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Esperance Port

Comprehensive Sediment Monitoring and Reporting Plan

March 2009

Esperance Port

Comprehensive Sediment Monitoring and Reporting Plan

Prepared for

Esperance Port Authority

Prepared by

Oceanica Consulting Pty Ltd

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Cover
Main image: Aerial photograph of Esperance Port (Esperance Port Authority);
Minor images: Sediment cores (Oceanica Consulting); Vessel at Berth 1 (Oceanica Consulting).

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1. Introduction

1.1. Background

Esperance Port is situated on the south coast of Western Australia (ca. 800 km south-east of Perth), on the north-eastern side of Dempster Head. Esperance Port is a regional port which services the south-east agricultural and the eastern and north-eastern Goldfields regions of Western Australia. The Port handles bulk, solid and liquid cargoes. The main exports are grain, nickel concentrates and iron ore. Lead concentrate was also exported between June 2005 and March 2007. The main imports are petroleum and fertiliser products.

Esperance Port is sheltered from the south and east by a 1,200 m breakwater. The Port has two adjacent land backed berths (Berths 1 and 2) and a third dolphin-type berth (Berth 3) located on the main breakwater (Figure 1.1). The dredged entrance channel is approximately 350 m long and adjoins a swing basin with an approximate diameter of 550 m. The channel and turning basin for Berths 1 and 2 cover 27 ha and are dredged to 14.5 m. Berth 3 and channel are dredged to 19.0 m.

Figure 1.1 Esperance Port Authority berths

Esperance Port Authority's environmental licence conditions have recently been revised (DEC Licence L5099/1974/12 issued on the 6 January 2009, see Appendix A), and General Licence Condition 5 is as follows: *the Licensee shall, by 31st March 2009, prepare and provide to the Director, a comprehensive sediment monitoring and reporting plan which incorporates the recommendations of the Oceanica Consulting Pty Ltd marine sediment sampling that was undertaken in 2007 and 2008 together with other existing sediment sampling programs*.

Esperance Port Authority subsequently contracted Oceanica Pty Ltd (Oceanica) to design and prepare the comprehensive sediment monitoring and reporting plan (CSMRP) required by Licence L5099/1974/12. The CSMRP is provided in this document.

1.2. Objectives

The key objectives for this comprehensive sediment monitoring and reporting plan are to:

1. Identify the sites, sampling frequency, sample collection methods, analytes and analytical methods for routine monitoring and reporting on sediments in Esperance Port inner harbour and adjacent areas;
2. Identify the criteria to be used to (i) assess the risks and likely effects of sediment contamination on ecological health and (ii) initiate management action; and
3. Establish contingency plans to be implemented if levels of sediment contamination exceed the criteria.
4. Identify the reporting requirements for the comprehensive sediment monitoring and reporting plan.

1.3. Criteria

Concentrations of metals (arsenic, cadmium, chromium, copper, nickel, lead, and zinc) and tributyltim (TBT) in sediments will be compared to the National (ANZECC/ARMCANZ 2000) sediment quality guidelines, Interim Sediment Quality Guideline-Lows (ISQG-Lows) and ISQG-Highs. ISQG-Lows and ISQG-Highs are also used Nationally and by the State as follows:

- As Screening Guidelines (equivalent to the ISQG-Lows) and Maximum Guidelines (equivalent to the ISQG-High) under the National Assessment Guidelines for Dredging, 2009 (Commonwealth of Australia 2009) ;
- For sediment assessment under the State's Contaminated Sites legislation ("Assessment Levels for Soil, Sediment and Water"; DoE 2003), which applies to sediments within State waters – and thus sediments within Esperance Port waters; and
- As Environmental Quality Guidelines (EQGs) specified in the Environmental Quality Criteria Reference Document for Cockburn Sound (EPA 2005), under the State Environmental Policy (SEP) for Cockburn Sound. The Cockburn Sound SEP is viewed by the EPA and DEC as the template for environmental management of coastal waters in Western Australia.

In addition to the National sediment guidelines, statistically significant increases in key contaminants (total lead and total nickel) over time will be used as criteria.

The National guidelines and temporal increases in total lead and total nickel in will be used as triggers for management actions detailed in Section 3.

2. Sediment monitoring design

2.1. Historic sediment sampling results and recommendations

Prior to Environmental Licence L5099/1974/12 there was no requirement for sediment monitoring in Esperance Port Authority's environmental licence conditions. There was, however, a requirement for sediment monitoring under Ministerial Statement 681 (Esperance Port – Upgrading of marine facilities & Increase in iron ore export through the port to 8 million tons per annum; 28 July 2005), which supersedes Ministerial Statement 555 (Esperance Port – Upgrading of marine facilities; 31 October 2000). Both Ministerial Statements required preparation (Condition 8.3) and implementation (Condition 8.4) of a Sediment Quality Management Plan for port operations to ensure that sediment quality outside the inner harbour meet relevant sediment quality criteria. Since 2002, Esperance Port Authority has routinely monitored sediment quality at sites inside and outside the inner harbour to meet Ministerial Condition 8.4 and provide an early warning of any spread of contamination.

Key aspects of previous sediment sampling programmes, and recommendations arising from them, are briefly discussed in this section.

2.1.1. Routine sediment monitoring, 2002 to 2006

To meet Ministerial Condition 8.4 of the 2002 upgrade of Esperance Port (Ministerial Statement 555; Esperance Port – Upgrading of marine facilities), the Esperance Port Authority has annually monitored sediment quality at three defined sites in the outer harbour (sites 5, 6 and 7, recently re-named sites A5, A6 and A7 in 2008, see Figure 2.1). Esperance Port Authority has also voluntarily monitored sediment quality at three inner harbour sites (sites 8, 9 and 10, recently re-named sites A8, A9 and A10 in 2008, and located in the berth pockets of Berth 3, 2 and 1, respectively, see Figure 2.1).

In 2006, Esperance Port Authority expanded its sediment monitoring programme to include three additional sites (sites 11, 12 and 13, recently re-named sites A11, A12 and A13 in 2008, see Figure 2.1) in order to provide an early warning of any spread of contamination. Monitoring of nickel in sediment commenced in October 2002 and monitoring of lead commenced in November 2004. Analysis of metal concentrations was largely centred on *total* concentration (based on strong acid extraction of sediments). In October 2002 high concentrations of nickel were found at site 9 and were followed up with further sampling in March 2003, which included measurement of nickel after dilute acid extraction, which better approximates the *biologically available* fraction[1] (ANZECC/ARMCANZ 2000). Since March 2003, analysis of sediments from the inner harbour sites (A8, A9 and A10) generally included both total nickel and bioavailable nickel. The exact depth of sediment samples taken in the earlier surveys is not known, but the October 2006 survey targeted the top 2 cm of sediment (in accordance with standard practice), with some deeper cores (approximately 40 cm) also taken.

