WorleyParsons
resources & energy

EcoNomics

PORT OF BRISBANE PTY LTD

Brisbane River and Moreton Bay

Annual Sediment Characterisation Report 2013

301001-01619 – 301001-01619-00-EN-REP-0001

19 July 2013

Infrastructure & Environment
Level 3, 60 Albert Street
Brisbane QLD 4000
Australia
Telephone: +61 7 3239 7400
Facsimile: +61 7 3221 7791
www.worleyparsons.com
ABN 61 001 279 812

Disclaimer

PROJECT 301001-01619 - BRISBANE RIVER AND MORETON BAY

REV	DESCRIPTION	ORIG	REVIEW	WORLEY-PARSONS APPROVAL	DATE	CLIENT APPROVAL	DATE
A	Issued for internal review	B Brooks	S Codi King	N/A	08-Mar-13	N/A	
B	Issued for client review	B Brooks	S Codi King	A Butcher	13-Mar-13		N/A
0	Issued for Use	B Brooks	S Codi King	S Wakefield	19-July-13		

EXECUTIVE SUMMARY

INTRODUCTION

The Port of Brisbane Pty Ltd (PBPL) is responsible for maintaining minimum channel depths within port limits to allow vessel access to port facilities. The channel depths are declared by the regional harbour master and designated on shipping charts. In late 2012/early 2013, PBPL propose to undertake its annual maintenance dredging within the navigational areas of the Brisbane River and Moreton Bay, primarily using the Trailer Suction Hopper Dredge (TSHD) '*Brisbane*'. Maintenance dredging works extend from the Hamilton Reach of the Brisbane River downstream to the North-West Channel located in northern Moreton Bay.

Options for the disposal of the resultant dredged material include placement within the approved PBPL reclamation area (onshore) and placement to designated material spoil areas within Moreton Bay. While all disposal options will be considered, PBPL, consistent with previous years, has benefited from the reuse of the dredged material for reclamation purposes within their future port expansion area.

An assessment of the contaminant status of the material proposed for dredging has been undertaken by PBPL to assist in the decision making process regarding material placement options, and the management of the dredging and material disposal operations.

Contaminant testing was undertaken in accordance with an annual sediment sampling and analysis plan (SAP), which has been developed and implemented to comply with the requirements of the *National Assessment Guidelines for Dredging* (NAGD; Commonwealth of Australia, 2009) and this report provides the characterisation of sediments and contaminants within the Port of Brisbane dredge area.

OBJECTIVES

The primary objectives of the 2013 SAP study were to undertake sediment sampling and analysis of a range of contaminants from forty-five locations within three zones representing the dredge area in accordance with the NAGD, the *Guideline for Contaminated Land Professionals* (DEH, 1998) and the *Guidelines for Sampling and Analysis for Lowland Acid Sulfate Soils* (ASS) in Queensland (QASSIT, 1998). A reference zone (Zone 1) was located upstream of the dredge area, containing three reference areas, which were also sampled to provide a comparison of contaminant concentrations to background concentrations.

In accordance with sampling undertaken in 2012, additional sampling was undertaken from three locations within Breakfast Creek and one location at Teneriffe to gain a better understanding of potential contaminant sources to the Brisbane River.

METHODOLOGY

Samples were collected using a boat deployed poly carbonate piston corer, 60mm in diameter and 1.2m in length. All coring operations were undertaken by Geochemical Assessments Pty Ltd. At each location, between four to six cores (including one representative core retained for core-logging) were

sampled and extracted to account for contaminant variability within the sediments. Lack of penetration of the piston corer occurred at locations that contained only a thin layer of sand and/or silts over a very stiff substrate. If after repeated attempts at using the piston corer, this method still did not yield reliable and accurate representations of the substrate, alternate methods of sample collection were used. In place of the piston corer, a van-Veen grab was used to collect the surface layer sediments. The van-Veen grab sampler enabled the collection of fine, surface sediments since the piston corer can disturb this material.

Sediments cores were logged for geotechnical information (colour, consistency, etc.), then homogenised and transferred to appropriate sample containers. All samples were placed on ice and shipped under a chain-of-custody (COC) documentation to a National Association of Testing Authorities (NATA) accredited laboratory for contaminant analysis, Advanced Analytical Australia (AAA). Field and laboratory quality assurance and quality control procedures were undertaken in accordance with NAGD requirements.

Sediments were analysed for total metals, polycyclic aromatic hydrocarbons (PAHs), total petroleum hydrocarbons (TPHs), benzene, toluene, ethylbenzene and xylenes (BTEX), polychlorinated biphenyls (PCBs), organochlorine pesticides (OCPs), organophosphorus pesticides (OPPs), organotins (i.e. tributyltin), nutrients, radionuclides, moisture content, and total organic carbon (TOC). Contaminant concentrations within each zone (Zones 1 - 4), and the total dredge area (Zones 2 - 4) were assessed through calculation of the 95% upper confidence level (UCL) of the mean for each parameter. The 95% UCL concentrations were then compared against three sets of guideline criteria: the NAGD Screening Levels, DEH (1998) Environmental Investigation Level (EIL) and Health Investigation Level for residential land use (HIL-A).

PHYSICAL CHARACTERISTICS

In addition to the chemical analyses, sediments were analysed for particle size distribution (PSD), bulk density and acid sulfate soils (ASS). Results of ASS analysis were compared to QASSIT guideline criteria.

RESULTS

A summary of contaminants that exceeded NAGD Screening Levels at each location is provided below:

- Total Mercury exceeded the Screening Level of 0.15 mg/kg at the following locations:
  - Zone 2: 4-0, 4-4, 4-8, 4-13, 8-3 and 8-4
  - Zone 3: 10-6 and 11-8
- Total Nickel exceeded the NAGD Screening Level of 21 mg/kg at the following locations:
  - Zone 1: 3-0
  - Zone 2: 4-0, 4-4, 4-5, 4-8, 4-10, 4-13, 5-0, 6-2, 6-3, 7-1, 8-1, 8-2, 8-3 and 8-4
  - Zone 3: 9-1, 9-2, 9-4, 10-1, 10-5, 10-6, 11-1, 11-3, 11-9, 11-11, 11-12 and 12-1

  - Zone 4: 13-3, 13-6 and 13-8

- Tributyltin (TBT) concentrations (normalised to TOC concentration) exceeded the NAGD Screening Level of 9 µgSn/kg at one location in Zone 2 (4-0).
- DDD (normalised to TOC concentration) exceeded the Screening Level of 2 µg/kg at the following locations:
  - Zone 2: 8-3
- DDE (normalised to TOC concentration) exceeded the Screening Level of 2.2 µg/kg at the following locations:
  - Zone 2: 4-8, 6-3, 7-1, 8-3, 8-4
  - Zone 3: 9-4, 10-1, 10-6, 11-8, 11-9, 11-11, 12-3, 12-1 and 14-1
- DDT (normalised to TOC concentration) exceeded the Screening Level of 1.6 µg/kg at the following locations:

  Zone 2: 8-3
- PCBs (normalised to TOC concentration) exceeded the Screening Level of 23 µg/kg at the following location:
  - Zone 3: 10-6

Total mercury, nickel, OCPs including *p,p'*-DDD, *p,p'*-DDE and *p,p'*-DDT, and TBT exceeded their NAGD Screening Levels of 0.15, 21, 2, 2.2 1.6 mg/kg respectively at the 95% UCL of the mean within at least one zone of the dredge area (Zones 2-4). In addition, total mercury and total nickel exceeded their NAGD Screening Levels of 0.15 and 21 mg/kg respectively in Zone 1. However as sediments within Zone 1 are not dredged, these results do not impact on the suitability of the material for sea disposal.

There is a general trend for sites within the dredge area (Zones 2 - 4) to show a decreasing trend in metal concentrations as you move downstream towards the mouth of the river; this is consistent with previous sediment characterisation studies (WorleyParsons 2011, WorleyParsons 2012). There is a further decline in metal concentrations at those sites located at the river mouth adjacent to Luggage Point.

Results of ASS analysis indicate that there are no management requirements for ASS if dredged material is to be placed on land.

CONCLUSIONS

The results show that none of the zones, including the reference zone, would be considered suitable for sea disposal in accordance with the NAGD Guidelines given that at least one contaminant in each zone exceeded NAGD Screening Level at the 95% UCL of the mean. Under the NAGD, further testing would be required to determine the potential bioavailability of these contaminants and potential impacts to water quality.

Comparison of the sediment material to the DEH (1998) EIL and HIL-A levels show that the mean and 95% UCL of the mean values for all chemicals in both Zone 1 and the total dredge area (Zones 2-4) were below EIL and HIL-A investigation levels. These results indicate that the sediment would be suitable for placement on land.

This is the third year that additional samples were collected within Breakfast Creek in order to gain a better understanding of potential contaminant sources into the port region. The results show reduced contaminant levels in Breakfast Creek compared to last year (WorleyParsons, 2012). Continued monitoring of Breakfast Creek is recommended as it is considered a sediment source of contaminants to the Brisbane River.

RECOMMENDATIONS

OPPs have not been detected within any zone since 2002 and BTEX have not been detected within the timeframe of the review (from 2000). It is recommended to reconsider the requirement to monitor these parameters.

Between 2003 and 2011, PCBs have been undetected within the Brisbane River. Given that results of the 2012 and 2013 SAP studies have identified PCBs within the dredge area, it is recommended to continue with PCB monitoring in the Brisbane River for 2014, with a review of results (particularly in comparison to results from Breakfast Creek) to identify the continued requirement for this analysis.

The design of the SAP for the PBPL is statistically a complex matrix using a “nested design” (a number of locations within a site, and a number of sites within a zone,) analysed over time and distance. The design is further complicated because of the uneven number of locations and sites being analysed within each zone which makes it unbalanced in terms of comparisons across zones. In addition, many of these locations and sites within each zone are different in their sediment characteristics, which makes it difficult to pool data and compare across zones. It is recommended to present the data per site with zone over time as a nested design so the patterns over time are more distinguishable compared to using a box plot, which summaries data within the zone over time and loses the patterns in the data.

Historical data for PBPL work has been collected since 2000 and was conducted in Zones 2-4 with no reference site or Zone 1. We recommend reviewing and evaluating this earlier data to confirm that the analytical results are comparable in methodology to present methods and results. In the last decade laboratory analytical methods and detection limits or LOR have improved considerably and it might be prudent to determine if early data is reliable for inclusion into the PBPL SAP annual sediment characterisation assessment.

CONTENTS

FIGURES

TABLES

1 INTRODUCTION

1.1 Background

The Port of Brisbane Pty Ltd (PBPL) is responsible for maintaining minimum channel depths within port limits to allow for vessel access to port facilities. The channel depths are declared by the regional harbour master and designated on shipping charts.

Port of Brisbane Pty Ltd undertakes an annual maintenance dredging program to ensure these minimum depths are maintained. The resultant dredged material is placed within port limits. In late 2012/early 2013, PBPL proposed to undertake maintenance dredging within the navigational areas of the Brisbane River and Moreton Bay, primarily using the Trailer Suction Hopper Dredge (TSHD) *Brisbane*. Maintenance dredging works extend from the Hamilton Reach of the Brisbane River downstream to the North-West Channel located in northern Moreton Bay.

Port of Brisbane Pty Ltd aims to ensure that all dredging activities, including extraction and placement of material, are undertaken in accordance with existing legislation and with minimal environmental harm. A key component of achieving this aim is to undertake a contaminant assessment of the material proposed for dredging prior to the commencement of the dredging program. This contaminant testing is undertaken in accordance with a Sediment Sampling and Analysis Plan (SAP), which has been developed to comply with the requirements of the National Assessment Guidelines for Dredging (NAGD; Commonwealth of Australia, 2009). The results provided in this sediment characterisation report are used to inform decisions regarding potential material placement locations, and the management of the dredging and material placement operations.

1.1.1 Sampling and Analysis Plan

The SAP includes assessment of both physical and chemical characteristics of the material to be dredged as well as an assessment of acid sulfate soil (ASS) potential. Whilst testing of ASS potential is undertaken for maintenance works, the presence of ASS within material which has recently been eroded or deposited from the system is generally very low.

Sediment testing protocols are undertaken in compliance with the NAGD. Results of analysis are compared against the NAGD Screening Levels as a benchmark for sediment quality.

The SAP includes:

- *'Testing for contamination of sediments by metals, hydrocarbons, pesticides, tributyl tin (TBT) and other contaminants to the depth of the proposed dredging;*
- *Comparison of contaminant levels with background levels from similar uncontaminated areas; and*
- *Comparison of contaminant levels against accepted sediment quality criteria.'*

1.2 Objectives of the Study

WorleyParsons was commissioned by PBPL to characterise sediments proposed for maintenance dredging in accordance with the SAP and the NAGD guidelines. The objectives of this project are to:

- Undertake the sediment sampling and analysis program according to the SAP study methods provided in the project brief;
- Test and analyse sediments for a range of physical and chemical properties (a detailed list of contaminants that have been analysed in accordance to the SAP are provided in Section 2.2.1); and
- Provide a comparison of contaminant concentrations against the NAGD, the Guideline for Contaminated Land Professionals (DEH, 1998), G*uidelines for Sampling and Analysis for Lowland Acid Sulfate Soils (ASS) in Queensland* (QASSIT, 1998) and previous SAP results.

1.3 Previous Studies

PBPL has undertaken fifteen SAP studies since 1998, which has included the sampling and analysis of sediments from up to forty eight locations within the Brisbane River and adjacent entrance channel.

Table 1-1 summarises the historical data set and provides sample dates, number of sample site locations and percentage of sample locations exceeding NODGDM/NAGD contaminant Screening Levels from previous SAP studies for metals and TBT. Historically total nickel, total mercury, and TBT, have been the dominant contaminants that have routinely exceeded Screening Levels within port limits. Nickel, mercury and TBT have all exceeded their own screening levels 15, 14 and 14 times respectively over the past 15 years.

Table 1-1: Percentage of sample locations exceeding NODGDM and NAGD Screening Levels for metals and TBT 1998 – Dec 2011

SAP Event	No. Locations	Percentage (%) of sample locations exceeding NODGDM/NAGD Screening Levels[1]							
		Cadmium (Cd)	Chromium (Cr)	Copper (Cu)	Mercury (Hg)	Lead (Pb)	Nickel (Ni)	Zinc (Zn)	Tributyltin (TBT)
Mar-98[2]	13	0	0	0	0	16	39	8	54
Dec-98[2]	24	4	0	0	33	0	33	8	42
Dec-99[2]	35	0	0	0	3	0	83	0	0
Nov-00[2]	36	0	11	9	26	20	43	17	63
Nov-01[3]	45*	0	0	7	31	0	76	7	9
Nov-02[4]	45*	0	2	0	16	4	91	0	29
Nov-03[5]	45*	0	0	0	18	0	60	0	40
Nov-04[6]	45*	0	0	2	4	2	67	4	58
Jan-06[7]	45*	0	0	0	7	0	71	0	31
Feb-07[8]	45*	0	0	2	13	0	33	2	31
Jan-08[9]	45*	2	0	4	15	2	13	0	10
Feb-09[10]	45*	2	0	4	24	2	53	0	11
Jan-10[11]	45*	0	0	0	20	0	78	0	18
Dec-10[12]	45*	0	0	4	9	2	56	0	7
Dec-11[13]	45*	0	2	0	16	2	48	2	2

Notes
[1] Results expressed as percentage of sites containing contaminants above the NODGDM Screening Level criteria. Note: results from Feb-09 onwards are compared against NAGD Screening Levels.
[2] Source: PBC Environmental Performance Report, 2001
[3] Butler & Partners 2002
[4] Hydrobiology 2003
[5] Hydrobiology 2004
[6] SKM, 2005
[7] SKM, 2006
[8] SKM, 2007
[9] WorleyParsons, 2008
[10] WorleyParsons, 2009
[11] GHD, May 2010
[12] WorleyParsons, 2011
[13] WorleyParsons, 2012
* Although 48 sample locations were tested in the 2001 to 2011 SAPs, 3 of these locations were upstream reference sites (hence not included in the above calculations)

1.4 Definitions

The following definitions have been taken from the NAGD:

Screening Level

Level of a substance in the sediment below which toxic effects on organisms are not expected.

Practical Quantitation Level, PQL

The lowest chemical analysis level that can be reliably achieved within specified limits of precision and accuracy during routine operating conditions. PQL is also referred to as Limit of Reporting (LOR).

2 METHODS

The methods implemented during the 2013 Brisbane River and Moreton Bay SAP study were consistent with the project terms of reference issued by PBPL and with the requirements of the NAGD. The following sections provide details of the sampling protocols, sample collection, sample processing and laboratory analysis of the sediment samples.

2.1 Sampling Protocols

The 2013 field sampling program was conducted from 3-9 December, 2012. Field sampling was undertaken from a total of forty-eight locations, thirty-nine within the Brisbane River and nine within the entrance channel in Moreton Bay (Figure 2-1). These forty-eight locations have been grouped according to zone and sites within zone, which is consistent with previous SAP studies:

Locations

- Zone 1 – All up-river reference locations (sites 1-3);
- Zone 2 – All sites between Colmslie and Pinkenba (sites 4 – 8);
- Zone 3 – All sites within Port reaches (sites 9 – 12 and 14-15); and
- Zone 4 – Site within Moreton Bay entrance channel (site 13).

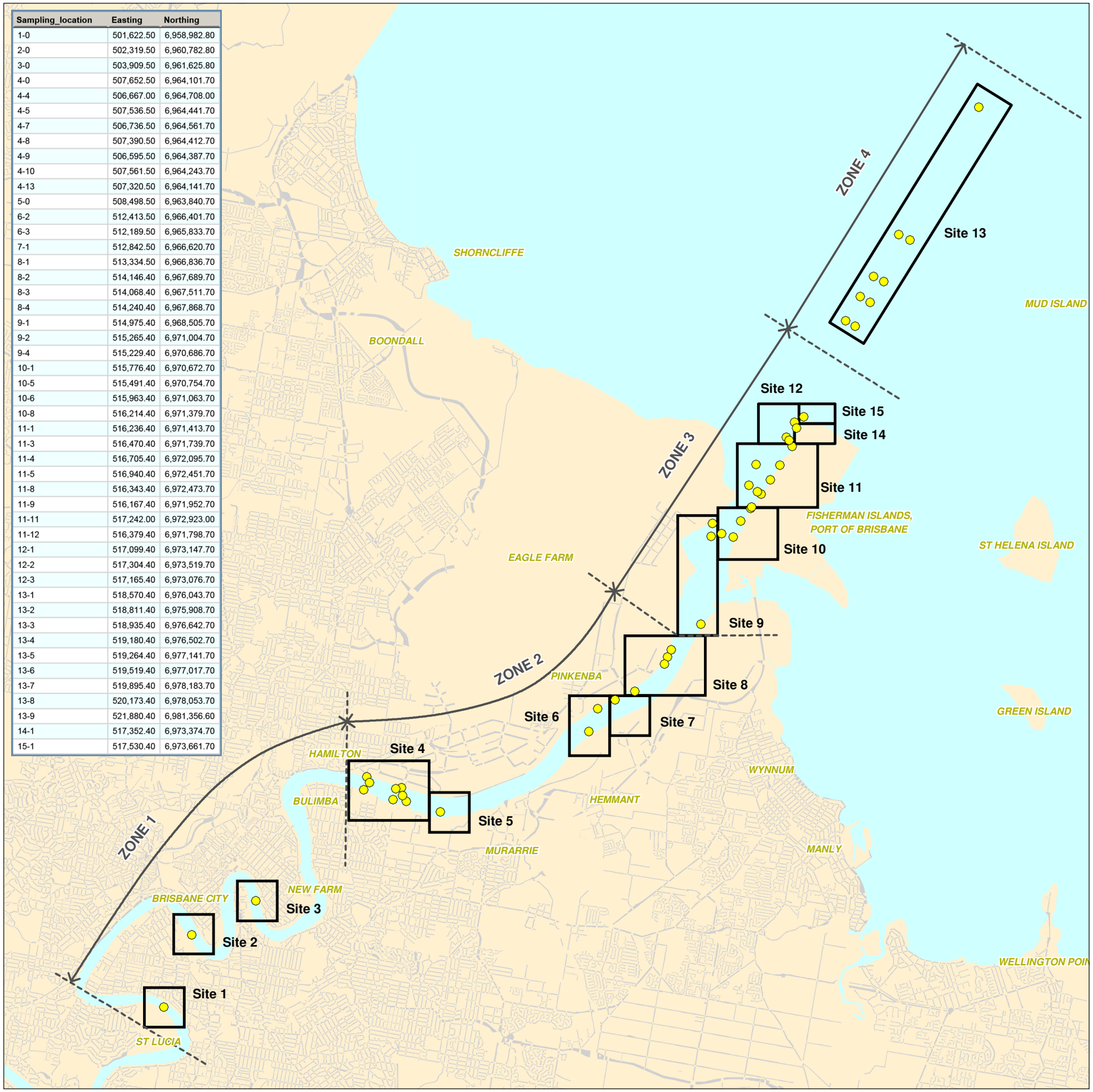
In addition, a further four locations were sampled, three within Breakfast Creek, and one in the Brisbane River upstream of Breakfast Creek (Teneriffe). These additional sample locations were added to help assess potential sources of contaminants into the Brisbane River.

Table 2-1 provides a list of the global positioning system (GPS) coordinates of sampling locations.

Sampling locations were sited using a Garmin Map 76 CSx, which has an accuracy of ±5 m. Sampling was conducted within 10m of the established location coordinates, with exceptions as follows:

- Site 2-0 was moved due to ferry movements.
- Site 4-5 was moved 30m towards the middle of the river as a cargo vessel was berthed at the established coordinates;
- Site 9-1 was moved next to the wharf;
- Site 10-8 was moved 5m from the stern of a berthed vessel;
- Site 11-1 was moved 10m due to a berthed vessel located at the established coordinates;
- BC-1 was moved 30m north to the centre of the creek as the original position was plotted onshore; and
- BC-3 was moved to the centre of the creek as the original position was plotted onshore.

Sampling_location	Easting	Northing
1-0	501,622.50	6,958,982.80
2-0	502,319.50	6,960,782.80
3-0	503,909.50	6,961,625.80
4-0	507,652.50	6,964,101.70
4-4	506,667.00	6,964,708.00
4-5	507,536.50	6,964,441.70
4-7	506,736.50	6,964,561.70
4-8	507,390.50	6,964,412.70
4-9	506,595.50	6,964,387.70
4-10	507,561.50	6,964,243.70
4-13	507,320.50	6,964,141.70
5-0	508,498.50	6,963,840.70
6-2	512,413.50	6,966,401.70
6-3	512,189.50	6,965,833.70
7-1	512,842.50	6,966,620.70
8-1	513,334.50	6,966,836.70
8-2	514,146.40	6,967,689.70
8-3	514,068.40	6,967,511.70
8-4	514,240.40	6,967,868.70
9-1	514,975.40	6,968,505.70
9-2	515,265.40	6,971,004.70
9-4	515,229.40	6,970,686.70
10-1	515,776.40	6,970,672.70
10-5	515,491.40	6,970,754.70
10-6	515,963.40	6,971,063.70
10-8	516,214.40	6,971,379.70
11-1	516,236.40	6,971,413.70
11-3	516,470.40	6,971,739.70
11-4	516,705.40	6,972,095.70
11-5	516,940.40	6,972,451.70
11-8	516,343.40	6,972,473.70
11-9	516,167.40	6,971,952.70
11-11	517,242.00	6,972,923.00
11-12	516,379.40	6,971,798.70
12-1	517,099.40	6,973,147.70
12-2	517,304.40	6,973,519.70
12-3	517,165.40	6,973,076.70
13-1	518,570.40	6,976,043.70
13-2	518,811.40	6,975,908.70
13-3	518,935.40	6,976,642.70
13-4	519,180.40	6,976,502.70
13-5	519,264.40	6,977,141.70
13-6	519,519.40	6,977,017.70
13-7	519,895.40	6,978,183.70
13-8	520,173.40	6,978,053.70
13-9	521,880.40	6,981,356.60
14-1	517,352.40	6,973,374.70
15-1	517,530.40	6,973,661.70



LEGEND

- Sampling locations
- Study sites

0 2 4km

SCALE - 1:100,000 (at A3)

Map Grid of Australia - Zone 56
Geocentric Datum of Australia 1994

N
W E
S

Rev	Date	Revision Description	DRN	CHK	ENG	APPD
A	02/03/2012	Issued for review	KK	DH		

WorleyParsons
resources & energy

PORT of BRISBANE
Here for the future

PORT OF BRISBANE PTY LTD

SEDIMENT SAMPLING AND ANALYSIS PLAN FOR BRISBANE RIVER AND MORETON BAY 2012

Figure 2.1(a)
Overview of Study Sites and Sampling Locations

Project No: 301001-01247	Figure: 01247-00-GM-DAL-0021	Rev: A

Compiled by BRISBANE INFRASTRUCTURE GIS SECTION

K:\POB\301001-01247\GIS\Maps\01247-00-GM-DAL-0021A(SAP2012_Sampling_Locations).wor

LEGEND

Sampling locations

Study sites

0 1 2km

SCALE - 1:50,000 (at A3)

ZONE 1

ZONE 2

BC-1

BC-2

BC-3

BC-4

HAMILTON

BULIMBA

NEW FARM

BRISBANE CITY

WEST END

ST LUCIA

Site 1

1-0

Site 2

2-0

Site 3

3-0

REFER INSET

Site 4

Site 5

MURARRIE

PINKENBA

Site 6

6-2

6-3

Site 7

7-1

8-1

8-2

8-3

8-4

Sampling Location	Easting	Northing
BC-1	503,991.79	6,965,508.39
BC-2	504,157.54	6,964,606.85
BC-3	504,677.69	6,964,631.88
BC-4	505,053.19	6,962,861.22

Sampling_location	Easting	Northing
1-0	501,622.50	6,958,982.80
2-0	502,319.50	6,960,782.80
3-0	503,909.50	6,961,625.80
4-0	507,652.50	6,964,101.70
4-4	506,667.00	6,964,708.00
4-5	507,536.50	6,964,441.70
4-7	506,736.50	6,964,561.70
4-8	507,390.50	6,964,412.70
4-9	506,595.50	6,964,387.70
4-10	507,561.50	6,964,243.70
4-13	507,320.50	6,964,141.70
5-0	508,498.50	6,963,840.70
6-2	512,413.50	6,966,401.70
6-3	512,189.50	6,965,833.70
7-1	512,842.50	6,966,620.70
8-1	513,334.50	6,966,836.70
8-2	514,146.40	6,967,689.70
8-3	514,068.40	6,967,511.70
8-4	514,240.40	6,967,868.70
9-1	514,975.40	6,968,505.70
9-2	515,265.40	6,971,004.70
9-4	515,229.40	6,970,686.70
10-1	515,776.40	6,970,672.70
10-5	515,491.40	6,970,754.70
10-6	515,963.40	6,971,063.70
10-8	516,214.40	6,971,379.70
11-1	516,236.40	6,971,413.70
11-3	516,470.40	6,971,739.70
11-4	516,705.40	6,972,095.70
11-5	516,940.40	6,972,451.70
11-8	516,343.40	6,972,473.70
11-9	516,167.40	6,971,952.70
11-11	517,242.00	6,972,923.00
11-12	516,379.40	6,971,798.70
12-1	517,099.40	6,973,147.70
12-2	517,304.40	6,973,519.70
12-3	517,165.40	6,973,076.70
13-1	518,570.40	6,976,043.70
13-2	518,811.40	6,975,908.70
13-3	518,935.40	6,976,642.70
13-4	519,180.40	6,976,502.70
13-5	519,264.40	6,977,141.70
13-6	519,519.40	6,977,017.70
13-7	519,895.40	6,978,183.70
13-8	520,173.40	6,978,053.70
13-9	521,880.40	6,981,356.60
14-1	517,352.40	6,973,374.70
15-1	517,530.40	6,973,661.70

HAMILTON

EAGLE FARM

Site 4

Site 5

4-4

4-7

4-9

4-8

4-5

4-10

4-13

4-0

5-0

BULIMBA

BALMORAL

Scale - 1:25,000 @ A3

INSET

N

W E

S

Map Grid of Australia - Zone 56
Geocentric Datum of Australia 1994

Rev	Date	Revision Description	DRN	CHK	ENG	APPD
A	02/03/2012	Issued for review	KK	DH	VS	

WorleyParsons resources & energy

PORT of BRISBANE Here for the future

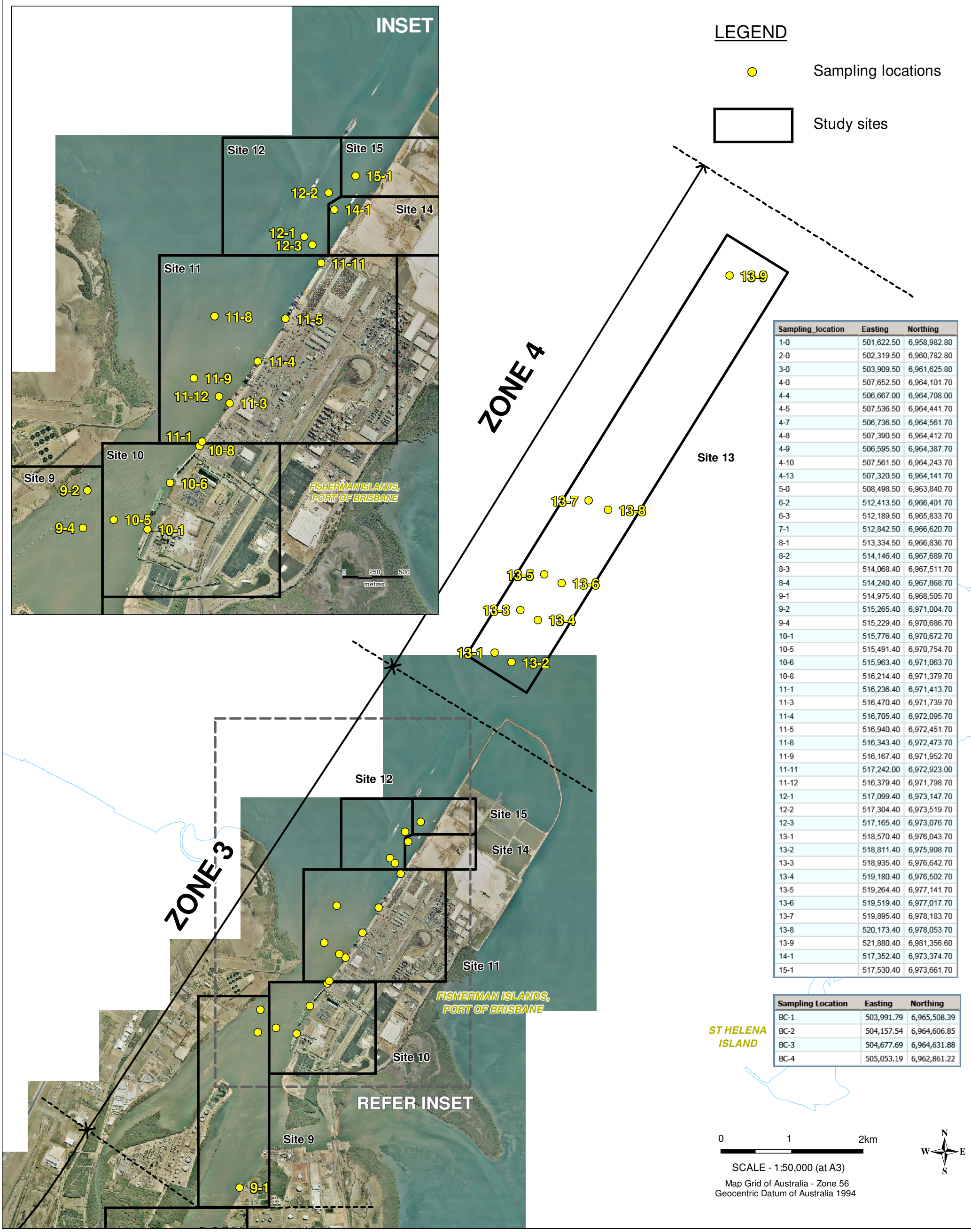
PORT OF BRISBANE PTY LTD

SEDIMENT SAMPLING AND ANALYSIS PLAN FOR BRISBANE RIVER AND MORETON BAY 2012
Figure 2.1(b)
SAP Sampling Locations (Sites 1-8)

Project No: 301001-01247	Figure: 01247-00-GM-DAL-0022	Rev: A

Compiled by BRISBANE INFRASTRUCTURE GIS SECTION

K:\POB\301001-01247\GIS\Maps\01247-00-GM-DAL-0022A(SAP2012_Sampling_Locations_1-8).wor



Sampling_location	Easting	Northing
1-0	501,622.50	6,958,982.80
2-0	502,319.50	6,960,782.80
3-0	503,909.50	6,961,625.80
4-0	507,652.50	6,964,101.70
4-4	506,667.00	6,964,708.00
4-5	507,536.50	6,964,441.70
4-7	506,736.50	6,964,561.70
4-8	507,390.50	6,964,412.70
4-9	506,595.50	6,964,387.70
4-10	507,561.50	6,964,243.70
4-13	507,320.50	6,964,141.70
5-0	508,498.50	6,963,840.70
6-2	512,413.50	6,966,401.70
6-3	512,189.50	6,965,833.70
7-1	512,842.50	6,966,620.70
8-1	513,334.50	6,966,836.70
8-2	514,146.40	6,967,689.70
8-3	514,068.40	6,967,511.70
8-4	514,240.40	6,967,868.70
9-1	514,975.40	6,968,505.70
9-2	515,265.40	6,971,004.70
9-4	515,229.40	6,970,686.70
10-1	515,776.40	6,970,672.70
10-5	515,491.40	6,970,754.70
10-6	515,963.40	6,971,063.70
10-8	516,214.40	6,971,379.70
11-1	516,236.40	6,971,413.70
11-3	516,470.40	6,971,739.70
11-4	516,705.40	6,972,095.70
11-5	516,940.40	6,972,451.70
11-8	516,343.40	6,972,473.70
11-9	516,167.40	6,971,952.70
11-11	517,242.00	6,972,923.00
11-12	516,379.40	6,971,798.70
12-1	517,099.40	6,973,147.70
12-2	517,304.40	6,973,519.70
12-3	517,165.40	6,973,076.70
13-1	518,570.40	6,976,043.70
13-2	518,811.40	6,975,908.70
13-3	518,935.40	6,976,642.70
13-4	519,180.40	6,976,502.70
13-5	519,264.40	6,977,141.70
13-6	519,519.40	6,977,017.70
13-7	519,895.40	6,978,183.70
13-8	520,173.40	6,978,053.70
13-9	521,880.40	6,981,356.60
14-1	517,352.40	6,973,374.70
15-1	517,530.40	6,973,661.70

Sampling Location	Easting	Northing
BC-1	503,991.79	6,965,508.39
BC-2	504,157.54	6,964,606.85
BC-3	504,677.69	6,964,631.88
BC-4	505,053.19	6,962,861.22

Rev	Date	Revision Description	ORIG	CHK	ENG	APPD
A	02/03/2012	Issued for review	KK	DH	VS	

WorleyParsons resources & energy

PORT of BRISBANE Here for the future

PORT OF BRISBANE PTY LTD

SEDIMENT SAMPLING AND ANALYSIS PLAN FOR BRISBANE RIVER AND MORETON BAY 2012

Figure 2.1(c)
SAP Sampling Locations (Sites 9 - 15)

Project No: 301001-01247	Figure: 01247-00-GM-DAL-0023	Rev: A

Compiled by BRISBANE INFRASTRUCTURE GIS SECTION

K:\POB\301001-01247\GIS\Maps\01247-00-GM-DAL-0023A(SAP2012_Sampling_Locations_9-15).wor

Table 2-1: Details of sediment sampling locations including: coordinates, date sampled, water depth and analysis performed.

Sampling Locations			Location Coordinates		Sample Details							
Zone	Site	Location	Easting (m)	Northing (m)	Date	Time	Water Depth (m)	Tide Height (MSQ Data 2012)	Top of Core (-m LAT)	Length of Core	No of Cores	Analyses
1	1	1-0	501622.5	6958982.8	4-12-12	15:40	11.1	1.866	9.234	0.15	4	Basic + Detailed
1	2	2-0	502328	6960793	4-12-12	14:55	11.1	0.8715	10.2285	1.2	4	Basic + Detailed
1	3	3-0	503909.5	6961625.8	4-12-12	17:15	13.0	1.126	11.874	0.6	6	Basic + Detailed
2	4	4-0	507652.5	6964101.7	6-12-12	09:30	9.4	0.884	8.516	0.87	4	Basic
2	4	4-4	506672.0	6964709.0	6-12-12	12:00	10.2	1.632	8.568	0.89	4	Basic
2	4	4-5	507521	6964411	6-12-12	12:45	14.0	1.968	12.032	0.3	4	Basic
2	4	4-7	506736.5	6964561.7	6-12-12	11:00	10.2	1.32	8.88	1.0	4	Basic + Detailed + Bulk Density + Radionuclides
2	4	4-8	507390.5	6964412.7	6-12-12	10:30	11.1	1.151	9.949	0.81	4	Basic + Bulk Density
2	4	4-9	506595.5	6964387.7	6-12-12	14:15	2.0	0.8775	1.1225	1.03	6	Basic
2	4	4-10	507561.5	6964243.7	6-12-12	07:45	10.6	1.6295	8.9705	0.8	4	Basic
2	4	4-13	507320.5	6964141.7	6-12-12	08:35	7.2	1.8525	5.3475	1.2	4	Basic
2	5	5-0	508498.5	6963840.7	4-12-12	09:00	9.0	1.181	7.819	1.2	4	Basic + Detailed + Radionuclides
2	6	6-2	512413.5	6966401.7	3-12-12	12:50	12.0	2.197	9.803	0.16	6	Basic + Bulk Density
2	6	6-3	512189.5	6965833.7	3-12-12	14:00	13.0	1.906	11.094	1.1	4	Basic + Detailed +

Table 2-1: Details of sediment sampling locations including: coordinates, date sampled, water depth and analysis performed.

Sampling Locations			Location Coordinates		Sample Details							
Zone	Site	Location	Easting (m)	Northing (m)	Date	Time	Water Depth (m)	Tide Height (MSQ Data 2012)	Top of Core (-m LAT)	Length of Core	No of Cores	Analyses
												Bulk Density + Radionuclides
2	7	7-1	512842.5	6966620.7	6-12-12	15:45	12.2	1.0115	11.1885	1.0	6	Basic + Detailed + Radionuclides
2	8	8-1	513334.5	6966836.7	6-12-12	07:15	11.5	0.903	10.597	0.90	4	Basic + Detailed + Radionuclides
2	8	8-2	514146.4	6967689.7	3-12-12	12:00	12.0	2.209	9.791	1.0	4	Basic
2	8	8-3	514068.4	6967511.7	3-12-12	11:10	7.4	2.067	5.333	1.0	4	Basic
2	8	8-4	514240.4	6967868.7	3-12-12	10:00	5.2	1.688	3.512	1.0	4	Basic
3	9	9-1	514962	6968529	4-12-12	07:30	10.6	0.688	9.912	1.2	6	Basic + Detailed
3	9	9-2	515265.4	6971004.7	5-12-12	11:15	10.6	1.3045	9.2955	1.0	4	Basic
3	9	9-4	515229.4	6970686.7	5-12-12	07:40	7.3	0.726	6.574	1.3	4	Basic + Bulk Density
3	10	10-1	515776.4	6970672.7	7-12-12	07:15	14.4	2.1085	12.2915	0.82	4	Basic + Bulk Density
3	10	10-5	515491.4	6970754.7	5-12-12	08:15	14.6	2.2175	12.3825	0.5	4	Basic
3	10	10-6	515963.4	6971063.7	5-12-12	14:00	-	2.194	-	1.2	4	Basic + Detailed
3	10	10-8	516187	6971390	9-12-12	8:10	15.6	1.661	13.939	0.5	6	Basic
3	11	11-1	516211	6971456	9-12-12	07:30	15.5	1.88	13.62	0.5	4	Basic

Table 2-1: Details of sediment sampling locations including: coordinates, date sampled, water depth and analysis performed.

