

Expert witness statement of Dr Véronique Catherine Louise Lévy Expert of Gunns Limited

**In the matter of the Bell Bay Pulp Mill Project: A project of State Significance
Resource Planning and Development Commission inquiry**

Proponent: Gunns Limited

1 Name and address

**Dr Véronique Lévy
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2 Area of expertise

My area of expertise is Water Chemistry with an emphasis on Water Quality and Water Treatment.

My qualifications and experience are detailed in Attachment 1.

I am sufficiently expert to make this statement because:

I hold a Ph.D in Water Chemistry and Microbiology and have worked on many projects relating to environmental chemistry and the impact of industrial waters on the environment and their treatment.

I am a chemist with experience in water quality and in the discharge of contaminated effluents in the environment. I have experience on sensitive sites, in particular the Jabiluka Uranium Project and the Ranger Uranium Mine. I also have a good understanding of the Australian and New Zealand Guidelines for Fresh and Marine Water Quality, ANZECC & ARMCANZ (2000). I previously studied environmental analytical chemistry and more specifically the speciation of heavy metals.

I have also been involved in several studies concerning the usage of the ANZECC & ARMCANZ guidelines including the development of trigger values.

3 Instructions

I was asked to provide advice on:

- the determination of trigger values for comparison with the hydrodynamic modelling of the mixing zone,
- issues relating to water quality, the appropriate usage of the ANZECC & ARMCANZ guidelines and analytical chemistry.

I have prepared a detailed report addressing these matters, which is to be found at attachment 2 to this statement.

In preparing the report, the following assumptions were made:

- the effluent data provided by Jakko Pöyry is correct;
- the organic compounds potentially present in the treated effluent and their respective concentrations are as listed by Toxikos in the Marine Impact Assessment (2007);
and
- the monitoring data is reliable and sufficient to provide an indication of the ambient conditions.

I have been provided with comments made by DTAE under cover of an e-mail dated 8th December 2006, which is a response to the proposed trigger values provided by GHD to DTAE on 22nd November 2006 presented in Attachment 3. I have reviewed those comments and have prepared a brief response. In Attachment 4 is a copy of DTAE's comments and in Attachment 5 is my response.

4 Declaration

I have made all the inquiries that I believe are desirable and appropriate and no matters of significance which I regard as relevant have, to my knowledge, been withheld from the Commission.

V. King

Curriculum Vitae

Dr Véronique Lévy

Dr Véronique Lévy Environmental Chemist,

Dr Véronique Lévy is an environmental chemist with nearly 15 years experience specialising in water quality assessment, water treatment and management. Véronique has worked on the impact and the treatment of contaminated water from various industry including mining, energy, pulp and paper, herbicide and pesticide, textile and food.

Areas of Expertise

- » Water quality assessment for pristine and industrial/disturbed environments.
- » Environmental sciences with an emphasis on chemical and microbiological processes in water and sediments.
- » Impact, behaviour and removal of a wide range of chemicals in the environment, including heavy metals (speciation), nutrients and complex aromatic compounds.
- » Collation, analysis and interpretation of large sets of data.
- » Familiar with several water and sediment guidelines (ANZECC & ARMCANZ, NODGDM, PNG).
- » Hydro-geochemistry modelling (Minteq, Phreeqc), database management, and laboratory QA/QC procedures.

Relevant Experience

- » Gold Coast Water – Qld. Seawater quality assessment for the Gold Coast desalination Reverse Osmosis plant. Monitoring Program.
- » Goro Nickel - New Caledonia- Marine effluent release: hydro-geochemical modelling to assess the chemical behaviour of the effluent.
- » Myuna Colliery: ANZECC & ARMCANZ study, NSW - Impact of the release of a naturally manganese contaminated underground mine water on the receiving bay. Ecotoxicology study and derivation of a new toxicity trigger value.
- » EPA, Treatment of the Binary Chemical Fire Runoff Water-Qld. Water quality review, analytical interlab comparison program. Development of a water treatment methodology using advanced oxidation processes to remove herbicides.
- » Swanbank Paper Project – Qld. Concept design of a wastewater treatment plant, using lime softening and membrane technologies. Water and chemistry balance model.
- » SEQ Water Evaluation of the commercial microtox test to assess the toxicity of runoff potentially charged in pesticides.
- » Interim Turbidity Trigger Value Port of Karumba, Qld - Statistical determination of an interim turbidity trigger value for the 2004 maintenance dredging.
- » Tenterfield Shire : Domestic Treatment Plant Augmentation, NSW - Water quality assessment of the receiving waterway (Tenterfield Shire Council).
- » Pavement Drainage Clogging, Vic - Carbonate material precipitation in a no fine concrete material used as a pavement drainage system – water quality modelling.

- » Jabiluka Water Management Options, NT – Identification of the different sources of water on site and estimation of the yearly water quality changes. BPT assessment.
- » Impact of Irrigation on the Jabiluka Catchment, NT.
- » Continuous assessment of the water quality monitoring data of the Ranger Mine and Jabiluka sites, NT.
- » Minewater Disposal Through Wetlands, Ranger Uranium Mine, NT - Disposal of RP2 water through wetland irrigation.
- » Reverse osmosis troubleshooting, Jabiluka retention pond, NT - Modelling of the retention pond water quality to identify the cause of RO membrane fouling.
- » Pond Sediment Characterisation, Jabiluka, NT - Chemical and mineralogical characterisation of the sediments of the Jabiluka retention pond to identify the contamination.
- » Environmental Impact Study Review, NT - Review of selected aspects (arsenic) of an environmental impact study for the Northern Land Council: “Environmental effects of a controlled release of alkaline wastewater from the Nabalco residue disposal area”.
- » Application for Water Disposal by Land Irrigation at Jabiluka, NT - Collation and review of historical water quality in creeks upstream and downstream of the mine site, statistical determination of the trigger values.
- » Evolution of water quality from the Waste Rock Dumps at ERA-Ranger mine, NT - Review and collation of 20 years of ground- and surface water data. Identification of trends and correlations between the changes in the water quality and the uranium content of the waste rock.
- » Contaminant Source Study, Mount Morgan Mine, Qld - Study of the sources of contamination of the Dee River during storm events. Collation and review of the chemistry data and calculations of contaminant loads during rain events.
- » R&D - Enzymatic Treatment of Food Dyes - Decolouration of 8 food dyes by *Pycnoporus Cinnabarinus* laccase. Development of a bench scale pilot for the continuous production of laccase. Ph.D University Supervisor.
- » R&D - Bioelimination of 4-chlorophenol under aerobic and anoxic conditions, sequential chemical/biological oxidation. Development of a bench scale pilot. Ph-D Thesis.
- » Heavy Metals in Stormwater - Speciation of heavy metals during storm events in urban zone - Total metal and speciation of the aqueous phase. Masters Thesis.
- » Drilling Gas and Oil Analysis, France - Analysis of drilling gas and oils by different chromatographic techniques - Identification of the components.

Qualifications and Affiliations

- » PhD in Water Chemistry and Microbiology, Ecole des Mines d'Alès/Université de Pau, France - 1995
- » Master in Water Chemistry and Microbiology, Université de Pau, France - 1991
- » Postgraduate degree in Chemistry, Université de Pau, France - 1989
- » Bilingual French-English (Technical translations) and notions in Spanish, German
- » Australian Water Association.

Attachment 2

Water Quality Assessment Report for Bell Bay Pulp Mill Draft IIS January 2007



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Gunns Limited
Bell Bay Pulp Mill Draft IIS
Water Quality Assessment
January 2007

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- A State Policy on Water Quality Management 1997 (extract)
- B Effluent Quality Data
- C Background Water Quality Monitoring Program

1. Introduction

1.1 Background

Gunns Limited is investigating the construction and operation of a pulp mill at Longreach, Bell Bay on the North Coast of Tasmania. The mill will use elemental chlorine free (ECF) bleaching technology and all wastewaters generated by the mill will be treated on site prior to discharge into Bass Strait via an ocean outfall. The diffuser will be located approximately 3 km from the coastline at an approximate depth of 26 m.

A draft Integrated Impact Statement (IIS) has been submitted to the Resource Planning and Development Commission (RPDC). In response to submissions concerning the Water Quality Objectives used in the draft IIS, Gunns Limited have commissioned GHD to further investigate the water quality parameters in the effluent that could impact on the environmental values in the vicinity of the discharge.

This report identifies the water quality parameters and the associated trigger and background values relevant to the definition of a mixing zone at the diffuser point, based on available information on the effluent and background water quality. The information contained in this report will be used as an input to the GHD hydrodynamic modelling study, which defines the extent of the mixing zone.

The current report also presents a discussion on the potential environmental impacts associated with organics and nutrients in the effluent discharge.

1.2 Mixing Zone Definitions

The mixing zone will be defined using the risk-based approach proposed by the ANZECC & ARMCANZ guidelines (2000). This approach was adopted following discussions with the Environment Division of the Department of Tourism, Arts and the Environment (DTAE). Definition of the mixing zone will also comply with the State Policy on Water Quality Management (1997) and the RPDC emission limit guidelines (2004).

Mixing zones are defined as:

“a three dimensional area of receiving waters around a point of discharge of pollutants within which it is recognised that the water quality objectives for the receiving waters may not be achieved” - Tasmanian State Policy on Water Quality Management (1997) and RPDC (2004).

and

“explicit areas around effluent discharges where the management goals of the ambient waters do not need to be achieved and hence the designated environmental values may not be protected” - Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC & ARMCANZ, 2000)

The requirements for a mixing zone, as defined by Clause 20 of the Tasmanian State Policy on Water Quality Management (1997) are provided in Appendix A.

Once the boundary of the mixing zone is reached, it is expected that the concentration of contaminants should not represent any toxicological risk to the ecosystem, as referred to in Clause 21 (Toxicity of emissions to aquatic organisms) of the Tasmanian State Policy on Water Quality Management (1997):

“Where a mixing zone has been designated in accordance with clause 20, the emission limits should be set at levels, which are unlikely to cause chronic or sub-lethal toxicity to living organisms present in the local ecosystem at the dilution expected at the boundary of the mixing zone.”

The ANZECC & ARMCANZ guidelines (2000) stipulate that:

“Mixing zones are generally designated to manage the controlled discharge of soluble, non-bioaccumulatory toxicants whose impacts on local biota are primarily related to their concentration. The use of mixing zones is not appropriate for managing the discharge of nutrients, bioaccumulatory or particulate substances. With respect to nutrients, for example, stimulation of algae (e.g. phytoplankton) may occur considerable distances away from the outfall and is mediated by the biological characteristics of the waterbody as a whole.”

