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P.O. Box 247, Bridgetown, Western Australia 6255
Phone: (61 8) 9761 2829 E-mail: gca@wn.com.au
ACN 061 827 674 ABN 37 061 827 674

Testing Laboratory: Unit B, 15 Rose Street, Bridgetown, WA 6255

1901/1

COMPANY:	Audalia Resources Limited
ATTENTION:	Geoffrey Han
FROM:	Graeme Campbell
SUBJECT:	Medcalf Project: Characterisation of Mine-Waste Samples from **Vesuvius**, **Fuji**, **Egmont**, and **Pinatubo Pits** – Implications for Mine-Waste Management

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Geoffrey,

The testwork results obtained in this study are presented in **Tables 1-8**.

Photographs of the samples received for testing, and various testing procedures, are shown on **Plates 1-9**.

An overview of the geology of the Vesuvius, Fuji, Egmont, and Pinatubo Deposits, is presented in **Attachment A**.

The proposed Vesuvius, Fuji, Egmont, and Pinatubo Pits are **"Oxide-Only" Pits** with production of waste-regolith streams predominantly from the following Waste-Zones:

- Mottled-Zone which may locally be up to 10-15 m bgl
- Saprolite-Zone extending to pit-floors at *ca.* 50 m bgl

The satellite Egmont and Pinatubo Pits are shallower than the Vesuvius and Fuji Pits.

For all Pits, the top 4-5 m (nominal) of the Mottled-Zone variously comprises 'Fe-rich' colluvium, conglomerate and laterite. Occurrences of pisolitic-gravels are also common.[1]

This **Upper-Mottled-Zone** is an important resource of a blocky, hard mining stream for fill and other infrastructure demands at Project start-up, and physical-stabilisation applications when the site is decommissioned and rehabilitated (e.g. cladding the outer-slopes of the tailings-storage facility [TSF], construction of pit-abandonment bunds, etc.).

Details of the sampling programme undertaken for the samples tested this study are presented in **Attachment B**.

The **23** samples (as 3m-composites) tested herein were chosen following review of %S 'hits', and other assays, in the Project's geological database.[2]

Copies of the laboratory reports are presented in **Attachment C**.

1.0 TESTWORK OUTCOMES FOR MOTTLED-ZONE SAMPLES

1.1 pH and Salinity

The samples were typically acidic with pH-(1:2) values of 3.7-4.8 (**Table 1**).[3]

One of the samples derived from Gabbro (GB) had a pH-(1:2) value of 8.4, due to 'trace-carbonates'.

All samples were saline with EC-(1:2) values of 2.18-7.47 mS/cm.[4]

The salinity (chiefly halite, NaCl) reflects local and regional lacustrine influences, and the natural acidic state reflects the 'heavily-weathered/leached' nature of the sesquioxides ('resistates'), especially Fe/Al-oxyhydroxides, that predominate in the Mottled-Zone.

1.2 Acid-Forming Tendency

All samples contained 'negligible-sulphides' (viz. Sulphide-S ≤ 0.005 %), and are thus classified as Non-Acid Forming (NAF) [**Table 1**].

Acid-Neutralisation-Capacity (ANC) values were typically 1 kg H_2SO_4/tonne.

The circum-neutral (GB-derived) sample ARD_004 from the Vesuvius Pit had a CO_3-C value of 0.16 %, and a Bulk-ANC value of 12 kg H_2SO_4/tonne, reflective of 'trace-carbonates'.

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[1] Though the photographs shown in **Attachment A** are for outcropping mineralised massive conglomerate, they are also representative of the hard, physical *in situ* state of the unmineralised (i.e. 'waste') conglomerate.

[2] No samples from the satellite Egmont and Pinatubo Pits were tested in this study. However, the geology of the Mottled-Zone and Saprolite-Zone in these Pits is essentially identical to that for the Vesuvius and Fuji Pits. Of the 23 samples tested, 5 were Fresh-Zone-Basalt samples from the Vesuvius Pit, and near the Pinatubo Pit, which serve as 'model-samples' for the this Fresh-Zone unit to be produced from the borrow-pit to be developed for TSF construction (Section 3.0).

[3] Refer footnotes to **Table 1** for the definition of pH-(1:2), etc.

[4] EC = Electrical-Conductivity.

1.3 Multi-Element Composition

The samples were characterised by minor-element contents either below, or close to, those typically recorded for soils, regoliths, and bedrocks derived from non-mineralised terrain (**Table 2**).

Though variously enriched in Se and Bi, the degree of enrichment was not marked, and falls within the range typically recorded for waste-regoliths at hard-rock mines located within the Yilgarn block (Campbell, unpublished results since the late-1980s).

The Fe and Al contents were each 10+ %, and attest to abundant Fe/Al-oxyhydroxides in accord with the 'resistate' nature of the Mottled-Zone (i.e. 'weathering-end-members').

1.4 Solubility Characteristics

1.4.1 Water-Extraction Testwork

The results of the water-extraction testwork, corresponding to a solid:water ratio of ***ca.* 1:2 (w/w)**, are presented in **Table 3**.

The water-extracts were characterised by minor-element concentrations either below, or near, the respective detection-limits (0.1-1 µg/L range typically).

Despite being variously acidic, the water-extract-Al concentrations were constrained, and ranged up to 1.6 mg/L.

1.4.2 Saturated-Leaching Columns

Solubility behaviour was investigated further using saturated-leaching columns (SLCs), as shown on **Plate 9**.

Leachate-assays are presented in **Table 4**.

The key findings from the SLC testing are that:

(a) salinity is rapidly depleted during leaching with an increasing trend in pH

(b) Al solubility is closely tied to salinity, and swiftly drops from the multi-mg/L range initially, to the sub-mg/L range as leaching progresses

(c) soluble-Zn forms are present initially, but are swiftly eluted during leaching. The 'pools' of such soluble-Zn forms are within the 5-10 mg/kg (dry-solids basis) range, and thus constrained.

The above trends in (a) to (c) reflect a combination of (interacting) cation-exchange reactions (e.g. stripping of exchangeable-Al by Na [at *ca.* 0.1 M activity], and hydrolysis of released Al), and the pH-dependent, variable-surface-charge characteristics of the sesquioxides which are also influenced by ionic-strength (salinity) variations.

Such interdependent physicochemical properties of the Mottled-Zone reflects both its 'type-mineralogy' (i.e. 'sesquioxide-rich'), and elevated salinity, courtesy of lacustrine influences.

1.5 Physical Characteristics

Physical testing of the 'fine-earth' (-2 mm) fractions was undertaken to assess the tendency for clay / sesquioxide dispersion of the 'soil-like' (earthy) component of the Mottled-Zone samples.

Emerson-Dispersion (ED) testing of wet-sheared 'soil-balls' was performed on both the 'fine-earth' fractions, as obtained directly via dry-sieving, and following leaching with deionised-water to remove excess soluble-salts (chiefly halites).[5]

The ED testing showed that the samples resisted dispersion of clays / sesquioxides when aggregates were immersed in deionised-water, and thus subjected to marked osmotic-stress. The samples had an Emerson Class Number of 6 (**Table 5**).[6]

The 'fine-earth' fractions were characterised by Exchangeable-Al contents of 0.04-1.21 cmol(+)/kg, and Total-Exchangeable-Acidity values of 0.34-1.81 cmol(+)/kg (**Table 5**). When expressed in units of kg H_2SO_4/tonne, the Total-Exchangeable-Acidity values ranged up to *ca.* 1 kg H_2SO_4/tonne (i.e. low 'H_2SO_4-equivalent' loadings). Thus, though the Mottled-Zone samples were typically naturally acidic, their intrinsic acidity levels are tightly constrained, reflective of Al-hydroxy species sorbed to sesquioxide-surfaces.

2.0 TESTWORK OUTCOMES FOR SAPROLITE-ZONE SAMPLES

2.1 pH and Salinity

All samples were circum-neutral with pH-(1:2) values of 6-8 (**Table 1**).

Salinities ranged from moderate to extreme (e.g. the Ultramafic-derived sample ARD_012 from the Vesuvius Pit had an EC-(1:2) value of 19.2 mS/cm).

Overall, the Saprolite-Zone samples were appreciably saline.

2.2 Acid-Forming Tendency

All samples contained 'negligible-sulphides' (viz. Sulphide-S $\leq$ 0.007 %), and thus classified as NAF (**Table 1**).

The Bulk-ANC values were typically 2 kg H_2SO_4/tonne.

2.3 Multi-Element Composition

Though variously enriched in Cu, Ni, Cr, Co, and Bi, the degree of enrichment was not marked. The modest enrichments in at least Ni, Cr, and Co reflect ultramafic influences.

2.4 Solubility Characteristics

The water-extracts were characterised by minor-element concentrations either below, or near, the respective detection-limits (0.1-1 µg/L range typically) [**Table 3**].

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[5] Photographs taken during the ED testing are contained in the GCA-test-report presented in **Attachment C**.

[6] Refer footnotes to **Table 5** for the definition of Emerson Class Number.

2.5 Physical Characteristics

The effective-Cation-Exchange Capacity (eCEC) values were 8-50 cmol [+]/kg, and the Exchangeable-Sodium-Percentage (ESP) values were 47-65 % (**Table 5**).

The tested Saprolite-Zone samples were therefore appreciably sodic, as expected from their elevated salinity generally.

The samples subjected to ED testing were typically highly dispersive with Emerson Class Numbers of either 1 or 2 (**Table 5**). Such testing used intact, dry aggregates (2-5 mm nominal) that survived the drilling and sample-preparation treatments.

The presence of 'swelling-clays' (smectites) was readily apparent during the execution of other testwork, as shown on **Plates 3**, **7** and **8**.[7]

3.0 TESTWORK OUTCOMES FOR FRESH-ZONE-BASALT SAMPLES: SUPPLEMENTARY MATERIALS EARMARKED FOR CONSTRUCTION OF TAILINGS-STORAGE FACILITY (TSF)

During the refinement of the mining and construction schedule for the Project, a need for additional sources of regolith and bedrock materials for TSF construction was identified.

An area of *ca.* 850 m in length, and *ca.* 100 m in width, located just to the south-west of the Vesuvius Pit has therefore been earmarked as a borrow-pit with a depth of *ca.* 20 m as a supplementary source of TSF-construction materials. Save for being below economic mineralisation, the geology of the borrow-pit area is similar to that of the various Pits.

The borrow-pit profile comprises:

(a) 0-5 m (nominal) of Saprolite-Zone (derived from Basalt, BAS)

(b) 5-25 m (nominal) of Fresh-Zone-Basalt

The Saprolite-Zone in (a) will therefore have characteristics similar to samples ARD_006 and ARD_007 tested herein (**Tables 1-3**).

Testwork results for Fresh-Zone-Basalt samples (viz. samples ARD_021 to ARD_025) are presented in **Tables 6-8**. Samples ARD_021 to ARD_024 are derived from the Vesuvius Pit, and sample ARD_025 is derived from just outside the Pinatubo Pit.

The Fresh-Zone-Basalt samples are geochemically benign (i.e. NAF [≤ 0.01%S], bereft of element-enrichments, and interact feebly with water).

Sample ARD_022 (MRC125, 47-50 m) was subjected to mineralogical assessment by CSIRO Land and Water (Adelaide).[8] Amphibole predominated with subordinate anorthite. Accessory amounts of quartz, and traces of kaolinite and smectite, also occurred. Given the occurrence of 'trace-smectite' in this 'deep-sample' of the Fresh-Zone-Basalt, there is the possibility that smectites may be more abundant in this unit at shallower depths (e.g. borrow-pit development). It is therefore recommended that, during the forward-works programme for the Project, the Fresh-Zone-Basalt to be produced

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[7] It is understood that smectite occurrences in the Saprolite-Zone are also evident from the appearance of stored drillcore, especially during wet-spells when the relative-humidity of the air is elevated.

[8] The CSIRO-report in Attachment C includes the powder X-ray diffraction traces, etc.

from the borrow-pit is assessed for its physical suitability (or otherwise) for cladding, and other applications, where exposure will occur over the longer-term.

4.0 MANAGEMENT IMPLICATIONS

4.1 Relative Proportions of Mine-Waste Streams

Although the mining plan is currently being refined, it is understood that the total amount of mine-waste to be produced from each pit is projected to be:

- *ca.* 1.07 million tonnes from the Vesuvius Pit
- *ca.* 1.36 million tonnes from the Fuji Pit
- *ca.* 0.10 million tonnes from the Egmont Pit
- *ca.* 0.26 million tonnes from the Pinatubo Pit

The total of *ca.* 2.79 million tonnes of mine-waste produced from all Pits is estimated to comprise:

- *ca.* 66 % from the Mottled-Zone
- *ca.* 34 % from the Saprolite-Zone

The demand of materials required for the construction and rehabilitation of the TSF means that there will be no waste-rock dump (WRD) for the Project.[9]

No LG-ores are planned to be stockpiled.

4.2 Upper-Mottled-Zone (0-5 m nominal)

The mining stream derived from the Upper-Mottled-Zone (0-5 m nominal) is projected to correspond to around one-half of the total amount of mine-waste from the Mottled-Zone overall (i.e. tonnes from the Upper-Mottled-Zone *ca.* 33 % of the total amount of mine-wastes produced from all Pits). This mining stream therefore corresponds to a sizeable fraction of the total mine-waste volume for the Project.

Though variously moderately-acidic (pH 3-5 range), and saline, the 'soil-like' (earthy) fraction of the Upper-Mottled-Zone is stable against clay / sesquioxide dispersion, and thus reduced erosion risks when located on sloped-surfaces. The overall blocky / rocky nature of this mining stream means that it will be useful for managing the Saprolite-Waste-Zone streams which **are** susceptible to erosion.

In terms of acidity and salinity the Upper-Mottled-Zone *in situ* is the natural substrate beneath the surficial-soil profiles across the various Project areas (viz. Pits, TSF, etc.). Use of the mining streams from the Upper-Mottled-Zone in rehabilitation works is therefore broadly reconfiguring the soil/substrate profile pre-mining.

The 'Fe-rich' streams (viz. laterites, colluvium, conglomerate, and pisolitic-gravels) within the Upper-Mottled-Zone need to be segregated and stockpiled. Though a portion

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[9] The borrow-pit to be developed for TSF construction provides an option for selective pit-backfilling, if required, for management of mine-waste produced from the Vesuvius, Fuji, Egmont, and Pinatubo Pits.

of these mining streams will be employed in the initial site-wide earthworks as inert fill and infrastructure preparation, and TSF construction, sufficient volumes need to be stockpiled to meet the demands of subsequent decommissioning and rehabilitation works.

4.3 Oxide-Waste-Zone

Apart from salinity (NaCl), there are no geochemical concerns associated with the mining streams to be produced from the Oxide-Waste-Zones of all Pits.

However, marked sodicity, and the prominence of 'swelling-clays' (smectites), mean that the mining streams produced from the Oxide-Waste-Zones are highly erosive with ensuing implications for physical stability post-decommissioning.

4.3.1 Lower-Mottled-Zone

The mining streams from the Lower-Mottled-Zone should not be as physically stable as those from the Upper-Mottled-Zone, due to increasing clay content, and decreasing ferruginisation, with depth.

Mining streams from the Lower-Mottled-Zone may therefore pose erosion risks if they reside within the outer-sections of the TSF's (sloped) outer-embankments. However, an engineering assessment would be required to fully evaluate this possibility.

4.3.2 Saprolite-Zone

Due to their erosive nature (sodic, saline, and smectitic), the mining streams derived from the Saprolite-Zone not reside within the outer-sections of the TSF's (sloped) outer-embankments.

5.0 CLOSING

Since the Medcalf Project will not have a WRD, mine-waste management rests with the construction, operation and decommissioning of the TSF comprising largely Mottled-Zone-Waste, and Oxide-Zone-Waste (e.g. saprolites) where the latter are susceptible to erosion.

Physical stabilisation of the outer-slopes of the TSF is therefore a key demand for the Medcalf Project.

For all Pits, mining streams derived from the Upper-Mottled-Zone (0-5 m nominal) are key resources for physical stabilisation of the final TSF-landform, pit-abandonment bunds, etc.

I trust the above is useful to you.

Regards,

Dr GD Campbell
Director

encl. Tables 1-8 (some formatted for A3-sized paper)
Plates 1-9
Attachments A-C

TABLES

Table 1: Acid-Base-Analysis Results for Mine-Waste Samples (Vesuvius and Fuji Pits)

SAMPLE_ ID	PIT	DRILLHOLE ID	DOWNHOLE-INTERVAL (m)	LITHOLOGY	pH-(1:2)	EC-(1:2) [mS/cm]	TOTAL-S (%)	Cr(II)-RED.-S (%)	TOTAL-C (%)	CO3-C (%)	CARB.-ANC (calc'd)	BULK-ANC	AFP CATEGORY
											kg H2SO4/tonne		
					GCA	GCA	GLS	SGS	GLS	GLS		GCA	
MOTTLED-ZONE													
ARD_001	Vesuvius	MDD010	6-9	UM	4.8	3.03	0.18	<0.005	0.13	0.08		1	**NAF**
ARD_004		MRC127	0-3	GB	8.4	2.39	0.05	<0.005	0.21	0.16	13	12 (12)	**NAF**
ARD_005		MRC130	1-4		4.0	3.68	0.07	<0.005	0.12	0.07		1 (1)	**NAF**
ARD_006		MRC125	1-4	BAS	3.7	4.14	0.17	<0.005	0.16	0.09		1	**NAF**
ARD_007			14-15		3.7	7.47	0.14	<0.005	0.11	<0.01		-1	**NAF**
ARD_002	Fuji	MRC137	0-3	UM	3.9	2.18	0.12	<0.005	0.25	0.13		1	**NAF**
ARD_003		MRC139	20-23		4.3	4.01	0.15	<0.005	0.08	0.02		<1	**NAF**
SAPROLITE-ZONE													
ARD_008	Vesuvius	MDD010	17-20	UM	6.7	9.69	0.10	<0.005	0.08	0.02	2	2 (2)	**NAF**
ARD_012		MDD006	21-24		6.0	19.2	0.12	<0.005	0.11	0.05	4	2	**NAF**
ARD_013			58-60.8		6.8	9.24	0.05	<0.005	0.04	<0.01	<1	2	**NAF**
ARD_014		MDD009	36-39.2		6.9	6.93	0.04	<0.005	0.02	<0.01	<1	2 (2)	**NAF**
ARD_017		MRC127	12-15	GB	7.2	1.63	0.02	<0.005	0.02	<0.01	<1	2	**NAF**
ARD_018		MRC130	15-18		5.7	1.74	0.03	0.006	0.07	0.03	2	2	**NAF**
ARD_019		MRC125	25-28	BAS	5.6	5.85	0.12	0.007	0.09	<0.01	<1	2	**NAF**
ARD_020			39-42		6.8 (6.8)	3.13 (3.05)	0.02	<0.005	0.06	<0.01	<1	2	**NAF**
ARD_009	Fuji	MRC137	12-15	UM	5.3	5.92	0.08	<0.005	0.12	0.03	2	1	**NAF**
ARD_010			27-30		6.7 (6.7)	4.30 (4.37)	0.06	<0.005	0.06	<0.01	<1	2	**NAF**
ARD_011			41-44		7.5	2.4	0.03	<0.005	0.18	<0.01	<1	3	**NAF**

Notes:

EC = Electrical-Conductivity; ANC = Acid-Neutralisation Capacity; AFP = Acid-Formation Potential; NAF = Non-Acid Forming.

pH-(1:2) and EC-(1:2) values correspond to pH and EC measured on sample slurries prepared with deionised-water, and a solid:solution ratio of *ca.* 1:2 (w/w).

All results expressed on a dry-weight basis, except for pH-(1:2), and EC-(1:2).

Values in parentheses represent duplicates.

Calculated Carbonate-ANC (Carb.-ANC) values assume that all CO3-C is associated with Ca/Mg-carbonates (i.e. 'non-ferroan-carbonates').

Carbonate-ANC values not calculated for the acidic-Mottled-Zone samples.

Geo-Codes:

UM	Ultramafic
GB	Gabbro
BAS	Basalt

Table 2: Multi-Element-Analysis Results for Mine-Waste Samples (Vesuvius and Fuji Pits)

SAMPLE_ ID	PIT	DRILLHOLE_ ID	DOWNHOLE-INTERVAL (m)	LITHOLOGY	AFP	S	Ca	Mg	K	Na	Fe	Al	Si	Ti	As	Sb	Se	Mo	B	F	Ni	Cr
						%									mg/kg						mg/kg	
MOTTLED-ZONE																						
ARD_001	Vesuvius	MDD010	6-9	UM	**NAF**	0.18	0.01	0.13	0.02	0.14	34	8.0	7.6	1.4	2	0.1	3.33	2.1	<20	471	320	680
ARD_004		MRC127	0-3	GB	**NAF**	0.05	0.38	0.19	0.16	0.20	17	12	1.7	1.3	4	0.2	1.05	7.1	75	242	93	80
ARD_005		MRC130	1-4		**NAF**	0.07	0.02	0.09	0.21	0.20	8.7	15	2.2	2.4	<1	0.2	1.02	2.9	50	251	71	75
ARD_006		MRC125	1-4	BAS	**NAF**	0.17	0.03	0.06	0.07	0.19	20	13	1.6	2.3	1	0.2	1.61	43	40	281	250	370
ARD_002	Fuji	MRC137	0-3	UM	**NAF**		0.02	0.09	0.11	0.14	22	11	17	0.46	2	<0.1	2.41	6.6	35	241	280	620
SAPROLITE-ZONE																						
ARD_013	Vesuvius	MDD006	58-60.8	UM	**NAF**	0.05	0.11	2.7	0.10	0.65	27	1.0	1.8	0.29	<1	<0.1	0.08	1.9	<20	167	2,800	270
ARD_019		MRC125	25-28	BAS	**NAF**	0.12	0.10	0.77	0.15	0.55	16	7.8	1.9	0.71	<1	<0.1	0.12	3.2	<20	229	1,700	700
ARD_011	Fuji	MRC137	41-44	UM	**NAF**	0.03	4.5	7.0	0.34	0.67	15	3.8	2.2	1.1	<1	<0.1	0.99	11	<20	494	2,200	1,900
						Average-Crustal Abundance (Bowen 1979)									1.5	0.2	0.05	1.5	10	950	80	100

SAMPLE_ ID	PIT	DRILLHOLE_ ID	DOWNHOLE-INTERVAL (m)	LITHOLOGY	AFP	Cu	Zn	Cd	Pb	Hg	Co	Mn	Ag	Bi	P	Sr	Ba	Sn	V	Tl	Th	U
						mg/kg																
MOTTLED-ZONE																						
ARD_001	Vesuvius	MDD010	6-9	UM	**NAF**	960		<0.1	16	0.02	54	600	0.4	1.5	100	1.9	9	0.8	370	<0.2	3.6	1.0
ARD_004		MRC127	0-3	GB	**NAF**	290	15	<0.1	22	0.01	46	110	0.2	1.7	<20	39	54	0.9	970	<0.2	3.9	0.76
ARD_005		MRC130	1-4		**NAF**	100	18	<0.1	9	<0.01	12	160	<0.1	6.2	35	5.3	51	1.2	800	0.2	1.8	0.33
ARD_006		MRC125	1-4	BAS	**NAF**	630	63	<0.1	10	0.01	29	160	<0.1	4.8	70	5.0	34	1.1	740	<0.2	1.4	0.59
ARD_002	Fuji	MRC137	0-3	UM	**NAF**	480	97	<0.1	9	0.01	27	100	0.3	0.7	50	6.1	54	0.6	370	<0.2	1.9	0.61
SAPROLITE-ZONE																						
ARD_013	Vesuvius	MDD006	58-60.8	UM	**NAF**	1,300	330	0.5	2	0.01	390	3,700	0.3	1.1	140	7.7	4	0.7	86	<0.2	0.68	0.09
ARD_019		MRC125	25-28	BAS	**NAF**	1,000	220	0.1	4	0.01	1,400	8,200	0.7	0.4	100	19	440	1.0	300	2.2	0.42	0.13
ARD_011	Fuji	MRC137	41-44	UM	**NAF**	1,900	130	0.7	11	0.01	180	2,000	1.4	3.1	240	47	48	1.9	300	0.8	1.5	0.31
			Average Crustal Abundance (Bowen 1979)			50	75	0.11	14	0.05	20	950	0.07	0.05	1,000	370	500	2.2	160	0.6	12	2.4

▨	signifies element content 10-100 times average-crustal abundance
🟥	signifies element content 100+ times average-crustal abundance

Geo-Codes:		
	UM	Ultramafic
	GB	Gabbro
	BAS	Basalt

Reference: Bowen HJM, 1979, "Environmental Chemistry of the Elements", Academic Press, New York

Table 3: Water-Extraction-Testwork Results for Mine-Waste Samples (Vesuvius and Fuji Pits)

SAMPLE_ ID	PIT	DRILLHOLE_ ID	DOWNHOLE-INTERVAL (m)	LITHOLOGY	AFP	pH	pH (GCA)	EC (µS/cm)	EC (GCA, µS/cm)	Acidity (as mg/L CaCO3)	HCO3 (as mg/L CaCO3)	CO3 (as mg/L CaCO3)	Cl (mg/L)	SO4 (mg/L)	F (mg/L)	Ca	Mg	K	Na	Fe	Al	Mn	Si	react.-Si	As	Sb	Se	Mo	B
																mg/L									µg/L				
MOTTLED-ZONE																													
ARD_001	Vesuvius	MDD010	6-9	UM	**NAF**	5.4	5.3	2,300	2,590		<1	<1	690	100	0.2	3.3	28	12	370	0.37	0.21	0.09	12	13	<1	<1	<1	<0.5	450
ARD_004		MRC127	0-3	GB	**NAF**	8.3	8.1	1,800	1,880		140	<1	420	120	1.7	9.0	7.5	7.0	320	0.32	0.02	0.00	7.4	7.7	<1	<1	2	7.6	1,500
ARD_005		MRC130	1-4		**NAF**	5.0	5.1	2,900	3,120	7	<1	<1	820	140	<0.1	5.9	27	8.1	470	0.47	0.18	0.18	20	20	<1	<1	<1	<0.5	640
ARD_006		MRC125	1-4	BAS	**NAF**	4.2	4.3	3,600	4,070	19	<1	<1	1,100	240	0.4	18.0	55	11	570	0.57	1.6	0.23	20	19	<1	<1	<1	<0.5	1,100
ARD_002	Fuji	MRC137	0-3	UM	**NAF**	4.3	4.4	1,800	2,090	14	<1	<1	490	100	0.2	3.7	20	4.7	290	0.29	0.86	0.24	20	20	<1	<1	<1	<0.5	670
SAPROLITE-ZONE																													
ARD_013	Vesuvius	MDD006	58-60.8	UM	**NAF**	7.1	6.7	7,000	7,650		10	<1	2,100	400	0.3	1.8	54	25	1,300	1.3	<0.01	0.01	11	11	<2	<2	<2	<1	580
ARD_019		MRC125	25-28	BAS	**NAF**	6.5	6.2	4,300	4,840		<1	<1	1,200	290	0.3	2.2	19	19	740	0.74	<0.01	0.25	19	19	2	<1	<1	<0.5	1,100
ARD_011	Fuji	MRC137	41-44	UM	**NAF**	7.0	6.7	1,400	1,540		10	<1	370	89	0.6	0.1	1.2	4.7	260	0.26	0.02	0.01	15	16	2	<1	4	17	340

SAMPLE_ ID	PIT	DRILLHOLE_ ID	DOWNHOLE-INTERVAL (m)	LITHOLOGY	AFP	Ti	Ni	Cr	Cr(VI)	Co	Cu	Zn	Cd	Pb	Hg	Ag	Bi	Sn	Ba	Sr	P	Tl	Th	U	V
						µg/L																			
MOTTLED-ZONE																									
ARD_001	Vesuvius	MDD010	6-9	UM	**NAF**	<1	58	<1	-	15	28	210	<0.1	<1	<0.05	<1	<1	<1	36	53	<50	<1	<1	<1	<1
ARD_004		MRC127	0-3	GB	**NAF**	<1	<1	<1	-	<1	7	<5	<0.1	<1	<0.05	<1	<1	<1	25	150	<50	<1	<1	<1	15
ARD_005		MRC130	1-4		**NAF**	<1	16	<1	-	37	24	23	<0.1	<1	0.07	<1	<1	<1	44	140	<50	<1	<1	<1	<1
ARD_006		MRC125	1-4	BAS	**NAF**	<1	80	2	<1	76	100	100	<0.1	<1	<0.05	<1	<1	<1	41	490	<50	<1	<1	<1	<1
ARD_002	Fuji	MRC137	0-3	UM	**NAF**	<1	84	20	<1	49	100	180	<0.1	<1	<0.05	<1	<1	<1	88	110	<50	<1	<1	<1	<1
SAPROLITE-ZONE																									
ARD_013	Vesuvius	MDD006	58-60.8	UM	**NAF**	<2	20	4	2	<2	8	16	<0.2	<2	<0.05	<2	<2	<2	1.4	30	<50	<2	<2	<2	<2
ARD_019		MRC125	25-28	BAS	**NAF**	<1	71	2	1	94	18	30	<0.1	<1	<0.05	<1	<1	<1	2.2	63	<50	<1	<1	<1	<1
ARD_011	Fuji	MRC137	41-44	UM	**NAF**	<1	2	5	4	<1	8	<5	<0.1	<1	<0.05	<1	<1	<1	0.9	2	95	<1	<1	<1	8

Notes:

Water-Extraction Testwork corresponds to slurries prepared from the 'coarse-**crushed' (nominal -5 mm)** samples prepared using high-purity-deionised-water (HPDW), and a solid:water ratio of **1:2 (w/w)**.

Test-slurries bottle-rolled overnight and then left to 'still-stand' for *ca.* 1-2 days prior to decanting supernatants for vacuum-filtration (0.45µm-membrane) for analysis.

Samples ARD_011 and ARD_019 produced water-extracts that were very difficult to filter through 0.45µm-membrane, even with centrifugation prior to filtration.

A hyphen indicates assaying not undertaken.

Geo-Codes:		
	UM	Ultramafic
	GB	Gabbro
	BAS	Basalt

Table 4: Leachate-Assays for Saturated-Leaching Columns: Mottled-Zone Samples from Vesuvius and Fuji Pits

SAMPLE_ ID	PIT	DRILLHOLE_ ID	DOWNHOLE-INTERVAL (m)	LITHOLOGY	AFP	pH	pH (GCA)	EC (µS/cm)	EC (GCA, µS/cm)	Acidity (as mg/L CaCO3)	HCO3 (as mg/L CaCO3)	Cl (mg/L)	SO4 (mg/L)	F (mg/L)	Ca	Mg	K	Na	Al	Fe	Mn	Si	react.-Si	As	Sb	Se	Mo	B
															mg/L									µg/L				
ARD_001_1	Vesuvius	MDD010	6-9	UM	NAF	5.8	6.2	16,000	16,240		2	4,800	710	<0.1	25	260	47	2,700	0.10	<0.03	0.30	13	13	<5	<5	<5	<3	1,500
ARD_001_2						5.7	6.0	1,200	1,460			200	240	<0.1					0.02	<0.01	<0.01	11	11					860
ARD_001_3						5.6	5.6	510	922			66	130	<0.1					0.02	<0.01	<0.01	9.0	9.4					560
ARD_001_4						5.4	5.5	350	435	3		56	59	<0.1	0.11	0.53	2.7	60	0.02	<0.01	<0.01	8.3	8.1	<1	<1	<1	<0.5	440
ARD_004_1	Vesuvius	MRC127	0-3	GB	NAF	8.1	8.1	9,500	9,700		120	2,600	740	1.2	9.7	120	27	1,600	0.04	<0.03	0.02	7.3	7.6	<5	<5	7	7.7	3,400
ARD_004_2						8.8	8.8	1,500	1,640			190	130	4.9					0.02	<0.01	<0.01	9.4	9.6					<5
ARD_004_3						8.6	8.8	630	646			30	14	5.1					0.02	<0.01	<0.01	8.3	8.6					<5
ARD_005_1	Vesuvius	MRC130	1-4	GB	NAF	4.0	3.9	16,000	16,240	88		5,100	720	0.5	43	270	27	2,700	7.6	0.08	0.91	16	17	5	<5	<5	<3	2,300
ARD_005_2						5.4	5.0	1,200	1,490	5		190	230	<0.1					0.04	<0.01	0.02	14	14					<5
ARD_005_3						6.1	5.7	390	422			19	150	<0.1					0.01	<0.01	<0.01	16	17					<5
ARD_005_4						5.6	5.7	270	295			10	88	<0.1	0.08	0.15	0.71	49	0.01	<0.01	<0.01	17	18	1	<1	<1	<0.5	<5
ARD_006_1	Vesuvius	MRC125	1-4	BAS	NAF	3.7	3.6	21,000	22,700	91		6,500	1,300	1.0	130	370	41	3,500	8.8	0.14	0.94	20	20	<5	<5	<5	<3	4,600
ARD_006_2						4.1	3.9	1,400	1,750	12		260	220	<0.1					0.08	0.03	0.03	16	16					<5
ARD_006_3						4.2	4.1	450	455	7		40	140	<0.1					0.02	0.02	0.01	16	16					<5
ARD_006_4						4.2	4.1	310	337	6		23	84	<0.1	0.77	2.0	2.4	48	0.03	0.01	0.02	15	16	<1	<1	<1	<0.5	<5
ARD_002_1	Fuji	MRC137	0-3	UM	NAF	3.9	3.7	9,800	10,040	150		2,900	580	1.2	23	140	14	1,700	18	0.31	1.1	19	20	6	<5	<5	<3	2,200
ARD_002_2						4.7	4.6	850	955	8		110	210	<0.1					0.10	0.06	0.03	17	17					810
ARD_002_3						4.8	4.5	380	415	5		41	86	<0.1					0.04	0.04	0.01	16	17					500
ARD_002_4						4.9	4.8	220	241	4		23	52	<0.1	0.14	0.51	0.55	40	0.02	0.02	0.01	13	13	<1	<1	<1	<0.5	350

SAMPLE_ ID	PIT	DRILLHOLE_ ID	DOWNHOLE-INTERVAL (m)	LITHOLOGY	AFP	Ti	Ni	Cr	Cr(VI)	Co	Cu	Zn	Cd	Pb	Hg	Ag	Bi	Sn	Ba	Sr	P	Tl	Th	U	V
						µg/L																			
ARD_001_1	Vesuvius	MDD010	6-9	UM	NAF	<5	79	<5	<1	52	38	15,000	<0.5	<5	0.11	<5	<5	<5	60	560	<50	<5	<5	<5	<5
ARD_001_2							13	<1		2	6	430													
ARD_001_3							3	<1		<1	3	140													
ARD_001_4						<1	2	<1		<1	2	120	<0.1	<1	<0.05	<1	<1	<1	2.9	1	<50	<1	<1	<1	<1
ARD_004_1	Vesuvius	MRC127	0-3	GB	NAF	<5	100	<5	<1	<5	6	<25	<0.5	<5	<0.05	<5	<5	<5	29	1,900	<50	<5	<5	<5	5
ARD_004_2							8	<1		<1	3	<5													
ARD_004_3							2	<1		<1	2	<5													
ARD_005_1	Vesuvius	MRC130	1-4	GB	NAF	<5	140	7	<1	140	150	4,800	<0.5	18	0.31	<5	<5	<5	57	1,300	<50	<5	<5	<5	<5
ARD_005_2							6	1	<1	2	8	69													
ARD_005_3							3	<1		<1	3	12													
ARD_005_4						<1	2	<1		<1	3	8	<0.1	<1	<0.05	<1	<1	<1	1.9	<1	<50	<1	<1	<1	<1
ARD_006_1	Vesuvius	MRC125	1-4	BAS	NAF	<5	320	11	<1	280	310	7,200	<0.5	19	0.22	<5	<5	<5	55	3,100	<250	<5	<5	<5	<5
ARD_006_2							11	2	<1	7	25	130													
ARD_006_3							4	<1		2	11	35													
ARD_006_4						<1	6	<1		4	11	47	<0.1	<1	<0.05	<1	<1	<1	26	16	<50	<1	<1	<1	<1
ARD_002_1	Fuji	MRC137	0-3	UM	NAF	<5	430	130	<1	240	660	6,200	<0.5	16	0.21	<5	<5	<5	59	630	<50	<5	<5	<5	<5
ARD_002_2							14	29	<1	5	36	93													
ARD_002_3							7	14	<1	2	18	34													
ARD_002_4						<1	4	7	<1	1	11	24	<0.1	<1	<0.05	<1	<1	<1	15	3	<50	<1	<1	<1	<1

Notes:

EC = Electrical-Conductivity

Saturated-Leaching Columns contained 1.00 kg (dry-solids equivalent) of 'coarse-crushings' (-5 mm nominal), and were leached with 0.50 kg lots of high-purity-deionised-water (HPDW).

It generally took 1-2 weeks for each lot of HPDW to drain through the columns; sample ARD_004 was much slower draining with up to *ca.* 1 month needed for each lot of HPDW to drain fully through.

All samples produced *ca.* 0.20 kg of leachate for Cycle-1, and then *ca.* 0.50 kg thereafter.

Geo-Codes:

UM	Ultramafic
GB	Gabbro
BAS	Basalt

Table 6: Acid-Base-Analysis Results for Fresh-Zone-Basalt Samples: Model of TSF-Construction Material

SAMPLE_ ID	PIT	DRILLHOLE ID	DOWNHOLE-INTERVAL (m)	LITHOLOGY	pH-(1:2)	EC-(1:2) [mS/cm]	TOTAL-S (%)	Cr(II)-RED.-S (%)	TOTAL-C (%)	CO3-C (%)	BULK-ANC (kg H2SO4/t)	AFP CATEGORY
					GCA	GCA	GLS	SGS	GLS	GLS	GCA	
FRESH-ZONE												
ARD_021	Vesuvius	MRC125	43-46	BAS	8.4	0.71	0.01	<0.005	0.02	<0.01	2	**NAF**
ARD_022			47-50		8.9	0.28	<0.01	<0.005	0.01	<0.01	2 (2)	**NAF**
ARD_023			52-55		9.1	0.16	<0.01	<0.005	0.04	0.02	2	**NAF**
ARD_024			57-60		8.9	0.20	<0.01	<0.005	0.02	<0.01	2	**NAF**
ARD_025	Pinatubo	PTC006	21-24		8.7	0.57	<0.01	<0.005	0.02	<0.01	2	**NAF**

Notes:

EC = Electrical-Conductivity; ANC = Acid-Neutralisation Capacity; AFP = Acid-Formation Potential; NAF = Non-Acid Forming.

pH-(1:2) and EC-(1:2) values correspond to pH and EC measured on sample slurries prepared with deionised-water, and a solid:solution ratio of *ca.* 1:2 (w/w).

All results expressed on a dry-weight basis, except for pH-(1:2), and EC-(1:2).

Values in parentheses represent duplicates.

Geo-Code:	BAS	Basalt

Table 7: Multi-Element-Analysis Results for Fresh-Zone-Basalt Samples: Model of TSF-Construction Material

SAMPLE_ ID	PIT	DRILLHOLE_ ID	DOWNHOLE-INTERVAL (m)	LITHOLOGY	AFP	S	Ca	Mg	K	Na	Fe	Al	Si	Ti	As	Sb	Se	Mo	B	F	Ni	Cr
						%									mg/kg						mg/kg	
FRESH-ZONE																						
ARD_022	Vesuvius	MRC125	47-50	BAS	**NAF**	<0.01	7.5	4.4	0.17	1.6	7.9	7.0	2.6	0.43	1	0.1	0.02	1.3	<20	422	170	200
ARD_025	Pinatubo	PTC006	21-24		**NAF**	<0.01	8.2	4.3	0.47	1.3	12	7.9	2.3	2.2	<1	<0.1	<0.01	0.8	<20	310	130	80
						Average-Crustal Abundance (Bowen 1979)									1.5	0.2	0.05	1.5	10	950	80	100

SAMPLE_ ID	PIT	DRILLHOLE_ ID	DOWNHOLE-INTERVAL (m)	LITHOLOGY	AFP	Cu	Zn	Cd	Pb	Hg	Co	Mn	Ag	Bi	P	Sr	Ba	Sn	V	Tl	Th	U
						mg/kg																
FRESH-ZONE																						
ARD_022	Vesuvius	MRC125	47-50	BAS	**NAF**	93	77	0.1	3	<0.01	54	1,200	0.2	0.5	220	110	13	0.7	250	<0.2	0.29	0.07
ARD_025	Pinatubo	PTC006	21-24		**NAF**	58	84	0.2	3	<0.01	83	1,200	<0.1	0.6	130	370	56	0.7	700	<0.2	0.52	0.13
			Average Crustal Abundance (Bowen 1979)			50	75	0.11	14	0.05	20	950	0.07	0.05	1,000	370	500	2.2	160	0.6	12	2.4

▨ signifies element content 10-100 times average-crustal abundance

▨ signifies element content 100+ times average-crustal abundance

Geo-Code: BAS Basalt

Reference: Bowen HJM, 1979, "Environmental Chemistry of the Elements", Academic Press, New York

Table 8: Water-Extraction-Testwork Results for Fresh-Zone-Basalt Samples: Model of TSF-Construction Material

SAMPLE_ ID	PIT	DRILLHOLE_ ID	DOWNHOLE-INTERVAL (m)	LITHOLOGY	AFP	pH	pH (GCA)	EC (µS/cm)	EC (GCA, µS/cm)	Acidity (as mg/L CaCO3)	HCO3 (as mg/L CaCO3)	CO3 (as mg/L CaCO3)	Cl (mg/L)	SO4 (mg/L)	F (mg/L)	Ca	Mg	K	Na	Fe	Al	Mn	Si	reactive-Si	As	Sb	Se	Mo	B
																mg/L									µg/L				
FRESH-ZONE																													
ARD_022	Vesuvius	MRC125	47-50	BAS	**NAF**	7.7	7.3	260	432		37	<1	48	16	0.7	0.7	0.10	0.99	48	0.05	0.41	<0.01	9.6	-	26	<1	<1	41	250
ARD_025	Pinatubo	PTC006	21-24		**NAF**	7.6	7.4	280	330		31	<1	56	20	0.8	0.23	0.59	0.34	51	0.69	0.69	<0.01	11	8.8	7	<1	<1	1.9	120

SAMPLE_ ID	PIT	DRILLHOLE_ ID	DOWNHOLE-INTERVAL (m)	LITHOLOGY	AFP	Ti	Ni	Cr	Cr(VI)	Co	Cu	Zn	Cd	Pb	Hg	Ag	Bi	Sn	Ba	Sr	P	Tl	Th	U	V
						µg/L																			
FRESH-ZONE																									
ARD_022	Vesuvius	MRC125	47-50	BAS	**NAF**	2	2	1	-	<1	12	<5	<0.1	<1	0.07	<1	<1	<1	2.0	5	130	<1	<1	1	130
ARD_025	Pinatubo	PTC006	21-24		**NAF**	11	5	1	<1	<1	8	<5	<0.1	<1	<0.05	<1	<1	<1	0.5	1	150	<1	<1	<1	110

Notes:

Water-Extraction Testwork corresponds to slurries prepared from the **crushed (nominal -2 mm)** samples prepared using high-purity-deionised-water (HPDW), and a solid:water ratio of **1:2 (w/w)**.
Test-slurries bottle-rolled overnight and then left to 'still-stand' for *ca.* 1-2 days prior to decanting supernatants for vacuum-filtration (0.45µm-membrane) for analysis.
Samples ARD_022, and ARD_025, produced water-extracts that were very difficult to filter through 0.45µm-membrane, even with centrifugation priort o filtration.
A hyphen indicates assaying not undertaken.

