

Before Commissioners appointed by the Canterbury Regional Council

In the matter	of the Resource Management Act 1991,
And	
In the matter of	Applications by Christchurch City Council To change and to cancel conditions of Resource Consent CRC012011 relating to the discharge of treated sewage effluent.

**Evidence from W C Clark on behalf of
Avon Heathcote Estuary Ihutai Trust**

About the Witness

1. My name is Walter Clive Clark. I live at 9 Thornley Place, Woodend. I am an emeritus professor of zoology in the University of Canterbury where I was formerly the Head of the Zoology Department. Before that I was Professor and Head of the Department of Zoology at Massey University.
2. I have been admitted to the degree of Bachelor of Science majoring in Zoology and Geology, and to the degree of Master of Science with First Class Honours in marine biology, in the University of New Zealand. My thesis involved much field work in the Avon Heathcote Estuary. I have been granted a Diploma of Membership of Imperial College of Science and Technology in the University of London. The for this diploma I did practical course work in the use, recovery, and identification of pesticides used in plant protection; further I prepared a thesis in applied toxicology, concerning the use, and limitations of use, of chloropicrin (a tear gas) in the control of seed borne diseases. My Ph D degree (Imperial College, University of London) involved the preparation of a thesis on New Zealand nematodes (round worms) and aspects of their biology as it contributes to an understanding of soil biology and plant pathology.
3. I have been admitted to the fellowships, life memberships, and memberships of a number of international and national learned scientific societies (Fellow of the Zoological Society of London, Fellow of the Linnean Society of London, and Fellow of the Royal New Zealand Institute of Horticulture. I am a life member of the Marine Biological Association of the United Kingdom, a foundation member of the New Zealand Society of Marine Science, a Life Member of the New Zealand Society for Parasitology, and a member of the New Zealand and International Societies for Soil Science, as well as several societies devoted to the study of animal parasites.) I have published more than 100 scientific papers on marine biology, soil biology, plant protection and plant pathology, animal taxonomy, and reproductive biology. I have published much work on parasitology and the ecology of infectious disease.
4. I have been deeply involved in water management matters since the 1970s, mostly on behalf of the North Canterbury Acclimatisation Society and its successor, the North Canterbury Fish and Game Council, where I chaired the Water Resources Committee. At different times I served on national bodies such as the Freshwater Fisheries Advisory Council and the National Water Conservation Council.

The Nub of the Matter.

5. Christchurch City Council (CCC) has a resource consent to discharge daily, up to 500,000 cubic metres of treated wastewater from their wastewater treatment plant at Bromley. It is now clear that they have so arranged the plant and its operation, that they believe that they cannot, and apparently do not wish to take the steps necessary to comply with the conditions that were agreed to when the resource consent was considered in 2001-2. Primarily, their problem is that in the course of modifying the operation of their STP, the water clarifiers succeeded in removing much carbon, thereby successfully contributing to the lowering of the BOD and the suspended solids content of the effluent. By lowering the carbon content they succeeded in greatly reducing the resources available to the freshwater algae that had previously abounded in the ponds.
6. By dramatically reducing photosynthesis in the ponds, the operators effected a marked improvement in the clarity of the effluent as reflected in the reduction in suspended solids load of the water discharged to the estuary. At this point it is to be noted that high levels of green algae in the effluent which were usually obvious, visually, from St Andrews Hill, are not toxic, or harmful in any way.
7. In the past, in the operation of the Bromley plant the evident active green algal production in the ponds greatly lowered the toxicity of the effluent by removing a good deal of the ammonia. As any competent third form science student could tell you, photosynthesis uses the energy of sunlight to convert the chemical elements carbon, hydrogen, oxygen, nitrogen and sulphur into new protoplasm, essentially consisting of carbohydrates and proteins. The student might need another year or two's study to appreciate that the proteins are composed of amino acids, each containing an amino (or NH₂) group. In the waste treatment ponds the nitrogen for the amino groups came largely from the ammonia in the effluent. Once the available carbon was radically reduced by the installation of the clarifiers, photosynthesis could not proceed as previously, and so little ammonia was removed from the effluent, with the results that have been described. The veracity of the above outline was confirmed by an incident recently reported to us in the Discharge Advisory Group. On one occasion recently, the carbon content of the effluent reaching the ponds was inadvertently elevated abnormally, and the ammonia content of the effluent reaching the estuary was greatly reduced, and I believe, unusually, the plant temporarily, complied with the resource consent conditions.
8. I believe the above account of these matters gives the lie to the statement in the AEE (foot of p.1-1) "***However, since this resource consent was granted, it has become apparent a number of conditions are no longer achievable, appropriate or relevant.***" This passage has become something of a mantra and was repeated by the applicant's counsel, by Mr Tipler, and others. The relevance of the conditions agreed to earlier, needs to be examined once more.
9. During the original consent hearings much evidence was presented about the nature and history of the Avon Heathcote estuary, and the biological communities that live there. I do not intend to re-traverse in detail material which was addressed on that occasion by Professor O'Connor. He demonstrated that considerable changes had been wrought in the nature of the estuary and the materials it has received from the city. It is clear that Christchurch City and other adjacent and antecedent councils have allowed the pollution

of the lower Heathcote River, and thus the estuary by a variety of noxious industrial wastes. The Avon River has served as a ditch to convey much sediment from construction and subdivision sites within the city. Of course these materials have been supplemented by diverse road wastes, ranging from the earlier biological wastes of the horse-drawn eras, to the present day when mineral sediments may predominate at times, but the roads yield everything from car-wash detergents to dog dung; petrochemical wastes, and metals and asbestos from brake linings. To these of course must be added the variety of trade wastes that were included in the sewer-conveyed materials. In the face of such a multifarious onslaught it would be surprising if the nature of the estuary; its chemical nutrients, toxins and the biological sequelae of these changes had not produced a range of effects.

