GS 1999/666

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Derelict Mine Investigation. Major's Creek area, NSW. Sampling and Analysis of Stream Waters and Sediments

EGS Report R990408B

Introduction

Gold was discovered in Major's Creek in 1851. The ensuing gold rush to the area resulted in extensive mine activity until well into the 20th century. The principal means of working the alluvial sediments at first was panning and cradling, giving way to ground sluicing when the richer patches of alluvium were exhausted. Because of the elevation of the gold field, being at the watershed of the Deua and Shoalhaven catchments, extraction was limited to times of good rainfall. During the 1860-70's gold was found in numerous reefs in the area. The largest and most important of these was Dargues Reef, situated on Spring Creek, a tributary of Major's Creek not far from Major's Creek township. Dredging of some of the wider waterways in the region for gold also took place early this century. Details of the geology and history of mining are given in Kennedy (1961), Clift (1975), Gilligan (1975) and McGowan (1998).

The early mining practices would have led to significant stream disturbance and water contamination. Excavation of river beds and sluicing of river banks would have created significant sedimentation problems. The effects on river bank erosion and stability is still evident near Major's Creek township today. A rehabilitation proposal, involving Community and Government agencies, to tackle gully erosion and weed infestation has been developed by the Braidwood Office of DLWC. (Rose, 1999)

There is a Community perception that mining at Major's Creek may have led to contamination of the streams by heavy metals which pose a threat to riverine ecosystems. The metals often associated with gold mineralisation, and of environmental concern, include lead, zinc, copper, mercury and arsenic. The mining of the natural alluvium from river beds and banks, and its disposal into streams would have greatly increased the sediment load and probably resulted in temporary elevation of dissolved metals in waters. However, alluvial mining itself is unlikely to have resulted in long term increases in concentrations of these base heavy metals in the sediments. Therefore the most likely sources of heavy metals arising from old mining operations which may harm aquatic ecosystems are

(1) the disposal of crushed tailings (sands) from the processing of ore from reef deposits which contained base metal sulphides, and

(2) the use of mercury to assist in gold recovery from alluvials or crushed reef ores,

(3) seepages from old reef workings or sulphide mullock dumps.

Metal contamination of streams may also occur from other natural or anthropogenic sources. Examples of possible sources in the study area are natural erosion and seepages from mineralised rocks, old urban/farm tip sites, stormwater from roads and waste water from urban residences, litter in creeks (eg batteries, galvanise iron, etc), chemical use in orchards (eg copper-containing fungcides.

Limited information on the base metal minerals in the various reef ores in the Major's Creek area has been summarised by Kennedy, 1961 and Gilligan, 1975. Base metal sulphides recorded in the treated gold ores include pyrite, chalcopyrite, galena, sphalerite and arsenopyrite (Kennedy, 1961; Gilligan 1975). The concentrations of the heavy metals in the treated ores, however, is not well documented. These ores were presumably crushed and processed in the Major's Creek area at stamper battery sites and the tailings disposed on land or into creeks possibly resulting in localised elevations of base metal concentrations in soils, stream sediments and waters.

The use of mercury to assist in gold recovery was no doubt practiced at Major's Creek by fossickers, in small "jigs" along the riverbank, and by operators of larger stamper batteries. Most of the mercury used was recovered and recycled. Nevertheless, loss of mercury, resulting in mercury contamination of streams and mine tailings, occurred by two mechanisms. These have been discussed by Fredrickson (1992) in relation to similar operations in the Sofala Goldfields;

(1) loss of concentrated liquid mercury as spills or disposal of waste, contaminated mercury, and

(2) scouring/adsorption of mercury onto tailings particles from the battery amalgamation plates.

Where mercury, originally in the more concentrated forms of waste (eg liquid mercury or amalgams), was discharged from the mining processes, it probably remained where it was buried or has been washed into streams. Due to mercury's high density, this waste has probably been reworked and distributed during floods, in the same way other heavy minerals segregate, resulting in accumulation within the alluvium in pockets, backwashes, holes, etc. It is these occurrence which are often recovered as amalgamated gold particles or droplets of liquid mercury by modern day fossickers when working alluvium in streams which were mined intensively last century. Sampling of stream sediment to survey for this type of mercury "hot spot" contamination is not straight forward. It is unlikely that grab samples of active surface sediments (as used in the present survey) will detect such contamination; rather, bulk samples (of, say, $1m^3$) would need to be taken at carefully selected sites and treated using gravity concentrations techniques of the same type and scale used by gold miners (eg. Pan, cradle or sluice). That type of bulk sampling was beyond the scope of this study.

The tailings produced by stamper batteries are likely to have been slightly contaminated by mercury as a result of scouring action and adsorption onto fine particles from the copper-amalgam tables. It is also possible that some of the "reef"

ore bodies, processed through the stampers, naturally contained traces of mercury-containing minerals.

For these reasons dumps of tailings near stamper battery sites often contain elevated concentrations of base metals and mercury, and remain an ongoing source of the river contamination or can render soils unsuited for agricultural or residential use. The finely divided tailings entering the river system may produce a downstream, localised increase in background base metal concentrations in stream sediments.
Whether this has occurred at Majors Creek goldfield and is a cause for concern depends on the concentrations of the base metals in the tailings, the quantity of tailings and methods/sites of tailings disposal. The survey described in this report aims to identify chronic metal contamination of stream water and sediments by eroding tailings deposits or other mine waste or workings; sampling did not include stable soils in the vicinity of old battery sites which could reasonably be the subject of a separate survey.

Previous Sampling and Analysis of Water and Sediment from Spring Creek and Major's Creek.
A survey of water and sediment quality near Majors Creek township was undertaken in 1985 (Brooks and Summerhayes, 1985 April) at the time of a proposal to reopen Dargue's Reef Mine. Samples were taken at five sites in Spring Creek, including upstream and downstream of Dargue's Reef Mine, and four sites along Major's Creek from the township to the junction with Araluen Creek. Results of analysis of waters and sediments showed no indication of significant contamination by mercury or by the base metals reported to occur in the nearby reef gold outcrops. Water samples taken from mine shafts at Dragues's Reef Mine were slightly more saline than nearby creek waters, but of neutral pH, moderate alkalinity and low As, Cd, Cu, Pb and Zn concentrations. Indications were that this mine is unlikely to be the source of acid mine drainage problems arising from oxidation of the reef sulphide minerals. The slight elevation of iron and manganese in the shaft waters was considered to be a natural process and of little environmental concern as it was believed to be the result of anoxic, bicarbonate nature of the groundwater seepages. (Brooks and Summerhayes, 1985 August)

Further sampling and analysis of waters and sediments - May 1999
This report describes the sampling of waters and stream sediments undertaken on 18 and 19 May 1999 and the results of analysis. The aim was to test more sites along Majors and Araluen Creeks and to resample some of the sites in Major's and Spring Creeks which were previously tested.

