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Darwin Harbour Baseline Sediment Survey 2012

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Summary

The aim of the study was to provide a comprehensive set of reference data for the mudflat intertidal zone to assist in the development of sediment quality guidelines for Darwin Harbour. A small number of mangrove sediment samples were also collected and analysed

- Intertidal and mangrove creek sediment samples from sites across Darwin Harbour have been analysed for a range of elements including metals, metalloids and nutrients as well as for their grainsize distribution.
- Frequency distribution diagrams show that the distribution of several metals and metalloids are positively skewed.
- Major element compositions indicate that clays and iron-oxy-hydroxides are the predominant metal-bearing minerals. Sulfides and organic phases constitute additional metal bearing phases in some sediment.
- Correlation analysis showed strong positive correlations between the abundance of fine grains <63 µm (clay + silt) and aluminium and the concentrations of several metal/metalloids.
- A normalisation procedure to correct metal/metalloid levels for grainsize variations between sites, using aluminium content as a proxy, was used to map the spatial distribution of metal/metalloids across Darwin Harbour.
- The spatial distribution of aluminium-normalised concentrations of several metals/metalloid indicate significant contributions of urban metals/metalloid sources to harbour sediment along the developed eastern side of Darwin Harbour and in the vicinity of the sewage treatment plant outfall at East Point / Ludmilla Creek.
- Data analysis using multivariable Generalized Estimating Equations has shown that copper, zinc and lead concentrations are significantly elevated in tidal flat sediment near Darwin City at levels 20-29 % above those found in the remaining areas of the Harbour (at the average aluminium level).
- Principal Co-Ordinates analysis show that mangrove creek sediment from Reichardt and Mitchell Creeks have separate profiles from intertidal sediment and that the sediment from the East Point / Fannie Bay area is separated from the bulk of other harbour sediment.
- Comparison of the intertidal flat and mangrove creek sediment with ANZECC sediment quality guideline levels show that of the seven metals/metalloids for which guideline levels have been defined, four samples exceeded the high-level arsenic guideline above which toxicity effects are possible.

1. Introduction and aims

Sediment health may be impacted by increased loadings of toxicants including metals from port related activity, and from discharges via stream flow and storm water from urban catchments. Existing data on sediment toxicants including metals in Darwin Harbour is largely confined to contaminated sites such as marinas and mooring basins, and mangroves receiving runoff from industrial catchments. Spatial coverage is poor and consequently our capacity to delineate locally-relevant reference conditions is also poor.

This paper reports on the collection and analysis of approximately 300 surface sediment samples from intertidal flats and two mangrove creek systems in Darwin Harbour during July-December 2012. The aim of the study was to provide a comprehensive set of reference data to assist in the development of sediment quality guidelines for Darwin Harbour. The report includes data analysis and a discussion of the spatial distribution of metal and metalloid levels in the tidal flat and mangrove creek sediment from Darwin Harbour.

2. Darwin Harbour geomorphology and previous studies

Darwin Harbour is a macro-tidal drowned river valley system on the coast of the Northern Territory. During low tide large expanses of mudflats are exposed and the fringes of these mudflats support large stands of mangroves.

The major waterways discharging to Darwin Harbour are Blackmore River and Berry Creek that flow to Middle Arm, and Elizabeth River that flows to East Arm. Major flows occur between December and March, but typically commence in December and cease in June.

Sediments in the river catchments are predominantly fine-grained, mainly clay and silt. Creeks and rivers may transport coarser material (e.g. sand) into the estuary during the wet season, though much is trapped by coastal vegetation, both riparian and mangrove (McKinnon et al. 2006). The fine sediment delivered to the upper arms of the harbour settles out of suspension and is then eroded and re-deposited mainly by tidal currents, especially at spring tides. Hard substrates generally occur in high current environments and soft substrates (mud) form in low current areas such as sub- and intertidal flats and mangroves. Substantial sediment components are also derived from marine biogeochemical processes such as calcium carbonate (shell material) (McKinnon et al 2006).

Hydrodynamic modelling of the fate of suspended sediment plumes has shown that substantial sediment fluxes are directed up-estuary causing trapping of fine sediment and that the sediment fraction exported to the ocean is relatively small (Williams et al. 2006). Parts of Darwin Harbour are relatively poorly flushed, especially in the dry season when the residence time in the upper arms is of the order of 20 days.

Within the Darwin Harbour catchment (Charles Point to Lee Point) urban and light industrial areas occupy about 7 % of the catchment area, and rural-residential 6 % (Padovan 1993, Skinner et al. 2009). There is no heavy industry in the catchment. Horticulture makes up about 1-2 % of the area. Low intensity uses (pastoral, conservation, recreation, open space and vacant Crown Land) make up the largest proportion of the catchment area (85%). Padovan (2003) highlighted that Darwin Harbour has a small catchment relative to the area of the estuary when compared to other developed estuaries in Australia. The terrestrial catchment (2,417 km^2) to the total catchment (harbour + land area) (3,227 km^2) ratio of 0.75 means that there is reduced potential for disturbance to the estuary compared to other estuaries which typically have higher catchment/estuary ratios.

McKinnon et al (2006) calculated that the annual total suspended sediment load transported to the harbour had increased by a factor of 1.3 compared to the pre-urbanisation load. Metal and nutrient loads were also estimated to have increased, with phosphorus (factor 5.9), lead (factor 3.8) and zinc (factor 3.1) the most substantial increases.

A previous survey of the spatial distribution of Darwin Harbour sediment grain sizes and metal content based on samples collected and analysed by the Northern Territory University in July 1993 was reported by Fortune (2006). Elevated concentrations of metals in sediment were recorded at relatively few sites with the exception being arsenic, which had elevated concentrations throughout the study area. Some areas of Darwin Harbour (e.g. West Arm) were regarded as being in near pristine condition.

3 Methodology

3.1 Field sampling

Field sampling was undertaken by the Aquatic Health Unit (AHU) of Department of Land Resource Management (DLRM). An overview of sampling locations is shown in Figure 1 and further details are provided in Appendix 1.

Open intertidal areas:

Sampling points within the harbour were determined using ArcGIS by overlaying a 500 m triangular point grid on digital maps of soft intertidal areas in Darwin Harbour. Intertidal areas adjacent to Darwin CBD and Fannie Bay were sampled on a 250m grid. Some sites could not be sampled because either the depth at the time of sampling exceeded 3.5 m beyond the reach of the corer, or the sediment was too coarse to be collected using the corer.

All samples were collected from a small boat using a ‘pole corer’. The top 5 cm of sediment cores was sectioned from the core using a plastic spatula.

All samples were double-bagged in labelled plastic zip-lock bags and stored on ice in the field, and later frozen at the laboratory.

At ten intertidal sites triplicate samples were collected. Furthermore, at the intertidal sites sediment samples were collected from both surface (0- 5 cm) and sub-surface (5-10 cm) from the same core.

At all sites a back-up sample was collected and stored using the same methods.

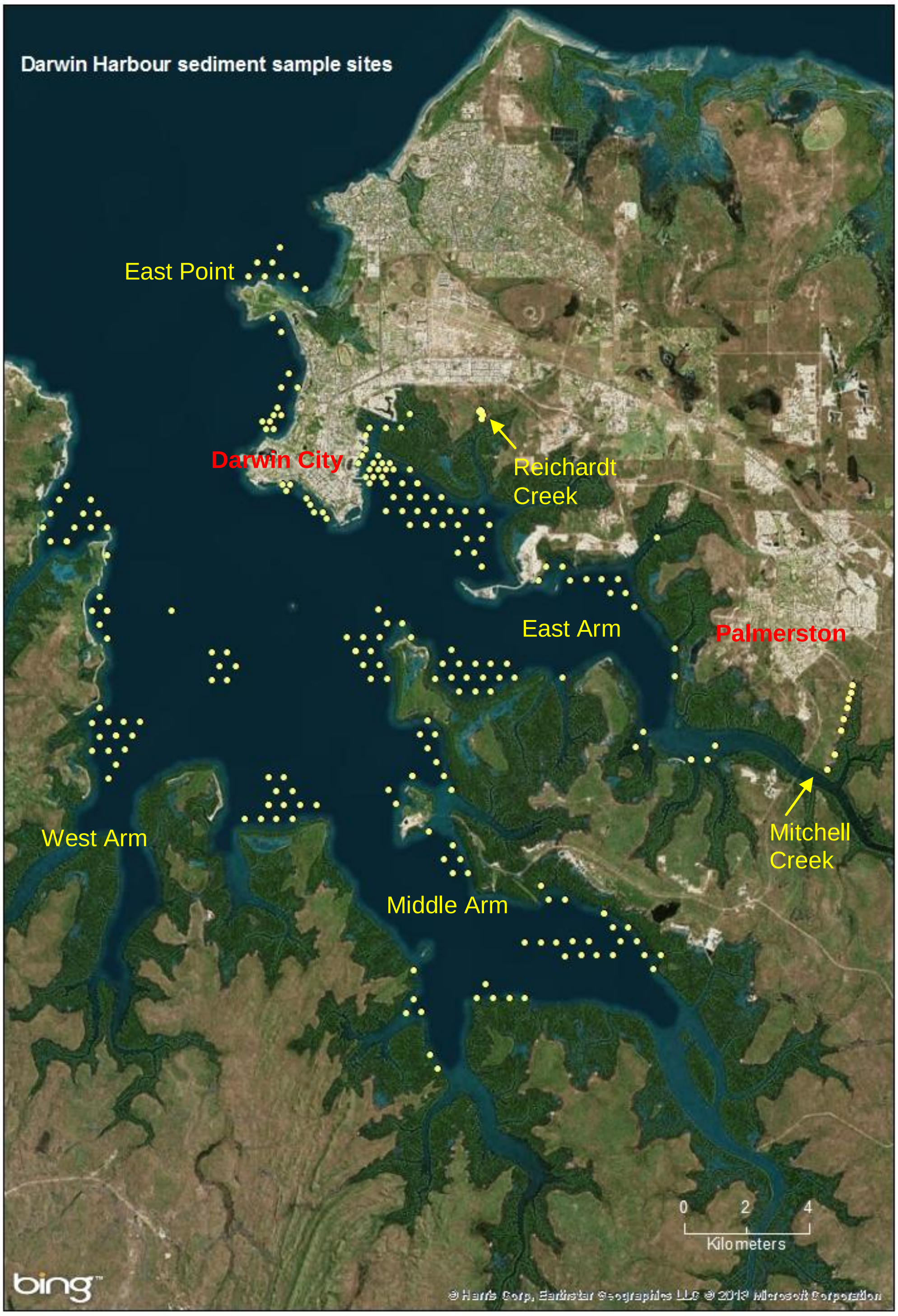

Figure 1. Sediment sampling sites on Darwin Harbour intertidal flats and mangrove creeks, July-December 2012. More detailed maps with labelled sites are included in Appendix. 1.

Mangrove-lined intertidal creeks:

Samples were collected at two areas from mangrove forests on exposed tidal flats dominated by the mangrove species *Ceriops tagal*. At Mitchell Creek triplicate samples were collected at 8 points positioned on a transect parallel to the tidal portion of the creek. At Reichardt Creek triplicate samples were collected at 9 points which had been sampled in earlier studies (Welch et al. 2008).

Replicate samples were collected at sub-sites spaced at 5 m intervals on a linear transect at each site using the corer. A spatula was used to collect 5 cm surface samples. Samples were double-bagged and frozen at the laboratory. No back-up samples were collected.

3.2 Analytical methods

Two sediment samples were received from each site, sample ‘A’ was processed whilst sample ‘B’ was stored frozen as received.

All ‘A’ samples were photographed as received.

Grainsize distribution analysis of whole sediment samples was undertaken using wet sieving and laser diffraction technique at Process Science and Engineering, CSIRO (Perth). Sediment samples were manually sieved to <1 mm grainsize and a representative subsample was dispersed in 1000 ppm sodium hexa-metaphosphate. Analysis was carried out using a Malvern Mastersizer MS2000 instrument.

Sediment samples processed for chemical analysis were wet sieved to <2 mm grainsize and dried in a ventilated oven at 60^{o}C.

Total Kjeldahl nitrogen (TKN) was analysed by flow injection method (LACHAT 13-107-06-2-D) at ECMU Charles Darwin University. Sediment samples were digested in sulfuric acid with a copper sulfate catalyst. Free ammonia and organic nitrogen compounds were converted to ammonium during digestion while nitrate/nitrite is not converted. Ammonium is neutralised to ammonia in-line with a concentrated buffer and heated with salicylate and hypochlorite to produce a blue colour absorbing at 660nm.

Total organic carbon (TOC) was analysed at the Marine and Freshwater Research Laboratory, Murdoch University, by high temperature combustion and non-dispersive infrared gas analysis using a Shimadzu TOC-V organic carbon analyser and Shimadzu solid sample module SSM 5000. The removal of inorganic carbon was carried out by acidification which also may result in some loss of volatile organic substances.

Elemental analysis was carried out by inductively coupled plasma mass spectrometry (ICPMS) at ECMU Charles Darwin University. Sediment samples were digested in Nitric + Perchloric Acid (1+4) using open digestion tubes in a heating block at 200°C for 6 hours. Analysis was carried out on an Agilent 7500ce ICPMS using a collision cell and H and He gases for suppression of elemental interferences.

Chemical data including quality control data are presented in Appendix 2.

3.3 Analytical Quality Control

The elemental composition of the certified reference material (CRM) MESS-3, a marine sediment from the Canadian Research Council, was measured a total of 33 times. The recovery percent (result / certified value * 100) was between 90-110 % for most elements while chromium and molybdenum recoveries were outside this range. Chromium recovery is commonly low when using a nitric + perchloric acid extraction method as chromium mainly resides in insoluble minerals such as spinels. Molybdenum analysis is affected by a relatively high detection limit (Appendix 2).

The relative standard deviations (RSD) of the MESS-3 determinations were below 10 % for the majority of elements. However, sulfur RSDs ranged from 8-14 % and chromium had an RSD range of 16-34 %.

Fifteen sediment samples were digested and analysed in duplicate and with a third portion spiked with known quantities of analytes to check analytical precision and recovery. The analytical precision for most elements was commonly better than 5 % RSD while chromium showed poorer precision (up to 19 %). Spike recoveries were within the expected 80-120 % recovery range in the majority of cases, where recoveries were outside this range it was usually caused by an insufficient spike level.

Recovery of Total Kjeldahl Nitrogen in CRMs was 95-101 % and duplicate RSDs ranged from 1-11 %.

Recovery of Total Organic Carbon in a glucose standard was 90-107 % and the percentage difference in duplicates ranged from 0-20 %.

3.4 Data analysis methods

Frequency distribution and correlation analyses were carried out using Microsoft Excel data analysis tools.

In order to compare the levels of key metals (Cu, Pb, Zn) between city and other areas in the intertidal Darwin Harbour zone, multivariable Generalized Estimating Equation (GEE) models were applied using the software Stata12/IC (www.stata.com). Sites included in the city area were located between the Navy Base and Sadgroves Creek (Appendix 1). These models were also used to compare metal levels between mangrove and intertidal areas in Darwin Harbour. GEE models are an ideal tool to analyse the average response of an outcome variable (i.e. metal levels) which is dependent on several covariates and whose observations are correlated with each other. An exchangeable correlation structure was applied to adjust for correlated metal levels of sediments collected in the same area. Data of surface sediment samples were used including for triplicates, the 2nd sample only. 223 samples were included in the intertidal model with the sample size per 17 sampling areas varying between 3 and 27 with an average of 13.1 samples. For the mangrove versus intertidal model, 274 samples were used with 19 sampling areas with an average of 14.4 samples per area.

In order to account for different clay content, the covariate aluminium was also included in the model as a covariate. If there was evidence that the effect of city areas upon metal levels changed with increasing aluminium content, an interaction term was also included in the model. Metal levels were log transformed (ln(raw metal data+1)) to adjust for positively skewed data. A robust variance was used to improve the variance estimation and the "nmp" option adjusted the variance estimation for the number of parameters in the model.

Using the software Primer-E 6, a principal coordinate analysis was carried out on the Euclidean distance resemblance matrix of log transformed and normalized metal and nutrient data incl. grain size.

Mapping of analytical data was carried out using ArcGIS software

4.0 Results and Discussion

4.1 Analytical data presentation

A summary of the grainsize distribution data is presented in Appendix 2. The complete data set which includes data for ninety size classes are available in electronic files. Elemental concentration data, including metals, metalloids and nutrients are also presented in Appendix 2.

4.2 Acid extraction method

Metals are preferentially bound in the fine-grained fraction of sediments and have higher bioavailability than metals in the bulk sediment (Groot et al. 1982). The nitric and perchloric acid digestion method used in this study does not result in total dissolution of some silicates, for example quartz, feldspars and zircon. However, in chemically and physically mature sediments, as predominantly found in Darwin Harbour, the majority of metals are associated with clays, Fe-oxy-hydroxides along with organic matter and sulphides (Alloway 1995). In such sediments, digestion by nitric and perchloric acids is vigorous enough to allow pseudo-total analysis of most metals of biological relevance (Urey 1995). This is demonstrated by the results obtained for the marine sediment CRM (section 3.3).

It should be noted that the nitric and perchloric acid digest is likely to result in higher concentrations of metals and metalloids in sediments than extractions aimed at determining the bioavailable fraction, e.g. the 1M hydrochloric acid extraction recommended by ANZECC (2000) for such a purpose.

4.3 Replicate sampling

Replication of sampling at intertidal sites was carried out to examine small scale (meter scale) variation in elemental composition. Triplicate sampling of sediment was carried out at 27 sites, 10 sites on the intertidal flats and 17 sites in the mangrove creeks. The relative standard deviation of elemental concentrations (nutrients and metals) was below 20% for a large majority of the triplicate samples. However, the variation between samples was in most cases significantly above the analytical uncertainty of 5-10% (se section 3.3).

In general, samples from intertidal flats showed less variation in composition than mangrove sediment. Furthermore, mangrove triplicates were more variable in grainsize distribution than was the case for intertidal flat triplicates, with most variation found in the contents of the coarse fractions (medium sand to gravel).

At the ten intertidal sites where both top (0-5cm depth) and bottom (5-10 cm depth) samples were collected, the standard deviation of elemental concentrations in top and bottom samples was also below 20% for a large majority of analytes and sites.

4.4 Frequency distribution

The frequency distribution for selected analytes of all analysed sediment samples (n=298), including replicate and top/bottom samples from some sites, are shown in Figures 2-5.

The median and mean percentage of fine grained sediment (clay+silt, <63 μm grainsize) for all harbour samples are 29.1 % and 32.5 % respectively, with the distribution skewed towards higher percentages mainly in samples from Middle Arm and Reichardt Creek (Figure 2).

The distribution of P, TKN, S and TOC concentrations are positively skewed and only few samples have elevated concentrations of these nutrients (Figure 3). The oxic conditions of surface sediment (0-5 cm depth) means that accumulation of sulphides and organic carbon would not be expected at most sites. However, higher S and TOC levels are to be expected at deeper levels where anoxic conditions are likely to prevail in fine-grained sediment (mud).

The distributions of several elements are also positively skewed (Figure 4), e.g. Cr, Fe, Zn, As and Pb have relatively high skewness coefficients (Fisher-Pearson standardized moment coefficient) of 3-4, whereas Mn, Co, Ni have moderate skewness coefficients around 1. A strong positive skew for some metals may be indicative of a normal distribution overprinted by elevated concentrations from anthropogenic impacts at a smaller number of sites; however, localised natural phenomena may also lead to a positively skewed distribution.

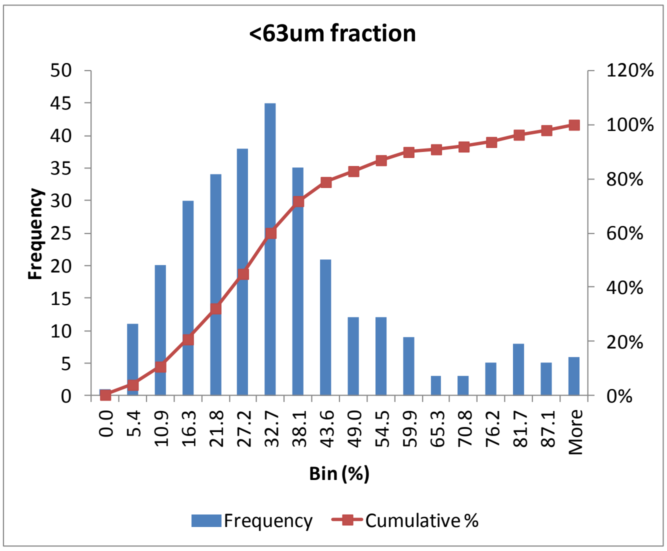

Figure 2. Frequency distribution of the <63 µm grainsize fraction (clay + silt) in Darwin Harbour sediment.

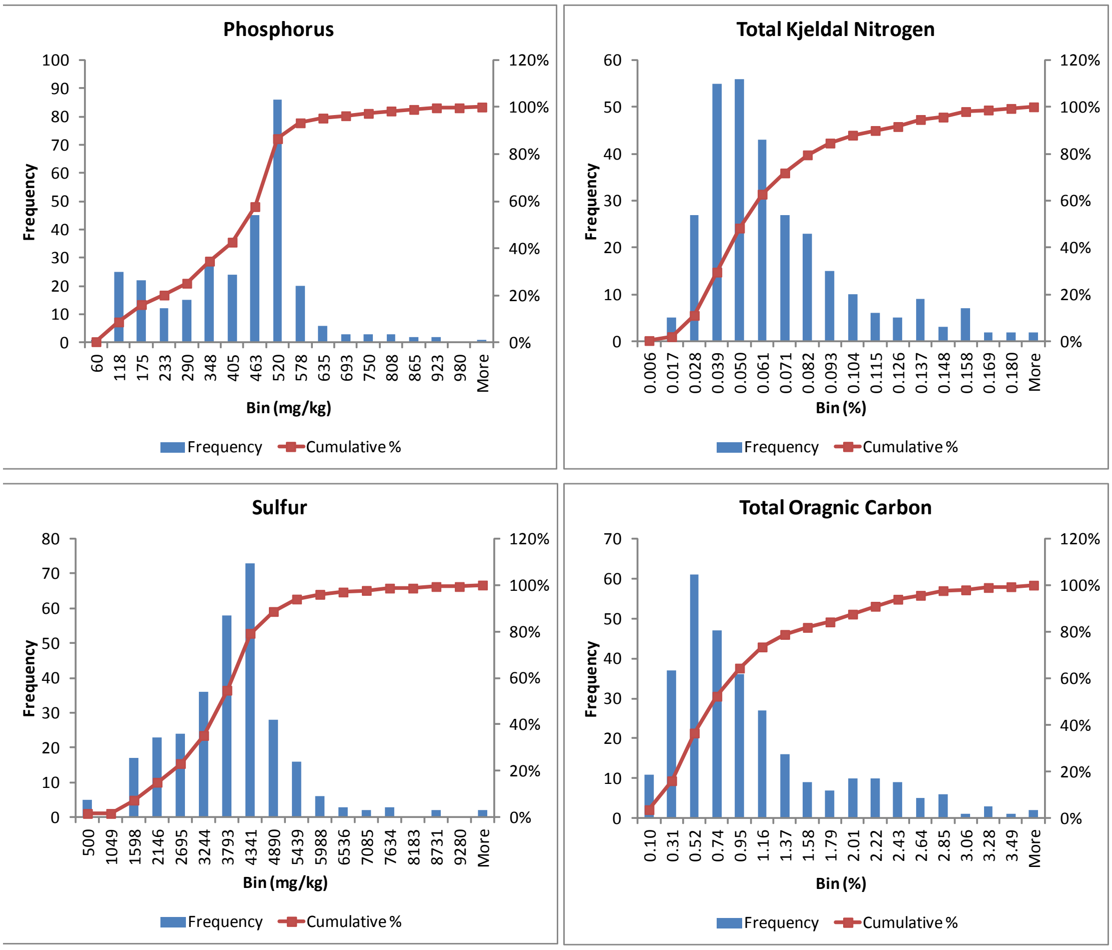

Figure 3. Frequency distribution of nutrient concentrations in Darwin Harbour sediment.

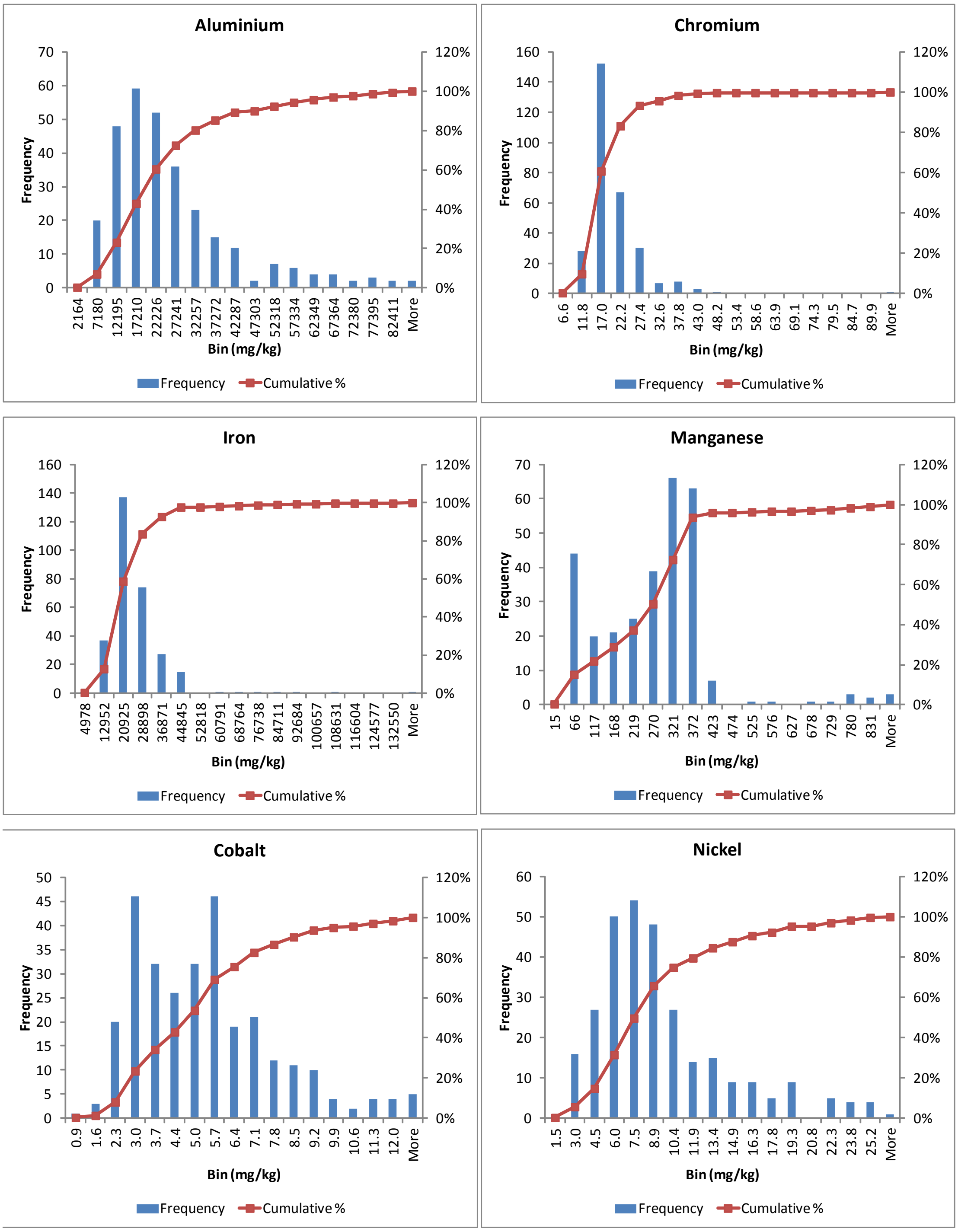

Figure 4. Frequency distribution of aluminium, chromium, iron, manganese, cobalt and nickel concentrations in Darwin Harbour sediment.

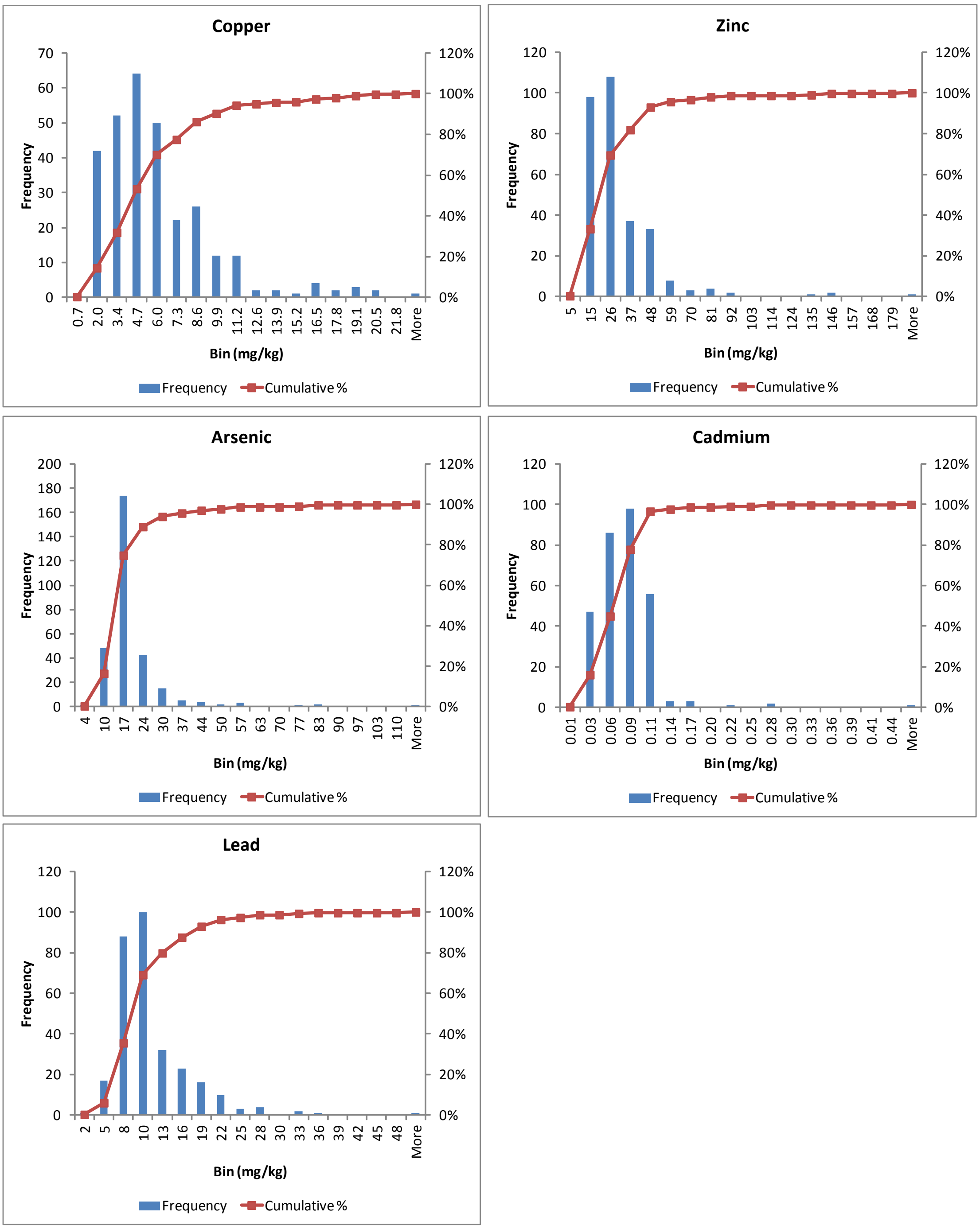

Figure 5. Frequency distribution of copper, zinc, arsenic, cadmium and lead concentrations in Darwin Harbour sediment.

4.5 *Correlation analysis*

A correlation matrix of all analytes is presented in Appendix 3. Several strong positive correlations exist in the data set, e.g. between clay content and Al concentration (R = 0.899). In addition, many metal and metalloid concentrations are highly correlated and there are strong positive correlations between the concentrations of total organic carbon (TOC) and several metals.

Negative correlations are present between the amounts of digestion residue and several elements. Metals/metalloids are not strongly correlated with S content.

Figure 6 shows that Al concentration is strongly correlated with clay + silt content (the <63 µm fraction) whereas Fe concentration versus clay + silt content is not well correlated due to a relatively small number of outlying data points. The highest Fe concentrations were recorded in mangrove sediment from Micket Creek and intertidal sediment from Wickham Point and Hudson Creek. Plots of Al concentration versus the amount of extraction residue and Al versus Ca concentration are also poorly correlated. These relationships can be interpreted in terms of the relative dominance of three major sediment components: clays (Al-rich, Ca-poor), quartz sand (Al-poor, high extraction residue) and carbonates (Al-poor, Ca-rich) as indicated in Figure 6.

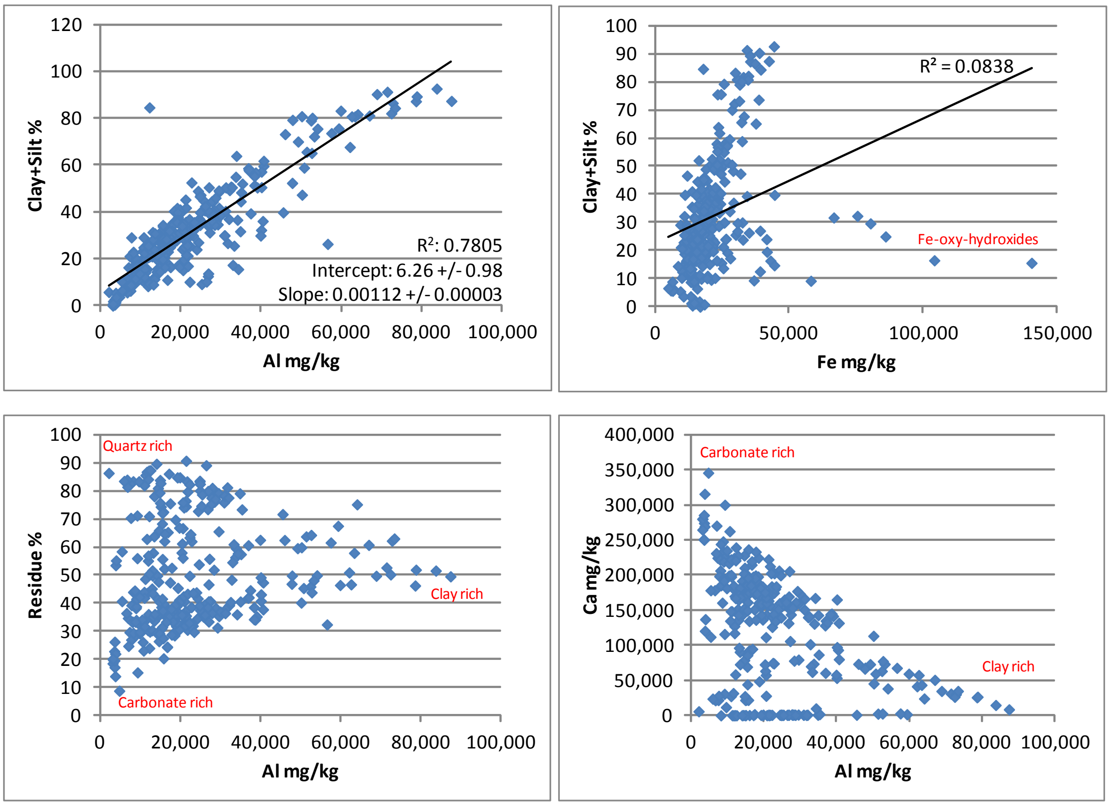

Figure 6. Bivariate plots of clay+silt vs. aluminium (regression intercept and slope with standard errors shown), clay+silt vs. iron, extraction residue vs. aluminium and Ca vs. aluminium. Labels in red indicate the compositions of major mineral phases in Darwin Harbour sediment.

A ternary Al, Ca, Fe (ACF) plot (Figure 7) captures the major element variation in Darwin Harbour sediment with the exception of Si. However, a large fraction of Si resides in minerals, mainly quartz and feldspar which carries low, and biologically unavailable, concentrations of metals and metalloids. Furthermore, these silicates are insoluble in the nitric and perchloric acid digests used in this study.

The ACF plot shows the composition of clay minerals, Fe-oxy-hydroxides and calcium carbonate, which commonly dominate north Australian marine sediment (Gingele 2001). The ACF plot shows a large variation in major element composition both within and between the areas sampled. For example, the Fannie Bay–East Point, Talc Head-Weed Reef and City sediment generally have high Ca concentrations presumably due to high calcite/aragonite shell/skeletal content. In contrast, the mangrove sediment from Reichardt Creek and Mitchell Creek are likely to be almost completely dominated by clays (Kaolinite and Smectite) and Fe-oxy-hydroxides with little calcium carbonate content. However, based on their major element composition, most sediment samples contain a mixture of all three mineral components: clays, calcium carbonate and Fe-oxy-hydroxides (in addition to quartz +/- feldspar). These components are partly catchment derived, partly from coastal marine sources and with post-depositional addition of biogenic shell/skeletal material and precipitation of Fe-oxy-hydroxides phase (e.g. as grain coatings).

The mineralogical and compositional variability across Darwin Harbour, in addition to the variation in grainsize distribution, will complicate the task of defining natural baseline sediment compositions.

