



Date: February 2010

Project: Redbank Copper ERL 94

Purpose: Provide the analyses and interpretation of the results of sediment samples taken to assess existing stream bed soil conditions.

Scope: Redbank ERL and surrounds (2010 – 2011)

Authorisation:

Prepared by: Huon Clark

Date: 4th March 2010

Accreditation by:

Date:

Approved by: Ray Hall

Date: 5th March 2010

■ **DARWIN**

Winlow House, 3rd Floor
75 Woods Street Darwin NT 0800
PO Box 381, Darwin NT 0800
P: +61 8 8981 1100 F: +61 8 8981 1102
E: ecoz@ecoz.com.au
W: www.vdmconsulting.com.au

■ **AUSTRALIA**

Perth
Melbourne
Sydney
Brisbane
Darwin

■ **INTERNATIONAL**

Abu Dhabi, UAE
Dubai, UAE
Hanoi, Vietnam



Methodology

Four sediment samples were taken in October 2009 from dry creek beds. Sample locations were downstream of the Sandy Flat Pit (SFP), and downstream of the expression point where treated water from Sandy Flat is released into Hanrahans Creek.

Sample locations matched surface water sample locations used in the past. Two of the sediment sample locations were chosen as reference sites, and two were selected within the contamination zone of the Sandy Flat Mine.

The four sediment sample sites are described in **Table 1** below.

Table 1: Sediment Sample Site Descriptions

Site #	Location	Km downstream of Expression Point	Purpose
1	Echo Creek upstream of Hanrahans Creek	1.4 km	Reference
2	Echo Creek downstream of Hanrahans Creek	1.6 km	Contaminated
3	Echo Creek upstream of 12 Mile Creek	5.1km	Contaminated
4	12 Mile Creek upstream of Echo Creek	5.25km	Reference

Results

The Laboratory Certificate of Analysis (COA) has been supplied as an attachment to this document. **Table 2** is a summary of the heavy metals that were found in high concentrations within the sediments. Samples were sent to a National Association of Testing Authorities (NATA) accredited laboratory (ALS laboratories Brisbane) for analysis.

Table 2: Major parameters that returned high levels within creek bed sediments taken from the Redbank Region.

Parameter	NEPM EIL GUIDELINES FOR SOILS	Site 1	Site 2	Site 3	Site 4
(mg/kg)	(mg/kg)	Reference	Contaminated	Contaminated	Reference
Aluminium	-	1000	1580	1980	1550
Copper	100	117	406	291	334
Iron	-	12200	8390	14800	8750

Discussion

As can be seen from **Table 1** and the COA, high levels of some heavy metals were detected in the soil samples (100mg/kg of copper triggers National Environment Protection Measure guidelines on ecological-based investigation levels for soils. These guidelines do not have a limit for Aluminium or Iron).

Similar results were found at both reference and contaminated sites, which could be due to the following possibilities:

- 1) Reference sites were positioned too close to creek junctions.

In the wet season, when creek flow rates are high, it is possible that if reference sites are situated too close to creek junctions, cross contamination could occur, resulting in elevated levels of contaminants in these perceived reference sites.

- 2) There are naturally high levels of these substances in the soils of this region.

It is obvious that copper and other heavy metals have been found in ore bodies and sediments in the surrounding region and it is possible that this has resulted in naturally high levels of these substances in the substrates.

Contradictory to the sediment sample results, water sample analysis from the same sites has indicated that there is a detectable difference in contamination between contaminated sites and reference sites, however water samples cannot be taken during times of peak flood when it is possible that the “reference” sites could be impacted. To clarify discrepancies, further soil sampling is planned for 2010. Future samples from reference sites will be taken further upstream of creek junctions in order to reduce the potential for cross contamination. If future sample results show similar loads of heavy metals across reference and contaminated sites, naturally high heavy metal content in soils will be confirmed as the most plausible explanation.

Due to the amount of contaminated water that has entered the Hanrahans Creek system unchecked for the past 15 years, it is not surprising that elevated concentrations of some substances have been detected. 2010 will be the first year in which contaminated flows will be largely restricted, including contaminated groundwater expression into Hanrahans Creek. As a result, it is expected that improvements in water quality should be observed from 2010 onwards. Improvements in water quality flowing through the downstream waterways should transpose to improvements in soil contamination in subsequent years. Redbank’s objective is to send only clean surface water down these creek systems, rather than contaminated waters, although contaminated groundwater that may leach into these creek systems will take longer to remediate. Improving the quality of the flow waters will dramatically reduce continued deposition of contaminants and commence flushing residual contaminants out of the soils.

A study by Chen *et al.* (2010), found that leaching contaminated soils with clean water results in a rapid reduction of soluble heavy metal levels in the soil. Copper, Lead, Zinc, Iron and Manganese were all rapidly reduced within the leachates of this treatment within 30 cleaning cycles. Acidity, however, was found to persist within the soil, and Chen *et al.* (2010) found that after 30 leaching events, only 20% of the acidity in the soil was removed through the leaching process. Although Chen *et al.*'s experiment was performed on a relatively small scale, and mimicked groundwater rather than surface water, it appears that acidity could be an ongoing issue, potentially persisting in the sediments of downstream Redbank waterways for many years.

