MEMORANDUM

Date: 23/07/13

Author: Rebecca Richards

TITLE: Geochemical Review – implications for management and environmental impact assessment for tailings.

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1. INTRODUCTION

ABM Resources have made an application for a mining lease to cover the Old Pirate deposit and smaller surrounding and associated deposits including Golden Hind and Old Glory. These deposits are collectively referred to as Old Pirate and surrounds. The tenement application is referred to as Twin Bonanza and also contains the Buccaneer deposit. Buccaneer has been included for the purposes of accessing clay material for the processing and waste management at the Old Pirate Plant.

The report focuses on the characterisation of tailings as a direct result of mining Old Pirate and Surrounds; primarily the processing tailings. The characterisation of the waste rock produced during operations is the focus of another memo.

1.1 BACKGROUND

Old Pirate and Surrounds is located around 33 km to the south of the Tanami Road and around 16 km east of the Western Australian border (Figure 1).

The proposed Stage 3 plan with mining block models of ore, siltstone, sandstone, intercalated sandstones and siltstones, and intrusives is outlined in Figures 2 and 3.

The object of this report is to evaluate whether the tailings material, after processing, will pose a threat to the environment as a result of acid mine or metalliferous drainage (AMD), and to establish the most appropriate form of containment for the post processing waste materials and design parameters for the tailings dam construction and monitoring.

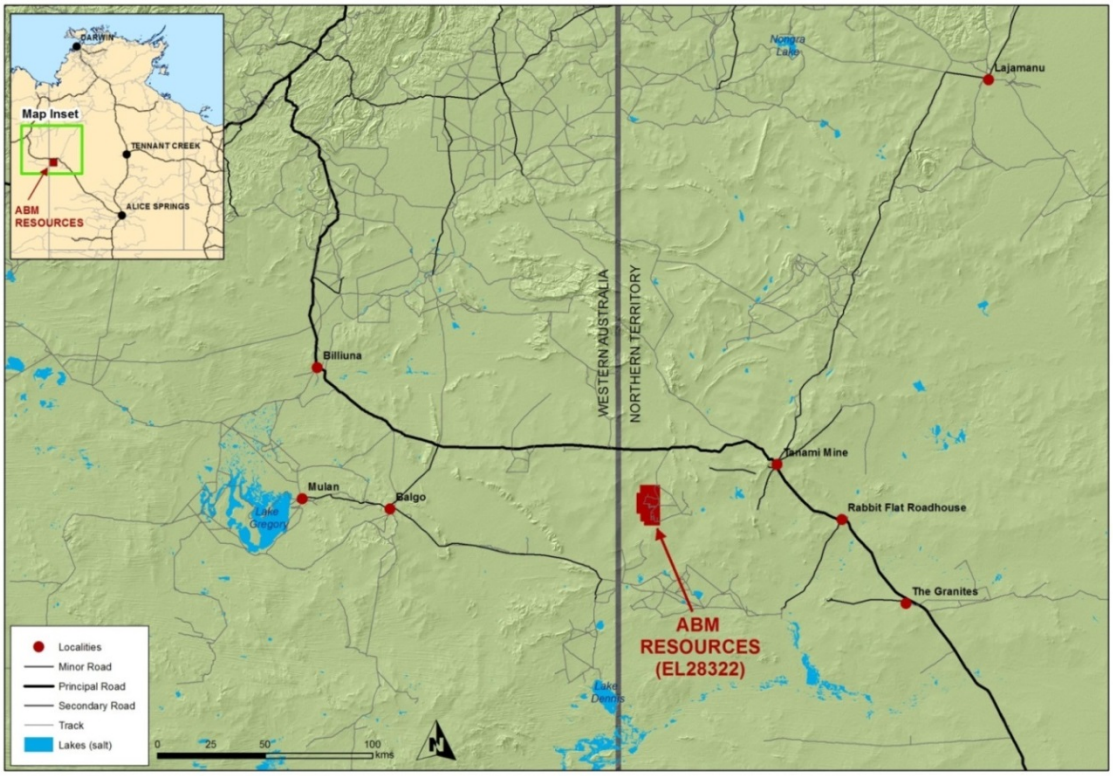

Figure 1. Twin Bonanza Locality Map

Historical sampling has been undertaken by both Newmont and ABM Resources; this report primarily focuses on ABM data and testing which is more current however extensive petrological programmes undertaken by Newmont are also included.

At the Old Pirate deposit there are 5 key geological units that will be disturbed by mining - quartz veins (representing the ore), sandstones, siltstones, intercalated sediments and diorite (the last 4 units characterised as waste). In addition to geological logging, analytical data aiding the characterisation of these units includes:

1. Multielement data
2. Petrography
3. X-ray diffraction (XRD)
4. X-Ray Fluorescence (XRF)
5. Acid Base Accounting (ABA)
6. Leachate quality – Water quality

Details on the nature of ore characterisation methods are presented in the following sections.

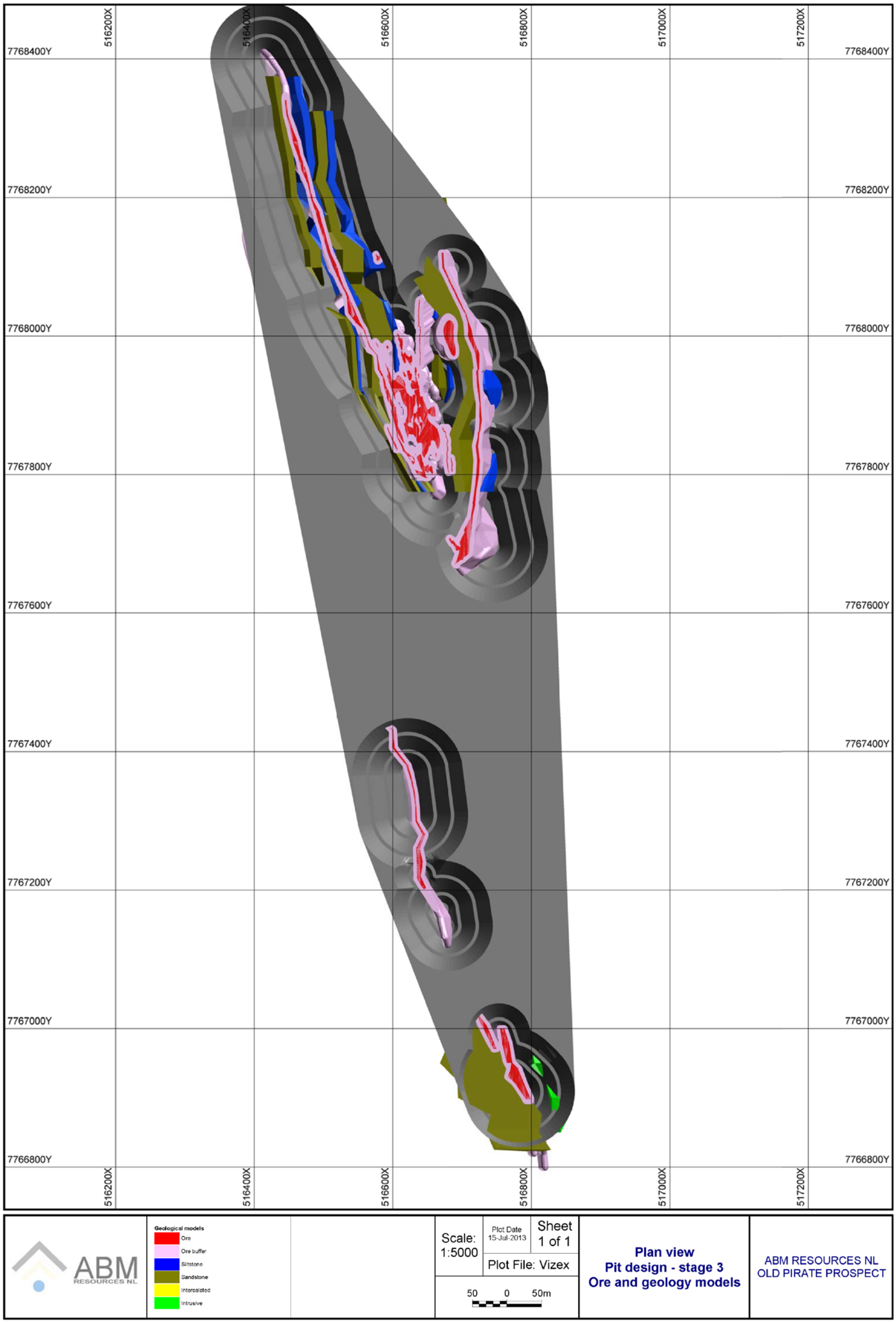

Figure 2. Plan view of proposed stage 3 with block models of ore (red), ore buffer representing intercalated rocks anomalous in As (pink), siltstone (dark blue), sandstone (olivine green), intrusives (green); all areas within the pit that do not have a block model applied are assumed to be intercalated based on geological interpretations (intercalated unit composed of sandstones and siltstones with minor intrusives).

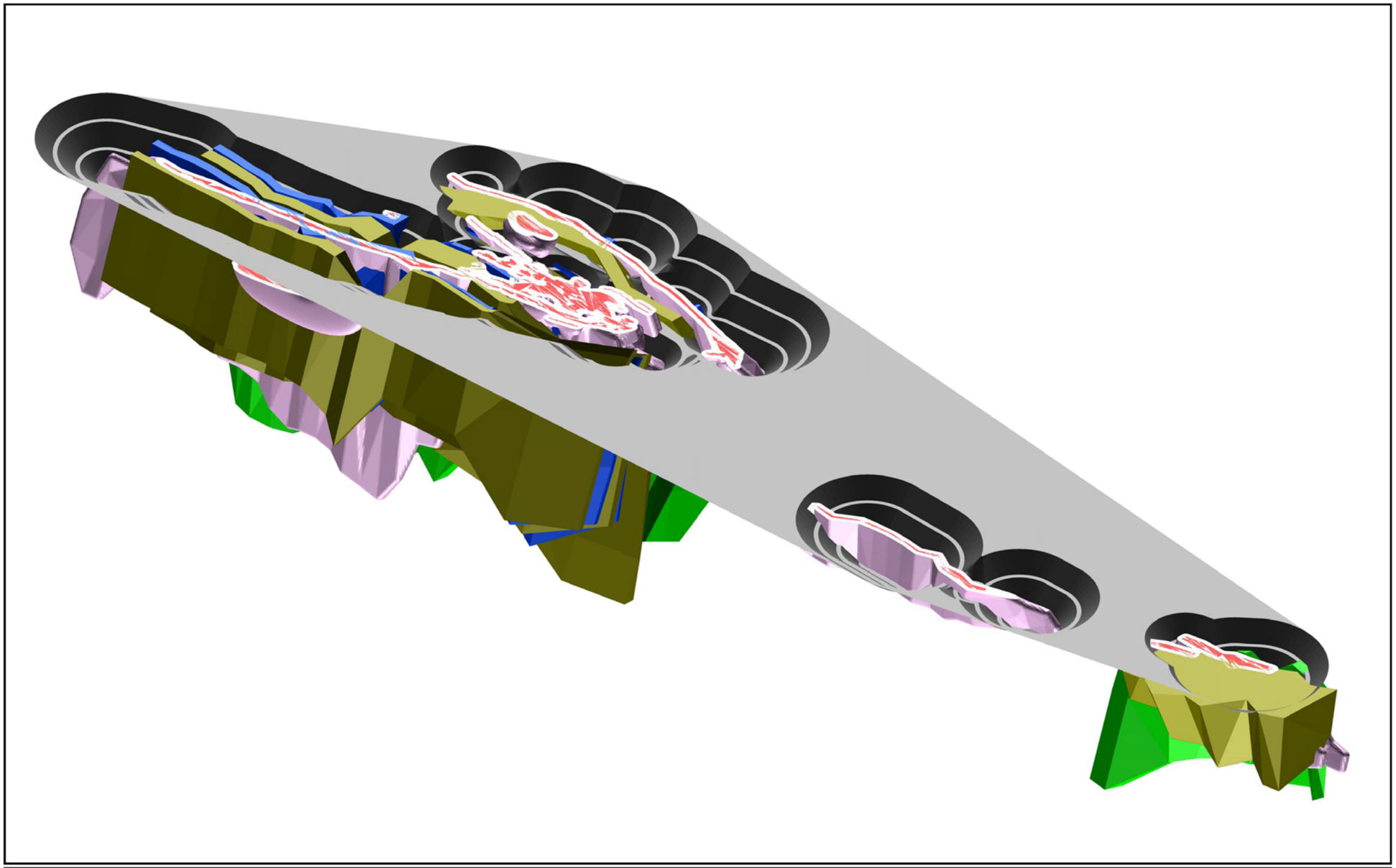

Figure 3. Oblique view of Proposed stage 3 with block models of ore (red), ore buffer representing intercalated rocks anomalous in As (pink), siltstone (dark blue), sandstone (olivine green), intrusives (green); all areas within the pit that do not have a block model applied are assumed to be intercalated based on geological interpretations (intercalated unit composed of sandstones and siltstones with minor intrusives).

2. TAILINGS ROCK TYPES & CHARECTERISATION

Table 1 outlines the 5 key rock units within the proposed pit shell, including 4 waste rock units. The table highlights the indicative volumes for each respective waste rock and ore (future tailings) component. Each of the 5 units have been further divided based on weathering characteristics and are grouped into 3 main categories; oxidised, transitional and fresh (Table 2). The Ore material is the focus of this memo, as parts of it will eventually be regarded as tailings waste material as a result of extraction and processing, and will be disposed of in the tailings dam. In-depth characterisation of the other waste rocks (pre-processing) will be the focus of another memo.

Table 1. Rock units within the proposed pit shell; indicative volumes, tonnage and specific gravity (SG).

UNIT TYPE	UNIT_NAME	VOLUME (m^3)	TONNAGE	SG	WASTE TYPE
Ore	Quartz Veins - Ore	195,700	518,500	2.65	Tailings
Waste rock	Sandstone	773,200	1,951,500	2.50	Waste dump
	Siltstone	169,300	428,300	2.50	Waste dump
	Diorite	1,900	4,800	2.61	Waste dump
	Intercalated sandstones & siltstones	2,111,500	5,317,800	2.50	Waste dump
	Intercalated Anomalous As	1,277,900	3,228,100	2.50	Waste dump
Pit (total)	**Stage 3**	**4,529,500**	**11,449,000**	**2.54**	

Ore comprises over 518,500 tonnes of material and 4.53% of the total tonnage mined.

Table 2. Rock units within the proposed pit shells, broken into units for characterisation.

UNIT TYPE	UNIT_NAME	PHASE	Volume (m^3)
Ore	Quartz veins - ore	OXIDISED	144,400
		TRANSITION	51,300
		FRESH - outside pit	225,500
Waste rock	Sandstone	OXIDISED	588,300
		TRANSITION	185,000
		FRESH - outside pit	2,921,600
	Siltstone	OXIDISED	116600
		TRANSITION	52700
	Intercalated sandstones & siltstones	OXIDISED	1,721,100
		TRANSITION	390,500
		FRESH - outside pit	6,351,300
	Intercalated Anomalous As	OXIDISED	943,200
		TRANSITION	334,700
	Diorite	OXIDISED	1,900
		FRESH - outside pit	2,707,000

The fresh phase for ore units has been included despite being outside the presently proposed pit boundaries. Extensive work has been completed on petrography, leachate

analysis, XRD, XRF and mineralogical characterisation for the deeper fresh rock components of the system with the aim of expanding the pits in the future upon further approvals. The fresh rock characterisations will provide additional information on the characterisation of other components in the deposit.

This memo incorporates previous analysis by Pendragon as detailed in the appendices and additional samples analysed by ALS Group, Environmental Division, using the same techniques as the Pendragon report. ALS Environmental laboratories are ISO 17025 (NATA) accredited.

2.1 TAILINGS PROCESS

The process flow for the ore and subsequent tailings is detailed in Figure 4.

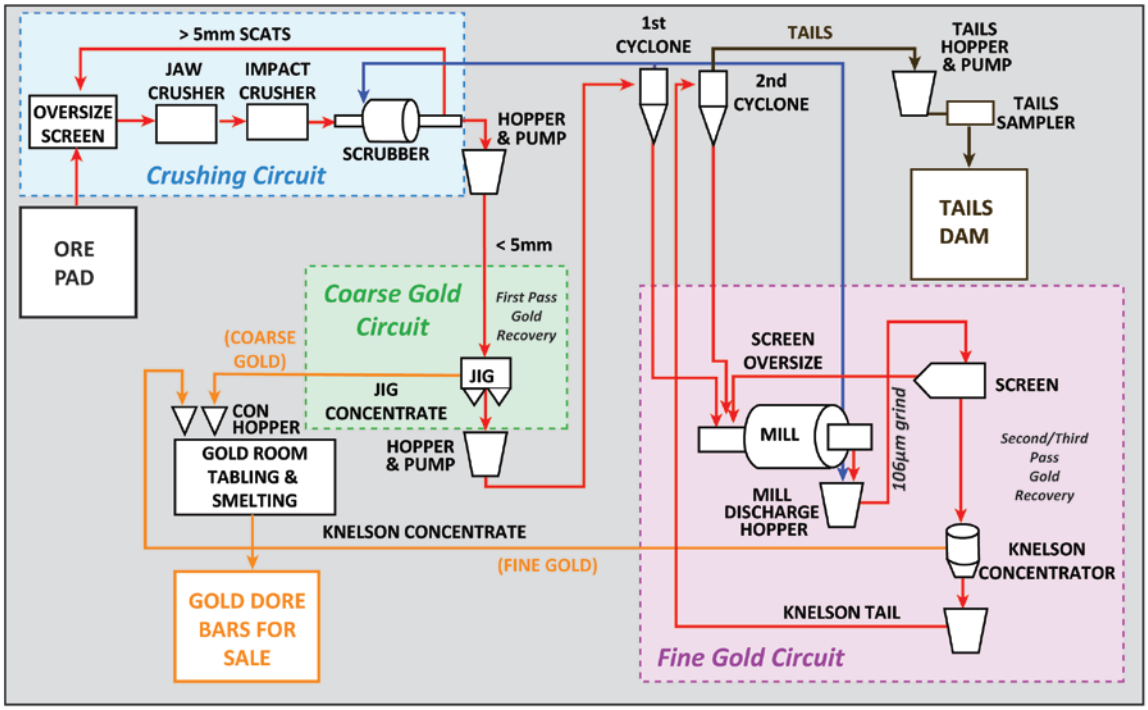

Figure 4. Grind and gravity circuit flowchart (Note: subject to change).

The expected processing flow is:

1. ROM pad.
2. Crushing circuit.
3. Coarse gold gravity recovery.
4. Milling.
5. Fine gold gravity recovery.
6. Concentrate upgrade.

Currently planned is a small crushing circuit with a Jaw, Cone and Impact crusher, however the crushing circuit will be modified as the scale of the operation changes. Crushed material will be fed into the jig with table upgrade for coarse gold gravity recovery.

The remaining ore material that has not been previously captured for coarse gold recovery will be milled to liberate finer gold particles. Target final grind size is expected to be 100 - 150 micron. All material from the mill, subject to screening of oversize, will pass through a centrifugal gravity concentrator for Fine Gold Gravity Recovery.

The tails from the centrifugal gravity concentrator will then be passed through a cyclone, and underflow, being the larger and heavier particles, will be returned to the mill for further grinding. Cyclone overflow, being the finer and lighter particles, will be sent to the tails storage facility. The final output of the tails is expected to be between 75 and 106 micron.

In addition to the gravity concentration, ABM will selectively leach small quantities of the gold-rich tailings (gravity separated concentrates). Intensive leaching would involve a small fraction of the total concentrate, and approximately 1 to 2 tonnes of concentrate recovered daily from tailings via a Knelson concentrator is expected to be leached. The concentrate will be leached in an Acacia Reactor that is a closed system, that is isolated from the environment, which introduces cyanide to the concentrate material. ABM proposes to use additional modules in the system to eliminate the discharge of cyanide into the environment. Details of the process flow sheet are provided in Figure 5.

The modules include:

1. A recycling module to recover as much cyanide as possible from the spent leach, thereby minimising cyanide use and the amount of cyanide containing solution needing detoxification each day.
2. A detoxification module which controls the detoxification process by using sodium hypochlorite (swimming pool chlorine) as the active reagent to neutralise and break down cyanide.

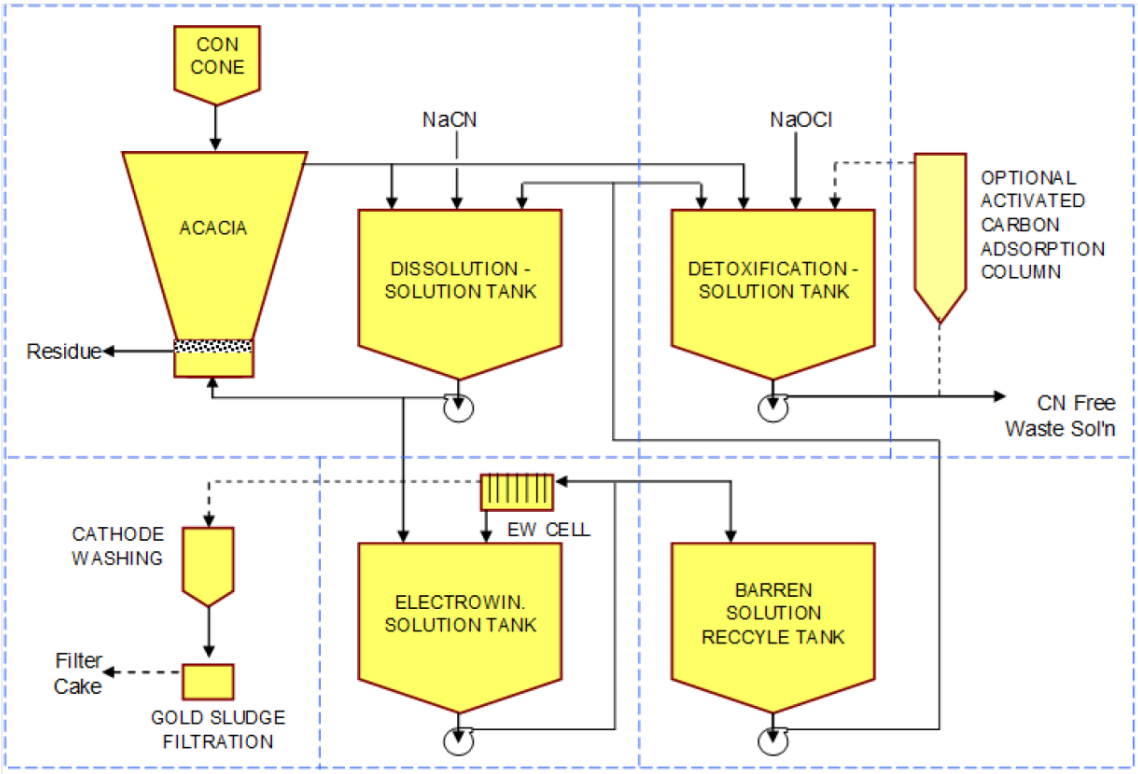

Figure 5. Simplified process flow diagram for a Concep Acacia Refinery System.

2.2 TAILINGS UNITS

Metamorphosed sedimentary rocks are host to the mineralisation in the Old Pirate area. The grade of metamorphism varies within the greater prospect area, such that primary and sedimentary textures are preserved on some areas relative to others. The sedimentary rocks are interpreted to comprise lithic quartz and quartz lithic feldspathic arenite and related siltstone, silty mudstones and mudstones. Detrital muscovite, tourmaline, rutile and zircon are present. The more voluminous lithic quartz arenite represents the ore material for the proposed pits.

The ore material has been classified based on the 2012 and 2013 resource estimate models. The models are based on a wire-frame of the gold assays using quartz as a guide (quartz is the dominant lithology in which the gold occurs). With dilution it is estimated that the ore unit contains 75% quartz and 25% intercalated sandstone and siltstone. The particle size of samples from within the 3 units of the ore is spread across fine grained (phi 2 – 36.2%), very fine grained (phi 9 – 33.3%) and medium grained (phi 1 – 14.4%)(Appendix 2 – Definition of Phi).

2.2.1 Oxidised Ore

The oxidised ore material comprises 75% quartz veins including banded, bucky, milky and smokey vein textures. A single petrographic analysis was undertaken on an unusual oxidised ore sample from the Golden Hind prospect; the sample was defined as *"an original quartz vein that has been recrystallised and subject to regional deformation to produce characteristic stress textures including undulose extinction, serrated grain boundaries and localised annealing".*

Figure 6. Above: Typical Oxidised Ore samples from OPRC100163 (0-20m depth).

Geological logging suggests that the unit's alteration is characterised by moderate haematite alteration and weaker kaolinite-limonite alteration, with rare goethite (Figure 6). The most commonly identified ore minerals within the unit are gold, pyrite and arsenopyrite.

XRD analyses, in conjunction with environmental leachate work, suggest that the oxidised ore samples are dominated by mass of 58 % kaolinite (average), 23.4 mass % quartz and less than 10% for mica and goethite (8.2% and 6.7% respectively). The kaolinite mass represents dilution of the sample with intercalated sediments surrounding the quartz.

2.2.2 Transition Ore

The transition ore contains metamorphosed and deformed quartz, with minor carbonate and biotite veining (Applied Petrological Services), no petrological samples fall directly within the "ore" unit, however further investigation into the model constraints and down dip plunge of "ore" (beneath the pits) suggests that the majority of the quartz is plastically deformed quartz veins (petrological sample 26011.03 & 26011.02) enclosed by wall rock fragments. The ore minerals include pyrite, chalcopyrite, pyrrhotite, galena/BiTeS minerals, and native gold. However on a pit scale the most commonly identified ore minerals within the unit are the same as the oxidised ore. Galena occurs most commonly in the Golden Hind pit to the south.

