SOUTHERN SEAWATER DESALINATION PLANT - MARINE INVESTIGATIONS

Water Quality Monitoring - September & October 2007

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Limitations Statement

The sole purpose of this report and the associated services performed by Kellogg Brown & Root Pty Ltd (KBR) is to provide a review water quality data at the proposed Southern Seawater Desalination Plant site in accordance with the scope of services set out in the contract between KBR and Water Corporation of Western Australia. That scope of services was defined by the requests of the Client, by the time and budgetary constraints imposed by the Client, and by the availability of access to the site.

KBR derived the data in this report primarily from field monitoring and laboratory analyses on the dates indicated. The passage of time, manifestation of latent conditions or impacts of future events may require further exploration at the site and subsequent data analysis, and re-evaluation of the findings, observations and conclusions expressed in this report.

In preparing this report, KBR has relied upon and presumed accurate certain information (or absence thereof) relative to the site provided by government officials and authorities, the Client and others identified herein. Except as otherwise stated in the report, KBR has not attempted to verify the accuracy or completeness of any such information.

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Revision History

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1 Introduction

The Water Corporation of Western Australia is progressing with the development of the Southern Seawater Desalination Plant (SSDP) located at Binningup, Western Australia. The SSDP has been selected as the preferred option to produce 100 GL/a of drinking water to meet the forecasted increase in demand. The plant will require the construction of a marine inlet to source influent seawater and an outfall to dispose of the brine reject.

Kellogg Brown and Root Pty Ltd was commissioned by the Water Corporation to undertake a series of marine investigations to determine the precise locations for the proposed SSDP inlet and outfall. A component of the marine investigations is the water quality monitoring program which aims to serve the following purposes:

- To provide information relating to the quality and variation of seawater that will be used in the desalination plant. This information will be used in the design and operation of the plant.
- To provide information on environmental conditions that exist in the area that will be receiving the brine discharge from the desalination plant. This information will be used to assist in determining the likelihood and extent of any influences on the receiving environment.

The complete water quality monitoring program will consist of six discrete monitoring events during autumn, winter, winter/spring, spring, spring/summer and summer. Water quality data shall be reported in three phases. A preliminary report presenting data obtained during the March (autumn) and July (winter) 2007 monitoring surveys, this Stage 1 report presenting data from the March (autumn), July (winter), September (winter/spring) and October (spring) 2007 monitoring surveys and the final Stage 2 report presenting data from all six monitoring events.

Water quality data presented in this Stage 1 report presents baseline data relating to parameters that are likely to be affected due to the receival of desalination brine via enrichment (nutrients and biologically available organic materials) and contamination (persistent organics and heavy metals) and impact desalination plant design and/or operations.

2 Methodology

2.1 FIELDWORK

This report presents the results of two field-sampling events conducted between 4–6 September and 9–11 October 2007 inclusive.

2.2 WATER SAMPLING

Water sampling, water column profiling and silt density index (SDI) testing were conducted over three consecutive days during both the September and October sampling events.

2.2.1 Sampling Protocol

Integrated water samples (5 L) collected across the entire water column, were obtained using a restricted-flow sampling vessel constructed of high-density polyethylene (HPDE) deployed from the water surface. Upon sampling, water was transferred to and stored in 5-litre HDPE containers. Water samples were kept cool and away from sunlight for approximately two hours before being filtered (where required) and transferred to appropriate sample containers/vials. All water samples were kept on ice during storage and transportation. Microbiological samples were analysed within 24 hours of sampling. Chemical samples were submitted to the laboratory on the final day of fieldwork.

Water column profiling was conducted using a Hydrolab Datasonde 5.

SDI testing was conducted using a custom-built SDI testing device. See Section 2.4.2 for further details.

Sampling was conducted by qualified KBR personnel and subcontractors.

2.3 SAMPLING SITES

Water quality monitoring sites were located along a north-south transect situated along a 10-m isobath. Site BY-0 represents the approximate location of the proposed outfall. Sites BY-500N and BY-500S are located 500 m to the north and south of BY-0 respectively. Control sites, BY-1250N and BY-5000S are located beyond the anticipated impact zone of the proposed outfall; this assumption will be confirmed by hydrodynamic modelling. Locations of Binningup water-quality monitoring sites are presented in Table 1 and Figure 1.

Table 1 Binningup water quality monitoring sites

Site	Latitude	Longitude
BY-1250N	-33° 07' 05.07"	115° 40' 53.50"
BY-500N	-33° 07' 29.42"	115° 40' 53.90"
BY-0	-33° 07' 45.65"	115° 40' 53.14"
BY-500S	-33° 08' 01.61"	115° 40' 53.11"
BY-5000S	-33° 10' 30.75"	115° 39' 59.23"

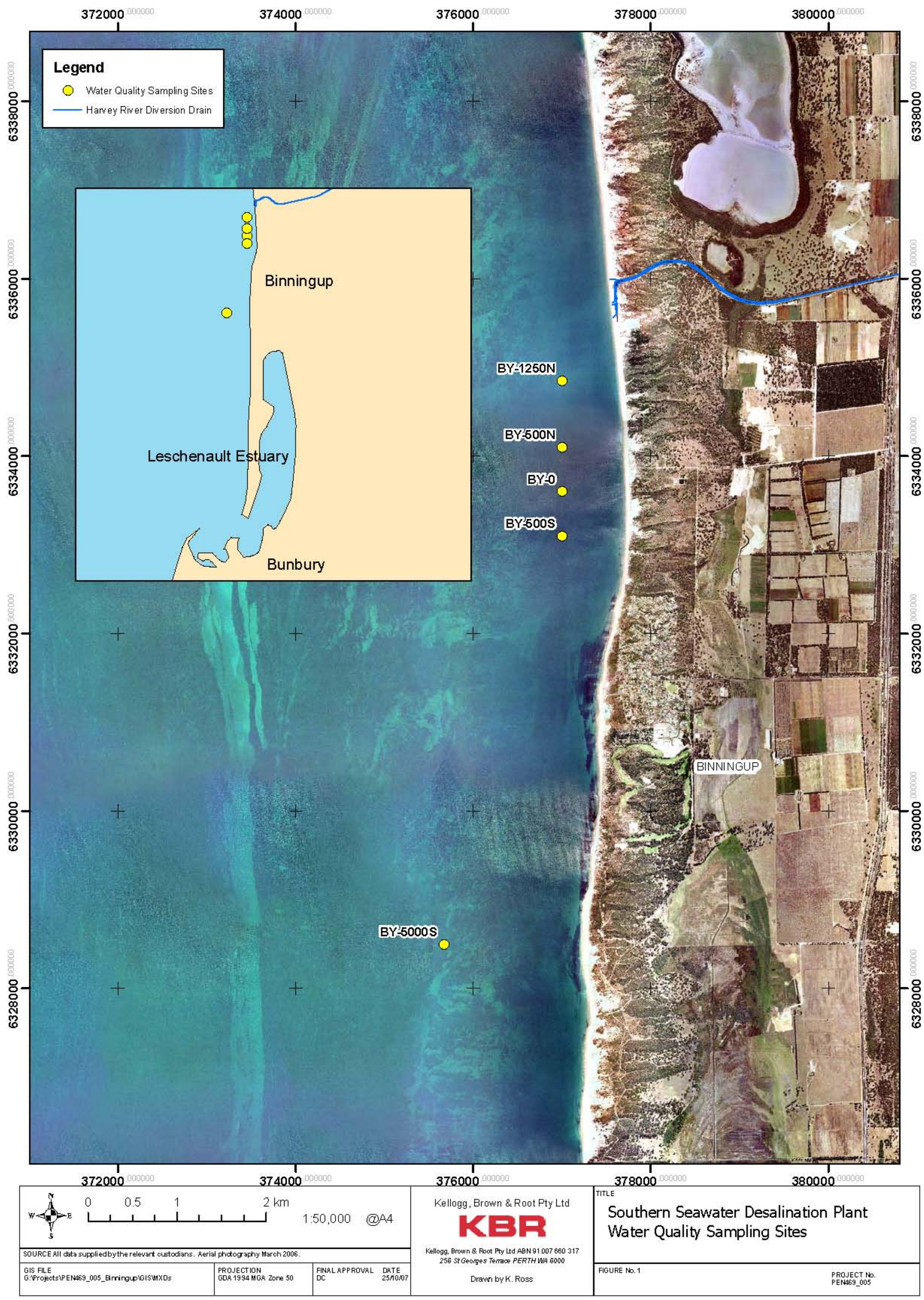

Figure 1 Binningup water quality monitoring sites

2.4 ANALYTICAL PARAMETERS

All water samples were analysed for a wide range of parameters grouped as general, nutrients, contaminants and biological parameters and are listed in tables 2, 3, 4 and 5 respectively. Parameters were selected in general accordance with ASTM D 4195-88 'Standard Guide for Water Analysis for Reverse Osmosis Application'. Limits of reporting (LOR) for each of the parameters are also provided in the following tables.

Table 2 General water quality parameter for Binningup seawater

Analyte	Unit	Method	LOR
Alkalinity	mg $CaCO_3.L^{-1}$	Titration	1
Barium, Ba	$mg.L^{-1}$	ICP-AES	0.0004
Bicarbonate, HCO_3	$mg.L^{-1}$	Titration	1
Bromide, Br	$mg.L^{-1}$	Ion Chromatography	0.1
Calcium, Ca	$mg.L^{-1}$	ICP-AES	0.001
Chloride, Cl	$mg.L^{-1}$	Lachat Flow Injection Analyser	1
Carbonate, CO_3	$mg.L^{-1}$	Titration	1
Fluoride, F	$mg.L^{-1}$	Ion Selective Electrode	0
Hardness (as $CaCO_3$)	$mg.L^{-1}$	Calculation	5
Magnesium, Mg	$mg.L^{-1}$	ICP-AES	0.005
Potassium, K	$mg.L^{-1}$	ICP-AES	0.05
Silicate	μg $Si.L^{-1}$	Lachat Flow Injection Analyser	2
Silicon, Si	$\mu g.L^{-1}$	ICP-AES	0.1
Sodium, Na	$mg.L^{-1}$	ICP-AES	0.05
Strontium, Sr	$mg.L^{-1}$	ICP-AES	0.001
Sulphate, SO_4	$mg.L^{-1}$	Lachat Flow Injection Analyser	1
Total Dissolved Solids, TDS	$g.L^{-1}$	Gravimetric	0.05
Total Suspended Solids	$mg.L^{-1}$	Gravimetric	0.5

Table 3 Nutrient water quality parameters for Binningup seawater

Analyte	Unit	Method	LOR
Ammonium	µg $N.L^{-1}$	Lachat Flow Injection Analyser	3
Nitrite & Nitrate	µg $N.L^{-1}$	Lachat Flow Injection Analyser	2
Total Nitrogen	µg $N.L^{-1}$	Lachat Flow Injection Analyser	50
Ortho-P	µg $N.L^{-1}$	Lachat Flow Injection Analyser	2
Total Phosphorus	µg $P.L^{-1}$	Lachat Flow Injection Analyser	5
Non-Purgable Total Organic Carbon	mg $C.L^{-1}$	Combustion-NDIR	0.5

Table 4 Contaminant water quality parameters for Binningup seawater

Analyte	Unit	Method	LOR
Filterable, Al	$mg.L^{-1}$	ICP-AES	0.01
Total Al	$mg.L^{-1}$	ICP-AES	0.01
Boron, B	$mg.L^{-1}$	ICP-AES	0.003
Chromium, Cr[1]	$mg.L^{-1}$	ICP-AES	0.001
Copper, Cu	$mg.L^{-1}$	ICP-AES	0.001
Filterable Iron, Fe	$mg.L^{-1}$	ICP-AES	0.002
Total Fe	$mg.L^{-1}$	ICP-AES	0.01
Filterable Manganese, Mn	$mg.L^{-1}$	ICP-AES	0.0002
Total Manganese, Mn	$mg.L^{-1}$	ICP-AES	0.0002
Nickel, Ni	$mg.L^{-1}$	ICP-AES	0.004
Vanadium, V	$mg.L^{-1}$	ICP-AES	0.001
Zinc, Zn	$mg.L^{-1}$	ICP-AES	0.002

Table 5 Biological water quality parameters for Binningup seawater

Analyte	Unit	Method	LOR
Chlorophyll 'a'	$µg.L^{-1}$	Spectrophotometric	0.1
Faecal Streptococci	$cfu.mL^{-1}$	Visual Count	1
Heterotrophic Plate Count @ 21°C	cfu.100 mL^{-1}	Visual Count	1
Heterotrophic Plate Count @ 37°C	cfu.100 mL^{-1}	Visual Count	1

Analyses were conducted by Marine and Freshwater Research Laboratory and Microserve Laboratory Pty Ltd (Perth). All laboratories are NATA-certified.

2.4.1 Physicochemical parameters

In-situ measurements of the water column were recorded at 0.25 m intervals (minimum) at each of the sites listed in Table 1 for the physicochemical parameters which are listed in Table 6.

Table 6 Physicochemical parameters measured across Binningup water column

Parameter	LOR
pH	± 0.1 pH units
Dissolved oxygen (DO)	± 0.1 $mg.L^{-1}$
Salinity	± 0.1 psu
Temperature	± 0.1°C
Turbidity	± 0.1 NTU

Physicochemical data have also been collected as part of the associated oceanographic monitoring survey. These data are collected across an area wider than the five monitoring sites used for this, the water quality monitoring program.

2.4.2 Silt Density Index Measurement

Silt density index (SDI) testing was performed in accordance with ASTM D 4189-1995, ‘Standard test method for silt density index (SDI) of water’.

Water, obtained from a depth of approximately 1 m below the surface, was passed through a 0.45 µm membrane filter at a pressure of 30 psi and the time taken to collect 500 mL of permeate was recorded (t_0). Water was continually passed through the membrane under isobaric conditions (30 psi). The time taken to collect 500 mL of permeate was again recorded at 5 minutes (t_5) and 15 minutes (t_{15}) after t_0.

A standard SDI test is performed over a period of 15 minutes. A measurement at 5 minutes was recorded in the event that a 15-minute test could not be completed (due to severe fouling of the membrane).

