APPENDIX F5

TSF supplemental geochemical investigations

Olympic Dam Expansion TSF Supplemental Geochemical Investigations

Report Prepared for

ODX - Olympic Dam Expansion
BHP Billiton Base Metals

Prepared by

SRK Consulting

BHP026 Final

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Olympic Dam Expansion TSF Supplemental Geochemical Investigations

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Executive Summary

Tailings from the Olympic Dam Operation (ODO) currently are being deposited in a paddock-type cellular Tailings Storage Facility (TSF). A similar strategy will be adopted for the proposed Olympic Dam Expansion (ODX) project. In 2007, a review of the available geochemical information was undertaken to develop a conceptual geochemical model for the ODX TSF. To build confidence in the conceptual model, and address information gaps that had been identified, a programme of supplemental geochemical investigations was developed. This report describes the outcomes of these supplemental investigations.

The overall objectives of the geochemical investigation were to:

- Assess the potential for acidity and contaminant release from the Olympic Dam TSF.
- Determine potential interactions of percolate from the TSF with the underlying soils and sediments, the Andamooka Limestone and the Arcoona Quartzite.

The work programme included:

- A field programme to obtain samples as a function of depth within and below the TSF.
- A laboratory programme to characterise samples and extracted porewater, and to examine water-rock interactions.
- Data collation, interpretation and processing to assess implications of the results with respect to the TSF conceptual model.
- Predictive modelling geochemical models to support predictions of the future behaviour of the system.

Acidic percolate from the base of the TSF will be neutralised by reacting with carbonate minerals present in the underlying sediments and soils, and the excess dolomite contained in the Andamooka Limestone formation. As the neutralisation capacity of the sediment is exhausted locally the acid front will migrate downwards from the tailings – sediment/soils contact interface.

Field evidence indicates that progression of the acid front is variable due to the variability in the carbonate content of the sediments. After 25 years of operation of the existing TSF, the acid front penetrated, on average, to depths of less than 1 m from the tailings interface, i.e. the front is contained within the soils/sediments that immediately underlie the TSF.

Field results also indicate that migration may not always be downwards but could occur laterally across less permeable clay formations, following paths of least resistance. In some localised regions, due to a combination of low neutralising capacity and rapid flow rates through, for example dune sands, the acid front has penetrated to depths of up to 10 m. Also, in calcareous sediments, net volume changes due to the acid neutralisation process may reduce porosity, which may lead to redirection of flows.

Acidity balance calculations show that the majority of acidity would still be present in the tailings deposit at the end of operations. Following closure, a large proportion of this acidity would drain down into the underlying sediments. The consequent acid front could eventually (after several hundred years) penetrate through the soils/sediments and reach the Andamooka Limestone. However, sufficient neutralisation capacity is available within the Andamooka Limestone to neutralise all of the acidity within about 2 to 3 m below the upper surface of the limestone; the Andamooka Limestone in the vicinity of the TSF is up to 60 m thick.

Short-term (operational) percolate loadings would be considerably higher than those expected in the long term (post-closure). Short-term loadings could apply for time periods of several decades to a few centuries (active operations followed by gradual drain-down). Long-term (post-closure loadings could apply thereafter, for periods of about 800 years to about 10 000 years before the acidity would be depleted from the tailings, albeit that solute loadings would decrease to very low rates in the post closure period due to very low percolation rates.

Result show significant attenuation of in particular Co, Cu, Pb, U, Th and Zn has taken place in the sediments underlying the TSF. Attenuation mechanisms include secondary mineral precipitation and sorption as follows:

- Precipitation coincides with the change from acidic to neutral pH conditions. Thus secondary mineral precipitation fronts would track with the acid front. Beyond the precipitation front, the concentrations in percolating waters of the solutes that are present in the secondary mineral phases would remain constant at applicable solubility limits.
- Sorption tends to coincide with neutral pH conditions but may ‘stretch’ well beyond the acid front. Sorption delays or retards the migration of high concentrations of dissolved element. The sorptive capacity of soils and sediments however may be finite, and may change if pH conditions change, and it is possible that ‘breakthrough’ could occur if solution concentrations remain high for a very long time (i.e. assuming the supply of the element from the source remains constant and unlimited). However, considering the finite acidity load from the tailings and the magnitude of the neutralisation capacity, this is considered unlikely to occur.

Water quality estimates that may be used in the groundwater model to assess potential water quality impacts further afield from the TSF have been generated. The test show that, in particular, uranium could reach an upper bound concentration of about 5 mg/L at a lower pH limit of about 6. However, unlike in the laboratory tests, much longer residence times will occur for in-situ conditions due to slower rates of percolation, and equilibrium would be expected to be reached. Geochemical speciation modelling indicate that for equilibrium conditions more typically concentrations of 0.7 mg/L or less at a pH of about 6.5 would be expected within the neutralised ground water.

Changes in solids volumes may affect the permeability of the formations underlying the TSF and affect the flow rates and paths of percolate. Net solids volume changes that may take place as a result of water-rock interactions are as follows:

- Net volume increases are expected in calcareous sediments due to reactions with calcite resulting in the precipitation of gypsum following acid neutralisation – the consequent reduction of porosity may result in decreased seepage flow, and possible changes in flow direction;
- In dolomitic sediments and in the Andamooka Limestone a net decrease in solid volume is indicated – this will lead to an increase in porosity facilitating flow;
- Whilst the results for the Arcoona Quartzite are inconclusive, carbonate minerals are not expected to form; there is however a possibility that other minerals may form but the likelihood of this occurring is considered low.

In conclusion, the conceptual model in general has been verified with the exception of the potential interactions that may occur within the Arcoona Quartzite.

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Disclaimer

The opinions expressed in this Report have been based on the information supplied to SRK Consulting (Australasia) Pty Ltd (SRK) by BHP Billiton (BHP), Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australian Nuclear Science and Technology Organisation (ANSTO), Australian Laboratory Services (ALS) and Australian Radiation Services (ARS). SRK has exercised all due care in reviewing the supplied information. Whilst SRK has compared key supplied data with expected values, the accuracy of the results and conclusions from the review are entirely reliant on the accuracy and completeness of the supplied data. SRK does not accept responsibility for any errors or omissions in the supplied information and does not accept any consequential liability arising from commercial decisions or actions resulting from them.

1 Introduction

1.1 Terms of Reference

Tailings from the Olympic Dam Operation (ODO) currently are being deposited in a paddock type cellular Tailings Storage Facility (TSF). Decant water is pumped to adjoining lined evaporation ponds from which a proportion of water is recycled but most is lost to evaporation. The tailings cells and evaporation ponds are periodically used to manage excess water from major rainfall events. The walls of the cells are constructed with rock and the cells are unlined except for the areas under the decant ponds.

A similar tailings storage strategy would be adopted for the proposed Olympic Dam Expansion (ODX) project. The proposed TSF for the expansion project would however be considerably larger than the existing TSF. Cells of the proposed TSF would be partially lined (beneath the pond area) to intercept and recover seepage during operations.

As part of the proposed expansion project a large open pit mine would be developed. Dewatering for the establishment of the open pit would result in a drawdown of the water table in the surrounding area. Groundwater modelling by others has indicated that the drawdown zone would extend beyond the limits of the TSF and that the seepage from the TSF would be captured within this drawdown zone. Furthermore, water balance modelling for the final void has indicated that, due to high evaporation rates, the pit lake would remain below the existing water table and the drawdown zone would be maintained indefinitely.

In 2007, Olympic Dam Expansion retained SRK Consulting to complete a review of the available geochemical information and develop a conceptual geochemical model for the ODX TSF. The results of this earlier data review and a full description of the conceptual model is given in an earlier report (SRK, 2007). To support the conceptual model, and address information gaps that were identified, a geochemical investigation programme was developed. This report describes the outcomes of the supplemental investigation.

1.2 Objectives and Approach

The overall objectives were to:

- Assess the potential for acidity and contaminant release from the tailings to be placed in the proposed Olympic Dam tailings storage facility; and,
- Determine potential interactions of the percolate from the TSF with the underlying soils and sediments, the Andamooka Limestone and the Arcoona Quartzite.

To meet these objectives, a geochemical investigation programme, comprising field and laboratory investigations, was designed and implemented. The programme was designed to also address information gaps identified during the 2007 review. The data obtained, along with information available from previous studies, were used to support detailed interpretative models of key aspects of the TSF system. Predictive models were then applied to estimate the future behaviour of the system, and potential water quality along groundwater flow paths away from the TSF.

The work programme included the following stages:

- Field sampling and testing (December 2007 to January 2008) – Sonic drilling (Boart Longyear) was undertaken to obtain samples as a function of depth within and below the TSF. Field paste parameters were measured as the samples were generated.
- Laboratory testing (January 2007 to March 2009) – Laboratory characterisation of samples and extracted porewaters and implementation of a detailed testing programme to examine water-rock interactions (CSIRO supported by ANSTO, ALS and ARS).

- Data interpretation (throughout the programme) – Data collation and processing (SRK) to assess implications of the results with respect to the TSF conceptual model.
- Predictive modelling – Incorporation data in geochemical models to support predictions of the future behaviour of the system (SRK).

The report is structured as follows:

- Section 2 provides a brief description of the TSF conceptual model (reproduced from SRK, 2007);
- Section 3 provides an overview of the work programme and methods (detailed descriptions can be found in Appendices to the report)
- Section 4 to 7 present and discuss the results from the investigation programme and has been ordered as follows:
    - Tailings
    - Underlying sediments
    - Andamooka Limestone
    - Arcoona Quartzite
- Section 8 describes and presents the outcomes of the predictive modelling.
- Overall conclusions are presented in Section 9.

2 Summary of the TSF Conceptual Model

Based on the current understanding of the conditions in and below the existing TSF, the geochemical reactions that would dictate the water quality of percolate from the TSF would to a large extent depend on the flow conditions. To illustrate these conditions and potential interactions, a very conceptual schematic of potential flow paths during the operational phase is shown in Figure 3.1. Note that the diagram is not to scale. Based on the conceptualization, five distinct zones can be identified as follows:

Zone 1 Tailings. Within the tailings zone, limited changes in the process water would be expected. First, evapo-concentration within the pond would lead to some secondary minerals becoming supersaturated (e.g. iron jarosites, gypsum, barite, anglesite etc.). As the water passes through the tailings, some of these supersaturated phases would precipitate from solution, leading to decreased concentrations of some solutes. Since the tailings water has a chemical oxygen demand, and since there are likely some residual sulphides present in the tailings, oxygen would be depleted at depth and anoxic conditions would be expected to prevail. This would sustain ferrous iron in solution and may preclude the formation of some phases.

Zone 2 Sediments. This zone represents the interaction of percolate with primarily the calcareous sediments. However, low permeability of some of the clays and some of the sediments may also affect the interaction. First, there is a potential for flows to migrate laterally on top of low permeability layers, which could lead to the formation of perched water tables and wicking of percolate to the surface soils outside the perimeter of the TSF. This mechanism could explain the ‘wet’ area observed at the existing TSF. The percolate would have limited opportunity to react with calcareous clays as it would likely migrate over the top of the clays. It is probable that this water would largely resemble percolate from the TSF except that oxygenation may affect the concentrations of some of the redox sensitive solutes in solution. Second, vertical flow through the calcareous clays would lead to the effective neutralization of the percolate and attenuation of metals for as long as excess neutralizing capacity remains. Acidification once the neutralizing capacity had been depleted may however remobilize some of the metals. The capacity of the sediments to neutralize the acidic percolate would depend on the total acidity loadings from the TSF. Neutralization reactions would lead to the generation of excess carbon dioxide which could lead to a decrease in the porewater pH and may affect the solubility of some solutes, and result in elevated alkalinity concentrations.

Zone 3 Unsaturated Andamooka Limestone. Neutralized percolate from the calcareous clays would be expected to have little interaction with the unsaturated Andamooka Limestone. The reduced pH caused by excess carbon dioxide could promote dissolution of dolomite. However, some flows may bypass the calcareous clays altogether and flow directly to the Andamooka Limestone Formation. At the contact, neutralization reactions would proceed but at a slower rate than indicated by the calcareous clays. Flow would likely occur as fracture flow which would lead to selective dissolution of dolomite along these fractures. Depending on the percolate properties and the redox conditions, the reactions are likely to result in a net dissolution of dolomite, i.e. the porosity of the dolomite would increase. Under certain circumstances (e.g. oxidizing conditions), however, it may be possible that net precipitation reactions could occur so that the reactive carbonate mineral surface may be become ‘blinded’ and leading to a net decrease in porosity.

Zone 4 Saturated Andamooka Limestone. The percolate within the saturated zone is expected to be completely neutralized, and anoxic. Due to excess dissolved carbon dioxide it is likely that the percolate would contain excess dissolved alkalinity (bicarbonate). The excess bicarbonate may complex certain solutes causing elevated concentrations within this zone.

Zone 5 Saturated Arcoona Quartzite. As the percolate passes from the Andamooka Limestone, in the absence of excess carbonate minerals, carbon dioxide may be lost from solution. This could lead to conditions that no longer support the excess dissolved carbonates and may lead to the precipitation of secondary calcite and/or dolomite. Net precipitation of these minerals could reduce the permeability of this formation and may lead to increased lateral flows.

After active tailings deposition ceases, ODX intends to place a cover on the tailings. A corresponding schematic for post closure conditions is shown in Figure 3.2. In broad terms, the same geochemical zones can be identified. Tailings deposition would cease and water would no longer pond on the tailings. Initially, percolation rates are likely to be sustained due to drain-down effects. Thereafter, flow rates would be much reduced and would equilibrate with natural recharge. This would mean that the groundwater mound would recede and the potential for lateral flow would decrease, provided the vertical hydraulic conductivities in the underlying formations had not significantly been affected. Due to the much lower flow rates, overall acidity loadings from the TSF would also decrease to very low levels.

The reduced rates of infiltration would also mean that the tailings would in time become unsaturated as the porewater drains away. This could lead to increasingly oxidizing conditions. Any residual acid generation potential in the tailings may then also contribute to acidity loadings.

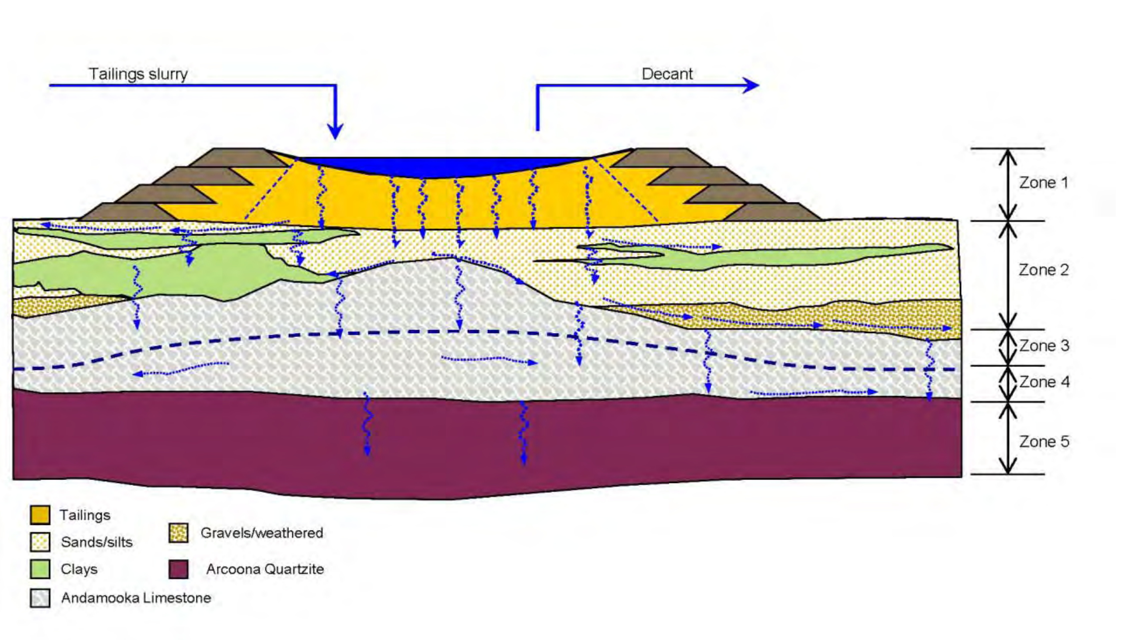


Figure 2.1: Schematic Illustrating Potential TSF Seepage Flowpaths (Not to Scale)

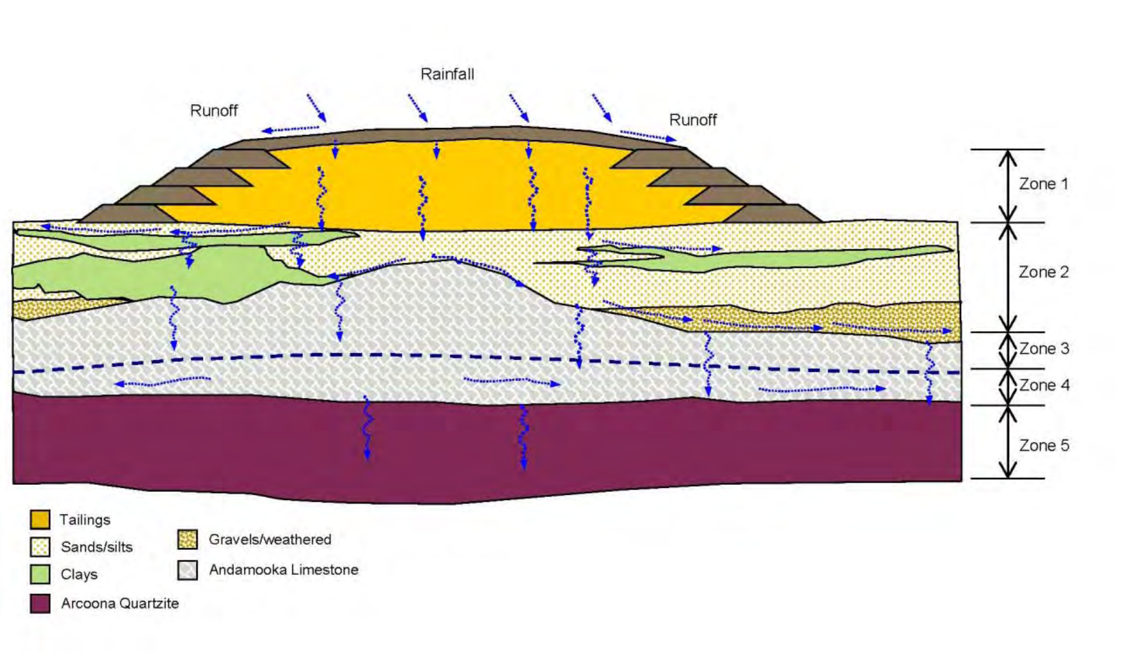


Figure 2.2: Schematic Illustrating Potential Post Closure TSF Seepage Flowpaths (Not to Scale)

3 Work Programme and Methods

3.1 Field Programme

Tailings and underlying sediment and soils samples were obtained by drilling through the tailings contained in the existing TSF. The field programme comprised sonic drilling at seven locations within the existing TSF (Figure 3.1). Field logs have been included as Appendix 1 and photographs taken during the field programme are given as Appendix 2.

Soil and sediment samples not affected by tailings percolate were also obtained by completing additional drilling in undisturbed areas. The drill programme included four locations within the footprint of the proposed rock storage facility (RSF).

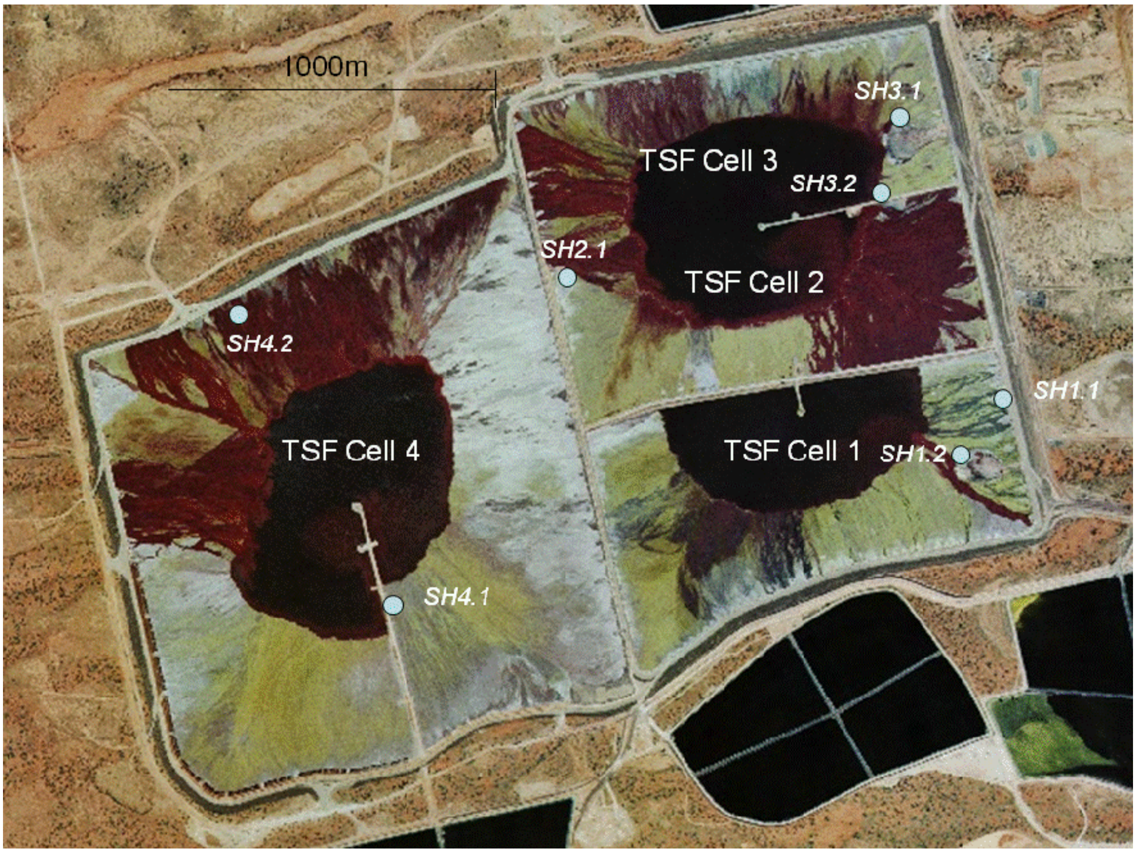


Figure 3.1: Aerial view of the TSF, showing locations of the drill holes

During the drilling programme, field measurements were undertaken to document key paste parameters as a function of depth (paste pH, electro-conductivity and redox potential). Samples collected were logged and dispatched to ANSTO (Lucas Heights) for use in the planned laboratory activities.

Following drilling and sampling from the holes, piezometers were installed within the TSF to furnish future samples of tailings porewater. Later water sampling was undertaken by SKM as part of the overall site groundwater monitoring programme. Groundwater monitoring data have been made available to SRK for use in the current work programme.

3.2 Laboratory Programme

The laboratory programme was undertaken by CSIRO, supported by ANSTO, ALS and Australian Radiation Services (ARS).

A total of 78 core samples were obtained from the holes drilled within the TSF. A further 60 samples were obtained from holes drilled within the proposed RSF footprint area. Five representative samples from the underlying rock strata (Andamooka Limestone and Arcoona Quartzite) were obtained from stored core material.

A subset of samples was selected for inclusion in basic characterisation activities. The selected samples were distributed laterally and vertically within the regions of interest, allowing collection of baseline information that would include a suitable spread of data according to material type, sample location and depth.

Details of the samples selected and the range of testwork undertaken for each are given in Appendix 3. The testwork included the following:

- Porewater extraction (tailings samples only) by centrifugation and analysis of the solution to determine existing porewater quality.
- Mineralogical Assessment (X-ray diffraction, optical and scanning electron microscopy) to assess primary and secondary minerals present in the tailings, underlying soils and sediments and within the undisturbed natural soils and sediments;
- Mineral Surface Characterisation (BET surface area, cation exchange capacity) to support the assessment of potential sorption mechanisms;
- Leach Extractions (static tests involving contacting the sample with deionised water and measuring the metals leached after a predetermined contact time) to assess the labile solutes present in the solids;
- Acid-Base Accounting (analysis of total and sulphate sulphur, total carbon, acid neutralising capacity) to assess the potential of future acid generation from the tailings and the capacity of the soils and underlying formations to neutralise acidity;
- Chemical Assays (acid digestion followed by ICP) to determine the elemental composition of samples;
- Attenuation Tests (contacting samples with acidic metalliferous percolate and measuring the final water composition after a predetermined contact time) to assess mechanisms that may limit contaminant mobility;
- Column Tests (kinetic tests during which a fixed volume of solution is passed through a solid-filled column at regular intervals and the changes in the effluent composition is measured as a function of time) to assess reaction kinetics and solute release rates; and,
- Radiological Investigation (analysis of radionuclide composition of solids and porewaters) to determine key radionuclide concentrations.

The results are described in detail in two CSIRO reports included as Appendices 4 and 5. Results from the additional testwork undertaken for the RSF footprint samples are included as Appendix 6. The results are discussed by material type in Sections 4 to 7.

3.3 Geochemical Modelling

Geochemical modelling has been used to help support experimental design and interpretation of observed trends. All calculations were undertaken using PHREEQC (Parkhurst and Appelo, 1999). Unless otherwise indicated, the thermodynamic data used were those contained in the HATCHES thermodynamic database, NEA v18 (Bond *et al.*, 1997). Data for K-jarosite were based on information given in Baron and Palmer, 1996.

4 Tailings Geochemistry

Complete results from the testing programme undertaken on the tailings samples are included in Appendices 4 and 5. The results are summarised and discussed in the following sections.

4.1 Mineralogy

The mineralogical assessment (XRD, optical microscopy) showed that the mineralogy of the tailings is dominated by quartz (24-71%(wt)), mica/illite (16-35%(wt)) and hematite (2-36%(wt)). Minor minerals (5%(wt) or less) included:

- Sulphate minerals: gypsum ($CaSO_4$), barite ($BaSO_4$), jarosite (iron sulphate mineral)
- Phosphates: florencite (a hydrated rare earth element phosphate mineral, e.g. $CeAl_3(OH)_6(PO_4)_2$);
- Halides and carbonate halides: fluorite (CaF_2), halite (NaCl), basnasite ($Re(CO_3)F$);
- Aluminosilicates: microcline/orthocloase, chlorite, kaolin
- Sulphides: chalcopyrite ($CuFeS_2$) - detected in one sample only, <1%(wt).

In one of the samples (ODXH3.2-01), scanning electron microscopy identified some rare spherical particles comprising dendritic Cu-Fe oxide within a silica rich matrix. These were interpreted to be of anthropogenic origin, possibly sourced from copper processing waste, e.g. flue dust.

The chalcopyrite was found in a sample that originated from an area where waste and spill material was actively being disposed of. It is possible that the chalcopyrite represents concentrate that was present in spill material that had been placed in the TSF.

Two samples indicated the presence of dolomite at trace amounts (Samples ODXH 3.2-01 and ODXH 4.1-04). As shown in Figure 3.1, both these holes are located adjacent the internal berms within the TSF that were constructed from natural borrow materials. The dolomite likely represents contamination from these borrow materials and is not characteristic of the tailings properties.

4.2 Bulk Chemistry

Selected results from elemental analyses of the tailings samples are summarised in Table 4.1. Global abundance indices were calculated to identify elements present in the tailings at levels significantly greater than the average crustal abundance. Elements enriched relative to average crustal abundance, in at least some of the samples, included antimony, arsenic, barium, bismuth, copper, gold, molybdenum, radium-226, rhenium, selenium, sulphur (predominantly as sulphate), silver, tungsten and uranium. Of these, antimony, arsenic, copper, molybdenum, radium-226, rhenium and uranium may have the potential to leach from the tailings over time, depending on the prevailing conditions. Testing under representative conditions is required to assess the extent to which these elements may be leached, and is addressed in the following sections of the report. Sulphur would be released as sulphate.

Table 4.1: Summary of Elemental Analyses of Tailings

Element	Units	Min	P5	P50	P95	Max	Fraction of samples with GAI >3[See Notes]
Ag	ppm	0.1	0.2	**2**	**12**	**27**	89%
As	ppm	7	10	**75**	**98**	**129**	89%
Au	ppm	0.0	**0.1**	**0.2**	**0.5**	**0.9**	94%
B	ppm	20	20	50	70	70	0%
Ba	ppm	269	1236	**6807**	**8652**	**9136**	74%
Be	ppm	0.6	0.6	1.6	2.4	2.6	0%
Bi	ppm	0.1	0.3	**5.7**	**12.7**	**20.7**	89%
Cd	ppm	0.01	0.01	0.01	0.03	0.06	0%
Co	ppm	16	16	36	72	94	0%
Cr	ppm	10	15	25	33	43	0%
Cu	ppm	35	341	**1460**	**5664**	**15150**	89%
Hg	ppm	0.01	0.01	0.14	0.27	0.59	0%
Li	ppm	10	11	13	18	18	0%
Mn	ppm	40	41	63	140	223	0%
Mo	ppm	1	2	**53**	**65**	**68**	89%
Ni	ppm	4	4	6	10	10	0%
Pb	ppm	10	13	70	**173**	**180**	11%
Ra-226	Bq/g	0.1	**0.3**	**5.7**	**10.7**	**13.4**	95%
Re	ppm	0.003	0.004	**0.031**	**0.040**	**0.044**	89%
S	%	0.27	**0.76**	**1.24**	**2.93**	**5.99**	94%
Sb	ppm	0	1	**9**	**11**	**13**	89%
Sc	ppm	2.4	2.6	3.2	4.2	5.8	0%
Se	ppm	**2**	**2**	**5**	**24**	**103**	100%
Sn	ppm	1	1	19	**27**	**43**	5%
Sr	ppm	147	188	378	545	655	0%
Th	ppm	5	19	31	42	42	0%
Ti	ppm	0.06	0.06	0.08	0.10	0.11	0%
Tl	ppm	0.1	0.2	0.5	0.7	0.8	0%
U	ppm	19	**110**	**142**	**264**	**267**	95%
V	ppm	17	17	21	36	83	0%
W	ppm	1	2	**40**	**49**	**60**	89%
Y	ppm	35	41	52	70	73	0%
Zn	ppm	14	27	36	56	118	0%

Notes: Results from nineteen samples tested
Global abundance indices (GAIs) compare sample abundances to average ‘crustal’ abundances. Positive GAI values indicate enrichment. As a general rule, a GAI value of 3 or higher indicates significant enrichment.
All values that result in a GAI >= 3 are given as bold.

4.3 Metal Partitioning

Metal partitioning was examined by exposing samples of tailings to a series of leaching steps using different leachants (chemical reagents exerting specific phyisico-chemical influences on the solids), each more 'aggressive' than the preceding step. The leachants were designed to target different components of the material to sequentially extract the following phases: i) labile, ii) adsorbed/exchangeable/carbonate, iii) amorphous iron oxy-hydroxide, and iv) crystalline iron oxyhydroxide, with the remaining material classed as v) residual (i.e. material remaining after treatment with the all the leachants).

Table 4.2 summarises the primary observations with respect to elemental partitioning in the tailings. Selected results are illustrated in Figure 4.1 to Figure 4.4.

Table 4.2: Metal Partitioning between Different Tailings Components

Target Component	Leachant	Major Element Partitioning	Minor and trace element partitioning[1]	Probable source of the major element and possible mineral associations
Labile	Water	SO_4, Ca, Mg	**Co** B, Be, Cd, Ce, Li, Ni, Re, Se, Tl, U, Y	Residual tailings porewater Very readily soluble salts Element very weakly bound to solids
Adsorbed/Ion exchangeable/(Carbonate)[5]	Sodium Acetate	Na, Mg	**Ra** B, Be, Cd, Re, Se, Tl	Equilibrium controlled soluble salts not removed by first leach Elements adsorbed on mineral surfaces Elements displaced from exchange sites
Amorphous Iron Oxy-hydroxide	Hydroxylamine Hydrochloride	Ca, Mg *K, Si*[2]	**Bi, Hg, Sb Sn** Ag, B, Ce, Cu, Re, Se, Sr, Sr, Th, Ti, Tl, U, Y, Ra	Dissolution of amorphous iron oxide, possibly accompanied by a minor amount of a silicate mineral
Crystalline Iron Oxy-hydroxide	Hydroxylamine Hydrochloride; Acetic Acid	*K, Si*[2]	**Ag, Cd, Hg, Sb, Sn, V, W** B, Cu, Mo, Re, Se, Tl, Zn, Ra	Dissolution of hematite, possibly accompanied by a minor amount of a silicate mineral
Residual		Mg, Al, Fe[3]	**A**s, **Ba**, **Cr**, **Mn**, **Mo**, **Ni**, **Pb**, **Ti**, **Zn** Bi, Ce, Co, Cu, Li, Sr, Th, W, Y	Aluminosilicates, insoluble sulphate (barite), phosphate?

Notes:

1. Elements given in bold show evidence of strong partitioning, i.e. more than 40% of the element was dissolved (in either one or both of the samples assessed).
2. The relative partitioning of these elements to this component may be overestimated due to underestimation of the quantities associated with the residual phase. It was noted that the cumulative mass of K, Al, Si and Fe following the five extractions (Appendix 5) is less than would be expected based on whole rock chemical assays (Appendix 4). The analytical methods used for the residual phase did not fully account for insoluble material present, e.g. silicates.
3. The majority of the Fe is associated with the residual phase, suggesting that only a small proportion of the iron oxide dissolved in the earlier amorphous and crystalline iron oxy-hydroxide extraction steps. Both samples contained more than 30%(wt) hematite. It would appear that some proportion of this hematite was resistant to the chemical conditions of the earlier extraction steps.
4. Some elements, (Na, Cl) are introduced to the test system via the reagents used and are not included in the table.
5. No carbonate phases are present in the tailings solids due to acidic nature of tailings

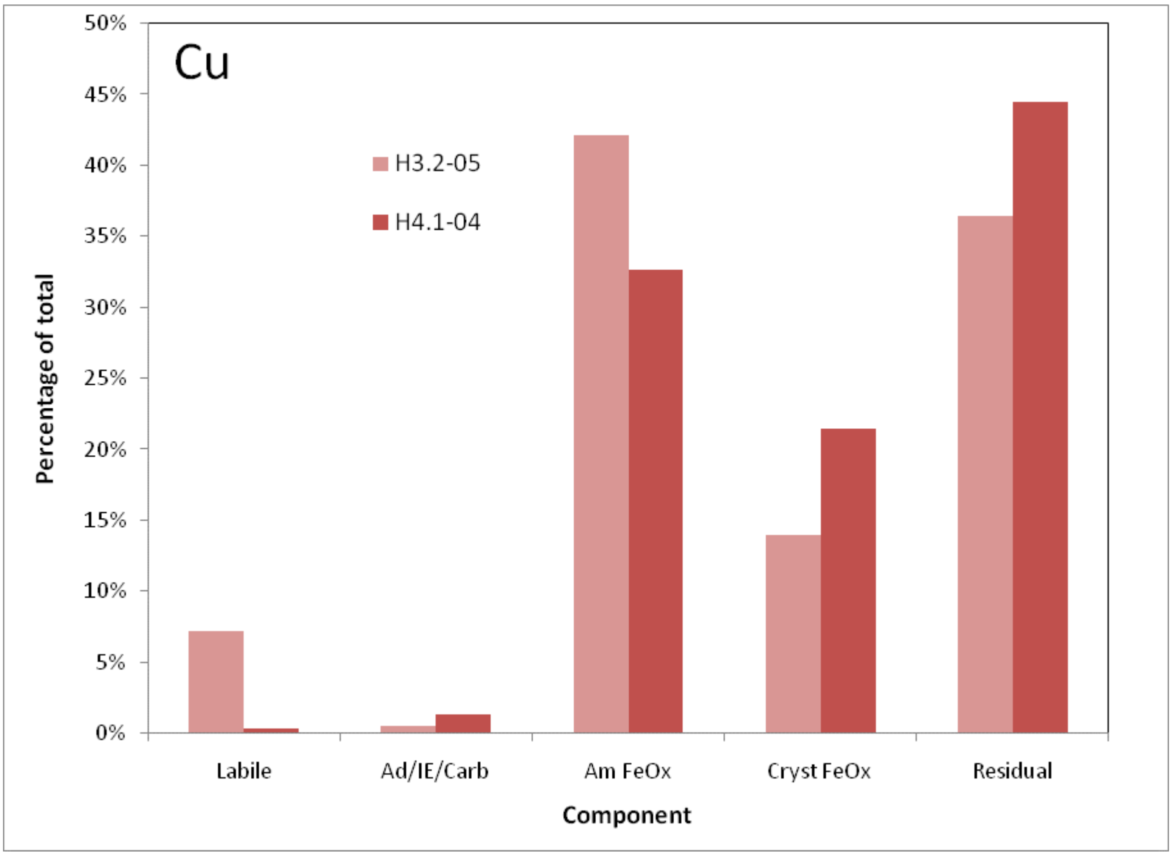


Figure 4.1: Partitioning of copper between different components in the tails

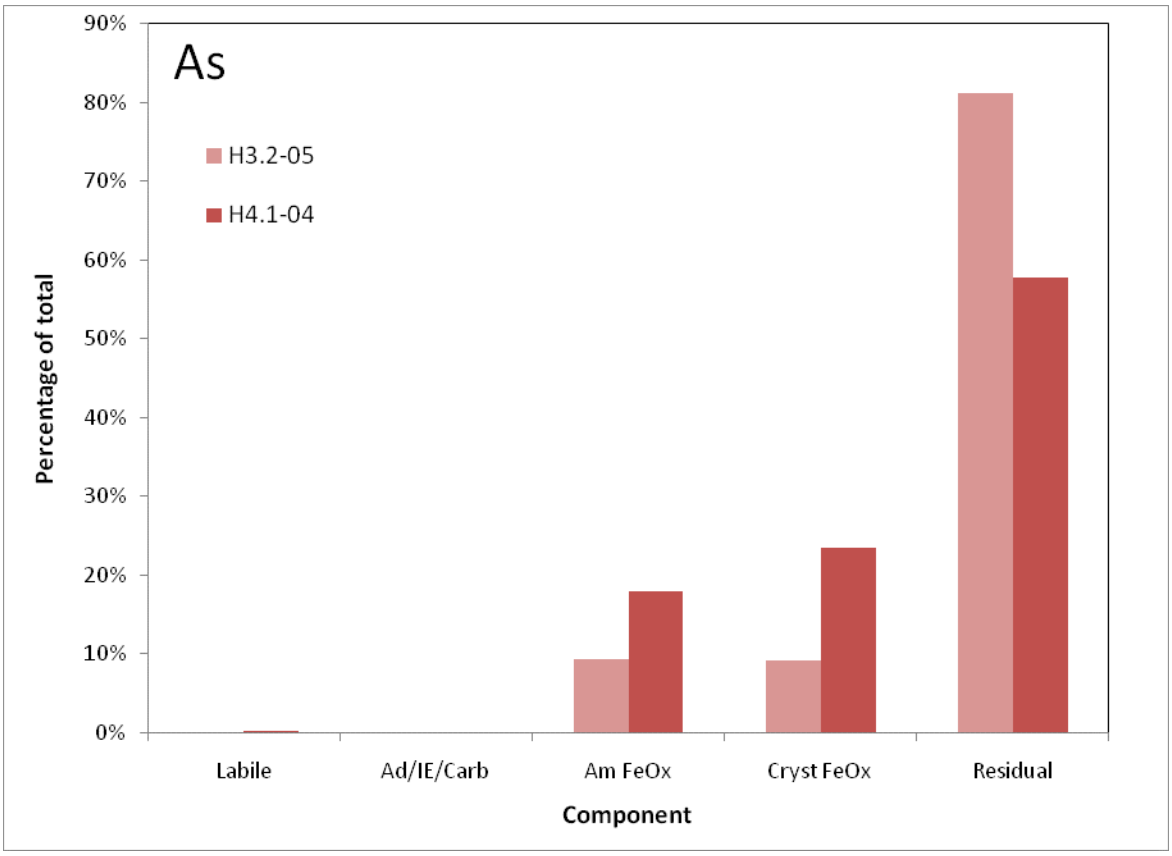


Figure 4.2: Partitioning of arsenic between different components in the tails

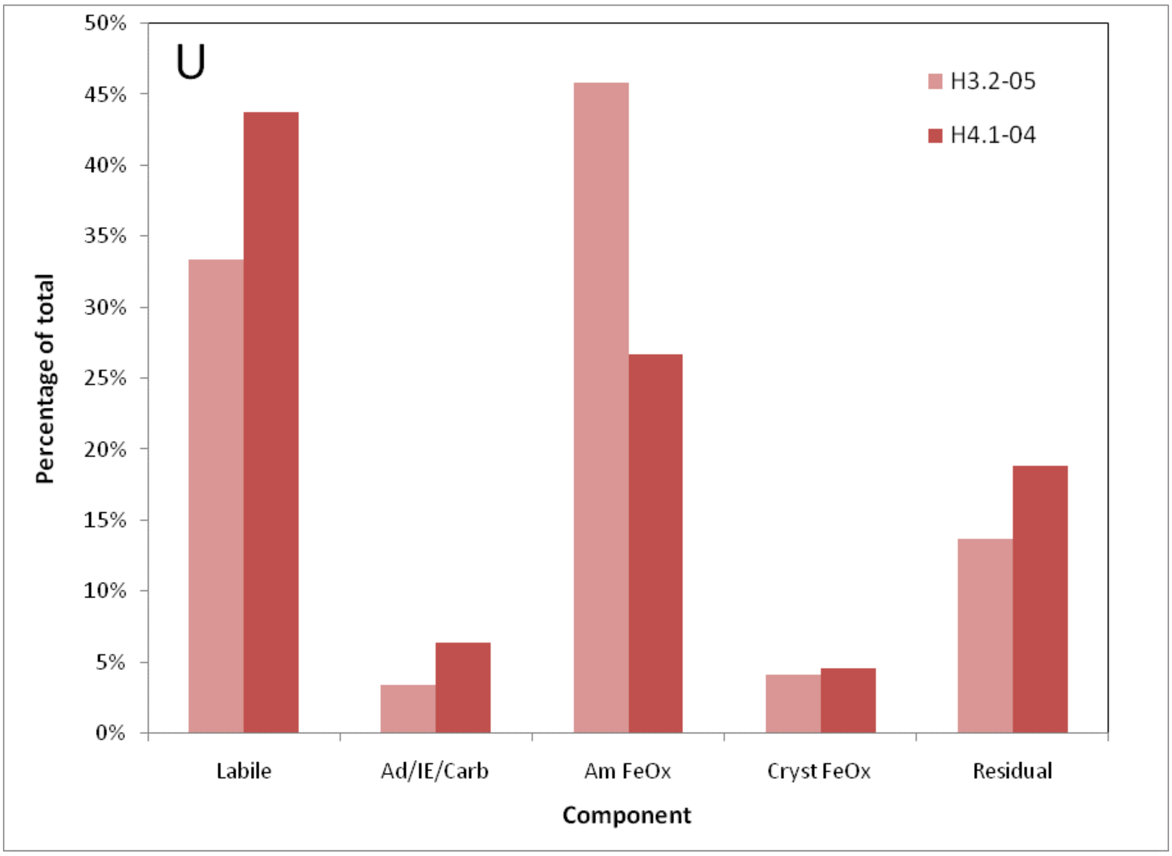


Figure 4.3: Partitioning of uranium between different components in the tails

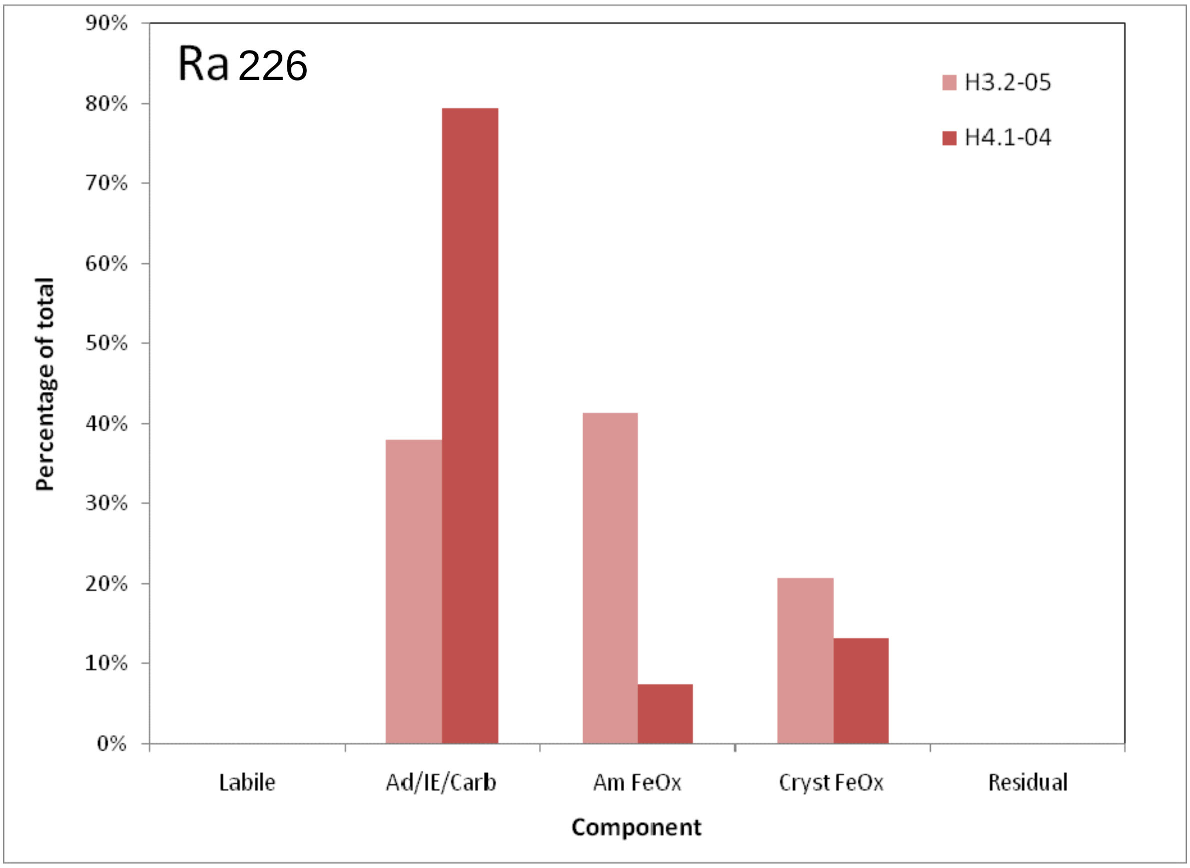


Figure 4.4 Partitioning of radium-226 between different components in the tails

Specifically the results indicate that:

- The labile or water soluble phases present in the tailings have a significant metal content primarily because the solution remained acidic in pH.
- Even though a high proportion of radium-226 is associated with the adsorbed/ion exchangeable component (Figure 4.4), the labile content of the tailings was negligible (leachate concentrations were below 0.0001 Bq/ml). Radium is an alkaline earth element, chemically analogous to calcium and magnesium. Incorporation of radium in calcium and magnesium bearing salts is possible, as is participation in ion exchange reactions. Typically radium would have been expected to be associated with sulphate minerals including barite and gypsum, since co-precipitation of radium with barium sulphate is commonly used in water treatment technology to remove radium-226 from solution. Soluble sulphate concentrations were most elevated for the labile test indicating that dissolution of the lesser soluble sulphate phases (i.e. barite, with which the radium-226 would be expected to be associated with) may have been inhibited. It is therefore possible that such sulphate phases would have been dissolved during the ion exchange leach and subsequent tests where sulphate concentrations were much lower. Consequently the radium-266 release may well be controlled by solubility constraints even though the response appears to mimic an ion exchange mechanism. Therefore the radium-226 in the tailings is not likely to be leached readily from the tailings solids.
- A larger range of metals is associated with amorphous iron oxy-hydroxide component compared to the crystalline phases. This is likely related to a higher tolerance for impurities in the case of the amorphous phase, suggesting co-precipitation of these metals could be occurring during the formation of the amorphous phase. This would also suggest that transitioning of the meta-stable phases from the amorphous to more crystalline phases is leading to the exclusion of metals previously associated with the amorphous phases.

4.4 Acid-Base Accounting

The acid base account results for the tailings are summarised in Table 4.3 and discussed below.

4.4.1 Acid Potential

Chalcopyrite was the only sulphide mineral identified in mineralogical investigations, being present at very low levels (<1%(wt)) in one of the four samples assessed. Also, a significant proportion of the sulphur is present in an oxidised form, i.e. sulphate (e.g. gypsum, jarosites, barite). In the tailings, as shown in Figure 4.5, between 40 and 90% of the sulphur is present as sulphate sulphur. Accounting for the oxidised sulphur, the calculated acid potential (AP) of the tailings ranged from about 2 to 106.4 kgH_2SO_4/t. However, as shown in Figure 8, the upper value corresponded to a single sample with a sulphur content of about 6 %. That sample (ODXH1.2-02) had a sulphate sulphur content of 2.5 % and a corresponding sulphide sulphur content of about 3.5 %. Compared to all the other tailings samples, the relatively high sulphide sulphur content is anomalous. That sample also returned a net acid generation potential below detection suggesting that the sulphur speciation may be erroneous. (Note that the standard sulphate analysis procedure does not accurately account for sulphate associated with some secondary mineral phases, such as alunite and barite, which may lead to overestimation of the sulphide sulphur content.)

The remainder of the samples, representing the bulk of the tailings, had total sulphur contents ranging up to 2.39 %, sulphate sulphur up to 1.98 % and sulphide sulphur ranging only up to 0.64 %. The AP values ranged up to about 19.7 kgH_2SO_4/t, with an average of 10.6 kgH_2SO_4/t and a median value of 10.3 kgH_2SO_4/t.

Table 4.3: Summary of Acid Base Account and NAG Test Results

Sample	Material	Net Acid Generation			Acid Neutralising Capacity		Sulphate (SO_4^{2-})	Total S as S	$S(S^{2-})$	MPA
		pHox	pH 4.5	pH 7.0						
			kg H_2SO_4/t	kg H_2SO_4/t	kg H_2SO_4/t	% CaCO3	mg/kg	%	%	kg H_2SO_4/t
ODXH 1.01	Tailings	6.3	<0.1	1.0	11.2	1.1	28200	1.14	0.20	6.1
ODXH 1.03	Tailings	3.4	1.9	9.3	<0.5	<0.1	30200	1.23	0.22	6.8
ODXH 1.05	Tailings	8.2	<0.1	<0.1	39.4	4	30200	1.23	0.22	6.8
ODXH 1.07	Tailings	3.5	1.5	9.3	<0.5	<0.1	18000	0.92	0.32	9.8
ODXH 1.2-05	Tailings	3.9	1	15.3	<0.5	<0.1	59500	2.39	0.41	12.4
ODXH 1.2-07	Tailings	3.9	0.5	10.8	<0.5	<0.1	20100	1.11	0.44	13.5
ODXH 3.2-01	Tailings	8.1	<0.1	<0.1	51.8	5.3	20900	1.34	0.64	19.7
ODXH 3.2-03	Tailings	9.9	<0.1	<0.1	37	3.8	11300	0.85	0.47	14.5
ODXH 3.2-05	Tailings	4.3	0.2	10.0	<0.5	<0.1	33700	1.24	0.12	3.6
ODXH 3.2-07	Tailings	5.4	<0.1	6.4	<0.5	<0.1	20700	1.08	0.39	11.9
ODXH 3.2-09	Tailings	3.7	0.8	9.9	<0.5	<0.1	20500	1.03	0.35	10.6
ODXH 4.1-02	Tailings	3.8	0.8	6.4	<0.5	<0.1	31800	1.35	0.29	8.9
ODXH 4.1-04	Tailings	7.1	<0.1	<0.1	51.8	5.3	40700	1.62	0.26	8.1
ODXH 4.1-06	Tailings	3.8	0.8	12.6	<0.5	<0.1	44900	1.82	0.32	9.9
ODXH 4.2-02	Tailings	3.3	2.7	9.7	<0.5	<0.1	29500	1.33	0.35	10.6
ODXH 4.2-04	Tailings	4.0	0.4	9.0	<0.5	<0.1	24600	1.34	0.52	15.9
Average			**1.1**	**9.1**			**29050**	**1.31**	**0.35**	**10.6**
Median			**0.8**	**9.5**			**28850**	**1.24**	**0.34**	**10.3**
ODXH 1.2-02	Tails/waste	7.3	<0.1	<0.1	90	9.2	75300	5.99	3.48	106.5

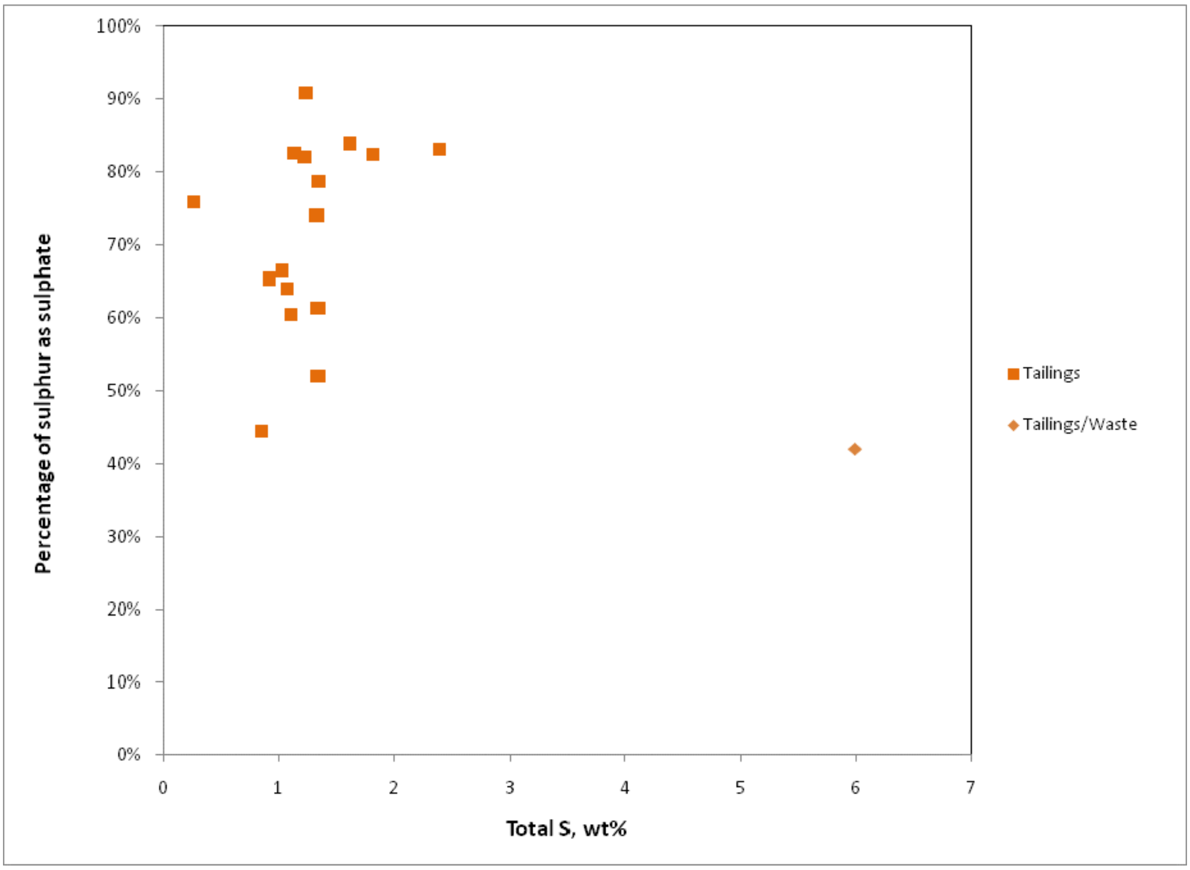


Figure 4.5: Percentage of sulphur as sulphate, plotted as a function of total sulphur content

4.4.2 Neutralisation Potential

The acid neutralisation capacity (ANC) of the tailings is generally very limited, with the ANC values of twelve of the nineteen samples below detection (<0.25 kgH_2SO_4/t). The measured ANC values for the remaining 7 samples ranged from <0.5 to 154 kgH_2SO_4/t. The maximum value, 154 kgH_2SO_4/t, was associated with a sample taken at the interface with underlying sediments and is likely influenced by the presence of some sedimentary material mixed with the tails. Two additional samples originating from drill hole SH3.2 had pH values of about 7 and above which clearly is not representative of the acid leached tailings. These samples likely do not represent tailings alone but could comprise a mixture of tailings with mill spillage (e.g. lime) or soils and therefore do not represent the bulk of the tailings. Whilst the ANC of the remaining samples ranged up to 51.8 kgH_2SO_4/t, these tailings samples were already acidic prior to testing (paste pH values less than 5) and the measured ANC values clearly are not available for acid neutralization at a near neutral pH condition. (The ANC values could be an artefact of hydronium jarosites that may be precipitated and "consuming" H^+ ions when acid is added to the sample during the ANC test.) The actual available neutralization capacity of the tailings therefore is considered to be negligible since the samples are already acidic.

4.4.3 Net Acid Generation

Net acid generation (NAG) tests measures the acidity that can be generated when the sulphide minerals are oxidised by a strong oxidant. In this test, the sample is contacted with hydrogen peroxide to oxidise the sulphides contained in the sample. Neutralising minerals that may be present concurrently neutralise all or part of the acidity generated. Following a predetermined contact time, the solution pH is recorded and the NAG acidity of the sample is quantified by titration with a base (sodium hydroxide). Titration to pH 4.5 generally accounts for acidity attributable to free acid (H_2SO_4) and ferric iron generated during the oxidation of sulphide minerals (that has not been neutralized by the contained ANC). Titration from pH 4.5 to pH 7 generally accounts for acidity associated with some metals, such as copper, that are soluble at pH 4.5 but practically insoluble at pH 7. Acidity attributed to ferrous iron will also be accounted for in the titration up to pH 7 (ferrous iron remains soluble at pH 4.5; however oxidation to ferric by atmospheric oxygen accelerates as the pH increases).

For the tailings samples, net acid generation (NAG) testing showed a range of final pH values, from acidic values (pH 3.3) to alkaline values (pH 10.7). Note that the NAG pH values recorded for some of the samples increased from the measured paste pH values. The reason for these increases is not known and the results are considered anomalous.

All of the samples had low measured acidities (<3 kgH_2SO_4/t) after titration to pH 4.5. The majority of the acidity appeared to be associated with the titration from 4.5 to 7, suggesting the presence of un-oxidised ferrous iron or metals, such as copper. The cumulative acidity measured in the samples was modest, up to 15.3 kgH_2SO_4/t. Note however that acidity already associated with the tailings before the tests (i.e. acidic paste pH, contained secondary minerals) would also contribute to the ‘measured’ acidity; consequently the NAG test would overestimate the acid generation potential of the tailings. As discussed in Section 4.6, the leach extractions performed on tailings samples (for which porewater could not be extracted) indicated that the tailings on average contained an acidity of about 6.5 kg kgH_2SO_4/t (ranging up to 11.1 kgH_2SO_4/t). Accounting for this acidity suggests that the actual additional acidity generated during the NAG tests would be about 9.1 – 6.5 = 2.6 kgH_2SO_4/t. Considering the potential analytical error associated with the sulphate analyses, this estimate of the acid generation potential of the tailings is considered to better reflect the ‘true’ potential for acid generation. (A similar conclusion can be reached if the porewater acidity together with an average tailings moisture content of about 10 % is assumed.)

4.4.4 Material Classification

Figure 4.6 shows the results for the tailings samples plotted on a conventional geochemical classification plot. The majority of the tailings samples are shown to be potentially acid forming (PAF). The samples that are known or suspected to be contaminated with natural sediments and soils are shown to be non acid forming.

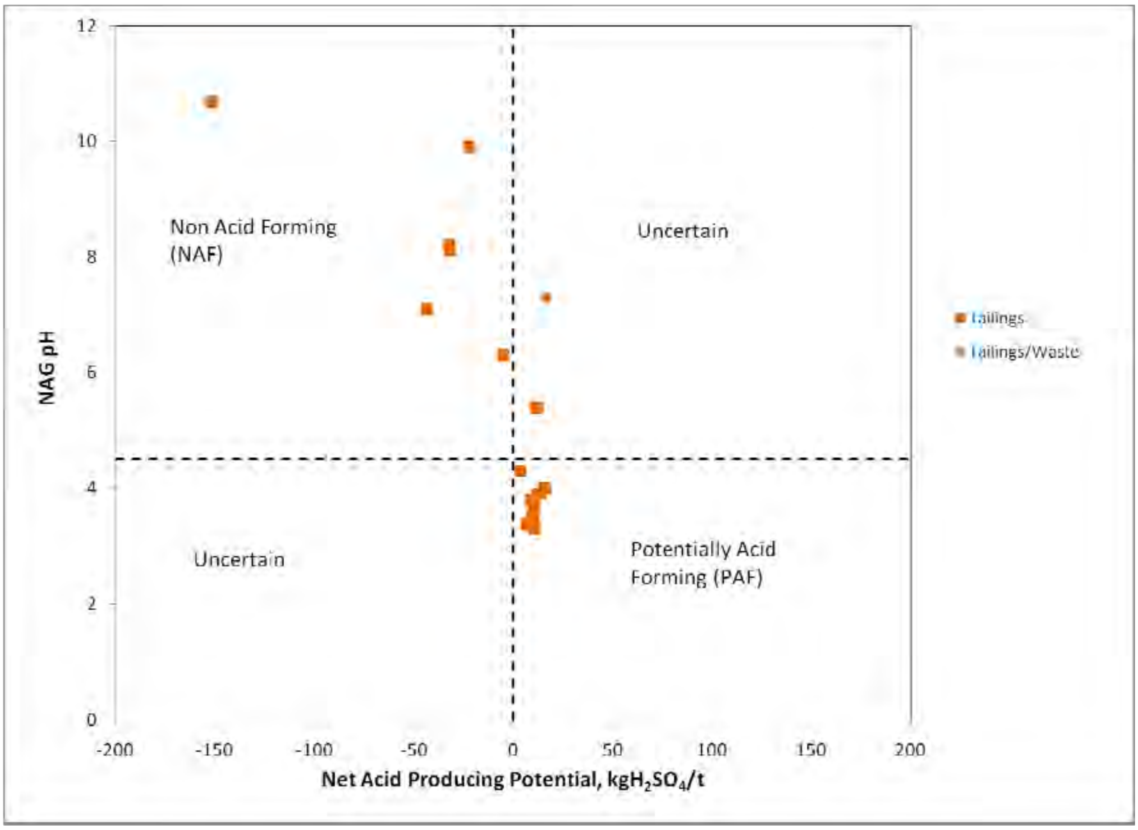


Figure 4.6: Geochemical Classification Plot

4.5 Physical Characteristics

A summary of the physical characteristics of the tailings is given in Table 4.4. The measured particle size distributions are illustrated in Figure 4.7.

Three of the four samples showed quite low surface areas, 3 to 5 m^2/g, and moderate cation exchange capacities (CECs), 35 to 58 meq/100g. One of the samples, ODXH1.2-09T, has a higher surface area (up to 31 m^2/g) and a higher CEC (129meq/100g) than the other samples tested. The results are somewhat counter-intuitive as the latter sample has a higher quartz content and a lower mica/illite content than the other samples. A lower CEC would be expected on the basis of the lower mica/illite content. The sample does however contain 3%(wt) kaolin, which could be contributing significant CEC.

ODXH1.2-09T was obtained from at the sediment interface and may contain some material sourced from the underlying sediments. The particles size distribution for that sample also was coarser that for the other three samples. Again this appears to be anomalous as the tailings would be expected to have a finer particle size distribution due the high proportion of precipitates contained in the samples. The data for the other three tailings samples are therefore considered to be more representative of the bulk of the tailings.

In general the results suggest the tailings have a capacity to attenuate some solutes due to cation exchange. The results also appear to be consistent with the results from the portioning assessment discussed in Section 4.3. The tailings also have a fine particle size distribution (up to 20 % less than 2 µm and would be expected to attenuate water well.

Table 4.4: Physical Characteristics of the Tailings

Sample	BET surface area, m^2/g	Cation exchange capacity, meq/100g[1,2]
ODXH1.2-09T	21, 31[3]	129
ODXH3.2-01	3	58.4
ODXH3.2-05	4	34.8
ODXH4.1-04	5	35.1

Notes:

1. The cation exchange capacity measurements were undertaken after first pretreating the sample to remove soluble cations.
2. The cation exchange capacity given in the table includes contributions from exchangeable Ca, Mg, Na, K and Al. Exchange sites were predominantly occupied by calcium ions (77 to 98%) (Appendix 4)
3. Duplicate analyses were undertaken for this sample.

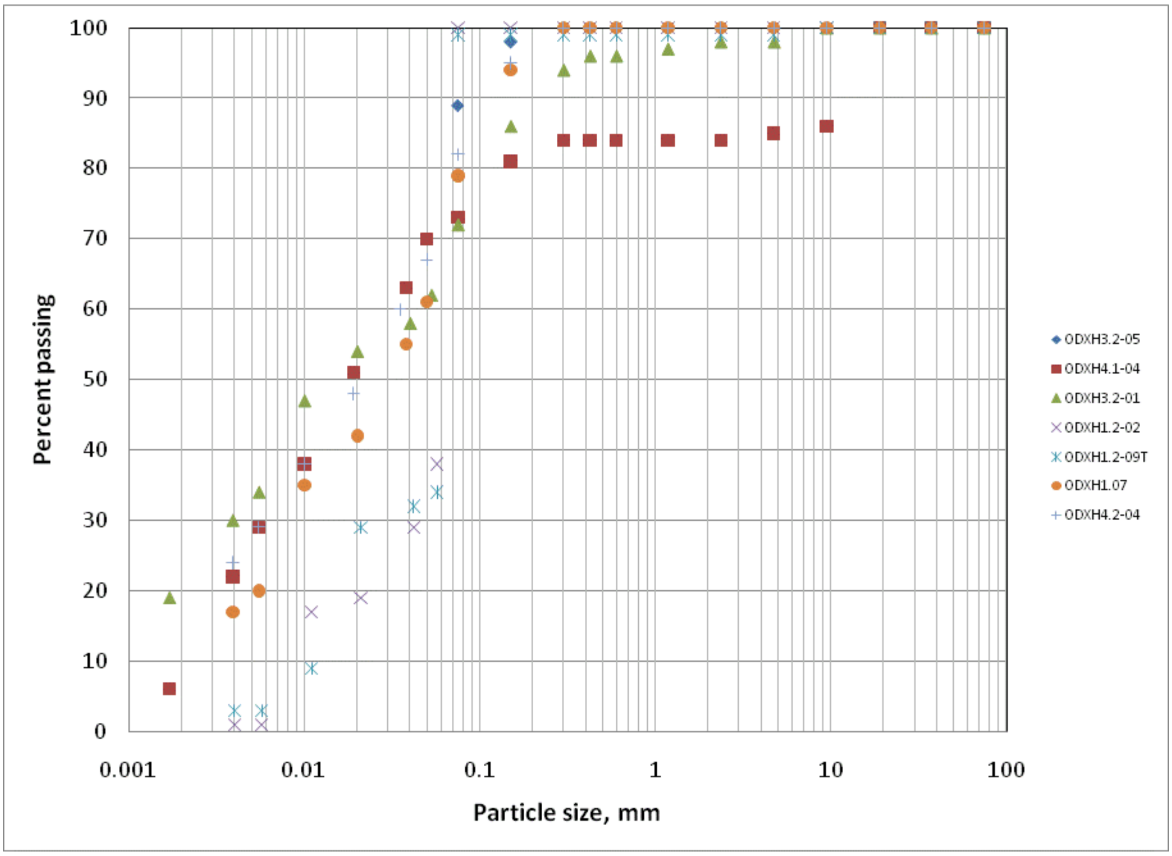


Figure 4.7: Particle Size Distribution of Tailings

4.6 Porewater Chemistry

Porewater was extracted from selected tailings samples ex-situ (see Appendix 4 for details). Where porewater could not be extracted, a 1:1 solid to liquid ratio water extraction was completed. In the case of 1:1 solid to liquid extractions, the extraction results do not reflect porewater concentrations since additional water is introduced which leads to dilution of the porewater. Estimates of porewater may be obtained from these tests by correcting the concentrations to the original sample moisture content and satisfying solubility constraints where they may exist through geochemical speciation modelling.

Results obtained from these samples have been compared to the groundwater monitoring programme results (based on samples collected from piezometers installed at the site). A statistical summary for selected parameters are shown in Table 4.5. The results for the 1:1 extraction results are presented separately in the table as they not directly comparable with the porewater and piezometer results.

The results for the prorewater and leach extraction test results can be summarised as follows:

- The porewater is acidic, with a median pH of about 3.5. (Note that the pH generally was higher in the 1:1 leach extraction results due to porewater dilution.)
- The major element composition is dominated by iron (Fe), aluminium (Al), sodium (Na), sulphate (SO_4) and chloride (Cl). Iron redox speciation measurements suggest that between 20 and 30% of the total iron was present as ferrous iron, Fe(2+).
- The porewater contained elevated concentrations (>20 mg/L) of cerium (Ce), cobalt (Co), copper (Cu), manganese (Mn), molybdenum (Mo), uranium (U), yttrium (Y), and zinc (Zn).
- Radiological analysis of extracted porewater samples was difficult due to the small volumes of sample available. Gross alpha emissions ranged from <0.005 to 0.021 Bq/ml, with an average of 0.011 Bq/ml in the tailings porewater, whereas Ra-226 activities ranged from 0.01 to 0.074 Bq/ml, with an average of about 0.025 Bq/ml. Although the average and maximum Ra-226 activities exceeded the gross alpha measurements, the average error associated with the Ra-226 activity measurements was about ± 0.009 Bq/ml (about 45 %) which is a result of the sample volume limitations. The gross alpha results for the 1:1 extractions ranged from <0.005 to 0.013 Bq/ml with an average of 0.01 Bq/L, whereas the Ra-226 activities were at or below the detection limit of 0.005 Bq/ml.

For the most part, extracted porewater quality compared well with the in-situ sample results for the samples obtained from in-situ piezometer sampling. Some exceptions are:

- In several cases, higher Fe and SO_4 concentrations were measured in the extracted porewaters than in piezometer samples.
- Elevated fluoride (F) concentrations observed in the piezometer samples were not observed in extracted porewaters.
- The Ra-226 activities for the in-situ piezometer samples were consistently lower than the porewater extraction results.

Some of the measured parameters show a relatively large range of values, indicating significant variability exists within the tailing porewater chemistry. No obvious trends as a function of depth or location in the TSF were detected.

Table 4.5: Tailing Porewater, Leach Extraction (1:1 L:S) and In-Situ Concentrations

Parameter		Extracted Porewater				1:1 (S:L) Extracted Porewater				In Situ (Piezometer) Porewater			
		n	min	p50	max	n	min	p50	max	n	min	p50	max
pH		8	3	3.3	4.1	4	3.2	3.9	7.6	13	2.5	3.5	5.2
EC	mS/cm	8	9.6	12.1	16.2	2	8.4	13.3	18.2	8	29.8	34.7	38.4
Acidity as $CaCO_3$	mg/L	7	10800	45000	66700	4	16	6550	11100	-	-	-	-
Cl-	mg/L	7	4440	5300	5790	4	463	560	4290	13	2662	3545	4599
F	mg/L	8	15	33	38	4	20	51	66	8	5010	9235	13400
NH_3-N	mg/L	8	72	341	431	4	6.88	74	280	-	-	-	-
Nitrate as N	mg/L	8	<0.01	<1	<1	4	<0.1	<0.1	0.63	8	<0.01	0.02	3.5
PO_4^{3-}	mg/L	8	0.2	0.9	1.1	4	0.02	0.06	0.08	-	-	-	-
SO_4^{2-}	mg/L	8	43300	53300	85100	4	6590	7330	8030	13	11230	31000	49300
Al	mg/L	8	3860	7405	9520	4	2.22	1133	1380	13	820	8200	13000
Ca	mg/L	8	539	1218	1910	4	73	89	719	13	560	690	1020
Fe	mg/L	8	7940	16200	32900	4	7	1460	1570	7	1640	7130	8600
K	mg/L	8	542	704	860	4	46	103	150	13	100	630	900
Mg	mg/L	8	598	687	860	4	496	511	656	8	492	825	1660
Na	mg/L	8	3300	3880	4360	4	510	545	4490	8	3100	3810	8370
Si	mg/L	8	32.3	59.9	229	4	5.8	22	46.1	5	3.5	41	220
As	mg/L	8	0.09	0.16	0.25	4	0.011	0.023	0.085	8	<0.005	0.01	0.05
Cd	mg/L	8	0.015	0.023	0.026	4	<0.0005	0.0035	0.0045	8	0.003	0.08	0.27
Co	mg/L	8	38.6	58.8	138	4	0.2	6.7	8.4	13	<1	43	75
Cr	mg/L	8	0.62	1.91	2.86	4	0.045	0.11	0.23	4	0.32	0.94	1.6
Cu	mg/L	8	0.09	14.5	407	4	0.06	1.28	41.3	13	<10	80	500
Mn	mg/L	8	52	135	266	4	<0.005	6.5	12.6	13	29	130	240
Mo	mg/L	8	<0.05	<0.01	<0.01	4	<0.005	<0.005	0.424	8	<0.001	<0.005	0.047
Ni	mg/L	8	4.8	6.8	10	4	0.03	0.83	0.89	8	3.5	6.2	9.7
Pb	mg/L	8	0.044	0.066	0.27	4	<0.005	0.015	0.043	8	<0.001	0.03	0.99
Ra-226	Bq/ml	8	0.01	0.016	0.074	4	<0.005	0.0023	0.005	2	0.00035	0.0004	0.00044
Sb	mg/L	8	<0.01	<0.01	<0.05	4	<0.005	<0.005	<0.005	8	<0.001	<0.001	0.0013
Se	mg/L	8	0.6	0.8	0.9	4	0.08	0.11	0.16	8	3.5	4.7	6.7
Th	mg/L	8	0.3	2.9	6.6	4	<0.005	0.05	0.79	-	-	-	-
U	mg/L	8	67	122	596	4	7.9	27	34	13	7	200	400
V	mg/L	8	<0.5	0.7	1.1	4	<0.05	0.06	0.08	8	0.34	0.73	0.91
Zn	mg/L	8	19	25	35	4	<0.025	3.4	4.2	13	<5	28	50

4.7 Water-Tailings Interactions

According to the conceptual model, following closure, tailings porewater would drain from the TSF to be displaced by percolating rainwater. Previous work had not included examination of leaching from the tailings under such conditions. In the current programme, interaction of tailings with deionised water (to simulate percolating rainwater) has been assessed under a range of conditions, using both static and kinetic test methodologies (Table 4.6).

Table 4.6: Test Programme for Assessing Interactions of Tails with Deionised Water

Organization	Experimental Conditions	Water:Solids Ratio	Number of Stages or Cycles
Static Sequential Leach Extraction Tests			
CSIRO	Air-equilibrated water	2	3
CSIRO	De-oxygenated water	2	3
Kinetic Column Tests			
CSIRO	Unsaturated, Air-equilibrated water	0.3-0.4[1]	21
CSIRO	Saturated, Air-equilibrated water	0.3-0.4[1]	10
CSIRO	Saturated, Deoxygenated water	0.3-0.4[1]	10

Notes:

- The water-to-solids ratio is estimated on the basis of the dry mass of solid occupying the column relative to the volume of leachant per cycle.

Detailed descriptions of the test methods are included in Appendix 5. Key aspects of the results are discussed in the following sections.

4.7.1 Sequential Water Leach Extractions

The sequential water leach tests were undertaken using:

i) de-oxygenated water and in a controlled anoxic (nitrogen) atmosphere; and
ii) oxygenated water under atmospheric conditions.

A summary of the results for key parameters is provided in Table 4.7 and calculated stage and cumulative releases are provided in Table 4.8.

Whilst the dissolved oxygen in the anoxic leach conditions were significantly lower than for the atmospheric test conditions (typically 0.2 to 1.7 ppm compared to 5 to 11 ppm, Appendix 5), the redox conditions were only marginally affected (likely due to the very high ferric iron concentrations) and reducing conditions did not eventuate in the tests. Consequently there were only slight differences between the oxygenated and anoxic tests. For example, zinc leaching is slightly greater in the case of the air atmosphere experiments than the nitrogen atmosphere experiments as shown in Figure 4.8, which illustrates results for uranium, zinc and iron. These effects generally are small and likely to be within sample variability and experimental error.

As discussed in Section 4.3, leachable fractions are likely to be present:

i) dissolved in residual tailings porewater,
ii) as very readily soluble salts, or,
iii) as elements very weakly bound to the solid phase.

The leach extraction results indicated that sulphate, sodium, magnesium and calcium were readily leachable (in excess of 10 % of the initial solids content). Minor and trace elements readily leachable included cobalt (Co), copper (Cu), manganese (Mn), nickel (Ni), uranium (U) and iron (Fe).

Figure 4.8 also illustrates the trends in consecutive leach extraction steps and clearly shows that most leaching occurred within the first cycle. This was true for the majority of the elements; the only exception was calcium which showed a slight increasing trend in concentration for consecutive extraction steps. The reason is that for each consecutive step the sulphate concentration decreased and hence the calcium solubility (dissolution of gypsum) increased.

Furthermore, one of the two tailings samples had a measurable neutralising capacity and the final step leachate pH increased to between 5 and 7 (sample ODXH4.1-04). The other sample (ODXH3.2-05) had no detectable neutralising capacity and the final leachate pH value was between 3 and 4. The results indicated that the fraction uranium leached under acidic conditions was more than twice that leached at near-neutral conditions. Uranium concentrations for acidic conditions were about three times that detected for near neutral pH conditions. Note that the decrease in concentration for consecutive extractions also suggest that the solution concentrations are likely not limited by solubility constraints (assuming there are no kinetic constraints limiting the rate of dissolution).

Other minor or trace elements that showed a similar degree of increased leachability for acidic conditions included beryllium (Be), copper (Cu), selenium (Se), thorium (Th) and yttrium (Y) (see Appendix 5). Leachability of zinc was similar for acidic and near-neutral conditions which is consistent with the geochemical behaviour of zinc. (Zinc hydrolyses only at a relatively high pH and so is soluble over a greater pH range than many other metals.) Other minor and trace elements that behaved similar to zinc include boron (B) barium (Ba), cobalt (Co) and lithium (Li). Of these, barium concentrations are solubility limited (by $BaSO_4$) as discussed later.

In summary, the observed leaching behaviour for acidic conditions appeared unaffected by oxygenated or anoxic conditions. Whilst the expectation was that the leachability of some elements would increase under anoxic conditions, oxygen was not completely depleted from the tests and reducing conditions did not develop (redox conditions remained approximately the same between the two test conditions). Nevertheless the results do show that most of the readily soluble elements are depleted rapidly from the tailings samples and similar behaviour would be expected for the tailings that remain oxygenated.

Table 4.7: Summary of Leach Extraction Results for Anoxic and Atmospheric Conditions

Sample	Atm.	Stage	pH	Al	As	Ce	Co	Cu	Mn	Ni	Th	U	SO_4	Cl	Ca	Mg	Na	K	Fe
				mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
3.2_05	N_2(g)	1	3.2	700	0.039	49.4	4.65	35.8	11.1	0.455	0.35	14.2	4170	306	437	45	293	37	579
		2	3.4	204	0.018	16.1	1.44	11.9	3.35	0.135	0.092	4.1	2240	89	525	15	91	16	170
		3	3.8	57.6	0.01	7.43	0.379	4.62	0.864	0.034	0.03	1.0	1610	18	577	4	21	7	38.5
	Air	1	3.2	719	0.036	60.6	4.74	56	10.6	0.475	0.393	15.0	4370	357	444	45	310	34	580
		2	3.6	176	0.018	18.8	1.33	28.9	2.86	0.133	0.104	4.2	2180	87	522	14	89	13	168
		3	3.6	40.7	0.01	8.5	0.426	18.1	0.769	0.04	0.035	1.1	1680	25	577	4	24	6	30.4
4.1_04	N_2(g)	1	7.1	292	0.038	40	8.76	0.016	16	0.73	0.002	4.6	7080	453	471	359	374	25	1620
		2	8.0	11.5	0.006	0.389	1.95	<0.001	8.13	0.128	<0.001	0.45	2640	103	569	167	99	11	240
		3	7.3	0.29	0.001	0.005	0.093	<0.001	1.65	0.01	<0.001	0.65	1640	25	590	91	27	6	0.1
	Air	1	7.8	397	0.026	37.5	8.93	0.015	15.6	0.792	0.002	5.3	5850	434	475	370	362	18	1220
		2	7.1	16.2	0.003	0.119	1.64	0.034	7.2	0.14	<0.001	0.18	2170	85	562	215	84	8	0.19
		3	6.2	0.63	0.002	0.003	0.225	<0.001	1.9	0.013	<0.001	0.20	1700	30	594	100	29	5	0.18

Table 4.8: Calculated Cumulative Solute Release

Sample	Condition	Week	Al	As	Ce	Co	Cu	Mn	Ni	Th	U	SO_4	Cl	Ca	Mg	Na	K	Fe
			mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
3.2_05	N_2(g)	1	1400	0.08	99	9.3	72	22.2	0.9	0.700	28.4	8340	612	874	90	586	74	1158
		2	408	0.04	32	2.9	24	6.7	0.3	0.184	8.2	4480	178	1050	30	182	32	340
		3	115	0.02	15	0.8	9.2	1.7	0.1	0.060	1.9	3220	36	1154	8	42	14	77
	Cumulative		1923	0.13	146	12.9	105	30.6	1.2	0.944	38.5	16040	826	3078	128	810	120	1575
	Air	1	1438	0.072	121	9.5	112	21.2	1.0	0.786	30.0	8740	714	888	90	620	68	1160
		2	352	0.036	38	2.7	58	5.7	0.3	0.208	8.3	4360	174	1044	28	178	26	336
		3	81.4	0.02	17	0.9	36	1.5	0.1	0.070	2.1	3360	50	1154	8	48	12	61
	Cumulative		1871	0.128	176	13	206	28.5	1.3	1.064	40.5	16460	938	3086	126	846	106	1557
4.1_04	N_2(g)	1	584	0.076	80	17.5	0.032	32	1.5	0.004	9.1	14160	906	942	718	748	50	3240
		2	23	0.012	0.78	3.9	< DL	16	0.3	< DL	0.9	5280	206	1138	334	198	22	480
		3	0.58	0.002	0.01	0.2	< DL	3.3	0.0	< DL	1.3	3280	50	1180	182	54	12	0.2
	Cumulative		608	0.09	81	22	0.032	52	1.7	0.004	11.3	22720	1162	3260	1234	1000	84	3720.2
	Air	1	794	0.052	75	17.9	0.030	31	1.6	0.004	10.7	11700	868	950	740	724	36	2440
		2	32	0.006	0.24	3.3	0.068	14	0.3	<DL	0.4	4340	170	1124	430	168	16	0.38
		3	1.3	0.004	0.01	0.5	<DL	3.8	0.0	<DL	0.4	3400	60	1188	200	58	10	0.36
	Cumulative		828	0.062	75	21.6	0.098	49	1.9	0.004	11.4	19440	1098	3262	1370	950	62	2441

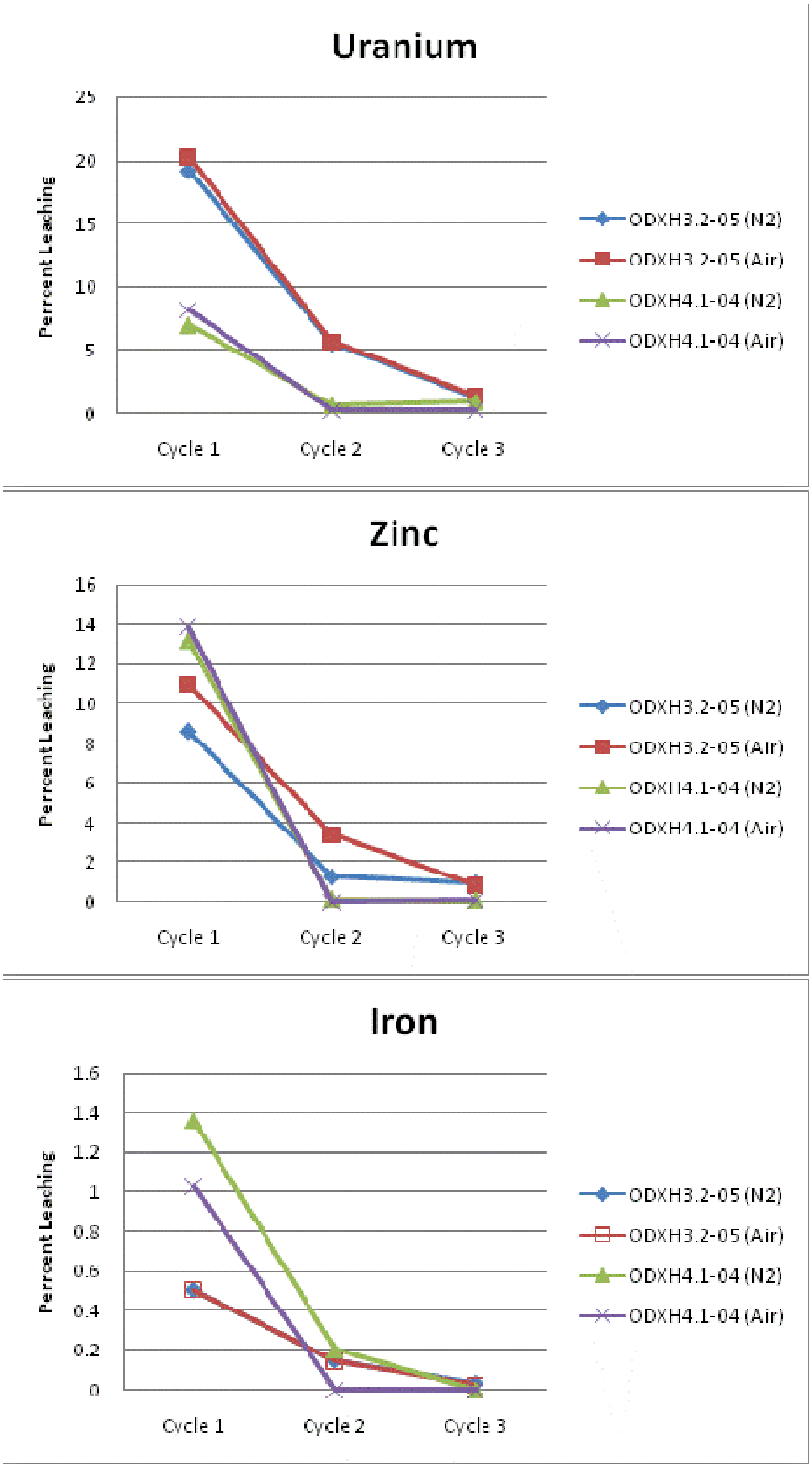


Figure 4.8: Percentage of uranium, zinc and iron leached during three cycles of leaching with de-ionised water

4.7.2 Column Leach Tests

The primary objectives of the saturated and unsaturated column tests were to determine solute release rates from the tailings and to establish the release mechanisms or controls (i.e. either oxidation or dissolution). The column test results are provided in Appendix 5, and plots illustrating leaching trends are provided in Appendix 7. Calculated contaminant release rates are summarised in Table 4.9. Cumulative solute releases through all cycles are summarised in Table 4.10.

Both the unsaturated and saturated column tests showed similar concentration profiles. At the onset of the tests concentrations were elevated and decreased thereafter tending toward steady state concentrations. Most of the elements being released at elevated rates (determined for conditions approaching steady state) are major elements and salts and included Ca, Mg, Na, K, Si, Fe, SO_4, and Cl. The concentrations of several of these elements are believed to be controlled by the solubility. For example, Ca and SO_4 concentrations are consistent with the solubility of gypsum. Unfortunately this means that the sulphate release rate cannot be used to calculate the rate of oxidation of any residual sulphides present in the tailings since incremental sulphate release would render the anticipated low rate of release from oxidation undistinguishable.

Minor or trace element being released at rates in excess of 1 mg/kg/week included Cu, Mn and Sr. Radium (Ra-226) activity was below the detection limit of 0.0001 Bq/mL for most samples. The second and third leach cycles from sample ODXH 3.2-05 were at 0.0004 Bq/mL (0.4 Bq/L) .

Element release rates that show some evidence of a positive correlation with the acidity of the leachate include: Al and Fe (majors) and As, Co, Cu, Pb, Ni, U and Zn (minor/trace). Such a trend is probably due to the change in solubility of source minerals under changing pH conditions (mineral solubility controls are discussed further in the next section, Section 4.8).

The release rates calculated for the saturated columns are often greater than those calculated in the case of the equivalent unsaturated column. There are two possible explanations:

- The saturated columns are closed systems with respect to gas – thus dissolved gases are present at fixed concentrations (no exchange with a contacting gas phase is possible). Consequently, dissolved oxygen and carbon dioxide levels in these columns may differ significantly from those of the unsaturated columns (the latter being open to exchange with the atmosphere). Thus the differing release rate may reflect a difference in element solubility with respect to key dissolved gas components.
- In the unsaturated columns, infiltrating water passes through a tailings thickness of between 2 and 3 cm. However, in the saturated columns the flowpaths are between 30 and 50 cm long; there is therefore a longer contact time between the infiltrating water and the solids resulting more complete dissolution and concentrations closer to equilibrium conditions. This explanation would apply only for those elements that are entering solution as a result of release from a slowly dissolving host phase.

Cumulative quantities of solute released from the two saturated columns for the more mobile solutes (e.g. Cl, Na, Mg) suggests that only about half the solute release (on a weight per weight tailings sample) occurred when compared to the release from the oxygenated tests, even though the same number of pore volumes had been displaced. In contrast, when compared to the unsaturated column test for the same sample, the oxygenated saturated column release was about 65 % for half the number of pore volume displacements. This suggests that flow through the anoxic saturated column may have been short circuiting along selective flowpaths or around the sample between the column walls and the tailings. When the cumulative release from the column tests are compared to those achieved in the three stage leach extraction tests (see Table 4.8) about 80 to 95 % of the solute release is achieved in three stages of leach extraction.

Table 4.9: Average Steady State Release Rates for Selected Contaminants

Element	Units	Unsaturated columns (21 cycles)			Saturated Columns (10 cycles)	
		H3.2-05 Air-equilibrated water	H4.1-04 Air-equilibrated water	H3.2-01 Air-equilibrated water	H3.2-01 Air-equilibrated water	H3.2-01 Deoxygenated water
Cycles used to calculate average release rates						
Start		9	9	15[1]	6	6
Finish		21	21	21	10	10
pH range for ‘average’ leachate		3.9-4.2	6.4-6.8	7.2-7.4	7.5-8	8.2-8.5
Acidity	mgCaCO$_3$/kg/wk	29	4	3.474	4.53	1.74
Alkalinity	mgCaCO$_3$/kg/wk	n/a	10.45	36	28	20
Sulphate	mg/kg/wk	511	509	360	456	610
Chloride	mg/kg/wk	6.64	8	20	106	31
Al	mg/kg/wk	0.64	0.099	0	0.12	0
Sb	mg/kg/wk	< DL	< DL	0.0003	< DL	< DL
As	mg/kg/wk	0.011	< DL	0.0006	< DL	< DL
Ba	mg/kg/wk	0.010	0.009	0.01	0.006	0.009
B	mg/kg/wk	0.064	< DL	0.14	0.37	0.27
Cd	mg/kg/wk	0.0002	0.0004	< DL	0.0007	0.0002
Ca	mg/kg/wk	208	200	154	185	260
Co	mg/kg/wk	0.16	0.039	0.0145	0.057	0.066
Cu	mg/kg/wk	6.50	0.008	0.087	0.15	0.060
Fe	mg/kg/wk	1.74	0.17	< DL	0.026	< DL
Pb	mg/kg/wk	0.002	0.0005	< DL	< DL	< DL
Li	mg/kg/wk	0.003	0.006	0.0226	0.050	0.034
Mg	mg/kg/wk	0.2	11.16	5.95	16.26	6.35
Mn	mg/kg/wk	0.008	0.091	0.424	1.72	1.77
Mo	mg/kg/wk	< DL	0.004	0.116	0.08	0.12
Ni	mg/kg/wk	0.006	0.0014	< DL	< DL	< DL
K	mg/kg/wk	2.60	1.47	4.24	5.19	5.20
Se	mg/kg/wk	0.0051	< DL	< DL	< DL	< DL
Si	mg/kg/wk	8.91	5.02	2.09	2	3
Na	mg/kg/wk	1	1.40	2.15	30.64	4.62
Sr	mg/kg/wk	0.39	0.32	1.42	1.59	1.60
U	mg/kg/wk	0.074	0.027	0.213	0.56	0.54
Zn	mg/kg/wk	0.008	< DL	0.004	0.023	< DL

Notes:

1. A shorter stable period was assumed for this column due to the apparent short-term depletion of an Fe-bearing phase (see Appendix 7)
2. Elements that were consistently below the limits of detection in the longer term leachates were: Ag, Be, Bi, Cr, Hg, P, Se, Sn, Ti. Tl, V, Zr
3. n/a – not available; <DL indicates concentrations below detection for the period shown

Table 4.10: Cumulative Release for Selected Contaminants

		Unsaturated columns (21 cycles)			Saturated Columns (10 cycles)	
		H3.2-05	H4.1-04	H3.2-01	H3.2-01	H3.2-01
Element	Units	Air-equilibrated water	Air-equilibrated water	Air-equilibrated water	Air-equilibrated water	Deoxygenated water
pH range for 'average' leachate		3.9-4.2	6.4-6.8	7.2-7.4	7.5-8	8.2-8.5
Pore Volumes displaced		20	19	21	10	10
Acidity	$mgCaCO_3/kg$	9132	15794	37	24	10
Alkalinity	$mgCaCO_3/kg$	8	129	753	490	454
Sulphate	mg/kg	20002	26839	20405	13118	6376
Chloride	mg/kg	1016	714	7758	6702	3309
Al	mg/kg	2301	940	0.41	0.62	0.28
Sb	mg/kg	0.020	0.019	0.022	0.008	0.010
As	mg/kg	0.296	0.080	0.032	0.019	0.023
Ba	mg/kg	0.892	0.937	8.2	5.8	7.6
B	mg/kg	0.620	0.626	3.8	4.4	2.7
Cd	mg/kg	0.015	0.013	0.008	0.003	0.005
Ca	mg/kg	4399	4093	3881	2054	2834
Co	mg/kg	15	24	0.38	0.44	0.66
Cu	mg/kg	321	0.26	2.23	1.34	1.03
Fe	mg/kg	1448	3927	2.32	0.53	0.55
Pb	mg/kg	0.12	0.024	0.019	0.007	0.007
Li	mg/kg	3.30	3.31	1.80	1.44	1.62
Mg	mg/kg	143	1443	1731	1228	743
Mn	mg/kg	30	85	11	12	17
Mo	mg/kg	0.019	0.058	3.3	1.8	2.4
Ni	mg/kg	1.3	2.1	0.022	0.010	0.020
K	mg/kg	120	31	347	237	204
Se	mg/kg	0.31	0.29	0.25	0.16	0.18
Si	mg/kg	241	124	44	22	26
Na	mg/kg	913	1306	8617	5705	3534
Sr	mg/kg	13	10	40	19	23
U	mg/kg	48	21	21	16	19
Zn	mg/kg	5.4	7.8	0.11	0.38	0.15

The delayed washout observed for both the unsaturated and saturated column tests indicate that while there is an approximate halving of concentrations for each consecutive pore volume displaced for the more mobile solutes (e.g. Cl, Na, Mg) it would take two to three pore volume displacements before most of the stored solutes would be 'flushed' from the tailings. Furthermore, whereas the concentrations of the more mobile solutes would continue to decrease, the solutes that that are subject to solubility controls would tend to remain constant over time (e.g. SO_4 after the more soluble phases such as $MgSO_4$ had be flushed from the tailings). The effects of pH controls on the solubility of the solutes are also evident when the results for tests completed on H3.2-05 are compared to the results obtained for H4.1-054 and H3.2-01 respectively.

4.8 Possible Solubility Controls

Geochemical modelling (PHREEQC) was undertaken to examine the porewater and leachate chemistries in more detail. Iron and aluminium are the main cationic components of the tailings porewaters. Figure 4.9 and Figure 4.10 show activity diagrams for these elements. Plotted onto the diagrams are the calculated activities of Al^{3+} and Fe^{3+} ions in tailings porewaters and various tailings leach solutions. The results for acidic porewaters and a small number of the leach solutions show some scatter and coincide with several of the phases shown on the diagrams. This scatter suggests that solubility is likely controlled by one or more hydroxysulphate phase, e.g. jurbanite, alunite, jarosite. At near-neutral and alkaline pH values, the solubility controls are more likely to be oxyhydroxide phases, such as boehmite or diaspore (Al), and ferrihydrite (Fe).

Figure 4.11 shows a uranyl (UO_2^{2+}) activity diagram. At an acidic pH, uranium solubility is consistent with either uranyl sulphate phases, or hydrated silicates such as soddyite [$(UO_2)_2SiO_4{:}2H_2O$] and haiweeite [$Ca(UO_2)_2(Si_2O_5)_3{:}5H_2O$]. At near-neutral or alkaline pH values the results are located between the stability lines for soddyite or uranyl hydroxides (schoepite); either mineral is a possibility. The displacement of the data points relative the theoretical lines could be due to the fact that the thermodynamic data used to calculate the theoretical lines were derived for pure, crystalline phases. The phases forming in the tests may be impure, or less crystalline.

Sulphates and analogous phases are likely to play an important role in controlling the solubility of not only the major elements, but also a range of minor and trace elements. The calculated saturation index (S.I.) of a mineral is a useful indicator of the thermodynamic stability of the mineral phase with respect to the solution chemistry in question:

- S.I. > 0 - the mineral is supersaturated. Unless kinetically inhibited, it might be expected that the mineral would precipitate.
- S.I. < 0 - the mineral is under-saturated. If the mineral is present within solid material contacting this solution, then it might be expected to dissolve from the solid in order to attain equilibrium.
- S.I. ≈ 0 - the solid is close to equilibrium with the solution.

Note however that the ionic strengths of the porewater solutions are very high, and ideally PITZER simulations should be undertaken to estimate equilibrium conditions. The available PITZER thermodynamic database however is very limited and precludes a detailed assessment of the equilibrated solutions.

The following minerals and mineral groups were found to be either close to equilibrium, or supersaturated in tailings porewater and leachate:

- Gypsum ($CaSO_4{:}2H_2O$) – gypsum tended to be supersatured in tailings porewater and close to equilibrium in leachate solutions.
- Barite ($BaSO_4$) and celestite ($SrSO_4$) – barite tended to be supersaturated whilst celestite was close to equilibrium in both porewater and leachate.
- Molybdates, arsenates, chromates and uranates.

In the case of sample ODXH3.2-01, metal-bearing carbonates and hydrated carbonates comprising malachite ($Cu_2CO_3(OH)_2$), rhodocrosite ($MnCO_3$) were indicated. As noted before in Section 4.1, this sample was obtained from a drill hole located adjacent the internal berms within the TSF and that it likely had been contaminated with dolomite. The metal bearing carbonates would have resulted from the reaction between the tailings porewater and the dolomite.

Residues from the columns were evaluated using optical microscopy to determine whether the solubility controls were due to dissolution of existing minerals present in the starting materials, or due to precipitation of secondary minerals during the tests.

In the case of sample ODXH3.2-01, occasional coatings of malachite/azurite were observed in the column residues, which confirmed the conclusions from the calculated saturation indices. These results may also be used to infer the potential secondary minerals that may form when the seepage from the tailings contact underlying calcareous soils and sediments.

No other conclusive evidence of dissolution or precipitation textures was found. Likely the scale of reaction was not sufficiently large to be detectable by using either optical or scanning electron microscopy. Full details of the microscopic investigations are included in Appendix 5.

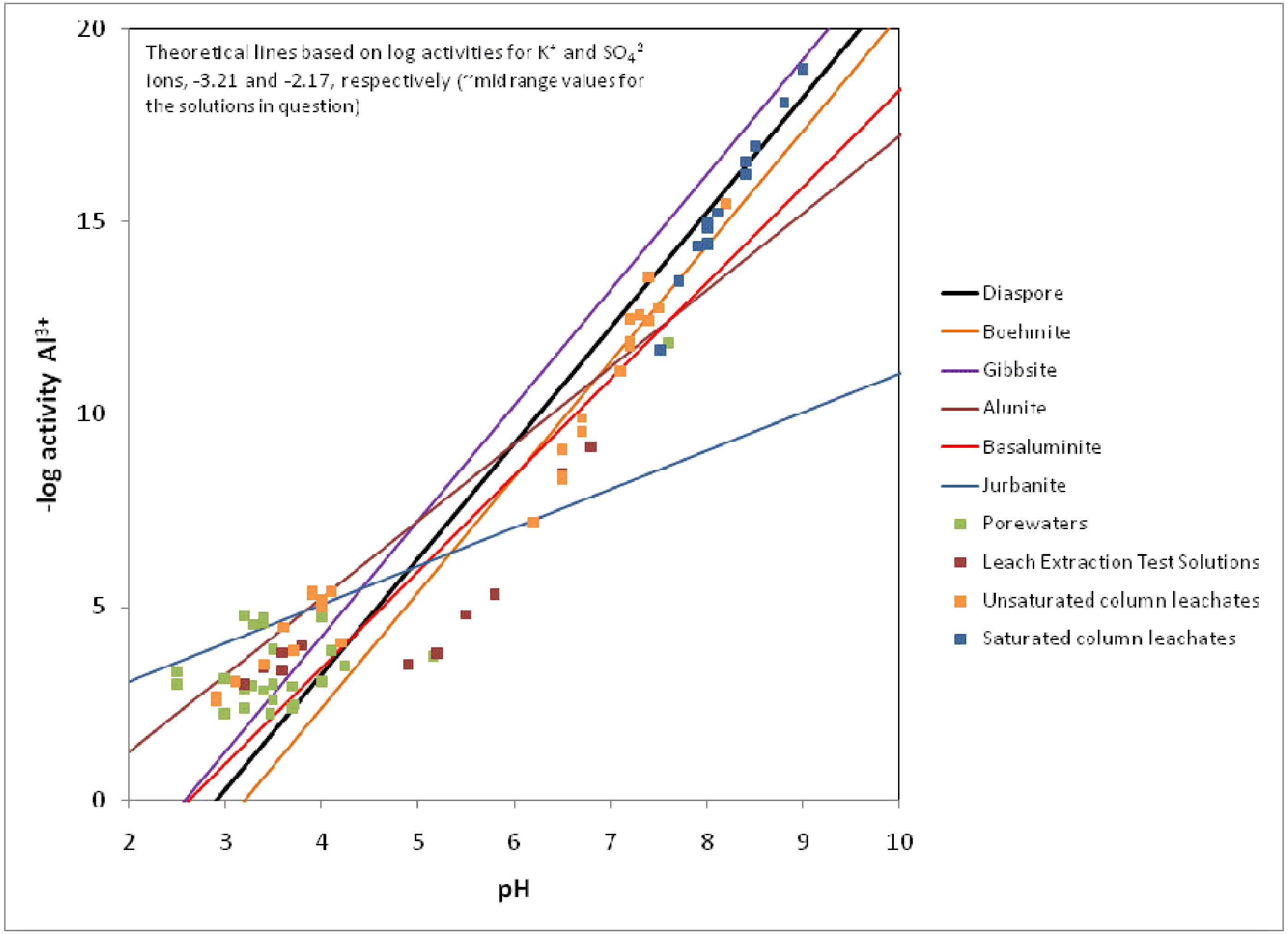
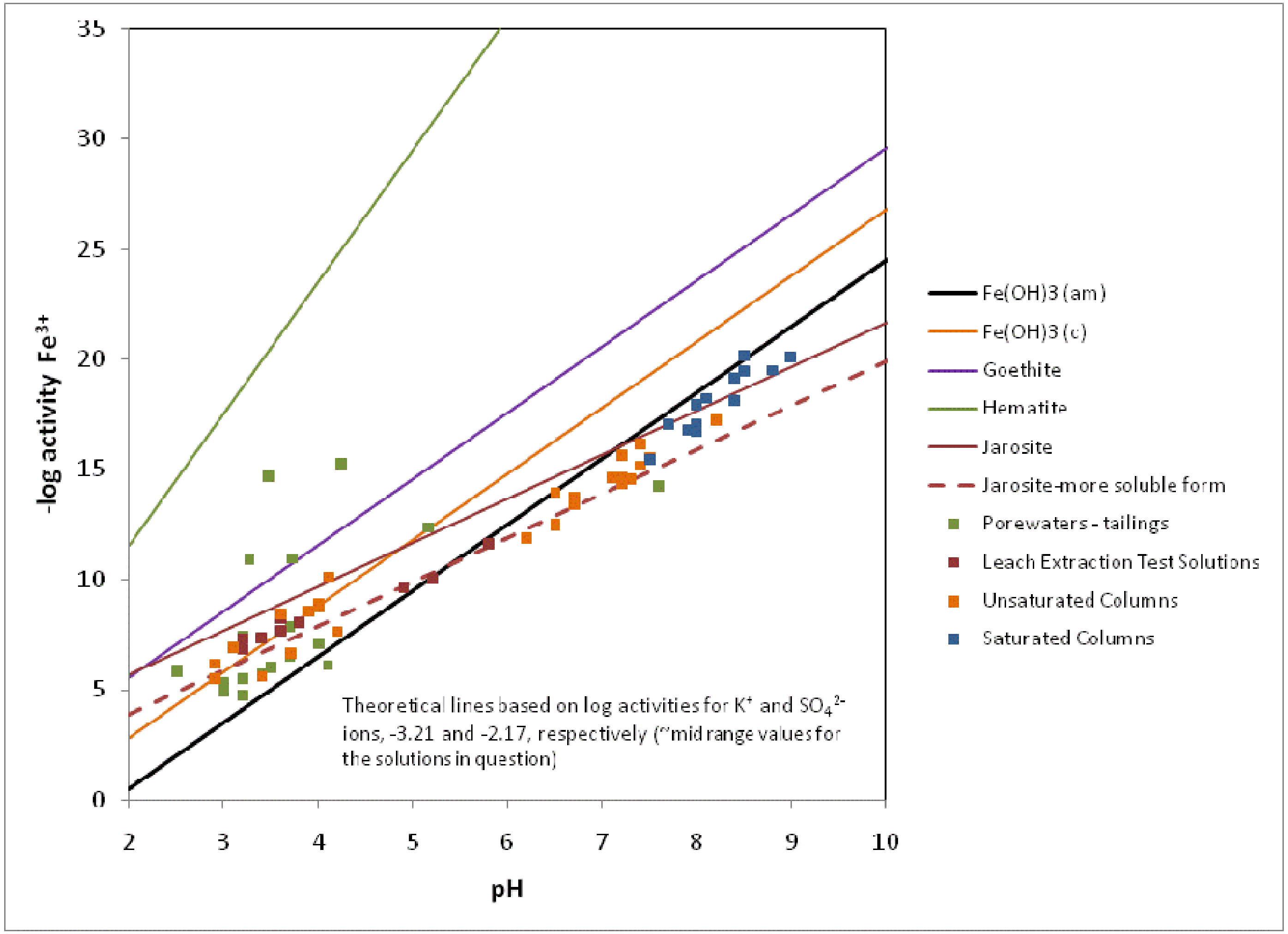


Figure 4.9: Aluminium activity diagram showing the calculated activities of tailings porewater and leach solutions. Also shown are the theoretical equilibrium lines for a range of minerals



Theoretical lines based on log activities for K^+ and SO_4^{2-} ions, -3.21 and -2.17, respectively (~mid range values for the solutions in question)

Figure 4.10: Iron activity diagram showing the calculated activities of tailings porewater and leach solutions Also shown are the theoretical equilibrium lines for a range of minerals

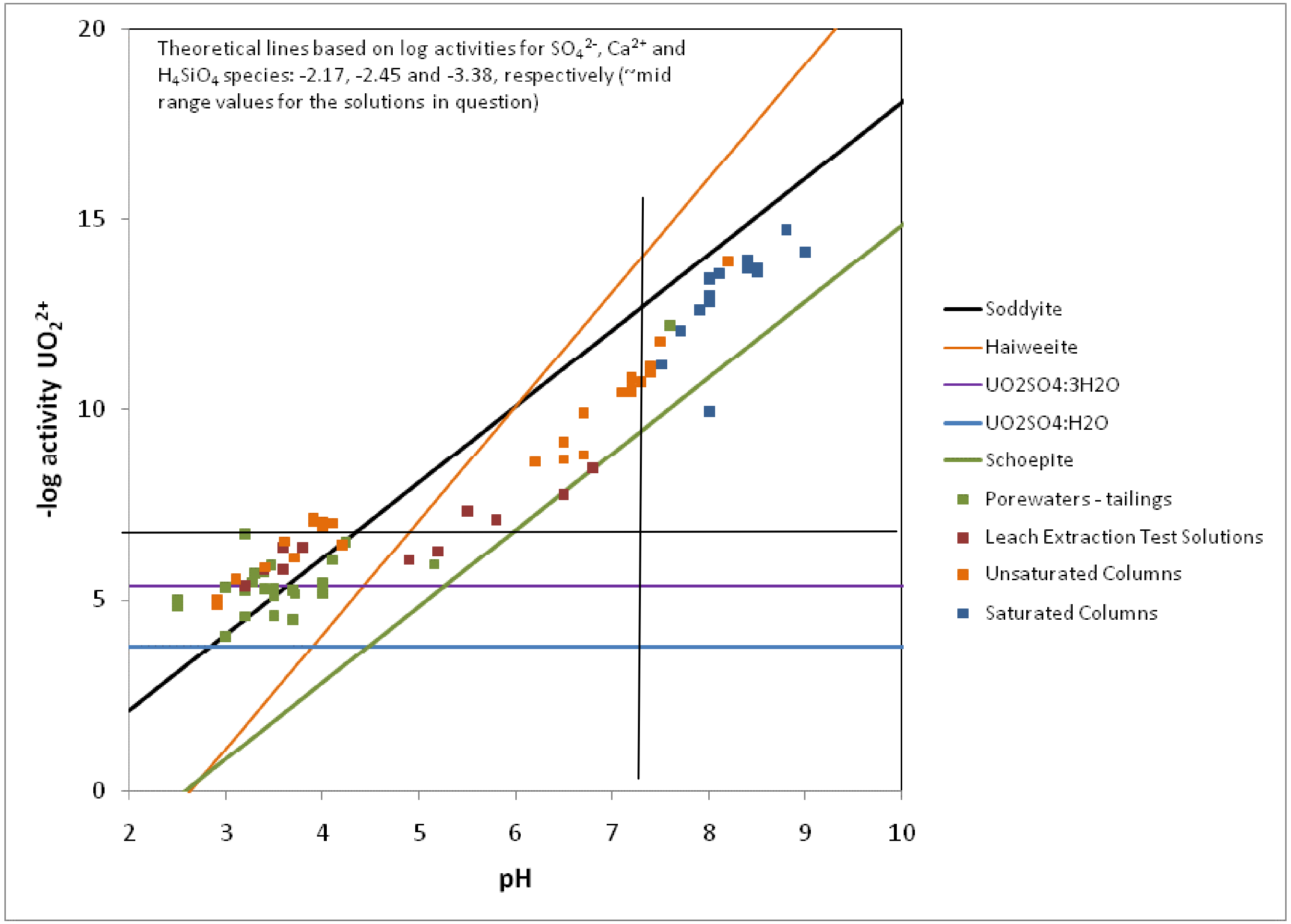


Figure 4.11: Uranyl (UO_2^{2+}) activity diagram showing the calculated activities of tailings porewater and leach solutions Also shown are the theoretical equilibrium lines for a range of minerals

5 Underlying Sediments: Results and Discussion

The near-surface sediment at Olympic Dam comprises unconsolidated Cainozoic sands and clays, predominantly sandy, but containing some discontinuous lenses of clay of varying thickness. The average thickness of the near-surface sediments is around 10 metres.

Previous studies (ENSR, 2008 and references therein) have identified the following soil and sediment types:

- Topsoil/dune sand consisting of fine to medium grained orange brown sand / silty sand;
- Calcareous soils consisting of clayey sand fine to medium grained, fines of medium plasticity, and variable amounts of fine to coarse grained gravel (typically calcareous sandstone);
- Sand / silty sand, fine to medium grained weakly cemented and grading to gravely sand in places.
- Silty Clay /clayey silt, high liquid limit, with inclusions of gypsum crystals.

For the current programme of work, sediments have been sampled from within the TSF footprint, and also at some distance to the east/northeast within the footprint of the proposed location for a possible waste rock storage facility (RSF). In the descriptions given below, the sampling location is indicated as appropriate.

5.1 Mineralogy

The mineralogical assessment comprising XRD and complemented by optical microscopy showed that the sediments were quite variable but tended to be dominated by the same four minerals, in varying proportions:

- Dolomite – up to 99%(wt) in very carbonate-rich samples;
- Quartz – up to 99%(wt) in sandy samples;
- Mica/illite – up to 80%(wt) in clay-rich samples
- Gypsum – up to 50%(wt), in gypsiferous clay samples.

Other minerals identified included:

- Carbonates: calcite was present at levels up to 29%(wt) (evidence suggests that calcite is confined to shallower depths in the sediments);
- Sulphate minerals: jarosite (up to 15%(wt)) and bassanite ($CaSO_4.0.5H_2O$) (up to 9%(wt)). The latter mineral is associated with the very high gypsum samples. Barite ($BaSO_4$) was also identified by scanning electron microscopy;
- Aluminosilicates: kaolin (up to 15%(wt)), minor K-feldspar (<1%(wt));
- Oxides: hematite (Fe_2O_3) (up to 2%(wt)). Ilmenite ($FeTiO_3$) was identified by scanning electron microscopy, as was a Cu/Fe mineral tentatively identified as delafossite ($CuFeO_2$).

5.2 Bulk Chemistry

Selected results from elemental analyses of sediment samples are summarised in Table 5.1. The results for sediments sampled from below the existing TSF (TSF sediments) and from the footprint of the proposed RSF (RSF sediments) are shown separately. Global abundance indices were calculated to determine which elements were present at levels significantly greater than the average abundance of the earths' 'crust'. Elements that were enriched relative to average crustal abundances (in at least some of the samples) included arsenic, boron, bismuth, carbon, copper, radium-226, rhenium, selenium, sulphur, tungsten and uranium.

A comparison of the results for the TSF sediments with those for the RSF sediments indicates that the occurrence of element enrichment is greater in the case of the TSF sediments. For some elements the maximum concentrations are also considerably greater in the TSF sediments than for the RSF sediment. For example, copper, radium-226 and uranium maximum concentrations in the TSF sediments are more than ten times those measured in the RSF sediment. To illustrate this point, Figure 5.1 compares the median and maximum concentrations for uranium in the TSF and RSF sediments. Invariably the maximum element concentration is coincident with sediment sampled at or immediately below the tailings interface, i.e. the high concentration can be taken as indicative of the effect of seepage from the TSF. The results further indicate that the solutes are being attenuated in the sediments immediately below the TSF. Seepage of tailings percolate into underlying sediments is discussed further in Section 8.2.2.

