29 June 2012 Project No. 1278203624-005-L

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INTERIM REPORT ON BIOACCESSIBILITY FEASIBILITY STUDY, MOANATAIARI SUBDIVISION, THAMES

Dear Francois

Golder Associates (NZ) Limited (Golder) is contracted to Thames-Coromandel District Council (TCDC) in relation to human health aspects of contaminated land investigation, assessment and remediation of the Moanataiari subdivision in Thames.

Tonkin and Taylor Ltd. (T&T) has identified elevated levels of arsenic and lead in shallow soils at Moanataiari, especially in eastern areas of the subdivision (T&T 2012). Concentrations of these elements often exceed the Soil Contaminant Standards (SCS) for generic residential use presented in *Methodology for Deriving Standards for Contaminants in Soil to Protect Human Health* (MfE, 2011; 'the Methodology').

While a formal conceptual site model has yet to be finalised, it appears that Moanataiari soils contain discontinuous layers of 'mullock' – sandy wastes from historic mining activities. This mullock appears to be the source of these elements. Different areas of the subdivision were infilled at different times, resulting in a range of concentrations across the subdivision.

International research indicates that elements in mineral forms, such as mullock, may not be very 'bioavailable'; that is, if the soil is ingested, then a proportion of the toxic element content generally passes through the body rather than being taken up by the digestive system. Bioavailability is a key factor in arsenic and lead toxicity (for lead, see MoH 2007). Generic screening criteria such as the SCS are typically conservative, and assume 100 percent bioavailability from soil ingestion. So if bioavailability is low at Moanataiari, the health risk of ingesting soil or dust will be less than the initial comparison with the SCS suggests.

However, there is no ready way of determining bioavailability directly. While it is possible to measure arsenic in urine or lead in blood, it is difficult to estimate how much of the elemental burden might be due to accidentally ingesting soil and dust, and unethical to expose people deliberately. Instead it is preferable to measure 'bioaccessibility' – the proportion of heavy metal that can be extracted from the soil, using leaching tests designed to mimic the action of the human stomach, and is therefore potentially available for uptake by the body.

Accordingly, TCDC contracted Golder Associates (NZ) Limited to conduct a bioaccessibility feasibility study on Moanataiari soils. This feasibility study has used the Relative Bioavailability Leaching Procedure (RBALP), developed in the laboratory of Dr. John Drexler at the University of Colorado at Boulder (refer SBRC, undated). The RBALP is simple to carry out, has been validated for specific soils in animal studies, and is routinely used by practitioners elsewhere, including Golder Associates in North America. The scope of work for the feasibility study was set out in the Golder proposal 1278203624-003-P dated 16 May 2012.

This interim report presents initial results from the bioaccessibility feasibility assessment. A final report will be provided subsequently, following comment from TCDC and other stakeholders.

Scope

The purpose of the bioaccessibility feasibility study was to investigate the hypothesis that Moanataiari soils have low arsenic and lead bioavailability. If bioaccessibility was found to be low, then the feasibility study would inform a subsequent full-scale bioaccessibility assessment, which in turn would be used to support a revised residents' health risk assessment for the subdivision. If bioaccessibility was close to 100 percent, that knowledge would also provide data for managing public health risks.

Further, because the RBALP procedure focuses on the 'fine' fraction of soil – the silt and clay particles passing a 250 μm sieve –, the feasibility study would provide information about concentrations of arsenic and lead in soil-derived dusts. Trace elements might be enriched in the finer soil fraction, or might be depleted.

Additionally, the feasibility study developed the capacity of a New Zealand laboratory, RJ Hill Laboratories Ltd. (Hill Labs) to undertake the RBALP procedure. This experience may be valuable should full-scale bioaccessibility assessment be desirable at Moanataiari, or at other local sites in the future.

