Prepared for

BlueScope Steel Limited

Application for Modification of Wollongong City Council Development Consent DA767/01A

Illawarra Cogeneration Plant Project – Salt Water Cooling



Final

May 2008

Reference: 332533

CH2MHILL

CH2M HILL Australia Pty Ltd
Level 7, 9 Help Street
CHATSWOOD NSW 2067
Phone 02 9950 0200
Fax 02 9950 0600

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Abbreviations	
ANZECC	Australian and New Zealand Environment and Conservation Council
ARA	Appropriate Regulatory Authority (as defined in *Protection of the Environment Operations Amendment Act 2005*)
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
CLT	Cardno Lawson Treloar Pty Ltd.
CW	Cooling Water
DEC	Former NSW Department of Environment and Conservation (formerly NSW EPA)
DECC	NSW Department of Environment and Climate Change (formerly NSW DEC)
Delta-T (ΔT)	Temperature change
DGH	Dodecylguanidine Hydrochloride
DoP	NSW Department of Planning (formerly DIPNR)
EIS	Environmental Impact Statement
EPA	NSW Environment Protection Authority (now part of DECC)
EPL	Environment Protection License
ICP	Illawarra Cogeneration Plant
m	Metre
max	Maximum
min	Minimum
ML	Megalitre
MSDS	Material Safety Data Sheet
MW	Megawatt
N	Number
NOEC	No Observable Effect Concentration
NSG	NewSouth Global Consulting Ltd
NSW	New South Wales
PAH	Polycyclic Aromatic Hydrocarbons
PKHEG	Port Kembla Harbour Environmental Group
PKSW	Port Kembla Steelworks
Pm	Proportion of Port Kembla Harbour through the ICP cooling system in one residence time.
POEO Act	*Protection of the Environment Operations Act NSW 1997*
ppm	Parts per million
PRP	Pollution Reduction Program
S.D.	Standard Deviation
STG	Steam Turbine Generator
STP	Sewage Treatment Plant
SW	Salt Water
TSS	Total Suspended Solids
TTE	Tertiary Treated Effluent
UNSW	University of New South Wales
WCC	Wollongong City Council
WQO	Water Quality Objective

Executive Summary

Wollongong City Council has granted development consent for the construction and operation of a cogeneration plant, known as the "Illawarra Cogeneration Plant" (ICP Project) at the BlueScope Steel Limited (BlueScope Steel) Port Kembla Steelworks (PKSW). Since the Development Consent for the Project was granted, various changes to PKSW (both internal and external) have occurred. These changes have resulted in proposed modifications to the ICP Project by BlueScope Steel. One of the key modifications, which is the focus of this report, is replacement of the approved recirculating fresh water cooling tower system with a once through salt water cooling system sourced from Port Kembla Harbour.

This report has been prepared to address the Department of Environment and Climate Change (DECC – formerly the Department of Environment and Conservation) requirements for the proposed modification. DECC correspondence dated 21/12/05 and 26/10/07 outline the issues to be addressed (see **Appendix A**).

The original Development Consent approved the construction and operation of a closed circuit cooling tower which would require the use of fresh dam water (sourced from Avon Dam) and tertiary treated effluent (TTE) from the Wollongong Sewage Treatment Plant (STP) as system make-up water.

The proposed modification involves drawing salt water from Port Kembla Harbour via the existing salt water channel to be used as cooling water through the condenser of the new ICP turbine. After passing through the condenser, the heated water (temperature increased by 6.9°C under typical conditions) would be returned to the Inner Harbour via a system of new underground pipelines and box culverts, running adjacent to the Raw Materials Secondary Ore Yards and a new discharge / dispersion structure located in the mouth of Allan's Creek.

As a result of the proposed modification to the ICP cooling system, BlueScope Steel engaged Cardno Lawson Treloar Pty Ltd and NewSouth Global Consulting to assess the potential impacts on the temperature and ecology, respectively, of Allan's Creek and Port Kembla Harbour resulting from the modification of the ICP cooling system. A temperature increase of greater than 3°C was considered by NewSouth Global Consulting to result in detectable ecologically important changes.

The following potential impacts on the surrounding environment were identified:

- An increase in temperature of less than 1°C into Allan's Creek and Port Kembla Inner Harbour during typical operations.
- A maximum increase in temperature of 2.6°C at any of the modelled locations for the conservative worst case summer maximum heat load conditions.
- The extent of the mixing zone during maximum summer heat load conditions is expected to be within 40m of the discharge device.
- A potential impact on the marine biota (including plankton) of Allan's Creek and Port Kembla Harbour resulting from the higher proportion of the Harbour volume passing through the Steelworks heat exchange devices; and

- The potential impact of an anti-fouling agent in Allan's Creek and Port Kembla Harbour required to control macro-fouling in the cooling system.

Based on the results of the temperature modelling, during typical summer and winter operating conditions, (i.e. the increase in water temperature in the Harbour is predicted to be less than 0.8°C at most depths), it was concluded by NewSouth Global Consulting that "no major loss of biota from marine communities within the already highly modified ecosystem of the Harbour would occur".

During the maximum summer conditions, where temperature increases may exceed 3°C at the mixing zone, a detectable impact on the marine biota, including a decrease in the abundance of plankton, may occur. However, the impact is likely to be confined to a relatively small area near the ICP discharge point.

The potential impacts associated with the proposed salt water cooling (as outlined in this report), are considered acceptable in light of the significant benefits associated with the proposed modification. They include:

- Elimination of the need to consume approximately 10 ML/day of Avon Dam water. BlueScope Steel is working with both Sydney Water regarding allocation and quality of the TTE, and with the NSW DECC regarding a Water Savings Action Plan for the PKSW.
- elimination of the large on-site chemical inventory necessary for operation of and extensive system of cooling towers; and
- elimination of the blow down water stream from the cooling tower back to the Wollongong STP.

The use of a once-through salt water cooling system to cool the ICP's steam turbine generator ensures the certainty of availability and quality of the salt water resource, is a method currently used and proven at the PKSW and in turn, will facilitate the efficient operation of the ICP.

In addition, analysis done to date shows a minimal potential impact on the Port Kembla Harbour.

Description of the Approved Project and Proposed Salt Water Cooling Modifications

1 Introduction

1.1 Purpose of Assessment

BlueScope Steel has identified a need to modify aspects of the currently approved Illawarra Cogeneration Plant Project (the ICP Project).

In November and December 2005, BlueScope Steel initiated discussions with the former NSW Department of Environment and Conservation (currently the Department of Environment and Climate Change, DECC) with respect to the proposed modifications.

DECC has provided BlueScope Steel with a number of issues to be addressed with respect to these modifications in correspondence dated 21 December 2005 and 26 October 2007 (see **Appendix A**). These issues include reference to earlier modelling and ecological assessments commissioned by BlueScope Steel and submitted to DECC that were undertaken between April and July 2005 by Cardno Lawson Treloar Pty Ltd (CLT) and the School of Botany, University of Melbourne, respectively.

Since the initiation by BlueScope Steel of discussions with the DECC in late 2005, regular consulting by BlueScope Steel with DECC has occurred in relation to the scope of the salt water cooling assessment.

This report addresses DECC's issues raised in correspondence with respect to a proposed modification from the currently approved recirculating fresh water cooling tower system to a once-through salt water cooling system.

1.2 Summary of Issues Raised by the DECC

Table 1.1 summarises the key issues raised by the DECC in relation to salt water cooling and identifies the location in this report where the issue is addressed.

Table 1.1 Summary of issues raised by DECC regarding salt water cooling

DECC Issues Raised (December 2005)	Reference in DECC letter	Location in this report
Priority Outcomes for DECC in considering the proposal of a once through salt water cooling system	Page 2	**Section 6**
Consideration of environmental values of water to include:		**Section 4**
• Definition of primary management aims	Page 4	Section 4.1
• Determine appropriate trigger values for selected indicators	Page 4	Section 4.2.1
• Assess test site data and refine trigger values	Page 4	Section 4.2.2
• Define Water Quality Objectives	Page 4	Section 4.3 and Table 4.1
• Establish a monitoring and assessment program	Page 4	Section 4.5

DECC Issues Raised (December 2005)	Reference in DECC letter	Location in this report
• Factors to be considered when assessing whether a change to the thermal regime will result in adverse effects to an aquatic ecosystem	Page 5	Section 4.3.1 - Section 4.3.6
o The lethal tolerance range	Page 5	Section 4.3.1
o The influence on the rate of primary production	Page 5	Section 4.3.2
o Influence on the rate of secondary production	Page 5	Section 4.3.3
o Tolerances of the various life stages of the species	Page 5	Section 4.3.4
o Impact on species richness and natural community composition	Page 5	Section 4.3.5
o Influence on enzyme-dependent microbial (biochemical) processes	Page 5	Section 4.3.6
Other Issues/Pollutants of Concern		
• Toxic effects of chemicals in the cooling water	Page 5	Section 4.4.1
• Change to flows or levels of pollutants	Page 5	Section 4.4.2
• Temperature effects on other parameters and toxicity of other parameters	Page 5	Section 4.4.3
• Physical impacts of the discharge on the water body	Page 5	Section 4.4.4
Review of the likely ecological effects of increased temperatures in Allan's Creek and Port Kembla Harbour dated August 2006 prepared by Jan Carey, School of Botany, University of Melbourne to be updated and include:		**Section 3**
• Comparative assessment of the organisms found in Port Kembla Harbour with those found in comparable more natural locations	Page 8	Section 3.2
• Identify species in a "Slightly to Moderately" disturbed system	Page 8	Section 3.2.2
• Aspects of the current environment and proposal that may be excluding species • Amelioration measures to minimise exclusion from the current environment.	Page 8	Section 3.2.3 Section 3.2.4
Numerical modelling of Cooling Water Field – Progress Report 3 dated 8 July 2005 and prepared by CLT to be updated and must include:		**Section 2**
• Explanation and justification of modelling technique used, modelling approach and set-up	Page 8	Section 2.2.5 Appendix D – Sections 2 - 4
• Model the predicted temperature change on Port Kembla Harbour post-ICP under both typical and worst case conditions for summer and winter	Page 8	Sections 2.3
• Simulated 50th percentile temperatures must be compared with 80th percentile natural ambient temperatures	Page 8	Appendix D
• Discuss factors which may bias the modelling assessments	Page 9	Section 2.2.5
• Substantiate the adoption of 22.5ºC as the boundary temperature	Page 9	Section 2.2.1
• Verification of model against observation of actual water temperature	Page 9	Section 2.2.1
• Consideration of location of discharge point and discharge port configuration	Page 9 Page 10	Section 2.2.2; Appendix D and Appendix E

DECC Issues Raised (December 2005)	Reference in DECC letter	Location in this report
• Modelled dilution estimates for toxicants in the discharge	Page 9	Section 3.3.2 and Section 3.5
• Clarification on volumes of discharge streams and position of intakes and outfalls	Page 9	Section 1.3 and Figure 1.2
• Near-field mixing zones	Page 6	Section2.2.6
• Optimising mixing performance of a discharge		Section 2.2.2;
Issues to be Addressed by BlueScope Steel		
• Temperature tolerances and preferences of organisms likely to be found in Port Kembla Harbour	Page 9	Section 4.4.5
• Effects of enhanced temperatures on uptake of heavy metals and Polycyclic Aromatic Hydrocarbons (PAHs)	Page 9	Section 3.3.1
• Risk of Introduced species	Page 9	Section 3.2.5
• Toxicity of discharge associated with biocide and elevated temperature	Page 9	Section 4.5.1
• Assessment of toxicity of discharge for a range of dilutions	Page 9	Section 3.3.2 and Section 3.5
• Assessment of potential effects of extraction on zooplankton	Page 9/10	Section 3.4
• Suggest options to ameliorate thermal impacts	Page 10	Section 2.2.2
• Monitoring.		Section 4.4

Key DECC Issues Raised (October 2007)	Reference in DECC letter	Location in this report
• Clarification of level of ecosystem protection	Issue 1	Section 2.1
• Update/revise issue of entrainment	Issue 2	Section 3.4.2 - 3.4.4
• Proportion of Harbour volume pumped through the salt water pumping station in each residence time (Pm).	Issue 3	Section 3.4.3
• Consequences of the loss of Pm proportions of plankton and larvae on Port Kembla Harbour Ecology.	Issue 4a	Section 3.4.4
• The importance of planktonic components to the ecology of Port Kembla Harbour, both as a food source and as a source of recruits	Issue 4b	Section 3.4.4
• Whether plankton show stratification in the water column and whether measures such as depth selective inlets would minimize entrainment.	Issue 4c	Section 3.4.4
• Entrainment consequences to aquatic organisms	Issue 5	Section 3.4.4
• Cumulative impacts associated with other thermal discharges	Issue 6	Section 2.3
• Consideration of potential configuration of Port Kembla Harbour	Issue 7	Section 3.4.1
• Assessment on viability of biological controls (physical and chemical)	Issue 8	Section 3.5
• Methodology to validate the modelling outcomes	Issue 9	Section 4.5.3

1.3 Description of the Proposed Salt Water Cooling Modification

The approved ICP Project included a closed circuit, recirculating, fresh water cooling system. It was designed to use tertiary treated effluent (TTE) at a rate of approximately 13ML/day from the Wollongong Sewerage Treatment Plant (STP) in a cooling tower located at the approved ICP site. A small volume (approximately 1.5ML/day) of blow down water was to be piped back to Wollongong STP.

Figure 1.1 shows the location of the approved ICP development including the TTE cooling system.

The proposed modification by BlueScope Steel addressed in this report is a modification of the recirculating, fresh water, cooling system to a once-through, salt water, cooling system.

Salt water drawn from Port Kembla Outer Harbour is proposed to be used as cooling water for the Steam Turbine Generator (STG) condenser of the ICP.

Salt water is presently drawn from Port Kembla Outer Harbour into the existing salt water inlet channel via high volume, low pressure lift pumps at a rate of approximately 30,000m^3/hr for use throughout the Steelworks. Post-ICP, approximately 60,000 m^3/hr of salt water would be extracted from the Harbour into the salt water inlet channel using the current lift pumps running at a higher rate. A flow of 30,000 m^3/hr (i.e. half of the total flow in the salt water inlet channel) will be drawn from the salt water channel and directed to the ICP using new cooling water pumps located on the ICP site.

The ICP would use the salt water to cool the STG condensers and then return this heated water back to Port Kembla Inner Harbour (see **Figure 1.2** and **Figure 1.3**). Cooling water would be transported to Allan's Creek from the ICP via a system of underground pipelines and culverts running adjacent to the Raw Materials Secondary Ore Yards (see **Figure 1.4**). The salt water would exit at the mouth of Allan's Creek via a discharge device approximately 200m downstream of the existing No. 2 Blower Station Drain where Allan's Creek widens before joining Port Kembla Inner Harbour.

Under existing average conditions, Allan's Creek has a flow rate of 839ML/day, 687ML/day of which flows from the existing No.2 Blower Station Drain, 101ML/day from Main Drain and 15ML/day as a result of off-site upstream 'natural' flow from the Creek itself. The balance of flow is made up of contributions from the Plate and Slab Mill Drains. Under post-ICP average conditions, Allan's Creek is expected to have a flow rate of approximately 1,300ML/day. No.1 Power House contributions into the Main Drain will cease with the remaining Main Drain flow consisting of Webb's Lagoon overflow and Cringila stormwater. No. 2 Blower Station Drain contributions will decrease to 608ML/day. The new ICP Drain will add approximately 650ML/day.[1]

The cooling water piped from the ICP will have a higher temperature than the waters of Allan's Creek and Port Kembla Inner Harbour. Recognising potential ecological effects, modelling has been undertaken to assist in the prediction of the dissipation of this heat load, the expected increase in temperature in these water bodies and the subsequent effect on the aquatic ecosystem. Before being discharged into Allan's Creek, the salt water would be distributed by a device which would ensure the cooling water is discharged into the upper layers of the water column to minimise vertical mixing and maximise cooling by atmospheric processes.

As a result of the proposed modification to the cooling system, the following would no longer be required for the ICP:

- Cooling tower; and
- Potable water or TTE from the Wollongong STP of the order of 13ML/day.

Operation of the ICP would still involve decommissioning of the No. 1 Power House and cessation of the associated flows and temperature loads into the Main Drain as per the approved ICP Project.

1.3.1 Options to Ameliorate Thermal Impacts

Prior to determining the proposed arrangement of the once-though salt water cooling system with a discharge to Allan's Creek, BlueScope Steel undertook a detailed assessment of the available methods of ameliorating the potential thermal (and associated ecological) impacts of cooling water discharge. **Appendix B** provides a detailed assessment of the options considered. These include:

- Dilution;
- Salt Water Cooling Tower;
- Remote discharge point;
- Chiller units; and
- Cooling by cryogenic liquid vaporisation.

A weighted assessment of options was undertaken by BlueScope Steel that used technical feasibility, cost, environmental issues and space requirements as the assessment criteria. The preferred option from this assessment was to refurbish the salt water channel to increase its capacity and then discharge into Allan's Creek via

*[1] Detailed tabulation of the existing and post-ICP drain flows and temperature differences (ΔT °C) from BlueScope Steel that contribute to heat load in Port Kembla Harbour under existing and maximum load conditions for summer are provided in Tables 4.1 and 4.3 respectively of **Appendix B**.*

underground outlet pipes running adjacent to the Raw Materials Secondary Ore Yards.

1.3.2 Location of Salt Water Discharge

The PKSW site presents a number of constraints with respect to the location of the discharge point as described below:

- Placement of the discharge point outside of Port Kembla Harbour would require a pipeline to cross various other industrial enterprises and other stakeholder properties. This would cause difficulties during construction and duruing general maintenance activities. In addition, this would direct the heat load to a less disturbed part of Port Kembla Harbour, increasing the zone affected by anthropogenic influences.

- Construction of a pipeline at an intermediate point along Allan's Creek would be required to negotiate many other utilities located around the No.2 Blower Station and elsewhere in the PKSW and would face construction challenges with other internal infrastructure such as bridges. In addition, due to the predicted salt water cooling discharge flow rate, construction of a pipeline at some intermediate point along Allan's Creek has the potential to cause erosion of the northern bank of Allan's Creek and/or increase sedimentation in Allan's Creek.

- Construction of a pipeline directly into Port Kembla Harbour directly introduces the possibility of the recirculation of heated cooling water being prematurely taken in at the lift pump station saltwater intake, thereby creating the possibility of an upwardly spiralling temperature regime which would have adverse effects on both ICP operability and the surrounding ecology.

Consequently, as shown in **Figure 1.2**, the discharge location has been sited at a location approximately 200m downstream of the existing No.2 Blower Station Drain at a wider point on Allan's Creek. This location takes advantage of reduced interaction with other services thereby minimising plant disruptions. The location is far enough away from the salt water intake lift pumps that it minimises the risk of recirculating heat load. The location is also exposed to the dispersing influences of the tide and atmospheric cooling effects. Whilst moving the discharge point upstream within Allan's Creek (including extension to the Main Drain confluence) emulates the existing heat load conditions, and would provide a greater degree of mixing with any cool water flowing down the creek, there is the potential that such increased flows could disturb sediments or alter the creek form.

1.3.3 Discharge Device Arrangement / Size

A range of options were considered by BlueScope Steel in the design of a device to discharge the ICP cooling water into Allan's Creek. **Appendix C** presents the range of options considered to practically achieve this discharge. These options included:

- A discharge device or pipe at the top of the bank (including ten variants);

- A discharge device or pipe at water level (including five variants);
- A pipe across the floor of the creek (including two variants);
- A discharge across the full width of the creek (including two variants); and
- The discharge further up the creek into shallow water.

BlueScope Steel undertook a detailed assessment of these alternatives. Criteria for the assessment of these options included the influence of tide on where in the water column the discharge will be at any given time relative to the high and low tide water marks, navigability of Allan's Creek, constructability, maintenance and cost.

In addition, to assist in the determination of the arrangement and size of the discharge device, the following scenarios were modelled to determine maximum heat dissipation to minimise the potential ecological effect on Allan's Creek and Port Kembla Inner Harbour:

- A single discharge port with a discharge of $7.5m^3/s$ with a temperature change (ΔT) of 9.4°C. Modelling of this scenario resulted in a possible increase to Port Kembla Harbour water temperature at maximum heat load conditions by over 3.5°C.
- Increased salt water flow through the ICP condensers leading to a lower temperature discharge through a single discharge port. In this case the total heat load remains the same, with no reduction in Harbour temperatures. The single port discharge would still cause mixing with the entire water column, inhibiting cooling by atmospheric processes.
- A multi-port discharge was considered but found to have little impact on the reduction of the temperature increases to Allan's Creek and Port Kembla Harbour.
- The use of a 30m discharge device where the cooling water would cascade down the batter of Allan's Creek and plunge into the creek water. This scenario was modelled as fully mixed through the layers of the water column. This resulted in an increase in the bottom layer temperature at the mouth of Allan's Creek with unacceptable ecological impacts (temperature increases in excess of 3.0°C).
- A discharge device 60m long with the cooling water mixing through the entire water column. There was no reduction in the bottom layer temperatures.
- A discharge device 60m long with the cooling water entering Allan's Creek as a horizontal flow entering only the upper half of the water column. This was found to reduce the temperature increase from the ICP cooling water discharge into Allan's Creek but required a large footprint to accommodate the structure.
- A discharge device 30m long with the cooling water entering Allan's Creek as a horizontal flow entering only the upper half of the water column. This method

was considered to be effective in reducing the temperature increase from the ICP cooling water discharge into Allan's Creek and required a smaller footprint.

Based on BlueScope Steel's own assessment of the alternatives, in conjunction with the modelling results, it was determined that a horizontal discharge into the upper layers of the water column and over a length of 30m would maximise atmospheric cooling effects, minimise the extent of the mixing zone and limit the potential ecological effects.