Table 5.1: Selected results from elemental analyses of sediments

		TSF Sediments						RSF Sediments					
Element	Units	Min	P5	P50	P95	Max	Fraction of samples GAI >3[See Notes]	Min	P5	P50	P95	Max	Fraction of samples GAI >3[See Notes]
Ag	ppm	0.02	0.03	0.09	0.32	0.34	0%	0.03	0.03	0.05	0.12	0.41	0%
As	ppm	2.2	3.2	8.0	**25**	**31**	15%	1.7	2.5	4.3	**18**	**45**	9%
B	ppm	5	5	20	**90**	**120**	8%	10	10	80	**164**	**200**	44%
Ba	ppm	45	45	179	734	896	0%	45	90	90	300	717	0%
Be	ppm	0.26	0.28	0.55	3.6	5.2	0%	0.09	0.1325	0.275	2.657	4.12	0%
Bi	ppm	0.01	0.02	0.12	0.5	0.48	0%	0.05	0.1	0.5	**3.9**	**14**	41%
Cd	ppm	0.01	0.01	0.01	0.054	0.06	0%	0.01	0.01	0.02	0.14	0.21	0%
Co	ppm	3.9	4.26	17.6	56.4	67.7	0%	0.9	1.3	3.5	18.7	35.5	0%
Cr	ppm	2.0	3.8	20	38	45	0%	17	17	17	80	103	0%
Cu	ppm	8.7	12	211	**4180**	**6370**	46%	0.6	0.97	3.1	23	50	0%
Hg	ppm	0.003	0.004	0.01	0.03	0.03	0%	0.003	0.003	0.005	0.03	0.06	0%
Li	ppm	1.9	3.46	11.2	28.86	29.4	0%	1.3	1.4	6.5	44	81	0%
Mn	ppm	39	52.2	111	896.8	1210	0%	24	29	588	1322	1850	0%
Mo	ppm	0.17	0.344	0.79	4.37	6.44	0%	0.36	0.5865	1.98	5.746	7.52	0%
Ni	ppm	2.8	3.28	7.7	24.64	34.3	0%	2.4	2.8	5.7	24	45	0%
Pb	ppm	2.3	2.54	4.7	42.56	87.5	0%	0.8	1.03	3.7	27	34	0%
Ra-226	Bq/g	0.01	0.01	0.03	**0.26**	**0.40**	8%	0.002	0.004	0.02	0.03	0.04	0%
Re	ppm	0.001	0.001	0.002	**0.0076**	**0.01**	15%	0.001	0.001	0.001	0.00235	0.003	0%
Sb	ppm	0.05	0.06	0.23	0.72	0.78	0%	0.06	0.07	0.28	1.3	1.9	0%
Sc	ppm	1.7	1.9	3.9	9	11	0%	0.3	0.4	2.1	11	15	0%
Se	ppm	0.5	**0.8**	**2**	**9.8**	**11**	92%	0.5	0.5	0.5	**6**	**10**	27%
Sn	ppm	0.3	0.36	1	3.3	3.6	0%	0.1	0.17	0.45	4.6	7.1	0%
Sr	ppm	25	35	107	329	396	0%						
Th	ppm	1.4	1.82	2.9	22	24	0%	0.3	0.4	2	21.6	39.9	0%
S	%	0.1	0.1	**1.8**	**3.9**	**4.0**	75%	0.005	0.005	0.01	**1.8**	**4.3**	18%
U	ppm	2	3.2	**67**	**550**	**648**	62%	0.4	0.5	1.2	7.0	10.6	0%
V	ppm	18	19.2	48	171	205	0%	3	4	27	153	197	0%
W	ppm	0.3	0.5	2.1	4.3	4.8	0%	0.4	0.565	2.8	**28**	**111**	9%
Y	ppm	5.6	5.8	48	235	257	0%	0.9	1.4	4.1	20	32	0%
Zn	ppm	11	13.4	35	134	222	0%	3	3.7	13.5	60	80	0%

Notes:

- A total of thirteen TSF sediment samples and 34 RSF sediment samples were analysed.
- Global abundance indices (GAIs) are a measure of how the measured elemental abundances compare to average ‘crustal’ abundances. Positive GAI values indicate enrichment of the element in the sample when compared to average-crustal abundances. As a general rule, a GAI value of 3 or higher indicates significant enrichment of that element.
- Values associated with GAI >=3 shown in bold

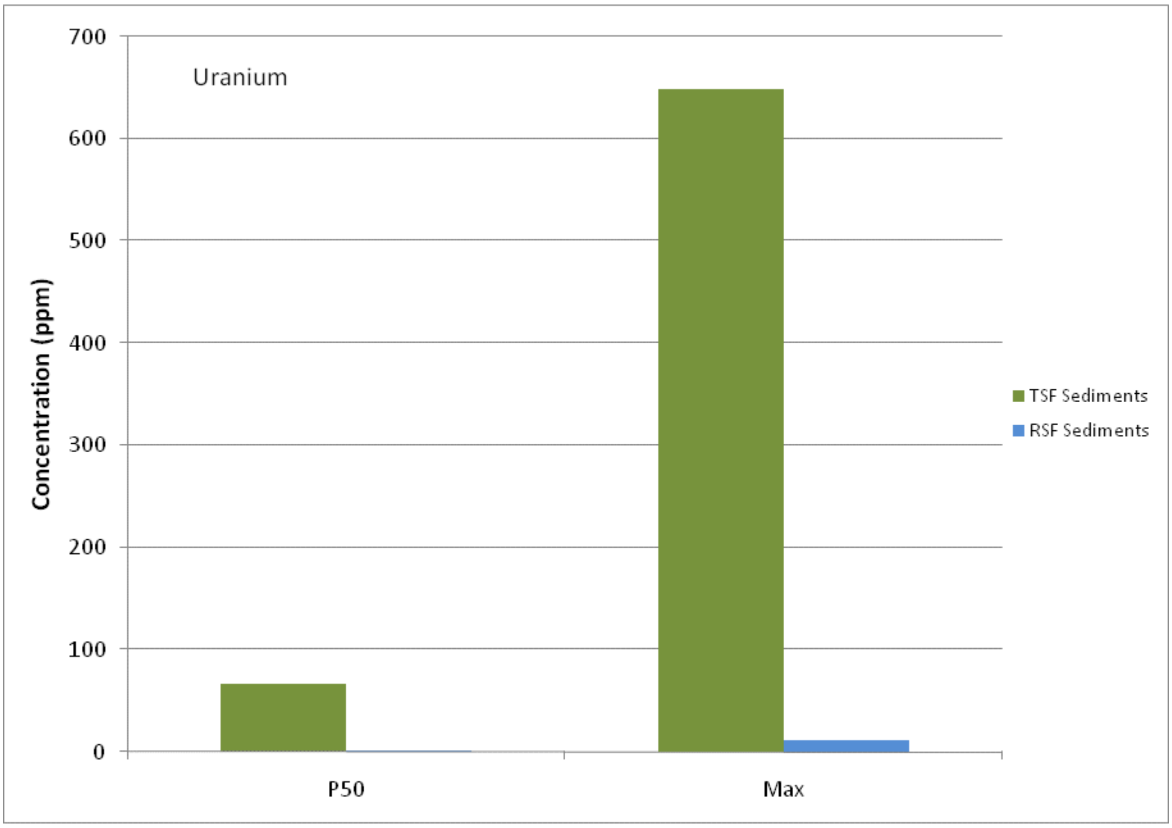


Figure 5.1: Comparison of the median and maximum uranium concentrations in TSF and RSF sediments

5.3 Metal Partitioning

Metal partitioning was examined by exposing samples of sediments to a series of leachants (chemical reagents), each more 'aggressive' than the last. The leachants were designed to target the dissolution of different mineralogical associations or components of the samples as follows:

(i) labile or water soluble,
(ii) adsorbed/exchangeable or carbonate minerals,
(iii) amorphous iron oxyhydroxide,
(iv) crystalline iron oxyhydroxide; and,
(v) residual (i.e. material remaining after treatment with the previous reagents).

Two sediment samples were tested, one sampled from directly below the interface with the tails. Table 5.2 summarises the main observations that can be made with respect to elemental partitioning in the samples.

The results indicate that the distribution of minor and trace element differs in the two samples analysed (copper and uranium are illustrated in Figure 5.2 and Figure 5.3, respectively). In the case of the sample at the interface with the tailings, the elements are distributed over several of the target components, with a significant proportion associated with the labile phase (Cu) and amorphous iron oxyhydroxide (U). In the case of the sample located away from the tails interface, much smaller concentrations of the elements are present (by up to two orders of magnitude) and most is associated with the residual phase.

Table 5.2: Metal Partitioning between Different Sediment Components

Target Component	Major Element Partitioning	Minor and trace element partitioning[1]	Probable source of the major element and possible mineral associations
Labile		**B, Co** Cd, Cu, Re, Sb, Tl	Element very weakly bound to solids or present in porewater; readily soluble salts
Adsorbed/Ion exchangeable/Carbonate	SO_4, Ca	**Hg** Be, Ce, Re, Sb, Sr, Tl, U	Elements adsorbed on mineral surfaces Elements displaced from exchange sites
Amorphous Iron Oxyhydroxide	Mg, Fe *K, Si*[2]	**Be, V, Y** Ag, B, Bi, Ce, Li, Re, Sb, Se, Th, Tl, U	Dissolution of amorphous iron oxide, possibly accompanied by a minor amount of a silicate mineral
Crystalline Iron Oxyhydroxide	Mg, *Si*[2]	**Ag, Cd, Sn** B, Bi, Ni, Re, Sb, Se, Si, Tl, Zn	Dissolution of hematite, possibly accompanied by a minor amount of a silicate mineral
Residual	Ca, Mg, SO_4, K, Fe, Al	**As, Ba, Co, Cr, Cu, Li, Mn, Mo, Ni, Pb, Sn, Ti, U, W, Y, Zn** Ce, Sr, Th, V	Aluminosilicates, insoluble sulphate (barite), phosphate?

Notes:

1. Elements given in bold show evidence of strong partitioning, i.e. more than 50% of the element was found associated with that component (in either one or both of the samples tested).
2. The relative partitioning of these elements to this component may be overestimated due to underestimation of the quantities associated with the residual phase. It was noted that the cumulative mass of K, Al and Si following the five extractions (Appendix 5) is less that would be expected based on whole rock chemical assays (Appendix 4). The analytical methods used for the residual phase did not fully account for insoluble material present, e.g. silicates.
3. A significant proportion of the Fe is associated with the residual phase. The two samples contained only between 1 and 2 %(wt) hematite. The samples contain between 20 and 30 %(wt) mica/illite. Fe present in the mica may explain the apparent portioning of Fe to the residual phase.
4. Some elements, (Na, Cl) are introduced to the test system via the reagents used – these elements are not included in the table.

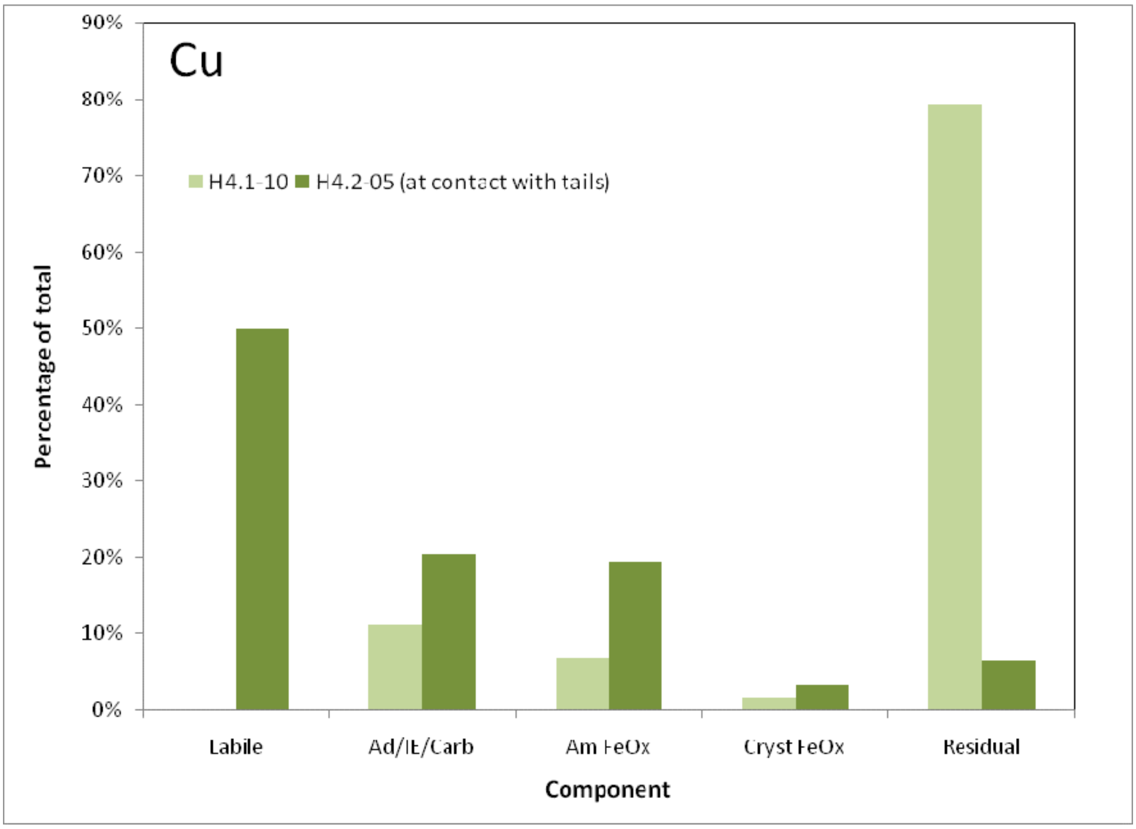


Figure 5.2: Partitioning of copper between different components in the sediments

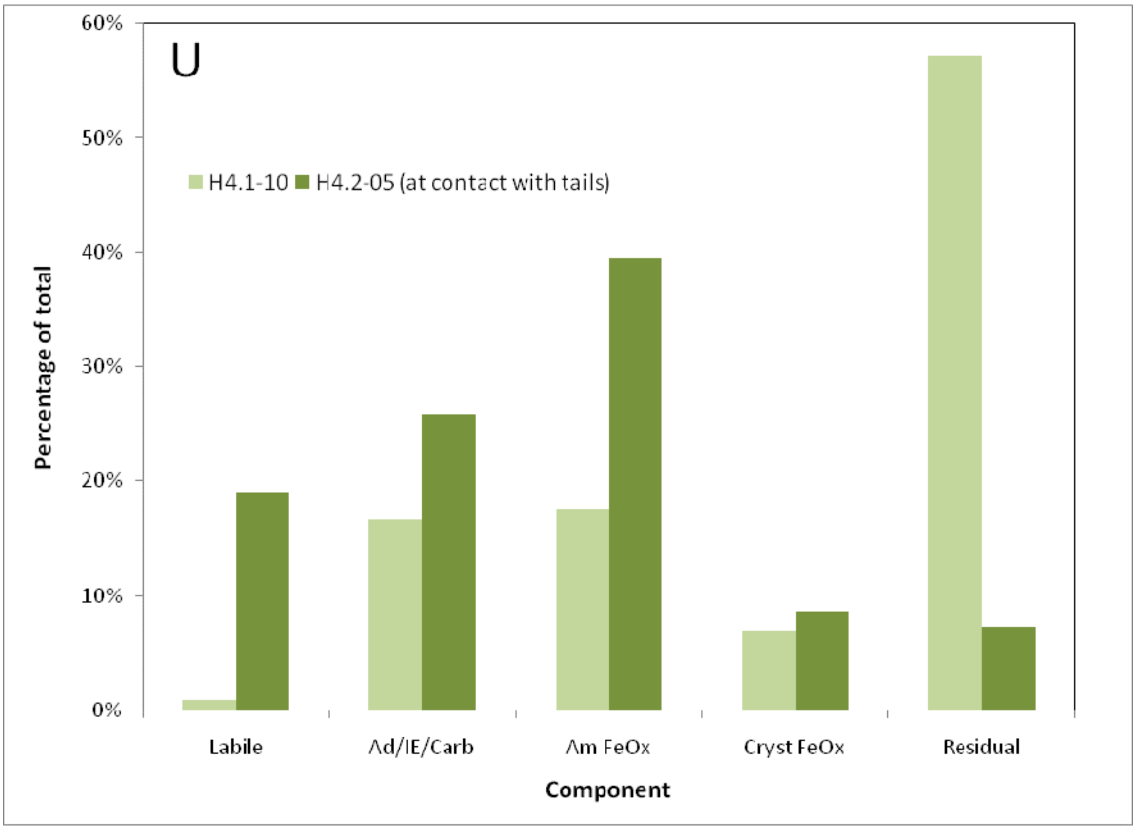


Figure 5.3: Partitioning of uranium between different components in the sediments

5.4 Acid-Base Accounting

5.4.1 Acid Potential

Sulphide minerals were not identified in the sediment samples. Generally, where significant sulphur was measured (total sulphur contents ranged up to 4%(wt)) it was present almost entirely as sulphate sulphur. Based on estimated sulphide sulphur content, the acid potential of the sediments ranges from below detection to about 8.6 kgH_2SO_4/t, with a median value of less than 1 kgH_2SO_4/t.

5.4.2 Neutralising Potential

In the current study, the acid neutralisation capacity (ANC) of the sediments ranged from < 0.5 kgH_2SO_4/t to 959 kgH_2SO_4/t. Previous studies have shown a similarly wide range of ANC values (Table 5.3).

Table 5.3: Range of ANC values measured in previous studies

Soil type	ANC range, (kg H_2SO_4/t)	ANC classification
Dune sand	2–4	low
Swale material	15–17	medium
Claypan material	9	low
Calcareous clay	139	high
Dolomite	975–1,041	high

Depletion of sediment ANC close to the tailings interface was recorded by EGi (1995 Addendum, 2007). Figure 5.4 shows a plot of ANC measurements in the current programme, as a function of depth relative to the tailings/sediment interface. Consistent with the EGi data, the samples taken from close to the tailings interface had lower ANC values.

Using results from the current study, Figure 5.5 compares the measured ANC values with the carbonate equivalent neutralisation capacity (CarbNP) estimated from the total carbon content. The majority of the results fall along the equivalence line, suggesting that total carbon content can be used with some confidence to estimate the neutralising capacity of the materials.

As shown in Figure 5.5, the majority of the results form two clusters as follows:

- One cluster is located at high neutralising capacities and corresponds to samples with high carbonate contents.
- The other cluster is located near the origin (low ANC) and corresponds to sandy or clay-rich samples.

Some results do not fall within the aforementioned clusters, and do not plot along the equivalence line. Some of these results plot below the equivalence line, and even along the x-axis, showing significant ANC that was not attributable to carbonate mineralogy. These samples likely contain aluminosilicate phase(s) that are reactive under the conditions of the ANC measurement but may not necessarily be reactive under expected field conditions (many aluminosilicates are known to react slowly). Thus the ANC measurement could overestimate the readily available neutralising capacity.

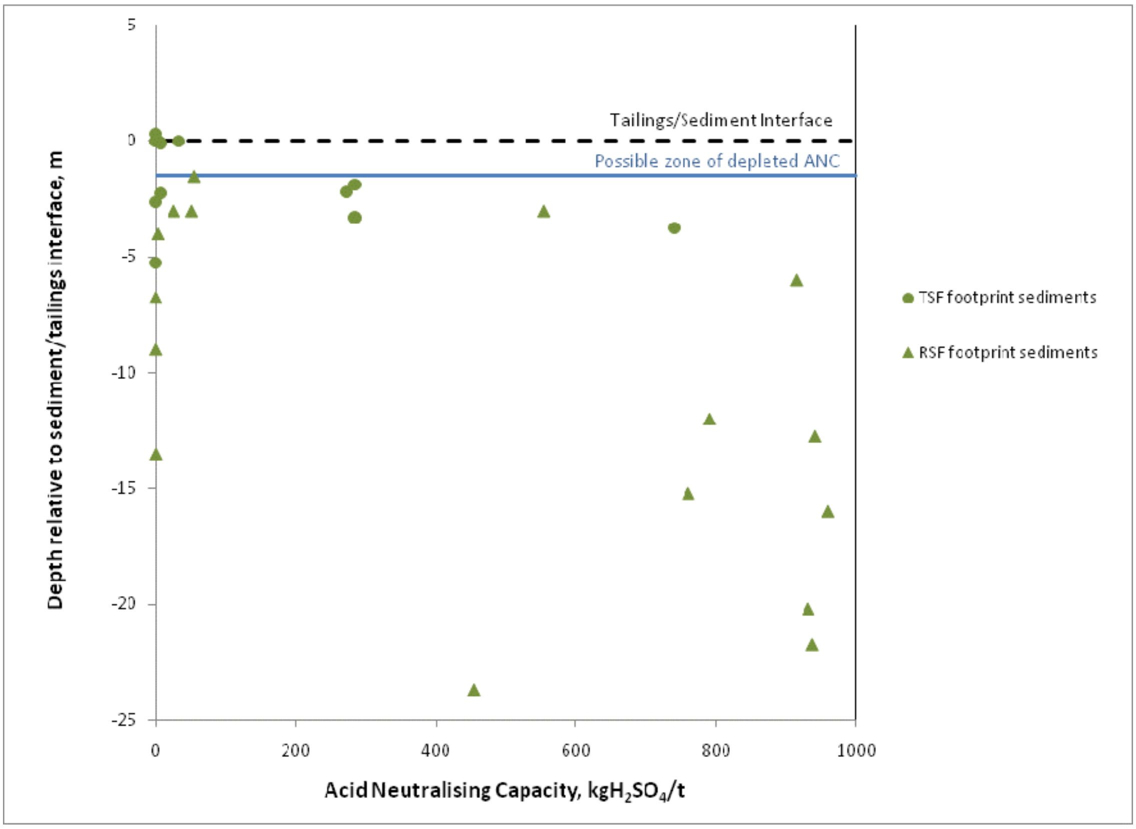


Figure 5.4: Acid neutralising capacity plotted as a function of depth

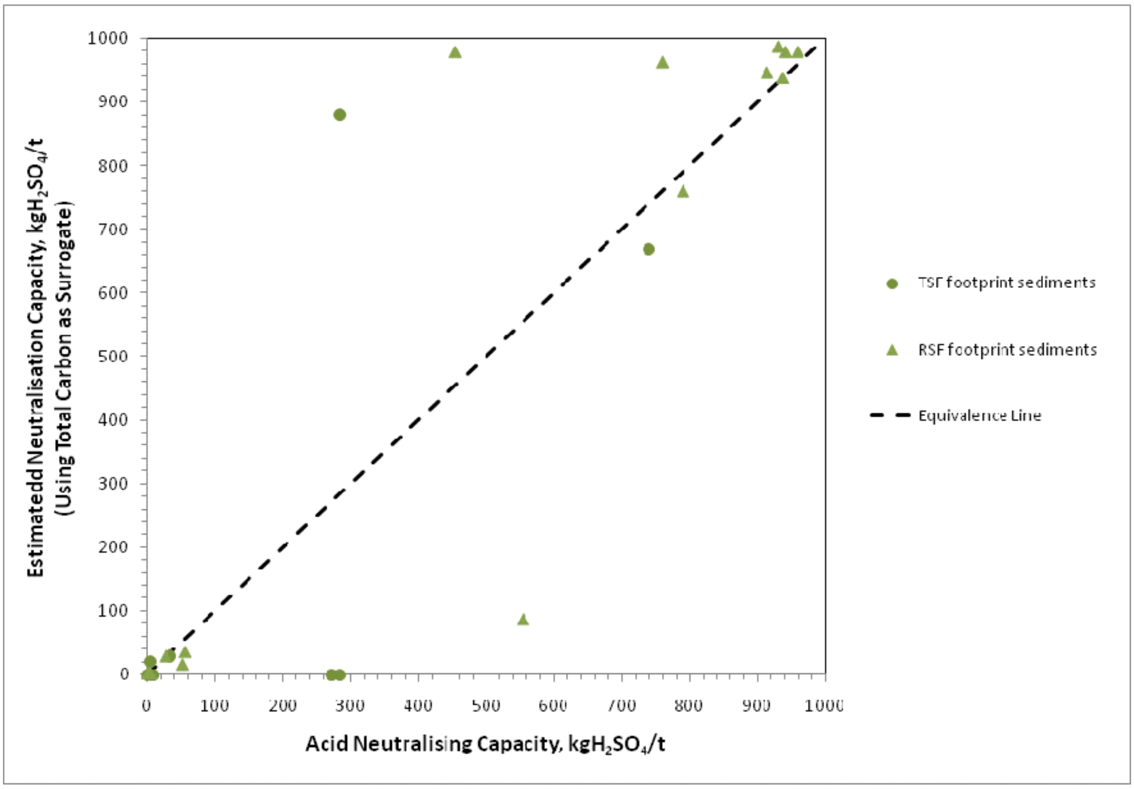


Figure 5.5: Comparison of measured and calculated acid neutralisation capacity

There are also a number of results that plot above the equivalence line, indicating that not all of the CarbNP may be readily available to react and neutralise acidity. Possible explanations for this observation are that:

- some carbonate minerals are present that do not contribute to acid neutralising, e.g. siderite or ankerite;
- reaction products formed during the test procedure may be coating or otherwise interfering with the reactivity of the carbonate minerals; or
- reaction rate of some of the carbonate minerals may be kinetically limited.

The first explanation is in conflict with the mineralogical results (Section 5.1) which indicated that the carbonate is predominantly dolomite. The second possibility requires the presence of a mineral that reacts with the acidic reagent used in the test (hydrochloric acid) to release elements that then precipitate to form secondary minerals that may coat the carbonates. Phases such as jarosite and alunite could form under acidic conditions but would generally require an increase in sulphate concentrations. However, it is difficult to infer phases that might be expected to precipitate under such conditions.

The third explanation may be more likely, but is unexpected given that dolomite would be expected to readily react under the conditions of the ANC method used (AMIRA, 2002). The possibility of kinetic control is however supported by the results from acid base characteristic curve (ABCC). The results from the ABCC tests are shown in Figure 5.6. One of the samples (ODXH3.2-12) indicated a moderate fizz rating and ANC value. The sample shows significant pH buffering between pH 6 and 7 (typical of dolomite), and indicates a neutralising capacity significantly greater than that measured during the ANC test. In the ABCC test, hydrochloric acid is added incrementally and the acid consumption measured at each stage. In the ANC test, excess hydrochloric acid is added to the sample and the amount of acid consumed is determined by back-titrating the solution to neutral pH with a strong base. In a slow reacting sample, it is possible that the neutralising capacity is ‘overwhelmed’ during the ANC test.

In summary, neutralising capacity in the sediments is variable, ranging from low and moderate (clay-rich and sandy sediments) to high in the carbonate-rich sediments (up to 1000 kg H_2SO_4/t). The most abundant carbonate mineral is dolomite and there is some evidence that neutralisation could be subject to kinetic controls. This is explored further in Section 5.7.1. Some samples contain significant calcite in addition to dolomite. The occurrence of calcite is restricted to shallower sediments.

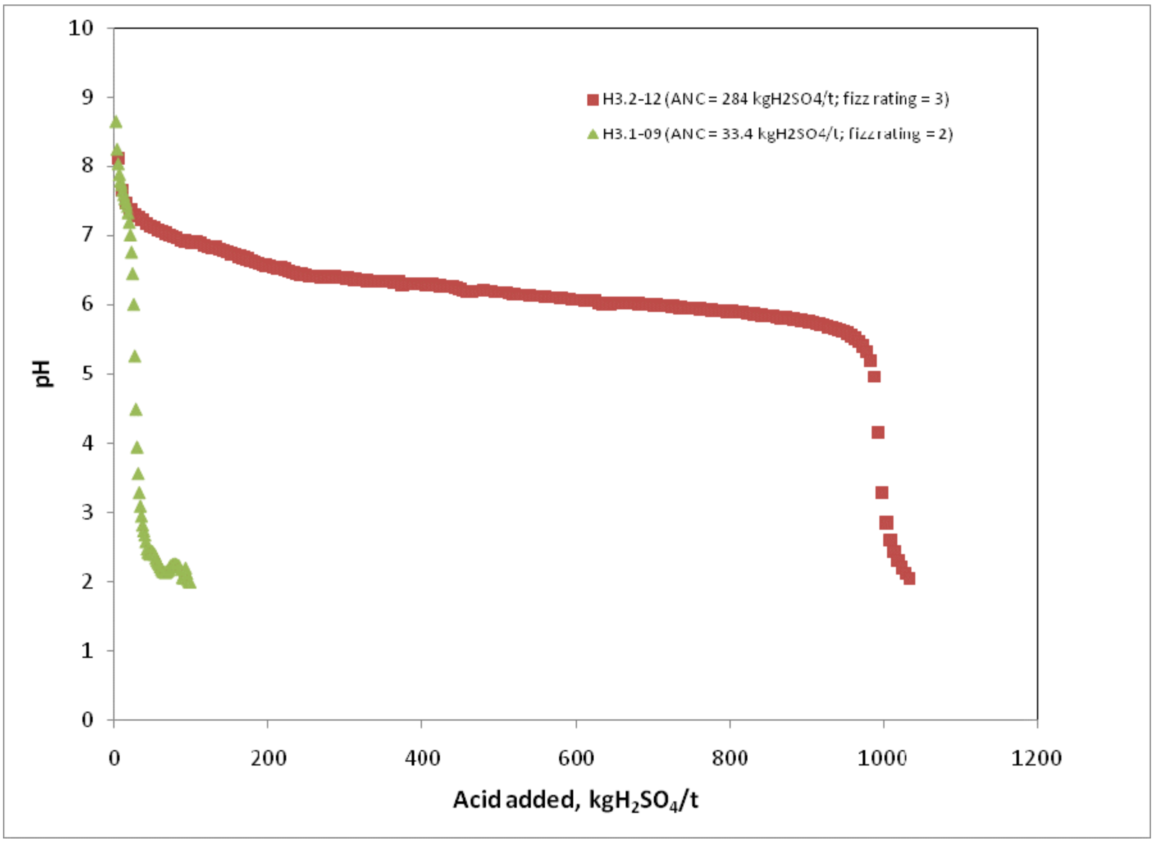


Figure 5.6: Acid base characteristic curves for samples of sediment

5.5 Physical Characteristics

A summary of the physical characteristics of the sediments is given in Table 5.4. The measured particle size distributions are illustrated in Figure 5.7.

The surface area of the samples ranges from 3-10 m^2/g (sandy samples, carbonate-rich samples), to up to 40 m^2/g (gypsiferous clay sample). Cation exchange capacities (CECs) range from 9.5 to 179 meq/100g. CECs greater than 100 meq/100g appear to correlate with samples that contain significant quantities of clay minerals (mica/illite and kaolin).

Table 5.4: Physical Characteristics of the Sediments

Sample	BET surface area, m^2/g	Cation exchange capacity, meq/100g[1,2]
ODXH1.2-09S[3]	29	179
ODXH2.1-7	3	9.5
ODXH3.1-04	17	47.7
ODXH3.1-09	10	30
ODXH3.2-12	4	30.2
ODXH4.1-10	30	192
ODXH4.2-05[3]	36, 39[4]	90.3

Notes:

1. The cation exchange capacity measurements were undertaken after first pretreating the sample to remove soluble cations.
2. The cation exchange capacity given in the table includes contributions from exchangeable Ca, Mg, Na, K and Al. Exchanges sites were predominantly occupied by calcium ions (77 to 98%) (Appendix 4)
3. These samples were located at the interface with the tailings.
4. Duplicate analyses were undertaken for this sample.

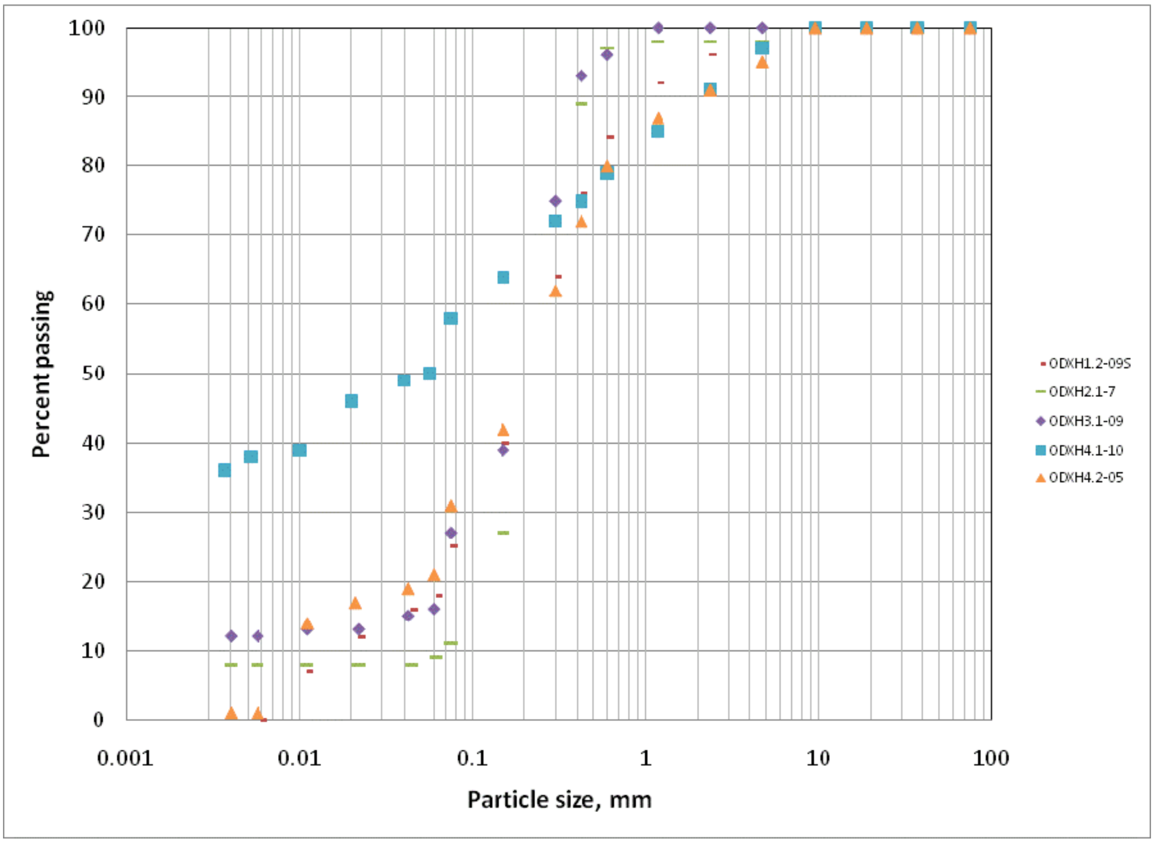


Figure 5.7: Particle size distribution (sediments)

5.6 Porewater Chemistry

Porewater could be extracted from only one sample of sediment (see Appendix 4 for details). The groundwater monitoring programme (based on samples collected from piezometers installed at the site) provided additional information on porewater quality.

The extracted porewater was acidic at a pH of 4, whilst porewater sampled by the groundwater monitoring programme were mildly acidic to near-neutral, ranging in pH from 5.9 to 7. The major element composition is dominated by Fe, Na, SO_4 and Cl. Iron redox speciation measurement suggested that 19% of the total Fe was ferrous iron, Fe(II). This percentage is not dissimilar to the range observed in the case of the tailings porewaters, 20-30% (Section 4.6) and indicates that if any oxidation of ferrous to ferric iron has taken place in the sediment it is very limited.

Dissolved elements that were detected at relatively high concentrations (>10 mg/L) included Br, Cu, F, Mn, Mo, NO_3, Sr, U. Radiological analyses of the extracted porewater sample gave low values of 0.005Bq/ml, 0.031Bq/ml and <0.005Bq/ml for gross alpha, gross beta and Ra-226, respectively.

As was the case with the tailings porewater, geochemical modelling (PHREEQC) suggested that solubility of sulphate minerals are contributing to the water chemistry. Possible solubility controls in the sediment porewater are discussed in more detail in Section 5.8.

5.7 Water-Rock Interactions

Two main types of water-rock interactions within the underlying sediments were assessed, using both static and kinetic test methodologies (Table 5.5), as follows:

- Interaction with acidic, metalliferous percolate;
- Interaction with de-ionised water (as a simulant for percolating rainwater).

The majority of work has focused on establishing the capacity of the sediments to neutralise TSF percolates and attenuate contaminants. Interaction with de-ionised water was included to assess the potential reversibility of some of the attenuation processes should conditions change with time.

Previous studies of interaction with acidic percolate used fresh tailings liquor with a pH less than 2. The current programme utilised partially-neutralised tailings liquor (tailings liquor reacted with calcite increase the pH to ~4.4; Appendix 5). This solution was believed to be representative of a percolate that 'travelled' through underlying sediment (as will be discussed later, Section 8.1, most of the sediments have a high capacity to neutralise acid, and it is expected that highly acidic percolate seeping from the tails would be at least partially neutralised within a short distance of the tailings/sediment interface).

Table 5.5: Water-Rock Interactions involving Underlying Sediments (Summary of Relevant Testwork

Organisation	Date	Experimental Conditions	Water:Rock Ratio	Number of cycles
Interaction with de-ionised water: Static Leach Extraction Tests				
CSIRO	Current	Air-equilibrated water	2	3
CSIRO	Current	Deoxygenated water	2	3
Interaction with acidic, metalliferous percolate: Static Attenuation Tests				
EGi	1995	Air-equilibrated (?) tailings liquor (pH <2)	0.2, 0.5	1
ENSR/EACOM	2008	Air-equilibrated (?) uranyl nitrate solution (pH ?)	1, 2, 20	1
CSIRO	Current	Deoxygenated simulated percolate (pH ~4.4; N_2 atmosphere)	1, 2, 20	Up to 4
Interaction with acidic, metalliferous percolate: Kinetic Attenuation Tests[1]				
EGi	1995	Saturated columns, air-equilibrated simulated percolate (pH ~4.4)	?	22

Notes:

1. Saturated column tests (using N_2-equilibrated acid percolates) were planned as part of the current CSIRO programme but problems were encountered due to impracticably slow flow rates through the columns (believed due to a combination of high clay content and formation of reaction product due to interaction of the sediment with acidic percolate). The planned column tests were replaced with sequential attenuation tests.

5.7.1 Acid Neutralisation

The neutralising capacity of the underlying sediments is discussed in Section 5.4.2. Results suggested that in the case of samples containing dolomite, slow reaction rates may reduce the immediate availability of the acid neutralising capacity. Therefore, at short contact times (i.e. water residence times are short), then neutralisation may be incomplete.

Figure 5.8 to Figure 5.10 show the evolution of pH as a function of time, for four contact cycles with acidic percolate. Results are shown for samples with differing acid neutralising capacities (ANC) and different mineralogical compositions. Equivalent results for a 'blank' test (containing no solid) and a test involving a quartzite sample (Core 4) are also shown.

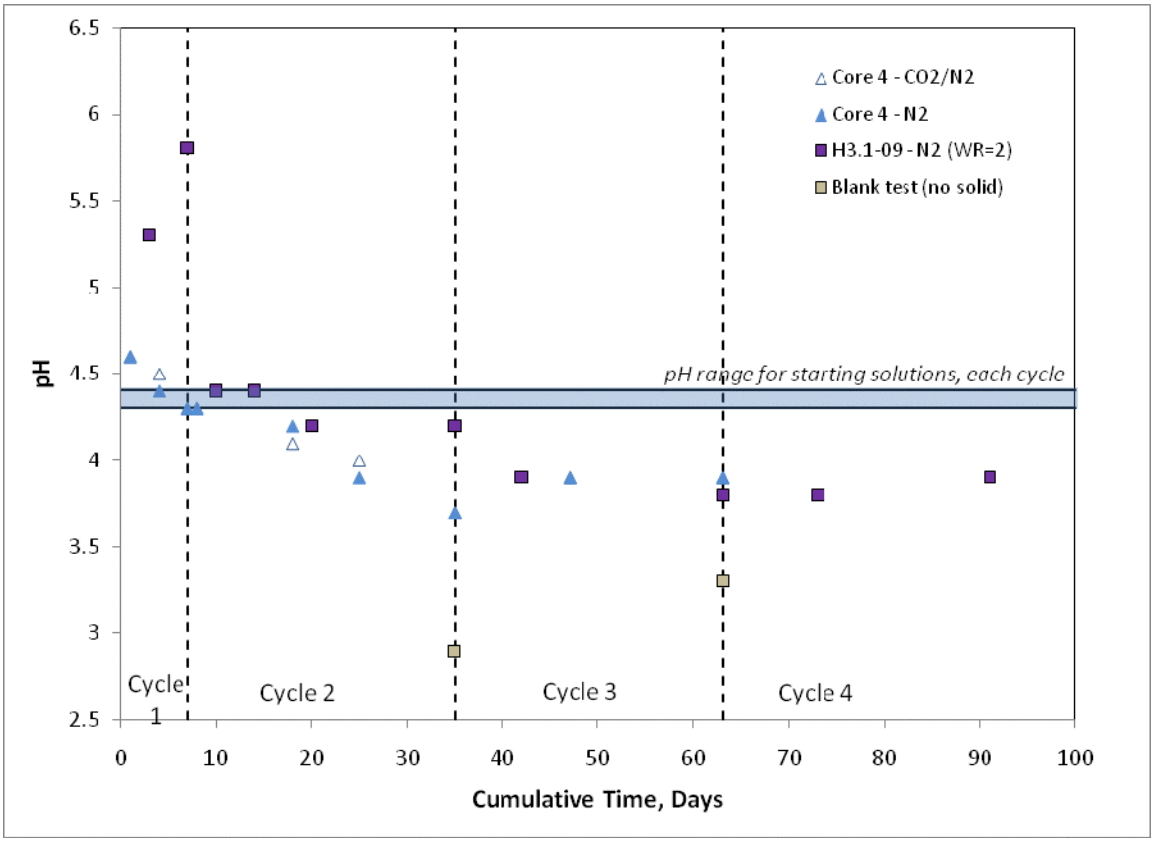


Figure 5.8: Acid Neutralisation as a function of time, four cycles of acid percolate addition (sandy sediment sample, ANC 33.4 kgH2SO4/t, 2%(wt) calcite)

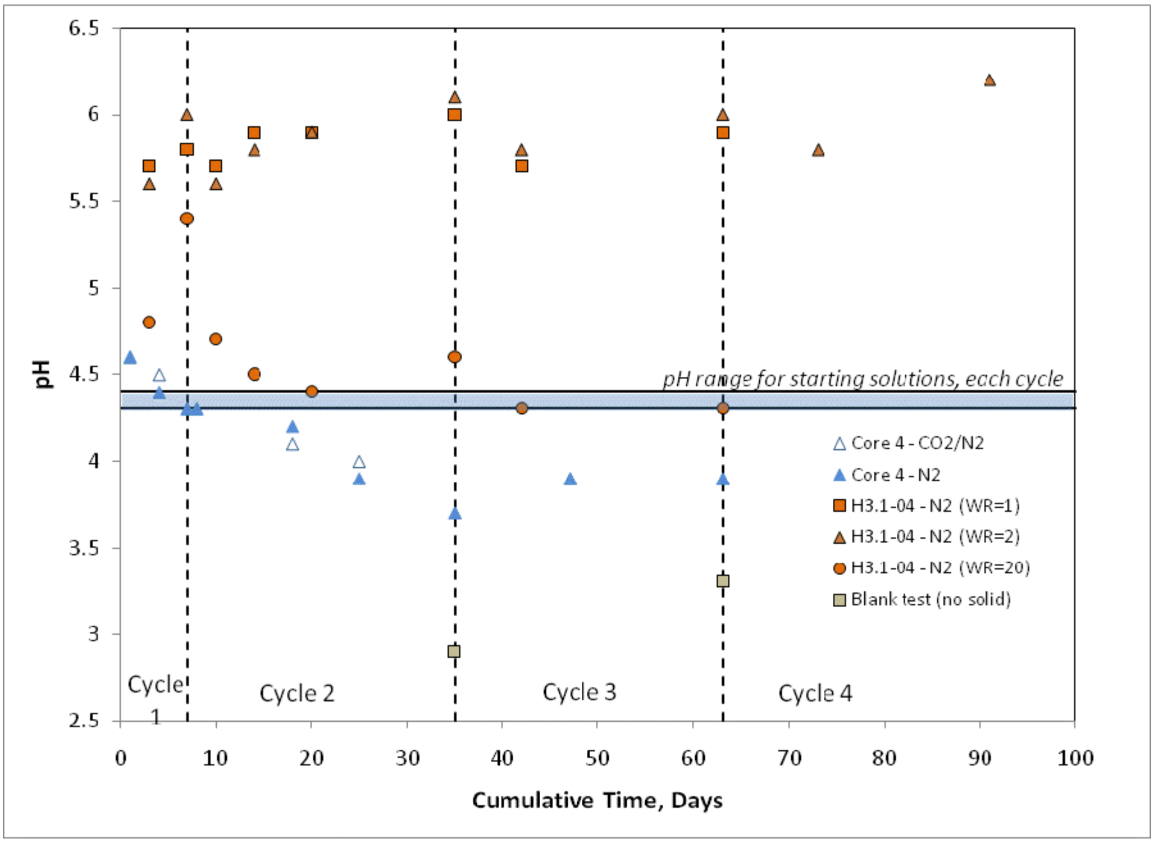


Figure 5.9: Acid Neutralisation as a function of time, four cycles of acid percolate addition (carbonate-rich sediment sample, ANC 739 kgH2SO4/t, 29%(wt) calcite, 46%(wt) dolomite)

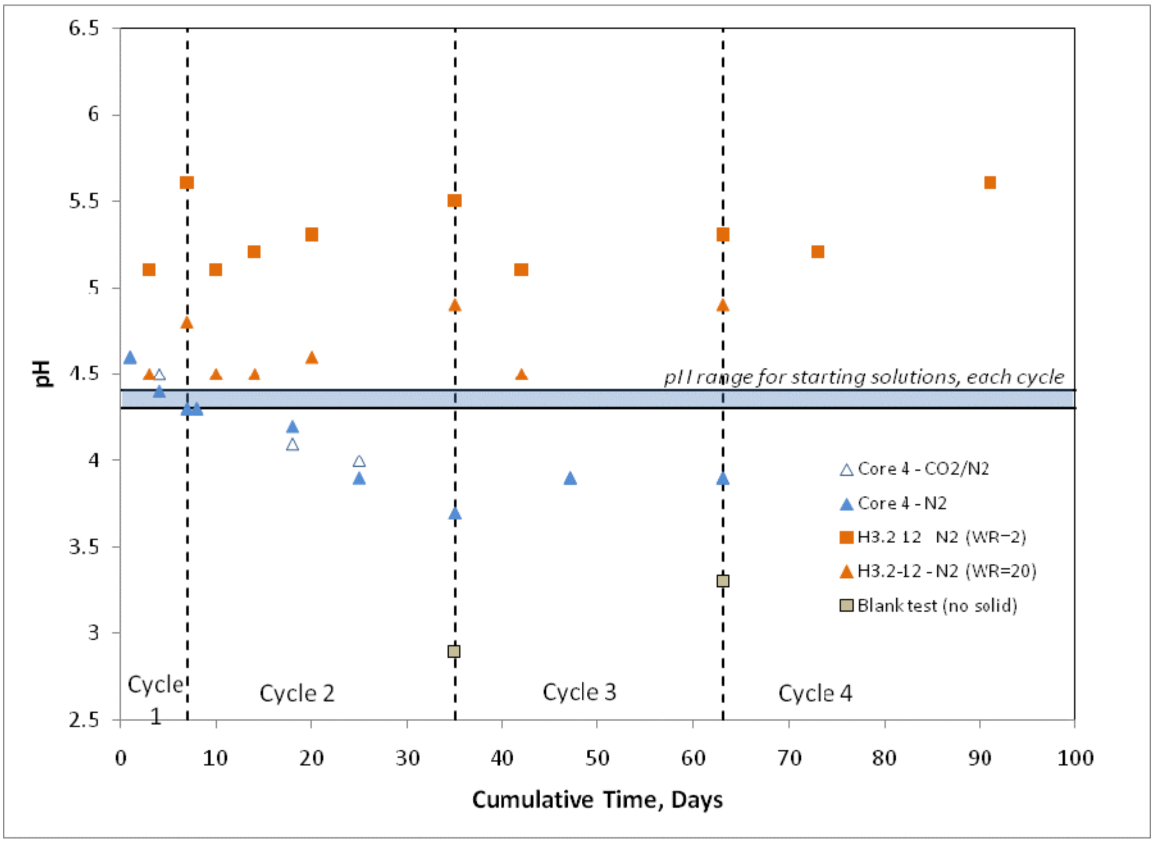


Figure 5.10: Acid Neutralisation as a function of time, four cycles of acid percolate addition (carbonate-rich sediment sample, ANC 284 kgH2SO4/t, 92%(wt) dolomite)

The quartzite sample had an ANC value below detection (<0.5 kgH_2SO_4/t) and no detectable carbonate. Results for these samples are included in the figures to show how the pH would evolve in cases where little or no neutralising capacity is available for reaction. A consequence of the high ferrous iron concentrations in the tailings percolate is that the solution itself has a potential generate free acidity (i.e. H^+ ions) in a two step process. In the first step ferrous iron is oxidised to ferric iron according the following reaction:

$$Fe^{2+} + \frac{1}{4} O_2 + H^+ \rightarrow Fe^{3+} + \frac{1}{2} H_2O \qquad [1]$$

Reaction [1], although very slow under acid conditions (pH <4), becomes much more rapid as pH increases. Unless pH conditions are acidic, ferric iron (Fe^{3+}) is insoluble and precipitates in the form of iron oxyhydroxide as follows:

$$Fe^{3+} + 3H_2O \rightarrow Fe(OH)_{3(solid)} + 3H^+ \qquad [2]$$

Reactions [1] and [2] combine to generate acidity according to:

$$Fe^{2+} + \frac{1}{4} O_2 + 2\frac{1}{2} H_2O \rightarrow Fe(OH)_{3(solid)} + 2H^+ \qquad [3]$$

This reaction causes a decrease in pH which explains the decrease in pH observed for the quartzite sample and the blank tests. Although the simulated percolate solutions used in the testwork were deoxygenated, and the experiments undertaken within a controlled nitrogen atmosphere, oxygen clearly could not be excluded completely. The pH drifted downwards from the starting values between pH 4.3 and 4.4, to values of around pH 3.7-3.9 (quartzite data), or around pH 2.9-3.3 ('blank' data).

The capacity of the samples to continue neutralising added acidity depends on (i) the ANC of the sample and (ii) the water-to-rock ratio (i.e. balance between acid neutralisation capacity of the solids and the acidity contained in the solution). The cumulative amount of acidity added in the consecutive solutions added (Cycle 1 to 4) is around 170 g (H_2SO_4 equiv.) for the 1:1 (Water:Rock) ratio, about 340 g H_2SO_4 equivalent for the 2:1 (Water:Rock) ratio and about 3400 g (H_2SO_4 equiv.) per 1 kg of rock sample at a Water:Rock (W:R) ratio of 20:1. The corresponding ANC values were 33.4 (H3.1-09), 739 (H3.1-04), 284 (H3.2-12) and 680 (H3.2-12) g H_2SO_4/kg sample.

The pH evolution in the tests can be readily interpreted by comparing the mass of acidity added to the available neutralising capacity in the test:

- Quartz-rich, sandy sediment sample, H3.1-09 (Figure 5.8). The limited ANC (33.4 kgH_2SO_4/t) reacts rapidly in the first cycle of percolate addition. Even though the first stage acidity addition (at W:R of 2:1) of about 35 g H_2SO_4 equivalent per kg slightly exceeded the ANC of the sample, the pH increased to 5.8 suggesting that most of the ANC was available for acid neutralization and that the reactions were not kinetically limited. Such behaviour is consistent with the rapid reaction rates expected of calcite (the carbonate mineral identified in this sample). The ANC is exhausted in the first cycle, and behaviour in the remaining cycles matches that of the quartzite sample.
- Carbonate-rich (mixed calcite/dolomite) sample, H3.1-04 (Figure 5.9). In the 20:1 water-to-rock ratio experiment the acidity addition exceeded the ANC within the first cycle. Whilst some neutralisation occurred in the first cycle, further neutralisation reactions occur in later cycles indicating that i) not all of the ANC had been consumed within the first stage, and ii) the reactions are kinetically controlled. In the 1:1 and 2:1 experiments, sufficient ANC is available to continue neutralising acidity in all four cycles. The final pH in each cycle was about 6, slightly higher than for the dolomite-rich sample (H3.2-12). This likely reflects the influence of the more rapidly reacting calcite present in the sample. The results further indicate that most of the ANC was available for acid neutralisation and that the degree of neutralisation is dependent on the contact time.
- Carbonate-rich (dolomite) sample, H3.2-12 (Figure 5.10). This material has the highest ANC. In the 20:1 experiment, even though the total acidity addition exceed the ANC by a factor of 5, sufficient neutralising capacity remained to result in an increase in pH to about5. This is because limited contact time prevents complete reaction in preceding stages and clearly demonstrates the kinetic control on acid neutralisation reactions. At lower water-to-rock ratios, the increase in pH is greater and generally reaches 5.5.

The results in general indicate that most of the ANC will be available for acid neutralisation. In all the tests, after an initial sharp increase of about 1 pH unit (in the first week), the pH continues to increase gradually and at a relatively constant rate. The initial rapid increase probably corresponds to initial reaction of the carbonate with the acidity in starting solution. Once the pH has risen beyond a certain threshold, oxidation of ferrous iron is initiated, generating new acidity. At this point the evolution of pH is a function of the balance between rates of generation and consumption of acidity. Analysis of trend lines (Cycle 2 onwards) suggests that the resulting gradient ranges from 0.01 to 0.02 pH units per day. Assuming the rate remains constant, it would take between 100 and 200 days to increase the pH from 4.3 to a final ‘equilibrium’ value of pH 6.5 (approximate pH expected for dolomite buffering).

5.7.2 Contaminant Attenuation

The transport of contaminants sourced from the TSF along seepage flow paths in the underlying sediment can be attenuated primarily as follows:

- Incorporation in precipitating secondary minerals or co-precipitation with secondary minerals (e.g. uptake of Ra in the matrix of barite ($BaSO_4$)) generally due to changing chemical conditions along the seepage flow path, e.g. increasing pH, or changes in solute concentrations. The role of solubility controls is addressed in Section 5.8.
- Mineral surface interactions, such as sorption and ion exchange.

Sorption onto oxyhydroxides of iron, aluminium and manganese is known to represent an important attenuation mechanism in rock-water systems. Even a very small quantity by mass can represent a significant sorptive capacity due to the tendency of such minerals to form surface coatings on other mineral grains.

Sorption is often represented by using a distribution coefficient, K_D:

$$K_D = C_{ads}/C_{aq}$$

Where C_{ads} is the concentration of element adsorbed to the solid phase and C_{aq} is the concentration remaining in solution. In the current work, K_D values were calculated in two ways:

- accounting for element 'already present' in the solid, i.e. assuming that it will participate in desorption/sorption during test, and
- excluding element already present, i.e. assuming the element is present in a form unlikely to participate in reaction during the test. Assessment of the partitioning of elements in sediments samples (Section 5.3) suggested that significant proportions of many elements were associated with the 'residual' phase (and therefore unlikely to interact with solutions during the tests).

In most cases, the amount of an element added in the percolate solution was much greater than that already present in the sediment and so, for the first cycle, it made little difference how the K_D was calculated. However, the second and subsequent cycles of the attenuation tests, it is important to account for the mass of the element that adsorbed during a previous cycle.

Figure 5.11 shows calculated K_D values for uranium sorption for different sediments, plotted for up to four cycles of percolate addition. As shown in Figure 5.12, where the same results are plotted as a function of the pH in the final solution of each stage, sorption is a pH dependent process. The results form an obvious 'pH edge' or threshold below which sorption does not occur. Sorption increases rapidly as the pH increases from 5 to 6. This type of behaviour is typical of the sorption of cationic species (in this case the uranyl cation, UO_2^{2+}).

At acidic pH values, mineral surfaces are predominantly positively-charged (protonated), whereas at alkaline pH values the predominant surface charge is negative (de-protonated). Positively charged cationic species are much more strongly sorbed at near-neutral and alkaline pH, when the mineral surface is more likely to be negatively charged. However the speciation of some ions also changes with changing pH conditions and also need to be considered.

Many of the trends shown in Figure 5.11 can be explained in terms of the different pH values in the final solutions of each stage (full discussion of acid neutralisation behaviour was given in the previous section, Section 5.7.1). The following additional observations can also be made:

- Comparing the first stage results for H3.1-04 (shaded blue columns in Figure 5.11; note H3.1-04 at water to rock ratios of 1:1 and 20:1 were completed for 3 stages only) K_D-values are independent of the water-to-rock ratio (within the error of measurements and variability in pH). The pH values for the first stage of the three tests in general were similar. Second stage results remained similar for the lower ratio tests (consistent with similar endpoint pH-values) whereas the K_D for the 20:1 water to solid ratio test decreased substantially, again so in the third stage. This is because there is a decrease in the pH for the second and third stages of this test. Therefore, the water to rock ratio does not appear to affect the attenuation capacity of the samples; rather the pH is the primary determinant.
- For equivalent conditions (Water:Rock ratio, final pH) it appears that sorption decrease in the following order: carbonate rich sediment (H3.1-04) > sandy sediment (H3.1-09) > carbonate sediment (H3.2-12). Sorption involves interaction with mineral surfaces and so sorptive capacity would be expected to correlate with measured surface properties. This is indeed the case. The surface areas measured for the samples were 17, 10 and 4 m^2/g, respectively (Table

5.4). Sample H3.1-04 also has the highest cation exchange capacity (48 meq/100g compared to 30 meq/100g for the other two samples).

- The sorption capacity of the materials has not been exceeded. In part the reason for this may the formation of additional iron oxyhydroxide precipitates (i.e. supplemental sorption sites) as neutralization progressed.

Table 5.6 summarises K_D values estimated from the results. For comparison, values reported in previous studies are also shown. For most of the elements shown, the K_D values measured in the current programme are comparable to those from previous studies. Considering the combined datasets, the following comments can be made:

- The sorption of most elements is low to moderate (K_D values between 1 and 100 mL/g). This is typical of sorption onto carbonate-rich substrates. The presence of carbonate minerals tend to result in higher dissolved carbonate which leads to the formation of aqueous anionic carbonate complexes of radionuclides and metals (e.g. uranium complexes to form $UO_2(CO_3)_2^{-2}$; $UO_2(CO_3)_3^{-4}$; or $UO_2(CO_3)(OH)_3^{-1}$) that leads to increased solubility and reduces the potential for sorption reactions, resulting in reduced K_D values.
- Whilst copper results indicated particularly high K_D values in some of the tests, the results are confounded by the precipitation of copper-bearing phases. Geochemical modelling suggests that the observed behaviour may be consistent with precipitation of a hydrated carbonate phase such as malachite ($Cu_2CO_3(OH)_2$).
- Arsenic sorption in the current programme (K_D values up to 20 mL/g) appears consistently lower than measured in the earlier EGi studies (86-210 mL/g). A similar trend could be true of other analogous elements, e.g. Mo and Se, but the effect is less marked. In the case of arsenic, the effect may be attributable to redox conditions (i.e. arsenic occurring in the reduced As(III) state rather than the oxidised As (V) state.)
- Of the elements in the uranium decay chain (uranium, thorium, radium-226 and lead), thorium sorbs most strongly, followed by lead, then uranium and lastly radium-226 (radium behaviour is being approximated using barium as an analogue since Ra-226 was not detectable in the experimental solutions and so radium-226 could not be assessed directly).

Table 5.6: Summary of K_D values measured for sediments (mL/g)

	Current program (CSIRO) De-oxygenated solutions, N_2 atmosphere									EGi, 1995 Air-equilbrated solutions although containers were sealed during test					ENSR/AECOM, 2008 Experimental conditions not recorded
Sample	**H3.1-04 Mixed calcite/dolomite sediment**			**H3.1-09 Quartz-rich sediment**			**H3.2-12 Dolomite-rich sediment**								
Element	**Min**	**Med**	**Max**	**Min**	**Med**	**Max**	**Min**	**Med**	**Max**	**Calcareous clay**	**Claypan**	**Dune sand**	**Swale Material**	**Dolomite**	**Various soils**
pH range	*4.3-6.2*			*3.8-5.8*			*4.8-5.6*			*7.7*	*3.7*	*3*	*6.1*	*7.7*	*Not recorded*
As	0	4.3	20	0	0	3.0	0	0.7	2.4	215	86	86	86	86	
Ba	0	1.1	3.2	0	0	0	0	0	0	3	0	0	1	2	
Cd	0	3.5	24	0	0	0.8	0	0.9	10.0	0	0	0	0	0	
Co	0	0.7	1.0	0	0.1	0.4	0.1	0.8	940	13	0	0	1	0	
Cu	12	2500	740000	1.0	1.3	160	2.1	170	1300	650	0	0	39	217	
Mo	0	3.1	44	0	1.6	4.0	0	4.4	44	102	41	41	41	8	
Ni	0	1.3	2.7	0	0	0.2	0	0.3	1.5	2	0	0	0	0	
Pb	6.2	13	180	9.6	15	18	9.6	18	180	57	0	6	23	23	
Se	0	2.9	17	0	0	2.5	0	1.4	6.6	10	4	4	4	4	
Th	7.4	28	280	5.1	11	28	15	28	280	1475	74	3	590	591	
U	0.4	9.7	35	0.6	0.9	24	0	8.7	11	10	0	0	38	6	12-141
Zn	0	6.9	80	0.5	0.6	1.6	0	0.6	1.3	65	0	0	4	3	

Notes: Where detectable, K_D values for current work are reported to two significant figures. Non-detectable sorption given as zero.

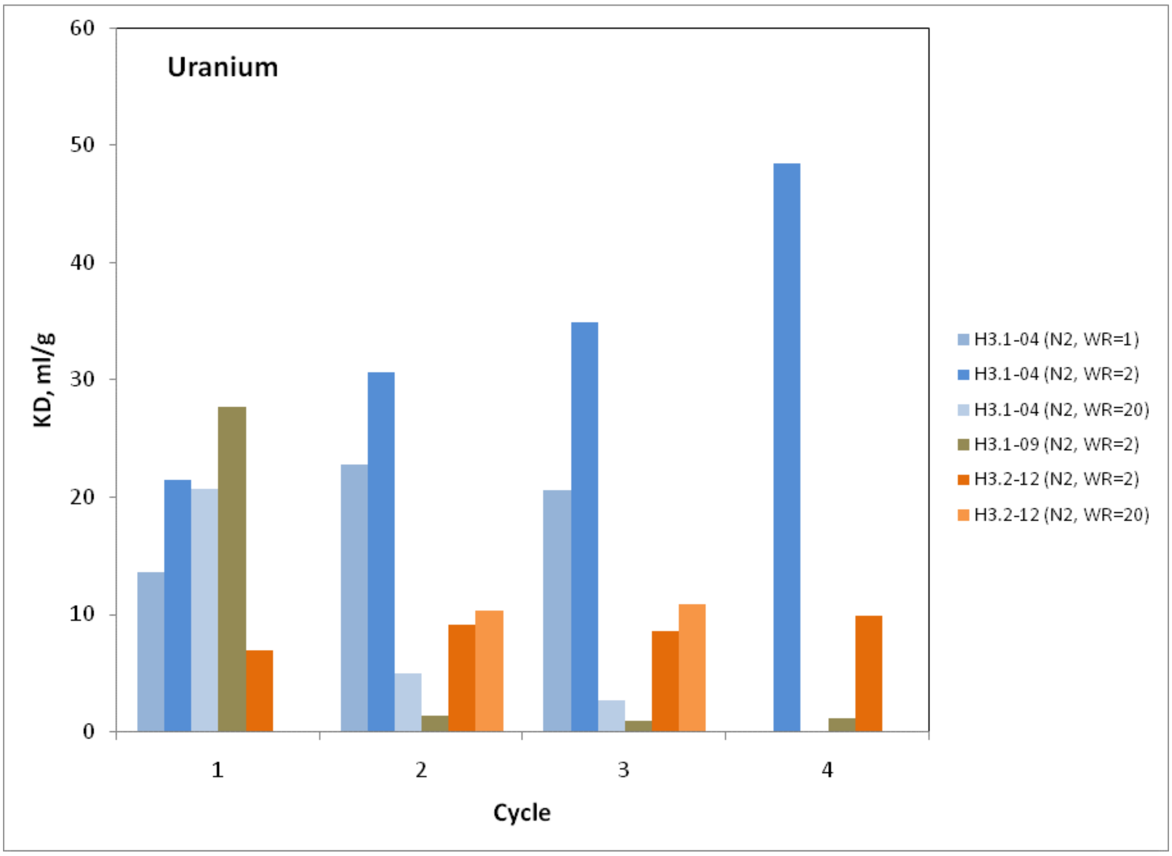


Figure 5.11: Uranium sorption onto different sediments, up to four cycles of percolate addition

(Note: Tests H3.1-04 at contact ratios WR=1 and WR=20 were completed for 3 stages only)

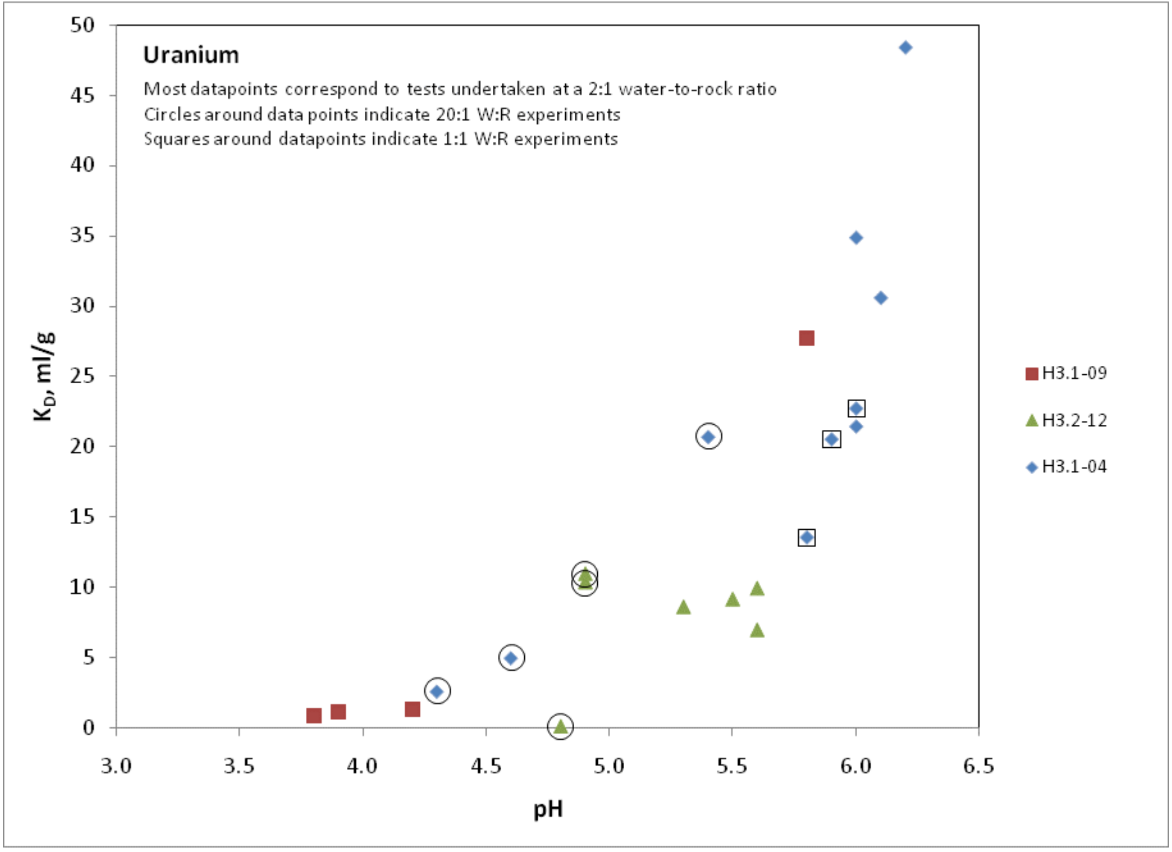


Figure 5.12: Uranium sorption onto sediments plotted as a function of solution pH

5.7.3 Metal Leachability

Water leach extraction test results for the sediments have been used to calculate the fraction of an element leachable under the conditions of the test. The leach tests were undertaken under two different sets of experimental conditions: i) de-oxygenated water and in a controlled nitrogen atmosphere; and, ii) oxygenated water for atmospheric conditions. As discussed in Section 5.3, elements leaching under the conditions of these tests are likely to be present as i) very readily soluble salts or ii) very weakly bound to the solid.

Elements that leached at more than 10% of the initial mass included SO_4, Na, and K (major elements), and B, Be, Cd, Co, Cu, Li, Mo, Mn, Ni, U, and Zn (minor and trace elements). For many tests, the observed leaching behaviour appears unaffected by experimental conditions with the observed fractions leached within a factor of two and therefore difficult to distinguish from the possible effects of sample variability. A number of elements however do appear to show increased leaching under de-oxygenated conditions including Al, Cd, Ce, Co, Cu, K, and Mn.

As for the tailings, the highest proportion of leaching occurred during the first cycle (for example, Figure 5.13 illustrates the results for uranium) for the majority of the elements. The exceptions were Ca, Ba and Si, which all showed a slight trend toward increased leaching with each cycle.

The overall proportion of leaching tended to increase with a decrease of the pH in the final solution. For example, TSF sediments sample (H4.2-05) sourced from close to the tailings interface had a relatively low final pH (<5) and the fraction of each element leached from this sample is significantly greater than for the other TSF sediments and most of the RSF sediments.

The results suggest that attenuation processes of some of the metals and radionuclides in sediments below the TSF are reversible and some metals could be mobilised in the very long term. However, considering the finite acidity load and the magnitude of the neutralisation capacity, this is considered unlikely to occur. The potential for, and implications of, remobilisation is discussed further in Section 8.2.2.

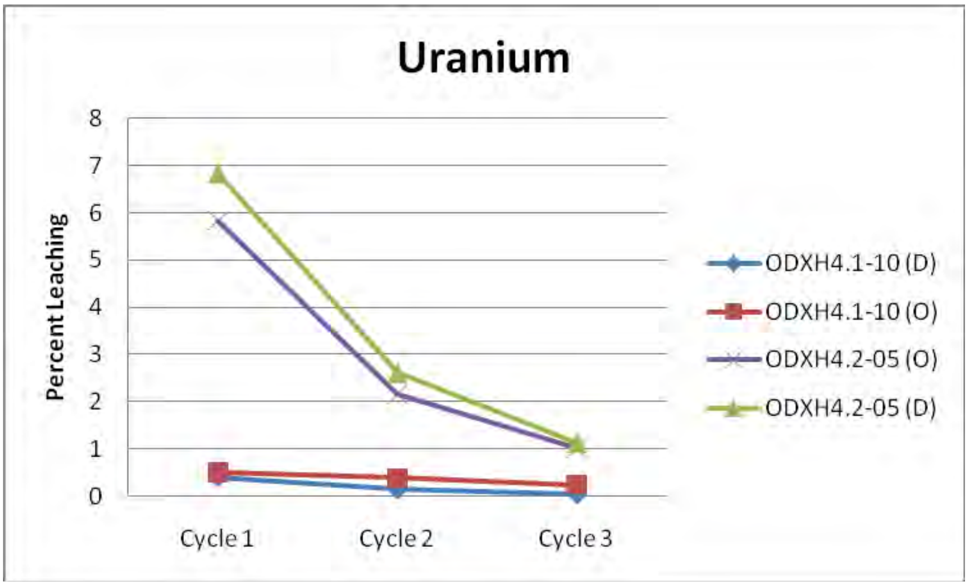


Figure 5.13: Percentage of uranium leached during three cycles of leaching with de-ionised water

5.8 Possible Solubility Controls

Geochemical modelling (PHREEQC) was undertaken to examine measured porewater and experimental solution chemistries in more detail. Figure 5.14 and Figure 5.15 show activity diagrams for iron and aluminium. Plotted onto the diagrams are the calculated activities of Al^{3+} and Fe^{3+} ions in sediment porewaters and various leach solutions.

The results for aluminium indicate that:

- Most of the leachate solution concentrations are controlled by oxyhydroxide phases (boehmite or diaspore).
- Porewater chemistry is consistent with the solubility of jurbanite ($AlOHSO_4$);
- The solutions from the attenuation tests contain high Al, and are supersaturated with respect to the sulphate and oxyhydroxide mineral phases considered.

In the case of iron, solubility is likely controlled by a combination of jarosite (acidic pH) and ferrihydrite (near-neutral to alkaline pH).

Figure 5.16 shows a corresponding uranyl (UO_2^{2+}) activity diagram. Most of the results fall in the near-neutral or alkaline pH range, between the stability lines for soddyite or uranyl hydroxides (schoepite). Either mineral is a possible solubility controlling phase. The displacement of the results relative the theoretical lines could be attributed to the fact that the thermodynamic data represent pure, crystalline phases. The phases forming in the tests may be impure, or less crystalline.

For sediment porewaters and leach solutions, the following minerals and mineral groups were found to be either close to equilibrium, or supersaturated:

- Gypsum ($CaSO_4{:}2H_2O$) – gypsum was close to equilibrium in most of the solutions.
- Barite ($BaSO_4$) and celestite ($SrSO_4$) – barite tended to be supersaturated whilst celestite was close to equilibrium in the porewaters and under-saturated in the leach solutions.
- Molybdates, arsenates, chromates and uranates.
- Native copper (Cu) and cuprite (Cu_2O)
- Metal-bearing carbonates and hydrated carbonates – malachite ($Cu_2CO_3(OH)_2$), rhodocrosite ($MnCO_3$).

To determine if the solubility controls represented i) dissolution of primary minerals present in the starting materials, or, ii) precipitation of secondary minerals during the test, residues from the leach tests were assessed using a combination of optical microscopy and scanning electron microscopy. In one of the carbonate-rich sediments (H3.1-04) some larger carbonate grains showed compositional zoning, e.g. dolomite cores surrounded by calcian siderite. Although this zoning could reflect reactions that took place during laboratory testing, it could also be explained on the basis of diagenetic processes taking place in-situ.

Some limited evidence for secondary mineral precipitation during the tests was found. For example, thin films of malachite/azurite (quartz-rich, sandy sediment sample, H3.1-09) and iron oxide coatings (carbonate-rich sediment, H3.2-12) were observed. Whilst no other conclusive evidence of dissolution or precipitation textures was found, other processes cannot be discounted because the scale of reactions may not have been sufficiently large (quantities formed) to have been detectable by using either optical or scanning electron microscopy.

Full details of the microscopic investigations are included in Appendix 5.

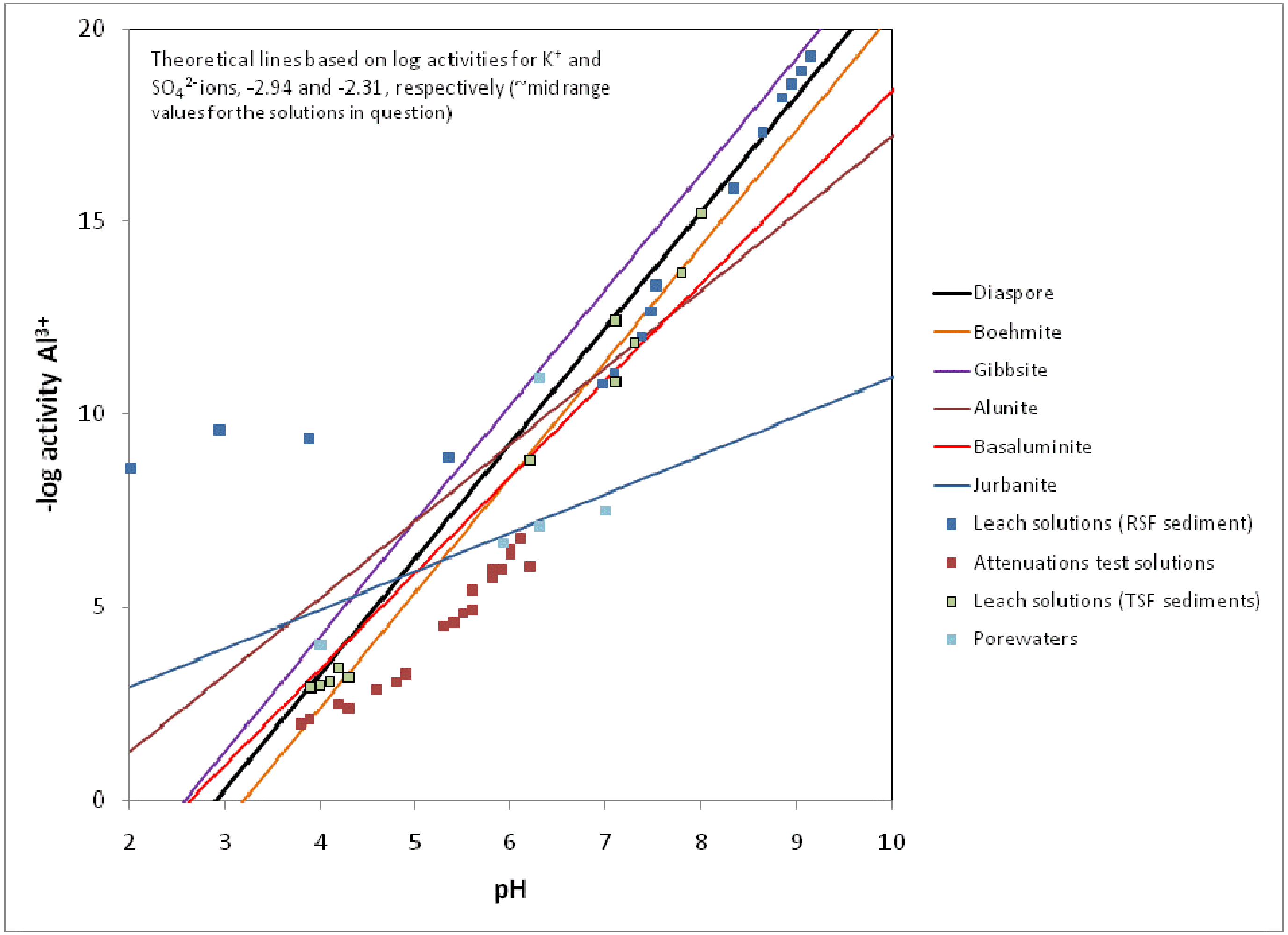


Figure 5.14: Aluminium activity diagram showing the calculated activities of sediment porewater and leach solutions

Also shown are the theoretical equilibrium lines for a range of minerals

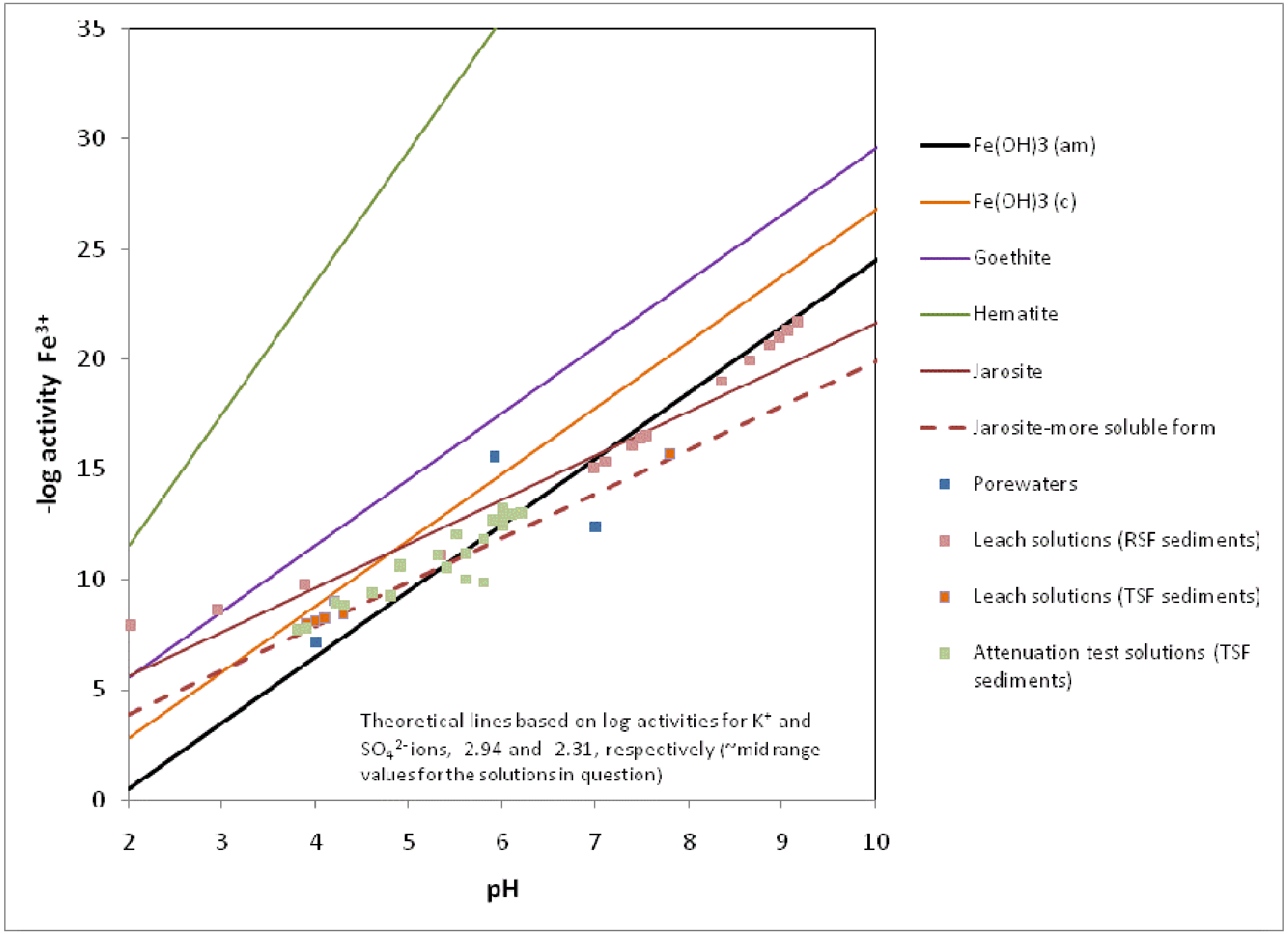


Figure 5.15: Iron activity diagram showing the calculated activities of sediment porewater and leach solutions

Also shown are the theoretical equilibrium lines for a range of minerals

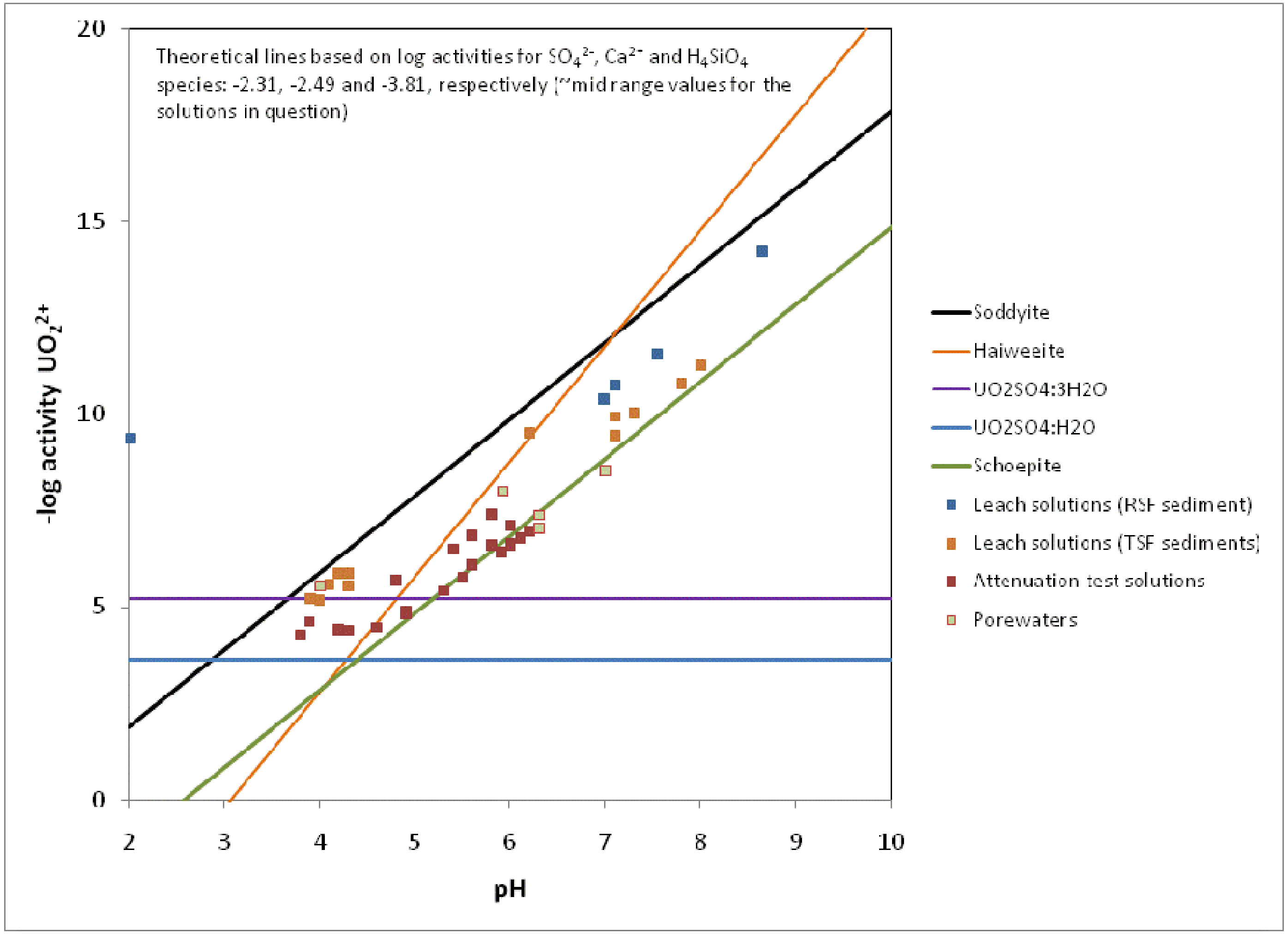


Figure 5.16: Uranyl (UO_2^{2+}) activity diagram showing the calculated activities of sediment porewater and leach solutions

Also shown are the theoretical equilibrium lines for a range of minerals

6 Andamooka Limestone: Results and Discussion

6.1 Mineralogy

Previous studies (ENSR, 2008 and references therein) have reported that the Andamooka Limestone is predominantly dolomite (98 %(wt)), with minor quartz. The mineralogical analysis of one sample of core (ODX Core 1) verified this observation (dolomite 84 %(wt)). Other minerals present in the sample were: quartz (12%(wt)) and muscovite/illite (1 %(wt)).

6.2 Bulk Chemistry Solids

The elemental concentrations in the three limestone samples analysed generally correlated with average 'crustal' abundances. Only rhenium and selenium were enriched in one of the samples.

6.3 Acid Base Accounting

Previous studies (ENSR, 2008 and references therein) have classed the Andamooka Limestone as non-acid forming (NAF). A summary of previous acid base account test results is provided in Table 6.1.

Table 6.1: Acid Base Accounting Statistics for Andamooka Limestone

	Total sulphur, %(wt)	MPA, kgH_2SO_4/t	ANC, kgH_2SO_4/t	NAPP, kgH_2SO_4/t	NPR
Minimum	0.01	0.3	120		
Maximum	0.54	16.5	930		
Mean	0.12	3.7	481	-477.3	130

Notes: MPA=Maximum potential acidity, ANC=Acid neutralising capacity, NAPP=net acid producing potential (MPA-ANC), NPR=net potential ratio (ANC/MPA).

The current programme focused on characterising further the neutralising potential of the limestone. Acid neutralising capacity (ANC) and an acid base characteristic curve (ABCC) were measured for the Andamooka Limestone sample (Core 1). The ABCC is shown in Figure 6.1, along with the results of the ANC measurement. As was the case with the sediment samples (discussed in Section 5.4.2), the ABCC results show significant pH buffering capacity down to a pH of 6 (typical of dolomite), and indicate a neutralising capacity significantly greater than that measured during the ANC test (about 530 to 550 kg H_2SO_4/t at a pH in excess of 6, compared to 261 kg H_2SO_4/t as measured by the ANC analysis).

These results furthermore suggest that, like the overlying sediments, the neutralising capacity available within the Andamooka Limestone may be subject to kinetic controls. A similar conclusion was reached in earlier studies of the limestone (EGi 2007).

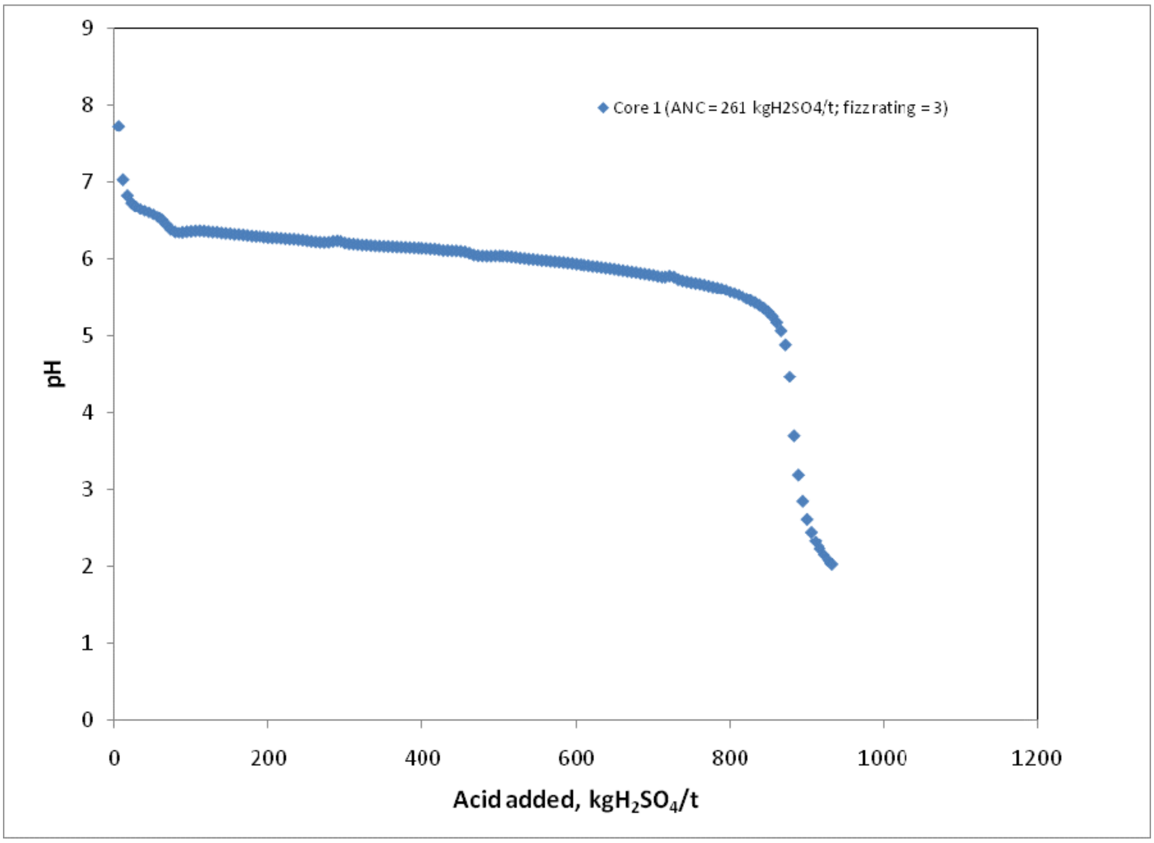


Figure 6.1: Acid base characteristic curve for a sample of Andamooka Limestone

6.4 Physical Characteristics

A summary of the physical characteristics of the crushed Andamooka Limestone sample is given in Table 6.2. The results suggest that the limestone has some limited ion exchange capacity.

Table 6.2: Physical Characteristics of the Andamooka Limestone

Sample	BET surface area, m^2/g	Cation exchange capacity, meq/100g[1,2]
Andamooka Limestone (Core 1)	6	26.6

Notes:

1. The cation exchange capacity measurements were undertaken after first pre-treating the sample to remove soluble cations.
2. The cation exchange capacity given in the table includes contributions from exchangeable Ca, Mg, Na, K and Al. Exchanges sites were predominantly occupied by calcium ions (77 to 98%) (Appendix 4)

6.5 Water-Rock Interactions

The primary focus of testing the Andamooka Limestone was to determine the interaction with acidic, metalliferous percolate from the TSF. Both static and kinetic test methodologies were used (Table 6.3).

Table 6.3: Water-Rock Interactions involving Andamooka Limestone (Summary of Relevant Testwork

Organisation	Date	Experimental Conditions	Water:Rock Ratio	Number of cycles
Interaction with acidic, metalliferous percolate: Static Attenuation Tests				
EGi	2007	Air-equilibrated (?) tailings liquor (pH<2)	0.5, 0.25, 0.08, 0.025	2
CSIRO	Current	Deoxygenated simulated percolate (pH ~4; N_2 atmosphere)	2	3
CSIRO	Current	Deoxygenated simulated percolate (pH ~4; N_2/CO_2 atmosphere)	2	3
Interaction with acidic, metalliferous percolate: Kinetic Attenuation Tests[1]				
CSIRO	Current	Saturated columns, N_2-equilibrated simulated percolate (pH ~4)	0.1[1]	4
CSIRO	Current	Saturated columns, N_2/CO_2-equilibrated simulated percolate (pH ~4)	0.1[1]	4

Notes:

1. The water-to-rock ratio is estimated on the basis of the dry mass of solid occupying the column, combined with the volume of leachant per cycle.

6.5.1 Acid Neutralisation

As noted in Section 6.3, the high dolomite content of the Andamooka Limestone appears to lead to slow reaction kinetics which may reduce the immediate availability of the acid neutralising capacity. Therefore, short water residence times (i.e. contact times) could lead to incomplete neutralisation.

Figure 6.2 shows the evolution of pH as a function of time, for up to four cycles of acid percolate addition and a range of experimental conditions. On each figure, equivalent data are also shown for a ‘blank’ test (containing no solid) and a test involving a quartzite sample (Core 4). The quartzite sample ANC was below detection (<0.5 kgH_2SO_4/t) and had no detectable carbonate. These latter results are included in the figures to show how the pH would evolve in cases where little or no neutralising capacity is available and to allow an assessment of the influence of iron oxyhydroxide precipitation on pH during the tests (see Section 5.7.1 for a full discussion).

The cumulative amount of acidity added in the start solutions (Cycle 1 to 4) was around 340 g H_2SO_4 equiv. per kg of sample. The pH evolution in the tests can be readily interpreted based on the neutralisation profiles shown in Figure 6.2. The results indicate that more than 4 cycles of contacting percolate would be required to exhaust the available ANC (if the higher ABCC-based estimate is used), with an increase in pH to between 5 and 5.5 in all cycles.

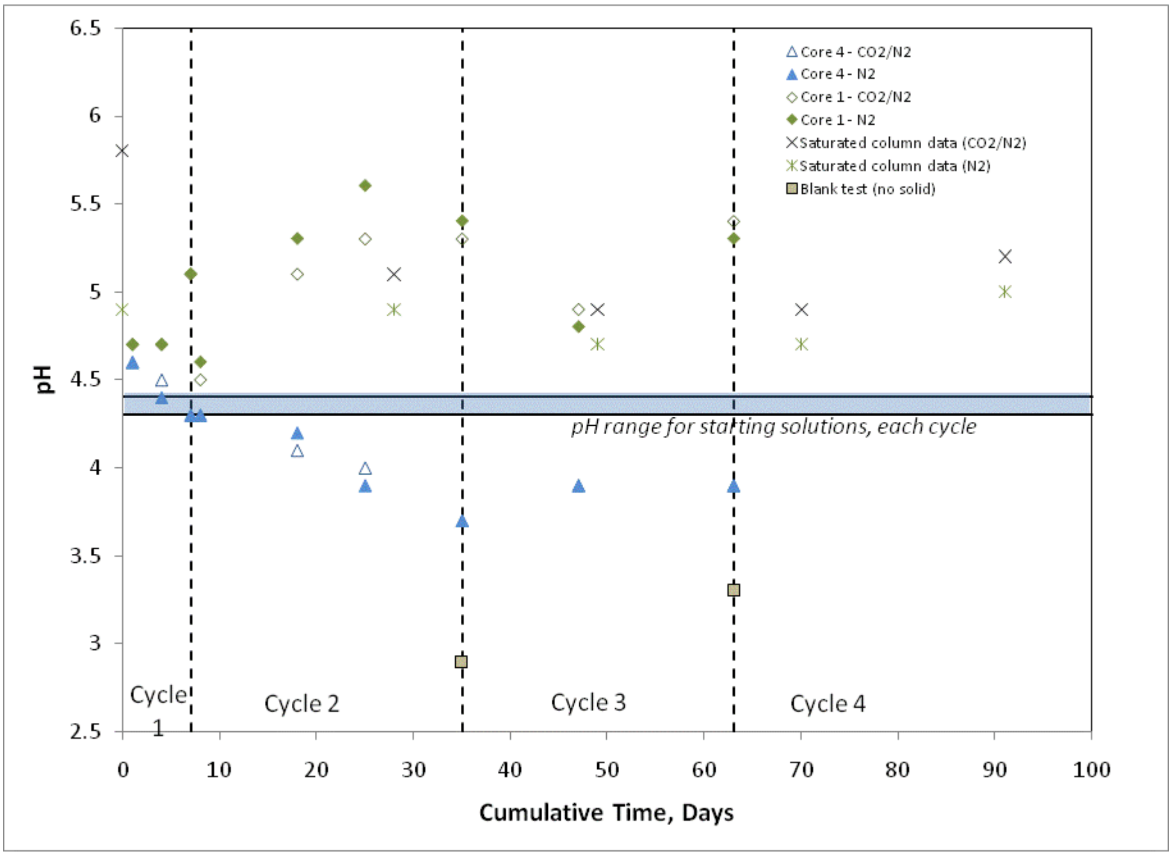


Figure 6.2: Acid Neutralisation as a function of time, four cycles of acid percolate addition (Andamooka Limestone, ANC 261 kgH_2SO_4/t , 84%(wt) dolomite)

As for the sediments, an initial sharp increase of about 0.5 pH units occurred in the first cycle. Thereafter the pH continues to increase gradually at a relatively constant rate. Once pH has risen beyond a certain threshold, oxidation of ferrous iron is initiated, generating additional free H^+ ions at which point the evolution of pH is a function of the balance between rates of H^+ generation and neutralization. Analysis of trend lines applied to the results (Cycle 2 onwards) suggests that the neutralization rate is at a gradient of 0.03 pH units per day, which is comparable to the range obtained for the sediments (0.01 to 0.02 pH units per day).

6.5.2 Contaminant Attenuation

Figure 6.3 shows calculated K_D values for uranium sorption onto Andamooka Limestone plotted for up to four cycles of percolate addition and different experimental conditions. Figure 6.4 shows the same results, plotted as a function of the pH in the final solution. The final solution pH in the tests falls within a small range, pH 4.5 to 5.5 and generally coincides with the sorption threshold identified for uranium (see Section 5.3 for further discussion). Consequently variability in the measured K_D values may reflect variability in pH.

The test were completed with nitrogen (N_2) and N_2 mixed with 10 %(v) carbon dioxide (CO_2). A mixed N_2/CO_2 atmosphere the dissolved carbonate concentration would be greater than for the equivalent N_2 case. Some elements form anionic complexes with aqueous carbonate species (e.g. uranium forms $UO_2(CO_3)_2^{-2}$, $UO_2(CO_3)_3^{-4}$, $UO_2(CO_3)(OH)_3^{-1}$) leading to reduced sorption.

In the current assessment, the results obtained for the two different atmospheric compositions were very similar. This is likely because the pH was not sufficiently high for such an effect to be detected. As noted above, the solution pH corresponds closely to the pH threshold at which sorption commences. In other studies (e.g. Waite et al, 1994) the effect of carbonate speciation becomes clear only at higher pH values, pH >7 (i.e. at complete neutralization of the solution).

Increased partial pressure of carbon dioxide may however extend the zone of influence of carbonate complexation.

As shown in Figure 6.3, the results suggest a lower K_D for the column tests compared to the roll-bottle contact tests (when results for equivalent pH and experimental conditions are compared). The primary difference between the tests is that the in the roll-bottles the water and solids are continuously mixed; the column tests are intended to simulate plug flow through the solids. In reality, water would tend to flow along the path of least resistance and therefore selective flowpaths form. Often flow short-circuits along the column walls since the solids do not form a perfect contact with the column walls. Short-circuiting of flows means that not all of solution necessarily contacts the solids (e.g. flow along the column walls), or that the flow along a selective flowpath effectively leads to a very high water to solid contact ratio such that neutralisation does not occur. The leachate represents a blend of flows from these different sources.

Table 6.4 summarises K_D values estimated from the results for the current assessment. Relevant values reported in previous studies are also shown in the table for comparison. With the exception of copper, the K_D values measured in the current programme were uniformly low. This is to be expected since the pH range for the current tests were consistently lower and generally tended to be near the pH threshold for sorption to occur. Nevertheless the results do indicate that as the pH increases (i.e. as neutralisation progresses) that attenuation increases. Note that the copper K_D values ranged up to a maximum of 1700 mL/g and, as discussed before, reflect the influence of secondary mineral precipitation rather than sorption.

Table 6.4: Summary of K_D values measured for Andamooka Limestone (mL/g)

Sample	De-oxygenated solutions, N_2 atmosphere Core 1 (Andamooka Limestone)			Air-equilibrated solutions although containers were sealed during test (EGi, 1995)
Element	**Min**	**Med**	**Max**	**Dolomite**
pH range	*4.7-5.4*			*7.7*
As	0	0	1.8	86
Ba	0	0	0	2
Cd	0	0.0	0.8	0
Co	0	0	0.2	0
Cu	0.3	2.1	1700	217
Mo	0	0	4.4	8
Ni	0	0	0	0
Pb	0	0.2	18	23
Se	0	0.0	0.5	4
Th	0	0	15	591
U	0.1	0.2	4.6	6
Zn	0	0	0	3

Notes: Where detectable, K_D values for current work are reported to two significant figures. Non-detectable sorption given as zero.

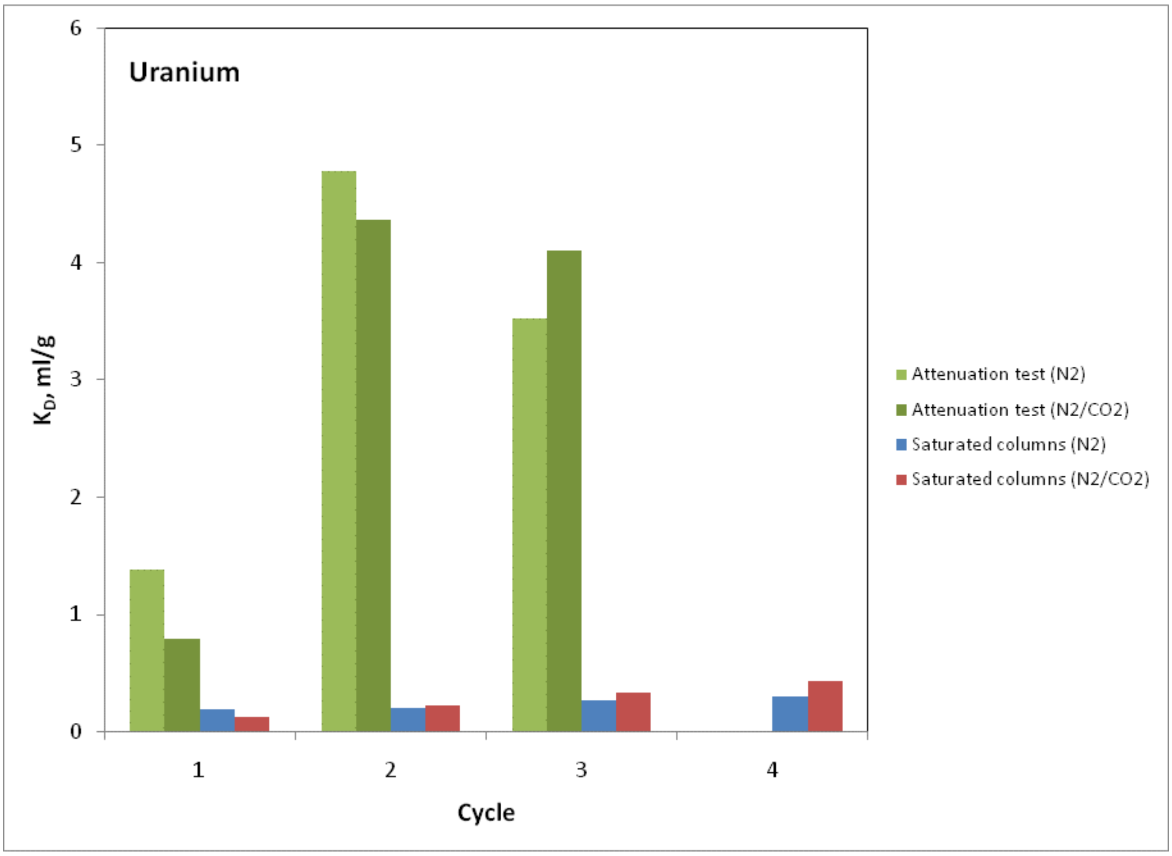


Figure 6.3: Uranium sorption onto Andamooka Limestone, up to four cycles of percolate addition and different experimental conditions

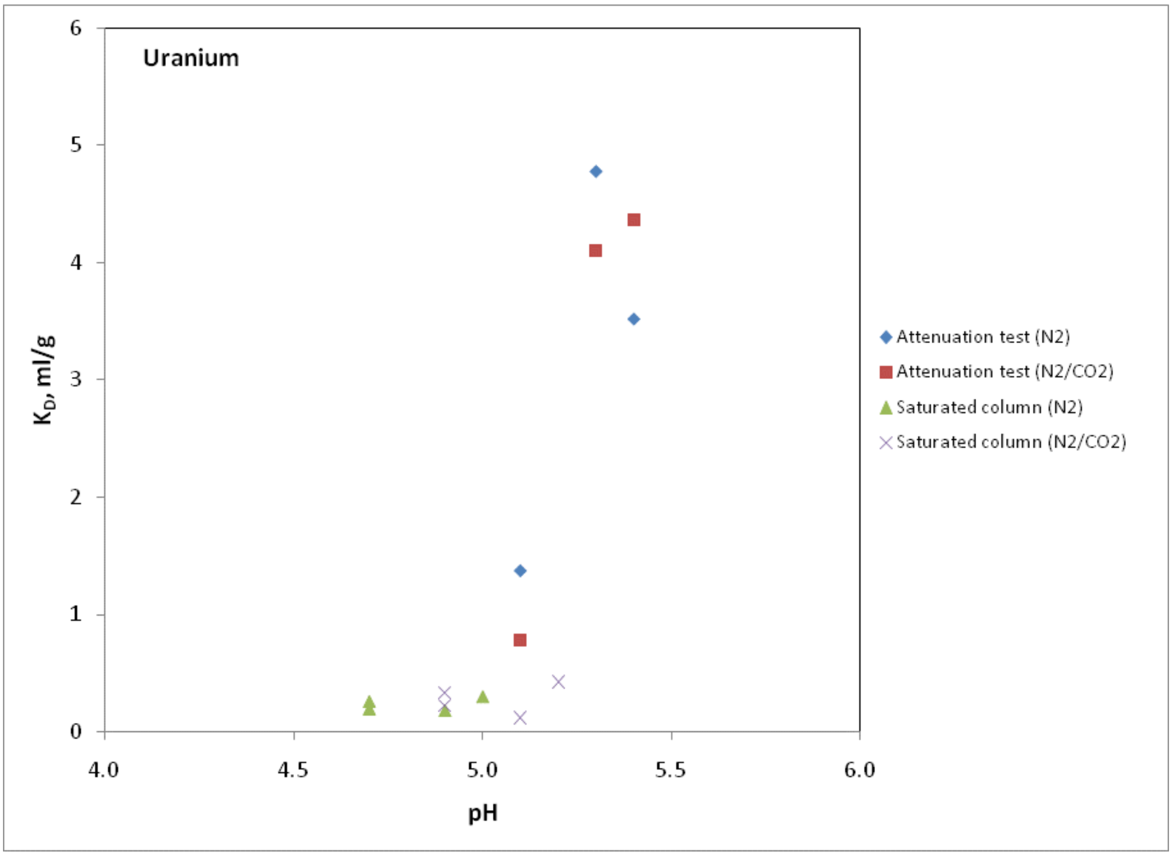


Figure 6.4: Uranium sorption onto Andamooka Limestone plotted as a function of solution pH

7 Arcoona Quartzite: Results and Discussion

7.1 Mineralogy

Previous studies (ENSR, 2008 and references therein) have reported that the Arcoona Quartzite is subdivided into three sub-units:

- Transition sub-unit (immediately underlying the Andamooka Limestone) – mainly quartz (>70%(wt)), accompanied by feldspars, muscovite, chlorite and hematite.
- Red Arcoona sub-unit – slightly less quartz (~60%(wt)) and a more significant mica, clay and hematite content.
- Deep White Arcoona sub-unit – predominantly quartz (>90%(wt)), with minor feldspar, chlorite and hematite.

In the current assessment mineralogical analyses were undertaken for two samples, one from each of the Red and White Arcoona sub-units (the results are shown in Appendix 4). The mineralogical analyses were consistent with the descriptions given above.

7.2 Bulk Chemistry Solids

The elemental concentrations in the three quartzite samples generally corresponded to average ‘crustal’ abundances. No elements were found to be enriched.

7.3 Acid-Base Accounting

Previous studies (ENSR, 2008 and references therein) have classed the Arcoona Quartzite as non-acid forming (NAF). A summary of previous results are reproduced in Table 7.1, along with results obtained for the three samples analysed as part of the current programme. Based on the results shown, the samples have very low total sulphur contents and the ANC values generally are lower than previously reported. Although the samples may be classed as potentially acid forming (PAF) based on the NPR of less than 3, the net potential for acid generation is insignificant. Furthermore, because of the very low total sulphur content, sulphate was not determined and the MPA likely overestimates the potential for acid generation. The material would therefore not be considered net acid forming.

Table 7.1: Acid Base Accounting Results for Arcoona Quartzite

	Total sulphur, %(wt)	MPA, kgH_2SO_4/t	ANC, kgH_2SO_4/t	NAPP, kgH_2SO_4/t	NPR
Summary statistics from previous studies					
Minimum	0.01	0.3	2		
Maximum	0.51	15.6	530		
Mean	0.19	5.8	112.7	-106.9	19
Results from the current programme					
Red Arcoona (ODXcore4)	0.06	1.8	<0.5	0.9	0.22
Red Arcoona (ODXcore5)	NM	-	2.6	-	-
White Arcoona (ODXcore3)	0.11	3.4	1.9	1.4	0.57

Notes: MPA=Maximum potential acidity, ANC=Acid neutralising capacity, NAPP=net acid producing potential (MPA-ANC), NPR=net potential ratio (ANC/MPA), NM=not measured

7.4 Physical Characteristics

Surface areas and cation exchange capacities (CECs) measured for the crushed Arcoona Quartzite samples were low, with a surface area of up to 4 m^2/g and a CEC of up to 2.2 meq/100g, respectively (Table 7.2).

Table 7.2: Physical Characteristics of the Arcoona Quartzite

Sample	BET surface area, m^2/g	Cation exchange capacity, meq/100g[1,2]
Red Arcoona (Core 4)	4	2.2
White Arcoona (Core 3)	1, 1[3]	0.4

Notes:

1. The cation exchange capacity measurements were undertaken after first pretreating the sample to remove soluble cations.
2. The cation exchange capacity given in the table includes contributions from exchangeable Ca, Mg, Na, K and Al. Exchanges sites were predominantly occupied by calcium ions (77 to 98%) (Appendix 4)
3. Duplicate analyses were undertaken for this sample.

7.5 Water-Rock Interactions

The focus for the testing of the Arcoona Quartzite was the potential interaction with neutralised percolate solutions (based on the premise that percolate would be neutralised as flows the Andamooka limestone before it enters the Arcoona Quartzite). Both static and kinetic test methodologies were used (Table 7.3) to establish the potential interaction.

Table 7.3: Summary of Water-Rock Interactions Assessment for the Arcoona Quartzite

Organisation	Date	Experimental Conditions	Water:Rock Ratio	Number of cycles
Interaction with neutralised metalliferous percolate: Static Attenuation Tests				
CSIRO	Current	Deoxygenated water (N_2 atmosphere)	2	3
CSIRO	Current	Deoxygenated water (N_2/CO_2 atmosphere)	2	3
Interaction with neutralised metalliferous percolate: Kinetic Attenuation Tests[1]				
CSIRO	Current	Saturated columns, N_2/CO_2-equilibrated water	0.2[1]	4

Notes:

1. The water-to-rock ratio is estimated on the basis of the dry mass of solid occupying the column, combined with the volume of leachant per cycle.

7.5.1 Mineral Reactions

Percolate passing from the Andamooka Limestone into the Arcoona Quartzite is expected to be at a near-neutral pH, but may contain relatively high dissolved carbonate (due to the previous contact with carbonate-rich materials) and supersaturated carbonate mineral forms. Precipitation of the carbonate minerals could ensue, possibly resulting in changes to the net porosity within the quartzite.

Results for saturated column tests undertaken (in duplicate) to examine possible interactions taking place as N_2/CO_2-equilibrated water percolates through quartzite are illustrated in Figure 7.1 and Figure 7.2. Figure 7.1 shows that the pH of the solution leaving the column is greater than when it entered the column. Figure 7.2 shows how that concentrations of some key major elements (Ca, Mg, Fe and Na) change between the inlet and the outlet. In all cases, the most significant changes take place within the first cycle of percolate displacement. Magnesium and calcium concentrations appear to increase in the outlet solution for the first cycle, whereas iron and sodium concentrations appear to decrease in the first cycle. Concentrations generally remain unchanged in later cycles.

The increased pH could be consistent with precipitation of carbonate minerals within the column. There is a coincident increase in dissolved Ca or Mg however suggesting a net release of these solutes from the Arcoona quartzite sample. Combined the increase in calcium concentration and the carbonate concentration of the inlet solution could cause the formation of calcite. However, elevated magnesium concentrations tend to inhibit the formation of calcite.

PHREEQC modelling was undertaken to assess the saturation indices of various carbonate minerals. The results indicated that that siderite is either supersaturated or close to equilibrium, whereas dolomite and calcite are under-saturated and would not be expected to precipitate. Whilst Fe concentrations do show a decrease, for the test conditions either siderite ($FeCO_3$) or ferrihydrite (as observed for the feed solution) could have been precipitated from solution. (Ferrihydrite is considered more likely because the kinetics for siderite formation at ambient temperatures generally are very slow.)

The observed decrease in Na concentration (K behaves analogously) could be explained by the potential formation of sodium and potassium jarosites. (PHREEQC calculations suggest that the outlet solutions are under-saturated with respect to Na-jarosite, but supersaturated with respect to K-jarosite.)

7.5.2 Contaminant Attenuation

Sorption of all minor and trace elements onto the Arcoona Quartzite was found to be negligible.

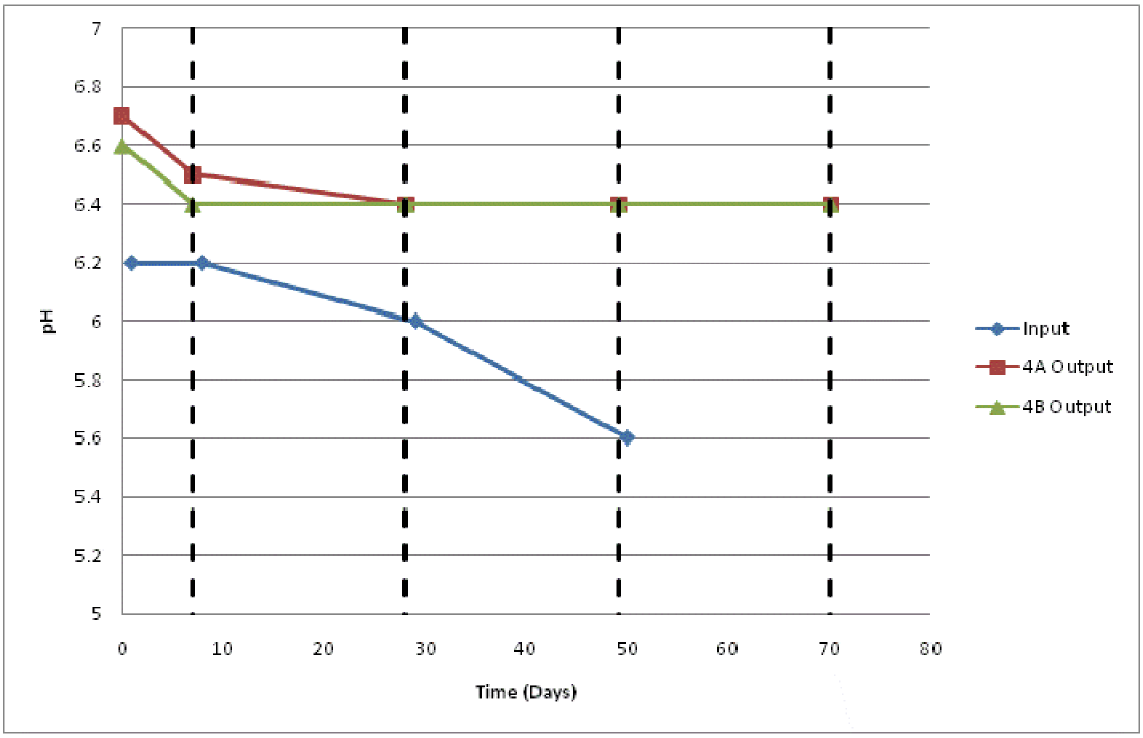


Figure 7.1: Inlet and Outlet pH for Arcoona Quartzite Saturated Column Tests

Note: The decrease in pH observed in the inlet solution over time likely reflects H^+ generation due to the oxidation of ferrous iron to ferric iron, followed by the formation of ferrihydrite (at near-neutral pH this conversion is very difficult to prevent, even under controlled atmospheric conditions). Figure 7.2 shows a concurrent decrease of the dissolved iron concentration in the inlet solution.

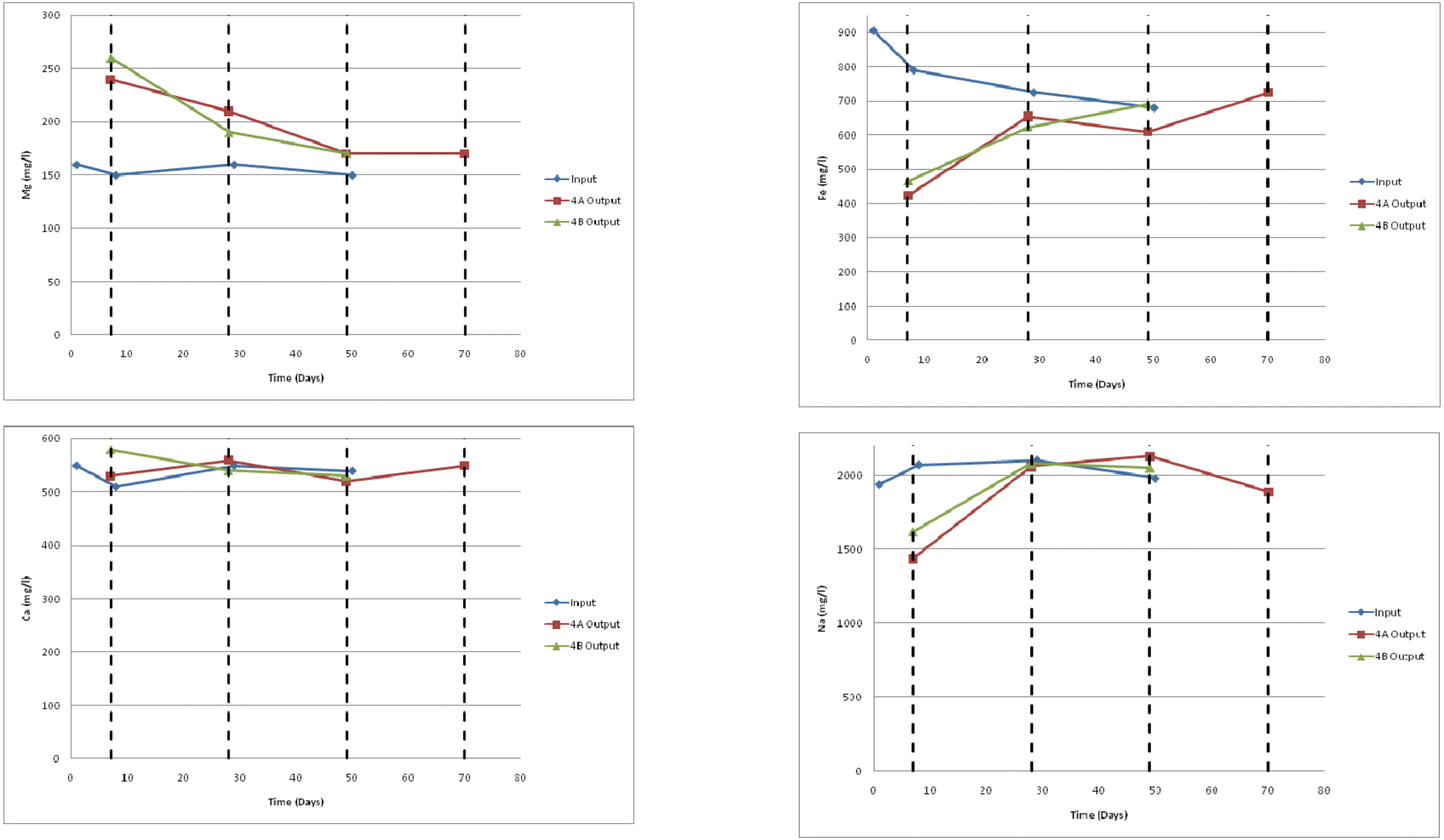


Figure 7.2: Evolution of inlet and outlet Mg, Ca, Fe and Na concentrations in Arcoona Quartzite saturated columns

8 Predictive Modelling

8.1 Acidity Balance

8.1.1 Operational

The TSF would be developed as a series of 9 cells (Cell 5 to 13, and an optional Cell 14), to be commissioned as required during the operational period. The TSF water balance can be used together with the tailings water quality estimates to determine the overall acidity loading that would accumulate within the TSF over time. The current water balance estimate indicates that the net process water inflow to the TSF would be about 149 900 m^3/day. About 8300 m^3/day of pond water would be decanted and recycled. Therefore about 136 600 m^3/day would accumulate in the TSF. Some of this water would be lost to evaporation but the associated acidity would remain in the TSF to, ultimately, be transported out of the tailings in percolating water.