Sampling Locations			Location Coordinates		Sample Details							
Zone	Site	Location	Easting (m)	Northing (m)	Date	Time	Water Depth (m)	Tide Height (MSQ Data 2012)	Top of Core (-m LAT)	Length of Core	No of Cores	Analyses
3	11	11-3	516470.4	6971739.7	5-12-12	14:45	16.0	1.9875	14.0125	0.5	4	Basic
3	11	11-4	516705.4	6972095.7	7-12-12	08:00	14.4	0.966	13.434	0.91	4	Basic
3	11	11-5	516940.4	6972451.7	7-12-12	08:30	14.4	0.89	13.51	0.9	4	Basic
3	11	11-8	516343.4	6972473.7	5-12-12	10:15	7.0	1.843	5.157	1.17	4	Basic + Detailed + Radionuclides
3	11	11-9	516167.4	6971952.7	5-12-12	08:45	14.4	0.7755	13.6245	0.8	4	Basic + Bulk Density
3	11	11-11	517261.1	6972881.4	7-12-12	10:00	14.2	0.874	13.326	0.9	6	Basic + Bulk Density
3	11	11-12	516379.4	6971798.7	5-12-12	09:30	14.6	1.182	13.418	0.7	4	Basic
3	12	12-1	517099.4	6973147.7	9-12-12	09:40	15.5	1.187	14.313	0.1	4	Basic + Detailed
3	12	12-2	517304.4	6973519.7	9-12-12	10:25	14.9	1.0885	13.8115	0.3	6	Basic + Detailed + Radionuclides
3	12	12-3	517165.4	6973076.7	7-12-12	09:05	15.0	0.7345	14.2655	0.12	4	Basic
4	13	13-1	518570.4	6976043.7	8-12-12	08:15	7.1	0.8485	6.2515	0.52	4	Basic + Detailed + Radionuclides
4	13	13-2	518811.4	6975908.7	8-12-12	09:00	4.9	1.005	3.895	1.2	6	Basic
4	13	13-3	518935.4	6976642.7	8-12-12	10:00	6.0	0.838	5.162	1.1	4	Basic
4	13	13-4	519180.4	6976502.7	8-12-12	09:30	6.3	0.907	5.393	1.1	4	Basic

Table 2-1: Details of sediment sampling locations including: coordinates, date sampled, water depth and analysis performed.

Sampling Locations			Location Coordinates		Sample Details							
Zone	Site	Location	Easting (m)	Northing (m)	Date	Time	Water Depth (m)	Tide Height (MSQ Data 2012)	Top of Core (-m LAT)	Length of Core	No of Cores	Analyses
4	13	13-5	519264.4	6977141.7	8-12-12	10:30	6.4	0.799	5.601	1.2	4	Basic
4	13	13-6	519519.4	6977017.7	8-12-12	13:00	7.4	1.299	6.101	1.0	4	Basic
4	13	13-7	519895.4	6978183.7	8-12-12	11:10	7.4	0.827	6.573	1.0	4	Basic + Bulk Density
4	13	13-8	520173.4	6978053.7	8-12-12	11:50	8.3	0.974	7.326	1.2	4	Basic + Bulk Density
4	13	13-9	521880.4	6981356.6	8-12-12	12:15	12.9	2.061	10.839	1.2	4	Basic
3	14	14-1	517352.4	6973374.7	9-12-12	11:45	14.4	0.8145	13.5855	0.45	4	Basic + Detailed
3	15	15-1	517530.4	6973661.7	9-12-12	13:15	14.6	0.786	13.814	0.3	4	Basic + Detailed
-	-	BC-1	504001	6965541	4-12-12	12:20	4.0	2.207	1.793	0.6	4	Basic + Detailed
-	-	BC-2	504158	6964607	4-12-12	13:00	4.2	2.328	1.872	1.0	6	Basic + Detailed
-	-	BC-3	504673	6964632	4-12-12	11:20	3.8	1.918	1.882	0.8	4	Basic + Detailed
-	-	BC-4	505053	6962861	4-12-12	10:30	10.0	1.629	8.371	1.1	4	Basic + Detailed

Notes: Tide data is sourced from Maritime Safety Queensland.

Tide heights and water depth (LAT) for Sites 1-3 and BC have been calculated from tide data collected from the MSQ Port Office Station.

Tide heights and water depth (LAT) for sites 4-8 and location 9-1 have been calculated based on tide data collected from MSQ Station at Gateway Bridge

Tide heights and water depth (LAT) for sites 9 (ex. 9-1) – 15 have been calculated based on tide data collected from MSQ Brisbane Bar Station.

Datum: UTM WGS84

2.1.1 Sample Collection

Samples were collected using a boat deployed poly carbonate piston corer, 60mm in diameter and 1.2m in length. At each sample location, the piston corer was lowered to the river/sea bed using a series of extension rods of a length determined by water depth at each location. Once the corer reached the river/sea bed it was manoeuvred to ensure a vertical profile would be obtained during sample collection. After a vertical profile was established, the corer was pushed into the river/sea bed and a sample was obtained. Once a sediment core had been collected the piston corer was retrieved to the surface and extruded manually either into a PVC core tray for core logging for geotechnical information, or directly into a stainless steel mixing bowl for sample processing. At each location, between three to six cores were extracted and homogenised to ensure an accurate representation of the sediments.

Lack of penetration of the piston corer occurred at locations that contained only a thin layer of sand and/or silts over a very stiff substrate. If after repeated attempts at using the piston corer, this method still did not yield reliable and accurate representations of the substrate, alternate methods of sample collection were used. In place of the piston corer, a van-Veen grab was used to collect the surface layer sediments. The van-Veen grab sampler enabled the collection of fine, surface sediments since the piston corer can disturb this material.

All coring operations were undertaken by Geochemical Assessments Pty Ltd.

2.1.2 Sample Processing

Once each set of cores had been collected, sample material designated for chemical analysis was homogenised in a large stainless steel bowl using stainless steel implements and nitrile gloves. . Samples were then placed in sample containers with zero headspace and stored in eskies on ice before being consigned under chain-of-custody documentation to the analytical laboratories, Advanced Analytical Australia (AAA-primary) and mgt-Labmark (secondary). Following receipt at the laboratories, samples were stored under refrigerated conditions prior to analysis. The jars for chemical analyses were solvent-rinsed, glass jars with Teflon lined lids, provided by the analytical laboratories.

At each location a site description sheet was completed. The following information was collected:

- Name of client;
- Sampling date;
- General location of sample collection;
- Sampling location number and sample identifiers assigned;
- Name of the sample collector;
- Type of sampler used;

- Weather conditions at the time of sampling;
- Sea state at time of sampling;
- General comments (e.g. wind speed, level of shipping traffic etc.);
- GPS location (easting and northing);
- Time of sampling;
- Water depth at each sampling location (based on surface deployed tape measure); and
- Photograph of each sediment sample.

A sediment log of each core was recorded on a field data sheet, providing a description of the composition of each sample, including the following information:

- Colour;
- Field texture;
- Observed sand grain size;
- Plasticity;
- Moisture content of sample (e.g. wet, moist, dry);
- % stones;
- Presence of shell/shell grit; and
- Odour (e.g. Marine, sulphurous).

2.2 Analysis Protocols

2.2.1 Laboratory Analysis

Sediment analysis was completed by two NATA accredited laboratories. Advanced Analytical Australia provided primary laboratory services and sub-contracted Envirolab to conduct acid sulfate soils (ASS), Golder Associates to conduct particle size and bulk density analysis, and Western Radiation Services to conduct radionuclides. The secondary laboratory, mgt-Labmark, provided laboratory services for QA/QC samples.

Table 2-2 provides a summary of the contaminant analysis completed for each sediment sample collected. Contaminant analysis was determined based on the project brief supplied by PBPL. All sites were analysed for a basic suite of parameters including:

- Particle size distribution (sieve and hydrometer analysis);
- Moisture content;
- Total Organic Carbon (TOC);

- Total Petroleum Hydrocarbons (TPH);
- Benzene, Toluene, Ethylbenzene and Xylene (BTEX);
- Trace Metals/metalloids (As, Cd, Cr, Cu, Pb, Hg, Ni, Zn);
- Total Phosphorus;
- Total Nitrogen (Nitrite and Nitrate as N, Total Kjeldahl Nitrogen as N);
- Organotins; and
- Organochlorine (OC) and Organophosphorous (OP) pesticides.

In addition, at selected locations a more detailed suite of parameters were analysed and they included:

- Total Polychlorinated biphenyls (PCBs);
- Polycyclic Aromatic Hydrocarbons (PAHs);
- Sum Total of PAHs; and
- Acid Sulfate Soils (ASS).

Bulk density testing at ten locations and radionuclides at eight locations were also completed as specified by PBPL.

Table 2-2: Contaminant analyses undertaken at each sampling location

Sample Location	Basic									Detailed				
	PSD	TOC	TPH/BTEX	Metals	Total P	Total N	Organotins	OC	OP	PCB	PAH	ASS	Bulk Density	Radionuclides
1-0	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
2-0	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
3-0	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
4-0	✓	✓	✓	✓	✓	✓	✓	✓	✓					
4-4	✓	✓	✓	✓	✓	✓	✓	✓	✓					
4-5	✓	✓	✓	✓	✓	✓	✓	✓	✓					
4-7	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
4-8	✓	✓	✓	✓	✓	✓	✓	✓	✓				✓	
4-9	✓	✓	✓	✓	✓	✓	✓	✓	✓					
4-10	✓	✓	✓	✓	✓	✓	✓	✓	✓					
4-13	✓	✓	✓	✓	✓	✓	✓	✓	✓					
5-0	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
6-2	✓	✓	✓	✓	✓	✓	✓	✓	✓				✓	
6-3	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
7-1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
8-1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
8-2	✓	✓	✓	✓	✓	✓	✓	✓	✓					
8-3	✓	✓	✓	✓	✓	✓	✓	✓	✓					
8-4	✓	✓	✓	✓	✓	✓	✓	✓	✓					
9-1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
9-2	✓	✓	✓	✓	✓	✓	✓	✓	✓					
9-4	✓	✓	✓	✓	✓	✓	✓	✓	✓				✓	
10-1	✓	✓	✓	✓	✓	✓	✓	✓	✓				✓	
10-5	✓	✓	✓	✓	✓	✓	✓	✓	✓					
10-6	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
10-8	✓	✓	✓	✓	✓	✓	✓	✓	✓					
11-1	✓	✓	✓	✓	✓	✓	✓	✓	✓					
11-3	✓	✓	✓	✓	✓	✓	✓	✓	✓					
11-4	✓	✓	✓	✓	✓	✓	✓	✓	✓					
11-5	✓	✓	✓	✓	✓	✓	✓	✓	✓					
11-8	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
11-9	✓	✓	✓	✓	✓	✓	✓	✓	✓				✓	
11-11	✓	✓	✓	✓	✓	✓	✓	✓	✓				✓	
11-12	✓	✓	✓	✓	✓	✓	✓	✓	✓					
12-1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		

Table 2-2: Contaminant analyses undertaken at each sampling location

Sample Location	Basic									Detailed			Bulk Density	Radionuclides
	PSD	TOC	TPH/BTEX	Metals	Total P	Total N	Organotins	OC	OP	PCB	PAH	ASS		
12-2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
12-3	✓	✓	✓	✓	✓	✓	✓	✓	✓					
13-1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
13-2	✓	✓	✓	✓	✓	✓	✓	✓	✓					
13-3	✓	✓	✓	✓	✓	✓	✓	✓	✓					
13-4	✓	✓	✓	✓	✓	✓	✓	✓	✓					
13-5	✓	✓	✓	✓	✓	✓	✓	✓	✓					
13-6	✓	✓	✓	✓	✓	✓	✓	✓	✓					
13-7	✓	✓	✓	✓	✓	✓	✓	✓	✓				✓	
13-8	✓	✓	✓	✓	✓	✓	✓	✓	✓				✓	
13-9	✓	✓	✓	✓	✓	✓	✓	✓	✓					
14-1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
15-1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
BC-1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
BC-2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
BC-3	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
BC-4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		

Laboratory limits of reporting (LORs) are identified as the lowest chemical analysis level that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions and are commonly referred to as Practical Quantitation Limits (PQLs). The PQLs reported in Table 2-3 were applicable to the analyses and comply with the PQLs required under Appendix A, Table 1 of the NAGD.

Table 2-3: Comparison of laboratory PQLs achieved and NAGD requirements

Analyte	PQLs	NAGD PQL
Moisture content	0.1%	0.1%
Total organic carbon	0.01%	0.1%
Particle size	0.002 mm diameter	-
total metals/metalloids	0.1 mg/kg (Hg 0.01 mg/kg, As 0.4mg/kg, Zn & Pb 0.5mg/kg)	200 mg/kg (Al), 100 mg/kg Fe, 10 mg/kg (Mn),2 mg/kg (V), 1 mg/kg (Cu, Pb, Zn, Cr, Ni, As), 0.5 mg/kg (Co, Sb), 0.1 mg/kg (Cd, Ag, Se), 0.01 mg/kg (Hg)
PAHs (individual)	5 -10 μg/kg	5 μg/kg
Total PAHs	100 μg/kg	100 μg/kg
Organotins	0.5 μgSn/kg	1 μgSn/kg
Nutrients	0.1 – 20 mg/kg	0.1 mg/kg
TPH	10-50 mg/kg	100 mg/kg
BTEX	0.2 mg/kg	0.2 mg/kg
Total PCBs	5 μg/kg	5 μg/kg
OCPs	1 μg/kg	varies
OPPs	20μg/kg	10-100 μg/kg

2.2.2 Data Analysis

2.2.2.1 Contaminants

Contaminant levels for sediments are compared against the following guidelines:

- Screening Level concentrations listed in Appendix A Table 2 of the NAGD (Commonwealth of Australia, 2009) to assess whether the material is suitable for unconfined placement at sea or if further testing is required (e.g. elutriate, bioavailability and/or direct toxicity assessment).
- EIL and HIL-A for residential land use listed in the Draft Guidelines for the Assessment and Management of Contaminated Land in Queensland (DEH, 1998) to assess the suitability for placement of dredged material on land, using the most stringent of the health investigation categories (residential use).

The comparison against guideline levels involves the comparison of mean contaminant concentrations at the 95% UCL of the mean. For the purposes of calculation of normalised values and of 95% UCLs, values below detection limits were set to one-half of the LOR in accordance with NAGD recommendations. Results for organic parameters are normalised to TOC concentration where the recorded value is within the range of 0.2 – 10%. If TOC values are outside this range, then the

highest or lowest of the 0.2 – 10% range is adopted as appropriate. Organic contaminants below LOR were not normalised to TOC concentration in 95% UCL calculations, but reported as one-half LORs for comparison.

The methods used to calculate the 95% UCLs were based on those required in Appendix A of the NAGD (P38, Comparison of Data to Screening Levels). Normality of datasets was determined using Shapiro-Wilks test and quantile-quantile plots in ProUCL Version 4 (4.1.00) developed by the US EPA. Datasets were determined as being normal, log-normal or neither in their distributions. Normal datasets were analysed using the 1-tailed student's 't' UCL. Log-normal datasets were analysed using non-parametric jacknife analysis as recommended in the NAGD. Similarly, datasets that were neither normal nor log-normally distributed were analysed using non-parametric jacknife analysis.

Outcomes regarding the tests are presented in each of the zone/dredge area tables in Section 3. Under the NAGD, if the 95%UCL values for all substances are below relevant Screening Levels, it is considered unlikely that sediment contaminants will have adverse effects on organisms living in or on that sediment. The sediment is therefore considered non-toxic and there are no chemical obstacles to unconfined sea disposal.

Temporal and spatial analysis of contaminant results was also undertaken. Data collected during previous SAP investigations has been collated and compared against results obtained during the 2013 sampling program. Temporal and spatial data has been analysed using summary statistical methodology and presented graphically as a series of geographic information system (GIS) maps and box plots.

2.2.2.2 Acid Sulfate Soils

The *Queensland Acid Sulfate Soil Technical Manual – Soil Management Guidelines* (Dear *et al*. 2002) provides action criteria for when acid sulfate soils (ASS) is disturbed at a site and should be managed (refer Table 2-4). In order to account for a soil's natural ability to resist pH change (buffering capacity) which is generally influenced by clay content, the action criteria have been grouped into the following three broad soil texture categories: coarse; medium; and fine.

Table 2-4: Soil management guidelines for acid sulfate soil action criteria

Type of material		Action criteria if 1 to 1000 tonnes of material is disturbed		Action criteria if more than 1000 tonnes of material is disturbed	
Texture range (McDonald et al. 1990)	**Approx. clay content (%)**	**Existing + Potential Acidity**		**Existing + Potential Acidity**	
		Equivalent sulphur (%S) (oven-dry basis)	**Equivalent acidity (mol H+/tonne) (oven-dry basis)**	**Equivalent sulphur (%S) (oven-dry basis)**	**Equivalent acidity (mol H+/tonne) (oven-dry basis)**
Coarse texture - Sands to loamy sands	<□5	0.03	18	0.03	18
Medium texture - Sandy loams to light clays	5 - 40	0.06	36	0.03	18
Fine texture - Medium to heavy clays and silty clays	>40	0.1	62	0.03	18

(Dear et al. 2002)

Action criteria for disturbances greater than 1,000 tonnes have been selected as the appropriate criteria based on the maintenance works that are likely to occur.

2.3 Quality Assurance/Quality Control (QA/QC)

2.3.1 QA/QC – Field Sampling

The following procedures were undertaken during sampling:

- Using suitably qualified environmental staff and support personnel experienced in piston corer sediment sampling, field supervision and sediment logging;
- Decontaminating all sampling equipment, including mixing bowls etc. between samples via a decontamination procedure involving washing with ambient sea water and a laboratory grade detergent (Decon 90), and successive rinsing with deionised water;
- Storing samples in appropriately cleaned, pre-treated and labelled sample containers that were provided by the analytical laboratory;
- Keeping samples cool in eskies containing bags of ice immediately after sampling, stored at 1°C in a mobile refrigerator until being transported to the laboratory in eskies containing ice-packs;
- Transportation of samples to the laboratories under chain of custody documentation; and
- Blind labelling all field QC (split and replicate samples) samples with identification that did not relate to sampling location names so the laboratory analyses these samples “blind”.

2.3.2 QA/QC – Laboratory Analysis

QA/QC procedures for contaminant assessment were used from sampling through to completion of laboratory analysis, including:

- Chain of custody (COC) documentation;
- Field and intra-laboratory QC protocols; and
- Inter-laboratory analyses.

Material submitted for testing included additional samples for quality control (QC) purposes in accordance with the project brief and NAGD requirements. Additional QC samples included:

- Sediment homogeneity – a 'replicate triplicate' sample (i.e. three separate samples taken within 1 m^3);
- Inter and intra-laboratory comparisons – a 'split triplicate' sample – two samples sent to the 'primary laboratory' (intra-laboratory) and a third sent to a secondary ('check') laboratory (inter-laboratory);
- Inter-batch duplicate- one sample split into two and submitted to the laboratory in two different batches to test for precision.

Table 2-5 provides a summary of the field QC samples obtained in accordance with the project brief and NAGD requirements and included; one inter-batch duplicate, seven samples to test for site homogeneity and three field replicate triplicate.

Table 2-5: Summary of QC analyses undertaken during 2013 SAP study

Site	Sediment Homogeneity	Field Split Triplicate	Inter-batch Duplicate	Sample Analyses Suite Type
3-0	X			Basic + Detailed
4-9	X			Basic
6-2		X		Basic + Bulk Density
7-1	X			Basic + Detailed + Radionuclides
9-1		X		Basic + Detailed
10-8	X			Basic
11-11	X			Basic + Bulk Density
12-2		X		Basic + Detailed + Radionuclides
13-2	X			Basic
BC-2	X		X	Basic + Detailed

Laboratory QC procedures were conducted in accordance with the requirements of Appendix F of the NAGD. These requirements included analysis of laboratory blanks, certified reference materials, replicates and spiked samples.

Validation of the laboratory analyses was undertaken in accordance with Appendix A of the NAGD to confirm that the data quality was suitable for undertaking an assessment to characterise material proposed for dredging and disposal. Laboratory data validation included assessment of results for laboratory blanks, standards, surrogate, matrix spikes and matrix duplicate samples. Field data validation included calculation of relative standard deviation (RSD) for field split triplicates and site homogeneity with comparisons against laboratory and NAGD criteria.

3 RESULTS

3.1 Chemical Results

Laboratory results obtained during the 2013 SAP study are summarised in Table 3-1. Primary laboratory analytical reports are provided in Appendix 3. Results are compared against the Screening Levels listed in Appendix A, Table 2 of the NAGD (Commonwealth of Australia, 2009) and EIL and HIL (A) guidelines listed in Appendix 9 (DEH, 1998).

3.1.1 Contaminant Concentrations Exceeding NAGD Screening Levels

Contaminants exceeding NAGD Screening Levels are described below and presented spatially in maps in Appendix 1.

3.1.1.1 METALS/METALLOIDS

- Eight of the forty-eight samples (17%) had total mercury concentrations that were greater than the NAGD Screening Level of 0.15 mg/kg. There were six locations that had values that exceeded this value in Zone 2 (4-0, 4-4, 4-8, 4-13, 8-3 and 8-4) and two locations in Zone 3 (10-6 and 11-8);
- Thirty of the forty-eight samples (63%) had total nickel levels that were greater than the NAGD Screening Level (21 mg/kg). There was one location that had values that exceeded this value in Zone 1 (3-0), fourteen locations in Zone 2 (4-0, 4-4, 4-5, 4-8, 4-10, 4-13, 5-0, 6-2, 6-3, 7-1, 8-1, 8-2, 8-3 and 8-4), twelve locations in Zone 3 (9-1, 9-2, 9-4, 10-1, 10-5, 10-6, 11-1, 11-3, 11-9, 11-11, 11-12 and 12-1), and three locations in Zone 4 (13-3, 13-6 and 13-8).

3.1.1.2 ORGANOTINS

- Tributyltin concentrations (normalised to TOC concentration) exceeded the NAGD Screening Level of 9 µgSn/kg at one location in Zone 2 (4-0).

3.1.1.3 BTEX

- All BTEX concentrations were below PQLs (0.2-0.4 mg/kg) at all locations.

3.1.1.4 POLYCYCLIC AROMATIC HYDROCARBONS

- Total PAHs (normalised to TOC concentration) were below the NAGD Screening Level of 10,000 µg/kg at all locations.

3.1.1.5 Total Petroleum Hydrocarbons

- Total TPHs (normalised to TOC concentration) were below the NAGD Screening Level of 550 µg/kg at all locations.

3.1.1.6 Polychlorinated Biphenyls

- Polychlorinated biphenyls (PCB) concentrations (normalised to TOC concentration) exceeded the NAGD Screening Level of 23 µg/kg at one location in Zone 3 (10-6).

3.1.1.7 Organochlorine Pesticides

- One of the samples had a p,p'-DDD concentration (normalised to TOC concentration) that was greater than the NAGD Screening Level of 2 µg/kg. The location that had a value that exceeded the NAGD value was in Zone 2 (8-3);
- Fourteen (14) of the 48 samples (29%) had p,p'-DDE concentrations (normalised to TOC concentration) that were greater than the NAGD Screening Level of 2.2 µg/kg. There were five locations that had values that exceeded this value in Zone 2 (4-8, 6-3, 7-1, 8-3, 8-4) and nine locations in Zone 3 (9-4, 10-1, 10-6, 11-8, 11-9, 11-11, 12-3, 12-1 and 14-1);
- One of the samples had p,p'-DDT concentrations (normalised to TOC concentration) that was greater than the NAGD Screening Level of 1.6 µg/kg. The location that had a value that exceeded the NAGD value was in Zone 2 (8-3);

3.1.1.8 Organophosphorus Pesticides

- OPPs were below PQLs (20 µg/kg) at all locations

3.1.1.9 Radionuclides

- Sum of gross alpha and gross beta radionuclides were below PQLs (<195 mBq/g) at all locations.

3.1.2 Contaminant Concentrations Exceeding EIL or HIL (A)

Only one of the samples had an analyte that had a concentration greater than its EIL. One sample had copper concentration in Zone 2 (4-0) that exceeded its respective EIL of 60 µg/kg.

There were no parameters that had reported concentrations equal to or exceeding HIL (A) guideline values.

Table 3-1: Summary of laboratory results (Primary Laboratory)

							Zone 1		
Sample	**Units**	**PQL**	**NAGD PQL**	**NAGD Screening Level**	**EIL**	**HIL-A**	**1-0**	**2-0**	**3-0**
Date sampled							4/12/12	4/12/12	4/12/12
Moisture Content	%	0.1	0.1				18	17.3	68.5
Total Organic Carbon	%	0.01	0.1				0.25	0.06	2
Metals and Metalloids									
Arsenic	mg/kg	0.4	1	20.0	20.0	100.0	2.10	1.60	9.30
Cadmium	mg/kg	0.1	0.1	1.5	3	20.0	<0.1	<0.1	<0.1
Chromium	mg/kg	0.1	1	80.0			11.00	8.10	43.00
Copper	mg/kg	0.1	1	65.0	60	1000.0	4.50	2.60	35.00
Lead	mg/kg	0.5	1	50	300	300.0	3.40	2.10	24.00
Mercury	mg/kg	0.01	0.01	0.15	1	15.0	0.01	<0.01	0.13
Nickel	mg/kg	0.1	1	21.0	60	600.0	7.40	6.40	28.00
Phosphorus*	mg/kg	1					240.00	200.00	970.00
Zinc	mg/kg	0.5	1	200	200	7,000	25.00	17.00	140.00
Organotins									
Monobutyl tin	µgSn/kg	0.5	*1*				<0.5	<0.5	<1.0
Dibutyl tin	µgSn/kg	0.5	*1*				<0.5	<0.5	<1.0
Tributyl tin	µgSn/kg	0.5	1				<0.5	<0.5	1.10
Normalised to TOC Concentration				9					0.55
BTEX									
Benzene	mg/kg	0.2	0.2				<0.2	<0.2	<0.4
Toluene	mg/kg	0.2	0.2				<0.2	<0.2	<0.4
Ethyl Benzene	mg/kg	0.2	0.2				<0.2	<0.2	<0.4
m+p xylenes	mg/kg	0.4					<0.4	<0.4	<0.8
o-xylene	mg/kg	0.2	0.2				<0.2	<0.2	<0.4
Total BTEX	mg/kg	1.2					<1.2	<1.2	<2.4
Total Petroleum Hydrocarbons									
TPH C6-C9	mg/kg	10	100				<10	<10	<20
TPH C10-14	mg/kg	10	100				<10	<10	<20
TPH C15-28	mg/kg	50	100				<50	<50	120.00
Normalised to TOC Concentration									60.00
TPH C29-36	mg/kg	50	100				<50	<50	140.00
Normalised to TOC Concentration									70.00
Total TPH	mg/kg		100						260.00
Normalised to TOC Concentration				550					130.00
Polycyclic Aromatic Hydrocarbons									
Naphthalene	µg/kg	5	5				<5	<5	21.00
Normalised to TOC Concentration									10.50
1-Methylnaphthalene	µg/kg	5	5				<5	<5	11.00
Normalised to TOC Concentration									5.50
2-Methylnaphthalene	µg/kg	5	5				<5	<5	31.00
Normalised to TOC Concentration									15.50
Acenaphthylene	µg/kg	5	5				<5	<5	13.00
Normalised to TOC Concentration									6.50
Acenaphthene	µg/kg	5	5				<5	<5	<10
Fluorene	µg/kg	5	5				<5	<5	22.00
Normalised to TOC Concentration									11.00
Phenanthrene	µg/kg	5	5				<5	<5	69.00
Normalised to TOC Concentration									34.50

Note: Only presenting results above limits of reporting.

Table 3-1 continued: Summary of laboratory results (Primary Laboratory)

							Zone 1		
Sample	**Units**	**PQL**	**NAGD PQL**	**NAGD Screening Level**	**EIL**	**HIL-A**	**1-0**	**2-0**	**3-0**
Anthracene	µg/kg	5	5				<5	<5	22.00
Normalised to TOC Concentration									11.00
Fluoranthene	µg/kg	5	5				7.00	<5	110.00
Normalised to TOC Concentration							28.00		55.00
Pyrene	µg/kg	5	5				8.00	<5	160.00
Normalised to TOC Concentration							32.00		80.00
Benz(a)anthracene	µg/kg	5	5				<5	<5	95.00
Normalised to TOC Concentration									47.50
Chrysene	µg/kg	5	5				<5	<5	76.00
Normalised to TOC Concentration									38.00
Benzo(b)&(k)fluoranthene	µg/kg	10	5				<10	<10	170.00
Normalised to TOC Concentration									85.00
Benzo(a)pyrene	µg/kg	5	5				<5	<5	93.00
Normalised to TOC Concentration									46.50
Indeno(1,2,3-cd)pyrene	µg/kg	5	5					<5	95.00
Normalised to TOC Concentration									47.50
Dibenz(a,h)anthracene	µg/kg	5	5				<5	<5	21.00
Normalised to TOC Concentration									10.50
Benzo(g,h,i)perylene	µg/kg	5	5				<5	<5	100.00
Normalised to TOC Concentration									50.00
Coronene	µg/kg	10	5				<10	<10	30.00
Normalised to TOC Concentration									15.00
Benzo(e)pyrene	µg/kg	5	5				<5	<5	75.00
Normalised to TOC Concentration									37.50
Perylene	µg/kg	5	5				25.00	<5	400.00
Normalised to TOC Concentration									200.00
Total PAHs (as above)	µg/kg	100	100	10000			<100	<100	1620.00
Normalised to TOC Concentration									810.00
Organochlorine Pesticides									
Aldrin	µg/kg	1					<1	<1	<2
alpha-BHC	µg/kg	1					<10	<10	<20
beta-BHC	µg/kg	1					<10	<10	<20
gamma-BHC (Lindane)	µg/kg	1					<10	<10	<20
delta-BHC	µg/kg	1					<10	<10	<20
cis-Chlordane	µg/kg	1	0.5				<1	<1	<2
trans-Chlordane	µg/kg	1	0.5				<1	<1	<2
p,p'-DDD	µg/kg	1	2				<10	<10	<20
p,p'-DDE	µg/kg	1	2.2				<1	<1	4.00
Normalised to TOC Concentration				2.20					2.00
p,p'-DDT	µg/kg	1	1.6				<10	<10	<20
Dieldrin	µg/kg	1	280				<1	<1	<2
alpha-Endosulfan	µg/kg	1					<10	<10	<20
beta-Endosulfan	µg/kg	1					<10	<10	<20
Endosulfan Sulphate	µg/kg	1					<1	<1	<2
Endrin	µg/kg	1	10				<1	<1	<2
Endrin ketone	µg/kg	1					<1	<1	<2
Endrin aldehyde	µg/kg	1					<1	<1	<2

Note: Only presenting results above limits of reporting.

Table 3-1 continued: Summary of laboratory results (Primary Laboratory)

							Zone 1		
Sample	**Units**	**PQL**	**NAGD PQL**	**NAGD Screening Level**	**EIL**	**HIL-A**	**1-0**	**2-0**	**3-0**
Heptachlor	µg/kg	1					<1	<1	<2
Heptachlor epoxide	µg/kg	1					<1	<1	<2
Hexachlorobenzene	µg/kg	1					<1	<1	<2
Methoxychlor	µg/kg	1					<1	<1	<2
Oxychlordane*	µg/kg	1					<1	<1	<2
Orgonophosphoros Pesticides									
Dichlorvos	µg/kg	20	10-100				<20	<20	<40
Demeton-S-methyl	µg/kg	20	10-100				<20	<20	<40
Dimethoate	µg/kg	20	10-100				<20	<20	<40
Diazinon	µg/kg	20	10-100				<20	<20	<40
Chlorpyrifos-methyl	µg/kg	20	10-100				<20	<20	<40
Parathion-methyl	µg/kg	20	10-100				<20	<20	<40
Pirimiphos-methyl	µg/kg	20	10-100				<20	<20	<40
Fenitrothion	µg/kg	20	10-100				<20	<20	<40
Malathion	µg/kg	20	10-100				<20	<20	<40
Chlorpyrifos	µg/kg	20	10-100				<20	<20	<40
Fenthion	µg/kg	20	10-100				<20	<20	<40
Parathion*	µg/kg	20	10-100				<20	<20	<40
Chlorfenvinphos	µg/kg	20	10-100				<20	<20	<40
Bromophos-ethyl	µg/kg	20	10-100				<20	<20	<40
Methidathion	µg/kg	20	10-100				<20	<20	<40
Fenamiphos	µg/kg	20	10-100				<20	<20	<40
Prothiofos	µg/kg	20	10-100				<20	<20	<40
Ethion	µg/kg	20	10-100				<20	<20	<40
Carbophenothion	µg/kg	20	10-100				<20	<20	<40
Phosalone	µg/kg	20	10-100				<20	<20	<40
Azinphos-methyl*	µg/kg	20	10-100				<20	<20	<40
Fenchlorvos*	µg/kg	20	10-100				<20	<20	<40
Mevinphos	µg/kg	20	10-100				<20	<20	<40
Trifluralin*	µg/kg	20	10-100				<20	<20	<40
Nutrients									
Nitrate as N	mg/kg	0.1	0.1				<0.1	<0.1	<0.1
Nitrite as N	mg/kg	0.1	0.1				<0.1	<0.1	<0.1
Total Kjeldahl Nitrogen	mg/kg	20					120	37	1730
Total Nitrogen	mg/kg	20					120	37	1730
PCB									
Mono-PCB congeners	µg/kg	5	1.00				<5	<5	<10
Di-PCB congeners	µg/kg	5	1.00				<5	<5	<10
Tri-PCB congeners	µg/kg	5	1.00				<5	<5	<10
Tetra-PCB congeners	µg/kg	5	1.00				<5	<5	<10
Penta-PCB congeners	µg/kg	5	1.00				<5	<5	<10
Hexa-PCB congeners	µg/kg	5	1.00				<5	<5	<10
Hepta-PCB congeners	µg/kg	5	1.00				<5	<5	<10
Octa-PCB congeners	µg/kg	5	1.00				<5	<5	<10
Nona-PCB congeners	µg/kg	5	1.00				<5	<5	<10
Deca-PCB congeners	µg/kg	5	1.00				<5	<5	<10
Total PCB congeners	µg/kg	5	5.00	23.00			<5	<5	<10

Note: Only presenting results above limits of reporting.

Table 3-1 continued: Summary of laboratory results (Primary Laboratory)

							Zone 2														
Sample	**Units**	**PQL**	**NAGD PQL**	**NAGD Screening Level**	**EIL**	**HIL-A**	**4-0**	**4-4**	**4-5**	**4-7**	**4-8**	**4-9**	**4-10**	**4-13**	**5-0**	**6-2**	**6-3**	**7-1**	**8-1**	**8-2**	**8-3**	**8-4**
Date sampled							6/12/12	6/12/12	6/12/12	6/12/12	6/12/12	6/12/12	6/12/12	6/12/12	4/12/12	3/12/12	3/12/12	6/12/12	6/12/12	3/12/12	3/12/12	3/12/12
Moisture Content	%	0.1	0.1				50.6	61.7	57.9	51.8	57.5	38	55	56.6	57.7	63.8	51.8	55.6	58.3	52.7	50.4	50.4
Total Organic Carbon	%	0.01	0.1				1.5	1.8	1.5	1.4	1.6	0.92	1.6	1.7	1.7	1.6	1.9	2.1	1.6	1.5	1.2	1.3
Metals and Metalloids																						
Arsenic	mg/kg	0.4	1	20.0	20.0	100.0	8.60	9.40	8.50	6.50	7.80	5.20	7.00	8.40	8.10	7.20	9.10	7.90	8.60	9.00	9.40	9.20
Cadmium	mg/kg	0.1	0.1	1.5	3	20.0	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.35	0.44
Chromium	mg/kg	0.1	1	80.0			50.00	49.00	45.00	33.00	45.00	33.00	40.00	47.00	47.00	42.00	46.00	44.00	43.00	46.00	53.00	54.00
Copper	mg/kg	0.1	1	65.0	60	1000.0	61.00	45.00	42.00	29.00	39.00	16.00	36.00	54.00	45.00	34.00	37.00	35.00	34.00	31.00	32.00	32.00
Lead	mg/kg	0.5	1	50	300	300.0	34.00	27.00	23.00	21.00	34.00	10.00	26.00	32.00	25.00	19.00	23.00	19.00	23.00	18.00	18.00	19.00
Mercury	mg/kg	0.01	0.01	0.15	1	15.0	0.15	0.15	0.14	0.10	0.17	0.06	0.13	0.17	0.12	0.09	0.14	0.13	0.11	0.09	0.35	0.36
Nickel	mg/kg	0.1	1	21.0	60	600.0	24.00	27.00	23.00	19.00	24.00	19.00	22.00	23.00	25.00	24.00	28.00	21.00	22.00	25.00	24.00	23.00
Phosphorus*	mg/kg	1					910.00	890.00	860.00	710.00	910.00	420.00	850.00	920.00	940.00	1000.00	990.00	670.00	750.00	770.00	920.00	1000.00
Zinc	mg/kg	0.5	1	200	200	7,000	180.00	150.00	130.00	110.00	130.00	50.00	130.00	160.00	140.00	120.00	110.00	110.00	120.00	100.00	100.00	100.00
Organotins																						
Monobutyl tin	µgSn/kg	0.5	*1*				<0.5	<1.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1.0	<0.5	0.90	<0.5	<0.5	<0.5	<0.5
Normalised to TOC Concentration																		0.43				
Dibutyl tin	µgSn/kg	0.5	*1*				4.80	2.70	2.90	1.90	5.40	<0.5	3.10	9.90	3.20	1.10	1.80	9.10	1.40	1.90	2.60	2.50
Normalised to TOC Concentration							3.20	1.50	1.93	1.36	3.38		1.94	5.82	1.88	0.69	0.95	4.33	0.88	1.27	2.17	1.92
Tributyl tin	µgSn/kg	0.5	1				22.00	2.30	3.50	1.20	6.60	<0.5	2.90	14.00	3.00	1.50	2.70	74.00	1.00	2.60	0.50	<0.5
Normalised to TOC Concentration				9			14.67	1.28	2.33	0.86	4.13		1.81	8.24	1.76	0.94	1.42	35.24	0.63	1.73	0.42	
BTEX																						
Benzene	mg/kg	0.2	0.2				<0.2	<0.4	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.4	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Toluene	mg/kg	0.2	0.2				<0.2	<0.4	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.4	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Ethyl Benzene	mg/kg	0.2	0.2				<0.2	<0.4	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.4	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
m+p xylenes	mg/kg	0.4					<0.4	<0.8	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.8	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
o-xylene	mg/kg	0.2	0.2				<0.2	<0.4	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.4	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Total BTEX	mg/kg	1.2					<1.2	<2.4	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<2.4	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2
Total Petroleum Hydrocarbons																						
TPH C6-C9	mg/kg	10	100				<10	<20	<10	<10	<10	<10	<10	<10	<10	<20	<10	<10	<10	<10	<10	<10
TPH C10-14	mg/kg	10	100				<10	<20	<10	<10	<10	<10	<10	<10	<10	<20	<10	<10	<10	<10	<10	<10
TPH C15-28	mg/kg	50	100				<50	<100	<50	<50	89.00	<50	56.00	61.00	94.00	<100	75.00	<50	<50	55.00	110.00	110.00
Normalised to TOC Concentration											55.63		35.00	35.88	55.29		39.47			36.67	91.67	84.62
TPH C29-36	mg/kg	50	100				51.00	<100	61.00	53.00	100.00	<50	81.00	84.00	120.00	<100	98.00	63.00	51.00	84.00	120.00	120.00
Normalised to TOC Concentration							34.00		40.67	37.86	62.50		50.63	49.41	70.59		51.58	30.00	31.88	56.00	100.00	92.31
Total TPH			100	550																		
Polycyclic Aromatic Hydrocarbons																						
Naphthalene	µg/kg	5	5							7.00					10.00		14.00	<5	<5			
Normalised to TOC Concentration										5.00	0.00	0.00	0.00	0.00	5.88		7.37					
1-Methylnaphthalene	µg/kg	5	5							<5					6.00		14.00	<5	<5			
Normalised to TOC Concentration															3.53		7.37					
2-Methylnaphthalene	µg/kg	5	5							6.00					8.00		22.00	<5	<5			
Normalised to TOC Concentration										4.29					4.71		11.58					
Acenaphthylene	µg/kg	5	5							18.00					11.00		10.00	8.00	5.00			
Normalised to TOC Concentration										12.86					6.47		5.26	3.81	3.13			
Acenaphthene	µg/kg	5	5							<5					<5		22.00	6.00	<5			
Normalised to TOC Concentration																	11.58	2.86				
Fluorene	µg/kg	5	5							6.00					8.00		21.00	6.00	<5			

Note: Only presenting results above limits of reporting.

