Marine Sediment Contaminant Monitoring: 2013 Data Report

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Marine Sediment Contaminant Monitoring: 2013 Data Report

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Executive summary

This document describes the marine sediment contaminant monitoring undertaken for the Auckland Council's Regional Sediment Contaminant Monitoring Programme (RSCMP) in November 2013.

Sediments from a total of 42 sites were sampled for sediment contaminants in 2013; 27 RSCMP sites, 2 Long Bay stream sites, 1 Central Waitemata Harbour benthic ecology programme (CWH) site, and 12 Upper Waitemata Harbour (UWH) programme sites. Of these sites, 28 were sampled by Diffuse Sources Ltd (DSL), 12 UWH sites by NIWA, and 2 sites by Auckland Council (AC).

This report summarises the sediment contaminant and particle size distribution (PSD) data for the RSCMP and CWH sites. The Long Bay data has been reported separately by Mills (2014a) and the UWH data is to be reported to Auckland Council by NIWA.

Samples from the RSCMP/CWH sites were analysed for the heavy metals copper (Cu), lead (Pb), zinc (Zn), arsenic (As), and mercury (Hg), and particle size distribution (PSD).

In addition to this core set of metals and PSD analyses, 11 RSCMP sites (and 2 Long Bay stream sites) were analysed for organic contaminants – polycyclic aromatic hydrocarbons (PAH), organochlorine pesticides (OCPs) and polychlorinated biphenyls (PCBs). These data, which complement a set of organics analyses on 13 other RSCMP sites sampled in 2012, have been reported separately (Mills 2014b). However, for completeness, quality assurance data for the organic contaminants have also been included in this report.

Benthic ecology sampling was also undertaken from 21 of the RSCMP sites and preserved samples were submitted to NIWA for analysis. These data are reported separately to Auckland Council by NIWA.

This report provides:

- sediment metals data (analysis by R J Hill Laboratories);
- sediment PSD data (analysis conducted by NIWA); and
- quality assurance data for sediment metals, organic contaminants, and PSD.

Single site reports (SSRs), which summarise the status and trends in sediment contaminants, have been updated to include the 2013 results, and have been provided separately to Auckland Council. The SSRs include the core sediment contaminant monitoring data for the RSCMP, CWH, UWH, and Long Bay sites.

Overall, the sediment contaminant data set obtained in 2013 was similar in quality to that obtained in previous years. The key issue identified by quality assurance data is the year-to-year consistency of extractable metals (in the <63 µm fraction) data. Analysis of Certified Reference Material (CRM), Bulk Reference Sediments (BRS), and analyses of

archived samples from 2012, indicate that extractable metals data obtained in 2013 were generally reasonably consistent with those from 2012, but were possibly higher than those obtained in 2011 due to analytical variation. Continued focus on quality assurance, as recommended in previous reports, is required to provide confidence in the comparability of monitoring data over time.

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1.0 Introduction

This document provides a summary of marine sediment contaminant and benthic ecology monitoring undertaken by Diffuse Sources Ltd (DSL) in November 2013 for the Auckland Council Regional Sediment Contaminant Monitoring Programme (RSCMP) and Long Bay streams and beach monitoring programme. The RSCMP monitoring was formerly conducted as the Regional Discharges Project (RDP) and State of the Environment (SoE) programmes.

Samples collected by NIWA for the Upper Waitemata Harbour benthic ecology monitoring programme (UWH) and by Auckland Council at one RSCMP site and one Central Waitemata Harbour benthic ecology programme (CWH) were also analysed with the 2013 RSCMP/Long Bay samples.

This report provides a summary of:

- Sampling undertaken – sites and methods;
- Sediment contaminant and particle size distribution (PSD) results; and
- Quality assurance (QA) results.

Single Site Reports (SSRs), which summarise sediment contaminant status and trends at each site, have been updated with the 2013 results and reported separately to Auckland Council. Copies of the SSRs can be obtained from Auckland Council's the Research and Evaluation Unit (RIMU). The SSRs include the core monitoring data for the RSCMP, CWH, UWH, and Long Bay sites.

This report summarises the sediment contaminant and particle size distribution (PSD) data for the RSCMP and CWH sites. The Long Bay data has been reported separately by Mills (2014a) and the UWH data is to be reported to Auckland Council by NIWA.

2.0 Sampling and analysis

2.1 Sampling

Sampling of the RSCMP sites was conducted by DSL between 30th October and 18th November 2013 following the procedures detailed in the ARC "monitoring blueprint" document, ARC Technical Publication 168 (ARC 2004).

Long Bay stream and beach sediments were sampled on 15th November 2013 as described in the ARC Long Bay Monitoring protocol document (ARC 2007).

Auckland Council staff carried out the sampling of the Pollen Island (former RDP, now RSCMP site) on 22nd March 2013, and Shoal Bay Lower (CWH) on 21st October 2013.

The UWH programme sites were sampled by NIWA on the 6th and 7th November 2013 using the protocols designed for that programme.

A list of sites, sampling dates, and analyses conducted at each site are given in Table 2-1. More detailed information on the sites selected for monitoring, including their locations, key physical characteristics, and sediment contaminant status and trends, is provided in the SSRs (copies of which can be obtained from Auckland Council's Research and Evaluation Unit (RIMU)). The rationale for the chemical contaminants measured and sampling strategy are given in TP 168 (ARC 2004). The most recent trends report for all sites is TR2012/041.

2.2 Sample preparation

2.2.1 Contaminant samples

Five replicate contaminant samples were taken at each site, as described in ARC (2004). Three replicates (replicates 1–3) were processed for contaminant analysis, and two (replicates 4 and 5) retained in cold storage (frozen) for reanalysis if required. Samples were frozen on the day of sampling and delivered to NIWA Hamilton on 22nd November 2013, where homogenisation, sieving (<63 µm and <500 µm), and freeze drying were undertaken.

Samples taken in the UWH programme were supplied directly to the NIWA Hamilton lab by the NIWA sampling team. Sample processing and analysis of the UWH samples was undertaken using the same protocols as the RSCMP/Long Bay samples.

Sieved samples (<63 µm and <500 µm) for metals analysis were freeze dried and provided to R J Hill Laboratories (Hamilton) for analysis in freeze dried form.

A portion of the freeze dried <500 µm replicate 1 sample from selected sites (see Table 2-1) was used for analysis of total organic carbon (TOC), polycyclic aromatic hydrocarbons (PAH), organochlorine pesticides (OCPs) and polychlorinated biphenyls (PCBs).

Remaining freeze dried <500 µm material from each sample was archived in glass jars. Following the completion of the analytical work, the archived samples were weighed and deposited in the Auckland Council store.

2.2.2 Particle size distribution (PSD) samples

A composite sample for particle size distribution (PSD) analysis was made up from each RSCMP site from 10 sub-samples taken from across the site, each sub-sample being taken from the top 2 cm immediately adjacent to the benthic ecology core sample. The composites were homogenised, and a portion transferred into 250 mL plastic pottle and frozen. The PSD samples were delivered to NIWA with the contaminant samples on 22nd November 2013.

2.3 Analysis

RSCMP sediment samples were analysed for:

- Total recoverable metals – copper (Cu), lead (Pb), zinc (Zn), arsenic (As), and mercury (Hg) – on the <500 µm fraction, by R J Hill laboratories (3 replicates per site);
- 2 M HCl extractable metals – Cu, Pb, and Zn – on the <63 µm fraction, by R J Hill laboratories (3 replicates per site); and
- particle size distribution (PSD) – one composite sample per site. PSD analysis was undertaken by NIWA (Hamilton) using wet sieving/pipette separation into 6 size fractions, followed by oven drying each fraction to constant weight.

Sediment contaminant data are summarised in Appendix A, and PSD data are tabulated in Appendix B. The analytical lab report from R J Hill Laboratories is provided in Appendix C.

In addition to the analysis of metals and PSD, a portion of the freeze dried <500 µm replicate 1 sample from selected sites (see Table 2-1) was used for analysis of total organic carbon (TOC) and organic contaminants – polycyclic aromatic hydrocarbons (PAH), organochlorine pesticides (OCPs) and polychlorinated biphenyls (PCBs).

TOC was analysed at R J Hill labs. Organic contaminants in the RSCMP samples were analysed by AsureQuality (Wellington). A single replicate from each of the UWH programme sites was also analysed for TOC and PAH, with the PAH analysis conducted by R J Hill labs. A check on the comparability of the PAH analysis by R J Hill labs and

AsureQuality was made on several samples from the RSCMP/Long Bay/UWH batch. Results are summarised in section 3.0 (quality assurance).

The PAH, OCP, and PCB data from the RSCMP sites sampled in 2013 (which were mostly former SoE programme sites) have been reported separately, along with complementary data collected from RSCMP sites (mostly former RDP sites) sampled and analysed in 2012 (Mills 2014b).

Table 2-1 Sites sampled and analyses conducted in 2013.

"Extended metals" suite is cadmium (Cd), chromium (Cr), iron (Fe), manganese (Mn), and nickel (Ni). For PAH, "✓✓" indicates samples were analysed at AsureQuality and also at R J Hill labs (for QA purposes). "AC" indicates sampled by Auckland Council.

					Metals			Organics					
Site	Programme	MRA	Sampling Date	Sampled by	Cu Pb Zn	As Hg	Extended	TOC	TPH	PAH	OCP PCB	Benthic Ecology	PSD
Pollen Island	CWH Eco	Central Waitemata Hbr	22/03/2013	AC	✓	✓						✓	✓
Shoal Bay Lower	CWH Eco	Central Waitemata Hbr	21/10/2013	AC	✓	✓						✓	✓
Awaruku Stream	Long Bay	East Coast Bays	15/11/2013	DSL	✓	✓	✓	✓	✓	✓✓	✓		✓
Vaughan's Stream	Long Bay	East Coast Bays	15/11/2013	DSL	✓	✓	✓	✓	✓	✓✓	✓		✓
Awaruku Beach	RSCMP/Long Bay	East Coast Bays	15/11/2013	DSL	✓	✓	✓						✓
Vaughan's Beach	RSCMP/Long Bay	East Coast Bays	15/11/2013	DSL	✓	✓	✓						✓
Anns Creek	RSCMP	Manukau Hbr	4/11/2013	DSL	✓	✓						✓	✓
Big Muddy Creek	RSCMP	Manukau Hbr	11/11/2013	DSL	✓	✓							✓
Blockhouse Bay	RSCMP	Manukau Hbr	5/11/2013	DSL	✓	✓						✓	✓
Henderson Upper	RSCMP	Central Waitemata Hbr	1/11/2013	DSL	✓	✓		✓		✓	✓	✓	✓
Hobson Bay, Awatea Rd	RSCMP	Central Waitemata Hbr	31/10/2013	DSL	✓	✓						✓	✓
Hobson Bay, Whakataka Bay	RSCMP	Central Waitemata Hbr	31/10/2013	DSL	✓	✓						✓	✓
Island Bay	RSCMP	Central Waitemata Hbr	5/11/2013	DSL	✓	✓							✓
Little Muddy	RSCMP	Manukau Hbr	11/11/2013	DSL	✓	✓						✓	✓
Lucas Upper	RSCMP	Upper Waitemata Hbr	5/11/2013	DSL	✓	✓						✓	✓
Mangere Cemetery	RSCMP	Manukau Hbr	4/11/2013	DSL	✓	✓		✓		✓	✓	✓	✓
Meola Inner	RSCMP	Central Waitemata Hbr	7/11/2013	DSL	✓	✓		✓		✓	✓	✓	✓
Meola Reef @ Te Tokaroa	RSCMP	Central Waitemata Hbr	6/11/2013	DSL	✓	✓						✓	✓
Middlemore	RSCMP	Tamaki Estuary	30/10/2013	DSL	✓	✓		✓		✓✓	✓	✓	✓
Motions	RSCMP	Central Waitemata Hbr	7/11/2013	DSL	✓	✓						✓	✓
Oakley	RSCMP	Central Waitemata Hbr	13/11/2013	DSL	✓	✓		✓		✓	✓	✓	✓
Pahurehure Papakura	RSCMP	Manukau Hbr	3/11/2013	DSL	✓	✓							✓
Pahurehure Papakura Eco	RSCMP	Manukau Hbr	3/11/2013	DSL	✓	✓						✓	✓
Pakuranga Lower	RSCMP	Tamaki Estuary	12/11/2013	DSL	✓	✓						✓	✓
Pakuranga Upper	RSCMP	Tamaki Estuary	12/11/2013	DSL	✓	✓		✓		✓	✓	✓	✓
Paremoremo	RSCMP	Upper Waitemata Hbr	18/11/2013	DSL	✓	✓						✓	✓
Te Matuku	RSCMP	Tamaki Strait	3/11/2013	DSL	✓	✓		✓		✓	✓		✓
Weiti	RSCMP	Hibiscus Coast	17/11/2013	DSL	✓	✓						✓	✓
Whau Lower	RSCMP	Central Waitemata Hbr	13/11/2013	DSL	✓	✓		✓		✓	✓	✓	✓
Whau Upper	RSCMP	Central Waitemata Hbr	14/11/2013	DSL	✓	✓		✓		✓	✓	✓	✓
Whau Wairau	RSCMP	Central Waitemata Hbr	14/11/2013	DSL	✓	✓		✓		✓	✓	✓	✓
Brigham Creek (Brig)	UWH	Upper Waitemata Hbr	7/11/2013	NIWA	✓	✓	✓	✓		✓		✓	✓
Central Main Channel (MainC)	UWH	Upper Waitemata Hbr	6/11/2013	NIWA	✓	✓	✓	✓		✓		✓	✓
Central Waitemata East (OHbv)	UWH	Central Waitemata Hbr	6/11/2013	NIWA	✓	✓	✓	✓		✓		✓	✓
Hellyers Creek (Hell)	UWH	Upper Waitemata Hbr	7/11/2013	NIWA	✓	✓	✓	✓		✓		✓	✓
Herald Island North (HIN)	UWH	Upper Waitemata Hbr	6/11/2013	NIWA	✓	✓	✓	✓		✓		✓	✓
Lucas Creek (Luc)	UWH	Upper Waitemata Hbr	6/11/2013	NIWA	✓	✓	✓	✓		✓		✓	✓
Lucas Te Wharau Creek (LucU)	UWH	Upper Waitemata Hbr	6/11/2013	NIWA	✓	✓	✓	✓		✓		✓	✓
Outer Main Channel (MainO)	UWH	Upper Waitemata Hbr	6/11/2013	NIWA	✓	✓	✓	✓		✓		✓	✓
Rangitopuni Creek (Rng)	UWH	Upper Waitemata Hbr	7/11/2013	NIWA	✓	✓	✓	✓		✓✓	✓	✓	✓
Upper Hellyers Creek (HellU)	UWH	Upper Waitemata Hbr	7/11/2013	NIWA	✓	✓	✓	✓		✓		✓	✓
Upper Main Channel (MainU)	UWH	Upper Waitemata Hbr	7/11/2013	NIWA	✓	✓	✓	✓		✓		✓	✓
Waiarohia Inlet (HIW)	UWH	Upper Waitemata Hbr	6/11/2013	NIWA	✓	✓	✓	✓		✓		✓	✓

2.4 Concentration units for 2013

Previous metals results (samples from 2004 to 2010) from R J Hill Laboratories were reported as mg/kg dry weight, but investigations conducted in 2011/12 revealed that these were actually mg/kg air-dried weight, where “air-dried” refers to “forced air” drying at 35°C. The laboratory considered that the difference between these measures was likely to be minor (on average, less than a few %).

For the 2011 and 2012 samples, moisture content of the air-dried <63 µm and <500 µm fractions used for metals analysis was assessed by oven drying sub-samples at 103°C.

The air-dried <63 µm fraction samples from 2012 had a mean moisture content of 4.0% (range 2–7%), while the <500 µm samples had mean moisture content of 1.6% (range 0–5%). These values were similar to those found in 2011, although the moisture contents of the <63 µm fraction air-dried samples in 2012 were slightly less variable than the 2011 samples (which had mean moisture content of 3.7%, range 0–11%).

Metals data for 2012 were corrected for the residual moisture content of each sample (as determined by oven drying at 103°C) and were reported in units of mg/kg dry weight.

This difference may introduce a slight increase in metals concentrations compared with previous years’ results from R J Hill Laboratories (RDP 2004–2010, SoE 2009, UWH 2008–2010). The difference is probably of the order of a few %, but it is likely to vary between sites and between sediment fractions (<63 µm and <500 µm fractions).

For 2013, samples were freeze dried after 63 µm and 500 µm sieving, and the freeze dried fractions analysed directly by R J Hill labs (metals, TOC, PAH) and AsureQuality (PAH, OCPs, PCBs). No correction for residual moisture in the freeze dried samples has been made. NIWA staff (Greg Olsen, pers. comm. May 2014) have indicated that their freeze dried sediments (including fine, organic-rich sediment) typically have moisture contents of less than 2%, and for sandy marine sediments usually <1%. NIWA’s analyses have found that the weighing errors for moisture correction are often higher than the mass difference measured between wet weight and oven dry weight (overnight at 103°C). Therefore, moisture correction of the freeze dried sediments is not warranted.

3.0 Quality Assurance

3.1 Quality assurance assessment

Quality assurance for metals analyses was conducted by:

- Laboratory quality control samples – analysis of procedural blanks, duplicate samples reanalysed by the laboratory, and analyses of Certified Reference Material (CRM; AGAL-10). Spike recoveries were also reported. These data are reported in the R J Hill Laboratories QC Report, which is included in the lab report (Appendix C).
- Blind duplicate samples from the 2013 sampling – "Blind Within-Batch (WB) Reps". These were 6 samples, covering a range of textures and contaminant levels, submitted to the lab as additional samples.
- Replicate 4 and 5 samples from four sites sampled in 2012, which were stored frozen and analysed in 2013. The results from the 2013 analyses were compared with the results from the 2012 analysis of replicates 1–3, to check comparability of analysis in each year (or "batch"). This check was made because of the change in sample processing made in 2013 (NIWA sieving and freeze drying, previously R J Hill labs sieving and air/oven drying). These analyses provide data similar to "Blind Between-Batch (BB) Replicates".
- Five Certified Reference Material samples dispersed through the analytical run as extra samples (in addition to the routine laboratory QC CRM samples).
- Analysis of Auckland Council "Bulk Reference Sediments" (BRS). BRS are sediments from two sites (a sandy sediment from Meola Outer, and a muddy sediment from Middlemore), which have been archived in frozen and freeze-dried form for repeated analysis with each year's monitoring samples. Analysis of the BRS each year provides an on-going record of within-year and between-year analytical variability and drift. Three replicates of each BRS (both frozen and freeze dried) were analysed with the 2013 sample batch.

More limited checks on data WB variability for TOC and organic contaminants (PAH, OCPs, PCBs) were also made from:

- Blind duplicate analysis of two samples for TOC (data summarised in Table 3 3);
- Blind duplicate analysis of one UWH programme sample for PAH (data summarised in Table 3 4);
- Analysis of three replicates of Middlemore Bulk Reference Sediment (BRS) for PAH by R J Hill labs (data summarised in Table 3 5);
- Blind duplicate analysis of Middlemore Bulk Reference Sediment (BRS) for PAH, OCPs, and PCBs by AsureQuality (data summarised in

- Table 3-6, along with blind duplicate results from a single sample from Cox's Bay RSCMP site analysed in the 2012 sample batch).

Checks on the comparability of PAH results generated by R J Hill and AsureQuality labs were made from:

- Analysis of Middlemore BRS – three replicates by R J Hill labs and two replicates by AsureQuality (data summarised in Table 3-8 and
- Analysis of three samples (two Long Bay stream sediments and one UWH programme site) for PAH by both AsureQuality and R J Hill labs (data summarised in Table 3-8.

Key features of the QA data are as follows. An overall summary of the 2013 QA results is presented in Table 3-24.

3.2 Background contamination – laboratory blanks

Metals concentrations in procedural blanks were below detection limits (DL):

- <1 mg/kg for extractable Cu, <0.2 mg/kg for extractable Pb, and <2 mg/kg for extractable Zn.
- Total recoverable metals blanks were <0.2, <0.2, <0.04, <0.4, and <0.01 mg/kg for As, Cu, Pb, Zn, and Hg respectively.
- The blank concentrations (in mg/kg) for the "extended" metals analysed in the UWH samples were <0.01 (Cd), <0.2 (Cr and Ni), <40 (Fe), and <1 (Mn). One value of 0.8 mg/kg for Cr was recorded, but the lab approved the data based on the blank value being <10% of the sample concentrations (see lab QC report, Appendix C).
- PAH analysis blank results generated by R J Hill labs (for the UWH samples) were also all <DL (which ranged from 0.002 to 0.01 mg/kg per PAH compound), except for one phenanthrene result, which was at the DL (0.002 mg/kg). This was considered acceptable to the lab (see lab QC report Appendix C).
- TOC blanks were <0.05 g/100 g (%).
- Laboratory blank concentrations for the PAH, OCPs, and PCBs analysed by AsureQuality were low, and are presented in the organic contaminants report (Mills 2014b).

In summary, there was therefore no significant background contamination introduced in the laboratory that would contribute significantly to the reported metals concentrations.

3.3 Within-batch data variability

3.3.1 Metals

Six RSCMP site samples were analysed as blind within-batch duplicates for metals. Results are tabulated in Table 3-1.

The relative percentage differences (RPDs) between duplicates were mostly <15%. Mercury (Hg) generally had poorer agreement between duplicates than other metals. Only Hg at Te Matuku (where concentrations were below or near DLs) exceeded a 30% difference (the USEPA Data Quality Objective – DQO – limit for acceptable agreement between within-batch replicates).

Differences between blind within-batch duplicates for 2 M HCl extractable metals (<63 µm fraction) ranged from 1.0–15%.

Apart from Hg, differences between blind within-batch duplicates for total recoverable metals (<0.5 mm fraction) ranged from 0–15%.

Differences between blind duplicates averaged 6–8% for the extractable metals, and 4–8% for total recoverable metals (excluding Hg). The average RPD for Hg was 17%. On average, therefore, analytical precision within the batch of RSCMP samples analysed in 2013 was good – similar to, or slightly better than, results obtained in previous years.

One UWH programme site was analysed in duplicate for metals, including the “extended” suite of total recoverable metals. Results are given in Table 3-2. Differences between duplicates ranged from 0–15%.

Table 3-1 Within-batch variation for metals in RSCMP samples submitted to the laboratory as blind duplicates. Differences between duplicates (expressed as relative percentage difference; RPD) are colour coded: Green <15%, Amber 15–30%, Red >30%.

		Extractable metals (<63 μm)			Total Recoverable Metals (<500 μm)				
Site	Rep	Cu	Pb	Zn	As	Cu	Pb	Hg	Zn
Anns Creek	2	11.6	17.6	109	10.8	18.0	23.0	0.079	129
	WB	10.0	16.6	96	10.6	17.5	23.0	0.064	132
difference (mg/kg)		-1.6	-1.0	-13.0	-0.2	-0.5	0.0	-0.015	3.0
RPD (%)		14.8	5.8	12.7	1.9	2.8	0.0	21.0	2.3
Blockhouse Bay	2	13.6	27.0	136	7.9	5.5	12.9	0.019	69
	WB	13.3	25.0	131	6.8	5.9	11.1	0.019	67
difference (mg/kg)		-0.3	-2.0	-5.0	-1.1	0.4	-1.8	0.000	-2.0
RPD (%)		2.2	7.7	3.7	15.0	7.0	15.0	0.0	2.9
Paremoremo	2	18.9	24.0	101	10.2	21.0	24.0	0.143	92
	WB	18.1	26.0	100	9.2	21.0	24.0	0.146	91
difference (mg/kg)		-0.8	2.0	-1.0	-1.0	0.0	0.0	0.003	-1.0
RPD (%)		4.3	8.0	1.0	10.3	0.0	0.0	2.1	1.1
Te Matuku	2	4.8	12.6	49	5.1	2.6	6.4	0.025	29
	WB	4.5	12.2	47	4.4	2.6	6.7	0.045	30
difference (mg/kg)		-0.3	-0.4	-2.0	-0.7	0.0	0.3	0.020	1.0
RPD (%)		6.5	3.2	4.2	14.7	0.0	4.6	57.1	3.4
Whakataka Bay	2	12.1	28.0	86	6.9	6.3	17.9	0.120	81
	WB	14.1	29.0	96	7.1	7.1	19.1	0.137	85
difference (mg/kg)		2.0	1.0	10.0	0.2	0.8	1.2	0.017	4.0
RPD (%)		15.3	3.5	11.0	2.9	11.9	6.5	13.2	4.8
Whau Upper	2	35.0	66.0	250	11.0	32.0	55.0	0.144	250
	WB	38.0	73.0	270	10.8	34.0	59.0	0.153	280
difference (mg/kg)		3.0	7.0	20.0	-0.2	2.0	4.0	0.009	30.0
RPD (%)		8.2	10.1	7.7	1.8	6.1	7.0	6.1	11.3

Table 3-2 Within-batch variation for metals in an UWH site sample submitted to the laboratory as blind duplicates. Differences between duplicates (expressed as relative percentage difference; RPD) are colour coded: Green <15%, Amber 15–30%, Red >30%.

		Extractable metals (<63 μm)			Total Recoverable Metals (<500 μm)									
Site	Rep	Cu	Pb	Zn	As	Cd	Cr	Cu	Pb	Hg	Ni	Zn	Fe	Mn
Brigham Creek (Brig) TOP	2	18.3	24.0	95	9.3	0.079	21.0	20.0	24.0	0.145	8.8	95	19500	95.0
	WB	19.4	27.0	102	9.1	0.068	19.8	19.9	24.0	0.157	8.5	95	20000	93.0
difference (mg/kg)		1.1	3.0	7.0	-0.2	-0.011	-1.2	-0.1	0.0	0.012	-0.3	0.0	500	-2.0
RPD (%)		5.8	11.8	7.1	2.2	15.0	5.9	0.5	0.0	7.9	3.5	0.0	2.5	2.1

3.3.2 Total organic carbon (TOC)

Within-batch laboratory data variability for TOC analysis was assessed by analysis of blind duplicate analysis of two samples – Middlemore BRS and Brighams UWH (rep 2). Data are summarised in Table 3-3, and show good agreement between blind duplicates (RPDs <4%).

TOC variability was also assessed from analysis of three replicates of Middlemore BRS (Table 3-5). These results indicate good WB repeatability, with a coefficient of variation (CV, %; N=3) of 4.1%.

Table 3-3 Within-batch variation for total organic carbon (TOC, %) in an UWH site sample (Brighams Rep 2) and Middlemore Bulk Reference Sediment (BRS) submitted to the laboratory as blind duplicates. Differences between duplicates (expressed as relative percentage difference; RPD) are colour coded: Green <15%, Amber 15–30%, Red >30%.

Sample	Result 1	WB Rep	RPD (%)
Middlemore Freeze dried BRS	1.87	1.81	-3.3
Brighams UWH Rep 2	2.50	2.50	0.0

3.3.3 Organic contaminants – PAH, OCPs, PCBs

Variability of PAH analysis was assessed from analysis of blind duplicates of Brighams (UWH) Rep 2 at R J Hill labs (Table 3-4), three replicates of Middlemore BRS at R J Hill labs (Table 3-5), and two replicates at AsureQuality Table 3-6. These results indicate good WB repeatability at both labs, with a coefficient of variation (CV, %; N=3) for total PAH for the R J Hill lab's analyses of 6% for the Middlemore BRS, and RPD (%) between blind duplicates for the Brighams UWH sample of 16% (R J Hill labs) and for the Middlemore BRS sample of 8% (AsureQuality).

However, comparison of the results from the Middlemore BRS analyses, two Long Bay stream samples, and one UWH sample (Rangitopuni) indicated that there was a substantial difference in the concentrations obtained by the two labs, of the order of 34–60% (the exception was for the low concentration Vaughans Stream sample, where <DL values made up a substantial proportion of the total PAH in the R J Hill lab's analysis; see Table 3-8).

The comparison of the PAH results from R J Hill labs and AsureQuality indicate that the R J Hill lab's data are likely to be significantly lower than those obtained by AsureQuality.

This difference possibly reflects, at least in part, the lack of recovery correction in the R J Hill lab's method – average PAH surrogate recoveries ranged between 43% and 81% for the 7 surrogate standards used to monitor PAH compound recoveries.

The comparison between the R J Hill labs and AsureQuality PAH results highlights the need for care in interpreting organic contaminant results between different data providers and over time. This is especially true for low sensitivity analytical methods, which results in many <DL values. There is a potential for substantial variation in analytical results, and therefore when different labs have been used, conclusions regarding differences between sites or years must be made with care.

Organochlorine pesticide (OCP) and PCB results from AsureQuality (Table 3-6) showed good agreement between blind duplicates, with RPDs of 0.2–10%.

Table 3-4 Within-batch variation for PAH in an UWH site sample (Brighams Rep 2) submitted to the laboratory (R J Hill labs) as blind duplicates. Concentrations are in mg/kg. Differences between duplicates (expressed as relative percentage difference; RPD) are colour coded: Green <15%, Amber 15–30%, Red >30%.