Geo-Code: BAS Basalt

PLATES

As-Received Drilling Samples Following Preparation

Crushings and Pulps for Testing

PLATE 1: 'As-Received' **Drilling Samples** at GCA Testing Laboratory (Bridgetown) following preparation by GLS Intertek (Maddington). Preparation of drillcore comprised 'coarse-crushing' to -5 mm nominal, and pulverising ('pulping') to -75 µm nominal. The so-generated crushings and pulps were employed in specific tests.

PLATE 2: Determination of pH-(1:2) and EC-(1:2) values (EC = Electrical-Conductivity) using crushings (-5 mm nominal). Test-slurries aged in contact with air at room-temperature (20-22 °C) for *ca.* 2-3 days prior to measuring pH and EC. The test-slurries were stirred using a spatula a number of times during this ageing period. Supernatant-water initially decanted for EC determination, and following return to beaker, slurry-pH measured. For a number of samples, the 'turbid/muddy' supernatants needed to be centrifuged at 3,000 G for 30 minutes in order to obtain clear supernatants suitable for EC measurement (see further below).

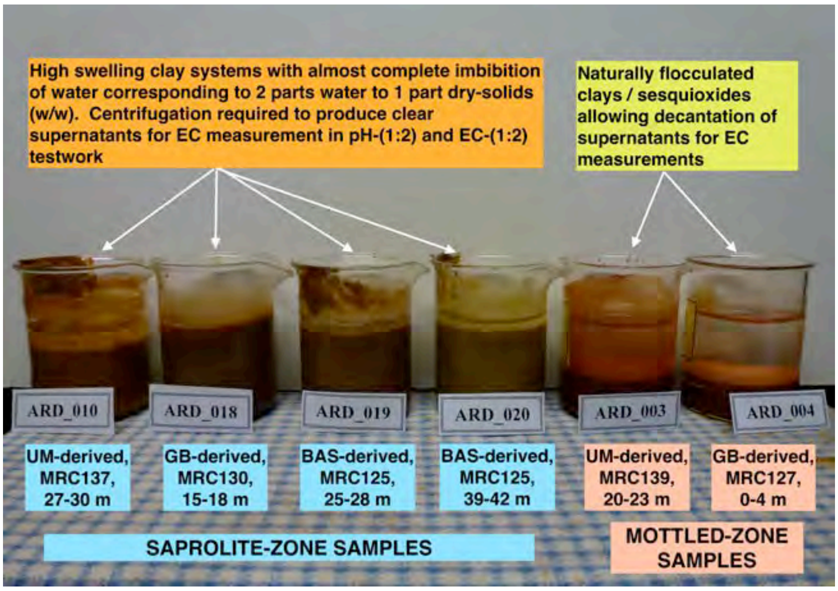
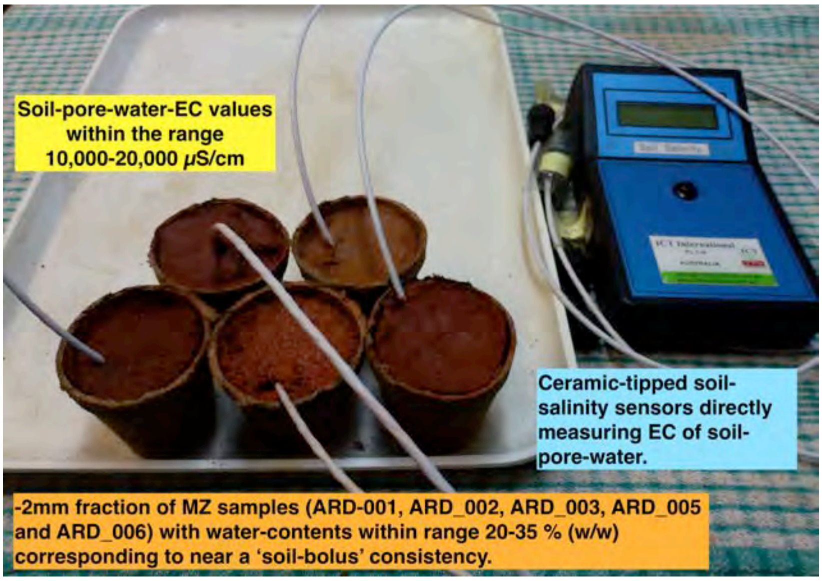


PLATE 3: The above shows how the **Saprolite-Zone** samples resembled **"clay-glugs"** when contacted with deionised-water reflective of their unstable "swelling" tendency.

See also **PLATE 7** and **PLATE 8**.

Soil-Salinity Sensors in "Potted" Fine-Earth (-2 mm) Fraction



Close-up of Soil-Salinity Sensor

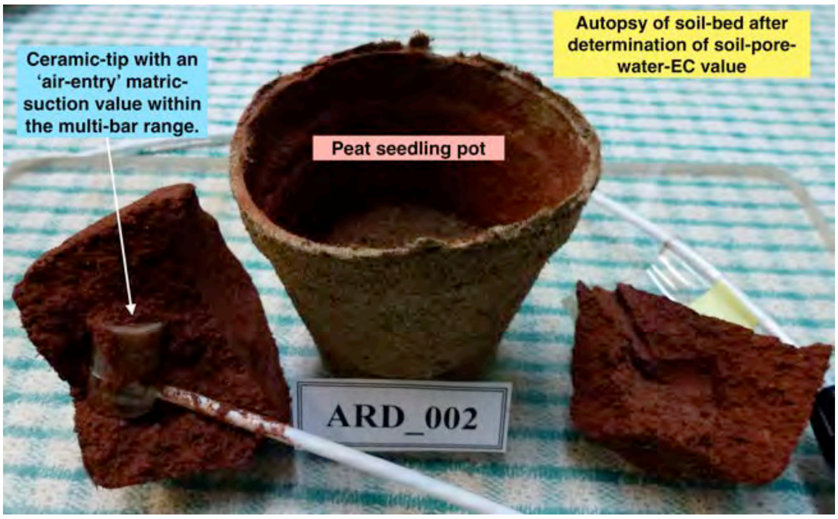


PLATE 4: Use of soil-salinity sensors in testing of Mottled-Zone samples.

Demonstration of the naturally elevated salinity of the uppermost, Fe-rich metres of the geologic-profile.

PLATE 5: Acid-Neutralisation-Capacity (ANC) testing using 'fine-crushings' (-2 mm, dry-sieved).

PLATE 6: Water-Extraction Testwork using 'coarse-crushings' (-5 mm nominal), and a solid:deionised-water ratio of **1:2 (w/w)**. Test-slurries agitated continuously via bottle-rolling, and then left to 'still-stand' for 1-2 days to allow 'fine-particulates' to settle, prior to decanting via siphoning. The decanted supernatants were then vacuum-filtered (0.45µm-membrane), and resulting filtrates preserved, as appropriate, for specific analytes. Centrifugation at *ca.* 3,000 G for 30 mins was required for some samples to facilitate vacuum-filtration (see **PLATE 7**).

PLATE 7: The above shows the highly-dispersed state (= **"clay-soup"**) of the decanted "mother-liquor" initially decanted following completion of the Water-Extraction Testwork for sample ARD_019 (Saprolite-[Basalt] from Vesuvius Pit). This was one of the samples for which centrifugation was required in order to undertake vacuum-filtration.

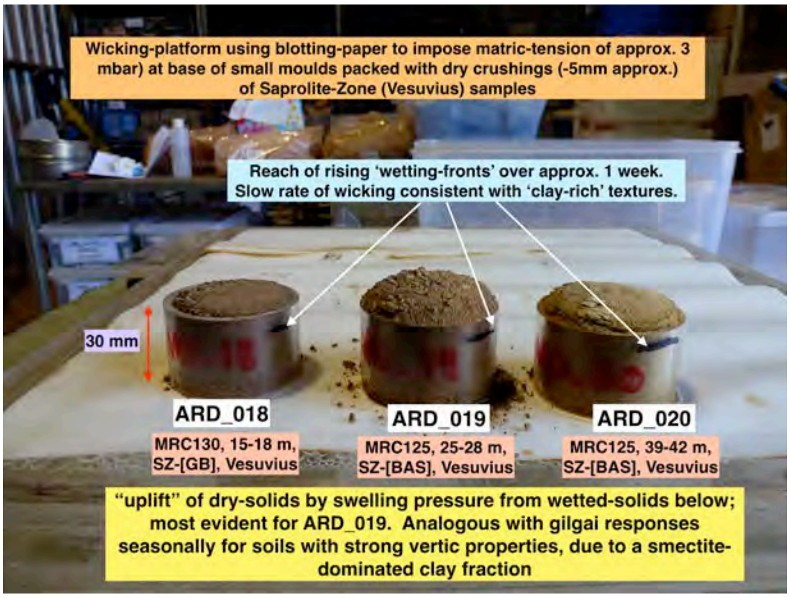
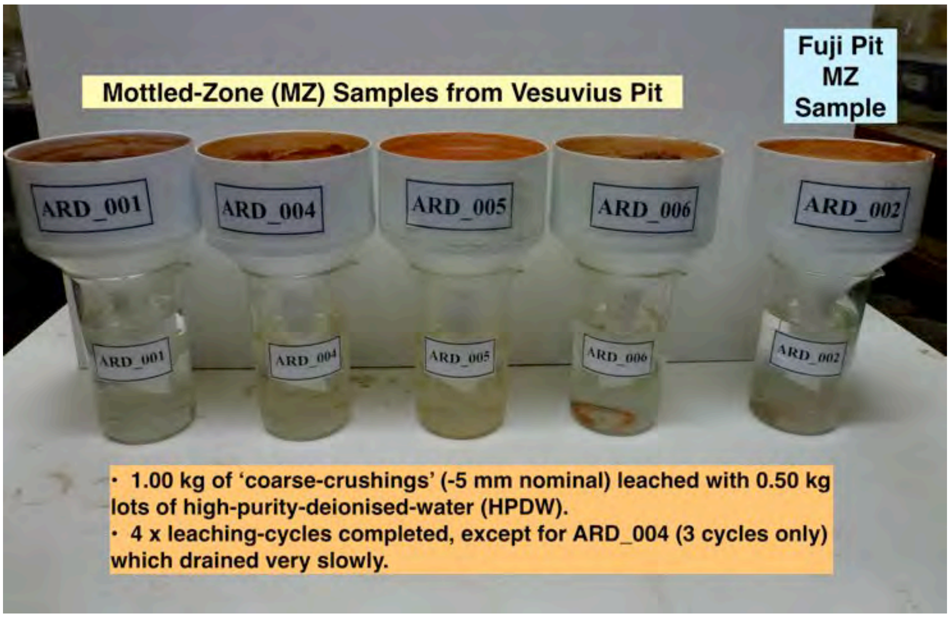


PLATE 8: Demonstration of the **swelling tendency** under unsaturated-flow conditions as 'wetting-front' (= 'wicking-front') advances under matric-suction gradient into dry Saprolite-Zone samples.



- 1.00 kg of 'coarse-crushings' (-5 mm nominal) leached with 0.50 kg lots of high-purity-deionised-water (HPDW).
- 4 x leaching-cycles completed, except for ARD_004 (3 cycles only) which drained very slowly.

PLATE 9: Saturated-Leaching Columns run for Mottled-Zone samples.

ATTACHMENT A

OVERVIEW OF GEOLOGY FOR MEDCALF PROJECT

Memo

To: Geoffrey Han

From: Brent Butler

cc: Graeme Campbell & Phil Scott

Date: 17 March 2020

Re: Brief description of Medcalf geology

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1 GEOLOGY

1.1 Introduction and background

The Medcalf Project lies in the Archaean aged Lake Johnston greenstone belt in the Yilgarn Craton. This belt contains komatiite lava flows, subvolcanic intrusions, mafic volcanic rocks, felsic volcanic rocks, banded iron formation (BIF) and sedimentary rocks. The deposit is hosted by the Medcalf layered sill, which is a flat lying igneous body which has intruded parallel to the enclosing basalts. The sill is comprised of an upper gabbroic zone, a middle pyroxenite zone, with a lower amphibolite zone.

The deposit was discovered by Union Laporte Miniere in the 1960s. Historic exploration in the 1970s and 1980s by Amoco defined three separate areas of vanadium mineralisation known as the Vesuvius, Fuji and Egmont Prospects.

The Medcalf deposit is located in the Archaean aged Lake Johnston greenstone belt in the southern portion of the Youanmi Terrane, part of the Yilgarn Craton (Figure 1). This belt is a narrow north-northwest trending belt, approximately 110 km in length. It is located near the south margin of the Yilgarn Craton, midway between the southern ends of Norseman-Wiluna and the Forrestonia-Southern Cross greenstone belts.

The eastern and northern limits of the Lake Johnston Greenstone Belt are defined by the large northwest-trending Koolyanobbing shear zone. To the west, the greenstones are bound by grantoids and gneissic rocks which extend some 70 km west to the Forrestonia-

Southern Cross greenstone belts. To the south, the greenstones appear to pinch out in granites.

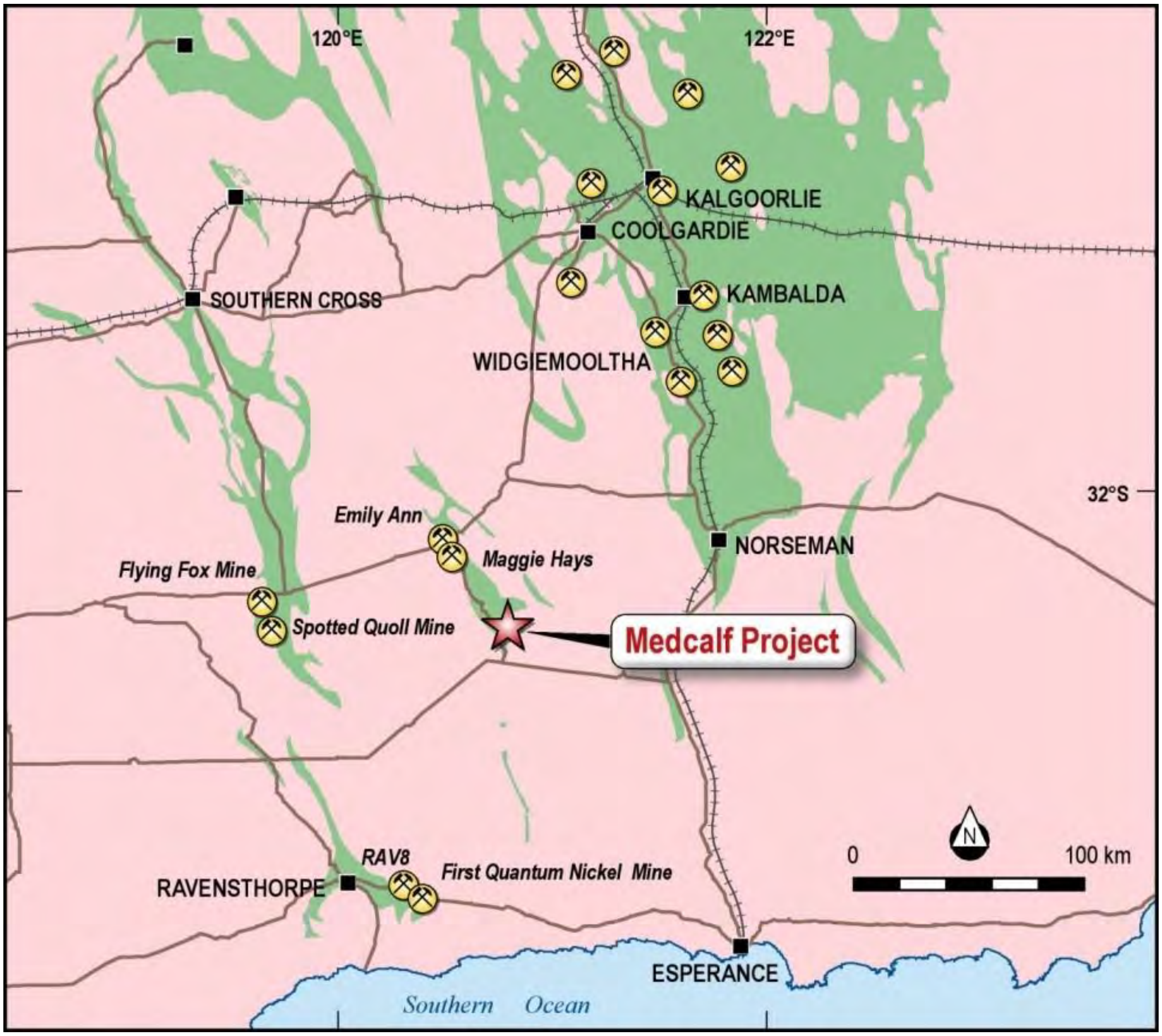


Figure 1: Regional geology showing greenstone belts and mine locations

The western margin of the Lake Johnston greenstone belt consists of a west facing succession of mafic and felsic volcanics, some sediment horizons, Banded Iron Formation (BIF) and three ultramafic units.

The volcanics and sediments are flanked and intruded by granitic rocks which disrupt the continuity of the greenstone belt. Pegmatitic doleritic dykes are common. The sequence is extensively faulted, and gently inclined. North and south plunging folds have been recognised. The boundaries of the greenstone belt are thought to be largely defined by strike parallel shears and faults.

The bedrock geology is widely masked by lateritic duricrust, deep oxidation and transported material. The average thickness of the regolith and weathered bedrock is 60 to 80 m. Weathering of ultramafic rock types is often intense with widespread development of silica-rich "cap-rock" in the saprolite zone.

1.1.1 Regional structure

The Regional structure strike approximates 330^0 with the foliation dipping most commonly steeply to the east, with the only major exception being dips within the metabasalt along the western edge of Lake Johnston to the west.

The Lake Johnston greenstone belt is considered to be a western overturned limb of a broad regional anticline. The eastern limb is no longer preserved having been removed by one or a combination of the following factors:

- Faulted out to a higher position followed by erosion to present levels
- Obliterated by late stage granite intrusion
- The unit corresponds to a thinner and less developed section of the pile

The third point above is also considered to be the reason for the general lensing out of the main layered intrusive toward the southern end.

The Medcalf layered sill has been intruded low in the greenstone succession and appears to be in the hinge zone of a major, gently north plunging regional anticline. The succession to the west of Medcalf is west-facing but is generally overturned, with steep easterly dips. To the east of Medcalf are the granite intruded remnants of the east-facing eastern limb of the regional anticline.

1.1.2 Regional mineralisation

Mineralisation in the Lake Johnston area includes nickel, base metals, vanadium, iron, titanium and gold.

Nickel is the dominant commodity in the area where there are several mines in the area. Western Areas Limited operate two underground mines at Forrestonia, Flying Fox and the Spotted Quoll mines which produce on average 25,000 t/a of nickel concentration per year. Poseidon Nickel Ltd (Poseidon) own the two underground nickel mines Emily Ann and Maggie Hays (both on care and maintenance) in the Lake Johnston area.

Audalia's Medcalf Project located some 50 km south of the Maggie Hays Nickel Mine. The mineralisation is contained within a pyroxenite sill and was drilled during 2013 by Audalia for Resource definition. The latest JORC (2012) Resource of 32Mt @ 0.47% V_2O_5, 8.98% TiO_2 and 49.2% Fe_2O_3 was announced to the market on August 31st, 2018.

The Medcalf Project lies within the Medcalf layered sill, which is a flat lying igneous body which has intruded parallel to the enclosing volcanic strata basalt, prior to regional metamorphism. It is a layered basic sill of the gravity differentiated type. The sill is comprised of an upper gabbroic zone, a middle pyroxenite zone, with a lower amphibolite zone in the footwall. Four separate zones of vanadium, titanium and iron mineralisation have been identified within the project area and named the Egmont, Vesuvius, Fuji and Pinatubo prospects. In the Medcalf deposit vanadium, iron and titanium have been concentrated in a pyroxenite unit, which has subsequently been enriched in these metals through weathering and regolith formation.

In the mineralised area (Figure 2) the magnetite-rich sequence is deeply weathered, with +60m of saprolite showing vertical zonation of weathering minerals due to progressive weathering. Mineralogy of the vanadium rich zone is dominated by hematite-goethite and kaolinite with minor ilmenite, diaspore, gibbsite, anatase, rutile, magnetite, quartz and mica.

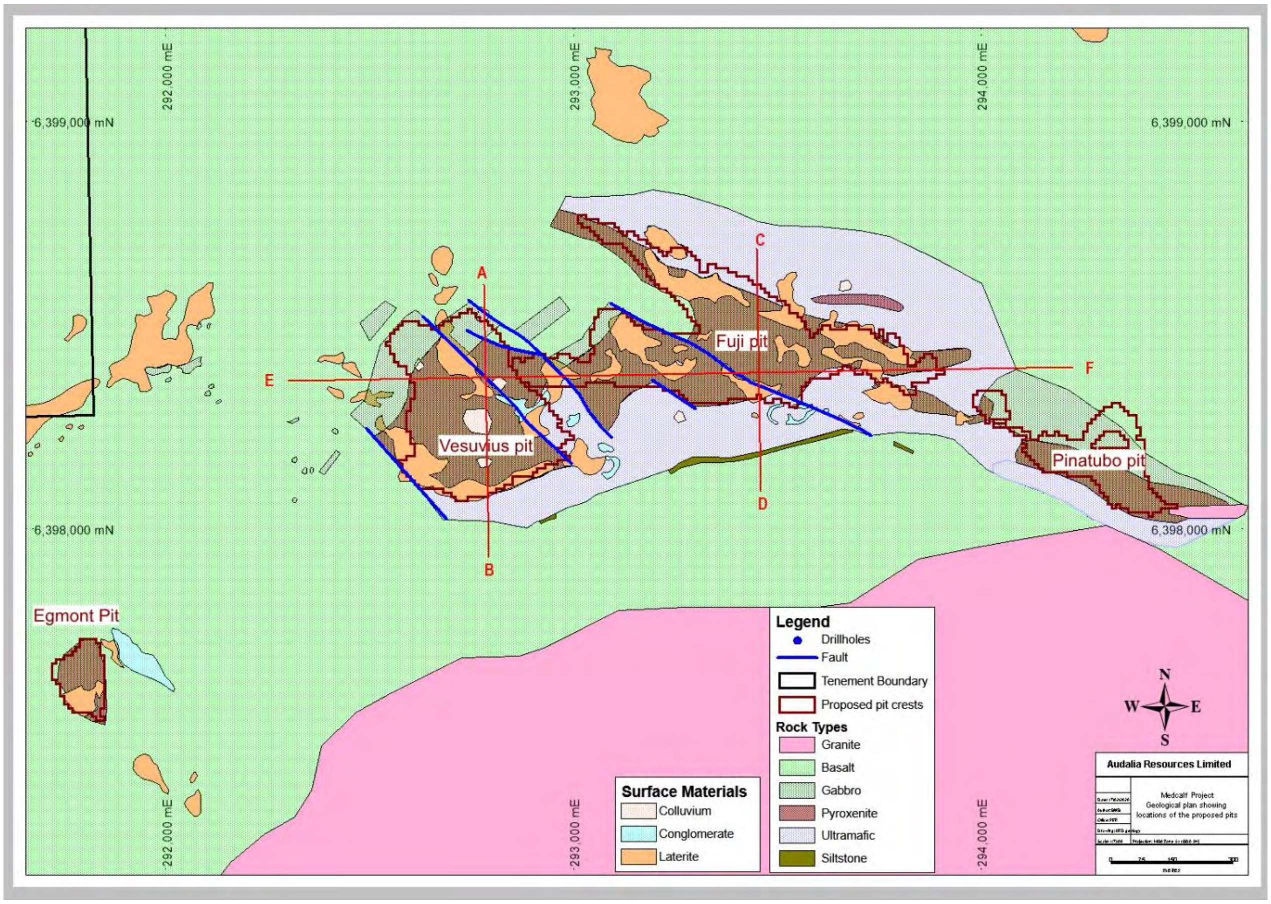


Figure 2 - Medcalf deposit geology

The fully developed lateritic weathering profile is divisible into four zones. Starting from the top, they are lateritic residuum, mottled zone, saprolite and saprock. All vanadium, iron and titanium mineralisation lie in the saprolitic zone. Saprolite extends to the bottom of all the holes drilled by Audalia.

The following figures (Figures 3 & 4) provide north-south oriented cross section views through the deposit, and an east-west oriented long section view (Figure 5) through the deposit.

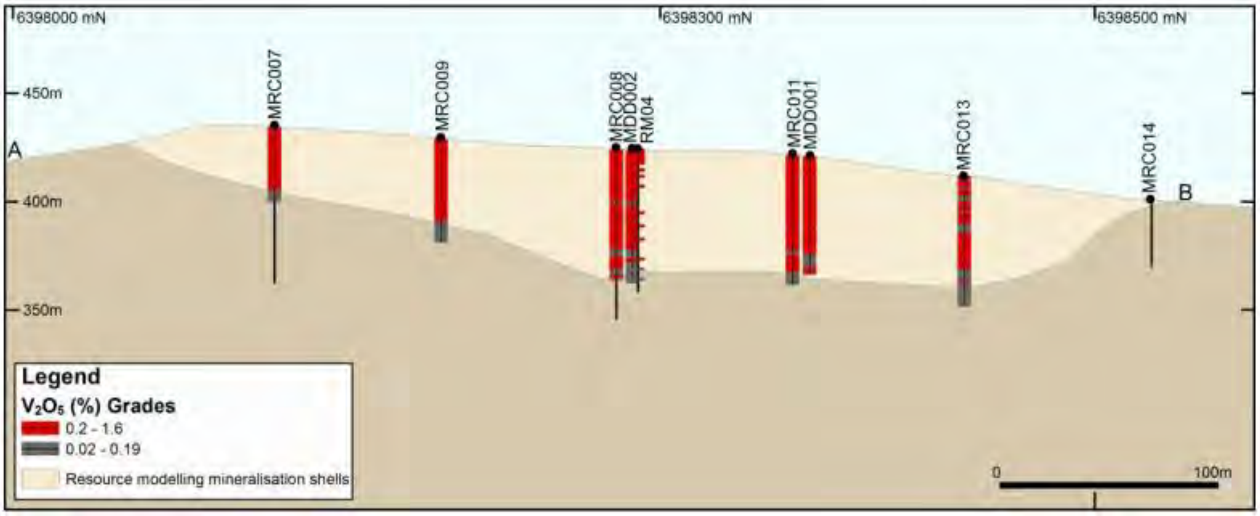


Figure 3 - Cross section A - B through the Vesuvius deposit

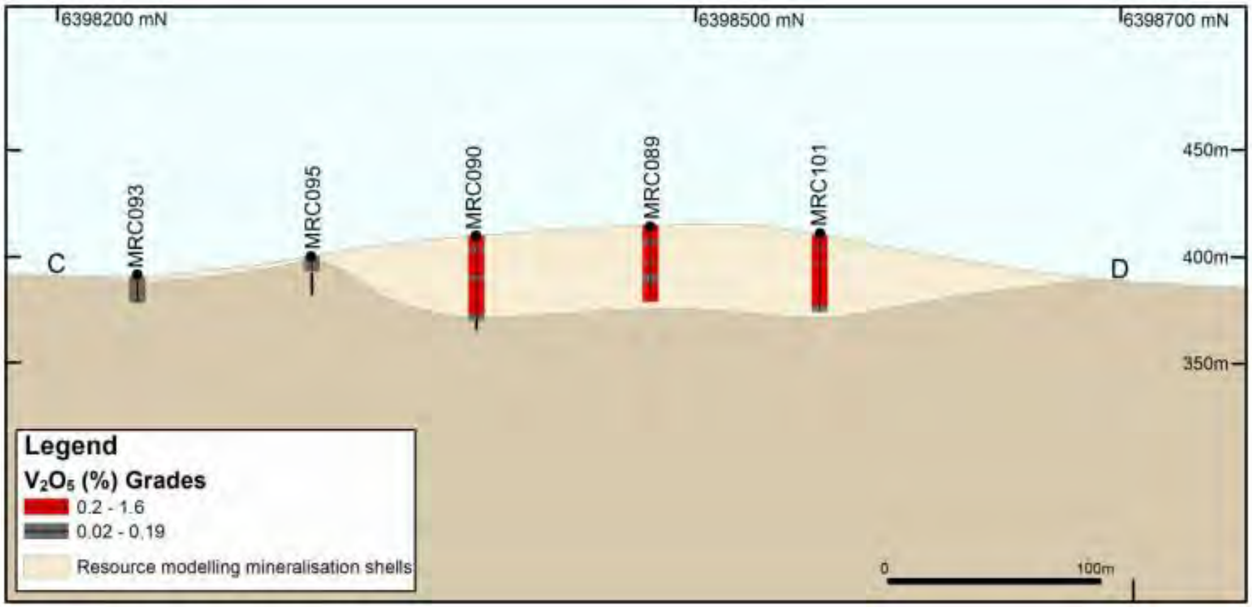


Figure 4 - Cross section C - D through the Fuji deposit

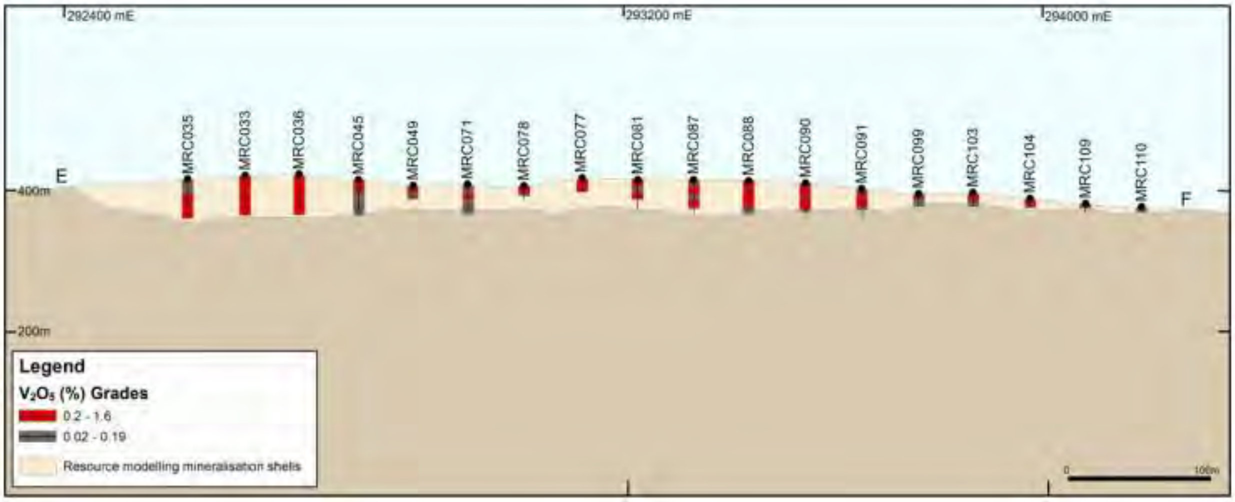


Figure 5 Long section E - F through the Vesuvius and Fuji deposits

1.2 Stratigraphy, structure, mineralisation and weathering controls

1.2.1 Stratigraphy

The stratigraphy in the Medcalf area is summarised in Table 1 below.

Medcalf Stratigraphy	
Geological period	**Lithologies**
Cainozoic	Soil, scree cover, minor alluvium, lateritic weathering profile
Proterozoic	Widgiemooltha mafic dykes
Archean	Quartz veins
	Pegmatites
	Granitic rocks
	Tholeiitic basalt and associated mafic sills
	Medcalf layered sill
	Siltsone (?)
	Biotite feldspar +/- quartz schist

Table 1 - Medcalf Stratigraphy

Individual lithologies are described in more detail below.

1.2.1.1 Archean

i. Siltstone

A finely-laminated haematitic saprolitc siltstone was intersected between 20.5 m and 24.0 m in vertical diamond drillhole MDD002 during Audalia's 2013 metallurgical core drilling programme located at GDA94 zone 51 - 292,780E, 6,398,286N.

This was possibly a carbonaceous siltstone originally (Figure 6). Pyroxenite occurs both above and below, suggesting that it is a sedimentary raft incorporated into the sill during intrusion.

Figure 6. Diamond drillhole MDD002 at 23.9 m

ii. Biotite Feldspar +/- Quartz Schist

Audalia's 2013 drill programme identified biotite feldspar +/- quartz schists up to several tens of metres thick in the Vesuvius deposits, at the base of the Medcalf Sill. In some drill holes it is absent, with basalt abutting the base of the sill.

Quartz feldspar biotite schist and gneiss were also recorded by Amoco in diamond drill hole LJ1, 3 km ESE of Vesuvius where it occupies a similar stratigraphic position beneath the Medcalf Sill.

This rock is interpreted as a metamorphosed siltstone, shale or airfall tuff. This interpretation is based on mineralogy, lateral extent and position in a thick subaqueous mafic volcanic sequence. Prior to metamorphism, this bed formed a zone of weakness along which the Medcalf Sill intruded.

Note that biotite-rich schists also occur in the middle of the pyroxenite unit. In upper greenschist facies, biotite can form in both sediments and mafic lithologies. A historic report by Amoco interprets these biotite-rich schists as shears.

iii. Basalt and Associated Dolerite Sills

Tholeiitic basalts form thick sequences above and below the Medcalf sill. They range from massive to schistose and generally subcrop as scattered fresh cobbles and boulders in red soil. Slightly coarser variants, up to about 1 mm grain size, are classified as dolerite, but they are not necessarily subvolcanic sills. The coarse grain size may result from metamorphism. Alternatively, coarse grain size could have developed in the slowly cooling interior of thick lava flows.

iv. Medcalf Layered Sill

Harris (1982) divides the Medcalf mafic sill into three units. From top down, they are:

- Gabbro at least 50 m thick
- Pyroxenite 36 m
- Peridotite 44 m

The sill is traceable along strike for at least 4 km and is roughly 130 m thick. The zones thicken and thin along strike; in some places they are absent altogether. Whether this is a primary feature related to intrusion, or to a later structural event is uncertain.

Distinguishing between mafic and ultramafic lithologies in weathered drill chips relied heavily on textures, sizes and percentage of relic black opaques. These opaques have survived metamorphism relatively unaltered, except where the rocks are strongly schistose.

v. Gabbro Zone

The gabbro has a grain size of 2 to 5 mm and ranges from massive to moderately foliated. It commonly subcrops as unweathered cobbles and boulders in red soil. Historic diamond drill holes LJ1 and LJ2 indicate gabbro is at least 50 m thick.

vi. Pyroxenite Zone

The pyroxenite has been metamorphosed to a tremolite-rich rock with variable amounts of black opaques. The highest TiO_2 analysis was 43.3 %, between 1 and 2 m in Audalia's RC drillhole MRC044. If all the titanium is contained in ilmenite, this mineral occupies 82 weight percent of the rock. Pyroxenite with higher volumes of black opaques is massive, as shown in drillhole MDD002 at 35.6m (Figure 7) whereas those with lower content tend to be more foliated (Figure 8).

In general, estimating percentage of black opaques in RC chip samples is difficult. The +2 mm opaques are retained, whereas the associated saprolitic clays (mainly weathered tremolite) pass through the 2 mm sieve aperture. In fresh rock, the opaques consist of magnetite and ilmenite. In the lower parts of the lateritic profile, they are partially weathered to haematite. Higher up, limonite takes the place of haematite. Under a 10x power hand lens 2 mm opaques are roughly equidimensional and frequently exhibit complex crystal faces.

On the western side of Vesuvius Hill, in the vicinity of Audalia's RC drillhole MRC017, banding in outcropping saprolitic pyroxenite is delineated by variations in the volume of black opaques. This is interpreted as primary layering, developed during cooling in a subhorizontal sill.

Figure 7. Diamond drillhole MDD002 at 35.6 m

The pyroxenite is 40 m thick in diamond drill hole LJ1, 1.5km southeast of Pinatubo. However, the 53 m pyroxenite interval in LJ2 passing through the eastern part of Fuji includes gabbroic and peridotitic bands. Departures from the simple zoning inferred for the Medcalf Sill are also seen in diamond drill hole MDD001. Two elevated zones of chromium (~0.5 to 1 % Cr) occur at about 25 m and 45 m in pyroxenite in MDD002, suggesting intervals of ultramafic within the pyroxenite.

Figure 8. Diamond drillhole MDD001 at 24.0 m

vii. Ultramafic Zone

The ultramafic zone is variously represented by serpentinite, talcose tremolite chlorite schist and pale orange jasper. Talc is stable through the weathering profile and can still be identified in iron-rich or clay-rich material otherwise lacking diagnostic features. The ultramafic zone intersected in Audalia's RC drilling programme consisted of brown to pale grey green clay with subordinate orange chert. Relic textures in the grey green clay were restricted to disseminated 1 to 5 %, bimodal 0.2 mm and 2 mm black opaques. The 2 mm opaques are probably original. The 0.2 mm may be metamorphic, derived from exsolution during transformation of olivine to serpentine. Similar textures occur in the orange chert, showing that it is a silicified equivalent. Ultramafic intersected in the lower parts of diamond drill holes MDD001 and MDD002 consist of brown puggy clay, as shown in Figure 9.

Figure 9 Diamond drillhole MDD002 at 60.2 m

Talc carbonate schists located during mapping are interpreted as shear zones within the ultramafic.

viii. Granite and Pegmatite

Foliated granite occupies the south-central part of the tenement. Non-foliated pegmatite occurs along the margin of the granite and as dykes up to a few metres wide intruding the greenstones.

ix. Quartz Veins

Quartz veins range up to 2 m thick, commonly in lenticular pods up to a few tens of metres long. Some veins can be traced discontinuously for more than 200 m.

1.2.1.2 Proterozoic

No outcropping Widgiemooltha mafic dykes were identified.

1.2.1.3 Cainozoic

Soil and scree cover over 50% of the Medcalf tenements. Cainozoic lateritic weathering within the pyroxenite zone has been critical in upgrading the vanadium, iron & titanium mineralisation to ore grade.

1.2.2 Structure

Structure is currently poorly understood. Polyphase deformation, upper greenschist facies metamorphism, deep weathering and sparse outcrop are all contributing factors.

1.2.2.1 Folding

Previous workers have interpreted a broad west-plunging anticline in the tenement block.

Near the base of the pyroxenite on the southern margin of Vesuvius schistosity dips about 30^0 north. This roughly parallels the pyroxenite-ultramafic contact outlined by drilling to the north and suggests tight to isoclinal folding.

Most measurements on schistosity within the Medcalf tenements dip steeply to moderately to the north on both limbs. This could be interpreted as folds overturned to the south.

1.2.2.2 Faulting

Deposit-scale faulting is interpreted in the mineralised areas based on displacement of the pyroxenite ultramafic contact.

The ultramafic zone in the Medcalf sill forms a weak zone along which faulting could preferentially develop. Early thrusting could explain the apparently out of sequence zones in the Medcalf sill, especially east of Fuji.

1.2.2.3 Schistosity

Schistosity in the greenstones strikes roughly northwest with dips ranging from vertical to moderately northeast. Foliation in the granite has a similar strike, but dips moderately to steeply to the southwest.

1.2.2.4 Banding in Medcalf Sill

Alternating centimetre to decimetre-scale iron-rich and iron-poor layers in the pyroxenite zone crop out on the southwest side of Vesuvius, near drill hole Audalia's RC drillhole MRC017. These layers dip 12^0 to 15^0 to the north and define the dip of the Medcalf Sill in this area.

1.2.3 Ore types

Two types of vanadium, iron and titanium mineralisation were recognised as "in-situ" and "conglomerate".

The conglomerate mineralisation forms a veneer on the flanks of Vesuvius and Egmont. A vertical face of conglomerate ore on the southeast side of Egmont is 3 m high. In-situ mineralisation varies with its position in the weathering profile, as it passes downwards from lateritic residuum through the mottled zone into saprolite.

1.2.4 Mineralisation genesis and controls

1.2.4.1 Geometry

Geometry of the Medcalf vanadium, iron & titanium mineralisation is controlled by several factors. These include:

1. Stratigraphic control, with mineralisation confined to approximately a 50m thick pyroxenite zone within the Medcalf Sill.
2. Depth of lateritic weathering, where weathering has increased grades to economic levels.
3. Structural deformation. Both folding and faulting occur, but which dominates at ore body scale is uncertain.
4. Primary geometry of the mineralisation, prior to deformation and metamorphism

1.2.4.2 Stratigraphic Controls

The known deposits are confined to the approximately 50 m thick pyroxenite zone within the Medcalf Sill. This sill can be traced discontinuously in outcrop and by aeromagnetics for five kilometres across the tenement block.

1.2.4.3 Structural Controls

Surface mapping and drill information suggests a structurally complex picture in the Vesuvius area. Ironstone bands outcropping over Vesuvius and Fuji are interpreted as iron-titanium-rich bands within the pyroxenite.

1.2.4.4 Metamorphism

Biotite-bearing schists and the apparent absence of garnet indicate upper greenschist facies metamorphism. There is also some evidence that the Medcalf sequence has undergone a degree of late-stage contact metamorphism-metasomatism due to the granite intrusion.

1.2.4.5 Regolith Controls

The fully developed lateritic weathering profile is divisible into four zones. Starting from the top, they are lateritic residuum, mottled zone, saprolite and saprock.

Small areas of lateritic residuum are represented by massive dark red haematite-rich outcrops located at (Figure 10) and “conglomerate ore” (Figure 11) over the Vesuvius, Fuji and Egmont deposits. Massive (Figure 13) and pisolitic (Figure 14) mineralisation illustrate variants of lateritic residuum in diamond drill core.

The yellow brown interval from 2 to 11 m vertical depth in Audalia's RC drillhole MRC008 (Figure 15) is the mottled zone, based on correlation with mottled zone in adjacent diamond drill hole MDD002 (Figure 14).