Hence, for this study, only non-bioaccumulatory substances were considered for the modelling of the mixing zones, though bioaccumulatory substances and nutrients are discussed in this report as part of the overall analysis of potential environmental impact.

More detailed information on mixing zones and how they should be determined can be found in the ANZECC & ARMCANZ guidelines, Volume 2 Appendix 1.

1.3 Process for Defining a Mixing Zone

The boundaries of the mixing zones have to abide by Clause 21 of the Tasmanian State Policy on Water Quality Management (1997). These boundaries are determined by identifying the compounds present in the effluent and their environmental “trigger” values, also taking into account the background concentration of these compounds. The process used to determine trigger values to define the mixing zone was based on the risk approach favoured by the ANZECC & ARMCANZ guidelines (2000), as confirmed through discussions and correspondence with DTAE.

The process for determining trigger values to assist in defining the mixing zone involves the following steps:

- » Define “Environmental Values” (Ecosystems, Human Health, Aquaculture, Recreation);
- » Review the quality of the effluent and identify constituents of concern;
- » Identify threatened species and those species which are sensitive to these potential toxicants;
- » Review appropriate guidelines;
- » Identify if further ecotoxicology tests are required;
- » Determine ambient conditions and toxicant concentrations; and
- » Determine Trigger Values for the mixing zones based on ambient conditions and toxicity /ecosystem protection.

This report outlines the results of applying the above process to assessing the proposed Gunns Limited ocean outfall.

2. Environmental Values

The ANZECC & ARMCANZ guidelines (2000) define Environmental Values as:

“Particular values or uses of the environment that are important for a healthy ecosystem or for public benefit, welfare, safety or health and that require protection from the effects of pollution, waste discharges and deposits. Several environmental values may be designated for a specific waterbody”.

As the diffuser is located approximately 3 km offshore, the principal environmental values relate to the protection of the local ecosystem. A thorough Marine Impact Assessment has been undertaken by Toxikos (2007) based on environmental studies by Aquenal (2005) and supported by toxicology studies by Ecotox (2006). The reader is referred to these reports as a comprehensive assessment of the Environmental Values relevant to the proposed outfall.

3. Effluent Characteristics

3.1 General characteristics

The characteristics of the effluent were provided by e-mail from Hannu Jappinen dated 31st October 2006, the content of which are reproduced in Appendix B. Jaakko Pöyry provided information for most general parameters both as an average and, in some cases, as a range. They advised that the average value should be used for modelling purposes as this best reflected the current understanding of likely emission concentrations. However, in the case of chlorate, based on advice from Toxikos, the higher value of the range was considered as more appropriate, as chlorate can present a risk of acute toxicity. For heavy metals and phosphorus, the maximum values from the three wood-types provided were selected. Jaakko Pöyry also provided a value for total resin acids. Resin acids are generated during the processing of pine but not during Eucalyptus processing (Toxikos, 2007). A more detailed list of potential organic compounds was developed by Toxikos in the Marine Impact Assessment (2007). This list was based on scientific literature and is discussed in section 3.2 below.

The final effluent water quality is provided in Table 1, while the data used to derive the final effluent quality is provided in Appendix B.

3.2 Potential organic compounds in the effluent

Potential organic compounds present in the effluent can be broken down in the following categories:

- » Organic acids, including: chloroacetic acids, resin acids (for pine only) and fatty acids;
- » Natural chlorinated phenols;
- » Chlorophenols;
- » Sterols;
- » Miscellaneous aromatic compounds;
- » Polychlorinated aromatic compounds; and
- » Miscellaneous compounds including hydrocarbons, aldehydes, ketones and chlorinated hydrocarbons.

An extensive list of organic compounds potentially present in the effluent is reported in the Marine Impact Statement prepared by Toxikos (2007). Based on an extensive literature research, Toxikos attributed a theoretical concentration to each organic compound and compared it with published environmental trigger values. They identified that only monochloroacetic acid could be sufficiently concentrated to require greater than 1 in 100 dilution to meet the proposed trigger value. This compound was not considered further in this report, as it was not identified by Jaakko Pöyry as a contaminant present in the effluent.

Table 1 Effluent Composition

Parameter	Units	Effluent
Final Flow	t/d	63,770
pH		6.5
DO	mgO ₂ /L	2
Colour	mgPt/L	493
TDS	mg/L	2250
TSS	mg/L	20
BOD ₅	mgO ₂ /L	11
COD	mgO ₂ /L	466
AOX	mg/L	6.8
Chlorate	mg/L	3.7
Total-N	mgN/L	2.5
Organic-N	mgN/L	1.5
Ammonia-N	mgN/L	0.02
Nitrate-N	mgN/L	0.98
Nitrite-N	mgN/L	0
NO _x	mgN/L	0.98 *
TKN	mgN/L	1.5 **
Total-P	mgP/L	0.8
Inorganic-P	mgP/L	0.50
Organic-P	mgP/L	0.30
Al	µg/L	601
As (III and V)	µg/L	2.8
B	µg/L	35
Ba	µg/L	17
Be	µg/L	1.4
Cd	µg/L	0.98
Co	µg/L	2.8
Cr	µg/L	26
Cu	µg/L	19
Fe	µg/L	817
Hg	µg/L	0.25
Mn	µg/L	817
Mo	µg/L	1.3
Ni	µg/L	26
Pb	µg/L	2.8
Sb	µg/L	1.3
Se-Total	µg/L	7.4
Si	µg/L	570
Sn	µg/L	13
V	µg/L	1.3
Zn	µg/L	84
Total Extractive; pine	µg/L	500
Total Extractive; eucalyptus	µg/L	500
Resin Acids; pine	µg/L	250
Resin Acids; eucalyptus	µg/L	0
Fatty Acids; pine	µg/L	190
Fatty Acids; eucalyptus	µg/L	350
Neutral Extractive; pine	µg/L	60
Neutral Extractive; eucalyptus	µg/L	150

Notes: * NO_x was defined as the sum of nitrate and nitrite in the effluent

** TKN was defined as the difference between TN and NO_x

4. Review of Existing Toxicity Trigger Values

4.1 Toxicity trigger values for marine water

The effluent will potentially contain a range of compounds and elements that could have a detrimental impact on the receiving environment (Table 1). The concentrations of each of these chemicals were compared to relevant guideline values for ecosystem protection.

The trigger values for marine ecosystems and toxicants in marine waters provided in the “Australian and New Zealand Guidelines for Fresh and Marine Water Quality” (ANZECC & ARMCANZ, 2000) were considered in the first instance. The trigger values for 95% species protection level were adopted except for bioaccumulatory metals, in which case 99% species protection level were adopted. When the trigger values provided by the ANZECC & ARMCANZ guidelines were of low reliability, further research was undertaken to identify if more appropriate trigger values existed.

The following guidelines and websites were utilised in this process:

- » Australian and New Zealand Guidelines for Fresh and Marine Water Quality” (ANZECC & ARMCANZ, 2000) for marine ecosystems and toxicants in freshwater and marine water;
- » Canadian Guidelines, including provincial water quality objectives from Ontario and British Columbia;
- » World Health Organisation and most particularly the International Program for Chemical Safety Concise International Chemical Assessment Documents (CICADs);
- » Australian Drinking Water Quality, 2004; and
- » RPDC guidelines – “Development of new environmental emission limit guidelines for any new bleached eucalypt kraft pulp mill in Tasmania” (2004), Volume 1 and 2.

The trigger values proposed for each chemical species and the effluent characteristics are detailed in Table 2.

Table 2 Trigger values compilation for the protection of the marine environment

Parameter	Units	Effluent	ANZECC & ARMCANZ Marine Ecosystem	ANZECC & ARMCANZ Toxicants in Seawater	Others
pH		6.5	8.0-8.4 (a)		
DO	mgO ₂ /L	2			
Colour	mgPt/L	493			15 (b)
TDS	mg/L	2250			
TSS	mg/L	20			
BOD ₅	mgO ₂ /L	11			
COD	mgO ₂ /L	466			
AOX	mg/L	6.8			
Chlorate	mg/L	3.7			0.005 (c)
Total-N	mgN/L	2.5	0.12 (a)		
Organic-N	mgN/L	1.5			
Ammonia-N	mgN/L	0.02	0.015 (a)	0.910 (d)	
Nitrate-N	mgN/L	0.98		<i>0.158 (e)</i>	
Nitrite-N	mgN/L	0			
NO _x	mgN/L	0.98*	0.005 (a)		
TKN	mgN/L	1.5**			
Total-P	mgP/L	0.80	0.02 (a)		
Inorganic-P	mgP/L	0.50			
Organic-P	mgP/L	0.30	0.01 (a)		
Al	µg/L	601		0.5 (f)	75 (g)
As (III and V)	µg/L	2.8		2.3 (III) (f) 4.5 (V) (f)	
B	µg/L	35		5100 (h)	
Ba	µg/L	17			
Be	µg/L	1.4			0.13 (i)
Cd	µg/L	0.98		0.7 (j)	
Co	µg/L	2.8		1 (k)	
Cr	µg/L	26		4.4(VI) (k) 27 (III) (k)	
Cu	µg/L	19		1.3 (k)	
Fe	µg/L	817			300 (l)
Hg	µg/L	0.25		0.1 (m)	
Mn	µg/L	817		80 (f)	400 (n)
Mo	µg/L	1.3		23 (f)	
Ni	µg/L	26		70 (k)	
Pb	µg/L	2.8		4.4 (k)	
Sb	µg/L	1.3		270 (f)	
Se-Total	µg/L	7.4		3 (f)	
Si	µg/L	570			
Sn	µg/L	13			10 (o)
V	µg/L	1.3		100 (k)	
Zn	µg/L	84		15 (k)	
Total Extractive; pine	µg/L	500			
Total Extractive; eucalyptus	µg/L	500			
Resin Acids; pine	µg/L	250			52 (p)
Resin Acids; eucalyptus	µg/L	0			
Fatty Acids; pine	µg/L	190			
Fatty Acids; eucalyptus	µg/L	350			
Neutral Extractive; pine	µg/L	60			
Neutral Extractive; eucalyptus	µg/L	150			

Notes: Numbers in *italic* indicate low reliability trigger values, numbers in **bold** indicate effluent concentration above guideline limits