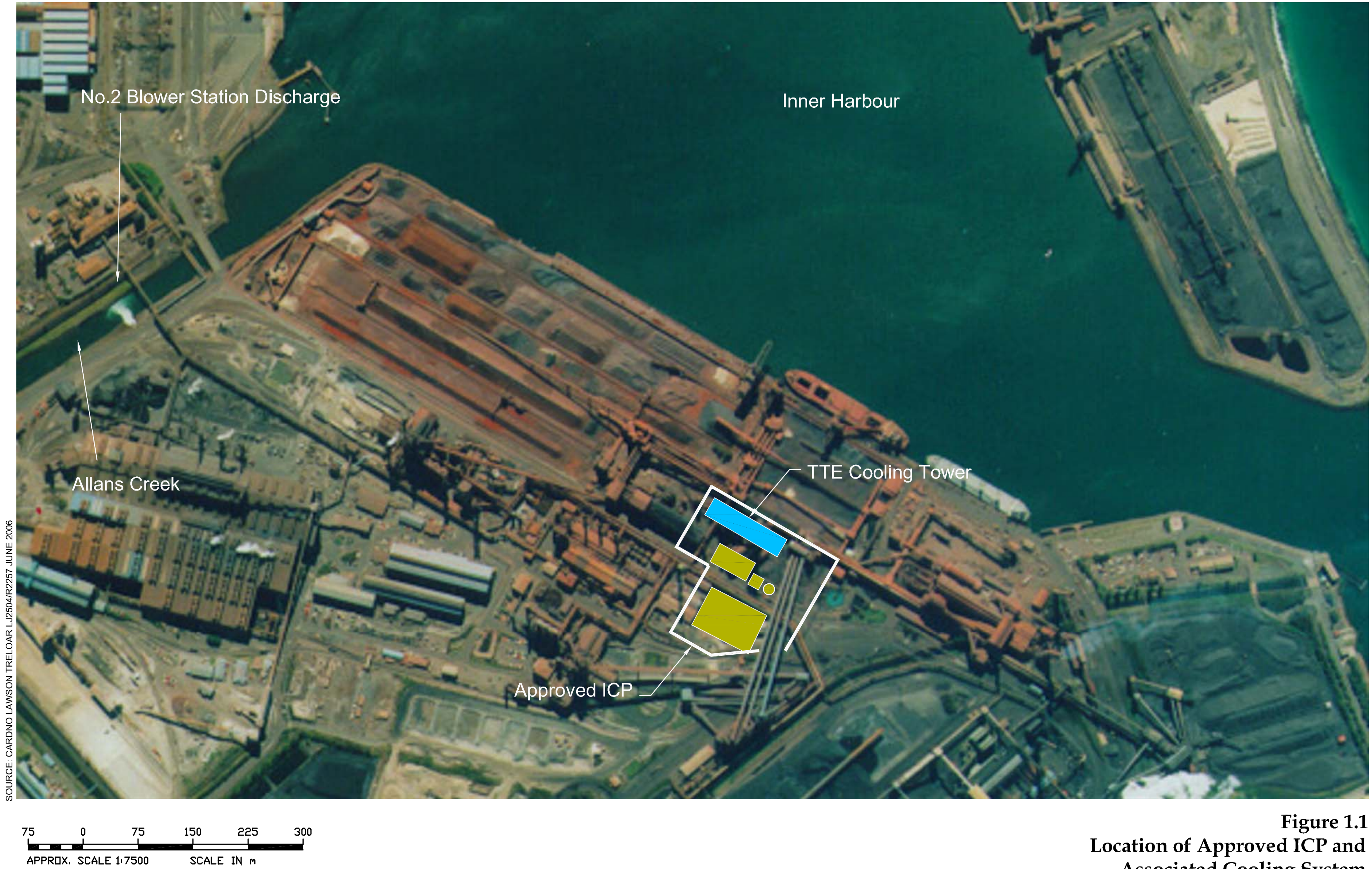


Figure 1.1
Location of Approved ICP and Associated Cooling System

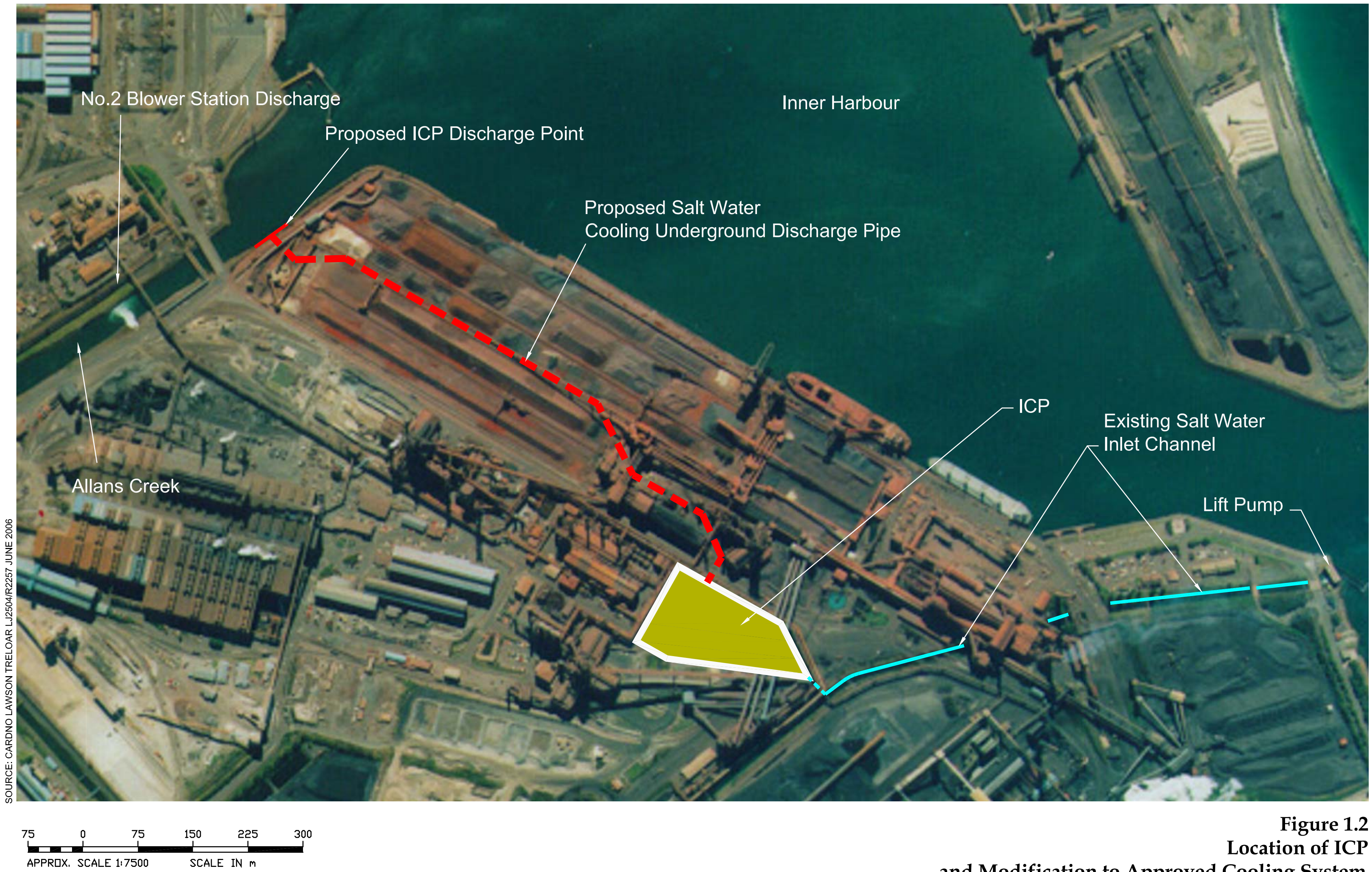


Figure 1.2
Location of ICP
and Modification to Approved Cooling System

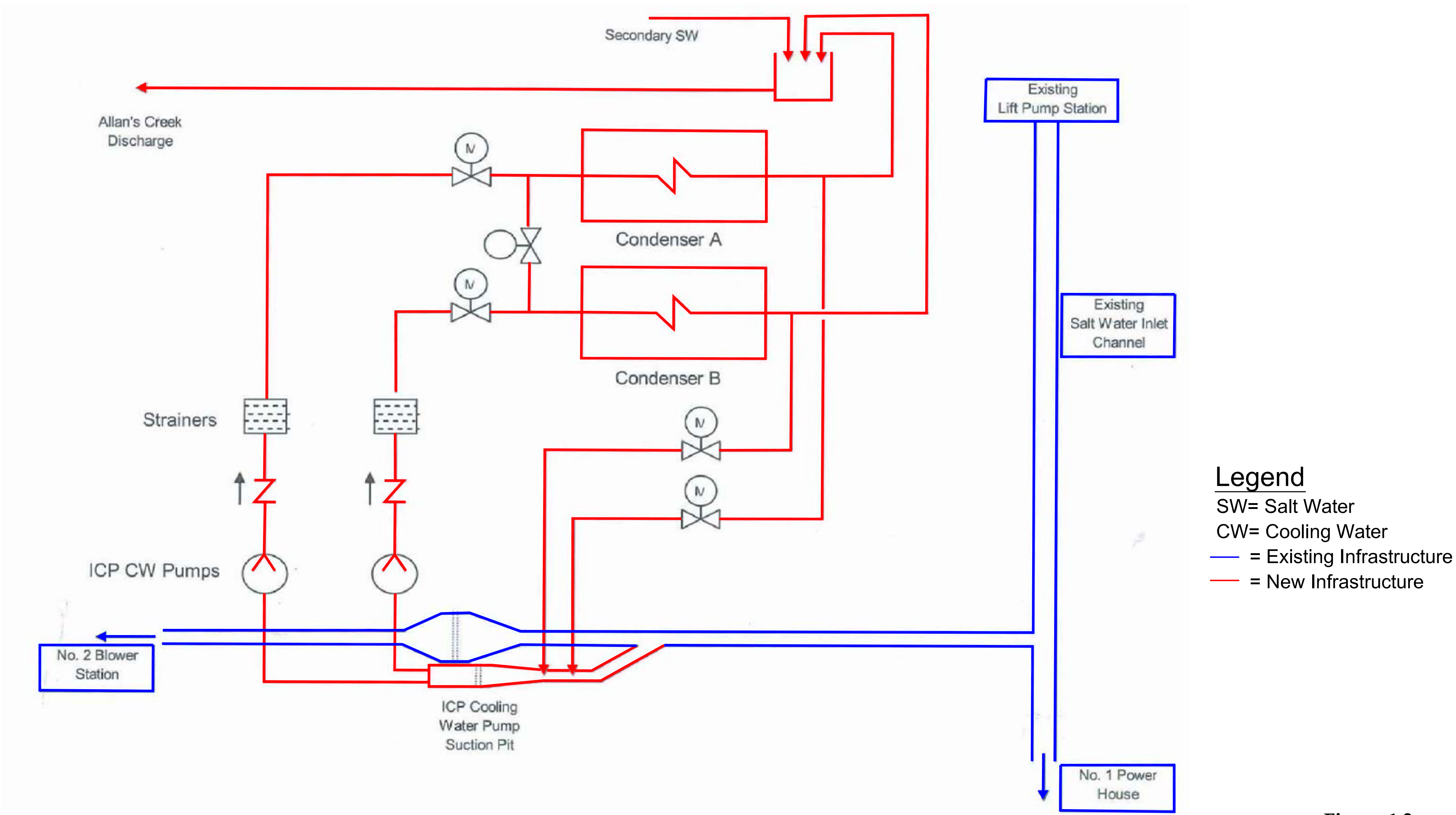


Figure 1.3
Proposed Salt Water Cooling System
Process Flow Diagram

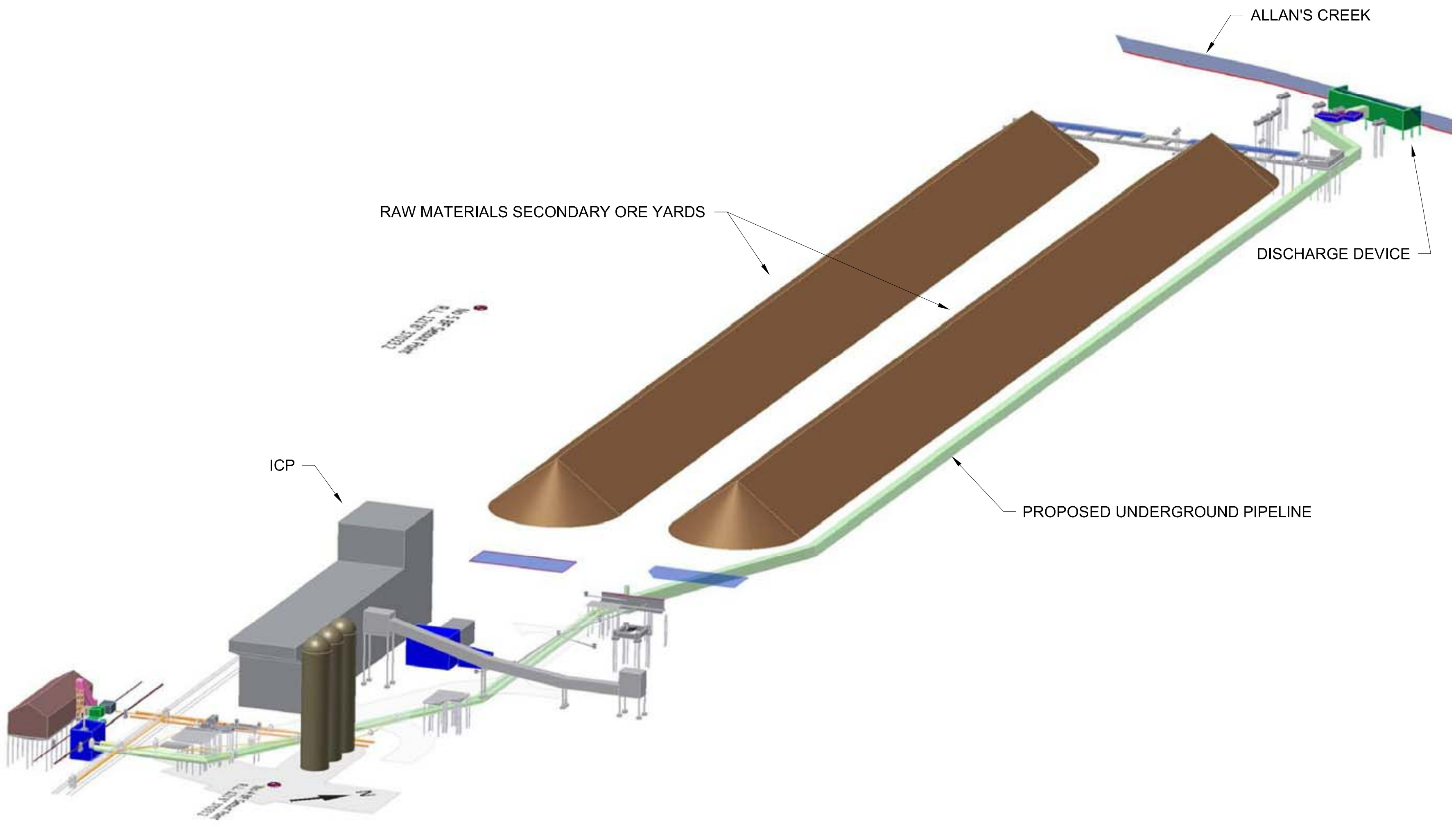


Figure 1.4
Proposed Underground Discharge Pipeline

2 Assessment of Proposed Salt Water Cooling Modifications

Operation of the proposed once-through salt water cooling system is expected to impact on the temperature of Port Kembla Harbour and Allan's Creek. To examine and predict the extent of this impact, temperature modelling was undertaken by Cardno Lawson Treloar Pty Ltd (CLT) in reports entitled, "*BlueScope Steel Limited Illawarra Cogeneration Plant (ICP) Proposed Salt Water Cooling Numerical Cooling Water Studies*" (CLT, August 2006) and "*BlueScope Steel Limited Illawarra Cogeneration Plant (ICP) Proposed Salt Water Cooling Numerical Cooling Water Studies – Addendum Report*" (CLT, April 2008) (see **Appendix D** and **Appendix E).** These reports address the concerns outlined by the DECC in its correspondence dated 21 December 2005 and 26 October 2007 (**Appendix A**).

2.1 Determining Temperature Guidelines and Trigger Values

In accordance with the Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) guidelines (2000), Port Kembla Harbour is considered to be a "highly disturbed" estuary. Highly disturbed estuaries are defined as "measurably degraded ecosystems of lower ecological value". There are no specific water quality or biological integrity values associated with this categorisation system however highly disturbed estuaries may be considered to be substantially impacted by human activities.

DECC has indicated that, in accordance with these guidelines, the longer-term objective level of protection for Port Kembla Harbour should be 'slightly to moderately disturbed' which are defined as those that retain largely intact habitats and associated biological communities.

An appropriate guideline or trigger value is required to determine whether the potential impact on Allan's Creek and Port Kembla Harbour is considered acceptable. The ANZECC guidelines (2000), Volume 2, Section 8.2.3.4 p8.2-66, as referenced by DECC, provide guidance for "Unnatural change in temperature" for slightly to moderately disturbed systems. The guidance states:

"Hot water discharges should not be permitted to increase the temperature of the aquatic ecosystem above the 80%ile temperature value obtained from the seasonal distribution of temperature data from the reference system."

When determining the scale of the proposed impact (i.e. temperature increase of the receiving water body), the ANZECC guidelines suggest an 80th percentile "trigger value" for guidance as to whether the proposed impact on the temperature of Allan's Creek and Port Kembla Harbour is considered acceptable. After determination of the trigger value, if the value is not considered appropriate, an investigation to develop more suitable guidelines based on the type of water resource and inherent differences in water quality across different water bodies may need to be determined.

The ANZECC Guidelines have been used for the proposed modification to the ICP cooling water system to determine the trigger values as follows:

1. Phillips (2002) provided sampling of surface water temperatures between 1992 and 1999 at 14 locations:- the mouth of Allan's Creek (2), Port Kembla Inner Harbour (6), Port Kembla Outer Harbour (4) and the Pacific Ocean (2) beyond the Harbour. A total of 22 data points relevant to the Project and covering all seasons were collected. The use of this data from the various parts of Port Kembla Harbour and the Pacific Ocean are suitable as a reference system.

2. BlueScope Steel (2006) collect temperature data on a daily basis at the lift pump intake station for the salt water channel that takes seawater from the Outer Harbour and provides cooling water for the PKSW. Data between January 2000 and March 2005 was used.

3. Statistical assessments were made between the Phillips and BlueScope Steel data sets (**Table 2.1**) to determine if they could be considered to be derived from the same population:

Table 2.1 Statistical Comparison of Port Kembla Harbour Water Temperature Data

Parameter	Phillips (2002)	BlueScope Steel (2006)
N	22	237
min. (°C)	15.5	12
max. (°C)	26	27
mean (°C)	19.9	19.9
Standard Deviation (S.D.)	3.2	2.9
variance	10.34997835	8.160087249
Pooled Variance	8.339027767	-
t-Test: Two-Sample Assuming Equal Variances Alpha = 0.05 Alpha = 0.01	 t critical = 1.9692, P (two tail): 0.9706, P>0.05 t critical = 2.5950, P (two tail): 0.9706,	
t-Test: Two-Sample Assuming Unequal Variances [1] Alpha = 0.05 Alpha = 0.01	 t critical = 2.0639, P (two tail): 0.9736 t critical = 2.7969, P (two tail): 0.9736	

Hypothesized Mean Difference of 0 (zero) used. Indicates that the sample means are hypothesized to be equal. Two-tailed test adopted in all cases – this test looks for any change in the parameter (which can be an increase or decrease)

The assessments identified the two data sets as not being significantly different and hence can be considered to be derived from the same population – that is, the larger BlueScope Steel data set is representative of water temperatures across Port Kembla Harbour (Inner and Outer).

4. Given the larger number of data points taken for BlueScope Steel's salt water intake channel, it was possible to generate meaningful data sets of winter (June/July) and summer (January/February) seasonal data from which it was possible to determine an appropriate 80th percentile temperature value for each season.

5. The 80th percentile values (**Table 2.2**) for winter and summer were then derived from the verified data set:

Table 2.2 80th percentile temperature values for summer and winter in Port Kembla Harbour

Parameter	Winter (June/July)	Summer (January/February)
n	37	44
min. (°C)	13	20
max. (°C)	19	27
Mean (°C)	17	23.2
S.D.	1.3	1.5
80th percentile temperature (°C)	**18**	**24**

Table 2.2 indicates that the 80th percentile temperature values for summer and winter in Port Kembla Harbour are 24°C and 18°C respectively. This means that for a slightly to moderately disturbed system during summer, the temperature in Port Kembla Harbour should not exceed 24°C for 80% of the time. During winter, the temperature in Port Kembla Harbour should not exceed 18°C for 80% of the time.

Based on the trigger values calculated, it was determined that further investigation into more appropriate guideline trigger values was required due to:

- The existing average water temperature of Port Kembla Harbour and Allan's Creek in winter ranging from 16.14°C to 21.08°C, exceeding the winter trigger value at all sampled locations;
- The existing average water temperature of Port Kembla Harbour and Allan's Creek in summer ranging from 22.64°C to 28.20°C, exceeding the trigger value at most sampled locations and depths; and
- The trigger values are applicable for a slightly to moderately disturbed system. Although this is the goal for Port Kembla Harbour, it is currently a highly disturbed system. As a highly disturbed system,, the 80th percentile value is recommended as a target for site improvement only.

Comparison of modelled Harbour temperatures with these trigger values has, however, been undertaken (see **Appendix D**).

Investigation into a more suitable guideline trigger value more appropriate to the existing water quality of Allan's Creek and Port Kembla Harbour was considered. Based on the potential impact on the temperature of Allan's Creek and Port Kembla Harbour and, in turn, the potential impact on the ecology, a trigger value was determined.

The temperature of the cooling water discharged into Allan's Creek may be elevated by up to 10.29°C during maximum summer heat load conditions. However, the temperature of the heated salt water discharged into Allan's Creek would be lowered due to mixing with the flow in Allan's Creek and the Port Kembla Inner Harbour.

The 'mixing zone' could be defined as being the area within which the temperature increase was considered to have an unacceptable ecological impact. In the report entitled "*Ecological issues in relation to BlueScope Steel SCP proposed salt water cooling*" prepared by NewSouth Global Consulting in August 2006 (see **Appendix F**), it was concluded that "If, however, temperatures are elevated by more than 3°C as a result of operation of the SCP, then some ecologically important changes may occur."

The mixing zone is therefore defined in this report as the area where a temperature increase of greater than 3°C may occur. Temperature modelling has been conducted to predict the extent of the mixing zone under a range of operating conditions to allow an assessment of the acceptability of the size of that area.

Therefore, an increase in water temperature of 3°C has been adopted as the trigger value for this assessment.

2.2 Model Parameters

2.2.1 Adoption of Boundary Temperature

A boundary temperature condition of 22.5ºC for summer was adopted by CLT for modelling purposes (see Section 2.4, **Appendix D**). Adoption of this figure is conservative.

Seasonal information from the Phillips data set recorded near the ocean entrance to the Outer Harbour (sites #11 -14, Figure 2.3, **Appendix D**) was used to determine typical average background temperatures of 22.5ºC and 16.8ºC for summer and winter, respectively. This data was used for the heat model ocean boundary because it was measured at the entrance to the Outer Harbour and most closely resembles the background temperatures of a system free from the influences present in Port Kembla Harbour.

Whilst **Table 2.1** indicates that the Phillips dataset is from the same sample population as that from the saltwater lift-pump station, it best represents the temperatures at the model boundary. Comparison between sites #11-14 and the lift-pump station indicates that the average temperatures at the lift-pump station are slightly higher (23.2ºC and 17ºC for summer and winter, respectively), which is evidence of heat circulation effects at the lift-pump station site.

CLT note that the actual ocean water temperature at the Harbour entrance (model boundary) was 21.6ºC, rather than the 22.5ºC adopted for this general summer simulation - a difference of 0.9ºC. The average of the model result temperatures on 14/01/2004 is about 0.8ºC greater than the average of the measured temperatures for the corresponding date; hence, adjusting for the boundary temperature difference, there is a 0.1ºC difference between the measured and modelled average temperatures on 14/01/2004. This difference is considered to be negligible and represents close corroboration between the model and reality given the multiple factors involved.

Although not precisely correct, the temperatures throughout the Harbour are generally linearly dependent upon the boundary temperature due to the mass of water in the ocean compared to that within Port Kembla Harbour. Thus any incremental change in seawater temperature at the model boundary/Harbour entrance is reflected in a similar incremental change throughout the Harbour. Hence the approach above, which accounts for spatial and temporal variation inherent in the data and model, is considered conservative and appropriate for use.

Water temperature data used in the modelling was recorded at two heights in the water column and at irregular intervals (Phillips, 2002). Upper water column (near surface) temperatures were recorded as being higher than those near the seabed as a result of existing cooling water flows from existing Steelworks' activities.

2.2.2 Discharge Point Location, Configuration / Size

Location

As described in **Section 1.3.2**, the discharge location has been sited approximately 200m downstream of the existing No.2 Blower Station Drain at the point where Allan's Creek enters the Port Kembla Inner Harbour.

Configuration / Size

As described in **Section 1.3.3**, modelling has indicated the best possible outcome during summer maximum heat load conditions would be from the use of a 30m long structure permitting the cooling water discharge to mix only with the upper half of the water column.

2.2.3 Modelling Assumptions

The following assumptions were made to conduct the modelling of the existing and post-ICP heat load impact on Port Kembla Harbour and Allan's Creek:

- The modelling was based on existing measured data and information identified during desktop review. No additional new data was measured or collected for this process;
- The cooling water discharge from the No.1 Power House into the Main Drain will cease post-ICP as a result of the shut down of the No.1 Power House. This will result in only Webb's Lagoon overflow and Cringila stormwater flow through the Main Drain. Currently cooling water is discharged from the Main Drain at an average flow rate of approximately 1.17m^3/s and an average ΔT of 7.1^{o}C;
- It was assumed that whilst the input salt water temperatures to the ICP would vary throughout the year, the same heat load would be imparted to the water by the ICP in all seasons. Consequently the same temperature change was modelled for summer and winter;
- Typical Discharge and ΔT from the No.2 Blower Station would change from 7.95m^3/s at 6.44^{o}C to 7.04m^3/s and 5.94^{o}C;
- Typical heat load from the new ICP Drain would be 7.5m^3/s and 5.9^{o}C ΔT;
- Discharge rates and temperature difference at all other drains remain unchanged from the existing case;

- "Typical" heat load (for modelling purposes only) is defined as two daily heat load peaks in the new ICP Drain, one in the morning and one in the evening. The ICP generating at a rate of 145MW with two one-hour bursts of peak generation (230MW) per day at 6am-7am and 6pm-7pm;

- Post-ICP summer maximum heat load would be produced during continuous operation of the STG at 240MW (225 MW design capacity plus performance degradation allowance plus short term overload allowance). An additional 10% heat load allowance was added for any changes that may occur during detailed design;

- The change in Port Kembla Harbour bathymetry due to recent dredging and current approved developments will have a negligible impact on previous modelled scenarios; and

- The change in discharge point, a further 30m east where Allan's Creek widens before meeting Port Kembla Inner Harbour will not impact upon previous modelling results.

2.2.4 Model Correlation

The following aspects of model correlation and verification were undertaken:

- Confirmation that the model was simulating tidal effects of Allan's Creek (tidal prism verification). Figure 4.1 of **Appendix D** indicates that there is a close correlation between the model run and the data measured by Acoustic Doppler Current-meter Profile within Allan's Creek on 25th May 2005; and

- Comparing model results with temperature data recorded in the Harbour. The recorded data was of limited extent, and although the actual record times were unknown, there was good agreement between the two – in the order of 0.1^{o}C difference on an average temperature basis. As an additional verification exercise, the model simulation demonstrated that a temperature difference of up to 2.5^{o}C occurred between the surface and creek bed near the mouth of Allan's Creek. This is consistent with observations made in the field on 25 May 2005.

In addition, verification information in terms of outcomes that were acceptable to the regulator between modelled and observed effects at three other sites in NSW was provided (CLT 2006).

Section 4 of CLT's report (**Appendix D**) provides a detailed analysis of the verification procedures undertaken.

2.2.5 Factors which may bias or impact the modelling assessments

Model Set-Up

Modelling of the cooling water field was undertaken using the model Delft3D developed by WL Delft Hydraulics.

The model was set up taking into account a range of factors that could influence the model results. These include temporal effects, bathymetry, salinity, effects of currents and tides, stratification, sediment transport, wind, season, solar radiation, relative humidity and heat load. A complete description of the model set-up and verification is provided in Sections 2 to 4 of the CLT report (Aug 2006) provided in **Appendix D**.

Inexperience in using this model has the potential to create inaccurate results including:

- Inappropriately large setting on the wet/dry algorithm and unrefined inter-tidal grid definition;
- Inappropriate bathymetric and boundary definition causing steep gradients; and
- Inappropriate time-step selection for simulation.

In addition, currents caused by shipping and freshwater floods cannot be readily simulated in the modelling procedure. The impact of shipping movements would cause greater vertical mixing of the cooling water in Port Kembla Harbour and flooding would transport the surface plume further downstream. However, both processes would be intermittent and transitory (CLT, Aug 2006).

However, each of these factors above has been recognised and taken into consideration in the model. It should be noted that the model is predictive. Changes between post-ICP and existing temperatures are based on model-to-model-comparisons and any uncertainty between model results and reality will be the same for both sets of model results ensuring that the differences seen in the results are reliably comparable.

Two sensitivity analyses were undertaken, one on the sensitivity of an error in the adopted boundary or drain discharge temperatures and one on total heat loads.

If the ΔT in the discharge cooling water were in error (either due to drain temperature or boundary temperature or both), then the corresponding error in receiving water temperatures, other than at the immediate point of discharge, would cause temperature differences generally in the Harbour of less than 1°C. This outcome is due to the relative volume of flow compared to Harbour volume and the tidal flow versus the cooling water flows. In summary, it can be said that the model (as a reflection of the Harbour) is relatively insensitive to temperature differences of this order. Harbour boundary temperatures do not vary by more than 1°C per month on average over the simulation period based on observations in the Phillips data, hence weekly fluctuations can be expected to be smaller. In reality on a weekly basis it is reasonable to assume negligible variation in temperature at the model boundary.

In order to assess the effect of errors in drain heat loads, a simulation could be undertaken with a temperature change in one drain (leaving all other heat loads unchanged). A comparison between modelled existing surface temperatures at locations (22,67) and (80, 34) shows a difference of 1.41°C and 0.15°C between average and maximum heat load cases, respectively. In the latter, it was assumed that maximum heat loads could occur in all drains simultaneously and persist for two months which would be unlikely in the context of the operational activities at the Steelworks. Consequently any change in a single variable such as an error in ΔT of say 1°C would cause much smaller changes to propagate through the model.

2.2.6 Near-Field Mixing Zone

Matters relating to the definition of the mixing zone are more appropriately described by the Delft3D modelling results in this situation than a near-field model (CLT, 2006) for the following reasons:

- The complex bathymetry cannot be described by the available near-field models;
- The presence of multiple cooling water discharges leads to cooling water field interaction that the available near-field models cannot handle; and
- The reversing tide transports previously discharged cooling water backwards and forwards through the discharge points which are not handled in near-field models.

2.2.7 Tidal / Meteorological Influences

Modelled physical parameters reflecting real-world variables were seen to impact on the modelling results. These variables included:

- Tidal phases; and
- Meteorological conditions.

In low wind speed conditions, the stage of the tide will dominate the extent of the cooling water field at the selected time. Alternatively, in high wind speed conditions, both tide and wind will affect the extent of the cooling water field (CLT, 2006). Therefore, depending on these variables, the contours produced will differ.

