LAKE WELLS
SOIL AND SEDIMENT ASSESSMENT

PREPARED FOR:

AUSTRALIAN POTASH LIMITED

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PREPARED BY:

Martinick Bosch Sell Pty Ltd
4 Cook Street
West Perth WA 6005
Ph: (08) 9226 3166
Fax: (08) 9226 3177
Email: info@mbsenvironmental.com.au
Web: www.mbsenvironmental.com.au

LAKE WELLS PROJECT
SOIL AND SEDIMENT ASSESSMENT

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1. INTRODUCTION

The Lake Wells Potash Project (the project) is located in the northeast part of the Yilgarn Craton of Western Australia over a significant area of palaeovalley and salt lakes. Pit sampling, auger and air-core drilling to date have demonstrated the presence of consistent high grade potash brine concentrations to significant depth both on and adjacent to salt lakes.

Australian Potash Limited (Australian Potash) proposes to develop and operate a facility to extract and purify natural brines at Lake Wells to produce potassium sulphate (sulphate of potash). Implementation of the project will require land clearing, groundwater abstraction, mineral processing, storage of waste salt and a variety of support activities (construction or upgrade of roads, operation of an accommodation village and airstrip).

The project was referred to the EPA on 20 December 2017 and on 5 February 2018 the EPA set the Level of Assessment at Environmental Review (No Public Comment).

The Environmental Scoping Document (ESD) was approved by the EPA on 28 September 2018 and included a summary of the work required to inform the completion of the Environmental Review document. In relation to the factor Inland Waters (a combination of the previous factors Hydrological Processes and Inland Water Environmental Quality), the following work was required:

- Characterise sediments to be disturbed by on-playa infrastructure in terms of the presence of acidic sulphate soils, metals and metalloid concentrations in addition to salt concentrations.
- Evaluate the potential for mobilisation of metals from sediment porewaters due to disturbance and evapo-concentration of metals within ponds and detail mitigation measures if required.
- Assess the likelihood for change in pH, salinity and metals concentrations of surface waters within the ponds and potential toxicity for waterbirds and aquatic invertebrate fauna.

This report presents data and key findings in relation to these requirements based on laboratory analysis of soil and lakebed sediment samples.

2. OBJECTIVES AND SCOPE OF WORK

2.1 OBJECTIVES

MBS Environmental (MBS) was engaged by Australian Potash to undertake a soil and sediment assessment to inform environmental impact assessment and closure planning. The primary objective of the study was to determine whether proposed site activities would pose any significant risks to the surrounding environment, particularly through disturbance of acid sulphate soils (if present) and metal and metalloid mobilisation.

2.2 SCOPE OF WORK

The scope of work comprised:

- Visual examination of eight lakebed sediment samples by an experienced geochemist to supplement field log descriptions supplied by Australian Potash.
- Assessment of assay data for 75 soil samples (from depth of 0 to 4 metres) collected during exploration drilling adjacent to the Lake Wells playa.
- Submission of lakebed sediment, soil and water samples for analysis by a NATA accredited laboratory for total and leachable metals and metalloids and other general chemical parameters.
- Review of laboratory data and incorporate findings into a technical report.

3. PREVIOUS STUDIES

In 2016, Galt Environmental (Galt) completed an assessment of lakebed sediment samples collected from boreholes and test pits in accordance with the former Department of Environmental Regulation (DER) (now Department of Water and Environmental Regulation (DWER) guideline 'Identification and Investigation of Acid Sulfate Soils and Acidic Landscapes'.

The study indicated that acid sulphate soil (ASS) was not present in the material tested. Furthermore, appreciable quantities of acid neutralising capacity (ANC) were present within the soils tested, suggesting that the material has significant self-buffering ability. Galt also noted that as the samples taken during this study were generally of shallow material (i.e. from less than 1.0 m depth), in the event that significant excavations below 1 m are required, additional characterisation of soils may be required. Furthermore, the testing done was considered to be "sparse" when compared with the test frequency recommended by the DER.

The samples were also tested for heavy metal and total organic carbon (TOC) content. Key findings were:

- The concentrations of the majority of heavy metals were recorded either below the laboratory limit of reporting (LOR) or marginally above the laboratory LOR.
- The concentrations of aluminium and iron were four to five times orders of magnitude higher than the laboratory LOR, which is consistent with the expected chemical composition of the material.
- High concentrations of calcium, magnesium, phosphorus, sodium and sulphur were detected in the majority of samples and this is consistent with the known composition of lakebed sediments.
- The concentration of TOC was either below or marginally above the LOR in all samples.

Australian Potash advised that eight additional samples of lakebed sediments had been collected from Lake Wells between 17 and 19 October 2018. The samples were collected from depths between 0.3 and 0.7 metres below ground level (mbgl).

4. SAMPLE DESCRIPTIONS

Samples and associated laboratory data for this assessment were provided from two sources:

- Australian Potash's exploration database for shallow drill holes (0 to 4 metres) of soil and sediment located immediately adjacent to the Lake Wells playa.
- Eight shallow samples (0 to 0.7 metres) from shallow trenches excavated in the Lake Wells playa surface in October 2018 specifically for this assessment.

4.1 EXPLORATION DATABASE SAMPLES

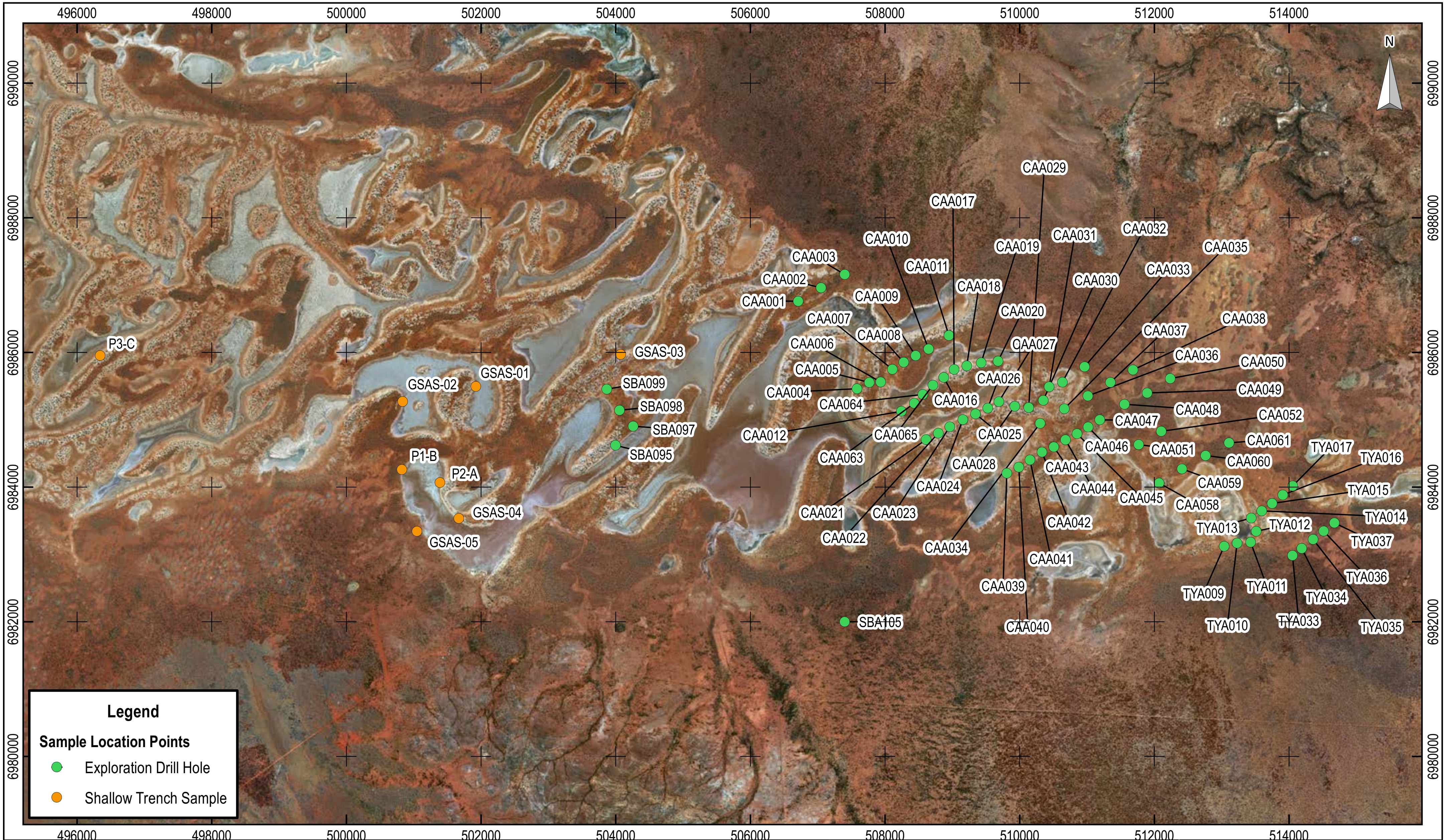
A total of 75 samples were collected for laboratory assay during a soil and sediment drilling program of Lake Wells in June – July 2016. Each sample was a 0 – 4 metre composite sample from each of the 75 drill holes included in this program. Locations of these drill holes are shown as green markers in Figure 1. Drill hole coordinates were included in the drill hole database supplied by Australian Potash. The samples are expected to comprise a mixture of aeolian sand, windblown playa sediments (including 'kopi gypsum') and underlying historic lakebed sediments.

4.2 SHALLOW TRENCH SAMPLES

Details on eight shallow lakebed sediment samples collected by Australian Potash field staff on the Lake Wells playa in October 2018 are presented in Table 1. Locations are shown as orange markers in Figure 1.

Table 1: Description of Shallow Lakebed Sediment Samples

Sample	Depth (mbgl)	Location (MGA94 Zone 51)		Description
		Easting	Northing	
P1-B	0.6	500821	6984259	Reddish brown silty sand, some clay; moist to wet; low plasticity
P2-A	0.5	501387	6984066	Reddish brown fine sand, some silt; damp to moist; non-plastic
P3-C	0.7	496339	6985953	Reddish brown fine sand, some silt and clay; wet; non-plastic
GSAS-01	0.4	501920	6985494	Brown, silty sand; damp
GSAS-02	0.5	500833	6985270	Red-brown, medium sand; damp
GSAS-03	0.6	504072	6985970	Red-brown, medium sand, some gravel; damp to moist
GSAS-04	0.3	501667	6983534	Light brown, fine sand, some gravel; dry
GSAS-05	0.3	501045	6983342	Red-brown, fine sand with calcrete gravel; dry



Scale: 1:75000
Original Size: A4
Aerial Photo: ESRI Satellite
Grid: EPSG:28351

0 0.5 1 1.5 2 km

Australian Potash Limited
Lake Wells Potash Project
Sediment Assessment

Figure 1

Lake Wells Soil and Sediment Sample Locations

Martinick Bosch Sell Pty Ltd
4 Cook St
West Perth WA 6005
Ph: (08) 9226 3166
Fax: (08) 9226 3177
info@mbsenvironmental.com.au
www.mbsenvironmental.com.au

MBS ENVIRONMENTAL

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5. METHODOLOGY

5.1 EXPLORATION DATABASE SAMPLES

Assay data from Australian Potash's exploration database were provided by multi-element geochemical analysis (50 elements) of samples submitted to Intertek Genalysis laboratories (Maddington, WA). The method involves digestion of a finely ground sample with aqua regia, followed by multi-element analysis using Inductively Coupled Plasma – Mass Spectrometry (ICP-MS).

From this data, the global abundance index (GAI) for each element was calculated by comparison to the average earth crustal abundance (AIMM 2001). The main purpose of the GAI is to provide an indication of any elemental enrichment that could be of environmental significance. The GAI (based on a log-2 scale) is expressed in integer increments from 0 to 6 (INAP 2009). A GAI of 0 indicates that the content of the element is less than or up to three times the average crustal abundance; a GAI of 1 corresponds to a three to six fold enrichment; a GAI of 2 corresponds to a 6 to 12 fold enrichment and so forth, up to a GAI of 6, which corresponds to a 96-fold, or greater, enrichment above average crustal abundances. A GAI of 3 or more is generally considered significant and may warrant further investigation.

