AUSTRALIA BUNDLE SITE

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SUPPLIER DOCUMENT REVIEW

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SAP NO	PURCHASE ORDER NUMBER	SEQUENCE NUMBER		REV NO
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360 environmental

Learmonth Bundle Launch Site

Baseline Water and Sediment Quality Assessment

Prepared for:

Subsea 7

October 2017

people • planet • professional

360 Environmental Pty Ltd

Document Reference	Revision	Prepared by	Reviewed by	Admin Review	Submitted to Client	
					Copies	Date
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2003 AE	CLIENT FINAL	AW	SS	-	1 Electronic (email)	23/10/17

Executive Summary

Subsea 7 has identified two sites along the coastline of northwest Australia that are considered suitable for the launch of bundles. The primary objective of this study was to characterise the existing water and sediment quality (baseline assessment) within and adjacent to the preferred bundle launch site at Learmonth, near Exmouth.

The sediment quality assessment indicates that the levels of potential contaminants within the sediments of the survey area are below both the ISQG-low and ISQG-high guidelines and/or are representative of sediment in the region, as identified through other studies. The particle size of the sediment varies across the site with the outer sites characterised typically by less coarse fractions, resulting in higher baseline sediment metal concentrations.

The water quality assessment concluded that the site is representative of the region, with light attenuation values representative of north-west WA. Nutrient and chlorophyll levels were typically within guidelines, and at the lower limit of the ranges expected for clear coral-dominated systems, while Exmouth Gulf represents a generally turbid, microtidal system where higher values might be expected.

It can be concluded that the site is free from contamination and disturbance of the sediments during construction and operation of the bundle launch site will cause minimal impact to the surrounding marine environmental quality. The particle size information suggests that turbidity could be generated within the water column following the physical disturbance of the offshore sediments.

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1 Introduction

1.1 Background

Learmonth (Exmouth) was chosen as the preferred site for Subsea 7 (Australia) Contracting Pty Ltd (Subsea7's) proposed bundle launch site, pending the outcomes of initial baseline studies (including this study) and the results of a hydrographic survey.

The survey area covered the proposed bundle launch route, plus an approximately 400m buffer to the north and south and an approximately 1 km buffer offshore.

1.2 Purpose

This investigation was undertaken to characterise the baseline water and sediment quality within and adjacent to the site and to support the future referral to the Office of the Environmental Protection Authority (EPA) under Section 38 of the *Environmental Protection Act 1986* (EP Act).

1.2.1 Water Quality

The objective of the baseline water quality survey was to characterise the ambient marine water quality in the vicinity of the proposed bundle launch site. The monitoring data will be used to:

- describe the ambient water quality conditions prior to the construction of the bundle launch site; and
- provide a quantitative baseline dataset which will enable an assessment of changes during construction/operation of the bundle launch site.

1.2.2 Sediment Quality

Sediment sampling was conducted at the same sites as water sampling to gain an understanding of the baseline sediment characteristics.

1.3 Guidelines

The EPA's Statement of Environmental Principles, Factors and Objectives (EPA 2016) presents the principles of the *Environmental Protection Act 1986*, the environmental factors (those parts of the environment that may be impacted by an aspect of a proposal) and the objectives for each factor.

For the factor 'Marine Environmental Quality' the objective is:

"To maintain the quality of water, sediment and biota so that environmental values are protected."

The most applicable guideline for the purpose of this monitoring programme is the National Water Quality Management Strategy Paper; Australian and New Zealand Guidelines for Fresh and Marine Water Quality (Australian and New Zealand Environment and Conservation Council [ANZECC] and Agriculture and Resource Management Council of Australia and New Zealand [ARMCANZ] 2000):

- Chapter 3 – Aquatic Ecosystems
    - Tropical Australia – marine inshore (Tables 3.3.4 & 3.3.5) for in-situ parameters and nutrients in water.
    - ISQG-low and ISQG-high (Table 3.5.1) for metals in sediment.

1.4 Previous Studies

There is limited information available on water and sediment quality in Exmouth Gulf, but the following documents were utilised for review and comparison purposes:

- Review of productivity levels of Western Australian coastal and estuarine waters for mariculture planning purposes, Fisheries Research Report No. 123, (Pearce et. al 2000);
- Geochemistry and particle size of surface sediments of Exmouth Gulf, North West Shelf, Australia, Continental Shelf Research 21 (2): 157-201, (Brunskill et. al 2001);
- Background quality of the marine sediments of the Pilbara coast: Marine Technical Report Series (DEC 2006);
- Yannarie Salt Project: Marine and coastal environment of the eastern Exmouth Gulf, Volume I: Report Straits Salt Pty Ltd, 391/3 (Oceanica 2006);
- Western Australian Integrated Marine Observing System (WAIMOS) Node Science and Implementation Plan 2015-25 (IMOS 2014);
- Western Australian Marine Science Institution (WAMSI) Dredging Science Node Project 5.3 (Vanderklift et al. 2016); and
- Background quality for coastal marine waters of the North West Shelf, Western Australia: Technical Report (Wenziker et. al 2006).

2 Methodology

2.1 Water Quality

Water monitoring and sampling was undertaken at 12 sites along three transects, positioned at increasing distances offshore in a northeast direction (inshore, mid-shore, and offshore) (refer Figure 1).

In-situ (physical) monitoring was undertaken as a full depth profile with a YSI 6920 multi-parameter sonde and included:

- Turbidity;
- Temperature;
- Salinity; and
- Dissolved oxygen.

Photosynthetically active radiation (PAR) was also measured at each site using a Li-Cor arrangement of two sensors. Readings were taken at five second intervals for a period of at least four minutes and then used to calculate light attenuation coefficient for each site, using the following equation:

$$LAC = \frac{Log_{10}\{\text{irradiance at depth}\} - Log\ \{\text{irradiance at surface}\}}{\text{depth interval}}$$

Vertically integrated water samples were collected using a high flow pump by qualified and experienced field technicians wearing nitrile gloves. Water was collected in clean plastic buckets and transferred into the appropriate laboratory supplied containers. Chlorophyll samples were filtered through GF/C filter papers in a filter tower and dissolved nutrients were filtered through 0.45 μm syringe filters immediately after collection. Samples were chilled prior to and during transport to Perth for analysis, which included:

- Chlorophyll-a, b and c; and
- Nutrients (ammonium, ortho-phosphorus, nitrate+nitrite, total nitrogen, total phosphorus).

