

Expert witness statement of Ross Macallister Fryar 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

Ross Fryar, c/- GHD Pty Ltd, 201 Charlotte Street, Brisbane, Qld, 4000

2 Area of expertise

My area of expertise is hydrology, hydraulics and hydrodynamics.

My qualifications and experience are detailed in Attachment 1.

I am sufficiently expert to make this statement because:

- I have over 19 years experience in these disciplines;
- I am responsible for establishing GHD's capabilities in hydrodynamic modelling; and
- I have been involved in coastal/hydrodynamic modelling projects for most of my career, with responsibility for a large portion of GHD's work in this area.

I lead a team (within GHD) which includes Dr Ivan Botev (principal hydrodynamic modeller), and several other modelling staff.

My primary role in this project was to review the modelling process and subsequent reports. This included reviewing and supervising the work completed, and reporting of that work.

I provide this witness statement on the basis of the work undertaken by the above mentioned team.

3 Scope

3.1 Reports Written by GHD

Three hydrodynamic modelling reports relating to the ocean outfall have been prepared, the first of which was part of the draft Integrated Impact Statement. The scope / contents of each of these are as follows:

- July 2006. Final report titled "Hydrodynamic Modelling". This report includes a response to comments on the draft report made by DPIWE. This was included in the Draft IIS as Appendix 63, but is wrongly dated March 2006.
- August 2006. "Addendum for Gunns Pulp Mill IIS – Additional Modelling Works". This report provides results and conclusions pertaining to modelling of the outfall using a denser model grid in 3 dimensional mode (i.e. 5 layers representing the vertical). A copy of this report is attached to the statement as Attachment 2.

- January 2007. "Addendum for Bell Bay Pulp Mill IIS – Additional Modelling Works Report 2". The January report provides a summary of modelling results and conclusions following changes to the range of key water quality parameters considered, revised assumptions with respect to background concentrations, and the updated definition of suggested water quality trigger values. In addition, the model simulates the release of pollutants in a different way, such that buoyancy effects are better represented. A copy of this report is attached to the statement as Attachment 3.

A December 2005 report was also prepared in relation to the proposed wharf facility in the Tamar River. This report was titled "*Hydrodynamic Modelling Associated with A Proposed Wharf Facility in Bell Bay*", and was included in the Draft IIS as Appendix 64.

I adopt the findings of these reports.

3.2 Definitions

| Term | Definition |
|------------------------|--|
| ADCP | Acoustic Doppler Current Profiler. Used to collect information on currents in the water column. |
| AHD | Australian Height Datum. 0m AHD is generally / approximately equivalent to mean sea level. |
| Far Field | In simple terms, far field is that area beyond the near field. Far-field is the region in which ambient environmental conditions will control trajectory and dilution of a turbulent plume through buoyant spreading motions, passive diffusion due to ambient turbulence, and advection by the ambient, often time-varying, velocity field. |
| Hydrodynamic Modelling | A simple definition of hydrodynamic modelling is the numerical simulation of moving water (or of fluid motion). In coastal and marine waters, this involves the prediction of tidal movements, in terms of both water level and currents. In this context, hydrodynamic modelling has also been referred to as "far field" modelling. The software package used for the hydrodynamic modelling of the proposed pulp mill outfall is Delft3D. |
| Metoccean | Meteorological and oceanographic |
| Mixing Zone | For the purpose of this study, the mixing zone is defined in accordance with the State Policy on Water Quality Management (1997) as a <i>three-dimensional area of the 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.</i> |
| Near Field | The term "near field" simply denotes an area of interest adjacent to the item of interest. For the Pulp Mill project, near field represents that part of the water column within one far-field cell of the outfall (a distance of 50 to 250m). It can also be said that the "near-field" encompasses the |

| | |
|--------------------------|---|
| | <p>buoyant jet flow and any surface, bottom or terminal layer interaction.</p> <p>Near field modelling has been based on the application of the Visual Plumes software package.</p> |
| Trigger Values | <p>Trigger values are values set by government agencies, against which conformance to discharge criteria may be judged. In the context of the hydrodynamic reports, the term trigger value has been treated the same as water quality objectives. In both cases, it is understood that values are merely proposed until such time that they are set by government. The terms are effectively interchangeable for the purpose of the various hydrodynamic reports and witness statement, though an attempt has been made to refer exclusively to (proposed) trigger values in the January 2007 report.</p> |
| Water Quality Objectives | <p>As above for trigger values. It is understood that this terminology denotes a legislative process.</p> |
| Zone of Initial Dilution | <p>The ZID is a term applied with respect to near field modelling. It is defined as the lateral distance from an individual diffuser port to the location where the plume reaches the surface. There is no link between the potential meeting of water quality objectives and the ZID. Instead, a comparison of predicted concentrations within the ZID can be made to the designated WQOs. This reveals whether sufficient dilution will be achieved in the near field or not.</p> |

3.3 Instructions

3.3.1 Scope

My group was engaged (as part of GHD) to undertake a hydrodynamic modelling assessment for the Bell Bay Pulp Mill project, with the majority of the work focussing on the fate of pollutants discharged from the proposed ocean outfall. We were also engaged to assess the impacts on river flows / currents of a new wharf proposed within the Tamar River at Long Reach in the vicinity of Bell Bay.

The commission required:

- The preparation of a hydrodynamic model capable of simulating the discharge of effluent from the proposed outfall, and its subsequent dispersion into the waters of Bass Strait. This model (hereafter referred to as the far field model) covers an area of 140 x150 km, with grid cell dimensions of 250m by 250m. It sits inside a larger model which covers all of Bass Strait.
- Modelling of the mixing characteristics of the plume in the vicinity of the outfall (i.e. the application of a near field model). In this case, the near field model applies tidal currents at the outfall, in order to simulate the mixing of the plume with receiving waters as the plume rises to the surface.
- The comparison of predicted (modelled) pollutant concentrations to suggested targets (i.e. proposed water quality objectives). The proposed water quality objectives (WQOs) were provided to the modelling group by environmental staff within GHD, with reference to a DPIWE email of 16th September 2005. DPIWE subsequently advised that the email should not be used to define water quality objectives. DPIWE (now DTAE) confirmed that the process defined by ANZECC was to be followed. The

derivation of suggested trigger values (TVs) is the subject of separate evidence by Dr Veronique Levy, and is also reported in the *Bell Bay Pulp Mill IIS – Water Quality Assessment (GHD Jan 2007)*. This document is hereafter referred to as the “water quality assessment report”.

- Estimation of the size of the mixing zone, at the boundaries of which, pollutants would not exceed the water quality objectives.
- The assessment of any changes in flow patterns in the Tamar River that might arise from the construction of a wharf facility in the vicinity of the proposed pulp mill. Given the proposed design of the wharf facility (using piles), modelling of the impacts of construction was not considered necessary.

3.3.2 Relevance of Scope and Environmental Emission Guidelines

The Scope Guidelines for the IIS require a description of the existing marine environment, both local and regional, which will serve to establish the baseline for evaluating environmental impacts and formulating environment protection measures and monitoring programs for the effluent outfall. Oceanographic dispersion characteristics were required to be determined at the site of the proposed outfall, including currents, tides, wave energy and temperature. In addition, a prediction of the initial dilution of the effluent and its subsequent dispersion and the fate of key pollutants is required.

3.3.2.1 Recommended environmental emission limit guidelines for any new bleached eucalypt kraft pulp mill in Tasmania, Volume 2 (August 2004)

[A] The following items concerning hydrodynamic studies were addressed:

D.3.13 At the preferred site, studies shall be conducted to predict the dispersion of effluent in the receiving waters. In particular the influence of water currents on the effluent plume distribution must be considered.