10. However, it seems remarkable that the City Council should now seek to use its impressive record sins, both of omission and commission, as the justification for not now taking adequate steps to at least reduce to more tolerable levels the current rate of pollution of this civic amenity. Over the years the Estuary has been investigated in a desultory fashion, often by a diversity of techniques and sampling procedures that have rendered it difficult, if not impossible, to relate the results of these diverse studies. It should be recognised that the various investigators often had different motivations, and no group assumed any sort of coordinatory role. The end result has been that after the expenditure of much money and effort, our total knowledge is much less than the sum of the parts. Many fundamental questions remain unacknowledged and unaddressed, and as a consequence it is not possible to reach secure and sound assessments of the status of many of the ecosystem components.
11. It is, I contend, impossible for a reasonably well informed biologist to give any sort of guarantee about the secure status of the estuary ecosystems as a whole. I do not see any way of issuing credible statements on the secure or imperilled status of that which we do not understand.
12. The question, of just how large an event is required to initiate an ecosystem collapse or near collapse, is imponderable. If the estuary is as modified at the AEE writers claimed when absolving themselves from the duty of fully protecting that which remains (pp.5-3 and 5-4), then it would be imprudent not to invoke the precautionary principle set out in s. 3 (f) of the RMA. "any potential effect of low probability which has high potential impact." In this context it is also important to observe that if indeed the estuary is as seriously assaulted, as claimed, then even more stringent conditions should be imposed to redress the alleged present status, and hopefully to prevent the sudden and total collapse of the ecosystems involved. In such an uncertain situation it is essential to review the adequacy of the protection of the estuary, and of course of the AEE itself.

Some Basic Biology

13. To appreciate the significance of the application before this hearing it is necessary to have an understanding of some basic biology. I shall briefly review some essential basic topics:

14. It often seems important in discourses of this kind to assert unmistakably and emphatically, that:

AN ORGANISM IS ITS WHOLE LIFE HISTORY. NO SINGLE, OR IDENTIFIABLE STAGE IS ANY MORE IMPORTANT THAN ANY OTHER PART OF THE WHOLE LIFE HISTORY. All life history stages must be successfully completed, and all are equally important.

15. Within a biological community different organisms commonly perform different functions. In complex and stable communities it is usual to find a variety of means, or routes, by which a given ecological function can be performed. That is, the ecological roles of a few species may overlap to variable extents. In practice this is usually considered to be “a good thing,” for it tends to ensure that even in the event of some minor disaster occurring to the population of one species, there will be an alternative means of having that function performed. It is a truism of ecology that stable ecosystems are the ones that have a plurality of means of performing essential community functions. It also follows that over-simplified ecosystems, (e.g. agricultural monocultures) are the least stable.
16. There has been some minor simplification of the estuary ecosystem since the pioneer studies of Thompson in 1928-29. Major differences have centred around a major decline in abundance of the eelgrass (*Zostera*), and a great reduction in the shrimp (*Palaemon affinis*) populations. There have been a recognisable increases in abundance of sea lettuce (*Ulva*), and to a lesser degree, from time to time in the abundance of *Enteromorpha intestinalis*. There has also been the appearance and exuberance of a red alga, a species of *Gracilaria*. The increases in algal abundance are generally agreed to be a reflection of the increased abundance of plant nutrients discharged into the estuary by the sewage works and via the rivers.
17. Amongst the estuarine animals, I remember at the last hearing there was a measure of agreement that the species composition of the burrowing polychaete worms in the vicinity of the oxidation ponds was considered to have an abundance of forms usually associated with pollution, or unusual enrichment. I make no claim to expertise in this particular matter (the polychaete worms), and am merely repeating the views of others.
18. As an indication that there are no clear signs of simplification of the estuarine fauna as a whole I have compiled, without reference to any works of reference, a simple list of animal and plant groups found in good numbers in the Estuary.

Table 1.
Biological Groups found in the Avon Heathcote Estuary

Zostera
Algae (green, brown and red types)
Abundant and diverse microorganisms, outnumbering everything else, generally grouped as viruses, bacteria, fungi, and protozoans, but not obvious to the lay observer.
Coelenterata (sea anemones, hydroids)
Porifera (sponges)
Platyhelminthes (flatworms, flukes, tapeworms,)
Nemertina (proboscis worms)
Nematoda (round worms in great variety, parasitic and free-living)
Rotifera (wheel animalcules)
Annelida (Polychaeta in great variety)
Mollusca (snails, bivalves, chitons)
Crustacea (copepods, amphipods, isopods, shrimps, barnacles, crabs etc.)
Echinodermata - starfishes
Bryozoa
Tunicata (sea squirts)
Fishes (Note that many freshwater fishes have marine phases and so pass through the estuary)
Birds
(No attention has been paid to ephemeral inhabitants such as members of the marine plankton., or to insects, spiders and the like.)