This survey aims to identify chronic contamination of stream water and sediments by testing water and sediment for inorganic "indicator" chemicals. The indicator chemicals are those likely to occur in or arise from the gold ores or processing chemicals during past mining operations. The significance or otherwise of contamination will be assessed by comparison of indicator concentrations with 'Background' concentrations and with ANZECC Guideline concentration values for healthy ecosystem protection.

Flowing water and active surface sediment were collected at 11 sites as described in table1. Four of the sites were the same as previously sampled by Brooks and Summerhayes in 1985 (the latter are noted in the right hand column of table 1).

Table 1. Sampling Sites 1-19 May 1999

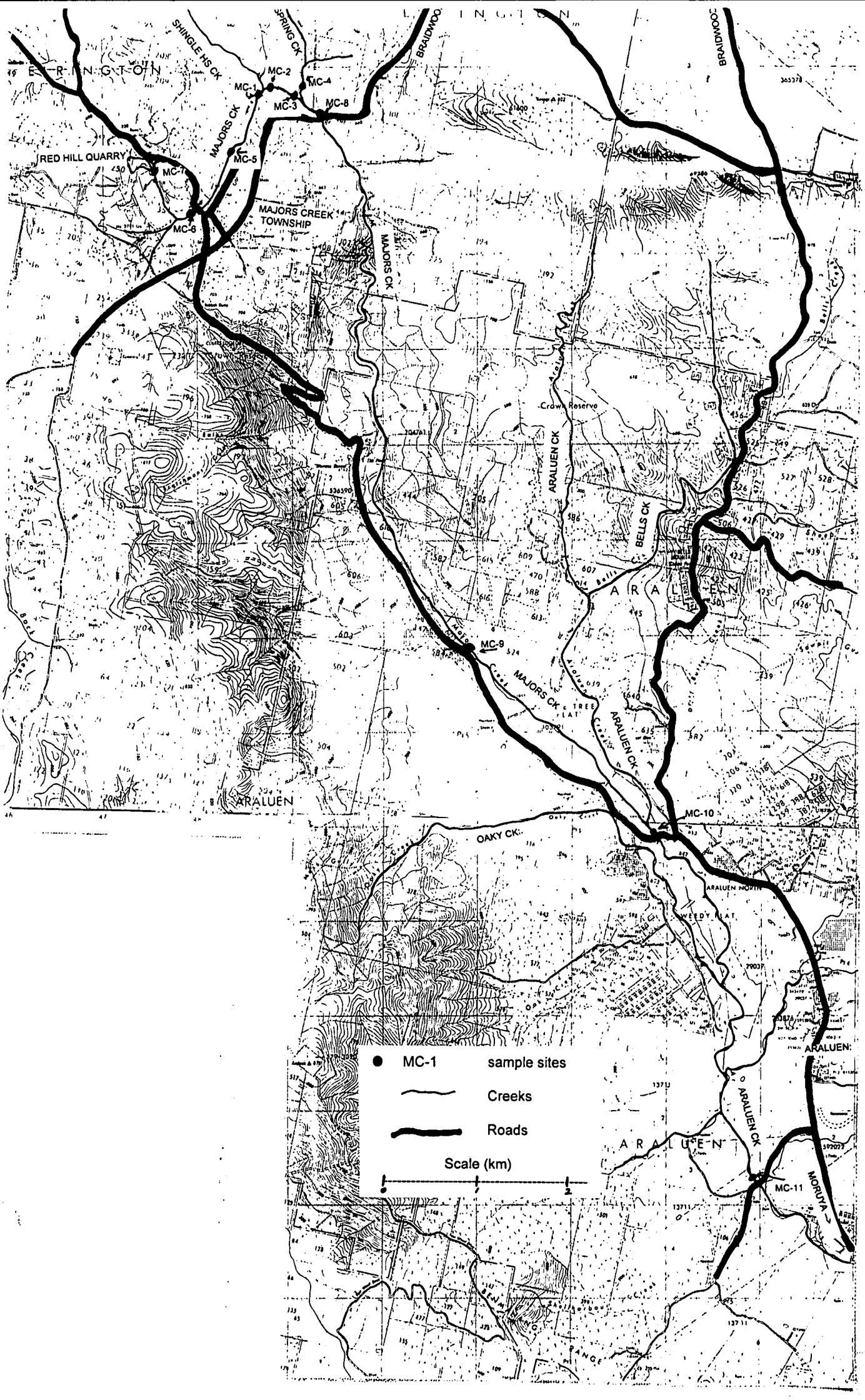
Site	Description	Site photo identity	Previous test site code*.
MC-1	Major' Creek at bend. 30m upstream of Shingle House Ck, about 250m upstream of Spring Ck. A series of rocky pools up to 1m deep. Estim flow 150L/min	5, 6	
MC-2	Major's Creek near bend. 30m downstream of Shingle House Ck and about 200m upstream of Spring Creek. A series of rocky pools up to 1m deep.		
MC-3	Major's Creek about 30m upstream of Spring Creek. A series of pools up to 1m deep, rocky with sediment.		
MC-4	Spring Creek. About 80m upstream from Major's Creek. Sandy flat streambed. Estimated flow 50L/min	3	DR-3
MC-5	Major's Creek. About 500m downstream of town. River running through narrow rocky cutting, very little sediment. Estimated flow 150 L/min		
MC-6	Major's Creek. Just above causeway near township. Large pool with sediment. Nutrient rich water - algal growths.	1	DR-8
MC-7	Dry creek draining Red Hill Quarry. Heavy erosion. (No water sample taken)	2	
MC-8	Major's Creek. Under bridge on Braidwood-to-Majors Ck road about 200m downstream of Spring Ck.		DR-9
MC-9	Major's Creek. Near N Wisby's property. Streambed of water-worn stones, very little sandy sediment.		DR-6
MC-10	Araluen Creek. Just downstream of Major's Ck junction. Under bridge on Araluen-to-Major's Ck road. Streambed wide with shallow pools and lots sandy sediment.		
MC-11	Araluen Creek. Under bridge on Araluen-to-Neragula Road. Steambed wide with shallow pools and lots of sandy sediment.	4	

* sample site identifications used in an earlier study by Brooks and Summerhayes (1985, April)

Sampling and Preparation.

Sampling and sample preparation methods are fully described in the Laboratory's Method Manual SAMPREP (Sample Collection, Preparation, Storage and Registration) and are summarised below.