114°7'16"E
114°8'18"E
114°9'20"E
114°10'22"E

22°12'48"S
22°13'50"S
22°14'52"S

1 km
6 km

WQ 1
WQ 2
WQ 3
WQ 4
WQ 5
WQ 6
WQ 7
WQ 8
WQ 9

Legend

Indicative Project Area

Sediment and Water Quality Monitoring Sites

ID	x	y
WQ 1	114.158240	-22.215145
WQ 2	114.162162	-22.217760
WQ 3	114.166118	-22.220397
WQ 4	114.143597	-22.234171
WQ 5	114.147357	-22.237008
WQ 6	114.151168	-22.239828
WQ 7	114.128962	-22.253191
WQ 8	114.132854	-22.255852
WQ 9	114.136776	-22.258532

- LOCALITY MAP SOURCED FROM LANDGATE 2006
- DPAW MANAGED LANDS SOURCED DPAW 2016
- HERITAGE SITES SOURCED DAA 2015
- NATIONALLY IMPORTANT WETLANDS SOURCED DEE 2016
- IMAGERY SOURCED FROM LANDSAT7
(© Western Australian Land Information Authority 2014)

PREPARED FOR

subsea 7 SLIP ENABLER

- NOTE THAT POSITION ERRORS CAN BE >5M IN SOME AREAS

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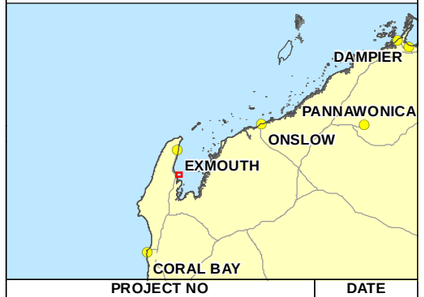
LOCALITY MAP



PROJECT NO	DATE
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HORIZONTAL DATUM AND PROJECTION
GCS WGS 1984

CREATED	CHECKED	APPROVED	REVISION
MH	SS	SS	0

Subsea 7
Bundle Site

Environmental Opportunities and Constraints

Figure 1 - Baseline Water and Sediment Quality Sites

K:\Projects\9.0 APP\2003 NW Coast Ops & Cons Baseline Studies\Figures\Bundle Site Figure X - Indicitive Survey Sites.mxd

2.2 Sediment Quality

Sediment samples were collected from the vessel using a Van Veen grab by qualified and experienced marine scientists wearing nitrile gloves[1]. Sampling equipment was rinsed thoroughly prior to commencement and between sites to reduce the potential for cross-contamination. Sediment was transferred into a clean plastic tray to allow sediment description and collection of field log photographs. The top 5 cm of sediment was sub-sampled into a glass bowl and homogenised before being separated into laboratory supplied containers. Samples were chilled in an esky ready for transportation to Perth and analysed for a suite of parameters, including:

- Nutrients (total Kjeldahl nitrogen, total phosphorus);
- Total organic carbon;
- Particle size distribution; and
- Metals (iron, copper, arsenic, chromium, lead, zinc, aluminium).[2]

[1] If the grab was more than half full, the sediment was sampled, if not, the grab was repeated.
[2] The selected metals were considered to be the most likely to be present and/or known to be naturally occurring at elevated levels.

3 Results and Discussion

3.1 Water Quality

3.1.1 Physical

Physical profiles were undertaken at all nine water quality sites and the median results are included in Table 1. The physical data recorded, including temperature, salinity and dissolved oxygen is typical of coastal waters in north-western Australia. The turbidity values are in the low range for waters in tropical north-west Australia. There was no significant vertical variation through the water column for any parameter, with the exception of higher turbidity readings typically recorded near the seabed. Graphs of the physical profiles are included as Appendix A.

Table 1: Physical Parameters (median values)

Site	Depth (m)*	Temperature (°C)	Specific Conductivity (mS/cm)	Salinity (psu)	Turbidity (NTU)	Dissolved Oxygen (% saturation)
WQ1	11.8	25.2	52.5	34.5	2.4	96.9
WQ2	11.7	25.2	52.4	34.5	2.3	98.4
WQ3	11.7	25.3	52.2	34.3	2.2	96.2
WQ4	10.8	25.3	52.2	34.4	1.1	97.4
WQ5	11.1	25.3	52.2	34.3	1.2	97.7
WQ6	11.0	25.4	52.2	34.3	1.5	97.8
WQ7	8.0	25.7	52.2	34.3	1.5	100.0
WQ8	8.9	25.8	52.4	34.5	1.5	100.4
WQ9	9.1	25.8	52.6	34.6	1.3	101.6

*depth values are total depth of the site, not median.

Light attenuation was measured at each site as a direct measure of the decrease in available PAR due to particulates within the water column. Light attenuation coefficient (LAC) values are calculated using the PAR measurements and logarithmic equation. The typical LAC values expected in waters off north-west WA range from 0.17 m^{-1} for inshore waters, to 0.07 m^{-1} for offshore waters (ANZECC & ARMCANZ 2000). The inshore value of 0.17 would be most applicable to the site, and it is apparent that the light attenuation at all sites is below (i.e. the water is clearer) than typical inshore waters of the region. Further, a study undertaken by Vanderkilft *et. al* (2016) at three locations; South Muiron Island, Bundegi and Exmouth Gulf found that light intensity measured at the seabed was the lowest within the Exmouth Gulf. The highest intensities were recorded during summer (the same time as this study).

The increased LAC values for sites WQ1-3 reflect the higher turbidity readings observed at these sites and suggest that these outer sites are naturally more turbid than the sites closer to shore. This may be attributed to the sediment at the offshore sites being characterised by a greater proportion of fine sediments (mud and fine sand) than the inshore sediments (refer Section 3.2.1).

Time-averaged light attenuation values for each site are detailed in Table 2.

Table 2: Light Attenuation Coefficient (LAC)

SITE	LAC (m^{-1})
WQ1	0.165
WQ2	0.156
WQ3	0.152
WQ4	0.139
WQ5	0.116
WQ6	0.121
WQ7	0.126
WQ8	0.131
WQ9	0.118

3.1.2 Nutrients

Total and dissolved nutrients were analysed to determine the baseline levels at the site.

All nutrients were recorded below the tropical waters guideline (ANZECC & ARMCANZ 2000) with the exception of total nitrogen at WQ8. The bioavailable fractions of nitrogen (ammonia and oxides of nitrogen) and phosphorus (ortho-phosphate) were recorded at or below detection limits, indicating that the nutrients are not readily available for primary producer uptake, or that all available fractions have already been utilised by primary producers.

Limited data for nutrient concentrations in the Exmouth Gulf are available, but nearshore data from the eastern side of the Exmouth Gulf (Oceanica 2005) indicates that dissolved nutrient levels were generally higher than the levels recorded during this investigation on the western side of the Gulf.

The full water quality results are detailed in Appendix B.

3.1.3 Chlorophyll

Chlorophyll is a vital pigment for photosynthesis, which allows plants to absorb energy from light. Trichromatic chlorophyll (a, b, c) content was analysed to determine the abundance/biomass of phytoplankton at the site.

Chlorophyll a is the most prevalent type of chlorophyll found in plants, algae and other aquatic organisms. The chlorophyll a levels recorded were all below the lower tropical limit (ANZECC & ARMCANZ 2000), which is more representative of clear coral dominated waters than the turbid waters of Exmouth Gulf, and well below the higher tropical limit for inshore waters.

Chlorophyll b, which is considered to be an indicator of the more harmful algae species, was not detected (i.e. below the laboratory limit of reporting) at any site. Chlorophyll c levels were consistent across the sites and low when compared to chlorophyll a levels (there are no applicable guidelines).