Measured acidities in tailings porewater range up to 70 g/L (as $CaCO_3$ eq.). Based on a total acidity concentration of about 70g/L, the total acidity loading to the TSF (9 cells, 3600 ha, 25 year operating period) would be about 3880 kgH_2SO_4/m^2, or less. Depending on the secondary mineralisation that may occur in the tailings, most of the acidity could be expected to be mobile and would be released in the very long term.

The tailings solids also have a potential for acid generation from the oxidation of residual sulphide minerals. During operations, this potential is unlikely to be realised (because the tailings are saturated and supply of oxygen to reactive sulphides would be limited); however, over time as the cells drain down, these residual sulphide minerals could contribute up to an additional 900 kgH_2SO_4/m^2 of acidity loading (assuming an acid generation potential of about 10.6 kgH_2SO_4/t and an average height of about 65 m for the TSF cells).

Combined, the total potential acidity loading therefore is estimated to be about 4780 kg H_2SO_4/m^2.

Flow modelling showed that the rate of percolation across the footprint of an active cell would range from about 146 mm/year (or 4 m^3/Ha/day) during the first 18 months to two years of operation to about 36 mm/year (or about 1 m^3/Ha/day) in the later part of the operation. Because multiple cells could be operational at any one time, the total seepage from the TSF would vary over time and would be equal to the sum of seepage from each cell. Long-term average percolation toward the end of operations and during closure is expected to be about 3600 m^3/day (from 9 cells with dimensions of 2 km x 2 km). After draindown is complete, the percolation would decrease further to be equivalent of the rate of recharge from rainfall.

On entering sediments, flow may not continue at the same rate and would depend on the nature of sediments encountered along the flow path. During the operational period it can be shown that a cumulative acidity release over the entire TSF would on average be about 101 kg H_2SO_4/m^2 (or only about 2 % of the total potential for acidity release). The majority of the acidity would therefore be released only after operations cease, and at a much reduced rate.

The possibility that the available neutralising potential in the sediments may be subject to kinetic controls has been discussed in previous sections (Section 5.4.2). The testwork presented earlier in this report was used to estimate that acidic percolation must be resident for at least 100-200 days to allow full neutralisation to take place. If seepage flow rates are rapid, slow reacting neutralisation potential may not be entirely effective in neutralising pH. Using the flow rate that applies as the seepage leaves the base of the tails (0.036 m/yr), residence times would be between 100 and 1200 days for a metre thickness of sediment with water contents between 1% and 10%. Should more rapid rates apply in parts of the sediment (if flow is focused along preferential flow paths) then residence times will get shorter and complete neutralisation may occur over longer distances travelled. In general however, where sufficient neutralisation capacity is available, complete neutralization would tend to occur within 1 m or less of flow depth.

Acidity released from the TSF would result in the consumption of ANC in the underlying sediments. The thickness of sediment affected would depend on its ANC (which ranges from negligible to a maximum of 959 kgH_2SO_4/t). Figure 8.1 shows the estimated thickness of potentially affected sediment (as a function of ANC) for different elapsed periods of TSF operation. The median ANC for the sediments is of order of 50 kgH_2SO_4/t. On the basis of this value, after 25 years of TSF operation, the thickness of ANC-depleted sediment would be about 0.7 m.

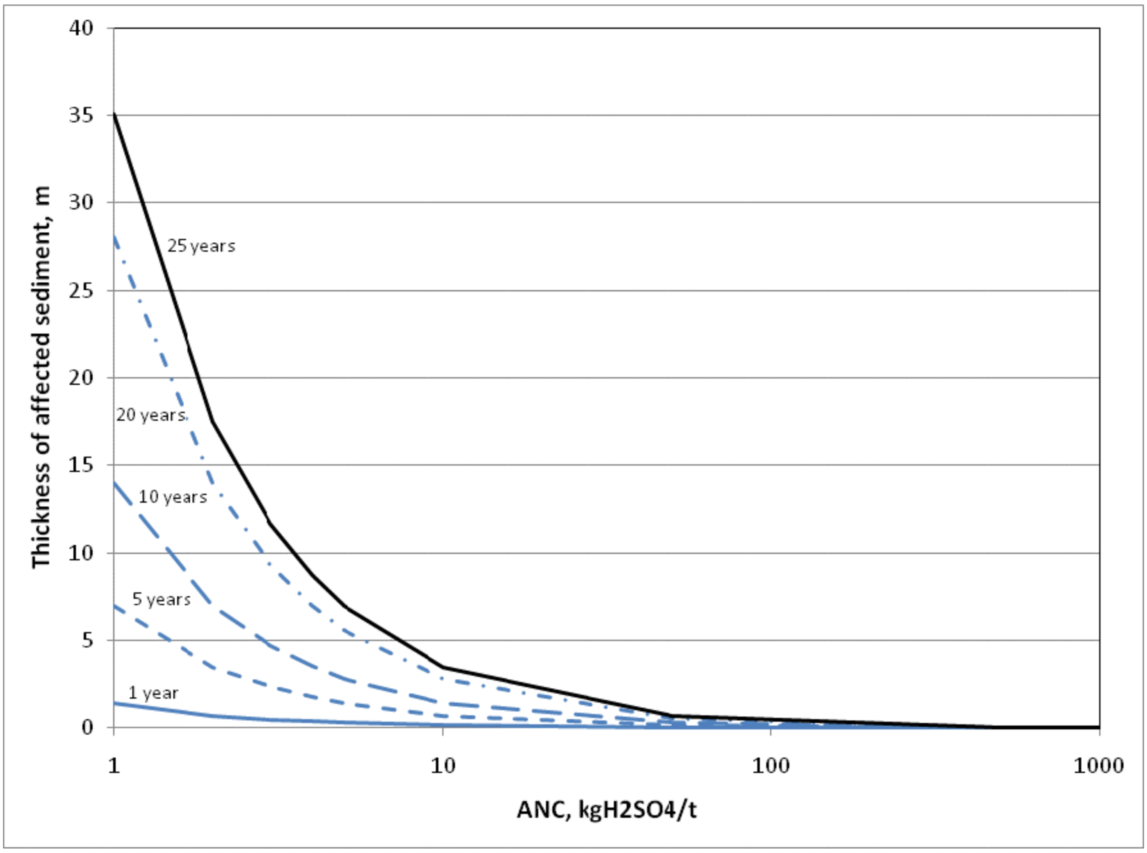


Figure 8.1: Thickness of affected sediment after different periods of TSF operation, as a function of sediment neutralising capacity

The current TSF cells (Cells 1 to 4) were commissioned over the period 1988 to 1999. Neutralisation of percolating acid is evidenced by gypsum precipitation at the tailings interface (e.g observed changes in mineralogy for sample H1.2-09S (sediment) and H1.2-09T (tailings) (Appendix 4). Based on Figure 8.1, the expected depth of ANC depletion for sediments containing on average about 10 kgH_2SO_4/t would be about 3 m, but could greater for sediments with very little ANC or less for samples higher initial ANC values. Observations made in the current and previous characterisation programmes indicated depths of depletion ranging from less than 1 m to about 3 m below the tailings interface. Based on the variability of the ANC in the sediments, these observations are consistent with the projected depths of depletion shown in the figure.

The progress of the acid front as a function of time based on paste pH and EC profiles beneath the tailings has been determined at different times:

- Davy and Green (1993) – acid front had reached a depth of up to 0.4 m;
- EGi (2005) – depth of up to 2 m;

- EGi (2006) – depth in excess of 3 m.

Figure 8.2 plots paste pH measurements made during the current field programme as a function of depth. In the majority of cases (in common with previous studies), there is an abrupt change in paste pH that coincides with the tailings/sediment interface. In five of the seven boreholes, the 'acid front' extends less than a metre into the underlying sediments. Results for borehole H4.1 indicated an acidic paste pH to a depth of almost 2 m below the interface. In the seventh hole, H2.1, acidic paste pH values were observed to a depth of up to 10 m from the interface.

For H2.1 the underlying sediment comprises dune sand as opposed to the clay-rich sediments logged in the case of the other holes. The greater penetration of an acid front in the case of H2.1 reflects the fact that sandy sediment has a lower ANC and therefore a lower capacity to neutralise acidity. Note that that drillhole did not encounter tailings; rather, a mixture of tailings and embankment construction materials were encountered throughout depth of the drillhole down to the natural terrain underlying the TSF. The pH profile of drillhole of the 'naturally neutralised' tailings contained in H2.1 overlying the natural sediments and soils ranged from about 6.5 to 7 providing ample evidence that neutralization of tailings porewater will proceed to fully neutralised conditions. Because the overlying profile is not acidic, it is apparent that the acid front detected within the underlying dune sand is likely due to tailings percolate that has travelled laterally from another location. The sandy sediment is more permeable to water flow than other sediment types and would act as conduits for lateral seepage flow under the TSF, should vertical flow paths encounter impermeable horizons within the sediments.

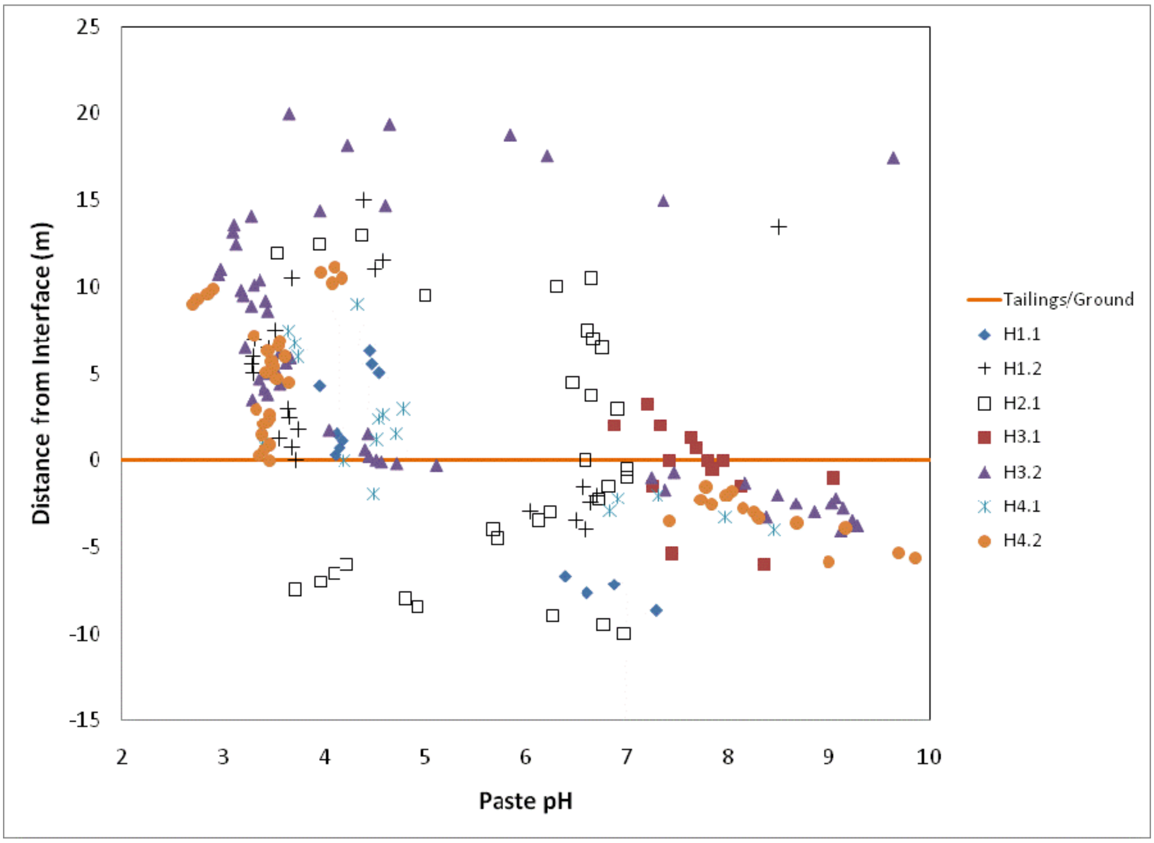


Figure 8.2: Field paste pH plotted as a function of depth

Based on the results presented above, the rate at which the acid front moves through the underlying sediment is variable, ranging from about 10 centimetres per year (clay-rich or carbonate-rich sediments) to perhaps in excess of 1m per year (sandy sediments, dune sands). That most of the TSF is underlain by the clay-rich and carbonate-rich sediments is evidenced by the fact that the majority of measurements to-date show that the acid front has penetrated only very small distances beneath the TSF. Thus, to a large extent it is expected that acid seepage during the operational period, will be neutralised within soil/sediment layer immediately underlying the TSF to a depth ranging from 2 m to in excess of 10 m depending on the type and ANC of the sediments encountered.

Some proportion of flow of flow could reach the Andamooka Limestone due the formation of preferred flow paths through the dune sands. However, the acidity will be neutralised by the abundant dolomite contained within this formation.

8.1.2 Post Closure

As noted before, the acidity loading present in seepage losses during the operational life of the TSF would be about 101 kgH_2SO_4/m^2, representing about 5% of the estimated potentially mobile acidity in the TSF. This means that the majority of the acidity would still be present in the tailings deposit at the end of operations.

After tailings deposition ceases a period of drain-down would occur during which seepage rates gradually decrease. In the long term, percolation rates will be dictated by recharge from natural precipitation and are expected to be very low.

Figure 8.3 shows the estimated thickness of sediments that would be required to neutralise the entire acid load in the TSF, as a function of sediment neutralising capacity.

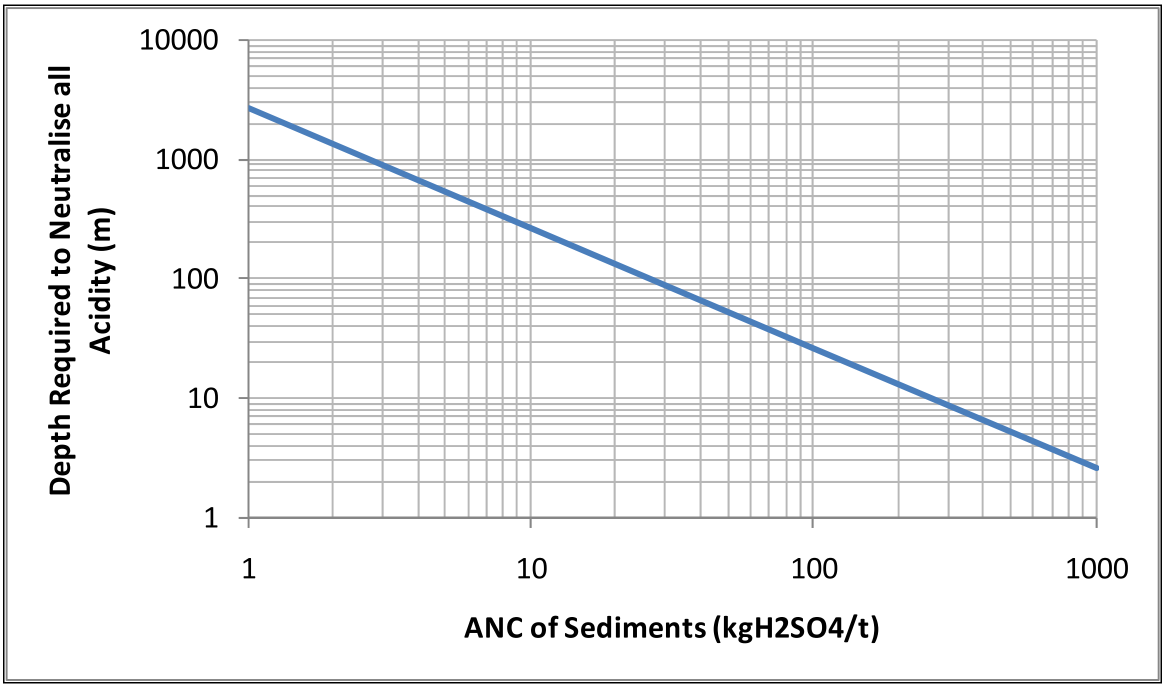


Figure 8.3: Thickness of sediment that would be required to neutralise total TSF loading, as a function of sediment neutralising capacity

Underlying the TSF are approximately 10 m of soils and sediments. With a total potential acidity loading of about to 4780 kgH_2SO_4/m^2 expected from the tailings, an average ANC of about 266 kg H_2SO_4/t would be required in the sediments to ensure neutralisation within a 10 m thick layer. The actual ANC within the sediments and soils however ranges from less than 0.5 to about 959 kgH_2SO_4/t. Furthermore, field investigations indicated that the sediment and soil layering is discontinuous and variable with depth across the footprint of the TSF. Consequently, whilst most of the acidity could be neutralised locally within the sediments, there will be localised areas where the ANC will be less than the estimated 266 kg H_2SO_4/t requirement and the acid front would be expected to break through the sediments and soils layer.

The Andamooka Limestone underlies the soils and sediments with a thickness of up to 60 m. The ANC of the Andamooka Limestone varies from about 120 to 930 kgH_2SO_4/t, with an average of about 480 kgH_2SO_4/t. At the average neutralization capacity, all of the acidity that may be released from the TSF could be neutralised within a depth of as little as 1.8 m of the limestone, discounting any neutralisation that may have occurred in the sediments. At the average ANC, all of the acidity would be neutralised within a depth of about 3.75 m. However as noted in Section 6.3, the ABCC results suggest that the ANC estimate may underestimate the available neutralisation capacity and, consequently, the depth of neutralisation could be less.

8.2 Tailings Source Term Assessment

8.2.1 Tailings Percolate Loadings

During the operational period, seepage water quality in general would correspond to that measured in the current tailings porewaters. Based on the long term steady state seepage rate the estimated solute loadings in the percolate are given in Table 8.1. The highest loadings would be for the major elements comprising Na, Fe, Al, Cl and SO_4. In addition Ca, Co, Cu, F, K, Mg, Mn, U, Zn loadings would be significant.

These loadings would be released from the base of the facility during active operation of the TSF, and during draindown.

As drain-down proceeds, chemical conditions in the TSF deposit could change, possibly becoming more neutral due to dilution with infiltrating rainwater. This may lead to the precipitation of supersaturated minerals which would attenuate acidity within the tailings. Therefore in the later stages of drain-down percolate loadings for some elements would tend decrease below the estimated loadings. The laboratory programme results furnished some insights to rate of contaminant release under such conditions (at a laboratory scale). The results suggest that for many contaminants, long term percolate loadings may be controlled by solubility.

Table 8.2 shows estimated long term annual solute loadings. For many solutes the long term loadings are expected to be negligible. These solutes are likely present in the form of residual minerals that are resistant to leaching by water, due to either low solubility under the prevailing conditions, or slow reaction kinetics. The solutes that would have significant loadings would be restricted to the more mobile salts comprising Ca, Cl, Cu, K, Mg, Si, and SO_4, albeit at much lower rates that estimated for operational conditions. For example Cl and SO_4 loadings would decrease decrease by a factor of 500 or more. Elements that may continue to show significant loadings would include Al, B, Fe, Mn, Sr, and U.

After closure, the TSF is expected to generate percolate at a rate equal to the net infiltration of the rehabilitated surface of the facility. Net infiltration is expected to be very low and therefore percolation rates would also be low. Because of the low rates of infiltration and the large amount of soluble products associated with the tailings, the time to flush or remove the solutes from the tailings would be very long (several millennia) and therefore porewater concentrations would remain at or near current concentrations for a long time. However, because of the low flow rates, the loadings of solutes would be low. For these low flow rates the contact time in the underlying sediments would be very long, and neutralisation would be expected to proceed to completion as discussed in the next section.

Table 8.1: Estimated annual percolate loading during TSF operation

Parameter	Contaminant loading, kg/ha/yr*					
	Based on extracted porewater chemistry			Based on data from piezometer-sourced samples		
	min	p50	max	min	p50	max
Cl-	148	1512	1855	853	1136	1473
SO_4^{2-}	2111	14703	27259	3597	9930	15792
F	5	11	21	1605	2958	4292
PO_4^{3-}	0.005	0.2	0.4	-	-	-
Na	163	1204	1438	993	1220	2681
K	15	176	275	32	202	288
Mg	159	210	275	158	264	532
Ca	23	268	612	179	221	327
Fe	2	2683	10539	525	2284	2755
Al	1	2028	3049	263	2627	4164
Si	2	16	73	-	-	70
As	0.004	0.03	0.08	-	-	0.02
Ba	-	0.01	0.02	0.001	0.01	0.02
Cd	-	-	0.01	0.001	0.03	0.09
Co	-	15	44	-	14	24
Cr	0.01	0.4	0.9	0.1	0.3	0.5
Cu	0.02	2	130	-	-	160
Mn	-	-	85	9	42	77
Mo	-	-	0.1	-	0.0001	0.02
Ni	0.01	2	3	1	2	3
Pb	-	-	-	-	-	0.3
Ra-226	-	-	0.0003	-	-	-
Sb	-	-	-	-	-	0.0004
Se	0.03	0.2	0.3	1	1	2
Th	-	-	2	-	-	-
Ti	-	-	0.07	0.01	0.01	0.02
U	3	32	191	2	64	128
V	-	-	0.3	0.1	0.2	0.3
Zn	-	-	11	-	-	16

Notes: * - Ra-226 loadings in Bq/ha/yr; “-“ indicates concentrations below detection limits.

Table 8.2: Estimated annual percolate loading (post closure)

	Contaminant loading, kg/ha/yr				
	Unsaturated conditions			Saturated Conditions	
Element	Acidic Percolate (H3.2-05)	(H4.1-04)	(H3.2-01)	(H3.2-01)	(H3.2-01)
Acidity (as $CaCO_3$)	1.21	0.158	0.165	0.254	0.0996
Alkalinity (as $CaCO_3$)	-	0.451	1.71	1.57	1.17
Sulphate	21.7	22	17.1	25.6	35
Chloride	0.281	0.326	0.944	5.94	1.78
Fluoride	-	-	-	0.00109	0.00111
Al	0.0273	0.0043	0.000161	0.00653	0.000826
Sb	-	-	0.0000165	0.000016	0.0000165
As	0.000457	0.0000387	0.0000286	0.0000641	0.0000496
Ba	0.000416	0.000371	0.000478	0.000359	0.000502
B	0.00272	0.00284	0.00658	0.0208	0.0154
Cd	0.00000842	0.0000168	-	0.0000405	0.0000111
Ca	8.83	8.66	7.34	10.4	14.9
Co	0.00696	0.0017	0.000688	0.00322	0.00378
Cu	0.275	0.000327	0.00415	0.0083	0.00345
Fe	0.0737	0.00713	0.000413	0.00145	-
Pb	0.0000721	0.0000195	-	-	-
Li	0.000139	0.000266	0.00108	0.00284	0.00197
Mg	0.00787	0.482	0.283	0.914	0.364
Mn	0.000356	0.00391	0.0202	0.0966	0.101
Mo	-	0.000192	0.0055	0.00471	0.00717
Ni	0.000248	0.00006	-	0.000032	0.0000826
K	0.11	0.0634	0.201	0.292	0.298
Se	0.000217	-	-	-	-
Si	0.377	0.217	0.0995	0.108	0.183
Na	0.0266	0.0603	0.102	1.72	0.265
Sr	0.0166	0.014	0.0675	0.0891	0.0917
U	0.00312	0.00118	0.0101	0.0313	0.031
Zn	0.000328	0.000124	0.000206	0.00131	0.000446
Be	-	-	-	-	-
Bi	-	-	-	-	-
Cr	0.0000619	0.0000178	-	0.000032	0.000033
Hg	-	-	-	-	-
P	-	-	-	-	-
Ag	-	-	-	-	-
S	7.22	7.32	5.7	8.54	11.7
Tl	-	-	-	-	-
Sn	-	-	-	-	-
Ti	-	-	-	-	-
V	-	-	-	-	-
Zr	-	-	-	-	-

Note: “-“ indicates concentrations below detection limits.

8.2.2 TSF Percolate Interaction

Field and laboratory results clearly indicate that the sediments and soils underlying the TSF neutralises the acidity and attenuates most solutes present in tailings percolate. The acidity balance further showed that an abundance of acid neutralisation capacity is available and that all of the acidity that may be mobilised from the TSF would be neutralize within the near-field of the facility.

Two primary attenuation mechanisms have been identified as follows: i) precipitation of secondary mineral phases, and, ii) solute sorption onto contacting mineral surfaces. The specific mechanism that applies varies from solute to solute and also depends on the prevailing conditions (i.e. pH, atmospheric conditions, redox etc.) and the sediment/soil.

Solutes removal through secondary mineral precipitation would proceed as follows:

- An immediate and sharp precipitation front corresponding to the point along the flow path where chemical conditions changed would occur; for example where the pH transitions from acidic to neutral. At this point the concentrations would tend to transition from the high concentration in the percolate to a low value in equilibrium with secondary mineral phase.
- Beyond the precipitation front, element concentrations in percolating waters will be constant at whatever solubility limit applies for the chemical conditions in question.
- The position of the precipitation front will migrate with the (be coincident with) the position of the acid neutralisation front in the sediments and soils, or the underlying Andamooka limestone.
- After the acidity has been depleted (i.e. the percolate from the TSF is no longer acidic) the solute concentrations would remain in equilibrium with the secondary mineral phase until it has been depleted through dissolution of secondary mineral phase. In other words the solute concentration would tend to remain constant over time for a period equivalent to the solute loading in the percolate from the TSF divided by the solute loading beyond the neutralisation front.

Solute removal occurring through sorption onto contacting mineral surfaces would proceed as follows:

- Solutes would tend to accumulate on mineral surfaces in those regions where conditions for sorption are favourable. An increase in sorption is likely to coincide with the point along the flow path when chemical conditions change from acidic to neutral (cationic species), or vice versa (anionic species). The solute would partition between the solid and the solution phases according to the K_D value.
- No matter what the solution concentration is, sorption would continue to take place along the flow path (as long as chemical conditions remain constant and favourable for sorption). The solution concentration would be progressively reduced along the flow path. The region of solid accumulation may be ‘smeared’ out over a greater distance than might be expected in the case of precipitation.
- Unlike secondary mineralisation, for protracted or very high solute loadings, the region of sorption and solid accumulation will gradually widen and extend to greater distances along the flow path, and may extend well below the acid neutralisation front. This is because close to neutralisation front it may be the case that the mass of sorbed solute already satisfies the K_D relationship. No further sorption would take place and so the dissolved load passes on (‘breaks through’ the neutralisation front) to be attenuated more remotely from the source provided the solid matrix has sufficient sorption capacity.
- Although sorption delays or retards the migration of high concentrations of dissolved element, it does not necessarily prevent ‘breakthrough’ (assuming the supply of the element from the source remains constant). Over very long times, solution concentrations above background levels and above those expected to be achieved by attenuation could be encountered significantly beyond the acid neutralisation front.

8.2.2.1 Evidence of Attenuation under Current TSF Cells

Paste EC is an approximate measure of dissolved metals in porewater. Figure 8.4 plots paste EC measurements made during the current field programme as a function of depth. In the majority of cases, there is an abrupt change in paste EC that coincides with the tailings/sediment interface. The results indicate and effective a reduction in dissolved solute loads within a metre of the tailings interface (and coincident with the position of the acid front). The exception is hole H2.1, which indicated elevated EC at greater depths, up to around 10m. As discussed in Section 8.1.1, this hole was located in dune sands (with no ANC) and hence the greater penetration of the acid front.

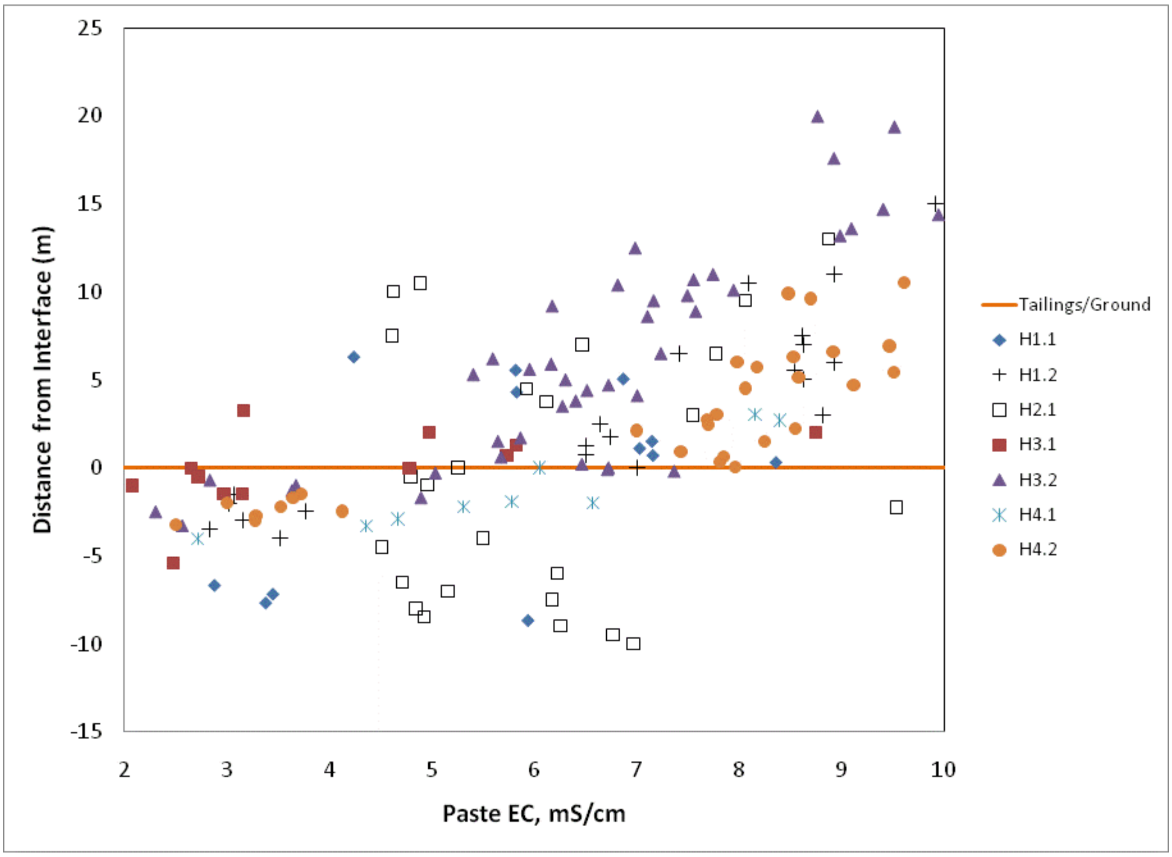


Figure 8.4: Field paste electro-conductivity plotted as a function of depth

Figure 8.5 to Figure 8.7 show how U, Cu, Co, Pb and Zn contents change as a function of depth away from the tailings interface. All of these elements show some evidence of accumulation within the sediment immediately underlying the tailings. Although poorly defined, the possible local extent of the zone has been indicated on the figures, based on concentrations in excess of considered ‘baseline’ values (as indicated by the RSF sediment data). Whilst copper, cobalt and zinc accumulation generally is restricted to a narrow zone immediately below the contact between the tailings and the sediments, limited results suggest that the zone may extend between 2 and 4m below the contact. Similarly, uranium mobility is limited to a narrow zone below the contact, but limited results suggest that the zone may extend locally to slightly more than 5 m below the tailings contact. Generally however the extent of accumulation appears to be limited to a very narrow band below the tailings.

Whether precipitation or sorption is the primary control causing the accumulation of these elements in the sediments cannot be determined unequivocally from the available information; either or both mechanisms combined could be plausible. However, the fact that uranium accumulation extends to greater distances would support a sorption mechanism.

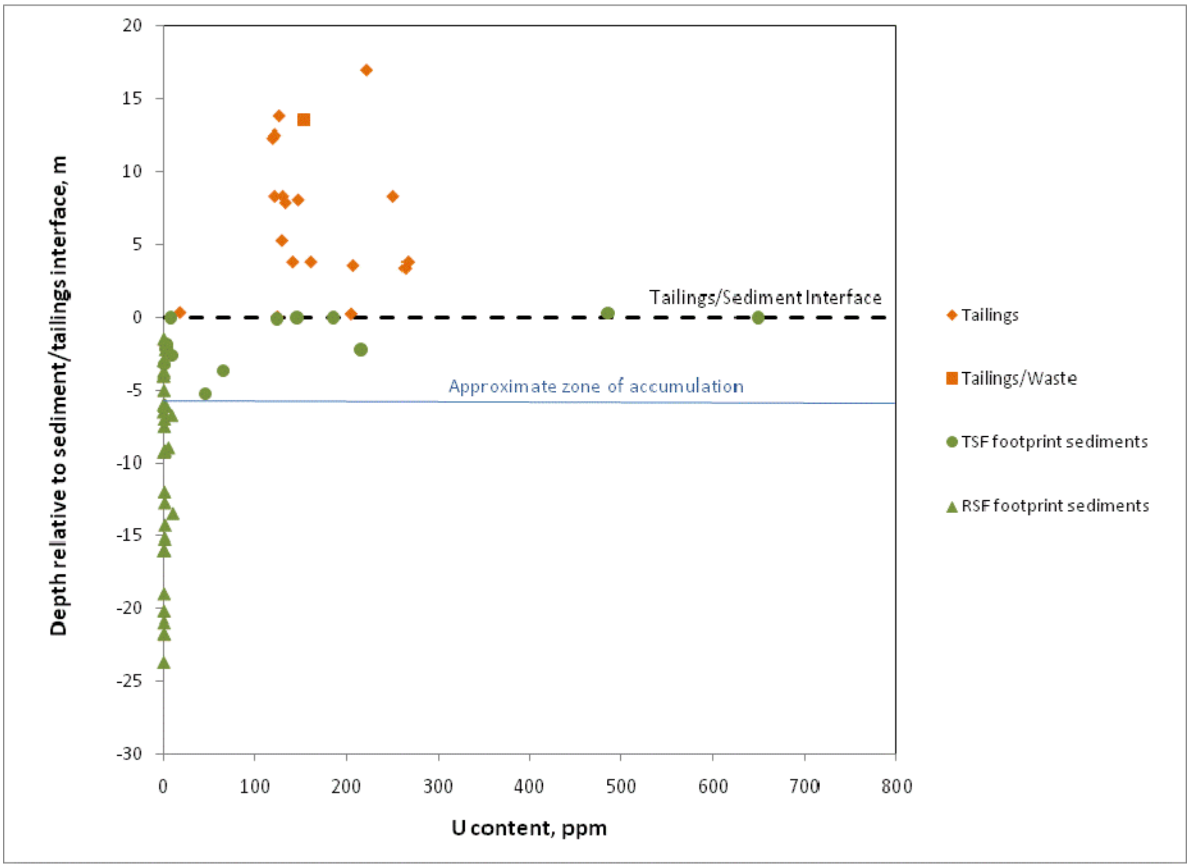
One sample with a high U content (H4.2-05; 648ppm U) was assessed for metal partitioning. As discussed in (Section 5.3), uranium was found to be preferentially associated with the adsorbed phases and the iron oxyhydroxide phases, supporting the conclusion that sorption could be the primary mechanism. The mass of uranium accumulated, 648 ppm, is consistent with the expected range of K_D values combined with solution concentrations in TSF seepage. For example, seepage with a U concentration of 100 mg/L (the median value for U concentration in TSF porewater) would be in equilibrium with an adsorbed concentration of 648 ppm if a K_D value of 6.5 mL/g is applied. This value is within the range of measured K_D values.

Conversely, solutes that showed more restricted zones of accumulation are likely controlled by secondary mineral precipitation. Partitioning testing involving a high Pb and Zn content sample (H4.1-10; 87.5ppm Pb and 222ppm Zn) showed that both Pb and Zn were associated with the residual phase.

No clear mechanism of accumulation in the sediments was found for some solutes. These solutes tended to fall into two categories:

- Elements present within TSF materials at concentrations higher than the baseline concentrations in the underlying sediments including: As, Ba, Hg, Mo, Ra, Sb, Sn, and Th. Profiles of arsenic and radium-226 contents as a function of depth are shown in Figure 8.8. Some of these elements such as lead (Pb) may be present as anglesite which has a low solubility, and may not be sufficiently mobile to be released from the tailings. Others that would show similar behaviour would include Ba and Ra. Other parameters such as As and Mo could be either sorbed or precipitated in the tailings, as indicated by the low concentrations measured in tailings porewater (see Table 4.5). As a result of these low concentrations in the percolate insufficient loading has occurred to the sediments to first cause accumulation, and second enable the verify the mechanism of accumulation.
- Elements present in the TSF materials at levels similar to or below those observed in the underlying sediments: Cd, Cr, Mn, Ni, Se, and V. Profiles of selenium and vanadium content as a function of depth are shown in Figure 8.9.

Of the elements that do show evidence of accumulation (U, Cu, Co, Pb and Zn), most show elevated percolate loadings during TSF operation (Table 8.1). The exception is Pb, which has very low loadings.



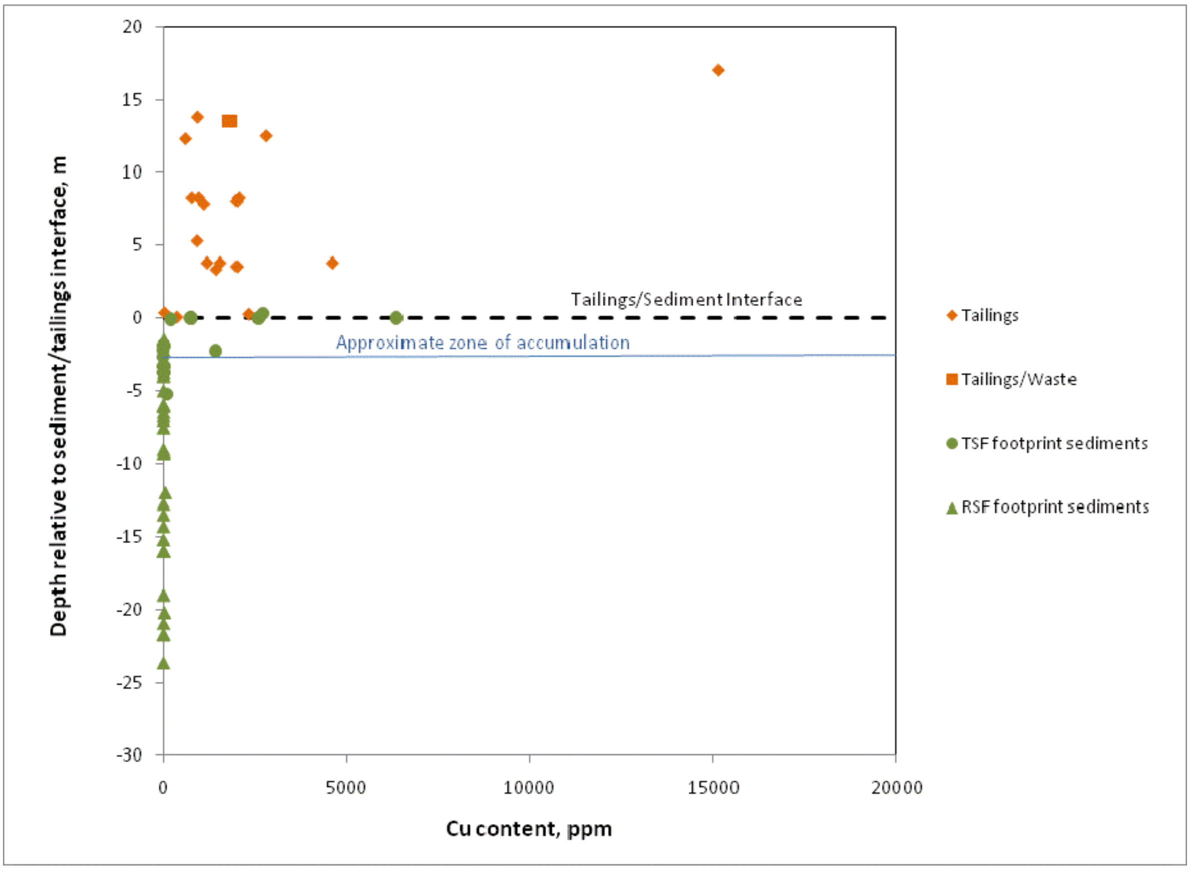
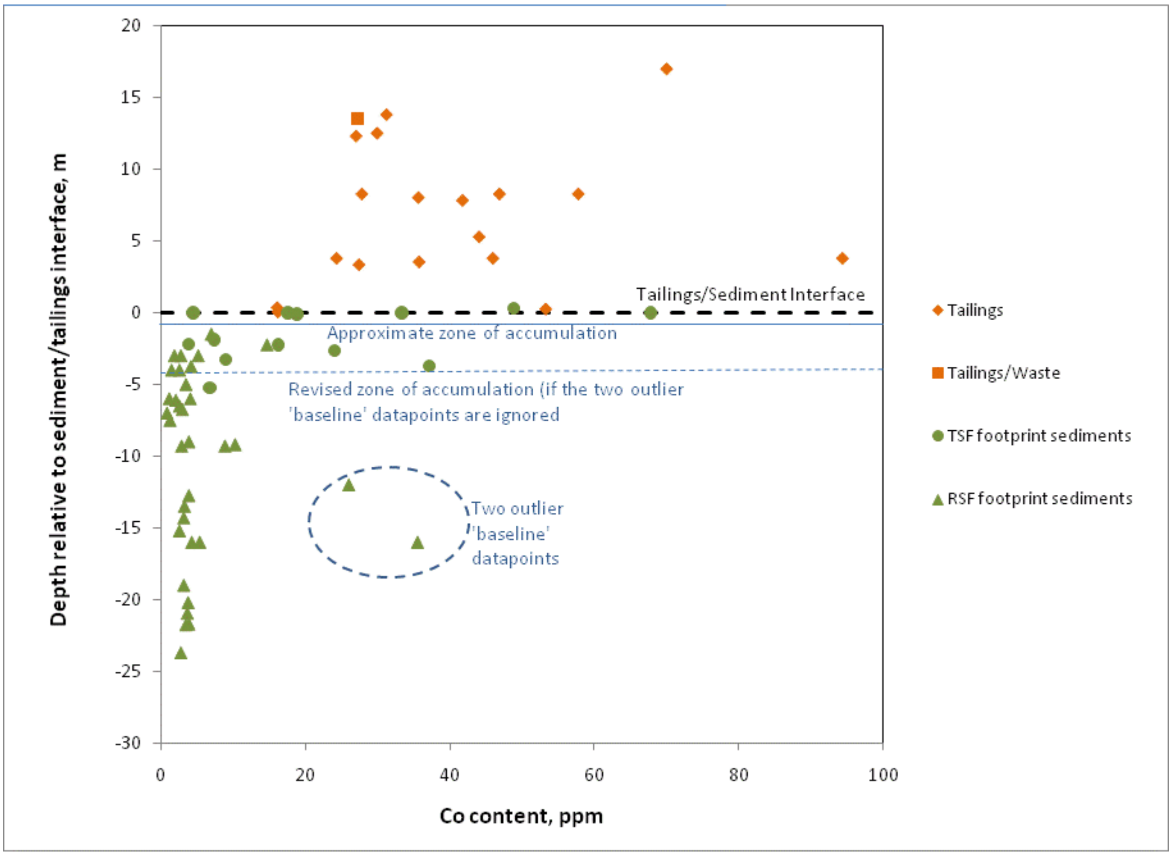


Figure 8.5: Uranium and copper content plotted as a function of depth



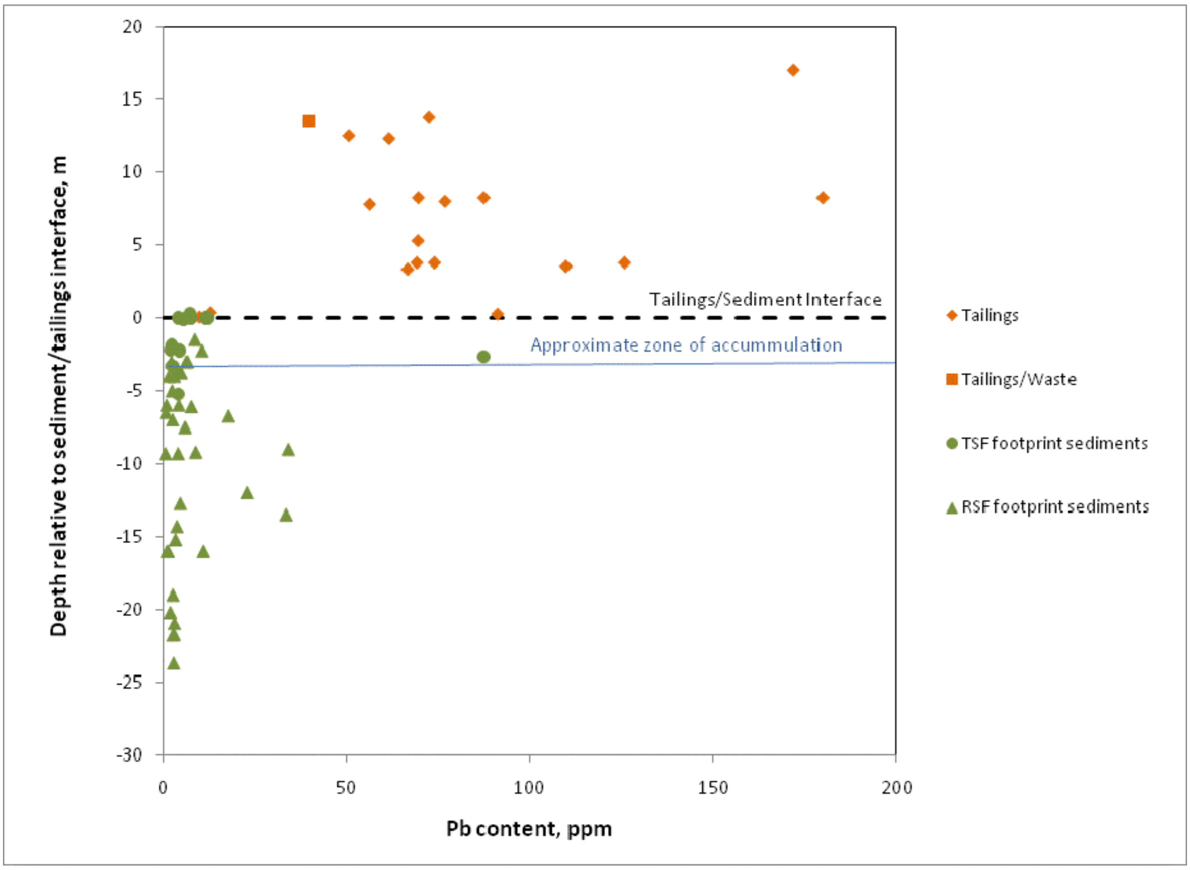


Figure 8.6: Cobalt and lead content plotted as a function of depth

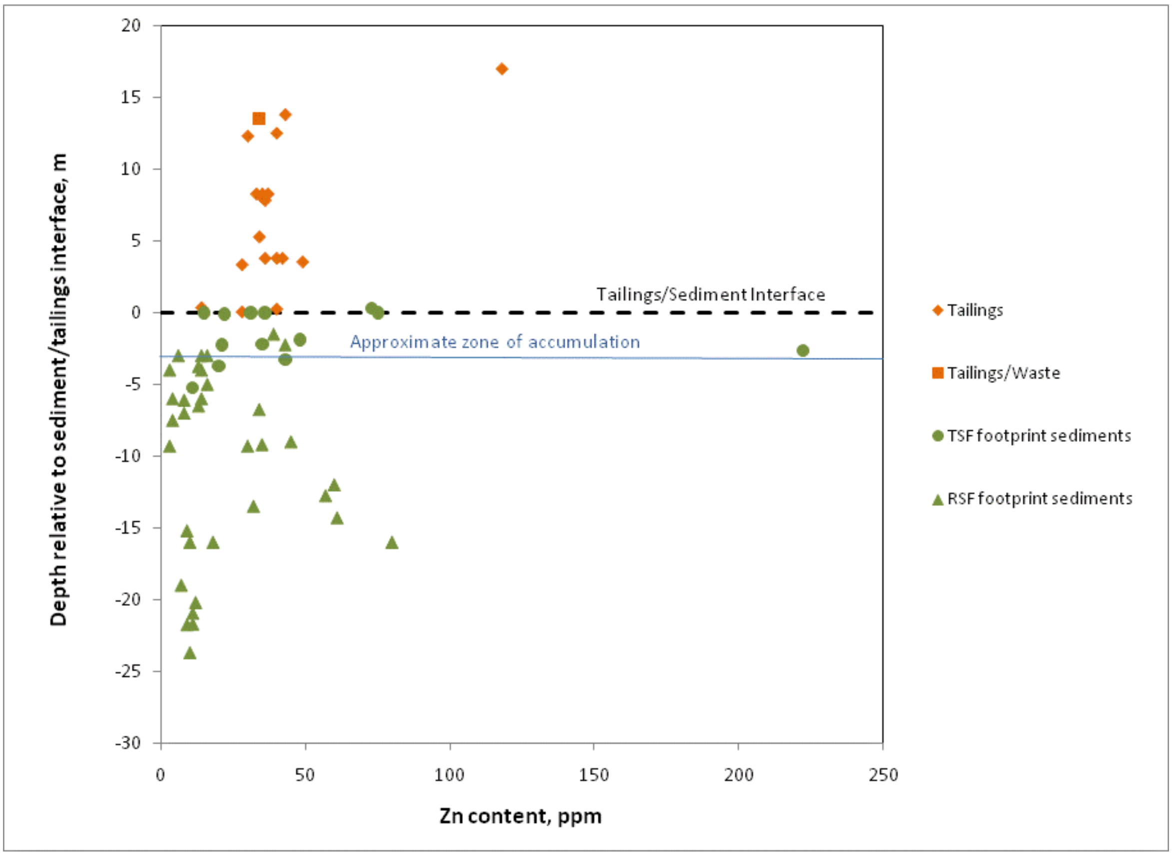
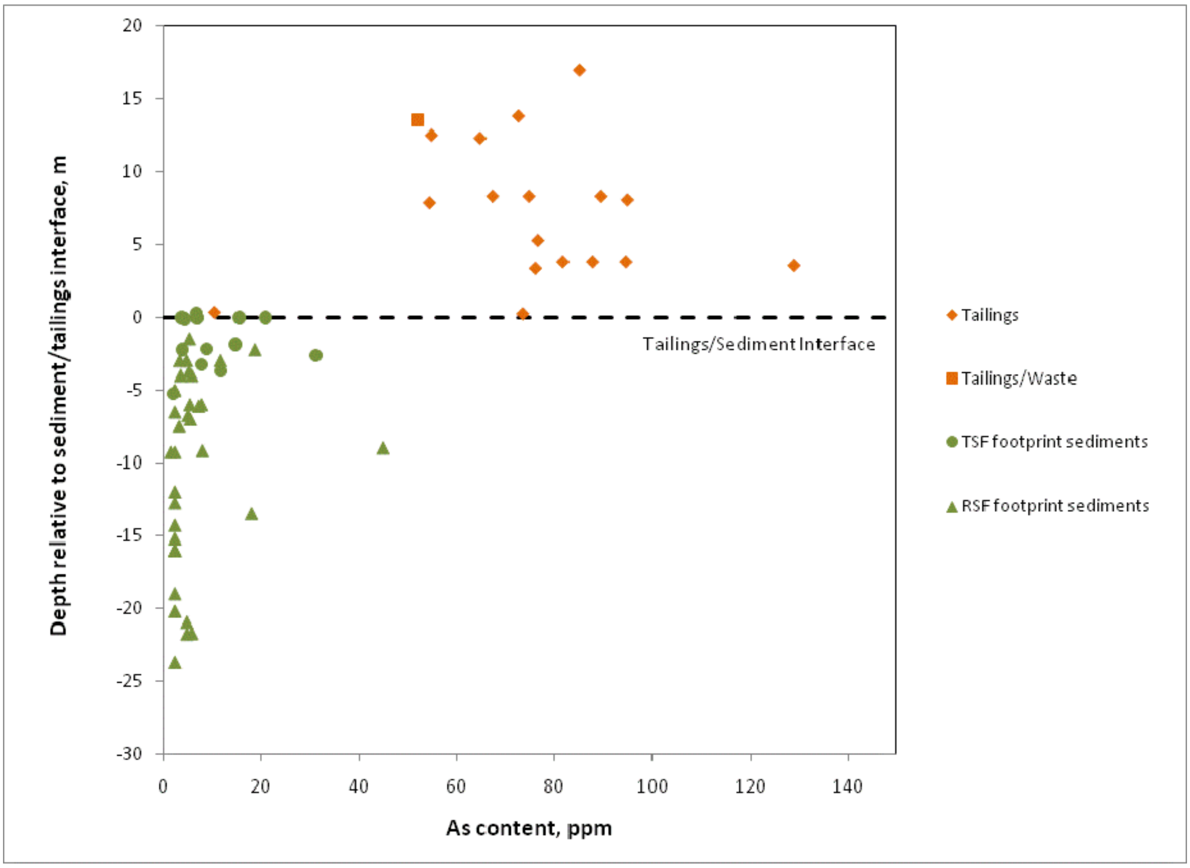


Figure 8.7: Zinc content plotted as a function of depth



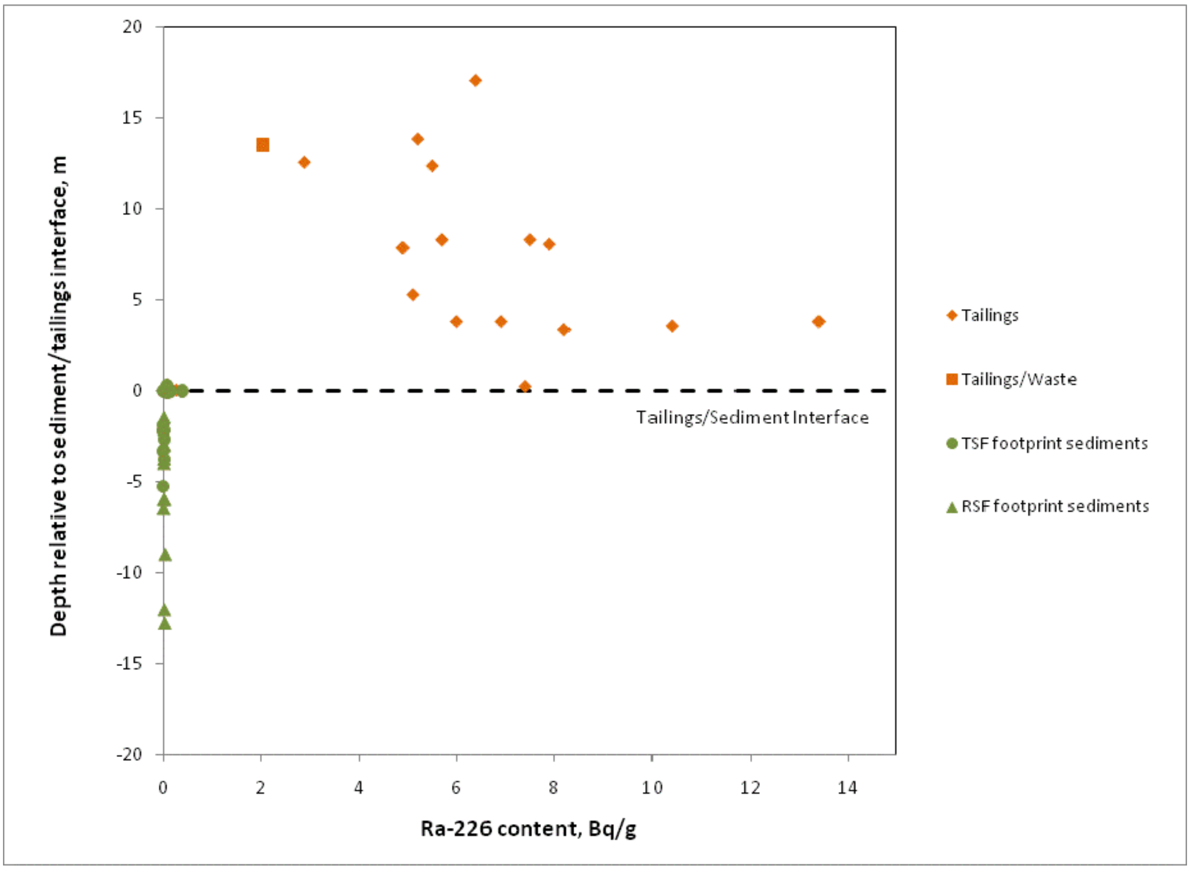
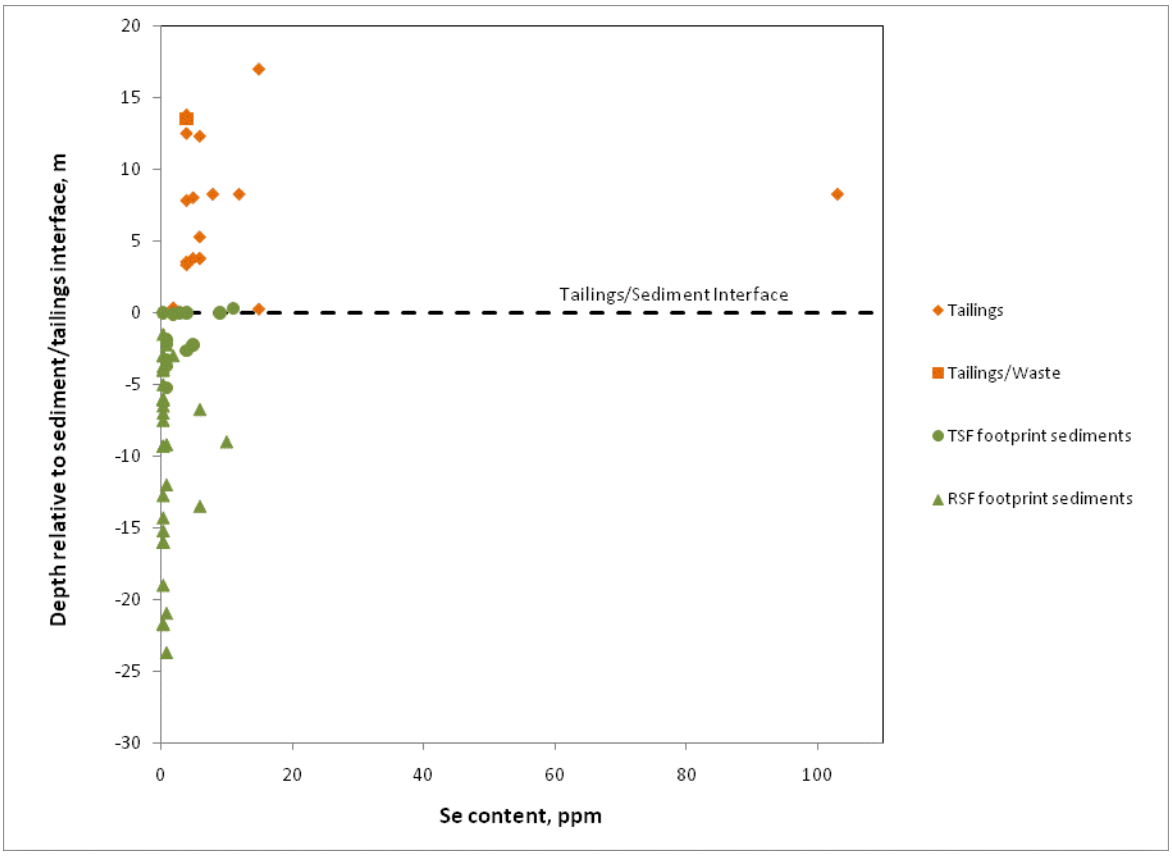


Figure 8.8: Arsenic and radium-226 content plotted as a function of depth



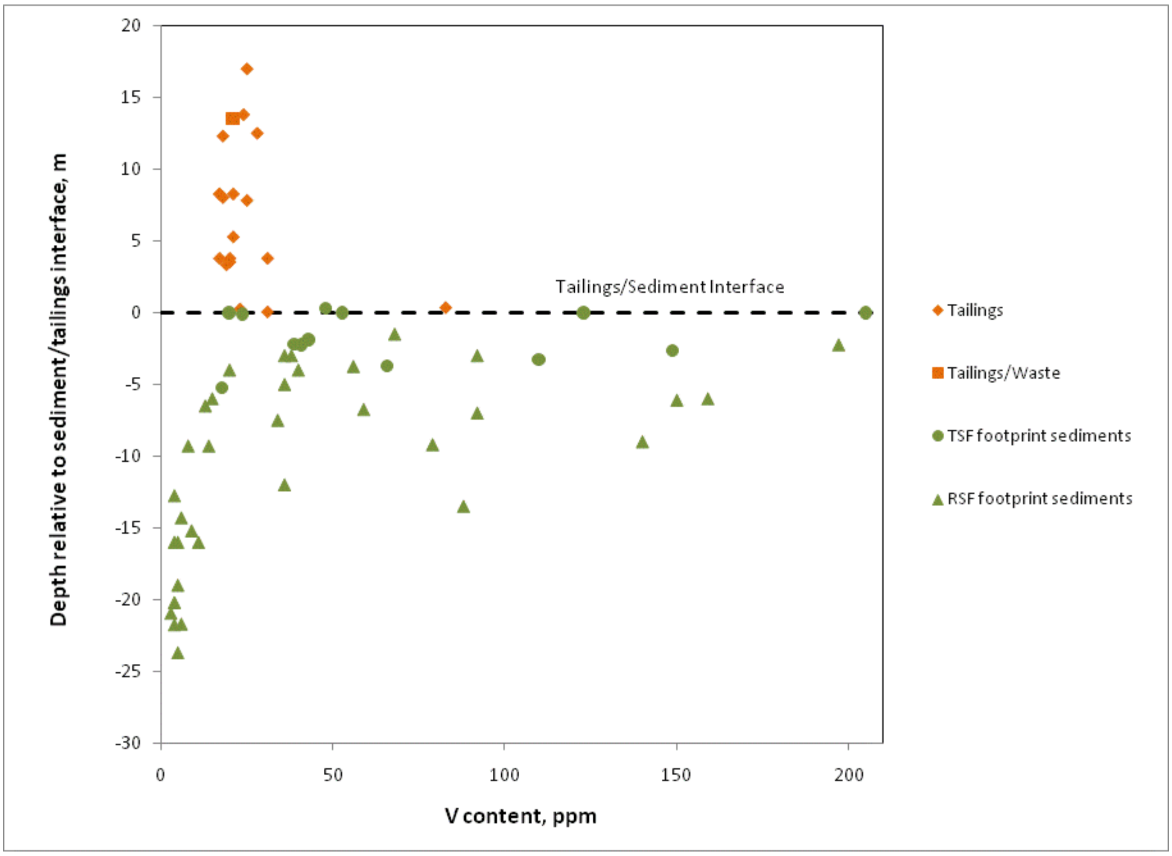


Figure 8.9: Selenium and vanadium content plotted as a function of depth

8.2.2.2 Long-Term Attenuation

Solutes whose mobility is controlled by a pH dependent solubility limit, as noted before the precipitation front over the long term would coincide with the position of the acid front (movement of the acid front is discussed in Section 8.1). The precipitation front would comprise a mineral assemblage that includes sulphates, oxyhydroxides and carbonates. As the acid front advances, minerals would dissolve and re-precipitate according to pH conditions. In the very long term the acidity would be depleted from the tailings so that the acid front would slowly diminish over time (i.e. neutral pH percolate from TSF would displace acidic porewater in the sediments downwards where it contacts neutralising minerals). Since there is a net abundance of neutralising capacity, especially in the Andamooka Limestone, the acidity would be neutralised in total and ultimately would cease to exist. Whilst a front of precipitates would remain after all of the acidity had been neutralised, solute concentrations would remain constant and in equilibrium with the secondary mineral phases at the prevailing conditions (pH, redox, pore gas conditions).

Carbon dioxide would be released from the carbonate minerals during the process of acid neutralisation. Since the release would occur beneath the TSF, with little opportunity for escape, the partial pressures of carbon dioxide at depth would increase and lead to a depression in pH and increased carbonate solubility. This is clearly evidenced in the water quality monitoring results within the water mound that has developed beneath the existing TSF where alkalinity (bicarbonate) concentrations are elevated above background levels, and the pH is depressed to about 6.5.

The elevated bicarbonate concentrations are coincident with higher uranium concentrations. For example, the monitoring results for boreholes LT05 and LT07 which are located in the Andamooka Limestone immediately below TSF Cells 1, 2 and 3, indicated average bicarbonate concentrations of 1116 mg/L and 1362 mg/L respectively. The corresponding uranium concentrations were 0.32 mg/L and 0.44 mg/L. Lowering of the pH is evident in borehole LT05 where the pH ranged from 5.83 to 6.91, with an average of 6.3, and that in borehole LT07 ranged from 7.4 to 6.28, with an average of 6.5.) The decrease in pH causes an increase in the solubility of some mineral phases. The slightly depressed pH may also affect sorption and attenuation reactions. But, as shown in the results of the current programme, the threshold pH value for uranium sorption is in the order of 4.5; at a pH range between 6 and 7 attenuation remains effective and the results indicate that the K_D values for uranium would be in the order of 25 to 35 mL/g within the sediments.

Therefore, for those solutes that are controlled by sorption, initially the sorption front would likely coincide with the acid front. However, should site accessibility and occupancy be saturated at the front, reduced sorption would cause the dissolved load to pass further along the flow path, in advance of the acid front to be sorbed at pH conditions closer to neutral. This effect will be mitigated to some extent by precipitation of iron and aluminium oxyhydroxides within the mineral assemblage at or immediately below the acid front (significant Fe and Al loadings are present in both short and long term percolates). These precipitates would increase the sorption capacity.

Over the long term, as the attenuation fronts migrate away from the base of the TSF, the influence of redox conditions will become more important. At greater depths reducing conditions would be encountered, due the combined effect of i) consumption of available oxygen by reactions such as the conversion of ferrous to ferric iron, and ii) slow supply of oxygen to reactive sites (due to the long travel distances to reservoirs of oxygen in air, either at the surface of the tailings deposit or at the perimeter of the deposit).

Since some solutes exist in more than one oxidation state, the prevailing redox conditions can have significant effects on geochemical behaviour of those solutes. Elements that exist in more than one oxidation state include Fe, As, Mo, Se, and U. Of particular interest is the behaviour of iron. Under oxidising conditions, the rate of oxidation of ferrous to ferric iron increases rapidly as pH increases and iron oxyhydroxides are readily precipitated from solution. As already discussed, these precipitates influence the behaviour of a sorption attenuation front. They may also incorporate other solutes (metals) as impurities, and so exert a solubility control on elements other than iron. Under anoxic conditions, ferrous iron will not be oxidised and would remain in solution so that the net mass of precipitate formed would be substantially less than is the case under oxidising conditions. The effectiveness of attenuation may therefore be significantly reduced both as a function of time (as the high ferrous iron loading in short term percolates consumes available oxygen) and with depth below the TSF (as the supply of oxygen becomes slower).

Mineral re-crystallisation and ageing may reduce the potential for remobilisation. Secondary minerals become more stable (i.e. less susceptible to dissolution) when they age to more crystalline equivalents. During this process there is the potential for some proportion of adsorbed load on the precipitate surface to be incorporated in the structure of the aged phase. Often crystalline forms are less reactive in response to changing solution conditions and incorporated elements are therefore more resistant to remobilisation. For example, it has been shown that around 30% of adsorbed uranium is ‘irreversibly’ incorporated during ageing from ferrihydrite to goethite or hematite (Payne et al, 1994). Iron and aluminium concentrations in the porewater and groundwater are consistent with the solubility of amorphous iron and aluminium oxyhydroxides. These phases will be important controls on the sorptive capacity of the sediments and the attenuation of metals and radionuclides. Over time as these phases age, some degree of incorporation of the adsorbed metals and radionuclides would be expected. These incorporated elements would be resistant to remobilisation.

8.2.2.3 Expected Long-Term Aquifer Water Quality

Results from the current programme indicate that sufficient buffering capacity is available in the near-field of the TSF to neutralise all of the acidity that could be released from the tailings. Therefore most metals that could be mobilised would be reduced to low concentrations, not dissimilar to concentrations existing in the groundwater mound. In particular for uranium, the results show that in addition to attenuation, uranium concentrations could also be controlled by the formation of secondary minerals including soddyite or uranyl hydroxides (schoepite) (see Figure 4.11).

To estimate the potential water quality that may develop in the aquifer, the results from the contact and column tests that yielded pH values in excess of 6 were assessed. The results are summarised in Table 8.3. The maximum concentrations tended to be associated with the low end of the pH scale (i.e. 6.0). In generally the water quality would be expected to transition from the minimum concentrations through to the average concentrations and may reach the maximum (considered and upper bound). After the peak concentrations are reached the water quality would be expected to transition back to the average and then the low end of the range as the acidity loadings from the TSF are depleted. The timescale could range from about 800 to 900 years should percolation rates remain steady at the projected initial rates. More realistically, the percolation rates would decrease over time so that the peak concentrations could occur within the first few decades after closure of the facility and then they would slowly decay back to the minimum concentrations. This process of slow decay could be stretched for up to 8000 to 10000 years, depending on the net infiltration rate to the tailings, after which the acidity would have been depleted.

Therefore, in general most solute concentrations would not be expected to change much beyond those currently observed in the groundwater mound beneath the TSF (i.e. remain in the range observed in the groundwater mound). With respect to uranium, although the maximum concentration indicated in the table is about 11 mg/L, a concentration of about 5 mg/L at a pH of about 6 would be considered as an upper bound because, unlike for the tests, much longer residence times will occur and conditions closer to equilibrium would be expected. More typically concentrations of 0.7 mg/L or less at a pH of about 6.5 would be expected (as indicated by speciation modelling).

Table 8.3: Summary of Estimated Aquifer Concentrations (post neutralisation)

Parameter	Units	Concentration Range		
		min	mean	max
pH		6.1	6.9	8
Eh	mV	81	323	495
EC	mS/cm	3	15.9	41.7
Cl	mg/L	83	3155	12500
F	mg/L	1.7	7.7	10.9
SO_4^{2-}	mg/L	1920	4726	12200
Nitrate as N	mg/L	1.2	7.3	10.4
Bicarbonate Alkalinity as CaCO3	mg/L	100	1160	2100
Na	mg/L	297	2786	9330
K	mg/L	3	192	780
Mg	mg/L	26	423	1010
Ca	mg/L	490	592	807
Ag	mg/L	< 0.01	< 0.01	< 0.01
Al	mg/L	< 0.01	2.48	12
As	mg/L	< 0.01	< 0.01	0.004
B	mg/L	1.4	9.8	33
Ba	mg/L	0.006	0.014	0.026
Be	mg/L	< 0.01	< 0.01	< 0.01
Bi	mg/L	< 0.01	< 0.01	< 0.01
Cd	mg/L	< 0.002	< 0.002	0.0044
Ce	mg/L	< 0.001	0.057	0.281
Co	mg/L	< 0.001	7.3	39.4
Cr	mg/L	< 0.01	0.02	0.11
Cu	mg/L	< 0.01	0.61	2.69
Fe	mg/L	0.11	1994	9170
Hg	mg/L	< 0.0001	< 0.0001	< 0.0001
Li	mg/L	0.009	0.834	3.78
Mn	mg/L	< 0.001	20	106
Mo	mg/L	< 0.01	0.020	0.074
Ni	mg/L	< 0.001	0.514	2.81
Pb	mg/L	< 0.01	< 0.01	0.013
Re	mg/L	< 0.001	0.002	0.017
Sb	mg/L	< 0.01	< 0.01	0.0034
Se	mg/L	< 0.01	0.03	0.12
Si	mg/L	0.20	6.36	35
Sn	mg/L	< 0.01	< 0.01	< 0.01
Sr	mg/L	2.27	7.76	24
Th	mg/L	< 0.01	< 0.01	< 0.01
Ti	mg/L	< 0.1	< 0.1	< 0.1
Tl	mg/L	< 0.005	< 0.005	0.023
U	mg/L	0.002	2.2	11
V	mg/L	< 0.1	< 0.1	< 0.1
W	mg/L	< 0.01	< 0.01	< 0.01
Y	mg/L	< 0.001	0.026	0.137
Zn	mg/L	< 0.005	0.94	4.79

Note: maximum values tended to be associated with a single contact test result at a pH of 6.

8.3 Net Volume Changes

8.3.1 Underlying Soils/Sediment

Based on current properties of the tailings percolate, the total mass of acid neutralization capacity (ANC) consumed considering both calcite and dolomite as neutralising minerals, and the resultant mass of solids that could be generated, were calculated and normalised to allow direct comparison of the net consequence of the chemical interaction that may occur (note that the mass of calcite required to neutralize the same amount of acidity is about 1.085 times the weight of dolomite, i.e. 1.085 grams of calcite has the same neutralizing capacity as 1 g of dolomite). Both oxidising and anoxic conditions were assessed. For oxidising conditions it was assumed that all of the iron would precipitate as ferrihydrite, whereas for anoxic conditions only the iron already in the ferric state would precipitate. The results are shown in Table 8.4.

Table 8.4: Summary of Solids Consumed and Generated During Neutralisation

Description		ANC Source	
		Calcite	Dolomite
Solids Consumed (g)		1	1
Solids Generated (g)	Oxidising Conditions	1.78	1.29
	Anoxic Conditions	1.44	0.93

The results indicate that the reactions occurring with calcite will under all circumstances result in a mass of precipitates formed that will exceed the mass of calcite consumed. A significant proportion of the precipitates formed will be gypsum, and since the solution is already supersaturated with respect to this mineral phase, the gypsum will accumulate at the reaction sites.

Results indicate that should the neutralizing reactions occur with dolomite, under anoxic conditions the net precipitate production will be less than the mass of dolomite consumed because i) the magnesium will remain in solution and will not form gypsum, and ii) the ferrous will not be precipitated from solution.

As noted, a significant proportion of the solids that would be precipitated would be gypsum which has a lower density than calcite, whereas the densities of the other secondary minerals are likely to be similar to that of calcite. Even though gypsum is denser than calcite, the mass of gypsum formed is sufficiently high that neutralisation reactions with calcite would result in a net reduction of porosity, i.e. the calcareous clays containing calcite are likely to become less permeable. Where calcareous clays and materials contain dolomite, the porosity in general would be expected to increase and the materials would expected to become more permeable over time as it interacts with the acidic percolate.

Since the tailings percolate is already supersaturated with respect gypsum, the percolate is not expected leach out the gypsum.

In the very long term, the percolate water quality may change and cause leaching of gypsum, however, this could occur only long after the facility has been closed and all of the gypsum has been leached from the tailings deposit.

8.3.2 Andamooka Limestone

Neutralisation capacity is predominantly in the form of dolomite and so a net loss of solids mass is expected, with a consequent opening up of porosity.

8.3.3 Arcoona Quartzite

As discussed before, percolate passing from the Andamooka Limestone into the Arcoona Quartzite is expected to be at a near-neutral pH, but may contain relatively high dissolved carbonate (due to the previous contact with carbonate-rich materials) and supersaturated carbonate mineral forms. Precipitation of the carbonate minerals could ensue, possibly resulting in changes to the net porosity within the quartzite.

Results for saturated column tests undertaken indicated an increased pH which could be consistent with precipitation of carbonate minerals. A coincident increase in dissolved Ca and Mg however indicated a net release of these solutes from the Arcoona quartzite sample. Furthermore, elevated magnesium concentrations tend to inhibit the formation of calcite. PHREEQC modelling indicated that while siderite is either supersaturated or close to equilibrium, dolomite and calcite are under-saturated and would not be expected to precipitate. Although iron concentrations showed a decrease, for the test conditions either siderite ($FeCO_3$) or ferrihydrite (as observed for the feed solution) could have been precipitated from solution. Ferrihydrite was considered more likely because the kinetics for siderite formation at ambient temperatures generally are very slow and because it is uncertain that oxygen had been completely excluded from the tests. Under field conditions it would be expected that oxygen would not be present. Therefore the potential for ferrihyrite to form would be considered small. Nevertheless, while the tests results are inconclusive, the general indication is that carbonate minerals are not likely to form in the percolate from the Andamooka Limestone. Therefore no net accumulation of precipitates would be expected within the Arcoona Quartzite.

9 Conclusions

Acidic percolate seeping from the TSF will be neutralised by reaction with carbonate minerals present in the underlying sediments and soils, and the excess dolomite contained in the Andamooka Limestone. As neutralisation capacity of the sediment is exhausted locally the acid front will progress away from the tailings – sediment/soils contact interface and slowly migrate downward.

Field evidence indicates that progression of the acid front is variable due to variability in the carbonate content of the sediments. After 25 years of operation the acid front penetrated, on average, to depths of less than 1 m from the tailings interface, i.e. the front is contained within the soils/sediments that immediately underlie the TSF.

Field evidence also indicates that migration may not always be downwards but could be lateral, following paths of least resistance. In some localised regions, due to a combination of low neutralising capacity and rapid flow rates through, for example dune sands, the acid front has penetrated to depths of up to 10 m. Impermeable clays lenses may redirect flow. Also, in calcareous sediments, net volume changes due to the acid neutralisation process may reduce porosity, also resulting in redirection of flow.

Acidity balance calculations show that the majority of acidity would still be present in the tailings deposit at the end of operations. Following closure, a large proportion of this acidity would drain down into the underlying sediments. The consequent acid front could eventually (after several hundred years) penetrate through the soils/sediments and reach the Andamooka Limestone. However, sufficient neutralisation capacity is available within the Andamooka Limestone to neutralise all of the acidity within about 2 to 3 m of upper part of the Andamooka Limestone; the Andamooka Limestone in the vicinity of the TSF is up to 60 m thick.

Short-term (operational) percolate loadings would be considerably higher than those expected in the long term (post-closure) loadings. Short-term loadings could apply for time periods of several decades to a few centuries (active operations followed by gradual drain-down). Long-term (post-closure loadings could apply thereafter, for periods of about 800 years to about 10000, albeit that solute loadings would decrease to very low rates at low percolation rates.

Result show that significant attenuation of in particular Co, Cu, Pb, U, Th and Zn has taken place in the sediments underlying the TSF. Attenuation mechanisms include precipitation and sorption:

- Precipitation would coincide with the change from acid to neutral pH conditions. Thus precipitation fronts would track with the acid front. Beyond the precipitation front, element concentrations in percolating waters would remain constant at applicable solubility limits.
- Sorption would tend to coincide with neutral pH conditions but could ‘stretch’ well beyond the acid front. Sorption delays or retards the migration of high concentrations of dissolved element. The sorptive capacity of soils and sediments however may be finite, and may change if pH conditions change, and it is possible that ‘breakthrough’ could occur if solution concentrations remain high for a very long time (i.e. assuming the supply of the element from the source remains constant and unlimited). However, considering the finite acidity load from the tailings and the magnitude of the neutralisation capacity, this is considered unlikely to occur.

Water quality estimates have been generated and are summarised elsewhere. The results show that, in particular, uranium could reach an upper bound concentration of about 5 mg/L at a pH of about 6 based on the test results. However, unlike for the tests, much longer residence times will occur for in-situ conditions and equilibrium would be expected to be reached. More typically concentrations of 0.7 mg/L or less at a pH of about 6.5 would be expected (as indicated by speciation modelling). .

Net solids volume changes taking place as a result of water-rock interactions are:

- Net increases are expected in calcareous sediments due to widespread precipitation of gypsum following acid neutralisation – the consequent reduction of porosity may result in decreased seepage flow, and possible changes in flow direction;
- In dolomitic sediments and in the Andamooka Limestone it is expected that there be a net decrease in solid volume – opening up porosity and increasing seepage flow;
- Whilst the results for the Arcoona Quartzite are inconclusive, carbonate minerals are not expected to form; there is however a possibility that other minerals may form but the likelihood of this occurring is considered low.

In conclusion, the conceptual model has in general been verified with the exception of the potential interactions that may occur within the Arcoona Quartzite.

10 References

ENSR/AECOM, 2008, *Olympic Dam Mine Rock Characterisation and RSF Hydrogeochemical Assessment.* Report No. B43318_RPTDraft_7Apr08., 2008, as summarised by SRK in Appendix K5 of the Draft EIS

Franchitto, A, *Baseline Groundwater Sampling Olympic Dam Expansion (ODX) – October 2007,* Resource Environmental Management (REM) Technical Report, 21 November 2007.

Parkhurst, D.L. and Appelo, C.A.J. User's guide to PHREEQC (Version 2) – A computer program for speciation, batch-reaction, one-dimensional transport, and inverse geochemical calculations. Water-Resources Investigations Report 99-4259, 1999.

T.E. Payne, J.A. Davis and T.D. Waite, Uranium retention by weathered schists. The role of iron minerals, Radiochim. Acta 66–67 (1994),

SRK 2007, Olympic Dam TSF Geochemical Model, SRK Report Number BHP021Rev1, August 2007, Appendix K4 of the Draft EIS.

Appendices

Appendix 1: Field Logs

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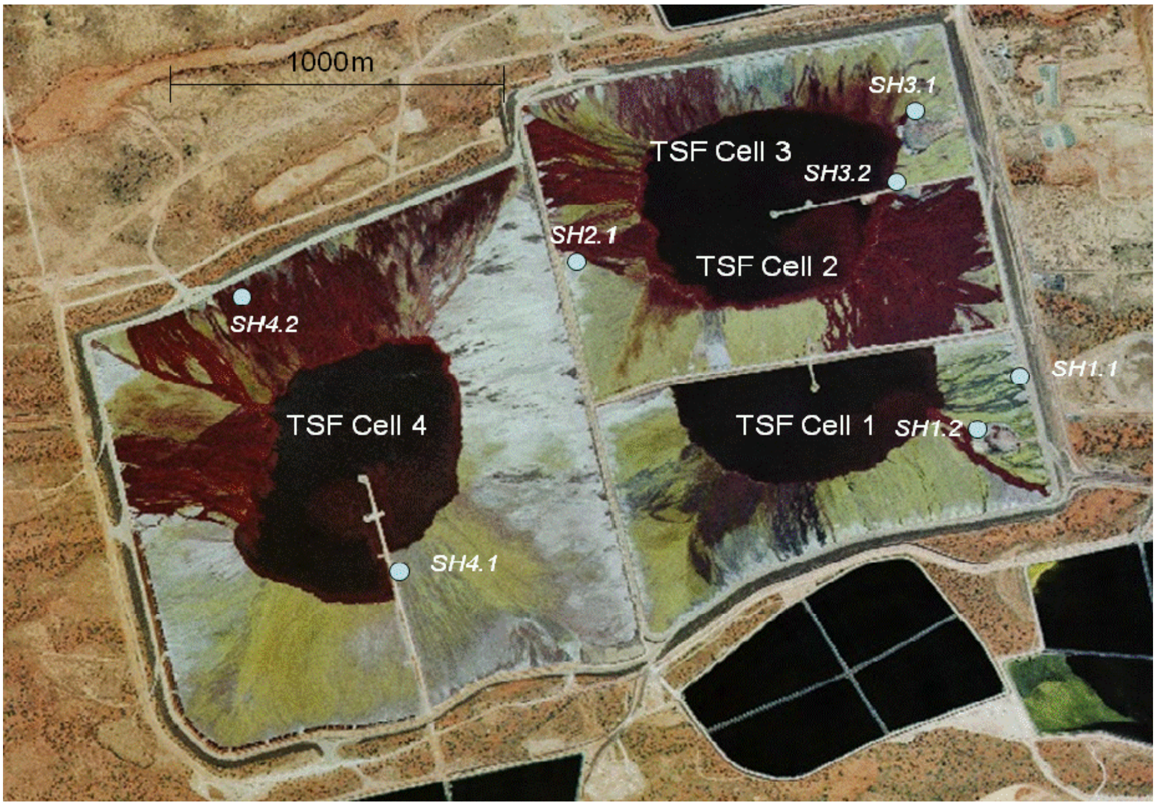


	Geochem Sonic Holes - December 2007									
Permit Number	**Hole ID**	**Cell**	**Location**	**Northing**	**Easting**	**Collar RL**	**Target Depth**	**Target Depth RL**	**Piezometer**	**Target aquifer**
140702	SH1.1	1	East Wall cell 1 - 150m south of NE corner - pad 20m into cell	6,630,788.6	677,352.1	124.241	25	99.241	Single	- Tailings
140704	SH1.2	1	On waste finger at end	6,630,678.1	677,214.7	122.925	25			
	SH2.1	2	West Wall cell 2 - on piezo pad	6,631,228.6	676,109.2	123.197	25	98.197	Single	- Tailings
140705	SH3.2S	3	Off north side of waste dump causeway cell 3 - approx 100m from wall. Pad can be 10-15m in. Shallow.	6,631,608.1	677,065.8	122.898	25	97.898	Single	- Tailings
140705	SH3.2D		Off north side of waste dump causeway cell 3 - approx 100m from wall. Pad can be 10-15m in. Deep.	6,631,607.6	677,064.2	122.835	25	97.835	Single	- Tailings
140706	SH3.1	3	Off north side of causeway cell 3 - approx 200m from wall. Not in pond - just out of it. Pad can be 10-15m in.	6,631,427.1	677,066.9	121.879	25	96.879	Single	- Tailings
140707	SH4.1	4	Off east side of causeway cell 4 - approx 360m from wall. Not in pond - just out of it. Pad can be 15-20m in.	6,630,315.4	675,625.9	113.858	25	88.858	Single	- Tailings
140708	SH4.2	4	Pad on waste finger for V2O5 approx 300m east from NW corner cell 4	6,631,062.6	675,196.6	116.008	25	91.008	Single	- Tailings

Key:

▓ Fill (Pad / Embankment)
□ Tailings
▒ Natural subsoils
▥ Limestone

7.5 - 9.0 LEXAN sample

░ Sand backfill Gravel Backfill
■ Bentonite
░ Slotted screen section

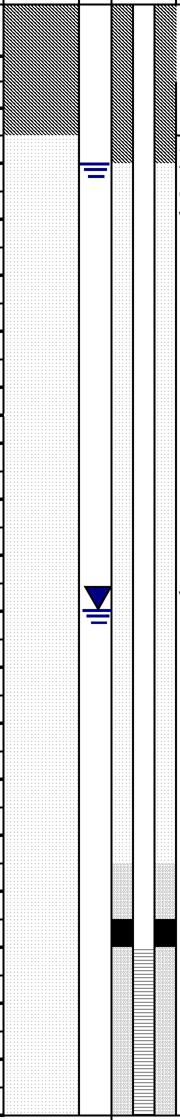
▼ Water level

Profile for Drillhole

Page: 1 of 2

SRK Consulting Engineers and Scientists

Client: BHP Olympic Dam Expansion		Drillhole No. 1.1	
Project: Supplemental Geochemical Investigations		Project No. BHP026	
Drill Rig: Sonic	Inclination	Easting 677352	Bedrock depth [m] 30.00
Location TSF	Type/Diameter Sonic; 80 mm	Northing 6630789	Depth to water [m] 3.10
Geologist JTC	Final Depth [m] 30	Elevation [m] 124.241	Date Drilled: 12-13/12/2007
			Date profiled



Depth [m]	Material Description	Material	Comments	Sample(s) Depth [m]	Sample(s) Type	SPT Blows
1	**Fill: Gravelly clayey sand,** fine to coarse grained pale orange brown	Pad fill				
2						
3	**SANDY SILT,** low plasticity dark red sand to fine (Note: elevated water during drilling may have been due to excessive wash water usage; water level dropped to 11 m by 15/12/2007)	Tailings	Poor tailings recovery Lost casing			
4						
5						
6			10 % core recovery Driller used excess water to flush pad fill Discarded sample - not suitable for paste parameters			
7						
8						
9				7.5-9	LEXAN	
10				9-10.5	LEXAN	
11	water level measured on 15/12/2007		Sample mixed with coarse rock; fill from pad carried down by casing? Very wet - excess wash water; not suitable for paste parameters			
12						
13						
14						
15				13.5 - 15	LEXAN	
16			1 m sand fill		paste	
17			0.5 m bentonite		paste	
18					paste	
19			Screen 3 m	18 - 19.5	LEXAN	
20	Base of well dipped at 19.7 m					

Notes:

Profile for Drillhole

Page: 2 of 2

SRK Consulting
Engineers and Scientists

Client:	BHP Olympic Dam Expansion	Drillhole No.	1.1
Project:	Supplemental Geochemical Investigations	Project No.	BHP026

Drill Rig: Sonic	Inclination	Easting 677352	Bedrock depth [m] 30.00
Location TSF	Type/Diameter Sonic; 80 mm	Northing 6630789	Depth to water [m] 3.10
Geologist JTC	Final Depth [m] 30	Elevation [m] 124.241	Date Drilled: 12-13/12/2007 / Date profiled

Depth [m]	Pictorial Log		Well Details	Material Description	Material	Comments	Sample(s)		SPT Blows
							Depth [m]	Type	
21				Tailings / soil contact at 21.3 m		bentonite plug set in tailings			
22				Clayey sand/ sand, orange brown	Natural soil		21 - 22.5	LEXAN	
23									
24									
25									
26				No core (2.5 m)					
27									
28									
29				Comptetent limestone; weathered orange brown staining	Limestone		28.6 - 29.1	GRAB	
30	C						29.1 - 30 30	GRAB BIT	
				EOH					
31									
32									
33									
34									
35									
36									
37									
38									
39									
40									

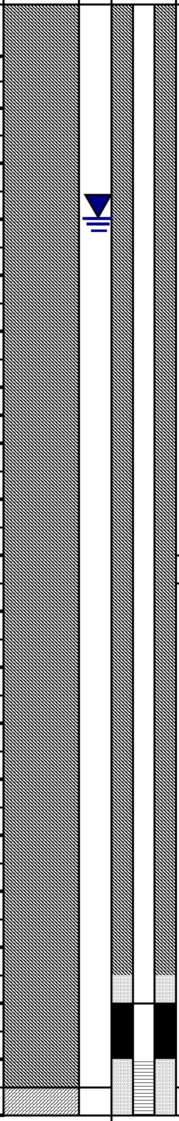
Notes:

Profile for Drillhole

Page: 1 of 2

SRK Consulting
Engineers and Scientists

Client: BHP Olympic Dam Expansion		Drillhole No. 3.1	
Project: Supplemental Geochemical Investigations		Project No. BHP026	
Drill Rig: Sonic	Inclination	Easting 677067	Bedrock depth [m]
Location TSF	Type/Diameter Sonic; 80 mm	Northing 6631427	Depth to water [m]
Geologist JTC	Final Depth [m] 25	Elevation [m] 121.879	Date Drilled: 14-15/12/2007 | Date profiled



Depth [m]	Material Description	Material	Comments	Sample(s) Depth [m]	Sample(s) Type	SPT Blows
1	**Fill: Gravelly clayey sand,** fine to coarse grained pale orange brown	Pad fill				
2						
3						
4			water level 15/12/07			
5						
6						
7						
8						
9						
10						
11	Encountered Coarse rock fill					
	Coarse grained coble to fine sandy clay; orange brown; very moist					
12						
13						
14						
15						
16						
17						
18						
19						
	Natural soil - fill contact					
20	**Silty SAND**, dark green to black	Soil	reducing?	19.5	Grab	

Notes:

Profile for Drillhole

Page: 2 of 2

SRK Consulting Engineers and Scientists	Client: BHP Olympic Dam Expansion	Drillhole No.	3.1
	Project: Supplemental Geochemical Investigations	Project No.	BHP026

Drill Rig: Sonic	Inclination	Easting 677067	Bedrock depth [m]	
Location TSF	Type/Diameter Sonic; 80 mm	Northing 6631427	Depth to water [m]	
Geologist JTC	Final Depth [m] 25	Elevation [m] 121.879	Date Drilled: 14-15/12/2007	Date profiled

Depth [m]	Pictorial Log		Well Details	Material Description	Material	Comments	Sample(s) Depth [m]	Sample(s) Type	SPT Blows
21	▨			**SAND,** red natural dune sands	Soil				
22	▨			**Sandy clay.** Reddish dark to black	Soil		21 - 22.5	LEXAN	
23	▨			Bleached clay, light yellow to white	Soil		22.5 - 24	LEXAN	
	▨			Yellow to red clay	Soil				
24	▨			**SAND,** red to dark brown	Soil		24 to 24.6 -	Grab	
25	▥			Competent limestone	Rock		a, b, c	Grab	
26 27 28 29 30 31 32 33 34 35 36 37 38 39 40				EOH					

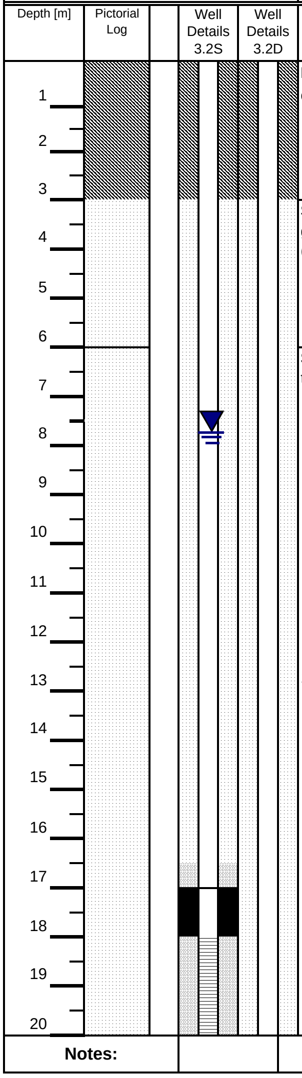
Notes:

Profile for Drillhole

Page: 1 of 2

SRK Consulting
Engineers and Scientists

Client: BHP Olympic Dam Expansion		Drillhole No.	3.2
Project: Supplemental Geochemical Investigations		Project No.	BHP026
Drill Rig: Sonic	Inclination	Easting [D] 677064 [S] 677066	Bedrock depth [m]
Location: TSF	Type/Diameter: Sonic; 80 mm	Northing [D] 6631607.6 [S] 6631608.1	Depth to water [m]
Geologist: JTC	Final Depth [m]: 27	Elevation [m]: 122.835	Date Drilled: 15-16/12/2007 / Date profiled



Depth [m]	Material Description	Material	Comments	Sample(s) Depth [m]	Sample(s) Type	SPT Blows
0 – 3	**Fill: Gravelly clayey sand,** fine to coarse grained pale orange brown	Pad fill				
3 – 6	**SANDY SILT**, low plasticity dark purple to grey sand to fine silt; some green patches (concentrate?- copper sulphates)	Tailings	encountered plastic bags			
6 – 20	**SANDY SILT**, low plasticity dark red sand to fine silt	Tailings		6 - 7.5	LEXAN	
8			water level measured on 17/12/2007			
10.5 – 12				10.5 - 12	LEXAN	
13.2	13.2m Fine white veining - paper?					
15 – 16.5				15 - 16.5	LEXAN	

Notes:

Profile for Drillhole

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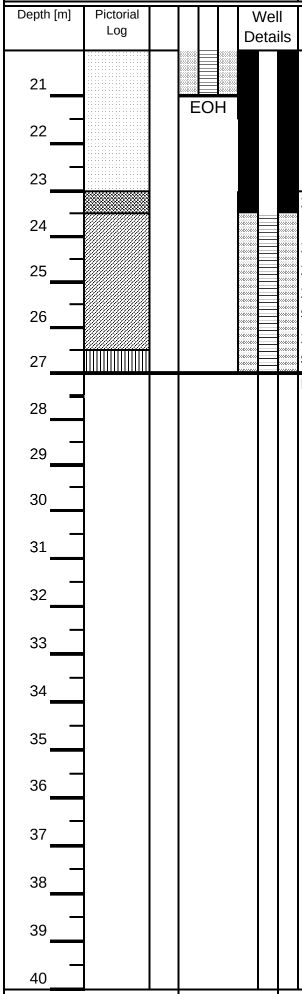
SRK Consulting
Engineers and Scientists

Client: BHP Olympic Dam Expansion		Drillhole No.	3.2
Project: Supplemental Geochemical Investigations		Project No.	BHP026
Drill Rig: Sonic	Inclination	Easting [D] 677064 [S] 677066	Bedrock depth [m]
Location TSF	Type/Diameter Sonic; 80 mm	Northing [D] 6631607.6 [S] 6631608.1	Depth to water [m]
Geologist JTC	Final Depth [m] 27	Elevation [m] 122.835	Date Drilled: 15-16/12/2007 · Date profiled



Material Description	Material	Comments	Sample(s) Depth [m]	Sample(s) Type	SPT Blows
		well found to be dry on 17/12/2007; high level of gas release (gas build-up hindering well recovery?)	19.5 - 21	LEXAN	
			22.8 - 23	Grab	
23.2 to 23.6 Gravel	Soil	3 m Screen set below tailings - to try and capture flow from moist zone	23.1-23.25	Grab	
			23.4-23.6	Grab	
24-24.3m: Material wet, slimey			24.9-25.2	Grab	
24.3-24.4m: Darker colour, competent					
24.4-25.2m: Light yellow/orange with red staining, loose and friable,			25.2-25.3	Grab	
			25.8-26.1	Grab	
25.5-26.5m: Light brown, feels moist, some larger more competent blocks			26.1-26.5	Grab	
EOH					

Notes:

Profile for Drillhole

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SRK Consulting
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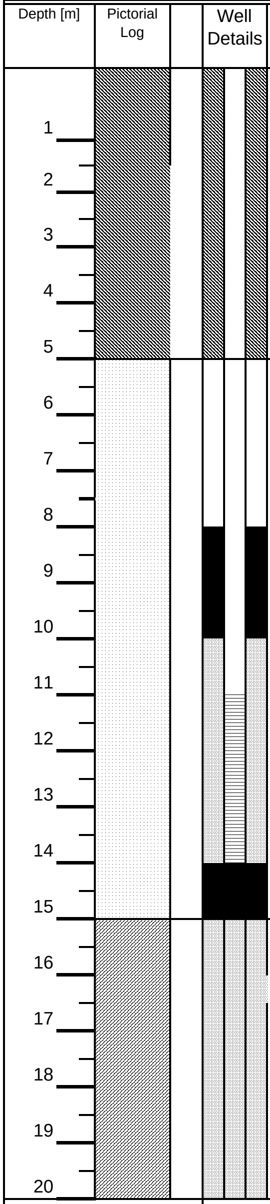
Client:	BHP Olympic Dam Expansion	Drillhole No.	4.1
Project:	Supplemental Geochemical Investigations	Project No.	BHP026

Drill Rig: Sonic	Inclination	Easting 675626	Bedrock depth [m]
Location TSF	Type/Diameter Sonic; 80 mm	Northing 6630315	Depth to water [m]
Geologist CML	Final Depth [m] 21	Elevation [m] 113.858	Date Drilled: 17/12/2007 / Date profiled



Material Description	Material	Comments	Sample(s) Depth [m]	Sample(s) Type	SPT Blows
Pad fill: Gravelly clayey sand, fine to coarse grained pale orange brown	Pad fill				
4.5m: drill bit = mixture gravel/tailings					
SANDY SILT, low plasticity dark red to purple sandy to silty grained tailings	Tailings				
			6-7.5	LEXAN	
		7.5-9m: sample lost, filled with water			
			9-10.5	LEXAN	
			10.5-12	LEXAN	
	Soils		15-16.5	LEXAN	
		16.5-16.9: sample contaminated by fall-in			
16.9m: Streaky dark red/creamy clay			16.9	Grab	
17.2m: Red orange Fe staining					
17.6m: Large grey-green crystals (gypsum			17.65-17.8	Grab	
White powdery clay, quite competent					
18.7m: Less competent, sandy			18.7-18.8	Grab	
Clay					

Notes:

Profile for Drillhole

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SRK Consulting
Engineers and Scientists

Client:	BHP Olympic Dam Expansion			Drillhole No.	4.1
Project:	Supplemental Geochemical Investigations			Project No.	BHP026
Drill Rig: Sonic		Inclination	Easting 675626	Bedrock depth [m]	
Location TSF		Type/Diameter Sonic; 80 mm	Northing 6630315	Depth to water [m]	
Geologist CML		Final Depth [m] 21	Elevation [m] 113.858	Date Drilled: 17/12/2007	Date profiled

Depth [m]	Pictorial Log		Well Details	Material Description	Material	Comments	Sample(s) Depth [m]	Sample(s) Type	SPT Blows
21	▨		▨	Clay	Soils				
22				EOH					
23									
24									
25									
26									
27									
28									
29									
30									
31									
32									
33									
34									
35									
36									
37									
38									
39									
40									

Notes:

Profile for Drillhole

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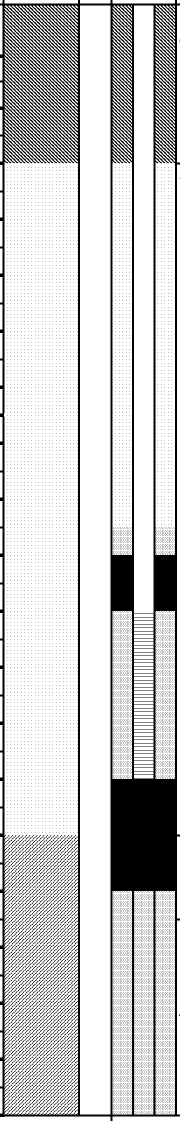
SRK Consulting
Engineers and Scientists

Client: BHP Olympic Dam Expansion		Drillhole No. 4.2	
Project: Supplemental Geochemical Investigations		Project No. BHP026	
Drill Rig: Sonic	Inclination	Easting 675197	Bedrock depth [m]
Location TSF	Type/Diameter Sonic; 80 mm	Northing 6631063	Depth to water [m]
Geologist JTC	Final Depth [m] 21	Elevation [m] 116.008	Date Drilled: 16-17/12/2007 / Date profiled



Depth [m]	Material Description	Material	Comments	Sample(s) Depth [m]	Sample(s) Type	SPT Blows
1 2 3	**Fill: Gravelly clayey sand,** fine to coarse grained pale orange brown	Pad fill				
4 5 6 7 8 9 10 11 12 13 14 15	**SANDY SILT**, low plasticity dark red to purple sandy to silty grained tailings	Tailings	3m: some gravel	6 - 7.5 10.5 - 12 15.0	LEXAN LEXAN End cap	
16	16.5m: Grey/green finely laminated 16.7m: More competent block ~6cm in length, powdery yellow/brown colour	Soils	15m end cap contains tails mixed with clay, tailings smeared down to 16.5 m	15 - 16.5	LEXAN	
17 18 19 20	17.3m: darker, feels damp, still powdery 17.5m: Yellow/brown sandy clay, moist 18.1m: Paler colour, larger pebbles of Andamooka (visible black crystals)			17.8-18 18.3-18.5 19.1-19.6	Grab Grab Grab	

Notes:

Profile for Drillhole

SRK Consulting Engineers and Scientists			Page: 2 of 2
Client:	BHP Olympic Dam Expansion	Drillhole No.	4.2
Project:	Supplemental Geochemical Investigations	Project No.	BHP026

Drill Rig: Sonic	Inclination	Easting 675197	Bedrock depth [m]
Location TSF	Type/Diameter Sonic; 80 mm	Northing 6631063	Depth to water [m]
Geologist JTC	Final Depth [m] 21	Elevation [m] 116.008	Date Drilled: 16-17/12/2007 / Date profiled

Depth [m]	Pictorial Log		Well Details	Material Description	Material	Comments	Sample(s) Depth [m]	Sample(s) Type	SPT Blows
21	▨		▨			20.4-20.7m sample: drill fluid, softer than material in this depth	20.4-20.7	Grab	
22				EOH					
23									
24									
25									
26									
27									
28									
29									
30									
31									
32									
33									
34									
35									
36									
37									
38									
39									
40									

Notes:

Profile for Drillhole

SRK Consulting Engineers and Scientists	Client: BHP Olympic Dam Expansion		Drillhole No. 2.1	Page: 1 of 2
	Project: Supplemental Geochemical Investigations		Project No. BHP026	
Drill Rig: MiniSonic	Inclination 90	Easting 676,109.2	Bedrock depth [m]	
Location Piezo west wall cell 2	Type/Diameter Sonic; 80 mm	Northing 6,631,228.6	Depth to water [m]	
Geologist AB	Final Depth [m] 25	Elevation [m] 123.2	Date Drilled: 08 Jan 2008	Date profiled

Depth [m]	Pictorial Log	Well Details	Material Description	Material	Comments	Sample(s) Depth [m]	Sample(s) Type	SPT Blows
1 2	▨	▨ N ▨	**Pad Materials**	Pad fill				
3 4	░		**Some tails**			3-3.75	Grab	
5 6 7 8	▨		Mixture pad gravel & tails	Pad fill	some minor tails + pad - tried tube but sample was compromised by pad			
9 10			Loss of sample					
11 12	▨		Mixture pad gravel & tails	Pad fill				
13 14 15			Loss of sample					
16	▨		Red sandy clay - competent in parts.	Interface Dune sand				
17 18 19	▨		17 m Appeared red dune sand in cemented clay layer. Sample taken Brown sandy clay Red dune sand + tyre	Dune sand	No sample 18.0 - 18.75 - tube obtained for 18.75 - 19.25	17 18 18.75 - 19.5	Grab Grab LEXAN	
20	▨		Red dune sand	Dune sand		19.5	grab	

Notes: **No piezo installed for this hole**

Profile for Drillhole

Profile for Drillhole				Page: 1 of 2
SRK Consulting Engineers and Scientists	Client: BHP Olympic Dam Expansion		Drillhole No. 2.1	
	Project: Supplemental Geochemical Investigations		Project No. BHP026	
Drill Rig: MiniSonic	Inclination 90	Easting 676,109.2	Bedrock depth [m]	
Location Piezo west wall cell 2	Type/Diameter Sonic; 80 mm	Northing 6,631,228.6	Depth to water [m]	
Geologist AB	Final Depth [m] 25	Elevation [m] 123.2	Date Drilled: 08 Jan 2008	Date profiled

Depth [m]	Pictorial Log	Well Details	Material Description	Material	Comments	Sample(s) Depth [m]	Sample(s) Type	SPT Blows
21	▨		Red dune sand	Dune sand		19.5-21	LEXAN	
22	▨		Red dune sand - 22.7 to 23 was weathered hard white clay - calcerious	Dune sand				
23	▥					23	Grab	
			loss sample 23 - 23.5					
24	▨		weathered hard brown white clays - pieces weathered limestone	Dune sand				
25	▥				Sample collected at 24.5	24.5	Grab	
			EOH					
26								
27								
28								
29								
30								
31								
32								
33								
34								
35								
36								
37								
38								
39								
40								

Notes:

Profile for Drillhole

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SRK Consulting
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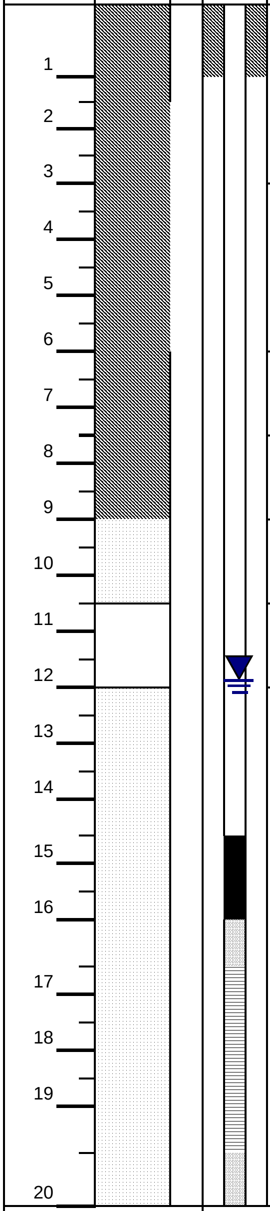
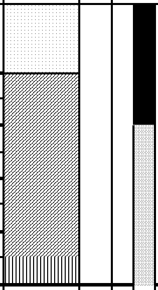
Client: BHP Olympic Dam Expansion		Drillhole No.	1.2
Project: Supplemental Geochemical Investigations		Project No.	BHP026
Drill Rig: Sonic	Inclination	Easting 677214.7	Bedrock depth [m]
Location TSF	Type/Diameter Sonic; 80 mm	Northing 6630678.1	Depth to water [m]
Geologist AB	Final Depth [m] 25	Elevation [m] 122.93	Date Drilled: 08 Jan 2008 / Date profiled



Material Description	Material	Comments	Sample(s) Depth [m]	Sample(s) Type	SPT Blows
Pad material - waste dump	Pad fill	Well +0.5m above pad level			
Mixed waste from dump					
sulphorous (smells) tails + gravel	Tailings		7.5	Grab	
Waste + tails - split obtained			7.5 - 9.0	LEXAN	
competent tailings					
Loss sample 10.5 - 12 Well water level measured 11.8 16/01/08					
Good tails - competent		Hole allowed to collapse around well above plug Bentonite to 14.5 Gravel 500mm to 16.2 3m slotted screen to 16.7m Base of well dipped at 19.7m Gravel 20 to 19.7 (300mm)	12 - 13.5 16.5 - 18	LEXAN LEXAN	

Notes:

Profile for Drillhole		Page:	1 of 2
SRK Consulting Engineers and Scientists	Client: BHP Olympic Dam Expansion	Drillhole No.	1.2
	Project: Supplemental Geochemical Investigations	Project No.	BHP026
Drill Rig: Sonic	Inclination	Easting 677214.7	Bedrock depth [m]
Location TSF	Type/Diameter Sonic; 80 mm	Northing 6630678.1	Depth to water [m]
Geologist AB	Final Depth [m] 25	Elevation [m] 122.93	Date Drilled: 08 Jan 2008 Date profiled



Depth [m]	Material Description	Material	Comments	Sample(s) Depth [m]	Sample(s) Type	SPT Blows
21	Good tails - competent	Tailings	Bentonite plug 22 - 20 m Interface at 21.1m	21.1	Grab	
22	Orange sandy clays (50% sand)	Sandy Clays	Backfill gravel to 22	21-22.5	LEXAN	
23	Refusal at 25. hard brown white weathered clays & limestone					
24						
25		Limestone				
26	EOH					
27						
28						
29						
30						
31						
32						
33						
34						
35						
36						
37						
38						
39						
40						

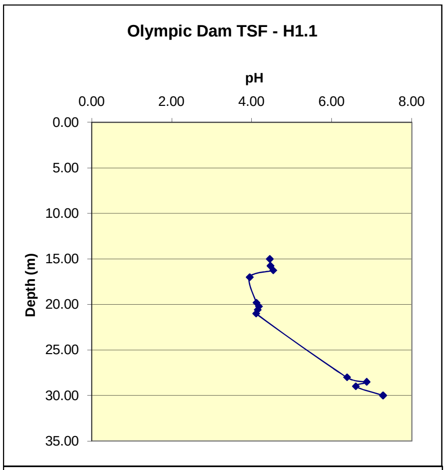
Notes:

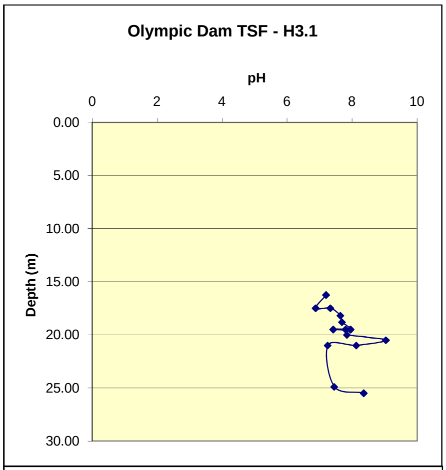
Hole ID	Sample Depth (m)	Description	Paste Result			
			pH	EC (mS)	Eh (mV)	T (ºC)
H1.1	15.00	Tailings	4.45	4.24	84	
H1.1	15.75	Tailings	4.47	5.82	131	
H1.1	16.25	Tailings	4.54	6.87	106	
H1.1	17.00	Tailings	3.95	5.83	191	
H1.1	19.80	Tailings	4.12	7.15	143	
H1.1	20.20	Tailings	4.18	7.03	130	
H1.1	20.60	Sandy clay	4.15	7.16	131	
H1.1	21.00	Sandy clay	4.11	8.36	151	
H1.1	28.00	Weathered Limestone	6.38	2.88	103	
H1.1	28.50	Weathered Limestone	6.87	3.45	178	
H1.1	29.00	Weathered Limestone	6.60	3.38	89	
H1.1	30.00	Weathered Limestone	7.28	5.94	-24	
H3.1	16.25	Embankment fill	7.2	3.16	70	
H3.1	17.50	Embankment fill	6.88	8.74	87	
H3.1	17.50	Embankment fill	7.33	4.97	268	
H3.1	18.20	Embankment fill	7.64	5.82	189	
H3.1	18.80	Embankment fill	7.69	5.73	138	
H3.1	19.50	Embankment fill	7.95	4.78	124	
H3.1	19.50	Embankment fill	7.42	10.44	-8	
H3.1	19.50	Silty sand	7.80	2.65	-48	
H3.1	20.00	Silty sand	7.84	2.72	49	
H3.1	20.50	Silty sand	9.04	2.08	66	
H3.1	21.00	Sandy clay	8.13	2.97	91	
H3.1	21.00	Sandy clay	7.25	3.15	53	
H3.1	24.90	Sandy clay	7.45	2.48	-4	
H3.1	25.50	Limestone	8.36	1.061	137	
H3.2	3.00	Tailings	3.66	8.77	243	
H3.2	3.60	Tailings	4.65	9.52	190	
H3.2	4.20	Tailings	5.85	10.34	124	
H3.2	4.80	Tailings	4.24	12.55	133	
H3.2	5.40	Tailings	6.21	8.93	83	
H3.2	5.50	Tailings	9.63	15.10	40	
H3.2	8.00	Tailings	7.36	12.22	-26	
H3.2	8.30	Tailings	4.61	9.41	223	
H3.2	8.60	Tailings	3.96	9.95	212	
H3.2	8.90	Tailings	3.28	10.97	234	
H3.2	9.40	Tailings	3.11	9.10	221	
H3.2	9.80	Tailings	3.10	8.99	220	
H3.2	10.50	Tailings	3.13	6.99	226	
H3.2	12.00	Tailings	2.98	7.75	261	
H3.2	12.30	Tailings	2.96	7.56	221	
H3.2	12.60	Tailings	3.37	6.82	203	
H3.2	12.90	Tailings	3.31	7.95	197	
H3.2	13.20	Tailings	3.18	7.50	191	
H3.2	13.50	Tailings	3.20	7.17	192	
H3.2	13.80	Tailings	3.43	6.18	189	
H3.2	14.10	Tailings	3.28	7.58	185	
H3.2	14.40	Tailings	3.45	7.11	212	
H3.2	16.50	Tailings	3.22	7.24	217	
H3.2	16.80	Tailings	3.57	5.60	190	
H3.2	17.10	Tailings	3.67	6.17	184	

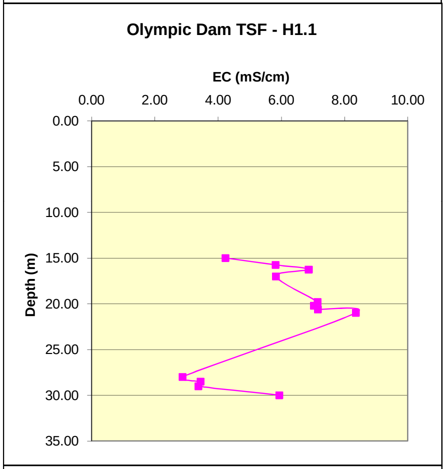
Hole ID	Sample Depth (m)	Description	Paste Result			
			pH	EC (mS)	Eh (mV)	T (ºC)
H3.2	17.40	Tailings	3.63	5.96	176	
H3.2	17.70	Tailings	3.52	5.41	178	
H3.2	18.00	Tailings	3.42	6.31	179	
H3.2	18.30	Tailings	3.36	6.73	178	
H3.2	18.60	Tailings	3.57	6.52	198	
H3.2	18.90	Tailings	3.41	7.01	186	
H3.2	19.20	Tailings	3.45	6.41	182	
H3.2	19.50	Tailings	3.29	6.28	176	
H3.2	21.30	Tailings	4.05	5.87	35	
H3.2	21.50	Tailings	4.44	5.65	118	
H3.2	22.40	Tailings	4.41	5.68	82	
H3.2	22.80	Tailings	4.45	6.47	28	
H3.2	23.00	Tailings	4.52	6.73	105	
H3.2	23.10	Tailings	4.57	6.72	101	
H3.2	23.20	Gravel	4.72	7.37	85	
H3.2	23.30	Gravel	5.12	5.04	91	
H3.2	23.70	Sandy clay	7.47	2.84	128	
H3.2	24.00	Sandy clay	7.24	3.68	123	
H3.2	24.30	Sandy clay	8.17	3.64	72	
H3.2	24.70	Sandy clay	7.38	4.90	69	
H3.2	25.00	Sandy clay/Limestone	8.49	1.24	66	
H3.2	25.20	Sandy clay/Limestone	9.07	1.63	82	
H3.2	25.50	Sandy clay/Limestone	8.67	2.31	93	
H3.2	25.50	Sandy clay/Limestone	9.03	1.67	83	
H3.2	25.80	Sandy clay/Limestone	9.14	1.68	71	
H3.2	26.00	Sandy clay/Limestone	8.85	1.39	62	
H3.2	26.30	Sandy clay/Limestone	8.38	2.57	83	
H3.2	26.50	Limestone	9.23	1.88	85	
H3.2	26.80	Limestone	9.28	1.35	75	
H3.2	27.10	Limestone	9.12	1.03	63	
H4.1	6.00	Tailings	4.33	11.78	92	
H4.1	7.50	Tailings	3.65	13.47	159	
H4.1	8.25	Tailings	3.71	11.95	139	
H4.1	9.00	Tailings	3.74	12.10	146	
H4.1	12.00	Tailings	4.78	8.15	56	
H4.1	12.30	Tailings	4.58	8.39	64	
H4.1	12.60	Tailings	4.54	10.27	73	
H4.1	13.50	Tailings	4.71	10.24	20	
H4.1	13.80	Tailings	4.52	10.91	63	
H4.1	14.10	Tailings	3.39	10.31	169	
H4.1	15.00	Tailings	4.20	6.05	129	
H4.1	16.90	Clay	4.49	5.78	181	
H4.1	17.00	Clay	7.30	6.57	89	
H4.1	17.20	Sandy clay	6.91	5.31	60	
H4.1	17.90	Sandy clay	6.83	4.67	109	
H4.1	18.30	Sandy clay/Limestone	7.97	4.36	47	
H4.1	19.00	Sandy clay/Limestone	8.46	2.72	36	
H4.2	3.90	Tailings	4.10	12.10	145	
H4.2	4.20	Tailings	3.96	11.22	128	
H4.2	4.50	Tailings	4.17	9.61	98	
H4.2	4.80	Tailings	4.07	10.96	82	
H4.2	5.10	Tailings	2.90	8.48	227	
H4.2	5.40	Tailings	2.84	8.70	243	
H4.2	5.70	Tailings	2.74	10.56	268	