5.2 SHALLOW TRENCH SAMPLES

The eight samples collected from shallow lakebed trenches were analysed by the following methods:

- pH and electrical conductivity (EC) in a 1:5 water extract.
- Acid Neutralising Capacity (ANC). The method is similar to that used in the 2016 ASS survey (Galt 2016, Section 3).
- Metals and metalloids using reverse aqua regia digestion (3:1 molar ratio of nitric acid to hydrochloric acid) and analysis by ICP-OES (Optical Emission Spectrometry) and ICP-MS. Elements analysed were antimony, arsenic, cadmium, chromium, copper, mercury, lead, silver and zinc.
- Bio-available metals. Two samples (P1-B and GSAS-02) were analysed for bio-available metals and metalloids using a method involving extraction with 1 M hydrochloric acid (one hour at room temperature). Mercury was analysed by Cold Vapour – Atomic Absorption Spectrometry (CV-AAS) and the other metals and metalloids were analysed by ICP-OES.
- Samples P1-B and GSAS-02 were analysed for water-soluble metals and metalloids following three sequential extractions with deionised water (1:5 extract ratio, extracts filtered through a 0.45 µm filter).
- Samples P1-B and GSAS-02 were also analysed for metals and metalloids following three sequential extractions with 10,000 mg/L sodium chloride solution (1:5 extract ratio, extracts filtered through a 0.45 µm filter). This method was selected to identify metals and metalloids in lakebed sediments that may be mobilised by infiltration of saline seepage from on-playa evaporation ponds.

6. RESULTS AND DISCUSSION

6.1 EXPLORATION DATABASE SAMPLES

A statistical summary of elemental concentrations and GAI values from analysis of the 75 soil samples is presented in Table 2. Full assay data provided by multi-element geochemical analysis by Intertek Genalysis laboratories (Maddington, WA) are provided in Appendix 1.

For many common rock forming elements, and especially heavy metal and metalloids, the range of concentrations were well below the global crustal averages, and hence GAI values of zero were obtained.

The only element that was present in significantly elevated concentrations in relation to the global crustal average (i.e. GAI greater than or equal to three) was sulphur. Concentrations ranged from 0.037% (366 mg/kg) to greater than 10%, with mean and 95th percentile concentrations of 4.5% and greater than 10%, respectively. The global crustal average concentration for sulphur is 0.026% (260 mg/kg). Comparison of total sulphur and calcium concentrations, as shown in Chart 1, indicated a very close correlation between both elements for samples containing greater than 1% total sulphur. Furthermore, the slope of relationship was very close to an atomic ratio of 1:1, which is consistent with the presence of calcium sulphate minerals. Such minerals are common in playa lake sediments and associated perimeter dune systems, and include gypsum ($CaSO_4.2H_2O$), anhydrite ($CaSO_4$) and bassanite ($CaSO_4.0.5H_2O$). This observation indicates that the presence of non-sulphate forms of sulphur, especially iron sulphide minerals associated with ASS materials (e.g. pyrite FeS_2), is unlikely and consistent with the inferred absence of ASS in an earlier assessment by Galt (Section 3, Galt 2016).

Chart 1 also shows a smaller set of samples that contain slightly elevated calcium concentrations (up to 3%), but with low concentrations of sulphur (less than 0.5%). These samples are expected to contain significant concentrations of calcium minerals other than calcium sulphate minerals. Common calcium minerals associated with playa lakebed sediments include calcite ($CaCO_3$), aragonite ($CaCO_3$) and dolomite ($CaMg(CO_3)_2$), all of which have appreciable ANC (Section 3).

The only other elements present at concentrations exceeding the global crustal average concentrations were:

- Arsenic, 95th percentile concentration of 5.3 mg/kg compared to global average concentration of 1.8 mg/kg (GAI = 1).
- Silver, 95th percentile concentration of 0.2 mg/kg compared to global average concentration of 0.07 mg/kg (GAI = 1). Silver forms a stable complex with chloride ions (as $[AgCl_2]^-$) and therefore has potential to accumulate in hypersaline environments.
- Strontium, 95th percentile concentration of 2,170 mg/kg compared to global average concentration of 375 mg/kg (GAI = 2). Strontium and calcium have similar geochemical properties and are likely to be associated with one another in sparingly soluble sulphate ($SrSO_4$, celestite) and carbonate (as $SrCO_3$, strontianite) minerals.
- Tungsten, 95th percentile concentration of 3.2 mg/kg compared to global average concentration of 1.5 mg/kg (GAI =1). Tungsten is a rare element that is slightly soluble under alkaline conditions, and effectively insoluble in circum-neutral and slightly acidic conditions. Tungsten forms a very insoluble calcium mineral (scheelite, $CaWO_4$), which has a similar structure to anhydrite ($CaSO_4$).

Table 2: Elemental Concentrations and GAI Values

Element	Units	Concentration					GAI	
		Crustal Average	Minimum	Maximum	Mean	95th %	Mean	95th %
Aluminium	%	8.23	0.57	7.04	2.96	4.82	0	0
Arsenic	mg/kg	1.8	1	6	2.8	5.3	0	1
Barium	mg/kg	425	85	583	210	337	0	0
Beryllium	mg/kg	2.8	0.25	1.3	0.42	0.93	0	0
Bismuth	mg/kg	0.17	0.025	0.34	0.12	0.19	0	0
Calcium	%	4.15	0.19	17.7	6.6	15.7	0	1
Cadmium	mg/kg	0.2	0.02	0.06	0.027	0.032	0	0
Cobalt	mg/kg	25	1.2	14.5	6.5	12.6	0	0
Chromium	mg/kg	100	13	95	6.5	12.6	0	0
Caesium	mg/kg	3	0.3	3.6	1.4	2.3	0	0
Copper	mg/kg	55	3	45	16	31	0	0
Europium	mg/kg	1.2	0.06	0.89	0.34	0.54	0	0
Iron	%	5.63	0.38	4.26	2.0	3.33	0	0
Gallium	mg/kg	15	1.4	18	7.2	12	0	0
Germanium	mg/kg	1.5	0.3	1.1	0.7	1.0	0	0
Gold	mg/kg	0.004	0.0005	0.004	0.0009	0.002	0	0
Hafnium	mg/kg	3	0.4	2.6	1.4	2.3	0	0
Indium	mg/kg	0.1	0.025	0.06	0.03	0.03	0	0
Potassium	%	2.09	0.15	1.32	0.59	1.05	0	0
Lithium	mg/kg	20	2.8	27	11	22	0	0
Magnesium	%	2.33	0.11	3.79	0.98	3.1	0	0
Manganese	mg/kg	950	34	705	246	492	0	0
Molybdenum	mg/kg	1.5	0.2	1.5	0.6	1.2	0	0
Silver	mg/kg	0.07	0.05	2.3	0.1	0.2	0	1
Sodium	%	2.36	0.11	2.22	0.78	1.36	0	0
Niobium	mg/kg	20	1.4	6.7	4.0	6.2	0	0
Nickel	mg/kg	75	3	44	18	34	0	0
Phosphorus	mg/kg	1,050	25	332	107	202	0	0
Lead	mg/kg	12.5	3	15	8.3	14	0	0
Rubidium	mg/kg	90	6.2	64	26	47	0	0
Sulphur	mg/kg	260	366	>10%	4.5%	>10%	6	6
Scandium	mg/kg	16	1	14	5.7	11	0	0
Tin	mg/kg	2	0.3	2.2	0.9	1.5	0	0
Strontium	mg/kg	375	21	3,690	492	2,170	0	2
Tantalum	mg/kg	2	0.11	0.53	0.32	0.52	0	0

Element	Units	Concentration					GAI	
		Crustal Average	Minimum	Maximum	Mean	95th %	Mean	95th %
Thorium	mg/kg	9.6	1.3	9.6	4.6	7.3	0	0
Titanium	mg/kg	5,700	558	3,570	1,770	2,860	0	0
Thallium	mg/kg	0.45	0.05	0.4	0.17	0.31	0	0
Uranium	mg/kg	2.7	0.24	4.9	1.4	2.6	0	0
Vanadium	mg/kg	135	14	106	55	99	0	0
Tungsten	mg/kg	1.5	0.2	29.3	1.8	3.2	0	1
Yttrium	mg/kg	30	1.4	17.9	6.2	10.4	0	0
Zinc	mg/kg	70	4	50	21	40	0	0
Zirconium	mg/kg	165	15	85	50	78	0	0

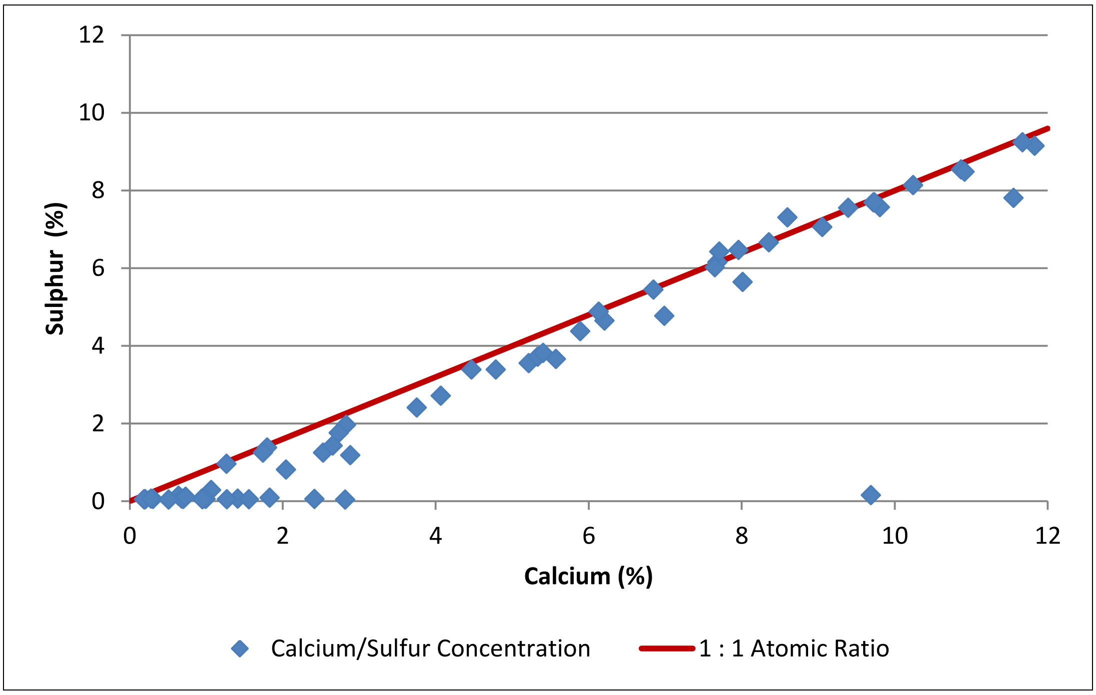

Chart 1: Comparison of Total Calcium and Sulphur Concentrations

6.2 SHALLOW TRENCH SAMPLES

6.2.1 Acid Formation Potential

Results for analysis of the shallow trench samples for ANC, pH and EC (1:5 water extract) are presented in Table 3.

ANC values were variable, ranging from 1.5 to 112 kg H_2SO_4/t, with a mean value of 25 kg H_2SO_4/t. Similar observation, ranging from 2.1 to 26 kg H_2SO_4/t (mean 11 kg H_2SO_4/t), were reported in the earlier ASS assessment (Galt 2016). The presence of substantial ANC and an absence of potentially acid forming minerals and dominance of oxidised sulphur (as calcium sulphate minerals) confirm the finding of the earlier ASS assessment that the risk of acid formation upon disturbance of Lake Wells playa sediments is low.