A data review undertaken by the Fisheries Research Division (Pearce et. al 2000) indicated that at the time of publication (2000) the only available information was from a single survey of the gulf in the spring of 1994 (McKinnon and Ayukai 1996). The chlorophyll a concentrations were low (0.15-0.35 μg/L), with the two highest values being from stations near the eastern shore of the gulf. The chlorophyll levels recorded during this site investigation were notably higher (0.6 to 0.8 μg/L) than these records, but considering the age of this available data and the seasonal difference in survey times, it may not be considered an appropriate comparison. Further studies were undertaken for Straits Salt (Oceanica 2005) during which nearshore values recorded in December 2004 were comparable to those recorded during this study.

The full water quality results are detailed in Appendix B.

3.1.4 QAQC

Water quality QAQC results were within the acceptable criteria (80-120%). All results were the same for primary and duplicate samples, with the exception of total phosphorous, which was within 10%. The trip and field blanks were all below detection limits.

3.2 Sediment Quality

3.2.1 Physical

Visual observations were undertaken during sediment sampling and particle size analysis was undertaken using the Wentworth Scale and the results are presented in Table 3.

The sites further offshore (SQ1-3) exhibited a greater proportion of fines when compared to the inshore sites (SQ7-9).

Table 3: Sediment Particle Size Distribution

Site	Visual assessment	Total Clay % (μM)	Total Silt % (4-63 μM)	Total Sand % (63-2000μM)	Total Gravels % (>2000μM)
SQ1	Mud with some rock, shell and sand present	9.11	30.5	**59.76**	0.66
SQ2	Mud with some shell and sand present	6.50	23.9	**68.72**	0.80
SQ3	Mud with some rock, shell and sand present	7.23	25.11	**66.96**	0.7
SQ4	Sandy mud with some rock, coral and shell present	3.54	11.41	**76.96**	8.08
SQ5	Sandy mud with some rock, shell and plant material present	5.64	17.36	**70.63**	6.38
SQ6	Mud with some rock, shell and sand present	7.84	23.68	**65.46**	3.03
SQ7	Mud with some rock, shell and sand present	2.67	13.6	**82.90**	0.79
SQ8	Muddy sand with some rock and shell present	1.88	10.78	**82.94**	4.39
SQ9	Muddy sand with some rock and shell present	2.85	9.27	**72.92**	14.96

Note: dominant fraction in bold.

3.2.2 Nutrients

Total Kjeldahl nitrogen (TKN) and total phosphorus (TP) were analysed to understand the nutrient load of the sediment. There are no applicable sediment guidelines for nutrients, but previous studies undertaken in the nearshore zone in the eastern Gulf region (Oceanica 2005, Brunskill et al. 2001) indicate that median values for TKN and TP were similar to the Learmonth site (refer Table 4).

Table 4: Median Nutrient Concentrations

Study	Nitrogen (mg/kg)	Phosphorous (mg/kg)
Learmonth (this study)	400	380
Exmouth Gulf (Brunskill 2001)	378	347
Straits Salt (Oceanica 2005)	400	340

It is considered that the nutrient content of the sediment within the site is consistent with other areas in the region and is not likely to cause significant elevated nutrient load to the water column in the event of disturbance.

The full sediment results are detailed in Appendix C and photographs are provided in Appendix D.

3.2.3 Organic Content

Organic content is important in determining the ability of sediments to retain contaminants as many chemicals are known to have a strong affinity to organic matter (ANZECC & ARMCANZ, 2000). Typical average organic carbon content for marine surface sediments is 0.5% (Seiter et. al 2004) and all samples collected during this study were below this value, with the exception of SQ6 (0.7%).

The full sediment results are detailed in Appendix C.

3.2.4 Metals

Aluminium (Al) and iron (Fe) were abundant, as expected, within all samples. All other metals with associated guidelines (chromium [Cr], copper [Cu], lead [Pb] and zinc [Zn]) were well below the lower limit trigger values (ISQG-low) (ANZECC & ARMCANZ 2000).

All metal concentrations at the site were consistent with other studies completed in Exmouth Gulf (EPA 2006, Brunskill 2001), including the relatively high levels of Al and Fe, which are known to be naturally abundant in the marine environment (Elder 1988).

Metals tend to have a high affinity for the very fine particulate fraction of sediments, which are mainly comprised of clay and silt particles (represented by the <63 µm fraction), and the organics fraction. Metals concentrations at the offshore sites (SQ 1-3) were typically recorded at greater concentrations than those recorded inshore (SQ 7-9), which is likely to be the result of the differing particle size distribution at these locations (refer Section 3.2.1).

The full sediment results are detailed in Appendix C.

3.2.5 QAQC

Sediment quality QAQC results were within the acceptable criteria (80-120%). All results were the same for primary and duplicate samples, with the exception of total phosphorous, which was within 10%.

The trip and field blanks were below detection limits for the majority of analytes, with the exception of Fe and Cu. Fe levels at all investigation sites were comparably than the blanks and it is therefore unlikely that the traces recorded in the blanks had any significant impact on the overall results. Cu levels may have been slightly elevated by the concentrations reported in the blank samples, however as all sites were well below the low trigger values, it is not considered to be a notable impact.

4 Summary

A baseline water and sediment quality monitoring programme was undertaken from 6-9 December 2016 to gain an understanding of the existing conditions at the site.

The sediment quality assessment indicated that there is no sign of contamination and therefore disturbance of sediments during construction and/or operations are unlikely to release contaminants into the water column.

The water quality was typically within guidelines and at the lower end of expected ranges in the region.

It can be concluded that there is a low risk of impact to marine environmental quality following the potential disturbance of sediments during site operations. It is considered likely that the quality of water, sediment and biota would be maintained following minor short-term disturbance of sediments, such that the local and regional environmental values, both ecological and social, would be protected.

5 Limitations

This report is produced strictly in accordance with the scope of services set out in the contract or otherwise agreed in accordance with the contract. 360 Environmental makes no representations or warranties in relation to the nature and quality of soil and water other than the visual observation and analytical data in this report.

In the preparation of this report, 360 Environmental has relied upon documents, information, data and analyses ("client's information") provided by the client and other individuals and entities. In most cases where client's information has been relied upon, such reliance has been indicated in this report. Unless expressly set out in this report, 360 Environmental has not verified that the client's information is accurate, exhaustive or current and the validity and accuracy of any aspect of the report including, or based upon, any part of the client's information is contingent upon the accuracy, exhaustiveness and currency of the client's information. 360 Environmental shall not be liable to the client or any other person in connection with any invalid or inaccurate aspect of this report where that invalidity or inaccuracy arose because the client's information was not accurate, exhaustive and current or arose because of any information or condition that was concealed, withheld, misrepresented, or otherwise not fully disclosed or available to 360 Environmental.

Aspects of this report, including the opinions, conclusions and recommendations it contains, are based on the results of the investigation, sampling and testing set out in the contract and otherwise in accordance with normal practices and standards. The investigation, sampling and testing are designed to produce results that represent a reasonable interpretation of the general conditions of the site that is the subject of this report. However, due to the characteristics of the site, including natural variations in site conditions, the results of the investigation, sampling and testing may not accurately represent the actual state of the whole site at all points.