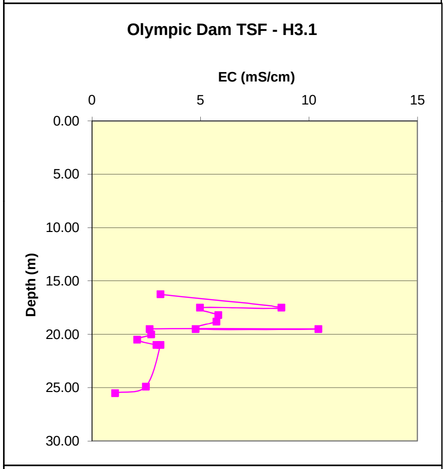
Hole ID	Sample Depth (m)	Description	Paste Result			
			pH	EC (mS)	Eh (mV)	T (ºC)
H4.2	6.00	Tailings	2.70	11.64	265	
H4.2	7.80	Tailings	3.30	10.24	229	
H4.2	8.10	Tailings	3.56	9.47	202	
H4.2	8.40	Tailings	3.55	8.92	175	
H4.2	8.70	Tailings	3.44	8.53	183	
H4.2	9.00	Tailings	3.61	7.98	188	
H4.2	9.30	Tailings	3.48	8.17	167	
H4.2	9.60	Tailings	3.50	9.51	164	
H4.2	9.90	Tailings	3.43	8.58	175	
H4.2	10.30	Tailings	3.53	9.12	191	
H4.2	10.50	Tailings	3.65	8.06	180	
H4.2	12.00	Tailings	3.32	7.78	220	
H4.2	12.30	Tailings	3.46	7.69	198	
H4.2	12.60	Tailings	3.46	7.70	184	
H4.2	12.90	Tailings	3.39	7.00	207	
H4.2	13.50	Tailings	3.38	8.25	209	
H4.2	12.80	Tailings	3.43	8.55	195	
H4.2	14.10	Tailings	3.46	7.43	201	
H4.2	14.40	Tailings	3.40	7.85	213	
H4.2	14.70	Tailings	3.35	7.81	220	
H4.2	15.00	Tailings	3.46	7.96	215	
H4.2	16.50	Clay	7.78	3.72	83	
H4.2	16.75	Clay	8.04	3.64	89	
H4.2	17.00	Clay	7.98	3.00	75	
H4.2	17.25	Clay	7.73	3.52	76	
H4.2	17.50	Clay	7.84	4.12	86	
H4.2	17.75	Clay	8.15	3.28	81	
H4.2	18.00	Clay	8.26	3.27	87	
H4.2	18.25	Clay	8.30	2.50	88	
H4.2	18.50	Clay	7.42	1.13	66	
H4.2	18.30	Clay	8.31	0.91	78	
H4.2	18.60	Clay	8.68	0.97	86	
H4.2	18.90	Clay	9.17	1.01	96	
H4.2	20.30	Clay	9.69	0.43	123	
H4.2	20.60	Clay	9.86	0.70	119	
H4.2	20.80	Clay	9.00	0.63	119	
H2.1	2.00	Mixed pad/tails	4.38	8.87	158	37.7
H2.1	2.50	Mixed pad/tails	3.95	10.08	196	37.1
H2.1	3.00	Mixed pad/tails	3.54	13.24	226	56.8
H2.1	4.50	Mixed pad/tails	6.65	4.89	-40	34.4
H2.1	5.00	Mixed pad/tails	6.30	4.63	-120	35.3
H2.1	5.50	Mixed pad/tails	5.00	8.06	15	35
H2.1	7.50	Mixed pad/tails	6.61	4.62	8	34.8
H2.1	8.00	Mixed pad/tails	6.67	6.47	-120	35.7
H2.1	8.50	Mixed pad/tails	6.76	7.77	65	34.5
H2.1	10.50	Mixed pad/tails	6.46	5.93	-124	34.9
H2.1	11.25	Mixed pad/tails	6.65	6.12	-7	33.9
H2.1	12.00	Mixed pad/tails	6.91	7.55	75	32.9
H2.1	15.00	Dune sand	6.59	5.26	87	34.5
H2.1	15.50	Dune sand	7.00	4.80	113	34.8
H2.1	16.00	Dune sand	7.00	4.96	123	35.6
H2.1	16.50	Dune sand	6.82	10.11	134	38.6

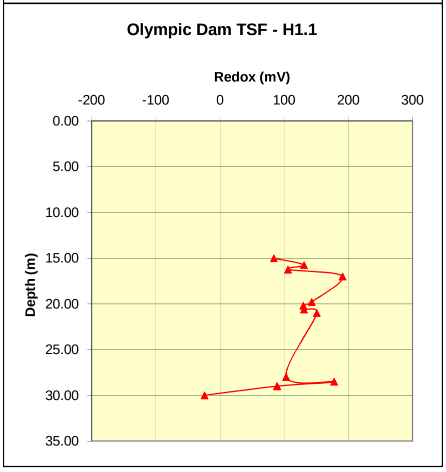
Hole ID	Sample Depth (m)	Description	Paste Result			
			pH	EC (mS)	Eh (mV)	T (ºC)
H2.1	17.25	Dune sand	6.73	9.53	-26	35.8
H2.1	18.00	Dune sand	6.24	10.91	-278	39.1
H2.1	18.50	Dune sand	6.13	12.65	-281	38.5
H2.1	19.00	Dune sand	5.67	5.50	-17	39.5
H2.1	19.50	Dune sand	5.72	4.52	-34	36.3
H2.1	21.00	Dune sand	4.22	6.23	174	36.5
H2.1	21.50	Dune sand	4.10	4.72	178	35.8
H2.1	22.00	Dune sand	3.96	5.16	180	35.7
H2.1	22.50	Dune sand	3.71	6.18	180	35.6
H2.1	23.00	Clay	4.80	4.85	56	35.9
H2.1	23.50	Clay	4.93	4.93	47	35.2
H2.1	24.00	Clay	6.26	6.26	-65	33.9
H2.1	24.50	Clay	6.77	6.77	-41	33.2
H2.1	25.00	Limestone	6.97	6.97	-65	32.9
H1.2	6.00	mixed waste and tails	4.39	9.91	239	21.7
H1.2	7.50	mixed waste and tails	8.51	12.08	93	21.7
H1.2	7.75	mixed waste and tails	10.97	18.16	-505	21.3
H1.2	9.00	mixed waste and tails	11.50	18.03	-507	21.5
H1.2	9.10	mixed waste and tails	10.12	15.54	-501	24
H1.2	9.50	Tailings	4.58	10.64	55	24.5
H1.2	10.00	Tailings	4.50	8.93	134	24.7
H1.2	10.50	Tailings	3.68	8.09	226	24.6
H1.2	13.50	Tailings	3.52	8.61	198	30.3
H1.2	14.00	Tailings	3.31	8.63	205	29.9
H1.2	14.50	Tailings	3.45	7.41	197	29.3
H1.2	15.00	Tailings	3.29	8.93	204	29.5
H1.2	15.50	Tailings	3.28	8.54	205	27.7
H1.2	16.00	Tailings	3.29	8.63	223	29.5
H1.2	18.00	Tailings	3.64	8.81	204	31.5
H1.2	18.50	Tailings	3.65	6.64	198	30.3
H1.2	19.25	Tailings	3.74	6.74	191	31.6
H1.2	19.75	Tailings	3.56	6.51	193	33.4
H1.2	20.25	Tailings	3.68	6.50	200	32.2
H1.2	21.00	Sandy clay	3.72	7.01	194	31
H1.2	22.50	Sandy clay	6.57	3.08	-56	34.9
H1.2	23.00	Clay	6.71	3.03	-69	34.7
H1.2	23.50	Clay	6.65	3.78	-22	34
H1.2	24.00	Clay	6.05	3.17	-160	35.6
H1.2	24.50	Clay	6.49	2.84	36	34.3
H1.2	25.00	Clay/limestone	6.60	3.52	37	33.5

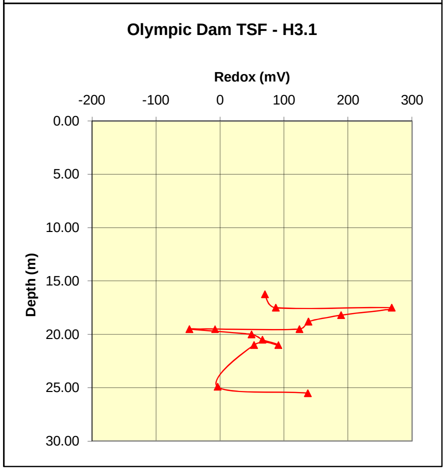

Olympic Dam TSF - H1.1
pH
0.00
2.00
4.00
6.00
8.00
Depth (m)
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00

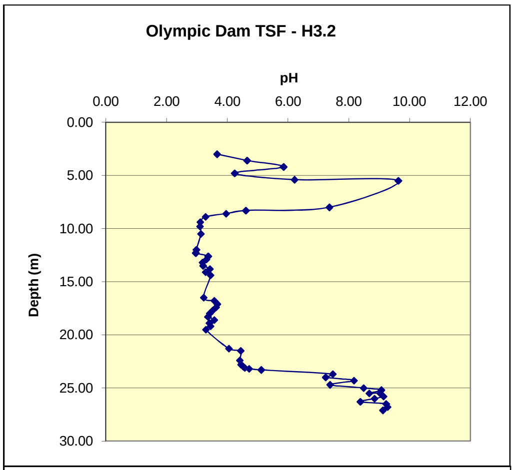

Olympic Dam TSF - H3.1
pH
0
2
4
6
8
10
Depth (m)
0.00
5.00
10.00
15.00
20.00
25.00
30.00

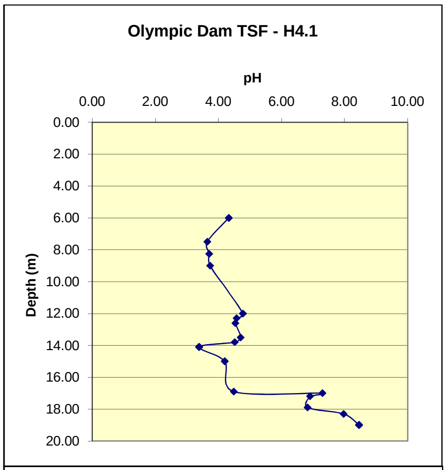

Olympic Dam TSF - H1.1
EC (mS/cm)
0.00
2.00
4.00
6.00
8.00
10.00
Depth (m)
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00

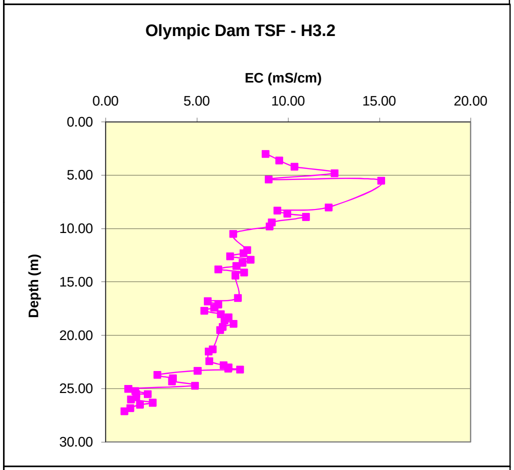

Olympic Dam TSF - H3.1
EC (mS/cm)
0
5
10
15
Depth (m)
0.00
5.00
10.00
15.00
20.00
25.00
30.00

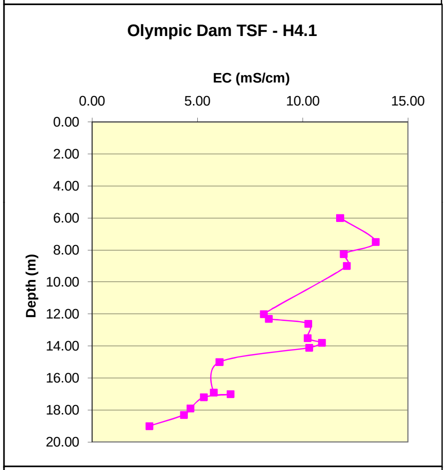

Olympic Dam TSF - H1.1
Redox (mV)
-200
-100
0
100
200
300
Depth (m)
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00

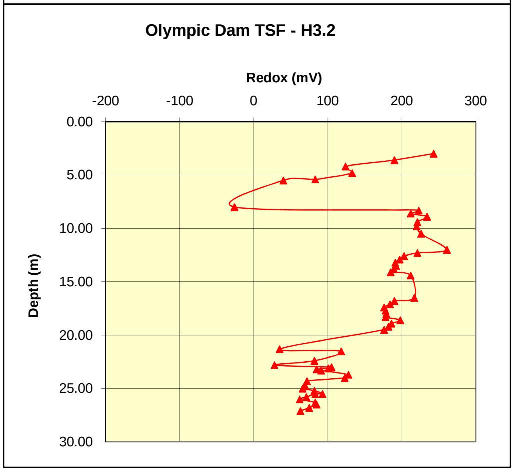

Olympic Dam TSF - H3.1
Redox (mV)
-200
-100
0
100
200
300
Depth (m)
0.00
5.00
10.00
15.00
20.00
25.00
30.00

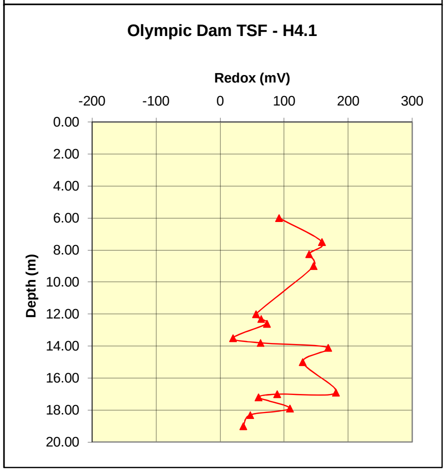

Olympic Dam TSF - H3.2
pH
0.00
2.00
4.00
6.00
8.00
10.00
12.00
Depth (m)
0.00
5.00
10.00
15.00
20.00
25.00
30.00

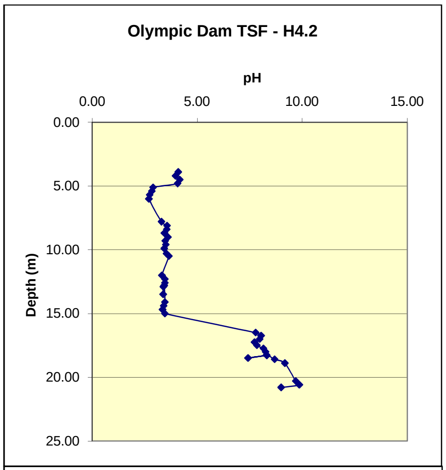

Olympic Dam TSF - H4.1
pH
0.00
2.00
4.00
6.00
8.00
10.00
Depth (m)
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00

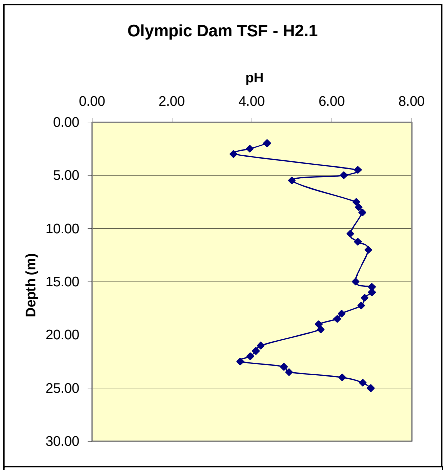

Olympic Dam TSF - H3.2
EC (mS/cm)
0.00
5.00
10.00
15.00
20.00
Depth (m)
0.00
5.00
10.00
15.00
20.00
25.00
30.00

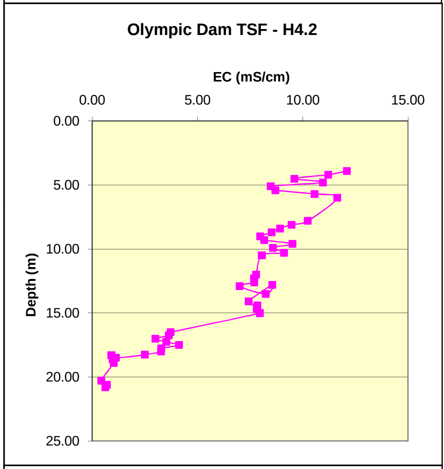

Olympic Dam TSF - H4.1
EC (mS/cm)
0.00
5.00
10.00
15.00
Depth (m)
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00

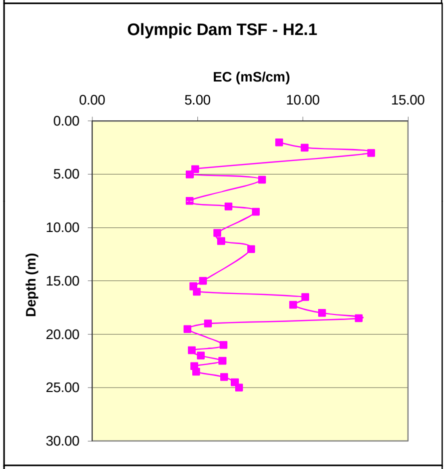

Olympic Dam TSF - H3.2
Redox (mV)
-200
-100
0
100
200
300
Depth (m)
0.00
5.00
10.00
15.00
20.00
25.00
30.00

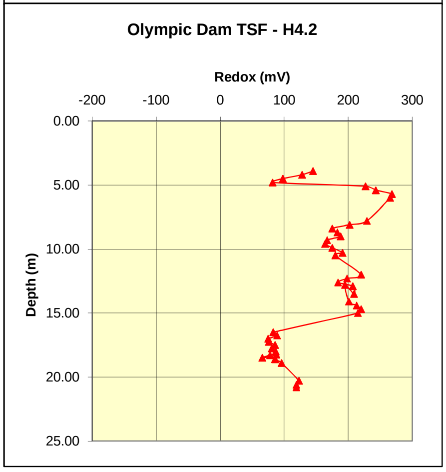

Olympic Dam TSF - H4.1
Redox (mV)
-200
-100
0
100
200
300
Depth (m)
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00

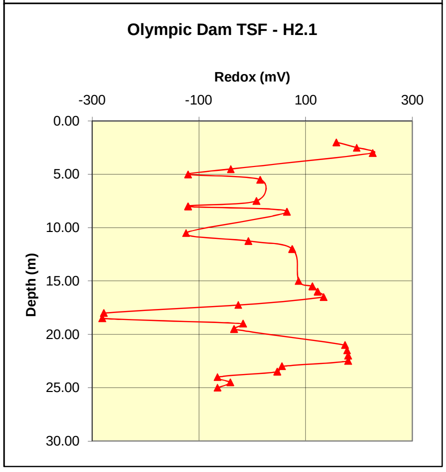

Olympic Dam TSF - H4.2
pH
0.00
5.00
10.00
15.00
Depth (m)
0.00
5.00
10.00
15.00
20.00
25.00

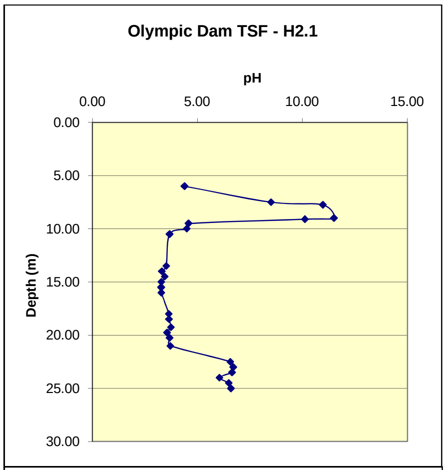

Olympic Dam TSF - H2.1
pH
0.00
2.00
4.00
6.00
8.00
Depth (m)
0.00
5.00
10.00
15.00
20.00
25.00
30.00

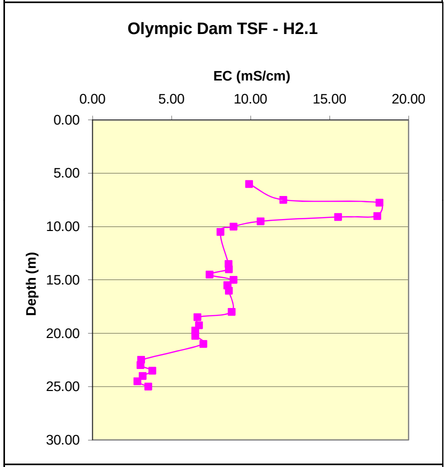

Olympic Dam TSF - H4.2
EC (mS/cm)
0.00
5.00
10.00
15.00
Depth (m)
0.00
5.00
10.00
15.00
20.00
25.00

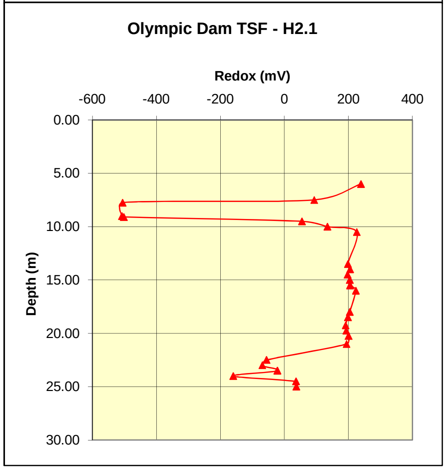

Olympic Dam TSF - H2.1
EC (mS/cm)
0.00
5.00
10.00
15.00
Depth (m)
0.00
5.00
10.00
15.00
20.00
25.00
30.00


Olympic Dam TSF - H4.2
Redox (mV)
-200
-100
0
100
200
300
Depth (m)
0.00
5.00
10.00
15.00
20.00
25.00


Olympic Dam TSF - H2.1
Redox (mV)
-300
-100
100
300
Depth (m)
0.00
5.00
10.00
15.00
20.00
25.00
30.00


Olympic Dam TSF - H2.1
pH
0.00
5.00
10.00
15.00
Depth (m)
0.00
5.00
10.00
15.00
20.00
25.00
30.00


Olympic Dam TSF - H2.1
EC (mS/cm)
0.00
5.00
10.00
15.00
20.00
Depth (m)
0.00
5.00
10.00
15.00
20.00
25.00
30.00


Olympic Dam TSF - H2.1
Redox (mV)
-600
-400
-200
0
200
400
Depth (m)
0.00
5.00
10.00
15.00
20.00
25.00
30.00

Appendix 2: Photographs taken during the field programme

H1.1

Tailings in a liner immediately after splitting the rod

Uncapped liner at contact with ground

Bagged samples (later discarded)

H1.1

Liners before and after capping, 21 to 22.5m

Drill bit sample (Andamooka Limestone, 22.5m)

Close up of iron staining in Andamooka Limestone

Gravel sample, 29.1 to 30m

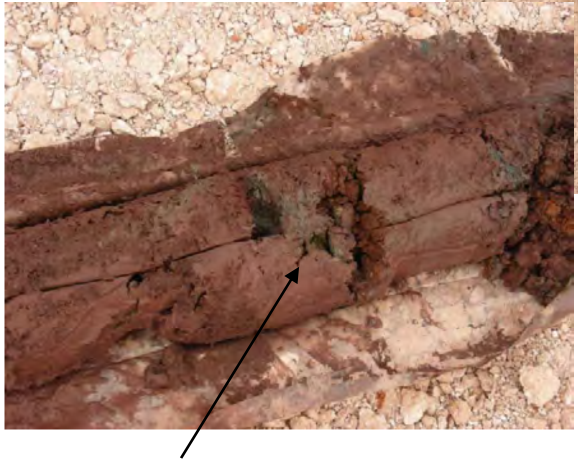
H3.1

The field laboratory setup

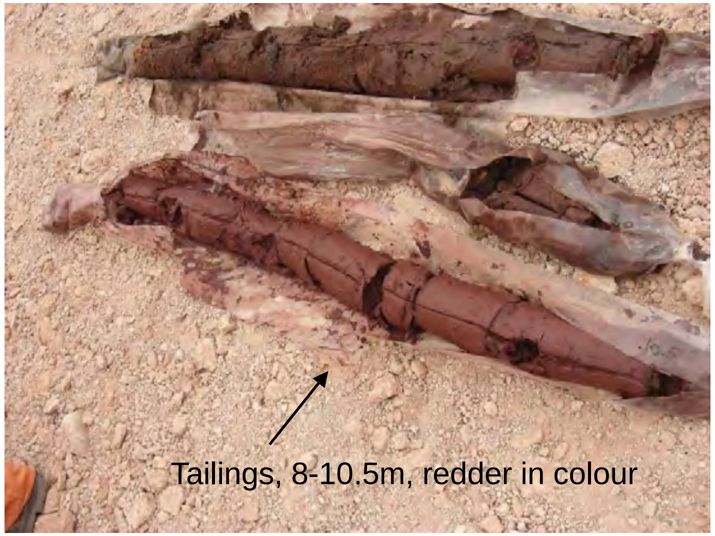
H3.1

H3.2

H3.2



Cu staining in the tailings, 3-6m

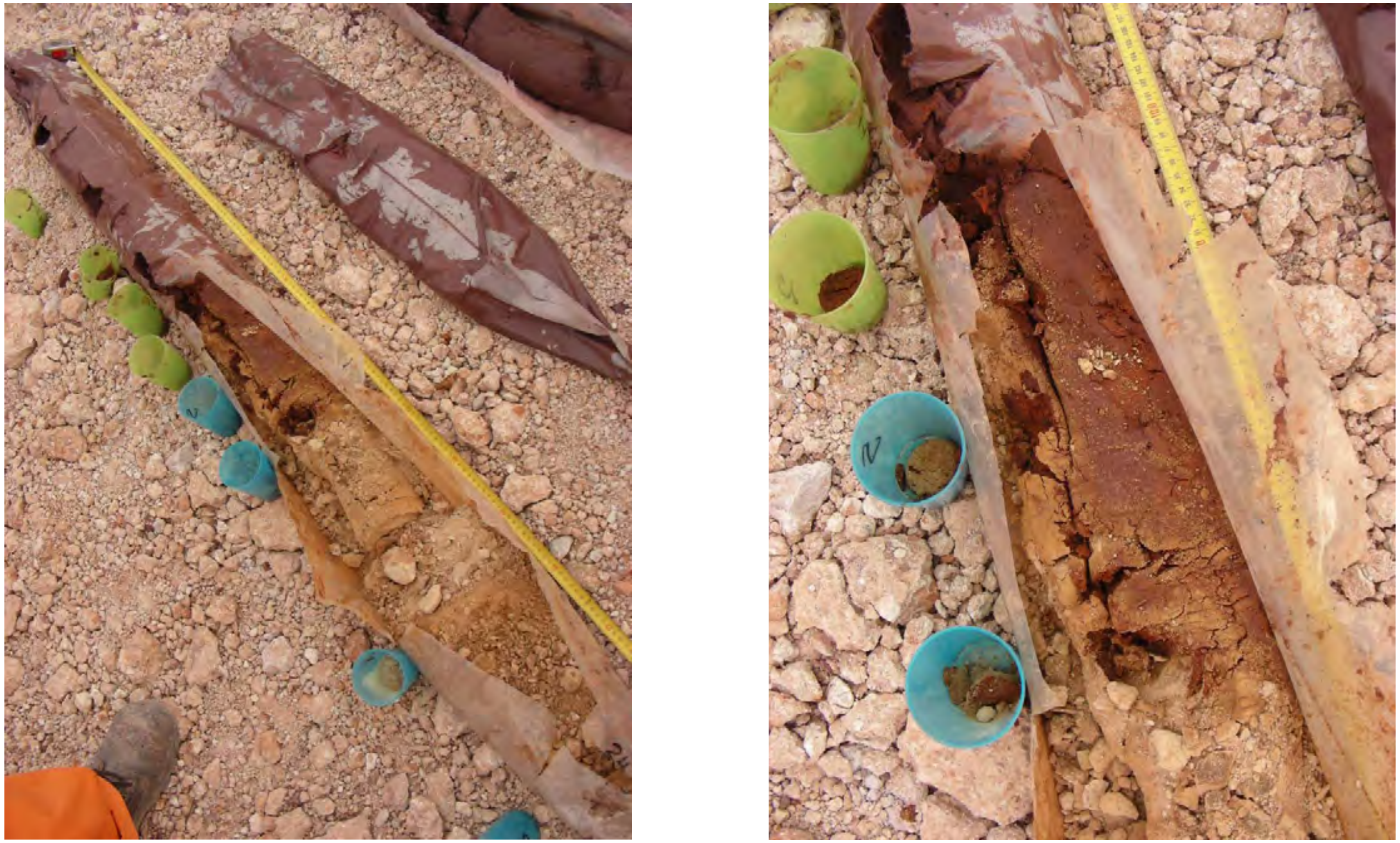


Tailings, 8-10.5m, redder in colour

Bagged tailings, four samples taken from the following depth intervals:
12-13.5m
13.5-15m
16.5-18m
18-19.5m

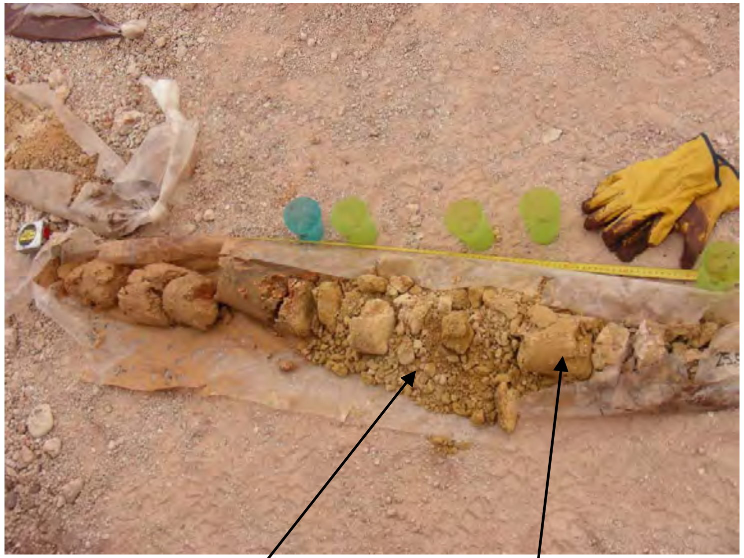
H3.2

21-24m interval, containing the transition zone between tailings and the underlying ground



H3.2

24-25.5m interval



More friable, weathered material
(Sample taken: ODXH3.2-12)

Competent material (Sample
taken: ODXH3.2-13)

25.5-26.5m interval

26.5-27.1m interval

H4.1

16.9-18m interval

18-19m interval

H4.2

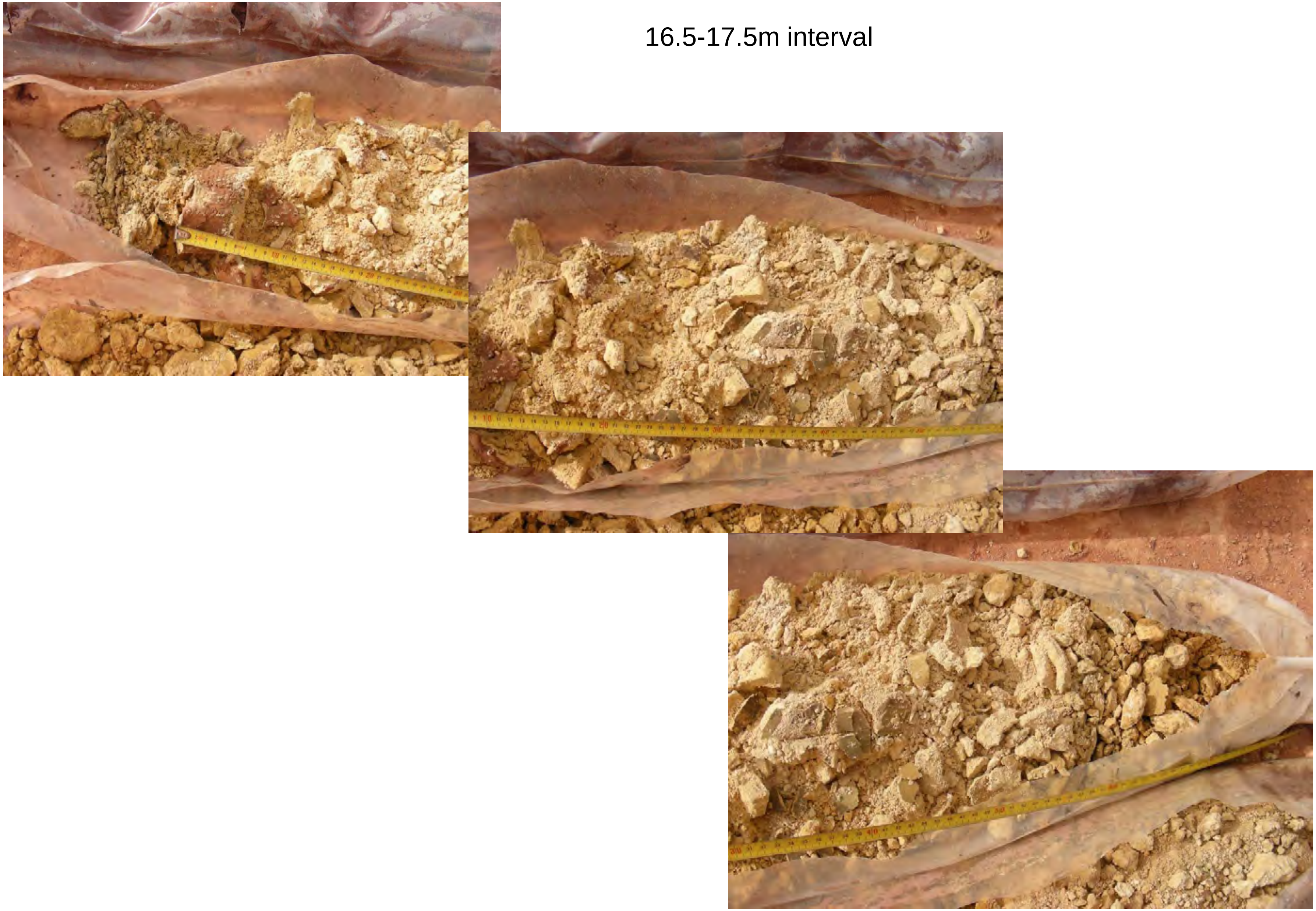
Fine layering visible in tailings

~14.7m

~8m

H4.2

16.5-17.5m interval



H4.2

17.5-18m interval

H4.2

18.5-20m interval

Close up of more competent material

20-21m interval

Appendix 3: Laboratory Programme: Selected Samples and Testwork Matrix

Table A3.1: Summary Testing Programme

Sample #	Hole	Top depth	Material	Porewater extraction & analysis	Composition		Phys/ Chem. Charact.	Paste pH/EC	ANC	Total C	Total S	SO_4 S	NAG	PSD	SA	CEC	XRD	Sequential extraction/ diagnostic leach	Leach tests	Contact Test	Columns		Microsc. /SEM
					Elem-ental	RNs															Unsat.	Sat.	
Tailings																							
ODXH1.01	1.1	7.5	Tailings		1	1	1	1	1		1	1	1										
ODXH1.03	1.1	9	Tailings	1	1	1	1	1	1		1	1	1										
ODXH1.05	1.1	13.5	Tailings		1	1	1	1	1		1	1	1										
ODXH1.07	1.1	18	Tailings	1	1	1	1	1	1		1	1	1	1									
ODXH1.09T	1.1	21	Tailings		1	1	1	1	1		1	1	1										
ODXH1.2-05	1.2	12.75	Tailings		1	1	1	1	1		1	1	1										
ODXH1.2-07	1.2	17.25	Tailings		1	1	1	1	1		1	1	1										
ODXH1.2-09T	1.2	21	Tailings		1	1	1		1			1		1	1	1	1						
ODXH3.2-01	3.2	6	Tailings	1	1	1	1	1	1		1	1	1	1	1	1	1				1	1	
ODXH3.2-03	3.2	10.5	Tailings		1	1	1	1	1		1	1	1										
ODXH3.2-05	3.2	15	Tailings	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1		1		
ODXH3.2-07	3.2	19.5	Tailings		1	1	1	1	1		1	1	1										
ODXH3.2-09	3.2	22.8	Tailings	1	1	1	1	1	1		1	1	1										
ODXH4.1-02	4.1	6.75	Tailings	1	1	1	1	1	1		1	1	1										
ODXH4.1-04	4.1	9.75	Tailings	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1		
ODXH4.1-06	4.1	11.25	Tailings	1	1	1	1	1	1		1	1	1										
ODXH4.2-02	4.2	6.75	Tailings	1	1	1	1	1	1		1	1	1										
ODXH4.2-04	4.2	11.25	Tailings	1	1	1	1	1	1		1	1	1	1									
ODXH1.2-02	1.2	7.5	Tailings & wastes		1	1	1	1	1		1	1	1	1									
TSF footprint sediments																							
ODXH1.09S	1.1	21	TSF footprint sediments		1	1	1		1			1											
ODXH1.12	1.1	29.1	TSF footprint sediments		1	1	1		1			1											
ODXH1.2-09S	1.2	21	TSF footprint sediments		1	1	1		1		1	1		1	1	1	1						
ODXH2.1-7	2.1	20.25	TSF footprint sediments	1	1	1	1		1		1	1		1	1	1	1						
ODXH3.1-02	3.1	21.75	TSF footprint sediments		1	1	1		1			1											

Sample #	Hole	Top depth	Material	Porewater extraction & analysis	Composition		Phys/ Chem. Charact.	Paste pH/EC	ANC	Total C	Total S	SO_4 S	NAG	PSD	SA	CEC	XRD	Sequential extraction/ diagnostic leach	Leach tests	Contact Test	Columns		Microsc. /SEM
					Elem-ental	RNs															Unsat.	Sat.	
ODXH3.1-04	3.1	23.25	TSF footprint sediments		1	1	1		1			1								1			
ODXH3.1-09	3.1	19.5	TSF footprint sediments		1	1	1		1	1	1	1		1	1	1	1			1			
ODXH3.2-10	3.2	23.1	TSF footprint sediments		1	1	1		1			1											
ODXH3.2-12	3.2	24.9	TSF footprint sediments		1	1	1		1			1								1			
ODXH3.2-13	3.2	25.2	TSF footprint sediments		1	1	1		1			1											
ODXH4.1-07	4.1	15	TSF footprint sediments		1	1	1		1			1											
ODXH4.1-10	4.1	17.65	TSF footprint sediments		1	1	1		1			1		1	1	1	1	1	1				
ODXH4.2-05	4.2	15	TSF footprint sediments		1	1	1		1	1	1	1		1	1	1	1	1	1				
ODXH4.2-09	4.2	18.3	TSF footprint sediments		1	1	1		1			1											
RSF footprint sediments																							
ODXPT15-1	PT15	3	RSF footprint sediments		1				1	1	1	1				1	1		1				
ODXPT15-3	PT15	4	RSF footprint sediments		1	1			1	1	1	1				1	1		1				
ODXPT15-5	PT15	9	RSF footprint sediments		1	1			1	1	1	1				1	1		1				
ODXPT15-7	PT15	13.5	RSF footprint sediments		1				1	1	1	1				1	1		1				
ODXPT15-9a	PT15	6.1	RSF footprint sediments		1					1	1	1				1							
ODXPT15-9c	PT15	7.5	RSF footprint sediments		1					1	1					1							
ODXPT15-9f	PT15	16	RSF footprint sediments		1				1	1	1					1	1		1				
ODXPT17-1	PT17	3	RSF footprint sediments		1				1	1	1	1				1	1		1				
ODXPT17-2	PT17	3.75	RSF footprint sediments		1	1				1	1	1				1							
ODXPT17-3d	PT17	6	RSF footprint sediments		1	1				1	1					1							
ODXPT17-3f	PT17	7	RSF footprint sediments		1					1	1					1							
ODXPT17-3h	PT17	9.3	RSF footprint sediments		1					1	1					1							
ODXRD2324-1	RD2324	3	RSF footprint sediments		1	1			1	1	1	1				1	1		1				
ODXRD2324-3	RD2324	6.75	RSF footprint sediments		1				1	1	1	1				1	1		1				
ODXRD2324-5	RD2324	12.75	RSF footprint sediments		1	1			1	1	1					1	1		1				
ODXRD2324-6	RD2324	15.2	RSF footprint sediments		1				1	1	1					1	1		1				
ODXRD2324-7b	RD2324	9.3	RSF footprint sediments		1					1	1					1							
ODXRD2324-7e	RD2324	14.3	RSF footprint sediments		1					1	1					1							

Sample #	Hole	Top depth	Material	Porewater extraction & analysis	Composition		Phys/ Chem. Charact.	Paste pH/EC	ANC	Total C	Total S	SO_4 S	NAG	PSD	SA	CEC	XRD	Sequential extraction/ diagnostic leach	Leach tests	Contact Test	Columns		Microsc. /SEM
					Elem-ental	RNs															Unsat.	Sat.	
ODXRD2324-7g	RD2324	16	RSF footprint sediments		1					1	1					1							
ODXRt16a -1	RT16a	1.5	RSF footprint sediments		1	1			1	1	1	1				1	1		1				
ODXRt16a -10	RT16a	21.7	RSF footprint sediments		1					1	1					1							
ODXRt16a -11	RT16a	23.7	RSF footprint sediments		1				1	1	1					1	1		1				
ODXRt16a -12b	RT16a	4	RSF footprint sediments		1					1	1					1							
ODXRt16a -12d	RT16a	5	RSF footprint sediments		1					1	1					1							
ODXRt16a -12g	RT16a	9.2	RSF footprint sediments		1					1	1					1							
ODXRt16a -12j	RT16a	16	RSF footprint sediments		1					1	1					1							
ODXRt16a -12k	RT16a	19	RSF footprint sediments		1					1	1					1							
ODXRt16a -2	RT16a	2.25	RSF footprint sediments		1					1	1	1				1							
ODXRt16a -3	RT16a	6	RSF footprint sediments		1	1			1	1	1					1	1		1				
ODXRt16a -4	RT16a	6.5	RSF footprint sediments		1	1				1	1					1							
ODXRt16a -5	RT16a	12	RSF footprint sediments		1	1			1	1	1					1	1		1				
ODXRt16a -7	RT16a	20.2	RSF footprint sediments						1	1	1	1				1	1		1				
ODXRt16a -8	RT16a	20.95	RSF footprint sediments		1	1				1	1					1							
ODXRt16a -9	RT16a	21.75	RSF footprint sediments		1				1	1	1					1	1		1				
Underlying Rocks																							
ODXcore1	RD2365	55.6	Andamooka limestone		1	1	1		1			1					1			1		1	
ODXcore2	RD2661	43.6	Andamooka limestone		1	1	1		1	1	1	1			1	1	1						
ODXcore4	RD2661	81.6	Red 2a Arcoona Quartzite		1	1	1		1		1	1			1	1	1			1		1	
ODXcore5	RD2661	117.6	Red Arcoona Quartzite		1	1	1		1			1											
ODXcore3	RD2365	189.6	White Arcoona Quartzite		1	1	1		1	1	1	1			1	1	1						

Appendix 4: CSIRO report: Characterisation of the Geochemistry of Olympic Dam Tailings Material

Characterisation of the Geochemistry of Olympic Dam Tailings Material

Stuart Simpson, Daniel Kilgore, Brad Angel, David Spadaro and Ian Hamilton

CSIRO Land and Water Report No. CLW44/08

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www.csiro.au

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EXECUTIVE SUMMARY

Thirty seven core samples were collected through the tailings dam at the main Olympic Dam mine, South Australia. The materials were collected from various locations (depth and laterally) and were classified as tailings, underlying sediments or bedrock, to 190 m depth. . A surrogate porewater was created by shaking the tailings material in deoxygenated deionised water (1:1 w/v) in a nitrogen atmosphere for three of the ten samples. The solid phase materials were characterised in terms of physical properties, acid-base accounting, radionuclides, the concentrations of major compounds and metals in the solid phase and in the pore waters of selected samples. X-ray diffraction (XRD) and surface area analyses were made on a limited number of samples. For ten tailings samples, the pore waters were extracted under nitrogen for analyses of dissolved constituents. Porewater extraction from most of the samples was very difficult due to the low amount of accessible water (compact, clay-like materials with low water content; 17±6% water)

The materials exhibited a wide range of physico-chemical properties, including wet density, particle size, pH and mineral type. There was equally, a wide range of concentrations of major compounds, metal and radionuclides. Interesting outcomes from the analyses related to the classification of the samples as tailings and/or sediments: (i) concentrations of uranium were greater than 45 mg/kg in all material classified as tailings materials, however many of the sediment samples also had high concentrations of uranium and the sample with the greatest concentration (650 mg/kg) was classified as sediment; and (ii) the tailings materials had radium-226 concentrations in the range 4-10 Bq/g, whereas the sediment concentrations were generally <0.1 Bq/g. However, the radium-226 concentrations measured in two sections of core believed to be above and below the tailings-sediment interface (samples 1.09T (tailings) and 1.09S (sediment)) each measured <0.1 Bq/g, indicating they were mostly sediment materials. This was in contrast to the uranium concentrations of 485 mg/kg in sample 1.09T and 19 mg/kg in 1.09S. In general, the sediments had higher BET surface area (10-39 m^2/g) than the tailings materials (3-5 m^2/g). The XRD analyses indicated the materials were mostly quartz minerals, and contained very small amounts of calcite and dolomite.

The pore waters exhibited an inverse relationship between pH and Eh, and Fe(II) comprised 20-40% of the total dissolved iron. The porewater cations with the greatest concentration were (in decreasing order) Fe>Al>Na>Ca>Mg>Ce>U>Mn>Cu. The mean concentrations of Fe, Al, Ce and U were 12000, 4700, 140 and 130 mg/L, respectively. The cores with the greatest uranium concentrations were 4.2-04 (596 mg/L), 1.07 (262 mg/L), 3.2-05 (215 mg/L), 4.2-02 (131 mg/L), 4.1-06 (113 mg/L), and 4.1-04 (105 mg/L).

Based on the characterisation data, samples of tailings, sediment and bedrock were selected for use in Phase 2 (partitioning, leaching and adsorption characteristics of the Olympic Dam tailings materials) and Phase 3 (saturated and unsaturated column leaching tests of tailings, sediment and bedrock materials from Olympic Dam) project stages.

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1. INTRODUCTION

Olympic Dam is located approximately 570 km north north-west of Adelaide in South Australia. The Olympic Dam mine currently produces approximately 220,000 tonnes per annum of copper, plus associated products (being 4,000 tpa of uranium oxide, 80,000 ounces of gold and 800,000 ounces of silver). The mine proponent, Olympic Dam Corporation Pty Ltd (a member of the BHP Billiton Group), proposes to expand the existing Olympic Dam copper, uranium, gold and silver mine and processing plant, including all associated infrastructure.

The Centre for Environmental Contaminants Research, CSIRO Land and Water (CLW) was engaged by SRK Consulting (Australasia) Pty Ltd to provide scientific advice and experimentation to assess the mobility of metals and radionuclides with the Olympic Dam tailings material located with the main tailings dam. The information from this study will be used for the preparation of an Environmental Impact Statement (EIS). The project comprised three stages:

(i) characterisation of the whole-rock samples and isolation and analyses of pore water (Stage 1 this report),

(ii) assessment of the partitioning, leaching and adsorption processes for major anions, cations, metals and radionuclides. Experiments undertaken with selected tailings, sediment and bedrock materials. Sequential extraction procedures to assess of the partitioning of to different solid phases. Leaching of selected tailings and sediments with deionised water. Adsorption reactions of bedrock materials with pH-6 modified tailings pore water. Materials equilibrated with air, nitrogen, nitrogen/CO_2 mixtures to simulate possible atmospheres existing at various depths in tailings dam (Stage 2; Simpson et al., 2008a), and

(iii) assessment of the kinetics of adsorption and desorption reactions of major anions, cations, metals and radionuclides. Unsaturated column experiments used for selected tailings (deionised water, air atmosphere). Saturated column experiments used for selected tailings (deionised water, air or nitrogen atmosphere), sediment (pH-6 modified tailings pore water, air or nitrogen atmosphere), and bedrock materials (pH-6 modified tailings porewater, nitrogen or N_2/CO_2 atmosphere). Adsorption reactions of bedrock materials with pH-6 modified tailings pore water. Materials equilibrated with air, nitrogen, nitrogen/CO_2 mixtures to simulate possible atmospheres existing at various depths in tailings dam (Stage 3, Simpson et al., 2008b).

1.1 Scope of Work

The scope of work for Stage 1 included:

(i) Baseline characterisation of tailings and underlying sediments collected as drill core samples. Extrusion from the vacuum packed drill core tubes and transfer to an inert gas environment for sectioning and sub-sampling. Pore waters extracted (under nitrogen) and the chemical composition of the pore waters and solid material determined.

(ii) Analyses of chemical composition included measurements of pH, redox potential (Eh), acidity/alkalinity, porewater metals and major anions and cations, radionuclides in waters and solids and analyses of solids. For some samples, analyses included cation exchange capacity, acid-base accounting, BET surface area analysis, and X-ray diffraction (XRD).

2. METHODS

2.1 Samples and Handling

From the drilling program, 37 core samples classified as tailings, underlying sediments or bedrock were selected for the laboratory program (Table 1).

Table 1. Tailings and Underlying Sediment Samples Selected for the Laboratory Program

Sample	Hole	Top depth	Bottom depth	Material
ODXH1.01	1.1	7.5	8.25	Tailings
ODXH1.03	1.1	9	9.75	Tailings
ODXH1.05	1.1	13.5	14.25	Tailings
ODXH1.07	1.1	18	18.75	Tailings
ODXH1.09	1.1	21	21.75	Tailings/underlying sediment
ODXH1.12	1.1	29.1	30	Limestone
ODXH1.2-02	1.2	7.5	8.25	Tailings & wastes
ODXH1.2-05	1.2	12.75	13.5	Tailings
ODXH1.2-07	1.2	17.25	18	Tailings
ODXH1.2-09	1.2	21	21.75	Underlying sediments
ODXH2.1-7	2.1	20.25	21	Underlying sediments
ODXH3.1-02	3.1	21.75	22.5	Underlying sediments
ODXH3.1-04	3.1	23.25	24	Underlying sediments
ODXH3.1-09	3.1	19.5	19.5	Underlying sediments
ODXH3.2-01	3.2	6	6.75	Tailings
ODXH3.2-03	3.2	10.5	11.25	Tailings
ODXH3.2-05	3.2	15	15.75	Tailings
ODXH3.2-07	3.2	19.5	20.25	Tailings
ODXH3.2-09	3.2	22.8	23	Tailings
ODXH3.2-10	3.2	23.1	23.25	Underlying sediments
ODXH3.2-12	3.2	24.9	25.2	Underlying sediments
ODXH3.2-13	3.2	25.2	25.3	Underlying sediments
ODXH4.1-02	4.1	6.75	7.5	Tailings
ODXH4.1-04	4.1	9.75	10.5	Tailings
ODXH4.1-06	4.1	11.25	12	Tailings
ODXH4.1-07	4.1	15	15.75	Underlying sediments
ODXH4.1-10	4.1	17.65	17.8	Underlying sediments
ODXH4.2-02	4.2	6.75	7.5	Tailings
ODXH4.2-04	4.2	11.25	12	Tailings
ODXH4.2-05	4.2	15	15.75	Underlying sediments
ODXH4.2-09	4.2	18.3	18.5	Underlying sediments

Table 2. Bedrock Samples Selected for the Laboratory Program

Sample		Material
Andamooka	Core store sample: 55.6-56 m RD2365	Limestone
Andamooka	Core store sample: 43.6-44 m RD2661	Limestone
Red 2A Arcoona	Core store sample: QT2 81.6-82 m RD2661	Quartzite
Red Arcoona	Core store sample: 117.6-118 m RD2661	Quartzite
White Arcoona	Core store sample: 189.6 m RD2365	Quartzite

2.1.1 Laboratory preparation

To minimise the risk of metal contamination of samples, extensive cleaning of the laboratory was carried out before any equipment was set up. Cleaning involved sweeping and mopping floors, and repeated wiping walls and ceiling with moist Kimwipes®. Most of the laboratory was cleaned in this way, with areas adjacent to where sample processing was to be carried out and air conditioning vents receiving particular attention. These surfaces were cleaned with a cloth moistened with tap water, then repeatedly with tissues moistened with mineral water until no dirt was visible, and finally wiping with tissues (Kimwipes) moistened with mineral water. To further minimise the risk of sample contamination from laboratory surfaces, and of the radioactive tailing material contaminating the laboratory, all benches used for sample handling were covered with plastic (white Bench-kote®).

2.1.2 Handling of radioactive tailings materials

All tailings samples were stored refrigerated at ANSTO Minerals (Building 21) in accordance with their ARPANSA licence conditions. Selected core samples (generally up to 50 kg at any one time) were transferred to CSIRO Land and Water (Building 2) using a large (1.2 m × 0.40 m × 0.30 m) lockable container. Sub-sampling of the samples was undertaken at CSIRO and the remaining sample was returned to ANSTO Minerals for further storage. Standard operating procedures for staff handling radioactive materials were strictly followed at all times.

2.1.3 Extrusion of samples from packaging

The samples were mostly stored in vacuum-packed drill core tubes and the integrity of this packing was examined before extruding the material from the packages. The condition of the tailings samples and photographs are provided in Appendix A. Many of the tailings materials were very compacted within the core, comprised sticky, clay-like, materials and could not be easily extruded. For some core samples the core required breaking to extract the material within. Due to the physical effort necessary to extrude the core contents it was not possible to undertake this in the nitrogen gas-filled glove box (which restricted arm movements). The extrusion of the cores was done on a laboratory bench whereby both ends of the core could be accessed. For extrusion of the material, photography and sectioning (if performed) generally took 5-30 min per core, with longer times required for cores in which the material was difficult to retrieve.

Immediately following extrusion, the core material was transferred to plastic bags and placed in the glove-box to minimise sample oxidation. Although air-exposure could have resulted in some oxidation, because oxygen penetration into the core materials would have been minimal, only a small amount of surface oxidation would be expected to have occurred during this short air-exposure period. All further handling of the samples was undertaken in the glove box. For all core samples, when the tailings were extruded from the core, subsamples of tailings material were taken from the top, middle and bottom of the cores. For some samples, further sectioning was also undertaken. For the whole-rock analyses, samples were taken from the middle of the cores.

All samples were handled using protocols to avoid sample contamination. This included the wearing of clean powder-free vinyl gloves for the handling of all sample bottles and sampling equipment. All containers used for samples were either new (in the case of plastic bags and containers) for storage of solid phases or new and acid-washed (in the case of plastic bottles) for handling and storage of water samples. The acid-washing of bottles involved soaking in 10% nitric acid (analytical reagent grade) for a minimum of 24 hours, followed by rinsing with copious amounts of deionised water (Milli-Q), afterwhich, the bottles were ‘double-bagged’ in two polyethylene bags.

2.1.4 Porewater extraction

Material from the middle of the cores was taken for porewater extractions. All samples were extracted in a nitrogen atmosphere created by filling and capping the containers within the glove bag. The technique used for the extraction of pore water was modified to reflect the water content, porosity and the physical nature (clay) of the samples. Preliminary tests on small amounts of material were used to determine if sufficient volumes of pore water could be extracted by direct centrifugation (under nitrogen). For samples where this was not deemed to be possible, a ‘surrogate pore water’ was prepared in which a mixture of 1 part tailings and 1 part deoxygenated deionised water was shaken for 2 h in a nitrogen atmosphere. The pore water extraction technique used for each sample is shown in Table 3.

Table 3. Core Sample Identification Codes and Porewater Extraction Technique

Tailings Core	**Description**	**Porewater Extraction Technique**
ODXH 1.03	Tailings	Porewater Extraction [a]
ODXH 1.07	Tailings	Porewater Extraction [a] and 1:1 Extraction [b]
ODXH 3.2 - 01	Tailings	1:1 Extraction [b]
ODXH 3.2 - 05	Tailings	Porewater Extraction [a] and 1:1 Extraction [b]
ODXH 3.2 - 09	Tailings	1:1 Extraction [b]
ODXH 4.1 - 02	Tailings	Porewater Extraction [a]
ODXH 4.1 - 04	Tailings	Porewater Extraction [a]
ODXH 4.1 - 06	Tailings	Porewater Extraction [a]
ODXH 4.2 - 02	Tailings	Porewater Extraction [a]
ODXH 4.2 - 04	Tailings	Porewater Extraction [a]
ODXH 2.1 - 7 [c]	Underlying sediments	1:1 Extraction [b]

[a] Porewater Extraction = Direct extraction of pore water via centrifugation of sample.

[b] 1:1 Extraction = Due to insufficient moisture content of the sample a direct porewater extraction was not possible and a surrogate pore water was generated by the addition of 1 part deionised water (Milli-Q) to 1 part sample. This mixture was shaken for 2 h then centrifuged before the surrogate pore water was collected.

[c] Sample from the underlying sediment

The pore water extraction by centrifugation was achieved by transferring 200 g of the moist solid phase into a 250 mL (acid-washed) polycarbonate bottle (Nalgene) and centrifuging for 5 min at 12,0000 rpm (Sovall RC 24 refrigerated centrifuge, (Du Pont) with Sorvall Super-lite SLA-1500 rotor). Generally, 5-30 mL of pore water / 100 g of material was obtained by the direct centrifugation method (for moist samples) and to obtain a sufficient volume of pore water, 4-8 quantities of material needed to be centrifuged per sample. For the least moist samples (i.e. those for which centrifugation gave <5 mL/100 g material), a surrogate pore water method was used. For the preparation of the surrogate pore water, 150 g of the moist solid phase was placed in a 250 mL (acid-washed) polycarbonate bottles (Nalgene) and 150 g of deoxygenated deionised water (Milli-Q) was added and the bottles shaken for 2 h, before centrifuging for 5 min at 12,0000 rpm. For both techniques, immediately after centrifuging the pore water was filtered (<0.45 µm) to the awaiting sample bottle and preserved according to the method used for the analyte.

2.2 Analytical Methods for Sediment Samples

Sediment moisture content, wet density and porosity were determined according to standard methods (Mudroch et al., 1997). For the majority of the chemical analyses the NATA-accredited laboratories ALS Environmental (Brisbane) and Australian Radiation Services Pty Ltd (ARS) were used. ARS was used for all radionuclide analyses of aqueous and solid phases. The methods used by ALS (Environmental Division) have been developed from internationally recognised procedures such as those published by the US EPA, APHA, AS and NEPM (1999) (Tables 4 to 6). For all outsourced analyses, analysis reports are attached as Appendix B.

2.2.1 Analytical quality assurance/quality control (QA/QC)

The accuracy and precision of analytical data was checked using a number of standard laboratory and field QA procedures:

Blanks – laboratory prepared samples that contain no measurable contaminants were prepared for all analyses and were designed to monitor the possible introduction of contaminants that were not present in the collected sample. Reagent blanks or method blanks were prepared and analysed for each method. Ideally, the concentration of an analyte in each blank should be below the reporting limit of that analyte.

Calibration check using matrix-matched standards – laboratory prepared samples that comprise, as closely as possible, the same matrix as the test samples being analysed along with a concentration series (gradient) of the tested analytes. These were used to confirm linearity of the method and adequate functioning of instruments.

Duplicate (Laboratory) samples – these samples were prepared by dividing a test sample into two or more portions, then analysing separately as individual samples.

Replicate samples – these were samples from the same field site or test placed into separate containers and analysed separately as individual samples. Replicate samples provide information on the site heterogeneity of field collected samples and reproducibility of test method.

Matrix spikes – to selected test samples, a known amount of test analyte was added (spiked) and analysed along with the original sample. The percent recovery of each spiked analyte was calculated and reported.

Table 4. Methods used for Analyses of Waters

Analyte	**Method Description and Reference**
Major Cations - Filtered	APHA 21st ed., 3120; USEPA SW 846 - 6010 The ICPAES technique ionises the 0.45um filtered samples, emitting a characteristic spectrum which is compared against matrix matched standards.
Dissolved Metals by ICP-AES	APHA 21st ed., 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020: The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Dissolved Metals by ICP-MS	APHA 21st ed., 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020: The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Dissolved Mercury by FIMS	AS 3550, APHA 21st ed. 3112 Hg - B (Flow-injection ($SnCl_2$) (Cold Vapour generation) AAS) FIM-AAS is an automated flameless atomic absorption technique. A bromate/bromide reagent is used to oxidise any organic mercury compounds in the filtered sample. The ionic mercury is reduced online to atomic mercury vapour by $SnCl_2$ which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve.
Silica (Total Dissolved) by ICPAES	APHA 21st ed., 4500-SiO_2. Silica (Total) determined by calculation from silicon by ICPAES.
Alkalinity by PC Titrator	APHA 21st ed., 2320 B This procedure determines alkalinity by both manual measurement and automated measurement (e.g. PC Titrate) using pH 4.5 for indicating the total alkalinity end-point.
Acidity as Calcium Carbonate	APHA 21st ed., 2310 B Acidity is determined by titration with a standardised alkali to an end-point pH of 8.3.
Major Anions - Filtered	APHA 21st ed., 4500 Cl - B. Automated silver nitrate titration.
Sulfate	APHA 21st ed., 3120 Sulphur and/or Silcon content is determined by ICP/AES and reported as Sulphate and/or Silica after conversion by gravimetric factor.
Chloride by PC Titrator	APHA 21st ed., 3120; USEPA SW 846 - 6010 The ICPAES technique ionises filtered sample atoms emitting a characteristic spectrum. This spectrum is then compared against matrix matched standards for quantification.
Fluoride by PC Titrator	APHA 21st ed., 4500 F--C CDTA is added to the sample to provide a uniform ionic strength background, adjust pH, and break up complexes. Fluoride concentration is determined by either manual or automatic ISE measurement.
Ammonia as N	APHA 21st ed., 4500 NH_3^+-H Ammonia is determined by direct colorimetry by FIA.
Nitrite as N	APHA 21st ed., 4500 NO_3^- I. Nitrite is determined by direct colorimetry by FIA.
Nitrate as N	APHA 21st ed., 4500 NO_3^--I Nitrate is reduced to nitrite by way of a cadmium reduction column followed by quantification by FIA. Nitrite is determined seperately by direct colourimetry and result for nitrate calculated as the difference between the two results.
Nitrite and Nitrate as N (NOx)	APHA 21st ed., 4500 NO3- I. Combined oxidised nitrogen (NO_2+NO_3) is determined by cadmium reduction and direct colorimetry by FIA.
Reactive Phosphorus - Filtered	APHA 21st ed., 4500 P-E Water samples are filtered through a 0.45 µm filter prior to analysis. Ammonium molybdate and potassium antimonyl tartrate reacts in acid medium with orthophosphate to form a heteropoly acid -phosphomolybdic acid - which is reduced to intensely coloured molybdenum blue by ascorbic acid. Quantification is achieved by FIA.
Total Inorganic Carbon (TOC) & Dissolved Inorganic Carbon (TIC)	APHA 21st ed., 5310 B. The automated TOC analyzer determines total and inorganic carbon by IR cell. TOC is calculated as the difference.
Radionuclides: Ra-226,	Analyses undertaken by Australian Radiation Services Pty. Ltd. Determination of radium-

and gross alpha-beta counting	226 carried out by liquid scintillation counting. Measured aliquot of each sample treated in accordance with USEPA co-precipitation method for gross alpha/beta determination in water. Counting carried out on a Ludlum low level alpha/beta counter after preliminary radiochemical separation to isolate radium isotopes..

Table 5. Methods used for Analyses of Solids

Analyte	Method Description and Reference
Exchangeable Cations Preparation	Rayment and Higginson (1992) method 15A1. A 1 M NH_4Cl extraction by end over end tumbling at a ratio of 1:20.There is no pretreatment for soluble salts. Extracts can be run by ICP for cations
Deionised Water Leach	AS4439.3 Preparation of Leachates
Digestion for Total Recoverable Metals EN25W SOIL	USEPA SW846-3005 Method 3005. Nitric/Hydrochloric acid digestion procedure used to prepare surface and ground water samples for analysis by ICPAES or ICPMS. This method is compliant with NEPM (1999) Schedule B(3) (Appendix. 2)
Water Leachable Metals by ICPAES EG005W SOIL	APHA 21st ed., 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020: The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Acid Neutralising Capacity (ANC)	USEPA 600/2-78-054, I. Miller (2000). A fizz test is done to semiquanititatively estimate the likely reactivity. The soil is then reacted with an known excess quanitity of an appropriate acid. Titration determines the acid remaining, and the ANC can be calculated from comparison with a blank titration. Exchangeable Na is exchangeable sodium as a percent of total CEC. Na% = 100 x Na/CEC. The Aluminium is the fraction (of Al^{3+}) exchanged at the same time as the other cations. The pre-treatment is to remove the soluble salts (NaCl, $CaSO_4$, $CaCO_3$, $MgCO_3$, etc) fraction, leaving only the true surface charge bound fraction.
Exchangeable Cations with pre-treatment ED008 SOIL	Rayment & Higginson (1992) Method 15A2. Soluble salts are removed from the sample prior to analysis. Cations are exchanged from the sample by contact with ammonium chloride. They are then quantitated in the final solution by ICPAES and reported as meq/100g of original soil. This method is compliant with NEPM (1999)
Net Acid Generation	Miller (1998) TitrIImetric procedure determines net acidity in a soil following peroxide oxidation. Titrations to both pH 4.5 and pH 7 are reported.
pH (Saturated Paste)	USEPA 600/2 - 78 - 054 - pH determined on a saturated paste by ISE.

In general, the frequency of QC sample processing involved:

- 5% Method Blanks – one analysed within each process lot of 20 samples.
- 10% Laboratory Duplicates – two analysed within each process lot of 20 samples.
- 5% Laboratory Control Samples (LCS) – one analysed within each set of 20 samples..
- 5% Matrix Spikes (MS) – one analysed within each process lot of 20 samples.

Table 6. Methods used for Analyses of Solids

Analyte	Method Description and Reference
Moisture Content	A gravimetric procedure based on weight loss over a 12 hour drying period at 103-105 degrees C. This method is compliant with NEPM (1999) Schedule B(3) (Method 102)
Sulphate as SO_4^{2-} Total	In-house. Total sulphate is determined off a HCl digestion by ICPAES as S , and reported as SO_4
Sulphur - Total as S (LECO)	In-house. Dried and pulverised sample is combusted in a LECO furnace at 1350C in the presence of strong oxidants / catalysts. The evolved S (as SO_2) is measured by infra-red detector
HCl Digest	1 g of soil is digested in 30 ml of 30% HCl and the resultant digest bulked and filtered for analysis by ICPAES
X-ray diffraction (XRD)	1g sub-samples were ground for 10 minutes in a McCrone micronizing mill under ethanol. The resulting slurries were oven dried at 60°C then thoroughly mixed in an agate mortar and pestle before being lightly back pressed into stainless steel sample holders for X-ray diffraction analysis. XRD patterns were recorded with a PANalytical X'Pert Pro Multi purpose diffractometer using Co Ka radiation, variable divergence slit, graphite post diffraction monochromator and fast X'Celerator strip detector. The diffraction patterns were recorded in steps of 0.05° 2 theta with a 0.5 second counting time per step, and logged to data files for analysis. Quantitative analysis was performed on the XRD data using the commercial package SIROQUANT from Sietronics Pty Ltd. The data was first background subtracted and calibrated for the automatic divergence slit. The results are normalised to 100%, and hence do not include estimates of unidentified or amorphous materials.
BET Surface area	The procedure for BET surface area analyses was based on the method of Brunauer (1938). An oven dried (105ºC), degassed sample has a mixture of adsorbate gas (N_2) and inert non adsorbable carrier gas (He) passed over it. Sample cell is immersed in liquid nitrogen and the change in thermal conductivity of the gas mixture is measured during either the adsorption or (more usually) desorption phase. The volume of gas adsorbed/or desorbed is calculated. This volume is then applied to the BET equation to calculate the volume of adsorbed gas on the sample surface as a mono-molecular layer, which is then used to calculate a surface area measured as m^2/g.
Radionuclides: Ra-226, Ra-228, Th-234, Th-228, Pb-210, K-40	Analyses undertaken by Australian Radiation Services Pty. Ltd. The sample was encapsulated in a standard container for measurement. Analysis carried out by high resolution gamma ray spectrometry to determine the content of radium-226 (Ra-226).

3. RESULTS

3.1 Characterisation of Solids (Tailings, Sediments and Bedrock)

3.1.1 Water content, density and porosity of materials

The moisture content, dry and wet density and porosity was measured for each sample following extrusion from the cores are shown in Table 7. The wet density was also calculated based on the mass and volume of the cores before extruding.

Table 7. Moisture (%), Dry and Wet Density and Porosity of Tailings Materials

	Moisture	**Density, g/cm^{3} [a]**			**Porosity [b]**
Sample	**% (wet weight)**	**Wet (measured)**	**Wet (calculated)**	**Dry**	
ODXH 1.01	20	2.3	2.2	1.8	0.46
ODXH 1.03	21	2.3	2.3	1.8	0.47
ODXH 1.05	22	2.2	2.1	1.7	0.49
ODXH 1.07	16	2.6	2.6	2.2	0.40
ODXH 1.09	30	2.1	2.2	1.5	0.63
ODXH 1.12	21	2.0	No core	1.6	0.43
ODXH 1.2-02	21	2.0	2.0	1.6	0.41
ODXH 1.2-05	23	2.1	2.2	1.6	0.49
ODXH 1.2-07	12	2.8	2.5	2.4	0.35
ODXH 1.2-09	18	2.0	2.0	1.7	0.37
ODXH 2.1-7	9.2	2.0	2.1	1.8	0.18
ODXH 3.1-02	9.4	1.8	2.1	1.7	0.17
ODXH 3.1-04	12	2.1	2.3	1.8	0.26
ODXH 3.1-09	13	2.2	No core	1.9	0.28
ODXH 3.2-01	13	2.0	2.1	1.8	0.26
ODXH 3.2-03	17	2.3	2.0	1.9	0.38
ODXH 3.2-05	24	2.1	2.2	1.6	0.49
ODXH 3.2-07	18	2.3	2.5	1.9	0.41
ODXH 3.2-09	13	2.2	No core	1.9	0.28
ODXH 3.2-10	13	2.1	No core	1.8	0.27
ODXH 3.2-12	8.0	1.7	No core	1.6	0.14
ODXH 3.2-13	10	1.9	No core	1.7	0.19
ODXH 4.1-02	24	2.1	2.1	1.6	0.51
ODXH 4.1-04	25	2.1	2.1	1.6	0.54
ODXH 4.1-06	26	2.1	1.9	1.6	0.54
ODXH 4.1-07	21	2.0	2.0	1.6	0.41
ODXH 4.1-10	18	1.5	No core	1.2	0.26
ODXH 4.2-02	17	2.4	2.2	2.0	0.41
ODXH 4.2-04	23	2.2	2.2	1.7	0.49
ODXH 4.2-05	18	1.5	2.0	1.2	0.26
ODXH 4.2-09	6.8	1.7	No core	1.6	0.12

[a] Wet density was measured for material removed from the cores and also calculated based on estimated volume (5000 cm^{3}) and core mass before extraction. For samples not in cores, no calculation was made.

[b] Porosity = wet density multiplied by the %-water

3.1.2 pH, net acid generation (NAG), acid neutralisation capacity (ANC), sulfur of tailings

The paste-pH of the top, middle and bottom solid samples was measured (Table 8).

Table 8. Paste-pH of sub-samples taken from the top, middle and bottom of selected core samples

			Sediment pH	
Sample	**Description**	**Top**	**Middle**	**Bottom**
ODXH 1.01	Tailings	4.2	4.1	4.3
ODXH 1.03	Tailings	3.9	3.5	3.9
ODXH 1.05	Tailings	4.7	4.7	3.9
ODXH 1.07	Tailings	3.1	3.3	3.1
ODXH 1.09 [b]	Tailings/underlying sediment	3.8	3.7	6.9
ODXH 1.12	Limestone	7.2	7.8	8.0
ODXH 1.2 – 02	Tailings & wastes	10.1	8.8	10.0
ODXH 1.2 – 05	Tailings	2.6	2.7	2.4
ODXH 1.2 – 07	Tailings	3.4	3.0	3.4
ODXH 1.2 – 09 [b]	Underlying sediments	3.2	3.3	3.7
ODXH 2.1 - 7 [c]	Underlying sediments	3.3	3.6	3.5
ODXH 3.1 – 02	Underlying sediments	3.9	4.4	6.5
ODXH 3.1 – 04	Underlying sediments	6.8	6.7	7.6
ODXH 3.1 – 09	Underlying sediments	NA [a]	8.6	NA
ODXH 3.2 – 01	Tailings	7.2	7.0	7.0
ODXH 3.2 – 03	Tailings	7.1	7.1	7.1
ODXH 3.2 – 05	Tailings	2.6	2.8	2.6
ODXH 3.2 – 07	Tailings	3.4	3.4	3.3
ODXH 3.2 – 09	Tailings	3.7	3.7	3.7
ODXH 3.2 – 10	Underlying sediments	NA	3.9	NA
ODXH 3.2 – 12	Underlying sediments	NA	7.8	NA
ODXH 3.2 – 13	Underlying sediments	NA	7.7	NA
ODXH 4.1 – 02	Tailings	2.6	3.3	2.4
ODXH 4.1 – 04	Tailings	4.0	3.9	4.0
ODXH 4.1 – 06	Tailings	4.3	3.5	3.3
ODXH 4.1 – 07	Underlying sediments	5.0	3.6	3.5
ODXH 4.1 - 10	Underlying sediments	NA	7.2	NA
ODXH 4.2 – 02	Tailings	2.4	2.7	2.9
ODXH 4.2 – 04	Tailings	2.6	2.7	2.7
ODXH 4.2 – 05	Underlying sediments	3.1	4.1	7.0
ODXH 4.2 – 09	Underlying sediments	NA	7.7	NA

[a] NA = bag of sample collected, rather than a core (no top, middle, bottom). [b] Sample from the underlying sediment

[c] Samples were observed to contain boundaries between different layers

For the sample ODXH1.09 the interface between the tailings and underlying sediment was clear and the core was split at this point and subsamples taken from each side of the boundary (Appendix 1). The bottom paste-pH represents the pH of the underlying sediments, while the top and middle paste-pH values were from the overlying tailings material. The tailing material and the underlying sediments were sliced into 5-cm sections away from the interface, each being place in labelled plastic bags. For the sample ODXH1.2-09 (Appendix 1), there was an interface between sandy material and clay-like material. This core was split at the interface point, however the paste-pH indicated little pH change between the two layers and it was all likely to be tailings material. The two material types were placed in separate plastic bags. The samples ODXH 4.1-07 and ODXH4.2-05 were also expected to be in close proximity to the tailings-underlying sediment interface, however, there was no apparent boundary within these cores. The shift in paste-pH measured from top to bottom for samples ODXH3.1–02 (pH 3.9 to 6.5) and ODXH4.2-05 (pH 3.1 to 7.0) indicated a possible transition in the type of material. Both of these cores were sliced into 10-cm sections from top to bottom.

The paste pH, pH following peroxide oxidation, net acid generation (NAG) acid neutralisation capacity (ANC), and sulfur concentrations of selected tailings samples are shown in Tables 9 and 10. All samples were taken from the centre of the core unless the core had been split into tailings (upper) and sediment (lower) sections (as for core 1.09), in which case the samples were taken from the top and bottom of the core respectively. The relationships between paste pH values measured by ALS and CSIRO and the peroxide pH (pH(ox)) value (by ALS) are shown in Figure 1. The pH_{OX} and NAG results indicate that the materials generally had very low acid generating capacity remaining. The acid-neutralising capacity (ANC) of both samples classified as tailings and underlying sediments was quite variable (Table 9).

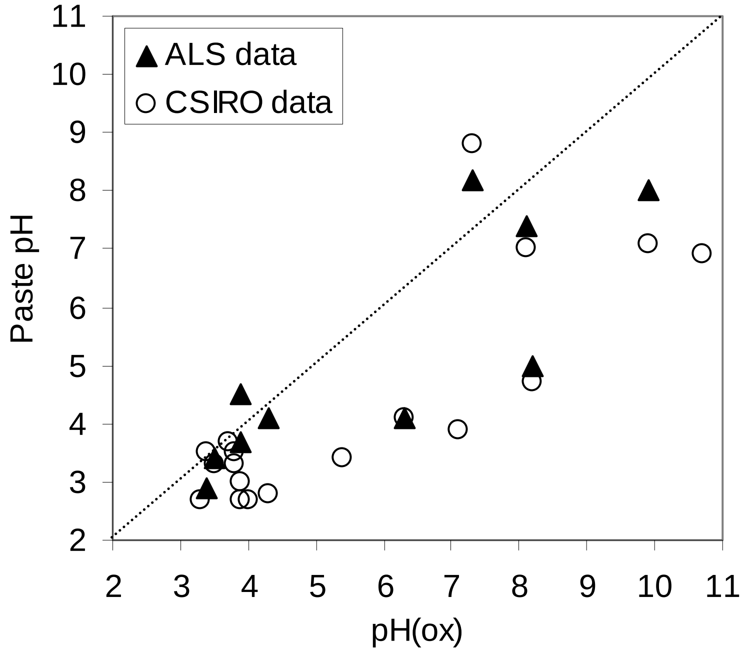


Figure 1. Relationships paste pH values measure by ALS and CSIRO and the peroxide pH (pH(ox)) value (by ALS)

Table 9. Paste pH, net acid generation (NAG) and acid neutralisation capacity (ANC) of selected tailings samples

Samples	Material type	Paste pH	Net Acid Generation			Acid Neutralising Capacity		
			pHox	pH 4.5	pH 7.0			Fizz Rating
				kg H_2SO_4/t		kg H_2SO_4 equivalent	% $CaCO_3$	Fizz units
ODXH 1.01	Tailings	4.1	6.3	<0.1	1.0	11.2	1.1	0
ODXH 1.03	Tailings	2.9	3.4	1.9	9.3	<0.5	<0.1	0
ODXH 1.05	Tailings	5.0	8.2	<0.1	<0.1	39.4	4.0	2
ODXH 1.07	Tailings	3.4	3.5	1.5	9.3	<0.5	<0.1	0
ODXH 1.09	Tailings	7.8				<0.5	<0.1	0
ODXH 1.09	Sediment		10.7	<0.1	<0.1	154	15.7	3
ODXH 1.12	Limestone					282	28.8	3
ODXH 1.2-02	Tails/waste	8.2	7.3	<0.1	<0.1	90.0	9.2	2
ODXH 1.2-05	Tailings	3.7	3.9	1.0	15.3	<0.5	<0.1	0
ODXH 1.2-07	Tailings	4.5	3.9	0.5	10.8	<0.5	<0.1	0
ODXH 1.2-09	Sediments					<0.5	<0.1	0
ODXH 1.2-09	Sediments					<0.5	<0.1	0
ODXH 2.1-7	Sediments					<0.5	<0.1	0
ODXH 3.1-02	Sediments					7.1	0.7	0
ODXH 3.1-04	Sediments					<0.5	<0.1	0
ODXH 3.1-09	Sediments					NA		
ODXH 3.2-01	Tailings	7.4	8.1	<0.1	<0.1	51.8	5.3	2
ODXH 3.2-03	Tailings	8.0	9.9	<0.1	<0.1	37.0	3.8	2
ODXH 3.2-05	Tailings	4.1	4.3	0.2	10.0	<0.5	<0.1	0
ODXH 3.2-07	Tailings		5.4	<0.1	6.4	<0.5	<0.1	0
ODXH 3.2-09	Tailings		3.7	0.8	9.9	<0.5	<0.1	0
ODXH 3.2-10	Sediments					7.5	0.8	0
ODXH 3.2-12	Sediments					284	28.9	3
ODXH 3.2-13	Sediments					272	27.7	3
ODXH 4.1-02	Tailings		3.8	0.8	6.4	<0.5	<0.1	0
ODXH 4.1-04	Tailings		7.1	<0.1	<0.1	51.8	5.3	2
ODXH 4.1-06	Tailings		3.8	0.8	12.6	<0.5	<0.1	0
ODXH 4.1-07	Sediments					<0.5	<0.1	0
ODXH 4.1-10	Sediments					<0.5	<0.1	0
ODXH 4.2-02	Tailings		3.3	2.7	9.7	<0.5	<0.1	0
ODXH 4.2-04	Tailings		4.0	0.4	9.0	<0.5	<0.1	0
ODXH 4.2-05	Sediments					3.1	0.3	0
ODXH 4.2-09	Sediments					284	29.0	3
Core 4, 81.6-82 m Red 2A Arcoona	Quartzite					<0.5	<0.1	0
Core 5, 118.6-118m Red Arcoona	Quartzite					2.6	0.3	0
Core 2, 43.6-44 m Andamooka	Limestone					4.4	0.4	0
Core 1, 55.6-56 m Andamooka	Limestone					261	26.6	3
Core3, 189.6 White Arcoona	Limestone					1.9	0.2	0

Table 10. The paste pH and conductivity, moisture content, sulfate and total sulfur of selected tailings samples

Samples	**Conductivity (EC) µS/cm**	**Moisture % water**	**Sulfate (SO_4^{2-}) mg/kg**	**Total as S %**
ODXH 1.01	3120	19.4	28200	1.14
ODXH 1.03	5700	14.6	30200	1.23
ODXH 1.05	4190	18.0	30200	1.23
ODXH 1.07	5300	15.8	18000	0.92
ODXH 1.09 (Tailings)		13.4	73400	
ODXH 1.09 (Sediment)	2650	15.5	6140	0.27
ODXH 1.12		19.5	24400	
ODXH 1.2-02	13800	27.1	75300	5.99
ODXH 1.2-05	7120	23.2	59500	2.39
ODXH 1.2-07	3690	14.0	20100	1.11
ODXH 1.2-09 (Tailing)		21.4	106000	
ODXH 1.2-09 (Sediment)		17.4	139000	
ODXH 2.1-7		9.3	4070	
ODXH 3.1-02		9.4	39000	
ODXH 3.1-04		12.6	7380	
ODXH 3.1-09		13.2	620	
ODXH 3.2-01	13700	20.9	20900	1.34
ODXH 3.2-03	11400	16.3	11300	0.85
ODXH 3.2-05	4360	19.7	33700	1.24
ODXH 3.2-07	4360	15.4	20700	1.08
ODXH 3.2-09	4150	15.0	20500	1.03
ODXH 3.2-10		12.8	21800	
ODXH 3.2-12		7.3	2520	
ODXH 3.2-13		10.9	7240	
ODXH 4.1-02	3270	17.4	31800	1.35
ODXH 4.1-04	4020	17.6	40700	1.62
ODXH 4.1-06	5480	18.0	44900	1.82
ODXH 4.1-07		21.4	238000	
ODXH 4.1-10		20.8	370000	
ODXH 4.2-02	4060	15.6	29500	1.33
ODXH 4.2-04	4290	16.0	24600	1.34
ODXH 4.2-05		17.6	110000	
ODXH 4.2-09		6.4	15500	
Core 4, 81.6-82 m Red 2A Arcoona QTZ		<1.0	680	
Core 5, 117.6-118m Red Arcoona		<1.0	110	
Core 2, 43.6-44 m Andamooka		1.2	660	
Core 1, 55.6-56 m Andamooka		<1.0	7240	
Core3, 189.6 White Arcoona		<1.0	<100	

3.1.3 Major compounds and metals, exchangeable cations, BET surface area and particle size of the materials

The concentrations of major compounds and metals in the samples are shown in Tables 11 to 16. The exchangeable cation concentrations were determined for selected samples (Table 17). BET surface area and particle size results are provided in Table 18 and XRD results are in Table 19. The concentrations of the radionuclides, radium-226, thorium-234, lead-210, radium-228, thorium-228, and potassium-40 are shown in Tables 20 and 21. There were a wide range of concentrations of major compounds, metal and radionuclides and detailed discussion of this data is beyond the scope of this report. Notably, concentrations of uranium were greater than 45 mg/kg (Table 16, arbitrary) in all material classified as tailings materials, however many of the sediment samples also had high concentrations of uranium and the sample with the greatest concentration (650 mg/kg) was classified as sediment.

The exchange capacities (CEC) ranged from 9.5 to 192 meg/100g for the sediment material 4.1-10 (Table 17). The sample ODXH 1.2-09 (TM) was described as a tailings material (Table 8), but the CEC was consistent with this material being predominantly sediment. In general, the sediments had higher BET surface area (10-39 m^2/g) than the tailings materials (3-5 m^2/g, exception being sample 1.2-09 (TM) directly above the sediment sample 1.2-09 (US). Again, this was consistent with this material being predominantly sediment.

Both the tailings and sediment samples had moderate to high portions of fine materials, i.e. 9-70% <60 µm (Table 18). The tailings materials did not necessarily have a smaller particle size than the sediment materials, although the 1.2-09 tailings material was finer (99% <150 µm) than the 1.2-09 sediment material (40% <150 µm).

The materials for which XRD analyses were performed (Table 19) indicated they were mostly comprised of quartz minerals, and contained very small amounts of calcite (2% in sample 3.1-09 only; none detected in others) and dolomite (2% in samples 3.2-01 and 4.1-04 only; none detected in others). A number of the samples had high gypsum concentrations.

In general, the tailings materials had radium-226 concentrations in the range 4-10 Bq/g, whereas the sediment concentrations were generally <0.1 Bq/g. Interestingly, the radium-226 concentrations of both the samples 1.09T (tailings) and 1.09S (sediment) were similar and <0.1 Bq/g, indicating they were mostly sediment materials. This in contrast to the uranium concentrations of these samples being 485 mg/kg in samples 1.09T (tailings) and 19 mg/kg in 1.09S (sediment). Similar tailings versus sediment relationships were observed for the other radionuclides.

Table 11. Percent concentrations of major compounds in Olympic Dam samples

Sample	Al_2O_3 %	BaO %	CaO %	Cr_2O_3 %	Fe_2O_3 %	K_2O %	MgO %	MnO %	Na_2O %	P_2O_5 %	SiO_2 %	SrO %	TiO_2 %	LOI [a] %
ODXH 1.01	6.53	0.9	3.07	0.01	44.2	1.79	0.58	0.02	0.04	0.3	34.3	0.07	0.21	4.8
ODXH 1.03	8.22	0.75	2.14	<0.01	40.4	2.3	0.19	0.01	0.1	0.3	38.1	0.09	0.22	4.0
ODXH 1.05	7.19	0.67	6.16	0.01	33.1	2.03	2.81	0.02	0.22	0.25	34.1	0.07	0.2	10
ODXH 1.07	7.96	0.73	1.57	<0.01	46.3	2.21	0.14	0.01	0.08	0.32	34.9	0.07	0.19	3.0
ODXH 1.09 (TM)	8.19	0.03	4.77	<0.01	4.12	0.4	0.8	0.03	0.18	0.04	66.7	0.02	0.27	7.4
ODXH 1.09 (US)	4.58	0.15	9.47	0.01	1.59	0.2	0.61	0.01	0.07	0.07	73.1	0.03	0.18	9.2
ODXH 1.12	1.09	<0.01	29.4	<0.01	0.44	0.02	20.4	0.04	0.1	0.08	2.39	0.01	0.04	45
ODXH 1.2-02	5.97	0.42	7.12	0.01	26	1.53	0.97	0.02	0.66	0.19	35.1	0.05	0.21	8.6
ODXH 1.2-05	8.48	0.88	2.76	<0.01	34.7	2.49	0.17	0.01	0.39	0.26	36	0.07	0.19	7.7
ODXH 1.2-07	5.57	1.02	0.62	<0.01	63.7	1.48	0.12	0.01	0.18	0.33	20.6	0.04	0.14	3.2
ODXH 1.2-09 (TM)	4.42	0.03	3.42	0.01	6.13	0.51	0.69	0.01	0.4	0.11	67.3	0.03	0.19	8.9
ODXH 1.2-09 (US)	9.48	0.03	7.37	<0.01	4.29	0.31	0.97	0.01	0.38	0.04	53.9	0.01	0.2	12
ODXH 2.1-7	1.58	0.01	0.24	<0.01	1.36	0.16	0.15	0.01	0.08	0.01	94.8	0.01	0.1	1.4
ODXH 3.1-02	5.3	0.02	3.61	<0.01	1.72	0.19	0.58	0.01	0.29	<0.01	78.1	0.01	0.16	5.8
ODXH 3.1-04	2.66	0.07	27.7	<0.01	1.45	0.23	9.61	0.02	0.23	0.04	23.5	0.02	0.13	33
ODXH 3.1-09	2.13	0.02	1.63	0.01	2.68	0.32	0.37	0.01	0.14	0.02	90.3	0.02	0.16	2.0
ODXH 3.2-01	10.5	0.77	3.51	<0.01	22.4	2.83	1.22	0.03	1.2	0.23	43.2	0.06	0.24	9.1
ODXH 3.2-03	7.83	0.49	3.11	<0.01	27	1.91	0.73	0.02	0.95	0.19	50.1	0.04	0.28	5.0
ODXH 3.2-05	10.1	0.91	2.01	<0.01	32.8	2.72	0.2	0.01	0.36	0.3	42.7	0.07	0.22	4.2

All data are for dry weight basis. TM denotes tailings material, US denotes underlying sediment. [a] LOI = loss on ignition (450ºC)

Table 12. Percent concentrations of major compounds in Olympic Dam samples

Sample	Al_2O_3 %	BaO %	CaO %	Cr_2O_3 %	Fe_2O_3 %	K_2O %	MgO %	MnO %	Na_2O %	P_2O_5 %	SiO_2 %	SrO %	TiO_2 %	LOI %
ODXH 3.2-07	8.06	0.92	1	<0.01	44.2	2.2	0.22	0.01	0.3	0.37	35.5	0.06	0.23	4.0
ODXH 3.2-09	5.23	0.81	0.57	<0.01	45.1	1.36	0.16	0.01	0.28	0.3	40.1	0.03	0.15	3.4
ODXH 3.2-10	3.1	0.03	1.86	<0.01	2.64	0.27	0.63	0.01	0.25	0.01	87.6	0.01	0.15	3.3
ODXH 3.2-12	1.09	0.01	29.1	<0.01	0.79	0.15	19.85	0.1	0.19	0.03	3.5	0.05	0.04	45
ODXH 3.2-13	1.28	<0.01	28.8	<0.01	0.53	0.16	19.75	0.06	0.22	0.03	4.26	0.02	0.05	44
ODXH 4.1-02	9.91	0.73	2.33	<0.01	31.1	2.96	0.26	0.01	0.33	0.3	43.4	0.07	0.24	5.0
ODXH 4.1-04	8.36	0.76	4.06	<0.01	34	2.33	1.43	0.02	0.35	0.31	35.7	0.07	0.21	8.3
ODXH 4.1-06	8.97	0.84	2.53	0.01	37.9	2.47	0.24	0.02	0.33	0.33	35.8	0.09	0.2	5.8
ODXH 4.1-07	13.2	0.02	11.3	0.01	2.27	1.3	0.67	0.02	0.28	0.02	46.8	0.02	0.52	8.4
ODXH 4.1-10	13.9	0.01	13.6	0.01	5.76	2.47	1.67	0.02	0.75	0.07	37.7	0.03	0.41	7.1
ODXH 4.2-02	8.18	0.65	1.91	<0.01	41.4	2.3	0.18	0.01	0.28	0.36	36.5	0.1	0.23	4.4
ODXH 4.2-04	9.14	0.96	2.14	<0.01	33.4	2.6	0.19	0.01	0.42	0.27	43.4	0.06	0.24	3.7
ODXH 4.2-05	10.5	0.1	6.19	<0.01	5.95	0.78	1.14	0.04	0.46	0.07	53.8	0.02	0.29	12
ODXH 4.2-09	0.42	<0.01	34.4	<0.01	0.99	<0.01	16.2	0.17	0.2	0.01	2.22	0.02	0.02	44
Core 4, 81.6-82m Red 2A Arcoona QTZ	3.83	0.01	0.12	0.01	1.4	1.52	0.43	<0.01	0.21	0.03	91.3	<0.01	0.27	0.83
Core 5, 117.6-118m Red Arcoona	2.13	0.01	0.12	0.02	0.85	1.12	0.25	0.01	0.15	0.03	94.5	<0.01	0.12	0.51
Core 2, 43.6-44m Andamooka	6.7	0.03	0.05	0.02	2.05	2.87	0.51	0.01	0.28	0.06	85.5	0.01	0.5	1.3
Core 1, 55.6-56m Andamooka	0.85	<0.01	23.9	<0.01	1.14	0.19	16.2	0.17	0.16	<0.01	17.75	0.01	0.04	39
Core3, 189.6 White Arcoona	0.62	<0.01	0.04	0.01	0.44	0.21	0.22	<0.01	0.13	0.03	97.8	<0.01	0.05	0.24

All data are for dry weight basis. [a] LOI = loss on ignition (450ºC)

Table 13. Primary mineral forming cations in solid rock samples (Part 1 of 4)

Samples	Ag mg/kg	Al %	As mg/kg	B mg/kg	Ba mg/kg	Be mg/kg	Bi mg/kg	Cd mg/kg
ODXH 1.01	2.57	3.11	72.7	30	800	1.44	4.41	<0.02
ODXH 1.03	2.22	3.88	64.9	40	680	1.51	5.83	<0.02
ODXH 1.05	1.63	3.47	54.5	40	610	1.29	4.11	<0.02
ODXH 1.07	2.91	3.82	76.2	40	1400	2.06	6.37	<0.02
ODXH 1.09 (TM)	0.08	2.42	10.7	20	1220	0.57	0.14	0.03
ODXH 1.09 (US)	0.09	3.51	6.9	10	240	1.87	0.12	0.06
ODXH 1.12	0.02	0.59	<5	10	20	0.34	<0.01	0.03
ODXH 1.2-02	1.52	3.17	52	50	1110	1.33	3.53	<0.02
ODXH 1.2-05	26.6	4.08	89.5	60	730	1.4	11.8	<0.02
ODXH 1.2-07	7.35	2.66	94.7	50	850	2.38	10.25	<0.02
ODXH 1.2-09 (TM)	0.21	2.26	7	20	250	0.58	0.28	<0.02
ODXH 1.2-09 (US)	0.31	4.51	7.1	20	230	1.64	0.15	<0.02
ODXH 2.1-7	0.07	0.83	2.2	20	180	0.29	0.08	<0.02
ODXH 3.1-02	0.03	2.59	4.1	20	170	1.69	0.06	<0.02
ODXH 3.1-04	0.02	1.52	12	20	510	0.48	0.03	0.05
ODXH 3.1-09	0.17	1.05	3.9	20	210	0.3	0.14	<0.02
ODXH 3.2-01	9.96	5.36	85.1	70	780	1.68	20.7	0.06
ODXH 3.2-03	2.61	3.95	54.9	60	1220	1.45	4.72	<0.02
ODXH 3.2-05	2.33	4.94	95	60	980	1.62	5.52	<0.02
ODXH 3.2-07	3.85	4.06	129	40	930	2.55	3.88	<0.02
ODXH 3.2-09	4.61	2.57	73.6	30	850	1.9	5.81	<0.02
ODXH 3.2-10	0.13	1.54	4.6	<10	340	0.55	0.18	<0.02
ODXH 3.2-12	0.09	0.61	15	10	150	0.41	0.03	0.02
ODXH 3.2-13	0.05	0.69	9	<10	30	0.4	0.01	0.03
ODXH 4.1-02	2.43	4.7	67.4	60	1060	1.83	6.55	<0.02
ODXH 4.1-04	1.9	4.34	76.7	50	640	1.63	5.68	<0.02
ODXH 4.1-06	1.97	4.39	87.8	60	640	2	5.84	<0.02
ODXH 4.1-07	0.09	6.35	15.7	70	170	1.39	0.45	<0.02
ODXH 4.1-10	0.08	6.3	31.4	120	100	5.24	0.4	<0.02
ODXH 4.2-02	2.59	4.04	74.9	60	700	1.86	9.14	<0.02
ODXH 4.2-04	2.01	4.44	81.8	70	880	1.58	4.83	<0.02
ODXH 4.2-05	0.34	5.19	21.1	30	580	2.54	0.48	0.05
ODXH 4.2-09	0.04	0.25	8	20	50	0.26	0.04	0.04
Core 4, 81.6-82 m Red 2A Arcoona QTZ	0.03	2.18	2.1	60	190	0.9	0.09	<0.02
Core 5, 117.6-118m Red Arcoona	0.02	1.09	4.9	40	140	0.4	0.02	<0.02
Core 2, 43.6-44 m Andamooka	0.08	3.08	2.1	50	230	0.88	0.08	0.03
Core 1, 55.6-56 m Andamooka	0.03	0.49	<5	20	20	0.31	0.01	0.09
Core3, 189.6 White Arcoona	0.02	0.3	1.6	10	40	0.07	<0.01	<0.02

All data are for dry weight basis. TM denotes tailings material, US denotes underlying sediment

Table 14. Primary mineral forming cations in solid rock samples (Part 2 of 4)

Samples	Ce mg/kg	Co mg/kg	Cr mg/kg	Cu mg/kg	Hg mg/kg	Li mg/kg	Mn mg/kg	Mo mg/kg
ODXH 1.01	>500	31.3	29	946	0.117	10.1	63	57.9
ODXH 1.03	>500	27.1	19	614	0.136	11.9	46	48.2
ODXH 1.05	>500	41.8	31	1120	0.137	10.9	131	51.8
ODXH 1.07	>500	27.5	10	1460	0.184	13.7	41	52.6
ODXH 1.09 (TM)	>500	48.8	15	2720	0.026	18.9	208	0.69
ODXH 1.09 (US)	50.1	16.2	43	35.4	0.011	13.5	67	2.3
ODXH 1.12	15.95	3	4	11.4	<0.005	1.9	248	0.41
ODXH 1.2-02	>500	27.2	29	1820	0.08	11.2	100	38.4
ODXH 1.2-05	>500	27.9	19	2070	0.231	13.9	47	53.3
ODXH 1.2-07	>500	94.3	15	4610	0.1	11.4	40	55
ODXH 1.2-09 (TM)	393	17.6	19	6370	0.012	19.3	61	1.13
ODXH 1.2-09 (US)	286	16.3	31	375	0.011	12.2	71	1.48
ODXH 2.1-7	41.4	6.8	30	102.5	0.007	10.1	39	0.79
ODXH 3.1-02	367	16.3	21	1450	0.015	26.4	98	0.64
ODXH 3.1-04	20.4	37.1	9	19.7	0.005	10	171	0.52
ODXH 3.1-09	38.5	4.5	45	782	0.017	8.8	97	6.44
ODXH 3.2-01	>500	70	25	15150	0.585	17.4	223	62
ODXH 3.2-03	>500	30	22	2810	0.144	13.4	100	39
ODXH 3.2-05	>500	35.7	19	2020	0.157	17.8	52	62.8
ODXH 3.2-07	>500	35.8	22	2020	0.095	17.5	67	58.1
ODXH 3.2-09	>500	53.3	27	2330	0.068	10.9	51	36.6
ODXH 3.2-10	147	18.8	23	211	0.011	11.2	79	1.57
ODXH 3.2-12	20.9	7.4	5	15.6	<0.005	4.5	688	0.46
ODXH 3.2-13	15.15	3.9	5	8.7	0.006	5.1	431	0.17
ODXH 4.1-02	>500	57.8	28	788	0.141	13.2	58	64.5
ODXH 4.1-04	>500	44.1	27	933	0.159	13.5	101	58.1
ODXH 4.1-06	>500	46	32	1210	0.163	15.2	79	67.7
ODXH 4.1-07	345	33.3	34	763	0.007	27.2	108	1.63
ODXH 4.1-10	475	24	34	13.4	0.007	28.5	111	2.87
ODXH 4.2-02	>500	46.9	17	980	0.107	10.7	57	50.6
ODXH 4.2-04	>500	24.4	19	1570	0.167	13.3	43	48.6
ODXH 4.2-05	>500	67.7	20	2600	0.03	29.4	269	2.99
ODXH 4.2-09	21.1	9	2	18.5	0.006	1.9	1210	0.62
Core 4, 81.6-82 m Red 2A Arcoona QTZ	38.9	5.4	53	19.8	0.009	8.9	41	1.32
Core 5, 117.6-118m Red Arcoona	14.75	2.4	94	7.2	0.008	7.3	72	3.75
Core 2, 43.6-44 m Andamooka	52.5	2.8	96	14.3	0.034	7.7	38	3.61
Core 1, 55.6-56 m Andamooka	8.95	5.2	12	4	0.006	5.7	1240	0.71
Core3, 189.6 White Arcoona	19.2	1.6	79	6.3	<0.005	5.5	16	2.79

All data are for dry weight basis. TM denotes tailings material, US denotes underlying sediment

Table 15. Primary mineral forming cations in solid rock samples (Part 3 of 4)

Samples	**Ni mg/kg**	**Pb mg/kg**	**Re mg/kg**	**Sb mg/kg**	**Sc mg/kg**	**Se mg/kg**	**Sn mg/kg**	**Sr mg/kg**
ODXH 1.01	4.3	72.6	0.031	8.89	2.6	4	21.4	377
ODXH 1.03	4.3	61.8	0.031	8.42	2.7	6	18	533
ODXH 1.05	5.8	56.5	0.027	6.88	2.6	4	17	378
ODXH 1.07	4.7	66.8	0.02	9.73	3.2	4	20.5	309
ODXH 1.09 (TM)	14.1	7.6	0.004	0.23	4	11	1	82.9
ODXH 1.09 (US)	9.5	13.1	0.004	0.33	3.5	2	1	192
ODXH 1.12	4.6	1	<0.002	0.06	1.3	1	0.3	46.1
ODXH 1.2-02	6.5	40.1	0.032	5.5	2.6	4	14.3	377
ODXH 1.2-05	4.2	180	0.036	10.3	2.8	103	21.7	386
ODXH 1.2-07	8.2	126	0.02	11	2.4	6	43.2	335
ODXH 1.2-09 (TM)	6.8	10	0.003	0.64	5.8	2	1.2	147
ODXH 1.2-09 (US)	10.2	7.7	0.002	0.28	7.9	4	1	107
ODXH 2.1-7	4.1	4.3	0.004	0.16	2	1	0.4	24.8
ODXH 3.1-02	7.9	4.7	<0.002	0.15	3.4	5	0.5	63.4
ODXH 3.1-04	7.7	4	0.002	0.15	4.2	1	0.6	183
ODXH 3.1-09	11.5	4.3	<0.002	0.45	1.7	<1	1.2	42.2
ODXH 3.2-01	9.8	172	0.04	8.84	4	15	14.5	495
ODXH 3.2-03	9.2	50.8	0.035	6.1	3.2	4	12.8	320
ODXH 3.2-05	4.9	77	0.029	9.78	3.3	5	18.5	388
ODXH 3.2-07	5.7	110	0.016	12.5	3.7	4	24.7	329
ODXH 3.2-09	5.5	91.3	0.017	6.15	2.8	15	25.7	303
ODXH 3.2-10	5.2	5.7	0.003	0.31	3	2	1	44.4
ODXH 3.2-12	4.2	2.7	<0.002	0.14	3.9	1	0.4	396
ODXH 3.2-13	2.8	2.3	<0.002	0.07	3.6	1	0.4	97.6
ODXH 4.1-02	5.2	87.6	0.037	7.64	3.1	12	16	487
ODXH 4.1-04	6.5	69.6	0.036	8.59	3.2	6	18.6	523
ODXH 4.1-06	5.3	74.1	0.044	9.07	3.4	6	21.3	455
ODXH 4.1-07	7.2	11.9	0.006	0.68	7.2	3	3.6	153
ODXH 4.1-10	34.3	87.5	0.003	0.78	11.3	4	3.1	284
ODXH 4.2-02	5.8	69.7	0.038	7.9	3.1	8	20.6	655
ODXH 4.2-04	4.1	69.3	0.023	9.89	3.2	5	17.3	387
ODXH 4.2-05	18.2	12.6	0.01	0.63	8.2	9	2	187
ODXH 4.2-09	3.6	2.8	<0.002	0.05	2	1	0.3	154
Core 4, 81.6-82 m Red 2A Arcoona QTZ	12.2	6.2	<0.002	0.27	4.8	<1	1.1	30.1
Core 5, 117.6-118m Red Arcoona	6.5	4.3	<0.002	0.14	1.9	<1	0.5	16.5
Core 2, 43.6-44 m Andamooka	7.4	18.3	<0.002	0.24	6.8	3	1.5	153
Core 1, 55.6-56 m Andamooka	1.7	10	0.023	0.13	1.3	<1	0.3	89.3
Core3, 189.6 White Arcoona	2.6	8.5	<0.002	0.06	0.4	<1	<0.2	10.9

All data are for dry weight basis. TM denotes tailings material, US denotes underlying sediment

Table 16. Primary mineral forming cations in solid rock samples (Part 4 of 4)

Samples	Th mg/kg	Ti mg/kg	Tl mg/kg	U mg/kg	V mg/kg	W mg/kg	Y mg/kg	Zn mg/kg
ODXH 1.01	30.7	0.073	0.48	127	24	48.1	52.6	43
ODXH 1.03	36.9	0.076	0.46	120	18	36.5	51.3	30
ODXH 1.05	30.7	0.071	0.42	134	25	35	51.8	36
ODXH 1.07	30	0.073	0.42	264	19	42.6	58.8	28
ODXH 1.09 (TM)	3.8	0.111	0.14	485	48	1.2	257	73
ODXH 1.09 (US)	4.9	0.094	0.1	19	83	1.2	50	14
ODXH 1.12	1.3	0.025	0.06	2	8	0.7	4.4	20
ODXH 1.2-02	27.7	0.074	0.33	154	21	31.7	45.8	34
ODXH 1.2-05	30.7	0.07	0.61	251	17	41.7	65.6	35
ODXH 1.2-07	28.5	0.056	0.36	267	31	59.6	46	40
ODXH 1.2-09 (TM)	20.7	0.106	0.21	125	31	1.7	34.5	28
ODXH 1.2-09 (US)	24.3	0.097	0.14	186	53	3.9	161	36
ODXH 2.1-7	2.8	0.055	0.05	47	18	2.6	11.4	11
ODXH 3.1-02	2.6	0.081	0.07	216	41	3.3	160	21
ODXH 3.1-04	2.9	0.073	0.07	67	66	0.7	14	20
ODXH 3.1-09	2.4	0.056	0.08	9	20	1.2	5.6	15
ODXH 3.2-01	36.3	0.096	0.65	222	25	27.6	57	118
ODXH 3.2-03	29.8	0.103	0.4	122	28	29.5	47.4	40
ODXH 3.2-05	41.7	0.084	0.55	148	18	42.3	69.5	35
ODXH 3.2-07	39.4	0.086	0.8	207	20	47.6	50.5	49
ODXH 3.2-09	28	0.06	0.46	205	23	34.8	41.3	40
ODXH 3.2-10	5.2	0.067	0.1	125	24	2.5	51.1	22
ODXH 3.2-12	2.4	0.025	0.05	4	43	0.6	9.2	48
ODXH 3.2-13	2.1	0.032	0.03	4	39	0.8	6.7	35
ODXH 4.1-02	41.3	0.086	0.51	122	17	36.3	56.1	37
ODXH 4.1-04	39.1	0.078	0.51	130	21	39.7	62	34
ODXH 4.1-06	41.8	0.077	0.58	142	20	43.7	73.1	36
ODXH 4.1-07	11.6	0.26	0.26	147	205	2.8	48.4	31
ODXH 4.1-10	20.7	0.194	0.38	10	149	2.1	87.1	222
ODXH 4.2-02	36.7	0.08	0.56	131	21	40.5	51.8	33
ODXH 4.2-04	40.8	0.083	0.61	162	17	40.3	62.8	42
ODXH 4.2-05	11.4	0.147	0.28	648	123	4.8	221	75
ODXH 4.2-09	1.4	0.011	0.03	2	110	0.3	6	43
Core 4, 81.6-82 m Red 2A Arcoona QTZ	5.7	0.167	0.2	4	27	0.9	12.2	9
Core 5, 117.6-118m Red Arcoona	2.4	0.063	0.13	1	15	0.6	5.7	4
Core 2, 43.6-44 m Andamooka	6.3	0.239	0.37	4	43	1.9	11.9	17
Core 1, 55.6-56 m Andamooka	1.5	0.025	0.05	2	13	0.3	3	28
Core3, 189.6 White Arcoona	1.6	0.024	0.04	1	8	0.4	3.5	5

All data are for dry weight basis. TM denotes tailings material, US denotes underlying sediment

Table 17. Exchangeable cations in solid rock samples

Samples	CEC-Ca Meq/100g	CEC-Mg meq/100g	CEC-K meq/100g	CEC-Na meq/100g	Al-exchangeable meq/100g	Na %	CEC meq/100g
ODXH 1.2-09 (TM)	122	1.3	0.1	1.3	3.8	1.1	125
ODXH 1.2-09 (US)	177	0.4	0.2	1.6	2.7	0.9	179
ODXH 2.1-7 (TM)	8.1	0.9	0.1	0.4	0.2	4.0	9.5
ODXH 3.1-09 (US)	27.4	1.7	0.3	0.6	<0.1	1.9	30.0
ODXH 3.2-01 (TM)	50.7	6.4	<0.6	1.3	<0.6	2.2	59.0
ODXH 3.2-05 (TM)	32.9	0.2	<0.1	1.0	0.7	2.8	34.1
ODXH 4.1-04 (TM)	27.2	7.2	0.1	0.6	<0.1	1.8	35.1
ODXH 4.1-10 (US)	180	2.6	0.4	9.2	<0.1	4.8	192
ODXH 4.2-05 (US)	81.9	1.6	3.5	3.3	<0.1	3.7	90.3
Core 2, 43.6-44 m Andamooka	1.0	1.0	0.2	1.1	<0.1	33.6	3.4
Core3, 189.6 White Arcoona	0.2	0.2	<0.1	<0.1	<0.1	4.9	0.4
Core 4, 81.6-82 m Red 2A Arcoona QTZ	1.3	0.6	0.2	0.1	<0.1	6.7	2.2

All data are for dry weight basis. TM denotes tailings material, US denotes underlying sediment. CEC = Cation exchange capacity = sum of CEC-Ca + CEC-Mg + CEC-K + CEC-Na.

Table 18. Surface area analyses (BET) and particle size of materials

Sample	BET Surface Area	Particle size, % [b]			
	m^2/g	<600 μm	<150 μm	<60 μm	<10 μm
ODXH 1.07 (TM)	NM	100	94	61	35
ODXH 1.2-02 (TM and waste)	NM	100	100	38	17
ODXH 1.2-09 (TM)	21, 31*	99	99	34	9
ODXH 1.2-09 (US)	29	84	40	18	7
ODXH 2.1-7 (TM)	3	97	27	9	8
ODXH 3.1-09 (US)	10	96	39	16	13
ODXH 3.2-01 (TM)	3	96	86	62	47
ODXH 3.2-05 (TM)	4	100	100	NM	NM
ODXH 4.1-04 (TM)	5	84	81	70	38
ODXH 4.1-10 (US)	30	79	64	50	39
ODXH 4.2-04 (TM)	NM	100	95	67	38
ODXH 4.2-05 (US)	36, 39 [a]	80	42	21	14
ODXcore2 (Andamooka 43.6-44m)	7	Rock samples			
ODXcore3 (White Arcoona 189.6)	1, 1 [a]	Rock samples			
ODXcore4 (Red 2A Arcoona QTZ81.6-82m)	4	Rock samples			

[a] Represent duplicate analyses. [b] Approximate size limits only - details provided in Appendices C.

TM denotes tailing material, US denotes underlying sediment. NM = not measured.

Table 19. Quantitative XRD of Olympic Dam samples

Sample	**Chalcopyrite**	**Hematite**	**Goethite**	**Quartz**	**Chlorite**	**Fluorite**	**Florencite**	**Barite**	**Basnasite**
ODXH 1.2-09 (TM)	-	2	-	71	-	-	-	-	-
ODXH 1.2-09 (US)	-	<1	-	52	-	-	?3	-	-
ODXH 2.1-7 (TM)	-	1	-	99	-	-	-	-	-
ODXH 3.1-09 (US)	-	1	-	96	-	-	-	-	-
ODXH 3.2-01 (TM)	<1	17	-	34	<1	2	1	1	<1
ODXH 3.2-05 (TM)	-	36	-	26	-	2	1	2	<1
ODXH 4.1-04 (TM)	-	32	-	24	-	1	1	2	<1
ODXH 4.1-10 (US)	-	1	8	2	-	-	-	-	-
ODXH 4.2-05 (US)	-	2	-	43	-	-	?6	-	-
ODXcore2 (Andamooka 43.6-44m)	-	<1	-	65	-	-	-	-	-
ODXcore3 (White Arcoona 189.6)	-	1	-	91	2	-	-	-	-
ODXcore4 (Red 2A Arcoona QT Z81.6-82m)	-	2	-	65	3	-	-	-	-

	Mica/ Illite	**Microcline/ Orthoclase**	**Calcite**	**Halite**	**Kaolin**	**Gypsum**	**Bassanite**	**Jarosite**	**Dolomite**
ODXH 1.2-09 (TM)	16	<1	-	-	3	4	-	5	-
ODXH 1.2-09 (US)	17	-	-	-	3	24	-	-	-
ODXH 2.1-7 (TM)	-	-	-	-	-	<1	-	-	-
ODXH 3.1-09 (US)	2	-	2	-	-	-	-	-	-
ODXH 3.2-01 (TM)	35	3	-	1	-	3	-	-	2
ODXH 3.2-05 (TM)	28	-	-	-	-	3	-	1	-
ODXH 4.1-04 (TM)	31	-	-	-	-	5	-	2	2
ODXH 4.1-10 (US)	31	-	-	-	-	50	9	-	-
ODXH 4.2-05 (US)	20	1	-	-	4	25	-	-	-
ODXcore2 Andamooka 43.6-44m)	19	12	-	-	3	<1	-	-	-
ODXcore3 (White Arcoona 189.6)	-	5	-	-	-	-	-	-	-
ODXcore4 (Red 2A Arcoona QTZ 81.6-82m)	19	11	-	-	-	-	-	-	-

Key: Mineral concentrations below the XRD method detection limit are designated by "-". - ? Indicates possible component. The ?3% and ?6% for florencite in samples ODXH4.2-05 and ODXH1.2-09S indicates uncertainty due to significant shifts in peak positions.

This may be another related phosphate such as gorceixite or plumbogummite.

