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Port of Esperance

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PORT OF ESPERANCE

ANNUAL MARINE SEDIMENT MONITORING REPORT 2015/16

Revision	Prepared	Reviewed	Approved	Date	Description
0.1	C. Aylott	A. Leonard	A. Leonard	22/11/2016	Final Report

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1 SUMMARY

The Annual Sediment Report has been produced in accordance with the Southern Ports Authority Port of Esperance (PoE) Operating Licence (L5099/1974/14) (herein the licence) and will present and discuss results from annual sampling of marine sediments at 19 sites in Esperance Harbour during the 2015-2016 licence year. The current version of the licence requires undertaking annual sediment monitoring between 1st June to 31st July each year with methodology in accordance with the Esperance Port Comprehensive Sediment Monitoring and Reporting Plan (Oceanica, 2009a). The first survey implementing the sampling design was conducted in 2010, and subsequent annual surveys have built on this baseline information.

For all metals (including contaminants of concern nickel and lead), all median (n=3) bioavailable concentrations were below the ISQG-Low values for each sampling location in 2016, which is consistent with results from the 2014 sampling event (refer to Table 5). Therefore, based on the 19 samples from Esperance Harbour, current levels of bioavailable metals in marine sediment are unlikely to be having a significant effect on marine biota and immediate reporting contingencies have not been triggered.

Within the inner harbour the results of the 15 sampling locations indicate concentrations of lead and nickel have declined five to eight-fold between 2010 and 2016. The highly variable nature of contaminant concentrations in sediments has prevented the detection of any statistical significant decline until this year results. The lead results from samples collected in July 2016 from 15 inner harbour sites showed a significant reduction in lead from samples collected in 2012, 2011 and 2010. The results for tributyltin (TBT) concentrations (standardised to 1% Total Organic Carbon (TOC) and dry weight) from the three berth pockets sampled were below the ISQG-High value (80 µg/kg). The number of sites exceeding the ISQG-High value since 2008 decreased from one zero sites; therefore the management actions stated in the CSMRP (Oceanica, 2009a) were not triggered. The 2008 ban on TBT applications and entry of IMO-registered only vessels will ensure the eventual decline of TBT exposures to marine biota.

Results from the previous annual monitoring (licence year) in October 2014 showed elevated metals concentrations in inner harbour sites. Maintenance dredging undertaken in July-August 2014 prior to sampling was a potential cause to the increases in levels of contamination in the top 10cm of sediment in the berth pockets. This increase, however, did not cause a statistically significant increase in concentrations of nickel and lead in the inner harbour compared to any of

the previous surveys. Concentrations of metals in sediments decreased in samples collected during July 2016 to levels lower than sediments sampled in 2013, before the 2014 maintenance dredging.

Maintenance dredging for removal of the remaining contaminated sediments at the berth pockets (disposal to land) is targeted for completion in the coming years.

2 INTRODUCTION

The Port of Esperance (PoE) was required by licence L5099/1974/14 to sample the top 10cm of harbour sediments from 19 locations on an annual basis between 1 June and 31st July within the licence year from 1st October 2015 to 30th September 2016. The most recent dredging operations undertaken was maintenance dredging of the inner harbour (berth pockets and turning circle) and outer harbour (harbour channel) which was completed in August 2014. A brief history of harbour sediment contamination and monitoring is provided below as background information.

Historical bulk handling of lead carbonate and nickel concentrate operations at PoE have led to lead and nickel contamination in the marine sediments within the berth pockets. PoE ceased handling and export of bulk lead carbonate in 2007, with all bulk handling of nickel exports ceasing in June 2012. PoE now exports nickel in a fully containerised handling system.

Ministerial Statement 681 (2005) required marine sediment monitoring for tri-butyl tin (TBT) and nickel between 2002 and 2006. Following commencement of bulk lead exports, lead monitoring began in 2005. In March 2006 Condition M8.5 of the Ministerial Statement was closed and monitoring temporarily ceased. In 2007, DER (formerly Department of Environment Conservation) found high lead and nickel levels near a stormwater discharge pipe at Berth 1 (close to existing Site A10a shown in Figure 2). As a result of this, Oceanica were contracted by PoE to develop a Sampling Analysis Program (SAP) to assess the ecological risks of the lead and nickel contamination within the harbour waters at the Port (Oceanica 2009b).

Between 2007 and 2010 Oceanica undertook an extensive survey and investigation of the toxicity of surficial sediments (Oceanica, 2010). This included testing for total and bioavailable metals in marine sediments and early life stage testing of three different marine species and an acute mortality test using a burrowing crustacean (Amphipod) in whole sediments. The early life stage testing was selected since these stages represent the most sensitive stages of an organism's life cycle. The testing was conducted in elutriate waters of contaminated sediments and deformities in larval development of scallops and rock oysters and the changes in growth rates of algae were assessed. These studies by Oceanica found that despite the high levels of contamination, neither lead nor nickel within the sediments had significant toxicity to marine biota in any of these tests (Oceanica, 2010).

PoE annually monitors sediments and report levels of contaminants in marine sediments under the current DER licence. Conditions 3.1.1, 3.8.3 and 5.2.1 specify the requirements and reference

the Comprehensive Sediment Monitoring and Reporting Plan (CSMRP) (Oceanica, 2009a). Contaminants analysed include nickel and lead at all 19 sites, plus arsenic, cadmium, chromium, copper, zinc, manganese and sulphur at nine sites (Sites A5-A13). Organotins and Total Organic Carbon were analysed for sites in the berth pockets (Sites A8, A9 and A10). Particle size is required to be analysed once every three years and was undertaken in conjunction with the 2013/14 monitoring and was therefore is not required until monitoring in the 2016/17 annual licence period. The ANZECC-ARMCANZ (2000) sediment quality criteria were adopted to form triggers for management actions (refer to Section 3 of the CSMRP, Oceanica, 2009a).

Maintenance dredging works were conducted at the Port in July and August 2014, however the removal and disposal of contaminated sediments in the Berth pockets was incomplete as a result of poor manoeuvrability of the dredge vessel which left high areas along the fender line of each berth. The results of the 2014 survey indicated higher concentrations of contaminants than before the dredging works due to the removal of a clean sediment “cap” and partial removal of underlying contaminated sediments close to the berth pockets. The sediments in the berth pockets redistributed as a result of the turbulence from tug and ship movements and natural accretion of sediments will also occur. These processes will have been ongoing over the last 12 months since the previous survey was conducted shortly after the dredging. The results of this year’s survey is of interest to indicate what effect this redistribution and capping of sediments will have had on the concentrations of contaminants in the top 10cm. Inputs of the main contaminants, TBT, nickel and lead are likely to have been negligible. However, some inputs of TBT are still possible by ships having historical layers of this paint on their hulls flake off as they rub against the berth fender. We can expect a gradual decline in TBT in sediments following the 2008 ban of application on IMO registered vessels accepted by the Port.

3 OBJECTIVES

The objectives of the 2015/16 annual marine sediment monitoring were to:

1. Determine whether overall contamination levels in marine sediment have decreased since elevated levels found in the October 2014 survey following maintenance dredging works;

2. Assess sediment quality of the inner harbour against the triggers for management action described in the CSMRP (Oceanica, 2009a). The triggers are as follows:

    a. Bioavailable metal concentrations exceed the ISQG-Low or ISQG-High values at a site where no previous exceedance has taken place;

    b. More than one out of three sites exceeds the Tributyltin ISQG-High values; and

    c. The mean nickel or mean lead concentration of the 15 inner harbour sites shows a statistically significant increase (from t-test results) since 2008 (revised to 2010 as 2008 monitoring was confounded by variable depth samples);

    If these triggers are exceeded, contingency management actions include investigation and conducting actions to reduce risk.

3. Submit the Annual Marine Sediment Monitoring Report to DER before 19th December 2016 as required by the licence.

4 METHODOLOGY

4.1 Sampling Works

The 2015/16 annual marine sediment monitoring was conducted from the 11th to the 14th July 2016. Samples were collected from 19 monitoring locations (sample locations have been grouped as per the CSMRP (Oceanica, 2009a)):

1. 11 monitoring locations within and around the berth pockets (A8, A9, A10b and A14 - A21);

2. Five monitoring locations within the turning basin and channel (A11, A12, A13, A22 and A23); and

3. Three outer harbour monitoring locations (A5, A6 and A7).

Professional divers previously contracted by Oceanica and PoE were appointed (consistent with AS/NZS 4122) to collect 330 sediment cores (including QA/QC samples) in July 2016. Three replicate samples were taken within five metres of each other at the 19 sites. Each replicate consists of a homogenate of five 0-10cm cores taken from each corner and in the centre of a 1m^2 quadrat (as shown on Figure 1). The locations of the 19 marine sediment sampling sites are provided on Figure 2.

Figure 1: Replicate sample within 1m^2 quadrat

Source: CSMRP (Oceanica 2009a)

In 2011 and 2012, sample Site A10 was sampled twice, with triplicate samples taken from the landward side (south side) of the metal sheet piling (A10a) and from the ocean side (northern side) of the metal sheet piling (A10b) located beneath Berth 1. Sample results at Site A10 between 2007 and 2008 indicated there may be a difference in results depending upon which side of the metal sheet piling the samples were taken. The 2011 results indicated the landward side retains historical sediments, as the sheet piling creates a barrier, while the ocean side undergoes regular flushing due to ocean currents and ships propeller wash. Samples were taken again in 2012 to provide further support for these differences observed in 2011. Subsequent surveys in 2013 and 2014 and 2016 omitted site A10a as it is not representative of the inner harbour with samples only being collected from the ocean side of the sheet piling only (A10b).

The polycarbonate corers used for the 2016 sediment sampling had an internal diameter ~100 mm in line with dimensions recommended in Section 2.2.4 of the CSMRP (Oceanica, 2009a). The corer dimensions recommended in CSMRP (Oceanica 2009a) are different to those specified in Australian Standard (AS 5667.12:1999 (Annex C)), which requires an internal diameter of 66mm and an outer diameter of 70mm. DER have clarified that the dimensions of the polycarbonate corers used are acceptable as described in CSMRP (Oceanica, 2009a).

Further details regarding sampling methodology are provided in Section 2.2.4 of the CSMRP (Oceanica, 2009a). Details of sampling sites are provided below in Table 1, while sample locations are shown on Figure 2. Due to operational constraints including inclement weather and scouring of sediment of the harbour bed, some of the 2016 sample location may deviate slightly from the below coordinates. Four monitoring sites (A5, A7, A11 and A12) were relocated during the 2016 monitoring as shown on Figure 2.