2.2.8 Modelling Approach

Modelling results were based on the change in temperature between pre-ICP and post-ICP conditions at six reference points within Port Kembla Harbour and Allan's Creek (see **Figure 2.1).**

Each location was modelled at three levels of the water column:

- Surface layer;
- Middle layer; and
- Bottom layer.

The actual depth of each level is dependent upon the total depth at the particular location as the model calculates the layers based on a percentage of the total depth.

The model separates the water column into ten layers and the relative percentage of each layer is smaller at the top and bottom layers, and largest in the mid layer to best reflect the physical process that occurs as a result of thermal stratification, wind and atmospheric effects and interactions with the substrate.

2.2.9 Modelling Cases

Pre-ICP conditions were modelled using historical values for flow and temperature of various BlueScope Steel drains that discharge into Allan's Creek or Port Kembla Inner Harbour.

Post-ICP conditions were modelled using estimates of the changes to a number of drain flows and/or temperatures, following introduction of the ICP. The following post –ICP conditions were modelled:

- **Typical Winter Heat Load** - Each 24 hour period included two periods of high heat load in the new ICP Drain; one in the morning, the other in the evening. This typical ICP heat load is described in Figure 2.2 of **Appendix D** (CLT, Aug 2006). This profile was adopted to simulate a typical ICP operating model where it would be expected to generate at a rate of 145MW per day for all times during the day, except for two one-hour bursts of peak generation (at a rate of 230MW) - these times coinciding with expected periods of peak power demand and being modelled as 0600 to 0700 and 1800 to 1900. Consequently the term 'typical' heat load condition is used as distinct from 'average' heat load condition.

- **Typical Summer Heat Load** – as for Typical Winter Heat Load, but with relevant historical values for drain flows not affected by ICP.

- **Maximum Summer Heat Load** - a conservative worst case representing the heat load produced during continuous operation of the STG at 240MW (225 MW plus performance degradation allowance plus short term overload allowance), plus an additional 10% heat load allowance as a design margin.

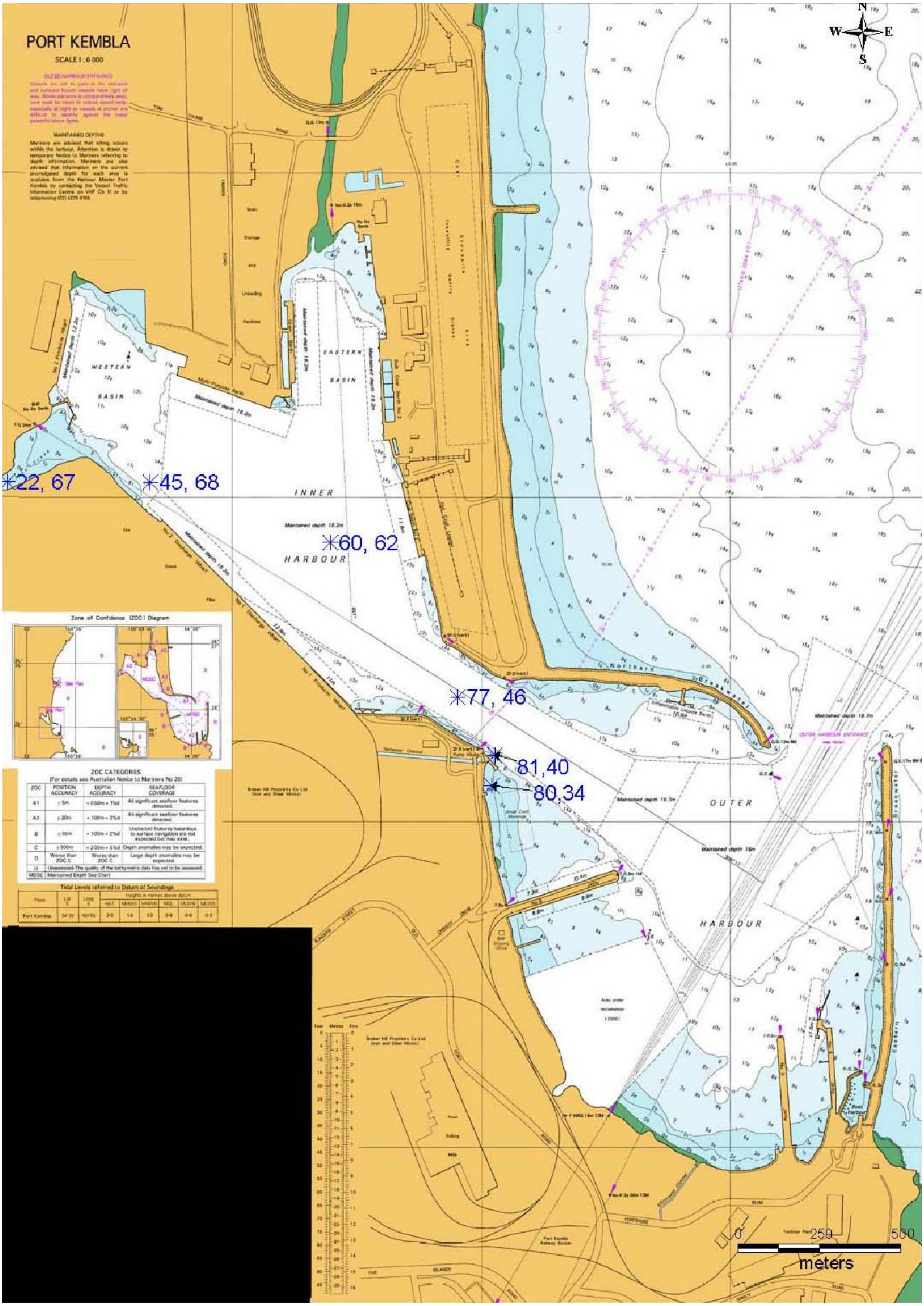


Figure 2.1
Location of Reference Points

Pre-ICP Conditions

A number of BlueScope Steel heat load contributors to Port Kembla Harbour would not be affected by ICP, and are therefore included in all modelling cases. Details of these streams are given in **Table 2.3.**

Table 2.3 Existing Operations – Heat Loads for Drains Not Affected by ICP

	Winter				Summer			
	Average		Maximum		Average		Maximum	
Drain	Q (m^3/s)	ΔT (°C)	Q (m^3/s)	ΔT (°C)	Q (m3/s)	ΔT (°C)	Q (m^3/s)	ΔT (°C)
3500mm Plate Mill Drain	0.408	2.41	0.405	4.21	0.395	2.84	0.43	3.5
Slab Mill Drain	0.016	21.37	0.081	22.00	0.013	31.41	0.013	32.68
No. 1 Flat Products East Drain	0.196	4.35	0.189	9.21	0.112	4.64	0.112	10.5
Allan's Creek Flow	0.170	16.80	0.170	16.80	0.17	22.5	0.17	22.5
North Gate Drain	0.102	17.98	0.172	17.00	0.077	28.06	0.13	30.22

The pre-ICP heat load contribution from drains affected by ICP are given in **Table 2.4**.

Table 2.4 Existing Operations – Heat Loads for Drains Affected by ICP

	Winter				Summer			
	Average		Maximum		Average		Maximum	
Drain	Q (m^3/s)	ΔT (°C)	Q (m^3/s)	ΔT (°C)	Q (m^3/s)	ΔT (°C)	Q (m^3/s)	ΔT (°C)
Main Drain	1.517	6.28	2.993	6.2	1.174	7.1	1.431	9.5
No.2 Blower Station Drain	8.211	7.11	8.413	13.20	7.953	6.44	8.233	8.5
Ironmaking East Drain	0.100	3.06	0.127	4.20	0.208	4.05	0.232	7.5

Post-ICP Conditions

The drain parameters associated with post-ICP Summer and Winter Typical Heat Loads are given in **Table 2.5.**

Table 2.5 Post-ICP Typical Heat Loads for Drains Affected by ICP

	145MW		230MW	
Drain	Q (m^3/s)	ΔT (°C)	Q (m^3/s)	ΔT (°C)
Main Drain	0	n/a	0	n/a
No.2 Blower Station Drain	7.04	5.94	7.32	8.0
Ironmaking East Drain	0.208	4.05	0.232	7.5
New SCP Drain	7.5	5.9	7.5	9.4

The drain parameters associated with post-ICP Maximum Summer Heat Loads are given in **Table 2.6**.

Table 2.6 Post-ICP Maximum Drain Heat Loads for Drains Affected by ICP

Drain	Q (m^3/s)	ΔT (°C)
Main Drain	0	n/a
No.2 Blower Station Drain	7.32	8.0
Ironmaking East Drain	0.156	6.27
New SCP Drain	8.682	10.29

2.3 Model Results

Modelling was undertaken by CLT to predict the impact of ICP operations on temperature levels in Allan's Creek and Port Kembla Inner and Outer Harbour. This was done by using a Delft3D model which compared existing conditions (pre-ICP) with expected post-ICP conditions. The modelling included all existing flows in Allan's Creek pre-ICP and the change to those flows post-ICP (i.e. the cumulative impact on Allan's Creek and Port Kembla Harbour). Modelling of the typical summer scenario post-ICP took into account the discharge of the cooling water via a structure to control the discharge to the upper layers only, as opposed to mixing through the whole water column.

Discussions held with DECC on the basis of modelling undertaken by CLT in 2005 showed that the increases in temperature during winter, even under the scenario of continuous maximum heat load did not result in ecologically significant temperature increases. DECC requested that subsequent modelling focus upon simulations that reflected likely and possible real-life scenarios.

2.3.1 Typical Summer Heat Loads

Table 2.7 compares the existing average temperature conditions at each location and layer (surface, middle and bottom) with predicted post-ICP average temperatures for Summer Typical Heat Loads (CLT, August 2006). See **Section 2.2.9** for the definition of 'typical' conditions.

Table 2.7 Existing and Post-ICP Average Water Temperatures (ºC) for Typical Summer Heat Load Conditions

	Surface			Middle			Bottom		
Location	Existing	Post-ICP	Change in Temp. (°C)	Existing	Post-ICP	Change in Temp. (°C)	Existing	Post-ICP	Change in Temp. (°C)
22,67 (Services Bridge)	27.21	26.94	-0.27	28.20	28.17	-0.03	27.57	28.29	**0.72**
45,68 (Inner Harbour)	24.42	24.93	0.51	23.32	23.55	0.23	22.92	23.02	0.10
60,62 (Inner Harbour)	23.85	24.28	0.43	23.23	23.45	0.22	22.81	22.89	0.08
77,46 (The Cut)	23.54	23.89	0.35	22.99	23.14	0.15	22.64	22.68	0.04
81,40 (Outer Harbour)	23.38	23.68	0.30	22.83	22.92	0.09	22.67	22.72	0.05
80,34 (Outer Harbour)	23.01	23.18	0.17	23.03	23.19	0.16	22.93	23.05	0.12
Allan's Creek 100 m	27.30	27.03	-0.27	28.25	28.23	-0.02	27.64	28.33	0.69
Allan's Creek 300 m	26.94	26.53	-0.41	27.99	27.85	-0.14	27.56	28.15	0.59
Allan's Creek 500 m	26.79	26.11	-0.68	27.83	27.27	-0.56	28.08	27.83	-0.25

The results outlined in **Table 2.7** indicate that the use of a specifically designed structure to discharge the proposed cooling water into the surface layers of Allan's Creek, maintains an average temperature increase at less than 0.8ºC throughout the six modelled Harbour locations with the greatest temperature increase occurring at the bottom layer at the Services Bridge (22,67) of 0.72ºC (see section 5, **Appendix D**).

Figure 2.2 and **Figure 2.3** describe the post-ICP temperature increase for the Typical Summer Heat Load scenario on the mouth of Allan's Creek and Port Kembla Harbour under different environmental conditions. **Figure 2.2** shows the temperature increase at one instance in time, being 4pm on the 14/2/2004. It indicates that higher temperature changes will occur on the surface layer of the Inner Harbour, due to the heat load being predominantly discharged to the top of the water column. **Figure 2.2** indicates a 0°C – 0.25°C temperature increase in Allan's Creek. Although the new heat load from the ICP cooling system is discharged into Allan's Creek, the existing temperature of Allan's Creek is already elevated due to the discharges from the existing No. 2 Blower Station Drain. Therefore, the temperature increase on Allan's Creek during typical summer conditions due to the addition of the heat load from the ICP cooling water is expected to be minimal. **Figure 2.2** indicates the greatest temperature increase to be north east of the mouth of Allan's Creek. This is due to the tidal phase and prevailing wind effects circulating the water north east at that moment in time. As the temperature of this small segment of the Inner Harbour north east of the Allan's Creek has not been affected by the existing heat load discharges into Allan's Creek, the addition of the ICP heat load is predicted to increase the temperature between 1°C - 1.75°C based on similar meteorological conditions.

Figure 2.3 shows the temperature increase at another instant in time, being midnight on the 25/2/04. The impact on the surface layer temperature is shown to be slowly dispersing out evenly from Allan's Creek into the Inner Harbour. This is due to the negligible tidal and meteorological conditions at that moment in time and prevailing wind effects. The increase in temperature of Port Kembla Inner Harbour can be seen to increase by up to 2°C due to the additional heat load from the ICP cooling water discharge. The shading on the Figure shows that the highest increase in water temperatures will be experienced at Port Kembla Inner Harbour, near the mouth of Allan's Creek.

The modelled results also indicate that as a result of the cessation of heat load from the Main Drain (a consequence of the shut down of the No.1 Power House), surface temperatures in Allan's Creek would be reduced by approximately 0.5ºC at 300m to 500m upstream of the No.2 Blower Station Drain.

Figure 2.4 describes the post-ICP 1ºC average temperature increase contour for this heat load case. The areas are small and occur in the bottom and mid layers only. This result shows that although there may be periods of time when temperature increases are greater than 3ºC, generally the area over which average temperature increase over 1ºC is small and confined to the mid to lower water column. Average temperature increases were all less than 1ºC, so illustration against the ecologically important 3ºC was not possible since this condition does not occur.

2.3.2 Maximum Summer Heat Loads

Table 2.8 compares the existing average temperature conditions at each location and layer (surface, middle and bottom) with predicted post-ICP average temperatures for Maximum Summer Heat Loads (CLT, April 2008). See **Section 2.2.9** for the definition of the 'maximum heat load' conditions.

Table 2.8 Existing and Post-ICP Average Water Temperatures (ºC) for Maximum Summer Heat Load Conditions

	Surface			Middle			Bottom		
Location	Existing	Post-ICP	Change in Temp. (°C)	Existing	Post-ICP	Change in Temp. (°C)	Existing	Post-ICP	Change in Temp. (°C)
22,67 (Services Bridge)	28.62	27.89	-0.73	28.04	28.63	0.59	23.92	26.49	**2.57**
45,68 (Inner Harbour)	25.08	26.24	1.16	23.38	23.74	0.36	22.94	23.11	0.17
60,62 (Inner Harbour)	24.30	25.25	0.95	23.30	23.66	0.36	22.84	22.97	0.13
77,46 (The Cut)	23.86	24.60	0.74	23.06	23.34	0.29	22.66	22.72	0.06
81,40 (Outer Harbour)	23.64	24.29	0.65	22.89	23.06	0.17	22.70	22.79	0.09
80,34 (Outer Harbour)	23.16	23.51	0.35	23.15	23.46	0.31	23.01	23.25	0.24

The results indicated that increasing the heat load increased temperatures at all locations. The largest temperature increase for this scenario occurred at the bottom layer at location (22,67) resulting in an increase of 2.6ºC.

Figure 2.5 indicates the extent of the mixing zone where the average temperature change post-ICP during the summer maximum heat load condition exceeds 3ºC. The contours indicate that only a small portion of Allan's Creek, in the middle to upper layers nearest the heat load discharge will increase above 3ºC. The area affected under these peak load conditions is small and any loss of biota in this location is not expected to be significant within the context of the whole Harbour.

2.3.3 Winter Typical Heat Loads

Table 2.9 compares the existing average temperature conditions at each location and layer (surface, middle and bottom) with predicted post-ICP average temperatures for Winter Typical Heat Loads (CLT, August 2006). See **Section 2.2.9** for the definition of 'typical' conditions.

Table 2.9 Existing and Post-ICP Average Water Temperatures (ºC) for Typical Winter Heat Load Conditions

	Surface			Middle			Bottom		
Location	Existing	Post-ICP	Change in Temp. (°C)	Existing	Post-ICP	Change in Temp. (°C)	Existing	Post-ICP	Change in Temp. (°C)
22,67 (Services Bridge)	20.14	19.80	-0.34	21.08	21.06	-0.02	21.05	21.70	**0.65**
45,68 (Inner Harbour)	17.42	17.89	0.47	16.44	16.76	0.32	16.29	16.54	0.25
60,62 (Inner Harbour)	16.84	17.29	0.45	16.40	16.72	0.32	16.25	16.46	0.21
77,46 (The Cut)	16.51	16.91	0.40	16.30	16.54	0.24	16.21	16.35	0.14
81,40 (Outer Harbour)	16.40	16.74	0.34	16.26	16.41	0.15	16.22	16.35	0.13
80,34 (Outer Harbour)	16.14	16.32	0.18	16.22	16.40	0.18	16.21	16.36	0.15
Allan's Creek 100 m	20.32	19.96	-0.36	21.20	21.13	-0.07	21.14	21.76	0.62
Allan's Creek 300 m	19.71	19.32	-0.39	20.77	20.75	-0.02	21.02	21.54	0.52
Allan's Creek 500 m	19.36	18.81	-0.55	20.52	20.13	-0.39	21.30	21.16	-0.14

The results in **Table 2.9** indicate some reductions and some increases in water temperatures throughout the water columns. Surface water temperatures are up to 0.34ºC lower (location 22,67), the middle layer is up to 0.32ºC higher (location 45,68) and the bottom layer water temperature up to 0.65ºC higher (location 22,67) for the post-ICP simulation. All increases in average temperatures were less than 0.7ºC at the six modelled Harbour locations, the greatest increase occurring at the bottom layer at the Services Bridge (22,67) of 0.65 ºC.

The results indicate that, during winter, there would be a minimal temperature increase on Port Kembla Harbour.

Similar to the summer typical scenario, the modelled results for Allan's Creek indicate that as a result of the cessation of heat load from the Main Drain (a consequence of the shut down of the No.1 Power House), surface temperatures would be reduced by approximately 0.5ºC at 300m to 500m upstream of the No.2 Blower Station Drain.

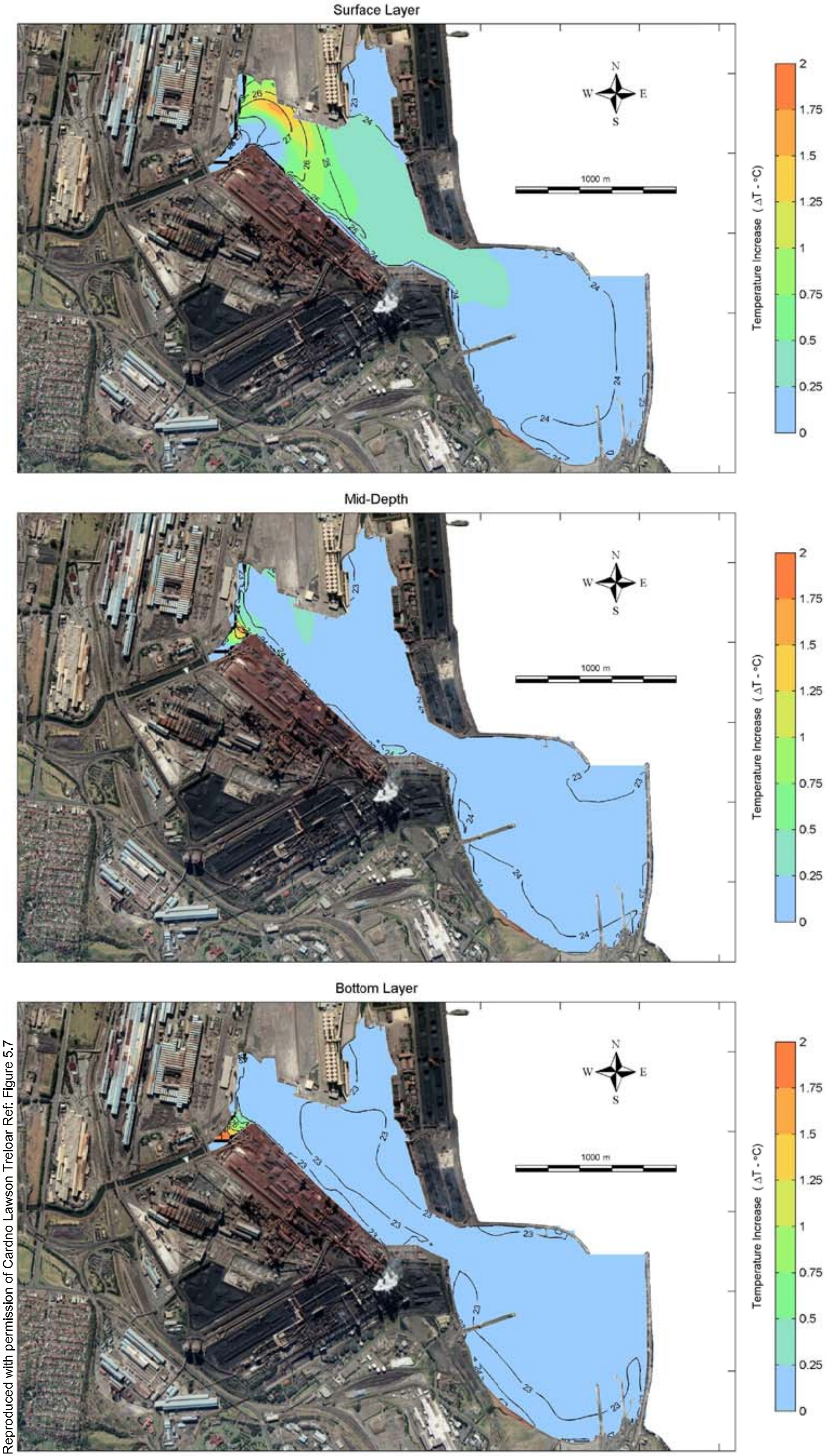
Summary

CLT concluded from the results generated (CLT Aug 2006):

> *"Generally, apart from locations near the post-ICP drain discharge, to be located near the mouth of Allan's Creek, average temperature increases in the post-ICP conditions would be less than 0.8°C and 0.7°C for typical summer and winter conditions, respectively."*

In addition, under conservative maximum heat load discharge conditions, it can be seen that the extent of the mixing zone, within which there may be expected to be noticeable changes to the ecology, is confined to the area immediately adjacent to the discharge point.

The cooling water modelling indicates that by using a specifically designed and engineered structure to discharge the cooling water to the upper layers of the water column, thereby limiting the vertical mixing, operation of the ICP is expected to result in temperature increases in Allan's Creek and Port Kembla Harbour that have acceptable ecological impacts in the context of the background temperatures and disturbed nature of the existing system.