D.3.14 It is expected that the studies will require the use of a hydrodynamic model and appropriate wind, current and water density measurements to determine the effluent dispersion characteristics under a variety of weather conditions, and allow for seasonal variability.

D.3.15 The hydrodynamic studies will need to provide an adequate level of detail required to determine an appropriate mixing zone (if necessary) and an appropriate post-commissioning monitoring program. The proponent will be responsible for undertaking the hydrodynamic studies to the required standard.

D.3.16 Data from the hydrodynamic studies should be utilised to define a mixing zone for the dilution of mill effluent at the point of discharge, in accordance with the State Policy on Water Quality Management 1997. The size of the mixing zone is site-specific and could be varied if site-specific environmental factors indicate some change of size.

[B] The following items were addressed with respect to ambient water quality

D.3.17 Water quality objectives for the receiving waters will be set in accordance with the State Policy on Water Quality Management 1997, and hydrodynamic studies should be utilised to assist demonstration that these objectives can be met at or beyond the edge of the mixing zone.

[It is noted that this is an ongoing task, in that data is still being collected, and hence proposed trigger values (which may then become water quality objectives) may be modified as this data is analysed.

3.3.2.2 Proposed bleached kraft pulp mill in Northern Tasmania by Gunns Limited, Final Scope Guidelines for the Integrated Impact Statement (December 2005)

The following guidelines are relevant to the three hydrodynamic modelling reports and one water quality report prepared by GHD (as defined earlier in the witness statement).

Page 35, (section 7.8.1(4)): *“The ability to comply with proposed mixing zones must be addressed. Predicted ambient levels of pollutants must be compared with required performance standards. Predictions must be based on modelling using adequate data as set out in the Environmental Emission Limit Guidelines, Tasmanian Government 2004 for any new bleached eucalypt kraft pulp mill in Tasmania. The maximum concentration level of each pollutant should be given (as required by the National Pollutant Inventory).”*

Page 35, (section 7.8.1(5)) *“The potential for the effluent to cause environmental and health impacts must be evaluated. This should include consideration of normal operating conditions and periods when pollution control equipment may fail or be shut-down. The management actions to minimize the pollutant concentrations and load discharged must be included in any discussion regarding any discharge of non-compliant effluent quality. The likelihood and frequency of shutdown/failure of key items of pollution equipment must be estimated. The review of potential impacts must include:*

- *the potential for the deposition of suspended solids and the accumulation of pollutants on the sea floor (deposition zones) or on river beds within the proposed mixing zone, zone of influence and the Tamar River estuary;”*

The first bullet point of Item 5 has not been addressed in our modelling, as indicated in the July 2006 report. We were advised by Bryce Skarratt (of GHD) that this was in accordance with discussions with government agencies held on the 20th January 2006, with provision for a desk-top assessment by others. However, we were subsequently advised that this was not the intention of the government agency, and hence we were to provide justification for our adopted course of action. This justification is provided in Section 7 of this statement.

3.3.3 Scope changes to address or respond to issues arising from the preliminary review by DPIWE and the community consultation process

In response to comments on the draft of the July 2006 report received from DPIWE, we undertook additional work as described below.

Far field modelling undertaken for the July 2006 report was based on grid cells 250 m by 250 m in size. The effluent from the outfall was simulated as discharging into a single one of these model cells.

For the August 2006 and January 2007 reports, individual model cells have been decreased to 50 m by 50 m in the vicinity of the outfall. In addition, the model has been run in 3D mode, with 5 layers used to represent water depth. These changes were made in response to discussions between GHD and DPIWE.

Given deadlines for the draft IIS, there was not sufficient time to incorporate these changes into the July 2006 report.

The primary benefit of the change to model structure is to reduce the perception of uncertainty associated with using the larger cells, where the size of the cells (250 m) is commensurate with the size of the suggested mixing zone.

Furthermore, the representation of the outfall was varied in response to the existence of the smaller grid elements, with the discharge of 25% of the effluent into each of 4 adjacent cells in the bottom layer of the model.

The August 2006 report summarises the results achieved.

The January 2007 report reflects a further revision, with the discharge being placed in 18 surface cells rather than 4 bottom layer cells. This provides a better representation of the effects of buoyancy associated with the plume when discharged through a diffuser.

3.4 Process and Methodology

3.4.1 Method

The adopted methodology for the preparation of the July 2006 report, and subsequently the August 2006 and January 2007 reports, is summarised as follows:

July 2006

- Receipt of data pertaining to the proposed outfall (location, effluent concentrations, previous reports, draft forms of guidelines);
- Review of data;
- Collection / acquisition of additional data (bathymetry, tidal data, wind data);
- Establishment of a hydrodynamic (far-field) model using the Delft3D software. This involved setting of the model extent, selection of grid size and the generation of boundary conditions;
- Preliminary running of the hydrodynamic model using April 2005 data;
- Comparison of modelled tidal elevations to tidal elevations predicted (by Seafarer Tides, Australian Hydrographic Service) for the same period;
- Processing of hydrodynamic results, including generation of current data into a statistical (frequency plot) format;
- Comparison of hydrodynamic results (frequency plots of predicted currents) with frequency plots for other locations in Bass Strait (obtained from previous reports)
- Rerunning of the model using December 2005 data in order to allow direct comparison with measured currents at the proposed outfall site;
- Storage of results (in a hydrodynamic database) for both the April 2005 and December 2005 modelling periods;
- Application of a water quality model using the hydrodynamic database for the April 2005 period. The model was run with 7 substances (TSS, BOD, COD, AOx, TDS, colour and chlorate), with all assumed as conservative substances (ie no provision for decay);
- Completion of near-field modelling using the Visual Plumes (VP) package. The primary module of the VP software that has been applied is known as UM3. This package provides estimates of pollutant concentrations and dilutions in the immediate vicinity of the outfall;
- Review of predicted pollutant concentrations / dilutions from the Delft3D and VP modelling packages;
- Consideration of the distance from the outfall at which WQOs will be achieved;
- Provide suggestion as to the required mixing zone size, based on the above;
- Provision of a draft technical report;
- Receive and respond to comments;
- Finalise report (July 2006);

August 2006

- Receive revised data with respect to background concentrations (from Aquenal) and discharge concentrations (from JP) via the project manager.;
- Create a modified D grid for the far-field model using smaller grid elements and 5 layers (i.e. a 3 dimensional approach);
- Review results, and prepare a new report (Aug 2006);

January 2007

- Modify means of introducing effluent into the model, such that effects of buoyancy were represented;
- Incorporate revised water quality data pertaining to background concentrations, effluent concentrations, and suggested trigger values;
- Re-estimate mixing zone; and
- Produce final report (January 2007).

In carrying out these tasks, I:

- Liaised with the GHD IIS manager (Bryce Skarratt);
- Supervised key staff (Dr Ivan Botev and Nilesh Kumar);
- Conducted numerous review meetings with the modelling team;
- Met with DPIWE staff (Tony Dell and Colin Shepherd) for discussion of the adopted approach, and the need for current measurements at the outfall;
- Reviewed results; and
- Reviewed draft reports.

3.4.2 Philosophy of Conservatism

The assessment of oceanographic conditions can be a complex matter, with a large number of variables, and it is a practical impossibility to assess all possible combinations of wind, tide and wave. For this reason, it is often necessary to make assumptions, or to simulate a sub-set of conditions. In making these assumptions and selections, an attempt has been made to choose the conservative option. This process of conservatism is explained in Section 3.7 of this witness statement.