Water extract pH values for these samples ranged from 5.5 to 8.5, which are consistent with those measured in the earlier ASS assessment; *viz*., 5.6 to 8.1 (Galt 2016). These results confirm that Lake Wells playa sediments are typically circum-neutral, ranging from slightly acidic (pH 5.5) to slightly alkaline (pH 8.5).

EC values were variable, ranging from 840 to 8,200 µS/cm, and corresponded to calculated salt contents of 0.26 to 2.6% as NaCl. These values indicated saline rather than hypersaline conditions in playa sediments, although a thin surface layer of salts may form by capillary action during periods of extended drought.

Table 3: ANC, pH and EC Results for Shallow Trench Sediment Samples

Sample	ANC	pH (1:5 water extract)	EC (1:5 water extract)
	kg H_2SO_4/t	pH units	µS/cm
P1-B	9.6	8.5	8,200
P2-A	22.1	8.3	3,100
P3-C	23.3	8.0	5,700
GSAS-01	4.7	7.1	3,200
GSAS-02	1.5	5.5	840
GSAS-03	23.8	8.4	5,900
GSAS-04	6.0	7.2	3,400
GSAS-05	112	6.8	1,700

6.2.2 Heavy Metals and Metalloids

Results for analysis of the shallow trench samples for selected metals and metalloids by strong acid (reverse aqua regia) digestion (Section 5.2) are presented in Table 4. Two guideline values are included for comparative purposes:

- Interim Sediment Quality Guideline – Low (ISQG-Low). According to Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC 2000) methodology, sediments containing these elements at concentrations below ISQG-Low present very little environmental risk and therefore do not trigger further assessment.
- Interim Sediment Quality Guideline – High (ISQG-High). According ANZECC 2000, sediments containing these elements at concentrations above ISQG-High have potential environmental risk, and therefore trigger further assessment. Techniques for further assessment may include elemental speciation in sediments and porewaters, organic carbon measurement and acute toxicity testing.

Concentrations were comparable with those reported for the 0 to 4 metre exploration drillhole samples presented in Table 2. With the exception of antimony, all measured concentrations were below ISQG-Low, with all arsenic, cadmium, mercury and silver concentrations below the method reporting limit. Antimony concentrations were below the method reporting limit (7 mg/kg) and consequently well below ISQG-High (25 mg/kg). As the ISQG-Low (2 mg/kg) was below the method reporting limit (7 mg/kg), comparison against ISQG-Low was not possible.

Table 4: Heavy Metals and Metalloids – Strong Acid Digest

Sample	Sb	As	Cd	Cr	Cu	Hg	Pb	Ag	Zn
	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
P1-B	<7	<2	<0.4	5	2	<0.1	<1	<1	2
P2-A	<7	<2	<0.4	26	6	<0.1	3	<1	6
P3-C	<7	<2	<0.4	6	2	<0.1	1	<1	4
GSAS-01	<7	<2	<0.4	5	2	<0.1	<1	<1	3
GSAS-02	<7	<2	<0.4	13	<1	<0.1	<1	<1	1
GSAS-03	<7	<2	<0.4	17	6	<0.1	2	<1	6
GSAS-04	<7	<2	<0.4	5	<1	<0.1	<1	<1	2
GSAS-05	<7	<2	<0.4	36	6	<0.1	3	<1	6
ISQG-Low	2	20	1.5	80	65	0.15	50	1	200
ISQG-High	25	70	10	370	270	1	220	3.7	410

6.2.3 Bio-Available and Leachable Metals and Metalloids

Results from analysis of bio-available metals and metalloids using extraction with 1 M hydrochloric acid on two samples (P1-B and GSAS-02) are presented in Table 5. All concentrations were below the method reporting limits. In the case of antimony, the method reporting limit is identical to ISQC-Low, thus indicating antimony present in Lake Wells playa sediments presents a low environmental risk.

These results also demonstrate that most of the chromium, copper, lead and zinc is present in non bio-available forms. As the strong acid digestion procedure involves use of a strong oxidising acid (nitric acid), the non bio-available forms of these elements are probably strongly bound to sediment organic matter (rather than sulphide minerals).

Table 5: Bio-Available Metals and Metalloids – 1 M HCl Extraction

Sample	Sb	As	Cd	Cr	Cu	Hg	Pb	Ag	Zn
	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
P1-B	<2	<3	<0.5	<1	<1	<0.1	<2	<0.5	<1
GSAS-02	<2	<3	<0.5	<1	<1	<0.1	<2	<0.5	<1
ISQG-Low	2	20	1.5	80	65	0.15	50	1	200
ISQG-High	25	70	10	370	270	1	220	3.7	410

As the proposed process for potassium sulphate and potassium chloride recovery requires construction of on-playa ponds for evaporation of abstracted brine, the samples were assessed for potential mobilisation of metals and metalloids by leaching with saline solutions. Table 6 presents results for metals and metalloids in samples P1-B and GSAS-02 by three sequential extractions using deionised water and 10,000 mg/L sodium chloride as extracting fluids.

Concentrations in sequential water extracts were generally below the method reporting limits. Exceptions were:

- Very low concentrations of antimony in the first water extracts only. Measured concentrations were 0.001 and 0.002 mg/L in samples P1-B and GSAS-02, respectively.

- A single, but very low, chromium concentration of 0.002 mg/L in the second extract of sample GSAS-02.
- Very low zinc concentrations of 0.007, 0.003 and 0.001 mg/L in each of three sequential extracts of sample GSAS-02.

Very low concentrations of antimony (0.001 mg/L), arsenic (0.002 mg/L), cadmium (0.0001 mg/L) and copper (0.001 mg/L) were recorded in the first extract of sample P1-B with 10,000 mg/L sodium chloride. Concentrations of these elements in subsequent extracts were below the corresponding method reporting limits. A low concentration of antimony (0.002 mg/L) was also recorded in the first sodium chloride leachate of sample GSAS-02. These results demonstrate that infiltration of process brines though Lake Wells playa sediments has limited potential to mobilise antimony, arsenic, cadmium, chromium, copper, mercury, lead and silver into the receiving environment.

Zinc was the only element in which sodium chloride extract concentrations were consistently higher than water extract concentrations for both samples. The highest concentrations were recorded in the first extracts, with values of 0.007 and 0.032 mg/L for samples P1-B and GSAS-02, respectively. Concentrations in subsequent leachates were progressively lower, indicating a "wash-out" effect of zinc mobilised by saline solutions. The "first flush" zinc concentrations are unlikely to result in adverse impacts to the receiving environment; given the maximum concentration (0.032 mg/L) was below the ANZECC 2000 freshwater, very hard water, trigger value of 0.072 mg/L for slightly to moderately disturbed aquatic ecosystems.

Table 6: Leachable Metals and Metalloids – Water and 10,000 mg/L NaCl Extractions

Element	Units	Water Extract (1:5)			10,000 mg/L NaCl Extract (1:5)		
		First	Second	Third	First	Second	Third
P1-B, 0.6 m, reddish brown silty sand, some clay							
Antimony	mg/L	0.001	<0.001	<0.001	0.001	<0.001	<0.001
Arsenic	mg/L	<0.001	<0.001	<0.001	0.002	<0.001	<0.001
Cadmium	mg/L	<0.0001	<0.0001	<0.0001	0.0001	<0.0001	<0.0001
Chromium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	mg/L	<0.001	<0.001	<0.001	0.001	<0.001	<0.001
Mercury	mg/L	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Lead	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Silver	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc	mg/L	<0.001	<0.001	<0.001	0.023	0.002	0.002
GSAS-02, 0.5 m, red-brown, medium sand							
Antimony	mg/L	0.002	<0.001	<0.001	0.002	<0.001	<0.001
Arsenic	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	mg/L	<0.001	0.002	0.001	<0.001	<0.001	<0.001
Copper	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Mercury	mg/L	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Lead	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Silver	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc	mg/L	0.007	0.003	0.001	0.032	0.010	0.006

7. CONCLUSIONS

7.1 ACID FORMATION POTENTIAL

Findings from this assessment and an earlier preliminary ASS investigation (Galt 2016) demonstrate the potential for acid formation by disturbance of ASS material in Lake Wells soil and lakebed sediments is low. This conclusion is based on the following key findings:

- No ASS materials were identified in the preliminary ASS assessment (Galt 2016).
- The pH values of shallow trench sediment samples measured in this study did not indicate acid formation, which would have been expected if the samples contained ASS materials as a consequence of extended storage under oxidising conditions.
- Analysis of 75 (0 to 4 metres) soil and sediment samples in this study indicated that most of the sulphur was likely to be present as calcium sulphate minerals, in which the sulphur is fully oxidised and therefore unlikely to generate acid when disturbed.
- All trench samples from this assessment and the previous ASS (Galt 2016) assessment recorded ANC values ranging from 1.5 to 112 kg H_2SO_4/t. The presence of appreciable ANC in lakebed sediments suggests they have significant pH buffering capacity and therefore expected to remain circum-neutral to slightly alkaline should trace amounts of any ASS materials be disturbed by proposed operations.

7.2 POTENTIAL FOR MOBILISATION OF METALS AND METALLOIDS

Results for analysis of shallow trench and 0 to 4 metre drill hole exploration samples indicate that Lake Wells soils and sediments are not geochemically enriched in heavy metals and metalloids. For all elements measured in the drill hole exploration samples (Section 6.1), mean concentrations were less than global crustal average concentrations (AIMM 2001). The 95th percentile concentrations for arsenic, silver, strontium and tungsten concentrations were slightly higher than global crustal average concentrations (AIMM 2001), but are unlikely to present a significant environmental risk.

Concentrations of environmentally significant metals (cadmium, copper, chromium, mercury, silver, lead and zinc) and metalloids (arsenic and antimony) were low. This study confirmed that bio-available concentrations of these elements in shallow trench samples were below ISQG-Low (ANZECC 2000) guideline values and therefore present very little environmental risk.

Comparison of metal and metalloid concentrations in sequential leachates of two selected samples of shallow trench sediments, using deionised water and 10,000 mg/L sodium chloride as the extracting fluids, identified zinc as the only element with potential for mobilisation by permeation of process brine fluids. Slightly elevated zinc concentrations (maximum 0.032 mg/L) were recorded in “first flush” sodium chloride extractions. These concentrations are unlikely to result in adverse impacts to ecology of the Lake Wells lakebed sediments as they were below the ANZECC 2000 trigger value for slightly to moderately disturbed aquatic ecosystems when corrected for hardness.