Compound	Result 1	WB Rep	RPD (%)
Acenaphthene	< 0.002	< 0.002	-
Acenaphthylene	0.003	0.002	40.0
Anthracene	0.004	0.003	28.6
Benzo[a]anthracene	0.023	0.020	14.0
Benzo[a]pyrene (BAP)	0.041	0.035	15.8
Benzo[b]fluoranthene + Benzo[j]fluoranthene	0.053	0.046	14.1
Benzo[g,h,i]perylene	0.044	0.038	14.6
Benzo[k]fluoranthene	0.021	0.018	15.4
Chrysene	0.027	0.023	16.0
Dibenzo[a,h]anthracene	0.005	0.004	22.2
Fluoranthene	0.056	0.047	17.5
Fluorene	< 0.002	< 0.002	-
Indeno(1,2,3-c,d)pyrene	0.040	0.035	13.3
Naphthalene	< 0.010	< 0.010	-
Phenanthrene	0.019	0.015	23.5
Pyrene	0.062	0.052	17.5
Total PAH (<DL=0)	0.40	0.34	16.3
Total PAH (<DL=DL)	0.41	0.35	15.7
HWPAH (<DL=0)	0.21	0.18	16.7
HWPAH (<DL=DL)	0.21	0.18	16.7

Table 3-5 Summary of replicate analysis (N=3) of Middlemore Bulk Reference Sediment (BRS) for PAH by R J Hill labs.

	TOC	Total PAH (mg/kg)		HWPAH (mg/kg)		HWPAH, mg/kg at 1% TOC	
Sample	%	<D.L. = 0	<D.L. = D.L.	<D.L. = 0	<D.L. = D.L.	<D.L. = 0	<D.L. = 0
Rep 1	1.95	0.780	0.790	0.451	0.451	0.400	0.231
Rep 2	1.80	0.865	0.875	0.484	0.484	0.481	0.269
Rep 3	1.90	0.871	0.881	0.484	0.484	0.458	0.255
Mean	1.88	0.839	0.849	0.473	0.473	0.446	0.252
C.V. (%)	4.1	6.1	6.0	4.0	4.0	9.3	7.5

Table 3-6 Summary of blind duplicate analysis results for Middlemore BRS (sampled and analysed in 2013) and Cox's Bay sediment (sampled and analysed in 2012) by AsureQuality. Note concentrations are in ng/g (parts per billion, µg/kg). <DL values treated as zero for calculation of group totals. Differences between duplicates (expressed as relative percentage difference; RPD) are colour coded: Green <15%, Amber 15–30%, Red >30%.

Site	Year	Rep	Total PAH	HWPAH	Dieldrin	Chlordane	Total DDT	Total PCB
Coxs	2012	1	889	518	0.059	0.027	0.231	0.531
		WB	955	565	0.060	0.029	0.229	0.588
difference between reps (ng/g)			65.6	46.9	0.001	0.003	-0.003	0.057
RPD (%)			7.1	8.7	1.8	9.0	1.1	10.3
Middlemore BRS	2013	1	1231	729	0.455	0.103	1.31	5.73
		WB	1139	672	0.426	0.107	1.30	5.50
difference between reps (ng/g)			-92.3	-57.6	-0.029	0.004	-0.003	-0.226
RPD (%)			7.8	8.2	6.6	4.0	0.2	4.0

Table 3-7 Comparison of PAH results obtained from analysis of Middlemore BRS by R J Hill and AsureQuality labs. Differences between duplicates (expressed as relative percentage difference; RPD) are colour coded: Green <15%, Amber 15–30%, Red >30%. Note that TOC analyses were done at R J Hill labs for all samples.

		TOC	Total PAH		HWPAH	
Sample	Lab	%	mg/kg	mg/kg at 1% TOC	mg/kg	mg/kg at 1% TOC
Rep 1	RJ Hill	1.95	0.780	0.400	0.451	0.231
Rep 2	RJ Hill	1.80	0.865	0.481	0.484	0.269
Rep 3	RJ Hill	1.90	0.871	0.458	0.484	0.255
Mean	RJ Hill	1.88	0.839	0.446	0.473	0.252
Rep 1	Asurequality	1.81	1.231	0.680	0.729	0.403
Rep 2	Asurequality	1.87	1.139	0.609	0.672	0.359
Mean	Asurequality	1.84	1.185	0.644	0.701	0.381
Difference in lab mean concentrations (mg/kg)		-0.04	0.346	0.198	0.228	0.129
Difference in lab mean concentrations (%)		-2.3	34.2	36.3	38.8	40.9

Table 3-8 Comparison of PAH results obtained from analysis of Long Bay stream sediments and Rangitopuni
(UWH site) sediment by R J Hill and AsureQuality labs. Note that the Rangitopuni sample analysed by R J Hills was a single replicate (Rep 2) whereas the AsureQuality analysis was done on a composite formed from N=3 replicates (due to limited sample). Differences between duplicates (expressed as relative percentage difference; RPD) are colour coded: Green <15%, Amber 15–30%, Red >30%.

		Total PAH		HWPAH	
Sample	Lab	<D.L. = 0	<D.L. = D.L.	<D.L. = 0	<D.L. = D.L.
Awaruku Stream Rep 1	RJ Hill	0.142	0.162	0.066	0.068
	Asurequality	0.317	0.317	0.164	0.164
difference between labs (mg/kg)		0.175	0.155	0.098	0.096
RPD between labs (%)		55.2	48.9	59.7	58.4
Vaughan Stream Rep 1	RJ Hill	0.021	0.049	0.012	0.018
	Asurequality	0.045	0.045	0.022	0.022
difference between labs (mg/kg)		0.024	-0.004	0.010	0.004
RPD between labs (%)		53.1	-9.5	44.8	17.2
Rangitopuni UWH Top Rep 2	RJ Hill	0.326	0.340	0.173	0.173
Rangitopuni UWH Top Composite	Asurequality	0.507	0.507	0.274	0.274
difference between labs (mg/kg)		0.181	0.167	0.101	0.101
RPD between labs (%)		35.7	32.9	36.8	36.8

3.4 Analysis of archived samples from 2012

Replicate 4 and 5 samples from four sites sampled in 2012, were stored frozen, and analysed for metals in 2013. The results from the 2013 analyses were compared with the results from the 2012 analysis of replicates 1–3, to check comparability of analysis in each year (or “batch”). This check was made because of the change in sample processing made in 2013 (NIWA sieving and freeze drying, previously R J Hill labs sieved and air/oven dried). These analyses provide data similar to “Blind Between-Batch (BB) Replicates”.

The sites chosen were Chelsea and Kendalls (sandy textured), Panmure (fine consistent mud), and Benghazi (gritty mud).

Comparison of metals data for the 2012 reps 1–3 and the 2013 analyses of archived replicates 4 and 5 is given in Table 3-9.

Agreement between means ranged from 0–21% for extractable metals, and 0.9–8.6% for total recoverable Cu, Pb, and Zn. Total As and Hg showed greater differences between means, 7.6–33%. Most of the 2012 and 2013 mean results for Cu, Pb, and Zn agreed within 15%. These RPDs are similar to the RPDs between WB duplicates (section 3.3.1), except for extractable Cu and total As, which had greater RPDs for the 2012/13 “BB” duplicates (indicating “systematic” differences between 2012 and 2013 results for these elements).

The 2012/13 reanalysis data are generally consistent with the findings of the 2013 BRS analyses (section 3.7), which found reasonably good agreement between the 2013 and

2012 results for most metals, but higher As results in 2013 than obtained in 2012. Note that the CRM results for As were also high in 2013 (section 3.5).

Given that the samples analysed in each year were processed by different labs using different methods, the agreement between the 2012 and 2013 results is reasonably good. It suggests that the sample processing methods employed by NIWA (2013) and R J Hill labs (2012) did not have a major effect on the final results.

The results are also consistent with the general view that differences in metals concentrations (especially for extractable metals) between years of 10–20% may well be sourced from analytical variation, rather than due to any "real" environmental changes.

Table 3-9 Comparison of metals concentrations for the 2012 replicates 1–3 obtained in 2012 with the 2013 analyses of archived replicates 4 and 5 samples (stored frozen since 2012). Values are means (N=3 for 2012 and N=2 for 2013). Differences between duplicates (expressed as relative percentage difference; RPD) are colour coded: Green <15%, Amber 15–30%, Red >30%.

		Extractable metals (<63 μm)			Total Recoverable Metals (<500 μm)				
Site	Year analysed	Cu	Pb	Zn	Cu	Pb	Zn	As	Hg
Benghazi	2012	20.6	25.4	124.0	11.2	16.2	85.8	6.25	0.068
	2013	16.7	22.5	113.5	10.7	16.1	81.0	7.45	0.080
difference (mg/kg)		-3.9	-2.9	-10.5	-0.5	-0.1	-4.8	1.20	0.011
RPD (%)		20.8	12.0	8.8	5.0	0.7	5.8	17.5	15.2
Chelsea	2012	20.6	29.7	108	5.5	12.4	46.8	5.93	0.041
	2013	17.5	26.0	99	5.4	13.4	50.0	8.30	0.050
difference (mg/kg)		-3.1	-3.7	-10.0	-0.1	1.0	3.2	2.37	0.008
RPD (%)		16.4	13.4	9.6	1.9	7.8	6.6	33.4	17.8
Kendall	2012	17.7	19.9	88	4.9	7.3	32.3	5.08	0.026
	2013	16.3	19.6	90	4.7	8.0	33.0	7.10	0.029
difference (mg/kg)		-1.5	-0.3	1.7	-0.3	0.7	0.7	2.02	0.003
RPD (%)		8.6	1.7	1.9	5.6	8.6	2.1	33.1	10.8
Panmure	2012	23.8	30.0	156	25.5	31.3	175.5	7.04	0.186
	2013	21.5	30.0	152	24.5	31.0	168.5	8.35	0.172
difference (mg/kg)		-2.3	0.0	-4.2	-1.0	-0.3	-7.0	1.31	-0.014
RPD (%)		10.1	0.0	2.7	4.0	0.9	4.1	17.0	7.6

3.5 Certified Reference Material analyses

As in previous years, the CRM “AGAL-10” (Hawkesbury River Sediment, Australian Government Analytical Laboratories) was used as a quality control check for metals analysis.

The CRM analyses involved extraction/digestion and ICP-MS analysis only, and did not include the sieving/drying/sub-sampling steps required for analysis of the field samples. This is required because of the high cost of the CRM material.

Five CRM samples were analysed through the analytical run as “unknowns”. In addition, R J Hill Lab’s in-house QC checks included separate CRM analyses – another 5 CRM analyses were performed for total recoverable metals and 4 for extractable metals.

CRM data are summarised in Table 3-10 (for the 5 CRM samples added as extra “unknowns”) and Table 3-11 (from the R J Hill Lab’s in-house QC programme).

All CRM results were within the laboratory in-house limits. This means that the data met the laboratory’s normal operating QC standards. Variability (coefficient of variation, cv %) for CRM analysis ranged between 2% and 7% for the various metals analyses, which is similar to previous years’ results.

Comparisons between measured CRM concentrations and certified concentrations for the five CRMs analysed as unknowns with the RSCMP samples showed that the total recoverable metals were, on average, within the certified ranges. [Note that Cr and Ni were much lower than the certified concentrations. This is because the EPA200.2 total recoverable metals digestion method recovers less of these metals than the stronger aqua regia digest used in the CRM certification – see footnote to the R J Hill lab QC report, Appendix C]. For the lab QC CRM sample data, average Fe and Zn were slightly lower than the certified lower limits.

Apart from Cr and Ni (see previous comment), average CRM concentrations were within approximately 15% of the certified concentrations – for the 5 CRMs added to the 2013 sample batch, average total As was 15% high, while the other metals ranged from 7% low (Zn and Hg) to 3% high (Cd and Pb). Individual CRM sample analyses were all within 13% of the certified concentrations, except for As, which were up to 22% high. Apart from the higher As results, these results are similar to previous years.

Overall, the CRM results indicate reasonable accuracy and good precision for metals in the 2013 sample analytical batch. However, these results apply only to the digestion and ICP-MS steps of the overall analysis method. Variability may be higher if sample sieving/drying steps were included (as for total analysis of field samples).

Note that there are no certified concentrations for extractable metals, and hence their accuracy cannot be assessed. However, the extractable metals results for the CRM

samples were within the “in house” limits, and are therefore consistent with previous data generated by R J Hill Labs. The variability was low, with CVs (%) of 2–5 %.

Comparisons of all the 2013 CRM results for total recoverable metals with those obtained in previous RDP and RSCMP monitoring conducted between 2002 and 2012 are shown in Figure 3-1, and for extractable metals in Figure 3-2. Trend plots for the 2002–2013 data are shown in Figure 3-3.

The data plotted in Figure 3-2 indicate that the extractable metals, especially Cu and Zn, appeared higher in 2012 than in most previous years (apart, perhaps for 2009). This is consistent with elevated Bulk Reference Sediment (BRS) results obtained in 2012 (Diffuse Sources 2012, and section 3.7). The 2013 extractable metals results for the CRM analysis were lower than in 2012, and were more comparable with the results obtained from earlier years.

There were no significant trends over time for Pb or Zn (Mann Kendall test, $p<0.05$), but Cu showed an increase of 0.52% per annum for total recoverable Cu and 0.81% per annum for extractable Cu (Table 3-12).

The CRM results indicate that the total recoverable metals data have been reasonably consistent over time, with no major consistent increasing or decreasing trends. Variability was similar in 2013 to that observed in previous years.

Overall, the CRM QC data provide a useful tool for monitoring the accuracy and variability of the metals data over time in the sediment monitoring programme. Continued analysis and reporting of CRM data is recommended.

Table 3-10 Metals concentrations (mg/kg) in five Certified Reference Material samples (CRM; AGAL10) included in the 2013 sediment analytical batch. The Certified Upper and Lower Limits are the reference value ±1 standard deviation. Yellow shaded values are outside the certified range (reference value ±1 s.d.). Means, as % of certified values, are colour coded: Green within 10%, Amber within 10–20%, Red greater than 20% of the certified concentrations. Note that Cr and Ni values are low because the EP200.2 digestion method recovers less of these metals than the CRM certification method (which uses a stronger aqua regia digest).

	Extractable metals (<63 μm)			Total Recoverable Metals (<500 μm)							
Sample	Cu	Pb	Zn	As	Cd	Cr	Cu	Pb	Hg	Ni	Zn
CRM - Agal 10 - 1	18.3	37.0	44.0	19.9	9.7	45.0	23.0	43.0	11.2	12.1	52.0
CRM - Agal 10 - 2	19.4	36.0	41.0	19.7	10.0	48.0	22.0	41.0	10.9	11.1	53.0
CRM - Agal 10 - 3	17.2	36.0	42.0	21.0	10.0	51.0	23.0	44.0	11.4	11.9	55.0
CRM - Agal 10 - 4	17.4	36.0	44.0	19.5	9.1	42.0	24.0	40.0	10.4	11.8	54.0
CRM - Agal 10 - 5	17.6	35.0	42.0	19.0	9.4	45.0	23.0	39.0	10.3	10.2	50.0
mean	18.0	36.0	42.6	19.8	9.6	46.2	23.0	41.4	10.8	11.4	52.8
cv (%)	5.0	2.0	3.1	3.7	4.1	7.4	3.1	5.0	4.5	6.8	3.6
Mean % of certified value	n/a	n/a	n/a	115.2	103.3	56.3	99.1	102.5	93.4	64.2	92.6
In-house lower limit (mg/kg; mean - 99% C.L.)	14.1	27.9	32.2	16.18	7.82	27.17	19.58	32.48	10.023	9.52	46.1
In-house upper limit (mg/kg; mean + 99% C.L.)	22.9	46.5	52.2	23.09	11.03	71.86	26.39	48.42	13.61	14.02	62.74
In-house 99% C.I. (mg/kg)	8.8	18.6	20	6.91	3.206	44.69	6.8	15.9	3.587	4.49	16.6
In-house 99% C.I. (+/- % mean)	23.8	25.0	23.7	17.6	17.0	45.1	14.8	19.7	15.2	19.1	15.3
Certified Reference Value (mg/kg)	..... no reference values			17.2	9.33	82	23.2	40.4	11.6	17.8	57
Certified Lower Limit (mg/kg; reference value - 1 s.d.)	..... no reference values			14.2	8.69	71	21.3	37.7	10.5	15.1	52.8
Certified Upper Limit (mg/kg; reference value + 1 s.d.)	..... no reference values			20.2	9.97	93	25.1	43.1	12.7	20.5	61.2

Table 3-11 Metals concentrations (mg/kg) in Certified Reference Material (CRM; AGAL10) samples analysed with the 2013 sediment analytical batch as part of the R J Hill Labs in-house QC process. The Certified Upper and Lower Limits are the reference value ±1 standard deviation. Yellow shaded values are outside the certified range (reference value ±1 s.d.). Means, as % of certified values, are colour coded: Green within 10%, Amber within 10–20%, Red greater than 20% of the certified concentrations. Note that Cr and Ni values are low because the EP200.2 digestion method recovers less of these metals than the CRM certification method (which uses a stronger aqua regia digest).

	Extractable metals (<63 μm)			Total Recoverable Metals (<500 μm)									
Sample	Cu	Pb	Zn	As	Cd	Cr	Cu	Pb	Hg	Ni	Zn	Fe	Mn
CRM - 1				21.0	9.6	47.0	24.0	41.0	11.3	12.0	51.0	18700	250
CRM - 2				18.4	10.2	47.0	22.0	40.0	10.3	11.2	51.0	17300	230
CRM - 3				19.5	10.0	49.0	23.0	42.0	11.2	11.6	54.0		240
CRM - 4				21.0	9.0	41.0	25.0	40.0	10.3	11.8	52.0	17100	230
CRM - 5				18.6	9.5	43.0	20.0	37.0	10.1	10.0	50.0	18000	
mean				19.7	9.7	45.4	22.8	40.0	10.6	11.3	51.6	17775	238
cv (%)				6.4	4.8	7.2	8.4	4.7	5.3	7.0	2.9	4.1	4.0
Mean % of certified value	n/a	n/a	n/a	114.5	103.5	55.4	98.3	99.0	91.7	63.6	90.5	95.1	95.0
In-house lower limit (mg/kg; mean - 99% C.L.)	14.1	27.9	32.2	16.18	7.824	27.17	19.6	32.5	10.023	9.53	46.1	15423	215
In-house upper limit (mg/kg; mean + 99% C.L.)	22.9	46.5	52.2	23.09	11.03	71.86	26.4	48.4	13.61	14.02	62.7	21623	277
In-house 99% C.I. (mg/kg)	8.8	18.6	20	6.91	3.206	44.69	6.8	15.9	3.587	4.49	16.6	6200	62
In-house 99% C.I. (+/- % mean)	23.8	25.0	23.7	17.6	17.0	45.1	14.8	19.7	15.2	19.1	15.3	16.7	12.6
Certified Reference Value (mg/kg)	..... no reference values			17.2	9.33	82	23.2	40.4	11.6	17.8	57	18700	250
Certified Lower Limit (mg/kg; reference value - 1 s.d.)	..... no reference values			14.2	8.69	71	21.3	37.7	10.5	15.1	52.8	18830	230.5
Certified Upper Limit (mg/kg; reference value + 1 s.d.)	..... no reference values			20.2	9.97	93	25.1	43.1	12.7	20.5	61.2	21170	251.5

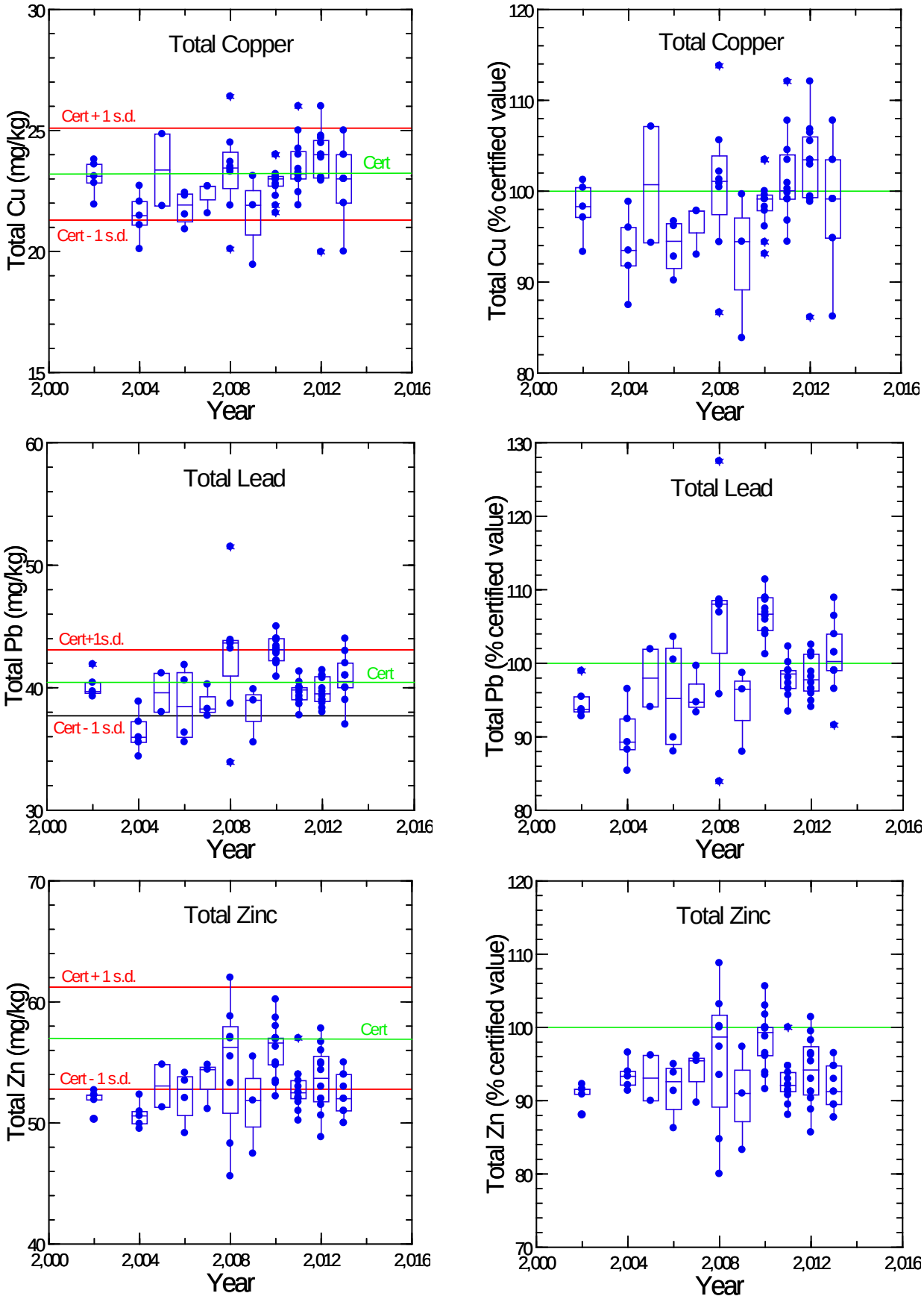

Figure 3-1 Certified Reference Material (CRM) quality control data for Total Recoverable Metals in CRM AGAL-10 for RDP/RSCMP samples analysed in 2002 to 2013. Plots show concentrations, with certified values and upper and lower limits (±1 s.d.), and as percentages of the certified values.

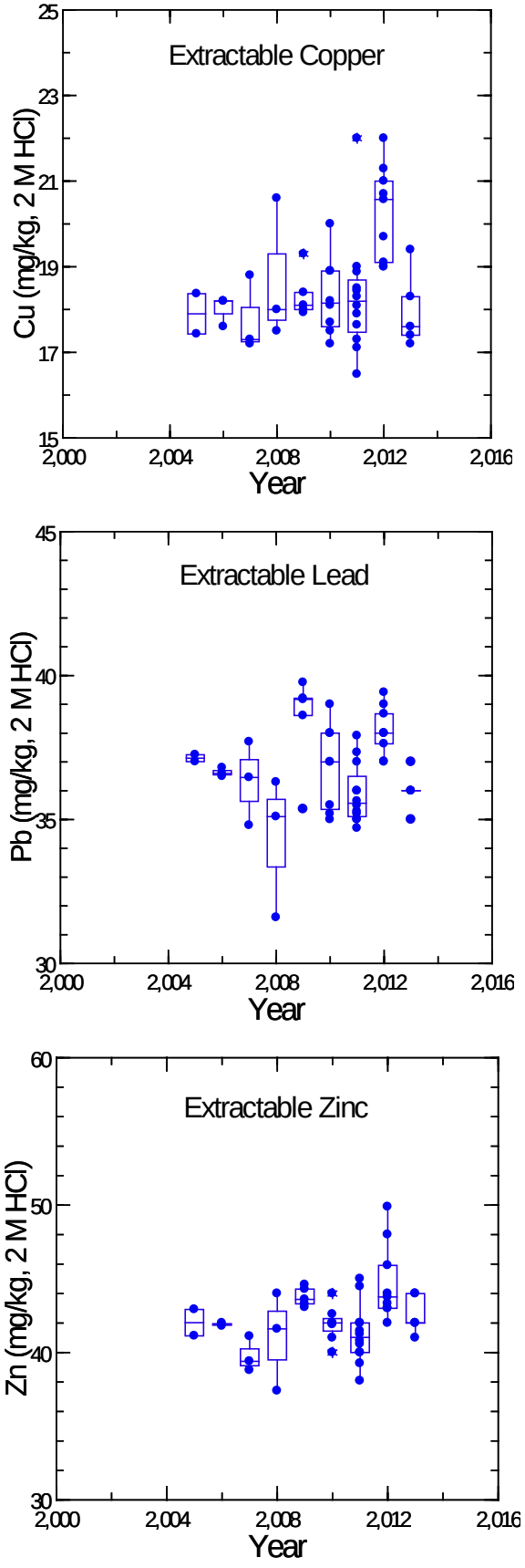

Figure 3-2 Certified Reference Material (CRM) quality control data for extractable metals (2 M HCl) in CRM AGAL-10 for samples analysed in 2005 to 2013. Note there are no certified values for extractable metals in AGAL-10.

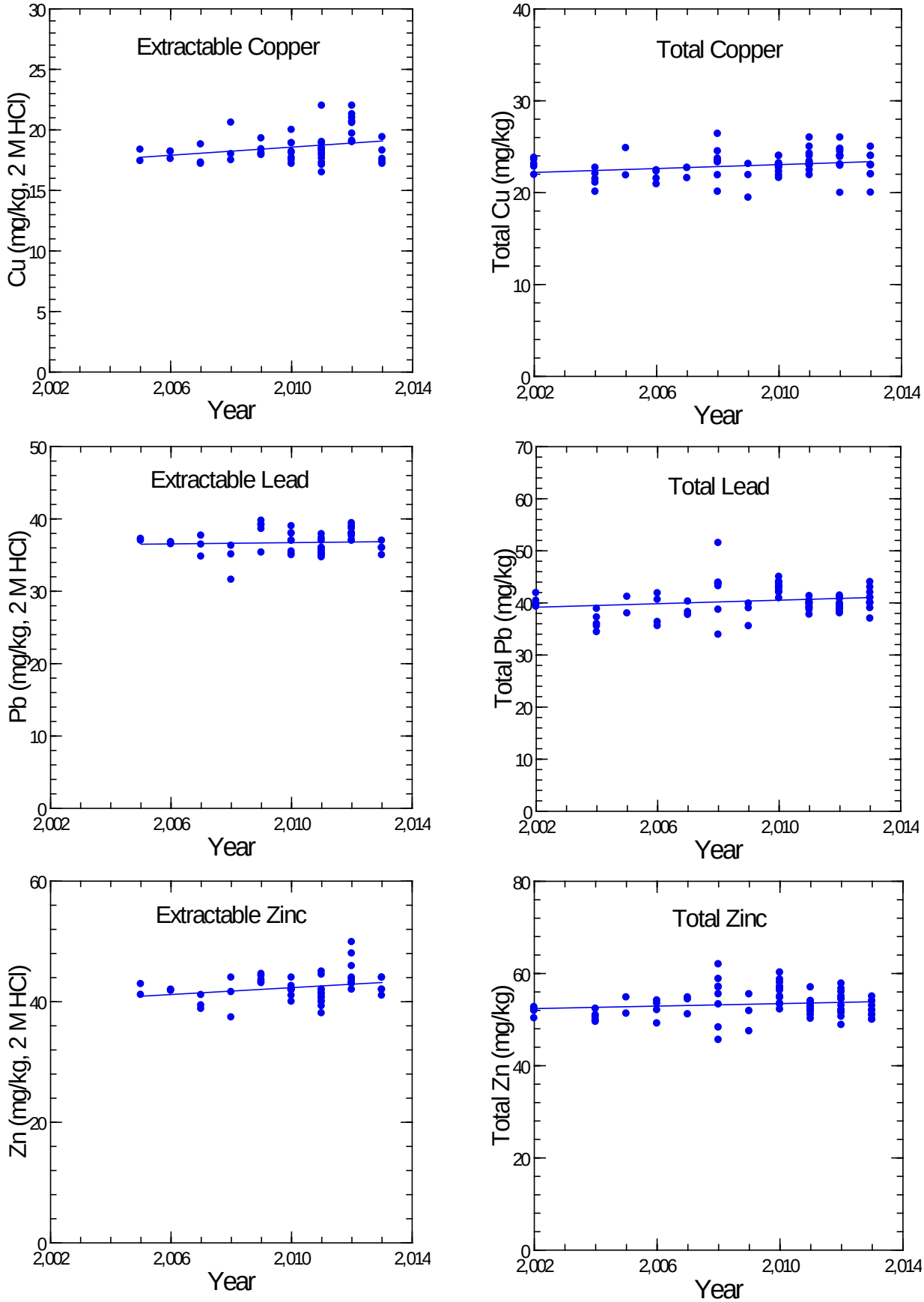

Figure 3-3 Trends in extractable and total recoverable metals in Certified Reference Material (CRM AGAL-10) for samples analysed from 2002–2013.