Petrography suggests that *"the gold occurs most commonly as inclusions within and along "primary" framework quartz grain boundaries. Recrystallization of quartz is*

coincidental with the occurrence of native gold. The gold has close spatial association with gas-rich/filled and coexisting aqueous liquid rich inclusions". In more oxidised samples it appears to be *"present as relict grains within pseudomorphed Fe-sulfides (morphologies indicative of pyrite and arsenopyrite), and is remobilised into micro fractures filled with ultrafine-grained hematite and hydrated Fe-oxides".* This is observed in geological logging throughout the Old Pirate system.

In transitional to fresh rock samples, increasing pyrite concentrations have been associated closely with strong quartz veining (when veining is present) or are present as trace amounts (<5%) which are highly disseminated throughout the ore. Shear zones, fracture planes and stringers also host increased quantities of pyrite (moderate intensity >20%) in isolated millimetre to centimetre scales. Even at depth the pyrite appears strongly oxidised especially along fracture planes and shears but this represents a small part of the ore.

Geological logging suggests that the unit's alteration is characterised by moderate haematite alteration and weaker kaolinite-limonite alteration, with rare goethite. The transitional ore unit is characterised by mass of kaolinite 44 %, quartz 38 % and minor mica and goethite <10% respectively; (XRD by Pendragon Environmental Solutions). The kaolinite represents dilution of the sample with intercalated sediments surrounding the quartz.

Figure 7. Above: Typical Transitional Ore samples from OPRC100163 (25-35 depth).

2.2.3 Fresh

The fresh ore zone contains metamorphosed and deformed quartz, with minor carbonate and biotite veining (Applied Petrological Services), no petrological samples fall directly within the "ore" unit, however further investigation as to the model constraints and down dip plunge of "ore" (beneath the pits) suggests that the majority of the quartz is plastically deformed quartz veins (petrological sample 26011.03 & 26011.02) enclosed by wall rock fragments. Ore minerals comprise 20-50% of sample volume disseminated pyrite and arsenopyrite.

All fresh samples fall outside the pit boundaries for the purposes of this report.

3. METHODOLOGY

3.1 GEOCHEMICAL CHARACTERISATION

Geochemical characterisation of the materials (8 samples in total) was calculated by a combination of two techniques;

1. Acid Base Accounting (ABA)
2. Net acid generation (NAG)

Acid Base Accounting (ABA) is a measure of the Net Acid Producing Potential (NAPP), and is calculated from the independent determination of acid generating potential of a material and its buffering potential and is assessed by determining the pH of paste solutions; oxidation pH, Total-S and acid-neutralizing capacity (ANC). The Net Acid Generation (NAG) procedure generates a single value that can be used to suggest the likelihood of net acid generation occurring (INAP, 2009, AMIRA (2002)). The NAG test is used in association with ABA to establish the geochemical classification of a sample and classify the results into one of the following categories:

- **Non-acid forming (NAF)** - Samples classified as NAF may have a significant acid generating potential but have adequate ANC within the samples to neutralise any acidity formed. A sample is classified as NAF when it has a negative NAPP and a final NAGpH $\leqslant$4.5. PAF samples in contrast, have significant sulfur content which exceeds the sample's inherent acid neutralising capacity.
- **Potentially acid forming (PAF**) - Samples with a PAF classification pose the risk that they will oxidise and generate acidic drainage when exposed to atmospheric conditions. A sample is generally defined as PAF when it has a positive NAPP and a final NAGpH <4.5.
- **Uncertain (UC)** - An uncertain classification is used when there is a conflict between the NAPP and NAG results (i.e. when the NAPP if positive and the NAGpH <4.5). Uncertain samples require more detailed investigation to determine the acid potential.

Whilst ABA and NAG tests have limitations, both tests in combination increase the reliability of predicting acid generation in waste and ore materials (INAP, 2009). These tests have been widely used and are based on accepted methodologies for the geochemical characterisation of mine waste materials (after Pendragon, 2013: e.g.,

INAP, 2009; DITR, 2007; Alarcón León *et al* 2004; Scharer *et al*., 2000; Rose and Cravotta, 1998; Morin and Hutt, 1997; Miller *et al*., 1997 and Sobek *et al*., 1978).

3.2 APR CLASSIFICATION

The Acid Potential Ratio (APR) is used to classify the leachate samples potential to produce acidic drainage. Samples with APR's less than 1 should produce acid drainage, while ratios greater than 2 should produce net alkaline drainage. Those sites with ratios between 1 and 2 could generate acid, alkaline or neutral drainage.
The APR is calculated by the following equation:

APR = ANC / MPA

where ANC is the acid-neutralizing capacity of the sample and MPA is the Maximum Potential Acidity.

The MPA is calculated by multiplying the Sulfide-S values (in %) by 30.6. The multiplication factor of 30.6 accounts for the reaction stoichiometry for the complete oxidation of pyrrhotite and pyrite by O_2 to $Fe(OH)_3$ and H_2SO_4 (Lei and Watkins, 2005).

3.3 WATER QUALITY PREDICTION

Leach testing of the materials was undertaken as a component of the AMD analysis to determine the risk of metalliferous drainage occurring under neutral conditions. A total of 22 samples were leached with de-ionised water in accordance with Australian Standard Leaching Procedures (after Pendragon, 2013: ASLP INAP, 2009) and the leachates analysed for pH, EC, major ions (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, HCO_3^{-}, Cl^{-} and SO_4^{2-}) and trace metals (Al, As, Be, Cd, Cr, Co, Cu, F, Fe, Hg, Mn, Ni, Pb, Se, Sb and Zn). The same characterisation units defined in Section 2 – Rock types, have been used.

Comparison of analysis results with National Water Quality Management Strategy (NWQMS) guidelines was undertaken. The NWQMS water guidelines are adapted from the National Water Quality Management Strategy and are set at 95% protection, meaning that the guidelines allow protection of 95% of aquatic species concerned (Australian and New Zealand Environment and Conservation Council *et al*. 2000a; Australian and New Zealand Environment and Conservation Council *et al*. 2000b). Two guideline values are reported for As; 0.024 mg/L As (III) and 0.013 mg/L As (V), the assumption has been made that the two As species occur in an approximate 1:1 ratio in groundwater (Mahaimairaja *et al*. 2005; Samanta *et al*. 1999) and the conservative guideline of 0.013 is most appropriate. The NHMRC Guideline values for physical and chemical characteristics of drinking water are also included, with recommended arsenic values below 0.01 mg/L (NHMRC *et al*. 2011).

3.4 ELEMENTAL ENRICHMENT (GAI) ASSESSMENT

X-Ray Diffraction (XRD) and X-Ray fluorescence (XRF) assays were also undertaken as a component of the characterisation process (after Pendragon, 2013). XRF data was used

to analyse the geochemical abundance index (GAI, Förstner *et al.*, 1993) which assesses the enrichment of the samples by major elements:

GAI = log[(Cn/(1.5*Bn)),2]

where Cn is the measured content of the nth element in the sample and Bn is the average-crustal abundance of the element.

Analysing enrichment employs:

GAI	Symbol	Relevance
0	AC	The content of the element is less than, or similar to, the average-crustal-abundance.
1	3F	A 3 - fold enrichment above the average-crustal-abundance.
2	6F	A 6 - fold enrichment above the average-crustal-abundance.
3	12F	A 12 - fold enrichment above the average-crustal-abundance.
4	24F	A 24 - fold enrichment above the average-crustal-abundance.
5	48F	A 48 - fold enrichment above the average-crustal-abundance.
>6	96F	A 96 - fold, or greater, enrichment above the average-crustal-abundance.

4. RESULTS

4.1 SULFUR AND NEUTRALISING CAPACITY (ANC)

The ore units (oxidised and transition) have intermediate concentrations (Table 3) of Carbonate (% $CaCO_3$), in relation to the waste units (refer to waste memo).

It appears that the majority of the ore material contains the mineralised quartz-carbonate veining, whereas the intercalated, siltstone and sandstone units contain the majority of the wall rock replacement assemblages which have higher $CaCO_3$ content.

Petrographic analysis suggests that a potential source of the neutralising capacity is the metamorphosed vein assemblages, which comprise quartz, carbonate, biotite, chlorite, feldspar, muscovite and ore minerals. The carbonate veining is considered to be secondary to the early quartz veining. In addition, some of the wall rock replacement assemblages (within most of the waste rock units) are dominated by quartz, muscovite, biotite, chlorite, carbonate, pyrrhotite and rutile.

Table 3. ABA/NAG Assessment.

UNIT TYPE	PHASE	SampleID	Hole_ID	mFrom	mTo	ANC (kg H_2SO_4 equiv./t)	ANC as %$CaCO_3$	% Sulfide as S	Final pH	ANC (Kg H_2SO_4w/t.)	NAPP (Kg H_2SO_4 /t.)	APR	APR_Classn	ABA Classification
ORE	Oxidised	X198255	OPRC100176	10	11	2.8	0.3	0.01	8.6	2.8	-2.49	9.15	Alkaline drainage	NAF & high NAG(pH7.0)
		X192565	GHRC100014	21	22	0	0	0.01	8.2	0	-0.19	1.63	Acid/Alk/Neutral	NAF
		X193897	GHRC100024	32	33	1.2	0.1	0.03	7.4	1.2	-0.28	1.31	Acid/Alk/Neutral	NAF
		X196477	OPRC100163	8	9	0	0	0.02	8	0	0.11	0.82	Acid drainage	UC
		X196489	OPRC100163	20	21	2.8	0.3	0.02	8.3	2.8	-2.19	4.58	Alkaline drainage	NAF & high NAG(pH7.0)
	Transition	X189057	OPRC100139	35	36	0	0	0.02	8.4	0	0.11	0.82	Acid drainage	NAF & high NAG(pH7.0)
		X189254	OPRC100140	34	35	2.8	0.3	0.01	7.6	2.8	-2.49	9.15	Alkaline drainage	NAF & high NAG(pH7.0)
		X196498	OPRC100163	29	30	1	0	0.02	7.9	1	-0.39	1.63	Acid drainage	NAF

The effect of the buffering capacity is illustrated in the ABA classification, where the majority of samples are NAF.

4.1.1Oxidised Ore

The leachate results (Table 3) indicate that the majority of the oxidised ore samples have a potentially large reactive buffering capacity, with slightly basic paste pH's (average 8.1).

The effect of the buffering capacity is illustrated in the ABA classification, where the majority of samples for the oxidised ore units (over 75%) are NAF.

4.1.2 Transition Ore

The Acid Neutralising Capacity for the transitional ore is similar to the oxidised ore samples and is outlined below.

The leachate results suggest that the majority of the samples have a potentially large reactive buffering capacity, with circum-neutral pH (average 7.9). The effect of the buffering capacity is illustrated in the ABA classification, where the majority of samples (over 80%) were classified as NAF.

4.2 ABA RESULTS

The ABA plot (Figure 8) displays the samples in relation to Total Sulfur versus ANC (as described in the AMIRA guidelines 2002), and is a measure of the net acid producing potential of a sample. All of the samples are extremely low in relation to the standard guidelines. The graph displays the division between NAPP positive samples and the NAPP negative samples, and the control lines show ANC/MPA ratios of 2 and 3.

Across all units, the findings were a low total sulphur level and potential to generate acid is very minimal, as the ANC counteracts the presence of sulphides.

The Geochemical Characterisation of the samples is displayed in Figure 9, which is a Geochemical Characterisation plot, displaying NAPP versus NAGpH, as reported by Pendragon Environmental Solutions Consultants; with the additional leach data conducted after the Pendragon report. Table 3 illustrates the ABA results for the samples analysed.

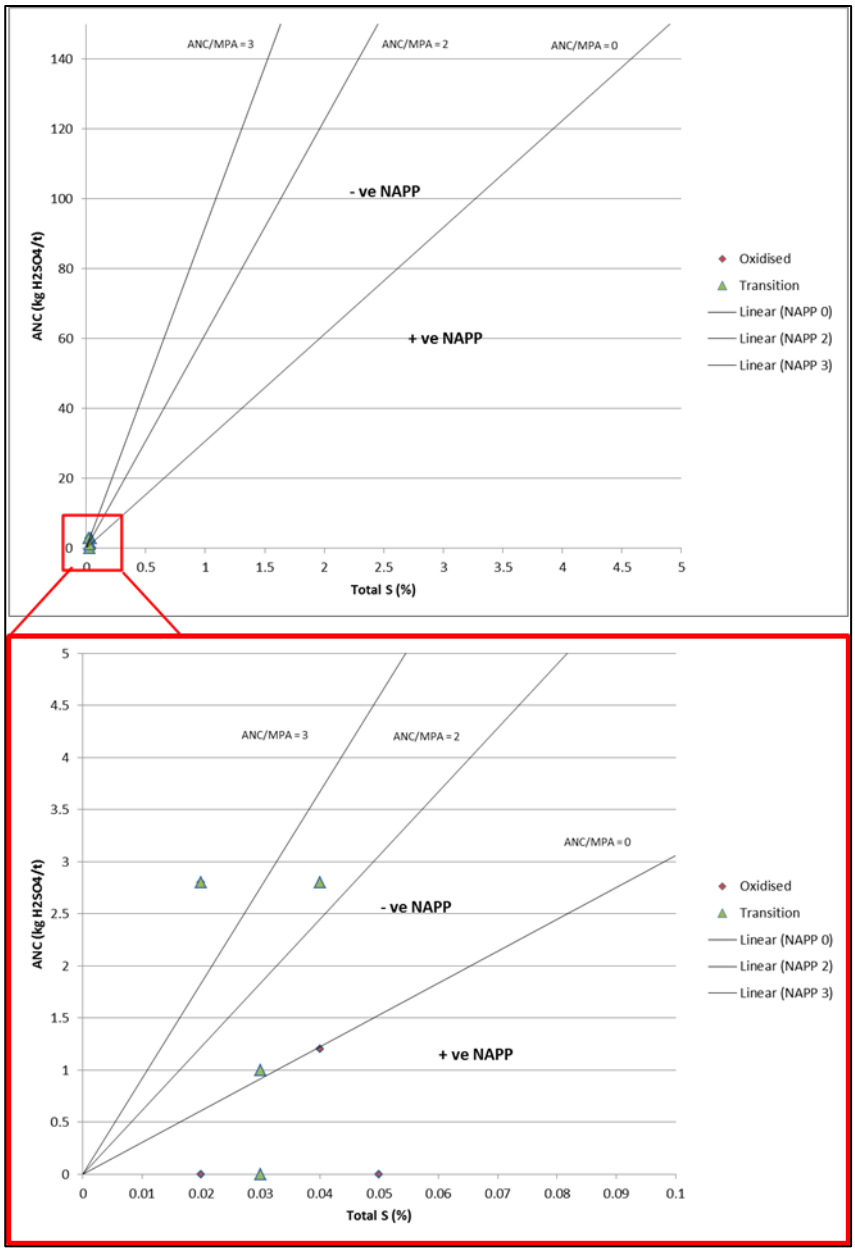

Figure 8. Acid-base account (ABA) plot for all tailings samples (as described in the AMIRA guidelines 2002(Wark 2002)).

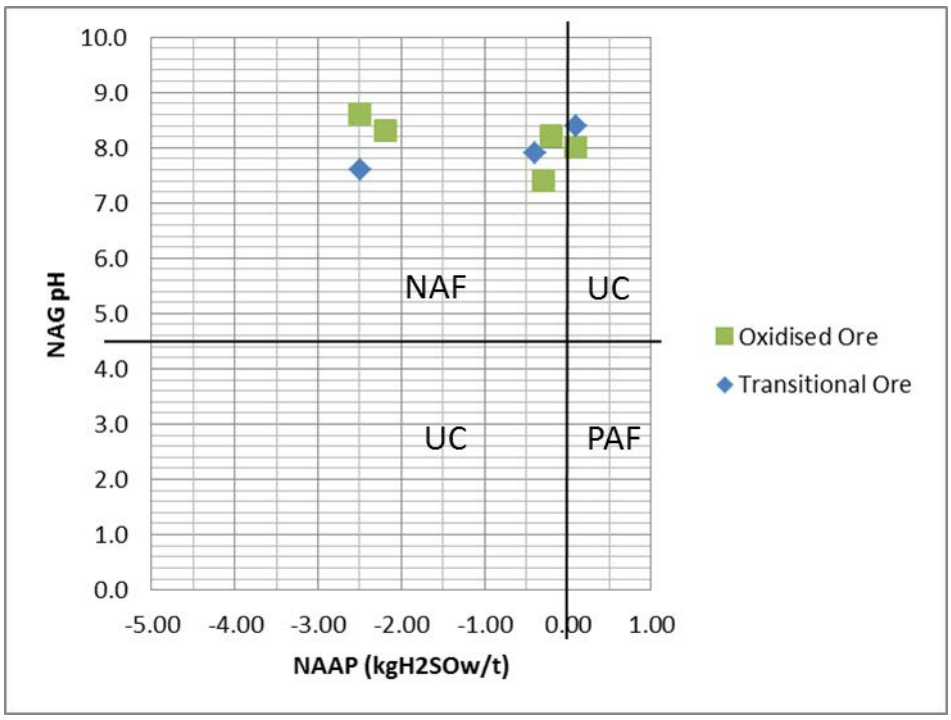

Figure 9. NAPP-NAG pH Classification scheme for all Ore samples: NAF – Non-acid forming, UC – uncertain, PAF – potentially acid forming. Green symbol – Ore Oxidised. Blue symbol – Ore Transitional.

Sections 7,768,325N and 7,767,950N (Figures 10-11) show the location of the samples with ABA classifications throughout the units of the proposed pit outline.

4.2.1 Oxidised Ore

Table 3 illustrates the Acid Base Accounting results for all the samples analysed. It is clear that the samples have Sulfide-S < 0.3%, a negative NAPP value and the majority of the samples have an APR < 2, which suggests that the ore has a low potential to generate AMD.

The oxidised ore samples show the closest potential to generate acid, although only 20% (1 sample) are classified as uncertain APR and ABA classifications; the remainder have high enough buffering capacities to counteract the small amount of acid formed during the oxidation of the sulphides (Figure 9).

Section 7,767,950N (Figures 10 and 11) shows the location of the UC sample to be at the top of the deposit (within the pit bounds), where it is possible that the carbonate buffering capacity has been removed through weathering. Oxidised sulfides are observed but it is much more common to observe partially oxidised pyrite and arsenopyrite at the surface as well. This may explain why samples in the oxidised units are highlighted as UC (ABA classification) or potentially acid forming (APR classification).

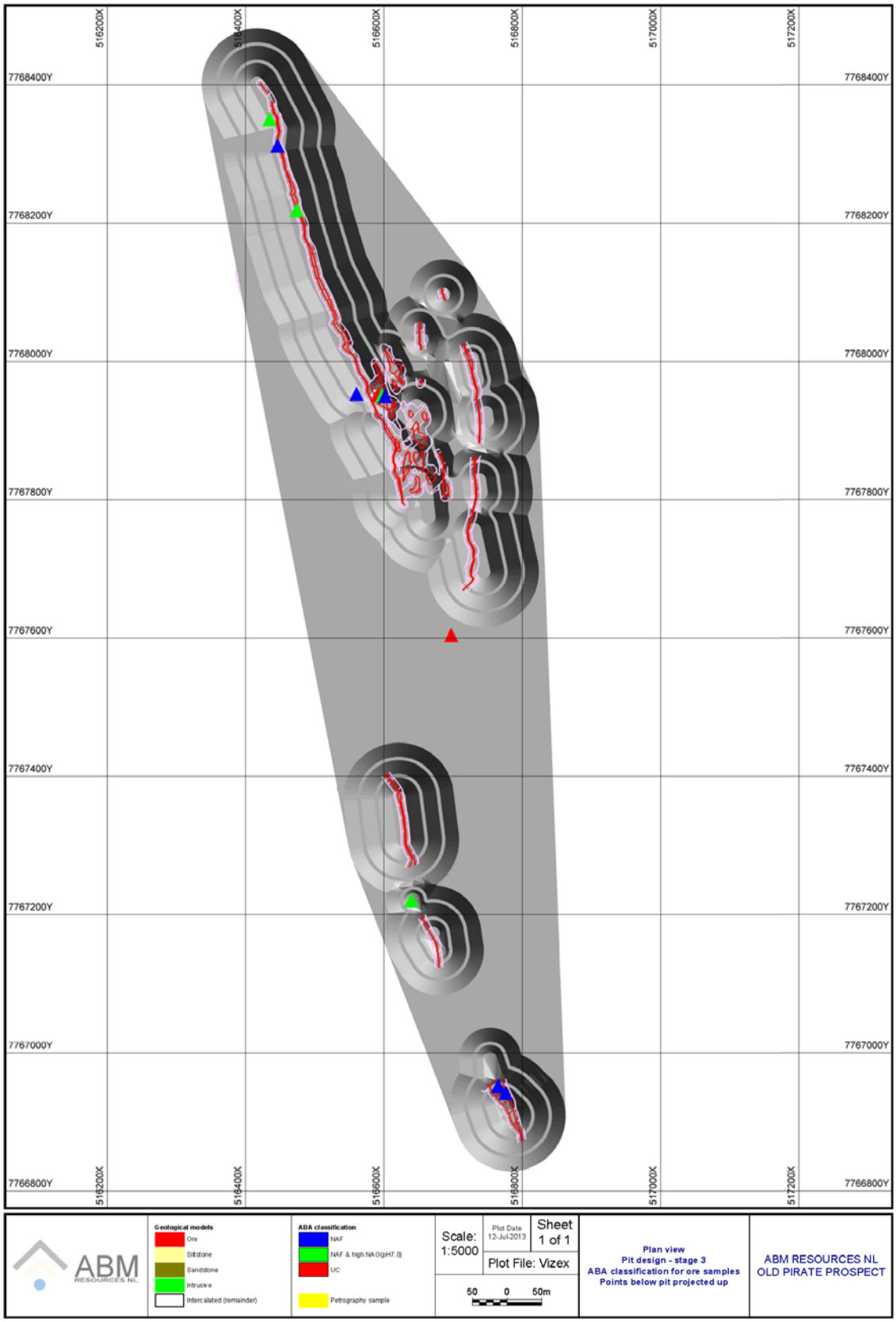

Figure 10. Plan view of stage 3 pit design with ABA classification: red UC, blue – NAF, green- NAF, high NAG.

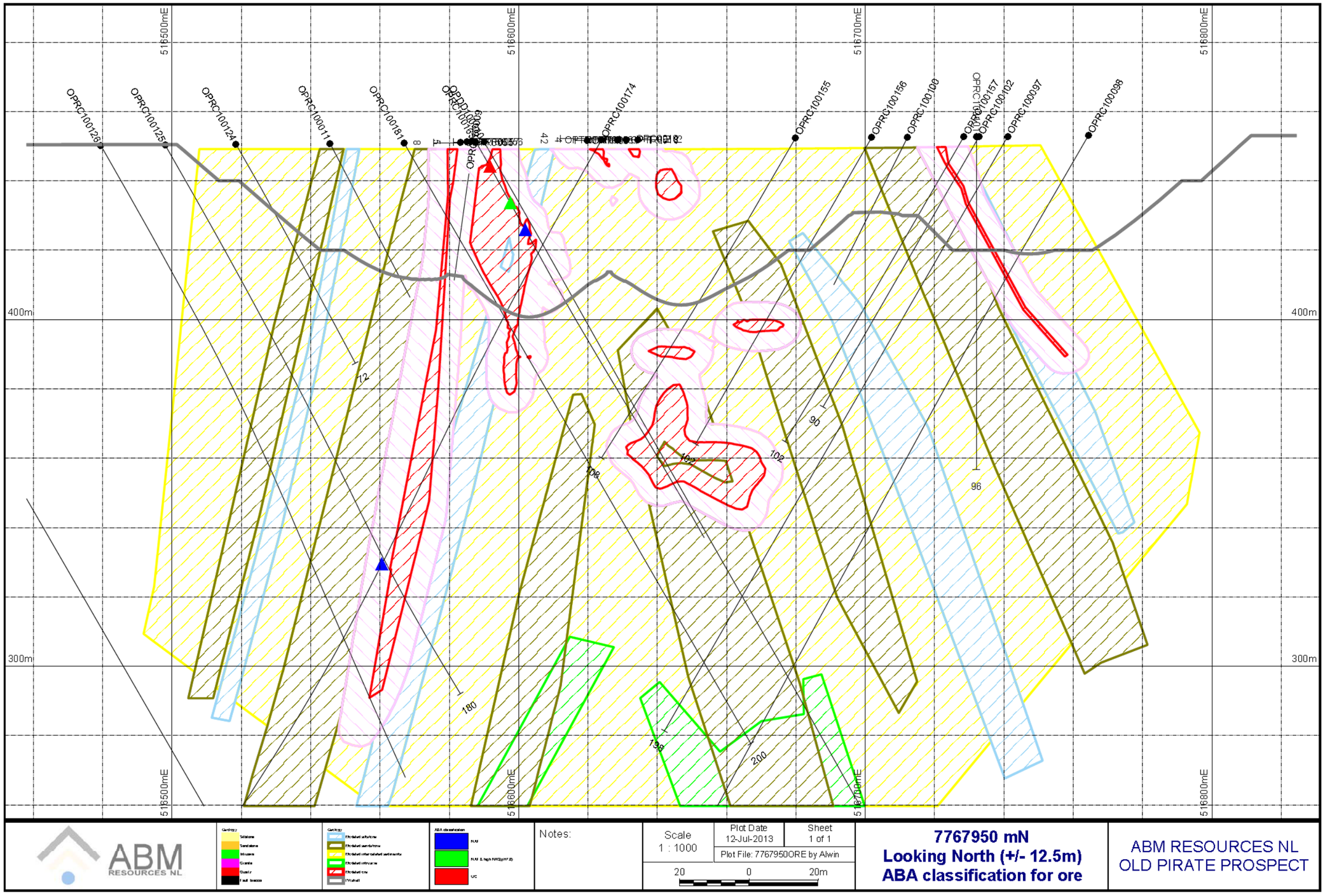

Figure 11.Cross-section through pit model (7767950N) with ABA classification: red UC, blue – NAF, green- NAF, high NAG) and geology.

4.2.2 Transition Ore

Two transitional ore samples were identified as potentially acid forming (APR), but with buffering capacities higher than acid generating potential were classified under the ABA classification to be NAF (Table 3).

