on the estuary and on her role in the CCC Waste Water Working Party and consideration of an ocean outfall.

(c) Emeritus Professor K.F. O'Connor. Professor O'Connor will give detailed evidence as to the magnitude and effects of enrichment (eutrophication) of the Estuary by nitrogen and phosphorus derived from effluent, and the changing budgets of these nutrients over the years.

(d) Mr P.A. Neal. Mr Neal has fished in the Estuary for over 30 years. He will give evidence on the trends of fish numbers since 1970.

(e) Mr C. L. Batcheler. Mr Batcheler is Chairman of the Christchurch Estuary Association. He will give evidence about aspects of public opinion, effects of the discharge on human health, effects of ammonia on aquatic life in the estuary and in particular on finfish and the sea lettuce problem in the estuary.

(f) Mr B.R. Hansen. Mr Hansen is a Foundation member of the Estuary Association. He reminds us of the many values of the Estuary to the people of Christchurch, and of the many assaults the city has inflicted on it from the beginnings of European settlement.

(g) Emeritus Professor W.C. Clark. Professor Clark submitted his case independently, and has indicated that he wishes it to be considered as given in alliance with the Estuary Association. He describes the important effects of large volumes of non-saline water (the effluent) on reproduction of invertebrates, public health, the effects of ammonia, and other important matters.

10. We also rely on the planning evidence of Mr R. Delamere of the Department of Conservation.

11. I also represent and submit these submissions on behalf of David and Karen Currie of 90A Bridle Path Road, Alayne McLaren of 7 Rangatira Terrace, Andrews Hill, and Janet Currie of the Rock, 1 Main Road, Redcliffs, Christchurch.

THE APPLICABLE LEGAL INSTRUMENTS

The Resource Management Act 1991

THE APPROACH

12. We submit that if the Commissioners accept that these applications are for a non-complying activity, as we submit is the case, then they should first apply the threshold tests in s 105(2A)(b). That requires assessment of whether adverse effects on the environment will be other than minor and whether granting the consent will be contrary to the objective and policies of the plan or proposed plan. Being a non-complying activity, the threshold tests in s 105(2A) suggest a burden of proof resting on the applicant when it refers to the consent authority being "satisfied that..." one of the two tests is met. *Shirley Primary School-v Christchurch City Council* C136/98.{ TA \l "*Shirley Primary School-v Christchurch City Council* C136/98." \s "Shirley Primary School-v Christchurch City Council C136/98." \c 1 }

13. The Commissioners should then apply the s 107 tests to ensure that resource consents are not thereby prohibited.

14. In considering whether an effect is minor, this Commission may use the test used by the Planning Tribunal in *BP Oil New Zealand Ltd v Auckland City Council* (1992) 2 NZRMA 218, 223 being that it is not a straight balance between 'major' and 'minor' and if an effect is appreciable it is not minor { TA \l "*BP Oil New Zealand Ltd v Auckland City Council* (1992) 2 NZRMA 218, 223" \s "BP Oil New Zealand Ltd v Auckland City Council (1992) 2 NZRMA 218, 223" \c 1 },.

15. The Commission should then, if the threshold is passed and the consents are not proscribed by s 107, apply Part II of the Act and then lastly the relevant considerations enumerated in s 104. We submit that in this case the applicants cannot pass the threshold tests as the effects are manifestly not minor and granting the consents would be contrary to the Plan's objectives and policies.

16. The primary matters to consider are Part II of the Act, to which the various considerations listed in s 104 are subject. Central to the Part II tests are considerations of sustainability and safeguarding the life-supporting capacity of air, water, soil and ecosystems and avoiding, remedying or mitigating adverse effects of activities on the environment under s 5. Matters of national importance that the Commission must recognise under s 6 should be considered together with s 7 matters to which it must give particular consideration. To have 'particular regard' has been described by the Environment Court as "an injunction to take the matter into account, recognising it as something important to the particular decision and therefore to be considered and carefully weighed in coming to a conclusion." { TA \l "*Marlborough DC v Southern Ocean Seafoods Ltd* W006/95 [1995] NZRMA 220" \s "Marlborough

DC v Southern Ocean Seafoods Ltd W006/95 [1995] NZRMA 220" \c 1 }*Marlborough DC v Southern Ocean Seafoods Ltd* W006/95 [1995] NZRMA 220, 228, per Judge Willy.

17. These having been considered, the various mandatory considerations in s 104(i), particularly paragraphs (a), (c), (d) and (i) should be considered, considering also the matters listed in the Fourth Schedule to the Act.

SECTION 5

18. The Applicant's proposal is inconsistent with every clause of S 5 of the RMA, which sets out its purpose.

> *5(1) The purpose of this Act is to promote the sustainable management of natural and physical resources.*
>
> *(2) In this Act, "sustainable management" means: managing the use, development, and protection of natural and physical resources in a way, or at a rate, which enables people and communities to provide for their social, economic, and cultural well-being and for their health and safety while ....*

19. The proposal does not enable the people and community of Christchurch to provide for their social, economic cultural well being. By polluting the estuary, the discharges: Interfere with the use and enjoyment of the estuary as a social and cultural amenity, value and icon; degrade the economic use of the estuary as a potential fishery and recreational amenity, and; does not provide for human health and safety because it promotes the discharge of contaminants including heavy metals, into the estuary, which can endanger people eating shellfish.

20. The word 'sustain' "places the emphasis on ensuring that resources are not used up at a rate greater than their recuperative properties allow. The overriding intention of the legislation is to ensure that successive generations husband the available resources and pass them onto the next in no lesser state than was available to the donor generation. If the resource consent sought will result in the resource not enduring or giving way then the proposed activity is contrary to s 5." See *Marlborough DC v Southern Ocean Seafoods Ltd* W006/95 [1995] NZRMA 220, 227{ TA \s "Marlborough DC v Southern Ocean Seafoods Ltd W006/95 [1995] NZRMA 220" }.

21. As Dr Burrows and Professor O'Connor state, the excessive nutrients contained in the discharge overwhelm the ability of the estuary to cope with them and the net result is adverse effects on the estuary which cannot be remedied or mitigated. They can only be avoided.

> *(a) Sustaining the potential of natural and physical resources (excluding minerals) to meet the reasonably foreseeable needs of future generations; and*

22. The proposal does not sustain the potential of the estuary as a natural resource to meet the needs of future generations for a clean, healthy and usable estuary.. See *Chance Bay Marine Farms Ltd v Marlborough District Council* Decision No. W070/99, 23{ TA \l "Chance Bay Marine Farms Ltd v Marlborough District Council

Decision No. W070/99" \s "Chance Bay Marine Farms Ltd v Marlborough District Council Decision No. W070/99" \c 1 } where Judge Kenderdine emphasized that protecting resources for future generations contributes to a community's wellbeing.

(b) Safeguarding the life-supporting capacity of air, water, soil, and ecosystems; and

23. Far from safeguarding the life-supporting capacity of the estuary and its related ecosystems, the proposal would continue to degrade and pollute it by the discharge of contaminants and excessive nutrients. The impact on fish alone is of note. Messrs Batcheler and Neal give evidence on the impact on fish. Mr G. James for CCC acknowledges (James, CCC, evidence page 4) that the most likely causes of declines of fish populations are the effects of pollutants and fishing activities. There is no doubt that the effect of the pollution is adverse on fish. As was noted by C. Tipler, "The numbers and diversity of fishes in the estuary appear to have decreased over the years as pollution has increased (James 1999). Although these changes could also have resulted from other causes that are not related to discharge into the estuary." (evidence of C. Tipler., CCC, page 70)

24. There is also concern at the feminisation in fish populations (James, loc. Cit. p. 5) and Batcheler's evidence, and accumulation of heavy metals (James, loc cit. p 5). Since it is known that the effect of metals on fish is generally adverse, the precautionary approach must be applied.

(c) Avoiding, remedying, or mitigating any adverse effects of activities on the environment.

25. The proposal does not take the opportunity to avoid the adverse effect of the discharge to the estuary and the nutrification and ammonia of the estuary cannot be mitigated significantly.

SECTION 6: MATTERS OF NATIONAL IMPORTANCE

26. The Applicant's proposal is inconsistent with virtually every clause of S 6 of the RMA, which sets out matters of national importance which Environment Canterbury *must* not only recognise but *provide for* in achieving the purpose of the Act.

a) The preservation of the natural character of the coastal environment (including the coastal marine area), wetlands, and lakes and rivers and their margins, and the protection of them from inappropriate subdivision, use, and development:

27. The proposal alters the natural character of the estuary in introducing contaminants with all their consequences and by promoting the growth of sea lettuce and inappropriately uses the estuary as a sewage outfall.

b)The protection of outstanding natural features and landscapes from inappropriate subdivision, use, and development:

28. The proposal inappropriately uses the estuary, an outstanding natural feature of Canterbury, as a sewage outfall.

c) The protection of areas of significant indigenous vegetation and significant habitats of indigenous fauna:

29. The proposal harms the estuary as a significant habitat of indigenous fish. While there is evidence that some introduced species of birds are attracted by the added nutrients, there is little information about indigenous species of birds that have left, been killed off or declined over the years due to the pollution.

e) The relationship of Maori and their culture and traditions with their ancestral lands, water, sites, waahi tapu, and other taonga.

30. The proposal harms the relationship of Maori and their culture and traditions with the estuary. This will be addressed in iwi submissions

Existing Status of Estuary Under s 6(a)

31. Mr Hearn QC has drawn to your attention two cases concerning natural character: *Trio Holdings v Marlborough District Council* W 103 A/96 (page 49 CCC bound volume) and *New Zealand Rail v Marlborough District Council* AP 169/93 (page 137 CCC bound volume).

We submit that in *Trio Holdings* the only adverse impacts of concern were visual (p 98/ p 50 CCC bound volume). The Planning Tribunal concluded that the adverse effects could in that case be mitigated sufficiently to still enable the promotion of the concept of sustainable management of the sites' natural resources to occur. The adverse effects were not so major as to refuse the proposal. This stands in sharp contrast to the current application, where the effects on the natural character of the estuary include ongoing effects of ammonia on fish and benthic life, eutrophic growth of sea lettuce, desalination, heavy metals and persistent organic pollutants (POPs). These are far more than visual and none promote the concept of sustainable management of the estuary's natural resources. { TA \l "*Trio Holdings v Marlborough District Council* W 103 A/96 (page 49 CCC bound volume)" \s "Trio Holdings v Marlborough District Council W 103 A/96 (page 49 CCC bound volume)" \c 1 } { TA \l "*New Zealand Rail v Marlborough District Council* AP 169/93 (page 137 CCC bound volume)" \s "*New Zealand Rail v Marlborough District Council* AP 169/93 (page 137 CCC bound volume)" \c 1 }

32. In the above *NZ Rail* case, the High Court in 1993 simply held that the preservation of the natural character of the coastal environment under s 6(a) of the Act was subordinate to the primary purpose of sustainable management. It was not an end or an objective on its own, but was accessory to the principal purpose. That being said, the words of the Act are mandatory: this panel **must** 'recognise **and** provide for' the preservation of the natural character of the coastal environment, and in this case the estuary, under s 6(a).

33. CEA would bring one more case to the attention of the panel. In *Aquamarine Limited v Southland Regional Council* C126/97 at 143 -144 Judge Skelton accepted that "as a matter of law a proposed activity cannot be justified on the basis that it will only further compromise the natural character of a coastal environment that has already been compromised. The ultimate test is whether consenting to such an activity will promote the sustainable management of natural and physical resources."

{ TA \l "*Aquamarine Limited v Southland Regional Council* C126/97" \s "Aquamarine Limited v Southland Regional Council C126/97" \c 1 }

34. If the CCC is suggesting that since the estuary is already polluted it can or should be further polluted, that position is in our submission wrong in law. Of course it must be noted that the application is for a considerably increased wastewater discharge volume.

35. We submit that the correct approach is that this panel must recognise and provide for the natural character of the estuary,[2] and that the discharge cannot be justified on the basis that the estuary's natural character has already been compromised by past discharges. After recognising and providing for the matters in s 6, the ultimate test is the sustainable management of the estuary. Under s 5 (2) this includes such matters as sustaining the potential of the estuary to meet the reasonably foreseeable needs of future generations, safeguarding the lifesupporting capacity of the estuary water and ecosystems and avoiding, remedying or mitigating adverse effects on the estuary. There is nothing in *Trio Holdings* or *NZ Rail* to support the proposition that as the wastewater discharge is already occurring the continuation (let alone increase) of the proposed discharge will provide for the preservation of the natural character of the estuary. Far less do either case support the proposition that s 5 is somehow bypassed. If anything its importance is elevated.

36. Professor O'Connor in his evidence shows that sewage treatment at Bromley has been responsible for an increasing loading of N and P to the Estuary and an increasing proportion of N from Bromley is being discharged as ammoniacal nitrogen. Bromley now discharges to the Estuary more than 13 times the total N load of the two rivers and more than 64 times the load of reactive phosphorus of the rivers. Worse, the current plant upgrade programme is a signpost that nutrient loading is increasing. We cannot be confident that the Estuary can continue to tolerate and adjust to increasing nutrient loading. Already sea lettuce is a symptom of a system fed beyond its powers of tolerance. According to Professor O'Connor, if we continue as we have done with the disposal of nutrients from our city, the Estuary will die.

37. As far as s 6(c) is concerned, the estuary has been identified as an Area of Significant Natural Value in Schedule One of the RCEP Plan and Mr R. Delamere for DOC deals with this aspect in more detail.

SECTION 7 MATTERS

38. In achieving the purpose of the Act, Environment Canterbury is required to have *particular regard* to a number of matters, including

a) Kaitiakitanga:

39. This will be addressed in iwi submissions

c) The maintenance and enhancement of amenity values

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[2] Clearly the estuary is included in the words of s 6(a): "the preservation of the natural character of the coastal environment (including the coastal marine area), wetlands, and lakes and rivers and their margins."

40. Environment Canterbury must have particular regard to the amenity value of the Estuary. This is harmed by sea lettuce becoming entangled with windsurfing boards and yacht rudders and centreboards, threats to health to those engaged in swimming and other water sports, and by the smell and appearance of sea lettuce. Compromise of various other amenity values are considered by specialist sports groups.

d) Intrinsic values of ecosystems

41. Environment Canterbury must have particular regard to the intrinsic value of the estuary ecosystems, including those of fish and shellfish and birds. They will hear evidence on this from Dr Burrows and Professor Clark.

f) Maintenance and enhancement of the quality of the environment:

42. Environment Canterbury must have particular regard to the maintenance *and enhancement* of the quality of the environment of the Estuary, which is harmed by this proposal. All our witnesses give evidence relevant to this matter.

h) The protection of the habitat of trout and salmon.

43. Environment Canterbury must have particular regard to the estuary as trout habitat, which is harmed by this proposal.

S 107

44. Section 107(1) of the Act prevents Environment Canterbury from granting any resource consent that, "after reasonable mixing", is likely to give rise to all or any of the following effects in the receiving waters:

(c) Produce any conspicuous oil or grease films, scums or foams, or floatable or suspended materials;

(d) Cause any conspicuous change in the colour or visual clarity of the water;

(e) Emit objectionable odor;

(f) Render fresh water unsuitable for consumption by farm animals; or

(g) Cause any significant adverse effect on aquatic life

45. There is a proviso for exceptional circumstances, temporary discharge or where the discharge is associated with necessary maintenance work, but only if it is consistent with the purpose of the Act to do so. The latter proviso is so important that it was re-enacted in 1997 in Section 23 of the Resource Management Amendment Act 1997, to avoid any misunderstanding due to a misprint in the Reprint of the Act when the 1993 Amendment was applied which omitted those words.

46. Section 107 applies to this proposal so Environment Canterbury has no jurisdiction to grant consent. Section 107(1)(a) would be breached in that after reasonable mixing, the discharged water (by itself or with other contaminants including any from the two rivers) is likely to give rise to all or any of the stated effects in the receiving waters. That list includes (c) the production of any conspicuous oil or grease films, scums or foams, or floatable or suspended materials; (d) any conspicuous change in colour or visual clarity, (e) any emission of objectionable odour and (g) any significant adverse effects on aquatic life. It is submitted that while (c) and (d) may be dealt with by way

of a consent condition, they could not be met with the current proposal, (e) cannot be avoided due to the sea lettuce problem and (g) is entirely unavoidable. The evidence of Mr Batcheler and Dr Burrows shows that there are many significant adverse effects on aquatic life, and Dr Burrows' evidence also explains that the scum is due to the effluent.

47. In addition, s 107 is breached with respect to colour. Dr Hawes (p12) for CCC and Mr Tipler (p73) for CCC acknowledge a visible plume that it will not be significantly reduced, and also scums and odour. Whether the odour emanates from the oxidation ponds, sludge lagoons or sea lettuce (Tracey Freeman for CCC, 14, 16) is immaterial. It is a reasonably foreseeable effect and thus is an effect controlled under the Act. { TA \l "*Andrews v Auckland Regional Council* A9/99" \s "Andrews v Auckland Regional Council A9/99" \c 1 }*Andrews v Auckland Regional Council* A9/99, 12.

NO EXCEPTIONAL CIRCUMSTANCES

48. Thus the Applicant is thrown back onto claiming 'exceptional circumstances'.

49. 'Exceptional' is just that: exceptional. A similar question came up in the context of interpreting the term 'exceptional circumstances' under s 33(4) of the Employment Contracts Act 1991. (*Ace Finance Ltd v Shanaher* [1995] 2 ERNZ 500, 518). The Employment Court adopted an interpretation sympathetic to the nature of the Act as a liberal enactment to reflect contemporary attitudes to such matters because of its expanded personal grievance provisions. He cited the dictionary definition of "exceptional" as "[o]f the nature of or forming an exception; out of the ordinary course, unusual, special." "The circumstances must be shown to be something out of the ordinary, not factors which might affect all cases. The circumstances must be judged on the facts of each individual case." On the facts in that case the matters claimed by the respondent were held not to be exceptional. { TA \l "*Ace Finance Ltd v Shanaher* [1995] 2 ERNZ 500, 518" \s "Ace Finance Ltd v Shanaher [1995] 2 ERNZ 500, 518" \c 1 })

50. Similarly in the present case, the phrase "exceptional circumstances" must be interpreted within the context of the Act and in particular its purpose. The context is clear enough: the discharge may be of a "temporary" nature, or be associated with necessary maintenance work, or somehow be exceptional. In other words, the circumstances must be consistent with the principles of the Act of sustainable management and all the other principles that have been discussed here. A natural emergency may be an example. In any case, the Applicant is simply in the position of having to apply for resource consent where it has not had to do so before. It has had plenty of time to prepare. Simply the desire to continue to pollute into its chosen receiving medium, the estuary, cannot be an exceptional circumstance. That would be to breach the underlying purpose of the Act, which requires sustainability. There are alternatives, and there has been time to investigate them. The CCC has known of the need for a resource consent for many years, and was advised by both the Working Party and the peer review group to adopt an ocean outfall as a viable alternative that would not have breached s 107..

51. It must be always remembered in any case that consent may be granted under s 107(2) if "it is consistent with the purpose of the Act to do so." Thus the

Commissioners must again refer to S 5 of the Act and the sustainable management of natural resources when considering s 107.

52. The only legal response under s 107, to the plea, or implied threat, of the Council, to stop taking sewage, is that if it must, it can have a temporary permit under s 107(2)(b) as an emergency measure. By that it may discharge effluent for a short period and undertake to arrange an alternative route, almost certainly to the ocean, as a matter of urgency.

CONSIDERATION OF ALTERNATIVES

53. The City Council has claimed that it is under no obligation to consider alternative methods of discharge. We consider this is wrong. Alternatives including such options as an ocean outfall **must** be considered by the consent authority under s 104(3)(b).[3]

54. S 104(3) provides that:

> Where an application is for a discharge permit or coastal permit to do something that would otherwise contravene section 15 or 15B (relating to discharge of contaminants), the consent authority shall, in having regard to the actual and potential effects on the environment of allowing the activity, have regard to—
>
> (a) the nature of the discharge and the sensitivity of the proposed receiving environment to adverse effects and the applicant's reasons for making the proposed choice; and
>
> (b) any possible alternative methods of discharge, including discharge into any other receiving environment

55. One test which has been applied is whether the alternative method of discharge could be regarded as reasonably available and feasible, given the nature and circumstances of the property and the intended ...operation. *Purnell v Waikato Regional Council* A085/96, 17{ TA \l "*Purnell v Waikato Regional Council* A085/96" \s "Purnell v Waikato Regional Council A085/96" \c 1 } per Judge Bollard. The Court also noted that the amount of consideration it is required to give to alternative methods is a question of degree. It must have regard to the circumstances of each case and the degree of consideration to be given to alternative methods is directly related to the extent of the adverse effects on the environment of allowing an activity. *Andrews v Auckland Regional Council* A9/99, 10 { TA \s "Andrews v Auckland Regional Council A9/99" } per Judge Whiting.

56. Dr Burrows and Professor Wood describe the work of the Working Party and their consideration of alternatives and final recommendation of an ocean outfall. An ocean outfall is readily available and feasible, given the nature and circumstances of the property and the intended operation. Clearly the Working Party and the peer review group endorsed this view.

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[3] See also the Fourth Schedule Clause 1(f)

National Coastal Policy Statement

57. The proposal is inconsistent with the National Coastal Policy Statement, relevant under s 104(1)(c). Mr Delamere has given evidence as to how it is inconsistent with Policy 1.1.2, Policy 1.1.4, and Policy 1.1.5 and 3.1.1 and 3.2.4. In considering the evidence of Dr Burrows, Professor O'Connor and Mr Batcheler on these Policy statements, please bear in mind the statements under Policy 1.1.4. They provide, under Policy 1.1.2 for preservation of the natural character of the coastal environment to protect the ***integrity, functioning, and resilience*** of the coastal environment. Preservation is described in terms of: natural water and air quality; natural biodiversity; productivity and biotic patterns and intrinsic values of ecosystems, and; national priority to protect ecosystems which are unique to the coastal environment and ***vulnerable to modification.*** It includes estuaries. In such a case as the estuary, where water quality is degraded, please judge the evidence against the facts of national priority under Policy 1.1.5. That is, to ***restore and rehabilitate*** the natural character of the coastal environment where appropriate and, that the habitats of fish, shellfish and crustaceans should be protected under Policy 3.2.8.

58. Amenity values, use and enjoyment of the estuary by the public and safety of the public would all suffer a significant adverse impact, contrary to Policy 3.1.1.

THE PRECAUTIONARY PRINCIPLE

59. In light of inadequate information about natural processes and effects, a precautionary approach should be adopted towards the proposed discharge, particularly if its effects may be as yet unknown or little understood. Under Policy 3.3.1 a precautionary approach is required because there is a relative lack of understanding about coastal processes and the effects of activities on coastal processes.

60. Policy 6.1 of the Regional Policy Statement similarly provides that the Regional Council shall adopt a precautionary approach in the decision making process where the effects of an activity are as yet unknown or little understood. This needs to be acknowledged in applications for resource consents such as those before us.

61. In a case involving the coastal marine area the Court concluded: "Where activities take place in the coastal environment, the precautionary principle as the precautionary approach should be applied where the potential effects are unknown or partially unknown (NZCPS) and RPS." (in *Golden Bay Marine Farmers* W042/01 6 NZED 399{ TA \l "*Golden Bay Marine Farmers* W042/01 6 NZED 399" \s "Golden Bay Marine Farmers W042/01 6 NZED 399" \c 1 }, 420)

62. In *Ngati Kahu v Northland Regional Council* A95/2000, Judge Sheppard held that with respect to resource consent applications, "[t]he Court makes a judgment on such an application after finding facts based on evidence of probative value. The precautionary approach may be applied in making the judgment where, on the totality of the evidence, it finds that due to scientific uncertainty, exercise of the consent would be likely to cause serious or irreversible harm to the environment." (43{ TA \l "*Ngati Kahu v Northland Regional Council* A95/2000" \s "Ngati Kahu v Northland Regional Council A95/2000" \c 1 }).

63. There is considerable uncertainty about the effects of eutrophication on the estuary as a whole, on individual species, on sea lettuce and on such things as the effects of ammonia on fish. The CCC's own evidence on the effect of reducing effluent concentration on sea lettuce growth has been revised from only 20% (AEE 6-31) to 50% (Dr. I. Hawes, page 2 CCC evidence; also page 11). Mr Batcheler of Estuary Association submits evidence that the effect may be yet greater.

64. There is a paucity of information on the current state of the estuary, on pollutants in the estuary, on the interrelationships of eutrophication, pollutants and the biota, and on the current state of significant species such as bony fish. Nevertheless, notwithstanding the uncertainties, there is ample evidence of significant adverse effects. Sea lettuce is known to smother intertidal animals where it accumulates in masses on the foreshores. Gross eutrophication is known to be harmful to ecosystems, and to sensitive species within those ecosystems. Exercise of the consent is likely to cause further serious harm. These uncertainties must be acknowledged when considering this application.

Regional Policy Statement

65. The Regional Policy Statement, relevant under s 104(1)(c), contains in Chapters 9 and 11 numerous relevant objectives and policies with which the application is inconsistent.

66. Under Objective 7.1 (as notified in the May 2001 variation), future generations should be enabled to gain cultural, social, recreational, economic, health and other benefits from Canterbury's waters. Those outcomes are sought *while safeguarding the life-supporting capacity of the water*, including its associated aquatic ecosystems, and significant habitats of indigenous fauna, and safeguarding their existing value for providing mahinga kai for Tangata Whenua.

67. The policy to manage discharges and set water quality conditions and standards that achieve (a) to (h) of Objective 9.3 would be frustrated by the application. Adverse effects of discharges on water quality should be avoided, remedied or mitigated and, where appropriate, degraded water quality should be improved. This would not be achieved either. Policy 9.10 provides that in relation to water quality, natural character and cultural and amenity values, to investigate and provide for water bodies which should be sustained as far as possible in their natural state, and progressively improve degraded water bodies and degraded coastal waters. To achieve this, water quality standards should be established where needed to resolve competing demands for Canterbury's water. Over the next ten years, priority for standard setting should be given to enclosed, degraded coastal waters and coastal waters that are prized for contact recreation. This clearly would not be achieved in the estuary if the entire estuary is designated a mixing zone so the designated standards would not apply.

68. With respect to the coastal environment, Objective 11.1 is to protect and where appropriate enhance life-supporting capacity of coastal ecosystems, areas of significant amenity value, including recreational attributes, and natural character. Under Policy 11.2, restoration or enhancement should be considered for areas within the ambit of Objective 11.1, where these areas have been degraded. These would be frustrated by the current proposal.

Proposed Regional Coastal Environment Plan (PRCEP)

OBJECTIVES AND POLICIES

69. The objectives and policies of the PRCEP (Proposed Regional Coastal Environment Plan) are relevant both under s 104(d) and under s 105(2A) when the application is for a non-complying activity.

70. Objective 6.1 is to protect, and where appropriate, enhance areas of significant conservation value, within the coastal marine area and areas of high natural, physical or cultural value. This includes the estuary. Policy 6.1 accordingly controls activities and prescribes a precautionary approach. The estuary is designated as an "Area of Significant Natural Value" in the PRCEP. It is thus a particularly inappropriate place to discharge sewage effluent. As is noted in the May 2001 variation, "the nature of the contaminant discharged and the ability of the receiving environmental (including ecosystem present) to assimilate that contaminant, is an important factor with respect to the environmental effects of a discharge." The estuary is unable to assimilate the contaminants without damage to its nature, which is why the Applicant has applied for the entire estuary to be designated a mixing zone. Dr Burrows and Prof. Clark in their evidence explain that the estuary is an inappropriate receiving environment since it is shallow, mixing is partial, discharge is incomplete and the ecosystem is vulnerable to damage by the discharge.

71. Objective 7.1 is to enable present and future generations to gain cultural, social, recreational, economic, health and other benefits from the quality of the water in the CMA (Coastal Marine Area). It includes safeguarding the life-supporting capacity of the water and its associated aquatic ecosystems, significant habitats of indigenous fauna and areas of significant indigenous vegetation. Further, the Objective seeks to:

    Safeguard and where appropriate enhance its value for mahinga kai;

    protect wahi tapu and wahi taonga of value to Tangata Whenua;

    preserve natural character and protect outstanding natural features and landscapes;

    where appropriate, protect water quality from degradation;

    where appropriate, maintain and enhance amenity values;

    recognise the intrinsic values of ecosystems and characteristics of the coastal environment.

The proposal is inconsistent with all of these objectives. The life-supporting capacity of the water is not safeguarded by the proposal, in that discharge results in super-enriched water and ammonia contained in the discharge represents a threat to aquatic life. The natural character is harmed, as are amenity values by the discharge, sea lettuce, effects on aquatic life, colour and scum.

72. Policy 7.2 designates the Avon and Heathcote River mouths as water managed for the maintenance of aquatic ecosystems, and the rest of the estuary as water managed for contact recreation and the maintenance of aquatic ecosystems. In both cases water quality is to be maintained and where necessary improved for these purposes. This policy would be frustrated by the application, which claims the entire estuary as a mixing zone.

73. Policy 7.4 addresses the situation, as with the current application, where the discharge, after reasonable mixing, would not achieve the required standards and would not avoid significant adverse effects on aquatic life. In such circumstances, the applicant must satisfy Environment Canterbury that (*inter alia*) exceptional circumstances justify granting the consent; or that practicable alternatives to avoid such a discharge are not available. There are no such exceptional circumstances so the discharge would be inconsistent with this Policy. In any case, this provision must be read together with s 107, which does not contain the 'practicable alternatives' exception, and which states in addition "and that it is consistent with the purpose of this Act to do so." S 107 would override this policy where it is inconsistent.

74. Policy 7.5 can grant a resource consent to discharge human sewage into water or land in the Coastal Marine Area without it passing through land or a specially constructed wetland outside the Coastal Marine Area. But this can only be done where, *inter alia,* such as discharge better meets the purpose of the Act. This submission disputes any contention that the Bromley ponds are a "wetland", whether specially constructed or not. They are artificially constructed, open, shallow, continuously flooded oxidation ponds and are managed as such. The proposal therefore cannot make use of this provision of the Act. Additionally, the estuary is an Area of Significant Natural Value, under Policy 7.5, so the applicant must satisfy Environment Canterbury that exceptional circumstances justify the discharge in such an area.

POLICY 7.6 AND THE MIXING ZONE

75. This Application cannot possibly succeed where it claims the reasonable mixing zone as the whole estuary. The fact that the Applicant has even made this claim shows that the estuary is an inappropriate recipient for the effluent. Professor Clark has given extensive evidence about the mixing zone and it is clear from his evidence and that of Dr Burrows and Prof. Wood that the discharge should not be to an enclosed and shallow receiving environment. Thus the proposition that the whole estuary is a mixing zone is absurd. It could not possibly be consistent with the RMA or the objectives and policies of the NCPS, RPS or the proposed CEP to use the entire estuary as Bromley's private discharge area, free of water classification standards or other RMA controls. This would negate the classification of the Regional Council, the scheme of the Act and the relevant policy statements and plans.

76. Some case law may assist. The question has arisen as to what comprises the boundaries of the Estuary. Judge Skelton adjudicated on an appeal by Christchurch City to regard the Estuary down to Shag Rock as a city waterway, not the coastal marine area. While the case did not concern the definition of a reasonable mixing zone, it is worth scrutiny in light of the considerable expert testimony that was heard and considered. Judge Skelton rejected the argument by the Christchurch City Council that the mouth of the river(s) was by Shag Rock. In doing so he noted on page 38 that "if the entry of the river water into the sea were to be found where the change from fresh water to sea water occurs, there again would be no definite line in the mixing zone." The Court concluded on page 39 that the estuary was part of the coastal system for five reasons. (1) The estuary foreshore is uncovered and covered by the ebb and flow of the tide. (2) The estuary water is substantially saline, even though at times and in places it is mixed to varying degrees with fresh water. (3) The

landforms are dominated by coastal processes. (4) Most of the animals and plants are salt tolerant marine and estuary species. (5) Finally, the Act recognises that estuaries are coastal (not riverine) in the definition of "coastal water". Judge Skelton determined that the boundaries were at the Ferrymead Bridge (Heathcote River) and South Brighton Bridge (Avon River). (s 2(1). Christchurch City Council, Canterbury Regional Council re an Application C 090/92{ TA \l "Christchurch City Council, Canterbury Regional Council re an Application C 090/92" \s "Christchurch City Council, Canterbury Regional Council re an Application C 090/92" \c 1 })

77. In the present context, this decision reaffirms that the estuary, forming part of the coastal marine area, is primarily saline, while freshwater flows from the two rivers and currently the Bromley outfall, but that water is mixed well before reaching the bar beyond Shag Rock.

78. A mixing zone was considered by Judge Bollard in the case of the *Minister of Conservation v Gisborne District Council*. The case concerned water classification where there was an effluent outfall. The Court held that the relevant SE zone was "suitably confined in its extent to allow for reasonable mixing," being 250 metres surrounding the diffuser, and the integrity and recreational use of the waters in the bay would not be unacceptably compromised. It is clear from that decision that a mixing zone must be suitably confined in its extent. Similarly in the present case, to consider the entire estuary a mixing zone would not be suitably confined in its extent and would unacceptably compromise the integrity and recreational waters in the estuary and would mean that no applicable standards are set. (A106/91{ TA \l "*Minister of Conservation v Gisborne District Council* A106/91" \s "Minister of Conservation v Gisborne District Council A106/91" \c 1 }

In *New Zealand Rail Ltd v Marlborough District Council* C049/95 the mixing zone was 100 metres radius from the discharge point. { TA \l "*New Zealand Rail Ltd v Marlborough District Council* C049/95" \s "*New Zealand Rail Ltd v Marlborough District Council* C049/95" \c 1 }

The mixing zone in *Rayonier New Zealand v Gore District Council* by consent was 250 metres downstream from the effluent discharge outfall in the Mataura River (C037/96{ TA \l "*Rayonier New Zealand v Gore District Council* C037/96" \s "Rayonier New Zealand v Gore District Council C037/96" \c 1 }.)

79. The Water and Soil Conservation Act 1967 s 21(3A) provided with respect to the discharge of waste into classified water included the condition "(a) after allowing for reasonable mixing of the discharge with the receiving water, the quality of the receiving water does not as a result of the discharge fall below the standards specified in the classification of that water." { TA \l "Water and Soil Conservation Act 1967 s 21(3A)" \s "Water and Soil Conservation Act 1967 s 21(3A)" \c 1 }[4]

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[4] Note that in s 21(3A(b)), a condition was that "the combined effect of the discharge being authorised and of all existing discharges and authorised discharges into the receiving water will not result in any failure to maintain the standards of quality specified in the classification of the receiving water." So under that Act, as under the now applicable Resource Management Act 1991, the discharge from the sewage works is added to the discharge from the rivers in assessing whether the result will meet classification standards. The effects are cumulative.

Accordingly, in *Mahuta v National Water and Soil Conservation Agency* [1973] the Tribunal held that it is the intention of the WSC Act that "mixing shall occur as quickly as possible in order that the intention of maintaining the classified standard is not frustrated." 5 NZTPA 73, 81{ TA \l "*Mahuta v National Water and Soil Conservation Agency* [1973] 5 NZTPA 73, 81" \s "*Mahuta v National Water and Soil Conservation Agency* [1973] 5 NZTPA 73, 81" \c 1 }

What is a reasonable mixing zone will be a question of fact and degree in each particular case. However under the Resource Management Act, the requirements in sections 5 and 17 to avoid, remedy and mitigate adverse effects, which will happen within the mixing zone, imply a necessity to keep the zone as small as possible. In addition, a restricted zone is necessary in order not to frustrate the object and purpose of the Act and the scheme of water classification set out in the Proposed Plan.

80. Policy 7.6 of the Proposed Plan provides criteria for determining a reasonable mixing zone:

    (a) Volumes, contaminant loading and contaminant concentrations involved with the discharge;

    (b) Factors such as sea conditions, tides, wave action, water depths, water velocity, and flushing characteristics that will normally affect the assimilative capacity of the receiving water and the dispersion of the contaminants or the [discharge] water;

    (c) The presence of an Area of Significant Natural Value at the site or in close proximity;

    (d) Existing use of the immediate area, including the presence of other discharges;

    (e) If in any area within which a water quality standard is set, the size of the area in relation to the mixing zone; and

    (f) Proximity of adjacent areas where water quality standards have been set; and

    (g) *Natural values of the receiving environment.*

81. Where, for instance, as Mr Batcheler shows, chronic (long term) ammonia concentrations in the effluent within the mixing zone may exceed those at which fish can survive, the mixing zone must be kept as small as possible to avoid and mitigate adverse effects on fish in the estuary. If the mixing zone comprised a significant portion of the estuary (let alone the entire estuary), then it would not be reasonable to deny a significant fish habitat to species feeding on impacted species. There is evidence that the estuary is a breeding ground for some 70% of Canterbury flounder (Graeme Inglis, CCC evidence, 6; Gavin James, CCC evidence, 3). Thus designating a significant portion of their habitat as a mixing zone of toxic water adversely affects the entire regional flounder population.

82. With respect to Contact Recreation standards, a mixing zone embracing the entire estuary would unreasonably impact on recreational uses such as yachting,

windsurfing and swimming, since contact recreation water quality standards would not have to be met anywhere. Swimming, windsurfing, sailing and other sports would be carried out in effluent contaminated water that is devoid of legal controls. Finally, the Regional Council has classified the estuary as CR and AE. Both classifications require that there be no significant adverse effect on aquatic life. It would be unreasonable to designate a large mixing zone that negated these classifications and the management objectives intended by the classification would clearly be compromised.

83. Besides classification as CR and AE water, the estuary is classified as an Area of Significant Natural Value. These classifications require there be no significant impact on aquatic life, In addition to factors previously set out, a mixing zone which comprised a significant part of the estuary would unreasonably impact on fish that live in, feed in or pass through the zone.

84. In conclusion, the Applicant has not made out the case for a large mixing zone, let alone one encompassing the whole estuary. The real reasons it wishes to secure a large mixing zone are not even articulated in Section B of the AEE. But in Section 1-18, the Applicant acknowledges that standards 'will not be able to be met by this discharge without a large mixing zone." That much is true. That is another way of saying the application cannot comply with the Act with respect to the entire estuary.

85. For instance, in 5-23 the Applicant notes decline in fish species in the estuary. Birds consume large numbers of heavy metal-contaminated shellfish (e.g. oystercatchers consume an average of 30-40 cockles per hour); sea lettuce growth is increased by the outfall. Ammonia in the wastewater (6-24) is present in toxic concentrations (6-34), shellfish are contaminated (6-36), a visible plume and foam (6-51) often occur, and malathion is released (6-24). Additionally on page 8-13, the assertion is made that however "beyond the mixing zone for the wastewater discharge these effects are considered to be significantly reduced." Either this statement is meaningless if by 'mixing zone' they mean the entire estuary, or the Applicant is acknowledging that there is in fact an actual mixing zone which is smaller than the estuary as a whole.