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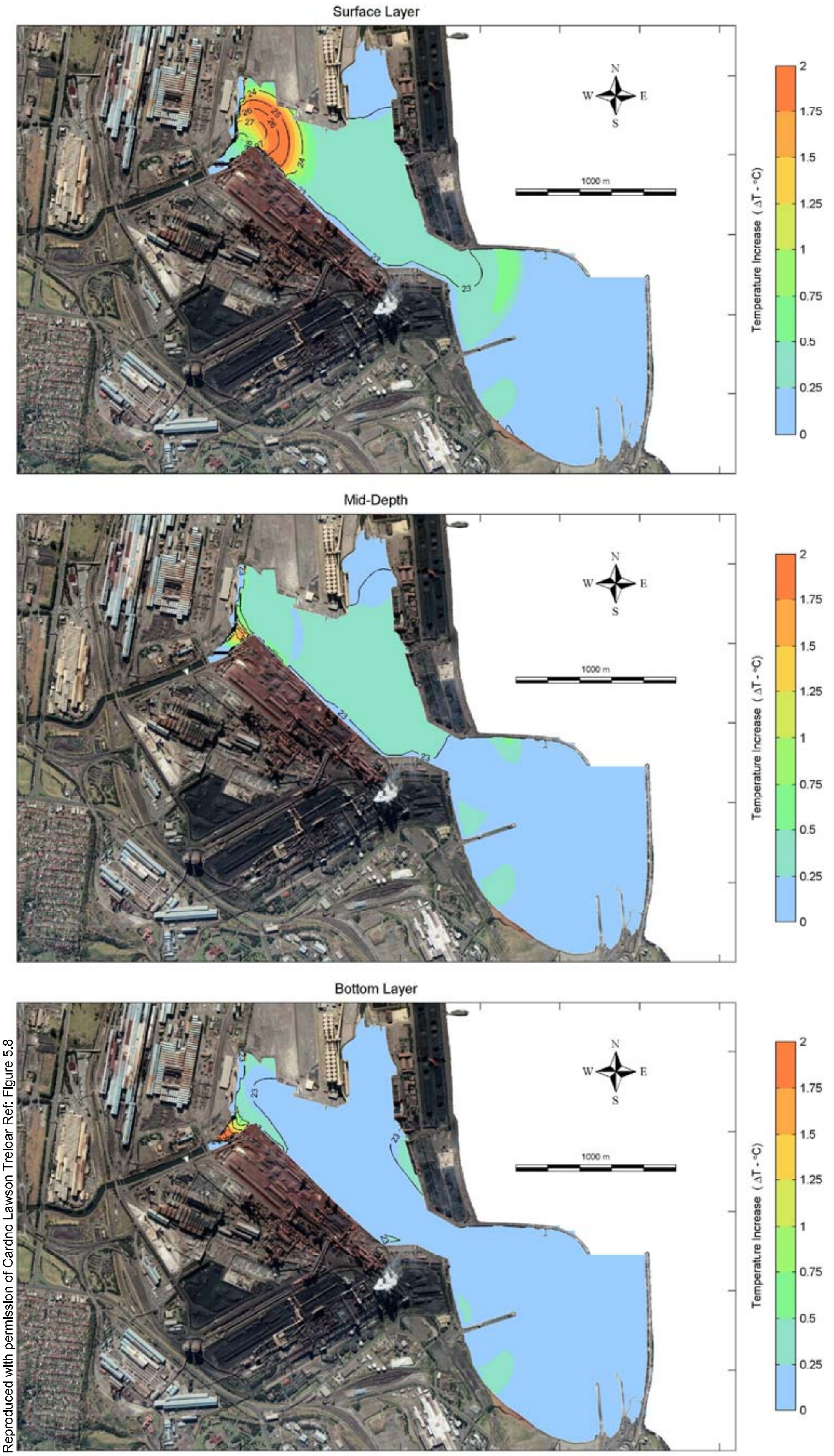
Note: Figure Shows One Instant in Time (2004/02/14 16:00)

Figure 2.2
Post-ICP Temperature Increase - Typical Summer Heat Load



Note: Figure Shows One Instant in Time (2004/02/25 00:00)

Figure 2.3
Post-ICP Temperature Increase - Typical Summer Heat Load

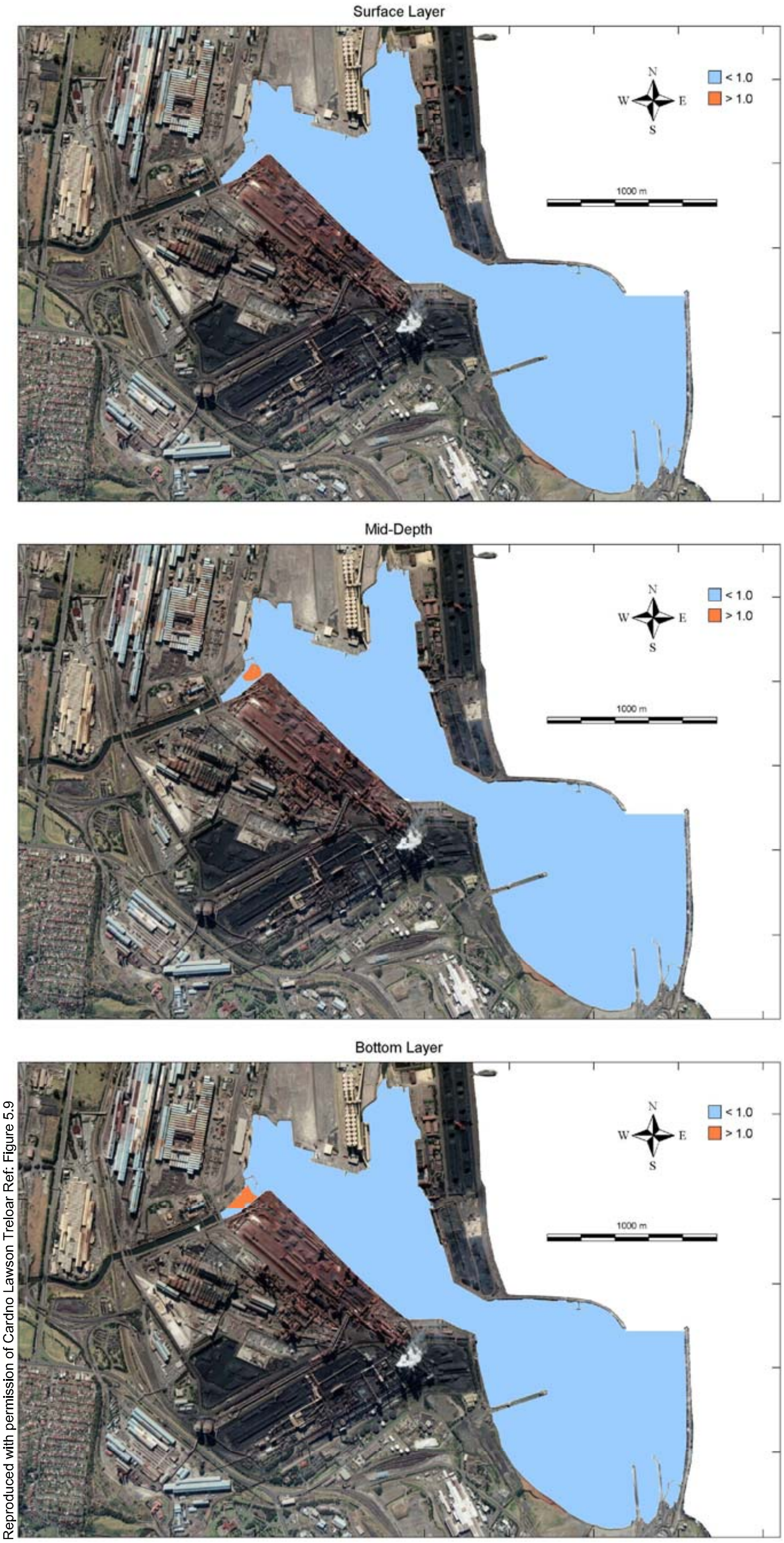


Figure 2.4
Post-ICP Average Temperature Increase - Typical Summer Heat Load

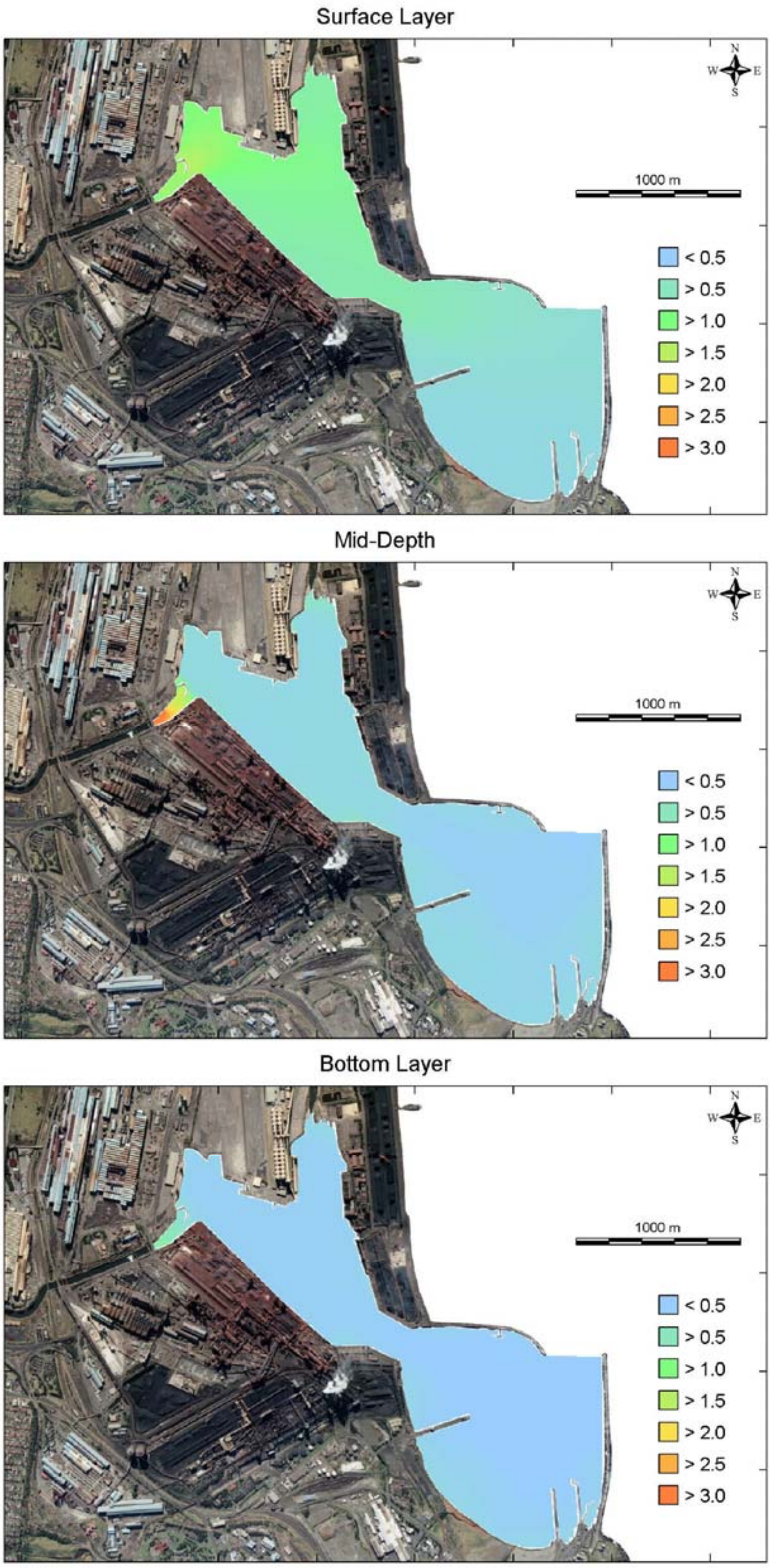


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Figure 2.5
Post-ICP Average Temperature Increase - Maximum Summer Heat Load

2.4 Impact of ICP on Port Kembla Harbour Currents

The potential impact on Port Kembla Harbour currents post-ICP has been investigated (see section 5.2 of **Appendix E**) to determine whether any change in vector velocity may impact upon shipping movements in Port Kembla Harbour. Depth-averaged currents in the Inner Harbour for an existing maximum summer heat load were compared with the maximum summer post-ICP heat load (ΔT of 10.29°C). Therefore, the results identify the potential average change in the currents throughout the whole water column. The simulations were undertaken in 3D for a 31 day period.

Figure 2.6 and **Figure 2.7** show depth-averaged currents at two points in time, 00:00am (low tide) and 06:00am (high tide), respectively, on 20 January 2004. The existing condition is indicated by black vectors and the post-ICP condition is indicated by the red vectors. The figures show that the velocity of the vectors, both pre-ICP and post-ICP are extremely small, less than 0.05m/s in the Inner Harbour. In addition, Figure 2.8 and Figure 2.9 show that the red vectors overlay the black vectors, indicating that the change in vector velocity is very minimal.

Figure 2.8 shows the water level and current time series at Location (45,68) over a two week period from the 14 January 2004 to the 28 January 2004. The current magnitude indicates a general vector velocity of approximately 0.01m/s with an increase in velocity of up to 0.03m/s on the 16 January and 20 January for both the existing and post-ICP case. Overall, the current magnitude indicates a very minimal change in velocity over the period between the existing and post-ICP case.

Figure 2.8 also indicates that the current direction is similar post-ICP but over some periods, post-ICP this may change. This is due to a change in flow structure. However, based on a movement of approximately 0.01m/s, the change in direction is considered very minor.

The modelling predicts a very minimal change to vector velocity (<0.005m/s) and on occasion, a change to vector direction post-ICP. Based on these results, operation of the ICP is not expected to impact upon the shipping movements or moored vessels within the Port Kembla Harbour.

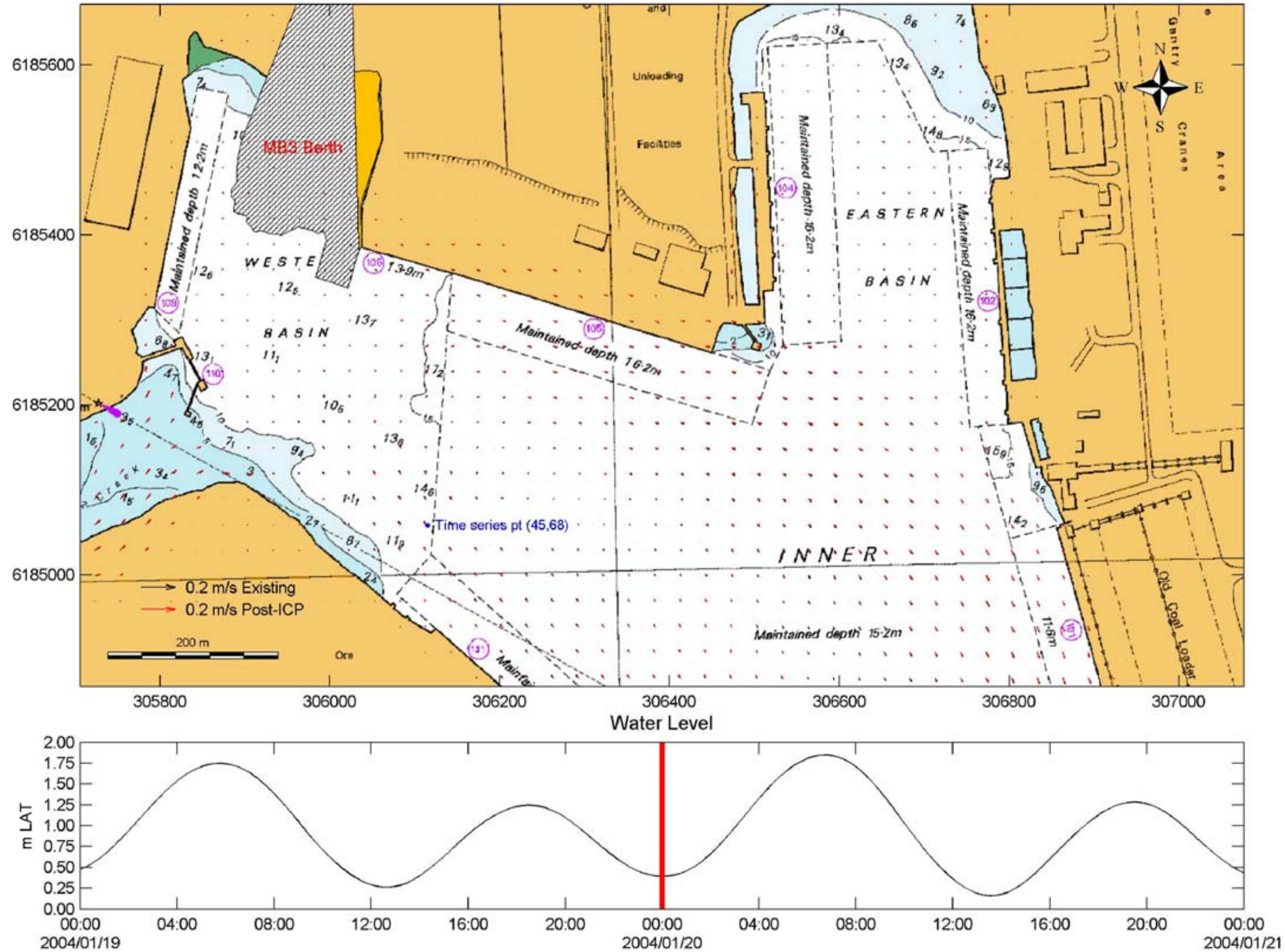


Figure 2.6
Velocity Vectors (20 January 2004 - 00.00)

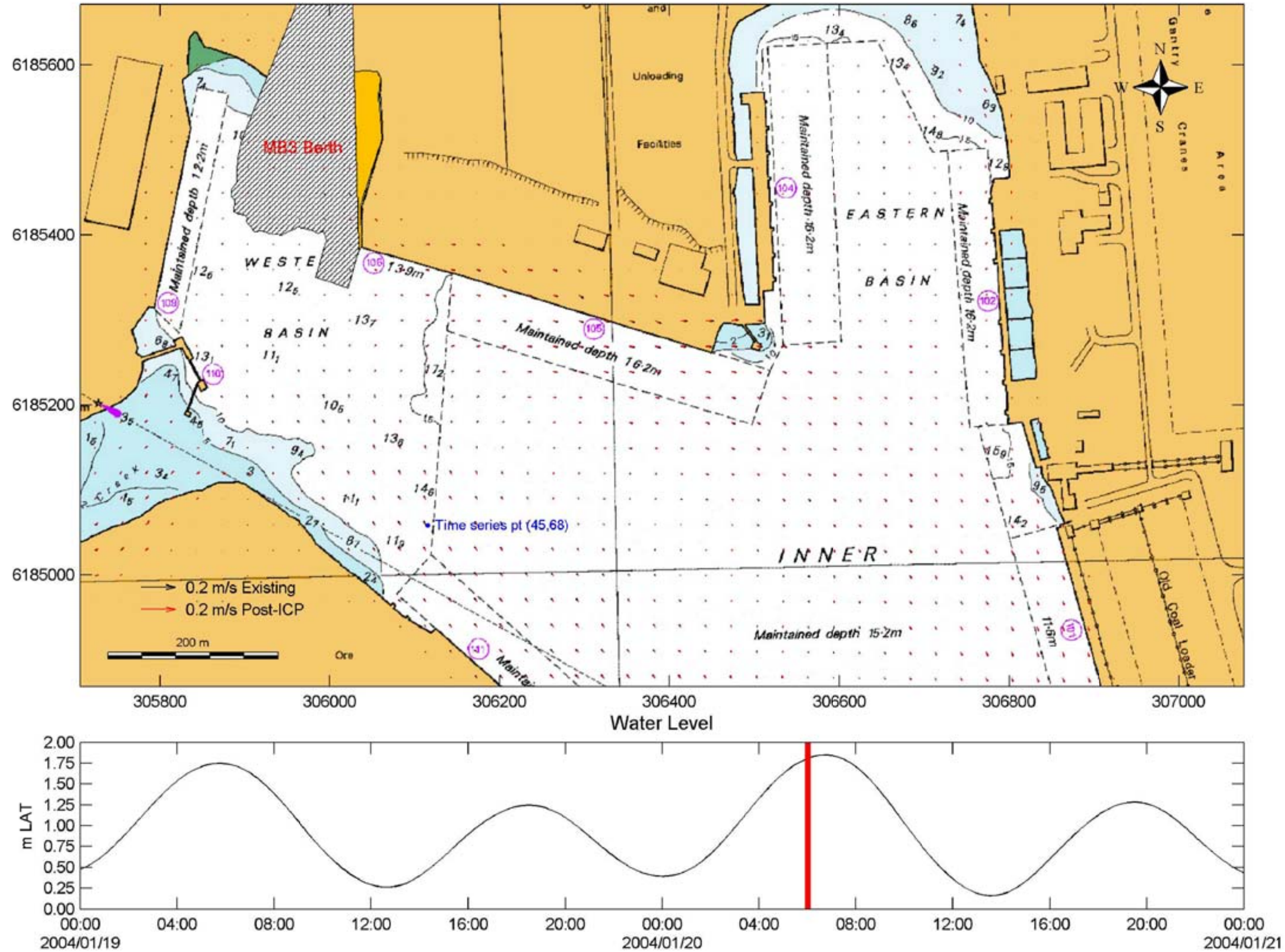


Figure 2.7
Velocity Vectors (20 January 2004 - 06.00)

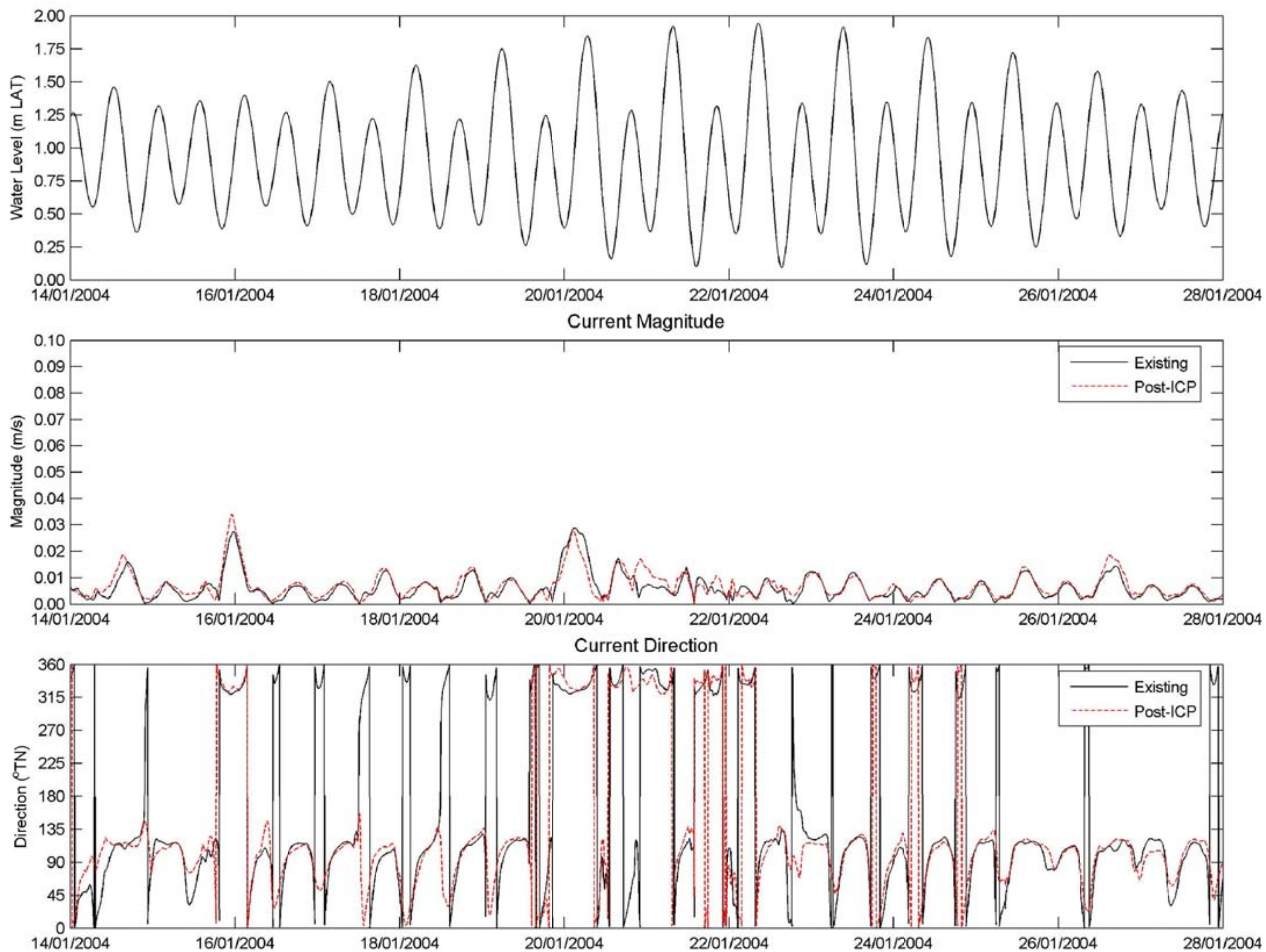


Figure 2.8
Water Level & Current Time Series
(Location 45,68)

3 Ecological Effects of Proposed Salt Water Cooling System

Due to the predicted increase in temperature on Port Kembla Harbour resulting from the proposed modification to the ICP cooling system, a study was undertaken to predict the effects of the once-through salt water cooling system on the ecology of Port Kembla Harbour and Allan's Creek. This study was undertaken by Dr Emma Johnston, Dr Jan Carey and Dr Nathan Knott from New South Global Consulting (NSG) in August 2006. The study entitled '*Ecological Issues in Relation to BlueScope Steel ICP Proposed Salt Water Cooling*' (NSG, August 2006) addresses many of the issues raised by the DECC in its correspondence dated 21 December 2005 (see **Appendix F**).

NSG considered the possible effects on the ecology of Port Kembla Harbour in accordance with the Interim Water Quality Objectives for the Illawarra Catchment region**.** Those objectives outline, at a minimum, maintaining the existing water quality levels. However, a precautionary approach was adopted and the effects of the modelled increase have been considered as well as the potential for an increase of up to 3°C in the temperature of the Harbour.

In addition, addendum reports entitled, "*Ecological Issues in Relation to BlueScope Steel ICP Proposed Salt Water Cooling*' (NSG, December 2006) and "*Conceptual Models of Potential Ecological Impacts of Plankton Entrainment in the Port Kembla Steelworks Cogeneration Plant*" (UNSW, March 2008) were also prepared. These reports focused on the impact of entrainment of plankton resulting from the additional salt water intake for the ICP cooling system (see **Appendices G** and **H**).

3.1 Thermal Effects

An assessment of the predicted temperature change as a direct result of operation of the ICP was undertaken by Cardno Lawson Treloar in August 2006 (See **Appendix B**). The modelled post-ICP temperature changes on Port Kembla Harbour and Allan's Creek were provided to NewSouth Global to assist in their assessment of the ecological impacts on the Harbour.

3.2 Comparative Biota Assessment

3.2.1 Reference system

NSG (August, 2006) identified Port Kembla Harbour as a "highly disturbed" estuary in accordance with the definitions of ANZECC 2000 water quality guidelines. Highly disturbed estuaries are defined as "measurably degraded ecosystems of lower ecological value" (ANZECC 2000). There are no specific water quality or biological integrity values associated with this categorisation system however highly disturbed estuaries may be considered to be substantially impacted by human activities.

DECC has indicated in accordance with these guidelines that the longer-term objective level of protection for Port Kembla Harbour should be 'slightly to moderately disturbed' which is defined as those ecosystems that retain largely intact habitats and associated biological communities. Following an extensive search of published literature, lists of organisms that inhabit such marine environments are not currently available. The NSW Environment Protection Authority's (EPAs) interim Water Quality Objectives for the Illawarra catchment area (EPA 2000) suggest the maintenance or rehabilitation of estuarine processes and habitats. However, there are no specific requirements for the species composition of any category (disturbed or otherwise) of the marine community (EPA 2000).

In the absence of agreed species lists or biotic indices of marine Harbour health, it is necessary to attempt to compare available information on species composition of Port Kembla Harbour with that from surrounding harbours that are considered slightly to moderately disturbed.

3.2.2 Species Expected in a Slightly to Moderately Disturbed Estuarine System

A comparison is made (NSG, August 2006), using all available data, between the species composition of Port Kembla Harbour with that from surrounding harbours that are considered slightly to moderately disturbed to identify the anthropogenic impact on Port Kembla Harbour and Allan's Creek.

> *"Many of the hard-substrate species found in Port Kembla's Outer Harbour are also found in other port environments that may be considered to be moderately to slightly disturbed such as Wollongong Harbour (Moran and Grant, 1989), Sydney Harbour (Glasby, 1998), Botany Bay (Clark and Johnston, 2005) and Port Phillip Bay (Johnston and Keough, 2005). These assemblages tend to have a wide variety of species including solitary and colonial ascidians (sea squirts), sponges, encrusting and arborescent bryozoans, barnacles, hydroids, bivalves and serpulid polychaete worms.*

A distinction is made between the abundance of species within the Outer Harbour versus the abundance of species within the Inner Harbour.

> *Many species found in Port Kembla's Outer Harbour, however, are not found in the Inner Harbour (Johnston and Clark, 2004)….. Inner Harbour assemblages of Port Kembla are indicative of a stressful environment subject to frequent disturbances in which only the early colonizing species have an opportunity to live very short lives (Johnston and Keough, 2002 and 2003).*
>
> *If the Inner Harbour sessile invertebrate assemblages were to match those of a "slightly to moderately disturbed" system, we would expect to see greater abundances of sponges, and ascidians…. Moreover, there are several species that are more often associated with tropical waters that seem to survive for long periods (and maybe even over the entire year) within the Inner Harbour; possibly due to the warm coolant water."*

NSG also noted that "fish assemblages appear to be similar to many other NSW estuaries" and that possible causes of the reduced number of species include changes to the hydrology, turbidity, salinity, temperature and toxicant load of this area.

The comparison between Port Kembla Harbour and other slightly to modified disturbed systems concludes that:

- Port Kembla Inner Harbour is indicative of a stressful environment;
- Many species found in the Outer Harbour are not present in the Inner Harbour;
- There are smaller numbers and varieties of sponges and ascidians found in Port Kembla Harbour than in slightly to moderately disturbed systems;
- There are some species more often associated with tropical waters found in Port Kembla Inner Harbour; and
- Fish assemblages do resemble other estuaries within NSW.