Table 3-1 continued: Summary of laboratory results (Primary Laboratory)

							Zone 2															
Sample	**Units**	**PQL**	**NAGD PQL**	**NAGD Screening Level**	**EIL**	**HIL-A**	**4-0**	**4-4**	**4-5**	**4-7**	**4-8**	**4-9**	**4-10**	**4-13**	**5-0**	**6-2**	**6-3**	**7-1**	**8-1**	**8-2**	**8-3**	**8-4**
Normalised to TOC Concentration										4.29					4.71		11.05	2.86				
Phenanthrene	µg/kg	5	5							25.00					34.00		68.00	22.00	14.00			
Normalised to TOC Concentration										17.86					20.00		35.79	10.48	8.75			
Anthracene	µg/kg	5	5							8.00					14.00		18.00	10.00	6.00			
Normalised to TOC Concentration										5.71					8.24		9.47	4.76	3.75			
Fluoranthene	µg/kg	5	5							70.00					76.00		130.00	67.00	43.00			
Normalised to TOC Concentration										50.00					44.71		68.42	31.90	26.88			
Pyrene	µg/kg	5	5							110.00					120.00		190.00	200.00	68.00			
Normalised to TOC Concentration										78.57					70.59		100.00	95.24	42.50			
Benz(a)anthracene	µg/kg	5	5							61.00					68.00		89.00	46.00	32.00			
Normalised to TOC Concentration										43.57					40.00		46.84	21.90	20.00			
Chrysene	µg/kg	5	5							54.00					63.00		79.00	54.00	33.00			
Normalised to TOC Concentration										38.57					37.06		41.58	25.71	20.63			
Benzo(b)&(k)fluoranthene	µg/kg	10	5							160.00					160.00		190.00	180.00	83.00			
Normalised to TOC Concentration										114.29					94.12		100.00	85.71	51.88			
Benzo(a)pyrene	µg/kg	5	5							94.00					82.00		110.00	61.00	42.00			
Normalised to TOC Concentration										67.14					48.24		57.89	29.05	26.25			
Indeno(1,2,3-cd)pyrene	µg/kg	5	5							80.00					93.00		89.00	56.00	37.00			
Normalised to TOC Concentration										57.14					54.71		46.84	26.67	23.13			
Dibenz(a,h)anthracene	µg/kg	5	5							21.00					19.00		15.00	13.00	9.00			
Normalised to TOC Concentration										15.00					11.18		7.89	6.19	5.63			
Benzo(g,h,i)perylene	µg/kg	5	5							94.00					92.00		99.00	51.00	38.00			
Normalised to TOC Concentration										67.14					54.12		52.11	24.29	23.75			
Coronene	µg/kg	10	5							25.00					30.00		26.00	11.00	10.00			
Normalised to TOC Concentration										17.86					17.65		13.68	5.24	6.25			
Benzo(e)pyrene	µg/kg	5	5							72.00					65.00		86.00	69.00	38.00			
Normalised to TOC Concentration										51.43					38.24		45.26	32.86	23.75			
Perylene	µg/kg	5	5							600.00					780.00		720.00	130.00	450.00			
Normalised to TOC Concentration										428.57					458.82		378.95	61.90	281.25			
Total PAHs (as above)	µg/kg	100	100	10000						1510.00					1730.00		2010.00	990.00	910.00			
Normalised to TOC Concentration										1078.57					1017.65		1057.89	471.43	568.75			
Organochlorine Pesticides																						
Aldrin	µg/kg	1					<1	<1	<1	<1	<1	<1	<1	<1	<1	<2	<1	<1	<1	<1	<1	<1
alpha-BHC	µg/kg	1					<10	<10	<10	<10	<10	<10	<10	<10	<10	<20	<10	<10	<10	<10	<10	<10
beta-BHC	µg/kg	1					<10	<10	<10	<10	<10	<10	<10	<10	<10	<20	<10	<10	<10	<10	<10	<10
gamma-BHC (Lindane)	µg/kg	1					<10	<10	<10	<10	<10	<10	<10	<10	<10	<20	<10	<10	<10	<10	<10	<10
delta-BHC	µg/kg	1					<10	<10	<10	<10	<10	<10	<10	<10	<10	<20	<10	<10	<10	<10	<10	<10
cis-Chlordane	µg/kg	1	0.5				<1	<1	<1	<1	<1	<1	<1	<1	<1	<2	<1	<1	<1	<1	<1	<1
trans-Chlordane	µg/kg	1	0.5				<1	<1	<1	<1	<1	<1	<1	<1	<1	<2	<1	<1	<1	<1	<1	<1
p,p'-DDD	µg/kg	1	2				<10	<10	<10	<10	<10	<10	<10	<10	<10	<20	<10	<10	<10	<10	29.00	<10
Normalised to TOC Concentration				2.00																	24.17	
p,p'-DDE	µg/kg	1	2.2				3.00	3.00	3.00	1.00	6.00	<1	3.00	3.00	3.00	3.00	5.00	6.00	3.00	3.00	12.00	7.00
Normalised to TOC Concentration				2.20			2.00	1.67	2.00	0.71	3.75		1.88	1.76	1.76	1.88	2.63	2.86	1.88	2.00	10.00	5.38
p,p'-DDT	µg/kg	1	1.6				<10	<10	<10	<10	<10	<10	<10	<10	<10	<20	<10	<10	<10	<10	150.00	<10
Normalised to TOC Concentration				1.60																	125.00	
Dieldrin	µg/kg	1	280				<1	<1	<1	<1	<1	<1	<1	<1	<1	5.00	<1	<1	<1	<1	<1	<1
Normalised to TOC Concentration				280.00												3.13						

Note: Only presenting results above limits of reporting.

Table 3-1 continued: Summary of laboratory results (Primary Laboratory)

							Zone 2													
Sample	**Units**	**PQL**	**NAGD PQL**	**NAGD Screening Level**	**EIL**	**HIL-A**	**4-0**	**4-4**	**4-5**	**4-7**	**4-8**	**4-9**	**4-10**	**4-13**	**5-0**	**6-2**	**6-3**	**7-1**	**8-1**	**8-2**	**8-3**	**8-4**
alpha-Endosulfan	µg/kg	1					<10	<10	<10	<10	<10	<10	<10	<10	<10	<20	<10	<10	<10	<10	<10	<10
Normalised to TOC Concentration																						
beta-Endosulfan	µg/kg	1					<10	<10	<10	<10	<10	<10	<10	<10	<10	<20	<10	<10	<10	<10	<10	<10
Endosulfan Sulphate	µg/kg	1					<1	<1	<1	<1	<1	<1	<1	<1	<1	<2	<1	<1	<1	<1	<1	<1
Endrin	µg/kg	1	10				<1	<1	<1	<1	<1	<1	<1	<1	<1	<2	<1	<1	<1	<1	<1	<1
Endrin ketone	µg/kg	1					<1	<1	<1	<1	<1	<1	<1	<1	<1	<2	<1	<1	<1	<1	<1	<1
Endrin aldehyde	µg/kg	1					<1	<1	<1	<1	<1	<1	<1	<1	<1	<2	<1	<1	<1	<1	<1	<1
Heptachlor	µg/kg	1					<1	<1	<1	<1	<1	<1	<1	<1	<1	<2	<1	<1	<1	<1	<1	<1
Heptachlor epoxide	µg/kg	1					<1	<1	<1	<1	<1	<1	<1	<1	<1	<2	<1	<1	<1	<1	<1	<1
Hexachlorobenzene	µg/kg	1					<1	<1	<1	<1	<1	<1	<1	<1	<1	<2	<1	<1	<1	<1	<1	<1
Methoxychlor	µg/kg	1					<1	<1	<1	<1	<1	<1	<1	<1	<1	<2	<1	<1	<1	<1	<1	<1
Oxychlordane*	µg/kg	1					<1	<1	<1	<1	<1	<1	<1	<1	<1	<2	<1	<1	<1	<1	<1	<1
Orgonophosphoros Pesticides																						
Dichlorvos	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20	<40	<20	<20	<20	<20	<20	<20
Demeton-S-methyl	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20	<40	<20	<20	<20	<20	<20	<20
Dimethoate	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20	<40	<20	<20	<20	<20	<20	<20
Diazinon	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20	<40	<20	<20	<20	<20	<20	<20
Chlorpyrifos-methyl	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20	<40	<20	<20	<20	<20	<20	<20
Parathion-methyl	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20	<40	<20	<20	<20	<20	<20	<20
Pirimiphos-methyl	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20	<40	<20	<20	<20	<20	<20	<20
Fenitrothion	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20	<40	<20	<20	<20	<20	<20	<20
Malathion	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20	<40	<20	<20	<20	<20	<20	<20
Chlorpyrifos	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20	<40	<20	<20	<20	<20	<20	<20
Fenthion	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20	<40	<20	<20	<20	<20	<20	<20
Parathion*	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20	<40	<20	<20	<20	<20	<20	<20
Chlorfenvinphos	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20	<40	<20	<20	<20	<20	<20	<20
Bromophos-ethyl	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20	<40	<20	<20	<20	<20	<20	<20
Methidathion	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20	<40	<20	<20	<20	<20	<20	<20
Fenamiphos	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20	<40	<20	<20	<20	<20	<20	<20
Prothiofos	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20	<40	<20	<20	<20	<20	<20	<20
Ethion	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20	<40	<20	<20	<20	<20	<20	<20
Carbophenothion	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20	<40	<20	<20	<20	<20	<20	<20
Phosalone	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20	<40	<20	<20	<20	<20	<20	<20
Azinphos-methyl*	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20	<40	<20	<20	<20	<20	<20	<20
Fenchlorvos*	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20	<40	<20	<20	<20	<20	<20	<20
Mevinphos	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20	<40	<20	<20	<20	<20	<20	<20
Trifluralin*	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20	<40	<20	<20	<20	<20	<20	<20
Radionuclides																						
Gross Alpha	mBq/g									<60					<60		<60	<60	<60			
Gross Beta	mBq/g									<135					<135		<135	<135	<135			
Nutrients																						
Nitrate as N	mg/kg	0.1	0.1				<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Nitrite as N	mg/kg	0.1	0.1				<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total Kjeldahl Nitrogen	mg/kg	20					1150.00	1490.00	1270.00	1100.00	1320.00	600.00	1310.00	1420.00	1450.00	1280.00	1510.00	1180.00	1330.00	1300.00	1060.00	990.00
Total Nitrogen	mg/kg	20					1150.00	1490.00	1270.00	1100.00	1320.00	600.00	1310.00	1420.00	1450.00	1280.00	1510.00	1180.00	1330.00	1300.00	1060.00	990.00
PCB																						
Mono-PCB congeners	µg/kg	5	1.00							<5					<5		<5	<5	<5			

Note: Only presenting results above limits of reporting.

Table 3-1 continued: Summary of laboratory results (Primary Laboratory)

							Zone 2															
Sample	**Units**	**PQL**	**NAGD PQL**	**NAGD Screening Level**	**EIL**	**HIL-A**	**4-0**	**4-4**	**4-5**	**4-7**	**4-8**	**4-9**	**4-10**	**4-13**	**5-0**	**6-2**	**6-3**	**7-1**	**8-1**	**8-2**	**8-3**	**8-4**
Di-PCB congeners	µg/kg	5	1.00							<5					<5		<5	<5	<5			
Tri-PCB congeners	µg/kg	5	1.00							<5					<5		<5	<5	<5			
Tetra-PCB congeners	µg/kg	5	1.00							<5					<5		<5	<5	<5			
Penta-PCB congeners	µg/kg	5	1.00							<5					<5		<5	<5	<5			
Hexa-PCB congeners	µg/kg	5	1.00							<5					<5		<5	<5	<5			
Hepta-PCB congeners	µg/kg	5	1.00							<5					<5		<5	<5	<5			
Octa-PCB congeners	µg/kg	5	1.00							<5					<5		<5	<5	<5			
Nona-PCB congeners	µg/kg	5	1.00							<5					<5		<5	<5	<5			
Deca-PCB congeners	µg/kg	5	1.00							<5					<5		<5	<5	<5			
Total PCB congeners	µg/kg	5	5.00	23.00						<5					<5		<5	<5	<5			

Note: Only presenting results above limits of reporting.

Table 3-1 continued: Summary of laboratory results (Primary Laboratory)

							Zone 3															
Sample	**Units**	**PQL**	**NAGD PQL**	**NAGD Screening Level**	**EIL**	**HIL-A**	**9-1**	**9-2**	**9-4**	**10-1**	**10-5**	**10-6**	**11-3**	**11-4**	**11-5**	**11-8**	**11-9**	**11-11**	**11-12**	**12-3**	**10-8**	**11-1**	**12-1**
Date sampled							4/12/12	5/12/12	5/12/12	7/12/12	5/12/12	5/12/12	5/12/12	7/12/12	7/12/12	5/12/12	5/12/12	7/12/12	5/12/12	7/12/12	9/12/12	9/12/12	9/12/12
Moisture Content	%	0.1	0.1				45.3	56.9	48	58.8	43.4	47.6	42.6	45.8	45.4	47.1	49.9	51	46.9	37.9	49.7	43.6	51.2
Total Organic Carbon	%	0.01	0.1				1.1	1.4	1.2	1.8	1.3	1.5	1.2	0.92	0.98	1.2	1.7	1.3	1.3	0.53	1.3	1.2	1.5
Metals and Metalloids																							
Arsenic	mg/kg	0.4	1	20.0	20.0	100.0	7.60	8.60	6.50	8.30	10.00	8.90	8.20	6.60	6.10	7.70	8.90	7.40	7.90	4.80	7.30	7.60	7.30
Cadmium	mg/kg	0.1	0.1	1.5	3	20.0	<0.1	<0.1	<0.1	<0.1	<0.1	0.26	<0.1	<0.1	<0.1	0.43	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium	mg/kg	0.1	1	80.0			48.00	48.00	38.00	41.00	39.00	49.00	39.00	33.00	32.00	50.00	43.00	35.00	39.00	22.00	39.00	36.00	37.00
Copper	mg/kg	0.1	1	65.0	60	1000.0	43.00	29.00	24.00	29.00	26.00	29.00	24.00	18.00	19.00	28.00	29.00	23.00	25.00	12.00	24.00	23.00	22.00
Lead	mg/kg	0.5	1	50	300	300.0	13.00	17.00	15.00	16.00	11.00	18.00	12.00	11.00	11.00	16.00	16.00	14.00	13.00	8.10	13.00	13.00	13.00
Mercury	mg/kg	0.01	0.01	0.15	1	15.0	0.07	0.10	0.09	0.10	0.06	0.19	0.07	0.06	0.06	0.21	0.10	0.08	0.07	0.04	0.09	0.07	0.10
Nickel	mg/kg	0.1	1	21.0	60	600.0	33.00	23.00	22.00	24.00	23.00	23.00	21.00	17.00	18.00	20.00	26.00	21.00	22.00	13.00	19.00	21.00	25.00
Phosphorus*	mg/kg	1					630.00	690.00	670.00	690.00	580.00	610.00	590.00	490.00	540.00	550.00	740.00	630.00	600.00	390.00	590.00	610.00	650.00
Zinc	mg/kg	0.5	1	200	200	7,000	110.00	110.00	82.00	93.00	70.00	94.00	78.00	69.00	70.00	93.00	90.00	77.00	71.00	44.00	79.00	68.00	74.00
Organotins																							
Monobutyl tin	µgSn/kg	0.5	*1*				<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Normalised to TOC Concentration																							
Dibutyl tin	µgSn/kg	0.5	*1*				4.90	2.60	1.60	1.20	<0.5	1.10	0.70	0.80	0.90	1.70	0.70	1.20	0.50	0.60	1.40	<0.5	1.20
Normalised to TOC Concentration							4.45	1.86	1.33	0.67		0.73	0.58	0.87	0.92	1.42	0.41	0.92	0.38	1.13	1.08		0.80
Tributyl tin	µgSn/kg	0.5	1				99.00	2.40	0.70	0.80	<0.5	<0.5	0.70	1.20	0.60	1.70	<0.5	0.80	<0.5	<0.5	0.60	<0.5	0.80
Normalised to TOC Concentration				9			90.00	1.71	0.58	0.44			0.58	1.30	0.61	1.42		0.62			0.46		0.53
BTEX																							
Benzene	mg/kg	0.2	0.2				<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Toluene	mg/kg	0.2	0.2				<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Ethyl Benzene	mg/kg	0.2	0.2				<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
m+p xylenes	mg/kg	0.4					<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
o-xylene	mg/kg	0.2	0.2				<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Total BTEX	mg/kg	1.2					<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2
Total Petroleum Hydrocarbons																							
TPH C6-C9	mg/kg	10	100				<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
TPH C10-14	mg/kg	10	100				<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	18.00
Normalised to TOC Concentration																							12.00
TPH C15-28	mg/kg	50	100				<50	<50	<50	<50	<50	74.00	<50	<50	<50	98.00	<50	<50	<50	<50	<50	<50	94.00
Normalised to TOC Concentration												49.33				81.67							62.67
TPH C29-36	mg/kg	50	100				<50	59.00	57.00	60.00	<50	89.00	<50	<50	<50	97.00	56.00	<50	<50	<50	50.00	<50	73.00
Normalised to TOC Concentration								42.14	47.50	33.33		59.33				80.83	32.94				38.46		48.67
Total TPH			100	550																			
Polycyclic Aromatic Hydrocarbons																							
Naphthalene	µg/kg	5	5				11.00					13.00				9.00							<5
Normalised to TOC Concentration							10.00					8.67				7.50					0.00	0.00	
1-Methylnaphthalene	µg/kg	5	5				5.00					5.00				<5							<5
Normalised to TOC Concentration							4.55					3.33									0.00	0.00	
2-Methylnaphthalene	µg/kg	5	5				7.00					9.00				7.00							<5
Normalised to TOC Concentration							6.36					6.00				5.83					0.00	0.00	
Acenaphthylene	µg/kg	5	5				21.00					12.00				9.00							12.00
Normalised to TOC Concentration							19.09					8.00				7.50					0.00	0.00	8.00
Acenaphthene	µg/kg	5	5				<5					<5				<5							6.00
Normalised to TOC Concentration																					0.00	0.00	4.00
Fluorene	µg/kg	5	5				10.00					8.00				5.00							6.00
Normalised to TOC Concentration							9.09					5.33				4.17					0.00	0.00	4.00
Phenanthrene	µg/kg	5	5				260.00					33.00				20.00							32.00
Normalised to TOC Concentration							236.36					22.00				16.67					0.00	0.00	21.33
Anthracene	µg/kg	5	5				23.00					17.00				10.00							14.00
Normalised to TOC Concentration							20.91					11.33				8.33					0.00	0.00	9.33
Fluoranthene	µg/kg	5	5				310.00					87.00				53.00							110.00
Normalised to TOC Concentration							281.82					58.00				44.17					0.00	0.00	73.33
Pyrene	µg/kg	5	5				350.00					130.00				93.00							120.00
Normalised to TOC Concentration							318.18					86.67				77.50					0.00	0.00	80.00
Benz(a)anthracene	µg/kg	5	5				210.00					79.00				50.00							50.00

Note: Only presenting results above limits of reporting.

Table 3-1 continued: Summary of laboratory results (Primary Laboratory)

							Zone 3															
Sample	**Units**	**PQL**	**NAGD PQL**	**NAGD Screening Level**	**EIL**	**HIL-A**	**9-1**	**9-2**	**9-4**	**10-1**	**10-5**	**10-6**	**11-3**	**11-4**	**11-5**	**11-8**	**11-9**	**11-11**	**11-12**	**12-3**	**10-8**	**11-1**	**12-1**
Normalised to TOC Concentration							190.91					52.67				41.67					0.00	0.00	33.33
Chrysene	µg/kg	5	5				180.00					67.00				42.00							46.00
Normalised to TOC Concentration							163.64					44.67				35.00					0.00	0.00	30.67
Benzo(b)&(k)fluoranthene	µg/kg	10	5				320.00					170.00				130.00							140.00
Normalised to TOC Concentration							290.91					113.33				108.33					0.00	0.00	93.33
Benzo(a)pyrene	µg/kg	5	5				160.00					98.00				72.00							89.00
Normalised to TOC Concentration							145.45					65.33				60.00					0.00	0.00	59.33
Indeno(1,2,3-cd)pyrene	µg/kg	5	5				140.00					95.00				83.00							70.00
Normalised to TOC Concentration							127.27					63.33				69.17					0.00	0.00	46.67
Dibenz(a,h)anthracene	µg/kg	5	5				59.00					22.00				24.00							16.00
Normalised to TOC Concentration							53.64					14.67				20.00					0.00	0.00	10.67
Benzo(g,h,i)perylene	µg/kg	5	5				100.00					74.00				63.00							57.00
Normalised to TOC Concentration							90.91					49.33				52.50					0.00	0.00	38.00
Coronene	µg/kg	10	5				34.00					16.00				15.00							16.00
Normalised to TOC Concentration							30.91					10.67				12.50					0.00	0.00	10.67
Benzo(e)pyrene	µg/kg	5	5				120.00					73.00				55.00							59.00
Normalised to TOC Concentration							109.09					48.67				45.83					0.00	0.00	39.33
Perylene	µg/kg	5	5				150.00					210.00				220.00							240.00
Normalised to TOC Concentration							136.36					140.00				183.33					0.00	0.00	160.00
Total PAHs (as above)	µg/kg	100	100	10000			2490.00					1220.00				960.00							1090.00
Normalised to TOC Concentration							2263.64					813.33				800.00					0.00	0.00	726.67
Organochlorine Pesticides																							
Aldrin	µg/kg	1					<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
alpha-BHC	µg/kg	1					<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
beta-BHC	µg/kg	1					<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
gamma-BHC (Lindane)	µg/kg	1					<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
delta-BHC	µg/kg	1					<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
cis-Chlordane	µg/kg	1	0.5				<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
trans-Chlordane	µg/kg	1	0.5				<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
p,p'-DDD	µg/kg	1	2				<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
p,p'-DDE	µg/kg	1	2.2				2.00	2.00	3.00	4.00	1.00	5.00	1.00	2.00	2.00	5.00	4.00	4.00	2.00	2.00	1.00	2.00	5.00
Normalised to TOC Concentration				2.20			1.82	1.43	2.50	2.22	0.77	3.33	0.83	2.17	2.04	4.17	2.35	3.08	1.54	3.77	0.77	1.67	3.33
p,p'-DDT	µg/kg	1	1.6				<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Dieldrin	µg/kg	1	280				<1	<1	<1	10.00	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Normalised to TOC Concentration				280.00						5.56													
alpha-Endosulfan	µg/kg	1					<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
beta-Endosulfan	µg/kg	1					<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Endosulfan Sulphate	µg/kg	1					<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Endrin	µg/kg	1	10				<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Endrin ketone	µg/kg	1					<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Endrin aldehyde	µg/kg	1					<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Heptachlor	µg/kg	1					<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Heptachlor epoxide	µg/kg	1					<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Hexachlorobenzene	µg/kg	1					<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Methoxychlor	µg/kg	1					<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Oxychlordane*	µg/kg	1					<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Orgonophosphoros Pesticides																							
Dichlorvos	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Demeton-S-methyl	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Dimethoate	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Diazinon	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Chlorpyrifos-methyl	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Parathion-methyl	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Pirimiphos-methyl	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Fenitrothion	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20

Note: Only presenting results above limits of reporting.

Table 3-1 continued: Summary of laboratory results (Primary Laboratory)

							Zone 3															
Sample	**Units**	**PQL**	**NAGD PQL**	**NAGD Screening Level**	**EIL**	**HIL-A**	**9-1**	**9-2**	**9-4**	**10-1**	**10-5**	**10-6**	**11-3**	**11-4**	**11-5**	**11-8**	**11-9**	**11-11**	**11-12**	**12-3**	**10-8**	**11-1**	**12-1**
Malathion	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Chlorpyrifos	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Fenthion	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Parathion*	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Chlorfenvinphos	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Bromophos-ethyl	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Methidathion	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Fenamiphos	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Prothiofos	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Ethion	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Carbophenothion	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Phosalone	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Azinphos-methyl*	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Fenchlorvos*	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Mevinphos	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Trifluralin*	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Nutrients																							
Nitrate as N	mg/kg	0.1	0.1				<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Nitrite as N	mg/kg	0.1	0.1				<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total Kjeldahl Nitrogen	mg/kg	20					890.00	1200.00	980.00	1500.00	850.00	1000.00	880.00	870.00	860.00	860.00	1200.00	1050.00	950.00	480.00	1030.00	900.00	990.00
Total Nitrogen	mg/kg	20					890.00	1200.00	980.00	1500.00	850.00	1000.00	880.00	870.00	860.00	860.00	1200.00	1050.00	950.00	480.00	1030.00	900.00	990.00
PCB																							
Mono-PCB congeners	µg/kg	5	1.00				<5					<5				<5							<5
Di-PCB congeners	µg/kg	5	1.00				<5					<5				<5							<5
Tri-PCB congeners	µg/kg	5	1.00				<5					<5				<5							<5
Tetra-PCB congeners	µg/kg	5	1.00				<5					<5				<5							<5
Penta-PCB congeners	µg/kg	5	1.00				<5					<5				<5							<5
Hexa-PCB congeners	µg/kg	5	1.00				<5					20.00				7.00							<5
Normalised to TOC Concentration												13.33				5.83							
Hepta-PCB congeners	µg/kg	5	1.00				<5					19.00				<5							<5
Normalised to TOC Concentration												12.67											
Octa-PCB congeners	µg/kg	5	1.00				<5					<5				<5							<5
Nona-PCB congeners	µg/kg	5	1.00				<5					<5				<5							<5
Deca-PCB congeners	µg/kg	5	1.00				<5					<5				<5							<5
Total PCB congeners	µg/kg	5	5.00				<5					39.00				7.00							<5
Normalised to TOC Concentration				23.00								26.00				5.83							

Note: Only presenting results above limits of reporting.

Table 3-1 continued: Summary of laboratory results (Primary Laboratory)

Sample	Units	PQL	NAGD PQL	NAGD Screening Level	EIL	HIL-A	12-2	14-1	15-1
Date sampled							9/12/12	9/12/12	9/12/12
Moisture Content	%	0.1	0.1				47.9	37.4	36.9
Total Organic Carbon	%	0.01	0.1				1.4	0.78	0.62
Metals and Metalloids									
Arsenic	mg/kg	0.4	1	20.0	20.0	100.0	6.20	5.30	5.10
Cadmium	mg/kg	0.1	0.1	1.5	3	20.0	<0.1	<0.1	<0.1
Chromium	mg/kg	0.1	1	80.0			33.00	27.00	26.00
Copper	mg/kg	0.1	1	65.0	60	1000.0	23.00	15.00	13.00
Lead	mg/kg	0.5	1	50	300	300.0	15.00	10.00	8.10
Mercury	mg/kg	0.01	0.01	0.15	1	15.0	0.09	0.08	0.09
Nickel	mg/kg	0.1	1	21.0	60	600.0	20.00	15.00	15.00
Phosphorus*	mg/kg	1					730.00	480.00	440.00
Zinc	mg/kg	0.5	1	200	200	7,000	74.00	53.00	47.00
Organotins									
Monobutyl tin	µgSn/kg	0.5	*1*				<0.5	<0.5	<0.5
Normalised to TOC Concentration									
Dibutyl tin	µgSn/kg	0.5	*1*				1.90	0.90	0.50
Normalised to TOC Concentration							1.36	1.15	0.81
Tributyl tin	µgSn/kg	0.5	1				1.10	0.50	<0.5
Normalised to TOC Concentration				9			0.79	0.64	
BTEX									
Benzene	mg/kg	0.2	0.2				<0.2	<0.2	<0.2
Toluene	mg/kg	0.2	0.2				<0.2	<0.2	<0.2
Ethyl Benzene	mg/kg	0.2	0.2				<0.2	<0.2	<0.2
m+p xylenes	mg/kg	0.4					<0.4	<0.4	<0.4
o-xylene	mg/kg	0.2	0.2				<0.2	<0.2	<0.2
Total BTEX	mg/kg	1.2					<1.2	<1.2	<1.2
Total Petroleum Hydrocarbons									
TPH C6-C9	mg/kg	10	100				<10	<10	<10
TPH C10-14	mg/kg	10	100				<10	<10	<10
Normalised to TOC Concentration									
TPH C15-28	mg/kg	50	100				<50	<50	<50
Normalised to TOC Concentration									
TPH C29-36	mg/kg	50	100				60.00	<50	<50
Normalised to TOC Concentration							42.86		
Total TPH			100	550					
Polycyclic Aromatic Hydrocarbons									
Naphthalene	µg/kg	5	5				<5	<5	<5
Normalised to TOC Concentration									
1-Methylnaphthalene	µg/kg	5	5				<5	<5	<5
Normalised to TOC Concentration									
2-Methylnaphthalene	µg/kg	5	5				<5	<5	<5
Normalised to TOC Concentration									
Acenaphthylene	µg/kg	5	5				9.00	7.00	<5
Normalised to TOC Concentration							6.43	8.97	
Acenaphthene	µg/kg	5	5				<5	<5	<5
Normalised to TOC Concentration									
Fluorene	µg/kg	5	5				<5	<5	<5
Normalised to TOC Concentration									
Phenanthrene	µg/kg	5	5				28.00	18.00	16.00
Normalised to TOC Concentration							20.00	23.08	25.81
Anthracene	µg/kg	5	5				12.00	8.00	6.00
Normalised to TOC Concentration							8.57	10.26	9.68
Fluoranthene	µg/kg	5	5				86.00	70.00	44.00
Normalised to TOC Concentration							61.43	89.74	70.97
Pyrene	µg/kg	5	5				100.00	91.00	44.00
Normalised to TOC Concentration							71.43	116.67	70.97
Benz(a)anthracene	µg/kg	5	5				49.00	48.00	23.00

Note: Only presenting results above limits of reporting.

Table 3-1 continued: Summary of laboratory results (Primary Laboratory)

Sample	Units	PQL	NAGD PQL	NAGD Screening Level	EIL	HIL-A	12-2	14-1	15-1
Normalised to TOC Concentration							35.00	61.54	37.10
Chrysene	µg/kg	5	5				43.00	44.00	21.00
Normalised to TOC Concentration							30.71	56.41	33.87
Benzo(b)&(k)fluoranthene	µg/kg	10	5				110.00	120.00	52.00
Normalised to TOC Concentration							78.57	153.85	83.87
Benzo(a)pyrene	µg/kg	5	5				68.00	66.00	29.00
Normalised to TOC Concentration							48.57	84.62	46.77
Indeno(1,2,3-cd)pyrene	µg/kg	5	5				59.00	59.00	25.00
Normalised to TOC Concentration							42.14	75.64	40.32
Dibenz(a,h)anthracene	µg/kg	5	5				14.00	14.00	5.00
Normalised to TOC Concentration							10.00	17.95	8.06
Benzo(g,h,i)perylene	µg/kg	5	5				49.00	50.00	21.00
Normalised to TOC Concentration							35.00	64.10	33.87
Coronene	µg/kg	10	5				16.00	16.00	<10
Normalised to TOC Concentration							11.43	20.51	
Benzo(e)pyrene	µg/kg	5	5				53.00	51.00	22.00
Normalised to TOC Concentration							37.86	65.38	35.48
Perylene	µg/kg	5	5				210.00	150.00	71.00
Normalised to TOC Concentration							150.00	192.31	114.52
Total PAHs (as above)	µg/kg	100	100	10000			910.00	810.00	380.00
Normalised to TOC Concentration							650.00	1038.46	612.90
Organochlorine Pesticides									
Aldrin	µg/kg	1					<1	<1	<1
alpha-BHC	µg/kg	1					<10	<10	<10
beta-BHC	µg/kg	1					<10	<10	<10
gamma-BHC (Lindane)	µg/kg	1					<10	<10	<10
delta-BHC	µg/kg	1					<10	<10	<10
cis-Chlordane	µg/kg	1	0.5				<1	<1	<1
trans-Chlordane	µg/kg	1	0.5				<1	<1	<1
p,p'-DDD	µg/kg	1	2				<10	<10	<10
p,p'-DDE	µg/kg	1	2.2				3.00	12.00	1.00
Normalised to TOC Concentration				2.20			2.14	15.38	1.61
p,p'-DDT	µg/kg	1	1.6				<10	<10	<10
Dieldrin	µg/kg	1	280				<1	<1	<1
Normalised to TOC Concentration				280.00					
alpha-Endosulfan	µg/kg	1					<10	<10	<10
beta-Endosulfan	µg/kg	1					<10	<10	<10
Endosulfan Sulphate	µg/kg	1					<1	<1	<1
Endrin	µg/kg	1	10				<1	<1	<1
Endrin ketone	µg/kg	1					<1	<1	<1
Endrin aldehyde	µg/kg	1					<1	<1	<1
Heptachlor	µg/kg	1					<1	<1	<1
Heptachlor epoxide	µg/kg	1					<1	<1	<1
Hexachlorobenzene	µg/kg	1					<1	<1	<1
Methoxychlor	µg/kg	1					<1	<1	<1
Oxychlordane*	µg/kg	1					<1	<1	<1
Orgonophosphoros Pesticides									
Dichlorvos	µg/kg	20	10-100				<20	<20	<20
Demeton-S-methyl	µg/kg	20	10-100				<20	<20	<20
Dimethoate	µg/kg	20	10-100				<20	<20	<20
Diazinon	µg/kg	20	10-100				<20	<20	<20
Chlorpyrifos-methyl	µg/kg	20	10-100				<20	<20	<20
Parathion-methyl	µg/kg	20	10-100				<20	<20	<20
Pirimiphos-methyl	µg/kg	20	10-100				<20	<20	<20
Fenitrothion	µg/kg	20	10-100				<20	<20	<20

Note: Only presenting results above limits of reporting.

Table 3-1 continued: Summary of laboratory results (Primary Laboratory)

Sample	Units	PQL	NAGD PQL	NAGD Screening Level	EIL	HIL-A	12-2	14-1	15-1
Malathion	µg/kg	20	10-100				<20	<20	<20
Chlorpyrifos	µg/kg	20	10-100				<20	<20	<20
Fenthion	µg/kg	20	10-100				<20	<20	<20
Parathion*	µg/kg	20	10-100				<20	<20	<20
Chlorfenvinphos	µg/kg	20	10-100				<20	<20	<20
Bromophos-ethyl	µg/kg	20	10-100				<20	<20	<20
Methidathion	µg/kg	20	10-100				<20	<20	<20
Fenamiphos	µg/kg	20	10-100				<20	<20	<20
Prothiofos	µg/kg	20	10-100				<20	<20	<20
Ethion	µg/kg	20	10-100				<20	<20	<20
Carbophenothion	µg/kg	20	10-100				<20	<20	<20
Phosalone	µg/kg	20	10-100				<20	<20	<20
Azinphos-methyl*	µg/kg	20	10-100				<20	<20	<20
Fenchlorvos*	µg/kg	20	10-100				<20	<20	<20
Mevinphos	µg/kg	20	10-100				<20	<20	<20
Trifluralin*	µg/kg	20	10-100				<20	<20	<20
Nutrients									
Nitrate as N	mg/kg	0.1	0.1				<0.1	<0.1	<0.1
Nitrite as N	mg/kg	0.1	0.1				<0.1	<0.1	<0.1
Total Kjeldahl Nitrogen	mg/kg	20					950.00	630.00	510.00
Total Nitrogen	mg/kg	20					950.00	630.00	510.00
PCB									
Mono-PCB congeners	µg/kg	5	1.00				<5	<5	<5
Di-PCB congeners	µg/kg	5	1.00				<5	<5	<5
Tri-PCB congeners	µg/kg	5	1.00				<5	<5	<5
Tetra-PCB congeners	µg/kg	5	1.00				<5	<5	<5
Penta-PCB congeners	µg/kg	5	1.00				<5	<5	<5
Hexa-PCB congeners	µg/kg	5	1.00				<5	<5	<5
Normalised to TOC Concentration									
Hepta-PCB congeners	µg/kg	5	1.00				<5	<5	<5
Normalised to TOC Concentration									
Octa-PCB congeners	µg/kg	5	1.00				<5	<5	<5
Nona-PCB congeners	µg/kg	5	1.00				<5	<5	<5
Deca-PCB congeners	µg/kg	5	1.00				<5	<5	<5
Total PCB congeners	µg/kg	5	5.00				<5	<5	<5
Normalised to TOC Concentration				23.00					

Note: Only presenting results above limits of reporting.

Table 3-1 continued: Summary of laboratory results (Primary Laboratory)

							Zone 4								
Sample	**Units**	**PQL**	**NAGD PQL**	**NAGD Screening Level**	**EIL**	**HIL-A**	**13-1**	**13-2**	**13-3**	**13-4**	**13-5**	**13-6**	**13-7**	**13-8**	**13-9**
Date sampled							8/12/12	8/12/12	8/12/12	8/12/12	8/12/12	8/12/12	8/12/12	8/12/12	8/12/12
Moisture Content	%	0.1	0.1				28.4	36.1	43.4	39.6	47	43.6	52	51	56.4
Total Organic Carbon	%	0.01	0.1				0.49	0.8	0.96	0.9	1.1	1	1.1	0.98	1.2
Metals and Metalloids															
Arsenic	mg/kg	0.4	1	20.0	20.0	100.0	8.00	5.80	8.00	8.70	8.50	9.60	8.50	10.00	7.20
Cadmium	mg/kg	0.1	0.1	1.5	3	20.0	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium	mg/kg	0.1	1	80.0			20.00	29.00	37.00	35.00	38.00	40.00	39.00	41.00	36.00
Copper	mg/kg	0.1	1	65.0	60	1000.0	7.10	13.00	15.00	12.00	15.00	13.00	15.00	13.00	13.00
Lead	mg/kg	0.5	1	50	300	300.0	7.60	6.60	8.20	14.00	10.00	7.20	9.80	7.30	10.00
Mercury	mg/kg	0.01	0.01	0.15	1	15.0	0.03	0.03	0.05	0.05	0.06	0.03	0.06	0.03	0.05
Nickel	mg/kg	0.1	1	21.0	60	600.0	12.00	17.00	21.00	19.00	20.00	21.00	20.00	21.00	17.00
Phosphorus*	mg/kg	1					380.00	410.00	470.00	420.00	460.00	440.00	430.00	450.00	440.00
Zinc	mg/kg	0.5	1	200	200	7,000	45.00	41.00	52.00	48.00	54.00	50.00	55.00	50.00	52.00
Organotins															
Monobutyl tin	µgSn/kg	0.5	*1*				<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Dibutyl tin	µgSn/kg	0.5	*1*				<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Tributyl tin	µgSn/kg	0.5	1				<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
BTEX															
Benzene	mg/kg	0.2	0.2				<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Toluene	mg/kg	0.2	0.2				<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Ethyl Benzene	mg/kg	0.2	0.2				<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
m+p xylenes	mg/kg	0.4					<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
o-xylene	mg/kg	0.2	0.2				<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Total BTEX	mg/kg	1.2					<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2
Total Petroleum Hydrocarbons															
TPH C6-C9	mg/kg	10	100				<10	<10	<10	<10	<10	<10	<10	<10	<10
TPH C10-14	mg/kg	10	100				<10	<10	<10	<10	<10	<10	<10	<10	<10
TPH C15-28	mg/kg	50	100				<50	<50	<50	<50	<50	<50	<50	<50	<50
TPH C29-36	mg/kg	50	100				<50	<50	<50	<50	<50	<50	<50	<50	<50
Total TPH			100	550											
Polycyclic Aromatic Hydrocarbons															
Naphthalene	µg/kg	5	5				<5								
1-Methylnaphthalene	µg/kg	5	5				14.00								
Normalised to TOC Concentration							28.57								
2-Methylnaphthalene	µg/kg	5	5				29.00								
Normalised to TOC Concentration							59.18								
Acenaphthylene	µg/kg	5	5				8.00								
Normalised to TOC Concentration							16.33								
Acenaphthene	µg/kg	5	5				7.00								
Normalised to TOC Concentration							14.29								
Fluorene	µg/kg	5	5				9.00								
Normalised to TOC Concentration							18.37								
Phenanthrene	µg/kg	5	5				65.00								
Normalised to TOC Concentration							132.65								
Anthracene	µg/kg	5	5				22.00								
Normalised to TOC Concentration							44.90								
Fluoranthene	µg/kg	5	5				150.00								
Normalised to TOC Concentration							306.12								

Note: Only presenting results above limits of reporting.