8. REFERENCES

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APPENDICES

APPENDIX 1: LAKE WELLS SEDIMENT EXPLORATION DRILLING ASSAY DATA

Hole_ID	mFrom	mTo	Au mg/kg	Ag mg/kg	As mg/kg	Ba mg/kg	Bi mg/kg	Ca mg/kg	Co mg/kg	Cr mg/kg	Cs mg/kg	Cu mg/kg	Fe mg/kg	Mg mg/kg	Mn mg/kg	Mo mg/kg	Ni mg/kg	Pb mg/kg
CAA001	0	4	0.0	0.1	1	164	0.1	115545	12.3	45	0.9	15	14200	4811	119	0.3	32	4
CAA002	0	4	0.0	0.1	2	268	0.1	28830	4.2	37	0.9	9	16200	2536	157	0.4	11	7
CAA003	0	4	0.0	0.1	2	236	0.1	96894	6.0	51	0.7	20	22700	9918	241	0.4	18	5
CAA004	0	4	0.0	0.1	2	290	0.1	97252	5.2	34	0.9	12	15100	3273	109	0.5	12	7
CAA005	0	4	0.0	0.1	1	148	0.0	90534	1.5	18	0.4	6	6800	1866	81	0.3	5	4
CAA006	0	4	0.0	0.1	1	138	0.0	120444	1.3	18	0.4	6	6500	1749	55	0.3	4	3
CAA007	0	4	0.0	0.1	6	336	0.2	25281	7.0	65	2.2	20	32400	17021	230	1.0	23	13
CAA008	0	4	0.0	0.1	1	141	0.1	152973	1.2	18	0.4	6	6200	1130	34	0.4	4	3
CAA009	0	4	0.0	0.1	1	236	0.0	142150	1.6	16	0.4	4	6400	3466	45	0.2	5	3
CAA010	0	4	0.0	0.1	3	174	0.1	44697	1.8	27	0.7	5	13300	1777	79	0.5	5	5
CAA011	0	4	0.0	0.1	1	119	0.0	118326	1.4	13	0.3	3	3800	2950	49	0.2	3	10
CAA012	0	4	0.0	0.1	5	340	0.2	62087	5.1	47	1.5	14	24700	9002	203	0.8	12	10
CAA016	0	4	0.0	0.1	4	199	0.1	52175	11.4	53	1.6	26	30600	30713	328	0.6	28	8
CAA017	0	4	0.0	0.1	5	222	0.2	47868	10.7	39	1.5	22	24200	37923	703	1.1	24	13
CAA018	0	4	0.0	0.1	6	248	0.2	37519	14.0	64	2.1	31	36300	25081	435	1.2	34	12
CAA019	0	4	0.0	0.1	4	157	0.1	69901	8.4	47	1.3	17	26000	13086	296	0.6	18	8
CAA020	0	4	0.0	0.1	5	243	0.2	26559	12.5	70	2.0	27	33900	23564	705	1.0	28	14
CAA021	0	4	0.0	0.1	1	142	0.1	129544	4.7	23	0.9	11	10800	33948	416	0.7	11	7
CAA022	0	4	0.0	0.1	2	165	0.1	108708	7.6	30	1.4	20	22300	13980	264	0.4	19	5
CAA023	0	4	0.0	0.1	1	186	0.1	136909	11.5	39	1.1	17	26900	20564	316	0.6	33	4
CAA024	0	4	0.0	0.1	3	182	0.1	116713	7.4	42	1.4	17	20700	13049	259	0.6	31	7
CAA025	0	4	0.0	0.1	3	153	0.1	134769	5.8	35	1.1	8	14700	8386	233	0.7	15	8
CAA026	0	4	0.0	0.1	2	163	0.1	121030	4.8	30	0.9	16	13400	6445	175	0.5	16	6
CAA027	0	4	0.0	0.1	3	172	0.1	98059	5.8	41	1.4	21	19400	7167	183	0.6	18	8
CAA028	0	4	0.0	0.1	1	127	0.1	126505	5.4	30	0.7	20	12400	4749	138	0.4	13	4
CAA029	0	4	0.0	0.1	1	137	0.1	151905	5.6	43	0.8	19	13900	4910	203	0.5	20	5
CAA030	0	4	0.0	0.1	4	182	0.2	79587	9.9	49	1.9	20	22000	8906	481	1.5	22	14
CAA031	0	4	0.0	0.1	2	124	0.1	109172	7.3	51	0.9	15	20300	9621	311	0.6	16	6
CAA032	0	4	0.0	0.1	5	220	0.2	53347	11.0	88	1.8	31	31200	10917	490	1.3	27	12
CAA033	0	4	0.0	0.1	2	188	0.1	3055	4.4	43	1.2	9	17500	2451	139	0.7	14	7
CAA034	0	4	0.0	0.1	3	174	0.2	80156	12.8	66	2.3	31	33100	10285	498	0.9	37	10
CAA035	0	4	0.0	0.1	1	99	0.1	176825	6.1	37	0.5	10	13100	6543	197	0.4	24	3
CAA036	0	4	0.0	0.1	3	186	0.1	6397	4.7	50	1.3	10	17200	2862	161	0.6	17	8
CAA037	0	4	0.0	0.1	4	231	0.1	6791	6.2	51	1.8	14	21700	4498	175	0.7	22	9
CAA038	0	4	0.0	0.3	6	239	0.2	7023	12.1	75	2.3	25	29500	8523	403	0.9	35	13
CAA039	0	4	0.0	0.1	3	198	0.1	76818	6.7	44	1.7	21	20700	7793	229	0.7	19	12
CAA040	0	4	0.0	0.2	2	130	0.1	129583	6.8	33	1.1	16	16200	5075	221	0.5	15	7
CAA041	0	4	0.0	0.1	1	85	0.1	176897	4.0	25	0.9	11	11500	4644	108	0.4	9	5
CAA042	0	4	0.0	0.1	1	86	0.1	167717	7.0	36	1.0	23	17400	6866	216	0.5	17	5

Hole_ID	mFrom	mTo	Au mg/kg	Ag mg/kg	As mg/kg	Ba mg/kg	Bi mg/kg	Ca mg/kg	Co mg/kg	Cr mg/kg	Cs mg/kg	Cu mg/kg	Fe mg/kg	Mg mg/kg	Mn mg/kg	Mo mg/kg	Ni mg/kg	Pb mg/kg
CAA043	0	4	0.0	0.1	4	170	0.2	93947	6.9	40	1.9	18	22500	7128	231	1.0	19	10
CAA044	0	4	0.0	0.1	1	148	0.1	102437	5.2	28	0.8	11	13400	4648	196	0.4	12	6
CAA045	0	4	0.0	0.1	3	229	0.1	17959	4.9	40	1.4	10	17600	3484	162	0.6	13	8
CAA046	0	4	0.0	0.1	4	160	0.1	83587	7.3	40	1.7	21	23000	6523	259	0.8	17	9
CAA047	0	4	0.0	0.1	1	92	0.1	172245	3.8	19	0.7	10	8900	2226	156	0.4	10	4
CAA048	0	4	0.0	0.1	5	271	0.3	10657	13.9	69	3.0	24	38400	8269	457	1.3	38	15
CAA049	0	4	0.0	0.1	4	228	0.1	2028	7.2	70	1.3	18	24200	4109	270	0.6	24	10
CAA050	0	4	0.0	0.1	4	227	0.2	1910	9.8	73	1.7	21	25400	5131	275	0.7	34	11
CAA051	0	4	0.0	0.1	3	197	0.1	20451	12.0	68	1.5	45	32500	10347	443	0.7	33	9
CAA052	0	4	0.0	0.1	4	249	0.2	9955	7.6	61	2.4	19	25600	6479	253	0.9	27	12
CAA058	0	4	0.0	0.1	3	257	0.1	28313	5.9	44	1.4	16	20000	13598	233	0.6	16	9
CAA059	0	4	0.0	0.1	3	235	0.1	55730	5.5	49	1.4	14	18900	5785	202	0.6	20	8
CAA060	0	4	0.0	0.1	5	234	0.2	7297	6.1	51	1.7	18	26100	4186	189	0.8	18	9
CAA061	0	4	0.0	0.1	3	283	0.1	1893	5.8	48	1.2	13	18800	3422	219	0.5	17	9
CAA063	0	4	0.0	0.5	3	278	0.1	58895	3.7	33	1.0	9	19300	6976	214	0.5	9	8
CAA064	0	4	0.0	0.1	1	281	0.1	27349	4.0	27	0.6	10	13300	19409	267	0.4	10	6
CAA065	0	4	0.0	0.1	3	190	0.1	68483	3.6	31	0.9	14	17600	34438	354	0.7	10	10
SBA095	0	4	0.0	0.1	5	194	0.2	61337	3.7	58	2.2	12	20400	5404	114	0.9	12	10
SBA097	0	4	0.0	0.2	2	176	0.1	5076	4.3	39	1.1	12	16500	3269	134	0.4	12	7
SBA098	0	4	0.0	0.2	1	157	0.1	54052	4.3	33	0.9	14	17800	4729	185	0.5	11	5
SBA099	0	4	0.0	0.2	3	230	0.2	12664	5.7	45	1.8	14	22200	4775	304	1.3	14	14
SBA105	0	4	0.0	0.1	4	521	0.3	24164	14.5	95	3.6	36	42600	8820	543	0.9	44	15
TYA009	0	4	0.0	0.1	1	175	0.1	40690	2.4	37	0.8	9	14800	14078	162	0.7	9	6
TYA010	0	4	0.0	0.1	2	160	0.1	17410	3.0	39	0.9	11	14500	32284	144	0.5	10	7
TYA011	0	4	0.0	0.1	2	116	0.1	86001	3.6	41	0.8	11	14400	30412	293	0.5	9	6
TYA012	0	4	0.0	0.1	3	194	0.1	76520	6.7	41	1.2	21	23600	10960	370	0.6	15	7
TYA013	0	4	0.0	0.1	1	142	0.1	97379	3.5	34	0.7	10	11200	10991	139	0.4	10	5
TYA014	0	4	0.0	0.1	3	281	0.1	77076	3.8	30	1.1	7	11700	4226	109	0.7	11	7
TYA015	0	4	0.0	0.2	3	260	0.1	9446	5.7	46	1.2	13	21000	3957	169	0.5	17	6
TYA016	0	4	0.0	0.1	4	254	0.2	14130	5.1	50	1.9	15	22600	4615	149	0.8	16	10
TYA017	0	4	0.0	0.1	6	223	0.2	2811	7.7	64	1.8	15	27000	10215	252	0.8	23	12
TYA033	0	4	0.0	0.1	1	583	0.1	15582	4.4	35	1.8	8	15500	3542	106	0.6	13	11
TYA034	0	4	0.0	0.1	3	305	0.2	28178	6.9	48	2.3	14	20500	13796	169	0.5	20	11
TYA035	0	4	0.0	0.1	3	349	0.2	18305	11.1	50	2.1	21	28800	15623	276	0.6	30	11
TYA036	0	4	0.0	0.2	4	230	0.2	9515	8.4	55	2.6	17	24700	7652	294	0.6	24	12
TYA037	0	4	0.0	2.3	3	232	0.2	12718	6.7	43	1.6	17	19900	8028	460	0.7	15	10