The transitional ore samples appear to have less potential to generate acid than the oxidised ore samples. Two transitional ore samples were classified as potentially acid forming under the APR classification guidelines. Geochemical classification of the sample found that there was a high enough buffering capacity to counteract the small amount of acid formed during the oxidation of the sulfides, and thus the sample was classified as NAF under the ABA Classification scheme.

The inconsistency between the APR (PAF) and ABA classification scheme (NAF) for the outlier sample is most likely due to the assumption that all of the sulfur is in the form of pyrite. This assumption may not hold true.

The outlier sample is located just outside of the proposed stage 3 pits (Figures 10 and 11). Sample X189057 is located deeper in the system, representing the down dip plunge of “ore” (beneath the pits) but is still comparable to ore within the pit.

4.3 APR VERSUS TOTAL ALKALINITY

The NAPP-NAG pH classification of the samples is displayed in Figure 12, which is a Water Quality Prediction tool that assesses pH characteristics of the drainage; as reported by Pendragon Environmental Solutions Consultants. Results are reported in Table 3 (above).

Samples that were found to have a low buffering capacity (total alkalinity) were also found to be at low risk of acid mine drainage.

4.2.1 Oxidised Ore

The pH of oxidised sandstone samples was circum-neutral to moderately alkaline, and ranged from 7.4 to 8.6 (Table 5). The neutral to basic pH samples also correlated with higher electrical conductivity (EC) and dissolved solids (TDS)

The majority of the samples have a good correlation between low APR and low total alkalinity, this suggests that the samples have a low buffering capacity (total alkalinity) but also have a low ability to produce acid mine drainage. The oxidised ore samples are highlighted with red circles (Figure 12, below).

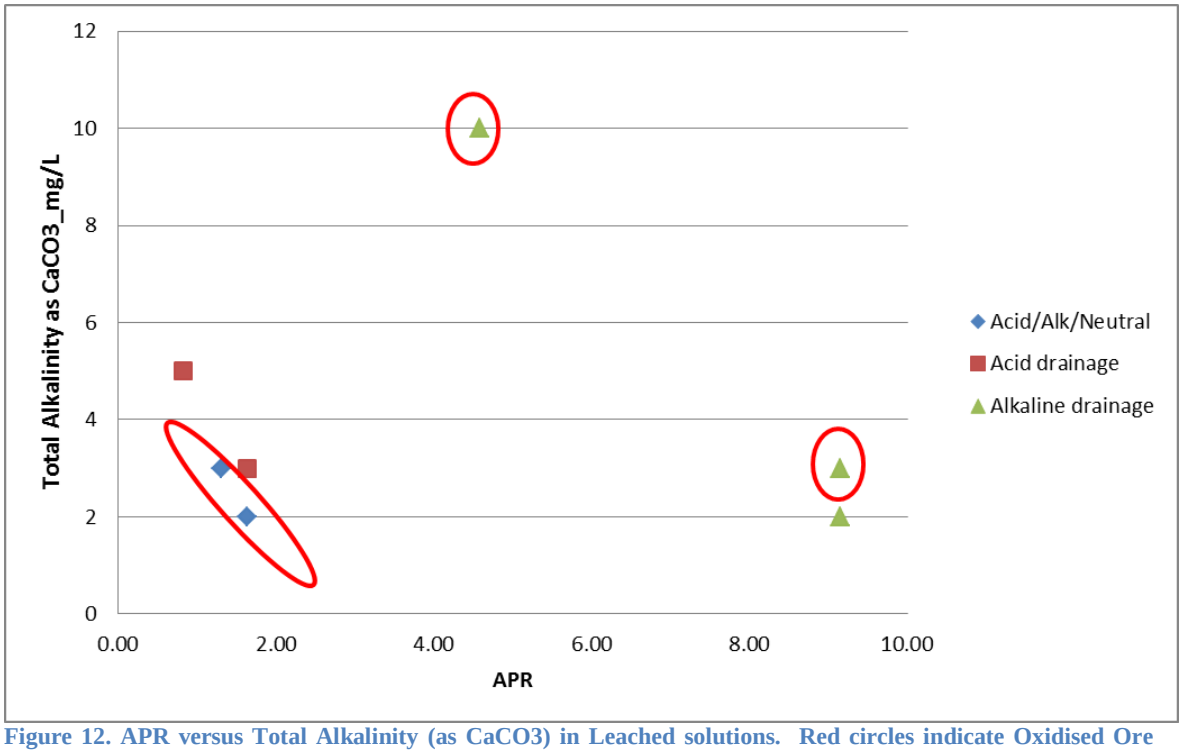

Figure 12. APR versus Total Alkalinity (as CaCO3) in Leached solutions. Red circles indicate Oxidised Ore samples.

4.2.2 Transition Ore

The pH of the transitional ore leachates was neutral to slightly alkaline, ranging from 6.5 to 8.67 (table 3). The samples with higher pH were also found to have a correspondingly high EC and TDS similar to the oxidised ore samples. Total alkalinity was highest in the waste rocks suggesting that the buffering capacity of the waste is much higher than the tailings.

Two samples were classified as producing acid drainage (X189057 & X196498) (Figure 13, below).

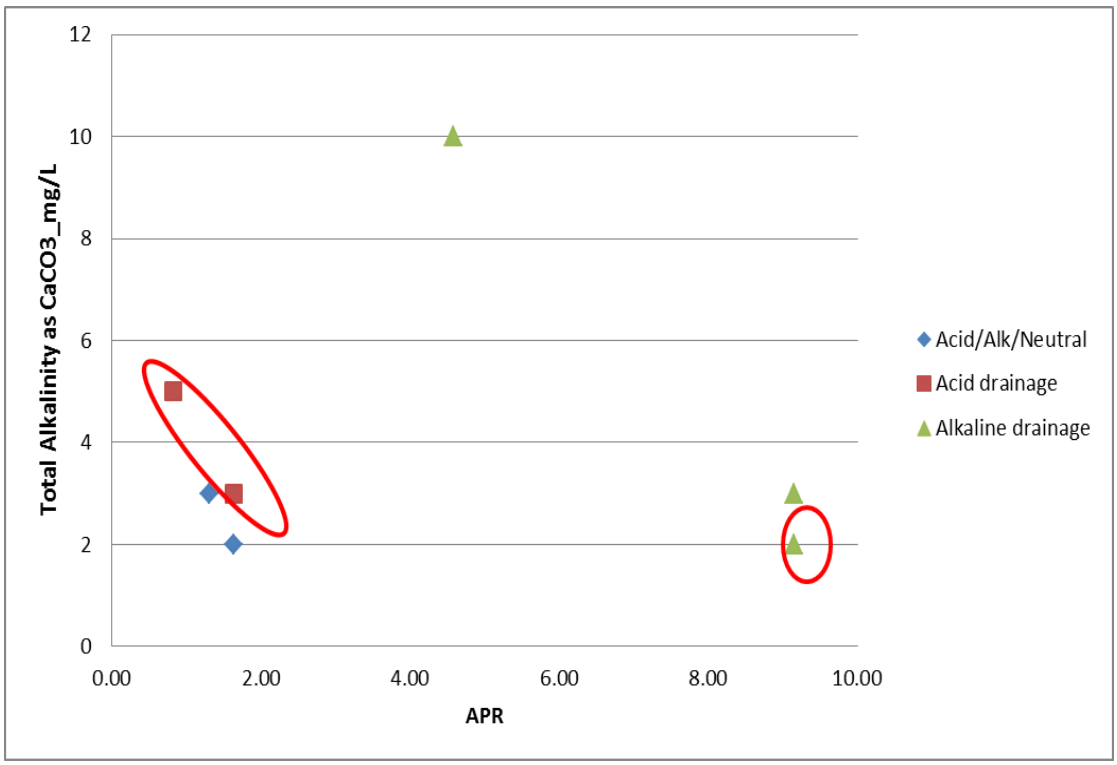

Figure 13. APR versus Total Alkalinity (as CaCO3) in Leached solutions. Red circles indicate Oxidised Ore samples.

4.4 GAI ENRICHMENT

GAI analysis identified arsenic as the primary potential contaminant, with elemental enrichment well above the average-crustal-abundance. Table 4 reports the GAI for all units that were assessed. Barium and tin were mentioned as potentially enriched in the Pendragon Reports but waste rock samples show no GAI above three, indicating that the elements are limited in their enrichment within the tailings (Table 4).

4.2.1 Oxidised Ore

An assessment of the elemental enrichment in the samples highlighted that all oxidised ore samples are enriched in As by up to 9.1 times average-crustal-abundance (Table 4). GAI analysis converts assayed values relative to their known crustal abundance with a trigger level set at 3 x crustal abundance. However the bulk of the samples returned NAF classifications' which suggests that the samples are unlikely to be at risk of AMD.

The UC sample (X196477) was found to be high in Fe (3.2) and Pb (4.2). Other samples classified as NAF also showed high Fe and occasionally Pb enrichment; although it is unlikely that metalliferous drainage as a result of low pH AMD will occur.

Table 4. GAI Analysis to assess element enrichment – average per characterisation unit.

UNIT_NAME	PHASE	Sample ID	Al	As	Ba	Ca	Cl	Co	Cr	Cu	Fe	K	Mg	Mn	Na	Ni	P	Pb	S	Si	Sn	Sr	Ti	V	Zn	Zr
Ore_Pit	OXIDISED	*X192565*	*0*	*8.5*	*1*	*0*	*0*	*0.1*	*0*	*0*	*3.1*	*0*	*0*	*1.2*	*0*	*0*	*0*	*3.4*	*0*	*0*	*1.7*	*0*	*0*	*0*	*0.9*	*0*
		X193897	*0*	*7.2*	*1.6*	*0*	*0*	*1.6*	*0.3*	*0.5*	*2.5*	*0*	*0*	*2.1*	*0*	*0*	*0*	*1.4*	*0*	*0*	*2.7*	*0*	*0*	*0*	*0.1*	*0*
		X196477	*0*	*8.7*	*0*	*0*	*0.7*	*0*	*0*	*0.4*	*3.2*	*0*	*0*	*0*	*0*	*0*	*0*	*4.2*	*0*	*0*		*0*	*0*	*0*	*0*	*0*
		X196489	*0*	*9.1*	*0.1*	*0*	*0*	*0*	*0*	*0*	*4.6*	*0*	*0*	*0*	*0*	*0*	*0*	*2.8*	*0*	*0*		*0*	*0*	*0*	*1.6*	*0*
		X198255	*0*	*7.7*	*0*	*0*	*0*	*0*	*0*	*0*	*1.7*	*0*	*0*	*0*	*0*	*0*	*0*	*1.7*	*0*	*0*	*2.7*	*0*	*0*	*0*	*0*	*0*
		AVERAGE	**0**	**8.24**	**0.54**	**0**	**0.14**	**0.34**	**0.06**	**0.18**	**3.02**	**0**	**0**	**0.66**	**0**	**0**	**0**	**2.7**	**0**	**0**	**2.37**	**0**	**0**	**0**	**0.52**	**0**
	TRANSITION	*X189057*	*0*	*7.7*	*0.5*	*0*	*0*	*0*	*0*	*0*	*2.7*	*0*	*0*	*0*	*0*	*0*	*0*	*1.9*	*0*	*0*	*1.7*	*0*	*0*	*0*	*0*	*0*
		X189254	*0*	*8.5*	*0*	*0*	*0*	*0*	*0*	*0*	*2.3*	*0*	*0*	*0*	*0*	*0*	*0*	*3.4*	*0*	*0*	*1.7*	*0*	*0*	*0*	*0*	*0*
		X196498	*0*	*8.4*	*0.6*	*0*	*0*	*0*	*0*	*0*	*3.6*	*0*	*0*	*0*	*0*	*0*	*0*	*1.1*	*0*	*0*		*0*	*0*	*0*	*0*	*0*
		AVERAGE	**0**	**8.2**	**0.37**	**0**	**0**	**0**	**0**	**0**	**2.87**	**0**	**0**	**0**	**0**	**0**	**0**	**2.13**	**0**	**0**	**1.7**	**0**	**0**	**0**	**0**	**0**

The average As GAI is above crustal abundance for all units that that were assessed. Ba and Sn show no GAI above three, suggests that the elements have limited risk of subsequent enrichment within the tailings waste. Lead is just below the GAI assessment (≥3 GAI), so still poses a potential risk of enrichment in the post-processing tailings wastes. Iron is also particularly high in the oxidised Ore; this may be a function of weathering and iron oxide formation in the oxidised zone and/or presence and subsequent weathering of pyrite and arsenopyrite.

Leachate analysis suggests that mobilisation and metalliferous leaching is likely to be restricted due to the slightly basic paste pH (average 8.1). AMD is therefore unlikely to occur, based on the sample leachate and water leachate results.

4.2.2 Transition Ore

An assessment of the elemental enrichment found that all transitional ore samples were enriched in As up to 8.5 times average-crustal-abundance, which is slightly lower than those found in the oxidised ore samples. Table 4 shows the averages GAI scores across unit types.

Leachate analysis suggests that mobilisation and metalliferous leaching is restricted due to the circum-neutral pH (average 7.9).

4. 5 WATER QUALITY PREDICTION

The water leachate analysis was a component of the AMD analysis; Table 5 shows the average values for all the analytes tested. Most analytes were recorded in very low concentrations, at or below the method limits of detection.

The pH was found to be neutral to slightly alkaline ranging from 7.4 to 8.6. Samples with higher pH also had correspondingly high electrical conductivity (EC) and total dissolved solids (TDS) and were found among the oxidised ore samples. Total alkalinity was highest in the waste rocks suggesting that the buffering capacity of the waste is much higher than the tailings.

Pendragon identified the following:

1. Major cation concentrations were in the order of Na > K > Ca > Mg.
2. Anions are also low in the order of Cl >SO_4.

4.2.1 Oxidised Ore

Individual elements that were found to be potentially problematic include As with the rest of the trace elements found at or below limits of detection for the method. As, as discussed previously, in the ore leachates, is also high in the leach solutions with an average of 0.0154mg/L, reaching a maximum of 0.03 mg/L (table 5).

Table 5. Predicted water quality averages for each pit classification unit and NWQMS water guidelines. The NWQMS water guidelines are adapted from the National Water Quality Management Strategy and are set at 95% protection, meaning that the guidelines allow protection of 95% of aquatic species concerned (Australian and New Zealand Environment and Conservation Council *et al*. 2000). Two values are reported for As 0.024 mg/L As (III) and 0.013 mg/L As (V), the assumption has been made that the two As species occur in relatively a 1:1 ratio in groundwater (Mahaimairaja *et al*. 2005; Samanta *et al*. 1999) and the guideline of 0.013 is most appropriate. Samples over NWQMS Guidelines are highlighted yellow. NHMRC Guideline values for physical and chemical characteristics of drinking water.

PHASE	SAMPLE ID	pH Value	Electrical Conductivity @ 25°C_µS/cm	Total Dissolved Solids @180°C_mg/L	Moisture Content (dried @ 103°C)_%	Hydroxide Alkalinity as CaCO3_mg/L	Carbonate Alkalinity as CaCO3_mg/L	Bicarbonate Alkalinity as CaCO3_mg/L	Total Alkalinity as CaCO3_mg/L	Sulfate as SO4 - Turbidimetric_mg/L	Chloride_mg/L	Calcium_mg/L	Magnesium_mg/L	Sodium_mg/L	Potassium_mg/L	Aluminium_mg/L	Antimony_mg/L	As_mg/L	Beryllium_mg/L	Ba_mg/L	Cadmium_mg/L	Chromium_mg/L	Cobalt_mg/L	Copper_mg/L	Lead_mg/L	Manganese_mg/L	Nickel_mg/L	Selenium_mg/L	Vanadium_mg/L	Zinc_mg/L	Iron_mg/L	Mercury_mg/L	Fluoride_mg/L
Freshwater aquatic systems																*0.055*		*0.024 OR **0.013***								*0.0015*				*0.008*	*0.04*		
Drinking water														*180*			*0.003*	*0.01*		*0.7*						*0.5*				*3*			*1.5*
OXIDISED	X192565	*6.94*	*68*	*62*		*0*	*0*	*2*	*2*	*9*	*9*	*0*	*0*	*8*	*9*	*0.12*	*0*	*0.03*	*0*	*0.118*	*0*	*0*	*0*	*0*	*0*	*0.006*	*0*	*0*	*0*	*0.042*	*0.21*	*0*	*0.4*
	X193897	*6.64*	*72*	*140*		*0*	*0*	*3*	*3*	*6*	*8*	*0*	*0*	*10*	*7*	*0.04*	*0.001*	*0.003*	*0*	*0.343*	*0*	*0*	*0*	*0.002*	*0*	*0.008*	*0*	*0*	*0*	*0.101*	*0.05*	*0*	*0.3*
	X196477	*6.91*	*178*	*104*	*0*					*40*	*24*	*0*	*0*	*32*	*6*	*0.02*	*0*	*0.014*	*0*	*0.231*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0.07*	*0.06*	*0*	*0.4*
	X196489	*7.47*	*127*	*75*		*0*	*0*	*10*	*10*	*24*	*12*	*2*	*2*	*17*	*8*	*0*	*0*	*0.019*	*0*	*0.234*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0.043*	*0*	*0*	*1.3*
	X198255	*7.14*	*72*	*85*		*0*	*0*	*3*	*3*	*8*	*11*	*0*	*0*	*14*	*4*	*0.11*	*0*	*0.011*	*0*	*0.173*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0.023*	*0.09*	*0*	*0.3*
	AVERAGE	7.02	103.4	93.2	<1.0	<1	<1	4.5	4.5	17.4	12.8	1	1	16.2	6.8	0.073	0.001	0.015	0	0.22	0	0	0	0	0	0.005	0	0	0	0.056	0.103	0	0.54
TRANSITION	*X189057*	*7.15*	*68*	*35*		*0*	*0*	*5*	*5*	*8*	*8*	*0*	*0*	*8*	*7*	*0.07*	*0*	*0.007*	*0*	*0.194*	*0*	*0*	*0*	*0*	*0*	*0.002*	*0*	*0*	*0*	*0.054*	*0.08*	*0*	*0.7*
	X189254	*6.99*	*40*	*49*		*0*	*0*	*2*	*2*	*4*	*6*	*0*	*0*	*5*	*7*	*0.05*	*0*	*0.011*	*0*	*0.132*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0.026*	*0*	*0*	*0.4*
	X196498	*7.03*	*77*	*75*		*0*	*0*	*3*	*3*	*13*	*9*	*0*	*0*	*12*	*8*	*0.02*	*0*	*0.01*	*0*	*0.408*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0.036*	*0*	*0*	*0.5*
	AVERAGE	7.057	61.667	53	0	<1	<1	3.333	3.333	8.333	7.667	<1	<1	8.333	7.333	0.047	<0.001	0.009	0	0.245	0	0	0	0	0	0.001	0	0	0	0.039	0.065	0	0.533

An average concentration of 0.0154 mg/L for As, in the leachate of the oxidised ore samples, falls outside the conservative guidelines for As (V) but still within the guidelines for As (III).

Mineralogical assessments indicate that, for all samples, there are high concentrations of goethite. Arsenic sorbs strongly to the surface of iron oxides such as goethite and is released under reduced/alkaline conditions (Yannick et al 2009). However, if the pH conditions do not change, the As can remain sorbed indefinitely. Changes in pH may explain why the arsenic is so readily available in the oxidised units, particularly the sandstone.

Results of the leachate analysis indicate that metalliferous leaching is likely to be limited due to the circum-neutral pH of the oxidised ore samples (average 8.1). However there is a potential to liberate As from the oxide ore. It can be concluded that, based on the sample leachate results, metalliferous mine drainage is unlikely to occur in these materials.

4.2.2 Transition Ore

The transitional ore samples reported an average As concentration of 0.009 mg/L in the leachate of the transitional ore samples is well below the accepted NWQMS water guidelines (table 5).

5. CONCLUSION AND SUMMARY OF MAIN FINDINGS

Processing of the ore material will reduce the ore to sand or silt sized particles (approximately 2 mm to 2µm) and expose the sulfides to oxidation. The use of a non-cyanide gravity circuit (with the exception of intensive leaching of a small volume of tailings concentrate) where no cyanide is used will result in no changes in pH and keep the pH of the tailings at pH ranges where As leaching is unlikely. The use of cyanide for a small volume of concentrates will increase the pH of the tailings to greater than 8. High pH conditions can result in the leaching of As.

Risk of AMD has been found to be associated with the presence of pyrite and arsenopyrite. Increased levels of pyrite associated with mineralisation are predominantly found proximal to the gold mineralisation within the ore regardless of weathering phase.

5.1 OXIDISED ORE

The oxidised ore is characterised by 75% quartz veins including banded, bucky, milky and smoky vein textures. Mineralisation occurs with variable sulphides including arsenopyrite, pyrite and galena in some localities. Pyrite appears strongly oxidised, especially along fracture planes and shears, but this represents a small part of the ore.

Scorodite is present as a weathered species of arsenopyrite in the oxidised zone, however the low AMD potential of the samples means that there is little possibility of metalliferous drainage being produced.

With the exception of a single sample, the oxidised ore materials are characterised by non-acid producing drainage and NAF classifications. The low % sulfur content, and the extremely low ANC, suggests that there may not be the capacity to neutralise the acid

generated from the oxidation of pyrite, however the pyrite content is small enough for acid generation to be minimal.

5.2 TRANSITIONAL ORE

The transitional ore is characterised by 75% quartz veins including banded, bucky, milky, smoky vein textures (Table 6). Mineralisation occurs with variable sulphides including arsenopyrite, pyrite and galena in some localities. Even at depth the pyrite appears strongly oxidised, especially along fracture planes and shears, but this represents a small part of the ore.

With the exception of a single sample, the transitional ore samples are characterised by non-acid producing drainage and NAF classifications.

The low % sulphur, and the extremely low ANC, suggests that this material has a limited capacity to neutralise the acid generated from the oxidation of pyrite, however the pyrite content is small enough for acid generation to be minimal.

The bulk tailings material is classified as benign, with minimal potential for AMD (Table 6). However, there are minerals in the system that could lead to the potential leaching of elements to the environment, these include arsenopyrite, pyrite and galena; resulting in the release of metals such as As and Pb. Management of pH, surface run-off, and porosity of the materials will reduce the risk of these elements leaching into the environment.

Table 6. Geochemical Charecterisation and Leahate results sumary for all waste rock units.

Unit Name	Phase	Lithology	Veins	Ore minerals	Alteration	APR	ABA	GAI Enrichment	Leachability
Ore	**Oxidised**	75% quartz veins, 25% sandstones and siltstones	Banded, Bucky, Smoky and milky quartz veins	Gold, pyrite, arsenopyrite, scorodite	Moderate hematite alteration, kaolinite-limonite alteration, rare goethite (XRD analysis- 58% mass kaolinite)	Predominately non-acid producing, 1 outlier potential acid drainage	Predominately NAF, 1 outlier UC (uncertain)	As - up to 9.1 times average crustal abundance	High GAI for As. Water leachates at neutral pH's would indicate that there would be limited leaching of elements (As).
	Transition	75% quartz veins, 25% sandstones and siltstones	Banded, Bucky, Smoky and milky quartz veins	Pyrite, chalcopyrite, pyrrhotite, galena, and native gold	Moderate haematite alteration and weaker kaolinite-limonite alteration, with rare goethite (XRD analysis - 44% mass kaolinite)	Predominately non-acid producing, 1 outlier potential acid drainage	NAF	As - up to 8.5 times average crustal abundance	High GAI for As. Water leachates at neutral pH's would indicate that there would be limited leaching of elements (As).

6. RECOMMENDATIONS FOR TAILINGS UNITS AND CONSTRUCTION OF THE TAILINGS DAM

To manage the tailings the following recommendations are put forward:

- The bulk of the tailings will require impounding in an engineered tailings dam.
- If practicable, the positioning of the tailings dam should be on existing mineralised soils that are proven to have a naturally high As and metal content. This will help to reduce the adverse effects of tailings to the natural soil chemistry.
- To reduce seepage from the tailings dam it is recommended that the basal layer of the tailings dam be designed to achieve a permeability of 10^{-8} and the recovery of supernatant water occurs. The internal recycling of processing waters will also reduce the chance of leachates entering the natural water cycle.
- The small volume of tailings concentrate samples that have been treated with cyanide (with cyanide subsequently removed) report to a secondary dam for disposal with an impermeable barrier of 10^{-8}.
- Monitoring bores need to be located based on the results of an electromagnetic survey to identify structural influences on water movement through the subsurface
- All supply bores, and designated monitoring bores, downstream of the tailings dam should be monitored on a monthly basis.
- Monitoring needs to comply with the Australian Guidelines for Water Quality Monitoring and Reporting NWQMS No. 7 October 2000.
- Additional to groundwater monitoring, monitoring of the water quality of the tailings dam supernatant water pond and water storage dam should be undertaken at the same time to monitor changes in water quality.
- Water quality trigger values need to reflect current guidelines but take into consideration the presence of mineralised soils in the area.
- Additionally, if seepage of ground water above defined trigger levels is detected then a groundwater recovery program should be established either along structural influences or identified areas of high permeability in the underlying geology.
- At closure the tailings dams requires capping with at store and release cover to miminise the volumes of water percolating into the underlying tailings pile.

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8. APPENDICES

APPENDIX A – PENDRAGON REPORT

APPENDIX B – DEFINITION OF PHI

The Phi scale (table 6) provides a basis for a terminology that describes grain size.

Grainsize is expressed in units called Phi units (ϕ).

Table 7. Phi Scale for grain size.

φ scale	Size range (metric)	Aggregate name (Wentworth Class)	Other names
−8 <	256 mm <	Boulder	
−6 to −8	64–256 mm	Cobble	
−5 to −6	32–64 mm	Very coarse gravel	Pebble
−4 to −5	16–32 mm	Coarse gravel	Pebble
−3 to −4	8–16 mm	Medium gravel	Pebble
−2 to −3	4–8 mm	Fine gravel	Pebble
−1 to −2	2–4 mm	Very fine gravel	Granule
0 to −1	1–2 mm	Very coarse sand	
1 to 0	½–1 mm	Coarse sand	
2 to 1	¼–½ mm	Medium sand	
3 to 2	125–250 µm	Fine sand	
4 to 3	62.5–125 µm	Very fine sand	
8 to 4	3.90625–62.5 µm	Silt	Mud
> 8	< 3.90625 µm	Clay	Mud
> 10	< 1 µm	Colloid	Mud

In some schemes, gravel is anything larger than sand (comprising granule, pebble, cobble, and boulder in the table above).