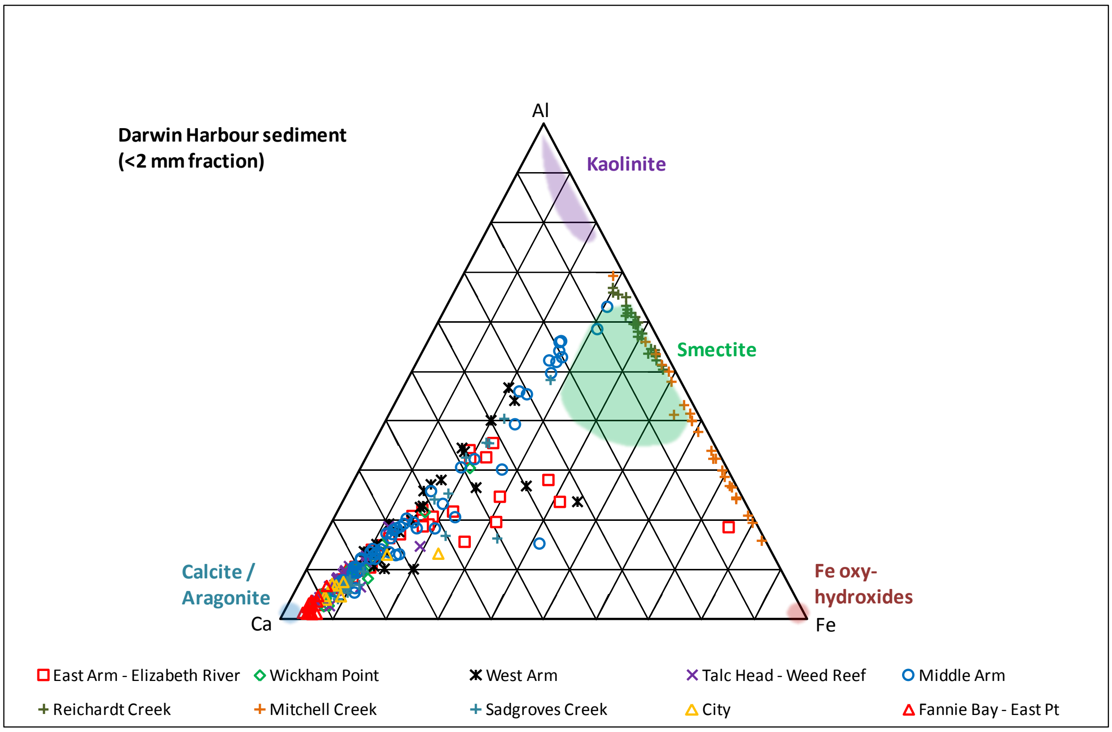

Figure 7. Ternary aluminium-calcium-iron (ACF) plot showing the location of all analysed sediment samples (n=298) sorted by area. Shaded areas indicate the range of compositions of major mineral phases in Darwin Harbour sediment.

4.6 Normalisation methods

While absolute metal and metalloid concentration data are commonly used to directly assess sediment quality, the confounding factor of variable grain size on the spatial distribution of metals has long been recognised (see e.g. Loring and Rantala 1995, Birch 2003). The grainsize effect has frequently been reduced by either separating or analysing a uniform sediment grain size (usually the <63 µm fraction), or the total sample data are normalized to a conservative element (e.g. Al or Sc) which acts as a proxy for fine material. Analysis of the fine fraction has several disadvantages, i.e. it is time-consuming, adds cost and a proportion of metals is discarded with the coarse fraction. A post-extraction normalisation (PEN) method accounting for undissolved non-metal-bearing silicates has been advocated by Birch (2003). In that method total sediment is analysed, thus capturing the metals associated with the coarse fraction and avoiding the necessity for costly grain size analysis.

Three methods of metal/metalloid normalisation were initially considered in this study: Grainsize normalisation, Al normalisation and the PEN method. However, it was concluded that the PEN method is unsuitable for use with the Darwin Harbour samples due to the variable, and frequently high, carbonate content. Since carbonates are relatively metal poor, but highly soluble in nitric and perchloric acid digest, the underlying assumption of the PEN method cannot be sustained, namely that the metal poor portion of sediments are composed mainly of insoluble silicates.

Normalisation to the clay+silt content (<63 µm fraction) produced similar results to Al-normalisation as would be expected due to the strong correlation between the two parameters. However, Al-normalisation was chosen in preference to grainsize normalisation, as this will allow the present data set to be compared to previous and future data for which grainsize data may not be available. Although Fe is relatively well correlated with grainsize if a relatively small number of samples are disregarded, normalisation by Fe content is unlikely to be as robust a normalisation procedure as Al normalisation. This is mainly due to the sensitivity of Fe to redox conditions which influence its solubility and potential reaction with sulphides in anoxic sediment. Non-metals/metalloids are usually not normalised for grainsize or Al concentration because their concentration and grainsize / clay content commonly is not strongly correlated.

The Al-normalised metal concentrations were calculated as the equivalent metal concentration at an Al concentration of 10,000 mg/kg (1% by weight) e.g.:

$\text{Zn/Al} = [\text{Zn}]_{\text{measured}} / [\text{Al}]_{\text{measured}} \times 10{,}000 \text{ mg/kg}$

The benefit of using Al-normalised metal data is the reduction of the confounding effect of grainsize where information on the spatial patterns of dispersion of metals from point sources is sought (Birch 2003). By using Al-normalised metal data, the fine grained portion of sediment, which is the fraction most easily transported and most easily accessed by filter feeders, may be flagged as high even when the total metal concentration of the whole sediment may be relatively low. As an example, the coarse grained sediment samples from near the East Point STP Outfall has a high Al-normalised metal content and if this, or similar, fine grained sediment (e.g. from the STP outfall or Ludmilla Creek) is deposited in substantial quantities in nearby environments, biological metal exposure may be significantly elevated.

Figure 8 shows a comparison of the frequency distribution of original and Al normalised Cu and Zn concentration data. It can be seen that the range of concentrations of both metals are substantially reduced for the normalised data as the confounding effects of grainsize are removed.

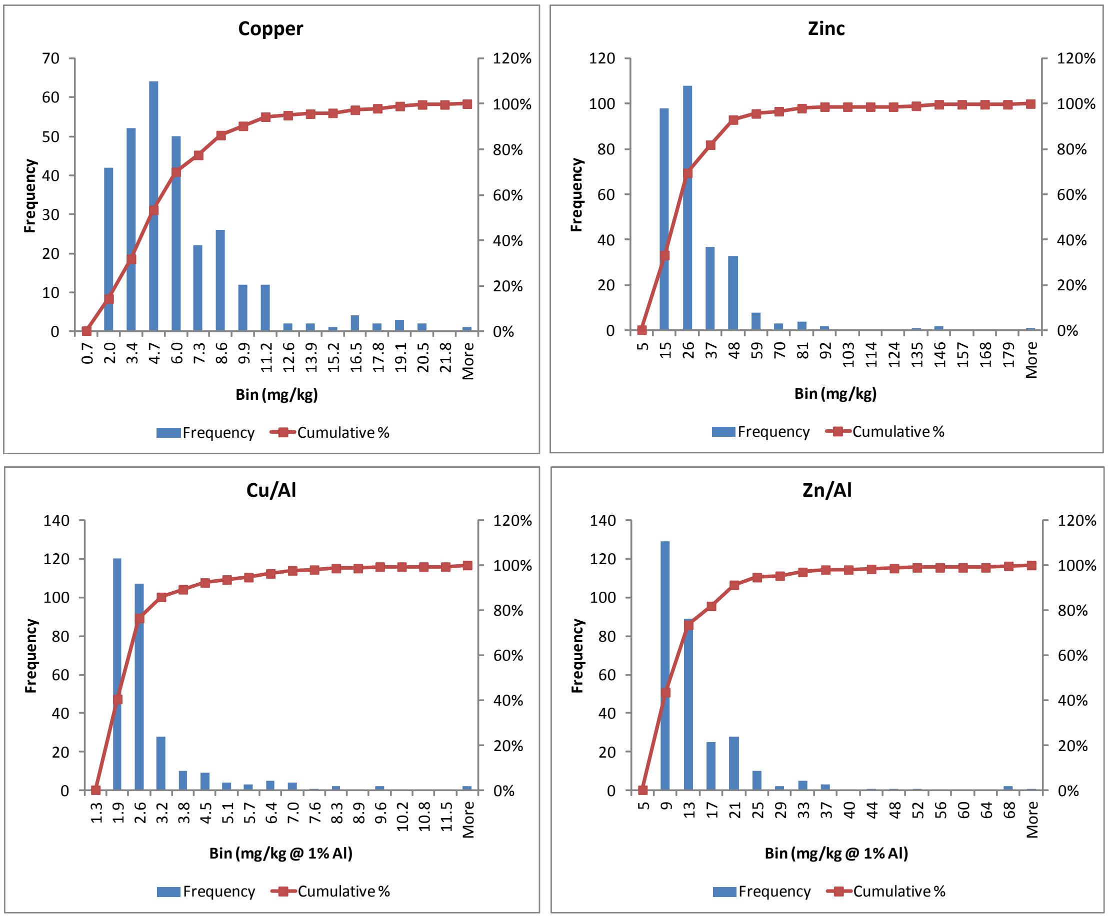

Figure 8. Frequency distribution of non-normalised and Al-normalised copper and zinc concentrations in Darwin Harbour sediment.

4.7 Spatial patterns

Figures 9-14 show the spatial distribution of selected sediment parameters displayed as ARC-GIS maps. Additional maps are provided in Appendix 4.

Clay plus silt content can be seen to be fairly evenly distributed around the harbour with one major exception being the cluster of low contents at East Point near the STP outfall. As would be expected, the distribution of Al concentrations shows a similar pattern.

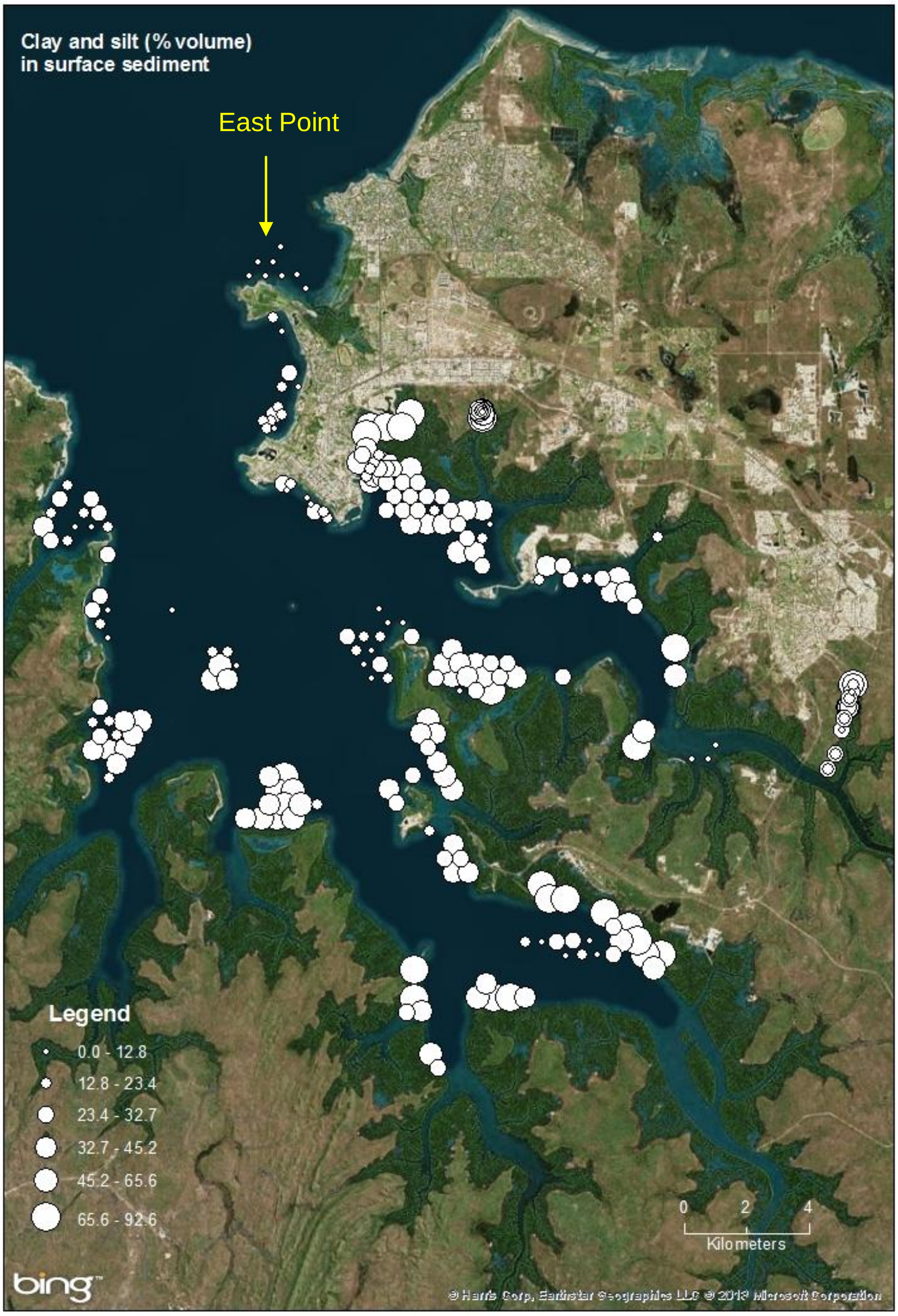

Figure 9. Clay + silt content (<63 µm fraction) in Darwin Harbour sediment.

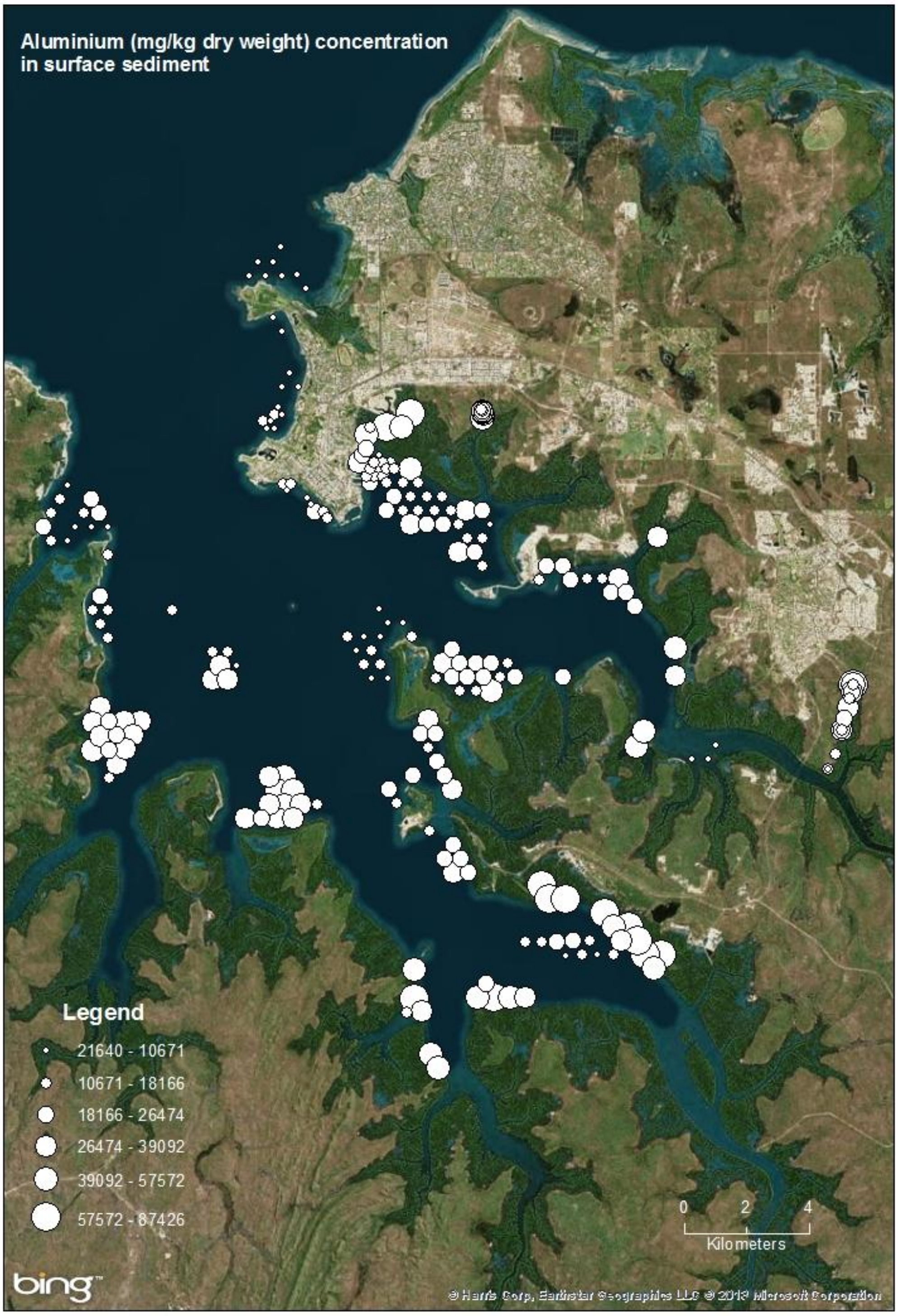

Figure 10. Aluminium concentration in Darwin Harbour sediment.

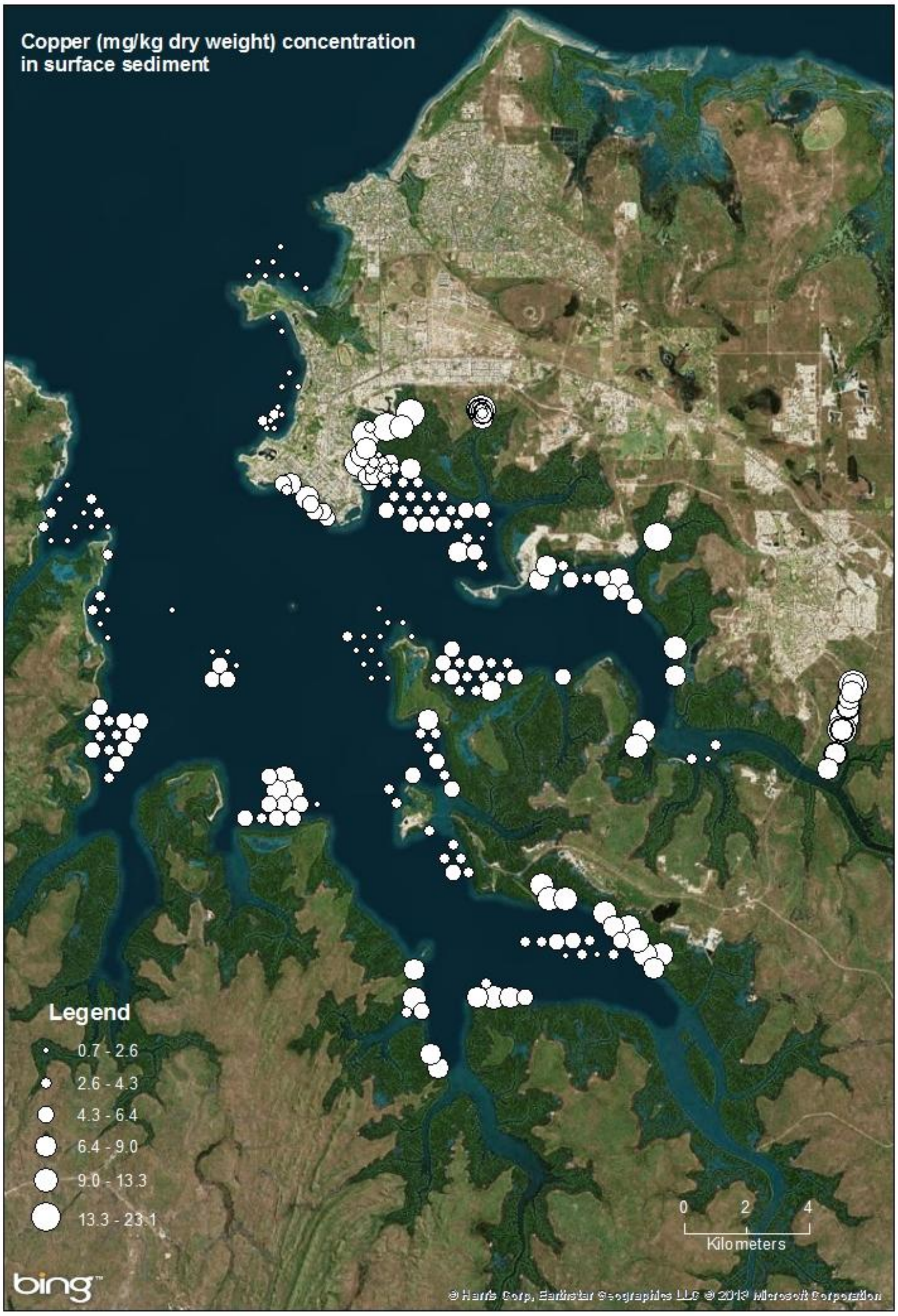

Figure 11. Copper concentration (non-normalised) in Darwin Harbour sediment.

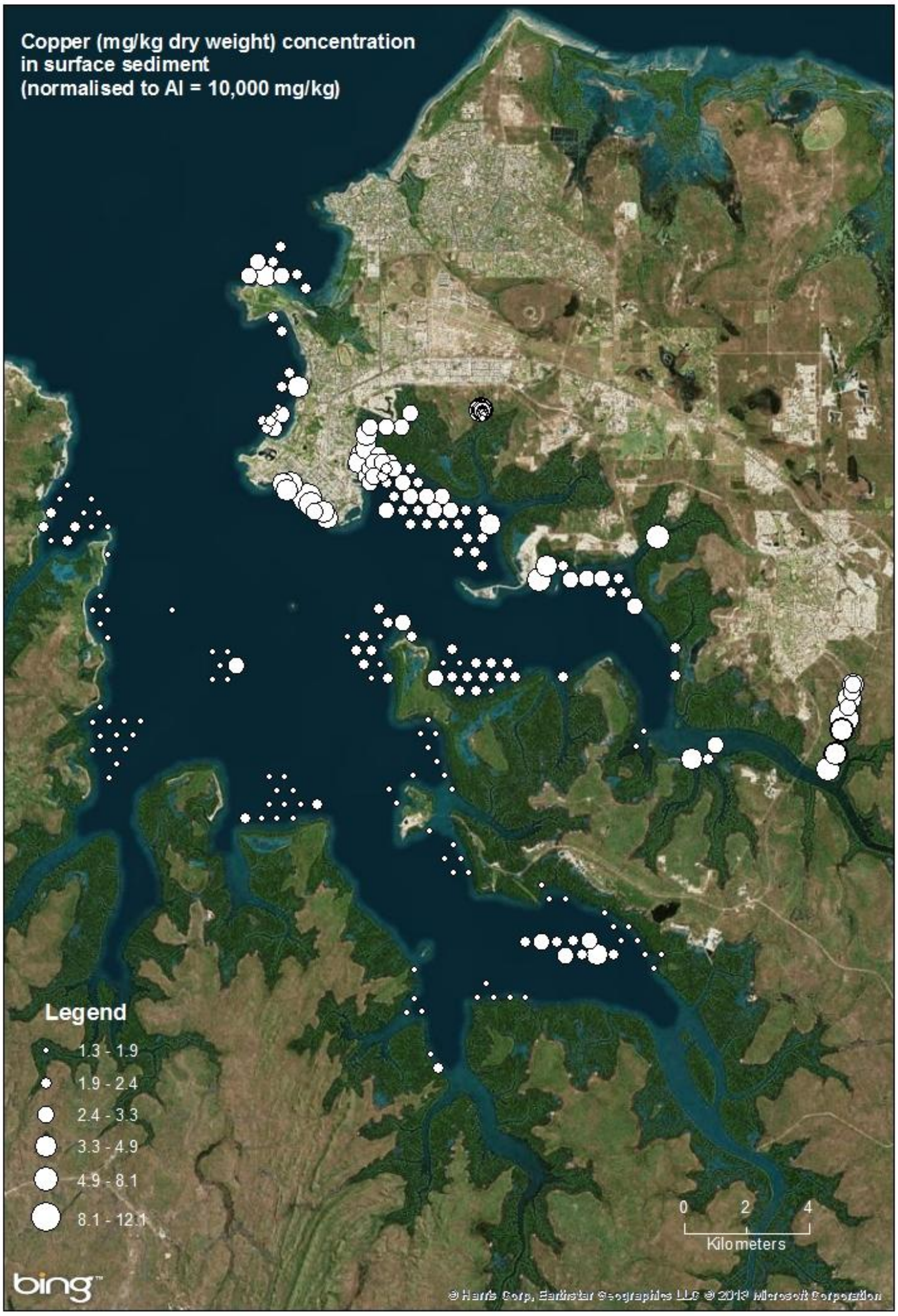

Figure 12. Aluminium-normalised copper concentration in Darwin Harbour sediment (@ 10,000 ppm Al).

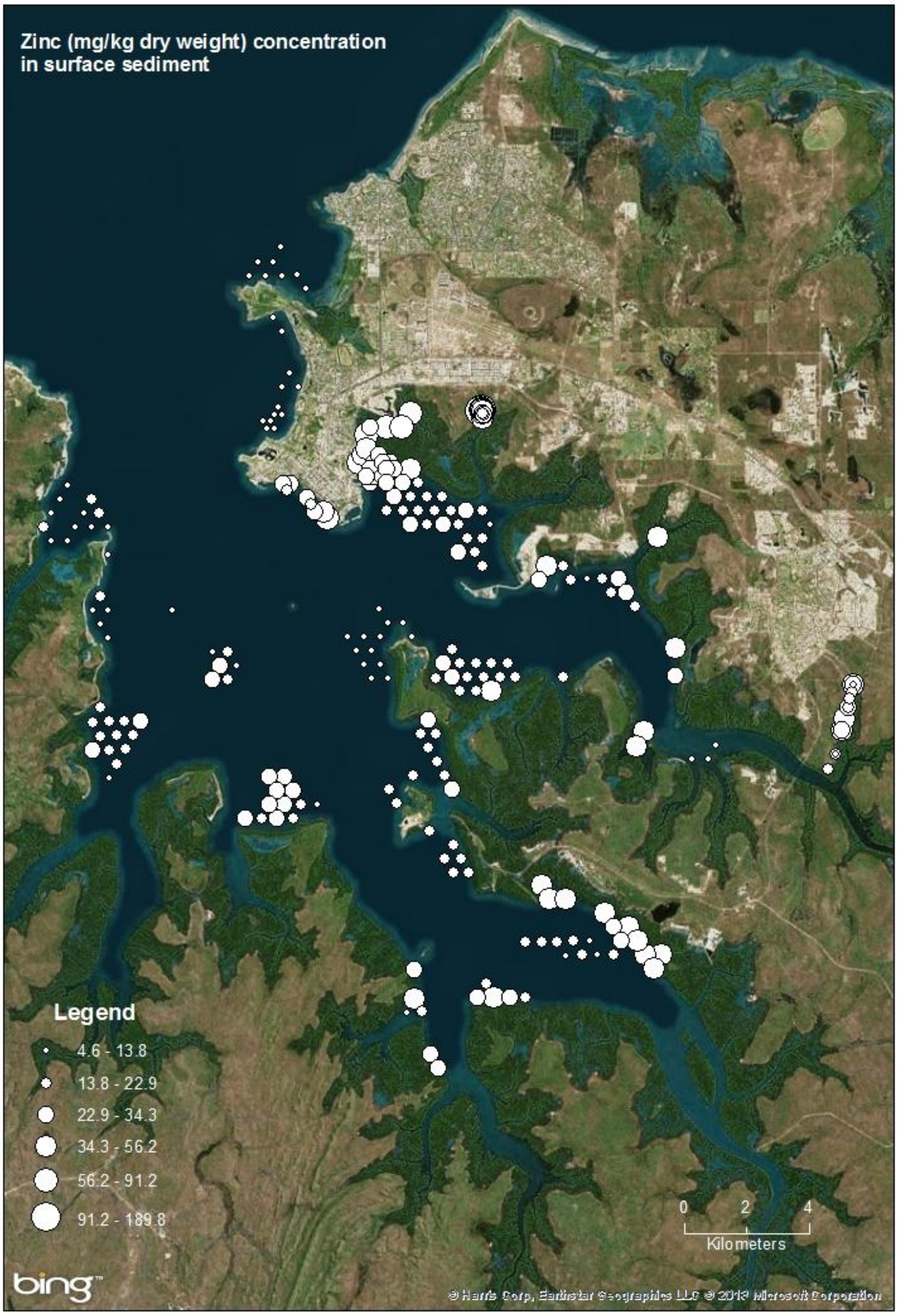

Figure 13. Zinc concentration (non-normalised) in Darwin Harbour sediment.

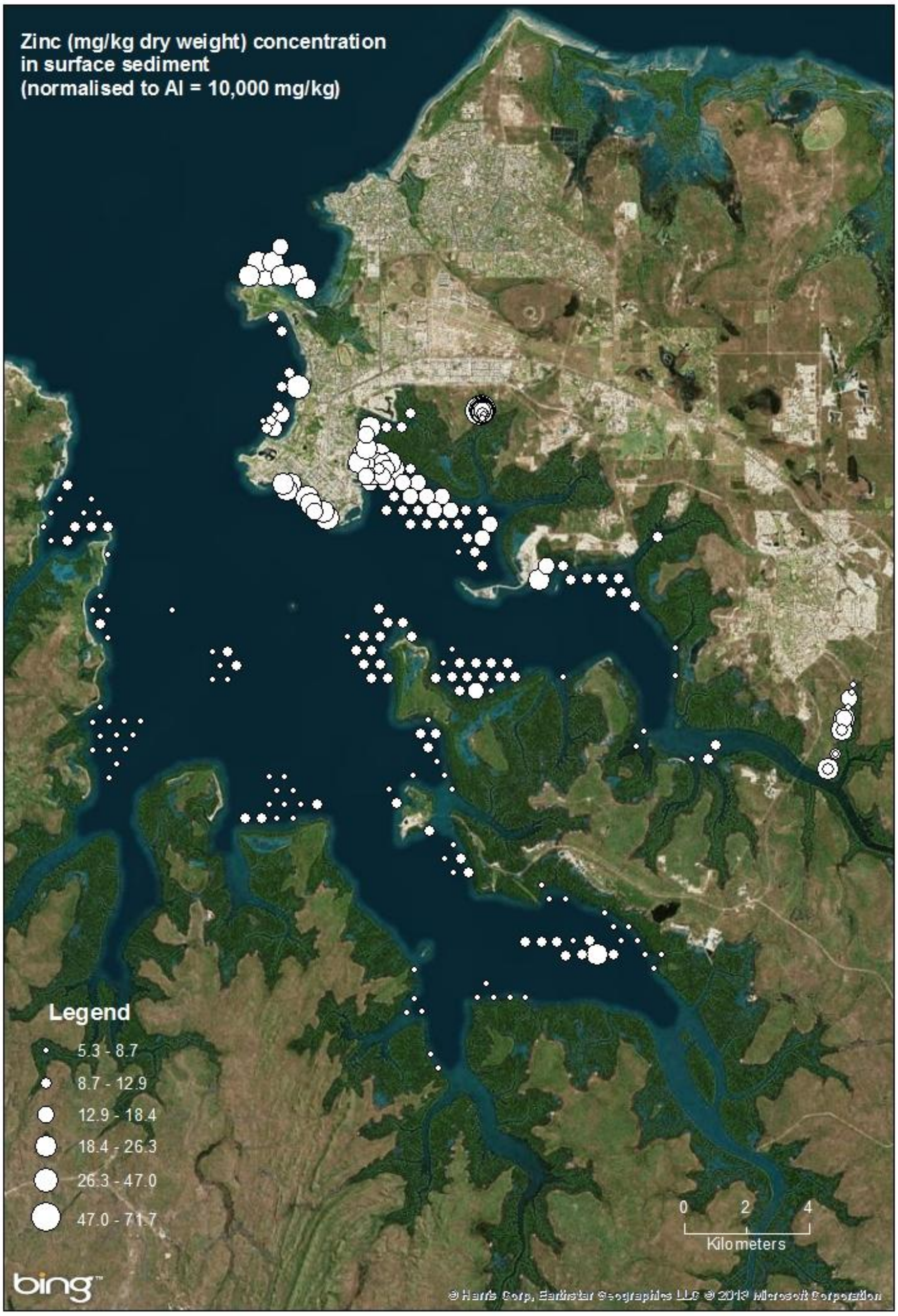

Figure 14. Aluminium-normalised zinc concentration in Darwin Harbour sediment (@ 10,000 ppm Al).

A comparison of the Cu and Al-normalised Cu concentration maps shows the effect of removing the confounding grainsize effect. The Al-normalised Cu map provides strong indication of the elevated Cu levels at sampling sites surrounding the urban Darwin-Palmerston area. The spatial distribution of sites with elevated Cu/Al levels suggest that urban emissions of Cu to waterways have been captured in the fine-grained portion (< 63 μm fraction) of sediment at these sites. In comparison, the non-normalised Cu map shows a much diminished signal of Cu dispersion from the urban area. Some areas distant from the urban area (e.g. at Upper Middle Arm) also contains elevated Cu levels. The reason for this occurrence is presently unclear but it is likely that some geochemical characteristics of weathering horizons in the catchment are preserved in sediment exported to the harbour.

Zinc maps show a similar contrast between non-normalised Zn and Al-normalised Zn, as seen for Cu. This provides further evidence for a significant urban source contributing to metal levels in fine grained sediment. Several other metals (e.g. As, Cd, Cr, Mn) show similar patterns of increased concentration near urban and other developed areas (Appendix 4).

4.8 Data analysis

Generalized Estimating Equation (GEE) Models:

GEE models were used to compare the levels of Cu, Zn and Pb between city and other areas in the intertidal zone as well as between mangrove and intertidal areas in Darwin Harbour. These 3 metals are the main contaminant metals likely to be dispersed from both point and diffuse sources in the urban area. For this purpose, eight sample sites surrounding the city area were separated from ‘other’ areas as shown in Appendix 1.

Additional covariates in the models were Al to adjust for clay content and – if there was evidence – an interaction term to address how the effect of the city (or intertidal) changed upon the metal levels with one unit increase of Al. A robust variance was used to improve the variance estimation and an exchangeable correlation structure to adjust for correlation of sample sites within an area. The ‘nmp’ option adjusted the variance estimation for the number of parameters in the model.

The results of the GEE modelling is shown in Table 1. Copper, Pb and Zn concentrations in sediment were significantly higher ($p<0.001$, $p<0.001$, $p=0.026$, respectively) at ‘City’ sites compared to ‘Other’ sites. The levels of change were in the range 20-29 % at the mean Al level. Increasing Al levels (i.e. increasing clay levels) were associated with significantly higher metal levels for all three metals and also significantly further increased the difference in metal levels between ‘City’ and ‘Other’ for Cu ($p<0.001$) and Pb ($p=0.002$), but not for Zn ($p=0.548$). These results back up the spatial distribution patterns evident in Al-normalised metal/metalloid maps presented in Section 4.6.

For the comparison of ‘Intertidal’ and ‘Mangrove’ areas the GEE modelling showed that Cu, Pb and Zn concentrations in sediment from intertidal sites were significantly lower ($p<0.001$, $p<0.001$, $p=0.014$, respectively) than in sediment from the mangrove creeks sites. The levels of change were in the range 39-44 % at the mean Al level. Increasing Al levels significantly decreased the difference in metal levels between ‘Intertidal’ and ‘Mangrove’ for all three metals (p<0.001).

Principal co-ordinates (PCO) analysis:

The PCO (Figure 15a,b) showed that 67.5% of the data variability was explained by the first two PCO axes. There is a clear separation in the profile between intertidal areas and the mangrove lined creeks (Mitchell Creek and Reichardt Creek). The direction and length of vectors indicate the strength of the nonparametric correlations of the corresponding variables. For example, the East Point / Fannie Bay sites on the bottom right of the Figure 16 tend to be separated from the bulk of harbour sites by sediment that is low in clay and high in fine sand.

Table 1. Generalised estimating equation (GEE) modelling results for Darwin Harbour sediment.

Metal	**Covariate**	**% change in metal levels** [1]	**95% confidence interval, P value** [2]
Cu (log transformed)	City vs Other [3]	27.5	12 to 45%, P<0.001
	Al [4]	0.001	P<0.001
	IA btw Al & City [5]	0.002	P<0.001
	Intertidal vs Mangrove [6]	-41.9	-23 to -57%, P<0.001
	Al [4]	0.001	P<0.001
	IA btw Al & Intertidal [7]	0.002	P<0.001
Pb (log transformed)	City vs Other	19.8	10 to 31%, P<0.001
	Al	0.002	P<0.001
	IA btw Al & City	0.00 (6e-6)	P=0.002
	Intertidal vs Mangrove	-38.5	-25 to -50%, P<0.001
	Al	0.00 (7e-6)	P=0.006
	IA btw Al & Intertidal	0.002	P<0.001
Zn (log transformed)	City vs Other	28.5	3 to 60%, P=0.026
	Al	0.00 (3e-4)	P<0.001
	IA btw Al & City	0.00 (3e-6)	P=0.548
	Intertidal vs Mangrove	-44.2	-65 to -11%, P=0.014
	Al	0.00 (5e-6)	P=0.165
	IA btw Al & Intertidal	0.00 (2e-5)	P<0.001

[1] The correct interpretation is the percent change of the geometric mean of the metal if the site is from the City area as compared to Other areas or if the site is from Intertidal areas as compared to Mangrove areas.

