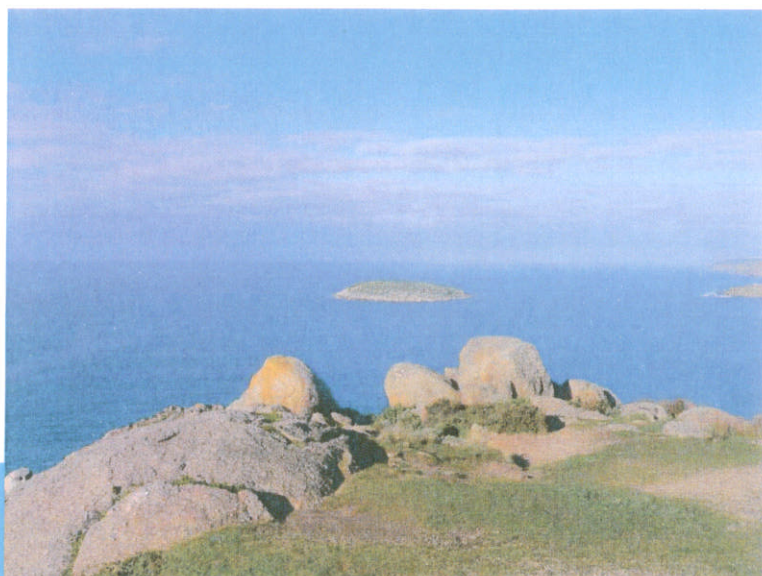


Review of Geotechnical Services reports (2006 – 2007) and recommendations on methods to calculate dilution factors, ongoing WET monitoring and appropriateness of using the copepod *Gladioferens imparipes*.

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EXECUTIVE SUMMARY

Whole effluent toxicity (WET) testing was conducted over three years in order to assess the toxicity of the saline brine discharged from the Perth Seawater Desalination Plant. WET tests were conducted using a fish, a microalga, a macroalga, a mussel and a copepod (a type of crustacean). There are limitations associated with the copepod toxicity data. The preferred approach of deriving the dilution factors was to use an estimate of the concentration that would cause a 10% reduction in copepod growth (i.e. estimated EC10) value for the copepod (i.e. the concentration that would cause a 50% reduction in copepod growth (EC50) from the copepod 24 hour pulse exposure tests divided by a conversion factor of five) with the EC10 or toxicity data from the other species. This resulted in dilution factors of 16 and 13 to meet the limits set for the high ecological protection area and the moderate ecological protection area respectively. According to information provided, these dilution factors are being met with a considerable margin of safety. The recommended dilution factors were ground truthed against the toxicity data for the test species and they provided more than adequate protection.

Given the available information I believe that a decision on whether further routine WET testing is necessary is a matter to be resolved between the Water Corporation and the WA Department of Environmental Protection. Further WET testing would be appropriate if any major changes to the Desal plant occurred or if the chemical additives used were modified as these could lead to changes in toxicity of the saline brine.

I believe that the copepod *G. imparipes* is an appropriate test species to be used for WET testing in Cockburn Sound for the reasons provided previously in Warne (2007). However, I believe it would be wise to conduct additional *G. imparipes* toxicity tests to determine if more reliable EC10 estimates can be obtained. If this succeeds then I believe that *G. imparipes* EC10 data should be used to derive dilution factors, rather than converted EC50 data. If it is not successful and the limitations of the EC10 can not be resolved, then I recommend that *G. imparipes* still be used and that the EC50 values be divided by a conversion factor of five. The resulting value should be combined with the EC10 data from the other species to derive dilution factors. Alternatively a new WET test could be developed to replace *G. imparipes* however, there is no guarantee of success and this could involve considerable development costs and time delays.