* NO_x was defined as the sum of nitrate and nitrite in the effluent

** TKN was defined as the difference between TN and NO_x

Data source

- (a) ANZECC & ARMCANZ (2000) guideline value for marine ecosystems South East Australia.
- (b) Australian Drinking Water Quality Guidelines (2004), value for colour as an aesthetic contaminant.
- (c) Ministry of Environment of British Columbia (Canada) guidelines on chlorate (2002), "*This guideline is based on the NOEC of 5 µg/L chlorate which resulted from a 6 month chronic study on the growth of Fucus vesiculosus (Lehtinen et al, 1988; Rosmarin et al, 1994)*".
<http://www.env.gov.bc.ca/wat/wq/BCguidelines/chlorate/chlorate.html#guide3>
- (d) ANZECC & ARMCANZ 95% toxicity value for pH 8 expressed in Nitrogen (Table 8.3.7 of the guidelines).
- (e) For nitrate in seawater, the ANZECC & ARMCANZ (2000) guidelines recommend to adopt the freshwater figure of 700 µg/L (as NO₃) for nitrate toxicity as a low reliability trigger value.
- (f) ANZECC & ARMCANZ (2000) low reliability toxicity trigger value.
- (g) Ministry of Environment of Ontario (Canada) (1999). Provincial Water Quality Objectives of the Ministry of Environment and Energy. Ontario Provincial Water Quality Objectives for freshwater: "*At pH >6.5 to 9.0, the Interim PWQO is 75µg/L based on total aluminium measured in clay-free samples.*"
<http://www.ene.gov.on.ca/envision/gp/3303e.htm>
- (h) ANZECC & ARMCANZ (2000) (ref p 8.3-110) recommends that the established background level in seawater be adopted as a trigger value.
- (i) There is no toxicity trigger value available for beryllium in seawater in the ANZECC & ARMCANZ (2000) guidelines, hence the freshwater trigger value was adopted.
- (j) ANZECC & ARMCANZ (2000) - Cd is bioaccumulatory, hence the 99% species protection level trigger value is adopted (95%=5.5 µg/L)
- (k) ANZECC & ARMCANZ (2000) trigger value for 95% species protection level for slightly to moderately disturbed environments.
- (l) There is no toxicity trigger value available for iron in seawater in the ANZECC & ARMCANZ (2000) guidelines. These recommend using the current Canadian guideline level as an interim, indicative working level "*There were insufficient data at this stage to derive a reliable trigger value for iron. The current Canadian guideline level is 300 µg/L, which could be used as an interim indicative working level but further data are required to establish a figure appropriate for Australian and New Zealand waters. Potential for iron deficiency needs to be considered in such studies. No marine data were available.*".
- (m) Mercury is bioaccumulatory, hence the 99% species protection level trigger value is adopted (95% = 0.4 µg/L).
- (n) World Health Organisation (2004) - the trigger value for Mn 99% species protection level of 400 µg/L is adopted, which includes data from an Australian study
(http://www.who.int/ipcs/publications/cicad/cicad63_rev_1.pdf .
- (o) There is no toxicity trigger value available for tin in seawater in the ANZECC & ARMCANZ (2000) guidelines. These recommend adopting the current UK value for inorganic Sn: "*The value of 10 µg/L, recommend in the UK (Mance et al, 1988b) from 0.25 of the saturated concentration of tin in seawater*

(35 µg/L) may better serve as a low reliability trigger value for inorganic tin in marine waters. These figures do not apply if the tin is present as organotins. They should only be used as indicative interim working levels.”

(p) Ministry of Environment of Ontario (Canada) (1999). Ontario Provincial Water Quality Objectives for freshwater. Interim guideline value for a pH of 8 (<http://www.ene.gov.on.ca/envision/gp/3303e.htm>).

5. Ambient Conditions and Locally Derived Trigger Values

5.1 Need for ambient conditions and locally derived trigger values

For the purpose of hydrodynamic modelling, it is essential to determine a background concentration for each chemical of interest. This can only be achieved through the use of background data collected locally or inferred from similar areas.

The background data collected was also used to derive local trigger values for some compounds as high reliability trigger values could not be attributed to many of the physico-chemical parameters and chemical species listed in Table 2, and in some cases, such as barium or colour, no values were available at all.

The ANZECC & ARMCANZ guidelines (2000) recommend that:

“A minimum of two years of contiguous monthly data at the reference site is required before a valid trigger value can be established.” (Volume 1, Section 7.4.4.1).

The background data available at the time of preparing this report is limited to the five sampling events undertaken from April 2005 to October 2006 and does not cover all potential seasonal variations. It should be highlighted that the sea and weather conditions in Bass Strait during autumn and winter months make sampling difficult and there are limited opportunities to undertake detailed background data collection.

Additional background monitoring will be required to improve the reliability of the calculated ambient conditions. As more data becomes available through additional monitoring, the reliability of these values will increase.

Based on the current status of the background dataset, the values presented should only be considered as an interim indication of the prevailing ambient conditions. The ambient conditions have been determined based on this dataset to enable other aspects of the Gunns project to progress while further data is collected.

5.2 Process for determining ambient conditions and locally derived trigger value

From April 2005 to October 2006, five background sampling campaigns were undertaken. The data collected during these campaigns was used to define:

- » The existing background or ambient conditions; and
- » Locally derived trigger values for physicochemical parameters, nutrients and heavy metals.

Relevant data from each of the sampling events are presented in Appendix C.

The ANZECC & ARMCANZ guidelines (2000) state that:

*“The recommended trigger-based approach for physical-chemical stressors may be stated as follows: A trigger for further investigation will be deemed to have occurred when the **median concentration** of *n* independent samples taken at a test site exceeds the **eightieth percentile** of the same indicator at a suitably chosen reference site. Where*

suitable reference site data do not exist, the comparison should be with the relevant guideline value published in this document.” (Volume 1, Section 7.4.4.1).

As discussed in Section 5.1, the above approach was adopted even though the existing reference site data set is not sufficiently robust to have high confidence in the derived values.

The ambient conditions were calculated as the 50th percentile of the data collected during the monitoring campaigns for all analytes considered.

Locally derived trigger values were calculated in the following way:

- » for physicochemical parameters: 20th and/or 80th percentile;
- » for nutrients: 80th percentile; and
- » for heavy metals: 95th percentile was compared with the derived trigger value. If the derived trigger value was lower than the 95th percentile, then the 80th percentile was selected as the ambient trigger value. This was only applied when the derived trigger value was of low reliability.

This approach is in accord with the process recommended by DTAE, although it also highlights the need for a more robust data set.

All ambient data collected to date was considered in the assessment of trigger values. When the analytical result was below the detection limit for a particular chemical species, then a value of half the detection limit was included in the calculation. This approach is one of the 4 approaches recommended by the Water Quality Monitoring and Reporting guidelines (ANZECC & ARMCANZ, 2000a, section 6.2.1). It is also understood that this approach has limitations, in particular, when over 25 % of the data is below the detection limit.

The ambient conditions and associated percentiles are detailed in Table 3. Additionally, background values for marine water, as provided by the ANZECC & ARMCANZ guidelines (2000) (Table 8.3.2) and the CRC Handbook of Chemistry and Physics, were also considered.

Table 3 Ambient values

Parameter	Units	20 th percentile	50 th percentile	80 th percentile	95 ^h percentile	ANZECC/ ARMCANZ background	Handbook of Chemistry
pH		8.07	8.14	8.21			
DO	mgO ₂ /L	8.40	9.45	10.20			
Colour	mgPt/L	0.5	1	2			
TDS	mg/L	41000	41000	53120			
TSS	mg/L	4	7	29			
BOD ₅	mgO ₂ /L	1	1	2			
COD	mgO ₂ /L	21	480	1200			
AOX	mg/L		0.016	0.029			
Chlorate	mg/L		1	1			
Total-N	mgN/L		0.12	0.14			0.5
Organic-N	mgN/L						
Ammonia-N	mgN/L						
Nitrate-N	mgN/L						
Nitrite-N	mgN/L						
NOx	mgN/L		0.005	0.01			
TKN	mgN/L		0.05	0.13			
Total-P	mgP/L		0.03	0.06			0.07
Inorganic-P	mgP/L						
Organic-P	mgP/L						
Al	µg/L		5	10	20		10
As (III and V)	µg/L		1.6	1.9	2.11	1-1.6	3
B	µg/L		4600	5400	5605		4600
Ba	µg/L		6	6	6		30
Be	µg/L		0.05	0.05	0.05		0.0006
Cd	µg/L		0.1	0.1	0.11	0.002-0.7	0.11
Co	µg/L		0.1	0.72	0.87		0.27
Cr (III and VI)	µg/L		0.25	0.25	0.51	0.062-0.1	0.05
Cu	µg/L		1	7.5	18.2	0.25-0.38	3
Fe	µg/L		2.5	8	13.8	0.006-0.14	10
Hg	µg/L		0.05	0.05	0.05		0.03
Mn	µg/L		0.8	1.6	2.03	0.003-0.38	2
Mo	µg/L		11	11.5	12		10
Ni	µg/L		0.25	2.5	4.9	0.13-0.5	5.4
Pb	µg/L		0.6	1.1	1.93	<0.006-0.03	0.03
Sb	µg/L		0.25	0.25	0.25		0.33
Se-Total	µg/L		1	1	1.45		0.09
Si	µg/L						3000
Sn	µg/L		2.5	2.5	2.5		3
V	µg/L		1.9	2.2	2.51		2
Zn	µg/L		6	2.1	23	<0.022-0.1	10
Total Extractive; pine	µg/L						
Total Extractive; eucalyptus	µg/L						
Resin Acids; pine	µg/L		Not detected				
Resin Acids; eucalyptus	µg/L						
Fatty Acids; pine	µg/L						
Fatty Acids; eucalyptus	µg/L						
Neutral Extractive; pine	µg/L						
Neutral Extractive; eucalyptus	µg/L						

6. Values Selected for Modelling of the Mixing Zone

The information assessed during the different stages of the current study is presented in Table 1, Table 2 and Table 3. This information was collated to produce a final table that defines effluent characteristics, background or ambient conditions and the trigger values selected for each chemical species. These values are provided in Table 4.

The general process applied was as follows:

- » The ambient conditions were defined as the 50th percentile of the monitoring data;
- » The ambient conditions were compared with the existing trigger value;
- » For nutrients and physicochemical parameters, if the ambient conditions were equal to or higher than the trigger value or when no trigger value existed, then the 80th percentile of the data set was recommended as the trigger value for comparison with the numerical modelling; and
- » For toxicants, if the ambient conditions were equal to or higher than the published trigger value or when no trigger value existed, then the 95th percentile of the data set was adopted as the trigger value for comparison with the numerical modelling.

The effluent dilution required to achieve the trigger value was also calculated to provide an indication of the fate of the chemical species and the risk presented to the environment.