It is important to recognise that site conditions, including the extent and concentration of contaminants, can change with time. This is particularly relevant if this report, including the data, opinions, conclusions and recommendations it contains, are to be used a considerable time after it was prepared. In these circumstances, further investigation of the site may be necessary.

6 References

Australian and New Zealand Environment and Conservation Council [ANZECC] and Agriculture and Resource Management Council of Australia and New Zealand [ARMCANZ] 2000, National Water Quality Management Strategy Paper; Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Chapter 3 – Aquatic Ecosystems

Brunskill GJ, Orpin AR, Zagorskis I, Woolfe KJ and Ellison J 2001, Geochemistry and particle size of surface sediments of Exmouth Gulf, Northwest Shelf, Australia. Continental Shelf Research 21, 157-201.

Department of Environment and Conservation (DEC, now DPaW) 2006, Background quality of the marine sediments of the Pilbara coast. DEC, Marine Technical Report Series, No. MTR 1.

Department of Conservation and Land Management 1994, A representative marine reserve system for Western Australia. Report of the Marine Parks and Reserves Selection Working Group. June 1994.

Department of Environment 2006, Pilbara Coastal Water Quality Consultation Outcomes: Environmental Values and Environmental Quality Objectives.

Department of Fisheries 2015, Status report of the fisheries and aquatic resources of Western Australia 2014/15.

Elder JF 1988, Metal Biogeochemistry in Surface-Water Systems - A Review of Principles and Concepts. U.S. Geological Survey Circular 1013.

EPA 2016, Statement of Environmental principles, factors and objectives.

EPA 2015, Protecting the Quality of Western Australia's Marine Environment. Environmental Assessment Guideline 15.

EPA 1975, Conservation Reserves for Western Australia. System 9 Report. Environmental Protection Authority, Western Australia.

McKinnon AD and Ayukai T 1996, *Copepod egg production and food resources in Exmouth Gulf, Western Australia*. Marine and Freshwater Research 47: 595-603.

Oceanica 2005, Yannarie Salt Project Marine and coastal environment of eastern Exmouth Gulf Prepared for Straits Salt Pty Ltd by Oceanica Consulting Pty Ltd, October 2005, Report No. 391/3

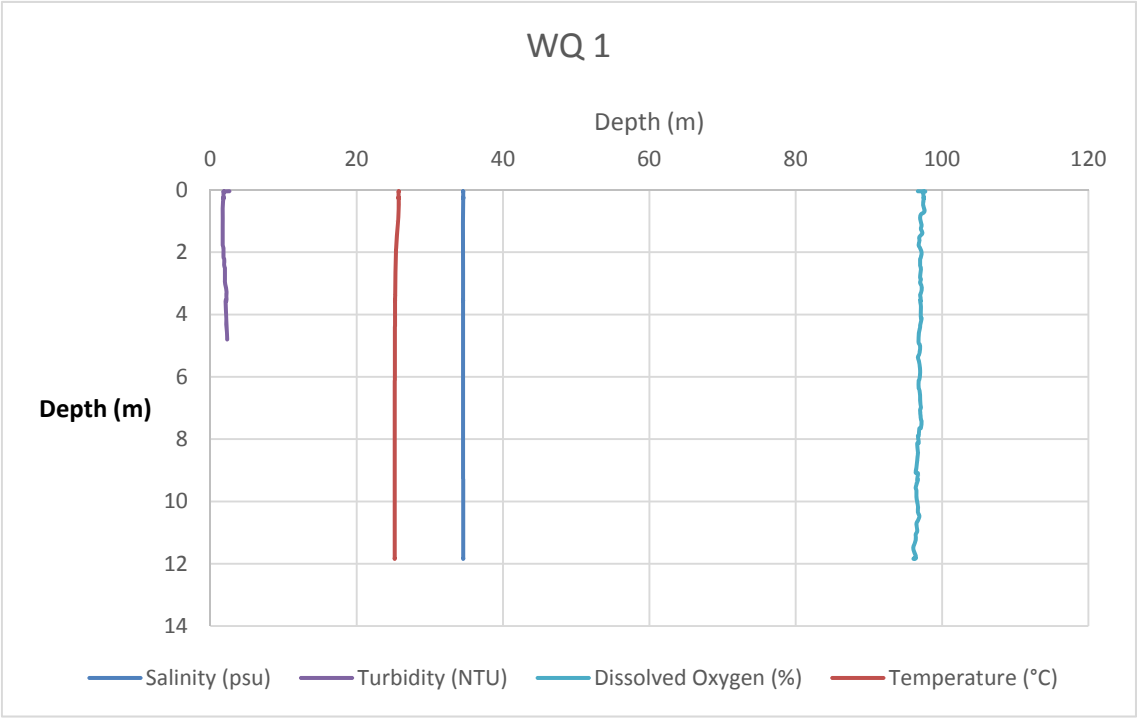
Pearce A, Helleren S, and Marinelli M 2000, Review of productivity levels of Western Australian coastal and estuarine waters for mariculture planning purposes, Fisheries Research Report No. 123, 2000.

Seiter, Katherina; Hensen, Christian; Schröter, Jürgen; Zabel, Matthias 2004, "Organic carbon content in surface sediments—defining regional provinces". Deep-Sea Research Part I: Oceanographic Research Papers. 51 (12): 2001–2026.

Western Australian Planning Commission (WAPC) 2004, Ningaloo Coast Regional Strategy Carnarvon to Exmouth.