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Table 1: Details of Sampling Sites 2016

Site Name	Latitude	Longitude	Site Location Description
Outer Harbour Sites			
A5	***33.51.826***	***121.54.464***	A5 moved in 2015/16 to the NW edge of channel to access sediment. Previously ~ 350m NNE from tip of northern break wall
A6	33.51.730	121.54.327	~600m NNW from tip of northern break wall
A7	***33.51.267***	***121.54.305***	A7 moved due to heavy seagrass coverage. Previously ~1,100m from tip of northern break wall
Inner Harbour Sites			
Berth Pockets			
A8	33.52.170	121.54.193	Berth 3
A9	33.52.328	121.54.022	Berth 2
A10b	33.52.250	121.53.860	Berth 1
A14	33.52.303	121.53.967	Western end of Berth 2
A15	33.52.275	121.53.912	Eastern end of Berth 1
A16	33.52.233	121.53.835	Western end of Berth 1
A17	33.52.297	121.54.101	~100m W of the Tugboat wharf
A18	33.52.291	121.54.031	~80m N of Berth 2
A19	33.52.243	121.53.928	~80m N of eastern end of Berth 1
A20	33.52.218	121.53.839	~80m N of western end of Berth 1
A21	33.52.181	121.53.793	~150m NW of western end of Berth 1
Channel and Turning Circle			
A11	***33.51.912***	***121.54.280***	A11 moved due to high amount of shells in 2014 sample. Previously ~ 200m WNW from tip of northern break wall
A12	***33.52.089***	***121.54.056***	A12 moved NW due to scouring of berth pocket. Previously ~ 150m W of Berth 3
A13	33.52.024	121.53.927	~500m NW of Berth 3
A22	33.52.265	121.54.125	~120m NW of the Tugboat wharf
A23	33.52.084	121.54.246	~ 100m N of northern end of Berth 3

Note:
Approximate (~) site locations were determined from sample locations provided on Figure 2
Bold marks sites which were moved in 2016. Previous and new locations for these sites are provided on Figure 2

Figure 2: Marine Sediment Sampling Sites at Port of Esperance

4.2 Laboratory Analyses

In accordance with condition 9(b) of the Licence, all samples were submitted to National Association of Testing Authorities (NATA) accredited laboratories for analysis. The same laboratories have been used for all analytes since 2007. All sediment samples collected were analysed in accordance with Licence requirements with analytes shown in Table 2 below. Triennial sampling for particle size distribution was not required during 2015/16 and will be next undertaken during 2016/17 licence annual period. Laboratory Certificates of Analysis have been provided in Appendix B.

Table 2: Laboratory Analysis Required and Frequency of Analysis

Sampling Sites	Annual Analysis		Analysis Every 3 years	
	Analytes	**Replicates to be analysed**	**Analytes**	**Replicates to be analysed**
All 19 Sites	Lead and nickel	All three replicates	Particle size distribution	One replicate per site
Sites A5 to A13	Arsenic, cadmium Chromium, copper zinc, manganese sulphur	All three replicates	-	-
Sites A8, A9 and A10 (the three berth pocket sites)	Total Organic Carbon (TOC) Organotins (TBT, DBT, MBT)	One replicate per site	-	-

Note: Table sourced from CSMPR (Oceanica 2009a) and Licence L5099/1974-14
Note: Metals analysed were analysed for totals (strong acid extraction) and bioavailable (dilute acid extraction)

NATA accredited analytical laboratories Marine and Freshwater Research Laboratory (MAFRL) and National Measurement Institute (NMI) were commissioned for sediment sample analysis, consistent with the laboratories utilised by Oceanica. All samples were frozen prior to transport and transported on ice at 4°C and couriered overnight to Perth in appropriate containers provided by each laboratory. NATA accredited laboratories undertook analysis of sediment samples for analytes required by condition 3.8 of the Licence as follows:

- NMI was used to analyse TOC and organotins (TBT, DBT, MBT);
- MAFRL were used to analyse for a suite of metal (arsenic, cadmium, chromium, copper, manganese, nickel, lead and zinc) and sulphur analysis;
- Duplicate (split replicate) samples of all three replicates from three sites (A8, A14 and A16) were sent to NMI to provide quality assurance, to ensure reliable metal results

were obtained. This is based on AS 4482.1 - 2005 for soil sampling that suggests one split sample per batch of 20 samples be sent to a secondary laboratory; and

- Particle size distribution is analysed at CSIRO every three years in accordance with the licence, and was not required in this 2015/16 survey.

4.3 Quality Assurance/Quality Control

Field QA/QC was undertaken and three split replicate samples were collected and sent to NMI for metals analysis. MAFRL and NMI undertook the required laboratory QA/QC. More detailed information regarding QA/QC methods are provided in Appendix C.

4.3.1 Statistical design and analyses

The required data analyses of laboratory results include:

1. Determine median triplicate concentrations at each site to assess compliance with sediment quality criteria (ANZECC-ARMCANZ, 2000);

2. Assess levels of organotins (TBT, DBT and MBT), normalised to 1% TOC content (as per National Assessment Guidelines for Dredging, (Commonwealth of Australia, 2009) in the sediments of the three berth pockets (Berths 1, 2, and 3) and compare to the number of sites exceeding the ANZECC-ARMCANZ (2000) guidelines in 2008.

3. Calculate the mean lead and nickel concentrations for each triplicate sample in 2016 for the 15 inner harbour sites and determine whether values are significantly different to those of 2014, 2013, 2012, 2011 and 2010 using a standard t-test (two tailed). The software package Statistica (Version 10, 2011) was used to conduct the t-tests. All data was Log10 transformed to normalise the data distribution that was inspected using a histogram. For comparison of the 2016 data to other years, the Levene's test for equal variances indicated the assumption of equal variances is valid, with all data passing the Levene's test for equal variances (Levene's p value > 0.05) with the exception of the Levenes t-test for Pb 2016 vs Pb 2010 (Levene's p value <0.05). Where the t-test fails the Levene's test for equal variance, a nonparametric equivalent test (Mann-Whitney U test) was utilized as a nonparametric alternative to the t-test for independent samples.

5 RESULTS AND DISCUSSION

Results of the 2015/16 annual marine sediment monitoring event are presented and discussed herein, including field sampling and observations, laboratory analytical results and their assessment against the relevant guidelines and changes from the baseline established in 2010 and to the previous survey in 2014.

5.1 Field Sample Observations

Samples were collected from all 19 monitoring sites during the 2015/16 monitoring event, however there were several sites where the total 10cm core of sediment was difficult to obtain. During the 2013/14 sampling event, sites A5, A7 and A12 were within a rocky limestone area, resulting in some of the samples at these sites containing a substantial amount of shell fragments and making it difficult for divers to collect the full 10cm sample depth. These sites were moved during the 2016 sampling event with original and new site locations shown on Figure 2. Site A11 was also moved during the 2016 sampling event due to minimal sediment present at this location due to scouring. A summary of field observations for samples collected at each site are provided in Table 3.

Table 3: Sample Field Observations

Site Name	Sample Description
Outer Harbour Sites	
A5	Light grey sand, odourless, minor seagrass
A6	Light grey sand, odourless, some seagrass. Difficult to get full 10cm sample as to seagrass rhizomes in sand made it difficult to push in sediment cores
A7	Light brown sand, odourless, major shells and shell fragments. Difficult to get 10 cm core, a small patch of sand was found after an extensive search by divers
Inner Harbour Sites	
Berth pocket sites	
A8	Light to dark grey sand, slight to strong H_2S odour, minor shells
A9	Pale grey sand, odourless
A10b	Light to dark grey sand, organic odour, minor shells. Thin layer of black on surface or cores
A14	Light grey sand, odourless, some small buried urchins
A15	Light to dark grey sand, organic odour, black discs on surface of cores
A16	Light grey sand, organic and slight H_2S odour, some black balls on surface
A17	Light to dark grey sand, some black balls on the surface
A18	Pale to dark grey sand, organic odour, some black organic spheres collected. Large amount of worm activity noted at this site
A19	Pale grey sand, odourless, large colony of large long worms seen on harbour floor at this site
A20	Pale to dark grey sand, organic odour, some minor seagrass at site
A21	Pale grey sand, odourless, seagrass and minor shells. Seagrass fibres in sand made it difficult to collect full 10cm sample. Razor clams collected
Channel and Turning Circle	
A11	Pale to dark grey sand, slight organic odour, small brittle star (replicate 1) and small worm (replicate 2). Site moved to NW of 2014 sample site to channel batter
A12	Pale grey coarse sand, odourless, scallop shells present – site moved
A13	Pale to dark grey sand, organic odour, some seagrass. Difficult to gain full 10cm core sample due to seagrass rhizomes under sand surface
A22	Pale grey sand, odourless, moderate to high shells and shell fragments. Sample depth 21 m at edge of sediment slope, may need to move next year
A23	Pale grey sand, slight H_2S odour, minor shells and seagrass
Note [1]:	

5.2 Particle Size Distribution

Triennial particle size distribution analysis was undertaken in the 2013/14 monitoring year, therefore is not required again until the 2016/17 monitoring year.

5.3 Comparison of Results to Sediment Quality Guidelines

Median values for total and bioavailable levels of each metal from the 2016 monitoring event were determined from the triplicate results for each site and compared to the results from 2014 sampling and the Australian and New Zealand Interim Sediment Quality Guidelines (ISQG) ISQG-Low and ISQG-High criteria (ANZECC-ARMCANZ, 2000) (refer to Tables 4 and 5). A full set of laboratory results are attached in Appendix B.

Analytical results have also been compared to the triggers and contingency actions outlined in Table 3.1 of the Comprehensive Sediment Monitoring and Reporting Plan (Oceanica, 2009) which have been provided below in Table 4.

Table 4: Triggers and Contingency Actions
(Source: Table 3.1 in CSMRP (Oceanica, 2009))

Trigger	Management action
Overall nickel and lead levels in inner harbour sediments	
The mean nickel or mean lead concentration of the 15 inner harbour sites shows a statistically significant increase[1] since 2008.	1. Investigate the source of contamination. 2. Address source of contamination via management as appropriate (improvement in bulk cargo handling practices, installation of stormwater traps/diversion).
Trace metals	
Bioavailable metal concentration exceeds the ISQG-Low, at a site where no previous exceedance has taken place.	1. DEC to be informed via annual reporting. 2. Investigate the source and extent of contamination in consultation with the DEC, as per the Contaminated Sites guidelines. 3. Address source of contamination via management as appropriate (improvement in bulk cargo handling practices, installation of stormwater traps/diversion).
Bioavailable metal concentration exceeds the ISQG-High, at a site where no previous exceedance has taken place.	1. DEC to be informed immediately, and via annual reporting. 2. Investigate the source and extent of contamination in consultation with the DEC, as per the Contaminated Sites guidelines. 3. Address source of contamination via management as appropriate (improvement in bulk cargo handling practices, installation of stormwater traps/diversion).
Tributyltin	
Increase in number of sites exceeding the ISQG-Low since 2008.	1. DEC to be informed via annual reporting. 2. Esperance Port to only accept IMO registered vessels that are compliant with MARPOL. 3. AQIS to conduct random checks on vessels. 4. Esperance Port Authority to do check on suspect vessels.
Increase in number of sites exceeding the ISQG-High since 2008	1. DEC to be informed via annual reporting. 2. Esperance Port to only accept IMO registered vessels that are compliant with MARPOL. 3. AQIS to conduct random checks on vessels. 4. Esperance Port Authority to do check on suspect vessels 5. Need for further action to be discussed in consultation with the DEC.

[1] Standard t-test (two tailed test), an effect size of 100%, alpha=0.05 (i.e. desired significance) and beta=0.2 (i.e. 1-statistical power).

5.3.1 Outer Harbour Sites

Median analytical results for total metals (strong acid extraction) and bioavailable metals (dilute acid extraction) for the three outer harbour sites (A5, A6 and A7) were below the ISQG-Low values for each analyte tested, with results consistent with the 2014 annual sediment monitoring results.

5.3.2 Inner Harbour Sites

Concentrations of both lead and nickel in the 2016 samples had decreased to five to eight-fold below levels recorded in 2010. For total metals, the total number of sites with concentrations of total nickel above the ISQG-High declined from 4 sites in 2014 to 1 site in 2016 (refer to Table 5). A decrease was also seen in the number of sites exceeding the ISQG-Low, with the number of sites decreasing from 6 in 2014 to 5 sites in 2016.

Reductions in total nickel concentrations were seen at 11 out of 16 inner harbour sites with reductions up to eight-fold in total nickel concentrations. The largest percentage reductions of eight and five-fold were seen at sites located along Berth 2 of A14 (98mg/kg reduction to 12 mg/kg) and A9 (186 mg/kg reduction to 34 mg/kg) respectively. Smaller increases in total nickel were seen at five out of 16 inner harbour sites with percentage increases up to two fold. Increases of approximately two-fold were seen at Site A13 (18mg/kg increase to 30mg/kg) and Site A11 (3mg/kg increase to 6.4 mg/kg) respectively. These two-fold changes in concentrations of nickel are likely to have occurred due to the natural variability of the sediments as well as sampling and analytical variability.