Data up to October 2006 indicated total nickel concentration were relatively stable in the berth pockets. Data from October 2006 for bioavailable nickel at sites A8, A9 and A10 were below the ISQG-low, indicating low risk of adverse biological effects.

Shipping of lead carbonate commenced at Esperance Port in July 2005. Routine sediment sampling results indicated little or no lead contamination at inner harbour sites A8, A9 and A10 in May 2005 but an appreciable level of contamination in September 2005 (especially at site 9, Berth 2), which increased between September 2005 and October 2006. The degree to which lead in Port sediments was bioavailable was unknown, as historic data were for total concentrations only.

[1] Dilute acid extraction still overestimates the biologically available fraction but is a better measure than strong acid extraction (ANZECC/ARMCANZ 2000).

2.1.2. Detailed survey of lead and nickel in sediments, 2007

Sampling by the Department of Environment and Conservation (DEC) in early 2007 established that sediment from an area under an Esperance Port discharge pipe (Berth 1) had lead and nickel concentrations that were orders of magnitude greater than the National guidelines for ecosystem health (ANZECC/ARMCANZ 2000). The DEC tests were for total metals, i.e., no analysis of bioavailable lead or nickel levels were undertaken. As a result of the sediment contamination found near the Port discharge pipe, Esperance Port Authority commissioned Oceanica to prepare and undertake a Stage 1 Screening Assessment Report and Stage 2 Bioavailability Investigation Report (Oceanica 2007b, 2008a). The sediment sampling for these investigations was carried out in August and September 2007, and sediment cores were taken to a depth 10 cm, with the major focus of analysis on the top 2 cm. This approach was taken because:

- Due to the relative stability of the harbour basin and entrance channel, and the recent nature of the contamination (December 2006), it was anticipated that any contamination would be largely confined to the surface sediments within the inner harbour;
- 10 cm is the depth typically associated with most biological activity; and
- The Esperance Port Authority's October 2006 sediment sampling included a ~40 cm deep core taken at berth pocket sites A8, A9 and A10 and approach channel site A11, and results for lead were much lower in these samples.

The Stage 1 Screening Assessment Report reported results for the top 2 cm of sediment, and found that lead (Figure 2.2) had a more spatially confined pattern of contamination than nickel, with a rapid decline in lead concentrations within 50 m of the discharge pipe. The results for nickel (Figure 2.3) were indicative of a roughly annular pattern of contamination, with highest levels of contamination adjacent to the berths and contamination decreasing towards the centre of the harbour.

The Stage 2 Bioavailability Investigation Report found that lead was more bioavailable than nickel, with approximately 85% of the total lead being bioavailable compared to 6% for nickel. Bioavailable lead contamination (Figure 2.4) was far more widespread than bioavailable nickel (Figure 2.5). The results were also used to identify those sites for which deeper (2-6 and 6-10 cm) fractions of sediment cores were to be taken for analysis in the Stage 3 investigation for bioavailable lead.

During the Stage 2 Bioavailability Investigation Report, particle size distribution was also analysed. Figure 2.6 shows the percentage of sediment that was less than 62µm (% of silt and clay-sized particles, or 'fines') at all of the sampling sites. The fines content of the sediments may help to explain some of patterns of contamination observed. The distribution of fines (Figure 2.6) follows the same pattern as the strong acid extraction (i.e. total) nickel concentrations shown in Figure 2.3. Site 46, for example, exhibits relatively high contamination by both lead and nickel and also exhibits relatively high fines content (6%). Contaminated fines may be transported to this site from Berth 1 during periods of sediment re-suspension. Similarly, lead and nickel contamination recorded at Berth 3 may be the result of contaminated fines settling out in this area (site BP8 had a fines content of 9%), or due to historic contamination. There is no known current or recent contamination source in the Berth 3 area.

Figure 2.1 Esperance Port Authority annual sediment monitoring sites.

Figure 2.2 **Total lead contamination (strong acid extraction) in surface sediments of Esperance Port, 2007**