3.5 Model Inputs

3.5.1 Overview

The modelling process requires a number of model inputs. These include descriptions of:

- The receiving environment in terms of physical and chemical conditions (refer also Section 3.5.8);
- Proposed infrastructure configuration (refer Table R1); and
- Proposed discharge.

In addition, suggested trigger values are required as inputs, in order to allow the estimation of the required mixing zone size. (Refer to Section 3.5.11 below).

Details of data and sources were provided in Chapter 3 of the July 2006 report.

3.5.2 Reliance on Others

The process of modelling is highly reliant on data, and in the absence of data, on assumptions. In keeping with this, there is a corresponding reliance on those providing the data or assumptions, which for this project included each of the organisations listed in Chapter 3 of the July 2006 report. In addition, we are reliant on other members of the project team (both GHD and sub-consultants) to provide further data and information.

3.5.3 Diffuser Configuration

Details of the proposed diffuser configuration were provided by the GHD project manager, and are summarised in Table R1 below. It was understood that these had

been developed in conjunction with Jaakko Poyry. Details of the effluent concentrations are provided in a later table.

Table R1 Diffuser Configuration

| Item | Parameters | Value |
|------|-----------------------------------|--------|
| 1 | Port Diameter (m) | 0.15 |
| 2 | Port Elevation (m) | 1.0 |
| 3 | Vertical Angle (degrees) | 75 |
| 4 | Horizontal Angle (degrees) | 90 |
| 5 | Number of Ports | 20 |
| 6 | Port Spacing (m) | 10.0 |
| 7 | Port Depth (m) | 24.0 |
| 8 | Effluent Flow (m ³ /s) | 0.81 # |
| 9 | Effluent Salinity (psu) | 2.0 |

Note:

Value subsequently changed to 0.74 m³/s (based on a flow volume of 63,770 t/d). We were informed by the GHD project manager that this change had been advised by Jaakko Poyry. The change is reflected in the August 2006 report.

3.5.4 Sources of Metocean data

The list of organisations from which data was sourced was provided in Chapter 3 of the July 2006 report.

Data was also sought from organisations such as Alinta and Esso, who had commissioned previous studies in the vicinity. However, these studies were not released to GHD.

3.5.5 Oceanographic Data

Relevant oceanographic data obtained during the project included that pertaining to water level predictions, bathymetry and coastline data, currents, wind, waves, salinity and temperature. Other data of relevance included sediment data, map/charts, aerial photographs, and reports.

The data was separated into two main categories:

- Data collected at the location of the proposed outfall site. This data (currents and wave heights) was collected during a December 2005 field campaign; and
- Existing data at other sites in Bass Strait and along the northern Tasmanian coast. Most of this data predates the project specific data.

3.5.6 Pollutant Data

Water quality is characterised by the concentration of pollutants in the water column. For the assessment of water quality associated with the proposed outfall, pollutant concentrations were considered in three ways:

- The concentration of pollutants in the discharge from the outfall (i.e. effluent loads as defined by Jaakko Poyry);
- The concentration of pollutants existing in the receiving waters at this point (based on field measurements by Aquenal); and

- The acceptable concentration of pollutants in the receiving waters (hereafter referred to as trigger values (TV)). For the July 2006 and August 2006 reports, these were based on a combination of:
 - Values nominated in an email received from DPIWE (though subsequently advised these as not approved); and
 - Values based on 110% of adopted background concentrations.
- For the January 2007 report, suggested trigger values were provided from the Water Quality Assessment Report.

Each data set was provided to us through others in the GHD project team, with the original source as indicated in brackets above.

3.5.7 Pollutant Concentrations at Point of Discharge (Effluent Loads)

The table below summarises information provided by Jaakko Poyry via the GHD project manager for the July 2006 report.

These numbers correspond to an effluent volume of 69,800 t/d.

Table R2 – Effluent Loads and Concentrations (July 2006)

| Parameter | mg/L | t/d |
|-----------|------|-------|
| TSS | 30 | 2.1 |
| BOD5 | 11 | 0.75 |
| COD_CR | 330 | 23 |
| AOX | 5.90 | 0.41 |
| TDS | 2190 | 153 |
| Colour | 220 | 25.5 |
| Chlorate | 1.80 | 0.125 |

The August 2006 report recognises the modified effluent loads that were specified in the draft IIS. These numbers are tabulated below in Table R3.

These numbers correspond to an effluent volume of 63,770 t/d.

Table R3 – Revised Effluent Loads and Concentrations (August 2006)

| Parameter | mg/L | t/d |
|-----------|------|-------|
| TSS | 20 | 1.3 |
| BOD5 | 11 | 0.69 |
| COD_CR | 361 | 23 |
| AOX | 6.8 | 0.44 |
| TDS | 1896 | 121 |
| Colour | 450 | 31.4 |
| Chlorate | 1.9 | 0.119 |

Table R4 – Effluent Concentrations for January 2007 report

| Parameter | Units | Concentration in Effluent | Comparison to August 2006 values |
|-----------|--------|---------------------------|--|
| AOX | mg/L | 6.8 | Same |
| BOD5 | mg/L | 11 | Same |
| Chlorate | mg/L | 3.7 | Maximum adopted |
| COD | mg/L | 466 | Higher load |
| Colour | mgPt/L | 493 | Higher load |
| Total-N | mgN/L | 2.5 | New parameter |
| Total-P | mgP/L | 0.80 | New parameter |
| N0x | mgN/L | 0.98 | New parameter |
| TDS | mg/L | 2250 | Greater than Aug 2006. Similar to July 2006 value. |
| TSS | mg/L | 20 | Same as Aug 06 |

The characteristics of the effluent in Table R4 were provided via an e-mail from Jaakko Poyry (Hannu Jappinen) dated 31st October 2006. The details of this are contained in the Water Quality Assessment Report (January 2007). These numbers correspond to an effluent volume of 63,770 t/d.

3.5.8 Pollutant Concentrations in Receiving Waters

Pollutant values for the receiving waters were based on interpretation of background concentrations measured by Aquenal. With the exception of BOD, values were unchanged for each of the July and August 2006 reports.

Changes were made for the January 2007 report, based on a combination of a wider literature review and access to more field data (refer Water Quality Assessment Report of January 2007).

Table R5 Assumed Receiving Water Conditions – July / August Reports

| Item | Parameter | Value | Source |
|------|-----------------|--------|---|
| 1 | AOX (mg/L) | 0.0176 | Aquenal Pty Ltd 2005 Survey |
| 2 | COD (mg/L) | 150 | Aquenal Pty Ltd 2005 Survey |
| 3 | BOD (mg/L) | 2.5 | Aquenal Pty Ltd 2005 Survey |
| 4 | TSS (mg/L) | 1 | Aquenal Pty Ltd 2005 Survey |
| 5 | TDS (mg/L) | 35240 | DPIWE email preliminary advice of 16 th September 2005 # |
| 6 | Chlorate (mg/L) | 0 | Aquenal Pty Ltd 2005 Survey |
| 7 | Colour | 0 | No data suggesting any presence of colour. |

Notes:

The value of 35240 for salinity is consistent with the value of 35,000 originally considered by GHD, which was obtained from the World Ocean Atlas (2001) for the month of April.

The concentration of chlorate in the receiving waters was below the detectable level quoted by Aquenal Pty Ltd. Accordingly, a background concentration of 0 mg/L was assumed for chlorate for the July and August reports.