Table 3-12 Trends in metals in CRM (AGAL-10) analysed from 2002–2013.
Results from Mann Kendal trend test. Significant trends in red.

Metal	Period	Median (mg/kg)	P	Median annual Sen slope (mg/kg/yr)	Sen Slope 5% confidence limit	Sen Slope 95% confidence limit	RSSE (% median value per year)
Extractable Cu	2005 to 2013	18.3	0.045	0.15	0.02	0.30	0.81
Extractable Pb	2005 to 2013	36.9	0.867	0.00	-0.17	0.19	0.00
Extractable Zn	2005 to 2013	42.0	0.084	0.20	0.00	0.50	0.48
Total Cu	2002 to 2013	23.0	0.006	0.12	0.04	0.21	0.52
Total Pb	2002 to 2013	40.0	0.474	0.05	-0.10	0.25	0.13
Total Zn	2002 to 2013	53.0	0.943	0.00	-0.16	0.18	0.00

3.6 Spike recovery data

Measuring the recovery of analytes added ("spiked") to sediment samples provides additional information on the accuracy and variability of the analytical data.

Spike recovery data were reported by R J Hill labs for:

- extractable metals, for five blanks and five spiked sediment samples (data are summarised in Table 3-13);
- PAH – three spiked samples (Table 3-14); and
- TPH – three spiked samples.

In addition, "system monitoring compound" (SMC) or analytical "surrogates" – compounds added to each sample to measure the efficiency and variability of target compound recoveries – for PAH were reported by R J Hill labs for 20 samples. These data are summarised in Table 3-14.

PAH, OCPs, and PCBs analysed by AsureQuality used isotope dilution high resolution gas chromatography-mass spectrometry (HRGC-MS). In this technique, the reported analyte concentrations are corrected for recovery (losses occurring during analysis) from isotopically-labeled (^{13}C) analogues of the target compounds. Recoveries are reported for each analyte (in each sample). The actual recoveries are not so critical with this technique because the final concentration data are recovery corrected. They have therefore not been included in the following discussion, but are given in the AsureQuality lab reports (see Mills 2014b).

3.6.1 Extractable metals

The data summarised in Table 3-13 show that, on average, extractable metals were reasonably well recovered (90–96%) with relatively low variability (CVs of 2.4–5.6%). Recoveries of Pb and Zn were a few per cent lower for spiked sediments than for blanks (no sediment present). The lowest recovery was 85% (for Zn added to Pakuranga Upper Rep 1).

Overall, the spike recovery results indicate that, on average, up to 10% of these metals are typically unrecovered during the analysis. This is a fairly “significant” amount below the 100% target, and would be expected to translate into slightly lower concentrations of extractable metals for samples analysed in 2013 (compared with years where recoveries were higher). For individual samples, the “losses” could be up to 15%, and ranged from 1% to 15%. This represents a reasonably significant level of variation between individual samples.

Table 3-13 Spike recoveries (%) for extractable (2 M HCl, <63 µm) metals analysis (R J Hill labs)

	Extractable metals (<63 µm)		
A. Sample spikes	Cu	Pb	Zn
Anns Rep 3	85	91	91
Pakuranga Upper Rep 1	97	92	85
Paremoremo Rep 2	90	87	91
Whau Wairau Rep 1	90	89	88
Lucas Te Wharau (LucU) Rep 2	97	92	98
mean sample spike recovery (%)	91.8	90.2	90.6
c.v. (%)	5.63	2.40	5.33

	Extractable metals (<63 um)		
B. Blank spikes	Cu	Pb	Zn
1	86	91	91
2	94	96	98
3	90	96	96
4	92	90	95
5	93	94	99
mean blank spike recovery (%)	91.0	93.4	95.8
c.v. (%)	3.48	2.99	3.25

3.6.2 PAH

Spike recovery data for PAH are presented in Table 3-14. These data indicate that spike recoveries were quite variable, between compounds and also between samples. For all the PAH compounds analysed, the average recovery in the three spiked samples was 78%, with individual sample compound recoveries ranging from 44–105%. For “high molecular weight PAH” (HWPAH), the average recovery was 84% (69–98%).

These data indicate that PAH results are likely to be, on average, approximately 20% lower than “true” (or recovery corrected) values, with the HWPAH being more accurate than total PAH (which includes more volatile compounds that are more easily lost during analysis).

Surrogate recovery data for 20 samples analysed in 2013, summarised in Table 3-15, indicate recoveries of around 68–81% (on average) for the HWPAH. Individual samples had recoveries of 46–101% for the surrogates representative of the HWPAH compounds.

These results indicate that, on average, the PAH data generated by R J Hill labs are likely to be at least approximately 20% lower than “true” values, and that considerable variability between individual samples could be expected. Comparisons of the results from AsureQuality and R J Hill labs (section 3.3.3), which showed that substantially higher results were obtained from AsureQuality (where recovery correction was used), support this.

The key implication of the low and variable recoveries obtained by R J Hill labs (coupled with no recovery correction) and the differences in the results observed between the two labs is that in order to reliably measure trends in PAH concentrations (or differences between sites from different surveys) consistent analytical methods should be used. If different methods (or labs) are used, QA data must be obtained to confirm the comparability of results (e.g. use of CRM or BRS samples). The QA results from 2013 indicate that differences between labs could be of the order of 30–60% (as discussed in section 3.3.3),

Table 3-14 Spike recoveries (%) for PAH analysis (R J Hill labs).
Green values indicate recoveries of 80–120%, amber 70–80% or 120–130%, and red <70% or >130%.

	Sample (Lab Code)					
Compound	1233136.4s	1233136.4sd	1233136.4slcs	mean	stdev	cv (%)
Acenaphthene	54	48	57	53.0	4.6	8.6
Acenaphthylene	54	46	52	50.7	4.2	8.2
Anthracene	67	64	63	64.7	2.1	3.2
Benzo[a]anthracene	100	83	72	85.0	14.1	16.6
Benzo[a]pyrene (BAP)	89	79	57	75.0	16.4	21.8
Benzo[b]fluoranthene + Benzo[j]fluoranthene	101	85	71	85.7	15.0	17.5
Benzo[g,h,i]perylene	105	95	77	92.3	14.2	15.4
Benzo[k]fluoranthene	97	87	76	86.7	10.5	12.1
Chrysene	103	89	73	88.3	15.0	17.0
Dibenzo[a,h]anthracene	92	86	73	83.7	9.7	11.6
Fluoranthene	101	89	71	87.0	15.1	17.4
Fluorene	57	52	60	56.3	4.0	7.2
Indeno(1,2,3-c,d)pyrene	102	91	72	88.3	15.2	17.2
Naphthalene	51	44	55	50.0	5.6	11.1
Phenanthrene	66	70	67	67.7	2.1	3.1
Pyrene	101	87	70	86.0	15.5	18.1

Table 3-15 PAH surrogate ("system monitoring compound; SMC) recoveries (%) for 20 samples analysed in 2013. Analysis by R J Hill labs. Green values indicate recoveries of 80–120%, amber 70–80% or 120–130%, and red <70% or >130%.

Surrogate	mean	stdev	cv (%)
biphenyl-d10	43.4	2.9	6.6
acenaphthylene-d8	62.9	9.0	14.4
anthracene-d10	75.0	8.3	11.0
fluoranthene-d10	67.6	6.8	10.0
benzo[a]anthracene-d12	75.5	10.6	14.1
benzo[a]pyrene-d12	80.7	11.0	13.7
dibenzo[a,h]anthracene-d14	75.4	13.7	18.1

3.6.3 TPH

TPH spike recoveries were measured on three samples. Values of 113%, 111%, and 106% (mean 110%, CV 3.3%). These are sufficiently accurate for the TPH screening conducted for the Long bay Stream sediment work (Mills 2014a).

3.7 Bulk Reference Sediment results

Bulk Reference Sediment (BRS) sample analysis in 2013 consisted of:

- Three samples from each of the sandy Meola Outer and muddy Middlemore sites, both frozen and freeze-dried forms, were analysed for metals. The results for metals are summarised in section 3.7.1;
- Three BRS samples (frozen form only) from each of the Middlemore and Meola Outer sites were analysed for particle size distribution (PSD). The results for PSD are summarised in section 3.7.2;
- Three replicates of the Middlemore BRS (freeze dried, <500 µm) were analysed for PAH and TOC by R J Hill labs.
- Two replicates (one sample, one blind duplicate) of the muddy Middlemore BRS (freeze dried, <500 µm) were analysed for PAH, OCP, and PCB by AsureQuality.
- The PAH, OCP, and PCB results from AsureQuality and R J Hill labs were summarised in section 3.3.3 (Table 3-5

- Table 3-6, and Table 3-7). Additional detail is provided in section 3.7.3 below.

Single Site Reports (SSRs) for the BRS samples have been updated with the 2013 results and provided separately to Auckland Council.

3.7.1 Metals

The 2013 BRS metals data had low within-batch variability with CVs (N = 3) of 1.3–5.3% for extractable metals (<63 µm), and 0–11.8% for total recoverable metals (<500 µm). For the primary monitoring metal contaminants (Cu, Pb, and Zn), CVs ranged from 0–5.4%. Data are summarised in Table 3-16.

Table 3-16 Summary of Bulk Reference Sediment (BRS) results for metals (mg/kg dry weight) obtained with the 2013 monitoring batch. Comparison of frozen and freeze dried (FD) samples – t-test significance Red p<0.05. N = 3 replicates for each sample type.

		Extractable Metals (<63 μm)			Total Metals (<500 μm)							
Site	Type	Cu	Pb	Zn	Cu	Pb	Zn	As	Hg	Cd	Cr	Ni
Middlemore	FD mean (mg/kg)	31.3	43.3	283.3	29.0	35.3	220.0	9.5	0.184	0.158	29.7	12.0
	FD stdev (mg/kg)	0.58	0.58	5.77	0.00	0.58	0.00	0.20	0.016	0.004	0.58	0.12
	FD c.v. (%)	1.8	1.3	2.0	0.0	1.6	0.0	2.1	8.4	2.8	1.9	1.0
	Frozen mean (mg/kg)	31.7	41.3	246.7	30.7	35.3	223.3	9.5	0.173	0.156	27.3	11.8
	Frozen stdev (mg/kg)	1.53	1.15	5.77	0.58	1.53	11.55	0.31	0.012	0.018	3.21	0.52
	Frozen c.v. (%)	4.8	2.8	2.3	1.9	4.3	5.2	3.2	6.9	11.3	11.8	4.4
	difference in means (mg/kg)	0.3	-2.0	-36.7	1.7	0.0	3.3	0.0	-0.012	-0.002	-2.3	-0.167
	difference in means (%)	1.1	-4.7	-13.8	5.6	0.0	1.5	0.4	-6.5	-1.3	-8.2	-1.4
	p (2-sample t-test)	0.751	0.076	0.001	0.038	1.000	0.667	0.883	0.364	0.865	0.335	0.638
Meola Outer	FD mean (mg/kg)	16.3	60.7	273.3	2.9	8.9	40.7	2.7	0.033	0.070	4.633	1.7
	FD stdev (mg/kg)	0.62	1.53	5.77	0.10	0.26	2.08	0.12	0.002	0.007	0.12	0.06
	FD c.v. (%)	3.8	2.5	2.1	3.4	3.0	5.1	4.3	4.6	10.5	2.5	3.3
	Frozen mean (mg/kg)	21.7	48.7	170.0	2.8	8.8	39.7	2.8	0.034	0.063	4.300	1.6
	Frozen stdev (mg/kg)	1.15	1.15	4.36	0.15	0.46	1.15	0.12	0.004	0.003	0.17	0.17
	Frozen c.v. (%)	5.3	2.4	2.6	5.4	5.2	2.9	4.1	10.4	4.2	4.0	10.8
	difference in means (mg/kg)	5.4	-12.0	-103.3	-0.1	-0.1	-1.0	0.2	0.000	-0.007	-0.333	-0.133
	difference in means (%)	28.3	-22.0	-46.6	-2.3	-1.1	-2.5	6.1	1.0	-11.0	-7.5	-8.0
	p (2-sample t-test)	0.005	0.001	0.000	0.567	0.764	0.518	0.152	0.891	0.221	0.059	0.313

As reported in Diffuse Sources (2013), extractable metals (<63 µm fraction) concentrations in the 2012 BRS analyses were much higher than those recorded in 2011, for both frozen and freeze dried BRS samples, and for both the Meola Outer and Middlemore sites. Differences in means were large and statistically significant.

In the 2013 BRS analyses, extractable metals (<63 µm fraction) were comparable with the 2012 results (and therefore substantially higher than the 2011 data) for both frozen and freeze dried material, and for both Meola Outer and Middlemore BRS samples. A comparison of the 2012 and 2013 results is given in Table 3-17 and shown in Figure 3-4, Figure 3-5 and Figure 3-6.

Table 3-17 Comparison of metals concentrations (mg/kg dry weight) in Bulk Reference Sediment (BRS) analysed in 2012 and 2013.
RPD (%) – relative percentage difference between mean values. Red values indicate significant differences in means; t-test, p<0.05. N = 6 BRS samples analysed in 2012 and N=3 in 2013.

			Extractable Metals (<63 um)			Total Metals (<500 um)				
BRS Sample	Measure	% Mud	Cu	Pb	Zn	Cu	Pb	Zn	As	Hg
Meola Outer FD	mean 2012	n/a	19.1	58.3	248.8	3.1	9.1	42.1	2.3	0.030
	mean 2013	n/a	16.3	60.7	273.3	2.9	8.9	40.7	2.7	0.033
	difference (mg/kg)		-2.8	2.4	24.5	-0.2	-0.2	-1.5	0.4	0.003
	RPD (%)		-15.6	4.0	9.4	-7.0	-2.2	-3.6	14.4	9.7
	t-test p-value		0.002	0.257	0.029	0.043	0.396	0.345	0.016	0.183

			Extractable Metals (<63 um)			Total Metals (<500 um)				
BRS Sample	Measures	% Mud	Cu	Pb	Zn	Cu	Pb	Zn	As	Hg
Meola Outer Frozen	mean 2012	3.1	26.2	50.0	163.3	3.1	9.1	41.6	2.2	0.029
	mean 2013	2.9	21.7	48.7	170.0	2.8	8.8	39.7	2.8	0.034
	difference (mg/kg)	-0.2	-4.6	-1.3	6.7	-0.3	-0.3	-2.0	0.6	0.004
	RPD (%)	-7.1	-19.1	-2.7	4.0	-9.9	-3.9	-4.9	24.8	13.4
	t-test p-value	0.149	0.107	0.767	0.520	0.064	0.319	0.078	0.002	0.161

			Extractable Metals (<63 um)			Total Metals (<500 um)				
BRS Sample	Measures	% Mud	Cu	Pb	Zn	Cu	Pb	Zn	As	Hg
Middlemore FD	mean 2012	n/a	33.7	42.5	272.9	30.6	35.0	233.0	7.9	0.164
	mean 2013	n/a	31.3	43.3	283.3	29.0	35.3	220.0	9.5	0.184
	difference (mg/kg)		-2.4	0.8	10.4	-1.6	0.3	-13.0	1.6	0.020
	RPD (%)		-7.3	2.0	3.7	-5.4	0.9	-5.7	18.1	11.4
	t-test p-value		0.131	0.223	0.189	0.028	0.636	0.025	0.000	0.139

			Extractable Metals (<63 um)			Total Metals (<500 um)				
BRS Sample	Measures	% Mud	Cu	Pb	Zn	Cu	Pb	Zn	As	Hg
Middlemore Frozen	mean 2012	69.2	34.1	40.7	247.4	29.7	34.1	228.7	7.8	0.152
	mean 2013	68.2	31.7	41.3	246.7	30.7	35.3	223.3	9.5	0.173
	difference (mg/kg)	-0.9	-2.4	0.7	-0.7	1.0	1.2	-5.3	1.8	0.020
	RPD (%)	-1.4	-7.4	1.7	-0.3	3.2	3.5	-2.4	20.5	12.6
	t-test p-value	0.030	0.098	0.620	0.878	0.198	0.326	0.525	0.001	0.080

Differences in mean concentrations for extractable metals between 2013 and 2012 were relatively small (0.3–7% for Middlemore, and 3–19% for Meola Outer). Statistically significant differences between the 2012 and 2013 results (t-test, 2-sided, p<0.05) were only observed for Cu and Zn in the Meola Outer freeze dried BRS.

For total recoverable Cu, Pb, and Zn (<500 µm fraction), differences between 2012 and 2013 were relatively small:

- For the Middlemore BRS, 0.9–5.7%, with significant differences (t-test, 2-sided, $p<0.05$) observed for Cu (5.4%) and Zn (5.7%) in the freeze dried samples – both lower in 2013 than in 2012.
- For the Meola Outer BRS, differences were 2.2–9.9%, with significant differences (t-test, 2-sided, $p<0.05$) observed for Cu in the freeze dried samples – 7% lower in 2013 than in 2012.

For total recoverable As, 2013 concentrations were 14–25% higher than the 2012 results. Absolute concentration differences were 0.4 and 0.6 mg/kg for Meola Outer, and 1.6 and 1.8 mg/kg for Middlemore. The differences were statistically significant. Note that the CRM results for As were also high in 2013 (section 3.5).

For total recoverable Hg, 2013 concentrations were 9.7–13.4% higher than the 2012 results. The differences were not significant.

Overall, the metals results from the 2013 analyses were generally comparable with those obtained in 2012, but both 2013 and 2012 data were substantially higher than the results obtained in 2011. Statistically significant differences between 2013 and 2012 mean data were observed for:

- extractable Cu and Zn in the Meola Outer freeze dried BRS (Cu 15% lower in 2013 than in 2012, and Zn 9% higher);
- total recoverable Cu and Zn in the Middlemore freeze dried BRS (5.4% and 5.7% lower respectively in 2013 than in 2012);
- total recoverable Cu in the Meola Outer freeze dried BRS (7% lower in 2013);
- total recoverable As in both frozen and freeze dried samples from both Meola Outer and Middlemore (14–25% higher in 2013).

Based on the BRS results, 2012 and 2013 data are probably reasonably consistent, but substantial differences in extractable metals between 2011 and 2013 from analytical variation would be expected. Total recoverable metals results were generally reasonably consistent between 2011 and 2013.

A comparison of the results for frozen and freeze dried samples in 2013 (Table 3-16 and Figure 3-7) showed:

- No significant differences between frozen and freeze dried samples for total recoverable metals, except for a small (1.7 mg/kg, or 5.6%) difference for Cu in the Middlemore BRS.
- Substantial differences between frozen and freeze dried samples for extractable metals (<63 µm fraction). Mean concentrations in the freeze dried material were significantly higher for Pb and Zn in the Meola Outer and for Zn in the Middlemore samples, but were lower for Cu in the Meola Outer samples.

These differences between the frozen and freeze-dried samples are generally consistent with results obtained in 2011 and 2012.

Based on the BRS results obtained to date, it can be concluded that freeze dried and frozen BRS material are likely to give comparable results for total recoverable metals, but not necessarily for extractable metals especially Zn, which was different (higher in the freeze dried material) in both the muddy Middlemore and sandy Meola OZ samples. The reason for the differences in extractable metals between the freeze dried and frozen samples is unknown.

Overall, the key result from the BRS analyses in 2013 (and 2012) was the substantially higher extractable metals results than were obtained in 2011, particularly for the sandy sediment (which has a low mud fraction content). This needs to be taken into consideration when comparing the 2013 (and 2012) RSCMP data with that from earlier years.

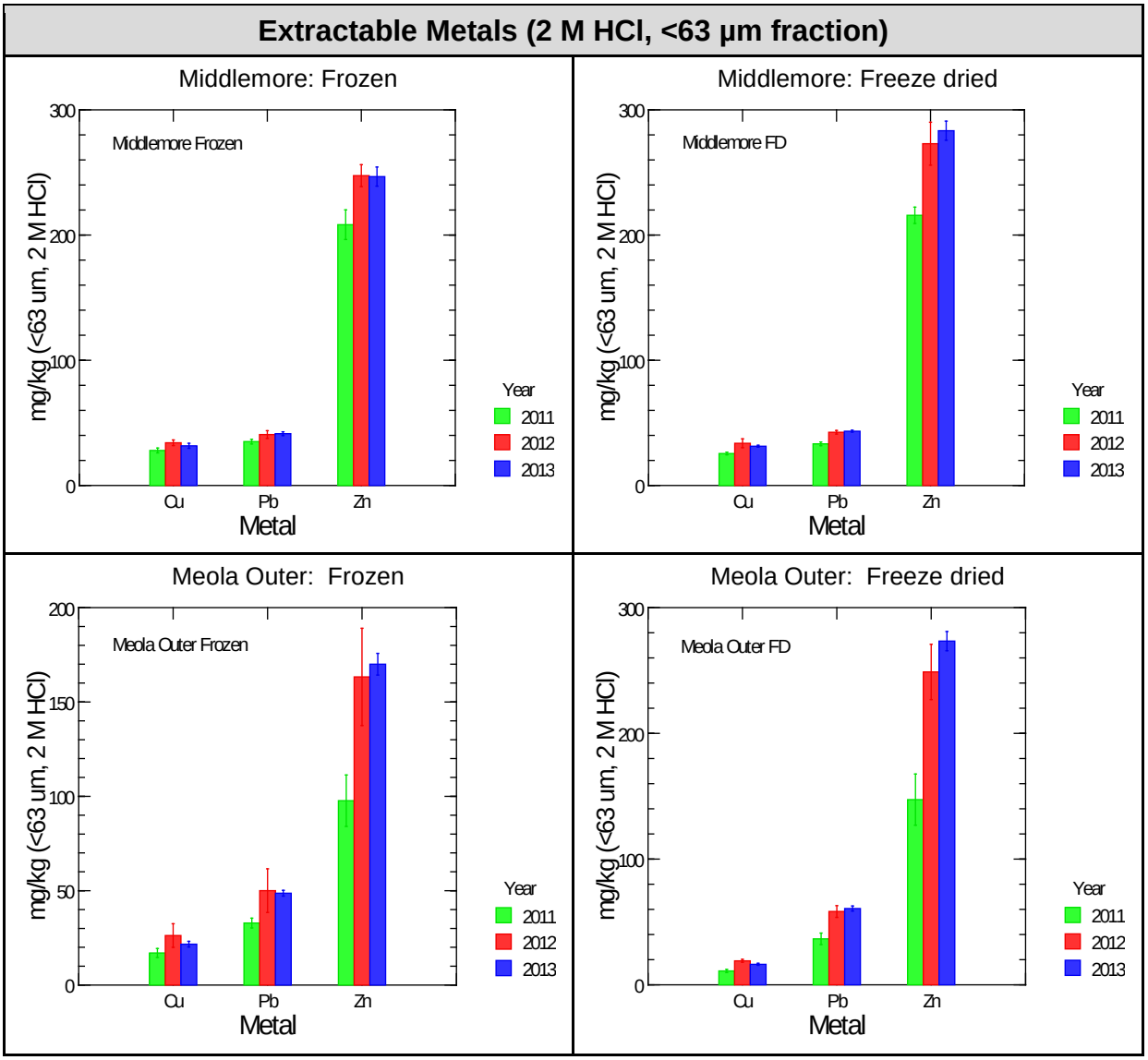

Figure 3-4 Extractable metals (<63 µm fraction) results for frozen and freeze-dried bulk reference sediments (BRS) analysed with RSCMP samples in 2011, 2012, and 2013. Bars are means ±1 standard deviation (N=6 for 2011, N=6 for 2012, and N=3 for 2013).

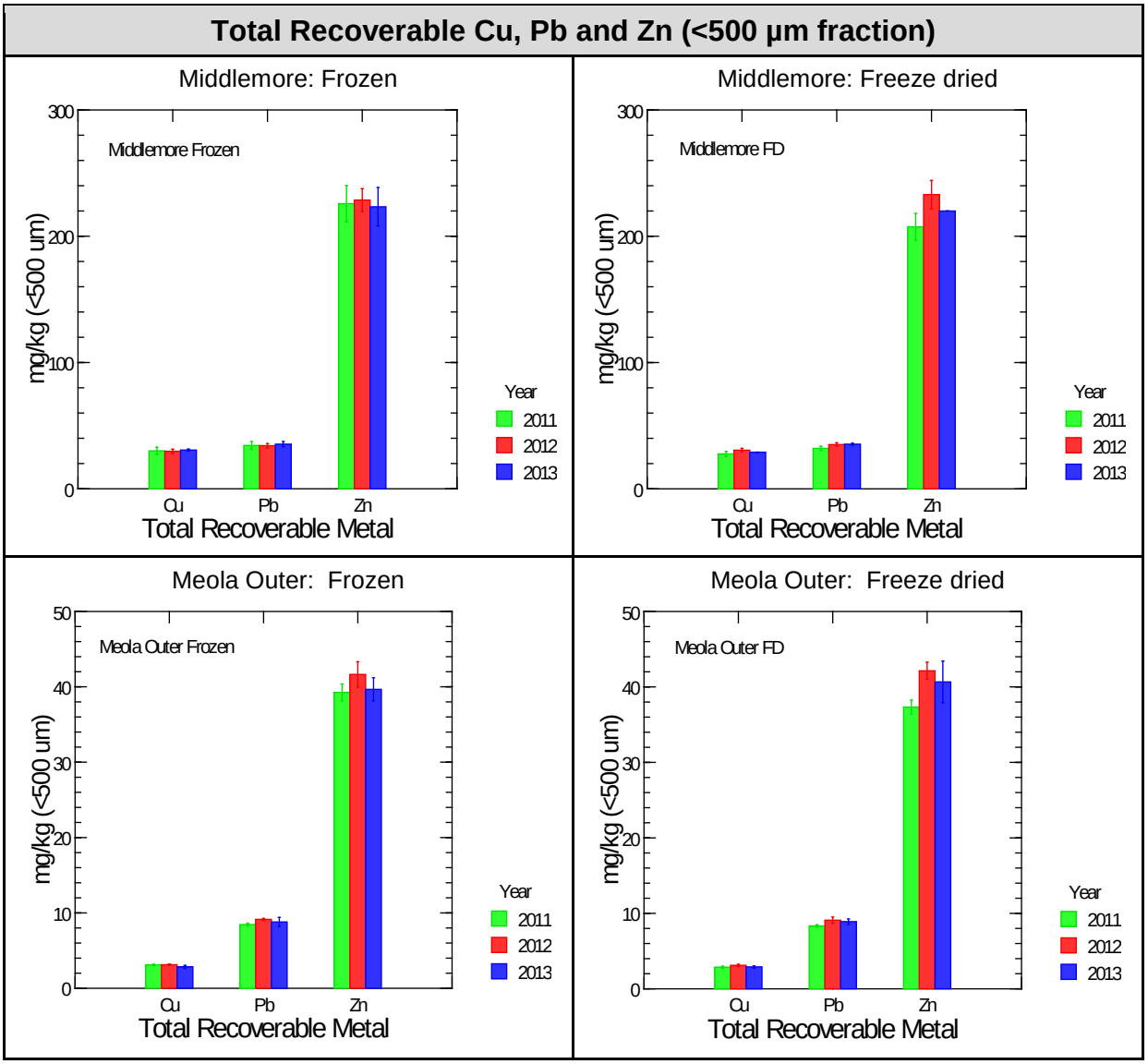

Figure 3-5 Total recoverable Cu, Pb, and Zn (<500 µm fraction) results for frozen and freeze-dried bulk reference sediments (BRS) analysed with RSCMP samples in 2011 and 2012. Bars are means ±1 standard deviation (N=6 for 2011, N=6 for 2012, and N=3 for 2013).