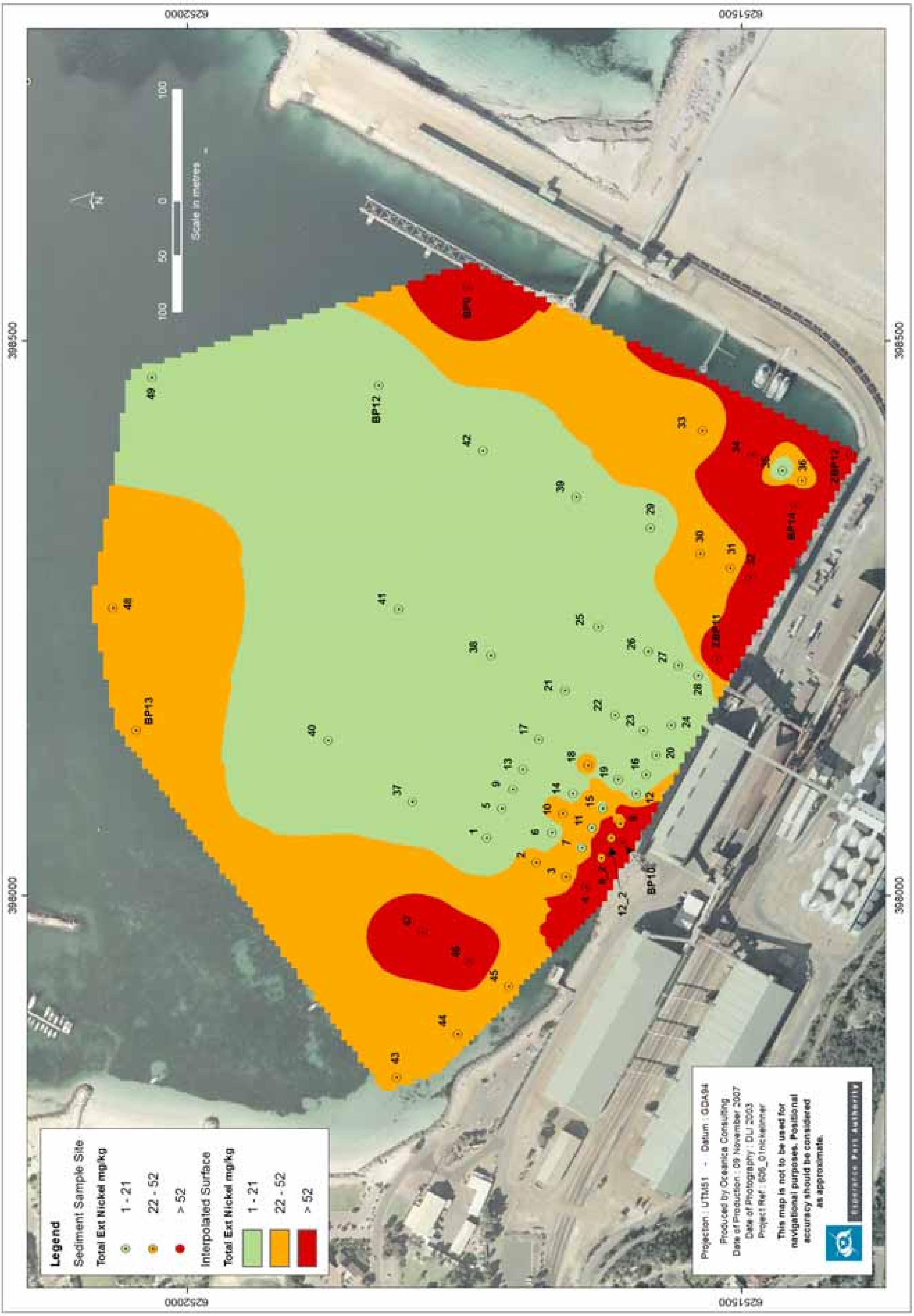

Figure 2.3 **Total nickel contamination (strong acid extraction) in surface sediments of Esperance Port, 2007**

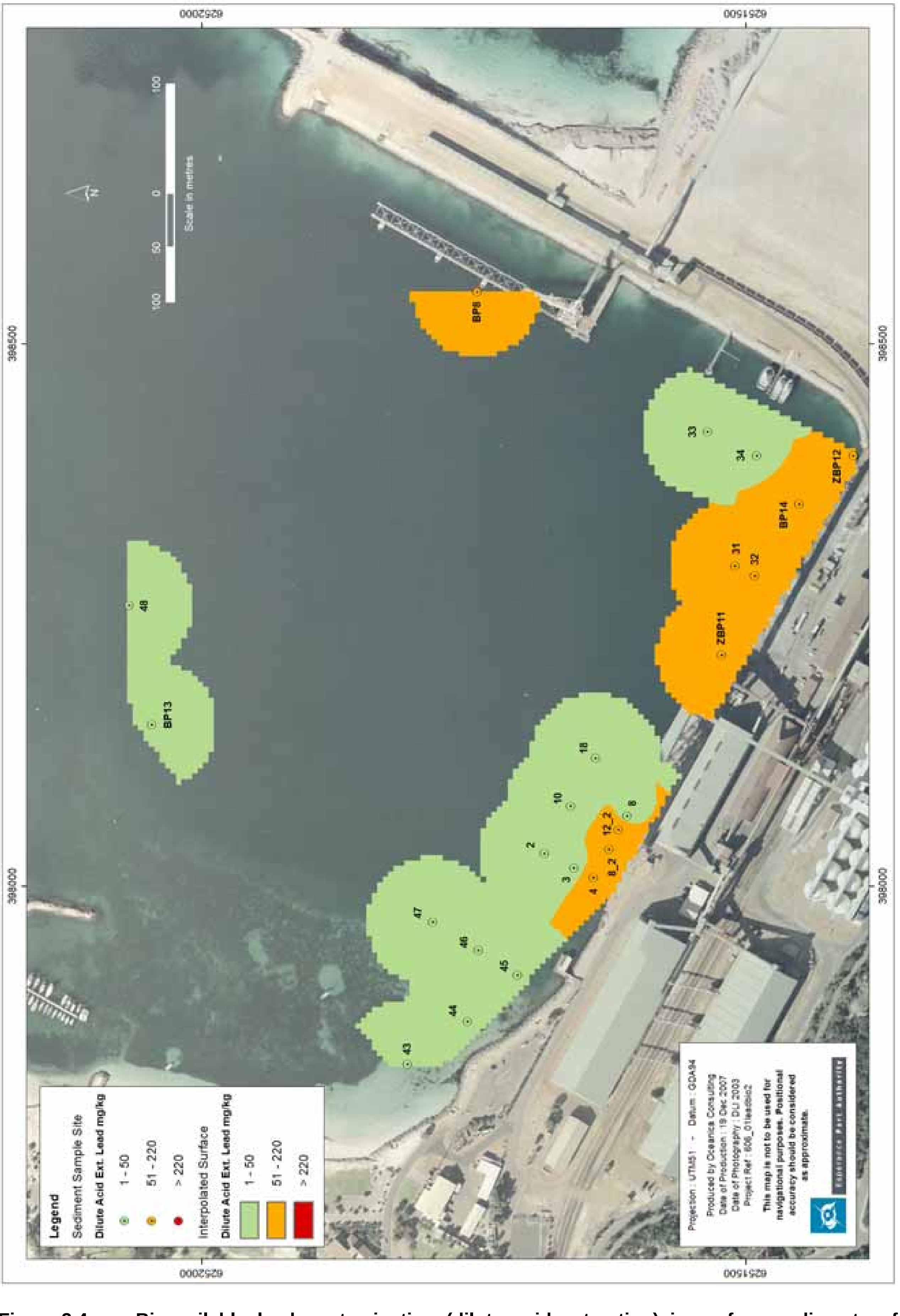

Figure 2.4 **Bioavailable lead contamination (dilute acid extraction) in surface sediments of Esperance Port, 2007**

Note: Central area unshaded because no dilute acid extractions done on these sediments (ISQG-Low not exceeded in strong acid extractions, see Figure 2.2)