86. Simply put, if the entire estuary is designated a mixing zone, then the Contact Recreation standard is inapplicable, there are no controls on the estuary and in effect the entire estuary becomes uncontrolled sewage effluent. If the request of the applicant is granted then the entire estuary could suffer adverse effects on aquatic life, colour, scum and other significant impacts. This argument by the applicant shows clearly the utter inadequacy of the estuary as a receiving environment and shows that the ocean outfall is the appropriate alternative.

87. Policy 7.8 provides that, after reasonable mixing, contaminated water discharged into the Coastal Marine Area should not cause any significant adverse effects on the existing habitats or feeding grounds of indigenous fauna or cause any significant adverse effects on aquatic ecosystems or have acute or chronic toxic effects on fish. All these prohibitions are breached. It is ironic that as is acknowledged in the Assessment of Environmental Effects, the discharge of wastewater does have significant effects.

Applicable Rules

88. It is common ground that the activity is a predominant use under the TRCP (Transitional Regional Coastal Plan) but that the volume of the discharge exceeds the consented amount so is non-complying under that Plan (evidence of Ms J. Keller for CCC, 22).

89. Rule 7.2, which provides for a discharge into water in the Coastal Marine Area to be a Discretionary Activity when it meets the standards and terms, is not applicable because Rule 7.3 applies. In this case, the sewage has not passed through soil or a wetland outside the Coastal Marine Area. There are and will be scums, foams and floating or suspended materials, contrary to Rule 7.3(b)(i).

90. The applicable Rule is then either Rule 7.6, if the CR water quality standards set out in Schedule 4 cannot be observed, and where the sewage has not passed through soil or a wetland outside the CMA, or Rule 7.4, if the CR standard can be met. In either case, it is a Restricted Coastal Activity, which is deemed likely to have a significant or irreversible adverse effect on the CMA. If Rule 7.4 applies, because there are (and will be) scums, foams, floating and suspended matter, the Applicant has to satisfy the Commissioners that exceptional circumstances justify granting the consent under Rule 7.4(a)(1). As stated earlier, there are no exceptional circumstances in the present case.

91. Thus whether Rule 7.6 or 7.4 apply, and whether the activity is non-complying or discretionary, turns on whether the CR standard is met.

92. The Third Schedule of the RMA specifies minimum standards for water quality classes.[5] Class CR water includes three criteria:

> 1. The visual clarity of the water shall not be so low as to be unsuitable for bathing
>
> 2. The water shall not be rendered unsuitable for bathing by the presence of contaminants
>
> 3. There shall be no undesirable biological growths as a result of any discharge of a contaminant to the water

93. Criterion 3 of the Third Schedule would be breached by the growth of sea lettuce, which undoubtedly would be an "undesirable biological growth".

94. Schedule 4 of the Proposed Plan[6] sets out standards for AE and CR classified water. According to s 69(1) of the Act, the Regional Council may only include rules about waters classified in the Third Schedule when in its opinion "those standards are not adequate or appropriate in respect of those waters". In that case the rules may state standards that are more stringent or specific. Rules 7.2 and 7.3 require that "the relevant water quality standards contained in the water quality classes set out in Schedule 4 shall be observed." There is thus some uncertainty as to whether sea

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[5] See RMA s 69

[6] As notified in the May 2001 Variation

lettuce is prohibited under 'CR', as it should be, since it clearly would have been under the Third Schedule.

95. Even if sea lettuce was not considered to fall under the CR standard, it appears that copper, and lead levels will be exceeded even under 9 times dilution (6-21 of AEE). The applicant claims "a dilution of 2-10 times over a large portion of the estuary" (Ms. J. Keller for CCC, submission no. 16). Mr C. Tipler for CCC (submission no. 24) acknowledges that "there is a limited scope for substantial dilution within the receiving waters or for separation from users of the estuary. Mr Tipler stated that dilutions may be as low as 5 times (Tipler, evidence ,CCC, 58). He concluded that "assuming that at the end of the mixing zone a 10 times dilution is achieved, all relevant water quality criteria within the estuary will be met" (evidence C. Tipler CCC, 58). But Mr Tipler's request that the whole estuary should be regarded as the mixing zone, reveals that in fact CR water quality criteria will not be met in the estuary.

96. At the outfall, BOD_5, chromium, copper, lead, nickel and zinc are all exceeded (6-20 of AEE). Faecal coliforms cannot meet the standards without UV treatment (AEE 6-21) and will not be met for the next four years. Under the Third Schedule, the second criteria would be breached by pathogens such as *Giardia, Cryptosporidium, Campylobacter* and viruses (see evidence Ms. Gretel Silyn-Roberts, CCC 16 and C. Tipler, CCC, 72). The applicant also acknowledges the possibility of 'some minor impact on windsurfers')

97. Thus the relevant water quality standards, being CR, are not met (J Keller CCC, 20, para 95). Additionally, there will be, as there are now, scums and changes of colour, and odour from the plant (Ms Tracy Freeman, CCC, 14) and sea lettuce. Thus rule 7.6 applies and the activity is "non-complying".

98. In the highly unlikely event water quality standards can be observed, Rule 7.4 applies and even then exceptional circumstances must be found to satisfy that Rule. Otherwise, Rule 7.6 applies and the discharge is "Non-Complying", since the applicable water standards cannot be observed. In any case, s 107 applies since there are significant adverse effects on aquatic life, and the already mentioned changes of colour, scums, foams and floating and suspended matter, where, under s 107(1), Rules 7.5 or 7.6 apply.

Conclusion

99. To sum up: on the facts: there will continue to be significant adverse effects on aquatic life, there will be conspicuous colour, objectionable odour, scums, foams and floating matter from the effluent from Bromley.

100. s 107(1) prohibits granting a resource consent in these circumstances. Section 104(3) of the RMA requires this Commission to have regard to other possible methods of discharge, which include an ocean outfall, as well as the applicant's reasons for making the proposed choice. S 105(2A) requires that the adverse effects on the environment be minor or the application not be contrary to the objectives and policies of the proposed plan. Even if this Commission holds the threshold tests are passed, the proposal does not promote the sustainable management of the Estuary in any respect under s 5(2), and the required matters of national importance under s 6

cannot be provided for. It would be wholly inconsistent with the purpose of the Act to avoid all of these considerations, and all legal controls, by declaring the entire estuary a mixing zone, and thus in effect its own cesspool, as the Applicant has requested.

For all these reasons this application must fail.

CASE REFERENCES

Cases

Ace Finance Ltd v Shanaher [1995] 2 ERNZ 500, 518

Andrews v Auckland Regional Council A9/99 9, 10

Aquamarine Limited v Southland Regional Council C126/97

BP Oil New Zealand Ltd v Auckland City Council (1992) 2 NZRMA 218, 223

Chance Bay Marine Farms Ltd v Marlborough District Council Decision No. W070/99

Christchurch City Council, Canterbury Regional Council re an Application C 090/92

Golden Bay Marine Farmers W042/01 6 NZED 399

Mahuta v National Water and Soil Conservation Agency [1973] 5 NZTPA 73, 81

Marlborough DC v Southern Ocean Seafoods Ltd W006/95 [1995] NZRMA 220

Minister of Conservation v Gisborne District Council A106/91

New Zealand Rail Ltd v Marlborough District Council C049/95

New Zealand Rail v Marlborough District Council AP 169/93 (page 137 CCC bound volume)

Ngati Kahu v Northland Regional Council A95/2000

Purnell v Waikato Regional Council A085/96

Rayonier New Zealand v Gore District Council C037/96

Shirley Primary School-v Christchurch City Council C136/98

Trio Holdings v Marlborough District Council W 103 A/96 (page 49 CCC bound volume)

Water and Soil Conservation Act 1967 s 21(3A)

December 2001. Further Legal Submissions for Christchurch Estuary Association

D.E.J. Currie

Insertion after paragraph 3.7 in Main Legal Submissions

Mr Hearn QC also brought the attention of the Commissioners to the Court of Appeal cases *of Bayley and Ors v Manukau City Council CA* II 5/98 (page 66 of CCC Legal Materials) and the more recent case of *Smith Chilcott Ltd v Auckland City Council* CA 267/00 CA 12/01 (page 69 of CCC Legal Materials).

Clearly *Bayley* concerned the notification provision of s 94(2)(a). This holds that the appropriate comparison under that subsection is between that activity and what is being lawfully done on the land or could be done of as of right (page 576, see p 72 CCC materials) (the permitted baseline test) for purposes of whether an application must be notified.

3. *Smith Chilcott* concerned a proposed building where the density provisions of the Auckland District Council had been changed and so three units were permitted as of right. The developers called evidence to demonstrate that a three-unit development could have the same impact on the views of a submitter as the eight-unit proposal. The Court of Appeal answered questions in paras 24, 27 and 33 of the Judgment. (para 34/page 80 CCC Legal Materials)

- The Court held (in paragraph 24) that a consent authority in considering whether to grant the application for consent to a non-complying activity under ss 104 and 105 of the RMA is obliged to apply the permitted baseline test formulated in Bayley. But that answer is to be understood in the light of the answer to question 3 concerning s 104.

- In paragraph 27, the Court held that the Environment Court did not apply the permitted baseline test in conformity with law when it asked itself whether a permitted development was 'likely' or 'more likely' or 'more credible'.

- In paragraph 33, the Court held that Salmon J did not err in law in finding that the density rule was relevant under s 104(l)(b) in respect of effects on amenities.

4. *The Court of Appeal specifically stated at paragraph 28 (page 77 CCC materials) that:*

"Section 104 only comes into operation in respect of an application for a resource consent for a non-complying activity (the present case) only when the consent authority is satisfied that one of the thresholds in s 105(2A) has been overcome."

5. With respect to s 104, the Court stated that *"Like the consent authority the [Environment Court] is required to make a broad assessment. Looking at the matter in a practical way the density rule, whatever its practical purpose, may well have an effect on the environment beyond its immediate purpose. "*

6. It must be emphasized that the Smith Chilcott approach is claim that the stated effect is indeed an effect, and a relevant consideration. Thus the most that *Smith Chilcott* can be stated to have held is that the effects found under the permitted baseline test may be a relevant consideration under s 104 and s 105. It does not hold that for all purposes as a matter of law the applicant takes the estuary as it finds it. *Aquamarine* makes that clear. To quote Judge Skelton again, "as a matter of law a proposed activity cannot be justified on the basis that it will only further compromise the natural character of a coastal environment that has already been compromised. The ultimate test is whether consenting to such an activity will promote the sustainable management of natural and physical resources."

7. Smith Chilcott has no impact on the assessment of sustainable management of natural and physical resources under s 5, or on the obligations under s 6 and 7, for instance. Still less does *Smith Chilcott* have any impact on s 107.

8. Finally, there is no 'permitted baseline' relevant to s 104 and 105 under the proposed Plan. It cannot be the discharges permitted in Rule 7.2, 7.3 or 7.4, which are discretionary - not permitted - activities, and Rule 7.1 (a) does not apply since it is 'sewage' under Rules 7.3 and 7.4. The explanation on page 7-27 of the May 2001 variation makes this clear. Holders of existing coastal permits must apply under Rule 7.3.

C.L. Batcheler's Case for the Estuary.

INTRODUCTION

1. In this paper I state for the Commissioners:

The policy of the Christchurch Estuary Association regarding protection of the estuary;

Some general matters about public opinion polls;

Notes on the effects of discharges on human health and aquatic life in the estuary - particularly of fin-fish;

The sea lettuce problem and briefly;

My experiences in the Working Party.

2. I emphasise that while there is considerable scientific uncertainty about the precise effects of the discharge, there is wide general understanding of the effects of pathogens on human health, the effects of ammonia and other forms of nitrogen on sea lettuce and the adverse effects of ammonia on fish. I submit that ignorance of the more subtle effects of decreased salinity on marine life and of the accumulative effects of heavy metals cannot justify taking no action to mitigate adverse effects on which we are well informed. We also know that the Bromley discharge is the major source of pollutants in the Estuary.

3. So, to begin at the end, ridding the Estuary of CWTP discharges is a good place to start. This being so, the only responsible, moral, and, I believe, lawful action is to remove Bromley effluent from the estuary, by a pipeline to the ocean, or (I would, in the long term prefer) to land, for irrigation. Then we could move on to addressing the remaining pollution from the rivers.

QUALIFICATIONS AND EXPERIENCE

4. I hold the degrees of BSc NZ from Victoria University College, Wellington, and MA Hons. Forestry from the University of Oxford, UK. My specialist research was in

mountain lands ecology. It mainly involved deer, chamois, grasshoppers, possums, their ecology and control, deterioration of vegetation cover, structure of forests and alpine grasslands; the development of control techniques; statistical assessment of control effects and; the uses and assay of 1080 and other poisons.

5. I published 38 refereed papers; 8 Formal Branch Reports; 5 Major Project file reports; and 5 popular journal articles between 1960 and 1989 and toured research establishments in France, Switzerland, Germany, Australia, USA, and Canada. I retired in 1989.

6. I was a member of the NZ Institute of Foresters. I am a member of NZ Royal Society Canterbury Branch, and the New Zealand Ecological Society. I was on NZES Council for eight years and was President for two years.

7. I have lived in Christchurch for 33 years; 8 of them at Southshore, flanking the Avon Heathcote Estuary. I am a member of the Southshore Ratepayers Association and was formerly its Chairman. I am their delegate to the Christchurch Estuary Association and have served as CEA's Chairman for three years. I represented the Estuary Association on the CCC Bromley Wastewater Working Party.

8. The Christchurch Estuary Association was formed in 1971, particularly in frustration at the ongoing plague of sea lettuce. The Association is a federation[1] whose membership is listed in a footnote. Through these Member Bodies we speak in a constitutional majority manner for some 50,000 Christchurch residents.

9. My evidence today flows from the Association's Constitutional Object: "To promote protection and enhancement of the Estuary and the landscapes, rivers and ecosystems within its catchment so that people and biota can enjoy its full benefits in perpetuity".

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[1] Members are: Canterbury Yachting Assoc., Mt Pleasant Yacht Club, Pleasant Point Yacht Club, Chch Yacht Club, Canty Rowing Assn., N.Brighton Power Boat Club, N.Canty Fish & Game Council, R. Forest & Bird Prot. Soc., Friends of the Avon-Heathcote Estuary, Clifton Neighbourhood Group, Redcliffs Residents Assn., Mt Pleasant Community C. & Residents Assn., S.N.Brighton Residents Assn., Sumner Residents Assn., Southshore Ratepayers Assn., Bexley Wetland Trust, DOC, Ecan, Burwood/Pegasus and Hagley/Ferrymead Comm. Boards.

ON PETITIONS, POLLS AND POLITICS

10. After publication in March 2001 of the City Council's preferred option to discharge effluent to the Avon Heathcote Estuary, the Southshore Residents Association petitioned people in the Estuary suburbs. The petition was conducted by a local mailbox drop, distribution of petition forms through four local retail businesses and by limited distribution in the Mt Pleasant and Sumner areas. In just three weeks, 910 people pleaded that "accumulations of sea lettuce continue to be removed as appropriate, and within five years, the nutrient causes of the sea lettuce nuisance be discharged directly into the ocean by pipeline, rather than through the estuary." Coincidentally, the petition was conducted when rotting sea lettuce stank from one end of the Estuary to the other.

11. 80% of petitioners lived in the Estuary suburbs of Southshore, Sth Brighton, Mt Pleasant, Ferrymead, Redcliffs, Clifton Hill and Sumner. Most of the remaining 20% were petitioned while visiting the cafes and bars at Ferrymead.

12. In its own poll, the City Council claimed from a random household poll of 500 people in September 2000 that it enjoys 70% support for estuary discharge (AEE 4.5.3). Ward-by-Ward analysis of the City Council poll and a study of the supporting maps (Opinions Research Ltd., pers. comm.) showed that 84% of their respondents live more than about 3 km from the Estuary. So regardless of any technical comment about the objectivity of the poll it is clear that the City Council mostly sought the opinions of people who reside some distance from the Estuary. Those relatively distant people, as a community, have little interest in the estuary or reason to be concerned about Estuary management, except so far as decisions might affect the costs involved in disposing of their effluent somewhere remote from their own place.

13. As you have also read in an ECan Officers Report, the "public consultation poll"[2] was far short of being objectively conducted. Supplemented by two documents[3] the whole

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[2]Mr Lamb. Critique of Tech. Report 30. Ecan, August 2001

[3] Don't Duck the Issue, CCC 2000, not numbered, and Wastewater Management Consultation Report 2000

exercise carried the appearance of bias towards seeking endorsement of the outcomes desired by a subcommittee of City Councillors, and endorsement of the cheapest possible discharge option. In our opinion that poll was of extremely limited value.

POLLUTION AND HUMAN HEALTH.

14. As a now-retired yachtsman of Mt Pleasant Yacht Club, I have been aware for years of the number of festering sores around the head, hands and legs - specially where yachties using the Estuary receive cuts from stainless steel fittings. This statement is supported by Mr Murray Snowden, a former Commodore of MPYC, who wrote to inform me that he saw many festering sores on the limbs and hands of his sailing pupils. We are aware of similar Statements about Estuary ailments made by General Practitioners and Long-Board sailors.

15. As to causes, we are aware of the reports on bacterial contamination issued by the City Council laboratories at Bromley Wastewater Treatment Plant (eg. Gilson 1996), and the data collected and tabulated by Environment Canterbury for the bathing beaches.

16. In addressing this material I have preferred to use simple Gaussian statistics, because I am mainly concerned here with determining how many bugs are there per unit volume of water, and how much variation occurs from place to place.

17. As against the above objective, the focus in public health research is quite properly on the chance that swimmers or other contact users will become infected with a pathogen. For such studies, the median is the preferred medical statistic. But the median of a bug easily change 100-fold without change of the population, or conversely the media may not change at all despite great change of the population. So in terms of tracing changes of populations, medians are a very crude tool. Medians are always far lower than averages in patchy population (those which tend to be in clumps). For example, Bromley laboratory 1994-95 survey data for the Estuary gave a median of 74 faecal colifoms/100 ml. The corresponding arithmetic average was 340. To lay people, "it sounds safer to swim in the median", or as a cynical commentator put it: "No one ever died of a median".

My analysis is based on sampling data from CCC and Ecan work and a joint monitoring enterprise of Environment Canterbury, with observers nominated by Christchurch Estuary Association.

18. They revealed important differences between the local ocean beaches and the Estuary.

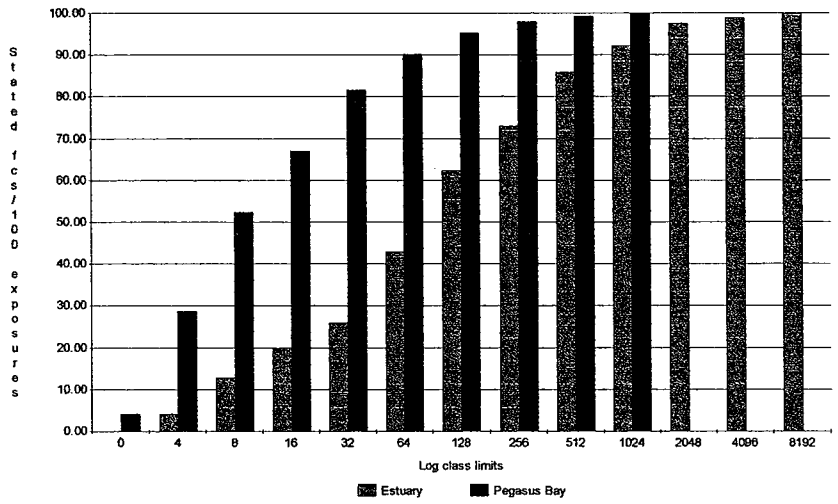

Figure 1. Accumulated chances (%) of exposure to stated concentrations of faecal coliform bacteria in the Estuary (CCC data) and local ocean beaches (Ecan data).

19. Accumulating from the left side of the figure, one can readily see that on 50% of visits, a swimmer at an ocean beach will be in water that contains less than 8 fcs per 100 mls. He/she will be immersed in less than 64 fcs on 90% occasions. Swimming in the Estuary, the corresponding figures are immersion in nearly 100 fcs on 50% of swims. Put another way, an Estuary swimmer is at about 12 times the risk of infection as one at an ocean beach.

20. From November 2000 to the end of February 2001, Estuary Association volunteers in association with Environment Canterbury sampled 11 swimming and yachting sites from South Brighton, round the tip of the Spit into the Estuary, round the shores of the Estuary, and along the beaches to Scarborough. Samples were collected 2 hr after high tide at Lyttelton or, relecting the lapse of time that occurs as the tide fills the Estuary, 1 1/4 hr

after high tide in the upper Estuary. Samples were analysed at Ecan's Bacteriology Laboratory. Results for *Enterococcus* are shown in Table 1.

Table 1. Enterococcus *contamination for Recreation Water Quality sampling at 11 sites from November 2000 to Febnruary 2001. Stations are: 1 - South Brighton SLSC; 2 - Caspian St. beach; 3 - Tip of Spit; 4 - Estuary at Penguin St.; 5 - Pleasant Point YC (Yacht Club); 6 - Humphreys Drive Windsurf Park; 7 - Mt Pleasant YC; 8 - Beachville Rd.; 9 - Chch YC (Moncks Bay); 10 - Sumner SLC; 11 - Scarborough Boat ramp. Samples for 12 January were "repeats" where 10 January samples exceeded 277* Enterococcus*/100 ml.*

							Site						Av
	1	2	3	4	5	6	7	8	9	10	11	Enterococc
Date	SBSLC	CASP	SPTIP	PENGU	PPYC	HDRIV	MPYC	BCHVR	MONC	SUMN	SCAR	
15/11/00	160	120	150	>200	54	150	11	74	48	130	32	**102.6**
22/11/00	13	<2	40	48	22	<2	nr	<10	2	2	52	**17.5**
29/11/00	6	32	6	15	60	90	28	2	20	28	230	**47.0**
12/06/00	3	3	8	16	2	10	<2	<2	<2	2	<10	**5.5**
13/12/00	12	<2	64	110	20	52	<2	<2	18	<2	<2	**26.0**
20/12/00	<2	<2	3	28	4	74	<2	<2	50	8	5	**16.4**
27/12/00	<10	<10	<10	10	<10	20	10	<10	10	<10	10	**10.9**
01/03/01	<10	<10	<10	<10	10	10	10	<10	<10	<10	20	**10.9**
01/10/01	16	34	38	>400	190	>400	>400	>400	76	26	130	**191.8**
17/1/01	2	12	2	210	2	46	12	8	13	<2	2	**28.3**
24/1/01	12	17	8	<400	24	10	30	<2	10	4	<2	**10.8**
31/1/01	<2	2	3	5	2	6	74	<2	20	2	<2	**10.9**
02/07/01	<10	<10	40	<180	<10	<10	70	<10	<10	<10	<10	**33.6**
14/2/01	<2	<2	4	38	140	93	56	<2	6	2	13	**32.5**
21/2/01	2	<2	10	12	150	100	36	2	38	4	<2	**32.5**
28/2/01	<2	<2	16	34	8	12	24	<2	<2	<2	6	**10.0**
Av. Enterococc.	**16.5**	**16.4**	**25.8**	**87.7**	**44.3**	**67.8**	**47.9**	**33.8**	**20.9**	**15.3**	**33.0**	
12/1/2001resample	*	*	*	*300*	*	*720*	*5*	*25*	*	*	*	

Estimates for the Estuary AND the open South Brighton- and Sumner-Scarborough beaches were high on 15 November and 10 January. Those were both rainy days. On 10 January 2001, estimates were high at most of the Estuary and Sumner-Scarborough stations. That day however, they were low at South Brighton

22. Only five of the 176 samples exceeded the single point Crown Public Health trigger value of 277 *Enterococcus*/100 ml. Their occurrence on the two rainy days invites the conclusion (which we often hear) that most of these organisms came from duck and dog

droppings via storm water in the rivers. But this cannot be true, because at the "gateway sites" of Pleasant Point Yacht Club and Mt Pleasant Yacht Club three of four relevant rainy day samples were much lower than were those at Penguin Street and Humphreys Drive. Effluent from the Waste Treatment Plant is the only possible source.

23. This conclusion is consistent with the relative volumes and bacterial concentrations from Bromley and the rivers. I analysed ECan Website 2000-2001 bathing area data for the Avon River site in the City centre. The average was 480 fcs/ 100mls. Assuming bacterial concentration in the Heathcote is about the same, and that mean low flow of both rivers combined is about 3 cumecs, the total from the rivers is about 1.24×10^{12} fcs per day. Similarly, effluent from Bromley averages around 10,000 fcs/100 mls (Gilson 1996). At 150,000 m3/day, this source produces 15×10^{12} fcs per day. The river contribution is thereby only 6% of the total. Blaming the rivers for pollution of the Estuary - as I often hear from local politicians -evades the truth about Bromley's contribution.

High tide and Low tide

24. Our recreational beach water observers suspected that samples taken at or near high tide, before most effluent is discharged (during the ebb tide), might give a conservative estimate of true pollution levels in the Estuary. Therefore, as a pilot trial, we collected samples at 2hr 5min intervals throughout 10 April 2001, when Lyttelton high tides occurred at 06.07am and 1836pm, and low tide was at 12.23pm.

25. Throughout that day, the beach current at Caspian Street (station 2) was from north to south. Therefore on that day Caspian Street samples served as an "ocean water benchmark" for events in the Estuary, but recognising that the whole of Pegasus Bay is polluted to some degree.

26. The results for FCs, *E. coli* and *Enterococcus* combined are shown in Fig.2. With Caspian Street samples as the base for comparison, the histogram shows the average indicator bacteria at Estuary-Scarborough stations from 2h after high tide (left), to low tide at 12.30

(middle) and back to high tide at 1830 (right). The dawn high tide (0607hr) sample was missed because it was too dark. At high tide, the Estuary water contains about 6 times the concentration of bacteria as at Caspian Street; about 20 times higher at low tide, and about 28 times higher on the incoming tide.

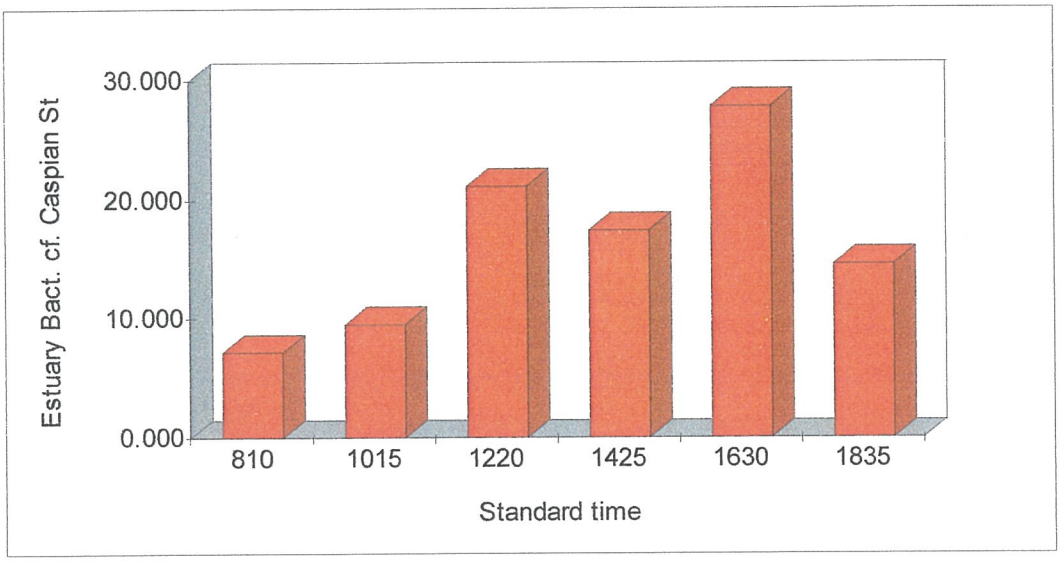

Fig. 2. The ratio of all faecal bacteria in the Estuary compared with Caspian St. beach at different states of the tide.

27. Samples at Caspian Street beach were consistently low throughout the day. But in the Estuary, the total bacterial burden increased by 580% from the first morning sample (falling tide) to 4pm, as the tide was rising, then reverted to lower values as high tide approached.

28. The observed peak on the incoming tide at 1600 hrs was not expected. The data showed that the 4pm peak was due to a record of 2000 *Enterococcus*/100 ml at Pleasant Point Yacht Club at 1600 hr. This could have been due to contamination of the sample by grit (which according to the analyst, Ms K. McGeorge, renders *Enterococcus* estimation unreliable. However, after this Hearing, in December 2001, we again obtained over 1000 *Enterococcus*/100 ml in a sample – the figure of 2000 is therefore probably reliable although I do not understand why this might be). Even ignoring the 1600hr samples, the

pattern of increasing bacteria concentrations from high to low tide, and decline on the incoming tide, is clear. Scaling the low tide data x5.8 times raises the frequency of occasions that high tide samples would exceed the single point trigger value (277/100 ml), from 2.4% to 20% (176 observations). That is, across the tide, a swimmer has about one chance in five of being in exceedingly, perhaps dangerously, dirty water in the Estuary.

29. This is based on only one summer of sampling, so is statistically a frail claim. But it is consistent with the smells, grey appearance and scums that often occur in the Estuary, especially towards low tide. This is particularly true of Moncks Bay (which alone among Estuary Yacht clubs runs a low tide sailing programme).

30. We therefore suggest that sampling at high tide, as has been standard practice in the Estuary for many years, has failed to reveal a foul situation which the people of Christchurch have tolerated in ignorance for many years.

The Proposed U/V Plant

31. We are aware that CCC has assured the Commission (Evidence Mr Tipler and AEE 7.5.9) that a UV plant would be built on the levee between ponds 5 and 6. CCC states that the UV-treated effluent will be of Contact Recreation standard at the pipe. We will have nothing more to worry about, we are told.

32. There are many problems with this. We accept that natural or artificial UV radiation kills bacteria in translucent water. But how efficient would it be in cloudy weather, or through water made turbid by immense populations of unicellular green algae that grow in the oxidation ponds? We have not seen any analyses of these factors. Nor have we seen any data about the costs of electricity to operate a UV plant, to assess that option against the costs for example of building a pipeline (we note from evidence given by Sth Brighton Residents Association that the power supply will run at 11,000 KV. This implies that the amount – and cost - of electricity consumed will be very large).

33. We are aware however that the required UV dosage (and cost) to kill *Giardia, Cryptosporidium,* other protozoans, bacteria, cestodes, nematodes and viruses, which are the **real** hazards to health, may be orders of magnitude greater than is required to kill faecal coliforms. Experiments are currently being conducted with a pilot ***Trojan 3000+*** UV pilot plant. Council claims through its witness Mr Tipler that this will solve the problems of efficiency loss in turbid water. But CCC has not produced any relevant information to substantiate these claims. Furthermore, current trials are limited to dosing a few buckets of water, but the reality is CCC is planning to discharge at up to 9 cumecs - around 900 buckets a second! At that rate the Trojan 3000+ system could turn out to be a Trojan Horse, accepted in good faith by a naïve city, as did ancient Troy receive the legendary horse. Without evidence, who can say? We have real concerns. Ultimately, the City Council must convince the people that UV and all its accessories will combine into a more economical and environmentally responsible effluent discharge option over the long-term. It has not done this.

34. Our doubts are consistent with the AEE Section 7.3 assessment: "In general, the proposed upgrade of the CWTP, Oxidation Ponds and discharge is unlikely to cause major changes to the existing environment of the Avon-Heathcote Estuary". That statement tacity concedes that no improvement is expected. However the resource consent requested is to increase the volume of the discharges, and we have been told of the plant upgrade. We expect further deterioration because we foresee adverse long term effects from enlarging the nutrient contribution to the Estuary.

35. Apart from that we believe that to predict "no material improvement" would be consistent with the fact that no upgrade of Bromley is planned beyond expanding plant capacity to provide for 25 years of city growth. The proposed largely cosmetic changes under the "Green Edge" title are utterly irrelevant and misleading. They have nothing to do with the purposes for which discharge resource consents are being sought.

36. No substantial improvement to the Estuary environment can be foreseen from the trivial wetland experiments which are foreshadowed in the AEE, for the simple reason that low-

technology nitrification would require at least 1400 ha of wetland[4]. Only about 500 ha - at a grossly intrusive stretch of the imagination - are available. (Note in passing that the entire Estuary is just over 600 Ha) Under this head, it would be grossly irresponsible for any New Zealand administration to contemplate the use of *Phragmites australis* for wetland nitrification purposes. It is already an intractable weed. As an alternative a proposed Biological Nutrient Removal Plant (BNR) studied by the Working Party was estimated to costs $100 million. Even so, that would still leave unresolved the removal of phosphorus. Prof. O'Connor considers both these nutrient elements in detail.

37. Accordingly, we consider these proposals so unrealistic and ill considered that we incline to believe that the City Council has opted to escape close scrutiny of its UV proposals by this Commission. What else are we to think when important pathogens such as G*iardia, Cryptosporidium* and, most importantly, viruses are all but ignored? Claims such as a '25 to 50 times improvement in the quality of the treated water' (Christchurch Press, 24.07.01) are mere puffery, not fact. Notwithstanding anything else, the claims refer only to faecal coliform bacteria, and are thus misleading.

THE NITROGEN PROBLEM

38. Protein-rich biological materials, urine etc. lose oxygen through anaerobic processes in sewage digesters to synthesise simpler nitrogen compounds, principally ammonia or ammonium salts. Here, regardless of its form, I refer to it simply as "ammonia". Professor O'Connor explains the chemistry involved in denitrification in his evidence. I want to address here sampling and effects on fish.

39. Gilson (1995) gives the concentrations in Bromley oxidation ponds 5 and 6 as about 21 - 23 ppm total N. Sampling on 10 April 2001 found an average of 28ppm of ammonia.

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[4] Humphrey Archer 1999. Christchurch wastewater treatment plant upgrading. NZWWA Conference paper. 212-220

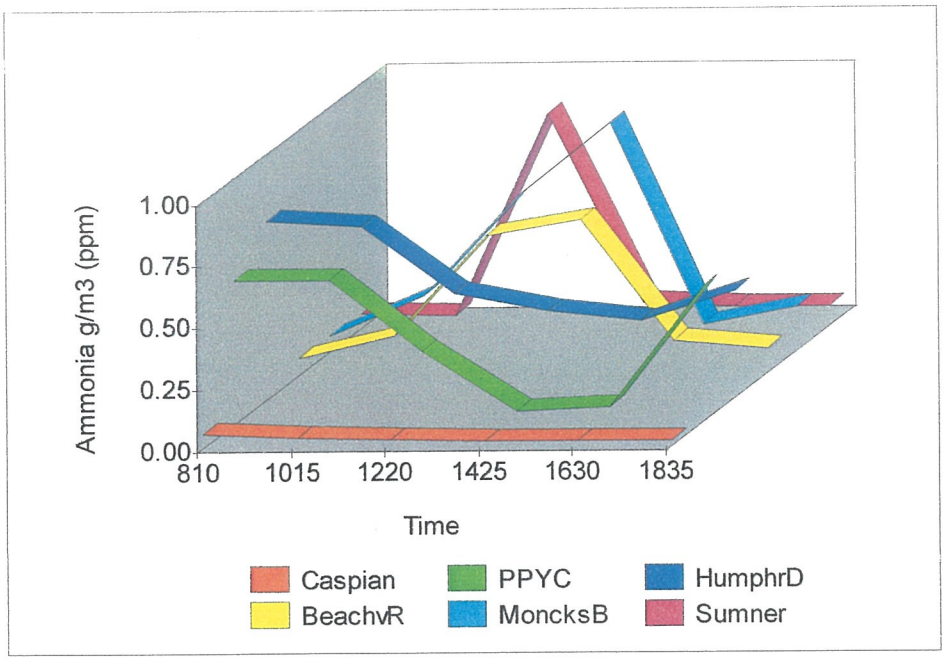

Fig. 3. Ammonia concentrations at Caspian Street ocean beach (red), 4 Estuary stations and Sumner (purple) on 10 April 2001 between 0810 hrs and 1835 hrs. For interpretation see text.

40. Elementary calculations show that the average daily discharge from Bromley of 150,000 m^3 day^{-1} of effluent would, if mixed into the 22,000,000 m^3 of total daily tidal water (2 tides) in the Estuary, give an average concentration of just over 0.2ppm of ammonia. Of the effluent pulse discharged on a tide, 1/3 remains in the Estuary and 2/3 exits from the channel. Of the 2/3rds discharged, 1/2 returns on the next tide[5]. Thus the concentration we found – of around 0.6 ppm. (Fig. 3) – would appear to be the result of repeated "topping up" by the effluent returning on the incoming tide, to the equivalent of the accumulated discharge for three tides.

41. On 10 April 2001 ammonia concentration was less than 0.04 ppm at Caspian Street at all states of the tide (Fig. 3). At Pleasant Point Yacht Club and Humphreys Drive, both "up-estuary" from the path of the effluent plume, ammonia concentration dropped from about

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[5] Anon. 1994. Avon-Heathcote Estuary dye study. Lincoln Environmental Report 60 pp.

0.6ppm to about 0.2 ppm at low tide (as the proportion of river water increased). Conversely, at the stations in the path of the plume, ammonia increased in a wave to 0.9 - 1.0 ppm as the tide ebbed past Beachville Rd, Moncks Bay and Sumner. The effect of the raised ammonia on sea life is of great concern to us.

DECLINE OF FISH POPULATIONS

42. The median toxic dose (LC_{50}, the concentration that will kill one-half of an immersed sample) of ammonia to fish is variously quoted at up to about 3 ppm. It varies according to salinity, pH and temperature, and is particularly toxic when pH is above about pH 8[6]. After the Hearings, we began to measure ammonia concentration in the Avon-Heathcote Estuary programme. During November 2001 – January 2002 pH averaged over 8. A British Columbian Guideline paper quotes less than 1ppm for marine life and maximum of 2.5ppm[7] at pH up to about 7.5, and less than 0.2 ppm at pH over 8.5. Studies of freshwater fish give the LC_{50} for rainbow trout at 0.53ppm[8] and 1.6ppm for Cockabully.[9]

43. The LC50 for shrimp (formerly in the Estuary in huge numbers, see below and Mr PA Neal's Evidence) is a very low 0.18 - >0.8ppm.[10] Another author, basing recommendations on US EPA and refereed journals suggests that to provide a margin of safety, short-term concentrations of ammonia should not exceed 0.1ppm and a 4-day average should not exceed 0.02ppm.[11]

44. These studies clearly show that the water in the Estuary is toxic or potentially toxic to fish and other marine animals such as shrimp.