Methodology

The feasibility study comprised:

- Reviewing the Pattle Delamore Partners Ltd. and T&T contamination data and soil descriptions for the subdivision soils.
- Selecting 20 soil samples collected by T&T during their previous soil investigation. The aim was to use a range of locations across the subdivision, a range of soil types and depths, and a range of likely lead and arsenic concentrations.
- Soil chemical analysis by Hill Labs, including:
  - Total extractable arsenic, lead, iron, manganese, phosphorus and pH in soil passing a 2 mm sieve
  - Total extractable arsenic and lead in soil passing a 250 μm sieve
  - Bioaccessible arsenic and lead using the RBALP method, which is performed on the <250 μm fraction only, and is designed to simulate the acidic human stomach environment.
- Estimating arsenic and lead bioaccessibility.
- Interpreting the results in a letter report (this report), including statistical analysis.

Results

Table 1 summarises the results from this feasibility study, together with relevant T&T data. Table 1 identifies the locations (properties) that the selected samples came from. The Hill Labs report is attached as Appendix A.

Total arsenic concentrations in the samples were similar to those determined by T&T in the field using a hand-held X-ray fluorescence detector (XRF). Total lead concentrations were closely similar to T&T XRF results. Therefore, the results of this feasibility study are considered generally comparable to those of the T&T site investigation.

As in the T&T investigation, arsenic concentrations were generally high in samples of fill material at depth in eastern areas of the subdivision (i.e., the samples from 101 Coromandel St., 109 Fergusson Drive, 114 Kuranui St, 208 Moanataiari St, 109 Tararu Rd, and 113 Tararu Rd.). These soils are generally dark brown or brownish orange sands, often with white mottling – although the 114 Kuranui St. sample is a clay. The samples of surface soil from 103 Coromandel St and 201 Tararu Rd, identified as 'topsoil' by T&T but with a virtually identical description, also seem to belong in this group.

However, the topsoil samples from 314 Kuranui St. and 117B Fergusson Drive in the eastern area of the subdivision, and the fill sample from 105 Burke St. in the extreme south-west corner, also show high arsenic concentrations (and moderately high lead) despite having rather different descriptions. Even from this small sample, it does not appear that the contaminants of concern are restricted to particular strata or to particular areas of the subdivision. This will require further evaluation to confirm.

Arsenic and lead concentrations in the <2 mm bulk material were closely similar to arsenic and lead concentrations in the <250 µm fine fraction. Arsenic and lead did not correlate with each other nor did they correlate strongly with iron, manganese or phosphorus. Statistical information relating to comments made in this interim report will be included in the final report.

According to the SBALP procedure, arsenic bioaccessibility in these samples was generally less than 10 percent, independent of soil type and other analyte concentrations. For lead the bioaccessibility picture is more complex. Figure 1 plots total recoverable lead (for the <250 µm fraction) against bioaccessible lead. It is evident that when total lead concentrations are low, bioaccessibility is low too. But at moderate to high lead concentrations, lead bioaccessibility is higher, around 70 %.