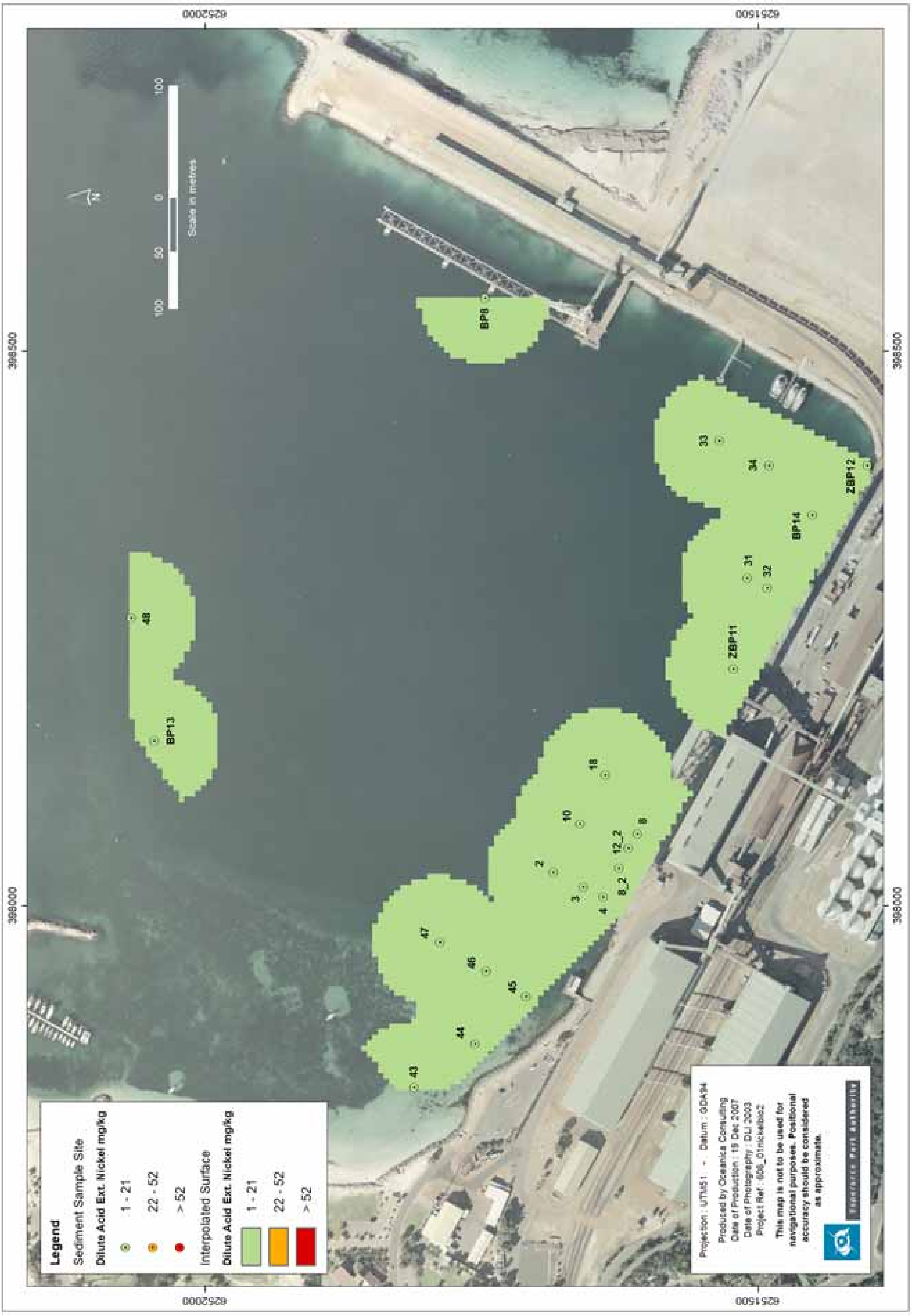

Figure 2.5 **Bioavailable nickel contamination (dilute acid extraction) in surface sediments of Esperance Port, 2007**

Note: Central area unshaded because no dilute acid extractions done on these sediments (ISQG-Low not exceeded in strong acid extractions, see Figure 2.3)

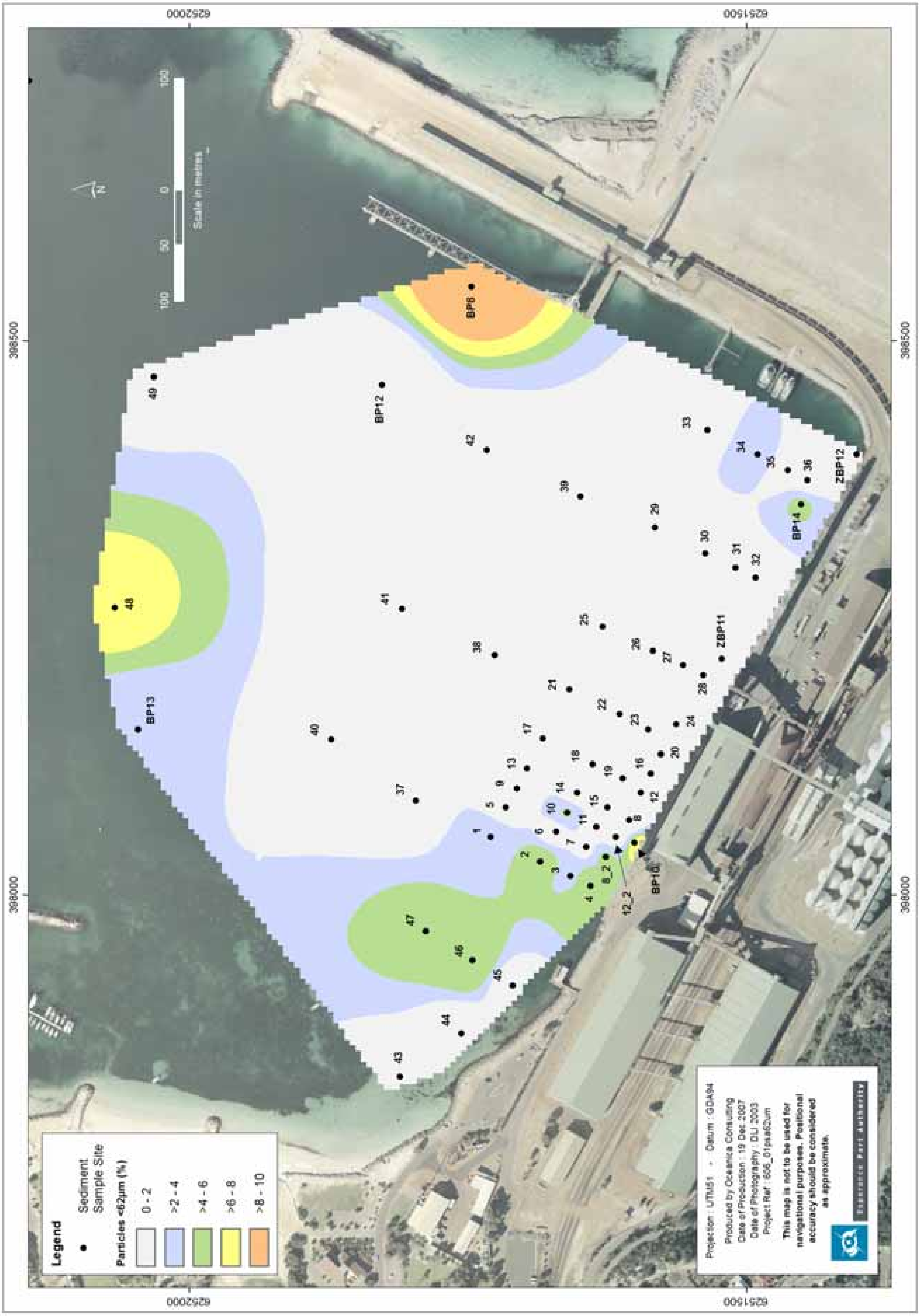

Figure 2.6 **Percentage of sediment particles <62 µm in surface sediments of Esperance Port, 2007**