The following comments explain how the different values were selected for the main parameters of concern.

pH	The 50 th percentile of the background dataset was adopted as the ambient concentration. The ANZECC & ARMCANZ (2000) guideline value for slightly disturbed marine ecosystems for South East Australia was retained. The current monitoring data provides a 20 th - 80 th percentile range of 8.07-8.21.
Dissolved Oxygen	The 50 th percentile of the background dataset was adopted as the ambient concentration. The 20 th – 80 th percentile of local ambient data were adopted as the trigger value range.
Colour	There is no environmental trigger value relating to colour, as it is not a known toxicant per se. However, because of its elevated concentration in the effluent, colour is one of the parameters that could be used to define the boundaries of the mixing zone. The 50 th percentile (1 mgPt/L) of the monitoring data was adopted as the background value. The 80 th percentile (2 mgPt/L) of local ambient data was adopted as the trigger value.
TDS (as salinity)	The 50 th percentile of the background dataset was adopted as the ambient concentration. Field measurements appear to be very high and not consistent between the two sets of data. Also, there are inconsistencies between the values reported for EC and TDS.

TSS	The 50 th percentile of the background dataset was adopted as the ambient concentration. The 80 th percentile of local ambient data was adopted as the trigger value.
BOD₅	The 50 th percentile of the background dataset was adopted as the ambient concentration. The 80 th percentile of local ambient data was adopted as the trigger value.
COD	The 50 th percentile of the background dataset was adopted as the ambient concentration. The 80 th percentile of local ambient data was adopted as the trigger value. The background values range from below detection limit in April 2005 to 2060 mgO ₂ /L in June 2006. It is well known that COD is an analyte that is particularly difficult to analyse in seawater due to the interferences between chromate (the oxidising reagent used in the analysis) and chlorides.
AOX	For Adsorbable Organic Halide Compounds, the 50 th percentile (0.016 mg/L) of the background dataset was adopted as the ambient concentration. The 80 th percentile (0.029 mg/L) of local ambient data was adopted as the trigger value.
Chlorate	<p>Chlorate is a contaminant of concern. It has been reported to be toxic to brown algae from the northern hemisphere (Rosemarin <i>et al</i>, 1994; Van Wijk and Hutchinson, 1995). Brown algae have been reported to be present in the outfall area, hence ecotoxicology tests were undertaken to determine an appropriate trigger value for the site. These tests were undertaken by Ecotox and the results were assessed by Toxikos. Toxikos derived a trigger value of 8 µg/L for 95% protection level (central estimate) determined from a species sensitivity distribution that includes three species local to Tasmanian coastal waters. The detailed procedure is presented in the "Marine Impact Assessment" (Toxikos, 2007).</p> <p>All data collected during the monitoring campaigns was below the limit of reporting in seawater (1 mg/L). In drinking water, the detection limit for chlorate is below 5 µg/L, but in seawater these levels cannot be achieved due to the interference between chloride and chlorate, hence a satisfying value for ambient conditions could not be derived from the monitoring data. A literature search was conducted but no information was found on background levels or on the existence of chlorate in the marine environment. Though it is unlikely that a high chlorate background should be present in the area of discharge, a precautionary approach was adopted by selecting half the lowest toxicity trigger value found in the literature. This trigger value of 5 µg/L was developed for a brown algae (<i>fucus vesiculosus</i>) from the Baltic sea in the northern hemisphere in low saline conditions (Rosemarin <i>et al</i>, 1994) and is published by the Canadian government (British Columbia). The assumption is that if algae are currently present on site, then chlorate concentration will be lower than the toxicity trigger value, hence a conservative background of 2.5 µg/L was adopted. In reality, the background concentration of chlorate may well be lower than this value.</p>
Total nitrogen	The 50 th percentile of the background dataset was adopted as the ambient concentration. This also corresponds to the trigger value provided for marine

	ecosystems. Hence, the 80 th percentile of local ambient data was adopted as the trigger value.
Total ammonia	There is currently no ambient monitoring data recorded for total ammonia. The trigger value adopted was the ANZECC & ARMCANZ (2000) trigger value for marine ecosystem protection of 0.015 mgN/L, which is considered preferably to the ANZECC & ARMCANZ (2000) trigger value for 95% species protection level of 0.910 mgN/L.
NO_x	The 50 th percentile (0.005 mgN/L) of the background data set was adopted as the ambient value. This value is equal to the trigger value for marine ecosystems. Hence, the 80 th percentile (0.01 mgN/L) of local ambient data was adopted as the trigger value.
Phosphorus	The 50 th percentile (0.03 mgP/L) of the background dataset was adopted as the ambient concentration. This value is higher than the trigger value for marine ecosystems (0.02 mgP/L). Hence, the 80 th percentile (0.06 mgP/L) of local ambient data was adopted as the trigger value.
Aluminium	The 50 th percentile (5 µg/L) of the background dataset was adopted as the ambient concentration. The 95 th percentile of the background dataset was compared to the low reliability ANZECC & ARMCANZ (2000) trigger value. As it is higher the 80 th percentile (10 µg/L) of the local ambient data was adopted as the trigger value.
Boron	The ANZECC & ARMCANZ (2000) guidelines recommend that the established background level should be adopted as a trigger value. This approach does not allow for the gap required for modelling purposes, hence the 50 th percentile (4,600 µg/L) of the background dataset was adopted as the ambient concentration and the 80 th percentile of local ambient data was adopted as the trigger value (5,400 µg/L).
Barium	Barium is not considered as a toxicant by the ANZECC & ARMCANZ (2000) guidelines.
Beryllium	The 50 th percentile (0.05 µg/L) of the background dataset was adopted as the ambient concentration. There is no ANZECC & ARMCANZ (2000) trigger value reported for seawater, hence a 95 th percentile trigger value was considered. However this value (0.05 µg/L) is equal to the background, hence the low reliability freshwater trigger value (0.13 µg/L) was adopted.
Cadmium	The 50 th percentile (0.1 µg/L) of the background dataset was adopted as the ambient concentration. The ANZECC & ARMCANZ (2000) 99% species protection level (0.7 µg/L) was adopted as Cd is bioaccumulatory.
Copper	The 50 th percentile (1 µg/L) of the background dataset was adopted as the ambient concentration. The ANZECC & ARMCANZ (2000) 95% species protection level (1.3 µg/L) was adopted as trigger value.
Iron	The 50 th percentile (2.5 µg/L) of the background dataset was adopted as the ambient concentration. There is no toxicity trigger value available for iron in

seawater in the ANZECC & ARMCANZ (2000) guidelines. These recommend adopting the current Canadian guideline level (300 µg/L).

Mercury	The 50 th percentile (0.05 µg/L) of the background dataset was adopted as the ambient concentration. The ANZECC & ARMCANZ (2000) 99% species protection level (0.1µg/L) was adopted, as Hg is bioaccumulatory.
Manganese	The 50 th percentile (0.8 µg/L) of the background dataset was adopted as the ambient concentration. The ANZECC & ARMCANZ (2000) trigger value reported is a low reliability trigger value, hence the WHO trigger value (400 µg/L) for marine ecosystems developed in 2003 and incorporating Australian data was considered.
Selenium	The 50 th percentile (1 µg/L) of the background dataset was adopted as the ambient concentration. The ANZECC & ARMCANZ (2000) low trigger reliability value (3 µg/L) was adopted.
Tin	The 50 th percentile (2.5 µg/L) of the background dataset was adopted as the ambient concentration. The UK value for inorganic Sn (10 µg/L) was adopted as recommended in the ANZECC & ARMCANZ (2000) guidelines.
Zinc	The 50 th percentile (6 µg/L) of the background dataset was adopted as the ambient concentration. The ANZECC & ARMCANZ (2000) 95% species protection level (15 µg/L) was adopted as a trigger value.
Resin Acids	The only trigger value found in the literature (Ontario, Canada) reports 52 µg/L, which was the value adopted as a trigger value. Resin acids were not detected in the June campaign; two types of resin acids (abietic and dehydroabietic acid) were detected in the October background data. Hence, the 50 th percentile of the sum of the abietic and dehydroabietic acid dataset (0.27 µg/L) was adopted as the ambient concentration.

Table 4 Summary table

Parameter	Units	Effluent	Background	Trigger Value selected	Dilution required
pH		6.5	8.14	8.0-8.4	
DO	mgO ₂ /L	2	9.45	8.4-10.2	
Colour	mgPt/L	493	1	2	493
TDS	mg/L	2250	41,000	<i>nr</i>	<i>nr</i>
TSS	mg/L	20	7	29	1
BOD ₅	mgO ₂ /L	11	1	2	11
COD	mgO ₂ /L	466	480	1200	<i>nr</i>
AOX	mg/L	6.8	0.016	0.029	523
Chlorate	mg/L	3.7	0.0025	0.008	673
Total-N	mgN/L	2.5	0.12	0.14	125
Organic-N	mgN/L	1.5	<i>nm</i>	<i>nm</i>	
Ammonia-N	mgN/L	0.02	<i>nm</i>	0.015	
Nitrate-N	mgN/L	0.98	<i>nm</i>	<i>nm</i>	
Nitrite-N	mgN/L	0	<i>nm</i>	<i>nm</i>	
NO _x	mgN/L	0.98	0.005	0.01	196
TKN	mgN/L	1.5	0.05	0.13	19
Total-P	mgP/L	0.80	0.03	0.06	27
Inorganic-P	mgP/L	0.50	<i>nm</i>	<i>nm</i>	
Organic-P	mgP/L	0.30	<i>nm</i>	0.01	
Al	µg/L	601	5	10	120
As (III and V)	µg/L	2.8	1.6	2.3 (III) 4.5 (V)	1
B	µg/L	35	4600	5400	<i>nr</i>
Ba	µg/L	17	3	6	6
Be	µg/L	1.4	0.05	0.13	18
Cd	µg/L	0.98	0.1	0.7	2
Co	µg/L	2.8	0.1	1	3
Cr (III and VI)	µg/L	26	0.25	4.4(VI) 27.4 (III)	6.3
Cu	µg/L	19	1	1.3	63
Fe	µg/L	817	2.5	300	3
Hg	µg/L	0.25	0.05	0.1	5
Mn	µg/L	817	0.8	400	2
Mo	µg/L	1.3	11	23	<i>nr</i>
Ni	µg/L	26	0.25	70	<i>nr</i>
Pb	µg/L	2.8	0.6	4.4	<i>nr</i>
Sb	µg/L	1.3	0.25	270	<i>nr</i>
Se-Total	µg/L	7.4	1	3	4
Si	µg/L	570	<i>nm</i>	<i>nm</i>	
Sn	µg/L	13	2.5	10	2
V	µg/L	1.3	1.9	100	<i>nr</i>
Zn	µg/L	84	6	15	9
Total Extractive: pine	µg/L	500	<i>nm</i>	<i>nm</i>	
Total Extractive; eucalyptus	µg/L	500	<i>nm</i>	<i>nm</i>	
Resin Acids; pine	µg/L	250	0.27	52	5
Resin Acids; eucalyptus	µg/L	0	<i>nm</i>	<i>nm</i>	
Fatty Acids; pine	µg/L	190	<i>nm</i>	<i>nm</i>	
Fatty Acids; eucalyptus	µg/L	350	<i>nm</i>	<i>nm</i>	
Neutral Extractive; pine	µg/L	60	<i>nm</i>	<i>nm</i>	
Neutral Extractive; eucalyptus	µg/L	150	<i>nm</i>	<i>nm</i>	

Notes: *nm*: not monitored
nr: no dilution required

7. Highest Dilution Requirements

7.1 Chlorate

Toxikos (2006) has assessed the toxicity of the effluent on the ambient flora and fauna. According to their work, the principal toxicant of concern will be chlorate, due to its high concentration and potential toxicity on the local brown algae (Rosemarin *et al*, 1994). As the toxicity trigger value for chlorate is of low reliability, ecotoxicology tests were undertaken by Ecotox and interpreted by Toxikos. These studies identified 8 µg/L as an appropriate trigger value for 95% species protection. This value considers toxicity studies undertaken on European brown algae species, which are more sensitive to chlorate than local Australian species.