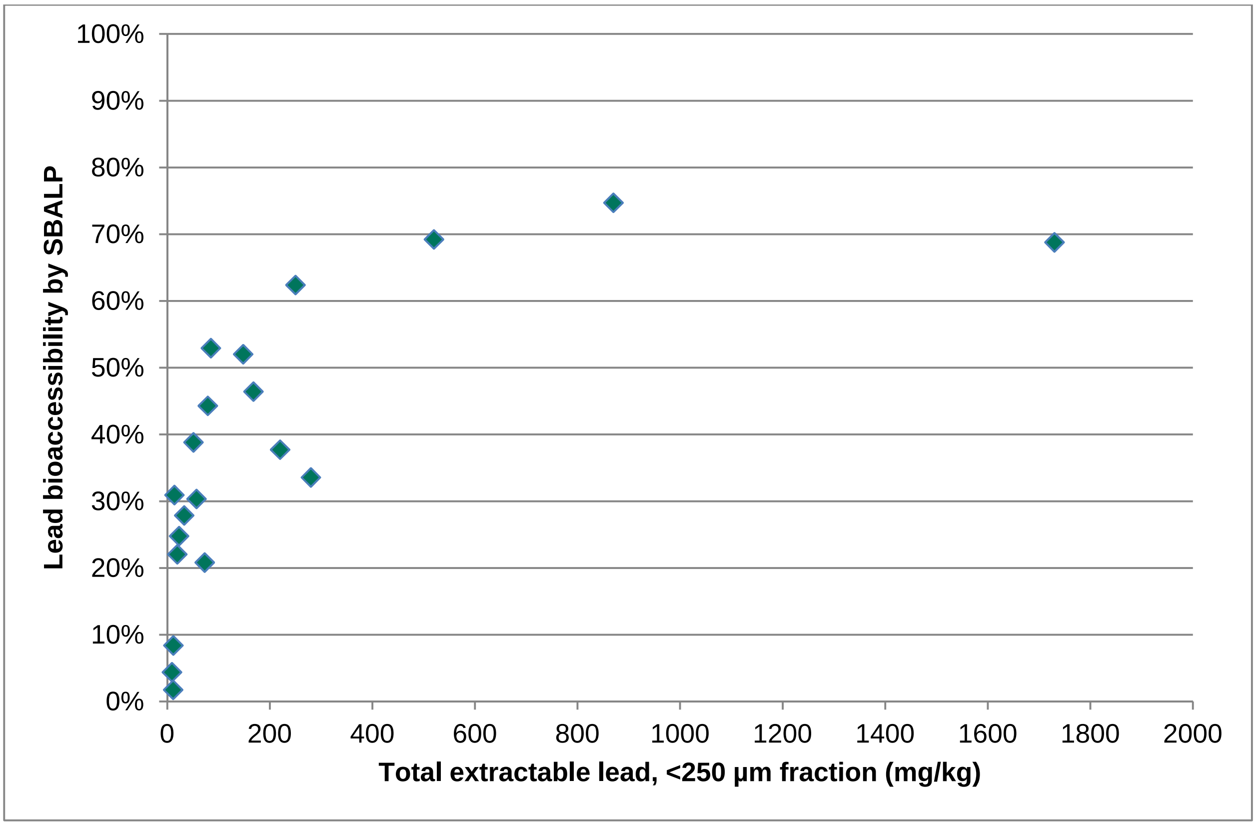

Figure 1: Total extractable lead compared to bioaccessible lead.

Discussion

Arsenic bioaccessibility

Arsenic in the Moanataiari soils examined in this study appears to have generally very low bioaccessibility, as would be expected for a mineral-bound form of arsenic.

However, there was one exception; the topsoil sample from the vegetable garden of 437 Fergusson Drive yielded an arsenic bioaccessibility of 38 %. Hill Labs re-analysed the gastric extract and obtained the same value, so it is not considered to be a laboratory error. Statistical analysis using the Grubbs test identifies this value as a highly significant outlier (T_n = 3.7; refer CIEH 2008), implying that this sample is fundamentally different from all the others. It is not yet clear why this is the case. This matter will be discussed further in the final report]

Setting this single result aside, the mean bioaccessibility of arsenic in Moanataiari soils appears to be less than 6.6 % (with 95 % confidence, using the one-tailed Chebychev theorem; refer CIEH 2008).

For comparison, arsenic bioaccessibility ranged from 12 to 45 % in some New Zealand orchard soils that had historically been treated with lead arsenate pesticide sprays, expected to be a relatively bioaccessible form of arsenic (Gaw et al. 2008). So the results obtained for Moanataiari soils are considered credible.

To provide some initial information, following the Methodology, but taking arsenic bioaccessibility for soil ingestion to be 10 %, would increase the arsenic SCS for standard residential end use from 20 mg/kg to 78 mg/kg. If any part of the subdivision were re-zoned commercial, then 10 percent bioaccessibility would yield a property-specific SCS for arsenic in that part of 630 mg/kg.

The standard residential use scenario includes 10 % home-grown fruit and vegetable consumption. When oral bioaccessibility is reduced to 10 %, consuming home-grown produce becomes the principal route of exposure for arsenic in residential use.

Golder notes that two fruit samples from a Moanataiari property were recently tested and found to contain no detectable arsenic. Health advice following testing of produce from the nearby Brightsmile Gardens, also sited on soils from former mining activities, is that consumption of seasonal fruit is unlikely to create a health risk (Hood 2012). Further testing and detailed risk assessment might therefore allow the site-specific arsenic SCS to be revised further upwards. If produce consumption could be ruled out altogether, due to remediation or management, the subdivision-specific arsenic SSC would be 220 mg/kg at 10 % oral bioaccessibility.