18. Since European settlement there have been considerable changes in the materials flowing into the estuary in the incoming waters. This has resulted in a large increase in the availability of plant nutrients in particular, and this is reflected in the much increased growth of macroscopic algae, especially sea lettuce, which often presents itself as a nuisance, as when large drifts of it decompose, emitting unpleasant odours. It is considered that this enhanced nutrient availability has so permeated the estuarine sediments as to be an enduring feature of the estuary. It has been observed that if by the stroke of a pen the nutrient input could be reduced to former levels, the growth of algae would continue for a period at the present unnatural levels.
19. The arrival and departure of the starch factory formerly on Humphreys Drive stands as an excellent example of a dramatic induced change, and of “natural” restoration on removal of the “pollutant.” The starch factory discharged large volumes of waste starch grains which in turn nourished a complete khaki - coloured superficial layer over the mud of the protozoan *Euglena limosa*. These in turn were “Hoovered” up by an abundance of the air breathing mud snail *Amphibola crenata* which followed its usual pattern of processing the superficial mud and leaving behind it a continuous faecal strand.

Size: some correlates and consequences

20. In considering the consequences of pollution of waters in a habitat one soon comes face to face with matters relating to organism size. We do well to note the relationships that often prevail between surface area and volume. In a sphere, as a simple example, the surface of a sphere varies as the square of the radius, whilst the volume contained in a sphere varies as the cube of the radius. Thus, it is evident that as organisms increase in size the volume typically increases at a much faster rate than the surface area through which everything must pass on its way into or out of the organism. It follows therefore that generally, the distance over which substances must travel, by diffusion or some other means, will also increase with size, as will the time taken for materials, toxic and otherwise, to enter or leave the organism.
21. It is also a common, if not universal, feature of living organisms that the basal metabolic rate (BMR) of an organism is inversely related to its size. Small individuals are more metabolically active per unit of size than are larger individuals of the same sort. Thus small individuals have higher relative energy demands; need more oxygen, and develop waste products more rapidly. A consequence of this phenomenon is that small, highly metabolically active individuals are, other things being equal, more readily and rapidly poisoned by toxins than are larger individuals. I include a page of figures of several common kinds of invertebrate larval stages.
22. A consequence of the relationships just touched on, is that freshwater is an excellent spermicide. Sperm are very small, and because of their shape have a very high surface area in relation to their volume. Osmotically they are further disadvantaged by the absence of any osmoregulatory mechanism. Thus it should come as no surprise that if the often very tiny larval stages of marine organisms encounter freshwater, the encounter is usually, rapidly fatal. (As an irrelevant, but illustrative example when breeding in rivers, trout and salmon sperm must enter the egg within about 30 seconds of their release into freshwater, if fertilisation is to be effected (the exact time depends upon the water temperature as that has a profound effect upon osmotic potential). By contrast, herring sperm in seawater are reported to be able to fertilise an ovum up to 24 hours after release.) It follows that often, freshwater is a hostile environmental medium for marine organisms. This needs to be borne in mind when considering the effect of the release of large quantities of “fresh-water” effluent into saltwater habitats.
23. Because of the matters just touched on, it will be apparent that the environmentally toxic disasters that result in mass deaths of conspicuous, large, adult size organisms will be unusual events, whilst events that result in the deaths of myriads of very small, juvenile stages will most commonly pass unnoticed.

Figures of marine larvae

The Estuarine Habitat

24. It will be clear that the estuary is far from a uniform habitat. Estuaries present features that do not seem to have been anticipated when the RMA was drafted. Many discrepancies arise as a result of the ebb and flow of the tides and the consequences of those events. On the normal seashore, of whatever lithology, the ebb and flow of the tides merely means that the water is present or absent for part of the tidal cycle. The organisms adjust, or are adapted to the presence or absence of seawater. In an estuary the

organisms may be immersed in water of *variable salinity* from fresh, to about 35 ‰ salinity. But they may also be immersed in air of variable temperature and relative humidity. The consequences of these possibilities are significant.

25. The Avon Heathcote estuary is roughly triangular. Water enters at four different points complicating understanding of the water's circulation, and of the notion of a "mixing zone." At the earlier hearing after much discussion and reporting of investigations it became apparent that the notion of a "mixing zone" was inapplicable to the estuary. The fact that there is this multiplicity of mixing zones (discharge of effluent, the river mouths and the entry and exit point for sea water, and the pattern of circulation of the incoming water being greatly influence by the unpredictable weather conditions and inconstant tidal regimes) their location and properties cannot be pre-determined. Under the Act "mixing zones" are often the polluter or discharger's salvation. They have become a means of permitting the intolerable. I would submit that to allow an unlimited, effectively undelineated mixing zone, that it may wander widely as the conditions ordain, is to fail to afford any effective protection to the estuary. The problem is a most difficult one, but one that you, gentlemen, may have to grasp. We have no secure knowledge of the present situation. Can a repetition of the past be tolerated? Should a problem of legal drafting become a licence to destroy habitats and their inhabitants?
26. I expect the applicants will have made clear to you the circulation of water within the estuary is anything but clear, and it is not, even in the short term predictable, without first specifying the weather and other conditions. It is also necessary for me to further complicate the matter by pointing out that until the discharges from the STP were instituted, freshwater entered the estuary at the Heathcote and Avon river mouths and generally flowed towards the mouth in the deeper channels until the rising tide reversed the flow. The rising tide pushed the lighter freshwater back up the rivers as the seawater moved progressively further into the estuary. Whilst it is accepted that freshwater is lighter than saltwater and tends to ride over it, the purely saltwater moves well up the estuary, and at full tide the water below the Heathcote Bridge is all seawater. Undoubtedly much of the water above this point is freshwater which moves down stream when the tide ebbs. This has some interesting consequences for the animals. The mudflats of the estuary below the bridges are naturally mostly covered with high salinity seawater and the animals are not normally subjected to marked osmotic stress. Certainly in the lower half of the estuary the water that covers the mud flats is normally full seawater.
27. It is usually asserted that the "fresh" water of the effluent rides above the salt water, and is subject to little mixing, except perhaps in turbulent conditions. I draw the Commissioner's attention to what seems to me to be a complete absence of evidence on this point. There seems never to have been any attempt to discover what really happens in this situation. Does the freshwater of the discharge *always* ride clearly above the bottom? Are the benthic (bottom-dwelling) animals immersed in the discharged effluent, or is there evidence that the effluent really does pass above them? How much mixing really occurs? I am unaware of any sampling to sort this out. We need to know, not just to guess.
28. If these burrowing, benthic animals are exposed to the high concentrations of ammonia,