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[6] Data collected in the CEA-Ecan programme in 2001-2002 has given an average pH about 8.2, and maximum 8.7. (CLB. see Supplementary submission for April 2002)

[7] Haywood 1983. Can Tech. Rep Fish. & Aq. Sci. 1177

[8] Arthur et al 1987. Bull Env. Cont. Tox. 38:324-33

[9] *G. maculatus*. Richardson 1991: NZJ Mar Freshw. Res.

[10] Hickey & Vickers 1993. Arch. Env. Cont. Toxic. 26: 292-298

[11] Neil Frank, "Ammonia Toxicity to Freshwater Fish: the effects of pH and temperature", at http://www.thekrib.com /Chemistry /ammonia-toxicity- html

45. It should therefore be no surprise to occasionally find dead fish on the shores of the Estuary. My wife and I have found two barracuda, a kahawai (photographs on record), six spiny dogfish (one photographed) and 15 anchovies on the tip of the Spit since 1993. Most of these could conceivably be by-catch dumped from fishing boats. But one example, that of the 15 anchovy, which I found one day in 1997 in a rough circle about 30cm diameter in a little sand depression at the tip of the spit, cannot be explained any way other than as the victims of a sudden event to the shoal. Ammonia from Bromley or perhaps from an illegal industrial discharge are the only tenable explanations which occur to me.

46. Here I shall poach for a moment on the evidence of Mr PA Neal and Gordon Ogilvie's "The Port Hills of Christchurch" (1978). Ogilvie wrote that before 1932, the lower estuary "was a wide beach leading to shrimp-grass-covered mudflats where eels and flounders could be speared and shrimps netted in large quantities".... The shrimps were a culinary delicacy that was "sent all over New Zealand". I thought until recently that this seafood basket had long since disappeared along with its *Zostera* (shrimp grass) habitat. But just a month ago I learned, as you have heard, that Mr Neal and his companions netted large numbers of shrimp at the end of spit, on the bare sand banks, from a bit after 1970 until the mid-1970s. They were "there one year, and gone the next", and then Mr Neal and his companions never caught another one, despite many attempts.

47. The timing may well be significant, since as noted in Mr Burke's evidence (para 9), the Bromley discharge was changed from a continuous dribble to a 3-hr slug on the ebb tide in 1972. This may well be the reason the shrimp disappeared soon after 1973. What was done in the name of sea lettuce control appears to have killed off the crustaceans! They were unfortunate to live in the path of the ammonia-rich effluent.

48. Mr James' Evidence for CCC amply confirms that fish populations have declined in the Estuary during recent years. Although based on only on a literature search, he concluded that since 1970, fish have declined because of pollution and overfishing. Earlier this year Mr Alec. Saunders of Christchurch Estuary Association found in an informal survey that

"former fishers say that while once it was easy to catch fish, now it is hardly worth their trouble". Mr Snowden of Christchurch Estuary Association, who has spent all his life but two years living, fishing and sailing around the Estuary also believes the fish have virtually disappeared in recent years.

49. There is no doubt. The fish have gone. Why?

50. I recall a newspaper report that the Russian Fishing Fleet took 6,800 tonnes of red cod from the Pegasus Trench about 1972. I caught very few red cod at Godley Head in the following few years. So overfishing could explain some of it. But Yellow-eyed mullet are not commercially harvested. For them the commercial overfishing argument does not hold good.

51. Nor does it hold for the shrimp.

52. Mr Neal's evidence that takeable flounder have disappeared from the Estuary, but that there are still considerable numbers of juveniles in the pools near the end of the spit, requires explanation. I have considered his information in the light of knowledge of the ammonia peak in the channel at low tide (Fig. 3). At low tide, the pools of which Mr Neal speaks are cut off from the channel.

53. The pattern indicates that juvenile flounders come in from the ocean on the incoming tide, as close to the shore as they can, to avoid their predators, and to avoid the ammonia. But the adult fish, moving up the deeper parts of the channel (where they were formerly fished by Mr Neal and his companions and, incidently, by me in the late 1960s-1970s) are in the ammonia stream. They either retreat to sea, or die.

54. This interpretation is consistent with the recollections of long-time residents' such as Mrs Marie East and Mr A. Beasley who tell me about the huge numbers of "tiny" flounder and other fish that used to occur right along the spit beach at Southshore. Mr Neal's evidence confines them now to the margin pools at the tip of the spit, near the open sea[12].

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[12] In February 2002 my wife and I saw huge numbers of tiny flounders in shallow water on the margin of the incoming tide on the estuary side of the tip of the spit. About the same time Mr Neal told me he saw a large

55. So I conclude that ammonia toxicity is the main cause of the disappearance of fish. To my mind, Occam's Razor, the principle that a cause that explains many phenomena should be preferred over piecemeal propositions that must be constructed to explain them. It is "the law of scientific parsimony". We may with confidence therefore ascribe the disappearance of the fin-fish and shrimps to ammonia toxicity.

56. I suggest that the populations of most fish species in the Estuary are at their last gasp. And we might wonder: Are we, through gross mismanagement of effluent, intent on losing them altogether?

SEA LETTUCE

57. Sea lettuce *(Ulva lactuca)* and Gracilaria *(Gracilaria chilenses),* and probably *Enteromorpha intestinalis* in the Estuary are "increaser species" which grow rapidly in enriched water. Since sea lettuce is by far the best known of the three, I confine my remarks to that species.

58. Up to 1950, sea lettuce was rare in the Avon Heathcote Estuary. Thompson (1929), is the first and often quoted author of a general study of Estuary biology. Stevenson[13] tells us Thompson recorded "a little *Ulva* in sheltered rock pools and on muddy sand banks". A subsequent survey (author not stated by Stevenson) in 1951 recorded that "blooms ... were apparent". These trends continued into the 1970s. Soon after Knox and Kilner reported recommendations for alleviating the sea lettuce problem, the then-Christchurch Drainage Board decided to discharge effluent on the ebb tide only[14]. Stevenson noted: "algal blooms have not been as severe in the last few years".

59. That change of management has not resolved the problem. There have been huge blooms of sea lettuce in four of the past five years. At Southshore, City Council staff remove

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number of red-billed gulls fishing for young flounder along the same margin a few days earlier. I have not seen them since that time.

[13] 1980: Water and Soil; p22-25

[14] Knox, G.A. & Kilner, A.R. 1973. *The Ecology of the Avon-Heathcote Estuary.* Estuarine Research Unit, Zoology Department, University of Canterbury, Christchurch. Report no 1. 358 pp.

decomposing masses of sea lettuce, more-or-less on request by neighbours. While this expedient has contented some residents, deposits of sea lettuce soon return, and the heavy machinery used has caused extensive damage by pressing deep ruts into the mud and crushing such animals as mud snails (*Amphibola crenata*), crabs (mainly *Helice crassa*) and also probably soft-bodied species under the surface. It does not appear to me to be a good or sustainable solution.

60. Knox[15] briefly reported for sea lettuce that increased nutrient levels resulted in faster growth, with a maximum at 0.7ppm ammonia and 0.5ppm phosphorus. "When ammonia and phosphate ... increased ... from 0.05ppm ... to 0.5ppm ... the yield of algae increased by a factor of 50".

61. Knox stated that because N and P were present in lesser amounts than associated with maximum growth, "any further increases in the levels of these nutrients (in the Estuary) ... would result in increased growth rates".

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[15] 1992, Ecology of the Estuary. Report to CCC; page 123

Petersen and Borum[16] confirm Knox' conclusion. Studying the same species in Denmark, they showed that the uptake rate per unit dry weight (i.e. growth *rate*) peaks at about the same concentration of N as stated by Knox. Growth of their plants levelled off in about

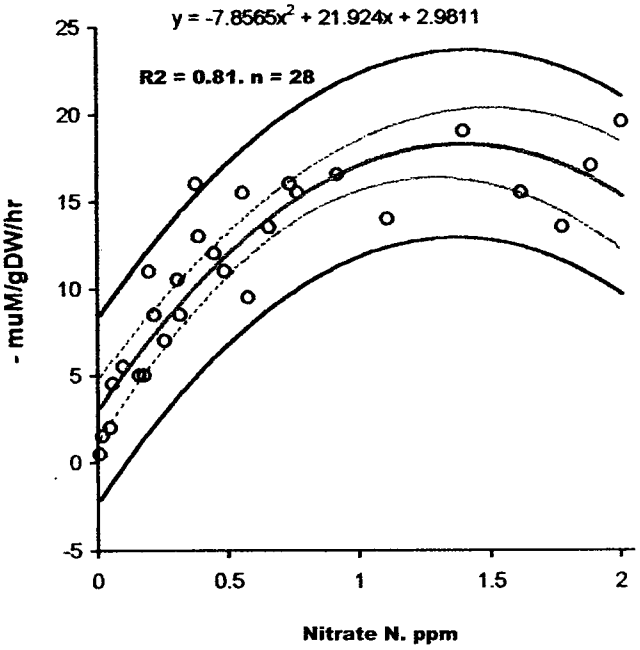

Fig. 4. Redrawn from Petersen & Borum 1997. Growth rate/g dry wt. peaks at 1- 1.2 ppm N. ***Reduction*** *of growth accelerates below about 0.5ppm AND at above about 1.5 ppm.*

1.0 - 1.2 ppm of nitrate-N (Fig. 4). This suggests that *Ulva* growth vs. nutrients is appropriately described by the second-degree polynomial curve depicted in Fig. 4[17]. This portrays rapid response of growth to changes at low nutrient levels, slowing through an asymptote, and decreasing as nutrients trend towards toxic levels – as can confidently be assumed to occur at some high concentration of ammonia. Considerable confidence can be placed in the overall quality of the correlation ($R^2 = 0.81$); it implies that 81% of the observed variation between growth of *Ulva* and N concentration is explained by the

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[16](1997, Nutrient Control of Estuarine macroalgae. Mar. Ecol. Progr. Series 161: 155-1673

[17] This statistical analysis was done after the Hearings in September 2001, by which time I had bought the necessary computer software package.

regression and that it can be confidently assumed that, if ammonia concentration were to drop towards 0.01 ppm or exceed about 1.5 ppm ammonia,, the growth of *Uva* would collapse, . The "oligotrophic" level for collapse is indicated for us by the sampling results at Caspian Street beach (<0.1 ppm).

62. This interpretation raises doubts about the explanation given by Hawes and O'Brien[18] to Estuary nutrient dynamics. They stated that they used equations derived from New Zealand populations of sea lettuce. They do not give their equations in deterministic terms of response to variation of ambient nutrient concentration. But despite this inscrutability, they predicted that sea lettuce in the Estuary would decline by only 20% following complete removal of nutrients from the treatment plant effluent. Dr Hawes revised this during the Hearings to suggest a reduction of about 50% in dense patches of sea lettuce. This extraordinary analysis and interpretation leads one to believe that sea lettuce, alone in the plant kingdom, will continue to grow vigorously without significant nutrient inputs. Speaking cynically, it would be of immense National advantage if we were able to apply such a novel hypothesis to plant and animal growth and nutrient inputs in New Zealand agriculture. Extraordinarily, some Councillors assert (Wastewater Management Consultation Report 2000), that Hawes' conclusion weakens one of the strongest arguments in favour of an ocean pipeline. Dr. Hawes and Cr. O'Rourke blindly ignored the likely geometry of the growth curve (Fig. 4) and, with a polynomial growth function, the extremes are the bits that really tell one what happens and what is the underlying nutrient response biology of *Ulva*.

63. I am aware that Wake and Chase in their preliminary assessment (Ecan Officers Report supplementary papers) are also critical of the models used by Hawes and O'Brien, from which the Council reached its preferred (estuary discharge) conclusion.

64. Besides the scientific evidence of which the above has merely skimmed the surface, many observations confirm the relationship between high nutrients and accelerated growth of sea lettuce. Hawes and O'Brien's themselves report: "Prolific growths of ... *Ulva* ... are a

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[18] 2000. NIWA contract report to CCC. "Contribution to the assessment of ... Bromley ....

regular feature of nutrient enriched embayments world wide".[19] My wife and I found no sea lettuce in Saltwater Lagoon, some 30km north of Christchurch. We found a little bit in the Pauatahanui Inlet north of Wellington. We found none along the foreshores at Kawhia, Aotea and Raglan Harbours of west Waikato. It was extremely rare or absent at Whangamata, Tairua or Whitianga on Coromandel Peninsula (or at Abel Tasman Park's Awaroa Inlet which we visited in March 2002). But in Tauranga Harbour, which is a comparatively large Estuary surrounded by a population of about 95,000 people, we found in March 2001 thick piles of sea lettuce on the beach at Mt Maunganui. (I was assured on enquiry by Tauranga City staff that Tauranga effluent is piped to sea from Te Maunga Treatment Plant. Nevertheless, I was informed recently by a local resident that a huge amount of sea lettuce occurred in Tauranga Harbour's Rangataua Bay during summer 2001-2002).

Concluding Remarks

65. The common sense conclusion is clear. Sea lettuce is rare or absent in estuaries which do not receive significant quantities of metropolitan effluent. It is abundant in those that do. Therefore to remove the sea lettuce, remove the nutrient. We believe the science summarised here supports this conclusion.

66. We appeal for this outcome for the welfare of the people and ecosystems of the Avon-Heathcote Estuary. And that is why my Association unequivocally requests that Consent Application CRC012011 and those associated with the diffuser (012014 and 012015) proposed by the City Council be declined.

67. Dr Currie and Dr. Wood deal with Legal aspects and the Mixing Zone respectively. I have not mentioned the impact of effluent on birds because the ornithologists assure us they are not threatened by enrichment. They have the good fortune to breathe in air, not estuary water.

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[19] Morand and Briand 1996: *Botanica Marina* 39: 155-166

68. Nor have I because of time constraints mentioned odour from the Treatment Plant, ponds (application 012016) or rotting sea lettuce. I have to bypass this topic even though upon visiting friends at Shortland Street, driving across the ponds on a still night, or coming home to Southshore, the smell is sometimes nauseating. I note that Mr Murray Sim presented information on odour.

69. I have not discussed heavy metal contamination of sea foods or *mahinga kai* values, even though I frequently see *tangata whenua* and *tangata tiriti* collecting cockles in the main Avon channel. (By the way, this is a remarkably pollution-tolerant species, but it is now generously signposted by CCC, Environment Canterbury and Crown Public Health as dangerous to eat). But I believe firmly that no *rahui* or edict of Crown Public Health will stop hungry or disadvantaged people from collecting seafood from wherever it occurs. In my view this imposes upon this Commission a moral as well as a legal duty to protect those people.

70. Nor have I discussed the sinister evidence from overseas studies about "feminisation" - the acquisition by male fish of female characters - that is attributed to the excretion of human oestrogen pill metabolites into wastewater. Does it happen in humans? Does it matter? Where does pollution end? It is too much like science fiction maybe, but maybe not. Society's experience with thalidomide, 245T and Benlate scream out that we would be stupid to adopt any but a precautionary approach.

71. I have spoken as a retired biologist, observer, yachtsman, resident of the Estuary shore and a member of the Estuary Association. I was impressed at three recent Public Forums by the priority that people resoundingly identified as what they wanted for "their" Estuary. They want clean water, because if they achieve that, everything else can follow.

72. On their behalf, I therefore plead that you will reject the Council's applications.

73. I came to the pipeline preference as a member of the Christchurch City Council Wastewater Working Party. From early 1997, the Working Party argued about discharges into the Estuary for nearly a year, but that option fell by the wayside because of perceptions of the problems you are now addressing. I then dabbled with spreadsheet

computations to find that we might enhance the production of coastal sand country on the north flank of Christchurch by around $520 million over 30 years if we were to return treated effluent to the land. But the possibility lapsed because Mr Tipler reckoned it would cost around $350 million – mainly in buying the land from farmers. I have no personal doubt that in Canterbury, with its fundamentally precarious water resources, we will come back to that in another 30 – 50 years, but for the short term it was thrown out of the Working Party options list on grounds of cost.

74. The pipeline into the ocean was then proposed and eventually adopted "provided shell-fish gathering standards" of water quality were attained on the beaches and with some stage-check conditions. It was the only option for which patient teasing out the implications failed to identify a single flaw. I am certain that it is the logical, long-term, affordable, environmentally sustainable option. This is notwithstanding the apparent inconsistency of the views given in my previous paragraph. Even when we want treated effluent for irrigation, we will need to dispose of it to the ocean during winter, when soils are saturated. So my Association and the great majority of the 50,000 people I represent oppose the 15-year Consent requests as poorly investigated, risky to community and environmental health, unbalanced, and ecologically dangerous. A good alternative is available.

75. A short transition period is obviously necessary to plan and construct a pipeline and its associated gear. A permit not exceeding five years would therefore suffice to do what good sense, the majority of the Volunteer Wastewater Working Party, its Peer Group Reviewers, and over 90 percent of the record 2,350 submitters requested.

November supplement

76. This supplement was presented in response to submissions that were made to the Commission by Prof. G.A. Knox and Dr. N. Wilson for the Applicant. These gentlemen were unavailable at the scheduled presentation of the City case in September 2001.

77. My name, qualifications and affiliations are stated in my main submission that was tabled as part of the folio of Evidence from Christchurch Estuary Association.

78. I comment on the evidence of Mr Lewthwaite, and the persisting weaknesses of the Final AEE, regarding Monitoring of effluent and contaminants in Estuary water.

79. It is clear that from an ecological perspective, the proposed criteria for Monitoring remain weak. Under Section 7.5, re Consent Conditions, a schedule of required parameters is proposed. Under "Wastewater Limits", page 7-23, it is stated that "based on weekly sampling, taken over a 26 week period, not more than 16 values exceed the following values", with ammonia nitrogen limits given as 30 ppm for the first two years, and 20 ppm thenafter.

80. But no maximum value, which must never be exceeded, is given, and the subject of penalties is not mentioned. In my main evidence I showed that at 30 ppm in the waste-water before discharge to the Estuary, about 0.2ppm would be expected in the Estuary upon instantaneous mixing of effluent with the full tidal volume of water (11 million m^3, twice daily, i.e. 22 million m^3). Measurements show that about 2/3rds of the total amount of effluent released either is retained in the Estuary, or returns to the Estuary on the next tide. This results in an average ammonia concentration of about 0.6 ppm. This exceeds the chronic exposure LD_{50} for common gilled fish and there is good evidence that, indeed, ammonia is killing the fish of the Avon Heathcote Estuary. Mr Neal in an Estuary Association submission, showed how abruptly disappearance occurred in the mid-1970s, and it is interesting to hear confirming evidence from the Salmon Anglers Association and Mr Evison's evidence from the decline of spotted shag populations in the vicinity of Whitewash Head.

81. This evidence appears to have been ignored by Mr Lewthwaite, who refers to standards proposed by USEPA, stating guideline limits of 4 ppm for 1-hour, and 0.59 for four days. (Sampling during recent weeks - since these Hearings - indicates that pH of water in the Estuary is approx. 8 - 8.5, at which ammonia is particularly toxic to gilled fish).

82. Fish in the Estuary have to endure ammonia at 0.5 to over 1 ppm indefinitely at pH typically over 8. We submit that in this real-life situation, the EPA guidelines have no value as indicators of what fish can actually tolerate. One exceedance of the toxic dose is in reality lethal. It should never be approached, and certainly never exceeded.

83. Mr Lewthwaite's supplementary evidence shows concentrations of ammonia at high tide (i.e. when the pulse of clean water enters on the flood tide) from <0.03 to 2.71 ppm. Low tide

concentrations range from 0.04 to 0.7 ppm; all sites measured showed < 4 ppm; mean concentration at all low tide sites were below 0.59 ppm; mean concentration of 0.59 ppm at Humphreys Drive; and 2.7 in the plume opposite the outfalls.

84. Mr Lewthwaite comments: "Overall the ammonia sampling has yielded encouraging results". Encouraging for what? We regard them as evidence of an ecological disaster by way of the loss of fish, and massive growths of sea lettuce and *Gracilaria*, occurring as our City Officials sit on their hands and pontificate.

85. Mr James evidence reported that in 1998, MSc student Nairn of University of Canterbury attempted to re-survey the abundance of fish in the Estuary using the same beach seine trawling methods used by PhD students Webb and Mundy in 1965-66. But Nairn abandoned the attempt because he could not pull the net through the large quantities of sea lettuce then present (see CCC Applicant evidence, Mr Gavin James).

86. Despite the difficulties, Mr Nairn concluded fish species ***diversity*** had not declined since the Webb/Mundy studies.

87. Prof. Knox commented on fish in his evidence. He noted that some 34 species have been recorded from the Estuary. He supervised Webb's and Mundy's studies in the late 1960s. He now reports that: "However, there have been no quantitative studies of fish numbers and distribution since 1965-66. It is therefore not possible to say whether fish populations have increased or decreased since then". He subsequently as a retained CCC Witness put a positive twist on the lack of quantitative evidence by noting: "As a result (of eutrophication) there have been increases in the populations of consumers such as filter and deposit feeding invertebrates, ***possibly fish*** (my italics), and birds".

88. Plainly, Witnesses for the CCC have during the course of these Hearings found it expedient to "prove" that there are still plenty of fish in the sea. The plain fact is, as shown by many recreational fishers, CEA Witness Mr Neal, and yesterday by the Salmon Anglers Association, that the fish population has collapsed.

89. Cause has always been the question. Some assert it is over-fishing in the Estuary, at sea, in both places, or because of some other cause. Mr Haughey yesterday argued that the decline applies both to the ocean and the Estuary. I accept that fish have declined in the ocean during the past 30 years. But any visit to the fishers on the pier will prove even to the most skeptical that there are still kahawai, mullet, cod, a few rig and other species there. They are gone altogether from the Estuary.

90. Also against the over-fishing hypothesis, the collapse also applies to such unloved and unfished creatures as the "puffer" (globefish) and lamprey. It applies also to sand shrimp as mentioned by Mr Neal and me in our earlier evidence.

91. Pollution of water by an agent which it toxic to fish is the only single, plausible explanation. I have heard no evidence to belie the belief that ammonia is the primary, dominant cause of the change.

92. The corollary of this conclusion is that ammonia in the water must be reduced to something in the order of 0.05 ppm (i.e. about 80% reduction from the current concentration) to ensure restoration and long-term survival of fish populations.

93. At least four ways to achieve this have been presented to this Hearing of evidence: (1) A Biological Nutrient Removal Plant at Bromley (my evidence and Mr Hansen's evidence - $100 million); (2) A wetland occupying the entire Estuary, adjacent paddocks and Heathcote Valley - an absurd proposition. (3) A pipeline direct to the ocean, and; (4) Irrigation of farmland northward from the Marshlands area.

94. We were agreeably surprised by most of the evidence of Dr Nick Wilson, for the Applicant. He endorsed our belief in the cardinal value of a reticulated sewerage and treatment system. We agree with him that a "sudden discontinuation of reticulated sewerage and treatment ... would pose a substantial "public health risk". But he was wrong to argue that "declining the application" to discharge to the Estuary "would (given the absence of viable alternative options) be reckless and pose a substantial threat to public health". Pray: Just who does Dr. Wilson think he is bluffing? **THERE IS A VIABLE ALTERNATIVE WHICH, DESPITE THE PROTESTATIONS OF THE CITY COUNCIL LEGAL ADVOCATE, IS A LEGITMATE SUBJECT FOR CONSIDERATION. THAT IS, DISCHARGE TO THE OCEAN.**

95. Finally, I comment on the comments by Mr MC Day who supported the CCC applications. Mr Day "suspected there was a strong 'not in my back yard' type campaign that was seeking to use political pressure to scuttle the applications and commit ratepayers to a more expensive solution that may not be the optimum resource management solution". We strenuously deny such an insulting claim and remind the Commission of the similarity of likely costs of Estuary vs. Ocean pipeline in the long-term. We note the unsubstantiated nature of Mr Day's assertion that an ocean pipe-line "**may** not be the optimum resource management solution. Cheap words, Mr Day. What is your evidence?

96. Several witnesses reported that the Estuary is grossly overloaded with nutrients. Many species are disappearing. It stinks. It is dangerous to swim in. It is dangerous to eat the fish or shellfish. More of Mr Day's approach would complete the Estuary's transformation from its icon-like status as a defining jewel in the crown of Christchurch, to that of a Third World sewer. This we shall continue to oppose by all possible means.

Tuesday, November 27, 2001

Final Evidence of C.L. Batcheler, April 2002.

Herewith I submit further information on the issues raised in your memorandum of 14 February 2002. It is in narrative form, following your numbering of matters as "Issues".

Issue 1

In previous evidence, Professor O'Connor and I recognised that different forms of nitrogen such as organic N, ammonium N ($NH4^+$) and ammonia (NH_3) may be transformed under microbiological attack to nitrite (NO_2) and nitrate (NO_3). Prof. O'Connor also made it clear that denitrification , a further microbiological process that generally requires anaerobic conditions, is necessary for nitrate to be transformed into nitrous oxide (laughing gas, NO_2) or di-nitrogen (N_2). Only the last of these transformations removes nitrogen from aqueous systems. It is also possible that organic and mineral forms of N might be incorporated into harvestable sludge and removed from the system (as may be achieved in the mechanical plant at CWTP). The questions have always been: (1) How much ammonia or ammonium N can be transformed to oxidized forms so that the concentration of NH_3 is no longer harmful to aquatic organisms? (2) How much nitrogen can be removed from the system altogether so that the nutrient loading of the receiving waters can be lowered? (3) How much lowering of NH_3 and how

much removal of total N can be achieved by the proposed modifications to the CWTP, and at what cost?

Your Commission has been told by Mr. Lewthwaite (Supplementary Evidence p. 14) that CWTP expects to discharge 3000 – 3500 kg total nitrogen per day from 2003 (when the current upgrade works are due to be completed), to 2008. After that, the estimated output is 5,000 kg/day. Associated with these engineering developments, ammonia discharge is expected to drop from 3,800 kg/day now, to 2,400 kg/day, then rise to 3,700 kg/day in 2009. These outputs represent a short term 36% reduction, but reduction by only 3% after 2009. At that point, PPCS Meat Works effluent is expected to be diverted from the Waimakariri River to Bromley.

Professor O'Connor will further examine these and related claims of mass loadings and the potentials for lowering the discharge of contaminants, particularly ammonia, to the Estuary.

Here, I acknowledge the broad statements regarding ammonia and in view of this assumption discuss their implications under Issue 2. I specifically respond to the information presented by the Applicant's Witness Mr. W. Lewthwaite about ammonia, the health of the Estuary ecosystem, and particularly about the survival of teleost fish in the Estuary.

Issue 2

Mr. Lewthwaite's supplementary evidence on pH and ammonia concentrations was based on "two runs of samples in October and November 2001" (Lewthwaite, supplementary evidence p4). That timing indicates that Council staff became aware of weaknesses in the evidence they presented at the September-October Hearings. Mr. Lewthwaite did not record the number of samples collected during these "runs". Without this crucial information the statistical power of the sampling and thus its validity is unknown.

He presented the following (slightly abbreviated) statements.

"At the usual nine high tide monitoring sites ammonia ranged from <0.03 to 2.71 ppm (= $g/m^{3)}$;

The usual five low tide sites … from 0.04 to 0.70 ppm;

At all sites and under all conditions below the 4 ppm (USEPA) guideline **for a 1-hour exposure**;

Mean concentrations (not maxima) at all low tide sites … below 0.59 ppm 4-day guideline;

Mean concentrations about 0.59 ppm at Humphreys Drive;

High tide figures **averaged** 2.70 ppm in the plume opposite the outfalls".

He then gave USEPA (United States Environment Protection Agency) data relevant to 30 ppt salinity water (taken from the URS AEE Table 6.4). Mr. Lewthwaite stated he was referring to the column for 20°C to represent Estuary conditions. However, as was noticed also by the Commissioners, Mr. Lewthwaite inadvertently used the Guideline column for 15^0C.

The URS and USEPA versions of the tables all show that – with variations at different pH values - saltwater fish can tolerate only 3/4 of the concentration of ammonia at 20°C as at 15°C. The error is progressively more pronounced at 25°C and 30°C and at higher pH's. Mr. Lewthwaite's summary and "hopeful" interpretation, and his misleading quotations of averages (rather than extreme values) is more complacent about the consequences of high concentrations of ammonia in the Estuary than is justified by the facts.

Data collected on water temperatures and pH during the summer of 2001 -2002 become highly significant in the context of ammonia toxicity.

pH

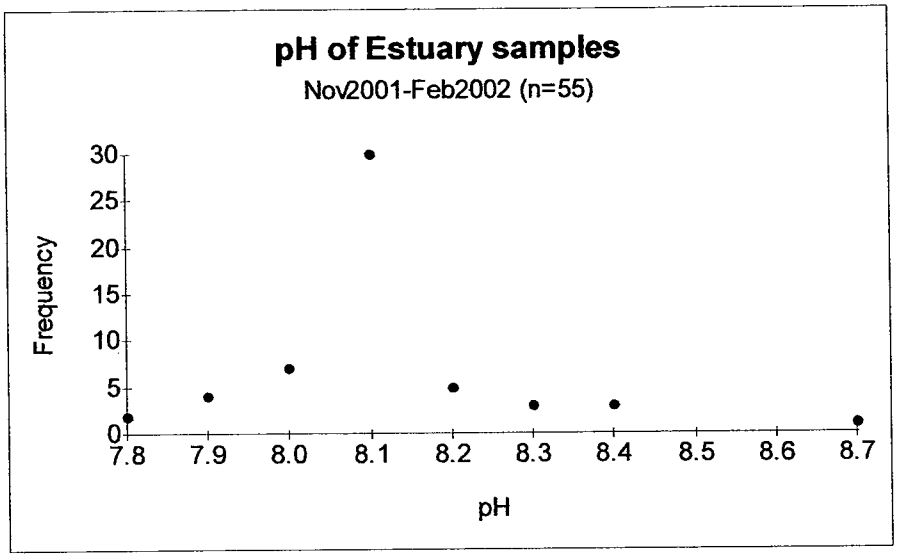

Fig. 5. pH of water sampled by volunteer observers. A strong mode at pH 8.1 is evident, and the measurements show that occasional values to at least pH 8.7 can be expected.

Fifty five Estuary samples collected at the 11 sites averaged pH 8.1, and ranged from 7.8 to 8.7 (Fig. 5). These results indicate that although Mr. Lewthwaite's use of EPA data for pH 8.4 seems "reasonable", the higher toxicity of un-ionised ammonia at higher pH's indicates it is prudent to assess the survival of fish on data for higher pH values, pH 8.5, pH 8.7 or even pH 9. This approach is consistent with Professor Clark's Evidence that assessment of the consequences of environmental extremes rather than medians is crucially important.

Temperature.

During 21 November 2000 to 28 February 2001, temperatures were measured by volunteer observers at all 11 sites at South Brighton, Sumner Beach and on the shores of the Estuary. These sites were described in my main Evidence. The results are shown here as Fig. 6.

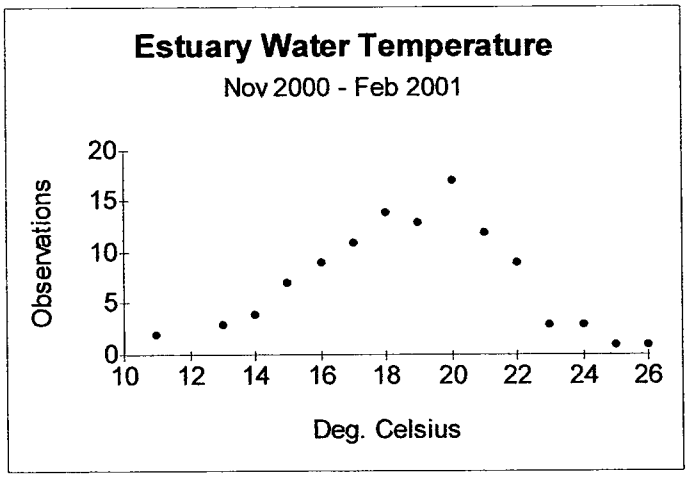

Figure 6. Estuary and adjacent beach temperatures sampled November 2000 – February 2001.

The figure shows that temperatures ranged in the 3-month summer period from 11°C to 26°C, and averaged 18.8°C. Since ammonia is more toxic to fish at higher temperatures[20], it is invalid to base assessment of impact on EPA criteria for 15°C as was done by Mr. Lewthwaite. 25°C better represents the least favourable data, but allowing for the virtually certain occurrence of occasional hot weather from time to time (and the certainty of climate change), I submit that is more prudent and realistic to base the required water standard for the Estuary at 30°C. Again, referring to Professor Clark's evidence, I acknowledge as true the rationale of using extreme values rather than medians or other statistical artifacts: They, not averages, are the ones that kill organisms.

Issues 2 & 3: Tide Cycle and Ammonia concentration

I showed in my main Evidence in September 2001 that on assumptions of instantaneous and perfect mixing of effluent in the Estuary, a single tide discharge of 75,000 m^3 adds

[20] USEPA 1989. Ambient water quality criteria for ammonia (saltwater) .... EPA 440/5-88-004. 59pp.

about 0.2 ppm ammonia to the Estuary. Also, as I reported the results of a 1994 study[21], 1/3 of the discharge remains in the Estuary. Of the 2/3rds that moves out to sea, ½ , equivalent to 1/3 of the total, returns to the Estuary on the next tide. Therefore, the actual concentration must rise to a dynamic balance between the rates of effluent recharge and "leakage" to the ocean. I assume that this balance comes to the total discharged over three tides, or 0.6 ppm, as was observed and given in my main Evidence.

The most important consequences of movements of the effluent pulse that concerns your Commission is the way they influence concentrations in the channels at various states of the tide.

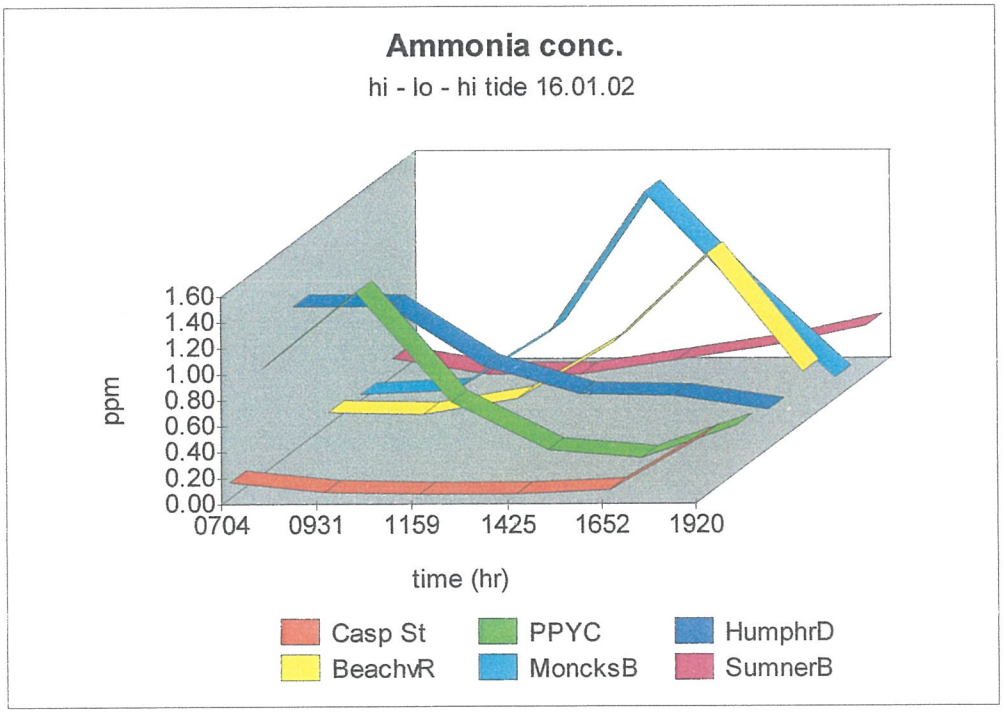

Fig. 7. Sampling for ammonia at six sites on 16 January 2002. For interpretation, see text.

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[21] Lincoln Environmental 1994. Avon-Heathcote Estuary Dye Study. Report to CCC 2481/2: 60 pp.

Our observations on this matter are summarised in Fig. 7. The pattern as we understood it in September 2001 was presented in my main Evidence. This season, samples were collected on 16 January 2002 from high tide at dawn (0704 hr) and at approx. 2-1/2 hr intervals as the tide ebbed to midday and flooded during the afternoon to the next high tide, at dusk (1920 hr). In the first five samples at Caspian Street, until 1652 hr., concentrations ranged from 0.06 to 0.13 ppm much as they did in the April 2001 samples. During the late afternoon however, on the flood tide, the ammonia concentration rose to 0.47 ppm as effluent moved north along the beach on a south-to-north rip that was running at the time. At Humphreys Drive, and in the channel at Beachville Road and Moncks Bay, ammonia peaked at levels up to 1.6 ppm at about low tide, then declined as the flood tide of clean ocean water moved into the Estuary (shown at right side of Fig. 7).

It is relevant to notice that the concentration of ammonia remained low (max. 0.38 ppm at dusk) at Sumner Beach throughout 16 January 2002, whereas at low tide on 10 April 2001 (see my main Evidence) it reached 1 ppm. I think the difference in the two years was caused by a north-to-south rip in April 2001, whereas on 16 January 2002, the rip was south-to-north. The 16 January 2002 current appeared to carry the effluent north to Caspian Street and New Brighton rather than across the Estuary mouth to Sumner and Scarborough (see main Evidence for further details).

A Synthesis of Relevant Standards Data for Ammonia

I have consulted the original USEPA tables of tolerance of ammonia by saltwater fish, a variant of the same data released by the British Columbian Provincial Government, and URS's Assessment of Environmental Effects, March 2001. They agree on all essential matters, and I summarise the critical values given by URS in a brief matrix as follows:

Table 2. Guideline maximum ammonia concentrations for protection of saltwater fish for one hour, or four days, at pH 8.1 (pH 8.1 was the average pH observed during 2001-2002 and was interpolated from AEE table 6.4 for pH 8.0) 8.4 and 9, at 25 and 30°C.*

	1-hr Guideline maximum			**4-day Guideline average**		
pH	8.1*	8.4	9	8.1	8.4	9
Temp						
25	3.9	2	0.69	0.59	0.3	0.1
30	2.7	1.5	0.54	0.4	0.22	0.08

The table shows that tolerance drops by about one-quarter as temperature increases from 25 to 30°C and by nearly three-quarters with pH rise from pH 8.4 to pH 9. If we choose to argue on the basis of values recorded in the field sampling, we are entitled to state confident (but not biologically safe) working maxima as pH 8.4 and 25°C. The tabulated four day guideline for that combination is 0.3 ppm ammonia.