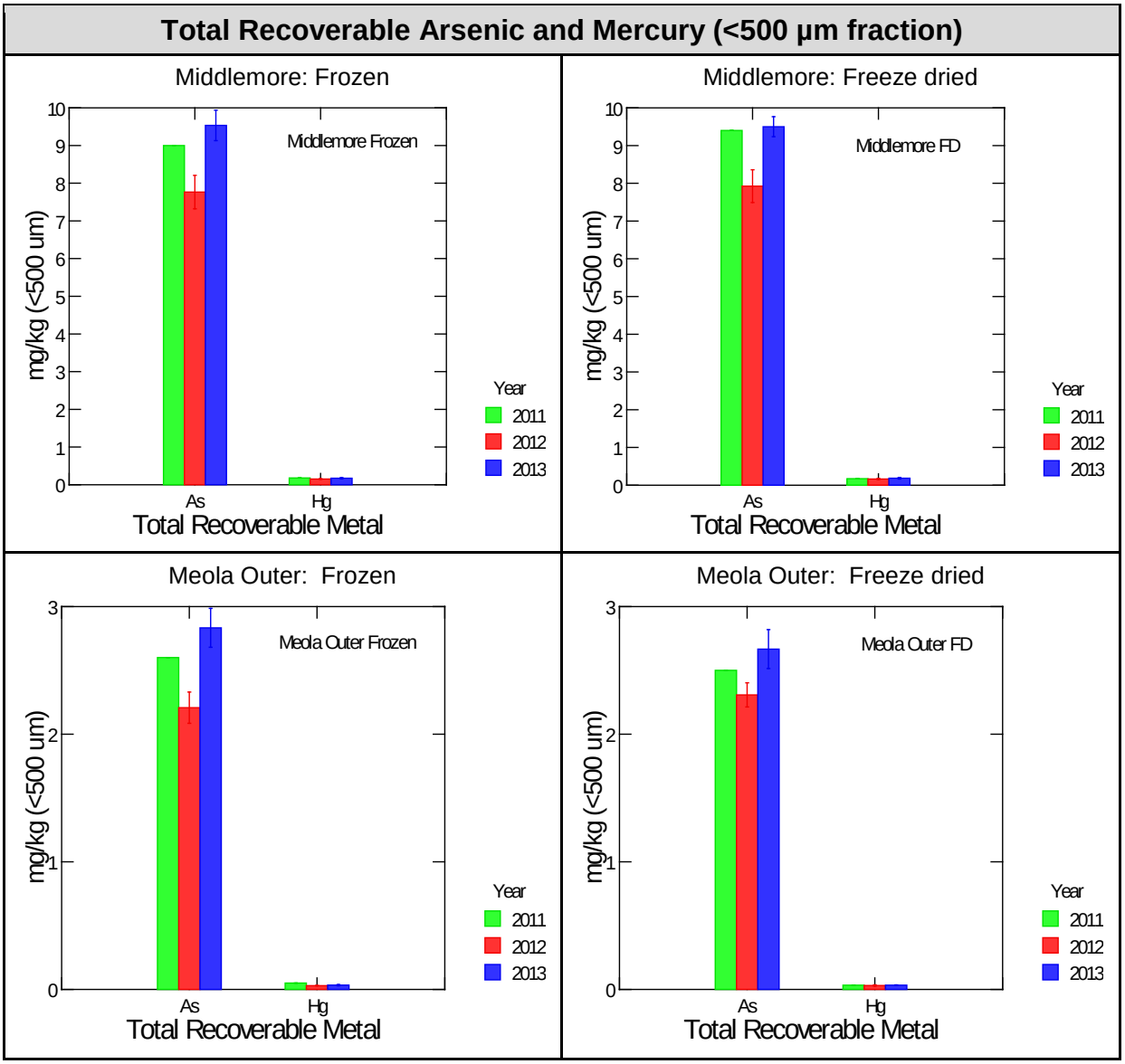

Figure 3-6 Total recoverable As and Hg (<500 µm fraction) results for frozen and freeze-dried bulk reference sediments (BRS) analysed with RSCMP samples in 2011 and 2012. Bars are means ±1 standard deviation (N=1 for 2011, N=6 for 2012, and N=3 for 2013).

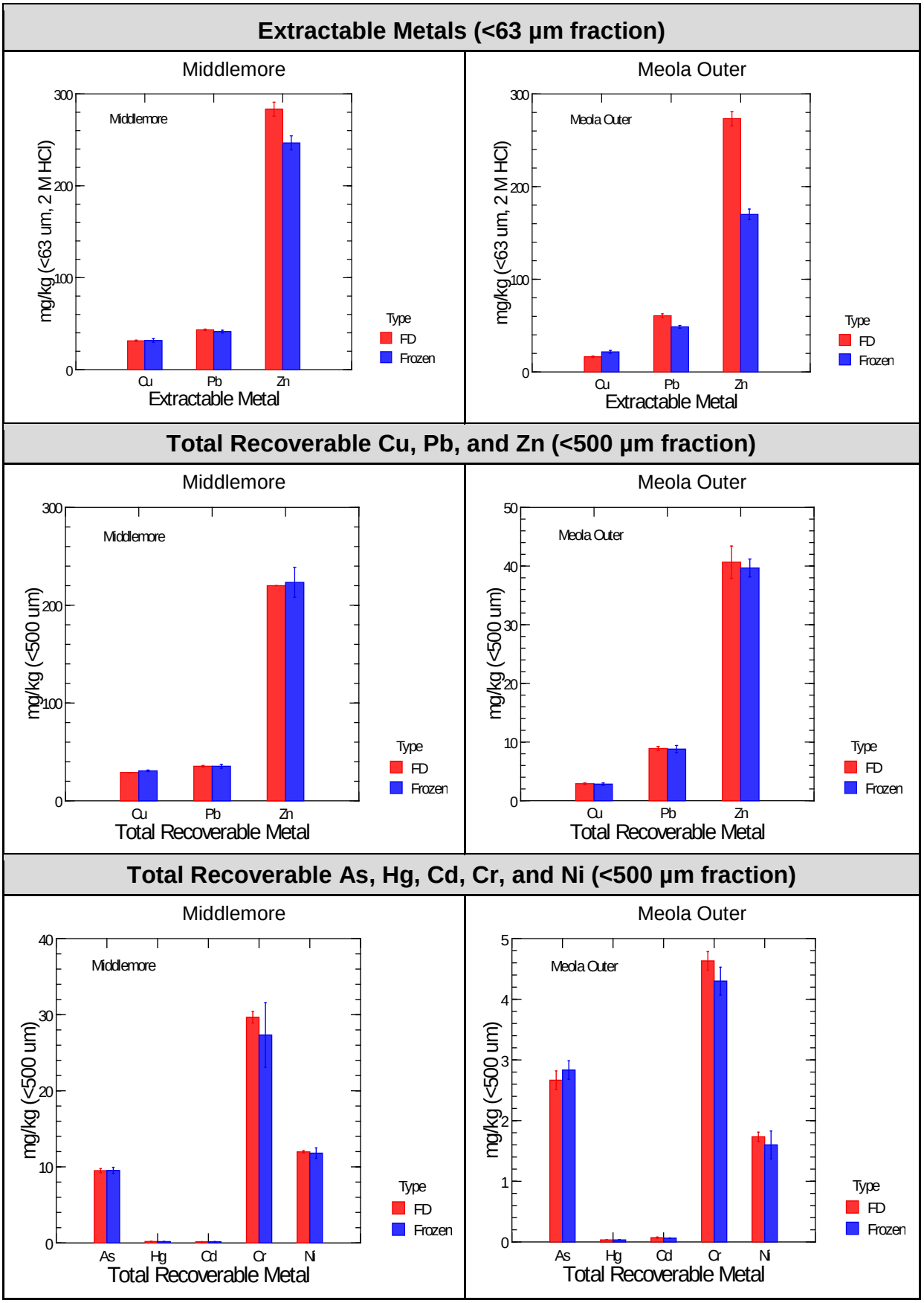

Figure 3-7 Comparison of metals results for frozen and freeze-dried bulk reference sediments (BRS) analysed with RSCMP samples in 2013. Bars are means ±1 standard deviation (N=3).

3.7.2 Particle size distribution

A summary of the 2013 PSD results is given in Table 3-18, and a comparison of 2011, 2012, and 2013 data in Table 3-19 and Figure 3-8.

The BRS results indicate that the sieve/pipette method is giving reproducible “mud content” (% <63 µm) results. Variability is low, with CVs of <1% for the muddy sediment (Middlemore) and <6% for the sandy sediment (Meola Outer).

Comparison of 2013 results with those from 2011 and 2012 showed:

- For Middlemore: Substantial differences in % silt and % clay were measured between 2011 and 2012, but much smaller differences between 2012 and 2013. Mud content (silt + clay) was relatively consistent – means were 66.7% in 2011, 69.1% in 2012, and 68.1% in 2013. While these differences in mud content were relatively small, they were statistically significant (Kruskall Wallis test between medians, p=0.027).
- For Meola Outer: Consistent results for all fractions were obtained between years, even for the minor fractions with <2% abundance. There was no significant difference in mud content between the years (Kruskall Wallis test between medians, p=0.148).

Only three sets of analyses of the BRS for PSD have been undertaken so far (2011, 2012, and 2013), so conclusions about the longer-term performance of the sieve/pipette method cannot yet be drawn. However, the results obtained to date indicate the method is providing mud content data with low variability and good year-to-year reproducibility.

Table 3-18 Summary of particle size distribution (PSD) results for Bulk Reference Sediment (BRS) obtained with the 2013 monitoring sample batch.
BRS for PSD are archived in frozen form.

Texture Class	Gravel	Coarse Sand	Medium Sand	Fine Sand	Silt	Clay	% of total sediment		% of <500 μm fraction
Particle size range	>2000 μm	500-2000 μm	250-500 μm	62.5-250 μm	3.9-62.5 μm	0-3.9 μm	<63 μm	<500 μm	<63 μm
Middlemore:									
MID PS17	0.00	0.19	0.58	30.83	47.28	21.11	68.39	99.81	68.52
MID PS38	0.04	0.15	0.62	31.02	46.09	22.08	68.17	99.82	68.29
MID PS64	0.05	0.18	0.56	31.51	44.88	22.82	67.71	99.78	67.86
mean	0.03	0.17	0.59	31.12	46.08	22.00	68.09	99.80	68.23
s.d.	0.02	0.02	0.03	0.35	1.20	0.86	0.35	0.02	0.34
c.v. (%)	88.83	13.78	5.67	1.12	2.60	3.91	0.51	0.02	0.50
Meola Outer:									
MO PS10	1.18	0.34	0.94	94.64	1.69	1.21	2.90	98.48	2.95
MO PS27	0.43	0.24	0.94	95.42	1.37	1.60	2.97	99.33	2.99
MO PS58	1.43	0.21	0.95	94.68	1.10	1.64	2.74	98.37	2.79
mean	1.01	0.26	0.94	94.91	1.39	1.48	2.87	98.72	2.91
s.d.	0.52	0.07	0.01	0.44	0.30	0.24	0.12	0.53	0.11
c.v. (%)	51.24	26.05	0.64	0.46	21.57	16.08	4.08	0.53	3.68

Table 3-19 Summary of particle size distribution (PSD) results for Bulk Reference Sediment (BRS) obtained with the 2011, 2012, and 2013 monitoring sample batches.
BRS for PSD are archived in frozen form. Differences in mud content between the years for Middlemore were significant (Kruskall Wallis test, p=0.027, N=3 per year). Differences between years for Meola Outer were not (p=0.148).

		Middlemore: Mud			Meola Outer: Sand		
Class	Particle size range	2011	2012	2013	2011	2012	2013
Gravel	>2000 μm	0.00	0.00	0.03	0.70	0.72	1.01
Coarse Sand	500-2000 μm	0.15	0.11	0.17	0.33	0.31	0.26
Medium Sand	250-500 μm	0.74	0.52	0.59	1.13	0.94	0.94
Fine Sand	62.5-250 μm	32.45	30.29	31.12	94.83	94.94	94.91
Silt	3.9-62.5 μm	57.31	50.50	46.08	1.08	0.91	1.39
Clay	<3.9 μm	9.35	18.58	22.00	1.93	2.18	1.48
"Mud" - % of total sediment <63 um		66.66	69.09	68.09	3.01	3.09	2.87
"Mud" - % of <500um fraction <63 um		66.76	69.16	68.23	3.04	3.12	2.91

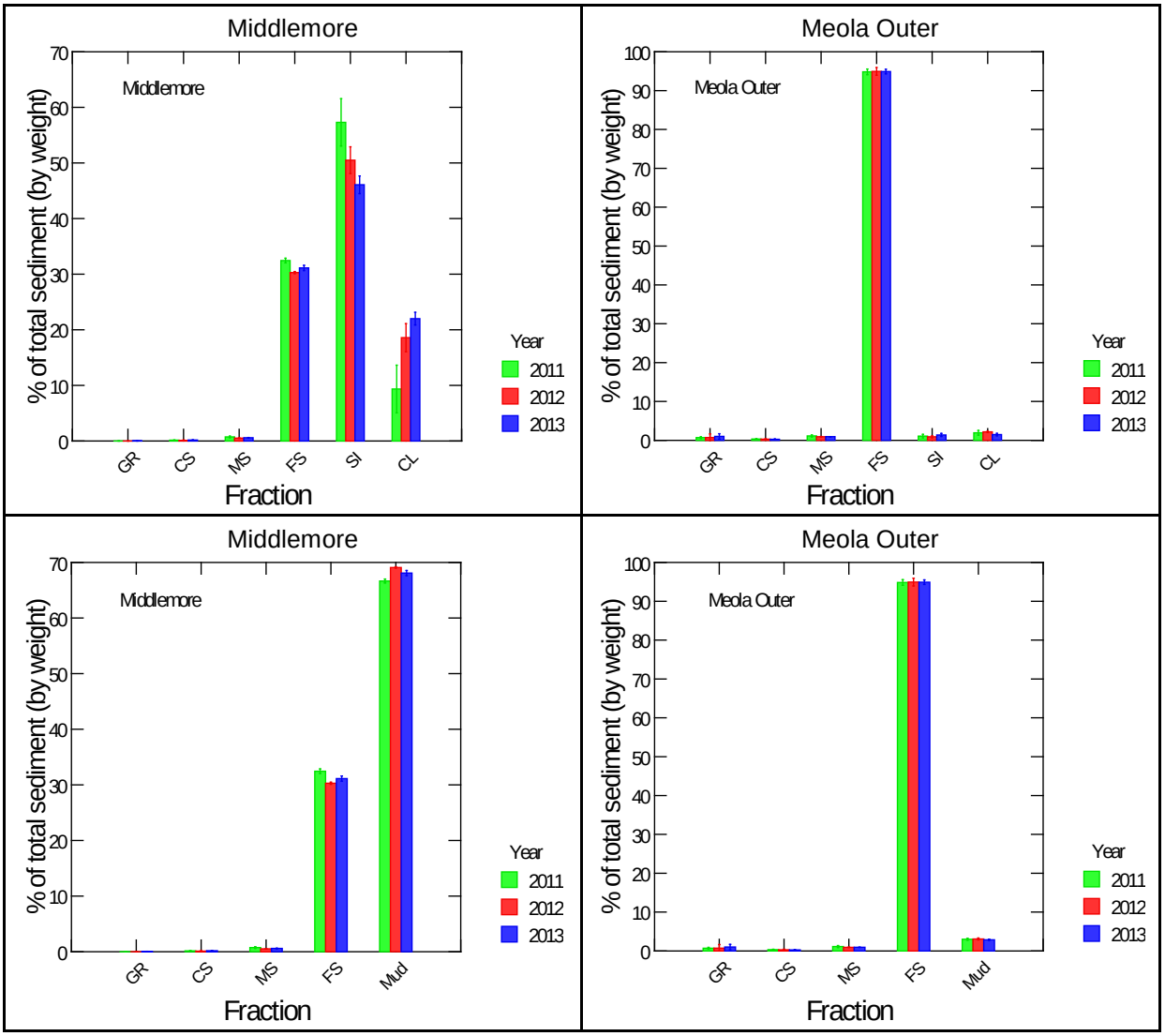

Figure 3-8 Particle size distribution (PSD) results for frozen bulk reference sediments (BRS) analysed with RSCMP samples in 2011 and 2012. Plots show means (n=3) ± 1 standard deviation. The upper plots show data for each particle size range (abbreviations given below), while the lower plots combine the silt and clay fractions in to a single "mud" fraction (<63 µm).
GR – gravel (>2 mm), CS – coarse sand (0.5–2 mm), MS – medium sand (0.25–0.5 mm), FS – fine sand (0.063–0.25 mm), SI – silt (3.9–63 µm), CL – clay (<3.9 µm).

3.7.3 Organic contaminants

Middlemore freeze dried BRS (<500 µm) was analysed in duplicate by AsureQuality for PAH, OCPs, and PCBs. Results are summarised in Table 3-20. A more detailed tabulation of individual compound data is given in Mills (2014b). PAH were also analysed on 3 replicates of the Middlemore freeze dried BRS by R J Hill Labs. The results from these analyses were presented earlier, in Table 3-5.

The AsureQuality results showed good precision, with RPDs between duplicates of 0.2–8.2%. PAH results were more variable than OCPs or PCBs.

The R J Hill lab's results for PAH analysis also showed good precision (CVs of 4–6% for total PAHs; Table 3-5). However, as discussed in section 3.3.3, and summarised in Table 3-21) the Hills results were lower by 34–41% than those obtained by AsureQuality.

Table 3-20 Summary of PAH and organochlorine (OCPs and PCBs) data obtained from AsureQuality analysis of blind duplicates of Middlemore BRS (freeze dried, <500 µm). Concentrations are in ng/g (µg/kg, parts per billion)

Sample Lab Number	Middlemore BRS 152076-12	Middlemore BRS WB Rep 152076-14	RPD (%)
PAH:			
Total PAH (<DL = 0 or <DL = DL)	1230.9	1138.6	-7.8
HWPAH (<DL=0 or <DL = DL)	729.3	671.7	-8.2
Organochlorines:			
Dieldrin	0.455	0.426	-6.6
Total DDTs (< DL = 0)	1.305	1.302	-0.2
Total DDTs (< DL = DL)	1.305	1.322	1.3
Total chlordane (< DL = 0 or <DL = DL)	0.103	0.107	4.0
Total PCB Lower Bound (< DL = 0)	5.73	5.50	-4.0
Total PCB Upper Bound (< DL = DL)	5.74	5.51	-4.1

Table 3-21 Comparison of PAH results obtained from analysis of Middlemore BRS by R J Hill and AsureQuality labs.
Differences between duplicates (expressed as relative percentage difference; RPDs are colour coded: Green <15%, Amber 15–30%, Red >30%. Note that TOC analyses were done at R J Hill labs for all samples.

		TOC	Total PAH		HWPAH	
Sample	Lab	%	mg/kg	mg/kg at 1% TOC	mg/kg	mg/kg at 1% TOC
Rep 1	RJ Hill	1.95	0.780	0.400	0.451	0.231
Rep 2	RJ Hill	1.80	0.865	0.481	0.484	0.269
Rep 3	RJ Hill	1.90	0.871	0.458	0.484	0.255
Mean	RJ Hill	1.88	0.839	0.446	0.473	0.252
Rep 1	Asurequality	1.81	1.231	0.680	0.729	0.403
Rep 2	Asurequality	1.87	1.139	0.609	0.672	0.359
Mean	Asurequality	1.84	1.185	0.644	0.701	0.381
Difference in lab mean concentrations (mg/kg)		-0.04	0.346	0.198	0.228	0.129
Difference in lab mean concentrations (%)		-2.3	34.2	36.3	38.8	40.9

3.8 Extra analyses

3.8.1 Repeat analyses of 2013 samples

No samples from the 2013 sampling were reanalysed.

3.8.2 Island Bay resampling and analysis

The 2012 sampling and analysis data for Island Bay 2012 found very high extractable metals (<63 µm) results from all of replicates 1–3; approximately double those found in the previous sampling in 2007. Total recoverable metals results from 2012 were comparable with 2007. Extractable metals were reanalysed in 2012 (see Diffuse Sources 2013), but results were variable.

Island Bay is a sandy site (mud content <5%) and the BRS analyses conducted in 2012 found markedly higher concentrations for extractable metals in the sandy BRS sample than previously obtained. This suggested that the elevated results for Island Bay in 2012 may have been an analytical artefact. Because of the uncertainty in the extractable metals data obtained, Island Bay was flagged for resampling and analysis in 2013.

The results obtained from the 2013 resampling and analysis were generally comparable with those obtained in 2012, except for extractable Cu and total As (Table 3-22). The lower extractable Cu and higher total As results in 2013 were consistent with the results obtained from the analysis of archived samples from 2012 (section 3.4) and comparisons of BRS data from 2012 and 2013 (section 3.7.1), indicating an analytical-sourced (rather than "real") difference.

The 2013 data for Island Bay therefore confirm the 2012 results. Both sets should remain for use in the Single Site report (SSR) and for tracking trends.

As previously discussed, the Island Bay results again indicate that differences in site mean concentrations for metals of the order of 10–20% due to short term and/or analytical variability can be considered "typical".

Table 3-22 Comparison of 2012 and 2013 results for Island Bay.
Concentrations are in mg/kg. RPDs are colour coded: Green <15%, Amber 15–30%, Red >30%.

			Extractable Metals (<63 μm)			Total Metals (<500 μm)				
Year	Rep	Mud (%)	Cu	Pb	Zn	Cu	Pb	Zn	As	Hg
2012	1	4.47	28.7	28.7	133.0	6.0	11.5	46.5	6.46	0.043
2012	2		33.0	35.1	151.1	5.3	11.0	47.5	8.59	0.031
2012	3		34.7	38.9	157.9	6.0	11.8	47.0	7.90	0.045
2013	1	2.79	21.0	30.0	126.0	5.7	12.0	49.0	10.50	0.039
2013	2		22.0	31.0	127.0	5.6	11.5	49.0	10.00	0.046
2013	3		23.0	32.0	131.0	5.6	12.6	55.0	13.50	0.046
Mean of 2012			32.1	34.3	147.3	5.7	11.4	47.0	7.7	0.0
Mean of 2013			22.0	31.0	128.0	5.6	12.0	51.0	11.3	0.0
Difference in means (mg/kg)			-10.1	-3.3	-19.3	-0.1	0.6	4.0	3.7	0.0
RPD (%)			37.5	10.0	14.0	1.8	5.0	8.2	38.8	9.0
t-test p-value			0.021	0.389	0.116	0.711	0.213	0.180	0.057	0.500

3.8.3 Pahurehure Papakura contaminant and benthic ecology plots

As in 2011, the benthic ecology sampling at Pahurehure Papakura was undertaken from a plot located closer to the low tide channel than the contaminant sampling plot, where sediment was deep enough to obtain a full ecology core (Diffuse Sources 2012).

A composite sample from the ecology plot (made up from 10 sub-samples, each sampled from immediately adjacent to the ecology core, as for PSD) was analysed for metals and PSD. The results are compared with those from the contaminant plot in Table 3-23.

The results indicate that the ecology plot was slightly muddier than the contaminants plot, while sediment metals concentrations were similar. In 2011, mud content was similar at both sites (41% at the SoE contaminants site, and 39% at the ecology site) as were sediment metals concentrations (Diffuse Sources 2012).

Table 3-23 Comparison of metals concentrations (mg/kg) at the Pahurehure Papakura RSCMP contaminant monitoring site and the adjacent benthic ecology sampling plot. RPDs are colour coded: Green <15%, Amber 15–30%, Red >30%.

			Extractable Metals (<63 μm)			Total Metals (<500 μm)				
Year	Rep	Mud (%)	Cu	Pb	Zn	Cu	Pb	Zn	As	Hg
Pahurehure Papakura: chemistry plot	1	45.0	5.0	11.7	65.0	5.9	11.0	66.0	10.4	0.040
	2		6.0	13.0	76.0	6.2	10.7	68.0	11.3	0.036
	3		4.9	11.5	62.0	5.4	10.0	60.0	10.0	0.033
	Mean		5.3	12.1	67.7	5.8	10.6	64.7	10.6	0.036
Pahurehure Papakura: Ecology plot	Composite	49.5	6.3	14.3	77.0	5.8	11.8	69.0	11.0	0.043
Difference in means (mg/kg)		4.5	1.0	2.2	9.3	-0.03	1.2	4.3	0.4	0.007
RPD (%)		9.0	17.2	16.9	12.9	0.6	11.0	6.5	4.0	16.8

3.9 Data quality summary

Table 3-24 summarises the QA information obtained for 2013.

The quality assurance data described above indicate that the 2013 metals data were of variable quality, which was generally consistent with previous RDP/RSCMP results.

Within-batch variation was relatively low, and the data were, on average, reasonably accurate, as shown by the results of the CRM analyses (although, as noted above, the CRM data do not necessarily reflect the accuracy and reproducibility of the entire analytical method). Between batch variability for metals (as assessed by analysis of archived samples from 2012) was reasonably good, although differences associated with analysis (primarily for As) were found.

However, the BRS results have confirmed a possible problem with extractable metals (<63 µm fraction) data that was raised in 2012 – the results were comparable with those obtained in 2012, but were higher than those obtained in 2011, especially for sandy sediment with low mud fraction content. This should be flagged so that future trend analysis can attempt to take this into account, or at least acknowledge that “increases” in extractable metals results between 2011 and 2013 were probably associated with analysis and are unlikely to be “real”.

The BRS results suggest that the analysis methods used for extractable metals analysis are not sufficiently robust for reliable trend analysis, where consistent year-to-year (or batch-to-batch) results must be obtained. Total recoverable metals analysis generally seems to be providing consistent data.

Organic contaminant results from AsureQuality showed good agreement between duplicates for PAH, OCPs, and PCBs. PAH and TOC results from R J Hills showed low within-batch variability, but PAH results were markedly lower than the AsureQuality results. This highlights the care needed when comparing organic contaminant data from different analytical providers without adequate benchmarking (e.g. CRM or BRS data).

The PSD from the BRS showed generally low variability and good comparability with 2011 and 2012 results. On this basis, they are judged to be reliable.

Overall, the 2013 monitoring data were similar in quality to those obtained in 2012. Given the potential for large batch-to-batch changes in results to occur, the suitability of extractable metals for trend assessment requires further evaluation. PAH (and other organic contaminant) results need to be assessed carefully to validate consistency between batches and data providers. PSD and total recoverable metals QA results indicate these analyses are robust, and should provide reliable data for trend assessments. However, on-going QA, in particular CRM and BRS analyses, are still required to validate each year’s data.

Table 3-24 Summary of analytical quality assurance results for 2013

QA Measure	Pass Note Fail	Comments
Blanks	**Pass**	All <D.L. except one Cr and one PAH phenanthrene) value - these are minor and had no observable effect on data quality.
Spike Recoveries	**Pass**	Metals: 5 samples and 5 blanks. Extractable Cu, Pb, Zn only. Mean recoveries 90-96%. Lowest recovery 85% (Zn, spiked sediment). Overall slightly low (by up to 15%).
	Note	PAH: 3 spiked samples (R.J. Hill labs). Mean recovery of HWPAH 84% (69-98%). Surrogate recoveries from 20 samples averaged 46-101%, and for HWPAH surrogates 68-81%. Overall slightly low (by ca. 20%). Care needed when comparing with other labs' data.
Within Batch blind duplicates	**Pass**	Metals: Six samples analysed in duplicate. All RPDs <20% (mostly <15%), except for 2 Total Hg results (RPDs 21 & 57%). Overall, good WB agreement.
	Pass	PAH: Measured by two labs. Both data sets showed good agreement for WB duplicates and low variability. [However, substantial difference in concentrations between the labs].
	Pass	Organochlorines: Good agreement for WB duplicates (for 2 duplicates analysed - one pair in 2012, one pair in 2013).
Between Batch duplicates	**Pass**	Samples from four sites sampled in 2012 analysed in 2013. Reasonable agreement between 2012 and 2013 results. RPDs for metals mostly <15% (mostly <10%). Total As showed greatest differences between years (RPDs 17-33%).
Certified Reference Material	**Pass**	Five CRMs analysed as unknownsfor metals. Means within 7% of certified values for total Cu, Pb, Zn, & Hg. Total As ca. 15% high. Individual samples within 13% of reference values, except As (up to 22% high). Variability low - CVs 2-5%. Trends over time 2002 to 2012 not significant, except for extractable Cu (0.15 mg/kg/yr, 0.81% per year) and Total Cu (0.12 mg/kg/yr, 0.52% per year).
Bulk Reference Sediments:		
Extractable metals	**Note**	2012 mean results substantially (& significantly) higher than mean results for 2011 (and for previous 3 BRS batches). Greatest differences for Meola Outer (sandy) but also for Middlemore (muddy BRS). 2013 results generally agreed with 2012 data, and were higher than 2011 results (and previous 3 BRS batches). Indicates extractable metals' analysis potentially variable, possibly too variable for trend monitoring.
Total Recoverable Metals	**Pass**	2013 mean results agreed with means from 2012 (and previous batches), except for Cu in freeze dried samples, which were slightly lower in 2013 (small absolute differences of 0.2 and 1.6 mg/kg, therefore of no great practical significance). Total As significantly higher in all samples than in 2012. Generally total recoverable metals' data is consistent over time.
Particle Size Distribution	**Pass**	% mud results had low variability (CV, n=3, of <1% for Middlemore and 6% for Meola Outer). 2013 means were similar to 2011 and 2012 results for both BRS samples. PSD results to date are robust.
OVERALL ASSESSMENT	**Extractable metals not OK**	Extractable metals batch-to-batch variability remains an issue. Need to consider suitability for future trend assessment.
	Total metals OK	Total recoverable metals generally OK. Watch for batch-to-batch changes from CRM and BRS results (e.g. As)
	PAH Care required	PAH analysis variability OK, but results markedly different between labs. Assess data quality carefully for trend assessment.
	OCPs PCBs OK	Asurequality data good. Low WB variability, good DLs.
	PSD OK	PSD data look good. Low WB and BB variability.

4.0 Mercury and arsenic

Total recoverable arsenic (As) and mercury (Hg) were analysed in 2012 to broaden the database for these toxic elements, which were last monitored at SoE sites in 2005. Sites sampled and analysed in 2012 were mainly former RDP sites.