[2] The 95% confidence interval can be interpreted as being 95% confident that this interval contains the average % change in metal levels.
Two-tailed P values <0.05 provide evidence for a difference in metal levels between covariates and <0.01 provide strong evidence for a difference.

[3] Percent change in metal levels for the City as compared to Other areas with Al kept at its mean. This is for Intertidal areas only.

[4] Percent change in metal levels for every unit increase of Al

[5] Interaction term between Al and the City vs other covariate, to be interpreted as the % change of metal levels between the City and Other areas for every unit increase of Al.

[6] Percent change in metal levels in Intertidal as compared to Mangrove areas with Al kept at its mean.

[7] Interaction term between Al and the Intertidal vs Mangrove covariate, to be interpreted as the % change of metal levels between Intertidal and Mangrove areas for every unit increase of Al.

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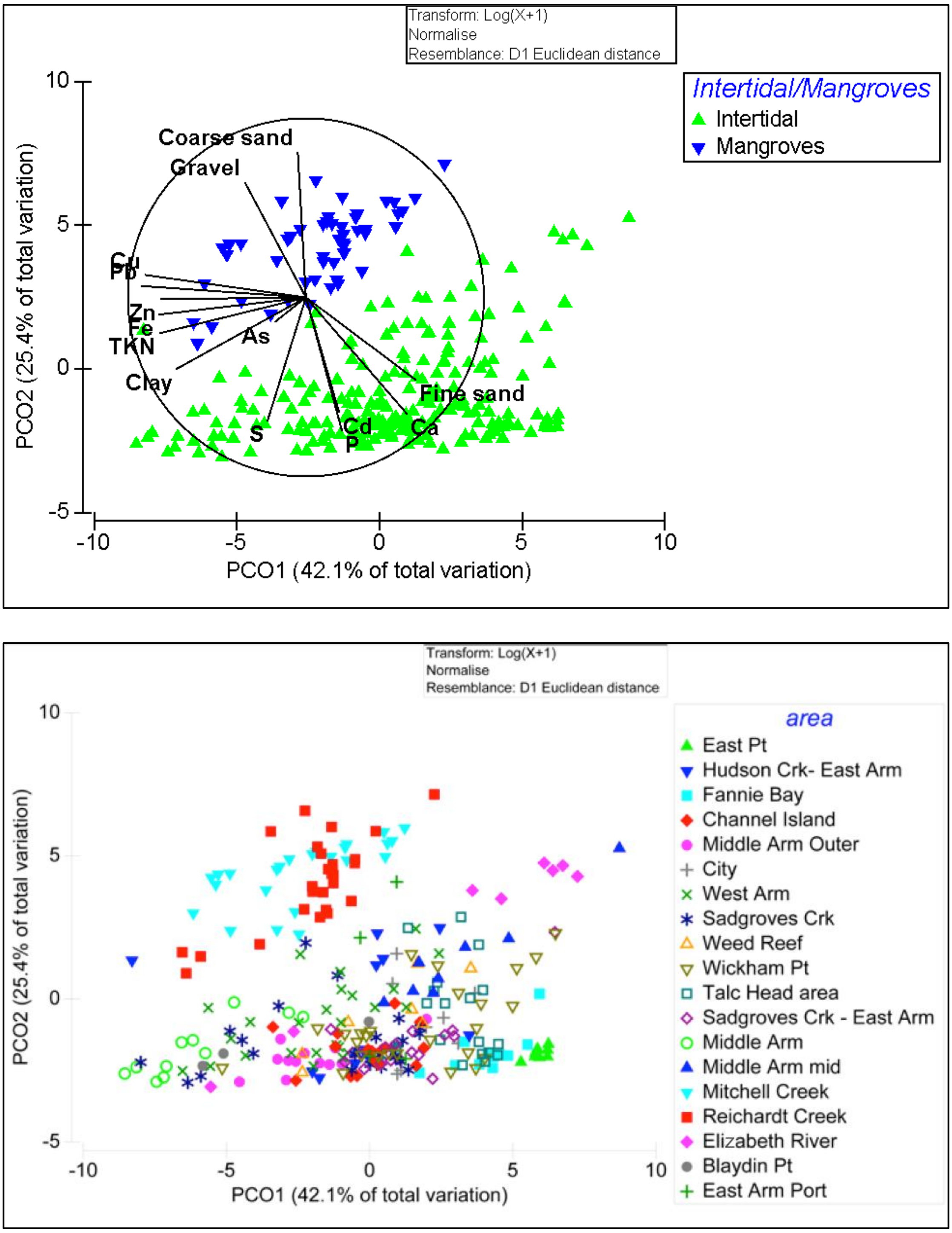

Figure 15. Principal co-ordinate (PCO) plot of Darwin Harbour sediment; (a) separation of intertidal and mangrove creek sediment and (b) separation of sampling areas. The direction and length of vectors shown in figure (a) apply to both figures and indicate the strength of the corresponding variables.

4.9 Comparison to ANZECC guideline levels

Tables 2 and 3 show a comparison of metal and metalloid levels (non-normalised) in intertidal (n=247) and mangrove sediments (n=51) with the ANZECC (2000) default guideline levels. The number of exceedances is also shown. No guideline level is available for the remaining elements analysed in this study. Only Ni and As show a substantial number of exceedances of the ISQG-Low level and only As show exceedances (4 samples) of the ISQG-High level.

The ANZECC (2000) interim sediment quality guideline (ISQG) levels are used to assess the likely toxicity risk for biota. Toxicant levels below the ISQG-low imply a low probability of toxic effects. For levels above ISQG-Low, but below ISQC-High, evaluation of study site levels compared to background concentrations is recommended and for levels above ISQG-High specific bioavailability testing is recommended as toxicity risks are likely to be significant.

Nickel levels are elevated by a small margin above the ISQG-Low level (maximum concentration = 26.7 mg/kg) and previous work suggests that Ni concentrations elevated above the ISQG-Low level is a natural occurrence in North Australian coastal sediment (Munksgaard and Parry, 2002). The majority of sites with elevated Ni levels are located in Middle Arm.

Elevated As concentrations in Darwin Harbour sediment have been reported previously by Fortune (2006) based on a harbour wide sediment survey carried out in 1993. Note that the 1993 study was not confined to intertidal and creek sediment. Arsenic levels of up to 222 mg/kg where recorded from areas with no known anthropogenic sources and was attributed mainly to natural weathering of As rich coastal substrata. In the present study sites with high As concentrations were also found scattered throughout the harbour but two localised areas with high As levels were indentified near the East Point STP Outfall and at Mitchell Creek.

Table 2. Comparison of metal and metalloid concentrations (mg/kg dry weight) in Darwin Harbour intertidal sediment (n=247) to ANZECC (2000) guideline levels.

	Cr	Ni	Cu	Zn	As	Cd	Pb
Average	17.5	8.7	4.7	21.4	16.0	0.071	8.8
Median	15.9	7.3	3.9	19.5	14.0	0.070	7.9
80%’ile	21.0	12.0	6.0	27.9	17.7	0.090	10.7
90%’ile	24.2	16.2	9.0	37.5	22.2	0.096	15.4
Maximum	95.1	26.7	18.9	79.4	75.1	0.467	30.6
ISQG-low	80	21	65	200	20	1.5	50
Number exceeding	1	13	0	0	24	0	0
ISQG-high	370	52	270	410	70	10	220
Number exceeding	0	0	0	0	1	0	0

Table 3. Comparison of metal and metalloid concentrations (mg/kg dry weight) in Darwin Harbour mangrove creek sediment (n=51) to ANZECC (2000) guideline levels.

	Cr	Ni	Cu	Zn	As	Cd	Pb
Average	18.5	8.9	8.6	44.4	19.0	0.041	15.5
Median	15.9	7.7	7.5	37.7	13.1	0.030	14.0
80%'ile	21.9	12.7	9.6	51.3	25.7	0.056	19.5
90%'ile	27.0	14.0	15.6	90.6	28.1	0.076	22.7
Maximum	40.0	17.9	23.1	190	116	0.120	50.4
ISQG-low	80	21	65	200	20	1.5	50
Number exceeding	0	0	0	0	14	0	1
ISQG-high	370	52	270	410	70	10	220
Number exceeding	0	0	0	0	3	0	0

5 Conclusions

- Intertidal and mangrove creek sediment from sites across Darwin Harbour have been analysed for a range of elements including metals, metalloids and nutrients as well as for their grainsize distribution.
- Frequency distribution diagrams show that the distribution of several metals and metalloids are positively skewed.
- Major element compositions indicate that clays and iron-oxy-hydroxides are the predominant metal-bearing minerals. Sulfides and organic phases constitute additional metal bearing phases in some sediment.
- Correlation analysis showed strong positive correlations between the abundance of fine grains <63 μm (clay + silt) and aluminium and the concentrations of several metal/metalloids.
- A normalisation procedure to correct metal/metalloid levels for grainsize variations between sites, using aluminium content as a proxy, have been used to map the spatial distribution of metal/metalloids across Darwin Harbour.
- The spatial distribution of aluminium-normalised concentrations of several metals/metalloid indicate significant contributions of urban metals/metalloid sources to harbour sediment along the developed eastern side of Darwin Harbour and in the vicinity of the sewage treatment plant outfall at East Point / Ludmilla Creek.
- Data analysis using multivariate *Generalized Estimating Equations* has shown that copper, zinc and lead concentrations are significantly elevated in tidal flat sediment near Darwin City at levels 20-29% above those found in the remaining areas of the Harbour (at the average aluminium level).
- *Principal Co-Ordinates* analysis show that mangrove creek sediment from Reichardt and Mitchell Creeks have separate profiles from intertidal sediment and that the sediment from the East Point / Fannie Bay area is separated from the bulk of other harbour sediment.
- Comparison of the intertidal flat and mangrove creek sediment with ANZECC sediment quality guideline levels show that of the seven metals/metalloids for which guideline levels have been defined, four

samples exceeded the high-level arsenic guideline above which toxicity effects are possible.

6 Acknowledgements

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Appendix 1: Site locations

Sampling site detail (supplied by Peter Dostine AHU)

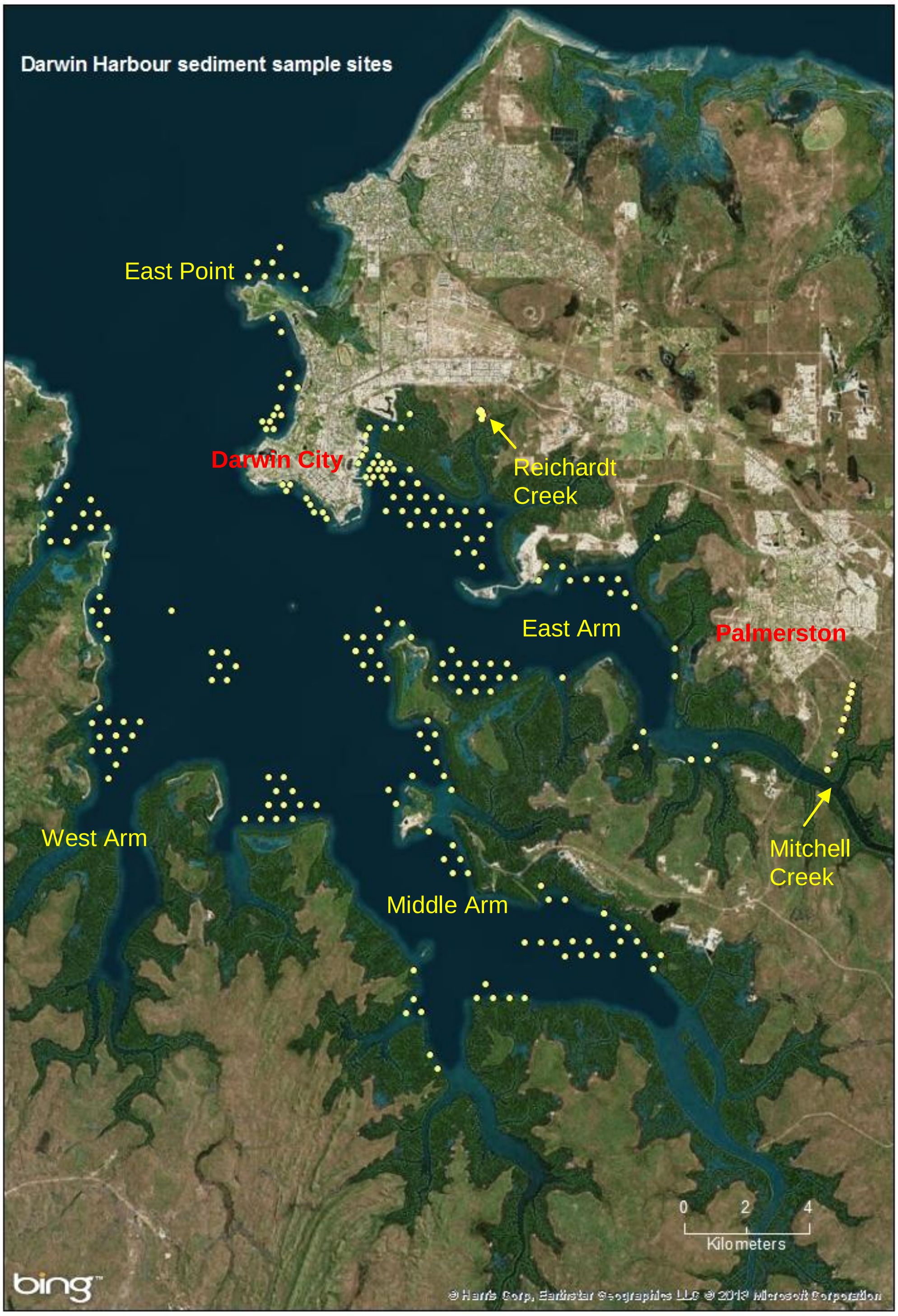
Sample	Comments	Zone	Date	Latitude	Longitude	Datum	Area
432A		Harbour intertidal	10/10/12	-12.40594	130.83515	GDA94	East Pt
434A		Harbour intertidal	10/10/12	-12.40213	130.81903	GDA94	East Pt
435A		Harbour intertidal	10/10/12	-12.40210	130.82363	GDA94	East Pt
436A		Harbour intertidal	10/10/12	-12.40207	130.82823	GDA94	East Pt
437A		Harbour intertidal	10/10/12	-12.40204	130.83282	GDA94	East Pt
440A		Harbour intertidal	10/10/12	-12.39820	130.82130	GDA94	East Pt
441A		Harbour intertidal	10/10/12	-12.39817	130.82590	GDA94	East Pt
446A		Harbour intertidal	10/10/12	-12.39424	130.82817	GDA94	East Pt
74A		Harbour intertidal	31/7/12	-12.49530	130.93007	GDA94	Hudson Crk- East Arm
79A		Harbour intertidal	31/7/12	-12.49143	130.92314	GDA94	Hudson Crk- East Arm
80A		Harbour intertidal	31/7/12	-12.49140	130.92774	GDA94	Hudson Crk- East Arm
84A		Harbour intertidal	31/7/12	-12.48760	130.91161	GDA94	Hudson Crk- East Arm
85A		Harbour intertidal	31/7/12	-12.48757	130.91621	GDA94	Hudson Crk- East Arm
86A		Harbour intertidal	31/7/12	-12.48754	130.92081	GDA94	Hudson Crk- East Arm
87A		Harbour intertidal	31/7/12	-12.48750	130.92541	GDA94	Hudson Crk- East Arm
93A		Harbour intertidal	31/7/12	-12.48370	130.90928	GDA94	Hudson Crk- East Arm
96A		Harbour intertidal	29/8/12	-12.48000	130.87936	GDA94	Hudson Crk- East Arm
F395A		Harbour intertidal	6/9/12	-12.44514	130.82623	GDA94	Fannie Bay
F410A		Harbour intertidal	6/9/12	-12.43338	130.82844	GDA94	Fannie Bay
F411A		Harbour intertidal	6/9/12	-12.43335	130.83304	GDA94	Fannie Bay
F414A		Harbour intertidal	6/9/12	-12.42945	130.83072	GDA94	Fannie Bay
M102A		Harbour intertidal	4/9/12	-12.56220	130.87766	GDA94	Channel Island
M108A		Harbour intertidal	30/8/12	-12.55834	130.87073	GDA94	Channel Island
M112A		Harbour intertidal	5/9/12	-12.55479	130.81780	GDA94	Middle Arm Outer
M113A		Harbour intertidal	5/9/12	-12.55476	130.82240	GDA94	Middle Arm Outer
M114A		Harbour intertidal	5/9/12	-12.55472	130.82700	GDA94	Middle Arm Outer
M115A		Harbour intertidal	5/9/12	-12.55469	130.83160	GDA94	Middle Arm Outer
M122AT1D	Sub-surface	Harbour intertidal	5/9/12	-12.55083	130.82467	GDA94	Middle Arm Outer
M122AT1U	Triplicate	Harbour intertidal	5/9/12	-12.55083	130.82467	GDA94	Middle Arm Outer
M122AT2	Triplicate	Harbour intertidal	5/9/12	-12.55083	130.82467	GDA94	Middle Arm Outer
M122AT3	Triplicate	Harbour intertidal	5/9/12	-12.55083	130.82467	GDA94	Middle Arm Outer
M123A		Harbour intertidal	5/9/12	-12.55080	130.82927	GDA94	Middle Arm Outer
M124A		Harbour intertidal	5/9/12	-12.55076	130.83387	GDA94	Middle Arm Outer
M125A		Harbour intertidal	30/8/12	-12.55073	130.83847	GDA94	Middle Arm Outer
M126A		Harbour intertidal	30/8/12	-12.55057	130.86147	GDA94	Channel Island
M131A		Harbour intertidal	5/9/12	-12.54690	130.82694	GDA94	Middle Arm Outer
M132A		Harbour intertidal	5/9/12	-12.54687	130.83154	GDA94	Middle Arm Outer
M1336A		Harbour intertidal	24/10/12	-12.47048	130.84135	GDA94	City
M133A		Harbour intertidal	30/8/12	-12.54668	130.85914	GDA94	Channel Island
M1359A		Harbour intertidal	24/10/12	-12.46854	130.83789	GDA94	City
M135A		Harbour intertidal	4/9/12	-12.54655	130.87754	GDA94	Channel Island
M1384A		Harbour intertidal	24/10/12	-12.46660	130.83673	GDA94	City
M139A		Harbour intertidal	27/9/12	-12.54331	130.77861	GDA94	West Arm
M1411A		Harbour intertidal	24/10/12	-12.46465	130.83556	GDA94	City
M1429A		Harbour intertidal	24/10/12	-12.46273	130.82980	GDA94	City
M143A		Harbour intertidal	5/9/12	-12.54300	130.82461	GDA94	Middle Arm Outer
M1446A		Harbour intertidal	24/10/12	-12.46078	130.82864	GDA94	City
M1447A		Harbour intertidal	24/10/12	-12.46076	130.83094	GDA94	City
M144A		Harbour intertidal	5/9/12	-12.54297	130.82921	GDA94	Middle Arm Outer
M1465A		Harbour intertidal	24/10/12	-12.45866	130.85277	GDA94	City
M1466A		Harbour intertidal	8/10/12	-12.45864	130.85506	GDA94	Sadgroves Crk
M1467A		Harbour intertidal	8/10/12	-12.45863	130.85736	GDA94	Sadgroves Crk
M146AT1D	Sub-surface	Harbour intertidal	30/8/12	-12.54271	130.86602	GDA94	Channel Island
M146AT1U	Triplicate	Harbour intertidal	30/8/12	-12.54271	130.86602	GDA94	Channel Island
M146AT2	Triplicate	Harbour intertidal	30/8/12	-12.54271	130.86602	GDA94	Channel Island
M146AT3	Triplicate	Harbour intertidal	30/8/12	-12.54271	130.86602	GDA94	Channel Island
M1477A		Harbour intertidal	8/10/12	-12.45669	130.85390	GDA94	Sadgroves Crk

M1479A		Harbour intertidal	8/10/12	-12.45666	130.85850	GDA94	Sadgroves Crk
M147A		Harbour intertidal	4/9/12	-12.54265	130.87522	GDA94	Channel Island
M1486A		Harbour intertidal	24/10/12	-12.45476	130.85044	GDA94	Sadgroves Crk
M1487A		Harbour intertidal	8/10/12	-12.45473	130.85504	GDA94	Sadgroves Crk
M1488A		Harbour intertidal	8/10/12	-12.45471	130.85734	GDA94	Sadgroves Crk
M1489A		Harbour intertidal	8/10/12	-12.45470	130.85964	GDA94	Sadgroves Crk
M1493A		Harbour intertidal	24/10/12	-12.45279	130.85157	GDA94	Sadgroves Crk
M1494A		Harbour intertidal	8/10/12	-12.45276	130.85617	GDA94	Sadgroves Crk
M1498A		Harbour intertidal	24/10/12	-12.45083	130.85271	GDA94	Sadgroves Crk
M1511A		Harbour intertidal	8/10/12	-12.44692	130.85268	GDA94	Sadgroves Crk
M1515A		Harbour intertidal	29/10/12	-12.44515	130.82393	GDA94	Fannie Bay
M151A		Harbour intertidal	27/9/12	-12.53938	130.78089	GDA94	West Arm
M1528A		Harbour intertidal	29/10/12	-12.44321	130.82277	GDA94	Fannie Bay
M1529A		Harbour intertidal	29/10/12	-12.44319	130.82506	GDA94	Fannie Bay
M1538A		Harbour intertidal	29/10/12	-12.44123	130.82620	GDA94	Fannie Bay
M1539A		Harbour intertidal	6/11/12	-12.44121	130.82850	GDA94	Fannie Bay
M1545A		Harbour intertidal	25/10/12	-12.43926	130.82734	GDA94	Fannie Bay
M157A		Harbour intertidal	30/8/12	-12.53875	130.87289	GDA94	Channel Island
M1615A		Harbour intertidal	6/11/12	-12.41773	130.82834	GDA94	Fannie Bay
M161A		Harbour intertidal	27/9/12	-12.53551	130.77396	GDA94	West Arm
M1628A		Harbour intertidal	6/11/12	-12.41383	130.82601	GDA94	Fannie Bay
M162A		Harbour intertidal	27/9/12	-12.53548	130.77856	GDA94	West Arm
M163A		Harbour intertidal	27/9/12	-12.53545	130.78316	GDA94	West Arm
M168A		Harbour intertidal	30/8/12	-12.53486	130.87056	GDA94	Channel Island
M173A		Harbour intertidal	27/9/12	-12.53158	130.77623	GDA94	West Arm
M174AT1D	Sub-surface	Harbour intertidal	27/9/12	-12.53155	130.78083	GDA94	West Arm
M174AT1U	Triplicate	Harbour intertidal	27/9/12	-12.53155	130.78083	GDA94	West Arm
M174AT2	Triplicate	Harbour intertidal	27/9/12	-12.53155	130.78083	GDA94	West Arm
M174AT3	Triplicate	Harbour intertidal	27/9/12	-12.53155	130.78083	GDA94	West Arm
M175A		Harbour intertidal	27/9/12	-12.53152	130.78543	GDA94	West Arm
M17A		Harbour intertidal	26/9/12	-12.60926	130.86420	GDA94	West Arm
M181A		Harbour intertidal	30/8/12	-12.53096	130.86823	GDA94	Channel Island
M182A		Harbour intertidal	4/9/12	-12.53093	130.87283	GDA94	Channel Island
M186A		Harbour intertidal	27/9/12	-12.52768	130.77390	GDA94	West Arm
M187A		Harbour intertidal	27/9/12	-12.52765	130.77850	GDA94	West Arm
M188A		Harbour intertidal	27/9/12	-12.52762	130.78310	GDA94	West Arm
M189A		Harbour intertidal	27/9/12	-12.52759	130.78770	GDA94	West Arm
M18A		Harbour intertidal	26/9/12	-12.60923	130.86880	GDA94	West Arm
M195A		Harbour intertidal	4/9/12	-12.52703	130.87050	GDA94	Channel Island
M197A		Harbour intertidal	27/9/12	-12.52375	130.77618	GDA94	West Arm
M223A		Harbour intertidal	14/9/12	-12.51571	130.80832	GDA94	Weed Reef
M224A		Harbour intertidal	14/9/12	-12.51568	130.81292	GDA94	Weed Reef
M226A		Harbour intertidal	9/10/12	-12.51540	130.85432	GDA94	Wickham Pt
M227A		Harbour intertidal	9/10/12	-12.51537	130.85892	GDA94	Wickham Pt
M241A		Harbour intertidal	14/9/12	-12.51178	130.81060	GDA94	Weed Reef
M242A		Harbour intertidal	14/9/12	-12.51175	130.81519	GDA94	Weed Reef
M243A		Harbour intertidal	28/9/12	-12.51150	130.85199	GDA94	Wickham Pt
M244A		Harbour intertidal	9/10/12	-12.51147	130.85659	GDA94	Wickham Pt
M255A		Harbour intertidal	14/9/12	-12.50788	130.80827	GDA94	Weed Reef
M256A		Harbour intertidal	14/9/12	-12.50785	130.81287	GDA94	Weed Reef
M25A		Harbour intertidal	26/9/12	-12.60533	130.86647	GDA94	West Arm
M265A		Harbour intertidal	9/10/12	-12.50417	130.77834	GDA94	Talc Head area
M26A		Harbour intertidal	26/9/12	-12.60520	130.88487	GDA94	West Arm
M276A		Harbour intertidal	9/10/12	-12.50027	130.77602	GDA94	Talc Head area
M27A		Harbour intertidal	26/9/12	-12.60517	130.88947	GDA94	West Arm
M287A		Harbour intertidal	9/10/12	-12.49637	130.77369	GDA94	Talc Head area
M288AT1	Triplicate	Harbour intertidal	9/10/12	-12.49634	130.77829	GDA94	Talc Head area
M288AT2D	Sub-surface	Harbour intertidal	9/10/12	-12.49634	130.77829	GDA94	Talc Head area
M288AT2U	Triplicate	Harbour intertidal	9/10/12	-12.49634	130.77829	GDA94	Talc Head area
M288AT3	Triplicate	Harbour intertidal	9/10/12	-12.49634	130.77829	GDA94	Talc Head area

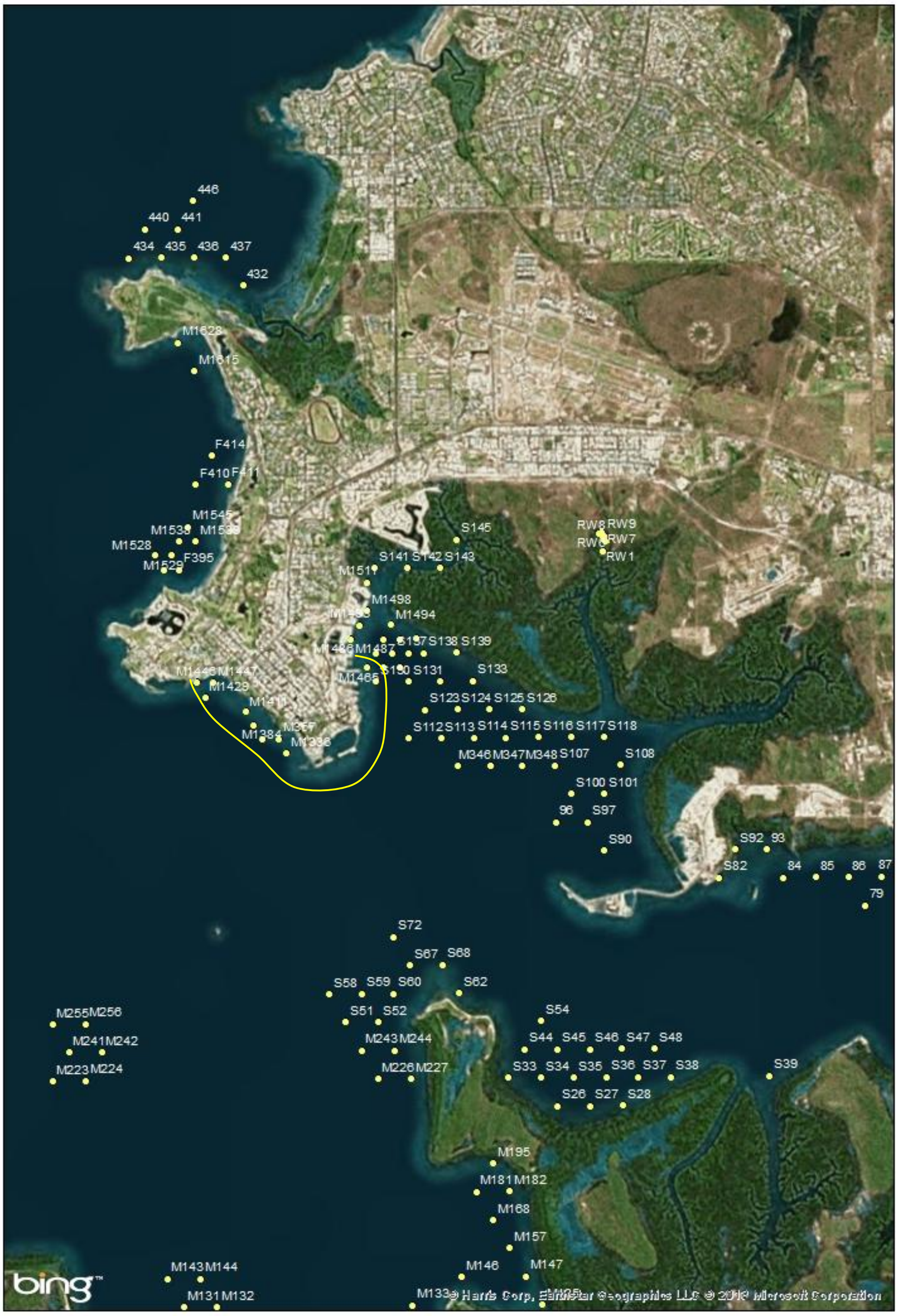
M289A		Harbour intertidal	14/9/12	-12.49622	130.79669	GDA94	Weed Reef
M28A		Harbour intertidal	26/9/12	-12.60514	130.89407	GDA94	West Arm
M296A		Harbour intertidal	9/10/12	-12.49244	130.77596	GDA94	West Arm
M29A		Harbour intertidal	26/9/12	-12.60511	130.89868	GDA94	West Arm
M328A		Harbour intertidal	9/10/12	-12.48069	130.77818	GDA94	Talc Head area
M333A		Harbour intertidal	11/10/12	-12.47688	130.76206	GDA94	Talc Head area
M334AT1D	Sub-surface	Harbour intertidal	11/10/12	-12.47685	130.76666	GDA94	Talc Head area
M334AT1U	Triplicate	Harbour intertidal	11/10/12	-12.47685	130.76666	GDA94	Talc Head area
M334AT2	Triplicate	Harbour intertidal	11/10/12	-12.47685	130.76666	GDA94	Talc Head area
M334AT3	Triplicate	Harbour intertidal	11/10/12	-12.47685	130.76666	GDA94	Talc Head area
M341A		Harbour intertidal	11/10/12	-12.47298	130.75973	GDA94	Talc Head area
M343A		Harbour intertidal	11/10/12	-12.47292	130.76893	GDA94	Talc Head area
M344A		Harbour intertidal	11/10/12	-12.47289	130.77353	GDA94	Talc Head area
M345A		Harbour intertidal	11/10/12	-12.47286	130.77813	GDA94	Talc Head area
M346A		Harbour intertidal	24/10/12	-12.47227	130.86551	GDA94	Sadgroves Crk - East Arm
M347AT1D	Sub-surface	Harbour intertidal	24/10/12	-12.47224	130.87011	GDA94	Sadgroves Crk - East Arm
M347AT1U	Triplicate	Harbour intertidal	24/10/12	-12.47224	130.87011	GDA94	Sadgroves Crk - East Arm
M347AT2	Triplicate	Harbour intertidal	24/10/12	-12.47224	130.87011	GDA94	Sadgroves Crk - East Arm
M347AT3	Triplicate	Harbour intertidal	24/10/12	-12.47224	130.87011	GDA94	Sadgroves Crk - East Arm
M348A		Harbour intertidal	24/10/12	-12.47220	130.87471	GDA94	Sadgroves Crk - East Arm
M353A		Harbour intertidal	11/10/12	-12.46905	130.76201	GDA94	Talc Head area
M355A		Harbour intertidal	11/10/12	-12.46899	130.77120	GDA94	Talc Head area
M356A		Harbour intertidal	11/10/12	-12.46896	130.77580	GDA94	Talc Head area
M357A		Harbour intertidal	28/9/12	-12.46853	130.84019	GDA94	Talc Head area
M367A		Harbour intertidal	11/10/12	-12.46512	130.76428	GDA94	Talc Head area
M368A		Harbour intertidal	11/10/12	-12.46506	130.77348	GDA94	Talc Head area
M36A		Harbour intertidal	26/9/12	-12.60127	130.88714	GDA94	West Arm
M378A		Harbour intertidal	11/10/12	-12.46119	130.76655	GDA94	Talc Head area
M40A		Harbour intertidal	26/9/12	-12.59751	130.86641	GDA94	West Arm
M41A		Harbour intertidal	24/9/12	-12.59701	130.93542	GDA94	Middle Arm
M44A		Harbour intertidal	26/9/12	-12.59328	130.91009	GDA94	Middle Arm mid
M45A		Harbour intertidal	26/9/12	-12.59325	130.91469	GDA94	Middle Arm mid
M46A		Harbour intertidal	26/9/12	-12.59322	130.91929	GDA94	Middle Arm mid
M47A		Harbour intertidal	26/9/12	-12.59318	130.92389	GDA94	Middle Arm mid
M48A		Harbour intertidal	24/9/12	-12.59312	130.93310	GDA94	Middle Arm
M49A		Harbour intertidal	24/9/12	-12.59308	130.93770	GDA94	Middle Arm
M4A		Harbour intertidal	26/9/12	-12.62485	130.87351	GDA94	West Arm
M53A		Harbour intertidal	26/9/12	-12.58945	130.89856	GDA94	Middle Arm mid
M54A		Harbour intertidal	26/9/12	-12.58942	130.90316	GDA94	Middle Arm mid
M55A		Harbour intertidal	26/9/12	-12.58939	130.90776	GDA94	Middle Arm mid
M56A		Harbour intertidal	24/9/12	-12.58935	130.91236	GDA94	Middle Arm mid
M57A		Harbour intertidal	26/9/12	-12.58932	130.91696	GDA94	Middle Arm mid
M58A		Harbour intertidal	24/9/12	-12.58925	130.92616	GDA94	Middle Arm
M59A		Harbour intertidal	24/9/12	-12.58922	130.93077	GDA94	Middle Arm
M62A		Harbour intertidal	24/9/12	-12.58536	130.92384	GDA94	Middle Arm
M63A		Harbour intertidal	24/9/12	-12.58532	130.92844	GDA94	Middle Arm
M70AT1D	Sub-surface	Harbour intertidal	24/9/12	-12.58146	130.92151	GDA94	Middle Arm
M70AT1U	Triplicate	Harbour intertidal	24/9/12	-12.58146	130.92151	GDA94	Middle Arm
M70AT2	Triplicate	Harbour intertidal	24/9/12	-12.58146	130.92151	GDA94	Middle Arm
M70AT3	Triplicate	Harbour intertidal	24/9/12	-12.58146	130.92151	GDA94	Middle Arm
M79A		Harbour intertidal	24/9/12	-12.57766	130.90537	GDA94	Middle Arm
M7A		Harbour intertidal	26/9/12	-12.62096	130.87118	GDA94	West Arm
M80A		Harbour intertidal	24/9/12	-12.57763	130.90998	GDA94	Middle Arm
M87A		Harbour intertidal	24/9/12	-12.57376	130.90305	GDA94	Middle Arm
M93A		Harbour intertidal	30/8/12	-12.57003	130.87771	GDA94	Channel Island
M94A		Harbour intertidal	4/9/12	-12.57000	130.88231	GDA94	Channel Island
M97A		Harbour intertidal	30/8/12	-12.56613	130.87539	GDA94	Channel Island
M98A		Harbour intertidal	4/9/12	-12.56610	130.87999	GDA94	Channel Island
MC1-1A		Mitchell Creek ma	28/11/12	-12.51725	130.99294	GDA94	Mitchell Creek
MC1-2A		Mitchell Creek ma	28/11/12	-12.51725	130.99294	GDA94	Mitchell Creek
MC1-3A		Mitchell Creek ma	28/11/12	-12.51725	130.99294	GDA94	Mitchell Creek
MC2-1A		Mitchell Creek ma	28/11/12	-12.51948	130.99275	GDA94	Mitchell Creek