Fish however live much longer in nature than the four days allotted to them in Toxicity Study guidelines. Aquarium studies (e.g. refs.[22],[23]) suggest that for life-long survival of fish in good health, ammonia concentrations should not exceed one-tenth of those given by EPA. Hudgins and Boardman report that even at 0.035ppm (an EPA Guideline figure for 30°C), fish may suffer loss of equilibrium, increase of breathing rate, decrease of nitrogen excretion, "red gills" (inflammation), and even death. At even lower concentrations, growth rate and egg hatching rates may be reduced.

Frank states that to ensure survival for long periods a 4-day average of ammonia should be less than 0.02 ppm. A US Aquaculture Survey came to a similar conclusion in proposing that the un-ionised form on ammonia should not exceed 0.03 ppm.

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[22] Nfrank@nando.net.

[23] Hudgins & Boardman 1997. Toxicity of ammonia to sheepshead minnow and grass shrimp. National Aquaculture Extension Conference

Thus conditions in the Estuary are far worse than those advised for health of saltwater fish. Therefore to restore their populations and maintain them in good health in the Avon-Heathcote Estuary, ammonia should be kept below something in the order of 0.03 ppm. If we argue from a datum of the Estuary-wide average concentration of 0.6 ppm found by CEA sampling, ammonia must be lowered 20-fold (95%). Based on data from the channels (at low tide), which are the vital pathways for fish moving in and out of the Estuary, we need to lower ammonia 50-fold (98%) from present levels.

I reported in my main and second evidence, and Mr. P. Neal for CEA and Mr. R. Dougherty of the Salmon Anglers Association, gave convincing evidence that fish have declined in the Estuary. As further confirmation, one might notice the recent declines of white-fronted terns (P.Neal), spotted shags nesting on Whitewash Head (Mr. H. Evison), and of white-flipper penguins during the past 30 years (C.N. Challies pers. comm.). Their reduction suggests that their food resources – fish – **have** declined dramatically.

The 40% reduction proposed by Mr. Lewthwaite in his supplementary evidence and by Mr. Bourke in his main paper must be seen in this light. It is a recipe for death of fish of the Estuary ecosystem and, with the costs associated with the only proposed feasible option so far announced for reducing ammonia at source (BNR, $100 million) – is a compelling argument for discharge by a pipeline to the ocean. As shown by the typical occurrence of ammonia from 0.002 to 0.05 ppm at Caspian Street, it is clear that if we can get the ammonia out to sea without killing the Estuary system, dilution solves the rest of the problem.

Overlap of Issues 2 and 3.

The above information on ammonia merges into consideration of Issue 3 on the effects of delaying discharges from 1 hr before Lyttelton high tide (equivalent to 1-3/4 hr before high tide at the two upper Estuary yacht clubs) to accommodate yacht racing.

The first point I make here is that the delays amount to tacit admission that the "effluent enriched" Estuary is an unpleasant place. I can vouch for that from the time I spent over

the years scrubbing Bromley scum off my boats, and puckering my nose at the stench near the Bromley outfalls as I sailed in races from "22" back to "T Stake".

More formally, while I recognise that we have no quantitative information on the effects of such delays, I believe there is good information now available as a basis for inference. It is logical to expect that, if the effluent pulse normally moves as shown in Fig. 7 (and Fig. 3 of my September 2001 Evidence), delay of discharge must delay the clearance of effluent from the Estuary. The consequence must be that the proportion of the effluent pulse retained, and the average concentration of pathogens and contaminants including ammonia, must rise.

Overall, that outcome is more adverse for the Estuary than it would be otherwise.

Issue 4.

We have little to add to the evidence on the effect of relocating the discharge outfalls to the north of Pond 5 other than that submitted by Mr. Leo Byatt. But we think it worth stressing his fear that discharging effluent nearer to the mouth of the Avon will force a bigger load of effluent further up the river than would otherwise be the case. That must force the smells and nutrient/pollutant impacts further upriver and extend the time effluent is retained in the Estuary. The outcome must further exacerbate the adverse effects of all effluent pollutants.

Issues 10 and 11.

We previously expressed concerns about encroachment by the proposed discharge embayments into the Estuary. The City Council proposes to "reclaim" about 18 hectares of the Estuary to accommodate these structures (I acknowledge that the figure of 18 ha was is wrong. I should have said 1.8 ha). We record the reality that the only purpose of these proposed embayments is to hide from public view the foam that accompanies the discharge of effluent. They are for cosmetic purposes only. They achieve nothing of any technical value whatsoever.

I noted in my CEA submission dated July 18 2001 that Resource Consent Application CRC 012015 for proposed diffusers "perpetuate the environmentally offensive notion that the Estuary is merely a wasteland awaiting development." "Further, the application has been made without hydraulic investigation of the effects of the 'reclamation' on nearby channels and banks of the Estuary, and the gross influence on inflows and outflows of the Estuary". These deficiencies remain, and continue to be matters of concern.

Concluding Remarks.

The Christchurch Estuary Association takes this opportunity to record its appreciation of the Commission's decision to invite the parties concerned to submit further information on the "Issues" recorded in its 14 February Memorandum. They remain important matters.

Those considered in this paper are a fraction of those that, throughout these hearings, reveal how evasive and fatally flawed are the proposals of the City Council for discharge from the CWTP. They have been riddled with errors and evasive about costs. They lack clear accounts of whatever technology might deliver an acceptable environmental outcome. Council witnesses have not revealed costs that may be buried within sweeping assurances about nutrient removal, ultra violet irradiation, and the like. Their testimony has been less than forthright about the way their proposals irrevocably lock the city into a discharge route that we assert will ultimately be an expensive environmental disaster. I can almost hear it now: "Having spent all that money on Estuary discharge, we are not going to change direction now!" – would even more certainly be the tune in another 15 years!

As Mr. Currie observed in his Legal Submission for the Association: "Alternative methods of discharge, including an ocean outfall, **must** be considered by the Consent Authority under (RMA) s 104(3)(b)".

We therefore reiterate our plea that, consistent with the dictates of careful analysis, Resource Consent applications CRC 012011, CRC 012 014 and CRC 012015 be declined.

Bernard Hansen's Case for the Estuary

1. My name is Bernard Robert Hansen[1].

2. I have a BA Canterbury in Education, a Teachers "B" Certificate, and a Diploma in Teaching. I retired from the Education Service in 1984 after serving as Principal of large schools.

3. I have received the following awards; The 1990 Queen's Medal for Community and Environmental interests; the Tower Achievers' Award for Voluntary Services; the Christchurch City Council Community Board Award for Community Services; Life Memberships of: the Sumner Residents' Association, the CEA, the Friends of the Avon-Heathcote Estuary Association and the Sumner Community Centre. I am Patron of the CEA.

4. I joined the CEA (CEA) in 1971, the year of its founding. I served as its President for 10 years. I now represent Friends of the Avon-Heathcote Estuary on the CEA.

5. Arising from these interests and achievements, I was selected as a member of the Christchurch City Council Wastewater Working Party (WP). That Body was appointed to study proposals and recommend a solution for the future disposal of Christchurch wastewater.

6. The Estuary can never be considered as a water body in isolation - it must be considered in conjunction with the catchments that drain into it.

7. A Science Congress held in Christchurch in the 1960s emphasised that Christchurch was graced by the rare distinction of possessing an Estuary within its boundaries. That rare asset warrants protection.

8. This submission is in three sections: (A) Evidence and comments on matters relevant to the Resource Consent application to discharge effluent into the Estuary for 15 years; (B) History of the Estuary relevant to the above-mentioned comments; and (C) my Conclusion. In addition, several annexes are referred to within the text.

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[1] Sadly, we record that Bernard Hansen died May 23 2002, three weeks after he heard in hospital that the City Council's Application for a 15 year consent had been declined.

A. WASTEWATER DISPOSAL – GENERAL COMMENTS

9. Rivers, lakes, harbours, estuaries and oceans near cities receive sewage and industrial/commercial and water-borne wastes in "wastewater" and stormwater. Early in European settlement times, the Avon, Heathcote and smaller streams received the town's domestic and animal wastes and transported them to the Estuary. The social history of Christchurch is punctuated by the resulting condition of its rivers. An outbreak of typhoid fever in the 1880s resulted in the authorities putting in a system to transfer sewage to a sewage farm adjacent to the Estuary at Bromley. The Public Hospital contributed in various ways to pollution of the river. Fears for schoolboy health at Christ's College led to closure of their swimming pool, UPSTREAM on the Avon River from the Hospital. Drunks who fell down the steep banks of the Avon near Montreal Street ran the risk of drowning or dying from water-borne diseases.

10. The development industries at Woolston led to a steady deterioration in the quality of the lower Heathcote River where the wastes of tanneries, wool scours, glue factories, metal works and so on were discharged. Ultimately, these practices led to accumulations of excavated mud heaps on the banks until they were restored by heavy dressings of lime and fertiliser and planted with shrubs, and the effluent disposed of through a new Industrial Trade Wastes Sewer in the 1970s.

11. The earlier problems of pollution of the Avon in the city were translated downstream. I remember when in the late 1940s the Estuary and Sumner Beach were closed to recreational water activities because of the presence of raw sewage. Something had to be done. The Public Works Act was invoked in the 1950s to take over a large area at Bromley for the development of a Sewage Treatment Station, and the Maori owners were compensated with a payment so small that its acceptance was refused as a gratuitous insult. The payment lay unused until the 1990s when it was used to fund research upon claims under the Treaty of Waitangi. Even then, the people with traditional responsibility for the Estuary did not associate themselves with this action.

12. As an adjunct to the present City Council Resource Consent application, a Memorandum of Understanding was drafted to bind Re Rununga o Ngai Tahu Inc. to confidentiality to facilitate long-term discharge of effluent into the Estuary in exchange for establishment of *mahinga kai* (presumably farmed mussels) in an area of Banks Peninsula that would be culturally acceptable to the tribe. This draft

proposal appears to have ignored the fact that the Council had no jurisdiction over Banks Peninsula. The draft was apparently withdrawn following objections publicly expressed by Upoko Rakiihia Tau who rejected discharge to the Estuary as an option. "The Press" of 14 June 2001 reported that he had "dismissed council claims (that) *tangata whenua* want wastewater discharged into the Estuary rather than out a pipe into the sea". Mr Tau also claimed that the Council had not consulted on the matter with the Maori people with Mana Whenua (traditional ownership Rights) over the Estuary. He had pointed out that *Tuahuriri Rununga* exercise of *mana whenua* is acknowledged in the Ngai Tahu Settlement Act, 1999.

13. At a public meeting held at Mt Pleasant Community Centre in the winter of 2001 to hear the City Council and other points of view, Mr Tau informed the meeting that under no circumstances would his *rununga* agree to an Estuary outfall. At that meeting of over 200 people, the Estuary outfall option was overwhelmingly rejected.

14. It is a fair historical judgement to observe that the Estuary has been a cheaply available wastewater and stormwater basin and a convenient rubbish dump. The major nearby landfill site, used until about 1971, is now closed. The sewage and industrial/commercial wastes, along with agricultural wastes, soil wastes and stormwater from a large catchment area, have ranged in quality from raw to highly treated material.

15. The Estuary has thus in European times received vast quantities of toxins and nutrients that it did not previously receive, and the ecosystem and its users have suffered as a consequence.

16. Heavy metals from all the City's activities inevitably accumulate in the Estuary. There the plants and animals of the Estuary, as well as in the seabed offshore, adsorb and accumulate them in the sediments.

17. Recreationists have suffered and continue to suffer from accidental ingestion of Estuary water. Contaminated shellfish are now regarded as unsafe for human consumption. Birds eat such shellfish but I am unaware of any long-term studies what have been undertaken to discover any detrimental effects upon them. I understand that Dr Islay Marsden is carrying out such studies at present. In the absence of formal evidence of such potential effects as Rachel Carson made famous

in her book "Silent Spring", we can speculate on the unknown effects from heavy metals and other pollutants, following their sustained consumption in the food chain of the Estuary ecosystem. It is reckoned that oystercatchers eat up to 370 cockles per bird per day. It is of interest to note that present-day cockles are about one-half the size cockles were reputed to be in pre-European times. This may be due to changed levels of harvesting and age distribution of the populations, or it may reflect reduced growth rates. We can speculate that it may be a consequence of semi-lethal concentrations of toxins, metals and nutrients in the Estuary water. These important problems should be investigated.

18. For years I taught in Christchurch Primary Schools. Under the former Education Board of Control, Primary Schools were not permitted to take their pupils to the Estuary if they were required to enter the water or walk on the mud flats. The perceived risk of infection was considered to be too great. Currently, under "Tomorrow's Schools" policies (introduced in 1985), schools decide independently upon field trips to the Estuary, despite the evidence that contamination by bacteria, viruses and protozoa is dangerously prevalent.[2]

19. ***Sea Lettuce***. Christchurch has suffered from sea lettuce for many years. It was one of the reasons for the establishment of the Estuary Association in 1971. The odour of tick rotting mats along the shores can be most objectionable. The gas emitted by rotting sea lettuce, including hydrogen sulphide, is notorious for for causing blackening of lead-based paints on nearby buildings. Efforts to remove sea lettuce by machine have caused much damage to the Estuary bed as shown on photographs by C.L. Batcheler of the CEA. It is well known that sea lettuce thrives on high concentrations of N and P and relatively warm temperatures.

20. The Working Party (WP) was at one time told that an ocean pipeline would reduce sea lettuce by 80%. Later, CCC evidence by Dr. I. Hawes and Ms O'Brien claimed that growth of sea lettuce in the Estuary would be reduced by only about 20% if effluent were disposed of by a pipeline to the ocean. During this hearing, it has been conceded that in some circumstances reduction may be 50 %. It is obvious that more

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[2] This was confirmed by the joint placing by City Council, Crown Public Health and Environment Canterbury of new signs warning of the dangers of eating shellfish or coming into contact with the water through such activities as windsurfing, sailing or swimming. (See "The Press" 29.10.2001)

research on the growth of sea lettuce in the Estuary is necessary. Nevertheless it is equally obvious that to be rid of such nuisances, we must have lower load of nutrients entering the Estuary.

SPECIFIC ISSUES IN THE APPLICATION

A1. Nutrient Removal. Reference: URS Final Report of Preliminary Assessment of Environmental Effects ... 18/9/2000. Page 3-7. 3.3.1 ; URS Final Report of Assessment of Environmental Effects ... 29/3/2001. Page 3-8. 3.4.1

21. Reduction of nutrients involves the removal of nitrogen and phosphorus. If one wants good growth in the vegetable garden, apply "nitrofoska", a pelleted fertilizer that includes both elements. Currently, the most reliable in-plant treatment for nutrient removal is reputedly "Biological Nutrient Removal" (BNR). The cost for a BNR plant is about $100 million, with annual operating costs of about $2 million. If there were to be a serious attempt to reduce nutrient entering from the Estuary and to reduce sea lettuce to an acceptable level, then such a plant must be considered, so long as effluent discharge to the Estuary continues. The only alternative is an ocean pipeline at one- third of the cost of a BNR Plant.

A2. Disinfection. Ref: URS Final Report of Preliminary Assessment Environmental Effects. ... 18/9.2000. Page 3-8.3.3.2; URS Final Report of Assessment of Environmental Effects ... 29/3/2001. Page 3-9. 3.4.2

22. Disinfection is necessary to ensure that potential infection risks to the public are minimized. It is assumed that if indicators of faecal contamination (such as *Enterococcus* in sea water, and coliforms in non-saline water) are reduced to low levels, then so also will be the concentrations of dangerous pathogens. This assumption may not be totally warranted in practice, depending on the pathogens involved and the methods of disinfection employed.

23. Because the Estuary is used intensively recreation, the required quality of water from an Estuary outfall would be much higher than for an ocean outfall. Ultraviolet (UV) light radiation is now the favoured disinfection treatment. However, effective UV disinfection depends on translucence of the water, which may be greatly reduced by the presence of plankton that grow in the oxidation ponds.

A3. Costs Significant to an Estuary Outfall Versus and Ocean Outfall.

24. Because of their practical importance, I comment on the costs of proposed public works. Due to the higher maintenance costs of an Estuary outfall compared with an ocean outfall, the relative costs after 15 years are predicted to be about the same (Evidence of Mr W. Lewthwaite to the WP). Using the data of Table 3.1 on page 3.12 in URS PAEE (2000) or Table 3.1 on page 3.15 in URS AEE (2001), one may calculate that the accumulated costs after 30 years would be greater for the Estuary outfall than for an Ocean outfall.

25. I also note that comparative costs for upgrades in Wellington ($158 million) and Auckland (>$400 million) are of the same order of magnitude as the land disposal options that were rejected by Christchurch, largely on grounds of costs. Comparatively, the Christchurch community has a paltry attitude towards the long-term management and disposal of its liquid wastes, even though in our case it would achieve safeguarding and enhancing the priceless Estuary asset (by an ocean pipeline).

A4. Estuary Discharge URS Final PAEE. Page 2-6 2.3.1

26. At present three concrete pipes drain the Bromley ponds to the Estuary. The foam they create is clearly visible from the hills and nearby shores. There is almost always some visible leakage, even when the outlets are closed.

27. It is now proposed to construct a rock diffuser structure of about 600m x 20m emerging 0.5m above the high water mark at the head of the Estuary. At least one other submitter has stated that this proposed structure could be much bigger than shown in the draft plans. Clearly it will be an intrusion onto the Estuary shore.

28. The most recent plan shows it extending along the full length of the Estuary boundary of a new Pond 7, forming a new artificial and irregular shoreline, pierced by embayments leading to new outfalls, and cosmetically revegetated with shrubs and saltmarsh plantings. Whether or not embayments will remain stable under the influence of tide and wind remains uncertain. Clearly it will be a further unnatural structure in the present environment, and it is important to remember that this piece of "environmental vandalism" has no other purpose that to hide the foam generated by

discharge of effluent. It ultimately achieves no more than to add another offensive engineering intrusion into the Estuary.

29. L. McCallum[3] has recorded that about 1980 the then City Council adopted a policy that no further Estuary land would be reclaimed. The present proposal makes that an empty commitment.

30. **A5. The Effectiveness of Ocean Discharge. URS Final PAEE. Page 2-7. 2.3.2**

31. The option designed in reponse to Working Party initiatives would be a 2km buried pipeline off Bridge Street in South Brighton into water 12-15 m depth. This would initially dilute the effluent 100 - 1000 times "as the buoyant plume rises to the surface and disperses", and the vastly greater dilution obtainable overall compared with discharge into the Estuary (about 10 - 25 times). An ocean discharge would flow continuously.

32. UV irradiation of the effluent prior to discharge by an ocean pipeline was strongly recommended by the WP. Clearly periodic ineffectiveness of UV treatment because of power limitations or water translucence would not have as serious implications from an ocean outfall as it would from an estuary outfall. A commercial fisherman informed the WP that the pipeline would not endanger fishing equipment.

33. A 3km pipeline, as detailed in the Final PAEE, pages 3-2 and 3-3, would further increase the dilution of ocean discharge, and might be an advantage worth considering to remove any conceivable threat to Surf Life Savers who work at up to one km off the beach. However, evidence from Unisearch (Sydney) showed the WP that the 2km pipeline would easily meet the standard of achieving shellfish-gathering bacterial standard of water quality (median 14 faecal coliforms per 100 ml) at the surf zone.

A6. The Ineffectiveness of Estuary Discharge URS Final PAEE. Page 3-3,3.2.2

34. With outfalls in the Estuary, about 1/3rd of the effluent remains trapped within the Estuary. Of the 2/3rd which reaches the ocean, about one-half returns on the next tide. So overall, 2/3rd is retained from tide-to-tide[4]. This retained proportion would continue with future Estuary discharge. As already mentioned, Estuary discharge

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[3] 1982. The Management and Administration of the Avon-Heathcote Estuary. U of C MA thesis 96 pp.
[4] 1994 Lincoln Environmental Contract Report 2481/2 to CCC

offers little dilution and diffusion capacity. Estuary discharge often contaminates the surrounding beaches.

35. C.L. Batcheler, of the Estuary Association, has informed the Hearing[5] of observations of water quality made by volunteers during November 2000 to February 2001, shortly after Estuary high tide. Estimates of *Enterococcus* exceeded the accepted guideline value on only two occasions. But sampling throughout one pilot trial day showed that *compared with the usual sampling at or after high tide,* bacterial concentrations increase by some 600% as the pulse of effluent moves down the Estuary. Calculations showed, towards low tide, the guidelines would be exceeded on about 20% of days. We do not think this is acceptable, particularly for the Yacht Club that regularly sails small craft at low tide at Moncks Bay.

36. South New Brighton School pupils, under the guidance of a Consultant Engineer also took samples from the Estuary. These samples were analysed by Environment Canterbury Laboratory and results discussed for their educational value in a local paper[6].

37. The newspaper heading reflected the bacterial count results: "Estuary test results shock students". They concluded that swimming, water skiing, windsurfing etc. were unsafe due to the high levels of bacterial contamination. Based on their findings, many of the students "couldn't believe that we used to swim in that". These results confirm the results obtained from the sampling reported in paragraph 33 above.

A7. The Experience of the Wastewater Working Party (WP)

38. What follows is a brief traverse of some of the issues considered by the Wastewater Working Party under the Facilitation of Ms Gay Pavelka. The over-riding issue during early discussions was water quality. The next phase was to develop a table of options for discharge. At this point applications were invited to secure the services of an experienced wastewater-engineering consultant to guide the discussions and provide professional input. The credentials submitted resulted in the appointment of Woodward Clyde Ltd., represented by Mr C. Tipler.

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[5] Evidence of C.L. Batcheler, Christchurch Estuary Association, 2001.
[6] Bay Harbour News 19 September 2001.

39. In early and, some WP members felt, fairly superficial discussions of options, the WP considered disposal to land. This fell into disfavour because of estimated capital costs in excess of $300 million for pipes, canals, land purchases (which was claimed without clear evidence – in an emerging water deficient climate and sinking aquifers - to be a necessary corollary of this option), and high operating costs. Contamination of aquifers (assuming the area chosen to be above the city supply strata), and the large areas of land required (>6000 ha) also concerned some Members of the WP.

40. Satellite plants in the South-west and north east (Cheneys Corner) were considered but they were forcefully rejected by the City Council members of the WP on grounds of costs and the multiplied difficulties of obtaining more than one set of Resource Consents for Treatment Plants and disposal routes. The view was that "it will be hard enough to get one discharge consent, let alone three or four. Therefore why try without overwhelming reason?" Estuary discharge and ocean discharge by a pipeline emerged as the two most viable options.

41. The immediate problem for an ocean pipeline was the inadequacy of oceanographic data on the effects of winds and currents on effluent movement from an offshore discharge point. An Australian Consultant Group, Unisearch Pty, from McQuarie University, Sydney, was contracted to provide information on outcomes of different discharge sites under different conditions.

42. It is relevant to note that the cost for all the Consultants employed on WP initiatives amounted to some $1.2 million.

43. As alternative Estuary discharges, two options were considered: (a) Outfall from the present site, and (b) Outfall in the channel near Beachville Road, Redcliffs.

44. The Beachville Road option was eventually discarded as seriously flawed. It would have required very large and intrusive pipes to be laid below low tide level in the Estuary. Much of the effluent would still return to the upper Estuary on the following tide. Sumner, the most popular beach in Christchurch, would receive a more concentrated slug of effluent than it does at present. Considering these factors and the costs involved (ca $16 million), the Beachville Road option was judged to be not worth the cost. Hence only two options survived this scrutiny, an Estuary outfall at or near to the present outfall, or an ocean pipeline.

45. After listening to the evidence from the Consultants, the WP in 1998 recommended an ocean outfall (pipeline). The City Council soon after (August 1998) voted to accord the recommendation favourable consideration, but called for more information.

46. Some seven months after that recommendation was made, the Council sub-committee of Messrs O'Rourke, Close and Wright proposed "The Third Way", the label for which soon evolved into the "Green Edge Proposal".

47. In May 2000 the WP again recommended an ocean pipeline 2km into Pegasus Bay. Of the 16 non-Statutory Body Members of the WP, most (13) voted in favour of the pipeline. Only three, all from South Brighton, voted for continuing Estuary discharge, apparently fearing adverse effects on their neighbourhood.

48. In June 2000, the City Council rejected the ocean pipeline recommendation in favour of an Estuary outfall, including a rock diffuser to hide objectionable foams. The Green Edge elements of the proposal remain unspecified but could include wetlands and further plantings at the edges of the oxidation ponds, modifying or closing Humphreys Drive, and even building a new bridge at Ferrymead.

49. The City Council has indicated that this proposal is more acceptable because of low costs, some unspecified prospects of reduction in nitrogen load and the prospects of UV sterilisation of the effluent. The rebuilding of the ponds in a new design, the development of wetlands and the environmental enhancement of the Linwood Paddocks area were indicated but not fully estimated because they were dependent on trial results. Beca Stevens through Mr Humphrey Archer informed the WP that wetland denitrification would require at least 1400 ha. Less than about 500 ha appears to be available for such a purpose, including the existing 214 ha Bromley ponds. Professor KF O'Connor in CEA evidence for the CEA suggested that the wetland area required for denitrifying the current nitrogen discharge load would be much greater than 1400 ha.

50. Cr O'Rourke has claimed that open pond-rock filter technology[7] as used at the village of Seddon, Marlborough shows that wetlands could work for Christchurch. That may be, but Seddon does not have wetlands as a model for Christchurch. Furthermore, its population is about 500, which suggests a nitrogen load equal to 1/660th that of

[7] Information from Marlborough District Council website.

Christchurch. A preliminary estimate by CEA suggests that at Bromley the total length of rock filter walls of the Seddon township type would need to be some 250 km in length. We cannot imagine where they could be tucked in to the available space!

A8. Publicity and Public Consultation.

51. The attached letter by Ms Gay Pavelka[8], dated 16 October 2000, refers to this matter. It notes that the City Council pamphlet "Don't Duck the Issue" purported to summarise the results of 3-1/2 years of deliberations by the WP. But it did not give a balanced view for people to make a considered judgment. The Council allocated more than $180,000 for such Public consultation. It used television, the Press and the Council "City Scene" - all supported by Ratepayer funds - to promote its own views. Those supporting the pipeline option had to raise their own funds for publicity. Furthermore, as a part of Council publicity, a survey of 500 people was claimed to show 77% of residents favour the Estuary outfall option. The independent assessment of this survey by Charles G. Lamb, as reported by ECan Officers Reports, concluded: "In conclusion, I would suggest that the (Contract Survey) Report has so many inconsistencies, errors and omissions as to make it a document of extremely limited use."

B. Brief History of the Estuary in relation to the foregoing Issues

B1. Historical Uses of the Estuary

52. For several centuries the Estuary and its environs were important to Maori as a source of fish, shellfish and birds. The people had little effect on its natural values. However, with European settlement, the effect of people has accelerated. Because of difficult access from Lyttelton to Christchurch over the Port Hills and the intervening swamps, carriage of freight on small ships through the Estuary and up the Heathcote River was important for many years.

53. 30,000 people per year crossed the Heathcote River by ferry before the first bridge was built in 1864 at Ferrymead. From there, travellers followed marker poles across the flax, sedge and raupo swamps to the town of Christchurch.

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[8] Copy of Letter of Ms Pavelka to Mayor and Councillors, copies being made available to members of WP on their request.

54. The Estuary was the source of most fish sold in the Christchurch market until the early 20th century[9]. It was probably pollution, mainly from industrial effluents into the Heathcote River that brought commercial fishing to an end. It is recognised that Estuary fish life has declined further even in recent times. Mr Peter Neal gave firm evidence for the Estuary Association on this matter. Cockles of today are only half the size of those that occurred before European settlement[10] Although it is possible that this reflects through persistent over-harvesting, it is also possible - and I think most likely - that reduction of size is at least partly due to deterioration of water quality. I am not aware of any studies on the growth rate of the modern cockle population.

55. The extent of the Estuary has declined and its shape has been changed radically since European settlement began, but I know of no precise measurements of these changes. Reclamations, particularly west of Humphreys Drive, at McCormacks Bay, Redcliffs and Moncks Bay, are extensive. The oxidation ponds, now about 215 ha, is the most extensive "reclamation" of all incursions into the primitive Estuary, perhaps excepting the gradual infilling west of Humphreys Drive. The area beyond Charlesworth Street and the site of present the Fire Station, 1/2 km west of the current Estuary limit, was salt marsh in the early days.

56. Despite the commonly assumed reduction of area, measurements in the 1970s[11] indicate that the tidal compartment of the Estuary has increased since 1854, from about 8 to 11 million m^3. This must imply that the Estuary is now somewhat deeper than formerly, although this is queried by yachtsmen who complain of the difficulty of lowering dinghy centreboards to their full extent. The weight of evidence from early recollections is that the channels became shallower while the inter-channel areas were lowered so that overall tidal capacity was increased[12].

57. Regardless of the true position, the City Council's present application intends to make another alteration to the perimeter with a proposed rock diffuser. Sea wall, jetties, steps, ramps, roads and the McCormacks Bay Causeway, which has separated the bay from the Estuary except through one functioning culvert, have all contributed to the

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[9] Ogilvie, Gordon. 1978. The Port Hills of Christchurch.
[10] Stevenson R. 1980. An Estuary under stress.
[11] McPherson, J.M. 1978. PhD Thesis *Environmental Geology of the Avon-Heathcote Estuary.*

degradation of the Estuary. There are reputed to be over sixty illegal or non-approved structures around the Estuary at the present time.

58. It can be seen on close observation that the Estuary has suffered as a consequence of such abuse, yet the Council proposes to inflict the huge diffuser upon it to the further detriment of its natural beauty.

59. Construction of the Causeway and infilling has led to the effective loss of most of McCormacks Bay as an integral part of the Estuary. As a consequence of the causeway and the single culvert, tidal flushing of McCormacks Bay is seriously impaired and sea lettuce is accumulating to the extent virtually the whole bay is now covered.

B2. Plans for reclamation of the Estuary

60. Plans for a canal from Shag Rock, and a ship canal to the city were seriously entertained from about 1860. Plans were dropped only in the early 1900s, when it was clear that the rail tunnel from Lyttelton was serving the city more economically and reliably than could be expected by ships in the Estuary.

61. Another plan proposed a deep-water port in the Estuary, with some 300 ha (about 1/2) of the Estuary reclaimed. A breakwater would have extended off Taylors Mistake. The plan was revived somewhat during W W II and was still being considered up to 1964 when the Lyttelton road tunnel was opened.

62. Another plan by a Real Estate developer proposed construction of finger groynes to reclaim building land along the Estuary side of the Spit (now Southshore). This did not proceed.

63. Another proposal was for a floating Japanese-type restaurant in McCormacks Bay.

64. Yet another proposed the construction of evaporation ponds for a salt works, along the Estuary side of the Spit. Like the finger groynes idea, it didn't proceed.

65. Yet another plan was to reclaim McCormacks Bay for construction of a secondary school. This proposal generated considerable interest because of the lack of suitable areas of relatively flat land suitable for schools or playing fields in the south-eastern suburbs. In fact, considerable areas at both ends of McCormacks Bay have been

[12] GG Andrews *op cit*

reclaimed. The eastern area is now occupied by a sports grounds and the western area is occupied by the Mt Pleasant Community Centre and Kindergarten.

66. At a Public Meeting at Mt Pleasant Community Centre during the early 1970s, the City Council presented a plan to reclaim virtually all of McCormacks Bay for sports fields. At the same meeting, the Estuary Association presented an alternative plan to limit reclamation to the present configuration.

67. This was an important historical moment in that it The Estuary Association became one of the earliest unofficial body to take a stand against treating the Estuary as a wasteland there to be "reclaimed" and used for whatever purposes the "development-minded" amongst us wished to pursue.

68. Since then, the only further encroachment into McCormacks Bay has been the building of three small islands to improve the nesting success and survival of birds vulnerable to predators. This is probably the first action taken by any sector of the community for environmental enhancement for biota rather than for convenience of the people. It still failed to restore the health of McCormacks Bay because it made no provision for the better flushing of that bay with the tides. This could only come about through opening the non-functional culverts.

69. A recent "Lifelines Study" to examine the susceptibility of Christchurch to Natural Disasters identified the vulnerability of Ferrymead Bridge to earthquake damage because of the kinds of sediments used in the abutments. This risk, combined with the complex road and traffic junctions near the bridge, hass prompted several alternative design solutions. One, proposed by the city roadways engineers, suggested a new causeway, from Humphreys Drive to McCormacks Bay. This becomes just another official proposal for encroachment on the Estuary.

70. Every few years someone suggests that a bridge should be built Shag Rock to Southshore "at the end of the spit". The northern abutments and approaches of such a bridge would have to rest on very deep foundations and piles, and reach high enough above the water to avoid impeding yachts sailing in and out of the Estuary. The bridge would sit astride the flight-path of oystercatchers and godwits to their only possible high tide roost, at the south-east tip of the Spit! This critical environment would thus be utterly compromised by such an edifice. There is little doubt that the

increased volume of traffic induced by such an "engineering benefit" would adversely affect the residents of both Southshore and Sumner.

B3. Plant harvesting and Plant introduction

71. ***Gracilaria.*** During the 1990s concerns developed a venture that began harvesting *Gracilaria* from the Estuary bed or the extraction of agar. An informal encounter with the organiser led an established Company, Tumblar Products Ltd, to promote the idea. Approaches were made to the City Council, Environment Canterbury and Ministry of Fisheries. The last-named was not particularly concerned because, under the Fisheries Act, free-floating *Gracilaria* could be harvested without restraint, whereas sessile or attached *Gracilaria* was considered a "fish" under the Fisheries Act, commercially harvestable under a permit.

72. Fortunately, Estuary Association members had visited the site the unauthorised *Gracilaria* harvesters were working. Mr Andrew Crossland, ornithologist, also visited the site and found people raking live plants from the Estuary bottom. Upon notification of this, Ministry of Fisheries took action and the operation was stopped. It was then discovered that the operators had no formal vehicular access authority into the locked area near Sandy Point. We found much damage had been done to rush (*Juncus* and *Leptocarpus*) communities fringing the Estuary. Much damage had also been done to the Estuary bed through the use of farm bikes heavily laden with the seaweed.

73. ***Spartina.*** *Spartina townsendii* was introduced at an unknown date, first at Bridge Street on the Avon, to control erosion of the river channel and the Estuary margins and bed. It soon spread to McCormacks Bay and other parts of the Estuary[13]. *Spartina* turned out to be a very vigorous invader and it soon became clear that it could lead eventually to loss of a significant part of the Estuary. Herbicide spray programmes were therefore developed, and are still used to control it. I am not aware of any research done to assess the impact of spraying on more desirable organisms in the Estuary, and I am informed that despite 30 years of intermittent control, *Spartina* still occurs in many places. It remains an object lesson against the introduction of foreign organisms, no matter how well intentioned, and a testament to the unexploited nutrient capacity of the Estuary in its present enriched condition.

74. Mindful of all these "reclamations", intended, incidental or merely tolerated, it is difficult to avoid the conclusion that the natural values of the Estuary have generally been considered as a free gift, expendable at whim for the "development" of the city and the convenience of its citizens. The "ecological services" that it has furnished over the years, including the fisheries, city waste receiving area, use of its waters for navigation and recreation, "reclaimed" margins for roadways, have never been reckoned in any way. It is little wonder that these qualities are sadly degraded. This is evident in the virtual elimination of the fisheries, reduced suitability for navigation, and decline of the quality of its waters.

B4. Stormwater and Flooding

75. Stormwater in the Estuary, and its pollutants, has always been of concern. Animal residues and vehicle wash water, spilled fuel, detritus from brake linings, tyre residues, and all our other effluvia enter the Estuary system. Silt from residential developments (much of which could be trapped by filters and settling ponds at source) is a significant source of pollution of the Estuary. All too evident has been the attitude even at the level of City Officials, that the best silt trap available for new hill suburbs silt, and for all our other junk, is the Estuary!

76. Many attempts have been made to control the flooding that is endemic to our low-lying, flat city, especially in the low-lying parts of the Opawa Heathcote-Woolston area. Norman Kirk, a former local Member of Parliament and later Prime Minister, suggested a barrage across the mouth of the Heathcote River at Ferrymead to control it. The former Drainage Board placed a research contract with the Wallingford Hydraulic Research Laboratory in UK and the University of Canterbury to determine the value of a barrage between Redcliffs and the Spit. The idea was that, if heavy rain was predicted, control gates could be closed to at low tide to provide a large basin in the Estuary for the storm water.

77. Wallingford's report was a long time awaited. Although no undue engineering or hydraulic problems were foreseen, Prof. Knox reported to CCC out that if the gates of a barrage were closed before heavy rain, the plants and animals adapted to the normal salinity range and periodicity of the Estuary would die. Prof. W.C. Clark has referred

[13] Knox, GA 1992. The Ecology of the Avon-Heathcote Estuary. Report to CCC. 158 pp.

to this scenario in his evidence to this Hearing. The proposal was abandoned. It has remained a good example for us of the dangers of piecemeal problem solving where an integrated approach is necessary.

78. Flooding has remained a problem. After the Wallingford Report episode, the City Council decided to construct a short-cut channel through the Heathcote Loop "bottleneck" in the Lower Heathcote, the "Woolston Cut", to mitigate flooding. It was soon found that the "Cut" enabled salt water and Estuary animals such as mud crabs to penetrate further upstream. Crabs burrowed into the banks, causing some collapse, and salt water caused serious dieback of many trees along the river. Control gates have now been installed in the "Cut", and are opened to pass the water through only during flood conditions. Otherwise, apart from the flood banks protecting the new Ferrymead commercial area, the lower reaches of the Heathcote are allowed to function more or less as nature designed. The "Cut" is now rapidly silting up with mud. Since no exceptional rains have occurred since it was built, its capacity to handle peak flows is uncertain. The Heathcote Loop remains one of the sectors of the river most in need of careful observation, possibly of innovative action, and restoration with native vegetation.

B5. Rehabilitation of Rivers and Riverbanks.

79. The origins and effects of industrial pollutants on the condition of the lower Heathcote have been noted in Para 10 of this evidence. In the early 1900s Woolston had enjoyed such rapid industrial growth that one fifth of the entire industrial work force of the country was employed there. The Combined Estuary Association looked forward to the rehabilitation of the river itself as a pathway to the restoration of a more natural regime to the Estuary. The Association welcomed the commissioning of the Trade Wastes Sewer in the 1970s.