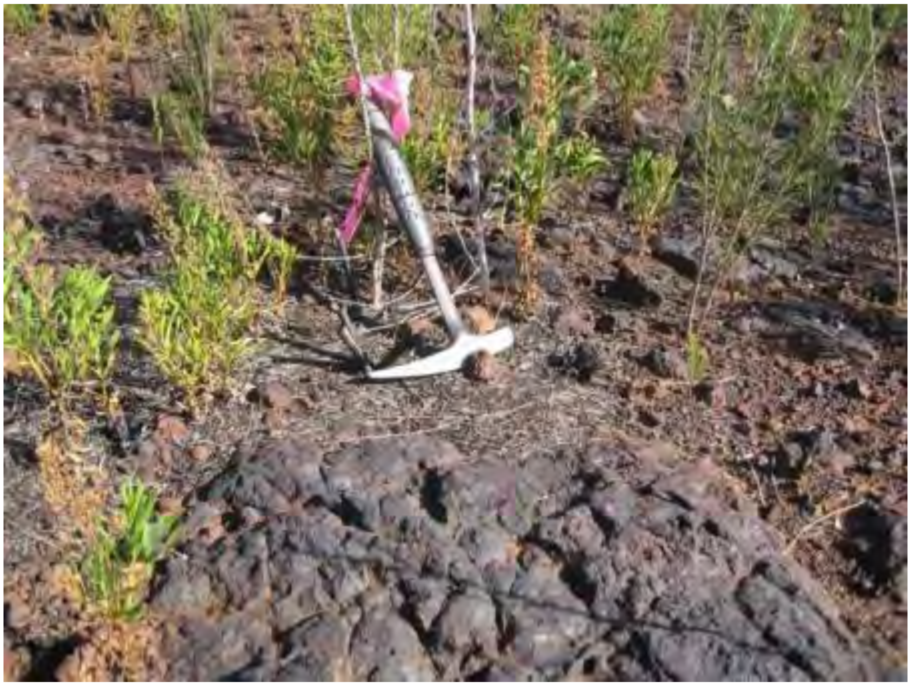


Figure 10. Massive vanadium, iron and titanium mineralisation outcrop (292,860E, 6,39,8140N)

Figure 11. Conglomeratic vanadium, iron and titanium mineralisation (292,932E 6,398,311N)

Most of the vanadium, iron & titanium mineralisation lies in the saprolitic zone Figure 5 and Figure 6 are typical. Saprolite extends to the bottom of all the holes drilled by Audalia. The purple-red haematitic interval from 11 m to 43 m in MRC008 (Figure 7) includes high grade vanadium and titanium mineralisation in the saprolitic zone. The low-grade interval between 23 m and 28 m in MRC008 is interpreted to be siltstone, based on siltstone identified in adjacent drill hole MDD002. This siltstone was not recognised during logging of the chips. There are no obvious differences in Ti and V grades moving upwards from the saprolite to mottled zone.

1.2.4.6 Other

Figure 12 shows lateritic residuum for diamond drillhole MDD002 at 2.0m (central channel). Interval 1.4 to 2.3m assayed 1.0 % V_2O_5, 21.4 % TiO_2 and 43.7 % Fe_2O_3.

Figure 13 shows lateritic residuum with pisolites for diamond drillhole MDD002 at 2.6 m. Interval 2.3 to 3.2 m assayed 1.12 % V_2O_5, 25.8 % TiO_2 and 38.8 % Fe_2O_3. Cutans, consisting of a thin rind of limonite on the pisolites, indicates that they developed in-situ.

Figure 14 shows mottled zone for diamond drillhole MDD002 at 6.1 m. This correlates to the yellow brown interval down to 11 m vertical depth in Figure 15.

Figure 15 shows RC drillhole MRC008, collar situated 8 m north of diamond drill hole MDD002. Wooden peg marks start of hole. Contact between limonitic mottled zone and dusky red saprolite at 11 m vertical depth. Contact between pyroxenite and underlying ultramafic marked by change from dusky red (haematite-rich) to light brown at 44 m.

Figure 12. Diamond drillhole MDD002 at 2.0 m

Figure 13. Diamond drillhole MDD002 at 2.6 m

Figure 14. Diamond drillhole MDD002 at 6.1 m

Figure 15. RC drillhole MRC008, Weathering and water table

The Medcalf Project lies on topographic highs some 50 m plus above the lower lying topography.

Distribution of the vanadium, iron and titanium deposits is controlled by several factors. One is depth of lateritic weathering, where weathering has increased grades to economic levels. As described in the Local geology Section, the depth of weathering is greater than 60 m and not one of Audalia's RC drillholes drilled in the deposits intersected the water table. The deepest hole was drilled to 102m from 413mRL.

The weathering profile is divided into four zones, lateritic residuum, mottled zone, saprolite and saprock. The strongest vanadium, iron and titanium grades have been developed near surface where the pyroxenite unit has been strongly weathered where most of the calcium, magnesium and silica have been removed from the rock by the lateritic weathering processes thus resulting in residual concentrations of vanadium and titanium.

Original silica minerals have been weathered to clay minerals predominately kaolinite but some gibbsite and diaspore. Magnetite is almost completely altered to hematite (martite) and goethite. Larger ilmenite grains have survived the weathering, but exsolved ilmenite platelets within other minerals have been altered to pseudorutile.

QEMSCAN (Figure 16) and XRD analysis (Figure 17 & Table 2) of 16 core samples taken from Audalia's core drilling programme in 2013, (MDD001 and MDD002) were carried out by Bureau Veritas (BV) in Canning Vale, Perth in 2013.

Neither the QEMSCAN nor the XRD studies were able to detect any vanadium minerals thus determining that vanadium was present in the samples as microscopic and sub microscopic constituents of hematite, goethite and several other iron minerals.

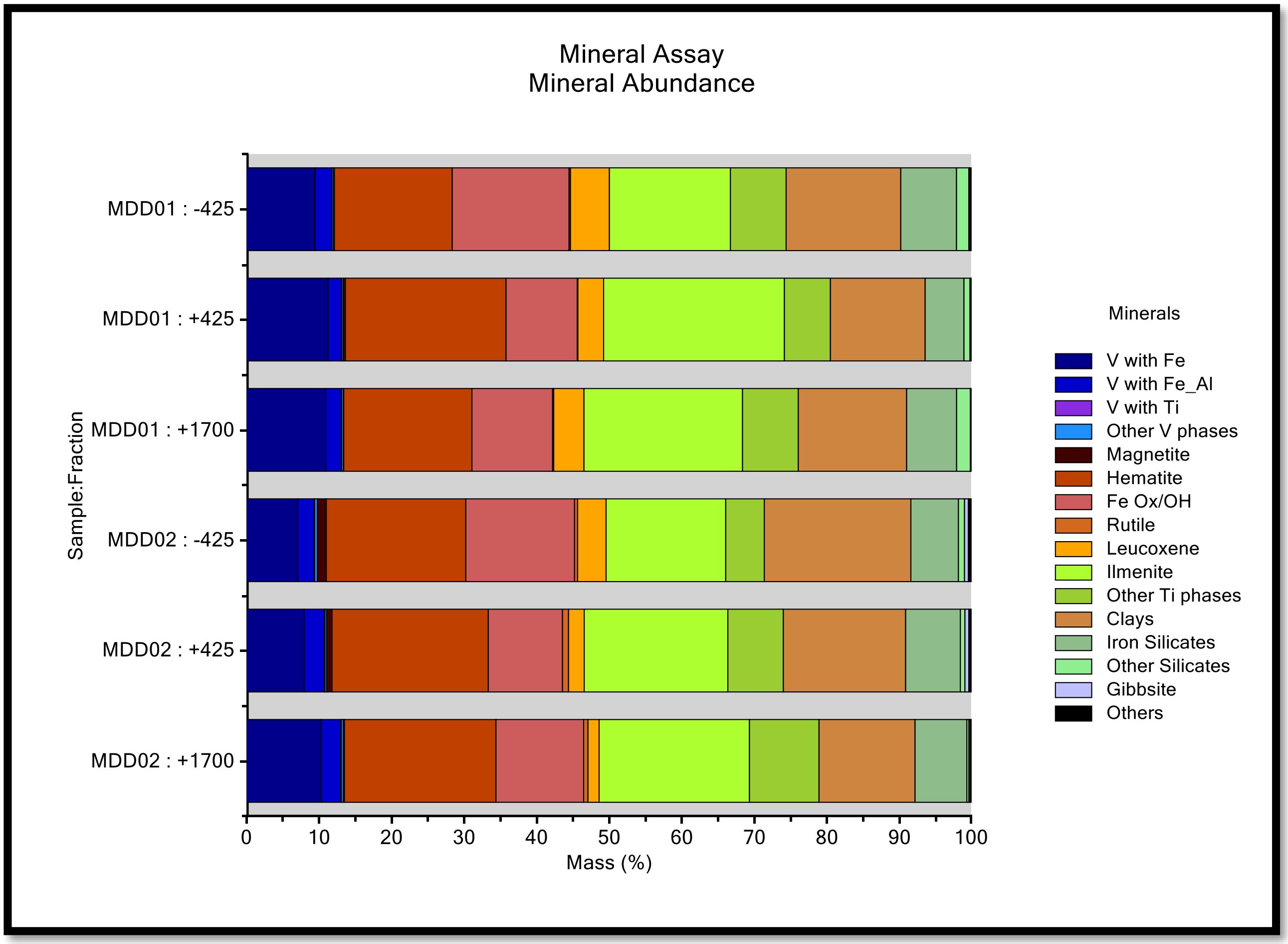
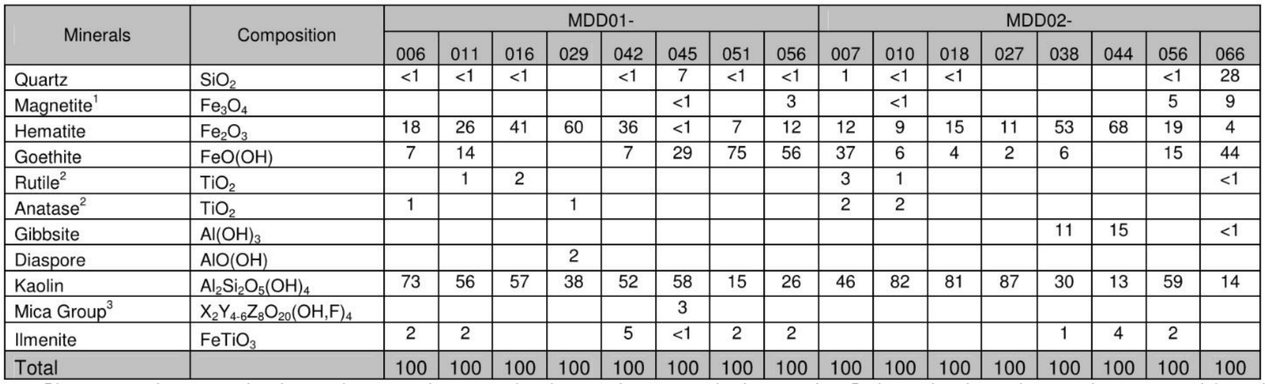


Figure 16. QEMSCAN mineral assay abundance data for 6 metallurgical composite core samples (Whittington 2013)



Minerals	Composition	MDD01-								MDD02-							
		006	011	016	029	042	045	051	056	007	010	018	027	038	044	056	066
Quartz	SiO_2	<1	<1	<1		<1	7	<1	<1	1	<1	<1				<1	28
Magnetite[1]	Fe_3O_4						<1		3		<1					5	9
Hematite	Fe_2O_3	18	26	41	60	36	<1	7	12	12	9	15	11	53	68	19	4
Goethite	$FeO(OH)$	7	14			7	29	75	56	37	6	4	2	6		15	44
Rutile[2]	TiO_2		1	2						3	1						<1
Anatase[2]	TiO_2	1			1					2	2						
Gibbsite	$Al(OH)_3$													11	15		<1
Diaspore	$AlO(OH)$				2												
Kaolin	$Al_2Si_2O_5(OH)_4$	73	56	57	38	52	58	15	26	46	82	81	87	30	13	59	14
Mica Group[3]	$X_2Y_{4-6}Z_8O_{20}(OH,F)_4$						3										
Ilmenite	$FeTiO_3$	2	2			5	<1	2	2					1	4	2	
Total		100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Table 2. Results of quantitative mineralogy XRD from 16 samples (BV, 2013)

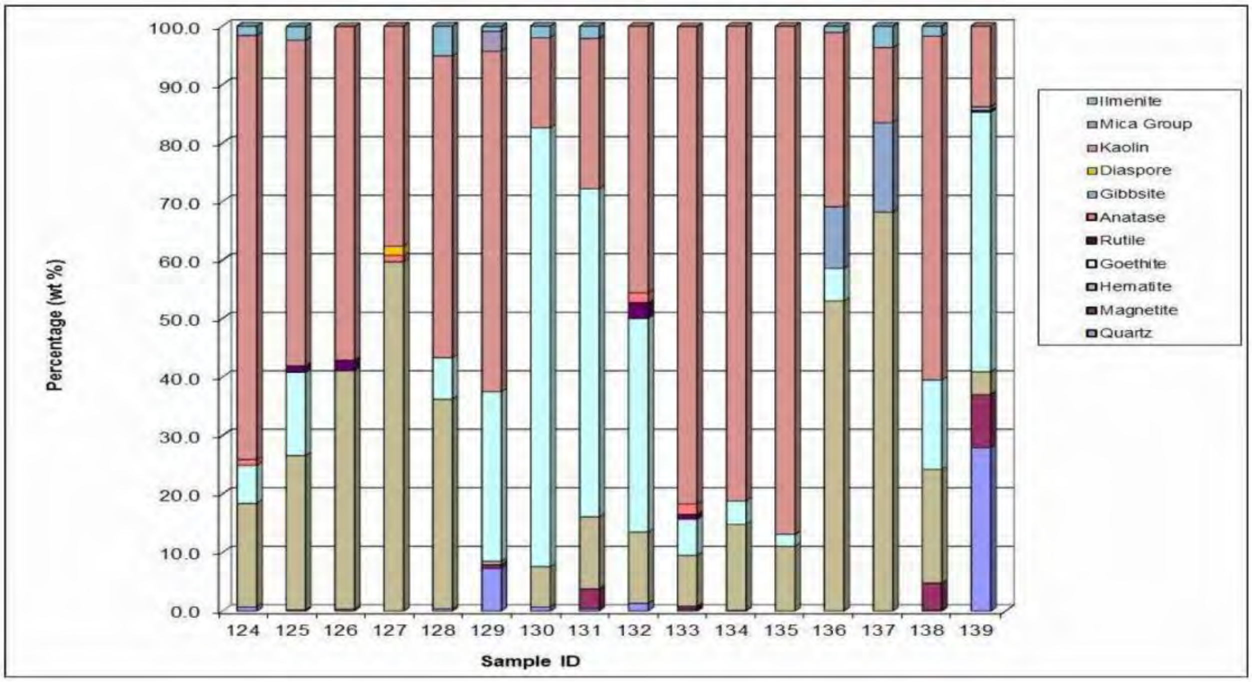


Figure 17. Graph of quantitative mineralogy by XRD, (BV, 2013)

ATTACHMENT B

DETAILS OF SAMPLING PROGRAMME

ATTACHMENT B

DETAILS OF SAMPLING PROGRAMME

1.0 SAMPLES INITIALLY COLLECTED IN EARLY 2019

- In early 2019, a set of 26 samples was selected for testing by Dr. GD Campbell following a review of the %S, and other assays, for 1m-intervals in the Project's geological database.

- Sample selection reflected the indicative pit-shells current at that time.

- The selected samples typically correspond to 3m-composites (i.e. 3 successive 1m-intervals composited).

- Assays from the geological database for the 'individual' 1m-intervals are presented in **Table B1**.

2.0 FINAL SAMPLE SET FOR THIS STUDY

- In light of refinements to the design of the pit-shells during 2019, 8 of the 3m-composites initially selected were no longer relevant for testing.

- Although earlier pit-shells were projected to produce minor amounts of the Basalt (BAS) unit from the Fresh-Waste-Zone, subsequent pit-optimisations show that mining will not occur within the Fresh-Waste-Zone of any Pit.

- Refinement of the pit-shells reflects both economic optimisations, and increases in the buffer-zone associated with the areas of the Declared Rare Flora (RDF).

- With the pit-shell revisions, the results presented and discussed in this study correspond to **18** samples (as 3m-composites).

  Though the Pits will not delve into the Fresh-Waste-Zone, 4 samples of Fresh-Zone-Basalt from the Vesuvius Pit, and one Fresh-Zone-Basalt sample from neat the Pinatubo Pit, were tested as 'model-samples' of the Fresh-Zone-Basalt to be produced from the borrow-pit for TSF construction.

- The locations of the drillholes employed for sampling, together with pit-area geology, are shown on **Figure B1**.

- Though some drillholes are located outside the pit-footprints, the geologic-profiles sampled from these drillholes are representative of the Mottled-Zone and Saprolite-Zone making-up the waste-zones of both Pits.

- In terms of S occurrences, for the waste-zones for both the Vesuvius and Fuji Pits, of just over 1,000 %S 'hits' (for 1m-intervals), the **mean-S value was 0.06 %** to 50 m which is the depth of the pit-floors.

  There were 5 %S 'hits' of 0.29 %, 0.32 %, 0.34 %, 0.90 %, and 1.63 % as outliers.

  For the satellite Egmont Pit, 59 %S 'hits' for 2 PQ-holes had a **mean-S value of 0.05 %**. The depth of the Egmont Pit will be less than 50 m.

  For the satellite Pinatubo Pit, 408 %S 'hits' for 13 PQ-holes had a **mean-S value of 0.07 %**. The depth of the Pinatubo Pit will be less than 50 m.

  The above %S assays from the Project's geological database attest to the **"Oxide-Only"** nature of the waste-zones for all Pits (i.e. 'negligible-sulphides').

Table B1: Original ARD Sample List

Count
26

										Major-Elemental-Oxides, Chloride, and Loss-on-Ignition (LOI)											Minor-Elements Associated with Mineralisation						
IDs to be used in ARD Study (GCA)	Current IDs to be submitted to GLS (Maddington)		Hole ID	Sample ID	From (m)	To (m)	Weathering-Zone (Regolith-Type)	Ascribed Lithology (Parent-Rock)	S (%)	CaO	MgO	K2O	Na2O	Fe2O3	Al2O3	SiO2	TiO2	MnO	Cl	LOI$_{1000oC}$ Gravimetric	Ni	Cr	Co	Cu	Zn	P	V
										%											mg/kg						
ARD_001	ARD10-69	1	MDD010	MDD10-007	6	7	MZ	UM	0.18	<0.01	0.21	0.01	0.19	62.22	12.50	11.83	4.69	0.12	0.17	8.15	320	153	70	780	100	70	2,001
			MDD010	MDD10-008	7	8			0.16	<0.01	0.25	0.02	0.22	56.42	15.47	15.49	1.25	0.07	0.17	10.16	420	51	60	1,190	60	90	541
			MDD010	MDD10-009	8	9			0.11	<0.01	0.22	0.03	0.24	54.24	16.25	16.83	0.99	0.06	0.19	10.99	470	45	60	1,370	60	170	453
ARD_002	MRC137 Sample15 0-3	1	MRC137	MD7664	0	1			0.08	0.09	0.33	0.17	0.10	32.84	18.68	35.54	0.97	0.02		10.89		54			90		422
			MRC137	MD7665	1	2			0.09	0.02	0.12	0.14	0.19	28.43	20.97	38.11	0.81	0.01		11.10		82			70		415
			MRC137	MD7666	2	3			0.11	<0.01	0.12	0.15	0.27	29.82	22.99	33.34	0.78	0.01		12.35		87			120		434
ARD_003	MRC139 Sample19 20-23	1	MRC139	MD7767	20	21			0.16	<0.01	0.07	0.02	0.17	63.66	10.23	11.56	2.55	0.08		10.12		3,660			20		51
			MRC139	MD7768	21	22			0.14	<0.01	0.15	0.02	0.29	53.02	14.60	16.82	3.70	0.12		10.18		3,530			30		735
			MRC139	MD7769	22	23			0.12	0.04	0.29	0.02	0.39	44.41	17.28	20.41	5.30	0.15		10.16		3,260			20		985
ARD_004	MRC127 Sample9 0-3	1	MRC127	MD6391	0	1		GB	0.04	0.94	0.62	0.23	0.32	32.80	21.07	30.72	2.50	0.03		10.01		18			<50		1,579
			MRC127	MD6392	1	2			0.04	0.53	0.29	0.17	0.34	17.98	24.78	40.54	3.14	0.01		11.37		<10			<50		812
			MRC127	MD6393	2	3			0.04	0.23	0.23	0.23	0.33	15.81	26.58	41.55	2.83	0.02		11.63		<10			<50		667
ARD_005	MRC130 Sample11 1-4	1	MRC130	MD6648	1	2			0.04	0.02	0.12	0.28	0.23	8.70	29.57	44.91	4.25	0.02		11.49		<10			<50		1,107
			MRC130	MD6649	2	3			0.05	0.01	0.14	0.28	0.31	9.25	28.71	46.06	3.79	0.02		11.38		<10			<50		900
			MRC130	MD6650	3	4			0.06	0.01	0.12	0.25	0.31	15.52	26.78	41.98	3.94	0.02		10.99		<10			<50		1,195
ARD_006	MRC125 Sample1 1-4	1	MRC125	MD6250	1	2		BAS	0.09	0.03	0.11	0.10	0.31	15.05	27.33	41.57	3.13	0.01		11.83		480			<50		850
			MRC125	MD6251	2	3			0.11	0.02	0.07	0.07	0.13	28.31	21.43	32.67	5.30	0.02		11.34		280			<50		970
			MRC125	MD6252	3	4			0.19	0.01	0.09	0.08	0.25	43.82	15.74	23.58	3.12	0.05		12.72		570			<50		570
ARD_007	MRC125 Sample2 14-17	1	MRC125	MD6263	14	15			0.12	0.01	0.17	0.11	0.44	17.32	24.15	44.46	1.40	0.03		11.21		560			<50		300
			MRC125	MD6264	15	16			0.14	0.01	0.19	0.07	0.47	19.84	23.25	42.42	1.39	0.03		11.58		500			<50		370
			MRC125	MD6265	16	17			0.13	0.01	0.27	0.11	0.44	19.84	24.42	40.90	1.38	0.04		11.73		510			60		370
ARD_008	ARD10-1720	1	MDD010	MDD10-018	17	18	SP	UM	0.07	0.02	0.21	0.03	0.65	44.53	18.43	22.36	3.22	0.15	0.47	9.58	200	408	<50	970	80	40	761
			MDD010	MDD10-019	18	19			0.10	0.02	0.19	0.03	0.82	48.52	15.94	19.13	2.57	0.16	0.76	10.82	540	482	50	2,090	90	40	541
			MDD010	MDD10-020	19	20			0.11	0.02	0.28	0.03	0.74	48.02	16.56	19.65	1.61	0.12	0.59	11.47	590	561	60	1,970	90	50	403
ARD_009	MRC137 Sample16 12-15	1	MRC137	MD7676	12	13			0.07	<0.01	0.21	0.10	0.34	36.22	17.03	26.96	5.92	0.06		10.77		807			460		1,346
			MRC137	MD7677	13	14			0.07	<0.01	0.28	0.04	0.34	44.09	15.57	19.89	4.93	0.11		11.17		1,338			780		1,120
			MRC137	MD7678	14	15			0.07	<0.01	0.26	0.04	0.37	45.30	14.73	21.25	3.38	0.11		11.49		1,108			680		1,070
ARD_010	MRC137 Sample17 27-30	1	MRC137	MD7692	27	28			0.07	0.03	5.57	0.07	0.82	38.76	12.80	25.16	5.81	0.43		8.69		365			460		1,082
			MRC137	MD7693	28	29			0.06	0.02	2.62	0.08	0.75	35.69	15.53	27.47	6.46	0.19		9.52		263			300		1,384
			MRC137	MD7694	29	30			0.04	0.02	1.32	0.07	0.61	40.79	14.54	26.08	4.03	0.16		10.76		166			340		1,032
ARD_011	MRC137 Sample18 41-44	1	MRC137	MD7707	41	42			0.05	6.75	13.19	0.39	0.98	22.85	5.23	43.30	1.72	0.24		4.03		167			130		333
			MRC137	MD7708	42	43			0.02	6.52	13.37	0.59	0.99	20.41	5.64	44.83	1.88	0.22		4.23		208			160		340
			MRC137	MD7709	43	44			0.02	6.46	14.32	0.40	0.91	19.75	4.64	46.46	1.67	0.23		3.74		211			140		302
ARD_012	ARD6-2124	1	MDD006	MDD06-022	21	22			0.11	0.03	0.83	0.03	1.21	68.50	6.60	7.46	6.05	0.35	1.22	6.96	2,030	584	330	2,610	100	30	1,195
			MDD006	MDD06-023	22	23			0.12	0.03	0.76	0.03	1.36	68.10	6.53	7.49	5.11	0.34	1.34	8.00	3,200	489	630	2,180	180	40	1,000
			MDD006	MDD06-024	23	24			0.11	0.03	0.76	0.03	0.97	68.07	7.24	8.41	5.07	0.31	1.04	7.39	2,870	456	480	1,880	170	40	994
ARD_013	ARD6-5860	1	MDD006	MDD06-059	58	59			0.04	0.01	6.11	0.16	1.16	50.98	2.04	31.51	0.62	0.49	0.33	5.98	3,170	25	460	2,010	350	140	132
			MDD006	MDD06-060	59	60			0.04	0.02	5.33	0.14	1.12	42.22	1.70	42.27	0.49	0.61	0.42	5.19	3,430	26	450	1,440	330	130	94
			MDD006	MDD06-061	60	60.8			0.04	0.02	3.48	0.07	0.99	42.74	1.77	44.39	0.55	0.51	0.70	4.95	3,090	34	420	840	280	170	120
ARD_014	ARD9-3639	1	MDD009	MDD09-037	36	37			0.04	0.02	9.29	0.07	1.16	34.30	4.78	39.83	1.68	0.51	0.71	6.12	3,550	488	550	2,640	300	260	315
			MDD009	MDD09-038	37	38			0.03	0.02	13.84	0.10	1.20	35.89	7.80	28.66	1.91	0.85	0.38	7.43	4,580	572	730	2,110	390	150	346
			MDD009	MDD09-039	38	39.2			0.02	0.04	11.93	0.12	1.07	33.17	5.02	38.12	1.86	0.59	0.31	5.97	3,890	600	560	1,660	310	70	327
ARD_015	MRC130 Sample13 81-84	1	MRC130	MD6729	81	82	SP	PX	0.01	0.76	12.57	0.02	0.12	41.04	3.20	33.48	3.95	0.27		3.60		105			240		1,441
			MRC130	MD6731	82	83			0.01	2.57	16.40	0.02	0.13	35.32	3.40	36.31	1.43	0.32		3.97		17			250		409
			MRC130	MD6732	83	84			0.02	4.11	15.26	0.04	0.24	36.07	4.17	31.40	1.04	0.57		6.56		10			250		201
ARD_016	MRC130 Sample14 92-95	1	MRC130	MD6741	92	93			0.01	2.88	14.02	0.03	0.12	25.45	2.39	49.52	0.60	0.56		3.69		12			140		107
			MRC130	MD6742	93	94			0.01	8.57	16.92	0.02	0.08	21.70	2.15	37.30	0.59	0.41		11.89		11			100		94
			MRC130	MD6743	94	95			0.04	9.80	18.31	0.03	0.09	20.58	1.88	32.59	0.55	0.37		15.31		10			100		76
ARD_017	MRC127 Sample10 12-15	1	MRC127	MD6403	12	13	SP	GB	0.02	4.36	4.67	1.78	1.26	21.24	15.01	42.20	4.03	0.13		4.61		<10			200		1,019
			MRC127	MD6404	13	14			0.01	5.18	5.04	1.65	1.52	20.91	14.43	43.41	3.71	0.15		3.71		<10			270		969
			MRC127	MD6405	14	15			0.02	3.72	4.27	1.20	1.09	26.09	13.64	39.26	4.65	0.16		5.35		10			300		1,139
ARD_018	MRC130 Sample12 15-18	1	MRC130	MD6662	15	16			0.03	0.19	0.86	0.23	0.51	53.53	8.03	20.68	10.30	0.67		4.64		<10			370		2,970
			MRC130	MD6663	16	17			0.02	3.06	3.46	0.37	0.56	44.56	7.24	26.31	9.21	0.71		3.50		<10			310		2,573
			MRC130	MD6664	17	18			0.02	4.55	4.22	0.31	0.52	43.29	5.59	26.68	9.10	0.68		3.63		<10			310		2,567
ARD_019	MRC125 Sample3 25-28	1	MRC125	MD6274	25	26	SP	BAS	0.04	0.06	1.44	0.23	0.91	21.02	20.86	42.54	1.28	0.57		10.27		600			160		330
			MRC125	MD6275	26	27			0.03	0.07	0.99	0.17	0.95	18.74	20.52	45.81	1.18	0.56		10.16		690			220		280
			MRC125	MD6276	27	28			0.03	0.16	0.96	0.20	1.07	16.99	20.26	48.79	1.14	0.20		9.64		1,880			280		260
ARD_020	MRC125 Sample4 39-42	1	MRC125	MD6288	39	40			0.02	0.24	4.49	0.25	1.34	27.06	14.56	39.59	2.67	0.39		8.40		530			300		470
			MRC125	MD6289	40	41			0.02	0.11	5.67	0.54	1.32	20.33	19.12	41.05	1.35	0.83		9.06		440			380		420
			MRC125	MD6290	41	42			0.02	3.60	3.88	0.25	1.91	15.06	17.14	50.91	1.15	0.17		5.65		360			150		250

IDs to be used in ARD Study (GCA)	Current IDs to be submitted to GLS (Maddington)	26	Hole ID	Sample ID	From (m)	To (m)	Weathering-Zone (Regolith-Type)	Ascribed Lithology (Parent-Rock)	S (%)	Major-Elemental-Oxides, Chloride, and Loss-on-Ignition (LOI)											Minor-Elements Associated with Mineralisation						
										CaO	MgO	K2O	Na2O	Fe2O3	Al2O3	SiO2	TiO2	MnO	Cl	LOI$_{1000oC}$ Gravimetric	Ni	Cr	Co	Cu	Zn	P	V
										%											mg/kg						
ARD_021	**MRC125 Sample5 43-46**	1	**MRC125**	**MD6292**	**43**	**44**	**FR**	**BAS**	0.01	8.57	6.63	0.20	2.57	12.28	15.47	50.87	0.82	0.15		2.32		350			80		270
			MRC125	**MD6293**	**44**	**45**			0.01	6.68	5.54	0.31	2.24	12.84	16.10	51.05	0.86	0.28		3.59		320			80		250
			MRC125	**MD6294**	**45**	**46**			0.01	9.12	7.02	0.20	2.18	12.22	15.09	51.16	0.83	0.19		1.73		320			70		280
ARD_022	**MRC125 Sample6 47-50**	1	**MRC125**	**MD6296**	**47**	**48**			0.01	10.21	7.38	0.23	2.13	11.90	14.78	51.11	0.82	0.17		1.06		320			70		280
			MRC125	**MD6297**	**48**	**49**			0.01	10.35	7.39	0.26	2.27	12.03	14.70	50.37	0.83	0.17		1.23		300			70		310
			MRC125	**MD6298**	**49**	**50**			0.01	10.54	7.52	0.23	2.49	11.77	14.64	50.83	0.81	0.17		0.81		310			70		300
ARD_023	**MRC125 Sample7 52-55**	1	**MRC125**	**MD6301**	**52**	**53**			<0.01	10.71	7.66	0.23	2.54	11.91	14.65	50.39	0.82	0.17		0.71		310			70		300
			MRC125	**MD6302**	**53**	**54**			<0.01	10.59	7.62	0.17	2.47	11.75	14.60	50.39	0.81	0.17		0.68		310			70		300
			MRC125	**MD6303**	**54**	**55**			<0.01	10.81	7.70	0.16	2.35	11.87	14.71	50.17	0.81	0.17		0.72		310			70		300
ARD_024	**MRC125 Sample8 57-60**	1	**MRC125**	**MD6306**	**57**	**58**			<0.01	10.55	7.84	0.13	2.50	12.05	14.81	50.07	0.81	0.17		0.72		300			60		311
			MRC125	**MD6307**	**58**	**59**			<0.01	10.26	7.69	0.13	2.71	11.89	14.92	50.54	0.83	0.17		0.64		310			70		310
			MRC125	**MD6308**	**59**	**60**			0.01	10.68	7.78	0.13	2.56	11.88	14.77	50.38	0.83	0.17		0.59					70		
ARD_025	**PTC006 Sample24 21-24**	1	**PTC006**	**MD5238**	**21**	**22**			0.01	10.52	7.31	0.55	1.69	18.38	12.84	43.60	3.47	0.16		1.18		135			100		790
			PTC006	**MD5239**	**22**	**23**			0.01	10.80	7.38	0.51	1.80	18.45	12.73	43.56	3.38	0.16		0.92		135			100		790
			PTC006	**MD5240**	**23**	**24**			0.01	10.44	7.28	0.61	1.72	19.00	11.60	44.03	3.55	0.17		1.27		135			100		845
ARD_026	**KJC020 Sample21 25-30**	1	**KJC020**	**MD4874**	**25**	**26**			0.02	11.35	7.60	1.20	1.98	11.06	12.76	51.25	0.68	0.20		1.42		610			100		225
			KJC020	**MD4875**	**26**	**27**			0.01	11.55	7.83	0.77	2.45	11.37	12.97	49.93	0.69	0.19		1.52		610			100		225
			KJC020	**MD4876**	**27**	**28**			0.01	11.99	7.89	0.63	2.58	11.13	12.85	50.38	0.69	0.20		1.54		610			100		283
			KJC020	**MD4877**	**28**	**29**			0.11	10.95	8.39	0.78	2.56	11.25	13.00	50.57	0.70	0.20		1.34		610			100		225
			KJC020	**MD4878**	**29**	**30**			0.21	10.37	8.30	0.81	2.64	11.23	12.61	51.54	0.70	0.19		1.35		610			100		225

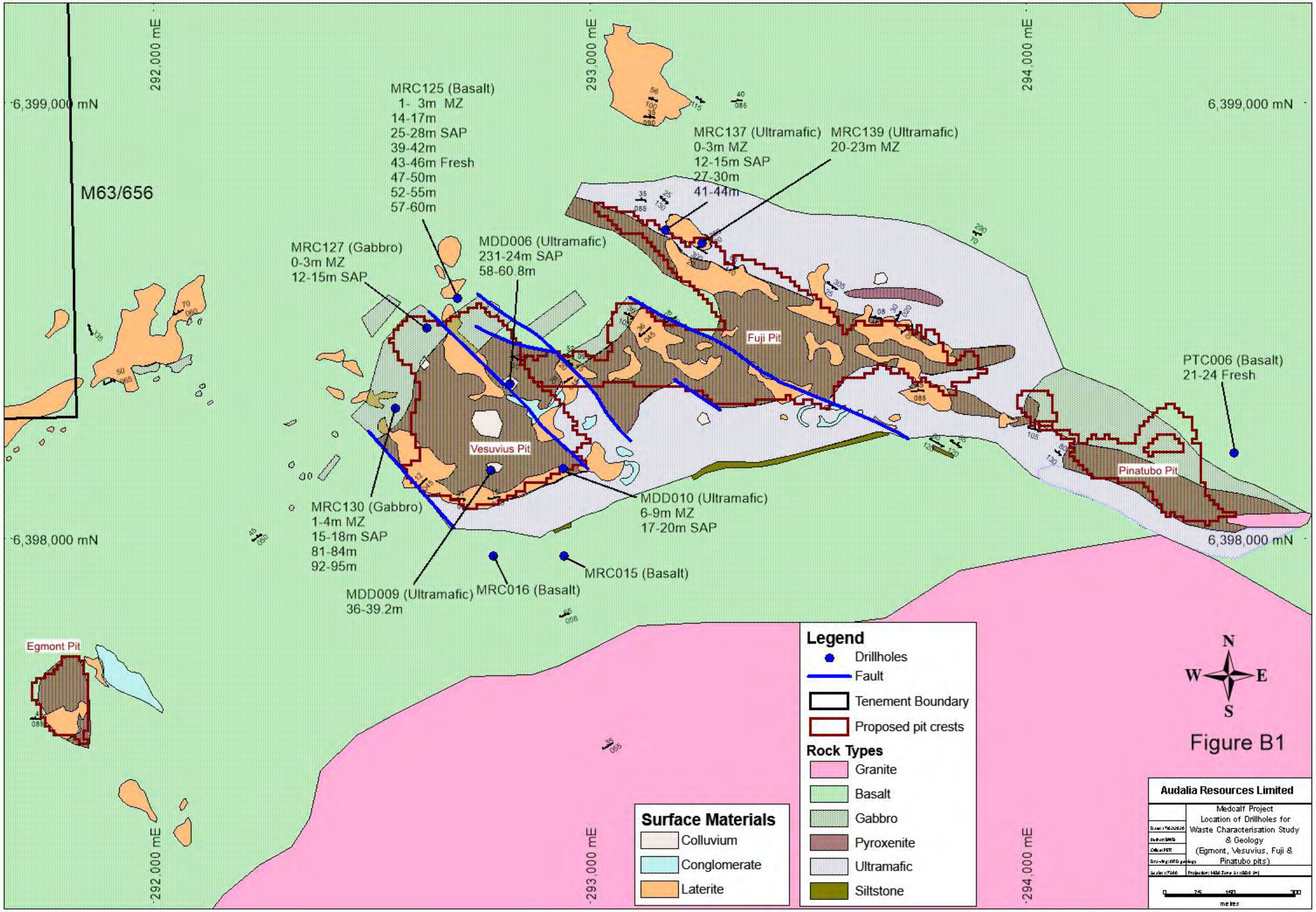


Figure B1

Audalia Resources Limited

Medcalf Project
Location of Drillholes for
Waste Characterisation Study
& Geology
(Egmont, Vesuvius, Fuji &
Pinatubo pits)

ATTACHMENT C

LABORATORY REPORTS

MINERALS
TEST REPORT

CLIENT

GRAEME CAMPBELL
CAMPBELL, GRAEME and ASSOCIATES
PO Box 247
BRIDGETOWN, W.A. 6255
AUSTRALIA

JOB INFORMATION

JOB CODE : 143.0/1902366
NO. SAMPLES : 26
NO. ELEMENTS : 7
CLIENT ORDER NO. : GCA1901/1 (Job 1 of 1)
SAMPLE SUBMISSION NO. :
PROJECT : MEDCALF
SAMPLE TYPE : Various
DATE RECEIVED : 20/02/2019
DATE REPORTED : 21/03/2019
DATE PRINTED : 21/03/2019

REPORT NOTES

TESTED BY

Intertek
15 Davison Street, Maddington 6109, Western Australia
PO Box 144, Gosnells 6990, Western Australia
Tel: +61 8 9251 8100
Email: min.aus.per@intertek.com

Accredited for compliance with ISO/IEC 17025.
Company Accreditation Number 3244

NOTES
NATA ENDORSED DOCUMENT
Company Accreditation Number 3244
Analysing Laboratory: Intertek Genalysis Perth

The contents of this report have been prepared in accordance with the terms of NATA accreditation and as such should only be reproduced in full.
The analysis results reported herein have been obtained using the following methods and conditions:

Project:Medcalf
The samples as listed were received as mine waste samples
The samples were coarse crushed to nominal -5mm .
Approx 1.5kgs of the corse crushings were crushed to nominal -2mm.
A split was taken from each sample and fine pulverised to nominal
-75um using a zirconia bowl.

The results have been determined according to Genalysis methods codes
Digestions : MPL_W005 (SE1/), ENV_W012 (FC7/SIE), and MPL_W008 (HG1/

Analytical Finishes: ICP_W003 (/MS) and AAS_W004 (/CV)

1.Total-C and Total-S were determined using an induction furnace
The samples are ignited in oxygen ~1700°C and the CO2 and SO2 measured by infrared detectors
Genalysis method code MPL_W043.

2.C-Acinsol (acid insoluble carbon) by a C&S analyser after removal of carbonates
and soluble organic carbon using hot hydrochloric acid
Genalysis method code MPL_W046

The results included the assay of blanks and international reference standards:
GTS-2a, AMIS0343,OREAS 45e and DS-1
Genalysis in house standards:
TOC-1a, and OREAS 97.01
The results are expressed as parts per million or percent by mass in the dried and
prepared material.

Intertek Genalysis signatory

Ann Patricia EVERS

Chief Chemist

Ann Evers

Date: 21-Mar-2019

SIGNIFICANT FIGURES

It is common practice to report data derived from analytical instrumentation to a maximum of two or three significant figures. Some data reported herein may show more figures than this. The reporting of more than two or three figures in no way implies that figures beyond the least significant digit have significance.

For more information on the uncertainty on individual reported values, please contact the laboratory.

SAMPLE STORAGE

All solid samples (assay pulps, bulk pulps and residues will be stored for 60 days without charge. Following this samples will be stored at a daily rate until clients written advice regarding return, collection or disposal is received. If storage information is not supplied on the submission, or arranged with the laboratory in writing the default will be to store the samples with the applicable charges. Storage is charged at $4.00 per m3 per day, expenses related to the return or disposal of samples will be charged at cost. Current disposal cost is charged at $150.00 per m3.

Samples received as liquids, waters or solutions will be held for 60 days free of charge then disposed of, unless written advice fo return or collection is received.

LEGEND

X = Less than Detection Limit
SNR = Sample Not Received
* = Result Checked
DTF = Result still to come
IS = Insufficient Sample for Analysis

NA = Not Analysed
UA = Unable to Assay
> = Value beyond Limit of Method
\+ = Extra Sample Received Not Listed

ELEMENTS	C	C-Acinsol	C-CO3	F	Hg	S	Se
UNITS	%	%	%	ppm	ppm	%	ppm
DETECTION LIMIT	0.01	0.01	0.01	50	0.01	0.01	0.01
DIGEST		C71/		FC7/	HG1/		SE1/
ANALYTICAL FINISH	/CSA	CSA	/CALC	SIE	CV	/CSA	MS
SAMPLE NUMBERS							
0001 ARD_001	0.13	0.05	0.08	471	0.02	0.18	3.33
0002 ARD_002	0.25	0.12	0.13	241	0.01	0.12	2.41
0003 ARD_003	0.08	0.06	0.02	212	0.02	0.15	1.34
0004 ARD_004	0.21	0.05	0.16	242	0.01	0.05	1.05
0005 ARD_005	0.12	0.05	0.07	251	X	0.07	1.02
0006 ARD_006	0.16	0.07	0.09	281	0.01	0.17	1.61
0007 ARD_007	0.11	0.10	X	225	X	0.14	0.11
0008 ARD_008	0.08	0.06	0.02	363	0.01	0.10	3.68
0009 ARD_009	0.12	0.09	0.03	446	0.02	0.08	1.87
0010 ARD_010	0.06	0.07	X	304	X	0.06	0.77
0011 ARD_011	0.18	0.18	X	494	0.01	0.03	0.99
0012 ARD_012	0.11	0.06	0.05	194	0.01	0.12	0.69
0013 ARD_013	0.04	0.04	X	167	0.01	0.05	0.08
0014 ARD_014	0.02	0.04	X	1695	0.02	0.04	0.08
0015 ARD_015	0.09	0.02	0.07	736	0.02	0.02	0.11
0016 ARD_016	2.16	0.02	2.14	335	0.02	0.02	0.15
0017 ARD_017	0.02	0.03	X	932	0.01	0.02	X
0018 ARD_018	0.07	0.04	0.03	642	X	0.03	0.09
0019 ARD_019	0.09	0.08	X	229	0.01	0.04	0.12
0020 ARD_020	0.06	0.06	X	272	0.02	0.02	0.03
0021 ARD_021	0.02	0.04	X	456	X	0.01	0.02
0022 ARD_022	0.01	0.03	X	422	X	X	0.02
0023 ARD_023	0.04	0.02	0.02	629	X	X	0.03
0024 ARD_024	0.02	0.02	X	503	X	X	0.03
0025 ARD_025	0.02	0.04	X	310	X	X	X
0026 ARD_026	X	0.03	X	1889	X	0.01	0.06
CHECKS							
0001 ARD_002	0.28	0.12	0.16	236	X	0.11	2.30
STANDARDS							
0001 OREAS 45e	0.57					0.06	
0002 TOC-1a		1.14					
0003 GTS-2a					0.27		
0004 OREAS 97.01							0.64
0005 AMIS0343				2240			
BLANKS							
0001 Control Blank	X	X		X	X	X	X

METHOD CODE DESCRIPTION

Method Code	Analysing Laboratory NATA Laboratory Accreditation	NATA Scope of Accreditation
/CALC	Intertek Genalysis Perth **3244 3237** No digestion or other pre-treatment undertaken. Results Determined by calculation from other reported data.	
/CSA	Intertek Genalysis Perth **3244 3237** Induction Furnace Analysed by Infrared Spectrometry	**MPL_W043, CSA : MPL_W043**
C71/CSA	Intertek Genalysis Perth **3244 3237** Digestion by hot acid(s) and Induction Furnace Analysed by Infrared Spectrometry	
FC7/SIE	Intertek Genalysis Perth **3244 3237** Alkaline fusion (Nickel crucible) specific for Fluorine. Analysed by Specific Ion Electrode.	**ENV_W012, SIE : ENV_W012**
HG1/CV	Intertek Genalysis Perth **3244 3237** Low temperature Perchloric acid digest specific for Mercury. Analysed by Cold Vapour Generation Atomic Absorption Spectrometry.	
SE1/MS	Intertek Genalysis Perth **3244 3237** Aqua-Regia digest followed by Precipitation and Concentration. Specific for Selenium. Analysed by Inductively Coupled Plasma Mass Spectrometry.	