MC2-2A		Mitchell Creek ma	28/11/12	-12.51948	130.99275	GDA94	Mitchell Creek
MC2-3A		Mitchell Creek ma	28/11/12	-12.51948	130.99275	GDA94	Mitchell Creek
MC3-1A		Mitchell Creek ma	28/11/12	-12.52114	130.99196	GDA94	Mitchell Creek
MC3-2A		Mitchell Creek ma	28/11/12	-12.52114	130.99196	GDA94	Mitchell Creek
MC3-3A		Mitchell Creek ma	28/11/12	-12.52114	130.99196	GDA94	Mitchell Creek
MC4-1A		Mitchell Creek ma	28/11/12	-12.52356	130.99152	GDA94	Mitchell Creek
MC4-2A		Mitchell Creek ma	28/11/12	-12.52356	130.99152	GDA94	Mitchell Creek
MC4-3A		Mitchell Creek ma	28/11/12	-12.52356	130.99152	GDA94	Mitchell Creek
MC5-1A		Mitchell Creek ma	28/11/12	-12.52691	130.99049	GDA94	Mitchell Creek
MC5-2A		Mitchell Creek ma	28/11/12	-12.52691	130.99049	GDA94	Mitchell Creek
MC5-3A		Mitchell Creek ma	28/11/12	-12.52691	130.99049	GDA94	Mitchell Creek
MC6-1A		Mitchell Creek ma	28/11/12	-12.52992	130.98955	GDA94	Mitchell Creek
MC6-2A		Mitchell Creek ma	28/11/12	-12.52992	130.98955	GDA94	Mitchell Creek
MC6-3A		Mitchell Creek ma	28/11/12	-12.52992	130.98955	GDA94	Mitchell Creek
MC7-1A		Mitchell Creek ma	28/11/12	-12.53679	130.98785	GDA94	Mitchell Creek
MC7-2A		Mitchell Creek ma	28/11/12	-12.53679	130.98785	GDA94	Mitchell Creek
MC7-3A		Mitchell Creek ma	28/11/12	-12.53679	130.98785	GDA94	Mitchell Creek
MC8-1A		Mitchell Creek ma	28/11/12	-12.54086	130.98573	GDA94	Mitchell Creek
MC8-2A		Mitchell Creek ma	28/11/12	-12.54086	130.98573	GDA94	Mitchell Creek
MC8-3A		Mitchell Creek ma	28/11/12	-12.54086	130.98573	GDA94	Mitchell Creek
RW1-1A		Reichardt Creek m	30/11/12	-12.44252	130.88606	GDA94	Reichardt Creek
RW1-2A		Reichardt Creek m	30/11/12	-12.44252	130.88606	GDA94	Reichardt Creek
RW1-3A		Reichardt Creek m	30/11/12	-12.44252	130.88606	GDA94	Reichardt Creek
RW2-1A		Reichardt Creek m	30/11/12	-12.44120	130.88638	GDA94	Reichardt Creek
RW2-2A		Reichardt Creek m	30/11/12	-12.44120	130.88638	GDA94	Reichardt Creek
RW2-3A		Reichardt Creek m	30/11/12	-12.44120	130.88638	GDA94	Reichardt Creek
RW3-1A		Reichardt Creek m	30/11/12	-12.44106	130.88629	GDA94	Reichardt Creek
RW3-2A		Reichardt Creek m	30/11/12	-12.44106	130.88629	GDA94	Reichardt Creek
RW3-3A		Reichardt Creek m	30/11/12	-12.44106	130.88629	GDA94	Reichardt Creek
RW4-1A		Reichardt Creek m	4/12/12	-12.44034	130.88600	GDA94	Reichardt Creek
RW4-2A		Reichardt Creek m	4/12/12	-12.44034	130.88600	GDA94	Reichardt Creek
RW4-3A		Reichardt Creek m	4/12/12	-12.44034	130.88600	GDA94	Reichardt Creek
RW5-1A		Reichardt Creek m	4/12/12	-12.44019	130.88547	GDA94	Reichardt Creek
RW5-2A		Reichardt Creek m	4/12/12	-12.44019	130.88547	GDA94	Reichardt Creek
RW5-3A		Reichardt Creek m	4/12/12	-12.44019	130.88547	GDA94	Reichardt Creek
RW6-1A		Reichardt Creek m	4/12/12	-12.44001	130.88594	GDA94	Reichardt Creek
RW6-2A		Reichardt Creek m	4/12/12	-12.44001	130.88594	GDA94	Reichardt Creek
RW6-3A		Reichardt Creek m	4/12/12	-12.44001	130.88594	GDA94	Reichardt Creek
RW7-1A		Reichardt Creek m	30/11/12	-12.44048	130.88615	GDA94	Reichardt Creek
RW7-2A		Reichardt Creek m	30/11/12	-12.44048	130.88615	GDA94	Reichardt Creek
RW7-3A		Reichardt Creek m	30/11/12	-12.44048	130.88615	GDA94	Reichardt Creek
RW8-1A		Reichardt Creek m	30/11/12	-12.44059	130.88611	GDA94	Reichardt Creek
RW8-2A		Reichardt Creek m	30/11/12	-12.44059	130.88611	GDA94	Reichardt Creek
RW8-3A		Reichardt Creek m	30/11/12	-12.44059	130.88611	GDA94	Reichardt Creek
RW9-1A		Reichardt Creek m	30/11/12	-12.44038	130.88611	GDA94	Reichardt Creek
RW9-2A		Reichardt Creek m	30/11/12	-12.44038	130.88611	GDA94	Reichardt Creek
RW9-3A		Reichardt Creek m	30/11/12	-12.44038	130.88611	GDA94	Reichardt Creek
S100A		Harbour intertidal	29/8/12	-12.47607	130.88163	GDA94	Sadgroves Crk - East Arm
S101A		Harbour intertidal	29/8/12	-12.47604	130.88623	GDA94	Sadgroves Crk - East Arm
S103A		Harbour intertidal	17/8/12	-12.47568	130.93682	GDA94	Hudson Crk- East Arm
S107A		Harbour intertidal	9/8/12	-12.47217	130.87931	GDA94	Sadgroves Crk - East Arm
S108A		Harbour intertidal	29/8/12	-12.47211	130.88850	GDA94	Sadgroves Crk - East Arm
S112A		Harbour intertidal	29/8/12	-12.46840	130.85858	GDA94	Sadgroves Crk - East Arm
S113A		Harbour intertidal	29/8/12	-12.46837	130.86318	GDA94	Sadgroves Crk - East Arm
S114A		Harbour intertidal	29/8/12	-12.46834	130.86778	GDA94	Sadgroves Crk - East Arm
S115A		Harbour intertidal	29/8/12	-12.46831	130.87238	GDA94	Sadgroves Crk - East Arm
S116A		Harbour intertidal	9/8/12	-12.46828	130.87698	GDA94	Sadgroves Crk - East Arm
S117A		Harbour intertidal	9/8/12	-12.46824	130.88158	GDA94	Sadgroves Crk - East Arm
S118A		Harbour intertidal	9/8/12	-12.46821	130.88618	GDA94	Sadgroves Crk - East Arm
S123A		Harbour intertidal	29/8/12	-12.46447	130.86085	GDA94	Sadgroves Crk - East Arm
S124A		Harbour intertidal	29/8/12	-12.46444	130.86545	GDA94	Sadgroves Crk - East Arm
S125A		Harbour intertidal	9/8/12	-12.46441	130.87005	GDA94	Sadgroves Crk - East Arm

S126A		Harbour intertidal	9/8/12	-12.46438	130.87465	GDA94	Sadgroves Crk - East Arm
S12AD	Sub-surface	Harbour intertidal	17/8/12	-12.53823	130.94648	GDA94	Elisabeth River
S12AT2	Triplicate	Harbour intertidal	17/8/12	-12.53823	130.94648	GDA94	Elisabeth River
S12AT3	Triplicate	Harbour intertidal	17/8/12	-12.53823	130.94648	GDA94	Elisabeth River
S12AU	Triplicate	Harbour intertidal	17/8/12	-12.53823	130.94648	GDA94	Elisabeth River
S130A		Harbour intertidal	29/8/12	-12.46061	130.85393	GDA94	Sadgroves Crk
S131A		Harbour intertidal	29/8/12	-12.46057	130.85853	GDA94	Sadgroves Crk
S132A		Harbour intertidal	9/8/12	-12.46054	130.86313	GDA94	Sadgroves Crk
S133AT1	Triplicate	Harbour intertidal	9/8/12	-12.46051	130.86772	GDA94	Sadgroves Crk
S133AT2D	Sub-surface	Harbour intertidal	9/8/12	-12.46051	130.86772	GDA94	Sadgroves Crk
S133AT2U	Triplicate	Harbour intertidal	9/8/12	-12.46051	130.86772	GDA94	Sadgroves Crk
S133AT3	Triplicate	Harbour intertidal	9/8/12	-12.46051	130.86772	GDA94	Sadgroves Crk
S137A		Harbour intertidal	9/8/12	-12.45668	130.85620	GDA94	Sadgroves Crk
S138A		Harbour intertidal	9/8/12	-12.45665	130.86080	GDA94	Sadgroves Crk
S139A		Harbour intertidal	9/8/12	-12.45661	130.86540	GDA94	Sadgroves Crk
S13A		Harbour intertidal	17/8/12	-12.53820	130.95108	GDA94	Elisabeth River
S141A		Harbour intertidal	9/8/12	-12.44495	130.85382	GDA94	Sadgroves Crk
S142A		Harbour intertidal	9/8/12	-12.44492	130.85842	GDA94	Sadgroves Crk
S143A		Harbour intertidal	9/8/12	-12.44489	130.86301	GDA94	Sadgroves Crk
S145A		Harbour intertidal	9/8/12	-12.44096	130.86529	GDA94	Sadgroves Crk
S16A		Harbour intertidal	28/8/12	-12.53443	130.93036	GDA94	Blaydin Pt
S17A		Harbour intertidal	17/8/12	-12.53427	130.95336	GDA94	Elisabeth River
S19A		Harbour intertidal	17/8/12	-12.53050	130.93263	GDA94	Blaydin Pt
S26A		Harbour intertidal	17/8/12	-12.51914	130.87965	GDA94	Wickham Pt
S27A		Harbour intertidal	17/8/12	-12.51910	130.88424	GDA94	Wickham Pt
S28A		Harbour intertidal	17/8/12	-12.51907	130.88884	GDA94	Wickham Pt
S33A		Harbour intertidal	2/8/12	-12.51527	130.87272	GDA94	Wickham Pt
S34A		Harbour intertidal	2/8/12	-12.51524	130.87732	GDA94	Wickham Pt
S35A		Harbour intertidal	2/8/12	-12.51521	130.88192	GDA94	Wickham Pt
S36A		Harbour intertidal	2/8/12	-12.51517	130.88652	GDA94	Wickham Pt
S37A		Harbour intertidal	2/8/12	-12.51514	130.89112	GDA94	Wickham Pt
S38A		Harbour intertidal	2/8/12	-12.51511	130.89572	GDA94	Wickham Pt
S39A		Harbour intertidal	2/8/12	-12.51501	130.90951	GDA94	Blaydin Pt
S41A		Harbour intertidal	2/8/12	-12.51478	130.94171	GDA94	Elisabeth River
S44A		Harbour intertidal	2/8/12	-12.51134	130.87499	GDA94	Wickham Pt
S45A		Harbour intertidal	2/8/12	-12.51131	130.87959	GDA94	Wickham Pt
S46A		Harbour intertidal	2/8/12	-12.51128	130.88419	GDA94	Wickham Pt
S47A		Harbour intertidal	2/8/12	-12.51124	130.88879	GDA94	Wickham Pt
S48A		Harbour intertidal	2/8/12	-12.51121	130.89339	GDA94	Wickham Pt
S51AT1D	Sub-surface	Harbour intertidal	28/8/12	-12.50760	130.84966	GDA94	Wickham Pt
S51AT1U	Triplicate	Harbour intertidal	28/8/12	-12.50760	130.84966	GDA94	Wickham Pt
S51AT2	Triplicate	Harbour intertidal	28/8/12	-12.50760	130.84966	GDA94	Wickham Pt
S51AT3	Triplicate	Harbour intertidal	28/8/12	-12.50760	130.84966	GDA94	Wickham Pt
S52A		Harbour intertidal	28/8/12	-12.50757	130.85426	GDA94	Hudson Crk- East Arm
S54A		Harbour intertidal	2/8/12	-12.50741	130.87726	GDA94	Wickham Pt
S57A		Harbour intertidal	2/8/12	-12.50695	130.94165	GDA94	Elisabeth River
S58A		Harbour intertidal	28/8/12	-12.50370	130.84734	GDA94	Wickham Pt
S59A		Harbour intertidal	28/8/12	-12.50367	130.85194	GDA94	Wickham Pt
S60A		Harbour intertidal	28/8/12	-12.50364	130.85654	GDA94	Wickham Pt
S62A		Harbour intertidal	28/8/12	-12.50358	130.86573	GDA94	Wickham Pt
S67A		Harbour intertidal	17/8/12	-12.49971	130.85881	GDA94	Wickham Pt
S68A		Harbour intertidal	17/8/12	-12.49968	130.86341	GDA94	Wickham Pt
S72A		Harbour intertidal	28/8/12	-12.49581	130.85648	GDA94	Wickham Pt
S82A		Harbour intertidal	17/8/12	-12.48767	130.90241	GDA94	East Arm Port
S90A		Harbour intertidal	29/8/12	-12.48387	130.88629	GDA94	East Arm Port
S92A		Harbour intertidal	2/8/12	-12.48374	130.90468	GDA94	East Arm Port
S97A		Harbour intertidal	29/8/12	-12.47997	130.88396	GDA94	East Arm Port



Darwin Harbour sampling sites



City area. Yellow line indicates the grouping of ‘City’ sites used in the data analysis (Section 4.8).

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East Arm and Middle Arm

West Arm and Middle Arm

Appendix 2. Analytical results

Grainsize distribution analysis by laser diffraction and wet sieving (CSIRO Particle Analysis Service)						
Sample Name	**Clay % (<4µm)**	**Silt % (4-62µm)**	**Fine sand % (62-250µm)**	**Medium sand % (250-500µm)**	**Coarse sand % (500-2000µm)**	**Gravel (>2000µm)**
432A	0.0	0.0	56.4	43.4	0.2	0.0
434A	0.2	0.2	72.9	25.9	0.8	0.0
435A	0.4	1.5	52.9	44.1	1.0	0.1
436A	0.9	1.8	61.9	34.5	0.6	0.2
437A	0.2	1.6	52.4	44.4	1.4	0.0
440A	0.0	1.2	69.4	27.9	1.2	0.3
441A	0.0	1.1	66.0	31.8	1.0	0.1
446A	0.9	0.4	65.0	31.2	2.2	0.3
74A	7.3	23.8	52.4	2.1	6.5	7.8
79A	7.5	27.7	53.7	2.1	3.9	5.0
80A	7.4	26.0	49.8	2.6	4.9	9.2
84A	7.5	21.7	36.6	22.4	8.3	3.5
85A	5.6	15.3	33.8	32.6	10.6	2.1
86A	6.3	17.8	20.8	32.6	16.6	5.9
87A	10.8	38.4	48.8	0.1	1.3	0.5
93A	5.6	23.1	28.8	20.0	11.0	11.4
96A	10.9	37.8	49.7	0.8	0.7	0.1
F395A	2.7	10.1	84.4	1.3	1.5	0.0
F410A	3.1	18.0	77.8	0.2	0.9	0.0
F411A	0.0	0.8	31.4	60.5	6.5	0.8
F414A	3.5	25.6	69.0	0.0	1.9	0.0
M102A	7.6	31.8	52.2	1.5	2.9	4.0
M108A	5.4	13.8	34.7	17.0	20.8	8.3
M112A	7.4	31.3	55.0	5.6	0.7	0.0
M113A	9.7	37.5	46.4	3.0	1.8	1.6
M114A	13.9	44.7	37.9	2.2	0.9	0.4
M115A	8.0	42.4	38.9	1.1	3.5	6.0
M122AT1D	7.2	26.5	51.7	8.5	2.4	3.7
M122AT1U	9.9	34.6	46.9	6.3	1.2	1.1
M122AT2	10.4	40.4	41.8	3.8	2.4	1.3
M122AT3	12.3	45.3	36.3	4.1	1.5	0.6
M123A	13.2	38.1	41.6	4.0	1.8	1.3
M124A	10.5	39.9	44.5	3.8	1.1	0.2
M125A	5.3	10.3	38.7	38.8	6.5	0.4
M126A	6.7	18.6	66.6	6.8	1.2	0.2
M131A	13.4	46.1	34.1	3.0	2.1	1.2
M132A	13.8	43.3	41.0	1.2	0.4	0.2
M1336A	4.6	17.6	67.4	7.5	2.7	0.2
M133A	8.2	25.6	56.2	6.5	2.5	1.0
M1359A	6.5	22.1	68.1	3.0	0.2	0.0
M135A	12.8	51.1	35.7	0.1	0.3	0.0
M1384A	2.7	6.2	49.1	33.4	7.9	0.7
M139A	4.5	16.1	33.6	30.6	12.5	2.8
M1411A	2.9	7.0	71.2	15.2	3.3	0.4
M1429A	3.2	8.7	75.3	11.7	1.1	0.0
M143A	10.8	28.5	35.3	13.3	8.8	3.3
M1446A	4.1	23.0	61.5	8.4	1.8	1.2
M1447A	4.9	17.3	46.6	22.0	8.4	0.8
M144A	22.1	58.7	19.1	0.1	0.0	0.1
M1465A	6.1	16.9	46.7	14.6	6.9	8.8
M1466A	6.1	29.1	60.5	0.2	1.8	2.3
M1467A	7.0	27.0	59.2	1.3	2.1	3.4
M146AT1D	6.9	20.8	52.6	10.1	8.5	1.0
M146AT1U	7.8	22.0	54.6	10.3	4.7	0.6
M146AT2	5.1	14.2	52.5	11.5	13.6	3.0
M146AT3	6.4	17.4	52.9	11.8	10.7	0.7
M1477A	4.4	16.5	64.0	4.5	4.4	6.2
M1479A	5.2	22.0	60.7	0.1	2.6	9.3
M147A	10.1	38.8	50.0	0.2	0.3	0.6
M1486A	9.9	45.0	31.7	5.2	4.7	3.4
M1487A	4.9	18.0	64.7	0.8	4.2	7.4
M1488A	6.0	27.7	62.6	0.0	1.8	1.8
M1489A	5.2	25.9	53.6	2.5	5.7	7.2
M1493A	4.6	19.4	21.2	8.8	16.0	30.0
M1494A	3.2	16.6	57.8	1.8	7.1	13.5
M1498A	7.5	26.4	35.6	9.4	10.6	10.5
M1511A	12.9	57.1	24.8	2.4	1.6	1.2
M1515A	2.9	15.9	79.4	1.7	0.1	0.0
M151A	8.2	28.0	53.8	6.1	2.2	1.7
M1528A	4.5	16.6	78.1	0.5	0.3	0.0
M1529A	4.0	18.9	76.8	0.0	0.3	0.0
M1538A	6.2	25.6	68.0	0.0	0.1	0.0

M1539A	3.0	13.3	82.3	1.3	0.1	0.0
M1545A	3.7	19.7	76.0	0.3	0.3	0.0
M157A	10.0	34.9	53.7	0.9	0.4	0.2
M1615A	1.0	2.6	45.5	47.8	2.5	0.6
M161A	9.5	26.6	40.3	17.0	4.7	2.0
M1628A	3.3	14.0	46.2	31.5	4.1	0.9
M162A	8.2	32.3	52.7	4.6	1.4	0.8
M163A	9.1	30.6	53.3	4.3	2.4	0.3
M168A	7.2	21.5	68.8	0.4	1.3	0.8
M173A	6.8	24.4	28.3	22.1	7.6	10.8
M174AT1D	4.0	15.5	37.2	10.4	11.1	21.8
M174AT1U	4.5	16.8	35.6	14.6	10.6	18.0
M174AT2	5.9	18.1	36.4	8.4	12.8	18.5
M174AT3	4.2	13.0	33.5	12.0	13.4	23.9
M175A	8.7	30.0	48.9	6.6	4.8	1.1
M17A	9.0	22.4	18.1	23.7	17.4	9.5
M181A	7.5	30.1	59.1	0.2	1.2	1.8
M182A	7.0	34.6	52.6	0.0	1.8	4.0
M186A	4.1	13.2	24.0	37.7	10.4	10.6
M187A	4.4	10.7	40.5	35.3	5.4	3.7
M188A	8.9	27.7	49.6	10.0	2.6	1.2
M189A	12.3	38.1	45.6	3.1	0.7	0.2
M18A	10.8	30.8	40.6	11.8	4.3	1.7
M195A	11.6	46.3	25.7	6.3	6.6	3.4
M197A	7.0	18.6	11.5	11.1	15.2	36.7
M223A	15.3	41.5	39.6	2.8	0.5	0.3
M224A	9.0	25.6	39.9	9.9	8.4	7.2
M226A	3.4	8.5	86.0	1.9	0.2	0.0
M227A	3.8	16.3	79.2	0.0	0.6	0.1
M241A	13.6	41.7	36.0	3.5	3.3	1.9
M242A	3.5	6.1	32.3	36.4	16.6	5.2
M243A	2.3	5.9	87.0	4.2	0.4	0.1
M244A	4.9	18.8	75.6	0.4	0.2	0.1
M255A	5.1	16.4	33.6	6.2	32.4	6.2
M256A	5.8	13.8	51.6	20.8	7.0	0.9
M25A	18.8	62.2	14.5	0.5	2.5	1.4
M265A	3.1	8.9	17.0	29.7	21.3	20.0
M26A	14.3	47.5	33.2	3.5	0.7	0.9
M276A	4.2	16.4	54.5	17.0	7.5	0.4
M27A	18.4	64.8	15.4	0.0	0.4	1.0
M287A	4.5	20.5	47.9	19.2	3.6	4.3
M288AT1	3.5	12.2	51.9	30.6	1.8	0.0
M288AT2D	4.2	12.8	50.4	30.0	2.4	0.2
M288AT2U	2.4	8.9	51.2	34.8	2.6	0.1
M288AT3	2.8	11.4	51.0	30.1	4.7	0.1
M289A	3.3	7.6	10.8	16.1	30.0	32.2
M28A	15.2	60.3	17.7	2.1	2.9	1.9
M296A	4.8	20.6	46.4	25.0	1.6	1.6
M29A	9.1	31.6	46.2	6.7	5.2	1.2
M328A	6.0	21.3	43.7	16.4	11.4	1.2
M333A	7.4	17.9	12.6	6.0	39.0	17.1
M334AT1D	3.5	11.0	82.6	2.7	0.3	0.0
M334AT1U	3.7	12.7	79.3	4.0	0.3	0.0
M334AT2	4.9	19.9	73.4	1.7	0.1	0.0
M334AT3	3.5	13.8	77.6	4.1	1.0	0.1
M341A	6.2	34.2	50.7	6.5	2.2	0.3
M343A	2.4	8.4	74.9	11.4	2.9	0.0
M344A	2.7	7.9	86.0	2.4	0.7	0.2
M345A	3.1	12.9	72.4	11.0	0.5	0.1
M346A	8.5	26.5	56.9	4.1	2.9	1.0
M347AT1D	7.8	27.7	56.7	3.7	3.2	0.9
M347AT1U	8.9	26.9	55.4	3.5	4.1	1.3
M347AT2	9.3	27.8	53.5	3.8	3.8	1.9
M347AT3	6.9	22.1	57.5	7.0	3.5	3.0
M348A	8.1	27.4	56.3	3.1	2.7	2.5
M353A	3.8	17.5	39.3	15.7	15.1	8.7
M355A	5.3	15.7	69.3	7.6	1.9	0.3
M356A	6.4	24.0	61.0	7.1	1.3	0.2
M357A	3.8	13.5	63.2	14.9	2.8	1.7
M367A	4.4	19.9	46.2	16.1	13.0	0.5
M368A	6.1	23.2	62.4	5.9	2.1	0.3
M36A	8.3	25.6	46.3	14.2	2.3	3.2
M378A	4.8	12.6	33.3	33.0	16.2	0.1
M40A	17.5	61.7	17.2	0.9	1.4	1.2
M41A	11.6	35.7	17.7	15.0	7.7	12.3

M44A	3.6	8.8	52.7	32.4	1.4	1.1
M45A	5.0	11.3	53.0	29.5	1.2	0.1
M46A	1.6	4.2	45.1	46.8	1.0	1.3
M47A	6.1	17.8	39.1	34.0	2.4	0.7
M48A	19.9	67.3	11.9	0.5	0.3	0.1
M49A	22.7	64.6	10.7	2.0	0.0	0.0
M4A	7.4	24.8	9.7	2.6	18.4	37.0
M53A	5.1	14.6	46.5	21.0	7.5	5.4
M54A	3.5	7.8	52.4	27.6	7.6	1.1
M55A	6.6	24.5	64.4	3.7	0.7	0.1
M56A	7.8	24.6	51.4	14.7	1.1	0.4
M57A	2.9	7.8	44.7	41.9	2.0	0.7
M58A	10.8	37.5	28.1	9.2	5.0	9.5
M59A	15.1	52.6	20.8	3.1	2.3	6.1
M62A	7.6	22.3	43.5	23.2	2.9	0.5
M63A	19.8	61.8	11.8	3.1	1.3	2.2
M70AT1D	26.3	64.9	3.9	0.0	1.6	3.3
M70AT1U	21.6	67.6	9.0	0.6	0.7	0.5
M70AT2	20.8	65.6	11.5	1.3	0.2	0.5
M70AT3	19.3	62.8	14.4	2.6	0.8	0.2
M79A	21.2	63.1	15.3	0.1	0.3	0.0
M7A	11.9	40.4	26.0	4.0	6.6	11.0
M80A	17.0	63.7	13.5	2.5	1.2	2.1
M87A	24.3	68.3	6.9	0.3	0.1	0.1
M93A	10.5	29.5	39.7	10.3	7.9	2.1
M94A	7.6	28.3	47.3	3.0	5.4	8.4
M97A	7.6	25.1	60.3	2.7	1.9	2.4
M98A	6.7	24.2	57.4	2.9	2.4	6.4
MC1-1A	12.9	26.8	12.4	13.7	18.5	15.6
MC1-2A	4.0	12.4	39.9	36.9	6.2	0.6
MC1-3A	15.1	60.4	20.6	1.7	1.0	1.1
MC2-1A	5.8	21.2	25.6	22.5	15.2	9.7
MC2-2A	2.9	9.6	24.3	34.7	14.1	14.4
MC2-3A	5.7	24.2	26.2	21.2	16.0	6.7
MC3-1A	5.0	21.8	30.3	13.1	11.9	17.9
MC3-2A	3.9	16.4	37.6	22.7	12.8	6.6
MC3-3A	5.0	21.0	38.5	17.9	11.5	6.1
MC4-1A	7.5	41.6	28.3	12.7	6.6	3.3
MC4-2A	4.7	25.2	24.6	23.0	12.0	10.5
MC4-3A	5.9	31.1	25.1	17.9	10.7	9.3
MC5-1A	3.1	13.4	26.5	20.3	16.1	20.6
MC5-2A	5.9	23.7	16.7	16.3	19.2	18.2
MC5-3A	4.9	20.0	21.3	16.0	19.2	18.6
MC6-1A	2.6	6.6	21.7	36.1	22.5	10.5
MC6-2A	2.7	6.6	25.3	38.4	22.2	4.7
MC6-3A	8.0	23.7	16.7	19.7	20.7	11.3
MC7-1A	3.5	12.9	30.1	16.4	14.6	22.6
MC7-2A	2.9	11.8	29.2	20.2	15.7	20.2
MC7-3A	4.8	24.9	38.1	13.3	13.1	5.8
MC8-1A	3.5	18.9	39.1	16.0	11.0	11.4
MC8-2A	3.5	20.3	39.1	16.5	13.4	7.2
MC8-3A	3.5	18.0	35.1	20.5	12.2	10.6
RW1-1A	11.5	54.1	18.2	8.9	4.9	2.4
RW1-2A	14.3	59.3	15.7	2.4	3.5	4.8
RW1-3A	12.1	53.0	18.6	5.0	5.9	5.4
RW2-1A	6.3	38.1	37.7	12.7	3.5	1.7
RW2-2A	6.1	38.4	36.6	11.5	2.8	4.6
RW2-3A	4.9	29.6	45.1	12.3	2.7	5.4
RW3-1A	6.3	34.7	37.1	11.3	5.5	5.1
RW3-2A	5.5	30.7	34.8	15.4	4.3	9.2
RW3-3A	8.2	43.8	30.3	10.9	3.4	3.4
RW4-1A	6.0	26.2	26.4	17.5	13.9	10.0
RW4-2A	5.0	21.6	32.9	28.4	7.3	4.7
RW4-3A	7.1	31.6	28.9	15.8	11.9	4.6
RW5-1A	4.1	21.6	25.6	24.5	15.0	9.2
RW5-2A	6.1	28.3	23.6	10.9	22.6	8.5
RW5-3A	4.0	17.6	21.6	19.4	20.7	16.7
RW6-1A	2.0	8.2	13.3	19.4	29.4	27.7
RW6-2A	2.3	12.1	22.4	19.5	25.7	18.0
RW6-3A	2.9	14.0	12.0	10.9	24.4	35.8
RW7-1A	1.9	8.2	44.2	32.0	9.3	4.4
RW7-2A	3.1	10.6	30.5	24.7	8.6	22.6
RW7-3A	6.0	33.8	28.0	12.7	11.9	7.6
RW8-1A	7.2	39.4	29.8	8.2	7.3	8.1
RW8-2A	6.1	33.7	29.2	7.9	9.0	14.1

RW8-3A	6.2	35.6	30.1	9.1	9.6	9.5
RW9-1A	5.2	30.4	26.0	9.6	11.8	17.0
RW9-2A	5.9	33.8	27.1	12.1	11.7	9.4
RW9-3A	6.5	39.5	22.2	5.9	8.3	17.6
S100A	6.9	22.9	67.0	0.8	1.6	0.9
S101A	4.4	15.1	67.9	1.7	5.8	5.1
S103A	4.2	11.4	4.5	8.0	24.1	47.8
S107A	6.9	21.5	62.8	4.3	2.2	2.2
S108A	2.4	3.0	40.0	33.6	14.0	7.0
S112A	6.8	20.9	60.9	5.0	4.3	2.1
S113A	6.0	19.9	68.1	2.5	2.6	1.0
S114A	5.7	18.2	69.9	2.2	3.5	0.5
S115A	5.2	17.3	68.3	7.4	1.9	0.0
S116A	4.2	19.8	75.0	0.7	0.1	0.2
S117A	8.8	31.8	40.1	8.5	5.2	5.6
S118A	8.4	36.8	53.1	0.0	0.6	1.1
S123A	6.5	24.6	62.4	0.4	3.2	3.0
S124A	5.7	23.5	66.8	0.3	1.1	2.7
S125A	4.9	19.1	67.4	1.3	2.4	5.0
S126A	5.3	26.0	55.3	5.6	4.4	3.3
S12AD	1.8	4.5	24.5	45.9	17.7	5.6
S12AT2	1.5	4.1	26.8	53.7	11.5	2.3
S12AT3	2.3	6.6	29.2	45.6	11.4	4.9
S12AU	2.5	6.3	27.6	49.0	13.4	1.3
S130A	7.8	28.8	56.3	1.9	3.2	2.0
S131A	5.5	22.7	68.4	0.4	1.4	1.7
S132A	5.5	25.0	65.0	0.7	1.7	2.1
S133AT1	4.7	21.7	56.1	1.9	3.8	11.8
S133AT2D	5.5	24.3	55.9	3.5	3.1	7.8
S133AT2U	5.2	23.1	58.6	2.9	2.3	8.0
S133AT3	6.0	28.3	59.3	1.9	1.9	2.6
S137A	4.5	21.8	64.9	0.8	1.8	6.2
S138A	5.2	25.5	61.5	1.2	1.7	4.8
S139A	9.0	41.5	13.7	2.7	5.7	27.4
S13A	1.5	5.0	24.8	45.4	19.4	3.9
S141A	15.0	69.5	15.2	0.0	0.2	0.0
S142A	16.6	64.2	17.7	1.2	0.2	0.1
S143A	15.2	63.7	20.5	0.0	0.2	0.3
S145A	19.3	70.9	9.7	0.0	0.1	0.0
S16A	16.2	56.0	24.3	1.1	1.9	0.5
S17A	3.4	7.8	18.7	52.0	15.0	3.1
S19A	13.3	45.6	25.0	8.9	3.6	3.6
S26A	2.6	6.4	36.9	25.2	13.5	15.4
S27A	5.4	23.2	39.3	2.5	9.2	20.3
S28A	15.3	57.9	21.9	1.5	2.1	1.3
S33A	5.1	22.9	34.9	17.7	10.4	8.9
S34A	9.2	33.2	37.5	3.4	10.1	6.6
S35A	6.5	27.6	48.8	3.5	6.7	6.8
S36A	6.4	29.1	55.1	1.3	4.0	4.1
S37A	5.7	26.2	59.6	1.7	3.1	3.7
S38A	8.9	43.6	45.3	0.1	1.9	0.2
S39A	7.5	24.7	42.4	13.4	8.6	3.4
S41A	10.5	40.0	32.4	4.2	6.5	6.4
S44A	10.3	30.1	32.3	4.7	11.1	11.5
S45A	7.5	27.3	47.1	4.0	7.5	6.5
S46A	7.9	29.0	54.0	1.6	4.6	2.9
S47A	7.4	24.5	62.8	2.5	1.5	1.3
S48A	5.8	21.1	64.6	4.7	2.4	1.4
S51AT1D	4.5	11.1	61.1	18.6	4.6	0.1
S51AT1U	4.4	9.0	63.1	17.7	5.6	0.2
S51AT2	4.0	7.9	58.0	23.4	6.7	0.0
S51AT3	3.7	7.8	54.7	27.6	6.1	0.1
S52A	3.7	8.5	73.0	7.6	7.2	0.0
S54A	8.8	26.8	43.0	7.9	9.9	3.7
S57A	19.4	60.7	19.4	0.0	0.3	0.2
S58A	8.6	19.9	55.4	11.9	4.2	0.0
S59A	5.1	11.9	54.8	10.7	17.1	0.5
S60A	4.1	9.5	78.4	3.0	4.5	0.5
S62A	5.7	19.8	50.9	14.1	6.7	2.8
S67A	2.1	4.3	23.4	24.6	44.3	1.3
S68A	1.3	2.3	16.2	50.1	29.3	0.9
S72A	3.8	6.4	41.9	32.7	14.7	0.4
S82A	3.5	11.0	8.4	15.3	33.9	27.9
S90A	6.7	21.6	67.1	2.1	1.2	1.3
S92A	6.9	28.1	23.3	10.6	16.3	14.8
S97A	8.5	25.5	59.8	0.4	2.6	3.2