The Stage 2 Bioavailability Investigation Report was originally intended to revise the sites sampled in the Esperance Port Authority's routine sediment sampling programme. Due to the need to better spatially define the extent of contamination around Berth 3, it was recommended that this exercise would be better undertaken following the Stage 3 (Ecological Risk Assessment) investigation. The Stage 3 Ecological Risk Assessment report is yet to be completed (eg ecotoxicity tests have yet to be carried out on selected sediment samples), however a review of the routine monitoring sites was undertaken in 2008, based on the results of the Stage 1, Stage 2 and Stage 3 results that were available (Oceanica 2008b). This review recommended the following:

- Annual sediment sampling to continue at the nine existing sites: three outer harbour sites (sites A5, A6 and A7), three sites in the berth pockets (A8, A9 and A10) and three sites in the turning basin and channel (A11, A12 and A13).
- Sampling to be expanded to include ten new sites, giving a total of 19 sites. The new sites to be located in and near the berth pockets (8 sites, A14 to A21), in the turning basin (1 site, A22) and in the channel (1 site, A23) (Figure 2.1). The new sites were chosen to give a spread of locations where high levels of lead and nickel contamination were found in the 2007 and 2008 surveys.
- Samples to be analysed for trace metals (arsenic, cadmium, chromium, copper, nickel, lead, and zinc), sulphur, organotins (TBT, and the breakdown products dibutyltin and monobutyltin; DBT and MBT) and total organic carbon (TOC).
- Analysis of particle size distribution also to be carried out on a regular basis to ensure data interpretation is not confounded by sediments of different fines content (i.e. the silt and clay fraction, typically sediment particles with diameters less than 63 microns). Analysis of particle size distribution to be carried out every three years, on the samples collected for that year's annual sampling of trace metals. The next analysis of particle size distribution should therefore be carried out during the 2010 annual sampling.
- Analytes and frequency of monitoring to be reviewed if there is a major change in port characteristics or operations, or a major spill.

2.1.3. Annual sampling of sediments, 2008

Annual sediment monitoring was carried out at 19 sites in November 2008, in accordance with the recommendations in Oceanica (2008b). Site locations and GPS coordinates are given in Figure 2.1 and Table 2.2, respectively. At this time, site names were standardised to overcome the confusion arising from a variety of names used in the past for sites in the Port Esperance routine sediment monitoring. A summary of current sites names and historic site names is presented in Table 2.2.

Table 2.1 Annual monitoring site names and locations. New site names and historic site names are shown (site locations have not changed, and sites A1 to A4 do not exist)

New annual monitoring site name	Historic site name	Historic site name quoted in	Target location UTM51 GDA94	
			Easting	Northing
A5	MSL5 5 BP5	Esperance Port Authority 2006[1] Oceanica 2007a[2] Oceanica 2007b[3], Oceanica 2008a[4]	399164	6252333
A6	MSL6 6 BP6	Esperance Port Authority 2006 Oceanica 2007a Oceanica 2007b, Oceanica 2008a	398760	6252588
A7	MSL7 7 BP7	Esperance Port Authority 2006 Oceanica 2007a Oceanica 2007b, Oceanica 2008a	398554	6253140
A8	BPL8, BPL8a 8 BP8	Esperance Port Authority 2006 Oceanica 2007a Oceanica 2007b, Oceanica 2008a	398568	6251754
A9	BPL9, BPL9a 9 BP9	Esperance Port Authority 2006 Oceanica 2007a Oceanica 2007b, Oceanica 2008a	398294	6251474

New annual monitoring site name	Historic site name	Historic site name quoted in	Target location UTM51 GDA94	
			Easting	Northing
A10	BPL10 10 BP10	Esperance Port Authority 2006* Oceanica 2007a Oceanica 2007b, Oceanica 2008a	398108* 398048	6251583* 6251608
A11	11 11 BP11	Esperance Port Authority 2006 Oceanica 2007a Oceanica 2007b, Oceanica 2008a	398734	6252144
A12	12 12 BP12	Esperance Port Authority 2006 Oceanica 2007a Oceanica 2007b, Oceanica 2008a	398460	6251827
A13	13 13 BP13	Esperance Port Authority 2006 Oceanica 2007a Oceanica 2007b, Oceanica 2008a	398149	6252045
A14	Equivalent to site ZBP11 [3]	New annual monitoring site	398213	6251522
A15	Equivalent to site 20 [3]	New annual monitoring site	398127	6251577
A16	Equivalent to site 4 [3]	New annual monitoring site	398008	6251640
A17	Equivalent to site 33 [3]	New annual monitoring site	398419	6251535
A18	Equivalent to site 30 [3]	New annual monitoring site	398308	6251537
A19	Equivalent to site 22 [3]	New annual monitoring site	398163	6251614
A20	Equivalent to site 2 [3]	New annual monitoring site	398030	6251685
A21	Equivalent to site 46 [3]	New annual monitoring site	397941	6251746
A22	Equivalent to site 61 [5]	New annual monitoring site	398450	6251597
A23	Equivalent to site 56 [5]	New annual monitoring site	398638	6251948

[1] Esperance Port Authority 2006, *Marine Sediment Monitoring Procedure, PR040*. Esperance Port Authority 14/08/06

[2] Oceanica 2007a, *Port of Esperance Survey of Lead and Nickel in Marine Sediments, Sampling and Analysis Program (SAP)*, prepared for Esperance Port Authority by Oceanica Consulting Pty Ltd, Report No. 606/1.

[3] Oceanica 2007b, *Port of Esperance Survey of Lead and Nickel in Marine Sediments, Level (Stage) 1 Screening Assessment*, prepared for Esperance Port Authority by Oceanica Consulting Pty Ltd, Report No. 606/2.

[4] Oceanica 2008a, *Port of Esperance Survey of Lead and Nickel in Marine Sediments, Level (Stage) 2 Bioavailability Investigation Report*, prepared for Esperance Port Authority by Oceanica Consulting Pty Ltd, Report No. 606_001/1.

[5] Oceanica 2009, *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.

* Original site 10 quoted in Esperance Port Authority 2006. Site 10 was moved when the location of the discharge pipe (Berth 1) was confirmed.

The results of annual sampling in 2008 were as follows:

Outer harbour sites

- All outer harbour sites had total arsenic, cadmium, chromium, copper, lead, nickel and zinc concentrations below relevant sediment guideline levels[2] (ISQG-Low).
- All outer harbour sites had tributyltin (TBT) concentrations below detection limits (and the ISQG-Low).