Silt density indices were calculated using the following equation:

$$SDI = 100 \text{ x } [1- (t_0 - t_f)] / T_f$$

where:

t_0 = time in seconds for the collection of the initial 500 mL

t_f = time in seconds for the collection of 500 mL at T_f

T_f = total time, in minutes, of the test (typically 15 minutes)

SDI measurement was performed at site BY-0, the proposed outfall site, on each of the days listed in Table 7.

Table 7 SDI measurement regime

	Site	Date	Day
September	BY-0	05/09/07	Day 2
	BY-0	05/09/07	Day 2
	BY-0	06/09/07	Day 3
October	BY-0	09/10/07	Day 1
	BY-0	10/10/07	Day 2
	BY-0	11/10/07	Day 3

3 Results

3.1 WEATHER OBSERVATIONS

Weather conditions during, and in the four days preceding the September and October sampling events are provided below in Tables 7 and 8 and Figures 2 and 3. Weather data were obtained from the Bureau of Meteorology's Carey Park (Bunbury) observation site.

Table 8 Bunbury weather conditions — September

	Date	Min temp (°C)	Max temp (°C)	Rainfall (mm)
	31-Aug-07	9.9	15.7	0.2
	01-Sept-07	10.8	18.1	0
	02-Sept-07	8.5	20.0	2.4
	03-Sept-07	9.6	24.4	0
Day 1	04-Sept-07	14.4	17.7	1.8
Day 2	05-Sept-07	7.8	17.1	3.2
Day 3	06-Sept-07	7.5	19.2	0

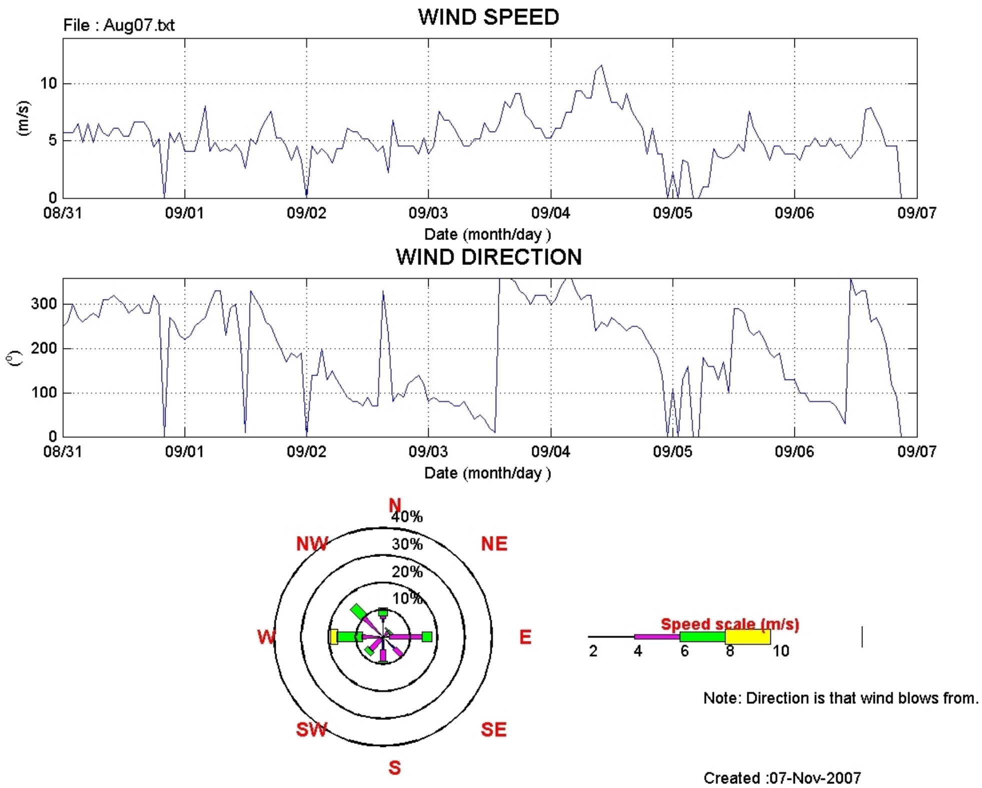

Figure 2 Bunbury wind data: 31 August–6 September 2007

Weather conditions for the seven-day period up to and including the September monitoring event were moderate with maximum air temperatures between 15.7°C and 24.4°C, with little rainfall (7.6 mm over the seven-day period) (Table 7) with moderate wind gusts (up to 10 m/s) with no predominant direction during this period (Figure 2).

Table 9 Bunbury weather conditions — October

	Date	Min temp (°C)	Max temp (°C)	Rainfall (mm)
	5-Oct-07	6.5	22.5	0
	6-Oct-07	11.9	21.8	0
	7-Oct-07	11.0	22.7	0
	8-Oct-07	12.7	20.0	14.8
Day 1	9-Oct-07	13.2	18.3	0.8
Day 2	10-Oct-07	9.5	18.5	1.0
Day 3	11-Oct-07	5.2	18.9	1.4

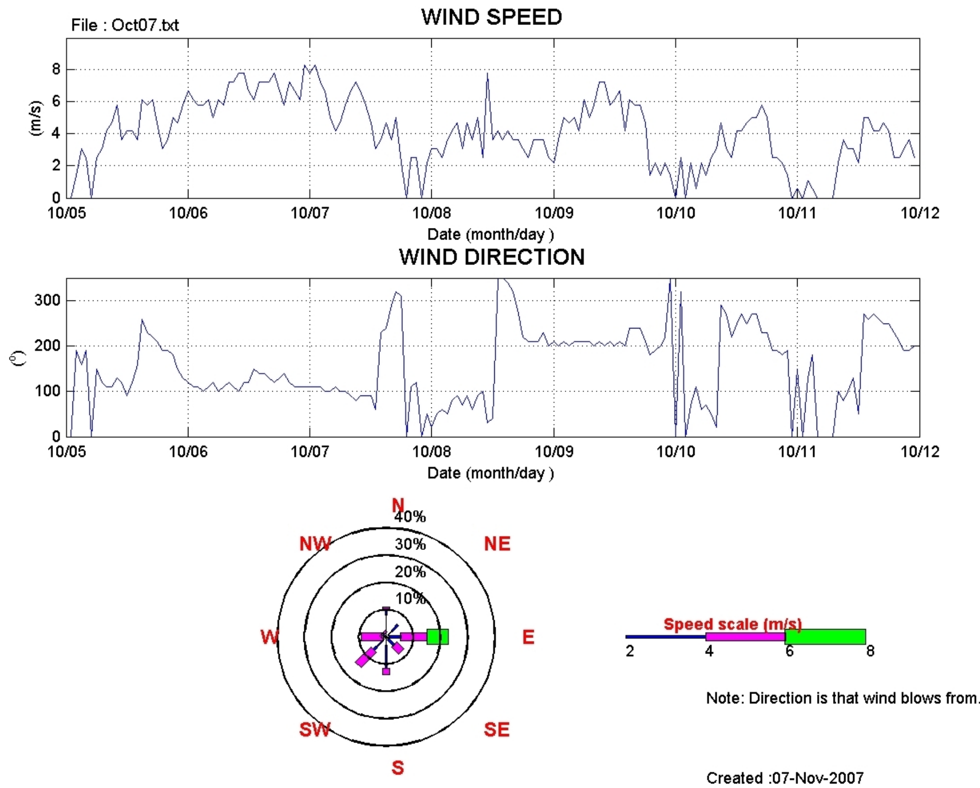

Figure 3 Bunbury wind data: 5–11 October 2007

In October, maximum air temperatures varied between 18.3°C and 22.7°C with moderate rainfall (18.0 mm) up to and during the sampling event (Table 8). Light to moderate winds (6–8 m/s) were generally from the west, south and east during this period (Figure 3).

3.2 WATER QUALITY

3.2.1 Physicochemical Properties

Physicochemical water column profiling data obtained during the September and October monitoring events are presented in Appendix A. Graphs present data obtained during each day of monitoring.

In September, water column temperatures varied 16.1–16.7°C on Day 1, 16.2–17.1°C on Day 2 and 16.1–16.8°C on Day 3. Water temperatures were generally consistent between sites however BY-5000S was measurably warmer than the other sites on all three days of monitoring. A slight inverse thermocline of approximately 8 m in depth was evident on Day 3 of monitoring.

In October water temperatures were warmer, 17.2–17.4°C on Day 1, 17.2–17.5°C and 17.3–18.1°C on Day 3. Temperatures were warmer at the top of the water column on Days 2 and 3 of monitoring but were consistent throughout the water column on Day 1. Water temperatures at BY-1250N were noticeably greater than those at the other sites on Day 1.

The pH values varied between 8.13 and 8.22 over three days of monitoring in September. Values were highly consistent through out the water column at each site. Differences were observed between the central sites (BY-500N, BY-0 and BY-500S; 8.18-8.19) and the northern (8.14-8.15) and southern (8.20-8.21) control sites on Days 1 and 2 of monitoring.

In October pH values were significantly lower, ranging between 7.99 and 8.09. Little variation was observed throughout the water column at each site. It should be noted that these values are considerably lower than what might be expected for marine waters (pH 8.1 - 8.2) and should be treated with some degree of scepticism.

Salinity varied 33.7–34.8 psu on Day 1, 34.6–35.2 psu on Day 2 and 34.4–5.7 psu on Day 3 of monitoring in September. Lower salinities (33.7 psu) observed on Day 1 were associated with the northern sites BY-1250N and BY-500N. Salinities generally increased gradually with increasing depth in the water column. Salinities increased in a southerly direction on Days 1 and 2 of monitoring.

In October salinities varied between 34.9 and 35.4 on Days 1 and 2 and 34.8 and 35.3 on Day 3 of monitoring, rising gradually with increasing depth.

Dissolved oxygen (DO) saturation levels varied between 90% and 125% saturation over three days of monitoring in September. DO saturation decreased with increasing depth.

In October DO saturation ranged between 89% and 99%, again decreasing with increasing depth.

Turbidity was high, generally between 2-10 NTU over the three days of monitoring in September, increasing with increasing depth.

Turbidity was greater in October than in September, particularly on Day 1 of monitoring where it reached as high as 20 NTU at the middle of the water column.

3.2.2 Silt Density Index (SDI)

The silt density index (SDI) of a given water sample is a dimensionless measure of that waters potential to foul a (reverse osmosis) membrane. Membranes may be fouled by a number of species including very fine suspended solids and colloidal materials. SDI results obtained during September and October 2007 sampling are presented in Table 10.

Table 10 SDI results for Binningup marine waters: September and October 2007

	Site	Date	Day	SDI @ 15 mins
September	BY-0	05 Sept 2007	Day 2	6.5
	BY-0	05 Sept 2007	Day 2	6.5
	BY-0	06 Sept 2007	Day 3	6.1
October	BY-0	09 Oct 2007	Day 1	6.4
	BY-0	10 Oct 2007	Day 2	6.4
	BY-0	11 Oct 2007	Day 3	6.2

The SDIs of Binningup waters (BY-0) were between 6.1 and 6.5 in September and October, generally greater than those in March and July (KBR 2007). The exceptionally high SDI (19.4) observed on Day 3 of the July monitoring event appears to have been an isolated incident however, additional monitoring is recommend to determine the frequency of these isolated high SDI events.

3.2.3 General

General marine water quality parameters provide a broad view of the water characteristics and are the most important parameters with respect to process design. The maximum recovery of a seawater desalination plant is determined by the salinity of the feedwater, which in turn dictates the driving force which must be applied to overcome the osmotic pressure. In addition, sparingly soluble salts such as barium, calcium and strontium sulfates and carbonates produce scale when their solubility is exceeded in water. The lower recoveries (~40%) used for large seawater reverse osmosis plants prevents the precipitation of many of these salts and generally only the solubility of calcium carbonate is considered to be an issue.

Spatial and temporal (seasonal and diurnal) variability in water quality is illustrated in Appendix B. No spatial trends were observed for general parameters in either September or October. Seasonal variation was observed for barium, fluoride and silicate (higher in September) and boron, calcium, hardness, magnesium, sodium, strontium and sulphate (higher in October). Diurnal variation , if any, was relatively low for most general parameters with the exception of total suspended solids.

3.2.4 Nutrients

The reverse osmosis process produces a concentrate stream, or brine, as a by-product. The brine contains species that do not pass through the membrane which results in nutrient enrichment within the brine and the receiving environment as well.

Nutrients are typically present in marine waters in concentrations (orders of magnitude) lower than those of most general parameters. Nutrients, particularly water-soluble species such as ammonia, nitrite & nitrate and orthophosphate, typically exhibit greater seasonal and diurnal variation in comparison to general parameters.

Nutrient concentrations were generally greater in October in comparison to September. There appeared to be slightly elevated nutrient concentrations at site BY-500S relative to other sites.

3.2.5 Contaminants

Contaminant species are typically rejected by the RO membrane with a high degree of efficiency and are concentrated in the brine. This can result in a localised accumulation of contaminants and, for heavy metals in particular, may result in deposition in the surrounding sediments. RO membranes are destroyed if they come into contact with hydrocarbons.

Many contaminants were at or below their respective detection limits in September and October.

Spatial and temporal (seasonal and diurnal) variability in water quality is illustrated in Appendix B. No spatial trends were observed for contaminants in either September or October.

The majority of total aluminium, iron and manganese were present as insoluble forms.

3.2.6 Biological

Biological growth is ubiquitous in natural environments; however, biological growth on an RO membrane can result in rapid fouling requiring more frequent cleaning and a loss in production efficiency.

Biological oxygen demand (BOD) was expected to be low in Binningup marine waters. This expectation was confirmed during the March survey when BOD levels were found to be at or below the limit of reporting (5 $mg.L^{-1}$). Monitoring of BOD was discontinued at this stage.

Chlorophyll-a is a commonly used surrogate measure for primary production in waters. Primary production was elevated (μ = 6.1 $mg.L^{-1}$) at site BY-500S in October but was as a result of one particularly high result (14.0 $mg.L^{-1}$; Day 2). This coincided with increased nutrients concentrations in Binningup waters at this location at this time (Section 3.2.4)

Heterotrophic plate count (HTPC) is a measure of a waters potential to support microbiological growth. HTPC in Binningup waters was generally low in both October and September. Elevated results were due to isolated events.