Hole_ID	Rb mg/kg	Sb mg/kg	Sr mg/kg	Te mg/kg	Tl mg/kg	U mg/kg	V mg/kg	W mg/kg	Zn mg/kg	Ti mg/kg	Zr mg/kg	Al mg/kg	Be mg/kg	Cd mg/kg	Eu mg/kg	Ga mg/kg	Hf mg/kg	In mg/kg
CAA001	13.0	0.2	245.1	0.1	0.1	0.8	53.0	1.0	15	1272	32.6	21723	0.25	0.03	0.24	4.3	0.8	0.03
CAA002	19.7	0.2	41.1	0.1	0.1	0.8	44.0	0.9	14	1529	49.4	20237	0.25	0.03	0.17	4.7	1.3	0.03
CAA003	15.1	0.1	106.4	0.1	0.1	1.0	68.0	0.6	18	1546	39.0	21507	0.25	0.03	0.23	4.6	0.9	0.03
CAA004	18.3	0.1	788.0	0.1	0.1	1.0	48.0	0.9	12	1271	34.0	19410	0.25	0.03	0.29	5.0	1.1	0.03
CAA005	10.0	0.1	343.2	0.1	0.1	0.3	14.0	0.3	6	839	26.1	9281	0.25	0.03	0.14	2.5	0.7	0.03
CAA006	9.3	0.1	465.3	0.1	0.1	0.2	18.0	0.2	5	699	18.5	7836	0.25	0.03	0.09	2.2	0.6	0.03
CAA007	43.0	0.3	52.7	0.1	0.3	1.9	90.0	1.2	29	2439	71.0	47805	0.50	0.03	0.53	11.4	2.2	0.03
CAA008	9.6	0.1	1017.2	0.1	0.1	0.6	25.0	0.5	5	685	20.3	9137	0.25	0.03	0.07	2.2	0.6	0.03
CAA009	9.0	0.1	393.1	0.1	0.1	0.4	18.0	0.4	6	705	22.4	8742	0.25	0.06	0.09	1.7	0.7	0.03
CAA010	15.3	0.2	104.1	0.1	0.1	0.9	40.0	0.7	9	1171	40.6	14452	0.25	0.03	0.11	3.4	1.2	0.03
CAA011	6.2	0.2	400.6	0.1	0.1	0.3	14.0	0.2	4	558	14.8	5689	0.25	0.03	0.06	1.4	0.4	0.03
CAA012	30.8	0.2	148.4	0.1	0.2	1.4	79.0	2.0	18	1923	54.3	36383	0.25	0.03	0.31	9.0	1.5	0.03
CAA016	29.0	0.2	115.6	0.1	0.2	1.6	85.0	1.5	31	2406	54.0	40721	0.25	0.03	0.46	9.4	1.5	0.03
CAA017	29.4	0.3	142.0	0.1	0.3	2.2	60.0	1.0	26	1806	56.8	31842	0.25	0.03	0.45	8.2	1.7	0.03
CAA018	37.5	0.4	172.5	0.1	0.2	3.2	102.0	0.9	41	2841	67.1	46853	0.60	0.03	0.54	11.6	2.0	0.03
CAA019	24.9	0.2	227.7	0.1	0.1	2.0	70.0	0.7	28	2525	68.7	32079	0.50	0.03	0.44	8.2	1.7	0.03
CAA020	36.8	0.3	85.9	0.1	0.3	2.2	104.0	1.1	36	2947	82.2	48213	0.70	0.03	0.52	12.1	2.4	0.03
CAA021	15.9	0.2	856.1	0.1	0.2	1.8	34.0	0.7	15	989	32.5	20148	0.25	0.03	0.33	4.7	0.9	0.03
CAA022	21.2	0.2	777.6	0.1	0.1	0.9	67.0	5.6	19	2144	35.7	31788	0.25	0.03	0.36	7.5	1.0	0.03
CAA023	15.8	0.6	1788.4	0.1	0.1	0.7	100.0	0.5	28	2731	30.5	26877	0.25	0.03	0.43	6.2	0.8	0.03
CAA024	23.4	0.3	785.3	0.1	0.2	1.2	58.0	0.7	21	1665	45.7	30944	0.25	0.03	0.37	7.1	1.4	0.03
CAA025	21.5	0.2	1822.8	0.1	0.2	1.2	47.0	3.7	15	1492	44.1	23488	0.25	0.03	0.29	5.6	1.2	0.03
CAA026	18.9	0.2	2159.3	0.1	0.1	0.8	39.0	0.5	15	1237	35.4	20108	0.25	0.03	0.24	4.7	1.0	0.03
CAA027	27.5	0.3	1146.0	0.1	0.2	1.3	54.0	1.3	22	1722	49.6	30565	0.25	0.03	0.39	7.8	1.5	0.03
CAA028	15.0	0.2	712.8	0.1	0.1	1.0	35.0	0.7	13	1170	33.5	17126	0.25	0.03	0.22	4.0	0.9	0.03
CAA029	14.9	0.2	538.5	0.1	0.1	0.6	37.0	0.6	17	1244	31.7	19744	0.25	0.03	0.27	4.5	0.9	0.03
CAA030	33.8	0.4	668.4	0.1	0.2	1.8	72.0	2.4	30	2280	73.0	38089	0.50	0.03	0.48	9.1	2.1	0.03
CAA031	16.6	0.2	293.2	0.1	0.1	0.8	58.0	1.0	23	1691	38.6	24007	0.25	0.03	0.31	5.6	1.0	0.03
CAA032	32.1	0.4	228.1	0.1	0.2	1.4	106.0	2.8	39	2791	77.8	45084	0.25	0.03	0.48	11.3	2.3	0.03
CAA033	22.7	0.3	21.7	0.1	0.2	0.6	38.0	1.4	14	1780	58.3	24263	0.25	0.03	0.24	5.9	1.6	0.03
CAA034	34.6	0.3	1273.9	0.1	0.2	1.8	93.0	1.0	40	2601	60.5	48302	0.60	0.05	0.45	10.8	1.7	0.03
CAA035	8.3	0.2	3691.0	0.1	0.1	0.6	40.0	0.4	12	1039	20.5	16004	0.25	0.03	0.16	3.4	0.6	0.03
CAA036	24.1	0.2	65.7	0.1	0.2	0.9	39.0	0.8	18	1696	54.6	26489	0.25	0.03	0.28	6.5	2.1	0.03
CAA037	28.7	0.3	48.8	0.1	0.2	1.1	54.0	2.7	21	2006	63.0	33916	0.25	0.03	0.40	8.5	1.9	0.03
CAA038	38.2	0.3	45.2	0.1	0.3	1.2	89.0	2.6	32	2392	70.0	47905	0.70	0.03	0.54	11.7	2.0	0.03
CAA039	34.2	0.2	2509.1	0.1	0.2	2.3	59.0	1.8	27	1981	58.7	36814	0.70	0.03	0.40	8.4	1.7	0.03
CAA040	19.8	0.2	2188.2	0.1	0.1	1.1	41.0	2.3	18	1254	29.8	23580	0.25	0.03	0.24	5.6	0.9	0.03
CAA041	16.3	0.2	2353.5	0.1	0.1	1.6	31.0	1.1	14	942	31.4	18515	0.25	0.03	0.22	4.4	0.8	0.03
CAA042	16.1	0.1	1247.2	0.1	0.1	1.1	51.0	0.9	20	1320	28.6	23443	0.25	0.03	0.26	5.5	0.8	0.03

Hole_ID	Rb mg/kg	Sb mg/kg	Sr mg/kg	Te mg/kg	Tl mg/kg	U mg/kg	V mg/kg	W mg/kg	Zn mg/kg	Ti mg/kg	Zr mg/kg	Al mg/kg	Be mg/kg	Cd mg/kg	Eu mg/kg	Ga mg/kg	Hf mg/kg	In mg/kg
CAA043	34.0	0.2	297.1	0.1	0.2	2.1	61.0	1.2	29	2289	59.2	39448	0.70	0.03	0.51	9.5	1.8	0.03
CAA044	16.4	0.2	296.5	0.1	0.1	0.9	34.0	2.1	17	1533	38.0	18313	0.25	0.03	0.29	4.5	1.0	0.03
CAA045	26.7	0.2	370.2	0.1	0.2	1.3	41.0	1.2	19	1935	56.1	27148	0.25	0.03	0.35	6.6	1.6	0.03
CAA046	28.0	0.2	828.8	0.1	0.2	1.7	64.0	1.8	27	2058	56.5	34533	0.50	0.03	0.36	8.3	1.6	0.03
CAA047	11.6	0.1	553.4	0.1	0.1	0.7	26.0	0.9	12	805	24.5	13974	0.25	0.03	0.21	3.4	0.7	0.03
CAA048	49.2	0.3	117.4	0.1	0.3	1.8	99.0	2.8	50	3574	85.3	66430	1.00	0.03	0.75	15.7	2.5	0.03
CAA049	24.5	0.2	40.0	0.1	0.2	0.9	58.0	1.7	23	1847	66.7	30872	0.60	0.03	0.37	7.3	1.6	0.03
CAA050	28.7	0.2	40.5	0.1	0.2	1.0	73.0	29.3	27	1823	58.0	38889	0.70	0.03	0.47	9.1	1.8	0.03
CAA051	26.7	0.2	703.7	0.1	0.2	1.7	98.0	1.7	38	2918	55.8	41232	0.25	0.03	0.47	9.6	1.6	0.03
CAA052	41.3	0.3	51.7	0.1	0.3	1.4	67.0	3.1	30	2388	71.1	46688	0.70	0.03	0.42	11.3	2.0	0.03
CAA058	33.4	0.3	122.3	0.1	0.2	2.4	52.0	3.4	29	2060	68.1	40709	0.60	0.03	0.39	9.6	2.0	0.03
CAA059	26.5	0.3	150.9	0.1	0.2	1.3	52.0	1.3	20	1746	60.3	31247	0.25	0.03	0.40	7.1	1.6	0.03
CAA060	29.2	0.3	33.6	0.1	0.2	1.5	70.0	2.7	25	2139	58.8	35315	0.60	0.03	0.31	8.7	1.6	0.03
CAA061	22.3	0.3	26.5	0.1	0.2	0.6	44.0	2.9	15	1675	55.5	25970	0.50	0.03	0.29	6.2	1.5	0.03
CAA063	21.6	0.2	119.6	0.1	0.1	1.0	43.0	0.9	13	1289	41.9	22504	0.25	0.03	0.23	5.3	1.2	0.03
CAA064	15.1	0.2	56.9	0.1	0.1	1.5	31.0	0.4	13	1084	39.3	13097	0.25	0.03	0.20	3.1	1.0	0.03
CAA065	18.4	0.2	175.2	0.1	0.2	2.1	40.0	0.8	14	1202	40.0	19467	0.25	0.03	0.21	4.9	1.4	0.03
SBA095	39.5	0.4	138.0	0.1	0.2	3.3	75.0	1.3	24	2366	72.8	40678	0.70	0.03	0.29	9.7	2.0	0.03
SBA097	23.1	0.2	21.3	0.1	0.2	0.7	40.0	2.2	18	1820	46.5	23330	0.25	0.06	0.24	5.6	1.4	0.03
SBA098	17.1	0.1	275.6	0.1	0.1	0.8	40.0	1.8	14	1408	38.9	19488	0.25	0.03	0.17	4.8	1.2	0.03
SBA099	35.9	0.4	92.3	0.1	0.3	1.9	53.0	1.1	25	2245	68.2	40215	0.60	0.03	0.67	10.5	2.2	0.03
SBA105	63.5	0.3	86.6	0.1	0.4	1.6	91.0	1.3	50	3076	83.9	70416	1.30	0.03	0.89	18.0	2.6	0.06
TYA009	19.0	0.2	90.3	0.1	0.1	2.0	25.0	1.1	9	1167	40.6	14400	0.25	0.03	0.18	3.4	1.3	0.03
TYA010	21.5	0.2	48.8	0.1	0.1	4.2	47.0	2.9	13	1455	42.4	18484	0.25	0.03	0.19	4.1	1.4	0.03
TYA011	17.5	0.2	251.5	0.1	0.2	4.9	37.0	1.0	11	1201	41.0	16703	0.25	0.03	0.18	4.1	1.0	0.03
TYA012	20.7	0.2	298.6	0.1	0.2	1.7	55.0	1.2	17	1649	45.9	24396	0.25	0.03	0.31	6.1	1.1	0.03
TYA013	13.3	0.1	885.5	0.1	0.1	1.6	30.0	0.5	10	1005	30.7	13624	0.25	0.03	0.19	3.3	0.8	0.03
TYA014	23.7	0.2	218.3	0.1	0.2	1.5	33.0	2.0	12	1213	44.4	20475	0.25	0.03	0.24	5.5	1.2	0.03
TYA015	22.8	0.2	32.5	0.1	0.2	0.8	57.0	1.1	18	1772	47.8	26396	0.25	0.03	0.25	6.5	1.6	0.03
TYA016	33.5	0.2	40.7	0.1	0.2	1.5	62.0	0.9	24	2198	71.8	39964	0.70	0.03	0.53	9.8	1.9	0.03
TYA017	35.2	0.2	34.9	0.1	0.2	2.2	78.0	1.7	31	2646	76.8	42141	0.70	0.03	0.43	10.2	2.3	0.03
TYA033	61.5	0.2	90.4	0.1	0.4	0.8	30.0	1.8	15	1290	51.6	38441	0.70	0.03	0.29	9.3	1.4	0.03
TYA034	46.3	0.2	66.0	0.1	0.3	1.4	51.0	1.4	24	1954	79.0	44002	0.90	0.03	0.45	11.1	2.1	0.03
TYA035	43.9	0.2	68.2	0.1	0.3	1.5	72.0	1.4	45	2463	76.4	47792	1.10	0.03	0.49	12.9	2.2	0.03
TYA036	47.8	0.3	45.1	0.1	0.3	1.2	62.0	1.5	30	2297	62.4	51258	1.10	0.03	0.46	12.5	2.0	0.03
TYA037	32.8	0.2	43.2	0.1	0.2	1.5	53.0	2.7	24	1902	59.4	33334	0.80	0.06	0.41	8.1	1.7	0.03