Conclusion

It is expected that the sediment of the creek systems down stream of the Sandy Flat Mine legacy issue will be rehabilitated slowly over time with reduced levels of contaminants in flows. Redbank's best management strategy at this time is to reduce the amount of contaminated waters entering these creek systems and continue to flush these sediments with uncontaminated runoff and treated, clean water. The next year's sediment sample results will provide an indication of the time frame that could be expected for remediation of residual contamination in sediments.

As mentioned earlier, sediment sampling will be conducted in 2010 to follow up on last year's sampling. This will help ascertain the extent of soil contamination and clarify the source of heavy metals within the sediments.

These samples can be utilised as contaminated baseline results. Revised sampling locations determined this year for the natural, uncontaminated sites will provide a realistic natural baseline and the target for the currently contaminated sites.

Attachment 1: Certificate of Analysis from Laboratory



Environmental Division

CERTIFICATE OF ANALYSIS

Work Order	: EB0916193	Page	: 1 of 6
Client	: ECOZ ENVIRONMENTAL SERVICES	Laboratory	: Environmental Division Brisbane
Contact	: THE RESULTS ADDRESS	Contact	: Tim Kilmister
Address	: PO BOX 381 DARWIN NT, AUSTRALIA 0801	Address	: 32 Shand Street Stafford QLD Australia 4053
E-mail	: ecoz@ecoz.com.au	E-mail	: Services.Brisbane@alsenviro.com
Telephone	: +61 08 89811100	Telephone	: +61-7-3243 7222
Facsimile	: +61 08 89811102	Facsimile	: +61-7-3243 7218
Project	: Redbank Mines	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: ----	Date Samples Received	: 14-OCT-2009
C-O-C number	: ----	Issue Date	: 26-OCT-2009
Sampler	: EcOz Staff	No. of samples received	: 6
Site	: Redbank Mines	No. of samples analysed	: 6
Quote number	: BN/262/09		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results



NATA Accredited Laboratory 825

This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Cass Sealby	Senior Chemist - Acid Sulphate Soils	Inorganics
Cass Sealby	Senior Chemist - Acid Sulphate Soils	Stafford Minerals - AY
Kim McCabe	Senior Inorganic Chemist	Inorganics
Matt Frost	Organic Instrument Chemist	Inorganics
Stephen Hislop	Senior Inorganic Chemist	Inorganics

Environmental Division Brisbane
Part of the **ALS Laboratory Group**

32 Shand Street Stafford QLD Australia 4053
Tel. **+61-7-3243 7222** Fax. +61-7-3243 7218 www.alsglobal.com

A Campbell Brothers Limited Company





General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When date(s) and/or time(s) are shown bracketed, these have been assumed by the laboratory for processing purposes. If the sampling time is displayed as 0:00 the information was not provided by client.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.

LOR = Limit of reporting

^ = This result is computed from individual analyte detections at or above the level of reporting

- **Total Metals (EG005T): LCS recovery for Chromium and Copper analyses fall outside Dynamic Control Limits. They are however within ALS Static Control Limits and hence deemed acceptable.**
- **Total Metals (EG005T): Sample 12M U/S@Echo (EB0916193-001) shows poor duplicate results for Copper and Manganese due to sample heterogeneity. Confirmed by visual inspection.**