Table 3-1 continued: Summary of laboratory results (Primary Laboratory)

							Zone 4								
Sample	**Units**	**PQL**	**NAGD PQL**	**NAGD Screening Level**	**EIL**	**HIL-A**	**13-1**	**13-2**	**13-3**	**13-4**	**13-5**	**13-6**	**13-7**	**13-8**	**13-9**
Pyrene	µg/kg	5	5				140.00								
Normalised to TOC Concentration							285.71								
Benz(a)anthracene	µg/kg	5	5				110.00								
Normalised to TOC Concentration							224.49								
Chrysene	µg/kg	5	5				120.00								
Normalised to TOC Concentration							244.90								
Benzo(b)&(k)fluoranthene	µg/kg	10	5				140.00								
Normalised to TOC Concentration							285.71								
Benzo(a)pyrene	µg/kg	5	5				78.00								
Normalised to TOC Concentration							159.18								
Indeno(1,2,3-cd)pyrene	µg/kg	5	5				48.00								
Normalised to TOC Concentration							97.96								
Dibenz(a,h)anthracene	µg/kg	5	5				17.00								
Normalised to TOC Concentration							34.69								
Benzo(g,h,i)perylene	µg/kg	5	5				42.00								
Normalised to TOC Concentration							85.71								
Coronene	µg/kg	10	5				<10								
Benzo(e)pyrene	µg/kg	5	5				64.00								
Normalised to TOC Concentration							130.61								
Perylene	µg/kg	5	5				57.00								
Normalised to TOC Concentration							116.33								
Total PAHs (as above)	µg/kg	100	100	10000			1120.00								
Normalised to TOC Concentration							2285.71								
Organochlorine Pesticides															
Aldrin	µg/kg	1					<1	<1	<1	<1	<1	<1	<1	<1	<1
alpha-BHC	µg/kg	1					<10	<10	<10	<10	<10	<10	<10	<10	<10
beta-BHC	µg/kg	1					<10	<10	<10	<10	<10	<10	<10	<10	<10
gamma-BHC (Lindane)	µg/kg	1					<10	<10	<10	<10	<10	<10	<10	<10	<10
delta-BHC	µg/kg	1					<10	<10	<10	<10	<10	<10	<10	<10	<10
cis-Chlordane	µg/kg	1		0.5			<1	<1	<1	<1	<1	<1	<1	<1	<1
trans-Chlordane	µg/kg	1		0.5			<1	<1	<1	<1	<1	<1	<1	<1	<1
p,p'-DDD	µg/kg	1		2			<10	<10	<10	<10	<10	<10	<10	<10	<10
p,p'-DDE	µg/kg	1		2.2			<1	<1	<1	<1	<1	<1	<1	<1	<1
p,p'-DDT	µg/kg	1		1.6			<10	<10	<10	<10	<10	<10	<10	<10	<10
Dieldrin	µg/kg	1		280			<1	<1	<1	<1	<1	<1	<1	<1	<1
alpha-Endosulfan	µg/kg	1					<10	<10	<10	<10	<10	<10	<10	<10	<10
beta-Endosulfan	µg/kg	1					<10	<10	<10	<10	<10	<10	<10	<10	<10
Endosulfan Sulphate	µg/kg	1					<1	<1	<1	<1	<1	<1	<1	<1	<1
Endrin	µg/kg	1	10				<1	<1	<1	<1	<1	<1	<1	<1	<1
Endrin ketone	µg/kg	1					<1	<1	<1	<1	<1	<1	<1	<1	<1
Endrin aldehyde	µg/kg	1					<1	<1	<1	<1	<1	<1	<1	<1	<1
Heptachlor	µg/kg	1					<1	<1	<1	<1	<1	<1	<1	<1	<1
Heptachlor epoxide	µg/kg	1					<1	<1	<1	<1	<1	<1	<1	<1	<1
Hexachlorobenzene	µg/kg	1					<1	<1	<1	<1	<1	<1	<1	<1	<1
Methoxychlor	µg/kg	1					<1	<1	<1	<1	<1	<1	<1	<1	<1
Oxychlordane*	µg/kg	1					<1	<1	<1	<1	<1	<1	<1	<1	<1
Orgonophosphoros Pesticides															
Dichlorvos	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20

Note: Only presenting results above limits of reporting.

Table 3-1 continued: Summary of laboratory results (Primary Laboratory)

							Zone 4								
Sample	**Units**	**PQL**	**NAGD PQL**	**NAGD Screening Level**	**EIL**	**HIL-A**	**13-1**	**13-2**	**13-3**	**13-4**	**13-5**	**13-6**	**13-7**	**13-8**	**13-9**
Demeton-S-methyl	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20
Dimethoate	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20
Diazinon	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20
Chlorpyrifos-methyl	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20
Parathion-methyl	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20
Pirimiphos-methyl	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20
Fenitrothion	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20
Malathion	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20
Chlorpyrifos	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20
Fenthion	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20
Parathion*	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20
Chlorfenvinphos	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20
Bromophos-ethyl	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20
Methidathion	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20
Fenamiphos	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20
Prothiofos	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20
Ethion	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20
Carbophenothion	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20
Phosalone	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20
Azinphos-methyl*	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20
Fenchlorvos*	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20
Mevinphos	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20
Trifluralin*	µg/kg	20	10-100				<20	<20	<20	<20	<20	<20	<20	<20	<20
Radionuclides															
Gross Alpha	mBq/g						<60								
Gross Beta	mBq/g						<135								
Nutrients															
Nitrate as N	mg/kg	0.1	0.1				<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Nitrite as N	mg/kg	0.1	0.1				<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.10	<0.1
Total Kjeldahl Nitrogen	mg/kg	20					330.00	540.00	700.00	570.00	850.00	740.00	950.00	820.00	1100.00
Total Nitrogen	mg/kg	20					330.00	540.00	700.00	570.00	850.00	740.00	950.00	820.00	1100.00
PCB															
Mono-PCB congeners	µg/kg	5	1.00				<5								
Di-PCB congeners	µg/kg	5	1.00				<5								
Tri-PCB congeners	µg/kg	5	1.00				<5								
Tetra-PCB congeners	µg/kg	5	1.00				<5								
Penta-PCB congeners	µg/kg	5	1.00				<5								
Hexa-PCB congeners	µg/kg	5	1.00				<5								
Hepta-PCB congeners	µg/kg	5	1.00				<5								
Octa-PCB congeners	µg/kg	5	1.00				<5								
Nona-PCB congeners	µg/kg	5	1.00				<5								
Deca-PCB congeners	µg/kg	5	1.00				<5								
Total PCB congeners	µg/kg	5	5.00	23.00			<5								

Note: Only presenting results above limits of reporting.

3.1.3 Comparison of Results in the Dredge Area and Reference Sites

3.1.3.1 Approach

The approach used to compare results in the dredge area and reference sites follows that described in the ANZECC/ARMCANZ (2000). Data for metals/metalloids, PAHs and TBT concentrations from Zones 2-4 were graphed, with the median concentration of each zone compared against the 80th percentile from Zone 1 (red control line in graphs presented in Figure 3-1and Figure 3-2). Adoption of the 80th percentile of the Zone 1 (reference site) data allows for natural variation within sediments throughout the river.

3.1.3.2 Results

Graphs are provided in Figure 3-1 and Figure 3-2, and summarized in Table 3-2. Key results include the following:

- Median arsenic and chromium concentrations in Zones 2, 3 and 4 were elevated above Zone 1 reference data;
- Median cadmium and lead concentrations in Zones 2 - 4 were below Zone 1 reference data;
- Median copper, mercury, nickel and zinc concentrations were above Zone 1 reference data in Zone 2, but below reference data in Zones 3 and 4;
- Total PAH median concentrations were below Zone 1 reference data in Zones 2 and 3, and above reference data in Zone 4.
- Median TBT concentrations were below Zone 1 reference data in Zones 2 and 3. No TBT was detected in Zone 4.

It should be noted that there were considerable textural differences in sediments between the upstream reference locations (Zone 1) and those from the areas to be dredged (Zones 2-4), as described in Section 3.2. Zone 1 is an inner city urban site. It is used as a “non-dredged” reference site for chemical comparison to show the annual accumulation and source inputs into the Brisbane River. Furthermore, previous SAP studies have established a strong relationship between the clay content and contaminant concentrations moving from Zone 1 to Zone 4 (particularly for metal/metalloid contaminants) (SKM, 2005).

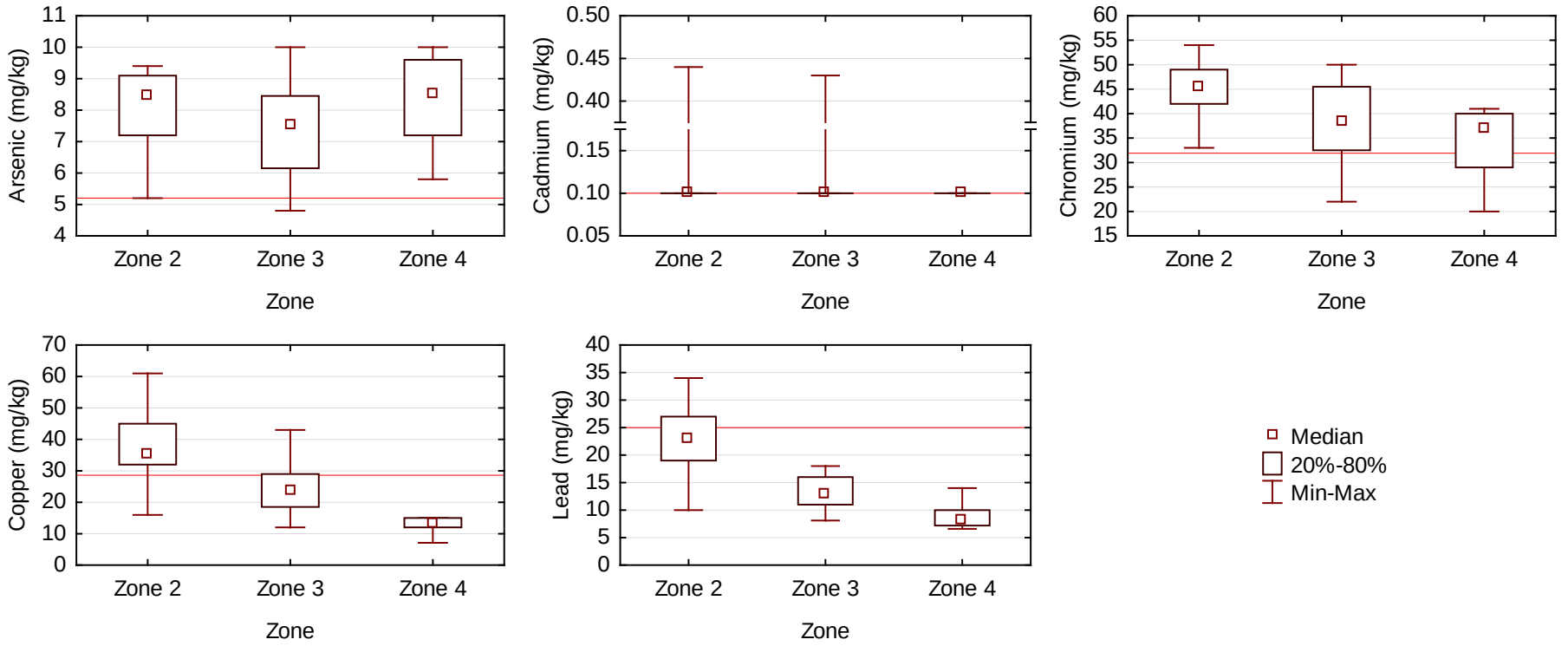


Figure 3-1: Comparison of arsenic, cadmium, chromium, copper and lead concentrations from dredge zones 2 – 4 against the 80th percentile of the reference site data (Zone 1 – red control line)

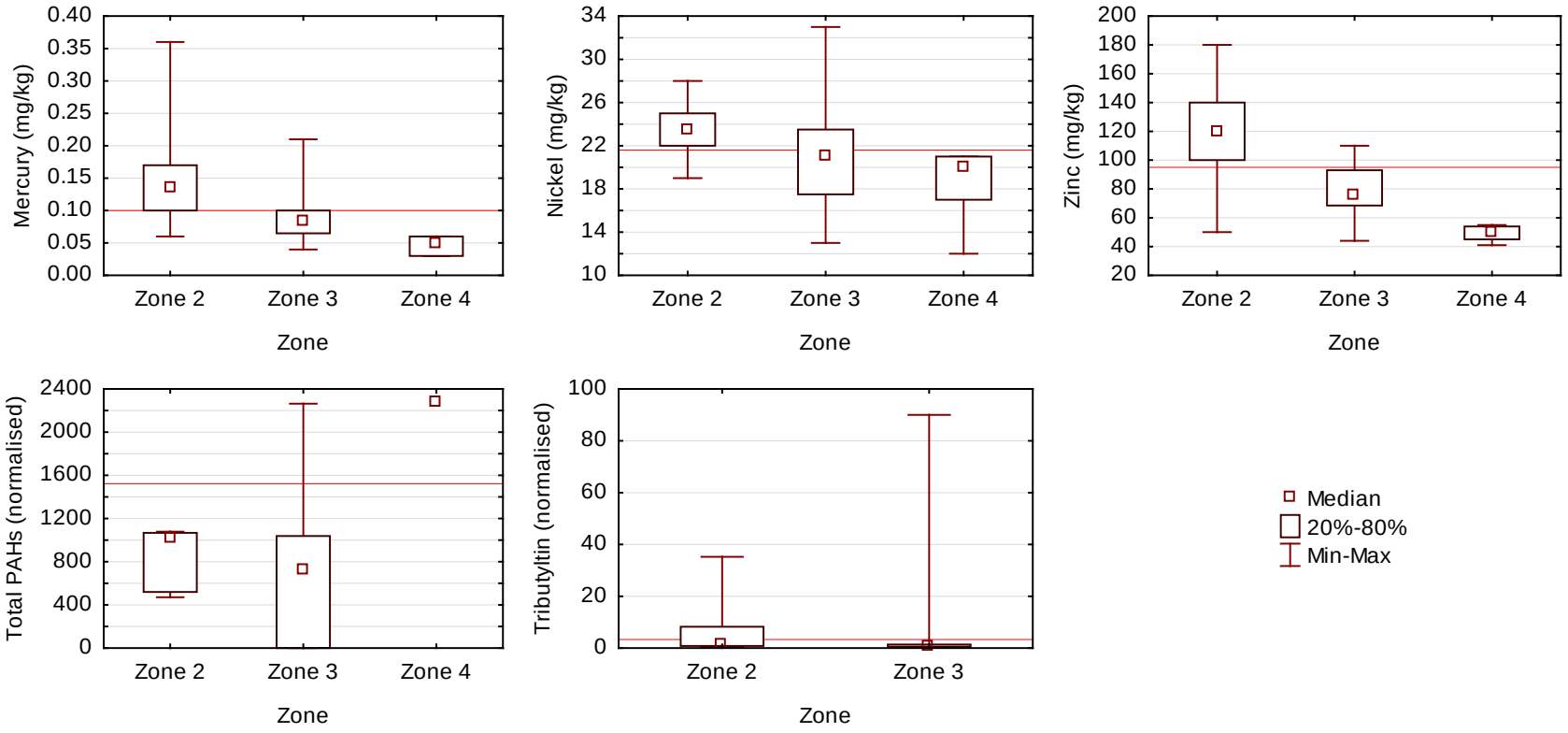


Figure 3-2: Comparison of mercury, nickel, zinc, total PAHs and TBT concentrations from dredge zones 2 – 4 against the 80th percentile of the reference site data (Zone 1 – red control line)

Table 3-2: Summary results comparing the median concentrations of parameters from each dredge zone against the 80th percentile established from the Zone 1, non-dredged area.

Parameter	Zone 1 (80th Percentile)	Zone 2 (Median)	Zone 3 (Median)	Zone 4 (Median)
Arsenic (mg/kg)	5.2	8.45	7.5	8.5
Cadmium (mg/kg)	0.1	0.1	0.1	0.1
Chromium (mg/kg)	31.9	45.5	38.5	37
Copper (mg/kg)	28.6	35.5	24	13
Lead (mg/kg)	25.0	23	13	8.2
Mercury (mg/kg)	0.1	0.135	0.085	0.05
Nickel (mg/kg)	21.6	23.5	21	20
Zinc (mg/kg)	95.0	120	75.5	50
Total PAHs (µg/kg)	1523	1017	726	2285
TBT (µgSn/kg)	3.3	1.75	0.62	Below LOR

Legend: Orange highlighting = above reference, Grey highlighting = below reference

3.1.4 Assessment of Acid Sulfate Soils

The presence of potential acid sulfate soils (PASS) was assessed at all locations undergoing detailed analysis using the chromium suite of analysis. The chromium suite, along with the suspension peroxide oxidation combined acidity and sulfur (SPOCAS) suite, is the ASS assessment recommended by Ahern *et al* (2003) and the most recent guidelines, Queensland Acid Sulfate Soil Technical Manual – Soil Management Guideline (Dear *et al*, 2002). The results of the chromium suite testing are provided in Table 3-3 and the analytical laboratory reports are provided in Appendix 4.

3.1.4.1 Actual Acidity

Actual acidity is assessed by the measurement of titratable actual acidity (TAA). The determination of pH potassium chloride (pH_{KCl}) is a means of estimating the actual soil acidity which is used to calculate TAA. Titratable actual acidity at all sample locations was less than the laboratory detection level of 5 mole H+/t, which is also less than the QASSIT guideline of 18 mole H+/t. This indicates all samples have very little or no actual acidity.

3.1.4.2 Potential Acidity

Potential acidity is assessed through the measurement of chromium reducible sulfur (S_{CR}). Most samples tested for ASS, with the exception of two locations (1-0 and 2-0) had S_{CR} values greater than the QASSIT guideline of 0.03%. This identifies 90% of sample locations as PASS.

Table 3-3: Results of chromium suite acid sulfate soils tests

Sample	Units	PQL	QASSIT Action Criteria	1-0	2-0	3-0	4-7	5-0	6-3	7-1	8-1	9-1	10-6	11-8	12-1	12-2	13-1	14-1	15-1
pH Measurements																			
pH_{KCl}	pH units			9.4	8.4	7.9	8.4	8.5	8.2	8.6	8.6	8.7	8.6	8.6	8.5	8.6	9.2	8.8	8.9
Potential Acidity																			
Chromium Reducible Sulfur	%w/w	0.005	0.03	0.02	0.01	0.17	0.16	0.23	0.16	0.4	0.25	0.29	0.41	0.54	0.18	0.19	0.05	0.12	0.11
a-Chromium Reducible Sulfur	moles H^+/t	3	18	15	6	110	100	140	100	250	160	180	250	330	120	120	30	78	67
Actual Acidity																			
s-TAA pH 6.5	%w/w S	0.01	0.03	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
TAA pH 6.5	moles H^+/t	5	18	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5

3.2 Physical Characteristics

In the following sections, PSD data is presented for Zones 1 – 4 with a graphical presentation of PSD results for each location and a table providing a statistically descriptive summary of the data across all locations. Field core log descriptions are provided in Appendix 2. Analytical laboratory reports for PSD and bulk density analyses are provided in Appendix 5.

3.2.1 Zone 1 – Reference Sites

Sediments within Zone 1 were dominated by sand fractions, which had a mean percentage fraction of (63%). The remainder of the material consists of clay (20%) and silt (13%). There was a very small amount (3%) of gravel detected(Table 3-4).

Within Zone 1, the three sites had different PSD. Locations 1 and 2 had similar PSD dominated by sand (90-95%), with little or no gravel (3-5%), silt (1-3%) or clay (1-2%). In contrast, location 3 was dominated by clay (58%), silt (35%) and sand (5%) with only 1% gravel (Figure 3-3).

Table 3-4: Summary statistics for Zone 1 particle size distribution

	Gravel (+ 2 mm)	Sand (2 mm - 0.060 mm)	Silt (0.060 mm - 0.002 mm)	Clay (-0.002 mm)
Number of Samples	3	3	3	3
Mean (%)	3	63	13	20
Standard Deviation (%)	2	41	16	27
Minimum (%)	1	5	1	1
Maximum (%)	5	95	35	58

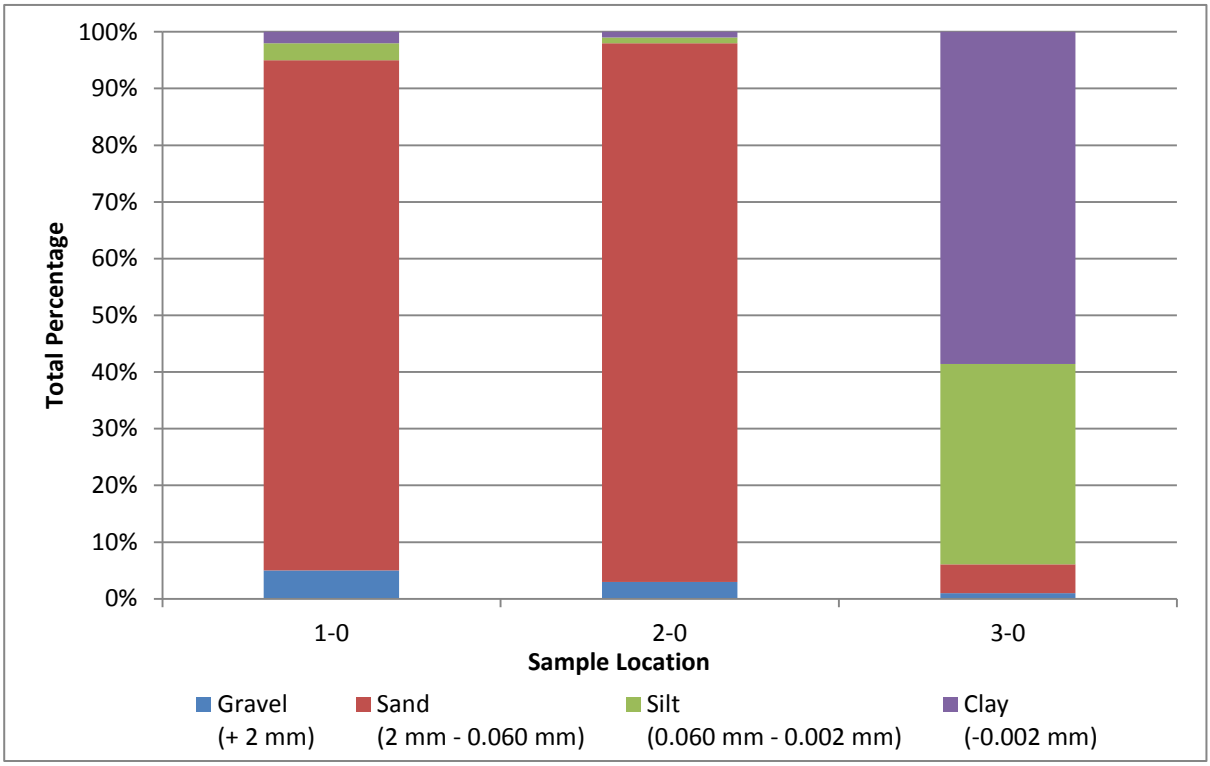


Figure 3-3: Particle size distribution at locations within Zone 1

3.2.2 Zone 2 – Colmslie to Pinkenba

The dominant PSD within Zone 2 was clay (43%), followed by silt (41%) and sand (16%). There was a very small amount (< 1%) of gravel detected (Table 3-5).

Each location within Zone 2 is similar in PSD, consisting predominantly of clay, followed by silt then sand (averages of 43%, 41% and 16% respectively). In locations 4-4, 4-8, 4-13 and 5-0 PSD was dominated mainly by clay and silt with minimal sand compared to the other locations. All sites showed no traces of gravel, except for site 4-7 which has a gravel content of 2% (Figure 3-4).

Table 3-5: Summary statistics for Zone 2 particle size distribution

	Gravel (+ 2 mm)	Sand (2 mm - 0.060 mm)	Silt (0.060 mm - 0.002 mm)	Clay (-0.002 mm)
Number of Samples	16	16	16	16
Mean (%)	0	16	41	43
Standard Deviation (%)	0	14	8	9
Minimum (%)	0	2	16	22
Maximum (%)	2	62	51	61

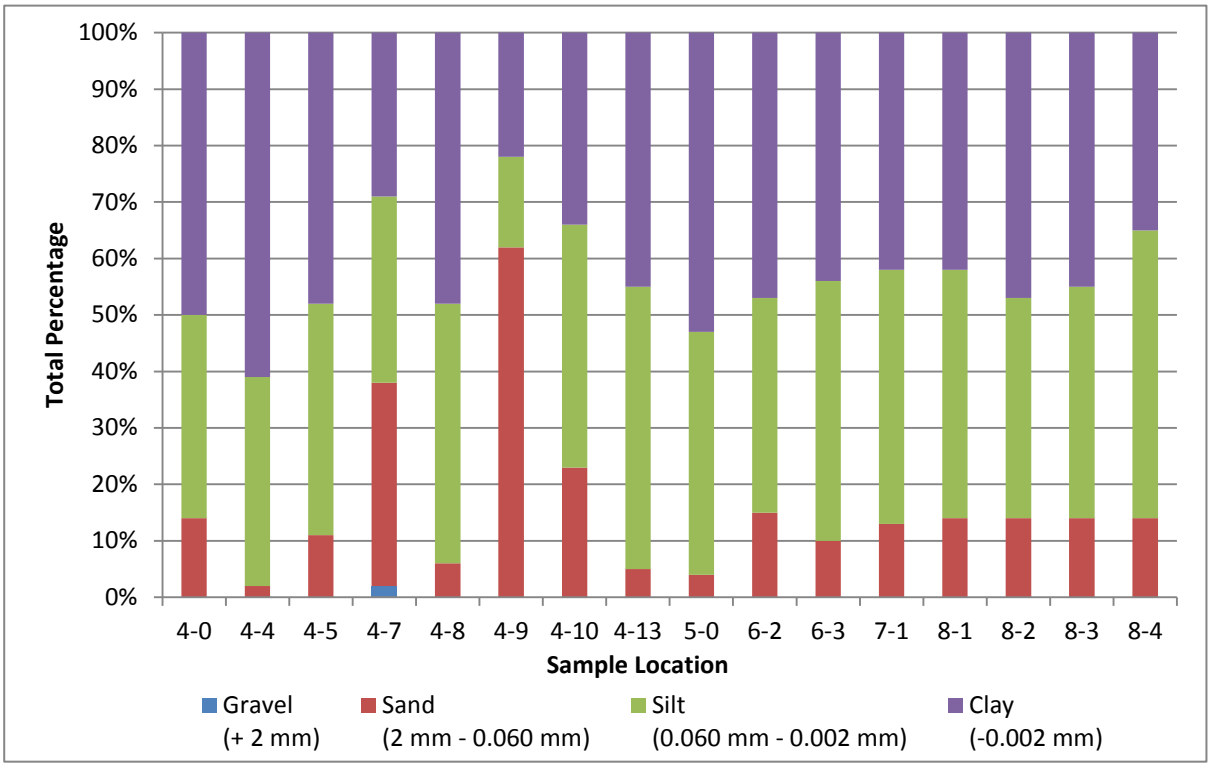


Figure 3-4: Particle size distribution at locations within Zone 2

3.2.3 Zone 3 – Port Reaches

The dominant PSD within Zone 3 was silt (38%) followed by clay (34%) and sand (28%). Gravel content was very small (< 1%) (Table 3-6).

The majority of sites located in Zone 3 had similar PSD consisting predominantly of silt, clay and sand (averages of 38%, 34% and 28%, respectively). Exceptions were locations 12-3, 14-1 and 15-1 which had noticeably higher levels of sand compared to other locations in zone 3. All sites showed no traces of gravel, except for 9-1 and 11-8, which showed gravel percentages of 2% and 1% respectively (Figure 3-5).

Table 3-6: Summary statistics for Zone 3 particle size distribution

	Gravel (+ 2 mm)	Sand (2 mm - 0.060 mm)	Silt (0.060 mm - 0.002 mm)	Clay (-0.002 mm)
Number of Samples	20	20	20	20
Mean (%)	0	28	38	34
Standard Deviation (%)	0	16	9	9
Minimum (%)	0	8	15	17
Maximum (%)	2	68	50	54

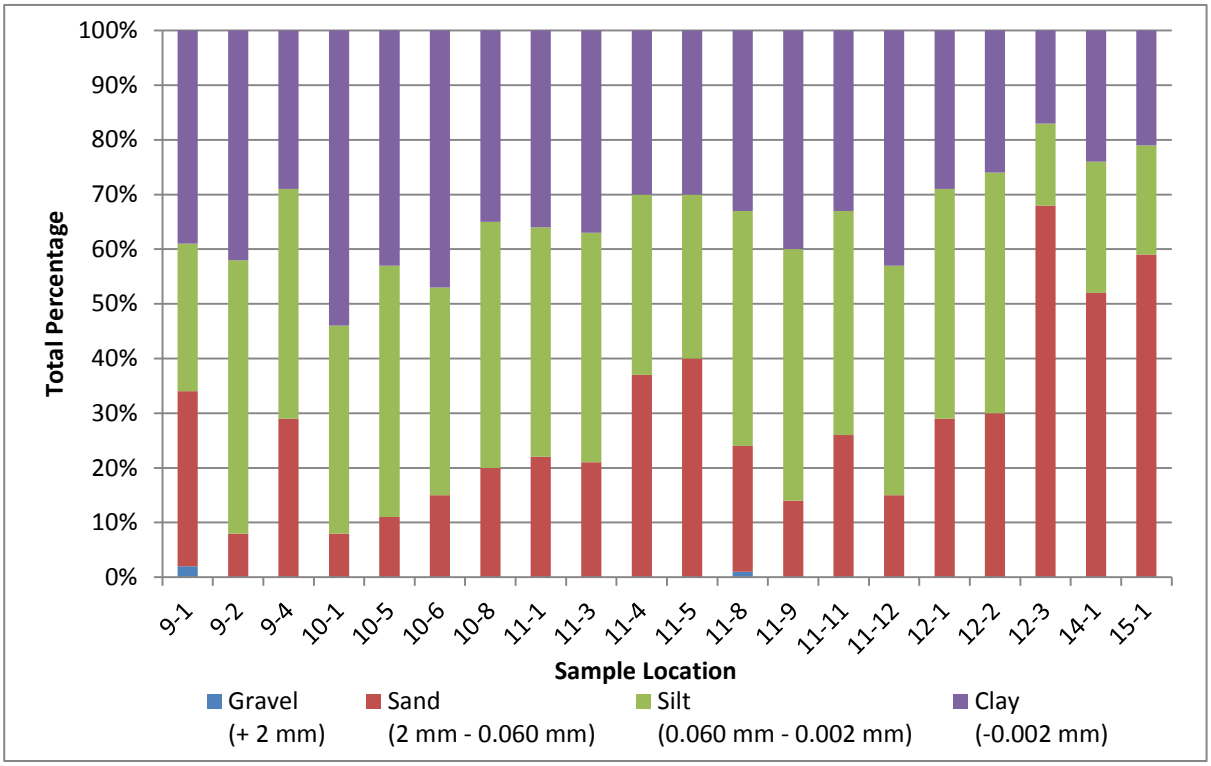


Figure 3-5: Particle size distribution at locations within Zone 3

3.2.4 Zone 4 – Moreton Bay (Entrance Channel)

The dominant PSD within Zone 4 was silt (39%) followed by clay (32%) and sand (29%). Gravel content was very small (< 1%) (Table 3-7).

The PSD pattern for Zone 4 generally follows a similar pattern to that which has been identified in previous studies (WorleyParsons 2011; GHD 2010). Sediments within Zone 4 show an increasing amount of silt (9% to 50%) and clay (10% to 46%) content as the distance from the mouth of the Brisbane river increases, with 13-1 being the closest location to the mouth, and 13-9 being the most seaward sampling location. (Figure 3-6).

Table 3-7: Summary statistics for Zone 4 particle size distribution

	Gravel (+ 2 mm)	Sand (2 mm - 0.060 mm)	Silt (0.060 mm - 0.002 mm)	Clay (-0.002 mm)
Number of Samples	9	9	9	9
Mean (%)	0	29	39	32
Standard Deviation (%)	0	23	13	11
Minimum (%)	0	4	9	10
Maximum (%)	0	81	50	46

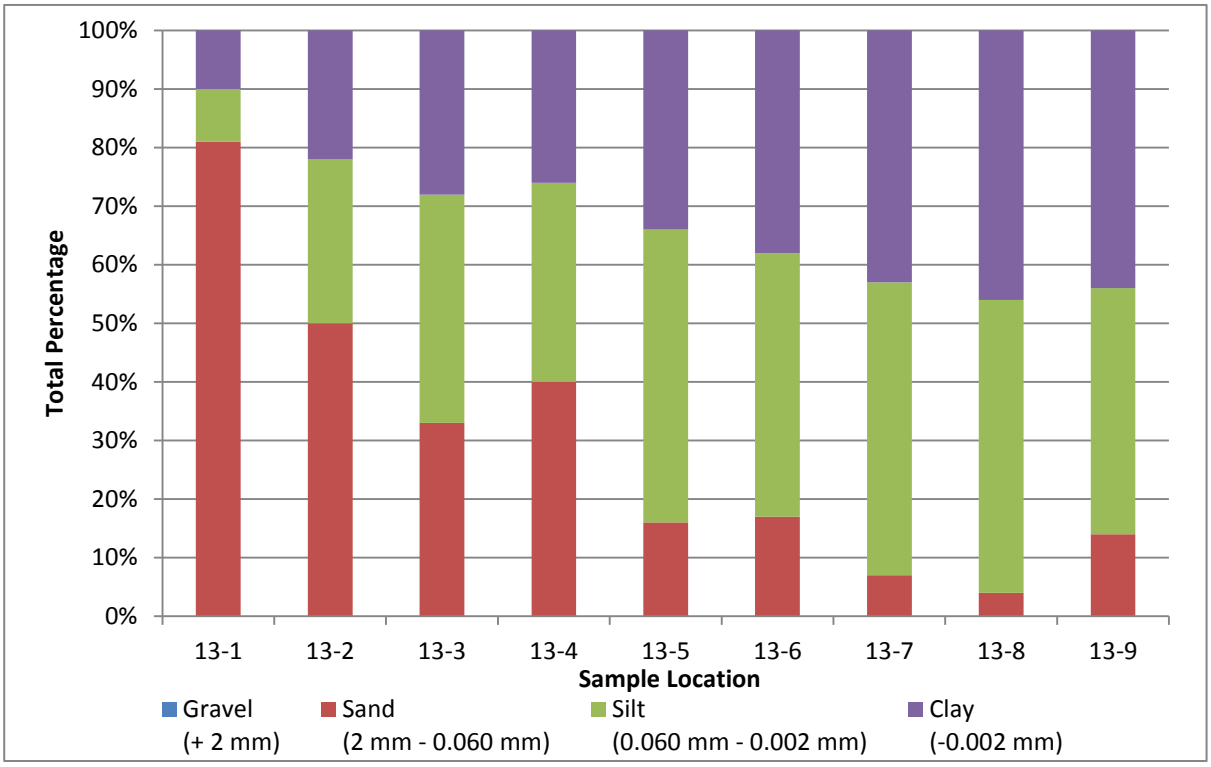


Figure 3-6: Particle size distribution at locations within Zone 4

3.2.5 Comparison Between Zones

Table 3-8 and Figure 3-7 show the mean percentage of PSD of sediments within Zones 1–4. In general, Zones 2 – 4 have relatively comparative PSD. Silt content was relatively consistent across these three zones, with silt ranging from 39 to 41%. Difference in PSD across these three zones was related to clay and sand content. Zone 3 (28%) and zone 4 (29%) had increased sand content compared to zone 2 (16%), which corresponds to an increase in clay content. Average gravel content in these zones was 0%.

Zone 1 was unlike zones 2 – 4, due primarily to the higher sand and gravel content of 63% and 3% respectively. The silt and clay content was much lower at 13% and 20% respectively.

Table 3-8: Mean percentage particle size distribution for each zone

	Gravel (+ 2 mm)	Sand (2 mm - 0.060 mm)	Silt (0.060 mm - 0.002 mm)	Clay (-0.002 mm)
Zone 1	3	63	13	20
Zone 2	0	16	41	43
Zone 3	0	28	38	34
Zone 4	0	29	39	32

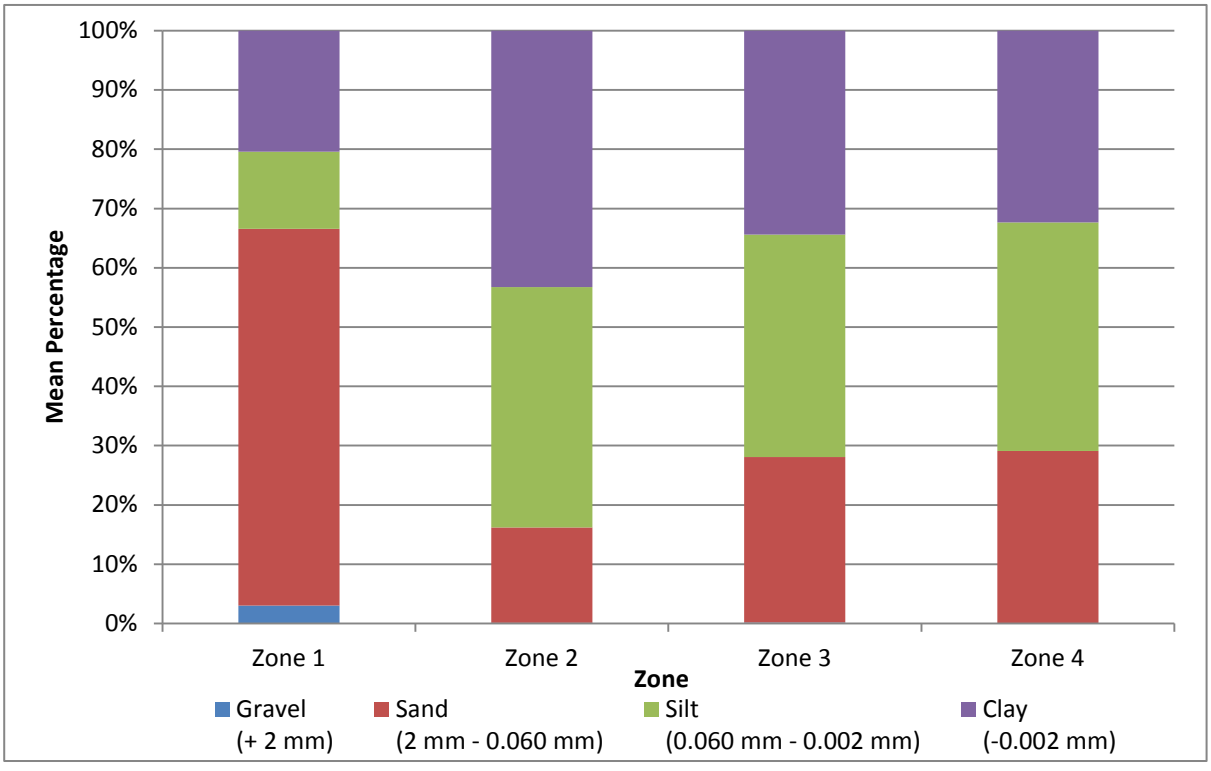


Figure 3-7: Mean percentage of particle size distribution of sediments within zones 1 – 4.

3.2.6 Bulk Density

PBPL requested that samples from ten selected locations across Zones 2 to 4 be analysed for bulk density and reported on. The results this analysis is to be taken into consideration by dredge operators. Results for bulk density analyses are presented in Table 3-9.

Table 3-9: Bulk density at ten locations across Zones 2 - 4

Sample Location	Wet Sediment Density (t/m^3)	Zone
4-7	1.354	2
4-8	1.322	2
6-2	1.295	2
6-3	1.400	2
9-4	1.455	3
10-1	1.309	3
11-9	1.455	3
11-11	1.419	3
13-7	1.388	4
13-8	1.403	4

3.3 Breakfast Creek Chemical Results

Samples taken from additional locations in Breakfast Creek were analysed for the basic and detailed suite of analysis. Laboratory results for these sampling locations are summarised in Table 3-11 and represented spatially in maps provided in Appendix 1. Primary laboratory analytical reports are provided in Appendix 3. Results are compared against the Screening Levels listed in Appendix A Table 2 of the NAGD (Commonwealth of Australia, 2009) and EIL and HIL(A) concentrations in DEH (1998).

3.3.1 Contaminant Concentrations in Comparison to NAGD Screening Levels

3.3.1.1 METALS/METALLOIDS

- All metals were detected above their respective NAGD PQLs at all sites with two exceptions. Cadmium was below NAGD PQL at BC-3 and BC-4.
- Copper concentrations were below the NAGD Screening Level (65 mg/kg) with one exception at BC-2 (92 mg/kg).
- Lead concentrations at BC-1 and BC-2 exceeded the NAGD Screening Level of 50 mg/kg.

- Two of the four sites had mercury concentrations that were greater than the NAGD Screening Level of 0.15 mg/kg; BC-1 and BC-2.
- Two of the four sites had nickel levels that were greater than the NAGD Screening Level of 21 mg/kg; BC-2 and BC-4.
- Zinc concentration at BC-2 exceeded the NAGD Screening Level (200 mg/kg).

3.3.1.2 ORGANOTINS

- Tributyltin concentrations were below the PQL (9 µgSn/kg) at all locations with the exception of BC-3. This site had a detectable concentration of TBT of 10 µgSn/kg.

3.3.1.3 BTEX

- All BTEX concentrations were below PQLs (0.2-0.4 mg/kg) at all locations.