In 2013, As and Hg analyses were also undertaken to complete the baseline reassessment. Sites were mainly former SoE sites (and also UWH programme sites). Results are shown in Figure 4-1.

Arsenic concentrations were elevated, at or above the “threshold effects level” (TEL) of 7.24 mg/kg, at 29 of the 40 sites (and very close to the TEL at 3 other sites). The highest concentration (site median = 16.5 mg/kg) was found at Little Muddy Creek (low density urban/rural site in the outer Manukau Harbour). As observed for SoE sites analysed in 2005 and 2012, there was no obvious relationship between As concentrations and the concentrations of other metals.

Mercury exceeded the TEL (0.13 mg/kg) at 18 of the 40 sites, and was close to TEL at 4 other sites. As observed for SoE sites in 2005, and RDP sites in 2012, there was a correlation between Hg and total Zn and Pb (but less so with Cu). However, the relationship between Hg and Zn (but less so for Pb) appeared to vary somewhat between programmes (Figure 4-2). Mercury concentrations at the UWH (and possibly RDP) programme sites were relatively high (based on their Zn concentrations) compared with former SoE sites.

Lucas UWH Replicate 3 had a higher Hg concentration than would be expected from correlation with Zn (see Figure 4-2), and was substantially higher than reps 1 and 2. Similarly, replicate 3 at Meola Inner was markedly higher than reps 1 and 2. These results could be checked in future monitoring rounds (reanalysis of archived samples), but provided data analysis is performed using site median concentrations, the effect of these “outlying” values is probably not great.

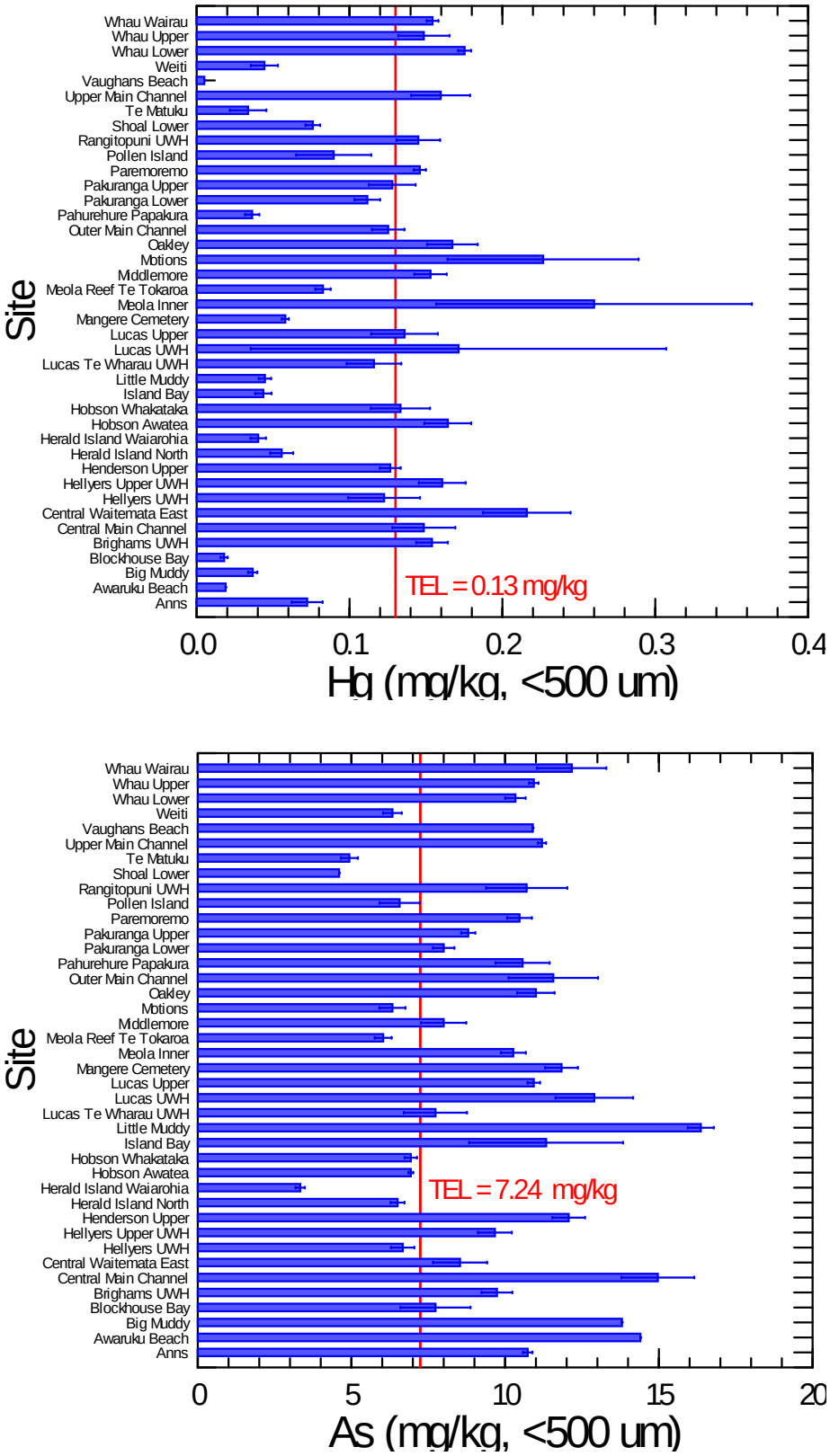

Figure 4-1 Total recoverable mercury (Hg) and arsenic (As) in sediments sampled in 2013. Bars are means ±1 standard deviation (N=3).

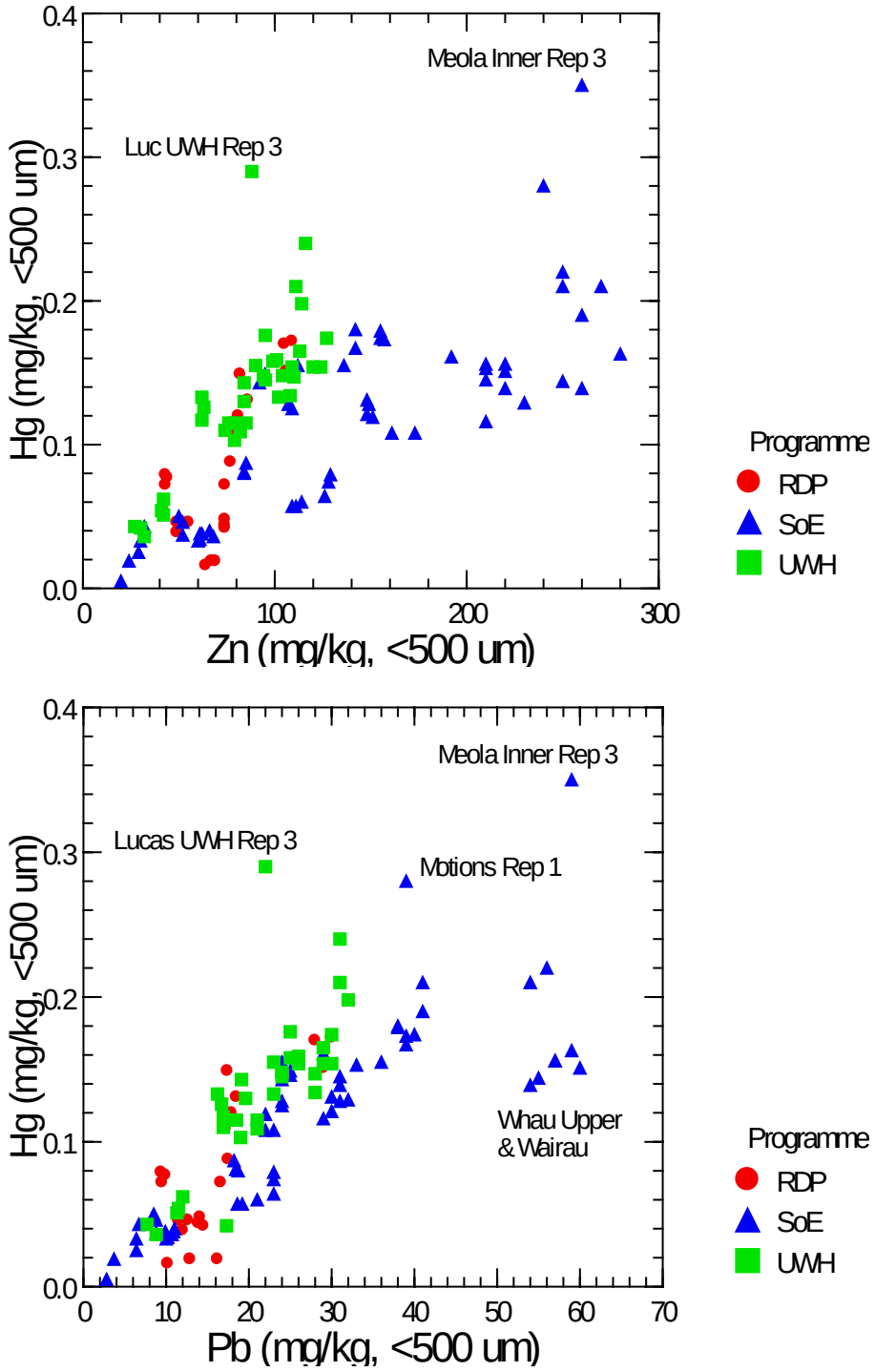

Figure 4-2 Relationships between total recoverable mercury (Hg), zinc (Zn) and lead (Pb) in 2013 samples. Data are grouped according to the sampling programme (UWH, and former SoE and RDP sites).

5.0 References

ARC (2004). *Blueprint for monitoring urban receiving environments.* Auckland Regional Council technical publication, TP168, August 2004

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Appendix A Sediment Contaminant Data

Metals data for RSCMP 2013 monitoring (concentrations in mg/kg freeze dry weight)

Note that UWH programme data are reported separately (NIWA).

			Extractable Metals (<63 um)			Total Recoverable Metals (<500 um)				
Site	Rep	Programme	Cu	Pb	Zn	Cu	Pb	Zn	As	Hg
Anns Creek	1	RSCMP	10.5	16.7	98.0	18.1	23.0	128.0	10.6	0.074
Anns Creek	2	RSCMP	11.6	17.6	109.0	18.0	23.0	129.0	10.8	0.079
Anns Creek	3	RSCMP	10.8	17.6	101.0	17.3	23.0	126.0	10.8	0.064
Awaruku Beach	1	RSCMP	n/a	n/a	n/a	2.1	3.7	24.0	14.4	0.019
Awaruku Beach	2	RSCMP	n/a	n/a	n/a	2.2	3.9	23.0	n/a	n/a
Awaruku Beach	3	RSCMP	n/a	n/a	n/a	2.0	3.7	23.0	n/a	n/a
Awaruku Stream	1	Long Bay	22.0	27.0	188.0	25.0	26.0	169.0	10.3	0.061
Awaruku Stream	2	Long Bay	23.0	27.0	193.0	27.0	26.0	178.0	n/a	n/a
Awaruku Stream	3	Long Bay	25.0	30.0	200.0	26.0	28.0	174.0	n/a	n/a
Awatea Rd	1	RSCMP	15.2	35.0	103.0	10.9	29.0	106.0	6.9	0.151
Awatea Rd	2	RSCMP	15.4	35.0	109.0	10.7	28.0	105.0	6.9	0.170
Awatea Rd	3	RSCMP	16.3	37.0	114.0	11.4	30.0	109.0	7.0	0.172
Big Muddy Creek	1	RSCMP	6.2	9.7	51.0	9.5	10.9	62.0	13.8	0.038
Big Muddy Creek	2	RSCMP	7.2	11.1	59.0	9.5	9.9	61.0	13.8	0.038
Big Muddy Creek	3	RSCMP	7.0	10.1	59.0	9.6	10.2	61.0	13.8	0.034
Blockhouse Bay	1	RSCMP	12.6	24.0	127.0	5.3	10.2	64.0	6.8	0.016
Blockhouse Bay	2	RSCMP	13.6	27.0	136.0	5.5	12.9	69.0	7.9	0.019
Blockhouse Bay	3	RSCMP	12.4	24.0	119.0	5.4	16.2	67.0	8.5	0.019
Henderson Upper	1	RSCMP	26.0	31.0	151.0	29.0	30.0	148.0	11.6	0.121
Henderson Upper	2	RSCMP	25.0	30.0	145.0	29.0	30.0	148.0	12.3	0.131
Henderson Upper	3	RSCMP	26.0	32.0	157.0	30.0	31.0	149.0	12.3	0.128
Island Bay	1	RSCMP	21.0	30.0	126.0	5.7	12.0	49.0	10.5	0.039
Island Bay	2	RSCMP	22.0	31.0	127.0	5.6	11.5	49.0	10.0	0.046
Island Bay	3	RSCMP	23.0	32.0	131.0	5.6	12.6	55.0	13.5	0.046
Little Muddy	1	RSCMP	9.2	12.3	67.0	11.0	14.1	74.0	16.6	0.048
Little Muddy	2	RSCMP	9.5	13.6	71.0	11.1	13.9	74.0	16.5	0.044
Little Muddy	3	RSCMP	8.9	12.2	66.0	11.3	14.5	74.0	16.0	0.042
Lucas Upper	1	RSCMP	18.6	26.0	117.0	22.0	24.0	112.0	11.1	0.155
Lucas Upper	2	RSCMP	21.0	26.0	131.0	21.0	24.0	107.0	10.9	0.128
Lucas Upper	3	RSCMP	19.5	26.0	118.0	21.0	24.0	109.0	10.8	0.125
Mangere Cemetery	1	RSCMP	11.5	19.8	101.0	15.5	21.0	114.0	11.4	0.060
Mangere Cemetery	2	RSCMP	10.2	16.7	94.0	15.0	18.6	109.0	12.2	0.057
Mangere Cemetery	3	RSCMP	10.0	17.3	90.0	15.5	19.2	111.0	11.9	0.057
Meola Inner	1	RSCMP	31.0	60.0	183.0	29.0	54.0	250.0	10.0	0.210
Meola Inner	2	RSCMP	28.0	58.0	174.0	27.0	56.0	250.0	10.2	0.220
Meola Inner	3	RSCMP	31.0	61.0	193.0	30.0	59.0	260.0	10.6	0.350
Meola Reef @ Te Tokaroa	1	RSCMP	20.0	38.0	128.0	8.3	18.7	84.0	6.1	0.080
Meola Reef @ Te Tokaroa	2	RSCMP	22.0	39.0	136.0	8.3	18.4	84.0	5.8	0.081
Meola Reef @ Te Tokaroa	3	RSCMP	23.0	39.0	138.0	8.0	18.2	85.0	6.2	0.087
Middlemore	1	RSCMP	28.0	38.0	230.0	24.0	29.0	192.0	7.4	0.161
Middlemore	2	RSCMP	28.0	38.0	220.0	28.0	33.0	210.0	8.5	0.153
Middlemore	3	RSCMP	28.0	37.0	230.0	26.0	31.0	210.0	8.1	0.145
Motions	1	RSCMP	36.0	62.0	197.0	19.0	39.0	240.0	6.1	0.280
Motions	2	RSCMP	38.0	61.0	199.0	19.1	41.0	270.0	6.7	0.210
Motions	3	RSCMP	36.0	61.0	210.0	18.8	41.0	260.0	6.2	0.190
Oakley	1	RSCMP	25.0	44.0	167.0	23.0	36.0	136.0	10.5	0.155
Oakley	2	RSCMP	25.0	44.0	171.0	24.0	39.0	142.0	11.1	0.167
Oakley	3	RSCMP	24.0	43.0	162.0	25.0	38.0	142.0	11.4	0.180
Pahurehure Papakura	1	RSCMP	5.0	11.7	65.0	5.9	11.0	66.0	10.4	0.040
Pahurehure Papakura	2	RSCMP	6.0	13.0	76.0	6.2	10.7	68.0	11.3	0.036
Pahurehure Papakura	3	RSCMP	4.9	11.5	62.0	5.4	10.0	60.0	10.0	0.033
Pahurehure Papakura Eco	Composite	RSCMP	6.3	14.3	77.0	5.8	11.8	69.0	11.0	0.043

Appendix A continued: Metals data from RSCMP 2013 monitoring.

			Extractable Metals (<63 um)			Total Recoverable Metals (<500 um)				
Site	Rep	Programme	Cu	Pb	Zn	Cu	Pb	Zn	As	Hg
Pakuranga Lower	1	RSCMP	23.0	31.0	180.0	15.7	22.0	161.0	7.9	0.108
Pakuranga Lower	2	RSCMP	26.0	31.0	186.0	16.7	23.0	173.0	8.3	0.108
Pakuranga Lower	3	RSCMP	22.0	29.0	165.0	15.6	22.0	151.0	7.8	0.119
Pakuranga Upper	1	RSCMP	29.0	39.0	240.0	25.0	29.0	210.0	8.6	0.116
Pakuranga Upper	2	RSCMP	28.0	39.0	240.0	26.0	31.0	220.0	8.9	0.139
Pakuranga Upper	3	RSCMP	27.0	36.0	230.0	27.0	32.0	230.0	8.9	0.129
Paremoremo	1	RSCMP	17.4	23.0	95.0	22.0	25.0	95.0	10.8	0.149
Paremoremo	2	RSCMP	18.9	24.0	101.0	21.0	24.0	92.0	10.2	0.143
Paremoremo	3	RSCMP	19.6	26.0	100.0	21.0	25.0	94.0	10.4	0.146
Pollen Island	1	RSCMP	15.5	28.0	98.0	8.4	17.5	77.0	6.9	0.088
Pollen Island	2	RSCMP	17.2	30.0	106.0	8.0	16.6	74.0	6.0	0.072
Pollen Island	3	RSCMP	15.9	27.0	101.0	8.9	17.2	78.0	6.8	0.109
Shoal Bay Lower	1	CWH Eco	16.2	29.0	98.0	3.9	9.4	43.0	4.6	0.079
Shoal Bay Lower	2	CWH Eco	14.4	27.0	91.0	4.1	9.5	43.0	4.6	0.072
Shoal Bay Lower	3	CWH Eco	15.5	28.0	97.0	4.3	9.9	44.0	4.6	0.077
Te Matuku	1	RSCMP	4.7	13.3	50.0	2.5	6.7	32.0	4.7	0.043
Te Matuku	2	RSCMP	4.8	12.6	49.0	2.6	6.4	29.0	5.1	0.025
Te Matuku	3	RSCMP	4.5	12.7	49.0	2.6	6.4	30.0	5.0	0.033
Vaughan's Beach	1	RSCMP	n/a	n/a	n/a	1.4	2.8	19.8	10.9	<0.01
Vaughan's Beach	2	RSCMP	n/a	n/a	n/a	1.5	2.8	20.0	n/a	n/a
Vaughan's Beach	3	RSCMP	n/a	n/a	n/a	1.6	2.9	20.0	n/a	n/a
Vaughan's Stream	1	Long Bay	10.8	8.5	60.0	5.6	4.1	29.0	4.4	0.020
Vaughan's Stream	2	Long Bay	11.1	9.2	59.0	5.1	3.8	27.0	n/a	n/a
Vaughan's Stream	3	Long Bay	11.4	8.9	60.0	5.2	3.9	28.0	n/a	n/a
Weiti	1	RSCMP	16.8	12.1	65.0	11.4	8.5	50.0	6.2	0.050
Weiti	2	RSCMP	16.3	11.8	64.0	12.2	8.8	52.0	6.6	0.046
Weiti	3	RSCMP	16.7	11.6	65.0	12.1	8.8	52.0	6.2	0.037
Whakataka Bay	1	RSCMP	12.5	28.0	87.0	6.8	18.5	86.0	7.1	0.131
Whakataka Bay	2	RSCMP	12.1	28.0	86.0	6.3	17.9	81.0	6.9	0.120
Whakataka Bay	3	RSCMP	14.4	28.0	94.0	6.4	17.4	82.0	6.8	0.149
Whau Lower	1	RSCMP	23.0	42.0	175.0	24.0	38.0	155.0	10.1	0.179
Whau Lower	2	RSCMP	21.0	39.0	166.0	24.0	40.0	155.0	10.3	0.174
Whau Lower	3	RSCMP	21.0	41.0	163.0	24.0	39.0	157.0	10.6	0.173
Whau Upper	1	RSCMP	34.0	68.0	240.0	34.0	59.0	280.0	11.0	0.163
Whau Upper	2	RSCMP	35.0	66.0	250.0	32.0	55.0	250.0	11.0	0.144
Whau Upper	3	RSCMP	32.0	64.0	230.0	32.0	54.0	260.0	10.8	0.139
Whau Wairau	1	RSCMP	38.0	68.0	250.0	41.0	57.0	220.0	13.0	0.156
Whau Wairau	2	RSCMP	38.0	65.0	240.0	37.0	57.0	210.0	11.3	0.156
Whau Wairau	3	RSCMP	37.0	63.0	240.0	37.0	60.0	220.0	12.2	0.151

Appendix B Particle Size Distribution Data

This appendix provides a table of sediment particle size distribution (PSD) data obtained for a composite surface (0–2 cm) sample per site. Samples were analysed by NIWA (Hamilton) by wet sieving/pipette analysis. The data are weight % for each fraction. Further details can be obtained from NIWA, Hamilton.

Site	Gravel > 2 mm	Coarse Sand 0.5 - 2 mm	Medium Sand 0.25 - 0.5 mm	Fine Sand 0.063 - 0.25 mm	Silt 3.9 - 63 μm	Clay < 3.9 μm
Anns	0.06	0.10	0.13	12.05	69.70	17.95
Awaruku Beach	0.60	6.25	15.97	76.86	0.33	0.00
Awaruku Stream	0.26	1.31	1.33	22.00	54.97	20.13
Big Muddy	0.03	0.14	1.06	22.41	62.18	14.19
Blockhouse Bay	4.27	7.55	12.14	70.59	3.46	1.98
Henderson Upper	0.05	0.12	0.36	29.46	42.97	27.03
Hobson Awatea	0.00	0.11	0.87	66.21	26.25	6.56
Hobson Whakataka	0.52	0.63	2.26	75.60	13.56	7.43
Island Bay	0.95	2.70	30.52	63.15	0.96	1.73
Little Muddy	0.54	3.97	7.30	50.07	28.88	9.24
Lucas Upper	0.00	0.10	1.28	23.35	59.42	15.85
Mangere Cemetery	0.02	0.07	0.14	21.52	68.00	10.25
Meola Inner	0.68	0.38	2.69	46.24	32.27	17.75
Meola Reef @ Te Tokaroa	2.21	2.68	10.05	70.02	8.78	6.27
Middlemore	0.00	0.71	2.66	40.98	35.55	20.10
Motions	0.03	0.58	3.90	72.40	14.96	8.12
Oakley	0.00	0.14	0.26	13.67	50.66	35.28
Pahurehure Papakura	0.33	7.10	5.37	45.54	32.89	8.77
Pahurehure Papakura Eco	0.00	0.91	2.67	47.40	37.92	11.10
Pakuranga Lower	0.86	1.57	2.43	57.46	24.44	13.24
Pakuranga Upper	0.09	0.94	3.62	39.57	37.60	18.18
Paremoremo	0.00	0.00	0.09	4.91	79.16	15.83
Pollen Island	4.34	0.66	1.56	74.57	9.70	9.17
Shoal Lower	0.82	0.36	0.51	85.37	9.37	3.57
Te Matuku	3.21	2.59	6.31	74.76	8.39	4.74
Vaughans Beach	0.05	0.52	15.60	83.60	0.17	0.06
Vaughans Stream	0.00	0.18	3.32	67.24	20.54	8.71
Weiti	0.05	0.01	3.10	70.16	15.41	11.28
Whau Lower	0.00	0.04	0.08	6.55	53.71	39.62
Whau Upper	0.00	0.16	1.62	38.92	33.02	26.27
Whau Wairau	0.03	0.15	0.98	28.46	50.77	19.60

Appendix C R J Hill Laboratory Report

Hill Laboratories
BETTER TESTING BETTER RESULTS

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ANALYSIS REPORT

Client:	Diffuse Sources Limited	**Lab No:**	1234172	SPv4
Contact:	Dr G Mills	**Date Registered:**	11-Feb-2014	
	C/- Diffuse Sources Limited	**Date Reported:**	29-May-2014	
	PO Box 12476	**Quote No:**	53594	
	Chartwell	**Order No:**		
	HAMILTON 3248	**Client Reference:**	RSCMP 2013	
		Submitted By:	Dr G Mills	

Sample Type: Sediment

	Sample Name:	172/1 [<63um]	172/40 [<63um]	172/76 [<63um]	172/112 [<63um]	172/151 [<63um]
	Lab Number:	1234172.1	1234172.2	1234172.3	1234172.4	1234172.5
Individual Tests						
Extractable Copper*	mg/kg dry wt	10.5	9.5	24	4.5	15.3
Extractable Lead*	mg/kg dry wt	16.7	13.6	43	12.7	22
Extractable Zinc*	mg/kg dry wt	98	71	162	49	109

	Sample Name:	172/183 [<63um]	172/QA1 [<63um]	172/2 [<63um]	172/41 [<63um]	172/79 [<63um]
	Lab Number:	1234172.6	1234172.7	1234172.8	1234172.9	1234172.10
Individual Tests						
Extractable Copper*	mg/kg dry wt	18.5	10.0	11.6	8.9	5.0
Extractable Lead*	mg/kg dry wt	26	16.6	17.6	12.2	11.7
Extractable Zinc*	mg/kg dry wt	106	96	109	66	65

	Sample Name:	172/120 [<63um]	172/152 [<63um]	172/186 [<63um]	172/QA2 [<63um]	172/3 [<63um]
	Lab Number:	1234172.11	1234172.12	1234172.13	1234172.14	1234172.15
Individual Tests						
Extractable Copper*	mg/kg dry wt	10.8	16.3	19.9	13.3	10.8
Extractable Lead*	mg/kg dry wt	8.5	25	33	25	17.6
Extractable Zinc*	mg/kg dry wt	60	97	112	131	101

	Sample Name:	172/44 [<63um]	172/80 [<63um]	172/121 [<63um]	172/153 [<63um]	172/187 [<63um]
	Lab Number:	1234172.16	1234172.17	1234172.18	1234172.19	1234172.20
Individual Tests						
Extractable Copper*	mg/kg dry wt	18.6	6.0	11.1	18.6	18.1
Extractable Lead*	mg/kg dry wt	26	13.0	9.2	27	30
Extractable Zinc*	mg/kg dry wt	117	76	59	100	107

	Sample Name:	172/QA3 [<63um]	172/11 [<63um]	172/45 [<63um]	172/81 [<63um]	172/122 [<63um]
	Lab Number:	1234172.21	1234172.22	1234172.23	1234172.24	1234172.25
Individual Tests						
Extractable Copper*	mg/kg dry wt	18.1	22	21	4.9	11.4
Extractable Lead*	mg/kg dry wt	26	27	26	11.5	8.9
Extractable Zinc*	mg/kg dry wt	100	188	131	62	60

	Sample Name:	172/154 [<63um]	172/188 [<63um]	172/QA4 [<63um]	172/12 [<63um]	172/46 [<63um]
	Lab Number:	1234172.26	1234172.27	1234172.28	1234172.29	1234172.30
Individual Tests						
Extractable Copper*	mg/kg dry wt	21	18.0	4.5	23	19.5
Extractable Lead*	mg/kg dry wt	30	31	12.2	27	26
Extractable Zinc*	mg/kg dry wt	157	109	47	193	118

Sample Type: Sediment						
Sample Name:		Agal10 - 1 [<63um]	172/84 [<63um]	172/123 [<63um]	172/155 [<63um]	172/191 [<63um]
Lab Number:		1234172.31	1234172.32	1234172.33	1234172.34	1234172.35
Individual Tests						
Extractable Copper*	mg/kg dry wt	18.3	6.3	16.8	22	21
Extractable Lead*	mg/kg dry wt	37	14.3	12.1	30	30
Extractable Zinc*	mg/kg dry wt	44	77	65	147	108

Sample Name:		172/QA5 [<63um]	172/13 [<63um]	172/49 [<63um]	172/85 [<63um]	172/124 [<63um]
Lab Number:		1234172.36	1234172.37	1234172.38	1234172.39	1234172.40
Individual Tests						
Extractable Copper*	mg/kg dry wt	14.1	25	11.5	23	16.3
Extractable Lead*	mg/kg dry wt	29	30	19.8	31	11.8
Extractable Zinc*	mg/kg dry wt	96	200	101	180	64

Sample Name:		172/156 [<63um]	172/192 [<63um]	172/QA6 [<63um]	172/14 [<63um]	172/50 [<63um]
Lab Number:		1234172.41	1234172.42	1234172.43	1234172.44	1234172.45
Individual Tests						
Extractable Copper*	mg/kg dry wt	19.6	19.9	38	15.2	10.2
Extractable Lead*	mg/kg dry wt	26	29	73	35	16.7
Extractable Zinc*	mg/kg dry wt	103	107	270	103	94

Sample Name:		172/86 [<63um]	172/125 [<63um]	172/157 [<63um]	172/193 [<63um]	172/QA7 [<63um]
Lab Number:		1234172.46	1234172.47	1234172.48	1234172.49	1234172.50
Individual Tests						
Extractable Copper*	mg/kg dry wt	26	16.7	18.3	20	19.4
Extractable Lead*	mg/kg dry wt	31	11.6	24	28	27
Extractable Zinc*	mg/kg dry wt	186	65	95	108	102