Hole_ID	K mg/kg	Li mg/kg	Nb mg/kg	P mg/kg	Pd mg/kg	Pt mg/kg	Re mg/kg	Sc mg/kg	Sn mg/kg	Ta mg/kg	Th mg/kg	Y mg/kg	S mg/kg	Se mg/kg	Ge mg/kg	Na mg/kg
CAA001	3318	6.8	2.1	108	0.00	0.00	0.03	5.0	0.4	0.15	2.32	3.80	78020	1.0	0.5	6770
CAA002	4737	7.2	3.5	77	0.00	0.00	0.03	4.0	0.8	0.28	3.90	3.60	11868	1.0	0.7	3819
CAA003	3811	8.3	2.8	98	0.00	0.00	0.03	6.0	0.6	0.21	3.12	5.40	1509	1.0	0.7	5875
CAA004	4917	5.6	2.7	62	0.00	0.00	0.03	4.0	0.6	0.20	3.26	5.20	76936	1.0	0.6	8022
CAA005	2280	4.2	2.0	25	0.00	0.00	0.03	2.0	0.3	0.17	2.04	2.50	70554	1.0	0.5	5146
CAA006	2167	2.8	1.7	25	0.00	0.00	0.03	1.0	0.3	0.26	1.35	1.70	94461	1.0	0.5	3221
CAA007	9597	17.5	5.7	121	0.00	0.00	0.03	8.0	1.5	0.49	7.31	10.20	12451	1.0	0.9	9085
CAA008	2152	3.2	1.5	25	0.00	0.00	0.03	2.0	0.3	0.12	1.76	1.40	100000	1.0	0.3	2560
CAA009	1940	3.9	1.8	25	0.00	0.00	0.03	1.0	0.3	0.14	2.03	1.90	85518	1.0	0.4	1319
CAA010	3228	5.4	3.0	25	0.00	0.00	0.03	2.0	0.5	0.24	3.26	2.40	33859	1.0	0.6	3930
CAA011	1457	3.0	1.4	25	0.00	0.00	0.03	1.0	0.3	0.11	1.29	1.40	91484	1.0	0.4	1054
CAA012	7855	10.4	4.5	79	0.00	0.00	0.03	6.0	1.0	0.34	5.58	5.50	46475	1.0	0.8	9474
CAA016	7235	23.2	4.2	104	0.00	0.00	0.03	10.0	0.9	0.31	4.76	9.60	35508	1.0	0.8	22237
CAA017	7041	20.5	4.5	95	0.00	0.00	0.03	6.0	1.5	0.38	5.66	8.30	33910	1.0	0.8	13398
CAA018	8769	22.8	5.6	140	0.00	0.00	0.03	11.0	1.3	0.47	6.80	10.90	24076	1.0	1.0	17293
CAA019	5993	12.0	5.0	153	0.00	0.00	0.03	8.0	0.9	0.47	4.84	10.70	47658	1.0	0.7	13136
CAA020	8865	17.4	6.5	173	0.00	0.00	0.03	11.0	1.4	0.53	7.78	10.20	14336	1.0	1.0	21489
CAA021	4175	11.6	2.5	223	0.00	0.00	0.03	3.0	0.5	0.18	3.01	3.50	95888	1.0	0.5	7200
CAA022	5685	8.7	2.9	182	0.00	0.00	0.03	6.0	0.6	0.23	3.39	4.90	85382	1.0	0.6	8553
CAA023	4614	8.3	2.5	287	0.00	0.00	0.03	8.0	0.5	0.19	2.37	5.10	100000	1.0	0.5	10334
CAA024	6380	9.0	3.4	128	0.00	0.00	0.03	6.0	0.8	0.27	4.16	6.50	92339	1.0	0.6	10383
CAA025	5354	8.3	3.5	93	0.00	0.00	0.03	4.0	0.7	0.25	3.89	5.40	100000	1.0	0.5	7783
CAA026	4817	7.1	3.0	105	0.00	0.00	0.03	4.0	0.6	0.22	3.12	4.40	96809	1.0	0.5	6961
CAA027	6939	8.8	3.9	156	0.00	0.00	0.03	6.0	0.9	0.28	4.81	6.70	75692	1.0	0.7	6358
CAA028	3966	5.6	2.7	87	0.00	0.00	0.03	4.0	0.5	0.20	2.67	4.30	100000	1.0	0.5	9721
CAA029	3423	5.7	2.8	120	0.00	0.00	0.03	5.0	0.5	0.21	2.80	5.10	100000	1.0	0.4	6926
CAA030	7956	10.9	5.2	178	0.00	0.00	0.03	7.0	1.1	0.40	6.51	8.10	64666	1.0	0.8	11967
CAA031	4041	6.9	2.9	114	0.00	0.00	0.03	7.0	0.6	0.22	3.01	6.30	84828	1.0	0.6	6281
CAA032	8001	10.6	5.9	134	0.00	0.00	0.03	11.0	1.3	0.46	7.08	9.50	37186	1.0	0.9	9572
CAA033	4329	9.0	4.6	53	0.00	0.00	0.03	4.0	0.8	0.34	4.68	5.10	549	1.0	0.9	3275
CAA034	7236	11.6	5.1	192	0.00	0.00	0.03	12.0	1.1	0.37	5.58	9.30	56408	1.0	0.8	6380
CAA035	2410	3.8	1.7	81	0.00	0.00	0.03	5.0	0.3	0.13	1.69	3.50	100000	1.0	0.3	9071
CAA036	4359	9.0	4.3	88	0.00	0.00	0.03	5.0	1.0	0.32	4.70	5.30	1362	1.0	0.8	3304
CAA037	5700	10.8	5.0	113	0.00	0.00	0.03	6.0	1.0	0.39	5.60	6.70	615	1.0	1.0	5989
CAA038	8085	14.5	5.6	92	0.00	0.00	0.03	9.0	1.4	0.43	7.25	9.20	525	1.0	1.0	5605
CAA039	8164	11.8	5.2	142	0.00	0.00	0.03	7.0	1.0	0.46	6.15	7.70	61488	1.0	0.8	6068
CAA040	4618	7.3	2.7	104	0.00	0.00	0.03	5.0	0.7	0.22	3.28	5.20	100000	1.0	0.6	4992
CAA041	3868	5.6	2.4	100	0.00	0.00	0.03	4.0	0.5	0.22	2.82	4.20	100000	1.0	0.4	4316
CAA042	3918	7.2	2.6	110	0.00	0.00	0.03	6.0	0.6	0.21	2.89	5.40	100000	1.0	0.5	8733

Hole_ID	K mg/kg	Li mg/kg	Nb mg/kg	P mg/kg	Pd mg/kg	Pt mg/kg	Re mg/kg	Sc mg/kg	Sn mg/kg	Ta mg/kg	Th mg/kg	Y mg/kg	S mg/kg	Se mg/kg	Ge mg/kg	Na mg/kg
CAA043	7835	12.0	4.9	232	0.00	0.00	0.03	7.0	1.1	0.42	6.45	8.50	75462	1.0	0.7	9601
CAA044	4264	6.2	3.5	128	0.00	0.00	0.03	4.0	0.6	0.31	3.06	4.50	81353	1.0	0.5	7791
CAA045	5622	9.1	4.5	109	0.00	0.00	0.03	5.0	0.9	0.39	4.93	6.00	13834	1.0	0.7	4406
CAA046	6449	10.4	4.4	170	0.00	0.00	0.03	7.0	0.9	0.37	5.59	7.00	66620	1.0	0.7	10162
CAA047	2671	4.3	1.9	66	0.00	0.00	0.03	3.0	0.4	0.16	1.97	4.20	100000	1.0	0.4	4268
CAA048	11424	18.8	6.3	332	0.00	0.00	0.03	11.0	1.5	0.52	8.12	11.50	2880	1.0	1.1	13287
CAA049	5485	11.5	4.2	69	0.00	0.00	0.03	6.0	0.9	0.33	5.19	6.10	490	1.0	1.0	5047
CAA050	5969	13.3	4.3	89	0.00	0.00	0.03	7.0	1.0	0.34	5.61	7.50	480	1.0	1.0	5576
CAA051	6319	9.5	5.0	193	0.00	0.00	0.03	11.0	1.0	0.36	5.13	9.50	8160	1.0	0.9	8252
CAA052	8850	13.3	5.5	119	0.00	0.00	0.03	8.0	1.4	0.42	6.47	8.00	587	1.0	1.1	6193
CAA058	7708	12.0	5.3	146	0.00	0.00	0.03	5.0	1.0	0.45	6.51	6.80	19612	1.0	0.8	12182
CAA059	6166	12.7	4.2	171	0.00	0.00	0.03	5.0	1.0	0.34	5.30	5.90	36594	1.0	0.9	8535
CAA060	6190	10.9	4.8	105	0.00	0.00	0.03	7.0	1.0	0.38	5.70	5.70	1168	1.0	1.0	4470
CAA061	4493	12.6	4.1	66	0.00	0.00	0.03	5.0	0.9	0.34	4.20	5.50	483	1.0	1.0	5108
CAA063	5617	7.8	3.1	56	0.00	0.00	0.03	4.0	0.7	0.25	3.94	4.00	43738	1.0	0.6	6964
CAA064	3776	11.8	2.5	25	0.00	0.00	0.03	2.0	0.5	0.19	2.87	4.60	17601	1.0	0.7	6709
CAA065	5249	19.3	3.0	58	0.00	0.00	0.03	4.0	0.6	0.24	3.83	3.80	54471	1.0	0.7	12918
SBA095	9581	11.1	6.1	118	0.00	0.00	0.03	6.0	1.5	0.52	7.11	6.70	48760	1.0	1.0	10544
SBA097	4577	6.8	3.8	89	0.00	0.00	0.03	5.0	0.8	0.34	4.07	6.40	366	1.0	0.8	3292
SBA098	3863	6.0	3.0	68	0.00	0.00	0.03	4.0	0.6	0.24	3.14	4.10	38154	1.0	0.7	5424
SBA099	7903	11.0	5.6	177	0.00	0.00	0.03	6.0	1.1	0.48	6.95	8.80	9574	1.0	0.9	10767
SBA105	11112	27.0	6.7	143	0.00	0.00	0.03	14.0	2.2	0.53	9.61	17.90	525	1.0	1.1	4704
TYA009	4428	8.4	3.2	25	0.00	0.00	0.03	2.0	0.7	0.26	3.40	3.60	27136	1.0	0.7	4642
TYA010	5209	12.6	3.6	66	0.00	0.00	0.03	3.0	0.7	0.30	3.94	3.80	12495	1.0	0.9	5736
TYA011	4560	13.5	2.9	57	0.00	0.00	0.03	2.0	0.6	0.24	3.42	2.90	73006	1.0	0.7	7006
TYA012	4900	11.1	3.4	62	0.00	0.00	0.03	6.0	0.7	0.30	4.04	4.70	60177	1.0	0.7	10003
TYA013	3310	6.3	2.1	25	0.00	0.00	0.03	3.0	0.4	0.17	2.24	3.70	76908	1.0	0.6	8034
TYA014	5506	7.3	3.3	25	0.00	0.00	0.03	3.0	0.7	0.29	3.72	4.30	64244	1.0	0.7	8532
TYA015	4872	8.6	3.7	61	0.00	0.00	0.03	6.0	0.8	0.29	4.08	5.30	675	1.0	1.0	9175
TYA016	7825	12.7	6.5	124	0.00	0.00	0.03	7.0	1.2	0.52	6.99	10.10	628	1.0	0.8	9115
TYA017	8952	12.5	5.8	104	0.00	0.00	0.03	7.0	1.3	0.51	7.31	8.50	681	1.0	0.9	9178
TYA033	13199	11.6	4.0	61	0.00	0.00	0.03	4.0	0.8	0.32	4.54	5.10	470	1.0	0.9	6939
TYA034	8905	18.3	5.7	81	0.00	0.00	0.03	7.0	1.3	0.43	6.72	8.40	409	1.0	1.0	4661
TYA035	10572	24.0	6.2	187	0.00	0.00	0.03	8.0	1.4	0.45	5.96	9.20	888	1.0	0.9	14202
TYA036	10407	21.7	5.6	89	0.00	0.00	0.03	8.0	1.4	0.47	7.29	8.90	515	1.0	1.1	6800
TYA037	7238	15.2	5.0	66	0.00	0.00	0.03	6.0	1.0	0.45	5.65	8.50	498	1.0	0.9	6321

APPENDIX 2: MPL ENVIROLAB LABORATORY REPORT

Envirolab Services (WA) Pty Ltd trading as MPL Laboratories
ABN 53 140 099 207
16-18 Hayden Court Myaree WA 6154
ph 08 9317 2505 fax 08 9317 4163
lab@mpl.com.au
www.mpl.com.au

CERTIFICATE OF ANALYSIS 219686

Client Details

Client	MBS Environmental
Attention	Michael North
Address	4 Cook Street, WEST PERTH, WA, 6005

Sample Details

Your Reference	**APLWSA Lake Wells Potash**
Number of Samples	8 Sediments
Date samples received	05/12/2018
Date completed instructions received	06/12/2018

Analysis Details

Please refer to the following pages for results, methodology summary and quality control data.