Water samples were taken at each site in two polyethylene bottles: (1) 500mL of Plain unpreserved water for pH, EC, major anions and cations, and (2) 250mL in a bottle containing 5mL 5M nitric acid for trace metals analysis. Samples were transported in an Esky and kept cool until analysis within 4 days. A 50mL subsample


MC-1
sample sites
Creeks
Roads
Scale (km)
MC-1
MC-2
MC-3
MC-4
MC-5
MC-6
MC-7
MC-8
MC-9
MC-10
MC-11
RED HILL QUARRY
MAJORS CREEK TOWNSHIP
MAJORS CK
SHINGLE HS CK
SPRING CK
BRAIDWOOD
ARALUEN CK
BELLS CK
OAKY CK
ARALUEN
ARALUEN NORTH
TREE FLAT
WEEDY FLAT
MORUYA

of the acidified sample was decanted into a 50mL PET bottle and transported overnight for analysis by Genalysis Laboratories.
Stream Sediment: Samples of recently deposited surface sediment were taken underwater within pools by using a plastic scoop. Large pebbles (>15mm) were generally avoided or discarded. From 10 to 20 small grab samples from a 4 to 5 m stretch of streambed were combined in a 2L plastic jar. In the laboratory excess water was decanted and the sediment dried in aluminium trays at 40oC for 48 hours. The dry sample was weighed then sieved using a 2mm square plastic mesh and oversize discarded. Yield of minus 2mm fraction was calculated. The minus 2mm sample was sieved through a stack of plastic sieves of 600, 200 and 100 micron mesh size, fractions weighed and yields calculated. Sieve fractions, except minus 100µm, were milled in a stainless steel ring grinder. Subsamples of 0.5 g were digested in 3mL concentrated acid mix (1:3 = nitric: perchloric) for 8 hours up to 180oC in test tubes, and the residue taken up into dilute aqua-regia. Cd, Cu, Pb, Mn and Zn were analysed by flame atomic absorption spectrometry (AAS) and As by hydride generation AAS. A number of Blank and Control Soils and Sediments are digested and analysed simultaneously. Mercury analysis was carried out on subsamples of the milled sieve fractions by Genalysis Laboratories using a controlled temperature perchloric acid digestion and vapour generation-AAS method.

All analyses, except mercury, were carried by Environmental Geochemistry Services laboratory of the Department of Mineral Resources

Results of Analysis

The detailed results of water analysis is shown in Appendix 1 and sediment analysis shown in Appendix 2.
A summary of selected results and comparison with Guideline values are shown in Table 2.

Table 2. Summary of results of metals analyses of waters and sediments

Site	Estimated distance downstream (km)	Water (mg/L)				Sediment (mg/kg dry). Range of concs. in sieve fractions				
		Cu	Hg	Pb	Zn	As	Cu	Hg	Pb	Zn
Majors Ck-Araluen Ck										
MC-6	0	<0.01	<0.0002	<0.005	<0.005	6-24	10-15	0.01-0.04	10-60	25-80
MC-5	0.6	<0.01	<0.0002	<0.005	0.005	7-38	10-20	0.01-0.06	10-30	30-120
MC-1	1.4	<0.01	<0.0002	<0.005	0.03	2-4	10-20	0.01-0.02	10-15	20-60
MC-2	1.6	<0.01	<0.0002	<0.005	0.10	2-5	10-25	0.01-0.03	10-25	25-70
MC-3	1.8	<0.01	<0.0002	<0.005	<0.005	2-5	10-20	0.01-0.05	10-25	15-65
MC-8	2.2	<0.01	<0.0002	<0.005	0.095	2-7	10-40	0.01-0.04	15-115	10-75
MC-9	9.5	<0.01	<0.0002	<0.005	<0.005	4-10	5-20	<0.01-0.03	<5-5	15-40
MC-10	12.5	<0.01	<0.0002	<0.005	0.03	2-8	5-20	<0.01-0.02	<5-15	5-40
MC-11	17	0.02	<0.0002	<0.005	0.025	2-6	5-20	is	<5-5	10-40
MC-7	**Red Hill Quarry Drainage**	(dry)	-	-	-	5-17	10	0.01-0.03	20-45	15-70
MC-4	**Spring Ck**	<0.01	<0.0002	<0.005	<0.005	1-3	10-20	0.01-0.07	<5-20	10-40
ANZECC 1992*	Ecosystem Protection	0.0002-0.0005	0.0001	0.001-0.005	0.005-0.05					
"	Stock Drinking	0.5	0.002	0.1	20					
"	Irrigation Uses	0.2	0.002	0.2	2					
ANZECC Draft**	Freshwater of moderate hardness	0.0084	-	0.0048	0.0061					
ANZECC Draft**	Interim Sediment. (ISQG Low - ISQG High)					20-70	65-270	0.15-1	50-220	200-410

is = insufficient sample for Hg analysis

* Australian Water Quality Guidelines for Fresh and Marine Waters. 1992. ANZECC

** Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Draft for Public Comment. July 1999. ANZECC/ARMCANZ

Discussion of Results.

Water samples: Within the limits of detection for the various inorganic parameters tested, water quality was generally good at all sites sampled. For all inorganic chemical parameters tests the waters meet the current ANZECC Guidelines for stock drinking and irrigation uses. Signs of acid mine drainage were not significant: pH was close to neutral, alkalinity was moderate, sulphate and heavy metal concentrations were low. Within the detection limitations the waters appeared to meet the current ANZECC Guidelines for aquatic ecosystem protection except for Zinc, which was above recommended guideline values at the time of sampling at sites MC-2 and MC-8 in Major's Creek, and for Copper at MC-11 in Araluen Creek. It should be noted that (1) these metals were not present at anomalous concentrations in the sediment taken at the same time at these sites, and (2) zinc and copper were not detected in water samples taken in Feb 1985 along Major's and Araluen Creeks. Additional water sampling at various times and flows would provide confirmation of these results.

Stream sediment. The active surface sediment samples contained very low yields of the finest particle size fraction (<100 um) which is typical of intermittent high energy streams. In Major's Creek the minus 100um fraction represented less than about 2% of the sand-sized sediment. Metal concentrations in sediment fractions were generally low compared to the ANZECC-ARMCANZ Draft Interim Sediment Quality Guideline (ISQG) values. No sieve fractions exceeded the *ISQG-High* values for the metals tested, and only in the finest particle size fractions at a few sites were the *ISQG-Low* values slightly exceeded. This occurred in Major's Creek at site MC-8 for Pb and closer to the township at MC-5 and MC-6 for As and Pb. An algal bloom in the pool at site MC-6 (upstream of site MC-5) was visual evidence of nutrient inputs from urban or agricultural activities; higher As and Pb in sediment at these sites may also have arisen from similar sources.
The Draft 1999 Guidelines provide a "decision tree" framework for applying the sediment quality guidelines. The framework recommends that, if contaminant concentrations in sediment exceed both the *ISQG-Low* and the local 'background" concentrations, then factors controlling bioavailablity may need further investigation. Such an investigation, however, was beyond the scope of the current survey.