Sample Name:		172/15 [<63um]	172/51 [<63um]	172/87 [<63um]	172/128 [<63um]	172/158 [<63um]
Lab Number:		1234172.51	1234172.52	1234172.53	1234172.54	1234172.55
Individual Tests						
Extractable Copper*	mg/kg dry wt	15.4	10.0	22	12.5	19.3
Extractable Lead*	mg/kg dry wt	35	17.3	29	28	26
Extractable Zinc*	mg/kg dry wt	109	90	165	87	103

Sample Name:		172/196 [<63um]	172/QA9 [<63um]	172/16 [<63um]	172/54 [<63um]	172/90 [<63um]
Lab Number:		1234172.56	1234172.57	1234172.58	1234172.59	1234172.60
Individual Tests						
Extractable Copper*	mg/kg dry wt	22	33	16.3	31	29
Extractable Lead*	mg/kg dry wt	28	42	37	60	39
Extractable Zinc*	mg/kg dry wt	113	250	114	183	240

Sample Name:		Agal10 - 2 [<63um]	172/129 [<63um]	172/161 [<63um]	172/197 [<63um]	172/QA10 [<63um]
Lab Number:		1234172.61	1234172.62	1234172.63	1234172.64	1234172.65
Individual Tests						
Extractable Copper*	mg/kg dry wt	19.4	12.1	17.9	20	30
Extractable Lead*	mg/kg dry wt	36	28	29	26	40
Extractable Zinc*	mg/kg dry wt	41	86	104	109	240

Sample Name:		172/19 [<63um]	172/55 [<63um]	172/91 [<63um]	172/130 [<63um]	172/162 [<63um]
Lab Number:		1234172.66	1234172.67	1234172.68	1234172.69	1234172.70
Individual Tests						
Extractable Copper*	mg/kg dry wt	6.2	28	28	14.4	19.0
Extractable Lead*	mg/kg dry wt	9.7	58	39	28	29
Extractable Zinc*	mg/kg dry wt	51	174	240	94	112

Sample Name:		172/198 [<63um]	172/201 [<63um]	172/QA11 [<63um]	172/20 [<63um]	172/56 [<63um]
Lab Number:		1234172.71	1234172.72	1234172.73	1234172.74	1234172.75
Individual Tests						
Extractable Copper*	mg/kg dry wt	19.9	18.7	32	7.2	31

Sample Type: Sediment						
	Sample Name:	172/198 [<63um]	172/201 [<63um]	172/QA11 [<63um]	172/20 [<63um]	172/56 [<63um]
	Lab Number:	1234172.71	1234172.72	1234172.73	1234172.74	1234172.75
Individual Tests						
Extractable Lead*	mg/kg dry wt	26	31	42	11.1	61
Extractable Zinc*	mg/kg dry wt	109	121	250	59	193

	Sample Name:	172/92 [<63um]	172/133 [<63um]	172/163 [<63um]	172/202 [<63um]	172/QA12 [<63um]
	Lab Number:	1234172.76	1234172.77	1234172.78	1234172.79	1234172.80
Individual Tests						
Extractable Copper*	mg/kg dry wt	27	23	18.2	18.8	23
Extractable Lead*	mg/kg dry wt	36	42	29	30	48
Extractable Zinc*	mg/kg dry wt	230	175	108	122	173

	Sample Name:	172/21 [<63um]	172/59 [<63um]	172/95 [<63um]	172/134 [<63um]	172/166 [<63um]
	Lab Number:	1234172.81	1234172.82	1234172.83	1234172.84	1234172.85
Individual Tests						
Extractable Copper*	mg/kg dry wt	7.0	20	17.4	21	14.7
Extractable Lead*	mg/kg dry wt	10.1	38	23	39	26
Extractable Zinc*	mg/kg dry wt	59	128	95	166	88

	Sample Name:	172/203 [<63um]	172/QA13 [<63um]	172/24 [<63um]	172/60 [<63um]	172/96 [<63um]
	Lab Number:	1234172.86	1234172.87	1234172.88	1234172.89	1234172.90
Individual Tests						
Extractable Copper*	mg/kg dry wt	17.9	21	12.6	22	18.9
Extractable Lead*	mg/kg dry wt	29	48	24	39	24
Extractable Zinc*	mg/kg dry wt	114	165	127	136	101

	Sample Name:	Agal10 - 3 [<63um]	172/135 [<63um]	172/167 [<63um]	172/206 [<63um]	172/QA14 [<63um]
	Lab Number:	1234172.91	1234172.92	1234172.93	1234172.94	1234172.95
Individual Tests						
Extractable Copper*	mg/kg dry wt	17.2	21	15.0	18.2	21
Extractable Lead*	mg/kg dry wt	36	41	26	23	50
Extractable Zinc*	mg/kg dry wt	42	163	85	101	172

	Sample Name:	172/25 [<63um]	172/61 [<63um]	172/97 [<63um]	172/138 [<63um]	172/168 [<63um]
	Lab Number:	1234172.96	1234172.97	1234172.98	1234172.99	1234172.100
Individual Tests						
Extractable Copper*	mg/kg dry wt	13.6	23	19.6	34	16.8
Extractable Lead*	mg/kg dry wt	27	39	26	68	28
Extractable Zinc*	mg/kg dry wt	136	138	100	240	90

	Sample Name:	172/207 [<63um]	172/QA15 [<63um]	172/26 [<63um]	172/64 [<63um]	172/100 [<63um]
	Lab Number:	1234172.101	1234172.102	1234172.103	1234172.104	1234172.105
Individual Tests						
Extractable Copper*	mg/kg dry wt	17.2	32	12.4	28	15.5
Extractable Lead*	mg/kg dry wt	24	44	24	38	28
Extractable Zinc*	mg/kg dry wt	99	290	119	230	98

	Sample Name:	172/139 [<63um]	172/171 [<63um]	172/208 [<63um]	172/QA16 [<63um]	172/29 [<63um]
	Lab Number:	1234172.106	1234172.107	1234172.108	1234172.109	1234172.110
Individual Tests						
Extractable Copper*	mg/kg dry wt	35	18.9	18.9	31	26
Extractable Lead*	mg/kg dry wt	66	27	26	43	31
Extractable Zinc*	mg/kg dry wt	250	101	101	280	151

	Sample Name:	172/65 [<63um]	172/101 [<63um]	172/140 [<63um]	172/172 [<63um]	172/211 [<63um]
	Lab Number:	1234172.111	1234172.112	1234172.113	1234172.114	1234172.115
Individual Tests						
Extractable Copper*	mg/kg dry wt	28	17.2	32	19.1	17.4

Sample Type: Sediment						
Sample Name:		172/65 [<63um]	172/101 [<63um]	172/140 [<63um]	172/172 [<63um]	172/211 [<63um]
Lab Number:		1234172.111	1234172.112	1234172.113	1234172.114	1234172.115
Individual Tests						
Extractable Lead*	mg/kg dry wt	38	30	64	28	27
Extractable Zinc*	mg/kg dry wt	220	106	230	106	101

Sample Name:		172/QA17 [<63um]	172/30 [<63um]	172/66 [<63um]	172/102 [<63um]	172/143 [<63um]
Lab Number:		1234172.116	1234172.117	1234172.118	1234172.119	1234172.120
Individual Tests						
Extractable Copper*	mg/kg dry wt	31	25	28	15.9	38
Extractable Lead*	mg/kg dry wt	43	30	37	27	68
Extractable Zinc*	mg/kg dry wt	280	145	230	101	250

Sample Name:		Agal10 - 4 [<63um]	172/173 [<63um]	172/212 [<63um]	172/QA18 [<63um]	172/31 [<63um]
Lab Number:		1234172.121	1234172.122	1234172.123	1234172.124	1234172.125
Individual Tests						
Extractable Copper*	mg/kg dry wt	17.4	19.6	16.7	16.5	26
Extractable Lead*	mg/kg dry wt	36	26	27	62	32
Extractable Zinc*	mg/kg dry wt	44	107	99	270	157

Sample Name:		172/69 [<63um]	172/105 [<63um]	172/144 [<63um]	172/176 [<63um]	172/213 [<63um]
Lab Number:		1234172.126	1234172.127	1234172.128	1234172.129	1234172.130
Individual Tests						
Extractable Copper*	mg/kg dry wt	36	16.2	38	19.5	17.7
Extractable Lead*	mg/kg dry wt	62	29	65	27	28
Extractable Zinc*	mg/kg dry wt	197	98	240	109	102

Sample Name:		172/QA19 [<63um]	172/34 [<63um]	172/70 [<63um]	172/106 [<63um]	172/145 [<63um]
Lab Number:		1234172.131	1234172.132	1234172.133	1234172.134	1234172.135
Individual Tests						
Extractable Copper*	mg/kg dry wt	16.8	21	38	14.4	37
Extractable Lead*	mg/kg dry wt	59	30	61	27	63
Extractable Zinc*	mg/kg dry wt	280	126	199	91	240

Sample Name:		172/177 [<63um]	172/QA20 [<63um]	172/35 [<63um]	172/71 [<63um]	172/107 [<63um]
Lab Number:		1234172.136	1234172.137	1234172.138	1234172.139	1234172.140
Individual Tests						
Extractable Copper*	mg/kg dry wt	21	15.6	22	36	15.5
Extractable Lead*	mg/kg dry wt	28	61	31	61	28
Extractable Zinc*	mg/kg dry wt	114	270	127	210	97

Sample Name:		172/148 [<63um]	172/178 [<63um]	172/36 [<63um]	172/74 [<63um]	172/110 [<63um]
Lab Number:		1234172.141	1234172.142	1234172.143	1234172.144	1234172.145
Individual Tests						
Extractable Copper*	mg/kg dry wt	15.8	19.7	23	25	4.7
Extractable Lead*	mg/kg dry wt	19.2	27	32	44	13.3
Extractable Zinc*	mg/kg dry wt	87	111	131	167	50

Sample Name:		172/149 [<63um]	172/181 [<63um]	172/39 [<63um]	172/75 [<63um]	172/111 [<63um]
Lab Number:		1234172.146	1234172.147	1234172.148	1234172.149	1234172.150
Individual Tests						
Extractable Copper*	mg/kg dry wt	16.7	18.3	9.2	25	4.8
Extractable Lead*	mg/kg dry wt	20	25	12.3	44	12.6
Extractable Zinc*	mg/kg dry wt	92	99	67	171	49

Sample Name:		172/150 [<63um]	172/182 [<63um]	Agal10 - 5 [<63um]	172/1 [<500um]	172/29 [<500um]
Lab Number:		1234172.151	1234172.152	1234172.153	1234172.154	1234172.155
Individual Tests						
Total Recoverable Arsenic	mg/kg dry wt	-	-	-	10.6	11.6

Sample Type: Sediment						
Sample Name:		172/150 [<63um]	172/182 [<63um]	Agal10 - 5 [<63um]	172/1 [<500um]	172/29 [<500um]
Lab Number:		1234172.151	1234172.152	1234172.153	1234172.154	1234172.155
Individual Tests						
Extractable Copper*	mg/kg dry wt	18.1	18.5	17.6	-	-
Total Recoverable Copper	mg/kg dry wt	-	-	-	18.1	29
Extractable Lead*	mg/kg dry wt	23	24	35	-	-
Total Recoverable Lead	mg/kg dry wt	-	-	-	23	30
Total Recoverable Mercury	mg/kg dry wt	-	-	-	0.074	0.121
Extractable Zinc*	mg/kg dry wt	118	101	42	-	-
Total Recoverable Zinc	mg/kg dry wt	-	-	-	128	148

Sample Name:		172/56 [<500um]	172/87 [<500um]	172/117 [<500um]	172/149 [<500um]	172/173 [<500um]
Lab Number:		1234172.156	1234172.157	1234172.158	1234172.159	1234172.160
Individual Tests						
Total Recoverable Arsenic	mg/kg dry wt	10.6	7.8	-	8.3	6.4
Total Recoverable Cadmium	mg/kg dry wt	-	-	-	-	0.040
Total Recoverable Chromium	mg/kg dry wt	-	-	-	-	8.0
Total Recoverable Copper	mg/kg dry wt	30	15.6	1.6	5.0	6.1
Total Recoverable Iron	mg/kg dry wt	-	-	-	-	8,500
Total Recoverable Lead	mg/kg dry wt	59	22	2.9	8.8	12.0
Total Recoverable Manganese	mg/kg dry wt	-	-	-	-	57
Total Recoverable Mercury	mg/kg dry wt	0.35	0.119	-	0.030	0.062
Total Recoverable Nickel	mg/kg dry wt	-	-	-	-	2.8
Total Recoverable Zinc	mg/kg dry wt	260	151	20	35	42

Sample Name:		172/206 [<500um]	172/QA14 [<500um]	172/2 [<500um]	172/30 [<500um]	172/59 [<500um]
Lab Number:		1234172.161	1234172.162	1234172.163	1234172.164	1234172.165
Individual Tests						
Total Recoverable Arsenic	mg/kg dry wt	11.1	2.9	10.8	12.3	6.1
Total Recoverable Cadmium	mg/kg dry wt	0.069	0.066	-	-	-
Total Recoverable Chromium	mg/kg dry wt	20	4.4	-	-	-
Total Recoverable Copper	mg/kg dry wt	19.5	3.0	18.0	29	8.3
Total Recoverable Iron	mg/kg dry wt	20,000	-	-	-	-
Total Recoverable Lead	mg/kg dry wt	23	9.3	23	30	18.7
Total Recoverable Manganese	mg/kg dry wt	180	-	-	-	-
Total Recoverable Mercury	mg/kg dry wt	0.155	0.034	0.079	0.131	0.080
Total Recoverable Nickel	mg/kg dry wt	9.1	1.8	-	-	-
Total Recoverable Zinc	mg/kg dry wt	90	41	129	148	84

Sample Name:		172/90 [<500um]	172/120 [<500um]	172/150 [<500um]	172/176 [<500um]	172/207 [<500um]
Lab Number:		1234172.166	1234172.167	1234172.168	1234172.169	1234172.170
Individual Tests						
Total Recoverable Arsenic	mg/kg dry wt	8.6	4.4	7.4	13.0	11.2
Total Recoverable Cadmium	mg/kg dry wt	-	0.071	-	0.053	0.058
Total Recoverable Chromium	mg/kg dry wt	-	7.4	-	22	21
Total Recoverable Copper	mg/kg dry wt	25	5.6	11.1	12.2	20
Total Recoverable Iron	mg/kg dry wt	-	9,300	-	21,000	21,000
Total Recoverable Lead	mg/kg dry wt	29	4.1	16.4	21	24
Total Recoverable Manganese	mg/kg dry wt	-	54	-	144	186
Total Recoverable Mercury	mg/kg dry wt	0.116	0.020	0.081	0.109	0.148
Total Recoverable Nickel	mg/kg dry wt	-	4.4	-	15.7	9.4
Total Recoverable Zinc	mg/kg dry wt	210	29	81	82	94

Sample Name:		172/QA15 [<500um]	172/3 [<500um]	172/31 [<500um]	172/60 [<500um]	172/91 [<500um]
Lab Number:		1234172.171	1234172.172	1234172.173	1234172.174	1234172.175
Individual Tests						
Total Recoverable Arsenic	mg/kg dry wt	9.3	10.8	12.3	5.8	8.9
Total Recoverable Cadmium	mg/kg dry wt	0.161	-	-	-	-
Total Recoverable Chromium	mg/kg dry wt	29	-	-	-	-

Sample Type: Sediment						
Sample Name:		172/QA15 [<500um]	172/3 [<500um]	172/31 [<500um]	172/60 [<500um]	172/91 [<500um]
Lab Number:		1234172.171	1234172.172	1234172.173	1234172.174	1234172.175
Individual Tests						
Total Recoverable Copper	mg/kg dry wt	29	17.3	30	8.3	26
Total Recoverable Lead	mg/kg dry wt	35	23	31	18.4	31
Total Recoverable Mercury	mg/kg dry wt	0.169	0.064	0.128	0.081	0.139
Total Recoverable Nickel	mg/kg dry wt	11.9	-	-	-	-
Total Recoverable Zinc	mg/kg dry wt	220	126	149	84	220

Sample Name:		172/121 [<500um]	172/151 [<500um]	172/177 [<500um]	172/208 [<500um]	172/QA16 [<500um]
Lab Number:		1234172.176	1234172.177	1234172.178	1234172.179	1234172.180
Individual Tests						
Total Recoverable Arsenic	mg/kg dry wt	-	7.5	11.9	11.3	9.7
Total Recoverable Cadmium	mg/kg dry wt	-	-	0.051	0.051	0.160
Total Recoverable Chromium	mg/kg dry wt	-	-	21	22	30
Total Recoverable Copper	mg/kg dry wt	5.1	10.3	12.1	21	29
Total Recoverable Iron	mg/kg dry wt	-	-	19,600	21,000	-
Total Recoverable Lead	mg/kg dry wt	3.8	15.8	21	25	36
Total Recoverable Manganese	mg/kg dry wt	-	-	133	186	-
Total Recoverable Mercury	mg/kg dry wt	-	0.078	0.115	0.176	0.184
Total Recoverable Nickel	mg/kg dry wt	-	-	14.3	9.8	11.9
Total Recoverable Zinc	mg/kg dry wt	27	81	79	95	220

Sample Name:		172/6 [<500um]	172/34 [<500um]	172/61 [<500um]	Agal 10 - 1 [<500um]	172/92 [<500um]
Lab Number:		1234172.181	1234172.182	1234172.183	1234172.184	1234172.185
Individual Tests						
Total Recoverable Arsenic	mg/kg dry wt	14.4	10.5	6.2	19.9	8.9
Total Recoverable Cadmium	mg/kg dry wt	< 0.010	-	-	9.7	-
Total Recoverable Chromium	mg/kg dry wt	7.7	-	-	45	-
Total Recoverable Copper	mg/kg dry wt	2.1	5.7	8.0	23	27
Total Recoverable Iron	mg/kg dry wt	12,800	-	-	-	-
Total Recoverable Lead	mg/kg dry wt	3.7	12.0	18.2	43	32
Total Recoverable Manganese	mg/kg dry wt	149	-	-	-	-
Total Recoverable Mercury	mg/kg dry wt	0.019	0.039	0.087	11.2	0.129
Total Recoverable Nickel	mg/kg dry wt	5.1	-	-	12.1	-
Total Recoverable Zinc	mg/kg dry wt	24	49	85	52	230

Sample Name:		172/122 [<500um]	172/152 [<500um]	172/178 [<500um]	172/211 [<500um]	172/QA17 [<500um]
Lab Number:		1234172.186	1234172.187	1234172.188	1234172.189	1234172.190
Individual Tests						
Total Recoverable Arsenic	mg/kg dry wt	-	8.9	13.8	3.4	9.5
Total Recoverable Cadmium	mg/kg dry wt	-	-	0.053	0.022	0.153
Total Recoverable Chromium	mg/kg dry wt	-	-	22	5.9	30
Total Recoverable Copper	mg/kg dry wt	5.2	5.4	13.1	4.8	29
Total Recoverable Iron	mg/kg dry wt	-	-	22,000	4,800	-
Total Recoverable Lead	mg/kg dry wt	3.9	12.9	22	17.3	35
Total Recoverable Manganese	mg/kg dry wt	-	-	151	45	-
Total Recoverable Mercury	mg/kg dry wt	-	0.053	0.29	0.042	0.20
Total Recoverable Nickel	mg/kg dry wt	-	-	15.4	2.2	12.1
Total Recoverable Zinc	mg/kg dry wt	28	49	88	30	220

Sample Name:		172/7 [<500um]	172/35 [<500um]	172/64 [<500um]	172/95 [<500um]	172/123 [<500um]
Lab Number:		1234172.191	1234172.192	1234172.193	1234172.194	1234172.195
Individual Tests						
Total Recoverable Arsenic	mg/kg dry wt	-	10.0	7.4	10.8	6.2
Total Recoverable Copper	mg/kg dry wt	2.2	5.6	24	22	11.4
Total Recoverable Lead	mg/kg dry wt	3.9	11.5	29	25	8.5
Total Recoverable Mercury	mg/kg dry wt	-	0.046	0.161	0.149	0.050

Sample Type: Sediment						
Sample Name:		172/7 [<500um]	172/35 [<500um]	172/64 [<500um]	172/95 [<500um]	172/123 [<500um]
Lab Number:		1234172.191	1234172.192	1234172.193	1234172.194	1234172.195
Individual Tests						
Total Recoverable Zinc	mg/kg dry wt	23	49	192	95	50

Sample Name:		172/153 [<500um]	172/181 [<500um]	172/212 [<500um]	172/QA18 [<500um]	172/8 [<500um]
Lab Number:		1234172.196	1234172.197	1234172.198	1234172.199	1234172.200
Individual Tests						
Total Recoverable Arsenic	mg/kg dry wt	7.7	7.5	3.4	2.6	-
Total Recoverable Cadmium	mg/kg dry wt	-	0.069	0.023	0.062	-
Total Recoverable Chromium	mg/kg dry wt	-	14.8	5.1	4.5	-
Total Recoverable Copper	mg/kg dry wt	5.3	13.2	4.6	2.9	2.0
Total Recoverable Iron	mg/kg dry wt	-	14,400	4,800	-	-
Total Recoverable Lead	mg/kg dry wt	13.9	19.0	7.7	8.8	3.7
Total Recoverable Manganese	mg/kg dry wt	-	67	48	-	-
Total Recoverable Mercury	mg/kg dry wt	0.046	0.103	0.043	0.032	-
Total Recoverable Nickel	mg/kg dry wt	-	6.3	2.0	1.7	-
Total Recoverable Zinc	mg/kg dry wt	51	79	27	39	23

Sample Name:		172/36 [<500um]	172/65 [<500um]	172/96 [<500um]	172/124 [<500um]	172/154 [<500um]
Lab Number:		1234172.201	1234172.202	1234172.203	1234172.204	1234172.205
Individual Tests						
Total Recoverable Arsenic	mg/kg dry wt	13.5	8.5	10.2	6.6	8.5
Total Recoverable Copper	mg/kg dry wt	5.6	28	21	12.2	25
Total Recoverable Lead	mg/kg dry wt	12.6	33	24	8.8	31
Total Recoverable Mercury	mg/kg dry wt	0.046	0.153	0.143	0.046	0.175
Total Recoverable Zinc	mg/kg dry wt	55	210	92	52	170

Sample Name:		172/182 [<500um]	172/213 [<500um]	172/QA19 [<500um]	172/11 [<500um]	172/39 [<500um]
Lab Number:		1234172.206	1234172.207	1234172.208	1234172.209	1234172.210
Individual Tests						
Total Recoverable Arsenic	mg/kg dry wt	7.1	3.2	2.6	10.3	16.6
Total Recoverable Cadmium	mg/kg dry wt	0.065	0.025	0.073	0.124	-
Total Recoverable Chromium	mg/kg dry wt	13.8	6.2	4.7	17.7	-
Total Recoverable Copper	mg/kg dry wt	12.2	5.3	2.8	25	11.0
Total Recoverable Iron	mg/kg dry wt	13,500	5,400	-	18,000	-
Total Recoverable Lead	mg/kg dry wt	18.1	8.8	8.7	26	14.1
Total Recoverable Manganese	mg/kg dry wt	63	49	-	76	-
Total Recoverable Mercury	mg/kg dry wt	0.115	0.036	0.033	0.061	0.048
Total Recoverable Nickel	mg/kg dry wt	5.7	2.4	1.7	10.1	-
Total Recoverable Zinc	mg/kg dry wt	76	32	40	169	74

Sample Name:		172/66 [<500um]	172/97 [<500um]	172/125 [<500um]	Agal 10 - 2 [<500um]	172/155 [<500um]
Lab Number:		1234172.211	1234172.212	1234172.213	1234172.214	1234172.215
Individual Tests						
Total Recoverable Arsenic	mg/kg dry wt	8.1	10.4	6.2	19.7	8.2
Total Recoverable Cadmium	mg/kg dry wt	-	-	-	10.0	-
Total Recoverable Chromium	mg/kg dry wt	-	-	-	48	-
Total Recoverable Copper	mg/kg dry wt	26	21	12.1	22	24
Total Recoverable Lead	mg/kg dry wt	31	25	8.8	41	31
Total Recoverable Mercury	mg/kg dry wt	0.145	0.146	0.037	10.9	0.169
Total Recoverable Nickel	mg/kg dry wt	-	-	-	11.1	-
Total Recoverable Zinc	mg/kg dry wt	210	94	52	53	167

Sample Name:		172/183 [<500um]	172/100 [<500um]	172/QA20 [<500um]	172/12 [<500um]	172/40 [<500um]
Lab Number:		1234172.216	1234172.217	1234172.218	1234172.219	1234172.220
Individual Tests						
Total Recoverable Arsenic	mg/kg dry wt	8.6	6.9	2.8	-	16.5

Sample Type: Sediment						
Sample Name:		172/183 [<500um]	172/100 [<500um]	172/QA20 [<500um]	172/12 [<500um]	172/40 [<500um]
Lab Number:		1234172.216	1234172.217	1234172.218	1234172.219	1234172.220
Individual Tests						
Total Recoverable Cadmium	mg/kg dry wt	0.066	-	0.076	-	-
Total Recoverable Chromium	mg/kg dry wt	14.7	-	4.7	-	-
Total Recoverable Copper	mg/kg dry wt	14.4	8.4	3.0	27	11.1
Total Recoverable Iron	mg/kg dry wt	14,200	-	-	-	-
Total Recoverable Lead	mg/kg dry wt	19.6	17.5	9.2	26	13.9
Total Recoverable Manganese	mg/kg dry wt	73	-	-	-	-
Total Recoverable Mercury	mg/kg dry wt	0.130	0.088	0.035	-	0.044
Total Recoverable Nickel	mg/kg dry wt	6.4	-	1.8	-	-
Total Recoverable Zinc	mg/kg dry wt	84	77	43	178	74

Sample Name:		172/69 [<500um]	172/QA1 [<500um]	172/128 [<500um]	172/156 [<500um]	172/186 [<500um]
Lab Number:		1234172.221	1234172.222	1234172.223	1234172.224	1234172.225
Individual Tests						
Total Recoverable Arsenic	mg/kg dry wt	6.1	10.6	7.1	10.0	9.3
Total Recoverable Cadmium	mg/kg dry wt	-	-	-	0.098	0.078
Total Recoverable Chromium	mg/kg dry wt	-	-	-	22	22
Total Recoverable Copper	mg/kg dry wt	19.0	17.5	6.8	22	18.5
Total Recoverable Iron	mg/kg dry wt	-	-	-	19,600	19,100
Total Recoverable Lead	mg/kg dry wt	39	23	18.5	25	32
Total Recoverable Manganese	mg/kg dry wt	-	-	-	95	110
Total Recoverable Mercury	mg/kg dry wt	0.28	0.064	0.131	0.158	0.198
Total Recoverable Nickel	mg/kg dry wt	-	-	-	9.5	8.3
Total Recoverable Zinc	mg/kg dry wt	240	132	86	99	114

Sample Name:		172/QA2 [<500um]	172/13 [<500um]	172/41 [<500um]	172/70 [<500um]	172/101 [<500um]
Lab Number:		1234172.226	1234172.227	1234172.228	1234172.229	1234172.230
Individual Tests						
Total Recoverable Arsenic	mg/kg dry wt	6.8	-	16.0	6.7	6.0
Total Recoverable Copper	mg/kg dry wt	5.9	26	11.3	19.1	8.0
Total Recoverable Lead	mg/kg dry wt	11.1	28	14.5	41	16.6
Total Recoverable Mercury	mg/kg dry wt	0.019	-	0.042	0.21	0.072
Total Recoverable Zinc	mg/kg dry wt	67	174	74	270	74

Sample Name:		172/129 [<500um]	172/157 [<500um]	172/187 [<500um]	172/QA3[<500um]	172/14 [<500um]
Lab Number:		1234172.231	1234172.232	1234172.233	1234172.234	1234172.235
Individual Tests						
Total Recoverable Arsenic	mg/kg dry wt	6.9	9.3	8.2	9.2	6.9
Total Recoverable Cadmium	mg/kg dry wt	-	0.079	0.073	-	-
Total Recoverable Chromium	mg/kg dry wt	-	21	21	-	-
Total Recoverable Copper	mg/kg dry wt	6.3	20	18.8	21	10.9
Total Recoverable Iron	mg/kg dry wt	-	19,500	18,700	-	-
Total Recoverable Lead	mg/kg dry wt	17.9	24	31	24	29
Total Recoverable Manganese	mg/kg dry wt	-	95	99	-	-
Total Recoverable Mercury	mg/kg dry wt	0.120	0.145	0.24	0.146	0.151
Total Recoverable Nickel	mg/kg dry wt	-	8.8	8.4	-	-
Total Recoverable Zinc	mg/kg dry wt	81	95	116	91	106