as seems probable from the EOS analyses of the sediments then the realities of whether, and where mixing occurs, or not is also important. (ECan has this report and can make it available if needed.) The ammonia in the sediments must have come from somewhere, so it is reasonable to assume some mixing from the ammonia contaminated water. Why is there no information on the ammonia content of the interstitial water? That is what the inhabitant are immersed in! Can consents be granted for actions that are not known or understood? There is a real need for some facts. This appears to be a prime candidate for the application of the cautions implicit in the precautionary principle.

Toxicity Testing

29. Much ink and paper has been expended on toxicity testing and the reputed results, but we still face a huge shortage of *reliable, relevant* data. Most of the acute toxicity testing is of the “dunk it and see” variety. In practice some test animals are immersed in a known concentration of the toxin of interest and maintained there, usually for 96 hours. Refinements such as maintaining a constant temperature, feeding or not feeding the test animals, ensuring an appropriate level of dissolved oxygen, and pH in the testing fluids, that ensuring that the concentration of the toxin is maintained at the specified level throughout the test, and recording the survival rate of the controls have all too often in the past been treated as optional extras. It seems that no-one is ever concerned about the long term survival of the animals that have been subjected to the 96 hour exposure. If they survive the 96 hours, there is no consideration of the possibility that they might die even after the removal of the toxin - that even death may take some time after it has become inevitable. Questions such as “: Did they really survive?”, or “Were they able to breed thereafter?”, never seem to have been asked. Despite the very uneven quality of much of the testing, there seems to have been little discrimination in using this work in compiling so-called standards such as the US EPA and ANZECC have published. When the test duration is reduced to much shorter periods, (e.g. 12 or 24 hours) it seems that reasons for the brief exposures are rarely stated. Perhaps they couldn’t sustain life. The notion that the subjects didn’t quite have time to die, is rarely considered.
30. The alternative to acute toxicity testing is a mixed grab-bag of trials usually grouped as chronic *toxicity testing*. The objective here is to employ a technique that gives much more realistic data on the effects of exposure to the candidate toxin over much longer periods. This kind of testing is much less common than acute testing. . It is much more costly; more time-consuming, and more demanding of techniques. Apparatus is tied up for long periods, often requiring long continued operation of constant temperature devices and monitoring conditions. An important question is how long should chronic tests be run. Clearly the ideal should be “for the totality of the life history phase that is likely to be exposed to the toxin,” and sufficient to check reproductive performance. Further, with chronic testing there arises the opportunity to detect the effects of longer term or repeated exposures to lower concentrations. In the present situation, conditions of repeated exposures to perhaps a “moderate” (whatever that means) level of a toxin, perhaps on a twice daily basis would be of great interest. Data from tests that repeatedly exposed animals to, say the levels of ammonia found in the sampling programmes would be a good start.
31. Fairly simple chronic toxin testing such as done by Hickey and Martin 1999 on the bivalve mollusc *Sphaerium novaezelandiae* would be very informative if carried out on a

variety of estuary inhabitants. In that paper he reported that continuous exposure to concentrations of ammonia far below those producing mortalities in acute tests on the same species, stopped growth and inhibited reproduction in the little clams. Animals that have ceased to reproduce are effectively dead as far as the species is concerned.

32. It is highly desirable that such toxicity testing as is done, serves some purpose. The tests reported by Lowe and Tremblay in the report supplied to us by the applicants, might as well never have been done for all the new information they provided. The acute tests reported by them simply served to assert that which no-one would have doubted - that the full strength effluent containing 33.3 mg/L total ammonia, and that seawater with 30 mg/L of added ammonia, will kill small flounders and triple fins if they are exposed to those solutions for long enough. It would have been much more valuable if they had been exposed repeatedly for shorter periods over many days so as to simulate conditions in the estuary, e.g. 2 or 3 hours dunking twice a day in dilute ammonia for a couple of months. The concentrations of the toxin should have reflected the levels reported in estuary surveys, not the maximum concentration in the ponds.
33. Any attempt to formulate test programmes that bear some relationship to conditions in the estuary immediately reveals the deficiencies of sampling programmes to date. To the best of my knowledge we have scant understanding of the changes in concentration with times for any set of sampling stations.