It is unlikely that a high chlorate background concentration should be present in the area of disposal. A thorough literature review could not identify any publications reporting the natural occurrence of chlorate in the environment. Additionally there are no anthropogenic sources of chlorate in the vicinity of the outfall or in the industries present in the area.

The analysis of chlorate in seawater is not as sensitive as in drinking water due to the interferences between chloride and chlorate. The detection limits reported were above the trigger value selected by Toxikos. However, based on discussions with DTAE, a precautionary approach was adopted and a background value was determined by selecting half the lowest toxicity trigger value found in the literature (Rosemarin *et al*, 1994) (2.5 µg/L). Under these assumptions, an effluent dilution of 673 would be required to achieve the trigger value.

Chlorate is a strong oxidant, which is known to be unstable in the presence of organic matters. For the purpose of hydrodynamic modelling, however, a conservative approach was taken and chlorate was assumed to be stable over time. This approach was based on the lack of data available for the decomposition rate of chlorate in seawater.

7.2 Colour

According to the Tasmanian State Policy on Water Quality Management (1997), the emission of the effluent should not cause *“any objectionable discolouration at the surface of the mixing zone, which could adversely affect the use of the surrounding environment”*.

Colour is not a toxicant and consequently there is no environmental trigger value. At this stage of the study, the favoured option was to use the monitoring data to derive a trigger value. The 50th percentile (1 mgPt/L) of the monitoring data was adopted as the background data. The 80th percentile (2 mgPt/L) of local ambient data was adopted as the trigger value.

Under these assumptions, an effluent dilution of 493 would be required.

Jaakko Pöyry has advised that, at the levels of colour present in the effluent, colour is expected to decrease linearly with dilution (E-mail dated 30th November 2006 from Hannu Jappinen to Richard Fawkes (Gunns)).

7.3 Other constituents of concern

7.3.1 Nutrients

Unless present at high concentration, nutrients are not considered as a toxicant. Consequently the trigger values recommended for ecosystem protection were selected where possible. For phosphorus, the 80th percentile value of the ambient data set had to be considered as the trigger value, as the 50th percentile representing the background is higher than what is reported in the ANZECC & ARMCANZ guidelines (2000). For both total nitrogen and NO_x, the 50th percentile of the ambient data set was above the ecosystem protection trigger values selected; hence the 80th percentile was selected as the trigger value. Under these conditions, dilutions of 125 and 196 are required for TN and NO_x respectively.

The ANZECC & ARMCANZ guidelines (2000) stipulate, “*the use of mixing zones is not appropriate for managing the discharge of nutrients*” hence nutrients should not be used for the hydrodynamic modelling of the mixing zones. However, the possible impact of nutrient on the ecosystem has been considered and is discussed in the Section 8.

7.3.2 AOX

There are no current trigger values for Adsorbable Organic Halides (AOX), hence, the 50th percentile (0.016 mg/L) of the background dataset was adopted as the ambient concentration and the 80th percentile (0.029 mg/L) of local ambient data was adopted as the trigger value. Under these assumptions, a dilution of 523 will be required.

In the pulp and paper industry, AOX or Adsorbable Organic Halides are essentially composed of adsorbable chlorinated organics. AOX's are primarily composed of non-toxic materials (99%) with a small amount of fat-soluble toxic chlorinated compounds (1%). These toxic compounds include dioxins, furans and polychlorinated phenols. In effluent discharge, AOX levels were considered to be a good indicator of mill performance, however they are not currently considered to be an appropriate indicator of environmental impact. In fact, several studies have shown that AOX occur naturally in the environment and that many of these are naturally biodegradable (RPDC, 2004). Additionally it has been shown that:

“...chlorinated compounds formed during ECF bleaching are biologically degradable in the environment. Pulp mill AOX will ultimately be mineralized through photochemical and biological processes and during mineralisation the chlorinated organic material will be released as chloride and carbon dioxide” (RPDC, 2004 referring to Archibald, 1997)

Hence, and in agreement with the ANZECC & ARMCANZ (2000) guidelines, AOX should not be considered as an appropriate parameter for modeling the mixing zone.

8. Impact of Nutrient Discharges

8.1 Eutrophication

Eutrophication is caused by the enrichment of an ecosystem with chemical nutrients, typically compounds containing nitrogen or phosphorus. Eutrophication is considered a form of pollution, despite the fact that it is a natural process, because it promotes excessive plant or microbial growth and decay, favors certain weedy species over others, and causes severe water quality problems. In aquatic environments, enhanced growth of choking aquatic vegetation or phytoplankton (algal bloom) disrupts normal functioning of the ecosystem, causing a variety of problems. The mixing of relatively high nutrient freshwater with low nutrient marine water has been reported as being a major cause of eutrophication.

Chemical forms of nitrogen are most often of concern with regard to eutrophication because plants have high nitrogen requirements so that additions of nitrogen compounds stimulate plant growth, which is also referred to as primary production. Many ecological effects can arise from stimulating primary production, including:

- » Increased biomass of phytoplankton;
- » Toxic or inedible phytoplankton species;
- » Increases in blooms of gelatinous zooplankton;
- » Increased biomass of benthic and epiphytic algae;
- » Changes in macrophyte species composition and biomass;
- » Decreases in water transparency;
- » Taste, odour, and water treatment problems;
- » Dissolved oxygen depletion;
- » Increased incidences of fish kills;
- » Loss of desirable fish species;
- » Reductions in harvestable fish and shellfish; and
- » Decreases in perceived aesthetic value of the water body

Table 4 provides a summary of the effluent composition, background levels, trigger values and the associated dilution factors that will be required to achieve the background trigger values. Although some effluent parameters are below the trigger values, many parameters require a dilution for compliance.

In regards to nutrients the dilution requirements are as follow:

- » Total nitrogen 125
- » NO_x-N 196
- » Total phosphorus 27

It is our understanding that the proposed diffuser is designed to achieve a 1 in 100 dilution at the water surface above the diffuser. Therefore, only two nutrient parameters will not be diluted sufficiently to comply with the trigger values within the 1 in 100 dilution zone, namely total nitrogen and nitrogen oxides. Total nitrogen will include the most common forms of nitrogen available for plant growth: nitrate, nitrite, total ammonia and organic forms such as urea. Oxides of nitrogen (NO_x) include nitrite and nitrate and are part of total nitrogen. The potential impact relates to excessive plant growth rate.

8.2 Potential impacts at the outfall

Several dilution and concentration maps were generated to understand the patterns of the effluent composition around the discharge point. Three-dimensional (3D) simulations were conducted over 5 layers. The effluent density was assumed to be 1 t/m³ with a constant discharge rate of 0.738 m³/s. The simulation was conducted for conditions occurring between the 10th April 2005 and 10th May 2005.

All dilution and concentrations maps are provided in Chapter 4 of the main hydrodynamic modelling report (GHD, 2007).

This section specifically considers dilution patterns and concentration maps for total nitrogen and total phosphorus at the outfall, as the risk of eutrophication is linked to these two chemical species. The design of the diffuser implies that the surface layer above the diffuser will encompass a larger area than in deeper waters. Hence, the concentration maps set for the surface layer were used to assess the risks associated with nutrient enrichment, as the greatest potential impacts will be found at the surface layer.

Total nitrogen: Surface layer concentration maps for total nitrogen at the discharge point indicate that the concentration of total nitrogen will be below 0.128 mgN/L within 100 m of the diffuser. This value is lower than the trigger value selected (0.14 mgN/L), indicating that the ecosystem outside of this 100 m radius area will not be subject to direct nutrient impact.

Oxides of nitrogen: NO_x are part of total nitrogen, hence it is expected that the concentration of NO_x nitrogen will be lower than the trigger value within 100 m of the diffuser.

Total phosphorus: Surface layer concentration maps for total phosphorus at the discharge point indicate that the concentration of total nitrogen will be lower than 0.033 mgP/L within 50 m of the diffuser. This value is lower than the trigger value selected (0.06 mgP/L), indicating that the ecosystem outside of this 50 m radius will not be subject to significant impact.

Both total nitrogen and total phosphorus concentrations will be diluted below the trigger values for ecosystem protection (ANZECC & ARMCANZ, 2000) within 100 m of the outfall. Under these conditions, it is highly unlikely that eutrophication would occur outside of this region.]

9. References

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Appendix A

State Policy on Water Quality Management 1997 (extract)

Mixing Zones

20. Mixing zones

20.1

If, after waste reduction in accordance with clause 16.2(b) it is not reasonable or practical to reduce the levels of pollutants in an emission to the levels, which would be required to achieve the water quality objectives for the receiving waters at the point of discharge, the Board may designate a mixing zone around the point of discharge.

20.2

Where a mixing zone has been designated, emission limits must be set at levels which will not prejudice the achievement of water quality objectives at or beyond the edge of the mixing zone.

20.3

Mixing zones must be set in accordance with the following principles:

- (a) The location and size of the mixing zone must be clearly defined in a permit or other legally enforceable instrument of approval.
- (b) The mixing zone must be as small as practical in accordance with the requirements of clauses 16 and 17, and either alone or in combination with other mixing zones, should not occupy a significant proportion of the receiving waters designated for any given protected environmental value.
- (c) The presence of the mixing zone, either alone or in combination with other mixing zones, should not detract from the values and uses of the surrounding waters.
- (d) Mixing zones should not generally be designated in waters which:
 - (i) receive significant and regular use for primary contact recreation; or
 - (ii) are recognised as of significant value as spawning or nursery areas; or
 - (iii) are close to areas used for aquaculture; or
 - (iv) are close to potable water supply intakes; or
 - (v) are of outstanding ecological or scientific importance; or
 - (vi) for which the protected environmental values include protection of pristine aquatic ecosystems.
- (e) Mixing zones must not create a significant barrier to the migration of fish or other aquatic organisms.
- (f) Mixing zones designated in rivers, streams and estuaries should be set having regard to the effects of the mixing zone under low flow conditions (7 day minimum flow for a 10 year annual exceedance probability).