Table 20. Radionuclide activity concentrations (becquerel per gram) of selected tailings and sediment samples

Samples	**radium-226**	**thorium-234**	**lead-210**	**radium-228**	**thorium-228**	**potassium-40**
ODXH 1.01 (TM)	5.2 ± 0.2	1.1 ± 0.1	3.6 ± 0.2	0.17 ± 0.05	0.14 ± 0.01	0.63 ± 0.07
ODXH 1.03 (TM)	5.5 ± 0.3	1.1 ± 0.4	3.4 ± 0.5	< 0.1	0.18 ± 0.05	< 0.5
ODXH 1.05 (TM)	4.9 ± 0.2	1.2 ± 1.8	3.6 ± 0.2	0.16 ± 0.03	0.14 ± 0.01	0.6 ± 0.1
ODXH 1.07 (TM)	8.2 ± 0.4	2.8 ± 0.5	6.0 ± 0.9	< 0.1	< 0.1	< 0.5
ODXH 1.09 (TM)	0.09 ± 0.01	6.9 ± 0.3	0.2 ± 0.1	< 0.03	< 0.03	< 0.1
ODXH 1.09 (US)	0.08 ± 0.01	0.37 ± 0.03	0.08 ± 0.02	0.03 ± 0.01	0.04 ± 0.01	0.11 ± 0.02
ODXH 1.12	0.01 ± 0.01	0.01 ± 0.01	0.01 ± 0.01	< 0.004	0.01 ± 0.01	< 0.01
ODXH 1.2-02 (TM)	2.04 ± 0.09	1.2 ± 0.2	2.8 ± 0.2	0.1 ± 0.03	0.1 ± 0.02	0.4 ± 0.1
ODXH 1.2-05 (TM)	5.7 ± 0.3	2.4 ± 0.2	4.6 ± 0.3	0.25 ± 0.05	0.18 ± 0.02	0.6 ± 0.2
ODXH 1.2-07 (TM)	13.4 ± 0.6	1.6 ± 0.1	7.9 ± 0.3	0.14 ± 0.04	0.10 ± 0.02	< 0.1
ODXH 1.2-09 (TM)	0.27 ± 0.01	1.36 ± 0.07	0.38 ± 0.04	0.11 ± 0.01	0.14 ± 0.01	0.21 ± 0.02
ODXH 1.2-09 (US)	0.16 ± 0.01	2.10 ± 0.09	0.14 ± 0.03	0.05 ± 0.01	0.07 ± 0.01	0.12 ± 0.02
ODXH 2.1-7 (TM)	0.01 ± 0.01	0.44 ± 0.05	0.01 ± 0.02	0.01 ± 0.01	0.01 ± 0.01	< 0.03
ODXH 3.1-02	< 0.02	1.7 ± 0.2	0.05 ± 0.08	< 0.02	< 0.02	< 0.09
ODXH 3.1-04	0.03 ± 0.01	0.70 ± 0.06	0.03 ± 0.04	< 0.01	0.02 ± 0.01	< 0.06
ODXH 3.1-09	0.02 ± 0.01	0.04 ± 0.02	< 0.04	< 0.01	< 0.01	< 0.06
ODXH 3.2-01 (TM)	6.4 ± 0.3	3.0 ± 0.4	5.0 ± 0.6	0.30 ± 0.07	0.30 ± 0.03	1.0 ± 0.3
ODXH 3.2-03 (TM)	2.9 ± 0.1	1.3 ± 0.3	2.4 ± 0.2	0.20 ± 0.04	0.18 ± 0.03	< 0.2
ODXH 3.2-05 (TM)	7.9 ± 0.4	1.3 ± 0.3	5.6 ± 0.4	0.26 ± 0.05	0.35 ± 0.09	0.7 ± 0.2
ODXH 3.2-07 (TM)	10.4 ± 0.5	2.0 ± 0.3	6.5 ± 0.4	< 0.1	0.21 ± 0.03	< 0.3
ODXH 3.2-09 (TM)	7.4 ± 0.3	1.8 ± 0.2	5.6 ± 0.3	0.20 ± 0.06	0.10 ± 0.01	< 0.2
ODXH 3.2-10	0.10 ± 0.01	1.06 ± 0.05	0.10 ± 0.03	< 0.007	0.03 ± 0.01	< 0.03
ODXH 3.2-12	0.01 ± 0.01	0.03 ± 0.02	0.02 ± 0.02	< 0.007	0.01 ± 0.01	< 0.03
ODXH 3.2-13	0.02 ± 0.01	0.04 ± 0.02	0.01 ± 0.01	0.02 ± 0.01	0.01 ± 0.01	< 0.04

TM denotes tailing material, US denotes underlying sediment

Table 21. Radionuclide activity concentrations (becquerel per gram) of selected tailings and sediment samples

Samples	**radium-226**	**thorium-234**	**lead-210**	**radium-228**	**thorium-228**	**potassium-40**
ODXH 4.1-02 (TM)	7.5 ± 0.3	1.2 ± 0.3	5.4 ± 0.6	< 0.1	0.20 ± 0.04	0.9 ± 0.3
ODXH 4.1-04 (TM)	5.1 ± 0.2	0.9 ± 0.2	3.6 ± 0.3	< 0.8	0.10 ± 0.02	0.6 ± 0.1
ODXH 4.1-06 (TM)	6.90 ± 0.03	1.4 ± 0.3	4.4 ± 0.4	0.20 ± 0.06	0.20 ± 0.04	0.7 ± 0.3
ODXH 4.1-07	0.07 ± 0.01	1.7 ± 0.2	0.10 ± 0.09	< 0.04	< 0.04	< 0.2
ODXH 4.1-10	0.04 ± 0.01	0.04 ± 0.02	0.04 ± 0.01	0.02 ± 0.01	0.02 ± 0.01	0.16 ± 0.02
ODXH 4.2-02 (TM)	5.7 ± 0.3	1.3 ± 0.3	4.2 ± 0.3	0.20 ± 0.07	0.20± 0.03	< 0.3
ODXH 4.2-04 (TM)	6.0 ± 0.3	1.5 ± 0.3	4.1 ± 0.3	0.20 ± 0.06	0.20 ± 0.03	< 0.3
ODXH 4.2-05	0.40 ± 0.02	6.1 ± 0.3	0.4 ± 0.1	< 0.03	0.08 ± 0.03	< 0.1
ODXH 4.2-09	0.01 ± 0.01	0.01 ± 0.01	< 0.01	0.01 ± 0.01	< 0.004	< 0.01
Core 4, 81.6-82 m Red 2A Arcoona	0.05 ± 0.01	0.02 ± 0.03	< 0.05	< 0.02	0.03 ± 0.01	0.47 ± 0.07
Core 5, 117.6-118m Red Arcoona	0.02 ± 0.09	0.03 ± 0.03	0.04 ± 0.03	< 0.02	0.03 ± 0.01	0.46 ± 0.06
Core 2, 43.6-44 m Andamooka	0.05 ± 0.01	0.08 ± 0.04	0.06 ± 0.04	0.06 ± 0.01	0.04 ± 0.01	0.44 ± 0.08
Core 1, 55.6-56 m Andamooka	0.02 ± 0.01	0.02 ± 0.03	0.03 ± 0.02	< 0.01	0.01 ± 0.01	< 0.05
Core3, 189.6 White Arcoona	< 0.005	0.02 ± 0.01	< 0.02	0.01 ± 0.01	< 0.02	< 0.03

TM denotes tailings material, US denotes underlying sediment

3.2 Characterisation of Tailings Pore Waters

3.2.1 pH, redox potential (Eh) and conductivity of pore waters

The pH, redox potential and conductivity of surrogate pore water extracts measured in samples where porewater was extracted are shown in Table 22. For the pore waters, as expected, there was an inverse relationship between pH and Eh (Figure 2).

Table 22. Paste-pH of Tailings Cores, and pH, Redox Potential and Conductivity of 1:1 Surrogate Pore Water

	Surrogate porewater (1:1 extraction) [a]		
Sample	**pH**	**Redox Potential, Eh (mV)**	**Conductivity (mS/cm)**
ODXH 1.03	3.5	470	12.4
ODXH 1.07	3.7	463	9.6
ODXH 3.2 – 01	7.6	512	18.2
ODXH 3.2 – 05	3.2	528	10.5
ODXH 3.2 – 09	4.0	479	8.4
ODXH 4.1 – 02	3.2	505	14.2
ODXH 4.1 – 04	4.1	432	15.2
ODXH 4.1 – 06	3.4	474	16.2
ODXH 4.2 – 02	3.0	536	11.4
ODXH 4.2 – 04	3.0	535	11.8
ODXH 2.1 - 7 [b]	4.0	496	6.3

[a] Surrogate pore water (1:1 extraction) was used to obtain the pH, Eh, conductivity for all samples

[b] Sample from the underlying sediment

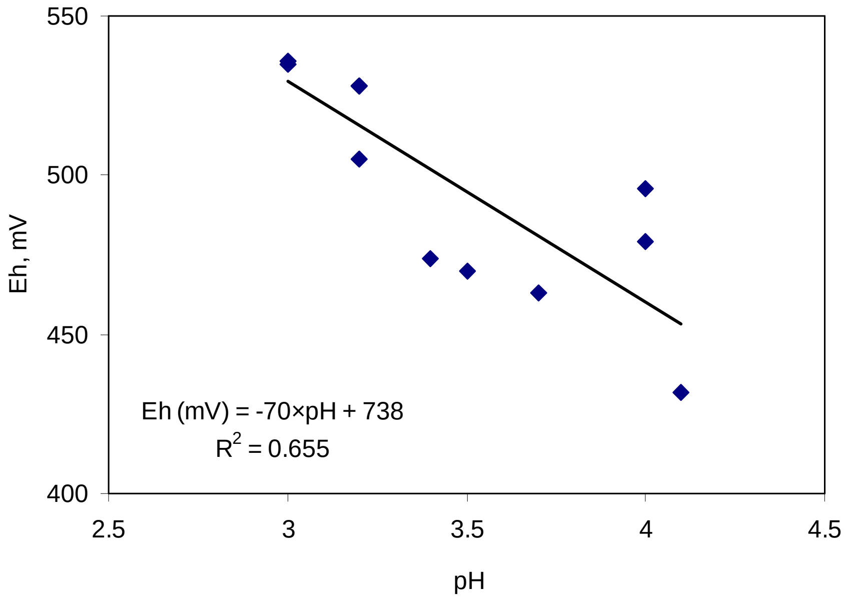


Figure 2. Relationship between pH and Eh of the surrogate pore water for tailings samples with pH <5

3.2.2 Porewater iron: Fe(II) and total dissolved Fe

The concentration of iron in the pore waters are shown in Table 23, as determined colorimetrically (ferrozine method) for Fe(II) and Fe(II)+Fe(III) by CSIRO and as total iron by ALS. The ratio of Fe(II) to Fe(III) measured by the ferrozine method was 0.27±0.01 for pore waters extracted using the direct method and 0.21±0.01 for surrogate pore waters extracted using the 1:1 extraction method. This indicates that either there was some oxidation of Fe(II), or additional release of Fe(III) during the 1:1 extraction. The total Fe determined by the two methods was quite similar (Figure 3).

Table 23. Porewater Iron Concentrations

	Porewater Iron, mg/L			
Sample	**Fe(II)**	**Fe(II) + Fe(III)** [a]	**Fe(II) / (Fe(II)+Fe(III))**	**Total Fe** [b]
ODXH 1.03 (PW)	6000	22000	0.27	16000
ODXH 1.07 (1:1)	620	2900	0.22	1570
ODXH 3.2 – 01 (1:1)	<0.5	<4	NA	<10
ODXH 3.2 – 05 (1:1)	530	2700	0.20	1440
ODXH 3.2 – 09 (1:1)	550	2600	0.21	1480
ODXH 4.1 – 02 (PW)	10000	36000	0.28	32900
ODXH 4.1 – 04 (PW)	9400	34000	0.28	31700
ODXH 4.1 – 06 (PW)	8700	31000	0.28	24900
ODXH 4.2 – 02 (PW)	6100	22000	0.28	16400
ODXH 4.2 – 04 (PW)	2900	11000	0.26	8070
ODXH 2.1 - 7 (1:1)	200	1070	0.19	521

[a] Spectrophotometric determination of Fe(II) and Fe(III)

[b] Total dissolved Fe determined by ALS

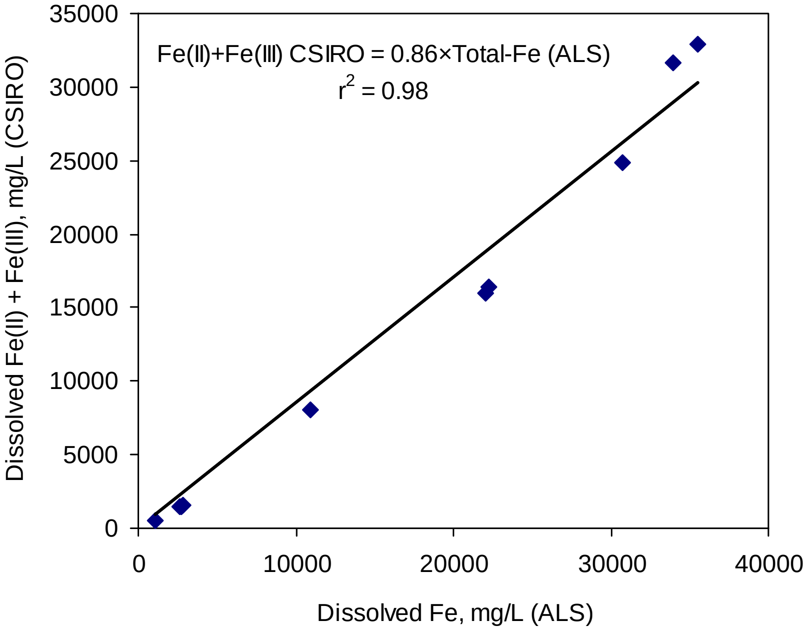


Figure 3. Comparison of Fe(II)+Fe(III) determined by CSIRO and total dissolved iron determined by ALS

3.2.3 Pore water analytes

The concentrations of major anions, major cations, acidity/alkalinity and carbon, and mineral-forming metals are shown in Tables 24-32. The cations with the greatest concentration were (in decreasing order) Fe>Al>Na>Ca>Mg>Ce>U>Mn>Cu (Table 13-16). The mean concentrations of Fe, Al, Ce and U were 12000, 4700, 140 and 130 mg/L, respectively. The cores with the greatest U concentrations were 4.2-04 (596 mg/L), 1.07 (262 mg/L), 3.2-05 (215 mg/L), 4.2-02 (131 mg/L), 4.1-06 (113 mg/L), and 4.1-04 (105 mg/L) (Table 30). A correlation matrix for the cations with the greatest concentrations are shown in Table 24, and correlations were strong for almost the entire set of cations.

The small volumes made the radionuclide analyses very difficult. In general, the radium-226 (<0.005 to 0.074 Bq/mL) and gross alpha (<0.005 to 0.021 Bq/mL) and gross beta (<0.005 to 0.56 Bq/mL) concentrations were very low (Table 33).

Table 24. Correlation between selected cations in the pore waters.

	Fe	**Al**	**Na**	**Ca**	**Mg**	**K**	**U**	**Cu**	**Mn**	**Ce**	**Si**	**Co**	**Y**	**Zn**
Fe		**0.60**	**0.59**	**0.75**	**0.80**	**0.75**	**0.05**	**-0.01**	**0.92**	**0.85**	**0.90**	**0.98**	**0.59**	**0.88**
p-value		0.029	0.035	0.003	0.001	0.003	0.862	0.970	0.000	0.000	0.000	0.000	0.033	0.000
Al	**0.60**		**0.69**	**0.78**	**0.71**	**0.92**	**0.63**	**0.27**	**0.70**	**0.88**	**0.52**	**0.62**	**0.98**	**0.89**
p-value	0.029		0.009	0.002	0.006	0.000	0.022	0.371	0.007	0.000	0.066	0.025	0.000	0.000
Na	**0.59**	**0.69**		**0.82**	**0.87**	**0.72**	**0.47**	**0.22**	**0.59**	**0.69**	**0.49**	**0.62**	**0.71**	**0.72**
p-value	0.035	0.009		0.001	0.000	0.006	0.107	0.472	0.035	0.010	0.092	0.024	0.007	0.005
Ca	**0.75**	**0.78**	**0.82**		**0.81**	**0.79**	**0.45**	**0.11**	**0.82**	**0.79**	**0.66**	**0.71**	**0.75**	**0.84**
p-value	0.003	0.002	0.001		0.001	0.001	0.121	0.716	0.001	0.001	0.014	0.006	0.003	0.000
Mg	**0.80**	**0.71**	**0.87**	**0.81**		**0.75**	**0.29**	**0.00**	**0.77**	**0.77**	**0.80**	**0.79**	**0.71**	**0.82**
p-value	0.001	0.006	0.000	0.001		0.003	0.345	0.999	0.002	0.002	0.001	0.001	0.006	0.001
K	**0.75**	**0.92**	**0.72**	**0.79**	**0.75**		**0.41**	**0.23**	**0.79**	**0.93**	**0.58**	**0.73**	**0.90**	**0.93**
p-value	0.003	0.000	0.006	0.001	0.003		0.161	0.459	0.001	0.000	0.039	0.004	0.000	0.000
U	**0.05**	**0.63**	**0.47**	**0.45**	**0.29**	**0.41**		**0.43**	**0.08**	**0.43**	**0.07**	**0.18**	**0.71**	**0.46**
p-value	0.862	0.022	0.107	0.121	0.345	0.161		0.143	0.786	0.147	0.820	0.549	0.007	0.110
Cu	**-0.01**	**0.27**	**0.22**	**0.11**	**0.00**	**0.23**	**0.43**		**0.05**	**0.31**	**-0.19**	**0.10**	**0.29**	**0.21**
p-value	0.970	0.371	0.472	0.716	0.999	0.459	0.143		0.860	0.295	0.524	0.750	0.336	0.500
Mn	**0.92**	**0.70**	**0.59**	**0.82**	**0.77**	**0.79**	**0.08**	**0.05**		**0.83**	**0.85**	**0.85**	**0.65**	**0.87**
p-value	0.000	0.007	0.035	0.001	0.002	0.001	0.786	0.860		0.000	0.000	0.000	0.017	0.000
Ce	**0.85**	**0.88**	**0.69**	**0.79**	**0.77**	**0.93**	**0.43**	**0.31**	**0.83**		**0.71**	**0.87**	**0.88**	**0.97**
p-value	0.000	0.000	0.010	0.001	0.002	0.000	0.147	0.295	0.000		0.007	0.000	0.000	0.000
Si	**0.90**	**0.52**	**0.49**	**0.66**	**0.80**	**0.58**	**0.07**	**-0.19**	**0.85**	**0.71**		**0.88**	**0.53**	**0.78**
p-value	0.000	0.066	0.092	0.014	0.001	0.039	0.820	0.524	0.000	0.007		0.000	0.065	0.002
Co	**0.98**	**0.62**	**0.62**	**0.71**	**0.79**	**0.73**	**0.18**	**0.10**	**0.85**	**0.87**	**0.88**		**0.64**	**0.90**
p-value	0.000	0.025	0.024	0.006	0.001	0.004	0.549	0.750	0.000	0.000	0.000		0.020	0.000
Y	**0.59**	**0.98**	**0.71**	**0.75**	**0.71**	**0.90**	**0.71**	**0.29**	**0.65**	**0.88**	**0.53**	**0.64**		**0.89**
p-value	0.033	0.000	0.007	0.003	0.006	0.000	0.007	0.336	0.017	0.000	0.065	0.020		0.000
Zn	**0.88**	**0.89**	**0.72**	**0.84**	**0.82**	**0.93**	**0.46**	**0.21**	**0.87**	**0.97**	**0.78**	**0.90**	**0.89**	
p-value	0.000	0.000	0.005	0.000	0.001	0.000	0.110	0.500	0.000	0.000	0.002	0.000	0.000	

Table 25. Major Anions in Pore Water

Sample	**Cl^-**	**SO_4^{2-}**	**Br^-**	**F^-**	**NH_3-N**	**NO_2^--N**	**NO_3^--N**	**NO_2^-- + NO_3^--N**	**PO_4^{3-}**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
ODXH 1.03 (PW)	4720	55800	5.3	33.6	369	<0.1	<0.1	<0.10	0.836
ODXH 1.07 (PW)	NM	43300	3.4	15	72.4	0.039	<0.01	0.035	0.788
ODXH 1.07 (1:1)	579	7820	0.6	50.5	75.5	<0.10	<0.1	<0.10	0.05
ODXH 3.2-01 (1:1)	4290	6590	6.9	19.5	6.88	<0.01	0.63	0.63	0.015
ODXH 3.2-05 (PW)	4440	44000	3.5	37.6	275	<0.1	<0.1	<0.10	0.898
ODXH 3.2-05 (1:1)	540	8030	0.6	51.8	280	<0.01	0.025	0.025	0.062
ODXH 3.2-09 (1:1)	463	6840	<0.5	66.1	73.3	<0.1	<0.1	<0.10	0.083
ODXH 4.1-02 (PW)	5640	74600	5.9	31.4	375	<1	<1	<1.0	1.12
ODXH 4.1-04 (PW)	5690	85100	<5.0	32.7	374	<1	<1	<1.0	1.04
ODXH 4.1-06 (PW)	5790	77000	<5.0	32.4	431	<1	<1	<1.0	0.97
ODXH 4.2-02 (PW)	5010	50800	5.4	34.2	313	<1	<1	<1.0	0.403
ODXH 4.2-04 (PW)	5300	47800	3.5	36.2	221	<1	<1	<1.0	0.193
ODXH 2.1-7 (1:1)	598	3420	0.7	189	29.9	<0.1	<0.1	<0.10	<0.010
Method Blank (1:1)	<1	<1	<0.1	4.4	0.07	<0.01	0.039	0.039	<0.01
Mean	3590	39300	3.6	48	223	0.039	0.33	0.23	0.54
Maximum	5790	85100	6.9	189	431	0.039	0.63	0.63	1.12
Minimum	463	3420	0.60	15	6.9	0.039	0.025	0.025	0.015
LOR	1	1	0.1	0.1	0.01	0.01	0.01	0.01	0.01

NM = not measured due to insufficient samples volume

Table 26. Major Cations in Pore Water

Sample	Na mg/L	K mg/L	Mg mg/L	Ca mg/L	Fe mg/L	Total Anions meq/L	Total Cations meq/L	Ionic Balance %
ODXH 1.03 (PW)	3660	860	655	1450	16000			
ODXH 1.07 (PW)	3460	755	662	539	8680			
ODXH 1.07 (1:1)	510	150	505	89	1570			
ODXH 3.2-01 (1:1)	4490	85	656	719	6.94	273	290	2.83
ODXH 3.2-05 (PW)	3900	543	712	590	7940			
ODXH 3.2-05 (1:1)	579	120	496	89	1440			
ODXH 3.2-09 (1:1)	510	46	516	73	1480			
ODXH 4.1-02 (PW)	3860	557	752	985	32900			
ODXH 4.1-04 (PW)	4330	819	860	1910	31700			
ODXH 4.1-06 (PW)	4040	736	751	1540	24900			
ODXH 4.2-02 (PW)	3300	671	598	953	16400			
ODXH 4.2-04 (PW)	4360	542	658	1620	8070			
ODXH 2.1-7 (1:1)	515	58	397	111	521			
Method Blank (1:1)	<1	<1	<1	<1	<0.05			
Mean	2890	460	630	820	11700			
Maximum	4490	860	860	1910	32900			
Minimum	510	46	397	73	6.9			
LOR	1	1	1	1	0.05	0.01	0.01	0.01

Table 27. Acidity, Alkalinity and Forms of Organic Carbon

Sample	pH [a]	Hydroxide Alkalinity as CaCO$_3$ mg/L	Carbonate Alkalinity as CaCO$_3$ mg/L	Bicarbonate Alkalinity as CaCO$_3$ mg/L	Total Alkalinity as CaCO$_3$ mg/L	Acidity as CaCO$_3$ mg/L	Total Organic Carbon mg/L	Total Inorganic Carbon mg/L	Dissolved Inorganic Carbon mg/L
ODXH 1.03 (PW)	3.5					47200	73	1	
ODXH 1.07 (PW)	3.7						25	<1	
ODXH 1.07 (1:1)						6560			
ODXH 3.2-01 (1:1)	7.6	<5	<5	765	765	16	62	41	40
ODXH 3.2-05 (PW)	3.2					10800	22	<1	
ODXH 3.2-05 (1:1)						6540			
ODXH 3.2-09 (1:1)	4.0					11100	6	<1	
ODXH 4.1-02 (PW)	3.2					26800	69	1	
ODXH 4.1-04 (PW)	4.1					63600	71	2	
ODXH 4.1-06 (PW)	3.4					66700	81	<1	
ODXH 4.2-02 (PW)	3.0					45000	77	<1	
ODXH 4.2-04 (PW)	3.0					43600	25	<1	
ODXH 2.1-7 (1:1)	4.0					3120	5	<1	
Method Blank (1:1)	6						<1	<1	
Mean						27600	47	11	
Maximum						66700	81	41	
Minimum						16	5	1	
LOR	0.1	1	1	1	1	1	1	1	1

[a] The pH values are from Table 22 and were made on the 1:1 surrogate pore water only . The analyses in Table 27 were on both extracted and surrogate porewater.

Table 28. Primary Mineral Forming Cations in Pore Water (Part 1 of 3)

Sample	Ag mg/L	Al mg/L	As mg/L	B mg/L	Ba mg/L	Be mg/L	Bi mg/L	Cd mg/L	Ce mg/L	Co mg/L	Cr mg/L	Cu mg/L
ODXH 1.03 (PW)	<0.010	7670	0.137	<0.1	0.043	0.53	<0.010	0.0244	211	47.7	2.01	0.606
ODXH 1.07 (PW)	<0.010	7310	0.095	<0.1	0.031	0.452	<0.010	0.0236	175	38.6	0.622	19.2
ODXH 1.07 (1:1)	<0.005	1280	0.029	<0.1	0.018	0.085	<0.005	0.0045	27	6.6	0.094	0.06
ODXH 3.2-01 (1:1)	<0.005	2.22	0.011	3.3	0.024	<0.005	<0.005	<0.0005	0.07	0.199	0.045	0.4
ODXH 3.2-05 (PW)	<0.010	7320	0.116	<0.1	0.042	0.458	<0.010	0.0152	176	46.5	1.23	227
ODXH 3.2-05 (1:1)	<0.005	1380	0.085	<0.1	0.03	0.09	<0.005	0.0038	89.8	8.35	0.227	41.3
ODXH 3.2-09 (1:1)	<0.005	986	0.017	<0.1	0.018	0.075	<0.005	0.0032	22.3	6.75	0.133	2.16
ODXH 4.1-02 (PW)	<0.050	3860	0.215	<0.5	<0.050	0.469	<0.050	0.021	232	138	2.23	0.46
ODXH 4.1-04 (PW)	<0.050	7490	0.22	<0.5	0.063	0.552	<0.050	0.0218	248	107	1.03	0.09
ODXH 4.1-06 (PW)	<0.050	9520	0.184	<0.5	0.056	0.855	<0.050	0.0259	243	89.1	2.86	9.79
ODXH 4.2-02 (PW)	<0.010	5350	0.249	<0.1	0.046	0.453	<0.010	0.0181	223	67.1	1.88	407
ODXH 4.2-04 (PW)	<0.010	8280	0.09	<0.1	0.046	0.509	<0.010	0.0236	191	50.5	1.94	192
ODXH 2.1-7 (1:1)	<0.001	291	<0.001	0.2	0.056	0.028	<0.001	0.0019	7.39	3.33	0.01	21.4
Method Blank (1:1)	<0.001	<0.01	<0.001	<0.1	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.001	<0.001	0.003
Mean	NA	4672	0.12	1.8	0.04	0.38	NA	0.02	142	47	1.1	71
Maximum	NA	9520	0.25	3.3	0.06	0.86	NA	0.03	248	138	2.9	407
Minimum	NA	2.22	0.01	0.20	0.02	0.03	NA	0.00	0.07	0.20	0.01	0.06
LOR	0.001	0.01	0.001	0.1	0.001	0.001	0.001	0.0001	0.001	0.001	0.001	0.001

Table 29. Primary Mineral Forming Cations in Pore Water (Part 2 of 3)

Sample	**Hg mg/L**	**Li mg/L**	**Mn mg/L**	**Mo mg/L**	**Ni mg/L**	**Pb mg/L**	**Re mg/L**	**Sb mg/L**	**Sc mg/L**	**Se mg/L**	**Si mg/L**
ODXH 1.03 (PW)	<0.0001	9.9	120	<0.010	6.52	0.044	0.06	<0.010	0.632	0.782	32.3
ODXH 1.07 (PW)	<0.0001	10.3	61.3	<0.010	4.87	0.058	0.11	<0.010	0.725	0.896	56.9
ODXH 1.07 (1:1)	<0.0001	1.91	12.6	<0.005	0.83	0.024	<0.005	<0.005	0.098	0.127	23.5
ODXH 3.2-01 (1:1)	<0.0001	0.409	2.47	0.424	0.034	0.006	0.13	<0.005	<0.005	0.084	5.81
ODXH 3.2-05 (PW)	<0.0001	9.85	51.8	<0.010	4.78	0.068	0.03	<0.010	0.0617	0.694	58.3
ODXH 3.2-05 (1:1)	<0.0001	1.98	<0.005	<0.005	0.893	0.043	0..6	<0.005	0.109	0.163	46.1
ODXH 3.2-09 (1:1)	<0.0001	1.44	10.6	<0.005	0.823	<0.005	<0.005	<0.005	0.035	0.088	17.5
ODXH 4.1-02 (PW)	<0.0001	7.43	149	<0.050	8.81	0.126	0.079	<0.050	0.23	0.807	179
ODXH 4.1-04 (PW)	<0.0001	11.4	266	<0.050	10	0.065	0.065	<0.050	0.315	0.662	229
ODXH 4.1-06 (PW)	<0.0001	13.6	257	<0.050	9.62	0.067	0.065	<0.050	0.787	0.822	163
ODXH 4.2-02 (PW)	<0.0001	6.75	150	<0.010	7	0.064	0.067	<0.010	0.482	0.606	33.1
ODXH 4.2-04 (PW)	<0.0001	11	65.7	<0.010	6.37	0.276	0.048	<0.010	0.894	0.794	61.5
ODXH 2.1-7 (1:1)	<0.0001	0.617	7.25	<0.001	0.407	0.007	0.005	<0.001	0.028	0.031	7.1
Method Blank (1:1)	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.010	<0.05
Mean	NA	6.7	96	0.42	4.7	0.07	0.07	NA	0.37	0.50	70
Maximum	NA	14	266	0.42	10	0.28	013	0.00	0.89	0.90	229
Minimum	NA	0.41	2.47	0.42	0.03	0.01	0.01	0.00	0.03	0.03	5.81
LOR	0.0001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.01	0.01

Table 30. Primary Mineral Forming Cations in Pore Water (Part 3 of 3)

Sample	Sn mg/L	Sr mg/L	Th mg/L	Ti mg/L	Tl mg/L	U mg/L	V mg/L	W mg/L	Y mg/L	Zn mg/L
ODXH 1.03 (PW)	<0.010	6.7	3.33	<0.10	<0.010	96	0.86	0.038	58	23.8
ODXH 1.07 (PW)	<0.010	4.49	0.32	<0.10	<0.010	262	0.45	0.043	71	23.5
ODXH 1.07 (1:1)	<0.005	1.38	0.026	<0.05	0.006	27.1	0.06	0.006	10.4	4.23
ODXH 3.2-01 (1:1)	<0.005	4.06	<0.005	<0.05	<0.005	7.89	<0.05	<0.005	0.026	<0.025
ODXH 3.2-05 (PW)	<0.010	3.99	2.72	0.16	0.011	215	0.55	0.038	64.2	19.1
ODXH 3.2-05 (1:1)	<0.005	2.79	0.792	<0.05	<0.005	27.3	0.08	0.006	10.7	3.73
ODXH 3.2-09 (1:1)	<0.005	1.06	0.07	<0.05	<0.005	33.5	<0.05	0.005	8.01	3.02
ODXH 4.1-02 (PW)	<0.050	11.4	0.908	<0.50	<0.050	67.3	<0.50	<0.050	42	30.7
ODXH 4.1-04 (PW)	<0.050	8.1	0.618	<0.50	<0.050	105	<0.50	<0.050	61.7	34.6
ODXH 4.1-06 (PW)	<0.050	6.74	3.74	<0.50	<0.050	113	0.95	<0.050	74.2	32.8
ODXH 4.2-02 (PW)	<0.010	7.9	3.06	0.21	0.015	131	1.06	0.029	44.5	24
ODXH 4.2-04 (PW)	<0.010	5.41	6.62	0.14	<0.010	596	0.94	0.049	78.8	26.6
ODXH 2.1-7 (1:1)	<0.001	1.9	0.009	<0.01	<0.001	12.8	<0.01	0.002	2.52	1.74
Method Blank (1:1)	<0.001	<0.001	<0.001	<0.01	<0.001	<0.001	<0.01	<0.001	<0.001	0.262
Mean	NA	5.1	1.9	0.17	0.011	130	0.62	0.024	40.5	19.0
Maximum	NA	11	6.6	0.21	0.015	596	1.1	0.049	79	35
Minimum	NA	1.06	0.009	0.14	0.006	7.89	0.06	0.002	0.03	1.74
LOR	0.1	0.001	0.001	0.01	0.001	0.001	0.01	0.001	0.001	0.005

Table 31. Concentrations of Major Cations and Metals in Order of Mean Concentration (in mg/L)

Rank:	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Analyte	**Fe**	**Al**	**Na**	**Ca**	**Mg**	**K**	**Ce**	**U**	**Mn**	**Cu**	**Si**	**Co**	**Y**
Mean	11670	4670	2890	821	632	457	142	130	96	71	70	47	40.5
Maximum	32900	9520	4490	1910	860	860	248	596	266	407	229	138	79
Minimum	6.9	2.22	510	73	397	46	0.07	7.89	2.47	0.06	5.81	0.20	0.03

Rank:	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**36**
Analyte	**Zn**	**Li**	**Sr**	**Ni**	**Th**	**B**	**Cr**	**V**	**Se**	**Mo**	**Sc**	**Be**	**Ti**
Mean	19.0	6.7	5.1	4.7	1.9	1.8	1.1	0.62	0.50	0.42	0.37	0.38	0.17
Maximum	35	14	11	10	6.6	3.3	2.9	1.1	0.90	0.42	0.89	0.86	0.21
Minimum	1.74	0.41	1.06	0.03	0.009	0.20	0.01	0.06	0.03	0.42	0.03	0.03	0.14

Rank:	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**36**
Analyte	**As**	**Pb**	**Re**	**Ba**	**W**	**Cd**	**Tl**	**Sb**	**Ag**	**Bi**	**Hg**	**Sn**	**Ti**
Mean	0.12	0.07	0.07	0.04	0.024	0.02	0.011	NA	NA	NA	NA	NA	0.17
Maximum	0.25	0.28	013	0.06	0.049	0.03	0.015	0.00	NA	NA	NA	NA	0.21
Minimum	0.01	0.01	0.01	0.02	0.002	0.002	0.006	0.00	NA	NA	NA	NA	0.14

Table 32. Radionuclides in Pore waters

	Radionuclide Activity Concentration (Bq.mL^{-1})[a,b,c]		
Sample	**radium-226**	**Gross Alpha**	**Gross Beta**[d]
ODXH 1.03 (PW)	0.014 ± 0.008	0.007 ± 0.001	0.031 ± 0.001
ODXH 1.07 (PW)	0.031 ± 0.010	0.019 ± 0.001	0.559 ± 0.001
ODXH 1.07 (1:1)	0.005 ± 0.005	0.012 ± 0.001	0.173 ± 0.001
ODXH 3.2-01 (1:1)	< 0.05	0.010 ± 0.001	0.074 ± 0.001
ODXH 3.2-05 (PW)	0.030 ± 0.010	0.007 ± 0.001	0.086 ± 0.001
ODXH 3.2-05 (1:1)	< 0.005	0.013 ± 0.001	0.065 ± 0.001
ODXH 3.2-09 (1:1)	0.005 ± 0.005	0.012 ± 0.001	0.138 ± 0.001
ODXH 4.1-02 (PW)	0.074 ± 0.015	0.005 ± 0.001	0.081 ± 0.001
ODXH 4.1-04 (PW)	0.014 ± 0.007	< 0.005	0.045 ± 0.001
ODXH 4.1-06 (PW)	0.018 ± 0.007	Data Unavailable	Data Unavailable
ODXH 4.2-02 (PW)	0.012 ± 0.005	0.021 ± 0.001	0.049 ± 0.001
ODXH 4.2-04 (PW)	0.010 ± 0.008	0.008 ± 0.001	0.049 ± 0.001
ODXH 2.1-7 (1:1)	< 0.005	0.005 ± 0.001	0.031 ± 0.001
Method Blank (1:1)	< 0.005	< 0.005	< 0.005

a. Activities are in becquerel (Bq) per milli-litre. One becquerel equals one nuclear transformation per second.

b. Less than (<) values indicate the limit of detection for each isotope for the measurement system.

c. The reported uncertainty in each result is the expanded uncertainty calculated using a coverage factor of 2.

d. Gross beta activity concentration does not include the contribution from potassium-40.

4. DISCUSSION

4.1.1 Sample handling

Throughout all stages of the project care was taken to avoid unnecessary exposure of the samples to air which may cause sample oxidation. However, due to (i) the size of the cores (~ 80 cm length and 5-10 kg mass) and the difficult, compact nature, of the materials within the cores, it was not possible to extrude the cores in a nitrogen atmosphere. All cores were extruded as quickly as possible in an air atmosphere and immediately transferred to plastic bags, excess air wasremoved and samples returned to cold storage.

For those core samples for which pore waters were extracted, the samples were stored in a nitrogen atmosphere immediately after extrusion from the core and pore waters were extracted on the same day. Porewater extraction from most of the samples was very difficult due to the low amount of accessible water (compact, clay-like materials with low water content; 17±6% water). For three of the ten samples for which porewater extraction was desirable, a surrogate porewater had to be created by shaking the tailings material in deoxygenated deionised water (1:1 w/v) in a nitrogen atmosphere for 2 h. The small volumes that could be extracted limited the amount of sample available for radionuclide analyses.

4.1.2 QA/QC

The quality control/quality assurance of the sample analyses were considered to be adequate. Full details of all the QA/QC are provided in the appendices.

Replicate sub-samples were not taken through any of the core samples analysed to determine within-core heterogeneity. The reason for this was that it was deemed better use of funds to perform analyses on a greater number of the cores. The analyses of samples from successive core depths from the same core hole sections (0.8 m lengths; e.g. cores 1.2-05, 1.2-07, 1.2-09 from hole 1.2 at depths 12.75-13.5, 17.25-18, and 21-21.75 m depths) indicated that this was quite appropriate as the concentrations of major metals were very similar in the adjacent core sections. It is always a great challenge to gain adequate information when sampling such large volumes of material. It is suggested that repeat sampling and analyses be undertaken on samples selected for the latter stages of the project to provide information on both analytical precision and heterogeneity of materials within a single core.

4.1.3 Analytes

The materials were fully characterised in terms of physical properties, acid-base accounting, radionuclides, the concentrations of major compounds and metals in the solid phase and in the pore waters of selected samples. XRD and BET analyses were made on a limited number of samples.

There were a wide range of concentrations of major compounds, metal and radionuclides and detailed discussion of this data is beyond the scope of this report Interesting outcomes from the analyses related to the classification of the samples as tailings and/or sediments: (i) concentrations of uranium were greater than 45 mg/kg (arbitrary) in all material classified as tailings materials, however many of the sediment samples also had high concentrations of uranium and the sample with the greatest concentration (650 mg/kg) was classified as sediment; and (ii) the tailings materials had radium-226 concentrations in the range 4-10 Bq/g, whereas the sediment concentrations were generally <0.1 Bq/g. However, the radium-226 concentrations measured in two sections of core believed to be above and below the tailings-sediment interface (samples 1.09T (tailings) and 1.09S (sediment)) each measured <0.1 Bq/g, indicating they were mostly sediment materials. This was in contrast to the uranium concentrations of these samples being 485 mg/kg in samples 1.09T and 19 mg/kg in 1.09S. Similar tailings versus sediment relationships were observed for the other radionuclides. In general, the sediments had higher BET surface area (10-39 m^2/g) than the tailings materials (3-5 m^2/g). The XRD analyses indicated the materials were mostly quartz minerals, and contained very small amounts of calcite and dolomite.

The pore waters exhibited an inverse relationship between pH and Eh, and Fe(II) comprised 20-30% of the total dissolved iron. The porewater cations with the greatest concentration were (in decreasing order) Fe>Al>Na>Ca>Mg>Ce>U>Mn>Cu. The mean concentrations of Fe, Al, Ce and U were 12000, 4700, 140 and 130 mg/L, respectively. The cores with the greatest uranium concentrations were 4.2-04 (596 mg/L), 1.07 (262 mg/L), 3.2-05 (215 mg/L), 4.2-02 (131 mg/L), 4.1-06 (113 mg/L), and 4.1-04 (105 mg/L).

5. REFERENCES

APHA (1998). Standard methods for the examination of water and wastewater. American Public Health Association, American Water Works Association and Water Environment Federation (APHA-AWWA-WEF).

ASTM (1998). Standard practice for oxidation-reduction potential of water, D 1498-00. American Society for Testing and Materials, West Conshohocken, PA, USA.

Brunauer,S., Emmett,P.H. and Teller, E. (1938). Adsorption of Gases in Multimolecular Layers. Am. Chem. Soc., 60, 309-319.

Mudroch, A., Azcue, J.M., and Mudroch, P. (1997). Manual of physico-chemical analysis of aquatic sediments. CRC Press, Boca Raton, FL, USA.

NEPM (1999) National Environment Protection (Assessment of Site Contamination) Measure 1999. http://www.ephc.gov.au/nepms/cs/con_sites.html.

Rayment, G.E. and Higginson, F.R. (1992). Australian Laboratory Handbook of Soil and Water Chemical Methods. 330 pp. (Reed International Books Australia P/L, trading as Inkata Press, Port Melbourne.).

Simpson, S.L., Spadaro, D.A., Angel, B.A., Hamilton, I. (2008a). Partitioning, leaching and adsorption characteristics of the Olympic Dam tailings materials. CSIRO Land and Water Report Number CLWXX/08. XX pages (under preparation).

Simpson, S.L., Spadaro, D.A., Angel, B.A., Hamilton, I. (2008b). Saturated and unsaturated column leaching tests of tailings, sediment and bedrock materials from Olympic Dam. CSIRO Land and Water Report Number CLWXX/08. XX pages (under preparation).

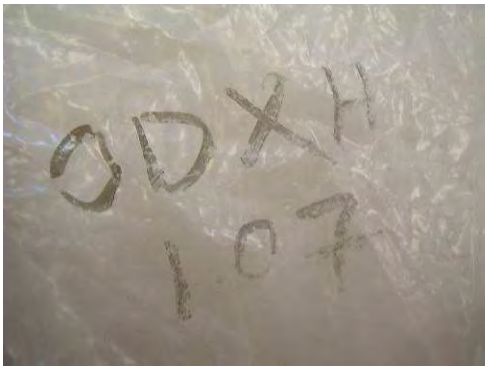
US EPA (1996). Test methods for evaluating solid waste, physical/chemical methods, SW-846. United States Environmental Protection Agency; Office of Solid Waste; Economic, Methods, and Risk Analysis. Division, Washington, DC.

USEPA 600/2-78-054, I. Miller (2000). A fizz test is done to semiquanititatively estimate the likely reactivity. The Characterizing, Subsampling and Crushing Samples 600/2-78-054 03/01/1978 USEPA method index.

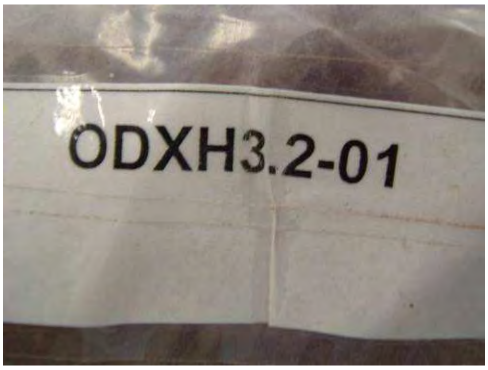
USEPA 600/2-78-054, I. Miller (2000). A fizz test is done to semiquanititatively estimate the likely reactivity. The soil is then reacted with an known excess quanitity of an appropriate acid. Titration determines the acid remaining, and the ANC can be calculated from comparison with a blank titration.

APPENDIX A. Sample Log

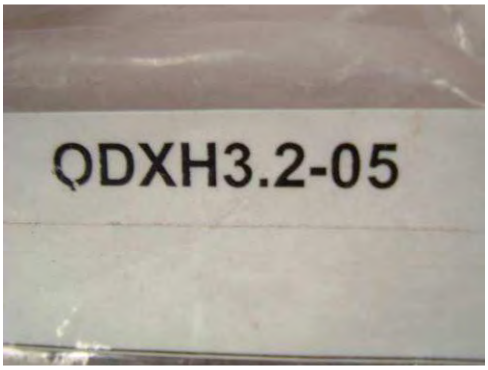
Sample: ODXH 1.07
Sample Condition: Core is double bagged and well sealed. Small amount of leaking occurred into inner bag. Inner bag marked 18.0 at one end (taken to be the top of the core) and 18.75 at the other end. The sediment did not contain sufficient moisture for porewater extraction.
Sample Treatment: Porewater extraction (radionuclide, dissolved metal and major cation analysis) and 1:1 extraction (all samples). And Solid Phase Analysis.



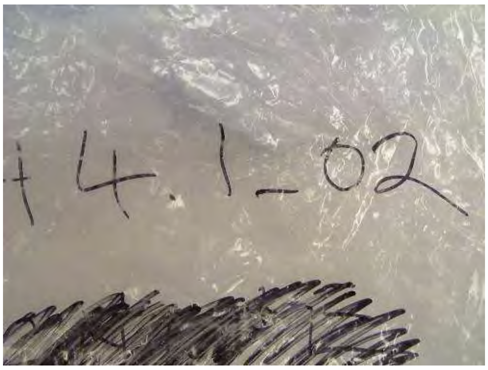
Sample: ODXH 3.2 - 01
Sample Condition: Leaking of water outside of both bags. Core was slightly wetter then previous core however still not wet enough to obtain enough porewater for analysis.
Sample Treatment: 1:1 Extraction and Solid Phase Analysis.



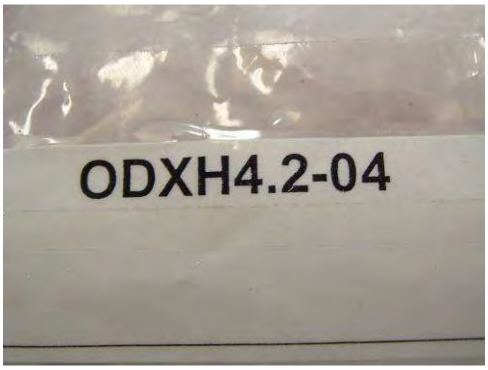
Sample: ODXH 3.2 - 05
Sample Condition: No leaking into the outside bag. The vacuum sealed bag (Inner bag) was very well sealed. The core was moist and slide easily out of the PVC core tube.
Sample Treatment: Porewater extraction (all samples) and 1:1 extraction (radionuclide, dissolved metal, major cation and Iron 2+ analysis) and Solid Phase Analysis.

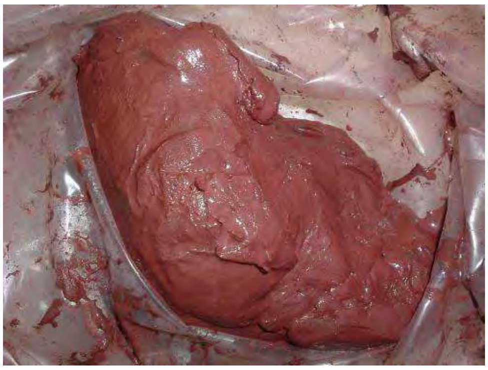


Sample: ODXH 4.1 - 02
Sample Condition: Both bags leaked badly, inside (vacuum) bag very poorly sealed. Sample leaked ground water from both bags, a considerable volume was leaked from outer bag onto cool room floor (approx. 30 mL)
Sample Treatment: Porewater Extraction and Solid Phase Analysis.

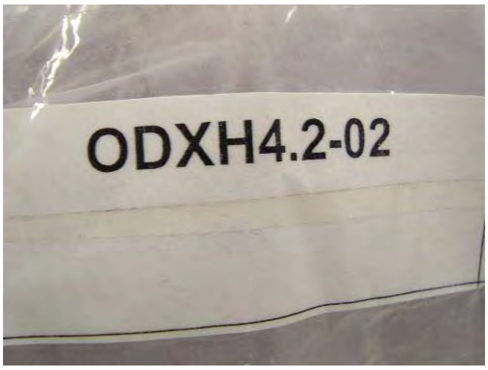


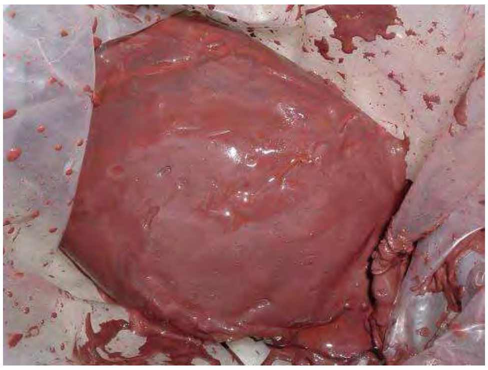
Sample: ODXH 4.2 - 04
Sample Condition: Both bags were very well sealed, no leakage occurred.
Sample Treatment: Porewater Extraction and Solid Phase Anlysis.



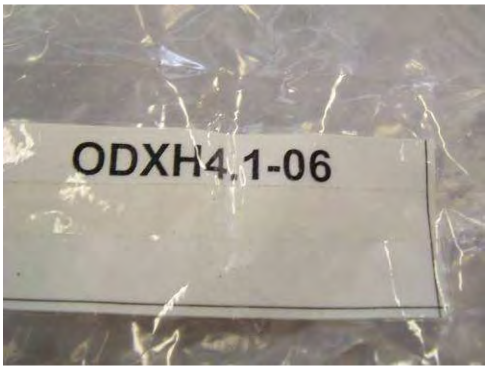


Sample Condition: Inner bag was not vacuum sealed and inner bag had leaked into the outer bag. No leakage occurred outside of the outer bag.
Sample Treatment: Porewater Extraction and Solid Phase Analysis



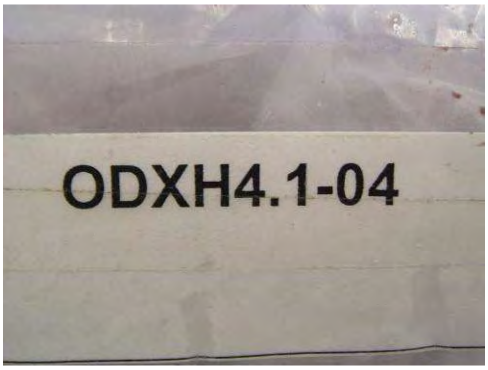


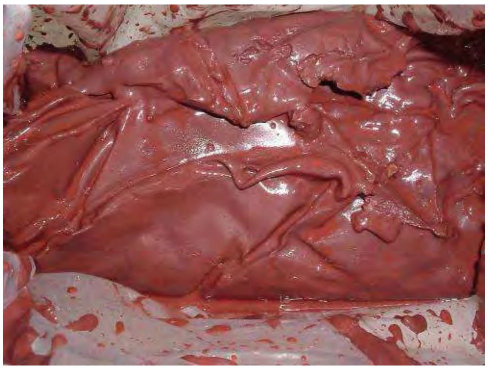
Sample: ODXH 4.1 - 06
Sample Condition: No leakage from outer bag, Minimal leakage from inner vacuum bag. Sample appeared to be very moist and slid out of the core tube very easily.
Sample Treatment: Porewater Extraction and Solid Phase Anlysis.



Sample: ODXH 1.03
Sample Condition: Sample leaked considerable volume from outer bag as well as inner vacuum sealed bag. The sample was very moist and easily extruded from the core tube.
Sample Treatment: Porewater extraction and Solid Phase Anlysis.

Sample: ODXH 4.1 - 04
Sample Condition: The inner vacuum sealed bag was well sealed and no leakage had occurred. In addition the sample was well contained within the outside bag with no leakage occurring.
Sample Treatment: Porewater Extraction and Solid Phase Analysis





Sample: ODXH 3.1 - 04
Sample Condition: Very dry core**,** very large rock blocking the bottom of the core tube. No leakage from outside bag, inside bag well sealed.
Sample Treatment: Solid Phase Analysis.

Sample: ODXH 2.1 - 7
Sample Condition: No leakage from outer bag, Inner bag well sealed. Core was very dry and sandy.
Sample Treatment: 1:1 Extraction and Solid Phase Analysis.

Sample: ODXH 3.1 - 02
Sample Condition: Inner bag well sealed, no leakage from inner or outer bags. Very dry core.
Sample Treatment: Solid Phase Analysis.

Sample: ODXH 1.09

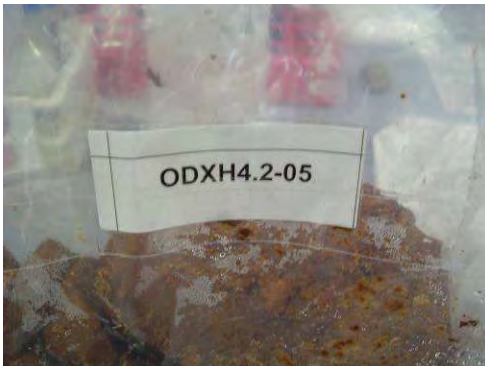
Sample Condition: No outer bag leakage. The inner bag was very well sealed. Core was extremely sticky in nature, contained a lot of clay. Clear stratification was observed within the core. The sediment change from being largely clay to largely sandy material from the top to the bottom of the core. This was assumed to be the boundary between the tailings material and the underlying natural sediment.

Sample Treatment: Solid Phase Analysis.

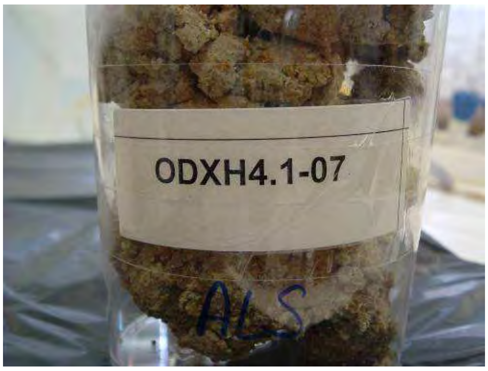
Sample: ODXH 4.2 - 05

Sample Condition: No outer bag leakage. The inner bag was very well sealed. Core was extremely sticky in nature, contained a lot of clay.

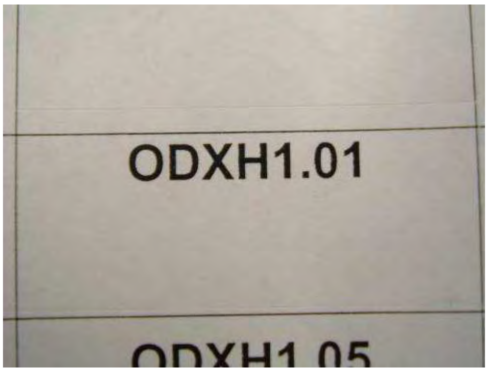
Sample Treatment: Solid Phase Analysis



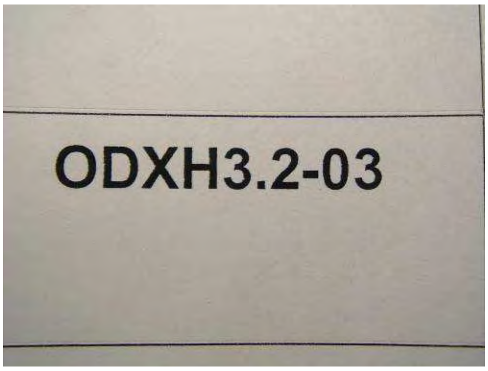
Sample: ODXH 4.1 - 07
Sample Condition: No outer bag leakage. The inner bag was very well sealed. Core was extremely sticky in nature, contained a lot of clay.
Sample Treatment: Solid Phase Analysis.



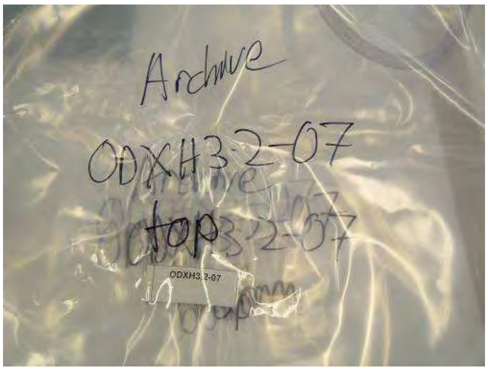
Sample: ODXH 1.01
Sample Condition: A large amount of leakage from the outside bag. Core appeared very wet and slide out of core tube easily.
Sample Treatment: Solid Phase Analysis.



Sample: ODXH 3.2 - 03
Sample Condition: Outside bag not leaking, small amount of moisture on the outside of the vacuum sealed bag (inner bag), however the vacuum sealed bag appeared to be very well sealed. A large amount of water came out of the core tube when it was tipped up (approx. 300 mL). Core was extremely wet and no stratification was observed within the core.
Sample Treatment: Solid Phase Analysis.

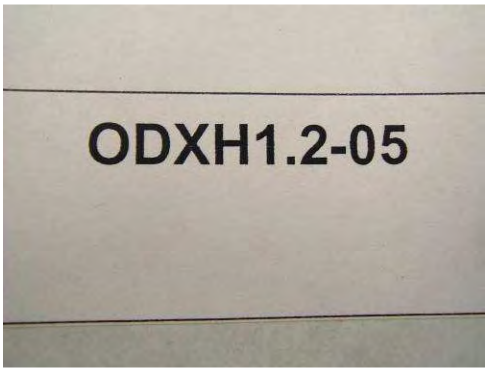


Sample: ODXH 3.2 - 07
Sample Condition: Outside bag was very well sealed (large amount of tape was used to seal the ends). The vacuum sealed bag had a great seal and the core appeared to be very wet.
Sample Treatment: Solid Phase Analysis.



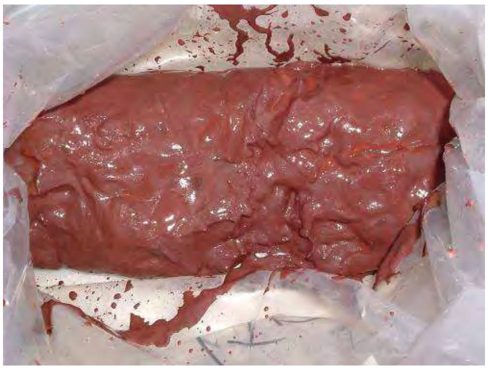
Sample: ODXH 1.2 - 07
Sample Condition: No leakage from the outer or inner bags. Sample appeared to be very moist.
Sample Treatment: Solid Phase Analysis.

Sample: ODXH 1.2 - 05
Sample Condition: No leakage from the outer or inner bags. Sample appeared to be very moist.
Sample Treatment: Solid Phase Analysis.


ODXH1.2-05

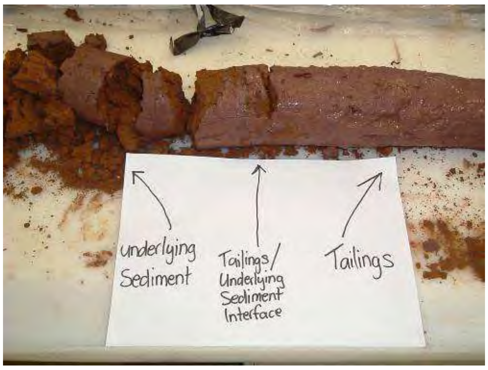
Sample: ODXH 1.05
Sample Condition: Small amount of leakage from outside bag. Inside bag not sealed well, a large amount of leakage from inside bag into outside bag. Core was extremely wet.
Sample Treatment: Solid Phase Analysis.


ODXH1.05



Sample: ODXH 1.2 - 02
Sample Condition: No inner or outer bag leakage. Core was black in colour, very sulfidic, extremely bad smelling (hydrogen sulphide gas).
Sample Treatment: Solid Phase Analysis.

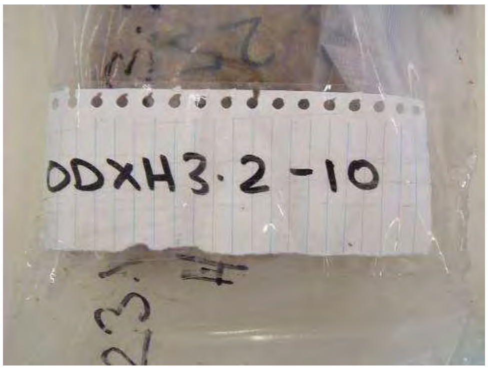
Sample: ODXH 1.2 - 09
Sample Condition: No leakage for either bag, inner vacuum sealed bag was well sealed. Top half of core was very moist and came out in one long piece. Bottom half as very dry and came out in pieces. Clear stratification was present in the sample. The wetter top section of the core was assumed to be tailings material whilst the bottom drier section of the core was assumed to be the underlying natural sediment.
Sample Treatment: Solid Phase Analysis.



Sample: ODXH 1.12
Sample Condition: No outer bag was present on this sample. No leakage from the vacuum sealed bag. No PVC core tube present around this sample. Sediment was bright yellow in colour and consisted of clay, large to small rocks and sand. Depth measurements were marked on the bag but as there was no core tube to indicate which end of the sample was the top and which was the bottom.
Sample Treatment: Solid Phase Analysis.

Sample: ODXH 3.2 - 13
Sample Condition: Very dry core, no outer or inner bag leakage. Vacuum sealed bag was intact and sealed very well. No liquid present. Very small sample, not in a core tube. Only 1 pH sample taken from in the middle of the sample.
Sample Treatment: Solid Phase Analysis.

Sample: ODXH 3.2 - 10
Sample Condition: Very dry core, no outer or inner bag leakage. Vacuum sealed bag was intact and sealed very well. No liquid present. Very small sample, not in a core tube. Only 1 pH sample taken from in the middle of the sample.
Sample Treatment: Solid Phase Analysis.



Sample: ODXH 3.2 - 12
Sample Condition: Very dry core, no outer or inner bag leakage. Vacuum sealed bag was intact and sealed very well. No liquid present. Very small sample, not in a core tube. Only 1 pH sample taken from in the middle of the sample.
Sample Treatment: Solid Phase Analysis.

Sample: ODXH 4.2 - 09
Sample Condition: Very dry core, no outer or inner bag leakage. Vacuum sealed bag was intact and sealed very well. No liquid present. Very small sample, not in a core tube. Only 1 pH sample taken from in the middle of the sample.
Sample Treatment: Solid Phase Analysis.

Sample: ODXH 4.1 - 10
Sample Condition: Small rock core, circular in appearance (as though it came out of a core tube). No core tube with sample. Sample was extremely dry and very hard.
Sample Treatment: Solid Phase Analysis.

APPENDIX B. Quality Assurance

The laboratory QA/QC results for the analyses of solids and pore waters are provided in the following pages.

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES

Environmental Division

QUALITY CONTROL REPORT

Work Order	: **EB0802634**	Page	: 1 of 5
Client	: **C S I R O AUSTRALIA**	Laboratory	: Environmental Division Brisbane
Contact	: DR STUART SIMPSON	Contact	: Tim Kilmister
Address	: 11 JULIUS AVENUE RIVERSIDE CORPORATE PARK, NORTH RYDE NSW, AUSTRALIA 2113	Address	: 32 Shand Street Stafford QLD Australia 4053
E-mail	: stuart.simpson@csiro.au	E-mail	: Services.Brisbane@alsenviro.com
Telephone	: +61 02 94908534	Telephone	: +61-7-3243 7222
Facsimile	: +61 02 94908499	Facsimile	: +61-7-3243 7218
Project	: ----	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Site	: ----		
C-O-C number	: ----	Date Samples Received	: 27-FEB-2008
Sampler	: ----	Issue Date	: 14-MAR-2008
Order number	: ----		
		No. of samples received	: 38
Quote number	: ----	No. of samples analysed	: 38

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 Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

NATA
WORLD RECOGNISED
ACCREDITATION

NATA Accredited Laboratory 825

This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

Signatories

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

Signatories	*Position*	*Accreditation Category*
Cass Sealby	Senior Chemist - Acid Sulphate Soils	Inorganics
Cass Sealby	Senior Chemist - Acid Sulphate Soils	Stafford Minerals
Jessica Garwood	Supervisor - Acid Sulphate Soils	Inorganics
Kim McCabe	Senior Inorganic Chemist	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 preformed, 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 insuffient 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.

Key :
Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = Chemistry Abstract Services number
LOR = Limit of reporting
RPD = Relative Percentage Difference
# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR:- No Limit; Result between 10 and 20 times LOR:- 0% - 50%; Result > 20 times LOR:- 0% - 20%.

Sub-Matrix: **SOIL**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EA011: Net Acid Generation (QC Lot: 610277)									
EB0802634-001	ODXH 1.01	EA011: NAG (pH 4.5)	----	0.1	kg H_2SO_4/t	<0.1	<0.1	0.0	No Limit
		EA011: NAG (pH 7.0)	----	0.1	kg H_2SO_4/t	1.0	1.0	0.0	0% - 50%
		EA011: pH (OX)	----	0.1	pH Unit	6.3	6.3	0.0	0% - 20%
EB0802634-020	ODXH 3.2-07	EA011: NAG (pH 4.5)	----	0.1	kg H_2SO_4/t	<0.1	<0.1	0.0	No Limit
		EA011: NAG (pH 7.0)	----	0.1	kg H_2SO_4/t	6.4	6.3	0.0	0% - 20%
		EA011: pH (OX)	----	0.1	pH Unit	5.4	5.4	0.0	0% - 20%
EA013: Acid Neutralising Capacity (QC Lot: 610276)									
EB0802634-001	ODXH 1.01	EA013: ANC as H_2SO_4	----	0.5	kg H_2SO_4/t	11.2	11.0	0.9	0% - 20%
EB0802634-012	ODXH 1.2-09 Underlying Sed	EA013: ANC as H_2SO_4	----	0.5	kg H_2SO_4/t	<0.5	<0.5	0.0	No Limit
EA013: Acid Neutralising Capacity (QC Lot: 610278)									
EB0802634-022	ODXH 3.2-10	EA013: ANC as H_2SO_4	----	0.5	kg H_2SO_4/t	7.5	7.1	4.8	0% - 50%
EB0802634-033	ODXH 4.2-09	EA013: ANC as H_2SO_4	----	0.5	kg H_2SO_4/t	284	291	2.5	0% - 20%
EA031: pH (saturated paste) (QC Lot: 612582)									
EB0802634-001	ODXH 1.01	EA031: pH (Saturated Paste)	----	0.1	pH Unit	4.1	4.0	0.0	0% - 20%
EB0802634-019	ODXH 3.2-05	EA031: pH (Saturated Paste)	----	0.1	pH Unit	4.1	4.1	0.0	0% - 20%
EA032: Electrical Conductivity (saturated paste) (QC Lot: 612585)									
EB0802634-001	ODXH 1.01	EA032: Electrical Conductivity (Saturated Paste)	----	1	µS/cm	3120	3120	0.0	0% - 20%
EB0802634-019	ODXH 3.2-05	EA032: Electrical Conductivity (Saturated Paste)	----	1	µS/cm	4360	4360	0.0	0% - 20%
EA055: Moisture Content (QC Lot: 606406)									
EB0802634-004	ODXH 1.07	EA055-103: Moisture Content (dried @ 103°C)	----	1.0	%	15.8	14.2	10.8	0% - 50%
EB0802634-011	ODXH 1.2-09 Tailings Material	EA055-103: Moisture Content (dried @ 103°C)	----	1.0	%	21.4	20.4	5.0	0% - 20%
EA055: Moisture Content (QC Lot: 606407)									
EB0802634-024	ODXH 3.2-13	EA055-103: Moisture Content (dried @ 103°C)	----	1.0	%	10.9	9.5	13.7	No Limit
EB0802634-031	ODXH 4.2-04	EA055-103: Moisture Content (dried @ 103°C)	----	1.0	%	16.0	14.5	10.0	0% - 50%
ED040T : Total Sulphate by ICPAES (QC Lot: 606020)									
EB0802634-001	ODXH 1.01	ED040T: Sulphate as SO_4^{2-}	14808-79-8	100	mg/kg	28200	31200	10.0	0% - 20%
EB0802634-010	ODXH 1.2-07	ED040T: Sulphate as SO_4^{2-}	14808-79-8	100	mg/kg	20100	18600	7.7	0% - 20%
ED040T : Total Sulphate by ICPAES (QC Lot: 606021)									
EB0802634-021	ODXH 3.2-09	ED040T: Sulphate as SO_4^{2-}	14808-79-8	100	mg/kg	20500	20400	0.4	0% - 20%
EB0802634-030	ODXH 4.2-02	ED040T: Sulphate as SO_4^{2-}	14808-79-8	100	mg/kg	29500	31100	5.4	0% - 20%
ED042T: Total Sulphur by LECO (QC Lot: 614578)									
EB0802634-010	ODXH 1.2-07	ED042T: Sulphur - Total as S (LECO)	----	0.01	%	1.11	1.10	0.9	0% - 20%
EB0802634-020	ODXH 3.2-07	ED042T: Sulphur - Total as S (LECO)	----	0.01	%	1.08	1.07	0.9	0% - 20%

Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **SOIL**

				Method Blank (MB) Report	*Laboratory Control Spike (LCS) Report*			
					Spike	*Spike Recovery (%)*	*Recovery Limits (%)*	
Method: Compound	*CAS Number*	*LOR*	*Unit*	*Result*	*Concentration*	*LCS*	*Low*	*High*
EA011: Net Acid Generation (QCLot: 610277)								
EA011: NAG (pH 7.0)	----	0.1	kg H2SO4/t	----	9.9 kg H2SO4/t	84.0	76.4	103
EA013: Acid Neutralising Capacity (QCLot: 610276)								
EA013: ANC as H2SO4	----	0.5	kg H2SO4/t	----	9.9 kg H2SO4/t	96.1	89	113
EA013: Acid Neutralising Capacity (QCLot: 610278)								
EA013: ANC as H2SO4	----	0.5	kg H2SO4/t	----	9.9 kg H2SO4/t	96.1	89	113
EA032: Electrical Conductivity (saturated paste) (QCLot: 612585)								
EA032: Electrical Conductivity (Saturated Paste)	----	1	µS/cm	<1	1413 µS/cm	99.9	98.5	101
ED040T : Total Sulphate by ICPAES (QCLot: 606020)								
ED040T: Sulphate as SO4 2-	14808-79-8	100	mg/kg	<100	800 mg/kg	73.6	70	113
ED040T : Total Sulphate by ICPAES (QCLot: 606021)								
ED040T: Sulphate as SO4 2-	14808-79-8	100	mg/kg	<100	800 mg/kg	75.0	70	113
ED042T: Total Sulphur by LECO (QCLot: 614578)								
ED042T: Sulphur - Total as S (LECO)	----	0.01	%	<0.01	100 %	100	70	130

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

- **No Matrix Spike (MS) Results are required to be reported.**

ALS Chemex
EXCELLENCE IN ANALYTICAL CHEMISTRY
Australian Laboratory Services Pty Ltd
32 Shand Street
Stafford
Brisbane QLD 4053
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QC CERTIFICATE BR08051161

Project:
P.O. No.:
This report is for 33 Soil samples submitted to our lab in Brisbane, QLD, Australia on 23-APR-2008.

The following have access to data associated with this certificate:

STUART SIMPSON		

SAMPLE PREPARATION

ALS CODE	DESCRIPTION
LEV-01	Waste Disposal Levy
LOG-22	Sample login - Rcd w/o BarCode
PUL-32	Pulverize 1000g to 85% < 75 um

ANALYTICAL PROCEDURES

ALS CODE	DESCRIPTION	INSTRUMENT
ME-MS42	Up to 34 elements by ICP-MS	ICP-MS
ME-MS61	48 element four acid ICP-MS	
ME-ICP85	Silicates by Fusion, ICP-AES	ICP-AES
ME-GRA05	H2O/LOI by TGA furnace	TGA
B-ICP69	Boron - HF Digest ICP-AES	ICP-AES

To: **C S I R O ENERGY TECHNOLOGY**
ATTN: STUART SIMPSON
PRIVATE MAIL BAG 7
BANGOR NSW 2234

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.
***** See Appendix Page for comments regarding this certificate *****

Signature:
Shaun Kenny, Brisbane Laboratory Manager

QC CERTIFICATE OF ANALYSIS BR08051161

Method	ME-ICP85	ME-ICP85	ME-ICP85	ME-ICP85	ME-ICP85	ME-ICP85	ME-ICP85	ME-ICP85	ME-ICP85	ME-ICP85	ME-ICP85	ME-ICP85	ME-GRA05	B-ICP69	ME-MS42
Analyte	Al2O3	BaO	CaO	Cr2O3	Fe2O3	K2O	MgO	MnO	Na2O	SiO2	SrO	TiO2	LOI	B	Hg
Units	%	%	%	%	%	%	%	%	%	%	%	%	%	ppm	ppm
Sample Description LOR	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	10	0.005
							STANDARDS								
BAUX CS2													24.45		
BAUX CS2													24.59		
Target Range - Lower Bound													23.80		
Upper Bound													25.30		
BM-8														160	
Target Range - Lower Bound														110	
Upper Bound														150	
BORON-C														2140	
BORON-C														2180	
Target Range - Lower Bound														1980	
Upper Bound														2310	
G2000															0.734
G2000															
Target Range - Lower Bound															0.633
Upper Bound															0.868
GBM306-6															0.089
GBM306-6															
Target Range - Lower Bound															
Upper Bound															
GBM999-5															
Target Range - Lower Bound															
Upper Bound															
GEOMS-03															
Target Range - Lower Bound															
Upper Bound															
SIL-CS3	13.55	0.04	3.21	<0.01	10.05	5.54	0.23	0.77	8.50	52.9	0.57	0.50			
SIL-CS3	13.60	0.04	3.21	<0.01	9.95	5.65	0.25	0.76	8.50	52.8	0.57	0.50			
SIL-CS3	13.55	0.04	3.28	<0.01	10.15	5.57	0.23	0.76	7.90	53.3	0.54	0.50			
SIL-CS3	13.60	0.04	3.31	<0.01	10.10	5.60	0.27	0.76	7.94	53.2	0.55	0.51			
Target Range - Lower Bound	12.25	0.04	2.89	<0.01	8.91	4.95	0.24	0.68	7.52	51.4	0.48	0.42			
Upper Bound	15.00	0.07	3.55	0.02	10.90	6.07	0.32	0.86	9.22	54.6	0.60	0.54			

QC CERTIFICATE OF ANALYSIS BR08051161

Method	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61
Analyte	Ag	As	Be	Bi	Cd	Ce	Co	Cu	Li	Mn	Mo	Ni	Pb	Re	Sb
Units	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Sample Description **LOR**	0.01	0.2	0.05	0.01	0.02	0.01	0.1	0.2	0.2	5	0.05	0.2	0.5	0.002	0.05
							STANDARDS								
BAUX CS2															
BAUX CS2															
Target Range - Lower Bound															
Upper Bound															
BM-8															
Target Range - Lower Bound															
Upper Bound															
BORON-C															
BORON-C															
Target Range - Lower Bound															
Upper Bound															
G2000															
G2000	3.67	460	1.60	2.49	7.58	56.2	25.7	296	44.4	567	7.15	262	639	0.007	36.4
Target Range - Lower Bound	3.22	435	1.25	0.98	6.82	47.9	22.6	273	37.0	506	5.62	246	603	0.003	29.3
Upper Bound	3.96	533	1.63	1.22	8.38	58.5	27.8	334	45.6	630	6.98	302	738	0.009	39.7
GBM306-6															
GBM306-6	2.73	13.2	0.60	7.07	11.30	20.7	39.3	4460	9.8	964	1.92	29.6	5260	<0.002	5.36
Target Range - Lower Bound	2.60	10.6	0.52	5.79	10.60	17.00	28.7	4230	8.8	940	1.64	22.3	5190	<0.002	4.49
Upper Bound	3.20	13.4	0.74	7.09	13.00	20.8	35.3	5180	11.2	1160	2.11	27.7	6350	0.004	6.19
GBM999-5	55.8	3.4	1.44	0.51	0.23	27.6	3.9	488	3.2	69	4.60	4.6	551	0.007	6.05
Target Range - Lower Bound	53.5	3.0	1.12	0.50	0.17	23.6	2.9	429	2.8	54	3.77	3.8	487	0.003	4.78
Upper Bound	65.4	4.2	1.48	0.64	0.25	28.9	3.7	525	3.8	78	4.71	5.0	597	0.008	6.58
GEOMS-03	0.74	617	1.51	0.42	0.36	53.6	12.6	131.5	40.4	525	3.68	55.7	6.2	0.003	19.50
Target Range - Lower Bound	0.67	570	1.34	0.31	0.30	47.0	10.7	120.5	37.6	483	3.05	48.1	7.2	<0.002	15.85
Upper Bound	0.85	697	1.74	0.41	0.42	57.4	13.3	147.5	46.4	601	3.83	59.3	9.9	0.004	21.5
SIL-CS3															
SIL-CS3															
SIL-CS3															
SIL-CS3															
Target Range - Lower Bound															
Upper Bound															

***** See Appendix Page for comments regarding this certificate *****

QC CERTIFICATE OF ANALYSIS BR08051161

Method	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61
Analyte	Sc	Se	Sn	Th	Tl	U	V	W	Y	Zn
Units	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Sample Description LOR	0.1	1	0.2	0.2	0.02	0.1	1	0.1	0.1	2
					STANDARDS					
BAUX CS2										
BAUX CS2										
Target Range - Lower Bound										
Upper Bound										
BM-8										
Target Range - Lower Bound										
Upper Bound										
BORON-C										
BORON-C										
Target Range - Lower Bound										
Upper Bound										
G2000										
G2000	11.4	5	2.5	6.9	1.12	3.4	99	20.7	24.5	1310
Target Range - Lower Bound	10.3	4	1.8	6.4	0.84	2.9	94	15.2	21.1	1155
Upper Bound	12.8	7	2.6	8.2	1.18	3.7	117	20.8	26.0	1415
GBM306-6										
GBM306-6	22.6	2	3.1	1.7	0.18	0.5	164	21.2	26.1	2920
Target Range - Lower Bound	<0.1	<1	2.5	1.6	<0.02	0.4	150	13.5	19.5	2700
Upper Bound	0.2	2	3.5	2.4	0.04	0.7	185	18.5	24.1	3300
GBM999-5	2.0	1	1.8	5.3	2.21	2.3	7	2.5	12.5	119
Target Range - Lower Bound	1.7	<1	1.3	4.4	1.75	1.8	5	2.1	10.3	102
Upper Bound	2.3	3	2.1	5.8	2.41	2.4	9	3.0	12.8	129
GEOMS-03	14.3	3	2.8	6.3	1.27	3.6	112	23.4	21.6	49
Target Range - Lower Bound	12.4	2	2.1	6.2	0.99	3.1	104	18.1	19.8	40
Upper Bound	15.4	4	3.0	8.0	1.39	4.0	130	24.7	24.4	54
SIL-CS3										
SIL-CS3										
SIL-CS3										
SIL-CS3										
Target Range - Lower Bound										
Upper Bound										

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QC CERTIFICATE OF ANALYSIS BR08051161

Sample Description	Method	ME-ICP85	ME-ICP85	ME-ICP85	ME-ICP85	ME-ICP85	ME-ICP85	ME-ICP85	ME-ICP85	ME-ICP85	ME-ICP85	ME-ICP85	ME-ICP85	ME-GRA05	B-ICP69	ME-MS42
	Analyte	Al2O3	BaO	CaO	Cr2O3	Fe2O3	K2O	MgO	MnO	Na2O	SiO2	SrO	TiO2	LOI	B	Hg
	Units	%	%	%	%	%	%	%	%	%	%	%	%	%	ppm	ppm
	LOR	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	10	0.005
BLANKS																
BLANK																<0.005
BLANK																
BLANK																
BLANK		<0.01	0.01	<0.01	<0.01	<0.01	<0.01	0.02	0.01	<0.01	0.02	0.01	0.02			
BLANK		<0.01	0.01	<0.01	<0.01	0.01	0.01	0.02	0.01	<0.01	<0.01	0.01	0.02			
BLANK															<10	
BLANK															<10	
BLANK		<0.01	0.01	0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	0.01	0.02			
BLANK		<0.01	0.01	0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	0.02	0.01	0.02			
Target Range - Lower Bound		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<10	<0.005
Upper Bound		0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02		20	0.010
DUPLICATES																
ODXPT15-3																
DUP																
Target Range - Lower Bound																
Upper Bound																
ODXPT17-3d		8.03	0.01	1.04	0.01	0.57	0.29	0.73	0.01	0.43	83.8	0.01	0.94	3.99	80	0.006
DUP		7.95	0.01	1.02	0.01	0.55	0.22	0.71	0.01	0.38	84.0	0.01	0.93	3.97	70	0.007
Target Range - Lower Bound		7.57	<0.01	0.96	<0.01	0.51	0.22	0.66	<0.01	0.36	79.7	<0.01	0.87	3.86	50	<0.005
Upper Bound		8.41	0.02	1.10	0.02	0.61	0.29	0.78	0.02	0.45	88.1	0.02	1.00	4.10	100	0.010
ODXRt16a-1		7.22	0.02	3.25	0.01	3.10	0.81	2.05	0.04	0.58	75.3	0.02	0.32			
DUP		7.30	0.02	3.34	0.01	3.11	0.80	2.08	0.05	0.57	75.4	0.02	0.32			
Target Range - Lower Bound		6.88	<0.01	3.11	<0.01	2.93	0.74	1.94	0.02	0.53	71.6	<0.01	0.28			
Upper Bound		7.64	0.04	3.48	0.02	3.28	0.87	2.19	0.07	0.62	79.1	0.04	0.36			
ODXRt16a-12b																
DUP																
Target Range - Lower Bound																
Upper Bound																
ODXRt16a-4															140	
DUP															140	
Target Range - Lower Bound															110	
Upper Bound															170	

QC CERTIFICATE OF ANALYSIS BR08051161

Method	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61
Analyte	Ag	As	Be	Bi	Cd	Ce	Co	Cu	Li	Mn	Mo	Ni	Pb	Re	Sb
Units	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Sample Description **LOR**	0.01	0.2	0.05	0.01	0.02	0.01	0.1	0.2	0.2	5	0.05	0.2	0.5	0.002	0.05
BLANKS															
BLANK															
BLANK	<0.01	<0.2	<0.05	<0.01	<0.02	<0.01	<0.1	<0.2	<0.2	<5	<0.05	<0.2	<0.5	<0.002	<0.05
BLANK	<0.01	<0.2	<0.05	<0.01	<0.02	<0.01	<0.1	<0.2	<0.2	<5	<0.05	<0.2	<0.5	<0.002	<0.05
BLANK															
BLANK															
BLANK															
BLANK															
BLANK															
BLANK															
Target Range - Lower Bound	<0.01	<0.2	<0.05	<0.01	<0.02	<0.01	<0.1	<0.2	<0.2	<5	<0.05	<0.2	<0.5	<0.002	<0.05
Upper Bound	0.02	0.4	0.10	0.02	0.04	0.02	0.2	0.4	0.4	10	0.10	0.4	1.0	0.004	0.10
DUPLICATES															
ODXPT15-3	0.05	3.7	0.1	0.35	<0.02	6.73	1.5	3.1	14.8	30	4.19	3.9	3.2	<0.002	0.27
DUP	0.05	3.4	0.11	0.14	<0.02	6.28	1.6	2.7	12.9	30	4.18	4.1	3.2	<0.002	0.27
Target Range - Lower Bound	0.03	3.0	<0.05	0.21	<0.02	6.16	1.3	2.4	12.8	19	3.88	3.4	2.0	<0.002	0.15
Upper Bound	0.07	4.1	0.21	0.28	0.04	6.85	1.8	3.4	14.9	42	4.49	4.6	4.4	0.004	0.39
ODXPT17-3d															
DUP															
Target Range - Lower Bound															
Upper Bound															
ODXRt16a-1															
DUP															
Target Range - Lower Bound															
Upper Bound															
ODXRt16a-12b	0.05	6	0.28	0.36	<0.02	10.7	2.6	2.7	2.7	633	0.62	3	1.7	<0.002	1.89
DUP	0.06	<5.0	0.29	0.07	0.02	10.55	2.6	3.8	2.4	618	0.53	3.1	2.6	<0.002	0.18
Target Range - Lower Bound	0.03	4.8	0.17	0.18	<0.02	10.05	2.3	2.7	2.0	584	0.45	2.5	1.0	<0.002	0.86
Upper Bound	0.08	6.2	0.40	0.25	0.04	11.20	2.9	3.8	3.1	667	0.70	3.6	3.3	0.004	1.21
ODXRt16a-4															
DUP															
Target Range - Lower Bound															
Upper Bound															

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QC CERTIFICATE OF ANALYSIS BR08051161

Method	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61
Analyte	Sc	Se	Sn	Th	Tl	U	V	W	Y	Zn
Units	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Sample Description LOR	0.1	1	0.2	0.2	0.02	0.1	1	0.1	0.1	2
					BLANKS					
BLANK										
BLANK	<0.1	<1	<0.2	<0.2	<0.02	<0.1	<1	<0.1	<0.1	<2
BLANK	<0.1	<1	<0.2	<0.2	<0.02	<0.1	<1	<0.1	<0.1	<2
BLANK										
BLANK										
BLANK										
BLANK										
BLANK										
BLANK										
Target Range - Lower Bound	<0.1	<1	<0.2	<0.2	<0.02	<0.1	<1	<0.1	<0.1	<2
Upper Bound	0.2	5	0.4	0.4	0.04	0.2	2	0.2	0.2	4
					DUPLICATES					
ODXPT15-3	2.4	<1	0.8	2.1	0.03	0.4	40	3.2	2.4	3
DUP	2.5	<1	0.8	2.1	0.03	0.4	41	2.3	2.5	3
Target Range - Lower Bound	2.1	<1	0.4	1.6	<0.02	0.2	36	2.3	2.1	<2
Upper Bound	2.8	2	1.2	2.6	0.04	0.6	45	3.2	2.8	4
ODXPT17-3d										
DUP										
Target Range - Lower Bound										
Upper Bound										
ODXRt16a-1										
DUP										
Target Range - Lower Bound										
Upper Bound										
ODXRt16a-12b	2.1	<1	0.3	2	0.02	0.6	20	0.8	4.3	14
DUP	2.1	1	0.3	2.0	0.02	0.6	19	0.1	4.2	13
Target Range - Lower Bound	1.8	<1	<0.2	1.5	<0.02	0.4	17	0.2	3.8	9
Upper Bound	2.4	2	0.4	2.5	0.04	0.8	22	0.7	4.7	18
ODXRt16a-4										
DUP										
Target Range - Lower Bound										
Upper Bound										

QC CERTIFICATE OF ANALYSIS BR08051161

	Method	ME-ICP85	ME-ICP85	ME-ICP85	ME-ICP85	ME-ICP85	ME-ICP85	ME-ICP85	ME-ICP85	ME-ICP85	ME-ICP85	ME-ICP85	ME-ICP85	ME-GRA05	B-ICP69	ME-MS42
	Analyte	Al2O3	BaO	CaO	Cr2O3	Fe2O3	K2O	MgO	MnO	Na2O	SiO2	SrO	TiO2	LOI	B	Hg
	Units	%	%	%	%	%	%	%	%	%	%	%	%	%	ppm	ppm
Sample Description	**LOR**	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	10	0.005
							DUPLICATES									
ODXRt16a-5														38.55		
DUP														38.59		
Target Range - Lower Bound														37.59		
Upper Bound														39.55		
ODXRt16a-8		0.15	0.01	29.9	<0.01	1.02	<0.01	21.2	0.11	0.12	0.69	0.01	0.02			<0.005
DUP		0.14	0.01	30.0	<0.01	0.99	<0.01	21.0	0.11	0.16	0.69	0.01	0.02			0.005
Target Range - Lower Bound		0.12	<0.01	28.4	<0.01	0.93	<0.01	20.0	0.08	0.11	0.64	<0.01	<0.01			<0.005
Upper Bound		0.17	0.02	31.5	0.02	1.08	0.02	22.2	0.14	0.17	0.74	0.02	0.04			0.010
ODXRt16a-11																
DUP																
Target Range - Lower Bound																
Upper Bound																

QC CERTIFICATE OF ANALYSIS BR08051161

Sample Description	Method	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61
	Analyte	Ag	As	Be	Bi	Cd	Ce	Co	Cu	Li	Mn	Mo	Ni	Pb	Re	Sb
	Units	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
	LOR	0.01	0.2	0.05	0.01	0.02	0.01	0.1	0.2	0.2	5	0.05	0.2	0.5	0.002	0.05
DUPLICATES																
ODXRt16a-5																
DUP																
Target Range - Lower Bound																
Upper Bound																
ODXRt16a-8																
DUP																
Target Range - Lower Bound																
Upper Bound																
ODXRt16a-11		0.05	<5	0.24	0.34	0.02	5.54	2.8	1.4	1.8	907	0.68	2.8	3	<0.002	0.09
DUP		0.04	<5.0	0.23	0.44	0.02	5.45	2.8	1.8	1.7	888	1.88	3.2	3.3	0.002	0.11
Target Range - Lower Bound		0.02	4.4	0.12	0.35	<0.02	5.20	2.5	1.1	1.3	843	1.12	2.5	2.0	<0.002	<0.05
Upper Bound		0.07	5.7	0.35	0.43	0.04	5.79	3.1	2.1	2.2	952	1.44	3.6	4.3	0.004	0.21

***** See Appendix Page for comments regarding this certificate *****

QC CERTIFICATE OF ANALYSIS BR08051161

Method	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61
Analyte	Sc	Se	Sn	Th	Tl	U	V	W	Y	Zn
Units	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Sample Description LOR	0.1	1	0.2	0.2	0.02	0.1	1	0.1	0.1	2
DUPLICATES										
ODXRt16a-5										
DUP										
Target Range - Lower Bound										
Upper Bound										
ODXRt16a-8										
DUP										
Target Range - Lower Bound										
Upper Bound										
ODXRt16a-11	1.3	1	0.3	1.3	0.03	0.7	5	2.4	2.8	10
DUP	1.3	1	0.3	1.3	0.03	0.7	6	7.4	2.8	10
Target Range - Lower Bound	1.0	<1	<0.2	0.8	<0.02	0.5	3	4.3	2.5	6
Upper Bound	1.6	2	0.4	1.8	0.04	0.9	8	5.5	3.1	15

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Total # Appendix Pages: 1
Finalized Date: 30-MAY-2008
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QC CERTIFICATE OF ANALYSIS BR08051161

Method	**CERTIFICATE COMMENTS**
ME-MS61	Interference: Ca>10% on ICP-MS As,ICP-AES results shown.
ME-MS61	REE's may not be totally soluble in this method.

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES

Environmental Division

QUALITY CONTROL REPORT

Work Order	: **EB0805273**	Page	: 1 of 5
Amendment	: **1**		
Client	: **C S I R O AUSTRALIA**	Laboratory	: Environmental Division Brisbane
Contact	: DR STUART SIMPSON	Contact	: Tim Kilmister
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Facsimile	: +61 02 94908499	Facsimile	: +61-7-3243 7218
Project	: ----	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Site	: ----		
C-O-C number	: ----	Date Samples Received	: 23-APR-2008
Sampler	: ----	Issue Date	: 21-JUL-2008
Order number	: ----		
		No. of samples received	: 15
Quote number	: ----	No. of samples analysed	: 12

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 Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

NATA
WORLD RECOGNISED
ACCREDITATION

NATA Accredited Laboratory 825

This document is issued in
accordance with NATA
accreditation requirements.

Accredited for compliance with
ISO/IEC 17025.

Signatories

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

Signatories	*Position*	*Accreditation Category*
Stephen Hislop	Senior Inorganic Chemist	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 preformed, 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 insuffient 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.

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = Chemistry Abstract Services number
LOR = Limit of reporting
RPD = Relative Percentage Difference
# = Indicates failed QC

Laboratory Duplicate (DUP) Report

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Sub-Matrix: **SOIL**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
ED008: Exchangeable Cations (QC Lot: 647440)									
EB0805273-001	ODXcore2	ED008: Exchangeable Sodium Percent	----	0.1	%	33.6	33.2	1.1	0% - 20%
		ED008: Exchangeable Calcium	----	0.1	meq/100g	1.0	1.0	0.0	0% - 50%
		ED008: Exchangeable Magnesium	----	0.1	meq/100g	1.0	1.0	0.0	0% - 50%
		ED008: Exchangeable Potassium	----	0.1	meq/100g	0.2	0.2	0.0	No Limit
		ED008: Exchangeable Sodium	----	0.1	meq/100g	1.1	1.1	0.0	0% - 50%
		ED008: Exchangeable Aluminium	----	0.1	meq/100g	<0.1	<0.1	0.0	No Limit
		ED008: Cation Exchange Capacity	----	0.1	meq/100g	3.4	3.3	0.0	0% - 20%
EB0805273-010	ODXH4.1-04	ED008: Exchangeable Sodium Percent	----	0.1	%	1.8	2.2	18.6	0% - 20%
		ED008: Exchangeable Magnesium	----	0.1	meq/100g	7.2	5.7	22.2	0% - 20%
		ED008: Exchangeable Potassium	----	0.1	meq/100g	0.1	<0.5	119	No Limit
		ED008: Exchangeable Sodium	----	0.1	meq/100g	0.6	1.1	56.6	0% - 50%
		ED008: Exchangeable Aluminium	----	0.1	meq/100g	<0.1	<0.5	133	No Limit

Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **SOIL**

				Method Blank (MB) Report	*Laboratory Control Spike (LCS) Report*			
					Spike	*Spike Recovery (%)*	*Recovery Limits (%)*	
Method: Compound	*CAS Number*	*LOR*	*Unit*	*Result*	*Concentration*	*LCS*	*Low*	*High*
ED008: Exchangeable Cations (QCLot: 647440)								
ED008: Exchangeable Calcium	----	0.1	meq/100g	<0.5	1.47 meq/100g	81.2	70.2	105
ED008: Exchangeable Magnesium	----	0.1	meq/100g	<0.5	0.77 meq/100g	# 70.1	76.4	110
ED008: Exchangeable Potassium	----	0.1	meq/100g	<0.5	0.20 meq/100g	87.6	70.0	95.3
ED008: Exchangeable Sodium	----	0.1	meq/100g	<0.5	0.51 meq/100g	74.5	70.0	104
ED008: Exchangeable Aluminium	----	0.1	meq/100g	<0.5	----	----	----	----
ED008: Exchangeable Sodium Percent	----	0.1	%	<0.5	----	----	----	----
ED008: Cation Exchange Capacity	----	0.1	meq/100g	<0.5	2.95 meq/100g	77.6	70.1	104

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

- **No Matrix Spike (MS) Results are required to be reported.**

Australian Radiation Services Pty Ltd
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Web Site: www.australian-radiation-services.com.au
ABN 66 006 528 267

Keeping people safe.

Radioactivity Analysis Report

To: CSIRO Land and Water
New Illawarra Road
Lucas Heights NSW 2234

Report No.: 08-7020.1GJ
Date: 2nd July 2008

Contact: Dr. Stuart Simpson

Sample description: Solid samples

Number of samples: Thirty-eight samples

Submission date: 22nd February 2008

Analysis required: Determination of the activity of radium-226 (Ra-226) by high resolution gamma spectroscopy.

Analytical method: The sample was encapsulated in a standard container for measurement. Analysis carried out by high resolution gamma ray spectrometry to determine the content of radium-226 (Ra-226).

Analysis performed by: Ms. Genelle Jones

Results:

Client Sample ID (ARS ID)	Radionuclide activity concentration (becquerel per gram)[a,b,c]					
	radium-226	**thorium-234**	**lead-210**	**radium-228**	**thorium-228**	**potassium-40**
ODXH 1.01 (08-7020-01)	5.2 ± 0.2	1.1 ± 0.1	3.6 ± 0.2	0.17 ± 0.05	0.14 ± 0.01	0.63 ± 0.07
ODXH 1.03 (08-7020-02)	5.5 ± 0.3	1.1 ± 0.4	3.4 ± 0.5	< 0.1	0.18 ± 0.05	< 0.5
ODXH 1.05 (08-7020-03)	4.9 ± 0.2	1.2 ± 1.8	3.6 ± 0.2	0.16 ± 0.03	0.14 ± 0.01	0.6 ± 0.1
ODXH 1.07 (08-7020-04)	8.2 ± 0.4	2.8 ± 0.5	6.0 ± 0.9	< 0.1	< 0.1	< 0.5
ODXH 1.09 Tailings Mat (08-7020-05)	0.08 ± 0.01	0.37 ± 0.03	0.08 ± 0.02	0.03 ± 0.01	0.04 ± 0.01	0.11 ± 0.02
ODXH 1.09 Underlying Sed (08-7020-06)	0.09 ± 0.01	6.9 ± 0.3	0.2 ± 0.1	< 0.03	< 0.03	< 0.1
ODXH 1.12 (08-7020-07)	0.01 ± 0.01	0.01 ± 0.01	0.01 ± 0.01	< 0.004	0.01 ± 0.01	< 0.01
ODXH 1.2 - 02 (08-7020-08)	2.04 ± 0.09	1.2 ± 0.2	2.8 ± 0.2	0.1 ± 0.03	0.1 ± 0.02	0.4 ± 0.1
ODXH 1.2 - 05 (08-7020-09)	5.7 ± 0.3	2.4 ± 0.2	4.6 ± 0.3	0.25 ± 0.05	0.18 ± 0.02	0.6 ± 0.2
ODXH 1.2 - 07 (08-7020-10)	13.4 ± 0.6	1.6 ± 0.1	7.9 ± 0.3	0.14 ± 0.04	0.10 ± 0.02	< 0.1

Client Sample ID (ARS ID)	Radionuclide activity concentration (becquerel per gram)[a,b,c]					
	radium-226	thorium-234	lead-210	radium-228	thorium-228	potassium-40
ODXH 1.2-0.9 Tailings Material (08-7020-11)	0.27 ± 0.01	1.36 ± 0.07	0.38 ± 0.04	0.11 ± 0.01	0.14 ± 0.01	0.21 ± 0.02
ODXH 1.2 – 09 Underlying Sed (08-7020-12)	0.16 ± 0.01	2.10 ± 0.09	0.14 ± 0.03	0.05 ± 0.01	0.07 ± 0.01	0.12 ± 0.02
ODXH 2.1 - 7 (08-7020-13)	0.01 ± 0.01	0.44 ± 0.05	0.01 ± 0.02	0.01 ± 0.01	0.01 ± 0.01	< 0.03
ODXH 3.1 - 02 (08-7020-14)	< 0.02	1.7 ± 0.2	0.05 ± 0.08	< 0.02	< 0.02	< 0.09
ODXH 3.1 - 04 (08-7020-15)	0.03 ± 0.01	0.70 ± 0.06	0.03 ± 0.04	< 0.01	0.02 ± 0.01	< 0.06
ODXH 3.1 - 09 (08-7020-16)	0.02 ± 0.01	0.04 ± 0.02	< 0.04	< 0.01	< 0.01	< 0.06
ODXH 3.2 - 01 (08-7020-17)	6.4 ± 0.3	3.0 ± 0.4	5.0 ± 0.6	0.30 ± 0.07	0.30 ± 0.03	1.0 ± 0.3
ODXH 3.2 - 03 (08-7020-18)	2.9 ± 0.1	1.3 ± 0.3	2.4 ± 0.2	0.20 ± 0.04	0.18 ± 0.03	< 0.2
ODXH 3.2 - 05 (08-7020-19)	7.9 ± 0.4	1.3 ± 0.3	5.6 ± 0.4	0.26 ± 0.05	0.35 ± 0.09	0.7 ± 0.2
ODXH 3.2 - 07 (08-7020-20)	10.4 ± 0.5	2.0 ± 0.3	6.5 ± 0.4	< 0.1	0.21 ± 0.03	< 0.3
ODXH 3.2 - 09 (08-7020-21)	7.4 ± 0.3	1.8 ± 0.2	5.6 ± 0.3	0.20 ± 0.06	0.10 ± 0.01	< 0.2
ODXH 3.2 - 10 (08-7020-22)	0.10 ± 0.01	1.06 ± 0.05	0.10 ± 0.03	< 0.007	0.03 ± 0.01	< 0.03
ODXH 3.2 - 12 (08-7020-23)	0.01 ± 0.01	0.03 ± 0.02	0.02 ± 0.02	< 0.007	0.01 ± 0.01	< 0.03
ODXH 3.2 - 13 (08-7020-24)	0.02 ± 0.01	0.04 ± 0.02	0.01 ± 0.01	0.02 ± 0.01	0.01 ± 0.01	< 0.04
ODXH 4.1 - 02 (08-7020-25)	7.5 ± 0.3	1.2 ± 0.3	5.4 ± 0.6	< 0.1	0.20 ± 0.04	0.9 ± 0.3
ODXH 4.1 - 04 (08-7020-26)	5.1 ± 0.2	0.9 ± 0.2	3.6 ± 0.3	< 0.8	0.10 ± 0.02	0.6 ± 0.1
ODXH 4.1 - 06 (08-7020-27)	6.90 ± 0.03	1.4 ± 0.3	4.4 ± 0.4	0.20 ± 0.06	0.20 ± 0.04	0.7 ± 0.3
ODXH 4.1 - 07 (08-7020-28)	0.07 ± 0.01	1.7 ± 0.2	0.10 ± 0.09	< 0.04	< 0.04	< 0.2
ODXH 4.1 - 10 (08-7020-29)	0.04 ± 0.01	0.04 ± 0.02	0.04 ± 0.01	0.02 ± 0.01	0.02 ± 0.01	0.16 ± 0.02
ODXH 4.2 - 02 (08-7020-30)	5.7 ± 0.3	1.3 ± 0.3	4.2 ± 0.3	0.20 ± 0.07	0.20± 0.03	< 0.3
ODXH 4.2 - 04 (08-7020-31)	6.0 ± 0.3	1.5 ± 0.3	4.1 ± 0.3	0.20 ± 0.06	0.20 ± 0.03	< 0.3
ODXH 4.2 - 05 (08-7020-32)	0.40 ± 0.02	6.1 ± 0.3	0.4 ± 0.1	< 0.03	0.08 ± 0.03	< 0.1
ODXH 4.2 - 09 (08-7020-33)	0.01 ± 0.01	0.01 ± 0.01	< 0.01	0.01 ± 0.01	< 0.004	< 0.01
RED 2A Arcoona QTZ 81.6 – 82 m (08-7020-34)	0.05 ± 0.01	0.02 ± 0.03	< 0.05	< 0.02	0.03 ± 0.01	0.47 ± 0.07
Red Arcoona 117.6 – 118 m (08-7020-35)	0.02 ± 0.09	0.03 ± 0.03	0.04 ± 0.03	< 0.02	0.03 ± 0.01	0.46 ± 0.06

Client Sample ID (ARS ID)	Radionuclide activity concentration (becquerel per gram)[a,b,c]					
	radium-226	thorium-234	lead-210	radium-228	thorium-228	potassium-40
Andamooka 43.6–44 m RD2661 (08-7020-36)	0.05 ± 0.01	0.08 ± 0.04	0.06 ± 0.04	0.06 ± 0.01	0.04 ± 0.01	0.44 ± 0.08
Andamooka 55.6-56 m (08-7020-37)	0.02 ± 0.01	0.02 ± 0.03	0.03 ± 0.02	< 0.01	0.01 ± 0.01	< 0.05
White Arcoona 189.6 – Indefinite m (08-7020-38)	< 0.005	0.02 ± 0.01	< 0.02	0.01 ± 0.01	< 0.02	< 0.03

NB:
- a. Activities are in becquerel (Bq) per gram. One becquerel equals one nuclear transformation per second.
- b. Less than (<) values indicate the limit of detection for each isotope for the measurement system.
- c. The reported uncertainty in each result is the expanded uncertainty calculated using a coverage factor of 2.

AUSTRALIAN RADIATION SERVICES PTY. LTD.

Report prepared by: Ms. Genelle Jones
Radiochemist
Signed:

Reviewed by: per Dr. Malcolm Cooper
Consultant Environmental Scientist
Signed:

Date: 2nd July 2008

Olympic Dam Project   Fe(II) Summary

Duplicates

Sample	***Fe(II)***	***Fe(II) and Fe(III)***
	(mg/L)	***(mg/L)***
ODXH 2.1 - 7	202	1069
ODXH 2.1 - 7 Dup	203	1075
ODXH 1.03	5954	21374
ODXH 1.03 Dup	5996	21904

Fe(II) Spike Recovery Results

Sample	***Fe(II) spiked***
AVS Determination	***% recovery***
ODXH 3.2 - 05 + Fe(II) Spike	**100**
ODXH 3.2 - 05 + Fe(II) Spike Dup	**100**
ODXH 3.2 - 09 + Fe(II) Spike	**103**

Fe(II) and Fe(III) Spike Recovery Results

Sample	***Fe(II) spiked***
AVS Determination	***% recovery***
ODXH 2.1 - 7 + Fe(III) Spike	**110**
ODXH 2.1 - 7 + Fe(III) Spike Dup	**110**
ODXH 1.07 + Fe(III) Spike	**109**
ODXH 3.2 - 05 + Fe(II) Spike	**99**
ODXH 3.2 - 05 + Fe(II) Spike Dup	**98**
ODXH 3.2 - 09 + Fe(II) Spike	**99**

QUALITY CONTROL REPORT

Work Order	: **EB0802236**	Page	: 1 of 12
Client	: **C S I R O AUSTRALIA**	Laboratory	: Environmental Division Brisbane
Contact	: DR STUART SIMPSON	Contact	: Tim Kilmister
Address	: 11 JULIUS AVENUE RIVERSIDE CORPORATE PARK, NORTH RYDE NSW, AUSTRALIA 2113	Address	: 32 Shand Street Stafford QLD Australia 4053
E-mail	: stuart.simpson@csiro.au	E-mail	: Services.Brisbane@alsenviro.com
Telephone	: +61 02 94908534	Telephone	: +61-7-3243 7222
Facsimile	: +61 02 94908499	Facsimile	: +61-7-3243 7218
Project	: ----	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Site	: ----		
C-O-C number	: ----	Date Samples Received	: 20-FEB-2008
Sampler	: ----	Issue Date	: 06-MAR-2008
Order number	: ----		
		No. of samples received	: 14
Quote number	: ----	No. of samples analysed	: 14

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WORLD RECOGNISED
ACCREDITATION

NATA Accredited Laboratory 825

This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

Signatories

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

Signatories	*Position*	*Accreditation Category*
Herman Lin	Senior Inorganic Chemist	Inorganics
Hoa Nguyen		Inorganics
Kim McCabe	Senior Inorganic Chemist	Inorganics
Stephen Hislop	Senior Inorganic Chemist	Inorganics

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Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
ED037P: Alkalinity by PC Titrator (QC Lot: 604258)									
EB0802201-001	Anonymous	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	167	172	2.8	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	167	172	2.8	0% - 20%
ED038A: Acidity (QC Lot: 604192)									
EB0802207-001	Anonymous	ED038: Acidity as CaCO3	----	1	mg/L	12	8	40.0	No Limit
EB0802207-002	Anonymous	ED038: Acidity as CaCO3	----	1	mg/L	4	8	66.7	No Limit
ED040F: Dissolved Major Anions (QC Lot: 600259)									
EB0802236-004	ODXH3.2-01(1:1)	ED040F: Sulphate as SO4 2-	14808-79-8	1	mg/L	6590	5680	14.8	0% - 20%
		ED040F: Silicon	7440-21-3	0.05	mg/L	5.81	5.10	13.0	0% - 20%
EB0802236-012	ODXH4.2-04(PW)	ED040F: Sulphate as SO4 2-	14808-79-8	1	mg/L	47800	46300	3.1	0% - 20%
		ED040F: Silicon	7440-21-3	0.05	mg/L	61.5	59.6	3.2	0% - 20%
ED040F: Dissolved Major Anions (QC Lot: 603564)									
EB0802236-013	ODXH2.1-7(1:1)	ED040F: Sulphate as SO4 2-	14808-79-8	1	mg/L	3420	3430	0.2	0% - 20%
		ED040F: Silicon	7440-21-3	0.05	mg/L	7.10	7.21	1.6	0% - 20%
ED045P: Chloride by PC Titrator (QC Lot: 604261)									
EB0802201-001	Anonymous	ED045-P: Chloride	16887-00-6	1	mg/L	14800	14800	0.3	0% - 20%
EB0802236-007	ODXH3.2-09(1:1)	ED045-P: Chloride	16887-00-6	1	mg/L	463	453	2.2	0% - 20%
ED093F: Dissolved Major Cations (QC Lot: 600260)									
EB0802236-004	ODXH3.2-01(1:1)	ED093F: Calcium	7440-70-2	1	mg/L	700	625	11.2	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	758	664	13.2	0% - 20%
		ED093F: Sodium	7440-23-5	1	mg/L	4730	4230	11.1	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	89	82	8.0	0% - 20%
EB0802236-012	ODXH4.2-04(PW)	ED093F: Calcium	7440-70-2	1	mg/L	658	652	0.9	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	1620	1570	2.9	0% - 20%
		ED093F: Sodium	7440-23-5	1	mg/L	4360	4320	0.8	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	542	536	1.2	0% - 20%
ED093F: Dissolved Major Cations (QC Lot: 603565)									
EB0802236-013	ODXH2.1-7(1:1)	ED093F: Calcium	7440-70-2	1	mg/L	397	392	1.4	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	111	112	0.0	0% - 20%

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
ED093F: Dissolved Major Cations (QC Lot: 603565) - continued									
EB0802236-013	ODXH2.1-7(1:1)	ED093F: Sodium	7440-23-5	1	mg/L	515	513	0.3	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	58	56	2.9	0% - 20%
EG005F: Dissolved Metals by ICP-AES (QC Lot: 600258)									
EB0802236-004	ODXH3.2-01(1:1)	EG005F: Boron	7440-42-8	0.1	mg/L	3.3	3.7	9.8	0% - 20%
		EG005F: Iron	7439-89-6	0.05	mg/L	6.94	8.38	18.8	0% - 20%
EB0802236-012	ODXH4.2-04(PW)	EG005F: Boron	7440-42-8	0.1	mg/L	<0.1	<0.1	0.0	No Limit
		EG005F: Iron	7439-89-6	0.05	mg/L	8070	8390	3.8	0% - 20%
EG020F: Dissolved Metals by ICP-MS (QC Lot: 600261)									
EB0802236-004	ODXH3.2-01(1:1)	EG020A-F: Aluminium	7429-90-5	0.01	mg/L	2.22	2.46	10.2	0% - 20%
		EG020A-F: Antimony	7440-36-0	0.001	mg/L	<0.005	<0.005	0.0	No Limit
		EG020A-F: Arsenic	7440-38-2	0.001	mg/L	0.011	0.010	14.3	0% - 50%
		EG020A-F: Beryllium	7440-41-7	0.001	mg/L	<0.005	<0.005	0.0	No Limit
		EG020A-F: Barium	7440-39-3	0.001	mg/L	0.024	0.025	0.0	0% - 20%
		EG020A-F: Cadmium	7440-43-9	0.0001	mg/L	<0.0005	0.0006	18.2	No Limit
		EG020A-F: Chromium	7440-47-3	0.001	mg/L	0.045	<0.005	160	No Limit
		EG020A-F: Cobalt	7440-48-4	0.001	mg/L	0.199	0.198	0.0	0% - 20%
		EG020A-F: Copper	7440-50-8	0.001	mg/L	0.400	0.412	3.2	0% - 20%
		EG020A-F: Lead	7439-92-1	0.001	mg/L	0.006	0.008	23.3	No Limit
		EG020A-F: Lithium	7439-93-2	0.001	mg/L	0.409	0.411	0.5	0% - 20%
		EG020A-F: Manganese	7439-96-5	0.001	mg/L	2.47	2.42	1.9	0% - 20%
		EG020A-F: Molybdenum	7439-98-7	0.001	mg/L	0.424	0.443	4.5	0% - 20%
		EG020A-F: Nickel	7440-02-0	0.001	mg/L	0.034	0.011	101	0% - 50%
		EG020A-F: Selenium	7782-49-2	0.010	mg/L	0.084	0.095	12.6	No Limit
		EG020A-F: Thallium	7440-28-0	0.001	mg/L	<0.005	<0.005	0.0	No Limit
		EG020A-F: Tin	7440-31-5	0.001	mg/L	<0.005	<0.005	0.0	No Limit
		EG020A-F: Vanadium	7440-62-2	0.01	mg/L	<0.05	<0.05	0.0	No Limit
		EG020A-F: Zinc	7440-66-6	0.005	mg/L	<0.025	<0.025	0.0	No Limit
		EG020A-F: Bromine	7726-95-6	0.1	mg/L	6.9	7.2	4.7	0% - 20%
EB0802236-012	ODXH4.2-04(PW)	EG020A-F: Aluminium	7429-90-5	0.01	mg/L	8280	8590	3.7	0% - 20%
		EG020A-F: Antimony	7440-36-0	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-F: Arsenic	7440-38-2	0.001	mg/L	0.090	0.142	45.5	0% - 20%
		EG020A-F: Beryllium	7440-41-7	0.001	mg/L	0.509	0.508	0.0	0% - 20%
		EG020A-F: Barium	7440-39-3	0.001	mg/L	0.046	0.046	0.0	0% - 20%
		EG020A-F: Cadmium	7440-43-9	0.0001	mg/L	0.0236	0.0260	9.9	0% - 20%

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EG020F: Dissolved Metals by ICP-MS (QC Lot: 600261) - continued									
EB0802236-012	ODXH4.2-04(PW)	EG020A-F: Chromium	7440-47-3	0.001	mg/L	1.94	1.97	1.4	0% - 20%
		EG020A-F: Cobalt	7440-48-4	0.001	mg/L	50.5	50.0	0.9	0% - 20%
		EG020A-F: Copper	7440-50-8	0.001	mg/L	192	202	5.0	0% - 20%
		EG020A-F: Lead	7439-92-1	0.001	mg/L	0.276	0.268	3.1	0% - 20%
		EG020A-F: Lithium	7439-93-2	0.001	mg/L	11.0	11.3	2.4	0% - 20%
		EG020A-F: Manganese	7439-96-5	0.001	mg/L	65.7	65.7	0.0	0% - 20%
		EG020A-F: Molybdenum	7439-98-7	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-F: Nickel	7440-02-0	0.001	mg/L	6.37	6.27	1.6	0% - 20%
		EG020A-F: Selenium	7782-49-2	0.010	mg/L	0.794	0.887	11.0	0% - 20%
		EG020A-F: Thallium	7440-28-0	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-F: Tin	7440-31-5	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-F: Vanadium	7440-62-2	0.01	mg/L	0.94	0.94	0.0	0% - 20%
		EG020A-F: Zinc	7440-66-6	0.005	mg/L	26.6	27.3	2.4	0% - 20%
		EG020A-F: Bromine	7726-95-6	0.1	mg/L	3.5	3.4	4.4	0% - 20%
EG020F: Dissolved Metals by ICP-MS (QC Lot: 600262)									
EB0802236-004	ODXH3.2-01(1:1)	EG020B-F: Bismuth	7440-69-9	0.001	mg/L	<0.005	<0.005	0.0	No Limit
		EG020B-F: Cerium	7440-45-1	0.001	mg/L	0.070	0.059	17.4	0% - 20%
		EG020B-F: Silver	7440-22-4	0.001	mg/L	<0.005	<0.005	0.0	No Limit
		EG020B-F: Strontium	7440-24-6	0.001	mg/L	4.06	4.21	3.6	0% - 20%
		EG020B-F: Thorium	7440-29-1	0.001	mg/L	<0.005	<0.005	0.0	No Limit
		EG020B-F: Titanium	7440-32-6	0.01	mg/L	<0.05	<0.05	0.0	No Limit
		EG020B-F: Uranium	7440-61-1	0.001	mg/L	7.89	7.89	0.06	0% - 20%
EB0802236-012	ODXH4.2-04(PW)	EG020B-F: Bismuth	7440-69-9	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020B-F: Cerium	7440-45-1	0.001	mg/L	191	189	1.0	0% - 20%
		EG020B-F: Silver	7440-22-4	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020B-F: Strontium	7440-24-6	0.001	mg/L	5.41	5.29	2.2	0% - 20%
		EG020B-F: Thorium	7440-29-1	0.001	mg/L	6.62	6.41	3.2	0% - 20%
		EG020B-F: Titanium	7440-32-6	0.01	mg/L	0.14	0.13	0.0	0% - 50%
		EG020B-F: Uranium	7440-61-1	0.001	mg/L	596	609	2.1	0% - 20%
EG020F: Dissolved Metals by ICP-MS (QC Lot: 600263)									
EB0802236-004	ODXH3.2-01(1:1)	EG020D-F: Yttrium	7440-65-5	0.001	mg/L	0.026	0.020	22.0	0% - 20%
EB0802236-012	ODXH4.2-04(PW)	EG020D-F: Yttrium	7440-65-5	0.001	mg/L	78.8	77.6	1.6	0% - 20%
EG020F: Dissolved Metals by ICP-MS (QC Lot: 600264)									
EB0802236-004	ODXH3.2-01(1:1)	EG020E-F: Tungsten	7440-33-7	0.001	mg/L	<0.005	<0.005	0.0	No Limit
EB0802236-012	ODXH4.2-04(PW)	EG020E-F: Tungsten	7440-33-7	0.001	mg/L	0.049	0.049	0.0	0% - 20%

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EG020F: Dissolved Metals by ICP-MS (QC Lot: 600264) - continued									
EG035F: Dissolved Mercury by FIMS (QC Lot: 604503)									
EB0802207-001	Anonymous	EG035F: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EB0802236-007	ODXH3.2-09(1:1)	EG035F: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EK040P: Fluoride by PC Titrator (QC Lot: 604262)									
EB0802201-001	Anonymous	EK040P: Fluoride	16984-48-8	0.1	mg/L	0.8	0.8	0.0	No Limit
EB0802236-007	ODXH3.2-09(1:1)	EK040P: Fluoride	16984-48-8	0.1	mg/L	66.1	54.4	19.4	0% - 20%
EK055: Ammonia as N (QC Lot: 600163)									
EB0802236-006	ODXH3.2-05(1:1)	EK055A: Ammonia as N	7664-41-7	0.010	mg/L	280	288	2.6	0% - 20%
EK055: Ammonia as N (QC Lot: 602322)									
EB0802092-001	Anonymous	EK055A: Ammonia as N	7664-41-7	0.010	mg/L	0.092	0.096	4.2	No Limit
EB0802218-001	Anonymous	EK055A: Ammonia as N	7664-41-7	0.010	mg/L	0.143	0.146	2.3	0% - 50%
EK055: Ammonia as N (QC Lot: 602327)									
EB0802236-013	ODXH2.1-7(1:1)	EK055A: Ammonia as N	7664-41-7	0.010	mg/L	29.9	30.2	1.0	0% - 20%
EB0802357-001	Anonymous	EK055A: Ammonia as N	7664-41-7	0.010	mg/L	0.810	0.810	0.0	0% - 20%
EK057: Nitrite as N (QC Lot: 600161)									
EB0802236-006	ODXH3.2-05(1:1)	EK057: Nitrite as N	----	0.010	mg/L	<0.010	<0.010	0.0	No Limit
EK057: Nitrite as N (QC Lot: 602323)									
EB0802092-001	Anonymous	EK057: Nitrite as N	----	0.010	mg/L	0.018	0.018	0.0	No Limit
EB0802218-001	Anonymous	EK057: Nitrite as N	----	0.010	mg/L	0.033	0.032	0.0	No Limit
EK057: Nitrite as N (QC Lot: 602328)									
EB0802236-013	ODXH2.1-7(1:1)	EK057: Nitrite as N	----	0.010	mg/L	<0.100	<0.100	0.0	No Limit
EB0802357-001	Anonymous	EK057: Nitrite as N	----	0.010	mg/L	0.091	0.092	0.0	No Limit
EK059: Nitrite plus Nitrate as N (NOx) (QC Lot: 600162)									
EB0802236-006	ODXH3.2-05(1:1)	EK059: Nitrite + Nitrate as N	----	0.010	mg/L	0.025	0.017	38.8	No Limit
EK059: Nitrite plus Nitrate as N (NOx) (QC Lot: 602324)									
EB0802092-001	Anonymous	EK059: Nitrite + Nitrate as N	----	0.010	mg/L	2.74	2.70	1.7	0% - 20%
EB0802218-001	Anonymous	EK059: Nitrite + Nitrate as N	----	0.010	mg/L	0.225	0.226	0.7	0% - 20%
EK059: Nitrite plus Nitrate as N (NOx) (QC Lot: 602330)									
EB0802236-013	ODXH2.1-7(1:1)	EK059: Nitrite + Nitrate as N	----	0.010	mg/L	<0.100	<0.100	0.0	No Limit
EB0802357-001	Anonymous	EK059: Nitrite + Nitrate as N	----	0.010	mg/L	0.071	0.073	2.4	No Limit
EK071: Reactive Phosphorus as P (Dissolved) (QC Lot: 600164)									
EB0802236-006	ODXH3.2-05(1:1)	EK071F: Reactive Phosphorus - Filtered	----	0.010	mg/L	0.062	0.062	0.0	No Limit
EK071: Reactive Phosphorus as P (Dissolved) (QC Lot: 602325)									
EB0802092-001	Anonymous	EK071F: Reactive Phosphorus - Filtered	----	0.010	mg/L	8.18	8.10	1.0	0% - 20%
EB0802218-001	Anonymous	EK071F: Reactive Phosphorus - Filtered	----	0.010	mg/L	0.250	0.251	0.5	0% - 20%

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EK071: Reactive Phosphorus as P (Dissolved) (QC Lot: 602325) - continued									
EK071: Reactive Phosphorus as P (Dissolved) (QC Lot: 602331)									
EB0802236-013	ODXH2.1-7(1:1)	EK071F: Reactive Phosphorus - Filtered	----	0.010	mg/L	<0.010	0.028	95.1	No Limit
EB0802357-001	Anonymous	EK071F: Reactive Phosphorus - Filtered	----	0.010	mg/L	0.017	0.018	6.5	No Limit
EP005: Total Organic Carbon (TOC) (QC Lot: 605265)									
EB0802185-001	Anonymous	EP005: Total Organic Carbon	----	1	mg/L	18	21	13.2	0% - 20%
EB0802207-002	Anonymous	EP005: Total Organic Carbon	----	1	mg/L	25	23	11.1	0% - 20%
EP005: Total Organic Carbon (TOC) (QC Lot: 605266)									
EB0802236-012	ODXH4.2-04(PW)	EP005: Total Organic Carbon	----	1	mg/L	25	22	11.1	0% - 20%
EB0802324-002	Anonymous	EP005: Total Organic Carbon	----	1	mg/L	7	7	0.0	No Limit
EP006 Total Inorganic Carbon (QC Lot: 602139)									
EB0802236-001	ODXH1.03(PW)	EP006: Total Inorganic Carbon	----	1	mg/L	1	1	0.0	No Limit
EB0802236-012	ODXH4.2-04(PW)	EP006: Total Inorganic Carbon	----	1	mg/L	<1	<1	0.0	No Limit

Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **WATER**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	*CAS Number*	*LOR*	*Unit*	*Result*	*Concentration*	*LCS*	*Low*	*High*
ED037P: Alkalinity by PC Titrator (QCLot: 604258)								
ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	----	200 mg/L	90.1	77.5	112
ED038A: Acidity (QCLot: 604192)								
ED038: Acidity as CaCO3	----	1	mg/L	----	100 mg/L	102	90.5	110
ED040F: Dissolved Major Anions (QCLot: 600259)								
ED040F: Sulphate as SO4 2-	14808-79-8	1	mg/L	<1	----	----	----	----
ED040F: Silicon	7440-21-3	0.05	mg/L	<0.05	----	----	----	----
ED040F: Dissolved Major Anions (QCLot: 603564)								
ED040F: Sulphate as SO4 2-	14808-79-8	1	mg/L	<1	----	----	----	----
ED040F: Silicon	7440-21-3	0.05	mg/L	<0.05	----	----	----	----
ED045P: Chloride by PC Titrator (QCLot: 604261)								
ED045-P: Chloride	16887-00-6	1	mg/L	<1	1000 mg/L	100	88.4	110
ED093F: Dissolved Major Cations (QCLot: 600260)								
ED093F: Calcium	7440-70-2	1	mg/L	<1	----	----	----	----
ED093F: Magnesium	7439-95-4	1	mg/L	<1	----	----	----	----
ED093F: Sodium	7440-23-5	1	mg/L	<1	----	----	----	----
ED093F: Potassium	7440-09-7	1	mg/L	<1	----	----	----	----
ED093F: Dissolved Major Cations (QCLot: 603565)								
ED093F: Calcium	7440-70-2	1	mg/L	<1	----	----	----	----
ED093F: Magnesium	7439-95-4	1	mg/L	<1	----	----	----	----
ED093F: Sodium	7440-23-5	1	mg/L	<1	----	----	----	----
ED093F: Potassium	7440-09-7	1	mg/L	<1	----	----	----	----
EG005F: Dissolved Metals by ICP-AES (QCLot: 600258)								
EG005F: Boron	7440-42-8	0.1	mg/L	<0.1	----	----	----	----
EG005F: Iron	7439-89-6	0.05	mg/L	<0.05	----	----	----	----
EG020F: Dissolved Metals by ICP-MS (QCLot: 600261)								
EG020A-F: Aluminium	7429-90-5	0.01	mg/L	<0.01	0.500 mg/L	110	70	130
EG020A-F: Antimony	7440-36-0	0.001	mg/L	<0.001	0.1000 mg/L	103	70.4	118
EG020A-F: Arsenic	7440-38-2	0.001	mg/L	<0.001	0.1000 mg/L	95.9	72.6	114
EG020A-F: Beryllium	7440-41-7	0.001	mg/L	<0.001	0.100 mg/L	108	73	130
EG020A-F: Barium	7440-39-3	0.001	mg/L	<0.001	----	----	----	----
EG020A-F: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.1000 mg/L	107	82.1	111
EG020A-F: Chromium	7440-47-3	0.001	mg/L	<0.001	0.1000 mg/L	115	81.8	127
EG020A-F: Cobalt	7440-48-4	0.001	mg/L	<0.001	0.1000 mg/L	110	84.6	115
EG020A-F: Copper	7440-50-8	0.001	mg/L	<0.001	0.200 mg/L	103	85.2	120
EG020A-F: Lead	7439-92-1	0.001	mg/L	<0.001	0.1000 mg/L	105	86.7	113
EG020A-F: Lithium	7439-93-2	0.001	mg/L	<0.001	----	----	----	----

Sub-Matrix: **WATER**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	*CAS Number*	*LOR*	*Unit*	*Result*	*Concentration*	*LCS*	*Low*	*High*
EG020F: Dissolved Metals by ICP-MS (QCLot: 600261) - continued								
EG020A-F: Manganese	7439-96-5	0.001	mg/L	<0.001	0.1000 mg/L	106	77.3	126
EG020A-F: Molybdenum	7439-98-7	0.001	mg/L	<0.001	0.1000 mg/L	100	85.4	109
EG020A-F: Nickel	7440-02-0	0.001	mg/L	<0.001	0.1000 mg/L	108	84.4	121
EG020A-F: Selenium	7782-49-2	0.01	mg/L	----	0.1000 mg/L	103	79.3	126
		0.010	mg/L	<0.010	----	----	----	----
EG020A-F: Thallium	7440-28-0	0.001	mg/L	<0.001	0.1000 mg/L	109	70.9	113
EG020A-F: Tin	7440-31-5	0.001	mg/L	<0.001	0.1000 mg/L	112	71.3	129
EG020A-F: Vanadium	7440-62-2	0.01	mg/L	<0.01	0.1000 mg/L	105	70.2	117
EG020A-F: Zinc	7440-66-6	0.005	mg/L	<0.005	0.200 mg/L	104	78.8	130
EG020A-F: Bromine	7726-95-6	0.1	mg/L	<0.1	----	----	----	----
EG020F: Dissolved Metals by ICP-MS (QCLot: 600262)								
EG020B-F: Bismuth	7440-69-9	0.001	mg/L	<0.001	0.100 mg/L	109	76.6	121
EG020B-F: Cerium	7440-45-1	0.001	mg/L	<0.001	----	----	----	----
EG020B-F: Silver	7440-22-4	0.001	mg/L	<0.001	0.100 mg/L	92.2	70	130
EG020B-F: Strontium	7440-24-6	0.001	mg/L	<0.001	0.500 mg/L	99.9	80.3	121
EG020B-F: Thorium	7440-29-1	0.001	mg/L	<0.001	----	----	----	----
EG020B-F: Titanium	7440-32-6	0.01	mg/L	<0.01	0.100 mg/L	103	79.5	121
EG020B-F: Uranium	7440-61-1	0.001	mg/L	<0.001	----	----	----	----
EG020F: Dissolved Metals by ICP-MS (QCLot: 600263)								
EG020D-F: Yttrium	7440-65-5	0.001	mg/L	<0.001	----	----	----	----
EG020F: Dissolved Metals by ICP-MS (QCLot: 600264)								
EG020E-F: Tungsten	7440-33-7	0.001	mg/L	<0.001	----	----	----	----
EG035F: Dissolved Mercury by FIMS (QCLot: 604503)								
EG035F: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.010 mg/L	107	77.2	129
EK040P: Fluoride by PC Titrator (QCLot: 604262)								
EK040P: Fluoride	16984-48-8	0.1	mg/L	<0.1	10 mg/L	94.2	72.9	113
EK055: Ammonia as N (QCLot: 600163)								
EK055A: Ammonia as N	7664-41-7	0.01	mg/L	----	1 mg/L	100	87.2	123
		0.010	mg/L	<0.010	----	----	----	----
EK055: Ammonia as N (QCLot: 602322)								
EK055A: Ammonia as N	7664-41-7	0.01	mg/L	----	1 mg/L	104	87.2	123
		0.010	mg/L	<0.010	----	----	----	----
EK055: Ammonia as N (QCLot: 602327)								
EK055A: Ammonia as N	7664-41-7	0.01	mg/L	----	1 mg/L	102	87.2	123
		0.010	mg/L	<0.010	----	----	----	----
EK057: Nitrite as N (QCLot: 600161)								
EK057: Nitrite as N	----	0.01	mg/L	----	0.5 mg/L	105	95.4	119
		0.010	mg/L	<0.010	----	----	----	----
EK057: Nitrite as N (QCLot: 602323)								

Sub-Matrix: **WATER**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	*CAS Number*	*LOR*	*Unit*	*Result*	*Concentration*	*LCS*	*Low*	*High*
EK057: Nitrite as N (QCLot: 602323) - continued								
EK057: Nitrite as N	----	0.01	mg/L	----	0.5 mg/L	105	95.4	119
		0.010	mg/L	<0.010	----	----	----	----
EK057: Nitrite as N (QCLot: 602328)								
EK057: Nitrite as N	----	0.01	mg/L	----	0.5 mg/L	105	95.4	119
		0.010	mg/L	<0.010	----	----	----	----
EK059: Nitrite plus Nitrate as N (NOx) (QCLot: 600162)								
EK059: Nitrite + Nitrate as N	----	0.01	mg/L	----	0.5 mg/L	110	85.5	118
		0.010	mg/L	<0.010	----	----	----	----
EK059: Nitrite plus Nitrate as N (NOx) (QCLot: 602324)								
EK059: Nitrite + Nitrate as N	----	0.01	mg/L	----	0.5 mg/L	102	85.5	118
		0.010	mg/L	<0.010	----	----	----	----
EK059: Nitrite plus Nitrate as N (NOx) (QCLot: 602330)								
EK059: Nitrite + Nitrate as N	----	0.01	mg/L	----	0.5 mg/L	104	85.5	118
		0.010	mg/L	<0.010	----	----	----	----
EK071: Reactive Phosphorus as P (Dissolved) (QCLot: 600164)								
EK071F: Reactive Phosphorus - Filtered	----	0.01	mg/L	----	1 mg/L	108	88.5	116
		0.010	mg/L	<0.010	----	----	----	----
EK071: Reactive Phosphorus as P (Dissolved) (QCLot: 602325)								
EK071F: Reactive Phosphorus - Filtered	----	0.01	mg/L	----	1 mg/L	101	88.5	116
		0.010	mg/L	<0.010	----	----	----	----
EK071: Reactive Phosphorus as P (Dissolved) (QCLot: 602331)								
EK071F: Reactive Phosphorus - Filtered	----	0.01	mg/L	----	1 mg/L	100	88.5	116
		0.010	mg/L	<0.010	----	----	----	----
EP005: Total Organic Carbon (TOC) (QCLot: 605265)								
EP005: Total Organic Carbon	----	1	mg/L	<1	100 mg/L	94.8	88.6	111
EP005: Total Organic Carbon (TOC) (QCLot: 605266)								
EP005: Total Organic Carbon	----	1	mg/L	<1	100 mg/L	95.1	88.6	111
EP006 Total Inorganic Carbon (QCLot: 602139)								
EP006: Total Inorganic Carbon	----	1	mg/L	<1	50 mg/L	94.5	70	130

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **WATER**

				Matrix Spike (MS) Report			
				Spike	Spike Recovery (%)	Recovery Limits (%)	
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*Concentration*	*MS*	*Low*	*High*
ED045P: Chloride by PC Titrator (QCLot: 604261)							
EB0802207-001	Anonymous	ED045-P: Chloride	16887-00-6	80 mg/L	96.2	70	130
EG020F: Dissolved Metals by ICP-MS (QCLot: 600261)							
EB0802236-007	ODXH3.2-09(1:1)	EG020A-F: Arsenic	7440-38-2	0.5 mg/L	94.2	70	130
		EG020A-F: Beryllium	7440-41-7	0.5 mg/L	102	70	130
		EG020A-F: Barium	7440-39-3	0.5 mg/L	127	70	130
		EG020A-F: Cadmium	7440-43-9	0.5 mg/L	105	70	130
		EG020A-F: Chromium	7440-47-3	0.5 mg/L	77.3	70	130
		EG020A-F: Cobalt	7440-48-4	0.5 mg/L	# Not Determined	70	130
		EG020A-F: Copper	7440-50-8	0.5 mg/L	# Not Determined	70	130
		EG020A-F: Lead	7439-92-1	0.5 mg/L	104	70	130
		EG020A-F: Manganese	7439-96-5	0.5 mg/L	# Not Determined	70	130
		EG020A-F: Nickel	7440-02-0	0.5 mg/L	79.2	70	130
		EG020A-F: Vanadium	7440-62-2	0.5 mg/L	100	70	130
		EG020A-F: Zinc	7440-66-6	0.5 mg/L	# Not Determined	70	130
EG035F: Dissolved Mercury by FIMS (QCLot: 604503)							
EB0802207-001	Anonymous	EG035F: Mercury	7439-97-6	0.01 mg/L	107	70	130
EK040P: Fluoride by PC Titrator (QCLot: 604262)							
EB0802207-001	Anonymous	EK040P: Fluoride	16984-48-8	4.9 mg/L	88.2	70	130
EK055: Ammonia as N (QCLot: 600163)							
EB0802236-002	ODXH1.07(PW)	EK055A: Ammonia as N	7664-41-7	0.4 mg/L	# Not Determined	70	130
EK055: Ammonia as N (QCLot: 602322)							
EB0802092-001	Anonymous	EK055A: Ammonia as N	7664-41-7	4 mg/L	102	70	130
EK055: Ammonia as N (QCLot: 602327)							
EB0802236-012	ODXH4.2-04(PW)	EK055A: Ammonia as N	7664-41-7	100 mg/L	91.4	70	130
EK057: Nitrite as N (QCLot: 600161)							
EB0802236-002	ODXH1.07(PW)	EK057: Nitrite as N	----	0.4 mg/L	96.8	70	130
EK057: Nitrite as N (QCLot: 602323)							
EB0802092-001	Anonymous	EK057: Nitrite as N	----	4 mg/L	110	70	130
EK057: Nitrite as N (QCLot: 602328)							
EB0802236-012	ODXH4.2-04(PW)	EK057: Nitrite as N	----	100 mg/L	100	70	130
EK059: Nitrite plus Nitrate as N (NOx) (QCLot: 600162)							
EB0802236-002	ODXH1.07(PW)	EK059: Nitrite + Nitrate as N	----	0.4 mg/L	107	70	130
EK059: Nitrite plus Nitrate as N (NOx) (QCLot: 602324)							
EB0802092-001	Anonymous	EK059: Nitrite + Nitrate as N	----	8 mg/L	100	70	130

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Matrix Spike (MS) Report Spike Concentration	Spike Recovery (%) MS	Recovery Limits (%) Low	High
EK059: Nitrite plus Nitrate as N (NOx) (QCLot: 602330)							
EB0802236-012	ODXH4.2-04(PW)	EK059: Nitrite + Nitrate as N	----	100 mg/L	92.5	70	130
EK071: Reactive Phosphorus as P (Dissolved) (QCLot: 600164)							
EB0802236-002	ODXH1.07(PW)	EK071F: Reactive Phosphorus - Filtered	----	0.4 mg/L	74.8	70	130
EK071: Reactive Phosphorus as P (Dissolved) (QCLot: 602325)							
EB0802092-001	Anonymous	EK071F: Reactive Phosphorus - Filtered	----	4 mg/L	102	70	130
EK071: Reactive Phosphorus as P (Dissolved) (QCLot: 602331)							
EB0802236-012	ODXH4.2-04(PW)	EK071F: Reactive Phosphorus - Filtered	----	100 mg/L	95.3	70	130
EP005: Total Organic Carbon (TOC) (QCLot: 605265)							
EB0802185-002	Anonymous	EP005: Total Organic Carbon	----	100 mg/L	85.3	70	130
EP005: Total Organic Carbon (TOC) (QCLot: 605266)							
EB0802236-013	ODXH2.1-7(1:1)	EP005: Total Organic Carbon	----	100 mg/L	97.3	70	130

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PO Box 3103, Nunawading, Victoria, 3131
22 King Street, Blackburn, Victoria, 3130
Telephone +61 3 9877 4898 **Facsimile** +61 3 9877 8272
Email: info@australian-radiation-services.com.au
Web Site: www.australian-radiation-services.com.au
ABN 66 006 528 267

Keeping people safe.