Concentrations of faecal streptococci, an indicator for the presence of faecal matter, were below the limit of reporting in September and October.

4 Discussion

4.1 WATER QUALITY

Discussion of water quality results is presented in the sections below. Where appropriate, default trigger levels are provided for comparative purposes. There seems to be little correlation between the three individual measures for suspended material in the water column, namely turbidity, total suspended solids, and SDI. These measurements are based on optical, gravimetric and empirical measurements respectively. This relationship shall be investigated further in the Stage 2 report.

4.1.1 Physicochemical Parameters

The water column appeared to be generally well mixed in both September and October with no significant stratification observed. Low salinities observed at the northern sites BY-1250N and BY-500N on Day 1 of the September monitoring event were consistent with a freshwater source in the vicinity of these sites. Turbidity was high throughout the entire water column during both the September and October monitoring events. This result is consistent with the very high (up to 54 $mg.L^{-1}$) total suspended solid content of the water during these monitoring events.

4.1.2 Silt Density Index

SDI results for marine waters at Binningup during September and October indicate that the water had a low-fouling potential. It was apparent that the high turbidity and suspended solid content observed in September and October did not significantly contribute to the fouling potential of the waters.

Most membranes manufacturers stipulate a maximum feed SDI of 5 to ensure membrane performance and longevity. Conventional pre-treatment such as coagulation and filtration is usually sufficient to reduce seawater obtained from open coastal regions to an SDI of below 5. Conventional treatment does not, however, respond well to isolated high SDI events. In locations where isolated high SDI events may be an issue, alternative pre-treatment options such as microfiltration should be considered.

4.1.3 General

Seawater has a typical total dissolved solids (TDS) content of 35,000 $mg.L^{-1}$ which is made up primarily of the 11 major ions presented in Table 11. Due to the high salinity of seawater, samples must often be diluted to facilitate analysis. The dilution process magnifies errors inherent in the analytical methods and there are also errors associated with the dilution itself. For these reasons, reported concentrations of analytes in seawater should not be considered as absolute values. A measure of these inherent errors can be estimated from the ionic balance of the sample. Molar concentrations of major ions are multiplied by their respective valencies. The ionic balance of the sample is the sum of these products. By definition, the ionic balance of seawater must be zero; any deviation from a value of zero (positive or negative) indicates a relative increase in these errors. The TDS of a particular seawater sample, measured gravimetrically, may also be compared with the sum of these major ions for verification.

Table 11 provides the major ion composition for a typical seawater sample with a TDS of approximately 35,000 $mg.L^{-1}$. It should be noted that in locations where seawater TDS differs from 35,000 $mg.L^{-1}$ due to concentration or dilution effects, the actual ratio (% abundance) of major ions remains constant. Any significant variation from this ratio may be due to analytical errors, or to some form of 'contamination' such as groundwater ingress.

Table 11 Typical major ion balance for seawater

	Concentration[1]	Abundance (%)	Molecular Weight (g)	No of Moles	Valency
Chloride	19345	55.03	35.5	0.545	-1
Sodium	10752	30.59	23	0.467	1
Sulfate	2701	7.68	96.1	0.028	-2
Magnesium	1295	3.68	24.3	0.053	2
Calcium	416	1.18	40.1	0.010	2
Potassium	390	1.11	39.1	0.010	1
Bicarbonate	145	0.41	61	0.002	-1
Bromide	66	0.19	79.9	0.001	-1
Borate	27	0.08	58.3	0.000	-3
Strontium	13	0.04	87.6	0.000	2
Fluoride	1	0.003	19	0.000	-1
Total	35151				
Ion Balance	-0.07%				

1 *Santa Barbara City College (2006)*

Ratios of each of the 11 major ions in seawater and ionic balances are presented for Binningup marine waters in September and October (Table 12). Concentrations presented in Table 12 have been developed from 3-day means of results obtained from site BY-0. For the purposes of this exercise it was assumed that all boron in these seawater samples was present as borate.

Table 12 Major ion balance for BY-0 marine waters September and October 2007

	September		October	
	Concentration	% Abundance	Concentration	% Abundance
Chloride	20000	56.55	19667	54.16
Sodium	10333	29.22	11000	30.30
Sulfate	2633	7.45	2900	7.99
Magnesium	1333	3.77	1600	4.41
Calcium	407	1.15	470	1.29
Potassium	420	1.19	423	1.17
Bicarbonate	140	0.40	143	0.39
Bromide	69	0.19	69	0.19
Borate	24.7	0.07	28.1	0.08
Strontium	6.8	0.02	7.9	0.02
Fluoride	1.0	0.003	0.8	0.002
Total	35368		36309	
Ion Balance	-3.25%		2.53%	

Abundances of major ions in Binningup marine waters in September were generally consistent with those of a typical seawater and in October were enriched slightly in sulfate, magnesium and calcium. This result may indicate the presence of groundwater or surface water intrusion, possibly related to the greater rainfall prior to and during the October monitoring event. TDS, calculated as the sum of the major ions, was greater in October than in September.

4.1.4 Nutrients

Mean nutrient concentrations in Binningup marine waters recorded at each site over the three-day monitoring periods in September and October are presented in Table 13.

Table 13 Nutrient concentrations for Binningup marine waters September and October 2007

	Ammonium (µg N.L^{-1})	Nitrite & Nitrate (µg N.L^{-1})	Total Nitrogen (µg N.L^{-1})	Orthophosphate (µg P.L^{-1})	Total Phosphorous (µg P.L^{-1})	Total Organic Carbon (mg.L^{-1})
September						
BY-1250N	3	2	173	3	18	1.3
BY-500N	3	2	177	4	17	1.4
BY-0	3	2	160	3	15	1.3
BY-500S	3	2	147	4	14	1.5
BY-5000S	3	2	120	4	9	1.1
October						
BY-1250N	***5***	2	173	3	***20***	1.9
BY-500N	3	2	***233***	3	***21***	2.0
BY-0	***5***	2	227	3	***25***	2.3
BY-500S	***10***	3	***320***	***13***	***23***	1.9
BY-5000S	3	2	93	2	9	1.5
Default trigger value[1]	5	5	230	5	20	-

1 *ANZECC/ARMCANZ (2000) Table 3.3.6; inshore marine waters in south-west Australia*

Nutrient concentrations were greater in October relative to September and some sites met or exceeded ANZECC/ARMCANZ (2000) default trigger values for inshore marine waters in south-west Australia for ammonium, total nitrogen, orthophosphate and total phosphorous in October.

Due to the fact that in some cases, ANZECC/ARMCANZ (2000) default trigger values were exceeded in Binningup marine waters under pre-operational condition, it is recommended that these trigger values not be applied for operational monitoring purposes.

4.1.5 Contaminants

Contaminant levels in Binningup marine waters were generally below respective limits of reporting. A comparison for selected contaminant concentrations in Binningup marine waters at monitoring sites against ANZECC/ARMCANZ (2000) trigger values for 95% and 99% species protection levels in marine waters is presented in Table 14.

Table 14 Contaminant concentrations in Binningup marine waters September and October 2007

Analyte ($\mu g.L^{-1}$)	Copper	Nickel	Vanadium	Zinc
September				
BY-1250N	***1***	4	1	2
BY-500N	***1***	4	1	2
BY-0	***1***	4	1	2
BY-500S	***1***	4	1	2
BY5000S	***3***	4	1	2
October				
BY-1250N	***1***	4	1	2
BY-500N	***1***	4	1	2
BY-0	***1***	4	1	2
BY-500S	***1***	4	1	2
BY-5000S	***1***	4	1	2
95% SPL[1]	1.3	70	100	15
99% SPL[2]	0.3	7	50	7

1 *Trigger value for marine water at 95% level of species protection (ANZECC/ARMCANZ Table 3.4.1)*

2 *Trigger value for marine water at 99% level of species protection (ANZECC/ARMCANZ Table 3.4.1)*

Contaminant species at monitoring sites were generally below their respective trigger value for 99% species protection level (99% SPL) and therefore 95% species protection level (95% SPL) in Binningup marine waters (Table 14). One exception was observed for copper which exceeded the 99% SPL in both September and October, however these 'exceedences' were generally (all except BY5000S in September) related to the limit of reporting being greater than that of the 99% SPL.

It should be noted that seawater is a difficult matrix, due to its high total dissolved solids content, in which to obtain very low limits of reporting, such as some of those proposed for 95% and 99% SPLs. As such, it is often impossible or impractical to achieve the limits of reporting as specified for the proposed 95% and 99% SPLs. It is likely that the exceedences of 95% and 99% SPLs identified above are solely as a result of modern analytical methods being unable to achieve such low limits of reporting in a seawater matrix.

4.1.6 Biological

Mean heterotrophic plate count (HTPC) results were typically low for Binningup marine waters in both September and October. Elevated means were a product of single isolated high results on one day of monitoring. Median enterococci streptococci concentrations were at or below the limit of reporting during both the September and October monitoring events and did not exceed the ANZECC/ARMCANZ (2000) guideline value for primary contact for recreational waters (35 enterococci.100 mL^{-1}).

Mean chlorophyll-a concentrations present at all monitoring sites equalled or exceeded the default trigger value for inshore marine waters during the September and October monitoring event (Table 15). Chlorophyll-a concentrations were particularly high at site BY-500S on Day 2 of monitoring during October. These elevated chlorophyll-a concentrations coincided with elevated nutrient concentrations at the same time at this location (Table 13).

Table 15 Chlorophyll-a concentrations in Binningup marine waters September and October 2007

September	Chlorophyll-a (μg.L^{-1})
BY-1250N	2.1
BY-500N	2.7
BY-0	1.6
BY-500S	1.6
BY-5000S	0.8
October	
BY-1250N	2.4
BY-500N	2.0
BY-0	2.0
BY-500S	6.1
BY-5000S	0.7
Default trigger value[1]	0.7

1 *ANZECC/ARMCANZ (2000) Table 3.3.6; inshore marine waters in south-west Australia*

5 Conclusions and Recommendations

September and October 2007 water-quality monitoring events were conducted at the proposed outfall for the Southern Seawater Desalination Plant (SSDP) in Binningup.

Monitoring of the water column for physicochemical parameters did not detect any significant stratification in either September or October. The continued use of integrated water samples was supported. High turbidity was observed throughout the water column.

General water quality parameters during September were found to be comparable with those typical of seawater. A slight enrichment in sulfate, magnesium and calcium was observed during the October monitoring event. The total dissolved solids content of Binningup marine waters were greater in October than in September.

There does not appear to be any significant deviation in general water quality parameters from typical seawater composition. Accordingly there may be the potential to reduce the total number of general parameters being monitored, as these could be related to total dissolved solids content or other such surrogate measure. This should be reviewed upon completion of the 2007 baseline monitoring programme.

Nutrient concentrations were generally greater in October in Binningup marine waters. Mean concentrations of water-soluble nutrients exceeded ANZECC/ARMCANZ (2000) default trigger values in October. It is recommended that these trigger values not be applied for operational monitoring purposes.

Chlorophyll-a concentrations obtained during preoperational monitoring were also found to exceed ANZECC/ARMCANZ (2000) default trigger values in both September and October. As such these default trigger values should not be applied for operational monitoring.

It is recommended that the determination of heterotrophic plate count at 37°C cease. This temperature is well above ambient water temperatures at this location. A temperature of 21°C is closer to ambient water temperatures at this location and is considered more applicable in determining the potential for microbiological growth.

Water quality at site BY-5000S is measurably different under pre-operational conditions to that at the other sites. It is recommended that monitoring at this site be continued and that an additional monitoring site located closer to site BY-0 be instated so that the water quality at the new site is comparable with the other monitoring sites used in this program.

The area is one of high primary productivity and, as seen from preliminary habitat mapping results, likely to be high in secondary productivity. It is expected that there will be considerable variability in many parameters, especially after storm events.

6 References

ANZECC/ARMCANZ 2000. Australian Water Quality Guidelines for Fresh and Marine Waters. Australian and New Zealand Environment and Conservation Council & Agriculture and Resource Management Council of Australia and New Zealand.

Kellogg Brown and Root 2007. Southern Seawater Desalination Plant — Marine Investigations Water Quality (March & July 2007). KBR Report: PEN469-005-G-REP-001.

Santa Barbara City College Biological Sciences Department: http://www.biosbcc.net/ocean/marinesci/02ocean/swcomposition.htm accessed 06/11/06.