Inner harbour sites

- All inner harbour sites had total arsenic, cadmium, chromium, copper and zinc concentrations below ISQG-Lows.
- Total nickel exceeded the ISQG-Low at 7 inner harbour sites. The ISQG-High[3] was exceeded at 2 sites (Berth 1 and 2). Bioavailable nickel was below the ISQG-Low at all sites.
- Total nickel concentrations in 2008 were similar to 2007.
- Total lead exceeded the ISQG-Low at two sites in Berth 1 and 2. The bioavailability of lead at these two sites was 84 and 100%, respectively. Bioavailable lead exceeded the ISQG-Low at one site in Berth 1.
- One site in Berth 3 had a TBT concentration of 1182 µg Sn/kg, 17 times above the ISQG-High. Four sites had TBT concentrations above the ISQG-Low.
- The sediments in the centre of Berth 1, 2 and 3 and near the tug pen were contaminated by TBT, and the ratio of TBT to its breakdown products dibutyltin (DBT) and monobutyltin (MBT) suggested that the TBT contamination was recent.

The results indicated that the spatial extent of any lead and nickel contamination was adequately captured by the 19 sites, and therefore that the proposed sites were suitable for the purpose of future annual monitoring. There was no indication of contamination with other trace metals, although in a relative sense the concentrations of copper and zinc were higher at sites A8, A9 and A13, all of which are historic monitoring sites.

Subsequent to the 2008 annual survey, further results of the Stage 3 investigation have become available on the deeper (2-6 and 6-10 cm) fractions of sediment cores (Oceanica DRAFT). These results indicate that – contrary to the pattern of greatest contamination in surface (0-2 cm) that is typically found, many sites (especially the most contaminated sites) had higher levels of lead in the 2-6 cm fraction, and highest levels in the 6-10 cm fraction. These results indicated that the usual focus of sampling on the top 2 cm of sediment to assess risks to ecosystem health (because this typically captures the 'worst-case' scenario) was not applicable to inner harbour sediments at Esperance Port. These results indicate that the entire top 10 cm should be analysed.

2.2. Proposed sediment monitoring design

2.2.1. Responsibilities

Implementation of the comprehensive sediment monitoring and reporting plan is the responsibility of the Esperance Port Authority.

2.2.2. Timing

Condition 13 of Licence L5099/1974/12 requires the Esperance Port Authority to provide to the DEC Director, prior to 1st November each year, an environmental monitoring report that contains all of the data required by all of the conditions of the licence for the 12 month period beginning 1st October previous year to 30th September that year.

Sediments were last sampled and analysed for all analytes (trace metals, sulphur, organotins, total organic carbon and particle size analysis) at the proposed sites in November 2008 (Oceanica 2009). Maintaining November surveys complements the reporting period required by Licence L5099/1974/12.

[2] Interim Sediment Quality Guideline–Low (ISQG-Low), the National sediment quality guidelines for ecological health, as provided in ANZECC/ARMCANZ (2000).
[3] Interim Sediment Quality Guideline-High (ISQG-High), which demarcates a sediment concentration above which adverse effects often (but not always) occur, depending on the bioavailability of the contaminant.

Sediment monitoring should occur annually in November. Samples should be analysed for trace metals, sulphur, organotins, and total organic carbon every year, and once every three years for particle size analysis.

2.2.3. Sampling locations

Sediment samples should be collected at the nineteen sites sampled in 2008 (Oceanica 2008b). These include three outer harbour sites (sites A5, A6 and A7), 11 sites in the berth pockets (A8 to A10 and A14 to A21) and five sites in the turning basin and channel (A11 to A13, A22 and A23) (Figure 2.1). The GPS co-ordinates of each site are presented in Table 2.2.

Table 2.2 Annual monitoring site names and locations (note: sites A1 to A4 do not exist)

New annual monitoring site name	Target location UTM51 GDA94	
	Easting	Northing
A5	399164	6252333
A6	398760	6252588
A7	398554	6253140
A8	398568	6251754
A9	398294	6251474
A10	398048	6251608
A11	398734	6252144
A12	398460	6251827
A13	398149	6252045
A14	398213	6251522
A15	398127	6251577
A16	398008	6251640
A17	398419	6251535
A18	398308	6251537
A19	398163	6251614
A20	398030	6251685
A21	397941	6251746
A22	398450	6251597
A23	398638	6251948

2.2.4. Sampling method

As noted previously, for the purpose of assessing risks to ecological health, it is appropriate to focus on surface sediments. Due to the results obtained in previous surveys (Section 2.1), sampling should target the surface 10 cm of sediments.

Three replicate samples should be obtained from each site within 5 m of each other. Each replicate should consist of a composite of five cores taken from each corner and the centre of a 1 m^2 quadrat (Figure 2.7), according to the methods in Environmental Protection Authority (2005). Polycarbonate cores (internal diameter ~100 mm) should be pushed into the sediment to a depth of just over 10 cm, with care taken to cause minimal disturbance to the sediment surface. Both ends of the core should then be sealed using rubber bungs and the sample returned upright to the surface. The top 10 cm of material from each core (five cores to make each replicate) should be combined and homogenised in the field, with sieving[4] and further homogenisation to be completed at the laboratory. As sampling for metals is to occur, homogenisation should occur in a white plastic bucket using a white plastic spoon[5]. Sediment samples should be placed in pre-cleaned polyethylene containers supplied by the analytical laboratory (Australian Standard AS/NZS 5667.12:1999) and kept on ice.

[4] Removal of gravel sized (>2 mm) material should occur within the laboratory before analysis, with the coarse particles to be retained by the laboratory for subsequent analysis, if required.
[5] As coloured plastics often contain trace metals, white plastic will be used.

Notes should be made on the characteristics of each sample (colour, sediment type, odour, apparent depth of redox zone, presence of foreign objects etc).

To avoid cross contamination between sampling events, all sample gear should be thoroughly washed in seawater after each sampling event.

Figure 2.7 Five cores within 1 m^2 quadrat to make one replicate sample. Three replicates to be taken at each site within 5 m of each other.

2.2.5. Sample storage and Transit

Samples should be stored chilled (for particle size analysis) or frozen (for other analytes) prior to transport to the laboratory. Samples should be couriered to the laboratory chilled or frozen but freeze-thaw cycles should be avoided. Recommended sample holding times for each group of analytes is shown in Table 2.3.