80. The legacy of toxic mud on the banks of the river has already been mentioned. The Estuary Association took up the issue of planting these banks, but initially it was found that nothing would grow there. The City Council therefore capped the mud with a veneer of new soil, and with the advice of Forest Research Institute, large quantities of lime were brought in to raise soil pH. After a slow start, the shrubs established and grew. The Lower Heathcote now looks very attractive.

81. The work of schools and neighbourhood groups to restore the margins of the Avon and Heathcote rivers, and some of their tributary drain channels and streams, has been integrated in the programme of the Parks and Waterways Unit of the City Council. The effects are shown in improved riparian condition and in the recent lowering of nutrient loads flowing to the Estuary, as was pointed out in the evidence of Professor O'Connor to this Hearing.

82. It is well known that the zones of poorest water quality in the Estuary are associated with the localities of inflows, especially near the Bromley pond outfalls and the western margins between the river mouths. It has been implied elsewhere that this condition is due to the rivers and not to Bromley discharge. In view of the periodic influx of Bromley discharges into the flood tide of water flowing upstream into the rivers, the river flows returning downstream may be reflecting their earlier pollution by Bromley discharge. Whether or not this is the effective cause, the zone between the river mouths is the area of perhaps greatest deterioration in the bed.

B6. Changes in the Bed of the Estuary

83. Changes in the composition and consistency of the bed of the Estuary have been complex in time and in space, as mentioned in paragraph 58 of this evidence. It is recorded that in the 1870s, a 50-60 cm layer of soft black mud accumulated in the Estuary. GG Andrews notes that the ***channels*** silted up appreciably in the 25 years prior to his observations in the 1890s but that even then, the channels "were still wide and deep; at least six feet of water could be found all the way from Heathcote to Sumner **at low tide.**" It is also noteworthy that GG Andrews refers to black ooze in his description of the Estuary bed in the 1890's. From his account it might be inferred that its accumulation was related to the destruction and disappearance of the *Zostera* beds once characterized the ***flats between*** the channels[14]. It is clear from his account that these flats were lowered over time by more than one foot (30cm).

84. From studies about 1970 by Kilner and by Robb[15] it was evident that the firm, sandy sediments that covered two-thirds of the Estuary were biologically active and

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[14] GG Andrews *op. cit.*
[15] JA Robb 1974 "Ecological Study of the Bromley Oxidation Ponds and Surrounding Environs" University of Canterbury Ph.D thesis, pp 71-74 discusses the significance of his own and Kilner's work on estuarine sediments, their seasonal dynamics, and their different properties and sources.

"oxidizing" down to at least 30mm. Black sulphide accumulations frequently noted at 50 mm indicated a change in reduction-oxidation conditions between those depths. Sediment character in the surface layer of this extensive area of the Estuary changed during the year with the growth, decay and dispersion of algae.

85. In contrast, the several hectares of black, glutinous deposits in front of the oxidation ponds evidently resulted from the continuous deposition of fine suspended material discharged from the ponds. These remained deficient in oxygen (reducing) at all depths, were very rich in carbon, nitrogen and phosphorus, and were physically stable despite their much higher proportions of silt and clay with less sand than the bulk of the estuarine area. Whether such differing organic sediments at one time are the same in nature and origin as those described by others at other times is a matter for more careful study.

86. Sediment study needs to be done; otherwise we shall never understand how to clean-up the Estuary once the main source of pollution is removed. Of course there is still the phenomenon from time to time since the 1950s, when the Estuary has been yellow with suspended subsoil loess, washed from hill developments during heavy rain. This is much more conspicuous but probably less persistent in its effect on water colour and clarity than the more subtle dispersion of organic materials, either as sea lettuce or other algae or from the plankton in discharge from the ponds.

87. ***Skylark Island*** was a once well-vegetated island, near the end of the present McCormacks Bay Causeway, about 150 metres offshore from the Redcliffs Cutting. It may not have been always an island[16]. During the 19th century it was a popular picnic ground. My neighbour, 92 years of age, remembers enjoying picnics there. It began to disappear during the period from 1905 to 1910, and had disappeared at high tide by 1926.[17] Les Batcheler of the Estuary Association suggests that construction of the Causeway for trams may have altered the hydrologic patterns and so led to its disappearance. Certainly work on that Causeway greatly affected the location of nearby channels.

C. Conclusion.

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[16] Andrews *op.cit*
[17] De Thier *From Sumner to Ferrymead*

88. As an avowed Conservationish, I reflect with sadness upon what we have done to the Planet Earth in such a short time, in many cases through greed and ignorance. A distinguished British scientist[18] suggested that Man might survive another 1000 years on earth, to be eradicated by some virus. Presumably we know better today, but the ominous question that hovers over the future of Man is whether we are prepared to protect our environment? In this case, are we prepared actually to protect our Estuary? Some folk, in my view enlightened, regard it as the "Jewel in the Crown of Christchurch". If this so, it should be given the respect and recognition that that status deserves. The question in my mind is: Is there another similar body of water in New Zealand that has been and continues to be so badly treated as The Avon Heathcote Estuary, after 150 years of settlement.

89. I quote from a Christchurch City Council document, "Planning for the Avon-Heathcote Estuary", 1980:

> "Man's impact on estuaries has almost always been accompanied by undesirable effects.... Those caused by man's use of estuaries have been compounded by the impact(s) in the surrounding watershed. If allowed to continue unchecked, Estuary values must change. Only relatively recently has society generally accepted (its) multi-purpose values and possibilities.... As well, there is a growing appreciation of the vulnerability of an estuary system. To maintain ...and manage the Estuary so that it remains an asset to the wider community, must become major objectives of the local authorities who have an impact on, or control over (it)".[19]

90. Twenty one years later the City Council has so far slipped from those clear understandings and fine aspirations that it seeks resource consent to continue with the very practices that have caused the loss of quality from which the Estuary suffers.

91. I have pointed out how to understand the deterioration of the Estuary and the abuse of its natural functions involved in those changes, one has to establish an historical perspective.

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[18] Stephen Hawking, the Press, October 17 2001
[19] Christchurch City Council 1980: Planning for the Avon-Heathcote Estuary, 72 p. CCC, Chch.

92. I have reported that the City Council established a working party in 1996 to consider the issues and options available and to recommend the best option for the future disposal of wastewater under a Resource Consent permit, due for renewal in 2001. Consultations with New Zealand and Australian scientists and engineers costing more than $1m informed and enlightened the Working Party's deliberations. In 1998, an ocean pipeline extending at least 2km offshore was recommended. After more deliberations, in May 2000, the recommendation was restated to the Council. The Working Party's Peer Group of distinguished assessors endorsed it.

93. In August 2000, the City Council resolved to seek Resource Consent to continue with an Estuary outfall, cobbled together with a partly formulated and partly budgeted "green edge" proposal with some mysterious and unquantified possibilities for the reduction of nutrients. The Council under the name of public consultation embarked on an expensive publicity campaign in favour of the Council's decision. In the judgement of the most impartial and perhaps best informed person involved in the working party, the Facilitator, the Council publicity failed to give a balanced view for people to make a considered judgement. Another impartial consultant likewise faulted the survey. In fact, the more information that people had of the respective merits of ocean pipeline and Estuary outfall, the lower was the proportion of support for the Council's decision, culminating in more than 90 % support for the ocean outfall in the 2,250 submissions to the Regional Council. Several public demonstrations, and the clear statement of Rakiihia Tau, Upoko of Rununga Tuahiriri have opposed continued discharge to the Estuary.

94. The Council has not enunciated its reasons for preferring to continue discharging Bromley wastewater to the Estuary. It is presumed to be the difference in initial cost attributable to an ocean pipeline. It may be that such money can be saved, but it is the Estuary and the people who would enjoy it who pay the difference.

95. The application for resource consent makes it plain that the Applicants still expect to discharge nutrients and organic matter to the Estuary regularly and some pathogens at least sometimes. The pathogens may be abated but they will not be assuredly removed.

96. The nutrients and organic matter will not be removed and the prospect of their reduction is problematic at best. The Council has shown no sign of seriously

considering the necessary steps to save the Estuary from enrichment, super-productivity and death as an ecosystem.

97. This is not a decision made in the interests of the Estuary.

98. More than 90% of the input of nitrogen to the Estuary is from Bromley and about 98% of the phosphorus. These are valuable nutrients but because of where they are we must waste them. We have had it dinned in our ears that pouring nutrients and organic matter into the sea is waste and that we should seek ways of using them. An ocean pipeline would be clean waste, functioning continuously and with ample opportunity for dilution, with no effect or health risk on our beaches.

99. In contrast, tipping nutrients and organic matter into the Estuary in effect supplies it with unclean waste that that has many consequences. It fouls it with sea lettuce, impairs its clarity, kills the fish, renders the shellfish dangerous to eat, reduces indigenous avifauna and biodiversity, and favours only a few organisms adapted to high nutrient concentration. And it still delivers the nutrient load to the sea.

100. Enrichment and high productivity in the Estuary is thus an undesirable environmental cost.

101. The naturalness of the Estuary would undoubtedly be enhanced by sensitive development of a western Green Edge, but the Green Edge is irrelevant to the treatment of wastewater from Bromley. The proposed rock diffuser would detract further from its natural character and would offset any nature restoration of the Green Edge and redesigned oxidation ponds.

102. As a member of the Working Party and as a citizen who has made it his business to keep abreast of local environmental affairs. It is my view that continuation of an Estuary outfall detracts from the quality of the Estuary for all our people and for the natural biota that flourished there before it was enriched and polluted.

- I therefore oppose the City Council application to continue the discharge of Bromley effluent into the Estuary.
- I therefore oppose the application by the City Council to install a diffuser structure on the Estuary shore as part of a modified Estuary outfall.

- I ask the Commissioners to reject the City Council applications CRC 012011 to CRC 012016 inclusive.
- Finally however, on the grounds of practical necessity, I concede that a conditional Consent might be granted to the Applicant for at most five years, to enable the City Council to prepare plans and proceed with the installation of a pipeline into Pegasus Bay.

I ask the above, so that the Estuary may be given the recognition and respect it deserves as a stable estuarine system and defining feature of Christchurch. These I ask so the Estuary can sustain its indigenous biota in perpetuity, and serve the recreational and environmental needs of our children and our children's children.

P.A. Neal's Case for the Estuary.

Biographical Note.

1. Peter Anthony Neal lives at Southshore. He was born and brought up in the UK and emigrated to New Zealand in 1970. He qualified to Higher National Certificate Level in Technical Engineering. Since migrating to New Zealand, he has worked in Tool Design for manufacture of Plastics components and was latterly Chief Draughtsman and Design Manager at PDL (Plastics Diemakers Ltd.).

Peter Neal's case.

2. Throughout my life I have been interested in Wildlife and Waterfowl Management. In UK, I was employed in a Wildfowl Sanctuary rearing pintail ducks and pheasants.

3. One of my hobbies then was fishing in the rivers of Norfolk, in pursuit of many species of coarse fish and trout, and later sea-fishing off the steep shingle beaches of north Norfolk.

4. I began fishing in Canterbury soon after my arrival. My evidence relating to the enquiries of your Commission is largely anecdotal, based on my own experience during the past 30 years. I have lived at Southshore, by the Estuary for the whole of this period, and have walked its perimeter almost every day during that time.

5. My fishing in New Zealand has included fly-fishing and use of spinners in high country lakes and rivers. But the greatest amount of time, over the period 1970-1990, has been spent saltwater fishing in the Estuary and around Banks Peninsula.

6. From 1970 to about 1985 a companion and I regularly caught elephant fish (*Callorhynchus millii*), yellow-eyed mullet (*Aldichetta forsteri*), kahawai (*Arripis trutta*), red cod (*Physiculus bacchus*), moki (*Lapsidopsis ciliaris*), Piper (*Hemirhamphus intermedius*) and flounder (*Rhombosolea spp.*).

Since 1985 however, it has become progressively more difficult to catch fish of any sort in and about the Estuary.

Shrimp

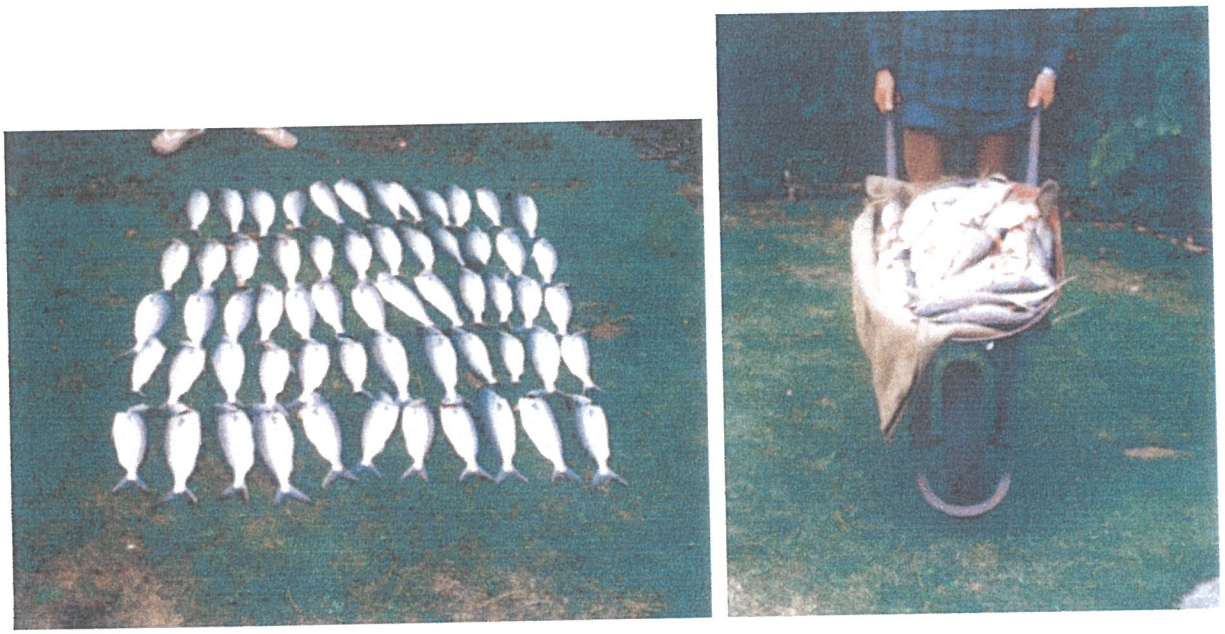
7. The most dramatic disappearance during that time has been of shrimps, which we knew by the name "sand shrimp" probably the Estuarine prawn (*Paleomon affinus*). For a few years after 1970 we used an old English patterned shrimp net at high tide on the submerged sand flats at the spit tip.

The shrimps were then plentiful. But after one year - I forget when - they were gone and we never caught another, despite many attempts.

Kahawai

8. About 1970, the Estuary channels were described to me by an experienced salmon angler as one of the prime kahawai fishing spots in the South Island. Most people I saw fishing for them at the spit tip and along Beachville Road at Redcliffs were bait fishing on the bottom. This is never productive, because Kahawai are pelagic surface feeders. This indicated to me that they were probably in the Estuary to feed on whitebait and the sprats of yellow-eyed mullet.

We trolled for them, using either a feathered lure to mimic whitebait or a floating spooned "mullet" bait. We simply had to follow the white-fronted terns (*Sterna striata*), and catch the fish beneath the flocks. Two of us in the dinghy often caught around 60 kahawai in about 1-1/2 hrs, then headed home while there was still water in the channels for the passage by boat.



Caption. A bygone age of fishing in the Estuary. Our typical catches of kahawai in the Avon Heathcote Estuary into the 1980s. Left 1985. Right 1987. P. Neal photo.

10. Catches of kahawai tapered off until by the late 1980s it was not worth the trouble to launch the boat.

Red cod and elephant fish.

11. I have never been much interested in fishing for red cod. However, my son was very keen, often fishing off the tip of the spit. He fished by casting well offshore, towards the centre of the channel. On occasions he was so successful that he came back for the wheel barrow to get his catch home.

12. We also caught a few elephant fish in the vicinity of the channel about 1975 although even by then, they were not very plentiful.

Moki

13. Moki could be fished off the spit or from a dinghy if one could cast the bait into the middle of the channel just off the old boat shed by Shag Rock. The largest moki caught by my son weighed 2.8kg. We caught 6 in one net haul in the channel about 1982.

14. We also caught a few sea-run trout and moki in the Avon River channel of the Estuary.

Flounder

15. Flounder were quite plentiful in the early 1970s and could be caught on a baited line at the Estuary mouth.

16. But much the most productive method was at night with a light and spear on high tide on the southern-300 metres of the east shore of the Estuary (the spit).

The flounder populations, particularly the yellow-bellied flounder, always seemed to fluctuate in numbers. Sand flounder populations seemed more stable, but this fish was not so much sought after because it is thinner and consequently yields less bone-free flesh.

18. We often fished for flounder with a drag-net. This involved a party of three: Two launched and hauled the net, and one handled the boat. Until about 1987 we usually limited our catch to about 20 - 24 fish. In recent years though, we would count ourselves fortunate to catch 3 - 4 fish in the course of 2 - 3 hrs of back-breaking work. Most recent drags of the net only succeeded in cleaning masses of sea lettuce off the bottom.

19. It was noticeable that when a bright moon lit the Estuary, or paddle crabs were present (they were occasionally there in huge numbers), then the flounders were absent.

20. Although takeable flounder (exceeding 10 inches length) are almost gone now, there are sizeable numbers of juveniles along the margins. I know this from watching white faced herons in the low-tide pools near the end of the spit, as they fish, strike, and lift their beak out of the water to swallow

the catch. That proves that there must be some breeding adults in the vicinity. Mr Batcheler has suggested an explanation in his contribution.

Nowadays

21. If I see an angler at the water's edge, I am always curious to enquire after their success. They seldom catch anything.

22. Yellow-eyed mullet usually move in on the incoming tide. The occurrence of pied shags are a good indicator that there are some fish there, but the days of hauling in three mullet at a time on a rod and line are long gone.

Summary

23. It is clear to me, as it is to other experienced fishers, that there are now few fish left in the Estuary. Those who I do see fishing are usually novices or "trying out" the area for the first time.

24. In my judgment, if there were fin fish present one would see pied shags surfacing to swallow their catch. It is tantalizing to speculate on the significance of the fact that I still occasionally see 3 - 4 shags right at the Estuary mouth, on the incoming tide.

25. Kahawai and white fronted terns will only come into the Estuary if there are mullet to catch. It is some years since I last saw large groups of terns diving over the Estuary. This used to be as certain evidence of the occurrence of fish as was anybody's catch.

26. So I am sure most fish have gone. And although heavy offshore fishing might be blamed for some of it, it cannot account for the disappearance of shrimp in the way it happened.

27. I therefore tend to throw my weight into the opinion that changes in the quality of water from the rivers and Bromley is probably the main cause. But pointing a finger at the relative importance of overfishing, effluent from the rivers, or from Bromley - is beyond my knowledge.

28. Thank you for this opportunity to present my evidence.

Peter A. Neal, 2 September 2001.

Walter C. Clark's case for the Estuary

Biographical Note

Walter Clive Clark. lives at Woodend, North Canterbury. He is Emeritus Professor of Zoology in the University of Canterbury where he was formerly the Head of the Department. He holds B.Sc. (zoology and geology) and M.Sc. 1st Class Hons (zoology:marine biology) degrees from the University of New Zealand and Ph.D. and Diploma of Membership of Imperial College of Science and Technology from University of London. He worked on pesticides for plant protection, toxicology and use of chloropicrin (a tear gas) to control seed borne diseases. His Ph D was on the biology of nematodes (round-worms) and their effects on soil biology and plant pathology.

He is a Fellow of the Zoological Society of London; Fellow of the Linnean Society; Fellow R. NZ Inst. Horticulture; Life Member of the Marine Biology Assn. of UK; Foundation member of NZ Marine Sciences Soc.; Life Member NZ Soc. Parasitology; Member NZ and International Societies for Soil Science, and of several societies concerned with studies of parasites, and others. He has published over100 papers on marine biology, soil biology, plant protection and pathology, animal taxonomy, reproductive biology, parasitology and the ecology of infectious diseases.

He has for the last two decades been deeply involved in water management matters, mostly on behalf of the North Canterbury Acclimatisation Society and its successor, the North Canterbury Fish and Game Council of which I chaired the Water Resources Committee. At different times he served on national bodies including the Freshwater Fisheries Advisory Council and the National Water Conservation Council.

INTRODUCTION

1. My case in defence of the Estuary embraces discussions on:

- The estuary as a habitat,
- Survey of the invertebrate animals and consideration of the potential effects of the proposal to discharge sewage effluent on them,
- The potential adverse impacts on the vulnerable, early life history stages of invertebrates,
- Freshwater as a pollutant for marine animals,
- The circulation of water and effluent within the estuary and associated problems,
- Effluent mixing zones, their nature, purpose and the implications of the concept on questions of water quality and compliance,

- The toxic effects of ammonia,
- Discussing public health aspects,
- Microalgae and s.107 of the RMA,
- Comment on Ultra Violet irradiation,
- State the view that **monitoring is not a remedy or a mitigant,**
- Discuss water conservation,
- Draw conclusions.

THE PROBLEM BEING ADDRESSED

2. The CCC (Christchurch City Council) has applied to the Canterbury Regional Council to discharge up to 500,000 m^3/day of treated sewage effluent into the Avon Heathcote Estuary at up to 17.4 m^3/second, at or about full tide, for the next 15 years. It has not commented on discharge options beyond that time.

3. Currently, the city discharges effluent into the Estuary pursuant to an existing use right granted under the Water and Soil Conservation Act (1967) and the Christchurch Drainage Act (1951). That Right expires in October 2001. There appear to be no consent conditions pertaining to the Right *per se.*

4. Evidence from the applicant establishes that the effluent has often been of very poor quality, but - in the absence of legal constraints - that has been permitted.

5. The 10-year sunset provisions of the RMA (Resource Management Act 1991) served notice on CCC that their Right would expire in October 2001. In 1996 the CCC established a Wastewater Working Party to examine and advise on the issues and options for future discharge. In the event, it ignored the recommendations it received (to pipe effluent directly to the ocean) and sought a "short" "15-year term" that would "enable Council to investigate the effects of effluent in the Estuary, and investigate alternatives". Clearly, the Council had ignored the looming problem until it was too late to draw up detailed plans for the future. I find it difficult to sympathise with their tardiness.

6. Consent to discharge effluent into water may be granted under the RMA, provided various requirements mainly of Part II are complied with.

7. The primary purpose of the RMA is to: **Promote the sustainable management of natural and physical resources** while providing for the needs of the present people and the reasonably foreseeable needs of future generations; safeguarding the life-supporting capacity or air, water, soil and ecosystems; and avoiding, remedying, or mitigating any adverse effects of the activities on the environment.

8. At the same time, those exercising powers under this Act are required to provide for the preservation of the natural character of the environment.

9. Discharges into the Avon Heathcote Estuary conflict with the requirements of the RMA in three major ways: (1) Public health; (2) Safeguarding the biological resources and all of their benefits of *mahinga kai* and recreational amenities, and; (3) to *sustainably* manage the biological and physical resources.

10. These legal requirements mean that examination of the application must consider ensuring that the present and future people will be able to use the estuary without risks to health, that its life-supporting capacity and natural character, and its biota (= all the naturally occurring living organisms), will be preserved and safeguarded.

ESSENTIAL BACKGROUND - AN HOLISTIC VIEW OF THE PROBLEM

11. In addressing the issue of effluent discharge we must remain aware of many other general matters. These include:-

- That the total human experience of living in large conurbations is very brief and limited in scope.
- That much experience of managing cities has been gained under circumstances very different from those applying today.
- That we depend utterly on the provision of safe water and safe removal of wastes, and thus probably owe our increasing human life span at least as much to plumbers and drain-layers as to medical practitioners.

12. In the context of the present application it is essential that we understand the dynamics of the receiving environment so that the potential ***effects*** of these applications, can be fully assessed within the well-established precautionary principle.

13. The **effects** of the proposed activity must be clearly established, so that any necessary precautions can be put in place and any adverse effects remedied or mitigated, as required by the Act. If this can not be done with certainty the application must fail. As I see it, the Hearing Panel, if **satisfied that all of the matters in Part II of the Act and other relevant requirements such as sections 104 and 107 CAN and WILL be met, the application can be granted with any necessary conditions to safeguard the environment and people. However, if substantial doubt remains about securing these assurances, the application must fail.**

14. I am convinced that the applicant to discharge effluent into the Estuary cannot meet the requirements of the Act and I beg to remind the Commissioners of the some realities of the situation:

- Sewage effluent must continue to be disposed of;
- The current consent has almost expired;
- Providing for discharge to a different place will take some time and;
- Public health must be safeguarded in the interim.

Because of these things, I urge that the following Consent and conditions be imposed:

- A Consent be granted for a maximum of five years;
- Within two years of the beginning of the Consent period the City should be required to lodge a *complete and processable*[1] application to discharge its treated effluent at some other site[2], and
- That appropriate work must be done immediately to reduce infectivity and ammonia content of the effluent so that the public health risk is greatly reduced and amenity values are improved.

THE ESTUARY

15. The Avon-Heathcote estuary has long been intimately involved in the lives of the people who live nearby. Archaeological excavations of the Moa Bone Cave at Redcliffs and the residues in old middens confirm reliance of Maori upon the birds, fish and molluscs for food. Later Maori and the early European settlers all found food and made other uses of the estuary, not the least important being as an access route into Christchurch *via* the Heathcote and the Avon rivers.

16. Estuaries are remarkable environments that are stressed by twice-daily tidal fluctuations of depth and salinity. Adaptations of organisms to survive such places are diverse, but often do not allow much leeway. They confer the ability - often tenuous - to cope with the daily rhythm but they may not be well suited to coping with the added insults of low salinity and toxins such as ammonia.

17. In addition to sewage effluent, the estuary receives increasingly disruptive river borne pulses of storm water from the hard surfaces of the city. This discharge includes plant nutrients, zinc, copper, asbestos from brake linings, and infective materials such as dog faeces. Whilst river-borne nutrients amount to only about 10% of those from Bromley, they have greatly increased since European settlement. The rivers would, even on their own, maintain

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[1] By "processable" I mean that as lodged the application will contain all of the information for it to be processed without any foreseeable need to invoke the provisions of section 92.

[2] It might be more fitting in legal terms if this were stated simply as an "alternative site," for it may not be appropriate for the hearing to determine the applicant's future options

sufficient phytoplankton to nourish the biota and to maintain some *Ulva, Enteromorpha* and *Gracilaria.*

18. As others will affirm, the estuary is an immensely complex ecosystem. Studies such as those of Thompson (1929)[3] and Bruce (1953)[4] and many more recent ones have given us lists of inhabitants and their habitats. However, these do not yet amount to an integrated understanding of the whole ecosystem. At best we may claim to have some small insights into the biology of a few of the constituents, but are very far from understanding the whole.

THE SEDIMENTS

19. My own studies in the 1950's,[5,6,7,8,9] showed that the distribution of estuary sediments can change markedly. On the seaward side of Humphrey's Drive in the 1950s, wastewater from the former starch factory nourished an almost continuous cover of a large brownish euglenoid protozoan on the mud surface. The sediments range from fairly fine sands to very fine "oozy" muds. The huge surface area and the electrical charges of the fine sediments undoubtedly conferred on them a huge capacity for the sorption of materials.

20. I expect it will eventually be shown that the mud is a huge reservoir of nutrients, and that it has a considerable capacity to buffer changes. Professor O'Connor considers the nutrients in some detail in his case.

21. The sediments and the materials they contain are the habitat of crabs, annelid worms in great variety; rounds worms, flat worms, and proboscis worms; burrowing molluscs such as

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[3]Thompson, E F 1929. *An introduction to the natural history of the Heathcote Estuary and Brighton Beach, Canterbury, New Zealand.* A study in littoral ecology. Unpublished M. Sc. Thesis in Biology, Canterbury University College, New Zealand..

[4] Bruce, A. 1953. *Report on a biological and chemical investigation of the waters of the Avon and Heathcote Rivers. Christchurch Drainage Board, Christchurch.*

[5] Clark, W C 1957: *Studies on some littoral trochid gastropods belonging to the genera* Melagraphia *Gray and* Zediloma *Finlay.* M. Sc. Thesis, Canterbury University College, University of New Zealand. 193 pp.

[6] Clark, W.C. 1958: Escape Responses of Herbivorous Gastropods when stimulated by Carnivorous Gastropods. *Nature,* **181:** 137-138.

[7] Clark,W.C. 1958: Notes on the Mantle Cavities of some Trochid and Turbinid Gastropods, *Proceedings of the Malacological Society of London,* **33:** (2) 57 - 64.

[8] Clark, W.C. 1958: A new Cotylocercous Cercaria from *Melagraphia aethiops* (Gm.) (Gastropoda). *Transactions of the Royal Society of New Zealand,* **85:** (4) 681 - 683.

[9] Clark, W.C. 1958: The New Zealand Species of *Melagraphia* Greay, and *Zediloma* Finlay (Mollusca, Gastropoda), *Transactions of the Royal Society of New Zealand,***85: (4) 659 - 679.**

cockles (*Austrovenus stutchburyi*), wedge shells *Tellina lliana*) , and pipis[10]. Some of these animals derive their food from the sediments, and some from the waters above or on the most superficial sediments. But to focus on the macroscopic is to very largely ignore the great abundance of microscopic life in and on the sediments, and so to fail to comprehend the ecosystem.

22. Much of the contained biota will either move with the containing sediments as these are moved around, or they will be exposed to predators. Because movements tend to be gradual, and most individuals are microscopic, few die-offs are ever noted.

VERTEBRATES

23. The survival of many specialised bird species depends utterly on survival of their prey. For example oystercatchers (*Haematopus finschi*) prey heavily on the cockles (*Austrovenus stutchburyi)*. Others such as stilts (*Himantopus leucocephalus*) and godwits (*Limosa lapponica*) probe for various worms, and a fewer still prey on the deeper burrowing wedge shells (*Tellina liliana*).

24. The bird populations of the estuary change seasonally. Some, like the godwits, migrate beyond New Zealand, others like South Island Pied oystercatchers leave the estuary in spring and spend the summers nesting in inland braided river beds and farms finding food for themselves and their chicks from terrestrial sources.

25. International migrants like godwits, curlews*(Calidris sp.*), and whimbrel (*Numenius variegatus*) that breed in the Arctic migrate through regions of burgeoning human populations. There they are hunted for food. Also threatening their survival, their food resources are shrinking because of pollution, reclamation and other causes. This is a matter of international concern. Reduction of food resources in such places as the Avon Heathcote estuary could have impacts far beyond New Zealand.

26. Many factors may limit the abundance and diversity of fin-fish in the estuary. Other witnesses have described marked reduction in numbers and species diversity during the 30 years that have elapsed since Webb's studies in the 1960's. We do not know precisely why or how this has happened. However, we do know that effluent discharge is likely to be deleterious to fin fish. CL Batcheler and PA Neal have given evidence on this for the Estuary Association (see elsewhere in this publication).

27. The AEE (p. 6-34) notes that A.R. Kilner[11] found that prolonged exposure to water of low salinity killed juvenile sand flounder (*Rhombosolea plebia*). A few years earlier R. Mundy[12]

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10 Few people now see any sign of the true pipi (*Paphies australe)* in the estuary.

11 Kilner, A. R. 1973: *The biology of the 0-group sand flounder (*Rhombosolea plebeia) *in the Avon-Heathcote estuary.* M. Sc thesis, Zoology, University of Canterbury.

12 Mundy, A. R. 1968: A study of the biology of the sand flounder *Rhombosolea plebeia Richardson* off the Canterbury Coast. Ph. D. thesis, Zoology Department, University of Canterbury.

identified the vital role of mud- and sand-flat areas of the Avon - Heathcote estuary as nurseries for Canterbury populations of juvenile sand flounder. Flounders about <2 cm total length were formerly very abundant on the estuary flats. They are very vulnerable to low salinity. Obviously, they must survive this vulnerable stage if the population is to persist. (The sand founder should not be confused with the euryhaline black flounder [*Rhombosolea retiaria*] which is most abundant in fresh or brackish waters and is the mainstay of the Lake Ellesmere flounder fishery[13]).

THE INVERTEBRATE FAUNA

28. Phytoplankton comprise the base layer of the estuary food chain and are only perceived by non-specialists as an olive-greenish tinge left on sand surfaces as the tide recedes. The invertebrates that depend on them are diverse and abundant, and also usually unseen, despite their vital roles near the base of the food chain.

29. Most conspicuous are the abundant mud crabs *Helice crassa* and *Macrophthalmia hirtipes*. Females typically hold the fertilised eggs beneath the "tail" until they hatch. These are released into the water as planktotrophic forms which, upon reaching a megalopa development stage, settle on the bottom.

30. Molluscs of the estuary fall into two main reproductive groups. The pulmonate snails (*Amphibola* and *Potamopyrgus spp.*), like all essentially freshwater-adapted snails, copulate or are parthenogenetic[14], and so do not expose their sperm to the water. The other group, as far as is known including all the other snails, winkles, top shells, whelks, etc. cockles, pipis, wedge shells, and mussels, all release ova and sperm into the water. The fertilised eggs hatch into free swimming, planktotrophic molluscan veliger larvae. Their drifting, swimming planktonic stage finishes when they settle on suitable bottoms and grow into adults.

31. The "worms" that inhabit the mud and all other imaginable habitats, belong to several different phyla,[15] of which the Annelida (which includes all of the paddle-worms or polychaetes) is the most diverse and conspicuous. But other vermiform creatures include the nemertine worms, and the much smaller and vastly more abundant round worms (or Nematoda). The flat worms, of several kinds, with their juvenile Müllers larva, all belong to the phylum Platyhelminthes.

32. With few exceptions, reproduction of all of these animals involves the release of gametes or larvae into the water. These very early life history stages are most vulnerable to the

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[13] Ayling, T. and Cox, G. J. 1982: *Collins Guide to the Sea Fishes of New Zealand* .Collins, Auckland, 343 pp.

[14] Clark, W.C. 1978: Hermaphroditism as a reproductive strategy for metazoans: some correlated benefits. *New Zealand Journal of Zoology* **5**: 769 - 780.

[15] A phylum (plural: phyla) is the major division of the Animal Kingdom. Well known large divisions of this rank include for examples: Annelida, Arthropoda, Mollusca, etc.

proposed effluent discharges.

33. A simple, but commonly over-looked fact of life is that sperm, which because of their shape have huge surface area to volume ratios, have no osmo-regulatory capacity whatsoever. Thus, in freshwater, spermatozoa quickly die[16]. This has profound consequences[17]. The sperm of freshwater fishes such as trout and salmon must penetrate into eggs in much less than a minute. If they take much longer they absorb water and burst. But herring sperm reportedly can fertilise eggs even after swimming in the sea for more than 24 hours!

34. It follows therefore that if a plume of sewage effluent, which is essentially only dirty "fresh" water should impinge upon the sperm of estuarine animals there is scant possibility of their survival. Not only will the water of low tonicity[18] destroy sperm, it must be expected to destroy larvae.

35. The marine invertebrate larvae being considered here -(veligers of molluscs, trochophores of polychaetes, pilidium larvae of proboscis worms, or Müller's larvae of flatworms) - all are minute creatures. They are "all surface and no core."[19]. Their surface is a semi-permeable membrane through which water moves according to the osmotic gradient. In the face of hostile osmotic gradients these tiny animals either burst from the uptake of water or shrivel from its loss. Death is typically rapid and inevitable. Crustacean larvae are different, but also at risk.

36. Because of the relatively large surface area, the minute larvae are very vulnerable to toxic materials in the water. Any toxic material in the discharged effluent, such as ammonia, can have devastating effects on juveniles or larvae even though adults of the same species can tolerate it. This explains why some populations may remain low or decline even although the adults appear able to tolerate the environment. Recruitment failure is the problem.

37. WATER MOVEMENT

38. The CCC Applicants described the movement of effluent after discharge. They did not ascertain its movement at the maximum discharge rate sought (17.4 m^3/second), even though that result (dispersion, mixing, creation of water channels?) is likely to be different from that of the Lincoln dye experiment (outflow 2 x 2.7m^3/second). As stated in the

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[16] Spallanzani, L.1776: *Opuscoli di Fisica Animale e Vegetabile.* Modena.

[17] Clark, W.C. 1981: Sperm transfer mechanisms: some correlates and consequences. *New Zealand Journal of Zoology* **8** 49-65.

[18] The "tonicity" of a solution is a measure of the osmotically active particles dissolved in it, and which contribute to the osmotic pressure of the solution.

[19] Surface area to volume ratios are vital considerations in the biology of small organisms because the volume of a sphere varies as the cube of its radius, but the surface area is proportional to the square of the radius.

AEE, and as Dr Peirson and Mr Tipler stated in evidence, the movement, location, and degree of mixing or dilution of the effluent is currently not understood, and very little information appears to be available for the greater part of the area involved.

39. They therefore asserted that they require a mixing zone that would be free of conditions, and that **the mixing zone should be the whole estuary.** This inevitably implies that at least occasionally effluent discharges must be expected to adversely effect reproduction of virtually all of the estuary's inhabitants over all of the estuary's area.

40. The Applicant's witnesses appear to have concentrated on what may happen in the estuary channels. Scant attention has been paid to the extensive flats where most of the inhabitants live at least some of the time. Do they not matter?

41. Effectively, hazarding a season's reproductive effort on the undetermined chances of adequate mixing is being proposed. I am strongly of the opinion that to embark on an activity that has unpredictable consequences, or an activity which can be confidently predicted to be inimical to the continued survival of significant parts of an ecosystem, is contrary to the provisions of the RMA.

42. Given these uncertainties, the Application warrants the diligent application of the precautionary principle, and for careful attention to the meaning of effects as set out in s.3, particularly (d), (e), and (f) of the RMA.[20] Mr Currie for the Estuary Association deals with these matters in detail.

43. Layering of saline and non-saline waters within the estuary could affect the outcomes. If heavier, more saline water impinges consistently on the benthic organisms at the time of gamete or larva release, osmotic or toxic effects could be avoided or ameliorated. On the other hand if propagules are thrust into near fresh water then mortalities may be high enough to destroy one or several season's reproductive effort.

44. The uniform sized populations of sandy shore bivalves show that they often consist of few annual recruitment pulses. This indicates that although huge numbers of propagules might appear to amount to prodigiously wasteful reproduction, high "insurance" is necessary to off-set high juvenile mortality for the maintenance of stable populations in the long-run. If replacement is more than this, the population grows: if it is less, the population shrinks, and may disappear.