Appendix A

PHYSIOCHEMICAL PROFILES

September & October 2007

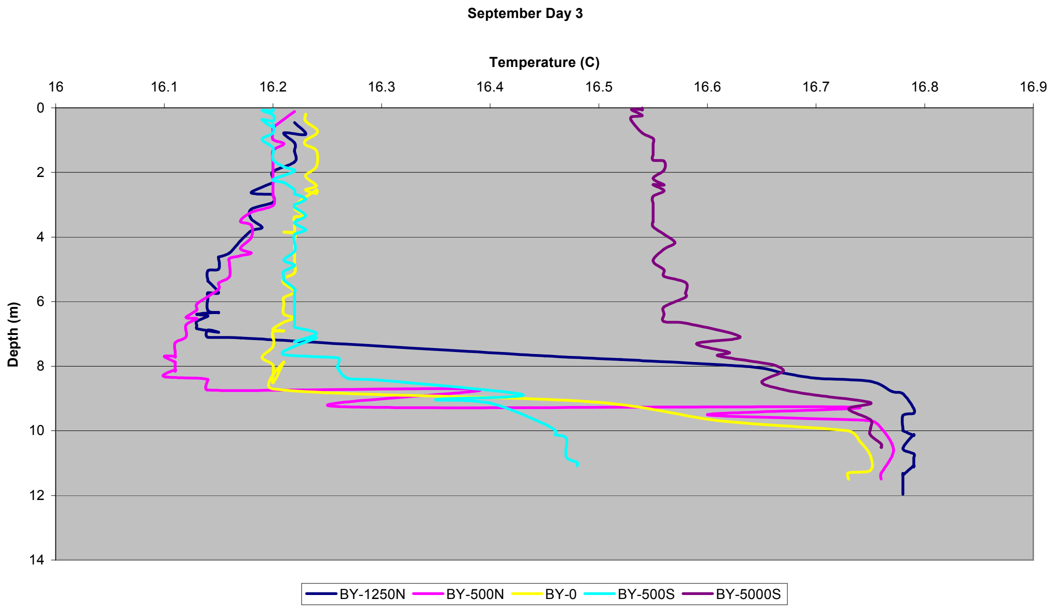

Figure A-3   Water column temperature - September 6th 2007

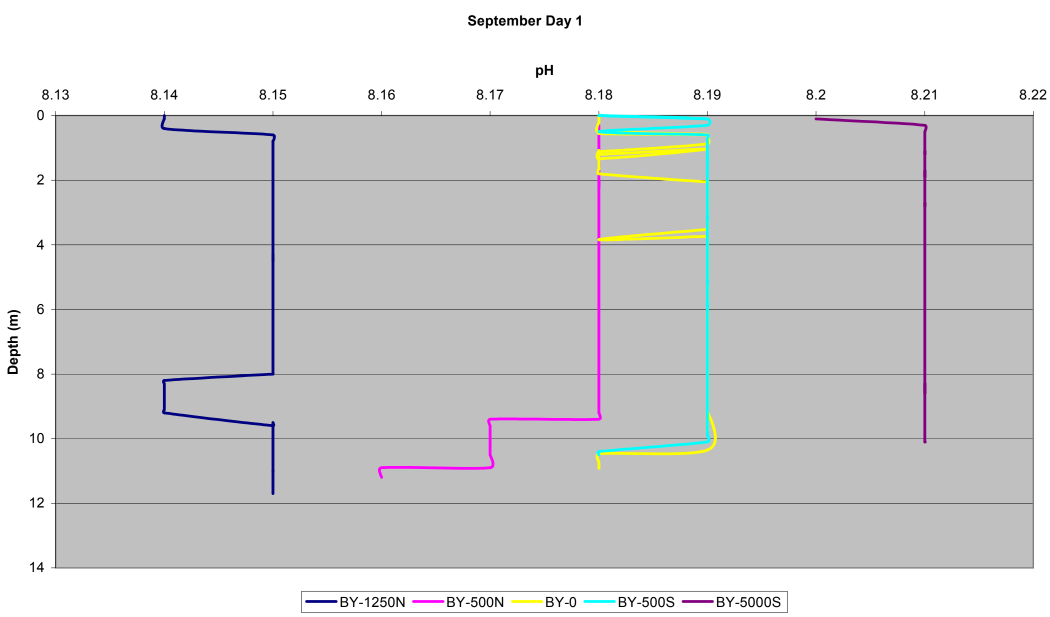

Figure A-4 Water column pH - September 4th 2007

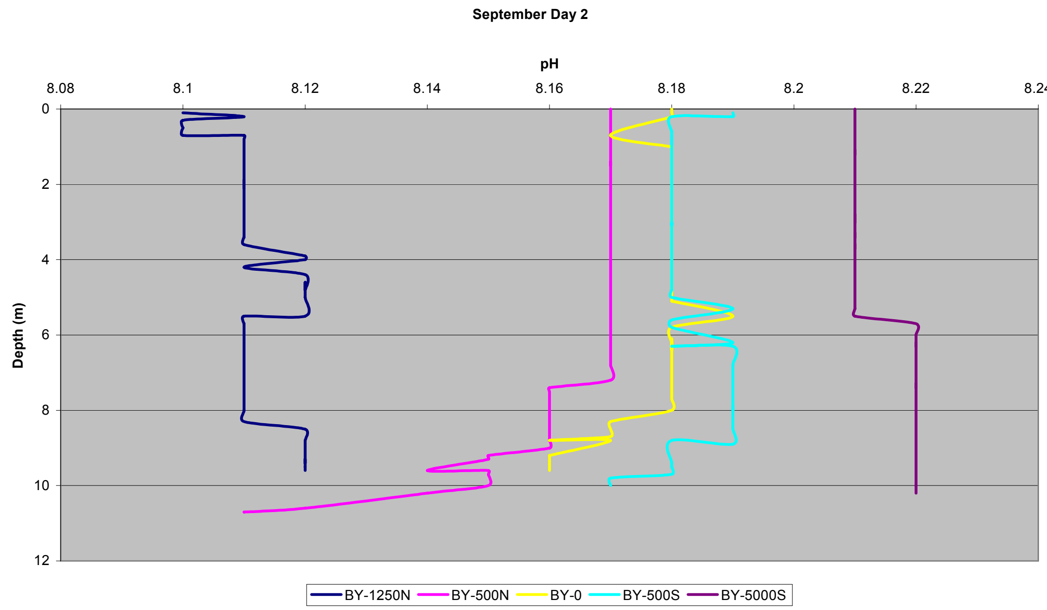

Figure A-5 Water column pH - September 5th 2007

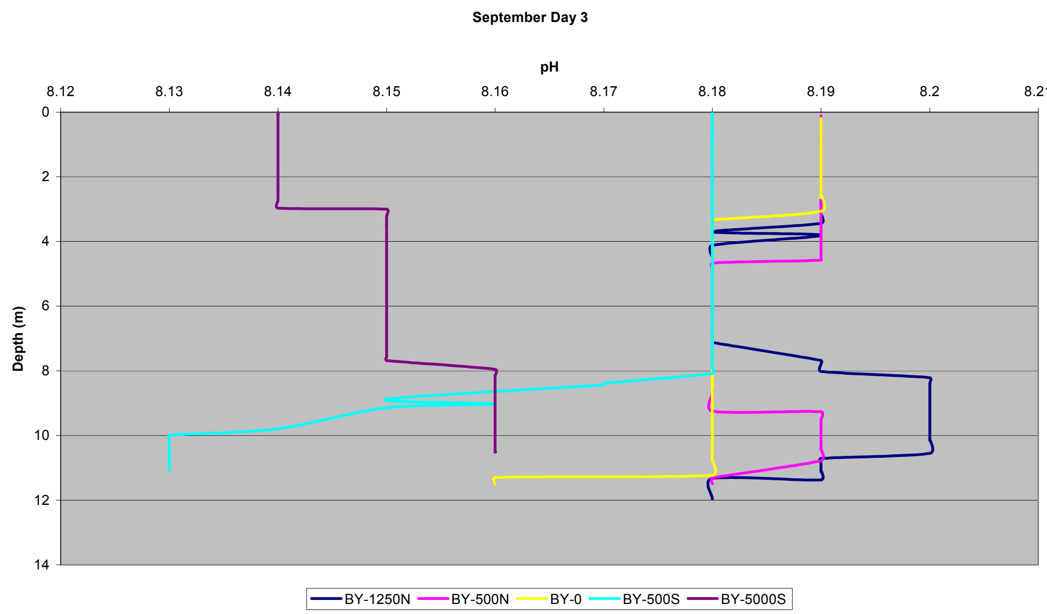

Figure A-6 Water column pH - September 6th 2007

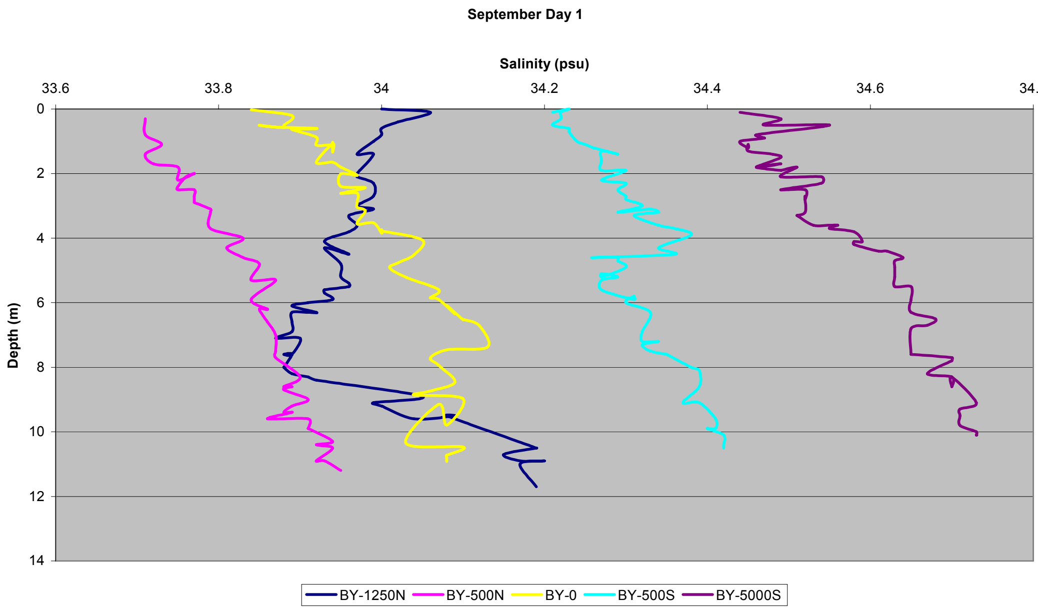

Figure A-7 Water column salinity - September 4th 2007

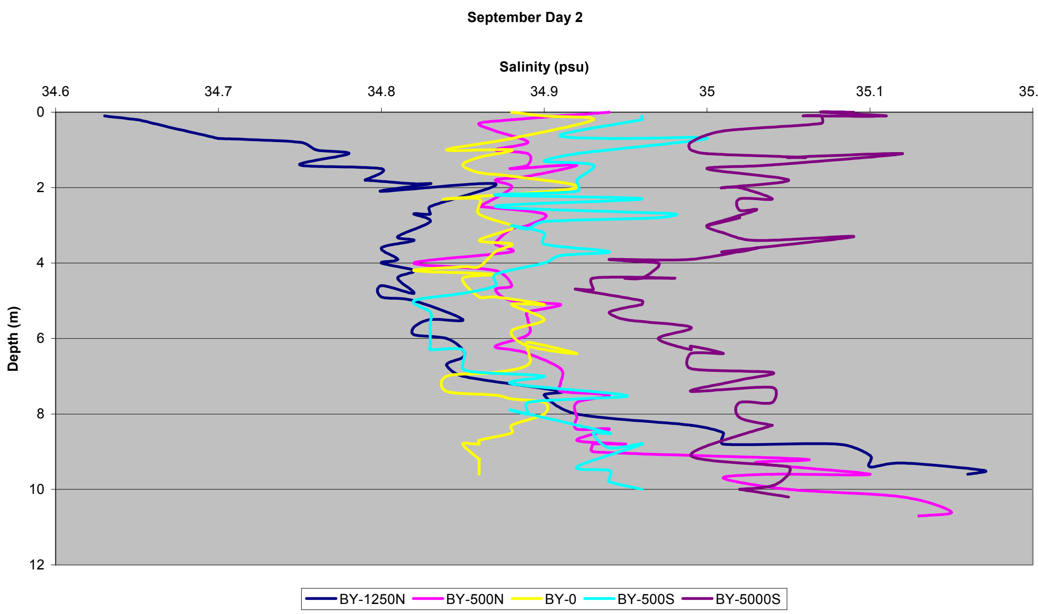

Figure A-8 Water column salinity - September 5th 2007

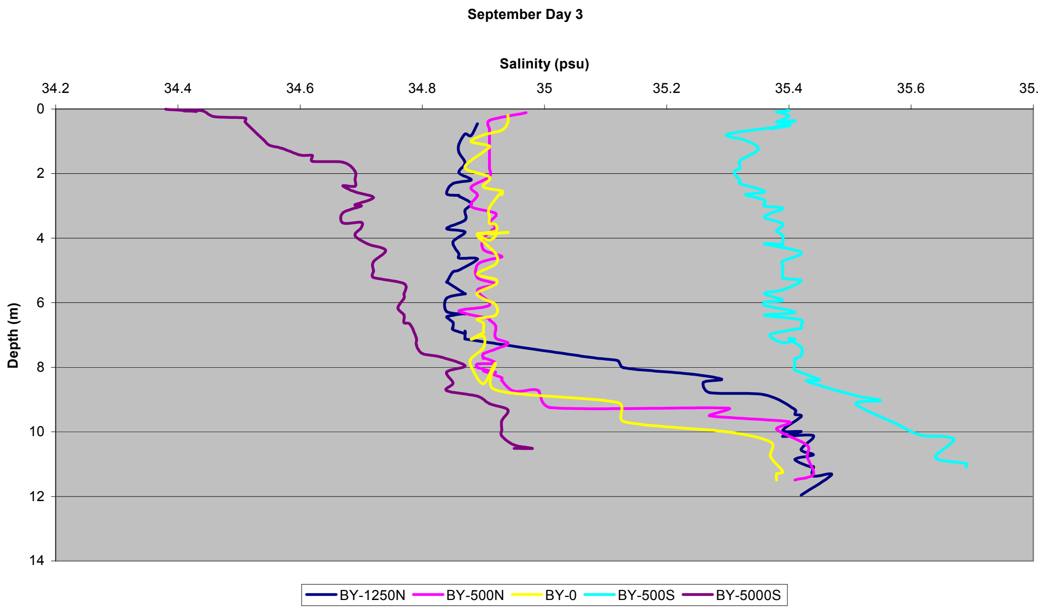

Figure A-9 Water column salinity - September 6th 2007

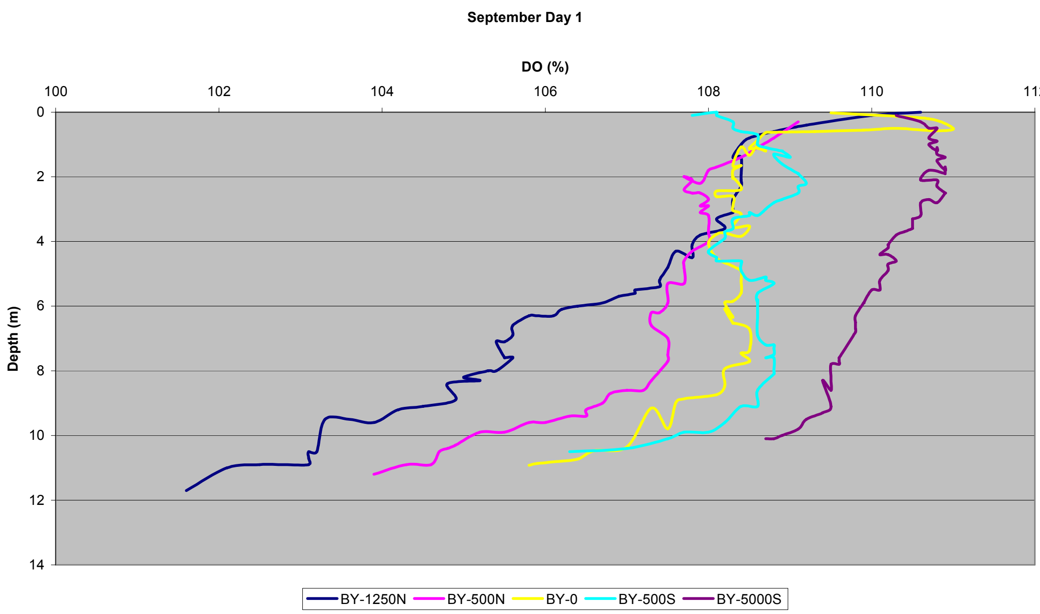

Figure A-10 Water column DO - September 4th 2007

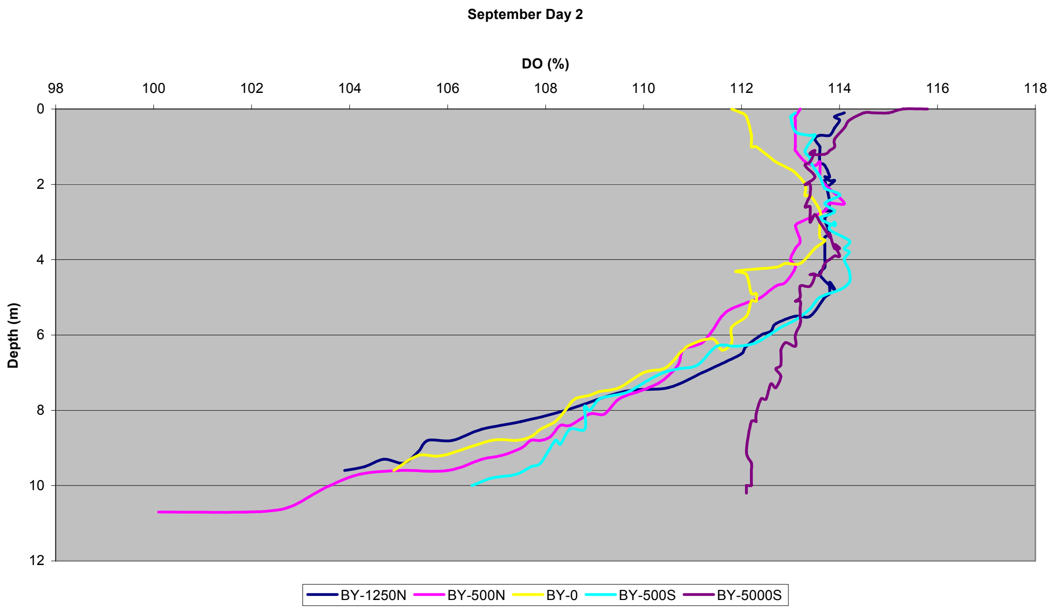

Figure A-11 Water column DO - September 5th 2007

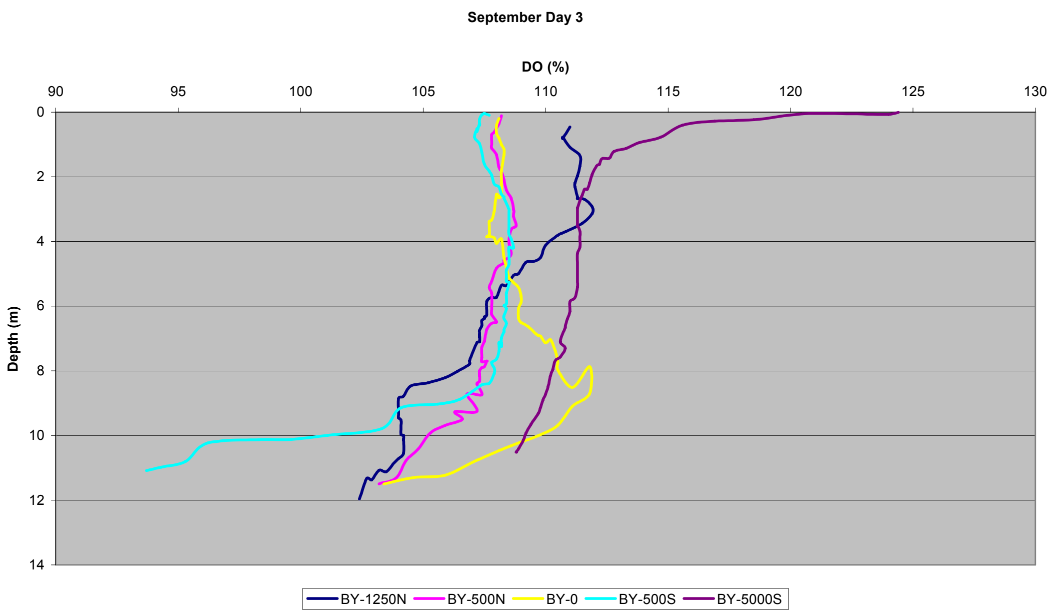

Figure A-12 Water column DO - September 6th 2007

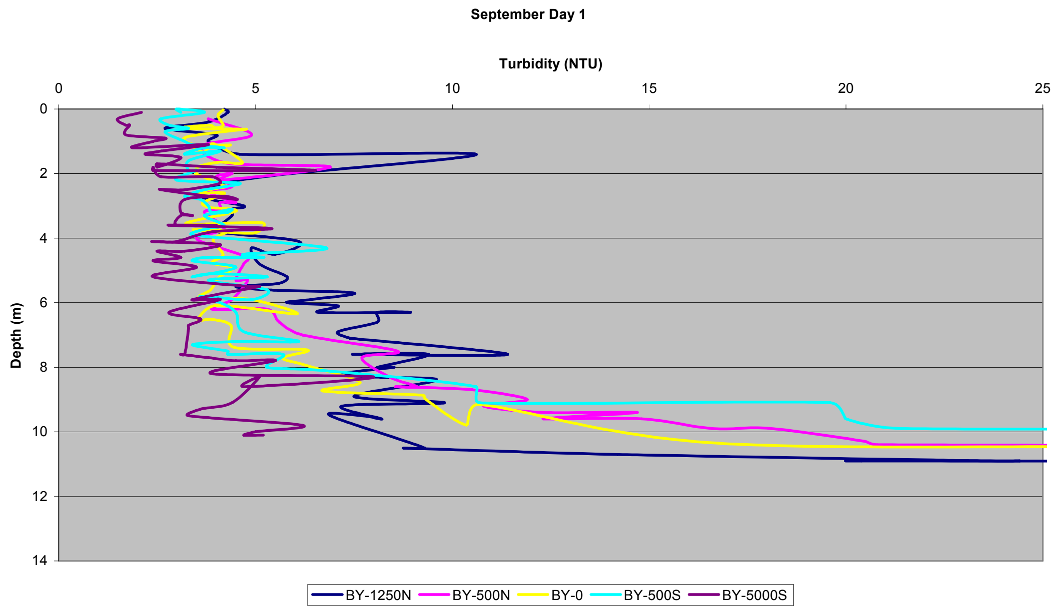

Figure A-13 Water column turbidity - September 4th 2007

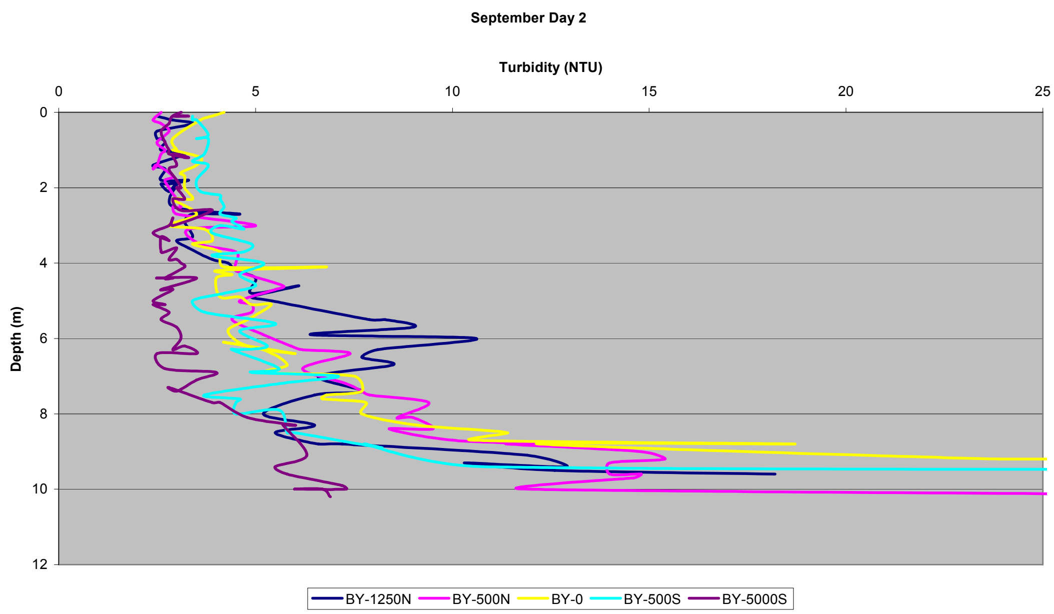

Figure A-14 Water column turbidity - September 5th 2007

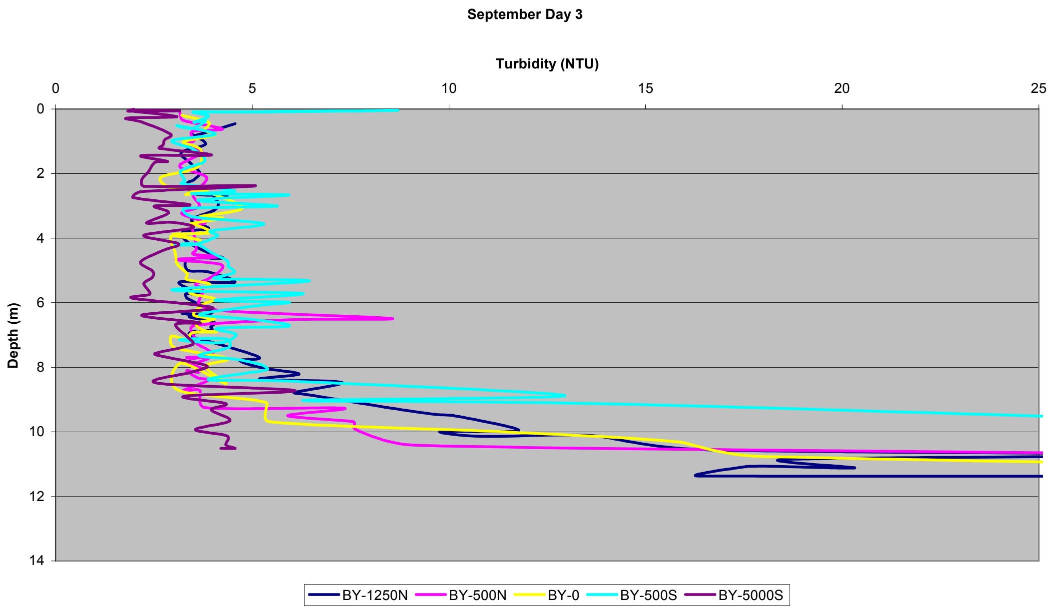

Figure A-15 Water column turbidity - September 6th 2007

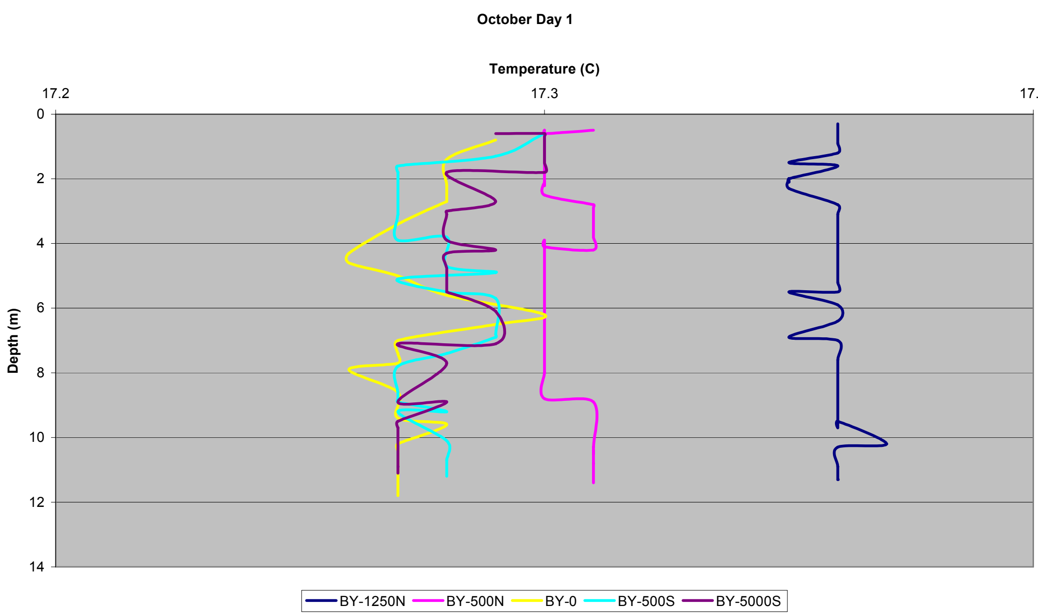

Figure A-16 Water column temperature - October 9h 2007

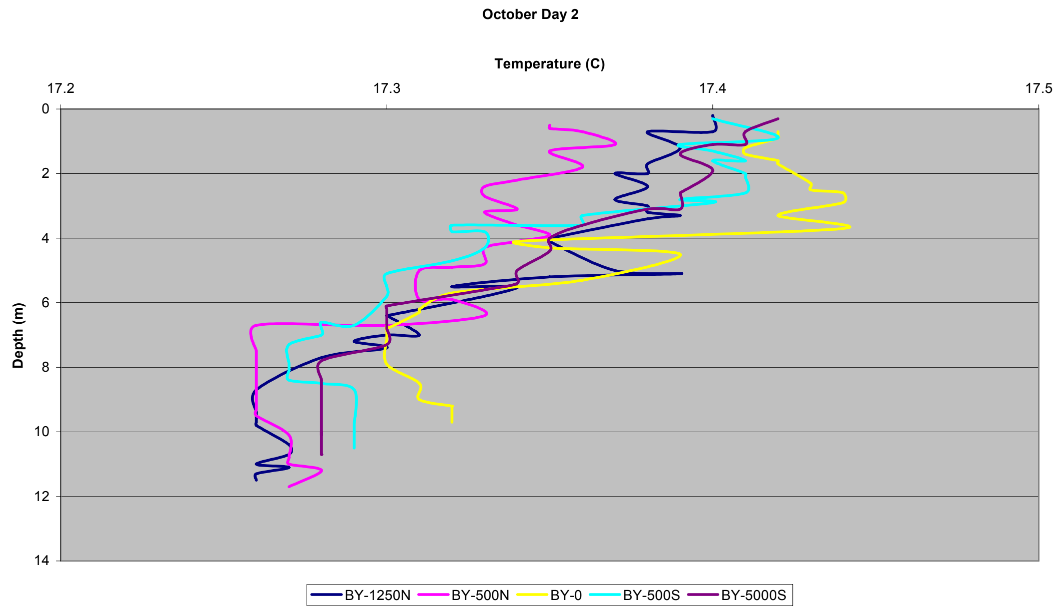

Figure A-17 Water column temperature - October 10th 2007

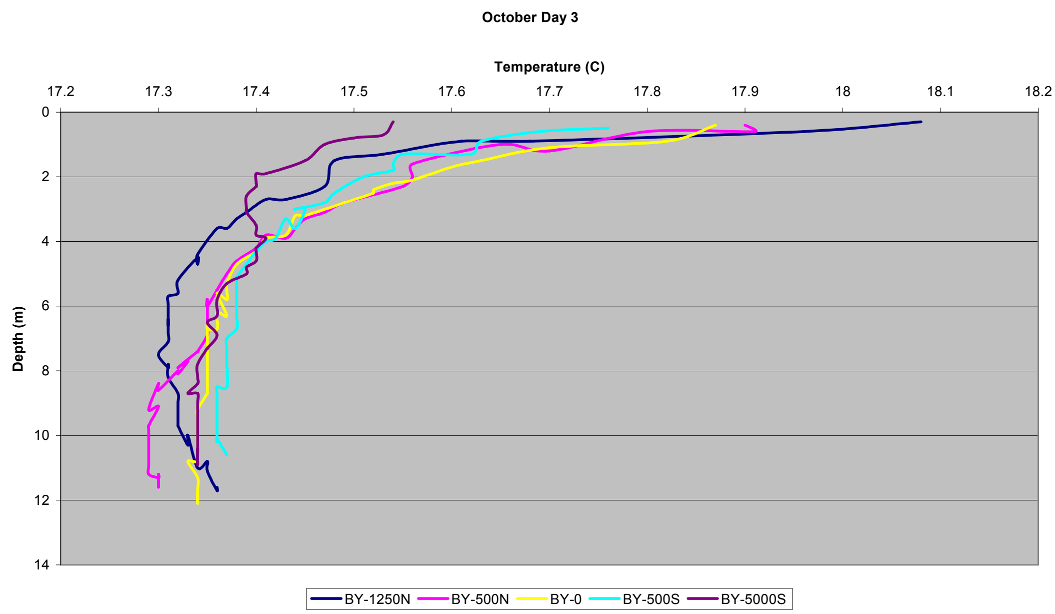

Figure A-18 Water column temperature - October 11th 2007

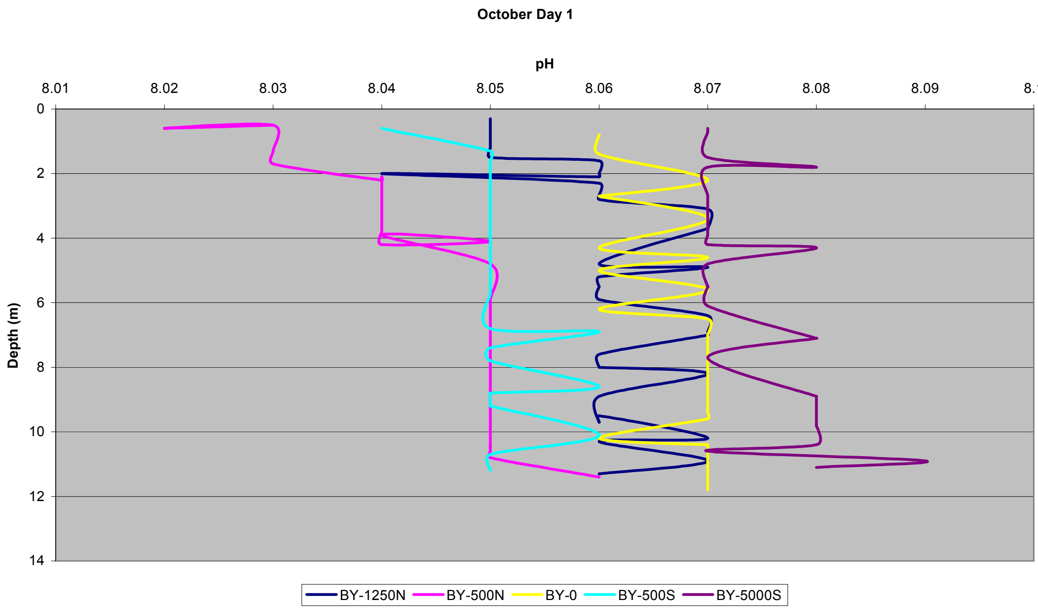

Figure A-19 Water column pH - October 9h 2007

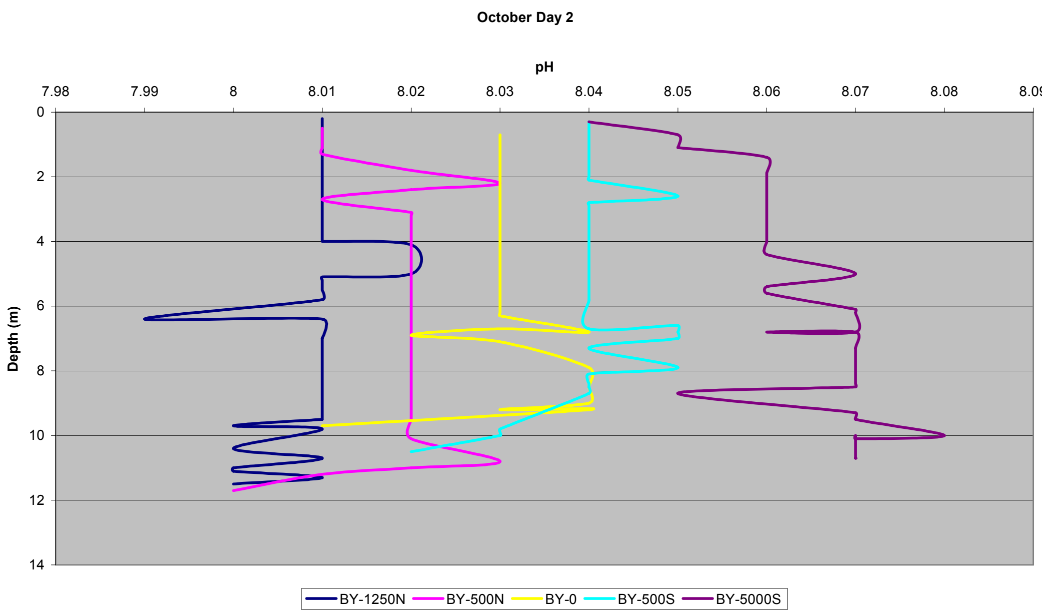

Figure A-20 Water column pH - October 10th 2007

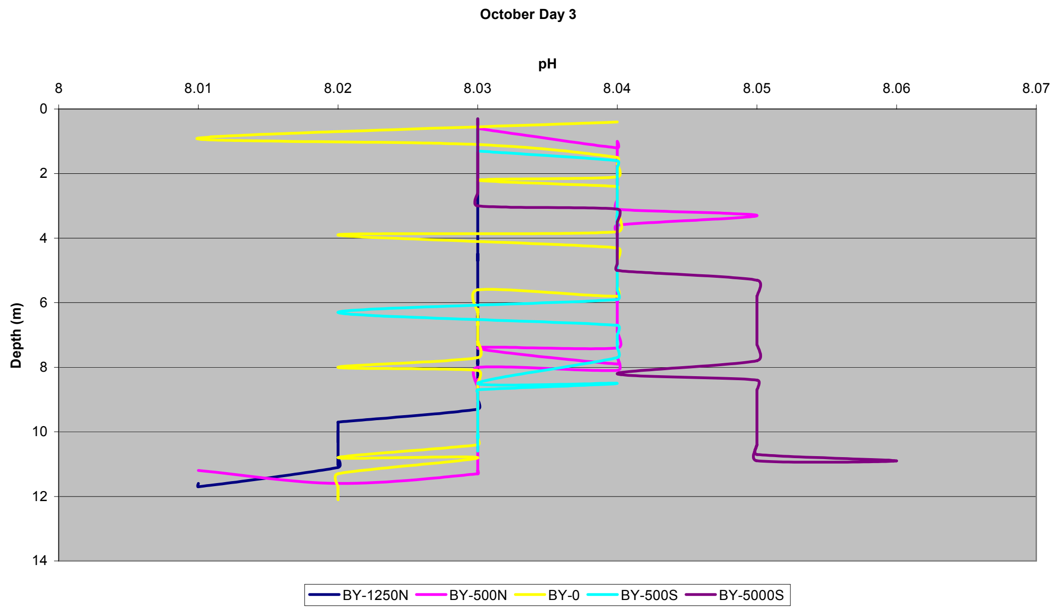

Figure A-21 Water column pH - October 11th 2007

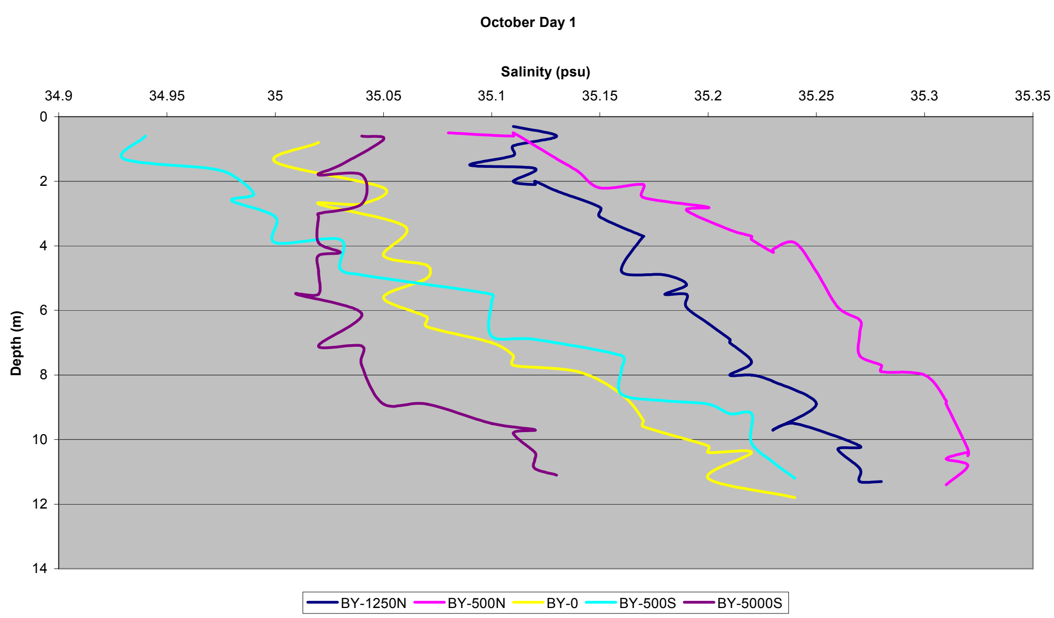

Figure A-22 Water column salinity - October 9h 2007

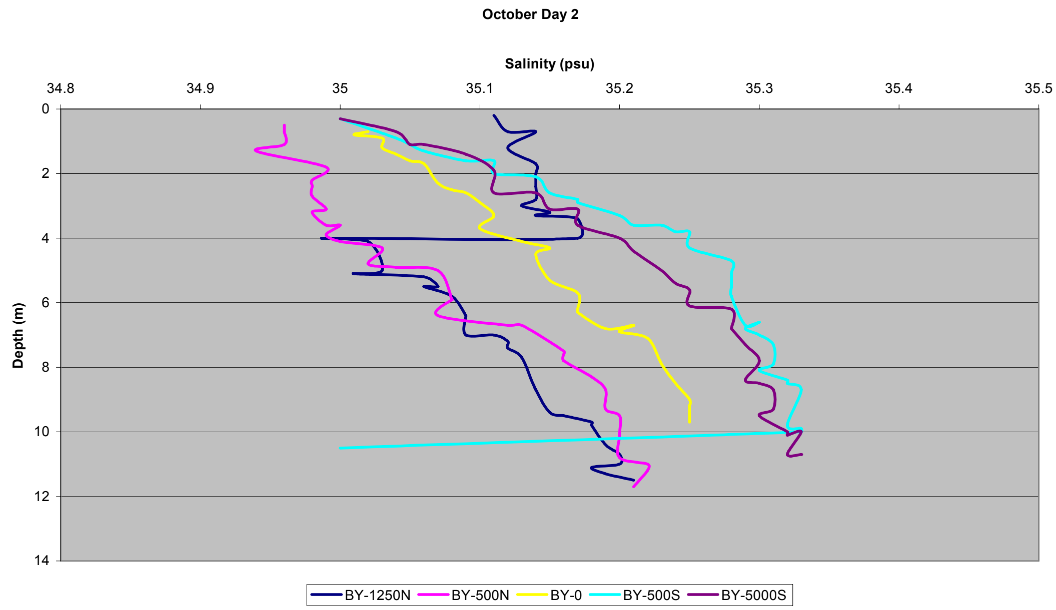

Figure A-23 Water column salinity - October 10th 2007

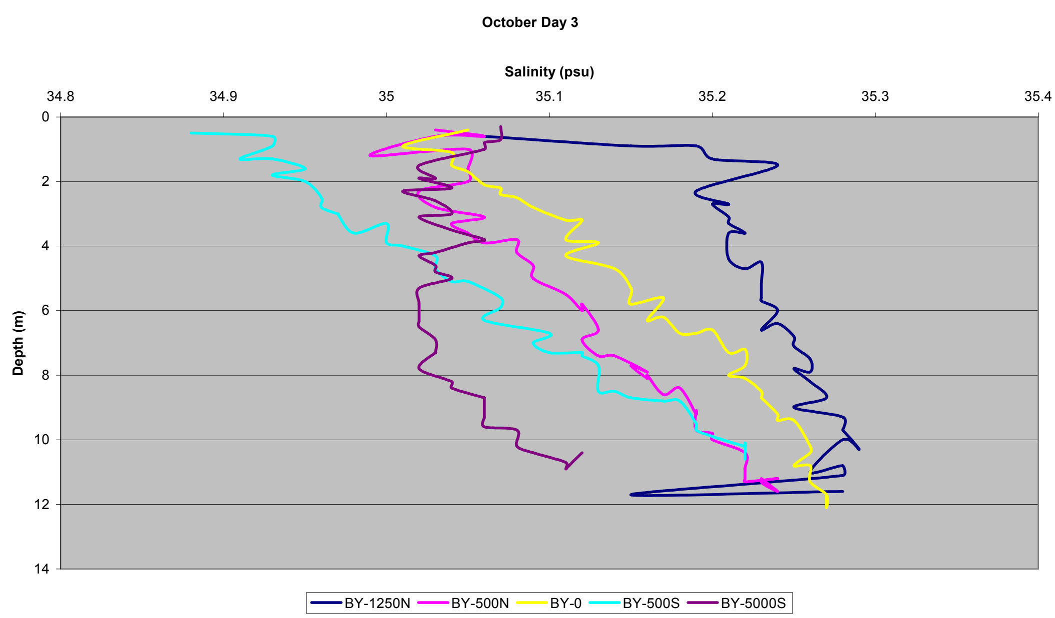

Figure A-24 Water column salinity - October 11th 2007

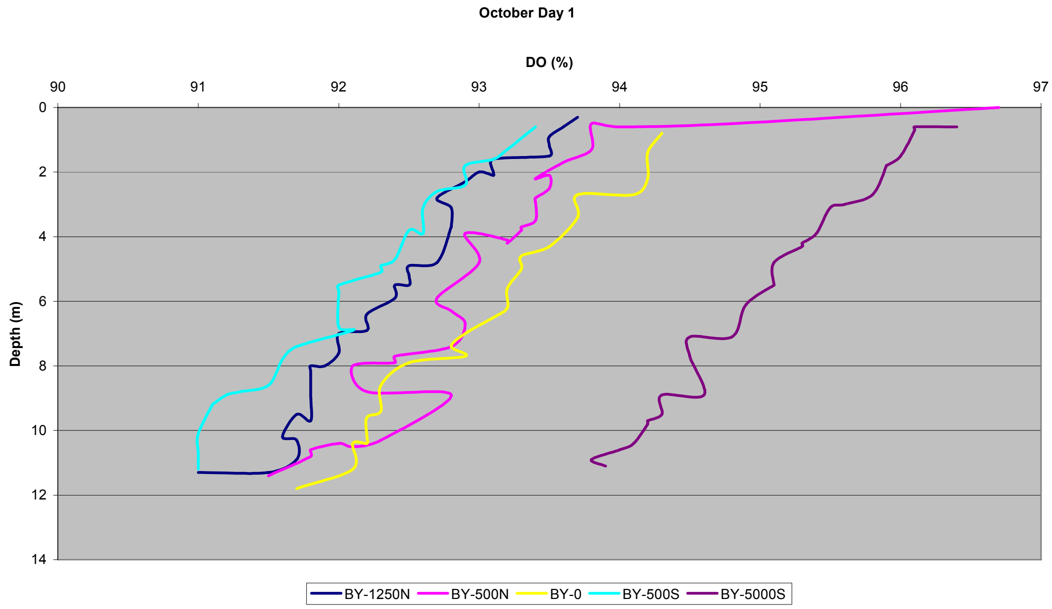

Figure A-25 Water column DO - October 9h 2007

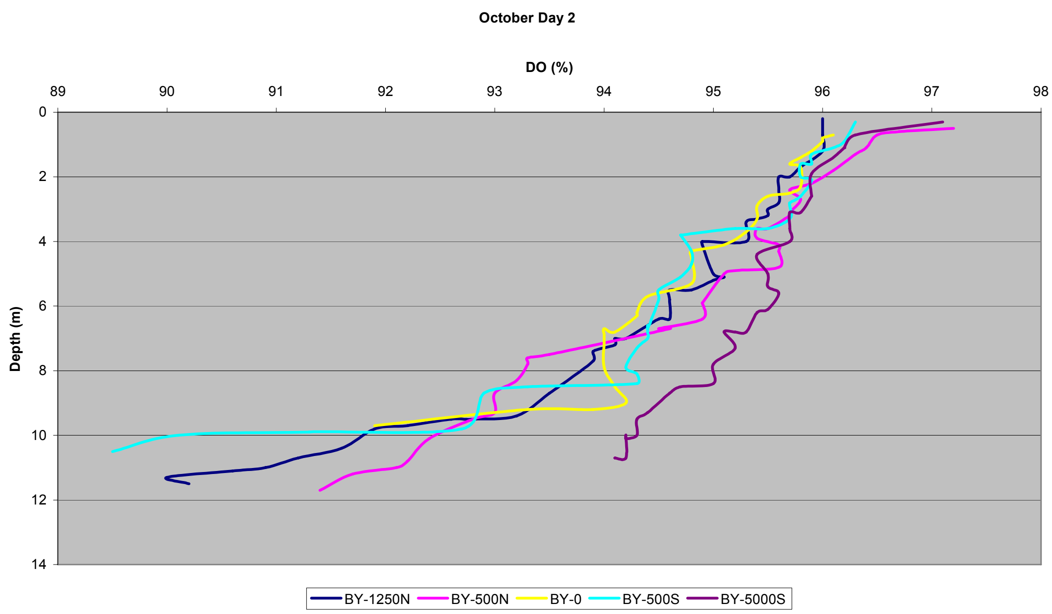

Figure A-26 Water column DO - October 10th 2007

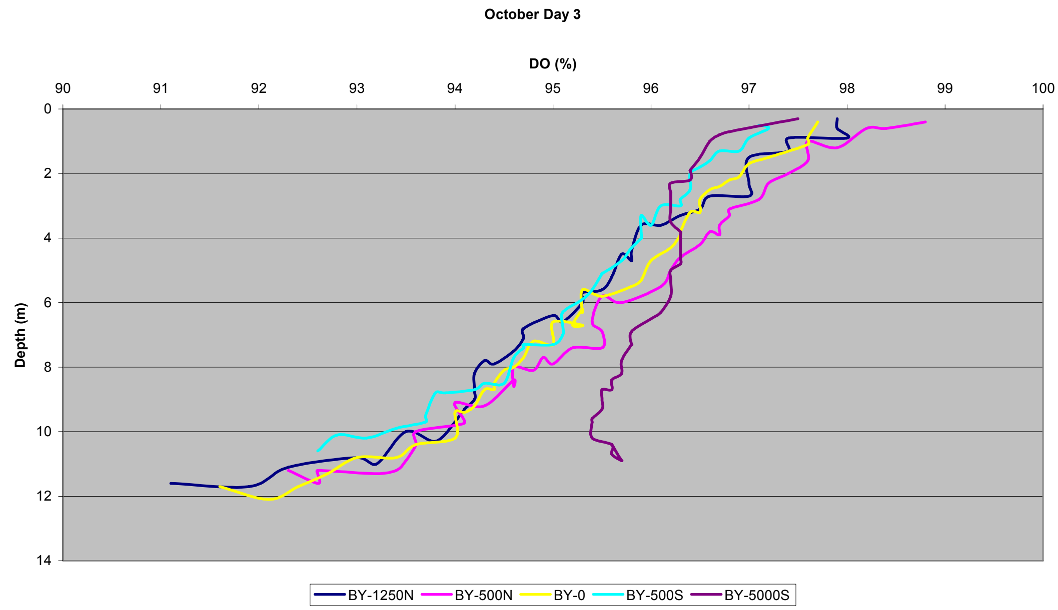

Figure A-27 Water column DO - October 11th 2007

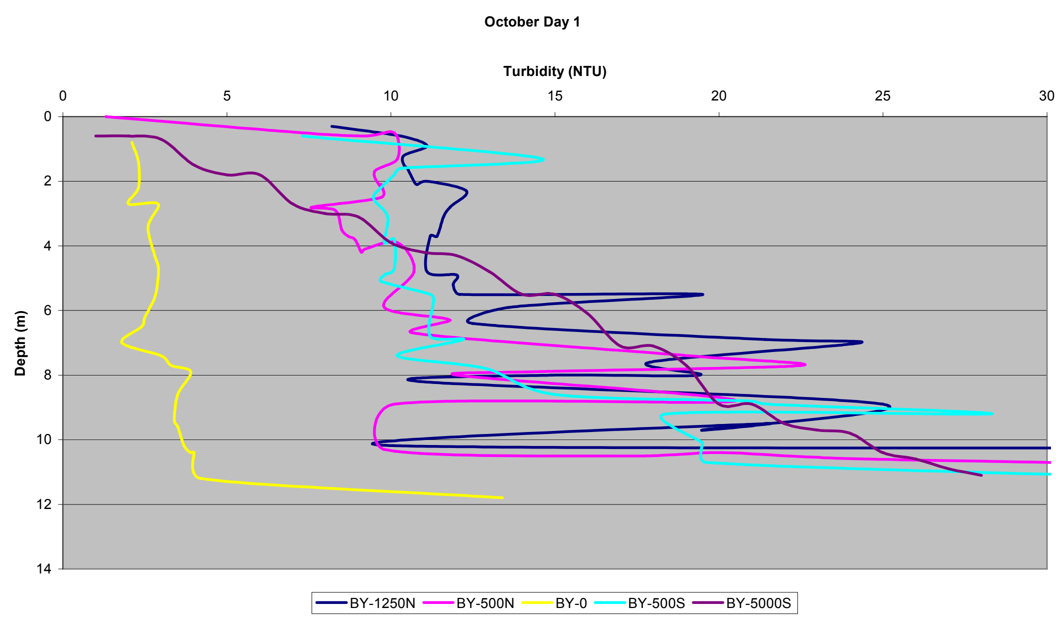