However, before any subdivision-specific values could be applied, the possibility of significant exceptions needs to be explored further.

Lead bioaccessibility

By contrast, lead bioaccessibility appears moderate, especially in those soils that have moderate to high lead concentrations, where bioaccessibility was estimated at around 70 %. It is not surprising that lead and arsenic should have different bioaccessibilities, since their chemistry in soils is rather different. This principle is supported by the observation in this study that lead and arsenic concentrations in Moanataiari soils are not closely tied, again suggesting they are present in different chemical and mineral forms.

Following the Methodology, but taking lead bioaccessibility for soil ingestion to be 70 %, would increase the lead SCS for standard residential end use from 210 mg/kg to 280 mg/kg. If home-grown produce ingestion could be reduced from 10 % to zero, the subdivision-specific SCS would increase further, to 360 mg/kg. In addition, if any part of the subdivision were re-zoned commercial, a property-specific SCS for lead in that part could be 4,700 mg/kg.

Soil-derived dust

Arsenic and lead concentrations in fine soil are much the same as in the bulk material. This is consistent with a mineral origin, without extensive chemical change or weathering. Since high concentrations of arsenic and lead can evidently be found in fine soil particles, soil-derived dust could pose a health risk at Moanataiari, especially if there are any major ground works in future. This risk is not accounted for within the generic SCS, which principally focuses on the risks of ingesting metal-contaminated soil.

Conclusion / recommendations

Based on the results of this initial assessment of the results from the bioaccessibility feasibility study, the following conclusions and recommendations are presented:

- The results strongly suggest that soil screening using the generic SCS significantly overestimates the health risk to Moanataiari residents, especially the risk from soil arsenic. This is because the SCS risk driver is principally soil ingestion, and 100 % bioavailability has been assumed in the calculation of these values.
- The results suggest that arsenic bioaccessibility is low and could be less than 10 %.
- The results suggest that the lead bioaccessibility could be moderate, on the order of 70 % in soils with elevated lead concentrations of 300 mg/kg or greater.
- Based on the above bioaccessibility estimates, and substituting these values into the SCS algorithms given in the Methodology, the revised SCS for arsenic and lead would be in the order of 78 mg/kg and 280 mg/kg respectively.
- Eliminating home-grown produce consumption further increases calculated SCS to 220 mg/kg for arsenic and 360 mg/kg for lead.
- The results obtained to-date indicate that a detailed bioaccessibility study be performed, in conjunction with a detailed site-specific human health risk assessment, before embarking on intrusive remediation. The health risk assessment should not be limited to risks associated with soil ingestion. It should consider other potentially significant exposure pathways, such as exposure to soil-derived dust, and uptake of arsenic and lead by fruit and vegetables. It is expected that this information will be needed to design, and obtain consent for, any programme of action to safeguard the residents of Moanataiari.
- The health risk assessment should assess risk before and after application of remediation methodologies or management options.

References

CIEH 2008. Comparing soil contamination data with a critical concentration. Chartered Institute of Environmental Health with Contaminated Land Applications in Real Environments. London.

Gaw S, Kim N, Northcott G, Wilkins A, Robinson G 2008. Developing site-specific guidelines for orchard soils based on bioaccessibility – can it be done? Chemistry in New Zealand, April 2008, pp. 47-50. New Zealand Institute of Chemistry. Christchurch.

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SBRC undated. *In vitro* method for determining lead bioaccessibility: standard operating procedure for stomach phase extraction. Revision 8. Solubility / Bioavailability Research Consortium. Boulder, Colorado, USA.

T&T 2012. Phase 2 site-specific property assessment reports. Nos. 1004, 1005, 1024, 1032, 1041, 1042, 1051, 1057, 1078, 1084, 1092, 1105, 1121, 1133, 1156, 1170, 1184, 1196, 1200, 1211. Reports prepared for Thames-Coromandel District Council by Tonkin and Taylor Ltd. Auckland.