APPENDIX A

Water Quality Profiles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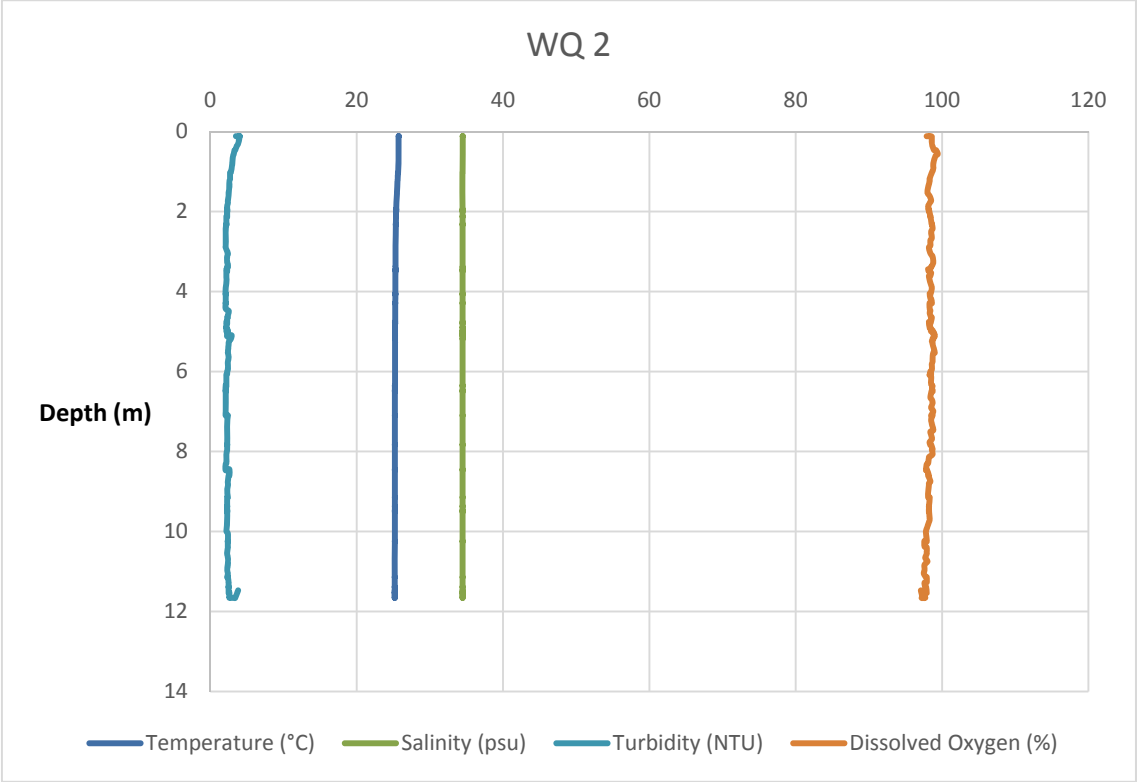
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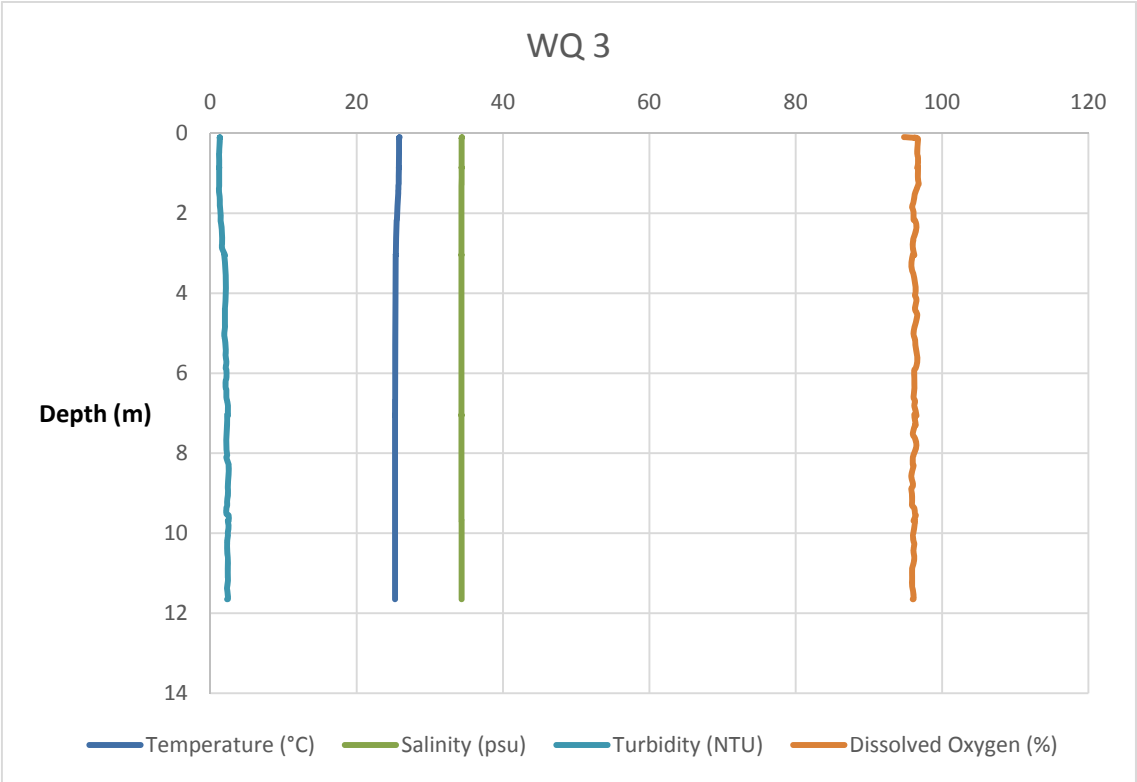
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