Figure A-28 Water column turbidity - October 9h 2007

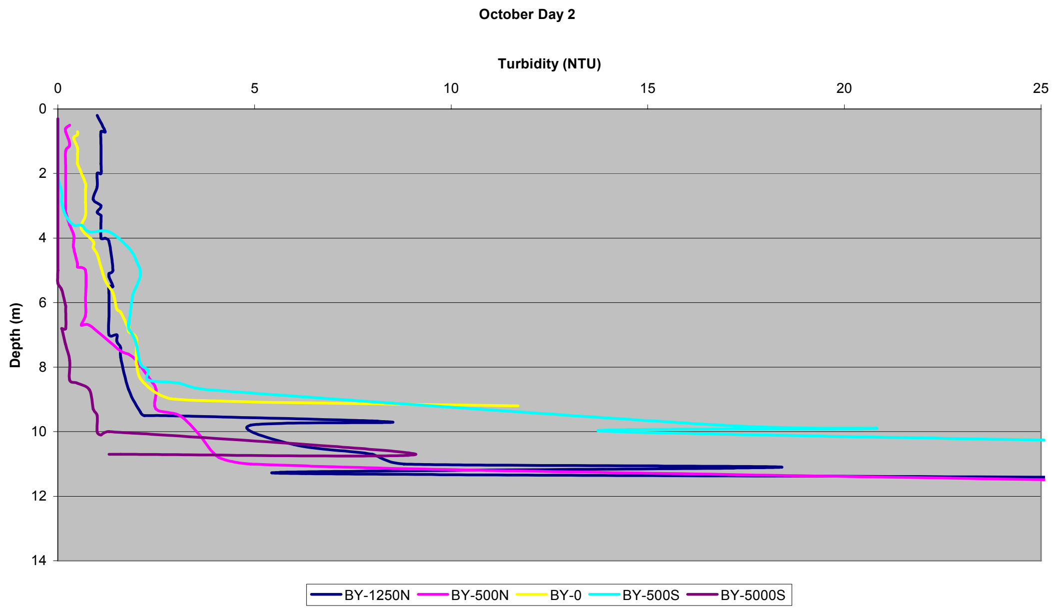

Figure A-29 Water column turbidity - October 10th 2007

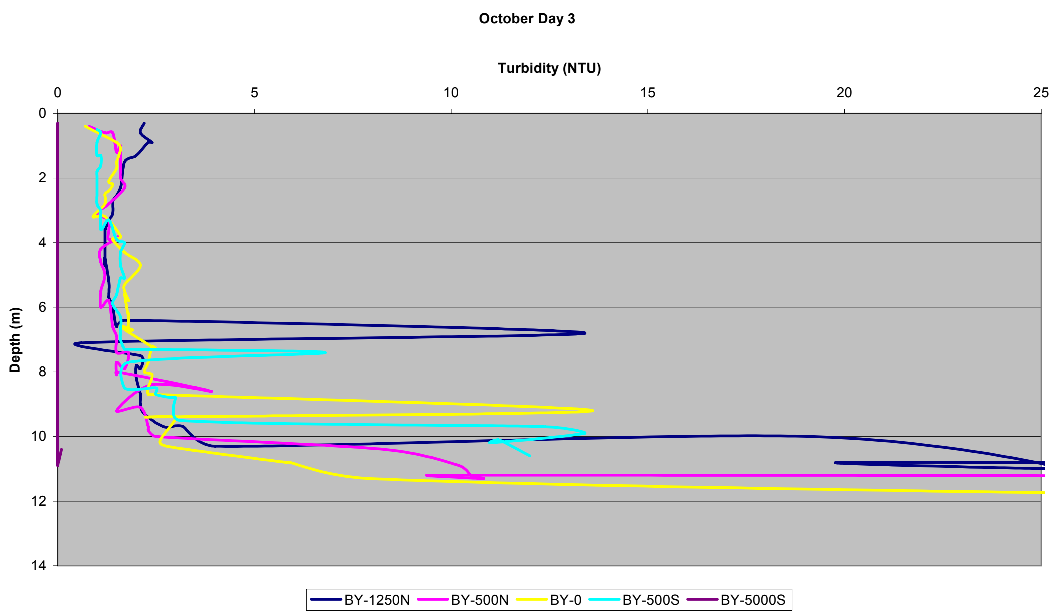

Figure A-30 Water column turbidity - October 11th 2007

Appendix B

RAW WATER QUALITY DATA

September & October 2007

		BY-1250N			BY-500N			BY-0			BY-500S			BY-5000S			BY-1250N	BY-500N	BY-0	BY-500S	BY-5000S	
Analyte	**Units**	Day 1	Day 2	Day 3	Day 1	Day 2	Day 3	Day 1	Day 2	Day 3	Day 1	Day 2	Day 3	Day 1	Day 2	Day 3						**Average (mg/L)**
General																						
Alkalinity	mg.$CaCO_3$/L	120	120	120	120	120	110	120	120	120	120	120	120	120	120	120	120	117	120	120	120	119
Barium, Ba	mg/L	0.0057	0.0053	0.0053	0.0056	0.0050	0.0051	0.0067	0.0055	0.0055	0.0052	0.0055	0.0053	0.0055	0.0053	0.0056	0.0054	0.0052	0.0059	0.0053	0.0055	0.0055
Bicarbonate, HCO3	mg/L	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140
Boron, B	mg/L	4.3	4.3	4.4	4.3	4.1	4.3	4.4	4.3	4.4	4.2	4.3	4.3	4.3	4.2	4.5	4	4	4	4	4	4
Bromide, Br	mg/L	68	70	71	68	69	70	67	69	70	69	67	68	71	70	70	70	69	69	68	70	69
Calcium, Ca	mg/L	410	410	410	400	390	400	410	400	410	390	400	400	410	400	410	410	397	407	397	407	403
Chloride, Cl	mg/L	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000
Carbonate, CO3	mg/L	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Fluoride, F	mg/L	1.1	1.1	1.0	1.1	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.1	1.0	1.0	1.1	1.1	1.0	1.0	1.0	1.0
Hardness (as CaCO3)	mg.$CaCO_3$/L	6300	6200	6300	6400	6400	6300	6700	6300	6300	6400	6400	6300	6300	6300	6400	6267	6367	6433	6367	6333	6353
Magnesium, Mg	mg/L	1300	1300	1300	1300	1300	1300	1400	1300	1300	1300	1300	1300	1300	1300	1300	1300	1300	1333	1300	1300	1307
Potassium, K	mg/L	420	400	410	410	420	420	420	420	420	420	440	410	410	400	370	410	417	420	423	393	413
Silicate	µg.Si/L	27	27	26	28	26	26	29	26	26	30	27	23	39	39	35	27	27	27	27	38	29
Silicon, Si	mg/L	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Sodium, Na	mg/L	10000	10000	10000	10000	11000	10000	11000	10000	10000	10000	11000	10000	10000	10000	10000	10000	10333	10333	10333	10000	10200
Strontium, Sr	mg/L	6.8	6.9	6.9	6.8	6.5	6.7	6.8	6.8	6.8	6.6	6.8	6.8	6.9	6.7	7.0	6.9	6.7	6.8	6.7	6.9	6.8
Sulphate, SO4	mg/L	2600	2600	2600	2600	2600	2600	2600	2600	2700	2600	2700	2600	2600	2600	2600	2600	2600	2633	2633	2600	2613
Total Dissolved Solids, TDS	g/L	36	36	35	35	35	36	35	35	36	35	35	36	36	35	36	36	35	35	35	36	35
Total Suspended Solids	mg/L	12.0	21.0	6.0	35.0	8.0	5.0	10.0	9.0	11.0	13.0	10.0	6.0	5.0	5.0	4.0	13.0	16.0	10.0	9.7	4.7	10.7