45. If the discharge so modifies the environment that reproduction of estuarine organisms is reduced, many "chain reactions" will be initiated within the ecosystem. Other species may breed less prolifically and thus, as the essential food of another, set a down-wards chain reaction going. The top predators would be most reduced most rapidly.

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[20] "(d) Any cumulative effect which arises over time or in combination with other effects - regardless of scale, intensity, duration, or frequency of the effect, and also includes -
(e) Any potential effect of high probability; and
(f) Any potential effect of low probability which has high potential impact."

46. Many matters discussed here are not immediately self-evident to lay people. Phytoplankton, pathogenic bacteria, gametes, or larvae are so small or transparent that we are not aware of them, and yet they are all important. It is a truism that an organism is its whole life history - no stage is more important than any other. Failure to survive at any stage is equally fatal!

47. MIXING ZONES

48. Mixing zone problems have been discussed, but not resolved. They are areas below discharge points in which water quality standards are not met, and do not have to be met. Nonetheless, under the RMA, the passage of fish must not be completely obstructed.

49. Some matters relevant to mixing zones are discussed in pp 8-11 to 8-13 of the AEE. The important conclusion is that the circulation is so poorly understood that the whole of the estuary is considered to be the mixing zone *for the water discharged at the peak of the tide.* We are told elsewhere that about 45% (or more) of the water discharged on one tide will return to the estuary on the next. I have found no satisfactory discussion of its circulation, mixing, or its salinity at specified points.

50. If certain knowledge were available, then presumably the whole of the estuary would not be claimed as the "mixing zone," and the statutory purpose of water classification would not be thereby compromised. This is surely a most significant declaration of the applicant's ignorance of the receiving waters and is tacit admission that without that knowledge, they cannot assert compliance with the requirements of the RMA.

51. If the whole estuary is the mixing zone, there will be no defined "mixing zone" as conveived under the Act. Thus there will be no effective limit for *E.coli* , enterococci, viruses, or any other pathogens within it. "Contact Recreation Standard Water" would simply not exist. The application thus knowingly seeks to classify the most important single body of recreation water in Christchurch as hazardous to health. I consider the proposition to be almost obscene.

52. Mixing zones may not be so situated, and so extensive as to frustrate the purposes of water classification[21]. If the mixing zone of the estuary is allowed to be co-extensive with the estuary then the mouths of both rivers may be so blocked by polluted water that migratory fish such as whitebait, trout, bullies, smelt and eels could be prevented from penetrating them. The City Council's case requires ultimately that the mixing zone should also extend out into Pegasus Bay if constant risk of breaching RMA conditions is to be removed. Again, the whole-estuary-mixing zone proposition becomes an absurdity.

53. The applicant has not furnished sufficient reliable information, for the effects to be known. Those assertions that are reported are often based on few samples, and rarely disclose

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[21] Rutherford, K., Zuur, B. and Race, P. 1994 Resource Management Ideas No.10: "Reasonable Mixing" A discussion of reasonable mixing in water quality management. Ministry for the Environment 15 pp.

annual patterns let alone year-to-year variation.

54. The Applicant's witnesses to not appear to realise that water of low salinity is a grave pollutant for many estuarine organisms. Effect on salinity does not constitute a water quality parameter and this, to any biologist, must be seen as a fundamental flaw because changes of salinity *per se* constitute habitat contamination for many estuary inhabitants

55. The distribution of organisms across the estuary reflects their ability to maintain their numbers in the face of regularly or even infrequently occurring conditions. The bottom of channels that convey freshwater at low tide are typically devoid of marine animals. Before effluent began to be discharged in the 3-4 hrs after high tide, the higher flats were usually covered with high-salinity water (c. 30 $^{0}/_{00}$ or more), and inhabited by animals that are relatively intolerant of freshwater. But the Consent proposal aims to discharge about 5 times the maximum rate of the average dry weather flow of the Avon and Heathcote combined - potentially in a deluge - into unknown areas of the Estuary, with unknown results. They may be dire.

56. AMMONIA

57. Understanding of the effects of ammonia in New Zealand fresh waters has advanced considerably through the recent work of Hickey and associates[22],[23],[24],[25]. There have not been comparable advances or New Zealand studies of the marine situation, but it is interesting to notice that the USEPA guidelines show little difference of tolerance of animals in marine and freshwater habitats. Dr Hickey advises me that the new ANZECC guidance value as total ammonia-N value for marine environments is 0.91 mg N/litre at pH 8. I note that the US EPA 1989 ambient water quality criteria for *saltwater* [not marine habitats] are all stated in terms of 96-hour exposures for which the LC_{50} and EC_{50} were determined. These short exposures are largely irrelevant when considering the fate of animals that are exposed for longer periods or are repeatedly exposed. For such circumstances chronic toxicity may be much more significant. For example, in his acute work (Hickey and Vickers 1994) found a 96 hour acute EC_{50} 0.59 g/m^3, for *Sphaerium novaezelandiae*, but when the same species was exposed for 60 days they found that concentrations of 0.28 g/m^3 (half the acute value) stopped reproduction completely. Of

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[22]Hickey,C.W. and Vickers, M. L. 1994: Toxicity of Ammonia to Nine Native New Zealand Freshwater Invertebrate Species. *Archives of Environmental Contamination and Toxicology* **20** 292 - 298.

[23]Hickey, C.W., Golding, M.L., Martin, M.L. and Croker, G.F. 1999: Chronic Toxicity of Ammonia to New Zealand Freshwater Invertebrates: A Mesocosm Study.*Ibid.* **37**338 - 351

[24] Hickey, C.W., Golding, L.A., Martin, M.L., and Croker, G.F. 1999: Chronic Toxicity of Ammonia to the Frshwater Bivalve *Sphaerium novaezealandiae. Ibid.* **36**, 38 - 46.

[25] Hickey, C.W. 2000: Ecotoxicology: laboratory and field approaches. Pp. 313 - 343 IN *New Zealand Strean Invertebrates: Ecology and Implications for Management.*[Eds. K.J. Collier and M.J. Winterbourn] N. Z. Limnological Society and NIWA, Hamilton, 415 pp.

course, a species that does not reproduce is effectively dead.

58. I do not know of any experimental results for repeated sub-lethal acute exposures to ammonia. Exposure for 60-days to what were formerly considered "low" or "very low" concentrations causes cessation of growth and/or reproduction (CL Batcheler also discusses chronic immersion in detail). We should therefore be very cautious about dismissing repeated exposures to intermediate concentrations as having little or no effect.

59. As stated earlier, the loss of potentially more vulnerable species near the base of a food chain ultimately condemns the predators nearer the top. Certainly, New Zealand freshwater studies clearly show that whilst ammonia often has grave effects on vertebrates, its effects on invertebrates can be cataclysmic. The effects on gametes, larvae, and very small young are currently unknown.

60. Data in the tables in the USEPA 1989 guideline for saltwater inhabitants appear to have been derived from non-larval fish. The brine shrimp *Artemia salina* is the only invertebrate whose name I recognise, and it is an inhabitant of strongly saline water bodies such as NZ Grassmere Salt Works. Curiously and importantly, *Artemia* populations consist of parthenogenetic females (i.e. they reproduce asexually). They often show unique degrees of polyploidy and aneuploidy[26]. They are not typical of shrimps that might inhabit the estuary.

61. The ammonia levels reported in the AEE as occurring in the discharge are quite intolerable over a long-term. At pH's over 8.0 and temperatures above 20^0C - as in the Estuary - ammonia is most toxic. (See table 14 (p.17) of Gilson's evidence).

62. At present we have only fragmentary data on the toxicity of ammonia to marine fishes, and I have seen none for marine invertebrates. Recent work on freshwater invertebrates by Hickey shows acute EC_{50} values[27] for 96 hour exposure (less for some species) for New Zealand freshwater invertebrates were all less than 1 gram of un-ionised ammonia /m^3. The amount of ammonia in the discharge will increase as the demands on the plant increase (see Tipler Table 6-8 (p.64)).

63. These toxicity considerations have to be considered in the light of the mixing data. At para 253 Tipler stated that "the ammonia criteria can be met provided the ammoniacal nitrogen concentration in the discharge is less than 24 g/m^3 in the summer and 46 g/m^3 in the winter, ***assuming a 10 times dilution in the mixing zone.***" Given that he doesn't know

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[26] Most species have individuals whose chromosome numbers that are 2 x *n*, where *n* is a whole number (in humans it is 13). 1*n* = the haploid number, 2*n* = the diploid number, any other multiple of *n* is a polyploid as triploid, or tetraploid. In *Artemia* populations are known up to 22-ploid. That is they have 11 times the normal chromosome number. Aneuploids are forms in which one or more chromosomes have been lost in the polyploids.

[27] For practical purposes the EC_{50} value (effective concentration at which 50% of the population give the response measured), is the same as the LC_{50}, that is the concentration at which 50% of the population dies, for that is the response that is measured.

where the mixing will occur, the effect is analogous to an interminable game of Russian roulette. Mixing of considerably less than 10-fold was considered likely during the presentation of evidence. There is no security.

64. Given the very tentative nature of the reference data for marine invertebrates, and the data supplied in evidence I consider that there is no margin of safety in this application. The precautionary principle surely prompts the outcome that it be dismissed.

65.PATHOGENS AND PUBLIC HEALTH

66. Apart from often short-lived concerns about goitre, tuberculosis and polio and the influenza pandemic of 1919, public health has not assumed a high profile importance in New Zealand,. This situation has changed, and concerns will continue to mount[28].

67. When New Zealand was first settled, the sea passages were so long and trying that generally only the fit, the lucky, and the essentially disease-free survived the journey. They introduced relatively few active pathogens.

68. Now, with mass-Aviation, exotic diseases can be moved into new areas, often within the incubation time of the infections, on or in people, animals and plants so visitors and tourists often unwittingly bring their diseases and parasites with them.

69. As recently as 30 years ago few New Zealanders had even heard of *Giardia* or *Cryptosporidium.* Fewer still were likely to return from Bali with a belly-full of the pig tapeworm (*Taenia solium*) that is virtually extinct in the rest of the world, but abundant in parts of Indonesia. So our welcome to people from such places obliges us to sanitise the residues they leave behind. Otherwise their tourist dollars will come at high cost.

70. The proposed plant upgrade is to increase the *capacity* of the plant to deal with a greater population and release the effluents and residual infective agents into our most important marine playground.

71. Certainly some attention is now being given to the control of coliforms and enterococci, ***in the future, but not now!*** This is the sort of stance that has resulted in the Centre for Disease Control noting that the incidence of gastrointestinal disease in New Zealand is at the very highest world levels for a developed country This national lack of concern seems to be reflected in the AEE. It also appeared in the reluctance of witnesses to consider that greater public safety from early installation of the UV facility would be justified. Currently the effluent contains a much greater number of faecal coliforms than are permitted in contact recreation waters, and this situation will persist for some years if present plans are implemented.

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[28] For readable, not too technical, reviews of this topic I suggest: Crump, J.A., Murdock, D.R. and Baker, M.G. 2001. Emerging Infectious Diseases in an Island Ecosystem: The New Zealand Perspective. *Emerging Infectious Diseases* 7 (5) Sept-Oct 2001. [Can be accessed at Center for Disease Control web site www.cdc.gov/ncidod/eid/vol7no5/crump.htm.] and Jason Eberhart-Phillips' paper-back *Plagues on our Doorstep* , 208 pp. Tandem Press, Auckland 1999

72. MICROSCOPIC ALGAE

73. The effluent is "visually intrusive" because of the bright green colour of its abundant algae. A discharge of this quality is ostensibly forbidden by s. 107 of the RMA, but much will depend on the decision arrived at about the nature of mixing zones.

74. I have not found any information in the Applicant's case that deals with the relative costs of removing algae and the consequences of this on the specification of the proposed UV plant. If as described the UV plant will be "a major user of electricity", removal of (UV absorbing) algae before irradiation would be an economic proposition.

75. ULTRA VIOLET IRRADIATION

76. No adequate discussion of the proposed UV facility has been published. Some UV plants are effective, but another close to my home is a disaster. At present we can only hope that whatever requirements are set will be met.

77. The trials reported have not dispelled my doubts. No information is supplied on their conduct. Were initial knock-downs measured, or were they measured after some "recovery time" had elapsed?

78. The AEE contains no data on the effectiveness of UV at any stated dose in killing encysted protozoans (e.g.*Giardia* or *Cryptosporidium*), or any stated kinds of bacterial spores. Helminth eggs are not mentioned. There is a dearth of information.

79. The limited sampling for viruses (two occasions) in February 2000 when solar radiation would be highest and viable viruses at their lowest, was hardly reassuring.

80. I notice there is no discussion of the expected effects of diverting influent away from the treatment plant and directly into the ponds when heavy rain causes high inflows. Under these circumstances the inflow may be dilute, but the high volumes may shorten residence time in the ponds. How is this circumstance expected to affect outcomes?

81. MONITORING AND SETTING LIMITS

82. There is much "loose talk", especially in the AEE, about "monitoring" in the context of avoiding, ameliorating, and remedying deleterious effects. **Monitoring,** *per se,* does not abate deleterious effects. Unless specified actions **must and always will** follow detection of "trigger" infection levels, there is no necessary connection between monitoring and any abatement of effects. Monitoring can therefore be understood as essential but this must not be confused with doing anything about any undesirable situations that may arise.

83. Much of Mr McBride's evidence was excellent, but there is room for a different view about reporting and setting limits. Maxima are of two kinds. As a biologist I am often appalled by the engineers' love affair with medians and means. They often avoid describing the range or fail to estimate the central tendency of their data (e.g. standard deviation).

The median that they so freely use is biologically a useless statistic. It merely enables engineers to make the sky the limit! Their use implies that exceeding some arbitrary limit, no matter by how much, or how lethal that may be, is acceptable provided it is not done too often!

84. Being slack about compliance in this way, seems to invite a mind-set in which it is OK to push the limits, because in fact there are none! Regardless of the size of the excursion, as long as their number is within limits all is well, despite compelling evidence to the contrary! As long as the consent holder has control of monitoring, all will be well for the holder, but not for the environment. If monitoring is in the hands of the consent holder, sampling can easily be arranged to be at times of low risk of offending values (such as at high tide in the Estuary, before effluent is discharged). Plant operation can be manipulated to ensure low values (such as delaying discharges until after samples are taken). Far too often samples are not taken at truly random times so do not reflect reality. Sampling must never be left wholly in the hands of any organisation whose work is under examination.

85. If the parameter being considered is an important one, then the interests of the RMA, and its objective, sustainable management, will be served by heeding Mr McBride's observation in para 45 (p.6). "*For example, in order to calculate the 16/25 rule for the median concentration limit it is* ***assumed that the median effluent concentration was exactly at its allowable limit.***" If this is so, then all exceedances must be potentially damaging, and logically should be avoided, so it will seem that in such a case a 16/26 rule favours the discharger at the environment's risk. He proposed alternatives.

86.COST OF LIFE IN CITIES

87. The costs of living in cities are rising as more and more elaborate and reliable means are used to protect the health of the people and their environment.

88. Over time Christchurch has enjoyed large-scale economies in the provision of safe potable water, but there has been no corresponding willingness to expend comparable sums on safe, secure sewage services. The city is currently spending much money on an art gallery, sporting venues, road highways; it is contemplating involvement in a marina at Lyttelton and an artificial wave-promoting reef at New Brighton. But it is evidently not prepared to spend money on securing the long term health of its inhabitants and their environment. As shown throughout this paper, there is abundant evidence that our health is being adversely affected by inadequate effluent discharge arrangements. It is therefore clear that we should take steps now to diminish these problems by using a well designed and constructed outfall to the ocean that will mitigate very strongly against encountering major public health problems in the long term. What will be the financial, health and costs in human misery of postponing this expenditure?

89.CONCLUSIONS

90. The AEE outlines several ill-coordinated studies that suggests an attitude of "anything is OK", and "conditions don't matter" that may have been inherited from the condition-less

Christchurch Drainage Act of 1951. The investigations into the ecology of the estuary have been sporadic, brief, and lacking in integration. Such understanding as emerges of the potential for harm rests mainly on the macroscopic and the obvious, whilst ignoring the multitudinous, but minute. The immediately invisible influences, like ammonia, pathogens, and low salinity water, have not received adequate consideration. Even the consequences of changing the discharge pattern in the 1970s have escaped assessment for 30 years. Fish have gone unstudied for more than 30 years. No attempt has been made to portray the year round picture for any parameter.

91. The Application and its AEE documents reveal no evidence among the planners of recognition that, to persist, the biota must reproduce. And as shown here, it is the immature life stages that are most vulnerable to polluted water. The unreported extreme values are the ones that kill!

92. Because of the large number of unresolved but important questions that remain, I urge that priority be given to improving effluent quality, rather than concentrating on immediate increases in capacity of the Bromley processing plant. Concurrently, the city should promote the investigations needed to support an application to discharge via an ocean outfall. CCC received sound advice from its Wastewater Working Party, but it perversely and arbitrarily ignored it. Now it should be denied a long-term consent to continue the destruction of the estuarine ecosystem.

93. **FINALLY:** The Resource Consent applied for conflicts with so many provisions of the RMA that it must be denied. BUT, sewage must continue to be removed. The Christchurch Estuary Association accordingly proposes that consent should be allowed for a few years to enable an alternative discharge to the ocean to be designed and built. This is NOT the time to rest on non-existent laurels.

94. CONTINUATION OF THE BRIEF OF EVIDENCE OF PROFESSOR W C CLARK REGARDING LATE EVIDENCE BY PROFESSOR G A KNOX.

95. This brief is prepared because evidence from Professor Knox was delayed because of his absence until Monday 26 November 2001.

96. Crucial to Professor Knox's evidence is the present system of discharging effluent from near high tide about 3 hr. thereafter. This discharges a large amount of non-saline (freshwater) into an essentially marine environment. A large number of estuarine environments are referred to in Prof Knox's evidence. I am not aware of any evidence from him of **any** place in the world where large discharges of freshwater occur into a marine habitat ***without harmful effects on a rich and diverse biota such as occurs in the Avon-Heathcote Estuary***.

97. In this connection I again highlight the fact that in natural estuaries the fresh waters are backed up into the contributing streams by the incoming tide. When the tide ebbs, the

saltwater drains off the upper flats and goes out to sea. As the tide ebbs, the water backed up into the lower tidal reaches drains away *via* the deeper channels. Thus the water in the tidal channels changes from salty when the tide is in to fresh- or river water - when the tide is low. Marine fishes are commonly found in the fully saltwater (salinity near 35 parts per thousand). The ebb-tide low-salinity water is typically devoid of inhabitants. Very few organisms tolerate both fully freshwater, and sea water.

98. It is therefore totally at odds with any notion of sustainable management to discharge large volumes of freshwater at the rates, volumes and times proposed in this application. Professor Knox has not commented on this matter. I suggest the problem highlights Mr P A Neal's evidence that fishing declined in the Estuary at about the time (early 1970s) that the pattern of discharges was altered. The greater ammonia concentrations in the more concentrated "slug" of post-1972 effluent has probably had significant toxic effects on juvenile fishes, and dissuaded adult fishes from entering the Estuary.

99. There does not appear to have been any serious attempt to assess the effects of this unnatural discharge pattern.

100. At §21 (c) ***Currents*** Knox notes that swift currents prevent settling and development of algal sporelings. I suggest that the swiftest currents in the estuary tend to occur in the channels where the water is regularly least saline and inimical to algal survival or growth. (Knox notes that *Ulva* and *Enteromorpha* tolerate 30% to 100% seawater).

101. At his § 23 [this with § 22 has been inadvertently inserted between §21 (f) and (g)] Knox explains that the "peak of the tide" discharge was seen as a means of reducing the upstream movement (and retention) of discharged effluent. If it is to: Minimise the residence time of nutrients that cause eutrophic conditions and bring about excessive growths of nuisance algae; to minimise the very toxic effects of the ammonia; to minimise public health risks from contained infectious materials; to avoid the uncontrolled effects of inadequate mixing within the mixing zone, and the re-entry of effluent into the estuary, then surely the best option is to discharge the effluent outside the estuary, where modelling of the dispersal from a diffuser 2 km off-shore showed that discharges seldom return to the estuary at all.

102. §32 creates problems of interpretation. We read "In 1977 Stephenson (1981) carried out...(Fig 4.4. [but the legend to Fig. 4.4 says: "Stephenson (1982)", while in the References the only Stephenson entry is "Stephenson, 1980." When was the work published?] Further, in §33 "In 1991-92 the cockle densities were resampled... The results are plotted in Fig 4.5... But, the legend to Fig.4.5 reads: "Density of the cockle *Austrovenus stutchburyi* from the 1979 - 80 survey." Whence the data in Figure 4.5? Did the changes incorporated in these maps occur over 2-3 years or over 14 years? Was it possible to tell if the changes resulted from deaths or from enhanced recruitment? If the changes occurred over 14 years, what changes occurred in the volume and characteristics in the effluent over this period? I find that overall, no consideration has been given to the changes that must have occurred in the volume and characteristics of the effluent since its first discharge in 1962, and the uncertain dates of sampling. It remains something of a

mystery just what is being measured. Do the population numbers reflect the growing extent of the Christchurch sewerage system, the quality or quantity of the effluent or both?

103. Prof. Knox notes:-

104. *"Changes in density towards low tide could be attributed to changes in channel configuration."* What does this mean? The most conspicuous change between the two figures is the disappearance of cockles from the southern shore of the estuary along the causeway and beyond. How is this related to changes in "configuration"? Perhaps it is directly related to the disappearance of the mud that was formerly there. On the other hand, perhaps we are meant to be looking at data from 1991-92. They are not supplied.

105. Table 4.2 Changes in density of *Amphibola crenata* at Mount Pleasant presents more difficulties in interpretation. First there is the problem of the meaning to be given to the label at "A" viz. "No. m^2 at 13 stations (counts per 20 m^2)" Are the values the means of counts from 13 different replicates, each of 20 m^2?

106. If so, we should be able to divide the value in A in Thompson's report 1929 (not 1920) by 20 to get the mean number of snails per square metre in those samples. This would give a *mean* density of 63.8 per square metre. But in part B of the table we find that the *maximum* density per square metre for Thompson's samples was 18, or 28% of the mean value per square metre calculated from the data given in part A. This indicates an error due to haste of preparation of Evidence. Similarly, for example, Griffen and Thompson's 1992 values in A yield a mean density of 974.8 per square metre, yet in part B Prof. Knox states that the *maximum density per square metre* is only 121! It is interesting to note that *Amphibola* increased by 513% between 1929 and 1959, a period during which discharge changed from seepage through Bromley sands to the piped discharges that began in 1962.

107. §41 Reduction in nitrogen levels. It is claimed that there will be a reduction of 25% in nitrogen following the upgrade. However, no allowance is made for the increased capacity of the plant from 130,000 m^3/day to 200,000m^3/day (a 54% increase) - and ignoring the increased peak flow of 500,000 m^3 which is also incorporated in the upgrade. The end result is surely an increase in the total nitrogen coming into the estuary from the sewage treatment plant. Knox does not discuss the toxic effects of the ammonia. Professor Knox's data and arguments should be considered alongside the evidence of Professor O'Connor and C.L. Batcheler who reached very different conclusions about nutrient inputs, balances etc.

108. At §47 Knox considers the estuarine biota solely in terms of nutrients from the sewage treatment plant. He does not consider the inputs from the Avon and Heathcote Rivers that originate in stormwater. Again O'Connor's evidence is especially germane. Note especially that Professor Knox discusses only what ***could*** happen. He offers no estimates of probability, or what is likely to happen. Perhaps even more importantly, he does not even suggest that any harm could result from reducing the nutrient input into an already

eutrophic estuarine ecosystem.

109. The concluding paragraph, §51 is interesting. Note the first sentence reads: *"Currently, the estuary, apart from a recent increase in green algal populations,* ***is in a stable situation.*** " But he then goes on to state that since Thompson's pioneer studies *"..it is clear that the overall productivity of the system has* ***increased*** *considerable [sic]. This is due to a probable* ***increase*** *in phytoplankton production, a* ***considerable increase*** *in benthic microalgal production and, as a compensation*[29] *for the loss of input of organic matter from the reduced marginal vegetation, by the* ***considerable input*** *of particulate organic matter (bacteria, phytoplankton, zooplankton and detritus) from the Oxidation Pond effluent. As a result there have been* ***increases*** *in the populations of consumers such as filter and deposit feeding invertebrates, possibly fish*[30] *and birds."*

110. From the above it is clear that Knox regards continuing increase as stability. He goes on: *"With a* ***reduction*** *in the input of nutrients, particularly of nitrogen, from the treatment plant the overall productivity* ***might*** *decline. It would stabilize at a lower sustainable level."* I agree with this statement, provided of course that other factors, such as the input of nutrients from other sources would allow such stability to be achieved.

111. "ISSUES" RAISED BY THE COMMISSIONERS ON 14 FEBRUARY 2002 AND PRESENTED IN APRIL 2002.

112. **Issue 1.** Mr Bourke listed options that could be used to reduce ammonia levels add nothing not included in the Becca Consultant's report that was not admitted in evidence. There is no commitment on the part of the applicant to use any of these options - merely an indication that they exist, and that if installed, and successfully operated, the amount of ammonia discharged *could* be reduced substantially. The costs were estimated. Economic viability was not assessed.

113. **Issue 2** The Commissioners requested further advice on the accuracy of Mr Lewthwaite's supplementary evidence on concentrations of ammonia in the Estuary. CCC data (Appendices 1 and 1 b) were presented for ammonia concentrations, temperature, and pH at high tide. None of the data relate to afternoon when water temperatures tend to be highest. The same crucial deficiency is found in the paucity or absence of data for low tide. It appears that the most likely times for high temperatures and higher pHs to occur have not been sampled.

114. The Ecan data summarised by Mr Lewthwaite do not show dates or times, but it is observed

115. That at all stations temperatures >23 °C were recorded, with max. 28.9°C.

116. That at all stations for which there are data on pH, values of at least pH 8.1 were

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[29] No evidence at all is advanced to support the notion of a causal relationship between these presumed occurrences.

[30] The evidence (e.g. P.A. Neal) is that fish have decreased in abundance.

recorded.

117. The highest pH recorded was 9.4.

118. Since Appendix 2 is only a subset of Appendix 2a, I give ammonia data for 2a stations with more than 50 observations (over the period 1973 - 2002).

119. Of 9 such stations, 6 had mean values above the 4-day USEPA value (0.44g).

120. Three stations had maximum values > the 1-hour maximum (2.9g) (USEPA values). Because of the way the data are presented there is no way of knowing how often these values were reached. In Appendix 2c a plethora of incomplete observations are presented with few pH records, and disappointingly few afternoon records. Their main value is that they direct attention to the need for representative sampling. The summary data on pp. 42 and 43 of Appendix 2c merely repeats data already presented in Appendix 2b, but with the means calculated to 4 decimal places (using data to only 1 or 2 places!).

121. The CCC and Ecan data confirm the results given by Mr Batcheler for Christchurch Estuary Association. It is clear that unacceptable combinations of temperature, pH, and high ammonia concentrations occur frequently enough to threaten the viability of some fin-fish and probably some crustaceans.

122. Dr Inglis' observations need to be treated with caution. I thought I heard him remark as an aside that the values had taken into account not only USEPA figures but also data for Australian and New Zealand fishes. When I asked him where the data on NZ marine fish had been published he conceded that there are no such data!

123. I have remarked elsewhere about the quaint ANZECC data on marine crustaceans. The problem is that this approach applies an apparently sophisticated mathematical approach to inappropriate or non-existent data. There are no relevant NZ toxicity data. It is unwise to guess, for the data on toxicity of ammonia to the New Zealand freshwater crustaceans established hitherto unknown levels of susceptibility. Almost all of the data used in compiling standards for USEPA and ANZECC are derived from short-term "dunk and die" acute toxicity tests. Nature however is concerned with chronic toxicity. The effects of short term exposure are often less dramatic than death; growth and/or reproduction may stop long before an animal dies. But an animal that has stopped reproducing is effectively dead as far as the population is concerned. Such effects have been shown in freshwater aquarium studies at much lower concentrations than those used in LD50s acute concentration testing. CL Batcheler for the Christchurch Estuary Association also discusses this topic.

124. **Issue 3.** I cannot find the data on ammonia in low tide channels referred to in Mr. Lewthwaite's and Dr. Inglis' contributions. The observations on Atlantic Salmon and Bream spp which do not occur in the estuary are perhaps of little help. I think there is a paucity of understanding of the toxicity considerations reported.

Dr. Vivienne Burrows' Case for the Estuary

Biographical Note.

1. I hold M Sc Zoology First Class Honours from the University of Canterbury (1961). My thesis study was on the ecology, behaviour and embryology of two species of the whitebait *Galaxias maculatus attenuatus* and *G. vulgaris*. Both species occur in the Avon-Heathcote Estuary. Two publications appeared in the New Zealand Journal of Ecology from this work.
2. I also hold the degree of D Phil Oxon (1965). I studied the behaviour of two species of small freshwater fish, sticklebacks, when threatened by predatory fish, trout, pike and perch, and the development of this behaviour.
3. I lectured at the University of Canterbury before and after study at Oxford, teaching animal behaviour and embryology. In 1974 I gave up teaching because of ill-health and the demands of a young family but have done some part-time teaching at the University since those years. I have also been involved with women's health issues as a member of Gynova and in an intensive study (with other professionals) of post-natal depression, with a publication in the New Zealand Medical Journal in 1995.
4. During 2000 and 2001 I worked with the Interchurch Commission on Genetic Modification, preparing a detailed submission for the Royal Commission on GM.
5. In the 1990s I guided many tour bus parties of mainly North American Elderhostel visitors to the Te Hui Nga Manu bird sanctuary at the wastewater settling ponds at Bromley, and the Estuary.
6. I was a member of the Christchurch City Council Working Party that considered the issues and options of future effluent discharge from CWTP (Christchurch Waste-water Treatment Plant). Therefore I regard myself as an informed observer of Avon-Heathcote Estuary issues.

MY CASE

In this evidence I will discuss the nature and sensitivity of the estuarine ecosystem and the Christchurch City Council Working Party and its recommendations

The nature and sensitivity of the estuarine system

7. This hearing is concerned with the Avon-Heathcote Estuary, the ocean and the rivers Avon and Heathcote, as well as with the City of Christchurch.
8. How well are the structure, function and life of an estuary understood? An inlet entered both by rivers and the sea is a challenging and changing environment for its inhabitants. When the turbulence and volume of the highly active ocean forces denser sea water into a wide shallow area into which two rivers are discharging, the freshwater slides over the encroaching tongues of sea water in the deepest channels. As the tide rises, water backs up so the first water to reach the wider banks is mainly fresh water. At high tide in calm weather the water at the bottom of the channel may be twice as salty as at the surface. Prevailing winds are from the north-east and south-west; when they blow mixing is facilitated. Twice daily tides carry away the treated wastewater discharge from the Christchurch Wastewater Treatment Plant ponds 5 and 6 for about two to three hours on the falling tide.

9. The beauty of the view over the estuary from the hills is matched by the complexity of processes occurring within it.
10. Our City Council Parks Unit has maintained excellent work on this area and Brooklands Lagoon. Their book (edited by S-J Owen[1]) gives a comprehensive and well-illustrated account of these areas. Their main references are listed in her Appendix 11.
11. Most people regard large numbers of birds as the main life of the estuary since the only other visible inhabitants are mud flat snails. Over a hundred species of birds visit the area. They include native and introduced species, migrants and residents. All are there to eat. Some graze, others fossick or hunt. Their large numbers tell us this is a very productive area.
12. Nine species of fish make up to 90% of the fish population, though 28 species occur there at least occasionally (reference 1, p. 56 and Appendix 9). The common ones include the sand flounder whose tiny young spend their hazardous first year in the estuary. Occasional ocean visitors include tuna, shark and swordfish. Fish are predators on other inhabitants of the area and so are in a similar category to the birds. A local fishing industry was once based in the estuary, but now even the fisherperson is seldom seen. And we know how reluctant they are to give up hope!
13. Birds and fish eat the native plants and animals of the estuary. In the varying depths and substrates and conditions of this entire area live large numbers of highly specialised species. Salt-tolerant plants and algae photosynthesise and provide the first level of nutrition. About 40 species of molluscs (snails, slugs, limpets, chitons and bivalves) graze, dig and consume the plankton or algae. About 32 species of marine worms burrow in the top 10 cm of the muddy or silty base, about 40 species of crustacea dig, cling or swim there. This is not a numbers game but even after about a century of waste disposal via the rivers and the Treatment Plant, a vast working biomass of productive organisms is still living, breeding and adapting to the twice-daily changes within this area. We couldn't do it!
14. I cannot over-emphasise the fundamental versatility of such species. They all have their own inbuilt tolerance limits and preferred range, all are vulnerable to unexpected disasters such as poisoning, suffocation or intolerable salinity fluctuations, and many of them eat things we wouldn't fancy. Their tiny young are their least resilient and most vulnerable phase and, from plankton size through to adults, they are prime food for predators. In addition, the high risk of highly toxic ammonia in the effluent, combined with variable degrees of mixing in the estuary on each tide, presents a most dangerous risk to successful breeding and recolonising by invertebrates and fish. This can have serious consequences for the food chain, of which any disturbance can unbalance the ecosystem. (Philip Ross gives relevant ammonia data in his evidence, pp.17-18, 98-103[2].)
15. Although I write as a Biologist with particular passion about the invertebrates of the estuary, the welfare of the people is of great importance to me, as it is to most of us. In introductory public meetings convened in association with the Waste Water Working Party, residents spoke of issues affecting them and that have since then remained substantial issues for the Working Party. Residual pollution is perceived as a problem in many places around the Estuary and adjacent beaches. The people are well aware that the treated water emerges with the falling tide and washes towards Brighton and Sumner every day. They also see the brownish scums on the beaches. These are due to bacterial scum rather than to raw sewage, which has been imaginatively mentioned in many angry letters to "The Press". However, some other foaming scums originate from the effluent.
16. Waste from various sources has been discharged into the Estuary for many years, and I fear that further sustained input of effluent could tip the balance of its life. The whole of life depends upon

the continuation of decay and recycling processes carried out by hosts of organisms we will never see. Our ignorance of this essential function blinds us to the risks of damaging any part of those cycles.

The Working Party and its recommendations

17. Over almost three years of regular monthly meetings, the volunteer Christchurch City Council Wastewater Working Party (WP) was presided over by a professional facilitator, Ms Gay Pavelka. Several options remained open until they could be assessed for feasibility and economy. Irrigation with wastewater in areas with an impermeable layer above aquifers proved unsuitable – it would cost about $350 million. Aquifer recharge with restored water would be dangerous and expensive. We felt we had to concentrate on ways to improve estuary discharge, yet there remained the problem of shellfish and beach contamination on every tide. We also had to address the heavy load of nutrients in the wastewater. A proposal for an ocean outfall of highly treated wastewater by a buried pipe was a surprise at first. When we heard that the cost was affordable the concept was very appealing because the Estuary is basically an inappropriate receiving environment. It is shallow, mixing is partial, discharge is incomplete and the ecosystem is vulnerable to damage by this discharge. An ocean outfall offers discharge directly into the open ocean in a continuous flow but even if/when that route is chosen, regular monitoring, review, and upgrading of the treatment plant would continue to be necessary to ensure that effluent continues to be of the highest quality. Eventually, I hope that this would result in the development shellfish-gathering quality water along the shores, no augmentation of pollution in the estuary. The costs developed by the Working Party indicated they would be about the same over 15 years as those 15 years discharge into the estuary. The rationale includes this argument – we have a high quality freshwater resource in a series of aquifers that lie below permeable land. To conserve the quality of our water we must avoid polluting the land. The cost of our health is not the cost of drinking water but the cost of good water treatment and biosolids disposal. There are no shortcuts.

18. I append documents dated 21 October 1998 (not reproduced here, Eds.) that the WP received from Council via Mr W Lewthwaite, Wastewater Engineer for Christchurch City Council[4i]. He included a Minute of City Council resolutions dated 31 August 1998 that acknowledge that it would:

> "Receive the report and recommendations of the WP for an ocean outfall, noting that the recommendation is conditional upon the results of further investigations as detailed in the report." Seven points detailed timing and nature of investigations recommended. The seventh called for by Council was for "...a coordinated plan for the western edge of the Estuary taking in the wastewater plant, Ferrymead Bridge area, the Green Edge concept and opportunities to enhance tourism, recreation and the protection and enhancement of wildlife in this area."

19. All points in this list were in accord with the WP's recommendations. Woodward-Clyde were selected as consultants to carry out the necessary research and present a report. Further WP meetings were with the Woodward-Clyde team and a larger circle of interested parties. All issues were covered.

20. In the end the WP voted almost unanimously for the ocean disposal of quality treated water. At a final meeting we were told that the option selected by Council was for estuary disposal and the

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[i] Often referred to as "Bromley"

Green Edge. In fact, the Green Edge proposal would have no impact on the discharge since it has no part in the water treatment process. It is an appropriate scheme to improve the appearance and habitat opportunities of land that includes the heavily overloaded Linwood Paddocks. Effectively the area will be retired and enhanced.

21. We subsequently learned that a Peer Review group was established by the Council to reassess the outcomes from the Working Party. They endorsed the WP recommendations (evidence of Mr Lewthwaite, p. 8), but the WP was not formally told of this result.

22. Disillusionment is deep. I oppose the Council's application to discharge into the Estuary for 15 years on grounds expressed in this evidence. The City of Christchurch deserves the best wastewater disposal system that is available. Residents deserve clean, healthy living conditions and that includes gathering and safely eating shellfish gathered on the Brighton and Sumner beaches. Sadly, we have been told that we cannot expect that now or in the predictable future, if discharge into the Estuary continues.

23. Natural systems change continually but their time scale is often so different from ours that humans do not perceive the shift. If we move to an ocean outfall, we will at least give a very hardworked ecosystem a chance to survive and recreational use of the estuary will become safer. To designate the whole Estuary area a mixing zone, thereby avoiding compliance with water quality standards, is unacceptable. Like other witnesses I believe it contravenes the principles and details of the Resource Management Act (1991).

24. I recommend also that Christchurch City Council raises the priority of long-term planning and budgeting for Treatment Plant development and infrastructure maintenance. Good water supply and safe and reliable sewerage treatment and disposal are absolutely vital for the health of the people of Christchurch, and for the health of the Estuary.