Tailings Acid Mine Drainage and Leachate Assessment

Old Pirate Operations, ABM Resources

Revision No 1
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Report

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Author(s):	Dr Edgardo Alarcón Léon
Client:	EcOz Environmental Services for ABM Resources NL
Contact:	Ray Hall
Synopsis:	This document details the acid mine drainage and leachate investigations of ore-tailing materials from the Old Pirate Operations in the Northern Territory.

Document Control

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Recipients are responsible for eliminating all superseded documents in their possession			

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Abbreviations

ANZECC	Australian and New Zealand Environment and Conservation Council
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
ASLP	Australian Standard Leaching Procedures
DEHWA	Commonwealth Department of the Environment, Water, Heritage and the Arts
DME	Northern Territory Department of Mines and Energy
LoR	Limit of Reporting
MMP	Mining Management Plan
NLC	Northern Land Council
WMP	Water Management Plan
ha	hectare
hr	hour
km	kilometre
m	metre
yr	year
s	second

Acid Mine Drainage:

Acronym	Parameter Definition/(Determination)	Unit
ACM	Acid Consuming Materials	kgH_2SO_4/ton
AFP	Acid Formation Potential	kgH_2SO_4/ton
AMD	Acid Metalliferous Drainage	
ANC	Acid Neutralisation Capacity (Laboratory Analysis)	kgH_2SO_4/ton
APR	Acid Potential Ratios (Calculation)	
ARD	Acid Rock Drainage	
MPA	Maximum-Potential Acidity (Calculation)	kgH_2SO_4/ton
NAF	Non Acid Forming (Calculation): - Sulfide-S < 0.3% - Sulfide-S ≥ 0.3%, and negative NAPP value with ANC/MPA ≥ 2.0	kgH_2SO_4/ton
NAG	Net Acid Generation (Laboratory Analysis)	kgH_2SO_4/ton
NAPP	Net Acid Producing Potential (Calculation)	kgH_2SO_4/ton
PAF	Potential Acid Forming (Calculation): - Sulfide-S ≥ 0.3% and any positive NAPP value - Sulfide-S ≥ 0.3% and a negative NAPP value with ANC/MPA < 2.0	kgH_2SO_4/ton
SOR	Sulfide Oxidation Rate ['kinetic' testing]	$mgSO_4/kg/week$
Sulfide-S	Sulfide Sulfur [Sulfide-S = Total-S - Sulfate-S]	%(w/w)
Total-S	Total Sulfur (Laboratory Analysis)	%(w/w)

Executive Summary

Background

Pendragon Environmental Solutions Pty Ltd was engaged by EcOz Environmental Services, on behalf of ABM Resources NL (ABM), to undertake assessments of bulk sample materials to assess the geochemical risk associated with tailings produced from the materials. The assessment included Acid Mine Drainage (AMD) and leachate quality investigations of laboratory testing of the bulk sample materials.

ABM intends to trial mine and process 10,000t of ore extracted from the shallow mineralised zone at the Old Pirate area. This trial will result in some 10,000t of tailings which will be disposed of in a tailings storage facility (TSF).

Objectives and Scope of Work

The objective of this study is to evaluate whether the tailings will pose a threat to the environment as a result of acid mine drainage (AMD) as expressed by:

- The potential of materials to generate acid.
- Solubility of trace metals that may leach from the materials once contained in the TSF.

Salient Findings

Twenty two samples comprising both bulk and pulp materials were assessed. The bulk samples represented ore-tailings and were collected from trenches whilst the pulp samples comprised materials which may contain low grade ore from the gravity recoverable gold tests (GRGG).

All samples were characterised for their qualitative and quantitative properties by means of X-Ray Diffraction (XRD) and X-Ray Fluorescence (XRF). The Potential for Acid Formation (PAF) of the ore-tailings materials was assessed by determining the pH of paste solutions, oxidation pH, Total-S, acid-neutralization capacity (ANC) and net-acid generation (NAG).

To assess the short term quality of seepages that may originate during processing and from the TSF, samples were leached using de-ionised water and analysed for a set of analytes including pH, electrical conductivity, major ions and key trace element fingerprints.

Relevant observations resulting from these studies are:

- Minerallogically both sets of samples contain significant amounts of phyllosilicates and amorphous materials and are chemically enriched by arsenic, tin and lead.
- The great majority of the samples (95%) can be classified as non-acid forming (NAF) materials. Owing to its high sulfide as S concentration, only one pulp sample can be characterised as ‘uncertain’ and therefore, if warranted, may require further assessment for its potential to produce acidity.
- Owing to apparent conflicting results between NAPP and NAG results in about 50% of the pulp samples, these may be classified with a potential to produce acidity. However, because the other ABA parameters, including Sulfide (as S) concentrations, are very low and/or insignificant, these materials can be classified as having very low or no acid forming capacity.
- pH values of all samples are circum-neutral and major ions are very low in concentrations, with sodium being the highest in most of the pulp samples.

- The concentrations of trace elements in all the samples are relatively low and most are below their limits of reporting. However, the exception is arsenic which occurs in elevated concentrations in all samples and appears to be readily available for release or mobilisation in the short term.
- Elemental concentrations and behaviour indicate that short term leachate qualities in all samples will likely have low concentrations of most traces and would not represent an immediate risk to the wider environment.

Conclusions and Recommendations

Most of the samples are characterised with having low likelihood of producing acidity. One sample returned results that are inconclusive. However, for this relatively small-scale bulk sampling activity, the uncertainty in the assessment is considered to present a relatively low risk overall. The development of specific AMD management procedures is therefore not warranted.

It is recommended that:

- Should the project move towards full-scale mining, more targeted studies be conducted to assist in further assessment of the current uncertainty presented by sample X201983 and those samples defined as 'uncertain' in the APR assessment.
- Weekly to monthly monitoring of tail solutions be conducted to detect potential loading of arsenic. Results should assist in ascertaining long term monitoring and rehabilitation processes and systems.

1. Introduction

Pendragon Environmental Solutions Pty Ltd was engaged by EcOz Environmental Services, on behalf of ABM Resources NL (ABM), to undertake Acid Mine Drainage (AMD), including leachate quality, assessments on bulk and pulp samples from the Old Pirate Operations. It is the intention to trial mine and process 10,000t of ore extracted from the Old Pirate area. The resultant tailings from this activity will be disposed of in a tailings storage facility (TSF), designed to store the tailings below ground level. Rehabilitation of the TSF will raise the natural ground level by 1.0m.

1.1 Objectives

The Department of Mines and Energy (DME) indicated that some bulk and pulp samples should be characterised. The objective of this study is to evaluate whether the tailings will pose an environmental hazard as a result of acid mine drainage (AMD) as expressed by:

- The potential of materials to generate acid.
- Solubility of trace metals that may leach from the TSF.

Analytical data used in this study include:

- X-Ray Diffraction (XRD).
- X-Ray Fluorescence (XRF).
- Acid Base Accounting (ABA).
- Leachate quality.

2. Site Characteristics

2.1 Location

The Old Pirate Gold Deposit is located in the Northern Territory of Australia in the Buccaneer Porphyry Gold Deposit (Figure 2.1).

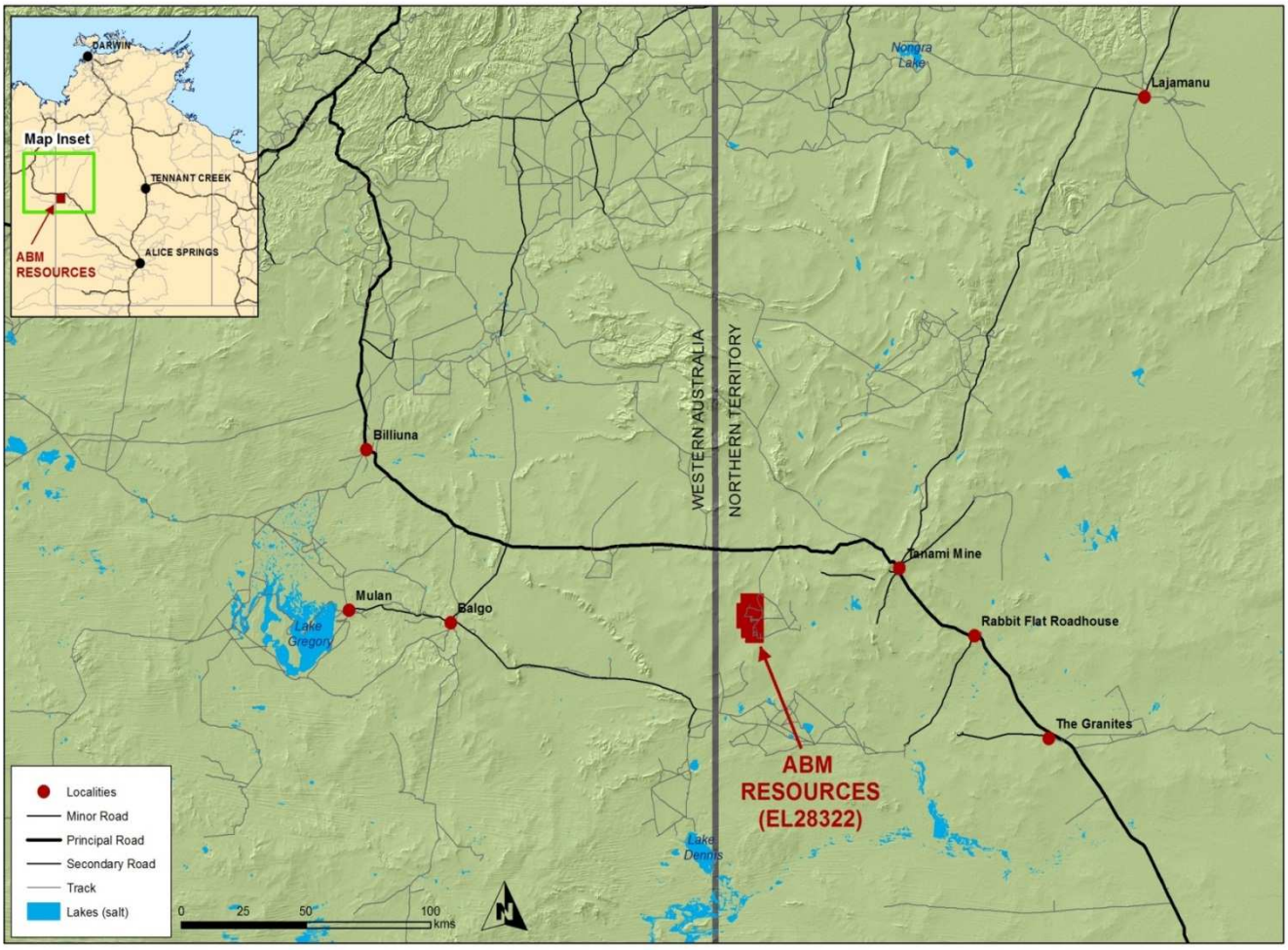

Figure 2.1: Location of the Old Pirate Deposit.

2.2 Climate

The project area is located in an arid subtropical climate with a distinctive dry (May to October) and a hot humid wet (November to April) season. Most rainfall occurs in the summer months between November and March (Figure 2.2). Rabbit Flat, the nearest weather station, has a mean annual precipitation of 427mm and an annual mean temperature of 33.6℃. Monthly temperatures vary from a December mean Maximum of 39℃ to 13 to 15℃ coole r during the winter months.

2.3 Geology and Geomorphology

The regional geology of the area has been described by many investigators (e.g. Wilford, 2003) to comprise of two major Precambrian tectonic units, with the oldest rocks related to the Granites-Tanami Block, including the lower Proterozoic metamorphosed sedimentary and volcanic rock, and the lower

to mid Proterozoic granites and acid volcanic rocks. The Birrindudu Basin sediment unit consist of arenite, siltstone, limestone, sandstone and others such as conglomerates (Wilford, 2003). These Proterozoic rocks are overlain by the Cambrian Antrim Plateau Volcanic and Upper Cambrian shallow marine and terrestrial sediments. The Cambrian and Proterozoic rocks are separated from the Cretaceous sediments by a major unconformity.

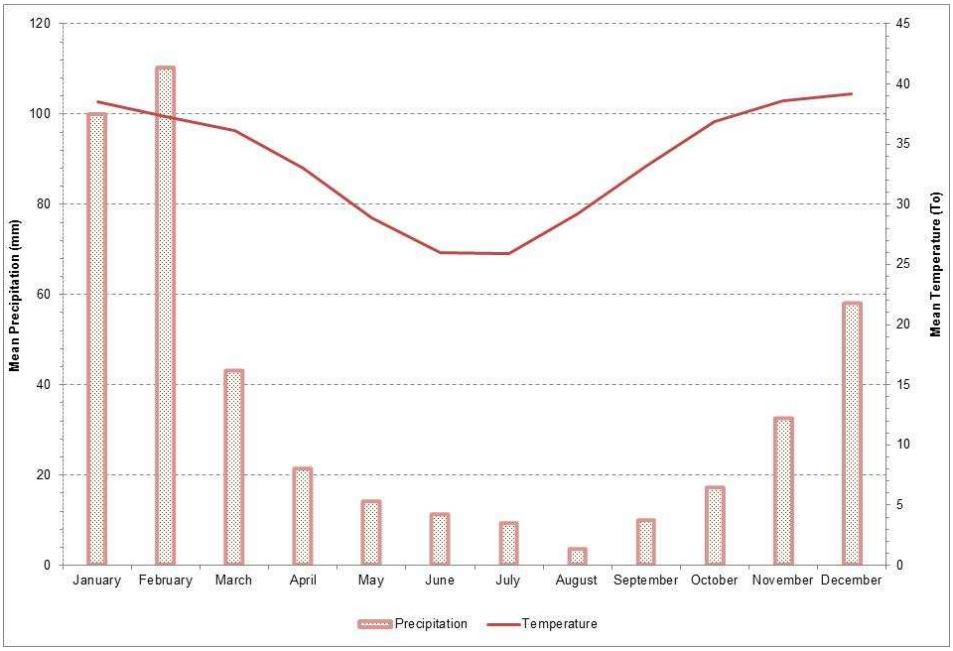

Figure 2.2: Average Monthly Temperature and Precipitation at the Rabbit Flat Station.

Locally, the Old Pirate deposit represents a high-grade (coarse) gold vein system hosted by a sequence of interlayered sandstone and shale horizons. Quartz veins ranging from 30cm to 6m in thickness host the gold mineralisation. The mineralised quartz veins preferentially follow the shale horizons with the 'mega' shales up to 25m thick (ABM Resources, 2012).

Low relief, almost flat and undulated landforms blanket the region. Outcrops are rare and bedrock is weathered extensively. Indurated regolith materials are formed by cementation with iron, silica and carbonates particularly along and above the scarp edges.

3. Geochemical Evaluation

3.1 Sample Collection

A total of 20 pulp and 8 composite samples, to compose 2 bulk samples, were obtained for this preliminary assessment (Appendix A). Locations of the composite bulk samples are indicated in Table 3.1 and Figure 3.1. Locations of the pulp samples appear in Table 3.2 and Figures 3.2 and 3.3. Bulk samples were collected from trenches and pulp samples from the gravity recoverable gold tests (GRGG). The ore-tailing samples; i.e. bulk/composite samples, comprise 3 samples from the eastern side, 2 from the central part of an area within the folding system and 3 from the western side of the proposed bulk sampling area (Figure 3.1). The pulp samples, i.e. materials which may contain low grade ore, are from the north-western side (Figure 3.2).

Table 3.1: Location of the Ore-Tailing (Bulk/Composite) Samples.

Sample ID	Eastern	Northern	Elevation (mRL)
T01575	516722	7767917	450
T01572	516722	7767920	450
T00301	516601	7767884	450
T00269	516635	7767917	452
T01215	516508	7768121	450
T00073	516642	7767893	452
T01941	516486	7768191	450
T01497	516720	7767981	450

Table 3.2: Location of the Pulp Samples.

Sample ID	Hole ID (prefix OPRC100)	From	To	Coordinates East	Coordinates North	Depth (mRL)	Weathering	Lith 1	Lith 1 %	Lith 2	Lith 2 %	Lith 3	Lith 3 %
X202044	200	1	2	516365	7768248	448	HW	NR	100				
X202045	200	2	3	516365	7768248	447	MW	SS	100				
X202046	200	3	4	516366	7768248	446	MW	SS	100				
X202047	200	4	5	516366	7768248	445	MW	SS	90	ST	10		
X201983	197	0	1	516424	7768326	449	HW	NR	100				
X201984	197	1	2	516425	7768326	448	HW	NR	100				
X201985	197	2	3	516425	7768326	447	MW	SS	100				
X201986	197	3	4	516426	7768326	446	MW	SS	100				
X201987	197	4	5	516426	7768326	446	MW	SS	100				
X202017	197	34	35	516441	7768326	419	MW	QT	90	ST	10		
X202019	197	36	37	516442	7768326	418	MW	NR	90	SS	5	Qz	5
X202020	197	37	38	516442	7768326	417	MW	NR	90	SS	5	Qz	5
X202021	197	38	39	516443	7768326	416	MW	NR	90	SS	5	Qz	5
X202022	197	39	40	516443	7768326	415	MW	NR	90	SS	5	Qz	5
X201777	195	88	89	516435	7768351	371	MW	NR	90	ST	10		
X201778	195	89	90	516436	7768351	370	MW	NR	89	ST	10	SS	1
X201779	195	90	91	516436	7768351	369	MW	NR	75	SS	20	ST	5
X201780	195	91	92	516437	7768351	368	MW	ST	95	SS	5		
X201781	195	92	93	516437	7768351	367	MW	SS	95	ST	5		
X201782	195	93	94	516438	7768351	367	MW	SS	95	ST	5		

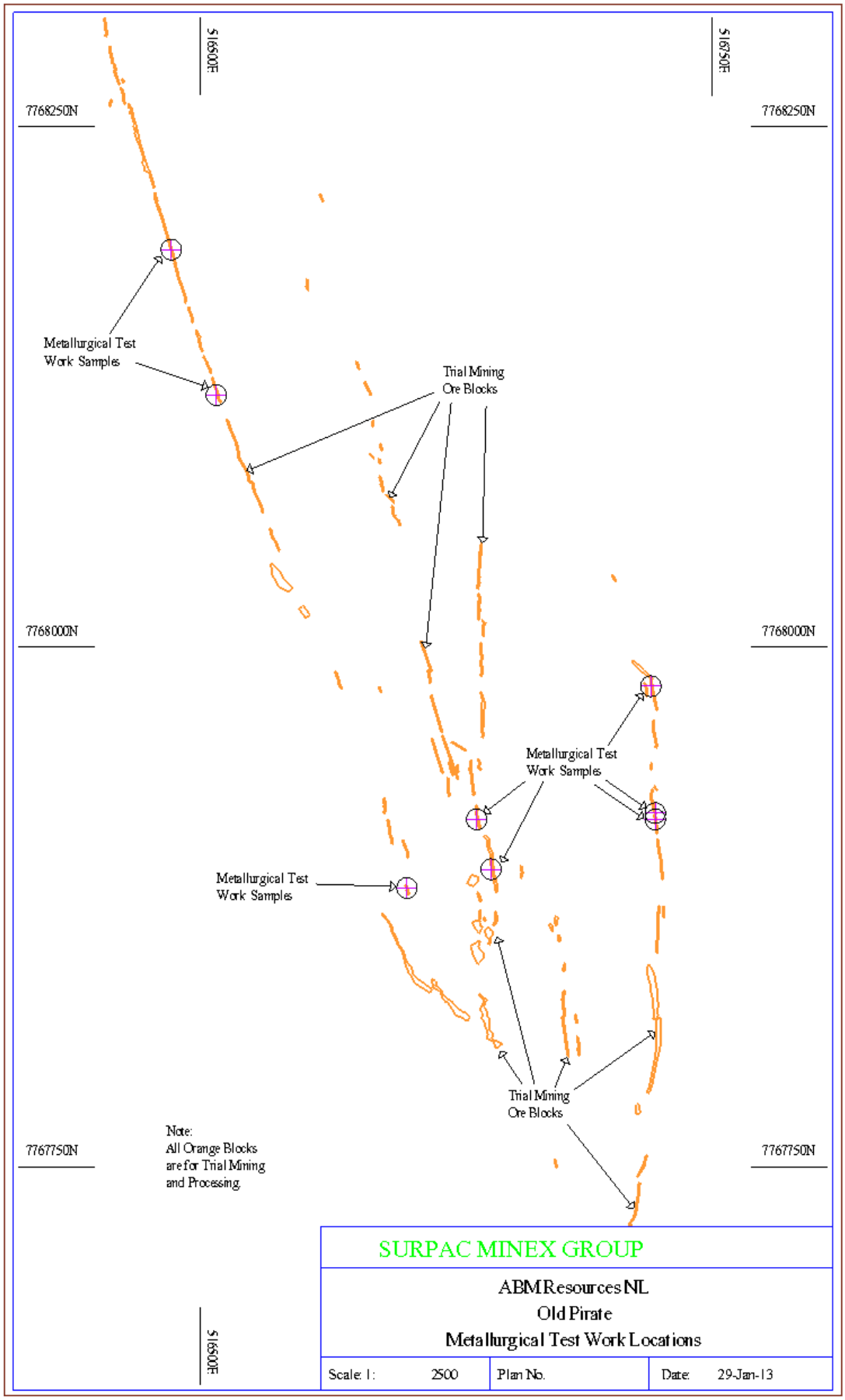

Figure 3.1: Locations of the Ore-Tailing Bulk/Composite Samples.

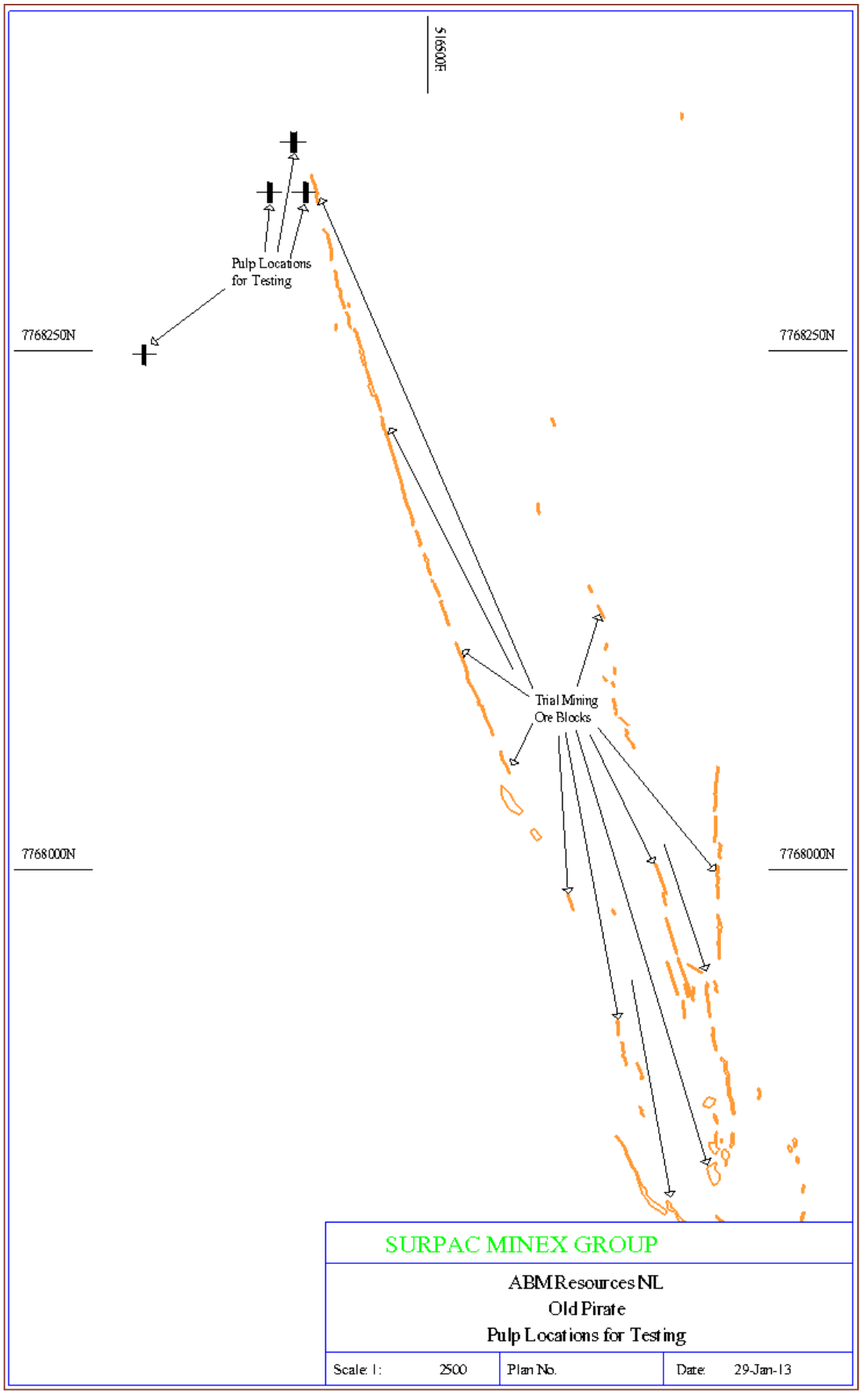

Figure 3.2: Location of the Pulp Samples for Analytical Testing.