Nutrients																						
Ammonia, NH3	µg.N/L	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
NOx	µg.N/L	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Total Nitrogen, N	µg.N/L	160	220	140	240	160	130	140	140	200	160	140	140	110	110	140	173	177	160	147	120	155
Ortho-P	µg.P/L	3	4	3	3	4	4	4	2	4	4	4	4	4	4	4	3	4	3	4	4	4
Total Phosphorus, P	µg.P/L	15	26	14	24	14	12	12	12	21	15	14	13	9	8	10	18	17	15	14	9	15
Non-Purgable Total Organic Carbon	mg/L	1.6	1.1	1.1	1.8	1.2	1.2	1.5	1.1	1.2	1.5	1.6	1.3	1.1	1.2	1.1	1.3	1.4	1.3	1.5	1.1	1.3
Contaminants																						
Filterable, Al	mg/L	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Total Al	mg/L	0.20	0.22	0.09	0.31	0.11	0.09	0.07	0.15	0.26	0.14	0.12	0.08	0.07	0.01	0.04	0.17	0.17	0.16	0.11	0.04	0.13
Arsenic, As	mg/L	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Cadmium, Cd	mg/L	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Chromium, Cr	mg/L	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Copper, Cu	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.008	0.001	0.001	0.001	0.001	0.001	0.003	0.001
Filterable Iron, Fe	mg/L	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Total Fe	mg/L	0.21	0.37	0.10	0.22	0.10	0.09	0.06	0.08	0.15	0.13	0.10	0.06	0.03	0.03	0.02	0.23	0.14	0.10	0.10	0.03	0.12
Lead,Pb	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Filterable Manganese, Mn	mg/L	0.0005	0.0005	0.0004	0.0005	0.0004	0.0005	0.0005	0.0005	0.0004	0.0006	0.0006	0.0004	0.0003	0.0003	0.0003	0.0005	0.0005	0.0005	0.0005	0.0003	0.0004
Total Manganese, Mn	mg/L	0.0027	0.0039	0.0016	0.0041	0.0018	0.0015	0.0015	0.0015	0.0026	0.0030	0.0018	0.0013	0.0011	0.0009	0.0008	0.0027	0.0025	0.0019	0.0020	0.0009	0.0020
Mercury, Hg	mg/L	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Molybdenum, Mo	mg/L	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Nickel, Ni	mg/L	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
Selenium, Se	mg/L	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Vanadium, V	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Zinc, Zn	mg/L	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Biological																						
Chlorophyll 'a'	µg/L	1.6	3.3	1.3	5.6	1.4	1.2	1.4	1.1	2.2	1.7	1.7	1.3	0.9	0.8	0.8	2.1	2.7	1.6	1.6	0.8	1.8
Faecal Streptococci	cfu/mL	1	0	1	1	0	1	1	0	1	1	0	1	1	0	1	1	1	1	1	1	1
Heterotrophic Plate Count @ 21°C	cfu/mL	860	0	2	18	0	4	16	0	3	18	0	4	170	0	1	287	7	6	7	57	73