20.4

Emission limits shall be set such that, within the mixing zone, the emission does not cause:

- (a) objectionable odours which would adversely affect the use of the surrounding environment; or
- (b) objectionable discolouration at the surface of the mixing zone, which could adversely affect the use of the surrounding environment; or
- (c) visible floating foam, oils, grease, scum, litter or other objectionable matter; or
- (d) mortality of fish or other aquatic vertebrates; or
- (e) fish or other aquatic organisms used for human consumption to become unacceptable for such use as determined by Tasmanian health standards.

20.5

Where a mixing zone has been designated by the Board in accordance with clause 20.1, the operator shall be responsible for monitoring their effluent(s) for pollutants, and the receiving waters, including baseline monitoring. These responsibilities shall be reflected in the conditions attached to the permit.

Appendix B
Effluent Quality Data

Parameter	Units	Average	Range	Plantation Eucalyptus	Native Eucalyptus	Pinus Radiata	Final Effluent
Final Flow	kt/d		50 - 94.5				63.77
pH		6.5-7.2	6.0 - 8.5				6.5
DO	mgO ₂ /L		0.5 - 5.0				2
Colour	mg/L	493	400 - 650				493
TDS	mg/L	2250	1800 -2600				2250
TSS	mg/L	20	5 - 30				20
BOD ₅	mgO ₂ /L	11	5 - 30				11
COD	mgO ₂ /L	466	220 - 650				466
AOX	mg/L	6.8	4 - 9				6.8
Chlorate	mg/L	1.9	1.0 - 3.7				3.7
Total-N	mgN/L	2.5	1 - 5				2.5
Organic-N	mgN/L	1.5	0.5-3				1.5
Ammonia-N	mgN/L	0.02	0.01 - 0.05				0.02
Nitrate-N	mgN/L	0.98	0.49-1.93				0.98
Nitrite-N	mgN/L	0	0 - 0.02				0
Total-P	mgP/L	0.8	0.5-1.8	0.84	0.51	1.14	0.8
Inorganic-P	mgP/L	0.5	0.3 - 1.0				0.50
Organic-P	mgP/L	0.3	0.2 - 0.8				0.30
Al	µg/L			250	236	601	601
As (III and V)	µg/L			1.2	2.5	2.8	2.8
B	µg/L			29	35	21	35
Ba	µg/L			17	15	5	17
Be	µg/L			1.3	1.2	1.4	1.4
Cd	µg/L			0.82	0.74	0.98	0.98
Co	µg/L			1.1	1.1	2.8	2.8
Cr (III and VI)	µg/L			26	12	19	26
Cu	µg/L			10	11	19	19
Fe	µg/L			441	388	817	817
Hg	µg/L			0.23	0.21	0.25	0.25
Mn	µg/L			397	208	817	817
Mo	µg/L			1.1	1.1	1.3	1.3
Ni	µg/L			22	19	26	26
Pb	µg/L			1.1	2.5	2.8	2.8
Sb	µg/L			1.1	1.1	1.3	1.3
Se-Total	µg/L			7.0	6.6	7.4	7.4
Si	µg/L			235	277	570	570
Sn	µg/L			11	11	13	13
V	µg/L			1.1	1.1	1.3	1.3
Zn	µg/L			23	30	84	84
Total Extractive; pine	µg/L	500					500
Total Extractive; eucalyptus	µg/L	500					500
Resin Acids; pine	µg/L	250					250
Resin Acids; eucalyptus	µg/L	0					0
Fatty Acids; pine	µg/L	190					190
Fatty Acids; eucalyptus	µg/L	350					350
Neutral Extractive; pine	µg/L	60					60
Neutral Extractive; eucalyptus	µg/L	150					150

Notes: * NO_x was defined as the sum of nitrate and nitrite in the effluent
** TKN was defined as the difference between TN and NO_x

Appendix C

Background Water Quality Monitoring Program

Selected Analytes

GHD Pty Ltd ABN 39 008 488 373

201 Charlotte Street Brisbane Qld 4000

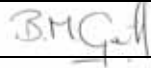

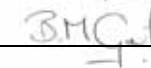
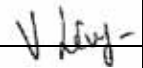
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Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
A	V Lévy	B Goebel		B Goebel		6/12/06
B	V Lévy	B Goebel		R Fryar	Per 	19/01/07

Attachment 3

Draft summary table provided to DTAE –22/11/2006

Date: 22-Nov-06

Rev
22/11/06 VL

Gunns Ltd. Bell Bay Pulp Mill
Set Data for Modelling Purposes: summary table

Parameter	Units	Final Effluent Quality	Background	Trigger Value selected	Notes
Final Flow	t/d	63770			
pH		6.5	8.14	8.0-8.4	(b1)
DO	mgO ₂ /L	2	9.45	-	
TSS	mg/L	20	7	-	
BOD5	mg/L	11	1	-	
COD	mg/L	466	476	-	
AOX	mg/L	6.8	16	-	
TDS	mg/L	2253	41000	-	
Colour	mg/L	493	1	15	(b2)
Chlorate	mg/L	3.7	0 to 0.0025	0.006	(b3)
Total-N	mgN/L	2.5	0.12	0.14	(b4)
Organic-N	mgN/l	1.5	-	-	
Ammonia-N	mgN/L	0.02	-	0.708	(b5)
Nitrate-N	mgN/L	0.98	-	0.158	(b6)
Nitrite-N	mgN/L	0	-	-	
NOx	mgN/L	0.98	0.005	0.01	(b7)
TKN	mgN/L		0.05	-	
Total-P	mgP/L	0.80	0.03	0.06	(b7)
Inorganic-P	mgP/L	0.50	-	-	
Organic-P	mgP/L	0.30	-	0.01	(b7)
Al	µg/L	601	5	20	(b8)
As (3 and 5)	µg/L	2.8	1.6	4.5	(b9)
B	µg/L	35	4600	5100	(b10)
Ba	µg/L	17	3	6	(b8)
Be	µg/L	1.4	0.05	0.13	(b11)
Cd	µg/L	0.98	0.1	0.7	(b12)
Co	µg/L	2.8	0.1	1	(b13)
Cr	µg/L	26	0.25	4.4(VI) 27.4 (III)	(b13)
Cu	µg/L	19	1	1.3	(b13)
Fe	µg/L	817	2.5	300	(b14)
Hg	µg/L	0.25	0.05	0.1	(b15)
Mn	µg/L	817	0.8	400	(b16)
Mo	µg/L	1.3	11	23	(b9)
Ni	µg/L	26	0.25	70	(b13)
Pb	µg/L	2.8	0.6	4.4	(b13)
Sb	µg/L	1.3	0.25	270	(b9)
Se-Total	µg/L	7.4	1	3	(b9)
Si	µg/L	570			
Sn	µg/L	13	2.5	10	(b17)
V	µg/L	1.3	1.9	100	(b13)
Zn	µg/L	84	6	15	(b13)
Tot Extr., pine	µg/L	500			
Tot Extr., euca	µg/L	500			
Resin Acids, pine	µg/L	250	26	52	(b18)
Resin Acids, euca	µg/L	0			
Fatty Acids, pine	µg/L	190			
Fatty Acids, euca	µg/L	350			
Neut. Extr., pine	µg/L	60			
Neut. Extr., euca	µg/L	15			

Explanatory Notes

Column D: Effluent characteristics.

All effluent data as provided by Jaakko Poyryr. The values retained for heavy metals were the highest values recorded for each type of wood. A range of values was provided for some analytes including chlorates. In all cases, the average values were retained except for chlorates for which the highest value was retained due to its acute toxicity.

Column E: Background.

The background values were calculated as the 50th percentile of the data collected during the monitoring campaigns for all analytes except barium, chlorate and resin acids. For barium, the background was reported as half the trigger value. For chlorate, the background data selected was half the British-columbian value. For resin acids, the background selected was half the Ontario value.

Column F: Trigger Values selected.

Whenever possible, the trigger values recommended by the ANZECC/ARMCANZ guidelines were retained. When no value existed or the background was higher than the value listed, the 80th percentile was retained for nutrients and the 95th percentile for heavy metals. The trigger value for chlorate was determined through ecotoxicity testings on brown algae, a species reputed as sensitive to chlorate through ecotoxicology tests. For Manganese, a trigger value published by WHO was retained, it contains values from an Australian study.

(b1) ANZECC/ARMCANZ Ecosystem guideline value for seawater

(b2) Australian Drinking Water Quality Guideline

(b3) The 95% protection level (central estimate) determined from a species sensitivity distribution that includes three species local to Tasmanian coastal waters.

(b4) 80 percentile of the background data as the 50 percentile of the background was equal to the trigger value hence not leaving any gap for modelling.

(b5) ANZECC/ARMCANZ toxicity value for pH 8

(b6) ANZECC/ARMCANZ toxicity value for 95% species protection

(b7) 50th percentile is higher than the literature trigger value, hence 80th percentile of the background

(b8) ANZECC/ARMCANZ toxicity value for 95% species protection

(b9) Toxicity Trigger Value for Toxicants

(b10) Toxicity Trigger Value for B in seawater covers a broad range, hence the ANZECC/ARMCANZ guidelines recommend to use the background for seawater

(b11) ANZECC/ARMCANZ no marine data, no marine values from WHO. Low Reliability Trigger Value for Freshwater (0.13)

(b12) ANZECC/ARMCANZ, Cd is bioaccumulable hence, 99% level of protection is considered (95%=5.5)

(b13) ANZECC/ARMCANZ slightly to moderately disturbed environments

(b14) Canadian guidelines for freshwater

(b15) ANZECC/ARMCANZ Toxicity Trigger value Inorganic Hg is bioaccumulable hence 99% is kept (99%=0.1) (95%=0.4)

(b16) ANZECC/ARMCANZ Low Reliability Trigger Value 80, WHO-Mn 99% =400 is kept considers our study !