Analytical results for bioavailable metal concentrations at the inner harbour monitoring sites (refer to Table 6), did not activate any of the triggers or management actions in Table 4. Total and bioavailable metals results did not record concentrations above the ISQG-Low or ISQG-High where this has not occurred at those sites in previous years.

For all metals, all median (n=3) bioavailable concentrations were below the ISQG-Low values for each sampling location in 2016, which is consistent with results from the 2014 sampling event (refer to Table 5). Therefore, total nickel in sediment is unlikely to be having a significant effect on marine biota and immediate reporting contingencies have not been triggered.

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Table 5: Total Metal (strong acid extraction) Median (n = 3) Results for 0-10cm Cores for 2016

	Arsenic		Cadmium		Chromium		Copper		Manganese		Nickel		Lead		Sulphur		Zinc	
Reporting Limit	*<2* ISQG Low = 20 ISQG High = 70 mg/kg		*<0.1* ISQG Low = 1.5 ISQG High = 10 mg/kg		*<0.2* ISQG Low = 80 ISQG High = 370 mg/kg		*<0.2* ISQG Low = 65 ISQG High = 270 mg/kg		*<0.05* ISQG Low = NA ISQG High = NA mg/kg		*<0.7* ISQG Low = 21 ISQG High = 52 mg/kg		*<1* ISQG Low = 50 ISQG High = 220 mg/kg		*<10* ISQG Low = NA ISQG High = NA mg/kg		*<0.5* ISQG Low = 200 ISQG High = 410 mg/kg	
Site	2014 results	2016 results	2014 results	2016 results	2014 results	2016 results	2014 results	2016 results	2014 results	2016 results	2014 results	2016 results	2014 results	2016 results	2014 results	2016 results	2014 results	2016 results
Outer Harbour Sites																		
A5	0	3	<0.1	*0.1	3.1	6.6	1.2	1.5	7	8.4	2	3.7	<1	1	1000	1300	2.3	2.4
A6	2	3	<0.1	<0.1	6.9	6.8	0.8	0.4	8.6	9.2	**0.7	0.9	<1	<1	1100	1200	1.1	1
A7	3	*2	**0.1	<0.1	4.9	3.9	1	0.3	6.4	5.5	1	<0.7	<1	<1	1100	910	1.3	1.2
Inner Harbour Sites																		
A8	3	3	**0.1	0.1	8.7	9	29	12	11	11	**52**	**30**	18	8	2500	1200	23	14
A9	6	*2	0.2	0.1	9.7	8.5	35	5.3	9.8	7.3	**220**	**34**	8	13	3700	1600	59	14
A10b	*3	4	0.1	0.1	7.5	8.7	6.8	13	7.5	8.7	**40**	**68**	25	8	1600	2000	9.2	21
A11	<	3	<0.1	0.1	4.6	8.9	1.4	2.7	6.6	10	3.4	6.4	2	2	950	1700	2.2	4.2
A12	*2	*2	<0.1	<0.1	4.1	6.1	1.2	1.1	6	7	3.2	6	*1	3	1000	1000	1.5	2.2
A13	6	3	0.1	0.1	8.1	9.7	5.3	9.5	9	9.5	12	**30**	4	7	1500	2100	10	13
A14	-	-	-	-	-	-	-		-		**110**	12	**60**	5	-	-	-	
A15	-	-	-	-	-	-	-		-		**38**	17	11	5	-	-	-	
A16	-	-	-	-	-	-	-		-		**27**	**35**	5	10	-	-	-	
A17	-	-	-	-	-	-	-		-		**62**	**26**	22	8	-	-	-	
A18	-	-	-	-	-	-	-		-		**31**	9.6	13	5	-	-	-	
A19	-	-	-	-	-	-	-		-		12	3.7	5	1	-	-	-	
A20	-	-	-	-	-	-	-		-		**28**	19	10	6	-	-	-	
A21	-	-	-	-	-	-	-		-		15	9.7	7	4	-	-	-	
A22	-	-	-	-	-	-	-		-		8.9	3	4	2	-	-	-	
A23	-	-	-	-	-	-	-		-		**24**	19	8	6	-	-	-	

Bold indicates median values that exceed the ISQG-Low guideline

Grey highlight indicates median values that exceed the ISQG-High guideline

NA = not available.

A10a - landward side of sheet piling beneath Berth 1; A10b - ocean side of sheet piling beneath Berth 1

*Where 1 triplicate was <LOD, the value equal to the LOD was used

**Where 2 triplicates were <LOD, the value equal to the LOD was used

Where all triplicates were <LOD, median result was left as <LOD

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Table 6: Bioavailable Metals (dilute acid extraction) Median (n = 3) Results for 0-10cm Cores for 2016

	Arsenic		Cadmium		Chromium		Copper		Manganese		Nickel		Lead		Sulphur		Zinc	
Reporting Limit	*<2* ISQG Low = 20 ISQG High = 70 mg/kg		*<0.1* ISQG Low = 1.5 ISQG High = 10 mg/kg		*<0.2* ISQG Low = 80 ISQG High = 370 mg/kg		*<0.2* ISQG Low = 65 ISQG High = 270 mg/kg		*<0.05* ISQG Low = NA ISQG High = NA mg/kg		*<0.7* ISQG Low = 21 ISQG High = 52 mg/kg		*<1* ISQG Low = 50 ISQG High = 220 mg/kg		*<10* ISQG Low = NA ISQG High = NA mg/kg		*<0.5* ISQG Low = 200 ISQG High = 410 mg/kg	
Site	2014 results	2016 results	2014 results	2016 results	2014 results	2016 results	2014 results	2016 results	2014 results	2016 results	2014 results	2016 results	2014 results	2016 results	2014 results	2016 results	2014 results	2016 results
Outer Harbour Sites																		
A5	3	3	<0.1	<0.1	2.2	5.8	0.5	0.6	4.1	6.2	<0.7	<0.7	<1	1	810	1200	1.1	1.5
A6	2	2	**0.1	<0.1	6.3	5.6	0.3	*0.2	7	5.7	<0.7	<0.7	<1	<1	1100	1000	*0.5	**0.5
A7	3	*2	**0.1	<0.1	4.2	3.5	0.3	<0.2	4.6	4.1	<0.7	<0.7	<1	<1	1100	790	0.8	**0.6
Inner Harbour Sites																		
A8	3	**2	0.2	*0.1	6.5	5.4	6.9	3.9	7.4	6.2	3.5	2	18	7	1400	1300	10	5.6
A9	**2	<2	0.3	*0.1	7	6.8	4.1	1.6	5.4	4.6	12	2.3	6	10	1200	1100	12	4.1
A10b	<2	**2	0.1	*0.1	6.2	6.1	2.5	3.7	5.2	4.9	3.6	4.8	24	8	1200	1100	21	7.5
A11	<2	2	<0.1	*0.1	3.1	6.8	0.6	1	5	7.4	<0.7	0.9	2	2	780	1400	1	1.7
A12	<2	<2	<0.1	<0.1	2.3	4.3	0.5	0.5	2.9	3.5	0.8	*0.8	*1	3	670	740	0.8	1
A13	3	**2	0.1	0.1	6.8	6.5	1.9	2.7	6.3	5.8	1.6	2.7	**4	6	1300	1400	5	6.3
A14	-	-	-	-	-	-	-	-	-	-	4.8	1.7	49	4	-	-	-	-
A15	-	-	-	-	-	-	-	-	-	-	4.7	1.7	11	5	-	-	-	-
A16	-	-	-	-	-	-	-	-	-	-	5	2.3	5	10	-	-	-	-
A17	-	-	-	-	-	-	-	-	-	-	3.7	2.1	21	8	-	-	-	-
A18	-	-	-	-	-	-	-	-	-	-	3.2	0.9	13	3	-	-	-	-
A19	-	-	-	-	-	-	-	-	-	-	1.4	*0.7	5	*1	-	-	-	-
A20	-	-	-	-	-	-	-	-	-	-	2.2	1.4	10	6	-	-	-	-
A21	-	-	-	-	-	-	-	-	-	-	1.4	1.5	7	4	-	-	-	-
A22	-	-	-	-	-	-	-	-	-	-	1	<0.7	4	<1	-	-	-	-
A23	-	-	-	-	-	-	-	-	-	-	2	2.1	8	5	-	-	-	-

Bold indicates median values that exceed the ISQG-Low guideline
Grey highlight indicates median values that exceed the ISQG-High guideline
NA = not available.
A10a - landward side of sheet piling beneath Berth 1; A10b - ocean side of sheet piling beneath Berth 1
*Where 1 triplicate was <LOD, the value equal to the LOD was used
**Where 2 triplicates were <LOD, the value equal to the LOD was used
Where all triplicates were <LOD, median result was left as <LOD

The results for tributyltin (TBT) concentrations (standardised to 1% Total Organic Carbon (TOC) and dry weight) from the three berth pockets sampled were below the ISQG-High value (80 µg/kg) (refer to Table 7). TBT results from 2016 sampling provided in Table 7 have been compared to 2008 results to provide a comparison to triggers and contingency actions outlined in the CSMRP (Oceanica 2009), see Table 4. The 2016 results show a decrease in TBT since the 2014 results where results at A8 (Berth 3 pocket) and A10b (Berth 1 pocket) were above the ISQG-High value (80 µg/kg).

The reduction of TBT concentrations is likely to be due to a combination of sediment disturbance and dispersal since the 2014 dredging and the patchy spatial distribution due to the association of TBT with antifouling paint flakes (Negri & Marshall, 2009). The number of sites exceeding the ISQG-High value since 2008 decreased from one zero sites; therefore the management actions stated in the CSMRP (Oceanica, 2009a) were not triggered. Should the management actions in the CSMRP be triggered, the below actions are required (Oceanica 2009a)

1. DER (previously DEC) to be informed via annual reporting;
2. Esperance Port Authority to only accept IMO registered vessels that are compliant with MARPOL;
3. AQIS to conduct random checks on vessels;
4. PoE to do checks on suspect vessels; and
5. Need for further action to be discussed with DER.

Table 7: Organotins Results 2016 - standardized to 1 % TOC

Site	Monobutyltin µg/kg/1%TOC ISQG Low = NA ISQG High = NA		Dibutyltin µg/kg/1%TOC ISQG Low = NA ISQG High = NA		Tributyltin µg/kg/1%TOC *ISQG Low = 9 *ISQG High = 80		TOC** mg/kg ISQG Low = NA ISQG High = NA		TOC** % NA NA	
	2008 results	2016 results	2008 results	2016 results	2008 results	2016 results	2008 results	2016 results	2008 results	2016 results
A8	<LOR	<LOR	20.2	1.9	**1181.8**	2.8	4400	6700	0.44	0.67
A9	<LOR	<LOR	5.2	<LOR	**14.1**	**11.7**	2700	1800	0.27	0.18
A10b	<LOR**	2	3.9**	5.7	**10.4****	**26.1**	2600	4600	0.26	0.46

*ISQG low and high trigger values in ug/Sn/kg^2 (National Assessment Guidelines for Dredging, 2009 – as suggested in CSMRP, 2009).
** 2008 results were for site A10a but are now compared to A10b as this site (oceanside of sheet piling) provides more representative data
Bold - indicated median value that exceed the ISQG-Low guideline
Grey highlight - indicates median value that exceeds the ISQG-High guideline

The breakdown of TBT in sediments has a half-life of 360 to 775 days in surficial sediments (Dowson *et al*, 1996), however the rate of breakdown is dependent on sediment

characteristics and temperatures. The MARPOL legislation on the use of TBT anti-fouling paint required commercial ships to cease application of TBT paints in September 2008. PoE only accepts vessels that are IMO registered and compliant with the MARPOL convention. Therefore, a gradual decline in TBT in sediments is expected, however the continued levels of TBT in sediments support the likelihood that ships still arrive at the Port with historical undercoats of TBT applied to their hulls.