Heterotrophic Plate Count @ 37°C	cfu/mL	770	0	10	2000	0	4	9	0	6	150	0	5	420	0	4	260	668	5	52	141	225

* Not Measured

Figure B-1 Binningup water quality data - September 2007

		BY-1250N			BY-500N			BY-0			BY-500S			BY-5000S			BY-1250N	BY-500N	BY-0	BY-500S	BY-5000S	
Analyte	**Units**	Day 1	Day 2	Day 3	Day 1	Day 2	Day 3	Day 1	Day 2	Day 3	Day 1	Day 2	Day 3	Day 1	Day 2	Day 3						**Average (mg/L)**
General																						
Alkalinity	$mg.CaCO_3/L$	120	110	120	130	120	120	120	120	120	120	120	120	120	120	120	117	123	120	120	120	120
Barium, Ba	mg/L	0.0051	0.0053	0.0053	0.0050	0.0050	0.0052	0.0053	0.0054	0.0057	0.0049	0.0048	0.0053	0.0050	0.0049	0.0050	0.0052	0.0051	0.0055	0.0050	0.0050	0.0051
Bicarbonate, HCO3	mg/L	140	140	140	150	140	140	150	140	140	150	140	140	140	150	150	140	143	143	143	147	143
Boron, B	mg/L	4.9	4.9	4.8	5	4.8	4.8	4.9	5	5	4.8	5	4.8	5	5.1	4.9	5	5	5	5	5	5
Bromide, Br	mg/L	66	69	70	69	69	69	69	68	70	70	69	69	69	69	70	68	69	69	69	69	69
Calcium, Ca	mg/L	480	480	460	470	470	470	470	470	470	480	480	460	460	470	470	473	470	470	473	467	471
Chloride, Cl	mg/L	19000	20000	20000	21000	20000	20000	20000	20000	19000	21000	20000	19000	19000	20000	19000	19667	20333	19667	20000	19333	19800
Carbonate, CO3	mg/L	5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1
Fluoride, F	mg/L	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Hardness (as CaCO3)	$mg.CaCO_3/L$	7800	7300	7200	7700	7800	7600	7600	7700	7600	7500	7800	7300	7200	7700	7600	7433	7700	7633	7533	7500	7560
Magnesium, Mg	mg/L	1600	1500	1500	1600	1600	1600	1600	1600	1600	1500	1600	1500	1500	1600	1600	1533	1600	1600	1533	1567	1567
Potassium, K	mg/L	440	450	430	420	420	420	430	420	420	440	430	430	430	430	430	440	420	423	433	430	429
Silicate	µg.Si/L	18	17	23	17	19	16	22	8	19	18	12	21	18	20	38	19	17	16	17	25	19
Silicon, Si	mg/L	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Sodium, Na	mg/L	11000	11000	11000	11000	11000	11000	11000	11000	11000	11000	11000	11000	11000	11000	11000	11000	11000	11000	11000	11000	11000
Strontium, Sr	mg/L	7.6	7.6	7.6	7.8	7.6	7.8	8.0	7.8	7.8	7.7	7.7	7.6	7.8	7.9	7.7	7.6	7.7	7.9	7.7	7.8	7.7
Sulphate, SO4	mg/L	2700	2900	2800	2800	2700	2900	3000	2900	2800	3000	2800	2700	2800	2700	2700	2800	2800	2900	2833	2733	2813
Total Dissolved Solids, TDS	g/L	36	34	35	36	36	35	35	34	35	36	35	34	35	36	35	35	36	35	35	35	35
Total Suspended Solids	mg/L	13.0	8.0	8.0	15.0	7.0	6.0	5.0	14.0	5.0	15.0	54.0	6.0	5.0	5.0	3.0	9.7	9.3	8.0	25.0	4.3	11.3
Nutrients																						