Toxicity Testing and Sensitivity of Invertebrates

34. The diversity of estuarine invertebrates was noted in the AEE, but it might be considered useful to note that the most numerous of the invertebrates are generally the microscopic members of the community that live on and in the mud, such as nematode worms, rotifers and similar sized animals. We have no knowledge of the kinds present, or whether their numbers have fluctuated or changed to any extent. All we know is that there have been superficial observations of marked diversity, and great numbers. What we can be sure of, is that such tiny organism present a large surface area to the surrounding water and the contained toxins, and that because of their small size they can be safely presumed to have high metabolic rates. Therefore, despite their small individual size, we ignore them at our peril. Their large surface areas and high metabolic rates very probably make them especially vulnerable to toxic substances.
35. It may be that the AEE authors were misled to some extent by the ANZECC 2000 which in Chapter 8.3 page 158 has an entry which reads:

“Marine Crustaceans: 15 spp 24 - 96h LC₅₀ 18 687 µg/L (*Pennaeus semisulcatus*) to 264 000 µg/L (brine shrimp *Artemia salina*); 11 spp had LC₅₀ values below 80 000 µg/L.”

The very high tolerance of ammonia by *Artemia salina* seems to have been accepted as a typical value for a marine invertebrate. It should be realised that *Artemia salina* is not a marine invertebrate. It certainly lives in very salt water, but it does not live in the sea. It is an inhabitant of extremely saline lakes and ponds in many parts of the world. In New Zealand the only habitat I know of is Lake Grassmere in Marlborough where it flourishes in the solar salt works lakes. In Lake Grassmere it feeds on the unicellular

microalga, *Dunaliella*. The various forms of *Artemia* all live in extremely saline waters.

36. The many different populations of brine shrimps are parthenogenetic, that is the females bring forth young without the intervention of a male. In their usual reproduction, sex is not involved. In any serious work using *Artemia* it is necessary to specify very precisely the strain that is used. Virtually all brine shrimp populations are polyploid¹, up to 22-ploid. A good number of populations whose chromosome complement has been examined have complicated the matter by the loss of one or more chromosomes in one or more of the replicate sets. This condition is known as aneuploidy. It is a very usual experience that changes in the ploidy of an organism are accompanied by changes in physiology, and occasionally in morphology: many polyploids are larger than the usual diploid forms. In organisms where populations of different ploidy are common, or even known to exist, the usual and simple use of a generic and specific name is not regarded as sufficient to adequately characterise the organism under discussion. Such populations cannot interbreed and do not meet the usual criteria of a species. *Artemia salina* is a mish-mash of non-interbreeding forms with variable physiologies. It is entirely inappropriate to base generalisations on such organisms, and to categorise them as *marine crustaceans* is a falsehood.

Review of AEE

37. A striking feature of the AEE is its apparent authorlessness. As seems to be common practice with many consultants, it has been “signed off” or approved by company officials, but no-one claims to have compiled it, or accepts responsibility for the views, statements etc. made therein. Nothing is known of the unacknowledged author(s), or his/her qualifications for the task.
38. The tone of the AEE is set by the passage reproduced earlier in my ¶ 8. It seems that the writer regarded the Resource Consent Conditions as something that could be observed or ignored as convenient to the consent holder. This despite the evident acceptance of the conditions by CCC, (they have been operating under its authority) and the implicit undertaking on their part that they would make their best endeavours to comply with the conditions after the second anniversary. But, in section 1.6 of the AEE the applicants simply state:...
- “The treatment plant upgrades that were carried out in 2003 - 2004 were overall very successful, except that the expected reduction in ammonia and nitrogen concentration did not occur. From the second anniversary of the commencement of the consent, the discharge will not be able to comply with the new conditions.”***
39. It is reasonable to ask whether the applicants ever intended to comply with the consent conditions. I refer the Commissioners to the second paragraph of section 2.8 “Effects of CWTP Upgrades” where it is stated:

¹ Polyploidy is the condition where an individual, or a population of organisms possesses a multiple of the haploid number of chromosomes in its cells. The vast majority of adult animals and seed plants possess two sets of the haploid number of chromosomes. This condition is known as diploidy ($= 2n$). When only a single set of chromosomes is present the condition is described as haploid ($= 1n$).

“However, the design of the system and the various improvements have never been intended to remove nutrients such as nitrogen and ammonia. The most recent upgrade works, completed in mid-2004, followed this pattern...”

40. >From the above it seems clear that the CCC or its servants did not commence discharging under that authority of resource consent CRC012011 intending to comply with its conditions. They admitted, as we saw in ¶ 15 above, that they did not even attempt to take steps to design their plant so that would meet the standards with which the Council had agreed to conform. It would seem reasonable that once these surrounding circumstances become known, all normal sympathy for people in a difficult situation will evaporate! To a huge extent CCC were the authors of their own fate. There is no evidence that the Council itself was informed of the intention, perhaps developed by the Council’s staff, to “brazen it out once the balloon went up!” The situation that this hearing now finds itself in, is that it is revealed the authors of this application for a variation never intended to comply with the original conditions. There seems every reason to believe that the applicants were prepared to endanger the environment to whatever extent fate imposed, whilst hoping that matters relating to the outfall would proceed apace. By the time the pollution matters came to a head, and their contempt for the Resource Consent conditions became known, it would, hopefully, be considered “too late” to do anything about a trivial matter like poisoning of the biota of the estuary with ammonia. It would take too long to effect a remedy for it to be of any use anyway! It is difficult to avoid the view that in slightly different legal circumstances the above actions would constitute “contempt of court.” What is it called here?
41. I note that it is very difficult to discover from the AEE how well (or poorly) the applicant has complied with the consent conditions to date. The most readily understood data seem to be those in Dr Bolton-Ritchie’s report on page 3, and these lack any data since July last year. Like Dr Bolton-Ritchie I reject the notion that the discharges have caused “no significant adverse effects.” To date there is no evidence that the applicant has even looked for adverse effects. If they have why did they not state what has been done, and what has been found? It is my experience that if you don’t look, you don’t find.