ANALYTICAL REPORT

Accreditation No. 2562

CLIENT DETAILS

Contact	Graeme Campbell
Client	Graeme Campbell & Associates Pty Ltd
Address	PO Box 247 Bridgetown WA 6255
Telephone	0897 612 829
Facsimile	0897 612 830
Email	gca@wn.com.au
Project	**GCA Job No. 1901/1 For CRS**
Order Number	**GCA Job No.1901/1**
Samples	26

LABORATORY DETAILS

Manager	Marjana Siljanoska
Laboratory	SGS Perth Environmental
Address	28 Reid Rd Perth Airport WA 6105
Telephone	(08) 9373 3500
Facsimile	(08) 9373 3556
Email	au.environmental.perth@sgs.com
SGS Reference	**PE133544 R0**
Date Received	22 Mar 2019
Date Reported	01 Apr 2019

COMMENTS

Accredited for compliance with ISO/IEC 17025 - Testing. NATA accredited laboratory 2562(898/20210).

SIGNATORIES

Michael McKay
Inorganics and ARD Supervisor

Parameter	Units	LOR	PE133544.001 Pulp 21 Mar 2019 ARD_001	PE133544.002 Pulp 21 Mar 2019 ARD_002

Chromium Reducible Sulphur (CRS) Method: AN217 Tested: 28/3/2019

Parameter	Units	LOR	PE133544.001	PE133544.002
Chromium Reducible Sulphur (Scr)	%	0.005	<0.005	<0.005
Chromium Reducible Sulphur (Scr)	moles H+/T	5	<5	<5
Chromium Reducible Sulphur (Scr)	kg H2SO4/T	0.25	<0.25	<0.25

Parameter	Units	LOR	PE133544.003 Pulp 21 Mar 2019 ARD_003	PE133544.004 Pulp 21 Mar 2019 ARD_004
Sample Number / Sample Matrix / Sample Date / Sample Name				
Chromium Reducible Sulphur (CRS) Method: AN217 Tested: 28/3/2019				
Chromium Reducible Sulphur (Scr)	%	0.005	<0.005	<0.005
Chromium Reducible Sulphur (Scr)	moles H+/T	5	<5	<5
Chromium Reducible Sulphur (Scr)	kg H2SO4/T	0.25	<0.25	<0.25

Parameter	Units	LOR	Sample Number: PE133544.005 Sample Matrix: Pulp Sample Date: 21 Mar 2019 Sample Name: ARD_005	Sample Number: PE133544.006 Sample Matrix: Pulp Sample Date: 21 Mar 2019 Sample Name: ARD_006

Chromium Reducible Sulphur (CRS) Method: AN217 Tested: 28/3/2019

Parameter	Units	LOR	PE133544.005	PE133544.006
Chromium Reducible Sulphur (Scr)	%	0.005	<0.005	<0.005
Chromium Reducible Sulphur (Scr)	moles H+/T	5	<5	<5
Chromium Reducible Sulphur (Scr)	kg H2SO4/T	0.25	<0.25	<0.25

Parameter	Units	LOR	PE133544.007	PE133544.008
Sample Matrix			Pulp	Pulp
Sample Date			21 Mar 2019	21 Mar 2019
Sample Name			ARD_007	ARD_008
Chromium Reducible Sulphur (CRS) Method: AN217 Tested: 28/3/2019				
Chromium Reducible Sulphur (Scr)	%	0.005	<0.005	<0.005
Chromium Reducible Sulphur (Scr)	moles H+/T	5	<5	<5
Chromium Reducible Sulphur (Scr)	kg H2SO4/T	0.25	<0.25	<0.25

			Sample Number Sample Matrix Sample Date Sample Name	PE133544.009 Pulp 21 Mar 2019 ARD_009	PE133544.010 Pulp 21 Mar 2019 ARD_010
Parameter	Units	LOR			

Chromium Reducible Sulphur (CRS) Method: AN217 Tested: 28/3/2019

Parameter	Units	LOR	PE133544.009	PE133544.010
Chromium Reducible Sulphur (Scr)	%	0.005	<0.005	<0.005
Chromium Reducible Sulphur (Scr)	moles H+/T	5	<5	<5
Chromium Reducible Sulphur (Scr)	kg H2SO4/T	0.25	<0.25	<0.25

Parameter	Units	LOR	PE133544.011 Pulp 21 Mar 2019 ARD_011	PE133544.012 Pulp 21 Mar 2019 ARD_012
Chromium Reducible Sulphur (CRS) Method: AN217 Tested: 28/3/2019				
Chromium Reducible Sulphur (Scr)	%	0.005	<0.005	<0.005
Chromium Reducible Sulphur (Scr)	moles H+/T	5	<5	<5
Chromium Reducible Sulphur (Scr)	kg H2SO4/T	0.25	<0.25	<0.25

Parameter	Units	LOR	PE133544.013 Pulp 21 Mar 2019 ARD_013	PE133544.014 Pulp 21 Mar 2019 ARD_014
Chromium Reducible Sulphur (CRS) Method: AN217 Tested: 28/3/2019				
Chromium Reducible Sulphur (Scr)	%	0.005	<0.005	<0.005
Chromium Reducible Sulphur (Scr)	moles H+/T	5	<5	<5
Chromium Reducible Sulphur (Scr)	kg H2SO4/T	0.25	<0.25	<0.25

		Sample Number	PE133544.015	PE133544.016
		Sample Matrix	Pulp	Pulp
		Sample Date	21 Mar 2019	21 Mar 2019
		Sample Name	ARD_015	ARD_016
Parameter	Units	LOR		

Chromium Reducible Sulphur (CRS) Method: AN217 Tested: 28/3/2019

Chromium Reducible Sulphur (Scr)	%	0.005	<0.005	<0.005
Chromium Reducible Sulphur (Scr)	moles H+/T	5	<5	<5
Chromium Reducible Sulphur (Scr)	kg H2SO4/T	0.25	<0.25	<0.25

Parameter	Units	LOR	Sample Number: PE133544.017 Sample Matrix: Pulp Sample Date: 21 Mar 2019 Sample Name: ARD_017	Sample Number: PE133544.018 Sample Matrix: Pulp Sample Date: 21 Mar 2019 Sample Name: ARD_018

Chromium Reducible Sulphur (CRS) Method: AN217 Tested: 28/3/2019

Chromium Reducible Sulphur (Scr)	%	0.005	<0.005	0.006
Chromium Reducible Sulphur (Scr)	moles H+/T	5	<5	<5
Chromium Reducible Sulphur (Scr)	kg H2SO4/T	0.25	<0.25	<0.25

Parameter	Units	LOR	Sample Number Sample Matrix Sample Date Sample Name	PE133544.019 Pulp 21 Mar 2019 ARD_019	PE133544.020 Pulp 21 Mar 2019 ARD_020
Chromium Reducible Sulphur (CRS) Method: AN217 Tested: 28/3/2019					
Chromium Reducible Sulphur (Scr)	%	0.005		**0.007**	<0.005
Chromium Reducible Sulphur (Scr)	moles H+/T	5		<5	<5
Chromium Reducible Sulphur (Scr)	kg H2SO4/T	0.25		<0.25	<0.25

Parameter	Units	LOR	Sample Number PE133544.021 Sample Matrix Pulp Sample Date 21 Mar 2019 Sample Name ARD_021	PE133544.022 Pulp 21 Mar 2019 ARD_022

Chromium Reducible Sulphur (CRS) Method: AN217 Tested: 28/3/2019

Chromium Reducible Sulphur (Scr)	%	0.005	<0.005	<0.005
Chromium Reducible Sulphur (Scr)	moles H+/T	5	<5	<5
Chromium Reducible Sulphur (Scr)	kg H2SO4/T	0.25	<0.25	<0.25

Parameter	Units	LOR	PE133544.023 Pulp 21 Mar 2019 ARD_023	PE133544.024 Pulp 21 Mar 2019 ARD_024
Sample Number / Sample Matrix / Sample Date / Sample Name				
Chromium Reducible Sulphur (CRS) Method: AN217 Tested: 28/3/2019				
Chromium Reducible Sulphur (Scr)	%	0.005	<0.005	<0.005
Chromium Reducible Sulphur (Scr)	moles H+/T	5	<5	<5
Chromium Reducible Sulphur (Scr)	kg H2SO4/T	0.25	<0.25	<0.25

		Sample Number Sample Matrix Sample Date Sample Name	PE133544.025 Pulp 21 Mar 2019 ARD_025	PE133544.026 Pulp 21 Mar 2019 ARD_026
Parameter	Units	LOR		

Chromium Reducible Sulphur (CRS) Method: AN217 Tested: 28/3/2019

Parameter	Units	LOR	PE133544.025	PE133544.026
Chromium Reducible Sulphur (Scr)	%	0.005	<0.005	<0.005
Chromium Reducible Sulphur (Scr)	moles H+/T	5	<5	<5
Chromium Reducible Sulphur (Scr)	kg H2SO4/T	0.25	<0.25	<0.25

MB blank results are compared to the Limit of Reporting
LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared the the amount of analyte spiked into the sample.
DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula : *the absolute difference of the two results divided by the average of the two results as a percentage.* Where the DUP RPD is 'NA' , the results are less than the LOR and thus the RPD is not applicable.

Chromium Reducible Sulphur (CRS) **Method: ME-(AU)-[ENV]AN217**

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Chromium Reducible Sulphur (Scr)	LB157738	%	0.005	<0.005	0%	91%
Chromium Reducible Sulphur (Scr)	LB157738	moles H+/T	5	<5		
Chromium Reducible Sulphur (Scr)	LB157738	kg H2SO4/T	0.25	<0.25		

METHOD	METHODOLOGY SUMMARY
AN217	Dried pulped sample is mixed with acid and chromium metal in a rapid distillation unit to produce hydrogen sulfide (H2S) which is collected and titrated with iodine (I2(aq)) to measure SCR.

FOOTNOTES

IS	Insufficient sample for analysis.	LOR	Limit of Reporting
LNR	Sample listed, but not received.	↑↓	Raised or Lowered Limit of Reporting
*	NATA accreditation does not cover the performance of this service.	QFH	QC result is above the upper tolerance
**	Indicative data, theoretical holding time exceeded.	QFL	QC result is below the lower tolerance
		-	The sample was not analysed for this analyte
		NVL	Not Validated

Unless it is reported that sampling has been perfomed by SGS, the samples have been analysed as received.
Solid samples expressed on a dry weight basis.

Where "Total" analyte groups are reported (for example, Total PAHs, Total OC Pesticides) the total will be calculated as the sum of the individual analytes, with those analytes that are reported as <LOR being assumed to be zero. The summed (Total) limit of reporting is calcuated by summing the individual analyte LORs and dividing by two. For example, where 16 individual analytes are being summed and each has an LOR of 0.1 mg/kg, the "Totals" LOR will be 1.6 / 2 (0.8 mg/kg). Where only 2 analytes are being summed, the " Total" LOR will be the sum of those two LORs.

Some totals may not appear to add up because the total is rounded after adding up the raw values.

If reported, measurement uncertainty follow the ± sign after the analytical result and is expressed as the expanded uncertainty calculated using a coverage factor of 2, providing a level of confidence of approximately 95%, unless stated otherwise in the comments section of this report.

Results reported for samples tested under test methods with codes starting with ARS-SOP, radionuclide or gross radioactivity concentrations are expressed in becquerel (Bq) per unit of mass or volume or per wipe as stated on the report. Becquerel is the SI unit for activity and equals one nuclear transformation per second.
Note that in terms of units of radioactivity:

a. 1 Bq is equivalent to 27 pCi
b. 37 MBq is equivalent to 1 mCi

For results reported for samples tested under test methods with codes starting with ARS-SOP, less than (<) values indicate the detection limit for each radionuclide or parameter for the measurement system used. The respective detection limits have been calculated in accordance with ISO 11929.

The QC criteria are subject to internal review according to the SGS QAQC plan and may be provided on request or alternatively can be found here : http://www.sgs.com.au/~/media/Local/Australia/Documents/Technical%20Documents/MP-AU-ENV-QU-022%20QA%20QC%20Plan.pdf

Graeme Campbell & Associates Pty Ltd

Laboratory Report

pH-(1:2) & EC-(1:2) TESTWORK

SAMPLE_ ID	SAMPLE WEIGHT (g)	pH-(1:2)	EC-(1:2) (µS/cm)	
ARD_001	29.9	4.8	3,030	
ARD_002	30.1	3.9	2,180	
ARD_003	30.0	4.3	4,010	
ARD_004	30.0	8.4	2,390	
ARD_005	29.9	4.0	3,680	
ARD_006	30.1	3.7	4,140	
ARD_007	30.0	3.7	7,470	
ARD_008	29.9	6.7	9,610	
ARD_009	30.0	5.3	5,920	
ARD_010	30.1	6.7	4,310	centrifuged
ARD_010 d	30.0	6.7	4,370	centrifuged
ARD_011	30.1	7.5	2,400	
ARD_012	30.0	6.0	19,200	
ARD_013	30.1	6.8	9,240	
ARD_014	29.9	6.9	6930	
ARD_015	30.1	8.6	912	
ARD_016	30.0	8.6	965	
ARD_017	30.0	7.2	1,630	
ARD_018	30.1	5.7	1,740	centrifuged
ARD_019	30.0	5.6	5,850	centrifuged
ARD_020	29.9	6.8	3,130	centrifuged
ARD_020 d	30.0	6.8	3,050	centrifuged
ARD_021	30.1	8.4	710	
ARD_022	29.9	8.9	276	
ARD_023	30.0	9.1	157	
ARD_024	30.0	8.9	191	
ARD_025	30.1	8.7	568	
ARD_026	30.1	8.8	831	

Testwork performed on fine-crushings (-2 mm nominal).

pH-(1:2) and EC=(1:2) values correspond to pH and EC values for suspensions prepared with deionised-water. and a solid:solution ratio of *ca.* 1:2 (w/w) [i.e. approx. 30 g solids + 60 mL DW).

Test-suspensions allowed to 'age' / 'breathe' / equilibrate for *ca.* 1 day before pH and EC determinations.

Test-suspensions were stirred with a spatula twice during ageing / equilibration.

Testwork performed in a CT-room (viz. 20 +/- 2 oC).

'centrifuged' means that insifficient clear supernatant could be decanted for EC measurement.

Accordingly, the 'clay-slop' was subjected to centrifugation to generate a clear centrifugate for EC measurement.

Dr GD Campbell 7th April 2019

ACID-NEUTRALISATION-CAPACITY (ANC) TESTWORK: BASED ON AMIRA (2002) WITH VARIATIONS TO CONSTRAIN DISSOLUTION OF NON-CARBONATE-MINERALS UNRELATED TO CIRCUM-NEUTRAL BUFFERING SAVE FOR VANISHINGLY-SMALL RATES OF PYRITE OXIDATION

SAMPLE		HCl		milli moles H+ Added	Digest-Slurry-Final-pH	NaOH		milli moles OH- Added	pH after H_2O_2 Added	BULK-ANC (kg H_2SO_4/ tonne)	
ID	WT (g)	Conc. (M)	Pipette Volume (mL)			Conc. (M)	Titre Volume (mL)				
ARD_007	15.01	0.10	10	1.00	1.9	0.05	25.45	1.273	> 4.0	**-1**	
ARD_010	15.03	0.10	10	1.00	2.9	0.05	7.20	0.360	> 4.0	**2**	magnetite
ARD_011	15.03	0.10	10	1.00	3.2	0.05	4.60	0.230	> 4.0	**3**	magnetite
ARD_013	15.01	0.10	10	1.00	2.9	0.05	6.10	0.305	> 4.0	**2**	magnetite
ARD_014	15.01	0.10	10	1.00	2.8	0.05	6.25	0.313	> 4.0	**2**	magnetite
ARD_014 d	14.99	0.10	10	1.00	2.7	0.05	5.70	0.285	> 4.0	**2**	
ARD_017	14.99	0.10	10	1.00	2.3	0.05	10.20	0.510	> 4.0	**2**	
ARD_019	15.03	0.10	10	1.00	2.9	0.05	10.50	0.525	> 4.0	**2**	magnetite
ARD_020	15.01	0.10	10	1.00	3.7	0.05	6.90	0.345	> 4.0	**2**	
ARD_021	15.01	0.10	10	1.00	2.5	0.05	7.40	0.370	> 4.0	**2**	
ARD_022	14.99	0.10	10	1.00	2.5	0.05	8.25	0.413	> 4.0	**2**	
ARD_022 d	15.03	0.10	10	1.00	2.6	0.05	8.55	0.428	> 4.0	**2**	
ARD_024	14.97	0.10	10	1.00	2.2	0.05	9.10	0.455	3.8	**2**	
ARD_025	14.99	0.10	10	1.00	2.5	0.05	7.30	0.365	> 4.0	**2**	
ARD_026	14.98	0.10	10	1.00	2.7	0.05	6.25	0.313	> 4.0	**2**	
ARD_003	10.00	0.10	10	1.00	1.7	0.05	21.20	1.060	> 4.0	**< 1**	
ARD_008	10.00	0.10	10	1.00	1.8	0.05	12.80	0.640	> 4.0	**2**	magnetite
ARD_008 d	9.97	0.10	10	1.00	1.8	0.05	12.95	0.648	> 4.0	**2**	magnetite
ANC Std	5.00	0.10	25	2.50	2.2	0.05	7.70	0.385	> 4.0	21	
ANC Std d	5.01	0.10	25	2.50	2.2	0.05	7.75	0.388	> 4.0	21	
0.1 M-HCl	-	0.10	10	1.00		0.05	20.15	1.01		100.8%	
0.1 M-HCl (d)	-	0.10	10	1.00		0.05	20.15	1.01		100.8%	

Notes:

1. Testing performed on **-2 mm** fraction from dry-sieving of crushings (nominal -5 mm).
2. ***ca.* 20 mL** of high-purity-deionised-water (HPDW) added to all samples (including HCl-solution 'blanks') initially.
3. HCl solution added manually via volumetric glass pipette (A Class).
4. **HCl** and **NaOH** solutions certified reagents from Merck (viz. Titripur® reagents in hermetically-sealed Titripac® casks).
5. Sample weight, and volume and strength of HCl added, based on corresponding CO3-C value(s).
6. During acid-digestion temperature of waterbath is **80 +/- 5 oC,** and digestion performed for **1.0 hr** with beakers swirled by hand 1-2 times during this reaction period. Digestion performed using 250 mL tall-form beakers covered with watchglasses.
7. After completion of acid-digestion step, the test-slurries are boiled for *ca.* 1 min to expel any dissolved $CO_2(aq)$ which is important for the attainment of a stable pH7 end-point in the subsequent back-titration with NaOH solution.
8. Following cooling to room-T, **digest-slurry-final-pH** is measured. HPDW is then added to bring test-slurry volume to *ca.* **125 mL** for titration with NaOH solution.
9. Titration with NaOH performed manually using 50 mL glass burette with slurry stirred using magnetic stirrer-bar. Fast titration with stopcock fully open until slurry-pH rises to approximate range 4.0-4.5 when titration stops for H_2O_2 addition.
10. Three drops of **30 % H_2O_2 (v/v)** [adjusted to pH 4.5] added to slurry to oxidise **soluble-Fe(II)** forms ('latent-acidity') and precipitation of Fe(III)/Al-oxyhydroxides, etc. Minimum slurry-pH attained following H_2O_2 addition recorded.
11. Following completion of H_2O_2 addition, titration with NaOH continues to a **pH7** end-point. Titration with NaOH undertaken so that slurry-pH at end-point is within range 6.9-7.1 (i.e. pH 7.0 +/- 0.1) for *ca.* 30 seconds. [Related pH-end-point stability criteria for manual titration (cf. autotititration) option applies in ASTM E1915-13, and AS-4969.12-09].
12. ANC Standard is pulped mixture of quartz and AR $CaCO_3$ (CO3-C = 0.27 %; ANC = 22 kg H_2SO_4/tonne).
13. Samples with 'magnetite' noted were characterised by a deposit clinging to magnetic-stirrer bar retrieved after completion of titration with NaOH solution.

The main variations to the AMIRA (2002) method are the use of -2 mm fraction (cf. pulp, -75 µm nominal), and initial 'applied HCl loading', as governed by CO3-C value.

Dr GD Campbell
4th June 2019

ACID-NEUTRALISATION-CAPACITY (ANC) TESTWORK: BASED ON AMIRA (2002) WITH VARIATIONS TO CONSTRAIN DISSOLUTION OF NON-CARBONATE-MINERALS UNRELATED TO CIRCUM-NEUTRAL BUFFERING SAVE FOR VANISHINGLY-SMALL RATES OF PYRITE OXIDATION

SAMPLE		HCl		milli moles H^+ Added	Digest-Slurry-Final-pH	NaOH		milli moles OH^- Added	pH after H_2O_2 Added	Vigour of 'Fizzing' from HCl Addition ('in-the-cold')	BULK-ANC (kg H_2SO_4/ tonne)	
ID	**WT (g)**	**Conc. (M)**	**Pipette Volume (mL)**			**Conc. (M)**	**Titre Volume (mL)**					
ARD_023	10.01	0.10	10	1.00	1.6	0.05	12.00	0.600	> 4.0		**2**	
ARD_009	9.97	0.10	10	1.00	1.7	0.05	15.55	0.778	> 4.0		**1**	magnetite
ARD_018	10.01	0.10	10	1.00	2.0	0.05	12.00	0.600	> 4.0		**2**	magnetite
ARD_012	6.99	0.10	10	1.00	1.6	0.05	15.25	0.763	> 4.0		**2**	magnetite
ARD_005	6.01	0.10	10	1.00	1.5	0.05	16.50	0.825	> 4.0		**1**	
ARD_005 d	6.00	0.10	10	1.00	1.5	0.05	16.50	0.825	> 4.0		**1**	
ARD_015	6.01	0.10	10	1.00	1.8	0.05	8.55	0.428	> 4.0		**5**	magnetite
ARD_001	5.99	0.10	10	1.00	1.6	0.05	16.60	0.830	> 4.0		**1**	
ARD_006	4.98	0.10	10	1.00	1.6	0.05	18.20	0.910	> 4.0		**1**	
ARD_002	4.99	0.10	15	1.50	1.5	0.05	27.55	1.378	> 4.0		**1**	
ARD_004	6.01	0.10	20	2.00	2.1	0.05	11.60	0.580	> 4.0	weak	**12**	
ARD_004 d	5.99	0.10	20	2.00	2.1	0.05	11.80	0.590	> 4.0		**12**	
ARD_016	2.59	0.50	20	10.00	1.5	0.10	13.35	1.335	> 4.0	moderate-to-strong	**164**	magnetite
ARD_016 d	2.60	0.50	20	10.00	1.5	0.10	11.70	1.170	> 4.0		**167**	magnetite
ANC Std	5.00	0.10	25	2.50	2.2	0.05	7.50	0.375	> 4.0		21	
ANC Std d	5.00	0.10	25	2.50	2.2	0.05	7.65	0.383	> 4.0		21	
0.1 M-HCl	-	0.10	10	1.00		0.05	20.10	1.01			100.5%	
0.1 M-HCl (d)	-	0.10	10	1.00		0.05	20.15	1.01			100.8%	

Notes:

1. Testing performed on fine-crushings (**-2 mm** fraction).

'Fizz' testing (where undertaken) employed 2-3 M-HCl determined on pulps.

2. *ca.* **20 mL** of high-purity-deionised-water (HPDW) added to all samples (including HCl-solution 'blanks') initially.
3. HCl solution added manually via volumetric glass pipette (A Class).
4. **HCl** and **NaOH** solutions certified reagents from Merck (viz. Titripur® reagents in hermetically-sealed Titripac® casks).
5. Sample weight, and volume and strength of HCl added, based on corresponding CO_3-C value(s).
6. During acid-digestion temperature of waterbath is **80 +/- 5 oC,** and digestion performed for **1.0 hr** with beakers swirled by hand 1-2 times during this reaction period. Digestion performed using 250 mL tall-form beakers covered with watchglasses.
7. After completion of acid-digestion step, the test-slurries are boiled for *ca.* 1 min to expel any dissolved $CO_2(aq)$ which is important for the attainment of a stable pH7 end-point in the subsequent back-titration with NaOH solution.
8. Following cooling to room-T, **digest-slurry-final-pH** is measured. HPDW is then added to bring test-slurry volume to *ca.* **125 mL** for titration with NaOH solution.
9. Titration with NaOH performed manually using 50 mL glass burette with slurry stirred using magnetic stirrer-bar. Fast titration with stopcock fully open until slurry-pH rises to approximate range 4.0-4.5 when titration stops for H_2O_2 addition.
10. Three drops of **30 % H_2O_2 (v/v)** [adjusted to pH 4.5] added to slurry to oxidise **soluble-Fe(II)** forms ('latent-acidity') and precipitation of Fe(III)/Al-oxyhydroxides, etc. Minimum slurry-pH attained following H_2O_2 addition recorded.
11. Following completion of H_2O_2 addition, titration with NaOH continues to a **pH7** end-point. Titration with NaOH undertaken so that slurry-pH at end-point is within range 6.9-7.1 (i.e. pH 7.0 +/- 0.1) for *ca.* 30 seconds. [Related pH-end-point stability criteria for manual titration (cf. autotititration) option applies in ASTM E1915-13, and AS-4969.12-09].
12. ANC Standard is pulped mixture of quartz and AR $CaCO_3$ (CO_3-C = 0.27 %; ANC = 22 kg H_2SO_4/tonne).
13. Samples with 'magnetite' noted were characterised by a deposit clinging to magnetic-stirrer bar retrieved after completion of titration with NaOH solution.

The main variations to the AMIRA (2002) method are the use of -2 mm fraction (cf. pulp, -75 µm nominal), and initial 'applied HCl loading', as governed by CO_3-C value.

Dr GD Campbell
6th June 2019

ANALYTICAL REPORT

Accreditation No. 2562

CLIENT DETAILS

Contact	Graeme Campbell
Client	Graeme Campbell & Associates Pty Ltd
Address	PO Box 247 Bridgetown WA 6255
Telephone	0897 612 829
Facsimile	0897 612 830
Email	gca@wn.com.au
Project	**GCA-Job-No. 1901/1**
Order Number	**GCA-Job-No. 1901/1**
Samples	12

LABORATORY DETAILS

Manager	Marjana Siljanoska
Laboratory	SGS Perth Environmental
Address	28 Reid Rd Perth Airport WA 6105
Telephone	(08) 9373 3500
Facsimile	(08) 9373 3556
Email	au.environmental.perth@sgs.com
SGS Reference	**PE134287 R0**
Date Received	15 Apr 2019
Date Reported	06 May 2019

COMMENTS

Accredited for compliance with ISO/IEC 17025 - Testing. NATA accredited laboratory 2562(898/20210).

Metals subcontracted to SGS Perth Minerals, 28 Reid Rd Perth Airport WA, NATA Accreditation Number 1936,WM192208

SIGNATORIES

Parameter	Units	LOR	Sample Number PE134287.001 Sample Matrix PULP Sample Name ARD_001	PE134287.002 PULP ARD_002

Metals in soil by Four Acid digest, ICPMS Method: IMS40Q Tested: 29/4/2019

Parameter	Units	LOR	ARD_001	ARD_002
Silver, Ag*	ppm	0.1	0.4	0.3
Arsenic, As*	ppm	1	2	2
Barium, Ba*	ppm	1	9	54
Bismuth, Bi*	ppm	0.1	1.5	0.7
Cadmium, Cd*	ppm	0.1	<0.1	<0.1
Cobalt, Co*	ppm	0.1	54	27
Molybdenum, Mo*	ppm	0.1	2.1	6.6
Lead, Pb*	ppm	1	16	9
Antimony, Sb*	ppm	0.1	0.1	<0.1
Tin, Sn*	ppm	0.3	0.8	0.6
Strontium, Sr*	ppm	0.1	1.9	6.1
Thorium, Th*	ppm	0.05	3.6	1.9
Thallium, Tl*	ppm	0.2	<0.2	<0.2
Uranium, U*	ppm	0.05	1.0	0.61

ICPAES after Four Acid Digest Digest Method: ICP40Q Tested: 29/4/2019

Parameter	Units	LOR	ARD_001	ARD_002
Aluminium, Al*	ppm	100	80000	110000
Calcium, Ca*	ppm	40	100	210
Chromium, Cr*	ppm	10	680	620
Copper, Cu*	ppm	5	960	480
Iron, Fe*	ppm	100	340000	220000
Potassium, K*	ppm	100	170	1100
Magnesium, Mg*	ppm	20	1300	880
Manganese, Mn*	ppm	5	600	100
Sodium, Na*	ppm	50	1400	1400
Nickel, Ni*	ppm	5	320	280
Phosphorus, P*	ppm	20	100	50
Sulphur, S*	ppm	20	1400	1100
Titanium, Ti*	ppm	10	14000	4600
Vanadium, V*	ppm	1	750	370
Zinc, Zn*	ppm	5	68	97

Metals in Soils from Alkali Fusion ICP AES Method: ICP90Q Tested: 6/5/2019

Parameter	Units	LOR	ARD_001	ARD_002
Silicon, Si*	%	0.42	76000	172000
Boron, B*	ppm	20	<20	35

		Sample Number	PE134287.003	PE134287.004
		Sample Matrix	PULP	PULP
		Sample Name	ARD_004	ARD_005
Parameter	Units	LOR		

Metals in soil by Four Acid digest, ICPMS Method: IMS40Q Tested: 29/4/2019

Silver, Ag*	ppm	0.1	0.2	<0.1
Arsenic, As*	ppm	1	4	<1
Barium, Ba*	ppm	1	54	51
Bismuth, Bi*	ppm	0.1	1.7	6.2
Cadmium, Cd*	ppm	0.1	<0.1	<0.1
Cobalt, Co*	ppm	0.1	46	12
Molybdenum, Mo*	ppm	0.1	7.1	2.9
Lead, Pb*	ppm	1	22	9
Antimony, Sb*	ppm	0.1	0.2	0.2
Tin, Sn*	ppm	0.3	0.9	1.2
Strontium, Sr*	ppm	0.1	39	5.3
Thorium, Th*	ppm	0.05	3.9	1.8
Thallium, Tl*	ppm	0.2	<0.2	0.2
Uranium, U*	ppm	0.05	0.76	0.33

ICPAES after Four Acid Digest Digest Method: ICP40Q Tested: 29/4/2019

Aluminium, Al*	ppm	100	120000	150000
Calcium, Ca*	ppm	40	3800	190
Chromium, Cr*	ppm	10	80	75
Copper, Cu*	ppm	5	290	100
Iron, Fe*	ppm	100	170000	87000
Potassium, K*	ppm	100	1600	2100
Magnesium, Mg*	ppm	20	1900	860
Manganese, Mn*	ppm	5	110	160
Sodium, Na*	ppm	50	2000	2000
Nickel, Ni*	ppm	5	93	71
Phosphorus, P*	ppm	20	<20	35
Sulphur, S*	ppm	20	430	580
Titanium, Ti*	ppm	10	13000	24000
Vanadium, V*	ppm	1	970	800
Zinc, Zn*	ppm	5	15	18

Metals in Soils from Alkali Fusion ICP AES Method: ICP90Q Tested: 6/5/2019

Silicon, Si*	%	0.42	17300	21500
Boron, B*	ppm	20	75	50

Parameter	Units	LOR	Sample Number Sample Matrix Sample Name: PE134287.005 PULP ARD_006	PE134287.006 PULP ARD_011

Metals in soil by Four Acid digest, ICPMS Method: IMS40Q Tested: 29/4/2019

Parameter	Units	LOR	PE134287.005	PE134287.006
Silver, Ag*	ppm	0.1	<0.1	1.4
Arsenic, As*	ppm	1	1	<1
Barium, Ba*	ppm	1	34	48
Bismuth, Bi*	ppm	0.1	4.8	3.1
Cadmium, Cd*	ppm	0.1	<0.1	0.7
Cobalt, Co*	ppm	0.1	29	180
Molybdenum, Mo*	ppm	0.1	43	11
Lead, Pb*	ppm	1	10	11
Antimony, Sb*	ppm	0.1	0.2	<0.1
Tin, Sn*	ppm	0.3	1.1	1.9
Strontium, Sr*	ppm	0.1	5.0	47
Thorium, Th*	ppm	0.05	1.4	1.5
Thallium, Tl*	ppm	0.2	<0.2	0.8
Uranium, U*	ppm	0.05	0.59	0.31

ICPAES after Four Acid Digest Digest Method: ICP40Q Tested: 29/4/2019

Parameter	Units	LOR	PE134287.005	PE134287.006
Aluminium, Al*	ppm	100	130000	38000
Calcium, Ca*	ppm	40	250	45000
Chromium, Cr*	ppm	10	370	1900
Copper, Cu*	ppm	5	630	1900
Iron, Fe*	ppm	100	200000	150000
Potassium, K*	ppm	100	720	3400
Magnesium, Mg*	ppm	20	620	70000
Manganese, Mn*	ppm	5	160	2000
Sodium, Na*	ppm	50	1900	6700
Nickel, Ni*	ppm	5	250	2200
Phosphorus, P*	ppm	20	70	240
Sulphur, S*	ppm	20	1500	310
Titanium, Ti*	ppm	10	23000	11000
Vanadium, V*	ppm	1	740	300
Zinc, Zn*	ppm	5	63	130

Metals in Soils from Alkali Fusion ICP AES Method: ICP90Q Tested: 6/5/2019

Parameter	Units	LOR	PE134287.005	PE134287.006
Silicon, Si*	%	0.42	16200	21500
Boron, B*	ppm	20	40	<20

Parameter	Units	LOR	Sample Number PE134287.007 Sample Matrix PULP Sample Name ARD_013	PE134287.008 PULP ARD_016

Metals in soil by Four Acid digest, ICPMS Method: IMS40Q Tested: 29/4/2019

Parameter	Units	LOR	PE134287.007	PE134287.008
Silver, Ag*	ppm	0.1	0.3	<0.1
Arsenic, As*	ppm	1	<1	<1
Barium, Ba*	ppm	1	4	<1
Bismuth, Bi*	ppm	0.1	1.1	<0.1
Cadmium, Cd*	ppm	0.1	0.5	<0.1
Cobalt, Co*	ppm	0.1	390	<0.1
Molybdenum, Mo*	ppm	0.1	1.9	<0.1
Lead, Pb*	ppm	1	2	<1
Antimony, Sb*	ppm	0.1	<0.1	<0.1
Tin, Sn*	ppm	0.3	0.7	<0.3
Strontium, Sr*	ppm	0.1	7.7	<0.1
Thorium, Th*	ppm	0.05	0.68	<0.05
Thallium, Tl*	ppm	0.2	<0.2	<0.2
Uranium, U*	ppm	0.05	0.09	<0.05

ICPAES after Four Acid Digest Digest Method: ICP40Q Tested: 29/4/2019

Parameter	Units	LOR	PE134287.007	PE134287.008
Aluminium, Al*	ppm	100	10000	11000
Calcium, Ca*	ppm	40	1100	50000
Chromium, Cr*	ppm	10	270	140
Copper, Cu*	ppm	5	1300	260
Iron, Fe*	ppm	100	270000	140000
Potassium, K*	ppm	100	1000	250
Magnesium, Mg*	ppm	20	27000	86000
Manganese, Mn*	ppm	5	3700	3200
Sodium, Na*	ppm	50	6500	980
Nickel, Ni*	ppm	5	2800	1000
Phosphorus, P*	ppm	20	140	190
Sulphur, S*	ppm	20	310	120
Titanium, Ti*	ppm	10	2900	2900
Vanadium, V*	ppm	1	86	88
Zinc, Zn*	ppm	5	330	110

Metals in Soils from Alkali Fusion ICP AES Method: ICP90Q Tested: 6/5/2019

Parameter	Units	LOR	PE134287.007	PE134287.008
Silicon, Si*	%	0.42	17900	21700
Boron, B*	ppm	20	<20	<20

		Sample Number	PE134287.009	PE134287.010
		Sample Matrix	PULP	PULP
		Sample Name	ARD_019	ARD_022
Parameter	Units	LOR		

Metals in soil by Four Acid digest, ICPMS Method: IMS40Q Tested: 29/4/2019

Silver, Ag*	ppm	0.1	0.7	0.2
Arsenic, As*	ppm	1	<1	1
Barium, Ba*	ppm	1	440	13
Bismuth, Bi*	ppm	0.1	0.4	0.5
Cadmium, Cd*	ppm	0.1	0.1	0.1
Cobalt, Co*	ppm	0.1	1400	54
Molybdenum, Mo*	ppm	0.1	3.2	1.3
Lead, Pb*	ppm	1	4	3
Antimony, Sb*	ppm	0.1	<0.1	0.1
Tin, Sn*	ppm	0.3	1.0	0.7
Strontium, Sr*	ppm	0.1	19	110
Thorium, Th*	ppm	0.05	0.42	0.29
Thallium, Tl*	ppm	0.2	2.2	<0.2
Uranium, U*	ppm	0.05	0.13	0.07

ICPAES after Four Acid Digest Digest Method: ICP40Q Tested: 29/4/2019

Aluminium, Al*	ppm	100	78000	70000
Calcium, Ca*	ppm	40	1000	75000
Chromium, Cr*	ppm	10	700	200
Copper, Cu*	ppm	5	1000	93
Iron, Fe*	ppm	100	160000	79000
Potassium, K*	ppm	100	1500	1700
Magnesium, Mg*	ppm	20	7700	44000
Manganese, Mn*	ppm	5	8200	1200
Sodium, Na*	ppm	50	5500	16000
Nickel, Ni*	ppm	5	1700	170
Phosphorus, P*	ppm	20	100	220
Sulphur, S*	ppm	20	210	45
Titanium, Ti*	ppm	10	7100	4300
Vanadium, V*	ppm	1	300	250
Zinc, Zn*	ppm	5	220	77

Metals in Soils from Alkali Fusion ICP AES Method: ICP90Q Tested: 6/5/2019

Silicon, Si*	%	0.42	18700	26300
Boron, B*	ppm	20	<20	<20

Parameter	Units	LOR	Sample Number PE134287.011 Sample Matrix PULP Sample Name ARD_025	PE134287.012 PULP ARD_026

Metals in soil by Four Acid digest, ICPMS Method: IMS40Q Tested: 29/4/2019

Parameter	Units	LOR	ARD_025	ARD_026
Silver, Ag*	ppm	0.1	<0.1	0.2
Arsenic, As*	ppm	1	<1	<1
Barium, Ba*	ppm	1	56	58
Bismuth, Bi*	ppm	0.1	0.6	1.7
Cadmium, Cd*	ppm	0.1	0.2	0.2
Cobalt, Co*	ppm	0.1	83	54
Molybdenum, Mo*	ppm	0.1	0.8	3.3
Lead, Pb*	ppm	1	3	4
Antimony, Sb*	ppm	0.1	<0.1	<0.1
Tin, Sn*	ppm	0.3	0.7	0.8
Strontium, Sr*	ppm	0.1	370	85
Thorium, Th*	ppm	0.05	0.52	0.16
Thallium, Tl*	ppm	0.2	<0.2	0.4
Uranium, U*	ppm	0.05	0.13	0.05

ICPAES after Four Acid Digest Digest Method: ICP40Q Tested: 29/4/2019

Parameter	Units	LOR	ARD_025	ARD_026
Aluminium, Al*	ppm	100	79000	85000
Calcium, Ca*	ppm	40	82000	87000
Chromium, Cr*	ppm	10	80	510
Copper, Cu*	ppm	5	58	130
Iron, Fe*	ppm	100	120000	82000
Potassium, K*	ppm	100	4700	8400
Magnesium, Mg*	ppm	20	43000	48000
Manganese, Mn*	ppm	5	1200	1400
Sodium, Na*	ppm	50	13000	13000
Nickel, Ni*	ppm	5	130	240
Phosphorus, P*	ppm	20	130	140
Sulphur, S*	ppm	20	120	160
Titanium, Ti*	ppm	10	22000	4600
Vanadium, V*	ppm	1	700	260
Zinc, Zn*	ppm	5	84	100

Metals in Soils from Alkali Fusion ICP AES Method: ICP90Q Tested: 6/5/2019

Parameter	Units	LOR	ARD_025	ARD_026
Silicon, Si*	%	0.42	22600	25200
Boron, B*	ppm	20	<20	<20

MB blank results are compared to the Limit of Reporting
LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared the the amount of analyte spiked into the sample.
DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula : *the absolute difference of the two results divided by the average of the two results as a percentage.* Where the DUP RPD is 'NA' , the results are less than the LOR and thus the RPD is not applicable.

No QC samples were reported for this job.

METHOD	METHODOLOGY SUMMARY
ICP40Q	Sample solutions (from Four Acid digest) are analysed by Inductively Coupled Plasma-Atomic Emission Spectrometry (ICP-AES) against matched standards.
ICP90Q	Sample solutions (from Alkali Fusion) are analysed by Inductively Coupled Plasma-Atomic Emission Spectrometry (ICP-AES) against matched standards.
IMS40Q	Sample solutions (from Four Acid Digest) are analysed by Inductively Coupled Plasma-Mass Spectrometry (ICP-MS) against matched standards.

FOOTNOTES

IS	Insufficient sample for analysis.	LOR	Limit of Reporting
LNR	Sample listed, but not received.	↑↓	Raised or Lowered Limit of Reporting
*	NATA accreditation does not cover the performance of this service.	QFH	QC result is above the upper tolerance
		QFL	QC result is below the lower tolerance
**	Indicative data, theoretical holding time exceeded.	-	The sample was not analysed for this analyte
		NVL	Not Validated

Unless it is reported that sampling has been perfomed by SGS, the samples have been analysed as received.
Solid samples expressed on a dry weight basis.