3.3.1.4 POLYCYCLIC AROMATIC HYDROCARBONS

- Total PAHs (normalised to TOC concentration) where detected, were below the Screening Level of 10,000 µg/kg at all locations.

3.3.1.5 TOTAL PETROLEUM HYDROCARBONS

- Total TPH (normalised to TOC concentration) where detected, were below the Screening Level of 550 µg/kg at all locations.

3.3.1.6 ORGANOCHLROINE PESTICIDES

- *p,p'*-DDE concentrations (normalised to TOC concentration) at three locations (BC-2, BC-3 and BC-4) exceeded the NAGD Screening Level of 2.2 µg/kg.

3.3.1.7 POLYCHLORINATED BIPHENYLS

- Total polychlorinated biphenyls (PCB) concentrations (normalised to TOC concentration) were all below NAGD Screening Level of 23 µg/kg.

3.3.1.8 ORGANOPHOSPHORUS PESTICIDES AND RADIONUCLIDES

- OPPs were below PQLs (20 µg/kg) at all locations.
- Sum of gross alpha and gross beta radionuclides were below PQLs (<195 mBq/g) at all locations

3.3.2 Contaminant Concentrations Exceeding EIL or HIL (A)

The following chemicals had concentrations that exceeded EIL guidelines indicated in the DEH (1998):

- Copper was greater than EIL of 60 µg/kg at one location (BC-2); and
- Zinc was greater than the EIL of 200 µg/kg at one location (BC-2).

None of the parameters analysed exceeded HIL (A) guideline values.

3.4 Breakfast Creek Physical Results

Table 3-10 shows that sediments within Breakfast Creek contain relatively even portions of sand (27%), silt (28%) and clay (32%). Figure 3-8 shows the mean percentage of PSD of sediments within BC1 to BC 4 and it clearly demonstrates that the composition of BC-1 is different compared to the other three locations. BC-1 was dominated by sand (44%) with lower portions of clay (20%), silt (25%) and gravel (11%). Sites BC2 –BC4 have similar PSD patterns dominated by clay and silt with a smaller proportion of sand.

Table 3-10: Summary statistics for Breakfast Creek particle size distribution

	Gravel (+ 2 mm)	Sand (2 mm - 0.060 mm)	Silt (0.060 mm - 0.002 mm)	Clay (-0.002 mm)
Number of Samples	4	4	4	4
Mean (%)	4	21	41	35
Standard Deviation (%)	5	15	10	11
Minimum (%)	0	7	25	20
Maximum (%)	11	44	50	46

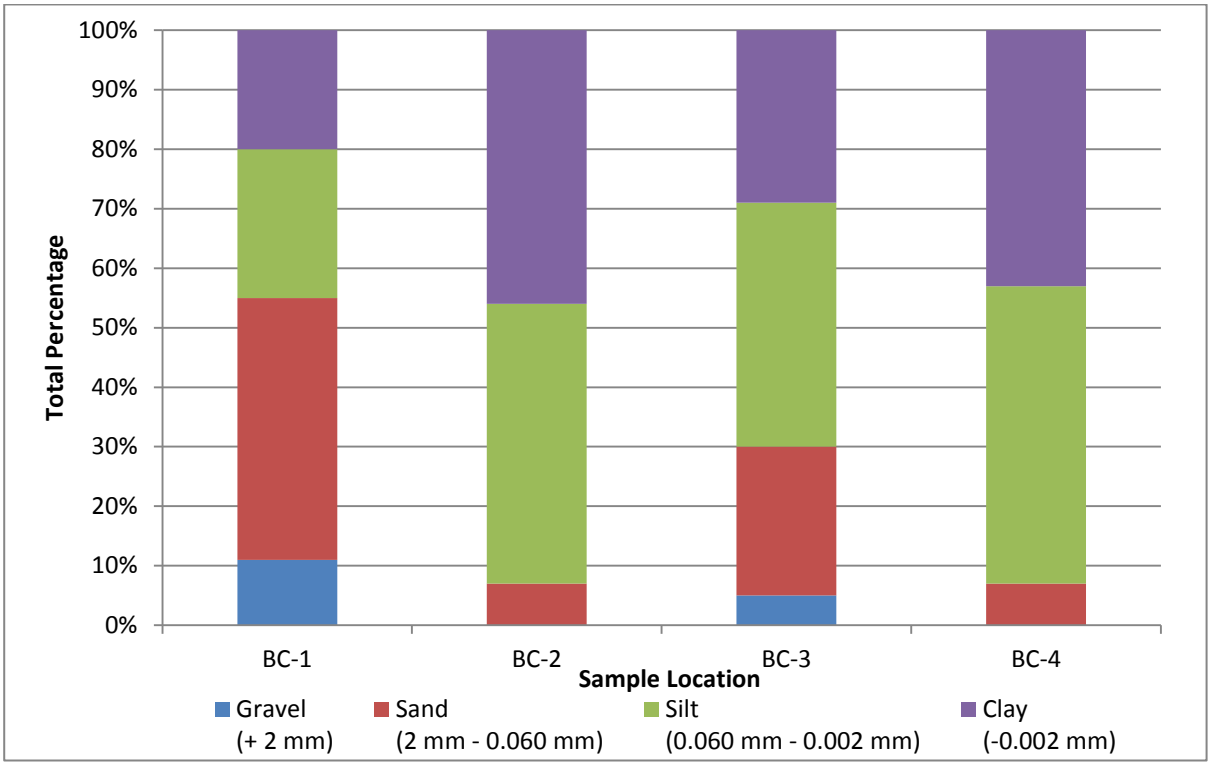


Figure 3-8: Particle size distribution for sediments within Breakfast Creek

Table 3-11: Summary of results for additional sampling locations at Breakfast Creek

							Breakfast Creek						
Sample	**Units**	**PQL**	**NAGD PQL**	**NAGD Screening Level**	**EIL**	**HIL-A**	**BC-1**	**BC-2**	**BC-3**	**BC-4**	**Mean**	**Standard Deviation**	**95% UCL**
Date sampled							4/12/12	4/12/12	4/12/12	4/12/12			
Moisture Content	%	0.1	0.1				38.1	56.8	48.4	57.7	50.3	9.1	61.0
Total Organic Carbon	%	0.01	0.1				3.2	2	1.6	2.3	2.3	0.7	3.1
Metals and Metalloids													
Arsenic	mg/kg	0.4	1	20.0	20.0	100.0	16.00	9.80	8.10	7.90	10.5	3.8	14.9
Cadmium	mg/kg	0.1	0.1	1.5	3	20.0	0.33	0.26	<0.1	<0.1	0.3	0.0	
Chromium	mg/kg	0.1	1	80.0			23.00	50.00	38.00	49.00	40.0	12.6	54.8
Copper	mg/kg	0.1	1	65.0	60	1000.0	38.00	92.00	55.00	39.00	56.0	25.2	85.7
Lead	mg/kg	0.5	1	50	300	300.0	90.00	94.00	36.00	27.00	61.8	35.2	103.1
Mercury	mg/kg	0.01	0.01	0.15	1	15.0	0.58	0.19	0.14	0.14	0.3	0.2	0.5
Nickel	mg/kg	0.1	1	21.0	60	600.0	16.00	26.00	19.00	31.00	23.0	6.8	31.0
Phosphorus*	mg/kg	1					350.00	850.00	740.00	860.00	700.0	239.6	981.9
Zinc	mg/kg	0.5	1	200	200	7,000	190.00	200.00	160.00	130.00	170.0	31.6	207.2
Organotins													
Monobutyl tin	µgSn/kg	0.5	*1*				<0.5	1.70	0.70	0.60			
Normalised to TOC Concentration								0.85	0.44	0.26	0.4	0.3	0.8
Dibutyl tin	µgSn/kg	0.5	*1*				<0.5	11.00	5.70	3.20			
Normalised to TOC Concentration								5.50	3.56	1.39	2.7	2.3	5.4
Tributyl tin	µgSn/kg	0.5	1				<0.5	2.50	16.00	0.60			
Normalised to TOC Concentration				9				1.25	10.00	0.26	2.9	4.7	8.5
BTEX													
Benzene	mg/kg	0.2	0.2				<0.2	<0.2	<0.2	<0.2			
Toluene	mg/kg	0.2	0.2				<0.2	<0.2	<0.2	<0.2			
Ethyl Benzene	mg/kg	0.2	0.2				<0.2	<0.2	<0.2	<0.2			
m+p xylenes	mg/kg	0.4					<0.4	<0.4	<0.4	<0.4			
o-xylene	mg/kg	0.2	0.2				<0.2	<0.2	<0.2	<0.2			
Total BTEX	mg/kg	1.2					<1.2	<1.2	<1.2	<1.2			
Total Petroleum Hydrocarbons													
TPH C6-C9	mg/kg	10	100				<10	<10	<10	<10			
TPH C10-14	mg/kg	10	100				<10	<10	<10	<20			
TPH C15-28	mg/kg	50	100				190.00	110.00	64.00	100.00			
Normalised to TOC Concentration							59.38	55.00	40.00	43.48	49.5	9.2	60.3
TPH C29-36	mg/kg	50	100				210.00	140.00	100.00	130.00			
Normalised to TOC Concentration							65.63	70.00	62.50	56.52	63.7	5.7	70.3
Total TPH			100	550			400.00	250.00	164.00	230.00			
Normalised to TOC Concentration			100	550			125.00	125.00	102.50	100.00	113.1	13.8	129.3
Polycyclic Aromatic Hydrocarbons													
Naphthalene	µg/kg	5	5				130.00	16.00	17.00	21.00			
Normalised to TOC Concentration							40.63	8.00	10.63	9.13	17.1	15.7	35.6
1-Methylnaphthalene	µg/kg	5	5				25.00	10.00	6.00	6.00			
Normalised to TOC Concentration							7.81	5.00	3.75	2.61	4.8	2.2	7.4
2-Methylnaphthalene	µg/kg	5	5				47.00	14.00	10.00	14.00			
Normalised to TOC Concentration							14.69	7.00	6.25	6.09	8.5	4.1	13.4
Acenaphthylene	µg/kg	5	5				240.00	17.00	36.00	20.00			
Normalised to TOC Concentration							75.00	8.50	22.50	8.70	28.7	31.6	65.8
Acenaphthene	µg/kg	5	5				54.00	8.00	6.00	9.00			
Normalised to TOC Concentration							16.88	4.00	3.75	3.91	7.1	6.5	14.8
Fluorene	µg/kg	5	5				120.00	10.00	11.00	17.00			
Normalised to TOC Concentration							37.50	5.00	6.88	7.39	14.2	15.6	32.5
Phenanthrene	µg/kg	5	5				830.00	56.00	70.00	95.00			
Normalised to TOC Concentration							259.38	28.00	43.75	41.30	93.1	111.1	223.8
Anthracene	µg/kg	5	5				440.00	23.00	37.00	36.00			
Normalised to TOC Concentration							137.50	11.50	23.13	15.65	46.9	60.6	118.2
Fluoranthene	µg/kg	5	5				3380.00	120.00	370.00	200.00			
Normalised to TOC Concentration							1056.25	60.00	231.25	86.96	358.6	471.1	913.0
Pyrene	µg/kg	5	5				3650.00	200.00	550.00	300.00			
Normalised to TOC Concentration							1140.63	100.00	343.75	130.43	428.7	486.8	1001.6
Benz(a)anthracene	µg/kg	5	5				1460.00	110.00	410.00	150.00			
Normalised to TOC Concentration							456.25	55.00	256.25	65.22	208.2	189.5	431.2
Chrysene	µg/kg	5	5				1360.00	97.00	340.00	130.00			

Note: Only presenting results above limits of reporting.

Table 3-11 continued: Summary of results for additional sampling locations at Breakfast Creek

							Breakfast Creek						
Sample	**Units**	**PQL**	**NAGD PQL**	**NAGD Screening Level**	**EIL**	**HIL-A**	**BC-1**	**BC-2**	**BC-3**	**BC-4**	**Mean**	**Standard Deviation**	**95% UCL**
Normalised to TOC Concentration							425.00	48.50	212.50	56.52	185.6	176.5	393.4
Benzo(b)&(k)fluoranthene	µg/kg	10	5				3350.00	270.00	930.00	280.00			
Normalised to TOC Concentration							1046.88	135.00	581.25	121.74	471.2	439.2	988.0
Benzo(a)pyrene	µg/kg	5	5				2060.00	150.00	570.00	150.00			
Normalised to TOC Concentration							643.75	75.00	356.25	65.22	285.1	274.6	608.1
Indeno(1,2,3-cd)pyrene	µg/kg	5	5				1360.00	170.00	490.00	150.00			
Normalised to TOC Concentration							425.00	85.00	306.25	65.22	220.4	174.8	426.0
Dibenz(a,h)anthracene	µg/kg	5	5				580.00	54.00	160.00	48.00			
Normalised to TOC Concentration							181.25	27.00	100.00	20.87	82.3	75.1	170.7
Benzo(g,h,i)perylene	µg/kg	5	5				1760.00	150.00	400.00	110.00			
Normalised to TOC Concentration							550.00	75.00	250.00	47.83	230.7	230.9	502.5
Coronene	µg/kg	10	5				480.00	47.00	99.00	30.00			
Normalised to TOC Concentration							150.00	23.50	61.88	13.04	62.1	62.2	135.3
Benzo(e)pyrene	µg/kg	5	5				1390.00	120.00	370.00	120.00			
Normalised to TOC Concentration							434.38	60.00	231.25	52.17	194.4	180.0	406.3
Perylene	µg/kg	5	5				930.00	740.00	420.00	1730.00			
Normalised to TOC Concentration							290.63	370.00	262.50	752.17	418.8	226.8	685.8
Total PAHs (as above)	µg/kg	100	100	10000			23700.00	2400.00	5290.00	3610.00			
Normalised to TOC Concentration							7406.25	1200.00	3306.25	1569.57	3370.5	2842.9	6715.7
Organochlorine Pesticides													
Aldrin	µg/kg	1					<1	<1	<1	<1			
alpha-BHC	µg/kg	1					<10	<10	<10	<10			
beta-BHC	µg/kg	1					<10	<10	<10	<10			
gamma-BHC (Lindane)	µg/kg	1					<10	<10	<10	<10			
delta-BHC	µg/kg	1					<10	<10	<10	<10			
cis-Chlordane	µg/kg	1	0.5				<1	<1	<1	<1			
trans-Chlordane	µg/kg	1	0.5				<1	<1	<1	<1			
p,p'-DDD	µg/kg	1	2				<10	<10	<10	<10			
p,p'-DDE	µg/kg	1	2.2				<1	7.00	4.00	11.00	7.3	3.5	
Normalised to TOC Concentration				2.20				3.50	2.50	4.78	2.8	1.8	4.9
p,p'-DDT	µg/kg	1	1.6				<10	<10	<10	<10			
Dieldrin	µg/kg	1	280				<1	<1	<1	<1			
alpha-Endosulfan	µg/kg	1					<10	<10	<10	10.00			
Normalised to TOC Concentration										4.35	4.8	0.3	5.2
beta-Endosulfan	µg/kg	1					<10	<10	<10	<10			
Endosulfan Sulphate	µg/kg	1					<1	<1	<1	<1			
Endrin	µg/kg	1	10				<1	<1	<1	<1			
Endrin ketone	µg/kg	1					<1	<1	<1	<1			
Endrin aldehyde	µg/kg	1					<1	<1	<1	<1			
Heptachlor	µg/kg	1					<1	<1	<1	<1			
Heptachlor epoxide	µg/kg	1					<1	<1	<1	<1			
Hexachlorobenzene	µg/kg	1					<1	<1	<1	<1			
Methoxychlor	µg/kg	1					<1	<1	<1	<1			
Oxychlordane*	µg/kg	1					<1	<1	<1	<1			
Orgonophosphoros Pesticides													
Dichlorvos	µg/kg	20	10-100				<20	<20	<20	<20			
Demeton-S-methyl	µg/kg	20	10-100				<20	<20	<20	<20			
Dimethoate	µg/kg	20	10-100				<20	<20	<20	<20			
Diazinon	µg/kg	20	10-100				<20	<20	<20	<20			
Chlorpyrifos-methyl	µg/kg	20	10-100				<20	<20	<20	<20			
Parathion-methyl	µg/kg	20	10-100				<20	<20	<20	<20			
Pirimiphos-methyl	µg/kg	20	10-100				<20	<20	<20	<20			
Fenitrothion	µg/kg	20	10-100				<20	<20	<20	<20			
Malathion	µg/kg	20	10-100				<20	<20	<20	<20			
Chlorpyrifos	µg/kg	20	10-100				<20	<20	<20	<20			
Fenthion	µg/kg	20	10-100				<20	<20	<20	<20			
Parathion*	µg/kg	20	10-100				<20	<20	<20	<20			
Chlorfenvinphos	µg/kg	20	10-100				<20	<20	<20	<20			

Note: Only presenting results above limits of reporting.

Table 3-11 continued: Summary of results for additional sampling locations at Breakfast Creek

							Breakfast Creek						
Sample	**Units**	**PQL**	**NAGD PQL**	**NAGD Screening Level**	**EIL**	**HIL-A**	**BC-1**	**BC-2**	**BC-3**	**BC-4**	**Mean**	**Standard Deviation**	**95% UCL**
Bromophos-ethyl	µg/kg	20	10-100				<20	<20	<20	<20			
Methidathion	µg/kg	20	10-100				<20	<20	<20	<20			
Fenamiphos	µg/kg	20	10-100				<20	<20	<20	<20			
Prothiofos	µg/kg	20	10-100				<20	<20	<20	<20			
Ethion	µg/kg	20	10-100				<20	<20	<20	<20			
Carbophenothion	µg/kg	20	10-100				<20	<20	<20	<20			
Phosalone	µg/kg	20	10-100				<20	<20	<20	<20			
Azinphos-methyl*	µg/kg	20	10-100				<20	<20	<20	<20			
Fenchlorvos*	µg/kg	20	10-100				<20	<20	<20	<20			
Mevinphos	µg/kg	20	10-100				<20	<20	<20	<20			
Trifluralin*	µg/kg	20	10-100				<20	<20	<20	<20			
Nutrients													
Nitrate as N	mg/kg	0.1	0.1				<0.1	<0.1	<0.1	<0.1			
Nitrite as N	mg/kg	0.1	0.1				<0.1	<0.1	<0.1	<0.1			
Total Kjeldahl Nitrogen	mg/kg	20					970.00	1220.00	1060.00	1540.00	1197.5	250.6	1492.4
Total Nitrogen	mg/kg	20					970.00	1220.00	1060.00	1540.00	1197.5	250.6	1492.4
PCB													
Mono-PCB congeners	µg/kg	5	1.00				<5	<5	<5	<5			
Di-PCB congeners	µg/kg	5	1.00				<5	<5	<5	<5			
Tri-PCB congeners	µg/kg	5	1.00				<5	<5	<5	<5			
Tetra-PCB congeners	µg/kg	5	1.00				<5	<5	<5	<5			
Penta-PCB congeners	µg/kg	5	1.00				<5	<5	<5	<5			
Hexa-PCB congeners	µg/kg	5	1.00				<5	7.00	5.00	8.00			
Normalised to TOC Concentration								3.50	3.13	3.48	3.2	0.5	3.7
Hepta-PCB congeners	µg/kg	5	1.00				<5	<5	<5	<5			
Octa-PCB congeners	µg/kg	5	1.00				<5	<5	<5	<5			
Nona-PCB congeners	µg/kg	5	1.00				<5	<5	<5	<5			
Deca-PCB congeners	µg/kg	5	1.00				<5	<5	<5	<5			
Total PCB congeners	µg/kg	5	5.00	23.00			<5	7.00	5.00	8.00			
Normalised to TOC Concentration								3.50	3.13	3.48	3.2	0.5	3.7

Note: Only presenting results above limits of reporting.

4 DATA VALIDATION

This section examines the validity of the analytical data obtained in the study. It provides the scientific confidence in the actual results presented.

4.1 Laboratory Accuracy and Precision

The primary laboratory (AAA) and secondary laboratory (mgt-Labmark) incorporated a range of QA/QC methods to ensure accuracy and precision of data as outlined below. Laboratory QA/QC reports are included in Appendix 3 (AAA) and Appendix 6 (mgt-Labmark).

4.1.1 Laboratory Blanks

Laboratory blanks or method blanks are artificial samples, usually distilled water, introduced to a chemical analyser to observe the response of the instrument to a sample that does not contain the material being measured. Blanks can also detect any contamination occurring during laboratory processing of the sample. An assessment of laboratory blank samples reported by AAA demonstrates concentrations below the detection limit for all parameters, so cross-contamination of samples does not appear to have occurred.

4.1.2 Laboratory Duplicates

Laboratory duplicates refers to an intra-laboratory split sample randomly selected from the sample batch. Laboratory duplicates provide information on method precision and sample heterogeneity. The precision of analysis performed by the laboratory is determined by the calculation of the relative percentage difference (RPD). The NAGD recommends that laboratory duplicate samples should be within an RPD of ±35%. The laboratory QC results provided by AAA identified that thirty-one PAH results, as well as four organotin results were outside of their respective criteria. In addition, p,p'-DDE and PCBs exceeded this criterion twice each. Mercury exceeded the NAGD criterion on a singular basis.

While the NAGD states that the RPD should be within ±35%, AAA prefers to use a sliding scale to account for greater analytical uncertainty for contaminant concentrations nearer to the LOR. The laboratory RPDs have been assessed using the following protocol:

- Results <10 times LOR: no limits; and
- Results > 10 times LOR: 0% - 50%

Using the criteria provided by AAA, the majority of PAHs were each outside of these limits at least once across the seven. When levels outside these limits are obtained, an investigation into the cause of the deviation is performed by the laboratory before the batch is accepted or rejected, and results are released. Investigations were conducted and the laboratory accepted the results for release. All other contaminants complied with this criterion. The laboratory duplicate results for PAHs being outside of the specified limits indicate that some of the results should be flagged as estimates as

opposed to precise values. The 95% UCL results for total PAHs in all zones are well below the NAGD screening level of 10,000µg/kg. In the event that the results are an estimate, there is a very low likelihood that the precise values are above the screening level. Based on this, the laboratory duplicate results would not alter the conclusions of this study.

4.1.3 Surrogate Spikes

Surrogate spikes are compounds similar in composition to the target analyte that will behave in a similar manner to the target compounds throughout preparation and analysis, will not interfere with the target analysis and do not occur in the environment. Samples are spiked with the surrogate material and a calculation of the percentage recovery of the returned concentration is performed. The percentage recovery result provides an indication of the ability of the laboratory to extract a specified contaminant type from the sample matrix. Typically surrogate spikes are performed only for organic compounds. NAGD states that recovery limits of 75% - 125% are generally acceptable.

For the analysis, BTEX were consistently outside of the set NAGD recovery limits. Organotins, TPH, PAHs, OPPs and PCBs were also outside of NAGD recovery limits for some locations.

The NAGD criteria range is likely based on surrogate recoveries from 'clean' matrix free samples. In real samples, the range of recoveries can be much greater and often lower due to matrix interference. As such, AAA has developed recovery limits for different contaminants. Refer to Appendix 3 for the relevant dynamic recovery limits applied by AAA. A single surrogate recovery for OPPs was outside of the AAA limit.

Matrix interference occurs when samples contain certain properties such as high moisture content, high salinity and/or contain substances such as plant sterols, waxes, lipids or other organic matter that can inhibit the full extrusion of a contaminant during laboratory surrogate extraction.

4.1.4 Matrix Spikes

A known concentration of the chemical of interest is mixed into a sample of the required matrix to verify that the physical properties or characteristics of the matrix do not interfere with the analytical result. The matrix spike is then prepared and analysed according to the analytical method, and results are compared with an analysis of the parent sample (the original sample with no added spike). Samples collected from the field are sub-sampled from the original sample and spiked with a known contaminant concentration. If there is no matrix interference, the result of the matrix spike should be equivalent to the result of the parent sample plus the amount of chemical added to the matrix spike sample:

$$\% \text{ Recovery} = \frac{\text{Matrix spike sample result - Parent (un-spiked) sample result}}{\text{Spike Amount}} \times 100$$

Matrix spikes measure the analytical methodology's performance on a specific matrix type.

NAGD recommends that:

> *"Recovery Rates (for matrix spiked samples) should be within the limits specified for the analysis method (typically 75-125%)".*

Matrix spike recoveries show that a number of Organotin, OCP, OPP, BTEX, PAH and TPH species were outside of the NAGD criteria. The majority however, were within the guidelines set by AAA. Monobutyltin at 14% and 48% and a single OPP (phosalone at 154%) fell outside of the criteria set by AAA. All results are investigated by AAA and samples reanalysed. If results demonstrate similar high recoveries, then the recoveries are confirmed outside of the acceptable range and deemed high due to matrix interference.

As the spikes recoveries are outside of the guidelines set by AAA (low), the reported contaminant concentrations by the laboratory are potentially lower than actual contaminant concentrations found within sediment samples. Given that monobutyltin and phosalone were not detected or were below Screening Levels, the matrix spike recovery values that exceeded Screening Levels do not impact on the results.

4.2 Field Split Triplicate, Replicate Triplicate and Inter-Batch Duplicate Analysis

Appendix 7 provides a summary of RPDs and Relative Standard Deviations (RSDs) of field split triplicate, field replicate triplicate and inter-batch duplicate analyses. Results for the various analyses are discussed below.

4.2.1 Field Split Triplicate Sample Analyses (inter- and intra-laboratory comparison)

Field split triplicates are samples which help identify variation associated with sub-sample handling and repeatability of laboratory analyses. Parameter concentrations are compared between the split samples through calculation of the Relative Standard Deviation (RSD). Three field split triplicates were collected from the following locations: 6-2, 9-1, and 12-2.

The NAGD states that RSDs for field split samples should be within ±50%. For location 6-2, mercury and dibutyltin exceeded the NAGD criteria. For location 9-1, lead, TBT and individual PAHs (phenanthrene, anthracene, fluoranthene, pyrene, benz(a)anthracene, chrysene, benzo(b)&(k)fluoranthene, benzo(a)pyrene, indeno(1,2,3-cd)pyrene, dibenz(a,h)anthracene, benzo(g,h,i)perylene, coronene, perylene, and total PAHs) exceeded the NAGD criteria. For location 12-2, mercury, phosphorous, TBT, dibenz(a,h)anthracene and perylene exceeded the NAGD criteria.

Relative standard distributions and RPDs for PAHs in site 9-1 indicate that the samples were not thoroughly homogenised. This is evident by the high RSDs for the PAHs in one of the samples taken.

These results highlight that there was site heterogeneity issues for field split samples. Most results were near the limit of detection so the impact on the data was minimal. Arrangements, such as longer mixing times and ensuring the boat remains over the sampling location (i.e. drifting), have been made to ensure a more homogenous sample is taken during future sampling events.

4.2.2 Field Triplicate Analyses

Seven field triplicate samples (i.e. three separate samples collected in the field at a given sampling location) were collected from site locations 3-0, 4-9, 7-1, 10-8, 11-11, 13-2, and BC-2 and tested for sediment homogeneity. Parameter results were compared through calculation of the RSD. According to NAGD:

> *"Field replicates (that is, two separate samples taken at the same location) should agree within an RPD (or for three samples at the one location, the relative standard deviation, RSD) of ±50%, although they may not always do so where the sediments are very inhomogeneous or greatly differing in grain size".*

Site location 13-2 demonstrated good sediment homogeneity as no parameters, where detected, exceeded the NAGD criteria of > 50% RSDs. The remaining sites had contaminants that exceeded the NAGD criteria >50% RSD for the following sites:

- 3-0: TPH;
- 4-9: Lead, mercury and TPH;
- 7-1: Copper, monobutyl tin, tributyl tin, TPH, flouranthene, chrysene, benzo(b)&(k)fluoranthene, benzo(a)pyrene, indeno(1,2,3-cd)pyrene, dibenz(a,h)anthracene, coronene, benzo(e)pyrene, perylene, and total PAHs;
- 10-8: Mercury and TPH
- 11-1: TPH
- BC-2: Tributyl tin, hexa-PCB congeners and total PCB congeners.

Based on these results, sites 3-0, 4-9, 10-8, 11-1 and BC-2 can be considered to be homogeneous. The RSDs for site 7-1 are close to the NAGD criteria, indicating that this site is showing signs of a heterogeneous sediment.

4.2.3 Inter-laboratory comparison

Inter-batch duplicates are samples which help identify any analysis variation between sample batches. Contaminant concentrations are compared between the two split samples through calculation of the RPD. The RPD value provides an indication of the accuracy of laboratory analysis between samples/batches. The NAGD states that RPDs for duplicate split samples should be within ±50%. One inter-batch duplicate sample was taken from location 8-3. All contaminants analysed were compliant with the NAGD criteria.

Based on RPD data analysis for the inter-batch duplicate, laboratory analysis between batches appears to be consistent.

4.2.4 Field Blanks

A field blank is a container of water, quality assured to be free of any of the substances - organic, inorganic or both - that are to be tested for in the real samples. The container is taken into the field and exposed to the atmosphere of the site for a period of time.Three field blanks for BTEX were collected in the field and sent to the primary laboratory for BTEX analysis. BTEX concentrations were below detection limits, so no cross-contamination is likely to have occurred during field sampling and handling procedures.

4.3 Holding Times

Samples were kept chilled whilst in the field (using eskies and bags of ice), during storage (using a mobile refrigerator at 2°C) and during delivery, then stored under refrigeration at the laboratories. All sample analyses were undertaken within required holding times by the primary laboratory (AAA) and the mgt-Labmark.

5 COMPARISON WITH GUIDELINE CRITERIA WITH 95% UCL

Compliance against NAGD Screening levels, and DEH EIL and HIL-A concentrations has been assessed for all zones. Individual assessment was undertaken for each individual zone, as well as a combined assessment of the dredge area (Zones 2 – 4).

The following sections provide a summary description and tables of mean and 95% UCL. Contaminants that were detected in the 2012 SAP study are assessed. Nutrients, moisture content and TOC were excluded from this comparison as they are not classified as contaminants under the NAGD.

5.1 Compliance with NAGD Screening Levels with 95% UCL

5.1.1 Zone 1 – Reference Sites

The 95% UCL of the mean for mercury (0.17 mg/kg) and nickel (34.49 mg/kg) were above their respective NAGD Screening Level (Table 5-1). All other contaminants were below respective NAGD Screening Levels.

5.1.2 Zone 2 – Colmslie to Pinkenba

The 95% UCL of the mean for mercury (0.19 mg/kg), nickel (24.38 mg/kg), trans-chlordane (0.5 µg/kg), *p,p'*-DDD (8.65 µg/kg), *p,p'*-DDE (3.66 µg/kg) and *p,p'*-DDT (25.94 µg/kg) were above their respective NAGD Screening Levels (Table 5-2). All other contaminants were below respective NAGD Screening Levels.

5.1.3 Zone 3 – Port reaches

The 95% UCL of the mean for nickel (22.77 mg/kg) and TBT (12.8 µgSn/kg) were above their respective NAGD Screening Levels (Table 5-3). All other contaminants were below respective NAGD Screening Levels.

5.1.4 Zone 4 – Moreton Bay (Entrance Channel)

All contaminants were below respective NAGD Screening Levels. (Table 5-4).

5.1.5 Whole Dredge Area (Zone 2 – Zone 4)

The 95% UCL concentrations calculated for each parameter for the total dredge area (Zones 2-4) were generally below respective NAGD Screening Levels with the exception of nickel (22.35 mg/kg), *p,p'*-DDD (6.27 µg/kg), *p,p'*-DDE (2.96 µg/kg) and *p,p'*-DDT (12.26 µg/kg) (Table 5-5).

5.2 Compliance with EIL and HIL (A) Guidelines

No contaminants exceeded the EIL or HIL (A) guideline values (DEH, 1998) at the 95% UCL of the mean for the whole dredge area (zones 1-4).

Table 5-1: Comparison of 95% UCL concentrations with NAGD Screening Levels and DEH Investigation Levels for contaminants in the reference area (Zone 1)

Sample	Units	PQL	NAGD PQL	NAGD Screening Level	EIL	HIL-A	1-0	2-0	3-0	Mean	Standard Deviation	95% UCL
Date sampled							4/12/12	4/12/12	4/12/12			
Moisture Content	%	0.1	0.1				18	17.3	68.5	34.60	29.36	84.10
Total Organic Carbon	%	0.01	0.1				0.25	0.06	2	0.77	1.07	2.57
Metals and Metalloids												
Arsenic	mg/kg	0.4	1	20.0	20.0	100.0	2.10	1.60	9.30	4.33	4.31	11.60
Cadmium	mg/kg	0.1	0.1	1.5	3	20.0	<0.1	<0.1	<0.1	<0.1	-	<0.1
Chromium	mg/kg	0.1	1	80.0			11.00	8.10	43.00	20.70	19.37	53.35
Copper	mg/kg	0.1	1	65.0	60	1000.0	4.50	2.60	35.00	14.03	18.18	44.69
Lead	mg/kg	0.5	1	50	300	300.0	3.40	2.10	24.00	9.83	12.29	30.55
Mercury	mg/kg	0.01	0.01	0.15	1	15.0	0.01	0.01	0.13	0.05	0.07	0.17
Nickel	mg/kg	0.1	1	21.0	60	600.0	7.40	6.40	28.00	13.93	12.19	34.49
Phosphorus*	mg/kg	1					240.00	200.00	970.00	470.00	433.47	1200.77
Zinc	mg/kg	0.5	1	200	200	7,000	25.00	17.00	140.00	60.67	68.82	176.69
Organotins												
Monobutyl tin	µgSn/kg	0.5	*1*				<0.5	<0.5	<1.0	<1.0	-	<1.0
Dibutyl tin	µgSn/kg	0.5	*1*				<0.5	<0.5	<1.0	<1.0	-	<1.0
Tributyl tin	µgSn/kg	0.5	1				<0.5	<0.5	1.10	-	-	-
Normalised to TOC Concentration				9					0.55	0.35	0.17	0.64
BTEX												
Benzene	mg/kg	0.2	0.2				<0.2	<0.2	<0.4	<0.4	-	<0.4
Toluene	mg/kg	0.2	0.2				<0.2	<0.2	<0.4	<0.4	-	<0.4
Ethyl Benzene	mg/kg	0.2	0.2				<0.2	<0.2	<0.4	<0.4	-	<0.4
m+p xylenes	mg/kg	0.4					<0.4	<0.4	<0.8	<0.8	-	<0.8
o-xylene	mg/kg	0.2	0.2				<0.2	<0.2	<0.4	<0.4	-	<0.4
Total BTEX	mg/kg	1.2					<1.2	<1.2	<2.4	<2.4	-	<2.4
Total Petroleum Hydrocarbons												
TPH C6-C9	mg/kg	10	100				<10	<10	<20	<20	-	<20
TPH C10-14	mg/kg	10	100				<10	<10	<20	<20	-	<20
TPH C15-28	mg/kg	50	100				<50	<50	120.0	120.00	-	-
Normalised to TOC Concentration									60.0	36.67	20.21	70.73
TPH C29-36	mg/kg	50	100				<50	<50	140.0	140.00	-	-
Normalised to TOC Concentration									70.0	40.00	25.98	83.80
Total TPH	mg/kg		100						260.0	120.00	-	-
Normalised to TOC Concentration				550					130.0	76.67	46.19	154.53
Polycyclic Aromatic Hydrocarbons												
Naphthalene	µg/kg	5	5				<5	<5	21.0			
Normalised to TOC Concentration									10.5	5.2	4.62	12.95
1-Methylnaphthalene	µg/kg	5	5				<5	<5	11.0			
Normalised to TOC Concentration									5.5	3.5	1.73	6.42
2-Methylnaphthalene	µg/kg	5	5				<5	<5	31.0			
Normalised to TOC Concentration									15.5	6.8	7.51	19.49
Acenaphthylene	µg/kg	5	5				<5	<5	13.0			
Normalised to TOC Concentration									6.5	3.8	2.31	7.73
Acenaphthene	µg/kg	5	5				<5	<5	<10	<10	-	<10
Fluorene	µg/kg	5	5				<5	<5	22.0			
Normalised to TOC Concentration									11.0	5.3	4.91	13.61
Phenanthrene	µg/kg	5	5				<5	<5	69.0			
Normalised to TOC Concentration									34.5	13.2	18.48	44.31
Anthracene	µg/kg	5	5				<5	<5	22.0			
Normalised to TOC Concentration									11.0	5.3	4.91	13.61
Fluoranthene	µg/kg	5	5				7.00	<5	110.0			
Normalised to TOC Concentration							28.00		55.0	28.5	26.25	72.76
Pyrene	µg/kg	5	5				8.00	<5	160.0			
Normalised to TOC Concentration							32.00		80.0	38.2	39.12	104.11
Benz(a)anthracene	µg/kg	5	5				<5	<5	95.0			
Normalised to TOC Concentration									47.5	17.5	25.98	61.30
Chrysene	µg/kg	5	5				<5	<5	76.0			
Normalised to TOC Concentration									38.0	14.3	20.50	48.89
Benzo(b)&(k)fluoranthene	µg/kg	10	5				<10	<10	170.0			
Normalised to TOC Concentration									85.0	31.7	46.19	109.53
Benzo(a)pyrene	µg/kg	5	5				<5	<5	93.0			
Normalised to TOC Concentration									46.5	17.2	25.40	59.99
Indeno(1,2,3-cd)pyrene	µg/kg	5	5					<5	95.0			
Normalised to TOC Concentration									47.5	17.5	25.98	61.30
Dibenz(a,h)anthracene	µg/kg	5	5				<5	<5	21.0			
Normalised to TOC Concentration									10.5	5.2	4.62	12.95
Benzo(g,h,i)perylene	µg/kg	5	5				<5	<5	100.0			
Normalised to TOC Concentration									50.0	18.3	27.42	64.57
Coronene	µg/kg	10	5				<10	<10	30.0			
Normalised to TOC Concentration									15.0	8.3	5.77	18.07
Benzo(e)pyrene	µg/kg	5	5				<5	<5	75.0			
Normalised to TOC Concentration									37.5	14.2	20.21	48.23
Perylene	µg/kg	5	5				25.00	<5	400.0			
Normalised to TOC Concentration									200.0	100.8	98.75	267.32
Total PAHs (as above)	µg/kg	100	100				<100	<100	1620.0			
Normalised to TOC Concentration				10000					810.0	303.3	438.79	1043.06
Organochlorine Pesticides												
Aldrin	µg/kg	1					<1	<1	<2	<2	-	<2
alpha-BHC	µg/kg	1					<10	<10	<20	<20	-	<20
beta-BHC	µg/kg	1					<10	<10	<20	<20	-	<20
gamma-BHC (Lindane)	µg/kg	1					<10	<10	<20	<20	-	<20
delta-BHC	µg/kg	1					<10	<10	<20	<20	-	<20
cis-Chlordane	µg/kg	1	0.5				<1	<1	<2	<2	-	<2
trans-Chlordane	µg/kg	1	0.5				<1	<1	<2	<2	-	<2
p,p'-DDD	µg/kg	1	2				<10	<10	<20	<20	-	<20
p,p'-DDE	µg/kg	1	2.2				<1	<1	4.00			
Normalised to TOC Concentration				2.20					2.00	1.00	0.87	2.46

Note: Only presenting results above limits of reporting.