Discharge of Effluent

42. In AEE ¶ 2.5.2 it is stated that the effluent is discharged from one hour before high tide until at most, three hours after high tide. Consent condition 11 (a) states that the high tide “referred to in this condition shall be the high tide in the Avon/Heathcote Estuary and not the high tide at any other location” which may still lack precision. As the AEE makes clear on p. 4-4 there can be much variation in the time of tides in the various parts of the estuary. In view of this information it seems we need to know for certain the point at which the high tide for discharges is taken from. Is it high tide at the entrance to the estuary, or high tide at the discharge point, or somewhere else?” From the data in Table 4-2 there could be a difference of about 2 hours, or in other words, a difference of about 80,000 cubic metres.
43. It seems reasonable to ask: “Is this discharge regime not an important component of the estuary pollution?” It is evident that discharge of wastewater commences while in the estuary the tide is still rising. Therefore the wastewater cannot move out of the estuary

until as much as two hours after it is first discharged. Instead, it is backed further up the estuary. Depending on the prevailing weather conditions it may go predominantly in the direction of the Bridge Street Bridge, or across the front of pond shore in the direction of the Heathcote Basin. This result is displayed clearly in Figure 1 (page 7) of Leslie Bolton-Ritchie's report. As indicated in that figure, this notion is supported by the samples that have been taken.

Figure from Dr Bolton-Ritchie's report.

44. The matter of discharge needs further consideration. The consent permits the discharge of up to 500,000 cubic metres of wastewater per day, but the discharge structure discharges a maximum of 40,000 cubic metres per hour. Thus it would take this structure 12.5 hours to discharge the allowable volume, *but* the conditions only allow discharging for four hours per tide. Problem???. In fact it seems the volume permitted to be discharged is much greater than requirements to date, and since that which does not exist cannot be discharged there is currently, it seems, no problem.
45. The notion that discharges must occur *before* high tide in the estuary could only be related to inadequacies in the diameter of the earlier discharge structures. That is, it formerly took a long time to discharge the required volume. Why was the new structure built too small? What was the thinking that perpetuated old physical deficiencies into the current discharge regime? We all know that freshwater is lighter than seawater, and so unless the waters are mixed by natural or induced turbulence, they will tend to stratify, but no adequate data have ever been presented to show the thickness, or areal or temporal extent of any stratified layers. Thus we can only *guess* at the extent to which they impinge on the benthic fauna, if at all, but the EOS data (reproduced in ¶ 10 of Bolton-Ritchie) indicate that ammonia is a substantial influence on the habitat of the burrowing fauna. Oddly this has not been discussed by the applicants, though they are aware of the research work. I understand the data relate to the sediments themselves, and not to the water that occupies the interconnected voids in the sediments. The same lack of data ensures that we cannot estimate the duration of exposure. >From what we do know about the sediments we can assume that the burrowers are steeped in ammonia.
46. It is an elementary fact of biology, that for most marine organisms freshwater is effectively a toxin. Its osmotic effects are often lethal. From the data relied upon for Bolton-Ritchie's figure there must be some mixing, but surely we must have some data to help us understand the commonest conditions, and to understand for how long they usually prevail. What salinities prevail over the mud flats? What is the incidence of osmotic stress, or death over the mud flats? What proportion of the invertebrate gametes, or larvae are killed by low salinity, or by the concentration of ammonia? Where are the data that would allow us to make intelligent decisions, or form soundly based views?
47. It may be argued that if the discharge was postponed till the top of the tide then all of the wastewater would enter the estuary when the flow direction was such that residence time in the estuary, and the harm done would be minimised. Is this too much to ask?
48. If the discharge could be released at high tide, the current regime which ensures maximum potential damage to the maximum area, and presumably the greatest number

of organisms would be avoided. If indeed a substantial volume of the effluent is in effect “perched” above the seawater, then a greater depth of non-toxic seawater between the pollutant and the benthic organisms would at least have *some* ameliorating effect.

49. At this point it is reasonable to direct attention to the absence of any sample-based data that inform us as to the depth of any overlying layer of freshwater, at any point under any stated conditions. We also lack information of the persistence of any such layering effect. We simply have no idea of the areal or vertical extent of exposure to the polluting water mass. In the absence of data it seems that the precautionary principle gives grounds for assuming that the polluting water is in contact with the biota everywhere, and that the biological damage is maximised. This would then demand some realistic conditions that would more adequately protect the biota.
50. I note that in the second paragraph on page 9 of Dr Bolton-Ritchie’s evidence she suggests that mobile animals in the water may be able to detect ammonia in high concentrations, and be stimulated to move away. We need to remember that such movements are likely to depend upon the animal’s ability to detect a difference in concentration over a very short distance in order to be able to detect the direction of the gradient, and thus the direction in which to move to find a refuge. From experiments on molluscs in the past, I thought I found that those animals could not perceive gradients of stimulus intensity over short distances such as their own body length. They tended to stay put, and just shut down and die!
51. There may be a serious public health issue affected by the discharge regime. When the applicants were considering appealing the original decision concerning consent CRC012011 they engaged specialist panels to advise them. When the public health specialists reported to the CCC attention was drawn to the panel’s view that gastrointestinal infections did not constitute the greatest health risk to people engaging in aquatic or boating recreations on the estuary. It was their view the pulmonary viral infections constituted the greatest health risk. This was considered a sufficient reason to prohibit long term discharge into the estuary. The opinion was stated that at least a million-fold improvement in the viral content of the effluent would be required to justify a long term discharge consent. The applicants had been largely inactive concerning the viral infectivity of the discharge, and at the last hearing, the only results available were for samples taken in February of one year. The month when the incidence of viruses would be expected to be at a minimum. It may be that the enthusiasm for clarifying the ponds was mis-placed zeal for using free UV to denature viruses.
52. The point of mentioning the viral contamination is that by discharging the effluent in such a way as to maximise its areal distribution and to ensure that it remained in the estuary for the longest possible time, is to maximise the public health hazard. Surely this is another important reason to reconsider the discharge regime.