3.2.3 Aspects of the current environment that may exclude species

NSG (August, 2006) recognises that Port Kembla Harbour is subject to frequent shipping activities and its surrounds include the Steelworks, coal and grain exporting terminals, and an acid plant. NSG reports that:

> *"Water quality in the Inner Harbour is poor, and heavy-metal concentrations in both the water and sediment frequently exceed Australian guidelines… The Outer Harbour is considered less polluted with better flushing and fewer pollution point sources. There is also some evidence of increased temperature and turbidity in the Inner Harbour."*

It is suggested that species such as sponges and ascidians may be excluded due to:

- Environmental water quality; or
- Intrinsic changes in the distribution of species among estuaries.

Although the Ecological Study assessed the water quality as poor, it recognises the substantial improvement in Port Kembla Harbour over the last thirty years:

> *"The concentrations of contaminants in the water in Port Kembla have been reduced dramatically since the 1970s and this improvement in water quality has correlated with an increase in the diversity and abundance of invertebrates and fish in Port Kembla Harbour."*

The study concluded that it was "highly likely" that continual improvement of the water quality would result in the biological diversity found in similar estuaries.

3.2.4 Amelioration Measures

NSG (August 2006) has identified that manipulative field experiments, comparative surveys amongst estuaries and laboratory bioassays would be required to distinguish the causal factors explaining the distribution of species within Port Kembla. In addition NSG noted that:

> *"Remediation of the chemical environment may be a prerequisite for biological remediation and this will not be achievable without massive intervention (e.g. removal of contaminated sediments from the Harbour)."*

In order to minimise the exclusion of species from Port Kembla Harbour, improvement of the water and sediment quality to that found in estuaries without the heavy industrial influences found in Port Kembla Harbour would be required to increase the diversity and abundance of organisms at all trophic levels (e.g. algae, invertebrates and fish).

It is noted that dredging works were subsequently undertaken in 2007 which had the potential to remove contaminated sediments from Port Kembla Harbour and improve the water quality.

3.2.5 Influence of Temperature Change on the Potential for Introduction of Exotic Species into Port Kembla Harbour

NSG (August 2006) assessed the potential effects of a temperature change of introducing species already established in Australia as well as international species not yet present in Australia. NSG noted that temperature changes of approximately 3°C have the potential to result in the creation of a warm water refuge throughout the year that could result in ecologically significant changes and therefore concluded that:

> *"Most of the species that have been identified as potential invaders (i.e. within other parts of Australia and from outside Australia) tend to inhabit a wide range of water temperatures (e.g. from temperate to tropical waters). Changes in temperature are unlikely to influence the potential for invasion of a large number of exotic species into Port Kembla Harbour. However, the changed temperature regime may heighten the likelihood of establishment of some exotic species including: Perna viridis, Mytilopsis sallei, Limnoperna fortunei, and the crab Hemigrapsus sanguineus…. These species are known to be introduced by shipping vectors and tend to occur in warm water areas. If successfully translocated, they may be able to colonise the area surrounding the cooling outfall similarly to the tropical fish assemblage identified in the Fish Study (MSE, 2002)."*

Although the possibility exists for exotic species to be introduced into the Harbour, notably from shipping movements, as the predicted temperature increase is less than 1°C during typical summer and winter conditions, this is not expected to increase the likelihood of an invasion of exotic species.

DECC has identified a concern regarding the potential for the change in conditions to encourage the introduction of threatening organisms such as dinoflagellates. Table 4 of **Appendix F** indicates that any increase in temperature is not likely to result in an effect on the population of this potentially harmful species.

Establishment of these pest species may have striking effects on the composition and biological diversity of Port Kembla Harbour from which recruitment into neighbouring habitats and other ports and estuaries could occur. Management options currently exist for reducing the risk of marine introductions and these include ocean ballast exchange and antifouling paints.

3.3 Contamination Impacts

In accordance with DECC's letter dated 21 December 2005 (see page 9, **Appendix A**), a review of contemporary literature on the "*effects of enhanced temperatures on uptake of contaminants (metals and PAHs) due to increase metabolism of Harbour biota*" was assessed by NSG (August 2006).

3.3.1 Influences of Temperature on Toxicity and Bioaccumulation of Heavy Metals and PAHs on Marine and Estuarine Organisms

Heavy metals

NSG (August 2006) describe that increases in temperature are related to increases in the toxicity of heavy metals. This pattern has been observed for a wide range of marine organisms (i.e. algae, invertebrates and fish) at various life history stages (i.e. fertilisation, larval development, juvenile and adult mortality) and for a wide range of metals and organic compounds.

The studies investigated by NSG involve ambient temperatures of less than 20ºC and/or compare differences in temperature that are greater than 5ºC, however a few studies have, evaluated the effects of increases in temperature over a range that may occur in Port Kembla Harbour (i.e. 2.6ºC). The results of these studies support the general finding that an increase in temperature leads to increased toxicity of heavy metals (e.g. cadmium, zinc and copper) on a range of algae, invertebrates and fish. None of these studies used species that occur in Port Kembla Harbour (see **Appendix F**).

Studies undertaken on the mortality of an inter-tidal gastropod within the temperature range that exists in Port Kembla Harbour after being exposed to mercury contaminated water concluded that:

> *"At 25 °C, 2 mgL-1 of mercury killed approximately 10% of the snails; while the same concentration at 30°C killed 30% of the snails. At slightly higher mercury concentrations (i.e. 8mgL-1) the effects were even greater with 35% of the snails being killed at 25°C compared to 82% at 35°C. Consistent increases in the mortality rate were also observed for intermediate concentrations."*

The results indicate that a temperature change of 5ºC increased the mortality rate of the inter-tidal gastropod by 20%. It should be noted that the studied species does not occur in Port Kembla Harbour, however several species from the same family (i.e. Trochidae; *Turbo torquatus*, *Austrocochlea porcata*, *Austrocochlea constricta*) occur in estuaries along the NSW coast and *Austrocochlea constricta* has been observed alive in Allan's Creek (MSE 2002). Estimates of the mercury concentration in the waters of Port Kembla could not be assessed as it is not measured in BlueScope Water Quality Surveys and it was not mentioned in available literature.

Polycyclic-aromatic hydrocarbons (PAHs)

The literature does not reveal much meaningful research on the influence of temperature on the effects of PAHs. None of the studies relevant to this topic involved species found in Port Kembla Harbour, although one study did involve tests on shrimp and several prawn species that have been found within the Harbour. The literature indicated that bioaccumulation of PAHs varies greatly among organisms. Fish are able to metabolise PAHs rapidly, while invertebrates are relatively slow to metabolise these contaminants. There appears to be no published literature, however, on the effects of temperature on the bioaccumulation of PAHs.

Bioaccumulation and metabolism

Bioaccumulation of metals in marine organisms has also been found to increase with increases in temperature.

Toxicity and bioaccumulation of heavy metals and organic contaminants associated with temperature increases are generally related to increases in the metabolism of the organisms which can lead to greater uptake of the contaminants through food consumption. Bioaccumulation of PAHs varies greatly amongst organisms (however there is no published literature on the effects of temperature on the bioaccumulation of PAHs).

NSG (August, 2006) made the following conclusion in relation to the influence of temperature on toxicity and bioaccumulation of contaminants on marine and estuarine organisms:

> *"It is unclear whether detectable increases in toxicity would be likely to occur following the commissioning of the ICP. It would, however, appear unlikely that a general increase of less than 0.8°C would cause a large (e.g.>50%) increase in the effects (toxic or bioaccumulation) of the heavy metals or PAHs at the entrance to Allan's Creek or the Inner Harbour. This prediction is based on the general relationship that temperature generally increases the toxicity of heavy metals but that this tends to be linear and not an exponential relationship (i.e. a small change would be unlikely to create a disproportionately large effect). If, however, the increase in temperature goes above the maximum predicted temperature change (i.e. > 3 °C), then it is possible that there may be significant increases in toxicity or bioaccumulation due to the temperature change but only for some organisms and some toxicants"*

3.3.2 Toxicant dilution

Measures to inhibit the growth of sessile marine organisms and prevent fouling of pipework are necessary when using salt water as a cooling system. The process additive Spectrus CT1300 (Clamtrol II) is currently used by BlueScope Steel in its existing salt water cooling systems for the No. 1 Power House and No.2 Blower Station. Clamtrol is an aqueous solution of an alcohol and quaternary ammonium compound. Colourless to yellow in appearance, it is 100% soluble in water (MSDS, 2002).

Dosing may be required for the ICP STG condenser. BlueScope Steel is currently trialling a 1mg/L dosing rate at the No. 4 Alternator condenser at No. 1 Power House, with results indicating a discharge concentration of less than 0.15mg/L. The reduction in concentration is due to:

- consumption of Clamtrol II in the system between the dosing point (ie. the condenser inlet) and the discharge from the Main Drain into Allan's Creek, and
- dilution from the other parallel undosed condenser circuit which also discharges into the Main Drain.

If, at the conclusion of this trial period, the dosing rate is proven to provide adequate cleaning, BlueScope Steel may seek to implement this dosing regime for the ICP salt water cooling system, with subsequent monitoring to verify its effectiveness. **Table 3.1** indicates past and current dosing rates and discharge limits at the No. 1 Power House and No. 2 Blower Station.

Table 3.1 Previous Dosing Rates and Discharge Concentrations

	Dosing Rate	Discharge Limit	Duration
No.2 Blower Station (Clamtrol I)	6mg/L	0.4mg/L	8 hrs
No.2 Blower Station (using Clamtrol II) – initial dosing regime	3mg/L	0.4mg/L	8 hrs
No.2 Blower Station (using Clamtrol II) – modified due to resultant macro-fouling	3mg/L	0.4mg/L	12 hrs
No.2 Blower Station (using Clamtrol II)	3mg/L	0.25mg/L[a]	12 hrs
No. 1 Power House (No.2 Turbo Alternator)	2.5mg/L	0.15mg/L[a]	12 hrs
No. 1 Power House (No.2 Turbo Alternator) (trial)	2.0mg/L	0.15mg/L	24 hrs
No. 1 Power House (No.4 Turbo Alternator)	2.0mg/L	0.15mg/L	12 hrs
No. 1 Power House (No.4 Turbo Alternator) (trial)	1.0mg/L	0.15mg/L	24 hrs
ICP	1mg/L	0.25mg/L[b]	24 hours initially

[a] Current discharge limits
[b] Proposed ICP dosing rate and discharge limits (based on ongoing trials)

Currently the No.1 Power House has a discharge limit of 0.15mg/L while the No. 2 Blower Station Drain has a discharge limit of 0.25mg/L. The lower discharge concentration at the No. 1 Power House is achievable due to its specific and unique drain configuration. The cooling water flows into the Main Drain which has a high residence time and contains a variety of natural anionic substrates and sediments, before being discharged into Allan's Creek at the discharge point (where the discharge concentration limit is applied). The high residence time allows Clamtrol II to be more fully adsorbed and deactivated before being discharged into Allan's Creek.

The No. 2 Blower Station Drain has a much shorter residence time before being directly discharged into Allan's Creek, therefore reducing the time for Clamtrol II to be adsorbed and deactivated.

See **Section 3.5** for further discussion on Clamtrol II and other anti-fouling measures.

3.4 Zooplankton Populations

Below is an assessment of the potential impact associated with the entrainment of plankton in the ICP salt water cooling system.

3.4.1 Calculation of Extraction Index

An extraction index for the existing and post-ICP conditions was calculated (CLT, Sept 2006, see **Appendix I**) to determine the potential impact on plankton biomass found in Port Kembla Harbour resulting from the proposed ICP cooling system.

The extraction index provides a basis for assessing and comparing the impact on plankton biomass in Port Kembla Harbour before and after commissioning of the ICP. The extraction index (I) was calculated by using the following formula:

I = Ti/Tr

where Ti = time required to extract a volume of cooling water equal to the volume of water in Port Kembla Harbour (both Inner and Outer Harbour) and Tr = average residence time of Harbour water.

To calculate Ti, the volume of Port Kembla Harbour was calculated based on the model bathymetry.[2] The volume of water was determined to be 24.25 x $10^6 m^3$. Cooling water flow rates (m^3/s) were required to assess the time of circulation of Port Kembla Inner and Outer Harbour waters through the cooling system. The flow rates were sourced from flow rates previously calculated and outlined in Tables 4.1, 5.1 and 6.1 from **Appendix D.** However, the flow rates considered in the extraction index only included flows which were drawn from the Harbour (i.e. Outer Harbour salt water intake lift pump station).

The average residence time (Tr) is the average time that water resides in Port Kembla Harbour under existing conditions including tidal flushing influences. To determine Tr, an inert tracer was placed in the model under the following scenarios;

- Existing average summer and typical post-ICP;
- Existing average winter and typical winter post-ICP; and
- Existing peak summer and peak summer post-ICP.

The modelling took into consideration cooling water flows, winds and tides.

With Ti and Tr determined, the extraction index was calculated (see **Table 3.2).**

[2] *Subsequent to the calculation of Port Kembla Harbour bathymetry of 24.25x$10^6 m^3$, developments at Port Kembla Harbour including harbour dredging were approved. The bathymetry was re-calculated (CLT, 2008) based on a loss of Harbour volume of 85,000m^3 and loss of tidal prism of 8,000m^3. This resulted in a net increase in harbour volume of 0.2% and a decrease in tidal prism of 0.3%. Changes to the previous extraction index calculations were found to be less than 0.5%.*

Table 3.2 Extraction Index

Parameter	Summer-Pre-Ave	Summer-Post-Ave	Winter-Pre-Ave	Winter-Post-Ave	Summer-Pre-Peak	Summer-Post-Peak
Ti (days)	28.5	18.4	26.9	18.4	26.9	17.9
Tr (days)	3.8	3.2	6.5	6.0	3.2	2.4
Index (I)	**7.5**	**5.8**	**4.1**	**3.1**	**8.4**	**7.5**
Pump Flow (m^3/s)	9.85	15.26	10.43	15.26	10.44	15.72

An index value of one (1) would indicate that the ICP pumping system pumps the entire volume of Port Kembla Harbour through the ICP cooling system at the same rate that the waters in the Harbour are exchanged by other forces dominated by tidal flushing but also strongly influenced by prevailing winds. Such a ratio would infer that the entire biological population of plankton would in turn be exposed to the mechanical, temperature and chemical influences imparted upon waters that pass through the ICP cooling system. Ratios higher than one (1) indicate that the volume of the Harbour is greater than the drawing capacity of the intake and that the existing forces of exchange in the Harbour are replacing the waters many times faster than the pumps can pass the resident water, or equivalent volume through the ICP.

Table 3.2 indicates that post-ICP the extraction index (I), under typical summer, typical winter and peak summer conditions, will decrease. These results are to be expected as the commissioning of the ICP will lead to an increase in the volume of Harbour water used for cooling, therefore reducing the time it would take for the volume of water in the Harbour to travel through the cooling system, therefore reducing Ti.

Table 3.3 indicates the percentage change in the extraction index after commissioning of the ICP.

Table 3.3 Comparative Extraction Index Pre-ICP and Post-ICP

	Extraction Index Pre-ICP	Extraction Index Post-ICP	Percentage Change (%)
Summer Typical	7.5	5.8	29.3
Winter Typical	4.1	3.1	32.3
Summer Peak	8.4	7.5	12.0

The table indicates a percentage change of the extraction index from 12.0% during the summer peak period to a 32.3% change during the typical winter period. The higher residence times observed in winter are due to differences in the prevailing winds which tend to be southerly and result in waters being retained in the Harbour. In contrast, northerly/north-westerly winds in summer facilitate current exchanges from the Harbour.

A discussion of the possible effects of this change on the plankton of Port Kembla Harbour is provided in **Section 3.4.2**.

3.4.2 Plankton within Port Kembla Harbour

A comprehensive literature review was undertaken (NSG, Dec 2006, **Appendix G**) to identify the existence and abundance of planktonic assemblages within both the Inner and Outer Harbour of Port Kembla and Allan's Creek. Three recent studies were identified which provided sufficient information to gain a general understanding about the diversity and abundance of planktonic assemblages within Port Kembla Harbour. The following general conclusions can be made:

- There is a trend of greater diversity and abundance of plankton in the Outer Harbour than the Inner Harbour;
- Planktonic assemblages in Port Kembla Harbour appeared to be generally less diverse and abundant than those of the open coast or from less disturbed estuaries;
- The assemblages comprise a wide range of taxa from tiny phytoplankton and zooplankton to an abundant and diverse array of copepods, to larvae of many benthic invertebrates, larval fish and macro-plankton like jellyfish; and
- There seemed to be variation in the diversity and abundance of the plankton throughout the Harbour (both horizontally and vertically) and through time (days, seasons and years).

This literature provides a general understanding of the diversity and abundance of plankton populations within Port Kembla Harbour and Allan's Creek.

3.4.3 Extraction Index and Potential Impact on Plankton

In considering the change in the extraction index and the planktonic assemblages in the Harbour, the desktop assessment undertaken by NSG (NSG Dec 2006) noted that the change in the extraction index may "be a matter for concern, if three assumptions hold". These assumptions are:

1. plankton are distributed evenly throughout the Harbour;
2. plankton are passive particles; and
3. entrainment will result in 100% mortality of plankton.

The merits of these assumptions are further discussed herein.

1. Plankton are distributed evenly throughout the Harbour

An increase in entrainment of plankton proportionate to the change in the extraction index necessitates the assumption that plankton are evenly distributed throughout the Harbour. However, NSG has recognised "substantial spatial variation among, within and between the Inner and Outer Harbour". NSG also suggests that, due to the position of the intake channel between the Inner and Outer Harbour, a general sample of plankton is likely to be entrained. There is therefore uncertainty in the assumption that plankton are distributed evenly throughout the Harbour. Further, hydraulic patterns evident from the cooling water modelling (CLT, 2006) indicate that tidal and wind effects are key influences on the spatial distribution of waters of differing temperatures and that there are distinct areas of the Harbour that are less influenced by such patterns. It is reasonable to suggest that entrainment of plankton from such areas may be much lower than average.

2. Plankton are passive particles

An increase in entrainment of plankton proportionate to the change in the extraction index, necessitates the assumption that plankton are passive particles. However, NSG has recognised that plankton have "limited motility". Whether this motility is enough to avoid the intake currents is not determined however the report notes that:

> *"vertical position can also influence the movement of plankton as currents at different depths often move at different speeds and in different directions. By regulating their position in the water column, plankton can travel in different directions."*

Therefore, even with limited motility, plankton may use the differing levels of the water column to avoid the intake currents from the ICP cooling system. In addition, the tidal influence on plankton may see many of the plankton removed from the Outer Harbour and replaced with other plankton from outside of the Harbour. Therefore, the increase in plankton entrainment may not be proportionate to the extraction index due to the limited motility of plankton and the fluctuation in plankton diversity due to tidal effects.

3. Entrainment will result in 100% mortality of plankton

Entrainment within the ICP cooling system will expose plankton to increased temperatures, biocide (during the dosing periods only – see **Section 3.5**) and the general mechanical effects of being pumped through the pipes and valves of the cooling system. The literature review indicated that previous studies have observed a large variation in the range of mortality rates for differing species. For example, a 2004 study by Bamber and Seaby suggested a 10-20% mortality of copepods and larval shrimp and lobster compared to a study by Carpenter in 1974 which indicated a 70% mortality of copepods. Such variability in literature introduces uncertainty regarding the precise effects of entrainment on the various planktonic assemblages in Port Kembla Harbour.

However, due to the large variation of mortality rates, NSG noted that "an assumption of 100% mortality is conservative". Therefore it is unlikely that the total plankton entrained in the cooling system will cause 100% mortality but, across the wide range of taxa, mortality rates may differ significantly.

In addition, the effects of entrainment must also be assessed against the likelihood of entrainment. Table 1 of **Appendix G** (NSG Dec 2006) compares the lifespan of certain taxa against the change in residence time to determine which planktonic assemblages are likely, during their lifespan, to be entrained into the system post-ICP. Due to the large variance of life spans of these planktonic assemblages, the lower and upper limits of life spans were considered.

Table 3.4 compares the proportion of Port Kembla Harbour through the cooling system, pre-ICP and post-ICP in one residence time. This is calculated by inverting the extraction index as follows:

$P_m = 1/I$

Where $I = T_i/T_r$ (extraction index)

Table 3.4 Comparison of Residence Times and Harbour Volume in One Residence Time.

	Tr (days) Pre-ICP	I	Pm (%)	Tr (days) Post-ICP	I	Pm (%)	Percentage Change (%)
Summer Ave/ Typical	3.8	7.5	**13**	3.2	5.8	**17**	4
Winter Ave/ Typical	6.5	4.1	**24**	6.0	3.1	**32**	8
Summer Peak	3.2	8.4	**12**	2.4	7.5	**13**	1

Due to the conservative assumption of 100% mortality of plankton through the ICP cooling system, P_m can be interpreted as not only the proportion of Port Kembla Harbour's volume of water through the ICP cooling system in one residence time, but also the mortality rate of plankton per residence time.

Table 3.4 indicates that post-ICP, during summer typical operations, in 1 residence time (3.2 days) approximately 17% of the volume of Port Kembla Harbour will travel through the ICP cooling system. In winter, in one residence time (6 days), approximately 32% of the volume of Port Kembla Harbour will travel through the ICP cooling system. This is an increase of 4% when compared with the current pre-ICP average summer conditions, 8% increase compared with the winter average conditions and 1% increase compared with the summer peak conditions. This suggests that there would be an increase in impact in one residence time on the aquatic ecology of Port Kembla Harbour based on the current salt water intake levels, an impact which is likely to be greater during the winter months.

Table 3.5 compares the residence time against the upper and lower life spans of a range of taxa pre-ICP and post-ICP for the increase in potential for entrainment in the cooling system.

Table 3.6 is an extract from Table 1, **Appendix F** which compares Ti against the upper and lower life spans of a range of taxa.

Table 3.5 and **Table 3.6** indicate that taxa such as bryozoan larvae, which have a maximum lifespan of five days, will be able to complete its lifespan before entrainment into the cooling water intake system throughout the year, although entrainment is possible.

Plankton such as diatoms or mussel larvae with a life or larval span of 3-7 days may increase the possibility of entrainment but it is still likely for this taxa to be able to spend their entire lives without being impacted by the cooling system, notably during the winter months.

Taxa such as copepods and crab larvae which have a life span of 90-365 days are highly likely to become entrained into the cooling system at one stage of their life depending on their levels of motility.

The above assessment has been based on a premise of 100% mortality for all plankton entrained in the salt water cooling system. However, operation of existing condensers at the PKSW (e.g. the No.1 Power House or No.2 Blower Station condensers) which are subject to salt water cooling have resulted in macro-fouling of these systems, fouling not only the discharge infrastructure but at the condenser as well. Experience by BlueScope Steel has identified the need to anti-foul the condensers used at PKSW which are notably the highest temperature point in the salt water cooling system. Therefore, it is acknowledged that the premise of 100% mortality for all plankton entrained into the cooling system is considered conservative.

In addition, the potential for entrainment can not be considered in isolation. Port Kembla Harbour is tidal and as a result, is impacted by tidal flushing. The Harbour is also strongly influenced by winds. Certain species may be moved out from Port Kembla Harbour and conversely, brought in to Port Kembla Harbour. Therefore, the impact on plankton assemblages originating in the Harbour may in fact be similar to the impact on plankton brought in from outside of the Harbour. This would therefore minimise the impact of the cooling water increase on plankton within Port Kembla Harbour.

Table 3.5 Comparison of the Life and Larval Span and Residence Time

		Summer								Winter			
Taxa	Life / Larval Span (days)	pre-ICP (3.8)	post-ICP (3.2)	pre-ICP (3.8)	post-ICP (3.2)	peak pre-ICP (3.2)	peak post-ICP (2.4)	peak pre-ICP (3.2)	peak post-ICP (2.4)	pre-ICP (6.5)	post-ICP (6.0)	pre-ICP (6.5)	post-ICP (6.0)
		Lower limit	Lower limit	Upper limit	Upper limit	Lower limit	Lower limit	Upper limit	Upper limit	Lower limit	Lower limit	Upper limit	Upper limit
Bryozoan Larvae	0.05-5	0.01	0.02	1.32	1.56	0.02	0.02	1.56	2.08	0.01	0.01	0.77	0.83
Diatoms	3-7	0.79	0.94	1.82	2.19	0.94	1.25	2.19	2.92	0.46	0.50	1.08	1.18
Mussel Larvae	3-7	0.79	0.94	1.82	2.19	0.94	1.25	2.19	2.92	0.46	0.50	1.08	1.18
Barnacle Larvae	14-21	3.68	4.38	5.53	6.56	4.38	5.83	6.56	8.75	2.15	2.33	3.23	3.50
Copepods	90-365	23.68	28.13	96.05	114.06	28.13	37.5	96.05	152.08	13.85	15.00	56.15	60.83
Crab Larvae	90-365	23.68	28.13	96.05	114.06	28.13	37.5	96.05	152.08	13.85	15.00	56.15	60.83

Table 3.6 Comparison of the Life and Larval Span and the time required to extract a volume of cooling water equal to the volume of water in Port Kembla Harbour (Ti)

		Summer								Winter			
Taxa	Life / Larval Span (days)	pre-ICP (28.5)	post-ICP (18.4)	pre-ICP (28.5)	post-ICP (18.4)	peak pre-ICP (26.9)	peak post-ICP (17.9)	peak pre-ICP (26.9)	peak post-ICP (17.9)	pre-ICP (29.6)	post-ICP (18.4)	pre-ICP (29.6)	post-ICP (18.4)
		Lower limit	Lower limit	Upper limit	Upper limit	Lower limit	Lower limit	Upper limit	Upper limit	Lower limit	Lower limit	Upper limit	Upper limit
Bryozoan Larvae	0.05-5	0.00	0.00	0.18	0.27	0.00	0.00	0.19	0.27	0.00	0.00	0.19	0.27
Diatoms	3-7	0.11	0.16	0.25	0.38	0.11	0.16	0.26	0.38	0.11	0.16	0.26	0.38
Mussel Larvae	3-7	0.11	0.16	0.25	0.38	0.11	0.16	0.26	0.38	0.11	0.16	0.26	0.38
Barnacle Larvae	14-21	0.49	0.76	0.74	1.14	0.52	0.76	0.78	1.14	0.52	0.76	0.78	1.14
Copepods	90-365	3.16	4.89	12.81	19.84	3.35	4.89	13.57	19.84	3.35	4.89	13.57	19.84
Crab Larvae	90-365	3.16	4.89	12.81	1.84	3.35	4.89	13.57	19.84	3.35	4.89	13.57	19.84

3.4.4 Consequences of the loss of Plankton and Larvae on Port Kembla Ecology

Importance of Plankton to the Aquatic Ecology of Port Kembla Harbour

Plankton are an important component to the ecology of Port Kembla Harbour. Plankton are both primary producers (phytoplankton) and a source of food for higher trophic level organisms such as fish (plankton and zooplankton). Many marine organisms spend at least part of their life-cycle as planktonic larvae before they settle and become sessile. Increased extraction of plankton through the ICP cooling system has the potential to impact upon various components of the marine ecosystem in Port Kembla Harbour which are reliant on plankton as a food source (UNSW, March 08).