Table R6 Assumed Receiving Water Conditions – January 2007 Report

| Item | Parameter | Value# |
|------|-----------------|--------|
| 1 | Chlorate (mg/L) | 0.0025 |
| 2 | Colour (mg/L) | 1 |
| 3 | TN (mg N /L) | 0.12 |
| 4 | TP (mgPN /L) | 0.03 |
| 5 | NOx (mg N /L) | 0.005 |
| 6 | COD (mg/L) | 480 |
| 7 | BOD (mg/L) | 1 |
| 8 | AOx (mg/L) | 0.016 |
| 9 | TDS (mg/L) | 41,000 |
| 10 | TSS (mg/L) | 7 |

All values derived from Aquenal field data, as discussed in the Water Quality Assessment Report (January 2007).

3.5.9 Trigger Values and Water Quality Objectives – Overview

The process outlined by ANZECC indicates the derivation of water quality objectives (WQOs) based on site specific data (collected over a minimum timeframe). Water quality objectives are regarded as interim until the required data has been obtained, and the formal approval process has been completed. Values proposed by GHD are referred to as trigger values (TVs) or proposed trigger values. These are required in order to allow the estimation of a mixing zone, and have been determined in the Water Quality Assessment Report (January 2007). The following two sections provide a brief overview of how these trigger values were derived (by others) for subsequent reference in the hydrodynamic modelling assessment.

It is noted that whilst the January 2007 report refers almost exclusively to trigger values, the two earlier reports typically referred to water quality objectives. However, a common definition is attached to all such references (i.e. interim / proposed values have been nominated in order to allow the assessment of potential size of the mixing zone).

3.5.10 Adopted Water Quality Objectives – July / August

Water quality objectives (WQOs) proposed for the July and August 2006 reports were as follows:

Table R7 – Proposed Water Quality Objectives

| Parameter | July 2006 (Tables 11 and 14) | August 2006 (Tables 4 and 6) |
|------------------------|---------------------------------|---------------------------------|
| TSS (mg/L) | 32 | 32 |
| BOD5 (mg/L) #1 | 3.0 | 3.0 |
| COD_CR (mg/L) | 2360 | 2360 |
| AOX (mg/L) | 0.046 | 0.046 |
| TDS (mg/L) | 41,000 | 41,000 |
| Colour (PCU / mg/L) #2 | 7.0 PCU / 2.2 mg/L | 7.0 PCU / 4.5 mg/L |
| Chlorate (mg/L) | 2.0 | 2.0 |

Notes:

- #1 Suggested WQO for BOD also reported as 3.3 mg/L in earlier tables (Table 7 in July report and Table 2 in August report), but the value of 3.0 was used.
- #2 It should also be noted that the WQO for colour was provided in terms of units known as PCU, whereas the modelling utilised units of mg/L. The WQO for colour changed from 4.5 to 2.2 mg/L for colour from the July 2006 to the August 2006 report, owing to changes to the effluent loads.
- That is, whilst linearity between units of PCU and mg/L assumed, conservative approach taken based on 1% of effluent discharge.

3.5.11 Adopted Water Quality Objectives – January

A revised set of water quality parameters and proposed WQOs (trigger values) has been adopted, based on work by others (refer Water Quality Assessment report of January 2007). Of these, the parameters of most relevance to the establishment of a mixing zone, and the assessment of potential impact are as listed below:

Table R8 – Revised Proposed Water Quality Objectives

| Parameter | January 2007 Trigger Values |
|-----------------|--------------------------------|
| Chlorate (mg/L) | 0.008 |
| Colour (mg/L) | 2 |

| | |
|---------------|-------|
| TN (mg N /L) | 0.14 |
| TP (mgPN /L) | 0.06 |
| NOx (mg N /L) | 0.01 |
| COD (mg/L) | 1200 |
| BOD (mg/L) | 2 |
| AOx (mg/L) | 0.029 |

3.6 Reports Reviewed

The following reports and guidelines relevant to the region were reviewed:

- Andrewartha, J. R., and S. J. Walker, "Hydrodynamic Modelling Study – Preliminary Report", CSIRO Division of Marine Research, Report OMR 96/107, 1996.
- Bell Bay Pulp Mill Project, Document 05-003-R-001, Atteris Pty Ltd, 2005.
- Basslink, Draft Integrated Impact Assessment Statement, Main Report, NSR Environmental Consultants Pty Ltd, 2001.
- Basslink Marine Ecology Survey, Report for NSR Environmental Consultants Pty Ltd, Aquenal, 2002.
- Bell Bay Environmental Baseline Programme, Physical Oceanographic Study, L&T Pty Ltd, 1996.
- Marine Biological and Pollutant Survey At The Proposed Outfall Site, Aquenal Pty Ltd, June 2005.
- Development of New Environmental Emission Limit Guidelines for any New Bleached Eucalypt Kraft Pulp Mill in Tasmania, Volumes 1 and 2, Resource Planning and Development Commission (RPDC), August 2004.
- Tasmania Natural Gas Project (TNGP), Development Proposal and Development Management Plan, Stage 1, Volume 4, Duke Energy International, April 2001.

Note: Other key documents relating to water quality have been referenced in the January 2007 Water Quality Assessment report.

Technical references included:

- Fandry, C. B., Walker, S. J. and J. R. Andrewartha, "Modelling Effluent Dispersion in Australian Coastal Waters", CSIRO Division of Oceanography, 1996.
- Frick, W. E., D. J. Baumgartner, D. L. Denton, P. J. W. Roberts, "New Developments of Visual Plumes – evaluation of bacterial pollution", 2nd International Conference On Marine Waste Water Discharges, Istanbul, September 16-20, 2002.
- Schnurbusch, S.A., A Mixing Zone Guidance Document prepared for the Oregon Department Of Environmental Quality, Portland State University, 2000.
- Smooth Modelling in Water Management, Good Modelling Practice Handbook; STOWA Report 99-05.
- U.S. EPA, 1982. Revised Section 301(h) Technical Support Document. EPA 430/9-82-011. Nov. 1982 Muellenhoff, W. P., A. M. Soldate, Jr., D. J. Baumgartner, M. D. Schuldt, L. R. Davis, and W. E. Frick, 1985. Initial mixing characteristics of municipal ocean outfall discharges: Volume 1. November 1985.

3.7 Assumptions / Conservatism

The modelling exercise is designed to be conservative. That is, recognising that not all factors can be represented in modelling exercises conducted outside an academic or R&D framework, a number of assumptions have therefore been applied.

These are summarised below, with reference to how the assumption has been regarded as conservative provided in brackets.

With respect to far field modelling:

1. In line with studies by others (Fandry et al., 1996), it is inherently assumed that the effluent makes no significant contribution to the momentum or volume of the water in the receiving model cell. [Standard assumption. No implications for conservatism of result].
2. All results discussed in the July 2006 and August 2006 reports were based on model simulations for the month of April 2005, with no representation of waves. This period contains neap and spring tides. [The absence of waves (which corresponds to low energy conditions in the receiving waters) should therefore lead to estimation of a higher average concentration at the proposed ocean outfall site, than if waves were represented].
3. There has been no allowance for the additional mixing forces of waves [Waves promote turbulence and will therefore increase the dilution of any discharge]
4. Actual pollutant concentrations may vary due to seasonal effects and ambient conditions, but are not expected to affect the definition of the mixing zone.
5. Decay of pollutants. Once discharged into an ocean environment, pollutants will be subjected to a variety of physical and chemical processes, many of which will act to reduce pollutant concentrations. By not representing these processes, the predicted results will tend to over-estimate concentrations. In the model, pollutants are only subject to dispersion and dilution by ambient currents. [This assumption is conservative, as the critical substances with respect to the determination of a mixing zone will decay or be subject to chemical processes which will result in a decrease in concentration]
6. Complex biological or physical processes (such as uptake of the substances by organisms or absorption to particles), which can reduce the concentration in the water column, have not been modelled. [As above. If these processes were simulated, lower concentrations of pollutants would be expected]
7. Chlorate. A high background level has been assumed. Chapter 7 of the Water Quality Assessment report (January 2007) indicates that "*It is unlikely that a high background concentration should be present in the area of disposal*", and notes that "*... a precautionary approach was adopted and a background value was determined by selecting the half the lowest trigger value found in the literature...*". Reference is also made in the Water Quality Assessment report to the work by Toxikos.
8. The outfall effluent has been discharged into 18 cells in the surface layer based on review of the near-field results, with the effluent fully mixed within these cells. [This arrangement represents the buoyant mixing effects that have been commented on by a number of parties]
9. In the hydrodynamic model, effluent is fully mixed within each of the discharge cells. [This is a standard procedure in far-field modelling rather than an assumption. Whilst it has been suggested that this can over-represent initial dilution, the implication is limited in keeping with the impacts associated with the preceding three points].