Water Samples, AEE section 4 and Appendix B.

53. I have difficulty in understanding the data presented in Appendix B. What are we to understand when there are a number of identical records of the discharge ammonia for the same day? Are they merely repeats of the same determination, or do they indicate

constancy of the pond environment with respect to this factor? Why are they all entered? Do they all contribute to the statistical data at the end of the table? What does it do to the statistics to include these iterated data points±? We have no way of relating them to clock time or the tidal time or phase of other samples. I have difficulty in evaluating some of the statistical data.

Note 3 states “Discharge NH not included in total.” Which total? What does this mean or convey to the reader?

Ammonia and Fish (¶ 4.4.1. of AEE)

54... Quote, first sentence:”

“Fish are generally considered to be the aquatic organisms most susceptible to ammonia toxicity, and it is thus important to describe this aspect of the biological environment of the estuary.”

I am at something of a loss to justify this statement. There are few reliable data that I know of relating to marine creatures generally. I know of none for New Zealand marine invertebrates, but the New Zealand data for freshwater invertebrates surely holds something of a record for sensitivity to ammonia. See Table 13.6 I have reproduced from Hickey’s 2000 paper². The table makes it clear that some aquatic invertebrates are much more sensitive to ammonia than are most fish, which is contrary to the message of the AEE.

55. Data presented to the earlier hearing on discharge to the estuary by Mr P A Neale, an enthusiastic, diary keeping, amateur estuary fisherman clearly supported his contention of a substantial decline in **fish numbers** in the estuary. The generally accepted major decline in shrimp numbers was also noted and supported by his diary entries at that time.
56. Evidence from other witnesses (Batcheler, Bolton-Ritchie) presents a different range of ammonia data from that offered in the AEE, and consequently, they portray a different picture of ammonia concentrations in the estuary, and the hazards faced by fish and other organisms.
57. It seems that great, and perhaps undue emphasis and importance are given to fish over all other members of the biological community, both as regular inhabitants and temporary visitors to the estuary, despite the fact that they constitute a fairly small fraction of the total biomass. It will be evident to the Commissioners that this “fishy” emphasis has been brought forward to this hearing. I observe that the Ihutai Trust, on whose behalf I appear as a witness, did not even mention the word “fish” in their submission. The Trust’s concern is with the continued survival, and if possible improvement, of the health of the whole estuary ecosystem
58. The AEE at 4.4.1 properly recognises the different life styles of the different fish that

² Hickey, C. W. 200: Ecotoxicology: laboratory and field approaches. Pp 313 - 343 In K. J. Collier and M. J. Winterbourne [eds.] *New Zealand Stream Invertebrates: Ecology and Implications for Management* New Zealand :Limnological Society, Christchurch, 415 pp.

occur in the estuary. I wonder, however, if the potential extreme vulnerability of some very juvenile stages is recognised. The newly hatched whitebait are very small (7 - 8 mm long). They usually hatch on the first high tide to reach the eggs after they were laid. These tiny fish go out to sea on that tide, and to do so must pass through the length of the estuary. Being so small and slender they would have an adverse surface area to volume ratio, and be expected to be very vulnerable, but as usual there are no hard facts. The journey into the sea may be a consequence of a great shortage of suitable sized food organisms in freshwater.

59. It may be useful to remember that fish are ammonotelic animals: that is they produce ammonia as their main nitrogenous excretory product. With a natural life-long association with ammonia through the kidneys it is reasonable to expect at least some tolerance of their main excretory product. It is important to recall though that they produce it in fairly dilute quantities.
60. Freshwater fish face a problem of “water logging as water passes into their bodies through the epithelium of the gills under the attractive osmotic forces of their body fluids. Marine fish, in contrast, are in danger of having an excessive amount of water removed from their bodies through ex-osmosis out into the oceans. In both cases the water passes through the gill epithelium. Considering the relative sizes of the oxygen, carbon dioxide and water molecules, it is inevitable that these odd relationships should exist.
61. Before young salmon migrate out to sea, they typically pause in the estuarine region while they pre-adapt to marine conditions. The operation of the kidneys is modified to change from the freshwater copious urine to the scanty urine typical of the marine phase. They need to acquire new enzymes to modify the body chemistry, and for no reason that I know, they also change their visual pigments.
62. The AEE has virtually ignored the other estuarine inhabitants, especially the invertebrate animals that provide virtually all of the animal foods for the abundant, and diverse birds and fish.