Environmental Chemistry and Microbiology Unit

Concentration in dry weight

	TKN	TOC	Mg	Al	P	S	Ca	V	Cr	Fe	Mn	Co	Ni	Cu	Zn	Ga	As	Mo	Cd	Pb
Sample	%	%	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
432A	0.025	<0.2	19,179	3,158	830	3,347	279,893	36.97	9.93	16,787	883	2.68	2.88	0.72	5.99	2.68	56.37	0.43	0.075	5.75
434A	0.028	0.2	16,968	3,646	762	3,576	250,110	29.69	9.66	13,927	743	2.52	3.01	1.14	7.39	2.68	41.66	0.49	0.082	5.21
435A	0.032	<0.2	20,695	3,794	902	4,417	315,538	30.94	10.62	15,036	812	2.76	3.35	1.80	8.90	3.02	43.42	0.32	0.089	5.84
436A	0.030	<0.2	17,910	3,640	750	3,600	273,937	30.76	9.77	14,246	766	2.55	2.96	0.90	7.17	2.75	43.49	0.36	0.085	5.46
437A	0.024	<0.2	18,647	3,252	849	3,667	279,922	36.71	10.39	16,541	863	2.67	2.94	0.75	6.63	2.67	53.20	0.43	0.074	5.74
440A	0.027	<0.2	16,545	3,549	725	3,213	250,896	29.61	10.39	13,541	746	2.44	2.88	0.91	7.27	2.60	41.07	0.42	0.080	5.37
441A	0.025	<0.2	19,387	3,598	803	4,048	285,317	33.32	11.13	15,004	833	2.69	3.12	0.80	7.29	2.95	46.72	0.40	0.084	5.58
446A	0.027	0.2	17,858	3,814	751	3,506	269,028	32.22	10.39	14,589	789	2.56	2.96	0.79	6.66	2.80	44.15	0.37	0.079	5.43
74A	0.054	0.8	9,581	19,734	450	4,720	136,559	35.02	17.78	20,946	265	5.37	8.01	4.86	19.88	6.40	16.19	<	0.252	8.45
79A	0.050	0.8	11,442	21,118	523	3,844	172,067	32.52	15.25	22,100	342	6.62	8.46	4.53	22.89	6.81	14.38	<	0.080	8.26
80A	0.056	0.7	10,645	21,030	546	4,011	156,333	33.30	16.63	23,953	343	7.25	8.76	4.72	23.92	7.20	15.54	<	0.206	8.39
84A	0.054	1.1	5,062	18,803	296	2,932	48,721	37.73	16.31	19,036	106	4.24	7.26	4.99	18.64	5.92	15.78	<	0.037	7.54
85A	0.021	0.5	2,779	11,038	227	2,171	27,658	34.46	15.08	17,568	85	3.17	4.95	3.64	12.13	4.03	13.82	<	0.025	4.89
86A	0.037	0.8	3,391	15,166	347	2,128	22,435	50.90	20.54	26,450	101	4.46	6.80	4.47	15.58	5.08	17.25	<	0.029	6.68
87A	0.073	1.1	11,622	32,217	504	3,779	139,996	42.38	15.43	24,688	293	7.22	11.36	6.83	30.32	9.36	13.76	<	0.071	10.76
93A	0.045	0.9	5,253	20,616	237	3,856	57,738	23.77	13.46	14,881	99	4.82	7.53	4.30	20.89	6.37	13.78	<	0.035	8.73
96A	0.071	1.0	12,652	29,661	504	4,382	159,822	40.09	21.42	21,997	300	5.88	11.03	6.65	25.35	8.83	12.71	<	0.091	11.80
F395A	0.026	0.2	11,197	8,114	514	3,015	206,324	21.26	14.90	11,957	369	2.73	4.25	2.00	11.38	3.49	14.89	<	0.094	5.73
F410A	0.024	0.2	10,741	7,365	470	3,485	224,442	16.91	13.49	9,662	299	2.33	3.65	1.58	7.54	3.20	9.46	<	0.095	4.51
F411A	0.012	<0.2	12,093	3,192	575	2,785	264,503	40.24	12.04	18,381	678	1.83	2.87	1.28	9.73	2.17	33.61	<	0.060	6.41
F414A	0.028	0.3	11,077	7,783	463	3,606	226,500	16.45	11.87	9,470	297	2.26	3.73	1.68	8.01	3.23	9.13	<	0.097	4.64
M102A	0.057	0.8	10,723	19,905	478	3,755	165,929	30.05	22.86	18,523	310	5.25	8.10	3.68	17.41	6.44	12.95	<	0.080	7.86
M108A	0.040	0.5	8,094	15,282	641	3,004	200,830	46.76	14.85	27,023	349	5.90	6.58	2.78	15.11	5.31	32.33	<	0.045	7.19
M112A	0.094	2.0	12,099	27,504	476	5,593	143,878	39.55	19.41	23,520	313	6.18	10.65	5.31	25.35	8.69	18.61	0.50	0.066	11.26
M113A	0.057	1.0	11,159	25,001	480	3,764	155,619	31.89	17.43	24,531	373	7.48	9.54	4.18	22.25	7.26	13.56	<	0.070	8.61
M114A	0.092	1.3	12,923	36,897	471	4,242	128,274	44.28	18.54	26,577	289	7.77	13.73	5.65	26.83	10.91	11.27	0.38	0.057	10.80
M115A	0.073	1.1	11,086	27,078	405	4,928	151,724	32.86	18.49	20,690	313	6.50	9.87	4.89	19.43	7.67	13.74	<	0.075	8.99
M122AT1D	0.061	1.2	12,460	27,067	445	5,394	155,463	37.49	19.17	23,717	300	6.77	10.59	4.57	21.80	8.60	15.40	0.34	0.067	10.14
M122AT1U	0.081	1.1	13,354	35,010	493	4,503	142,964	43.22	20.07	25,908	300	7.18	12.92	5.82	24.47	10.45	14.39	0.40	0.062	10.83
M122AT2	0.086	1.3	13,195	32,562	445	4,609	140,825	41.93	21.79	25,564	298	7.47	12.62	5.48	23.88	9.76	15.05	0.40	0.060	10.73
M122AT3	0.083	1.1	13,251	37,110	475	4,318	134,999	44.89	16.85	26,853	289	7.65	13.70	6.01	26.62	11.01	12.28	0.39	0.058	10.77
M123A	0.089	1.0	13,002	38,420	480	4,618	143,654	46.08	26.05	27,104	312	8.08	14.43	6.38	28.13	11.31	11.96	0.40	0.066	10.66
M124A	0.079	0.9	13,636	31,279	476	4,348	166,092	39.44	15.96	23,152	288	6.51	11.71	5.00	22.07	9.36	12.15	0.34	0.071	9.79
M125A	0.031	0.4	8,279	11,700	563	3,123	180,326	39.88	12.23	24,763	331	6.50	5.57	2.29	13.79	4.52	29.98	<	0.036	5.83
M126A	0.039	0.5	10,566	15,978	460	3,427	173,854	26.96	14.09	16,099	296	4.52	6.55	3.02	14.67	5.25	12.80	<	0.077	6.63
M131A	0.097	1.4	14,241	40,671	472	4,673	131,883	48.94	19.64	27,807	295	7.86	14.89	6.55	27.12	11.86	14.25	0.45	0.056	11.77
M132A	0.084	1.1	13,766	40,134	507	4,624	165,156	48.31	23.27	26,814	318	7.66	14.87	6.71	28.34	11.62	11.58	0.42	0.075	10.57
M1336A	0.044	0.4	9,714	15,297	415	3,522	171,157	27.12	15.47	16,807	275	3.42	7.28	6.41	71.87	5.68	11.23	0.36	0.467	11.74
M133A	0.061	0.8	11,955	22,866	475	3,842	174,795	33.55	15.28	18,993	319	5.29	8.98	4.22	17.78	7.02	13.33	<	0.076	8.37
M1359A	0.054	0.5	12,763	18,573	496	3,912	224,577	28.84	15.59	16,365	335	4.08	7.54	5.19	25.65	6.05	10.82	0.30	0.157	7.92
M135A	0.096	1.2	11,226	33,911	506	3,088	130,730	42.27	23.99	23,583	388	6.50	12.46	5.80	24.78	9.79	13.76	<	0.070	10.98
M1384A	0.031	0.2	8,060	8,267	423	3,301	185,289	21.19	12.22	13,968	260	2.83	4.88	5.18	18.03	3.64	12.53	0.30	0.077	5.63
M139A	0.039	0.6	6,852	16,049	258	2,036	92,896	27.00	12.81	13,589	139	3.27	6.10	2.67	12.02	5.24	9.46	0.27	0.032	5.96
M1411A	0.030	0.2	8,631	8,640	387	3,479	160,629	23.25	15.92	17,231	284	2.99	5.92	10.45	30.69	4.12	12.44	0.44	0.162	6.96
M1429A	0.035	0.3	10,387	10,477	439	3,863	199,196	21.98	16.27	13,785	318	3.15	5.25	3.67	21.64	4.25	11.84	0.26	0.129	6.14
M143A	0.090	1.2	12,036	37,480	647	4,282	132,462	59.36	22.84	34,278	338	8.34	14.11	6.25	27.88	11.14	25.88	0.69	0.055	10.95
M1446A	0.040	0.4	8,508	13,087	403	4,267	164,657	23.11	13.38	13,863	222	2.65	5.54	4.65	26.72	5.13	9.73	0.34	0.118	8.97
M1447A	0.027	0.3	4,127	12,236	283	2,778	58,514	31.89	14.37	21,661	146	2.66	6.24	8.05	27.76	5.28	10.13	0.59	0.053	21.52
M144A	0.107	1.3	15,851	50,173	483	4,582	113,436	55.81	23.16	30,578	287	8.71	18.22	7.87	31.70	14.22	11.25	0.51	0.058	13.28
M1465A	0.040	0.8	6,298	16,904	385	4,148	94,935	27.80	14.40	17,900	176	4.40	6.78	5.27	25.19	5.61	12.31	0.40	0.048	8.09
M1466A	0.055	0.7	12,367	18,034	629	3,649	195,378	29.29	17.75	20,951	352	5.47	7.34	4.56	31.18	5.91	16.40	0.38	0.100	9.10

	TKN	TOC	Mg	Al	P	S	Ca	V	Cr	Fe	Mn	Co	Ni	Cu	Zn	Ga	As	Mo	Cd	Pb
Sample Na	**%**	**%**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
M1467A	0.052	0.5	12,155	17,789	531	3,659	199,343	29.09	16.19	21,585	376	6.01	7.46	3.94	27.77	5.97	16.33	0.29	0.090	8.38
M146AT1D	0.049	0.6	10,780	18,476	498	3,929	197,801	34.22	14.40	18,826	296	4.90	7.46	3.62	15.31	5.89	17.51	<	0.070	7.74
M146AT1U	0.056	0.7	11,815	23,161	640	3,942	180,272	36.82	15.11	20,546	324	5.51	8.99	4.39	19.48	7.24	16.34	<	0.078	8.71
M146AT2	0.040	0.5	10,269	14,678	552	3,819	227,826	35.91	13.04	20,046	333	4.79	6.26	2.92	13.19	4.98	23.22	<	0.066	6.63
M146AT3	0.046	0.6	9,701	16,722	566	3,857	214,675	39.52	13.78	21,403	328	5.11	6.93	3.18	13.97	5.46	25.36	<	0.059	7.30
M1477A	0.048	0.7	9,413	12,934	414	3,756	151,551	26.34	17.03	21,507	321	5.36	5.85	3.80	29.58	4.64	17.99	0.47	0.063	8.35
M1479A	0.048	0.5	10,814	15,191	573	3,424	191,513	26.13	17.24	20,005	359	5.58	6.52	3.27	25.88	5.27	16.23	0.28	0.089	7.34
M147A	0.062	0.8	11,630	24,384	451	4,149	159,883	33.57	15.11	18,906	287	5.13	9.18	4.09	18.60	7.56	11.36	<	0.082	8.46
M1486A	0.064	1.1	7,686	33,752	331	4,564	73,717	44.95	18.92	25,685	165	5.64	12.37	15.96	65.88	10.20	12.86	0.62	0.081	15.80
M1487A	0.039	0.5	11,126	11,754	538	3,572	184,756	26.27	17.05	22,172	393	5.69	5.65	3.05	30.77	4.59	19.44	0.40	0.077	7.76
M1488A	0.053	0.6	11,743	15,631	502	4,154	187,324	26.25	17.34	20,769	354	5.73	6.68	3.83	27.89	5.38	16.36	0.36	0.093	8.01
M1489A	0.054	0.9	10,338	15,883	432	5,002	175,896	23.21	17.67	19,182	327	5.80	6.78	4.54	29.97	5.72	17.02	0.26	0.098	9.20
M1493A	0.041	0.6	5,367	20,475	393	2,831	63,597	61.83	22.20	41,604	135	4.14	8.71	12.73	47.89	7.33	23.63	3.14	0.057	12.74
M1494A	0.042	0.7	10,359	9,076	528	4,145	193,833	20.29	15.85	19,953	379	5.85	4.99	2.57	29.45	4.00	18.26	0.52	0.093	7.03
M1498A	0.042	0.8	5,939	20,351	424	3,675	72,774	46.98	17.61	27,852	166	4.28	7.51	8.58	38.53	6.74	18.98	1.05	0.052	10.62
M1511A	0.102	1.6	10,611	49,264	355	5,111	73,133	53.39	19.70	28,735	163	7.10	15.98	18.89	69.36	13.47	15.03	0.71	0.089	22.85
M1515A	0.033	0.2	12,400	8,857	467	3,166	247,814	19.49	13.81	11,027	321	2.50	4.10	2.03	9.36	3.47	11.10	<	0.095	5.20
M151A	0.067	1.0	12,985	28,841	483	4,235	160,887	39.12	21.31	22,081	264	5.60	10.83	4.65	21.02	8.91	13.91	0.36	0.064	9.60
M1528A	0.043	0.3	12,590	12,415	490	3,012	239,214	22.89	14.71	12,904	334	3.04	5.39	2.98	10.84	4.40	10.78	<	0.096	6.09
M1529A	0.034	0.2	11,536	8,261	461	2,970	244,065	18.61	11.34	10,687	295	2.41	4.14	1.79	9.04	3.45	9.54	0.39	0.098	4.86
M1538A	0.050	0.4	13,234	17,853	496	3,329	233,158	26.97	16.63	14,612	320	3.60	7.05	3.02	13.42	5.53	10.01	0.26	0.096	6.40
M1539A	0.032	0.2	12,253	7,077	518	4,213	270,237	19.56	13.70	11,626	372	2.60	4.04	1.81	11.85	3.24	13.96	0.21	0.101	5.27
M1545A	0.037	0.3	13,251	10,671	489	3,312	262,366	20.20	13.69	11,643	332	2.72	4.76	1.96	9.83	3.80	10.68	<	0.105	5.22
M157A	0.061	0.9	12,163	25,738	490	3,822	165,058	34.94	17.60	19,368	305	5.45	9.80	4.66	19.23	7.81	11.13	<	0.084	8.89
M1615A	0.031	<0.2	15,421	4,795	706	5,576	345,554	28.07	9.90	13,259	700	2.50	3.16	1.10	6.20	2.80	34.17	0.28	0.070	5.44
M161A	0.093	1.5	10,368	40,481	337	4,481	93,485	42.03	27.32	22,437	166	6.61	13.31	6.01	24.07	10.54	11.87	<	0.057	11.00
M1628A	0.040	0.3	14,114	9,349	610	5,117	299,921	28.27	14.18	13,450	566	2.54	4.62	2.16	12.06	3.83	22.27	0.45	0.086	5.68
M162A	0.065	1.1	12,350	26,035	471	4,726	163,601	36.73	20.73	20,574	253	5.23	9.79	4.26	18.59	8.08	13.19	0.37	0.062	8.96
M163A	0.075	1.0	11,707	26,926	451	4,037	169,416	36.73	18.69	21,086	287	5.49	10.28	4.70	20.09	8.37	13.43	0.36	0.074	8.72
M168A	0.040	0.5	11,685	15,930	508	3,638	185,644	25.18	14.25	16,654	361	4.80	6.60	2.92	15.15	5.37	12.72	<	0.083	6.49
M173A	0.067	0.9	9,557	27,271	370	3,809	106,032	38.72	24.28	21,307	160	5.18	10.11	4.30	18.13	8.34	15.64	0.44	0.043	8.91
M174AT1D	0.039	0.6	9,533	20,804	518	3,991	143,183	78.21	45.23	41,751	221	4.60	8.25	3.51	15.43	8.58	30.84	1.29	0.058	10.38
M174AT1U	0.051	0.7	10,874	21,814	473	3,310	156,575	47.69	25.28	25,433	230	4.61	8.52	3.46	15.45	7.15	17.77	0.73	0.057	7.95
M174AT2	0.061	0.8	10,452	24,022	470	3,311	151,419	48.12	21.06	26,273	215	4.88	9.02	3.90	16.69	7.56	19.86	0.65	0.054	8.51
M174AT3	0.053	0.6	9,123	19,404	464	3,004	143,137	54.60	26.94	28,051	222	4.45	8.41	3.45	14.77	6.78	18.58	0.77	0.056	7.91
M175A	0.069	0.9	13,585	30,016	465	4,168	173,171	39.41	21.39	21,890	270	5.73	11.09	4.60	21.04	9.24	11.94	0.34	0.067	9.63
M17A	0.032	0.6	3,075	14,972	329	2,046	22,176	32.90	14.15	18,573	97	3.50	5.27	2.69	10.74	4.13	15.34	<	0.018	4.91
M181A	0.052	0.9	11,803	19,389	457	4,146	169,233	28.42	16.13	18,864	333	5.64	7.87	3.56	18.08	6.36	12.02	<	0.081	7.57
M182A	0.052	0.8	10,394	19,178	489	3,942	154,650	28.07	15.10	19,904	330	5.93	7.75	3.28	18.53	6.39	13.93	<	0.073	7.72
M186A	0.075	1.4	8,299	33,022	236	4,900	70,177	33.63	23.26	18,317	128	5.36	10.97	5.16	20.17	8.44	11.26	<	0.049	9.23
M187A	0.048	0.8	8,766	20,625	380	3,020	111,540	35.77	18.97	20,324	186	4.21	7.83	3.32	14.38	6.72	15.73	0.43	0.039	7.09
M188A	0.076	1.1	14,642	34,162	511	4,387	167,272	44.30	26.01	24,338	270	6.31	12.23	5.10	22.29	10.10	13.07	0.40	0.068	10.15
M189A	0.073	1.0	12,913	39,092	397	4,148	141,613	42.05	20.95	22,515	262	6.58	12.85	5.57	24.05	10.20	11.20	<	0.084	10.66
M18A	0.078	1.3	7,944	29,586	308	3,786	79,607	37.48	22.66	20,395	201	6.05	11.05	5.23	21.92	8.82	11.71	0.50	0.045	8.98
M195A	0.104	1.8	9,630	36,979	319	6,810	60,731	41.15	23.83	23,011	174	6.84	13.40	6.96	28.97	10.83	13.97	<	0.063	12.38
M197A	0.056	0.9	8,404	33,342	338	4,032	62,157	50.46	23.85	30,081	119	5.48	12.05	5.79	21.02	9.85	14.98	1.56	0.028	11.78
M223A	0.089	1.0	13,008	38,701	473	3,866	145,071	43.12	24.10	23,434	314	6.63	12.94	5.91	23.70	9.97	12.52	<	0.075	10.04
M224A	0.065	0.8	10,979	29,281	454	3,771	177,135	40.39	15.16	22,901	285	5.50	10.14	4.63	21.31	7.87	16.16	<	0.063	8.89
M226A	0.036	0.3	12,616	9,879	495	3,156	223,967	20.86	13.45	13,110	334	3.25	4.45	1.80	11.44	3.66	13.75	<	0.092	5.39
M227A	0.034	0.3	11,911	8,929	472	3,915	233,494	18.72	15.80	11,800	335	3.13	4.13	1.73	10.85	3.67	12.89	<	0.093	5.42
M241A	0.077	1.1	12,925	38,412	419	3,852	144,251	41.95	22.04	23,267	296	6.80	12.94	5.71	24.51	9.91	11.09	<	0.073	10.19
M242A	0.028	0.2	5,807	6,958	489	3,071	231,073	40.66	15.42	20,933	238	3.07	3.64	1.90	7.77	3.29	30.62	0.55	0.033	4.82
M243A	0.039	0.3	11,761	11,907	471	3,796	224,273	24.03	15.15	14,427	344	3.65	5.43	2.46	12.97	4.47	12.71	0.24	0.089	5.66
M244A	0.046	0.4	13,309	12,972	488	4,201	227,295	21.93	12.64	13,701	321	3.47	5.25	2.28	12.23	4.37	13.96	0.23	0.094	6.00
M255A	0.039	0.5	9,468	15,834	594	3,276	236,416	42.09	14.24	21,354	322	4.08	5.90	2.44	11.29	4.85	27.49	<	0.055	6.07
M256A	0.033	0.4	9,039	14,114	494	2,886	191,693	33.48	13.69	21,650	322	5.50	5.76	2.39	14.41	4.72	22.22	<	0.048	6.43
M25A	0.149	2.8	13,166	67,026	432	7,433	50,803	63.60	29.21	34,214	244	10.73	20.81	9.89	38.81	16.56	17.06	<	0.068	16.83
M265A	0.035	0.4	5,185	13,465	230	2,690	90,689	23.44	12.77	12,301	98	2.36	4.95	2.38	9.05	4.32	10.25	0.36	0.025	4.97
M26A	0.086	1.3	10,553	40,698	340	4,019	80,202	42.20	15.09	24,001	240	7.84	13.65	6.51	27.95	10.61	11.30	<	0.054	11.22

	TKN	TOC	Mg	Al	P	S	Ca	V	Cr	Fe	Mn	Co	Ni	Cu	Zn	Ga	As	Mo	Cd	Pb
Sample Na	%	%	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
M276A	0.037	0.3	7,898	11,979	291	3,177	127,322	16.49	11.47	10,100	166	2.58	4.79	2.19	11.00	4.16	7.34	<	0.049	4.98
M27A	0.135	2.3	12,309	59,887	333	3,205	59,543	56.19	21.69	29,910	340	9.82	19.23	9.21	36.78	15.01	15.69	<	0.057	15.32
M287A	0.049	0.5	9,569	17,463	374	3,473	150,805	23.69	15.31	13,619	205	3.59	6.57	2.80	13.41	5.75	10.14	0.23	0.059	6.51
M288AT1	0.048	0.4	8,242	14,274	307	2,654	144,266	20.03	11.84	11,503	172	2.89	5.47	2.41	11.24	4.60	8.33	0.21	0.053	5.24
M288AT2D	0.041	0.5	8,027	16,030	288	3,526	134,540	21.63	12.08	12,169	162	3.14	5.94	2.74	13.93	4.96	8.89	0.23	0.053	5.49
M288AT2U	0.042	0.4	7,624	13,034	293	2,808	135,860	18.59	10.82	10,731	170	2.66	4.93	2.36	10.46	4.34	8.05	<	0.043	4.96
M288AT3	0.035	0.4	7,957	11,260	295	3,082	148,486	17.27	12.00	10,270	172	2.49	4.44	1.95	10.16	3.92	8.74	<	0.052	4.65
M289A	0.040	0.5	8,356	16,754	513	3,095	219,565	43.99	13.01	19,577	225	3.63	5.98	2.53	10.17	4.83	25.99	<	0.049	5.62
M28A	0.127	2.7	10,693	54,104	213	8,421	38,520	41.81	22.35	23,284	211	9.08	17.37	8.42	33.77	13.51	13.82	<	0.064	15.01
M296A	0.061	0.6	9,678	22,337	348	3,132	126,130	27.21	14.23	14,910	168	3.91	8.12	3.53	15.31	6.65	7.76	0.23	0.052	6.94
M29A	0.066	1.2	7,822	28,391	309	4,294	78,076	33.74	17.30	19,248	185	6.07	10.00	4.99	21.32	7.85	12.26	<	0.054	9.09
M328A	0.048	0.5	9,225	17,867	329	2,965	136,271	23.29	11.31	13,001	169	3.23	6.62	3.07	13.52	5.42	7.12	0.31	0.058	6.07
M333A	0.048	0.5	5,576	15,475	303	1,952	69,498	38.06	13.81	20,255	100	2.86	5.68	2.47	9.89	4.78	13.00	0.56	0.027	5.89
M334AT1D	0.036	0.4	12,329	9,306	530	4,699	225,130	21.24	12.91	12,526	324	2.83	4.32	1.75	8.76	3.90	12.61	0.22	0.090	5.10
M334AT1U	0.037	0.3	12,592	8,013	469	3,833	221,976	19.98	11.35	12,079	336	2.70	3.89	1.62	8.22	3.53	12.52	<	0.088	4.95
M334AT2	0.045	0.4	12,246	10,818	479	3,883	221,319	22.44	13.36	13,014	321	2.98	4.78	2.02	9.46	4.24	12.29	0.23	0.088	5.34
M334AT3	0.040	0.4	12,440	9,016	508	4,274	219,158	20.55	13.82	12,287	318	2.75	4.11	1.78	8.63	3.70	12.39	0.20	0.090	5.52
M341A	0.063	0.8	11,775	18,374	436	5,478	189,356	28.02	14.46	16,963	261	3.88	7.31	3.58	14.69	6.23	12.95	0.34	0.080	7.56
M343A	0.040	0.5	12,935	10,475	541	4,908	216,843	22.88	13.03	14,101	345	3.14	4.74	2.03	9.47	4.09	15.41	0.29	0.085	5.60
M344A	0.033	0.3	10,871	7,842	476	3,115	198,360	22.36	14.32	12,735	323	2.71	3.87	1.47	8.63	3.42	13.24	0.20	0.077	4.75
M345A	0.039	0.3	13,542	9,890	519	3,920	234,715	20.66	10.70	13,159	374	2.95	4.52	1.87	9.40	3.85	13.34	<	0.090	5.25
M346A	0.064	0.6	13,211	27,080	568	4,115	205,434	41.38	16.10	23,045	331	5.91	10.42	6.04	24.72	8.33	13.77	0.38	0.084	8.94
M347AT1D	0.058	0.6	12,722	24,222	538	3,997	206,187	38.56	19.25	22,237	329	5.70	9.48	5.49	24.46	7.62	14.96	0.37	0.095	8.83
M347AT1U	0.055	0.5	12,718	21,351	580	3,889	222,356	36.23	17.65	21,168	344	5.32	8.58	4.68	21.98	6.83	15.51	0.35	0.092	7.79
M347AT2	0.059	0.7	12,648	24,660	576	3,808	199,620	39.02	15.84	22,475	336	5.72	9.60	5.37	24.01	7.71	15.08	0.37	0.084	8.59
M347AT3	0.056	0.6	12,452	21,777	627	3,908	212,393	36.58	15.89	21,369	354	5.52	8.61	5.13	23.14	7.03	15.83	0.36	0.090	8.17
M348A	0.060	0.7	12,385	22,921	536	3,781	202,486	35.46	15.75	20,772	325	5.32	8.91	5.40	24.51	7.29	15.00	0.34	0.094	8.48
M353A	0.046	0.5	8,992	14,573	380	3,043	151,979	23.14	10.89	15,097	228	3.35	6.06	3.26	12.15	5.41	10.11	0.23	0.059	6.50
M355A	0.048	0.6	11,451	14,379	458	3,711	179,961	25.67	12.51	15,316	292	3.51	6.03	2.59	11.48	5.23	12.33	0.25	0.072	6.04
M356A	0.062	0.7	13,632	22,462	487	4,093	204,218	32.58	17.72	17,994	297	4.45	8.78	3.89	15.82	6.90	11.48	0.29	0.084	7.62
M357A	0.048	0.5	10,552	17,123	467	4,472	197,612	28.89	16.52	17,143	285	4.03	7.91	5.90	44.96	6.14	11.87	0.38	0.251	8.92
M367A	0.041	0.4	10,371	14,820	403	3,534	184,266	28.65	14.41	14,763	226	3.02	5.80	2.58	10.80	4.99	11.03	0.31	0.069	5.80
M368A	0.060	0.6	13,247	22,055	475	4,021	202,591	32.34	14.01	18,041	291	4.34	8.44	3.62	14.82	6.89	10.70	0.31	0.079	7.35
M36A	0.049	0.8	6,998	22,827	297	2,876	74,202	30.77	15.43	17,086	191	4.97	8.16	4.22	17.36	7.00	11.27	<	0.045	7.64
M378A	0.029	0.2	6,423	9,263	235	2,105	116,088	42.15	14.06	17,183	116	1.78	4.06	1.73	8.77	3.44	12.98	0.36	0.030	4.31
M40A	0.122	1.8	10,790	47,886	353	5,101	68,105	45.88	19.35	25,683	212	8.17	15.51	7.41	31.37	12.28	13.95	<	0.058	13.00
M41A	0.103	1.4	9,529	50,246	386	4,935	45,676	55.83	35.50	31,881	203	9.01	17.69	8.62	36.14	14.38	14.28	0.72	0.043	13.33
M44A	0.021	0.3	3,194	9,235	169	1,378	30,957	19.07	10.26	10,195	164	2.75	3.97	2.30	9.41	2.89	8.99	<	0.019	4.22
M45A	0.040	0.5	5,871	14,708	269	2,704	78,864	26.03	17.51	15,176	243	3.94	6.66	3.47	15.32	5.09	10.54	0.31	0.037	5.89
M46A	0.006	<0.2	1,134	2,164	87	<	6,109	11.82	8.34	5,895	114	1.33	1.53	1.07	4.57	1.17	5.86	<	0.006	1.82
M47A	0.037	0.5	3,904	15,774	184	1,687	22,338	26.39	16.54	14,131	195	3.81	6.11	3.53	15.78	5.28	8.85	<	0.023	6.49
M48A	0.158	2.7	13,953	78,606	394	6,372	26,041	65.71	33.67	35,521	199	11.54	23.12	10.84	42.71	18.60	13.20	<	0.054	17.40
M49A	0.173	2.8	13,194	87,426	520	4,266	8,849	76.86	39.82	42,507	362	12.21	24.94	11.37	46.34	20.58	21.36	2.14	0.042	19.17
M4A	0.081	1.7	8,286	40,095	1,038	4,909	53,557	110.48	26.38	75,515	311	12.54	15.53	8.77	25.92	11.03	75.08	3.78	0.041	14.10
M53A	0.034	0.6	6,522	15,555	347	2,803	85,992	34.30	14.13	18,639	336	4.55	6.58	3.49	14.85	4.92	18.40	<	0.038	6.62
M54A	0.031	0.4	5,507	13,526	301	2,629	73,005	29.70	18.65	16,551	313	4.06	6.47	3.40	14.58	4.84	13.28	0.34	0.034	5.66
M55A	0.061	0.9	9,604	22,340	415	4,300	140,375	34.14	24.01	20,263	288	5.65	9.38	4.78	21.30	7.35	12.67	0.43	0.069	10.11
M56A	0.053	0.7	7,051	22,560	313	2,446	74,844	32.71	14.90	17,958	180	4.80	8.60	4.49	19.52	6.70	10.65	0.34	0.036	8.16
M57A	0.026	0.4	3,449	11,655	186	1,904	31,953	24.04	16.87	12,981	184	3.35	5.32	3.05	12.84	4.23	8.55	0.28	0.020	4.75
M58A	0.080	1.1	8,593	35,146	413	3,731	86,747	50.55	19.55	29,099	253	7.86	13.20	6.14	29.05	10.83	17.71	0.63	0.046	10.74
M59A	0.129	2.1	11,540	62,152	402	7,098	41,714	58.18	28.79	33,150	260	10.19	18.99	9.14	37.34	15.35	18.48	<	0.050	15.58
M62A	0.077	1.1	8,655	39,940	341	4,012	58,064	45.29	23.82	25,708	210	8.12	14.11	6.60	29.35	11.75	11.97	0.47	0.035	10.92
M63A	0.133	2.1	12,001	64,117	352	6,001	24,319	60.46	35.92	32,920	192	10.89	21.73	9.73	42.01	17.78	15.88	0.78	0.050	16.72
M70AT1D	0.142	2.3	13,720	71,469	291	4,426	31,221	60.05	20.76	34,261	232	11.88	23.98	10.37	45.17	19.72	14.71	0.75	0.047	17.97
M70AT1U	0.149	2.4	13,165	78,809	382	4,296	26,784	64.71	33.57	35,445	269	11.53	23.05	10.61	44.26	18.79	16.44	<	0.045	17.33
M70AT2	0.150	2.4	13,547	72,845	398	5,258	30,301	67.52	25.92	37,259	260	12.00	24.38	10.62	46.37	20.17	17.38	0.89	0.046	18.08
M70AT3	0.157	2.5	12,350	72,484	414	5,939	26,706	62.72	36.82	34,807	258	10.89	21.86	10.47	42.03	17.66	18.60	<	0.046	17.38
M79A	0.170	2.8	13,520	73,402	449	4,545	35,067	70.75	30.94	39,418	359	11.95	24.48	11.21	47.00	19.90	19.52	0.93	0.048	18.34
M7A	0.129	2.3	10,452	47,801	298	6,539	66,702	44.91	21.63	23,939	161	8.59	15.56	7.42	31.14	12.29	14.28	<	0.058	13.37
M80A	0.138	2.3	12,870	63,402	266	3,767	43,617	56.69	25.00	30,997	245	11.16	21.74	9.97	41.22	17.60	13.90	0.70	0.047	16.44

Sample	TKN %	TOC %	Mg mg/kg	Al mg/kg	P mg/kg	S mg/kg	Ca mg/kg	V mg/kg	Cr mg/kg	Fe mg/kg	Mn mg/kg	Co mg/kg	Ni mg/kg	Cu mg/kg	Zn mg/kg	Ga mg/kg	As mg/kg	Mo mg/kg	Cd mg/kg	Pb mg/kg
M87A	0.186	2.8	15,129	83,761	531	3,283	15,051	81.69	42.64	44,370	514	12.65	26.72	11.34	49.57	22.05	21.03	1.13	0.026	20.88
M93A	0.061	0.9	10,717	27,934	496	3,846	153,253	42.93	15.86	24,165	272	6.42	10.49	5.05	21.56	8.38	16.19	<	0.065	9.44
M94A	0.066	1.0	10,727	24,773	454	5,146	139,594	33.39	20.50	23,272	317	7.33	9.81	4.11	22.56	7.90	15.52	<	0.067	9.01
M97A	0.050	0.7	11,267	21,361	457	3,771	163,426	30.82	14.94	18,473	295	5.28	8.34	4.02	17.18	6.77	11.87	<	0.077	7.72
M98A	0.046	0.7	10,894	18,627	469	3,820	160,156	28.80	14.03	19,653	321	5.72	7.62	3.15	18.16	6.32	13.52	<	0.077	7.36
MC1-1A	0.050	0.9	2,444	45,553	188	<	1,097	95.37	40.03	44,587	241	8.56	16.56	16.89	33.43	14.45	29.05	3.84	0.029	19.21
MC1-2A	0.017	0.4	1,047	17,494	98	<	1,941	48.23	17.95	23,000	43	2.24	5.35	7.52	13.54	6.04	14.35	1.91	0.014	9.07
MC1-3A	0.110	2.0	3,217	59,383	251	<	1,831	59.24	21.90	24,573	95	4.78	14.03	14.50	43.20	17.02	11.00	1.33	0.026	13.95
MC2-1A	0.056	1.5	3,907	24,462	61	3,228	1,099	107.03	23.44	39,202	33	6.97	10.07	7.23	18.05	8.52	26.70	16.15	0.039	10.10
MC2-2A	0.060	1.7	3,581	26,852	65	4,055	1,208	90.65	25.57	39,176	30	6.83	10.03	6.89	16.73	8.83	27.93	16.53	0.030	9.59
MC2-3A	0.066	2.1	3,648	30,925	103	2,079	1,113	106.54	33.13	32,549	33	3.83	9.24	7.80	17.61	10.00	19.61	11.15	0.029	8.73
MC3-1A	0.023	0.5	1,681	14,963	93	1,305	483	63.46	17.86	30,769	59	3.98	9.40	8.35	22.20	5.95	28.76	7.42	0.021	10.76
MC3-2A	0.029	0.7	1,806	11,353	65	1,539	501	38.99	14.01	16,489	35	2.66	6.98	7.55	18.04	4.84	15.19	4.31	0.015	9.17
MC3-3A	0.031	0.8	2,013	11,669	65	1,811	455	35.00	13.31	14,904	29	2.31	10.16	7.44	15.40	5.07	13.12	3.82	0.019	6.12
MC4-1A	0.086	2.0	3,507	29,528	174	2,431	1,395	47.15	15.80	21,883	124	5.91	10.15	7.72	20.11	9.41	16.64	2.86	0.019	8.83
MC4-2A	0.067	1.3	3,463	30,996	171	2,381	1,113	55.87	14.43	25,879	87	7.00	11.52	8.52	22.87	10.16	20.60	3.89	0.022	9.88
MC4-3A	0.078	1.3	3,659	32,052	175	2,385	1,173	57.64	12.26	29,259	146	8.79	12.75	9.62	23.66	11.12	25.73	4.76	0.023	10.18
MC5-1A	0.024	0.6	2,944	19,752	169	1,954	747	150.59	25.64	#####	102	5.84	13.92	23.10	43.39	12.00	116.62	42.58	0.050	21.71
MC5-2A	0.033	0.8	2,598	21,427	163	1,706	688	134.78	20.55	80,405	57	5.14	12.86	20.23	39.37	11.90	81.66	36.61	0.050	15.88
MC5-3A	0.027	0.6	2,465	20,903	162	1,521	581	136.70	19.56	86,024	63	5.42	12.87	19.30	37.67	11.96	80.98	35.33	0.048	14.26
MC6-1A	0.056	1.2	2,844	25,279	265	1,831	858	98.54	26.98	58,145	171	8.60	13.02	10.36	30.70	9.33	25.99	11.56	0.034	16.29
MC6-2A	0.036	0.6	1,578	12,176	155	1,649	547	72.41	29.59	36,888	50	4.59	7.56	7.55	24.69	5.52	16.07	9.12	0.022	8.63
MC6-3A	0.073	1.3	3,360	34,884	278	2,611	1,126	120.20	36.06	66,691	95	8.33	15.80	15.57	43.97	12.91	28.07	12.94	0.056	20.31
MC7-1A	0.036	0.8	2,077	16,085	149	2,055	699	74.63	31.26	43,080	40	5.22	7.42	10.64	13.13	6.84	19.74	11.45	0.020	13.06
MC7-2A	0.055	1.1	1,811	14,462	158	2,154	753	64.84	26.93	44,505	48	5.66	6.58	11.09	15.38	5.94	20.02	12.29	0.018	12.53
MC7-3A	0.056	1.1	2,024	15,093	140	1,921	724	52.60	19.84	30,826	34	4.02	6.11	7.42	12.18	5.70	15.09	9.20	0.017	10.02
MC8-1A	0.014	0.3	1,791	8,248	60	1,729	345	36.41	14.20	20,140	45	6.77	6.26	6.70	17.55	3.63	14.05	7.90	0.018	10.22
MC8-2A	0.021	0.4	1,410	12,004	95	1,325	404	42.47	15.95	32,762	57	8.47	7.93	9.04	22.39	4.93	26.80	13.77	0.020	14.68
MC8-3A	0.029	0.6	1,439	12,571	73	1,384	420	36.57	14.39	17,335	34	4.74	6.35	7.93	14.67	4.76	11.48	6.91	0.014	9.40
RW1-1A	0.167	3.1	6,742	51,418	276	2,234	2,689	78.04	20.15	32,242	89	6.83	16.59	8.32	41.25	14.89	15.03	4.12	0.021	19.53
RW1-2A	0.121	3.4	7,688	57,572	326	3,337	3,045	83.09	20.21	38,691	107	7.56	17.93	8.14	43.31	16.01	19.78	5.40	0.020	20.61
RW1-3A	0.191	3.7	6,956	52,653	289	2,466	2,871	85.08	21.08	37,592	102	6.85	15.97	8.00	42.47	14.90	20.69	11.31	0.026	18.39
RW2-1A	0.096	2.1	3,644	28,064	138	2,284	1,305	39.19	16.91	17,883	40	3.39	7.93	4.46	21.98	8.33	9.90	3.21	0.019	10.35
RW2-2A	0.105	2.2	3,771	27,812	115	2,159	1,428	37.79	16.46	15,843	43	3.41	8.14	4.66	23.85	8.35	8.40	2.01	0.020	11.26
RW2-3A	0.093	2.2	3,459	28,506	132	2,181	1,305	39.92	18.26	18,165	54	3.87	8.12	5.06	27.24	8.59	9.33	2.46	0.026	11.44
RW3-1A	0.104	2.6	3,122	19,902	116	2,681	1,244	29.55	15.40	13,798	31	2.55	5.63	4.16	18.24	6.37	7.78	2.25	0.018	8.83
RW3-2A	0.122	3.0	4,120	27,762	89	2,265	1,716	36.84	15.81	15,911	39	4.47	8.30	5.21	27.79	8.77	8.20	2.36	0.029	11.67
RW3-3A	0.156	3.6	4,353	35,398	95	3,420	2,058	35.12	15.72	16,296	51	5.77	10.40	7.24	38.66	10.86	9.11	1.98	0.053	15.74
RW4-1A	0.072	1.3	1,092	17,186	115	1,120	613	29.99	14.75	10,922	26	1.39	4.51	5.32	58.54	5.24	4.80	1.31	0.047	15.32
RW4-2A	0.072	1.3	2,248	31,740	113	1,258	886	41.56	14.18	16,252	27	2.55	7.52	6.69	70.00	9.04	6.75	1.58	0.072	19.87
RW4-3A	0.072	1.6	2,385	27,985	152	2,255	1,111	40.52	15.93	16,224	30	2.68	7.04	7.11	90.55	8.24	8.41	1.60	0.120	22.66
RW5-1A	0.078	1.4	1,420	21,693	182	1,734	802	38.01	13.51	17,902	24	2.04	5.56	8.47	139.42	6.74	11.58	2.76	0.105	31.17
RW5-2A	0.065	1.4	1,397	24,856	157	1,519	773	38.41	14.49	20,176	25	1.86	5.73	7.83	127.51	7.30	9.49	3.10	0.088	25.08
RW5-3A	0.084	1.5	1,505	21,463	195	<	798	41.73	17.17	19,726	29	1.80	10.56	9.60	137.31	6.45	12.26	2.93	0.076	33.53
RW6-1A	0.110	2.3	1,206	26,474	240	1,166	1,074	48.02	21.41	22,368	39	2.19	7.62	16.16	189.80	7.96	8.95	2.24	0.100	50.39
RW6-2A	0.039	1.1	810	14,081	83	1,298	477	22.98	11.91	8,552	15	0.90	3.20	4.32	51.00	4.34	3.65	0.95	0.050	9.77
RW6-3A	0.096	1.9	1,904	21,857	112	1,193	995	30.15	12.89	12,163	22	1.55	7.72	8.56	91.16	6.49	5.70	1.34	0.097	26.40
RW7-1A	0.078	1.6	2,473	22,307	117	1,445	1,034	36.19	12.79	19,398	34	2.22	5.95	6.28	66.85	6.93	18.71	3.72	0.051	17.51
RW7-2A	0.092	2.1	2,897	26,923	154	2,039	1,128	41.40	12.08	25,443	33	2.32	6.48	4.97	44.97	7.96	11.39	5.63	0.040	13.64
RW7-3A	0.077	1.7	2,783	24,943	136	2,449	1,045	35.71	14.50	17,311	25	2.13	6.04	5.16	51.32	7.35	8.32	2.92	0.045	15.12
RW8-1A	0.089	2.5	2,613	24,841	73	1,852	1,155	30.96	12.57	11,956	23	2.47	6.40	5.84	49.62	7.06	6.43	1.63	0.072	16.98
RW8-2A	0.115	2.5	2,891	24,921	100	2,537	1,267	31.04	13.13	11,118	25	2.45	6.52	5.23	43.42	7.24	6.07	1.49	0.074	14.52
RW8-3A	0.111	3.1	2,825	21,383	147	3,258	1,322	36.22	12.97	17,230	35	2.27	5.55	5.80	47.05	6.56	8.09	2.10	0.044	14.23
RW9-1A	0.085	2.3	2,604	25,455	130	1,798	1,081	37.05	12.63	13,752	26	1.89	5.55	5.48	37.62	7.94	8.33	2.22	0.041	14.34
RW9-2A	0.065	1.6	1,841	19,286	126	1,600	812	33.28	12.01	15,292	32	1.71	4.46	5.14	56.17	6.20	8.22	2.55	0.033	13.44
RW9-3A	0.079	2.0	2,261	28,741	126	2,689	987	39.29	12.65	18,300	28	2.55	5.97	6.14	46.93	8.88	10.19	2.44	0.066	13.63
S100A	0.049	0.8	11,440	18,115	483	4,690	174,971	29.71	16.30	18,075	332	4.63	7.09	4.10	20.03	5.79	15.02	<	0.081	7.78
S101A	0.039	0.4	11,291	11,069	507	3,915	222,304	23.63	13.21	15,432	344	3.86	4.80	2.30	16.35	4.23	16.34	0.26	0.082	6.53
S103A	0.041	0.9	4,751	34,380	921	3,607	10,223	291.96	95.12	#####	268	12.33	23.22	18.56	37.56	17.19	52.08	5.63	0.039	30.59
S107A	0.043	0.6	10,859	17,655	484	3,687	172,768	29.46	17.45	17,346	309	4.59	7.09	4.18	18.59	5.82	13.75	<	0.082	7.84