We trust our interim report meets your requirements. Should you have any queries, please contact Dr. Dave Bull in the first instance, either on 021 330 397 or by email at dbull@golder.co.nz.

Yours sincerely

GOLDER ASSOCIATES (NZ) LIMITED

For:

Dave Bull
Senior Contaminated Site Consultant

Simon Hunt
Associate

Attachments: Table 1: Soils analysed in this feasibility study.
Hills Laboratory Reports

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Table 1: Soils analysed in this feasibility study.

Address	105 Burke St.	107 Burke St.	113 Centennial Ave.	202 Centennial Ave.	101 Coromandel St.	103 Coromandel St.	204 Ensor St.	303 Ensor St.	109 Fergusson Dve.	117B Fergusson Dve.
General Location	Front lawn	Vegetable garden	Front lawn	N boundary	Back lawn	Back lawn near patio / peach tree	Front lawn	Front lawn	NE corner back yard	SE side
Property Number:	1004	1005	1024	1032	1041	1042	1051	1057	1078	1084
Borehole Number:	1	2	1	2	2	2	1	1	1	1
Depth (mm bgl)	750-850	500-600	500-600	1000-1100	500-600	0-100	0-100	500-600	1000-1100	0-100
Material Type	Fill	Fill	Fill	Fill	Fill	Topsoil?	Topsoil	Fill	Fill	Topsoil
Soil Description	Silty fine to coarse SAND; dark brown, mottled brown. Loose; moist.	Silty fine-coarse SAND; light brown mottled white. Medium dense; white	SILT with minor medium sand; light brownish orange. Soft dry.	Coarse SAND with minor fine to medium gravel; light brown mottled brown. Loose, wet.	Sandy SILT with minor clay; brownish orange with mottled white. Firm; moist; sand, fine-coarse.	Fine SAND with minor fine gravel, dark brown mottled white. Loose, dry.	Silty fine-medium SAND; brown. Medium-dense, dry.	Fine-coarse SAND; mottled light brown and white. Loose; dry	Fine SAND; light brownish orange. Loose; wet.	Sandy SILT; dark brown. Very soft; moist; sand medium to coarse.
Arsenic (XRF)	344	90	106	237	60	156	115	235	187	142
Lead (XRF)	478	8	5	9	40	137	46	13	434	179
Thallium (XRF)	7.3	3	4.7	6.3	3	no result	5	3	3	0
Lab Number: <2 mm fraction	1014558.2 / 994697.1	1014558.1	1014558.2	1014558.3	1014558.4	1014558.5	1014558.6	1014558.7	1014558.8	1014558.9
Total Recoverable Arsenic	240 / 260	130	110	173	127	250	139	300	480	240
Total Recoverable Iron	44,000	26,000	16,500	42,000	41,000	49,000	42,000	41,000	18,700	37,000
Total Recoverable Lead	840 / 780	15.1	10.5	11.5	104	175	48	26	540	240
Total Recoverable Manganese	500	106	28	86	480	320	830	123	250	540
Total Recoverable Phosphorus	880	270	124	490	760	1,750	370	470	167	1,780
pH (pH units)	7.4	4.2	4.3	4.7	7.1	5.3	5	4.2	7.6	6
Lab Number: <250 μm fraction	1014558.4	1014558.21	1014558.22	1014558.23	1014558.24	1014558.25	1014558.26	1014558.27	1014558.28	1014558.29
Gastric Extractable Arsenic	24	2.1	1.8	4.2	8.3	19.1	1.1	1.9	33	18.9
Total Recoverable Arsenic	240	135	127	200	131	270	140	320	440	250
Gastric Extractable Lead	650	4.3	1	4.3	78	83	19.8	9.2	360	94
Total Recoverable Lead	870	19.5	11.9	13.9	168	220	51	33	520	280
Arsenic Bioaccessibility	10 %	2 %	1 %	2 %	6 %	7 %	1 %	1 %	8 %	8 %
Lead Bioaccessibility	75 %	22 %	8 %	31 %	46 %	38 %	39 %	28 %	69 %	34 %

All concentrations mg/kg dry weight unless otherwise specified. Address, general location, property number, borehole number, sample depth, material type, soil description, XRF results, and the initial lab result for the sample from 105 Burke St. borehole 1 all supplied by T&T and shown in gray.