Ammonia, NH3	µg.N/L	3	3	9	4	3	3	5	7	3	4	5	22	3	4	3	5	3	5	10	3	5
NOx	µg.N/L	2	2	3	2	3	2	2	3	2	2	2	6	2	2	2	2	2	2	3	2	2
Total Nitrogen, N	µg.N/L	200	190	130	270	150	280	170	360	150	170	690	100	90	60	130	173	233	227	320	93	209
Ortho-P	µg.P/L	5	2	3	3	3	2	3	5	2	3	29	6	2	2	2	3	3	3	13	2	5
Total Phosphorus, P	µg.P/L	28	17	15	25	19	19	11	51	13	23	30	15	9	9	10	20	21	25	23	9	20
Non-Purgable Total Organic Carbon	mg/L	2.3	1.6	1.7	1.9	2.3	1.7	1.7	3.5	1.6	1.9	2.4	1.5	1.5	1.6	1.3	1.9	2.0	2.3	1.9	1.5	1.9
Contaminants																						
Filterable, Al	mg/L	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Total Al	mg/L	0.30	0.06	0.12	0.23	0.22	0.28	0.05	1.30	0.08	0.20	0.22	0.16	0.07	0.06	0.04	0.16	0.24	0.48	0.19	0.06	0.23
Arsenic, As	mg/L	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Cadmium, Cd	mg/L	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Chromium, Cr	mg/L	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Copper, Cu	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Filterable Iron, Fe	mg/L	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Total Fe	mg/L	0.52	0.08	0.14	0.34	0.33	0.14	0.08	1.20	0.09	0.29	0.31	0.10	0.06	0.06	0.05	0.25	0.27	0.46	0.23	0.06	0.25
Lead,Pb	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Filterable Manganese, Mn	mg/L	0.0010	0.0006	0.0008	0.0008	0.0008	0.0008	0.0005	0.0007	0.0009	0.0008	0.0007	0.0009	0.0004	0.0005	0.0009	0.0008	0.0008	0.0007	0.0008	0.0006	0.0007
Total Manganese, Mn	mg/L	0.0058	0.0015	0.0024	0.0040	0.0039	0.0033	0.0013	0.0140	0.0029	0.0039	0.0055	0.0025	0.0010	0.0009	0.0013	0.0032	0.0037	0.0061	0.0040	0.0011	0.0036
Mercury, Hg	mg/L	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Molybdenum, Mo	mg/L	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Nickel, Ni	mg/L	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
Selenium, Se	mg/L	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Vanadium, V	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Zinc, Zn	mg/L	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Biological																						
Chlorophyll 'a'	µg/L	4.3	1.3	1.5	3.6	1.2	1.2	1.0	4.2	0.9	3.1	14.0	1.1	0.7	0.8	0.6	2.4	2.0	2.0	6.1	0.7	2.6
Faecal Streptococci	cfu/mL	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Heterotrophic Plate Count @ 21°C	cfu/mL	29	150	4	4	22	4	26	14	3	8	14	4	90	100	11	61	10	14	9	67	32
Heterotrophic Plate Count @ 37°C	cfu/mL	14	180	1	1	14	4	9	1000	3	4	360	4	7	37	1	65	6	337	123	15	109

* Not Measured

Figure B-2 Binningup water quality data - October 2007