Page for Hickey Table 13.6

63. In their AEE (p.5-4) the applicants advance the notion that the present Avon Heathcote Estuary ecosystem is “a degraded ecosystem”, and that it matches the description of “a Type 3 highly disturbed system.” This argument is advanced to support a lower grade, or 90% level of species protection. This alleged degraded status is asserted to have arisen “After over 100 years of inputs from the highly urbanised catchments of the Avon and Heathcote Rivers, and many decades of input of treated wastewater from the CWTP.” This argument claims in effect “It’s had it, so why bother protecting it any longer?” Coming as it does from the organisation that is responsible for the alleged historic degradation, it seems worthy of the same consideration as pleadings from the rapist who claims his deeds are not repulsive, because the complainant is not a virgin! It has the same merit. It seems the argument being advanced is: “We have wrecked the estuary, so any insults we impose should be quietly accepted, despite the conditions we accepted in 2001.

64. As one who has had a particular interest in the Estuary since I did much field work there in 1956 - 57, I believe it is important to examine this proposition that the estuary community has been modified to the point where it is unworthy of serious effort to maintain it in anything near its natural condition. Ecological collapse should be avoided.

ANZECC Guidelines, Trigger Levels, and desired outcome

65. Determining a suitable trigger level is a complex matter that is likely to be influenced by the standpoint and values of the party making the decision. Some will be influenced by the quality and quantity of the biological data available to substantiate any assessment. In the present case the applicants, or their antecedents are those who inflicted damage on the ecosystem, or who failed to take adequate steps to prevent others imposing damage. Now the CCC wishes to continue to fail to comply with conditions that they had earlier undertaken to accept.
66. It is agreed that the estuary ecosystems have been modified since settlement, but there is no sure way of assessing the extent of that modification. At the lowest probable assessment, I consider the A-H Estuary should be placed in the upper part of the Type 2 condition, in other words, probably a slightly modified system.
67. It has to be recognised that the ANZECC Guidelines are significantly deficient when it comes to an examination of the underlying data that purport to establish trigger levels for marine invertebrates. As is clearly stated, they are only “guidelines.” The paucity of data is so impressive, that any so-called “protection” based on them must have little or no credibility. For example there are no data at all for soft bodied invertebrates like annelids, coelenterates platyhelminthes, or nemertines, and only two molluscs are cited (and because I have never heard of either genus before, I cannot tell whether they are bivalves, snails or squids! I have commented elsewhere on the reliability of the Crustacean data! I remind you that the few data available are apparently all from acute toxicity tests. Thus it is obvious that the data are simply not to be trusted as far as invertebrates are concerned, but invertebrates make up far and away the greater part of the estuary biomass!
68. >From the above it is clear that there are no sound guidelines, appropriate to our situation, to be derived from the ANZECC publication.
69. In the absence of a ready made solution, we must of necessity arrive at one of our own devising. Firstly, we need to agree, either: that the biological community of the estuary is worth protecting, so that the amenity values can continue to be enjoyed, or: that they are not of that value. If it is formally agreed that they can be deliberately endangered (by those who do not understand biological matters?) then we agree to risk their potential destruction, and the literal stink that will cause. If we agree that not to preserve our estuarine birds and the pleasure they give so many, despite their habitat’s probable international status, many would say we deserve all of the consequential opprobrium.
70. If, on the other hand there is a view that congenial surroundings and recreational opportunities are worth preserving, then we will need to extend a measure of protection that in my view would lie between Type 1 and Type 2 ecosystems, and be accorded a

very high level of protection, say midway between the 99% and 95% levels that ANZECC would accord Type 1 and Type 2 ecosystems respectively. Because the AEE is so deficient in information about the prevailing conditions in the estuary and the precise effect of the CCC operations, I am unable to reach a precise, informed recommendation about acceptable levels of pollution.

71. The level of protection from ammonia should be set for the maximum conditions of temperature and pH that occur in the estuary in summer.
72. Serious consideration must be given to restricting the discharge of effluent to the period immediately after high tide at the discharge point. Given that the rate of discharge is 40,000 cubic metres per hour, and that the usual volume to be discharged per day is about 160,000 cubic metres, such a regime should easily accommodate even wet weather discharges.
73. As made clear earlier, such a regime would minimise the period over which the ammonia polluted waters remain in the estuary, and their dispersion over areas of potentially sensitive organisms. It would at the same time limit the dispersion of deleterious viruses, and this reduce the public health disease risks from droplet infection. All would win at no additional costs to the ratepayers.
74. I am not clear whether by seeking a variation of certain conditions the applicant opened all of the conditions to review or not. We were most unimpressed by the foolish provision in condition 16 which allowed the consent holder to exceed the permitted contaminant values 16 times out of every 26, or on 61.5% of the sampling occasions. I urge that as the second anniversary has passed, the original consent condition 16 provision, viz. “and after the second anniversary of commencement of this consent, no value in each 13 week period shall exceed the maximum value for ammoniacal nitrogen.” be confirmed, and enforced immediately. We observe that the consent authority has allowed departures from the specified limits up to the present. This should now cease.
75. I believe I have noticed an unacceptable use of median and averaged values in consents relating to biological matters. Such usage supports the view that the stated maxima may be exceeded on whim. Death is an irreversible phenomenon, and is not reversed by the operation of a calculator.
76. Because of the impossibility of drafting new information-based conditions, we urge that the original consents be affirmed, and the application for a change in the allowable amount of ammonia in the discharge be denied.
77. I thank you for your patience, and tolerance of my imperfect typing.