BACKGROUND

In the latter part of 2007 Dr Michael Warne (CSIRO) was approached by Ms Suzanne Brown to act as an expert advisor to the Water Corporation (Western Australia) on matters relating to whole effluent toxicity (WET) testing and the derivation of suitable dilution factors for saline brine discharges associated with the desalination plants being developed in Western Australia. He was subsequently approached by Mr Gordon Groth to provide advice on a report provided to Water Corporation by Geotechnical Services Pty. Ltd. (Woodworth, 2007). This report (Warne, 2007) reviewed the work done on copepod toxicity testing.

In January, 2008 Dr Warne was again approached by Mr Gordon Groth regarding three reports on the WET testing conducted by Geotechnical Services (2006a, 2006b, 2007). Specifically Dr Warne was asked to:

- comment on the appropriateness of the method used to derive dilution factors and if appropriate to recommend an alternate method and dilution factors;
- clarify the issue of representivity of species;
- comment on whether any further WET testing was required; and
- comment on the appropriateness of continuing the use of the copepod WET test.

CALCULATION OF DILUTION FACTORS

The report (Geotechnical Services, 2007) calculates the dilution factors that corresponded to a PC80 and PC90. In doing this the 2007 WET test data were used. I believe it is appropriate that separate dilution factors were derived based on the 2006 and 2007 WET testing results. The 2007 data used were either sub-chronic EC10 or NOEC values apart for the acute EC10 value for *Gladioferens imparipes*. It is not ideal to combine acute and chronic toxicity when using species sensitivity distribution methods such as BurliOZ (Campell et al., 2000) as they may have different distributions. However, based on the modelling of Yeates (2006) the 24 hour pulse exposure test for the planktonic *G. imparipes* will overestimate the likely exposure of copepods in Cockburn Sound by more than 4 fold (i.e. 24 hours compared to 5 hours). Therefore from an environmental realism point of view it would be more appropriate to use an acute test such as that conducted rather than a chronic test.

Therefore one faces the situation of either using *G. imparipes* toxicity data from an acute but environmentally realistic test or use chronic data that is not environmentally relevant. Neither option is optimal.

There is also another issue with the *G. imparipes* toxicity data – the fact that the EC10 are not reliable. Invariably if toxicity data is plotted against the duration of the exposure then an asymptotic relationship occurs (i.e. the plot at both small and long exposure duration times will approach but never reach the axes). Such a plot was obtained for the EC50 data but not for the EC10. This raises the issue of whether the less reliable but more environmentally conservative EC10 values or the more reliable but less conservative EC50 values should be used to derive dilution factors. Again neither option is ideal. The Australian and New Zealand water quality guidelines (ANZECC and ARMCANZ, 2000) provided a means of resolving this. They recommend that a conversion factor of five is used to convert EC50 data to NOEC data (ANZECC and ARMCANZ, 2000; Warne 2001). This same factor can be used to convert EC50 to EC10 data as the NOEC is considered to be equivalent to the EC10 (Moore and Caux, 1997; USEPA, 1991 and Hoekstra and Van Ewijk, 1993).

Given the above I calculated dilution factors for four different scenarios:

1. using the 2007 sub-chronic EC10 values for the microalga, the macroalga, the mussel, and the fish and the acute EC10 value for the copepod;
2. using the same dataset as scenario 1 except the value for the copepod was the acute EC50; and
3. using the same dataset as scenario 1 except that the copepod value was omitted.
4. using the same dataset as scenario 1 but the copepod acute EC50 had been divided by 5.

Comparison of the dilution factors generated by scenarios 1 and 2 would reveal the effect of using EC10 or EC50 values for *G. imparipes*. Comparison of scenario 3 with 1 and 2 would reveal the effect of using the acute *G. imparipes* toxicity values. Comparison of scenario 2 and 4 would show the effect of using the conversion factor and comparison of 1 and 4 would show the difference between using the unreliable EC10 values and the estimated EC10 value. The data that was used is presented in Table 1.

Table 1. Toxicity data used to derive dilution factors for three different scenarios.

Organism type	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Microalga	13.7	13.7	13.7	13.7
Macroalga	92.9	92.9	92.9	92.9
Mussel	12.5	12.5	12.5	12.5
Copepod	16.8	29.8		5.9
Fish	9.6	9.6	9.6	9.6

The resulting dilution factors generated by the four different scenarios are presented in Table 2.