With respect to near field modelling:

10. It is assumed that there is no stratification in the water column during the simulation period as suggested by the review of literature; In addition, the zone of initial dilution (ZID) is defined as the lateral distance where the plume either reaches the surface or

is trapped by stratification. In this case, the former condition is adopted; [No implications for conservatism]

11. All near field runs were performed using time series of depth-averaged ambient currents extracted from outfall cell #25 in the 2D numerical model; [There are no implications for conservatism, as 2D and 3D runs have shown minimal difference in current magnitudes at the outfall location for the modelled conditions]
12. The interaction (or merging) between plumes generated by individual ports and the consequent increase in background concentration is not taken into account by the near field modelling package. However, allowance has been made for the latter effect by defining the discharge into surface cells in the far-field model;

3.8 Exclusions

In this case:

- Wave effects have not been modelled. Waves tend to increase turbulence, and hence dilution. Hence, the adopted modelling process should indicate higher concentrations than if waves were also represented. Waves can also modify current directions, and hence the extent of the plume could conceivably be broader than indicated, albeit at weaker concentrations.
- Simulations cover a 4 to 6 week period (rather than 12 months). The selected period contains a range of tides, and hence different tidal velocities are referred to in the model results. Running the model for a longer period may well show different plume patterns each month, but is unlikely to make any change to the recommended size of the mixing zone.
- East Coast Lows. Low pressure systems can and do affect tidal currents in Bass Strait. However, as with waves, these changes to currents would tend to increase the energy available for dilution in the receiving waters, and therefore it is conservative to not represent these in the model. Furthermore, it is understood that East Coast Lows play a less significant role in the southern part of Bass Strait (along the Tasmanian Coast) than along the Victorian coast.
- No calculations were performed with respect to the outfall hydraulics, and no representation is made here as to the available hydraulic head to sustain the flow for the length and depth of the outfall options. These calculations (which relate to whether the outfall will operate in accordance with the concept design) will be the responsibility of the outfall designer.

4 Findings with Respect to The Ocean Outfall

This section of the statement provides a summary of the findings of the hydrodynamic, water quality and plume modelling. The results of modelling are used by others involved in the project to determine impacts, and hence this section focuses on results rather than impacts. The primary deliverable is therefore the recommendation of a mixing zone. The size of the mixing zone was determined by comparing predicted pollutant concentrations with water quality objectives. Predictions were made using two modelling packages: Delft 3D provided a “far-field” solution, whilst “Visual Plumes” provided a near field solution. Both solutions were considered in recommending the extent of the mixing zone.

4.1 Model Authentication

The characteristics of the receiving waters at the site of the outfall were assessed using the Delft3D software for hydrodynamics and water quality. The system has been applied at a high resolution on a large scale extending over the entire Bass Strait.

Initially a one month period from 10th April 2005 was simulated. However, the lack of recorded currents at the outfall (for this time) meant that verification of the model had to be made against predicted tidal elevations at major ports in the vicinity of the outfall.

To compensate for the lack of April 2005 field data, predicted tidal currents were compared to historical data at other locations in Bass Strait. The results of the verification were satisfactory.

Additional verification was subsequently undertaken using field data collected during December 2005. This data was statistically compared to model results for December 2005 owing to the high variability of recorded data.

The comparisons showed that the modelling results compare well with respect to trends in amplitude and direction, and that the model can accurately describe the hydrodynamics of the receiving waters, as generated by wind and tide.

4.2 July 2006 Conclusions

Far Field Modelling

The far field modelling exercise assessed the dispersion and gradual dilution of the effluent as it is transported by ambient currents away from the outfall. It also provided a preliminary understanding of the process of pollutant build-up over time.

The far-field analysis was undertaken on a 250 m resolution. All conclusions in relation to the far-field assessment were based on the inherent assumption that the effluent discharged into the receiving waters is instantaneously diluted into the entire volume of the outfall cell(s), as commonly adopted in far-field analysis.

It was concluded that:

- Of the modelled parameters, only AOx was predicted to exceed the proposed WQO within a distance of 250 m by 250 m;
- The results suggested that in the absence of decay, AOX concentrations would exceed the WQO less than 1% of the time within this 250 m by 250 m cell, on the basis of a background concentration of 0.0176 mg/L (average value from initial field work);
- If the maximum measured ambient concentration for AOX (0.026 mg/L) is adopted in the analysis, the adopted WQO would be exceeded approximately 5% of the time within a distance of 250 m by 250 m; and
- The mixing zone would therefore need to be larger than 250 m by 250 m.

Near Field Modelling

Results of near field modelling (using the Visual Plumes software) indicated that:

- The minimum extent of the ZID can be of the order of a few meters during zero-flow conditions with the plume rising vertically to the free surface above the diffuser.
- The maximum extent suggested a mixing zone of at least 150 m from the 200 m long diffuser would be required.
- With the exception of AOX, the near-field modelling showed that key effluent constituents would be diluted to the proposed trigger values within a zone of 350 m by 150 m.

Recommended Mixing Zone

Far field results suggested a minimum mixing zone of more than 250 m;

Near field results indicate a zone of at least 350 m by 150 m;

After taking into account the results of both forms of modelling, and adding an allowance for the translating effect of constant winds or waves, a minimum mixing zone of 500 m x 275 m was recommended.

4.3 August 2006 Results and Conclusions

Far Field Modelling

The August report was based on a grid resolution with model cells in the vicinity of the outfall of 50 m. AOx was still shown to be the critical pollutant with respect to setting the mixing zone. Pollutant concentrations were presented in terms of the following statistical

envelopes: mean, median and 95th percentile. Results were presented for two different background concentrations, as for the July report.

Results were presented in two forms:

- Plots of concentration exceedance for each 50 m by 50 m cell in the vicinity of the outfall, and
- Spatial maps of plume concentration, presented as means and 95th percentiles.

The exceedance plots showed that concentrations would exceed WQOs close to the diffuser, but that cells around the boundary of a 500 m by 500 m area would have concentrations below the adopted WQOs.

The spatial maps confirmed that for all pollutant constituents other than AOx, concentrations fall below WQOs within this 500m by 500m area.

It was noted that if a high background concentration for AOx was assumed, the potential would exist for concentrations above the WQO to occur beyond the 500 m by 500 m area in 1 of the 5 layers modelled. However, the adoption of a high background level was considered likely to be an additional conservative assumption, and hence the need for a larger mixing zone was rejected.

Near Field Modelling

The results were similar to those for July 2006, suggesting a minimum required mixing zone of 400 m (NS) x 230 m (EW).