Where "Total" analyte groups are reported (for example, Total PAHs, Total OC Pesticides) the total will be calculated as the sum of the individual analytes, with those analytes that are reported as <LOR being assumed to be zero. The summed (Total) limit of reporting is calcuated by summing the individual analyte LORs and dividing by two. For example, where 16 individual analytes are being summed and each has an LOR of 0.1 mg/kg, the "Totals" LOR will be 1.6 / 2 (0.8 mg/kg). Where only 2 analytes are being summed, the " Total" LOR will be the sum of those two LORs.

Some totals may not appear to add up because the total is rounded after adding up the raw values.

If reported, measurement uncertainty follow the ± sign after the analytical result and is expressed as the expanded uncertainty calculated using a coverage factor of 2, providing a level of confidence of approximately 95%, unless stated otherwise in the comments section of this report.

Results reported for samples tested under test methods with codes starting with ARS-SOP, radionuclide or gross radioactivity concentrations are expressed in becquerel (Bq) per unit of mass or volume or per wipe as stated on the report. Becquerel is the SI unit for activity and equals one nuclear transformation per second.
Note that in terms of units of radioactivity:

a. 1 Bq is equivalent to 27 pCi
b. 37 MBq is equivalent to 1 mCi

For results reported for samples tested under test methods with codes starting with ARS-SOP, less than (<) values indicate the detection limit for each radionuclide or parameter for the measurement system used. The respective detection limits have been calculated in accordance with ISO 11929.

The QC and MU criteria are subject to internal review according to the SGS QAQC plan and may be provided on request or alternatively can be found here: www.sgs.com.au.pv.sgsvr/en-gb/environment.

ANALYTICAL REPORT

Accreditation No. 2562

CLIENT DETAILS

Contact	Graeme Campbell
Client	Graeme Campbell & Associates Pty Ltd
Address	PO Box 247 Bridgetown WA 6255
Telephone	0897 612 829
Facsimile	0897 612 830
Email	gca@wn.com.au
Project	**GCA-Job-No. 1901/1**
Order Number	**GCA-Job-No. 1901/1**
Samples	14

LABORATORY DETAILS

Manager	Marjana Siljanoska
Laboratory	SGS Perth Environmental
Address	28 Reid Rd Perth Airport WA 6105
Telephone	(08) 9373 3500
Facsimile	(08) 9373 3556
Email	au.environmental.perth@sgs.com
SGS Reference	**PE134647 R1**
Date Received	06 May 2019
Date Reported	20 May 2019

COMMENTS

Accredited for compliance with ISO/IEC 17025 - Testing. NATA accredited laboratory 2562(898/20210).

Samples ARD_025 and ARD_026 were filtered (0.45µm) prior to preservation / assaying. They were very difficult to filter and we could only obtain a few drops through the filter. Hence the samples were run in dilution and LOR raised as a result.
Sample ARD_013 - metal LORs raised as dilution required due to high conductivity.

Metals: The over range results on ICPMS Method AN318 were reported using ICPOES method AN320.

SIGNATORIES

Hue Thanh Ly
Metals Team Leader

LouiseHope

Louise Hope
Laboratory Technician

Ohmar David
Metals Chemist

		Sample Number	PE134647.001	PE134647.002
		Sample Matrix	Water	Water
		Sample Name	ARD_022	ARD_025
Parameter	Units	LOR		

pH in water Method: AN101 Tested: 6/5/2019

pH**	pH Units	0.1	7.7	8.2

Conductivity and TDS by Calculation - Water Method: AN106 Tested: 6/5/2019

Conductivity @ 25 C	µS/cm	2	260	470

Alkalinity Method: AN135 Tested: 6/5/2019

Bicarbonate Alkalinity as HCO3	mg/L	1	37	140
Carbonate Alkalinity as CO3	mg/L	1	<1	<1
Hydroxide Alkalinity as OH	mg/L	1	<1	<1
Total Alkalinity as CaCO3	mg/L	1	30	110

Acidity and Free CO2 Method: AN140 Tested: 9/5/2019

Acidity to pH 8.3	mg CaCO3/L	5	-	-

Chloride by Discrete Analyser in Water Method: AN274 Tested: 9/5/2019

Chloride, Cl	mg/L	1	48	88

Sulfate in water Method: AN275 Tested: 9/5/2019

Sulfate, SO4	mg/L	1	16	56

Fluoride by Ion Selective Electrode in Water Method: AN141 Tested: 8/5/2019

Fluoride by ISE	mg/L	0.1	0.7	1.3

Metals in Water (Dissolved) by ICPOES Method: AN320 Tested: 8/5/2019

Phosphorus, P	µg/L	50	130	<500↑
Silicon, Si	µg/L	20	9600	66000
Sulfur, S	µg/L	100	4600	8900

Cations in Water (Dissolved) by ICPOES Method: AN020/AN320 Tested: 8/5/2019

Calcium, Ca	µg/L	10	700	1100
Magnesium, Mg	µg/L	10	97	5500
Potassium, K	µg/L	50	990	980
Sodium, Na	µg/L	50	48000	100000

		Sample Number	PE134647.001	PE134647.002
		Sample Matrix	Water	Water
		Sample Name	ARD_022	ARD_025
Parameter	Units	LOR		

Trace Metals (Dissolved) in Water by ICPMS Method: AN318 Tested: 8/5/2019

Aluminium, Al	µg/L	5	410	9000
Antimony, Sb	µg/L	1	<1	<10↑
Arsenic, As	µg/L	1	26	<10↑
Barium, Ba	µg/L	0.2	2.0	11
Bismuth, Bi	µg/L	1	<1	<10↑
Boron, B	µg/L	5	250	360
Cadmium, Cd	µg/L	0.1	<0.1	<1.0↑
Chromium, Cr	µg/L	1	1	100
Cobalt, Co	µg/L	1	<1	46
Copper, Cu	µg/L	1	12	290
Iron, Fe	µg/L	5	140	17000
Lead, Pb	µg/L	1	<1	<10↑
Manganese, Mn	µg/L	1	2	80
Molybdenum, Mo	µg/L	0.5	41	<5.0↑
Nickel, Ni	µg/L	1	2	210
Selenium, Se	µg/L	1	<1	<10↑
Silver, Ag	µg/L	1	<1	<10↑
Strontium, Sr	µg/L	1	5	18
Thallium, Tl	µg/L	1	<1	<10↑
Thorium, Th	µg/L	1	<1	<10↑
Tin, Sn	µg/L	1	<1	<10↑
Titanium, Ti	µg/L	1	2	1900
Uranium, U	µg/L	1	1	<10↑
Vanadium, V	µg/L	1	130	440
Zinc, Zn	µg/L	5	<5	120

Mercury (dissolved) in Water Method: AN311(Perth)/AN312 Tested: 8/5/2019

Mercury	µg/L	0.05	0.07	<0.50↑

Parameter	Units	LOR	Sample Number: PE134647.003 Sample Matrix: Water Sample Name: ARD_026	Sample Number: PE134647.004 Sample Matrix: Water Sample Name: ARD_011

pH in water Method: AN101 Tested: 8/5/2019

Parameter	Units	LOR	PE134647.003	PE134647.004
pH**	pH Units	0.1	9.0	7.0

Conductivity and TDS by Calculation - Water Method: AN106 Tested: 8/5/2019

Parameter	Units	LOR	PE134647.003	PE134647.004
Conductivity @ 25 C	µS/cm	2	590	1400

Alkalinity Method: AN135 Tested: 8/5/2019

Parameter	Units	LOR	PE134647.003	PE134647.004
Bicarbonate Alkalinity as HCO3	mg/L	1	65	10
Carbonate Alkalinity as CO3	mg/L	1	8	<1
Hydroxide Alkalinity as OH	mg/L	1	<1	<1
Total Alkalinity as CaCO3	mg/L	1	67	8

Acidity and Free CO2 Method: AN140 Tested: 9/5/2019

Parameter	Units	LOR	PE134647.003	PE134647.004
Acidity to pH 8.3	mg CaCO3/L	5	-	-

Chloride by Discrete Analyser in Water Method: AN274 Tested: 9/5/2019

Parameter	Units	LOR	PE134647.003	PE134647.004
Chloride, Cl	mg/L	1	140	370

Sulfate in water Method: AN275 Tested: 9/5/2019

Parameter	Units	LOR	PE134647.003	PE134647.004
Sulfate, SO4	mg/L	1	56	89

Fluoride by Ion Selective Electrode in Water Method: AN141 Tested: 8/5/2019

Parameter	Units	LOR	PE134647.003	PE134647.004
Fluoride by ISE	mg/L	0.1	1.5	0.6

Metals in Water (Dissolved) by ICPOES Method: AN320 Tested: 8/5/2019

Parameter	Units	LOR	PE134647.003	PE134647.004
Phosphorus, P	µg/L	50	<500↑	95
Silicon, Si	µg/L	20	81000	15000
Sulfur, S	µg/L	100	11000	28000

Cations in Water (Dissolved) by ICPOES Method: AN020/AN320 Tested: 8/5/2019

Parameter	Units	LOR	PE134647.003	PE134647.004
Calcium, Ca	µg/L	10	2200	130
Magnesium, Mg	µg/L	10	11000	1200
Potassium, K	µg/L	50	2200	4700
Sodium, Na	µg/L	50	130000	260000

Parameter	Units	LOR	Sample Number: PE134647.003 Sample Matrix: Water Sample Name: ARD_026	Sample Number: PE134647.004 Sample Matrix: Water Sample Name: ARD_011

Trace Metals (Dissolved) in Water by ICPMS Method: AN318 Tested: 8/5/2019

Parameter	Units	LOR	PE134647.003	PE134647.004
Aluminium, Al	µg/L	5	16000	15
Antimony, Sb	µg/L	1	<10↑	<1
Arsenic, As	µg/L	1	<10↑	2
Barium, Ba	µg/L	0.2	66	0.9
Bismuth, Bi	µg/L	1	<10↑	<1
Boron, B	µg/L	5	550	340
Cadmium, Cd	µg/L	0.1	<1.0↑	<0.1
Chromium, Cr	µg/L	1	1100	5
Cobalt, Co	µg/L	1	68	<1
Copper, Cu	µg/L	1	1300	8
Iron, Fe	µg/L	5	32000	40
Lead, Pb	µg/L	1	10	<1
Manganese, Mn	µg/L	1	400	5
Molybdenum, Mo	µg/L	0.5	40	17
Nickel, Ni	µg/L	1	590	2
Selenium, Se	µg/L	1	<10↑	4
Silver, Ag	µg/L	1	<10↑	<1
Strontium, Sr	µg/L	1	16	2
Thallium, Tl	µg/L	1	<10↑	<1
Thorium, Th	µg/L	1	<10↑	<1
Tin, Sn	µg/L	1	<10↑	<1
Titanium, Ti	µg/L	1	1800	<1
Uranium, U	µg/L	1	<10↑	<1
Vanadium, V	µg/L	1	390	8
Zinc, Zn	µg/L	5	430	<5

Mercury (dissolved) in Water Method: AN311(Perth)/AN312 Tested: 8/5/2019

Parameter	Units	LOR	PE134647.003	PE134647.004
Mercury	µg/L	0.05	<0.50↑	<0.05

Parameter	Units	LOR	Sample Number Sample Matrix Sample Name: PE134647.005 Water ARD_013	PE134647.006 Water ARD_016

pH in water Method: AN101 Tested: 6/5/2019

pH**	pH Units	0.1	7.1	8.8

Conductivity and TDS by Calculation - Water Method: AN106 Tested: 6/5/2019

Conductivity @ 25 C	µS/cm	2	7000	820

Alkalinity Method: AN135 Tested: 6/5/2019

Bicarbonate Alkalinity as HCO3	mg/L	1	10	120
Carbonate Alkalinity as CO3	mg/L	1	<1	<1
Hydroxide Alkalinity as OH	mg/L	1	<1	<1
Total Alkalinity as CaCO3	mg/L	1	9	97

Acidity and Free CO2 Method: AN140 Tested: 9/5/2019

Acidity to pH 8.3	mg CaCO3/L	5	-	-

Chloride by Discrete Analyser in Water Method: AN274 Tested: 9/5/2019

Chloride, Cl	mg/L	1	2100	140

Sulfate in water Method: AN275 Tested: 9/5/2019

Sulfate, SO4	mg/L	1	400	92

Fluoride by Ion Selective Electrode in Water Method: AN141 Tested: 8/5/2019

Fluoride by ISE	mg/L	0.1	0.3	0.5

Metals in Water (Dissolved) by ICPOES Method: AN320 Tested: 8/5/2019

Phosphorus, P	µg/L	50	<50	<50
Silicon, Si	µg/L	20	11000	11000
Sulfur, S	µg/L	100	130000	29000

Cations in Water (Dissolved) by ICPOES Method: AN020/AN320 Tested: 8/5/2019

Calcium, Ca	µg/L	10	1800	2800
Magnesium, Mg	µg/L	10	54000	6700
Potassium, K	µg/L	50	25000	5200
Sodium, Na	µg/L	50	1300000	140000

		Sample Number Sample Matrix Sample Name	PE134647.005 Water ARD_013	PE134647.006 Water ARD_016
Parameter	Units	LOR		

Trace Metals (Dissolved) in Water by ICPMS Method: AN318 Tested: 8/5/2019

Aluminium, Al	µg/L	5	<10↑	17
Antimony, Sb	µg/L	1	<2↑	<1
Arsenic, As	µg/L	1	<2↑	<1
Barium, Ba	µg/L	0.2	1.4	0.8
Bismuth, Bi	µg/L	1	<2↑	<1
Boron, B	µg/L	5	580	150
Cadmium, Cd	µg/L	0.1	<0.2↑	<0.1
Chromium, Cr	µg/L	1	4	<1
Cobalt, Co	µg/L	1	<2↑	<1
Copper, Cu	µg/L	1	8	4
Iron, Fe	µg/L	5	<10↑	<5
Lead, Pb	µg/L	1	<2↑	<1
Manganese, Mn	µg/L	1	9	2
Molybdenum, Mo	µg/L	0.5	<1.0↑	38
Nickel, Ni	µg/L	1	20	1
Selenium, Se	µg/L	1	<2↑	<1
Silver, Ag	µg/L	1	<2↑	<1
Strontium, Sr	µg/L	1	30	10
Thallium, Tl	µg/L	1	<2↑	<1
Thorium, Th	µg/L	1	<2↑	<1
Tin, Sn	µg/L	1	<2↑	<1
Titanium, Ti	µg/L	1	<2↑	<1
Uranium, U	µg/L	1	<2↑	<1
Vanadium, V	µg/L	1	<2↑	2
Zinc, Zn	µg/L	5	16	9

Mercury (dissolved) in Water Method: AN311(Perth)/AN312 Tested: 8/5/2019

Mercury	µg/L	0.05	<0.05	<0.05

Parameter	Units	LOR	PE134647.007 Water ARD_001	PE134647.008 Water ARD_002
pH in water Method: AN101 Tested: 6/5/2019				
pH**	pH Units	0.1	5.4	4.3
Conductivity and TDS by Calculation - Water Method: AN106 Tested: 6/5/2019				
Conductivity @ 25 C	µS/cm	2	2300	1800
Alkalinity Method: AN135 Tested: 6/5/2019				
Bicarbonate Alkalinity as HCO3	mg/L	1	1	<1
Carbonate Alkalinity as CO3	mg/L	1	<1	<1
Hydroxide Alkalinity as OH	mg/L	1	<1	<1
Total Alkalinity as CaCO3	mg/L	1	1	<1
Acidity and Free CO2 Method: AN140 Tested: 9/5/2019				
Acidity to pH 8.3	mg CaCO3/L	5	-	14
Chloride by Discrete Analyser in Water Method: AN274 Tested: 9/5/2019				
Chloride, Cl	mg/L	1	690	490
Sulfate in water Method: AN275 Tested: 9/5/2019				
Sulfate, SO4	mg/L	1	100	100
Fluoride by Ion Selective Electrode in Water Method: AN141 Tested: 8/5/2019				
Fluoride by ISE	mg/L	0.1	0.2	0.2
Metals in Water (Dissolved) by ICPOES Method: AN320 Tested: 8/5/2019				
Phosphorus, P	µg/L	50	<50	<50
Silicon, Si	µg/L	20	12000	20000
Sulfur, S	µg/L	100	31000	33000
Cations in Water (Dissolved) by ICPOES Method: AN020/AN320 Tested: 8/5/2019				
Calcium, Ca	µg/L	10	3300	3700
Magnesium, Mg	µg/L	10	28000	20000
Potassium, K	µg/L	50	12000	4700
Sodium, Na	µg/L	50	370000	290000

Parameter	Units	LOR	Sample Number PE134647.007 Sample Matrix Water Sample Name ARD_001	PE134647.008 Water ARD_002

Trace Metals (Dissolved) in Water by ICPMS Method: AN318 Tested: 8/5/2019

Parameter	Units	LOR	PE134647.007	PE134647.008
Aluminium, Al	µg/L	5	210	860
Antimony, Sb	µg/L	1	<1	<1
Arsenic, As	µg/L	1	<1	<1
Barium, Ba	µg/L	0.2	36	88
Bismuth, Bi	µg/L	1	<1	<1
Boron, B	µg/L	5	450	670
Cadmium, Cd	µg/L	0.1	<0.1	<0.1
Chromium, Cr	µg/L	1	<1	20
Cobalt, Co	µg/L	1	15	49
Copper, Cu	µg/L	1	28	100
Iron, Fe	µg/L	5	30	60
Lead, Pb	µg/L	1	<1	<1
Manganese, Mn	µg/L	1	94	240
Molybdenum, Mo	µg/L	0.5	<0.5	<0.5
Nickel, Ni	µg/L	1	58	84
Selenium, Se	µg/L	1	<1	<1
Silver, Ag	µg/L	1	<1	<1
Strontium, Sr	µg/L	1	53	110
Thallium, Tl	µg/L	1	<1	<1
Thorium, Th	µg/L	1	<1	<1
Tin, Sn	µg/L	1	<1	<1
Titanium, Ti	µg/L	1	<1	<1
Uranium, U	µg/L	1	<1	<1
Vanadium, V	µg/L	1	<1	<1
Zinc, Zn	µg/L	5	210	180

Mercury (dissolved) in Water Method: AN311(Perth)/AN312 Tested: 8/5/2019

Parameter	Units	LOR	PE134647.007	PE134647.008
Mercury	µg/L	0.05	<0.05	<0.05

		Sample Number	PE134647.009	PE134647.010
		Sample Matrix	Water	Water
		Sample Name	ARD_004	ARD_005
Parameter	Units	LOR		

pH in water Method: AN101 Tested: 6/5/2019

Parameter	Units	LOR	PE134647.009	PE134647.010
pH**	pH Units	0.1	8.3	5.0

Conductivity and TDS by Calculation - Water Method: AN106 Tested: 6/5/2019

Parameter	Units	LOR	PE134647.009	PE134647.010
Conductivity @ 25 C	µS/cm	2	1800	2900

Alkalinity Method: AN135 Tested: 6/5/2019

Parameter	Units	LOR	PE134647.009	PE134647.010
Bicarbonate Alkalinity as HCO3	mg/L	1	140	<1
Carbonate Alkalinity as CO3	mg/L	1	<1	<1
Hydroxide Alkalinity as OH	mg/L	1	<1	<1
Total Alkalinity as CaCO3	mg/L	1	110	<1

Acidity and Free CO2 Method: AN140 Tested: 9/5/2019

Parameter	Units	LOR	PE134647.009	PE134647.010
Acidity to pH 8.3	mg CaCO3/L	5	-	7

Chloride by Discrete Analyser in Water Method: AN274 Tested: 9/5/2019

Parameter	Units	LOR	PE134647.009	PE134647.010
Chloride, Cl	mg/L	1	420	820

Sulfate in water Method: AN275 Tested: 9/5/2019

Parameter	Units	LOR	PE134647.009	PE134647.010
Sulfate, SO4	mg/L	1	120	140

Fluoride by Ion Selective Electrode in Water Method: AN141 Tested: 8/5/2019

Parameter	Units	LOR	PE134647.009	PE134647.010
Fluoride by ISE	mg/L	0.1	1.7	<0.1

Metals in Water (Dissolved) by ICPOES Method: AN320 Tested: 8/5/2019

Parameter	Units	LOR	PE134647.009	PE134647.010
Phosphorus, P	μg/L	50	<50	<50
Silicon, Si	μg/L	20	7400	20000
Sulfur, S	μg/L	100	39000	45000

Cations in Water (Dissolved) by ICPOES Method: AN020/AN320 Tested: 8/5/2019

Parameter	Units	LOR	PE134647.009	PE134647.010
Calcium, Ca	μg/L	10	9000	5900
Magnesium, Mg	μg/L	10	7500	27000
Potassium, K	μg/L	50	7000	8100
Sodium, Na	μg/L	50	320000	470000

Parameter	Units	LOR	Sample Number PE134647.009 Sample Matrix Water Sample Name ARD_004	PE134647.010 Water ARD_005

Trace Metals (Dissolved) in Water by ICPMS Method: AN318 Tested: 8/5/2019

Parameter	Units	LOR	ARD_004	ARD_005
Aluminium, Al	µg/L	5	20	180
Antimony, Sb	µg/L	1	<1	<1
Arsenic, As	µg/L	1	<1	<1
Barium, Ba	µg/L	0.2	25	44
Bismuth, Bi	µg/L	1	<1	<1
Boron, B	µg/L	5	1500	640
Cadmium, Cd	µg/L	0.1	<0.1	<0.1
Chromium, Cr	µg/L	1	<1	<1
Cobalt, Co	µg/L	1	<1	37
Copper, Cu	µg/L	1	7	24
Iron, Fe	µg/L	5	13	10
Lead, Pb	µg/L	1	<1	<1
Manganese, Mn	µg/L	1	2	180
Molybdenum, Mo	µg/L	0.5	7.6	<0.5
Nickel, Ni	µg/L	1	<1	16
Selenium, Se	µg/L	1	2	<1
Silver, Ag	µg/L	1	<1	<1
Strontium, Sr	µg/L	1	150	140
Thallium, Tl	µg/L	1	<1	<1
Thorium, Th	µg/L	1	<1	<1
Tin, Sn	µg/L	1	<1	<1
Titanium, Ti	µg/L	1	<1	<1
Uranium, U	µg/L	1	<1	<1
Vanadium, V	µg/L	1	15	<1
Zinc, Zn	µg/L	5	<5	23

Mercury (dissolved) in Water Method: AN311(Perth)/AN312 Tested: 8/5/2019

Parameter	Units	LOR	ARD_004	ARD_005
Mercury	µg/L	0.05	<0.05	0.07

Parameter	Units	LOR	Sample Number Sample Matrix Sample Name: PE134647.011 Water ARD_006	PE134647.012 Water ARD_019

pH in water Method: AN101 Tested: 6/5/2019

pH**	pH Units	0.1	4.2	6.5

Conductivity and TDS by Calculation - Water Method: AN106 Tested: 6/5/2019

Conductivity @ 25 C	µS/cm	2	3600	4300

Alkalinity Method: AN135 Tested: 6/5/2019

Bicarbonate Alkalinity as HCO3	mg/L	1	<1	3
Carbonate Alkalinity as CO3	mg/L	1	<1	<1
Hydroxide Alkalinity as OH	mg/L	1	<1	<1
Total Alkalinity as CaCO3	mg/L	1	<1	3

Acidity and Free CO2 Method: AN140 Tested: 8/5/2019

Acidity to pH 8.3	mg CaCO3/L	5	19	-

Chloride by Discrete Analyser in Water Method: AN274 Tested: 9/5/2019

Chloride, Cl	mg/L	1	1100	1200

Sulfate in water Method: AN275 Tested: 9/5/2019

Sulfate, SO4	mg/L	1	240	290

Fluoride by Ion Selective Electrode in Water Method: AN141 Tested: 8/5/2019

Fluoride by ISE	mg/L	0.1	0.4	0.3

Metals in Water (Dissolved) by ICPOES Method: AN320 Tested: 8/5/2019

Phosphorus, P	µg/L	50	<50	<50
Silicon, Si	µg/L	20	20000	19000
Sulfur, S	µg/L	100	77000	91000

Cations in Water (Dissolved) by ICPOES Method: AN020/AN320 Tested: 8/5/2019

Calcium, Ca	µg/L	10	18000	2200
Magnesium, Mg	µg/L	10	55000	19000
Potassium, K	µg/L	50	11000	19000
Sodium, Na	µg/L	50	570000	740000

Parameter	Units	LOR	Sample Number: PE134647.011 Sample Matrix: Water Sample Name: ARD_006	Sample Number: PE134647.012 Sample Matrix: Water Sample Name: ARD_019

Trace Metals (Dissolved) in Water by ICPMS Method: AN318 Tested: 8/5/2019

Parameter	Units	LOR	PE134647.011	PE134647.012
Aluminium, Al	µg/L	5	1600	<5
Antimony, Sb	µg/L	1	<1	<1
Arsenic, As	µg/L	1	<1	2
Barium, Ba	µg/L	0.2	41	2.2
Bismuth, Bi	µg/L	1	<1	<1
Boron, B	µg/L	5	1100	1100
Cadmium, Cd	µg/L	0.1	<0.1	<0.1
Chromium, Cr	µg/L	1	2	2
Cobalt, Co	µg/L	1	76	94
Copper, Cu	µg/L	1	100	18
Iron, Fe	µg/L	5	33	<5
Lead, Pb	µg/L	1	<1	<1
Manganese, Mn	µg/L	1	230	250
Molybdenum, Mo	µg/L	0.5	<0.5	<0.5
Nickel, Ni	µg/L	1	80	71
Selenium, Se	µg/L	1	<1	<1
Silver, Ag	µg/L	1	<1	<1
Strontium, Sr	µg/L	1	490	63
Thallium, Tl	µg/L	1	<1	<1
Thorium, Th	µg/L	1	<1	<1
Tin, Sn	µg/L	1	<1	<1
Titanium, Ti	µg/L	1	<1	<1
Uranium, U	µg/L	1	<1	<1
Vanadium, V	µg/L	1	<1	<1
Zinc, Zn	µg/L	5	100	30

Mercury (dissolved) in Water Method: AN311(Perth)/AN312 Tested: 8/5/2019

Parameter	Units	LOR	PE134647.011	PE134647.012
Mercury	µg/L	0.05	<0.05	<0.05

		Sample Number	PE134647.013	PE134647.014
		Sample Matrix	Water	Water
		Sample Name	BLANK	HPDW
Parameter	Units	LOR		

pH in water Method: AN101 Tested: 6/5/2019

pH**	pH Units	0.1	5.7	5.6

Conductivity and TDS by Calculation - Water Method: AN106 Tested: 6/5/2019

Conductivity @ 25 C	µS/cm	2	<2	<2

Alkalinity Method: AN135 Tested: 6/5/2019

Bicarbonate Alkalinity as HCO3	mg/L	1	2	2
Carbonate Alkalinity as CO3	mg/L	1	<1	<1
Hydroxide Alkalinity as OH	mg/L	1	<1	<1
Total Alkalinity as CaCO3	mg/L	1	2	2

Acidity and Free CO2 Method: AN140 Tested: 9/5/2019

Acidity to pH 8.3	mg CaCO3/L	5	-	-

Chloride by Discrete Analyser in Water Method: AN274 Tested: 9/5/2019

Chloride, Cl	mg/L	1	<1	<1

Sulfate in water Method: AN275 Tested: 9/5/2019

Sulfate, SO4	mg/L	1	<1	<1

Fluoride by Ion Selective Electrode in Water Method: AN141 Tested: 8/5/2019

Fluoride by ISE	mg/L	0.1	<0.1	<0.1

Metals in Water (Dissolved) by ICPOES Method: AN320 Tested: 8/5/2019

Phosphorus, P	µg/L	50	<50	<50
Silicon, Si	µg/L	20	23	31
Sulfur, S	µg/L	100	<100	<100

Cations in Water (Dissolved) by ICPOES Method: AN020/AN320 Tested: 8/5/2019

Calcium, Ca	µg/L	10	55	150
Magnesium, Mg	µg/L	10	12	<10
Potassium, K	µg/L	50	<50	<50
Sodium, Na	µg/L	50	67	<50

Parameter	Units	LOR	Sample Number PE134647.013 Sample Matrix Water Sample Name BLANK	Sample Number PE134647.014 Sample Matrix Water Sample Name HPDW

Trace Metals (Dissolved) in Water by ICPMS Method: AN318 Tested: 8/5/2019

Parameter	Units	LOR	PE134647.013	PE134647.014
Aluminium, Al	µg/L	5	18	58
Antimony, Sb	µg/L	1	<1	<1
Arsenic, As	µg/L	1	<1	<1
Barium, Ba	µg/L	0.2	<0.2	0.4
Bismuth, Bi	µg/L	1	<1	<1
Boron, B	µg/L	5	110	93
Cadmium, Cd	µg/L	0.1	<0.1	<0.1
Chromium, Cr	µg/L	1	<1	<1
Cobalt, Co	µg/L	1	<1	<1
Copper, Cu	µg/L	1	<1	<1
Iron, Fe	µg/L	5	<5	<5
Lead, Pb	µg/L	1	<1	<1
Manganese, Mn	µg/L	1	<1	<1
Molybdenum, Mo	µg/L	0.5	<0.5	<0.5
Nickel, Ni	µg/L	1	<1	<1
Selenium, Se	µg/L	1	<1	<1
Silver, Ag	µg/L	1	<1	<1
Strontium, Sr	µg/L	1	<1	1
Thallium, Tl	µg/L	1	<1	<1
Thorium, Th	µg/L	1	<1	<1
Tin, Sn	µg/L	1	<1	<1
Titanium, Ti	µg/L	1	<1	<1
Uranium, U	µg/L	1	<1	<1
Vanadium, V	µg/L	1	<1	<1
Zinc, Zn	µg/L	5	8	6

Mercury (dissolved) in Water Method: AN311(Perth)/AN312 Tested: 8/5/2019

Parameter	Units	LOR	PE134647.013	PE134647.014
Mercury	µg/L	0.05	<0.05	<0.05

MB blank results are compared to the Limit of Reporting
LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared the the amount of analyte spiked into the sample.
DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula : *the absolute difference of the two results divided by the average of the two results as a percentage.* Where the DUP RPD is 'NA' , the results are less than the LOR and thus the RPD is not applicable.

Acidity and Free CO2 Method: ME-(AU)-[ENV]AN140

Parameter	QC Reference	Units	LOR	MB	DUP %RPD
Acidity to pH 8.3	LB159250	mg CaCO3/L	5	<5	0%

Alkalinity Method: ME-(AU)-[ENV]AN135

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Bicarbonate Alkalinity as HCO3	LB159161	mg/L	1	2		
	LB159413	mg/L	1	1		
Carbonate Alkalinity as CO3	LB159161	mg/L	1	<1		
	LB159413	mg/L	1	<1		
Hydroxide Alkalinity as OH	LB159161	mg/L	1	<1		
	LB159413	mg/L	1	<1		
Total Alkalinity as CaCO3	LB159161	mg/L	1	2	14%	98%
	LB159413	mg/L	1	1		100%

Cations in Water (Dissolved) by ICPOES Method: ME-(AU)-[ENV]AN020/AN320

Parameter	QC Reference	Units	LOR	MB	DUP %RPD
Calcium, Ca	LB159191	µg/L	10	<10	52 - 194%
Magnesium, Mg	LB159191	µg/L	10	<10	0%
Potassium, K	LB159191	µg/L	50	<0	0 - 144%
Sodium, Na	LB159191	µg/L	50	<0	0%

Chloride by Discrete Analyser in Water Method: ME-(AU)-[ENV]AN274

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Chloride, Cl	LB159241	mg/L	1	<1	0%	109%	105%

Conductivity and TDS by Calculation - Water Method: ME-(AU)-[ENV]AN106

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Conductivity @ 25 C	LB159160	µS/cm	2	<2	0 - 1%	104%
	LB159412	µS/cm	2	<2		106%

MB blank results are compared to the Limit of Reporting
LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared the the amount of analyte spiked into the sample.
DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula : *the absolute difference of the two results divided by the average of the two results as a percentage.* Where the DUP RPD is 'NA' , the results are less than the LOR and thus the RPD is not applicable.

Fluoride by Ion Selective Electrode in Water Method: ME-(AU)-[ENV]AN141

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Fluoride by ISE	LB159200	mg/L	0.1	<0.1	0 - 1%	97%	92%

Mercury (dissolved) in Water Method: ME-(AU)-[ENV]AN311(Perth)/AN312

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Mercury	LB159214	μg/L	0.05	<0.00 - <0.05	38 - 170%	106 - 108%	93 - 119%

Metals in Water (Dissolved) by ICPOES Method: ME-(AU)-[ENV]AN320

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Phosphorus, P	LB159190	μg/L	50	<50	0%	99%	97%
Silicon, Si	LB159190	μg/L	20	<20	1 - 199%	105%	130%
Sulfur, S	LB159190	μg/L	100	<100	0 - 75%	98%	110%

pH in water Method: ME-(AU)-[ENV]AN101

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
pH**	LB159160	pH Units	0.1	5.6	1 - 2%	100%
	LB159412	pH Units	0.1	5.7		101%

Sulfate in water Method: ME-(AU)-[ENV]AN275

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Sulfate, SO4	LB159241	mg/L	1	<1	0 - 1%	107%	97%

Trace Metals (Dissolved) in Water by ICPMS Method: ME-(AU)-[ENV]AN318

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Aluminium, Al	LB159182	μg/L	5	<5	3%	97%	92%
Antimony, Sb	LB159182	μg/L	1	<1	0%	102%	101%
Arsenic, As	LB159182	μg/L	1	<1	0%	118%	114%
Barium, Ba	LB159182	μg/L	0.2	<1.0	0 - 73%	106%	108%
Bismuth, Bi	LB159182	μg/L	1	<1	0%	111%	98%
Boron, B	LB159182	μg/L	5	<5	0 - 12%	100%	101%
Cadmium, Cd	LB159182	μg/L	0.1	<0.1	0%	107%	106%
Chromium, Cr	LB159182	μg/L	1	<1	0%	104%	103%
Cobalt, Co	LB159182	μg/L	1	<1	0 - 5%	102%	100%
Copper, Cu	LB159182	μg/L	1	<1	0 - 5%	112%	107%
Iron, Fe	LB159182	μg/L	5	<5	5 - 59%	100%	92%
Lead, Pb	LB159182	μg/L	1	<1	0%	115%	113%
Manganese, Mn	LB159182	μg/L	1	<1	0 - 4%	100%	98%
Molybdenum, Mo	LB159182	μg/L	0.5	<1.0	0%	110%	106%
Nickel, Ni	LB159182	μg/L	1	<1	0 - 6%	114%	104%
Selenium, Se	LB159182	μg/L	1	<1	0%	113%	125%
Silver, Ag	LB159182	μg/L	1	<1	0%	95%	91%
Strontium, Sr	LB159182	μg/L	1	<1	0 - 3%	101%	93%
Thallium, Tl	LB159182	μg/L	1	<1	0%	97%	96%
Thorium, Th	LB159182	μg/L	1	<1	0%	105%	106%
Tin, Sn	LB159182	μg/L	1	<1	0%	103%	102%
Titanium, Ti	LB159182	μg/L	1	<1	0%	109%	98%
Uranium, U	LB159182	μg/L	1	<1	0%	100%	97%
Vanadium, V	LB159182	μg/L	1	<1	0%	102%	98%
Zinc, Zn	LB159182	μg/L	5	<5	4 - 9%	116%	120%

METHOD	METHODOLOGY SUMMARY
AN020/AN320 LL	Dissolved Cations Low LOR by ICP-OES: Method is as per routine ICP OES method reporting a variation to the method being lower limit of reporting (LOR) for selected cations as validated by the site. Referenced to APHA 3120B.
AN101	pH in Soil Sludge Sediment and Water: pH is measured electrometrically using a combination electrode (glass plus reference electrode) and is calibrated against 3 buffers purchased commercially. For soils, an extract with water is made at a ratio of 1:5 and the pH determined and reported on the extract. Reference APHA 4500-H+.
AN106	Conductivity and TDS by Calculation: Conductivity is measured by meter with temperature compensation and is calibrated against a standard solution of potassium chloride. Conductivity is generally reported as µmhos/cm or µS/cm @ 25°C. For soils, an extract with water is made at a ratio of 1:5 and the EC determined and reported on the extract, or calculated back to the as-received sample. Total Dissolved Salts can be estimated from conductivity using a conversion factor, which for natural waters, is in the range 0.55 to 0.75. SGS use 0.6. Reference APHA 2510 B.
AN106	Salinity may be calculated in terms of NaCl from the sample conductivity. This assumes all soluble salts present, measured by the conductivity, are present as NaCl.
AN135	Alkalinity (and forms of) by Titration: The sample is titrated with standard acid to pH 8.3 (P titre) and pH 4.5 (T titre) and permanent and/or total alkalinity calculated. The results are expressed as equivalents of calcium carbonate or recalculated as bicarbonate, carbonate and hydroxide. Reference APHA 2320. Internal Reference AN135
AN140	Acidity by Titration: The water sample is titrated with sodium hydroxide to designated pH end point. In a sample containing only carbon dioxide, bicarbonates and carbonates, titration to pH 8.3 at 25°C corresponds to stoichiometric neutralisation of carbonic acid to bicarbonate. Method reference APHA 2310 B.
AN141	Determination of Fluoride by ISE: A fluoride ion selective electrode and reference electrode combination, in the presence of a pH/complexation buffer, is used to determine the fluoride concentration. The electrode millivolt response is measured logarithmically against fluoride concentration. Reference APHA F- C.
AN274	Chloride by Aquakem DA: Chloride reacts with mercuric thiocyanate forming a mercuric chloride complex. In the presence of ferric iron, highly coloured ferric thiocyanate is formed which is proportional to the chloride concentration. Reference APHA 4500Cl-
AN275	sulfate by Aquakem DA: sulfate is precipitated in an acidic medium with barium chloride. The resulting turbidity is measured photometrically at 405nm and compared with standard calibration solutions to determine the sulfate concentration in the sample. Reference APHA 4500-SO42-. Internal reference AN275.
AN311(Perth)/AN312	Mercury by Cold Vapour AAS in Waters: Mercury ions are reduced by stannous chloride reagent in acidic solution to elemental mercury. This mercury vapour is purged by nitrogen into a cold cell in an atomic absorption spectrometer or mercury analyser. Quantification is made by comparing absorbances to those of the calibration standards. Reference APHA 3112/3500.
AN318	Determination of elements at trace level in waters by ICP-MS technique, in accordance with USEPA 6020A.
AN320	Metals by ICP-OES: Samples are preserved with 10% nitric acid for a wide range of metals and some non-metals. This solution is measured by Inductively Coupled Plasma. Solutions are aspirated into an argon plasma at 8000-10000K and emit characteristic energy or light as a result of electron transitions through unique energy levels. The emitted light is focused onto a diffraction grating where it is separated into components .
AN320	Photomultipliers or CCDs are used to measure the light intensity at specific wavelengths. This intensity is directly proportional to concentration. Corrections are required to compensate for spectral overlap between elements. Reference APHA 3120 B.

METHOD	METHODOLOGY SUMMARY
Calculation	Free and Total Carbon Dioxide may be calculated using alkalinity forms only when the samples TDS is <500mg/L. If TDS is >500mg/L free or total carbon dioxide cannot be reported. APHA4500CO2 D.

FOOTNOTES

IS	Insufficient sample for analysis.	LOR	Limit of Reporting
LNR	Sample listed, but not received.	↑↓	Raised or Lowered Limit of Reporting
*	NATA accreditation does not cover the performance of this service.	QFH	QC result is above the upper tolerance
**	Indicative data, theoretical holding time exceeded.	QFL	QC result is below the lower tolerance
		-	The sample was not analysed for this analyte
		NVL	Not Validated

Unless it is reported that sampling has been perfomed by SGS, the samples have been analysed as received.
Solid samples expressed on a dry weight basis.

Where "Total" analyte groups are reported (for example, Total PAHs, Total OC Pesticides) the total will be calculated as the sum of the individual analytes, with those analytes that are reported as <LOR being assumed to be zero. The summed (Total) limit of reporting is calcuated by summing the individual analyte LORs and dividing by two. For example, where 16 individual analytes are being summed and each has an LOR of 0.1 mg/kg, the "Totals" LOR will be 1.6 / 2 (0.8 mg/kg). Where only 2 analytes are being summed, the " Total" LOR will be the sum of those two LORs.

Some totals may not appear to add up because the total is rounded after adding up the raw values.

If reported, measurement uncertainty follow the ± sign after the analytical result and is expressed as the expanded uncertainty calculated using a coverage factor of 2, providing a level of confidence of approximately 95%, unless stated otherwise in the comments section of this report.

Results reported for samples tested under test methods with codes starting with ARS-SOP, radionuclide or gross radioactivity concentrations are expressed in becquerel (Bq) per unit of mass or volume or per wipe as stated on the report. Becquerel is the SI unit for activity and equals one nuclear transformation per second.
Note that in terms of units of radioactivity:

a. 1 Bq is equivalent to 27 pCi
b. 37 MBq is equivalent to 1 mCi

For results reported for samples tested under test methods with codes starting with ARS-SOP, less than (<) values indicate the detection limit for each radionuclide or parameter for the measurement system used. The respective detection limits have been calculated in accordance with ISO 11929.

The QC and MU criteria are subject to internal review according to the SGS QAQC plan and may be provided on request or alternatively can be found here: www.sgs.com.au.pv.sgsvr/en-gb/environment.

ANALYTICAL REPORT

Accreditation No. 2562

CLIENT DETAILS

Contact	Graeme Campbell
Client	Graeme Campbell & Associates Pty Ltd
Address	PO Box 247 Bridgetown WA 6255
Telephone	0897 612 829
Facsimile	0897 612 830
Email	gca@wn.com.au
Project	**GCA-Job-No. 1901/1**
Order Number	**GCA-Job-No. 1901/1**
Samples	11

LABORATORY DETAILS

Manager	Marjana Siljanoska
Laboratory	SGS Perth Environmental
Address	28 Reid Rd Perth Airport WA 6105
Telephone	(08) 9373 3500
Facsimile	(08) 9373 3556
Email	au.environmental.perth@sgs.com
SGS Reference	**PE134647A R0**
Date Received	18 May 2019
Date Reported	24 May 2019

COMMENTS

Accredited for compliance with ISO/IEC 17025 - Testing. NATA accredited laboratory 2562(898/20210).

Unable to analyse for Reactive Silica and Cr6+ for sample ARD_022 as no sample left from previous analysis.