Conclusion.
Within the limits of detection for the various inorganic parameters tested, water and sediment quality was generally good at the sites tested in Major's, Spring and Araluen Creeks. The typical signs of contamination arising from past metalliferous mining; ie. increase in acidity, salinity, sulphate and heavy metal concentrations in water and sediment, were minimal. The survey however flagged a number of localised water quality issues which may or may not have arisen from past mining but which might warrant further investigations: zinc in water in Major's Ck at sites MC-2 and MC-8, and copper in Araluen Ck at MC-11, lead and/or arsenic in fine sediment at sites MC-5, MC-6 and MC-8. Visual evidence of stream contamination at site MC-8 (in the form of excess nutrient from urban and/or agricultural activities) was noted and may be associated with the As and Pb levels at this site and downstream.

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Photo 1. Site MC-6. Majors Ck near township. Algal bllom evident in pool

Photo 2. Site MC-7. Drainage line with severe erosion near Red Hill Quarry.

Photo 3. Site MC-4. Spring Creek, shallow, filled with sandy sediment.

Photo 4. Site MC-11. Araluen Creek near Araluen.

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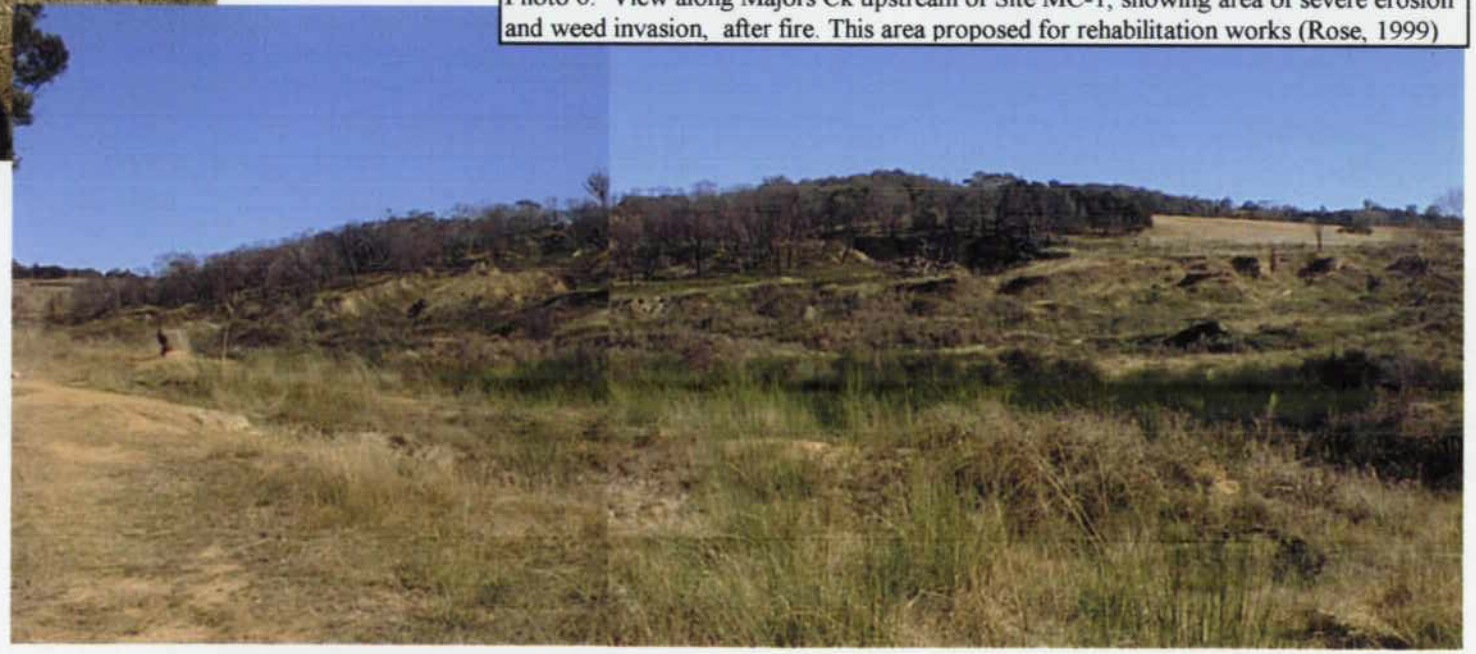
Photo 5. Site MC-1. Majors Creek u/s of Shingle House Ck

Photo 6. View along Majors Ck upstream of Site MC-1, showing area of severe erosion and weed invasion, after fire. This area proposed for rehabilitation works (Rose, 1999)



APPENDIX 1

RESULTS OF ANALYSIS OF WATER SAMPLES TAKEN 18-19 MAY 1999

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New South Wales Department of Mineral Resources

MINERAL RESOURCES DEVELOPMENT LABORATORY

WATER ANALYSIS RESULTS (Sample Analysed As Received)

Locality: Majors Creek **Report No. : R990206A**

Registration No.: E99/2404-2405 **Date Collected:** 18/5/99

Field Designation: MC-1. (Majors Ck. At bend on Val Ayer's property. 30mU/S of unnamed Ck.and ≈250m U/S of Spring Ck. (est. flow 200 L/min.)) **Collected By:** P Fredrickson

Appearance: Clear and colourless with no settleable matter

	Result	Units	Method Code
pH	7.20	pH units	
Electrical Conductivity	275	µS/cm @ 25°	
Bicarbonate	84	mg/L	
Chloride	36	mg/L	
Nitrate	<1	mg/L	
Sulphate	10	mg/L	
Alkalinity	69	mg/L($CaCO_3$)	
	Unfiltered, acidified, digested.	**Filtered, acidified**	
Cadmium	<0.002	mg/L	
Copper	<0.01	mg/L	
Lead	<0.005	mg/L	
†Mercury	<0.0002	mg/L	
Zinc	0.030	mg/L	

Sample Notes: * Plain water sample filtered through 0.6um glass fibre filter then preserved with 0.1M nitric acid

†Analysis by GENALYSIS Report/Batch Nos. : 595.0/992506 (24/5/99)

= not determined i.s. = insufficient sample NR = not required

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New South Wales Department of Mineral Resources

MINERAL RESOURCES DEVELOPMENT LABORATORY

WATER ANALYSIS RESULTS (Sample Analysed As Received)

Locality: Majors Creek **Report No. : R990206A**

Registration No.: E99/2406-2407 **Date Collected:** 18/5/99

Field Designation: MC-2 Majors Ck. 30m D/S of unnamed Ck. 60m D/S of MC-1 **Collected By:** P Fredrickson

Appearance: Clear and colourless with no settleable matter

	Result	Units	Method Code
pH	7.30	pH units	
Electrical Conductivity	290	µS/cm @ 25°	
Bicarbonate	84	mg/L	
Chloride	37	mg/L	
Nitrate	<1	mg/L	
Sulphate	10	mg/L	
Alkalinity	68	mg/L($CaCO_3$)	
	Unfiltered, acidified, digested.	**Filtered, acidified**	
Cadmium	<0.002	mg/L	
Copper	<0.01	mg/L	
Lead	<0.005	mg/L	
†Mercury	<0.0002	mg/L	
Zinc	0.100	mg/L	