Vivienne Benzie Burrows

References

1. Owens, S-J. (1992). The Estuary – Where Our Rivers Meet The Sea. Christchurch's Avon-Heathcote Estuary and Brooklands Lagoon. Christchurch: Christchurch City Council, Parks Unit.
2. Ross, Philip *et al.* (2001). Christchurch Wastewater Plant. Officer Reports. Environment Canterbury (pages 17-18, 98-103).
3. Robb, J. A. (2001). Personal communication regarding data collected when he was employed by the Christchurch City Council as a biologist and environmental scientist.
4. Letter from Walter Lewthwaite to Waste Water Working Party, dated 21 October 1998. It included the Christchurch City Council resolutions dated 21 August 1998 and questions raised by community groups who attended Working Party consultation meetings.

NUTRIENT ENRICHMENT OF THE ESTUARY AND THE NEED FOR PRECAUTIONARY ACTION

KEVIN F O'CONNOR

BIOGRAPHICAL NOTE

1. Kevin Francis O'Connor resides at 21 Tuawera Terrace, Clifton, Sumner. He holds a B. A. in Philosophy and Economics and B. Agr. Sc. from the University of New Zealand, and Ph.D. from Cornell University, New York. He has been a Fellow of the NZ Institute of Agricultural Science for some twenty years and is a member of the New Zealand Soil Science Society, the International Soil Science Society, the New Zealand Ecological Society and the Royal Society of New Zealand. He was a member of the New Zealand National Commission for Unesco for some twelve years and its Chairman for four years. He has represented New Zealand in Science Commissions at several Unesco General Assemblies and in international inter-disciplinary meetings for the Man and Biosphere Program of Unesco and for the World Conservation Union (IUCN).

2. He is now Professor Emeritus in Range Management of Lincoln University, in the Division of Environmental Management and Design.

3. He was engaged in soil science and systems ecology, first for land use assessment in inland Otago, later for grassland management on the Canterbury plains and downlands, and in the South Island high country. In 1964 he held a Canadian NRC post-Doctoral fellowship in the University of Guelph, Ontario to continue studies of nitrogen transformations in soils that he had begun in New Zealand with Dr John B Robinson of Ontario. In his field research in the lowlands and high country, he has had a central focus on the dynamics of nitrogen, phosphorus and sulfur in natural and cultural terrestrial systems and their interactions with waterways.

4. In 1969 he was appointed as the first Professor of Range Management at Lincoln College. In that post he was engaged in supervision of research in soil and erosion survey and land evaluation on the Port Hills and in the mountains, and in ecological studies of terrestrial and aquatic vegetation. He established New Zealand's first post-graduate programme in Natural Resources and in collaboration with University of Canterbury assisted with the first Masters degree in Resource Management. He taught in Lincoln's post-graduate programmes as well as in undergraduate resource studies and nature conservation, landscape, park and recreation programmes until he retired in 1991.

INTRODUCTION

5. In this Case on behalf of the Christchurch Estuary Association I draw attention to the effects of discharging wastewater on nutrient regimes in the Avon-Heathcote Estuary ecosystem.

6. I also show how, in the light of widely accepted international experience and principles, the CCC (Christchurch City Council) has failed to make proper use of appropriate environmental science to justify what it has applied to do. Further, it has failed to apply principles of resource management essential for 'sustainable management'.

7. The first part of my case is as a scientist evaluating published information on nutrients and their ecological effects in the Estuary. In the second part I draw on my experience of natural resource management and of the integration and use of science in resource management.

Changes in Elemental Pools and Fluxes of the Estuary System and their Effects.

8. I detail the distortions of element fluxes into the estuary that have occurred through the settlement of greater Christchurch and the continuing major contributions to those distortions that are made by waste-water from the CWTP (Christchurch Waste Water Treatment Plant) at Bromley. I demonstrate that the claims of the applicant that current or projected improvements to the CWTP can be expected to reduce the contribution of nutrients to the Estuary are unwarranted, even though there may be some temporary abatement of ammonia N.

9. I detail the influence of these augmented influxes on the nutrient concentration of estuary waters and the mass balance of nutrient influx and efflux through tidal discharge.

10. I outline the influence of augmented nutrient influxes on the behaviour of biota in the Estuary and on dynamic relationships between them and their environment, and the likely consequences of maintaining or ceasing nutrient influxes from CWTP.

Limitations of Conventional Science, and the Need to Apply Conservative Principles, the Precautionary Principle, in an Integrated Management Approach to the Estuary

11. I explain some inherent limitations of conventional science approaches to the situation of estuaries in general as complex dynamic systems and the need for common sense.

12. I outline institutional limitations of the employment, conduct and application of scientific investigations for the present nutrient and trophic ecology issues of the Avon-Heathcote Estuary and the discharge consent application.

13. I point to the significance of the issues and values at stake in sustainable management, coastal resource policies, regional and city planning objectives and the New Zealand biodiversity strategy. All these suggest likely benefits to the city and people of Christchurch from diversion of CWTP wastewater away from the Estuary and from extending the Wetlands and Waterways Enhancement Programme of the City Council to the Estuary.

DETAILS OF EVIDENCE

Changing Contribution of Nutrients from Rivers and CWTP to the Estuary

14. Elemental pools and fluxes of the Avon-Heathcote Estuary have been greatly changed in the 150 years of Canterbury European settlement. The principal elements of concern are nitrogen (N) and phosphorus (P). These, with sulfur, carbon, hydrogen and oxygen, form all organic matter. Low concentrations of atmospheric sulfur limit the formation of soil organic matter in the eastern South Island, except near the coast. In estuaries, with abundant sulfate in the water, sulfur does not limit growth. In the pristine Estuary, N and P would formerly have limited plant growth and so set the ceiling to the production and accumulation of organic matter.

Nutrient Contributions from the Rivers

15. The rivers, functioning as drains and sewers for Christchurch, initiated changes in the nutritional regime of the Estuary. Their role was soon compounded by the transport of sediments and trade wastes. Thanks to industrial waste retention and treatment on site, trade waste sewers, and the waterways enhancement programme, the contribution of nutrients from the rivers now appears to be comparatively minor and diminishing. The supply of N and P from sewage treated at CWTP, especially since the 1950s, has increased and is principally responsible for raising productivity in the Estuary. The present sea lettuce nuisance is the most conspicuous outcome of that increase, as is well established by a vast amount of comparative geographical, historical, field and experimental laboratory evidence.

16. Nutrients such as N and P are now in such rich supply in the Estuary that neither of them is likely to limit plant growth. Such factors as light, temperature or supply of plant propagules must now be the growth-limiting factors.

17. Knox and Kilner (1973) reviewed the concepts of eutrophication by such definitions as that adopted by OECD (Organisation for Economic Cooperation and Development):

> "Eutrophication is the nutrient enrichment of waters which results in stimulation of an array of symptomatic changes among which increased production of algae and macrophytes, deterioration of fisheries, deterioration of water quality and other symptomatic changes that are found to be undesirable and interfere with water uses."

18. So far as nutrient regimes themselves are concerned, the Estuary is now essentially eutrophic, whereas 150 years ago it was probably oligotrophic, poor in nutrients. Only by comprehending how this came about can we appreciate how deleterious are the activities for which the Applicant has sought resource consent under the RMA (Resource Management Act).

19. When first monitored in the 1950s, nitrogen concentration in the Heathcote River increased as it flowed through its (upper) pastoral sector[1],[2] then further increased in the lower industrial reaches.[3] Both the Heathcote and the Avon rivers tend to indicate further fluctuations in nitrate concentration and reactive P concentration in their urbanised sectors.[4] There is also some chemical evidence that some of the CWTP effluent flows up the rivers with the incoming tide.[5]

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[1] The estimated mean annual flow of the Avon River from its 84.3 km^2 catchment for the period 1991 – 1999 was approximately 60 million m^3. That of the Heathcote from its 104-km2 catchment was approximately 33 million m^3 (Gilson and Mitchell 1999). It is assumed that these mean annual flows into the Estuary have not varied much over the time of European settlement, although behaviour of each river would have altered considerably with new regimes of urban hydrology.

[2] Hogan D J and Wilkinson L, 1959, A survey of pollution in the Avon and Heathcote Rivers, Christchurch, New Zealand. *New Zealand Journal of Science 2*: 506-529.

[3] Robb, J. A. 1974, *An ecological study of the Bromley Oxidation Ponds and surrounding environs,* Ph D thesis, University of Canterbury.

[4] As Pratt *op.cit.* has indicated, regardless of sampling locations, most of the temporal variations in concentration of N and P components over the last ten years or so have not shown very marked trends.

[5] Robb's Estuary data (1974, Figures 4.1 and 4.2) of reactive P in Avon and Heathcote Rivers suggests CWTP effluent had been carried upstream on the incoming tide. Whether this occurs under current discharge regimes is not known with quantitative confidence, but Mr L. Byatt gave Evidence of recent observations of effluent flowing upriver as far as Kerrs Reach.

Phosphorus:

20. Robb[6] reported reactive phosphorus loads in 1970 - 1972 as 12.7 kg/day in the Avon and 3.9 kg/day in the Heathcote. He also reported from limited sampling by Kilner a combined load of 13.6 kg/day of organic phosphorus in the two rivers. With the assumption that there are no further appreciable P components in "total P", these various phosphorus loads amount to less than 11.2 tonnes P per year for the two rivers together. The increase in reactive phosphorus from 1972 to the present principally reflects a fourfold increase from the Heathcote that may largely be due to run-off from an accident at a Hornby fertiliser factory.

Nitrogen:

21. The daily loads of total nitrogen during 1970 – 1972 were likewise reported by Knox and Kilner[7] as 318 kg from the Avon and 396 kg in the Heathcote.[8] The combined annual total N load in the two rivers was 278.4 tonnes in 1962 and 261.5 tonnes in 1972.[9]

22. At the present time the total influx into the Estuary from both rivers (including storm flows) is reported as 189 tonnes per year total N, principally as nitrate, and 9.1 tonnes per year of reactive phosphorus.[10] The comparable values excluding storm flows are 131.4 tonnes per year of total N and 13.5 tonnes per year of total P including 2.9 tonnes of reactive P.[11] These data give a strong indication that net contributions from the rivers of total N and perhaps total P may have declined in recent years.

23. Table 1 summarises from the sources identified, some recent historical information on N and P mean daily influxes to the Estuary from the Avon and Heathcote Rivers.

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[6] Robb, 1974, p.66, Individual river loadings of 3.9 kg/day reactive P in Heathcote, 12.7 kg/day in the Avon and a combined river estimate of 13.6 kg/day of organic phosphorus are used as bases for the estimates of total P for 1970-72 in Table 1 here. According to Knox and Kilner, citing Robb's incomplete work for 1970 -1972, the daily contribution of total phosphorus from the Avon River was 43 lb, and from the Heathcote 13.5 lb, somewhat greater than the 30 kg estimated from Robb's completed work

[7] Knox and Kilner, 1973, p.98. These were compared with those recorded earlier by Wilkinson (1963).

[8] In his complete work, Robb (1974, pp.63–65) showed total N in the Avon had declined from 1962 to 1972 from 481.2 kg/day to 319.2 kg/day, principally because of substantial decrease in nitrate. In contrast, total N loadings from the Heathcote increased from 281.6 kg/day in 1962 to 397.2 kg/day in 1972, principally because of appreciable concentrations of ammoniacal and organic nitrogen in the Heathcote from the effluent of Bells Creek at that time.

[9] i.e. 762.8 kg/day in 1962 and 716.4 kg/day in 1972.

[10] Table 5.2 of URS NZ, 2001. The values for total N and reactive P are consistent with the evidence of M Gilson to the hearing, Table 7 for annual loadings, including storm flows.

[11] Gilson M and Mitchell K, 1999,*Christchurch City Surface Water Quality Data 1995-97; Water Quality Trends 1986-97,* Report from the Waste Management Unit Laboratory to the Christchurch City Council. (p.14 Avon, p.66 Heathcote). They computed mean daily nutrient loadings to the estuary for each of the rivers, "using dry weather river flows". These values are consistent with what M. Gilson reported as annual loadings in Table 8 of his evidence to the hearing, for "both rivers", "excluding storm flows".

Table 1 Mean Daily Influxes of N and P (kg) to Estuary from the Heathcote and Avon Rivers

	Heathcote			Avon		
Period and Source	Total N	Reactive P	Total P	Total N	Reactive P	Total P
1962 (Wilkinson[12])	281.6.	n.a	n.a	481.2	n.a.	n.a.
1970-72 (Robb)	397.2	3.9	8.4	319.2	12.7	21.8
1995-97 (URS, Gilson, incl. storm flows)	219	16.1	?	299	8.7	?
1995-97 (Gilson & Mitchell excl. storm flows)	140	3.3	7.5	200	4.6	6

24. What is the magnitude of these changes of nutrient influxes compared with the unpeopled state of the Estuary? Some New Zealand observations and more plentiful overseas data give good insights. They take into account the very low levels of N and P concentration in drainage waters likely in the absence of livestock or fertilisers from stable grassland and wetland communities, including kahikatea forest and scrub. Extensive wetlands probably retained any reactive phosphorus present, and in the wet soils, nitrate N could have been denitrified to nitrous oxide by bacteria such as *Clostridia*, or completely to dinitrogen. It is therefore unlikely that the total N influx to the Estuary from both rivers would have reached a tonne per year, while the reactive P load would probably have been negligible. The estuary system was almost certainly what is now described as oligotrophic.

25. Apart from any influx of N and P from sewage treatment in the early "sewage farm" or CWTP, we can confidently estimate that 150 years of settlement in Christchurch has increased the annual N and P **influx by rivers** to the Estuary by some 200-fold. (This does not include the many-fold further increase in influx deriving from CWTP.) It is pleasing to see this river situation is improving, through the City wetlands and waterways enhancement programme. Nevertheless, as I have pointed out of agriculture some thirty years ago, "it becomes very difficult to have infertile streams draining fertile lands."[13]

Nutrient Contributions from the CWTP

26. Changes in nutrient load from the CWTP to the Estuary in recent years have been in the opposite direction, with further substantial increases in both nitrogen and phosphorus. We should recognise the massive distortion of nutrient influx to the Estuary that comes from the CWTP. The recent history of CWTP as a transformer and discharger of nutrients makes bad reading for the Estuary. Examining the combined role of rivers and CWTP in increasing the nutrient loads to the Estuary reveals this.

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[12] Wilkinson L 1963, Nitrogen transformations in a polluted estuary. *Air and Water Pollution 7*: 737-752.

[13] O'Connor K F, 1969 The role of agricultural land use in affecting water quality. *Lincoln Papers in Water Resources 1*: 52-68; O'Connor K F, 1974 Nitrogen in agrobiosystems and its environmental significance. *New Zealand Agricultural Science 8*: 137-148.

27. In 1962 the estimated mean load of total N from CWTP was 1071 kg per day.[14] The combined load from the CWTP and rivers in 1962 would therefore have been 437 tonnes/year. By 1972, total N from CWTP increased 2.5 times to 1051 tonnes per year.[15] The total P load (reckoned as reactive P plus organic P) reached 158 tonnes per year by 1972. In that decade,[16] the proportion of ammoniacal nitrogen from all sources increased from 50 per cent in 1962 to 65 percent in 1972[17]. At the present time, according to the amended evidence of M.Gilson, the total nitrogen load from CWTP is presented as 1800 tonnes/ year.[18] This includes virtually no nitrite or nitrate, 1460 tonnes of ammonia nitrogen as well as at least 340 tonnes of organic N.[19] There is some evidence from the composition of discharge water from Ponds 5 and 6 that the present annual mass loading of total N to the Estuary may exceed 2000 tonnes. Gilson and Mitchell[20] report a mean daily loading, apparently from 1989-97, from Ponds 5 and 6 that computes to 2150 tonnes of total N per annum. In the same context they report a mean daily loading for total P from Ponds 5 and 6, equivalent to 365 tonnes of total P per annum. It appears impossible to reconcile this last value with the 584 tonnes per annum of reactive P, reported in the evidence of M Gilson to the hearing. For reasons that will become clear, I now believe that the value of 584 tonnes of reactive P per annum is an error and that the true value is much lower.

28. The dominance of the CWTP contribution of ammonia and of reactive P to the Estuary is beyond dispute. What is not altogether clearly established is the annual loading of total N and total P to the Estuary. In line with more conservative estimates available from official sources, Table 2 summarises changes in total N and P contributions to the Estuary from CWTP. In view of comments in the previous paragraph, the first set of values for 1997-99 total N contribution of CWTP must be considered conservative. Conversely, the value cited for reactive P must be excessive. I believe that for both N and P, the values in the last two rows of Table 2, calculated from Gilson and Mitchell's published data may be closer to reality than those given in evidence.

29. The proportion of total N and reactive P entering the Estuary that is contributed from CWTP has increased dramatically over the last forty years. In 1962 the rivers contributed 39% of total N. In 1972 the rivers' contribution was 20% and is now <10%. The contribution of N from treated sewage in 1962 was 61% of total N; in 1972 it was 80% and is now >90%. In 1972 total P contribution from the rivers was 5.6% (Knox 1992, p.34) and reactive P was 4.5%. Now they contribute <2 per cent[21].

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[14] Wilkinson 1963 *op.cit.* To make valid comparisons between this daily loading and that measured in 1972, Robb (1974) added estimates for sewage from SE hill suburbs that had been connected to CWTP in the interim.

[15] Robb, 1974, p.63 for nitrogen, p.66 for phosphorus.

[16] As noted by Knox and Kilner (1973)

[17] Comparison of the values for CWTP alone (Robb, 1974, p.63) indicates very little change in the proportion of ammoniacal nitrogen from 78 per cent in 1962 to 75 percent in 1972. It is now 80 percent with no nitrate N, the remaining 20 per cent being organic.

[18] M.Gilson evidence, Tables 7 and 8, amended by Mr Gilson at the hearing to take account of organic N

[19] It may be noted that the AEE tabulation (Table 5.2 a and b) also omits organic N.

[20] M Gilson and K Mitchell *op.cit.* (p.204) report "the mean combined loadings of nutrients and BOD discharged to the estuary from oxidation ponds 5 and 6" as 5900 kg/day Total N and 1000 kg/day Total P. It appears from the context that these values are from the period 1986-1997, but which exact period is uncertain

[21] In Table 5.2, AEE does not tabulate how much organic P or total P is now coming from the treatment station into the Estuary. In 1972 organic P was equivalent to one fifth of the reactive phosphorus loading and four to five times what was in the rivers. In fortnightly samples from January 1989 to April 1992 the concentration of reactive P in

Table 2. Annual contributions to the Estuary of N and P from CWTP in tonnes/annum

(CWTP Proportion of influx of total N and total P from all land sources is shown as percentage)

Period	Mineral N	Total N	CWTP %	Reactive P	Total P	CWTP %
1962	308	391	61%	n.a.	n.a..	
1970-72	800	1051	80%	128	157	94%
1995-97	1460*	1800*	90%*	584*	678 (est.)	98%*
1995-97	1485 (est.)	2150**		314 (est.)	365**	
1995-97	1460#	2119#	92%	311#	361#	99%

* Values marked in this fashion are as recorded in evidence of M.Gilson in Tables 7 and 8. Values for total N and total P marked with double asterisk (**) have been computed from the mean daily loadings reported by Gilson and Mitchell, on page 204. All values here marked as estimates (est.) I have calculated in proportion to the mean concentration of related constituents in Ponds 5 and 6 over the period 1995-1997, as reported by Gilson and Mitchell on page 197 and 201 respectively. Values in the last row marked (#) have been calculated directly from the mean of constituents from Ponds 5 and 6, on the basis of a dry weather flow of 153,000 cubic metres per day.

To summarise these disturbing trends from the last thirty or forty years:

30. Sewage treatment at CWTP has been responsible for an increasing loading of N and P to the Estuary in absolute terms. In both relative and absolute terms, the loads of N from the rivers have been decreasing, and despite a major industrial accident, so also have the loads of P, at least over the last 30 years.

31. An increasing proportion of the mineral N discharged from CWTP has been as ammonia. CWTP now discharges at least 1460 tonnes of ammonia N per year, at least 1800, but possibly more than 2000 tonnes of total N, more than 15 times the total N load from the rivers. Now some 300 to 400 tonnes of reactive P per year comes from CWTP – perhaps 50 times the load from the rivers! The biota and sediments of the Estuary are consequently now in a grossly eutrophic ecosystem.

32. Christchurch's people might properly ask about future prospects. CCC Consultants claimed as part of the Council's preferred Estuary discharge option that nutrients will be lowered[22]. Other than a temporary lowering of the level of ammonia, these claims have not been substantiated. Statements have been made that the present CWTP upgrade will enhance nitrification of ammonia and offer the opportunity to install further equipment for nutrient stripping. In discussion of alternative "nutrient removal" methods, the AEE (p3.9) notes that cost for a biological nutrient removal (BNR) plant "is approximately $100M, with approximately $2M annual operating costs".

Pond 6 was 5.84 ± 0.99 g m^3, 89 per cent of total P for the same period (Knox, 1992, p.35). For 1995-1997 the mean concentration of reactive P in Pond 6 was 5.57 ± 1.01 g m^3, 85 per cent of total P (6.53 g m^3) for the same period (Gilson and Mitchell, 1999, p.201)

[22] Wastewater Management Consultation Report 2000, p.23

33. It is not clear whether this kind of facility, with or without chemical precipitation of P, has any concrete prospects for the future. In any case it is not relevant to this proposal,[23] for which only an investigative phase is proposed into some possible nitrogen removal processes, "in tank" and in ponds-and-wetlands. No detailed prospect or approach is given in the AEE about these exercises as mechanisms for nutrient removal. No proposal is made to do anything more than investigate, and the Applicant does not seem to consider that the City Council needs to show what quantitative prospects there actually are, whether now or in the future. It appears to me cavalier to acknowledge that nutrient removal is desirable (we believe CEA evidence shows that it is imperative), yet make no concrete provisions for that to occur, and seek an approval for the discharge of wastes with its massive nutrient load intact.

This matter of N transformation, reduction or removal is now examined in more detail in a section incorporating my later comments to the Hearing on this topic. These comments had followed the introduction of new or revised material by the Applicant, in response to requests from the Commissioners.

Nitrogen Transformations and Claims for the Reduction of Nutrient Load to the Estuary

34. The increase of plant capacity to provide for expansion of the city until 2030 was accorded a Resource Consent in 1996. It has little or nothing to do with the present Discharge Consent debate. In misleading manner, the capacity upgrade is now being promoted by some City Council spokesmen as providing for expansion of Christchurch AND neighbouring towns (e.g. Belfast) AND improving the quality of effluent! All these claims cannot be true at one time.

35. Some other misleading comments also warrant comment. It is suggested in the AEE[24] that total ammonia from CWTP will be reduced by increased nitrification to nitrate-N. In Mr. M. Bourke's evidence (from Para 27) the claim is made:

> "In the short term the upgraded treatment plant is also expected to provide some nitrogen reduction. Currently the present plant reduces total nitrogen by an average of 20%, but increases ammonium nitrogen by approximately 18%. From the upgraded plant 40% ammonium nitrogen reduction can be expected at flows up to 160,000 m^3/day (a median discharge concentration of 15 gm/m^3). This reduction will decline to approximately 25% (20 gm/m^3) at flows of 200,000-m^3/ day unless other measures are put in place. These reductions are relevant in considering potential impacts on fish in the Estuary."

36. This item of evidence calls for careful examination. Ambiguity and obscurity[25] may reside in the lack of definition of the base line from which 'reduction' is to be reckoned. Lowering "total

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[23] Section 2.4.2 of the AEE and accompanying diagrams (ca. p. 2-26) on the Upgraded Treatment Plant make no mention of nutrient removal, additional to what is described for the existing plant, e.g. Biosolids and Sludge on p.2-11. The closest to a proposal for nutrient removal appears in Section 2.4.3 Future Upgrades p 2-31: "In addition to the upgrades described above, during the term of the consent applied for, it is proposed that trials be undertaken to determine the potential for nutrient reduction in the main treatment plant and the ponds... ". The next paragraph states: "There are a number of nitrogen removal processes that will be fully assessed as part of the ongoing investigations."

[24] AEE, p. 6-24

[25] Additional ambiguity arises because the word 'reduction' has a general meaning of 'diminution' or 'lessening', and a chemistry meaning of 'removing oxygen from or combining with hydrogen' or 'lessening positive valency by adding electrons'.

nitrogen by an average of 20%" and increasing "ammonium nitrogen by approximately 18%" together seem to imply changes occurring to the influent and effluent wastewater at CWTP. If so, whether this present "nitrogen reduction" and associated increase in ammonium concentration has any influence on the total N discharged depends on the chemical pathways of nitrogen conversion. If incoming N were converted to a sludge that is abstracted and used as fertiliser, reduction of the amount of N in the effluent would be real. If however, ammonia is converted to nitrite or nitrate or incorporated into organic N, each of which remains in the wastewater, ammonia concentration and even ammonia load may be lowered while the total amount of N in the receiving system would be unchanged.

37. The oxidation of NH_4-N to nitrite and then to nitrate represents a potentially valuable change to forms that are less toxic to fish, and perhaps also other organisms. The high proportion of ammonia in current effluent from CWTP thus represents a lethal trend that has occurred since 1962. [26] Lowering toxicity to fish in this way, however, has no likely benefit in the form of reduction in growth of vegetation.

38. The above pattern of consequences from system upgrading, combined with evidence of absence of significant nitrite and nitrate from CWTP (AEE, Table 5.2) and the amended evidence of M. Gilson (his Tables 7 and 8) and Gilson 1996, may be very important. All indicate that as reported by Robb (1974), nitrification is declining as the total sewage processing load increases, likewise indicated by the projected one-third increase in ammonium concentration as the processed volume increases from 160,000 to 200,000 m^3/day[27].

39. This has further possible future implications. The prospect of wetland nutrient reduction by denitrification in some proposed "green edge" wetland exists in the mind of some people. Denitrification is the ordinary bacteriological process by which anaerobes such as *Clostridia* in wetlands convert soluble nitrate–N to gaseous forms, N_2 or N_20.[28] Denitrification depends for its substrate on nitrate N. At the present time the wastewaters discharged from CWTP contain virtually no nitrate, the nitrogen being principally as ammonia and secondarily as organic N.

40. Only about 500 ha is potentially available in the vicinity of the Estuary for the development of a denitrifying wetland. However, between 3,000 and 35,000 ha would be required[29] for

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[26] Robb (1974, Figure 3.11) calculated the mean annual percentage nitrogen contributions to the Estuary from the Sewage Treatment Plant as 3.3 % Nitrate, 0.05 % Nitrite, 75.65 % Ammoniacal, 13.6 % Albuminoid and 7.4 % Non-albuminoid Organic Kjeldahl Nitrogen. Knox (1992, p.35) reported of the CWTP effluent: "Ammonia N levels which ranged from 16 - 22 $g.m^3$ in 1973 were similar (23 - 25$g.m^3$) in 1989/1992. Nitrate levels appear to have decreased from 0.5 –1.2 $g.m^3$ in 1973 to 0.10 – 0.60 $g.m^3$ in 1989/91".

[27] Excerpt from M. Bourke CCC, cited above

[28] The gases produced into the atmosphere are either dinitrogen (N_2), which is harmless and already makes up nearly 80% of the atmosphere, or as a less complete conversion, nitrous oxide (N_2O). This used to be quaintly known as 'laughing gas' but is now known to be a gas, like methane, that injures the protective upper atmosphere, contributing to the greenhouse effect. Deliberate or careless production of further nitrous oxide would undermine New Zealand's commitment to the Kyoto agreement. (cf. K C Cameron *et al.* "Nitrous Oxide Inventory and Mitigation: a National Science Strategy and Research Programme for New Zealand" Report for MAF Policy, Nov 2000)

[29] Common rates of conversion of nitrate to N_2O in denitrification range from 5 to 50 kg N/ha/yr. The upper level of the range of conversion rates estimated overseas from short-term studies on small plots in riparian wetlands may exceed 650 kg N_2O-N/ha/yr, but seldom approach that level. Even at that extreme rate, some 3000ha of wetland would be required to denitrify the existing N input to the Estuary from CWTP. At a conversion rate of 50 kg N/ha/yr, which from the soil science and edaphic ecology literature would seem a more realistic level of field performance, more than 35,000ha would be required for denitrification of 1,800 tonnes N/yr!

denitrification, depending on the rate of conversion achieved. This clearly poses problems for any nutrient-stripping function for the Council's Green Edge scenario. Additionally, to avoid international environmental embarrassment from N_2O emissions[30], intensive management of denitrification would be needed to complete conversion to the dinitrogen stage,

41. These considerations show how tenuous are the prospects for lowering nutrient inputs to the Estuary, except by diverting wastewater away from it. Wetlands associated with the Green Edge proposal may have considerable ecological and recreational values, but they appear to be irrelevant to reduction of the nutrient loading from CWTP to the Estuary.

42. **Christchurch by its urban development and drainage increased nutrient inflows by some 200 times. By way of its sewage, it has already increased the natural influx of total N and reactive P to the Estuary by some 2000 times.** I shall come back later to discuss how harmful this has been to the Estuary ecosystem.

On 26 November, 2001, Mr Lewthwaite responded to questions raised in earlier parts of the Hearings. Among them in paragraph 14 and in a graph in Appendix 5, he referred to the question of "amount of nitrogen and ammonia discharged from the plant". The paragraphs that here follow are drawn from my evidence in response.

43. I accept his assurances about "cautious assumptions". However, I cannot find Evidence from the Applicant of the ability of the upgraded plant to remove nitrogen altogether from the aqueous system. "Lowering of levels of ammonia" is not "removing nitrogen" if the change converts ammonia to nitrite and nitrate or organic N (incorporated in algae etc.). There is no net removal until nitrate is reduced to escape in gaseous form as N_2 or N_2O.

44. Whether nitrogen was to be removed in solid wastes (sludge), otherwise to be removed from the plant, or whether it is to be lost to the atmosphere, and if so, whether it will be lost as NH_3 gas (potentially offensive), as nitrous oxide N_20 (with its major implications for the Kyoto Protocol on Greenhouse gases) or as N_2 (harmless inert dinitrogen) - the last two being brought about by "denitrification" – has not been declared by Council Witnesses at the hearing. Until the processes and rates of nitrogen removal are demonstrated, we remain in the dark. It is important public information and should be available.

45. Mr Lewthwaite's supplementary evidence (his Appendix 5) stated that in the period following the integration of Belfast meat works effluents, the amount of nitrogen or ammonia discharged will revert from a temporary dip to about the present levels.

In response to questions raised later by the Commissioners, Mr Michael Bourke and Mr Walter Lewthwaite offered information at the resumption of hearings in 2002 about projected further treatment to achieve lower ammonia N (and total N) in discharges from CWTP. Mr C L Batcheler and Prof. W C Clark, deal with Christchurch Estuary Association perceptions of some claims made concerning conditions in the Estuary environment and their effects on organisms including fish. The following comments derive from my evidence in response at that time, showing the need to treat claims made for projected lowering of nutrients in discharges from CWTP with great caution. Care is necessary in reading CCC's claims and interpreting their meaning

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[30] Regardless of these possible difficulties, to make use of the denitrification process would presume the prior aerobic oxidation of ammoniacal nitrogen to nitrate before nitrate can be anaerobically reduced to nitrous oxide or dinitrogen. Whether some or all of that nitrification of ammonia is expected to occur in modified trickle filters or in the extended and redesigned passage of effluent through the oxidation ponds is not discussed in the AEE.

46. The first caution I identify is to establish the status of "the Plant". By status I mean:

- "existing" (i.e. pre current upgrade to TFSC).
- "upgraded" (i.e. first stage upgrade to TFSC and other associated plant modification e.g. pre-aeration tanks etc (p.2.10)
- "fully upgraded" (i.e. modification of existing ponds to have all ponds in one series) with or without UV disinfection following reconfiguration of the ponds.

47. The AEE enables a reader to pick one's way through these status stages with considerable but not absolute confidence. Not all other presentations of data make clear the status of the plant to which they apply.

48. My second caution is about the definition of the area and scope of the "plant" and whether the ponds are always considered to be an integral part of it. This is significant because percentage reductions in nutrients indicated may refer to particular stages of treatment. Their total influence needs to be assessed at the final discharge point.

49. Finally, careful specification of the units of analysis and measurement and the procedure employed for these are necessary, but have not always been made clear. I have already stressed that this problem still remained, even after Mr Lewthwaite's supplementary evidence was tabled. For example, the caution shared by Beca Consultants in the May 2000 report now referred to by Mr Bourke, concerning TN (total nitrogen) and TKN (total Kjeldahl N) applies. Nitrate N included with other N forms yields TN. Unless special modifications to the Kjeldahl digestion are used, TKN does not include nitrate. If nitrate is present therefore, TN is greater than TKN. In such situations, TKN should not be considered as equivalent to Total Nitrogen.

50. Since the hearings were adjourned in November 2001, I have seen the Report prepared by Mr H. Archer of Beca Steven[31] for the Christchurch City Council, in May 2000. Mr Bourke refers to several of the N removal options given there by Mr Humphrey Archer. In his report, Mr Archer also included an excellent account of the microbiological processes involved in nitrogen removal. He describes it as a two-step process of biological oxidation of ammonia N (NH_4-N) to nitrite and nitrate by two successive kinds of autotrophic bacteria. This (aerobic) process requires dissolved oxygen for it to occur. Its optimum temperature range is 30°-36° C.

51. Mr Archer also explains the roles of anaerobic denitrifying bacteria in reducing and releasing nitrate as gaseous nitrogen or N-oxides to the atmosphere. This may occur in the bottom layer of a pond, if the water is stratified. Optimum temperature range may be as wide as 5°–25° C.

52. As I stated earlier, I have noticed various misunderstandings and misrepresentations given for the City Council in Evidence about the chemical processes of reduction and oxidation. Council witnesses have used the word "reduction" ambiguously, and "N removal" is presumed to occur through the oxidation of ammonia to nitrite and nitrate, without further exposition. If a nitrogen compound is merely converted from a less oxidised state (as ammonia) to a more oxidised state (as nitrate), total N is not being "reduced" in either sense of the word.

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[31] Humphrey Archer 2000, *Comparison of Nitrogen Removal Processes for the CWTP*. Report prepared for the Christchurch City Council. Beca Steven, Engineering Consultants

53. By courtesy of Beca Stevens, I have also recently received copies of reports by Mr Archer and Mr Donaldson (Marlborough District Council) on monitoring treatment systems at Seddon[32] and Blenheim[33]. These papers are especially concerned with the upgrading and redesign of oxidation ponds as "Waste Stabilisation Ponds" (WSP), and the integration of rock filters and biofilms to secure nitrification.

54. These reports represent encouraging progress in wastewater treatment, especially for reduction of faecal coliforms and presumptive Enterococci. Archer and Donaldson considered the lowering of ammonia and the imputed lowering of total N as significant side benefits of the upgrading. The Marlborough experience was the basis for the several options presented by Mr Bourke in his further supplementary evidence to the hearing in April 2002. I discuss them here as they were numbered by Mr Bourke in his evidence to the resumed hearing.

55. **Option 1** ***Nitrogen Removal from Biosolids Dewatering Stream.*** Beca Stevens acknowledged that nitrogen content of the recycle stream may be as high as "20 % of the total nitrogen content in a wastewater plant", indicating its likely cost effectiveness for specific treatment. The N in the CWTP recycle stream is there reported at "8 % of the total N leaving the ponds at present". This was based on a fairly detailed appendix from the CWTP laboratory. Bourke reports: "Actual measurements at the CWTP indicate that this recycle stream is only 17 % of the total nitrogen leaving the plant". One of these values appears to be twice the other but they appear to be for the same parameter. Are both statements correct? Does this matter affect the economics, cost effectiveness or any other consideration?

56. **Option 2. "*Series Operation of Trickle Filters*".** Operation in series has been used for many years elsewhere to enhance nitrification. The Beca Steven report points out that the first Trickle Filter (TF) reduces BOD with heavy biomass growth while the second TF achieves nitrification, allowing the nitrifiers to function as a consequence of lower BOD resulting from the first. Therefore the lead/lag phase has to be switched on a weekly or fortnightly basis. Mr Bourke acknowledges that the conversion of ammonia to nitrate assumes that the nitrate is then removed in the ponds by denitrification to nitrogen gas. It is also possible that high nitrate content in the filters might repress nitrification. No net N removal from the system occurs unless there is successful nitrification followed by denitrification. I believe that the 30% conversion of ammonia may be an upper limit dictated by the filter medium, rather than be a mean value for the whole year or the winter. The conversion would be lowered as more waste was put through the plant. Provided that it continues to work in all seasons with the lag/lead switch operation of trickle filters in series, the system thus modified could provide some low investment lowering of ammonia, but probably not by very much. Its influence on total N is entirely dependent on other factors beyond the Trickle Filter component of the treatment system.

57. **Option 3. "*Extra aeration in the solids contact tanks*".** If we have enough air passing through enough tanks and remove the nitrate formed, we can oxidize quite a load of ammonia. If we wanted substantial lowering of ammonia and didn't worry much about either the cost, or the nitrate, we could have substantial effect, but it may not be very cost-efficient.

58. **Option 4 "*Rock lined Baffles, Rock filters and submerged reefs*".** This appears as Option 3 in the Beca Steven Report. It is the substantial pond modification option that has the highest

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[32] Humphrey Archer and Stuart Donaldson 1998. *NZWWA 1998 Conference Papers.*

[33] Humphrey Archer and Stuart Donaldson 2002. *NZWWA 2002 Conference Papers*

promise and the greatest uncertainty. I have several doubts and reservations about it, especially for its effects on the Estuary. These are summarily listed below.

- Will we achieve as good results as were claimed at Blenheim if we scale up for Christchurch? (On a *per capita* comparison, we need to multiply about 30-fold).
- Will we have sufficient head in the low relief Christchurch landscape for ponds in series with rock filter or gravel beds that will provide the nitrification capacity we need
- Will anoxic conditions sufficiently develop in the ponds to achieve denitrification? If the prevailing north-east wind stirs up the water, or if we have to stir water to control algal blooms (as Archer and Donaldson suggest), how will the layered water column develop that is necessary for effective denitrification?

59. Assume that we have substantial nitrification of ammonia so that we seem to be lowering the load of ammonia in the Estuary, but at the same time have incomplete denitrification, we may expect substantial nitrate feeding of estuary plants possessing a faculty for nitrate reductase. For a great number of plants, nitrate or ammonium ions can provide their nitrogen requirements although there may be considerable differences in the balance of other ions as a consequence.

60. If we were to remove, say, 90 % of the N by nitrification of ammonia followed by denitrification, would the residual reactive phosphorus being loaded into the Estuary trigger a blue-green algal bloom, fixing from the atmosphere as much N as occurs now from CWTP, to again return the system to a eutrophic condition? Mr Bourke has recognised this risk (Evidence, item 14), but no one knows its likelihood. He acknowledges that it could negate the expenditure upstream. But could we have a similar algal N-fixation risk in the pond system? It is after all, "fresh-water", so the ordinary hesitations about blue-green blooms in saline water are hardly relevant. But how salty does water have to be before it inhibits blue-green algae fixing N? Apparently Peel Harvey Inlet in Western Australia was not salty enough to prevent a massive blue-green bloom that led to high nitrogen fixation and then brought on massive growth of sea lettuce at the beginning of the 1980s. Why should it not happen here with similar loss of amenity and lowering of property values?