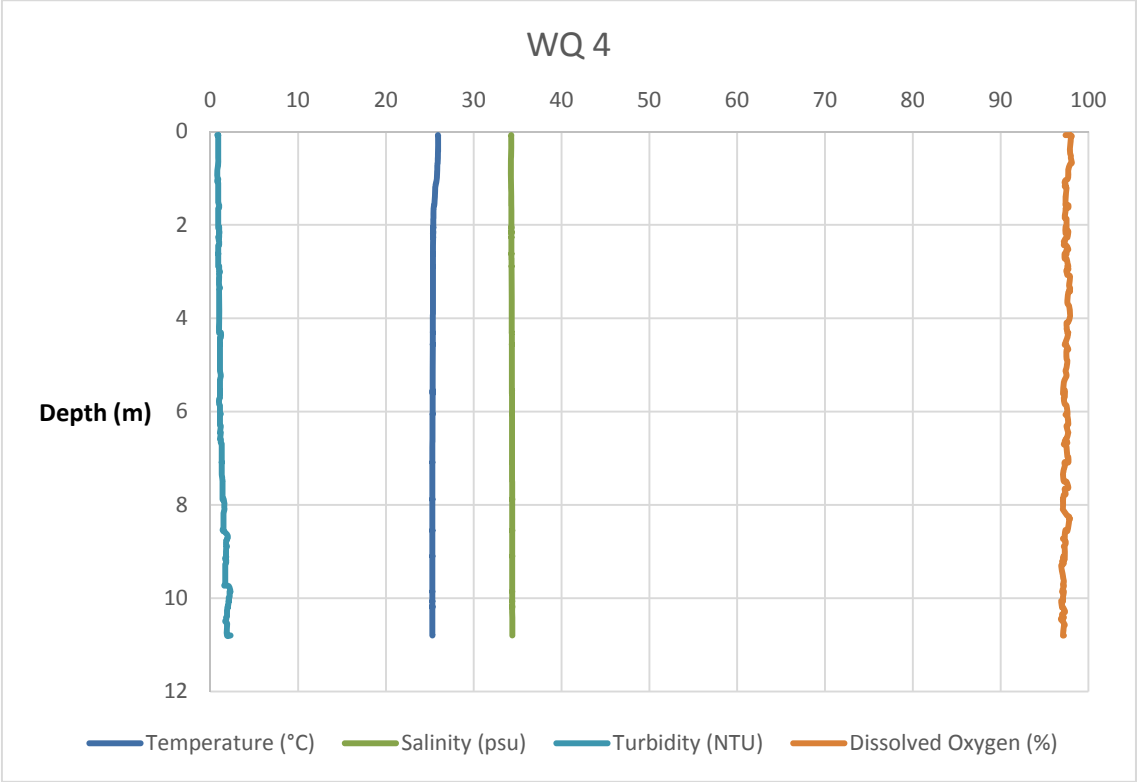
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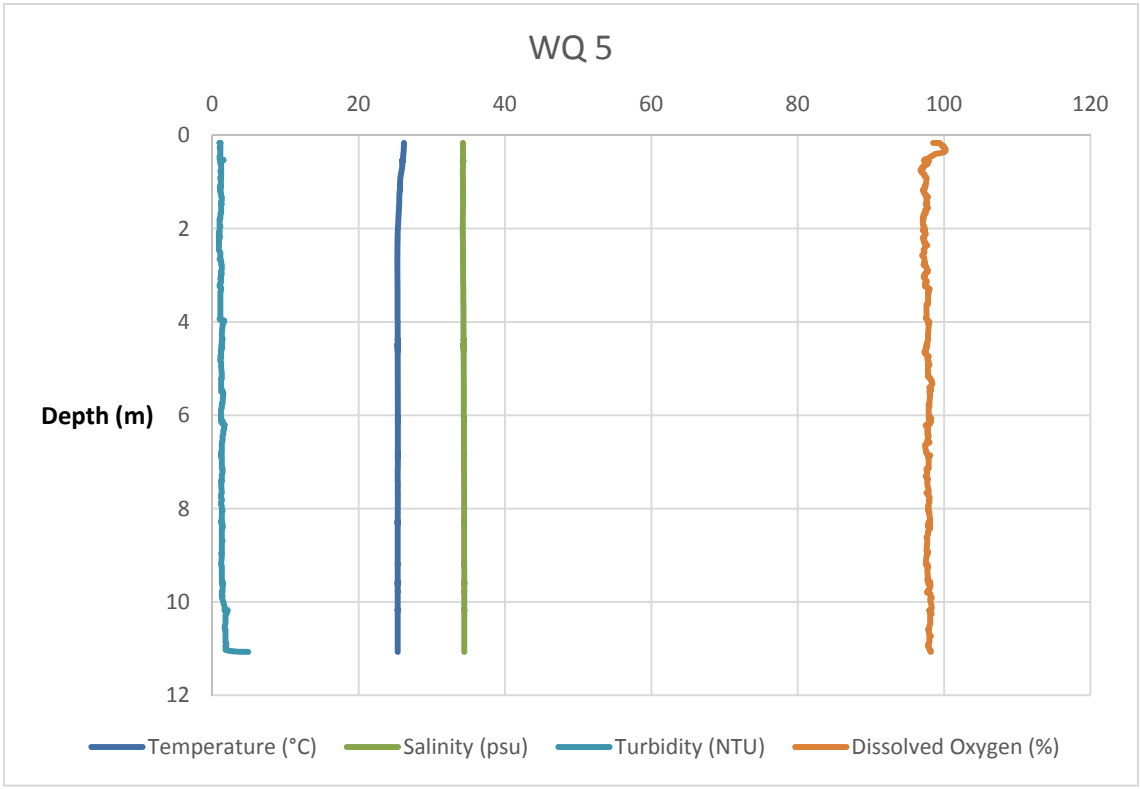
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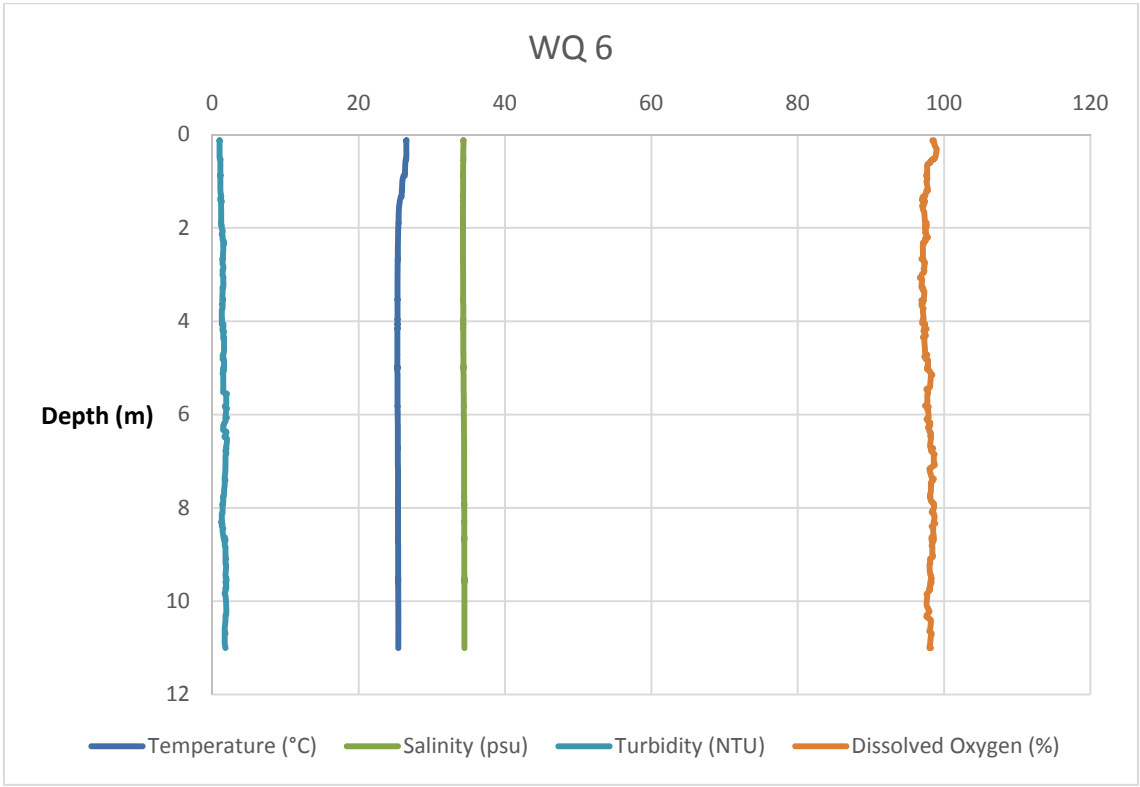