Address	207 Fergusson Dve.	411A Fergusson Dve.	437 Fergusson Dve.	114 Kuranui St.	314 Kuranui St.	105 Moanataiari St.	208 Moanataiari St.	109 Tararu Rd.	113 Tararu Rd.	201 Tararu Rd.
General Location	Back yard	Front lawn	Vegetable garden	Back lawn near deck	Rear lawn	Front yard	Fruit trees	Back lawn	Front lawn	Front garden
Property Number:	1092	1105	1121	1133	1156	1170	1184	1196	1200	1211
Borehole Number:	2	1	3	2	2	1	2	2	1	1
Depth (mm bgl)	0-100	1000-1100	0-100	500-600	0-100	500-600	500-600	500-600	500-600	0-100
Material Type	Topsoil	Fill	Topsoil	Fill	Topsoil	Fill	Fill	Fill	Fill	Topsoil?
Strata	Medium SAND with minor medium-coarse gravel. Dark brown. Loose. Dry.	Coarse SAND with minor medium-coarse gravel; orange mottled white. Loose; saturated.	Sandy SILT; brown. Soft; moist; sand, fine-coarse	Silty CLAY; brownish orange. Very soft; 0.5-0.6m moist.	Fine SAND with minor medium to coarse gravel; dark brown. Loose; dry.	Silty CLAY with minor sand; mottled light brown and white. Firm; moist.	Medium SAND with minor fine-medium gravel; brownish orange. Medium dense; dry.	Silty medium SAND; brown. Loose; dry.	Silty fine SAND with minor fine gravel; brown. Medium dense; moist.	Silty fine SAND; brownish orange. Loose; dry.
Arsenic (XRF)	13	71	67	212	179	126	436	67	208	189
Lead (XRF)	60	5	170	36	860	7	3	95	44	66
Thallium (XRF)	12	3	9.3	4	23	3	4.3	3	3	4
Lab Number: <2 mm fraction	1014558.1	1014558.11	1014558.12	1014558.13	1014558.14	1014558.15	1014558.16	1014558.17	1014558.18	1014558.19
Total Recoverable Arsenic	26	111	81	450	270	156	670	85	330	370
Total Recoverable Iron	26,000	16,400	27,000	57,000	53,000	43,000	61,000	41,000	52,000	33,000
Total Recoverable Lead	86	7.3	220	51	1,420	23	9.8	116	64	94
Total Recoverable Manganese	800	78	700	163	910	80	197	580	670	197
Total Recoverable Phosphorus	820	143	2,200	350	1,660	270	500	440	440	410
pH (pH units)	5.8	6.7	7.2	7.4	7	3.5	3.5	7.5	7.2	5.5
Lab Number: <250 µm fraction	1014558.3	1014558.31	1014558.32	1014558.33	1014558.34	1014558.35	1014558.36	1014558.37	1014558.38	1014558.39
Gastric Extractable Arsenic	<1.0	3.9	34	1.9	15.8	1.5	2.4	4.4	10.4	10.2
Total Recoverable Arsenic	24	120	89	470	300	150	720	99	340	330
Gastric Extractable Lead	45	0.4	156	17.3	1,190	5.7	0.2	77	15.2	35
Total Recoverable Lead	85	9.1	250	57	1,730	23	11.4	148	73	79
Arsenic Bioaccessibility	<4%	3%	38%	0%	5%	1%	0%	4%	3%	3%
Lead Bioaccessibility	53%	4%	62%	30%	69%	25%	2%	52%	21%	44%

All concentrations mg/kg dry weight unless otherwise specified.

Address, general location, property number, borehole number, sample depth, material type, soil description, and XRF results supplied by T&T and shown in gray.