	TKN	TOC	Mg	Al	P	S	Ca	V	Cr	Fe	Mn	Co	Ni	Cu	Zn	Ga	As	Mo	Cd	Pb
Sample	**%**	**%**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
S108A	0.024	0.3	2,897	3,880	404	3,518	120,541	15.47	8.56	9,431	147	1.61	1.93	1.46	5.89	2.60	11.38	0.51	0.013	3.40
S112A	0.047	0.5	12,106	18,991	591	3,317	183,456	36.63	15.24	21,324	348	5.12	7.76	4.68	21.18	6.18	17.96	<	0.102	8.42
S113A	0.041	0.5	11,992	17,701	529	3,798	195,658	31.07	17.20	18,334	330	4.75	6.96	3.91	19.66	5.54	15.45	<	0.099	7.18
S114A	0.034	0.5	11,066	15,523	448	3,607	185,831	25.64	13.90	16,451	348	4.59	6.06	3.40	19.42	4.91	15.39	<	0.096	6.91
S115A	0.031	0.4	8,754	10,994	434	3,393	148,430	21.71	12.20	14,322	287	3.93	4.83	2.74	15.88	4.17	14.18	<	0.071	5.96
S116A	0.040	0.5	12,823	12,296	505	4,414	220,813	22.92	12.67	15,162	363	3.83	5.37	3.16	20.37	4.57	14.60	<	0.109	7.21
S117A	0.073	1.1	9,885	26,845	422	5,098	131,559	37.57	16.40	21,516	249	5.69	9.92	5.68	27.04	8.18	14.35	<	0.068	10.72
S118A	0.058	0.8	12,074	21,252	479	3,350	174,504	31.84	16.41	18,104	313	4.80	8.21	4.82	22.35	6.79	12.40	<	0.096	9.03
S123A	0.050	0.6	11,711	19,706	485	3,590	183,616	30.02	14.06	18,795	361	5.09	7.32	4.10	23.25	5.85	19.09	<	0.101	7.96
S124A	0.041	0.5	8,665	10,840	339	2,913	134,852	18.71	11.85	11,760	243	3.18	4.60	2.88	14.43	3.77	9.98	<	0.071	5.74
S125A	0.038	0.5	10,507	13,506	463	4,554	181,563	23.98	16.55	15,754	319	4.20	5.88	3.36	19.77	5.38	15.33	<	0.101	7.55
S126A	0.046	0.7	9,762	13,084	376	5,023	143,400	22.02	16.32	14,769	286	4.06	5.76	3.37	20.43	4.65	16.24	<	0.093	8.02
S12AD	0.016	0.3	2,020	7,550	98	1,591	22,133	14.81	8.76	6,806	42	1.87	3.00	1.63	6.71	2.59	5.11	<	0.016	3.25
S12AT2	0.016	0.3	1,978	6,737	116	1,467	21,918	13.75	7.92	6,559	38	1.61	2.63	1.46	6.69	2.20	5.59	<	0.013	3.08
S12AT3	0.024	0.3	2,037	6,833	108	1,365	23,167	13.83	7.32	6,472	44	1.69	2.71	1.44	6.39	2.26	5.45	<	0.017	3.14
S12AU	0.021	0.3	2,549	7,664	159	1,655	28,019	26.38	9.32	13,350	52	2.64	2.98	2.82	6.35	3.65	8.29	<	0.017	3.73
S130A	0.056	1.0	11,292	19,270	487	4,333	158,742	31.83	15.59	22,093	339	5.90	8.14	5.70	34.29	6.36	16.08	<	0.096	10.02
S131A	0.035	0.4	12,653	14,796	466	3,496	210,277	24.57	15.05	17,817	396	5.18	6.11	3.42	23.18	4.88	14.76	<	0.107	7.53
S132A	0.038	0.4	12,178	14,601	512	3,782	201,957	26.46	16.04	19,145	365	5.36	6.50	3.64	23.31	5.39	15.81	0.24	0.093	7.57
S133AT1	0.036	0.4	10,078	12,062	465	4,091	169,906	22.29	14.55	17,236	329	4.86	5.53	2.87	21.69	4.52	17.54	<	0.083	7.14
S133AT2D	0.040	0.6	10,433	14,510	464	4,328	168,846	24.92	16.55	18,615	333	5.34	6.41	3.31	24.64	5.36	15.91	<	0.094	7.94
S133AT2U	0.036	0.5	10,060	13,173	454	3,799	171,455	23.17	16.52	17,427	322	4.91	5.83	3.03	22.03	4.92	15.52	<	0.080	7.29
S133AT3	0.045	0.7	10,728	15,615	453	4,335	161,354	25.75	16.78	18,072	322	5.03	6.70	3.71	24.44	5.55	15.48	<	0.094	8.17
S137A	0.037	0.5	12,209	56,624	493	4,578	67,904	64.11	19.47	35,059	243	8.75	19.15	18.83	72.48	15.94	18.07	<	0.078	25.76
S138A	0.044	0.6	11,188	13,635	492	4,475	167,970	24.56	15.33	19,780	352	5.68	6.46	3.33	26.21	5.23	16.36	<	0.090	7.83
S139A	0.097	1.9	11,495	40,152	410	9,829	97,433	43.70	18.62	28,660	244	8.24	14.93	8.96	44.58	11.96	22.72	<	0.110	18.56
S13A	0.021	0.4	1,966	6,003	87	2,676	24,054	9.39	6.55	4,978	42	1.68	2.46	1.36	5.51	2.06	5.53	<	0.109	3.17
S141A	0.116	2.0	10,584	12,280	467	3,474	167,054	23.59	14.76	17,941	337	5.00	5.67	3.03	24.64	4.48	15.03	<	0.092	7.25
S142A	0.131	2.3	13,497	62,624	489	9,671	57,632	64.49	21.95	34,634	240	9.71	21.12	15.42	58.83	16.96	15.22	<	0.067	22.09
S143A	0.135	2.2	11,892	52,488	428	5,279	63,431	59.11	26.08	31,549	226	8.49	17.99	13.26	57.57	14.62	16.83	<	0.083	21.08
S145A	0.159	2.5	12,526	68,896	480	3,480	35,006	74.58	32.82	38,921	309	10.09	22.31	17.70	79.36	18.58	19.44	2.60	0.067	26.75
S16A	0.133	2.1	12,052	53,281	382	5,376	73,404	56.30	20.50	29,588	186	8.89	17.85	9.54	37.52	14.53	16.66	0.74	0.052	15.90
S17A	0.025	0.5	2,161	9,688	196	1,189	12,068	27.06	12.64	12,727	98	2.61	4.00	2.93	9.14	3.45	9.43	<	0.014	4.46
S19A	0.156	3.1	12,097	50,766	484	8,332	59,668	61.84	32.47	32,439	190	9.65	17.96	9.65	38.44	14.21	19.82	<	0.156	17.43
S26A	0.038	0.6	5,362	13,255	262	3,810	96,465	20.91	14.46	14,540	243	4.54	5.59	2.87	15.37	4.74	13.66	<	0.037	6.43
S27A	0.040	0.7	9,431	15,500	483	4,495	149,501	25.94	20.75	23,762	355	7.52	7.22	3.02	22.64	5.80	16.72	<	0.070	7.75
S28A	0.139	2.2	12,791	46,037	461	7,535	73,540	52.28	27.75	31,437	251	8.93	16.56	8.53	35.85	13.11	19.42	<	0.062	16.19
S33A	0.055	1.3	4,858	15,550	206	4,718	44,392	18.82	12.74	12,028	100	3.92	6.35	3.87	15.02	5.05	12.39	<	0.034	6.91
S34A	0.028	0.8	10,766	26,150	503	3,948	161,163	36.17	16.89	22,456	265	6.79	9.87	5.01	23.36	8.21	13.20	<	0.089	9.32
S35A	0.053	0.7	11,107	20,848	495	3,843	159,804	31.37	20.52	22,710	346	6.90	8.61	4.12	21.42	6.84	14.32	<	0.069	8.32
S36A	0.043	0.6	11,490	19,126	517	4,532	181,306	28.96	15.57	20,688	331	6.08	7.79	3.70	20.38	6.39	14.52	<	0.086	8.12
S37A	0.049	0.7	11,177	17,202	505	4,758	178,077	26.86	16.71	18,256	319	5.12	7.02	3.66	18.51	5.87	13.80	<	0.084	7.83
S38A	0.065	1.1	10,933	22,755	441	6,038	144,484	31.46	16.86	21,240	309	6.03	9.00	4.70	22.77	7.27	15.37	<	0.078	9.56
S39A	0.054	0.8	9,887	23,221	447	4,651	134,319	32.05	15.38	17,904	242	5.03	8.83	4.85	19.12	7.09	12.38	<	0.066	8.76
S41A	0.086	1.5	10,038	32,814	406	5,771	101,499	43.52	18.81	23,172	216	6.70	11.90	7.62	27.40	9.84	15.04	<	0.072	11.81
S44A	0.064	0.8	11,716	31,206	489	4,281	150,762	40.29	17.30	24,462	266	7.17	11.52	5.66	25.49	9.51	12.66	<	0.062	10.72
S45A	0.052	0.6	11,498	21,451	499	3,419	168,431	30.82	18.56	20,201	308	6.15	8.47	4.10	20.95	6.79	12.46	<	0.075	8.27
S46A	0.051	0.7	12,502	22,194	507	4,025	183,896	31.72	20.05	19,340	311	5.46	8.62	4.82	19.54	6.99	12.21	<	0.089	8.71
S47A	0.053	0.9	11,666	20,706	454	4,069	168,002	30.02	16.70	18,116	295	5.09	8.12	4.10	18.22	6.61	11.79	<	0.083	8.26
S48A	0.048	0.9	11,436	18,166	453	5,660	173,474	27.57	13.86	17,239	298	4.63	7.22	3.70	16.79	5.89	14.12	<	0.089	8.15
S51AT1D	0.025	0.4	10,105	11,110	415	3,861	197,692	26.60	12.70	13,777	305	3.38	4.66	2.08	9.92	3.72	15.53	<	0.076	5.41
S51AT1U	0.027	0.3	9,597	9,019	561	3,379	195,225	26.02	11.40	13,619	306	3.16	4.09	1.92	9.26	3.40	16.94	<	0.059	4.86
S51AT2	0.021	0.3	8,346	6,581	401	3,213	178,351	23.48	10.80	12,267	301	2.79	3.34	1.47	7.42	2.78	16.59	<	0.049	4.25
S51AT3	0.029	0.3	9,097	8,797	414	3,090	194,171	26.51	10.37	13,492	315	3.13	3.86	1.83	8.72	3.30	18.26	<	0.055	4.72
S52A	0.030	0.4	11,425	11,046	459	3,649	200,160	22.73	12.24	13,230	325	3.38	4.71	2.12	11.10	3.94	13.97	<	0.077	7.25
S54A	0.052	0.7	11,878	23,428	511	3,630	183,752	31.28	20.99	18,644	286	5.46	8.71	4.51	19.05	7.32	11.02	<	0.071	8.86
S57A	0.136	2.0	12,551	52,798	537	4,187	77,444	59.03	23.91	32,282	337	9.25	18.42	10.74	38.55	14.87	16.78	<	0.062	15.63
S58A	0.043	0.5	10,908	15,725	516	3,630	195,803	30.19	12.17	16,157	325	3.91	6.01	2.80	11.96	4.71	17.39	<	0.065	6.02
S59A	0.031	0.2	9,294	9,096	462	2,962	191,689	27.99	13.52	14,178	260	2.82	4.04	1.75	9.20	3.36	18.61	0.32	0.062	4.67
S60A	0.036	0.3	10,125	9,841	431	2,718	181,247	24.12	14.29	13,095	295	2.98	4.33	1.78	10.67	3.69	14.52	0.27	0.072	5.23
S62A	0.036	0.4	7,026	12,004	306	4,011	117,205	18.75	15.12	10,957	167	2.80	4.65	2.62	10.57	3.92	9.76	<	0.053	5.52
S67A	0.017	<0.2	8,117	5,449	442	3,068	178,345	35.93	12.29	15,710	235	2.57	2.82	1.12	5.85	2.30	26.03	<	0.045	3.80
S68A	0.018	<0.2	4,914	3,988	356	2,387	137,102	23.62	10.50	10,584	160	1.67	2.03	1.26	4.73	2.02	18.01	<	0.025	3.29
S72A	0.017	0.2	5,181	5,439	292	2,307	112,036	21.48	11.29	9,918	158	2.12	2.60	1.27	5.37	2.39	15.41	<	0.031	3.52
S82A	0.035	0.5	2,792	14,855	199	1,959	27,592	28.20	11.81	17,663	68	3.12	6.25	8.04	29.62	4.73	10.71	<	0.030	8.34
S90A	0.043	0.5	11,562	16,491	468	4,341	185,396	27.30	13.86	16,178	315	4.31	6.70	3.99	17.59	5.64	13.72	<	0.089	8.23
S92A	0.061	1.0	4,530	20,668	183	3,302	28,177	22.56	13.09	14,436	70	4.10	7.75	7.72	37.19	6.55	12.70	<	0.039	8.44
S97A	0.051	0.7	11,245	20,368	483	4,042	175,318	31.73	19.45	18,157	322	4.85	8.06	4.76	19.91	6.65	13.11	<	0.082	8.23

<: less than detection limit Data accurate to 2-3 digits onl Cr is not quantitatively extracted in HNO3+HClO4 digestion

Quality Control ICPMS

Detection limit

	Mg	Al	P	S	Ca	V	Cr	Fe	Mn	Co	Ni	Cu	Zn	Ga	As	Mo	Cd	Pb
	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Run 1	2	1	3	1,000	3	0.03	0.03	1	0.01	0.002	0.01	0.02	0.3	0.002	0.07	2.0	0.002	0.009
Run 2	2	2	10	1,000	6	0.02	0.02	2	0.04	0.007	0.02	0.03	0.2	0.010	0.09	0.2	0.003	0.010
Run 3	1	2	2	1,000	4	0.02	0.04	5	0.02	0.005	0.01	0.03	0.2	0.005	0.03	0.2	0.005	0.005

Digest blank

	Mg	Al	P	S	Ca	V	Cr	Fe	Mn	Co	Ni	Cu	Zn	Ga	As	Mo	Cd	Pb
	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Run 1 (av of 15)	<	3	<	<	<	<	0.17	<	<	<	<	0.03	<	<	0.09	<	<	0.058
Run 2 (av of 7)	<	8	<	<	<	<	0.18	<	<	<	<	0.05	1.0	<	<	<	<	<
Run 3 (av of 14)	16	30	<	<	18	0.17	0.22	22	0.17	0.010	0.03	<	0.7	0.019	0.04	<	<	0.030

Certified Reference Material MESS-3 (marine sediment, Canadian Research Council)

	Mg	Al	P	S	Ca	V	Cr	Fe	Mn	Co	Ni	Cu	Zn	Ga	As	Mo	Cd	Pb
	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Run 1 (av of 12)	16,162	79,610	1,183	1,881	13,949	211	36.9	40,367	319	11.9	43.1	31.6	142	22.1	21.2	2.25	0.217	21.2
Stdev	334	3,649	42	257	221	5	12.4	539	12	0.1	0.5	1.1	2	0.3	0.3	0.12	0.018	0.9
RSD%	2.1	4.6	3.6	13.7	1.6	2.2	33.5	1.3	3.6	0.9	1.2	3.5	1.6	1.3	1.2	5.1	8.3	4.3
Rec%	101	93	99	99	95	87	35	93	99	82	92	93	89	nc	100	81	91	101
Run 2 (av of 8)	16,380	78,416	1,097	1,917	14,591	210	45.6	39,858	314	11.4	42.7	30.4	140	22.2	21.2	2.15	0.218	21.1
Stdev	587	1,287	30	170	185	4	7.2	727	3	0.1	0.4	0.4	2	0.4	0.3	0.14	0.015	0.5
RSD%	3.6	1.6	2.8	8.9	1.3	1.9	15.8	1.8	1.0	1.0	1.0	1.3	1.3	1.6	1.6	6.4	6.8	2.5
Rec%	102	91	91	101	99	86	43	92	97	79	91	90	88	nc	100	77	91	100
Run 3 (av of 13)	15,436	79,199	1,168	1,981	15,033	219	32.9	42,281	328	12.6	45.8	32.2	148	23.2	20.5	2.10	0.212	20.5
Stdev	509	1,140	42	285	254	4	7.0	636	6	0.2	0.2	0.4	2	0.5	0.3	0.14	0.007	0.5
RSD%	3.3	1.4	3.6	14.4	1.7	1.7	21.4	1.5	1.8	1.2	0.5	1.1	1.4	2.1	1.5	6.6	3.2	2.4
Rec%	96	92	97	104	102	90	31	97	101	87	98	95	93	nc	97	76	88	97
Certified value	16,000	85,900	1,200	1,900	14,700	243	105.0	43,400	324	14.4	46.9	33.9	159	nc	21.2	2.78	0.240	21.1

nc: not certified

Note: Per USEPA guidelines replication target is <20% RSD, recovery target is 80-120%

Quality Control TKN (FIA)

Detection limit

	TKN
	%
Run 1	0.003
Run 2	0.002

Check Solution (High Purity Standards)

	TKN
	ug/L
Run 1 (av of 20)	10.14
Stdev	0.15
Run 2 (av of 20)	9.59
Stdev	0.15
Certified value:	10.00

CRM LOAM-1 (High Purity Standards)

	TKN
	%
Run 1 (av of 8)	0.095
Stdev	0.002
Run 2 (av of 8)	0.098
Stdev	0.002
Certified value:	0.100

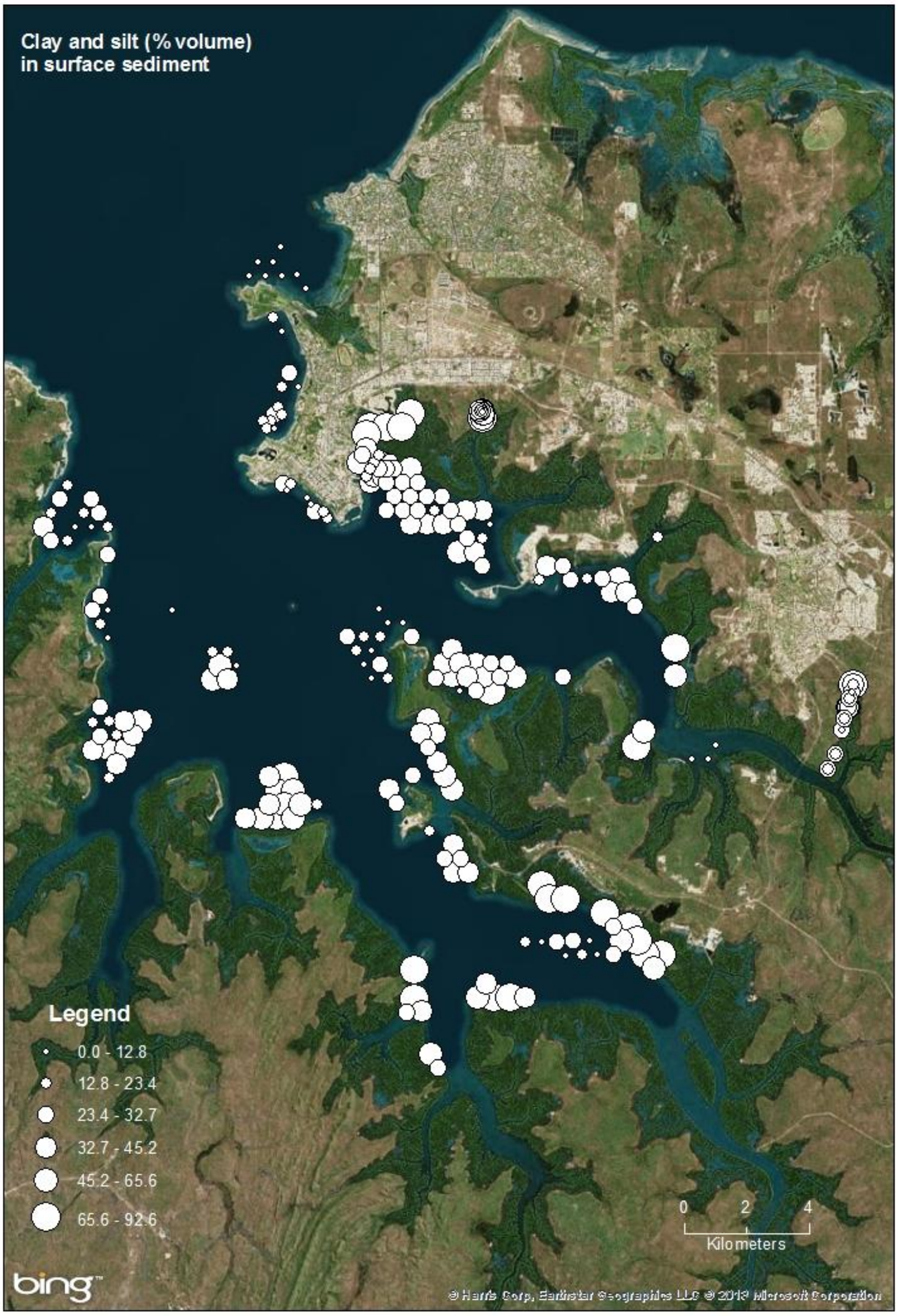
Appendix 3. Correlation matrix for grainsize and chemical parameters (two-tailed distribution, n=298, df=299, p=0.05, R critical = 0.113).

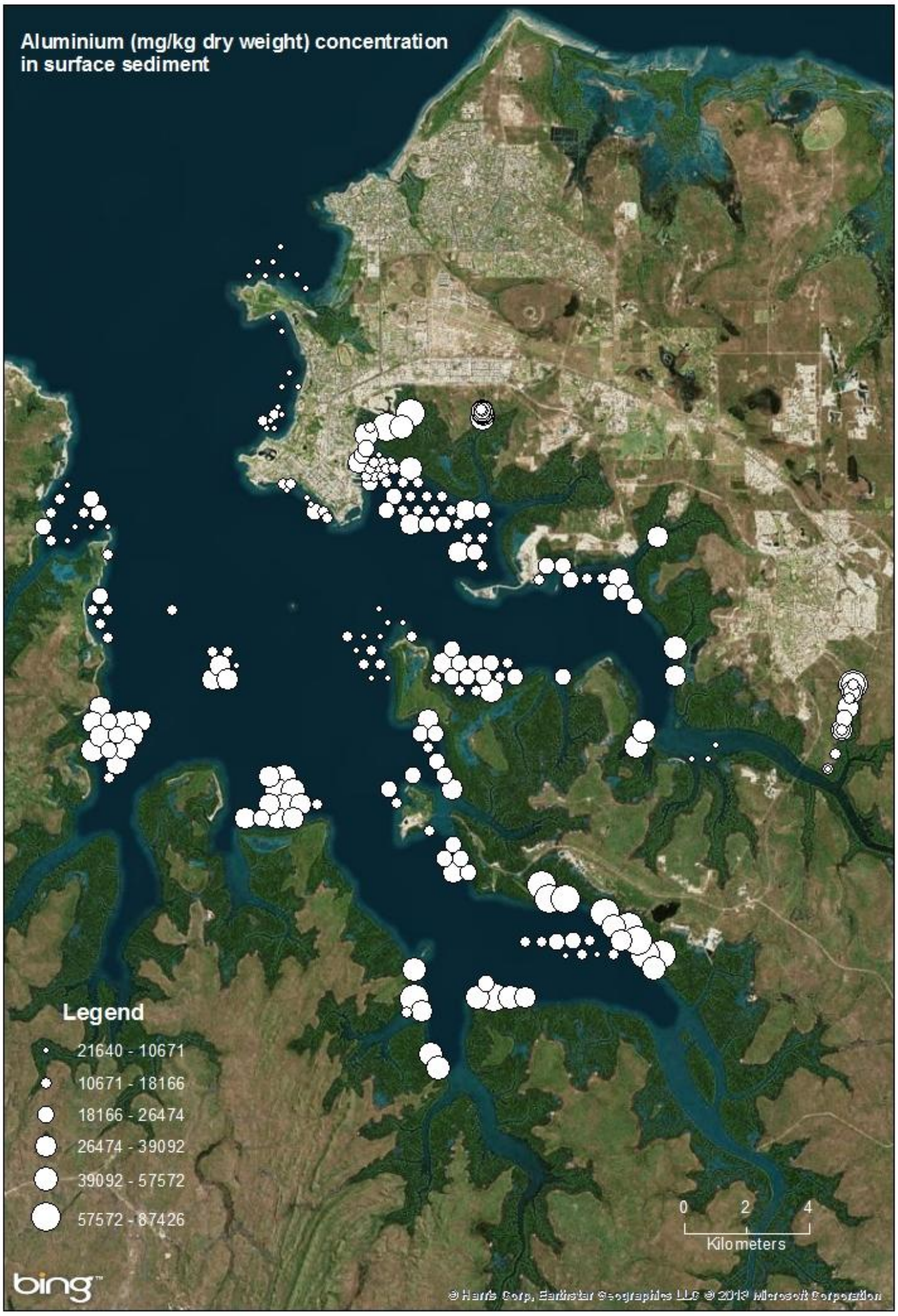
>0.5 <-0.5

Correlation coefficient (R)

	Clay	*Silt*	*Fine sand*	*ledium san*	*oarse sanc*	*Gravel*	*Residue*	*TKN*	*TOC*	*Mg*	*Al*	*P*	*S*	*Ca*	*V*	*Cr*	*Fe*	*Mn*	*Co*	*Ni*	*Cu*	*Zn*	*Ga*	*As*	*Se*	*Mo*	*Cd*	*Pb*
Clay	1.000																											
Silt	0.926	1.000																										
Fine sand	-0.461	-0.453	1.000																									
Medium s	-0.528	-0.604	-0.210	1.000																								
Coarse sar	-0.319	-0.355	-0.508	0.391	1.000																							
Gravel	-0.184	-0.149	-0.481	0.047	0.627	1.000																						
Residue	0.003	0.075	-0.612	0.340	0.466	0.380	1.000																					
TKN	0.818	0.865	-0.539	-0.411	-0.233	-0.023	0.183	1.000																				
TOC	0.662	0.767	-0.615	-0.294	-0.076	0.126	0.399	0.925	1.000																			
Mg	0.303	0.224	0.439	-0.428	-0.623	-0.458	-0.866	0.144	-0.125	1.000																		
Al	0.899	0.864	-0.582	-0.410	-0.203	0.009	0.146	0.892	0.791	0.175	1.000																	
P	0.057	-0.043	0.429	-0.291	-0.354	-0.208	-0.852	-0.095	-0.313	0.837	-0.047	1.000																
S	0.439	0.436	0.088	-0.464	-0.445	-0.196	-0.520	0.373	0.221	0.669	0.392	0.499	1.000															
Ca	-0.271	-0.330	0.750	-0.179	-0.375	-0.398	-0.914	-0.421	-0.609	0.757	-0.445	0.793	0.340	1.000														
V	0.307	0.272	-0.534	-0.057	0.267	0.456	0.244	0.330	0.381	-0.153	0.481	-0.007	-0.004	-0.430	1.000													
Cr	0.490	0.422	-0.432	-0.258	0.040	0.324	0.114	0.464	0.417	0.053	0.613	0.108	0.233	-0.322	0.798	1.000												
Fe	0.317	0.277	-0.467	-0.144	0.216	0.466	0.165	0.287	0.307	-0.085	0.457	0.073	0.075	-0.359	0.954	0.767	1.000											
Mn	-0.027	-0.113	0.499	-0.119	-0.470	-0.373	-0.819	-0.158	-0.359	0.844	-0.142	0.868	0.396	0.802	-0.168	-0.072	-0.108	1.000										
Co	0.800	0.728	-0.416	-0.462	-0.227	0.047	-0.071	0.666	0.537	0.325	0.829	0.217	0.524	-0.227	0.547	0.680	0.610	0.091	1.000									
Ni	0.869	0.812	-0.559	-0.418	-0.178	0.072	0.101	0.809	0.694	0.211	0.957	0.036	0.424	-0.401	0.618	0.716	0.621	-0.082	0.906	1.000								
Cu	0.483	0.509	-0.576	-0.216	0.143	0.343	0.393	0.507	0.529	-0.224	0.654	-0.247	0.048	-0.594	0.733	0.599	0.749	-0.344	0.569	0.727	1.000							
Zn	0.287	0.366	-0.417	-0.187	0.163	0.287	0.382	0.490	0.526	-0.241	0.446	-0.249	-0.057	-0.461	0.272	0.247	0.250	-0.320	0.196	0.392	0.616	1.000						
Ga	0.856	0.829	-0.596	-0.403	-0.160	0.093	0.171	0.852	0.769	0.138	0.975	-0.042	0.357	-0.468	0.625	0.694	0.608	-0.151	0.848	0.977	0.752	0.456	1.000					
As	-0.115	-0.156	-0.130	0.160	0.187	0.283	-0.133	-0.122	-0.098	0.108	-0.027	0.314	0.009	0.071	0.582	0.225	0.656	0.323	0.180	0.123	0.331	-0.045	0.110	1.000				
Se	0.560	0.558	-0.154	-0.439	-0.355	-0.037	-0.322	0.512	0.406	0.499	0.592	0.412	0.537	0.060	0.464	0.437	0.536	0.380	0.697	0.664	0.464	0.142	0.653	0.468	1.000			
Mo	-0.218	-0.198	-0.419	0.206	0.676	0.635	0.534	-0.051	0.095	-0.570	-0.051	-0.373	-0.449	-0.458	0.466	0.246	0.415	-0.457	-0.115	-0.001	0.370	0.370	0.041	0.242	-0.222	1.000		
Cd	-0.052	-0.024	0.453	-0.354	-0.302	-0.182	-0.466	-0.070	-0.176	0.415	-0.117	0.387	0.322	0.472	-0.213	-0.099	-0.150	0.356	-0.056	-0.094	-0.088	0.172	-0.120	-0.057	0.143	-0.234	1.000	
Pb	0.433	0.493	-0.552	-0.226	0.147	0.359	0.385	0.625	0.658	-0.193	0.633	-0.205	0.041	-0.549	0.558	0.517	0.525	-0.307	0.437	0.628	0.790	0.894	0.678	0.116	0.334	0.401	0.001	1.000

Appendix 4. Categorised distribution maps of grainsize, nutrient and metal/metalloid concentrations in Darwin Harbour sediment (note that metal/metalloid maps are Al normalised (@ 10,000 mg/kg Al)