5.4 Quality Assurance/Quality Control Results

Details of the laboratory and field QA/QC results are provided in Appendix C. Some of the field QA/QC showed % Relative Standard Deviation above 50% however, the results are still considered reliable, given that all sites had all triplicate results below the ISQG-Low value for the relevant analyte. The Relative Percentage Difference (RPD) comparing primary environmental samples sent to MAFRL to split samples sent to NMI laboratory showed variable compliance with the ±30 - 50% RPD range (AS4482.1, 2005). Split samples in 2016 were collected using three replicate samples at three sampling locations. Considering the variability between triplicate samples, RPDs outside the 30-50% RPD range should not affect the overall validity of the data for the purpose of the 2016 annual sediment monitoring.

5.5 Time Series Analysis

A t-test was conducted to detect any change in nickel and lead concentrations across the 15 inner harbour sites between the 2016 results and previous surveys in 2014, 2013, 2012, 2011 and 2010. As stated in the 2013 report, comparisons to results from 2007 and 2008 were confounded by the variable depths sampled in the earlier surveys.

Average values of nickel and lead concentrations for the 15 inner harbour sites between 2010 and 2016 are shown in Tables 8 (total nickel) and 9 (total lead). Results of the t-tests are presented in Tables 10 and 11. Raw and log10 transformed data was assessed for normal distribution using a histogram in Statistica. Subsequently, Log10 transformed was selected to conduct t-tests. A statistically significant difference was based on a p-value of less than 0.05 (<0.05). The raw output from Statistica is provided in Appendix A.

Table 8: Average Values (n = 3) for Total Nickel for T-tests

Sampling Site	Ni 2016	Ni 2014	Ni 2013	Ni 2012	Ni 2011	Ni 2010
	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
A8	28.7	60.00	20.67	26.3	28	32.0
A9	35.3	386.67	37.00	34.7	107	623.3
A10b	58.7	41.33	160.00	160.0	86	543.3
A12	6.1	3.07	4.73	4.0	7	3.1
A13	29.7	11.67	31.67	21.7	27	32.7
A14	12.0	40.33	29.00	13.7	46	58.0
A15	17.7	40.33	22.67	9.2	16	45.7
A16	31.7	37.67	36.00	41.3	28	112.7
A17	26.0	57.33	12.00	11.7	24	34.3
A18	11.8	32.33	6.30	3.2	14	10.3
A19	6.7	10.70	4.07	8.9	15	6.0
A20	19.3	29.33	16.00	17	32	38.3
A21	10.0	13.67	31.67	29.7	33	44.7
A22	2.5	8.10	1.37	22.7	2	2.6
A23	18.7	23.33	33.00	36.3	33	39.7
Mean	***20.98***	***53.06***	***29.74***	***29***	***33***	***108***

Note: Data in this table was not normally distributed. All data was Log10 transformed to provide a normally distributed data set prior to undertaking t-test

Table 9: Average Values (n = 3) for Total Lead for T-tests

Sampling Site	Pb 2016	Pb 2014	Pb 2013	Pb 2012	Pb 2011	Pb 2010
	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
A8	8.33	20.00	7.00	10.33	10.67	18.67
A9	12.00	14.33	17.00	20.33	39.33	210.00
A10b	9.00	26.00	47.00	65.67	58.67	326.67
A12	2.67	1.00	2.67	4.33	2.67	3.33
A13	6.67	4.33	7.67	8.67	8.67	10.00
A14	5.00	57.00	10.00	8.33	21.33	27.67
A15	5.33	20.67	7.00	7.00	7.33	21.33
A16	9.33	5.00	13.00	20.33	9.67	38.67
A17	8.33	20.33	5.67	6.67	11.00	16.33
A18	4.67	17.67	4.00	4.00	5.33	5.33
A19	1.33	4.33	2.00	6.67	11.67	3.00
A20	6.33	10.33	5.33	8.00	11.33	13.00
A21	4.33	6.67	11.67	12.00	14.33	18.33
A22	1.67	4.33	1.00	3.00	1.67	2.33
A23	5.67	8.33	11.00	13.00	12.00	15.00
Mean	***6.04***	***14.69***	***10.13***	***13.22***	***15.04***	***48.64***

Note: Data in this table was not normally distributed. All data was Log10 transformed to provide a normally distributed data set prior to undertaking t-test

5.5.1 T-test Inner Harbour Nickel Results

1. *Analyses of the 2016 data against the 2014, 2013, 2012, 2011 and 2010 data for all 15 inner harbour sites*

T-tests were conducted for average concentrations of nickel in the top 10cm of sediment for all 15 inner harbour sites in 2010, 2011, 2012, 2013, 2014 and 2016. T-test results comparing 2016 total nickel results against the previous year's results are provided below in Table 10. T-test results show that there was no significant difference ($p>0.05$) when comparing 2016 to 2014, 2013, 2012, 2011 and 2010 data.

Table 10: T-Test Results for all Inner Harbour Sites for Total Nickel

	t value	p value	df
Nickel 2016 vs. 2014	-1.63640	0.112950	28
Nickel 2016 vs. 2013	-0.148286	0.883180	28
Nickel 2016 vs. 2012	0.109724	0.913411	28
Nickel 2016 vs. 2011	-1.30162	0.203653	28
Nickel 2016 vs. 2010	-1.77385	0.086966	28
Note: All data was Log10 transformed to provide normal distribution of data			

Although patterns in total nickel are indicative of exposure, exposures of nickel to marine biota are measured via bioavailable concentrations. All bioavailable concentrations were below ISQG-Low values in 2016 and so are unlikely to present significant risks of toxicity.

5.5.2 T-test Inner Harbour Lead Results

The results for the t-test conducted for lead data (Table 9) for all 15 inner harbour sites are provided below in Table 11. There was a significant difference ($p<0.05$) for total lead concentrations in the top 10cm of sediment sampled at 15 inner harbour sites when comparing 2016 results to those of 2012, 2011 and 2010. There was no significant difference ($p>0.05$) for total lead when comparing 2016 results to 2014 and 2013 results. The Levene's t-test for equal variance for Pb 2016 vs Pb 2010 returned a Levene's p-value <0.05 (see Test 8, Appendix A), therefore the assumption that the two data sets have equal variance is rejected. A nonparametric equivalent to a t-test (Mann-Whitney U test) was undertaken which resulted in a similar p-value to that of the Levene's t-test (p-value of 0.00650) demonstrating a significant difference between lead data from 2016 vs 2010.

Concentrations of total lead were three fold higher in 2010 than in subsequent four surveys between 2011 and 2014 (refer to Table 9). A decrease in mean total lead concentrations can be seen from 2011, 2012 and 2016 with an increase in 2014, following a maintenance dredging event. The significant difference between 2016 results (when compared to 2012, 2011 and 2010 results), shows a pattern of decreasing total lead concentrations in the 15 inner harbor site marine sediments. Although patterns in total lead are indicative of exposure, exposures of lead to marine biota are measured via bioavailable concentrations. All bioavailable concentrations were below ISQG-Low values and so are unlikely to present significant risks of toxicity.

Table 11: T-Test Results for all Inner Harbour Sites for Total Lead

	t value	**p value**	**df**
Lead 2016 vs. 2014	-1.09149	0.284362	28
Lead 2016 vs. 2013	-1.09149	0.284362	28
Lead 2016 vs. 2012	-2.35165	***0.025957***	28
Lead 2016 vs. 2011	-2.55849	***0.016209***	28
Lead 2016 vs. 2010	-2.94407	***0.006448***	28
Lead 2016 vs. 2010 (Mann-Whitney U test)	n/a	***0.006580***	n/a

Note:
All data was Log10 transformed prior to undertaking t-test to provide normal distribution of data
Bold red indicates p values <0.05, therefore statistically different
All statistical tests performed were Levene's t-test unless otherwise specified

6 CONCLUSION

Levels of contamination of metals (particularly nickel and lead) in the top 10cm of sediment in the inner and outer harbour sites were all below ISQG-Low values and therefore are unlikely to present a significant risk of toxicity to marine biota.

Despite the increase in contamination at marine sediments in some inner harbour locations during the October 2014 monitoring program (following dredging works in July-August 2014), contamination levels in marine sediments sampled in July 2016 showed an overall decrease since the 2014 monitoring event, as a likely result of the redistribution of sediments from the movement of ships into and out of the harbour and natural accretion. Furthermore, concentrations of both contaminants decreased to five to eight-fold below levels recorded in 2010 and bioavailable concentrations of metals did not present significant risks of toxicity to marine biota. No triggers for contingency actions were activated. The 2008 ban on TBT applications and entry of IMO-registered only vessels will ensure the eventual decline of TBT exposures to marine biota.

7 RISK MANAGEMENT AND RECOMMENDATIONS

7.1 Actions taken since 2014 Annual Sediment Monitoring

1. Cleaning procedures on the multi-user Berth 2 have been upgraded and continue to be reviewed for additional improvements. These improvements aim to reduce the potential for nickel (containerised export), bulk sulphur and bulk fertiliser contaminated water from entering the harbour;

2. Four marine sediment monitoring sites were moved in 2016 with new locations recorded. The relocated sites include:

    a. A5 was moved approximately 200m west nor west into the shipping channel. The previous location on the batter slope of the shipping channel contained a high volume of shells and seagrass fragments, making it difficult for divers to collect the full 10cm core.

    b. A7 was moved approximately 340m to the north nor east towards the Tanker Jetty. Dense seagrass coverage was found in the proximity of A7, the new location was selected as it was the only area in the vicinity which provided enough exposed sand to collect samples.

    c. A11 was moved approximately 130m north nor west into the shipping channel. High proportion of shells and a rocky limestone bottom encountered at this location on the batter slope of the channel in previous monitoring years had made it difficult for divers to collect the full 10cm sample.

    d. A12 was moved approximately 150m north west into the turning basin. Sampling at this location had proven difficult in previous years due to scouring of sediment from ships propellers exposing the rocky limestone harbour floor.

7.2 Further actions to be taken

1. Aim to complete maintenance dredging that removes the remaining contaminated sediments at the berth pockets (disposal to land) in the coming years. Timing of

these works will be dependent on a number of factors including bathymetry surveys, availability of a suitable vessel and timing of other capital PoE projects;

2. Reduce potential for future nickel contamination of the marine sediments by continuing to receive nickel products within sealed containers to reduce the potential for nickel entering the marine environment; and

3. Continue to monitor the quality of sample volume at each site and propose changes to monitoring locations as required to enable full sample collection and provide a representative sample.

8 REFERENCES

ANZECC-ARMCANZ, 2000. *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*, Australian and New Zealand Environment and Conservation Council/Agriculture and Resource Management Council of Australia and New Zealand, National Water Quality Management Strategy No. 4.

AS 4482.1 - 2005. Australian Standard: Guide to the sampling and investigation of potentially contaminated soil. Part 1: Non-volatile and semi-volatile compounds.

AS/NZS 4122: 2000. Australian Standard: General Conditions of Contract for Engagement of Consultants

AS/NZS 5667.12:1999 Australian/New Zealand Standard™ ISO 5667-12:1995. Water quality - Sampling Part 12: Guidance on sampling of bottom sediments.

Commonwealth of Australia, 2009. *National Assessment Guidelines for Dredging*. Canberra.