Radioactivity Analysis Report

To: CSIRO Land and Water
New Illawarra Road
Lucas Heights NSW 2234

Report No.: 08-7020-R2
Date: 18th September 2008

Contact: Dr. Stuart Simpson

Sample description: Water samples

Number of samples: Thirteen samples

Submission date: 22nd February 2008

Analysis required: Determination of the activity of radium-226 (Ra-226) by liquid scintillation counting[1] and gross alpha-beta counting[2].

Analytical method: 1. Analysis carried out by liquid scintillation counting.
2. Measured aliquot of each sample treated in accordance with USEPA co-precipitation method for gross alpha/beta determination in water. Counting carried out on a Ludlum low level alpha/beta counter.

Analysis performed by: Ms. Genelle Jones & Dr. Malcolm Cooper

---

Results:

Client Sample ID (ARS ID)	Radionuclide Activity Concentration (Bq.mL^{-1})[a,b,c]		
	radium-226	**Gross Alpha**	**Gross Beta**[d]
ODXH 1.03 (08-7020-39)	0.014 ± 0.008	0.007 ± 0.001	0.031 ± 0.001
ODXH 1.07 (08-7020-40)	0.031 ± 0.010	0.019 ± 0.001	0.559 ± 0.001
ODXH 1.07 (1:1) (08-7020-41)	0.005 ± 0.005	0.012 ± 0.001	0.173 ± 0.001
ODXH 3.2-01 (1:1) (08-7020-42)	< 0.05	0.010 ± 0.001	0.074 ± 0.001
ODXH 3.2-05 (PW) (08-7020-43)	0.030 ± 0.010	0.007 ± 0.001	0.086 ± 0.001
ODXH 3.2-05 (1:1) (08-7020-44)	< 0.005	0.013 ± 0.001	0.065 ± 0.001
ODXH 3.2-09 (1:1) (08-7020-45)	0.005 ± 0.005	0.012 ± 0.001	0.138 ± 0.001
ODXH 4.1-02 (PW) (08-7020-46)	0.074 ± 0.015	0.005 ± 0.001	0.081 ± 0.001

Client Sample ID (ARS ID)	Radionuclide Activity Concentration (Bq.mL^{-1})[a,b,c]		
	radium-226	Gross Alpha	Gross Beta[d]
ODXH 4.1-04 (PW) (08-7020-47)	0.014 ± 0.007	< 0.005	0.045 ± 0.001
ODXH 4.1-06 (PW) (08-7020-48)	0.018 ± 0.007	Data Unavailable	Data Unavailable
ODXH 4.2-02 (PW) (08-7020-49)	0.012 ± 0.005	0.021 ± 0.001	0.049 ± 0.001
ODXH 4.1-04 (PW) (08-7020-50)	0.010 ± 0.008	0.008 ± 0.001	0.049 ± 0.001
ODXH 2.1-7 (1:1) (08-7020-51)	< 0.005	0.005 ± 0.001	0.031 ± 0.001
Method Blank (08-7020-52)	< 0.005	< 0.005	< 0.005

NB:
a. Activities are in becquerel (Bq) per milli-litre. One becquerel equals one nuclear transformation per second.
b. Less than (<) values indicate the limit of detection for each isotope for the measurement system.
c. The reported uncertainty in each result is the expanded uncertainty calculated using a coverage factor of 2.
d. Gross Beta activity concentration does <u>not</u> include the contribution from potassium-40.

AUSTRALIAN RADIATION SERVICES PTY. LTD.

Report prepared by: Ms. Genelle Jones
Radiochemist
Signed:

Reviewed by: Dr. Malcolm Cooper
Consultant Environmental Scientist
Signed: MB Cooper

Date: 18th September 2008

APPENDIX C. Particle Size Analyses

Certificate of Analysis

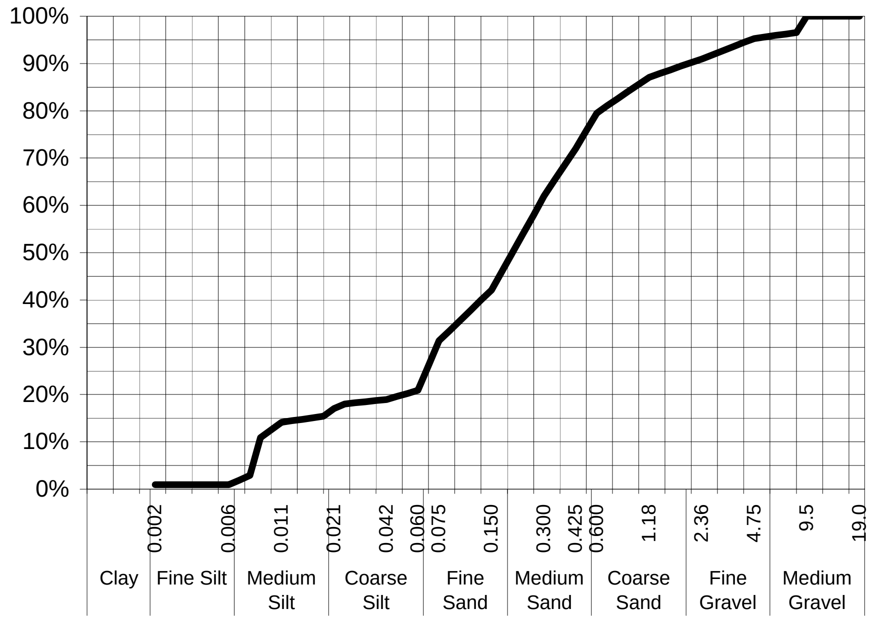
ALS Laboratory Group Pty Ltd
5 Rosegum Road
Warabrook, NSW 2304
pH 02 4968 9433
fax 02 4968 0349
peter.keyte@alsenviro.com

ALS Environmental

Newcastle, NSW

CLIENT:	Stuart Simpson	**DATE REPORTED:**	26-Jun-2008
COMPANY:	C S I R O Australia	**DATE RECEIVED:**	4-Jun-2008
ADDRESS:	11 Julius Avenue Riverside Corporate Park, North Ryde, NSW, Australia 2113	**REPORT NO:**	EB0807391-001 / PSA
PROJECT:		**SAMPLE ID:**	ODXHA4.2-05

Particle Size Distribution



Particle Size (mm)	Percent Passing
150	100%
75	100%
37.5	100%
19.0	100%
9.5	100%
4.75	95%
2.36	91%
1.18	87%
0.600	80%
0.425	72%
0.300	62%
0.150	42%
0.075	31%
Particle Size (microns)	
60	21%
42	19%
21	17%
11	14%
5.7	1%
4.0	1%
1.6	1%

Samples analysed as received with Peroxide Oxidation pretreatment before hydrometer analysis

Analysed: 12-Jun-08

Sample Comments:

Limit of Reporting: 1%

Loss on Pretreatment

Dispersion Method Mortar & Pestle

Sample Description: Orange clay with coarse crumbly solid

Hydrometer Type ASTM E100

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density 2.65 Assumed

Peter Keyte
Manager, Newcastle
Authorised Signatory

Certificate of Analysis

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Newcastle, NSW

CLIENT: Stuart Simpson

DATE REPORTED: 26-Jun-2008

COMPANY: C S I R O Australia

DATE RECEIVED: 4-Jun-2008

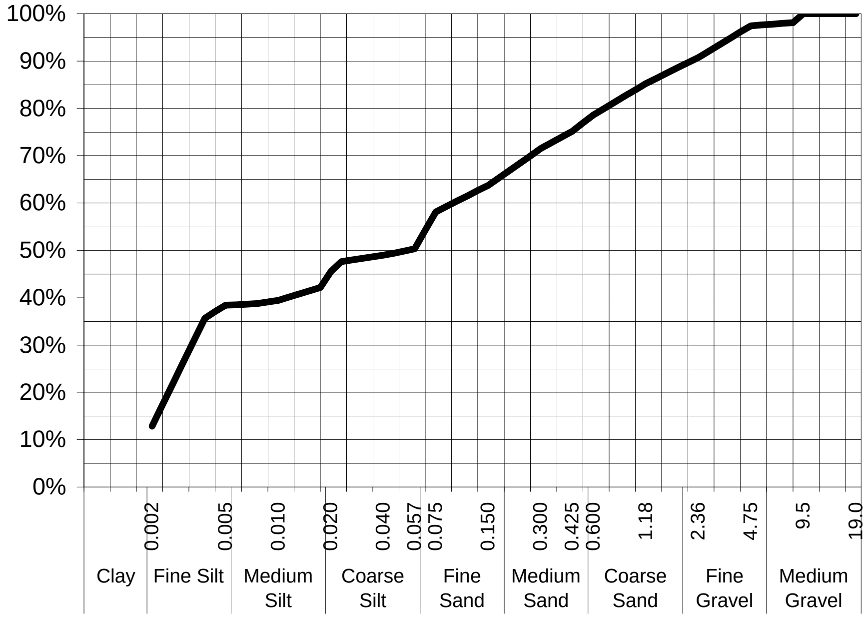
ADDRESS:
11 Julius Avenue
Riverside Corporate Park, North
Ryde, NSW, Australia 2113

REPORT NO: EB0807391-002 / PSA

PROJECT:

SAMPLE ID: ODXH4.1-10

Particle Size Distribution



Particle Size (mm)	Percent Passing
150	100%
75	100%
37.5	100%
19.0	100%
9.5	100%
4.75	97%
2.36	91%
1.18	85%
0.600	79%
0.425	75%
0.300	72%
0.150	64%
0.075	58%
Particle Size (microns)	
57	50%
40	49%
20	46%
10	39%
5.2	38%
3.7	36%
1.6	13%

Samples analysed as received with Peroxide Oxidation pretreatment before hydrometer analysis

Analysed: 12-Jun-08

Sample Comments:

Limit of Reporting: 1%

Loss on Pretreatment

Dispersion Method Mortar & Pestle

Sample Description: Light clay & crumbly white solids

Hydrometer Type ASTM E100

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density 2.65 Assumed

Peter Keyte
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Authorised Signatory

Certificate of Analysis

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CLIENT: Stuart Simpson

DATE REPORTED: 26-Jun-2008

COMPANY: C S I R O Australia

DATE RECEIVED: 4-Jun-2008

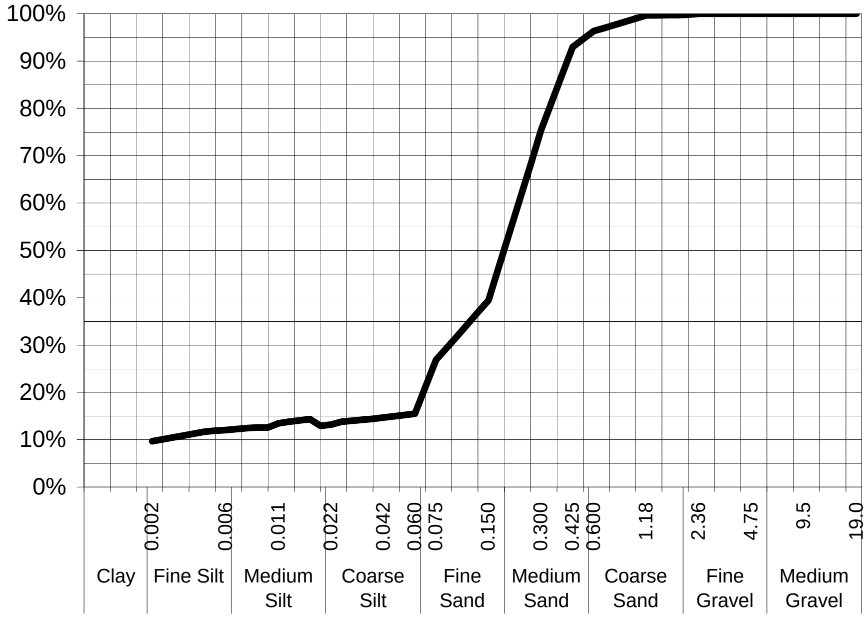
ADDRESS: 11 Julius Avenue
Riverside Corporate Park, North
Ryde, NSW, Australia 2113

REPORT NO: EB0807391-003 / PSA

PROJECT:

SAMPLE ID: ODXH3.1-09

Particle Size Distribution



Particle Size (mm)	Percent Passing
150	100%
75	100%
37.5	100%
19.0	100%
9.5	100%
4.75	100%
2.36	100%
1.18	100%
0.600	96%
0.425	93%
0.300	75%
0.150	39%
0.075	27%
Particle Size (microns)	
60	16%
42	15%
22	13%
11	13%
5.7	12%
4.0	12%
1.6	10%

Samples analysed as received with Peroxide Oxidation pretreatment before hydrometer analysis

Analysed: 12-Jun-08

Sample Comments:

Limit of Reporting: 1%

Loss on Pretreatment

Dispersion Method Mortar & Pestle

Sample Description: Orange clay-like solids and coarse crumbly solids

Hydrometer Type ASTM E100

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density 2.65 Assumed

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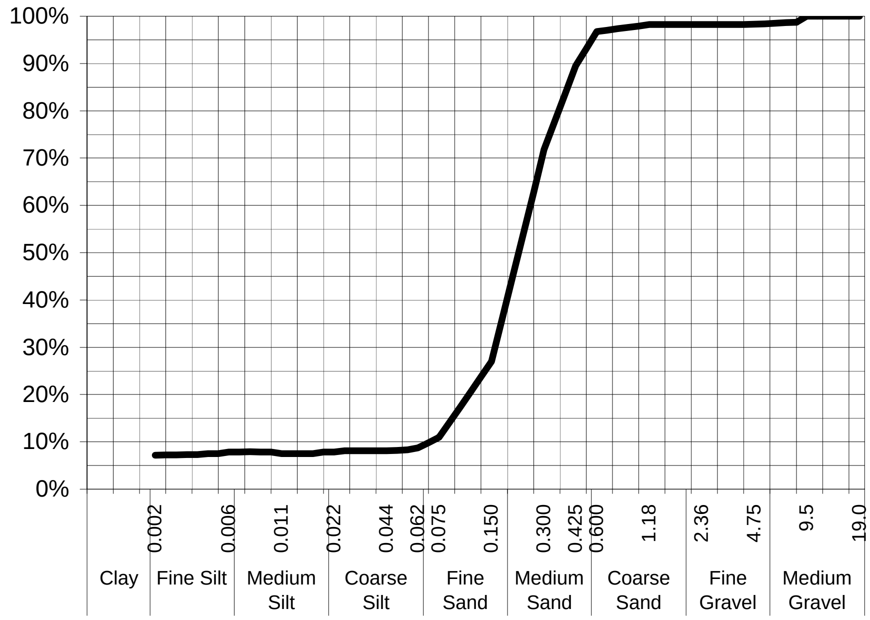
COMPANY:	C S I R O Australia	**DATE RECEIVED:**	4-Jun-2008
ADDRESS:	11 Julius Avenue Riverside Corporate Park, North Ryde, NSW, Australia 2113	**REPORT NO:**	EB0807391-004 / PSA
PROJECT:		**SAMPLE ID:**	ODXH2.1-7

Particle Size Distribution



Particle Size (mm)	Percent Passing
150	100%
75	100%
37.5	100%
19.0	100%
9.5	100%
4.75	98%
2.36	98%
1.18	98%
0.600	97%
0.425	89%
0.300	72%
0.150	27%
0.075	11%
Particle Size (microns)	
62	9%
44	8%
22	8%
11	8%
5.7	8%
4.0	8%
1.6	7%

Samples analysed as received with Peroxide Oxidation pretreatment before hydrometer analysis

Analysed: 12-Jun-08

Sample Comments:

Limit of Reporting: 1%

Loss on Pretreatment

Dispersion Method Mortar & Pestle

Sample Description: Fine grit and orange clay-like solid

Hydrometer Type ASTM E100

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density 2.65 Assumed

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Certificate of Analysis

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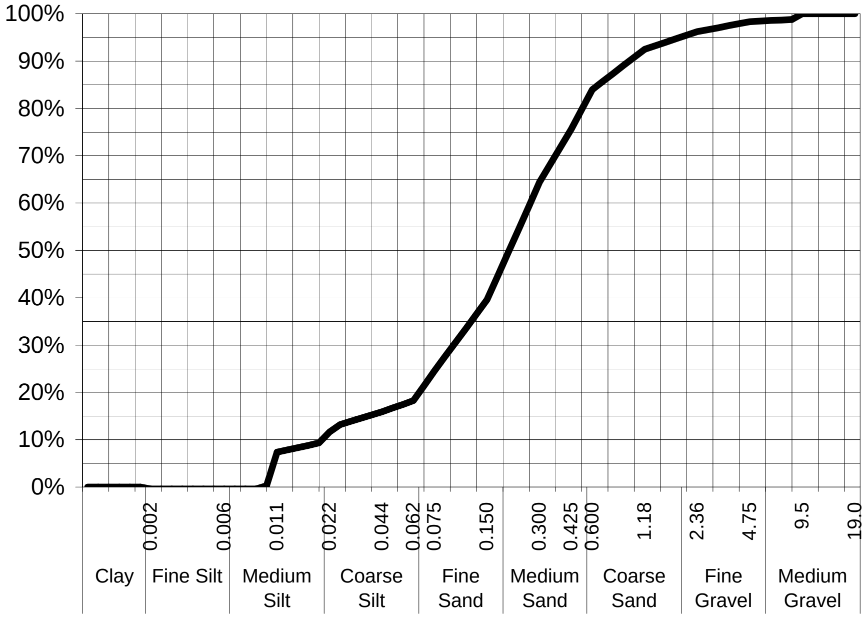
CLIENT:	Stuart Simpson	**DATE REPORTED:**	26-Jun-2008
COMPANY:	C S I R O Australia	**DATE RECEIVED:**	4-Jun-2008
ADDRESS:	11 Julius Avenue Riverside Corporate Park, North Ryde, NSW, Australia 2113	**REPORT NO:**	EB0807391-005 / PSA
PROJECT:		**SAMPLE ID:**	ODXH1.2-09S

Particle Size Distribution



Particle Size (mm)	Percent Passing
150	100%
75	100%
37.5	100%
19.0	100%
9.5	100%
4.75	98%
2.36	96%
1.18	92%
0.600	84%
0.425	76%
0.300	64%
0.150	40%
0.075	25%
Particle Size (microns)	
62	18%
44	16%
22	12%
11	7%
6.0	0%
4.2	0%
1.7	0%

Samples analysed as received with Peroxide Oxidation pretreatment before hydrometer analysis

Analysed: 12-Jun-08

Limit of Reporting: 1%

Dispersion Method Mortar & Pestle

Hydrometer Type ASTM E100

Sample Comments:

Loss on Pretreatment

Sample Description: Red clay-like solid

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density 2.65 Assumed

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Certificate of Analysis

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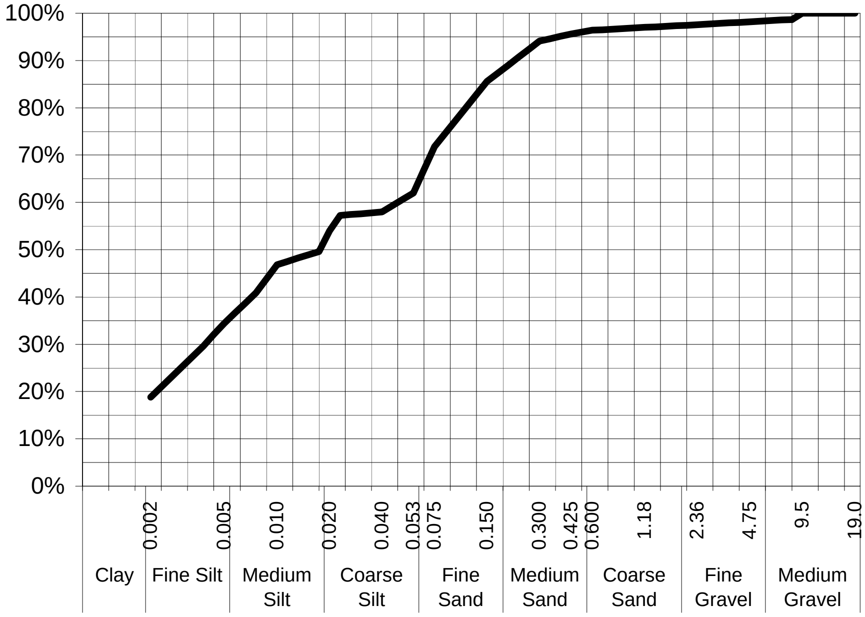
CLIENT:	Stuart Simpson	**DATE REPORTED:**	26-Jun-2008
COMPANY:	C S I R O Australia	**DATE RECEIVED:**	4-Jun-2008
ADDRESS:	11 Julius Avenue Riverside Corporate Park, North Ryde, NSW, Australia 2113	**REPORT NO:**	EB0807391-006 / PSA
PROJECT:		**SAMPLE ID:**	ODXH3.2-01

Particle Size Distribution



Particle Size (mm)	Percent Passing
150	100%
75	100%
37.5	100%
19.0	100%
9.5	100%
4.75	98%
2.36	98%
1.18	97%
0.600	96%
0.425	96%
0.300	94%
0.150	86%
0.075	72%
Particle Size (microns)	
53	62%
40	58%
20	54%
10	47%
5.5	34%
3.9	30%
1.7	19%

Samples analysed as received with Peroxide Oxidation pretreatment before hydrometer analysis

Analysed:	12-Jun-08
Limit of Reporting:	1%
Dispersion Method	Mortar & Pestle
Hydrometer Type	ASTM E100

Sample Comments:

Loss on Pretreatment

Sample Description: Red clay-like solid

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density 2.65 Assumed

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CLIENT: Stuart Simpson

DATE REPORTED: 26-Jun-2008

COMPANY: C S I R O Australia

DATE RECEIVED: 4-Jun-2008

ADDRESS: 11 Julius Avenue
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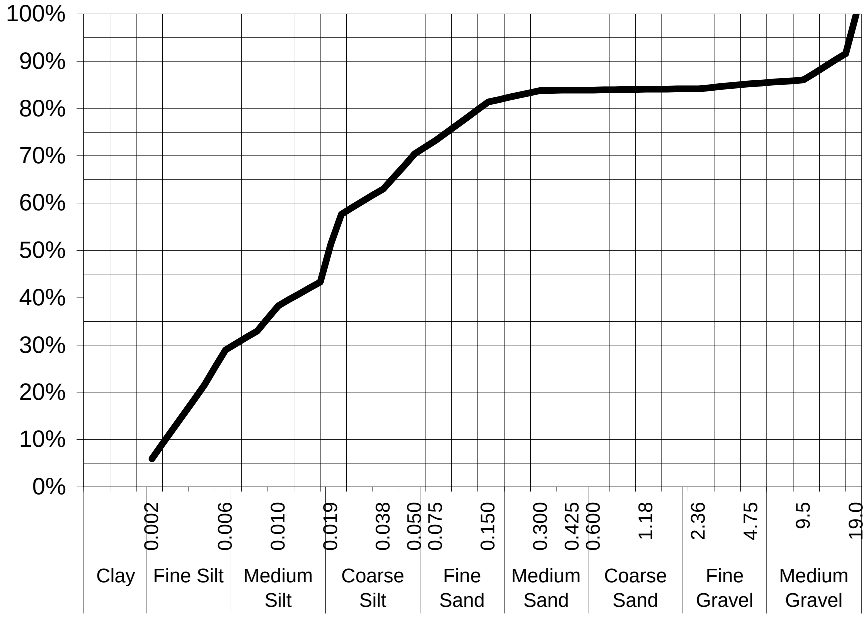
Ryde, NSW, Australia 2113

REPORT NO: EB0807391-007 / PSA

PROJECT:

SAMPLE ID: ODXH4.1-04

Particle Size Distribution



Particle Size (mm)	Percent Passing
150	100%
75	100%
37.5	100%
19.0	100%
9.5	86%
4.75	85%
2.36	84%
1.18	84%
0.600	84%
0.425	84%
0.300	84%
0.150	81%
0.075	73%
Particle Size (microns)	
50	70%
38	63%
19	51%
10	38%
5.5	29%
3.9	22%
1.7	6%

Samples analysed as received with Peroxide Oxidation pretreatment before hydrometer analysis

Analysed: 12-Jun-08

Sample Comments:

Limit of Reporting: 1%

Loss on Pretreatment

Dispersion Method Mortar & Pestle

Sample Description: Red clay-like solid

Hydrometer Type ASTM E100

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density 2.65 Assumed

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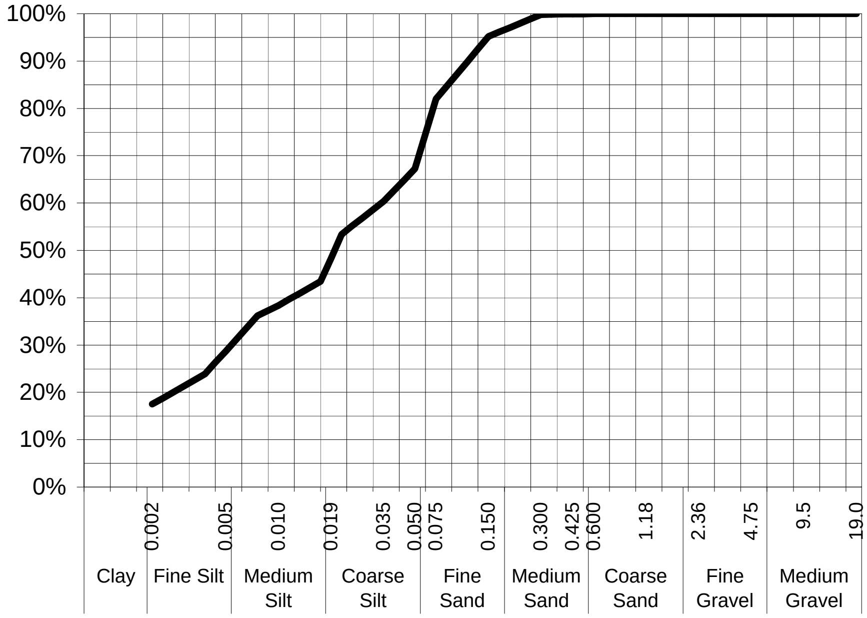
ALS Environmental

Newcastle, NSW

CLIENT:	Stuart Simpson	**DATE REPORTED:**	26-Jun-2008
COMPANY:	C S I R O Australia	**DATE RECEIVED:**	4-Jun-2008
ADDRESS:	11 Julius Avenue Riverside Corporate Park, North Ryde, NSW, Australia 2113	**REPORT NO:**	EB0807391-008 / PSA
PROJECT:		**SAMPLE ID:**	ODXH4.2-04

Particle Size Distribution



Particle Size (mm)	Percent Passing
150	100%
75	100%
37.5	100%
19.0	100%
9.5	100%
4.75	100%
2.36	100%
1.18	100%
0.600	100%
0.425	100%
0.300	100%
0.150	95%
0.075	82%
Particle Size (microns)	
50	67%
35	60%
19	48%
10	38%
5.5	29%
3.9	24%
1.6	17%

Samples analysed as received with Peroxide Oxidation pretreatment before hydrometer analysis

		Analysed:	12-Jun-08
Sample Comments:		**Limit of Reporting:**	1%
Loss on Pretreatment		**Dispersion Method**	Mortar & Pestle
Sample Description:	Red clay-like solid	**Hydrometer Type**	ASTM E100
Test Method:	AS1289.3.6.2/AS1289.3.6.3		
Soil Particle Density	2.65 Assumed		

Peter Keyte
Manager, Newcastle
Authorised Signatory

Certificate of Analysis

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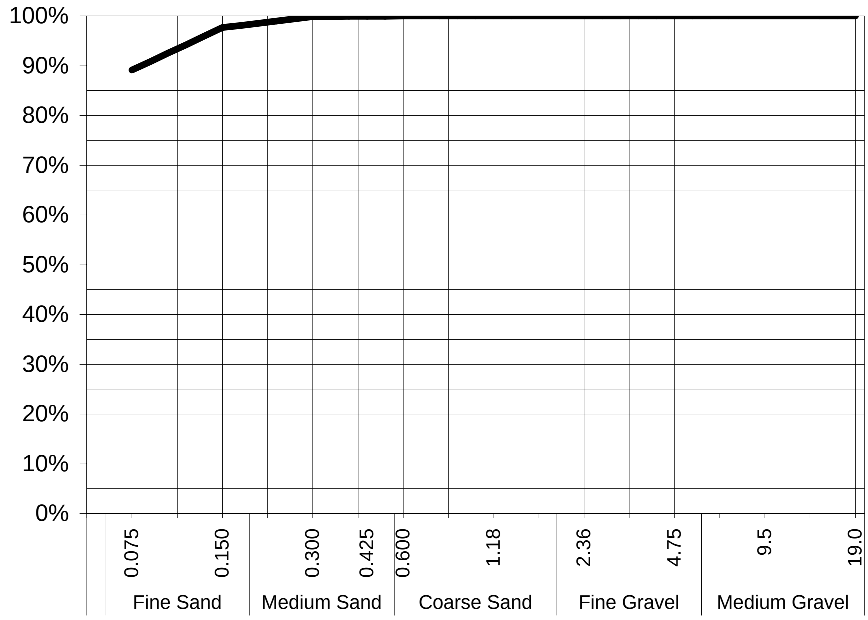
CLIENT:	Stuart Simpson	**DATE REPORTED:**	26-Jun-2008
COMPANY:	C S I R O Australia	**DATE RECEIVED:**	4-Jun-2008
ADDRESS:	11 Julius Avenue Riverside Corporate Park, North Ryde, NSW, Australia 2113	**REPORT NO:**	EB0807391-009 / PSA
PROJECT:		**SAMPLE ID:**	ODXH3.2-05

Particle Size Distribution



Particle Size (mm)	Percent Passing
150	100%
75	100%
37.5	100%
19.0	100%
9.5	100%
4.75	100%
2.36	100%
1.18	100%
0.600	100%
0.425	100%
0.300	100%
0.150	98%
0.075	89%

Samples analysed as received with Peroxide Oxidation pretreatment before hydrometer analysis

Analysed:	12-Jun-08
Limit of Reporting:	1%
Dispersion Method	Mortar & Pestle
Hydrometer Type	ASTM E100

Sample Comments:

Loss on Pretreatment

Sample Description: Red clay-like solid

Test Method: AS1289.3.6.1

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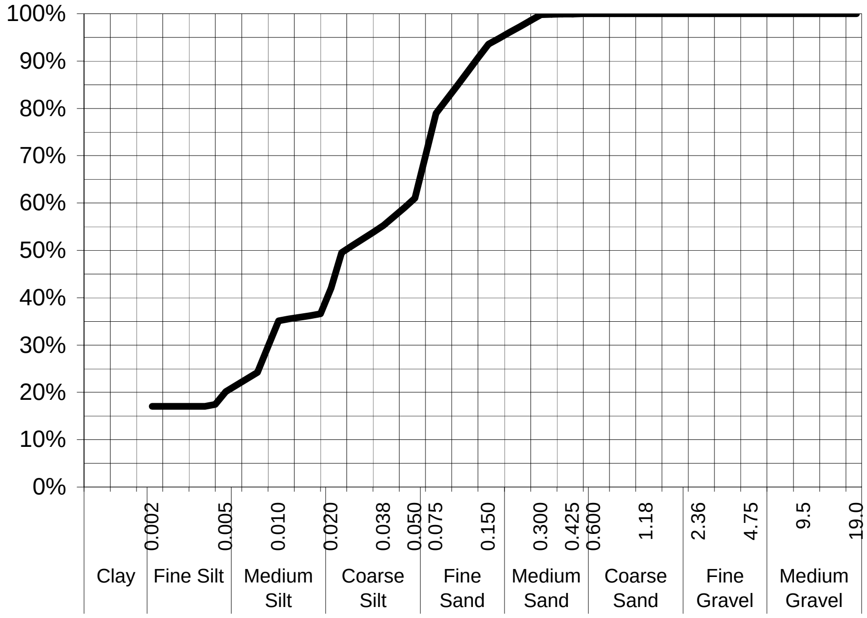
CLIENT:	Stuart Simpson	**DATE REPORTED:**	26-Jun-2008
COMPANY:	C S I R O Australia	**DATE RECEIVED:**	4-Jun-2008
ADDRESS:	11 Julius Avenue Riverside Corporate Park, North Ryde, NSW, Australia 2113	**REPORT NO:**	EB0807391-010 / PSA
PROJECT:		**SAMPLE ID:**	ODXH1.07

Particle Size Distribution



Particle Size (mm)	Percent Passing
150	100%
75	100%
37.5	100%
19.0	100%
9.5	100%
4.75	100%
2.36	100%
1.18	100%
0.600	100%
0.425	100%
0.300	100%
0.150	94%
0.075	79%
Particle Size (microns)	
50	61%
38	55%
20	42%
10	35%
5.5	20%
3.9	17%
1.6	17%

Samples analysed as received with Peroxide Oxidation pretreatment before hydrometer analysis

Analysed:	12-Jun-08
Limit of Reporting:	1%
Dispersion Method	Mortar & Pestle
Hydrometer Type	ASTM E100

Sample Comments:

Loss on Pretreatment

Sample Description: Red clay-like solid

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density 2.65 Assumed

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CLIENT: Stuart Simpson

DATE REPORTED: 26-Jun-2008

COMPANY: C S I R O Australia

DATE RECEIVED: 4-Jun-2008

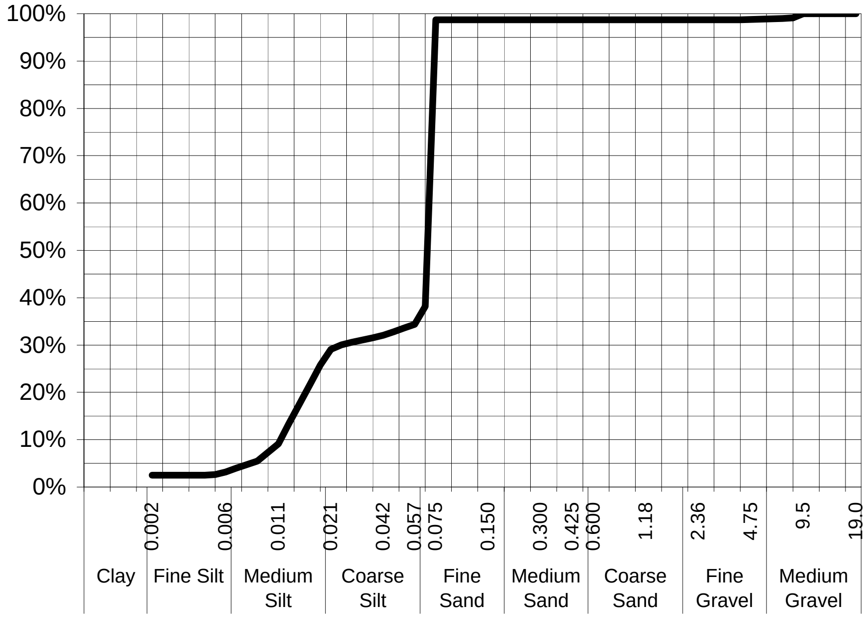
ADDRESS:
11 Julius Avenue
Riverside Corporate Park, North
Ryde, NSW, Australia 2113

REPORT NO: EB0807391-011 / PSA

PROJECT:

SAMPLE ID: ODXH1.2-09T

Particle Size Distribution



Particle Size (mm)	Percent Passing
150	100%
75	100%
37.5	100%
19.0	100%
9.5	100%
4.75	99%
2.36	99%
1.18	99%
0.600	99%
0.425	99%
0.300	99%
0.150	99%
0.075	99%
Particle Size (microns)	
57	34%
42	32%
21	29%
11	9%
5.7	3%
4.0	3%
1.6	3%

Samples analysed as received with Peroxide Oxidation pretreatment before hydrometer analysis

Analysed: 12-Jun-08

Sample Comments:

Limit of Reporting: 1%

Loss on Pretreatment

Dispersion Method Mortar & Pestle

Sample Description: Orange clay-like solids

Hydrometer Type ASTM E100

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density 2.65 Assumed

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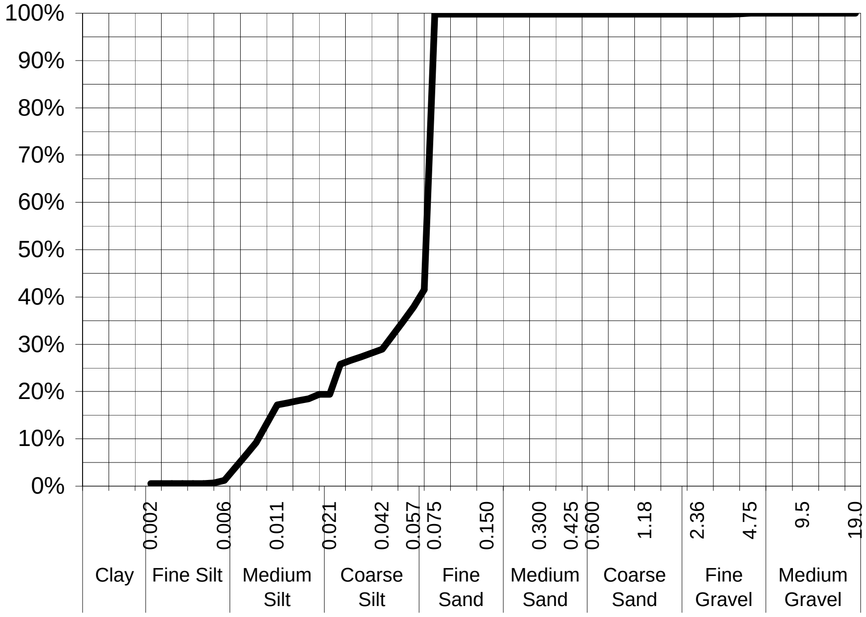
CLIENT:	Stuart Simpson	**DATE REPORTED:**	26-Jun-2008
COMPANY:	C S I R O Australia	**DATE RECEIVED:**	4-Jun-2008
ADDRESS:	11 Julius Avenue Riverside Corporate Park, North Ryde, NSW, Australia 2113	**REPORT NO:**	EB0807391-012 / PSA
PROJECT:		**SAMPLE ID:**	ODXH1.2-02

Particle Size Distribution



Particle Size (mm)	Percent Passing
150	100%
75	100%
37.5	100%
19.0	100%
9.5	100%
4.75	100%
2.36	100%
1.18	100%
0.600	100%
0.425	100%
0.300	100%
0.150	100%
0.075	100%
Particle Size (microns)	
57	38%
42	29%
21	19%
11	17%
5.7	1%
4.0	1%
1.6	1%

Samples analysed as received with Peroxide Oxidation pretreatment before hydrometer analysis

Analysed: 12-Jun-08

Limit of Reporting: 1%

Dispersion Method Mortar & Pestle

Hydrometer Type ASTM E100

Sample Comments:

Loss on Pretreatment

Sample Description: Black solid with thin gray surface coating

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density 2.65 Assumed

Peter Keyte
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Authorised Signatory

Appendix 5: CSIRO report: Partitioning, Leaching and Adsorption Characteristics of Tailings, Sediment and Bedrock Materials from Olympic dam

Partitioning, Leaching and Adsorption Characteristics of Tailings, Sediment and Bedrock Materials from Olympic Dam

Stuart Simpson, Ian Hamilton, Rob Jung, Brad Angel and David Spadaro

CSIRO Land and Water Report No. CLW11/09.

June 2009

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CSIRO Land and Water

ABN: 41 687 119 230

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ACKNOWLEDGEMENTS

Graeme Batley (of CSIRO Land and Water) is thanked for comments of the draft report.

EXECUTIVE SUMMARY

An assessment of the mobility metals, radionuclides and major anions and cations was made on tailings, sediment and bedrock samples collected from the beneath the main tailings dam of the Olympic Dam mine, and previously characterised in Simpson et al. (2008). The assessment included (i) sequential extraction procedures to assess of the partitioning to different solid phases, (ii) bottle rolling tests, unsaturated column tests and saturated column tests to assess the leachability of tailings and sediments with deionised water, and (iii) adsorption and desorption tests for major anions, cations, metals and radionuclides. The influence of dissolved oxygen and carbon dioxide on the mobilisation and adsorption processes was also investigated.

The sequential extractions provided information on the ‘relative proportions’ of substances extractable sequentially using each reagent. The 3-week bottle rolling tests of tailings and sediments indicated little difference in leachability in air or nitrogen atmosphere. The 21-week unsaturated column leach tests of the tailings indicated that, for most substances, most of the leaching occurred within 3-6 weeks. During the 10-week saturated column leach tests a number of operational problems were encountered due to the fine particle size of the materials. The materials compressed in the columns over the duration of the tests and horizontal fractures appeared within both columns by week 5. Oxic conditions caused greater leaching of major anions and cations and most metals from the tailing than anoxic conditions (deoxygenated water). Leaching of manganese, which is soluble in its reduced form, Mn(II), was greater under anoxic conditions.

For the saturated column tests of the Core-1 (limestone) material, there was significantly greater removal from the pH-4.5 tailings water of a number of metals (e.g. Al, Cu, U, Zn) under a 10%-CO_2/90%-N_2 (g) atmosphere than a 100%-N_2 atmosphere. These differences were not apparent from the bottle rolling tests with the same material and test conditions. The limestone (Core-1) material was much more effective than quartzite (Core-4) at removing/adsorbing substances from the pH-4.5 tailings water. In most cases, there was less removal of metals in the first cycle than in the subsequent 2-3 cycles (addition of new pH-4.5 tailings water).

For the sediment materials, the removal metals from the pH-4.5 tailings water was greater for lower water:rock (W:R) ratios. At W:R ratios of 1 and 2, generally the % removal did not decrease with successive cycles. For the sediment, 3.1-04, at W:R=20 the % removal of Al, Ce, Cu, and U decreased with successive cycles. This trend was not observed for the sediment 3.2-12.

Mineralogical examination of leach residues found very little evidence of dissolution of primary phases or precipitation of secondary phases as a result of leaching. The only definitive evidence of precipitation was found in the quartz-rich sediment and quartz-rich tailing in which coatings of malachite/azurite were present on some grains. Traces of copper sulfides (bornite and covellite) were found one sample, some of which showed signs of oxidation although the oxidation could not be confirmed as being due to leaching. These sulfides probably account for the occurrence of copper in the bulk analysis of the pre leach sample..

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1. INTRODUCTION

Olympic Dam is located approximately 570 km north north-west of Adelaide in South Australia. The Olympic Dam mine current produces approximately 220,000 tpa of copper plus associated products (being 4,000 tpa of uranium oxide, 80,000 ounces of gold and 800,000 ounces of silver). The mine proponent, Olympic Dam Corporation Pty Ltd (a member of the BHP Billiton Group), proposes to expand the existing Olympic Dam copper, uranium, gold and silver mine and processing plant, including all associated infrastructure.

The Centre for Environmental Contaminants Research, CSIRO Land and Water (CLW) was engaged by SRK Consulting (Australasia) Pty Ltd to provide scientific advice and experimentation to assess the mobility of metals and radionuclides with the Olympic Dam tailings material located with the main tailings dam. The information from this study will be used for the preparation of an Environmental Impact Statement (EIS). The project comprised three stages:

(i) Characterisation of the whole-rock samples and isolation and analyses of pore water (Stage 1 report; Simpson et al., 2008),

(ii) Assessment of the partitioning and leaching processes for major anions, cations, metals and radionuclides (Stage 2; this report). Experiments undertaken with selected tailings and sediment materials. Sequential extraction procedures were used to assess of the partitioning to different solid phases. Bottle rolling tests, unsaturated column tests and saturated column tests were used to assess of the leachability of tailings and sediments with deionised water. The unsaturated column experiments used deionised water and an air atmosphere. The bottle rolling and saturated column experiments used deionised water and air or nitrogen atmosphere, and

(iii) Assessment of the kinetics of adsorption and desorption reactions of major anions, cations, metals and radionuclides (Stage 3; this report). Experiments undertaken with selected sediment and bedrock materials. Bottle rolling tests and saturated column tests were used to assess of the capacity of selected sediment and bedrock materials to neutralise and adsorb substances from pH-4.5 modified tailings water. The tests were undertaken as closed systems in equilibrium with air, 100% N_2 or 10% CO_2/90% N_2 atmospheres to simulate possible atmospheres existing at various depths in tailings dam.

1.1 Scope of Work

The scope of work for Stage 2 included:

(i) The partitioning of substances to different solid phases on two tailings and two sediment materials. The sequential extraction procedure described by Hall et al. (1996) was modified to enable its use to obtain the required analyte volumes. The procedure adopted involved sequential extractions of solid materials with reagents that targeted release of major anions, cations, metals and radionuclides present in the forms: (i) labile-dissolved and weakly exchangeable, (ii) exchangeable-weakly adsorbed, easily exchangeable, associated with carbonate phases. (iii) associated amorphous iron oxy(hydr)oxides, (iv) associated with crystalline iron oxides, and (v) residual forms extractable with concentrated acids.

(ii) Bottle rolling leachability tests of major anions, cations, metals and radionuclides from two tailings and two sediment materials. Separate samples of the materials were leached with (i) air-equilibrated deionised water, in an air atmosphere, and (ii) deoxygenated deionised water, in a nitrogen atmosphere. Three successive 1-week leaches were undertaken under the desired conditions.

(iii) Unsaturated column leachability tests of major anions, cations, metals and radionuclides for three tailings materials. Leaching with deionised water using “free draining leach column test procedures” adapted from AMIRA.

(iv) Saturated column leachability tests of major anions, cations, metals and radionuclides for one tailings material in air and nitrogen atmospheres.

The scope of work for Stage 3 included:

(i) Bottle-rolling adsorption tests of major anions, cations, metals and radionuclides from three sediment and two bedrock materials. The sediments were tested using a pH-4.5 neutralised tailings porewater equilibrated and rolled in a nitrogen atmosphere. The bed-rock tests were undertaken using pH-4.5 neutralised tailings porewater that was either equilibrated and rolled in a (i) 100% N_2 or (ii) 10% CO_2/90% N_2 atmosphere - to simulate possible atmospheres existing at various depths in tailings dam.

(ii) Saturated column tests on two bedrock materials. For the limestone column tests the inflow solution was pH-4.5 neutralised tailings porewater that was either equilibrated in a (i) 100% N_2 or (ii) 10% CO_2/90% N_2 atmosphere. For the quartzite column tests the inflow solution was pH-6 lime-neutralised tailing porewater that had been equilibrated either (i) in a nitrogen atmosphere, or (ii) 10% CO_2/90% N_2 atmosphere with added dolomite to increase the alkalinity.

2. METHODS

2.1 Analytical Methods for Waters and Solids

Sediment moisture content, wet density and porosity were determined according to standard methods (Mudroch et al., 1997). For the majority of the chemical analyses, the NATA-accredited laboratories of ALS Environmental (Brisbane) and Australian Radiation Services Pty Ltd (ARS) were used. General descriptions of the methods used by ALS (Environmental Division) have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM (1999) (Table 2 and 3). For all outsourced analyses, analysis reports are attached as Appendices.

2.1.1 Analytical Quality Assurance/Quality Control (QA/QC)

The accuracy and precision of analytical data was checked using a number of standard laboratory and field QA procedures.

Blanks: Laboratory-prepared samples that contain no measureable contaminants were prepared for all analyses and were designed to monitor the possible introduction of contaminants that were not present in the collected sample. Reagent blanks or method blanks were prepared and analysed for each method. Ideally, the concentration of an analyte in each blank should be below the reporting limit of that analyte.

Calibration Check using Matrix-matched Standards: Laboratory prepared samples that comprise, as closely as possible, the same matrix as the test samples being analyses along with a concentration series (gradient) of the tested analytes, were used confirm linearity of the method and adequate functioning of instruments.

Duplicate (Laboratory) Samples: These samples were prepared by dividing a test sample into two or more portions, then analysed separately as individual samples.

Replicate Samples: These are samples from the same field site or test taken to separate containers. They were analysed separately as individual samples. Replicate samples provide information on the site heterogeneity of field collected samples and reproducibility of tests (precision of tests, but not analyses).

Matrix Spikes: To selected test samples, a known amount of test analyte was added (spiked) and analysed along with the original sample. The percent recovery of each ‘spiked’ analyte was calculated and reported.

In general, the following summarizes the frequency QC samples processed:

- 5% Method Blanks – one analysed within each process lot of 20 samples.
- 10% Laboratory Duplicates – two analysed within each process lot of 20 samples.
- 5% Laboratory Control Samples (LCS) – one analysed within each process lot of 20 samples.
- 5% Matrix Spikes (MS) – one analysed within each process lot of 20 samples.

Table 1. Methods used for Analyses of Waters

Analyte	Method
Major Cations - Filtered	APHA 21st ed., 3120; USEPA SW 846 - 6010 The ICPAES technique ionises the 0.45um filtered samples, emitting a characteristic spectrum which is compared against matrix matched standards.
Dissolved Metals by ICPAES	(APHA 21st ed., 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020): The ICPAES technique utilizes a highly efficient argon plasma to ionize selected elements. Ions emissions were detected and quantified by spectrometry.
Dissolved Metals by ICPMS	(APHA 21st ed., 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020): The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Dissolved Mercury by FIMS	AS 3550, APHA 21st ed. 3112 Hg - B (Flow-injection (SnCl2)(Cold Vapour generation) AAS) FIM-AAS is an automated flameless atomic absorption technique. A bromate/bromide reagent is used to oxidise any organic mercury compounds in the filtered sample. The ionic mercury is reduced online to atomic mercury vapour by SnCl2 which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve.
Silica (Total Dissolved) by ICPAES	APHA 21st ed., 4500-SiO2. Silica (Total) determined by calculation from Silicon by ICPAES.
Alkalinity and acidity as $CaCO_3$ by PC Titration	APHA 21st ed., 2320 B Alkalinity was dertemined by automated measurement (e.g. PC Titrate) using pH 4.5 for indicating the total alkalinity end-point. Acidity is determined by titration with a standardised alkali to an end-point pH of 8.3.
Major Anions - Filtered	APHA 21st ed., 4500 Cl - B. Automated Silver Nitrate titration.
Chloride by PC Titrator	APHA 21st ed., 3120; USEPA SW 846 - 6010 (ICPAES technique).
Fluoride by PC Titrator	APHA 21st ed., 4500 F--C CDTA is added to the sample to provide a uniform ionic strength background, adjust pH, and break up complexes. Fluoride concentration is determined by either manual or automatic ISE measurement.
Ammonia as N	APHA 21st ed., 4500 NH3+-H Ammonia is determined by direct colorimetry by FIA.
Nitrite and Nitrate as N (NOx)	APHA 21st ed., 4500 NO3- I. Combined oxidised Nitrogen (NO2+NO3) is determined by Cadmium Reduction and direct colorimetry by FIA.. Nitrate is reduced to nitrite by way of a cadmium reduction column followed by quantification by FIA. Nitrite is determined by direct colorimetry and result for Nitrate calculated as the difference between the two results.
Reactive Phosphorus - Filtered	APHA 21st ed., 4500 P-E Water samples are filtered through a 0.45um filter prior to analysis. Ammonium molybdate and potassium antimonyl tartrate reacts in acid medium with othophosphate to form a heteropoly acid -phosphomolybdic acid - which is reduced to intensely coloured molybdenum blue by ascorbic acid. Quantification is achieved by FIA.
Ionic Balance	APHA 21st Ed. 1030F.
Total organic carbon (TOC) & dissolved inorganic carbon (TIC)	APHA 21st ed., 5310 B. The automated TOC analyser determines total carbon (TC) and total inorganic carbon (TIC) by IR cell. TOC is calculated as the difference.
Radionuclides: Ra-226, and gross alpha-beta counting	Analyses undertaken by Australian Radiation Services Pty. Ltd. Determination of radium-226 carried out by liquid scintillation counting. Measured aliquot of each sample treated in accordance with USEPA co-precipitation method for gross alpha/beta determination in water. Counting carried out on a Ludlum low level alpha/beta counter after preliminary radiochemical separation to isolate radium isotopes.

Table 2. Methods used for Analyses of Solids

Analyte	Method
Digestion for Total Recoverable Metals EN25W SOIL	USEPA SW846-3005 Method 3005 is a Nitric/Hydrochloric acid digestion procedure used to prepare surface and ground water samples for analysis by ICPAES or ICPMS. This method is compliant with NEPM (1999)
Moisture Content	A gravimetric procedure based on weight loss over a 12 hour drying period at 103-105 degrees C. This method is compliant with NEPM (1999) Schedule B(3) (Method 102)
Sulfate as SO_4^{2-} Total	In-house. Total Sulfate is determined off a HCl digestion by ICPAES as S , and reported as SO4
Sulphur - Total as S (LECO)	In-house. Dried and pulverised sample is combusted in a LECO furnace at 1350C in the presence of strong oxidants / catalysts. The evolved S (as SO2) is measured by infra-red detector
HCl Digest	1g of soil is digested in 30 ml of 30% HCl and the resultant digest bulked and filtered for analysis by ICP
Radionuclides: Ra-226,	Analyses undertaken by Australian Radiation Services Pty. Ltd. The sample was encapsulated in a standard container for measurement. Analysis carried out by high resolution gamma ray spectrometry to determine the content of radium-226 (Ra-226).

2.2 Test Solids

The procedures for laboratory preparation, handling of radioactive tailings materials, extrusion of samples from packaging etc was described in the Phase 1 report (Simpson et al., 2008a).

The tailings, sediment and bedrock core samples were selected for the column test laboratory program based on characteristics of the materials (Simpson et al., 2008a) and the amounts of material available. Because each column tests used 1-2 kg of material, there was not always a sufficient amount of the selected materials to allow them to be used in all tests.

Tailings materials:

- Sequential extractions:
  ODXH3.2-05, ODXH4.1-05
- Leach tests with deionised water (air/oxygenated and nitrogen/deoxygenated): ODXH3.2-05 and ODXH4.1-05
- Unsaturated column tests with deionised water (air/oxygenated):
  ODXH3.2-01, ODXH3.2-05 and ODXH4.1-04.
- Saturated column tests with deionised water (air/oxygenated and nitrogen/deoxygenated):
  ODXH3.2-05

Sediment materials:

- Sequential extractions:
  ODXH4.2-05 or ODXH4.1-10
- Leach tests with deionised water (air/oxygenated and nitrogen/deoxygenated): ODXH4.2-05 and ODXH4.1-10.
- Adsorption tests pH 4.5 neutralised tailing water (nitrogen/deoxygenated): ODXH3.1-04, ODXH2.1-07 and ODXH3.2-12.

Bedrock materials:

- Adsorption tests pH 4.5 neutralised tailing water: Core 1 (limestone) and Core 4 (quartzite)

- Saturated column tests with pH 4.5 neutralised tailing water: Core 1 (limestone)
- Saturated column tests with pH 6 neutralised porewater: Core 4 (quartzite)

The tailings and sediment materials were used as supplied. The bed-rock materials, Core1 (Andamooka limestone, 55.6-56 cm depth) and Core 4 (Arcoona quartzite, 81.6-82 cm) were crushed to <5 mm size using a jaw-crusher, then the materials sieved and sorted to achieve the same size fractions for each core: 55% 2.5-5 mm, 18% 1-2.5 mm, 12% 0.21-1 mm, and 15% 0.063-0.21 mm.

2.3 Waters

De-ionised water (18 MΩ/cm, Milli-Q) was used for the unsaturated and saturated column tests of the tailings materials. Where necessary, the water was deoxygenated by bubbling with nitrogen gas for a period of 48 h before use.

Two mine-tailings waters were supplied for the study: (i) a tailings pond liquor (TL) collected from the surface water of the tailings dam, and (ii) a tailing porewater (PW) collected by pumping waters from piezometers at 1-3 m depth in the tailings dam. The composition of each water was analysed for pH, conductivity and the analytes (major anions and cations and trace metals) (Table 3).

2.3.1 Water neutralisation

Groundwater within the tailings dam, sediment and bed-rock

The conceptual model for the groundwater with the tailings dam, sediment and bed-rock, based on piezometer water measurements, is that the tailings liquor is neutralised from pH 1 to pH 3-4 within the tailings and then is neutralised to pH 5-7 near the top of the sediments. Consequently, the sediments are expected to be exposed to partly neutralised tailings pore water and the bed-rock materials beneath the sediment only exposed to neutralised waters for which the majority of the metals may have either precipitated or adsorbed to particulates as the pH increases and the waters are transported downwards through the solids. At deeper locations in the tailings dams/sediment/bed-rock system, the partial pressures of CO_2(g) (dissolved in the waters) will increase dramatically (based on dissolved carbonate measurements). The concentrations of porewater Fe(II) and Mn(II) may also remain very high due to the absence of oxygen or other substances that can facilitate oxidative precipitation as Fe(III) and Mn(IV) solid phases.

pH-6 neutralised tailings pore water

For the saturated column tests, it was desirablethat neutralised (e.g. pH 6) or partly neutralised (pH 4-5) waters should be used. Initially it was believed that the tailings liquor (TL, pH <1) was too acidic, and neutralisation would be undertaken of the pore water (PW, pH ~3.9). Initial tests indicated that neutralisation using dolomite ($MgCa(CO_3)_2$) and then calcite ($CaCO_3$) and would be too slow and would only allow pH 4-5 to be easily achieved. Lime (CaO) was then used and was successful at achieving a pH of 6 over period of several days application to deoxygenated PW. The dissolved concentrations of selected porewater metals are shown as a function of pH in Figure 1. However, monitoring of the pH-6 modified pore water for dissolved metals and pH indicated that pH 6 could not easily be maintained without ongoing additions of lime and bubbling with nitrogen to facilitate mixing. Two competing processes were occurring, namely lime neutralising the acidity, and hydrolysis reactions of Al(III) and Fe(III) (some produced from the oxidation of Fe(II)). Although these reactions were expected to cease after some period of time and provide pH-6 PW with stable pH and composition (under nitrogen), the changes in composition continued for weeks, until the water was abandoned.

Measurements of dissolved iron in the pH-6 neutralised water indicated that it had decreased from ~6000 mg/L to ~600 mg/L and was continuing to decrease. Furthermore, the concentrations of Cu, U and Zn, for example, decreased from 320, 230 and 30 mg/L, to <0.5, <1 <0.05 mg/L, respectively. This water was considered suitable for undertaking saturated column tests on the quartzite bed-rock material. The water was separated from the residual lime and equilibrated over dolomite 10 g/L in both (i) nitrogen atmosphere and (ii) 10% CO_2/90% N_2 atmospheres (Table 3).

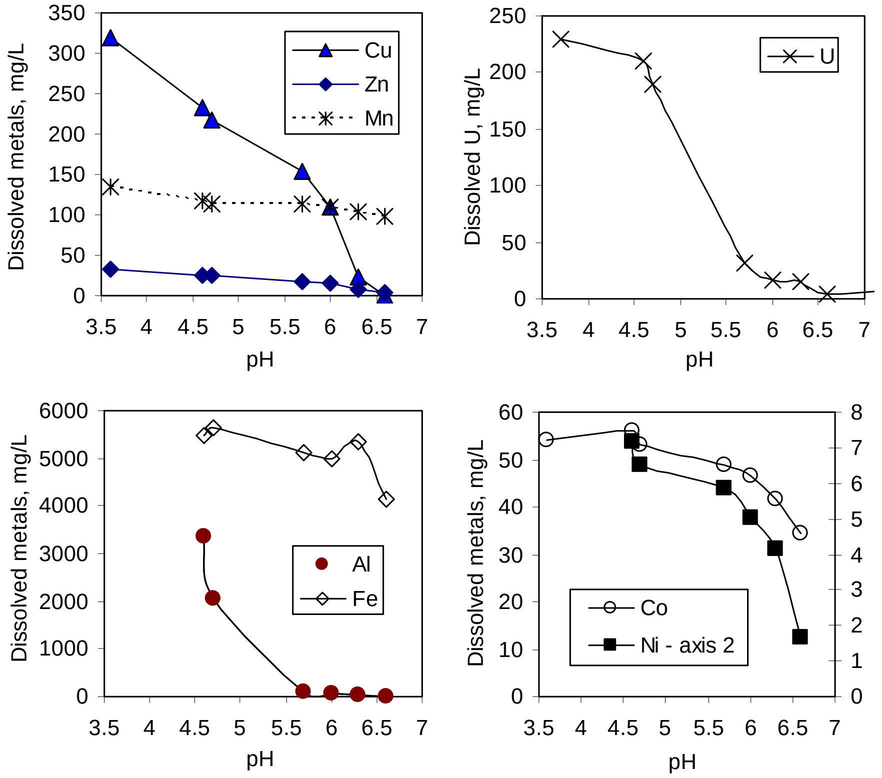

Figure 1. The dissolved concentrations of selected porewater metals are shown as a function of pH (4-h neutralisation using $CaCO_3$).

Table 3. Major Anions, Cations and Metals in the Tailings Liquor (TL) and Tailings porewater Samples

Sample	Cl^-	SO_4^{2-}	Na	K	Mg	Ca	Fe	Carbonate Alkalinity as $CaCO_3$	Bicarbonate Alkalinity as $CaCO_3$	Total Alkalinity as $CaCO_3$	Acidity as $CaCO_3$	Dissolved Inorganic Carbon
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Tailings liquor (TL)	6200	147000	7010	2290	3030	770	51000	<1	<1	<1	184000	<1
Pore water (PW)	4200	32400	3520	<10	1010	570	2910	<1	<1	<1	53200	<1
	Ag	Al	As	B	Ba	Be	Bi	Cd	Ce	Co	Cr	
Tailings liquor (TL)	0.025	9060	20.5	5.46	0.079	0.97	1.93	0.0655	423	142	10.8	
Pore water (PW)	<0.010	7130	0.124	1.74	0.018	0.74	0.014	0.0244	155	47.8	1.64	
	Cu	Hg	Li	Mn	Mo	Ni	Pb	Re	Sb	Se	Si	
Tailings liquor (TL)	1850	0.0001	17.5	181	3.84	12.3	4.25	0.005	0.169	1.70	40.2	
Pore water (PW)	282	<0.0001	18.3	124	0.030	5.13	0.026	0.005	<0.010	0.798	32.6	
	Sn	Sr	Th	Ti	Tl	U	V	W	Y	Zn		
Tailings liquor (TL)	0.085	20.2	21.8	12.3	0.106	128	3.48	0.260	88.1	56.3		
Pore water (PW)	<0.010	3.42	2.31	<0.10	<0.010	236	0.61	0.052	78.8	25.8		

pH-4.5 neutralised tailings liquor water

Initial experiments found that mixing tailing tiquor (TL) with the pH-6 lime-neutralised PW (pH-6 PW) result in water with pH 2.8, 3.5 and 4.3 at dilutions of 1:20, 1:199 and 1:200 respectively. These dilutions were too great. Neutralisation with dolomite was found to be too slow. The deoxygenated pH-1 TL was partially neutralised to pH 4.5 using calcite ($CaCO_3$). pH-4.5 neutralised tailings water with suitable concentrations of major anions and cations and trace metals was prepared by mixing 1 part deoxygenated TL and 2 parts 10 g/L $CaCO_3$ in deoxygenated deionised water on a bottle roller (nitrogen head space) for 2 h then allowing to settle for 16-20 h before filtration (Figure 2). The final water was considered stable for up to 1 week when stored in a nitrogen atmosphere (Table 3).

Figure 2. Partial neutralisation of tailings liquor using calcite

2.4 Sequential Extraction Procedure

10 g of sample of sample (ODXH3.2-05, ODXH4.1-05, ODXH4.2-05 or ODXH4.1-10) was weighed out into 250 mL Nalgene bottles. The following procedure operationally characterises the extracted substances:

1. Dissolved and weakly exchangeable extraction phase (Labile)

200 mL of de-ionised water was added to the 250 mL Nalgene bottles, then capped, shaken for 10-15 s and placed on a bottle roller for 30 minutes. The bottles were centrifuged (5 minutes at 6000 rpm) and the supernatant liquid decanted into a labelled 250 mL bottle. The remaining residue was rinsed with 50 mL of de-ionised water, placed on a roller for 10 minutes and centrifuged again. The supernatant was combined with the pervious supernatant rinse to make a total volume of 250 mL.

2. Adsorbed/exchangeable/carbonate phase (Exchangeable)

The remaining solid residue (from 1) was combined with 200 mL of 1.0 M CH_3COONa (at pH 5), shaken for 10-15 s and placed on a bottle roller for 6 h. The bottles were centrifuged (5 minutes at 6000 rpm) and the supernatant liquid decanted into a labelled 250 mL bottle. The remaining residue was rinsed with 50 mL of 1.0 M CH_3COONa, placed on a roller for 30 minutes and centrifuged again. The supernatant was combined with the pervious supernatant rinse to make a total volume of 250 mL.

3. Amorphous iron oxy(hydr)oxides (Am-FeOOH)
The remaining solid residue (from 2) was combined with 140 mL of 0.25 M $NH_2OH{\cdot}HCl$, shaken for 10-15 s and placed in a 60 ºC water bath for two hours with the cap loosened. Every 30 minute the sample was re-capped and shaken. The bottles were centrifuged (5 minutes at 6000 rpm) and the supernatant liquid decanted into a labelled 250 mL bottle. A second leach was performed with 140 mL of 0.25 M $NH_2OH{\cdot}HCl$ but heated in a water bath for 30 minutes, shaken, centrifuged and combined with the pervious supernatant rinse.

4. Crystalline iron oxides (Cryst-FeOX)
The remaining solid residue (from 3) was combined with 140 mL of 1 M $NH_2OH{\cdot}HCl$ in 25% CH_3COOH, capped and vortexed for 10-15 s, placed in a 90 ºC water bath for three hours with the cap on tightly and shaken every 20 minutes. The bottles were centrifuged (5 minutes at 6000 rpm) and the supernatant liquid decanted into a labelled 250 mL bottle. A seconded leach was performed with 140 mL of 1 M $NH_2OH{\cdot}HCl$ but heated in a water bath for 90 minutes, shaken, centrifuged and combined with the pervious supernatant rinse.

5. Residual material (Residual)
The remaining solid residue (from 4) was analysed for total recoverable analytes.

2.5 Bottle-rolling Leach and Adsorption Tests

2.5.1 Leach tests using deionised water

These tests investigated the leaching of metals (Al, As, Ba, Cd, Co, Cr, Cu, Ni, Mn, Pb, Se, Sn, Sr, Th, Ti, U, Zn, Ag, B, Be, Bi, Ce, Hg, Li, Mo, Re, Si, Sb, Sc, Tl, V, W, Y), major ions (Na, K, Ca, Mg, Fe, chloride and sulfate) , alkalinity/acidity, inorganic carbon and radium-226 from tailings from the test samples. The leach test procedure involved resuspending, for a defined period of time, the test solid in deionised water equilibrated with a specific test atmosphere (air or nitrogen). At the end of the test period, measurements of physicochemical parameters (pH, redox potential (Eh), conductivity (EC) and dissolved oxygen (DO)) and the leachate removed for analyte analyses. Each material was leached three times.

Specifically, 300 g (wet weight) of solid sample was added to a 1-L wide mouth Nalgene bottle with 600 mL of test water and rolled at a rate of 30-40 rpm for 1 week in the test atmosphere (Table 4). A replicate bottle containing only the test water (no solids) was prepared and treated the same way as the samples. All measurements and manipulations of the bottles were made within a nitrogen filled glove box. Measurements of pH, Eh, EC and DO were made 2-3 times per week. After one week, the leachate was removed for testing and replaced with new test water. For this operation, the overlying water was decanted into four 250 mL centrifuge bottles and centrifuged for 5 minute at 6000 rpm (Sorvall RC 24 refrigerated centrifuge, (Du Pont) with Sorvall Super-lite SLA-1500 rotor). The volume of overlying water removed from the bottles was recorded. The supernatant was filtered in a 500 mL polycarbonate filter unit (0.45 µm filter) and decanted into 125 mL bottles (2 mL of HNO_3 for preservation) for metal analyses and into 500 mL bottle (no preservation) for major ion and alkalinity/acidity analyses. The test solid in the centrifuged bottles was then rinsed back into the 1-L test bottle using the new test water. The added test water resulted in the total water volume being the same as that recorded prior to decanting for centrifugation. It is expected that losses of up to 5% of the test solid may have occurred with each water exchange.

Table 4. Tailings and Sediment Leach Tests with Deionised Water

Material	Sample	Test water	Test atmosphere	% water [a]	Water / solid [b]
Tailings 1	ODXH3.2-05	De-ionised water	Air	24	2.9
Tailings 2	ODXH4.1-04	De-ionised water	Air	25	3.0
Sediment 1	ODXH4.2-05	De-ionised water	Air	18	2.7
Sediment 2	ODXH4.1-10	De-ionised water	Air	18	2.7
Tailings 1	ODXH3.2-05	Deoxygenated de-ionised water	Nitrogen	24	2.9
Tailings 2	ODXH4.1-04	Deoxygenated de-ionised water	Nitrogen	25	3.0
Sediment 1	ODXH4.2-05	Deoxygenated de-ionised water	Nitrogen	18	2.7
Sediment 2	ODXH4.1-10	Deoxygenated de-ionised water	Nitrogen	18	2.7

[a] Of the test material added to the leach test bottle (300 g wet weight)

[b] Adjusted for the % water in the original material (300 g wet weight + 600 mL test water)

2.5.2 Adsorption tests using pH-4.5 neutralised tailings water

These tests investigated the adsorption of metals (Al, As, Ba, Cd, Co, Cr, Cu, Ni, Mn, Pb, Se, Sn, Sr, Th, Ti, U, Zn, Ag, B, Be, Bi, Ce, Hg, Li, Mo, Re, Si, Sb, Sc, Tl, V, W, Y), major ions (Na, K, Ca, Mg, Fe, chloride and sulfate), alkalinity/acidity, inorganic carbon and radium-226 to sediments and rock material from acidic tailings water. The adsorption test procedure involved resuspending, for a defined period of time, the test solid in fully characterised tailings water equilibrated with a specific test atmosphere (nitrogen or 10% CO_2/90% N_2). At the end of the test period measurements of physicochemical parameters (pH, redox (Eh), conductivity (EC) and dissolved oxygen (DO)) and the final solution removed for analyte analyses. The adsorption processes was repeated multiple times to provide information on adsorption capacity and rate at which test solids reacted with the tailings water.

The required dry weight of the test material was calculated based on water content of each material. The test material was added 1-L wide mouth Nalgene bottle with 300 mL, 400 mL or 600 mL of test water. The test water had been purged with nitrogen or a 10% CO_2/90% N_2 gas mixture and the head space of the bottles was filled with this gas before closing. The bottles were rolled continuously in a nitrogen atmosphere at a rate of 30-40 rpm (Figure 2). Measurements of pH, Eh, EC and DO were made 2-3 times per test cycle (within a nitrogen atmosphere) and then the head-space of the bottle purged with the respective gas mixture before capping and continuing to roll. The test cycles were either 1 or 4 weeks, after which the test water was removed for testing and replaced with new test water (same composition as originally added). For this operation, the overlying water was decanted into four 250 mL centrifuge bottles and centrifuged for 5 minute at 6000 rpm (Sovall RC 24 refrigerated centrifuge, (Du Pont) with Sorvall Super-lite SLA-1500 rotor). The volume of overlying water removed from the bottles was recorded. The supernatant was filtered in a 500 mL polycarbonate filter unit (0.45 µm filter) and decanted into 125 mL bottles (2 mL of HNO_3 for preservation) for metal analyses and into 500 mL bottle (no preservation) for major ion and alkalinity/acidity analyses. The test solid in the centrifuged bottles was then rinsed back into the 1-L test bottle using the new test water. The added test water resulted in the total water volume being the same as that recorded prior to decanting for centrifugation. It is expected that losses of up to 5% of the test solid may have occurred with each water exchange. A replicate bottle containing only the test water (no solids) was prepared and treated the same way as the samples.

Variations to this procedure involved test water:solid material ratios of 1 and 20 (v/w) (Table 5). The bed-rock materials, Core1 (Andamooka limestone, 55.6-56 cm depth) and Core 4 (Arcoona quartzite, 81.6-82 cm) had been prepared with the same size fractions for each core: 55% 2.5-5 mm, 18% 1-2.5 mm, 12% 0.21-1 mm, and 15% 0.063-0.21 mm.

Table 5. Sediment and Bedrock Adsorption-Desorption Tests with pH-4.5 Neutralised Tailing Water

Material	Sample	Test water (deoxygenated)	Test atmosphere	% water [a]	Water / solid [b]
Sediment	ODXH3.1-04	pH 4.5 neutralised tailing water	Nitrogen	25	1
Sediment	ODXH3.1-04	pH 4.5 neutralised tailing water	Nitrogen	25	2
Sediment	ODXH3.1-04	pH 4.5 neutralised tailing water	Nitrogen	25	20
Sediment	ODXH2.1-07	pH 4.5 neutralised tailing water	Nitrogen	13	2
Sediment	ODXH3.2-12	pH 4.5 neutralised tailing water	Nitrogen	8	2
Sediment	ODXH3.2-12	pH 4.5 neutralised tailing water	Nitrogen	8	20
Bedrock	Core 1 (limestone)	pH 4.5 neutralised tailing water equilibrated with test atmosphere	Nitrogen	0	2
Bedrock	Core 4 (quartzite)	pH 4.5 neutralised tailing water equilibrated with test atmosphere	Nitrogen	0	2
Bedrock	Core 1 (limestone)	pH 4.5 neutralised tailing water equilibrated with test atmosphere	10% CO_2 / 90% N_2	0	2
Bedrock	Core 4 (quartzite)	pH 4.5 neutralised tailing water equilibrated with test atmosphere	10% CO_2 / 90% N_2	0	2

[a] Of the test material added to the leach test bottle (300 g wet weight)0

[b] Adjusted for the % water in the original material (varying mass + 300 or 600 mL test water)

Figure 3. Rolling of materials in a nitrogen atmosphere for leach and adsorption tests

2.6 Unsaturated Column Tests

Unsaturated columns tests were undertaken on the three tailings materials: ODXH3.2-05, ODXH4.1-04, and ODXH3.2-01 (Table 6). These tailings materials were used without further manipulation. The method used was a “free draining leach column test procedure” adapted from (AMIRA P387A Project the ARD Test Handbook – Appendix F). The tests were conducted in a temperature-controlled room at 27±2ºC (no heating lamps over test materials). The grain size of the material was not adjusted (Simpson et al., 2008a). The Bruhner funnels had dimensions 260 mm diameter (531 cm^2), 100 mm depth for 2 kg tests or 160 mm diameter (201 cm^2), 50 mm depth for 1 kg tests. Whatman No. 1 filter paper was placed below the material. The mass of solid material per column was 2 kg (large funnels) for samples ODXH3.2-05 (2±0.2 cm depth) and ODXH3.2-01 (2±0.2 cm depth) and 1 kg (smaller funnel) for sample ODXH4.1-04 (3±0.2 cm depth) (Figure 3). The large and small funnels were irrigated with 600 mL and 300 mL deionised water, respectively, on a weekly basis. The percolation of the deionised water through the tailings was allowed to proceed unassisted for 5 days, after which vacuum assistance was generally applied to draw through the water remaining on the surface. Tailings 3.2-01 generally required assistance under vacuum for 2-4 hours for the first 12 cycles (10-30% of total water), but required no vacuum during the last 8 cycles (the water had percolated through naturally). Tailings 3.2-05 generally required vacuum assistance for up to 24 h for the first 12 cycles (20-50% of total water), and for 4-6 h during the last 8 cycles (10-30% of total water). For all cycles, tailings 4.1-04 required vacuum assistance of ~2 h (on day five) to remove the final (<10%) amount of water residing on the surface. Note, for 4.1-04 the tailings depth was ~ 3 cm compared to ~2 cm for the other two tailings (wider funnels). Measurements of pH, redox potential (Eh), and electrical conductivity (EC) were made on the leachate water on day 5. Water samples were then taken and filtered (<0.45 µm) before analyses of analytes. The surface of the samples remained exposed to the air for day 6 (drying) and on day 7 (day 0 of next week), new water was added. If cracks had developed through the materials, through which the added water might pass too quickly, these were removed by mixing the re-wetted surface layer. The tests were run for a period of 21 weeks. The leachate from the first three cycles, then from every third cycle was analysed (weekly irrigation continuing). Other leachate samples were stored refrigerated.

Table 6. Tailings Samples Selected for the Unsaturated Column Tests

Tailings	Properties	Inflow solution	Atmosphere	Scenario
ODXH3.2-05	Typical tails	De-ionised water	Air	Rain water percolating through unsaturated tailings, tests will determine rates at which contaminants released
ODXH4.1-04	Tailings with ANC			
ODXH3.2-01	Tailings with Cu staining			

Tailings	Water %	Wet density g/cm^3	Dry density g/cm^3	Porosity
ODXH3.2-01	12.7	2.0	1.8	0.26
ODXH3.2-05	24.1	2.0	1.6	0.49
ODXH4.1-04	25.5	2.1	1.6	0.54

Figure 4. Operation of unsaturated column tests

2.7 Saturated Column Tests

The column experiments used polycarbonate columns that were either 500 mm length × 50 mm internal diameter, or 300 mm length × 50 mm internal diameter. At either end of the columns there were two diffusion plates, between which was a 0.7 µm glass-fibre filter to disperse the inlet liquids (Figure 5).

The inlet water was pumped from the bottom of the column upwards using a peristaltic pump (Gilson, Minipuls3) with 1.14 diameter tubing (orange/green, I.D. = 0.38 mm, A.i. Scientific, Australia). The column tests following a modified version of the ASTM column test (D 4874 Standard Test method for Leaching Solid Waste in a Column Apparatus) protocol (ASTM 2001).

The saturated columns tests were undertaken on one tailings and two bedrock materials shown in Table 7. Due to the low moisture contents of the tailing materials, they could not be packed directly into the columns (i.e. large air-pockets would have been created). Instead, the materials were initially wetted with deoxygenated deionised water in the nitrogen glove box, so that a paste-like material could be used to fill the columns. Although this approach resulted in no void spaces in the initial packed columns, the materials could pack further during the course of the column tests, i.e. due to the pressure exerted by the inflow water. It was initially intended that these test be undertaken on the sediment materials ODXH3.1-04, ODXH2.1-07, ODXH3.2-12 (Figure 6) also, however after preparing the column it was observed that the reaction of the pH 4.5 partially neutralised tailing water with the materials caused reactions that prevented column operation. The sediment materials contained considerable amounts of clay material and flow rates were very slow. The reaction with acidic water caused the columns to block completely and operation was not possible under the desired conditions. The bedrock materials were crushed and the mixed materials within the columns were: 55% 2.5-5 mm, 18% 1-2.5 mm, 12% 0.21-1 mm, and 15% 0.063-0.21 mm (Figure 7).

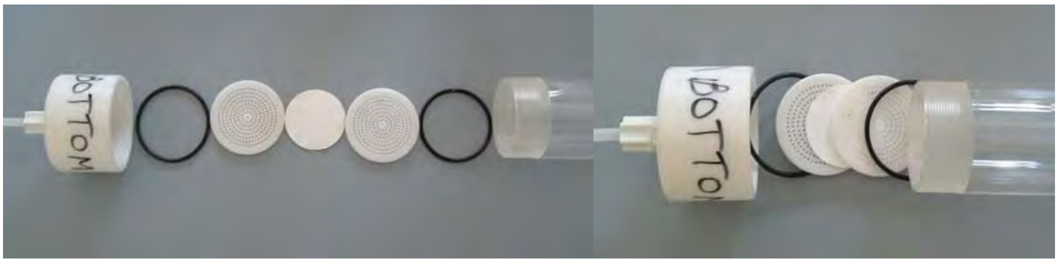

Figure 5. Construction of the saturated columns: threaded top and base, rubber O-ring, first diffusion plate with 0.5 mm diameter holes, 0.7 µm glass-fibre filter, second diffusion plate with 0.5 mm diameter holes, rubber O-ring, polycarbonate column (identical at other end).

Table 7. Tailings and Bedrock Saturated Column Leach Tests

Sample type	Sample	Inflow solution	Atmosphere	Scenario
Tailings	ODXH3.2-01	De-ionised water	Air	Rain water percolating through aerated, saturated tails
Tailing	ODXH3.2-01	Deoxygenated de-ionised water	Nitrogen	Rain water percolating through anoxic, saturated tails
Bedrock	Core 1 (limestone)	pH 4.5 neutralised tailing water equilibrated with test atmosphere	Nitrogen	Future percolating groundwater, reducing, carbonate-poor*
Bedrock	Core 1 (limestone)		10% CO_2 / 90% N_2	Future percolating groundwater, reducing, carbonate-equilibrated
Bedrock	Core 4 (quartzite)	pH 6 neutralised tailing porewater equilibrated with dolomite in test atmosphere	Both 10% CO_2 / 90% N_2	Future percolating groundwater, reducing, carbonate-equilibrated
Bedrock	Core 4 (quartzite)			

Sample type	Sample	Water %	Wet density g/cm^3	Dry density g/cm^3	Porosity	Volume, cm^3 Column	Volume, cm^3 Pore
Tailings	ODXH3.2-01 [a]	22	2.1	1.7	0.26	589	270-290
Andamooka limestone	ODXcore1 [b] (55.6-56 cm)	15	2.2	1.7	0.32	982	320-340
Arcoona quartzite	ODXcore4 [b] (81.6-82 cm)	18	2.1	1.7	0.37	982	370-390

[a] The moisture content of these materials were modified to allow packing into columns.
[b] The bedrock materials were crushed to specific particle size ranges before packing into the columns

Tailings column tests 1 and 2:

Intermittent inlet flows were used for the tailings column tests, with approximately 50 mL of water passing through each column per day until the 'pore volume' was achieved. Tailing column test 1 was placed in an air atmosphere and deionised water was the inflow solution. Tailing column test 2 was placed in a nitrogen atmosphere (purpose-built container) and deoxygenated deionised water was the inflow solution (Figure 6). The inlet and outlet waters reservoirs were sealed and in the case of deoxygenated deionised water tests, the containers were flushed with a continuous supply of nitrogen gas. These tests were carried out in a temperature-controlled room maintained at 27.5±2.5 ºC.

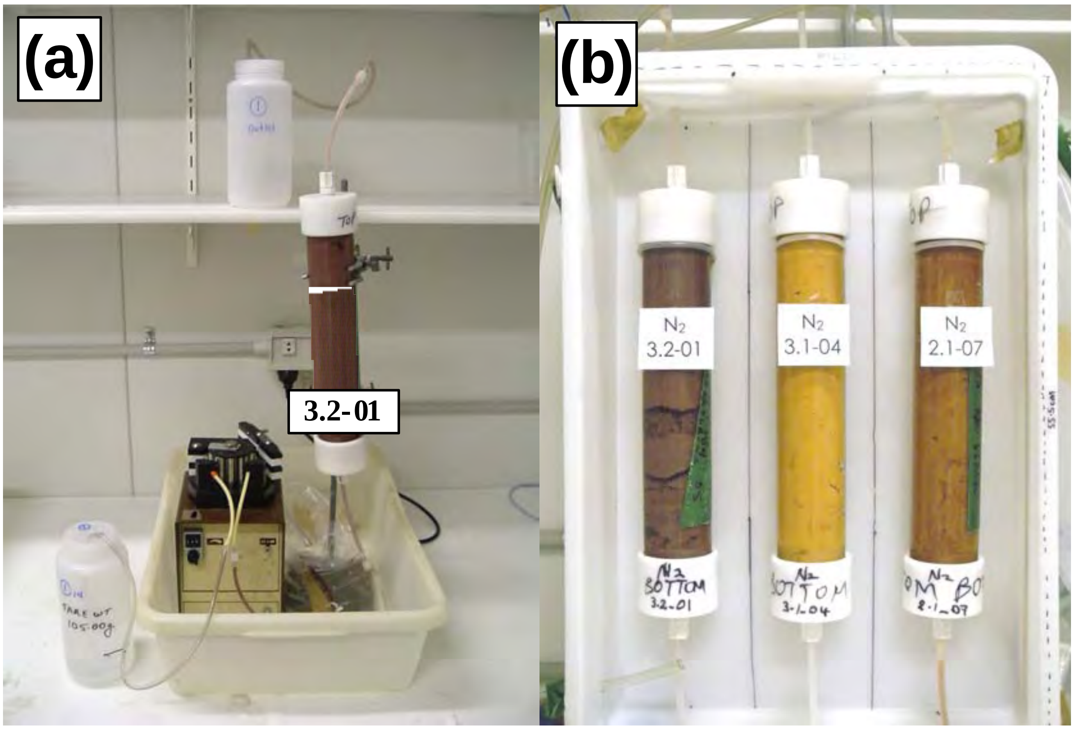

Figure 6. Operation of saturated column tests for (a) sediment 3.2-01 in air atmosphere, and (b) tailings materials (discontinued) within nitrogen-filled container (cover placed over front to close).

Bedrock column tests3-6:

For the bedrock column tests, the flow rates used were sufficient to replace one pore volume during a single day (8 h), and this was undertaken once every 7-10 days. The bedrock column tests were placed in an in a nitrogen atmosphere (glove box) and the inflow solution was equilibrated with 100% nitrogen or 10% carbon dioxide/90% nitrogen (Table 7).

The inlet and outlet waters reservoirs were contained within the glove box and the containers were flushed with a continuous supply of the nitrogen or the CO_2/nitrogen gas mixture (Figure 7).

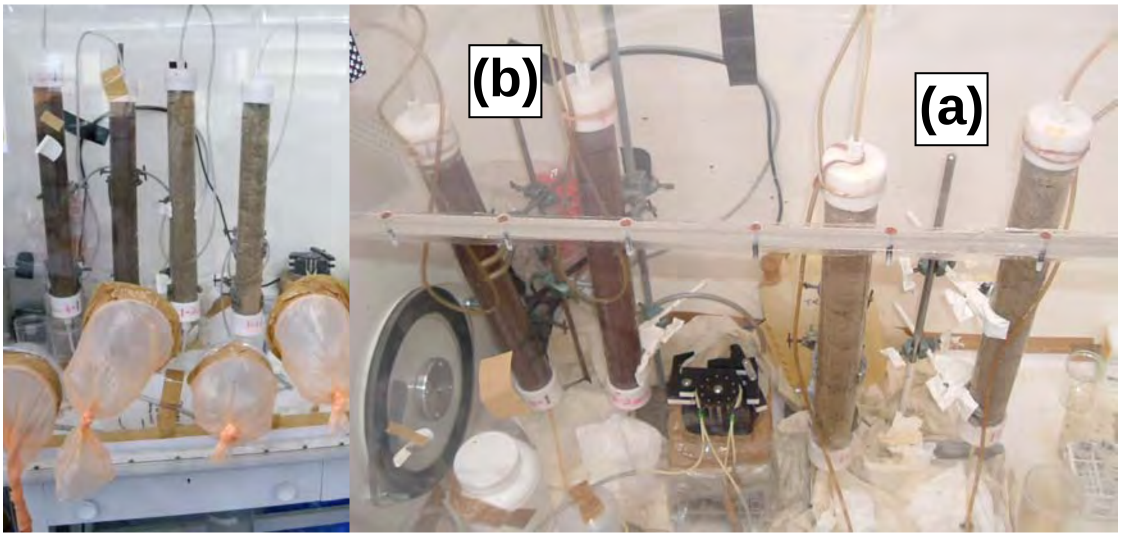

Figure 7. Operation of saturated column tests for bedrock materials (a) Core 1 (limestone) and (b) Core 4 (quartzite) within nitrogen gas-filled glove box.

2.8 Mineralogical Examination of Leach Residues

Mineralogical examination of 10 samples of residues from leaching experiments conducted on a range of materials to identify possible mineralogical changes arising from the experiments. The samples were examined using a combination of binocular microscopy and reflected polarised-light microscopy by Dr David French from CSIRO Energy Technology.

Samples:
- ODXH3.2-05 (Residue from unsaturated column test)
- ODXH4.1-04 (Residue from unsaturated column test)
- ODXH3.2-01 (tailings with Cu staining) (Residue from unsaturated column test)
- ODXH3.2-01 (tailings with Cu staining) (Residue from saturated column test)
- ODXH3.1-04 (clay-rich sediment) (Residue from 2:1 bottle roll sorption tests)
- ODXH3.2-12 (carbonate-rich sediment) (Residue from 2:1 bottle roll sorption tests)
- ODXH3.1-09 (sandy sediment, black colour) (Residue from 2:1 bottle roll sorption tests)
- Core 1 (Andamooka Limestone) (Residue from 2:1 bottle roll sorption tests)
- Core 4 (Arcoona Quartzite) (Residue from saturated column test)
- Core 4 (Arcoona Quartzite) (Unreacted parent sample)

The ten samples were prepared as polished grain mounts. Additional pre- and post-leach materials were was provided but, only a binocular microscope examination was carried out on these samples. The polished grain mounts were examined using reflected polarised light microscopy.

3. RESULTS

3.1 Sequential Extraction of Tailings and Sediment Samples

The samples ODHX 3.2-05, 4.1-05, 4.2-05 and 4.1-10 were subjected to a five-stage sequential extraction which targeted analytes in the forms: (1) dissolved and weakly exchangeable extraction phase (Labile), (2) adsorbed/exchangeable/carbonate phase (Exchangeable), (3) amorphous iron oxy(hydr)oxides (Am-FeOOH), (4) crystalline iron oxides (Cryst-FeOX), and (5) residual material (Residual) (Tables 8 – 11). Measurements for blanks and replicates provided in Appendix A.

The concentrations, in mg/kg, of each analyte extracted in the forms (1) to (5) are shown in Tables 8-11. Also shown in these tables are sum of the five extraction concentrations and the total concentrations measured for a separate subsample of the material analysed previous (Simpson et al., 2008). For aluminium, the total concentrations measured in the earlier sub-sample (Simpson et al., 2008a) were always 2-12 times greater than that measured as the sum of the sequential extraction fractions (1-5). For manganese and lead the opposite was observed, i.e. the sum of extracted phases was much greater than the total measured in the earlier sub-sample. However, for many of the analytes, there was reasonable accord between the sum of the analyte concentrations of the extracted phases and the previously measured total analyte concentration.

The radium-226 extracted from the tailings and sediments was very low, with detectable concentrations only measured for tailings 4.1-04 (Table 11).

A more useful way to interpret the sequential extraction data is as percentages of the total amount extracted (Tables 12 and 13). For the major analytes, the residual fraction contained high percentages of Al (51-87%), Ba (84-92%), Mn (92-98%, Pb (>97%), and Zn (46-72%), but lower percentages of sulfate (1-25%), Sr (18-44%), and U (1-19% of the U in three samples and 58% in sample 4.1-10 which had ~10 mg U/kg).

For the samples 3.2-05, 4.1-05, and 4.2-05, which had >100 mg U/kg, as a percentage of the total, fractions (1) (dissolved) comprised 19-44%, and fraction (2) (Am-FeOOH) comprised 27-46%. For these samples, copper was mostly associated with fractions (3) (9-42% with Am-FeOOH,) and (4) (3-21% with Cryst-FeOX), although for sample 4.2-05 51% of the copper was dissolved, fraction (1). The strontium and zinc were reasonably well distributed amount the different fractions.

Table 8. Metal Concentrations Sequentially Extracted from the Tailing and Sediment Samples, mg/kg (Part 1 of 3)

Sample	Phase [a]	Ag	Al	As	B	Ba	Be	Bi	Cd	Ce	Co	Cr	Cu	Hg	Li	Mn	Mo
3.2-05	Total	2.00	49400	95	60	980	2.00	6.00	<DL	<DL	36.0	19.0	2020	<DL	18	52	63
	1	0.03	2330	0.10	1.67	1.40	0.17	0.03	0.01	76.0	14.3	0.17	122	<DL	4.47	33.7	0.03
	2	0.10	94.0	0.10	1.67	126	0.27	0.20	0.01	42.3	0.97	0.03	7.37	<DL	0.23	2.33	0.10
	3	0.37	1470	15.3	5.97	299	0.07	4.14	0.02	463	0.49	0.49	717	0.03	0.90	1.46	3.10
	4	0.63	1790	15.0	5.23	235	0.11	0.34	0.13	239	0.60	0.04	237	0.04	0.93	1.27	12.4
	5	<DL	6760	134	<DL	3660	<DL	2.00	<DL	713	12	44	620	<DL	4	622	20
	Sum	<DL	12400	165	<DL	4320	<DL	7.00	<DL	1530	28	45	1700	<DL	10	661	36
4.1-04	Total	1.90	43400	77	50	640	2	6	<DL	<DL	44	27	933	<DL	14	101	58
	1	0.03	1670	0.13	1.67	1.70	0.13	0.03	0.02	222	29.0	0.03	0.93	<DL	3.43	97.3	0.03
	2	0.07	25.0	0.03	1.67	246	0.20	0.13	0.02	38.0	0.33	0.27	4.50	<DL	0.13	1.73	0.03
	3	0.30	803	8.10	2.24	135	0.07	2.28	0.01	240	0.52	1.31	113	0.04	0.49	5.23	0.97
	4	0.41	586	10.6	1.87	109	0.04	0.67	0.02	172	0.41	0.04	74	0.03	0.37	1.08	6.38
	5	<DL	3190	26	<DL	3280	<DL	1	<DL	249	8	86	154	<DL	4	2090	8
	Sum	<DL	6270	45	<DL	3770	<DL	4	<DL	921	38	88	346	<DL	8	2200	15
4.1-10	Total	0.08	63000	31	120	100	5	<DL	<DL	475	24	34	13	<DL	29	111	3
	1	0.03	15	0.03	6.40	0.06	0.03	0.03	0.01	0	0.03	0.03	0.03	<DL	0.06	0.09	0.06
	2	0.03	12.8	0.03	1.52	1	0.30	0.03	0.06	1.22	0.15	0.30	6.43	<DL	0.18	0.52	0.09
	3	0.10	326	1.43	2.39	5	0.51	0.07	0.02	80	1.20	0.48	4	<DL	0.20	4.81	0.14
	4	0.34	303	2.70	2.05	2	0.20	0.07	0.83	8	1.50	0.03	1	<DL	0.14	8.60	0.72
	5	<DL	4570	27	<DL	40	<DL	<DL	<DL	78	4	33	46	<DL	2	839	2
	Sum	<DL	5230	31	<DL	48	<DL	<DL	<DL	167	7	34	58	<DL	3	853	3
4.2-05	Total	0.34	51900	21	30	580	3	<DL	<DL	<DL	68	20	2600	<DL	29	269	3
	1	0.03	1870	0.03	1.52	0.67	0.24	0.03	0.03	162	12.71	0.03	1400	<DL	5.34	31.71	0.03
	2	0.06	481	0.03	1.52	8	0.30	0.03	0.01	262	2.16	0.46	570	0.06	0.91	5.30	0.03
	3	0.20	0	1.57	3.76	66	1.50	0.20	0.01	192	2.46	7.07	543	0.01	7.38	16.70	0.03
	4	0.17	9937	3.76	2.73	61	0.31	0.14	0.02	29	0.82	1.09	91	0.01	4.06	18.10	0.72
	5	<DL	28200	16	<DL	1650	<DL	<DL	<DL	191	4	61	181	<DL	9	883	5
	Sum	<DL	40491	21	<DL	1785	<DL	1	<DL	836	22	70	2800	<DL	27	955	6

[a] Phases targeted: 1 = Labile, 2 =Exchangeable, 3 = Am-FeOOH, 4 = Cryst-FeOOH, 5 =Residual. Sum = the sum of phases 1+ 2+3+4+5. Total = the total concentration reported for a different sub-sample of the same material (Simpson et al., 2008a)

Table 9. Metal Concentrations Sequentially Extracted from the Tailing and Sediment Samples, mg/kg (Part 2 of 3)

Sample	Phase [a]	Ni	Pb	Re	Sb	Se	Si	Sn	Sr	Th	Ti	Tl	U	V	W	Y	Zn
3.2-05	Total	5	77	<DL	10	5	ND	19	388	42	<DL	1	148	18	42	70	35
	1	1.50	0.40	0.03	0.03	0.33	95.3	0.03	12.4	0.73	0.33	0.03	44.0	0.33	0.03	15.4	6.83
	2	0.20	6.83	0.03	0.03	0.33	68.7	0.03	12.7	3.00	0.33	0.03	4.47	0.67	0.03	7.33	6.63
	3	0.19	8.18	0.04	1.19	0.41	2780	1.05	26.3	13.6	42.2	0.04	60.5	0.37	0.67	25.4	2.46
	4	0.37	9.89	0.04	0.60	0.49	2530	0.75	11.6	6.76	17.9	0.04	5.38	3.73	3.06	10.4	13.6
	5	5	821	<DL	<DL	<DL	40	<DL	22	12	120	<DL	18	<DL	2	20	75
	Sum	7	846	<DL	<DL	<DL	5520	<DL	85	36	181	<DL	132	<DL	6	78	105
4.1-04	Total	7	70	<DL	9	6	ND	19	523	39	<DL	1	130	21	40	62	34
	1	2.70	0.33	0.03	0.03	0.33	42.0	0.03	17.1	0.77	0.33	0.03	30.2	0.33	0.03	17.2	10.4
	2	0.13	4.53	0.03	0.03	0.33	103	0.03	15.3	2.63	0.33	0.03	4.37	0.67	0.03	2.77	10.9
	3	0.34	10.2	0.04	0.34	0.37	1400	0.37	18.9	10.0	20.9	0.04	18.4	0.75	0.22	12.0	10.2
	4	0.49	7.32	0.04	0.45	0.37	787	0.52	8.06	3.25	14.2	0.04	3.14	4.11	1.61	5.00	23.1
	5	10.0	1880	<DL	<DL	<DL	61.0	<DL	47	6	100	<DL	13	<DL	1	8	46
	Sum	14.0	1902	<DL	<DL	<DL	2410	<DL	106	23	136	<DL	69	<DL	3	45	101
4.1-10	Total	34	88	<DL	1	4	ND	3	284	21	<DL	<DL	10	149	2	87	222
	1	0.03	0.06	0.03	0.03	0.30	51.8	0.03	24.3	0.03	0.30	0.03	0.06	0.30	0.03	0.03	0.73
	2	0.03	1.43	0.03	0.03	0.30	57.9	0.03	68.3	0.06	0.30	0.03	1.16	1.22	0.03	0.40	3.99
	3	0.41	8.13	0.03	0.03	0.41	492	0.03	64.2	3.55	1.37	0.03	1.23	23.2	0.03	5.43	17.0
	4	3.07	2.05	0.03	0.07	0.34	427	0.10	21.5	0.99	8.20	0.03	0.48	11.6	0.07	1.30	39.3
	5	8	715	<DL	<DL	<DL	27	<DL	122	5	60	<DL	4	13	1	21	85
	Sum	12	727	<DL	<DL	<DL	1055	<DL	300	10	70	<DL	7	49	1	28	146
4.2-05	Total	18.0	13.0	<DL	1	9	ND	2	188	11.0	<DL	<DL	648	123	5	221	75.0
	1	1.59	0.06	0.03	0.03	0.30	13.1	0.03	29.4	0.21	0.30	0.03	57.0	0.30	0.03	23.3	19.6
	2	0.27	0.61	0.03	0.03	0.30	71.0	0.03	72.0	6.16	0.30	0.03	77.7	0.91	0.03	40.2	6.86
	3	3.28	4.47	0.03	0.03	0.41	6760	0.03	21.5	8.06	6.83	0.07	119	44.7	0.07	110	11.2
	4	2.46	2.46	0.03	0.03	0.34	3900	0.10	7.82	1.57	8.20	0.03	25.8	19.8	0.10	25.2	14.4
	5	8	844	<DL	<DL	<DL	64.0	5	29.0	15.0	210	<DL	22.0	20.0	0	20	45
	Sum	16	852	<DL	<DL	<DL	10800	5	160	31	226	<DL	301	86.0	1	219	97

[a] Phases targeted: 1 = Labile, 2 =Exchangeable, 3 = Am-FeOOH, 4 = Cryst-FeOOH, 5 =Residual. Sum = the sum of phases 1+ 2+3+4+5. Total = the total concentration reported for a different sub-sample of the same material (Simpson et al., 2008a)

Table 10. Major Anion and Cation Concentrations Sequentially Extracted from the Tailing and Sediment Samples, mg/kg (Part 3 of 3)

Sample	Phase [a]	Cl	SO_4	Ca	Mg	Na	K	Fe
3.2-05	1	1100	25900	6567	167	1000	100	413
	2	297000	567	500	167	560000	267	95
	3	612000	1420	5300	37	14700	1010	2250
	4	1360000	1940	3060	37	112	971	5530
	5	NA	1260	1080	310	200	1370	26400
	Sum	2270000	31100	16500	718	NC	3720	34700
4.1-04	1	1530	37300	8270	767	1270	33	5830
	2	297000	567	500	167	557000	267	7
	3	612000	2910	4820	1270	11200	784	3140
	4	1360000	2730	933	112	37	597	4520
	5	NA	1050	580	440	120	690	19200
	Sum	2270000	44600	15100	2760	NC	2370	32700
4.1-10	1	266000	1460	549	30	506000	274	5
	2	267000	138000	62500	30	515000	213	2
	3	563000	12700	3690	3140	18900	888	13200
	4	1250000	50200	21400	68	34	34	3000
	5	NA	108000	68400	360	60	750	15300
	Sum	2340000	310000	157000	3630	NC	2160	31500
4.2-05	1	1620	47600	17400	122	1070	579	147
	2	264000	80500	29000	30	497000	823	277
	3	574000	2560	4230	1160	10000	717	2800
	4	1280000	6320	1910	1230	444	615	5600
	5	NA	2700	1440	2130	200	2160	20700
	Sum	2120000	1400000	53900	4670	NC	4890	29500

[a] Phases targeted: 1 = Labile, 2 =Exchangeable, 3 = Am-FeOOH, 4 = Cryst-FeOOH, 5 =Residual. Sum = the sum of phases 1+ 2+3+4+5. NA= not analysed. NC = not calculated due to Na content of sodium acetate extractant

Table 11. Radium-226 Sequentially Extracted from the Tailing and Sediment Samples

Sample	Phase [a]	Ra-226, Bq/mL
3.2-05	1	<0.001
	2	0.022 ± 0.002
	3	0.024 ± 0.002
	4	0.012 ± 0.001
	5	<0.001
4.1-04	1	<0.001
	2	0.054 ± 0.005
	3	0.005 ± 0.001
	4	0.009 ± 0.001
	5	<0.001
4.1-10	1	<0.001
	2	<0.001
	3	<0.001
	4	<0.001
	5	<0.001
4.2-05	1	<0.001
	2	<0.002
	3	<0.001
	4	<0.001
	5	<0.001

[a] Phases targeted: 1 = Labile, 2 = Exchangeable, 3 = Am-FeOOH, 4 = Cryst-FeOOH, 5 = Residual. Sum = the sum of phases 1+ 2+3+4+5.