Recommended Mixing Zone

Taking account of other factors, and recognising the level of uncertainty associated with assumptions and ambient conditions, the recommended mixing zone was 550 m by 500 m.

4.4 January 2007 Results

In the modelling undertaken for January 2007, the effects of initial dilution have been simulated by injecting the effluent into 18 cells, rather than a single cell (for 250 m grid), or 4 cells (for 50 m grid model). This has resulted in a plume exhibiting the highest concentrations (i.e. lowest dilutions) at the surface layer in the vicinity of the outfall, with much lower concentrations in sub-surface layers.

As one moves away from the outfall, concentrations are similar in all layers, illustrating that vertical mixing effects have been represented.

No new near-field modelling was conducted, with dilution maps based on far field (hydrodynamic) modelling results.

AOx has been retained in the assessment, but only for the sake of continuity, as it not currently considered to be a good representative of potential environmental impact (refer Section 7.3.2 of Water Quality Assessment (January 2007)).

Revised water quality parameters have been defined, with respect to background concentrations and proposed trigger values. A comparison of these two sets of numbers indicates that chlorate is the critical parameter, with a required dilution of 670, on the basis that the background concentration of chlorate is 2.5 ug/L. The resultant mixing zone is of the order of 800m by 800m, with a smaller mixing zone (400m by 400m) suggested if no background concentration is evident.

Colour is the second most critical parameter, with a required mixing zone also of the order of 430m by 400m.

It is recognised that background values and trigger values could change again, as more data is obtained, and hence an upper and lower bound to the mixing zones has been suggested.

This comprises:

- A minimum zone of 500m by 500m, and
- A maximum zone of 800m by 800m.

5 Proposed Bell Bay Wharf Facility

A hydrodynamic assessment was undertaken in response to the project requirement for a sound understanding of the impacts of the proposed wharf facility on the hydrodynamics of the Tamar River.

The proposed wharf (located within Long Reach upstream of Bell Bay) was represented in the model.

Two high-resolution regional models were developed. These provided detailed coverage of the Tamar River with emphasis on the fine scale representation of hydrodynamics within the river. A verification of the models against predicted tidal elevations yielded good results.

Runs were performed for the period 1st to 15th of July 2004, with river flows represented in the model. During the period of simulation, discharges in the North Esk and South Esk Rivers (i.e. the two tributaries of the Tamar River) reached a peak of 3,000 ML/day and 8,200 ML/day, respectively.

The main findings from the study were:

- The most significant impact from the proposed wharf facility with respect to local scale hydrodynamics is located upstream from the facility. The impact is associated with the proposed land reclamation, which is part of the facility and is limited in extent.
- Predictions are that the land reclamation will only cause a small scale local obstruction of the currents along the eastern bank of the river adjacent to the wharf facility, with a reduction of post-construction peak current magnitude down to 14 cm/s from 37 cm/s at one location. The mean current magnitude corresponding to existing conditions (16.1 cm/s) will be reduced down to 2.5 cm/s at this point.

Other conclusions from the study can be summarised as follows:

- The majority of the structure for the proposed facility will be constructed on pylons, with a small amount of land reclamation. The installation method of the pylons, expected to be piling, and construction of the reclamation area is expected to cause little suspension of sediments and therefore associated turbidity plumes should be localised and short term.
- With the exception of the area located upstream from the land reclamation associated with the proposed wharf facility, the facility is predicted to cause little effect on the hydrodynamics of the river.

6 Response to Community Concerns and Key Submissions

Several sets of comments have been received, both from government agencies during the preparation of reports, and arising from the public release of the draft IIS for display and comment. Comments were received from Tasmanian Government agencies (Whole of Government submission), The Tasmanian Greens, Surfrider Foundation Australia, other organisations and a number of individuals.

These comments can be broken into a number of themes, each of which has been responded to in the following sections.

6.1 Flushing Characteristics of Bass Strait.

6.1.1 Overview of Submissions relating to flushing

A large number of submissions have suggested that the flushing regime of Bass Strait is poor, and that the discharge of effluent from the Bell Bay pulp mill should therefore not be allowed. The majority of these submissions cross reference a paper by Paul Sandery (*Towards an understanding of the flushing of Bass Strait*). The paper (name and date of conference not provided) provides a summary of Sandery's conclusions arising from his modelling of the flushing of Bass Strait.

The key points conclusions offered in the paper include the following:

- *"The main findings of the 180 day simulation suggest winter-spring flushing of Bass Strait waters results from eastwards advection of SACW and SASW. In this case, SACW denotes South Australian Current Water and SASW denotes sub-Antarctic Surface Water.*
- *"Results also suggest strait waters can be replenished to some degree in most places with SASW (excepting minute concentrations in the stagnation-area) in a period of approximately 30 days in conditions of strong mean westerly winds."*
- *Winter-spring flushing with SASW is a significant inter-annual process replenishing nutrients..."*
- *"Water in the stagnation-area takes the longest time to be replenished by external water mass and occurs at timescales of the order of > 6 months."*
- *There is a "...dominance of mean wind driven flow over tidal flow at the seasonal scale";*
- *These currents determine meso-scale residual flow in Bass Strait in the winter-spring period...*

The majority of submissions that reference Sandery's work suggest that a flushing of Bass Strait may take up to 6 months, and that impacts are therefore not acceptable (i.e. there is a concern associated with effluent discharge into this area and the potential for build-up of pollutant concentrations). Several submissions also suggest that GHD's model is not adequate, whether due to the lack of consideration of flushing characteristics, or the lack of reference to Sandery's work.

An example of the type of comments offered in relation to flushing are provided below:

- *Flushing is poor (only 1% a day according to Sandery which means 100 days of effluent will be permanently sitting off-shore)- (RPDC reference 188).*
- *"...it is likely that much of the "Gunns discharge" will finish back up in the Tamar River and along the pristine beaches of our north coast".(RPDC reference 94)*
- *"There appears to be an underlying assumption that contaminants will rapidly mix through the entire water depth and will also be advected entirely from Bass Strait" (RPDC reference 351)*
- *"I am not satisfied by the Gunn's IIS, that adequate scientific modelling has been undertaken which reflects the complex circulation and eventual dispersal of polluted effluent within this area of restricted flow". (RPDC reference 534).*
- *"The significant concern is that dilution is overemphasised at the expense of natural mechanisms that cause an opposite effect of accumulation" (RPDC reference 301).*

It is noted that many of these comments were made after reading of the draft IIS, and reference the Hydrodynamic Modelling report of July 2006. Since that time, additional modelling work has been completed, much of which addresses some of the submissions pertaining to hydrodynamic modelling and the flushing of Bass Strait.

On this basis, the following responses provide a more detailed summary of the modelling tasks undertaken, and how these reflect (account for) the flushing characteristics of Bass Strait.

6.1.2 Model Extent

The modelling effort has been significant, with the extent of the far-field model covering all of Bass Strait. This means that results in the vicinity of the outfall are not limited (or influenced) by having a small model with the model boundary close to the area of interest. By adopting a model that covers all of Bass Strait, GHD's approach allows large scale forces to be represented, similar to the approach by Sandery.

Hence, global scale driving forces are represented in both GHD's and Sandery's models, and should yield similar results. Indeed, a preliminary comparison of a longer model run by GHD to Sandery's results would appear to confirm that both operate in a similar manner, and achieve similar results with respect to flushing.