Table 2.3 Sampling, storage, holding time and transport of samples

Parameter	Sample volume (mL)	Sample container	Storage	Holding time[1]	Transport to laboratory
Metals	70	70 mL polyethylene jar	Esky with ice on the vessel Refrigerated <4˚C on land	6 months	Esky with ice or bricks. Car from site to holding freezer. Courier from holding freezer to laboratory (transport time 1 day)
Organo Tins (TBT, DBT, MBT)	250	250 mL glass jar		Extended storage (>14 days) when kept frozen	
TOC				Undetermined.	
Particle size distribution	50-100	Whirl-pac bag			

[1] As per National Assessment Guidelines for Dredging (2009)

Sufficient sediment sample will be archived under appropriate storage conditions to enable any subsequent analysis required (eg dilute acid extraction, see Section 2.2.7).

2.2.6. Analytes

The analytes and frequency of analysis to be carried out on sediment samples in the CSMRP are summarised in Table 2.4, and include provision for extra sites and/or analytes if there is a major change in port characteristics or operations, a major spill, or any revision required due to exceedance of sediment criteria. Note that all 19 sites are analysed for total lead and total nickel, but only the Port's nine historic monitoring sites are analysed for other contaminants because available data (see Section 2.1.3) do not indicate the need for more extensive sampling.

Table 2.4 Analytes and frequency of analysis for sediments in Esperance Port's comprehensive sediment monitoring and reporting plan

Sites	Annual analysis		Analysis every three years	
	Analytes	Replicates to be analysed	Analytes	Replicates to be analysed
All sites	Total[1] lead Total nickel	All three replicates	Particle size distribution	One replicate per site
Sites A5 t- A13	Total arsenic Total cadmium Total chromium Total copper Total zinc Sulphur	All three replicates	-	-
Sites A5 - A13	Total organic carbon Organotins (TBT,	One replicate per site	-	-

Sites	Annual analysis		Analysis every three years	
	Analytes	Replicates to be analysed	Analytes	Replicates to be analysed
	DBT MBT)			
Other sites as required[2]	Other analytes as required	As required	Other analytes as required	As required

[1] Total levels based on strong acid (aqua regia) extraction of sediment samples
[2] Due to a major change in port characteristics or operations, a major spill, or any revision of sites required due to exceedance of sediment criteria.

Analysis of particle size distribution is only required every three years, on samples collected for that year's annual sampling of trace metals. This is to ensure that data interpretation is not confounded by sediments of different fines content (i.e. the silt and clay fraction, typically sediment particles with diameters less than 63 microns), which can influence natural levels of trace metals.

The required laboratory reporting limits for analytes (to enable comparison to relevant sediment guidelines) are shown in Table 2.5.

Table 2.5 Analytes, reporting limits and assessment level

Analytes	Required reporting Limit (mg/kg)	ISQG[1]-low (mg/kg)	ISQG[1]-high (mg/kg)
Arsenic (As)	<1	20	70
Cadmium (Cd)	<0.06	1.5	10
Chromium (Cr)	<0.2	80	370
Copper (Cu)	<0.2	65	270
Lead (Pb)	<1	50	220
Nickel (Ni)	<0.4	21	52
Zinc (Zn)	<0.5	200	410
Sulphur	<10	n/a	n/a
Organotins (TBT, DBT, MBT)	0.5 µg Sn/kg	9 µg Sn/kg[2]	80 µg Sn/kg[2]
TOC	100-200	n/a	n/a

[1] Interim Sediment Quality Guideline (ANZECC/ARMCANZ 2000).
2 Updated to reflect TBT guidelines in National Assessment Guidelines for Dredging (2009).

2.2.7. Laboratory analysis and QA/QC

Analysis of contaminants in sediment samples should be carried out by a National Association of Testing Authorities (NATA) accredited laboratory. In previous surveys, metals analysis has been undertaken by the Marine and Freshwater Research Laboratory (MAFRL), and organotin and TOC analysis by the National Measurement Institute (NMI). Particle size distribution has been undertaken by CSIRO Particle Analysis Services. MAFRL's and NMI's analysis methods are NATA accredited and meet the laboratory reporting limits (based on analytical detection limits) specified in Table 2.5. CSIRO Particle Analysis Services is not NATA accredited, but has relevant QA processes in place[6]. It is considered preferable to continue using the same laboratories if possible, to avoid the introduction of inter-laboratory variation in analytical results. Should a different laboratory be used, a representative selection of sites should be analysed by both the new and old laboratory, to determine the level of inter-laboratory variation present.

Total metal concentrations (strong acid extraction) should be determined for all trace metals (Table 2.5). Bioavailable metal concentration (dilute acid extraction) should also be carried out on all sediment samples for lead and nickel. In addition, if the strong acid extraction results for any other trace metal indicates exceedance of the ISQG-Low, dilute acid extraction should be carried out for that metal using sample archived for this purpose.

[6] Particle size distribution results are determined purely by the physical properties of the sediment particles, and so 'percentage recovery' is not a QA/QC issue (as it is for chemical analyses), but the 'goodness of fit' of the modelled results is. The instrument used for particle size analysis is calibrated once a month using certified reference materials.

Strong acid digestion extraction methods should be used to obtain a measure of the total metal fraction in sediments, to allow comparison with historic data on lead and nickel contamination collected by Esperance Port Authority and the Department of Environment and Conservation.

Dilute acid extraction (1 M hydrochloric acid for one hour) better approximates the bioavailable fraction of metals (ANZECC/ARMCANZ 2000). As sediment data are to be compared against relevant ecological health guidelines, it is appropriate to undertake the analysis for the bioavailable fraction of metals using a dilute acid extraction[7].

Laboratory QA/QC should be carried out. The precision of the analysis can be determined with laboratory duplicate samples, with a percentage difference between results of ± 35% being considered acceptable (National Assessment Guidelines for Dredging 2009). Analysis accuracy can be checked with the analysis of standard reference material (material with known concentration of chemical) and spikes (addition of known amount of chemical or surrogate chemical). Recovery rates should typically be between 75-125% (National Assessment Guidelines for Dredging 2009).

2.2.8. Data Analysis

Comparison with National sediment guidelines

The <u>median</u> concentrations of metals (arsenic, cadmium, chromium, copper, nickel, lead, and zinc), TBT, DBT, MBT at each site should be compared to the ANZECC/ARMCANZ (2000) sediment quality guidelines, ISQG-Low and ISQG-High. Results for TBT, DBT and MBT should be normalised to 1% TOC content (as per National Assessment Guidelines for Dredging 2009), before comparison to ANZECC/ARMCANZ (2000) guidelines.

Time series analysis

Total nickel and total lead data for the 15 inner harbour sites (defined here as sites A8-A10 and A12-A23) should be examined for temporal changes in the overall amounts of these contaminants.