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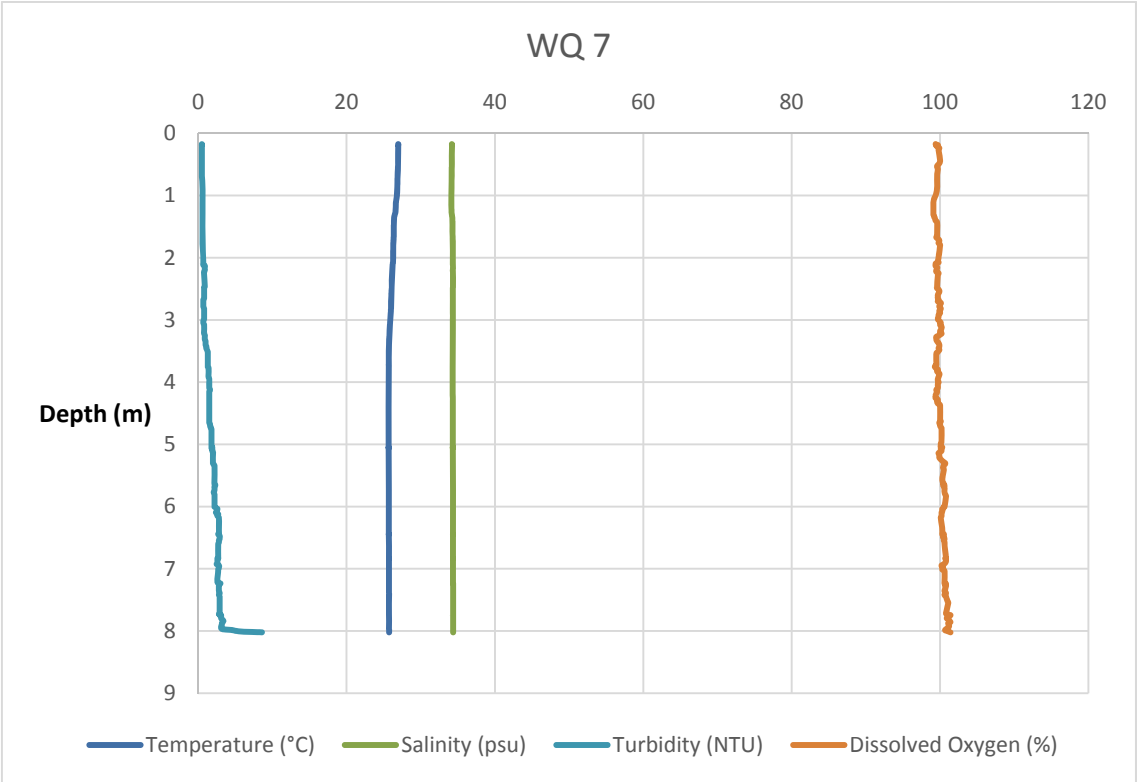
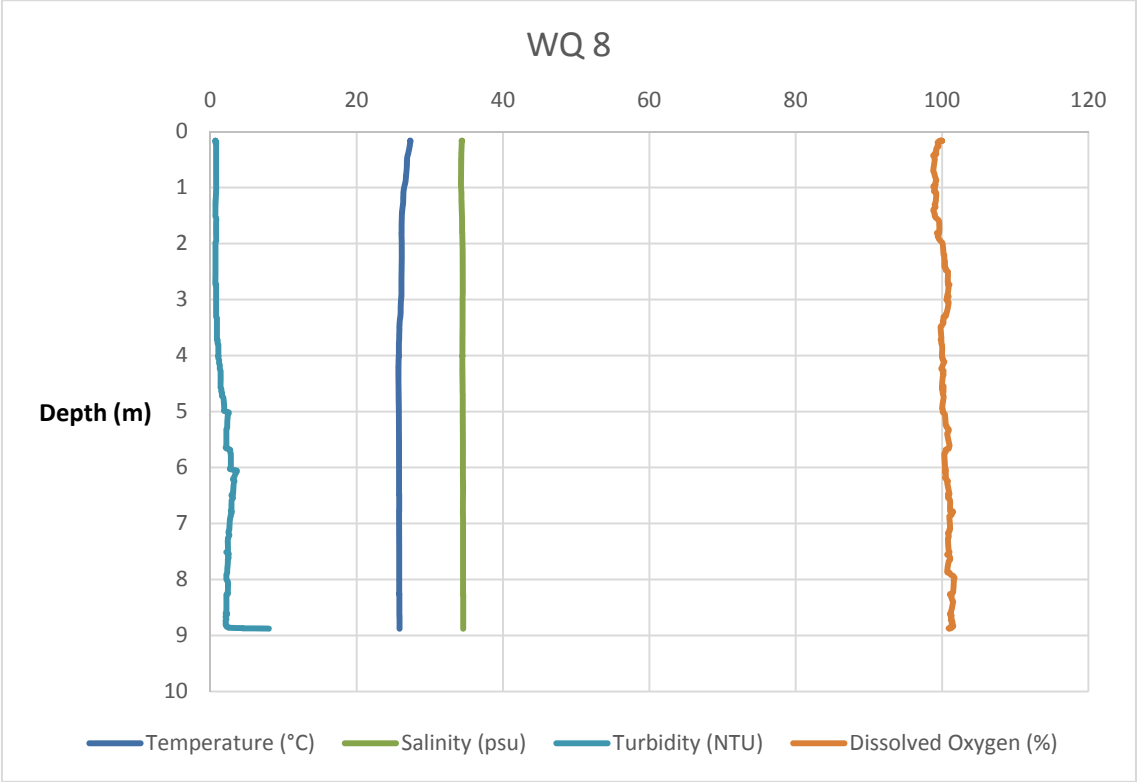
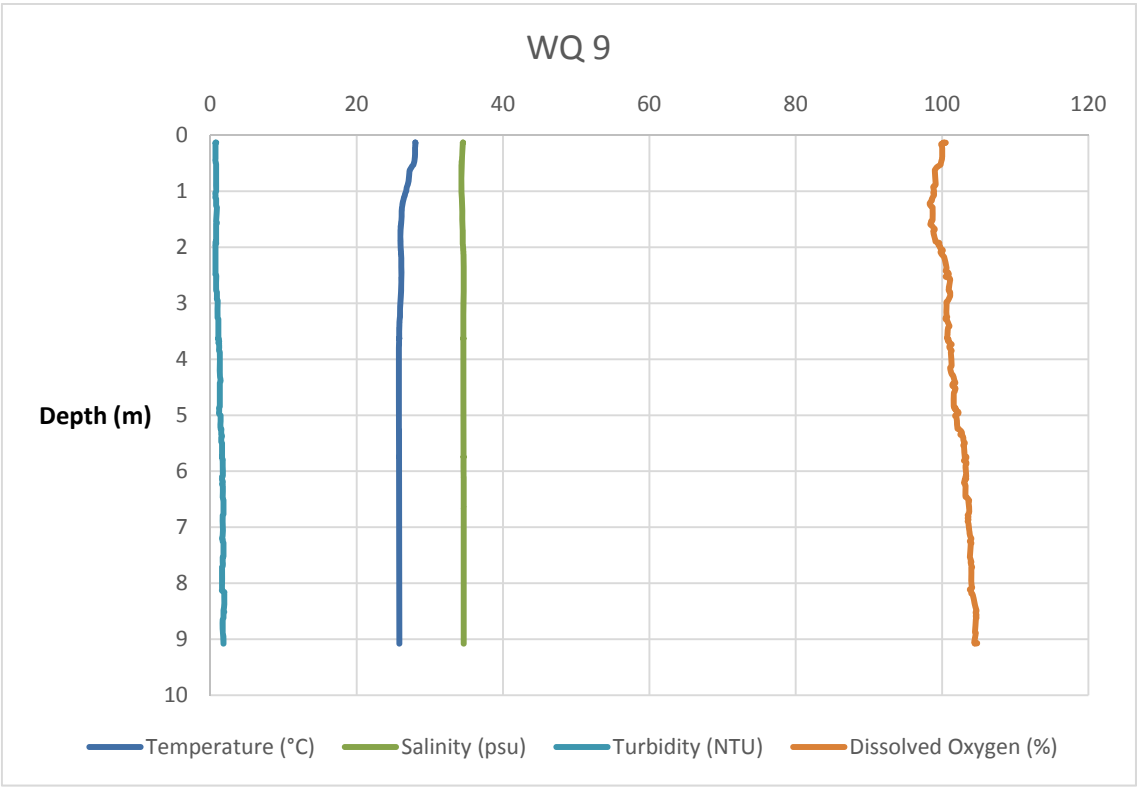
20
40
60
80
100
120
0
2
4
6
8
10
12
Depth (m)
Temperature (°C)
Salinity (psu)
Turbidity (NTU)
Dissolved Oxygen (%)