61. We might ask some further questions in passing: How is it that this option, the most cost-effective but uncertain prospect for removing nutrients is dependent on the design and function of a new pond system that has hardly figured in any of the Resource-Consent application documentation or Evidence?

62. How real is the nutrient removal achievement at Seddon and Blenheim anyway? I don't see convincing evidence in Table 1 of the first (Seddon alone),1998 paper that I have from Mr Archer. Furthermore, I wonder if the TKN has been determined in a way that includes nitrate. I don't see any substantial evidence of Total N removal at Seddon (in Table 1, second 2002 paper) nor any substantial removal of Total N at Blenheim (in Table 3, same paper), except for summer. (cf. Table 1 of Mr Bourke's attachment).

63. I would like to be assured that nitrate has been determined and included in Total N. (*Cave TKN!*) I can see evidence of summer nitrification, but I see very little sign of nitrification, if any, in winter. (I am aware that nitrification can occur in winter. I measured it in the surface centimetre of a previously frozen soil at Guelph, Ontario, when it thawed during a "green Christmas". Even so, the rate of nitrification was less than 1 % of the rate that prevailed during late spring and summer.)

64. At the present time, from the evidence of Ponds 5 and 6, where virtually all mineral N is as ammonia, I see little evidence of nitrification at any season of the year. I expect that nitrification in the remodelled ponds at CWTP will be negligible in winter. I therefore expect that ammonia levels will remain high and relatively unaltered in the ponds, at least during cooler months of the year. We cannot expect susceptible aquatic fauna to survive the dissolved ammonia levels of winter discharges from CWTP, even after pond remodelling.

65. **Option 5. *"Full Wetlands Development"*** (Beca Steven Option 4) was not discussed by Mr Bourke except (Para 3) where he states: "With our present understanding of wetland operations we consider there is simply not enough area available". Likewise the Beca Steven report concedes that only 500 ha were "potentially" available whereas "1400 ha would be needed for a conventional wetlands development to remove 90% of the ammonia N". These statements support my earlier evidence, where I indicated that even 1400ha might be inadequate. I have recommended elsewhere that the wetlands option might usefully be applied to cleaning up the Avon and Heathcote Rivers before they discharge into the Estuary.

66. In short, I consider that each of the possible options advanced by Mr Bourke could be useful, if ammonia were the only concern and if there were some assurance that the level of nitrification to be achieved was to be sustained into the future. Instead, the NH_3 load, for a mere six years, will remain at two thirds of its current amount (M Bourke, attachment 4). From 2010 onward, even with constant lowered NH_3 concentration (M Bourke attachment 3), current ammonia and nitrogen loads will be matched or progressively exceeded (M Bourke attachment 4).

Influences of Augmented Nutrient Inflows on the Estuarine System

67. As regular nutrient inflow is increased over a period of time, it might be expected that its influence would show in the composition of estuarine waters, in the chemical composition of its sediments, and in the productivity and biodiversity of its biota. Such influences might be mitigated to some degree by the discharge of tidal water to the ocean, but this last factor might be affected by the return of portion of the discharged waters on the next incoming tide.

Changes in Nutrient Concentration in Estuary Waters and Sediments

At the April 2002 Mr Lewthwaite presented to the resumed Hearing accumulated ECan data on water quality since 1973 (his Appendix 2c, re: Issue 2) together with summary statistics for comparison of data for 1995 to 2002 (Appendix 2) as well as for the whole time from 1973-2002, mostly from 1989.

68. This availability of more comparative data on chemical properties of Estuary water presented to the third (final) session of the hearing allows us to compare levels of nitrogen and phosphorus in estuary waters at several different sites over different periods. My summary appears as Table 3.

69. Five locations have been selected from among the total recorded in Lewthwaite's Appendix 2c. Two periods have been selected, the earliest period for which regular data were available, 1989-1991, and a more recent period of four years for which available river and CWTP inflow data appeared relevant, 1995-1999. (cf. Tables 1 and 2 in this paper). Means for 1989-1991 and 1995-1999 from ECan approximately monthly samplings, were calculated from the primary data in Lewthwaite's Appendix 2c. These are presented to compare with means at the same locations

for 1970 - 1972 and 1989-1991 recorded by Knox[34]. In Knox's record, the samplings for 1991 were incomplete. Values are means for mineral N components (nitrite + nitrate and ammonia), total N (where available), dissolved reactive P (DRP) and total P, expressed throughout as g/m^3.

70. When the earlier data were summarised by Knox[35], he warned that 1970-1972 data were from channel stations sampled at low tide whereas the samples from 1989 onwards were mostly taken at various stages of ebb tide (generally from 2 to 4 hours after Lyttelton high water). Lewthwaite also warned against direct comparisons of such statistics without sufficient regard to the sampling times and methods involved. These warnings have to be heeded in arriving at any conclusions.

71. From 1989 onwards low tide sampling has been generally avoided, and time of sampling and time of high tide at Lyttelton are both recorded in Lewthwaite's Appendix 2c. The two sets of data for each station for the period 1989-1991 naturally show fairly close agreement, which is to be expected, being from almost the same period from the same primary source. Comparisons between 1989-91 and 1995-99 are less subject to the caveat of tidal stage at sampling. Total N determinations began only in May 1991 and therefore inadequately sample the whole 1989-91 period. Nevertheless, total N generally appears to be elevated at all sites by 1995-99.

72. Closer examination of the data in Lewthwaite's Appendix 2c reveals high variability within period data sets for all N components, standard deviations being often of the same magnitude as the mean. Variation is much less in P components. The N variation appears to be attributable to occasional high values, especially for ammonia. Because of these variations, it is doubtful if statistical analysis would reveal any clear changes over the last decade in the concentrations of nutrients N and P in the water column.

73. Perhaps the most indicative feature of data in Table 3 is the differences between sites, and in the way that different sites may be varying over time. This is borne out if we include in our consideration two further sites, Bone Tip (or Sandy Point) and Pleasant Point Jetty, two sites that were regularly sampled by CRC (ECan) and included in Lewthwaite's Appendix 2c. They were not included in this comparative presentation, because they had not been included in the earlier studies by Knox and his associates. Of these two additional sites, Pleasant Point Jetty indicates, like all the other sites, higher total N in 1995-1999 than in the limited sampling of 1991, but no other consistent change. In partial contrast, the Bone Tip site is now grossly contaminated by all N forms except nitrate, but also exhibits further increase from 1989-1991 to 1995-1999 in all other contaminants. This site also had the lowest proportion of organic nitrogen (estimated by difference) in its total N, even though the absolute level of organic nitrogen was more than twice the level at all other sites and the amount of organic material in sediments was conspicuously high.

74. Examination of the data that include total N as well as ammonia and oxidised forms of mineral nitrogen, allows us to assess the contribution of organic nitrogen to the total nitrogen in estuarine waters. At the present time organic N is a substantial contaminant of estuary waters, constituting nearly 50 per cent of total N at Beachville Road and Shag Rock. This level of contamination appears to be an outcome of the substantial amounts discharged with ammonia N

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[34] *idem* Table 3.3, p.32.

[35] George A Knox 1992 *The Ecology of the Avon-Heathcote Estuary.* p.32 A Report prepared for the Christchurch City Council and the Canterbury Regional Council, 158 pp

from the CWTP (cf Table 2 earlier), together with the residues of organisms that have assimilated nitrogen in the estuarine system. How much of this is attributable to suspended sea lettuce residues cannot be assessed without knowledge of the filtering practices involved in water testing.

Table 3. N and P (g/m^3) in Estuary Water for various periods and locations

Location	Years	NO_2-N + NO_3-N	NH_3-N	Total N	RDP	Total P
Mt Pleasant Yacht Club	1970-72	0.468	0.729		0.059	0.149
(Knox)	1989-91	0.469	0.798		0.235 #	0.294
(ECan)	1989-91	0.481	0.913	1.644*	0.237	0.303
(ECan)	1995-99	0.463	0.902	2.041	0.197	0.307
Pleasant Pt Yacht Club	1970-72	0.333	0.530		0.146	0.225
(Knox)	1989-91	0.714	0.928		0.343	0.433
(ECan)	1989-91	0.572	1.074	2.080 *	0.344	0.441
(ECan)	1995-99	0.670	1.012	2.270	0.221	0.310
McCormacks Bay culvert	1970-72	0.078	0.074		0.043	0.086
(Knox)	1989-91	0.066	.063		0.033	0.060
(ECan)	1989-91	0.067	0.067	0.258*	0.040	0.064
(ECan)	1995-99	0.090	0.130	0.540	0.033	0.070
Beachville Road	1970-72	0.113	0.214		0.125	0.268
(Knox)	1989-91	0.109	0.236		0.069	0.103
(ECan)	1989-91	0.099	0.217	0.388*	0.068	0.100
(ECan)	1995-99	0.110	0.225	0.650	0.049	0120
Shag Rock	1970-72	1.070	0.099		0.079	0.149
(Knox)	1989-91	0.087	0.259		0.072	0.099
(ECan)	1989-91	0.093	0.261	0.525*	0.071	0.095
(ECan)	1995-99	0.140	0.430	0.970	0.093	0.160

* values derived from few samples; # value corrected from transcription error from Table 3.2 in same source (Knox).

75. Oxidised nitrogen forms, nitrite and nitrate, are noteworthy features of the water column at all sites in Table 3 over the thirty-year span of sampling, despite their virtually complete absence from the CWTP discharges in recent years. Even when we take account of the significant proportion of N that occurs as nitrate in the incoming rivers, it would appear that the Estuary

has been the site of appreciable nitrification of ammonia discharged from Ponds 5 and 6. Whether denitrification of nitrate has been occurring at any part of the Estuary at any time cannot be inferred without more attention to careful mass balances and other indications.

76. Interpretation of chemical composition of estuary water at different sites calls for some attention to the sediments underlying the water column for their two-way interaction with water. Many of the major studies of the Estuary have paid some attention to the variation in physical, chemical, and biological composition of the sediments from place to place. Some have pointed to the significance of their location in relation to CWTP discharge points. Robb (*op.cit.* p.69) in an intensive but short-term survey showed how both N and P accumulation in sediments were related to organic matter. He found close correlation between organic matter content and total P content ($r = 0.94$) and between organic matter content and albuminoid N content ($r = 0.87$). The possible roles of sediments in accumulation and release of nutrients demands comparable survey, samplings and analysis at intervals into the future.

Possible Changes in N and P Mass Balances

77. How much of the Estuary's nutrients are removed by tidal efflux from the Estuary? The Estuary exchanges nearly its total volume of water with the ocean almost twice a day (Time lapse between tides is approx. 12 hr 25 minutes, giving daily lag of 50 minutes). Nearly forty years ago, Wilkinson[36] attempted to work out a balance for nitrogen, on the basis of the influx and efflux in pounds of N, inorganic and organic, on each tide. Total influx (converted here from pounds per tide) was 690 tonnes per annum and efflux was 1048 tonnes per annum. In his study, 76 per cent of the N influx was inorganic whereas more than 90 per cent of the net efflux of N was organic. He estimated that some 50 per cent more total nitrogen was leaving the Estuary than was coming into it from the land.

78. In my evidence to the first session of the Hearing, I reported how I had used a different approach from Wilkinson to derive some tentative annual mass balances of mineral N, total N, reactive P and total P, between what comes in from the oxidation ponds and rivers (influx) and what is lost (efflux) to the sea. I used CCC records (CWTP Laboratory Manager M. Gilson, pers. comm.) and Environment Canterbury records (M. Main, pers. comm. and M Gilson) of nutrient concentrations in water for inflows and the Estuary itself. The results were presented (in what was Table 2 of my evidence) for two periods, 1989-1991 and 1995-1997. These two periods appeared to have markedly different balances, net influx being higher in the first period, but net efflux being much greater in the 1995-97 period, arising from much greater values for nutrient efflux to the sea. In my evidence, I speculated on the possibly considerable significance of such a difference if it were to prove to be real.

79. I nevertheless considered the conclusion as very tentative, because of fears of sampling inadequacy, and perhaps because of faulty assumptions concerning numbers of tides and proportion of efflux returning on the next tide. My initial approach and its result seemed especially unsound, being based on inadequate sampling over the tidal range. How much bias occurred is unknown, but sampling the efflux at Shag Rock may have variably intercepted the pulse of effluent from CWTP that occurs on the ebb tide. The significance of interaction with such a pulse of effluent is demonstrated in Mr Batcheler's revelations in his own evidence,

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[36] Wilkinson, L. 1964. Nitrogen transformations in a polluted estuary. *Advances in water pollution research.* 3> 405- 420.

concerning ammonia concentrations in samples taken at intervals over the whole of a tidal cycle. My hope was to return to mass balancing when more data became available. I have since re-examined the mass balance situation over different periods, in an effort to find some tenable conclusion on possible trends.

80. For the information I have used and their permission to use it, I am especially grateful to Mr Gilson and Mr Lewthwaite (CCC) as well as Mr Mains (ECan). For many later discussions, suggestions and exchanges of information with Mr C.L. Batcheler, I am greatly in his debt. An earlier Lincoln Environmental Study[37] had shown that a net discharge of about one third of the total Estuary capacity occurs on each tide. On this basis, and accepting that the Estuary tidal compartment[38] is 11 x 10^6 m^3 and given that there are some 705 tides per year, I made my estimate of total effluxes of mineral and total N and reactive and total P. Because of continuing deficiencies in the estuary water quality data *for the calculation of nutrient effluxes*, I have still not been able to arrive at any valid quantitative balance. This failure occurred despite my extension of the periods of samplings from 1989 until 1997, as shown in Lewthwaite's 2002 Appendix 2c, and despite my inclusion of Beachville Road data as an additional location.

81. An indication of qualitative balances may be of value. From Mr Gilson's chemical data from ponds 5 and 6 and assuming output of 150,000 m^3/day at the beginning of the decade rising to 153,000 m^3/day in 1995-97, and from annual calculated loadings of N and P for mean low flows for the Avon and Heathcote rivers, fairly reliable estimates of influxes have been made. For these estimates I take personal responsibility.

82. The combined annual influx of total N from ponds and rivers grew from <1700 tonnes per year at the start of the decade to >2300 tonnes per year for 1995-97. About 500 tonnes per year of this influx was organic N from the ponds. Annual influxes of P, mostly reactive P, remained relatively constant over the period despite some greater variability in concentrations from one pond sampling to another later in the decade. Although little confidence can be attached to the absolute values, efflux of total N and total P over the decade appears to have remained a fairly high and relatively constant proportion of the influx, with some increase in net efflux on the tide of total N in recent years (indicated earlier by higher concentrations in Table 3 earlier) accompanying the increased N influx of recent years.

83. Qualitative balances for N and P suggest that mineral N and perhaps reactive P may be greatly transformed in the Estuary. Table 2 of this paper shows that for most recent assessment of loads to the Estuary that take account of organic N, ammonia loads in discharge from Ponds 5 and 6 were from 70% to 80% of total N, with negligible nitrate. Table 3 of this paper and Lewthwaite, 2002 Appendix 2 indicate that in the Estuary generally, ammonia is some two thirds of the total nitrogen. It is clear from the abundance of nitrate and organic nitrogen in the efflux to the sea as well as in the estuary water columns that ammonia N is being converted in the system. Nitrification and incorporation of ammonia into other organisms are both at work in the Estuary. The Estuary is evidently functioning as a milieu for nitrification much better than the ponds, despite the short residence time of estuarine water.

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[37] Anon 1994. Avon-Heathcote Estuary Dye Study. Lincoln Environmental Ltd. Report. 2481/2. 60 pp.

[38] Findlay and Kirk 1988. Post 1847 changes in the Avon-Heathcote Estuary, Christchurch: A study of the effect of urban development around a tidal estuary. *NZ J. Marine & Freshwater Res. 22*: 101-127.

84. These apparent effects are net effects. Any changes in balances will not be *understood or explained without careful correlated studies of physical, chemical and biological changes in the sediments* of the Estuary bed. If, in fact, nutrients in one form or another were discharged from the Estuary at loads in excess of incoming nutrients, as Wilkinson (*op.cit*) had earlier concluded, it may be easier to recognise that such nutrients are not being used to support the productivity of the Estuary, in any guise. Glib assertions are made that nutrients delivered to the Estuary are being "used" whereas piping them to sea would be "wasted". Both forms of disposal in fact waste nutrients.

85. The obvious ecological importance of the matter warrants repeating, expanding and developing Robb's surveys of N and P in sediments, in relation to the chemical composition and processes of the water column. The work of Gardiner (1993) and Hicks (1993) reinforce that argument. I consider that if we continue to neglect the understanding of nitrogen transformations in the Estuary, we may be overlooking the development of environmental disasters on our doorstep[39]. Furthermore, as mentioned earlier, were we to concentrate on lowering nitrogen levels and neglect phosphorus, we might readily create conditions ideal for a blue-green algal bloom, fixing nitrogen from the atmosphere and so renewing the likes of sea lettuce that could dwarf our experience to this point[40].

86. At present nutrients and microorganisms are discharged from the Estuary outflow onto the Sumner and South Brighton beaches. Ironically, some opposition to a 2km marine discharge pipeline was largely based on the notion that keeping effluent in the Estuary would keep the beaches clean. Those who espouse that view may have their heads stuck in beach sand. To those experienced in gathering light driftwood at Clifton beach, the ammoniacal smell and the crackle of saltpetre in the fire are familiar enough.

87. As recreational beach water quality monitoring by Environment Canterbury since 1998 and CEA sampling during 2000-2001 have abundantly shown, the present discharge regime into the Estuary contaminates the ocean beaches. Whatever is discharged on the tide, nutrients and organisms as well as some of the detached residues of the sea lettuce nourished in the Estuary are beach contaminants. The eventual destruction of the Estuary ecosystem as we know it is also ensured at some time in the future, notwithstanding its practical and symbolic value. We should likewise recognise that annually, loads approaching 4000 tons of elemental nitrogen and 400 tonnes of elemental P are discharged to the ocean on the tide. This is waste that should not be beyond our collective wit to find safe ways to avoid.

Changes in Biological Features of the Estuarine System

88. Dr. Burrows' and Prof. W.C. Clark have shown how the estuary is a very complex ecosystem, with many adaptive features. As Prof. Knox's in his own evidence remarked, it has already had

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[39] Recent studies in Denmark, Netherlands, Japan and United States of America indicate the significance of nitrogen transformations in estuarine systems. (Rob Sherlock, pers. comm. September 2001). Especially disconcerting is evidence that complete eutrophication may be being delayed by denitrification to nitrous oxide. It would be serious if this was found to be occurring in the Avon-Heathcote Estuary: Large-scale denitrification promoted without ensuring that it avoids major liberation of nitrous oxide would be internationally irresponsible.

[40] Peel Harvey Inlet in Western Australia suffered such a disaster a few years ago as an apparent consequence of leaching of phosphate from coastal sandy soils, which were being developed for dairying. Whether such algal blooms are also poisonous depends on species composition. Canterbury's Lake Forsythe experience should not be forgotten.

to adjust to several major anthropogenic changes. We cannot be confident that these can continue, in the face of continued increase in nutrient loading, especially if this is reflected in nutrient accumulations in organic sediments. Knox's report in 1992[41] and his statement of evidence inform us on the density and distribution and some recent induced changes therein, of plants, fish and various invertebrate benthic communities.

89. As Dr Burrows and Prof. Clark remark, it is far from clear whether the evolutionary forces that fitted our biota to an oligotrophic system can adapt to unnatural enrichment. The food chains and habitats of the oxidation ponds differ from those of the Estuary, but some animals adapted to the Estuary benefit from attachment of the ponds system. For example, for most waterfowl species except grey teal, the ponds rather than the Estuary are especially important[42]. The Estuary itself is more significant for the waders. The nutrient enrichment associated with sewage treatment greatly enhances the food supply for some bird species, especially the introduced black swan, Canada goose, mallard duck, and a few waders such as the pied oystercatcher. Expansion of the ponds themselves was at the expense of wetlands that used to provide nesting sites for other species. Enrichment with nutrients may foster productivity at the cost of biodiversity.

90. In the absence of an integrated model, confident predictions cannot be made about the effects of restorative approaches such as reducing nutrients or development of the proposed 'Green Edge' or other engineering works. Such measures as are primarily intended to improve the sanitary quality of effluent are not especially intended to reduce the loads of nitrogen and phosphorus delivered to the Estuary and ocean. We should nevertheless recognise that reduction in nutrient load is an essential precursor to any rehabilitation of the Estuary

91. The abundance of N and P in the estuarine environment has created a photosynthetic productivity vacuum which sea lettuce has done its best to fill. If we get rid of it other than by reducing its nutrient substrate, the vacuum could be occupied by something else. *Gracilaria* looks to be performing this function now. Regardless of the species involved, the system will eventually run out of oxygen and rotting will become anaerobic. Death and decay in this way through eutrophication would be fatal and sooner or later, the Estuary system as we have known it will die.

The Ability of the Estuary to Adapt to or Recover from Disturbance

92. In relation to Professor George Knox's evidence, I would point out that his discussion of changes in sediments and sediment processes, following Deeley and MacPherson, begins virtually from 1925 with the start of river sweeping. De Thier and GG Andrews (see BR Hansen's Evidence) showed that changes to the estuary sediments and bed levels have been many and various from the early days of European settlement. As Prof. Knox and Mr Hansen (both in Evidence) and my own statements from the work of Kinder and Robb all indicate, the changes have occurred in different directions in different places and may be continuing to the present time. Since alteration of sediments has been occurring differently at different places under the influence of wastewater discharge and other disturbances, and since different organisms are adapted to different kinds of sediment substrates, we should be wary of inferring too much about overall changes from temporal snapshots, rather than from sustained and

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[41] Knox, GA 1992. The ecology of the Avon-Heathcote Estuary. Report to Christchurch City Council. 158 pp.

[42] Crossland, Andrew C, 1993 "*Birdlife of the Avon-Heathcote Estuary and Rivers, and their margins*". Department of Conservation Canterbury Conservancy Technical Report No 6, 104 p.

systematic monitoring. The Latin phrase *post hoc, ergo propter hoc* (after this, therefore because of this) is an apt reminder of a logical fallacy about ascribing effects to causes.

93. Professor Knox (paragraph 50) claims: "Over the years since human settlement the Avon-Heathcote Estuary has been subjected to numerous perturbations and it has ***recovered*** (my italics) from them". In my view, "adapt" or perhaps "adjust" could be used validly, but not "recover", for this implies that it has been "restored in health" or "restored to a similar state". Rather, the estuary is continuously changing under a changing regime that is driven primarily by enrichment with nutrients.

94. In his 2 vol. textbook "*Estuarine Ecosystems - a Systems Approach*" (1986), Knox[43], following the classic work of Odum, warns especially how the 'nutrient trap' and induced high productivity interact to heighten the precarious balance of estuarine ecosystems. The high adsorptive capacity and biodeposition through filter feeders in the sediments, and the horizontal ebb and flow of nutrients, give estuaries their productivity. But whether augmentation of productivity is good for maintaining the condition of the Avon-Heathcote Estuary in the long-term is highly contestable. It is also a clear violation of the principle of precaution.

Employing Science in Resource Management

Inherent Limitations to Conventional Science for Complex Dynamic Systems

95. Despite the weight of data and evidence adduced to its cause, I do not consider that the Christchurch City Council has made appropriate use of relevant and necessary science for this issue in environmental resource management. Science is needed for the public good in these complex civic issues. For such situations as these, Professor O'Riordan[44] expresses some new and valuable ideas. I offer some of them that clarify a Resource Management perspective relevant to the Estuary.

> "Interdisciplinarity means taking a more negotiated science into the policy realm and engaging with the public. This is because societal understanding is vital to the conduct of science under conditions of great uncertainty, value conflict and value ambiguity". O'Riordan acknowledges "a more formal multidisciplinarity is often found in the ever-widening area of environmental impact assessment (EIA). Admittedly even today, almost quarter of a century after the Americans first introduced the approach in the 1969 National Environmental Policy Act, this technique is more an amalgamation of mini reports based on predetermined approaches than a truly integrative document."(This I suggest may well describe the mind-set portrayed by the preparation and presentation of Christchurch City Council's effluent discharge case.)
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> "For Environmental Impact Assessment to flourish," writes O'Riordan, "it needs not just to integrate the disciplines. It also needs to provide regular guidance over how a project should evolve. Interdisciplinarity recognises that power is shared ....when those likely to be affected by change actually negotiate their values and reactions from the outset, and that data are a function of knowledge, experience and power. In other words, the vital ingredients for the EIA (Environmental Impact Assessment) have to come from the people on the ground

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[43] Knox, George A, 1983, 1986 *Estuarine Ecosystems – A Systems Approach* 2 vols, Boca Raton, CRC Press.

[44] O'Riordan, T, 1998. *Environmental Science for Environmental Management,* Longman Scientific and Technical.

whose interests are directly affected. This is not just a matter of well-intentioned liberalism: it recognizes that those who have used a resource for generations are the best judge of how impacts of change can be evaluated."

96. Public good science in New Zealand has had a tumultuous history in recent years. In the middle of the last century, we had science and scientists on some kind of "expert" pedestal, regardless of their capabilities to deal with a whole issue. Being disappointed with their performance as "problem-solvers", we restructured them into ways where they could be managed to help achieve outcomes seen as desirable by those with civic or commercial responsibility of one kind or another. This last step may have reduced the quality of science and the public interest content of science, at the same time as it avoided the social transaction process described by O'Riordan as essential and integral to it. In pursuit of genuine public participation in a new mode of "*Integrated Environmental Management*", we now have to keep science vigorous, improve its intellectual quality, and maintain or enhance its relevance. In engaging science with public policy, we have to engender respect for observable facts and their understanding, while we attend to the clarification of our various social values by repeatedly confronting them with the facts of the world about us.

97. In these commercially dominated times, I am well aware how our values become confused when we try to sort out a way of living with a piece of nature of which different parties expect different services, but no one wants to pay the full price or meet the full cost. In passing, I appreciate the difference between contamination and pollution[45], and I sense the reluctance of the City Administration to name the CWTP nutrient inputs to the Estuary as contaminants under the RMA.

98. I recognize also the ironic parallels that may be drawn from the history of England's Thames River and our own Estuary. London's corruption of the Thames eventually led to "the Great Stink" of 1856, Parliament abandoning the city, and a special act of Parliament to create a Metropolitan Commissioner of Sewers. The sequel was gradual elimination of sewage discharges into the river and, over a century, its gradual recovery and the reappearance of fish and macro-invertebrate communities by the 1960s - a full century later!

99. I submit that in contrast with conventional administration, O'Riordan's principles for assessing the environmental impact of a major work on our greatest remaining wetland, and for managing it better, have more than merely idealistic appeal to professional resource managers.

100. For our Council, the idealism may have become difficult to sustain as the financial going has grown tougher. Interdisciplinarity is seen as threatening the conventional budget process when it is suspected that what may be called "ecological services" that have been taken for granted may now have to be paid for, and past debts repaid. With so little of "ecosystem interdisciplinarity" involved in the dialogue, it is quite understandable that our Council should attempt to renege. The sequence of decisions taken by the Council during the past few years shows clearly that they framed a short-term financial decision ***before*** the case was heard, and in which the ecological future of the Estuary had been ignored. I believe the strength of the Case for the Estuary will eventually prompt the Council to regret and redress that decision.

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[45] Alastair Grant and Tim Jickells (1998): Marine and estuarine pollution ; p. 263 – 282 *In "Environmental Science for Environmental Management"* Longman Scientific and Technical.

Understanding Uncertainty in Environmental Processes and the Precautionary Principle

101. O'Riordan (*op.cit.* p.8) distinguishes three levels of uncertainty in environmental science that are relevant to the Estuary situation. Each is illustrated by an example from our present situation

Data shortage. There is little information on historical trends if any in populations and distributions of indicator organisms, although there are bases for some analyses in data collected by the Estuarine Research Unit of University of Canterbury, in the Drainage Board programme. As O'Riordan writes: "No amount of new data will make up for the lack of historical record in the medium term."

Model deficiencies. The evidence of Hawes and O'Brien regarding nitrogen and the growth of sea lettuce was not complete enough to make general ecological sense. The model had not had the benefit of field validation in New Zealand before being applied to such a politically and economically important problem. The greatest error, however, was in politicians drawing important but unjustifiable conclusions from misapplying it.

Beyond the knowable. Terrestrial and aquatic systems "appear to act chaotically (randomly) and catastrophically (flipping into new phase states or exhibiting huge but transitory turbulence)".

So - I rhetorically entreat – you may ask **whether**, but don't ask a competent ecologist **when** the Avon Heathcote Estuary will flip! At least don't expect her or him to give you a reliable answer. Because of these three qualities of uncertainty, we have to fall back on the *principle of precaution.*

Applying the Precautionary Principle

102. O'Riordan distinguishes four meanings to this principle: 1) thoughtful action in advance of scientific proof; 2) leaving ecological space as room for ignorance; 3) care in management; 4) shifting the burden of proof from the victim to the developer. No matter which facet is applied to wastewater discharge to the Estuary, it is a valid and necessary principle to be applied by declining the Application for resource consent. Continued discharge has such uncertain social, environmental and economic consequences, that application of the precautionary principle is imperative.

103. If the discharge consent is declined, the city can meet the obligations of the Coastal Resources Policy and turn immediately to disposing of the properly-treated effluent elsewhere. If it cannot brook the cost of using water and nutrients on the coastal silts and sands to the north of the city for recharging groundwaters with properly treated effluent and growing valuable wood products, then away with this "wastewater" to the ocean, but by a feasible pipeline, not by destroying the Estuary on the way!

Ian R. Wood's Evidence, with special reference to Mixing Zones, Ocean Outfalls and Christchurch City Council Working Party on Wastewater Options.

Biographical Note

1. Ian Ruthven Wood has degrees in Civil Engineering (BE Hons 1954) at the University of Canterbury, and ME (1958) and PhD (1966), both from the University of NSW. He is a Fellow of the Institute of Professional Engineers of New Zealand and a Fellow of the Royal Society of New Zealand
2. He has presented papers on various aspects of fluid mechanics and keynote addresses at many conferences and in the past 20 years and given courses in several countries on aspects of fluid mechanics, including the fluid mechanics of Ocean Outfalls in Pune (India), Nanjing (China), Singapore, and Cornell (USA).
3. He has published 43 papers in refereed journals and 38 papers in conferences proceedings and was the major author of a book on Ocean Disposal of Wastewater (World Scientific 1993) and editor of a book on Air Entrainment in Free-surface Flows for the International Association of Hydraulic Research (A.A.Balkema 1991)
4. He has been an engineer at the Commonwealth Department of Works (1955-60), Lecturer at the University of New South Wales, Associate Professor (1960-71) and Professor of Civil Engineering at the University of Canterbury (1971-1993). He has taken two sabbatical leaves at Cambridge and one at Cornell.
5. During these appointments he maintained contact with local consultants and served as a consultant. These assignments including investigation for the Waitari Outfall and review of the measurements and computer models for the Sydney tunnelled outfalls. Since retiring he has had short university appointments in Singapore and Hongkong, and as a consultant in connection with a cooling system for a major thermal power station in Thailand.

Introduction

6. In this Statement of Evidence I draw the attention of readers to relevant issues relating to the Christchurch City Council Wastewater Working Party and the mixing of the proposed effluent discharge in the Estuary.

Christchurch City Council Working Party

7. I was employed by Ngai Tahu to review the numerical models relating to the dispersion of the effluent both from the Avon and Heathcote Estuary and the ocean outfall. (This was a limited brief and this is a personal submission). The Christchurch City Council set up a Working Party to advise and recommend on the issues, options and potential treatment and disposal options and in my capacity as a consultant I attended some of working party meetings and was given access to the reports commissioned by the Council. Included in these reports was an external peer review which was carried out by "experts in the three areas of technology which were crucial to

the Council's decisions - namely wastewater technology, estuarine ecology and ocean and estuarine hydraulics"

8. The majority of the Working Party recommended that the effluent be disposed of *via* an ocean outfall. The Peer Review Committee consisting of Dr Alex Sutherland (specialist in Hydraulic processes) Mr Humphrey Archer (specialist in Treatment Processes) and Dr Paul Gillespie (Estuarine Ecologist) read and commented on all the reports. They had both the local knowledge and the technical expertise to assess the project. Based on the technical evidence that they saw, they agreed with the Working Party's conclusion. Having independently read the reports I also agree with the Working Party's conclusion.

Mixing Zones

9. I comment on the mixing zone section in the AEE page 8-11 The mixing zone is a specified area allocated for the initial mixing of pollutants in the discharge and at the edge of the of the mixing zone the ambient standards must be met. As mixing does not take place instantaneously the pollutant concentrations in this area will exceed the water quality standards. As Rutherford (1994) states this area is one of non-compliance. In the United States, in addition to the legal mixing zone, specified pollutant levels are set for areas that are sensitive to any pollutant interference (Jirka 1993). This may be outside the legal mixing zone.

10. Indeed there also some times when more stringent mixing zone definitions are required for toxic pollutants and they specify a smaller region within the regular mixing zone. For a well-designed ocean outfall, the mixing zone is well offshore and the dilutions from the diffuser to the surface (or to the trapped layer for the case where the ocean is stratified) are such that the specification of the mixing zone is relatively unimportant. Indeed, I have attempted to make measurements at the surface of the plume arising from the old outfall at Waitara. These measurements showed that the mixing zone was very variable and indeed we had difficulty in manoeuvring the boat into the zone.

11. In addition, while reviewing the Sydney Outfall measurements and computations, I concluded that the mixing zone in estuaries and in the ocean is a useful artifice for numerical and physical models. However in the field, measurements are so difficult and the zone is so variable that its definition is almost impossible. With the Estuary, the release of the effluent is on the falling tide and the mixing zone is more complicated as it will vary with the state of the falling tide. However the Estuary Proposal states that effluent from the oxidation ponds meets the standard for micro-organisms and when the UV Disinfection Unit is installed the effluent from the oxidation pond will meet the recreation standard. It is thus difficult to see why the applicant wants a mixing zone of the whole estuary (an area of non-compliance) unless the mixing of the non salty water from the effluent and the salty estuary water creates problems with the estuarine ecology.

12. When the Avon and Heathcote rivers enter the Estuary there is the natural mixing of the fresh water and the salty estuary water. However the difference is that less than 10% of the nutrients contributed come from the river system. If the Estuary is ever to be returned to something like it's natural state then we should first remove the major part of the nutrients and this suggests that the ocean outfall is the only long term solution. However even if the major portion of the nutrients are removed, the return of the Estuary to something like its natural state will take a long time and indeed the river system may need cleaning up.

13. Experience shows even with a nutrient rich effluent, well designed outfalls in an open coastline have little effect on the environment.

References:

Rutherford, K. Zur. B and Race. P, 1994 Resource Management Ideas.

No 10 Reasonable Mixing " A discussion of reasonably mixing in water quality management" Published by the Ministry of the Environment.

Jones. G, R., Nash. J, D and Jirka, (1996)

G H. "Cormix3 : An Expert System for Mixing Zone Analysis and the prediction of Buoyant Surface Discharge " De Frees Hydraulic Laboratory, School of Civil and Environmental Engineering, Cornell University, Ithaca, New York, USA

LEO BYATT'S SUPPLEMENTARY EVIDENCE IN DEFENCE OF THE ESTUARY.

(Mr Byatt's main statement was a personal submission to the Commissioners. However, knowing the relevance some of his information had to the proposed relocation of the CWTP diffusers for effluent discharge, he prepared the following statement for the Christchurch Estuary Association. CLB and KF O'C, Eds.).

1. My original statement of evidence included reference to my interests and affiliations.
2. In "Issue 11", the Commissioners requested further information on "the likely effects of relocating the discharge points" from the oxidation ponds into the Estuary. According to the sketch plans given by the Applicant during the Hearings in September 2001, between 7 and 9 embayment diffusers are proposed, to be located on reclamations adjacent to existing pond 6.
3. This places the discharge up to 700 metres north of the location of the currently used three outfalls, and thus brings the discharge some 700 metres closer to the mouth of the Avon River.
4. I am concerned about the consequence of this proposal. Consent sought by both the CCC Advocate and witnesses seek to begin discharging **up to one hour before high tide at Lyttelton.** This is about ¾ hr before high tide in the upper Estuary. The consequence must be that the effluent slug will penetrate the lower reaches of the river more rapidly and affect them for a longer period. This must also maintain higher pollutant levels in the broad body of the Estuary for a longer period. Of these, the emerging evidence is that ammonia in the Estuary and rivers at the pH's prevailing is the key poison which is affecting finned fish, and therefore to be avoided.
5. For the above reasons, I submit in the strongest terms my objection against the Applicant's proposal to move the discharge points and begin discharges before Estuary high tide. I notice that the matter of times of discharge relative to high tide in the Estuary and at Lyttelton also appears under "Issue 14". Emphatically, in my opinion, discharge should never be permitted before high tide at some arbitrary

Estuary location, for example, Pleasant Point Yacht Club or Mt. Pleasant Yacht Club (about 50 minutes after high tide at Lyttelton).

6. Nothing has emerged in any evidence given by the Applicant about contamination of the rivers by effluent from Bromley. This in my opinion amounts to deliberate evasion of the effects of discharges on contiguous bodies of water related to the Estuary catchment. Prior to December 2001, the river water was a cloudy brown and opaque to and beyond Kerrs Reach. It has cleared to a noticeable degree since then. However, rowers, dragon boat and waka paddlers using Kerrs Reach still complain about the smell off the river. A fisherman of my acquaintance, who is a commercial trout fishing tour guide, has remarked on the diseased appearance of the internal organs of trout caught further upriver.

7. Ammonia concentrations and effects are referred to in Issues 1, 2, 3, 5 and 6 as printed by the Commissioners in February 2002. This reflects the signal importance of ammonia pollution.

8. I am therefore concerned that no arrangements have been made for measurement of ammonia concentration in the rivers. For the Avon, I suggest that ammonia and pH should be sampled weekly at the following locations:

    Bridge Street bridge

    New Brighton at Pages Road bridge

    Wainoni Road bridge

    Avondale Road bridge

    Union or Avon Rowing club launching ramps on Kerrs Reach

    Under the old Victoria Street bridge at the Town Hall.

9. Comparable sampling should also be undertaken on the Heathcote River.