SIGNATORIES

Mary Ann Ola-A
Inorganics Team Leader

			Sample Number Sample Matrix Sample Name	PE134647A.004 Water ARD_011
Parameter	Units	LOR		

Reactive Silica by Aquakem Discrete Analyser Method: AN270 Tested: 23/5/2019

Reactive Silica, Si	mg/L	0.05	16

Hexavalent Chromium in water by Discrete Analyser Method: AN283 Tested: 24/5/2019

Hexavalent Chromium, Cr6+	mg/L	0.001	0.004

Parameter	Units	LOR	Sample Number Sample Matrix Sample Name	PE134647A.005 Water ARD_013	PE134647A.006 Water ARD_016

Reactive Silica by Aquakem Discrete Analyser Method: AN270 Tested: 23/5/2019

Parameter	Units	LOR	PE134647A.005	PE134647A.006
Reactive Silica, Si	mg/L	0.05	11	12

Hexavalent Chromium in water by Discrete Analyser Method: AN283 Tested: 24/5/2019

Parameter	Units	LOR	PE134647A.005	PE134647A.006
Hexavalent Chromium, Cr6+	mg/L	0.001	0.002	-

Parameter	Units	LOR	PE134647A.007 Water ARD_001	PE134647A.008 Water ARD_002

Reactive Silica by Aquakem Discrete Analyser Method: AN270 Tested: 23/5/2019

Reactive Silica, Si	mg/L	0.05	13	20

Hexavalent Chromium in water by Discrete Analyser Method: AN283 Tested: 24/5/2019

Hexavalent Chromium, Cr6+	mg/L	0.001	-	<0.001

Parameter	Units	LOR	PE134647A.009 Water ARD_004	PE134647A.010 Water ARD_005
		Sample Number Sample Matrix Sample Name		

Reactive Silica by Aquakem Discrete Analyser Method: AN270 Tested: 23/5/2019

Reactive Silica, Si	mg/L	0.05	7.7	20

Hexavalent Chromium in water by Discrete Analyser Method: AN283 Tested: 24/5/2019

Hexavalent Chromium, Cr6+	mg/L	0.001	-	-

Parameter	Units	LOR	Sample Number Sample Matrix Sample Name	PE134647A.011 Water ARD_006	PE134647A.012 Water ARD_019

Reactive Silica by Aquakem Discrete Analyser Method: AN270 Tested: 23/5/2019

Reactive Silica, Si	mg/L	0.05	19	19

Hexavalent Chromium in water by Discrete Analyser Method: AN283 Tested: 24/5/2019

Hexavalent Chromium, Cr6+	mg/L	0.001	<0.001	0.001

Parameter	Units	LOR	Sample Number Sample Matrix Sample Name	PE134647A.013 Water BLANK	PE134647A.014 Water HPDW

Reactive Silica by Aquakem Discrete Analyser Method: AN270 Tested: 24/5/2019

Parameter	Units	LOR	PE134647A.013	PE134647A.014
Reactive Silica, Si	mg/L	0.05	-	-

Hexavalent Chromium in water by Discrete Analyser Method: AN283 Tested: 24/5/2019

Parameter	Units	LOR	PE134647A.013	PE134647A.014
Hexavalent Chromium, Cr6+	mg/L	0.001	<0.001	<0.001

MB blank results are compared to the Limit of Reporting
LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared the the amount of analyte spiked into the sample.
DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula : *the absolute difference of the two results divided by the average of the two results as a percentage*. Where the DUP RPD is 'NA' , the results are less than the LOR and thus the RPD is not applicable.

Hexavalent Chromium in water by Discrete Analyser **Method: ME-(AU)-[ENV]AN283**

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Hexavalent Chromium, Cr6+	LB159840	mg/L	0.001	<0.001	0 - 11%	NA	NA

Reactive Silica by Aquakem Discrete Analyser **Method: ME-(AU)-[ENV]AN270**

Parameter	QC Reference	Units	LOR	DUP %RPD	LCS %Recovery	MS %Recovery
Reactive Silica, Si	LB159807	mg/L	0.05	0 - 1%	100 - 101%	94%

METHOD SUMMARY

METHOD	METHODOLOGY SUMMARY
AN270	Reactive forms of silicon in acid solution below pH 2 react with ammonium molybdate ions to form a yellow silicomolybdate which is then reduced with ascorbic acid to produce a blue silicomolybdate complex. Oxalic acid is added to destroy any molybdophosphoric acid. Colourimetric determination by Aquakem Discrete Analyser.
AN283	Hexavalent Chromium via Discrete Analyser: Soluble hexavalent chromium forms a red/violet colour with diphenylcarbazide in acidic solution. This procedure is very sensitive and nearly specific for Cr6+. If total chromium is also measured the trivalent form of chromium Cr3+ can be calculated from the difference (Total Cr - Cr6+). Reference APHA3500CrB.

FOOTNOTES

IS	Insufficient sample for analysis.	LOR	Limit of Reporting
LNR	Sample listed, but not received.	↑↓	Raised or Lowered Limit of Reporting
*	NATA accreditation does not cover the performance of this service.	QFH	QC result is above the upper tolerance
		QFL	QC result is below the lower tolerance
**	Indicative data, theoretical holding time exceeded.	-	The sample was not analysed for this analyte
		NVL	Not Validated

Unless it is reported that sampling has been perfomed by SGS, the samples have been analysed as received.
Solid samples expressed on a dry weight basis.

Where "Total" analyte groups are reported (for example, Total PAHs, Total OC Pesticides) the total will be calculated as the sum of the individual analytes, with those analytes that are reported as <LOR being assumed to be zero. The summed (Total) limit of reporting is calcuated by summing the individual analyte LORs and dividing by two. For example, where 16 individual analytes are being summed and each has an LOR of 0.1 mg/kg, the "Totals" LOR will be 1.6 / 2 (0.8 mg/kg). Where only 2 analytes are being summed, the " Total" LOR will be the sum of those two LORs.

Some totals may not appear to add up because the total is rounded after adding up the raw values.

If reported, measurement uncertainty follow the ± sign after the analytical result and is expressed as the expanded uncertainty calculated using a coverage factor of 2, providing a level of confidence of approximately 95%, unless stated otherwise in the comments section of this report.

Results reported for samples tested under test methods with codes starting with ARS-SOP, radionuclide or gross radioactivity concentrations are expressed in becquerel (Bq) per unit of mass or volume or per wipe as stated on the report. Becquerel is the SI unit for activity and equals one nuclear transformation per second.
Note that in terms of units of radioactivity:
a. 1 Bq is equivalent to 27 pCi
b. 37 MBq is equivalent to 1 mCi

For results reported for samples tested under test methods with codes starting with ARS-SOP, less than (<) values indicate the detection limit for each radionuclide or parameter for the measurement system used. The respective detection limits have been calculated in accordance with ISO 11929.

The QC and MU criteria are subject to internal review according to the SGS QAQC plan and may be provided on request or alternatively can be found here: www.sgs.com.au.pv.sgsvr/en-gb/environment.

ANALYTICAL REPORT

Accreditation No. 2562

CLIENT DETAILS		LABORATORY DETAILS	
Contact	Graeme Campbell	Manager	Marjana Siljanoska
Client	Graeme Campbell & Associates Pty Ltd	Laboratory	SGS Perth Environmental
Address	PO Box 247 Bridgetown WA 6255	Address	28 Reid Rd Perth Airport WA 6105
Telephone	0897 612 829	Telephone	(08) 9373 3500
Facsimile	0897 612 830	Facsimile	(08) 9373 3556
Email	gca@wn.com.au	Email	au.environmental.perth@sgs.com
Project	**GCA Job No.1901/1**	SGS Reference	**PE135111 R1**
Order Number	**GCA Job No. 1901/1**	Date Received	22 May 2019
Samples	2	Date Reported	07 Jun 2019

COMMENTS

Accredited for compliance with ISO/IEC 17025 - Testing. NATA accredited laboratory 2562(898/20210).

Metals: The over range results on ICPMS Method AN318 were reported using ICPOES method AN320.

This report cancels and supersedes the report No.PE135111 R0 dated 4/6/2019 issued by SGS Environment, Health and Safety due to the addition of Hexavalent Chromium result.

SIGNATORIES

Hue Thanh Ly
Metals Team Leader

Louise Hope

Louise Hope
Laboratory Technician

Mary Ann Ola-A
Inorganics Team Leader

Ohmar David
Metals Chemist

		Sample Number	PE135111.001	PE135111.002
		Sample Matrix	Water	Water
		Sample Date	21 May 2019	21 May 2019
		Sample Name	ARD_025	ARD_026
Parameter	Units	LOR		

pH in water Method: AN101 Tested: 22/5/2019

pH**	pH Units	-	7.6	7.6

Conductivity and TDS by Calculation - Water Method: AN106 Tested: 22/5/2019

Conductivity @ 25 C	µS/cm	2	280	580

Alkalinity Method: AN135 Tested: 22/5/2019

Total Alkalinity as CaCO3	mg/L	1	31	33
Carbonate Alkalinity as CO3	mg/L	1	<1	<1
Bicarbonate Alkalinity as HCO3	mg/L	1	38	40

Fluoride by Ion Selective Electrode in Water Method: AN141 Tested: 24/5/2019

Fluoride by ISE	mg/L	0.1	0.8	1.5

Chloride by Discrete Analyser in Water Method: AN274 Tested: 4/6/2019

Chloride, Cl	mg/L	1	56	140

Sulfate in water Method: AN275 Tested: 4/6/2019

Sulfate, SO4	mg/L	1	20	38

Reactive Silica by Aquakem Discrete Analyser Method: AN270 Tested: 23/5/2019

Reactive Silica, Si	mg/L	0.05	8.8	9.7
Reactive Silica, SiO_2	mg/L	0.1	19	21

Metals in Water (Dissolved) by ICPOES Method: AN320 Tested: 23/5/2019

Phosphorus, P	µg/L	50	150	<50
Silicon, Si	µg/L	20	11000	13000
Sulfur, S	µg/L	100	5600	11000

Cations in Water (Dissolved) by ICPOES Method: AN020/AN320 Tested: 28/5/2019

Calcium, Ca	µg/L	10	230	220
Magnesium, Mg	µg/L	10	590	480
Potassium, K	µg/L	50	340	680
Sodium, Na	µg/L	50	51000	110000

Trace Metals (Dissolved) in Water by ICPMS Method: AN318 Tested: 23/5/2019

Aluminium, Al	µg/L	5	690	900
Antimony, Sb	µg/L	1	<1	<1
Arsenic, As	µg/L	1	7	16

Parameter	Units	LOR	Sample Number PE135111.001 Sample Matrix Water Sample Date 21 May 2019 Sample Name ARD_025	PE135111.002 Water 21 May 2019 ARD_026

Trace Metals (Dissolved) in Water by ICPMS Method: AN318 Tested: 23/5/2019 (continued)

Parameter	Units	LOR	ARD_025	ARD_026
Barium, Ba	μg/L	0.2	0.5	0.6
Bismuth, Bi	μg/L	1	<1	<1
Boron, B	μg/L	5	120	170
Cadmium, Cd	μg/L	0.1	<0.1	<0.1
Chromium, Cr	μg/L	1	1	13
Cobalt, Co	μg/L	1	<1	1
Copper, Cu	μg/L	1	8	18
Iron, Fe	μg/L	5	690	1700
Lead, Pb	μg/L	1	<1	<1
Manganese, Mn	μg/L	1	1	6
Molybdenum, Mo	μg/L	0.5	1.9	20
Nickel, Ni	μg/L	1	5	10
Selenium, Se	μg/L	1	<1	<1
Silver, Ag	μg/L	1	<1	<1
Strontium, Sr	μg/L	1	1	1
Thallium, Tl	μg/L	1	<1	<1
Thorium, Th	μg/L	1	<1	<1
Tin, Sn	μg/L	1	<1	<1
Titanium, Ti	μg/L	1	11	21
Uranium, U	μg/L	1	<1	<1
Vanadium, V	μg/L	1	110	72
Zinc, Zn	μg/L	5	<5	<5

Mercury (dissolved) in Water Method: AN311(Perth)/AN312 Tested: 23/5/2019

Parameter	Units	LOR	ARD_025	ARD_026
Mercury	μg/L	0.05	<0.05	<0.05

Hexavalent Chromium in water by Discrete Analyser Method: AN283 Tested: 6/6/2019

Parameter	Units	LOR	ARD_025	ARD_026
Hexavalent Chromium, Cr6+	mg/L	0.001	<0.001	<0.001

MB blank results are compared to the Limit of Reporting
LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared the the amount of analyte spiked into the sample.
DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula : *the absolute difference of the two results divided by the average of the two results as a percentage.* Where the DUP RPD is 'NA' , the results are less than the LOR and thus the RPD is not applicable.

Alkalinity Method: ME-(AU)-[ENV]AN135

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Total Alkalinity as CaCO3	LB159822	mg/L	1	1	1 - 5%	110 - 111%
Carbonate Alkalinity as CO3	LB159822	mg/L	1	<1		
Bicarbonate Alkalinity as HCO3	LB159822	mg/L	1	1		

Cations in Water (Dissolved) by ICPOES Method: ME-(AU)-[ENV]AN020/AN320

Parameter	QC Reference	Units	LOR	MB	DUP %RPD
Calcium, Ca	LB159947	µg/L	10	<10	0 - 1%
Magnesium, Mg	LB159947	µg/L	10	<10	0%
Potassium, K	LB159947	µg/L	50	<50	0%
Sodium, Na	LB159947	µg/L	50	<50	0%

Chloride by Discrete Analyser in Water Method: ME-(AU)-[ENV]AN274

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Chloride, Cl	LB159961	mg/L	1	<1	0 - 6%	108 - 109%	87 - 103%

Conductivity and TDS by Calculation - Water Method: ME-(AU)-[ENV]AN106

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Conductivity @ 25 C	LB159940	µS/cm	2	<2	0%	102%

Fluoride by Ion Selective Electrode in Water Method: ME-(AU)-[ENV]AN141

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Fluoride by ISE	LB159831	mg/L	0.1	<0.1	0%	101%	110%

MB blank results are compared to the Limit of Reporting
LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared the the amount of analyte spiked into the sample.
DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula : *the absolute difference of the two results divided by the average of the two results as a percentage.* Where the DUP RPD is 'NA' , the results are less than the LOR and thus the RPD is not applicable.

Hexavalent Chromium in water by Discrete Analyser   Method: ME-(AU)-[ENV]AN283

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Hexavalent Chromium, Cr6+	LB160265	mg/L	0.001	<0.001	0 - 9%	NA	NA

Mercury (dissolved) in Water   Method: ME-(AU)-[ENV]AN311(Perth)/AN312

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Mercury	LB159787	µg/L	0.05	<0.05	6 - 181%	102 - 110%	103 - 109%

Metals in Water (Dissolved) by ICPOES   Method: ME-(AU)-[ENV]AN320

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Phosphorus, P	LB159766	µg/L	50	<50	0%	103%
Silicon, Si	LB159766	µg/L	20	<20	43%	107%
Sulfur, S	LB159766	µg/L	100	<100	160%	103%

pH in water   Method: ME-(AU)-[ENV]AN101

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
pH**	LB159940	pH Units	-	5.7	0 - 1%	101%

Reactive Silica by Aquakem Discrete Analyser   Method: ME-(AU)-[ENV]AN270

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Reactive Silica, Si	LB159807	mg/L	0.05		0 - 1%	100 - 101%	94%
Reactive Silica, SiO_2	LB159807	mg/L	0.1	<0.10	0 - 1%	100 - 101%	94%

Sulfate in water   Method: ME-(AU)-[ENV]AN275

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Sulfate, SO4	LB159961	mg/L	1	<1	1 - 4%	108 - 110%	100 - 102%

QC SUMMARY

MB blank results are compared to the Limit of Reporting
LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared the the amount of analyte spiked into the sample.
DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula : *the absolute difference of the two results divided by the average of the two results as a percentage.* Where the DUP RPD is 'NA' , the results are less than the LOR and thus the RPD is not applicable.

Trace Metals (Dissolved) in Water by ICPMS Method: ME-(AU)-[ENV]AN318

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Aluminium, Al	LB159771	µg/L	5	<5	0%	89%	105%
Antimony, Sb	LB159771	µg/L	1	<1		86%	
Arsenic, As	LB159771	µg/L	1	<1	0%	100%	97%
Barium, Ba	LB159771	µg/L	0.2	<1.0		87%	
Bismuth, Bi	LB159771	µg/L	1	<1		104%	
Boron, B	LB159771	µg/L	5	<5	5%	111%	
Cadmium, Cd	LB159771	µg/L	0.1	<0.1	0%	107%	110%
Chromium, Cr	LB159771	µg/L	1	<1	7%	91%	
Cobalt, Co	LB159771	µg/L	1	<1		92%	
Copper, Cu	LB159771	µg/L	1	<1	0%	97%	96%
Iron, Fe	LB159771	µg/L	5	<5	0%	84%	95%
Lead, Pb	LB159771	µg/L	1	<1	0%	101%	108%
Manganese, Mn	LB159771	µg/L	1	<1		90%	95%
Molybdenum, Mo	LB159771	µg/L	0.5	<1.0		99%	
Nickel, Ni	LB159771	µg/L	1	<1	0%	95%	
Selenium, Se	LB159771	µg/L	1	<1		106%	
Silver, Ag	LB159771	µg/L	1	<1		97%	
Strontium, Sr	LB159771	µg/L	1	<1	3%	86%	
Thallium, Tl	LB159771	µg/L	1	<1		100%	
Thorium, Th	LB159771	µg/L	1	<1		99%	
Tin, Sn	LB159771	µg/L	1	<1		99%	
Titanium, Ti	LB159771	µg/L	1	<1		82%	
Uranium, U	LB159771	µg/L	1	<1	4%	83%	
Vanadium, V	LB159771	µg/L	1	<1		89%	
Zinc, Zn	LB159771	µg/L	5	<5	0%	85%	

METHOD	METHODOLOGY SUMMARY
AN020/AN320 LL	Dissolved Cations Low LOR by ICP-OES: Method is as per routine ICP OES method reporting a variation to the method being lower limit of reporting (LOR) for selected cations as validated by the site. Referenced to APHA 3120B.
AN101	pH in Soil Sludge Sediment and Water: pH is measured electrometrically using a combination electrode (glass plus reference electrode) and is calibrated against 3 buffers purchased commercially. For soils, an extract with water is made at a ratio of 1:5 and the pH determined and reported on the extract. Reference APHA 4500-H+.
AN106	Conductivity and TDS by Calculation: Conductivity is measured by meter with temperature compensation and is calibrated against a standard solution of potassium chloride. Conductivity is generally reported as µmhos/cm or µS/cm @ 25°C. For soils, an extract with water is made at a ratio of 1:5 and the EC determined and reported on the extract, or calculated back to the as-received sample. Total Dissolved Salts can be estimated from conductivity using a conversion factor, which for natural waters, is in the range 0.55 to 0.75. SGS use 0.6. Reference APHA 2510 B.
AN106	Salinity may be calculated in terms of NaCl from the sample conductivity. This assumes all soluble salts present, measured by the conductivity, are present as NaCl.
AN135	Alkalinity (and forms of) by Titration: The sample is titrated with standard acid to pH 8.3 (P titre) and pH 4.5 (T titre) and permanent and/or total alkalinity calculated. The results are expressed as equivalents of calcium carbonate or recalculated as bicarbonate, carbonate and hydroxide. Reference APHA 2320. Internal Reference AN135
AN141	Determination of Fluoride by ISE: A fluoride ion selective electrode and reference electrode combination, in the presence of a pH/complexation buffer, is used to determine the fluoride concentration. The electrode millivolt response is measured logarithmically against fluoride concentration. Reference APHA F- C.
AN270	Reactive forms of silicon in acid solution below pH 2 react with ammonium molybdate ions to form a yellow silicomolybdate which is then reduced with ascorbic acid to produce a blue silicomolybdate complex. Oxalic acid is added to destroy any molybdophosphoric acid. Colourimetric determination by Aquakem Discrete Analyser.
AN274	Chloride by Aquakem DA: Chloride reacts with mercuric thiocyanate forming a mercuric chloride complex. In the presence of ferric iron, highly coloured ferric thiocyanate is formed which is proportional to the chloride concentration. Reference APHA 4500Cl-
AN275	sulfate by Aquakem DA: sulfate is precipitated in an acidic medium with barium chloride. The resulting turbidity is measured photometrically at 405nm and compared with standard calibration solutions to determine the sulfate concentration in the sample. Reference APHA 4500-SO42-. Internal reference AN275.
AN283	Hexavalent Chromium via Discrete Analyser: Soluble hexavalent chromium forms a red/violet colour with diphenylcarbazide in acidic solution. This procedure is very sensitive and nearly specific for Cr6+. If total chromium is also measured the trivalent form of chromium Cr3+ can be calculated from the difference (Total Cr - Cr6+). Reference APHA3500CrB.
AN311(Perth)/AN312	Mercury by Cold Vapour AAS in Waters: Mercury ions are reduced by stannous chloride reagent in acidic solution to elemental mercury. This mercury vapour is purged by nitrogen into a cold cell in an atomic absorption spectrometer or mercury analyser. Quantification is made by comparing absorbances to those of the calibration standards. Reference APHA 3112/3500.
AN318	Determination of elements at trace level in waters by ICP-MS technique, in accordance with USEPA 6020A.
AN320	Metals by ICP-OES: Samples are preserved with 10% nitric acid for a wide range of metals and some non-metals. This solution is measured by Inductively Coupled Plasma. Solutions are aspirated into an argon plasma at 8000-10000K and emit characteristic energy or light as a result of electron transitions through unique energy levels. The emitted light is focused onto a diffraction grating where it is separated into components .

METHOD	METHODOLOGY SUMMARY
AN320	Photomultipliers or CCDs are used to measure the light intensity at specific wavelengths. This intensity is directly proportional to concentration. Corrections are required to compensate for spectral overlap between elements. Reference APHA 3120 B.
Calculation	Free and Total Carbon Dioxide may be calculated using alkalinity forms only when the samples TDS is <500mg/L. If TDS is >500mg/L free or total carbon dioxide cannot be reported. APHA4500CO2 D.

FOOTNOTES

IS	Insufficient sample for analysis.	LOR	Limit of Reporting
LNR	Sample listed, but not received.	↑↓	Raised or Lowered Limit of Reporting
*	NATA accreditation does not cover the performance of this service.	QFH	QC result is above the upper tolerance
**	Indicative data, theoretical holding time exceeded.	QFL	QC result is below the lower tolerance
		-	The sample was not analysed for this analyte
		NVL	Not Validated

Unless it is reported that sampling has been perfomed by SGS, the samples have been analysed as received.
Solid samples expressed on a dry weight basis.

Where "Total" analyte groups are reported (for example, Total PAHs, Total OC Pesticides) the total will be calculated as the sum of the individual analytes, with those analytes that are reported as <LOR being assumed to be zero. The summed (Total) limit of reporting is calcuated by summing the individual analyte LORs and dividing by two. For example, where 16 individual analytes are being summed and each has an LOR of 0.1 mg/kg, the "Totals" LOR will be 1.6 / 2 (0.8 mg/kg). Where only 2 analytes are being summed, the " Total" LOR will be the sum of those two LORs.

Some totals may not appear to add up because the total is rounded after adding up the raw values.

If reported, measurement uncertainty follow the ± sign after the analytical result and is expressed as the expanded uncertainty calculated using a coverage factor of 2, providing a level of confidence of approximately 95%, unless stated otherwise in the comments section of this report.

Results reported for samples tested under test methods with codes starting with ARS-SOP, radionuclide or gross radioactivity concentrations are expressed in becquerel (Bq) per unit of mass or volume or per wipe as stated on the report. Becquerel is the SI unit for activity and equals one nuclear transformation per second.
Note that in terms of units of radioactivity:

a. 1 Bq is equivalent to 27 pCi
b. 37 MBq is equivalent to 1 mCi

For results reported for samples tested under test methods with codes starting with ARS-SOP, less than (<) values indicate the detection limit for each radionuclide or parameter for the measurement system used. The respective detection limits have been calculated in accordance with ISO 11929.

The QC and MU criteria are subject to internal review according to the SGS QAQC plan and may be provided on request or alternatively can be found here: www.sgs.com.au.pv.sgsvr/en-gb/environment.

ANALYTICAL REPORT

Accreditation No. 2562

CLIENT DETAILS		LABORATORY DETAILS	
Contact	Graeme Campbell	Manager	Marjana Siljanoska
Client	Graeme Campbell & Associates Pty Ltd	Laboratory	SGS Perth Environmental
Address	PO Box 247 Bridgetown WA 6255	Address	28 Reid Rd Perth Airport WA 6105
Telephone	0897 612 829	Telephone	(08) 9373 3500
Facsimile	0897 612 830	Facsimile	(08) 9373 3556
Email	gca@wn.com.au	Email	au.environmental.perth@sgs.com
Project	**GCA Job No. 1901/1**	SGS Reference	**PE136601 R1**
Order Number	**GCA Job No. 1901/1**	Date Received	24 Jul 2019
Samples	15	Date Reported	01 Aug 2019

COMMENTS

Accredited for compliance with ISO/IEC 17025 - Testing. NATA accredited laboratory 2562(898/20210).

Metals: The over range results on ICPMS Method AN318 were reported using ICPOES method AN320.
Metals: Dissolved B & Zn : Spike recovery failed acceptance criteria due to the presence of significant concentration of analyte (i.e. the concentration of analyte exceeds the spike level).

SIGNATORIES

Hue Thanh Ly Metals Team Leader	LouiseHope Louise Hope Laboratory Technician	Mary Ann Ola-A Inorganics Team Leader
Ohmar David Metals Chemist	Sanaa Hussain Chemist	

		Sample Number	PE136601.001	PE136601.002
		Sample Matrix	Water	Water
		Sample Name	ARD_001_2	ARD_001_3
Parameter	Units	LOR		
pH in water Method: AN101 Tested: 24/7/2019				
pH**	pH Units	0.1	5.7	5.6
Conductivity and TDS by Calculation - Water Method: AN106 Tested: 24/7/2019				
Conductivity @ 25 C	µS/cm	2	1200	510
Alkalinity Method: AN135 Tested: 24/7/2019				
Total Alkalinity as CaCO3	mg/L	1	1	<1
Chloride by Discrete Analyser in Water Method: AN274 Tested: 30/7/2019				
Chloride, Cl	mg/L	1	200	66
Sulfate in water Method: AN275 Tested: 30/7/2019				
Sulfate, SO4	mg/L	1	240	130
Fluoride by Ion Selective Electrode in Water Method: AN141 Tested: 25/7/2019				
Fluoride by ISE	mg/L	0.1	<0.1	<0.1
Acidity and Free CO2 Method: AN140 Tested: 25/7/2019				
Acidity to pH 8.3	mg CaCO3/L	1	-	-
Metals in Water (Dissolved) by ICPOES Method: AN320 Tested: 25/7/2019				
Phosphorus, P	µg/L	50	-	-
Silicon, Si	µg/L	20	11000	9000
Sulfur, S	µg/L	100	-	-
Cations in Water (Dissolved) by ICPOES Method: AN020/AN320 Tested: 26/7/2019				
Calcium, Ca	µg/L	10	-	-
Magnesium, Mg	µg/L	10	-	-
Potassium, K	µg/L	50	-	-
Sodium, Na	µg/L	50	-	-

Parameter	Units	LOR	Sample Number PE136601.001 Sample Matrix Water Sample Name ARD_001_2	PE136601.002 Water ARD_001_3

Trace Metals (Dissolved) in Water by ICPMS Method: AN318 Tested: 25/7/2019

Parameter	Units	LOR	PE136601.001	PE136601.002
Aluminium, Al	µg/L	5	19	13
Antimony, Sb	µg/L	1	-	-
Arsenic, As	µg/L	1	-	-
Barium, Ba	µg/L	0.2	-	-
Bismuth, Bi	µg/L	1	-	-
Boron, B	µg/L	5	860	560
Cadmium, Cd	µg/L	0.1	-	-
Chromium, Cr	µg/L	1	<1	<1
Cobalt, Co	µg/L	1	2	<1
Copper, Cu	µg/L	1	6	3
Iron, Fe	µg/L	5	<5	<5
Lead, Pb	µg/L	1	-	-
Manganese, Mn	µg/L	1	8	3
Molybdenum, Mo	µg/L	0.5	-	-
Nickel, Ni	µg/L	1	13	3
Selenium, Se	µg/L	1	-	-
Silver, Ag	µg/L	1	-	-
Strontium, Sr	µg/L	1	-	-
Thallium, Tl	µg/L	1	-	-
Thorium, Th	µg/L	1	-	-
Tin, Sn	µg/L	1	-	-
Titanium, Ti	µg/L	1	-	-
Uranium, U	µg/L	1	-	-
Vanadium, V	µg/L	1	-	-
Zinc, Zn	µg/L	5	430	140

Mercury (dissolved) in Water Method: AN311(Perth)/AN312 Tested: 26/7/2019

Parameter	Units	LOR	PE136601.001	PE136601.002
Mercury	µg/L	0.05	-	-

Parameter	Units	LOR	Sample Number PE136601.003 Sample Matrix Water Sample Name ARD_001_4	PE136601.004 Water ARD_002_2

pH in water Method: AN101 Tested: 24/7/2019

pH**	pH Units	0.1	5.4	4.7

Conductivity and TDS by Calculation - Water Method: AN106 Tested: 24/7/2019

Conductivity @ 25 C	µS/cm	2	350	850

Alkalinity Method: AN135 Tested: 24/7/2019

Total Alkalinity as CaCO3	mg/L	1	-	-

Chloride by Discrete Analyser in Water Method: AN274 Tested: 30/7/2019

Chloride, Cl	mg/L	1	56	110

Sulfate in water Method: AN275 Tested: 30/7/2019

Sulfate, SO4	mg/L	1	59	210

Fluoride by Ion Selective Electrode in Water Method: AN141 Tested: 25/7/2019

Fluoride by ISE	mg/L	0.1	<0.1	<0.1

Acidity and Free CO2 Method: AN140 Tested: 25/7/2019

Acidity to pH 8.3	mg CaCO3/L	1	3	8

Metals in Water (Dissolved) by ICPOES Method: AN320 Tested: 25/7/2019

Phosphorus, P	µg/L	50	<50	-
Silicon, Si	µg/L	20	8300	17000
Sulfur, S	µg/L	100	22000	-

Cations in Water (Dissolved) by ICPOES Method: AN020/AN320 Tested: 25/7/2019

Calcium, Ca	µg/L	10	110	-
Magnesium, Mg	µg/L	10	530	-
Potassium, K	µg/L	50	2700	-
Sodium, Na	µg/L	50	60000	-

Parameter	Units	LOR	Sample Number PE136601.003 Sample Matrix Water Sample Name ARD_001_4	PE136601.004 Water ARD_002_2

Trace Metals (Dissolved) in Water by ICPMS Method: AN318 Tested: 25/7/2019

Parameter	Units	LOR	PE136601.003	PE136601.004
Aluminium, Al	µg/L	5	11	100
Antimony, Sb	µg/L	1	<1	-
Arsenic, As	µg/L	1	<1	-
Barium, Ba	µg/L	0.2	2.9	-
Bismuth, Bi	µg/L	1	<1	-
Boron, B	µg/L	5	440	810
Cadmium, Cd	µg/L	0.1	<0.1	-
Chromium, Cr	µg/L	1	<1	29
Cobalt, Co	µg/L	1	<1	5
Copper, Cu	µg/L	1	2	36
Iron, Fe	µg/L	5	<5	51
Lead, Pb	µg/L	1	<1	-
Manganese, Mn	µg/L	1	2	23
Molybdenum, Mo	µg/L	0.5	<0.5	-
Nickel, Ni	µg/L	1	2	14
Selenium, Se	µg/L	1	<1	-
Silver, Ag	µg/L	1	<1	-
Strontium, Sr	µg/L	1	1	-
Thallium, Tl	µg/L	1	<1	-
Thorium, Th	µg/L	1	<1	-
Tin, Sn	µg/L	1	<1	-
Titanium, Ti	µg/L	1	<1	-
Uranium, U	µg/L	1	<1	-
Vanadium, V	µg/L	1	<1	-
Zinc, Zn	µg/L	5	120	93

Mercury (dissolved) in Water Method: AN311(Perth)/AN312 Tested: 25/7/2019

Parameter	Units	LOR	PE136601.003	PE136601.004
Mercury	µg/L	0.05	<0.05	-

		Sample Number	PE136601.005	PE136601.006
		Sample Matrix	Water	Water
		Sample Name	ARD_002_3	ARD_002_4
Parameter	Units	LOR		

pH in water Method: AN101 Tested: 24/7/2019

pH**	pH Units	0.1	4.8	4.9

Conductivity and TDS by Calculation - Water Method: AN106 Tested: 24/7/2019

Conductivity @ 25 C	µS/cm	2	380	220

Alkalinity Method: AN135 Tested: 24/7/2019

Total Alkalinity as CaCO3	mg/L	1	-	-

Chloride by Discrete Analyser in Water Method: AN274 Tested: 30/7/2019

Chloride, Cl	mg/L	1	41	23

Sulfate in water Method: AN275 Tested: 30/7/2019

Sulfate, SO4	mg/L	1	86	52

Fluoride by Ion Selective Electrode in Water Method: AN141 Tested: 25/7/2019

Fluoride by ISE	mg/L	0.1	<0.1	<0.1

Acidity and Free CO2 Method: AN140 Tested: 25/7/2019

Acidity to pH 8.3	mg CaCO3/L	1	5	4

Metals in Water (Dissolved) by ICPOES Method: AN320 Tested: 25/7/2019

Phosphorus, P	µg/L	50	-	<50
Silicon, Si	µg/L	20	16000	13000
Sulfur, S	µg/L	100	-	18000

Cations in Water (Dissolved) by ICPOES Method: AN020/AN320 Tested: 26/7/2019

Calcium, Ca	µg/L	10	-	140
Magnesium, Mg	µg/L	10	-	510
Potassium, K	µg/L	50	-	550
Sodium, Na	µg/L	50	-	40000

Parameter	Units	LOR	Sample Number PE136601.005 Sample Matrix Water Sample Name ARD_002_3	PE136601.006 Water ARD_002_4

Trace Metals (Dissolved) in Water by ICPMS Method: AN318 Tested: 25/7/2019

Parameter	Units	LOR	PE136601.005	PE136601.006
Aluminium, Al	µg/L	5	36	16
Antimony, Sb	µg/L	1	-	<1
Arsenic, As	µg/L	1	-	<1
Barium, Ba	µg/L	0.2	-	15
Bismuth, Bi	µg/L	1	-	<1
Boron, B	µg/L	5	500	350
Cadmium, Cd	µg/L	0.1	-	<0.1
Chromium, Cr	µg/L	1	14	7
Cobalt, Co	µg/L	1	2	1
Copper, Cu	µg/L	1	18	11
Iron, Fe	µg/L	5	35	16
Lead, Pb	µg/L	1	-	<1
Manganese, Mn	µg/L	1	9	7
Molybdenum, Mo	µg/L	0.5	-	<0.5
Nickel, Ni	µg/L	1	7	4
Selenium, Se	µg/L	1	-	<1
Silver, Ag	µg/L	1	-	<1
Strontium, Sr	µg/L	1	-	3
Thallium, Tl	µg/L	1	-	<1
Thorium, Th	µg/L	1	-	<1
Tin, Sn	µg/L	1	-	<1
Titanium, Ti	µg/L	1	-	<1
Uranium, U	µg/L	1	-	<1
Vanadium, V	µg/L	1	-	<1
Zinc, Zn	µg/L	5	34	24

Mercury (dissolved) in Water Method: AN311(Perth)/AN312 Tested: 26/7/2019

Parameter	Units	LOR	PE136601.005	PE136601.006
Mercury	µg/L	0.05	-	<0.05

Parameter	Units	LOR	Sample Number PE136601.007 Sample Matrix Water Sample Name ARD_004_2	PE136601.008 Water ARD_004_3

pH in water Method: AN101 Tested: 24/7/2019

pH**	pH Units	0.1	8.8	8.6

Conductivity and TDS by Calculation - Water Method: AN106 Tested: 24/7/2019

Conductivity @ 25 C	µS/cm	2	1500	630

Alkalinity Method: AN135 Tested: 24/7/2019

Total Alkalinity as CaCO3	mg/L	1	370	260

Chloride by Discrete Analyser in Water Method: AN274 Tested: 30/7/2019

Chloride, Cl	mg/L	1	190	30

Sulfate in water Method: AN275 Tested: 30/7/2019

Sulfate, SO4	mg/L	1	130	14

Fluoride by Ion Selective Electrode in Water Method: AN141 Tested: 25/7/2019

Fluoride by ISE	mg/L	0.1	4.9	5.1

Acidity and Free CO2 Method: AN140 Tested: 25/7/2019

Acidity to pH 8.3	mg CaCO3/L	1	-	-

Metals in Water (Dissolved) by ICPOES Method: AN320 Tested: 25/7/2019

Phosphorus, P	µg/L	50	-	-
Silicon, Si	µg/L	20	9400	8300
Sulfur, S	µg/L	100	-	-

Cations in Water (Dissolved) by ICPOES Method: AN020/AN320 Tested: 26/7/2019

Calcium, Ca	µg/L	10	-	-
Magnesium, Mg	µg/L	10	-	-
Potassium, K	µg/L	50	-	-
Sodium, Na	µg/L	50	-	-

		Sample Number	PE136601.007	PE136601.008
		Sample Matrix	Water	Water
		Sample Name	ARD_004_2	ARD_004_3
Parameter	Units	LOR		

Trace Metals (Dissolved) in Water by ICPMS Method: AN318 Tested: 25/7/2019

Aluminium, Al	μg/L	5	13	14
Antimony, Sb	μg/L	1	-	-
Arsenic, As	μg/L	1	-	-
Barium, Ba	μg/L	0.2	-	-
Bismuth, Bi	μg/L	1	-	-
Boron, B	μg/L	5	<5	<5
Cadmium, Cd	μg/L	0.1	-	-
Chromium, Cr	μg/L	1	<1	<1
Cobalt, Co	μg/L	1	<1	<1
Copper, Cu	μg/L	1	3	2
Iron, Fe	μg/L	5	<5	<5
Lead, Pb	μg/L	1	-	-
Manganese, Mn	μg/L	1	<1	<1
Molybdenum, Mo	μg/L	0.5	-	-
Nickel, Ni	μg/L	1	8	2
Selenium, Se	μg/L	1	-	-
Silver, Ag	μg/L	1	-	-
Strontium, Sr	μg/L	1	-	-
Thallium, Tl	μg/L	1	-	-
Thorium, Th	μg/L	1	-	-
Tin, Sn	μg/L	1	-	-
Titanium, Ti	μg/L	1	-	-
Uranium, U	μg/L	1	-	-
Vanadium, V	μg/L	1	-	-
Zinc, Zn	μg/L	5	<5	<5

Mercury (dissolved) in Water Method: AN311(Perth)/AN312 Tested: 26/7/2019

Mercury	μg/L	0.05	-	-

Parameter	Units	LOR	Sample Number Sample Matrix Sample Name: PE136601.009 Water ARD_005_2	PE136601.010 Water ARD_005_3

pH in water Method: AN101 Tested: 24/7/2019

pH**	pH Units	0.1	5.4	6.1

Conductivity and TDS by Calculation - Water Method: AN106 Tested: 24/7/2019

Conductivity @ 25 C	µS/cm	2	1200	390

Alkalinity Method: AN135 Tested: 24/7/2019

Total Alkalinity as CaCO3	mg/L	1	-	2

Chloride by Discrete Analyser in Water Method: AN274 Tested: 30/7/2019

Chloride, Cl	mg/L	1	190	19

Sulfate in water Method: AN275 Tested: 30/7/2019

Sulfate, SO4	mg/L	1	230	150

Fluoride by Ion Selective Electrode in Water Method: AN141 Tested: 25/7/2019

Fluoride by ISE	mg/L	0.1	<0.1	<0.1

Acidity and Free CO2 Method: AN140 Tested: 25/7/2019

Acidity to pH 8.3	mg CaCO3/L	1	5	-

Metals in Water (Dissolved) by ICPOES Method: AN320 Tested: 25/7/2019

Phosphorus, P	µg/L	50	-	-
Silicon, Si	µg/L	20	14000	16000
Sulfur, S	µg/L	100	-	-

Cations in Water (Dissolved) by ICPOES Method: AN020/AN320 Tested: 26/7/2019

Calcium, Ca	µg/L	10	-	-
Magnesium, Mg	µg/L	10	-	-
Potassium, K	µg/L	50	-	-
Sodium, Na	µg/L	50	-	-

Parameter	Units	LOR	Sample Number Sample Matrix Sample Name: PE136601.009 Water ARD_005_2	PE136601.010 Water ARD_005_3

Trace Metals (Dissolved) in Water by ICPMS Method: AN318 Tested: 25/7/2019

Parameter	Units	LOR	PE136601.009	PE136601.010
Aluminium, Al	µg/L	5	32	7
Antimony, Sb	µg/L	1	-	-
Arsenic, As	µg/L	1	-	-
Barium, Ba	µg/L	0.2	-	-
Bismuth, Bi	µg/L	1	-	-
Boron, B	µg/L	5	<5	<5
Cadmium, Cd	µg/L	0.1	-	-
Chromium, Cr	µg/L	1	1	<1
Cobalt, Co	µg/L	1	2	<1
Copper, Cu	µg/L	1	8	3
Iron, Fe	µg/L	5	<5	<5
Lead, Pb	µg/L	1	-	-
Manganese, Mn	µg/L	1	16	2
Molybdenum, Mo	µg/L	0.5	-	-
Nickel, Ni	µg/L	1	6	3
Selenium, Se	µg/L	1	-	-
Silver, Ag	µg/L	1	-	-
Strontium, Sr	µg/L	1	-	-
Thallium, Tl	µg/L	1	-	-
Thorium, Th	µg/L	1	-	-
Tin, Sn	µg/L	1	-	-
Titanium, Ti	µg/L	1	-	-
Uranium, U	µg/L	1	-	-
Vanadium, V	µg/L	1	-	-
Zinc, Zn	µg/L	5	69	12

Mercury (dissolved) in Water Method: AN311(Perth)/AN312 Tested: 26/7/2019

Parameter	Units	LOR	PE136601.009	PE136601.010
Mercury	µg/L	0.05	-	-

Parameter	Units	LOR	Sample Number: PE136601.011 Sample Matrix: Water Sample Name: ARD_005_4	Sample Number: PE136601.012 Sample Matrix: Water Sample Name: ARD_006_2

pH in water Method: AN101 Tested: 24/7/2019

Parameter	Units	LOR	PE136601.011	PE136601.012
pH**	pH Units	0.1	5.6	4.1

Conductivity and TDS by Calculation - Water Method: AN106 Tested: 24/7/2019

Parameter	Units	LOR	PE136601.011	PE136601.012
Conductivity @ 25 C	µS/cm	2	270	1400

Alkalinity Method: AN135 Tested: 24/7/2019

Parameter	Units	LOR	PE136601.011	PE136601.012
Total Alkalinity as CaCO3	mg/L	1	<1	-

Chloride by Discrete Analyser in Water Method: AN274 Tested: 30/7/2019

Parameter	Units	LOR	PE136601.011	PE136601.012
Chloride, Cl	mg/L	1	10	260

Sulfate in water Method: AN275 Tested: 30/7/2019

Parameter	Units	LOR	PE136601.011	PE136601.012
Sulfate, SO4	mg/L	1	88	220

Fluoride by Ion Selective Electrode in Water Method: AN141 Tested: 25/7/2019

Parameter	Units	LOR	PE136601.011	PE136601.012
Fluoride by ISE	mg/L	0.1	<0.1	<0.1

Acidity and Free CO2 Method: AN140 Tested: 25/7/2019

Parameter	Units	LOR	PE136601.011	PE136601.012
Acidity to pH 8.3	mg CaCO3/L	1	-	12

Metals in Water (Dissolved) by ICPOES Method: AN320 Tested: 25/7/2019

Parameter	Units	LOR	PE136601.011	PE136601.012
Phosphorus, P	µg/L	50	<50	-
Silicon, Si	µg/L	20	17000	16000
Sulfur, S	µg/L	100	31000	-