Dowson P.H, Bubb J.M & Lester J.N, 1996: *Persistence and Degradation Pathways of Tributyltin in Freshwater and Estuarine Sediments*. Estuarine, Coastal and Shelf Science vol 42 issue 5 pp 551-562

Negri, A & Marshall, P, 2009: *TBT contamination of remote marine environments: Ship groundings and icebreakers as sources of organotins in the Great Barrier Reef and Antarctica.* Journal of Environmental Management 90 (2009) S31-S40. Australian Institute of Marine Science Townsville QLD

Environment Australia, 2002. *National Ocean Disposal Guidelines for Dredged Material. Commonwealth of Australia*, May 2002.

Oceanica, 2009a. Comprehensive Sediment Monitoring and Reporting Plan March 2009. A report prepared for EPSL by Oceanica Consultants. Esperance Port. Report No. 606_003/1

Oceanica, 2009b. Esperance Port 2008 Annual Sediment Sampling. Sampling and Analysis (SAP) Implementation Report. Prepared for Esperance Port Authority by Oceanica Consulting Pty Ltd. Report No. 606_002/2.

Oceanica, 2010. *Esperance Port Survey of Lead and Nickel in Marine Sediments, Level (Stage) 3 Ecological Risk Assessment Report,* prepared for Esperance Port Authority by Oceanica Consulting Pty Ltd, Report No. 606_001/2.

9 APPENDICES

9.1 Appendix A - T-test Results from Statistica

T-Tests comparing Data for all 15 inner harbour sites

Note: For all tests, T-test for independent samples. Variables were treated as independent samples. All data was Log10 transformed to provide normally distributed data sets

Test 1: Levene's T-test for mean total Nickel results comparing 2016 and 2014 data for 15 inner harbour sites

Group 1 vs. Group 2	Mean Group 1	Mean Group 2	t-value	df	p	Valid N Group 1	Valid N Group 2	Std.Dev. Group 1	Std.Dev. Group 2	F-ratio Variances	p Variances	Levene F(1,df)	df Levene	p Levene
Ni 2016 vs. Ni 2014	1.231650	1.472170	-1.63640	28	0.112950	15	15	0.329643	0.464102	1.982156	0.212901	0.749498	28	0.393993

Test 2: Levene's T-test for mean total Nickel results comparing 2016 and 2013 data for 15 inner harbour sites

Group 1 vs. Group 2	Mean Group 1	Mean Group 2	t-value	df	p	Valid N Group 1	Valid N Group 2	Std.Dev. Group 1	Std.Dev. Group 2	F-ratio Variances	p Variances	Levene F(1,df)	df Levene	p Levene
Ni 2016 vs. Ni 2013	1.231650	1.253449	-0.148286	28	0.883180	15	15	0.329643	0.464216	1.983135	0.212577	1.569888	28	0.220586

Test 3: Levene's T-test for mean total Nickel results comparing 2016 and 2012 data for 15 inner harbour sites

Group 1 vs. Group 2	Mean Group 1	Mean Group 2	t-value	df	p	Valid N Group 1	Valid N Group 2	Std.Dev. Group 1	Std.Dev. Group 2	F-ratio Variances	p Variances	Levene F(1,df)	df Levene	p Levene
Ni 2016 vs. Ni 2012	1.231650	1.215395	0.109724	28	0.913411	15	15	0.329643	0.469620	2.029573	0.197802	1.091110	28	0.305160

Test 4: Levene's T-test for mean total Nickel results comparing 2016 and 2011 data for 15 inner harbour sites

Group 1 vs. Group 2	Mean Group 1	Mean Group 2	t-value	df	p	Valid N Group 1	Valid N Group 2	Std.Dev. Group 1	Std.Dev. Group 2	F-ratio Variances	p Variances	Levene F(1,df)	df Levene	p Levene
Ni 2016 vs. Ni 2011	1.231650	1.398505	-1.30162	28	0.203653	15	15	0.329643	0.371249	1.268356	0.662569	0.001232	28	0.972253

Test 5: Levene's T-test for mean total nickel results comparing 2016 and 2010 data for 15 inner harbour sites

Group 1 vs. Group 2	Mean Group 1	Mean Group 2	t-value	df	p	Valid N Group 1	Valid N Group 2	Std.Dev. Group 1	Std.Dev. Group 2	F-ratio Variances	p Variances	Levene F(1,df)	df Levene	p Levene
Ni 2016 vs. Ni 2010	1.231650	1.564238	-1.77385	28	0.086966	15	15	0.329643	0.647035	3.852717	0.016626	1.900686	28	0.178917

Test 6: Levene's T-test for mean total Lead results comparing 2016 and 2014 data for 15 inner harbour sites

Group 1 vs. Group 2	Mean Group 1	Mean Group 2	t-value	df	p	Valid N Group 1	Valid N Group 2	Std.Dev. Group 1	Std.Dev. Group 2	F-ratio Variances	p Variances	Levene F(1,df)	df Levene	p Levene
Pb 2016 vs. Pb 2014	0.799329	0.911780	-1.09149	28	0.284362	15	15	0.214554	0.336423	2.458660	0.103720	1.545161	28	0.224160

Test 7: Levene's T-test for mean total Lead results comparing 2016 and 2013 data for 15 inner harbour sites

Group 1 vs. Group 2	Mean Group 1	Mean Group 2	t-value	df	p	Valid N Group 1	Valid N Group 2	Std.Dev. Group 1	Std.Dev. Group 2	F-ratio Variances	p Variances	Levene F(1,df)	df Levene	p Levene
Pb 2016 vs. Pb 2013	0.799329	0.911780	-1.09149	28	0.284362	15	15	0.214554	0.336423	2.458660	0.103720	1.545161	28	0.224160

Test 8: Levene's T-test for mean total Lead results comparing 2016 and 2012 data for 15 inner harbour sites

Group 1 vs. Group 2	Mean Group 1	Mean Group 2	t-value	df	p	Valid N Group 1	Valid N Group 2	Std.Dev. Group 1	Std.Dev. Group 2	F-ratio Variances	p Variances	Levene F(1,df)	df Levene	p Levene
Pb 2016 vs. Pb 2012	0.799329	1.023289	-2.35165	28	0.025957	15	15	0.214554	0.300021	1.955382	0.221968	0.741378	28	0.396533

Test 9: Levene's T-test for mean total Lead results comparing 2016 and 2011 data for 15 inner harbour sites

Group 1 vs. Group 2	Mean Group 1	Mean Group 2	t-value	df	p	Valid N Group 1	Valid N Group 2	Std.Dev. Group 1	Std.Dev. Group 2	F-ratio Variances	p Variances	Levene F(1,df)	df Levene	p Levene
Pb 2016 vs. Pb 2011	0.799329	1.066817	-2.55849	28	0.016209	15	15	0.214554	0.343401	2.561722	0.089336	0.832846	28	0.369242

Test 8: Levene's T-test for mean total Lead results comparing 2016 and 2010 data for 15 inner harbour sites

Group 1 vs. Group 2	Mean Group 1	Mean Group 2	t-value	df	p	Valid N Group 1	Valid N Group 2	Std.Dev. Group 1	Std.Dev. Group 2	F-ratio Variances	p Variances	Levene F(1,df)	df Levene	p Levene
Pb 2016 vs. Pb 2010	0.799329	1.260267	-2.94407	28	0.006448	15	15	0.214554	0.567146	6.987438	0.000828	4.383205	28	0.045473

Test 9: Mann-Whitney U Test for mean total Lead results comparing 2016 and 2010 data for 15 inner harbour sites

variable	Rank Sum Group 1	Rank Sum Group 2	U	Z	p-value	Z adjusted	p-value	Valid N Group 1	Valid N Group 2	2*1sided exact p
Pb 2016 & 2010	166.5000	298.5000	46.50000	-2.71681	0.006592	-2.71742	0.006580	15	15	0.004940

Mann-Whitney U Test (Spreadsheet10)By variable year codeMarked tests are significant at p <.05000

T-Tests comparing data for sites which exceeded ISQG-Low in 2010

Test 10: Levene's T-test for mean total Nickel results comparing 2016 and 2014 for 10 Inner Harbour Sites

	Mean Group 1	Mean Group 2	t-value	df	p	Valid N Group 1	Valid N Group 2	Std.Dev. Group 1	Std.Dev. Group 2	F-ratio Variances	p Variances	Levene F(1,df)	df Levene	p Levene
Ni 2016 vs. Ni 2014	1.410713	1.591708	-1.31428	18	0.205254	10	10	0.193922	0.389930	4.043151	0.049351	1.282904	18	0.272223

Test 11: Levene's T-test for mean total Nickel results comparing 2016 and 2013 for 10 Inner Harbour Sites

	Mean Group 1	Mean Group 2	t-value	df	p	Valid N Group 1	Valid N Group 2	Std.Dev. Group 1	Std.Dev. Group 2	F-ratio Variances	p Variances	Levene F(1,df)	df Levene	p Levene
Ni 2016 vs. Ni 2013	1.410713	1.465029	-0.441399	18	0.664181	10	10	0.193922	0.337367	3.026576	0.114521	0.652016	18	0.429935

Test 12: Levene's T-test for mean total Nickel results comparing 2016 and 2012 for 10 Inner Harbour Sites

	Mean Group 1	Mean Group 2	t-value	df	p	Valid N Group 1	Valid N Group 2	Std.Dev. Group 1	Std.Dev. Group 2	F-ratio Variances	p Variances	Levene F(1,df)	df Levene	p Levene
Ni 2016 vs. Ni 2012	1.410713	1.450797	-0.332175	18	0.743594	10	10	0.193922	0.328652	2.872232	0.131884	1.061897	18	0.316431

Test 13: Levene's T-test for mean total Nickel results comparing 2016 and 2011 for 10 Inner Harbour Sites

	Mean Group 1	Mean Group 2	t-value	df	p	Valid N Group 1	Valid N Group 2	Std.Dev. Group 1	Std.Dev. Group 2	F-ratio Variances	p Variances	Levene F(1,df)	df Levene	p Levene
Ni 2016 vs. Ni 2011	1.410713	1.550355	-1.42377	18	0.171618	10	10	0.193922	0.242052	1.557993	0.519336	0.153706	18	0.699622

Test 14: Levene's T-test for mean total Nickel results comparing 2016 and 2010 for 10 Inner Harbour Sites

	Mean Group 1	Mean Group 2	t-value	df	p	Valid N Group 1	Valid N Group 2	Std.Dev. Group 1	Std.Dev. Group 2	F-ratio Variances	p Variances	Levene F(1,df)	df Levene	p Levene
Ni 2016 vs. Ni 2010	1.410713	1.864161	-2.70024	18	0.014644	10	10	0.193922	0.494363	6.498888	0.010231	7.036576	18	0.016198

Test 15: Mann-Whitney U Test for mean total Nickel results comparing 2016 and 2010 for 10 Inner Harbour Sites

	Rank Sum Group 1	Rank Sum Group 2	U	Z	p-value	Z adjusted	p-value	Valid N Group 1	Valid N Group 2	2*1sided exact p
Ni	65.00000	145.0000	10.00000	-2.98592	0.002827	-2.98592	0.002827	10	10	0.001505

9.2 Appendix B – Laboratory Reports

Marine and Freshwater
Research Laboratory
Environmental Science
Tel: +61 8 93602907 Address: 90 South St, Murdoch, WA, 6150

Accreditation Number: 10603
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Murdoch UNIVERSITY

SEDIMENT DATA

Contact: Caroline Aylott
Customer: Southern Ports Authority
Address: Crn Bower Avenue and The Esplande, Esperance 6450

Date of Issue: 17/08/2016
Date Received: 19/07/2016
Our Reference: SPA16-1
Your Reference: 152686