Aluminium (mg/kg dry weight) concentration in surface sediment
Legend
21640 - 10671
10671 - 18166
18166 - 26474
26474 - 39092
39092 - 57572
57572 - 87426
0
2
4
Kilometers
bing™
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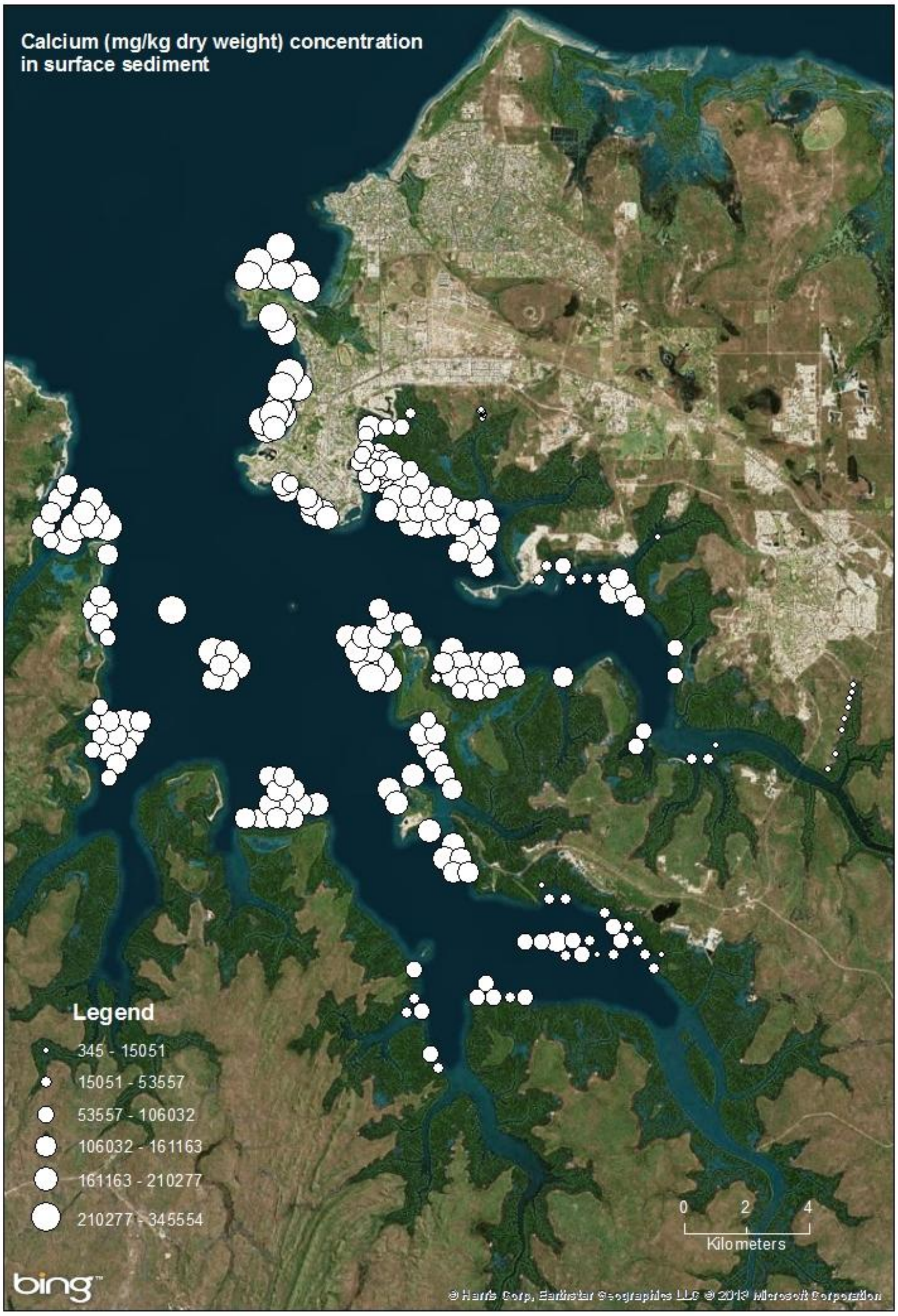
Calcium (mg/kg dry weight) concentration in surface sediment
Legend
345 - 15051
15051 - 53557
53557 - 106032
106032 - 161163
161163 - 210277
210277 - 345554
0
2
4
Kilometers
bing
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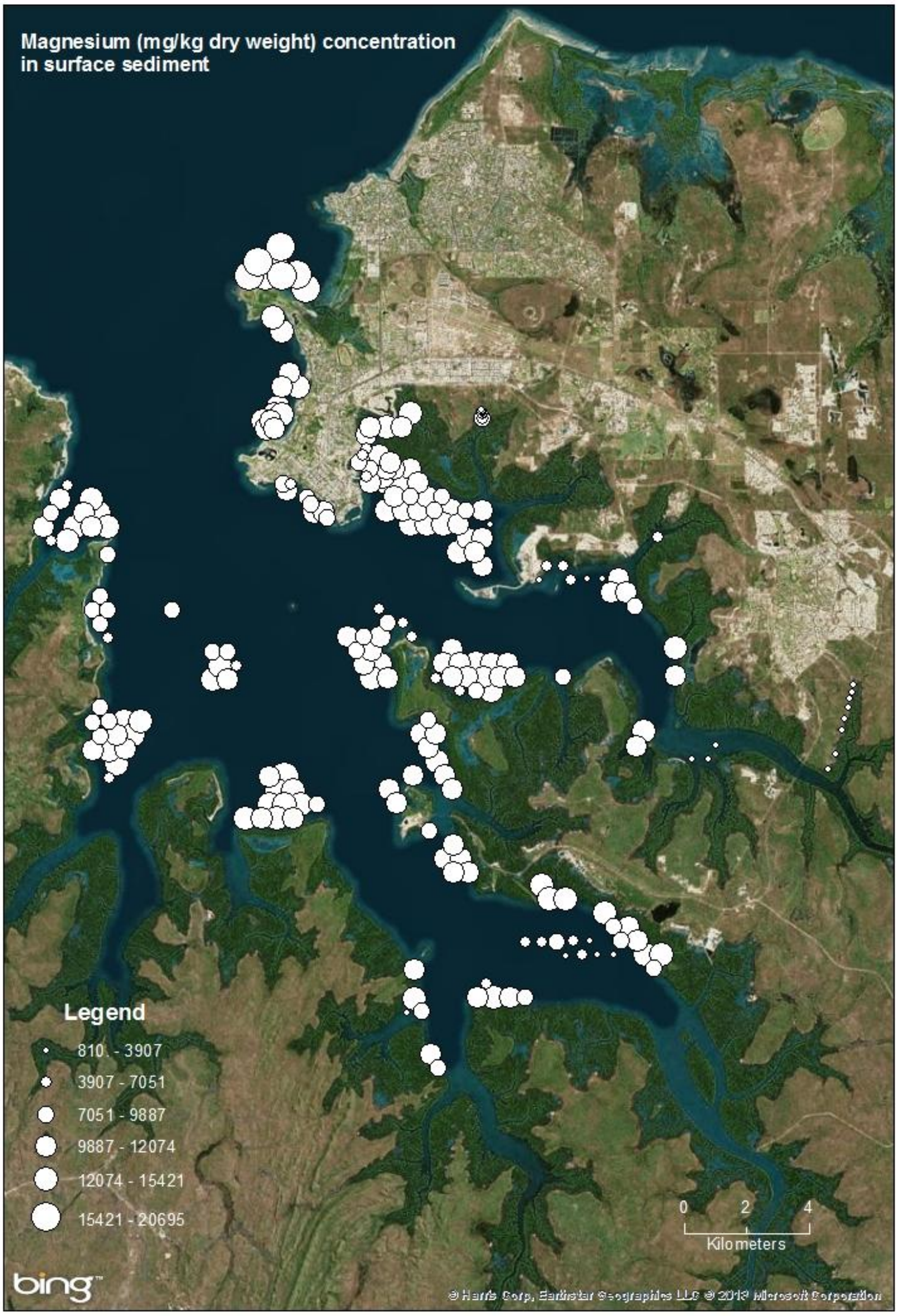
Magnesium (mg/kg dry weight) concentration in surface sediment
Legend
810 - 3907
3907 - 7051
7051 - 9887
9887 - 12074
12074 - 15421
15421 - 20695
0
2
4
Kilometers
bing
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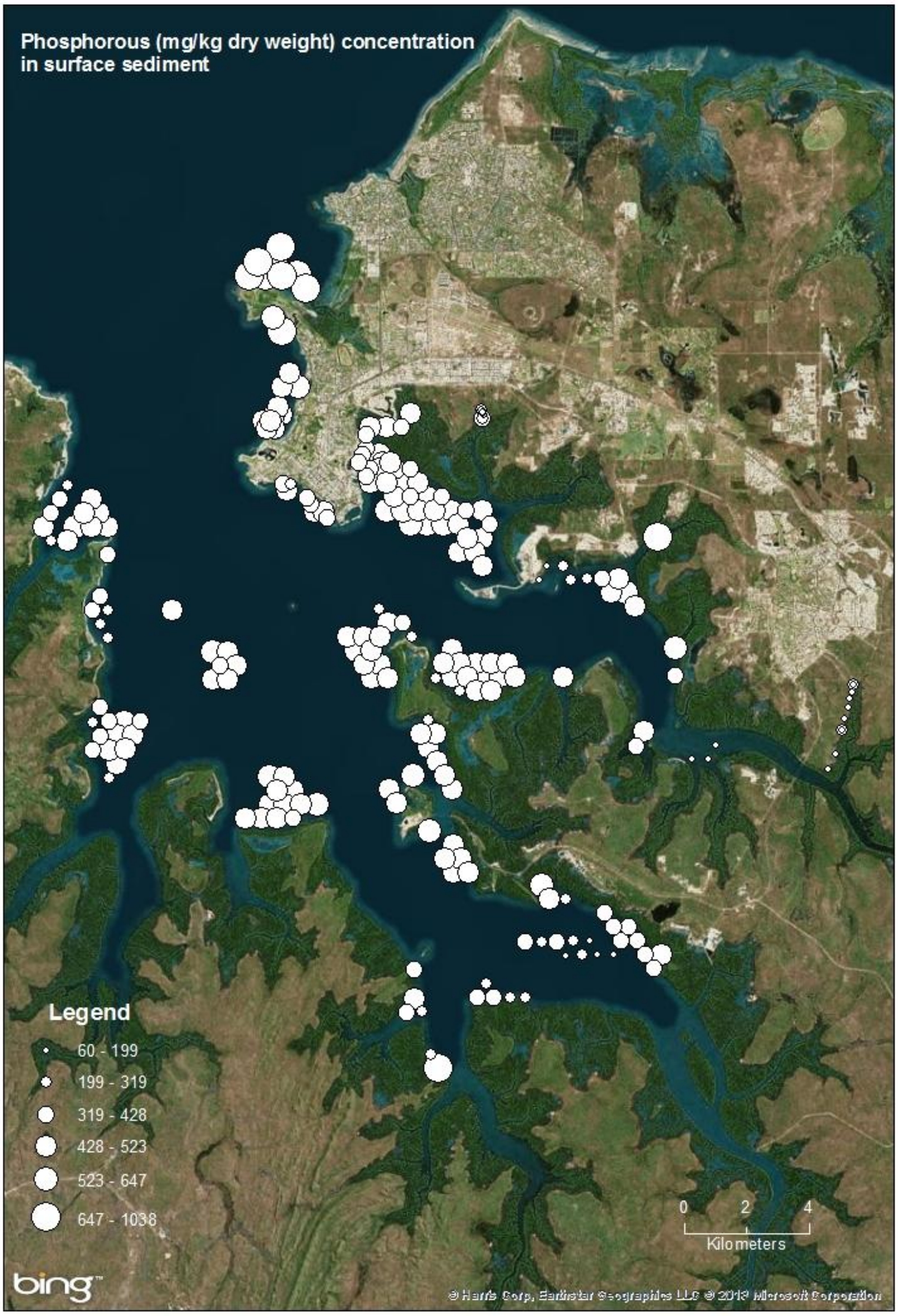
Phosphorous (mg/kg dry weight) concentration in surface sediment
Legend
60 - 199
199 - 319
319 - 428
428 - 523
523 - 647
647 - 1038
0
2
4
Kilometers
bing
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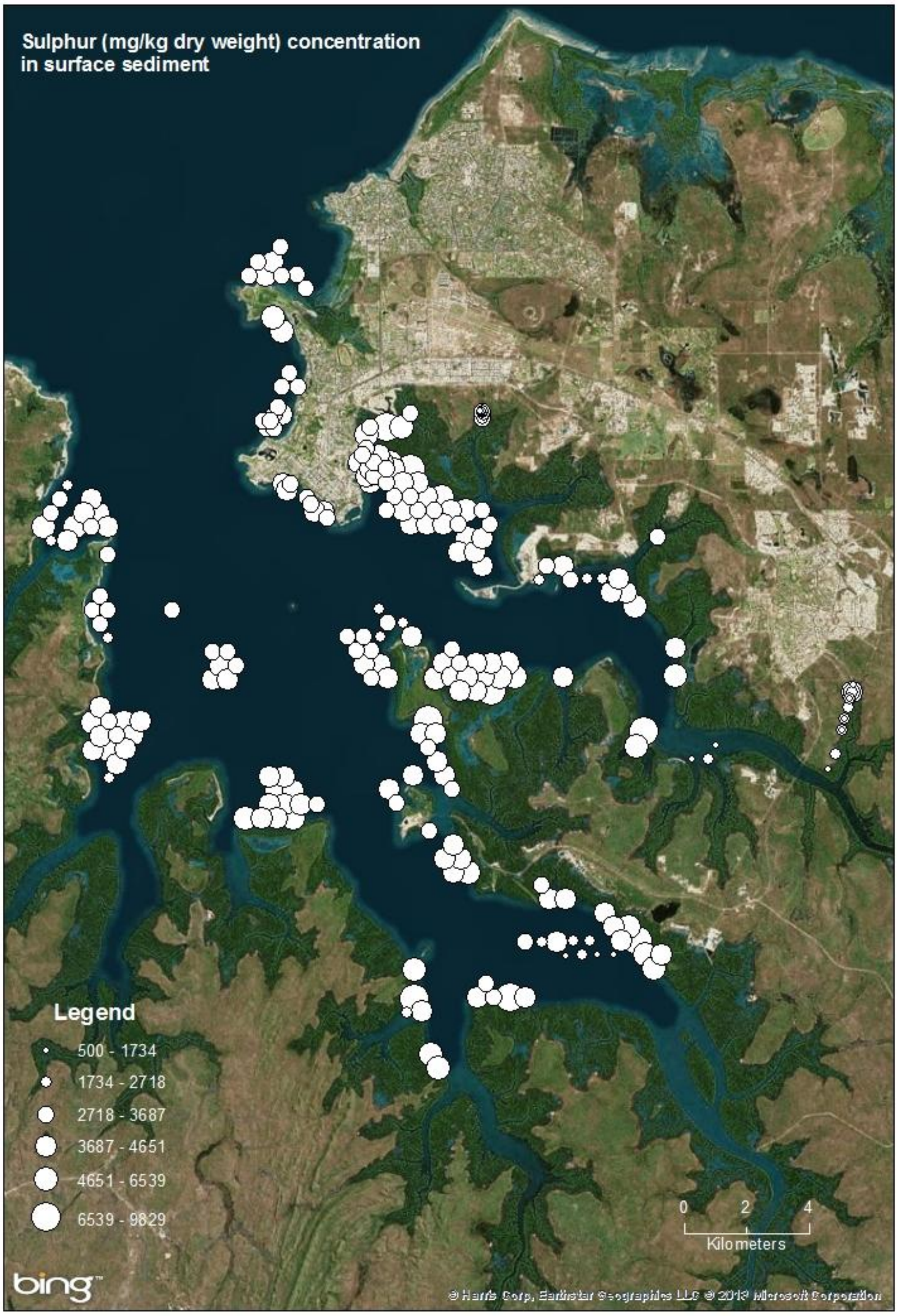
Sulphur (mg/kg dry weight) concentration in surface sediment
Legend
500 - 1734
1734 - 2718
2718 - 3687
3687 - 4651
4651 - 6539
6539 - 9829
0
2
4
Kilometers
bing
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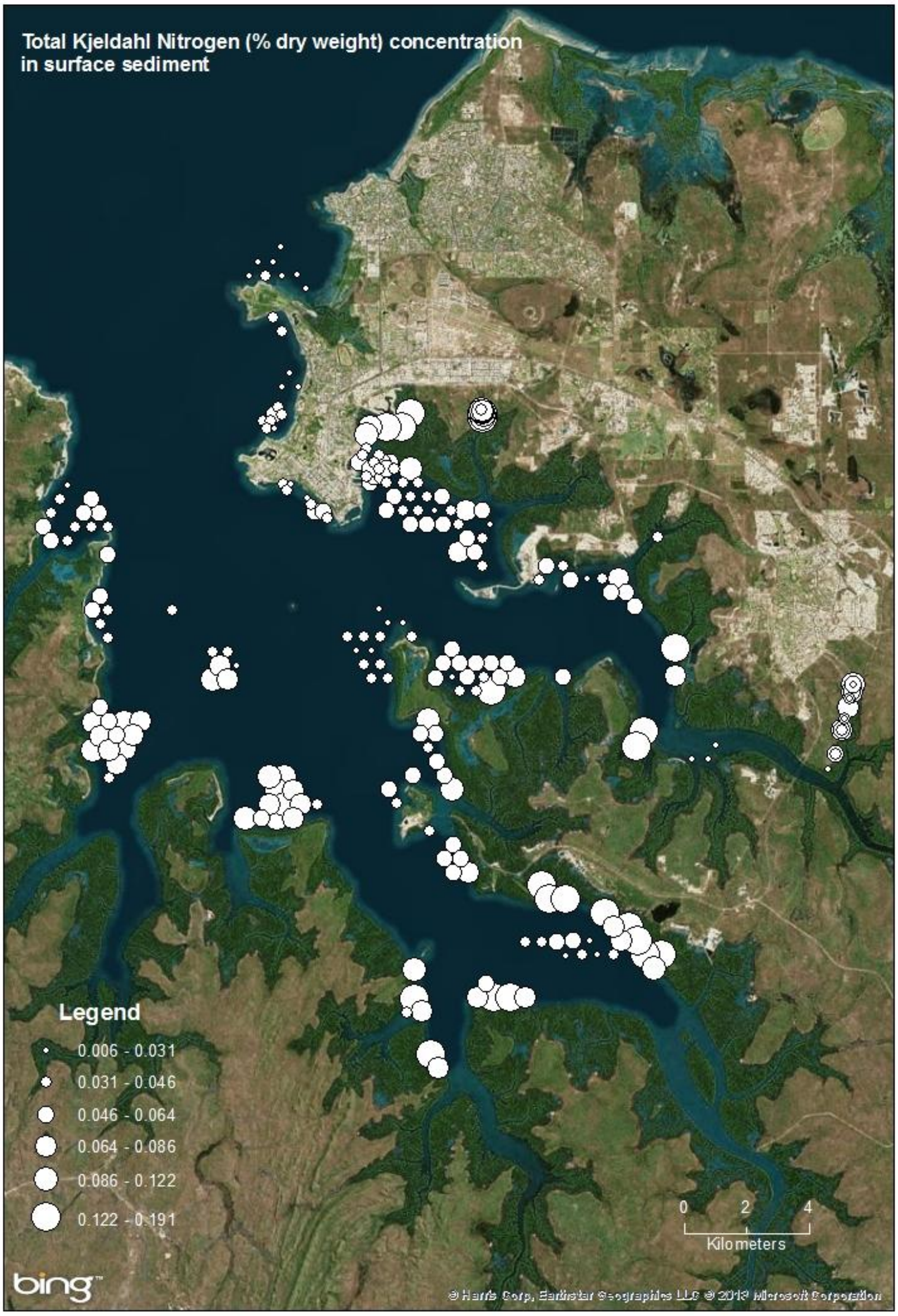
Total Kjeldahl Nitrogen (% dry weight) concentration in surface sediment
Legend
0.006 - 0.031
0.031 - 0.046
0.046 - 0.064
0.064 - 0.086
0.086 - 0.122
0.122 - 0.191
0
2
4
Kilometers
bing
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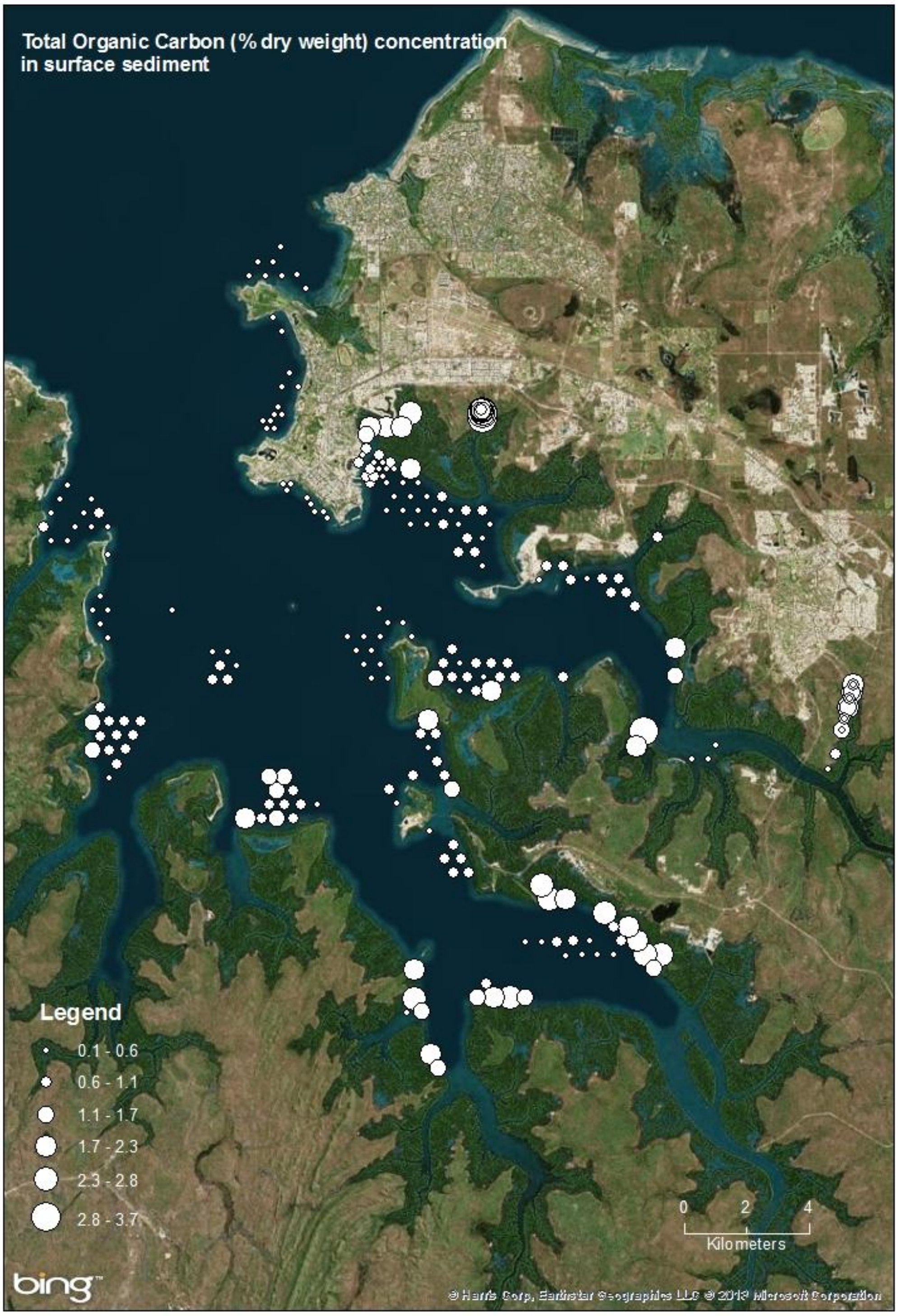
Total Organic Carbon (% dry weight) concentration in surface sediment
Legend
0.1 - 0.6
0.6 - 1.1
1.1 - 1.7
1.7 - 2.3
2.3 - 2.8
2.8 - 3.7
0
2
4
Kilometers
bing
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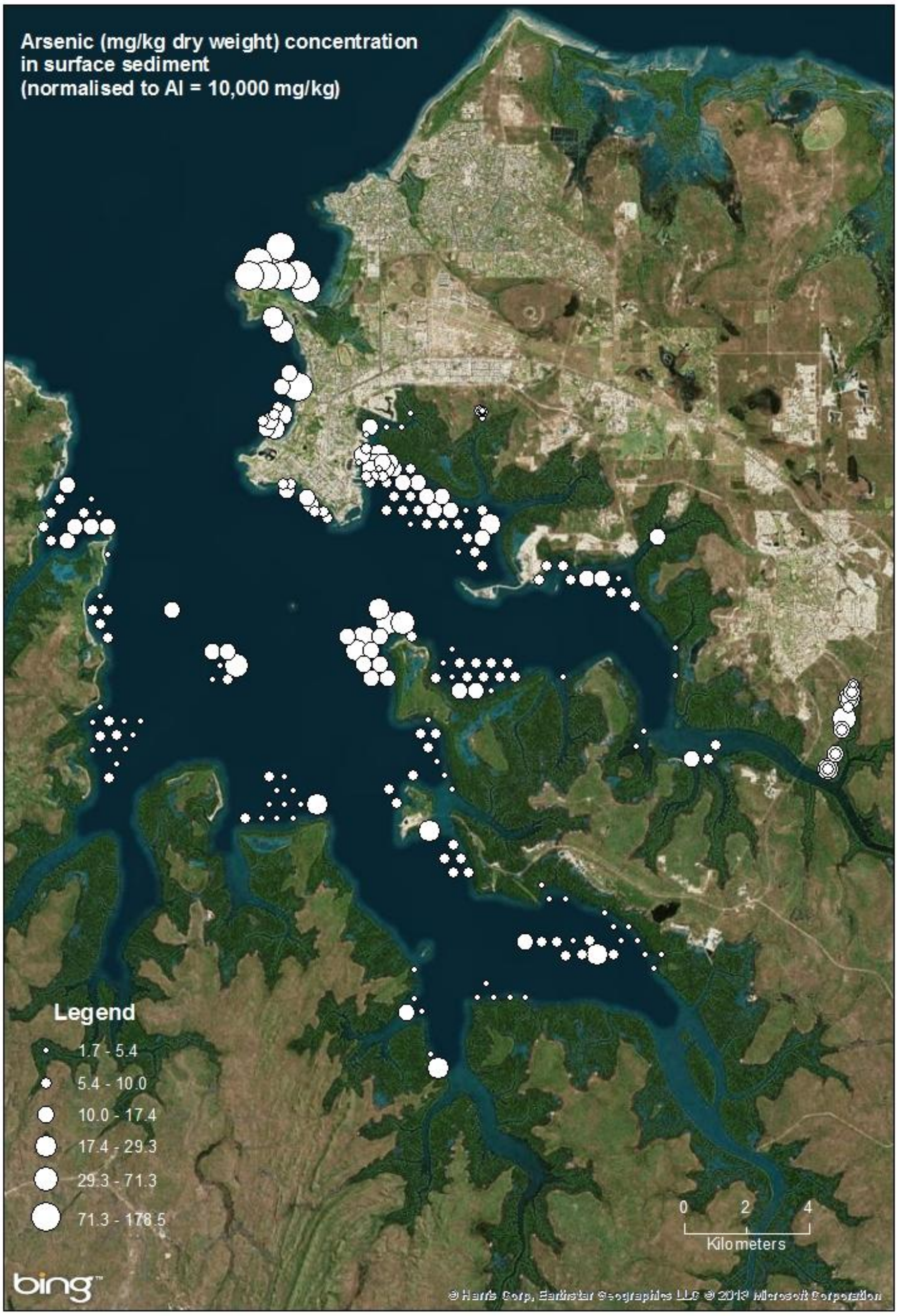
Arsenic (mg/kg dry weight) concentration
in surface sediment
(normalised to Al = 10,000 mg/kg)
Legend
1.7 - 5.4
5.4 - 10.0
10.0 - 17.4
17.4 - 29.3
29.3 - 71.3
71.3 - 178.5
0
2
4
Kilometers
bing
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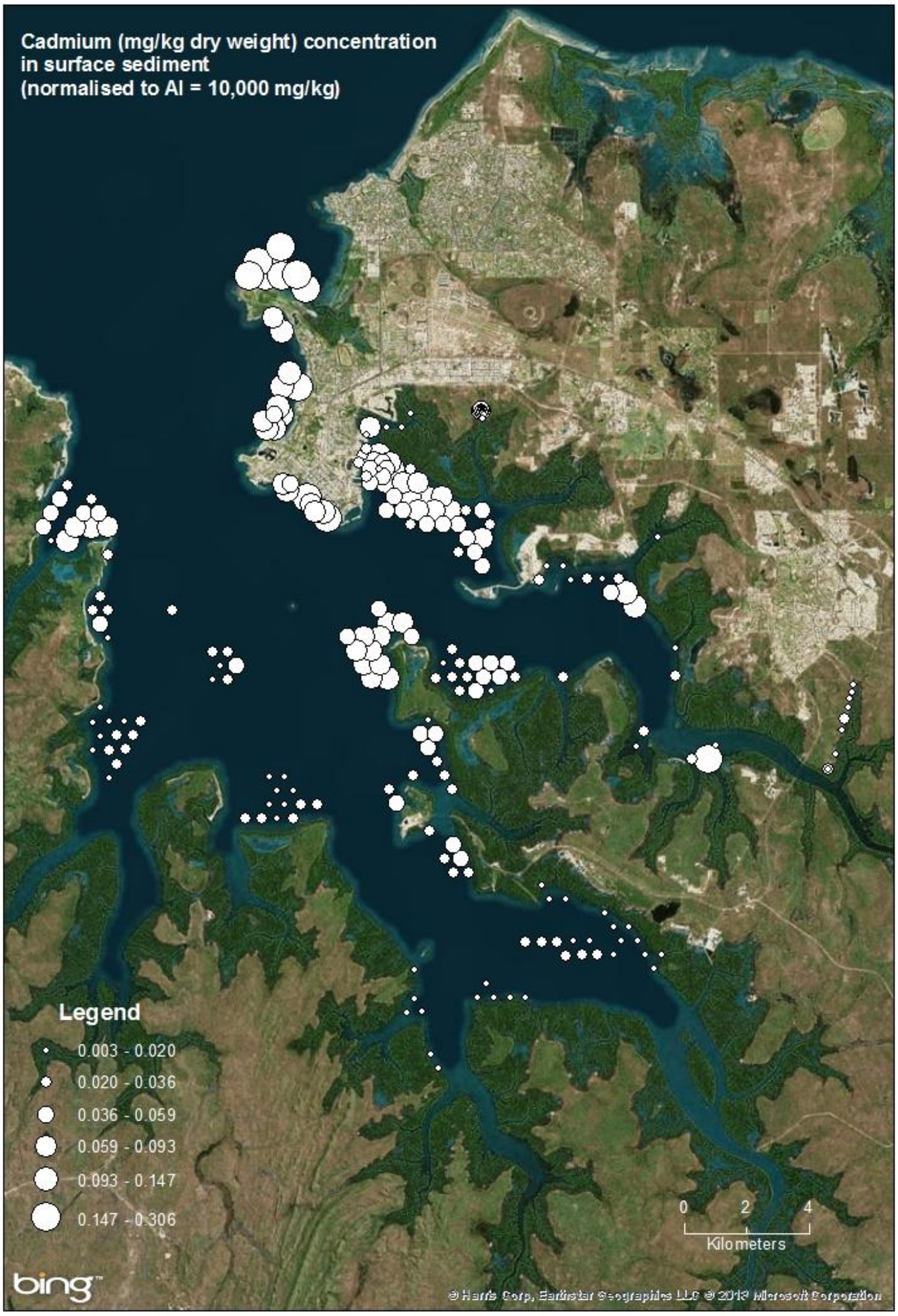
Cadmium (mg/kg dry weight) concentration
in surface sediment
(normalised to Al = 10,000 mg/kg)
Legend
0.003 - 0.020
0.020 - 0.036
0.036 - 0.059
0.059 - 0.093
0.093 - 0.147
0.147 - 0.306
0
2
4
Kilometers
bing
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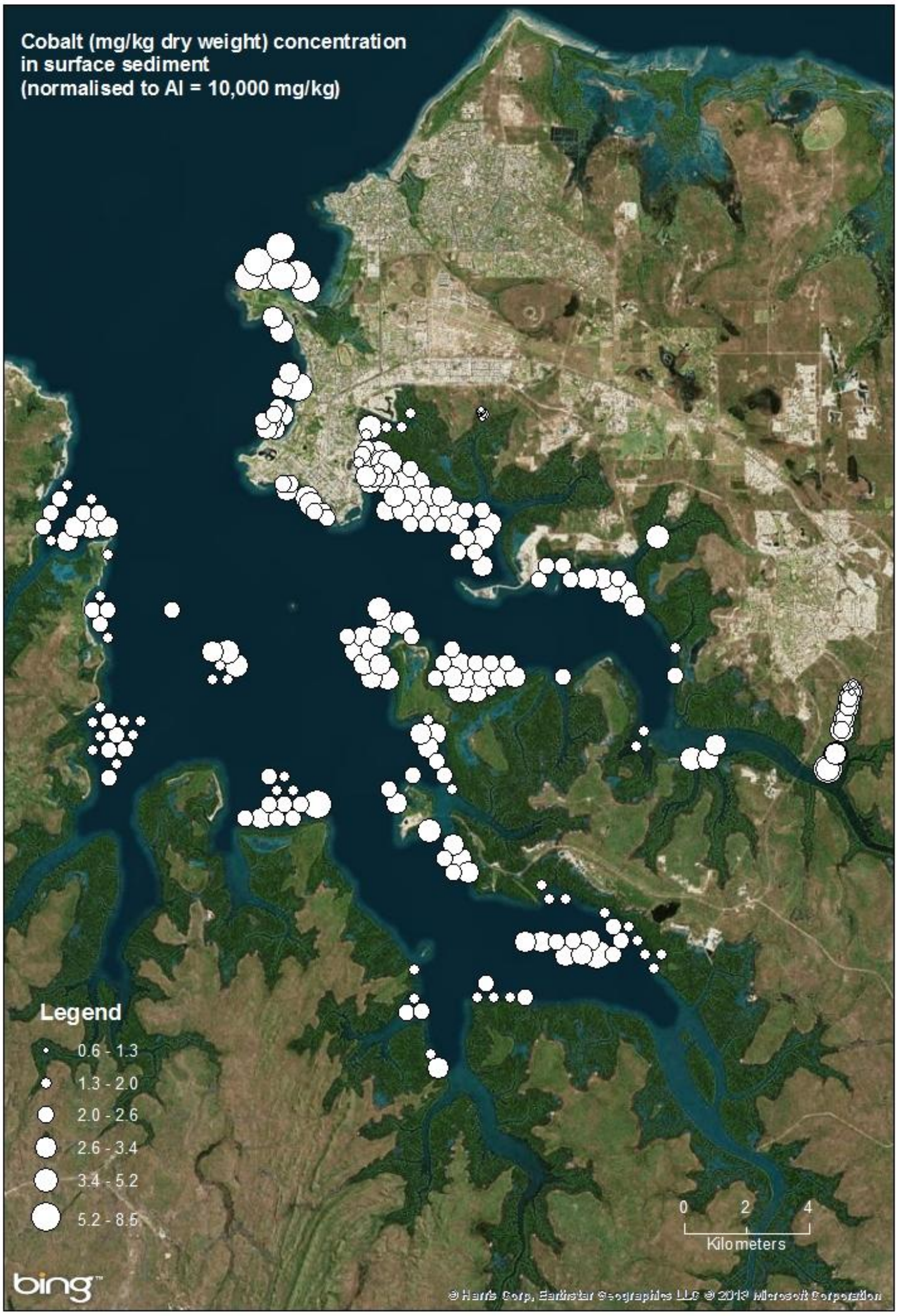
Cobalt (mg/kg dry weight) concentration
in surface sediment
(normalised to Al = 10,000 mg/kg)
Legend
0.6 - 1.3
1.3 - 2.0
2.0 - 2.6
2.6 - 3.4
3.4 - 5.2
5.2 - 8.5
0
2
4
Kilometers
bing
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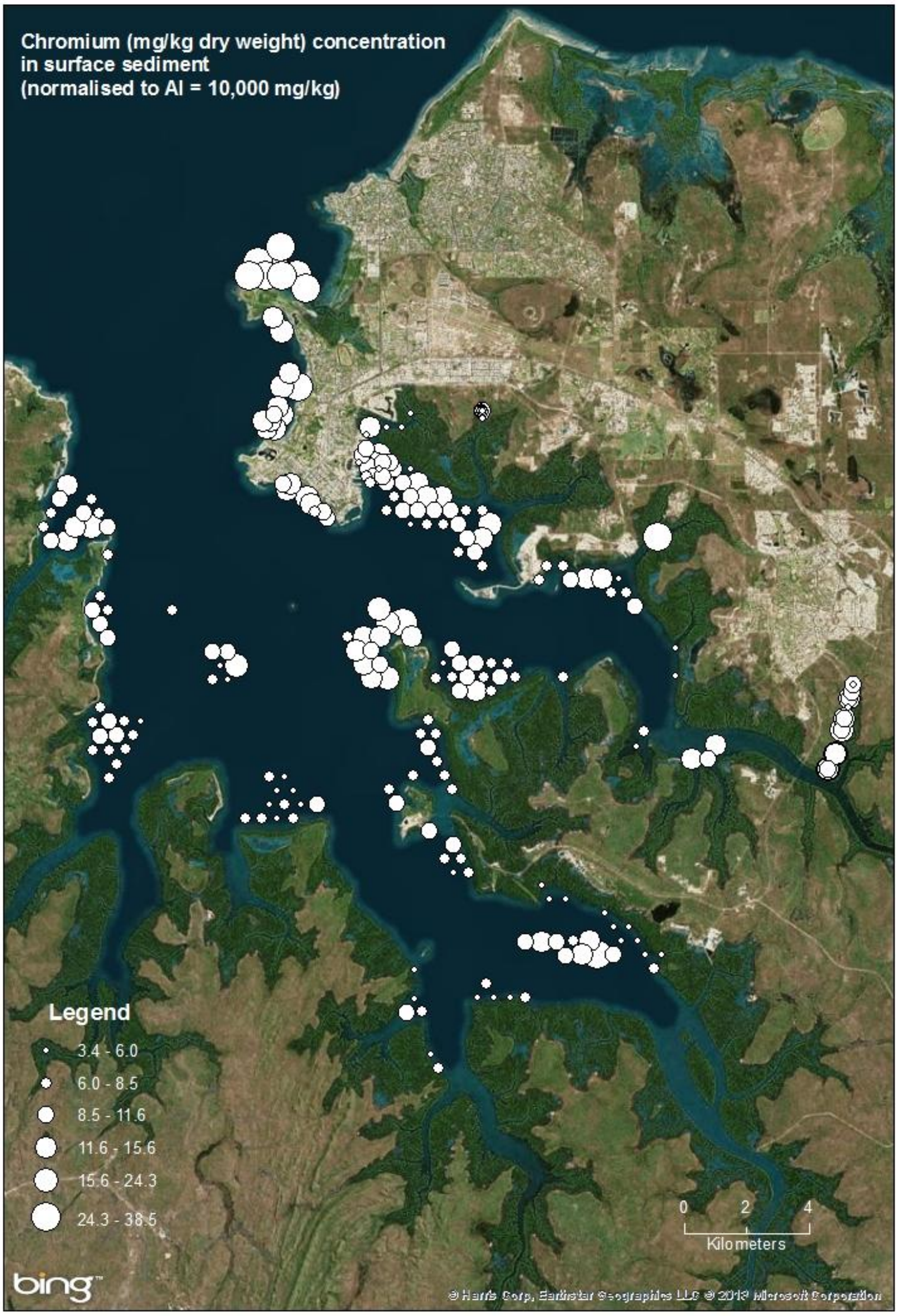