Table 12. Relative Percentage Sequentially Extracted from the Tailing and Sediment Samples, % of total (Part 1 of 3)

Sample	Phase [a]	Al	As	Ba	Bi	Ce	Co	Cr	Cu	Li	Mn	Mo	Ni	Pb	Si	Sr
									% of total							
3.2-05	1	19%	0%	0%	0%	5%	50%	0%	7%	43%	5%	0%	21%	0%	2%	15%
	2	1%	0%	3%	3%	3%	3%	0%	0%	2%	0%	0%	3%	1%	1%	15%
	3	12%	9%	7%	61%	30%	2%	1%	42%	9%	0%	9%	3%	1%	50%	31%
	4	14%	9%	5%	5%	16%	2%	0%	14%	9%	0%	35%	5%	1%	46%	14%
	5	54%	81%	85%	31%	46%	42%	98%	36%	37%	94%	56%	69%	97%	1%	26%
4.1-04	1	27%	0%	0%	1%	24%	76%	0%	0%	42%	4%	0%	20%	0%	2%	16%
	2	0%	0%	7%	4%	4%	1%	0%	1%	2%	0%	0%	1%	0%	4%	14%
	3	13%	18%	4%	63%	26%	1%	1%	33%	6%	0%	6%	2%	1%	59%	18%
	4	9%	24%	3%	19%	19%	1%	0%	21%	5%	0%	41%	4%	0%	33%	8%
	5	51%	58%	87%	14%	27%	21%	98%	44%	46%	95%	52%	73%	99%	3%	44%
4.1-10	1	0%	0%	0%	6%	0%	0%	0%	0%	2%	0%	2%	0%	0%	5%	8%
	2	0%	0%	2%	6%	1%	2%	1%	11%	6%	0%	3%	0%	0%	5%	23%
	3	6%	5%	9%	14%	48%	17%	1%	7%	7%	1%	5%	4%	1%	47%	21%
	4	6%	9%	4%	14%	5%	22%	0%	2%	5%	1%	24%	27%	0%	40%	7%
	5	87%	87%	84%	60%	47%	58%	97%	79%	80%	98%	67%	69%	98%	3%	41%
4.2-05	1	5%	0%	0%	4%	19%	57%	0%	51%	20%	3%	1%	10%	0%	0%	18%
	2	1%	0%	0%	4%	31%	10%	1%	20%	3%	1%	1%	2%	0%	1%	45%
	3	0%	7%	4%	29%	23%	11%	10%	19%	28%	2%	1%	21%	1%	62%	13%
	4	25%	18%	3%	19%	4%	4%	2%	3%	15%	2%	12%	16%	0%	36%	5%
	5	70%	75%	92%	43%	23%	18%	88%	6%	34%	92%	86%	51%	99%	1%	18%

a Phases targeted: 1 = Labile, 2 = Exchangeable, 3 = Am-FeOOH, 4 = Cryst-FeOOH, 5 = Residual

Table 13. Relative Percentage Sequentially Extracted from the Tailing and Sediment Samples (Part 1 of 3)

Sample	Phase [a]	Th	Ti	U	W	Y	Zn	Cl	SO_4	Ca	Mg	Na	K	Fe
		% of total						% of total						
3.2-05	1	2%	0%	33%	1%	20%	7%	0%	83%	40%	23%	NC	3%	1%
	2	8%	0%	3%	1%	9%	6%	13%	2%	3%	23%	NC	7%	0%
	3	38%	23%	46%	12%	32%	2%	27%	5%	32%	5%	NC	27%	6%
	4	19%	10%	4%	56%	13%	13%	60%	6%	19%	5%	NC	26%	16%
	5	33%	66%	13%	31%	25%	72%	NC	4%	7%	43%	NC	37%	76%
4.1-04	1	3%	0%	44%	1%	39%	10%	0%	84%	55%	28%	NC	1%	18%
	2	12%	0%	6%	1%	6%	11%	13%	1%	3%	6%	NC	11%	0%
	3	44%	15%	27%	7%	27%	10%	27%	7%	32%	46%	NC	33%	10%
	4	14%	10%	5%	50%	11%	23%	60%	6%	6%	4%	NC	25%	14%
	5	26%	74%	19%	41%	17%	46%	NC	2%	4%	16%	NC	29%	59%
4.1-10	1	0%	0%	1%	4%	0%	1%	11%	0%	0%	1%	NC	13%	0%
	2	1%	0%	16%	4%	1%	3%	11%	44%	40%	1%	NC	10%	0%
	3	36%	2%	17%	4%	19%	12%	24%	4%	2%	87%	NC	41%	42%
	4	10%	12%	7%	9%	5%	27%	53%	16%	14%	2%	NC	2%	10%
	5	52%	86%	58%	79%	75%	58%	NC	35%	44%	10%	NC	35%	48%
4.2-05	1	1%	0%	19%	6%	11%	20%	0%	34%	32%	3%	NC	12%	0%
	2	20%	0%	26%	6%	18%	7%	12%	58%	54%	1%	NC	17%	1%
	3	26%	3%	40%	14%	50%	12%	27%	2%	8%	25%	NC	15%	9%
	4	5%	4%	9%	20%	12%	15%	60%	5%	4%	26%	NC	13%	19%
	5	48%	93%	7%	54%	9%	46%	NC	2%	3%	46%	NC	44%	70%

a Phases targeted: 1 = Labile, 2 = Exchangeable, 3 = Am-FeOOH, 4 = Cryst-FeOOH, 5 = Residual.

3.2 Deionised Water Leaching of Tailings and Sediment Samples

These tests investigated the successive leaching of substances from two tailings and two sediment materials using deionised water under oxic (oxygenated) and anoxic conditions (deoxygenated). A nominal test-water to test-solid ratio (W:S) of 2, however, as the materials were moist, the actual W:S ratios varied from 2.7 to 3.0 (Table 4).

The water quality characteristics during the leach tests are provided in Tables 14-17. Measurements for blanks and replicates provided in Appendix B.

Concentrations of radium-226 were below <0.001 Bq/mL for all week-1 leachates (Table 18). The concentrations of analytes extracted using successive week-long extractions in oxygenated and deoxygenated deionised water are shown in Tables 19-21). The ratio of analyte concentration extracted in oxygenated water to that extracted in deoxygenated water for each week indicated that, in general, there was not a large difference in the two sets of results (calculations not shown), i.e. the presence of oxygen in the deionised water did not significantly affect the leachability of the materials.

Table 14. Measurements of pH, Redox Potential, Conductivity and Dissolved Oxygen Concentrations During Leach Tests for sample 4.1-04:

Week	Day	Sample	Water (deionised) / Atmosphere	pH	Redox Potential, Eh, mV	Conductivity mS/cm	Dissolved oxygen, mg/L
1	1	4.1_04	Oxygenated, Air	4.3	368	6.8	4.5
1	3		Oxygenated, Air	4.9	342	7.4	7.5
1	5		Oxygenated, Air	4.9	331	7.2	7.9
2	8		Oxygenated, Air	5.0	343	7.2	7.8
2	10		Oxygenated, Air	5.2	341	3.1	7.5
2	12		Oxygenated, Air	5.5	377	3.0	7.9
3	15		Oxygenated, Air	6.0	412	2.9	10.4
3	17		Oxygenated, Air	6.9	568	2.5	10.4
3	19		Oxygenated, Air	6.8	476	2.5	11.2
3	21		Oxygenated, Air	6.8	458	2.4	10.4
1	1	4.1_04	Deoxygenated, $N_{2(g)}$	4.4	362	7.0	0.4
1	3		Deoxygenated, $N_{2(g)}$	4.9	320	7.8	0.3
1	5		Deoxygenated, $N_{2(g)}$	5.2	299	7.7	0.2
2	8		Deoxygenated, $N_{2(g)}$	5.2	292	7.5	0.3
2	10		Deoxygenated, $N_{2(g)}$	5.5	291	3.3	0.6
2	12		Deoxygenated, $N_{2(g)}$	5.8	249	3.3	0.1
3	15		Deoxygenated, $N_{2(g)}$	5.9	242	3.2	0.7
3	17		Deoxygenated, $N_{2(g)}$	6.7	397	2.4	1.2
3	19		Deoxygenated, $N_{2(g)}$	6.5	409	2.4	1.0
3	21		Deoxygenated, $N_{2(g)}$	6.5	415	2.2	0.8

Table 15. Measurements of pH, Redox Potential, Conductivity and Dissolved Oxygen Concentrations During Leach Tests for sample 3.2-05

Week	Day	Sample	Water (deionised) / Atmosphere	pH	Redox Potential, Eh, mV	Conductivity mS/cm	Dissolved oxygen, mg/L
1	1	3.2_05	Oxygenated, Air	3.0	502	5.2	3.8
1	3		Oxygenated, Air	3.1	513	6.0	7.8
1	5		Oxygenated, Air	3.2	514	6.0	9.1
2	8		Oxygenated, Air	3.2	523	5.9	9.8
2	10		Oxygenated, Air	3.3	514	3.1	9.1
2	12		Oxygenated, Air	3.4	509	3.1	9.3
3	15		Oxygenated, Air	3.5	519	2.9	10.4
3	17		Oxygenated, Air	4.0	516	2.5	10.7
3	19		Oxygenated, Air	3.8	502	2.2	11.2
3	21		Oxygenated, Air	3.8	509	2.2	11.3
1	1	3.2_05	Deoxygenated, $N_{2(g)}$	3.2	494	4.7	0.4
1	3		Deoxygenated, $N_{2(g)}$	4.0	466	6.4	0.5
1	5		Deoxygenated, $N_{2(g)}$	3.2	484	5.8	0.3
2	8		Deoxygenated, $N_{2(g)}$	3.2	484	5.7	0.2
2	10		Deoxygenated, $N_{2(g)}$	3.4	479	3.1	0.9
2	12		Deoxygenated, $N_{2(g)}$	3.6	489	3.1	0.2
3	15		Deoxygenated, $N_{2(g)}$	3.5	490	2.9	1.3
3	17		Deoxygenated, $N_{2(g)}$	4.1	502	2.4	1.2
3	19		Deoxygenated, $N_{2(g)}$	3.7	482	2.3	1.0
3	21		Deoxygenated, $N_{2(g)}$	3.6	489	2.3	0.9

Table 16. Measurements of pH, Redox Potential, Conductivity and Dissolved Oxygen Concentrations During Leach Tests for sample 4.2-05

Week	Day	Sample	Water (deionised) / Atmosphere	pH	Redox Potential, Eh, mV	Conductivity mS/cm	Dissolved oxygen, mg/L
1	1	4.2_05	Oxygenated, Air	3.7	486	5.4	5.1
1	3		Oxygenated, Air	3.9	472	6.4	8.5
1	5		Oxygenated, Air	3.9	477	6.3	9.7
2	8		Oxygenated, Air	4.0	489	6.3	9.7
2	10		Oxygenated, Air	3.9	489	3.9	9.0
2	12		Oxygenated, Air	4.1	491	3.9	9.2
3	15		Oxygenated, Air	4.1	472	3.8	10.4
3	17		Oxygenated, Air	4.5	487	2.3	10.7
3	19		Oxygenated, Air	4.3	489	3.1	11.0
3	21		Oxygenated, Air	4.3	499	3.2	11.0
1	1	4.2_05	Deoxygenated, $N_{2(g)}$	3.9	478	5.0	0.4
1	3		Deoxygenated, $N_{2(g)}$	3.1	498	5.8	0.8
1	5		Deoxygenated, $N_{2(g)}$	4.0	472	6.4	0.3
2	8		Deoxygenated, $N_{2(g)}$	4.1	421	6.2	0.5
2	10		Deoxygenated, $N_{2(g)}$	4.2	462	3.9	1.0
2	12		Deoxygenated, $N_{2(g)}$	4.3	466	3.9	0.2
3	15		Deoxygenated, $N_{2(g)}$	4.3	447	3.9	1.3
3	17		Deoxygenated, $N_{2(g)}$	4.6	476	3.0	1.2
3	19		Deoxygenated, $N_{2(g)}$	4.2	469	3.0	1.1
3	21		Deoxygenated, $N_{2(g)}$	4.2	461	2.9	0.9

Table 17. Measurements of pH, Redox Potential, Conductivity and Dissolved Oxygen Concentrations During Leach Tests for sample 4.1-10

Week	Day	Sample	Water (deionised) / Atmosphere	pH	Redox Potential, Eh, mV	Conductivity mS/cm	Dissolved oxygen, mg/L
1	1	4.1_10	Oxygenated, Air	6.8	340	4.7	4.5
1	3		Oxygenated, Air	7.0	330	6.3	8.5
1	5		Oxygenated, Air	7.1	360	6.3	9.4
2	8		Oxygenated, Air	7.1	415	6.1	9.9
2	10		Oxygenated, Air	7.9	360	4.4	9.9
2	12		Oxygenated, Air	8.0	495	4.4	9.3
3	15		Oxygenated, Air	7.3	374	4.3	10.5
3	17		Oxygenated, Air	7.3	387	3.2	10.5
3	19		Oxygenated, Air	7.3	491	3.3	11.0
3	21		Oxygenated, Air	7.3	479	3.4	11.0
1	1	4.1_10	Deoxygenated, $N_{2(g)}$	7.8	365	4.5	0.4
1	3		Deoxygenated, $N_{2(g)}$	7.7	267	5.9	0.4
1	5		Deoxygenated, $N_{2(g)}$	7.8	363	5.7	0.3
2	8		Deoxygenated, $N_{2(g)}$	7.5	349	5.8	0.3
2	10		Deoxygenated, $N_{2(g)}$	7.6	322	4.2	0.8
2	12		Deoxygenated, $N_{2(g)}$	7.1	332	4.2	0.3
3	15		Deoxygenated, $N_{2(g)}$	6.8	326	4.1	1.0
3	17		Deoxygenated, $N_{2(g)}$	6.6	430	3.0	1.7
3	19		Deoxygenated, $N_{2(g)}$	6.2	385	3.0	1.2
3	21		Deoxygenated, $N_{2(g)}$	6.2	392	3.0	1.0

Table 18. Radium-226 Extracted from the Tailing and Sediment Samples - week 1

Sample	Atmosphere	Ra-226, Bq/mL
3.2-05	$N_{2(g)}$	<0.001
4.1-04		<0.001
4.1-10		<0.001
4.2-05		<0.001
3.2-05	Air	<0.001
4.1-04		<0.001
4.1-10		<0.001
4.2-05		<0.001

Table 19. Metals Leached From Tailings and Sediment Samples (1 of 3).

Sample	Water Atmos	Week	Ag mg/L	Al mg/L	As mg/L	B mg/L	Ba mg/L	Be mg/L	Bi mg/L	Cd mg/L	Ce mg/L	Co mg/L	Cr mg/L	Cu mg/L
3.2_05	$N_{2(g)}$	1	<0.001	700	0.039	0.38	0.019	0.063	<0.001	0.0026	49.4	4.65	0.083	35.8
		2	<0.001	204	0.018	0.16	0.013	0.019	<0.001	0.0008	16.1	1.44	0.019	11.9
		3	<0.001	57.6	0.01	<0.05	0.013	0.005	<0.001	0.0006	7.43	0.379	0.003	4.62
	Air	1	<0.001	719	0.036	0.14	0.018	0.042	<0.001	0.0014	60.6	4.74	0.087	56
		2	<0.001	176	0.018	0.09	0.014	0.014	<0.001	0.0005	18.8	1.33	0.013	28.9
		3	<0.001	40.7	0.01	0.05	0.012	0.004	<0.001	0.0003	8.5	0.426	<0.001	18.1
4.1_04	$N_{2(g)}$	1	<0.001	292	0.038	0.68	0.022	0.025	<0.001	0.0022	40	8.76	<0.001	0.016
		2	<0.001	11.5	0.006	0.14	0.012	0.004	<0.001	0.0006	0.389	1.95	<0.001	<0.001
		3	<0.001	0.29	0.001	<0.05	0.012	<0.001	<0.001	0.0004	0.005	0.093	<0.001	<0.001
	Air	1	<0.001	397	0.026	0.49	0.016	0.029	<0.001	0.0031	37.5	8.93	<0.001	0.015
		2	<0.001	16.2	0.003	<0.05	0.012	0.004	<0.001	0.0003	0.119	1.64	0.002	0.034
		3	<0.001	0.63	0.002	<0.05	0.011	<0.001	<0.001	0.0002	0.003	0.225	<0.001	<0.001
4.1_10	$N_{2(g)}$	1	<0.001	0.17	0.002	4.28	0.008	<0.001	<0.001	0.0002	0.013	0.003	<0.001	<0.001
		2	<0.001	0.19	<0.001	5.56	0.011	<0.001	<0.001	0.0007	0.007	0.005	0.002	0.012
		3	<0.001	0.02	<0.001	2.64	0.011	<0.001	<0.001	0.001	0.002	0.003	0.002	<0.001
	Air	1	<0.001	<0.01	0.004	4.69	0.006	<0.001	<0.001	<0.0001	0.004	0.001	0.002	<0.001
		2	<0.001	0.03	0.002	3.7	0.008	<0.001	<0.001	<0.0001	0.005	0.001	0.002	0.012
		3	<0.001	0.11	<0.001	2.48	0.007	<0.001	<0.001	0.0001	<0.001	<0.001	0.002	0.01
4.2_05	$N_{2(g)}$	1	<0.001	818	0.009	0.34	0.035	0.11	<0.001	0.0037	37.8	5.17	0.003	382
		2	<0.001	385	0.006	0.28	0.032	0.053	<0.001	0.0019	16	2.27	0.002	170
		3	<0.001	192	0.003	0.16	0.027	0.027	<0.001	0.0009	9.32	1.23	<0.001	85.8
	Air	1	<0.001	865	0.009	0.31	0.034	0.097	<0.001	0.0018	28.7	4.39	0.006	177
		2	<0.001	470	0.005	0.25	0.034	0.052	<0.001	0.0008	12	1.97	0.002	81.5
		3	<0.001	330	0.004	0.13	0.03	0.028	<0.001	0.0006	7.97	1.18	<0.001	47.6

Table 20. Metals Leached from Tailings and Sediment Samples (2 of 3).

Sample	Water Atmos	Week	Hg mg/L	Li mg/L	Mn mg/L	Mo mg/L	Ni mg/L	Pb mg/L	Re mg/L	Sb mg/L	Se mg/L	Si mg/L	Sn mg/L	Sr mg/L
3.2_05	$N_{2(g)}$	1	<0.0001	1.51	11.1	<0.001	0.455	0.059	<0.001	0.001	0.037	18.1	0.002	2.81
		2	<0.0001	0.454	3.35	<0.001	0.135	0.032	<0.001	<0.001	0.014	11.9	<0.001	1.52
		3	0.0001	0.09	0.864	<0.001	0.034	0.012	<0.001	<0.001	<0.010	8.47	<0.001	1.01
	Air	1	<0.0001	1.21	10.6	<0.001	0.475	0.045	<0.001	<0.001	0.07	14.5	<0.001	2.5
		2	<0.0001	0.354	2.86	<0.001	0.133	0.023	<0.001	<0.001	0.018	12.8	<0.001	1.41
		3	<0.0001	0.081	0.769	<0.001	0.04	0.008	<0.001	<0.001	0.01	8.6	<0.001	0.963
4.1_04	$N_{2(g)}$	1	<0.0001	1.06	16	<0.001	0.73	<0.001	<0.001	<0.001	0.032	6.25	<0.001	2.41
		2	<0.0001	0.303	8.13	<0.001	0.128	<0.001	<0.001	<0.001	<0.010	6.59	<0.001	1.22
		3	<0.0001	0.058	1.65	0.003	0.01	<0.001	<0.001	<0.001	<0.010	4.31	<0.001	0.789
	Air	1	<0.0001	1.22	15.6	<0.001	0.792	<0.001	<0.001	<0.001	0.044	6.47	<0.001	2.26
		2	<0.0001	0.318	7.2	<0.001	0.14	<0.001	<0.001	<0.001	<0.010	7.71	<0.001	1.02
		3	<0.0001	0.084	1.9	0.004	0.013	<0.001	<0.001	<0.001	0.011	5.05	<0.001	0.717
4.1_10	$N_{2(g)}$	1	<0.0001	0.022	0.01	0.074	<0.001	<0.001	<0.001	<0.001	<0.010	2.3	<0.001	3.58
		2	<0.0001	0.031	0.053	0.005	<0.001	<0.001	<0.001	<0.001	<0.010	3.46	<0.001	2.86
		3	<0.0001	0.016	0.04	0.006	<0.001	0.001	<0.001	<0.001	<0.010	2.78	<0.001	2.36
	Air	1	<0.0001	0.02	0.002	0.068	<0.001	<0.001	<0.001	<0.001	<0.010	2.45	<0.001	3.59
		2	<0.0001	0.015	0.003	0.039	<0.001	<0.001	<0.001	<0.001	<0.010	2.61	<0.001	2.87
		3	<0.0001	0.009	<0.001	0.028	<0.001	<0.001	<0.001	<0.001	<0.010	2.31	<0.001	2.51
4.2_05	$N_{2(g)}$	1	<0.0001	2.55	2.95	<0.001	0.581	<0.001	<0.001	<0.001	0.05	14.5	<0.001	2.19
		2	<0.0001	1.08	6.87	<0.001	0.258	<0.001	<0.001	<0.001	0.024	13.8	<0.001	1.67
		3	<0.0001	0.473	3.58	<0.001	0.143	<0.001	<0.001	<0.001	0.012	11.6	<0.001	1.55
	Air	1	<0.0001	2.2	10.8	<0.001	0.512	<0.001	<0.001	<0.001	0.039	17.6	<0.001	2.1
		2	<0.0001	1.01	4.72	<0.001	0.232	<0.001	<0.001	<0.001	0.017	16.6	<0.001	1.68
		3	<0.0001	0.504	2.79	<0.001	0.143	<0.001	<0.001	<0.001	0.015	14.2	<0.001	1.62

Table 21. Metals Leached from Tailings and Sediment Samples (3 of 3).

Sample	Water Atmos	Week	Th mg/L	Ti mg/L	Tl mg/L	U mg/L	V mg/L	W mg/L	Y mg/L	Zn mg/L
3.2_05	$N_{2(g)}$	1	0.35	0.02	0.001	14.2	0.04	0.004	6	1.5
		2	0.092	<0.01	<0.001	4.1	<0.01	0.001	1.88	0.219
		3	0.03	<0.01	<0.001	0.968	<0.01	<0.001	0.74	0.162
	Air	1	0.393	0.02	0.002	15	0.03	0.005	6.23	1.92
		2	0.104	0.01	<0.001	4.17	<0.01	0.001	1.9	0.597
		3	0.035	<0.01	<0.001	1.06	<0.01	<0.001	0.778	0.153
4.1_04	$N_{2(g)}$	1	0.002	<0.01	<0.001	4.56	<0.01	0.003	2.83	2.24
		2	<0.001	<0.01	<0.001	0.454	<0.01	<0.001	0.09	0.019
		3	<0.001	<0.01	<0.001	0.653	<0.01	<0.001	0.003	0.008
	Air	1	0.002	<0.01	<0.001	5.34	<0.01	0.003	3.78	2.36
		2	<0.001	<0.01	<0.001	0.18	<0.01	<0.001	0.028	<0.005
		3	<0.001	<0.01	<0.001	0.201	<0.01	<0.001	0.001	0.01
4.1_10	$N_{2(g)}$	1	<0.001	<0.01	<0.001	0.02	<0.01	<0.001	0.001	<0.005
		2	<0.001	<0.01	<0.001	0.007	<0.01	<0.001	0.001	<0.005
		3	<0.001	<0.01	<0.001	0.002	<0.01	<0.001	<0.001	<0.005
	Air	1	<0.001	<0.01	<0.001	0.025	0.01	<0.001	<0.001	0.039
		2	<0.001	<0.01	<0.001	0.019	<0.01	<0.001	<0.001	<0.005
		3	<0.001	<0.01	<0.001	0.012	0.01	<0.001	<0.001	0.006
4.2_05	$N_{2(g)}$	1	0.084	<0.01	0.003	22.1	<0.01	0.004	6.04	2.99
		2	0.027	<0.01	0.002	8.44	<0.01	0.002	2.61	1.16
		3	0.011	<0.01	0.001	3.64	<0.01	0.001	1.48	0.803
	Air	1	0.14	<0.01	0.003	18.9	<0.01	0.004	5.04	1.79
		2	0.044	<0.01	0.002	7.01	<0.01	0.001	2.16	0.679
		3	0.019	<0.01	0.001	3.31	<0.01	0.001	1.37	0.587

Table 22. Major Anion and Cations Leached from Tailings and Sediment Samples.

Sample	Water Atmos	Week	Sulfate mg/L	Chloride mg/L	Calcium mg/L	Magnesium mg/L	Sodium mg/L	Potassium mg/L	Iron mg/L
3.2_05	$N_{2(g)}$	1	4170	306	437	45	293	37	579
		2	2240	89	525	15	91	16	170
		3	1610	18	577	4	21	7	38.5
	Air	1	4370	357	444	45	310	34	580
		2	2180	87	522	14	89	13	168
		3	1680	25	577	4	24	6	30.4
4.1_04	$N_{2(g)}$	1	7080	453	471	359	374	25	1620
		2	2640	103	569	167	99	11	240
		3	1640	25	590	91	27	6	0.10
	Air	1	5850	434	475	370	362	18	1220
		2	2170	85	562	215	84	8	0.19
		3	1700	30	594	100	29	5	0.18
4.1_10	$N_{2(g)}$	1	3200	700	543	46	1290	4	0.56
		2	2490	279	550	36	729	5	0.19
		3	1920	83	566	26	297	4	0.13
	Air	1	3200	828	518	47	1400	4	0.34
		2	2570	296	529	35	781	3	0.11
		3	2220	128	560	29	465	3	0.33
4.2_05	$N_{2(g)}$	1	4490	680	477	54	420	508	149
		2	2960	212	521	28	186	72	53.0
		3	2360	62	563	20	90	48	22.1
	Air	1	4410	453	454	54	405	92	161
		2	2970	142	511	36	203	65	47.7
		3	2420	54	551	27	108	48	17.7

3.3 Unsaturated Column Tests

These tests were undertaken for 21 weeks on three tailings materials using deionised water.

The seepage rates of water through tailings in the unsaturated columns tests differed for each material. For tailings 3.1-05, after 5 days ~50% of 'rainwater' has percolated through, then remainder assisted through with vacuum over long day (slow). For tailings sample 4.1-04, after 5 days ~50% of 'rainwater' has percolated through, then remainder assisted through with vacuum over ~4 h (relatively quick). For tailings 3.2-01, after 5 days ~90% of 'rainwater' has percolated through, then remainder assisted through with vacuum over 1-2 h (relatively quick). Care was taken not to use vacuum too much as this results in cracks right through the tailings column. To ensure no preferential flow paths, at the start of each water-renewal, the surface layer was wet and mixed to fill in any small surface cracks. From week 17 onwards, the tailings material was mixed right through when re-wet to further ensure no preferential flow paths existed.

The volumes of water passed through each column and the physico-chemical parameters measured for each unsaturated column test are shown for each week in Tables 23 and 24. The concentrations of radium-226 measured in the leachates are shown in Table 25. The concentrations of all other analytes are shown in Tables 26-37. Quality assurance data are provided in Appendix C.

Table 23. Masses and Volumes Leached for Unsaturated Column Test of Tailings

	ODXH 3.2-01	ODXH 3.2-05	ODXH 4.1-04
Mass, g	Wet / Dry	Wet / Dry	Wet / Dry
	2000 / 1740	2000 / 1550	1000 / 785
Week	Volume, mL	Volume, mL	Volume, mL
1	807	622	309
2	615	607	292
3	569	635	308
4	597	566	309
5	573	594	283
6	628	569	280
7	586	537	316
8	605	617	285
9	599	569	296
10	613	555	311
11	603	534	279
12	581	566	323
13	591	591	299
14	576	580	283
15	659	569	315
16	570	535	287
17	603	568	300
18	589	576	303
19	525	550	290
20	638	572	295
21	651	622	316

Aerated deionised water (weekly cycle) and air atmosphere

Table 24. Physico-Chemical Parameters for Unsaturated Column Test of Tailings

	ODXH 3.2-01			ODXH 3.2-05			ODXH 4.1-04		
	pH	Eh	EC	pH	Eh	EC	pH	Eh	EC
Week		mV	mS/cm		mV	mS/cm		mV	mS/cm
1	8.2	277	23.6	2.9	559	16.5	3.4	520	35.6
2	7.5	514	17.5	2.9	549	8.2	3.7	502	9.3
3	7.1	506	10.4	3.1	527	4.6	4.2	473	4.7
4	7.1	513	6.1	3.2	515	3.0	4.6	492	2.7
5	7.0	510	4.2	3.5	507	2.6	5.5	498	2.6
6	7.4	577	3.5	3.6	501	2.4	6.2	556	2.5
7	7.3	522	2.8	3.6	500	2.3	6.3	509	2.4
8	7.4	525	2.5	3.9	516	2.1	6.4	519	2.2
9	7.2	531	2.2	4.0	514	2.3	6.5	524	2.3
10	7.4	528	2.2	4.0	506	2.2	6.4	520	2.2
11	7.1	537	1.6	3.9	514	2.3	6.6	518	2.3
12	7.3	534	2.3	4.0	507	2.2	6.5	525	2.3
13	7.2	528	2.1	4.0	519	2.1	6.6	512	2.4
14	7.3	486	1.9	4.1	539	2.1	6.8	522	2.4
15	7.2	537	1.9	4.1	509	2.0	6.7	518	2.2
16	7.2	547	1.9	4.0	522	2.1	6.8	537	2.3
17	7.3	541	1.7	4.1	507	2.0	6.7	525	2.3
18	7.2	523	1.8	3.9	528	2.1	6.7	524	2.3
19	7.2	536	1.7	4.2	522	1.0	6.6	529	2.2
20	7.3	610	1.3	4.1	558	1.3	6.7	578	2.3
21	7.4	611	1.5	3.9	522	1.9	6.5	573	2.0

Aerated deionised water (weekly cycle) and air atmosphere

Table 25. Radionuclides in Leachates from Unsaturated Column Test Of Tailings

	Radium-226, Bq/mL		
Week	ODXH 3.2-01	ODXH 3.2-05	ODXH 4.1-04
1	<0.0001	<0.0001	<0.0001
2	<0.0001	0.0004±0.0001	<0.0001
3	<0.0001	0.0004±0.0001	<0.0001
6	<0.0001	<0.0001	<0.0001
15	NA	NA	NA

Table 26. Major Anions, Cations, Alkalinity/Acidity and Inorganic Carbon in Leachate Water for Tailings 3.2-05

Week	Cl^- mg/L	SO_4^{2-} mg/L	Na mg/L	K mg/L	Mg mg/L	Ca mg/L	Fe mg/L	Carbonate Alkalinity as $CaCO_3$ mg/L	Bicarbonate Alkalinity as $CaCO_3$ mg/L	Total Alkalinity as $CaCO_3$ mg/L	Acidity as $CaCO_3$ mg/L	Dissolved Inorganic Carbon mg/L
1	1090	17600	1550	88	253	577	2270	<1	<1	<1	18700	<1
2	422	3360	234	28	30	465	722	<1	<1	<1	1540	<1
3	184	2940	205	29	26	464	265	<1	<1	<1	515	<1
6	139	1610	21	11	3	558	15.5	<1	<1	<1	176	<1
9	37	1680	2	8	<1	644	4.9	<1	<1	<1	85	<1
12	33	1540	1	7	<1	640	4.5	<1	<1	<1	77	<1
15	2	1190	2	6	<1	478	<0.50	<1	<1	<1	70	<1
18	23	1470	2	8	<1	590	4.84	<1	<1	<1	85	4
21	6	1190	<1	7	<1	494	5.36	<1	<1	<1	74	3

NM = not measured due to insufficient samples volume

Table 27. Major Anions, Cations, Alkalinity/Acidity and Inorganic Carbon in Leachate Water for Tailings 4.1-04

Week	Cl^- mg/L	SO_4^{2-} mg/L	Na mg/L	K mg/L	Mg mg/L	Ca mg/L	Fe mg/L	Carbonate Alkalinity as $CaCO_3$ mg/L	Bicarbonate Alkalinity as $CaCO_3$ mg/L	Total Alkalinity as $CaCO_3$ mg/L	Acidity as $CaCO_3$ mg/L	Dissolved Inorganic Carbon mg/L
1	610	30900	2100	6	1840	613	7720	<1	<1	<1	NM	<1
2	546	9390	701	5	656	606	1550	<1	<1	<1	NM	<1
3	213	3430	221	4	287	541	393	<1	<1	<1	NM	<1
6	12	1840	24	5	96	584	0.63	<1	26	26	NM	4
9	2	831	4	2	24	325	0.73	<1	18	18	NM	4
12	7	779	3	2	18	309	0.60	<1	17	17	4	4
15	<5	1390	4	4	32	539	<0.50	<1	30	30	7	<1
18	37	1690	4	5	37	665	0.11				15	10
21	38	1230	2	4	20	508	<0.05	<1	28	28		<1

NM = not measured due to insufficient samples volume

Table 28. Major Anions, Cations, Alkalinity/Acidity and Inorganic Carbon in Leachate Water for Tailings 3.2-01

	Cl^-	SO_4^{2-}	Na	K	Mg	Ca	Fe	Carbonate Alkalinity as $CaCO_3$	Bicarbonate Alkalinity as $CaCO_3$	Total Alkalinity as $CaCO_3$	Acidity as $CaCO_3$	Dissolved Inorganic Carbon
Week	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1	11500	15000	10700	298	2050	759	0.39	<1	285	285	<1	66
2	4520	9560	5540	170	822	906	0.19	<1	156	156	<1	36
3	407	3880	1990	69	340	546	0.14	<1	112	112	<1	29
6	258	1890	278	30	112	548	0.26	<1	91	91	<1	20
9	88	1300	50	19	49	493	0.49	<1	67	67	5	16
12	50	1320	22	17	41	525	0.54	<1	75	75	NM	17
15	43	967	9	12	23	412	<0.50	<1	69	69	6	26
18	66	1140	7	13	19	472	<0.05	<1	115	115	10	15
21	33	753	4	10	12	369	<0.05	<1	73	73	10	15

NM = not measured due to insufficient samples volume

Table 29. Primary Mineral Forming Cations in Leachate Water for Tailings 3.2-05 (Part 1 of 3)

	Ag	Al	As	B	Ba	Be	Bi	Cd	Ce	Co	Cr	Cu
Week	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1	<0.001	3520	0.096	<0.001	0.42	0.072	0.169	0.0073	256	17.9	0.352	252
2	<0.001	1250	0.079	<0.001	0.37	0.0375	0.071	0.00465	149	6.065	0.1015	101
3	<0.001	453	0.049	<0.001	0.33	0.022	0.032	0.0026	60.6	2.66	0.033	61.2
6	<0.001	14.1	0.030	<0.001	0.15	0.024	0.003	0.0032	15.5	0.711	0.002	29.2
9	<0.001	4.29	0.033	0.10	0.031	<0.001	<0.001	0.0019	9.77	0.743	<0.001	25.4
12	<0.001	2.47	0.028	0.25	0.024	<0.001	<0.001	0.0007	6.99	0.582	0.004	21.4
15	<0.010	1.3	0.037	<0.10	0.02	<0.010	<0.010	<0.0010	5.78	0.496	<0.010	21
18	<0.001	1.52	0.024	0.06	0.035	<0.001	<0.001	0.0003	4.33	0.301	<0.001	12.1
21	<0.001	1.53	0.024	0.07	0.027	<0.001	<0.001	0.0003	4.16	0.309	<0.001	12.2

Au <0.001 mg/L in all samples

Table 30. Primary Mineral Forming Cations in Leachate Water for Tailings 4.1-04 (Part 1 of 3)

Week	Ag mg/L	Al mg/L	As mg/L	B mg/L	Ba mg/L	Be mg/L	Bi mg/L	Cd mg/L	Ce mg/L	Co mg/L	Cr mg/L	Cu mg/L
1	<0.010	1980	0.078	<0.010	0.99	0.015	0.217	0.0089	248	41.7	<0.001	0.232
2	<0.001	286	0.035	<0.001	0.31	0.016	0.043	0.0043	99.8	9.66	<0.001	0.074
3	<0.001	67.0	0.010	<0.001	0.23	0.012	0.015	0.0026	16.3	3.31	<0.001	0.024
6	<0.001	0.83	0.006	<0.001	0.10	0.059	<0.001	0.0011	0.071	0.272	<0.001	0.015
9	<0.001	0.40	0.004	0.18	0.043	<0.001	<0.001	0.0008	0.017	0.173	0.002	0.021
12	<0.001	0.34	0.003	0.16	0.017	<0.001	<0.001	0.0014	0.009	0.118	0.001	0.015
15	<0.010	<0.10	<0.010	<0.10	0.019	<0.010	<0.010	<0.0010	<0.010	0.102	<0.010	<0.010
18	<0.001	0.11	0.001	<0.05	0.028	<0.001	<0.001	0.0003	0.006	0.085	<0.001	0.025
21	<0.001	0.07	<0.001	<0.05	0.024	<0.001	<0.001	0.0002	0.009	0.064	<0.001	0.024

Au <0.001 mg/L in all samples

Table 31. Primary Mineral Forming Cations in Leachate Water for Tailings 3.2-01 (Part 1 of 3)

Week	Ag mg/L	Al mg/L	As mg/L	B mg/L	Ba mg/L	Be mg/L	Bi mg/L	Cd mg/L	Ce mg/L	Co mg/L	Cr mg/L	Cu mg/L
1	<0.001	0.10	0.010	<0.001	5.22	0.018	<0.001	0.0131	0.009	0.086	<0.001	0.700
2	<0.001	0.09	0.008	<0.001	4.19	0.024	<0.001	<0.0001	0.003	0.055	<0.001	0.297
3	<0.001	0.10	0.005	<0.001	3.40	0.019	<0.001	<0.0001	0.002	0.033	<0.001	0.186
6	<0.001	0.07	0.003	<0.001	1.735	0.029	<0.001	<0.0001	0.006	0.0605	<0.001	0.3085
9	<0.001	0.04	0.002	1.11	0.025	<0.001	<0.001	<0.0001	0.002	0.048	0.001	0.201
12	<0.001	0.02	0.002	1.02	0.021	<0.001	<0.001	<0.0001	0.001	0.050	<0.001	0.265
15	<0.010	<0.10	<0.010	0.81	0.057	<0.010	<0.010	<0.0010	<0.010	0.054	<0.010	0.379
18	<0.001	0.01	0.002	0.42	0.030	<0.001	<0.001	<0.0001	0.001	0.043	<0.001	0.252
21	<0.001	<0.01	0.001	0.34	0.026	<0.001	<0.001	<0.0001	<0.001	0.038	<0.001	0.250

Au <0.001 mg/L in all samples

Table 32. Primary Mineral Forming Cations in Leachate Water for Tailings 3.2-05 (Part 2 of 3)

Week	Hg mg/L	Li mg/L	Mn mg/L	Mo mg/L	Ni mg/L	Pb mg/L	Re mg/L	Sb mg/L	Se mg/L	Si mg/L
1	<0.0001	4.67	45.3	0.003	1.70	0.048	0.012	0.006	0.251	103
2	<0.0001	1.82	14.7	0.001	0.5935	0.036	0.004	0.002	0.094	32
3	<0.0001	0.758	5.98	<0.001	0.263	0.044	0.002	<0.001	0.041	29.3
6	<0.0001	0.044	0.645	<0.001	0.059	0.013	<0.001	<0.001	0.022	29.5
9	<0.0001	0.009	0.136	<0.001	0.048	0.007	<0.001	<0.001	0.018	28.5
12	<0.0001	0.010	0.032	<0.001	0.025	0.005	<0.001	<0.001	0.014	26.2
15	<0.0001	<0.010	<0.010	<0.010	0.016	<0.010	<0.001	<0.010	<0.050	20
18	<0.0001	0.007	0.010	<0.001	0.009	0.004	<0.001	<0.001	0.013	25.7
21	<0.0001	0.008	0.007	<0.001	0.009	0.004	<0.001	<0.001	0.015	24.2

Table 33. Primary Mineral Forming Cations in Leachate Water for Tailings 4.1-04 (Part 2 of 3)

Week	Hg mg/L	Li mg/L	Mn mg/L	Mo mg/L	Ni mg/L	Pb mg/L	Re mg/L	Sb mg/L	Se mg/L	Si mg/L
1	<0.0001	5.83	151	0.001	3.81	0.008	0.001	<0.001	0.324	34.3
2	<0.0001	1.34	35.8	<0.001	0.829	0.005	0.007	<0.001	0.067	31.2
3	<0.0001	0.483	12.8	<0.001	0.284	0.001	0.003	<0.001	0.017	18.9
6	<0.0001	0.050	1.40	0.001	0.021	0.001	0.004	<0.001	0.016	17.4
9	<0.0001	0.026	0.473	0.004	0.010	<0.001	<0.001	<0.001	<0.010	9.06
12	<0.0001	0.018	0.264	0.006	0.005	0.001	<0.001	<0.001	<0.010	8.58
15	<0.0001	<0.010	<0.010	0.012	<0.010	<0.010	<0.001	<0.010	<0.050	13.3
18	<0.0001	0.012	0.184	0.014	0.001	<0.001	<0.001	<0.001	<0.010	15.8
21	<0.0001	0.008	0.102	0.016	0.001	0.002	<0.001	<0.001	<0.010	13.2

Table 34. Primary Mineral Forming Cations in Leachate Water for Tailings 3.2-01 (Part 2 of 3)

Week	Hg mg/L	Li mg/L	Mn mg/L	Mo mg/L	Ni mg/L	Pb mg/L	Re mg/L	Sb mg/L	Se mg/L	Si mg/L
1	0.0002	1.10	1.92	1.29	0.005	0.002	0.032	0.005	0.195	6.66
2	<0.0001	0.666	1.35	0.708	0.003	<0.001	0.013	0.003	0.076	7.79
3	<0.0001	0.468	1.01	0.524	0.002	<0.001	0.006	0.002	0.037	4.98
6	<0.0001	0.231	1.755	0.3035	0.002	<0.002	<0.001	0.002	0.010	6.05
9	<0.0001	0.142	1.26	0.274	<0.001	<0.001	<0.001	0.001	<0.010	5.30
12	<0.0001	0.132	1.68	0.348	<0.001	<0.001	<0.001	0.001	<0.010	6.00
15	<0.0001	0.092	1.82	0.488	<0.010	<0.010	<0.001	<0.010	<0.050	5.18
18	<0.0001	0.070	1.27	0.343	<0.001	<0.001	<0.001	0.001	<0.010	6.06
21	<0.0001	0.052	1.09	0.306	<0.001	<0.001	<0.001	0.001	<0.010	5.91

Table 35. Primary Mineral Forming Cations in Leachate Water for Tailings 3.2-05 (Part 3 of 3)

Week	Sn mg/L	Sr mg/L	Th mg/L	Ti mg/L	Tl mg/L	U mg/L	V mg/L	W mg/L	Y mg/L	Zn mg/L
1	0.001	6.20	2.34	0.06	0.005	77.4	0.20	0.023	30.7	7.79
2	<0.001	4.65	0.939	0.03	0.003	22.7	0.05	0.006	8.55	2.65
3	<0.001	2.88	0.332	0.02	0.002	7.98	<0.01	0.002	3.26	1.12
6	<0.001	1.08	0.049	<0.01	<0.001	0.723	<0.01	<0.001	0.836	0.175
9	<0.001	1.17	0.024	<0.01	<0.001	0.324	<0.01	<0.001	0.536	0.062
12	<0.001	1.10	0.018	<0.01	<0.001	0.230	<0.01	<0.001	0.363	0.027
15	<0.010	1.17	0.011	<0.10	<0.010	0.205	<0.10	<0.010	0.275	<0.010
18	<0.001	0.953	0.012	<0.01	<0.001	0.167	<0.01	<0.001	0.201	0.012
21	<0.001	0.926	0.012	<0.01	<0.001	0.182	<0.01	<0.001	0.184	0.012

Table 36. Primary Mineral Forming Cations in Leachate Water for Tailings 4.1-04 (Part 3 of 3)

Week	Sn mg/L	Sr mg/L	Th mg/L	Ti mg/L	Tl mg/L	U mg/L	V mg/L	W mg/L	Y mg/L	Zn mg/L
1	<0.001	5.42	0.535	<0.10	0.002	41.2	<0.01	0.024	25.0	14.8
2	<0.001	2.94	0.034	<0.01	<0.001	8.06	<0.01	0.004	4.71	3.19
3	<0.001	1.51	0.003	<0.01	<0.001	1.47	<0.01	<0.001	0.850	0.905
6	<0.001	0.744	<0.001	<0.01	<0.001	0.093	<0.01	<0.001	0.007	0.019
9	<0.001	0.800	<0.001	<0.01	<0.001	0.086	<0.01	<0.001	0.002	0.009
12	<0.001	0.821	<0.001	<0.01	<0.001	0.085	<0.01	<0.001	0.001	0.007
15	<0.010	0.829	<0.010	<0.10	<0.010	0.043	<0.10	<0.010	<0.010	<0.010
18	<0.001	0.810	<0.001	<0.01	<0.001	0.090	<0.01	<0.001	<0.001	<0.005
21	<0.001	0.714	<0.001	<0.01	<0.001	0.032	<0.01	<0.001	<0.001	<0.005

Table 37. Primary Mineral Forming Cations in Leachate Water for Tailings 3.2-01 (Part 3 of 3)

Week	Sn mg/L	Sr mg/L	Th mg/L	Ti mg/L	Tl mg/L	U mg/L	V mg/L	W mg/L	Y mg/L	Zn mg/L
1	<0.001	8.45	<0.001	<0.01	0.001	19.8	<0.01	0.028	0.001	0.022
2	<0.001	7.29	<0.001	<0.01	<0.001	7.52	<0.01	0.018	<0.001	0.019
3	<0.001	6.18	<0.001	<0.01	<0.001	4.02	<0.01	0.015	<0.001	0.013
6	<0.001	4.95	<0.001	<0.01	<0.001	2.055	<0.01	0.006	<0.001	0.0225
9	<0.001	4.43	<0.001	<0.01	<0.001	1.06	<0.01	0.005	<0.001	0.014
12	<0.001	5.04	<0.001	<0.01	<0.001	1.15	<0.01	0.005	<0.001	0.017
15	<0.010	6.28	<0.010	<0.10	<0.010	1.09	<0.10	<0.010	<0.010	<0.010
18	<0.001	4.23	<0.001	<0.01	<0.001	0.669	<0.01	0.004	<0.001	0.013
21	<0.001	3.69	<0.001	<0.01	<0.001	0.464	<0.01	0.003	<0.001	0.011

3.4 Saturated Column Tests of Tailings with Deionised Water

These tests were undertaken for 10 weeks on one tailings material using deionised water that was either oxygenated or deoxygenated. The tests were undertaken using a partial stop-flow technique, whereby the test water was introduced from the base of the columns over a period of 3-4 days (e.g. ~80 mL/day), then allowed to interact with the tailings material until one week had passed since the water began to be introduced. The pore volume of the oxic column (~290 mL) was slightly greater than that of the anoxic (deoxygenated) column (~270 mL). The volume of pore water expressed from the columns during the first week was 400 mL occurred due to a Peristaltic pump malfunction.

The volumes of pore water passed through each column and the physico-chemical parameters measured for each column test are shown for each week in Table 38. The concentrations of radium-226 measured in the pore water are shown in Table 39. The concentrations of all other analytes are shown in Tables 40-47. Quality assurance data are provided in Appendix D.

Table 38. Physico-Chemical Parameters of Column Experiments of Tailings ODXH 3.2-01

	ODXH 3.2-01				Pore volume =	ODXH 3.2-01				Pore volume =
	Oxic deionised water (oxic)				290 mL	Deoxygenated deionised water (anoxic)				270 mL
	Air atmosphere					Nitrogen atmosphere				
	pH	Eh	EC	DO	Volume	pH	Eh	EC	DO	Volume
Week		mV	mS/cm	mg/L	mL		mV	mS/cm	mg/L	mL
1	8.0	531	34.0	NA	400	8.0	524	24.4	NA	400
2	8.0	522	23.2	6.9	290	9.0	278	44.4	0.1	260
3	8.0	480	13.3	7.3	290	8.8	310	6.3	0.1	276
4	7.9	471	6.1	7.6	283	8.4	346	4.8	0.6	250
5	8.1	517	5.8	6.9	280	8.4	376	4.1	0.2	255
6	8.0	495	3.6	10	293	8.4	396	3.0	0.2	274
7	7.6	520	3.0	8.2	282	8.4	364	2.7	0.2	278
8	7.7	475	3.7	7.9	278	8.5	379	3.1	1.4	268
9	7.9	505	2.8	8.5	284	8.2	405	3.3	2.3	267
10	7.5	500	2.8	8.5	290	8.5	377	2.9	1.4	270

Table 39. Radionuclides in Pore Water from Column Experiments of Tailings ODXH 3.2-01

	Radium-226, Bq/mL	
Week	Air atmosphere	Nitrogen atmosphere
1	<0.0001	<0.0001
2	<0.0001	NA
3	<0.0001	<0.0001
6	NA	<0.0001

Table 40. Major Anions, Cations, Alkalinity/Acidity and Inorganic Carbon in Column Pore Water – Tailings 3.2-01 (air)

	Cl^-	SO_4^{2-}	Na	K	Mg	Ca	Fe	Carbonate Alkalinity as $CaCO_3$	Bicarbonate Alkalinity as $CaCO_3$	Total Alkalinity as $CaCO_3$	Acidity as $CaCO_3$	Dissolved Inorganic Carbon
Week	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1	7790	12900	8470	261	1440	822	0.34	<1	191	191	NM	35.5
2	3750	1590	923	25	165	124	0.21	<1	198	198	NM	49
3	1620	4700	2120	94	447	547	0.19	<1	176	176	NM	38
4	NM	2370	722	42	213	454	0.16	<1	99	99	NM	25
5	354	2880	608	48	256	584	<0.05	<1	158	158	8	36
6	108	2040	76	32	164	620	<0.05	<1	122	122	8	26
7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
8	320	1672	156	20	72	672	<0.05	<1	106	106	4	24
9	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
10	452	1392	10	14	26	580	0.26	<1	78	78	38	20

Table 41. Major Anions, Cations, Alkalinity/Acidity and Inorganic Carbon in Column Pore Water – Tailings 3.2-01 (nitrogen)

	Cl^-	SO_4^{2-}	Na	K	Mg	Ca	Fe	Carbonate Alkalinity as $CaCO_3$	Bicarbonate Alkalinity as $CaCO_3$	Total Alkalinity as $CaCO_3$	Acidity as $CaCO_3$	Dissolved Inorganic Carbon
Week	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1	4410	735	5380	<1	753	590	0.38	159	289	448	NM	<1
2	1000	NM	1180	340	208	580	0.30	<1	115	115	NM	22
3	800	<1000	700	45	300	650	0.24	<1	<1	<1	<1	24
4	450	2630	213	59	250	812	0.26	NM	NM	NM	NM	26
5	332	2560	116	60	166	882	<0.05	<1	106	106	0	24
6	96	2000	16	24	34	898	<0.05	<1	110	110	4	24
7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
8	98	2160	16	20	26	922	<0.05	<1	78	78	4	16
9	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
10	126	2020	16	14	14	852	<0.01	<1	56	56	10	12

Table 42. Primary Mineral Forming Cations in Column Pore Water – Tailings 3.2-01 (air)

Week	Ag mg/L	Al mg/L	As mg/L	B mg/L	Ba mg/L	Be mg/L	Bi mg/L	Cd mg/L	Ce mg/L	Co mg/L	Cr mg/L	Cu mg/L
1	<0.001	0.18	0.007	<0.001	3.85	0.03	<0.001	0.00045	0.006	0.058	<0.001	0.431
2	<0.001	0.07	0.008	<0.001	4.53	0.026	<0.001	<0.0001	0.003	0.061	<0.001	0.382
3	<0.001	0.06	0.006	<0.001	4.30	0.021	<0.001	0.0006	0.002	0.065	<0.001	0.256
4	<0.001	0.08	0.004	<0.001	2.59	0.052	<0.001	0.0008	0.002	0.059	<0.001	0.180
5	<0.001	0.07	0.004	4.28	0.023	<0.001	<0.001	0.0002	0.002	0.126	0.002	0.278
6	<0.001	0.05	0.003	2.44	0.024	<0.001	<0.001	0.0001	0.001	0.151	0.005	0.342
7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
8	<0.001	0.10	0.004	1.36	0.020	<0.001	<0.001	0.0027	0.002	0.154	0.002	0.287
9	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
10	<0.010	0.98	<0.010	1.12	0.026	<0.010	<0.010	0.0021	0.035	0.282	<0.010	0.939

Au <0.001 mg/L in all samples. NM = not measured (archived).

Table 43. Primary Mineral Forming Cations in Column Pore Water – Tailings 3.2-01 (nitrogen)

Week	Ag mg/L	Al mg/L	As mg/L	B mg/L	Ba mg/L	Be mg/L	Bi mg/L	Cd mg/L	Ce mg/L	Co mg/L	Cr mg/L	Cu mg/L
1	<0.001	0.17	0.007	<0.001	2.84	0.031	<0.001	0.0022	0.013	0.041	0.001	0.339
2	<0.001	0.05	0.020	<0.001	10.6	0.051	0.001	0.0086	0.001	0.167	0.002	0.578
3	<0.001	0.06	0.003	<0.001	3.88	0.025	<0.001	0.0010	<0.001	0.083	<0.001	0.195
4	<0.001	0.11	0.006	<0.001	3.63	0.046	<0.001	<0.0001	0.004	0.195	<0.001	0.242
5	<0.001	0.05	0.005	3.05	0.037	<0.001	<0.001	<0.0001	<0.001	0.322	<0.001	0.221
6	<0.001	0.05	0.003	1.09	0.028	<0.001	<0.001	0.0004	<0.001	0.218	0.003	0.322
7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
8	<0.001	0.05	0.003	1.06	0.030	<0.001	<0.001	0.0005	<0.001	0.242	0.002	0.194
9	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
10	<0.010	<0.10	<0.010	0.68	0.031	<0.010	<0.010	0.001	<0.010	0.201	<0.010	0.236

Table 44. Primary Mineral Forming Cations in Column Pore Water – Tailings 3.2-01 (air)

Week	Hg mg/L	Li mg/L	Mn mg/L	Mo mg/L	Ni mg/L	Pb mg/L	Re mg/L	Sb mg/L	Se mg/L	Si mg/L
1	<0.0001	0.732	1.79	0.881	0.003	0.0015	0.022	0.003	0.125	6.12
2	<0.0001	0.685	1.70	0.901	0.003	<0.001	0.014	0.002	0.102	1.24
3	<0.0001	0.522	1.78	0.688	0.003	<0.001	0.006	0.002	0.055	7.02
4	<0.0001	0.282	1.62	0.322	0.002	<0.001	0.001	<0.001	0.020	5.42
5	<0.0001	0.495	2.98	0.453	0.001	<0.001	<0.001	0.001	0.017	7.78
6	<0.0001	0.338	3.44	0.324	0.001	<0.001	<0.001	0.001	<0.010	7.48
7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
8	<0.0001	0.202	4.90	0.240	0.002	<0.001	<0.001	0.001	<0.010	6.76
9	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
10	<0.0001	0.122	7.95	0.385	<0.010	<0.010	<0.001	<0.010	<0.050	

NM = not measured (archived).

Table 45. Primary Mineral Forming Cations in Column Pore Water – Tailings 3.2-01 (nitrogen)

Week	Hg mg/L	Li mg/L	Mn mg/L	Mo mg/L	Ni mg/L	Pb mg/L	Re mg/L	Sb mg/L	Se mg/L	Si mg/L
1	<0.0001	0.509	1.21	0.588	0.004	0.001	0.015	0.002	0.092	0.37
2	<0.0001	1.89	5.52	2.51	0.010	0.001	0.036	0.007	0.266	<0.05
3	<0.0001	0.450	2.05	0.500	0.004	<0.001	<0.001	0.001	0.018	
4	<0.0001	0.466	5.00	0.447	0.007	<0.001	<0.001	0.001	<0.010	11.5
5	<0.0001	0.500	6.55	0.618	0.006	<0.001	<0.001	0.002	<0.010	14.2
6	<0.0001	0.186	5.74	0.372	0.003	<0.001	<0.001	0.001	<0.010	9.00
7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
8	<0.0001	0.147	6.64	0.454	0.005	<0.001	<0.001	0.001	<0.010	11.1
9	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
10	<0.0001	0.064	5.08	0.39	<0.010	<0.010	<0.001	<0.010	<0.050	

Table 46. Primary Mineral Forming Cations in Column Pore Water – Tailings 3.2-01 (air)

Week	Sn mg/L	Sr mg/L	Th mg/L	Ti mg/L	Tl mg/L	U mg/L	V mg/L	W mg/L	Y mg/L	Zn mg/L
1	<0.001	5.035	<0.001	<0.01	<0.001	10.5	<0.01	0.02	<0.001	0.06
2	<0.001	5.83	<0.001	<0.01	<0.001	8.57	<0.01	0.019	<0.001	0.163
3	<0.001	5.45	<0.001	<0.01	<0.001	5.63	<0.01	0.013	<0.001	0.146
4	<0.001	3.46	<0.001	<0.01	<0.001	2.67	<0.01	0.005	<0.001	0.139
5	<0.001	5.69	<0.001	<0.01	<0.001	3.92	<0.01	0.006	<0.001	0.128
6	<0.001	5.43	<0.001	<0.01	<0.001	2.86	<0.01	0.003	<0.001	0.105
7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
8	<0.001	4.97	<0.001	<0.01	<0.001	1.83	<0.01	0.002	<0.001	0.060
9	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
10	<0.010	6.47	<0.010	<0.10	<0.010	2.11	<0.10	<0.010	0.011	0.12

NM = not measured (archived).

Table 47. Primary Mineral Forming Cations in Column Pore Water – Yailings 3.2-01 (nitrogen)

Week	Sn mg/L	Sr mg/L	Th mg/L	Ti mg/L	Tl mg/L	U mg/L	V mg/L	W mg/L	Y mg/L	Zn mg/L
1	<0.001	3.65	<0.001	<0.01	<0.001	6.88	<0.01	0.013	<0.001	0.049
2	<0.001	12.0	<0.001	0.02	0.002	23.4	<0.01	0.050	<0.001	0.053
3	<0.001	5.19	<0.001	<0.01	<0.001	4.04	<0.01	0.009	<0.001	0.065
4	<0.001	6.67	<0.001	<0.01	<0.001	4.15	<0.01	0.006	<0.001	0.034
5	<0.001	8.43	<0.001	<0.01	<0.001	4.84	<0.01	0.006	<0.001	0.028
6	<0.001	5.96	<0.001	<0.01	<0.001	2.40	<0.01	0.003	<0.001	0.060
7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
8	<0.001	5.95	<0.001	<0.01	<0.001	2.18	<0.01	0.003	<0.001	0.027
9	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
10	<0.010	4.71	<0.010	<0.10	<0.010	1.26	<0.10	<0.010	<0.010	<0.010

3.5 Saturated Column Test: Core 1 Limestone Bedrock Material - Adsorption Tests Using pH 4.5 Tailing Liquor Input Water

These tests were undertaken for four porewater cycles (1 week, , followed by three cycles of 28 weeks) on the limestone bedrock material Core 1 using partially-neutralised pH-4.5 tailings water that was equilibrated with either $N_{2(g)}$ or 10%:90% $CO_{2(g)}/N_{2(g)}$. The tests were undertaken using a stop-flow technique, whereby the test water was introduced from the base of each column during the first day of each cycle (e.g. 280-300 mL/day; 320-340 mL pore volume), then allowed to interact with the limestone material from the remained for the cycle period. Because the added water was acidic, it reacted with the limestone and caused significant $CO_{2(g)}$-production, as evident by 'frothing'. For this reason the tubes at the top of the column were allowed to remain open for 24 h after the water was introduced to relieve the pressure creased by the produced gas. The volume of pore water passed through the columns was a little variable and low on the third cycle. This variability was associated with the void produced by the gas, which was difficult to predict. Great care was taken to ensure that the volume of input water introduced to the columns each cycle was less than the total pore volume, including the 'unknown' void created by CO_2 gas.

The physico-chemical properties and chemical analyte concentrations of the partially-neutralised pH-4.5 tailings water are shown in Tables 48 and 50. The pH 4.5 input water was prepared 24 to 72 h before use in the tests (Tables 49 and 51). The water was equilibrated with 100% $N_{2(g)}$ initially, then a sub-sample was taken equilibrated with a mixture 10%:90% $CO_{2(g)}/N_{2(g)}$ for 24 h before use in the mixed-gas experiments. Analyses of both waters was only undertaken once (week 4), but indicated that the 24-h equilibration with the 10%:90% $CO_{2(g)}/N_{2(g)}$ atmosphere did not greater modify the composition of the input water. Greater variability was expected due to repeat preparations.

The volumes of pore water passed through each column and the physico-chemical parameters measured for each column test are shown in Table 49. The concentrations of the analytes measured in the pore water removed at the end of each cycle are shown in Tables 51 and 52. Quality assurance data are provided in Appendix D. The concentrations of radium-226 measured in the tailings water were not measured.

Table 48. Physico-Chemical Parameters of Inlet Water (pH-4.5 TL)

		pH 4.5 tailings water Equilibrated with 10%/90% CO_2(g)/N_2(g)			
		pH	Eh	EC	DO
Cycle	Day		mV	mS/cm	mg/L
1	1	4.3	334	33.8	<0.1
2	1	4.3	497	33.1	<0.1
3	1	4.4	572	32.6	0.12
4	1	4.4	529	32.7	<0.1

Table 49. Physico-Chemical Parameters of Column Experiments of Limestone Bedrock Core 1 – Outlet Water

		Limestone bedrock Core 1, pH-4.5 tailings water									
		Core 1A					Core 1B				
		Equilibrated with 10%:90% $CO_{2(g)}/N_{2(g)}$				Porewater volume, mL	Equilibrated with Deoxygenated, $N_{2(g)}$				Porewater volume, mL
		pH	Eh	EC	DO		pH	Eh	EC	DO	
Cycle	Day		mV	mS/cm	mg/L			mV	mS/cm	mg/L	
1	7	5.1	330	25.6	0.2	271	4.9	325	27.4	<0.1	275
2	21	4.9	298	30.3	<0.1	326	4.7	308	30.5	<0.1	325
3	21	4.9	285	31.2	0.1	219	4.7	299	30.9	<0.1	222
4	21	5.2	300	30.6	<0.1	241	5.0	300	30.6	<0.1	243

Table 50. Major Anions, Cations, Acidity and Inorganic Carbon in Column Inlet Water (pH-4.5 TL water)

Cycle/ Day	Cl^- mg/L	SO_4^{2-} mg/L	Na mg/L	K mg/L	Mg mg/L	Ca mg/L	Fe mg/L	Bicarbonate Alkalinity as $CaCO_3$ mg/L	Total Alkalinity as $CaCO_3$ mg/L	Acidity as $CaCO_3$ mg/L	Dissolved Inorganic Carbon mg/L
1 / 1 (N_2 (g))	1410	25100	1580	460	710	630	10100	<1	<1	37000	<1
2 / 1 (CO_2 / (N_2 (g)) [a]	3330	34900	2300	720	1030	940	13100	<1	<1	49100	<1
3 / 1 (CO_2 / (N_2 (g)) [a]	4040	35600	2300	730	1040	860	12800	<1	<1	51200	<1
4 / 1 (N_2 (g))	3300	35900	1960	660	930	890	10700	<1	<1	34700	<1
4 / 1(CO_2 / (N_2 (g))	3400	34600	2080	700	1010	930	11800	<1	<1	38800	<1

Cycle/ Day	Ag mg/L	Al mg/L	As mg/L	B mg/L	Ba mg/L	Be mg/L	Bi mg/L	Cd mg/L	Ce mg/L	Co mg/L	Cr mg/L
1 / 1 (N_2 (g))	<0.010	3650	0.03	2.48	0.077	0.297	<0.010	0.0256	69.6	63.7	0.047
2 / 1 (CO_2 / (N_2 (g))	<0.010	2620	0.023	2.28	0.064	0.272	<0.010	0.0182	59.6	52.4	0.016
3 / 1 (CO_2 / (N_2 (g))	<0.010	2430	<0.010	2.11	0.056	0.238	<0.010	0.0196	47.8	53.0	0.019
4 / 1 (N_2 (g))	<0.010	2220	0.029	1.85	0.050	0.171	<0.010	0.0187	34.2	48.2	<0.010
4 / 1(CO_2 / (N_2 (g))	<0.010	2600	0.031	2.31	0.062	0.206	<0.010	0.0232	41.7	57.9	<0.010

Cycle/ Day	Cu mg/L	Hg mg/L	Li mg/L	Mn mg/L	Mo mg/L	Ni mg/L	Pb mg/L	Re mg/L	Sb mg/L	Se mg/L	Si mg/L
1 / 1 (N_2 (g))	724	<0.0001	5.62	156	0.016	5.87	0.051	0.002	<0.010	0.247	NM
2 / 1 (CO_2 / (N_2 (g))	575	<0.0001	6.37	126	0.013	4.67	0.048	0.002	<0.010	0.229	11.2
3 / 1 (CO_2 / (N_2 (g))	552	<0.0001	6.05	127	0.015	4.68	0.036	0.002	<0.010	0.175	7.46
4 / 1 (N_2 (g))	479	<0.0001	4.22	117	0.014	4.54	0.030	0.016	<0.010	0.205	NM
4 / 1(CO_2 / (N_2 (g))	571	<0.0001	5.49	141	<0.010	5.40	0.029	0.020	<0.010	0.222	NM

Cycle/ Day	Sn mg/L	Sr mg/L	Th mg/L	Ti mg/L	Tl mg/L	U mg/L	V mg/L	W mg/L	Y mg/L	Zn mg/L
1 / 1 (N_2 (g))	<0.010	3.31	0.042	<0.10	0.038	29.2	<0.10	0.019	22.7	25.3
2 / 1 (CO_2 / (N_2 (g))	<0.010	2.68	0.037	<0.10	0.033	29.0	<0.10	0.013	18.3	21.0
3 / 1 (CO_2 / (N_2 (g))	<0.010	2.54	<0.010	<0.10	0.033	25.5	<0.10	0.012	14.4	20.8
4 / 1 (N_2 (g))	<0.010	2.16	<0.010	<0.10	0.029	24.0	<0.10	<0.010	10.2	18.4
4 / 1(CO_2 / (N_2 (g))	<0.010	2.60	<0.010	<0.10	0.036	29.5	<0.10	0.012	12.4	22.2

[a] Chloride and sulfate concentration were estimated from composition measured in separate sub-sample (Table 60).

Table 51. Major Anions, Cations, Acidity and Inorganic Carbon in Column Outlet Water – Limestone Bedrock Core 1A (Nitrogen)
Inlet water = pH 4.5 TL water (Table 50)

Cycle/ Day	Cl^-	SO_4^{2-}	Na	K	Mg	Ca	Fe	Bicarbonate Alkalinity as $CaCO_3$	Total Alkalinity as $CaCO_3$	Acidity as $CaCO_3$	Dissolved Inorganic Carbon
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1 / 7	1750	22700	1470	430	1100	600	9060	<1	<1	21000	3
2 / 21	NM	NM	2080	650	1340	720	6320	<1	<1	19900	<1
3 / 21	NM	NM	2060	660	1490	620	10500	<1	<1	9310	<1
4 / 21	3200	33600	1940	680	1500	670	11000	<1	<1	22000	12
	Ag	Al	As	B	Ba	Be	Bi	Cd	Ce	Co	Cr
	Mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1 / 7	<0.010	1930	0.019	3.25	0.321	0.196	<0.010	0.0214	23	67.1	0.011
2 / 21	<0.010	1490	<0.010	2.26	0.124	0.161	<0.010	0.0208	34.5	49.2	0.017
3 / 21	<0.010	1040	0.010	2.27	0.103	0.116	<0.010	0.0182	25.8	50.8	0.014
4 / 21	<0.010	1120	0.027	2.52	0.098	0.114	<0.010	0.0150	23.4	54.2	<0.010
	Cu	Hg	Li	Mn	Mo	Ni	Pb	Re	Sb	Se	Si
	mg/L	mg/L	Mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1 / 7	182	<0.0001	4.00	694	<0.010	8.3	<0.010	0.002	<0.010	0.157	14.2
2 / 21	304	<0.0001	4.84	242	<0.010	5.01	0.016	0.002	<0.010	0.118	8.94
3 / 21	205	0.0001	5.02	232	<0.010	5.03	0.013	0.002	<0.010	0.154	8.14
4 / 21	207	<0.0001	4.52	197	<0.010	5.38	<0.010	0.018	<0.010	0.160	NM
	Sn	Sr	Th	Ti	Tl	U	V	W	Y	Zn	
	mg/L	mg/L	Mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	
1 / 7	<0.010	4.31	<0.010	<0.10	0.021	17.5	<0.10	<0.010	7.99	42.4	
2 / 21	<0.010	2.68	<0.010	<0.10	0.021	20.6	<0.10	<0.010	10.3	24.1	
3 / 21	<0.010	2.38	<0.010	<0.10	0.020	18.3	<0.10	<0.010	7.09	24.0	
4 / 21	<0.010	2.22	<0.010	<0.10	0.020	19.2	<0.10	<0.010	6.15	23.1	

Table 52. Major Anions, Cations, Acidity and Inorganic Carbon in Column Outlet Water – Limestone Bedrock Core 1B (CO_2-Nitrogen)
Inlet water = pH 4.5 TL water (Table 50)

Cycle/ Day	Cl^- mg/L	SO_4^{2-} mg/L	Na mg/L	K mg/L	Mg mg/L	Ca mg/L	Fe mg/L	Bicarbonate Alkalinity as $CaCO_3$ mg/L	Total Alkalinity as $CaCO_3$ mg/L	Acidity as $CaCO_3$ mg/L	Dissolved Inorganic Carbon mg/L
1 / 7	2370	24400	1560	460	970	640	9120	<1	<1	23600	<1
2 / 21	NM	NM	2000	640	1540	620	10200	<1	<1	24600	<1
3 / 21	NM	NM	2030	660	1730	540	13400	<1	<1	7430	<1
4 / 21	3100	33200	1830	660	1640	600	10600	<1	<1	16860	<1

	Ag mg/L	Al mg/L	As mg/L	B mg/L	Ba mg/L	Be mg/L	Bi mg/L	Cd mg/L	Ce mg/L	Co mg/L	Cr mg/L
1 / 7	<0.010	2590	0.021	3.34	0.279	0.232	<0.010	0.0217	41.8	64.6	0.012
2 / 21	<0.010	922	0.020	2.12	0.128	0.109	<0.010	0.0168	23.3	48.7	0.015
3 / 21	<0.010	425	<0.010	2.20	0.110	0.066	<0.010	0.0150	18.2	51.9	0.013
4 / 21	<0.010	561	0.043	2.29	0.099	0.072	0.018	0.0182	19.9	52.4	<0.010

	Cu mg/L	Hg mg/L	Li mg/L	Mn mg/L	Mo mg/L	Ni mg/L	Pb mg/L	Re mg/L	Sb mg/L	Se mg/L	Si mg/L
1 / 7	405	<0.0001	4.82	460	<0.010	7.08	0.015	0.002	<0.010	0.21	10.1
2 / 21	160	0.0002	4.48	244	<0.010	4.95	<0.010	0.002	<0.010	0.178	9.62
3 / 21	50.6	0.0002	4.80	205	<0.010	4.83	<0.010	0.002	<0.010	0.122	9.12
4 / 21	84.0	<0.0001	4.13	177	<0.010	5.04	<0.010	0.018	<0.010	0.170	NM

	Sn mg/L	Sr mg/L	Th mg/L	Ti mg/L	Tl mg/L	U mg/L	V mg/L	W mg/L	Y mg/L	Zn mg/L
1 / 7	<0.010	4.02	<0.010	<0.10	0.031	22.6	<0.10	0.012	13.8	35.7
2 / 21	<0.010	2.36	<0.010	<0.10	0.018	17.4	<0.10	<0.010	6.73	22.3
3 / 21	<0.010	1.95	<0.010	<0.10	0.026	14.9	<0.10	<0.010	4.41	21.2
4 / 21	<0.010	1.90	<0.010	<0.10	0.026	15.0	<0.10	<0.010	4.59	20.7

3.6 Saturated Column Test: Core 4 Quartzite Bedrock Material - Adsorption Tests Using pH 6 Pore water as Input Water

These tests were undertaken for 4 (1A) or 3 (1B) porewater cycles (1 week, followed by three cycles of 28 weeks) on the limestone bedrock material Core 1 using neutralised pH-6 tailings pore water that was equilibrated with either $N_{2(g)}$ or 10/90% $CO_{2(g)}/N_{2(g)}$. The tests were undertaken using a stop-flow technique, whereby the test water was introduced from the base of each column during the first day of each cycle (e.g. 320-350 mL/day; 370-390 mL pore volume), then allowed to interact with the limestone material for the remaining cycle period. The volume of pore water passed through the columns was a little variable, but was less than the total pore volume.

The physico-chemical properties and chemical analyte concentrations of the neutralised pH-6 tailings pore water are shown in Tables 53 and 55. The concentrations of radium-226 measured in the tailings water was not measured.

The volumes of pore water passed through each column and the physico-chemical parameters measured for each column test are shown in Table 54. The concentrations of the analytes measured in the pore water removed at the end of each cycle are shown in Tables 56 and 57. Quality assurance data are provided in Appendix D.

Table 53. Physico-Chemical Parameters of Inlet Water (pH 6 pore water)

		pH 6 - dolomite porewater			
		Equilibrated with 10%:90% CO2(g)/N2(g)			
		pH	Eh	EC	DO
Cycle	Day		mV	mS/cm	mg/L
1	1	6.2	NM	NM	<0.1
2	1	6.2	413	15.0	0.5
3	1	6.0	400	14.8	0.7
4	1	5.6	425	15.1	0.7

Table 54. Physico-Chemical Parameters of Column Experiments of Quartzite Bedrock Core 4 - Outlet Water

		Quartzite bedrock Core 4, pH 6 - dolomite porewater									
		Core 4A					Core 4B				
		Equilibrated with 10%:90% $CO_{2(g)}/N_{2(g)}$				Porewater volume, mL	Equilibrated with 10%:90% $CO_{2(g)}/N_{2(g)}$				Porewater volume, mL
		pH	Eh	EC	DO		pH	Eh	EC	DO	
Cycle	Day		mV	mS/cm	mg/L			mV	mS/cm	mg/L	
0	0	6.7	193	1.42	1.4	303	6.6	188	2.57	1.2	316
1	7	6.5	124	11.4	0.9	338	6.4	126	12.8	0.9	366
2	21	6.4	128	14.6	0.6	322	6.4	130	14.6	0.6	329
3	21	6.4	114	14.9	0.6	325	6.4	105	14.9	0.5	328
4	21	6.4	103	15.1	0.3	330	6.4	107	15.0	0.2	334

Table 55. Major Anions, Cations, Alkalinity/Acidity and Inorganic Carbon in Column Inlet Water (pH 6, Dolomite-Equilibrated Porewater, CO_2-Nitrogen)

Cycle/ Day	Cl^-	SO_4^{2-}	Na	K	Mg	Ca	Fe	Bicarbonate Alkalinity as $CaCO_3$	Total Alkalinity as $CaCO_3$	Acidity as $CaCO_3$	Dissolved Inorganic Carbon
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1 / 1	2950	4800	1940	310	160	550	904	<1	<1	1700	NM
2 / 1	NM	NM	2070	340	150	510	789	<1	<1	2000	<1
3 / 1	NM	NM	2100	340	160	550	724	<1	<1	4100	<1
4 / 1	3100	5200	1980	330	150	540	680	<1	<1	3320	<1

	Ag	Al	As	B	Ba	Be	Bi	Cd	Ce	Co	Cr
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1 / 1	<0.010	7.99	<0.010	0.57	0.019	<0.010	<0.010	0.0056	0.176	4.57	<0.010
2 / 1	<0.010	12.2	0.004	0.33	0.015	0.002	<0.010	0.0036	0.310	3.58	0.159
3 / 1	<0.010	<0.10	<0.010	0.25	0.017	<0.010	<0.010	0.0045	0.100	3.12	0.010
4 / 1	<0.010	<0.10	<0.010	0.32	0.02	<0.010	<0.010	0.0041	0.223	3.65	0.092

	Cu	Hg	Li	Mn	Mo	Ni	Pb	Re	Sb	Se	Si
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1 / 1	0.694	<0.0001	3.71	58.7	<0.010	0.186	<0.010	<0.001	<0.010	<0.050	NM
2 / 1	2.57	<0.0001	3.64	43.3	0.009	0.341	<0.001	<0.001	<0.001	<0.010	2.76
3 / 1	<0.010	<0.0001	3.39	42.7	<0.010	0.068	<0.010	<0.001	<0.010	<0.050	2.64
4 / 1	<0.010	<0.0001	3.65	45.5	<0.010	0.182	<0.010	<0.001	<0.010	<0.050	2.73

	Sn	Sr	Th	Ti	Tl	U	V	W	Y	Zn
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1 / 1	0.034	1.19	<0.010	<0.10	<0.010	2.25	<0.10	<0.010	0.07	0.392
2 / 1	0.023	0.996	<0.010	<0.10	0.001	1.87	<0.01	<0.010	0.093	0.279
3 / 1	0.022	0.983	<0.010	<0.10	<0.010	1.87	<0.10	<0.010	0.024	0.169
4 / 1	0.022	0.98	<0.010	<0.10	<0.010	1.91	<0.10	<0.010	0.059	0.222

Table 56. Major Anions, Cations, Alkalinity/Acidity and Inorganic Carbon in Column Outlet Water – Quartzite Bedrock Core 4A (CO_2-Nitrogen)
Inlet Water = pH 6, Dolomite Porewater (Table 55)

Cycle/ Day	Cl^- mg/L	SO_4^{2-} mg/L	Na mg/L	K mg/L	Mg mg/L	Ca mg/L	Fe mg/L	Bicarbonate Alkalinity as $CaCO_3$ mg/L	Total Alkalinity as $CaCO_3$ mg/L	Acidity as $CaCO_3$ mg/L	Dissolved Inorganic Carbon mg/L
1 / 7	2090	3750	1440	170	240	530	423	<1	<1	400	3
2 / 21	NM	NM	2060	310	210	560	654	<1	<1	962	<1
3 / 21	NM	NM	2130	340	170	520	609	<1	<1	1060	<1
4 / 21	5340	12380	1890	350	170	550	724	<1	<1	2040	26

	Ag mg/L	Al mg/L	As mg/L	B mg/L	Ba mg/L	Be mg/L	Bi mg/L	Cd mg/L	Ce mg/L	Co mg/L	Cr mg/L
1 / 7	<0.010	0.53	<0.010	1.04	0.171	<0.010	<0.010	0.004	0.019	1.34	<0.010
2 / 21	<0.010	5.98	<0.010	0.63	0.073	<0.010	<0.010	0.0046	0.130	1.85	<0.010
3 / 21	<0.010	0.30	<0.010	0.65	0.074	<0.010	<0.010	0.0025	0.093	2.21	<0.010
4 / 21	<0.010	5.58	0.016	0.72	0.069	<0.010	<0.010	0.0028	0.096	2.75	<0.010

	Cu mg/L	Hg mg/L	Li mg/L	Mn mg/L	Mo mg/L	Ni mg/L	Pb mg/L	Re mg/L	Sb mg/L	Se mg/L	Si mg/L
1 / 7	0.216	<0.0001	2.93	110	<0.010	0.068	<0.010	<0.001	<0.010	<0.050	9.52
2 / 21	1.13	<0.0001	3.39	65.6	<0.010	0.077	<0.010	<0.001	<0.010	<0.050	9.51
3 / 21	0.039	0.0001	2.92	56.8	<0.010	0.103	<0.010	<0.001	<0.010	<0.050	9.54
4 / 21	0.857	<0.0001	2.90	51.6	<0.010	0.115	<0.010	<0.010	<0.010	<0.050	NM

	Sn mg/L	Sr mg/L	Th mg/L	Ti mg/L	Tl mg/L	U mg/L	V mg/L	W mg/L	Y mg/L	Zn mg/L
1 / 7	<0.010	5.18	<0.010	<0.10	<0.010	0.033	<0.10	<0.010	<0.010	7.23
2 / 21	<0.010	2.18	<0.010	<0.10	<0.010	0.114	<0.10	<0.010	0.038	0.575
3 / 21	<0.010	1.46	<0.010	<0.10	<0.010	0.091	<0.10	<0.010	0.025	0.386
4 / 21	<0.010	1.19	<0.010	<0.10	<0.010	0.115	<0.10	<0.010	0.026	0.462

Table 57. Major Anions, Cations, Alkalinity/Acidity and Inorganic Carbon in Column Outlet Water – Quartzite Bedrock Core 4B (CO_2-Nitrogen)
Inlet Water = pH 6, dolomite Porewater (Table 55)

Cycle/ Day	Cl^- mg/L	SO_4^{2-} mg/L	Na mg/L	K mg/L	Mg mg/L	Ca mg/L	Fe mg/L	Bicarbonate Alkalinity as $CaCO_3$ mg/L	Total Alkalinity as $CaCO_3$ mg/L	Acidity as $CaCO_3$ mg/L	Dissolved Inorganic Carbon mg/L
1 / 7	2220	4180	1620	200	260	580	466	<1	<1	700	2
2 / 21	NM	NM	2080	310	190	540	623	<1	<1	1040	<1
3 / 21	NM	NM	2050	320	170	530	691	<1	<1	1080	<1

	Ag mg/L	Al mg/L	As mg/L	B mg/L	Ba mg/L	Be mg/L	Bi mg/L	Cd mg/L	Ce mg/L	Co mg/L	Cr mg/L
1 / 7	<0.010	<0.10	<0.010	0.95	0.155	<0.010	<0.010	0.008	<0.010	1.58	<0.010
2 / 21	<0.010	<0.10	<0.010	0.61	0.073	<0.010	<0.010	0.0017	<0.010	1.60	<0.010
3 / 21	<0.010	<0.10	<0.010	0.52	0.065	<0.010	<0.010	<0.0010	<0.010	2.22	<0.010

	Cu mg/L	Hg mg/L	Li mg/L	Mn mg/L	Mo mg/L	Ni mg/L	Pb mg/L	Re mg/L	Sb mg/L	Se mg/L	Si mg/L
1 / 7	0.055	<0.0001	3.16	114	<0.010	0.087	<0.010	<0.001	<0.010	<0.050	9.53
2 / 21	<0.010	<0.0001	3.35	63.2	<0.010	0.069	<0.010	<0.001	<0.010	<0.050	11.5
3 / 21	<0.010	<0.0001	3.28	50.9	<0.010	0.088	<0.010	<0.001	<0.010	<0.050	10.2

	Sn mg/L	Sr mg/L	Th mg/L	Ti mg/L	Tl mg/L	U mg/L	V mg/L	W mg/L	Y mg/L	Zn mg/L
1 / 7	<0.010	5.34	<0.010	<0.10	<0.010	0.02	<0.10	<0.010	<0.010	8.18
2 / 21	<0.010	1.96	<0.010	<0.10	<0.010	0.015	<0.10	<0.010	<0.010	0.322
3 / 21	<0.010	1.25	<0.010	<0.10	<0.010	<0.010	<0.10	<0.010	<0.010	0.169

3.7 Adsorption Tests using pH-4.5 Neutralised Tailings Liquor as Input Water

These tests were undertaken on two bedrock materials (limestone and quartzite) and three sediment samples. The test water to test solid ratio (W:S) was used for all the tests, but for two of the sediments the effect of varying W:S ratio was investigated (W:S = 1, 2, 20). The tests involved three (3) cycles (1 week, 28 weeks and 28 weeks), between which the water was recovered for analyses and replaced with new test water.

The test water used for these experiments was the same as that used for the saturated column tests. The physico-chemical properties and chemical analyte concentrations of the partially-neutralised pH-4.5 tailings input water are shown in Tables 48 and 51.

3.7.1 Input water before and during adsorption tests

The pH 4.5 input water was the same water as used for the Core 1 column tests (Tables 58 and 60). The pH 4.5 input water was prepared 24 to 72 h before use in the tests. The water was equilibrated with 100% $N_{2(g)}$. In Tables 58 and 60, the data are for the pH 4.5 test water equilibrated with nitrogen or a nitrogen-carbon dioxide gas mixture.

Table 58. Physico-Chemical Parameters of Input Water (pH 4.5 TL)

		pH 4.5 tailings water Equilibrated with 10%:90% CO2(g)/N2(g)			
		pH	Eh	EC	DO
Cycle	Day		mV	mS/cm	mg/L
1	1	4.3	334	33.8	<0.1
2	1	4.3	497	33.1	<0.1
3	1	4.4	572	32.6	0.12
4	1	4.4	529	32.7	<0.1

During the adsorption tests, where cycles lasted for 7 or 28 days between water exchanges, the input water composition changed in the absence of added solids (Tables 59 and 61).

Table 59. Physico-Chemical Parameters of Final Water (pH 4.5 TL) – no solids

Cycle	Day	Recovered [a] volume, mL	pH 4.5 tailings water / atmosphere	pH	Redox potential, (Eh), mV	Conductivity mS/cm	Dissolved oxygen, mg/L
1	-	-	-	-	-	-	-
2	28	308		2.9	487	32.2	1.2
3	12	---		4.2	338	33.6	0.19
3	28	308		3.3	442	33.5	0.49

[a] 300 mL of water added to blank bottle at start of each cycle.

Table 60. Major Anions, Cations, Acidity and Inorganic Carbon in Column Input Water (pH 4.5 TL water)

Cycle/ Day	Cl^-	SO_4^{2-}	Na	K	Mg	Ca	Fe	Bicarbonate Alkalinity as $CaCO_3$	Total Alkalinity as $CaCO_3$	Acidity as $CaCO_3$	Dissolved Inorganic Carbon
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1 / 1 (N_2 (g))	1410	25100	1580	460	710	630	10100	<1	<1	37000	<1
2 / 1 (CO_2 / (N_2 (g)) [a]	3330	34900	2300	720	1030	940	13100	<1	<1	49100	<1
3 / 1 (CO_2 / (N_2 (g)) [a]	4040	35600	2300	730	1040	860	12800	<1	<1	51200	<1
4 / 1 (N_2 (g))	3300	35900	1960	660	930	890	10700	<1	<1	34700	<1
	Ag	Al	As	B	Ba	Be	Bi	Cd	Ce	Co	Cr
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1 / 1 (N_2 (g))	<0.010	3650	0.03	2.48	0.077	0.297	<0.010	0.0256	69.6	63.7	0.047
2 / 1 (CO_2 / (N_2 (g))	<0.010	2620	0.023	2.28	0.064	0.272	<0.010	0.0182	59.6	52.4	0.016
3 / 1 (CO_2 / (N_2 (g))	<0.010	2430	<0.010	2.11	0.056	0.238	<0.010	0.0196	47.8	53.0	0.019
4 / 1 (N_2 (g))	<0.010	2220	0.029	1.85	0.050	0.171	<0.010	0.0187	34.2	48.2	<0.010
	Cu	Hg	Li	Mn	Mo	Ni	Pb	Re	Sb	Se	Si
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1 / 1 (N_2 (g))	724	<0.0001	5.62	156	0.016	5.87	0.051	0.002	<0.010	0.247	NM
2 / 1 (CO_2 / (N_2 (g))	575	<0.0001	6.37	126	0.013	4.67	0.048	0.002	<0.010	0.229	11.2
3 / 1 (CO_2 / (N_2 (g))	552	<0.0001	6.05	127	0.015	4.68	0.036	0.002	<0.010	0.175	7.46
4 / 1 (N_2 (g))	479	<0.0001	4.22	117	0.014	4.54	0.030	0.016	<0.010	0.205	NM
	Sn	Sr	Th	Ti	Tl	U	V	W	Y	Zn	
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	
1 / 1 (N_2 (g))	<0.010	3.31	0.042	<0.10	0.038	29.2	<0.10	0.019	22.7	25.3	
2 / 1 (CO_2 / (N_2 (g))	<0.010	2.68	0.037	<0.10	0.033	29.0	<0.10	0.013	18.3	21.0	
3 / 1 (CO_2 / (N_2 (g))	<0.010	2.54	<0.010	<0.10	0.033	25.5	<0.10	0.012	14.4	20.8	
4 / 1 (N_2 (g))	<0.010	2.16	<0.010	<0.10	0.029	24.0	<0.10	<0.010	10.2	18.4	

[a] Chloride and sulfate concentration were estimated from composition measured in separate sub-sample (Table 60).

Table 61. Major Anions, Cations, Acidity and Inorganic in the Output Water – no solids
Input water = pH 4.5 TL water (Table 60)

Cycle/ Day	Cl^- mg/L	SO_4^{2-} mg/L	Na mg/L	K mg/L	Mg mg/L	Ca mg/L	Fe mg/L	Bicarbonate Alkalinity as $CaCO_3$ mg/L	Total Alkalinity as $CaCO_3$ mg/L	Acidity as $CaCO_3$ mg/L	Dissolved Inorganic Carbon mg/L
1 / 7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2 / 28	3330	34900	2550	580	1210	630	12100	<1	<1	34000	10
3 / 28	4040	35600	2610	810	1170	590	13500	<1	<1	31900	10

	Ag mg/L	Al mg/L	As mg/L	B mg/L	Ba mg/L	Be mg/L	Bi mg/L	Cd mg/L	Ce mg/L	Co mg/L	Cr mg/L
1 / 7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2 / 28	<0.100	2850	0.103	2.14	<0.100	0.263	<0.100	0.0175	58.2	52.3	<0.100
3 / 28	<0.100	3040	<0.100	2.42	<0.100	0.262	<0.100	0.0199	63.8	57.2	<0.100

	Cu mg/L	Hg mg/L	Li mg/L	Mn mg/L	Mo mg/L	Ni mg/L	Pb mg/L	Re mg/L	Sb mg/L	Se mg/L	Si mg/L
1 / 7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2 / 28	566	<0.0001	4.74	123	<0.100	5.13	<0.100	<0.100	<0.100	0.517	7.27
3 / 28	650	0.0001	5.21	136	<0.100	5.55	<0.100	<0.100	<0.100	<0.500	7.89

	Sn mg/L	Sr mg/L	Th mg/L	Ti mg/L	Tl mg/L	U mg/L	V mg/L	W mg/L	Y mg/L	Zn mg/L
1 / 7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2 / 28	<0.100	2.28	<0.100	<1.00	<0.100	29.3	<1.00	<0.100	18.8	19.5
3 / 28	<0.100	2.76	<0.100	<1.00	<0.100	30.1	<1.00	<0.100	19.5	21.2

3.7.2 Core 1 adsorption tests

These adsorption tests were run for three cycles. The volumes of reacted test water recovered after each test cycle and the physico-chemical parameters measured for the adsorption test are shown in Table 62. The concentrations of the analytes measured in the reacted (output) test water recovered at the end of each cycle are shown in Tables 63 and 64. Quality assurance data are provided in Appendix D.

Table 62. Core 1: pH, Redox Potential, Conductivity and Dissolved Oxygen Concentrations during Adsorption Tests

Cycle	Day	Recovered [a] volume, mL	pH 4.5 tailings water / atmosphere	pH	Redox potential, (Eh), mV	Conductivity mS/cm	Dissolved oxygen, mg/L
Core 1A							
1	1	-	Equilibrated with 10%:90% $CO_{2(g)}/N_{2(g)}$	4.7	307	32.3	0.4
1	4	-		4.7	288	30.3	1.3
1	7	494 [b]		5.1	221	29.9	0.6
2	1	-		4.5	303	30.3	0.8
2	10	-		5.1	212	26.6	<0.1
2	17	-		5.3	214	25.8	<0.1
2	28	603		5.3	234	24.0	0.1
3	12	-		4.9	205	26.0	0.1
3	28	577		5.4	212	24.9	0.1
Core 1B							
1	1	-	Equilibrated with Deoxygenated, $N_{2(g)}$	4.7	310	32.9	0.3
1	4	-		4.7	288	30.3	0.9
1	7	396 [b]		5.1	188	29.0	0.2
2	1	-		4.6	293	28.9	0.2
2	10	-		5.3	228	26.0	0.1
2	17	-		5.6	202	26.2	<0.1
2	28	610		5.4	196	24.0	<0.1
3	12	-		4.8	214	27.8	0.18
3	28	587		5.3	235	26.4	0.14

[a] 600 mL of water added to 300 g (dry weight) of each bedrock material. 600 mL of test water replaced at start of each cycle

[b] Some volume lost due to pressure-related leakages: reaction of carbonate and acid

Table 63. Major Anions, Cations, Acidity and Inorganic Carbon in the Output Adsorption Test Water – Limestone Bedrock Core 1A (Nitrogen)
Input water = pH 4.5 TL water (Table 60)

Cycle/ Day	Cl^-	SO_4^{2-}	Na	K	Mg	Ca	Fe	Bicarbonate Alkalinity as $CaCO_3$	Total Alkalinity as $CaCO_3$	Acidity as $CaCO_3$	Dissolved Inorganic Carbon
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1 / 7	2010	30500	2050	630	1660	520	11400	<1	<1	14500	<1
2 / 28	3040	28600	2050	710	1990	510	11700	<1	<1	14200	14
3 / 28	3330	31600	2120	740	2000	520	13500	<1	<1	16700	16

	Ag	Al	As	B	Ba	Be	Bi	Cd	Ce	Co	Cr
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1 / 7	<0.010	133	0.029	2.31	0.225	0.031	<0.010	0.0251	23	66.6	<0.010
2 / 28	<0.100	15.9	<0.100	1.61	<0.100	<0.100	<0.100	0.0132	14.4	48.3	<0.100
3 / 28	<0.100	32.9	<0.100	1.91	<0.100	<0.100	<0.100	0.0221	14.7	53.0	<0.100

	Cu	Hg	Li	Mn	Mo	Ni	Pb	Re	Sb	Se	Si
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1 / 7	59.1	<0.0001	4.51	317	<0.010	7.87	<0.010	0.002	<0.010	0.209	19.6
2 / 28	1.50	<0.0001	4.14	160	<0.100	4.78	<0.100	<0.100	<0.100	<0.500	9.99
3 / 28	8.80	0.0002	5.21	161	<0.100	5.31	<0.100	<0.100	<0.100	<0.500	10.5

	Sn	Sr	Th	Ti	Tl	U	V	W	Y	Zn
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1 / 7	<0.010	2.67	<0.010	<0.10	0.034	17.9	<0.10	<0.010	3.99	31.2
2 / 28	<0.100	1.94	<0.100	<1.00	<0.100	12.2	<1.00	<0.100	1.62	16.8
3 / 28	<0.100	2.13	<0.100	<1.00	<0.100	19.8	<1.00	<0.100	3.53	20.2

Table 64. Major Anions, Cations, Acidity and Inorganic Carbon in the Output Adsorption Test Water – Limestone Bedrock Core 1B (CO_2-Nitrogen)
Input water = pH 4.5 TL water (Table 60)

Cycle/ Day	Cl^- mg/L	SO_4^{2-} mg/L	Na mg/L	K mg/L	Mg mg/L	Ca mg/L	Fe mg/L	Bicarbonate Alkalinity as $CaCO_3$ mg/L	Total Alkalinity as $CaCO_3$ mg/L	Acidity as $CaCO_3$ mg/L	Dissolved Inorganic Carbon mg/L
1 / 7	1550	28800	1830	600	1530	510	11000	<1	<1	27400	2
2 / 28	1900	28700	2120	770	2000	540	11300	<1	<1	16300	17
3 / 28	3090	29600	1930	740	1860	510	12200	<1	<1	16800	10

	Ag mg/L	Al mg/L	As mg/L	B mg/L	Ba mg/L	Be mg/L	Bi mg/L	Cd mg/L	Ce mg/L	Co mg/L	Cr mg/L
1 / 7	<0.010	222	0.016	2.46	0.224	0.04	<0.010	0.0294	25.8	69.4	<0.010
2 / 28	<0.100	30.3	<0.100	1.56	<0.100	<0.100	<0.100	0.0132	15.1	47.4	<0.100
3 / 28	<0.100	19.0	<0.100	1.85	<0.100	<0.100	<0.100	<0.0100	13.0	51.3	<0.100

	Cu mg/L	Hg mg/L	Li mg/L	Mn mg/L	Mo mg/L	Ni mg/L	Pb mg/L	Re mg/L	Sb mg/L	Se mg/L	Si mg/L
1 / 7	271	<0.0001	4.83	331	<0.010	8.04	<0.010	0.003	<0.010	0.2	18.3
2 / 28	5.56	<0.0001	4.26	160	<0.100	5.14	<0.100	<0.100	<0.100	<0.500	12.3
3 / 28	4.53	<0.0001	4.77	155	<0.100	5.00	<0.100	<0.100	<0.100	<0.500	9.60

	Sn mg/L	Sr mg/L	Th mg/L	Ti mg/L	Tl mg/L	U mg/L	V mg/L	W mg/L	Y mg/L	Zn mg/L
1 / 7	<0.010	2.83	<0.010	<0.10	0.036	21.7	<0.10	<0.010	4.93	33.5
2 / 28	<0.100	1.90	<0.100	<1.00	<0.100	11.8	<1.00	<0.100	2.05	17.5
3 / 28	<0.100	2.09	<0.100	<1.00	<0.100	16.8	<1.00	<0.100	2.34	18.2

3.7.3 Core 4 adsorption tests

These adsorption tests were run for three cycles. The volumes of reacted test water recovered after each test cycle and the physico-chemical parameters measured for the adsorption test are shown in Table 65. The concentrations of the analytes measured in the reacted test water recovered at the end of each cycle are shown in Tables 66 and 67. Quality assurance data are provided in Appendix D.

Table 65. Core 4: pH, Redox Potential, Conductivity and Dissolved Oxygen Concentrations during Adsorption Tests

Cycle	Day	Recovered [a] volume, mL	pH 4.6 tailings water / atmosphere	pH	Redox potential, (Eh), mV	Conductivity mS/cm	Dissolved oxygen, mg/L
			Core 4A				
1	1	-	Equilibrated with Deoxygenated, $N_{2(g)}$	4.6	300	31.1	0.1
1	4	-		4.4	321	31.2	0.3
1	7	567		4.3	324	31.2	0.2
2	1	-		4.3	339	29.8	0.2
2	10	-		4.2	337	28.7	<0.1
2	17	-		3.9	381	28.7	0.1
2	28	602		3.7	410	27.4	0.3
3	12	-		3.9	361	32.7	0.3
3	28	617		3.9	442	33.5	0.1
			Core 4B				
1	1	-	Equilibrated with 10%:90% $CO_{2(g)}/N_{2(g)}$	4.6	303	31.2	0.2
1	4	-		4.5	322	30.8	0.4
1	7	578		4.3	336	30.4	0.2
2	1	-		4.3	338	29.6	<0.1
2	10	-		4.1	338	28.1	<0.1
2	17	-		4.0	379	28.4	0.1
2	28	607		3.7	408	26.2	0.2
3	12	-		3.9	357	29.5	0.3
3	28	616		3.9	357	27.7	<0.1

[a] 600 mL of water added to 300 g (dry weight) of each bedrock material. 600 mL of test water replaced at start of each cycle

Table 66. Primary Mineral Forming Cations in Outlet Adsorption Test Water – Quartzite Bedrock Core 4A (Nitrogen).
Input water = pH 4.5 TL water (Table 60)

Cycle/ Day	Cl^-	SO_4^{2-}	Na	K	Mg	Ca	Fe	Bicarbonate Alkalinity as $CaCO_3$	Total Alkalinity as $CaCO_3$	Acidity as $CaCO_3$	Dissolved Inorganic Carbon
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1 / 7	1440	27200	1700	550	790	440	9920	<1	<1	31000	<1
2 / 28	2850	33300	2290	720	1040	550	12400	<1	<1	29000	12
3 / 28	3090	33100	2200	780	1040	560	12900	<1	<1	32600	11
	Ag	Al	As	B	Ba	Be	Bi	Cd	Ce	Co	Cr
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1 / 7	<0.010	3680	0.028	3.06	0.29	0.338	<0.010	0.0342	71.5	73.6	0.588
2 / 28	<0.100	2520	<0.100	2.37	0.135	0.271	<0.10	0.0187	52.7	49.7	0.191
3 / 28	<0.100	2600	0.106	2.20	<0.100	0.247	<0.10	0.0188	54.1	51.2	0.176
	Cu	Hg	Li	Mn	Mo	Ni	Pb	Re	Sb	Se	Si
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1 / 7	744	<0.0001	6.01	201	0.017	7.49	0.021	0.002	<0.010	0.269	37.7
2 / 28	590	<0.0001	4.98	126	<0.100	5.23	<0.10	<0.100	<0.100	<0.500	52.5
3 / 28	586	<0.0001	5.35	126	<0.100	5.03	<0.10	<0.100	<0.100	<0.500	39.2
	Sn	Sr	Th	Ti	Tl	U	V	W	Y	Zn	
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	
1 / 7	<0.010	4.18	0.032	<0.10	0.036	33	<0.10	0.02	23.3	34.1	
2 / 28	<0.100	2.62	<0.100	<1.00	<0.100	28.8	<1.00	<0.100	15.6	20.1	
3 / 28	<0.100	2.58	<0.100	<1.00	<0.100	27.6	<1.00	<0.100	16.4	19.6	

Table 67. Major Anions, Cations, Acidity and Inorganic Carbon in the Output Adsorption Test Water – Quartzite Bedrock Core 4B (Nitrogen/CO_2). Input water = pH 4.5 TL water (Table 60)

Cycle/ Day	Cl^-	SO_4^{2-}	Na	K	Mg	Ca	Fe	Bicarbonate Alkalinity as $CaCO_3$	Total Alkalinity as $CaCO_3$	Acidity as $CaCO_3$	Dissolved Inorganic Carbon
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1 / 7	2480	28800	1880	580	830	440	11300	<1	<1	32500	<1
2 / 28	2610	33200	2550	820	1100	600	12700	<1	<1	31200	10
3 / 28	3800	38500	2400	870	1120	560	14100	<1	<1	34200	11
	Ag	Al	As	B	Ba	Be	Bi	Cd	Ce	Co	Cr
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1 / 7	<0.010	3500	0.04	2.73	0.274	0.317	<0.010	0.0262	69.3	69.8	0.853
2 / 28	<0.100	2480	<0.100	2.18	0.108	0.254	<0.10	<0.010	53.4	49.7	0.312
3 / 28	<0.100	2710	0.117	2.29	0.100	0.245	<0.10	0.0223	60.0	54.7	0.278
	Cu	Hg	Li	Mn	Mo	Ni	Pb	Re	Sb	Se	Si
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1 / 7	736	<0.0001	5.5	182	0.017	7.08	0.012	0.002	<0.010	0.259	39.1
2 / 28	577	<0.0001	4.96	121	<0.100	5.19	<0.10	<0.100	<0.100	<0.500	58.0
3 / 28	614	<0.0001	5.41	131	<0.100	5.37	<0.10	<0.100	<0.100	<0.500	40.4
	Sn	Sr	Th	Ti	Tl	U	V	W	Y	Zn	
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	
1 / 7	<0.010	3.87	0.038	<0.10	0.032	31.8	<0.10	0.02	22.5	28.9	
2 / 28	<0.100	2.60	<0.100	<1.00	<0.100	28.9	<1.00	<0.100	15.8	19.0	
3 / 28	<0.100	2.72	<0.100	<1.00	<0.100	29.1	<1.00	<0.100	18.2	20.4	

3.7.4 Sediment 3.1-04 adsorption tests

For sediment 3.1-04, the volumes of reacted test water recovered after each test cycle and the physico-chemical parameters measured for the adsorption test are shown in Tables 68, 69 and 70 for the tests with W:S ratios of 1 (3 cycles), 2 (4 cycles)and 20 (3 cycles). In each case, the amount of reacted test water recovered after the first cycle was less than that added due to the material becoming more hydrous upon wetting with the test water. For the 2nd and 3rd cycles, the test water recoveries were reasonable for the W:S= 1 test (Table 68), approximately 15% low for the W:S= 2 test (Table 69), and within 5% for the W:S= 20 test (Table 70).

The concentrations of the analytes measured in the reacted test water recovered at the end of each cycle are shown in Tables 71, 72 and 73. Quality assurance data are provided in Appendix D.

Table 68. Sediment 3.1-04 (W:R=1): pH, Redox Potential, Conductivity and Dissolved Oxygen Concentrations for Outlet Adsorption Test Water. Input water = pH 4.5 TL water (Table 58)

Cycle	Day	Recovered volume, mL [a]	Water (deionised) / Atmosphere	pH	Redox potential, (Eh), mV	Conductivity mS/cm	Dissolved oxygen, mg/L
1	1	-	Equilibrated with Deoxygenated, $N_{2(g)}$	NM	NM	NM	NM
1	3	-		5.7	152	13.9	0.8
1	7	236		5.8	162	12.8	0.1
2	3	-		5.7	172	17.4	0.1
2	7	-		5.9	138	15.8	<0.1
2	13	-		5.9	99	15.8	<0.1
2	28	300		6.0	72	15.3	<0.1
3	7	-		5.7	122	18.7	<0.1
3	28	358		5.9	96	17.6	<0.1

[a] 300 mL of water added to 300 g (dry weight) of sediment. 300 mL added at start of each cycle.

Table 69. Sediment 3.1-04(W:R=2): pH, Redox Potential, Conductivity and Dissolved Oxygen Concentrations for Outlet Adsorption Test Water. = pH 4.5 TL water (Table 58)

Cycle	Day	Recovered volume, mL [a]	Sample, water / Atmosphere	pH	Redox potential, (Eh), mV	Conductivity mS/cm	Dissolved oxygen, mg/L
1	1	-	3.1-04 Deionised water Equilibrated with Deoxygenated, $N_{2(g)}$	NM	NM	NM	NM
1	3	-		5.6	162	18.1	0.8
1	7	257		6.0	115	16.5	<0.1
2	3	-		5.6	181	20.7	<0.1
2	7	-		5.8	150	19.9	<0.1
2	13	-		5.9	98	19.6	<0.1
2	28	333		6.1	82	18.9	<0.1
3	7	-		5.8	117	21.1	<0.1
3	28	341		6.0	88	21.7	<0.1
4	10	-		5.8	115	20.8	<0.1
4	28	370		6.2	81	18.9	<0.1

[a] 400 mL of water added to 200 g (dry weight) of sediment. 400 mL added at start of each cycle.

Table 70. Sediment 3.1-04(W:R=20): pH, Redox Potential, Conductivity and Dissolved Oxygen Concentrations for Outlet Adsorption Test Water. Input water = pH 4.5 TL water (Table 58)

Cycle	Day	Recovered volume, mL [a]	Water (deionised) / Atmosphere	pH	Redox potential, (Eh), mV	Conductivity mS/cm	Dissolved oxygen, mg/L
1	1	-	3.1-04 (1:20) Deionised water Equilibrated with Deoxygenated, $N_{2(g)}$	NM	NM	NM	NM
1	3	-		4.8	286	27.6	0.3
1	7	291		5.4	217	23.6	<0.1
2	3	-		4.7	324	29.3	<0.1
2	7	-		4.5	320	27.6	<0.1
2	13	-		4.4	311	27.4	<0.1
2	28	291		4.6	283	26.7	<0.1
3	7	-		4.3	325	21.7	<0.1
3	28	313		4.3	311	21.6	<0.1

[a] 300 mL of water added to 15 g (dry weight) of sediment. 300 mL added at start of each cycle.

Table 71. Major Anions, Cations, Acidity and Inorganic Carbon in the Output Adsorption Test Water – Sediment 3.1-04(W:R=1): (Nitrogen)
Input water = pH 4.5 TL water (Table 60)

Cycle/ Day	Cl^-	SO_4^{2-}	Na	K	Mg	Ca	Fe	Bicarbonate Alkalinity as $CaCO_3$	Total Alkalinity as $CaCO_3$	Acidity as $CaCO_3$	Dissolved Inorganic Carbon
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1 / 7	1560	14200	1600	290	660	490	6250	<1	<1	6000	<3
2 / 28	NM	NM	1830	480	680	490	8120	<1	<1	8600	<1
3 / 28	NM	NM	1850	560	690	480	10500	<1	<1	17900	<1

	Ag	Al	As	B	Ba	Be	Bi	Cd	Ce	Co	Cr
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1 / 7	<0.010	12.2	<0.010	2.21	0.042	<0.010	<0.010	0.0033	0.17	35	<0.010
2 / 28	<0.010	2.07	<0.010	1.52	0.029	<0.010	<0.010	0.0078	0.211	34.0	<0.010
3 / 28	<0.010	3.79	<0.010	1.72	0.027	<0.010	<0.010	0.0072	0.260	43.0	<0.010

	Cu	Hg	Li	Mn	Mo	Ni	Pb	Re	Sb	Se	Si
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1 / 7	0.375	<0.0001	2.52	115	<0.010	2.77	<0.010	0.002	<0.010	0.084	NM
2 / 28	<0.010	<0.0001	2.74	103	<0.010	1.92	<0.010	0.001	<0.010	0.059	2.97
3 / 28	0.602	<0.0001	3.71	112	<0.010	2.54	<0.010	0.002	<0.010	0.070	2.71

	Sn	Sr	Th	Ti	Tl	U	V	W	Y	Zn
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1 / 7	<0.010	2.49	<0.010	<0.10	0.011	6.61	<0.10	<0.010	0.082	5.57
2 / 28	<0.010	2.18	<0.010	<0.10	0.014	5.00	<0.10	<0.010	0.078	4.57
3 / 28	<0.010	2.34	<0.010	<0.10	0.019	6.46	<0.10	<0.010	0.112	6.11

Table 72. Major Anions, Cations, Acidity and Inorganic Carbon in the Output Adsorption Test Water – sediment 3.1-04(W:R=2): (Nitrogen)
Input water = pH 4.5 TL water (Table 60)

Cycle/ Day	Cl^-	SO_4^{2-}	Na	K	Mg	Ca	Fe	Bicarbonate Alkalinity as $CaCO_3$	Total Alkalinity as $CaCO_3$	Acidity as $CaCO_3$	Dissolved Inorganic Carbon
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1 / 7	240	17700	1660	420	700	480	8550	<1	<1	9300	3
2 / 28	NM	NM	1840	540	700	490	9170	<1	<1	8860	<1
3 / 28	NM	NM	1920	610	710	490	10200	<1	<1	38400	<1
4 / 28	3200	2260	2060	690	880	540	8640	<1	<1	10300	<1

	Ag	Al	As	B	Ba	Be	Bi	Cd	Ce	Co	Cr
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1 / 7	<0.010	5.25	<0.010	2.19	0.048	<0.010	<0.010	0.0059	0.354	45.2	<0.010
2 / 28	<0.010	1.40	<0.010	1.42	0.026	<0.010	<0.010	0.0044	0.142	36.4	0.111
3 / 28	<0.010	1.78	<0.010	1.53	0.026	<0.010	<0.010	0.0068	0.130	42.8	<0.010
4 / 28	<0.010	12.9	<0.010	1.41	0.024	<0.010	<0.010	0.0018	0.281	39.4	<0.010

	Cu	Hg	Li	Mn	Mo	Ni	Pb	Re	Sb	Se	Si
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1 / 7	0.083	<0.0001	2.49	139	<0.010	2.9	<0.010	0.002	<0.010	0.092	NM
2 / 28	<0.010	<0.0001	3.25	106	0.011	2.00	<0.010	0.002	<0.010	0.091	3.10
3 / 28	<0.010	<0.0001	3.90	107	<0.010	2.69	<0.010	0.002	<0.010	0.070	2.86
4 / 28	2.69	<0.0001	3.78	83.1	<0.010	2.81	<0.010	0.017	<0.010	0.063	0.20

	Sn	Sr	Th	Ti	Tl	U	V	W	Y	Zn
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1 / 7	<0.010	2.8	<0.010	<0.10	0.015	5.35	<0.10	<0.010	0.105	6.39
2 / 28	<0.010	2.34	<0.010	<0.10	0.019	5.30	<0.10	<0.010	0.075	4.79
3 / 28	<0.010	2.27	<0.010	<0.10	0.021	5.78	<0.10	<0.010	0.094	5.14
4 / 28	<0.010	2.27	<0.010	<0.10	0.023	5.17	<0.10	<0.010	0.137	1.79

Table 73. Major Anions, Cations, Acidity and Inorganic Carbon in the Output Adsorption Test Water – sediment 3.1-04(W:R=20): (Nitrogen)
Input water = pH 4.5 TL water (Table 60)

Cycle/ Day	Cl^-	SO_4^{2-}	Na	K	Mg	Ca	Fe	Bicarbonate Alkalinity as $CaCO_3$	Total Alkalinity as $CaCO_3$	Acidity as $CaCO_3$	Dissolved Inorganic Carbon
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1 / 7	10	22900	1740	610	710	470	10300	<1	<1	15600	4
2 / 28	NM	NM	2000	650	1040	490	12100	<1	<1	16920	<1
3 / 28	NM	NM	2080	680	1200	520	12700	<1	<1	29600	<1
	Ag	Al	As	B	Ba	Be	Bi	Cd	Ce	Co	Cr
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1 / 7	<0.010	315	0.015	2.3	0.148	0.039	<0.010	0.0221	9.57	69.4	<0.010
2 / 28	<0.010	539	0.034	1.91	0.077	0.086	<0.010	0.0220	31.6	51.4	<0.010
3 / 28	<0.010	1250	0.020	1.96	0.066	0.159	<0.010	0.0202	49.5	50.5	<0.010
	Cu	Hg	Li	Mn	Mo	Ni	Pb	Re	Sb	Se	Si
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1 / 7	237	<0.0001	4.91	172	<0.010	6.38	<0.010	0.002	<0.010	0.134	NM
2 / 28	403	<0.0001	5.06	124	<0.010	4.66	<0.010	0.002	<0.010	0.214	8.76
3 / 28	749	<0.0001	5.40	121	<0.010	4.48	0.021	0.002	<0.010	0.254	7.85
	Sn	Sr	Th	Ti	Tl	U	V	W	Y	Zn	
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	
1 / 7	<0.010	3.35	<0.010	<0.10	0.028	16	<0.10	<0.010	1.78	26.9	
2 / 28	<0.010	2.29	<0.010	<0.10	0.028	36.5	<0.10	<0.010	6.06	21.1	
3 / 28	<0.010	2.40	<0.010	<0.10	0.030	30.6	<0.10	0.012	11.8	20.6	

3.7.5 Sediment 3.1-09 and 3.2-12 adsorption tests

For sediments 3.1-09 and 3.2-12, the volumes of reacted test water recovered after each test cycle and the physico-chemical parameters measured for the adsorption test are shown in Tables 74, 75 and 76. In each case the amount of reacted test water recovered was less than that added due to the material becoming more hydrous upon wetting with the test water, however recoveries of reacted water were within 5% of that expected for the 2nd and 3rd cycles.

The concentrations of the analytes measured in the reacted test water recovered at the end of each cycle are shown in Tables 77, 78 and 79. Quality assurance data are provided in Appendix D.

Table 74. Sediment 3.1-09 (W:R=2): pH, Redox Potential, Conductivity and Dissolved Oxygen Concentrations for Outlet Adsorption Test Water.. Input water = pH 4.5 TL water (Table 58)

Cycle	Day	Recovered volume, mL [a]	Water (deionised) / Atmosphere	pH	Redox potential, (Eh), mV	Conductivity mS/cm	Dissolved oxygen, mg/L
1	1	-	3.1-09 Deionised water Equilibrated with Deoxygenated, $N_{2(g)}$	NM	NM	NM	NM
1	3	-		5.3	199	25.9	0.7
1	7	320		5.8	260	24.4	0.4
2	3	-		4.4	276	28.4	0.1
2	7	-		4.4	293	27.4	<0.1
2	13	-		4.2	301	27.7	<0.1
2	28	397		4.2	304	27.4	<0.1
3	7	-		3.9	339	29.3	<0.1
3	28	418		3.8	371	29.0	<0.1
4	10	-		3.8	367	29.0	<0.1
4	28	391		3.9	379	28.9	<0.1

[a] 400 mL of water added to 200 g (dry weight) of sediment. 400 mL added at start of each cycle.

Table 75. Sediment 3.2-12 (W:R=2): pH, Redox Potential, Conductivity and Dissolved Oxygen Concentrations for Outlet Adsorption Test Water.. Input water = pH 4.5 TL water (Table 58)

Cycle	Day	Recovered volume, mL [a]	Water (deionised) / Atmosphere	pH	Redox potential, (Eh), mV	Conductivity mS/cm	Dissolved oxygen, mg/L
1	1	-	3.2-12 Deionised water Equilibrated with Deoxygenated, $N_{2(g)}$	NM	NM	NM	NM
1	3	-		5.1	227	24.9	0.8
1	7	330		5.6	251	22.8	0.6
2	3	-		5.1	211	26.2	0.3
2	7	-		5.2	20.	24.9	0.1
2	13	-		5.3	178	23.7	<0.1
2	28	390		5.5	127	23.4	<0.1
3	7	-		5.1	201	24.5	<0.1
3	28	394		5.3	184	24.3	<0.1
4	10	-		5.2	204	24.0	<0.1
4	28	386		5.6	183	23.9	<0.1

[a] 400 mL of water added to 200 g (dry weight) of sediment. 400 mL added at start of each cycle.

Table 76. Sediment 3.2-12 (W:R=20): pH, Redox Potential, Conductivity and Dissolved Oxygen Concentrations for Outlet Adsorption Test Water.. Input water = pH 4.5 TL water (Table 58)

Cycle	Day	Recovered volume, mL [a]	Water (deionised) / Atmosphere	pH	Redox potential, (Eh), mV	Conductivity mS/cm	Dissolved oxygen, mg/L
1	1	-	3.2-12 Deionised water Equilibrated with Deoxygenated, $N_{2(g)}$	NM	NM	NM	NM
1	3	-		4.5	317	29.9	0.2
1	7	309		4.8	301	28.1	<0.1
2	3	-		4.5	312	29.8	0.2
2	7	-		4.5	330	29.9	<0.1
2	13	-		4.6	305	29.4	<0.1
2	28	292		4.9	210	27.5	<0.1
3	7	-		4.5	308	31.0	<0.1
3	28	301		4.9	206	28.5	<0.1

[a] 300 mL of water added to 15 g (dry weight) of sediment. 300 mL added at start of each cycle.