Table 5-1 continued: Comparison of 95% UCL concentrations with NAGD Screening Levels and DEH Investigation Levels for contaminants in the reference area (Zone 1)

Sample	Units	PQL	NAGD PQL	NAGD Screening Level	EIL	HIL-A	1-0	2-0	3-0	Mean	Standard Deviation	95% UCL
p,p'-DDT	µg/kg	1	1.6				<10	<10	<20	<20	-	<20
Dieldrin	µg/kg	1	280				<1	<1	<2	<2	-	<2
alpha-Endosulfan	µg/kg	1					<10	<10	<20	<20	-	<20
beta-Endosulfan	µg/kg	1					<10	<10	<20	<20	-	<20
Endosulfan Sulphate	µg/kg	1					<1	<1	<2	<2	-	<2
Endrin	µg/kg	1	10				<1	<1	<2	<2	-	<2
Endrin ketone	µg/kg	1					<1	<1	<2	<2	-	<2
Endrin aldehyde	µg/kg	1					<1	<1	<2	<2	-	<2
Heptachlor	µg/kg	1					<1	<1	<2	<2	-	<2
Heptachlor epoxide	µg/kg	1					<1	<1	<2	<2	-	<2
Hexachlorobenzene	µg/kg	1					<1	<1	<2	<2	-	<2
Methoxychlor	µg/kg	1					<1	<1	<2	<2	-	<2
Oxychlordane*	µg/kg	1					<1	<1	<2	<2	-	<2
Orgonophosphoros Pesticides												
Dichlorvos	µg/kg	20	10-100				<20	<20	<40	<40	-	<40
Demeton-S-methyl	µg/kg	20	10-100				<20	<20	<40	<40	-	<40
Dimethoate	µg/kg	20	10-100				<20	<20	<40	<40	-	<40
Diazinon	µg/kg	20	10-100				<20	<20	<40	<40	-	<40
Chlorpyrifos-methyl	µg/kg	20	10-100				<20	<20	<40	<40	-	<40
Parathion-methyl	µg/kg	20	10-100				<20	<20	<40	<40	-	<40
Pirimiphos-methyl	µg/kg	20	10-100				<20	<20	<40	<40	-	<40
Fenitrothion	µg/kg	20	10-100				<20	<20	<40	<40	-	<40
Malathion	µg/kg	20	10-100				<20	<20	<40	<40	-	<40
Chlorpyrifos	µg/kg	20	10-100				<20	<20	<40	<40	-	<40
Fenthion	µg/kg	20	10-100				<20	<20	<40	<40	-	<40
Parathion*	µg/kg	20	10-100				<20	<20	<40	<40	-	<40
Chlorfenvinphos	µg/kg	20	10-100				<20	<20	<40	<40	-	<40
Bromophos-ethyl	µg/kg	20	10-100				<20	<20	<40	<40	-	<40
Methidathion	µg/kg	20	10-100				<20	<20	<40	<40	-	<40
Fenamiphos	µg/kg	20	10-100				<20	<20	<40	<40	-	<40
Prothiofos	µg/kg	20	10-100				<20	<20	<40	<40	-	<40
Ethion	µg/kg	20	10-100				<20	<20	<40	<40	-	<40
Carbophenothion	µg/kg	20	10-100				<20	<20	<40	<40	-	<40
Phosalone	µg/kg	20	10-100				<20	<20	<40	<40	-	<40
Azinphos-methyl*	µg/kg	20	10-100				<20	<20	<40	<40	-	<40
Fenchlorvos*	µg/kg	20	10-100				<20	<20	<40	<40	-	<40
Mevinphos	µg/kg	20	10-100				<20	<20	<40	<40	-	<40
Trifluralin*	µg/kg	20	10-100				<20	<20	<40	<40	-	<40
Nutrients												
Nitrate as N	mg/kg	0.1	0.1				<0.1	<0.1	<0.1	<0.1	-	<0.1
Nitrite as N	mg/kg	0.1	0.1				<0.1	<0.1	<0.1	<0.1	-	<0.1
Total Kjeldahl Nitrogen	mg/kg	20					120.00	37.00	1730.00	629.00	954.40	2237.97
Total Nitrogen	mg/kg	20					120.00	37.00	1730.00	629.00	954.40	2237.97
PCB												
Mono-PCB congeners	µg/kg	5	1.00				<5	<5	<10	<10	-	<10
Di-PCB congeners	µg/kg	5	1.00				<5	<5	<10	<10	-	<10
Tri-PCB congeners	µg/kg	5	1.00				<5	<5	<10	<10	-	<10
Tetra-PCB congeners	µg/kg	5	1.00				<5	<5	<10	<10	-	<10
Penta-PCB congeners	µg/kg	5	1.00				<5	<5	<10	<10	-	<10
Hexa-PCB congeners	µg/kg	5	1.00				<5	<5	<10	<10	-	<10
Hepta-PCB congeners	µg/kg	5	1.00				<5	<5	<10	<10	-	<10
Octa-PCB congeners	µg/kg	5	1.00				<5	<5	<10	<10	-	<10
Nona-PCB congeners	µg/kg	5	1.00				<5	<5	<10	<10	-	<10
Deca-PCB congeners	µg/kg	5	1.00				<5	<5	<10	<10	-	<10
Total PCB congeners	µg/kg	5	5.00	23.00			<5	<5	<10	<10	-	<10

Note: Only presenting results above limits of reporting.

Table 5-2 continued: Comparison of 95% UCL concentrations with NAGD Screening Levels and DEH Investigation Levels for contaminants in the Colmslie to Pinkenba area (Zone 2)

Sample	Units	PQL	NAGD PQL	NAGD Screening Level	EIL	HIL-A	Mean	Standard Deviation	95% UCL	Normal (N) Log-Normal (L) Neither (X)
Date sampled										
Moisture Content	%	0.1	0.1				54.36	5.933	56.96	N
Total Organic Carbon	%	0.01	0.1				1.558	0.277	1.679	N
Metals and Metalloids										
Arsenic	mg/kg	0.4	1	20.0	20.0	100.0	8.119	1.162	8.628	N
Cadmium	mg/kg	0.1	0.1	1.5	3	20.0	0.0931	0.119	0.145	X
Chromium	mg/kg	0.1	1	80.0			44.81	5.902	47.4	N
Copper	mg/kg	0.1	1	65.0	60	1000.0	37.63	10.42	42.19	N
Lead	mg/kg	0.5	1	50	300	300.0	23.19	6.442	26.01	N
Mercury	mg/kg	0.01	0.01	0.15	1	15.0	0.138	0.0841	0.191	L
Nickel	mg/kg	0.1	1	21.0	60	600.0	23.31	2.442	24.38	N
Phosphorus*	mg/kg	1					844.4	151.5	910.8	X
Zinc	mg/kg	0.5	1	200	200	7,000	121.3	29.64	134.2	N
Organotins										
Monobutyl tin	µgSn/kg	0.5	*1*							
Normalised to TOC Concentration							0.292	0.0924	0.333	X
Dibutyl tin	µgSn/kg	0.5	*1*							
Normalised to TOC Concentration							1.647	1.453	2.728	L
Tributyl tin	µgSn/kg	0.5	1							
Normalised to TOC Concentration				9			1.711	8.952	8.67	L
Total Petroleum Hydrocarbons										
TPH C15-28	mg/kg	50	100							
Normalised to TOC Concentration							42.76	21.01	51.97	X
TPH C29-36	mg/kg	50	100							
Normalised to TOC Concentration							52.03	21.12	61.28	N
Polycyclic Aromatic Hydrocarbons										
Naphthalene	µg/kg	5	5							
Normalised to TOC Concentration							4.65	2.138	6.688	N
1-Methylnaphthalene	µg/kg	5	5							
Normalised to TOC Concentration							3.68	2.11	5.691	X
2-Methylnaphthalene	µg/kg	5	5							
Normalised to TOC Concentration							5.114	3.752	8.691	N
Acenaphthylene	µg/kg	5	5							
Normalised to TOC Concentration							6.305	3.885	10.01	N
Acenaphthene	µg/kg	5	5							
Normalised to TOC Concentration							4.387	4.023	8.223	X
Fluorene	µg/kg	5	5							
Normalised to TOC Concentration							5.08	3.466	8.384	N
Phenanthrene	µg/kg	5	5							
Normalised to TOC Concentration							18.57	10.74	28.81	N
Anthracene	µg/kg	5	5							
Normalised to TOC Concentration							6.387	2.397	8.673	N
Fluoranthene	µg/kg	5	5							
Normalised to TOC Concentration							44.38	16.37	59.99	N
Pyrene	µg/kg	5	5							
Normalised to TOC Concentration							77.38	22.88	99.2	N
Benz(a)anthracene	µg/kg	5	5							
Normalised to TOC Concentration							34.46	12.59	46.46	N
Chrysene	µg/kg	5	5							
Normalised to TOC Concentration							32.71	9.04	41.33	N
Benzo(b)&(k)fluoranthene	µg/kg	10	5							
Normalised to TOC Concentration							89.2	23.32	111.4	N
Benzo(a)pyrene	µg/kg	5	5							
Normalised to TOC Concentration							45.71	17.82	62.71	N
Indeno(1,2,3-cd)pyrene	µg/kg	5	5							
Normalised to TOC Concentration							41.7	15.85	56.81	N
Dibenz(a,h)anthracene	µg/kg	5	5							
Normalised to TOC Concentration							9.177	3.908	12.9	N
Benzo(g,h,i)perylene	µg/kg	5	5							
Normalised to TOC Concentration							44.28	19.38	62.75	N
Coronene	µg/kg	10	5							
Normalised to TOC Concentration							12.14	6.077	17.93	N
Benzo(e)pyrene	µg/kg	5	5							
Normalised to TOC Concentration							38.31	10.75	48.55	N
Perylene	µg/kg	5	5							
Normalised to TOC Concentration							321.9	160.2	474.6	N
Total PAHs (as above)	µg/kg	100	100							
Normalised to TOC Concentration				10000			838.9	293.8	1119	N
Organochlorine Pesticides										
p,p'-DDD	µg/kg	1	2							
Normalised to TOC Concentration				2.00			6.51	4.871	8.645	X
p,p'-DDE	µg/kg	1	2.2							
Normalised to TOC Concentration				2.20			2.105	2.262	3.657	L
p,p'-DDT	µg/kg	1	1.6							

Note: Only presenting results above limits of reporting.

Table 5-2 continued: Comparison of 95% UCL concentrations with NAGD Screening Levels and DEH Investigation Levels for contaminants in the Colmslie to Pinkenba area (Zone 2)

Sample	Units	PQL	NAGD PQL	NAGD Screening Level	EIL	HIL-A	Mean	Standard Deviation	95% UCL	Normal (N) Log-Normal (L) Neither (X)
Normalised to TOC Concentration				1.60			12.81	29.94	25.94	X
Dieldrin	µg/kg	1	280							
Normalised to TOC Concentration				280.00			0.664	0.656	0.952	X
Nutrients										
Total Kjeldahl Nitrogen	mg/kg	20					1235	227	1334	X
Total Nitrogen	mg/kg	20					1235	227	1334	X

Note: Only presenting results above limits of reporting.

Table 5-3 continued: Comparison of 95% UCL concentrations with NAGD Screening Levels and DEH Investigation Levels for contaminants in the Port Reaches (Zone 3)

Sample	Units	PQL	NAGD PQL	NAGD Screening Level	EIL	HIL-A	Mean	Standard Deviation	95% UCL	Normal (N) Log-Normal (L) Neither (X)
Date sampled										
Moisture Content	%	0.1	0.1				46.67	5.686	48.86	N
Total Organic Carbon	%	0.01	0.1				1.212	0.325	1.337	N
Metals and Metalloids										
Arsenic	mg/kg	0.4	1	20.0	20.0	100.0	7.315	1.367	7.843	N
Cadmium	mg/kg	0.1	0.1	1.5	3	20.0	0.0795	0.0949	0.116	X
Chromium	mg/kg	0.1	1	80.0			37.7	7.685	40.67	N
Copper	mg/kg	0.1	1	65.0	60	1000.0	23.9	6.866	26.55	N
Lead	mg/kg	0.5	1	50	300	300.0	13.16	2.777	14.23	N
Mercury	mg/kg	0.01	0.01	0.15	1	15.0	0.091	0.0409	0.107	X
Nickel	mg/kg	0.1	1	21.0	60	600.0	21.05	4.442	22.77	N
Phosphorus*	mg/kg	1					595	93.05	631	N
Zinc	mg/kg	0.5	1	200	200	7,000	77.3	17.83	84.19	N
Organotins										
Dibutyl tin	µgSn/kg	0.5	*1*							
Normalised to TOC Concentration							0.851	0.899	1.416	L
Tributyl tin	µgSn/kg	0.5	1							
Normalised to TOC Concentration				9			5.072	19.99	12.8	X
Total Petroleum Hydrocarbons										
TPH C10-14	mg/kg	10	100							
Normalised to TOC Concentration							5.35	1.565	5.955	X
TPH C15-28	mg/kg	50	100							
Normalised to TOC Concentration							30.93	15.42	36.9	X
TPH C29-36	mg/kg	50	100							
Normalised to TOC Concentration							35.05	14.99	40.85	X
Polycyclic Aromatic Hydrocarbons										
Naphthalene	µg/kg	5	5							
Normalised to TOC Concentration							5.167	3.403	7.666	X
1-Methylnaphthalene	µg/kg	5	5							
Normalised to TOC Concentration							2.98	0.836	3.668	X
2-Methylnaphthalene	µg/kg	5	5							
Normalised to TOC Concentration							4.028	1.912	5.433	X
Acenaphthylene	µg/kg	5	5							
Normalised to TOC Concentration							8.642	5.067	12.36	N
Acenaphthene	µg/kg	5	5							
Normalised to TOC Concentration							2.714	0.567	3.131	X
Fluorene	µg/kg	5	5							
Normalised to TOC Concentration							3.854	2.375	6.043	L
Phenanthrene	µg/kg	5	5							
Normalised to TOC Concentration							52.18	81.27	111.9	X
Anthracene	µg/kg	5	5							
Normalised to TOC Concentration							11.2	4.399	14.43	X
Fluoranthene	µg/kg	5	5							
Normalised to TOC Concentration							97.07	82.69	157.8	X
Pyrene	µg/kg	5	5							
Normalised to TOC Concentration							117.3	89.92	183.4	X
Benz(a)anthracene	µg/kg	5	5							
Normalised to TOC Concentration							64.6	56.63	106.2	X
Chrysene	µg/kg	5	5							
Normalised to TOC Concentration							56.42	48.17	91.81	X
Benzo(b)&(k)fluoranthene	µg/kg	10	5							
Normalised to TOC Concentration							119	74.5	186.5	L
Benzo(a)pyrene	µg/kg	5	5							
Normalised to TOC Concentration							67.68	34.36	98.1	L
Indeno(1,2,3-cd)pyrene	µg/kg	5	5							
Normalised to TOC Concentration							66.36	30.18	88.53	N
Dibenz(a,h)anthracene	µg/kg	5	5							
Normalised to TOC Concentration							15.77	15.76	30.86	L
Benzo(g,h,i)perylene	µg/kg	5	5							
Normalised to TOC Concentration							51.96	20.34	66.9	N
Coronene	µg/kg	10	5							
Normalised to TOC Concentration							14.53	8.549	20.8	N
Benzo(e)pyrene	µg/kg	5	5							
Normalised to TOC Concentration							26.07	26.07	73.67	N
Perylene	µg/kg	5	5							
Normalised to TOC Concentration							153.8	27.22	173.8	N
Total PAHs (as above)	µg/kg	100	100							
Normalised to TOC Concentration				10000			986.4	580.1	1412	X
Organochlorine Pesticides										
p,p'-DDE	µg/kg	1	2.2							
Normalised to TOC Concentration				2.20			2.172	3.104	4.047	L
Dieldrin	µg/kg	1	280							
Normalised to TOC Concentration				280.00			0.753	1.13	1.855	X
Nutrients										
Total Kjeldahl Nitrogen	mg/kg	20					929	229.5	1018	N
Total Nitrogen	mg/kg	20					929	229.5	1018	N
PCB										
Hexa-PCB congeners	µg/kg	5	1.00							
Normalised to TOC Concentration							4.524	4.078	7.519	X
Hepta-PCB congeners	µg/kg	5	1.00							
Normalised to TOC Concentration							3.952	3.843	10.28	X
Total PCB congeners	µg/kg	5	5.00	23.00						
Normalised to TOC Concentration							6.333	8.761	12.77	X

Note: Only presenting results above limits of reporting.

Table 5-4 continued: Comparison of 95% UCL concentrations with NAGD Screening Levels and DEH Investigation Levels for contaminants in Moreton Bay (Entrance Channel) (Zone 4)

Sample	Units	PQL	NAGD PQL	NAGD Screening Level	EIL	HIL-A	Mean	Standard Deviation	95% UCL	Normal (N) Log-Normal (L) Neither (X)
Date sampled										
Moisture Content	%	0.1	0.1				44.17	8.669	49.54	N
Total Organic Carbon	%	0.01	0.1				0.948	0.208	1.077	N
Metals and Metalloids										
Arsenic	mg/kg	0.4	1	20.0	20.0	100.0	8.256	1.247	9.029	N
Cadmium	mg/kg	0.1	0.1	1.5	3	20.0				
Chromium	mg/kg	0.1	1	80.0			35	6.633	39.11	X
Copper	mg/kg	0.1	1	65.0	60	1000.0	12.9	2.442	14.41	X
Lead	mg/kg	0.5	1	50	300	300.0	8.967	2.295	10.39	N
Mercury	mg/kg	0.01	0.01	0.15	1	15.0	0.0433	0.0132	0.0515	X
Nickel	mg/kg	0.1	1	21.0	60	600.0	18.67	2.958	20.5	X
Phosphorus*	mg/kg	1					433.3	27.39	450.3	N
Zinc	mg/kg	0.5	1	200	200	7,000	49.67	4.444	52.42	N
Nutrients										
Nitrite as N	mg/kg	0.1	0.1				0.0556	0.0167	0.0659	X
Total Kjeldahl Nitrogen	mg/kg	20					733.3	231.9	877.1	N
Total Nitrogen	mg/kg	20					733.3	231.9	877.1	N

Table 5-5 continued: Comparison of 95% UCL concentrations with NAGD Screening Levels and DEH Investigation Levels for contaminants in the whole dredge area (Zone 2 – Zone 4)

Sample	Units	PQL	NAGD PQL	NAGD Screening Level	EIL	HIL-A	Mean	Standard Deviation	95% UCL	Normal (N) Log-Normal (L) Neither (X)
Zone										
Date sampled										
Moisture Content	%	0.1	0.1				48.9	7.6	50.8	N
Total Organic Carbon	%	0.01	0.1				1.3	0.4	1.4	N
Metals and Metalloids										
Arsenic	mg/kg	0.4	1	20.0	20.0	100.0	7.8	1.3	8.1	N
Cadmium	mg/kg	0.1	0.1	1.5	3	20.0	0.1	0.1	0.1	X
Chromium	mg/kg	0.1	1	80.0			39.7	7.8	41.7	N
Copper	mg/kg	0.1	1	65.0	60	1000.0	26.6	12.0	29.6	N
Lead	mg/kg	0.5	1	50	300	300.0	14.5	7.1	17.7	L
Mercury	mg/kg	0.01	0.01	0.15	1	15.0	0.1	0.1	0.1	L
Nickel	mg/kg	0.1	1	21.0	60	600.0	21.4	3.9	22.4	N
Phosphorus*	mg/kg	1					651.3	190.8	699.1	X
Zinc	mg/kg	0.5	1	200	200	7,000	81.0	34.6	96.1	L
Organotins										
Monobutyl tin	µgSn/kg	0.5	*1*							
Normalised to TOC Concentration							0.3	0.1	0.3	X
Dibutyl tin	µgSn/kg	0.5	*1*							
Normalised to TOC Concentration							1.3	1.2	1.6	X
Tributyl tin	µgSn/kg	0.5	1							
Normalised to TOC Concentration				9			4.0	14.3	7.6	X
Total Petroleum Hydrocarbons										
TPH C10-14	mg/kg	10	100							
Normalised to TOC Concentration							5.4	1.5	5.7	X
TPH C15-28	mg/kg	50	100							
Normalised to TOC Concentration							34.0	17.4	38.3	X
TPH C29-36	mg/kg	50	100							
Normalised to TOC Concentration							39.1	18.9	43.8	X
Polycyclic Aromatic Hydrocarbons										
Naphthalene	µg/kg	5	5							
Normalised to TOC Concentration							4.8	2.8	6.1	X
1-Methylnaphthalene	µg/kg	5	5							
Normalised to TOC Concentration							5.4	7.4	9.3	X
2-Methylnaphthalene	µg/kg	5	5							
Normalised to TOC Concentration							8.7	15.4	16.3	X
Acenaphthylene	µg/kg	5	5							
Normalised to TOC Concentration							8.3	5.0	10.8	N
Acenaphthene	µg/kg	5	5							
Normalised to TOC Concentration							4.2	3.9	6.2	X
Fluorene	µg/kg	5	5							
Normalised to TOC Concentration							5.7	4.6	8.0	X
Phenanthrene	µg/kg	5	5							
Normalised to TOC Concentration							45.4	65.6	77.9	X
Anthracene	µg/kg	5	5							
Normalised to TOC Concentration							9.6	10.7	17.3	L
Fluoranthene	µg/kg	5	5							
Normalised to TOC Concentration							92.9	91.0	137.9	X
Pyrene	µg/kg	5	5							
Normalised to TOC Concentration							114.9	85.1	157.0	X
Benz(a)anthracene	µg/kg	5	5							
Normalised to TOC Concentration							65.3	64.5	97.2	X
Chrysene	µg/kg	5	5							
Normalised to TOC Concentration							61.8	66.0	94.4	X
Benzo(b)&(k)fluoranthene	µg/kg	10	5							
Normalised to TOC Concentration							112.5	75.3	164.4	L
Benzo(a)pyrene	µg/kg	5	5							
Normalised to TOC Concentration							60.6	40.1	88.9	L
Indeno(1,2,3-cd)pyrene	µg/kg	5	5							
Normalised to TOC Concentration							59.3	28.7	73.5	N
Dibenz(a,h)anthracene	µg/kg	5	5							
Normalised to TOC Concentration							13.3	13.6	23.3	L
Benzo(g,h,i)perylene	µg/kg	5	5							
Normalised to TOC Concentration							51.6	21.2	62.1	N
Coronene	µg/kg	10	5							
Normalised to TOC Concentration							12.9	7.5	16.6	N
Benzo(e)pyrene	µg/kg	5	5							
Normalised to TOC Concentration							48.2	31.2	69.5	L
Perylene	µg/kg	5	5							
Normalised to TOC Concentration							184.1	129.2	279.4	L
Total PAHs (as above)	µg/kg	100	100							
Normalised to TOC Concentration				10000			915.0	587.2	1320.0	L
Organochlorine Pesticides										
p,p'-DDD	µg/kg	1	2							

Note: Only presenting results above limits of reporting.

Table 5-5 continued: Comparison of 95% UCL concentrations with NAGD Screening Levels and DEH Investigation Levels for contaminants in the whole dredge area (Zone 2 – Zone 4)

Sample	Units	PQL	NAGD PQL	NAGD Screening Level	EIL	HIL-A	Mean	Standard Deviation	95% UCL	Normal (N) Log-Normal (L) Neither (X)
Normalised to TOC Concentration				2.00			5.5	2.9	6.3	X
p,p'-DDE	µg/kg	1	2.2							
Normalised to TOC Concentration				2.20			2.3	2.6	3.0	X
p,p'-DDT	µg/kg	1	1.6							
Normalised to TOC Concentration				1.60			7.8	17.9	12.3	X
Dieldrin	µg/kg	1	280							
Normalised to TOC Concentration				280.00			0.7	0.8	0.9	X
alpha-Endosulfan	µg/kg	1								
Normalised to TOC Concentration							5.1	0.7	5.3	X
Nutrients										
Nitrite as N	mg/kg	0.1	0.1				0.1	0.0	0.1	X
Total Kjeldahl Nitrogen	mg/kg	20					998.7	295.0	1073.0	N
Total Nitrogen	mg/kg	20					998.7	295.0	1073.0	N
PCB										
Hexa-PCB congeners	µg/kg	5	1.00							
Normalised to TOC Concentration							3.6	3.1	5.1	X
Hepta-PCB congeners	µg/kg	5	1.00							
Normalised to TOC Concentration							3.3	2.8	4.7	X
Total PCB congeners	µg/kg	5	5.00	23.00						
Normalised to TOC Concentration							4.6	6.5	7.8	X

Note: Only presenting results above limits of reporting.

6 COMPARISON WITH PREVIOUS SAP DATA

This section provides a series of spatial and temporal analysis graphs utilizing the PBPL data set collated between 1998 and December 2011. NAGD Screening Levels are provided for additional reference. Results for the 2013 SAP are identified in the graphs to indicate current conditions. Key metals/metalloids (arsenic, cadmium, chromium, copper, lead, mercury, nickel and zinc), TBT and total PAHs have been presented. No other parameters have been included due to the fact that results are either below respective LORs or too few for statistical comparisons.

Statistical analysis of the data has been completed using a one-way analysis of variance (ANOVA). One-way ANOVA assumes that the data come from populations that are Gaussian (normally distributed) and have equal variances. Homogeneity tests validate this assumption. If the assumption is true then site comparisons can be made without further manipulation of the data. If the assumption is false, then the data needs to be transformed to make it more normality distributed before comparisons can be made.

Spatial graphs present zone, site and location data for each parameter. Temporal graphs present data from each dredge zone against each year sampled for each parameter.

6.1 Contaminant Spatial and Temporal Analysis

6.1.1 Arsenic

Median arsenic concentrations continue to remain below the NAGD Screening Level. Results of the December 2012 survey generally follow the median concentrations reported from previous investigations. One exception is location 3-0 which shows that December 2012 results have noticeably higher concentrations compared to the median of historical data (Figure 6-1).

Based on the historical dataset which demonstrates homogeneity (transformation of data was not required), arsenic concentrations from Zone 1 are significantly lower than Zones 2, 3 and 4 (Figure **6-2**). (Zone 1<Zone 3<Zone 2<Zone 4 ($F_{(3,427)}$=45.7352, p=0.0000))

6.1.2 Cadmium

Median cadmium concentrations across all locations remain less than the NAGD Screening Level (Figure 6-3). Results from this SAP are consistent with median concentrations reported from previous years with one exception, location 6-2, which reported a lower concentration compared to previous years.

Based on the historical dataset, which demonstrates homogeneity (transformation of data was not required), cadmium concentrations from Zone 1 are lower than Zones 3 and 4, all of which are lower than Zone 2. (Zone1<Zone3=Zone4<Zone2 ($F_{(3,427)}$=45.7352, p=0.0000))

Temporal trends indicate that cadmium seems to be higher in Zone 2 after Feb 2007. However in that year the variability for Zone 2 is so high, it is higher than differences between zones for all years. Before Feb 2007 cadmium seems to be elevated in Zone 3. This site had elevated levels in both 2008 and 2009, exceeding the NAGD Screening Level of 1.5 mg/kg. There is no significant difference in cadmium concentrations between each dredge zone over time due to the high variability. Cadmium concentrations have generally been consistent over previous studies, except for 2008 which shows an elevation in concentrations across all dredge zones (Figure 6-4).

6.1.3 Chromium

December 2012 SAP data are generally consistent with previous studies, with no samples exceeding the NAGD Screening Level (Figure 6-5).

Based on the historical dataset which demonstrates homogeneity so transformation of data was not required, chromium concentrations from Zone 1 are significantly lower than Zones 2, 3 and 4 (Figure 6-6). (Zone 1<Zone 3=Zone 4<Zone 2 ($F_{(3,608)}$=35.5782, p=0.0000))

6.1.4 Copper

All median copper values are below the NAGD Screening Levels (65 mg/kg). Results of sampling in December 2012 generally follow trends of the median concentrations reported from previous years (Figure 6-7).

Based on the historical dataset, copper concentrations within Zone 2 are significantly higher than those within all other zones (Zone1=Zone4<Zone3<Zone2) ($F_{(3,608)}$=102.9547, p=0.0000)). Copper concentrations appear to decrease as you move towards the mouth of the Brisbane River. (Figure 6-8).

6.1.5 Lead

All 2012 data are consistent with previous studies (Figure 6-9).

Based on the historical dataset, lead concentrations are significantly higher in Zone 2 than Zones 3 and 4. Zone 1 has a high variability and overlaps with zones 2 and 3. (Zone1=Zone2=Zone3>Zone4 ($F_{(3, 608)}$=20.3418, p=0.0000)). There are no temporal trends evident in lead concentrations (Figure 6-10).

6.1.6 Mercury

Six locations had mercury concentrations that were greater than the NAGD Screening Level of 0.15 mg/kg during this SAP study. Four of the six locations are also above the median of historical data for their respective sampling locations. Mercury concentration appears to be greater and more variable in Zones 2 and 3 (Figure 6-11).

Based on the historical dataset, Zone 2 has significantly higher median mercury concentrations than all other sites (Zone 2>Zone 3>Zone1=Zone4 ($F_{(3, 608)}$=26.7354, p=.00000)). There are no clear temporal trends in mercury concentrations (Figure 6-12).

6.1.7 Nickel

Results of sampling in December 2012 are generally consistent with historical data. The mean nickel concentration at sites 3, 12, 14 and 15 were higher than the median of historical data. Results from the December 2012 SAP are consistent with the median concentrations of the previous studies (Figure 6-13).

Based on the historical dataset, Zone 2 has significantly higher median nickel concentrations than all other sites (Zone 2>Zone 4>Zone3>Zone 1 ($F_{(3,608)}$=19.9969, p=.00000)). There are no temporal trends in nickel concentrations (Figure 6-14).

6.1.8 Zinc

Zinc concentrations from the December 2012 survey are generally consistent when compared to previous years (Figure 6-15). Site 12 however, recorded a slightly higher concentration in comparison to historical data.

Based on the historical dataset, Zone 2 had significantly higher median zinc concentrations compared to all other sites (Zone 2>Zone1=Zone3=Zone 4 ($F_{(3,608)}$=79.2521, p=0.0000)). There are no temporal trends in zinc concentrations (Figure 6-16).