Analytical Results

Sub-Matrix: SOIL

Client sample ID

Client sampling date / time

				12M U/S@Echo	Echo Ck U/S	Echo D/S	Echo U/S@12M	----
				08-OCT-2009 08:15	08-OCT-2009 08:15	08-OCT-2009 08:15	08-OCT-2009 08:15	----
Compound	CAS Number	LOR	Unit	EB0916193-001	EB0916193-002	EB0916193-003	EB0916193-004	----
EA055: Moisture Content								
^ Moisture Content (dried @ 103°C)	----	1.0	%	<1.0	<1.0	14.2	<1.0	----
ED040T : Total Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	100	mg/kg	180	<100	340	270	----
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.01	<0.01	0.01	0.01	----
ED093S: Soluble Major Cations								
Calcium	7440-70-2	10	mg/kg	<10	<10	30	<10	----
Magnesium	7439-95-4	10	mg/kg	10	<10	40	<10	----
Sodium	7440-23-5	10	mg/kg	<10	<10	80	<10	----
Potassium	7440-09-7	10	mg/kg	20	<10	30	<10	----
EG005S : Soluble Metals by ICPAES								
Aluminium	7429-90-5	1	mg/kg	9	8	12	2	----
Cadmium	7440-43-9	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	----
Chromium	7440-47-3	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	----
Cobalt	7440-48-4	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	----
Copper	7440-50-8	0.1	mg/kg	<0.1	1.0	1.0	8.6	----
Iron	7439-89-6	1	mg/kg	10	5	9	2	----
Lead	7439-92-1	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	----
Manganese	7439-96-5	0.1	mg/kg	1.2	<0.1	<0.1	0.4	----
Nickel	7440-02-0	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	----
Zinc	7440-66-6	0.1	mg/kg	<0.1	<0.1	<0.1	0.1	----
EG005T: Total Metals by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	1550	1000	1580	1980	----
Cadmium	7440-43-9	1	mg/kg	<1	<1	<1	<1	----
Chromium	7440-47-3	2	mg/kg	5	5	6	8	----
Cobalt	7440-48-4	2	mg/kg	4	<2	4	3	----
Copper	7440-50-8	5	mg/kg	334	117	406	291	----
Iron	7439-89-6	50	mg/kg	8750	12200	8390	14800	----
Lead	7439-92-1	5	mg/kg	<5	<5	<5	<5	----
Manganese	7439-96-5	5	mg/kg	38	17	38	48	----
Nickel	7440-02-0	2	mg/kg	2	<2	2	3	----
Zinc	7440-66-6	5	mg/kg	<5	<5	<5	<5	----
EG020S: Soluble Metals by ICPMS								
Uranium	7440-61-1	0.01	mg/kg	<0.01	<0.01	<0.01	<0.01	----
EG020T: Total Metals by ICP-MS								
Uranium	7440-61-1	0.1	mg/kg	0.3	0.2	0.3	0.4	----
EK085M: Sulfide as S2-								

Page : 5 of 6
 Work Order : EB0916193
 Client : ECOZ ENVIRONMENTAL SERVICES
 Project : Redbank Mines



Analytical Results

Sub-Matrix: SOIL

Client sample ID

Client sampling date / time

				12M U/S@Echo	Echo Ck U/S	Echo D/S	Echo U/S@12M	----
				08-OCT-2009 08:15	08-OCT-2009 08:15	08-OCT-2009 08:15	08-OCT-2009 08:15	----
Compound	CAS Number	LOR	Unit	EB0916193-001	EB0916193-002	EB0916193-003	EB0916193-004	----
EK085M: Sulfide as S2- - Continued								
^ Sulfide as S	----	0.01	%	<0.01	<0.01	<0.01	<0.01	----



Analytical Results

Sub-Matrix: WATER

				Client sample ID	RB P1 AMD	NaOHT			
				Client sampling date / time	09-OCT-2009 08:15	09-OCT-2009 08:15			
Compound	CAS Number	LOR	Unit	EB0916193-005	EB0916193-006				
ED040F: Dissolved Major Anions									
Sulfate as SO4 2-	14808-79-8	1	mg/L	2810	----	----	----	----	----
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L	668	----	----	----	----	----
Magnesium	7439-95-4	1	mg/L	307	----	----	----	----	----
Sodium	7440-23-5	1	mg/L	17	----	----	----	----	----
Potassium	7440-09-7	1	mg/L	2	----	----	----	----	----
EG020F: Dissolved Metals by ICP-MS									
Aluminium	7429-90-5	0.01	mg/L	0.14	1.02	----	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	0.0001	<0.0001	----	----	----	----
Chromium	7440-47-3	0.001	mg/L	0.001	0.005	----	----	----	----
Cobalt	7440-48-4	0.001	mg/L	0.209	0.001	----	----	----	----
Copper	7440-50-8	0.001	mg/L	0.110	0.004	----	----	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	----	----	----	----
Manganese	7439-96-5	0.001	mg/L	3.18	0.025	----	----	----	----
Nickel	7440-02-0	0.001	mg/L	0.025	<0.001	----	----	----	----
Uranium	7440-61-1	0.001	mg/L	<0.001	<0.001	----	----	----	----
Zinc	7440-66-6	0.005	mg/L	0.015	<0.005	----	----	----	----
Iron	7439-89-6	0.05	mg/L	0.64	0.27	----	----	----	----
EG020T: Total Metals by ICP-MS									
Aluminium	7429-90-5	0.01	mg/L	0.50	2.23	----	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	0.0002	<0.0001	----	----	----	----
Chromium	7440-47-3	0.001	mg/L	<0.001	0.006	----	----	----	----
Cobalt	7440-48-4	0.001	mg/L	0.219	0.068	----	----	----	----
Copper	7440-50-8	0.001	mg/L	0.741	1.76	----	----	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	----	----	----	----
Manganese	7439-96-5	0.001	mg/L	2.96	0.128	----	----	----	----
Nickel	7440-02-0	0.001	mg/L	0.042	0.028	----	----	----	----
Uranium	7440-61-1	0.001	mg/L	<0.001	<0.001	----	----	----	----
Zinc	7440-66-6	0.005	mg/L	0.027	0.050	----	----	----	----
Iron	7439-89-6	0.05	mg/L	0.96	1.21	----	----	----	----
EK085M: Sulfide as S2-									
Sulfide as S2-	18496-25-8	0.1	mg/L	<0.1	----	----	----	----	----