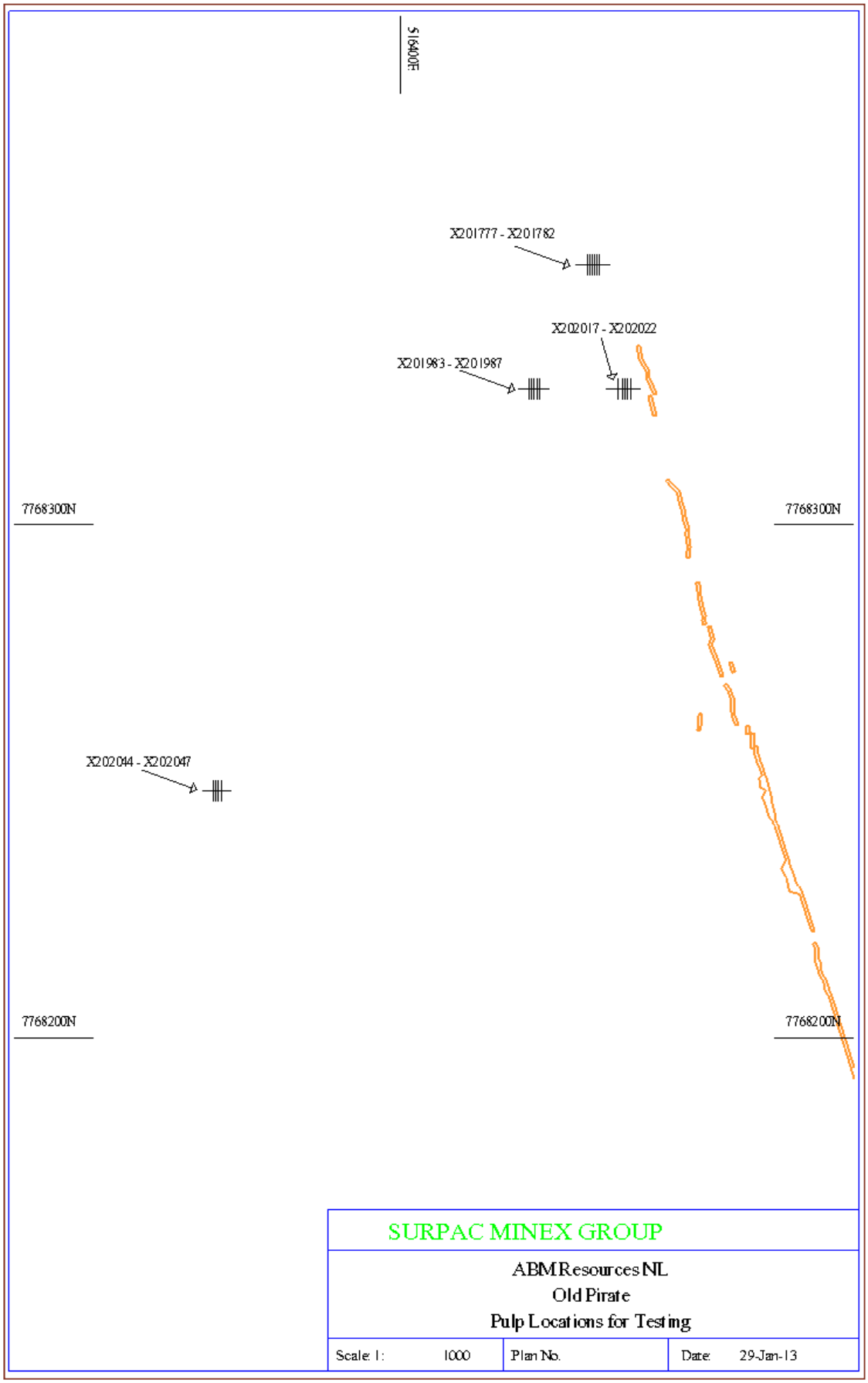

Figure 3.3 : Location of the Pulp Samples Showing Sample IDs.

3.2 Mineralogical Assessment

X-Ray Diffraction (XRD) and X-Ray fluorescence (XRF) assays were undertaken on twenty tailing samples. XRF data is used to analyse the geochemical abundance index (GAI, Förstner *et al.*, 1993) which assesses the enrichment of the samples by major elements:

GAI = log[(Cn/(1.5*Bn)),2]

where Cn is the measured content of the n^{th} element in the sample and Bn is the average-crustal-abundance of the element.

Analysing enrichment employs:

GAI	Symbol	Relevance
0	AC	The content of the element is less than, or similar to, the average-crustal-abundance.
1	3F	A 3 - fold enrichment above the average-crustal-abundance.
2	6F	A 6 - fold enrichment above the average-crustal-abundance.
3	12F	A 12 - fold enrichment above the average-crustal-abundance.
4	24F	A 24 - fold enrichment above the average-crustal-abundance.
5	48F	A 48 - fold enrichment above the average-crustal-abundance.
>6	96F	A 96 - fold, or greater, enrichment above the average-crustal-abundance.

3.3 Acid Base Accounting (ABA and NAG Tests)

The Potential for Acid Formation (PAF) of the ore-tailings materials was assessed by determining the pH of paste solutions, oxidation pH, Total-S, acid-neutralization capacity (ANC) and net-acid generation (NAG). Whilst ABA and NAG tests have limitations, both tests in combination increase the reliability of predicting acid generation in waste and ore materials (INAP, 2009). These tests have been widely used and are based on accepted methodologies for the geochemical characterisation of mine waste materials (e.g., INAP, 2009; DITR, 2007; Alarcón León et al 2004; Scharer et al., 2000; Rose and Cravotta, 1998; Morin and Hutt, 1997; Miller et al., 1997 and Sobek et al., 1978).

3.4 Hydrogeochemical Assessment

Leachate tests employed in this study are based on accepted procedures for the characterisation of mines wastes, including leaching using de-ionised water in accordance with Australian Standard Leaching Procedures (ASLP INAP, 2009). Leach solutions attained from a total of 22 samples were analysed for pH, EC, major ions (Ca, Mg, Na, K, HCO_3, Cl and SO_4) and trace metals (Al, As, Be, Cd, Cr, Co, Cu, F, Fe, Hg, Mn, Ni, Pb, Se, Sb and Zn).

3.5 Calculated Parameters

The Maximum Potential Acidity (MPA) values (in kgH_2SO_4/t) of the ore tailings were calculated by multiplying the Sulfide-S values (in %) by 30.6. The multiplication factor of 30.6 accounts for the reaction stoichiometry for the complete oxidation of pyrrotite and pyrite by O_2 to $Fe(OH)_3$ and H_2SO_4 (Lei and Watkins, 2005).

The Net Acid Producing Potential (NAPP) values (in kgH_2SO_4/t) were calculated from the corresponding MPA and Acid Neutralisation Capacity (ANC) values: NAPP = MPA - ANC. The acid potential ratios (APR) were calculated from the relationship of ANC/MPA (Paktunc, 1999).

The acid potential ratio (APR) criteria for the non-acid forming (NAF) Category reflects the need to compensate for the availability of alkalinity forms for neutralisation of acid produced through pyrite-oxidation. *A sample with an APR < 1 is classified as PAF, while a sample with an APR ≥ 2 is NAF. Samples with APR between 1 and 2 could generate either acid, alkaline, or neutral drainage* (Alarcón León, 2012 and INAP, 2009).

3.6 Classification Criteria

Table 3.3 lists the most accepted criteria for classifying PAF of mine waste materials.

Table 3.3: AFP Classification Criterion.

Category	DITR, 2007 and others	Lei and Watkins, 2005	OSS-ACMRR*-DITR
Non-Acid Forming (NAF):	Sulfide-S < 0.3% For Sulfide-S ≥ 0.3%, a negative NAPP value and APR ≥ 2.0	NAPP < -20 APR >3	NAG-pH > 4.5 NAG <5-10
Potentially Acid Forming (PAF):	For Sulfide-S ≥ 0.3%, any positive NAPP value, negative NAPP value with an APR < 2.0	NAPP > 20 APR < 1	NAG-pH <4.5 NAG > 10
Zone of Uncertainty	NAPP: between -20 and +20; APR: between 1 and 3		
***Office of the Supervising Scientist and the Australian Centre for Mine Rehabilitation Research.**			

Lithotypes with Sulfide-S concentrations less than 0.3% are unlikely to oxidise at rates fast enough to result in acidification (pH less than 4.0 to 5.0). Table 3.3, which reflects field experiences in Australia and includes an APR < 1, in addition to a cut-off NAG-pH value of 4.5 (Table 3.4), was employed in the current assessment to classify the AFP of the samples. The NAG international and national approach is based upon:

Table 3.4: NAG Classification Criterion.

NAG pH	NAG (kgH_2SO_4/t)	Geochemical Classification
≥ 4.5	0	Non-Acid Forming (NAF).
<4.5	≤ 5	Potentially Acid Forming - Lower Capacity (PAF-LC).
<4.5	> 5 - 10	Potentially Acid Forming (PAF).

4. Results and Discussion

4.1 Mineralogical Analysis

4.1.1 XRD Assessment

A semi-quantitative XRD assessment is summarized in Table 4.1 below (refer also Appendix B). Negative values generally indicate a larger than usual uncertainty with regard to the quantity of the phase reported and, for some of the minor and trace phases, it might also indicate an uncertainty with regard to the phase itself, or both.

Kaolinite with an average concentration of ~40% is the most prominent mineral in the samples. A significant amount of amorphous material (e.g. goethite) appears also to be present in all samples, particularly in the near surface (up to 5m deep) pulp samples.

Hazardous elements e.g. arsenic, chromium, etc. could be present in both the zeolite minerals and goethite as well as in the amorphous component.

Table 3.5: XRD Semi-Quantitative Mineralogy Results.

Sample ID	From	To	Alpha quartz	Kaolinite	Mica	Goethite	Clay mineral	Zeolite	Chlorite	Serpentine	Amphibole	Microcline - Rutile - Titanite	Hematite
			(%)										
Coarse Bulk Sample			**91**	**2**	**1**	**-3**	**< 1**	**3**	**0**	**0**	**1**	**0**	**0**
Fine Bulk Sample			**92**	**1**	**1**	**-2**	**-1**	**2**	**0**	**0**	**< 1**	**0**	**0**
X202044	1	2	17	46	4	29	-1	-1	0	-1	-2	0	0
X202045	2	3	22	44	4	28	< 1	< 1	0	0	< 1	< 1	< 1
X202046	3	4	20	52	6	20	-1	< 1	0	-1	0	0	0
X202047	4	5	26	44	6	21	< 1	0	< 1	0	0	-2	0
X201983	0	1	69	18	1	3	-1	2	< 1	0	0	3	3
X201984	1	2	26	44	1	26	-1	0	0	0	0	< 1	2
X201985	2	3	27	46	2	23	< 1	0	0	0	0	< 1	0
X201986	3	4	46	45	3	5	< 1	-1	0	0	0	0	0
X201987	4	5	35	50	3	11	< 1	< 1	0	0	0	0	0
X202017	34	35	37	39	16	6	< 1	-1	0	0	0	0	0
X202019	36	37	25	64	6	3	< 1	-1	0	0	0	0	0
X202020	37	38	44	46	6	-2	< 1	-1	0	0	0	0	0
X202021	38	39	26	62	9	-2	< 1	-1	0	0	0	0	0
X202022	39	40	34	56	6	-2	< 1	-1	0	0	< 1	0	0
X201777	88	89	31	41	21	-5	< 1	1	0	0	0	0	0
X201778	89	90	37	34	16	10	< 1	1	0	0	-1	0	0
X201779	90	91	33	36	18	13	< 1	1	0	0	0	0	0
X201780	91	92	24	38	24	13	< 1	< 1	0	0	0	< 1	0
X201781	92	93	35	43	10	11	< 1	-1	0	0	0	0	0
X201782	93	94	57	19	6	16	-1	1	< 1	0	0	0	0

4.1.2 XRF and GAI Assessment

The elemental chemistries of both sets of samples (i.e. bulk and pulp samples) are provided in Table 4.2 and Appendix C.

The mineralogical assessment indicated that parent materials are dominantly demarcated by aluminium quartz, phyllosilicates (e.g. kaolinites and micas) and hematite minerals. Hence, the chemical fingerprint in both sets of samples are logically in the order of silicon>aluminium>iron>potassium. Among the other significant fingerprint ions, average titanium oxides are slightly higher that magnesium, sodium and calcium oxide concentrations (Table 4.2).

Minor elements are dominated by barium with an average concentration of 0.041%. Subsequent higher concentrations are those of arsenic>zirconium>chromium>lead (Table 4.2). Nutrients in the form of phosphorous are also significantly high with an average concentration of 0.031%.

Although with a scatter correlation between affine minerals such as arsenic, iron and copper (Figure 4.1), arsenic alike barium shows a distinctive concentration pattern with depth (Figure 4.2). Both elements occur in an almost steady concentration within the near surface pulp samples, increase at intermediate depths (~35m below ground level) and then steadily decrease to the lowest concentrations at about 90m depth. This behaviour indicates that these elements are somewhat associated with kaolinites and micas, which display a steadiness in abundance with depth.

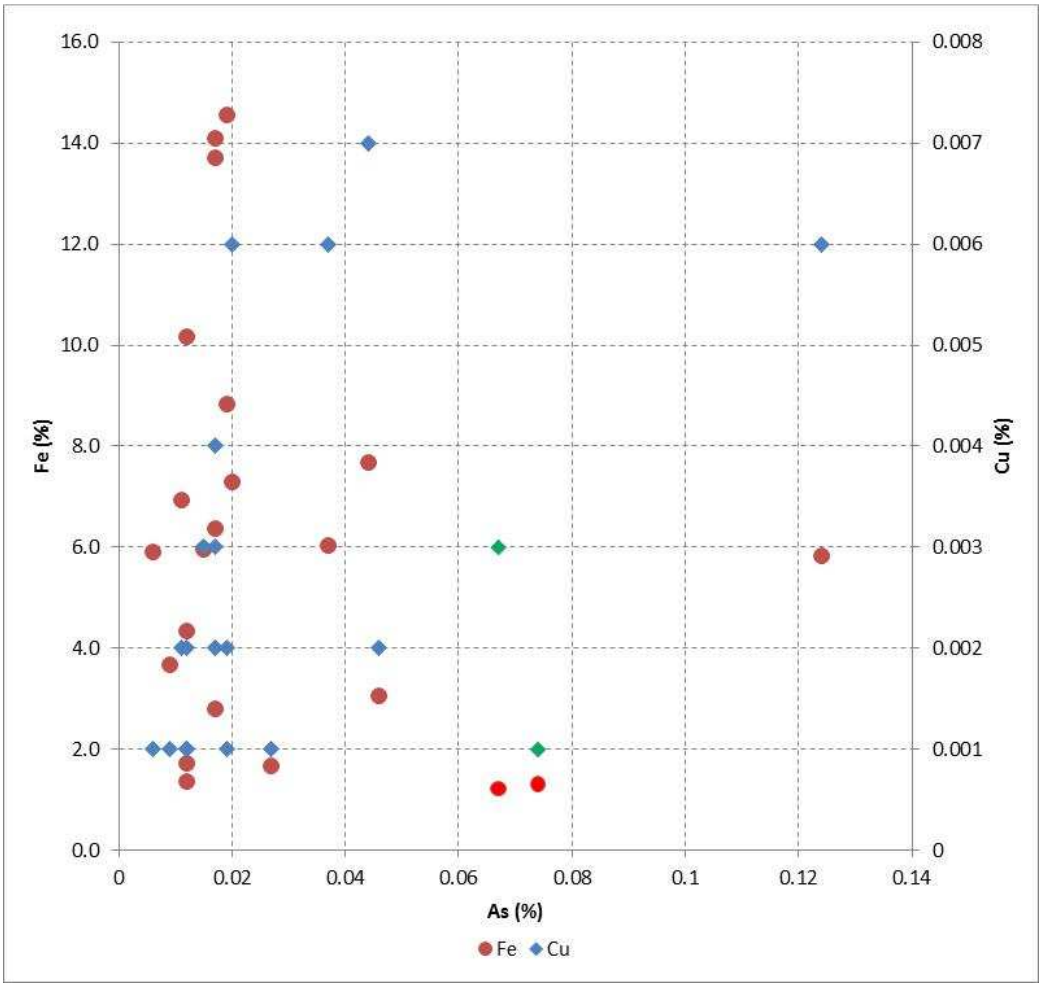

Figure 3.4: Arsenic versus Iron and Copper Concentrations.
(bulk samples are shown in Red and Green).

Table 3.6: XRF Elemental Chemistry of Bulk and Pulp Samples.

	Al	As	Ba	Ca	Cl	Co	Cr	Cu	Fe	K	Mg	Mn	Na	Ni	P	Pb	S	Si	Sn	Sr	Ti	V	Zn	Zr
Sample ID / Limits of Detection	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
	0.01	0.001	0.001	0.01	0.001	0.001	0.0006	0.001	0.01	0.001	0.01	0.001	0.005	0.001	0.001	0.001	0.001	0.01	0.001	0.001	0.01	0.001	0.001	0.001
X202044	10.84	0.017	0.023	0.122	0.004	0.001	0.020	0.002	14.10	1.017	0.229	0.030	0.064	0.002	0.025	0.009	0.007	22.37	<0.001	0.005	0.437	0.028	0.004	0.028
X202045	9.60	0.017	0.028	0.093	0.002	<0.001	0.020	0.002	13.70	1.004	0.241	0.015	0.042	0.001	0.022	0.007	0.007	23.96	<0.001	0.003	0.467	0.027	0.002	0.028
X202046	9.99	0.012	0.057	0.093	0.001	<0.001	0.014	<0.001	10.16	1.444	0.247	0.007	0.071	0.001	0.011	0.004	0.010	26.29	<0.001	0.004	0.383	0.017	0.002	0.025
X202047	8.49	0.011	0.061	0.064	0.001	<0.001	0.011	0.002	6.94	1.859	0.241	0.002	0.074	0.002	0.012	0.009	0.009	30.21	0.001	0.003	0.270	0.010	0.002	0.013
X201983	3.70	0.006	0.012	0.057	0.003	<0.001	0.012	<0.001	5.92	0.457	0.090	0.012	0.023	<0.001	0.013	<0.001	0.006	37.22	0.002	0.001	0.240	0.012	0.001	0.035
X201984	9.55	0.019	0.012	0.057	0.002	<0.001	0.011	0.002	14.55	0.632	0.163	0.013	0.042	0.002	0.012	0.005	0.015	24.00	0.001	0.003	0.407	0.028	0.002	0.030
X201985	8.44	0.019	0.092	0.057	0.002	<0.001	0.007	<0.001	8.82	1.133	0.217	0.002	0.076	<0.001	0.005	<0.001	0.027	28.95	0.001	0.003	0.347	0.014	0.001	0.019
X201986	6.45	0.009	0.029	0.064	0.008	<0.001	0.002	<0.001	3.67	0.888	0.199	0.002	0.118	<0.001	0.004	<0.001	0.020	35.26	0.001	<0.001	0.246	0.003	0.001	0.012
X201987	6.88	0.012	0.022	0.186	0.010	<0.001	0.004	<0.001	4.35	1.013	0.241	<0.001	0.108	<0.001	0.005	<0.001	0.014	34.09	0.001	0.001	0.222	0.003	0.001	0.015
X202017	8.57	0.124	0.066	0.021	0.021	<0.001	0.006	0.006	5.84	3.536	0.338	0.004	0.082	0.002	0.069	0.034	0.012	30.63	0.002	0.008	0.252	0.009	0.015	0.007
X202019	6.90	0.046	0.036	0.014	0.016	<0.001	0.005	0.002	3.06	1.751	0.187	0.002	0.051	<0.001	0.039	0.009	0.008	35.30	0.001	0.004	0.264	0.004	0.010	0.019
X202020	7.14	0.027	0.038	0.014	0.012	<0.001	0.003	<0.001	1.68	1.818	0.187	0.001	0.047	0.002	0.024	0.007	0.006	36.05	0.002	0.002	0.264	0.003	0.005	0.016
X202021	8.81	0.012	0.063	0.007	0.014	<0.001	0.006	0.001	1.36	2.822	0.271	0.002	0.070	<0.001	0.019	0.007	0.005	33.99	0.003	0.002	0.347	0.006	0.004	0.017
X202022	7.51	0.012	0.045	0.007	0.012	<0.001	0.004	0.002	1.72	1.917	0.205	0.002	0.068	<0.001	0.022	0.008	0.006	35.49	0.002	0.002	0.300	0.005	0.005	0.019
X201777	10.58	0.017	0.063	0.014	0.011	<0.001	0.008	0.003	2.80	4.258	0.404	0.004	0.089	0.002	0.040	0.006	0.003	30.40	0.001	0.004	0.311	0.006	0.009	0.007
X201778	7.64	0.044	0.044	0.021	0.007	<0.001	0.005	0.007	7.67	3.104	0.314	0.011	0.056	0.005	0.102	0.014	0.004	30.63	<0.001	0.004	0.222	0.009	0.018	0.007
X201779	9.73	0.037	0.062	0.014	0.010	<0.001	0.008	0.006	6.03	4.075	0.434	0.007	0.081	0.003	0.075	0.007	0.003	29.00	0.001	0.005	0.270	0.007	0.016	0.008
X201780	10.63	0.020	0.067	0.014	0.006	0.001	0.016	0.006	7.30	4.499	0.410	0.007	0.084	0.012	0.057	0.007	0.002	26.99	<0.001	0.005	0.300	0.008	0.017	0.009
X201781	7.91	0.015	0.040	0.014	0.005	<0.001	0.006	0.003	5.96	2.913	0.271	0.009	0.059	0.002	0.050	0.002	0.002	31.76	0.002	0.003	0.270	0.004	0.012	0.013
X201782	5.84	0.017	0.030	0.014	0.004	<0.001	0.002	0.004	6.36	1.917	0.187	0.009	0.042	0.002	0.067	0.004	0.002	34.14	<0.001	0.002	0.210	0.003	0.017	0.018
Coarse bulk sample	0.397	0.074	0.004	0.007	0.002	<0.001	0.003	<0.001	1.32	0.120	0.024	0.006	0.004	<0.001	0.001	0.027	0.007	45.16	0.002	<0.001	0.018	<0.001	<0.001	<0.001
Fine bulk sample	0.354	0.067	0.008	0.043	0.002	<0.001	0.102	0.003	1.22	0.110	0.030	0.010	0.007	0.047	0.001	0.026	0.007	45.21	0.003	<0.001	0.012	<0.001	0.001	<0.001
Average	7.54	0.03	0.04	0.05	0.007	0.001	0.013	0.003	6.12	1.92	0.23	0.007	0.06	0.006	0.03	0.011	0.008	32.14	0.002	0.003	0.28	0.010	0.007	0.017
Median	8.17	0.02	0.04	0.02	0.006	0.001	0.007	0.003	5.94	1.78	0.24	0.007	0.07	0.002	0.02	0.007	0.007	31.20	0.002	0.003	0.27	0.008	0.004	0.017
Maximum	10.84	0.12	0.09	0.19	0.021	0.001	0.102	0.007	14.55	4.50	0.43	0.030	0.12	0.047	0.10	0.027	0.027	45.21	0.003	0.008	0.47	0.028	0.018	0.035
Minimum	0.35	0.01	0.004	0.01	0.001	0.001	0.001	0.001	1.22	0.11	0.02	0.001	0.004	0.001	0.001	0.002	0.001	22.37	0.001	0.001	0.01	0.003	0.001	0.007
No Samples	22	22	22	22	22	2	22	15	22	22	22	21	22	14	22	18	22	22	16	19	22	20	21	20

Table 3.7: GAI Analysis to Assess Element Enrichment.

Sample ID	Al	As	Ba	Ca	Cl	Co	Cr	Cu	Fe	K	Mg	Mn	Na	Ni	P	Pb	S	Si	Sn	Sr	Ti	V	Zn	Zr
Coarse bulk sample	0.0	8.1	0.0	0.0	0.0		0.0		0.0	0.0	0.0	0.0	0.0		0.0	3.7	0.0	0.1	2.5		0.0			
Fine bulk sample	0.0	8.0	0.0	0.0	0.0		2.7	0.0	0.0	0.0	0.0	0.0	0.0	1.9	0.0	3.6	0.0	0.1	3.1		0.0		0.0	
X202044	0.0	6.0	0.0	0.0	0.0	0.0	0.4	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	2.1	0.0	0.0		0.0	0.0	0.6	0.0	0.2
X202045	0.0	6.0	0.0	0.0	0.0		0.4	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	1.7	0.0	0.0		0.0	0.0	0.6	0.0	0.2
X202046	0.0	5.5	0.0	0.0	0.0		0.0		0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.0		0.0	0.0	0.0	0.0	0.0
X202047	0.0	5.3	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0
X201983	0.0	4.5	0.0	0.0	0.0		0.0		0.0	0.0	0.0	0.0	0.0		0.0		0.0	0.0	2.5	0.0	0.0	0.0	0.0	0.5
X201984	0.0	6.1	0.0	0.0	0.0		0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.0	1.5	0.0	0.0	0.6	0.0	0.3
X201985	0.0	6.1	0.5	0.0	0.0		0.0		0.1	0.0	0.0	0.0	0.0		0.0		0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0
X201986	0.0	5.1	0.0	0.0	0.0		0.0		0.0	0.0	0.0	0.0	0.0		0.0		0.0	0.0	1.5		0.0	0.0	0.0	0.0
X201987	0.0	5.5	0.0	0.0	0.0		0.0		0.0	0.0	0.0		0.0		0.0		0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0
X202017	0.0	8.8	0.1	0.0	0.0		0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	4.0	0.0	0.0	2.5	0.0	0.0	0.0	0.5	0.0
X202019	0.0	7.4	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	2.1	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0
X202020	0.0	6.6	0.0	0.0	0.0		0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	0.0	0.0	2.5	0.0	0.0	0.0	0.0	0.0
X202021	0.0	5.5	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	1.7	0.0	0.0	3.1	0.0	0.0	0.0	0.0	0.0
X202022	0.0	5.5	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	1.9	0.0	0.0	2.5	0.0	0.0	0.0	0.0	0.0
X201777	0.0	6.0	0.0	0.0	0.0		0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	1.5	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0
X201778	0.0	7.3	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.7	0.0	0.0		0.0	0.0	0.0	0.8	0.0
X201779	0.0	7.1	0.0	0.0	0.0		0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	1.7	0.0	0.0	1.5	0.0	0.0	0.0	0.6	0.0
X201780	0.0	6.2	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	1.7	0.0	0.0		0.0	0.0	0.0	0.7	0.0
X201781	0.0	5.8	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5	0.0	0.0	0.0	0.2	0.0
X201782	0.0	6.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.0		0.0	0.0	0.0	0.7	0.0
Average	0.0	6.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	1.8	0.0	0.0	2.0	0.0	0.0	0.1	0.2	0.1
Maximum	0.0	8.8	0.5	0.0	0.0	0.0	0.4	0.0	0.8	0.5	0.0	0.0	0.0	0.0	0.0	4.0	0.0	0.0	3.1	0.0	0.0	0.6	0.8	0.5
Minimum	0.0	4.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0

Table 3.8: ABA/NAG Assessment.