Sample Notes: * Plain water sample filtered through 0.6um glass fibre filter then preserved with 0.1M nitric acid

†Analysis by GENALYSIS Report/Batch Nos. : 595.0/992506 (24/5/99)

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WATER ANALYSIS RESULTS (Sample Analysed As Received)

Locality: Majors Creek **Report No. : R990206A**

Registration No.: E99/2408-2409 **Date Collected:** 18/5/99

Field Designation: MC-3 (Majors Ck. 30m U/S of Spring Ck) **Collected By:** P Fredrickson

Appearance: Clear and colourless with no settleable matter

	Result	Units	Method Code
pH	7.40	pH units	
Electrical Conductivity	290	µS/cm @ 25°	
Bicarbonate	89	mg/L	
Chloride	36	mg/L	
Nitrate	<1	mg/L	
Sulphate	15	mg/L	
Alkalinity	73	mg/L($CaCO_3$)	
	Unfiltered, acidified, digested.	**Filtered, acidified**	
Cadmium	<0.002	mg/L	
Copper	<0.01	mg/L	
Lead	<0.005	mg/L	
†Mercury	<0.0002	mg/L	
Zinc	<0.005	mg/L	

Sample Notes: • Plain water sample filtered through 0.6um glass fibre filter then preserved with 0.1M nitric acid

†Analysis by GENALYSIS Report/Batch Nos. : 595.0/992506 (24/5/99)

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New South Wales Department of Mineral Resources

MINERAL RESOURCES DEVELOPMENT LABORATORY

WATER ANALYSIS RESULTS (Sample Analysed As Received)

Locality: Majors Creek **Report No. : R990206A**

Registration No.: E99/2410-2411 **Date Collected:** 18/5/99

Field Designation: MC-4 (Spring Ck. 30m U/S of Majors Ck. [same as DR-4] est. flow 100L/min) **Collected By:** P Fredrickson

Appearance: Clear and colourless with no settleable matter

	Result	Units	Method Code
pH	7.55	pH units	
Electrical Conductivity	885	µS/cm @ 25°	
Bicarbonate	111	mg/L	
Chloride	187	mg/L	
Nitrate	<1	mg/L	
Sulphate	25	mg/L	
Alkalinity	91	mg/L($CaCO_3$)	
	Unfiltered, acidified, digested.	**Filtered, acidified**	
Cadmium	<0.002	mg/L	
Copper	<0.01	mg/L	
Lead	<0.005	mg/L	
†Mercury	<0.0002	mg/L	
Zinc	<0.005	mg/L	

Sample Notes: * Plain water sample filtered through 0.6um glass fibre filter then preserved with 0.1M nitric acid

†Analysis by GENALYSIS Report/Batch Nos. : 595.0/992506 (24/5/99)

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New South Wales Department of Mineral Resources

MINERAL RESOURCES DEVELOPMENT LABORATORY

WATER ANALYSIS RESULTS (Sample Analysed As Received)

Locality: Majors Creek **Report No. : R990206A**

Registration No.: E99/2412-2413 **Date Collected:** 18/5/99

Field Designation: MC-5 (Majors Ck. 50m D/S of town in rock steep section. Est. flow 200L/min) **Collected By:** P Fredrickson

Appearance: Clear and colourless with a small amount of grey settleable matter.

	Result	Units	Method Code
pH	7.50	pH units	
Electrical Conductivity	240	µS/cm @ 25°	
Bicarbonate	78	mg/L	
Chloride	32	mg/L	
Nitrate	<1	mg/L	
Sulphate	5	mg/L	
Alkalinity	64	mg/L($CaCO_3$)	
	Unfiltered, acidified, digested.	**Filtered, acidified**	
Cadmium	<0.002	mg/L	
Copper	<0.01	mg/L	
Lead	<0.005	mg/L	
†Mercury	<0.0002	mg/L	
Zinc	0.005	mg/L	

Sample Notes: * Plain water sample filtered through 0.6um glass fibre filter then preserved with 0.1M nitric acid

†Analysis by GENALYSIS Report/Batch Nos. : 595.0/992506 (24/5/99)

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New South Wales Department of Mineral Resources

MINERAL RESOURCES DEVELOPMENT LABORATORY

WATER ANALYSIS RESULTS (Sample Analysed As Received)

Locality: Majors Creek **Report No. : R990206A**

Registration No.: E99/2414-2415 **Date Collected:** 18/5/99

Field Designation: MC-6 (Majors Ck. At bridge in town [same as DR-8]) **Collected By:** P Fredrickson

Appearance: Clear and colourless with no settleable matter

	Result	Units	Method Code
pH	7.10	pH units	
Electrical Conductivity	240	µS/cm @ 25°	
Bicarbonate	77	mg/L	
Chloride	35	mg/L	
Nitrate	1	mg/L	
Sulphate	<5	mg/L	
Alkalinity	63	mg/L($CaCO_3$)	
	Unfiltered, acidified, digested.	**Filtered, acidified**	
Cadmium	<0.002	mg/L	
Copper	<0.01	mg/L	
Lead	<0.005	mg/L	
†Mercury	<0.0002	mg/L	
Zinc	<0.005	mg/L	

Sample Notes: * Plain water sample filtered through 0.6um glass fibre filter then preserved with 0.1M nitric acid

†Analysis by GENALYSIS Report/Batch Nos. : 595.0/992506 (24/5/99)

= not determined i.s. = insufficient sample NR = not required

N A T A Registration No 62

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New South Wales Department of Mineral Resources

MINERAL RESOURCES DEVELOPMENT LABORATORY

WATER ANALYSIS RESULTS (Sample Analysed As Received)

Locality: Majors Creek **Report No. : R990206A**

Registration No.: E99/2416-2417 **Date Collected:** 18/5/99

Field Designation: MC-8 (Majors Ck. At Braidwood Road. Bridge) **Collected By:** P Fredrickson

Appearance: Clear and colourless with a small amount of brown settleable matter

	Result	Units	Method Code
pH	7.45	pH units	
Electrical Conductivity	440	µS/cm @ 25°	
Bicarbonate	98	mg/L	
Chloride	73	mg/L	
Nitrate	<1	mg/L	
Sulphate	15	mg/L	
Alkalinity	80	mg/L($CaCO_3$)	
	Unfiltered, acidified, digested.	**Filtered, acidified**	
Cadmium	<0.002	mg/L	
Copper	<0.01	mg/L	
Lead	<0.005	mg/L	
†Mercury	<0.0002	mg/L	
Zinc	0.095	mg/L	

Sample Notes: * Plain water sample filtered through 0.6um glass fibre filter then preserved with 0.1M nitric acid

†Analysis by GENALYSIS Report/Batch Nos. : 595.0/992506 (24/5/99)

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MINERAL RESOURCES DEVELOPMENT LABORATORY

WATER ANALYSIS RESULTS (Sample Analysed As Received)