WQ 7
0
20
40
60
80
100
120
0
1
2
3
4
5
6
7
8
9
Depth (m)
Temperature (°C)
Salinity (psu)
Turbidity (NTU)
Dissolved Oxygen (%)


WQ 8
0
20
40
60
80
100
120
0
1
2
3
4
5
6
7
8
9
10
Depth (m)
Temperature (°C)
Salinity (psu)
Turbidity (NTU)
Dissolved Oxygen (%)


WQ 9
0
20
40
60
80
100
120
0
1
2
3
4
5
6
7
8
9
10
Depth (m)
Temperature (°C)
Salinity (psu)
Turbidity (NTU)
Dissolved Oxygen (%)

APPENDIX B

Water Quality Results

Subsea 7
Learmonth
Appendix B: Water Quality Analytical Results

			Sample ID	WQ1	WQ2	WQ3	Duplicate	WQ4	WQ5	WQ6	WQ7	WQ8	WQ9	Trip Blank	Field Blank
			Sample Matrix	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water
			Laboratory	MAFRL	MAFRL	MAFRL	MAFRL	MAFRL	MAFRL	MAFRL	MAFRL	MAFRL	MAFRL	MAFRL	MAFRL
			Date Sampled	8/12/2016	8/12/2016	8/12/2016	8/12/2016	8/12/2016	8/12/2016	8/12/2016	8/12/2016	8/12/2016	8/12/2016	8/12/2016	8/12/2016
			Date Recieved	14/12/2016	14/12/2016	14/12/2016	14/12/2016	14/12/2016	14/12/2016	14/12/2016	14/12/2016	14/12/2016	14/12/2016	14/12/2016	14/12/2016
Analyte	**LOR (MAFRL)**	**Units**	**Tropical Australia (ANZECC 2000)**												
Ammonia (as N)	<3	µg.N/L	1-10^	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
Ortho-Phosphate	<2	µg.P/L	NG	3	3	3	3	3	3	3	2	2	2	<2	<2
Nitrate and Nitrite (NO3+NO2)	<2	µg.N/L	2-8^	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Total Phosphorous	<5	µg.P/L	15	15	14	16	15	14	14	15	14	15	15	<5	<5
Total Nitrogen	<50	µg.N/L	100	90	90	100	100	90	90	90	100	110	100	<50	<50
Chlorophyll-a	<0.1	µg/L	0.7-1.4^	0.6	0.5	0.6	0.6	0.6	0.6	0.6	0.7	0.7	0.7	<0.1	-
Chlorophyll-b	<0.1	µg/L	NG	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-
Chlorophyll-c	<0.1	µg/L	NG	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	<0.1	-

Notes:
^ The lower values are typical of clear coral dominated waters (e.g. Great Barrier Reef), while higher values are typical of turbid microtidal systems (e.g North West Shelf of Western Australia)
ANZECC & ARMCANZ (2000) Tropical Australia Guidelines
Acronyms:
LOR = limits of reporting
NG = No Guideline
Font and Cell :
- coloured cells indicate exceedence of relevant assessment criteria
- grey text denotes value below laboratory limit of reporting

APPENDIX C

Sediment Quality Results

Subsea 7
Learmonth
Appendix C: Sediment Analytical Results

				Sample ID	SQ1	SQ2	SQ3	Duplicate	SQ4	SQ5	SQ6	SQ7	SQ8	SQ9	Trip Blank	Field Blank
				Sample Matrix	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment
				Laboratory	MAFRL	MAFRL	MAFRL	MAFRL	MAFRL	MAFRL	MAFRL	MAFRL	MAFRL	MAFRL	MAFRL	MAFRL
				Date Sampled	7/12/2016	7/12/2016	7/12/2016	7/12/2016	7/12/2016	7/12/2016	7/12/2016	8/12/2016	8/12/2016	8/12/2016	7/12/2016	7/12/2016
				Date Received	14/12/2016	14/12/2016	14/12/2016	14/12/2016	14/12/2016	14/12/2016	14/12/2016	14/12/2016	14/12/2016	14/12/2016	14/12/2016	14/12/2016
Analyte	**LOR**	**Units**	**ISQG-Low (ANZECC 2000)**	**ISQG-High (ANZECC 2000)**												
Total Kjeldahl Nitrogen	<0.1	mg.N/g	NG	NG	0.5	0.5	0.5	0.5	0.4	0.4	0.5	0.3	0.3	0.4	<0.1	<0.1
Total Phosphorous	<0.05	mg.P/g	NG	NG	0.38	0.37	0.39	0.36	0.38	0.32	0.38	0.24	0.32	0.39	<0.05	<0.05
Total Organic Carbon	<0.2	% C	NG	NG	0.4	0.4	0.4	0.4	0.3	0.3	0.7	<0.2	0.3	0.3	NT	NT
Total Aluminium	<20	mg/kg	NG	NG	6900	5900	6200	6400	4000	4500	5900	2600	2500	3200	<20	<20
Total Arsenic	<2	mg/kg	20	70	14	14	13	14	10	11	12	9	9	16	<2	<2
Total Chromium	<0.2	mg/kg	80	370	30	27	28	30	18	20	25	14	13	15	<0.2	<0.2
Total Copper	<0.2	mg/kg	65	270	6.1	5.2	5.4	5.5	3	3.4	4.8	1.8	1.6	2.2	0.2	0.5
Total Iron	<5	mg/kg	NG	NG	21000	20000	20000	22000	16000	16000	19000	10000	12000	16000	9	13
Total Lead	<1	mg/kg	50	220	5	5	5	5	4	4	5	3	2	3	<1	<1
Total Zinc	<0.5	mg/kg	200	410	16	14	14	15	9.1	10	13	5.8	5.5	7.1	<0.5	<0.5

Notes:
Results expressed as dry weight basis.
ANZECC & ARMCANZ (2000) Interim Sediment Quality Guidelines
Acronyms:
LOR = limits of reporting
mg/kg = milligrams per kilogram
mg.N/g = milligrams of nitrogen per gram
mg.P/g = milligrams of phosphorous per gram
C% = Carbon Percentage
NG = No Guideline
NT = Not Tested
Font and Cells
- grey text denotes value below laboratory limit of reporting

APPENDIX D

Sediment Quality Photos

SQ1

SQ2

SQ3

SQ4

SQ5

SQ6

SQ7

SQ8

SQ9

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