Cations in Water (Dissolved) by ICPOES Method: AN020/AN320 Tested: 25/7/2019

Parameter	Units	LOR	PE136601.011	PE136601.012
Calcium, Ca	µg/L	10	73	-
Magnesium, Mg	µg/L	10	150	-
Potassium, K	µg/L	50	710	-
Sodium, Na	µg/L	50	49000	-

Parameter	Units	LOR	Sample Number PE136601.011 Sample Matrix Water Sample Name ARD_005_4	PE136601.012 Water ARD_006_2

Trace Metals (Dissolved) in Water by ICPMS Method: AN318 Tested: 25/7/2019

Parameter	Units	LOR	ARD_005_4	ARD_006_2
Aluminium, Al	µg/L	5	6	77
Antimony, Sb	µg/L	1	<1	-
Arsenic, As	µg/L	1	1	-
Barium, Ba	µg/L	0.2	1.9	-
Bismuth, Bi	µg/L	1	<1	-
Boron, B	µg/L	5	<5	<5
Cadmium, Cd	µg/L	0.1	<0.1	-
Chromium, Cr	µg/L	1	<1	2
Cobalt, Co	µg/L	1	<1	7
Copper, Cu	µg/L	1	3	25
Iron, Fe	µg/L	5	<5	22
Lead, Pb	µg/L	1	<1	-
Manganese, Mn	µg/L	1	2	28
Molybdenum, Mo	µg/L	0.5	<0.5	-
Nickel, Ni	µg/L	1	2	11
Selenium, Se	µg/L	1	<1	-
Silver, Ag	µg/L	1	<1	-
Strontium, Sr	µg/L	1	<1	-
Thallium, Tl	µg/L	1	<1	-
Thorium, Th	µg/L	1	<1	-
Tin, Sn	µg/L	1	<1	-
Titanium, Ti	µg/L	1	<1	-
Uranium, U	µg/L	1	<1	-
Vanadium, V	µg/L	1	<1	-
Zinc, Zn	µg/L	5	8	130

Mercury (dissolved) in Water Method: AN311(Perth)/AN312 Tested: 25/7/2019

Parameter	Units	LOR	ARD_005_4	ARD_006_2
Mercury	µg/L	0.05	<0.05	-

		Sample Number	PE136601.013	PE136601.014
		Sample Matrix	Water	Water
		Sample Name	ARD_006_3	ARD_006_4
Parameter	Units	LOR		

pH in water Method: AN101 Tested: 24/7/2019

pH**	pH Units	0.1	4.2	4.2

Conductivity and TDS by Calculation - Water Method: AN106 Tested: 24/7/2019

Conductivity @ 25 C	µS/cm	2	450	310

Alkalinity Method: AN135 Tested: 24/7/2019

Total Alkalinity as CaCO3	mg/L	1	-	-

Chloride by Discrete Analyser in Water Method: AN274 Tested: 30/7/2019

Chloride, Cl	mg/L	1	40	23

Sulfate in water Method: AN275 Tested: 30/7/2019

Sulfate, SO4	mg/L	1	140	84

Fluoride by Ion Selective Electrode in Water Method: AN141 Tested: 25/7/2019

Fluoride by ISE	mg/L	0.1	<0.1	<0.1

Acidity and Free CO2 Method: AN140 Tested: 25/7/2019

Acidity to pH 8.3	mg CaCO3/L	1	7	6

Metals in Water (Dissolved) by ICPOES Method: AN320 Tested: 25/7/2019

Phosphorus, P	µg/L	50	-	<50
Silicon, Si	µg/L	20	16000	15000
Sulfur, S	µg/L	100	-	28000

Cations in Water (Dissolved) by ICPOES Method: AN020/AN320 Tested: 26/7/2019

Calcium, Ca	µg/L	10	-	770
Magnesium, Mg	µg/L	10	-	2000
Potassium, K	µg/L	50	-	2400
Sodium, Na	µg/L	50	-	48000

Parameter	Units	LOR	PE136601.013 Water ARD_006_3	PE136601.014 Water ARD_006_4
		Sample Number Sample Matrix Sample Name		

Trace Metals (Dissolved) in Water by ICPMS Method: AN318 Tested: 25/7/2019

Parameter	Units	LOR	PE136601.013 (ARD_006_3)	PE136601.014 (ARD_006_4)
Aluminium, Al	µg/L	5	16	21
Antimony, Sb	µg/L	1	-	<1
Arsenic, As	µg/L	1	-	<1
Barium, Ba	µg/L	0.2	-	26
Bismuth, Bi	µg/L	1	-	<1
Boron, B	µg/L	5	<5	<5
Cadmium, Cd	µg/L	0.1	-	<0.1
Chromium, Cr	µg/L	1	<1	<1
Cobalt, Co	µg/L	1	2	4
Copper, Cu	µg/L	1	11	11
Iron, Fe	µg/L	5	11	9
Lead, Pb	µg/L	1	-	<1
Manganese, Mn	µg/L	1	9	12
Molybdenum, Mo	µg/L	0.5	-	<0.5
Nickel, Ni	µg/L	1	4	6
Selenium, Se	µg/L	1	-	<1
Silver, Ag	µg/L	1	-	<1
Strontium, Sr	µg/L	1	-	16
Thallium, Tl	µg/L	1	-	<1
Thorium, Th	µg/L	1	-	<1
Tin, Sn	µg/L	1	-	<1
Titanium, Ti	µg/L	1	-	<1
Uranium, U	µg/L	1	-	<1
Vanadium, V	µg/L	1	-	<1
Zinc, Zn	µg/L	5	35	47

Mercury (dissolved) in Water Method: AN311(Perth)/AN312 Tested: 26/7/2019

Parameter	Units	LOR	PE136601.013 (ARD_006_3)	PE136601.014 (ARD_006_4)
Mercury	µg/L	0.05	-	<0.05

		Sample Number	PE136601.015
		Sample Matrix	Water
		Sample Name	HPDW
Parameter	Units	LOR	

pH in water Method: AN101 Tested: 24/7/2019

pH**	pH Units	0.1	5.5

Conductivity and TDS by Calculation - Water Method: AN106 Tested: 24/7/2019

Conductivity @ 25 C	µS/cm	2	<2

Alkalinity Method: AN135 Tested: 24/7/2019

Total Alkalinity as CaCO3	mg/L	1	<1

Chloride by Discrete Analyser in Water Method: AN274 Tested: 30/7/2019

Chloride, Cl	mg/L	1	<1

Sulfate in water Method: AN275 Tested: 30/7/2019

Sulfate, SO4	mg/L	1	<1

Fluoride by Ion Selective Electrode in Water Method: AN141 Tested: 25/7/2019

Fluoride by ISE	mg/L	0.1	<0.1

Acidity and Free CO2 Method: AN140 Tested: 25/7/2019

Acidity to pH 8.3	mg CaCO3/L	1	-

Metals in Water (Dissolved) by ICPOES Method: AN320 Tested: 25/7/2019

Phosphorus, P	µg/L	50	<50
Silicon, Si	µg/L	20	<20
Sulfur, S	µg/L	100	<100

Cations in Water (Dissolved) by ICPOES Method: AN020/AN320 Tested: 25/7/2019

Calcium, Ca	µg/L	10	<10
Magnesium, Mg	µg/L	10	<10
Potassium, K	µg/L	50	<50
Sodium, Na	µg/L	50	<50

		Sample Number	PE136601.015
		Sample Matrix	Water
		Sample Name	HPDW
Parameter	Units	LOR	

Trace Metals (Dissolved) in Water by ICPMS Method: AN318 Tested: 25/7/2019

Aluminium, Al	µg/L	5	<5
Antimony, Sb	µg/L	1	<1
Arsenic, As	µg/L	1	<1
Barium, Ba	µg/L	0.2	0.2
Bismuth, Bi	µg/L	1	<1
Boron, B	µg/L	5	210
Cadmium, Cd	µg/L	0.1	<0.1
Chromium, Cr	µg/L	1	<1
Cobalt, Co	µg/L	1	<1
Copper, Cu	µg/L	1	<1
Iron, Fe	µg/L	5	<5
Lead, Pb	µg/L	1	<1
Manganese, Mn	µg/L	1	<1
Molybdenum, Mo	µg/L	0.5	<0.5
Nickel, Ni	µg/L	1	<1
Selenium, Se	µg/L	1	<1
Silver, Ag	µg/L	1	<1
Strontium, Sr	µg/L	1	<1
Thallium, Tl	µg/L	1	<1
Thorium, Th	µg/L	1	<1
Tin, Sn	µg/L	1	<1
Titanium, Ti	µg/L	1	<1
Uranium, U	µg/L	1	<1
Vanadium, V	µg/L	1	<1
Zinc, Zn	µg/L	5	<5

Mercury (dissolved) in Water Method: AN311(Perth)/AN312 Tested: 25/7/2019

Mercury	µg/L	0.05	<0.05

MB blank results are compared to the Limit of Reporting
LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared the the amount of analyte spiked into the sample.
DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula : *the absolute difference of the two results divided by the average of the two results as a percentage.* Where the DUP RPD is 'NA' , the results are less than the LOR and thus the RPD is not applicable.

Acidity and Free CO2 Method: ME-(AU)-[ENV]AN140

Parameter	QC Reference	Units	LOR	MB	DUP %RPD
Acidity to pH 8.3	LB162137	mg CaCO3/L	1	<1	1 - 22%

Alkalinity Method: ME-(AU)-[ENV]AN135

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Total Alkalinity as CaCO3	LB162174	mg/L	1	<1	2%	98%

Cations in Water (Dissolved) by ICPOES Method: ME-(AU)-[ENV]AN020/AN320

Parameter	QC Reference	Units	LOR	MB	DUP %RPD
Calcium, Ca	LB162037	µg/L	10	<0	0%
Magnesium, Mg	LB162037	µg/L	10	<10	0%
Potassium, K	LB162037	µg/L	50	<0	144%
Sodium, Na	LB162037	µg/L	50	<0	66%

Chloride by Discrete Analyser in Water Method: ME-(AU)-[ENV]AN274

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Chloride, Cl	LB162206	mg/L	1	<1	0 - 1%	96 - 97%	89 - 95%

Conductivity and TDS by Calculation - Water Method: ME-(AU)-[ENV]AN106

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Conductivity @ 25 C	LB162175	µS/cm	2	<2	0%	102 - 103%

Fluoride by Ion Selective Electrode in Water Method: ME-(AU)-[ENV]AN141

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Fluoride by ISE	LB162038	mg/L	0.1	<0.1	0 - 4%	98 - 103%	93 - 105%

MB blank results are compared to the Limit of Reporting
LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared the the amount of analyte spiked into the sample.
DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula : *the absolute difference of the two results divided by the average of the two results as a percentage.* Where the DUP RPD is 'NA' , the results are less than the LOR and thus the RPD is not applicable.

Mercury (dissolved) in Water Method: ME-(AU)-[ENV]AN311(Perth)/AN312

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Mercury	LB162057	µg/L	0.05	<0.05	0 - 25%	99 - 104%	88 - 104%

Metals in Water (Dissolved) by ICPOES Method: ME-(AU)-[ENV]AN320

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Phosphorus, P	LB162035	µg/L	50	<50	0%	97%	
Silicon, Si	LB162035	µg/L	20	<20	0 - 2%	106%	118%
Sulfur, S	LB162035	µg/L	100	<100	0%	102%	

pH in water Method: ME-(AU)-[ENV]AN101

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
pH**	LB162175	pH Units	0.1	5.2 - 5.5	0 - 1%	100 - 101%

Sulfate in water Method: ME-(AU)-[ENV]AN275

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Sulfate, SO4	LB162206	mg/L	1	<1	0 - 1%	99 - 100%	87 - 94%

Trace Metals (Dissolved) in Water by ICPMS Method: ME-(AU)-[ENV]AN318

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Aluminium, Al	LB162030	µg/L	5	<5	0 - 6%	83%	71%
Antimony, Sb	LB162030	µg/L	1	<1	0%	91%	
Arsenic, As	LB162030	µg/L	1	<1	0%	117%	
Barium, Ba	LB162030	µg/L	0.2	<0.2	0%	100%	
Bismuth, Bi	LB162030	µg/L	1	<1	0%	99%	
Boron, B	LB162030	µg/L	5	<5	0 - 3%	108%	847%
Cadmium, Cd	LB162030	µg/L	0.1	<0.1	0%	109%	
Chromium, Cr	LB162030	µg/L	1	<1	0%	100%	98%
Cobalt, Co	LB162030	µg/L	1	<1	0%	100%	99%
Copper, Cu	LB162030	µg/L	1	<1	0 - 4%	110%	100%
Iron, Fe	LB162030	µg/L	5	<5	0%	96%	79%
Lead, Pb	LB162030	µg/L	1	<1	0%	103%	
Manganese, Mn	LB162030	µg/L	1	<1	0 - 3%	96%	89%
Molybdenum, Mo	LB162030	µg/L	0.5	<0.5	0%	102%	
Nickel, Ni	LB162030	µg/L	1	<1	0 - 6%	106%	95%
Selenium, Se	LB162030	µg/L	1	<1	0%	110%	
Silver, Ag	LB162030	µg/L	1	<1	0%	93%	
Strontium, Sr	LB162030	µg/L	1	<1	0%	89%	
Thallium, Tl	LB162030	µg/L	1	<1	0%	103%	
Thorium, Th	LB162030	µg/L	1	<1	0%	94%	
Tin, Sn	LB162030	µg/L	1	<1	0%	97%	
Titanium, Ti	LB162030	µg/L	1	<1	0%	100%	
Uranium, U	LB162030	µg/L	1	<1	0%	87%	
Vanadium, V	LB162030	µg/L	1	<1	0%	95%	
Zinc, Zn	LB162030	µg/L	5	<5	0 - 2%	117%	-27%

METHOD	METHODOLOGY SUMMARY
AN020/AN320 LL	Dissolved Cations Low LOR by ICP-OES: Method is as per routine ICP OES method reporting a variation to the method being lower limit of reporting (LOR) for selected cations as validated by the site. Referenced to APHA 3120B.
AN101	pH in Soil Sludge Sediment and Water: pH is measured electrometrically using a combination electrode (glass plus reference electrode) and is calibrated against 3 buffers purchased commercially. For soils, an extract with water is made at a ratio of 1:5 and the pH determined and reported on the extract. Reference APHA 4500-H+.
AN106	Conductivity and TDS by Calculation: Conductivity is measured by meter with temperature compensation and is calibrated against a standard solution of potassium chloride. Conductivity is generally reported as µmhos/cm or µS/cm @ 25°C. For soils, an extract with water is made at a ratio of 1:5 and the EC determined and reported on the extract, or calculated back to the as-received sample. Total Dissolved Salts can be estimated from conductivity using a conversion factor, which for natural waters, is in the range 0.55 to 0.75. SGS use 0.6. Reference APHA 2510 B.
AN106	Salinity may be calculated in terms of NaCl from the sample conductivity. This assumes all soluble salts present, measured by the conductivity, are present as NaCl.
AN135	Alkalinity (and forms of) by Titration: The sample is titrated with standard acid to pH 8.3 (P titre) and pH 4.5 (T titre) and permanent and/or total alkalinity calculated. The results are expressed as equivalents of calcium carbonate or recalculated as bicarbonate, carbonate and hydroxide. Reference APHA 2320. Internal Reference AN135
AN140	Acidity by Titration: The water sample is titrated with sodium hydroxide to designated pH end point. In a sample containing only carbon dioxide, bicarbonates and carbonates, titration to pH 8.3 at 25°C corresponds to stoichiometric neutralisation of carbonic acid to bicarbonate. Method reference APHA 2310 B.
AN141	Determination of Fluoride by ISE: A fluoride ion selective electrode and reference electrode combination, in the presence of a pH/complexation buffer, is used to determine the fluoride concentration. The electrode millivolt response is measured logarithmically against fluoride concentration. Reference APHA F- C.
AN274	Chloride by Aquakem DA: Chloride reacts with mercuric thiocyanate forming a mercuric chloride complex. In the presence of ferric iron, highly coloured ferric thiocyanate is formed which is proportional to the chloride concentration. Reference APHA 4500Cl-
AN275	sulfate by Aquakem DA: sulfate is precipitated in an acidic medium with barium chloride. The resulting turbidity is measured photometrically at 405nm and compared with standard calibration solutions to determine the sulfate concentration in the sample. Reference APHA 4500-SO42-. Internal reference AN275.
AN311(Perth)/AN312	Mercury by Cold Vapour AAS in Waters: Mercury ions are reduced by stannous chloride reagent in acidic solution to elemental mercury. This mercury vapour is purged by nitrogen into a cold cell in an atomic absorption spectrometer or mercury analyser. Quantification is made by comparing absorbances to those of the calibration standards. Reference APHA 3112/3500.
AN318	Determination of elements at trace level in waters by ICP-MS technique, in accordance with USEPA 6020A.
AN320	Metals by ICP-OES: Samples are preserved with 10% nitric acid for a wide range of metals and some non-metals. This solution is measured by Inductively Coupled Plasma. Solutions are aspirated into an argon plasma at 8000-10000K and emit characteristic energy or light as a result of electron transitions through unique energy levels. The emitted light is focused onto a diffraction grating where it is separated into components .
AN320	Photomultipliers or CCDs are used to measure the light intensity at specific wavelengths. This intensity is directly proportional to concentration. Corrections are required to compensate for spectral overlap between elements. Reference APHA 3120 B.

METHOD SUMMARY

METHOD	METHODOLOGY SUMMARY
Calculation	Free and Total Carbon Dioxide may be calculated using alkalinity forms only when the samples TDS is <500mg/L. If TDS is >500mg/L free or total carbon dioxide cannot be reported. APHA4500CO2 D.

FOOTNOTES

IS	Insufficient sample for analysis.	LOR	Limit of Reporting
LNR	Sample listed, but not received.	↑↓	Raised or Lowered Limit of Reporting
*	NATA accreditation does not cover the performance of this service.	QFH	QC result is above the upper tolerance
**	Indicative data, theoretical holding time exceeded.	QFL	QC result is below the lower tolerance
		-	The sample was not analysed for this analyte
		NVL	Not Validated

Unless it is reported that sampling has been performed by SGS, the samples have been analysed as received.
Solid samples expressed on a dry weight basis.

Where "Total" analyte groups are reported (for example, Total PAHs, Total OC Pesticides) the total will be calculated as the sum of the individual analytes, with those analytes that are reported as <LOR being assumed to be zero. The summed (Total) limit of reporting is calcuated by summing the individual analyte LORs and dividing by two. For example, where 16 individual analytes are being summed and each has an LOR of 0.1 mg/kg, the "Totals" LOR will be 1.6 / 2 (0.8 mg/kg). Where only 2 analytes are being summed, the " Total" LOR will be the sum of those two LORs.

Some totals may not appear to add up because the total is rounded after adding up the raw values.

If reported, measurement uncertainty follow the ± sign after the analytical result and is expressed as the expanded uncertainty calculated using a coverage factor of 2, providing a level of confidence of approximately 95%, unless stated otherwise in the comments section of this report.

Results reported for samples tested under test methods with codes starting with ARS-SOP, radionuclide or gross radioactivity concentrations are expressed in becquerel (Bq) per unit of mass or volume or per wipe as stated on the report. Becquerel is the SI unit for activity and equals one nuclear transformation per second.
Note that in terms of units of radioactivity:

a. 1 Bq is equivalent to 27 pCi
b. 37 MBq is equivalent to 1 mCi

For results reported for samples tested under test methods with codes starting with ARS-SOP, less than (<) values indicate the detection limit for each radionuclide or parameter for the measurement system used. The respective detection limits have been calculated in accordance with ISO 11929.

The QC and MU criteria are subject to internal review according to the SGS QAQC plan and may be provided on request or alternatively can be found here: www.sgs.com.au.pv.sgsvr/en-gb/environment.

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ANALYTICAL REPORT

Accreditation No. 2562

CLIENT DETAILS

Contact	Graeme Campbell
Client	Graeme Campbell & Associates Pty Ltd
Address	PO Box 247 Bridgetown WA 6255
Telephone	0897 612 829
Facsimile	0897 612 830
Email	gca@wn.com.au
Project	**GCA Job No. 1901/1**
Order Number	**GCA Job No. 1901/1**
Samples	15

LABORATORY DETAILS

Manager	Marjana Siljanoska
Laboratory	SGS Perth Environmental
Address	28 Reid Rd Perth Airport WA 6105
Telephone	(08) 9373 3500
Facsimile	(08) 9373 3556
Email	au.environmental.perth@sgs.com
SGS Reference	**PE136601A R0**
Date Received	01 Aug 2019
Date Reported	13 Aug 2019

COMMENTS

Accredited for compliance with ISO/IEC 17025 - Testing. NATA accredited laboratory 2562(898/20210).

SIGNATORIES

Mary Ann Ola-A
Inorganics Team Leader

		Sample Number	PE136601A.001	PE136601A.002
		Sample Matrix	Water	Water
		Sample Name	ARD_001_2	ARD_001_3
Parameter	Units	LOR		

Hexavalent Chromium in water by Discrete Analyser Method: AN283 Tested: 8/8/2019

Parameter	Units	LOR	PE136601A.001	PE136601A.002
Hexavalent Chromium, Cr6+	mg/L	0.001	-	-

Reactive Silica by Aquakem Discrete Analyser Method: AN270 Tested: 12/8/2019

Parameter	Units	LOR	PE136601A.001	PE136601A.002
Reactive Silica, Si	mg/L	0.05	11	9.4

Parameter	Units	LOR	Sample Number PE136601A.003 Sample Matrix Water Sample Name ARD_001_4	PE136601A.004 Water ARD_002_2
Hexavalent Chromium in water by Discrete Analyser Method: AN283 Tested: 8/8/2019				
Hexavalent Chromium, Cr6+	mg/L	0.001	-	<0.001
Reactive Silica by Aquakem Discrete Analyser Method: AN270 Tested: 12/8/2019				
Reactive Silica, Si	mg/L	0.05	8.1	17

Parameter	Units	LOR	PE136601A.005 Water ARD_002_3	PE136601A.006 Water ARD_002_4
Sample Number / Sample Matrix / Sample Name			PE136601A.005 Water ARD_002_3	PE136601A.006 Water ARD_002_4

Hexavalent Chromium in water by Discrete Analyser Method: AN283 Tested: 7/8/2019

Hexavalent Chromium, Cr6+	mg/L	0.001	<0.001	<0.001

Reactive Silica by Aquakem Discrete Analyser Method: AN270 Tested: 12/8/2019

Reactive Silica, Si	mg/L	0.05	17	13

Parameter	Units	LOR	Sample Number Sample Matrix Sample Name	PE136601A.007 Water ARD_004_2	PE136601A.008 Water ARD_004_3

Hexavalent Chromium in water by Discrete Analyser Method: AN283 Tested: 8/8/2019

Parameter	Units	LOR	PE136601A.007	PE136601A.008
Hexavalent Chromium, Cr6+	mg/L	0.001	-	-

Reactive Silica by Aquakem Discrete Analyser Method: AN270 Tested: 12/8/2019

Parameter	Units	LOR	PE136601A.007	PE136601A.008
Reactive Silica, Si	mg/L	0.05	9.6	8.6

		Sample Number Sample Matrix Sample Name	PE136601A.009 Water ARD_005_2	PE136601A.010 Water ARD_005_3
Parameter	Units	LOR		

Hexavalent Chromium in water by Discrete Analyser Method: AN283 Tested: 7/8/2019

Hexavalent Chromium, Cr6+	mg/L	0.001	<0.001	-

Reactive Silica by Aquakem Discrete Analyser Method: AN270 Tested: 12/8/2019

Reactive Silica, Si	mg/L	0.05	14	17

Parameter	Units	LOR	Sample Number Sample Matrix Sample Name	PE136601A.011 Water ARD_005_4	PE136601A.012 Water ARD_006_2

Hexavalent Chromium in water by Discrete Analyser Method: AN283 Tested: 8/8/2019

Parameter	Units	LOR	PE136601A.011	PE136601A.012
Hexavalent Chromium, Cr6+	mg/L	0.001	-	<0.001

Reactive Silica by Aquakem Discrete Analyser Method: AN270 Tested: 12/8/2019

Parameter	Units	LOR	PE136601A.011	PE136601A.012
Reactive Silica, Si	mg/L	0.05	18	16

Parameter	Units	LOR	Sample Number Sample Matrix Sample Name	PE136601A.013 Water ARD_006_3	PE136601A.014 Water ARD_006_4

Hexavalent Chromium in water by Discrete Analyser Method: AN283 Tested: 8/8/2019

Parameter	Units	LOR	PE136601A.013	PE136601A.014
Hexavalent Chromium, Cr6+	mg/L	0.001	-	-

Reactive Silica by Aquakem Discrete Analyser Method: AN270 Tested: 12/8/2019

Parameter	Units	LOR	PE136601A.013	PE136601A.014
Reactive Silica, Si	mg/L	0.05	16	16

Parameter	Units	LOR	Sample Number: PE136601A.015 Sample Matrix: Water Sample Name: HPDW

Hexavalent Chromium in water by Discrete Analyser Method: AN283 Tested: 8/8/2019

Parameter	Units	LOR	PE136601A.015
Hexavalent Chromium, Cr6+	mg/L	0.001	-

Reactive Silica by Aquakem Discrete Analyser Method: AN270 Tested: 12/8/2019

Parameter	Units	LOR	PE136601A.015
Reactive Silica, Si	mg/L	0.05	<0.05

MB blank results are compared to the Limit of Reporting
LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared the the amount of analyte spiked into the sample.
DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula : *the absolute difference of the two results divided by the average of the two results as a percentage.* Where the DUP RPD is 'NA' , the results are less than the LOR and thus the RPD is not applicable.

Hexavalent Chromium in water by Discrete Analyser **Method: ME-(AU)-[ENV]AN283**

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Hexavalent Chromium, Cr6+	LB162474	mg/L	0.001	<0.001	0%	NA	NA

Reactive Silica by Aquakem Discrete Analyser **Method: ME-(AU)-[ENV]AN270**

Parameter	QC Reference	Units	LOR	DUP %RPD	LCS %Recovery	MS %Recovery
Reactive Silica, Si	LB162619	mg/L	0.05	0 - 1%	100%	86%

METHOD SUMMARY

METHOD	METHODOLOGY SUMMARY
AN270	Reactive forms of silicon in acid solution below pH 2 react with ammonium molybdate ions to form a yellow silicomolybdate which is then reduced with ascorbic acid to produce a blue silicomolybdate complex. Oxalic acid is added to destroy any molybdophosphoric acid. Colourimetric determination by Aquakem Discrete Analyser.
AN283	Hexavalent Chromium via Discrete Analyser: Soluble hexavalent chromium forms a red/violet colour with diphenylcarbazide in acidic solution. This procedure is very sensitive and nearly specific for Cr6+. If total chromium is also measured the trivalent form of chromium Cr3+ can be calculated from the difference (Total Cr - Cr6+). Reference APHA3500CrB.

FOOTNOTES

IS	Insufficient sample for analysis.	LOR	Limit of Reporting
LNR	Sample listed, but not received.	↑↓	Raised or Lowered Limit of Reporting
*	NATA accreditation does not cover the performance of this service.	QFH	QC result is above the upper tolerance
		QFL	QC result is below the lower tolerance
**	Indicative data, theoretical holding time exceeded.	-	The sample was not analysed for this analyte
		NVL	Not Validated

Unless it is reported that sampling has been performed by SGS, the samples have been analysed as received.
Solid samples expressed on a dry weight basis.

Where "Total" analyte groups are reported (for example, Total PAHs, Total OC Pesticides) the total will be calculated as the sum of the individual analytes, with those analytes that are reported as <LOR being assumed to be zero. The summed (Total) limit of reporting is calcuated by summing the individual analyte LORs and dividing by two. For example, where 16 individual analytes are being summed and each has an LOR of 0.1 mg/kg, the "Totals" LOR will be 1.6 / 2 (0.8 mg/kg). Where only 2 analytes are being summed, the " Total" LOR will be the sum of those two LORs.

Some totals may not appear to add up because the total is rounded after adding up the raw values.

If reported, measurement uncertainty follow the ± sign after the analytical result and is expressed as the expanded uncertainty calculated using a coverage factor of 2, providing a level of confidence of approximately 95%, unless stated otherwise in the comments section of this report.

Results reported for samples tested under test methods with codes starting with ARS-SOP, radionuclide or gross radioactivity concentrations are expressed in becquerel (Bq) per unit of mass or volume or per wipe as stated on the report. Becquerel is the SI unit for activity and equals one nuclear transformation per second.
Note that in terms of units of radioactivity:
a. 1 Bq is equivalent to 27 pCi
b. 37 MBq is equivalent to 1 mCi

For results reported for samples tested under test methods with codes starting with ARS-SOP, less than (<) values indicate the detection limit for each radionuclide or parameter for the measurement system used. The respective detection limits have been calculated in accordance with ISO 11929.

The QC and MU criteria are subject to internal review according to the SGS QAQC plan and may be provided on request or alternatively can be found here: www.sgs.com.au.pv.sgsvr/en-gb/environment.

ANALYTICAL REPORT

Accreditation No. 2562

CLIENT DETAILS		LABORATORY DETAILS	
Contact	Graeme Campbell	Manager	Marjana Siljanoska
Client	Graeme Campbell & Associates Pty Ltd	Laboratory	SGS Perth Environmental
Address	PO Box 247 Bridgetown WA 6255	Address	28 Reid Rd Perth Airport WA 6105
Telephone	0897 612 829	Telephone	(08) 9373 3500
Facsimile	0897 612 830	Facsimile	(08) 9373 3556
Email	gca@wn.com.au	Email	au.environmental.perth@sgs.com
Project	**GCA Job No. 1901/1**	SGS Reference	**PE136602 R1**
Order Number	**GCA Job No. 1901/1**	Date Received	24 Jul 2019
Samples	5	Date Reported	01 Aug 2019

COMMENTS

Accredited for compliance with ISO/IEC 17025 - Testing. NATA accredited laboratory 2562(898/20210).

Metals: LORs raised due to high conductivity.
Metals: Dissolved B: Spike recovery failed acceptance criteria due to the presence of significant concentration of analyte (i.e. the concentration of analyte exceeds the spike level).
Metals: The over range results on ICPMS Method AN318 were reported using ICPOES method AN320.

SIGNATORIES

Hue Thanh Ly
Metals Team Leader

LouiseHope

Louise Hope
Laboratory Technician

Mary Ann Ola-A
Inorganics Team Leader

Ohmar David
Metals Chemist

Sanaa Hussain
Chemist

Parameter	Units	LOR	Sample Number: PE136602.001 Sample Matrix: Water Sample Name: ARD_001_1	PE136602.002 Water ARD_002_1

pH in water Method: AN101 Tested: 24/7/2019

pH**	pH Units	0.1	5.8	3.9

Conductivity and TDS by Calculation - Water Method: AN106 Tested: 24/7/2019

Conductivity @ 25 C	µS/cm	2	16000	9800

Chloride by Discrete Analyser in Water Method: AN274 Tested: 30/7/2019

Chloride, Cl	mg/L	1	4800	2900

Sulfate in water Method: AN275 Tested: 30/7/2019

Sulfate, SO4	mg/L	1	710	580

Fluoride by Ion Selective Electrode in Water Method: AN141 Tested: 25/7/2019

Fluoride by ISE	mg/L	0.1	<0.1	1.2

Alkalinity Method: AN135 Tested: 24/7/2019

Total Alkalinity as CaCO3	mg/L	1	2	-

Acidity and Free CO2 Method: AN140 Tested: 25/7/2019

Acidity to pH 8.3	mg CaCO3/L	1	-	150

Metals in Water (Dissolved) by ICPOES Method: AN320 Tested: 25/7/2019

Phosphorus, P	µg/L	50	<50	<50
Silicon, Si	µg/L	20	13000	19000
Sulfur, S	µg/L	100	260000	200000

Cations in Water (Dissolved) by ICPOES Method: AN020/AN320 Tested: 25/7/2019

Calcium, Ca	µg/L	10	25000	23000
Magnesium, Mg	µg/L	10	260000	140000
Potassium, K	µg/L	50	47000	14000
Sodium, Na	µg/L	50	2700000	1700000

		Sample Number	PE136602.001	PE136602.002
		Sample Matrix	Water	Water
		Sample Name	ARD_001_1	ARD_002_1
Parameter	Units	LOR		

Trace Metals (Dissolved) in Water by ICPMS Method: AN318 Tested: 25/7/2019

Aluminium, Al	µg/L	5	100	18000
Antimony, Sb	µg/L	1	<5↑	<5↑
Arsenic, As	µg/L	1	<5↑	6
Barium, Ba	µg/L	0.2	60	59
Bismuth, Bi	µg/L	1	<5↑	<5↑
Boron, B	µg/L	5	1500	2200
Cadmium, Cd	µg/L	0.1	<0.5↑	<0.5↑
Chromium, Cr	µg/L	1	<5↑	130
Cobalt, Co	µg/L	1	52	240
Copper, Cu	µg/L	1	38	660
Iron, Fe	µg/L	5	<25↑	310
Lead, Pb	µg/L	1	<5↑	16
Manganese, Mn	µg/L	1	300	1100
Molybdenum, Mo	µg/L	0.5	<2.5↑	<2.5↑
Nickel, Ni	µg/L	1	79	430
Selenium, Se	µg/L	1	<5↑	<5↑
Silver, Ag	µg/L	1	<5↑	<5↑
Strontium, Sr	µg/L	1	560	630
Thallium, Tl	µg/L	1	<5↑	<5↑
Thorium, Th	µg/L	1	<5↑	<5↑
Tin, Sn	µg/L	1	<5↑	<5↑
Titanium, Ti	µg/L	1	<5↑	<5↑
Uranium, U	µg/L	1	<5↑	<5↑
Vanadium, V	µg/L	1	<5↑	<5↑
Zinc, Zn	µg/L	5	15000	6200

Mercury (dissolved) in Water Method: AN311(Perth)/AN312 Tested: 25/7/2019

Mercury	µg/L	0.05	0.11	0.21

Parameter	Units	LOR	PE136602.003	PE136602.004
Sample Number			PE136602.003	PE136602.004
Sample Matrix			Water	Water
Sample Name			ARD_004_1	ARD_005_1

pH in water Method: AN101 Tested: 24/7/2019

pH**	pH Units	0.1	8.1	4.0

Conductivity and TDS by Calculation - Water Method: AN106 Tested: 24/7/2019

Conductivity @ 25 C	µS/cm	2	9500	16000

Chloride by Discrete Analyser in Water Method: AN274 Tested: 30/7/2019

Chloride, Cl	mg/L	1	2600	5100

Sulfate in water Method: AN275 Tested: 30/7/2019

Sulfate, SO4	mg/L	1	740	720

Fluoride by Ion Selective Electrode in Water Method: AN141 Tested: 25/7/2019

Fluoride by ISE	mg/L	0.1	1.2	0.5

Alkalinity Method: AN135 Tested: 24/7/2019

Total Alkalinity as CaCO3	mg/L	1	120	-

Acidity and Free CO2 Method: AN140 Tested: 25/7/2019

Acidity to pH 8.3	mg CaCO3/L	1	-	88

Metals in Water (Dissolved) by ICPOES Method: AN320 Tested: 25/7/2019

Phosphorus, P	µg/L	50	<50	<50
Silicon, Si	µg/L	20	7300	16000
Sulfur, S	µg/L	100	270000	270000

Cations in Water (Dissolved) by ICPOES Method: AN020/AN320 Tested: 25/7/2019

Calcium, Ca	µg/L	10	97000	43000
Magnesium, Mg	µg/L	10	120000	270000
Potassium, K	µg/L	50	27000	27000
Sodium, Na	µg/L	50	1600000	2700000

		Sample Number	PE136602.003	PE136602.004
		Sample Matrix	Water	Water
		Sample Name	ARD_004_1	ARD_005_1
Parameter	Units	LOR		

Trace Metals (Dissolved) in Water by ICPMS Method: AN318 Tested: 25/7/2019

Parameter	Units	LOR	PE136602.003	PE136602.004
Aluminium, Al	µg/L	5	37	7600
Antimony, Sb	µg/L	1	<5↑	<5↑
Arsenic, As	µg/L	1	<5↑	5
Barium, Ba	µg/L	0.2	29	57
Bismuth, Bi	µg/L	1	<5↑	<5↑
Boron, B	µg/L	5	3400	2300
Cadmium, Cd	µg/L	0.1	<0.5↑	<0.5↑
Chromium, Cr	µg/L	1	<5↑	7
Cobalt, Co	µg/L	1	<5↑	140
Copper, Cu	µg/L	1	6	150
Iron, Fe	µg/L	5	<25↑	83
Lead, Pb	µg/L	1	<5↑	18
Manganese, Mn	µg/L	1	11	910
Molybdenum, Mo	µg/L	0.5	7.7	<2.5↑
Nickel, Ni	µg/L	1	100	140
Selenium, Se	µg/L	1	7	<5↑
Silver, Ag	µg/L	1	<5↑	<5↑
Strontium, Sr	µg/L	1	1900	1300
Thallium, Tl	µg/L	1	<5↑	<5↑
Thorium, Th	µg/L	1	<5↑	<5↑
Tin, Sn	µg/L	1	<5↑	<5↑
Titanium, Ti	µg/L	1	<5↑	<5↑
Uranium, U	µg/L	1	<5↑	<5↑
Vanadium, V	µg/L	1	5	<5↑
Zinc, Zn	µg/L	5	<25↑	4800

Mercury (dissolved) in Water Method: AN311(Perth)/AN312 Tested: 25/7/2019

Parameter	Units	LOR	PE136602.003	PE136602.004
Mercury	µg/L	0.05	<0.05	0.31

		Sample Number	PE136602.005
		Sample Matrix	Water
		Sample Name	ARD_006_1
Parameter	Units	LOR	

pH in water Method: AN101 Tested: 24/7/2019

pH**	pH Units	0.1	3.7

Conductivity and TDS by Calculation - Water Method: AN106 Tested: 24/7/2019

Conductivity @ 25 C	µS/cm	2	21000

Chloride by Discrete Analyser in Water Method: AN274 Tested: 30/7/2019

Chloride, Cl	mg/L	1	6500

Sulfate in water Method: AN275 Tested: 30/7/2019

Sulfate, SO4	mg/L	1	1300

Fluoride by Ion Selective Electrode in Water Method: AN141 Tested: 25/7/2019

Fluoride by ISE	mg/L	0.1	1.0

Alkalinity Method: AN135 Tested: 24/7/2019

Total Alkalinity as CaCO3	mg/L	1	-

Acidity and Free CO2 Method: AN140 Tested: 25/7/2019

Acidity to pH 8.3	mg CaCO3/L	1	91

Metals in Water (Dissolved) by ICPOES Method: AN320 Tested: 25/7/2019

Phosphorus, P	µg/L	50	<250↑
Silicon, Si	µg/L	20	20000
Sulfur, S	µg/L	100	510000

Cations in Water (Dissolved) by ICPOES Method: AN020/AN320 Tested: 25/7/2019

Calcium, Ca	µg/L	10	130000
Magnesium, Mg	µg/L	10	370000
Potassium, K	µg/L	50	41000
Sodium, Na	µg/L	50	3500000

		Sample Number	PE136602.005
		Sample Matrix	Water
		Sample Name	ARD_006_1
Parameter	Units	LOR	

Trace Metals (Dissolved) in Water by ICPMS Method: AN318 Tested: 25/7/2019

Aluminium, Al	µg/L	5	8800
Antimony, Sb	µg/L	1	<5↑
Arsenic, As	µg/L	1	<5↑
Barium, Ba	µg/L	0.2	55
Bismuth, Bi	µg/L	1	<5↑
Boron, B	µg/L	5	4600
Cadmium, Cd	µg/L	0.1	<0.5↑
Chromium, Cr	µg/L	1	11
Cobalt, Co	µg/L	1	280
Copper, Cu	µg/L	1	310
Iron, Fe	µg/L	5	140
Lead, Pb	µg/L	1	19
Manganese, Mn	µg/L	1	940
Molybdenum, Mo	µg/L	0.5	<2.5↑
Nickel, Ni	µg/L	1	320
Selenium, Se	µg/L	1	<5↑
Silver, Ag	µg/L	1	<5↑
Strontium, Sr	µg/L	1	3100
Thallium, Tl	µg/L	1	<5↑
Thorium, Th	µg/L	1	<5↑
Tin, Sn	µg/L	1	<5↑
Titanium, Ti	µg/L	1	<5↑
Uranium, U	µg/L	1	<5↑
Vanadium, V	µg/L	1	<5↑
Zinc, Zn	µg/L	5	7200

Mercury (dissolved) in Water Method: AN311(Perth)/AN312 Tested: 25/7/2019

Mercury	µg/L	0.05	0.22

MB blank results are compared to the Limit of Reporting
LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared the the amount of analyte spiked into the sample.
DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula : *the absolute difference of the two results divided by the average of the two results as a percentage.* Where the DUP RPD is 'NA' , the results are less than the LOR and thus the RPD is not applicable.

Acidity and Free CO2 Method: ME-(AU)-[ENV]AN140

Parameter	QC Reference	Units	LOR	MB	DUP %RPD
Acidity to pH 8.3	LB162137	mg CaCO3/L	1	<1	1 - 22%

Alkalinity Method: ME-(AU)-[ENV]AN135

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Total Alkalinity as CaCO3	LB162127	mg/L	1	<1		97%
	LB162174	mg/L	1	<1	2%	98%

Cations in Water (Dissolved) by ICPOES Method: ME-(AU)-[ENV]AN020/AN320

Parameter	QC Reference	Units	LOR	MB	DUP %RPD
Calcium, Ca	LB162037	µg/L	10	<0	0%
Magnesium, Mg	LB162037	µg/L	10	<10	0%
Potassium, K	LB162037	µg/L	50	<0	144%
Sodium, Na	LB162037	µg/L	50	<0	66%

Chloride by Discrete Analyser in Water Method: ME-(AU)-[ENV]AN274

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Chloride, Cl	LB162207	mg/L	1	<1	0 - 3%	96 - 97%	83 - 91%

Conductivity and TDS by Calculation - Water Method: ME-(AU)-[ENV]AN106

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Conductivity @ 25 C	LB162128	µS/cm	2	<2	0%	102%
	LB162175	µS/cm	2	<2	0%	102 - 103%

Fluoride by Ion Selective Electrode in Water Method: ME-(AU)-[ENV]AN141

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Fluoride by ISE	LB162038	mg/L	0.1	<0.1	0 - 4%	98 - 103%	93 - 105%

MB blank results are compared to the Limit of Reporting
LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared the the amount of analyte spiked into the sample.
DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula : *the absolute difference of the two results divided by the average of the two results as a percentage.* Where the DUP RPD is 'NA' , the results are less than the LOR and thus the RPD is not applicable.