Locality: Majors Creek **Report No. : R990206A**

Registration No.: E99/2418-2419 **Date Collected:** 18/5/99

Field Designation: MC-9 (Majors Ck. At Araluen [same as DR-6] est. flow ≈100/min.) **Collected By:** P Fredrickson

Appearance: Clear and colourless with a small amount of brown settleable matter

	Result	Units	Method Code
pH	7.45	pH units	
Electrical Conductivity	515	µS/cm @ 25°	
Bicarbonate	127	mg/L	
Chloride	66	mg/L	
Nitrate	<1	mg/L	
Sulphate	45	mg/L	
Alkalinity	104	mg/L($CaCO_3$)	
	Unfiltered, acidified, digested.	**Filtered, acidified**	
Cadmium	<0.002	mg/L	
Copper	<0.01	mg/L	
Lead	<0.005	mg/L	
†Mercury	<0.0002	mg/L	
Zinc	<0.005	mg/L	

Sample Notes: * Plain water sample filtered through 0.6um glass fibre filter then preserved with 0.1M nitric acid

†Analysis by GENALYSIS Report/Batch Nos. : 595.0/992506 (24/5/99)

= not determined i.s. = insufficient sample NR = not required

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New South Wales Department of Mineral Resources

MINERAL RESOURCES DEVELOPMENT LABORATORY

WATER ANALYSIS RESULTS (Sample Analysed As Received)

Locality: Majors Creek **Report No. : R990206A**

Registration No.: E99/2420-2421 **Date Collected:** 18/5/99

Field Designation: MC-10 (Araluen Ck. At Araluen 50m D/S of Majors Ck. Junction at Majors Ck. Rd. Bridge[sandy; neglegible surface flow]) **Collected By:** P Fredrickson

Appearance: Clear and colourless with no settleable matter

	Result	Units	Method Code
pH	7.35	pH units	
Electrical Conductivity	350	µS/cm @ 25°	
Bicarbonate	124	mg/L	
Chloride	39	mg/L	
Nitrate	<1	mg/L	
Sulphate	15	mg/L	
Alkalinity	101	mg/L($CaCO_3$)	
	Unfiltered, acidified, digested.	**Filtered, acidified**	
Cadmium	<0.002	mg/L	
Copper	<0.01	mg/L	
Lead	<0.005	mg/L	
†Mercury	<0.0002	mg/L	
Zinc	0.030	mg/L	

Sample Notes: * Plain water sample filtered through 0.6um glass fibre filter then preserved with 0.1M nitric acid

†Analysis by GENALYSIS Report/Batch Nos. : 595.0/992506 (24/5/99)

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New South Wales Department of Mineral Resources

MINERAL RESOURCES DEVELOPMENT LABORATORY

WATER ANALYSIS RESULTS (Sample Analysed As Received)

Locality: Majors Creek **Report No. : R990206A**

Registration No.: E99/2422-2423 **Date Collected:** 18/5/99

Field Designation: MC-11 (Araluen Ck. At bridge to Neragula) **Collected By:** P Fredrickson

Appearance: Clear and colourless with a small amount of black settleable matter

	Result	Units	Method Code
pH	7.45	pH units	
Electrical Conductivity	330	µS/cm @ 25°	
Bicarbonate	137	mg/L	
Chloride	29	mg/L	
Nitrate	<1	mg/L	
Sulphate	10	mg/L	
Alkalinity	112	mg/L($CaCO_3$)	
	Unfiltered, acidified, digested.	**Filtered, acidified**	
Cadmium	<0.002	mg/L	
Copper	0.02	mg/L	
Lead	<0.005	mg/L	
†Mercury	<0.0002	mg/L	
Zinc	0.025	mg/L	

Sample Notes: * Plain water sample filtered through 0.6um glass fibre filter then preserved with 0.1M nitric acid

†Analysis by GENALYSIS Report/Batch Nos. : 595.0/992506 (24/5/99)

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APPENDIX 2

RESULTS OF ANALYSIS OF STREAM SEDIMENT SAMPLES TAKEN 18-19 MAY 1999

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ENVIRONMENTAL GEOCHEMISTRY SERVICES

STREAM SEDIMENT ANALYSIS RESULTS (Sample Analysed As Received)

Report No: R990207C

Locality: MAJORS CREEK AREA

Field Designation: MC-1 **Date Collected:** 18/5/99

Parent Registration No.: E99/2424 **Collected By:** PF,DJ

Preparation Notes: Dried at 40° C in air oven

Sample Notes:

Yield of -2mm fraction (% of dry whole sample) 69 %

ANALYSIS OF SIEVE FRACTIONS (dry basis)

	-2 mm +600 µm	-600 µm +200 µm	-200 µm +100 µm	-100 µm	Method Code
Sample Reg. No.	2424	2425	2426	2427	
Sieve fraction yield (% of -2mm material)	53	41	4.0	1.9	SAMPREP
Arsenic (mg/kg)	2	2	4	4	HE-9506
Cadmium (mg/kg)	<0.5	<0.5	<0.5	<0.5	SED6-9512
Copper (mg/kg)	10	15	15	15; 20	SED6-9512
Lead (mg/kg)	15	15	20	10;10	SED6-9512
Manganese(mg/kg)	185	225	435	430; 450	SED6-9512
Mercury (mg/kg)	0.01	0.01	0.01	0.02	*CM/CVA
Zinc (mg/kg)	20	30	55	60; 60	SED6-9512

* Subcontract results: Analysis performed by Genalysis Batch Nos: 595.0/993038 (22/6/99)

- = not determined N.A. = not applicable

ENVIRONMENTAL GEOCHEMISTRY SERVICES

STREAM SEDIMENT ANALYSIS RESULTS (Sample Analysed As Received)

Report No: R990207C

Locality: MAJORS CREEK AREA

Field Designation: MC-2 **Date Collected:** 18/5/99

Parent Registration No.: E99/2428 **Collected By:** PF,DJ

Preparation Notes: Dried at 40° C in air oven

Sample Notes:

Yield of -2mm fraction (% of dry whole sample) 70 %

ANALYSIS OF SIEVE FRACTIONS (dry basis)

	-2 mm +600 µm	-600 µm +200 µm	-200 µm +100 µm	-100 µm	Method Code
Sample Reg. No.	2428	2429	2430	2431	
Sieve fraction yield (% of -2mm material)	69	28	2.5	0.8	SAMPREP
Arsenic (mg/kg)	2	2	4	5	HE-9506
Cadmium (mg/kg)	<0.5	<0.5	<0.5	<0.5	SED6-9512
Copper (mg/kg)	10	15	20	25	SED6-9512
Lead (mg/kg)	15	15	25	10	SED6-9512
Manganese(mg/kg)	170	225	400	450	SED6-9512
Mercury (mg/kg)	0.01	0.01	0.03	0.03	*CM/CVA
Zinc (mg/kg)	25	40	65	70	SED6-9512

* Subcontract results: Analysis performed by Genalysis Batch Nos: 595.0/993038 (22/6/99)