Methods / Acronyms	Fizz Rating	pH (OX)	Final pH	NAG (pH 4.5)	NAG (pH 7.0)	Total Carbon	Sulfur - Total as S	Sulfate as SO_4^{2-}	Sulfur as S	Sulfide as S	Maximum Potential Acidity	Acid Neutralisation Capacity	Net Acid Production Potential	Acid Potential Ratio	ABA Classification
							LECO	14808-79-8	63705-05-5		MPA	ANC	NAPP	APR	
Units	Fizz	pH	pH	kg H_2SO_4/t	kg H_2SO_4/t	%	%	mg/kg	mg/kg	%	kg H_2SO_4/t		kg H_2SO_4/t		
LOR	0	0.1	0.1	0.1	0.1	0.02	0.01	10	10	0.01		0.5			
Sample ID															
X202044	1	6.1	8	<0.1	4.4	<0.02	0.06	<10	<10	0.06	1.84	<0.5	1.34	0.27	NAF
X202045	1	6.5	8.1	<0.1	3	<0.02	0.04	10	<10	0.04	1.22	<0.5	0.72	0.41	NAF
X202046	1	6.3	8.2	<0.1	4	<0.02	0.02	20	<10	0.02	0.61	<0.5	0.11	0.82	NAF
X202047	1	6	8.2	<0.1	8.1	<0.02	0.02	50	20	0.01	0.31	1	-0.69	3.27	NAF
X201983	1	5.2	7.5	<0.1	**12.1**	<0.02	0.57	30	<10	**0.57**	17.44	<0.5	16.94	0.03	**UC**
X201984	1	5.6	8.1	<0.1	9.4	<0.02	0.06	10	<10	0.06	1.84	1	0.84	0.54	NAF
X201985	1	5.9	7.8	<0.1	8.8	<0.02	0.04	80	30	0.03	0.92	<0.5	0.42	0.54	NAF
X201986	1	6.1	8.1	<0.1	7.6	<0.02	<0.01	60	20	<0.01	0.31	7	-6.69	22.88	NAF
X201987	1	6	8.5	<0.1	**18.1**	<0.02	0.05	80	30	0.04	1.22	3.6	-2.38	2.94	NAF
X202017	1	5.9	7.6	<0.1	10	<0.02	<0.01	170	60	<0.01	0.31	1.5	-1.19	4.90	NAF
X202019	1	5.4	7.6	<0.1	**16.7**	<0.02	<0.01	110	40	<0.01	0.31	1	-0.69	3.27	NAF
X202020	1	5.7	7.4	<0.1	**14.6**	<0.02	<0.01	20	<10	<0.01	0.31	<0.5	-0.19	1.63	NAF
X202021	1	5.7	7.9	<0.1	**11.6**	<0.02	<0.01	80	20	<0.01	0.31	<0.5	-0.19	1.63	NAF
X202022	1	5.7	8	<0.1	**13.6**	<0.02	<0.01	30	<10	<0.01	0.31	<0.5	-0.19	1.63	NAF
X201777	1	5.9	8.4	<0.1	**10.5**	<0.02	<0.01	20	<10	<0.01	0.31	0.9	-0.59	2.94	NAF
X201778	1	6	7.9	<0.1	7.7	<0.02	0.02	30	<10	0.02	0.61	<0.5	0.11	0.82	NAF
X201779	1	6.1	8.2	<0.1	8.2	<0.02	0.02	30	10	0.02	0.61	<0.5	0.11	0.82	NAF
X201780	1	6	8.5	<0.1	9.1	<0.02	0.03	20	<10	0.03	0.92	0.8	0.12	0.87	NAF
X201781	1	6.1	8.5	<0.1	6.8	<0.02	0.03	10	<10	0.03	0.92	<0.5	0.42	0.54	NAF
X201782	1	6.2	8.2	<0.1	6	<0.02	0.04	<10	<10	0.04	1.22	<0.5	0.72	0.41	NAF
Coarse Bulk Sample	1	6.2	8.2	<0.1	7.5	<0.02	<0.01	20	<10	<0.01	0.31	<0.5	-0.19	1.63	NAF
Fine Bulk Sample	1	6.4	9.2	<0.1	6.6	<0.02	<0.01	40	10	<0.01	0.31	1.5	-1.19	4.90	NAF
Average	1.00	5.95	8.10	<0.1	9.29	<0.02	0.08	46.00	26.67	0.07	1.47	2.03	0.35	2.62	
Maximum	1.00	6.50	9.20	<0.1	18.10	<0.02	0.57	170.00	60.00	0.57	17.44	7.00	16.94	22.88	
Minimum	1.00	5.20	7.40	<0.1	3.00	<0.02	0.02	10.00	10.00	0.01	0.31	0.80	-6.69	0.03	

Note: In Bold and blue is the highest Sulfide as S Concentration. Samples with Sulphide-S>0.3% are commonly characterised as **PAF**. In bold and black are those which contains high (>10) NAG pH as H_2SO_4/t values.

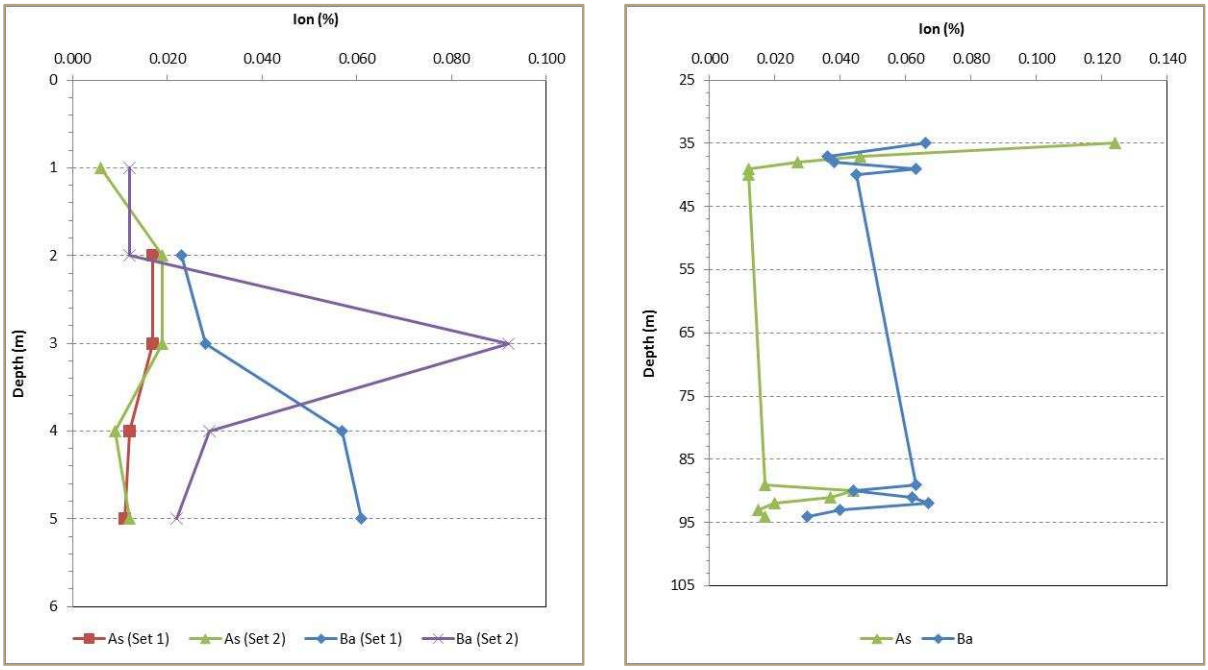

Figure 3.5: Arsenic and Barium Concentrations with Depth.

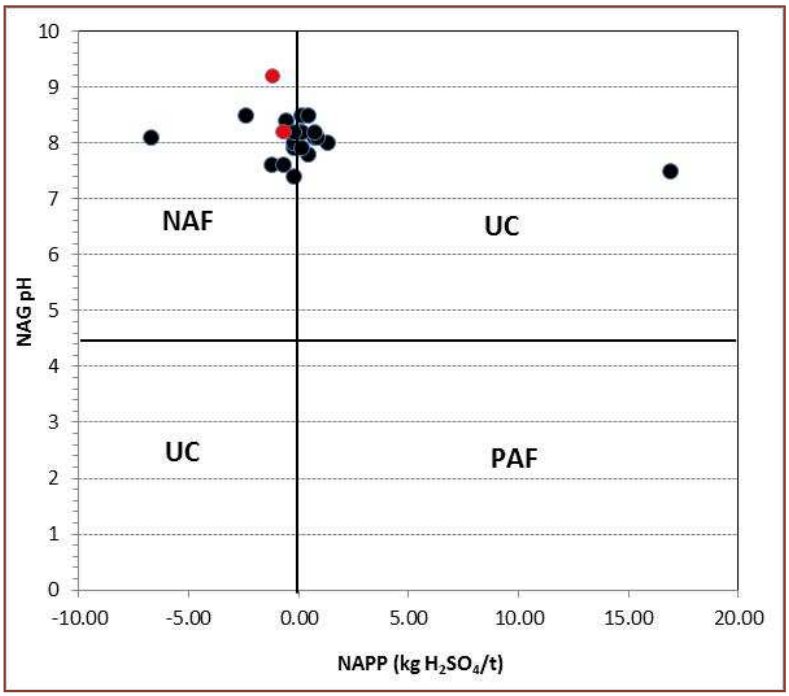

Figure 3.6: NAPP-NAG pH Classification Scheme.
(the bulk samples are shown in red dots)

An assessment of the elemental enrichment in the samples is provided in Table 4.3 and it is evident that all samples are significantly enriched with arsenic; up to about a 96-fold (or greater) enrichment above the average-crustal-abundance. Tin and lead are also enriched up to a 6-fold enrichment above the average-crustal-abundance.

The Old Pirate area has been reported to be naturally anomalous in arsenic and lead. ABM advises that these elements were the key fingerprint elements used in the discovery of the Old Pirate gold mineralised deposits (ABM historical database). The local arsenic and lead anomalies are contained within the multiple narrow high grade veins, which are within the highly weathered and poorly exposed

rock outcrops. Locally, arsenic values may vary from <10ppm up to 4,000ppm in soil and rock chip samples. Rocks and soils around the Old Pirate Deposit may also contain significant concentrations of bismuth and uranium.

4.2 ABA Acid Base Chemistry Assessment

The ABA-NAG assessment data (Appendix D) are provided in Table 4.4. A NAPP-NAG pH classification scheme is presented in Figure 4.3 (above); where NAF is non-acid forming, PAF is potentially acid forming and UC is uncertain to be defined as acid or alkaline producing materials. Red dots are the bulk samples; i.e., the fine bulk sample (high pH) and coarse bulk sample (lower pH).

An overall assessment of the ABA properties of the samples indicates:

4.2.1 Ore-Tailing Materials

- Paste pHs are circum-neutral, with an average of 6.3, while NAG pH is alkaline with an average pH of 8.7. Results indicate that both the coarse and fine bulk samples contain noteworthy and large reactive buffering capacities.
- ABA classification with regard to sulfur concentration indicates that both samples are non-acid forming (NAF) materials.
- Because of the low concentration of total sulfur in the samples, it is assumed that an ANC/MPA ratio of <1 is indicative of a rock likely to produce acid. Accordingly, both samples can be classified with no likely potential to produce acidity.
- A negative NAPP (particularly <20kg H_2SO_4 equiv/t) indicates samples have a net neutralising capacity and a positive NAPP (>20kg H_2SO_4 equiv/t) indicates samples have a net acid generating capacity. Both samples have negative NAPP values and therefore are unlikely to produce acidity.
- NAG pH <4.5 indicate rocks are likely to produce acidity. None of the samples produced low NAG pHs. If NAG is assessed against NAPP, both samples are within the NAF zone (Figure 4.3).

4.2.2 Pulp Materials

- Paste pHs are mostly circum-neutral with an average of 5.92 ranging from 5.20 (slightly acidic) to 6.50 (circum-neutral), while NAG pH are slightly alkaline with an average 8.04, ranging from 7.40 to 8.50. Results indicate that there is little or no freely available acidity in the samples.
- ABA classification with regard to sulfur concentration indicates that with the exception of a single surface sample (X201983), all samples are non-acid forming (NAF) materials. Sample X201983 was detected to contain the highest 0.57% of sulphide as S.
- ABA classification in relation to NAPP indicates that no pulp samples have the potential to produce acidity and that all can be classified as NAF samples.
- A classification on the ANC/MPA (acid potential ratio APR) ratio of <1 specify about 50% of the samples appears to have the potential to produce acidity. Significant variability in relation to the other ABA assessment criteria indicates that samples may have an overall lower buffering capacity.
- If NAG is assessed against NAPP (Figure 4.3), none of the samples are classified as PAF. However, all samples that are classified by the APR as having the potential to produce acid fall within the UC area. This would suggest that these samples need further characterisation.

5. Water Quality Prediction

Sites with APRs less than 1 should produce acid drainage, while ratios greater than 2 should produce net alkaline drainage. Those sites with ratios between 1 and 2 could generate either acid, alkaline or neutral drainage.

As detailed in Sections 4.2.1 and 4.2.2 above, neither of the ore-tailings samples (bulk materials) has the potential to produce acidity, while about 50% of the pulp samples have APRs less than 1 and are described as having the potential to produce acidity. However, as presented in Table 4.4, these samples have low NAPP and all of their other corresponding ABA values suggest that they would not impact water quality as any acid produced will be offset by the buffering capacity of the samples.

A hydro-chemical assessment of the samples (Table 5.1 and Appendix D) indicates that most of the analytes in the leachates occur in very low concentrations and/or are below their limits of reporting (LoRs). Leachates are characterised by having an overall circum-neutral pH, ranging from 6.10 to 7.49. The elevated pH corresponds to the fine bulk sample, with the lowest being pulp sample X202021. Corresponding electrical conductivities range from 15µS/cm to 107µS/cm.

Major cation concentrations in all samples are in the order of Na>K>Ca>Mg. Although sodium is very low in both bulk samples, these are relevant in the pulp samples with an average 6.23mg/L and a maximum of 14.0mg/L. Anions are also low in the order of $Cl>SO_4$, with average values of 4.74mg/L and 3.95mg/L respectively.

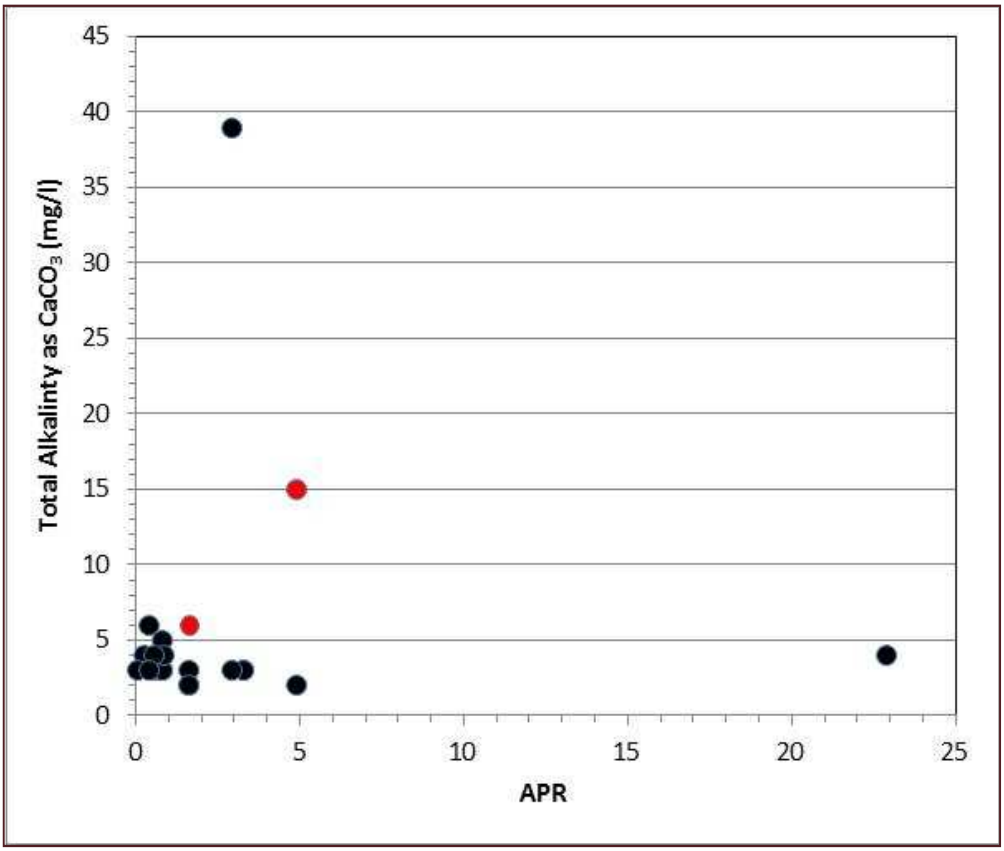

Figure 3.7: APR versus Total Alkalinity (as $CaCO_3$) in Leached Solutions.
(the bulk samples are indicated in red).

Table 3.9: Predicted Water Quality.

Analyte	pH Value	Electrical Conductivity (EC)	Hydroxide Alkalinity as $CaCO_3$	Carbonate Alkalinity as $CaCO_3$	Bicarbonate Alkalinity as $CaCO_3$	Total Alkalinity as $CaCO_3$	Sulfate as SO_4	Chloride	Calcium	Magnesium	Sodium	Potassium	Aluminium	Antimony	Arsenic	Barium	Chromium	Lead	Manganese	Nickel	Zinc	Iron	Fluoride
Units	pH Unit	µS/cm	mg/L																				
LOR	0.01	1	1	1	1	1	1	1	1	1	1	1	0.01	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.005	0.05	0.1
Sample ID																							
X202044	6.14	20	<1	<1	4	4	<1	2	<1	<1	5	1	0.28	0.003	0.002	0.213	<0.001	<0.001	0.001	<0.001	0.095	0.16	0.3
X202045	7.38	22	<1	<1	6	6	3	2	<1	<1	5	2	0.33	<0.001	0.003	0.229	<0.001	<0.001	0.001	<0.001	0.088	0.2	0.4
X202046	6.35	32	<1	<1	5	5	4	<1	<1	<1	8	<1	0.67	<0.001	0.006	0.341	0.001	<0.001	0.004	<0.001	0.104	0.71	0.5
X202047	6.18	22	<1	<1	3	3	6	<1	<1	<1	6	1	0.17	<0.001	0.009	0.11	<0.001	<0.001	<0.001	<0.001	0.065	0.1	0.5
X201983	6.16	20	<1	<1	3	3	2	1	<1	<1	3	3	0.41	<0.001	0.005	0.18	<0.001	<0.001	0.043	<0.001	0.149	0.4	<0.1
X201984	6.21	15	<1	<1	3	3	2	2	<1	<1	4	<1	0.16	<0.001	0.003	0.131	<0.001	<0.001	<0.001	<0.001	0.039	0.11	0.2
X201985	6.11	42	<1	<1	3	3	12	2	<1	<1	8	3	0.2	<0.001	0.002	0.316	<0.001	<0.001	<0.001	<0.001	0.088	0.1	0.7
X201986	6.27	41	<1	<1	4	4	6	5	<1	<1	10	<1	0.22	<0.001	0.003	0.251	<0.001	<0.001	<0.001	<0.001	0.07	0.09	0.5
X201987	7.24	107	<1	<1	39	39	6	6	6	3	14	4	0.08	<0.001	0.02	0.281	<0.001	<0.001	<0.001	<0.001	0.041	<0.05	0.7
X202017	6.2	74	<1	<1	2	2	11	11	<1	<1	9	9	0.02	<0.001	0.01	0.173	<0.001	<0.001	<0.001	<0.001	0.071	<0.05	0.8
X202019	6.13	52	<1	<1	3	3	7	8	<1	<1	8	5	<0.01	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.05	0.6
X202020	6.13	37	<1	<1	2	2	2	7	<1	<1	5	6	0.05	<0.001	0.008	0.129	<0.001	<0.001	<0.001	<0.001	0.078	<0.05	0.4
X202021	6.1	49	<1	<1	3	3	4	8	<1	<1	9	4	0.12	<0.001	0.008	0.441	<0.001	<0.001	<0.001	0.001	0.087	0.06	0.5
X202022	6.14	39	<1	<1	2	2	2	8	<1	<1	8	3	0.06	<0.001	0.005	0.353	<0.001	<0.001	<0.001	<0.001	0.059	<0.05	0.5
X201777	6.28	35	<1	<1	3	3	1	5	<1	<1	7	4	0.38	<0.001	0.055	0.396	0.001	<0.001	<0.001	<0.001	0.098	0.26	0.7
X201778	6.28	28	<1	<1	3	3	2	4	<1	<1	5	5	0.05	<0.001	0.05	0.142	<0.001	<0.001	<0.001	<0.001	0.024	0.09	0.8
X201779	6.3	37	<1	<1	3	3	2	6	<1	<1	5	7	0.08	<0.001	0.067	0.146	<0.001	<0.001	<0.001	<0.001	0.023	0.09	0.8
X201780	6.29	28	<1	<1	4	4	2	4	<1	<1	5	4	0.11	<0.001	0.049	0.147	0.001	<0.001	0.002	<0.001	0.035	0.34	0.8
X201781	6.25	24	<1	<1	4	4	1	4	<1	<1	6	2	0.09	<0.001	0.046	0.2	<0.001	<0.001	<0.001	<0.001	0.03	0.17	0.6
X201782	6.26	21	<1	<1	3	3	<1	3	<1	<1	3	4	<0.01	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.005	<0.05	0.7
Coarse Bulk Sample	6.23	22	<1	<1	6	6	2	2	2	<1	3	<1	0.06	0.004	0.054	0.29	<0.001	0.004	0.033	<0.001	0.054	0.1	0.1
Fine Bulk Sample	7.49	32	<1	<1	15	15	2	<1	6	<1	1	<1	0.04	0.002	0.09	0.148	<0.001	0.002	<0.001	<0.001	0.014	0.06	0.1
Average	6.37	36	<1	<1	6	6	4	4.74	4.67	3.00	6.23	3.94	0.18	0.003	0.02	0.22	0.00	0.003	0.014	0.001	0.07	0.19	0.53
Maximum	7.49	107	<1	<1	39	39	12	11.00	6.00	3.00	14.00	9.00	0.67	0.004	0.09	0.44	0.00	0.004	0.043	0.001	0.15	0.71	0.80
Minimum	6.10	15	<1	<1	2	2	1	1.00	2.00	3.00	1.00	1.00	0.02	0.002	0.00	0.00	0.00	0.002	0.001	0.001	0.01	0.06	0.10

Total alkalinities of the samples have a low average value of 5.6mg/L with a range from 2.0mg/L to 39.0mg/L (Table 5.1 and Figure 5.1). Figure 5.1 shows that the majority of samples have a good correlation between low APR and low total alkalinity, which could indicate that samples have an average low buffering capacity and may tend to produce acidity. Most trace elements in all samples are relatively low in concentrations and most of them are below their LoRs (Table 5.2). Although these elements are in the order of fluoride>barium>iron>aluminium, their overall behaviour are indicative of these solutes being available for dilution and exchanges in low concentrations.

Individual toxic elements such as arsenic, chromium and lead are in the order of arsenic>lead>chromium. Arsenic is particularly high with an average of 0.02mg/L ranging from 0.002mg/L to 0.09mg/L in the fine bulk sample. Subsequent highest concentrations with an average of 0.053mg/L are confined to the pulp samples from depths between 35m to 94m below ground (deeper than any of the proposed bulk sample trenches). A mineralogical assessment indicates that all samples contain high amorphous mineral concentrations such as goethite, to which arsenic may attach and is readily available for release in the short term. Overall element concentrations and behaviours indicate short term leachate qualities in all samples will likely have low concentrations of these traces and would not present an immediate risk to the wider environment. However, arsenic, as explained, may be significant in the short term.

Table 3.10: Trace Elements with Concentrations (mg/L) below their LoRs.

Element	LoR
Beryllium	0.001
Cadmium	0.0001
Cobalt	0.001
Copper	0.001
Mercury	0.0001
Selenium	0.01
Vanadium	0.01

6. Conclusions

6.1 Mineralogical and ABA Assessments

- Mineralogically both sets of samples contain significant amounts of phyllosilicates and amorphous materials and are chemically enriched by arsenic, tin and lead.
- The great majority of the samples (95%) can be classified as non-acid forming (NAF) materials. Owing to its high sulfide as S concentration, only one pulp sample (i.e. near surface sample X201983) can be characterised as 'uncertain' and therefore, if warranted, may require further assessment for its potential to produce acidity.
- Owing to apparent conflicting results between NAPP and NAG results, about 50% of the pulp samples may be classified with a potential to produce acidity. However, because the other ABA parameters (including sulfide concentrations) are very low and/or insignificant, these materials can be classified as having very low or no acid forming capacity.

6.2 Hydrochemical Assessment

- pHs of all samples are circum-neutral and major ions are very low in concentrations with sodium being the highest in most of the pulp samples.
- Trace element concentrations in all samples are relatively low and most of them are below their limits of reporting. Generally, these are in the order of fluoride>barium>iron>aluminium.
- Individual toxic elements such as arsenic, chromium and lead are in the order of arsenic>lead>chromium. Arsenic is particularly high in all samples and appears to be readily available for release or mobilisation in the short term.
- Overall elemental concentrations and behaviour indicate short term leachate qualities in all samples will likely have low concentrations of these traces and would not represent an immediate risk to the wider environment.