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ANALYSIS REPORT

Client:	Golder Associates (NZ) Limited	**Lab No:**	1014558 SPv2
Contact:	S Hunt	**Date Registered:**	07-Jun-2012
	C/- Golder Associates (NZ) Limited	**Date Reported:**	22-Jun-2012
	PO Box 33849	**Quote No:**	49039
	Takapuna	**Order No:**	
	NORTH SHORE CITY 0740	**Client Reference:**	Moanataiari Soil
		Submitted By:	Joanne Ferry

Sample Type: Soil

Sample Name:		1005_2_500	1024_1_500	1032_2_1000	1041_2_500	1042_2_0
Lab Number:		1014558.1	1014558.2	1014558.3	1014558.4	1014558.5
Total Recoverable Arsenic	mg/kg dry wt	130	110	173	127	250
Total Recoverable Iron	mg/kg dry wt	26,000	16,500	42,000	41,000	49,000
Total Recoverable Lead	mg/kg dry wt	15.1	10.5	11.5	104	175
Total Recoverable Manganese	mg/kg dry wt	106	28	86	480	320
Total Recoverable Phosphorus	mg/kg dry wt	270	124	490	760	1,750
pH*	pH Units	4.2	4.3	4.7	7.1	5.3

Sample Name:		1051_1_0A	1057_1_500	1078_1_1000	1084_1_0	1092_2_0
Lab Number:		1014558.6	1014558.7	1014558.8	1014558.9	1014558.10
Total Recoverable Arsenic	mg/kg dry wt	139	300	480	240	26
Total Recoverable Iron	mg/kg dry wt	42,000	41,000	18,700	37,000	26,000
Total Recoverable Lead	mg/kg dry wt	48	26	540	240	86
Total Recoverable Manganese	mg/kg dry wt	830	123	250	540	800
Total Recoverable Phosphorus	mg/kg dry wt	370	470	167	1,780	820
pH*	pH Units	5.0	4.2	7.6	6.0	5.8

Sample Name:		1105_1_1000	1121_3_0	1133_2_500	1156_2_0	1170_1_500
Lab Number:		1014558.11	1014558.12	1014558.13	1014558.14	1014558.15
Total Recoverable Arsenic	mg/kg dry wt	111	81	450	270	156
Total Recoverable Iron	mg/kg dry wt	16,400	27,000	57,000	53,000	43,000
Total Recoverable Lead	mg/kg dry wt	7.3	220	51	1,420	23
Total Recoverable Manganese	mg/kg dry wt	78	700	163	910	80
Total Recoverable Phosphorus	mg/kg dry wt	143	2,200	350	1,660	270
pH*	pH Units	6.7	7.2	7.4	7.0	3.5

Sample Name:		1184_2_500	1196_2_500	1200_1_500	1211_1_0	1004-1-750 [994697.1]
Lab Number:		1014558.16	1014558.17	1014558.18	1014558.19	1014558.20
Total Recoverable Arsenic	mg/kg dry wt	670	85	330	370	240
Total Recoverable Iron	mg/kg dry wt	61,000	41,000	52,000	33,000	44,000
Total Recoverable Lead	mg/kg dry wt	9.8	116	64	94	840
Total Recoverable Manganese	mg/kg dry wt	197	580	670	197	500
Total Recoverable Phosphorus	mg/kg dry wt	500	440	440	410	880
pH*	pH Units	3.5	7.5	7.2	5.5	7.4

Sample Name:		1005_2_500 (<250um fraction)	1024_1_500 (<250um fraction)	1032_2_1000 (<250um fraction)	1041_2_500 (<250um fraction)	1042_2_0 (<250um fraction)
Lab Number:		1014558.21	1014558.22	1014558.23	1014558.24	1014558.25
Gastric Extractable Arsenic*	mg/kg dry wt	2.1	1.8	4.2	8.3	19.1
Total Recoverable Arsenic	mg/kg dry wt	135	127	200	131	270
Gastric Extractable Lead*	mg/kg dry wt	4.3	1.0	4.3	78	83
Total Recoverable Lead	mg/kg dry wt	19.5	11.9	13.9	168	220