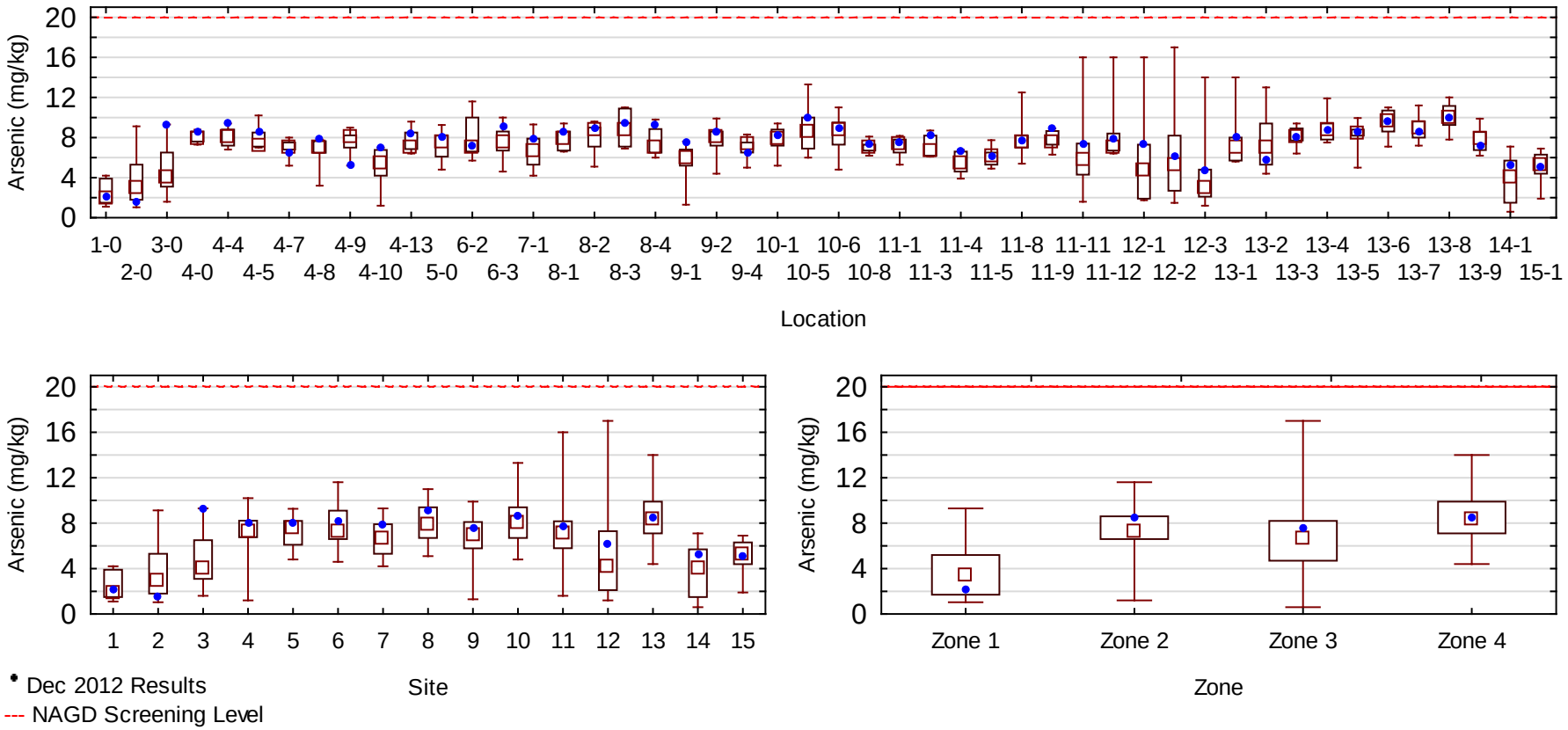


Figure 6-1: Spatial presentation of arsenic (mg/kg) by location, zone and site

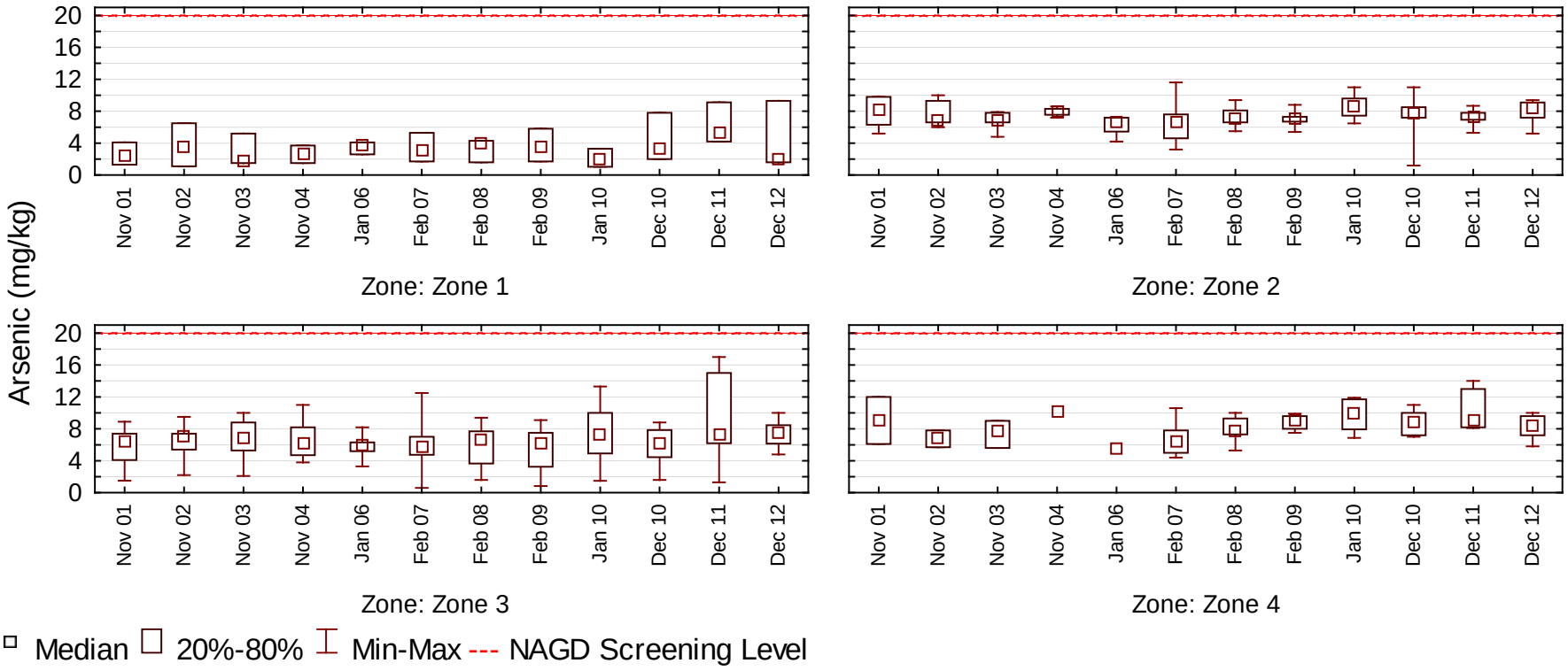


Figure 6-2**: Temporal presentation of arsenic (mg/kg) within zones**

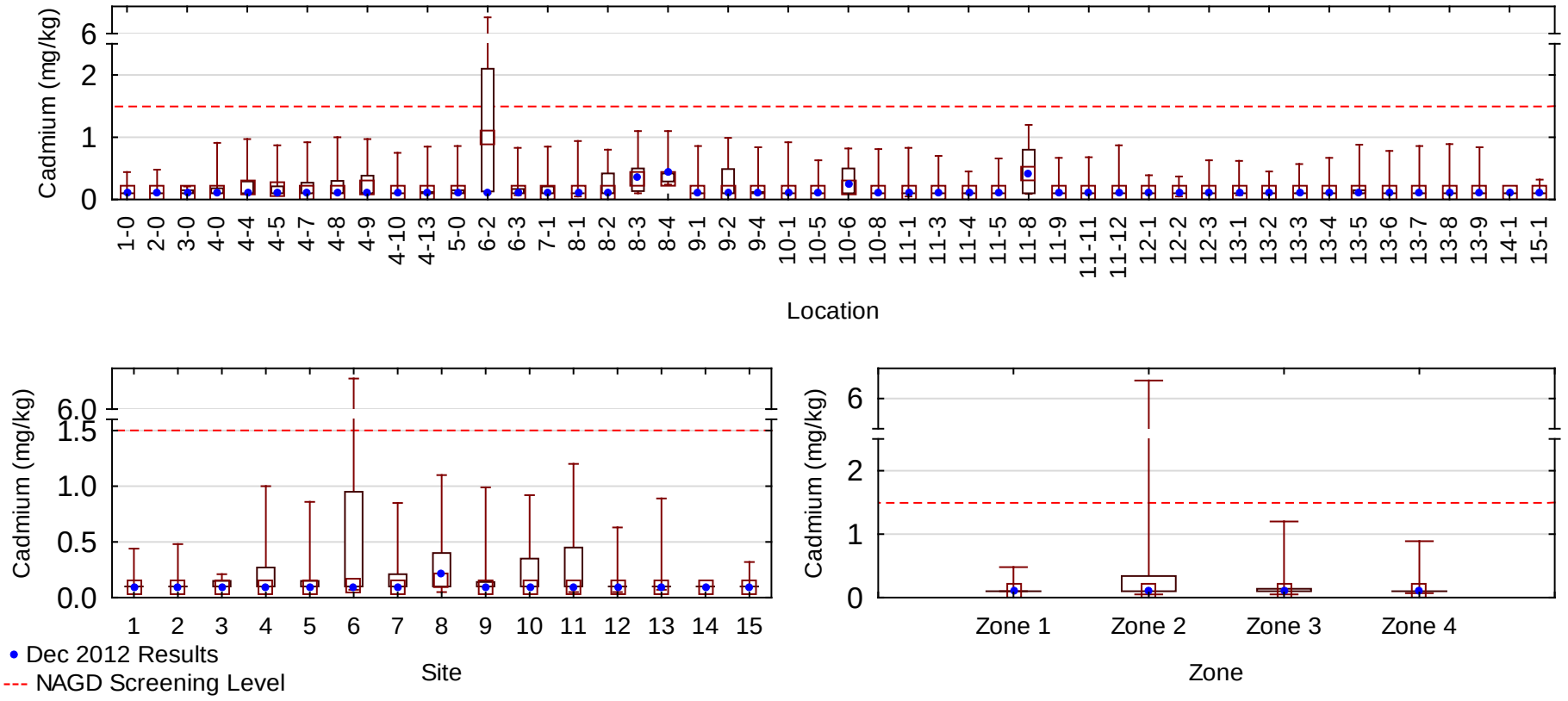


Figure 6-3: Spatial presentation of cadmium (mg/kg) by location, zone and site

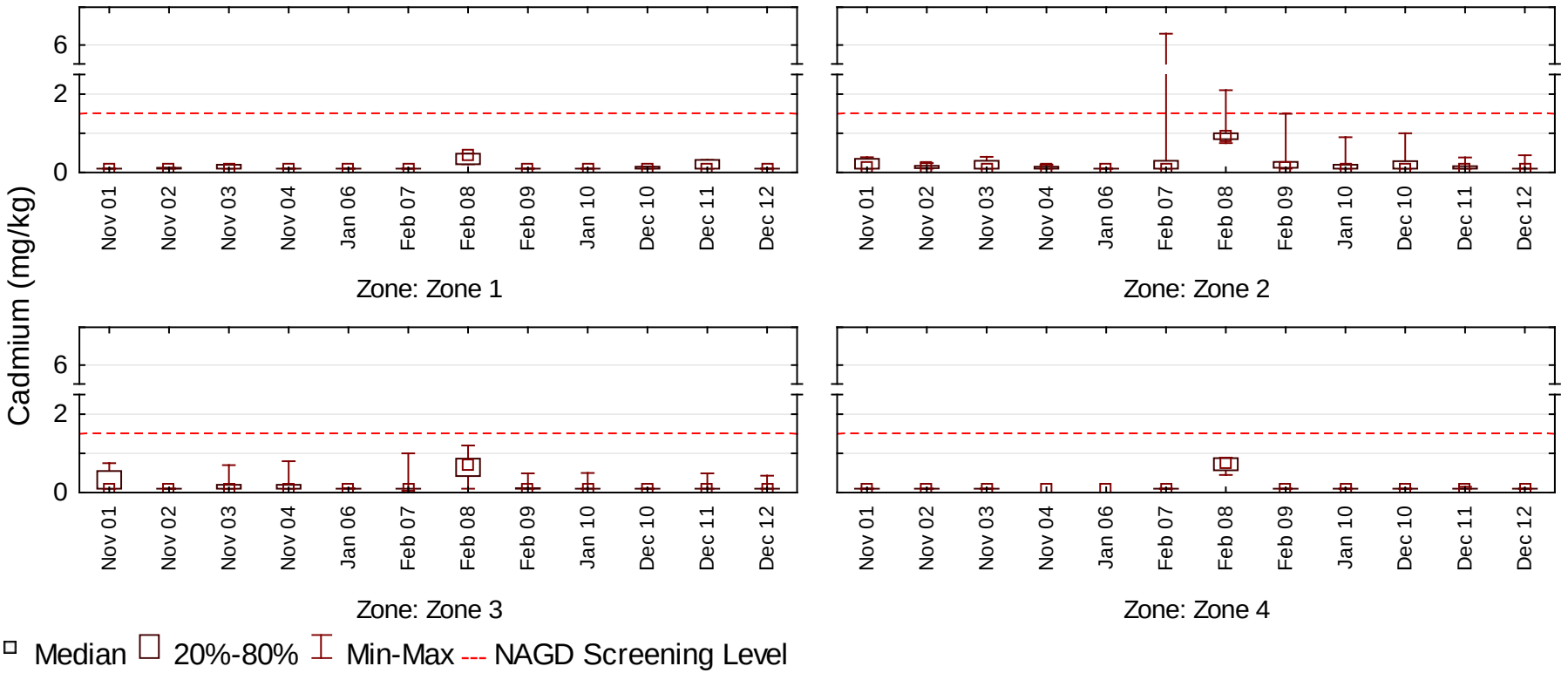


Figure 6-4: Temporal presentation of cadmium (mg/kg) within zones

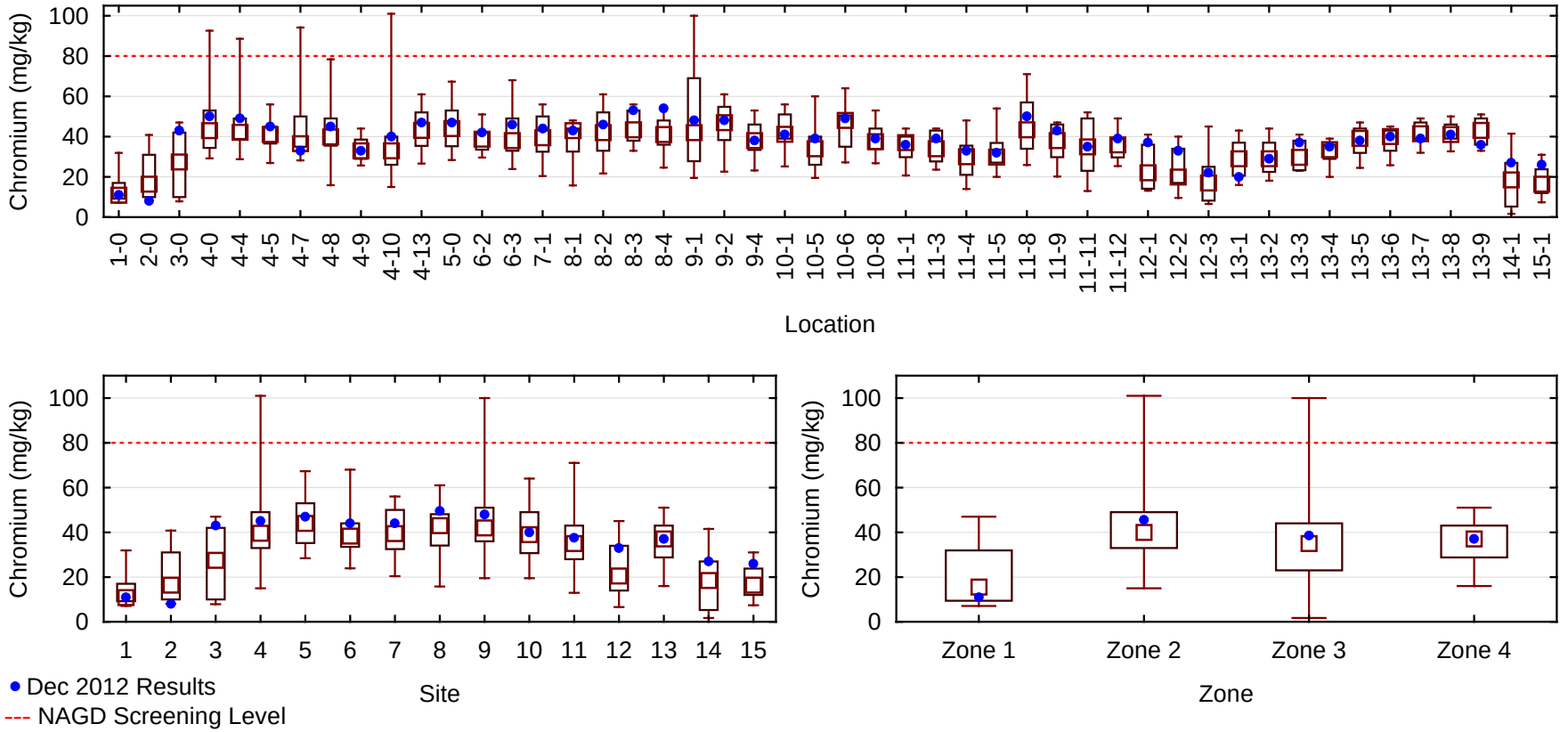


Figure 6-5: Spatial presentation of chromium (mg/kg) by location, zone and site

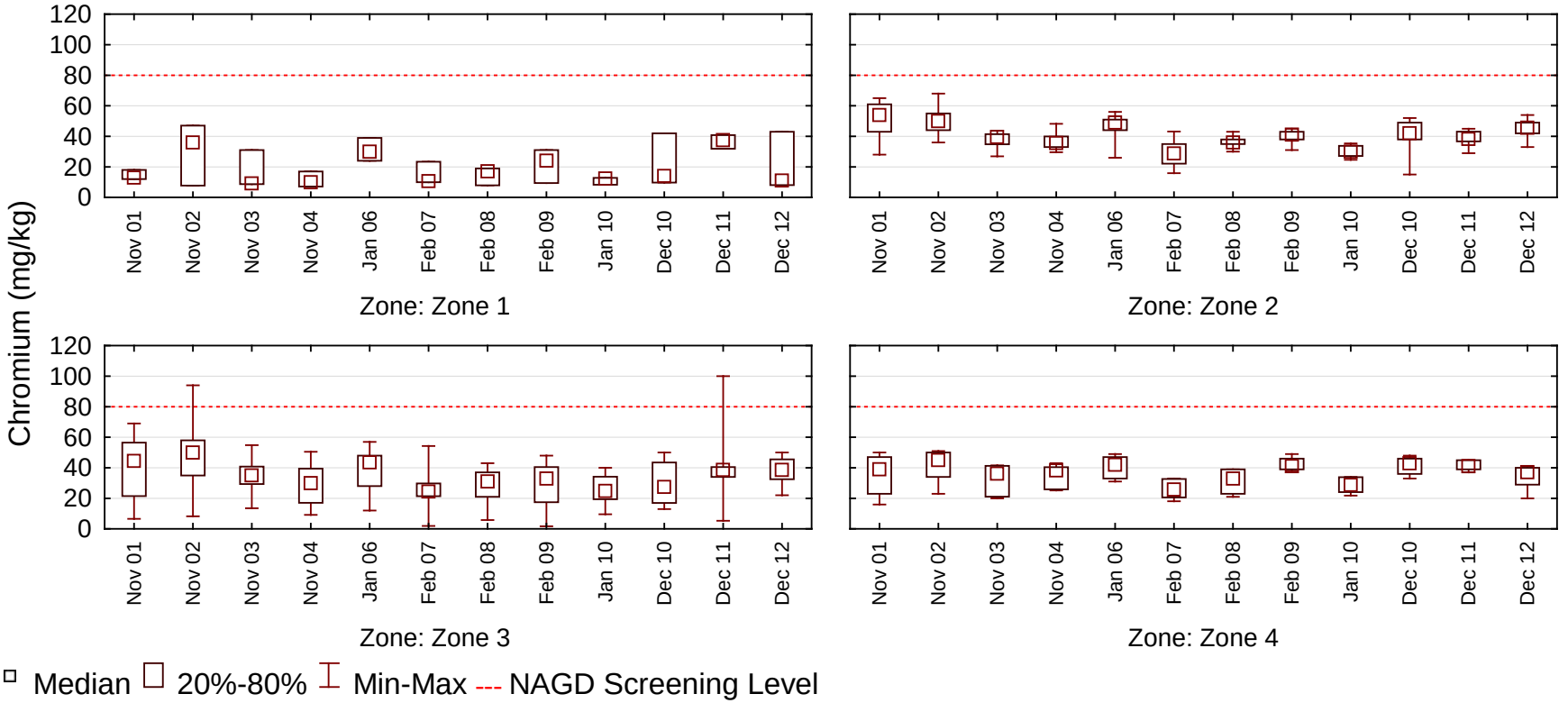


Figure 6-6: Temporal presentation of chromium (mg/kg) within zones

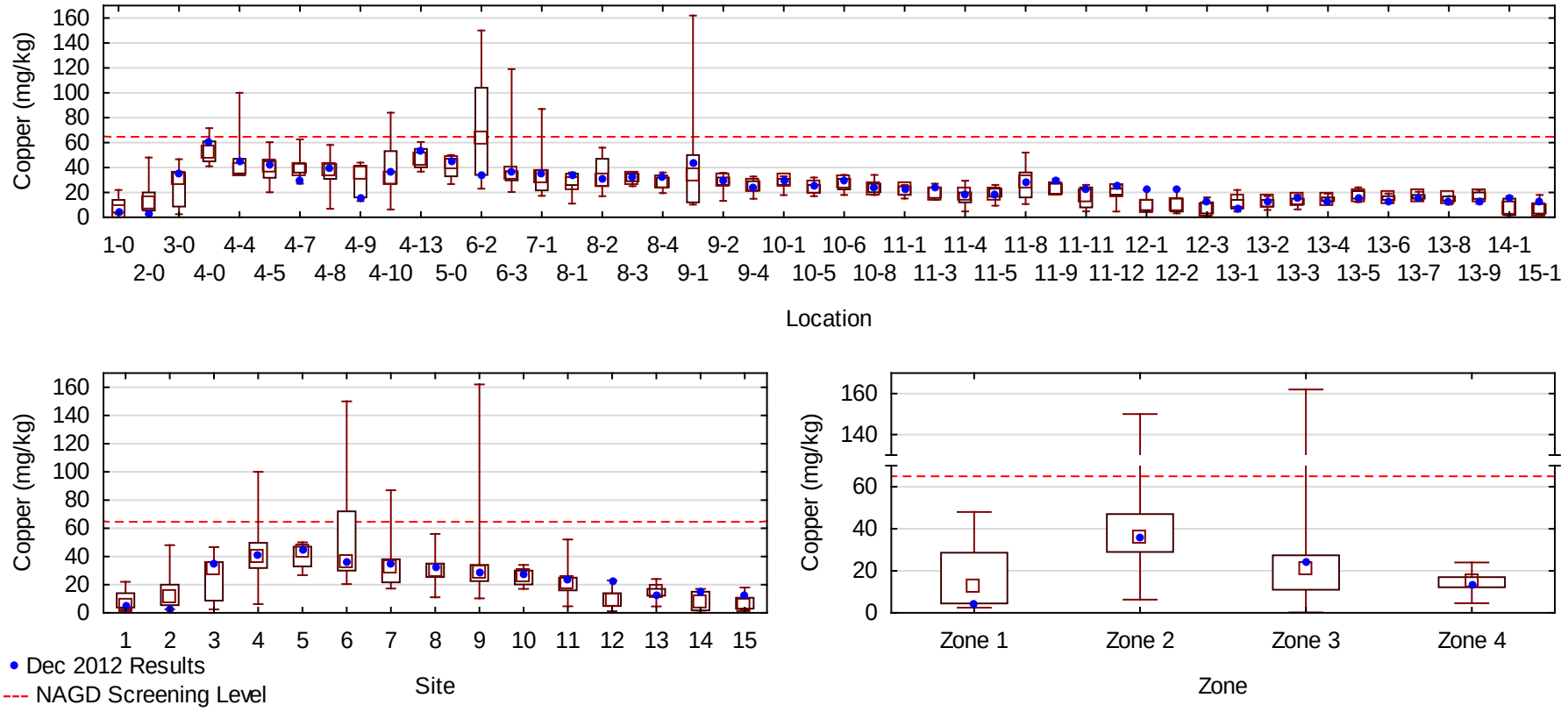


Figure 6-7: Spatial presentation of copper (mg/kg) by location, zone and site

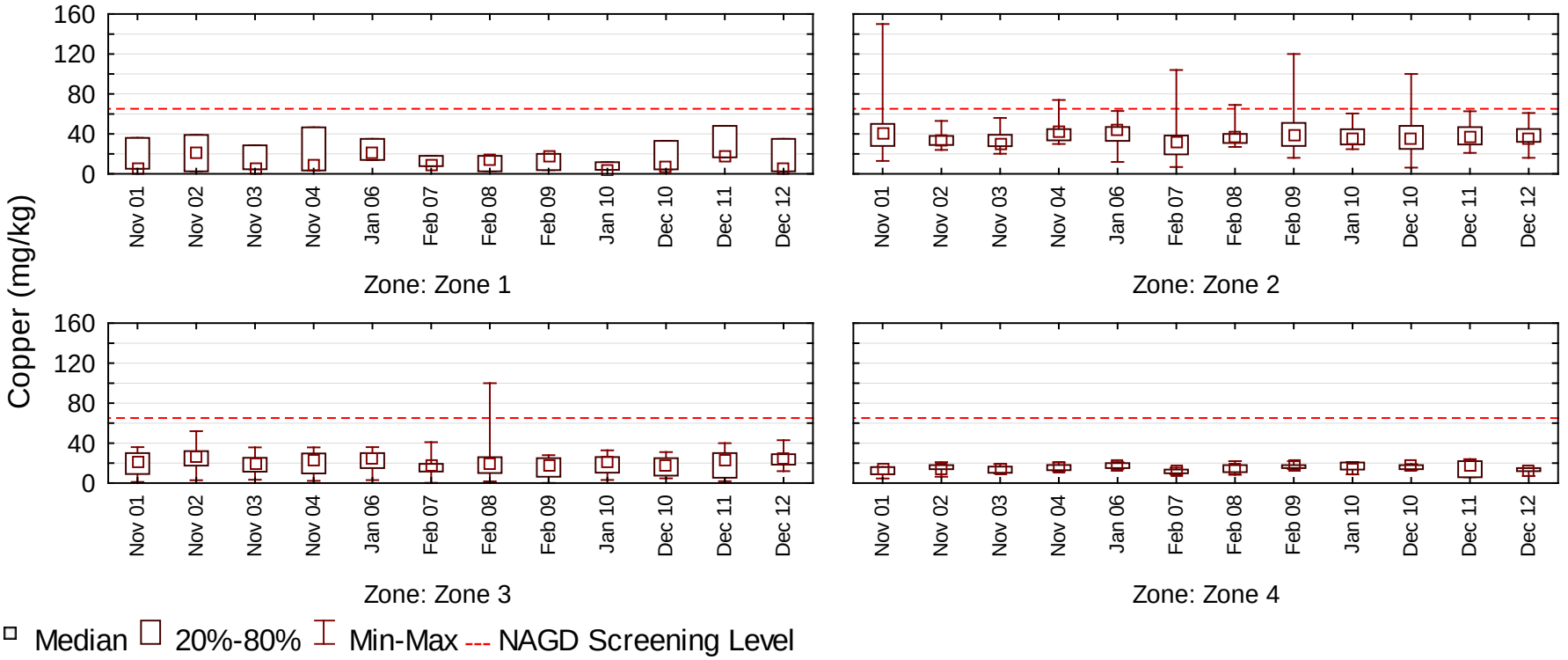


Figure 6-8: Temporal presentation of copper (mg/kg) within zones

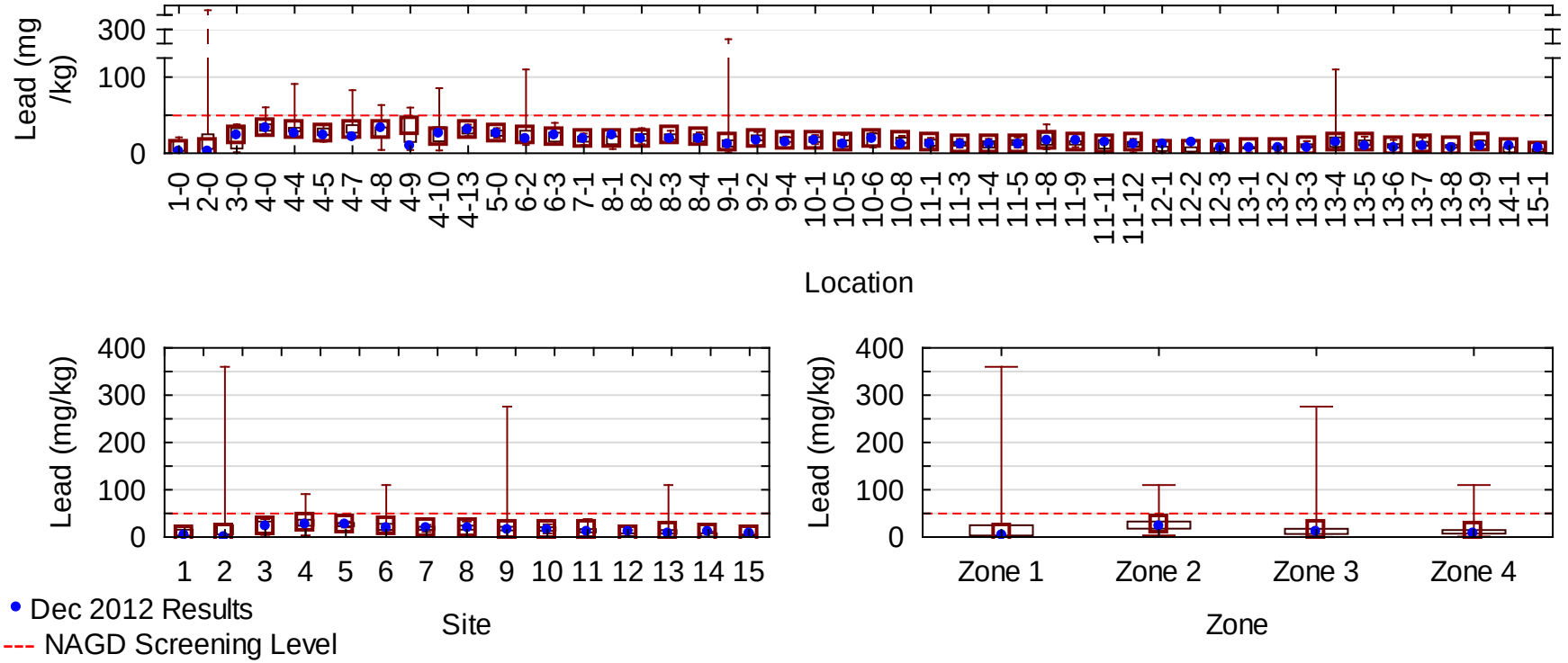


Figure 6-9: Spatial presentation of lead (mg/kg) by location, zone and site

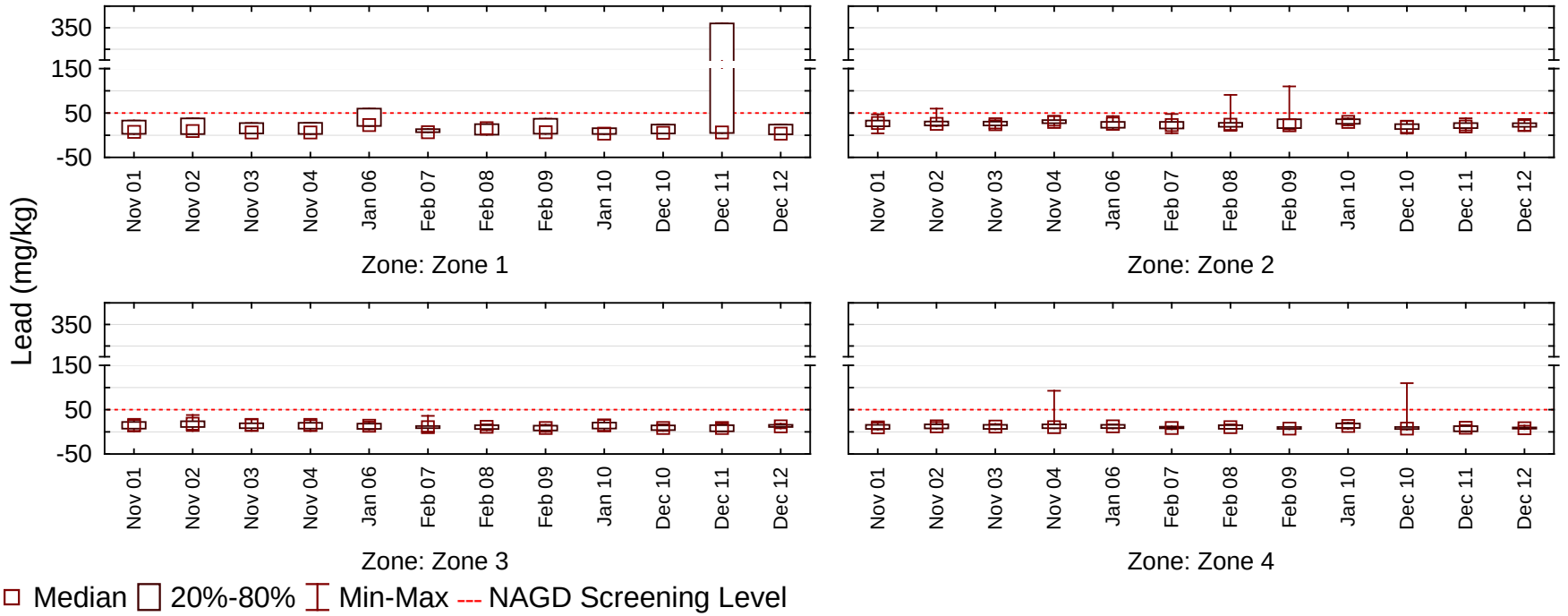


Figure 6-10: Temporal presentation of lead (mg/kg) within zones

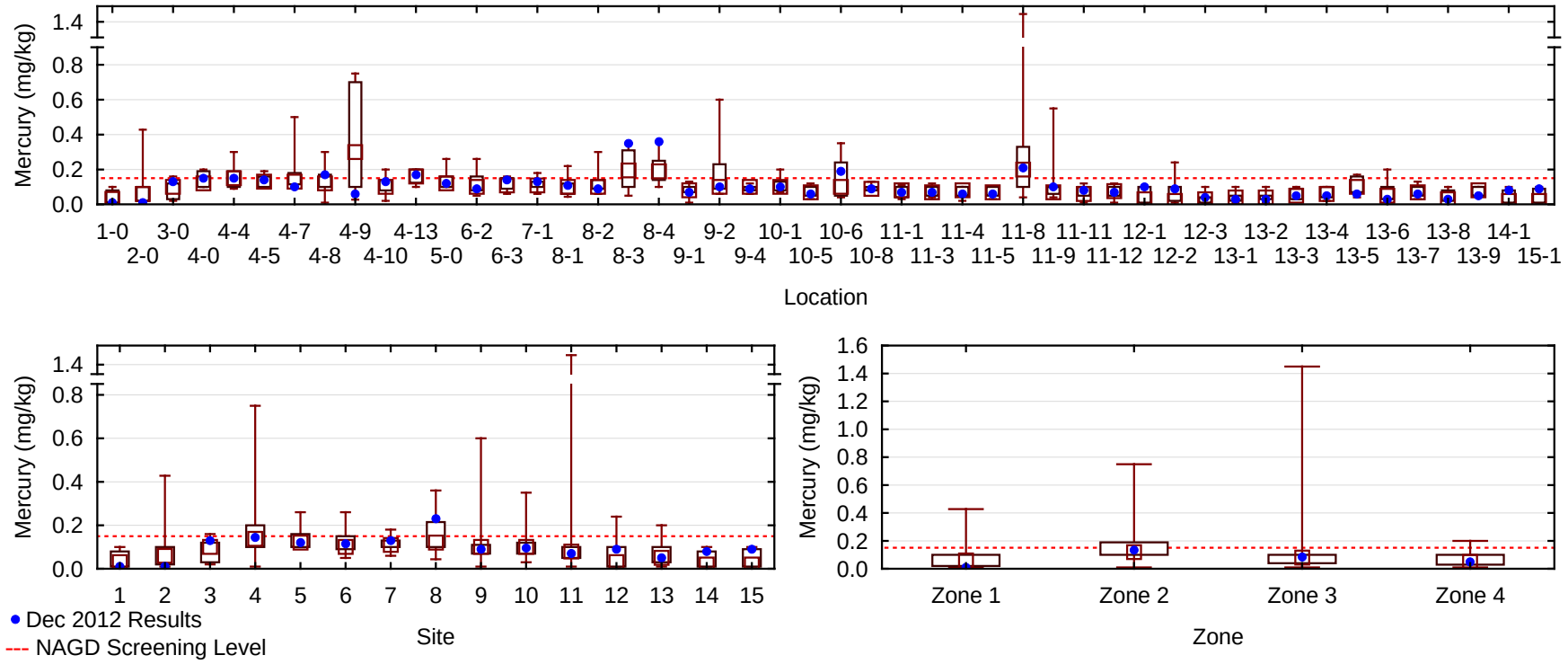


Figure 6-11: Spatial presentation of mercury (mg/kg) by location, zone and site

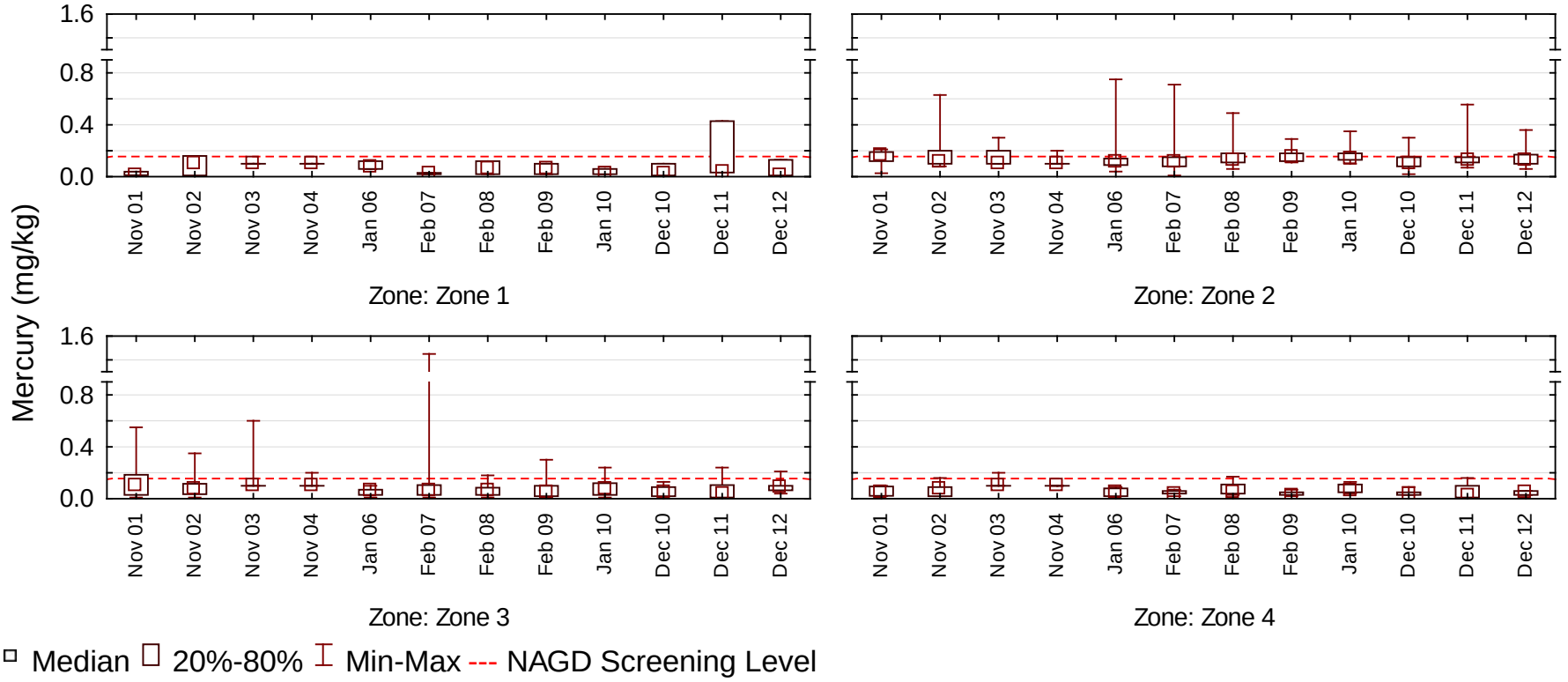


Figure 6-12: Temporal presentation of mercury (mg/kg) within zones

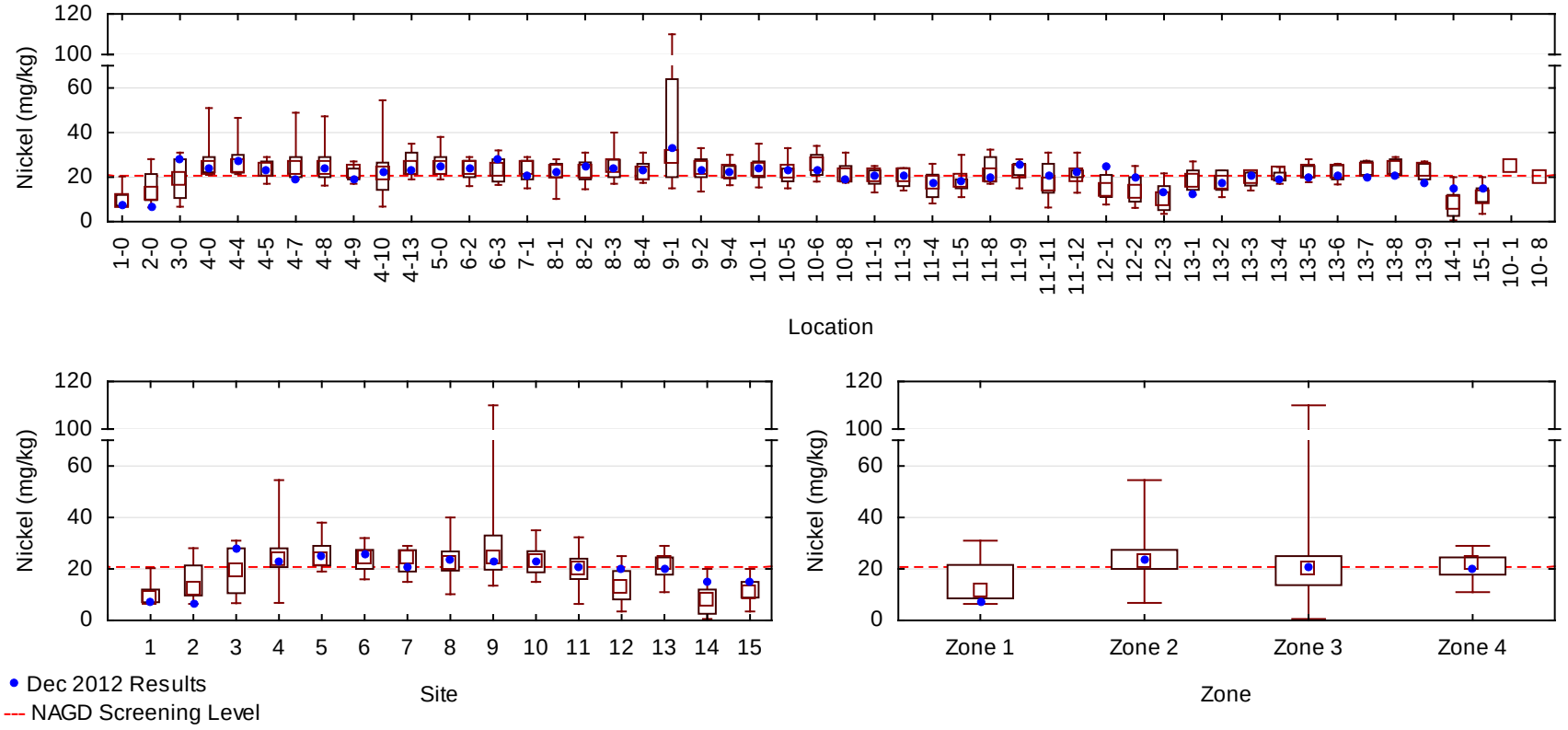


Figure 6-13: Spatial presentation of nickel (mg/kg) by location, zone and site

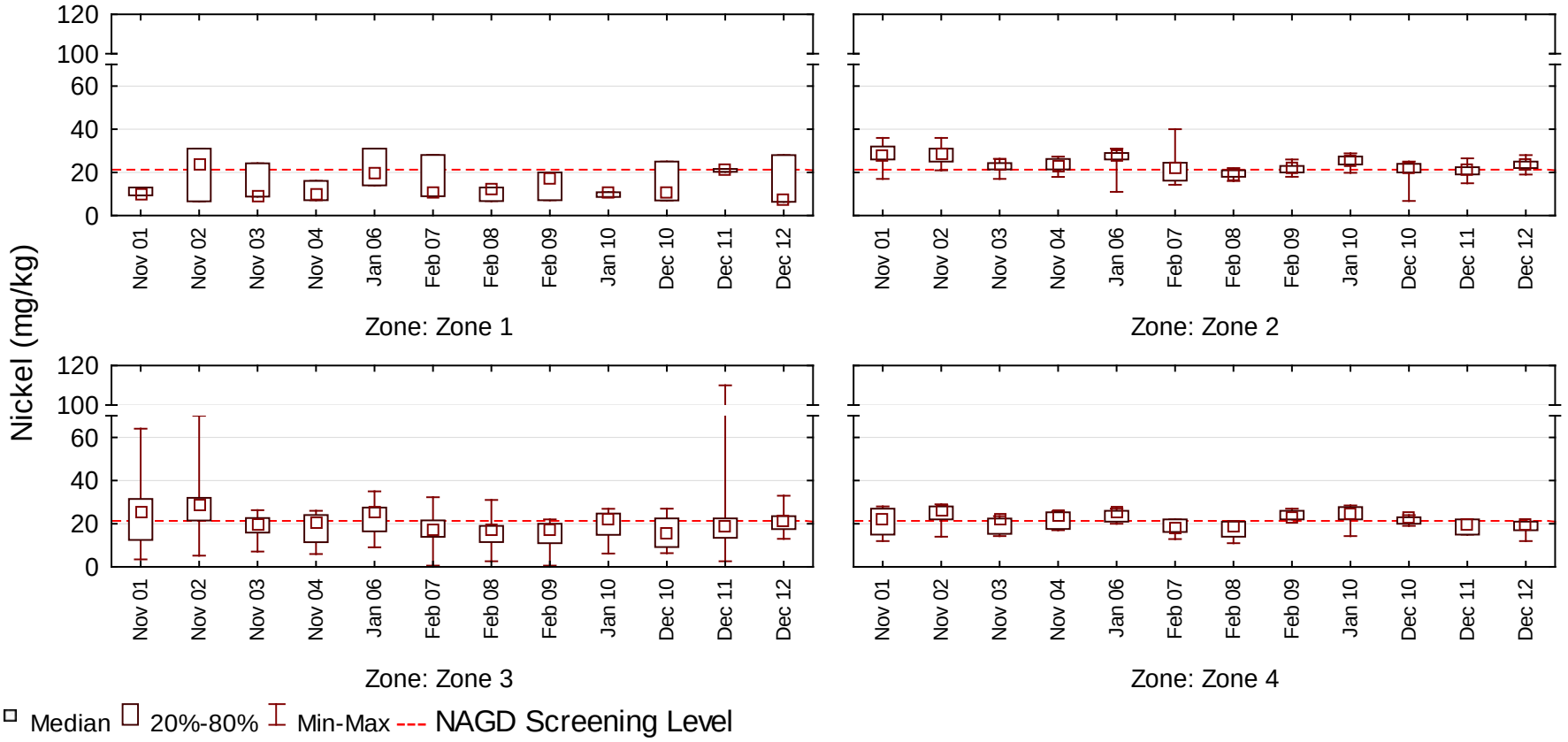


Figure 6-14: Temporal presentation of nickel (mg/kg) within zones

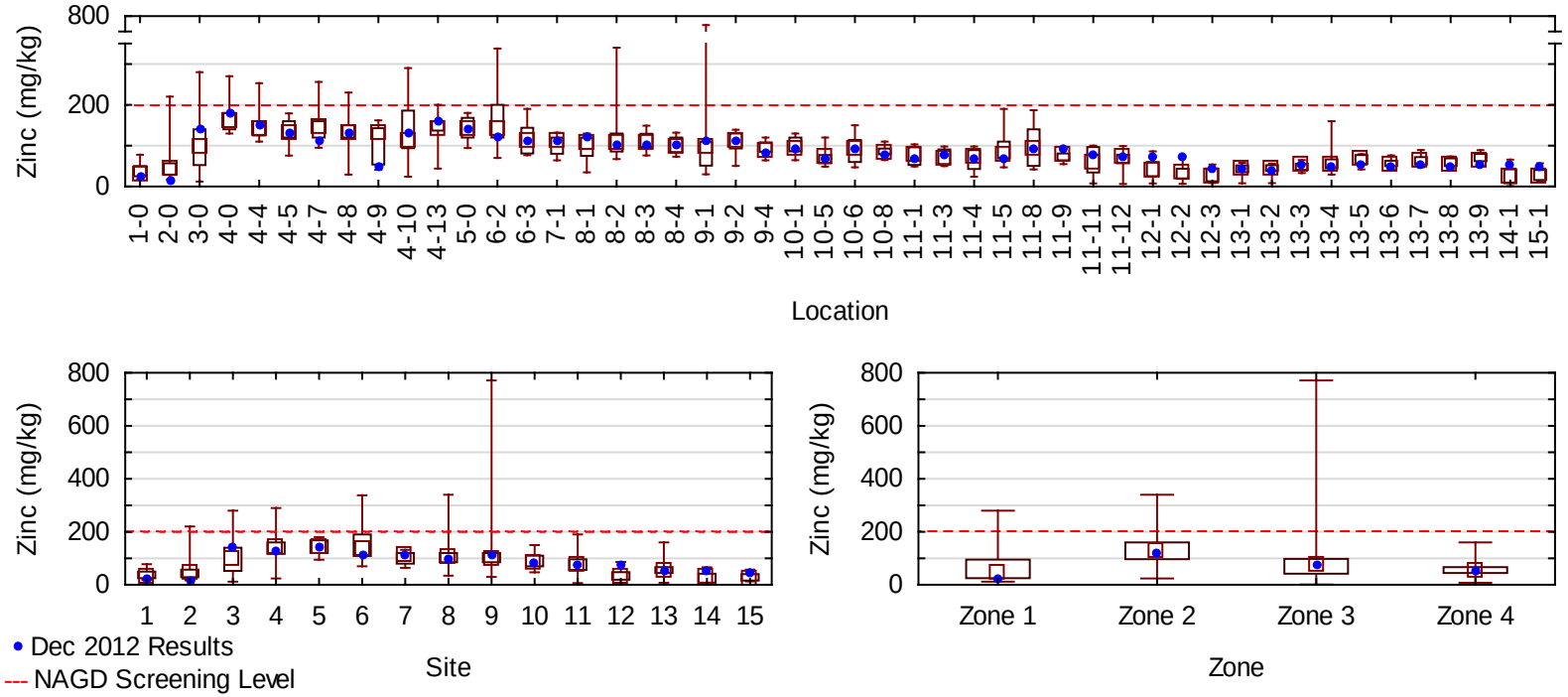


Figure 6-15: Spatial presentation of zinc (mg/kg) by location, zone and site

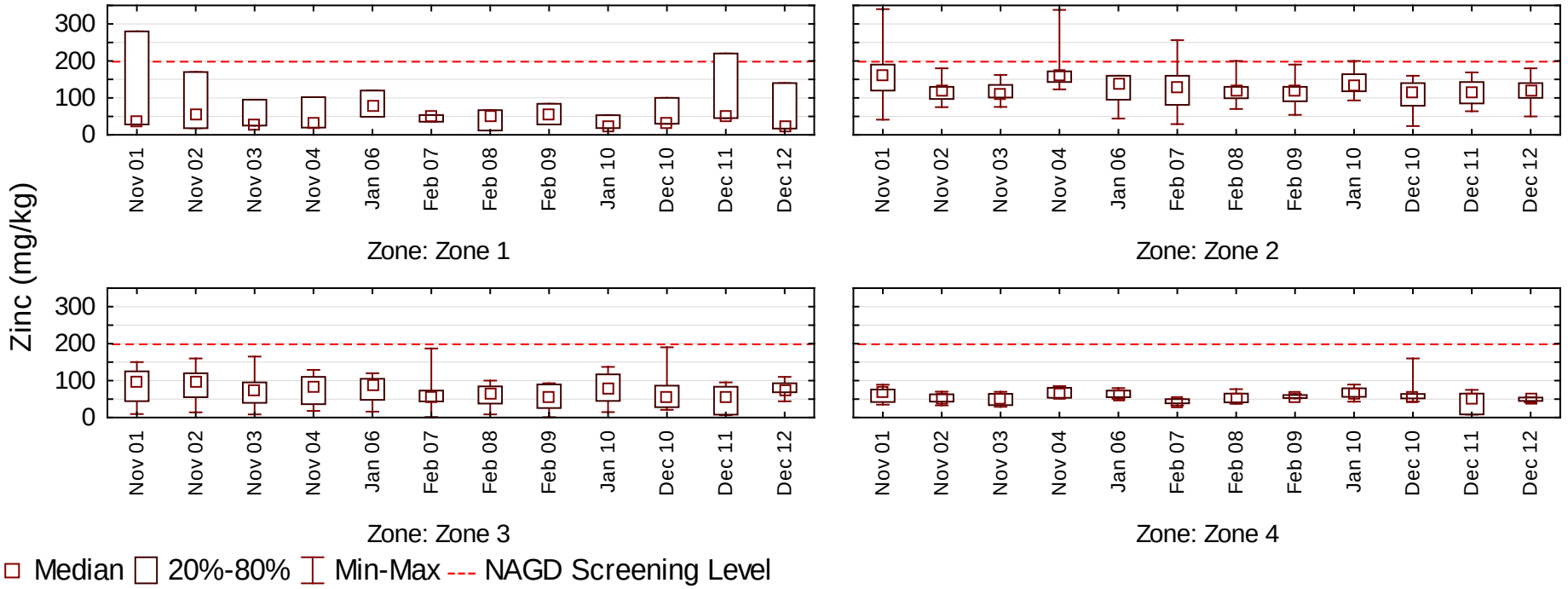


Figure 6-16: Temporal presentation of zinc (mg/kg) within zones

6.1.9 Tributyltin

Results of this survey show that TBT concentrations are comparable to the median of historical data. In comparison, location 4-0 recorded a higher concentration compared to the historical median. Historically, Zone 2 appears to have a slightly elevated TBT concentration compared to other zones (Figure 6-17).