METHOD SAMPLE CODE	Sampling Date	ICP002 Total Ext As mg/kg	ICP002 Total Ext Cd mg/kg	ICP002 Total Ext Cr mg/kg	ICP002 Total Ext Cu mg/kg	ICP002 Total Ext Mn mg/kg	ICP002 Total Ext Ni mg/kg	ICP002 Total Ext Pb mg/kg	ICP002 Total Ext S mg/kg	ICP002 Total Ext Zn mg/kg
Reporting Limit		<2	<0.1	<0.2	<0.2	<0.05	<0.7	<1	<10	<0.5
File		16080401	16080401	16080401	16080401	16080401	16080401	16080401-1201	16080401	16080401
A5-1	13/07/2016	3	<0.1	7.4	1.5	9.5	3.6	1	1500	2.4
A5-2	13/07/2016	2	0.1	6.3	1.3	8.2	3.7	1	1300	2.3
A5-3	13/07/2016	3	0.1	6.6	1.6	8.4	3.7	1	1300	2.4
A6-1	14/07/2016	3	<0.1	6.8	0.4	9.4	1.1	<1	1200	1.4
A6-2	14/07/2016	3	<0.1	6.7	0.3	8.5	0.9	<1	1200	0.9
A6-3	14/07/2016	2	<0.1	7.0	0.4	9.2	0.9	<1	1100	1.0
A7-1	13/07/2016	3	<0.1	3.7	0.3	4.8	<0.7	<1	930	1.1
A7-2	13/07/2016	<2	<0.1	6.6	0.3	6.1	<0.7	<1	910	1.2
A7-3	13/07/2016	2	<0.1	3.9	0.3	5.5	<0.7	<1	900	1.3
A8-1	11/07/2016	3	0.1	9.0	13	11	26	8	2100	12
A8-2	11/07/2016	4	0.2	9.4	12	11	30	9	2200	16
A8-3	11/07/2016	3	0.1	8.7	11	11	30	8	2100	14
A9-1	12/07/2016	2	0.1	8.7	5.3	7.7	34	13	1600	14
A9-2	12/07/2016	<2	0.2	8.5	10	7.3	45	15	1500	14
A9-3	12/07/2016	2	0.1	8.5	4.0	7.2	27	8	1600	34
A10b-1	11/07/2016	4	0.1	8.7	13	8.7	68	8	2000	17
A10b-2	11/07/2016	3	0.1	8.1	7.1	8.1	34	6	1600	21
A10b-3	11/07/2016	5	0.2	9.9	15	9.6	74	13	2400	26
A11-1	14/07/2016	3	0.2	8.5	2.7	9.6	6.3	2	1700	4.1
A11-2	14/07/2016	3	0.1	8.9	2.7	10	7.8	3	1800	4.2
A11-3	14/07/2016	4	0.1	8.9	14	10	6.4	2	1700	4.3

All test items tested as received. Spare test items will be held for two months unless otherwise requested.

Signatory: Jamie Woodward
Date: 17/08/2016

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Reporting Limit		<2	<0.1	<0.2	<0.2	<0.05	<0.7	<1	<10	<0.5
File		16080401	16080401	16080401	16080401	16080401	16080401	16080401-1201	16080401	16080401
A12-1	14/07/2016	<2	<0.1	6.0	1.1	7.0	4.3	2	980	2.2
A12-2	14/07/2016	3	<0.1	6.3	2.1	6.8	8.1	3	1100	2.7
A12-3	14/07/2016	<2	<0.1	6.1	1.1	7.0	6.0	3	1000	2.1
A13-1	17/07/2016	4	0.2	9.7	9.5	10	31	7	2100	13
A13-2	17/07/2016	3	0.1	9.7	9.8	9.5	30	7	2100	13
A13-3	17/07/2016	3	0.1	9.0	8.4	9.1	28	6	1900	12
A14-1	12/07/2016						12	5		
A14-2	12/07/2016						11	5		
A14-3	12/07/2016						13	5		
A15-1	11/07/2016						17	5		
A15-2	11/07/2016						19	6		
A15-3	11/07/2016						17	5		
A16-1	12/07/2016						36	10		
A16-2	12/07/2016						35	10		
A16-3	12/07/2016						24	8		
A17-1	12/07/2016						23	8		
A17-2	12/07/2016						26	9		
A17-3	12/07/2016						29	8		
A18-1	13/07/2016						18	6		
A18-2	13/07/2016						9.6	5		
A18-3	13/07/2016						7.7	3		

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Reporting Limit		<2	<0.1	<0.2	<0.2	<0.05	<0.7	<1	<10	<0.5
File		16080401	16080401	16080401	16080401	16080401	16080401	16080401-1201	16080401	16080401
A19-1	13/07/2016						2.4	1		
A19-2	13/07/2016						14	1		
A19-3	13/07/2016						3.7	2		
A20-1	13/07/2016						22	7		
A20-2	13/07/2016						17	6		
A20-3	13/07/2016						19	6		
A21-1	12/07/2016						9.2	4		
A21-2	12/07/2016						9.7	4		
A21-3	12/07/2016						11	5		
A22-1	11/07/2016						3.0	2		
A22-2	11/07/2016						2.3	2		
A22-3	11/07/2016						2.1	1		
A23-1	11/07/2016						19	6		
A23-2	11/07/2016						20	6		
A23-3	11/07/2016						17	5		
Black Organic - 1	13/07/2016	10	0.3	21	76	25	230	56	6100	94
Black Organic - 2	14/07/2016	11	0.3	23	75	24	210	49	8000	92

Note: Results expressed as dry weight basis

Signatory: Jamie Woodward
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Reporting Limit		<2	<0.1	<0.2	<0.2	<0.05	<0.7	<1	<10	<0.5
File		16080301	16080301	16080301	16080301	16080301	16080301	16080301-1201	16080301	16080301
A5-1	13/07/2016	3	<0.1	6.1	0.7	6.5	<0.7	1	1300	1.2
A5-2	13/07/2016	3	<0.1	5.5	0.6	5.8	<0.7	1	1200	1.2
A5-3	13/07/2016	3	<0.1	5.8	0.6	6.2	<0.7	1	1200	1.2
A6-1	14/07/2016	2	<0.1	5.7	0.2	6.0	<0.7	<1	1000	0.5
A6-2	14/07/2016	3	<0.1	5.6	<0.2	5.6	<0.7	<1	1000	<0.5
A6-3	14/07/2016	2	<0.1	5.5	0.2	5.7	<0.7	<1	960	<0.5
A7-1	13/07/2016	2	<0.1	3.5	<0.2	4.1	<0.7	<1	840	<0.5
A7-2	13/07/2016	<2	<0.1	3.4	<0.2	3.8	<0.7	<1	700	<0.5
A7-3	13/07/2016	2	<0.1	3.7	<0.2	5.1	<0.7	<1	790	0.6
A8-1	11/07/2016	<2	<0.1	5.4	3.5	6.1	2.0	7	1200	5.1
A8-2	11/07/2016	<2	0.1	5.7	4.1	6.3	2.2	7	1300	6.5
A8-3	11/07/2016	2	0.1	5.3	3.9	6.2	2.0	7	1300	5.6
A9-1	12/07/2016	<2	0.1	7.5	1.6	5.1	2.3	10	1200	4.1
A9-2	12/07/2016	<2	<0.1	6.4	1.6	4.5	2.3	10	1000	3.5
A9-3	12/07/2016	<2	0.1	6.8	1.2	4.6	2.0	7	1100	6.9
A10b-1	11/07/2016	<2	0.1	5.9	3.7	4.9	5.7	8	1100	7.5
A10b-2	11/07/2016	<2	<0.1	6.1	2.2	4.8	2.6	5	1100	5.8
A10b-3	11/07/2016	2	0.2	6.2	4.2	5.2	4.8	12	1300	11
A11-1	14/07/2016	3	0.2	6.9	1.0	7.4	0.9	2	1400	1.9
A11-2	14/07/2016	2	<0.1	6.7	1.0	7.2	0.7	2	1400	1.7
A11-3	14/07/2016	2	0.1	6.8	1.1	7.4	0.9	2	1300	1.5

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Date of Issue: 17/08/2016
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METHOD SAMPLE CODE	Sampling Date	ICP002 Dilute Acid As mg/kg	ICP002 Dilute Acid Cd mg/kg	ICP002 Dilute Acid Cr mg/kg	ICP002 Dilute Acid Cu mg/kg	ICP002 Dilute Acid Mn mg/kg	ICP002 Dilute Acid Ni mg/kg	ICP002 Dilute Acid Pb mg/kg	ICP002 Dilute Acid S mg/kg	ICP002 Dilute Acid Zn mg/kg
Reporting Limit		<2	<0.1	<0.2	<0.2	<0.05	<0.7	<1	<10	<0.5
File		16080301	16080301	16080301	16080301	16080301	16080301	16080301-1201	16080301	16080301
A12-1	14/07/2016	<2	<0.1	4.1	0.5	3.5	0.8	1	710	1.0
A12-2	14/07/2016	<2	<0.1	4.6	0.7	3.7	1.3	3	800	1.3
A12-3	14/07/2016	<2	<0.1	4.3	0.5	3.3	<0.7	3	740	1.0
A13-1	17/07/2016	<2	0.1	6.5	2.7	5.7	2.5	6	1400	6.3
A13-2	17/07/2016	3	0.1	6.9	2.9	6.1	2.8	6	1400	6.8
A13-3	17/07/2016	<2	0.1	6.5	2.7	5.8	2.7	5	1300	6.3
A14-1	12/07/2016						2.0	6		
A14-2	12/07/2016						1.6	3		
A14-3	12/07/2016						1.7	4		
A15-1	11/07/2016						1.4	5		
A15-2	11/07/2016						1.8	5		
A15-3	11/07/2016						1.7	5		
A16-1	12/07/2016						2.3	10		
A16-2	12/07/2016						2.4	10		
A16-3	12/07/2016						2.0	7		
A17-1	12/07/2016						1.9	8		
A17-2	12/07/2016						2.1	6		
A17-3	12/07/2016						2.2	8		
A18-1	13/07/2016						1.0	4		
A18-2	13/07/2016						0.7	3		
A18-3	13/07/2016						0.9	3		

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Signatory: Jamie Woodward
Date: 17/08/2016

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METHOD SAMPLE CODE	Sampling Date	ICP002 Dilute Acid As mg/kg	ICP002 Dilute Acid Cd mg/kg	ICP002 Dilute Acid Cr mg/kg	ICP002 Dilute Acid Cu mg/kg	ICP002 Dilute Acid Mn mg/kg	ICP002 Dilute Acid Ni mg/kg	ICP002 Dilute Acid Pb mg/kg	ICP002 Dilute Acid S mg/kg	ICP002 Dilute Acid Zn mg/kg
Reporting Limit		<2	<0.1	<0.2	<0.2	<0.05	<0.7	<1	<10	<0.5
File		16080301	16080301	16080301	16080301	16080301	16080301	16080301-1201	16080301	16080301
A19-1	13/07/2016						<0.7	<1		
A19-2	13/07/2016						1.7	1		
A19-3	13/07/2016						0.7	2		
A20-1	13/07/2016						1.2	4		
A20-2	13/07/2016						1.4	6		
A20-3	13/07/2016						1.8	6		
A21-1	12/07/2016						1.2	3		
A21-2	12/07/2016						1.5	4		
A21-3	12/07/2016						2.2	4		
A22-1	11/07/2016						<0.7	<1		
A22-2	11/07/2016						<0.7	<1		
A22-3	11/07/2016						<0.7	<1		
A23-1	11/07/2016						2.1	5		
A23-2	11/07/2016						2.2	6		
A23-3	11/07/2016						1.9	5		
Black Organic - 1	13/07/2016	4	0.2	8.4	24	13	16	55	2700	39
Black Organic - 2	14/07/2016	4	0.2	8.0	24	13	14	49	4200	33

Note: Results expressed as dry weight basis

Signatory: Jamie Woodward
Date: 17/08/2016

All test items tested as received. Spare test items will be held for two months unless otherwise requested.