7. Acid Mine Drainage (AMD) Management

Geochemical assessments indicate that most if not all of the samples are characterised with having low potentials for producing acidity. One sample returned results that are inconclusive. However, for this relatively small-scale bulk sampling activity, the uncertainty in the assessment is considered an overall low risk to the surrounding environment. The development of an AMD management procedure is therefore not warranted.

However, it is recommended that:

- Should the project move towards full-scale mining, more targeted studies be conducted to assist in further assessment of the current uncertainty presented by sample X201983 and those samples defined as 'uncertain' in the APR assessment.
- Weekly to monthly monitoring of tail solutions be conducted to detect potential loading of arsenic. Results should assist in ascertaining long term monitoring and rehabilitation processes and systems.

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Appendices

Appendix A: Coordinates and General Description of Bulk Samples

Appendix B: XRD Data Base and General Assessment

Appendix C: XRF Base Data

Appendix D: Results and Laboratory Certificates of ABA and Leachate Data

Appendix A:
Coordinates and General Description of Bulk Samples

SampleID	Au ppm	HoleID	Collar X	Collar Y	Collar Z	From	To	Sample X	Sample Y	Sample Z	Weathering	Lith 1	Lith 1 %	Lith 2	Lith 2 %	Lith 3	Lith 3 %
X202044	0.03	OPRC100200	516364.09	7768248.15	449.15	1	2	516364.85	7768248.15	447.85	HW	NR	100				
X202045	0.17	OPRC100200	516364.09	7768248.15	449.15	2	3	516365.35	7768248.15	446.99	MW	SS	100				
X202046	0.02	OPRC100200	516364.09	7768248.15	449.15	3	4	516365.86	7768248.15	446.13	MW	SS	100				
X202047	0.03	OPRC100200	516364.09	7768248.15	449.15	4	5	516366.36	7768248.15	445.26	MW	SS	90	ST	10		
X201983	0.03	OPRC100197	516424.02	7768326.42	449.46	0	1	516424.26	7768326.43	449.03	HW	NR	100				
X201984	0.01	OPRC100197	516424.02	7768326.42	449.46	1	2	516424.76	7768326.43	448.16	HW	NR	100				
X201985	0.01	OPRC100197	516424.02	7768326.42	449.46	2	3	516425.25	7768326.43	447.29	MW	SS	100				
X201986	0.02	OPRC100197	516424.02	7768326.42	449.46	3	4	516425.75	7768326.43	446.42	MW	SS	100				
X201987	0.01	OPRC100197	516424.02	7768326.42	449.46	4	5	516426.25	7768326.43	445.55	MW	SS	100				
X202017	0.51	OPRC100197	516424.02	7768326.42	449.46	34	35	516440.91	7768326.43	419.39	MW	QT	90	ST	10		
X202019	0.17	OPRC100197	516424.02	7768326.42	449.46	36	37	516441.88	7768326.43	417.63	MW	NR	90	SS	5	QT	5
X202020	0.23	OPRC100197	516424.02	7768326.42	449.46	37	38	516442.36	7768326.43	416.76	MW	NR	90	SS	5	QT	5
X202021	0.05	OPRC100197	516424.02	7768326.42	449.46	38	39	516442.84	7768326.43	415.88	MW	NR	90	SS	5	QT	5
X202022	0.08	OPRC100197	516424.02	7768326.42	449.46	39	40	516443.33	7768326.43	415.01	MW	NR	90	SS	5	QT	5
X201777	0.31	OPRC100195	516393.42	7768350.60	448.99	88	89	516435.21	7768350.60	370.99	MW	NR	90	ST	10		
X201778	0.29	OPRC100195	516393.42	7768350.60	448.99	89	90	516435.69	7768350.60	370.11	MW	NR	89	ST	10	SS	1
X201779	0.19	OPRC100195	516393.42	7768350.60	448.99	90	91	516436.16	7768350.60	369.23	MW	NR	75	SS	20	ST	5
X201780	0.24	OPRC100195	516393.42	7768350.60	448.99	91	92	516436.64	7768350.60	368.35	MW	ST	95	SS	5		
X201781	0.28	OPRC100195	516393.42	7768350.60	448.99	92	93	516437.12	7768350.60	367.47	MW	SS	95	ST	5		
X201782	0.26	OPRC100195	516393.42	7768350.60	448.99	93	94	516437.60	7768350.60	366.60	MW	SS	95	ST	5		

Notes:

NR - No recognisable lithology, SS - Sandstone, ST - Siltstone, QT - Quartz

HW - Highly weathered, MW - Moderately weathered

Appendix B:
XRD Data Base and General Assessment

MIN1418 (E)
PO A6898
ABM Resources

Samples received

The following samples were received for investigation from Patrick Smillie.

Sample 1	Coarse Bulk Sample
Sample 2	Fine Bulk Sample
Sample 3	X201777
Sample 4	X201778
Sample 5	X201779
Sample 6	X201780
Sample 7	X201781
Sample 8	X201782
Sample 9	X201983
Sample 10	X201984
Sample 11	X201985
Sample 12	X201986
Sample 13	X201987
Sample 14	X202017
Sample 15	X202019
Sample 16	X202020
Sample 17	X202021
Sample 18	X202022
Sample 19	X202044
Sample 20	X202045
Sample 21	X202046
Sample 22	X202047

Sample preparation

The samples were lightly ground and subsequently packed into a back-packed sample holder.

Method of analysis

The XRD traces were collected under the following instrument conditions:

XRD	Panalytical Empyrean
Radiation	Cu Kα 1.5406
Generator	45 kV 40 mA
Angular Range	5° to 65° 2θ
Time/Step	1s
Step Size	0.02º 2θ
Divergence Slit	0.5 mm
Anti-Scatter Slit	0.5°
Slit Type	Fixed
Rotation Speed	120 rpm

Results

This report includes the following data

- semi - quantitative mineralogy of the samples.

The quantitative results shown in the table have been normalised to 100%, and it should be noted that the values shown represent the relative proportion of the crystalline material in the sample. Totals greater or smaller than 100% are due to rounding errors.

Negative results in the table indicate normally a larger than usual uncertainty in regard to the quantity of the phase reported; for some of the minor and trace phases it might also indicate an uncertainty in regard of the phase itself, or both.

A significant amount of amorphous material appears to be present in all samples. Hazardous elements could be present in both the zeolite minerals and goethite as well as in the amorphous component. All samples should be assayed for all hazardous elements that might potentially be present.

Reported by:
Karsten Winter and Ian Davies

Date:
25-January-2013

	Coarse Bulk Sample	Fine Bulk Sample	X201777	X201778	X201779	X201780	X201781	X201782	X201983	X201984	X201985	X201986	X201987	X202017	X202019	X202020	X202021	X202022	X202044	X202045	X202046	X202047
Clay mineral	< 1	-1	< 1	< 1	< 1	< 1	< 1	-1	-1	-1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	-1	< 1	-1	< 1
Zeolite	3	2	1	1	1	< 1	-1	1	2	0	0	-1	< 1	-1	-1	-1	-1	-1	-1	< 1	< 1	0
Kaolinite	2	1	41	34	36	38	43	19	18	44	46	45	50	39	64	46	62	56	46	44	52	44
Chlorite	0	0	0	0	0	0	0	< 1	< 1	0	0	0	0	0	0	0	0	0	0	0	0	< 1
Mica	1	1	21	16	18	24	10	6	1	1	2	3	3	16	6	6	9	6	4	4	6	6
Serpentine	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	0	-1	0
Amphibole	1	< 1	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	< 1	-2	< 1	0	0
Microcline - Rutile - Titanite	0	0	0	0	0	< 1	0	0	3	< 1	< 1	0	0	0	0	0	0	0	0	< 1	0	-2
Alpha quartz	91	92	31	37	33	24	35	57	69	26	27	46	35	37	25	44	26	34	17	22	20	26
Goethite	-3	-2	-5	10	13	13	11	16	3	26	23	5	11	6	3	-2	-2	-2	29	28	20	21
Hematite	0	0	0	0	0	0	0	0	3	2	0	0	0	0	0	0	0	0	0	< 1	0	0

Appendix C:
XRF Base Data

Australian Laboratory Services Pty. Ltd.
32 Shand Street
Stafford
Brisbane QLD 4053
Phone: +61 (7) 3243 7222 Fax: +61 (7) 3243 7218
www.alsglobal.com

Finalized Date: 6-DEC-2012
This copy reported on 30-JAN-2013
Account: ABMRES

CERTIFICATE PH12280384

Project:

P.O. No.:

This report is for 22 Pulp samples submitted to our lab in Perth, WA, Australia on 29-NOV-2012.

The following have access to data associated with this certificate:

BERDINE M PATRICK SMILLIE	ROBIN M BRAD VALIUKAS	LAB RESULTS

SAMPLE PREPARATION

ALS CODE	DESCRIPTION
LEV-01	Waste Disposal Levy
LOG-24	Pulp Login - Rcd w/o Barcode

ANALYTICAL PROCEDURES

ALS CODE	DESCRIPTION	INSTRUMENT
ME-XRF21n	Iron Ore by XRF Fusion	XRF
ME-GRA05	H2O/LOI by TGA furnace	TGA

To: **ABM RESOURCES NL**
ATTN: BRAD VALIUKAS
LEVEL 1
141 BROADWAY ROAD
NEDLANDS WA 6009

This is the Final Report and supersedes any preliminary report with this certificate number. Results apply to samples as submitted. All pages of this report have been checked and approved for release.

Signature:

Wayne Abbott, Operations Manager, Western Australia

Australian Laboratory Services Pty. Ltd.
32 Shand Street
Stafford
Brisbane QLD 4053
Phone: +61 (7) 3243 7222 Fax: +61 (7) 3243 7218
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CERTIFICATE OF ANALYSIS PH12280384

Sample Description	Method	ME-XRF21n	ME-XRF21n	ME-XRF21n	ME-XRF21n	ME-XRF21n	ME-XRF21n	ME-XRF21n	ME-XRF21n	ME-XRF21n	ME-XRF21n	ME-XRF21n	ME-XRF21n	ME-XRF21n	ME-XRF21n	ME-XRF21n
	Analyte	Al2O3	As	Ba	CaO	Cl	Co	Cr2O3	Cu	Fe	K2O	MgO	Mn	Na2O	Ni	P
	Units	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
	LOR	0.01	0.001	0.001	0.01	0.001	0.001	0.0006	0.001	0.01	0.001	0.01	0.001	0.005	0.001	0.001
X202044		20.5	0.017	0.023	0.17	0.004	0.001	0.0296	0.002	14.10	1.225	0.38	0.030	0.086	0.002	0.025
X202045		18.15	0.017	0.028	0.13	0.002	<0.001	0.0290	0.002	13.70	1.210	0.40	0.015	0.056	0.001	0.022
X202046		18.90	0.012	0.057	0.13	0.001	<0.001	0.0201	<0.001	10.16	1.740	0.41	0.007	0.096	0.001	0.011
X202047		16.05	0.011	0.061	0.09	0.001	<0.001	0.0159	0.002	6.94	2.24	0.40	0.002	0.100	0.002	0.012
X201983		7.00	0.006	0.012	0.08	0.003	<0.001	0.0182	<0.001	5.92	0.551	0.15	0.012	0.031	<0.001	0.013
X201984		18.05	0.019	0.012	0.08	0.002	<0.001	0.0164	0.002	14.55	0.762	0.27	0.013	0.057	0.002	0.012
X201985		15.95	0.019	0.092	0.08	0.002	<0.001	0.0104	<0.001	8.82	1.365	0.36	0.002	0.102	<0.001	0.005
X201986		12.20	0.009	0.029	0.09	0.008	<0.001	0.0029	<0.001	3.67	1.070	0.33	0.002	0.159	<0.001	0.004
X201987		13.00	0.012	0.022	0.26	0.010	<0.001	0.0058	<0.001	4.35	1.220	0.40	<0.001	0.146	<0.001	0.005
X202017		16.20	0.124	0.066	0.03	0.021	<0.001	0.0091	0.006	5.84	4.26	0.56	0.004	0.110	0.002	0.069
X202019		13.05	0.046	0.036	0.02	0.016	<0.001	0.0067	0.002	3.06	2.11	0.31	0.002	0.069	<0.001	0.039
X202020		13.50	0.027	0.038	0.02	0.012	<0.001	0.0047	<0.001	1.68	2.19	0.31	0.001	0.064	0.002	0.024
X202021		16.65	0.012	0.063	0.01	0.014	<0.001	0.0085	0.001	1.36	3.40	0.45	0.002	0.094	<0.001	0.019
X202022		14.20	0.012	0.045	0.01	0.012	<0.001	0.0054	0.002	1.72	2.31	0.34	0.002	0.092	<0.001	0.022
X201777		20.00	0.017	0.063	0.02	0.011	<0.001	0.0118	0.003	2.80	5.13	0.67	0.004	0.120	0.002	0.040
X201778		14.45	0.044	0.044	0.03	0.007	<0.001	0.0068	0.007	7.67	3.74	0.52	0.011	0.075	0.005	0.102
X201779		18.40	0.037	0.062	0.02	0.010	<0.001	0.0118	0.006	6.03	4.91	0.72	0.007	0.109	0.003	0.075
X201780		20.1	0.020	0.067	0.02	0.006	0.001	0.0234	0.006	7.30	5.42	0.68	0.007	0.113	0.012	0.057
X201781		14.95	0.015	0.040	0.02	0.005	<0.001	0.0095	0.003	5.96	3.51	0.45	0.009	0.079	0.002	0.050
X201782		11.05	0.017	0.030	0.02	0.004	<0.001	0.0031	0.004	6.36	2.31	0.31	0.009	0.056	0.002	0.067
Coarse bulk sample		0.75	0.074	0.004	0.01	0.002	<0.001	0.0039	<0.001	1.32	0.144	0.04	0.006	0.006	<0.001	0.001
Fine bulk sample		0.67	0.067	0.008	0.06	0.002	<0.001	0.1495	0.003	1.22	0.132	0.05	0.010	0.010	0.047	0.001

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CERTIFICATE OF ANALYSIS PH12280384

Sample Description	Method	ME-XRF21n	ME-XRF21n	ME-XRF21n	ME-XRF21n	ME-XRF21n	ME-XRF21n	ME-XRF21n	ME-XRF21n	ME-XRF21n	ME-XRF21n	ME-GRA05
	Analyte	Pb	S	SiO2	Sn	Sr	TiO2	V	Zn	Zr	Total	LOI
	Units	%	%	%	%	%	%	%	%	%	%	%
	LOR	0.001	0.001	0.01	0.001	0.001	0.01	0.001	0.001	0.001	0.01	0.01
X202044		0.009	0.007	47.9	<0.001	0.005	0.73	0.028	0.004	0.028	99.96	8.49
X202045		0.007	0.007	51.3	<0.001	0.003	0.78	0.027	0.002	0.028	99.94	8.04
X202046		0.004	0.010	56.3	<0.001	0.004	0.64	0.017	0.002	0.025	100.00	7.02
X202047		0.009	0.009	64.7	0.001	0.003	0.45	0.010	0.002	0.013	99.97	5.81
X201983		<0.001	0.006	79.7	0.002	0.001	0.40	0.012	0.001	0.035	99.99	3.44
X201984		0.005	0.015	51.4	0.001	0.003	0.68	0.028	0.002	0.030	100.00	7.66
X201985		<0.001	0.027	62.0	0.001	0.003	0.58	0.014	0.001	0.019	99.95	6.63
X201986		<0.001	0.020	75.5	0.001	<0.001	0.41	0.003	0.001	0.012	99.97	4.82
X201987		<0.001	0.014	73.0	0.001	0.001	0.37	0.003	0.001	0.015	100.05	5.31
X202017		0.034	0.012	65.6	0.002	0.008	0.42	0.009	0.015	0.007	99.97	3.88
X202019		0.009	0.008	75.6	0.001	0.004	0.44	0.004	0.010	0.019	100.05	3.77
X202020		0.007	0.006	77.2	0.002	0.002	0.44	0.003	0.005	0.016	100.05	3.68
X202021		0.007	0.005	72.8	0.003	0.002	0.58	0.006	0.004	0.017	99.98	3.84
X202022		0.008	0.006	76.0	0.002	0.002	0.50	0.005	0.005	0.019	99.95	3.84
X201777		0.006	0.003	65.1	0.001	0.004	0.52	0.006	0.009	0.007	100.00	4.16
X201778		0.014	0.004	65.6	<0.001	0.004	0.37	0.009	0.018	0.007	100.05	3.82
X201779		0.007	0.003	62.1	0.001	0.005	0.45	0.007	0.016	0.008	99.95	4.21
X201780		0.007	0.002	57.8	<0.001	0.005	0.50	0.008	0.017	0.009	99.96	4.53
X201781		0.002	0.002	68.0	0.002	0.003	0.45	0.004	0.012	0.013	99.93	3.68
X201782		0.004	0.002	73.1	<0.001	0.002	0.35	0.003	0.017	0.018	99.98	3.38
Coarse bulk sample		0.027	0.007	96.7	0.002	<0.001	0.03	<0.001	<0.001	<0.001	99.96	0.21
Fine bulk sample		0.026	0.007	96.8	0.003	<0.001	0.02	<0.001	0.001	<0.001	100.00	0.14

Appendix D:
Results and Laboratory Certificates of ABA Leachate Data

CHAIN OF CUSTODY

ALS Laboratory: please tick →

☐ **Sydney**: 277 Woodpark Rd, Smithfield NSW 2176 Ph: 02 8784 8555 E:samples.sydney@alsenviro.com
☐ **Newcastle**: 5 Rosegum Rd, Warabrook NSW 2304 Ph:02 4968 9433 E:samples.newcastle@alsenviro.com
☐ **Brisbane**: 32 Shand St, Stafford QLD 4053 Ph:07 3243 7222 E:samples.brisbane@alsenviro.com
☐ **Townsville**: 14-15 Desma Ct, Bohle QLD 4818 Ph:07 4796 0600 E: townsville.environmental@alsenviro.com
☐ **Melbourne**: 2-4 Westall Rd, Springvale VIC 3171 Ph:03 8549 9600 E: samples.melbourne@alsenviro.com
☐ **Adelaide**: 2-1 Burma Rd, Pooraka SA 5095 Ph: 08 8359 0890 E:adelaide@alsenviro.com
☐ **Perth**: 10 Hod Way, Malaga WA 6090 Ph: 08 9209 7655 E: samples.perth@alsenviro.com
☐ **Launceston**: 27 Wellington St, Launceston TAS 7250 Ph: 03 6331 2158 E: launceston@alsenviro.com

CLIENT: ABM RESOURCES	**TURNAROUND REQUIREMENTS :** ☐ Standard TAT **(List due date):**	**FOR LABORATORY USE ONLY (Circle)**	
OFFICE:	(Standard TAT may be longer for some tests e.g., Ultra Trace Organics) ☐ Non Standard or urgent TAT **(List due date):**	Custody Seal Intact?	Yes No N/A
PROJECT: **PROJECT NO.:**	**ALS QUOTE NO.: EP/825/12 V2**	Free ice / frozen ice bricks present upon receipt?	Yes No N/A
ORDER NUMBER: **PURCHASE ORDER NO.:**	**COUNTRY OF ORIGIN:**	Random Sample Temperature on Receipt:	°C
PROJECT MANAGER: Patrick Smillie **CONTACT PH: 9423 9713**	**COC SEQUENCE NUMBER (Circle)** COC: 1 2 3 4 5 6 7 OF: 1 2 3 4 5 6 7	Other comment:	

SAMPLER: **SAMPLER MOBILE:**	**RELINQUISHED BY:**	**RECEIVED BY:** *Luke Jones*	**RELINQUISHED BY:**
COC Emailed to ALS? (YES / NO) **EDD FORMAT (or default):**			
Email Reports to : labresults@abmresources.com.au	DATE/TIME:	DATE/TIME: *06/12/2012 10:25*	DATE/TIME:
Email Invoice to : patricks@abmresources.com.au			

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

ALS USE ONLY	SAMPLE DETAILS MATRIX: Solid(S) Water(W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where **Metals** are required, specify **Total** (unfiltered bottle required) or **Dissolved** (field filtered bottle required).							Additional Information
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE *(refer to codes below)*	TOTAL BOTTLES	ANALYSIS AS PER QUOTE EP/825/12 V2							Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.
#1-#22	See attached Spreadsheet		S		1-18 (1 Bag), 19-22 (2 Bags)	×							
				TOTAL									

Environmental Division
Perth
Work Order
EP1210177

Telephone : +61-8-9209 7655

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag; LI = Lugols Iodine Preserved Bottles; STT = Sterile Sodium Thiosulfate Preserved Bottles.

ALS ID	Sample ID	Analysis as per quote EP/825/12 V2 (Both DI Suite and AMD Suite)
1	X202044	×
2	X202045	×
3	X202046	×
4	X202047	×
5	X201983	×
6	X201984	×
7	X201985	×
8	X201986	×
9	X201987	×
10	X202017	×
11	X202019	×
12	X202020	×
13	X202021	×
14	X202022	×
15	X201777	×
16	X201778	×
17	X201779	×
18	X201780	×
19	X201781	×
20	X201782	×
21	Coarse Bulk Sample	×
22	Fine Bluk Sample	×

Environmental Division

CERTIFICATE OF ANALYSIS

Work Order	: **EP1210177**	Page	: 1 of 17
Client	: **ABM RESOURCES NL**	Laboratory	: Environmental Division Perth
Contact	: Kate Eiloart	Contact	: Scott James
Address	: level 1, 141 Broadway Nedlands - Perth Perth Western Australia 6009	Address	: 10 Hod Way Malaga WA Australia 6090
E-mail	: katee@abmresources.com.au	E-mail	: perth.enviro.services@alsglobal.com
Telephone	: +61 08 9423 9777	Telephone	: +61-8-9209 7655
Facsimile	: ----	Facsimile	: +61-8-9209 7600
Project	: ----	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: ----		
C-O-C number	: ----	Date Samples Received	: 06-DEC-2012
Sampler	: ----	Issue Date	: 18-DEC-2012
Site	: ----		
		No. of samples received	: 22
Quote number	: EP/825/12 V2	No. of samples analysed	: 22

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

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.