6.1.3 Model Structure

The modelling structure adopted comprises a nested approach, where nested refers to a series of model grids sitting inside each other (consider Russian Dolls as providing a good analogy of the nesting process). Hence, the largest model (grid B) covers all of Bass Strait. Model C sits inside this, and covers an area of 140km by 150km. Model D sits inside model C, covering an area of 27km by 27km. The advantage of this approach is that a more detailed grid (i.e. finer resolution) can be used in the primary area of interest, with larger grid cells used at more remote points (in this case, larger grid cells are located over 100km away from the outfall).

Each of GHD's models possesses a finer resolution than that used by Sandery, as summarised below:

- Sandery grid (approx 3.7km x 3.7km)
- GHD B grid (approx 1km grid cells)
- GHD C grid (250m grid cells)
- GHD grid D (varying grid cell dimensions with the largest cells at 250 x 250m, and the smallest cells 50m x 50m).

Finally, the D grid is a 3 dimensional grid, with 5 layers represented. Each layer is 5m in thickness, allowing vertical mixing to be represented.

6.1.4 Representation of Winds

GHD have obtained wind data covering the whole of Bass Strait, rather than rely on a land based wind record. This data allows a more thorough representation of wind effects on circulation, which is important given the dominance of wind referred to in Section 7.1.1 above. Of equal importance is that the GHD model is driven by both wind and tide, with these driving forces applied at the model boundary (i.e. at the edge of grid B which covers the whole of Bass Strait).

6.1.5 Equilibrium / Pollutant Build-up

A common opinion offered in the submissions related to whether pollutant build-up has been adequately simulated. This is considered to be an important issue, and one that is commonly addressed in these types of projects. In order to consider the potential for build-up to occur, GHD have conducted model runs spanning periods of 10 days, 60 days, and several months. We have then reviewed results in two different ways. The first of these relates to the preparation of a time history plot showing concentration vs time. An example of this is provided as Figure E11 in the January 2007 report. This figure illustrates concentrations predicted during the last 30 days of a 60 day simulation, and demonstrated no increase in concentration compared to the first 30 day simulation.

The second means of comparison involved the preparation of dilution contour maps, presented in terms of 5th percentile, median, and 95th percentile values. Similar maps were prepared for each of the different simulation periods. Results did differ, but were of

similar magnitude in all cases, with emphasis placed on predicted dilutions at the mouth of the Tamar. The differences reflect the different tidal conditions over the period of simulation, and in the case of the 6 month run, different models (i.e. the 6 month run utilised the C grid and was run in 2D mode, whereas the other runs relied on the 3 dimensional D grid.)

Overall, the review of results as described above, indicates that the shorter run does provide a good representation of dilution, with similar magnitude results generated for all three cases. In other words, concentrations would appear to reach a point of equilibrium in a period of no more than 30 days.

6.1.6 Implications with respect to flushing time

GHD's modelling effort supports the suggestion that parts of Bass Strait can take up to 6 months to flush. However, as indicated above, this does not mean that pollutant levels will build up over this timeframe. It is noted that:

- Large bodies of water do take a long time to flush. This does not mean that they are poorly flushed. If a small body of water were to take 6 months to flush, then this might be a problem. However, Bass Strait is a very large body of water, with two lengthy deep ocean boundaries.
- The modelling takes account of the flushing characteristics of Bass Strait, and is conservative in terms of not representing decay processes. Hence, if build up is likely, the model will demonstrate this. Additional tests undertaken suggest that in the vicinity of the outfall, maximum concentrations occur with a period of 30 days, and that longer runs do not show further increases in concentration.

6.1.7 Conclusion with respect to flushing

The adopted modelling process has been rigorous, and takes account of key processes / driving forces. We note that:

- The model extent covers the whole of Bass Strait;
- A nesting process has been adopted, resulting in a fine resolution mesh;
- Large scale winds have been represented;
- The dispersion and dilution of pollutants within the model extent is well represented;
- A conservative approach has been adopted (refer Section 3.7), with processes such as pollutant decay, sub-Arctic surface current and wave induced mixing not represented. If these factors were included, greater mixing / dilution would be evident, and lower pollutant concentrations predicted.
- Model results suggest a state of relative equilibrium has been reached within a relatively short period of time, and that the build-up of concentrations beyond this equilibrium state are not indicated.

6.2 Flushing of the Tamar River

A number of submissions suggested that flushing of the Tamar needed to be addressed, or that long term pollutant accumulation would occur, and that modelling of the Tamar is inadequate. It is noted that the modelling system adopted by GHD includes the full length of the Tamar, and that river flows corresponding to a period of low flow were included. Hence flushing characteristics of the Tamar are also well represented.

6.3 Model Grid Size

The majority of concerns expressed with respect to model grid size related to the modelling reported in July 2006. For this report, the grid consisted of 250m long cells, with modelling conducted in 2 dimensions. Since that time, the grid cell size in the vicinity

of the outfall is 50m, with 5 layers evident. Hence, there are now 125 cells where previously there was one.

6.4 Two Dimensional (2D) versus Three Dimensional (3D)

Concerns were expressed in relation to the use of 2D rather than 3D models. This has now been addressed, with use made of 2D and 3D models. It is noted that 2D models remain valid for large scale assessments, with 3D models providing greater detail in the vicinity of the outfall itself. A review of results close to the outfall shows the plume concentrating in the surface layer close to the diffuser, but becoming fully vertically mixed with distance from the diffuser. In areas where full vertical mixing has occurred, 2D remains valid.

6.5 Model Calibration and Verification / Concurrency of data

At the time of model development, recorded data at the site was not available. For this reason, current data from other locations in Bass Strait was sought. However, this data covered different time periods, hence several comments about the lack of concurrent data. It is suggested that having the model represent tidal patterns throughout Bass Strait is a strong indication of model performance, and that the lack of concurrent data is not a concern. Concurrent data was held for December 2005 (wind, tide and currents), with tide and wind data also available for April 2005. Given that the model is used to address a range of tidal conditions, with winds superimposed, the concurrency of data has not inhibited the reliability of the modelling process, nor the conclusions that have been drawn.

6.6 Use of April 2005 as the month upon which results are based

Average concentrations and probability of exceedance may vary due to seasonal effects but are not expected to exceed the current values which have been obtained for a period of relatively low energy in the receiving waters leading to generally high average concentration at the proposed ocean outfall site. The month of April is conservative owing to the non-representation of waves or significant wind events. Waves will add turbulence, thereby increasing the dilution achieved. Hence it is reasonable (and conservative) to apply any month of results where wave effects are not represented.

Reference should also be made to Section 3.7 (Assumptions and Conservatism)

6.7 Representation of Wind and Waves

There has been no allowance for the additional mixing forces of waves, which promote turbulence. The absence of waves (which corresponds to low energy conditions in the receiving waters) should lead to estimation of higher average pollutant concentrations at the proposed ocean outfall site, than if waves were represented.

6.8 Stratification

A range of comments were received with respect to stratification. Some of these indicated that stratification can occur, and should be represented, whilst others suggested that stratification in the vicinity of the outfall was quite unlikely. Sandery's submission of 25th August 2006 notes that "*Of course there will be little or no stratification observed at this location due to the shallowness and relatively strong tidal currents in the area*".

On this basis, it is considered that the model is appropriate for the consideration of effluent discharge in shallow waters, and that stratification does not need to be considered.

6.9 Impacts of Wharf Construction in the Tamar River

Hydrodynamic impacts associated with construction of a wharf in the Tamar River were dealt with in a December 2005 report (refer Chapter 5 of Appendix 64 in Volume 18 of the draft IIS). This showed negligible impact, with only one location (Point D adjacent to the shoreline) likely to result in a reduction in velocities and shear stresses experienced. We do not agree with submissions stating this is a significant impact, and that large scale sediment deposition and stagnation will occur. The river will remain well flushed, with negligible impact associated with the presence of a piled wharf. Hydrodynamic modelling indicated almost no change post construction, and hence we now regard it as unnecessary to perform water quality modelling.