Statistical analysis of the 2008 annual survey data for total nickel and total lead for the 15 inner harbour sites (*p* value of 0.05 for Type 1 errors, and power of 80% for Type 2 errors; according to ANZECC/ARMCANZ 2000) indicated that it would not be possible to detect temporal changes at each site unless the number of replicates/site are increased considerably. However, a minimum detectable difference of ~100% (i.e. a doubling of contaminant levels, or a halving of contaminant levels) is achievable based on the mean of the average contaminant levels of the 15 inner harbour sites. This approach is based on the assumption that each site is well characterised by the three replicates taken, which is considered technically defensible since each replicate is based on a composite of five cores (i.e. the average value for each site is based on 15 cores taken within 5 m of each other).

The proposed approach for time series analysis is as follows

- For any given annual survey, calculate the mean total lead and mean total nickel value for the 15 inner harbour sites (sites A8-A10 and A12-A23) using the average value for each site (calculated from the three replicates for each site); and
- Determine whether the mean total lead value and mean total nickel value for the inner harbour sites for the annual survey are significantly different to those of previous annual surveys using a 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).

This approach of checking for a change in the overall level of contaminants in inner harbour sediments is considered preferable to a site-by-site assessment, as effects due to re-distribution of sediments (eg due to propeller wash) within the harbour are taken into account.

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[7] Sediment contaminants may not always be present in biologically available forms, however, it is only the bioavailable fraction that will have effects on organisms (Commonwealth of Australia 2009).

2.2.9. Review of Comprehensive Sediment Monitoring and Reporting Plan

It is recommended that the CSMRP be reviewed every three years, or if there is a major change in port characteristics or operations, a major spill, or an exceedance of sediment criteria that indicates the need for a revision of sites and/or analytes.

3. Contingencies

Contingency actions to be implemented if sediment criteria are exceeded are provided in Table 3.1, and are based on the status of Esperance Port sediments as found in the 2008 annual sediment survey The contingency actions comprise three main groups:

- Those mainly concerned with the Esperance Port Authority's internal management of Port activities (temporal changes in total lead and total nickel levels in inner harbour sediments, but no exceedance of bioavailable contaminant levels);
- Those that may require further investigation of environmental risk, as per the State's Contaminated Sites legislation, and/or further discussion with the DEC (bioavailable trace metal concentrations – as determined by dilute acid extraction of sediments - exceed ISQG-Lows or ISQG-Highs); and
- The proposed management actions for TBT, which recognise that the use of TBT-based antifoulants on vessels using Esperance Port is not under the Esperance Port Authority's jurisdiction. The International Convention on the Control of Harmful Anti-fouling Systems on Ships entered into force 17 September 2008, but this cannot prevent vessels illegally using TBT, TBT inputs from antifouling paint applied prior to the ban. As TBT breakdown in sediments takes years, the TBT detected in the 2008 survey will take some time to degrade.

Table 3.1 Triggers and contingency actions for Esperance Port's comprehensive sediment monitoring and reporting plan

Trigger	Management action
Total nickel and total lead	
The mean total nickel or mean total 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	
<u>Total</u> 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 potential sources (dust/spillage, washdown, stormwater inputs). 3. Address source of contamination via management as appropriate (improvement in bulk cargo handling practices, installation of stormwater traps/diversion).
<u>Bioavailable</u> 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).
<u>Bioavailable</u> metal concentration exceeds the ISQG-High, at a site where no previous exceedance has taken place.	1. DEC to be informed <u>immediately</u>, 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
Increase in number of sites exceeding the ISQG-High since 2008	1. DEC to be informed via annual reporting. 2. 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).

4. Reporting

A stand-alone report on each year's sediment survey should be prepared. The report should include a description of the study, methodology and a comparison of monitoring results against the criteria identified in this CSMRP. Raw data (data sheets from laboratories) should be included in an appendix. Due to laboratory turn around times, a draft report shall be completed and submitted to Esperance Port Authority within two months of receipt of laboratory reports.

The final report should be prepared before 1st November each year, to ensure its inclusion in the environmental monitoring report required by 1st November each year under Condition 13 of Esperance Port Authority's Licence L5099/1974/12.

5. Acknowledgements

This report was prepared by **Samantha Green** (Oceanica) and reviewed by **Karen Hillman** (Oceanica). Figure preparation was completed by **Philip Kindleysides** (Oceanica) and report formatting was completed by **Alex Mayer** (Oceanica).

6. 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.

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

Environment Canada, 2005, Assessment of the integrity of chemicals in environmental samples over an extended period of time. Prepared for: Environment Canada, Pacific Region, Vancouver B.C. by: Mary McFarland, Dr. Sarah England, Dr. M. Coreen Hamilton.

Environmental Protection Authority 2005, *Manual of Standard Operating Procedures for Environmental Monitoring against the Cockburn Sound Environmental Quality Criteria (2003–2004) – A Supporting Document to the State Environmental (Cockburn Sound) Policy 2005*, Report 21, Environmental Protection Authority, Perth, Western Australia.

Esperance Port Authority 2006, *Marine Sediment Monitoring Procedure, PR040*. Esperance Port Authority 14 August 2006.

Oceanica 2007a, *Port of Esperance Survey of Lead and Nickel in Marine Sediments, Sampling and Analysis Program (SAP)*, prepared for Esperance Port Authority by Oceanica Consulting Pty Ltd, Report No. 606/1.

Oceanica 2007b, *Port of Esperance Survey of Lead and Nickel in Marine Sediments, Level (Stage) 1 Screening Assessment*, prepared for Esperance Port Authority by Oceanica Consulting Pty Ltd, Report No. 606/2

Oceanica 2008a, *Port of Esperance Survey of Lead and Nickel in Marine Sediments, Level (Stage) 2 Bioavailability Investigation Report*, prepared for Esperance Port Authority by Oceanica Consulting Pty Ltd, Report No. 606_001/1.

Oceanica 2008b, *Esperance Port Annual Sediment Sampling - Sampling and Analysis Program (SAP)*, Prepared for Esperance Port Authority by Oceanica Consulting Pty Ltd, Report no. 606_002/1, Perth, Western Australia, November 2008.

Oceanica 2009, *Esperance Port Annual Sediment Sampling - Sampling and Analysis (SAP) Implementation Report - DRAFT*, Prepared for Esperance Port Authority by Oceanica Consulting Pty Ltd, Report no. 606_002/2, Perth, Western Australia.

Simpson, S. L., Batley, G. E, Chariton, A. A., Stauber, J. L., King, C. K., Chapman, J. C., Hyne, R. V., Gale, S. A., Roach, A. C. and Maher, W. A. 2005, *Handbook of Sediment Quality Assessment*, CSIRO, Bangor, NSW.

Quevauviller, P. and Donard, O.F.X., 1991. Organotin Stability During Storage of Marine Waters and Sediments. Resenius's Zeitschrift fur Analytical Chemistry, Vol. 339, p6-14.

Appendix A

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