Consequences of the loss of Plankton and Larvae on Port Kembla Ecology

Due to the limited available information on the aquatic ecology of Port Kembla Harbour and limited research to date on the potential effects of plankton entrainment, mortality and its impact beyond the point of discharge, UNSW Global (formerly NewSouth Global Consulting) undertook a study entitled, "*Conceptual Models of Potential Ecological Impacts of Plankton Entrainment in the Port Kembla Steelworks Cogeneration Plant*" (UNSW, March 2008 – see **Appendix H**)) This Report assessed the potential ecological effects of plankton extraction and mortality upon the ecology of Port Kembla Harbour beyond the discharge point using conceptual models to determine likely scenarios and the scale of impact on the aquatic ecology. The conceptual models took into consideration pre-ICP and post-ICP circulation patterns in Port Kembla Harbour. The importance of circulation patterns was noted in this report:

> *"Turnover of seawater through tidal flushing of the Outer Harbour, and the sub-surface thermal counter current between the Outer and Inner Harbours are important factors which will interact with the thermal plume to determine the precise scale of ecological impact."*

The following scenarios and conclusions were made having regard to both the Outer Harbour and Inner Harbour of Port Kembla:

Outer Harbour

The Report concluded that there is unlikely to be an appreciable impact on the abundance of plankton in Port Kembla Outer Harbour as "*plankton removed in cooling water is likely to be replaced by plankton entering the Harbour during tidal exchange relatively quickly*" (UNSW, March 2008).

Inner Harbour

Three possible scenarios were outlined to assess the potential impact of plankton entrainment on the ecology of Port Kembla Inner Harbour. The Report recognised that the scale of the potential impact would be largely determined by the circulation patterns within the Inner Harbour post-ICP. The following scenarios and conclusions for the Inner Harbour were made:

- Scenario 1 – Additional extraction does not appreciably influence pre-ICP circulation patterns resulting in no detectable, or slight ecological impacts. Under this scenario, any deleterious effects would most likely be confined to the mouth of Allan's Creek;
- Scenario 2 – Additional extraction increases flow rates in thermal plume, and underlying counter current resulting in moderate impacts. Under this scenario, replenishment from the counter current beneath the thermal plume may be slow, resulting in a larger area of the Inner Harbour being affected by the outflow of cooling water; and
- Scenario 3 – Additional extraction dominates circulation patterns within Port Kembla Harbour resulting in large impacts (worst case scenario). Under this scenario, a uni-directional flow of water across most depths is generated resulting in the Inner Harbour being unable to replenish plankton communities.

The report concluded that the most likely outcomes were those proposed in scenarios 1 and 2, with scenario 3 being unlikely to occur (see section 4 of **Appendix H**).

CLT modelled the potential impact on currents in the Inner Harbour post-ICP (refer **Section 2.4** and Section 5.2 of **Appendix E**) to determine whether the ICP would impact upon currents in Port Kembla Inner Harbour, consequently impacting upon shipping operations. The results of the modelling indicated a very small change to the current conditions in Port Kembla Harbour:

> "*the currents inside the Inner Harbour are small – generally less than 0.02m/s (depth-averaged). The ICP is not expected to change the general current conditions and changes to current speeds are small, generally less than 0.005m/s.*"

Based on these results, the potential scale of impact on current conditions (i.e. circulation patterns) and current velocities is expected to be small. The consequent impact on plankton entrained into the ICP cooling system, based on the three scenarios outlined by UNSW (March, 2008) and the impact on circulation patterns post-ICP as modelled by CLT, suggest that the impact on plankton in Port Kembla Harbour would more likely correspond to Scenario 1, "*Additional extraction does not appreciably influence pre-ICP circulation patterns*". Based on Scenario 1, the impact on plankton is more likely to be confined to the mouth of Allan's Creek.

In addition to the direct impact on plankton, an indirect impact on the ecology in Port Kembla Harbour may also occur. Based on a conservative assumption of 100% mortality, the following consequences of the ICP salt water cooling system may occur:

- If the plankton remain suspended in the water column, the abundance of filter feeders and fish which rely on live plankton may decrease;
- If filter feeders and fish don't require live plankton, the abundance of filter feeders may increase – the discharge may act as a delivery vector, concentrating food particles in a small area, allowing certain species to feed off the suspended matter;

- If the plankton sink to the seafloor, benthic deposit feeders such as amphipods and polychaetes which consume dead organic matter in surface sediments would be expected to increase in abundance.

Therefore, a change in the abundance of certain species (both positive and negative) in Port Kembla Inner Harbour may occur from the ICP cooling system (see section 2.1 UNSW March 2008, **Appendix H**).

Vertical Stratification of Plankton in the Water Column and Depth Selective Devices

The NSG Report (March 2008) noted that "plankton often show vertical zonation, with a greater diversity of plankton in the surface or middle depths than at the sea floor". It also noted that there is daily movement of plankton from deeper water to the surface during the night time.

A study was undertaken in 1991 by MSE and CEC to determine whether there was any variation in planktonic communities at the surface and at a depth of 6m in Port Kembla Harbour. Conclusive results were not found. These results suggest that there was not significant vertical stratification in the water column which would effectively minimise entrainment of plankton into the cooling system if, at the intake, it sourced the salt water from a particular depth in the water column. The UNSW Report (March 2008) concluded that "there is not enough conclusive evidence to ascertain the effectiveness of the use of a depth selective device at the existing intake pump station". It is noted that due to the current configuration of the existing intake pump station, a depth selective device is not currently possible.

3.4.5 Dinoflagellates

Previous studies have identified the existence of dinoflagellates in Port Kembla Harbour including the dinoflagellate *Alexandrium* spp. and phytoplankta *Psuedo-nitzchia* spp". NSG (August 2006) identified that a temperature increase in Port Kembla Harbour may affect the uptake of nutrients which are considered to be a key factor in causing plankton blooms. However, as well as nutrients, a combination of factors must be aligned for a toxic bloom of certain dinoflagellates including *Pfiesteria piscicida* to occur. Other factors include salinity, light, pH, algal prey and water motion (Glasgow *et al* 2001).

Although dinoflagellates have been identified in the Harbour, NSG concluded that "plankton blooms have not been reported in Port Kembla Harbour, and the chances of such blooms occurring is unlikely to increase if the changes in water temperature occur as predicted (i.e. generally less than 0.8˚C change)". In addition, as the proposed cooling water system will not have a significant impact upon other factors which have the potential to create an algal bloom such as pH, light or salinity, the predicted temperature change of 0.8˚C during summer typical periods is not expected to increase the likelihood of algal blooms in Port Kembla Harbour.

3.5 Anti-Fouling Measures

The use of salt water for cooling purposes leads to the introduction and accumulation of aquatic plants, algae and macro-organisms, such as mussels and barnacles, within the cooling system. The accumulation of these organisms, a process known as macro-fouling, leads to blockages within the cooling pipes reducing coolant flow and efficiencies within the plant. At the PKSW, macro-fouling affects both the salt water inlet channel (which currently supplies water from the Port Kembla Inner Harbour to the No. 1 Power House and the No.2 Blower Station), and individual cooling circuits such as STG condensers.

A number of options exist for the control of macro-fouling, including mechanical, physical, thermal and chemical controls. BlueScope Steel currently uses a chemical control (biocide) called Spectrus CT1300 (Clamtrol II) in conjunction with physical and mechanical controls to control macro-fouling at the No.1 Power House and No.2 Blower Station.

For a detailed assessment on macro-fouling control for condenser cooling at the PKSW see **Appendix J**.

3.5.1 History of Anti-fouling Measures Used at the PKSW

Until the late 1980s PKSW used direct chlorination to control macro-fouling. The dosing system injected a metered flow of gaseous chlorine into a side stream flow of secondary salt water, which tapped into each piece of plant equipment's cooling water flow. This process was effective in controlling macro-fouling; however issues arose with problematic injectors and breakages of injection piping, which resulted in gaseous chlorine evolving and building up to hazardous levels in the low-lying saltwater pump basement area of the station (Pers com B. Prince, 18 Feb 2008). The use of gaseous chlorine also required the on-site storage of large amounts of bulk chlorine cylinders, creating a high risk installation.

Gaseous chlorine use and storage was soon replaced by a chlorine dioxide generator. The generator required the on-site storage of hydrochloric acid and sodium chlorite. This system, although regularly serviced by the vendor, had numerous operational issues including pipe and valve breakage and failure of electrical components. The installation of the chlorine dioxide generator was intended to remove the risks of bulk chlorine storage. However, when a chemical delivery mistakenly transferred chemicals into the wrong tank, this resulted in the mixing of hypochlorite and hydrochloric acid together. This reaction generated a highly toxic gas. Due to the risk to human health associated with the use of a chlorine dioxide generator, it is no longer used for macro-fouling.

Another option installed in the early 1980's was an online tube cleaning system for turbine condensers. The salt water cooling system was fitted with a 'Taprogge' ball cleaning system. The Taprogge system works by adding a number of plain and grit coated sponge rubber balls to the cooling water flow which abrasively clean the tubes. Once the balls have passed through the cooling water system they are caught in a strainer and returned to the beginning of the system for re-use. The system experienced a number of problems including:

- Frequent loss of balls from the circuits, often due to jamming at tube inlets

- Loss of balls in eddies formed in the condenser water boxes or the circulating system
- Fouling of the catching strainers and other smaller pipes affecting the flow of cooling water.

As a result of the abovementioned problems, the systems have all been decommissioned and largely removed.

In 1995, Spectrus CT 1301 (Clamtrol I), a non-oxidising chemical was first employed at the No. 2 Blower Station. It was found to be effective in eliminating marine organisms.

In May 2004, Spectrus CT 1300 (Clamtrol II) replaced Clamtrol I at the PKSW which was considered to be more environmentally acceptable.

3.5.2 Assessment of Anti-fouling Controls

Table 3.7 contains a summary of the advantages and disadvantages of the various macro-fouling control options considered for the ICP cooling water system.

Table 3.7 Advantages and Disadvantages of Macro-Fouling Options

Control Method	Advantages	Disadvantages
Mechanical		
Screens	• Minimal impact on the environment	• Limited in effectiveness as sole option as fails to remove microscopic larvae of macro-organisms
Physical		
Manual Cleaning	• Low environmental impact	• Highly intensive and laborious • Costly as cleaning must take place off-line • Some smaller diameter pipelines cannot be manually cleaned
Taprogge Ball	• Minimal impact on the environment (when successfully operated)	• Ball causes erosion of the condenser cooling surfaces • Some smaller diameter pipelines cannot be reached by the ball • Requires a large, on-site footprint • High levels of maintenance required • Known to create environmental issues when balls are not captured
Thermal	• Economical benefits when incorporated into original plant design • Relatively rapid mortality rates for many macro-organisms	• High water temperatures can be lethal to non-target organisms • Use of high water temperatures can create excessive turbine back pressure • Retrofitting of plants is cumbersome and expensive • Large footprint required • Not all forms of macro-fouling removed thermally
Paints and Coatings	• Affects only macro-organisms within the cooling system	• Formation of corrosion-resistant films within pipes reduces the effectiveness of the coating • Re-application required every 2-5 years • Re-application required complete dewatering of the cooling water system • Reduces efficiency of cooling water efficiency through reduction in the heat transfer co-efficient
Chemical		

Control Method	Advantages	Disadvantages
Oxidising Compounds	• Highly effective	• Long exposure time required as readily detected by macro-organisms, which withdraw for protection • Large amounts of chemical are required • Lethal to non-target species, such as plankton and fish at similar concentrations to macro-organisms • Reactive nature of the agents causes corrosion • React to produce chlorinated and halogenated bi-products • Many oxidising agents are highly toxic to humans • Risk to human health
Non-oxidising Compounds	• More specific to target organisms and hence more environmentally sound • Do not react with naturally occurring organics to produce chlorinated and halogenated by-products • Lower exposure time than oxidising compounds • Active ingredient is short-lived in the environment and biodegrades to CO_2 or H_2O	• Some environmental impacts on marine ecology • Not effective on marine plants entrained in the cooling water system

3.5.3 Current Anti-Fouling Methods Used at the PKSW

BlueScope Steel currently uses a variety of methods to control macro-fouling at the PKSW. They include the following:

- *Mechanical* –salt water channel inlet screens; filters in individual machine cooling circuits

- *Physical* – manual cleaning of large channels by divers during normal operation, and of condensers during maintenance outages;

- *Chemical* – Clamtrol II is currently dosed at the No. 1 Power House and the No. 2 Blower Station (the current discharge limits for Clamtrol II are 0.15 mg/L at the Main Drain licensed discharge point (for No. 1 Powerhouse) and 0.25mg/L at the No. 2 Blower Station Drain licensed discharge point Allan's Creek discharge point (for No. 2 Blower Station). Dosing occurs at approximately four-weekly intervals during summer and six-weekly intervals during winter.

3.5.4 Anti-fouling Methods Used Across the World

Industrial plants that use salt water for cooling purposes also require anti-fouling measures to keep their cooling systems free from marine organisms and debris. The following is a brief outline of a number of other power plants and the anti-fouling methods they employ:

- *Power plant on the Venice Lagoon (Italy)* – this power plant uses an in-service ball cleaning system combined with chemical treatment;

- *Koeburg Nucelar Power Plant (South Africa)* – chlorine injection is currently being used after operational problems associated with its salt water ball cleaning system.
- *AES Hawaii Inc. Cogeneration Plant, (Barbers Point, Hawaii)* - this cogeneration plant uses a Taprogge ball cleaning system;
- *Eraring Power Station (Lake Macquarie, Australia)* – this power station uses a Taprogge ball cleaning system in conjunction with dosing the condensers with $FeCl_2$ to coat and protect their condenser tubes from salt water corrosion. Eraring has found that ball cleaning systems are troublesome, requiring high levels of inspection, monitoring and troubleshooting. They have had issues with ball loss, jamming of balls, and trapping of balls in air pockets.

3.5.5 Preferred Option(s) By BlueScope Steel for Control of ICP Macro-fouling

The preferred option for the control of macro-fouling within the cooling water system is a combination of a variety of measures which are outlined below.

Inlet Channel

Divers are currently contracted by BlueScope Steel to physically remove marine organisms from the salt water cooling inlet channel. With the significant increase in channel velocity post-ICP, this will no longer be an option due to safety concerns.

BlueScope Steel is proposing to control macro-fouling at the inlet channel by dosing it with Clamtrol II. A dosing protocol would be developed and implemented through a Macro-Fouling Management Plan to ensure macro-fouling is adequately controlled.

In addition, new screens and filters will be constructed which the salt water would pass through. These screens and filters would remove large macro-fouling organisms, many plants and other debris. Due to the significant level of macro-fouling that occurs within the inlet channel, dosing of Clamtrol II would increase the load on the screens and filters. Therefore, initial dosing of Clamtrol II would be required at low concentrations and/or progressively from close to the band screens back to the lift pump station, to minimise the likelihood of blockages at the existing screens and subsequent loss of cooling water flow and equipment efficiency, caused by an uncontrolled increase in organic materials.

In addition, it may be possible to reduce the frequency or duration of current dosing of Clamtrol II at the No. 2 Blower Station machines due to removal of macro-fouling organisms in those cooling circuits caused by residual concentration of Clamtrol II from the inlet channel dosing.

ICP Condenser and Discharge Pipework

Mechanical

As described above, salt water supply to the ICP from the inlet channel would pass through a series of screens and filters to remove large macro-fouling organisms.

However, the screen and filters cannot prevent microscopic larvae and ribbon weed from entering the cooling water system and therefore alone, would not be adequate to prevent macro-fouling.

Physical

Physical cleaning of each half of the STG condensers would still be undertaken on-line every six months, with cleaning of the entire system carried out during major outages every six years and minor outages every two years. Injection of "darts" would still be required to clean the inside surfaces of the small diameter condenser tubes.

Thermal

BlueScope Steel would prefer to use a form of thermal treatment to control macro-fouling which would significantly reduce (and potentially eliminate) the need for dosing of Clamtrol II at the ICP condenser. BlueScope Steel proposes to periodically recirculate the salt water cooling discharge from the STG condenser back to the cooling water pump inlet basin (see **Figure 3.1**). Recirculation of the cooling water would result in an increase in the salt water temperature to a level which is fatal to the organisms. The system would continue to recirculate the heated cooling water for a period of 4-8 hours approximately every three to four weeks in summer and every six weeks in winter, similar to the required frequency for chemical dosing. Over the recirculation period, the system would continually release some of the heated water back into Allan's Creek. This discharge would be of a higher temperature but a significantly lower volume. Recent modelling undertaken by CLT April, 2008 (see Section 5.1, **Appendix E**), revealed that during summer maximum conditions, at a flow rate of 10,000kL/hr (2.78m^3/s) with an outlet temperature of 40°C, the expected highest temperature increase was 2.6°C at Location (22,67).

BlueScope Steel intends to arrange testing, using local macro-fouling organisms, to confirm acceptable mortality rates are achievable within the allowable temperature constraints of the turbine (condenser discharge temperature of 40°C).

If, after commissioning and monitoring of thermal treatment, BlueScope Steel becomes aware that thermal treatment alone is not adequate in controlling macro-fouling of the ICP cooling system, BlueScope Steel would also intermittently dose the ICP cooling system (as well as the inlet channel) with Clamtrol II, to control macro-fouling. A protocol would be developed to ensure that any dosing of Clamtrol II, in conjunction with dosing of the inlet channel, would adhere to the discharge concentration limit.

Chemical

If the testing described above demonstrates that the proposed thermal treatment method is not viable, or after commissioning of the thermal treatment process and monitoring of it's effectiveness, BlueScope Steel concludes that the thermal method alone was not suitable for use in controlling macro-fouling, it would be necessary to supplement or replace the thermal treatment. This may include intermittent dosing of the ICP cooling system with Clamtrol II or an alternative method determined in consultation with DECC. This has proven over the past 13 years to be a successful method of controlling macro-fouling at the No. 2 Blower station.

The STG condenser would be designed with two individual water circuits which would be dosed separately. The current practice of only dosing one cooling circuit at any time, to ensure dilution is provided by the undosed streams to minimise the discharge concentration of Clamtrol II, would be maintained.

BlueScope Steel is currently trialling a dosing rate of 1mg/L (over a 24 hour period) at the No. 1 Power House. Due to the reduced dosing concentration, an increase in dosing duration is required to achieve adequate macro-fouling control. If a 1mg/L dosing concentration is found to provide adequate protection against macro-fouling over both the summer and winter periods, BlueScope Steel would propose to dose the ICP cooling circuit at this concentration. This dosing concentration is expected to result in a concentration of approximately 0.225mg/L in the stream discharged to Allan's Creek. Dosing would occur approximately every four weeks in summer and every six weeks in winter for a period of 24 hours.

BlueScope Steel is committed to continued trials aimed at further reducing the dosing concentration of Clamtrol II and duration of the dosing period while maintaining an adequate degree of macro-fouling control.

Impact on Port Kembla Harbour Ecology – Ecotoxicity Testing

Clamtrol II is adsorbed onto pipework, valves, debris and macro-fouling organisms. The adsorbed layer creates a film which inhibits oxygen transfer to molluscs, resulting in mollusc mortality within short periods of time and preventing the settlement of macro-fouling organisms on affected surfaces.

The active ingredient of Clamtrol II is readily absorbed by natural anionic substances and then biodegraded to compounds such as water and carbon dioxide. This means that Clamtrol II is detoxified and rendered harmless to aquatic organisms within a short time of being introduced to an aquatic environment.

BlueScope Steel engaged the CSIRO Centre for Environmental Contaminants Research in 2004/2005 to undertake specific toxicity testing of Clamtrol II and toxicity testing of effluent from the No.2 Blower Station Drain following dosing with Clamtrol II. The report was entitled, "*Assessment of the Toxicity of the Biocide Clamtrol II to Maine Biota*" (November 2004).

Samples were taken of Clamtrol II and seawater from the PKSW salt water channel and two samples were taken from the No.2 Blower Station Drain effluent, post dosing with Clamtrol II. The concentrations of Clamtrol II for these samples were 0.15 – 0.20 mg/L and 0.18 mg/L.

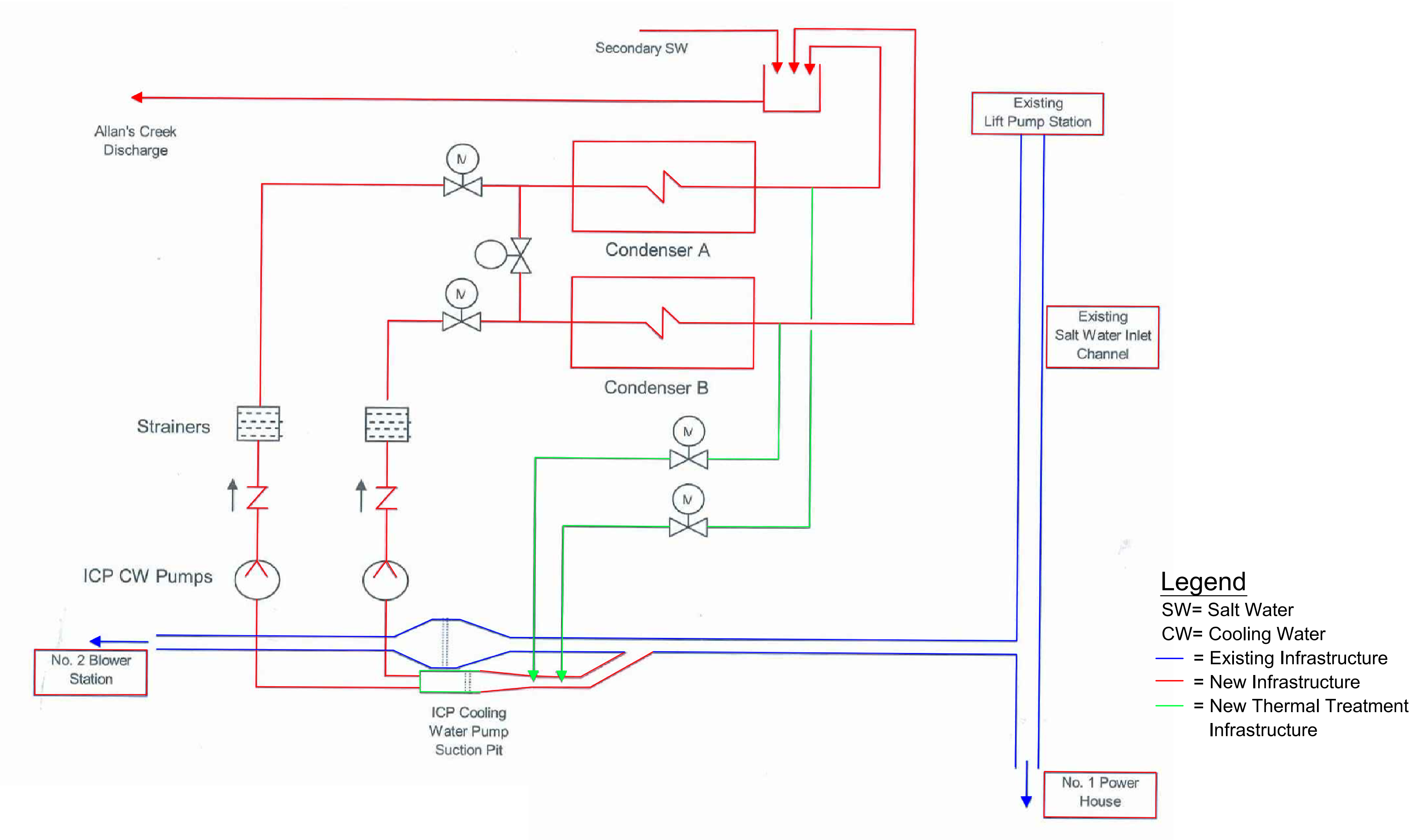


Figure 3.1
Thermal Treatment Infrastructure

Table 3.8 outlines the ecotoxicity tests that were carried out and the results of those tests. The results were divided into four different categories:

- EC50 (concentration having 50% effect compared to controls, for example, the test sample concentration at which there is 50% inhibition of light output compared to controls), or
- IC50 (concentration inhibiting 50% of a parameter such as the growth rate compared to controls), and also included
- LOEC (lowest observable effect concentration; the concentration with a very weak observable effect) where available, and
- NOEC (no observable effect concentration; the highest concentration tested for which the effect is significantly not different from controls).

In order to test the correctness of the NOEC assumptions, the two samples from the No.2 Blower Station Drain were diluted until no observable effected were noted.

Table 3.8 Summary of Toxicity Test Results - Clamtrol II

Test	Exposure Period	EC50/IC50	LOEC (mg/L)	NOEC (mg/L)
Light Inhibition in Marine Bacteria	15 min	1.4[a]	0.3[a]	0.15[a]
	5 min	2.3	0.75	0.37
Growth Inhibition in microalgae	72 hr	0.75	>IC50	0.3
Fertilisation Inhibition in Sea Urchin	72 hr	0.023	0.01	0.003
Scallop Larval Development	1 hr	0.043	0.03	0.01
Immobilisation of Fish Larvae	96 hr	1-3 (lack of partial response)	-	1.0

[a] geometric mean of n=3

The results of the toxicity tests indicate that as expected, sea urchin (i.e. invertebrates which are the target species), were most sensitive to Clamtrol II with a NOEC of 0.003mg/L and a LOEC of 0.01mg/L. The scallop larval development test showed a similar sensitivity with an NOEC of 1mg/L. The light inhibition, growth inhibition and immobilisation test were less sensitive to Clamtrol II, with NOEC values of 0.15mg/L (15min), 0.3mg/L and 1mg/L respectively.

Based on the results as outlined in **Table 3.8**, CSIRO concluded the following:

> *"although fish fry and microalgal growth would be unlikely to be affected by Clamtrol II at these concentrations, it may be preferable to reduce dosing so that Clamtrol concentrations in the BS2 drain do not exceed 0.15 mg/L (bacterial NOEC). Further dilution in Allan's Creek and Port Kembla Inner Harbour should reduce Clamtrol concentrations even further so that impact on non-target invertebrate populations (if they exist in the vicinity) could be minimised".*

The CSIRO report recommends a conservative 0.15gm/L discharge concentration limit based on the marine bacteria NOEC value of 15 minutes. However, the following is noted:

- Mixing of the ICP cooling water stream with the flow in Allan's Creek, and then the Inner Harbour, will quickly dilute the concentration of any residual Clamtrol II. It is understood that the CSIRO report has used the marine bacteria 15 minute NOEC value (the lowest calculated NOEC concentration for non-target species) as the basis for their recommended discharge concentration. The immediate dilution of the Clamtrol concentration when the ICP discharge enters Allan's Creek suggests that a 5 minute NOEC value would be more appropriate than a 15 minute value. The 5 minute NOEC value for the same species is 0.37mg/L.
- The ecotoxicology test method involves testing at discrete concentrations, and does not attempt to determine the actual NOEC value. The NOEC value falls between the observed NOEC and LOEC values. Therefore, it is appreciated that the NOEC value has been used for conservative purposes.