Mercury (dissolved) in Water Method: ME-(AU)-[ENV]AN311(Perth)/AN312

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Mercury	LB162057	µg/L	0.05	<0.05	0 - 25%	99 - 104%	88 - 104%

Metals in Water (Dissolved) by ICPOES Method: ME-(AU)-[ENV]AN320

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Phosphorus, P	LB162033	µg/L	50	<0		95%
Silicon, Si	LB162033	µg/L	20	<0	3%	100%
Sulfur, S	LB162033	µg/L	100	<0		98%

pH in water Method: ME-(AU)-[ENV]AN101

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
pH**	LB162128	pH Units	0.1	5.2 - 5.6		100 - 101%
	LB162175	pH Units	0.1	5.2 - 5.5	0 - 1%	100 - 101%

Sulfate in water Method: ME-(AU)-[ENV]AN275

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Sulfate, SO4	LB162207	mg/L	1	<1	0 - 2%	101 - 105%	97 - 99%

Trace Metals (Dissolved) in Water by ICPMS Method: ME-(AU)-[ENV]AN318

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Aluminium, Al	LB162029	µg/L	5	<5	4 - 9%	87%	
Antimony, Sb	LB162029	µg/L	1	<1	0%	89%	95%
Arsenic, As	LB162029	µg/L	1	<1	0 - 2%	114%	108%
Barium, Ba	LB162029	µg/L	0.2	<1.0	0%	100%	
Bismuth, Bi	LB162029	µg/L	1	<1	0%	99%	
Boron, B	LB162029	µg/L	5	<5	0%	112%	21%
Cadmium, Cd	LB162029	µg/L	0.1	<0.1	0%	110%	105%
Chromium, Cr	LB162029	µg/L	1	<1	1%	98%	100%
Cobalt, Co	LB162029	µg/L	1	<1	0%	100%	100%
Copper, Cu	LB162029	µg/L	1	<1	0 - 2%	108%	104%
Iron, Fe	LB162029	µg/L	5	<5	0 - 4%	88%	98%
Lead, Pb	LB162029	µg/L	1	<1	0 - 1%	103%	102%
Manganese, Mn	LB162029	µg/L	1	<1	0 - 1%	99%	100%
Molybdenum, Mo	LB162029	µg/L	0.5	<1.0	0 - 7%	99%	
Nickel, Ni	LB162029	µg/L	1	<1	0 - 1%	106%	97%
Selenium, Se	LB162029	µg/L	1	<1	0%	96%	127%
Silver, Ag	LB162029	µg/L	1	<1	0%	93%	
Strontium, Sr	LB162029	µg/L	1	<1	0 - 2%	86%	
Thallium, Tl	LB162029	µg/L	1	<1	0%	101%	102%
Thorium, Th	LB162029	µg/L	1	<1	0%	93%	
Tin, Sn	LB162029	µg/L	1	<1	0%	96%	
Titanium, Ti	LB162029	µg/L	1	<1	0 - 11%	94%	
Uranium, U	LB162029	µg/L	1	<1	0%	89%	
Vanadium, V	LB162029	µg/L	1	<1	0 - 5%	99%	
Zinc, Zn	LB162029	µg/L	5	<5	0 - 1%	118%	109%

METHOD	METHODOLOGY SUMMARY
AN020/AN320 LL	Dissolved Cations Low LOR by ICP-OES: Method is as per routine ICP OES method reporting a variation to the method being lower limit of reporting (LOR) for selected cations as validated by the site. Referenced to APHA 3120B.
AN101	pH in Soil Sludge Sediment and Water: pH is measured electrometrically using a combination electrode (glass plus reference electrode) and is calibrated against 3 buffers purchased commercially. For soils, an extract with water is made at a ratio of 1:5 and the pH determined and reported on the extract. Reference APHA 4500-H+.
AN106	Conductivity and TDS by Calculation: Conductivity is measured by meter with temperature compensation and is calibrated against a standard solution of potassium chloride. Conductivity is generally reported as µmhos/cm or µS/cm @ 25°C. For soils, an extract with water is made at a ratio of 1:5 and the EC determined and reported on the extract, or calculated back to the as-received sample. Total Dissolved Salts can be estimated from conductivity using a conversion factor, which for natural waters, is in the range 0.55 to 0.75. SGS use 0.6. Reference APHA 2510 B.
AN106	Salinity may be calculated in terms of NaCl from the sample conductivity. This assumes all soluble salts present, measured by the conductivity, are present as NaCl.
AN135	Alkalinity (and forms of) by Titration: The sample is titrated with standard acid to pH 8.3 (P titre) and pH 4.5 (T titre) and permanent and/or total alkalinity calculated. The results are expressed as equivalents of calcium carbonate or recalculated as bicarbonate, carbonate and hydroxide. Reference APHA 2320. Internal Reference AN135
AN140	Acidity by Titration: The water sample is titrated with sodium hydroxide to designated pH end point. In a sample containing only carbon dioxide, bicarbonates and carbonates, titration to pH 8.3 at 25°C corresponds to stoichiometric neutralisation of carbonic acid to bicarbonate. Method reference APHA 2310 B.
AN141	Determination of Fluoride by ISE: A fluoride ion selective electrode and reference electrode combination, in the presence of a pH/complexation buffer, is used to determine the fluoride concentration. The electrode millivolt response is measured logarithmically against fluoride concentration. Reference APHA F- C.
AN274	Chloride by Aquakem DA: Chloride reacts with mercuric thiocyanate forming a mercuric chloride complex. In the presence of ferric iron, highly coloured ferric thiocyanate is formed which is proportional to the chloride concentration. Reference APHA 4500Cl-
AN275	sulfate by Aquakem DA: sulfate is precipitated in an acidic medium with barium chloride. The resulting turbidity is measured photometrically at 405nm and compared with standard calibration solutions to determine the sulfate concentration in the sample. Reference APHA 4500-SO42-. Internal reference AN275.
AN311(Perth)/AN312	Mercury by Cold Vapour AAS in Waters: Mercury ions are reduced by stannous chloride reagent in acidic solution to elemental mercury. This mercury vapour is purged by nitrogen into a cold cell in an atomic absorption spectrometer or mercury analyser. Quantification is made by comparing absorbances to those of the calibration standards. Reference APHA 3112/3500.
AN318	Determination of elements at trace level in waters by ICP-MS technique, in accordance with USEPA 6020A.
AN320	Metals by ICP-OES: Samples are preserved with 10% nitric acid for a wide range of metals and some non-metals. This solution is measured by Inductively Coupled Plasma. Solutions are aspirated into an argon plasma at 8000-10000K and emit characteristic energy or light as a result of electron transitions through unique energy levels. The emitted light is focused onto a diffraction grating where it is separated into components.
AN320	Photomultipliers or CCDs are used to measure the light intensity at specific wavelengths. This intensity is directly proportional to concentration. Corrections are required to compensate for spectral overlap between elements. Reference APHA 3120 B.

METHOD	METHODOLOGY SUMMARY
Calculation	Free and Total Carbon Dioxide may be calculated using alkalinity forms only when the samples TDS is <500mg/L. If TDS is >500mg/L free or total carbon dioxide cannot be reported. APHA4500CO2 D.

FOOTNOTES

IS	Insufficient sample for analysis.	LOR	Limit of Reporting
LNR	Sample listed, but not received.	↑↓	Raised or Lowered Limit of Reporting
*	NATA accreditation does not cover the performance of this service.	QFH	QC result is above the upper tolerance
		QFL	QC result is below the lower tolerance
**	Indicative data, theoretical holding time exceeded.	-	The sample was not analysed for this analyte
		NVL	Not Validated

Unless it is reported that sampling has been performed by SGS, the samples have been analysed as received.
Solid samples expressed on a dry weight basis.

Where "Total" analyte groups are reported (for example, Total PAHs, Total OC Pesticides) the total will be calculated as the sum of the individual analytes, with those analytes that are reported as <LOR being assumed to be zero. The summed (Total) limit of reporting is calcuated by summing the individual analyte LORs and dividing by two. For example, where 16 individual analytes are being summed and each has an LOR of 0.1 mg/kg, the "Totals" LOR will be 1.6 / 2 (0.8 mg/kg). Where only 2 analytes are being summed, the " Total" LOR will be the sum of those two LORs.

Some totals may not appear to add up because the total is rounded after adding up the raw values.

If reported, measurement uncertainty follow the ± sign after the analytical result and is expressed as the expanded uncertainty calculated using a coverage factor of 2, providing a level of confidence of approximately 95%, unless stated otherwise in the comments section of this report.

Results reported for samples tested under test methods with codes starting with ARS-SOP, radionuclide or gross radioactivity concentrations are expressed in becquerel (Bq) per unit of mass or volume or per wipe as stated on the report. Becquerel is the SI unit for activity and equals one nuclear transformation per second.
Note that in terms of units of radioactivity:

a. 1 Bq is equivalent to 27 pCi
b. 37 MBq is equivalent to 1 mCi

For results reported for samples tested under test methods with codes starting with ARS-SOP, less than (<) values indicate the detection limit for each radionuclide or parameter for the measurement system used. The respective detection limits have been calculated in accordance with ISO 11929.

The QC and MU criteria are subject to internal review according to the SGS QAQC plan and may be provided on request or alternatively can be found here: www.sgs.com.au.pv.sgsvr/en-gb/environment.

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ANALYTICAL REPORT

Accreditation No. 2562

CLIENT DETAILS

Contact	Graeme Campbell
Client	Graeme Campbell & Associates Pty Ltd
Address	PO Box 247 Bridgetown WA 6255
Telephone	0897 612 829
Facsimile	0897 612 830
Email	gca@wn.com.au
Project	**GCA Job No. 1901/1**
Order Number	**GCA Job No. 1901/1**
Samples	5

LABORATORY DETAILS

Manager	Marjana Siljanoska
Laboratory	SGS Perth Environmental
Address	28 Reid Rd Perth Airport WA 6105
Telephone	(08) 9373 3500
Facsimile	(08) 9373 3556
Email	au.environmental.perth@sgs.com
SGS Reference	**PE136602A R0**
Date Received	01 Aug 2019
Date Reported	13 Aug 2019

COMMENTS

Accredited for compliance with ISO/IEC 17025 - Testing. NATA accredited laboratory 2562(898/20210).

SIGNATORIES

Mary Ann Ola-A
Inorganics Team Leader

		Sample Number	PE136602A.001	PE136602A.002
		Sample Matrix	Water	Water
		Sample Name	ARD_001_1	ARD_002_1
Parameter	Units	LOR		

Hexavalent Chromium in water by Discrete Analyser Method: AN283 Tested: 7/8/2019

Hexavalent Chromium, Cr6+	mg/L	0.001	<0.001	<0.001

Reactive Silica by Aquakem Discrete Analyser Method: AN270 Tested: 12/8/2019

Reactive Silica, Si	mg/L	0.05	13	20

		Sample Number Sample Matrix Sample Name	PE136602A.003 Water ARD_004_1	PE136602A.004 Water ARD_005_1
Parameter	Units	LOR		

Hexavalent Chromium in water by Discrete Analyser Method: AN283 Tested: 7/8/2019

Parameter	Units	LOR	ARD_004_1	ARD_005_1
Hexavalent Chromium, Cr6+	mg/L	0.001	<0.001	<0.001

Reactive Silica by Aquakem Discrete Analyser Method: AN270 Tested: 12/8/2019

Parameter	Units	LOR	ARD_004_1	ARD_005_1
Reactive Silica, Si	mg/L	0.05	7.6	17

Parameter	Units	LOR	Sample Number PE136602A.005 Sample Matrix Water Sample Name ARD_006_1

Hexavalent Chromium in water by Discrete Analyser Method: AN283 Tested: 7/8/2019

Hexavalent Chromium, Cr6+	mg/L	0.001	<0.001

Reactive Silica by Aquakem Discrete Analyser Method: AN270 Tested: 12/8/2019

Reactive Silica, Si	mg/L	0.05	20

MB blank results are compared to the Limit of Reporting
LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared the the amount of analyte spiked into the sample.
DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula : *the absolute difference of the two results divided by the average of the two results as a percentage.* Where the DUP RPD is 'NA' , the results are less than the LOR and thus the RPD is not applicable.

Hexavalent Chromium in water by Discrete Analyser Method: ME-(AU)-[ENV]AN283

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Hexavalent Chromium, Cr6+	LB162474	mg/L	0.001	<0.001	0%	NA	NA

Reactive Silica by Aquakem Discrete Analyser Method: ME-(AU)-[ENV]AN270

Parameter	QC Reference	Units	LOR	DUP %RPD	LCS %Recovery	MS %Recovery
Reactive Silica, Si	LB162619	mg/L	0.05	0 - 1%	100%	86%

METHOD	METHODOLOGY SUMMARY
AN270	Reactive forms of silicon in acid solution below pH 2 react with ammonium molybdate ions to form a yellow silicomolybdate which is then reduced with ascorbic acid to produce a blue silicomolybdate complex. Oxalic acid is added to destroy any molybdophosphoric acid. Colourimetric determination by Aquakem Discrete Analyser.
AN283	Hexavalent Chromium via Discrete Analyser: Soluble hexavalent chromium forms a red/violet colour with diphenylcarbazide in acidic solution. This procedure is very sensitive and nearly specific for Cr6+. If total chromium is also measured the trivalent form of chromium Cr3+ can be calcuIated from the difference (Total Cr - Cr6+). Reference APHA3500CrB.

FOOTNOTES

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**	Indicative data, theoretical holding time exceeded.	QFL	QC result is below the lower tolerance
		-	The sample was not analysed for this analyte
		NVL	Not Validated

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Solid samples expressed on a dry weight basis.

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Note that in terms of units of radioactivity:
a. 1 Bq is equivalent to 27 pCi
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The QC and MU criteria are subject to internal review according to the SGS QAQC plan and may be provided on request or alternatively can be found here: www.sgs.com.au.pv.sgsvr/en-gb/environment.

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Dr G Campbell
GRAEME CAMPBELL and ASSOCIATES PTY LTD
PO Box 247
BRIDGETOWN WA 6255

JOB INFORMATION

JOB CODE	143/1906246
No. of SAMPLES	16
CLIENT O/N	GCA 1901/1
PROJECT	MEDCALF
STATE	Soils
DATE RECEIVED	23/04/2019
DATE COMPLETED	25/05/2019

LEGEND

X = Less than Detection Limit
N/R = Sample Not Received
* = Result Checked
( ) = Result still to come
I/S = Insufficient Sample for Analysis
E6 = Result X 1,000,000
UA = Unable to Assay
\> = Value beyond Limit of Method

The determination of effective Cation Exchange Capacity (eCEC), and reporting of results, as given below, correspond to the requirements specified by GCA for the testing of samples of soils and mine waste (regolith) materials. These determinations are based on classical soil science procedures developed for calcareous and non-calcareous systems, and where the cation-exchange properties are dominated by permanent-charge clay minerals (cf. variable-charge sesquioxides and soil humic materials).

The samples were received as -2mm fractions from dry-sieving. For samples ARD_022, ARD_025 and ARD_026 pulps (nominal -75µm) were also tested.

1.0 Prewashing step using organic solvent for removal of soluble salts

A prewashing step is carried out for all samples to remove soluble salts using an organic solvent in which loss of dispersed / peptised clays, induced by dilution during washing, is restricted / prevented. Unwanted hydrolysis-related alteration of the initial cation suite on the exchange complex is also thereby minimised.

1g of sample is weighed into a centrifuge tube and pre-washed with 2 x 12.5ml 10% (v/v) deionised ethylene glycol in 90% (v/v) ethanol which has been previously deionised by passing through Amberlite resin.

After the centrifugation, the centrifugate / supernatant may contain dispersed colloids (clays / sesquioxides). If this is the case the addition of a few drops of PVA may be necessary to clarify the supernatant. The PVA aqueous solution is 0.05% (w/v) polyvinyl alcohol. No additions.

2.0 Extraction of Exchangeable Ca, Mg, K, and Na using 1 M-NH_4Cl buffered solutions

Cationic forms of Ca, Mg, K, and Na exchangeable with 1 M-NH_4Cl buffered solutions are determined at either pH 8.5 for calcareous samples, or pH 7 for non-calcareous samples.
For calcareous samples, the 1 M-NH_4Cl solution is an alcoholic solution: the combination of the ethanol-aqueous solvent, and the pH buffered at 8.5 (cf. 7), strongly suppresses dissolution of calcites, dolomites, etc., and thereby miminises both overestimation of eCEC, and underestimation of ESP.

A Vortex mixer is used to ensure thorough resuspension of the 'soil-plug' at the bottom of the centrifuge tube during the step-wise extraction process.

3.0 Extraction step for Calcareous samples

GLS method AmCl was used as follows for the calcareous samples: **no calcareous samples**

4.0 Extraction step for Non-calcareous samples

GLS method AmCl7 was used on all the samples, being non-calcareous:
ARD_022 pulp, ARD_025 pulp, ARD_026 pulp, ARD_022 -2mm, ARD_025 -2mm, ARD_026 -2mm, ARD_008 -2mm, ARD_015 -2mm, ARD_018 -2mm, ARD_019 -2mm and ARD_010 -2mm.

After decanting following completion of the 2nd pre-wash, the residue in the centrifuge tube is subjected to 2 x 30-minute extractions via end-over-end tumbling at approx. 10 rpm. Each extraction uses 20 ml of 1 M-NH_4Cl buffered at pH 7.0 using ammonia solution 28 % (w/w). At the completion of each extraction, the suspension is centrifuged and the supernatant decanted and collected into a communal extract. The final communal extract is brought to 50 ml with 4 M-HCl, and analysed for Ca, Mg, K and Na by OES.

Reference:
Based on procedure 15B2 in "Soil Chemical Methods – Australasia", G.E. Rayment & D.J. Lyons, 2011, CSIRO Publishing.

Results:

Element	eCEC	Na	Mg	Ca	K
Method		exch	exch	exch	exch
		ESP			
Units	cmol(+)/kg	%	%	%	%
ARD_022 pulp	5	31	37	30	2
ARD_025 pulp	8	45	35	20	0
ARD_026 pulp	12	51	30	16	2
ARD_022 -2mm	5	49	41	10	0
ARD_025 -2mm	9	58	33	8	1
ARD_026 -2mm	10	64	26	9	1
ARD_008 -2mm	8	65	27	4	4
ARD_015 -2mm	7	37	49	14	0
ARD_018 -2mm	22	53	42	2	4
CH: ARD_018 -2mm	22	53	42	2	3
ARD_019 -2mm	50	47	46	4	3
ARD_010 -2mm	21	62	33	2	3
ASS1511-3	10	2	15	72	11

5.0 Significant figures and rounding-off

The eCEC and ‘exchangeable percentage’ values are expressed to no more than 2 significant figures.
The exchangeable percentage of the individual ‘base-cations’ (as a percentage of the eCEC value) is rounded to the nearest integral value (e.g. 4%) or expressed as <1%, as appropriate. With such rounding-off for practical purposes, the sum of the respective exchangeable percentage may therefore not always equate to 100%.

6.0 Total Exchangeable Acidity and Exchangeable Aluminium

Total Exchange Acidity and Exchangeable Aluminium were determined on the supplied -2mm fractions, and based on Method 15G1 in Rayment and Lyons (2011).

Extractions were carried out on the following soil:leach ratio as per reference method 15G1

- 8 gms of sample, 80ml 1M KCl, dilution factor 1:10 extract, 1 hr agitation (bottle-rolling) at room temperature

Following filtration the extracts were titrated with dilute NaOH to a pH = 8.0 end-point to determine the Total

Exchange Acidity, expressed as cmol(+)/Kg, corresponding to cmol H+ per Kg.

In place of determining the contribution to the Total Exchange Acidity from soluble-Al forms via treatment with NaF (as per 15G1), the Al concentration in the filtered extracts was measured by ICPOES.
Calculations of exchangeable aluminium assumes all Al present as Al3+. Exchangeable aluminium is expressed in units of cmol(+)/Kg.

Gravimetric water content (GWC) measured on each sample. Intertek Genalysis codes: MPL_W022

Measurement of exchange acidity is not part of the NATA scope of accreditation

Reference:
Based on procedure 15G1 Soil Chemical Methods – Australasia, Rayment & Lyons, CSIRO 2011

Element	pH	Al	Al exch	Total Exch acidity*	GWC
Units	initial	mg/kg	cmol(+)/Kg	cmol(+)/Kg	%
	DF10	DF10			
ARD001	4.6	10	0.11	0.34	1.29
ARD002	3.7	108	1.20	1.79	1.39
CH: ARD002	4.0	109	1.21	1.81	1.39
ARD003	4.4	4	0.04	0.57	1.23
ARD005	4.2	32	0.36	1.04	1.34
ARD006	4.0	24	0.27	0.94	1.29

*expressed as Oven Dry basis

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Intertek Genalysis Signatory:

Huong Pham

Date: 11/06/2019

Emerson Dispersion Testing

- Testing is based on **Emerson (2002)**.

Reference:

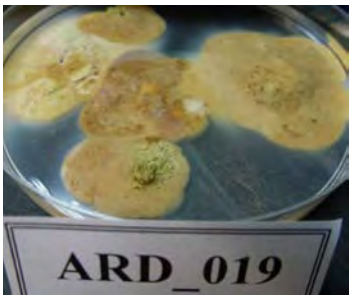
- Emerson WW, 2002, "Emerson Dispersion Test", Chapter 13, pp. 190-0199 in McKenzie N, Coughlan K, and Cresswell H (eds), *"Soil Physical Measurement and Interpretation for Land Evaluation"* , CSIRO Publishing, Collingwood.

1.0 TESTING OF DRY 'SAPROLITE-AGGREGATES'

- The following samples were tested as dry 'saprolite-aggregates' which 'survived' the original drilling, and subsequent 'coarse-crushing' during sample preparation for testing. The 'saprolite-aggregates' were hand-picked from the **+2 mm fraction** obstained via dry sieving.

- **ARD_019**

After approx. 1 hr



After approx. 24 hrs

- **ARD_020**

After approx. 1 hr

After approx. 24 hrs

- **ARD_018**

After approx. 1 hr

After approx. 24 hrs

- **ARD_010**

After approx. 1 hr

After approx. 24 hrs

- Important Observation: Immediately following immersion in deionised-water, the aggregates for the above saprolite samples did not slake in the normal manner for soil aggregates (i.e. break-down erratically with a 'flying-apart' action). Instead, the tested 'saprolite-aggregates' instantly expanded both laterally and vertically (i.e. **rapid '3D-swelling'**). Clay dispersion then ensued over the course of 24 hrs with collapse of the 'swollen-masses' initially.

2.0 TESTING OF 'SOIL-BALLS' REMOULDED FROM WET-SHEARED 'FINE-EARTH' (-2 mm) FRACTIONS

Notes:

1. Testing based on **Emerson (2002)**.
2. Testing performed on **-2 mm fraction** from dry-sieving.
3. The testing procedure employed was as follows. Approx. 50-100 gms of the air-dry solids is moistened with deionised-water and kneaded into a 'soil-bolus'.
4. The wet-shearing was undertaken using a stainless-steel-spatula, and a plastic bowl. Some physical effort was expended to repetitively 'scrape-and-smear' the **'wet-sheared-soil'** over the walls of the plastic bowl using the spatula.
5. **'Soil-balls'** around 3-5mm in diameter were then moulded by hand for immersion in deionised-water.
6. Photographs below correspond to an ageing period of 1 day in a CT-room at 20 oC.
7. Subjecting the regolith samples to wet-shearing action simulates the mechanical stresses, and ensuing breakdown of of short-range bonding between clay particles, applicable to soil-aggregates impacted by rain drops at the soil / ground surface (e.g. Wuddivira et al. 2009; Emerson 1991). In the case of waste-regoliths (e.g. saprolites), related breakdown of aggregates and clay dispersion with the onset of tunnel-erosion effects, occur where gap-graded, voidy profiles of chunky rock are used for for armouring of WRD side-slopes. Such pervious rip-rap mantles allow rapid rainfall infiltration and ensuing erosive saturated-flow at the (inclined) saprolite/rock-interface (i.e. physically unstable decommissioned WRD).

References:

- Emerson WW, 1991, "Structural Decline of Soils, Assessment and Prevention", *Australian Journal of Soil Research* , 29:905-921
- Emerson WW, 2002, "Emerson Dispersion Test", Chapter 13, pp. 190-0199 in McKenzie N, Coughlan K, and Cresswell H (eds), *"Soil Physical Measurement and Interpretation for Land Evaluation"* , CSIRO Publishing, Collingwood.
- Wuddivira MN, Stone RJ, and Ekwue EI, 2009, "Clay, Organic Matter, and Wetting Effects on Splash Detachment and Aggregate Breakdown Under Intense Rainfall", *Soil Science Society of America Journal* , 73:226-232

3.0 TESTING BOTH UNLEACHED AND LEACHED SAMPLES

1. In addition to assessing the clay-dispersion tendency of the -2 mm fractions derived from dry-sieving, dispersion testing was also undertaken on the -2 mm fractions folloowing leaching with deionised-water to elute soluble-salts (chiefly NaCl).
2. The pre-leaching treatment was conducted in the following way.

Approx. 100 g of air-dry solids was placed in a Buechner funnel on top of a Whatman No. 2 'filter-paper. 200 mL of deionised-water was then added and the resulting 'soil-mud/slurry' stirred gently using a rubber policeman attached to a glass-rod. Stirring in this way reduced a 'run-down' in salinity to unrealistically low levels in the latter stages of leaching.

3. The geometry of the leaching-test arrangement broadly corresponds to a **'surface-soil-skin' of around 20-30 mm** in thickness that is fully leached by a **storm-depth of around 20-30 mm**.
4. Following completion of leaching the Buechner funnels were placed in an oven at 40 oC to partially dewater the leached samples. The resulting sticky soil/pulp samples were then worked-up into a 'soil-bolus', as above, before being 'wet-sheared' using the stainless-steel spatula.
5. 'Soil-balls' around 3-5mm in diameter were moulded by hand for immersion in deionised-water, as before.

Setup for Leaching of Waste-Regolith Samples

4.0 RESPONSE WHEN 'SOIL-BALLS' IMMERSED IN DEIONISED-WATER

4.1 Mottled-Zone

- **ARD_001**

- **ARD_002**

- **ARD_003**

- **ARD_004**

- **ARD_005**

- **ARD_006**

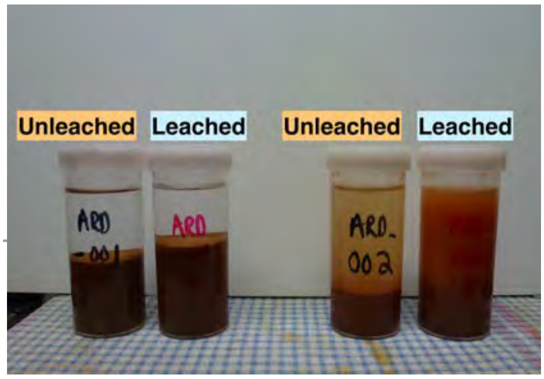
4.2 Saprolite-Zone

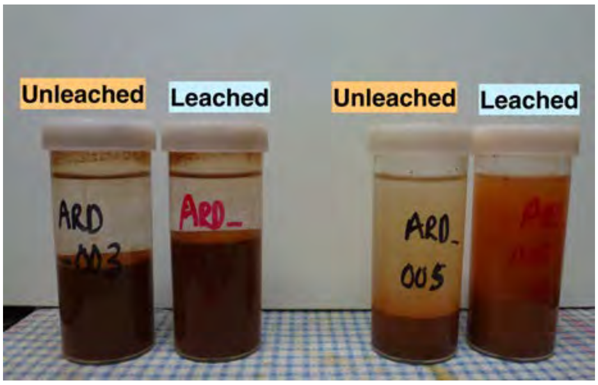
- **ARD_008**

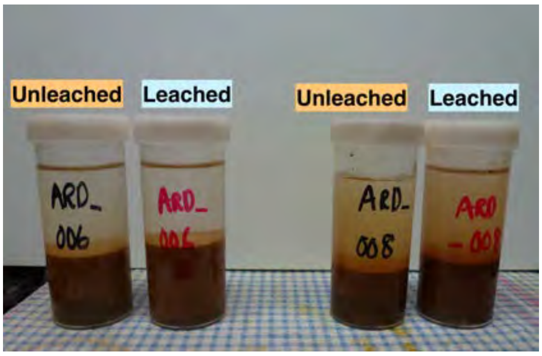
- **ARD_015**

5.0 PEPTISATION / FLOCCULATION RESPONSES FOR SAMPLES WHERE 'SOIL-BALLS' DID NOT DISPERSE WHEN IMMERSED IN DEIONISED-WATER

1. This testing was undertaken for samples ARD_001, ARD_002, ARD_003, ARD_005, ARD_006, and ARD_008.
2. None of these samples were calcareous, and none were gypsiferous. Therefore, Emerson Class Number 4 does not apply.
3. 20 gms of the -2 mm fraction was mixed with 100 mL of deionised-water, and vigorously agitated via a flask-shaker for 10 minutes. The agitated suspensions were then left to 'still-stand' for 15 minutes before assessing peptisation or flocculation.
4. Both the initial unleached and leached samples (see above) were tested.







6.0 ASSIGNMENT OF EMERSON CLASS NUMBER

	Emerson Class Number Unleached	 Leached
Mottled-Zone		
• ARD_001	6	6
• ARD_002	6	5
• ARD_003	6	6
• ARD_004	**3b**	**3a**
• ARD_005	6	5
• ARD_006	6	6
Saprolite-Zone		
• ARD_010	**2**	
• ARD_018	**1**	
• ARD_019	**1**	
• ARD_020	**1**	
• ARD_008	6	6
• ARD_015	6	

Dr GD Campbell
15th June 2019

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XRD Report – Quantitative Mineralogy of Pulped Waste-Bedrock Sample ARD_022, GCA Job No 1901/1

Mark D Raven, Peter G Self and Rodrigo Gomez-Camacho
Report No: D4608

May 2019

Graeme Campbell

Commercial-in-confidence

Citation

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Copyright and disclaimer

Important disclaimer

Introduction

One pulped bedrock sample labelled ARD_022 was submitted by Graeme Campbell for quantitative mineralogy by X-ray diffraction (XRD) analysis.

Sample Preparation

Approximately 1.5g of the as-received samples were ground for 10 minutes in a McCrone micronizing mill under ethanol. The resulting slurries were oven dried at 60°C then thoroughly mixed in an agate mortar and pestle before being lightly back pressed into stainless steel sample holders for X-ray diffraction analysis.

The XRD pattern of the micronized sample showed a broad XRD peak which indicated the presence of a partially dehydrated swelling clay (i.e. smectite) so to confirm this the sample was calcium saturated. This involved dispersing the sample in a 1M $CaCl_2$ solution, centrifuging at 5150g for 10 minutes, calcium saturating a second time, washing with water then ethanol (centrifuging at 5150g for 10 minutes after each step) before oven drying at 60°C. The dried material was thoroughly mixed in an agate mortar and pestle before being lightly back pressed into a stainless steel sample holder for X-ray diffraction analysis.

X-ray Diffraction Analysis

XRD patterns were recorded with a PANalytical X'Pert Pro Multi-purpose Diffractometer using Fe filtered Co $K\alpha$ radiation, automatic divergence slit, 2° anti-scatter slit and fast X'Celerator Si strip detector. The diffraction patterns were recorded from 3 to 80° in steps of 0.017° 2 theta with a 0.5 second counting time per step for an overall counting time of approximately 35 minutes.

Qualitative analysis was performed on the XRD data using in-house XPLOT and HighScore Plus (from PANalytical) search/match software. Quantitative analysis was performed on the XRD data using the commercial package SIROQUANT from Sietronics Pty Ltd. The results are normalised to 100%, and hence do not include estimates of unidentified or amorphous materials.

Results

Preliminary examination of the XRD pattern from the micronized, as received sample showed the presence of a very weak broad peak at approximately 14Å (~7.4° 2-theta) indicating possible swelling clays (i.e. smectite). After calcium saturation the peak intensified and shifted to ~15Å (~6.8° 2-theta, see Figure 1) confirming smectite.

Quantitative XRD analysis results are shown in Table 1 for the calcium saturated bulk samples. The XRD patterns for the bulk as received and bulk calcium saturated samples are shown in Figure 2 and 3 respectively.

The sample is composed of dominant amphibole (possibly actinolite), sub-dominant anorthite, minor quartz and trace smectite and kaolin.

Table 1 Quantitative XRD analysis (wt.%) of the micronized, calcium saturated bulk sample (oven dried 60°C basis)

CSIRO ID	**Client ID**	**Quartz**	**Anorthite**	**Amphibole**	**Smectite**	**Kaolin**
52797	**ARD_022**	5	30	61	2	2

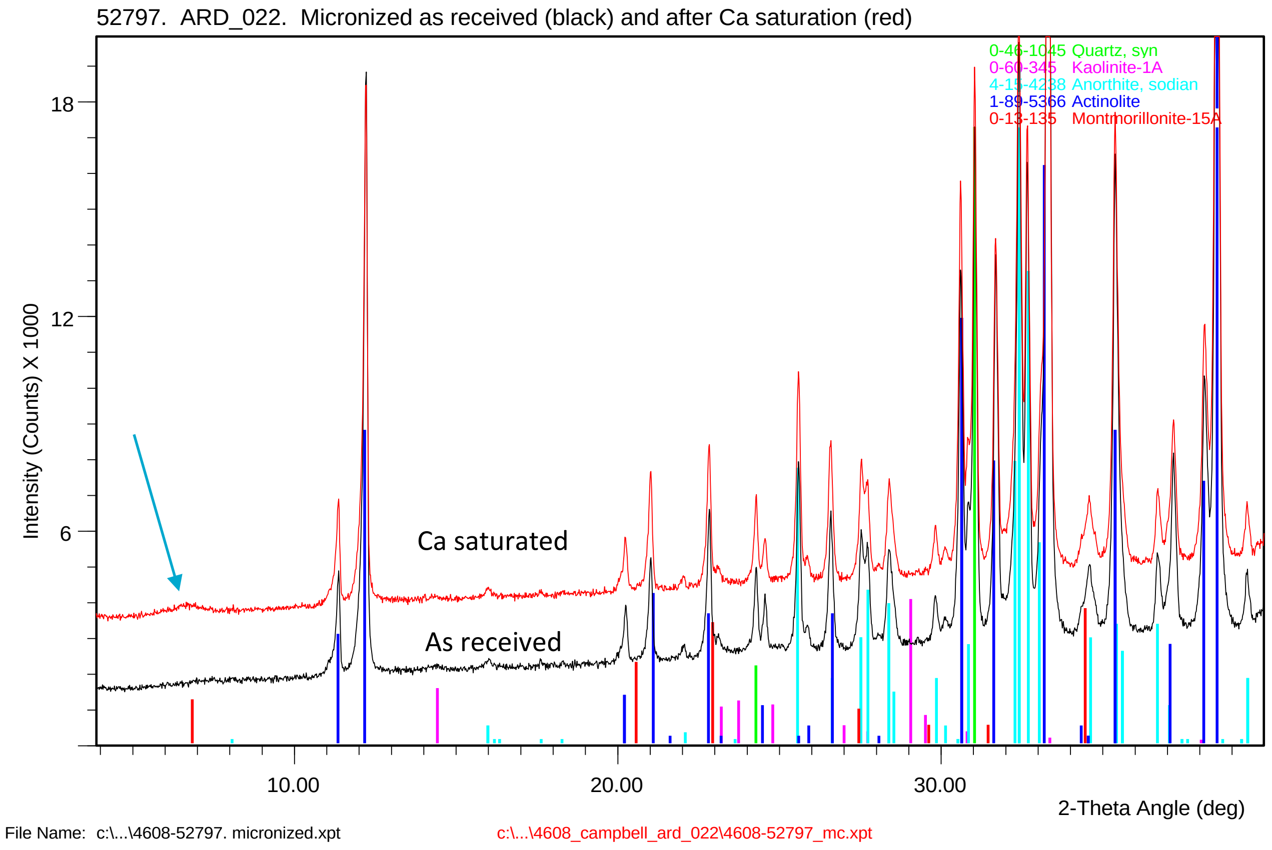

Figure 1 Comparison of the XRD pattern of ARD_022, bulk micronized, as received (black pattern) and after calcium saturation (red pattern) showing the peak at ~7.4° 2-theta shifting to ~6.8° 2-theta (Co Kα radiation)

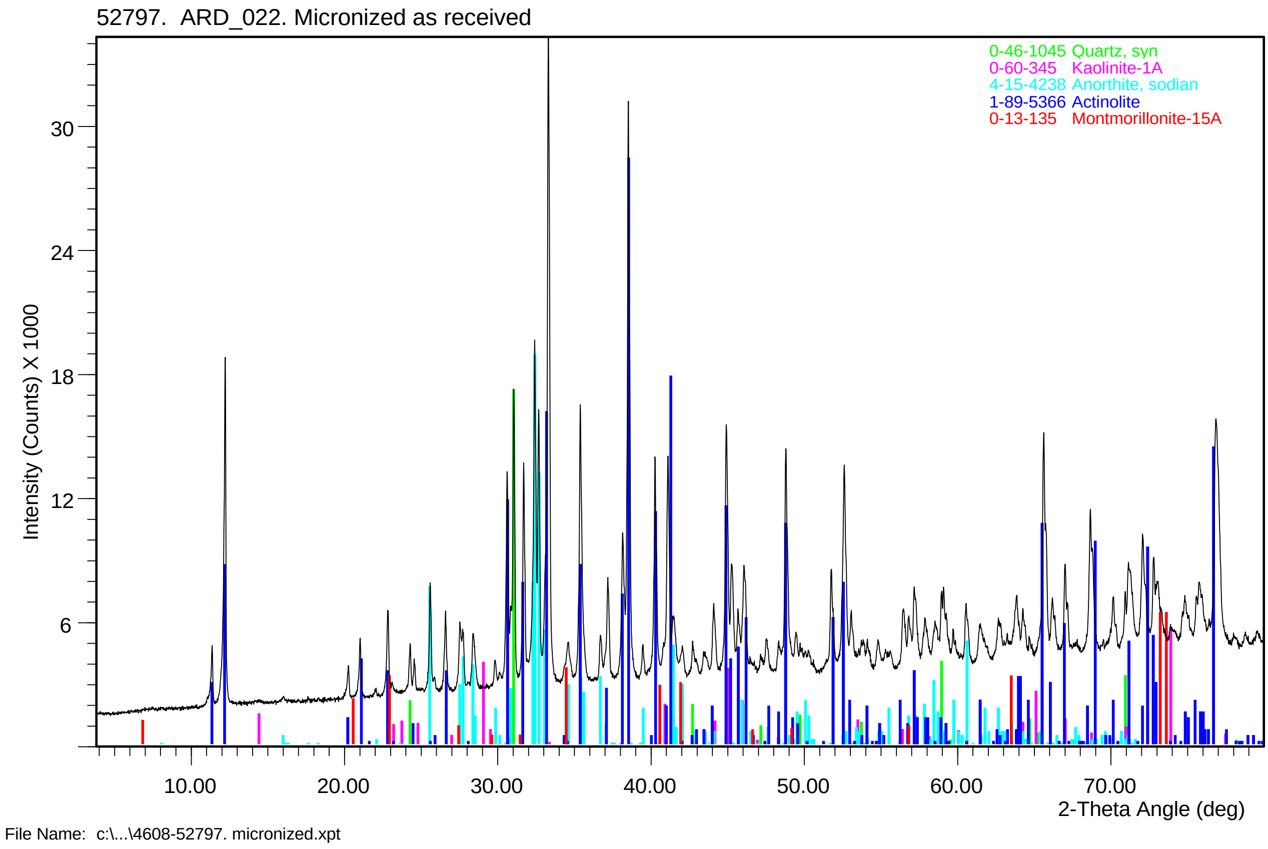

Figure 2 XRD pattern of ARD_022, bulk micronized, as received sample (Co Kα radiation)

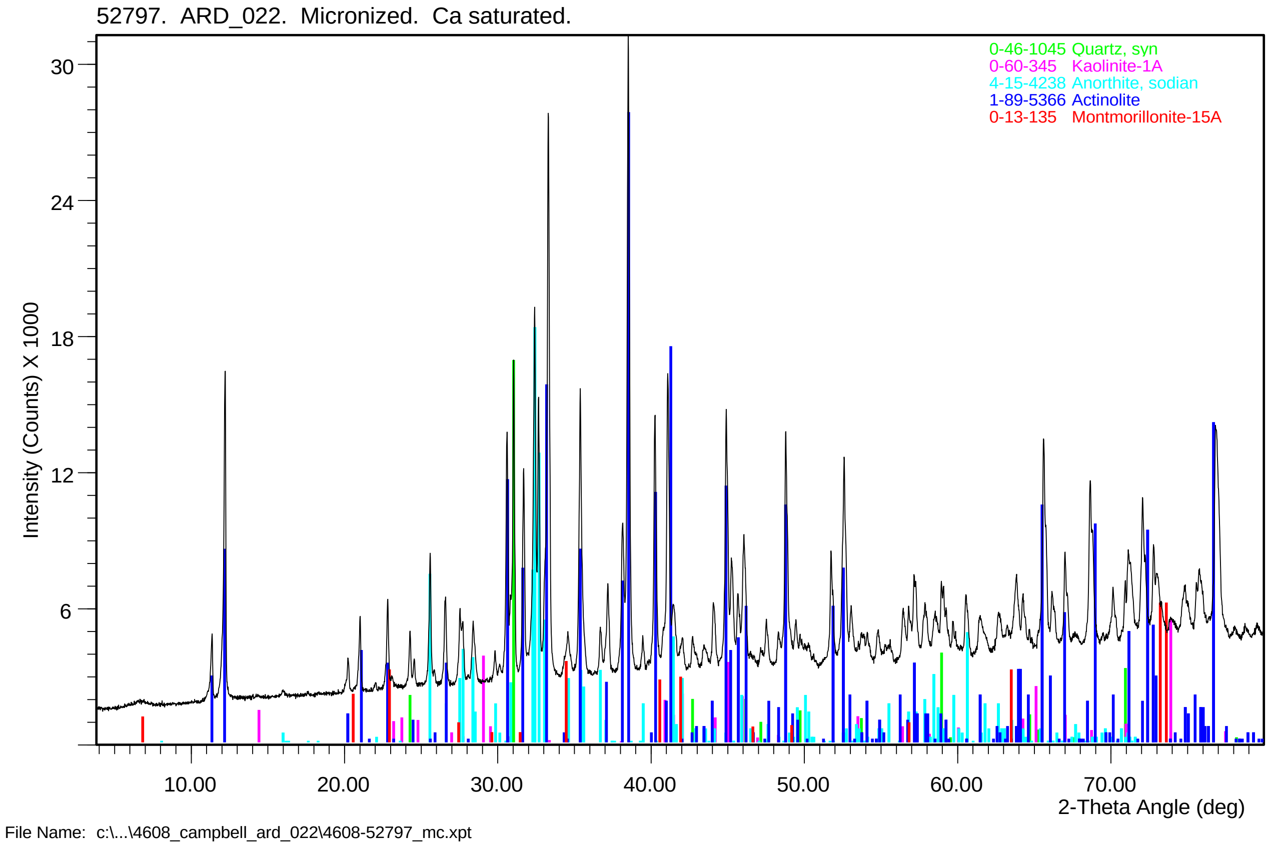

Figure 3 XRD pattern of ARD_022, bulk micronized, calcium saturated sample (Co Kα radiation)

CONTACT US

t 1300 363 400
+61 3 9545 2176
e enquiries@csiro.au
w www.csiro.au

FOR FURTHER INFORMATION

CSIRO Land and Water
Mark Raven
t +61 8 8303 8497
e mark.raven@csiro.au
w www.csiro.au