Samples were analysed as received from the client. Results relate specifically to the samples as received.

Results are reported on a dry weight basis for solids and on an as received basis for other matrices.

Please refer to the last page of this report for any comments relating to the results.

Report Details

Date results requested by	14/12/2018
Date of Issue	17/12/2018

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Results Approved By
Heram Halim, Inorganics Team Leader
Stacey Hawkins, Acid Soils Supervisor
Todd Lee, Laboratory Manager, Perth

Authorised By

Todd Lee, Laboratory Manager

Miscellaneous Inorg - soil						
Our Reference		219686-1	219686-4	219686-5	219686-6	219686-7
Your Reference	UNITS	P1-B	P2-A	P3-C	GSAS-01	GSAS-02
Date Sampled		17/10/2018	17/10/2018	18/10/2018	19/10/2018	19/10/2018
Type of sample		Sediment	Sediment	Sediment	Sediment	Sediment
Date prepared	-	11/12/2018	11/12/2018	11/12/2018	11/12/2018	11/12/2018
Date analysed	-	11/12/2018	11/12/2018	11/12/2018	11/12/2018	11/12/2018
pH	pH Units	8.5	8.3	8.0	7.1	5.5
Electrical Conductivity (EC)	µS/cm	8,200	3,100	5,700	3,200	840

Miscellaneous Inorg - soil				
Our Reference		219686-10	219686-11	219686-12
Your Reference	UNITS	GSAS-03	GSAS-04	GSAS-05
Date Sampled		19/10/2018	19/10/2018	19/10/2018
Type of sample		Sediment	Sediment	Sediment
Date prepared	-	11/12/2018	11/12/2018	11/12/2018
Date analysed	-	11/12/2018	11/12/2018	11/12/2018
pH	pH Units	8.4	7.2	6.8
Electrical Conductivity (EC)	µS/cm	5,900	3,400	1,700

Acid Neutralisation Capacity*						
Our Reference		219686-1	219686-4	219686-5	219686-6	219686-7
Your Reference	UNITS	P1-B	P2-A	P3-C	GSAS-01	GSAS-02
Date Sampled		17/10/2018	17/10/2018	18/10/2018	19/10/2018	19/10/2018
Type of sample		Sediment	Sediment	Sediment	Sediment	Sediment
Date Prepared		05/12/2018	05/12/2018	05/12/2018	05/12/2018	05/12/2018
Date Analysed		11/12/2018	11/12/2018	11/12/2018	11/12/2018	11/12/2018
Fizz Rating		0	1	1	0	0
ANC	kg H2SO4/tonne	9.6	22.1	23.3	4.7	1.5
ANC	% CaCO3	1	2.3	2.4	0.5	0.2

Acid Neutralisation Capacity*				
Our Reference		219686-10	219686-11	219686-12
Your Reference	UNITS	GSAS-03	GSAS-04	GSAS-05
Date Sampled		19/10/2018	19/10/2018	19/10/2018
Type of sample		Sediment	Sediment	Sediment
Date Prepared		05/12/2018	05/12/2018	05/12/2018
Date Analysed		11/12/2018	11/12/2018	11/12/2018
Fizz Rating		1	0	2
ANC	kg H2SO4/tonne	23.8	6.0	112
ANC	% CaCO3	2.4	0.6	12

Metals - soil						
Our Reference		219686-1	219686-4	219686-5	219686-6	219686-7
Your Reference	UNITS	P1-B	P2-A	P3-C	GSAS-01	GSAS-02
Date Sampled		17/10/2018	17/10/2018	18/10/2018	19/10/2018	19/10/2018
Type of sample		Sediment	Sediment	Sediment	Sediment	Sediment
Date digested	-	11/12/2018	11/12/2018	11/12/2018	11/12/2018	11/12/2018
Date analysed	-	11/12/2018	11/12/2018	11/12/2018	11/12/2018	11/12/2018
Antimony	mg/kg	<7	<7	<7	<7	<7
Arsenic	mg/kg	<2	<2	<2	<2	<2
Cadmium	mg/kg	<0.4	<0.4	<0.4	<0.4	<0.4
Chromium	mg/kg	5	26	6	5	13
Copper	mg/kg	2	6	2	2	<1
Mercury	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Lead	mg/kg	<1	3	1	<1	<1
Silver	mg/kg	<1	<1	<1	<1	<1
Zinc	mg/kg	2	6	4	3	1

Metals - soil				
Our Reference		219686-10	219686-11	219686-12
Your Reference	UNITS	GSAS-03	GSAS-04	GSAS-05
Date Sampled		19/10/2018	19/10/2018	19/10/2018
Type of sample		Sediment	Sediment	Sediment
Date digested	-	11/12/2018	11/12/2018	11/12/2018
Date analysed	-	11/12/2018	11/12/2018	11/12/2018
Antimony	mg/kg	<7	<7	<7
Arsenic	mg/kg	<2	<2	<2
Cadmium	mg/kg	<0.4	<0.4	<0.4
Chromium	mg/kg	17	5	36
Copper	mg/kg	6	<1	6
Mercury	mg/kg	<0.1	<0.1	<0.1
Lead	mg/kg	2	<1	3
Silver	mg/kg	<1	<1	<1
Zinc	mg/kg	6	2	6

Metals 1M HCl extractable			
Our Reference		219686-1	219686-7
Your Reference	UNITS	P1-B	GSAS-02
Date Sampled		17/10/2018	19/10/2018
Type of sample		Sediment	Sediment
Antimony	mg/kg	<2	<2
Arsenic	mg/kg	<3	<3
Cadmium	mg/kg	<0.5	<0.5
Chromium	mg/kg	<1	<1
Copper	mg/kg	<1	<1
Mercury	mg/kg	<0.1	<0.1
Lead	mg/kg	<2	<2
Silver	mg/kg	<0.5	<0.5
Zinc	mg/kg	<1	<1

1:5 Sequential Water Leachate						
Our Reference		219686-1	219686-2	219686-3	219686-7	219686-8
Your Reference	UNITS	P1-B	P1-B 2nd Leach	P1-B 3rd Leach	GSAS-02	GSAS-02 2nd Leach
Date Sampled		17/10/2018	17/10/2018	17/10/2018	19/10/2018	19/10/2018
Type of sample		Sediment	Sediment	Sediment	Sediment	Sediment
Antimony	mg/L	0.001	<0.001	<0.001	0.002	<0.001
Arsenic	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	mg/L	<0.001	<0.001	<0.001	<0.001	0.002
Copper	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Mercury	mg/L	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Lead	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Silver	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc	mg/L	<0.001	<0.001	<0.001	0.007	0.003

1:5 Sequential Water Leachate		
Our Reference		219686-9
Your Reference	UNITS	GSAS-02 3rd Leach
Date Sampled		19/10/2018
Type of sample		Sediment
Antimony	mg/L	<0.001
Arsenic	mg/L	<0.001
Cadmium	mg/L	<0.0001
Chromium	mg/L	0.001
Copper	mg/L	<0.001
Mercury	mg/L	<0.00005
Lead	mg/L	<0.001
Silver	mg/L	<0.001
Zinc	mg/L	0.001

1:5 Sequential NaCl Leachate						
Our Reference		219686-1	219686-2	219686-3	219686-7	219686-8
Your Reference	UNITS	P1-B	P1-B 2nd Leach	P1-B 3rd Leach	GSAS-02	GSAS-02 2nd Leach
Date Sampled		17/10/2018	17/10/2018	17/10/2018	19/10/2018	19/10/2018
Type of sample		Sediment	Sediment	Sediment	Sediment	Sediment
Antimony	mg/L	0.001	<0.001	<0.001	0.002	<0.001
Arsenic	mg/L	0.002	<0.001	<0.001	<0.001	<0.001
Cadmium	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	mg/L	0.001	<0.001	<0.001	<0.001	<0.001
Mercury	mg/L	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Lead	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Silver	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc	mg/L	0.023	0.002	0.002	0.032	0.010

1:5 Sequential NaCl Leachate		
Our Reference		219686-9
Your Reference	UNITS	GSAS-02 3rd Leach
Date Sampled		19/10/2018
Type of sample		Sediment
Antimony	mg/L	<0.001
Arsenic	mg/L	<0.001
Cadmium	mg/L	<0.0001
Chromium	mg/L	<0.001
Copper	mg/L	<0.001
Mercury	mg/L	<0.00005
Lead	mg/L	<0.001
Silver	mg/L	<0.001
Zinc	mg/L	0.006

Moisture						
Our Reference		219686-1	219686-4	219686-5	219686-6	219686-7
Your Reference	UNITS	P1-B	P2-A	P3-C	GSAS-01	GSAS-02
Date Sampled		17/10/2018	17/10/2018	18/10/2018	19/10/2018	19/10/2018
Type of sample		Sediment	Sediment	Sediment	Sediment	Sediment
Date prepared	-	11/12/2018	11/12/2018	11/12/2018	11/12/2018	11/12/2018
Date analysed	-	11/12/2018	11/12/2018	11/12/2018	11/12/2018	11/12/2018
Moisture	%	24	16	19	18	2.6

Moisture				
Our Reference		219686-10	219686-11	219686-12
Your Reference	UNITS	GSAS-03	GSAS-04	GSAS-05
Date Sampled		19/10/2018	19/10/2018	19/10/2018
Type of sample		Sediment	Sediment	Sediment
Date prepared	-	11/12/2018	11/12/2018	11/12/2018
Date analysed	-	11/12/2018	11/12/2018	11/12/2018
Moisture	%	17	15	4.0

Method ID	Methodology Summary
AMD-001	Acid Mine Drainage determined by AMIRA International - Acid Rock Drainage Test Handbook.
INORG-001	pH - Measured using pH meter and electrode base on APHA latest edition, Method 4500-H+. Please note that the results for water analyses may be indicative only, as analysis can be completed outside of the APHA recommended holding times. Soils are reported from a 1:5 water extract unless otherwise specified.
INORG-002	Conductivity and Salinity - measured using a conductivity cell at 25°C based on APHA latest edition Method 2510. Soils reported from a 1:5 water extract unless otherwise specified.
INORG-008	Moisture content determined by heating at 105 deg C for a minimum of 12 hours.
METALS-020	Determination of various metals by ICP-AES.
METALS-020	Metals in soil and water by ICP-OES.
METALS-021	Determination of Mercury by Cold Vapour AAS.
	For urine samples total Mercury is determined, however, mercury in urine is almost entirely in the inorganic form (CDC).
METALS-022	Determination of various metals by ICP-MS.
METALS-027	1M HCl extractable (Bioavailable) metals - The sample is extracted with 1M HCl for one hour at room temperature. The extract is analysed by ICP-OES for all metals except Mercury which is tested by CV-AAS.