Based on current trial results, BlueScope Steel is expecting a discharge concentration of approximately 0.225mg/L. This expected concentration is lower than:

- 5 min NOEC value of 0.37 mg/L for marine bacteria;
- quoted NOEC value of 0.3 mg/L for microalgae; and
- the current No 2 Blower Station Drain discharge limit.

Operational Controls

Dosing of Clamtrol II would be conducted by GE Water and Process Technologies (GE Technologies) and administered by an automatic dosing system. The system would consist of a chemical storage tank, drawdown assembly with pump and a PaceSetter controller. The system would minimise exposure to and handling of Clamtrol II.

The system continuously measures the amount of chemical being fed against the calculated amount. Small deviations from the expected output are corrected by adjusting the speed of the drawdown pump, while large variations cause a pump trip and complete system shut-down. Any errors in drawdown limits, pump performance or Programmable Logic Controller also trigger a complete system shutdown.

The PaceSetter controls the operation of the drawdown assembly and communicates directly to the central plant control system. It has four verified and separate chemical control loops, adding to the reliability of the system.

During commissioning, dosing would commence at low concentration levels whilst monitoring the discharge concentration. The dosing concentration would be slowly increased to ensure that concentrations of Spectrus CT 1300 remain under the discharge limits at all times.

An operational procedure would be developed to provide clear instruction for the operation of the dosing system within discharge limits. GE Technologies would manage and operate the dosing system in accordance with this procedure on behalf of BlueScope Steel.

License for Use – Clamtrol II

Clamtrol II is supplied to BlueScope Steel by GE Technologies under an Australian Pesticides and Veterinary Medicines Authority (APVMA) provisional permit (PER9324). The provisional permit is issued to allow time for the assessment of the application for full APVMA registration of Clamtrol II. The current provisional permit is due to expire in June 2008. An extension or renewal of this provisional permit is subject to GE Technologies showing satisfactory compliance with APVMA requests. This is currently being demonstrated and registration is expected in December this year.

While Clamtrol II is not registered, the only active ingredient, benzalkonium chloride, is registered as an approved active constituent which is excluded from APVMA approval.

Monitoring

The implementation of thermal treatment of the ICP cooling system would be monitored to determine its adequacy as a control measure for macro-fouling of the ICP condenser. If monitoring revealed it was not entirely effective, options to further control macro-fouling would be considered. These options would include consideration of more frequent thermal treatment, increasing the duration of thermal treatment or alternatively, dosing the ICP condenser with Clamtrol II, in combination with, or instead of, thermal treatment. Any dosing of Clamtrol II would be monitored by the PaceSetter controller and managed by GE Technologies. This on-line monitoring would assist in maintaining dosing within the discharge limits. As mentioned previously, only one cooling system would be dosed with Clamtrol II at any time.

In addition to the on-line measurements by the PaceSetter Controller, GE Technologies would also undertake sampling at the licensed discharge point and produce a report for each dosing event detailing the levels of Clamtrol II at this point.

During dosing with Clamtrol II the discharge point at Allan's Creek would be sampled and analysed. The testing will take place:

- Prior to commencement – to verify a zero result
- At the middle of dosing
- At the end of dosing.

Test results have shown that the discharge concentration during dosing is relatively static and therefore there is no added value in conducting further sampling throughout the dosing period.

4 Environmental Values of Water

The Protection of the Environment Operations Act 1997 (the POEO Act) requires appropriate regulatory authorities (ARAs) to consider, when issuing licenses under the POEO Act, activities or work that cause or is likely to cause, or has caused, water pollution (s45(f1)). Factors which are impacted by the activity or works are called "environmental values of water".

The relevant environmental values of water which may be impacted by the proposed modification from recirculated TTE to once through salt water cooling are considered below using the ANZECC and ARMCANZ (2000) Guidelines as the framework.

4.1 Definition of Primary Management Aims

4.1.1 Definition of the water body

The primary water body of concern to BlueScope Steel is Port Kembla Outer Harbour, Port Kembla Inner Harbour and its tributary, Allan's Creek.

Allan's Creek is a waterway, rising on the Illawarra escarpment, which collects the discharge from a number of tributaries, such as American Creek, Branch Creek, Brandy and Water Creek, Jenkins Creek and Charcoal Creek and which passes through Port Kembla Steelworks.

The Allan's Creek catchment includes areas of the Illawarra Escarpment that are now protected but which have in previous times been extensively logged, cleared and farmed. The catchment includes considerable urban development including the largely residential suburbs of Cordeaux Heights, Kembla Heights, Mt Kembla, Figtree, Farmborough Heights, Unanderra and the industrial suburbs of Spring Hill and Port Kembla.

A weir structure adjacent to the State Rail line at the northwest of the 21 Recycling Area divides fresh and tidal salt water reaches of the Creek. There are no known influences of the Steelworks upstream of the weir.

Downstream of the weir the course of Allan's Creek has been significantly modified as part of the Steelworks development.

The Inner Harbour is an artificial harbour managed by the Port Kembla Port Corporation. Major facilities on the Inner Harbour include the Steelworks, Multi Purpose Wharf, Grain Terminal and Port Kembla Coal Loader. Inflows to the Harbour are from Allan's Creek, Ironmaking East Drain, Town Drain and other various industrial discharges. The Harbour is tidal.

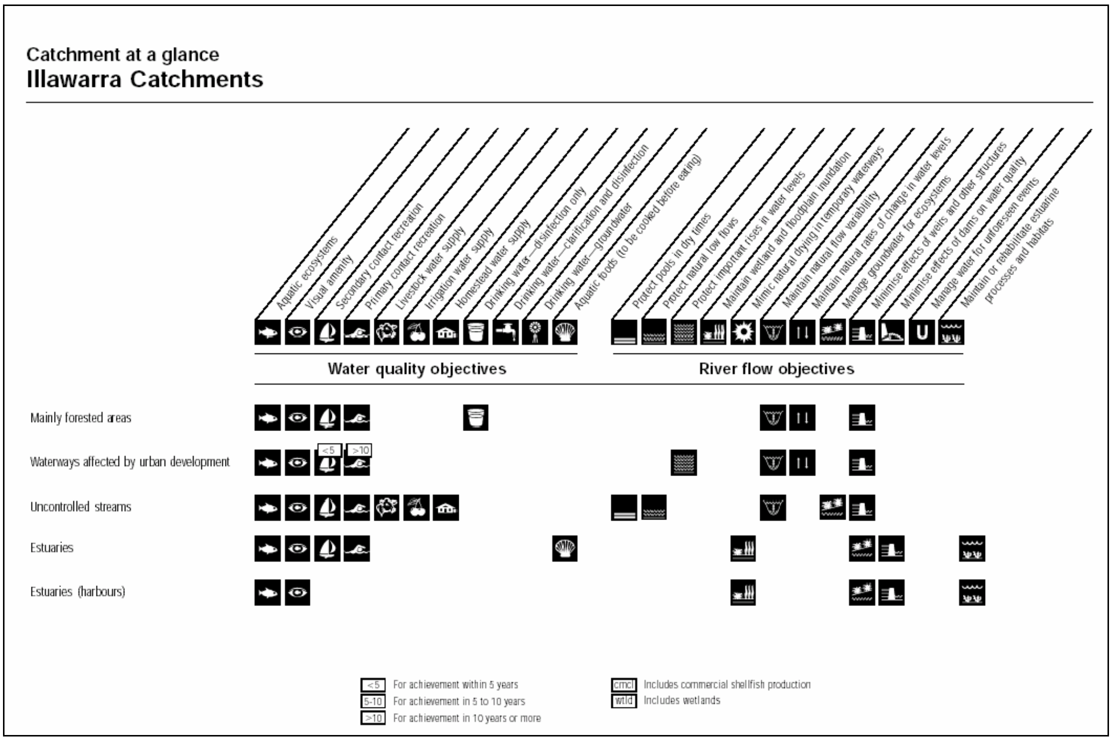
The Outer Harbour is an artificial harbour managed by the Port Kembla Port Corporation. Facilities on the Outer Harbour include the Steelworks, No 6 Jetty (Gateway Jetty), CRM Works and Incitec. Inflows to the Harbour are various industrial, commercial and residential drains.

4.1.2 Environmental Values

Environmental values are particular values or uses of the environment that are important for a healthy ecosystem or for public benefit, welfare, safety or health which require protection from the effects of pollution, waste discharges and deposits (ANZECC 2000).

The DECC published Water Quality and River Flow Interim Environmental Objectives for Illawarra Catchments, outlines the environmental values relevant for different types of waterways. **Figure 4.1** outlines the types of waterways and their corresponding environmental values under the interim objectives.

Figure 4.1 Water Quality Guidelines for the Illawarra Catchment Area



Source: Published Guidelines EPA Illawarra Catchment Area WQO Appendix 6

The classification of the relevant receiving water at PKSW is "*Estuaries/Estuaries (Harbours)*". Therefore the applicable water quality guidelines in respect of the proposed new salt water cooling system are:

- Maintenance of aquatic ecosystems; and
- Visual amenity.

Within the Inner Harbour and Allan's Creek there is no primary or secondary contact recreation therefore only the two water quality objectives listed above apply.

Aquatic Ecosystems

Allan's Creek, although highly disturbed, has a significantly improved ecosystem as a result of environmental improvements by the Steelworks and others over the last 30 years (NSG, August 2006). In accordance with ANZECC and ARMCANZ Guidelines

(2000), maintenance of aquatic ecosystems requires, at a minimum, that the existing water quality be maintained with the emphasis on continual improvement.

Visual Amenity

Visual amenity is affected by:

- Visual clarity and colour;
- Surface films and debris; and
- Nuisance organisms.

BlueScope Steel monitoring indicates that Allan's Creek and the Inner Harbour, where they are subject to discharge from the Steelworks, generally achieve good compliance with visual amenity measures in dry weather. All breaches of visual (and water quality) objectives are referred to the DECC in accordance with the requirements of BlueScope Steel's Environment Protection License (EPL).

4.1.3 Level of Protection

"Highly disturbed systems" are defined in Section 3.1.3.1 of the ANZECC Guidelines as:

> "*… measurably degraded ecosystems of lower ecological value. Examples of highly disturbed systems would be some shipping ports and sections of harbours serving coastal cities, urban streams receiving road and storm water runoff, or rural streams receiving runoff from intensive horticulture*"

Allan's Creek and Port Kembla Inner Harbour meet the description criteria for "Highly Disturbed" ecosystems. However, the desired target level of protection in the longer term would be a "slightly to moderately disturbed" ecosystem.

4.1.4 Environmental Concerns

The environmental value 'aquatic ecosystems' has the potential to be affected by the 'unnatural change in temperature' resulting from a once-through salt water cooling system. Once the salt water drawn from the salt water channel is used to cool the STG condensers, its discharge back into Allan's Creek has been predicted to result in elevated temperature levels (refer **Section 2**). As a result, an increase in water temperature may affect the current aquatic ecosystem (refer **Section 3**).

Entrainment of aquatic organisms into the cooling system and subsequent exposure to mechanical, thermal and chemical stresses has the potential to result in mortality of all entrained organisms. This may result in a decrease in abundance of plankton in Port Kembla Inner Harbour (refer **Sections 3.4.3**and **3.4.4**).

In addition, the need for intermittent dosing of biocide for cleaning purposes has the potential to result in residual traces being discharged into Allan's Creek. Therefore, toxicity levels from chemical contaminants (namely Clamtrol II) into the Harbour are also an environmental concern (refer **Section 3.3** for further discussion on the influences of temperature on toxicity and bioaccumulation of heavy metals and PAHs on marine and estuarine organisms).

4.1.5 Natural and Anthropogenic Factors Affecting the Ecosystem

There are, in general, no adverse natural factors affecting the ecosystem within Port Kembla Inner Harbour and Allan's Creek. It is noted however that Port Kembla Harbour is a man-made harbour and is not a natural ecosystem.

The main anthropogenic factor affecting the Port Kembla aquatic ecosystem in respect to the proposed salt water cooling modification involves industrial discharges (e.g. cooling water) from the Steelworks. It is likely that there are additional anthropogenic factors that affect the ecosystem from other Steelworks processes and other industrial processes from the wider Port Kembla Harbour including ballast exchange from ships entering and exiting the Harbour. In addition, storm water discharges from residential areas upstream in Allan's Creek and its tributaries also affects the water quality and the aquatic ecosystem.

4.1.6 Management Goals

The published guidelines 'EPA Illawarra Catchment Area Water Quality Objectives' set the overall objective as: -

> "*Maintaining or improving the ecological condition of water bodies and their riparian zones over the long term.*"

It is clear that the water quality objectives aim to maintain, at the very least, the current standard of water quality over a long term period with the overall goal of improvement.

4.2 Definition of appropriate guideline trigger values

4.2.1 Indicators

Information on trigger values has been obtained from both ANZECC & ARMCANZ 2000 and the Water Quality and River Flow Interim Environmental Objectives for the Illawarra Catchment.

4.2.1.1 ANZECC & ARMCANZ Guidelines (2000)

ANZECC 2000 guidelines identify *"species composition and abundance"* as the key indicator for determining how the aquatic ecosystem is coping with an increase in temperature. In addition to the increase in heat load in Allan's Creek and Port Kembla Inner Harbour, species composition and abundance will be affected by entrainment in the salt water cooling system.

For highly disturbed systems, the guidelines recommend appropriate site-specific studies to be undertaken together with professional judgment to derive the trigger values. If site specific studies are not possible, a discharge should not be permitted to increase the temperature of the aquatic ecosystem above the 80^{th} percentile temperature value obtained from the seasonal distribution of temperature data from the reference system (similar body of water with comparable characteristics).

In the determination of toxicity levels, the ANZECC and ARMCANZ Guidelines (2000) recommend that the trigger value should present the concentration of chemical that would not cause a significant adverse effect on an ecosystem.

4.2.1.2 Water Quality and River Flow Interim Environmental Objectives, Illawarra Catchments

The Interim Water Quality Objectives identify indicators for protection of Aquatic Ecosystems in the Illawarra Catchment region. **Table 4.1** outlines the relevant indicators for Port Kembla Harbour.

Table 4.1 Assessment of proposed Salt Water Cooling modification relative to Interim Water Quality Indicators and Objectives for Protection of Aquatic Ecosystems for Port Kembla Harbour

Indicator	Objective	Assessment of Port Kembla Harbour relative to ICP Salt Water Cooling proposal
Temperature	< 2°C increase in natural temperature levels. No current guidelines for acceptable temperature reductions.	Existing temperature already exceeds the natural temperature of the Harbour by the 2ºC trigger
Chemical contaminants	Summary: 'Waters shall be free from pollutants in amounts or combinations that are toxic to humans, animals, plants and other organisms.'	The proposed Salt Water Cooling will not contain chemical constituents not otherwise present in the salt waters of Port Kembla except biocide that is controlled under licence
Fringing vegetation of waterbodies	No specific criteria. One aspect where related ANZECC (1992) guidance is given is under Ecosystem function: 'In any waterbody, changes that vary the relative importance of detrital and grazing food chains should be minimised. Production-to-respiration ratios should not vary significantly from those of similar, local, unaffected systems.'	There is negligible vegetation fringing the affected waterways that would provide detrital or grazing opportunities. The flow within Allan's Creek will be changed (revert to more natural levels upstream with an increase downstream). This is not expected to affect the total abundance or detritus, algal or marine flora levels.
Macroinvertebrates	No specific criteria. Species richness of the predominant invertebrate assemblages, as measured by an appropriate biotic index, should not be altered; and impacts that result in significant changes in species composition, compared with those in similar, local, unaffected systems, should not be permitted.	The proposal will change the location of existing flows and this may affect the diversity and abundance of some species or result in their relocation. Entrainment of plankton into the ICP cooling system has the potential to impact on the abundance of macroinvertebrates within Port Kembla Inner Harbour. With a Pm increase from 24-32% post-ICP (see **Table 3.4**), a detectable impact on macroinvertebrates may occur.

Indicator	Objective	Assessment of Port Kembla Harbour relative to ICP Salt Water Cooling proposal
Water plants	No specific criteria. Species richness of the predominant macrophyte assemblages, as measured by an appropriate index, should not be altered; and impacts that result in significant changes in species composition, compared with those in similar, local, unaffected systems, should not be permitted.	Altered flows and temperatures resulting from the proposed modification are not expected to alter the overall species richness of macrophyte assemblages.
Fish	No specific criteria. For biological communities including fish: Communities should be protected such that the species composition, diversity, and functional organisation remain comparable to that of the natural habitat of the region; and Impacts that result in significant changes in species composition or diversity should not be permitted.	Whilst the location and temperature of flows may alter the current community, the species composition, diversity, and functional organisation are expected to remain comparable to that of the existing habitat. It is possible in the upper reaches of Allan's Creek that the reduction in flow and cessation of temperature will result in this area supporting a community that is more representative of a 'natural' habitat.

Although most of the above mentioned indicators state that "no specific criteria" can be provided, the interim water quality guidelines note that:

> *"Any actions resulting in a significant change to a species composition or diversity should not be permitted."*

4.2.2 Test site data and refined trigger values

The appropriate trigger value for the proposed modification relates to temperature. It should also be noted that the existing temperature of Port Kembla Harbour already exceeds the natural temperature of the Harbour by the 2ºC trigger identified in the Interim Water Quality Indicators and Objectives for Protection of Aquatic Ecosystems.

Therefore, in accordance with both ANZECC and ARMCANZ (2000) Guidelines and the Illawarra Water Quality Objectives, monitored temperature values from 2000-2005 data have been utilised to verify an appropriate reference system and derive appropriate 80th percentile trigger values (refer **Section 2.1**). Site data has been tested through verification of the model used (as described in **Section 2.2.4**). In addition, professional judgment has been sought from CLT and NSG to assist in the assessment of the predicted thermal heat load change and consequently whether this change will result in adverse affects to the aquatic ecosystem of Port Kembla Harbour. These matters are the focus of other sections of this report (refer **Section 3**).

4.3 Water Quality Objectives

ANZECC & ARMCANZ Guidelines (2000) outline in Section 8.2.1.5 certain considerations to be addressed when assessing whether a change to the thermal regime will result in an adverse effect to an aquatic ecosystem. These considerations are outlined below.

4.3.1 Lethal tolerance range

The lethal tolerance range (including length of exposure) of all stages of the lifecycle of endemic populations (feeding, breeding, reproduction, timing and success).

Thermal tolerance is discussed in **Section 3** and **Section 4.4.5 .**

Table 4.2 provides an indication of the thermal tolerances of species known to occur within Port Kembla Harbour.

Whilst this assessment focuses on the temperature tolerance of organisms, the salt water cooling modification also involves the use of Clamtrol II. Clamtrol II is a biocide by design with extremely low acute LD_{50}[3] concentrations that has the potential to have ecological impacts beyond the target area if not managed appropriately. The need for, and appropriate management of Clamtrol II is discussed in **Section 3.5.**

In addition, BlueScope Steel's preferred method of macro-fouling is a system of thermal treatment to remove the organisms and debris. This would involve intermittent recirculation of heated cooling water through the ICP cooling system. A description of this method is outlined in **Section 3.5.5**.

4.3.2 Rate of primary production

The influence on the rate of primary production in the system.

NSG (August, 2006) reports that temperature is likely to increase the rate of photosynthesis of algae up until the temperature exceeds the optimum for each species. The alga *Ulva lactuca*, for example, has a temperature optimum at approximately 25ºC. Hence, for this species, any increase in temperature due to the ICP during the cooler months may lead to an increase in its rate of photosynthesis.

During the summer months, however, increases above 25ºC are likely to lead to a decrease in its rate of photosynthesis. Photosynthetic rates do not translate directly to growth rates (primary production) which depend on a multitude of other factors related to respiration and nutrient availability.

The majority of macroscopic algal populations within Port Kembla Harbour (and one seagrass species *Halophila ovalis*; **Appendix F**, Annexure A) are restricted to sections of the Outer Harbour. The temperature increase in Port Kembla Inner Harbour is expected to be 0.8°C in summer during typical conditions and 0.7°C during typical winter conditions and is expected to occur in Port Kembla Inner Harbour. The

[3] *LD_{50} is the concentration which on exposure will kill 50% of the target population. Concentrations range from 0.04 to approximately 2 mg/L based on toxicological tests on freshwater species. Marine toxicology data is limited.*

expected temperature change in this area is highly unlikely to cause significant changes to the abundance or density of these algal populations located in the Outer Harbour.

Further increases in temperatures within the Inner Harbour may continue to restrict algal populations from establishing in these areas, however, other environmental factors (such as increased turbidity) may also be restricting macroalgal populations within the Inner Harbour.

4.3.3 Rate of secondary production

Influence on the rate of secondary production of key species within the system.

NSG (August, 2006) observed that, whilst difficult to predict, as an indirect result of the temperature increase, a further secondary effect may occur where there is a decrease in predator numbers or reduced competition for space that may allow another species to increase in abundance. Under these conditions, the barnacles and ascidians are the most likely candidates to generate secondary effects though this may also extend to aquatic flora. However, even in the event of such a change, there may be minimal net change to the physical structure of the habitat as a reduction in the abundance of one species may be counteracted by an increase of another.

4.3.4 Life stage tolerances

Tolerances of the various life stages of the species that occur within the affected area.

Specific data does not exist on the tolerances of various life stages to temperature. Literature of laboratory studies show that increases in temperature are related to increases in the toxicity of heavy metals. This pattern has been observed for a wide range of marine organisms (i.e. algae, invertebrates and fish) at various life history stages (i.e. fertilisation, larval development, juvenile and adult mortality) and for a wide range of metals and organic compounds.

Whilst no specific data exists comparing temperature tolerances of various life stages of most species, including those within Port Kembla Harbour, it is acknowledged that organisms will have variable tolerance levels to temperature variations at different life stages (Pechenik, Marsden & Pechenik, 2003, Bryars & Havenhand, 2006). Notably, larvae are often found to be more vulnerable to variations in temperature than adults.

Due to the limited information available on the specific thermal tolerance of individual species, NSG (August 2006) used geographic distribution for predicting possible gains or losses of species as a result of the predicted temperature increase (see Section **4.4.5**). A temperature increase during typical operating conditions is expected to 0.8°C in summer and 0.7°C during typical winter conditions. It is likely that organisms at various life stages will be able to adapt to this minor change or will move to lower levels of the water column below the thermal plume to compensate.

4.3.5 Species richness and community composition

Likely impact on species richness and natural community composition (geographic distribution, vertical distribution, impacts on whole habitats such as seagrass) in the affected area.

Due to the absence of specific data on the temperature tolerances of the various life stages of most species, this issue could not be directly addressed. **Section 3** provides a discussion of possible changes in species distribution/responses as a result of an increase in water temperature.

4.3.6 Temperature effects on major biochemical processes

Influence on enzyme-dependent microbial processes such as photosynthesis, N2 fixation, dentrification, respiration and methanogenesis.

The general temperature effects on major biochemical processes including photosynthesis and denitrification have been assessed in accordance with ANZECC & ARMCANZ (2000) guidelines. The assessment (NSG 2006) outlined that:

- The major biochemical processes of photosynthesis, respiration and methanogenesis are strongly temperature sensitive;
- The marine nitrogen cycle including bacterially mediated nitrogen fixation, and denitrification are also temperature sensitive;
- An increase in temperature will, in general, increase the rate of the abovementioned processes. However, they cannot be considered in isolation as many other factors influence the rate of biochemical processes;
- Factors that influence denitrification in estuaries include temperature, the supply of nitrate and organic matter, and oxygen concentration; and
- Temperature is likely to increase the rate of photosynthesis of algae up until the temperature exceeds the optimum for each species.

NSG (2006) concluded that:

"The expected temperature change in this area is highly unlikely to cause significant changes to the abundance or density of these algal populations. Further increases in temperatures within the Inner Harbour may continue to restrict algal populations from establishing in these areas, however, other environmental factors (such as increased turbidity) may also be restricting macroalgal populations within the Inner Harbour."

4.4 Other Water Quality Risks

In addition to those issues already outlined, other water quality risks should also be considered when assessing whether a change to the thermal regime will result in adverse effects to an aquatic ecosystem. These are discussed below.

4.4.1 Toxic effects of chemicals

Toxic effects of chemicals in the cooling water (cleaning agents or biocides).

The proposed salt water cooling modification reduces the inventory of chemicals previously required with the use of TTE on the pre- and post-treatment of cooling water for the ICP.

Section 3.5 provides a detailed assessment of the expected toxic effects of Clamtrol II (Spectrus CT 1300) as part of the salt water cooling system.

4.4.2 Changes to flows

Changes to flows or levels of pollutants in discharges from the proposal or separately planned environmental works in BSL's premises (relate to existing PRP conditions on the BSL EPL).

The current discharge from the No.1 Power House into the Main Drain, which in turn discharges into Allan's Creek, will cease with the closure of No.1 Power House. The average daily flow from the Main Drain, mainly comprised of flow from the No.1 Power House, is approximately 180ML/day at a maximum flow rate of $1.431m^3/s$.

After construction of the ICP and the decommissioning of the No.1 Power House, the only flow through the Main Drain will consist of Webb's Lagoon overflow and Cringila stormwater. The new underground drain to be constructed below Raw Materials Secondary Ore Yards will discharge approximately 650ML/day from the ICP at peak times into Allan's Creek. This is in addition to the 15ML/day natural flow of Allan's Creek.

BlueScope Steel's current EPL requires that each licensed discharge point be the subject of detailed monitoring and reporting requirements including limitations on the level of certain pollutants discharged. Any changes resulting from the proposed new once-through cooling system would be monitored by BSL in compliance with their EPL.

PRP 97 requires BlueScope Steel to investigate and evaluate the sources of contaminants discharged from the Main Drain. Specific reference is made in this PRP to the closure of No. 1 Power House, which is currently the main source of discharge into the Main Drain. The toxicity of the discharge into the Main Drain must be monitored under a range of conditions, including low and high flow post the closure of No.1 Power House.

PRP 98 requires monitoring of licensed discharge points during storm events to determine appropriate licence limits. Specified parameters that must be monitored are pH, Total Suspended Solids (TSS) and total iron. Included in this PRP are four specific drains including the Main Drain.

Section 4.5.1 provides a detailed assessment of the current monitoring practices undertaken in accordance with current PRPs as set out in BlueScope Steel's EPL.