6.10 Representing Buoyancy

Concerns with respect to the lack of representation of buoyant effects of the plume have now been addressed. This process is described in Sections 3.5 and 3.6 of the January 2007 report, and may be summarised as follows:

- Near field results were reviewed to see over what distance the plume disperses;
- The buoyancy effect was accounted for by releasing the entire plume at the surface above the diffuser; and
- Consideration of both items led to the decision to release effluent in 18 surface layer cells, covering a surface area of 300m by 150m. It is reiterated that the diffuser is 200m long, and hence the plume must be released over an area at least 200m in length.

6.11 Modelling of Sediment Deposition

The Scope Guidelines (refer Page 35, (section 7.8.1(5)) require a review of potential impacts associated with sediment deposition.

However, a review of data provided by Jaakko Poyry suggests that discharged particles will be fine in nature, with low settling velocities (potentially as low as 0.3m per day, in the absence of wind or waves which would act to resuspend or hinder settling of the particles).

With a depth of 25m of water, settling could take 5 to 80 days, if in a quiescent environment. Over this period of time, particles would be widely dispersed, and could easily cover distances of the order of 20km or more.

Jaakko Poyry have advised that fine (organic) particulate matter would be discharged at 20 mg/L. This equates to 1.28 m³/day, or 466 m³/year.

Whilst the simulation of drogues in the model has indicated extensive tidal excursions on a daily basis, a conservatively small estimate of the area over which deposition might settle is 20km x 0.5 km = 10 km². A similar value can be surmised by viewing plume footprints covering 5km by 2km area.

A volume of 466 m³ spread over 10 km² would result in a depth of only 0.047mm per year. However, given that particles may not settle as quickly as estimated, and given that the material is organic, and will decay, the actual rate of sedimentation could easily be lower than predicted. This depth of settlement is negligible, and confirms that modelling of sediment deposition is not warranted.

6.12 Selection of Water Quality Parameters

A large number of statements were received with respect to the selection of water quality parameters, and the assignment of trigger values for each of these parameters. Many of the concerns (or uncertainty) raised in these submissions have been dealt with in the Water Quality Assessment report (January 2007). That report provides scientific

justification for the selection of a range of pollutant concentrations. It is also recognised that the proposed water quality objectives (and background concentrations) are effectively interim values, and will be updated as additional field data is collected.

6.13 Looping of Data to Perform Water Quality Runs

The Tasmanian Government (whole of government submission) suggests that looping of 1 day of hydrodynamics to drive the water quality model is unusual, and is therefore not adequate. Our response is that the method is quite common. However, the January 2007 report does refer to results based on 50 to 60 days of simulation, with results recorded over a 10 day period. A comparison with longer period runs has also been made, suggesting that the shorter period provides a good representation of dilution in the vicinity of the diffuser, and that the recommendation of mixing zone based on this period of results is justified.

6.14 Potential Impacts on Beaches

A submission by Victoria Jansen-Riley (Sept 2006) queries whether there is a human health risk at beaches. This has been dealt with by others (Toxikos), using dilution predictions from the modelling exercise. The modelling indicates that dilutions beyond the mixing zone are high, and hence concentrations of pollutants beyond this zone would be negligible. A query is also raised with respect to whether the regular loss of sand at Bell Buoy Beach is due to tidal currents, and whether returning sand could be contaminated. It is suggested that in the vast majority of cases, sand is lost from beaches during high wave conditions, with the sand deposited a short distance off-shore. The same sand returns when conditions are calmer. It is considered most unlikely that sand would be transported 3 kilometres offshore to the diffuser location, and then be transported back.

6.15 Climate Change

Sandery (August 2006) suggests that climate change may lead to decreased flushing within Bass Strait. Whilst climate change is undoubtedly an important consideration in many cases, reference to Section 6.1 above should indicate that such a change would appear unlikely to cause a significant change in flushing characteristics closer to the outfall, which are dominated by tide, wind and waves. The conservative nature of the work completed to date would also counter changes that may be attributed to future climate change.

7 Conclusion

Conclusions reached from modelling process are discussed below.

7.1 July 2006 Mixing Zone

Based on consideration of near field and far field results, the original report defined the mixing zone as 500 m x 275 m.

7.2 August 2006 Mixing Zone

Based on the additional hydrodynamic modelling works, the following observations leading to a re-evaluation of the extent of the mixing zone were made:

- ▶ AOX was the primary substance exceeding the nominated WQO.

- ▶ With the effluent plume released in the bottom layer, the extent of the mixing zone was at a maximum near the bottom. This result is consistent with the assumption of the effluent being fully mixed in the receiving (bottom) cells, but does not account for buoyancy effects.
- ▶ However, near field assessments confirm the buoyant properties (and behaviour) of the plume, with the knowledge that maximum concentrations should not occur on the bottom layer. Both sets of results were therefore taken into account when defining (proposing) the mixing zone.
- ▶ Allowances need to be made for unrepresented factors (e.g. minor translation of the plume owing to prevailing winds). An allowance of 125m was selected,
- ▶ This led to a minimum recommended mixing zone of 550m (EW) X 500m (NS).
- ▶ From a near field context, the minimum extent of mixing zone was suggested as 250 m (EW) x 500 m (NS).
- ▶ Based on each of the above, the minimum suggested mixing zone was defined as 550 m (EW) x 500 m (NS), which is slightly larger than suggested in the previous (July 2006) report.

7.3 January 2007 Definition of Mixing Zone

The January 2007 report provides the most comprehensive representation of dispersion of the plume. This has occurred for two reasons:

- Additional work was completed with respect to the definition of background concentrations of pollutants and recommended trigger values, whilst to a lesser extent, slightly modified effluent characteristics were also provided.
- The recognition of near field results in defining the discharge of the plume into the far field model has also led to a better representation of plume characteristics, accounting for the effects of buoyancy and turbulent mixing in the near-field.

The recommended mixing zone is presented as a range, in accordance with some uncertainty as to the background concentration of chlorate. Whilst a commonly expressed opinion by many of those involved in this project is that chlorate is unlikely to be present in the receiving environment, a background concentration has been considered. Hence, the recommended mixing zone lies in the range of 500m by 500m, up to 800m by 800m.

It is noted that should additional information be discovered with respect to chlorate, then the size of the recommended mixing zone may decrease. This may also be true as additional water quality data is collected at the proposed outfall site.

7.4 Overall Conclusion

Revised modelling using a higher density grid (50m element size) and three dimensional representation of depth (5 layers) has been completed subsequent to exhibition of the Draft IIS. Furthermore, the discharge of the plume was simulated as if released into the surface layer of the model, in order that buoyancy effects could be more realistically represented. This allowed a better derivation (understanding) of plume shape, whilst confirming that a mixing zone of the order of between 500m by 500m and 800m by 800m should be considered on the basis of hydrodynamic modelling, and a comparison of predicted concentrations against water quality objectives.

It is considered that the smaller mixing zone is more realistic, given several layers of conservatism built into assumptions, and the potential for additional field data to result in lower pollutant concentrations.

It is noted that this recommendation is based on the consideration of 95th percentile results, which would need to be reflected in the compliance monitoring regime.

8 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.

Attachment 1

Qualifications

Refer attached CV

Relevant publications

Refer attached list of papers

Attachment 2

August 2006 Report

Attachment 3

January 2007 Report