Signatories	*Position*	*Accreditation Category*
Canhuang Ke	Metals Instrument Chemist	Perth Inorganics
Chas Tucker	Inorganic Chemist	Perth Inorganics
Jonathon Angell	Inorganic Coordinator	Stafford Minerals - AY
Leanne Carey	Acid Sulfate Soils Supervisor	Perth ASS
Scott James	Laboratory Manager	Perth Inorganics

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 sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

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

- **ASS: EA013 (ANC) Fizz Rating: 0- None; 1- Slight; 2- Moderate; 3- Strong; 4- Very Strong; 5- Lime.**

Analytical Results

Sub-Matrix: **DI WATER LEACHATE** (Matrix: **WATER**)

Compound	CAS Number	LOR	Unit	Client sample ID	X202044	X202045	X202046	X202047	X201983
				Client sampling date / time	11-DEC-2012 12:00	11-DEC-2012 12:00	11-DEC-2012 12:00	11-DEC-2012 12:00	11-DEC-2012 12:00
					EP1210177-001	EP1210177-002	EP1210177-003	EP1210177-004	EP1210177-005
EA005P: pH by PC Titrator									
pH Value	----	0.01	pH Unit		**6.14**	**7.38**	**6.35**	**6.18**	**6.16**
EA010P: Conductivity by PC Titrator									
Electrical Conductivity @ 25°C	----	1	µS/cm		**20**	**22**	**32**	**22**	**20**
EA055: Moisture Content									
Moisture Content (dried @ 103°C)	----	1.0	%		<1.0	<1.0	<1.0	<1.0	<1.0
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L		<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L		<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L		**4**	**6**	**5**	**3**	**3**
Total Alkalinity as CaCO3	----	1	mg/L		**4**	**6**	**5**	**3**	**3**
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L		<1	**3**	**4**	**6**	**2**
ED045G: Chloride Discrete analyser									
Chloride	16887-00-6	1	mg/L		**2**	**2**	<1	<1	**1**
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L		<1	<1	<1	<1	<1
Magnesium	7439-95-4	1	mg/L		<1	<1	<1	<1	<1
Sodium	7440-23-5	1	mg/L		**5**	**5**	**8**	**6**	**3**
Potassium	7440-09-7	1	mg/L		**1**	**2**	<1	**1**	**3**
EG020W: Water Leachable Metals by ICP-MS									
Aluminium	7429-90-5	0.01	mg/L		**0.28**	**0.33**	**0.67**	**0.17**	**0.41**
Antimony	7440-36-0	0.001	mg/L		**0.003**	<0.001	<0.001	<0.001	<0.001
Arsenic	7440-38-2	0.001	mg/L		**0.002**	**0.003**	**0.006**	**0.009**	**0.005**
Beryllium	7440-41-7	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Barium	7440-39-3	0.001	mg/L		**0.213**	**0.229**	**0.341**	**0.110**	**0.180**
Cadmium	7440-43-9	0.0001	mg/L		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	7440-47-3	0.001	mg/L		<0.001	<0.001	**0.001**	<0.001	<0.001
Cobalt	7440-48-4	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Copper	7440-50-8	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Lead	7439-92-1	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	7439-96-5	0.001	mg/L		**0.001**	**0.001**	**0.004**	<0.001	**0.043**
Nickel	7440-02-0	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Selenium	7782-49-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	<0.01

Analytical Results

Sub-Matrix: DI WATER LEACHATE (Matrix: WATER)				Client sample ID	X202044	X202045	X202046	X202047	X201983
				Client sampling date / time	11-DEC-2012 12:00	11-DEC-2012 12:00	11-DEC-2012 12:00	11-DEC-2012 12:00	11-DEC-2012 12:00
Compound	CAS Number	LOR	Unit		EP1210177-001	EP1210177-002	EP1210177-003	EP1210177-004	EP1210177-005
EG020W: Water Leachable Metals by ICP-MS - Continued									
Vanadium	7440-62-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	7440-66-6	0.005	mg/L		**0.095**	**0.088**	**0.104**	**0.065**	**0.149**
Iron	7439-89-6	0.05	mg/L		**0.16**	**0.20**	**0.71**	**0.10**	**0.40**
EG035W: Water Leachable Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		**0.3**	**0.4**	**0.5**	**0.5**	<0.1

Analytical Results

Sub-Matrix: **DI WATER LEACHATE** (Matrix: **WATER**)

Compound	CAS Number	LOR	Unit	Client sample ID	X201984	X201985	X201986	X201987	X202017
				Client sampling date / time	11-DEC-2012 12:00	11-DEC-2012 12:00	11-DEC-2012 12:00	11-DEC-2012 12:00	11-DEC-2012 12:00
					EP1210177-006	EP1210177-007	EP1210177-008	EP1210177-009	EP1210177-010
EA005P: pH by PC Titrator									
pH Value	----	0.01	pH Unit		6.21	6.11	6.27	7.24	6.20
EA010P: Conductivity by PC Titrator									
Electrical Conductivity @ 25°C	----	1	µS/cm		15	42	41	107	74
EA055: Moisture Content									
Moisture Content (dried @ 103°C)	----	1.0	%		<1.0	<1.0	<1.0	<1.0	<1.0
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L		<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L		<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L		3	3	4	39	2
Total Alkalinity as CaCO3	----	1	mg/L		3	3	4	39	2
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L		2	12	6	6	11
ED045G: Chloride Discrete analyser									
Chloride	16887-00-6	1	mg/L		2	2	5	6	11
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L		<1	<1	<1	6	<1
Magnesium	7439-95-4	1	mg/L		<1	<1	<1	3	<1
Sodium	7440-23-5	1	mg/L		4	8	10	14	9
Potassium	7440-09-7	1	mg/L		<1	3	<1	4	9
EG020W: Water Leachable Metals by ICP-MS									
Aluminium	7429-90-5	0.01	mg/L		0.16	0.20	0.22	0.08	0.02
Antimony	7440-36-0	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic	7440-38-2	0.001	mg/L		0.003	0.002	0.003	0.020	0.010
Beryllium	7440-41-7	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Barium	7440-39-3	0.001	mg/L		0.131	0.316	0.251	0.281	0.173
Cadmium	7440-43-9	0.0001	mg/L		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	7440-47-3	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	7440-48-4	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Copper	7440-50-8	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Lead	7439-92-1	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	7439-96-5	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Nickel	7440-02-0	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Selenium	7782-49-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	<0.01

Analytical Results

Sub-Matrix: DI WATER LEACHATE (Matrix: WATER)				Client sample ID	X201984	X201985	X201986	X201987	X202017
				Client sampling date / time	11-DEC-2012 12:00	11-DEC-2012 12:00	11-DEC-2012 12:00	11-DEC-2012 12:00	11-DEC-2012 12:00
Compound	CAS Number	LOR	Unit		EP1210177-006	EP1210177-007	EP1210177-008	EP1210177-009	EP1210177-010
EG020W: Water Leachable Metals by ICP-MS - Continued									
Vanadium	7440-62-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	7440-66-6	0.005	mg/L		**0.039**	**0.088**	**0.070**	**0.041**	**0.071**
Iron	7439-89-6	0.05	mg/L		**0.11**	**0.10**	**0.09**	<0.05	<0.05
EG035W: Water Leachable Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		**0.2**	**0.7**	**0.5**	**0.7**	**0.8**

Analytical Results

Sub-Matrix: **DI WATER LEACHATE** (Matrix: **WATER**)

Compound	CAS Number	LOR	Unit	Client sample ID	X202019	X202020	X202021	X202022	X201777
				Client sampling date / time	11-DEC-2012 12:00	11-DEC-2012 12:00	11-DEC-2012 12:00	11-DEC-2012 12:00	11-DEC-2012 12:00
					EP1210177-011	EP1210177-012	EP1210177-013	EP1210177-014	EP1210177-015
EA005P: pH by PC Titrator									
pH Value	----	0.01	pH Unit		6.13	6.13	6.10	6.14	6.28
EA010P: Conductivity by PC Titrator									
Electrical Conductivity @ 25°C	----	1	µS/cm		52	37	49	39	35
EA055: Moisture Content									
Moisture Content (dried @ 103°C)	----	1.0	%		<1.0	<1.0	<1.0	<1.0	<1.0
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L		<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L		<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L		3	2	3	2	3
Total Alkalinity as CaCO3	----	1	mg/L		3	2	3	2	3
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L		7	2	4	2	1
ED045G: Chloride Discrete analyser									
Chloride	16887-00-6	1	mg/L		8	7	8	8	5
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L		<1	<1	<1	<1	<1
Magnesium	7439-95-4	1	mg/L		<1	<1	<1	<1	<1
Sodium	7440-23-5	1	mg/L		8	5	9	8	7
Potassium	7440-09-7	1	mg/L		5	6	4	3	4
EG020W: Water Leachable Metals by ICP-MS									
Aluminium	7429-90-5	0.01	mg/L		<0.01	0.05	0.12	0.06	0.38
Antimony	7440-36-0	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic	7440-38-2	0.001	mg/L		<0.001	0.008	0.008	0.005	0.055
Beryllium	7440-41-7	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Barium	7440-39-3	0.001	mg/L		<0.001	0.129	0.441	0.353	0.396
Cadmium	7440-43-9	0.0001	mg/L		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	7440-47-3	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	0.001
Cobalt	7440-48-4	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Copper	7440-50-8	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Lead	7439-92-1	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	7439-96-5	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Nickel	7440-02-0	0.001	mg/L		<0.001	<0.001	0.001	<0.001	<0.001
Selenium	7782-49-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	<0.01

Analytical Results

Sub-Matrix: DI WATER LEACHATE (Matrix: WATER)				Client sample ID	X202019	X202020	X202021	X202022	X201777
				Client sampling date / time	11-DEC-2012 12:00	11-DEC-2012 12:00	11-DEC-2012 12:00	11-DEC-2012 12:00	11-DEC-2012 12:00
Compound	CAS Number	LOR	Unit		EP1210177-011	EP1210177-012	EP1210177-013	EP1210177-014	EP1210177-015
EG020W: Water Leachable Metals by ICP-MS - Continued									
Vanadium	7440-62-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	7440-66-6	0.005	mg/L		<0.005	**0.078**	**0.087**	**0.059**	**0.098**
Iron	7439-89-6	0.05	mg/L		<0.05	<0.05	**0.06**	<0.05	**0.26**
EG035W: Water Leachable Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		**0.6**	**0.4**	**0.5**	**0.5**	**0.7**

Analytical Results

Sub-Matrix: **DI WATER LEACHATE** (Matrix: **WATER**)

Compound	CAS Number	LOR	Unit	Client sample ID	X201778	X201779	X201780	X201781	X201782
				Client sampling date / time	11-DEC-2012 12:00	11-DEC-2012 12:00	11-DEC-2012 12:00	11-DEC-2012 12:00	11-DEC-2012 12:00
					EP1210177-016	EP1210177-017	EP1210177-018	EP1210177-019	EP1210177-020
EA005P: pH by PC Titrator									
pH Value	----	0.01	pH Unit		**6.28**	**6.30**	**6.29**	**6.25**	**6.26**
EA010P: Conductivity by PC Titrator									
Electrical Conductivity @ 25°C	----	1	µS/cm		**28**	**37**	**28**	**24**	**21**
EA055: Moisture Content									
Moisture Content (dried @ 103°C)	----	1.0	%		<1.0	<1.0	<1.0	<1.0	<1.0
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L		<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L		<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L		**3**	**3**	**4**	**4**	**3**
Total Alkalinity as CaCO3	----	1	mg/L		**3**	**3**	**4**	**4**	**3**
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L		**2**	**2**	**2**	**1**	<1
ED045G: Chloride Discrete analyser									
Chloride	16887-00-6	1	mg/L		**4**	**6**	**4**	**4**	**3**
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L		<1	<1	<1	<1	<1
Magnesium	7439-95-4	1	mg/L		<1	<1	<1	<1	<1
Sodium	7440-23-5	1	mg/L		**5**	**5**	**5**	**6**	**3**
Potassium	7440-09-7	1	mg/L		**5**	**7**	**4**	**2**	**4**
EG020W: Water Leachable Metals by ICP-MS									
Aluminium	7429-90-5	0.01	mg/L		**0.05**	**0.08**	**0.11**	**0.09**	<0.01
Antimony	7440-36-0	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic	7440-38-2	0.001	mg/L		**0.050**	**0.067**	**0.049**	**0.046**	<0.001
Beryllium	7440-41-7	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Barium	7440-39-3	0.001	mg/L		**0.142**	**0.146**	**0.147**	**0.200**	**0.002**
Cadmium	7440-43-9	0.0001	mg/L		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	7440-47-3	0.001	mg/L		<0.001	<0.001	**0.001**	<0.001	<0.001
Cobalt	7440-48-4	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Copper	7440-50-8	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Lead	7439-92-1	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	7439-96-5	0.001	mg/L		<0.001	<0.001	**0.002**	<0.001	<0.001
Nickel	7440-02-0	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Selenium	7782-49-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	<0.01

Analytical Results

Sub-Matrix: **DI WATER LEACHATE** (Matrix: **WATER**)

Compound	CAS Number	LOR	Unit	Client sample ID	X201778	X201779	X201780	X201781	X201782
				Client sampling date / time	11-DEC-2012 12:00	11-DEC-2012 12:00	11-DEC-2012 12:00	11-DEC-2012 12:00	11-DEC-2012 12:00
					EP1210177-016	EP1210177-017	EP1210177-018	EP1210177-019	EP1210177-020
EG020W: Water Leachable Metals by ICP-MS - Continued									
Vanadium	7440-62-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	7440-66-6	0.005	mg/L		**0.024**	**0.023**	**0.035**	**0.030**	<0.005
Iron	7439-89-6	0.05	mg/L		**0.09**	**0.09**	**0.34**	**0.17**	<0.05
EG035W: Water Leachable Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		**0.8**	**0.8**	**0.8**	**0.6**	**0.7**

Analytical Results

Sub-Matrix: DI WATER LEACHATE (Matrix: WATER)				Client sample ID	Coarse Bulk Sample	Fine Bluk Sample	----	----	----
				Client sampling date / time	11-DEC-2012 12:00	11-DEC-2012 12:00	----	----	----
Compound	CAS Number	LOR	Unit		EP1210177-021	EP1210177-022	----	----	----
EA005P: pH by PC Titrator									
pH Value	----	0.01	pH Unit		**6.23**	**7.49**	----	----	----
EA010P: Conductivity by PC Titrator									
Electrical Conductivity @ 25°C	----	1	µS/cm		**22**	**32**	----	----	----
EA055: Moisture Content									
Moisture Content (dried @ 103°C)	----	1.0	%		<1.0	<1.0	----	----	----
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L		<1	<1	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L		<1	<1	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L		**6**	**15**	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L		**6**	**15**	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L		**2**	**2**	----	----	----
ED045G: Chloride Discrete analyser									
Chloride	16887-00-6	1	mg/L		**2**	<1	----	----	----
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L		**2**	**6**	----	----	----
Magnesium	7439-95-4	1	mg/L		<1	<1	----	----	----
Sodium	7440-23-5	1	mg/L		**3**	**1**	----	----	----
Potassium	7440-09-7	1	mg/L		<1	<1	----	----	----
EG020W: Water Leachable Metals by ICP-MS									
Aluminium	7429-90-5	0.01	mg/L		**0.06**	**0.04**	----	----	----
Antimony	7440-36-0	0.001	mg/L		**0.004**	**0.002**	----	----	----
Arsenic	7440-38-2	0.001	mg/L		**0.054**	**0.090**	----	----	----
Beryllium	7440-41-7	0.001	mg/L		<0.001	<0.001	----	----	----
Barium	7440-39-3	0.001	mg/L		**0.290**	**0.148**	----	----	----
Cadmium	7440-43-9	0.0001	mg/L		<0.0001	<0.0001	----	----	----
Chromium	7440-47-3	0.001	mg/L		<0.001	<0.001	----	----	----
Cobalt	7440-48-4	0.001	mg/L		<0.001	<0.001	----	----	----
Copper	7440-50-8	0.001	mg/L		<0.001	<0.001	----	----	----
Lead	7439-92-1	0.001	mg/L		**0.004**	**0.002**	----	----	----
Manganese	7439-96-5	0.001	mg/L		**0.033**	<0.001	----	----	----
Nickel	7440-02-0	0.001	mg/L		<0.001	<0.001	----	----	----
Selenium	7782-49-2	0.01	mg/L		<0.01	<0.01	----	----	----

Analytical Results

Sub-Matrix: DI WATER LEACHATE (Matrix: WATER)				Client sample ID	Coarse Bulk Sample	Fine Bluk Sample	----	----	----
				Client sampling date / time	11-DEC-2012 12:00	11-DEC-2012 12:00	----	----	----
Compound	CAS Number	LOR	Unit		EP1210177-021	EP1210177-022	----	----	----
EG020W: Water Leachable Metals by ICP-MS - Continued									
Vanadium	7440-62-2	0.01	mg/L		<0.01	<0.01	----	----	----
Zinc	7440-66-6	0.005	mg/L		**0.054**	**0.014**	----	----	----
Iron	7439-89-6	0.05	mg/L		**0.10**	**0.06**	----	----	----
EG035W: Water Leachable Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	<0.0001	----	----	----
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		**0.1**	**0.1**	----	----	----

Analytical Results

Sub-Matrix: **SOIL** (Matrix: **SOIL**)

Compound	CAS Number	LOR	Unit	Client sample ID	X202044	X202045	X202046	X202047	X201983
				Client sampling date / time	06-DEC-2012 10:25	06-DEC-2012 10:25	06-DEC-2012 10:25	06-DEC-2012 10:25	06-DEC-2012 10:25
					EP1210177-001	EP1210177-002	EP1210177-003	EP1210177-004	EP1210177-005
EA009: Nett Acid Production Potential									
Acid Production Potential (APP)	----	0.5	kg H2SO4/t		**1.8**	**1.2**	**0.6**	**0.6**	**17.4**
Net Acid Production Potential	----	0.5	kg H2SO4/t		**1.8**	**1.2**	**0.6**	<0.5	**17.4**
EA011: Net Acid Generation									
pH (OX)	----	0.1	pH Unit		**6.1**	**6.5**	**6.3**	**6.0**	**5.2**
NAG (pH 4.5)	----	0.1	kg H2SO4/t		<0.1	<0.1	<0.1	<0.1	<0.1
NAG (pH 7.0)	----	0.1	kg H2SO4/t		**4.4**	**3.0**	**4.0**	**8.1**	**12.1**
EA013: Acid Neutralising Capacity									
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t		<0.5	<0.5	<0.5	**1.0**	<0.5
ANC as CaCO3	----	0.1	% CaCO3		<0.1	<0.1	<0.1	**0.1**	<0.1
Fizz Rating	----	0	Fizz Unit		**1**	**1**	**1**	**1**	**1**
ED040: Sulfur as SO4 2-									
Sulfate as SO4 2-	14808-79-8	100	mg/kg		<100	<100	**110**	**160**	<100
ED040S : Soluble Sulfate by ICPAES									
Sulfate as SO4 2-	14808-79-8	10	mg/kg		<10	**10**	**20**	**50**	**30**
Sulfur as S	63705-05-5	10	mg/kg		<10	<10	<10	**20**	<10
Silica	7631-86-9	1	mg/kg		**64**	**104**	**101**	**77**	**64**
Silicon	7440-21-3	1	mg/kg		**30**	**48**	**47**	**36**	**30**
ED042T: Total Sulfur by LECO									
Sulfur - Total as S (LECO)	----	0.01	%		**0.06**	**0.04**	**0.02**	**0.02**	**0.57**
EK085M: Sulfide as S2-									
Sulfide as S	----	0.01	%		**0.06**	**0.04**	**0.02**	**0.01**	**0.57**
EN60: Bottle Leaching Procedure									
Final pH	----	0.1	pH Unit		**8.0**	**8.1**	**8.2**	**8.2**	**7.5**
EP003TC: Total Carbon (TC) in Soil									
Total Carbon	----	0.02	%		<0.02	<0.02	<0.02	<0.02	<0.02

Analytical Results

Sub-Matrix: **SOIL** (Matrix: **SOIL**)

Compound	CAS Number	LOR	Unit	Client sample ID	X201984	X201985	X201986	X201987	X202017
				Client sampling date / time	06-DEC-2012 10:25	06-DEC-2012 10:25	06-DEC-2012 10:25	06-DEC-2012 10:25	06-DEC-2012 10:25
					EP1210177-006	EP1210177-007	EP1210177-008	EP1210177-009	EP1210177-010
EA009: Nett Acid Production Potential									
Acid Production Potential (APP)	----	0.5	kg H2SO4/t		**1.8**	**1.2**	<0.5	**1.5**	<0.5
Net Acid Production Potential	----	0.5	kg H2SO4/t		**0.8**	**1.2**	**-7.0**	**-2.1**	**-1.5**
EA011: Net Acid Generation									
pH (OX)	----	0.1	pH Unit		**5.6**	**5.9**	**6.1**	**6.0**	**5.9**
NAG (pH 4.5)	----	0.1	kg H2SO4/t		<0.1	<0.1	<0.1	<0.1	<0.1
NAG (pH 7.0)	----	0.1	kg H2SO4/t		**9.4**	**8.8**	**7.6**	**18.1**	**10.0**
EA013: Acid Neutralising Capacity									
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t		**1.0**	<0.5	**7.0**	**3.6**	**1.5**
ANC as CaCO3	----	0.1	% CaCO3		**0.1**	<0.1	**0.7**	**0.4**	**0.2**
Fizz Rating	----	0	Fizz Unit		**1**	**1**	**1**	**1**	**1**
ED040: Sulfur as SO4 2-									
Sulfate as SO4 2-	14808-79-8	100	mg/kg		**120**	**410**	**210**	**160**	**280**
ED040S : Soluble Sulfate by ICPAES									
Sulfate as SO4 2-	14808-79-8	10	mg/kg		**10**	**80**	**60**	**80**	**170**
Sulfur as S	63705-05-5	10	mg/kg		<10	**30**	**20**	**30**	**60**
Silica	7631-86-9	1	mg/kg		**78**	**77**	**58**	**124**	**11**
Silicon	7440-21-3	1	mg/kg		**36**	**36**	**27**	**58**	**5**
ED042T: Total Sulfur by LECO									
Sulfur - Total as S (LECO)	----	0.01	%		**0.06**	**0.04**	<0.01	**0.05**	<0.01
EK085M: Sulfide as S2-									
Sulfide as S	----	0.01	%		**0.06**	**0.03**	<0.01	**0.04**	<0.01
EN60: Bottle Leaching Procedure									
Final pH	----	0.1	pH Unit		**8.1**	**7.8**	**8.1**	**8.5**	**7.6**
EP003TC: Total Carbon (TC) in Soil									
Total Carbon	----	0.02	%		<0.02	<0.02	<0.02	<0.02	<0.02

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	X202019	X202020	X202021	X202022	X201777
				Client sampling date / time	06-DEC-2012 10:25	06-DEC-2012 10:25	06-DEC-2012 10:25	06-DEC-2012 10:25	06-DEC-2012 10:25
Compound	CAS Number	LOR	Unit		EP1210177-011	EP1210177-012	EP1210177-013	EP1210177-014	EP1210177-015
EA009: Nett Acid Production Potential									
Acid Production Potential (APP)	----	0.5	kg H2SO4/t		<0.5	<0.5	<0.5	<0.5	<0.5
Net Acid Production Potential	----	0.5	kg H2SO4/t		-1.0	<0.5	<0.5	<0.5	-0.9
EA011: Net Acid Generation									
pH (OX)	----	0.1	pH Unit		5.4	5.7	5.7	5.7	5.9
NAG (pH 4.5)	----	0.1	kg H2SO4/t		<0.1	<0.1	<0.1	<0.1	<0.1
NAG (pH 7.0)	----	0.1	kg H2SO4/t		16.7	14.6	11.6	13.6	10.5
EA013: Acid Neutralising Capacity									
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t		1.0	<0.5	<0.5	<0.5	0.9
ANC as CaCO3	----	0.1	% CaCO3		0.1	<0.1	<0.1	<0.1	<0.1
Fizz Rating	----	0	Fizz Unit		1	1	1	1	1
ED040: Sulfur as SO4 2-									
Sulfate as SO4 2-	14808-79-8	100	mg/kg		180	140	120	110	<100
ED040S : Soluble Sulfate by ICPAES									
Sulfate as SO4 2-	14808-79-8	10	mg/kg		110	20	80	30	20
Sulfur as S	63705-05-5	10	mg/kg		40	<10	20	<10	<10
Silica	7631-86-9	1	mg/kg		12	19	10	16	17
Silicon	7440-21-3	1	mg/kg		5	9	5	8	8
ED042T: Total Sulfur by LECO									
Sulfur - Total as S (LECO)	----	0.01	%		<0.01	<0.01	<0.01	<0.01	<0.01
EK085M: Sulfide as S2-									
Sulfide as S	----	0.01	%		<0.01	<0.01	<0.01	<0.01	<0.01
EN60: Bottle Leaching Procedure									
Final pH	----	0.1	pH Unit		7.6	7.4	7.9	8.0	8.4
EP003TC: Total Carbon (TC) in Soil									
Total Carbon	----	0.02	%		<0.02	<0.02	<0.02	<0.02	<0.02

Analytical Results

Sub-Matrix: **SOIL** (Matrix: **SOIL**)

Compound	CAS Number	LOR	Unit	Client sample ID	X201778	X201779	X201780	X201781	X201782
				Client sampling date / time	06-DEC-2012 10:25	06-DEC-2012 10:25	06-DEC-2012 10:25	06-DEC-2012 10:25	06-DEC-2012 10:25
					EP1210177-016	EP1210177-017	EP1210177-018	EP1210177-019	EP1210177-020
EA009: Nett Acid Production Potential									
Acid Production Potential (APP)	----	0.5	kg H2SO4/t		**0.6**	**0.6**	**0.9**	**0.9**	**1.2**
Net Acid Production Potential	----	0.5	kg H2SO4/t		**0.6**	**0.6**	<0.5	**0.9**	**1.2**
EA011: Net Acid Generation									
pH (OX)	----	0.1	pH Unit		**6.0**	**6.1**	**6.0**	**6.1**	**6.2**
NAG (pH 4.5)	----	0.1	kg H2SO4/t		<0.1	<0.1	<0.1	<0.1	<0.1
NAG (pH 7.0)	----	0.1	kg H2SO4/t		**7.7**	**8.2**	**9.1**	**6.8**	**6.0**
EA013: Acid Neutralising Capacity									
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t		<0.5	<0.5	**0.8**	<0.5	<0.5
ANC as CaCO3	----	0.1	% CaCO3		<0.1	<0.1	<0.1	<0.1	<0.1
Fizz Rating	----	0	Fizz Unit		**1**	**1**	**1**	**1**	**1**
ED040: Sulfur as SO4 2-									
Sulfate as SO4 2-	14808-79-8	100	mg/kg		<100	<100	<100	<100	<100
ED040S : Soluble Sulfate by ICPAES									
Sulfate as SO4 2-	14808-79-8	10	mg/kg		**30**	**30**	**20**	**10**	<10
Sulfur as S	63705-05-5	10	mg/kg		<10	**10**	<10	<10	<10
Silica	7631-86-9	1	mg/kg		**18**	**18**	**16**	**15**	**20**
Silicon	7440-21-3	1	mg/kg		**8**	**8**	**8**	**7**	**10**
ED042T: Total Sulfur by LECO									
Sulfur - Total as S (LECO)	----	0.01	%		**0.02**	**0.02**	**0.03**	**0.03**	**0.04**
EK085M: Sulfide as S2-									
Sulfide as S	----	0.01	%		**0.02**	**0.02**	**0.03**	**0.03**	**0.04**
EN60: Bottle Leaching Procedure									
Final pH	----	0.1	pH Unit		**7.9**	**8.2**	**8.5**	**8.5**	**8.2**
EP003TC: Total Carbon (TC) in Soil									
Total Carbon	----	0.02	%		<0.02	<0.02	<0.02	<0.02	<0.02

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	Coarse Bulk Sample	Fine Bluk Sample	----	----	----
			Client sampling date / time	06-DEC-2012 10:25	06-DEC-2012 10:25	----	----	----
Compound	CAS Number	LOR	Unit	EP1210177-021	EP1210177-022	----	----	----
EA009: Nett Acid Production Potential								
Acid Production Potential (APP)	----	0.5	kg H2SO4/t	<0.5	<0.5	----	----	----
Net Acid Production Potential	----	0.5	kg H2SO4/t	<0.5	**-1.5**	----	----	----
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	**6.2**	**6.4**	----	----	----
NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	<0.1	----	----	----
NAG (pH 7.0)	----	0.1	kg H2SO4/t	**7.5**	**6.6**	----	----	----
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	<0.5	**1.5**	----	----	----
ANC as CaCO3	----	0.1	% CaCO3	<0.1	**0.2**	----	----	----
Fizz Rating	----	0	Fizz Unit	**1**	**1**	----	----	----
ED040: Sulfur as SO4 2-								
Sulfate as SO4 2-	14808-79-8	100	mg/kg	<100	<100	----	----	----
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	**20**	**40**	----	----	----
Sulfur as S	63705-05-5	10	mg/kg	<10	**10**	----	----	----
Silica	7631-86-9	1	mg/kg	**38**	**35**	----	----	----
Silicon	7440-21-3	1	mg/kg	**18**	**16**	----	----	----
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	<0.01	<0.01	----	----	----
EK085M: Sulfide as S2-								
Sulfide as S	----	0.01	%	<0.01	<0.01	----	----	----
EN60: Bottle Leaching Procedure								
Final pH	----	0.1	pH Unit	**8.2**	**9.2**	----	----	----
EP003TC: Total Carbon (TC) in Soil								
Total Carbon	----	0.02	%	<0.02	<0.02	----	----	----