4.4.3 Temperature effects on other parameters

Temperature effects on other parameters and toxicity of other parameters.

Whilst the approved ICP arrangement involved a range of parameters within the blowdown discharge, the salt water cooling modification retains the number of parameters that may have a physical or chemical effect to temperature and biocide. Consequently there are no additional temperature or toxicity effects from other parameters.

4.4.4 Physical impacts of the discharge

Physical impacts of the discharge on the waterbody

Sections 2 and **3** discuss the temperature effects of the proposed once through salt water cooling system and the potential impacts of this temperature increase on the aquatic ecology of the Harbour, respectively.

In addition, the proposed salt water modification will introduce a large, new flow into Allan's Creek. The impacts of this include:

- Removal of a flow of approximately 100ML/day from the Main Drain. The Main Drain will be subsequently used for other purposes in the Steelworks. The flow into Allan's Creek at the confluence will be reduced, having a positive effect in returning flows of the creek at this point to levels that might be expected in the creeks reference condition;
- Introduction of a new flow of approximately 650ML/d approximately 200m downstream of the existing No. 2 Blower Station Drain. This may:
  - Have a scouring effect or disturb sediments at the base of the creek. However, the discharge will be carefully designed to discharge into the upper layers of the water column so that it will, by design, avoid sediment disturbance and scouring effects;
  - Create a 'thermal plug'. Fish will be reluctant to pass through an area of heated water. However, a thermal plug does not presently exist as a result of the No. 2 Blower Station Drain and is not likely to be created by the addition of the ICP discharge. Modelling indicates that with the proposed discharge structure, the temperature of the lower layers of the creek should not vary significantly from current levels and such temperatures will be within limits which fish should comfortably pass (NSG, 2006);
  - Generate noise. However, the discharge is to be designed to be submerged and flow across (rather than down into) Allan's Creek to minimise vertical mixing as far as possible. Consequently the flow is likely to generate noise only at times of extremely low tide. It is not expected that this will be audible at sensitive receptors within the context of the industrial surroundings; and

  - Generate a visual plume. Whilst every effort will be made to minimise the appearance of the discharge structure (subject to detailed design), it is likely that the structure of the discharge device will introduce a new visual element into Allan's Creek. In addition, the flow discharged may generate white water that may be visible from beyond the site boundary. Within the context of the industrial surroundings, this impact is not expected to be significant; and

- Possible introduction of discharge devices that will present navigation obstacles within Allan's Creek. However, this is not expected to be a key concern as Allan's Creek is presently confined by a range of utility installations. Where submerged obstacles are in place, appropriate Waterways and navigation identification aids will be put in place.

4.4.5 Identification of Temperature Tolerances and Preferences of Organisms Currently Found in Port Kembla Harbour

An extensive literature review was undertaken (refer Annexure B.1 in **Appendix F**).[4]

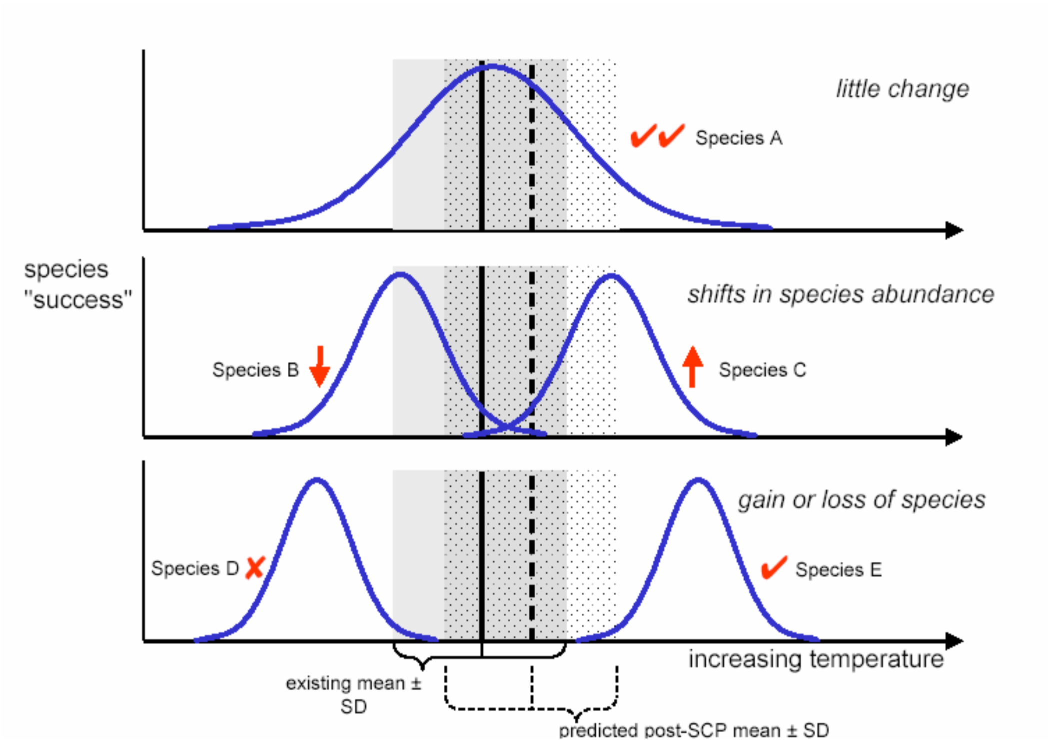
Due to the limited information available on the specific thermal tolerance of individual species, NSG (August 2006) used geographic distribution for predicting possible gains or losses of species as a result of the predicted temperature increase. Over 500 species were identified in Port Kembla Harbour and thermal tolerance levels were available on nine of those species (refer Annexure A in **Appendix F**). It is expected however that there are many more species present in the Harbour than have been recorded to date (as is typically the case with ecological sampling in marine habitats).

It should be noted that inferences of possible changes in species distributions should be considered as indicative because the known distribution of a species may be more a reflection of the incidence of observations of the species than of its true distribution and the stratification of the water column in the Inner Harbour not only offers alternative temperature regimes for organisms with a narrow range of preferred temperature, but also complicates the interpretation of geographic range as a surrogate for temperature.

NSG (2006) recognised three types of responses to a change in temperature. Species which might be expected to respond to a changed temperature regime in the Inner Harbour were broadly categorised and shown in the conceptual model in **Figure 4.2.**

[4] *The literature search included reviews of over 915 articles extracted from over 1300 hits from database searches of the University of Melbourne library's ISI Web of Science, Biosis and Current Content databases and the University of NSW's Aquatic Science and Fisheries abstracts, Web of Science and Zoological record.*

Figure 4.2. Conceptual model of effects of temperature change on species with different temperature tolerances.



Source: NSG (August, 2006)

There are a few types of expected ecological responses as a result of a temperature change. These are:

i) Little to no change for some species;

ii) Reduction in numbers of some species;

iii) Increase in numbers for some species;

iv) Some species may be eliminated; or

v) Some species not currently found in the Inner Harbour may emerge.

Table 4.2 illustrates some specific species that may respond in a similar fashion within Port Kembla Harbour. They are based on a scenario temperature increase of > 3°C.

There are other possibilities for some species other than reduced abundances or elimination from the Inner Harbour. Other possible reactions include:

- Moving from the upper warmer water layer in the Inner Harbour to the cooler water beneath the thermal plume. Consequently, the continuing presence of a distinct thermal plume at the surface under the ICP proposal presents a better ecological alternative than a more uniform temperature regime through the water column; or

- Relocation by motile species (fish) horizontally to cooler parts of the Inner Harbour.

Effects within Allan's Creek

NSG (2006) reports that changes in water temperature in Allan's Creek between the Main Drain and the ICP discharge point under typical conditions of ICP operation seem unlikely to have a major effect on biota in the creek. However, a return to a more natural temperature regime in this part of the creek, may make the area less attractive to species such as the small fish with tropical affinities that have been reported there in the past (Carey 2005).

Of the four mollusc, three crab and 17 fish species recorded in Allan's Creek during the 2002 fish study (MSE, 2002), only two fish species (*Caranx sexfasciatus* and *Gerres subfasciatus*) and one crab (the mud crab *Scylla serrata*) would seem to be at risk from reduced temperatures on the basis of their known geographic distribution. However, both fish species are active swimmers so may well be able to move to warmer water within the Harbour, while the crab is known to occur in estuaries, suggesting it is likely to tolerate higher temperatures than suggested by its geographic range alone. Irrespective of possible changes to the biotic assemblage, any return to a more natural regime in Allan's Creek should be seen as a positive step.

Summary

With respect to the impacts of temperature change on the biota within Allan's Creek and Port Kembla Harbour, NSG (2006) has concluded that;

"No major losses of biota from the Inner Harbour are anticipated as a result of the proposed temperature increases given:

- *The predicted changes to water temperatures are less than 0.8°C across most of Inner Harbour, and*
- *Species currently residing in the Inner Harbour have been shown to survive temperatures higher than would be expected at the latitude of Port Kembla.*

However, some changes to the composition of the assemblages may be expected to occur, particularly at the innermost locations near the mouth of Allan's Creek where the predicted changes in water temperatures are greatest."

Table 4.2 Port Kembla Harbour ecological temperature response types, indicative species and possible fates

Species group	A	B	C	D	E
Description of Species Group	Species already in the Inner Harbour and able to tolerate a relatively wide range of temperatures	moderately successful species under the current temperature regime	currently moderately successful under the existing temperature regime	Species presently found in the Inner Harbour at or near the northern limits of their distribution	Warmer-water species that may appear in the Inner Harbour
Typical Distribution of Species Group	tropical and warm temperate waters in Australia	temperate waters in Australia	currently near the southern limit of their ranges within Port Kembla Harbour	at or near the northern limits of their distribution within Port Kembla Harbour	may be exotic species introduced via shipping vessels such as ballast water or hull fouling
Candidate Species in Port Kembla Harbour and (temperature tolerance range)	• Barnacle *Balanus trigonus* (13 - 31ºC) • Ascidian *Herdmania momus* (13 - 30ºC) • Ascidian *Styela plicata* (13 - 31ºC).	• Barnacle *Amphibalanus variegates* (13 - 27ºC) • Barnacle *Chthamalus antennatus* (11 - 27ºC)	• Gastropod *Littoraria luteola* (15 - 31ºC) • spider crab *Hyastenas elatus* (17 - 31ºC) • blue swimmer crab *Portunus pelagicus* (15 - 31ºC)	• peanut worm *Phascolosoma annulatum* (11 - 22ºC) • gastropod *Clanculus plebejus* (13 - 24ºC) • Tasmanian blenny (fish) *Parablennius tasmanianus* (11 - 23ºC)	• Asian Green Mussel *Perna viridis* • Black-striped Mussel *Mytilopsis sallei* • Golden Mussel *Limnoperna fortunei*
Possible fate of organisms	expected to show little change	may be reduced in parts of the Inner Harbour where predicted increases are highest	may become somewhat more abundant	may be eliminated with any further increase in water temperature	May be introduced into Port Kembla Harbour

Source: NSG (August, 2006)

4.4.6 Mitigation Options

During the design phase of the salt water cooling system, mitigation options to reduce temperature levels and consequently the effects on the ecology of Port Kembla Harbour were considered (see **Sections 2.2.2** and **3.2.4**).

However, once the discharge structure and cooling method has been approved and commissioned, it is not feasible to make changes or alterations to the cooling system as any modification would be expensive and produce only minimal (if any) positive results. Therefore, the discharge structure will be designed and engineered to have the least impact on the Port Kembla Harbour.

As noted by NSG (2006), there are many other factors in addition to temperature which require improvement to change Port Kembla Harbour towards a slightly to moderately disturbed system. **Section 4.5** provides further detail on the current and future management strategies to be undertaken by BlueScope Steel in order to improve the water quality of Allan's Creek and Port Kembla Harbour.

4.5 Monitoring and Assessment

A monitoring program is required to assess whether the actual effects on the ecology of the Harbour are comparable to those predicted. A monitoring program would provide sufficient data to help identify whether certain impacts are within acceptable limits.

A monitoring program should be responsive to the risks identified through assessment studies. DECC note that, in relation to this Project, a monitoring program would be likely to contain:

- Discharge monitoring (volume, temperature, toxicity); and
- Periodic ambient condition monitoring (pelagic and benthic communities).

Below is an outline of the current monitoring practices undertaken by BlueScope Steel.

4.5.1 Current Monitoring Practices

The BlueScope Steel EPL dictates specific plant operating conditions, PRPs and monitoring conditions for BlueScope Steel's licensed drains. Monitoring conditions outlined in the EPL include parameters setting out measurement and frequency of each discharge. There are 13 licensed discharge points, ten of which discharge directly into Allan's Creek. Chapter 2 of EPL 6092 details the monitoring requirements or the setting of limits for discharges of pollutants to water from each specific point. Relevant monitoring practices undertaken in compliance with the EPL include:

Monitoring Point 79 – No.2 Blower Station Drain

The EPL outlines monitoring requirements for the No.2 Blower Station Drain. This drain discharges straight into Allan's Creek via two pipes, approximately 200m upstream from the proposed ICP discharge on the southern side. An extensive list of metals, non-metals, pH, temperature and TSS is monitored on a regular basis.

Monitoring Point 80 - Slab Mill Drain

The EPL outlines monitoring criteria for the Slab Mill Drain which is located 500m from the mouth of Allan's Creek on the northern side. The monitoring requirements include temperature, pH levels, metals, non-metals and TSS and is also monitored on a regular basis.

Monitoring Point 88 – Main Drain

The EPL outlines monitoring criteria for the Main Drain which is located 800m from the mouth of Allan's Creek on the southern side. The EPL also has an extensive list of monitoring requirements including temperatures, pH, metals, non-metals and TSS. As required by the EPL, this discharge point is monitored on a regular basis.

Chapter 6 of the EPL 6092 also outlines specific PRPs, agreed to by BlueScope Steel, which establish long-term strategies and goals to improve the PKSW environmental performance outside of regular monitoring practices. PRPs outlined in the EPL that are relevant to water discharges and their associated monitoring requirements are outlined in **Section 4.5.2**.

4.5.2 Pollution Reduction Programs

Pollution Reduction Program (PRP) 96 – Toxicity Testing of No.2 Blower Station Drain Water

NSG (2006) noted a general lack of data on the toxicity of Clamtrol to marine organisms and the influence of temperature on its toxicity make it impossible to provide a reasonable estimation of the effects of the release of this biocide at elevated temperatures into Port Kembla Harbour.

In accordance with PRP 96, BlueScope Steel collected and reported data to the DECC on the toxicity levels and pollutants of the No.2 Blower Station Drain. The toxicity of the discharge had to be evaluated under a range of conditions including high flow, low flow and immediately after Clamtrol dosing.

As a direct result of PRP 96, BlueScope Steel and others moved away from using Clamtrol 1 due to its primary ingredient of Dodecylguanidine Hydrochloride (DGH), and began to trial Clamtrol II in 2004. The use of Clamtrol II resulted in a substantial reduction in the amount of dosing necessary and an improvement in analysis equipment to accurately measure the lower concentration levels of Clamtrol II in the water. Clamtrol II is the biocide currently used by BlueScope Steel to prevent fouling.

PRP 97 – Investigate Remaining Source of Contaminants in the Main Drain

In accordance with PRP 97, BlueScope Steel currently monitors toxicity of the Main Drain by monitoring specific contaminants including the process additive, Clamtrol II. The results of this monitoring are to be submitted to the DECC by 31 July 2008 to assist in the determination as to whether the current discharge licence limits are sufficient to ensure a minimal impact on Allan's Creek from the drain. However it should be noted that discharges from the No.1 Power House into the Main Drain will cease due to the shutdown of the No.1 Power House.

PRP 99 - Stormwater Pollution Control Plan

In accordance with this PRP and ANZECC guidelines, BlueScope Steel has prepared a Stormwater Pollution Control Plan that defines water quality objectives and implements strategies to minimise stormwater impacts and maximise stormwater reuse. This PRP is currently being implemented.

In addition to monitoring drain discharge points in accordance with its EPL, BlueScope Steel undertakes further monitoring practices in accordance with a monitoring program, the results of which are shared with the Port Kembla Harbour Environmental Group (PKHEG). PKHEG is made up of a group of local community members, Port Kembla Harbour industries, local government organisations and non-government organisations. Consultation between PKHEG and BlueScope Steel resulted in BlueScope Steel creating a monitoring program for Inner and Outer Port Kembla Harbour. The monitoring covers a wide range of metals and TSS of the water as well as organic substances.

BlueScope Steel currently undertakes extensive monitoring of its discharge points in compliance with its EPL. This includes temperature, toxicity and a wide range of contaminants. BlueScope Steel complies with its PRPs including toxicity testing and stormwater management and with its social obligations involving water quality monitoring to ensure that environmental impacts on Allan's Creek and Port Kembla Harbour are detected.

PRP 146 –Port Kembla Inner Harbour Flora and Fauna Study

In accordance with this PRP, BlueScope Steel will conduct an assessment of water quality as well as fish, intertidal and benthos populations and health to assess the biological condition of the Inner Harbour and at the same time identify any pollutants of concern. By 31 July 2009, BlueScope Steel will submit to DECC a scope, methodology and timetable. By 30 June 2012, a written report must be submitted detailing the findings of the study.

PRP 147 – Investigate the Stormwater First Flush Impact

In accordance with this PRP, BlueScope Steel monitors four licensed discharge points for TSS, nitrogen, phosphorus, total iron and pH during storm events. A written report detailing the findings of the investigations are submitted to DECC within a six month period after a minimum of six storm events are monitored at each licensed point.

Pollution Reduction Program 152 – Green and Golden Bell Frog Management Plan

The Green and Golden Bell Frog (GGBF - *Litoria aurea*) is a listed endangered species in NSW. The objective of this PRP is to minimise the risk of harm or damage to the GGBF and its habitat from any actual or potential pollution from the premises.

By 31 July 2008, BlueScope Steel will develop a draft GGBF Management Plan and implementation timeline. By 30 September 2008, the final Management Plan will be submitted to the DECC. By the 30 November 2011, BlueScope Steel will prepare a report for submission to the DECC on the progress of the Management Plan.

4.5.3 Future Monitoring Practices

The extensive monitoring currently undertaken by BlueScope Steel would continue. Further monitoring practices will include:

Discharge Conditions

BlueScope Steel will monitor the following at the ICP discharge point:

- Water temperature;
- Flow rate; and
- Chemical concentration (i.e. BlueScope Steel will monitor the concentration of biocide at the ICP cooling water discharge point during periods of dosing of biocide for macro-fouling control).

Temperature Monitoring

BlueScope Steel will monitor the temperature of Port Kembla Harbour to validate the predicted increase in temperature resulting from the ICP cooling water discharge. BlueScope Steel, in consultation with DECC, will prepare a validation plan which will include a scope, methodology and timetable for sampling at Port Kembla Harbour.

Ecological Monitoring

The goal of PRP 146 is to identify the biological conditions of Port Kembla Inner Harbour. To determine the potential impact the ICP has on the ecology of Port Kembla Inner Harbour, BlueScope Steel will ensure the study, in accordance with PRP 146 is completed before the ICP is in operation. This study would be extended to include plankton as part of its scope. This study will provide a base line for a subsequent survey. BlueScope Steel would also undertake an aquatic flora and fauna study post-ICP.

Any monitoring undertaken will be considered and undertaken in a manner consistent with the objectives of the ANZECC & ARMCANZ Guidelines (2000) and in consultation with DECC.

5 Long-term Management Strategies

5.1 Physico-chemical Monitoring

Currently BlueScope Steel undertakes monitoring and reporting practices in accordance with its EPL as well as its community obligations. This monitoring assists BlueScope Steel in assessing the effects of its activities on the quality of Allan's Creek and Port Kembla Harbour.

BlueScope Steel will continue to conduct its current level of extensive monitoring of Port Kembla Harbour including Allan's Creek to ensure it is compliant with its environmental obligations. This includes monitoring of each drain and its discharge make-up as well as monitoring in compliance with its PRPs.

5.2 Biological Monitoring

BlueScope Steel has a long term strategy to monitor the ecological effects during the operation of the ICP to monitor the impact on the environment, as predicted. In accordance with this objective, BlueScope Steel will conduct an aquatic flora and fauna study pre-ICP and post-ICP (refer **Section 4.5.3**). This study will be undertaken in accordance with BlueScope Steel's PRP and in consultation with DECC.

6 Conclusion

6.1 Summary

A once-through salt water cooling system for the ICP Project will result in many environmental benefits. These include:

- Removal of the need to manage blow down and aerosol water (and associated treatment requirements and environmental effects) from the currently approved ICP cooling tower;
- Elimination of the need to consume approximately 10 ML/day of Avon Dam water;
- Removal of safety issues from the cooling tower such as a higher chemical inventory and vapour plumes.

The temperature modelling conducted by CLT which took into account typical ICP operating conditions including a specifically designed discharge structure, concluded that average temperature increases post-ICP at the six modelled Harbour locations would be less than 0.8˚C and 0.7˚C for typical summer and winter conditions respectively.

Maximum summer heat load scenarios were modelled to predict the increase on Allan's Creek and Port Kembla Harbour. This modelling resulted in a predicted maximum temperature increase of up to 2.6 ˚C at Location (22,67).

The extent of the mixing zone during maximum summer heat load conditions is expected to be within 40m of the discharge device.

In addition, a further scenario was modelled to determine the heat load associated with a thermal macro-fouling treatment process. The heat load in Allan's Creek and Port Kembla Inner Harbour did not exceed a maximum temperature increase of 2.6 ˚C at Location (22,67).

The ecological study conducted by NSG (2006) and UNSW (2008) made the following conclusions:

- No major losses of biota from the Inner Harbour or Allan's Creek are anticipated as a result of the proposed temperature increases;
- It would appear unlikely that a <0.8ºC change would cause a significant increase in the effects (toxic or bioaccumulation) of the heavy metals or PAHs at the entrance to Allan's Creek or the Inner Harbour;
- The expected changes in temperature are unlikely to influence the potential for invasion of a large number of exotic species into Port Kembla Harbour;

- The extraction index (a measure of the proportion of the plankton population passing through the ICP cooling system) is likely to increase by 30% during summer and winter typical periods and 12% during summer peak periods;
- The exposure to increased temperature will result in different impacts on different species;
- The current use of biocide by BlueScope Steel is likely to have a relatively small effect on plankton in Port Kembla Harbour;
- Plankton blooms are unlikely to occur as a result of the predicted increase in temperature; and
- Entrainment of plankton may range from 17% to 32% during 1 residence time in summer and winter respectively resulting in varied impacts on the planktonic communities in Port Kembla Inner Harbour (the Outer Harbour is unlikely to be affected due to Harbour flushing).
- The potential impact of entrainment of plankton in the ICP cooling system on Port Kembla Harbour beyond the discharge point is highly dependent on the Harbour's circulation patterns.

6.2 Conclusions

This report demonstrates BlueScope Steel's consistency with the DECC's priority outcomes as outlined in DECC correspondence dated 21 December 2005. These priority outcomes are discussed below:

- *Demonstrates transparent decision making with full consideration of all impacts.*

BlueScope Steel has recognised that the proposed modification to the ICP cooling system may have physical, chemical and biological impacts and has engaged specialists to investigate the potential impacts within the parameters agreed with the DECC. This process, by its nature, has been iterative as each design modification is tested for ecological impact. Specialist studies have looked at a range of potential impacts including the physical effects of temperature, temperature impacts on bioavailability of potential toxicants, alterations to biological communities including introduced species and those at different life stages. The potential impact on planktonic assemblages in Port Kembla Harbour has also been examined including the impacts of entrainment, increased temperature, the potential to create algal blooms and the potential impact of biocide. The results of these investigations have prompted modifications to the design of the ICP and the way cooling water is discharged and the way anti-fouling measures have been considered. It is believed that adoption of the design modifications and configuration presented herein will minimise ecological impacts.

- *Discusses potential adverse local impacts and considers options to ameliorate thermal loads and associated impacts.*

  BlueScope Steel have extensively considered a diverse range of options to cool the STG condensers and discharge cooling water to Allan's Creek. These options include dilution, refrigeration, cryogenesis and use of a salt water cooling tower. Cooling water studies have looked at the temperature impacts within the confines of Allan's Creek as well as Port Kembla Inner and Outer Harbour, taking into consideration a range of factors including temporal effects, seasonal effects, bathymetry, effects of currents and tides, wind, solar radiation, relative humidity and heat-load.

  Ecologists have considered the localised impacts taking into account known existing ecological benthic and pelagic communities within Allan's Creek and Port Kembla Harbour and anthropogenic influences on the Harbour such as those of BlueScope Steel and other port activities. The ecological requirements have led to the development and proposed adoption of an engineered discharge device to enable the cooling water to be discharged into the upper layers of Allan's Creek to maximise the heat dissipation and confine the mixing zone to the smallest possible area.

- *Ensures long-term progress towards the desired environmental condition of Port Kembla Harbour*

  BlueScope Steel will continue to consult and work with DECC in the appropriate prioritisation of resources to maximise favourable environmental outcomes at the PKSW including Port Kembla Harbour. The existing mechanism to achieving this is through licensing and Pollution Reduction Programs (PRPs) and is effective in driving positive change at the PKSW. The proposed modification to the water cooling system principally affects water quality and potentially increases entrainment of plankton into the cooling system. Management of these issues will be prioritised in accordance with agreed revisions to existing management plans or PRPs.

  BlueScope Steel will undertake monitoring of Allan's Creek and Port Kembla Harbour in compliance with its existing EPL including existing and future PRP's. BlueScope Steel will also extend its ecological monitoring as part of PRP 146 "Port Kembla Inner Harbour Flora and Fauna Study" to include plankton sampling prior to and post-commissioning of the ICP. In addition, one fish study pre- and post-ICP will be undertaken in accordance with PRP 146 to assess the ecological effects of the operation of the ICP cooling system on Port Kembla Harbour and Allan's Creek.

- *Ensures BlueScope Steel commits to a program of works where 10ML/d of dam water savings will be complimented by the use of tertiary treated effluent (TTE) from Wollongong Sewage Treatment Plant (STP).*

  Following approval of the proposed modification, BlueScope Steel will no longer require the use of the previously allocated potable and TTE water for use in the ICP cooling towers and as make-up water.. BlueScope Steel is working with both Sydney Water regarding allocation and quality of the TTE, and with the New South Wales

(NSW) DECC regarding a Water Savings Action Plan for the Port Kembla Steelworks (PKSW). BlueScope Steel is committed to meeting its own target of zero dam water use.

Based on the outcomes of desktop modelling and ecological assessments and consistent with the DECC's priority outcomes, it is considered that operation of the proposed ICP salt water cooling system, using a device that discharges the ICP cooling water to the upper layers of the water column, will maximise heat dissipation and minimise any impacts on marine communities within Port Kembla Harbour. The impacts identified in this report are considered acceptable in light of the significant benefits provided by the ICP Project.

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