(b17) UK value for inorganic Sn as listed in ANZECC/ARMCANZ

(b18) Interim guideline value from Ontario

Attachment 4

**DTAE's response to GHD's draft modelling parameters –
8/12/2006**

Gunns Limited – Bell Bay Pulp Mill Project

Response to GHD proposed modelling parameters and triggers received on 22 November 2006

The following response is based on a review of proposed modelling parameters and triggers sent to Environment Division by GHD on 22 November 2006. As with other aspects of the IIS, the Environment Division does not have a formal role in relation to endorsing or otherwise the marine impact assessment contained in the IIS, and the RPDC should be consulted if definitive advice on the acceptability or otherwise of the proposed modelling parameters and triggers is sought.

pH and dissolved oxygen

The recommended approach for defining background for pH and DO is to use the 20th and 80th % ile levels of the reference site(s) not a single value as proposed. The DO default range for marine waters is 90-110 % saturation, however trigger values should be derived from (optimally 24 months of) reference site data. The levels derived from the monitoring at Hebe Reef were 97-101 % saturated. However, the Hebe Reef site would not represent an optimal reference site for the pulp mill project.

It is recommended to further explain how dissolved oxygen is going to be modelled as a function of BOD, COD, background DO and other factors.

AOX

While no default trigger values are available for AOX for the protection of aquatic ecosystems, the inland water European value for moderate burden of 25 µg/L would be considered a reasonable value to apply until robust background values are available. The proposed 16000 µg/L (16mg/L) for background appears high for ambient levels, when considering results submitted to the RPDC as part of the IIS ranged from 14-26 µg/L.

The recommended interim trigger value for AOX is 25 µg/L, but this would need to be confirmed by site specific data.

Colour

The use of a colour target derived from drinking water guidelines is potentially problematic. The issues associated with colour in drinking water are different to those associated with the marine environment off Five Mile Bluff. It is noted that the site data shows colour as being measured as less than or equal to 1mg/L.

No default trigger values for the protection of aquatic ecosystem are available for colour. The euphotic depth could be used which is a measure of the penetration of diffuse light where the photosynthetic available radiation is reduced to 1% of the level at the water surface. The low risk trigger value of the light penetration could be determined by the 80th % ile value of the

- Internal working draft -

reference site. Also a measure of success for protecting marine waters is that the natural euphotic depth should not be permitted to change by more than 10% for the marine waters.

It is recommended to refer to clause D.3.18 of the *Environmental Emission Limit Guidelines for any new Bleached Eucalypt Kraft Pulp Mill in Tasmania (2004)* which specifies certain optical quality properties which should be protected in the receiving environment. If colour is to be modelled in mg/L or ppm then it is recommended that this be related back to compliance with the properties specified in the guidelines.

Colour can also affect the spectral distribution of underwater light, which may affect plant species composition and associated species dependent on these plants. Certain fish have spectrally sensitive eyes thus effluents with colour pollution may affect species behaviour including feeding. Biological monitoring of benthic communities will assist in assessing the effect of colour.

Nutrients

The values provided in the table mainly apply to eutrophication effects which may be beyond the defined mixing zone. For modelling of the mixing zone the toxicant values for ammonia (710 µg/L for pH 8.14) and nitrate (700 µg/L) are recommended. Note the following excerpt from Volume 2 of the ANZECC (2000) guidelines (Section 8.3.7 page 169):

“As nitrates are a known stimulant for algal growth at low concentrations, it was considered acceptable to derive trigger values on an adequate number of data without algae. Separate marine figures were derived because of the apparent differences in sensitivity on the limited marine data.

A freshwater moderate reliability trigger value for nitrate toxicity as NO₃ (nitrate) of 700 µg/L was calculated using the statistical distribution method 95% protection and the default ACR.

Although a marine low reliability figure of 13 000 µg/L (13 mg/L) could be calculated using an AF of 200 (limited data but a lesser factor due to essentiality), it is preferable to adopt the freshwater figure of 700 µg/L for nitrate toxicity as NO₃ (nitrate) as a marine low reliability trigger value.”

Metals

Several metals in the estimated effluent composition seem unusually elevated. In particular aluminium, iron and manganese seem high. In addition, considering the Interim Working Levels (IWL) recommended by ANZECC (see notes below) and therefore the necessary dilutions, these metals appear to have potential to impact on the marine environment.

It is recommended that the proponent review the process inputs to the effluent treatment plant to determine if there are inputs with elevated levels of metals, such as raw water treatment plant sludge, which could be managed as a solid waste rather than be discharged with the total effluent stream via the marine outfall.

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Several metals have different forms such as Arsenic, Selenium, Mercury and Tin. It is recommended to consider the recommended triggers for each form/species of these metals. Refer to the ANZECC (2000) guidelines for which metal species need to be considered.

The following commentary relates only to those metals and parameters where the Environment Division has queried the recommended trigger (or target) values, their reliability status or their derivation.

The following commentary relates only to those metals and parameters where the Environment Division has queried the recommended trigger (or target) values, their status or derivation.

Interim Working Levels

Where a trigger has been identified as being derived from an Interim Indicative Working Level (IWL) these values are considered low reliability guideline trigger values. The recommended approach is, where possible, to derive triggers from site specific data, consistent with the process outlined in ANZECC (2000). It is equally important to always conduct literature reviews to maintain contemporary knowledge on toxicants to enable review and possible subsequent changes to the IWLs.

In this regard while it is considered acceptable for the purposes of the next round of modelling to use the IWLs as interim targets or triggers, the recommended value may change based on the collection and analysis of further water samples or more thorough literature reviews. Note that higher reliability triggers thus derived may be significantly different from the identified IWLs and may affect the scope of the proposed mixing zone. Refer to the ANZECC (2000) guidelines (and in particular Page 31 of section 8.3.4.4) where the use of low reliability guideline trigger values are discussed.

Aluminium (Al)

The recommended low reliability trigger value for aluminium in marine waters is an interim indicative working level (IWL) of 0.5 µg/L, which is inconsistent with the proposed 20 µg/L in the table. Note the following excerpt from Volume 2 of the ANZECC (2000) guidelines (Section 8.3.7 page 10).

“There was an insufficient spread of data to calculate a reliable guideline trigger value for aluminium in seawater.

There were limited marine data and procedures for calculating an Environmental Concern Level (ECL; Section 8.3.4.5) were used to calculate a low reliability marine trigger value of 0.5 µg/L derived for aluminium using an AF of 200. This figure should only be used as an indicative interim working level but could be revisited as more data become available. The factor of 200 was used because the ECL factor of 1000 was considered excessive for such a commonly found element.”

Note that the provision of sufficient site specific data would allow for the development of a site specific trigger using the process recommended in ANZECC (2000). Previous investigations have shown background Al < 5 µg/L at other Bass Strait locations.

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Antimony (Sb)

The value selected for modelling (270 µg/L) is consistent with the ANZECC (2000).

Note the following excerpt from the ANZECC (2000) guidelines (Volume 2, Section 8.3.7 page 105):

“In the absence of sufficient marine data, a marine low reliability antimony (III) trigger value of 270 µg/L was derived using an AF of 1000, for use only as an indicative interim working level. Caution is advised, however, if the freshwater figure is exceeded because of the more limited marine data.”

The value of 270 µg/L for Sb is accepted at this stage, but noting that this is considered to be an IWL.

Arsenic (As)

Arsenic can bioaccumulate to some extent in marine organisms but secondary poisoning is unlikely. The value of 4.5 µg/L in the table of values for modelling relates only to As(V).

Refer to ANZECC (2000) guidelines, Volume 2, Section 8.3.7 page 107 and 108:

“As (III)

An Environmental Concern Level (ECL) of 2.3 µg/L was derived for As (III) in marine waters, using an AF of 100. This figure could be adopted as a marine low reliability trigger value, to be used only as an indicative interim working level. Further review at a later revision may produce a more reliable trigger value.”

As (V)

“There were insufficient data to derive a reliable marine trigger value. A low reliability marine guideline trigger value of 4.5 µg/L for As (V) was derived using an AF of 200 on the lowest NOEC (200 was used because the limited data were chronic). This should be used only as an indicative interim working level.”

It is recommended to consider triggers for both forms of the metal. Based on ANZECC, these would be 2.3 µg/L for As(III) and 4.5 µg/L for As (V) noting that these are both IWLs.

Barium (Ba)

There is no trigger value for Barium in the ANZECC(2000) guidelines however the Australian Drinking Water Guidelines recommend a value of 0.7 mg/L. The origin of 6mg/L in the table for modelling purposes is unclear.

It is recommended to derive a trigger value for Barium from site specific data.

Chromium (Cr)

It is recommended to provide predicted values for Cr (III) and Cr (VI) in the effluent.

Iron (Fe)

The proposed trigger value of 300 µg/L is considered an IWL only.

- Internal working draft -

Mercury (Hg)

The recommended trigger for inorganic mercury is 0.1 µg/L as identified as the 99%ile figure reported in ANZECC (2000). However, methyl mercury, which has a higher reported BCF should also be carefully considered.

Inorganic forms of mercury, which are of relatively low toxicity and availability to bioconcentrate, may be converted by bacteria *in situ* into organomercury complexes (particularly methylmercury), which are more toxic and tend to bioaccumulate. It is uncertain whether the treatment of the pulp mill wastewater through the effluent treatment plant will result in significant conversion of inorganic mercury to organomercury complexes. It is recommended to provide an estimate of the potential methyl mercury content of the effluent and assess the potential for uptake and bioaccumulation of methyl mercury. As part of this exercise it is recommended to consider the conversion of inorganic mercury to the methyl form in both the effluent treatment plant and in the marine environment. Refer to ANZECC (2000), Volume 2, Section 8.3.7 page 132:

“A marine high reliability trigger value of 0.4 µg/L was calculated for inorganic mercury using the statistical distribution method with 95% protection. This has not specifically considered bioaccumulation. The 99% protection level is 0.1 µg/L and is recommended for slightly-moderately disturbed systems if there are no data to allow for adjustment for bioaccumulation at the specific site. The 99% figure (0.1 µg/L) is the same as that recommended by Canada (CCREM 1987) to protect human consumers of fish.

There were insufficient data to derive a trigger value for methyl mercury.”

A brief review (neither thorough nor comprehensive) of reported literature for methyl mercury revealed the following.

Methylmercury appears to have the highest chronic toxicity of the tested mercury compounds, with chronic toxicity occurring at less than 0.04 ug/L for *D. magna* and 0.52 ug/L for brook trout (McKim et al. 1976, Biesinger et al. 1982). The most sensitive plant species generally appear to be less sensitive than sensitive animal species to both mercury (II) and methylmercury (CCREM 1987). The freshwater alga *Scenedesmus dimorphus* was strongly inhibited by 10 ug/L mercury (as methylmercury), with similar inhibition requiring 50 ug/L inorganic mercury (as HgCl₂). In mixed phytoplankton populations, concentrations of methylmercury as low as 0.1ug/L inhibited primary productivity by 30%.