REPORT OF ANALYSIS

Client	: SOUTHERN PORTS AUTHORITY	Job No.	: SOUT97_W/160719
	CORNER BOWER AVENUE & THE ESPLANADE	Quote No.	: QT-02002
	ESPERANCE WA 6450	Order No.	: 152532
		Date Sampled	: 10-JUL-2016
		Date Received	: 19-JUL-2016
Attention	: CAROLINE AYLOTT	Sampled By	: CLIENT
Project Name :			
Your Client Services Manager	: David Lynch	Phone	: (08) 9368 8400

Lab Reg No.	Sample Ref	Sample Description
W16/012929	A8-1	MARINE SEDIMENT 11/07/16
W16/012930	A9-1	MARINE SEDIMENT 12/07/16
W16/012931	A10b-1	MARINE SEDIMENT 11/07/16
W16/012932	A8-1	MARINE SEDIMENT 11/07/16

Lab Reg No.		W16/012929	W16/012930	W16/012931	W16/012932	
Sample Reference	Units	A8-1	A9-1	A10b-1	A8-1	Method
Organotins						
Monobutyltin as Sn	ng/g	< 0.5	< 0.5	0.73	Not Tested	NR_35
Dibutyltin as Sn	ng/g	1.3	< 0.5	2.6	Not Tested	NR_35
Tributyltin as Sn	ng/g	1.9	2.1	12	Not Tested	NR_35
Surrogate: Tripropyltin	%REC	70	90	87	Not Tested	NR_35
Dates						
Date extracted		29-JUL-2016	29-JUL-2016	29-JUL-2016	Not Tested	
Date analysed		2-AUG-2016	2-AUG-2016	2-AUG-2016	Not Tested	

Danny Slee, Section Manager
Organic - NSW
Accreditation No. 198

15-DEC-2016

Lab Reg No.		W16/012929	W16/012930	W16/012931	W16/012932	
Sample Reference	Units	A8-1	A9-1	A10b-1	A8-1	Method
Trace Elements						
Arsenic - Bioavailable	mg/kg	Not Tested	Not Tested	Not Tested	0.64	NT2_49B
Cadmium - Bioavailable	mg/kg	Not Tested	Not Tested	Not Tested	< 0.5	NT2_49B
Chromium - Bioavailable	mg/kg	Not Tested	Not Tested	Not Tested	7	NT2_49B
Copper - Bioavailable	mg/kg	Not Tested	Not Tested	Not Tested	4.1	NT2_49B
Total Solids	%	71.1	76.3	74.3	Not Tested	NT2_49

REPORT OF ANALYSIS

Lab Reg No.		W16/012929	W16/012930	W16/012931	W16/012932	
Sample Reference	Units	A8-1	A9-1	A10b-1	A8-1	Method
Trace Elements						
Lead - Bioavailable	mg/kg	Not Tested	Not Tested	Not Tested	7.5	NT2_49B
Manganese - Bioavailable	mg/kg	Not Tested	Not Tested	Not Tested	7.3	NT2_49B
Nickel - Bioavailable	mg/kg	Not Tested	Not Tested	Not Tested	2.5	NT2_49B
Sulphur - Bioavailable	mg/kg	Not Tested	Not Tested	Not Tested	1250	NT2_49B
Zinc - Bioavailable	mg/kg	Not Tested	Not Tested	Not Tested	6.4	NT2_49B

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Lab Reg No.		W16/012929	W16/012930	W16/012931	W16/012932	
Sample Reference	Units	A8-1	A9-1	A10b-1	A8-1	Method
Miscellaneous						
Carbon - Total Organic	mg/kg	6700	1800	4600	Not Tested	NW_S15

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Lab Reg No.		W16/012929	W16/012930	W16/012931	W16/012932	
Sample Reference	Units	A8-1	A9-1	A10b-1	A8-1	Method
Inorganics						
Moisture	%	Not Tested	Not Tested	Not Tested	32	WL170
Trace Elements						
Arsenic	mg/kg	Not Tested	Not Tested	Not Tested	2.6	WL273
Cadmium	mg/kg	Not Tested	Not Tested	Not Tested	< 0.4	WL273
Chromium	mg/kg	Not Tested	Not Tested	Not Tested	8.2	WL273
Copper	mg/kg	Not Tested	Not Tested	Not Tested	10	WL273
Lead	mg/kg	Not Tested	Not Tested	Not Tested	6.9	WL273

REPORT OF ANALYSIS

Lab Reg No.		W16/012929	W16/012930	W16/012931	W16/012932	
Sample Reference	Units	A8-1	A9-1	A10b-1	A8-1	Method
Trace Elements						
Manganese	mg/kg	Not Tested	Not Tested	Not Tested	8.8	WL273
Nickel	mg/kg	Not Tested	Not Tested	Not Tested	27	WL273
Sulfur	mg/kg	Not Tested	Not Tested	Not Tested	4200	WL273
Zinc	mg/kg	Not Tested	Not Tested	Not Tested	14	WL273

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REPORT OF ANALYSIS

Client	: SOUTHERN PORTS AUTHORITY	Job No.	: SOUT97_W/160719
	CORNER BOWER AVENUE & THE ESPLANADE	Quote No.	: QT-02002
	ESPERANCE WA 6450	Order No.	: 152532
		Date Sampled	: 10-JUL-2016
		Date Received	: 19-JUL-2016
Attention	: CAROLINE AYLOTT	Sampled By	: CLIENT
Project Name :			
Your Client Services Manager	: David Lynch	Phone	: (08) 9368 8400

Lab Reg No.	Sample Ref	Sample Description
W16/012933	A8-2	MARINE SEDIMENT 11/07/16
W16/012934	A8-3	MARINE SEDIMENT 11/07/16
W16/012935	A14-1	MARINE SEDIMENT 12/07/16
W16/012936	A14-2	MARINE SEDIMENT 12/07/16

Lab Reg No.		W16/012933	W16/012934	W16/012935	W16/012936	
Sample Reference	Units	A8-2	A8-3	A14-1	A14-2	Method
Organotins						
Monobutyltin as Sn	ng/g	Not Tested	Not Tested	Not Tested	Not Tested	NR_35
Dibutyltin as Sn	ng/g	Not Tested	Not Tested	Not Tested	Not Tested	NR_35
Tributyltin as Sn	ng/g	Not Tested	Not Tested	Not Tested	Not Tested	NR_35
Surrogate: Tripropyltin	%REC	Not Tested	Not Tested	Not Tested	Not Tested	NR_35
Dates						
Date extracted		Not Tested	Not Tested	Not Tested	Not Tested	
Date analysed		Not Tested	Not Tested	Not Tested	Not Tested	

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Lab Reg No.		W16/012933	W16/012934	W16/012935	W16/012936	
Sample Reference	Units	A8-2	A8-3	A14-1	A14-2	Method
Trace Elements						
Arsenic - Bioavailable	mg/kg	0.55	0.56	Not Tested	Not Tested	NT2_49B
Cadmium - Bioavailable	mg/kg	< 0.5	< 0.5	Not Tested	Not Tested	NT2_49B
Chromium - Bioavailable	mg/kg	6.4	6.6	Not Tested	Not Tested	NT2_49B
Copper - Bioavailable	mg/kg	3.7	4	Not Tested	Not Tested	NT2_49B
Total Solids	%	Not Tested	Not Tested	Not Tested	Not Tested	NT2_49

REPORT OF ANALYSIS

Lab Reg No.		W16/012933	W16/012934	W16/012935	W16/012936	
Sample Reference	Units	A8-2	A8-3	A14-1	A14-2	Method
Trace Elements						
Lead - Bioavailable	mg/kg	8.6	8.3	5	4.1	NT2_49B
Manganese - Bioavailable	mg/kg	6.6	6.9	Not Tested	Not Tested	NT2_49B
Nickel - Bioavailable	mg/kg	2.4	2.6	1.9	1.7	NT2_49B
Sulphur - Bioavailable	mg/kg	1280	1260	Not Tested	Not Tested	NT2_49B
Zinc - Bioavailable	mg/kg	6.1	6.8	Not Tested	Not Tested	NT2_49B

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Lab Reg No.		W16/012933	W16/012934	W16/012935	W16/012936	
Sample Reference	Units	A8-2	A8-3	A14-1	A14-2	Method
Miscellaneous						
Carbon - Total Organic	mg/kg	Not Tested	Not Tested	Not Tested	Not Tested	NW_S15

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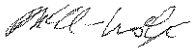
Lab Reg No.		W16/012933	W16/012934	W16/012935	W16/012936	
Sample Reference	Units	A8-2	A8-3	A14-1	A14-2	Method
Inorganics						
Moisture	%	34	33	27	28	WL170
Trace Elements						
Arsenic	mg/kg	2.1	2.4	Not Tested	Not Tested	WL273
Cadmium	mg/kg	< 0.4	< 0.4	Not Tested	Not Tested	WL273
Chromium	mg/kg	8.9	8.9	Not Tested	Not Tested	WL273
Copper	mg/kg	13	13	Not Tested	Not Tested	WL273
Lead	mg/kg	8.1	7.0	5.1	4.3	WL273

REPORT OF ANALYSIS

Lab Reg No.		W16/012933	W16/012934	W16/012935	W16/012936	
Sample Reference	Units	A8-2	A8-3	A14-1	A14-2	Method
Trace Elements						
Manganese	mg/kg	9.4	9.3	Not Tested	Not Tested	WL273
Nickel	mg/kg	31	28	16	13	WL273
Sulfur	mg/kg	4700	4000	Not Tested	Not Tested	WL273
Zinc	mg/kg	17	17	Not Tested	Not Tested	WL273



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REPORT OF ANALYSIS

Client	: SOUTHERN PORTS AUTHORITY	Job No.	: SOUT97_W/160719
	CORNER BOWER AVENUE & THE ESPLANADE	Quote No.	: QT-02002
	ESPERANCE WA 6450	Order No.	: 152532
		Date Sampled	: 11-JUL-2016
		Date Received	: 19-JUL-2016
Attention	: CAROLINE AYLOTT	Sampled By	: CLIENT
Project Name :			
Your Client Services Manager	: David Lynch	Phone	: (08) 9368 8400

Lab Reg No.	Sample Ref	Sample Description
W16/012937	A14-3	MARINE SEDIMENT 12/07/16
W16/012938	A16-1	MARINE SEDIMENT 12/07/16
W16/012939	A16-2	MARINE SEDIMENT 12/07/16
W16/012940	A16-3	MARINE SEDIMENT 12/07/16

Lab Reg No.		W16/012937	W16/012938	W16/012939	W16/012940	
Sample Reference	Units	A14-3	A16-1	A16-2	A16-3	Method
Organotins						
Monobutyltin as Sn	ng/g	Not Tested	Not Tested	Not Tested	Not Tested	NR_35
Dibutyltin as Sn	ng/g	Not Tested	Not Tested	Not Tested	Not Tested	NR_35
Tributyltin as Sn	ng/g	Not Tested	Not Tested	Not Tested	Not Tested	NR_35
Surrogate: Tripropyltin	%REC	Not Tested	Not Tested	Not Tested	Not Tested	NR_35
Dates						
Date extracted		Not Tested	Not Tested	Not Tested	Not Tested	
Date analysed		Not Tested	Not Tested	Not Tested	Not Tested	

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Lab Reg No.		W16/012937	W16/012938	W16/012939	W16/012940	
Sample Reference	Units	A14-3	A16-1	A16-2	A16-3	Method
Trace Elements						
Arsenic - Bioavailable	mg/kg	Not Tested	Not Tested	Not Tested	Not Tested	NT2_49B
Cadmium - Bioavailable	mg/kg	Not Tested	Not Tested	Not Tested	Not Tested	NT2_49B
Chromium - Bioavailable	mg/kg	Not Tested	Not Tested	Not Tested	Not Tested	NT2_49B
Copper - Bioavailable	mg/kg	Not Tested	Not Tested	Not Tested	Not Tested	NT2_49B
Total Solids	%	Not Tested	Not Tested	Not Tested	Not Tested	NT2_49