- = not determined N.A. = not applicable

ENVIRONMENTAL GEOCHEMISTRY SERVICES

STREAM SEDIMENT ANALYSIS RESULTS (Sample Analysed As Received)

Report No: R990207C

Locality: MAJORS CREEK AREA

Field Designation: MC-3 **Date Collected:** 18/5/99

Parent Registration No.: E99/2432 **Collected By:** PF,DJ

Preparation Notes: Dried at 40° C in air oven

Sample Notes:

Yield of -2mm fraction (% of dry whole sample) 62 %

ANALYSIS OF SIEVE FRACTIONS (dry basis)

	-2 mm +600 µm	-600 µm +200 µm	-100 µm	-200 µm +100 µm	Method Code
Sample Reg. No.	2432	2433	2434	2435	
Sieve fraction yield (% of -2mm material)	80	18	0.4	1.1	SAMPREP
Arsenic (mg/kg)	2	2	5	3	HE-9506
Cadmium (mg/kg)	<0.5	<0.5	<0.5	<0.5	SED6-9512
Copper (mg/kg)	10	15;10	20	15	SED6-9512
Lead (mg/kg)	15	15;15	25	10	SED6-9512
Manganese(mg/kg)	90	135;140	460	385	SED6-9512
Mercury (mg/kg)	0.01	0.01	0.05	0.04	*CM/CVA
Zinc (mg/kg)	15	25;25	65	50	SED6-9512

* Subcontract results: Analysis performed by Genalysis Batch Nos: 595.0/993038 (22/6/99)

- = not determined N.A. = not applicable

ENVIRONMENTAL GEOCHEMISTRY SERVICES

STREAM SEDIMENT ANALYSIS RESULTS (Sample Analysed As Received)

Report No: R990207C

Locality: MAJORS CREEK AREA

Field Designation: MC-4 **Date Collected:** 18/5/99

Parent Registration No.: E99/2436 **Collected By:** PF,DJ

Preparation Notes: Dried at 40° C in air oven

Sample Notes:

Yield of -2mm fraction (% of dry whole sample) 73 %

ANALYSIS OF SIEVE FRACTIONS (dry basis)

	-2 mm +600 µm	-600 µm +200 µm	-200 µm +100 µm	-100 µm	Method Code
Sample Reg. No.	2436	2437	2438	2439	
Sieve fraction yield (% of -2mm material)	82	16	1.2	0.4	SAMPREP
Arsenic (mg/kg)	1	1	2	3 ; 3	HE-9506
Cadmium (mg/kg)	<0.5	<0.5	<0.5	<0.5	SED6-9512
Copper (mg/kg)	10	10	20	15;15	SED6-9512
Lead (mg/kg)	<5	<5	15	10;20	SED6-9512
Manganese(mg/kg)	130	225	610	700;725	SED6-9512
Mercury (mg/kg)	0.01	0.02	0.05	0.07	*CM/CVA
Zinc (mg/kg)	10	10	30	40;35	SED6-9512

* Subcontract results: Analysis performed by Genalysis Batch Nos: 595.0/993038 (22/6/99)

- = not determined N.A. = not applicable

 New South Wales Department of Mineral Resources

ENVIRONMENTAL GEOCHEMISTRY SERVICES

STREAM SEDIMENT ANALYSIS RESULTS (Sample Analysed As Received)

Report No: R990207C

Locality: MAJORS CREEK AREA

Field Designation: MC-5 **Date Collected:** 18/5/99

Parent Registration No.: E99/2440 **Collected By:** PF,DJ

Preparation Notes: Dried at 40° C in air oven

Sample Notes:

Yield of -2mm fraction (% of dry whole sample) 25 %

ANALYSIS OF SIEVE FRACTIONS (dry basis)

	-2 mm +600 µm	-600 µm +200 µm	-200 µm +100 µm	-100 µm	Method Code
Sample Reg. No.	2440	2441	2442	2443	
Sieve fraction yield (% of -2mm material)	74	21	3.1	1.4	SAMPREP
Arsenic (mg/kg)	7	7	19	38	HE-9506
Cadmium (mg/kg)	<0.5	<0.5	<0.5	<0.5	SED6-9512
Copper (mg/kg)	10	10	15	20;20	SED6-9512
Lead (mg/kg)	10	15	25	30	SED6-9512
Manganese(mg/kg)	310	460	990	1290	SED6-9512
Mercury (mg/kg)	0.01	0.02	0.04	0.06	*CM/CVA
Zinc (mg/kg)	30	45	95	120	SED6-9512

* Subcontract results: Analysis performed by Genalysis Batch Nos: 595.0/993038 (22/6/99)

- = not determined N.A. = not applicable

ENVIRONMENTAL GEOCHEMISTRY SERVICES

STREAM SEDIMENT ANALYSIS RESULTS (Sample Analysed As Received)

Report No: R990207C

Locality: MAJORS CREEK AREA

Field Designation: MC-6 **Date Collected:** 18/5/99

Parent Registration No.: E99/2444 **Collected By:** PF,DJ

Preparation Notes: Dried at 40° C in air oven

Sample Notes:

Yield of -2mm fraction (% of dry whole sample) 50 %

ANALYSIS OF SIEVE FRACTIONS (dry basis)

	-2 mm +600 µm	-600 µm +200 µm	-200 µm +100 µm	-100 µm	Method Code
Sample Reg. No.	2444	2445	2446	2447	
Sieve fraction yield (% of -2mm material)	59	35	4.1	2.3	SAMPREP
Arsenic (mg/kg)	6	7	10	24	HE-9506
Cadmium (mg/kg)	<0.5	<0.5	<0.5	<0.5	SED6-9512
Copper (mg/kg)	10	10	15	15	SED6-9512
Lead (mg/kg)	10	60	25	30	SED6-9512
Manganese(mg/kg)	175	420	580	550	SED6-9512
Mercury (mg/kg)	0.01	0.01	0.02	0.04	*CM/CVA
Zinc (mg/kg)	25	60	75	80	SED6-9512

* Subcontract results: Analysis performed by Genalysis Batch Nos: 595.0/993038 (22/6/99)

- = not determined N.A. = not applicable

ENVIRONMENTAL GEOCHEMISTRY SERVICES

STREAM SEDIMENT ANALYSIS RESULTS (Sample Analysed As Received)

Report No: R990207C

Locality: MAJORS CREEK AREA

Field Designation: MC-7 **Date Collected:** 18/5/99

Parent Registration No.: E99/2448 **Collected By:** PF,DJ

Preparation Notes: Dried at 40° C in air oven

Sample Notes:

Yield of -2mm fraction (% of dry whole sample) 72 %

ANALYSIS OF SIEVE FRACTIONS (dry basis)