Bioconcentration factors of 5000 have been reported for mercury (II); factors for methylmercury ranged from 4000 to 85 000 (USEPA 1986). Bioconcentration factors 10 000 to 40 000 were found for mercuric chloride and methylmercury with an oyster (USEPA 1986).

The 99% protection level for inorganic mercury is 0.1ug/L and is recommended for slightly-moderately disturbed systems if there are no data to allow for adjustment for bioaccumulation at the specific site (Section 8.3.5.7). The 99% figure (0.1 ug/L) is the same as that recommended by Canada (CCREM 1987) to protect human consumers of fish.

Considering the above information and the recommended approach for chemicals not specified in the guidelines, an interim working level for methyl mercury could be derived by using an assessment factor which is dependent on the size of the data set. For the limited data set for

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methyl mercury, and the fact that it is chronic data, an AF of 200 is recommended. In the absence of other data a proposed interim working level could potentially be 0.0002 ug/L (i.e., 0.04/200), however a thorough literature review is recommended.

Manganese (Mn)

The use of the WHO Drinking water guidelines of 400 µg/L in preference to the ANZECC (2000) IWL of 80 µg/L is not considered justified considering the background level (albeit from a small data set) is 0.8 µg/L.

Refer to ANZECC (2000), Volume 2, Section 8.3.7 page 128:

“The marine dataset was more limited and there were some anomalies...The outlying crab data and the photosynthesis EC50 for the alga were not used. A marine low reliability trigger value at 80 µg/L was derived for manganese from the mollusc figure using an AF of 200.

The recommended trigger value for Manganese is therefore 80 µg/L noting this is an IWL.

Molybdenum (Mo)

The proposed trigger of 23 µg/L for Molybdenum is accepted, however the marine data for Molybdenum is limited therefore this should be considered an IWL.

Refer to ANZECC (2000), Volume 2, Section 8.3.7 page 133:

“Marine data were only available on one species of diatom and a species of dinoflagellate. EC50 (growth) figures ranged from 4500 to 18 000 µg/L. There were insufficient data to derive a marine trigger value for Molybdenum. An ECL of 23 µg/L is derived from an AF of 200 (as Mo is an essential element) and this was adopted as a low reliability trigger value. Both of these figures should only be used as indicative interim working levels.”

Nickel (Ni)

The proposed level in the table for modelling is the marine high reliability guideline value of 70 µg/L, however, to give sufficient protection from acute toxicity the 99% protection level of 7 µg/L should be considered for slightly to moderately disturbed marine systems.

Refer to ANZECC (2000), Volume 2, Section 8.3.7 page 136:

“A marine high reliability guideline value of 70 µg/L was derived for nickel using the statistical distribution method at 95% protection. The 99% protection level was 7 µg/L and is recommended for slightly-moderately disturbed marine systems. The 95% protection level does not give sufficient margin of safety from acute toxicity for a juvenile mysid (152 µg/L, Gentile et al. 1982). Low acute toxicity figures, unconfirmed, were also reported for a mollusc (60 µg/L), a diatom (50–100 µg/L) and two dinoflagellates (100 µg/L). Hence, the 99% protection level (7 µg/L) is recommended for slightly-moderately disturbed marine systems.”

As such, a trigger value of 7 µg/L is recommended for Nickel.

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Selenium (Se)

As there is a potential biological hazard from bioaccumulation of selenium it is recommended that the speciation levels be included in the review. An IWL of 3 µg/L is recommended for both Se (total) and Se (IV).

Refer to ANZECC (2000) guidelines, Volume 2, Section 8.3.7 page 140.

Se (total)

“A marine low reliability trigger value of 3 µg/L was calculated for Se (total) using an AF of 100. This has not specifically considered bioaccumulation.”

Se (IV)

“An ECL of 6 µg/L for Se (IV) could be derived from the USEPA data. However, it would be preferable to use the Se (total) trigger value (3 µg/L) as an indicative interim working level until more marine data can be obtained for Se (IV).

No figure could be derived for Se (VI) in marine systems.”

Tin (Sn)

The proposed trigger for inorganic tin of 10 µg/L is accepted, however this is considered an IWL. It is important to also consider the potential presence of tributyl tin and to consult the ANZECC (2000) guidelines for recommended triggers for this species.

Refer to ANZECC (2000) guidelines, Volume 2, Section 8.3.7 page 144.

“The value of 10 µg/L, recommend in the UK (Mance et al. 1988b) from 0.25 of the saturated concentration of tin in seawater (35 µg/L) may better serve as a low reliability trigger value for inorganic tin in marine waters. These figures do not apply if the tin is present as organotins. They should only be used as indicative interim working levels.”

Organic Chemicals

The environmental parameter screening process cannot be considered comprehensive without a rigorous review of known organic chemicals of concern which may occur in the pulp mill effluent and be discharged to the marine environment. The approach outlined in the ANZECC (2000) guidelines is recommended.

It is noted that such an exercise was carried out for the Human Health Risk assessment (undertaken by Toxikos) and a similar exercise is also recommended for the environmental parameter screening process. Note that guidelines and recommended trigger values exist for many organic chemicals, some of which are known to occur within pulp mill effluent. Several organic chemicals have also been identified in the environmental emission limit guidelines (2004) and these should be considered in the development of a suite of triggers for organic chemicals. It is also recommended to consider other relevant guidelines including those pertaining to recreational use, taste tainting and aquaculture.

Attachment 5

Response from GHD to DTAE's comments

Response from GHD to DTAE's comments

The following is a response to DTAE's comments on the draft modelling parameters summary table (further referred to as draft summary table). The draft summary table was provided on 22nd November 2006, DTAE's comments were received on 8th December 2006. During this time, I had undertaken substantial work and the draft summary table provided to DTAE had been superseded by what is now the Water Quality Assessment report.

pH and dissolved oxygen (DO)

The draft summary table did propose a range for pH (marine ecosystem protection for SE Australia, ANZECC & ARMCANZ) but at that stage DO had not been considered. For DO, the 20th and 80th percentile range of the local ambient data has been included in the Water Quality Assessment report.

AOX

The background value listed in the draft summary table was erroneous and should have read 0.016 mg/L. This has been changed in the Water Quality Assessment report. The monitoring data was used to derive a local trigger value of 0.029 mg/L as listed in the Water Quality Assessment report.

Colour

It was recognised very early in the study that the ADWQ trigger value was not appropriate; hence the derived local trigger value of 2 mgPt/L was adopted.

Nutrients

The process for obtaining the values in the draft summary table was similar to that stated by DTAE, which recommends using toxicant values for ammonia and nitrate. However, it was subsequently decided to adopt the trigger values for marine ecosystem protection, as these values were more stringent and more representative of the risk of eutrophication.

Heavy Metals

Most trigger values for heavy metals originate from the ANZECC & ARMCANZ Guidelines 2000. Section 8.3.7, Volume 2 of the Guidelines was extensively referred to as it discusses the reliability of the values adopted by the guidelines. This approach accords with the recommendation made by DTAE in their response.

Speciation of heavy metals

Heavy metals can be present in the environment under different degree of oxidation or as different ionic species, and this will affect their toxicity. Some of these different forms have been taken into account by the ANZECC & ARMCANZ Guidelines 2000 and different trigger values are

recommended for the same analyte. This is the case for arsenic, chromium, selenium, mercury and tin.

DTAE recommends that speciation of these elements in the effluent should be investigated. To consider the speciation of heavy metals in the effluent would require an understanding of the speciation of heavy metals in wood and the chemical changes likely to occur through the process plant and the wastewater treatment plant. Another approach would be to utilise a geochemical model to identify the different chemical forms, however I am not aware of any models containing information specific to pulp and paper mill processes. The model's output data is only representative of the input data and it should be reminded that effluent the quality data provided by Jakko Pöyry is based on calculations and their experience of the process. Hence, I believe that, at this stage of the study, it is excessive to consider the different forms of the chemical species.

To overcome not having an effluent water quality detailing the different forms under which heavy metals would be present, I have considered that:

- » for arsenic and chromium, the metal would be present in its highest oxidised form, which is the most toxic form.
- » for selenium, the lowest trigger value quoted by the ANZECC & ARMCANZ guidelines should be adopted. It should be highlighted that the low reliability trigger value for total metal is lower than the one recommended for Selenium (IV) metal which is an obvious inconsistency.
- » for tin, the trigger value for inorganic tin should be adopted as it is unlikely that tin will be present as tributyl tin in the effluent.
- » for mercury, the value for inorganic mercury should be adopted. I am currently not aware of methyl mercury originating from wooden compounds or pulp mill wastewater processing.

Manganese

The comment by DTAE on “The use of the WHO drinking water guidelines of 400 µg/L in preference to the ANZECC (2000) IWL” is erroneous.

The correct document used is entitled “Manganese and its compounds: environmental aspect”. It includes a study on the guideline values for manganese for the protection of aquatic species (Appendix 4). It is quoted in this document that:

“It should be noted that further Australian studies were provided after the cut-off date. Adding these data — a NOEC for Nitzschia closterium (algal) growth rate inhibition over 72 h of 18 mg manganese/litre, a 96-h LC50 for tiger prawn (Penaeus monodon) survival of 26.1 mg manganese/litre, a 96-h LC50 for Australian bass (Macquaria novemaculeata) of 100 mg manganese/litre, and a 60-h NOEC for rock oyster (Saccostrea glomerata) larval abnormalities of 1 mg manganese/litre — and converting them in the same way to chronic NOECs (18, 2.6, 10, and 1 mg manganese/litre, respectively) gives an HC5 (50) of 0.4 mg manganese/litre. These extra data points improve the distribution of the data (the method requires unimodality of distribution) and decrease uncertainty.”

Hence, a trigger value of 0.4 mg/L was adopted as more representative of an Australian ecosystem system.

Nickel

The 95% level of protection trigger value was systematically adopted for most heavy metals except those presenting potential for bioaccumulation. DTAE recommends that the 99% level of protection

be used instead. If the 99% level of protection was adopted, the dilution requirements for nickel would be of 3.5. A dilution of 3.5 is much lower than the dilution requirements for other compounds of concerns such as chlorate and colour, which are likely to be used for comparison with the hydrodynamic modelling of the mixing zone. Hence, the impact of nickel would be limited to the mixing zone.

Selenium

See comments on heavy metal speciation.

Tin

DTAE recommends consideration of tributyl tin (TBT). TBT is commonly used in anti fouling paints, hence it is unlikely that TBT should be present in the pulp mill effluent. In the environment, TBT will be present in sediments and biota rather than water. For these reasons, TBT was not considered in this study.