QUALITY CONTROL: Miscellaneous Inorg - soil					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Date prepared	-			11/12/2018	[NT]	[NT]	[NT]	[NT]	11/12/2018	[NT]
Date analysed	-			11/12/2018	[NT]	[NT]	[NT]	[NT]	11/12/2018	[NT]
pH	pH Units		INORG-001	[NT]	[NT]	[NT]	[NT]	[NT]	102	[NT]
Electrical Conductivity (EC)	µS/cm	1	INORG-002	<1	[NT]	[NT]	[NT]	[NT]	102	[NT]

QUALITY CONTROL: Acid Neutralisation Capacity*					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Date Prepared				05/12/2018	1	05/12/2018	05/12/2018		05/12/2018	[NT]
Date Analysed				11/12/2018	1	11/12/2018	11/12/2018		11/12/2018	[NT]
Fizz Rating			AMD-001	[NT]	1	0	0		[NT]	[NT]
ANC	kg H2SO4/tonne	0.5	AMD-001	[NT]	1	9.6	9.6	0	100	[NT]
ANC	% CaCO3	0.01	AMD-001	[NT]	1	1	1	0	100	[NT]

QUALITY CONTROL: Metals - soil					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	219686-4
Date digested	-			10/12/2018	1	11/12/2018	11/12/2018		10/12/2018	11/12/2018
Date analysed	-			11/12/2018	1	11/12/2018	11/12/2018		11/12/2018	11/12/2018
Antimony	mg/kg	7	METALS-020	<7	1	<7	<7	0	99	79
Arsenic	mg/kg	2	METALS-020	<2	1	<2	<2	0	92	95
Cadmium	mg/kg	0.4	METALS-020	<0.4	1	<0.4	<0.4	0	91	90
Chromium	mg/kg	1	METALS-020	<1	1	5	5	0	97	106
Copper	mg/kg	1	METALS-020	<1	1	2	2	0	98	107
Mercury	mg/kg	0.1	METALS-021	<0.1	1	<0.1	<0.1	0	96	93
Lead	mg/kg	1	METALS-020	<1	1	<1	<1	0	92	90
Silver	mg/kg	1	METALS-020	<1	1	<1	<1	0	105	113
Zinc	mg/kg	1	METALS-020	<1	1	2	2	0	97	100

QUALITY CONTROL: Metals 1M HCl extractable					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Antimony	mg/kg	2	METALS-027	<2	1	<2	<2	0	98	[NT]
Arsenic	mg/kg	3	METALS-027	<3	1	<3	<3	0	100	[NT]
Cadmium	mg/kg	0.5	METALS-027	<0.5	1	<0.5	<0.5	0	99	[NT]
Chromium	mg/kg	1	METALS-027	<1	1	<1	<1	0	102	[NT]
Copper	mg/kg	1	METALS-027	<1	1	<1	<1	0	103	[NT]
Mercury	mg/kg	0.1	METALS-021	<0.1	1	<0.1	<0.1	0	89	[NT]
Lead	mg/kg	2	METALS-027	<2	1	<2	<2	0	103	[NT]
Silver	mg/kg	0.5	METALS-027	<0.5	1	<0.5	<0.5	0	103	[NT]
Zinc	mg/kg	1	METALS-027	<1	1	<1	<1	0	101	[NT]

QUALITY CONTROL: 1:5 Sequential Water Leachate						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Antimony	mg/L	0.001	METALS-022	<0.001	1	0.001	<0.001	0	82	[NT]
Arsenic	mg/L	0.001	METALS-022	<0.001	1	<0.001	<0.001	0	99	[NT]
Cadmium	mg/L	0.0001	METALS-022	<0.0001	1	<0.0001	<0.0001	0	99	[NT]
Chromium	mg/L	0.001	METALS-022	<0.001	1	<0.001	<0.001	0	95	[NT]
Copper	mg/L	0.001	METALS-022	<0.001	1	<0.001	<0.001	0	99	[NT]
Mercury	mg/L	0.00005	METALS-021	<0.00005	1	<0.00005	<0.00005	0	104	[NT]
Lead	mg/L	0.001	METALS-022	<0.001	1	<0.001	<0.001	0	102	[NT]
Silver	mg/L	0.001	METALS-022	<0.001	1	<0.001	<0.001	0	100	[NT]
Zinc	mg/L	0.001	METALS-022	<0.001	1	<0.001	<0.001	0	99	[NT]

QUALITY CONTROL: 1:5 Sequential Water Leachate						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Antimony	mg/L	0.001	METALS-022	[NT]	2	<0.001	<0.001	0	[NT]	[NT]
Arsenic	mg/L	0.001	METALS-022	[NT]	2	<0.001	<0.001	0	[NT]	[NT]
Cadmium	mg/L	0.0001	METALS-022	[NT]	2	<0.0001	<0.0001	0	[NT]	[NT]
Chromium	mg/L	0.001	METALS-022	[NT]	2	<0.001	<0.001	0	[NT]	[NT]
Copper	mg/L	0.001	METALS-022	[NT]	2	<0.001	<0.001	0	[NT]	[NT]
Mercury	mg/L	0.00005	METALS-021	[NT]	2	<0.00005	<0.00005	0	[NT]	[NT]
Lead	mg/L	0.001	METALS-022	[NT]	2	<0.001	<0.001	0	[NT]	[NT]
Silver	mg/L	0.001	METALS-022	[NT]	2	<0.001	<0.001	0	[NT]	[NT]
Zinc	mg/L	0.001	METALS-022	[NT]	2	<0.001	<0.001	0	[NT]	[NT]

QUALITY CONTROL: 1:5 Sequential Water Leachate						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Antimony	mg/L	0.001	METALS-022	[NT]	3	<0.001	<0.001	0	[NT]	[NT]
Arsenic	mg/L	0.001	METALS-022	[NT]	3	<0.001	<0.001	0	[NT]	[NT]
Cadmium	mg/L	0.0001	METALS-022	[NT]	3	<0.0001	<0.0001	0	[NT]	[NT]
Chromium	mg/L	0.001	METALS-022	[NT]	3	<0.001	<0.001	0	[NT]	[NT]
Copper	mg/L	0.001	METALS-022	[NT]	3	<0.001	<0.001	0	[NT]	[NT]
Mercury	mg/L	0.00005	METALS-021	[NT]	3	<0.00005	<0.00005	0	[NT]	[NT]
Lead	mg/L	0.001	METALS-022	[NT]	3	<0.001	<0.001	0	[NT]	[NT]
Silver	mg/L	0.001	METALS-022	[NT]	3	<0.001	<0.001	0	[NT]	[NT]
Zinc	mg/L	0.001	METALS-022	[NT]	3	<0.001	<0.001	0	[NT]	[NT]

QUALITY CONTROL: 1:5 Sequential NaCl Leachate					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Antimony	mg/L	0.001	METALS-022	<0.001	1	0.001	<0.001	0	82	[NT]
Arsenic	mg/L	0.001	METALS-022	<0.001	1	0.002	0.001	67	99	[NT]
Cadmium	mg/L	0.0001	METALS-022	<0.0001	1	0.0001	<0.0001	0	99	[NT]
Chromium	mg/L	0.001	METALS-022	<0.001	1	<0.001	<0.001	0	95	[NT]
Copper	mg/L	0.001	METALS-022	<0.001	1	0.001	0.001	0	99	[NT]
Mercury	mg/L	0.00005	METALS-021	<0.00005	1	<0.00005	<0.00005	0	104	[NT]
Lead	mg/L	0.001	METALS-022	<0.001	1	<0.001	<0.001	0	102	[NT]
Silver	mg/L	0.001	METALS-022	<0.001	1	<0.001	<0.001	0	100	[NT]
Zinc	mg/L	0.001	METALS-022	<0.001	1	0.023	0.011	71	99	[NT]

QUALITY CONTROL: 1:5 Sequential NaCl Leachate					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Antimony	mg/L	0.001	METALS-022	[NT]	2	<0.001	<0.001	0	[NT]	[NT]
Arsenic	mg/L	0.001	METALS-022	[NT]	2	<0.001	<0.001	0	[NT]	[NT]
Cadmium	mg/L	0.0001	METALS-022	[NT]	2	<0.0001	<0.0001	0	[NT]	[NT]
Chromium	mg/L	0.001	METALS-022	[NT]	2	<0.001	<0.001	0	[NT]	[NT]
Copper	mg/L	0.001	METALS-022	[NT]	2	<0.001	<0.001	0	[NT]	[NT]
Mercury	mg/L	0.00005	METALS-021	[NT]	2	<0.00005	<0.00005	0	[NT]	[NT]
Lead	mg/L	0.001	METALS-022	[NT]	2	<0.001	<0.001	0	[NT]	[NT]
Silver	mg/L	0.001	METALS-022	[NT]	2	<0.001	<0.001	0	[NT]	[NT]
Zinc	mg/L	0.001	METALS-022	[NT]	2	0.002	0.002	0	[NT]	[NT]

QUALITY CONTROL: 1:5 Sequential NaCl Leachate					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Antimony	mg/L	0.001	METALS-022	[NT]	3	<0.001	<0.001	0	[NT]	[NT]
Arsenic	mg/L	0.001	METALS-022	[NT]	3	<0.001	<0.001	0	[NT]	[NT]
Cadmium	mg/L	0.0001	METALS-022	[NT]	3	<0.0001	<0.0001	0	[NT]	[NT]
Chromium	mg/L	0.001	METALS-022	[NT]	3	<0.001	<0.001	0	[NT]	[NT]
Copper	mg/L	0.001	METALS-022	[NT]	3	<0.001	<0.001	0	[NT]	[NT]
Mercury	mg/L	0.00005	METALS-021	[NT]	3	<0.00005	<0.00005	0	[NT]	[NT]
Lead	mg/L	0.001	METALS-022	[NT]	3	<0.001	<0.001	0	[NT]	[NT]
Silver	mg/L	0.001	METALS-022	[NT]	3	<0.001	<0.001	0	[NT]	[NT]
Zinc	mg/L	0.001	METALS-022	[NT]	3	0.002	0.002	0	[NT]	[NT]

QUALITY CONTROL: Moisture					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date prepared	-			11/12/2018	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Date analysed	-			11/12/2018	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Moisture	%	0.1	INORG-008	<0.1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]

Result Definitions

NT	Not tested
NA	Test not required
INS	Insufficient sample for this test
PQL	Practical Quantitation Limit
<	Less than
>	Greater than
RPD	Relative Percent Difference
LCS	Laboratory Control Sample
NS	Not specified
NEPM	National Environmental Protection Measure
NR	Not Reported

Quality Control Definitions

Blank	This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.
Duplicate	This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.
Matrix Spike	A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.
LCS (Laboratory Control Sample)	This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.
Surrogate Spike	Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Australian Drinking Water Guidelines recommend that Thermotolerant Coliform, Faecal Enterococci, & E.Coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC & ARMC 2011.

The recommended maximums for analytes in urine are taken from “2018 TLVs and BEIs”, as published by ACGIH (where available).

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.

Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.

Spikes for Physical and Aggregate Tests are not applicable.

For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: >10xPQL - RPD acceptance criteria will vary depending on the analytes and the analytical techniques but is typically in the range 20%-50% – see ELN-P05 QA/QC tables for details; <10xPQL - RPD are higher as the results approach PQL and the estimated measurement uncertainty will statistically increase.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals; 60-140% for organics (+/-50% surrogates) a

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

Measurement Uncertainty estimates are available for most tests upon request.

Report Comments

Sequential water leachates - conducted as per client request. 1:5 ratio solid to DI water. Retain supernatant for metals analysis and retain solids for second and third extractions. Leachates filtered through 0.45 micron filters for metals analysis.

Sequential NaCl leachates - conducted as per client request. 1:5 ratio solid to 10,000 mg/L NaCl solution. Retain supernatant for metals analysis and retain solids for second and third extractions. Leachates filtered through 0.45 micron filters for metals analysis.

A reagent blank for the 10,000 mg/L NaCl solution was analysed - all target metals were <PQL.