Chromium (mg/kg dry weight) concentration
in surface sediment
(normalised to Al = 10,000 mg/kg)
Legend
3.4 - 6.0
6.0 - 8.5
8.5 - 11.6
11.6 - 15.6
15.6 - 24.3
24.3 - 38.5
0
2
4
Kilometers
bing
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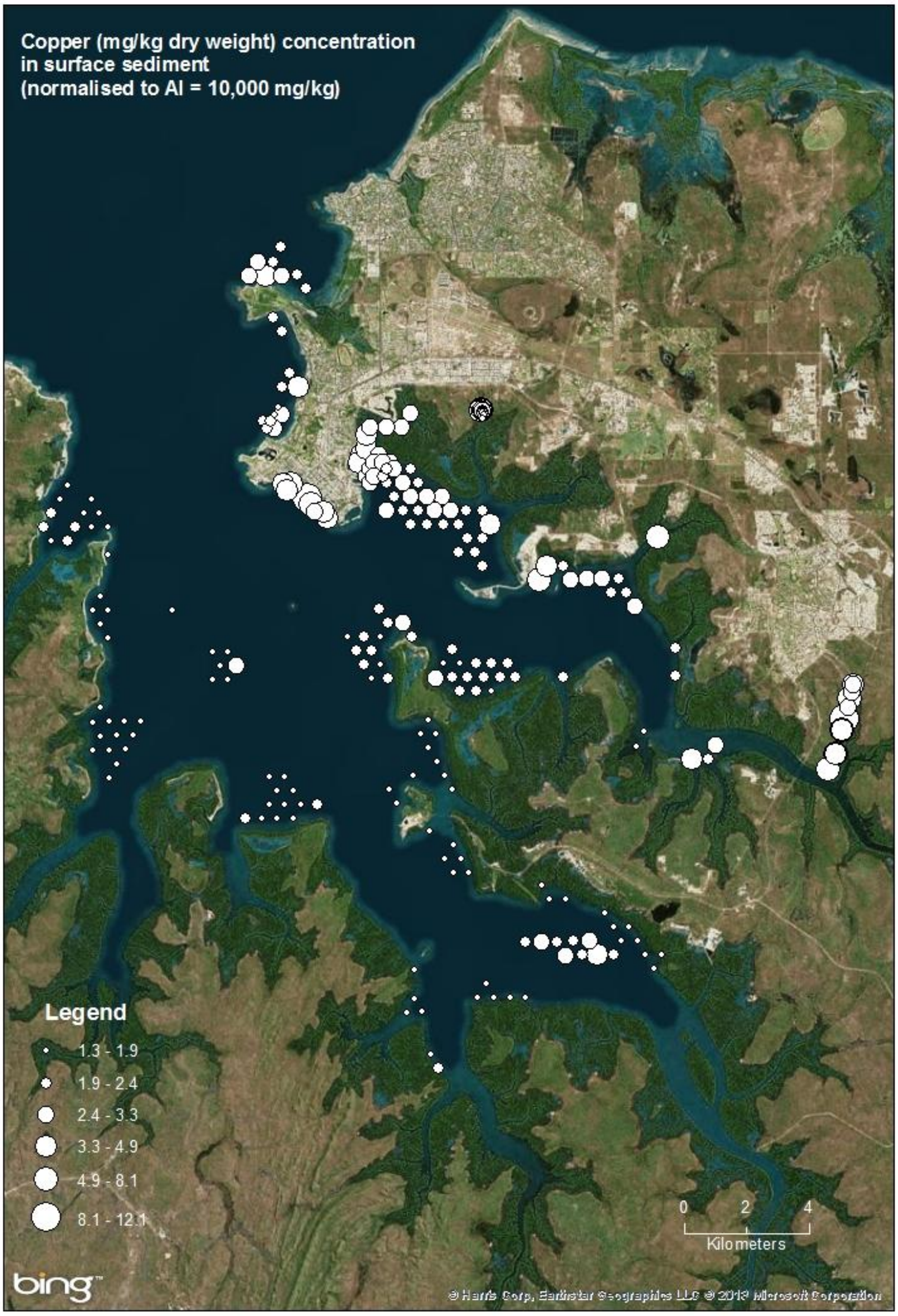
Copper (mg/kg dry weight) concentration
in surface sediment
(normalised to Al = 10,000 mg/kg)
Legend
1.3 - 1.9
1.9 - 2.4
2.4 - 3.3
3.3 - 4.9
4.9 - 8.1
8.1 - 12.1
0
2
4
Kilometers
bing
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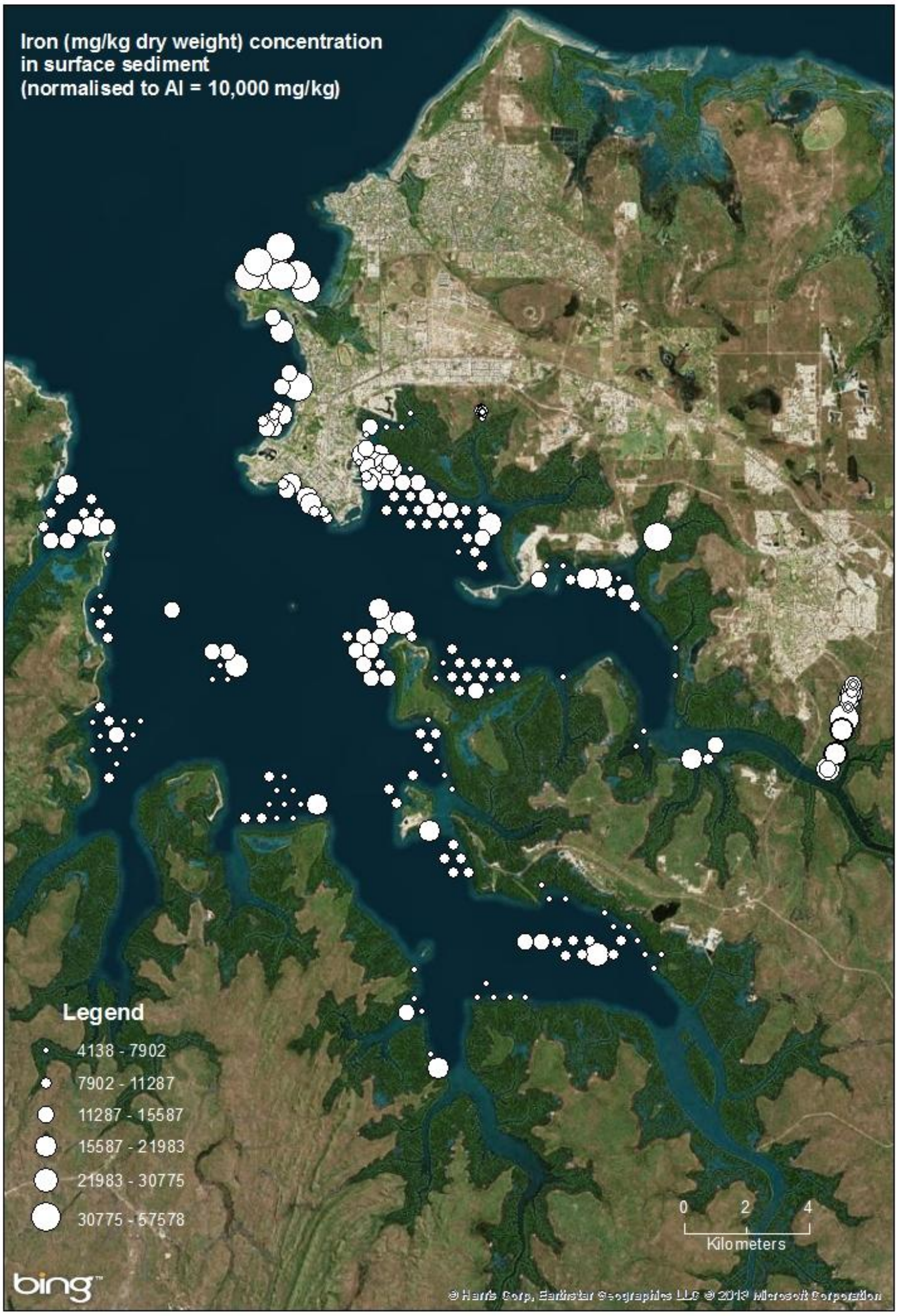
Iron (mg/kg dry weight) concentration
in surface sediment
(normalised to Al = 10,000 mg/kg)
Legend
4138 - 7902
7902 - 11287
11287 - 15587
15587 - 21983
21983 - 30775
30775 - 57578
0
2
4
Kilometers
bing
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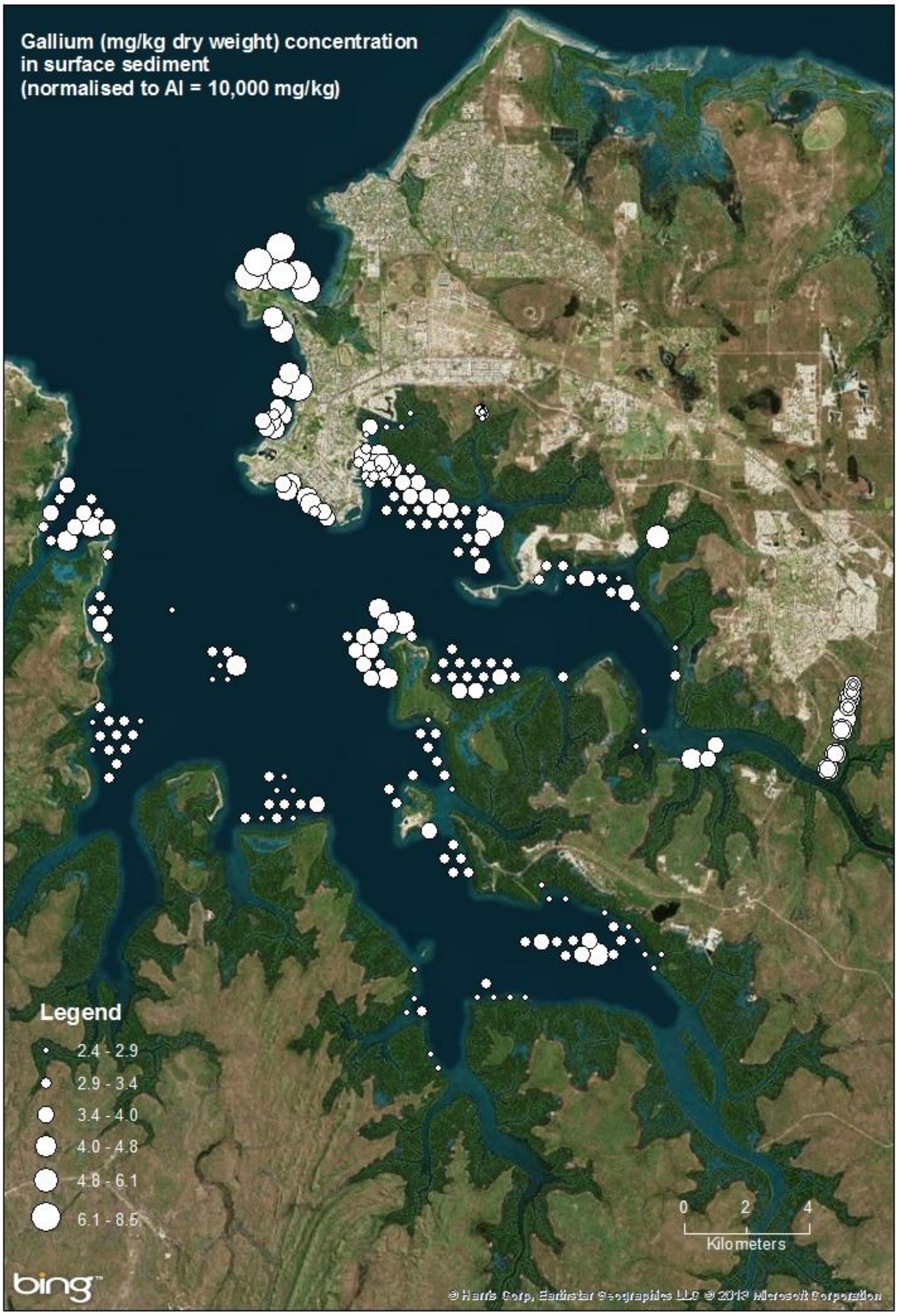
Gallium (mg/kg dry weight) concentration
in surface sediment
(normalised to Al = 10,000 mg/kg)
Legend
2.4 - 2.9
2.9 - 3.4
3.4 - 4.0
4.0 - 4.8
4.8 - 6.1
6.1 - 8.5
0
2
4
Kilometers
bing
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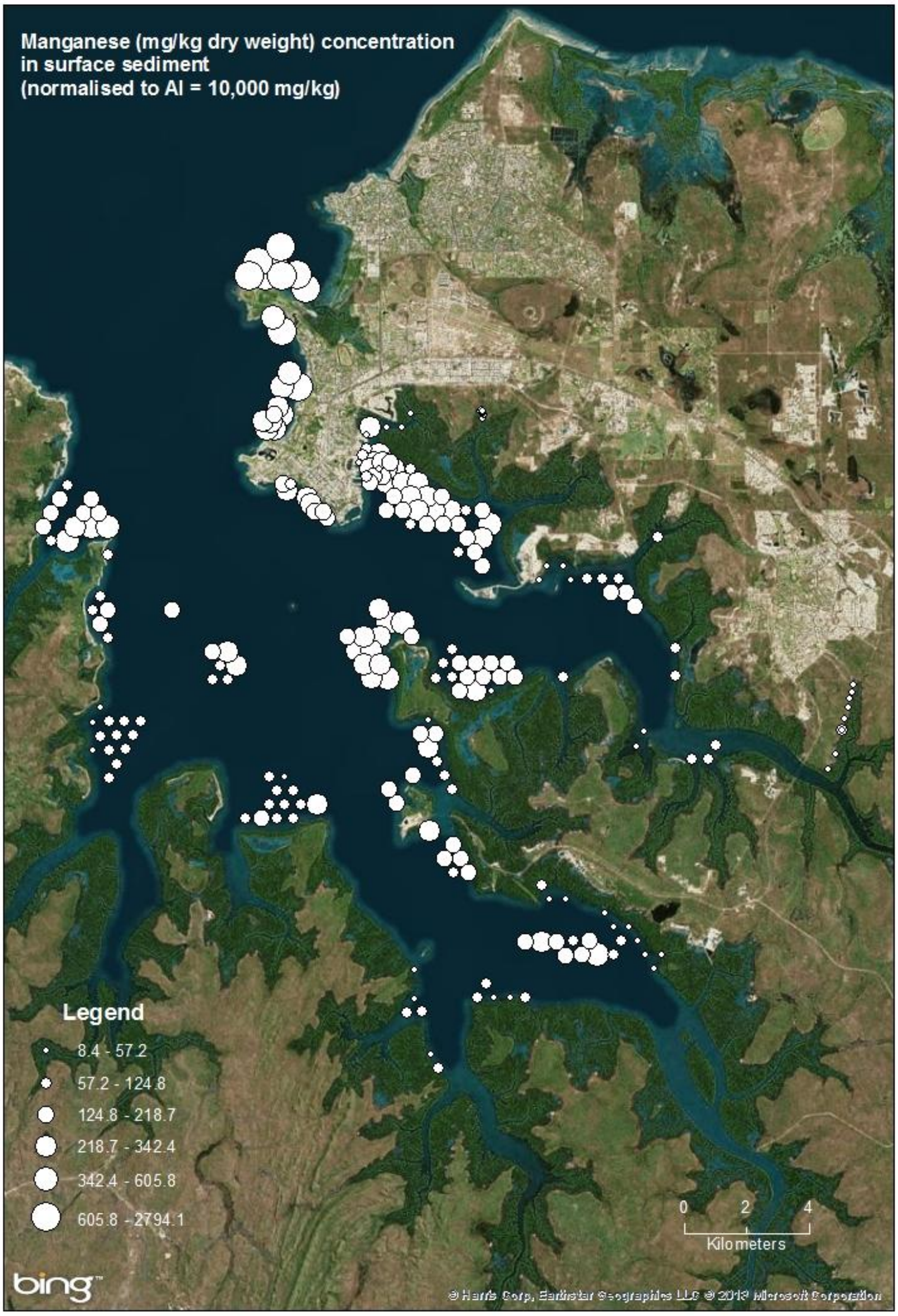
Manganese (mg/kg dry weight) concentration
in surface sediment
(normalised to Al = 10,000 mg/kg)
Legend
8.4 - 57.2
57.2 - 124.8
124.8 - 218.7
218.7 - 342.4
342.4 - 605.8
605.8 - 2794.1
0
2
4
Kilometers
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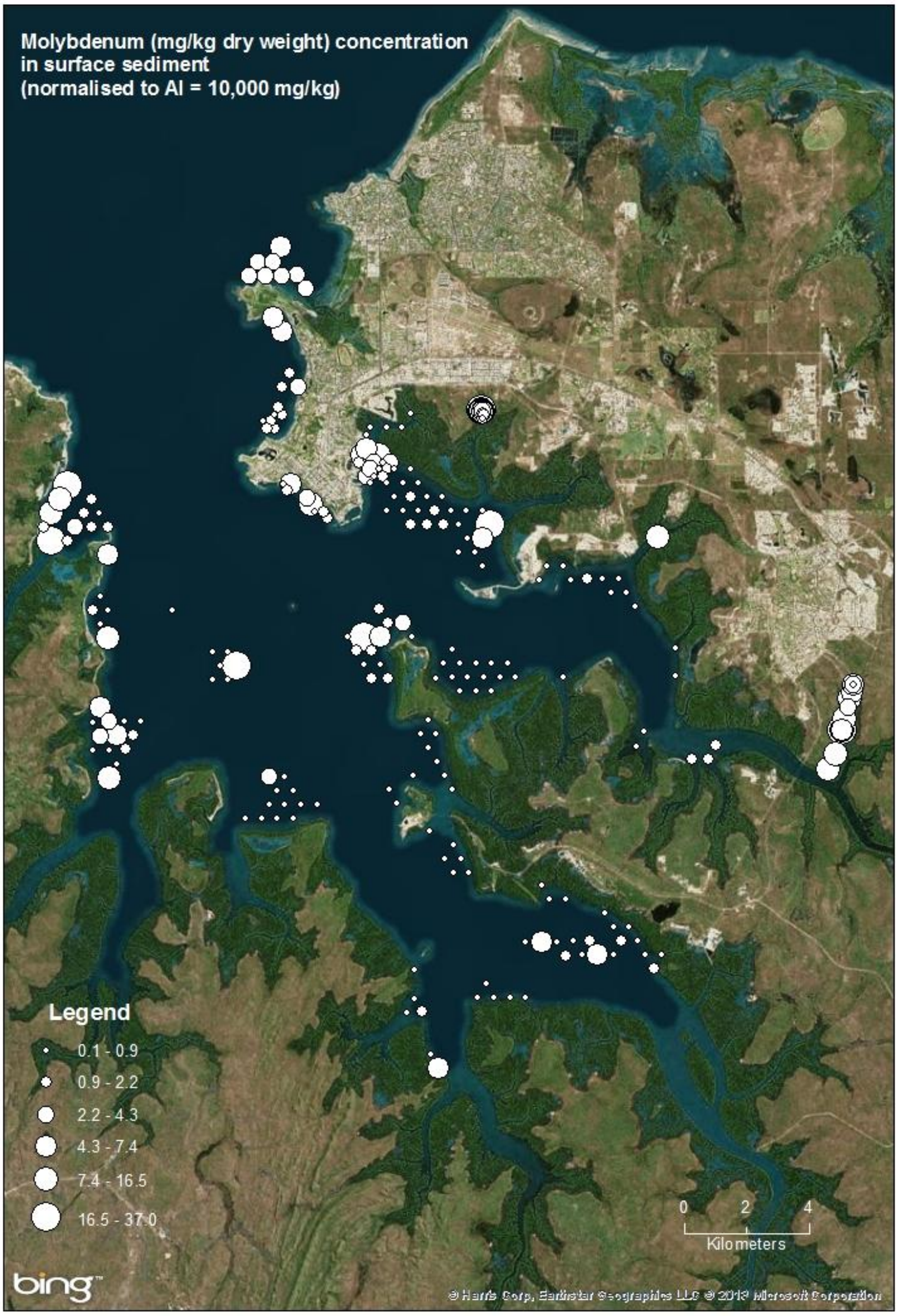
Molybdenum (mg/kg dry weight) concentration
in surface sediment
(normalised to Al = 10,000 mg/kg)
Legend
0.1 - 0.9
0.9 - 2.2
2.2 - 4.3
4.3 - 7.4
7.4 - 16.5
16.5 - 37.0
0
2
4
Kilometers
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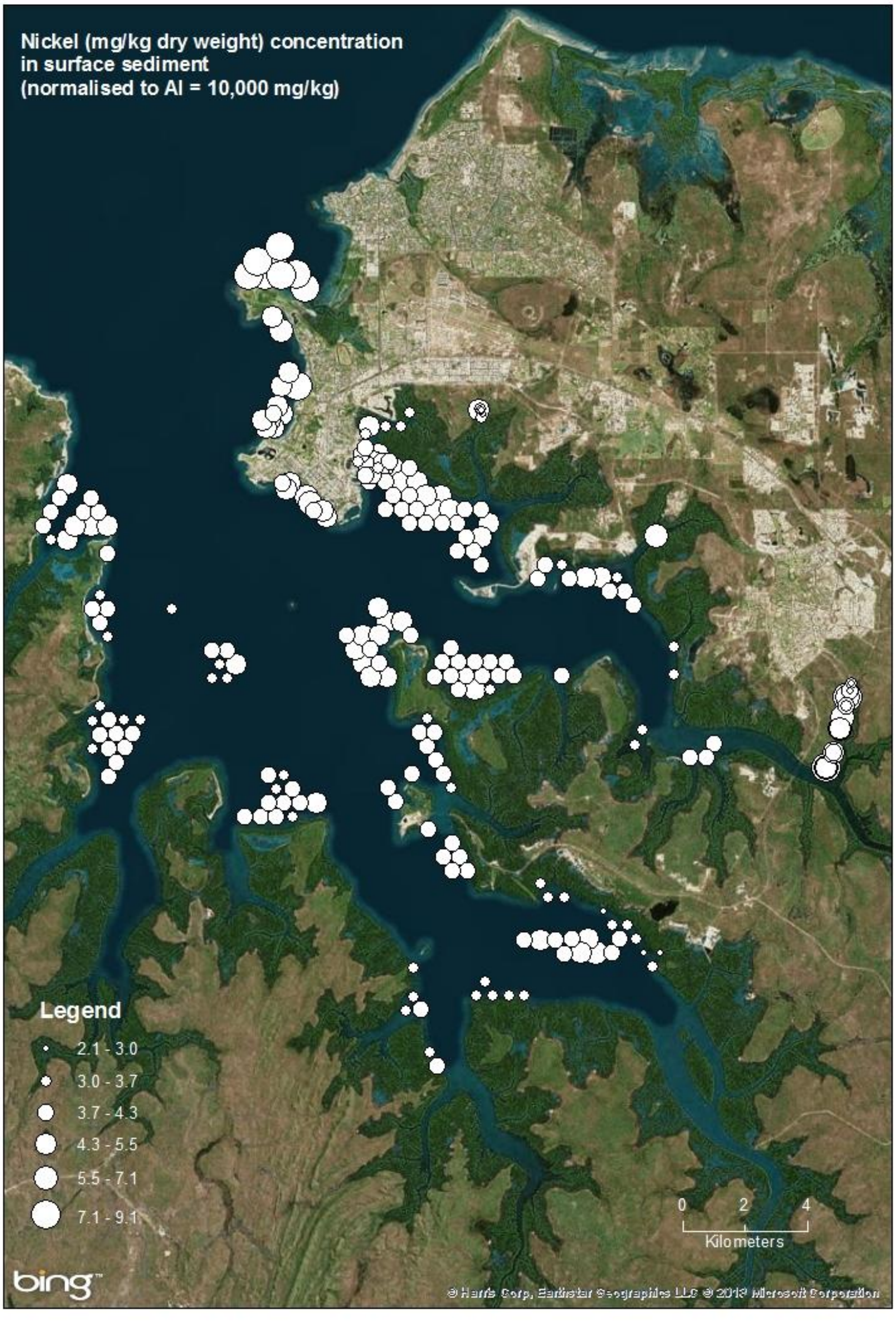
Nickel (mg/kg dry weight) concentration
in surface sediment
(normalised to Al = 10,000 mg/kg)
Legend
2.1 - 3.0
3.0 - 3.7
3.7 - 4.3
4.3 - 5.5
5.5 - 7.1
7.1 - 9.1
0
2
4
Kilometers
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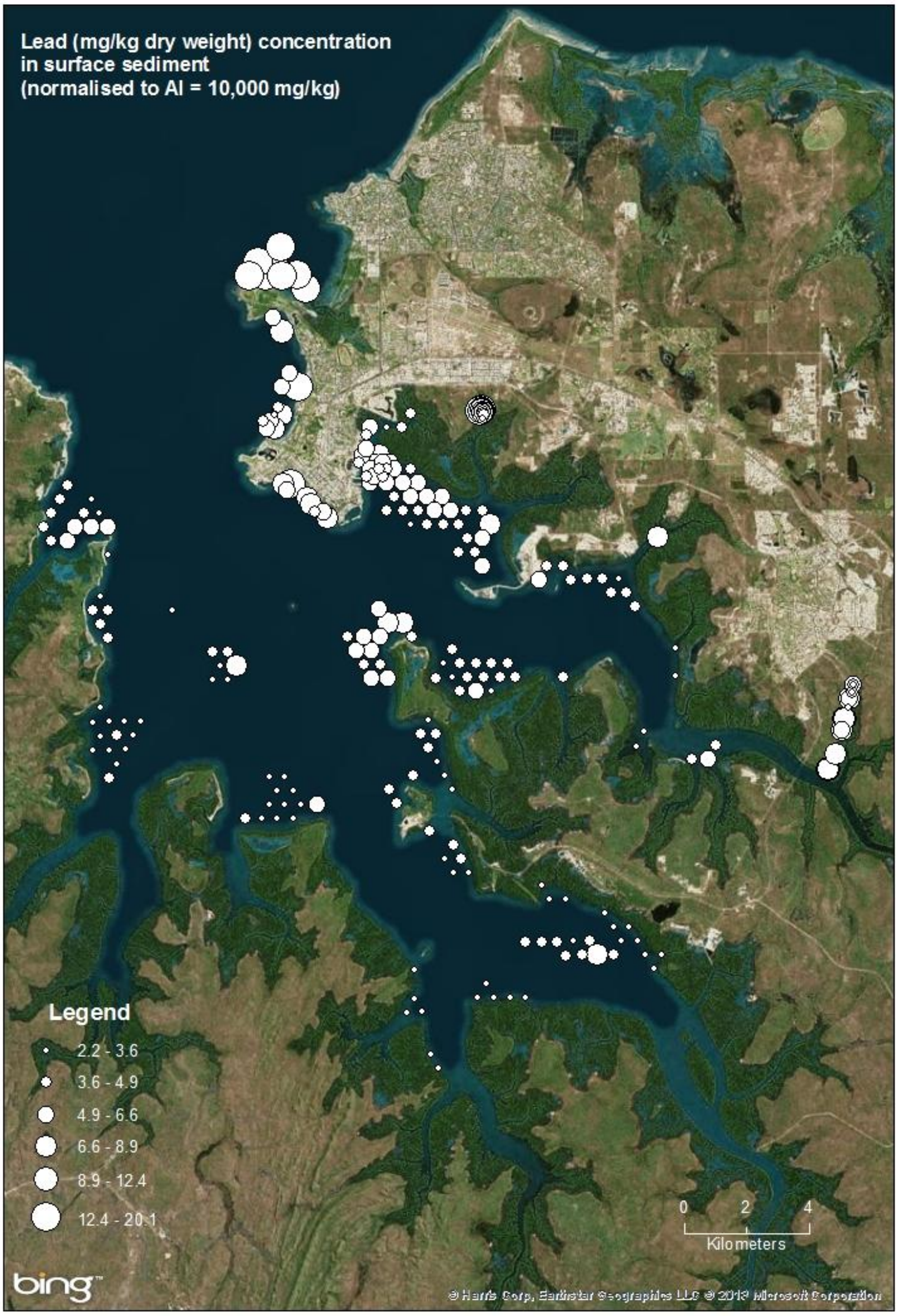
Lead (mg/kg dry weight) concentration
in surface sediment
(normalised to Al = 10,000 mg/kg)
Legend
2.2 - 3.6
3.6 - 4.9
4.9 - 6.6
6.6 - 8.9
8.9 - 12.4
12.4 - 20.1
0
2
4
Kilometers
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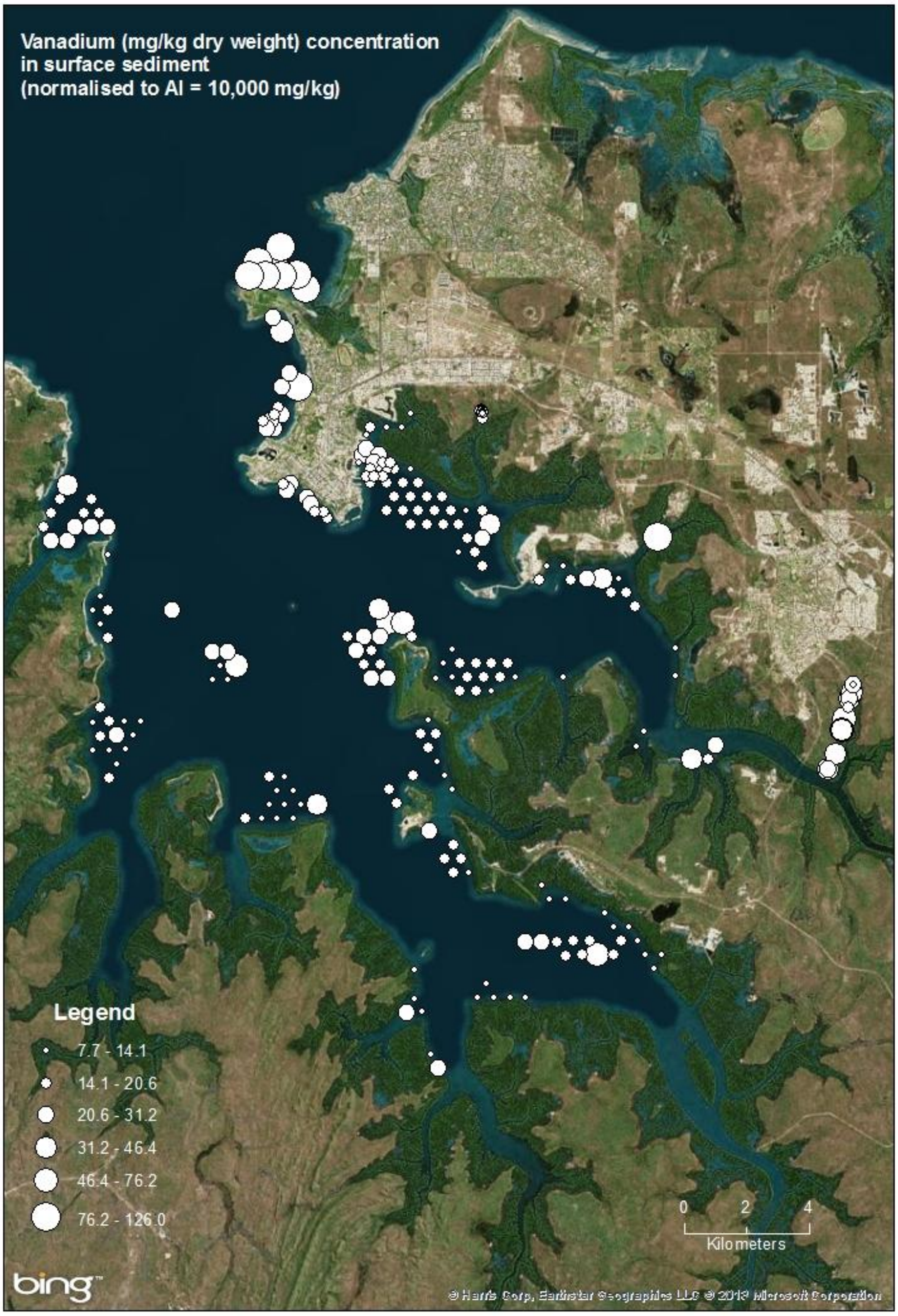
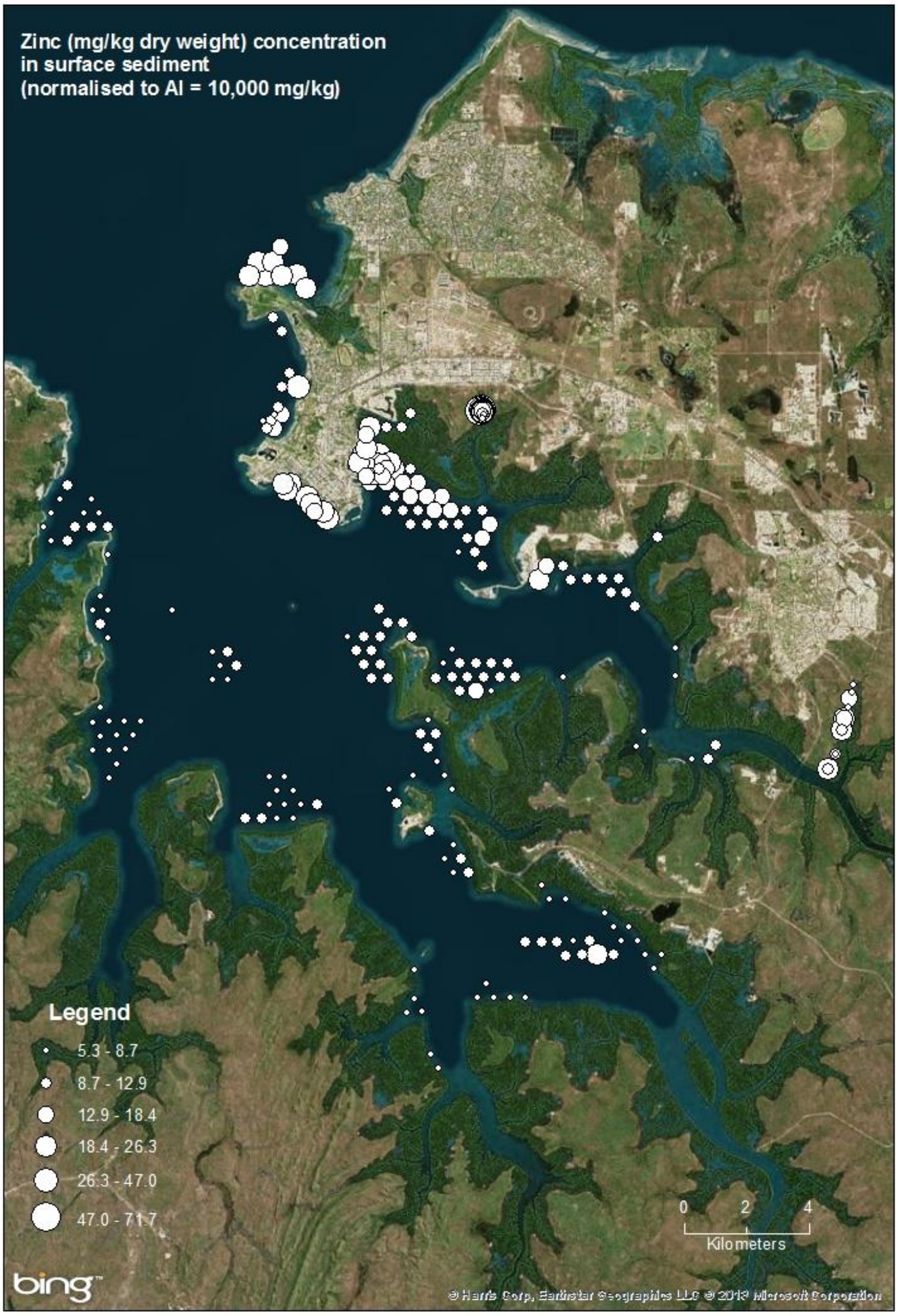


Vanadium (mg/kg dry weight) concentration in surface sediment (normalised to Al = 10,000 mg/kg)


Zinc (mg/kg dry weight) concentration
in surface sediment
(normalised to Al = 10,000 mg/kg)
Legend
5.3 - 8.7
8.7 - 12.9
12.9 - 18.4
18.4 - 26.3
26.3 - 47.0
47.0 - 71.7
0
2
4
Kilometers
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