Sample Type: Soil

Sample Name:		1051_1_0A (<250um fraction)	1057_1_500 (<250um fraction)	1078_1_1000 (<250um fraction)	1084_1_0 (<250um fraction)	1092_2_0 (<250um fraction)
Lab Number:		1014558.26	1014558.27	1014558.28	1014558.29	1014558.30
Gastric Extractable Arsenic*	mg/kg dry wt	1.1	1.9	33	18.9	< 1.0
Total Recoverable Arsenic	mg/kg dry wt	140	320	440	250	24
Gastric Extractable Lead*	mg/kg dry wt	19.8	9.2	360	94	45
Total Recoverable Lead	mg/kg dry wt	51	33	520	280	85

Sample Name:		1105_1_1000 (<250um fraction)	1121_3_0 (<250um fraction)	1133_2_500 (<250um fraction)	1156_2_0 (<250um fraction)	1170_1_500 (<250um fraction)
Lab Number:		1014558.31	1014558.32	1014558.33	1014558.34	1014558.35
Gastric Extractable Arsenic*	mg/kg dry wt	3.9	34	1.9	15.8	1.5
Total Recoverable Arsenic	mg/kg dry wt	120	89	470	300	150
Gastric Extractable Lead*	mg/kg dry wt	0.4	156	17.3	1,190	5.7
Total Recoverable Lead	mg/kg dry wt	9.1	250	57	1,730	23

Sample Name:		1184_2_500 (<250um fraction)	1196_2_500 (<250um fraction)	1200_1_500 (<250um fraction)	1211_1_0 (<250um fraction)	1004-1-750 (<250um fraction)
Lab Number:		1014558.36	1014558.37	1014558.38	1014558.39	1014558.40
Gastric Extractable Arsenic*	mg/kg dry wt	2.4	4.4	10.4	10.2	24
Total Recoverable Arsenic	mg/kg dry wt	720	99	340	330	240
Gastric Extractable Lead*	mg/kg dry wt	0.2	77	15.2	35	650
Total Recoverable Lead	mg/kg dry wt	11.4	148	73	79	870

SUMMARY OF METHODS

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

Sample Type: Soil

Test	Method Description	Default Detection Limit	Samples
Environmental Solids Sample Preparation	Air dried at 35°C and sieved, <2mm fraction. Used for sample preparation. May contain a residual moisture content of 2-5%.	-	1-20
Sieving through 250 um sieve, no gravimetric result*	<250µm Dry Sieved with no gravimetric determination.	-	1-20
Soil Prep Dry & Sieve for Agriculture	Air dried at 35°C and sieved, <2mm fraction.	-	1-20
Gastric Extraction*	Simulated gastric extraction using glycine/HCl fluid , pH 1.5. Shaken for 1hr at 37°C. Assessing Oral Bioavailability of Metals in Soil, 2002.	-	21-40
Total Recoverable digestion	Nitric / hydrochloric acid digestion. US EPA 200.2.	-	1-40
Gastric Extractable Arsenic*	Gastric extraction, 37°C, 1hr, ICP-MS, screen level. APHA 3125 B 21st ed. 2005.	1.0 mg/kg dry wt	21-40
Total Recoverable Arsenic	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, screen level. US EPA 200.2.	2 mg/kg dry wt	1-40
Total Recoverable Iron	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, screen level. US EPA 200.2.	40 mg/kg dry wt	1-20
Gastric Extractable Lead*	Gastric extraction, 37°C, 1hr, ICP-MS, screen level. APHA 3125 B 21st ed. 2005.	0.2 mg/kg dry wt	21-40
Total Recoverable Lead	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, screen level. US EPA 200.2.	0.4 mg/kg dry wt	1-40
Total Recoverable Magnesium	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, screen level. US EPA 200.2.	40 mg/kg dry wt	1-20
Total Recoverable Manganese	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, screen level. US EPA 200.2.	1.0 mg/kg dry wt	1-20
Total Recoverable Phosphorus	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, screen level. US EPA 200.2.	40 mg/kg dry wt	1-20
pH*	1:2 (v/v) soil : water slurry followed by potentiometric determination of pH.	0.1 pH Units	1-20

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

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

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