Sample Name:		172/44 [<500um]	172/71 [<500um]	172/102 [<500um]	172/130 [<500um]	172/158 [<500um]
Lab Number:		1234172.236	1234172.237	1234172.238	1234172.239	1234172.240
Individual Tests						
Total Recoverable Arsenic	mg/kg dry wt	11.1	6.2	6.8	6.8	9.9
Total Recoverable Cadmium	mg/kg dry wt	-	-	-	-	0.091
Total Recoverable Chromium	mg/kg dry wt	-	-	-	-	21
Total Recoverable Copper	mg/kg dry wt	22	18.8	8.9	6.4	22
Total Recoverable Iron	mg/kg dry wt	-	-	-	-	20,000

Sample Type: Sediment						
Sample Name:		172/44 [<500um]	172/71 [<500um]	172/102 [<500um]	172/130 [<500um]	172/158 [<500um]
Lab Number:		1234172.236	1234172.237	1234172.238	1234172.239	1234172.240
Individual Tests						
Total Recoverable Lead	mg/kg dry wt	24	41	17.2	17.4	26
Total Recoverable Manganese	mg/kg dry wt	-	-	-	-	85
Total Recoverable Mercury	mg/kg dry wt	0.155	0.190	0.109	0.149	0.159
Total Recoverable Nickel	mg/kg dry wt	-	-	-	-	9.8
Total Recoverable Zinc	mg/kg dry wt	112	260	78	82	101

Sample Name:		172/188 [<500um]	172/QA4 [<500um]	172/15 [<500um]	Agal 10 - 3 [<500um]	172/45 [<500um]
Lab Number:		1234172.241	1234172.242	1234172.243	1234172.244	1234172.245
Individual Tests						
Total Recoverable Arsenic	mg/kg dry wt	8.1	4.4	6.9	21	10.9
Total Recoverable Cadmium	mg/kg dry wt	0.066	-	-	10.0	-
Total Recoverable Chromium	mg/kg dry wt	21	-	-	51	-
Total Recoverable Copper	mg/kg dry wt	18.6	2.6	10.7	23	21
Total Recoverable Iron	mg/kg dry wt	17,700	-	-	-	-
Total Recoverable Lead	mg/kg dry wt	31	6.7	28	44	24
Total Recoverable Manganese	mg/kg dry wt	98	-	-	-	-
Total Recoverable Mercury	mg/kg dry wt	0.21	0.045	0.170	11.4	0.128
Total Recoverable Nickel	mg/kg dry wt	8.4	-	-	11.9	-
Total Recoverable Zinc	mg/kg dry wt	111	30	105	55	107

Sample Name:		172/74 [<500um]	172/105 [<500um]	172/133 [<500um]	172/161 [<500um]	172/191 [<500um]
Lab Number:		1234172.246	1234172.247	1234172.248	1234172.249	1234172.250
Individual Tests						
Total Recoverable Arsenic	mg/kg dry wt	10.5	4.6	10.1	14.4	12.3
Total Recoverable Cadmium	mg/kg dry wt	-	-	-	0.060	0.053
Total Recoverable Chromium	mg/kg dry wt	-	-	-	15.1	9.8
Total Recoverable Copper	mg/kg dry wt	23	3.9	24	13.0	11.4
Total Recoverable Iron	mg/kg dry wt	-	-	-	21,000	12,300
Total Recoverable Lead	mg/kg dry wt	36	9.4	38	28	16.7
Total Recoverable Manganese	mg/kg dry wt	-	-	-	97	60
Total Recoverable Mercury	mg/kg dry wt	0.155	0.079	0.179	0.134	0.126
Total Recoverable Nickel	mg/kg dry wt	-	-	-	6.5	3.7
Total Recoverable Zinc	mg/kg dry wt	136	43	155	108	63

Sample Name:		172/QA5 [<500um]	172/16 [<500um]	172/46 [<500um]	172/75 [<500um]	172/106 [<500um]
Lab Number:		1234172.251	1234172.252	1234172.253	1234172.254	1234172.255
Individual Tests						
Total Recoverable Arsenic	mg/kg dry wt	7.1	7.0	10.8	11.1	4.6
Total Recoverable Copper	mg/kg dry wt	7.1	11.4	21	24	4.1
Total Recoverable Lead	mg/kg dry wt	19.1	30	24	39	9.5
Total Recoverable Mercury	mg/kg dry wt	0.137	0.172	0.125	0.167	0.072
Total Recoverable Zinc	mg/kg dry wt	85	109	109	142	43

Sample Name:		172/134 [<500um]	172/162 [<500um]	172/192 [<500um]	172/QA6 [<500um]	172/19 [<500um]
Lab Number:		1234172.256	1234172.257	1234172.258	1234172.259	1234172.260
Individual Tests						
Total Recoverable Arsenic	mg/kg dry wt	10.3	14.5	10.3	10.8	13.8
Total Recoverable Cadmium	mg/kg dry wt	-	0.056	0.048	-	-
Total Recoverable Chromium	mg/kg dry wt	-	15.8	10.6	-	-
Total Recoverable Copper	mg/kg dry wt	24	14.1	11.2	34	9.5
Total Recoverable Iron	mg/kg dry wt	-	21,000	11,800	-	-
Total Recoverable Lead	mg/kg dry wt	40	28	16.9	59	10.9
Total Recoverable Manganese	mg/kg dry wt	-	108	69	-	-
Total Recoverable Mercury	mg/kg dry wt	0.174	0.147	0.117	0.153	0.038
Total Recoverable Nickel	mg/kg dry wt	-	6.8	4.0	-	-

Sample Type: Sediment						
Sample Name:		172/134 [<500um]	172/162 [<500um]	172/192 [<500um]	172/QA6 [<500um]	172/19 [<500um]
Lab Number:		1234172.256	1234172.257	1234172.258	1234172.259	1234172.260
Individual Tests						
Total Recoverable Zinc	mg/kg dry wt	155	110	62	280	62

Sample Name:		172/49 [<500um]	172/76 [<500um]	172/107 [<500um]	172/135 [<500um]	172/163 [<500um]
Lab Number:		1234172.261	1234172.262	1234172.263	1234172.264	1234172.265
Individual Tests						
Total Recoverable Arsenic	mg/kg dry wt	11.4	11.4	4.6	10.6	16.0
Total Recoverable Cadmium	mg/kg dry wt	-	-	-	-	0.072
Total Recoverable Chromium	mg/kg dry wt	-	-	-	-	16.3
Total Recoverable Copper	mg/kg dry wt	15.5	25	4.3	24	14.7
Total Recoverable Iron	mg/kg dry wt	-	-	-	-	21,000
Total Recoverable Lead	mg/kg dry wt	21	38	9.9	39	29
Total Recoverable Manganese	mg/kg dry wt	-	-	-	-	114
Total Recoverable Mercury	mg/kg dry wt	0.060	0.180	0.077	0.173	0.165
Total Recoverable Nickel	mg/kg dry wt	-	-	-	-	6.8
Total Recoverable Zinc	mg/kg dry wt	114	142	44	157	113

Sample Name:		172/193 [<500um]	172/QA7 [<500um]	172/79 [<500um]	172/110 [<500um]	172/138 [<500um]
Lab Number:		1234172.266	1234172.267	1234172.268	1234172.269	1234172.270
Individual Tests						
Total Recoverable Arsenic	mg/kg dry wt	12.1	9.1	10.4	4.7	11.0
Total Recoverable Cadmium	mg/kg dry wt	0.054	0.068	-	-	-
Total Recoverable Chromium	mg/kg dry wt	9.9	19.8	-	-	-
Total Recoverable Copper	mg/kg dry wt	11.1	19.9	5.9	2.5	34
Total Recoverable Iron	mg/kg dry wt	12,500	20,000	-	-	-
Total Recoverable Lead	mg/kg dry wt	16.2	24	11.0	6.7	59
Total Recoverable Manganese	mg/kg dry wt	65	93	-	-	-
Total Recoverable Mercury	mg/kg dry wt	0.133	0.157	0.040	0.043	0.163
Total Recoverable Nickel	mg/kg dry wt	3.9	8.5	-	-	-
Total Recoverable Zinc	mg/kg dry wt	62	95	66	32	280

Sample Name:		172/166 [<500um]	172/196 [<500um]	172/QA9 [<500um]	Agal 10 - 4 [<500um]	172/20 [<500um]
Lab Number:		1234172.271	1234172.272	1234172.273	1234172.274	1234172.275
Individual Tests						
Total Recoverable Arsenic	mg/kg dry wt	7.0	9.7	9.2	19.5	13.8
Total Recoverable Cadmium	mg/kg dry wt	0.076	0.081	0.175	9.1	-
Total Recoverable Chromium	mg/kg dry wt	13.5	24	31	42	-
Total Recoverable Copper	mg/kg dry wt	11.7	23	31	24	9.5
Total Recoverable Iron	mg/kg dry wt	12,700	22,000	-	-	-
Total Recoverable Lead	mg/kg dry wt	19.1	26	37	40	9.9
Total Recoverable Manganese	mg/kg dry wt	71	132	-	-	-
Total Recoverable Mercury	mg/kg dry wt	0.143	0.154	0.186	10.4	0.038
Total Recoverable Nickel	mg/kg dry wt	5.7	10.6	12.1	11.8	-
Total Recoverable Zinc	mg/kg dry wt	84	109	230	54	61

Sample Name:		172/50 [<500um]	172/139 [<500um]	172/167 [<500um]	172/197 [<500um]	172/QA10 [<500um]
Lab Number:		1234172.276	1234172.277	1234172.278	1234172.279	1234172.280
Individual Tests						
Total Recoverable Arsenic	mg/kg dry wt	12.2	11.0	6.5	11.7	9.6
Total Recoverable Cadmium	mg/kg dry wt	-	-	0.063	0.063	0.153
Total Recoverable Chromium	mg/kg dry wt	-	-	10.4	19.2	26
Total Recoverable Copper	mg/kg dry wt	15.0	32	10.5	23	31
Total Recoverable Iron	mg/kg dry wt	-	-	10,500	23,000	-
Total Recoverable Lead	mg/kg dry wt	18.6	55	16.9	23	35
Total Recoverable Manganese	mg/kg dry wt	-	-	57	192	-
Total Recoverable Mercury	mg/kg dry wt	0.057	0.144	0.110	0.133	0.169

Sample Type: Sediment						
Sample Name:		172/50 [<500um]	172/139 [<500um]	172/167 [<500um]	172/197 [<500um]	172/QA10 [<500um]
Lab Number:		1234172.276	1234172.277	1234172.278	1234172.279	1234172.280
Individual Tests						
Total Recoverable Nickel	mg/kg dry wt	-	-	5.4	10.0	12.1
Total Recoverable Zinc	mg/kg dry wt	109	250	74	102	230

Sample Name:		172/21 [<500um]	172/51 [<500um]	172/80 [<500um]	172/111 [<500um]	172/140 [<500um]
Lab Number:		1234172.281	1234172.282	1234172.283	1234172.284	1234172.285
Individual Tests						
Total Recoverable Arsenic	mg/kg dry wt	13.8	11.9	11.3	5.1	10.8
Total Recoverable Copper	mg/kg dry wt	9.6	15.5	6.2	2.6	32
Total Recoverable Lead	mg/kg dry wt	10.2	19.2	10.7	6.4	54
Total Recoverable Mercury	mg/kg dry wt	0.034	0.057	0.036	0.025	0.139
Total Recoverable Zinc	mg/kg dry wt	61	111	68	29	260

Sample Name:		172/168 [<500um]	172/198 [<500um]	172/QA11 [<500um]	172/24 [<500um]	172/54 [<500um]
Lab Number:		1234172.286	1234172.287	1234172.288	1234172.289	1234172.290
Individual Tests						
Total Recoverable Arsenic	mg/kg dry wt	6.5	10.7	9.8	6.8	10.0
Total Recoverable Cadmium	mg/kg dry wt	0.071	0.059	0.140	-	-
Total Recoverable Chromium	mg/kg dry wt	11.4	20	25	-	-
Total Recoverable Copper	mg/kg dry wt	12.2	23	30	5.3	29
Total Recoverable Iron	mg/kg dry wt	11,300	22,000	-	-	-
Total Recoverable Lead	mg/kg dry wt	18.5	24	34	10.2	54
Total Recoverable Manganese	mg/kg dry wt	64	178	-	-	-
Total Recoverable Mercury	mg/kg dry wt	0.115	0.148	0.163	0.016	0.21
Total Recoverable Nickel	mg/kg dry wt	6.2	10.0	11.2	-	-
Total Recoverable Zinc	mg/kg dry wt	85	104	210	64	250

Sample Name:		172/81 [<500um]	172/112 [<500um]	172/143 [<500um]	172/171 [<500um]	172/201 [<500um]
Lab Number:		1234172.291	1234172.292	1234172.293	1234172.294	1234172.295
Individual Tests						
Total Recoverable Arsenic	mg/kg dry wt	10.0	5.0	13.0	6.4	9.2
Total Recoverable Cadmium	mg/kg dry wt	-	-	-	0.038	0.077
Total Recoverable Chromium	mg/kg dry wt	-	-	-	6.9	21
Total Recoverable Copper	mg/kg dry wt	5.4	2.6	41	5.6	22
Total Recoverable Iron	mg/kg dry wt	-	-	-	8,100	17,600
Total Recoverable Lead	mg/kg dry wt	10.0	6.4	57	11.3	30
Total Recoverable Manganese	mg/kg dry wt	-	-	-	52	85
Total Recoverable Mercury	mg/kg dry wt	0.033	0.033	0.156	0.051	0.174
Total Recoverable Nickel	mg/kg dry wt	-	-	-	2.5	8.9
Total Recoverable Zinc	mg/kg dry wt	60	30	220	42	127

Sample Name:		172/QA12 [<500um]	172/25 [<500um]	172/55 [<500um]	172/84 [<500um]	172/115 [<500um]
Lab Number:		1234172.296	1234172.297	1234172.298	1234172.299	1234172.300
Individual Tests						
Total Recoverable Arsenic	mg/kg dry wt	2.9	7.9	10.2	11.0	10.9
Total Recoverable Cadmium	mg/kg dry wt	0.062	-	-	-	< 0.010
Total Recoverable Chromium	mg/kg dry wt	4.4	-	-	-	6.9
Total Recoverable Copper	mg/kg dry wt	2.8	5.5	27	5.8	1.4
Total Recoverable Iron	mg/kg dry wt	-	-	-	-	12,000
Total Recoverable Lead	mg/kg dry wt	8.7	12.9	56	11.8	2.8
Total Recoverable Manganese	mg/kg dry wt	-	-	-	-	117
Total Recoverable Mercury	mg/kg dry wt	0.037	0.019	0.22	0.043	< 0.010
Total Recoverable Nickel	mg/kg dry wt	1.5	-	-	-	3.9
Total Recoverable Zinc	mg/kg dry wt	39	69	250	69	19.8

Sample Type: Sediment						
Sample Name:		172/144 [<500um]	172/26 [<500um]	172/85 [<500um]	Agal 10 - 5 [<500um]	172/116 [<500um]
Lab Number:		1234172.301	1234172.302	1234172.303	1234172.304	1234172.305
Individual Tests						
Total Recoverable Arsenic	mg/kg dry wt	11.3	8.5	7.9	19.0	-
Total Recoverable Cadmium	mg/kg dry wt	-	-	-	9.4	-
Total Recoverable Chromium	mg/kg dry wt	-	-	-	45	-
Total Recoverable Copper	mg/kg dry wt	37	5.4	15.7	23	1.5
Total Recoverable Lead	mg/kg dry wt	57	16.2	22	39	2.8
Total Recoverable Mercury	mg/kg dry wt	0.156	0.019	0.108	10.3	-
Total Recoverable Nickel	mg/kg dry wt	-	-	-	10.2	-
Total Recoverable Zinc	mg/kg dry wt	210	67	161	50	20

Sample Name:		172/145 [<500um]	172/202 [<500um]	172/QA13 [<500um]	172/86 [<500um]	172/148 [<500um]
Lab Number:		1234172.306	1234172.307	1234172.308	1234172.309	1234172.310
Individual Tests						
Total Recoverable Arsenic	mg/kg dry wt	12.2	9.8	2.7	8.3	5.9
Total Recoverable Cadmium	mg/kg dry wt	-	0.076	0.061	-	-
Total Recoverable Chromium	mg/kg dry wt	-	20	4.1	-	-
Total Recoverable Copper	mg/kg dry wt	37	20	2.7	16.7	4.3
Total Recoverable Iron	mg/kg dry wt	-	16,800	-	-	-
Total Recoverable Lead	mg/kg dry wt	60	29	8.4	23	7.2
Total Recoverable Manganese	mg/kg dry wt	-	105	-	-	-
Total Recoverable Mercury	mg/kg dry wt	0.151	0.154	0.030	0.108	0.027
Total Recoverable Nickel	mg/kg dry wt	-	8.2	1.5	-	-
Total Recoverable Zinc	mg/kg dry wt	220	120	39	173	31

Sample Name:		172/172 [<500um]	172/203 [<500um]	172/11 - 13	172/120 - 122	172/157
Lab Number:		1234172.311	1234172.312	1234172.313	1234172.314	1234172.315
Individual Tests						
Total Recoverable Arsenic	mg/kg dry wt	6.7	10.0	-	-	-
Total Recoverable Cadmium	mg/kg dry wt	0.035	0.086	-	-	-
Total Recoverable Chromium	mg/kg dry wt	7.0	21	-	-	-
Total Recoverable Copper	mg/kg dry wt	5.3	21	-	-	-
Total Recoverable Iron	mg/kg dry wt	8,000	18,600	-	-	-
Total Recoverable Lead	mg/kg dry wt	11.5	30	-	-	-
Total Recoverable Manganese	mg/kg dry wt	47	93	-	-	-
Total Recoverable Mercury	mg/kg dry wt	0.054	0.154	-	-	-
Total Recoverable Nickel	mg/kg dry wt	2.5	8.3	-	-	-
Total Recoverable Zinc	mg/kg dry wt	41	124	-	-	-
Total Organic Carbon*	g/100g dry wt	-	-	2.8	1.13	2.5
Polycyclic Aromatic Hydrocarbons Trace in Soil						
Acenaphthene	mg/kg dry wt	-	-	< 0.002	< 0.002	< 0.002
Acenaphthylene	mg/kg dry wt	-	-	< 0.002	< 0.002	0.003
Anthracene	mg/kg dry wt	-	-	< 0.002	< 0.002	0.004
Benzo[a]anthracene	mg/kg dry wt	-	-	0.007	< 0.002	0.023
Benzo[a]pyrene (BAP)	mg/kg dry wt	-	-	0.010	< 0.002	0.041
Benzo[b]fluoranthene + Benzo[j]fluoranthene	mg/kg dry wt	-	-	0.016	0.002	0.053
Benzo[g,h,i]perylene	mg/kg dry wt	-	-	0.028	< 0.002	0.044
Benzo[k]fluoranthene	mg/kg dry wt	-	-	0.006	< 0.002	0.021
Chrysene	mg/kg dry wt	-	-	0.007	< 0.002	0.027
Dibenzo[a,h]anthracene	mg/kg dry wt	-	-	0.002	< 0.002	0.005
Fluoranthene	mg/kg dry wt	-	-	0.018	0.003	0.056
Fluorene	mg/kg dry wt	-	-	< 0.002	< 0.002	< 0.002
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	-	-	0.013	< 0.002	0.040
Naphthalene	mg/kg dry wt	-	-	0.015	< 0.010	< 0.010
Phenanthrene	mg/kg dry wt	-	-	0.006	< 0.002	0.019
Pyrene	mg/kg dry wt	-	-	0.021	0.003	0.062

Sample Type: Sediment						
Sample Name:		172/162	172/167	172/172	172/177	172/182
Lab Number:		1234172.316	1234172.317	1234172.318	1234172.319	1234172.320
Individual Tests						
Total Organic Carbon*	g/100g dry wt	1.25	0.98	0.62	0.87	1.23
Polycyclic Aromatic Hydrocarbons Trace in Soil						
Acenaphthene	mg/kg dry wt	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Acenaphthylene	mg/kg dry wt	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Anthracene	mg/kg dry wt	< 0.002	0.003	< 0.002	< 0.002	< 0.002
Benzo[a]anthracene	mg/kg dry wt	0.010	0.018	0.002	0.007	0.010
Benzo[a]pyrene (BAP)	mg/kg dry wt	0.017	0.027	0.005	0.013	0.018
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	0.023	0.034	0.007	0.017	0.024
Benzo[g,h,i]perylene	mg/kg dry wt	0.018	0.027	0.005	0.014	0.021
Benzo[k]fluoranthene	mg/kg dry wt	0.009	0.013	0.002	0.007	0.010
Chrysene	mg/kg dry wt	0.011	0.019	0.003	0.008	0.012
Dibenzo[a,h]anthracene	mg/kg dry wt	0.002	0.003	< 0.002	< 0.002	< 0.002
Fluoranthene	mg/kg dry wt	0.026	0.043	0.008	0.018	0.027
Fluorene	mg/kg dry wt	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	0.016	0.027	0.005	0.014	0.020
Naphthalene	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Phenanthrene	mg/kg dry wt	0.007	0.013	< 0.002	0.005	0.010
Pyrene	mg/kg dry wt	0.026	0.045	0.008	0.019	0.030

Sample Name:		172/187	172/192	172/197	172/202	172/207
Lab Number:		1234172.321	1234172.322	1234172.323	1234172.324	1234172.325
Individual Tests						
Total Organic Carbon*	g/100g dry wt	1.43	0.70	3.0	2.1	2.7
Polycyclic Aromatic Hydrocarbons Trace in Soil						
Acenaphthene	mg/kg dry wt	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Acenaphthylene	mg/kg dry wt	0.006	< 0.002	0.002	0.003	0.003
Anthracene	mg/kg dry wt	0.007	< 0.002	0.003	0.006	0.004
Benzo[a]anthracene	mg/kg dry wt	0.053	0.007	0.018	0.033	0.024
Benzo[a]pyrene (BAP)	mg/kg dry wt	0.074	0.013	0.035	0.048	0.039
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	0.095	0.017	0.046	0.063	0.051
Benzo[g,h,i]perylene	mg/kg dry wt	0.070	0.013	0.039	0.051	0.040
Benzo[k]fluoranthene	mg/kg dry wt	0.038	0.007	0.018	0.025	0.020
Chrysene	mg/kg dry wt	0.051	0.008	0.022	0.036	0.026
Dibenzo[a,h]anthracene	mg/kg dry wt	0.011	< 0.002	0.005	0.005	0.004
Fluoranthene	mg/kg dry wt	0.096	0.018	0.044	0.075	0.056
Fluorene	mg/kg dry wt	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	0.068	0.012	0.033	0.044	0.036
Naphthalene	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Phenanthrene	mg/kg dry wt	0.027	0.004	0.012	0.026	0.019
Pyrene	mg/kg dry wt	0.105	0.019	0.049	0.079	0.061

Sample Name:		172/212	172/QA7	OA172/11	OA172/29	OA172/49
Lab Number:		1234172.326	1234172.327	1234172.328	1234172.329	1234172.330
Individual Tests						
Total Organic Carbon*	g/100g dry wt	0.62	2.5	3.0	2.7	1.81
Polycyclic Aromatic Hydrocarbons Trace in Soil						
Acenaphthene	mg/kg dry wt	< 0.002	< 0.002	-	-	-
Acenaphthylene	mg/kg dry wt	< 0.002	0.002	-	-	-
Anthracene	mg/kg dry wt	< 0.002	0.003	-	-	-
Benzo[a]anthracene	mg/kg dry wt	0.006	0.020	-	-	-
Benzo[a]pyrene (BAP)	mg/kg dry wt	0.008	0.035	-	-	-
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	0.012	0.046	-	-	-
Benzo[g,h,i]perylene	mg/kg dry wt	0.008	0.038	-	-	-
Benzo[k]fluoranthene	mg/kg dry wt	0.005	0.018	-	-	-

Sample Type: Sediment						
Sample Name:		172/212	172/QA7	OA172/11	OA172/29	OA172/49
Lab Number:		1234172.326	1234172.327	1234172.328	1234172.329	1234172.330
Polycyclic Aromatic Hydrocarbons Trace in Soil						
Chrysene	mg/kg dry wt	0.006	0.023	-	-	-
Dibenzo[a,h]anthracene	mg/kg dry wt	< 0.002	0.004	-	-	-
Fluoranthene	mg/kg dry wt	0.014	0.047	-	-	-
Fluorene	mg/kg dry wt	< 0.002	< 0.002	-	-	-
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	0.007	0.035	-	-	-
Naphthalene	mg/kg dry wt	< 0.010	< 0.010	-	-	-
Phenanthrene	mg/kg dry wt	0.005	0.015	-	-	-
Pyrene	mg/kg dry wt	0.014	0.052	-	-	-

Sample Name:		OA172/54	OA172/74	OA172/90	OA172/110	OA172/120
Lab Number:		1234172.331	1234172.332	1234172.333	1234172.334	1234172.335
Individual Tests						
Total Organic Carbon*	g/100g dry wt	1.94	2.3	1.73	0.80	1.37

Sample Name:		OA172/133	OA172/138	OA172/143	OA172/196 - 198	OA172/QA21
Lab Number:		1234172.336	1234172.337	1234172.338	1234172.339	1234172.340
Individual Tests						
Total Organic Carbon*	g/100g dry wt	1.98	2.1	2.5	2.9	1.87

Sample Name:		OA172/MID BRS	OA172/11	OA172/120	Awaruku Str OA172/11 - 13	Vaughn Str OA172/120 - 122
Lab Number:		1234172.341	1234172.342	1234172.343	1234172.344	1234172.345
Individual Tests						
Dry Matter	g/100g as rcvd	-	-	-	47	61
Total Organic Carbon*	g/100g dry wt	1.81	-	-	-	-
Polycyclic Aromatic Hydrocarbons Trace in Soil						
Acenaphthene	mg/kg dry wt	-	< 0.002	< 0.002	-	-
Acenaphthylene	mg/kg dry wt	-	< 0.002	< 0.002	-	-
Anthracene	mg/kg dry wt	-	< 0.002	< 0.002	-	-
Benzo[a]anthracene	mg/kg dry wt	-	0.007	< 0.002	-	-
Benzo[a]pyrene (BAP)	mg/kg dry wt	-	0.011	0.003	-	-
Benzo[b]fluoranthene + Benzo[j]fluoranthene	mg/kg dry wt	-	0.018	0.003	-	-
Benzo[g,h,i]perylene	mg/kg dry wt	-	0.032	0.003	-	-
Benzo[k]fluoranthene	mg/kg dry wt	-	0.006	< 0.002	-	-
Chrysene	mg/kg dry wt	-	0.008	< 0.002	-	-
Dibenzo[a,h]anthracene	mg/kg dry wt	-	< 0.002	< 0.002	-	-
Fluoranthene	mg/kg dry wt	-	0.018	0.004	-	-
Fluorene	mg/kg dry wt	-	< 0.002	< 0.002	-	-
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	-	0.015	0.003	-	-
Naphthalene	mg/kg dry wt	-	< 0.010	< 0.010	-	-
Phenanthrene	mg/kg dry wt	-	0.005	< 0.002	-	-
Pyrene	mg/kg dry wt	-	0.022	0.005	-	-
Total Petroleum Hydrocarbons in Soil, GC						
C7 - C9	mg/kg dry wt	-	-	-	< 30	< 11
C10 - C11	mg/kg dry wt	-	-	-	< 30	< 11
C12 - C14	mg/kg dry wt	-	-	-	< 30	< 11
C15 - C20	mg/kg dry wt	-	-	-	< 30	< 11
C21 - C25	mg/kg dry wt	-	-	-	< 30	< 11
C26 - C29	mg/kg dry wt	-	-	-	< 30	< 11
C30 - C44	mg/kg dry wt	-	-	-	< 40	< 20
Total hydrocarbons (C7 - C44)	mg/kg dry wt	-	-	-	< 300	< 90

Sample Name:		172/QA15	172/QA16	172/QA17		
Lab Number:		1234172.346	1234172.347	1234172.348		
Individual Tests						
Total Organic Carbon*	g/100g dry wt	1.95	1.80	1.90	-	-

Sample Type: Sediment						
Sample Name:		172/QA15	172/QA16	172/QA17		
Lab Number:		1234172.346	1234172.347	1234172.348		
Polycyclic Aromatic Hydrocarbons Trace in Soil						
Acenaphthene	mg/kg dry wt	0.003	0.003	0.003	-	-
Acenaphthylene	mg/kg dry wt	0.003	0.003	0.004	-	-
Anthracene	mg/kg dry wt	0.006	0.008	0.009	-	-
Benzo[a]anthracene	mg/kg dry wt	0.064	0.063	0.061	-	-
Benzo[a]pyrene (BAP)	mg/kg dry wt	0.065	0.081	0.080	-	-
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	0.104	0.114	0.113	-	-
Benzo[g,h,i]perylene	mg/kg dry wt	0.062	0.084	0.085	-	-
Benzo[k]fluoranthene	mg/kg dry wt	0.040	0.046	0.044	-	-
Chrysene	mg/kg dry wt	0.059	0.064	0.062	-	-
Dibenzo[a,h]anthracene	mg/kg dry wt	0.010	0.012	0.011	-	-
Fluoranthene	mg/kg dry wt	0.131	0.134	0.137	-	-
Fluorene	mg/kg dry wt	0.003	0.003	0.002	-	-
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	0.061	0.079	0.084	-	-
Naphthalene	mg/kg dry wt	< 0.010	< 0.010	< 0.010	-	-
Phenanthrene	mg/kg dry wt	0.047	0.041	0.043	-	-
Pyrene	mg/kg dry wt	0.122	0.130	0.133	-	-

Analyst's Comments

Supplement to test report 1234172v1, issued 11/3/14.