Table 2. The dilution factors generated using the data in the four scenarios presented in Table 1.

Scenario	Dilution factors	
	PC90	PC80
1	10.8	9.2
2	10.8	8.8
3	11.7	9.6
4	16	12.9

It is clear that the dilution factors that correspond to the same level of protection (i.e. PC90 or PC80) are essentially the same for scenarios 1 to 3. The dilution factors derived using the estimated EC10 value (scenario 4) are considerably higher than the other dilution factors, reflecting the fact that the estimated EC10 value is considerably smaller than the other toxicity values.

None of the above methods of deriving the dilution factors are optimal. The limitations with scenario 1 and 2 have already been discussed. The limitation of scenario 3 is that it only uses toxicity data for four species that belong to four taxonomically different groups and therefore it does not meet the minimum data requirements of the BurriOZ method (ANZECC and ARMCANZ, 2000; Warne, 2001). The limitation of scenario 4 is that it uses an estimate of the EC10 value. From a regulatory point of view the datasets that use reasonable assumptions and yet yield the most conservative dilution factors are preferred. Given this, the most appropriate approach would be to use the estimated acute *G. imparipes* EC10 value (i.e. the EC50 value divided by five) and the most appropriate dilution factors to adopt are 16 and 13 for the PC90 and PC80 respectively.

The diffuser for Desal 1 was designed to achieve a dilution factor of 50 – 75 within 50 m of the diffuser (Geotechnical Services, 2006a). I have been informed (Gordon Groth, pers. comm.) that the diffuser has always delivered at least a 45 fold dilution factor. Assuming that the above dilution factors are achieved then the levels of protection established for the low

ecological protection area (LEPA – PC80) and moderate ecological protection area (MEPA – PC90) will be met with a considerable margin of safety. For example, if a 48 fold dilution was achieved the resulting water would be approximately 1.6% saline brine.

The last step in the derivation of the Australian and New Zealand water quality guidelines was to ground-truth the trigger values (Warne, 2001) and if necessary to adjust the trigger values downwards by manipulating the calculations or the data in various ways (e.g. by increasing the level of protection from 95% to 99% or using a larger assessment factor (AF)). This was done by comparing the trigger values to all the raw toxicity data, paying particular attention to field-based, mesocosm or microcosm toxicity data. This ground truthing was also conducted for this report.

The PC80 values calculated for the four scenarios were compared to the toxicity data used to generate them. In scenarios 1 - 3 the PC80 was larger than the toxicity value for the fish *Pagrus aratus*. Thus, for scenarios 1 and 2, 20% of the test organisms (one out of the five species) would suffer a toxic effect which is exactly what would be expected from a PC80. For scenario 3, 25% of the test organisms (one out of the four species) would suffer a toxic effect which is slightly more than what would be expected from a PC80. However, in scenario four the PC80 was lower than the EC10 values for all the test species – thus less than 20% of the species tested would suffer a toxic effect at the PC80. Another ground truthing relates to the diffuser. If a 48 fold dilution is achieved by the diffuser then the resulting water would be 1.6% saline brine. There would thus be a six-fold safety factor between the dilution achieved and the lowest toxicity value used to derive the dilution factors (i.e. 9.6).

While the method used in the Geotechnical Services report (Geotechnical Services, 2007) is sound, I believe that converting the EC50 value to an estimated EC10 is more rigorous and defensible and also results in more conservative dilution factors. Provided the outfall diffuser is providing approximately a 45 fold dilution then there will be a considerable margin of safety between the percentage of brine in the receiving water outside the mixing zone and the percentages that will exceed the PC80.

Given the limitations of the *G. imparipes* toxicity data (discussed above) I believe that the best way to determine dilution factors is to use divide the acute *G. imparipes* EC50 value by five and then use the resulting value combined with the sub-chronic EC10 values for the other species to calculate dilution factors.