REPORT OF ANALYSIS

Lab Reg No.		W16/012937	W16/012938	W16/012939	W16/012940	
Sample Reference	Units	A14-3	A16-1	A16-2	A16-3	Method
Trace Elements						
Lead - Bioavailable	mg/kg	5.1	12	8.9	8.5	NT2_49B
Manganese - Bioavailable	mg/kg	Not Tested	Not Tested	Not Tested	Not Tested	NT2_49B
Nickel - Bioavailable	mg/kg	2.5	2.5	2.2	2.1	NT2_49B
Sulphur - Bioavailable	mg/kg	Not Tested	Not Tested	Not Tested	Not Tested	NT2_49B
Zinc - Bioavailable	mg/kg	Not Tested	Not Tested	Not Tested	Not Tested	NT2_49B

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Lab Reg No.		W16/012937	W16/012938	W16/012939	W16/012940	
Sample Reference	Units	A14-3	A16-1	A16-2	A16-3	Method
Miscellaneous						
Carbon - Total Organic	mg/kg	Not Tested	Not Tested	Not Tested	Not Tested	NW_S15

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Lab Reg No.		W16/012937	W16/012938	W16/012939	W16/012940	
Sample Reference	Units	A14-3	A16-1	A16-2	A16-3	Method
Inorganics						
Moisture	%	28	30	29	28	WL170
Trace Elements						
Arsenic	mg/kg	Not Tested	Not Tested	Not Tested	Not Tested	WL273
Cadmium	mg/kg	Not Tested	Not Tested	Not Tested	Not Tested	WL273
Chromium	mg/kg	Not Tested	Not Tested	Not Tested	Not Tested	WL273
Copper	mg/kg	Not Tested	Not Tested	Not Tested	Not Tested	WL273
Lead	mg/kg	4.6	12	8.1	6.6	WL273

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Lab Reg No.		W16/012937	W16/012938	W16/012939	W16/012940	
Sample Reference	Units	A14-3	A16-1	A16-2	A16-3	Method
Trace Elements						
Manganese	mg/kg	Not Tested	Not Tested	Not Tested	Not Tested	WL273
Nickel	mg/kg	12	40	31	25	WL273
Sulfur	mg/kg	Not Tested	Not Tested	Not Tested	Not Tested	WL273
Zinc	mg/kg	Not Tested	Not Tested	Not Tested	Not Tested	WL273

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All results (except moisture) are expressed on a dry weight basis. Unless notified to the contrary, the above samples will be disposed of one month from the reporting date.

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This Report supersedes reports: RN1123699 RN1123833 RN1123927 RN1124041 RN1124206 RN1124611

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9.3 Appendix C – QA/QC Information and Results

Field QA/QC Methods

The following field quality assurance/quality control (QA/QC) steps were taken during sampling which included:

- Laboratory provided sample jars were used for sampling;
- White plastic sample spatulas and bucket were used for homogenisation of samples, to prevent contamination from trace metals which may be present in coloured plastic;
- The sample spatula and bucket were washed thoroughly with sea water after each replicate sample to minimise cross contamination between samples;
- All polycarbonate sample corers and lids were thoroughly washed with sea water after each sample site to avoid cross contamination between sample sites;
- Frozen samples were transported on ice to NATA accredited laboratories (NMI and MAFRL) in hard eskies;
- Split duplicate samples were collected from 3 monitoring sites (A8, A14 and A16) and sent to NMI, as a reference laboratory, to ensure results were reliably comparable to primary laboratory results for the same samples; and
- Relative Standard Deviation % (RSD) for each QA/QC sample site was calculated.

Laboratory QA/QC Methods

MAFRL and NMI carried out the required QA/QC as part of their digestions and analysis methods, which include blanks, duplicates, spikes and standard reference material. MAFRL and NMI QA/QC results have been provided in Appendix B. Reported results from MAFRL and NMI laboratories were all within the acceptable percentage recovery ranges.

QA/QC Results
Lab QA/QC

The relative standard deviations (RSD) of the triplicates for total metals were calculated for all sites using the following equation:

$$\text{Relative Standard Deviation (RSD \%)} = \frac{\text{(standard deviation of triplicate)} \times 100}{\text{(average of triplicate)}}$$

The acceptable RSD for triplicates is <50%. This calculation is based on the National Ocean Disposal Guidelines for Dredged Material (Environment Australia, 2002). Where concentrations for a triplicate metals were below the laboratory limit of detection (LOD), the LOD value was divided by two and the resulting value used in the RSD calculation on the triplicate results (Environment Australia, 2002).

RSD results for total metals and sulphur are provided in Table A9-1. Calculated RSDs were below 50% for all metals and sulphur results with the following exceptions:

- RSD results for arsenic at site A7 (50%) and A12 (69%);
- RSD results for copper at site A11 (101%);
- RSD results for nickel at site A19 (95%); and
- RSD results for zinc at site A9 (56%).

The above mentioned RSDs greater than 50% account for 5 out of the total 101 calculated RSD's for total metals.

Arsenic results used for RSD calculations at sites with RSD values >50% included arsenic concentrations below the laboratory level of detection (LOD) of 2mg/kg. This increased the standard deviation of the triplicates and, in turn, increased the RSD value, therefore the RSDs for arsenic >50% do not reduce the validity of the data.

Total copper triplicate results at A11, total nickel triplicate results at site A19 and total zinc triplicate results at site A9 were all below the ISQG-Low values, therefore the elevated RSDs are likely to represent the variability of metals in sediment samples and is does not impact on the validity of the results.

Table A9-1 Total Metal Results Relative Standard Deviation (RSD %)

Reporting Limit	**Arsenic** *<2*	**Cadmium** *<0.1*	**Chromium** *<0.2*	**Copper** *<0.2*	**Manganese** *<0.05*	**Nickel** *<0.7*	**Lead** *<1*	**Sulphur** *<10*	**Zinc** *<0.5*
Site	RSD %	RSD %	RSD %	RSD %	RSD %	RSD %	RSD %	RSD %	RSD %
A5	22	*35	8	10	8	2	0	8	2
A6	22	<LOD	2	16	5	12	<LOD	5	24
A7	***50**	<LOD	34	0	12	<LOD	<LOD	2	8
A8	17	43	4	8	0	8	7	3	14
A9	*35	43	1	49	4	26	30	4	**56**
A10b	25	*43	10	35	9	37	40	20	21
A11	17	43	3	**101**	2	12	25	3	2
A12	****69**	<LOD	2	40	2	31	22	6	14
A13	17	43	4	8	5	5	9	6	5
A14	-	-	-	-	-	8	0	-	-
A15	-	-	-	-	-	7	11	-	-
A16	-	-	-	-	-	21	12	-	-
A17	-	-	-	-	-	12	7	-	-
A18	-	-	-	-	-	47	33	-	-
A19	-	-	-	-	-	**95**	43	-	-
A20	-	-	-	-	-	13	9	-	-
A21	-	-	-	-	-	9	13	-	-
A22	-	-	-	-	-	19	35	-	-
A23	-	-	-	-	-	8	10	-	-

Bold: RSD % above 50
<LOD: all triplicates for that site were <LOD
* one triplicate result <LOD (was given value of LOD/2)
** two triplicate results <LOD (were given values of LOD/2)
Based on Oceanica, 2008 and reference (Environment Australia, 2002)

Field QA/QC

Three split duplicate samples were collected at sampling sites A8, A14 and A16 and sent to the secondary laboratory (NMI) for analysis. The Relative Percentage Difference (RPD) was calculated, based on the Australian Standard (AS 4482.1, 2005). RPD results for total and bioavailable metals are provided below in Tables A9-2 and A9-3 respectively.

All total metals results were within the ±50% RPD range with the exception of total sulphur at site A8. AS4482.1 (2005) states the variability of samples should be considered when evaluating RPD results. Total sulphur concentrations over all sites sampled ranged from 910 mg/kg (Site A7) to 2100 mg/kg (Site A13). The total sulphur result provided by NMI is double that of the highest sulphur result provided by MAFRL.

All bioavailable metals results were within the ±50% RPD range with the exception of arsenic and lead at samples collected from site A8. As results for both bioavailable arsenic and lead at A8 were well below the ISQG-Low concentrations for both analytes, these high RPD's should not affect the overall validity of the data for the purpose of the annual marine sediment monitoring. Variability between triplicate samples has been illustrated in section 5.3.2 and 5.4 due to the variable nature of sediment sampling, therefore it is determined

that RPDs outside the ±50% RPD range should not affect the overall validity of the data for the purpose of the annual sediment monitoring.

Table A9-2: RPD results for total metals

	Arsenic	Cadmium	Chromium	Copper	Manganese	Nickel	Lead	Sulphur	Zinc
Reporting Limit	*<2*	*<0.1*	*<0.2*	*<0.2*	*<0.05*	*<0.7*	*<1*	*<10*	*<0.5*
	ISQG Low = 20	ISQG Low = 1.5	ISQG Low = 80	ISQG Low = 65	ISQG Low = NA	ISQG Low = 21	ISQG Low = 50	ISQG Low = NA	ISQG Low = 200
	ISQG High = 70	ISQG High = 10	ISQG High = 370	ISQG High = 270	ISQG High = NA	ISQG High = 52	ISQG High = 220	ISQG High = NA	ISQG High = 410
	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Site									
A8 (MAFRL)	3	0.1	9	12	11	30	8	2100	14
A8 (NMI)	2.4	<0.4	8.9	13	9.3	28	7	4200	17
RPD	22.22	<LOR	1.12	8.00	16.75	6.90	13.33	**66.67**	19.35
A14 (MAFRL_	nt	nt	nt	nt	nt	12	5	nt	nt
A14 (NMI)	nt	nt	nt	nt	nt	13	4.6	nt	nt
RPD						8.00	8.33		
A16 (MAFRL)	nt	nt	nt	nt	nt	35	10	nt	nt
A16 (NMI)	nt	nt	nt	nt	nt	31	8.1	nt	nt
RPD						12.12	20.99		

Table A9-3: RPD results for bioavailable metals

	Arsenic	Cadmium	Chromium	Copper	Manganese	Nickel	Lead	Sulphur	Zinc
Reporting Limit	*<2*	*<0.1*	*<0.2*	*<0.2*	*<0.05*	*<0.7*	*<1*	*<10*	*<0.5*
	ISQG Low = 20	ISQG Low = 1.5	ISQG Low = 80	ISQG Low = 65	ISQG Low = NA	ISQG Low = 21	ISQG Low = 50	ISQG Low = NA	ISQG Low = 200
	ISQG High = 70	ISQG High = 10	ISQG High = 370	ISQG High = 270	ISQG High = NA	ISQG High = 52	ISQG High = 220	ISQG High = NA	ISQG High = 410
	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Site									
A8 (MAFRL)	2	0.1	5.4	3.9	6.2	2	7	1300	5.6
A8 (NMI)	0.56	<LOR	6.6	4	6.9	2.5	2.5	1260	6.4
RPD	***112.50***	*<LOR*	*20.00*	*2.53*	*10.69*	*22.22*	***94.74***	*3.13*	*13.33*
A14 (MAFRL_	nt	nt	nt	nt	nt	1.7	4	nt	nt
A14 (NMI)	nt	nt	nt	nt	nt	1.9	5	nt	nt
RPD						11.11	22.22		
A16 (MAFRL)	nt	nt	nt	nt	nt	2.3	10	nt	nt
A16 (NMI)	nt	nt	nt	nt	nt	2.2	8.9	nt	nt
RPD						4.44	11.64		