	-2 mm +600 µm	-600 µm +200 µm	-200 µm +100 µm	-100 µm	Method Code
Sample Reg. No.	2448	2449	2450	2451	
Sieve fraction yield (% of -2mm material)	74	20	3.1	3.7	SAMPREP
Arsenic (mg/kg)	5	9	16	17	HE-9506
Cadmium (mg/kg)	<0.5	<0.5	<0.5	<0.5	SED6-9512
Copper (mg/kg)	10	10	10	10	SED6-9512
Lead (mg/kg)	20	30	45	40	SED6-9512
Manganese(mg/kg)	75	105	210	215	SED6-9512
Mercury (mg/kg)	0.01	0.01	0.02	0.03	*CM/CVA
Zinc (mg/kg)	15	25	60	70	SED6-9512

* Subcontract results: Analysis performed by Genalysis Batch Nos: 595.0/993038 (22/6/99)

- = not determined N.A. = not applicable

ENVIRONMENTAL GEOCHEMISTRY SERVICES

STREAM SEDIMENT ANALYSIS RESULTS (Sample Analysed As Received)

Report No: R990207C

Locality: MAJORS CREEK AREA

Field Designation: MC-8 **Date Collected:** 18/5/99

Parent Registration No.: E99/2452 **Collected By:** PF,DJ

Preparation Notes: Dried at 40° C in air oven

Sample Notes:

Yield of -2mm fraction (% of dry whole sample) 42 %

ANALYSIS OF SIEVE FRACTIONS (dry basis)

	-2 mm +600 µm	-600 µm +200 µm	-200 µm +100 µm	-100 µm	Method Code
Sample Reg. No.	2452	2453	2454	2455	
Sieve fraction yield (% of -2mm material)	79	18	2.3	0.6	SAMPREP
Arsenic (mg/kg)	2	3; 3	5	7	HE-9506
Cadmium (mg/kg)	<0.5	<0.5	<0.5	<0.5	SED6-9512
Copper (mg/kg)	10	15;15	35	40	SED6-9512
Lead (mg/kg)	15	30;30	70; 60	105; 115	SED6-9512
Manganese(mg/kg)	110	310;280	525	585	SED6-9512
Mercury (mg/kg)	0.01	0.01	0.02	0.04	*CM/CVA
Zinc (mg/kg)	10	30;30	55	75	SED6-9512

* Subcontract results: Analysis performed by Genalysis Batch Nos: 595.0/993038 (22/6/99)

- = not determined N.A. = not applicable

ENVIRONMENTAL GEOCHEMISTRY SERVICES

STREAM SEDIMENT ANALYSIS RESULTS (Sample Analysed As Received)

Report No: R990207C

Locality: MAJORS CREEK AREA

Field Designation: MC-9 **Date Collected:** 18/5/99

Parent Registration No.: E99/2456 **Collected By:** PF,DJ

Preparation Notes: Dried at 40° C in air oven

Sample Notes:

Yield of -2mm fraction (% of dry whole sample) 27 %

ANALYSIS OF SIEVE FRACTIONS (dry basis)

	-2 mm +600 µm	-600 µm +200 µm	-200 µm +100 µm	-100 µm	Method Code
Sample Reg. No.	2456	2457	2458	2459	
Sieve fraction yield (% of -2mm material)	89	9.7	0.8	0.3	SAMPREP
Arsenic (mg/kg)	4	4	10	4	HE-9506
Cadmium (mg/kg)	<0.5	<0.5	<0.5	<0.5	SED6-9512
Copper (mg/kg)	5	10	20	5	SED6-9512
Lead (mg/kg)	<5	<5	5	5	SED6-9512
Manganese(mg/kg)	305	520	860	270	SED6-9512
Mercury (mg/kg)	<0.01	0.01	0.03	0.03	*CM/CVA
Zinc (mg/kg)	15	30	40	16	SED6-9512

* Subcontract results: Analysis performed by Genalysis Batch Nos: 595.0/993038 (22/6/99)

- = not determined N.A. = not applicable

ENVIRONMENTAL GEOCHEMISTRY SERVICES

STREAM SEDIMENT ANALYSIS RESULTS (Sample Analysed As Received)

Report No: R990207C

Locality: MAJORS CREEK AREA

Field Designation: MC-10 **Date Collected:** 18/5/99

Parent Registration No.: E99/2460 **Collected By:** PF,DJ

Preparation Notes: Dried at 40° C in air oven

Sample Notes:

Yield of -2mm fraction (% of dry whole sample) 47 %

ANALYSIS OF SIEVE FRACTIONS (dry basis)

	-2 mm +600 µm	-600 µm +200 µm	-200 µm +100 µm	-100 µm	Method Code
Sample Reg. No.	2460	2461	2462	2463	
Sieve fraction yield (% of -2mm material)	90	9.2	0.7	0.3	SAMPREP
Arsenic (mg/kg)	2	3	7	8	HE-9506
Cadmium (mg/kg)	<0.5	<0.5	<0.5	<0.5	SED6-9512
Copper (mg/kg)	5	10	15	20;20	SED6-9512
Lead (mg/kg)	<5	5	15	15	SED6-9512
Manganese(mg/kg)	125	215	515	515;565	SED6-9512
Mercury (mg/kg)	<0.01	0.01	0.01	0.02	*CM/CVA
Zinc (mg/kg)	5	15	35	40	SED6-9512

* Subcontract results: Analysis performed by Genalysis Batch Nos: 595.0/993038 (22/6/99)

- = not determined N.A. = not applicable

 New South Wales Department of Mineral Resources

ENVIRONMENTAL GEOCHEMISTRY SERVICES

STREAM SEDIMENT ANALYSIS RESULTS (Sample Analysed As Received)

Report No: R990207C

Locality: MAJORS CREEK AREA

Field Designation: MC-11 **Date Collected:** 18/5/99

Parent Registration No.: E99/2464 **Collected By:** PF,DJ

Preparation Notes: Dried at 40° C in air oven

Sample Notes:

Yield of -2mm fraction (% of dry whole sample) 79 %

ANALYSIS OF SIEVE FRACTIONS (dry basis)

	-2 mm +600 µm	-600 µm +200 µm	-200 µm +100 µm	-100 µm	Method Code
Sample Reg. No.	2464	2465	2466	2467	
Sieve fraction yield (% of -2mm material)	69	29	1.9	0.5	SAMPREP
Arsenic (mg/kg)	2	2; 2	4	6; 5	HE-9506
Cadmium (mg/kg)	<0.5	<0.5	<0.5	<0.5	SED6-9512
Copper (mg/kg)	5	5	5	15;20	SED6-9512
Lead (mg/kg)	<5	<5	<5	5	SED6-9512
Manganese(mg/kg)	130	155	230	430;400	SED6-9512
Mercury (mg/kg)	-	-	-	-	*CM/CVA
Zinc (mg/kg)	10	10	20	40;40	SED6-9512

* Subcontract results: Analysis performed by Genalysis Batch Nos: 595.0/993038 (22/6/99)

- = not determined N.A. = not applicable