Appendix No.1 - QC report

SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Sediment			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Polycyclic Aromatic Hydrocarbons Trace in Soil	Sonication extraction, SPE cleanup, GC-MS SIM analysis US EPA 8270C. Tested on dried sample	0.002 - 0.010 mg/kg dry wt	313-327, 342-343, 346-348
Total Petroleum Hydrocarbons in Soil, GC	Sonication extraction, Silica cleanup, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines. Tested on as received sample [KBIs:5786,2805,10734]	8 - 70 mg/kg dry wt	344-345
Dry Matter (Env)	Dried at 103°C for 4-22hr (removes 3-5% more water than air dry) , gravimetry. US EPA 3550. (Free water removed before analysis).	0.10 g/100g as rcvd	344-345
ARC 2M HCl Extraction*	<63µm Sieved Fraction, extracted with 2M HCl. Solid:Liquid 1:50 w/v. ARC Tech Publication No. 47, 1994.	-	1-153
Total Recoverable digestion	Nitric / hydrochloric acid digestion. US EPA 200.2.	-	154-312
Total Recoverable Arsenic	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, trace level. US EPA 200.2.	0.2 mg/kg dry wt	154-157, 159-175, 177-185, 187-190, 192-199, 201-218, 220-226, 228-304, 306-312

Sample Type: Sediment			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Total Recoverable Cadmium	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, trace level. US EPA 200.2.	0.010 mg/kg dry wt	160-162, 167, 169-171, 178-181, 184, 188-190, 197-199, 206-209, 214, 216, 218, 224-225, 232-233, 240-241, 244, 249-250, 257-258, 265-267, 271-274, 278-280, 286-288, 294-296, 300, 304, 307-308, 311-312
Total Recoverable Chromium	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, trace level. US EPA 200.2.	0.2 mg/kg dry wt	160-162, 167, 169-171, 178-181, 184, 188-190, 197-199, 206-209, 214, 216, 218, 224-225, 232-233, 240-241, 244, 249-250, 257-258, 265-267, 271-274, 278-280, 286-288, 294-296, 300, 304, 307-308, 311-312
Extractable Copper*	2M HCl extraction (<63µm fraction), ICP-MS. ARC Tech Publication No. 47, 1994.	1.0 mg/kg dry wt	1-153
Total Recoverable Copper	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, trace level. US EPA 200.2.	0.2 mg/kg dry wt	154-312
Total Recoverable Iron	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, screen level. US EPA 200.2.	40 mg/kg dry wt	160-161, 167, 169-170, 178-179, 181, 188-189, 197-198, 206-207, 209, 216, 224-225, 232-233, 240-241, 249-250, 257-258, 265-267, 271-272, 278-279, 286-287, 294-295, 300, 307, 311-312

Sample Type: Sediment			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Extractable Lead*	2M HCl extraction (<63µm fraction), ICP-MS. ARC Tech Publication No. 47, 1994.	0.2 mg/kg dry wt	1-153
Total Recoverable Lead	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, trace level. US EPA 200.2.	0.04 mg/kg dry wt	154-312
Total Recoverable Manganese	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, screen level. US EPA 200.2.	1.0 mg/kg dry wt	160-161, 167, 169-170, 178-179, 181, 188-189, 197-198, 206-207, 209, 216, 224-225, 232-233, 240-241, 249-250, 257-258, 265-267, 271-272, 278-279, 286-287, 294-295, 300, 307, 311-312
Total Recoverable Mercury	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, trace level. US EPA 200.2.	0.010 mg/kg dry wt	154-157, 159-175, 177-185, 187-190, 192-199, 201-218, 220-226, 228-304, 306-312
Total Recoverable Nickel	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, trace level. US EPA 200.2.	0.2 mg/kg dry wt	160-162, 167, 169-171, 178-181, 184, 188-190, 197-199, 206-209, 214, 216, 218, 224-225, 232-233, 240-241, 244, 249-250, 257-258, 265-267, 271-274, 278-280, 286-288, 294-296, 300, 304, 307-308, 311-312
Extractable Zinc*	2M HCl extraction (<63µm fraction), ICP-MS. ARC Tech Publication No. 47, 1994.	2 mg/kg dry wt	1-153
Total Recoverable Zinc	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, trace level. US EPA 200.2.	0.4 mg/kg dry wt	154-312
Total Organic Carbon*	Acid pretreatment to remove carbonates if present, neutralisation, Elementar Combustion Analyser.	0.05 g/100g dry wt	313-341, 346-348

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

Graham Corban MSc Tech (Hons)
Client Services Manager - Environmental Division

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QUALITY CONTROL REPORT

Client:	Diffuse Sources Limited	**Lab No:**	1234172
Contact:	Geoff Mills	**Date Registered:**	11-Feb-2014
	c/o Diffuse Sources Limited	**Date Reported:**	
	PO Box 12476	**Quote No:**	53594
	HAMILTON 3248	**Order No:**	
		Client Reference:	RSCMP 2013
		Submitted By:	Geoff Mills

This report includes quality control data for the following analytes:

Sample Type: Soil	
Sediment Extractable metals (Cu, Pb, Zn)	Procedural Blank results Blank spike recoveries Duplicate sample analyses Sample spike recoveries
Total Recoverable metals (As,Cd,Cr,Cu,Fe,Hg,Mn,Ni,Pb,Zn)	Procedural Blank results Certified Reference material (CRM) Duplicate sample analyses
Total Organic Carbon	Procedural Blank results In House QC results
Polycyclic Aromatic Hydrocarbons (PAH)	Procedural Blank results System Monitoring Compound (SMC) Recoveries Matrix and Control Spike Recoveries
Total Petroleum Hydrocarbons (TPH)	Procedural Blank results Matrix and Control Spike Recoveries

Worksheet: esTR7744	For samples 1234172.1 - 31		
QC Name	Extractable Copper	Extractable Lead	Extractable Zinc
	(mg/kg/dry wt)	(mg/kg/dry wt)	(mg/kg/dry wt)
Procedural Blank	<1	<0.2	<2
Blank Spike recovery (% recovery)	86	91	91
Duplicate 1 (1234172.15)	10.8	17.6	101
Duplicate 2 (1234172.15)	10.7	18.3	100
Sample Spike recovery (% recovery)	85	91	91

Worksheet: esTR7754	For samples 1234172.32 - 61		
QC Name	Extractable Copper	Extractable Lead	Extractable Zinc
	(mg/kg/dry wt)	(mg/kg/dry wt)	(mg/kg/dry wt)
Procedural Blank	<1	<0.2	<2
Blank Spike recovery (% recovery)	94	96	98
Duplicate 1 (1234172.60)	29	39	240
Duplicate 2 (1234172.60)	27	36	230
Sample Spike recovery (% recovery)	97	92	85

Worksheet: esTR7770	For samples 1234172.62 - 91		
QC Name	Extractable Copper	Extractable Lead	Extractable Zinc
	(mg/kg/dry wt)	(mg/kg/dry wt)	(mg/kg/dry wt)
Procedural Blank	<1	<0.2	<2
Blank Spike recovery (% recovery)	90	96	96
Duplicate 1 (1234172.90)	18.9	24	101
Duplicate 2 (1234172.90)	18.4	23	95
Sample Spike recovery (% recovery)	90	87	91

Worksheet: esTR7776	For samples 1234172.92 - 121		
QC Name	Extractable Copper	Extractable Lead	Extractable Zinc
	(mg/kg/dry wt)	(mg/kg/dry wt)	(mg/kg/dry wt)
Procedural Blank	<1	<0.2	<2
Blank Spike recovery (% recovery)	92	90	95
Duplicate 1 (1234172.120)	38	68	250
Duplicate 2 (1234172.120)	37	66	240
Sample Spike recovery (% recovery)	90	89	88

Worksheet: esTR7784	For samples 1234172.122- 153		
QC Name	Extractable Copper	Extractable Lead	Extractable Zinc
	(mg/kg/dry wt)	(mg/kg/dry wt)	(mg/kg/dry wt)
Procedural Blank	<1	<0.2	<2
Blank Spike recovery (% recovery)	93	94	99
Duplicate 1 (1234172.152)	18.5	24	101
Duplicate 2 (1234172.152)	17.2	24	98
Sample Spike recovery (% recovery)	97	92	98

Worksheet: esTR7764	For samples 1234172.160,161,167,169,170,178,179,181,188,189,197,198,206,207,209,216,224,225,232	
QC Name	**Total Recoverable Iron**	**Total Recoverable Manganese**
	(mg/kg/dry wt)	**(mg/kg/dry wt)**
Procedural Blank	<40	<1
CRM (AGAL 10)	18700	250
CRM Certified Range (AGAL 10)	18830 -21170	230.5- 251.5
CRM In House Limits (AGAL 10)	15423- 21623	215- 277
CRM (AGAL 10)	18100	250

Worksheet: esTR7769	For samples 1234172.233,240,241,249,250,257,258,265-267,271,272	
QC Name	**Total Recoverable Iron**	**Total Recoverable Manganese**
	(mg/kg/dry wt)	**(mg/kg/dry wt)**
Procedural Blank	<40	<1
CRM (AGAL 10)	17300	230
CRM Certified Range (AGAL 10)	18830 -21170	230.5- 251.5
CRM In House Limits (AGAL 10)	15423- 21623	215- 277
Duplicate 1 (1234172.233)	18700	99
Duplicate 2 (1234172.233)	19100	101

Worksheet: esTR7781	For samples 1234172.278,279,286,287
QC Name	**Total Recoverable Manganese**
	(mg/kg/dry wt)
Procedural Blank	<1
CRM (AGAL 10)	240
CRM Certified Range (AGAL 10)	230.5- 251.5
CRM In House Limits (AGAL 10)	215- 277

Worksheet: esTR7782	For samples 1234172.294,295,300,307,311,312	
QC Name	**Total Recoverable Iron**	**Total Recoverable Manganese**
	(mg/kg/dry wt)	**(mg/kg/dry wt)**
Procedural Blank	<40	<1
CRM (AGAL 10)	17100	230
CRM Certified Range (AGAL 10)	18830 -21170	230.5- 251.5
CRM In House Limits (AGAL 10)	15423- 21623	215- 277

Worksheet: esTR7788	For samples 1234172.278,279,286,287
QC Name	**Total Recoverable Iron**
	(mg/kg/dry wt)
Procedural Blank	<40
CRM (AGAL 10)	18000
CRM Certified Range (AGAL 10)	18830 -21170
CRM In House Limits (AGAL 10)	15423- 21623

Worksheet: eITR2257	For samples 1234172.154 - 191		
QC Name	**Total Recoverable Arsenic**	**Total Recoverable Cadmium**	**Total Recoverable Chromium**
	(mg/kg/dry wt)	**(mg/kg/dry wt)**	**(mg/kg/dry wt)**
Procedural Blank	<0.2	<0.01	<0.2
CRM (AGAL 10)	21	9.6	47
CRM Certified Range (AGAL 10)[#1]	14.2 – 20.2	8.69 – 9.97	71 - 93
CRM In House Limits (AGAL 10)	16.18 - 23.09	7.82 – 11.03	27.17 – 71.86
Duplicate 1 (1234172.165)	6.1	N\A	N\A
Duplicate 2 (1234172.165)	6.1	N\A	N\A

Worksheet: eITR2257	For samples 1234172.154 - 191		
QC Name	**Total Recoverable Copper**	**Total Recoverable Lead**	**Total Recoverable Mercury**
	(mg/kg/dry wt)	**(mg/kg/dry wt)**	**(mg/kg/dry wt)**
Procedural Blank	<0.2	<0.04	<0.01
CRM (AGAL 10)	24	41	11.3
CRM Certified Range (AGAL 10)	21.3 – 25.1	37.7 – 43.1	10.5 – 12.7
CRM In House Limits (AGAL 10)	19.58 – 26.39	32.48 – 48.42	10.023– 13.61
Duplicate 1 (1234172.165)	8.3	18.7	0.080
Duplicate 2 (1234172.165)	8.3	18.2	0.089

Worksheet: eITR2257	For samples 1234172.154 - 191	
QC Name	**Total Recoverable Nickel**	**Total Recoverable Zinc**
	(mg/kg/dry wt)	**(mg/kg/dry wt)**
Procedural Blank	<0.2	<0.4
CRM (AGAL 10)	12	51
CRM Certified Range (AGAL 10)[#1]	15.1 – 20.5	52.8 – 61.2
CRM In House Limits (AGAL 10)	9.52 – 14.02	46.1 – 62.74
Duplicate 1 (1234172.165)	N\A	84
Duplicate 2 (1234172.165)	N\A	85

Worksheet: eITR2261	For samples 1234172.192 - 232		
QC Name	**Total Recoverable Arsenic**	**Total Recoverable Cadmium**	**Total Recoverable Chromium**
	(mg/kg/dry wt)	**(mg/kg/dry wt)**	**(mg/kg/dry wt)**
Procedural Blank	<0.2	<0.01	<0.2
CRM (AGAL 10)	18.4	10.2	47
CRM Certified Range (AGAL 10)[#1]	14.2 – 20.2	8.69 – 9.97	71 - 93
CRM In House Limits (AGAL 10)	16.18 - 23.09	7.82 – 11.03	27.17 – 71.86
Duplicate 1 (1234172.192)	10	N\A	N\A
Duplicate 2 (1234172.192)	11.4	N\A	N\A

Worksheet: eITR2261	For samples 1234172.192 - 232		
QC Name	**Total Recoverable Copper**	**Total Recoverable Lead**	**Total Recoverable Mercury**
	(mg/kg/dry wt)	**(mg/kg/dry wt)**	**(mg/kg/dry wt)**
Procedural Blank	<0.2	<0.04	<0.01
CRM (AGAL 10)	22	40	10.3
CRM Certified Range (AGAL 10)	21.3 – 25.1	37.7 – 43.1	10.5 – 12.7
CRM In House Limits (AGAL 10)	19.58 – 26.39	32.48 – 48.42	10.023– 13.61
Duplicate 1 (1234172.192)	5.6	11.5	0.04[#3]
Duplicate 2 (1234172.192)	5.2	11.6	0.058[#3]

Worksheet: eITR2261	For samples 1234172.192 - 232	
QC Name	**Total Recoverable Nickel**	**Total Recoverable Zinc**
	(mg/kg/dry wt)	**(mg/kg/dry wt)**
Procedural Blank	<0.2	<0.4
CRM (AGAL 10)	11.2	51
CRM Certified Range (AGAL 10)[#1]	15.1 – 20.5	52.8 – 61.2
CRM In House Limits (AGAL 10)	9.52 – 14.02	46.1 – 62.74
Duplicate 1 (1234172.192)	N\A	49
Duplicate 2 (1234172.192)	N\A	50

Worksheet: eITR2262	For samples 1234172.233 - 273		
QC Name	**Total Recoverable Arsenic**	**Total Recoverable Cadmium**	**Total Recoverable Chromium**
	(mg/kg/dry wt)	**(mg/kg/dry wt)**	**(mg/kg/dry wt)**
Procedural Blank	<0.2	<0.01	<0.2
CRM (AGAL 10)	19.5	10	49
CRM Certified Range (AGAL 10)[#1]	14.2 – 20.2	8.69 – 9.97	71 - 93
CRM In House Limits (AGAL 10)	16.18 - 23.09	7.82 – 11.03	27.17 – 71.86
Duplicate 1 (1234172.233)	8.2	0.073	21
Duplicate 2 (1234172.233)	8.6	0.069	20

Worksheet: eITR2262	For samples 1234172.233 - 273		
QC Name	**Total Recoverable Copper**	**Total Recoverable Lead**	**Total Recoverable Mercury**
	(mg/kg/dry wt)	**(mg/kg/dry wt)**	**(mg/kg/dry wt)**
Procedural Blank	<0.2	<0.04	<0.01
CRM (AGAL 10)	23	42	11.2
CRM Certified Range (AGAL 10)	21.3 – 25.1	37.7 – 43.1	10.5 – 12.7
CRM In House Limits (AGAL 10)	19.58 – 26.39	32.48 – 48.42	10.023– 13.61
Duplicate 1 (1234172.233)	18.8	31	0.24
Duplicate 2 (1234172.233)	19.4	31	0.23

Worksheet: eITR2262	For samples 1234172.233 - 273	
QC Name	**Total Recoverable Nickel**	**Total Recoverable Zinc**
	(mg/kg/dry wt)	**(mg/kg/dry wt)**
Procedural Blank	<0.2	<0.4
CRM (AGAL 10)	11.6	54
CRM Certified Range (AGAL 10)[#1]	15.1 – 20.5	52.8 – 61.2
CRM In House Limits (AGAL 10)	9.52 – 14.02	46.1 – 62.74
Duplicate 1 (1234172.233)	8.4	116
Duplicate 2 (1234172.233)	8.3	116

Worksheet: eITR2266	For samples 1234172.274 - 293		
QC Name	**Total Recoverable Arsenic**	**Total Recoverable Cadmium**	**Total Recoverable Chromium**
	(mg/kg/dry wt)	**(mg/kg/dry wt)**	**(mg/kg/dry wt)**
Procedural Blank	<0.2	<0.01	0.80[#2]
CRM (AGAL 10)	21	9	41
CRM Certified Range (AGAL 10)[#1]	14.2 – 20.2	8.69 – 9.97	71 - 93
CRM In House Limits (AGAL 10)	16.18 - 23.09	7.82 – 11.03	27.17 – 71.86
Duplicate 1 (1234172.277)	11	N\A	N\A
Duplicate 2 (1234172.277)	10.3	N\A	N\A

Worksheet: eITR2266	For samples 1234172.274 - 293		
QC Name	Total Recoverable Copper	Total Recoverable Lead	Total Recoverable Mercury
	(mg/kg/dry wt)	(mg/kg/dry wt)	(mg/kg/dry wt)
Procedural Blank	<0.2	<0.04	<0.01
CRM (AGAL 10)	25	40	10.3
CRM Certified Range (AGAL 10)	21.3 – 25.1	37.7 – 43.1	10.5 – 12.7
CRM In House Limits (AGAL 10)	19.58 – 26.39	32.48 – 48.42	10.023– 13.61
Duplicate 1 (1234172.277)	32	55	0.144
Duplicate 2 (1234172.277)	30	52	0.148

Worksheet: eITR2266	For samples 1234172.274 - 293	
QC Name	Total Recoverable Nickel	Total Recoverable Zinc
	(mg/kg/dry wt)	(mg/kg/dry wt)
Procedural Blank	<0.2	<0.4
CRM (AGAL 10)	11.8	52
CRM Certified Range (AGAL 10)[#1]	15.1 – 20.5	52.8 – 61.2
CRM In House Limits (AGAL 10)	9.52 – 14.02	46.1 – 62.74
Duplicate 1 (1234172.277)	N\A	250
Duplicate 2 (1234172.277)	N\A	240

Worksheet: eITR2267	For samples 1234172.294 - 312		
QC Name	Total Recoverable Arsenic	Total Recoverable Cadmium	Total Recoverable Chromium
	(mg/kg/dry wt)	(mg/kg/dry wt)	(mg/kg/dry wt)
Procedural Blank	<0.2	<0.01	<0.2
CRM (AGAL 10)	18.6	9.5	43
CRM Certified Range (AGAL 10)[#1]	14.2 – 20.2	8.69 – 9.97	71 - 93
CRM In House Limits (AGAL 10)	16.18 - 23.09	7.82 – 11.03	27.17 – 71.86
Duplicate 1 (1234172.296)	2.9	0.062	4.4
Duplicate 2 (1234172.296)	2.8	0.063	4.3

Worksheet: eITR2267	For samples 1234172.294 - 312		
QC Name	Total Recoverable Copper	Total Recoverable Lead	Total Recoverable Mercury
	(mg/kg/dry wt)	(mg/kg/dry wt)	(mg/kg/dry wt)
Procedural Blank	<0.2	<0.04	<0.01
CRM (AGAL 10)	20	37	10.1
CRM Certified Range (AGAL 10)	21.3 – 25.1	37.7 – 43.1	10.5 – 12.7
CRM In House Limits (AGAL 10)	19.58 – 26.39	32.48 – 48.42	10.023– 13.61
Duplicate 1 (1234172.296)	2.8	8.7	0.035[#3]
Duplicate 2 (1234172.296)	2.9	8.9	0.023[#3]

Worksheet: eITR2267	For samples 1234172.294 - 312	
QC Name	Total Recoverable Nickel	Total Recoverable Zinc
	(mg/kg/dry wt)	(mg/kg/dry wt)
Procedural Blank	<0.2	<0.4
CRM (AGAL 10)	10	50
CRM Certified Range (AGAL 10)[#1]	15.1 – 20.5	52.8 – 61.2
CRM In House Limits (AGAL 10)	9.52 – 14.02	46.1 – 62.74
Duplicate 1 (1234172.296)	1.5	39
Duplicate 2 (1234172.296)	1.7	38

Worksheet: elTR2270	For samples 1234172.192,296
QC Name	**Total Recoverable Mercury**
	(mg/kg/dry wt)
Procedural Blank	<0.01
CRM (AGAL 10)	10.1
CRM Certified Range (AGAL 10)	10.5 – 12.7
CRM In House Limits (AGAL 10)	10.023– 13.61
Duplicate 1 (1234172.192)	0.046
Duplicate 2 (1234172.192)	0.054
Duplicate 1 (1234172.296)	0.037
Duplicate 2 (1234172.296)	0.044

Worksheet: esNC2144	For samples 1234172.313 - 334
QC Name	**Total Organic Carbon**
	(g/100g/dry wt)
Procedural Blank	<0.05
In House QC Soil A1	2.8
In House QC Soil A1	3.0
In House Limits (QC Soil A1)	2.32 – 3.314

Worksheet: esNC2147	For samples 1234172.335 - 348
QC Name	**Total Organic Carbon**
	(g/100g/dry wt)
Procedural Blank	<0.05
In House QC Soil A1	2.8
In House QC Soil A1	3.0
In House Limits (QC Soil A1)	2.32 – 3.314

PAH Blanks	For samples 1234172.313 - 348
Lab No	**ext423blk2**
Units	**(mg/kg/dry wt)**
Acenaphthene	<0.002
Acenaphthylene	<0.002
Anthracene	<0.002
Benzo[a]anthracene	<0.002
Benzo[a]pyrene [BAP]	<0.002
Benzo[b]fluoranthene + Benzo[j]	<0.002
Benzo[g,h,i]perylene	<0.002
Benzo[k]fluoranthene	<0.002
Chrysene	<0.002
Dibenzo[a,h]anthracene	<0.002
Fluoranthene	<0.002
Fluorene	<0.002
Indeno(1,2,3-c,d)pyrene	<0.002
Naphthalene	<0.01
Phenanthrene	<0.002
Pyrene	<0.002

PAH Blanks	For samples 1234172.313, 314, 317, 318, 326, 327, 342, 346
Lab No	**ext428blk2**
Units	**(mg/kg/dry wt)**
Acenaphthene	<0.002
Acenaphthylene	<0.002
Anthracene	<0.002
Benzo[a]anthracene	<0.002
Benzo[a]pyrene [BAP]	<0.002
Benzo[b]fluoranthene + Benzo[j]	<0.002
Benzo[g,h,i]perylene	<0.002
Benzo[k]fluoranthene	<0.002
Chrysene	<0.002
Dibenzo[a,h]anthracene	<0.002
Fluoranthene	<0.002
Fluorene	<0.002
Indeno(1,2,3-c,d)pyrene	<0.002
Naphthalene	<0.01
Phenanthrene	<0.002
Pyrene	<0.002

PAH Blank	For sample 1234172.346
Lab No	**ext430blk1**
Units	**(mg/kg/dry wt)**
Acenaphthene	<0.002
Acenaphthylene	<0.002
Anthracene	<0.002
Benzo[a]anthracene	<0.002
Benzo[a]pyrene [BAP]	<0.002
Benzo[b]fluoranthene + Benzo[j]	<0.002
Benzo[g,h,i]perylene	<0.002
Benzo[k]fluoranthene	<0.002
Chrysene	<0.002
Dibenzo[a,h]anthracene	<0.002
Fluoranthene	<0.002
Fluorene	<0.002
Indeno(1,2,3-c,d)pyrene	<0.002
Naphthalene	<0.01
Phenanthrene	0.002[#3]
Pyrene	<0.002

PAH SMCs				
Lab No	1234172.313	1234172.314	1234172.315	1234172.316
Units	(%)	(%)	(%)	(%)
Biphenyl-d10	41	42	45	40
Acenaphthylene-d8	51	66	64	55
Anthracene-d10	67	71	80	74
Fluoranthene-d10	60	62	73	67
Benzo[a]anthracene-d12	62	61	84	73
Benzo[a]pyrene-d12	65	66	90	79
Dibenzo[a,h]anthracene-d14	66	46	87	84

PAH SMCs				
Lab No	1234172.317	1234172.318	1234172.319	1234172.320
Units	(%)	(%)	(%)	(%)
Biphenyl-d10	41	43	42	46
Acenaphthylene-d8	52	73	60	62
Anthracene-d10	66	61	74	89
Fluoranthene-d10	61	52	68	76
Benzo[a]anthracene-d12	67	54	74	84
Benzo[a]pyrene-d12	72	59	80	90
Dibenzo[a,h]anthracene-d14	71	57	80	95

PAH SMCs				
Lab No	1234172.321	1234172.322	1234172.323	1234172.324
Units	(%)	(%)	(%)	(%)
Biphenyl-d10	47	45	40	45
Acenaphthylene-d8	65	63	56	65
Anthracene-d10	73	73	66	79
Fluoranthene-d10	67	65	63	71
Benzo[a]anthracene-d12	79	68	69	80
Benzo[a]pyrene-d12	84	73	75	85
Dibenzo[a,h]anthracene-d14	85	75	66	75

PAH SMCs				
Lab No	1234172.325	1234172.326	1234172.327	1234172.342
Units	(%)	(%)	(%)	(%)
Biphenyl-d10	47	46	42	41
Acenaphthylene-d8	66	78	47	57
Anthracene-d10	81	90	70	65
Fluoranthene-d10	72	78	65	60
Benzo[a]anthracene-d12	80	84	74	67
Benzo[a]pyrene-d12	83	89	81	70
Dibenzo[a,h]anthracene-d14	70	52	78	69

PAH SMCs				
Lab No	**1234172.343**	**1234172.346**	**1234172.347**	**1234172.348**
Units	**(%)**	**(%)**	**(%)**	**(%)**
Biphenyl-d10	44	41	50	40
Acenaphthylene-d8	65	70	84	58
Anthracene-d10	77	89	74	80
Fluoranthene-d10	68	77	74	73
Benzo[a]anthracene-d12	78	97	90	85
Benzo[a]pyrene-d12	83	101	98	91
Dibenzo[a,h]anthracene-d14	85	76	96	90

PAH Spike recoveries[#4]			
Lab No	**1233136.4s**	**1233136.4sd**	**1233136.4slcs**
Units	**(%)**	**(%)**	**(%)**
Acenaphthene	54	48	57
Acenaphthylene	54	46	52
Anthracene	67	64	63
Benzo[a]anthracene	100	83	72
Benzo[a]pyrene [BAP]	89	79	57
Benzo[b]fluoranthene + Benzo[j]	101	85	71
Benzo[g,h,i]perylene	105	95	77
Benzo[k]fluoranthene	97	87	76
Chrysene	103	89	73
Dibenzo[a,h]anthracene	92	86	73
Fluoranthene	101	89	71
Fluorene	57	52	60
Indeno(1,2,3-c,d)pyrene	102	91	72
Naphthalene	51	44	55
Phenanthrene	66	70	67
Pyrene	101	87	70

TPH Blanks		
Lab No	**ext5125blk1**	**ext5125blk2**
Units	**(mg/kg dry wt)**	**(mg/kg dry wt)**
C7-C9	<8	<8
C10-C14	<20	<20
C15-C36	<40	<40
Total hydrocarbons (C7-C36)	<70	<70

TPH Spike Recoveries[#4]			
Lab No	**1234521.1s**	**1234521.1sd**	**1234521.1lcs**
Units	**(%)**	**(%)**	**(%)**
C7-C9	-	-	-
C10-C14	-	-	-
C15-C36	-	-	-
Total hydrocarbons (C7-C36)	113	111	106

[#1] The AGAL-10 (marine sediment) In-House Limits obtained in the laboratory for Chromium and Nickel are lower than the values in the 'Certified Range' due to the nature of the digestion used to obtain the Certified results. The 'Certified' results are obtained following a strong aqua regia digestion, which releases more of the interstitially-bound metals than the EPA 200.2 method which is used for these analyses in this laboratory. Recovery of contaminant metals will not be affected as these are not interstitially bound, and are available to either digestion method.

[#2] The Chromium result for the Procedural Blank was outside the acceptable levels. This worksheet was approved based on the Blank result being less than 10% of the sample amounts.

[#3]One of the PAH results for the Procedural Blanks was outside the acceptable levels. The worksheet was approved based on the Blank result being less than 10% of the sample amounts.

[#4]No duplicate sample was spiked for this job. The data presented is that of a job on the same batch of samples.

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