Based on the historical dataset, Zone 2 and 3 had significantly higher median TBT concentrations compared to all other sites (Zone 2=Zone3>Zone1=Zone 4 ($F_{(3,498)}$=1.1904, p=0.3128)). The temporal trends for TBT concentrations show that Zone 2 and 3 are consistently higher than Zone 1 and 4 (Figure 6-18).

6.1.10 Polycyclic Aromatic Hydrocarbons

Total PAHs (normalised to TOC concentration), where detected, were higher across sampling locations, sites and zones in December 2012 compared to historical data (

Figure 6-19). However all results remain below the NAGD Screening Level of 10,000 µg/kg.

Based on the historical dataset, Zone 1 had a higher median PAH concentration compared to all other sites (Zone 1>Zone2=Zone3=Zone 4 ($F_{(3,193)}$=3.3918, p=0.0191)). Temporal trends of total PAHs (normalised to TOC concentration) show a consistent pattern over time (Figure 6-20).

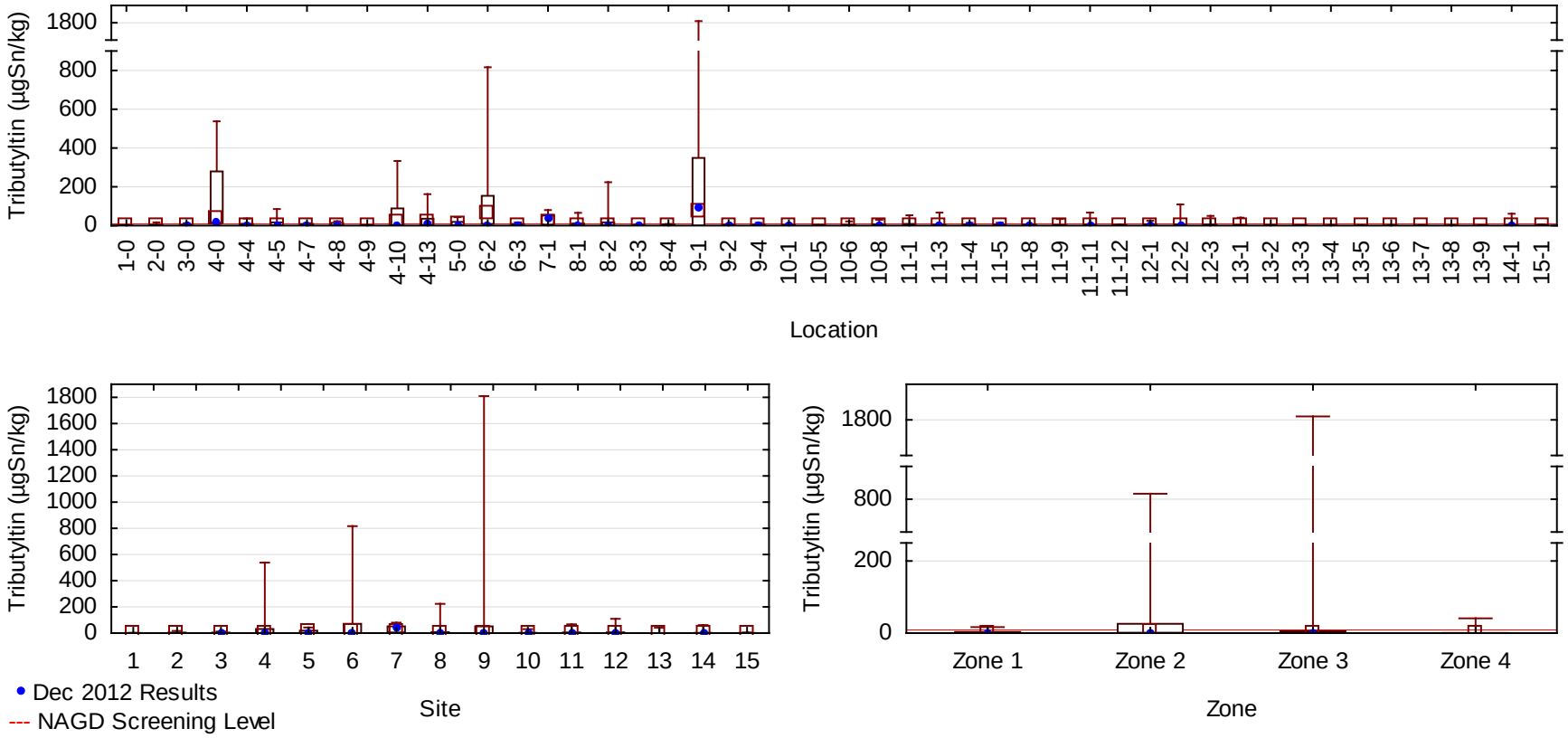


Figure 6-17: Spatial presentation of tributyltin (µgSn/kg) by location, zone and site

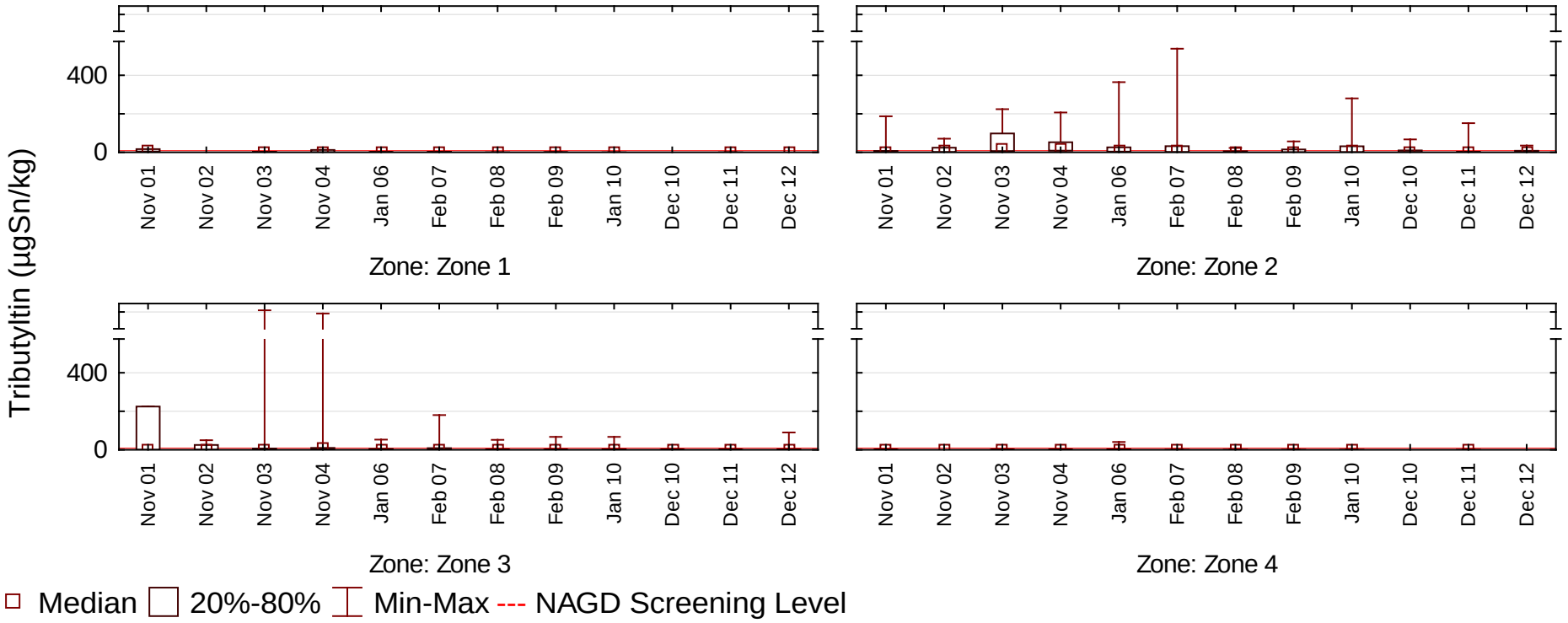


Figure 6-18: Temporal presentation of tributyltin (µgSn/kg) within zones

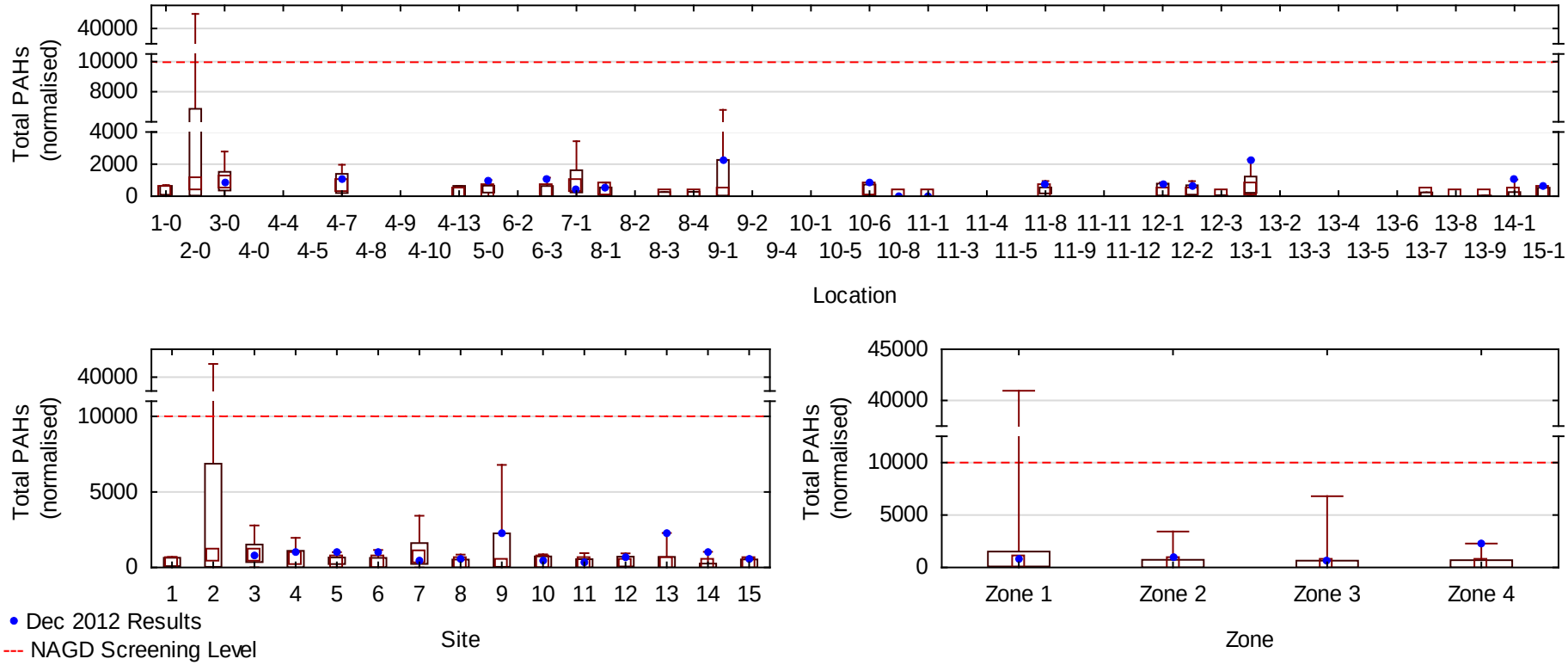


Figure 6-19: Spatial presentation of total PAHs (normalised to TOC concentration) (µg/kg) by location, zone and site

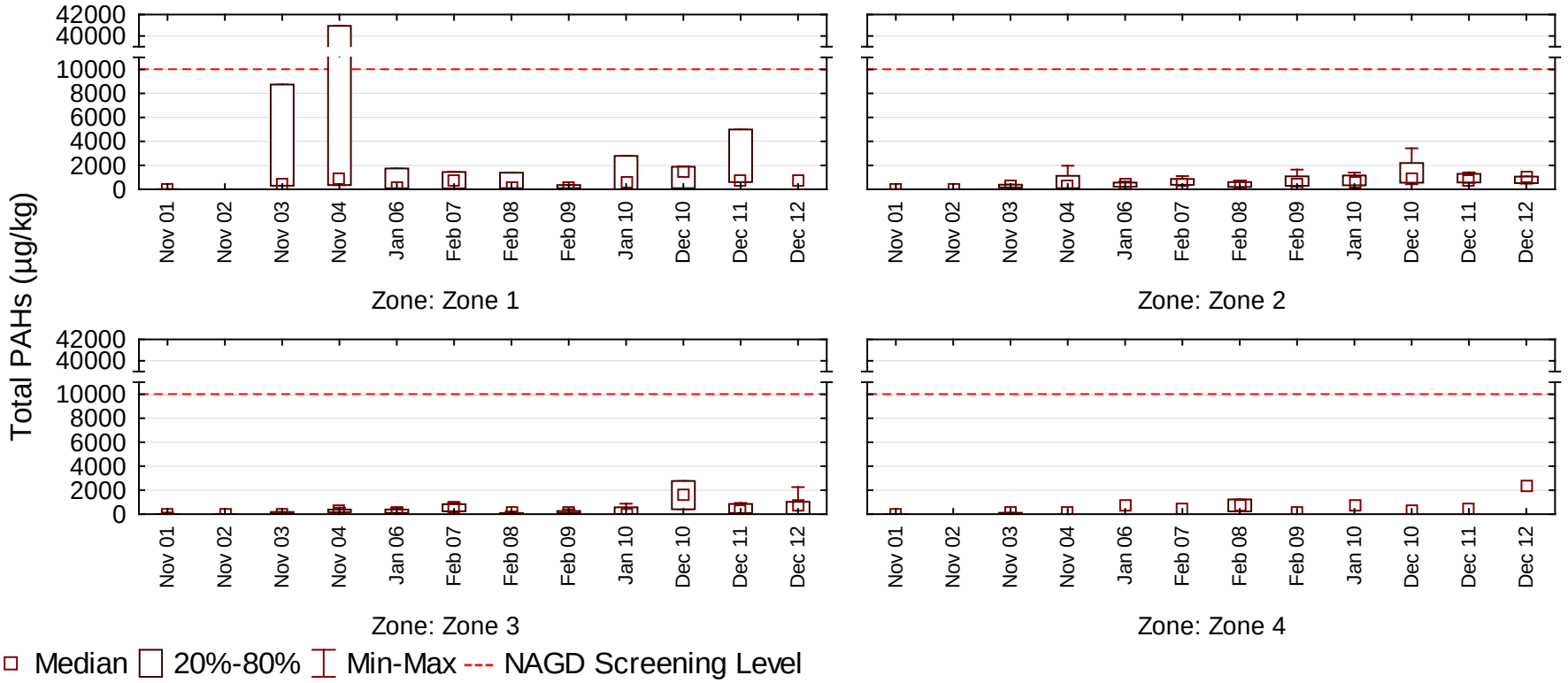


Figure 6-20: Temporal presentation of total PAHs (normalised to TOC concentration) (µg/kg) within zones

6.2 Patterns in the Distribution of Metal/metalloid Contaminants

Metals concentrations across the dredge area study sites (sites 4 – 15) for the past fourteen years are presented in

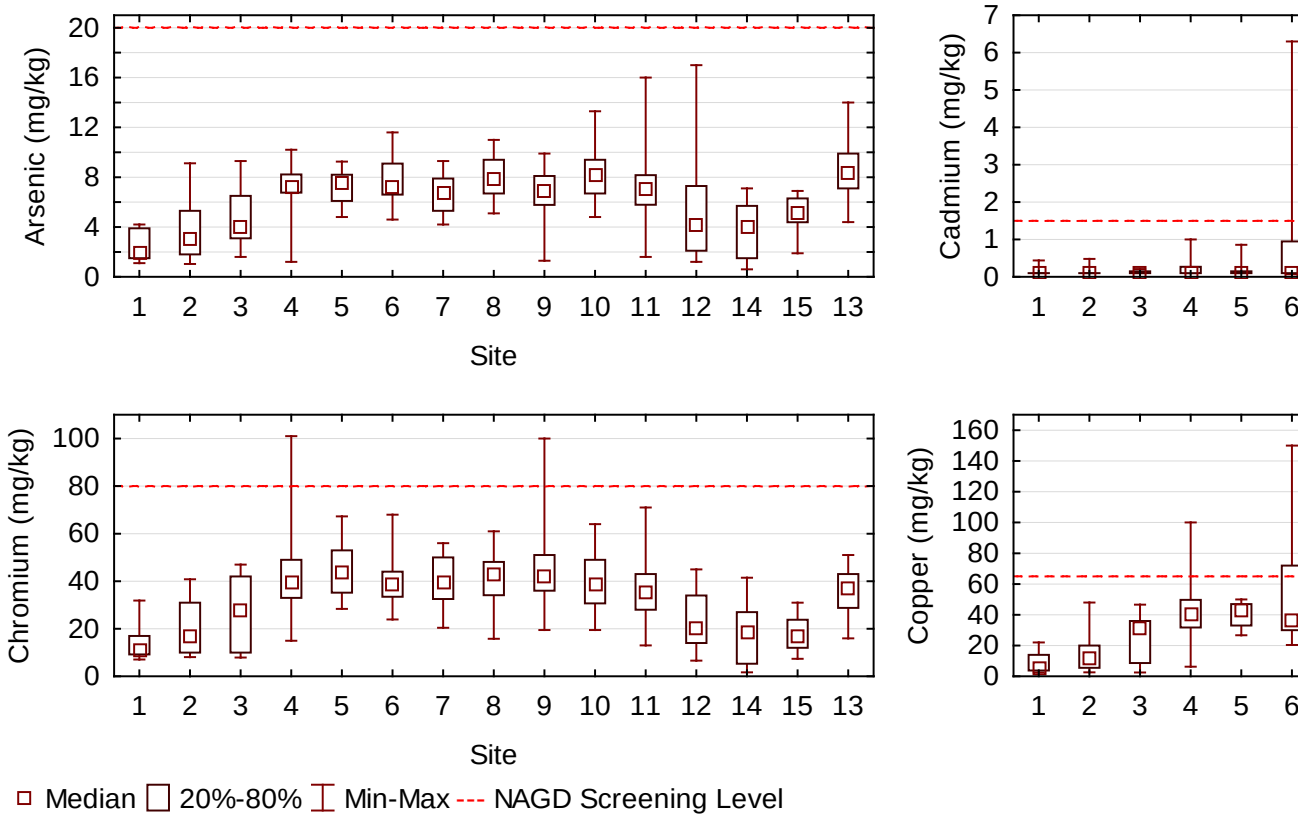


Figure 6-21 and Figure 6-22. Patterns in the distribution of metals/metalloid concentrations follow a distinct pattern. Metal concentrations are similar between sites 4 to 11, then decrease from sites 12 to 15 followed by clear increase in concentrations at site 13.

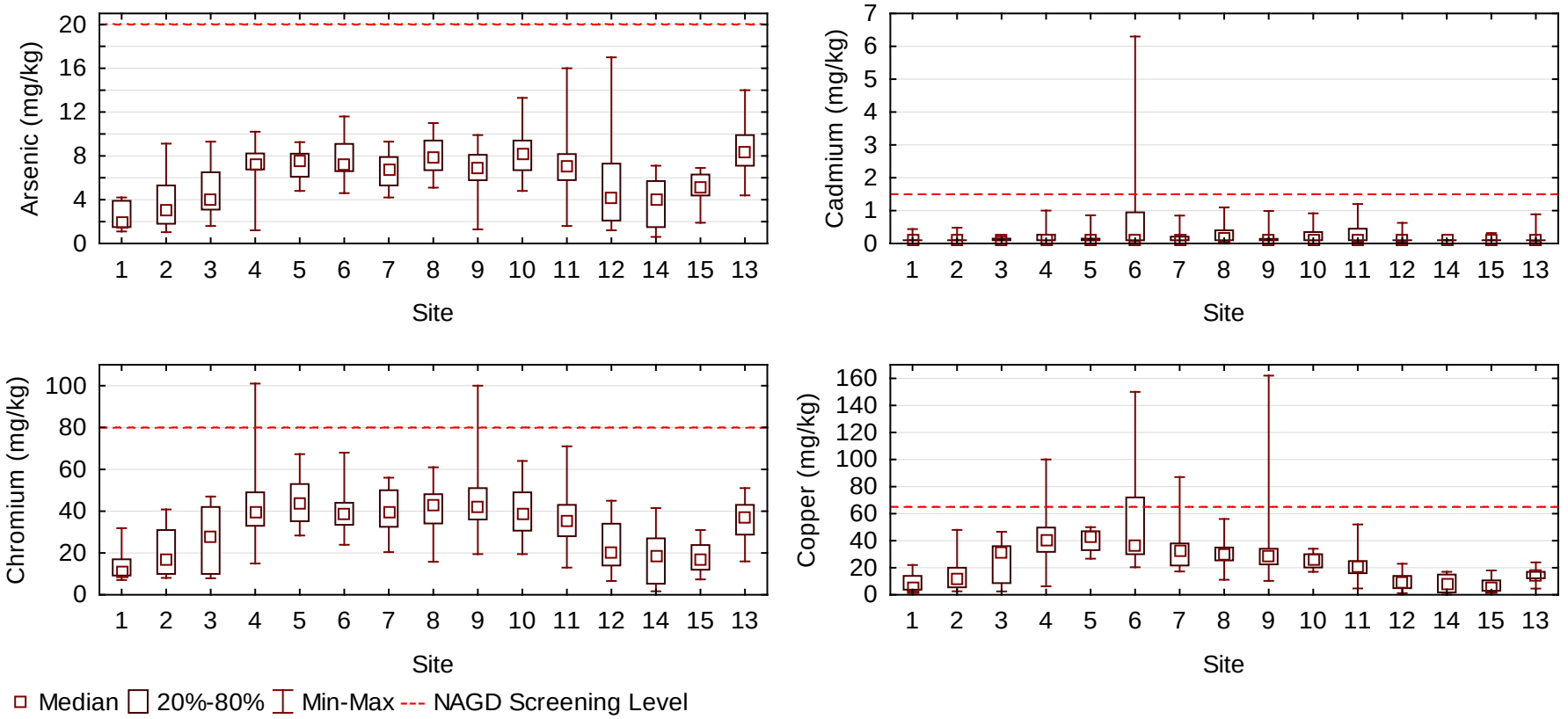


Figure 6-21: Spatial distribution of arsenic, cadmium, chromium and copper (1998-2012).

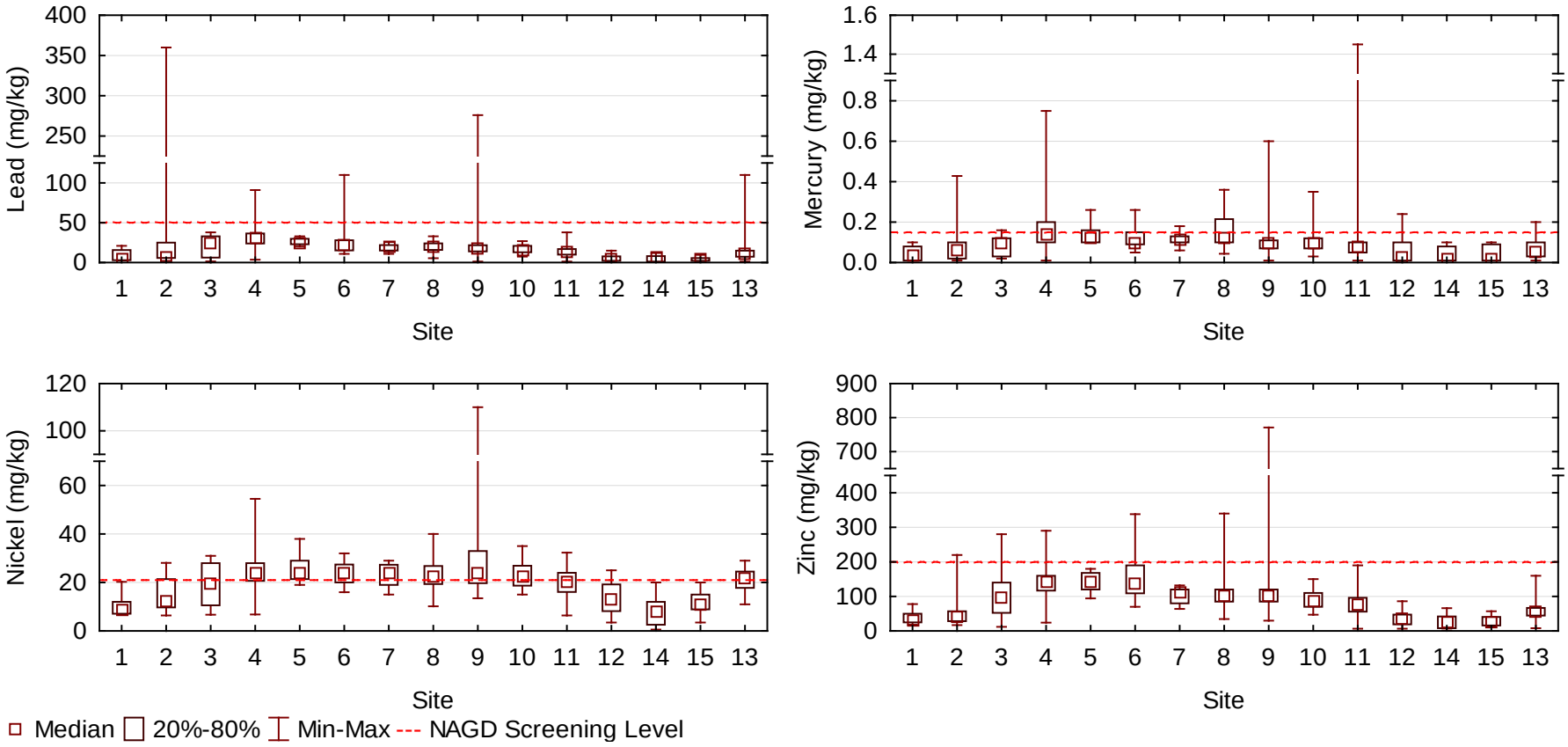


Figure 6-22: Spatial distribution of lead, mercury, nickel and zinc (1998 – 2012).

6.3 Temporal Comparison of Metals and TBT Exceeding NAGD Screening Levels

Table 6-1 presents the percentage of locations exceeding the NODGDM and NAGD Screening Levels for each year of the SAP study program (1998 – Dec 2011). In comparison with previous sampling events, the December 2012 percentage of compliance for cadmium, chromium, copper, lead and zinc compared to NAGD Screening Levels are within the range recorded from previous years. The percentage of non-compliance for mercury, nickel and TBT is higher than for the previous two years.

Table 6-1: Percentage of sample locations exceeding NODGDM and NAGD Screening Levels for metal and TBT 1998 – Dec 2012

SAP Event	No. Locations	Percentage (%) of sample locations exceeding NODGDM/NAGD Screening Levels[1]							
		Cadmium (Cd)	Chromium (Cr)	Copper (Cu)	Mercury (Hg)	Lead (Pb)	Nickel (Ni)	Zinc (Zn)	Tributyltin (TBT)
Mar-98[2]	13	0	0	0	0	16	39	8	54
Dec-98[2]	24	4	0	0	33	0	33	8	42
Dec-99[2]	35	0	0	0	3	0	83	0	0
Nov-00[2]	36	0	11	9	26	20	43	17	63
Nov-01[3]	45*	0	0	7	31	0	76	7	9
Nov-02[4]	45*	0	2	0	16	4	91	0	29
Nov-03[5]	45*	0	0	0	18	0	60	0	40
Nov-04[6]	45*	0	0	2	4	2	67	4	58
Jan-06[7]	45*	0	0	0	7	0	71	0	31
Feb-07[8]	45*	0	0	2	13	0	33	2	31
Jan-08[9]	45*	2	0	4	15	2	13	0	10
Feb-09[10]	45*	2	0	4	24	2	53	0	11
Jan-10[11]	45*	0	0	0	20	0	78	0	18
Dec-10[12]	45*	0	0	4	9	2	56	0	7
Dec-11	45*	0	1	0	8	1	48	1	1
Dec-12	45*	0	0	0	18	0	65	0	7

[1] Results expressed as percentage of sites containing contaminants above the NODGDM Screening Level criteria. Note: results from Feb-09 onwards are compared against NAGD Screening Levels.
[2] Source: PBC Environmental Performance Report, 2001
[3] Butler & Partners 2002
[4] Hydrobiology 2003
[5] Hydrobiology 2004
[6] SKM, 2005
[7] SKM, 2006
[8] SKM, 2007
[9] WorleyParsons, 2008
[10] WorleyParsons, 2009
[11] GHD, May 2010
[12] WorleyParsons, 2011
* Although 48 sample locations were tested in the 2001 to 2009 SAPs, 3 of these locations were upstream reference sites (hence not included in the above calculations)

6.4 Acid Sulfate Soils

Acid sulfate soils analysis results indicate that soils are generally consistent with previous sampling events which identified soils that are considered to be PASS. Although buffering capacity was not

analysed on these sediments, previous results of this material from each of the dredge zones (2 – 4) has indicated that these sediments have sufficient acid neutralizing capacity to buffer any acid potentially generated through onshore disposal.

6.5 Physical Characteristics

The PSD of sediments within each zone recorded during the December 2012 SAP are comparable to previous SAP surveys. However, individual locations within each zone can vary from year to year.

The largest shift in PSD was in Zone 1 where the percentage of sand increased from ~ 35% to 63 %. Zones 2 to 4 showed very similar proportion of fractions compared to 2011 data, with little change.

7 DISSCUSSION AND CONCLUSIONS

Chemical analysis of sediments requiring maintenance dredging by PBPL in early 2013 identified a number of parameters that exceeded NAGD Screening Levels across the dredge area. Nickel, mercury, *p,p'*-DDD, *p,p'*-DDE and *p,p'*-DDT, and TBT exceeded their respective NAGD Screening Levels at the 95% UCL of the mean within at least one zone of the dredge area (Zones 2-4). In addition, mercury and nickel exceeded their respective NAGD Screening Levels in Zone 1. However as sediments within Zone1 are not dredged, these results do not impact on the suitability of the material for sea disposal.

If PBPL were to seek approval for placement of the maintenance dredge material at the Mud Island Dredged Material Placement Area, further contaminant analysis would be required in accordance with the sediment assessment framework of the NAGD. Under this framework, elutriate, dilute acid extraction and/or porewater analysis may be required to estimate bioavailability of contaminants and potential water quality impacts. This process is required for those contaminants that exceeded the 95% UCL of the mean over the whole dredge area (Zones 2-4) and would include nickel, mercury, *p,p'*-DDD, *p,p'*-DDE and *p,p'*-DDT, and TBT.

Comparison of the sediment material to the DEH (1998) EIL and HIL (A) indicate that the sediment would be suitable for placement on land. The mean and 95% UCL of the mean values for both Zone 1 and the total dredge area (Zones 2-4) were below EIL and HIL (A) investigation levels.

Results of ASS analysis indicate that there are no management requirements for ASS if dredged material is to be placed on land. Previous results of this material from each of the dredge zones (2 – 4) has indicated that these sediments have sufficient acid neutralizing capacity to buffer any acid potentially generated through onshore disposal.

Results indicate a similar trend as seen in previous years for sites within the dredge area (Zones 2-4). There is a decrease in metal concentrations as you move downstream to the river mouth (between sites 4 and 11) with a sharp decline at sites 12, 14 and 15 (river mouth) before a rise again at site 13 (entrance channel). Sampling locations within site 13 (entrance channel) highlight clear site heterogeneity with sediments collected on the northern side of the channel being consistently elevated in concentrations compared to those sites on the southern side. These results could be due to the predominating currents during the floods and tides.

Data validation for field and laboratory samples was conducted with results showing some poor surrogate spike recoveries for BTEX. Organotins, TPH, PAHs, OPPs and PCBs were also outside of NAGD recovery limits for some locations. These results may be due to matrix interference that occurs when samples contain certain properties such as high moisture content (>50%) and/or organic matter that interfere with the extraction efficiency. Consequently, reported contaminant concentrations by the laboratory are lower than actual sediment concentrations.

All three of the split triplicate analyses had parameters that exceeded the NAGD criteria of 50%. The main concern with these results is that the primary laboratory had % RSD for duplicate values that

were > 100%. However, all values detected were below NAGD Screening Levels and therefore do not impact on the data or change the chemical suitability of the material for ocean or land disposal.

One of the six locations for site homogeneity was below the NAGD criteria of 50%. The other five sites did show RSDs > 50% for copper, lead, mercury, monobutyltin, tributyltin, TPH, Hexa-PCB congeners and total PCBs, 10 of the 20 individual PAHs, and total PAHs. Zones 2 and 3 have a history of both temporal and spatial heterogeneity and therefore, the results may potentially be considered an over estimate of concentration. Since most metals, organotins, total PAHs and OCs were below the NAGD Screening Level these results do not impact on the conclusions of the study.

8 RECOMMENDATIONS

As discussed in the 2012 SAP recommendations, OP pesticides have not been detected since 2002 and BTEX have not been detected within the timeframe of the review (from 2000). It was recommended that continued assessment of these parameters be reconsidered. The recommendation to remove these parameters from the analyte list is still current.

The 2011 and 2012 SAPs undertook additional sampling in Breakfast Creek which detected a number of PCBs, with totals exceeding the NAGD Screening Level in 2011. Levels within Breakfast Creek for the 2012 survey had decreased compared to 2011; with PCBs present within dredge areas (Zone 3 and Zone 4) where they have not been detected since 2003. This is likely due to the downstream movement of sediments out of Breakfast Creek. Results from the 2013 SAP show PCBs are above detection levels in Zone 3, but are no longer present in Zone 4. Given that PCBs still remain undetected from Zone 1, these results highlight that Breakfast Creek is still a potential contaminant source to the Brisbane River and the downstream sediments so monitoring for PCBs should continue.

The design of the SAP for the PBPL is statistically a complex matrix using a “nested design” (a number of locations within a site, and a number of sites within a zone,) analysed over time and distance. The design is further complicated because of the uneven number of locations and sites being analysed within each zone which makes it unbalanced in terms of comparisons across zones. In addition, many of these locations and sites within each zone are different in their sediment characteristics, which makes it difficult to pool data and compare across zones. It is recommend to present data per site with zone over time as a nested design so the patterns over time are more distinguishable compared to using a box plot, which summaries data within the zone over time and loses the patterns in the data.

Historical data for PBPL work has been collected since 2000 and was conducted in Zones 2-4 with no reference site or Zone 1. We recommend reviewing and evaluating this earlier data to confirm that the analytical results are comparable in methodology to present methods and results. In the last decade laboratory analytical methods and detection limits or LOR have improved considerably and it might be prudent to determine if early data is reliable for inclusion into the PBPL SAP annual sediment characterisation assessment.

9 REFERENCES

Butler & Partners (2002) *Sediment Sampling and Analysis Plan: Brisbane River and Outer Bar Moreton Bay, November 2001*. Prepared by Butler & Partners Pty Ltd for the Port of Brisbane Corporation, April 2002.

Commonwealth of Australia (2002) *National Ocean Disposal Guidelines for Dredged Material*. Commonwealth of Australia, Canberra, May 2002.

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

Dear, S.E., Moore, N.G., Dobos, S.K. Watling, K.M. and Ahern, C.R. (2002) *Soil Management Guidelines. In Queensland Acid Sulfate Soil Technical Manual.* Department of Natural Resources and mines, Indooroopilly, Queensland, Australia.

DEH (1998). *Draft Guidelines for the Assessment and Management of Contaminated Land in Queensland.* May 1998. Department of Environment and Heritage (now EPA): Brisbane.

GHD (2010). *Report for Sediment Sampling and Analysis Plan – Brisbane River and Moreton Bay*. Prepared by GHD for the Port of Brisbane Corporation, May 2010.

Hydrobiology (2003). *Sediment Sampling and Analysis Plan (SAP) in the Brisbane River and Outer Bar (November 2002)*. Prepared by Hydrobiology Pty Ltd for the Port of Brisbane Corporation, February 2003.

Hydrobiology (2004). *Sediment Sampling and Analysis Plan (SAP) in the Brisbane River and Outer Bar (November 2003)*. Prepared by Hydrobiology Pty Ltd for the Port of Brisbane Corporation, May 2004.

QASSIT (1998) *Guidelines for Sampling and Analysis of Lowland Acid Sulfate Soils (ASS) in Queensland.* Queensland Acid Sulfate Soils Investigation Team (QASSIT), Department of Natural Resources and Mines (now Department of Natural Resources and Water). DNRQ980124.

SKM (2005). *Sediment Sampling and Analysis Plan for the Brisbane River and Outer Bar, November 2004*. Prepared by Sinclair Knight Merz for the Port of Brisbane Corporation, 2005.

SKM (2006). *Sediment Sampling and Analysis Plan for the Brisbane River and Outer Bar, January 2006.* Prepared by Sinclair Knight Merz for the Port of Brisbane Corporation, July 2006.

SKM (2007) *Sediment Sampling and Analysis Plan (SAP) for Brisbane River and Moreton Bay, 2007.* Prepared by Sinclair Knight Merz for the Port of Brisbane Corporation, July 2007.

US EPA (2006). *Data Quality Assessment: Statistical Methods for Practitioners*. Unites States Environmental Protection Agency. February 2006. EPA/240/B-06.003.

WorleyParsons (2008). *Sediment Sampling and Analysis Plan – Brisbane River and Moreton Bay*. Prepared by WorleyParsons for the Port of Brisbane Corporation. May 2008.

WorleyParsons (2009). *Sediment Sampling and Analysis Plan – Brisbane River and Moreton Bay, February 2009*. Prepared by WorleyParsons for the Port of Brisbane Corporation. June 2009.

WorleyParsons (2011) Brisbane River and Moreton Bay Annual Sediment Characterisation Report *2011*. Prepared by WorleyParsons for Port of Brisbane Pty Ltd. May 2011.

WorleyParsons (2012) Brisbane River and Moreton Bay Annual Sediment Characterisation Report *2012*. Prepared by WorleyParsons for Port of Brisbane Pty Ltd. April 2012.