Table 77. Major Anions, Cations, Acidity and Inorganic Carbon in the Output Adsorption Test Water – sediment 3.1-09 (W:R=2): (Nitrogen)
Input water = pH 4.5 TL water (Table 60)

Cycle/ Day	Cl^-	SO_4^{2-}	Na	K	Mg	Ca	Fe	Bicarbonate Alkalinity as $CaCO_3$	Total Alkalinity as $CaCO_3$	Acidity as $CaCO_3$	Dissolved Inorganic Carbon
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1 / 7	1770	21300	1940	560	730	470	10500	<1	<1	21900	3
2 / 28	NM	NM	2040	680	880	550	13200	<1	<1	19500	<1
3 / 28	NM	NM	2180	720	970	560	13900	<1	<1	24600	<1
4 / 28	3100	3700	2320	690	1060	580	11900	<1	<1	32000	12

	Ag	Al	As	B	Ba	Be	Bi	Cd	Ce	Co	Cr
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1 / 7	<0.010	14.1	0.012	2.23	0.089	<0.010	<0.010	0.0181	2.09	53.7	<0.010
2 / 28	<0.010	1020	0.042	2.50	0.074	0.166	<0.010	0.0237	42.3	51.2	<0.010
3 / 28	<0.010	2120	0.028	2.36	0.077	0.310	<0.010	0.0235	58.5	54.7	<0.010
4 / 28	<0.010	2530	0.058	2.25	0.071	0.288	<0.010	0.0257	55.9	52.8	<0.010

	Cu	Hg	Li	Mn	Mo	Ni	Pb	Re	Sb	Se	Si
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1 / 7	8.97	<0.0001	3.81	163	0.018	5.31	<0.010	0.002	<0.010	0.11	NM
2 / 28	781	<0.0001	5.68	131	<0.010	5.42	<0.010	0.002	<0.010	0.260	73.7
3 / 28	710	<0.0001	6.21	131	<0.010	5.11	<0.010	0.002	<0.010	0.308	64.5
4 / 28	574	<0.0001	5.13	129	<0.010	5.14	<0.010	0.018	<0.010	0.292	6.01

	Sn	Sr	Th	Ti	Tl	U	V	W	Y	Zn
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1 / 7	<0.010	3.48	<0.010	<0.10	0.011	2.27	<0.10	<0.010	0.358	14.1
2 / 28	<0.010	3.30	<0.010	<0.10	0.026	36.7	<0.10	0.011	9.09	24.9
3 / 28	<0.010	2.95	0.015	<0.10	0.031	34.9	<0.10	0.014	15.1	22.5
4 / 28	<0.010	2.66	0.018	<0.10	0.032	28.3	<0.10	0.014	14.9	21.1

Table 78. Major Anions, Cations, Acidity and Inorganic Carbon in the Output Adsorption Test Water – sediment 3.2-12(W:R=2): (Nitrogen)
Input water = pH 4.5 TL water (Table 60)

Cycle/ Day	Cl^-	SO_4^{2-}	Na	K	Mg	Ca	Fe	Bicarbonate Alkalinity as $CaCO_3$	Total Alkalinity as $CaCO_3$	Acidity as $CaCO_3$	Dissolved Inorganic Carbon
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1 / 7	1550	22400	1740	510	1310	440	9850	<1	<1	22050	<3
2 / 28	NM	NM	1940	620	1690	480	11700	<1	<1	25800	<1
3 / 28	NM	NM	1980	660	1740	480	12100	<1	<1	19200	<1
4 / 28	3150	3350	2060	700	1880	520	11800	<1	<1	13300	9

	Ag	Al	As	B	Ba	Be	Bi	Cd	Ce	Co	Cr
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1 / 7	<0.010	43.3	0.019	2.3	0.135	0.01	<0.010	0.0042	5.02	1.33	<0.010
2 / 28	<0.010	15.1	0.017	1.60	0.071	<0.010	<0.010	0.0076	7.89	48.5	<0.010
3 / 28	<0.010	22.3	0.013	1.70	0.064	<0.010	<0.010	0.0225	11.8	51.1	<0.010
4 / 28	<0.010	18.5	0.014	1.53	0.067	<0.010	<0.010	0.0204	3.97	50.9	<0.010

	Cu	Hg	Li	Mn	Mo	Ni	Pb	Re	Sb	Se	Si
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1 / 7	44.1	<0.0001	4.6	327	<0.010	6.62	<0.010	0.002	<0.010	0.147	NM
2 / 28	6.47	<0.0001	5.01	163	<0.010	4.03	<0.010	0.002	<0.010	0.118	16.3
3 / 28	6.43	<0.0001	5.57	140	<0.010	4.16	<0.010	0.002	<0.010	0.127	14.6
4 / 28	3.60	<0.0001	4.66	141	<0.010	4.28	<0.010	0.016	<0.010	0.133	0.98

	Sn	Sr	Th	Ti	Tl	U	V	W	Y	Zn
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1 / 7	<0.010	5.22	<0.010	<0.10	0.026	7	<0.10	<0.010	0.944	19.8
2 / 28	<0.010	3.12	<0.010	<0.10	0.025	9.59	<0.10	<0.010	0.982	17.3
3 / 28	<0.010	2.68	<0.010	<0.10	0.026	13.1	<0.10	<0.010	1.76	20.2
4 / 28	<0.010	3.48	<0.010	<0.10	0.026	14.4	<0.10	<0.010	1.26	19.2

Table 79. Major Anions, Cations, Acidity and Inorganic Carbon in the Output Adsorption Test Water – sediment 3.2-12 (W:R=20): (Nitrogen)
Input water = pH 4.5 TL water (Table 60)

Cycle/ Day	Cl^-	SO_4^{2-}	Na	K	Mg	Ca	Fe	Bicarbonate Alkalinity as $CaCO_3$	Total Alkalinity as $CaCO_3$	Acidity as $CaCO_3$	Dissolved Inorganic Carbon
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1 / 7	1650	26400	1820	560	1210	500	8860	<1	<1	38400	3
2 / 28	NM	NM	1890	630	1660	490	11700	<1	<1	28200	<1
3 / 28	NM	NM	2020	680	1740	500	12800	<1	<1	25000	<1

	Ag	Al	As	B	Ba	Be	Bi	Cd	Ce	Co	Cr
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1 / 7	<0.010	2810	0.027	2.31	0.227	0.193	<0.010	0.0198	39.1	1.33	<0.010
2 / 28	<0.010	245	0.026	1.82	0.120	0.041	<0.010	0.0174	25.5	49.6	<0.010
3 / 28	<0.010	257	0.033	1.90	0.100	0.052	<0.010	0.0192	36.9	50.9	<0.010

	Cu	Hg	Li	Mn	Mo	Ni	Pb	Re	Sb	Se	Si
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1 / 7	656	<0.0001	5.21	183	<0.010	6.03	<0.010	0.002	<0.010	0.202	NM
2 / 28	152	<0.0001	5.16	131	<0.010	4.34	<0.010	0.002	<0.010	0.172	8.90
3 / 28	107	<0.0001	5.72	132	<0.010	4.53	<0.010	0.002	<0.010	0.231	9.00

	Sn	Sr	Th	Ti	Tl	U	V	W	Y	Zn
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1 / 7	<0.010	3.6	<0.010	<0.10	0.035	29.3	<0.10	0.012	13.2	25.7
2 / 28	<0.010	2.48	<0.010	<0.10	0.026	19.2	<0.10	<0.010	4.76	26.2
3 / 28	<0.010	2.33	<0.010	<0.10	0.027	22.9	<0.10	<0.010	7.39	20.3

3.8 Mineralogical Examination of Leach Residues

The full mineralogy report is provided in Appendix E.

3.8.1 Basement lithologies

The post-leach sample of Andamooka limestone varied in particle size from 10-400 µm with most particles falling within the 100-300 µm range (Appendix E, Figure 3.1). Sub-angular polycrystalline aggregates of carbonate (indentified as dolomite by x-ray diffraction) were common, occurring in association with sub-angular quartz grains. No evidence for dissolution or precipitation of phases was found either in the polished block or in a comparison of the pre and post leach samples under a binocular microscope. Although the leaching data suggested that copper had been absorbed/precipitated, no evidence of any copper compound was found in the optical examination.

Pre- and post-leach samples of Arcoona quartzite were available for detailed petrographic examination. The grain size of both samples varied from 10 to 300 µm and both were dominated by equant to sub-equant sub-angular to rounded quartz grains (Appendix E, Figures 3.2 and 3.3). Potash feldspar and micaceous grains (identified as mica/illite by x-ray diffraction) were also present. Rare, anhedral grains of hematite are also present, varying in size from 10 to 100 µm, although most are less than 50 µm in size. Although the leaching data indicated that iron may have been deposited there was no indication of this, in fact the reverse, as a binocular microscopic examination suggested that the colouring on the grains (most likely due to iron) was less intense in the post-leach sample.

ODXH 3.2-12 was comprised largely of equant to sub-equant sub-angular grains varying in size from 10 to 300 µm although most grains are less than 100µm (Appendix E, Figure 3.4). Carbonate (identified as dolomite by x-ray diffraction) was the dominant phase, occurring as polycrystalline aggregates in the larger particles. Rare quartz and clay (likely to be smectite) were also present. Binocular microscopic examination of pre- and post-leach samples indicates that some grains have a thin coating of iron oxide which was at variance with the leaching results which indicated very little change in the iron content of the leach liquor. No other indication of dissolution or reprecipitation was identified.

ODXH 3.1-04 was similar to ODXH 3.2-12, although polycrystalline aggregates up to 600 µm in size were present (Appendix E, Figure 3.5). Carbonate grains were dominant (calcite and dolomite by x-ray diffraction) but angular grains of quartz were common and clay rich aggregates were also present. Although the leaching data indicated that aluminium and copper were precipitated/absorbed no clear evidence for precipitation was found. However, some clay rich grains appeared to have a distinct partial rim (Appendix E, Figure 3.5) although it was unclear as to if this is a primary or a secondary feature as no sample of the pre-leach material was available for a detailed optical examination.

ODXH 3.1-09 had a distinctive mineralogy in comparison to the other two sediment samples, consisting almost exclusively of quartz with only minor carbonate (calcite by x-ray diffraction) (Appendix E, Figure 3.6). Quartz occurs as sub-equant to equant sub-angular grains varying in size from 10 µm to 300µm with 100 to 200 µm grains being abundant. Although only one leach experiment suggested that copper precipitation had occurred, films of malachite/azurite were observed in a binocular microscope examination of the post leach sample which were absent in the pre-leach material.

ODXH 3.2-05 and ODXH 4.1-04 had a similar mineralogy, containing abundant hematite, mica/illite and quartz. The particle size varies from <5 μm to 100 μm. Quartz occurred as angular, sub-equant to equant grains and mica/illite as large granular aggregates (Appendix E, Figures 3.7 and 3.8). Hematite was common, occurring either as 10 to 100 μm angular grains or as complex intergrowths with other phases (Appendix E, Figure 3.7). Although elements such as copper appeared to have been leached from ODXH 3.2-05, no evidence was found in the optical examination of dissolution. There was some evidence that iron may have been leached from ODXH 4.1-04 as the post leach material was slightly paler than the pre-leach material. However, the leaching data indicated that iron was only removed in the initial leach experiments.

ODXH 3.2-01 and ODXH 3.2-01 were of the same tailings material leached under unsaturated and saturated conditions respectively. The tailings sample differed from samples 1 and 2 in containing more abundant quartz and mica/illite as shown by X-ray diffraction analysis. Quartz grains were common, ranging in size up to nearly 400 μm (Appendix E, Figures 3.9 and 3.10). In a binocular microscope examination of the pre- and post-leach material, sparse coatings of malachite/azurite were observed on some grains in the post-leach material that are absent in the pre-leach sample. Minor copper sulfhides were present in ODXH 3.2-01 as shown in Figure 3.11 (Appendix E). Whereas covellite appears to be unaffected, some bornite grains have a rim of secondary oxidation products (malachite/azurite). It was unclear as to if the sulfide oxidation was a primary or secondary feature as samples of the pre-leach material were unavailable for a detailed optical examination.

4. DISCUSSION

The characterisation of tailings, sediment and bedrock samples collected from the beneath the main tailings dam of the Olympic Dam mine was undertaken and reported in Simpson et al. (2008). Based on this initial assessment, samples were selected for a more detailed assessment of the mobility metals, radionuclides and major anions and cations. This assessment included (i) sequential extraction procedures to assess of the partitioning to different solid phases, (ii) bottle rolling tests, unsaturated column tests and saturated column tests to assess of the leachability of tailings and sediments with deionised water, (iii) adsorption and desorption tests for major anions, cations, metals and radionuclides. The influence of dissolved oxygen and carbon dioxide on the mobilisation and adsorption processes was investigated.

Interpretation of the results was not within the scope of this report, however there are a number of methodological points worth noting, and are discussed below. Detailed interpretatioin of the results and findings are made in the full report (SRK Consulting, 2009).

4.1 Sequential Extractions

The sequential extractions provided information on the ‘relative proportions’ of substances extractable sequentially using each reagent. The ‘total’ concentration (in mg/kg) was taken from the initial characterisation of the sample (Simpson et al., 2008), and because this was a different sub-sample of the material, the ‘sum’ of the sequentially extracted concentrations (1-5) may be quite different to the ‘total’. Due to the small mass of material retrievable at the completion of step

4 (~4-8 g), only the ‘soluble’ fraction, rather than ‘total recoverable’ fraction was analysed for the major anions and cations. In general, radium-226 was below the detection limit.

4.2 Deionised Water Leaching Tests

The 3-week bottle rolling tests of tailings and sediments were completed successfully and indicated little difference in leachability in air or nitrogen atmosphere. The 21-week unsaturated column leach tests of the tailings were completed successfully and indicated that, for most substances, most of the leaching occurred within 3-6 weeks. The 10-week saturated column leach tests of the tailings were completed, however a number of operational problems were encountered due to the fine particle size of the materials. The materials compressed in the columns over the duration of the tests and horizontal fractures appeared within both columns by week 5. Between cycles, an attempt was made to redistribute the material compressed towards the top of the column by tapping the columns (which caused material to descend back towards the base to the columns. While this was not ideal, it did not result in any longitudinal cracking and preferential flow paths through the columns. Oxic conditions caused greater leaching of major anions and cations and most metals from the tailing than anoxic conditions (deoxygenated water). Leaching of manganese, which is soluble in the reduced form of Mn(II), was greater under anoxic conditions. Again, in general, radium-226 was below the detection limit.

4.3 Adsorption Tests with pH 4.5 Tailings Liquid

It was not possible to undertake all the adsorption tests as column tests due to fine particle size of most of the materials. Fine clays caused high back-pressure in test columns and the flow rates of liquids through these materials in sub-surface aquifers cannot be replicated in laboratory-based column experiments. Consequently, after several failed attempts at commencing column tests, the majority of the experiments were undertaken as bottle rolling tests. The bottle-rolling adsorption tests were considered to be appropriate for investigating the adsorption properties of sediment materials.

For the saturated column tests of the Core-1 (limestone) material, there was significantly greater removal from the pH-4.5 tailings water of a number of metals (e.g. Al, Cu, U, Zn) under a 10%-CO_2/90% N_2 (g) atmosphere than a 100% N_2 atmosphere. These differences were not apparent from the bottle rolling tests with the same material and test conditions. The limestone (Core-1) material was much more effective than the quartzite (Core-4) material at removing/adsorbing substances from the pH-4.5 tailings water. In most cases, there was less removal of metals in the 1st cycle than in the subsequent 2-3 cycles (addition of new pH-4.5 tailings water).

For the sediment materials, the removal metals from the pH-4.5 tailings water was greater for lower water:rock (W:R) ratios. At W:R ratios of 1 and 2, generally the % removal did not decrease with successive cycles. For the 3.1-04 sediment, at W:R=20 the % removal of Al, Ce, Cu, and U decreased with successive cycles was similar (e.g. with 20%). This trend was not observed for the 3.2-12 sediment.

5. REFERENCES

APHA (1998). Standard methods for the examination of water and wastewater. American Public Health Association, American Water Works Association and Water Environment Federation (APHA-AWWA-WEF).

ASTM (1998). Standard practice for oxidation-reduction potential of water, D 1498-00. American Society for Testing and Materials, West Conshohocken, PA, USA.

Brunauer, S., Emmett P.H. and Teller, E. (1938). Adsorption of gases in multimolecular layers. Am. Chem. Soc., 60, 309-319.

Mudroch, A., Azcue, J.M., and Mudroch, P. (1997). Manual of physico-chemical analysis of aquatic sediments. CRC Press, Boca Raton, FL, USA.

NEPM (1999) National Environment Protection (Assessment of Site Contamination) Measure 1999. http://www.ephc.gov.au/nepms/cs/con_sites.html.

Rayment, G.E. and Higginson, F.R. (1992). Australian Laboratory Handbook of Soil and Water Chemical Methods. 330 pp. (Reed International Books Australia P/L, trading as Inkata Press, Port Melbourne.).

Simpson, S.L., Kilgore, D., Spadaro, D.A., Angel, B.A., Hamilton, I. (2008). Characterisation of the geochemistry of Olympic Dam tailings material. CSIRO Land and Water Report No. CLW44/08, 120 pages.

US EPA (1996). Test methods for evaluating solid waste, physical/chemical methods, SW-846. United States Environmental Protection Agency; Office of Solid Waste; Economic, Methods, and Risk Analysis. Division, Washington, DC.

APPENDIX A. Sequential Extractions

Dissolved concentrations from sequential extraction tests

Table A1. Dissolved metal concentrations for sequentially extracted tailing and sediment samples (Part 1 of 3)

Samples	Ag	Al	As	B	Ba	Be	Bi	Cd	Ce	Co	Cr
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
ODXH3.2-05 (1)	<0.001	69.9	0.003	<0.05	0.042	0.005	<0.001	0.0002	2.29	0.428	0.005
ODXH4.1-04 (1)	<0.001	50.1	0.004	<0.05	0.051	0.004	<0.001	0.0007	6.67	0.871	<0.001
ODXH4.2-05 (1)	<0.001	61.4	<0.001	<0.05	0.022	0.008	<0.001	0.0010	5.31	0.417	<0.001
ODXH4.1-10 (1)	<0.001	0.49	<0.001	0.21	0.002	<0.001	<0.001	0.0002	0.009	<0.001	<0.001
ODXH3.2-05 (2)	0.003	2.82	0.003	<0.05	3.78	0.008	0.006	0.0002	1.27	0.029	<0.001
ODXH4.1-04 (2)	0.002	0.75	<0.001	<0.05	7.38	0.006	0.004	0.0005	1.14	0.010	0.008
ODXH4.2-05 (2)	0.002	15.8	<0.001	<0.05	0.254	0.010	<0.001	0.0003	8.60	0.071	0.015
ODXH4.1-10 (2)	0.001	0.42	<0.001	<0.05	0.029	0.010	<0.001	0.0021	0.040	0.005	0.010
ODXH3.2-05 (3)	0.010	39.4	0.411	0.16	8.02	0.002	0.111	0.0006	12.4	0.013	0.013
ODXH4.1-04 (3)	0.008	21.5	0.217	0.06	3.61	0.002	0.061	0.0004	6.42	0.014	0.035
ODXH4.2-05 (3)	0.006	<0.01	0.046	0.11	1.92	0.044	0.006	0.0003	5.61	0.072	0.207
ODXH4.1-10 (3)	0.003	9.55	0.042	0.07	0.132	0.015	0.002	0.0006	2.34	0.035	0.014
ODXH3.2-05 (4)	0.017	47.8	0.401	0.14	6.30	0.003	0.009	0.0036	6.40	0.016	<0.001
ODXH4.1-04 (4)	0.011	15.7	0.285	<0.05	2.91	0.001	0.018	0.0005	4.62	0.011	<0.001
ODXH4.2-05 (4)	0.005	291	0.110	0.08	1.80	0.009	0.004	0.0007	0.858	0.024	0.032
ODXH4.1-10 (4)	0.010	8.86	0.079	0.06	0.062	0.006	0.002	0.0244	0.224	0.044	<0.001

Table A2. Dissolved metal concentrations for sequentially extracted tailing and sediment samples (Part 2 of 3)

Samples	Cu mg/L	Hg mg/L	Li mg/L	Mn mg/L	Mo mg/L	Ni mg/L	Pb mg/L	Re mg/L	Sb mg/L	Se mg/L
ODXH3.2-05 (1)	3.66	<0.0001	0.134	1.01	<0.001	0.045	0.012	<0.001	<0.001	<0.010
ODXH4.1-04 (1)	0.028	<0.0001	0.103	2.92	<0.001	0.081	0.010	<0.001	<0.001	<0.010
ODXH4.2-05 (1)	46.4	0.0001	0.175	1.04	<0.001	0.052	0.002	<0.001	<0.001	<0.010
ODXH4.1-10 (1)	<0.001	<0.0001	0.002	0.003	0.002	<0.001	0.002	<0.001	<0.001	<0.010
ODXH3.2-05 (2)	0.221	<0.0001	0.007	0.070	0.003	0.006	0.205	<0.001	<0.001	<0.010
ODXH4.1-04 (2)	0.135	<0.0001	0.004	0.052	<0.001	0.004	0.136	<0.001	<0.001	<0.010
ODXH4.2-05 (2)	18.7	0.0019	0.030	0.174	<0.001	0.009	0.020	<0.001	<0.001	<0.010
ODXH4.1-10 (2)	0.211	<0.0001	0.006	0.017	0.003	<0.001	0.047	<0.001	<0.001	<0.010
ODXH3.2-05 (3)	19.2	0.0009	0.024	0.039	0.083	0.005	0.219	<0.001	0.032	0.011
ODXH4.1-04 (3)	3.02	0.0010	0.013	0.140	0.026	0.009	0.274	<0.001	0.009	<0.010
ODXH4.2-05 (3)	15.9	0.0004	0.216	0.489	0.001	0.096	0.131	<0.001	<0.001	0.012
ODXH4.1-10 (3)	0.126	<0.0001	0.006	0.141	0.004	0.012	0.238	<0.001	<0.001	0.012
ODXH3.2-05 (4)	6.34	0.0012	0.025	0.034	0.333	0.010	0.265	<0.001	0.016	0.013
ODXH4.1-04 (4)	1.98	0.0009	0.010	0.029	0.171	0.013	0.196	<0.001	0.012	<0.010
ODXH4.2-05 (4)	2.67	0.0003	0.119	0.530	0.021	0.072	0.072	<0.001	<0.001	<0.010
ODXH4.1-10 (4)	0.036	<0.0001	0.004	0.252	0.021	0.090	0.060	<0.001	0.002	<0.010

Table A3. Dissolved metal concentrations for sequentially extracted tailing and sediment samples (Part 3 of 3)

Samples	Si mg/L	Sn mg/L	Sr mg/L	Th mg/L	Ti mg/L	Tl mg/L	U mg/L	V mg/L	W mg/L	Y mg/L	Zn mg/L
ODXH3.2-05 (1)	2.86	<0.001	0.371	0.022	<0.01	<0.001	1.32	<0.01	<0.001	0.461	0.205
ODXH4.1-04 (1)	1.26	<0.001	0.513	0.023	<0.01	<0.001	0.905	<0.01	<0.001	0.517	0.311
ODXH4.2-05 (1)	0.43	<0.001	0.964	0.007	<0.01	0.001	1.87	<0.01	<0.001	0.765	0.642
ODXH4.1-10 (1)	1.70	<0.001	0.797	<0.001	<0.01	<0.001	0.002	<0.01	<0.001	<0.001	0.024
ODXH3.2-05 (2)	2.06	<0.001	0.380	0.090	<0.01	<0.001	0.134	0.02	<0.001	0.220	0.199
ODXH4.1-04 (2)	3.11	<0.001	0.460	0.079	<0.01	<0.001	0.131	0.02	<0.001	0.083	0.326
ODXH4.2-05 (2)	2.33	<0.001	2.36	0.202	0.01	<0.001	2.55	0.03	0.001	1.32	0.225
ODXH4.1-10 (2)	1.90	<0.001	2.24	0.002	0.01	<0.001	0.038	0.04	<0.001	0.013	0.131
ODXH3.2-05 (3)	74.5	0.028	0.704	0.365	1.13	<0.001	1.62	0.01	0.018	0.679	0.066
ODXH4.1-04 (3)	37.8	0.010	0.506	0.268	0.56	<0.001	0.493	0.02	0.006	0.321	0.274
ODXH4.2-05 (3)	198	0.001	0.630	0.236	0.20	0.002	3.49	1.31	0.002	3.21	0.329
ODXH4.1-10 (3)	14.4	0.001	1.88	0.104	0.04	<0.001	0.036	0.68	<0.001	0.159	0.497
ODXH3.2-05 (4)	67.8	0.020	0.311	0.181	0.48	<0.001	0.144	0.10	0.082	0.278	0.365
ODXH4.1-04 (4)	21.1	0.014	0.216	0.087	0.38	<0.001	0.084	0.11	0.043	0.134	0.618
ODXH4.2-05 (4)	115	0.003	0.229	0.046	0.24	0.001	0.755	0.58	0.003	0.738	0.423
ODXH4.1-10 (4)	12.5	0.003	0.630	0.029	0.24	<0.001	0.014	0.34	0.002	0.038	1.15

Table A4. Dissolved major cation and anions for sequentially extracted tailing and sediment samples

Samples	Sulfate as SO_4^{2-} mg/L	Chloride mg/L	Calcium mg/L	Magnesium mg/L	Sodium mg/L	Potassium mg/L	Iron mg/L
ODXH3.2-05 (1)	777	33	197	5	30	3	12.4
ODXH4.1-04 (1)	1120	46	248	23	38	1	175
ODXH4.2-05 (1)	1560	53	570	4	35	19	4.81
ODXH4.1-10 (1)	1400	27	596	4	46	<1	1.56
ODXH3.2-05 (2)	48	8720	18	<1	16600	9	0.17
ODXH4.1-04 (2)	17	8920	15	5	16800	8	2.86
ODXH4.2-05 (2)	2640	8670	950	<1	16300	27	9.07
ODXH4.1-10 (2)	4530	8770	2050	<1	16900	7	<0.05
ODXH3.2-05 (3)	38	16400	142	<1	394	27	60.2
ODXH4.1-04 (3)	75	16800	124	34	293	21	82.1
ODXH4.2-05 (3)	371	16500	108	92	554	26	388
ODXH4.1-10 (3)	3190	16500	1400	6	246	1	6.69
ODXH3.2-05 (4)	52	36500	82	1	3	26	148
ODXH4.1-04 (4)	73	36500	25	3	1	16	121
ODXH4.2-05 (4)	185	37400	56	36	13	18	164
ODXH4.1-10 (4)	1470	36500	628	2	<1	<1	87.8

Duplicates and blanks metal concentrations from sequential extraction tests

Table A5.Duplicate analyses for sequential extractions: metals

Samples	Ag mg/L	Al mg/L	As mg/L	B mg/L	Ba mg/L	Be mg/L	Bi mg/L	Cd mg/L
ODXH4.2-05 (1)	<0.001	61.4	<0.001	<0.05	0.022	0.008	<0.001	0.0010
ODXH4.2-05 D (1)	<0.001	64.4	<0.001	<0.05	0.031	0.008	<0.001	0.0004
ODXH4.1-10 (3)	0.003	9.55	0.042	0.07	0.132	0.015	0.002	0.0006
ODXH4.1-10 D (3)	0.002	9.53	0.044	0.07	0.131	0.014	0.002	0.0003
Reagent Blank (1)	<0.001	0.02	<0.001	<0.05	<0.001	<0.001	<0.001	<0.0001
Reagent Blank (2)	<0.001	0.02	<0.001	<0.05	0.019	0.006	<0.001	0.0003
Reagent Blank (3)	0.002	<0.05	<0.005	<0.05	<0.005	<0.005	<0.001	0.0006
Reagent Blank (4)	0.005	0.02	<0.001	<0.05	<0.001	<0.001	<0.001	0.0008

Samples	Co mg/L	Cr mg/L	Cu mg/L	Hg mg/L	Li mg/L	Mn mg/L	Mo mg/L	Ni mg/L
ODXH4.2-05 (1)	0.417	<0.001	46.4	0.0001	0.175	1.04	<0.001	0.052
ODXH4.2-05 D (1)	0.416	<0.001	46.7	<0.0001	0.183	1.05	<0.001	0.051
ODXH4.1-10 (3)	0.035	0.014	0.126	<0.0001	0.006	0.141	0.004	0.012
ODXH4.1-10 D (3)	0.035	0.016	0.117	<0.0001	0.006	0.145	0.004	0.016
Reagent Blank (1)	<0.001	<0.001	0.003	0.0009	<0.001	<0.001	<0.001	<0.001
Reagent Blank (2)	<0.001	0.006	0.010	<0.0001	0.005	0.008	0.010	0.003
Reagent Blank (3)	<0.005	<0.005	<0.005	<0.0001	<0.005	<0.005	<0.005	<0.005
Reagent Blank (4)	<0.001	<0.001	0.002	<0.0001	<0.001	<0.001	<0.001	0.007

Samples	Pb mg/L	Re mg/L	Sb mg/L	Se mg/L	Si mg/L	Sn mg/L	Sr mg/L	Th mg/L
ODXH4.2-05 (1)	0.002	<0.001	<0.001	<0.010	0.43	<0.001	0.964	0.007
ODXH4.2-05 D (1)	0.002	<0.001	<0.001	<0.010	3.23	<0.001	0.958	0.008
ODXH4.1-10 (3)	0.238	<0.001	<0.001	0.012	14.4	0.001	1.88	0.104
ODXH4.1-10 D (3)	0.238	<0.001	<0.001	0.011	13.8	<0.001	1.86	0.105
Reagent Blank (1)	<0.001	<0.001	<0.001	<0.010	<0.05	<0.001	<0.001	<0.001
Reagent Blank (2)	0.002	<0.001	<0.001	<0.010	<0.25	<0.001	0.022	<0.001
Reagent Blank (3)	<0.005	<0.001	<0.005	<0.025	0.14	<0.005	<0.001	<0.001
Reagent Blank (4)	0.001	<0.001	<0.001	<0.010	0.17	0.002	<0.001	<0.001

Samples	Ti mg/L	Tl mg/L	U mg/L	V mg/L	W mg/L	Y mg/L	Zn mg/L
ODXH4.2-05 (1)	<0.01	0.001	1.87	<0.01	<0.001	0.765	0.642
ODXH4.2-05 D (1)	<0.01	<0.001	1.86	<0.01	0.001	0.755	0.228
ODXH4.1-10 (3)	0.04	<0.001	0.036	0.68	<0.001	0.159	0.497
ODXH4.1-10 D (3)	0.04	<0.001	0.035	0.68	<0.001	0.159	0.149
Reagent Blank (1)	<0.01	<0.001	<0.001	<0.01	<0.001	<0.001	0.130
Reagent Blank (2)	<0.01	<0.001	<0.001	0.02	<0.001	<0.001	0.110
Reagent Blank (3)	<0.01	<0.005	<0.001	<0.05	<0.001	<0.001	0.040
Reagent Blank (4)	0.18	<0.001	<0.001	0.10	<0.001	<0.001	0.162

Table A6.Duplicate analyses for sequential extractions: major ions

Samples	Sulfate as SO_4^{2-} mg/L	Chloride mg/L	Calcium mg/L	Magnesium mg/L	Sodium mg/L	Potassium mg/L	Iron mg/L
ODXH4.1-04 (2)	17	8920	15	5	16800	8	2.86
ODXH4.1-04 D (2)	17	8920	15	5	16700	8	0.20
ODXH4.1-04 D (3)	78	16400	129	34	300	21	84.0
ODXH4.1-04 (3)	75	16800	124	34	293	21	82.1
Reagent Blank (1)	1	1	<1	<1	<1	<1	<0.05
Reagent Blank (2)	35	7790	16	<1	19400	4	<0.05
Reagent Blank (3)	2	16800	1	<1	<1	<1	<0.05
Reagent Blank (4)	8	36500	1	<1	<1	<1	<0.05

APPENDIX B. Deionised Water Leaching of Tailings and Sediments

Duplicates and blank concentrations from leach experiment

Table B1. Duplicate metal concentrations leached from tailings and sediment samples (1 of 3) 1 = Week 1 air atmosphere, 2 = Week 1 nitrogen atmosphere, 3 = Week 2 air atmosphere, 4 = Week 2 nitrogen atmosphere, 5 = Week 3 air atmosphere, 6 = Week 3 nitrogen atmosphere,

Samples		Ag mg/L	Al mg/L	As mg/L	B mg/L	Ba mg/L	Be mg/L	Bi mg/L	Cd mg/L	Ce mg/L	Co mg/L	Cr mg/L
4.1_04	2	<0.001	292	0.038	0.68	0.022	0.025	<0.001	0.0022	40	8.76	<0.001
4.1_04	2	<0.001	283	0.031	0.68	0.021	0.024	<0.001	0.0031	38	8.44	<0.001
3.2_05	4	<0.001	204	0.018	0.16	0.013	0.019	<0.001	0.0008	16.1	1.44	0.019
3.2_05	4	<0.001	199	0.02	0.14	0.012	0.018	<0.001	0.0038	15.8	1.36	0.019
4.2_05	5	<0.001	330	0.004	0.13	0.03	0.028	<0.001	0.0006	7.97	1.18	<0.001
4.2_05	5	<0.001	320	0.001	0.11	0.028	0.03	<0.001	0.0042	7.43	1.12	<0.001

Samples		Cu mg/L	Hg mg/L	Li mg/L	Mn mg/L	Mo mg/L	Ni mg/L	Pb mg/L	Re mg/L	Sb mg/L	Se mg/L	Cu mg/L
4.1_04	2	0.016	<0.0001	1.06	16	<0.001	0.73	<0.001	<0.001	<0.001	0.032	0.016
4.1_04	2	0.002	<0.0001	1.02	15.6	<0.001	0.7	0.001	<0.001	<0.001	0.031	0.002
3.2_05	4	11.9	<0.0001	0.454	3.35	<0.001	0.135	0.032	<0.001	<0.001	0.014	11.9
3.2_05	4	11.6	<0.0001	0.439	3.24	<0.001	0.132	0.032	<0.001	<0.001	0.016	11.6
4.2_05	5	47.6	<0.0001	0.504	2.79	<0.001	0.143	<0.001	<0.001	<0.001	0.015	47.6
4.2_05	5	45.5	<0.0001	0.489	2.68	<0.001	0.135	0.002	<0.001	<0.001	<0.010	45.5

Samples		Si mg/L	Sn mg/L	Sr mg/L	Th mg/L	Ti mg/L	Tl mg/L	U mg/L	V mg/L	W mg/L	Y mg/L	Zn mg/L
4.1_04	2	6.25	<0.001	2.41	0.002	<0.01	<0.001	4.56	<0.01	0.003	2.83	2.24
4.1_04	2	6.08	<0.001	2.27	0.002	<0.01	<0.001	4.34	<0.01	0.002	2.7	2.3
3.2_05	4	11.9	<0.001	1.52	0.092	<0.01	<0.001	4.1	<0.01	0.001	1.88	0.219
3.2_05	4	11.4	<0.001	1.47	0.089	<0.01	<0.001	3.94	<0.01	0.001	1.79	0.294
4.2_05	5	14.2	<0.001	1.62	0.019	<0.01	0.001	3.31	<0.01	0.001	1.37	0.587
4.2_05	5	13.3	<0.001	1.56	0.018	<0.01	0.001	3.27	<0.01	0.001	1.32	1.46

Table B3. Blank metal concentrations from leach experiments (1 of 3).

Samples	Ag mg/L	Al mg/L	As mg/L	B mg/L	Ba mg/L	Be mg/L	Bi mg/L	Cd mg/L	Ce mg/L	Co mg/L	Cr mg/L
Blank	<0.001	<0.01	<0.001	<0.05	0.047	<0.001	<0.001	0.0003	<0.001	<0.001	<0.001
deoxy Blank	<0.001	0.12	<0.001	<0.05	0.012	<0.001	<0.001	0.0004	<0.001	<0.001	<0.001

Samples	Cu mg/L	Hg mg/L	Li mg/L	Mn mg/L	Mo mg/L	Ni mg/L	Pb mg/L	Re mg/L	Sb mg/L	Se mg/L	Cu mg/L
Blank	<0.001	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.010	<0.001
deoxy Blank	<0.001	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.010	<0.001

Samples	Si mg/L	Sn mg/L	Sr mg/L	Th mg/L	Ti mg/L	Tl mg/L	U mg/L	V mg/L	W mg/L	Y mg/L	Zn mg/L
Blank	0.55	<0.001	<0.001	<0.001	<0.01	<0.001	<0.001	<0.01	<0.001	<0.001	<0.005
deoxy Blank	0.28	<0.001	<0.001	<0.001	<0.01	<0.001	<0.001	<0.01	<0.001	<0.001	0.014

Table B4. Blanks (no tailings or sediment): pH, redox potential, conductivity and dissolved oxygen concentrations during leach tests

Week	Day	Sample	Water (deionised) / Atmosphere	pH	Redox potential, (Eh), mV	Conductivity mS/cm	Dissolved oxygen, mg/L
1	1	MQ Blank	Oxygenated, Air	7.0	485	13.4	5.9
1	3		Oxygenated, Air	6.6	362	6.3	8.0
1	5		Oxygenated, Air	6.8	327	17.6	8.7
2	8		Oxygenated, Air	6.7	449	4.2	9.9
2	10		Oxygenated, Air	6.3	476	4.4	9.3
2	12		Oxygenated, Air	6.3	409	7.9	9.3
3	15		Oxygenated, Air	6.9	403	16.5	10.5
3	17		Oxygenated, Air	7.6	417	9.2	8.8
3	19		Oxygenated, Air	7.2	444	9.7	11.3
3	21		Oxygenated, Air	7.2	429	9.0	11.4
1	1	MQ Blank	Deoxygenated, $N_{2(g)}$	6.5	412	8.6	0.5
1	3		Deoxygenated, $N_{2(g)}$	6.6	358	14.6	0.4
1	5		Deoxygenated, $N_{2(g)}$	6.8	436	26.6	0.2
2	8		Deoxygenated, $N_{2(g)}$	6.7	430	5.8	0.2
2	10		Deoxygenated, $N_{2(g)}$	7.2	334	0.2	0.4
2	12		Deoxygenated, $N_{2(g)}$	7.0	265	5.4	0.3
3	15		Deoxygenated, $N_{2(g)}$	7.2	350	12.0	1.3
3	17		Deoxygenated, $N_{2(g)}$	7.6	459	6.9	1.2
3	19		Deoxygenated, $N_{2(g)}$	7.2	430	3.9	1.1
3	21		Deoxygenated, $N_{2(g)}$	7.2	434	3.2	0.9

APPENDIX C. Replicate analyses of selected samples from column and adsorption tests

Table C1. Comparison of analyses on replicate samples from same test

Sample	Cl^-	SO_4^{2-}	Na	K	Mg	Ca	Fe	Bicarbonate Alkalinity as $CaCO_3$	Total Alkalinity as $CaCO_3$	Acidity as $CaCO_3$	Dissolved Inorganic Carbon
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
OW-TW 10			10	14	26	580	0.26				
R_OW-TW 10			10	20	30	570	<0.5				
	Ag	Al	As	B	Ba	Be	Bi	Cd	Ce	Co	Cr
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
OW-TW 10	<0.010	0.98	<0.010	1.12	0.026	<0.010	<0.010	0.0021	0.035	0.282	<0.010
R_OW-TW 10	<0.010	<0.10	<0.010	0.47	0.015	<0.010	<0.010	0.0017	<0.010	0.138	<0.010
	Cu	Hg	Li	Mn	Mo	Ni	Pb	Re	Sb	Se	Si
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
OW-TW 10	0.939	<0.0001	0.122	7.95	0.385	<0.010	<0.010	<0.001	<0.010	<0.050	
R_OW-TW 10	0.094	<0.0001	0.094	4.47	0.236	<0.010	<0.010	<0.001	<0.010	<0.050	7.19
	Sn	Sr	Th	Ti	Tl	U	V	W	Y	Zn	
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	
OW-TW 10	<0.010	6.47	<0.010	<0.10	<0.010	2.11	<0.10	<0.010	0.011	0.12	
R_OW-TW 10	<0.010	3.86	<0.010	<0.10	<0.010	1.27	<0.10	<0.010	<0.01	0.018	

Table C2. Comparison of analyses on replicate samples from same test

Sample	Cl^-	SO_4^{2-}	Na	K	Mg	Ca	Fe	Bicarbonate Alkalinity as $CaCO_3$	Total Alkalinity as $CaCO_3$	Acidity as $CaCO_3$	Dissolved Inorganic Carbon
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
N2TW5			116	60	166	882	<0.05				
R_N2TW5			100	60	150	700	0.5				
	Ag	Al	As	B	Ba	Be	Bi	Cd	Ce	Co	Cr
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
N2TW5	<0.001	0.05	0.005	3.05	0.037	<0.001	<0.001	<0.0001	<0.001	0.322	<0.001
R_N2TW5	<0.010	<0.10	<0.010	2.48	0.034	<0.010	<0.010	<0.0010	<0.010	0.309	<0.010
	Cu	Hg	Li	Mn	Mo	Ni	Pb	Re	Sb	Se	Si
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
N2TW5	0.221	<0.0001	0.5	6.55	0.618	0.006	<0.001	<0.001	0.002	<0.010	14.2
R_N2TW5	0.048	<0.0001	0.388	6.40	0.620	<0.010	<0.010	<0.001	<0.010	<0.050	14.9
	Sn	Sr	Th	Ti	Tl	U	V	W	Y	Zn	
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	
N2TW5	<0.001	8.43	<0.001	<0.01	<0.001	4.84	<0.01	0.006	<0.001	0.028	
R_N2TW5	<0.010	7.76	<0.010	<0.10	<0.010	4.77	<0.10	<0.010	<0.010	<0.010	

Table C3. Comparison of analyses on replicate samples from same test

Sample	Cl^-	SO_4^{2-}	Na	K	Mg	Ca	Fe	Bicarbonate Alkalinity as $CaCO_3$	Total Alkalinity as $CaCO_3$	Acidity as $CaCO_3$	Dissolved Inorganic Carbon
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
pH4.5_TL2W3			2300	730	1040	860	12800				
R-pH4.5_TL2W3			2220	690	1040	760	12900				
	Ag	Al	As	B	Ba	Be	Bi	Cd	Ce	Co	Cr
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
pH4.5_TL2W3	<0.010	2430	<0.010	2.11	0.056	0.238	<0.010	0.0196	47.8	53	0.019
R-pH4.5_TL2W3	<0.010	2650	0.022	2.30	0.061	0.266	<0.010	0.0208	56.2	60.0	0.015
	Cu	Hg	Li	Mn	Mo	Ni	Pb	Re	Sb	Se	Si
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
pH4.5_TL2W3	552	<0.0001	6.05	127	0.015	4.68	0.036	0.002	<0.010	0.175	7.46
R-pH4.5_TL2W3	635	<0.0001	6.48	145	<0.010	5.37	0.040	0.002	<0.010	0.282	9.82
	Sn	Sr	Th	Ti	Tl	U	V	W	Y	Zn	
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	
pH4.5_TL2W3	<0.010	2.54	<0.010	<0.10	0.033	25.5	<0.10	0.012	14.4	20.8	
R-pH4.5_TL2W3	<0.010	2.84	0.042	<0.10	0.034	28.7	<0.10	0.013	17.7	23.8	

Table C4. Comparison of analyses on replicate samples from same test

Sample	Cl^-	SO_4^{2-}	Na	K	Mg	Ca	Fe	Bicarbonate Alkalinity as $CaCO_3$	Total Alkalinity as $CaCO_3$	Acidity as $CaCO_3$	Dissolved Inorganic Carbon
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Core 1B_N2W2			2080	650	1340	720	534				
R-Core 1B_N2W2			2000	500	1370	590	11600				
	Ag	Al	As	B	Ba	Be	Bi	Cd	Ce	Co	Cr
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Core 1B_N2W2	<0.010	1490	<0.010	2.26	0.124	0.161	<0.010	0.0208	34.5	49.2	0.017
R-Core 1B_N2W2	<0.010	1520	0.021	2.37	<0.010	0.174	<0.010	0.0212	35.2	49.8	0.021
	Cu	Hg	Li	Mn	Mo	Ni	Pb	Re	Sb	Se	Si
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Core 1B_N2W2	304	<0.0001	4.84	242	<0.010	5.01	0.016	0.002	<0.010	0.118	8.94
R-Core 1B_N2W2	302	<0.0001	5.20	248	<0.010	5.03	<0.010	0.002	<0.010	0.199	10.4
	Sn	Sr	Th	Ti	Tl	U	V	W	Y	Zn	
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	
Core 1B_N2W2	<0.010	2.68	<0.010	<0.10	0.021	20.6	<0.10	<0.010	10.3	24.1	
R-Core 1B_N2W2	<0.010	2.56	<0.010	<0.10	0.021	21.2	<0.10	<0.010	10.3	24.4	

Table C5. Comparison of analyses on replicate samples from same test

Sample	Cl^-	SO_4^{2-}	Na	K	Mg	Ca	Fe	Bicarbonate Alkalinity as $CaCO_3$	Total Alkalinity as $CaCO_3$	Acidity as $CaCO_3$	Dissolved Inorganic Carbon
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Core 1B_N2W3			2060	660	1490	620	13400				
R-Core 1B_N2W3			2020	640	1520	640	12900				
	Ag	Al	As	B	Ba	Be	Bi	Cd	Ce	Co	Cr
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Core 1B_N2W3	<0.010	1040	0.01	2.27	0.103	0.116	<0.010	0.0182	25.8	50.8	0.014
R-Core 1B_N2W3	<0.010	1050	<0.010	2.34	0.104	0.128	<0.010	0.0194	26.1	50.6	0.015
	Cu	Hg	Li	Mn	Mo	Ni	Pb	Re	Sb	Se	Si
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Core 1B_N2W3	<0.100	15.9	<0.100	1.61	<0.100	<0.100	<0.100	0.0132	14.4	48.3	<0.100
R-Core 1B_N2W3	<0.010	14.0	0.018	1.59	<0.010	0.010	<0.010	0.0160	15.1	48.3	<0.010
	Sn	Sr	Th	Ti	Tl	U	V	W	Y	Zn	
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	
Core 1B_N2W3	<0.010	2.38	<0.010	<0.10	0.02	18.3	<0.10	<0.010	7.09	24	
R-Core 1B_N2W3	<0.010	2.39	<0.010	<0.10	0.020	18.4	<0.10	<0.010	7.26	24.2	

Table C6. Comparison of analyses on replicate samples from same test

Sample	Cl^-	SO_4^{2-}	Na	K	Mg	Ca	Fe	Bicarbonate Alkalinity as $CaCO_3$	Total Alkalinity as $CaCO_3$	Acidity as $CaCO_3$	Dissolved Inorganic Carbon
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Core 1A_N2LW2			2050	710	1990	510	11700				
R-Core 1A_N2LW2			1940	530	1780	490	11500				
	Ag	Al	As	B	Ba	Be	Bi	Cd	Ce	Co	Cr
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Core 1A_N2LW2	1.5	<0.0001	4.14	160	<0.100	4.78	<0.100	<0.100	<0.100	<0.500	9.99
R-Core 1A_N2LW2	2.15	<0.0001	5.15	165	<0.010	4.48	<0.010	0.002	<0.010	0.155	10.3
	Cu	Hg	Li	Mn	Mo	Ni	Pb	Re	Sb	Se	Si
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Core 1A_N2LW2	205	0.0001	5.02	232	<0.010	5.03	0.013	0.002	<0.010	0.154	8.14
R-Core 1A_N2LW2	207	<0.0001	5.19	227	<0.010	5.01	0.013	0.002	<0.010	0.146	8.89
	Sn	Sr	Th	Ti	Tl	U	V	W	Y	Zn	
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	
Core 1A_N2LW2	<0.100	1.94	<0.100	<1.00	<0.100	12.2	<1.00	<0.100	1.62	16.8	
R-Core 1A_N2LW2	<0.010	1.97	<0.010	<0.10	0.024	12.0	<0.10	<0.010	1.66	18.4	

Table C7. Comparison of analyses on replicate samples from same test

Sample	Cl^-	SO_4^{2-}	Na	K	Mg	Ca	Fe	Bicarbonate Alkalinity as $CaCO_3$	Total Alkalinity as $CaCO_3$	Acidity as $CaCO_3$	Dissolved Inorganic Carbon
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Core 1A_N2LW3			2120	740	2000	520	13500				
R-Core 1A_N2LW3			2110	720	1800	490	13600				
	Ag	Al	As	B	Ba	Be	Bi	Cd	Ce	Co	Cr
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Core 1A_N2LW3	<0.100	32.9	<0.100	1.91	<0.100	<0.100	<0.100	0.0221	14.7	53	<0.100
R-Core 1A_N2LW3	<0.010	28.0	0.015	1.85	0.070	0.016	<0.010	0.0229	15.3	54.3	<0.010
	Cu	Hg	Li	Mn	Mo	Ni	Pb	Re	Sb	Se	Si
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Core 1A_N2LW3	8.8	0.0002	5.21	161	<0.100	5.31	<0.100	<0.100	<0.100	<0.500	10.5
R-Core 1A_N2LW3	8.19	<0.0001	6.08	164	<0.010	4.90	<0.010	0.002	<0.010	0.165	10.8
	Sn	Sr	Th	Ti	Tl	U	V	W	Y	Zn	
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	
Core 1A_N2LW3	<0.100	2.13	<0.100	<1.00	<0.100	19.8	<1.00	<0.100	3.53	20.2	
R-Core 1A_N2LW3	<0.010	2.21	<0.010	<0.10	0.027	20.4	<0.10	<0.010	3.54	21.8	

Table C8. Comparison of analyses on replicate samples from same test

Sample	Cl^-	SO_4^{2-}	Na	K	Mg	Ca	Fe	Bicarbonate Alkalinity as $CaCO_3$	Total Alkalinity as $CaCO_3$	Acidity as $CaCO_3$	Dissolved Inorganic Carbon
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Core 4B_CO2LW3			2200	780	1040	560	12900				
R-Core 4B_CO2LW3			2120	680	940	530	13100				
	Ag	Al	As	B	Ba	Be	Bi	Cd	Ce	Co	Cr
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Core 4B_CO2LW3	<0.100	2600	0.106	2.2	<0.100	0.247	<0.10	0.0188	54.1	51.2	0.176
R-Core 4B_CO2LW3	<0.010	2280	0.021	2.10	0.080	0.254	<0.010	0.0177	54.9	48.4	0.235
	Cu	Hg	Li	Mn	Mo	Ni	Pb	Re	Sb	Se	Si
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Core 4B_CO2LW3	586	<0.0001	5.35	126	<0.100	5.03	<0.10	<0.100	<0.100	<0.500	39.2
R-Core 4B_CO2LW3	544	<0.0001	5.88	121	<0.010	4.40	0.026	0.002	<0.010	0.265	37.5
	Sn	Sr	Th	Ti	Tl	U	V	W	Y	Zn	
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	
Core 4B_CO2LW3	<0.100	2.58	<0.100	<1.00	<0.100	27.6	<1.00	<0.100	16.4	19.6	
R-Core 4B_CO2LW3	<0.010	2.50	0.040	<0.10	0.031	27.2	<0.10	0.012	15.9	20.2	

Table C9. Comparison of analyses on replicate samples from same test

Sample	Cl^-	SO_4^{2-}	Na	K	Mg	Ca	Fe	Bicarbonate Alkalinity as $CaCO_3$	Total Alkalinity as $CaCO_3$	Acidity as $CaCO_3$	Dissolved Inorganic Carbon
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
3.1_04 R2 W2 L			1840	540	700	490	9170				
R-3.1_04 R2 W2 L			1840	440	700	470	8820				
	Ag	Al	As	B	Ba	Be	Bi	Cd	Ce	Co	Cr
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
3.1_04 R2 W2 L	<0.010	1.4	<0.010	1.42	0.026	<0.010	<0.010	0.0044	0.142	36.4	0.111
R-3.1_04 R2 W2 L	<0.010	12.2	<0.010	1.64	<0.010	<0.010	<0.010	0.0068	0.416	38.2	<0.010
	Cu	Hg	Li	Mn	Mo	Ni	Pb	Re	Sb	Se	Si
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	Mg/L	mg/L	mg/L	mg/L	mg/L
3.1_04 R2 W2 L	<0.010	<0.0001	3.25	106	0.011	2	<0.010	0.002	<0.010	0.091	3.1
R-3.1_04 R2 W2 L	3.28	<0.0001	4.02	110	<0.010	1.92	<0.010	0.002	<0.010	0.057	3.50
	Sn	Sr	Th	Ti	Tl	U	V	W	Y	Zn	
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	
3.1_04 R2 W2 L	<0.010	2.34	<0.010	<0.10	0.019	5.3	<0.10	<0.010	0.075	4.79	
R-3.1_04 R2 W2 L	<0.010	2.40	<0.010	<0.10	0.018	5.52	<0.10	<0.010	0.157	4.95	

Table C10. Comparison of analyses on replicate samples from same test

Sample	Cl^-	SO_4^{2-}	Na	K	Mg	Ca	Fe	Bicarbonate Alkalinity as $CaCO_3$	Total Alkalinity as $CaCO_3$	Acidity as $CaCO_3$	Dissolved Inorganic Carbon
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
3.2_12 R2 W3 L			1980	660	1740	480	12100				
R-3.2_12 R2 W3 L			1960	650	1760	480	12400				
	Ag	Al	As	B	Ba	Be	Bi	Cd	Ce	Co	Cr
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
3.2_12 R2 W3 L	<0.010	22.3	0.013	1.7	0.064	<0.010	<0.010	0.0225	11.8	51.1	<0.010
R-3.2_12 R2 W3 L	<0.010	15.7	<0.010	1.76	0.064	<0.010	<0.010	0.0168	11.7	49.6	<0.010
	Cu	Hg	Li	Mn	Mo	Ni	Pb	Re	Sb	Se	Si
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
3.2_12 R2 W3 L	6.43	<0.0001	5.57	140	<0.010	4.16	<0.010	0.002	<0.010	0.127	14.6
R-3.2_12 R2 W3 L	5.51	<0.0001	5.66	142	<0.010	4.11	<0.010	0.002	<0.010	0.119	13.8
	Sn	Sr	Th	Ti	Tl	U	V	W	Y	Zn	
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	
3.2_12 R2 W3 L	<0.010	2.68	<0.010	<0.10	0.026	13.1	<0.10	<0.010	1.76	20.2	
R-3.2_12 R2 W3 L	<0.010	2.66	<0.010	<0.10	0.025	13.2	<0.10	<0.010	1.73	19.8	

APPENDIX D. General QA/QC from analyses by ALS

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES

Environmental Division

QUALITY CONTROL REPORT

Work Order	: **EB0810407**	Page	: 1 of 6
Client	: **C S I R O AUSTRALIA**	Laboratory	: Environmental Division Brisbane
Contact	: DR STUART SIMPSON	Contact	: Tim Kilmister
Address	: 11 JULIUS AVENUE RIVERSIDE CORPORATE PARK, NORTH RYDE NSW, AUSTRALIA 2113	Address	: 32 Shand Street Stafford QLD Australia 4053
E-mail	: stuart.simpson@csiro.au	E-mail	: Services.Brisbane@alsenviro.com
Telephone	: +61 02 94908534	Telephone	: +61-7-3243 7222
Facsimile	: +61 02 94908499	Facsimile	: +61-7-3243 7218
Project	: Olympic Dam Analysis	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Site	: ----		
C-O-C number	: ----	Date Samples Received	: 05-AUG-2008
Sampler	: ----	Issue Date	: 14-AUG-2008
Order number	: ----		
		No. of samples received	: 29
Quote number	: BN/328/08	No. of samples analysed	: 29

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 Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

NATA
WORLD RECOGNISED
ACCREDITATION

NATA Accredited Laboratory 825

This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

Signatories

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

Signatories	*Position*	*Accreditation Category*
Kim McCabe	Senior Inorganic Chemist	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 preformed, 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 insuffient 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.

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = Chemistry Abstract Services number
LOR = Limit of reporting
RPD = Relative Percentage Difference
# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR:- No Limit; Result between 10 and 20 times LOR:- 0% - 50%; Result > 20 times LOR:- 0% - 20%.

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
ED040F: Dissolved Major Anions (QC Lot: 724486)									
EB0810403-001	Anonymous	ED040F: Sulfate as SO4 2-	14808-79-8	1	mg/L	210	212	1.0	0% - 20%
EB0810407-006	deoxy 3.2_05 (6)	ED040F: Sulfate as SO4 2-	14808-79-8	1	mg/L	4170	4310	3.3	0% - 20%
ED040F: Dissolved Major Anions (QC Lot: 724488)									
EB0810407-017	deoxy 4.1_10 (19)	ED040F: Sulfate as SO4 2-	14808-79-8	1	mg/L	2490	2460	1.1	0% - 20%
EB0810407-026	deoxy 3.2_05 (27)	ED040F: Sulfate as SO4 2-	14808-79-8	1	mg/L	1610	1620	1.0	0% - 20%
ED045P: Chloride by PC Titrator (QC Lot: 726213)									
EB0810383-005	Anonymous	ED045-P: Chloride	16887-00-6	1	mg/L	3	3	0.0	No Limit
EB0810383-022	Anonymous	ED045-P: Chloride	16887-00-6	1	mg/L	1	1	0.0	No Limit
ED045P: Chloride by PC Titrator (QC Lot: 726214)									
EB0810407-011	3.2_05 D (12)	ED045-P: Chloride	16887-00-6	1	mg/L	87	87	0.0	0% - 20%
EB0810407-020	3.2_05 (22)	ED045-P: Chloride	16887-00-6	1	mg/L	25	25	0.0	0% - 20%
ED093F: Dissolved Major Cations (QC Lot: 724487)									
EB0810403-001	Anonymous	ED093F: Calcium	7440-70-2	1	mg/L	32	33	0.0	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	32	32	0.0	0% - 20%
		ED093F: Sodium	7440-23-5	1	mg/L	235	238	1.1	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	8	8	0.0	No Limit
EB0810407-006	deoxy 3.2_05 (6)	ED093F: Calcium	7440-70-2	1	mg/L	437	462	5.6	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	45	46	0.0	0% - 20%
		ED093F: Sodium	7440-23-5	1	mg/L	293	296	0.9	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	37	38	3.2	0% - 20%
ED093F: Dissolved Major Cations (QC Lot: 724489)									
EB0810407-017	deoxy 4.1_10 (19)	ED093F: Calcium	7440-70-2	1	mg/L	550	538	2.3	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	36	35	2.9	0% - 20%
		ED093F: Sodium	7440-23-5	1	mg/L	729	704	3.5	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	5	5	0.0	No Limit
EB0810407-026	deoxy 3.2_05 (27)	ED093F: Calcium	7440-70-2	1	mg/L	577	577	0.0	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	4	4	0.0	No Limit
		ED093F: Sodium	7440-23-5	1	mg/L	21	22	0.0	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	7	7	0.0	No Limit
EG020T: Total Metals by ICP-MS (QC Lot: 727288)									
EB0810407-001	3.2_05 (2)	EG020A-T: Iron	7439-89-6	0.05	mg/L	580	600	3.4	0% - 20%
EB0810407-010	3.2_05 (12)	EG020A-T: Iron	7439-89-6	0.05	mg/L	168	169	0.5	0% - 20%
EG020T: Total Metals by ICP-MS (QC Lot: 727289)									
EB0810407-021	4.1_04 (23)	EG020A-T: Iron	7439-89-6	0.05	mg/L	0.18	0.24	25.5	No Limit

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
				Laboratory Duplicate (DUP) Report					
EG020T: Total Metals by ICP-MS (QC Lot: 727289) - continued									
EB0810452-001	Anonymous	EG020A-T: Iron	7439-89-6	0.05	mg/L	0.33	0.28	16.8	No Limit

Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **WATER**

				Method Blank (MB) Report	*Laboratory Control Spike (LCS) Report*			
					Spike	*Spike Recovery (%)*	*Recovery Limits (%)*	
Method: Compound	*CAS Number*	*LOR*	*Unit*	*Result*	*Concentration*	*LCS*	*Low*	*High*
ED040F: Dissolved Major Anions (QCLot: 724486)								
ED040F: Sulfate as SO4 2-	14808-79-8	1	mg/L	<1	----	----	----	----
ED040F: Dissolved Major Anions (QCLot: 724488)								
ED040F: Sulfate as SO4 2-	14808-79-8	1	mg/L	<1	----	----	----	----
ED045P: Chloride by PC Titrator (QCLot: 726213)								
ED045-P: Chloride	16887-00-6	1	mg/L	<1	1000 mg/L	100	88.4	110
ED045P: Chloride by PC Titrator (QCLot: 726214)								
ED045-P: Chloride	16887-00-6	1	mg/L	<1	1000 mg/L	99.1	88.4	110
ED093F: Dissolved Major Cations (QCLot: 724487)								
ED093F: Calcium	7440-70-2	1	mg/L	<1	----	----	----	----
ED093F: Magnesium	7439-95-4	1	mg/L	<1	----	----	----	----
ED093F: Sodium	7440-23-5	1	mg/L	<1	----	----	----	----
ED093F: Potassium	7440-09-7	1	mg/L	<1	----	----	----	----
ED093F: Dissolved Major Cations (QCLot: 724489)								
ED093F: Calcium	7440-70-2	1	mg/L	<1	----	----	----	----
ED093F: Magnesium	7439-95-4	1	mg/L	<1	----	----	----	----
ED093F: Sodium	7440-23-5	1	mg/L	<1	----	----	----	----
ED093F: Potassium	7440-09-7	1	mg/L	<1	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 727288)								
EG020A-T: Iron	7439-89-6	0.05	mg/L	<0.05	0.500 mg/L	92.9	70	130
EG020T: Total Metals by ICP-MS (QCLot: 727289)								
EG020A-T: Iron	7439-89-6	0.05	mg/L	<0.05	0.500 mg/L	98.9	70	130

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **WATER**

				Matrix Spike (MS) Report			
				Spike	Spike Recovery (%)	Recovery Limits (%)	
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*Concentration*	*MS*	*Low*	*High*
ED045P: Chloride by PC Titrator (QCLot: 726213)							
EB0810383-006	Anonymous	ED045-P: Chloride	16887-00-6	20 mg/L	100	70	130
ED045P: Chloride by PC Titrator (QCLot: 726214)							
EB0810407-012	4.1_04 (13)	ED045-P: Chloride	16887-00-6	80 mg/L	96.2	70	130

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES

Environmental Division

QUALITY CONTROL REPORT

Work Order : **EB0810408**

Client : **C S I R O AUSTRALIA**
Contact : DR STUART SIMPSON
Address : 11 JULIUS AVENUE
RIVERSIDE CORPORATE PARK, NORTH RYDE NSW,
AUSTRALIA 2113

E-mail : stuart.simpson@csiro.au
Telephone : +61 02 94908534
Facsimile : +61 02 94908499

Project : Olympic Dam Analysis
Site : ----
C-O-C number : ----
Sampler : ----
Order number : ----

Quote number : BN/328/08

Page : 1 of 7

Laboratory : Environmental Division Brisbane
Contact : Tim Kilmister
Address : 32 Shand Street Stafford QLD Australia 4053

E-mail : Services.Brisbane@alsenviro.com
Telephone : +61-7-3243 7222
Facsimile : +61-7-3243 7218

QC Level : NEPM 1999 Schedule B(3) and ALS QCS3 requirement

Date Samples Received : 05-AUG-2008
Issue Date : 22-AUG-2008

No. of samples received : 4
No. of samples analysed : 4

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 Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

NATA
WORLD RECOGNISED ACCREDITATION

NATA Accredited Laboratory 825

This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

Signatories

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

Signatories	*Position*	*Accreditation Category*
Kim McCabe	Senior Inorganic Chemist	Virginia Minerals
Stephen Hislop	Senior Inorganic Chemist	Inorganics
Stephen Hislop	Senior Inorganic Chemist	Virginia Minerals

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 preformed, 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 insuffient 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.

Key :
Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = Chemistry Abstract Services number
LOR = Limit of reporting
RPD = Relative Percentage Difference
# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR:- No Limit; Result between 10 and 20 times LOR:- 0% - 50%; Result > 20 times LOR:- 0% - 20%.

Sub-Matrix: **SOIL**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
ED042T: Total Sulfur by LECO (QC Lot: 731934)									
EB0810408-001	ODXH3.2-05	ED042T: Sulfur - Total as S (LECO)	----	0.01	%	0.23	0.25	8.3	0% - 20%
ED093T: Total Major Cations (QC Lot: 727262)									
EB0810408-001	ODXH3.2-05	ED093T: Sodium	7440-23-5	10	mg/kg	200	220	5.8	0% - 20%
		ED093T: Potassium	7440-09-7	10	mg/kg	1370		7.7	0% - 20%
		ED093T: Calcium	7440-70-2	10	mg/kg	1080		11.1	0% - 20%
		ED093T: Magnesium	7439-95-4	10	mg/kg	310	370	18.8	0% - 20%
EG005T: Total Metals by ICP-AES (QC Lot: 724061)									
EB0810408-001	ODXH3.2-05	EG005T: Beryllium	7440-41-7	1	mg/kg	<1		0.0	No Limit
		EG005T: Cadmium	7440-43-9	1	mg/kg	<1	<1	0.0	No Limit
		EG005T: Barium	7440-39-3	10	mg/kg	3660	3960	7.7	0% - 20%
		EG005T: Titanium	7440-32-6	10	mg/kg	120		0.0	0% - 50%
		EG005T: Chromium	7440-47-3	2	mg/kg	44		5.2	0% - 20%
		EG005T: Cobalt	7440-48-4	2	mg/kg	12	14	14.1	No Limit
		EG005T: Molybdenum	7439-98-7	2	mg/kg	20		0.0	0% - 50%
		EG005T: Nickel	7440-02-0	2	mg/kg	5	5	0.0	No Limit
		EG005T: Silver	7440-22-4	2	mg/kg	<2		0.0	No Limit
		EG005T: Strontium	7440-24-6	2	mg/kg	22		13.2	0% - 50%
		EG005T: Antimony	7440-36-0	5	mg/kg	<5	<5	0.0	No Limit
		EG005T: Arsenic	7440-38-2	5	mg/kg	134	141	4.6	0% - 20%
		EG005T: Copper	7440-50-8	5	mg/kg	620	655	5.5	0% - 20%
		EG005T: Lead	7439-92-1	5	mg/kg	821	898	8.9	0% - 20%
		EG005T: Manganese	7439-96-5	5	mg/kg	622		5.2	0% - 20%
		EG005T: Selenium	7782-49-2	5	mg/kg	<5		0.0	No Limit
		EG005T: Tin	7440-31-5	5	mg/kg	<5	<5	0.0	No Limit
		EG005T: Vanadium	7440-62-2	5	mg/kg	<5		0.0	No Limit
		EG005T: Zinc	7440-66-6	5	mg/kg	75	82	9.3	0% - 50%
		EG005T: Thallium	7440-28-0	5	mg/kg	<5		0.0	No Limit
		EG005T: Aluminium	7429-90-5	50	mg/kg	6760	7320	8.1	0% - 20%
		EG005T: Boron	7440-42-8	50	mg/kg	<50		0.0	No Limit
		EG005T: Iron	7439-89-6	50	mg/kg	26400	29100	9.7	0% - 20%
		EG005T: Sulfur as S	----	50	mg/kg	1260	1370	8.9	0% - 20%
EG020T: Total Metals by ICP-MS (QC Lot: 724063)									
EB0810408-001	ODXH3.2-05	EG020X-T: Uranium	7440-61-1	0.1	mg/kg	17.6	17.9	2.1	0% - 20%
		EG020X-T: Lithium	7439-93-2	0.1	mg/kg	3.8		2.7	0% - 20%
EG020T: Total Metals by ICP-MS (QC Lot: 724064)									

Sub-Matrix: **SOIL**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EG020T: Total Metals by ICP-MS (QC Lot: 724064) - continued									
EB0810408-001	ODXH3.2-05	EG020Y-T: Bismuth	7440-69-9	0.1	mg/kg	2.1		5.5	0% - 20%
EG020T: Total Metals by ICP-MS (QC Lot: 724066)									
EB0810408-001	ODXH3.2-05	EG020R-T: Cerium	7440-45-1	0.1	mg/kg	713		1.8	0% - 20%
		EG020R-T: Thorium	7440-29-1	0.1	mg/kg	12.1	12.3	1.8	0% - 20%
		EG020R-T: Yttrium	7440-65-5	0.1	mg/kg	19.6	19.0	2.9	0% - 20%
EG035T: Total Recoverable Mercury by FIMS (QC Lot: 724062)									
EB0810408-001	ODXH3.2-05	EG035T: Mercury	7439-97-6	0.1	mg/kg	<0.1		0.0	No Limit
MEICP81: Silicon by Peroxide Fusion (QC Lot: 731935)									
EB0810408-004	ODXH4.1-10	ME-ICP81: Silica	7631-86-9	0.01	%	26.9	26.9	0.1	0% - 20%

Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **SOIL**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result	Concentration	LCS	Low	High
ED042T: Total Sulfur by LECO (QCLot: 731934)								
ED042T: Sulfur - Total as S (LECO)	----	0.01	%	<0.01	100 %	99.6	70	130
ED093T: Total Major Cations (QCLot: 727262)								
ED093T: Sodium	7440-23-5	50	mg/kg	<50	----	----	----	----
ED093T: Potassium	7440-09-7	50	mg/kg	<50	----	----	----	----
ED093T: Calcium	7440-70-2	50	mg/kg	<50	----	----	----	----
ED093T: Magnesium	7439-95-4	50	mg/kg	<50	----	----	----	----
EG005T: Total Metals by ICP-AES (QCLot: 724061)								
EG005T: Aluminium	7429-90-5	50	mg/kg	<50	----	----	----	----
EG005T: Antimony	7440-36-0	5	mg/kg	<5	----	----	----	----
EG005T: Arsenic	7440-38-2	5	mg/kg	<5	13.8 mg/kg	86.9	79.7	120
EG005T: Barium	7440-39-3	10	mg/kg	<10	143 mg/kg	100	91.2	121
EG005T: Beryllium	7440-41-7	1	mg/kg	<1	----	----	----	----
EG005T: Boron	7440-42-8	50	mg/kg	<50	----	----	----	----
EG005T: Cadmium	7440-43-9	1	mg/kg	<1	2.82 mg/kg	97.9	80.9	115
EG005T: Chromium	7440-47-3	2	mg/kg	<2	61.6 mg/kg	98.0	87.2	121
EG005T: Cobalt	7440-48-4	2	mg/kg	<2	----	----	----	----
EG005T: Copper	7440-50-8	5	mg/kg	<5	54.7 mg/kg	102	90.2	122
EG005T: Iron	7439-89-6	50	mg/kg	<50	----	----	----	----
EG005T: Lead	7439-92-1	5	mg/kg	<5	55.5 mg/kg	99.1	85.9	116
EG005T: Manganese	7439-96-5	5	mg/kg	<5	----	----	----	----
EG005T: Molybdenum	7439-98-7	2	mg/kg	<2	----	----	----	----
EG005T: Nickel	7440-02-0	2	mg/kg	<2	55.1 mg/kg	101	87.8	122
EG005T: Selenium	7782-49-2	5	mg/kg	<5	----	----	----	----
EG005T: Silver	7440-22-4	2	mg/kg	<2	----	----	----	----
EG005T: Strontium	7440-24-6	2	mg/kg	<2	----	----	----	----
EG005T: Tin	7440-31-5	5	mg/kg	<5	----	----	----	----
EG005T: Vanadium	7440-62-2	5	mg/kg	<5	----	----	----	----
EG005T: Zinc	7440-66-6	5	mg/kg	<5	105 mg/kg	99.3	86.7	119
EG005T: Sulfur as S	----	50	mg/kg	<50	----	----	----	----
EG005T: Titanium	7440-32-6	10	mg/kg	<10	----	----	----	----
EG005T: Thallium	7440-28-0	5	mg/kg	<5	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 724063)								
EG020X-T: Uranium	7440-61-1	0.1	mg/kg	<0.1	----	----	----	----
EG020X-T: Lithium	7439-93-2	0.1	mg/kg	<0.1	----	----	----	----

Sub-Matrix: **SOIL**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result	Concentration	LCS	Low	High
EG020T: Total Metals by ICP-MS (QCLot: 724064)								
EG020Y-T: Bismuth	7440-69-9	0.1	mg/kg	<0.1	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 724065)								
EG020V-T: Rhenium	7440-15-5	0.01	mg/kg	<0.05	----	----	----	----
EG020V-T: Tungsten	7440-33-7	0.01	mg/kg	<0.05	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 724066)								
EG020R-T: Cerium	7440-45-1	0.1	mg/kg	<0.1	----	----	----	----
EG020R-T: Thorium	7440-29-1	0.1	mg/kg	<0.1	----	----	----	----
EG020R-T: Yttrium	7440-65-5	0.1	mg/kg	<0.1	----	----	----	----
EG035T: Total Recoverable Mercury by FIMS (QCLot: 724062)								
EG035T: Mercury	7439-97-6	0.1	mg/kg	<0.1	----	----	----	----
		0.10	mg/kg	----	1.34 mg/kg	108	79.5	129
MEICP81: Silicon by Peroxide Fusion (QCLot: 731935)								
ME-ICP81: Silica	7631-86-9	0.01	%	<0.01	----	----	----	----

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix**: SOIL**

				Matrix Spike (MS) Report			
				Spike	*Spike Recovery (%)*	*Recovery Limits (%)*	
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*Concentration*	*MS*	*Low*	*High*
EG005T: Total Metals by ICP-AES (QCLot: 724061)							
EB0810408-002	ODXH4.1-04	EG005T: Arsenic	7440-38-2	50 mg/kg	87.0	70	130
		EG005T: Barium	7440-39-3	50 mg/kg	# Not Determined	70	130
		EG005T: Beryllium	7440-41-7	5 mg/kg	101	70	130
		EG005T: Cadmium	7440-43-9	25 mg/kg	96.8	70	130
		EG005T: Chromium	7440-47-3	50 mg/kg	92.2	70	130
		EG005T: Cobalt	7440-48-4	50 mg/kg	96.6	70	130
		EG005T: Copper	7440-50-8	50 mg/kg	92.4	70	130
		EG005T: Lead	7439-92-1	50 mg/kg	# Not Determined	70	130
		EG005T: Manganese	7439-96-5	50 mg/kg	# Not Determined	70	130
		EG005T: Nickel	7440-02-0	50 mg/kg	97.5	70	130
		EG005T: Vanadium	7440-62-2	50 mg/kg	96.3	70	130
		EG005T: Zinc	7440-66-6	50 mg/kg	99.7	70	130
EG035T: Total Recoverable Mercury by FIMS (QCLot: 724062)							
EB0810408-002	ODXH4.1-04	EG035T: Mercury	7439-97-6	5.0 mg/kg	88.8	70	130

QUALITY CONTROL REPORT

Work Order	: **EB0810410**	Page	: 1 of 5
Client	: **C S I R O AUSTRALIA**	Laboratory	: Environmental Division Brisbane
Contact	: DR STUART SIMPSON	Contact	: Tim Kilmister
Address	: 11 JULIUS AVENUE RIVERSIDE CORPORATE PARK, NORTH RYDE NSW, AUSTRALIA 2113	Address	: 32 Shand Street Stafford QLD Australia 4053
E-mail	: stuart.simpson@csiro.au	E-mail	: Services.Brisbane@alsenviro.com
Telephone	: +61 02 94908534	Telephone	: +61-7-3243 7222
Facsimile	: +61 02 94908499	Facsimile	: +61-7-3243 7218
Project	: ----	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Site	: ----		
C-O-C number	: ----	Date Samples Received	: 05-AUG-2008
Sampler	: ----	Issue Date	: 15-AUG-2008
Order number	: ----		
		No. of samples received	: 22
Quote number	: ----	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 Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

NATA Accredited Laboratory 825

This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

Signatories

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

Signatories	*Position*	*Accreditation Category*
Kim McCabe	Senior Inorganic Chemist	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.

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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.

Key :
Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = Chemistry Abstract Services number
LOR = Limit of reporting
RPD = Relative Percentage Difference
# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR:- No Limit; Result between 10 and 20 times LOR:- 0% - 50%; Result > 20 times LOR:- 0% - 20%.

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
ED040F: Dissolved Major Anions (QC Lot: 724824)									
EB0810410-001	ODXH3.2-05 (1)	ED040F: Sulfate as SO4 2-	14808-79-8	1	mg/L	777	787	1.3	0% - 20%
EB0810410-010	ODXH4.1-10 (2)	ED040F: Sulfate as SO4 2-	14808-79-8	1	mg/L	4530	4690	3.4	0% - 20%
ED040F: Dissolved Major Anions (QC Lot: 724826)									
EB0810410-021	ODXH4.1-10 (4)	ED040F: Sulfate as SO4 2-	14808-79-8	1	mg/L	1470	1490	1.2	0% - 20%
EB0810422-008	Anonymous	ED040F: Sulfate as SO4 2-	14808-79-8	1	mg/L	19	19	0.0	0% - 50%
ED045P: Chloride by PC Titrator (QC Lot: 725007)									
EB0810410-001	ODXH3.2-05 (1)	ED045-P: Chloride	16887-00-6	1	mg/L	33	34	3.0	0% - 20%
EB0810410-010	ODXH4.1-10 (2)	ED045-P: Chloride	16887-00-6	1	mg/L	8770	8770	0.0	0% - 20%
ED045P: Chloride by PC Titrator (QC Lot: 725008)									
EB0810410-021	ODXH4.1-10 (4)	ED045-P: Chloride	16887-00-6	1	mg/L	36500	36500	0.0	0% - 20%
ED093F: Dissolved Major Cations (QC Lot: 724825)									
EB0810410-001	ODXH3.2-05 (1)	ED093F: Calcium	7440-70-2	1	mg/L	197	203	2.8	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	5	5	0.0	No Limit
		ED093F: Sodium	7440-23-5	1	mg/L	30	30	0.0	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	3	3	0.0	No Limit
EB0810410-010	ODXH4.1-10 (2)	ED093F: Calcium	7440-70-2	1	mg/L	2050	2060	0.1	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	<1	<1	0.0	No Limit
		ED093F: Sodium	7440-23-5	1	mg/L	16900	16900	0.2	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	7	7	0.0	No Limit
ED093F: Dissolved Major Cations (QC Lot: 724827)									
EB0810410-021	ODXH4.1-10 (4)	ED093F: Calcium	7440-70-2	1	mg/L	628	632	0.6	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	2	2	0.0	No Limit
		ED093F: Sodium	7440-23-5	1	mg/L	<1	<1	0.0	No Limit
		ED093F: Potassium	7440-09-7	1	mg/L	<1	<1	0.0	No Limit
EG020T: Total Metals by ICP-MS (QC Lot: 727292)									
EB0810410-003	ODXH4.2-05 (1)	EG020A-T: Iron	7439-89-6	0.05	mg/L	4.81	5.04	4.8	0% - 20%
EB0810410-012	ODXH3.2-05 (3)	EG020A-T: Iron	7439-89-6	0.05	mg/L	60.2	59.1	1.8	0% - 20%
EG020T: Total Metals by ICP-MS (QC Lot: 727293)									
EB0810410-021	ODXH4.1-10 (4)	EG020A-T: Iron	7439-89-6	0.05	mg/L	87.8	88.1	0.4	0% - 20%
EB0810516-001	Anonymous	EG020A-T: Iron	7439-89-6	0.05	mg/L	114	114	0.1	0% - 20%

Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **WATER**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result	Concentration	LCS	Low	High
ED040F: Dissolved Major Anions (QCLot: 724824)								
ED040F: Sulfate as SO4 2-	14808-79-8	1	mg/L	<1	----	----	----	----
ED040F: Dissolved Major Anions (QCLot: 724826)								
ED040F: Sulfate as SO4 2-	14808-79-8	1	mg/L	<1	----	----	----	----
ED045P: Chloride by PC Titrator (QCLot: 725007)								
ED045-P: Chloride	16887-00-6	1	mg/L	<1	1000 mg/L	98.6	88.4	110
ED045P: Chloride by PC Titrator (QCLot: 725008)								
ED045-P: Chloride	16887-00-6	1	mg/L	<1	1000 mg/L	99.1	88.4	110
ED093F: Dissolved Major Cations (QCLot: 724825)								
ED093F: Calcium	7440-70-2	1	mg/L	<1	----	----	----	----
ED093F: Magnesium	7439-95-4	1	mg/L	<1	----	----	----	----
ED093F: Sodium	7440-23-5	1	mg/L	<1	----	----	----	----
ED093F: Potassium	7440-09-7	1	mg/L	<1	----	----	----	----
ED093F: Dissolved Major Cations (QCLot: 724827)								
ED093F: Calcium	7440-70-2	1	mg/L	<1	----	----	----	----
ED093F: Magnesium	7439-95-4	1	mg/L	<1	----	----	----	----
ED093F: Sodium	7440-23-5	1	mg/L	<1	----	----	----	----
ED093F: Potassium	7440-09-7	1	mg/L	<1	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 727292)								
EG020A-T: Iron	7439-89-6	0.05	mg/L	<0.05	0.500 mg/L	95.3	70	130
EG020T: Total Metals by ICP-MS (QCLot: 727293)								
EG020A-T: Iron	7439-89-6	0.05	mg/L	<0.05	0.500 mg/L	93.4	70	130

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix**: WATER**

				Matrix Spike (MS) Report			
				Spike	Spike Recovery (%)	Recovery Limits (%)	
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
ED045P: Chloride by PC Titrator (QCLot: 725007)							
EB0810410-002	ODXH4.1-04 (1)	ED045-P: Chloride	16887-00-6	20 mg/L	75.0	70	130
ED045P: Chloride by PC Titrator (QCLot: 725008)							
EB0810410-022	Reagent Blank (4)	ED045-P: Chloride	16887-00-6	20000 mg/L	98.6	70	130

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES

Environmental Division

QUALITY CONTROL REPORT

Work Order : **EB0810412**

Client : **C S I R O AUSTRALIA**
Contact : DR STUART SIMPSON
Address : 11 JULIUS AVENUE
RIVERSIDE CORPORATE PARK, NORTH RYDE NSW,
AUSTRALIA 2113

E-mail : stuart.simpson@csiro.au
Telephone : +61 02 94908534
Facsimile : +61 02 94908499

Project : Olympic Dam Analysis
Site : ----
C-O-C number : ----
Sampler : ----
Order number : ----

Quote number : BN/328/08

Page : 1 of 9

Laboratory : Environmental Division Brisbane
Contact : Tim Kilmister
Address : 32 Shand Street Stafford QLD Australia 4053

E-mail : Services.Brisbane@alsenviro.com
Telephone : +61-7-3243 7222
Facsimile : +61-7-3243 7218

QC Level : NEPM 1999 Schedule B(3) and ALS QCS3 requirement

Date Samples Received : 05-AUG-2008
Issue Date : 21-AUG-2008

No. of samples received : 29
No. of samples analysed : 29

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 Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

NATA
WORLD RECOGNISED ACCREDITATION

NATA Accredited Laboratory 825

This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

Signatories

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

Signatories	*Position*	*Accreditation Category*
Kim McCabe	Senior Inorganic Chemist	Inorganics
Stephen Hislop	Senior Inorganic Chemist	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 preformed, 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 insuffient 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.

Key :
Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = Chemistry Abstract Services number
LOR = Limit of reporting
RPD = Relative Percentage Difference
# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR:- No Limit; Result between 10 and 20 times LOR:- 0% - 50%; Result > 20 times LOR:- 0% - 20%.

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
ED040F: Dissolved Major Anions (QC Lot: 724488)									
EB0810407-017	Anonymous	ED040F: Silicon	7440-21-3	0.05	mg/L	3.02	2.96	2.0	0% - 20%
EB0810407-026	Anonymous	ED040F: Silicon	7440-21-3	0.05	mg/L	7.59		0.0	0% - 20%
ED040F: Dissolved Major Anions (QC Lot: 725609)									
EB0810121-001	Anonymous	ED040F: Silicon	7440-21-3	0.05	mg/L	2.09	2.09	0.0	0% - 20%
EB0810337-008	Anonymous	ED040F: Silicon	7440-21-3	0.05	mg/L	3.01	3.01	0.0	0% - 20%
ED040F: Dissolved Major Anions (QC Lot: 725611)									
EB0810412-009	deoxy 4.2_05 (10)	ED040F: Silicon	7440-21-3	0.05	mg/L	14.5	15.2	4.9	0% - 20%
EB0810412-018	deoxy 4.2_05 (20)	ED040F: Silicon	7440-21-3	0.05	mg/L	13.8		0.7	0% - 20%
ED040F: Dissolved Major Anions (QC Lot: 726766)									
EB0810498-001	Anonymous	ED040F: Silicon	7440-21-3	0.05	mg/L	15.0		0.0	0% - 20%
EB0810498-006	Anonymous	ED040F: Silicon	7440-21-3	0.05	mg/L	11.1	11.1	0.3	0% - 20%
EG020T: Total Metals by ICP-MS (QC Lot: 724515)									
EB0810412-001	3.2_05 (2)	EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	0.0014		24.5	0% - 50%
		EG020A-T: Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Arsenic	7440-38-2	0.001	mg/L	0.036		7.8	0% - 20%
		EG020A-T: Beryllium	7440-41-7	0.001	mg/L	0.042	0.043	3.1	0% - 20%
		EG020A-T: Chromium	7440-47-3	0.001	mg/L	0.087		14.5	0% - 20%
		EG020A-T: Cobalt	7440-48-4	0.001	mg/L	4.74		10.0	0% - 20%
		EG020A-T: Copper	7440-50-8	0.001	mg/L	56.0	51.3	8.8	0% - 20%
		EG020A-T: Lead	7439-92-1	0.001	mg/L	0.045		3.7	0% - 20%
		EG020A-T: Lithium	7439-93-2	0.001	mg/L	1.21		3.4	0% - 20%
		EG020A-T: Manganese	7439-96-5	0.001	mg/L	10.6		10.1	0% - 20%
		EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Nickel	7440-02-0	0.001	mg/L	0.475		10.9	0% - 20%
		EG020A-T: Thallium	7440-28-0	0.001	mg/L	0.002		0.0	No Limit
		EG020A-T: Tin	7440-31-5	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Zinc	7440-66-6	0.005	mg/L	1.92		6.2	0% - 20%
		EG020A-T: Aluminium	7429-90-5	0.01	mg/L	719		2.8	0% - 20%
		EG020A-T: Vanadium	7440-62-2	0.01	mg/L	0.03		0.0	No Limit
		EG020A-T: Selenium	7782-49-2	0.010	mg/L	0.070		6.3	No Limit
		EG020A-T: Boron	7440-42-8	0.05	mg/L	0.14	0.13	0.0	No Limit
EB0810412-010	3.2_05 (12)	EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	0.0005	0.0007	22.4	No Limit
		EG020A-T: Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Arsenic	7440-38-2	0.001	mg/L	0.018	0.020	9.6	0% - 20%
		EG020A-T: Beryllium	7440-41-7	0.001	mg/L	0.014		0.0	0% - 50%

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EG020T: Total Metals by ICP-MS (QC Lot: 724515) - continued									
EB0810412-010	3.2_05 (12)	EG020A-T: Chromium	7440-47-3	0.001	mg/L	0.013	0.014	12.0	0% - 50%
		EG020A-T: Cobalt	7440-48-4	0.001	mg/L	1.33	1.28	3.8	0% - 20%
		EG020A-T: Copper	7440-50-8	0.001	mg/L	28.9		3.4	0% - 20%
		EG020A-T: Lead	7439-92-1	0.001	mg/L	0.023	0.023	0.0	0% - 20%
		EG020A-T: Lithium	7439-93-2	0.001	mg/L	0.354	0.342	3.5	0% - 20%
		EG020A-T: Manganese	7439-96-5	0.001	mg/L	2.86	2.80	2.3	0% - 20%
		EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Nickel	7440-02-0	0.001	mg/L	0.133	0.129	3.1	0% - 20%
		EG020A-T: Thallium	7440-28-0	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Tin	7440-31-5	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Zinc	7440-66-6	0.005	mg/L	0.597	0.559	6.5	0% - 20%
		EG020A-T: Aluminium	7429-90-5	0.01	mg/L	176	174	0.9	0% - 20%
		EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	0.0	No Limit
		EG020A-T: Selenium	7782-49-2	0.010	mg/L	0.018	0.017	0.0	No Limit
		EG020A-T: Boron	7440-42-8	0.05	mg/L	0.09		0.0	No Limit
EG020T: Total Metals by ICP-MS (QC Lot: 724516)									
EB0810412-001	3.2_05 (2)	EG020B-T: Bismuth	7440-69-9	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020B-T: Cerium	7440-45-1	0.001	mg/L	60.6	59.9	1.2	0% - 20%
		EG020B-T: Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020B-T: Strontium	7440-24-6	0.001	mg/L	2.50		2.7	0% - 20%
		EG020B-T: Thorium	7440-29-1	0.001	mg/L	0.393	0.398	1.3	0% - 20%
		EG020B-T: Uranium	7440-61-1	0.001	mg/L	15.0	15.3	2.3	0% - 20%
		EG020B-T: Titanium	7440-32-6	0.01	mg/L	0.02	0.02	0.0	No Limit
EB0810412-010	3.2_05 (12)	EG020B-T: Bismuth	7440-69-9	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020B-T: Cerium	7440-45-1	0.001	mg/L	18.8		1.4	0% - 20%
		EG020B-T: Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020B-T: Strontium	7440-24-6	0.001	mg/L	1.41	1.40	0.6	0% - 20%
		EG020B-T: Thorium	7440-29-1	0.001	mg/L	0.104		1.8	0% - 20%
		EG020B-T: Uranium	7440-61-1	0.001	mg/L	4.17		1.9	0% - 20%
		EG020B-T: Titanium	7440-32-6	0.01	mg/L	0.01		0.0	No Limit
EG020T: Total Metals by ICP-MS (QC Lot: 724517)									
EB0810412-001	3.2_05 (2)	EG020D-T: Yttrium	7440-65-5	0.001	mg/L	6.23		1.5	0% - 20%
EB0810412-010	3.2_05 (12)	EG020D-T: Yttrium	7440-65-5	0.001	mg/L	1.90	1.89	0.7	0% - 20%
EG020T: Total Metals by ICP-MS (QC Lot: 724518)									
EB0810412-001	3.2_05 (2)	EG020E-T: Tungsten	7440-33-7	0.001	mg/L	0.005		0.0	No Limit
EB0810412-010	3.2_05 (12)	EG020E-T: Tungsten	7440-33-7	0.001	mg/L	0.001	0.001	0.0	No Limit
EG020T: Total Metals by ICP-MS (QC Lot: 724519)									
EB0810412-010	3.2_05 (12)	EG020G-T: Rhenium	7440-15-5	0.001	mg/L	<0.001	<0.001	0.0	No Limit
EB0810412-020	3.2_05 (22)	EG020G-T: Rhenium	7440-15-5	0.001	mg/L	<0.001	<0.001	0.0	No Limit

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EG020T: Total Metals by ICP-MS (QC Lot: 724520)									
EB0810412-020	3.2_05 (22)	EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	0.0003		44.8	No Limit
		EG020A-T: Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Arsenic	7440-38-2	0.001	mg/L	0.010		12.0	0% - 50%
		EG020A-T: Beryllium	7440-41-7	0.001	mg/L	0.004		0.0	No Limit
		EG020A-T: Barium	7440-39-3	0.001	mg/L	0.012		0.0	0% - 50%
		EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.001	0.002	0.0	No Limit
		EG020A-T: Cobalt	7440-48-4	0.001	mg/L	0.426	0.426	0.0	0% - 20%
		EG020A-T: Copper	7440-50-8	0.001	mg/L	18.1		1.1	0% - 20%
		EG020A-T: Lead	7439-92-1	0.001	mg/L	0.008	0.008	0.0	No Limit
		EG020A-T: Lithium	7439-93-2	0.001	mg/L	0.081		3.4	0% - 20%
		EG020A-T: Manganese	7439-96-5	0.001	mg/L	0.769	0.781	1.6	0% - 20%
		EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	<0.001		0.0	No Limit
		EG020A-T: Nickel	7440-02-0	0.001	mg/L	0.040	0.041	3.2	0% - 20%
		EG020A-T: Thallium	7440-28-0	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Tin	7440-31-5	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Zinc	7440-66-6	0.005	mg/L	0.153	0.156	1.4	0% - 20%
		EG020A-T: Aluminium	7429-90-5	0.01	mg/L	40.7	42.7	4.8	0% - 20%
		EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	0.0	No Limit
		EG020A-T: Selenium	7782-49-2	0.010	mg/L	0.010		23.4	No Limit
		EG020A-T: Boron	7440-42-8	0.05	mg/L	0.05		0.0	No Limit
EG020T: Total Metals by ICP-MS (QC Lot: 724521)									
EB0810412-020	3.2_05 (22)	EG020B-T: Bismuth	7440-69-9	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020B-T: Cerium	7440-45-1	0.001	mg/L	8.50		0.7	0% - 20%
		EG020B-T: Silver	7440-22-4	0.001	mg/L	<0.001		0.0	No Limit
		EG020B-T: Strontium	7440-24-6	0.001	mg/L	0.963		2.0	0% - 20%
		EG020B-T: Thorium	7440-29-1	0.001	mg/L	0.035	0.035	0.0	0% - 20%
		EG020B-T: Uranium	7440-61-1	0.001	mg/L	1.06	1.06	0.5	0% - 20%
		EG020B-T: Titanium	7440-32-6	0.01	mg/L	<0.01		0.0	No Limit
EG020T: Total Metals by ICP-MS (QC Lot: 724522)									
EB0810412-020	3.2_05 (22)	EG020D-T: Yttrium	7440-65-5	0.001	mg/L	0.778	0.773	0.6	0% - 20%
EG020T: Total Metals by ICP-MS (QC Lot: 724523)									
EB0810412-020	3.2_05 (22)	EG020E-T: Tungsten	7440-33-7	0.001	mg/L	<0.001		0.0	No Limit
EG035T: Total Recoverable Mercury by FIMS (QC Lot: 727442)									
EB0810383-021	Anonymous	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001		0.0	No Limit
EB0810412-003	4.1_10 (4)	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001		0.0	No Limit
EG035T: Total Recoverable Mercury by FIMS (QC Lot: 727443)									
EB0810412-013	4.2_05 (15)	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EB0810412-023	4.2_05 (25)	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit

Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **WATER**

				Method Blank (MB) Report	*Laboratory Control Spike (LCS) Report*			
					Spike	*Spike Recovery (%)*	*Recovery Limits (%)*	
Method: Compound	*CAS Number*	*LOR*	*Unit*	*Result*	*Concentration*	*LCS*	*Low*	*High*
ED040F: Dissolved Major Anions (QCLot: 724488)								
ED040F: Silicon	7440-21-3	0.05	mg/L	<0.05	----	----	----	----
ED040F: Dissolved Major Anions (QCLot: 725609)								
ED040F: Silicon	7440-21-3	0.05	mg/L	<0.05	----	----	----	----
ED040F: Dissolved Major Anions (QCLot: 725611)								
ED040F: Silicon	7440-21-3	0.05	mg/L	<0.05	----	----	----	----
ED040F: Dissolved Major Anions (QCLot: 726766)								
ED040F: Silicon	7440-21-3	0.05	mg/L	<0.05	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 724515)								
EG020A-T: Aluminium	7429-90-5	0.01	mg/L	<0.01	0.500 mg/L	102	74	130
EG020A-T: Antimony	7440-36-0	0.001	mg/L	<0.001	0.100 mg/L	105	84.6	112
EG020A-T: Arsenic	7440-38-2	0.001	mg/L	<0.001	0.100 mg/L	# 126	75.7	110
EG020A-T: Beryllium	7440-41-7	0.001	mg/L	<0.001	0.100 mg/L	101	76.7	130
EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.100 mg/L	105	81.8	111
EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.001	0.100 mg/L	110	80.9	125
EG020A-T: Cobalt	7440-48-4	0.001	mg/L	<0.001	0.100 mg/L	102	81.3	117
EG020A-T: Copper	7440-50-8	0.001	mg/L	<0.001	0.200 mg/L	100	80.9	115
EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.001	0.100 mg/L	103	84.4	113
EG020A-T: Lithium	7439-93-2	0.001	mg/L	<0.001	----	----	----	----
EG020A-T: Manganese	7439-96-5	0.001	mg/L	<0.001	0.100 mg/L	106	76.8	123
EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	<0.001	0.100 mg/L	96.1	85.2	111
EG020A-T: Nickel	7440-02-0	0.001	mg/L	<0.001	0.100 mg/L	97.4	81.5	117
EG020A-T: Selenium	7782-49-2	0.01	mg/L	----	0.100 mg/L	80.0	78.9	113
		0.010	mg/L	<0.010	----	----	----	----
EG020A-T: Thallium	7440-28-0	0.001	mg/L	<0.001	0.100 mg/L	110	84.5	117
EG020A-T: Tin	7440-31-5	0.001	mg/L	<0.001	0.100 mg/L	108	70	130
EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.01	0.100 mg/L	104	70.5	119
EG020A-T: Zinc	7440-66-6	0.005	mg/L	<0.005	0.200 mg/L	97.5	81	127
EG020A-T: Boron	7440-42-8	0.05	mg/L	<0.05	0.500 mg/L	115	70	130
EG020T: Total Metals by ICP-MS (QCLot: 724516)								
EG020B-T: Bismuth	7440-69-9	0.001	mg/L	<0.001	0.100 mg/L	121	118	126
EG020B-T: Cerium	7440-45-1	0.001	mg/L	<0.001	----	----	----	----
EG020B-T: Silver	7440-22-4	0.001	mg/L	<0.001	0.100 mg/L	# 92.6	120	123
EG020B-T: Strontium	7440-24-6	0.001	mg/L	<0.001	0.500 mg/L	# 102	115	123
EG020B-T: Thorium	7440-29-1	0.001	mg/L	<0.001	----	----	----	----

Sub-Matrix: **WATER**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	*CAS Number*	*LOR*	*Unit*	*Result*	*Concentration*	*LCS*	*Low*	*High*
EG020T: Total Metals by ICP-MS (QCLot: 724516) - continued								
EG020B-T: Titanium	7440-32-6	0.01	mg/L	<0.01	0.100 mg/L	# 97.6	118	121
EG020B-T: Uranium	7440-61-1	0.001	mg/L	<0.001	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 724517)								
EG020D-T: Yttrium	7440-65-5	0.001	mg/L	<0.001	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 724518)								
EG020E-T: Tungsten	7440-33-7	0.001	mg/L	<0.001	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 724519)								
EG020G-T: Rhenium	7440-15-5	0.001	mg/L	<0.001	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 724520)								
EG020A-T: Aluminium	7429-90-5	0.01	mg/L	<0.01	0.500 mg/L	124	74	130
EG020A-T: Antimony	7440-36-0	0.001	mg/L	<0.001	0.100 mg/L	100	84.6	112
EG020A-T: Arsenic	7440-38-2	0.001	mg/L	<0.001	0.100 mg/L	# 113	75.7	110
EG020A-T: Beryllium	7440-41-7	0.001	mg/L	<0.001	0.100 mg/L	129	76.7	130
EG020A-T: Barium	7440-39-3	0.001	mg/L	<0.001	----	----	----	----
EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.100 mg/L	101	81.8	111
EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.001	0.100 mg/L	113	80.9	125
EG020A-T: Cobalt	7440-48-4	0.001	mg/L	<0.001	0.100 mg/L	102	81.3	117
EG020A-T: Copper	7440-50-8	0.001	mg/L	<0.001	0.200 mg/L	100	80.9	115
EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.001	0.100 mg/L	101	84.4	113
EG020A-T: Lithium	7439-93-2	0.001	mg/L	<0.001	----	----	----	----
EG020A-T: Manganese	7439-96-5	0.001	mg/L	<0.001	0.100 mg/L	109	76.8	123
EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	<0.001	0.100 mg/L	95.3	85.2	111
EG020A-T: Nickel	7440-02-0	0.001	mg/L	<0.001	0.100 mg/L	106	81.5	117
EG020A-T: Selenium	7782-49-2	0.01	mg/L	----	0.100 mg/L	# 70.3	78.9	113
		0.010	mg/L	<0.010	----	----	----	----
EG020A-T: Thallium	7440-28-0	0.001	mg/L	<0.001	0.100 mg/L	105	84.5	117
EG020A-T: Tin	7440-31-5	0.001	mg/L	<0.001	0.100 mg/L	106	70	130
EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.01	0.100 mg/L	113	70.5	119
EG020A-T: Zinc	7440-66-6	0.005	mg/L	<0.005	0.200 mg/L	104	81	127
EG020A-T: Boron	7440-42-8	0.05	mg/L	<0.05	0.500 mg/L	98.8	70	130
EG020T: Total Metals by ICP-MS (QCLot: 724521)								
EG020B-T: Bismuth	7440-69-9	0.001	mg/L	<0.001	0.100 mg/L	# 117	118	126
EG020B-T: Cerium	7440-45-1	0.001	mg/L	<0.001	----	----	----	----
EG020B-T: Silver	7440-22-4	0.001	mg/L	<0.001	0.100 mg/L	# 79.8	120	123
EG020B-T: Strontium	7440-24-6	0.001	mg/L	<0.001	0.500 mg/L	# 103	115	123
EG020B-T: Thorium	7440-29-1	0.001	mg/L	<0.001	----	----	----	----
EG020B-T: Titanium	7440-32-6	0.01	mg/L	<0.01	0.100 mg/L	# 103	118	121
EG020B-T: Uranium	7440-61-1	0.001	mg/L	<0.001	----	----	----	----

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
				Result	Concentration	LCS	Low	High
EG020T: Total Metals by ICP-MS (QCLot: 724522)								
EG020D-T: Yttrium	7440-65-5	0.001	mg/L	<0.001	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 724523)								
EG020E-T: Tungsten	7440-33-7	0.001	mg/L	<0.001	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 724524)								
EG020G-T: Rhenium	7440-15-5	0.001	mg/L	<0.001	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 730992)								
EG020A-T: Aluminium	7429-90-5	0.01	mg/L	<0.01	0.500 mg/L	104	74	130
EG020A-T: Antimony	7440-36-0	0.001	mg/L	<0.001	0.100 mg/L	97.8	84.6	112
EG020A-T: Arsenic	7440-38-2	0.001	mg/L	<0.001	0.100 mg/L	98.0	75.7	110
EG020A-T: Beryllium	7440-41-7	0.001	mg/L	<0.001	0.100 mg/L	94.8	76.7	130
EG020A-T: Barium	7440-39-3	0.001	mg/L	<0.001	----	----	----	----
EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.100 mg/L	100	81.8	111
EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.001	0.100 mg/L	110	80.9	125
EG020A-T: Cobalt	7440-48-4	0.001	mg/L	<0.001	0.100 mg/L	101	81.3	117
EG020A-T: Copper	7440-50-8	0.001	mg/L	<0.001	0.200 mg/L	96.6	80.9	115
EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.001	0.100 mg/L	102	84.4	113
EG020A-T: Lithium	7439-93-2	0.001	mg/L	<0.001	----	----	----	----
EG020A-T: Manganese	7439-96-5	0.001	mg/L	<0.001	0.100 mg/L	96.8	76.8	123
EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	<0.001	0.100 mg/L	97.6	85.2	111
EG020A-T: Nickel	7440-02-0	0.001	mg/L	<0.001	0.100 mg/L	95.6	81.5	117
EG020A-T: Selenium	7782-49-2	0.01	mg/L	----	0.100 mg/L	89.1	78.9	113
		0.010	mg/L	<0.010	----	----	----	----
EG020A-T: Thallium	7440-28-0	0.001	mg/L	<0.001	0.100 mg/L	103	84.5	117
EG020A-T: Tin	7440-31-5	0.001	mg/L	<0.001	0.100 mg/L	99.4	70	130
EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.01	0.100 mg/L	92.9	70.5	119
EG020A-T: Zinc	7440-66-6	0.005	mg/L	<0.005	0.200 mg/L	110	81	127
EG020A-T: Boron	7440-42-8	0.05	mg/L	<0.05	0.500 mg/L	97.6	70	130
EG035T: Total Recoverable Mercury by FIMS (QCLot: 727442)								
EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.0100 mg/L	111	84.2	118
EG035T: Total Recoverable Mercury by FIMS (QCLot: 727443)								
EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.0100 mg/L	110	84.2	118

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix**: WATER**

				Matrix Spike (MS) Report			
				Spike	*Spike Recovery (%)*	*Recovery Limits (%)*	
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*Concentration*	*MS*	*Low*	*High*
EG020T: Total Metals by ICP-MS (QCLot: 724515)							
EB0810412-002	4.1_04 (3)	EG020A-T: Arsenic	7440-38-2	1.000 mg/L	125	70	130
		EG020A-T: Beryllium	7440-41-7	0.100 mg/L	128	70	130
		EG020A-T: Cadmium	7440-43-9	0.500 mg/L	102	70	130
		EG020A-T: Chromium	7440-47-3	1.000 mg/L	101	70	130
		EG020A-T: Cobalt	7440-48-4	1.000 mg/L	# Not Determined	70	130
		EG020A-T: Copper	7440-50-8	1.000 mg/L	99.3	70	130
		EG020A-T: Lead	7439-92-1	1.000 mg/L	102	70	130
		EG020A-T: Manganese	7439-96-5	1.000 mg/L	# Not Determined	70	130
		EG020A-T: Nickel	7440-02-0	1.000 mg/L	93.4	70	130
		EG020A-T: Vanadium	7440-62-2	1.000 mg/L	115	70	130
		EG020A-T: Zinc	7440-66-6	1.000 mg/L	95.5	70	130
EG020T: Total Metals by ICP-MS (QCLot: 724520)							
EB0810412-022	4.1_10 (24)	EG020A-T: Arsenic	7440-38-2	1.000 mg/L	130	70	130
		EG020A-T: Beryllium	7440-41-7	0.100 mg/L	122	70	130
		EG020A-T: Barium	7440-39-3	1.000 mg/L	96.0	70	130
		EG020A-T: Cadmium	7440-43-9	0.500 mg/L	101	70	130
		EG020A-T: Chromium	7440-47-3	1.000 mg/L	104	70	130
		EG020A-T: Cobalt	7440-48-4	1.000 mg/L	101	70	130
		EG020A-T: Copper	7440-50-8	1.000 mg/L	104	70	130
		EG020A-T: Lead	7439-92-1	1.000 mg/L	99.0	70	130
		EG020A-T: Manganese	7439-96-5	1.000 mg/L	111	70	130
		EG020A-T: Nickel	7440-02-0	1.000 mg/L	99.9	70	130
		EG020A-T: Vanadium	7440-62-2	1.000 mg/L	119	70	130
		EG020A-T: Zinc	7440-66-6	1.000 mg/L	106	70	130
EG035T: Total Recoverable Mercury by FIMS (QCLot: 727442)							
EB0810383-021	Anonymous	EG035T: Mercury	7439-97-6	0.0100 mg/L	89.0	70	130
EG035T: Total Recoverable Mercury by FIMS (QCLot: 727443)							
EB0810412-013	4.2_05 (15)	EG035T: Mercury	7439-97-6	0.0100 mg/L	110	70	130

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES

Environmental Division

QUALITY CONTROL REPORT

Work Order	: **EB0810422**	Page	: 1 of 10
Client	: **C S I R O AUSTRALIA**	Laboratory	: Environmental Division Brisbane
Contact	: DR STUART SIMPSON	Contact	: Tim Kilmister
Address	: 11 JULIUS AVENUE RIVERSIDE CORPORATE PARK, NORTH RYDE NSW, AUSTRALIA 2113	Address	: 32 Shand Street Stafford QLD Australia 4053
E-mail	: stuart.simpson@csiro.au	E-mail	: Services.Brisbane@alsenviro.com
Telephone	: +61 02 94908534	Telephone	: +61-7-3243 7222
Facsimile	: +61 02 94908499	Facsimile	: +61-7-3243 7218
Project	: Olympic Dam Analysis	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Site	: ----		
C-O-C number	: ----	Date Samples Received	: 05-AUG-2008
Sampler	: ----	Issue Date	: 15-AUG-2008
Order number	: ----		
		No. of samples received	: 22
Quote number	: BN/328/08	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 Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

NATA
WORLD RECOGNISED ACCREDITATION

NATA Accredited Laboratory 825

This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

Signatories

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

Signatories	*Position*	*Accreditation Category*
Kim McCabe	Senior Inorganic Chemist	Inorganics
Stephen Hislop	Senior Inorganic Chemist	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 preformed, 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 insuffient 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.

Key :
Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = Chemistry Abstract Services number
LOR = Limit of reporting
RPD = Relative Percentage Difference
# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR:- No Limit; Result between 10 and 20 times LOR:- 0% - 50%; Result > 20 times LOR:- 0% - 20%.

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
ED040F: Dissolved Major Anions (QC Lot: 724826)									
EB0810410-021	Anonymous	ED040F: Silicon	7440-21-3	0.05	mg/L	13.4	13.2	1.7	0% - 20%
EB0810422-008	ODXH4.1-04 (2)	ED040F: Silicon	7440-21-3	0.05	mg/L	3.11	3.38	8.2	0% - 20%
ED040F: Dissolved Major Anions (QC Lot: 725612)									
EB0810301-001	Anonymous	ED040F: Silicon	7440-21-3	0.05	mg/L	7.94	7.89	0.6	0% - 20%
EB0810452-002	Anonymous	ED040F: Silicon	7440-21-3	0.05	mg/L	2.45	2.34	4.3	0% - 20%
EG020F: Dissolved Metals by ICP-MS (QC Lot: 723968)									
EB0810422-001	ODXH3.2-05 (1)	EG020A-F: Cadmium	7440-43-9	0.0001	mg/L	0.0002	0.0002	0.0	No Limit
		EG020A-F: Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-F: Arsenic	7440-38-2	0.001	mg/L	0.003	0.003	0.0	No Limit
		EG020A-F: Beryllium	7440-41-7	0.001	mg/L	0.005	0.005	0.0	No Limit
		EG020A-F: Barium	7440-39-3	0.001	mg/L	0.042	0.043	0.0	0% - 20%
		EG020A-F: Chromium	7440-47-3	0.001	mg/L	0.005	0.004	0.0	No Limit
		EG020A-F: Cobalt	7440-48-4	0.001	mg/L	0.428	0.436	1.7	0% - 20%
		EG020A-F: Copper	7440-50-8	0.001	mg/L	3.66	3.68	0.4	0% - 20%
		EG020A-F: Lead	7439-92-1	0.001	mg/L	0.012	0.012	0.0	0% - 50%
		EG020A-F: Lithium	7439-93-2	0.001	mg/L	0.134	0.142	5.8	0% - 20%
		EG020A-F: Manganese	7439-96-5	0.001	mg/L	1.01	1.02	1.2	0% - 20%
		EG020A-F: Molybdenum	7439-98-7	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-F: Nickel	7440-02-0	0.001	mg/L	0.045	0.045	0.0	0% - 20%
		EG020A-F: Thallium	7440-28-0	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-F: Tin	7440-31-5	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-F: Zinc	7440-66-6	0.005	mg/L	0.205	0.202	1.4	0% - 20%
		EG020A-F: Aluminium	7429-90-5	0.01	mg/L	69.9	72.0	2.9	0% - 20%
		EG020A-F: Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	0.0	No Limit
		EG020A-F: Selenium	7782-49-2	0.010	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-F: Boron	7440-42-8	0.05	mg/L	<0.05	<0.05	0.0	No Limit
EB0810422-010	ODXH4.1-10 (2)	EG020A-F: Cadmium	7440-43-9	0.0001	mg/L	0.0021	0.0019	7.3	0% - 50%
		EG020A-F: Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-F: Arsenic	7440-38-2	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-F: Beryllium	7440-41-7	0.001	mg/L	0.010	0.011	0.0	0% - 50%
		EG020A-F: Barium	7440-39-3	0.001	mg/L	0.029	0.029	0.0	0% - 20%
		EG020A-F: Chromium	7440-47-3	0.001	mg/L	0.010	0.010	0.0	0% - 50%
		EG020A-F: Cobalt	7440-48-4	0.001	mg/L	0.005	0.005	0.0	No Limit
		EG020A-F: Copper	7440-50-8	0.001	mg/L	0.211	0.209	1.1	0% - 20%
		EG020A-F: Lead	7439-92-1	0.001	mg/L	0.047	0.047	0.0	0% - 20%

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EG020F: Dissolved Metals by ICP-MS (QC Lot: 723968) - continued									
EB0810422-010	ODXH4.1-10 (2)	EG020A-F: Lithium	7439-93-2	0.001	mg/L	0.006	0.008	19.1	No Limit
		EG020A-F: Manganese	7439-96-5	0.001	mg/L	0.017	0.017	0.0	0% - 50%
		EG020A-F: Molybdenum	7439-98-7	0.001	mg/L	0.003	0.003	0.0	No Limit
		EG020A-F: Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-F: Thallium	7440-28-0	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-F: Tin	7440-31-5	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-F: Zinc	7440-66-6	0.005	mg/L	0.131	0.124	5.4	0% - 20%
		EG020A-F: Aluminium	7429-90-5	0.01	mg/L	0.42	0.44	5.0	0% - 20%
		EG020A-F: Vanadium	7440-62-2	0.01	mg/L	0.04	0.05	0.0	No Limit
		EG020A-F: Selenium	7782-49-2	0.010	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-F: Boron	7440-42-8	0.05	mg/L	<0.05	<0.05	0.0	No Limit
EG020F: Dissolved Metals by ICP-MS (QC Lot: 723969)									
EB0810422-001	ODXH3.2-05 (1)	EG020B-F: Bismuth	7440-69-9	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020B-F: Cerium	7440-45-1	0.001	mg/L	2.29	2.31	0.9	0% - 20%
		EG020B-F: Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020B-F: Strontium	7440-24-6	0.001	mg/L	0.371	0.367	1.2	0% - 20%
		EG020B-F: Thorium	7440-29-1	0.001	mg/L	0.022	0.022	0.0	0% - 20%
		EG020B-F: Uranium	7440-61-1	0.001	mg/L	1.32	1.32	0.5	0% - 20%
		EG020B-F: Titanium	7440-32-6	0.01	mg/L	<0.01	<0.01	0.0	No Limit
EB0810422-010	ODXH4.1-10 (2)	EG020B-F: Bismuth	7440-69-9	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020B-F: Cerium	7440-45-1	0.001	mg/L	0.040	0.037	6.1	0% - 20%
		EG020B-F: Silver	7440-22-4	0.001	mg/L	0.001	0.001	0.0	No Limit
		EG020B-F: Strontium	7440-24-6	0.001	mg/L	2.24	2.29	2.0	0% - 20%
		EG020B-F: Thorium	7440-29-1	0.001	mg/L	0.002	0.001	0.0	No Limit
		EG020B-F: Uranium	7440-61-1	0.001	mg/L	0.038	0.038	0.0	0% - 20%
		EG020B-F: Titanium	7440-32-6	0.01	mg/L	0.01	0.01	0.0	No Limit
EG020F: Dissolved Metals by ICP-MS (QC Lot: 723970)									
EB0810422-001	ODXH3.2-05 (1)	EG020D-F: Yttrium	7440-65-5	0.001	mg/L	0.461	0.462	0.3	0% - 20%
EB0810422-010	ODXH4.1-10 (2)	EG020D-F: Yttrium	7440-65-5	0.001	mg/L	0.013	0.013	0.0	0% - 50%
EG020F: Dissolved Metals by ICP-MS (QC Lot: 723971)									
EB0810422-001	ODXH3.2-05 (1)	EG020E-F: Tungsten	7440-33-7	0.001	mg/L	<0.001	<0.001	0.0	No Limit
EB0810422-010	ODXH4.1-10 (2)	EG020E-F: Tungsten	7440-33-7	0.001	mg/L	<0.001	<0.001	0.0	No Limit
EG020F: Dissolved Metals by ICP-MS (QC Lot: 723972)									
EB0810422-001	ODXH3.2-05 (1)	EG020G-F: Rhenium	7440-15-5	0.001	mg/L	<0.001	<0.001	0.0	No Limit
EB0810422-010	ODXH4.1-10 (2)	EG020G-F: Rhenium	7440-15-5	0.001	mg/L	<0.001	<0.001	0.0	No Limit
EG020F: Dissolved Metals by ICP-MS (QC Lot: 723973)									
EB0810422-021	ODXH4.1-10 (4)	EG020A-F: Cadmium	7440-43-9	0.0001	mg/L	0.0244	0.0235	3.6	0% - 20%
		EG020A-F: Antimony	7440-36-0	0.001	mg/L	0.002	0.002	0.0	No Limit
		EG020A-F: Arsenic	7440-38-2	0.001	mg/L	0.079	0.076	4.5	0% - 20%

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EG020F: Dissolved Metals by ICP-MS (QC Lot: 723973) - continued									
EB0810422-021	ODXH4.1-10 (4)	EG020A-F: Beryllium	7440-41-7	0.001	mg/L	0.006	0.005	0.0	No Limit
		EG020A-F: Barium	7440-39-3	0.001	mg/L	0.062	0.062	0.0	0% - 20%
		EG020A-F: Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-F: Cobalt	7440-48-4	0.001	mg/L	0.044	0.044	0.0	0% - 20%
		EG020A-F: Copper	7440-50-8	0.001	mg/L	0.036	0.034	6.2	0% - 20%
		EG020A-F: Lead	7439-92-1	0.001	mg/L	0.060	0.058	3.2	0% - 20%
		EG020A-F: Lithium	7439-93-2	0.001	mg/L	0.004	0.004	0.0	No Limit
		EG020A-F: Manganese	7439-96-5	0.001	mg/L	0.252	0.246	2.3	0% - 20%
		EG020A-F: Molybdenum	7439-98-7	0.001	mg/L	0.021	0.020	0.0	0% - 20%
		EG020A-F: Nickel	7440-02-0	0.001	mg/L	0.090	0.087	3.5	0% - 20%
		EG020A-F: Thallium	7440-28-0	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-F: Tin	7440-31-5	0.001	mg/L	0.003	0.003	0.0	No Limit
		EG020A-F: Zinc	7440-66-6	0.005	mg/L	1.15	1.10	4.7	0% - 20%
		EG020A-F: Aluminium	7429-90-5	0.01	mg/L	8.86	8.63	2.6	0% - 20%
		EG020A-F: Vanadium	7440-62-2	0.01	mg/L	0.34	0.34	0.0	0% - 20%
		EG020A-F: Selenium	7782-49-2	0.010	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-F: Boron	7440-42-8	0.05	mg/L	0.06	0.06	0.0	No Limit
EG020F: Dissolved Metals by ICP-MS (QC Lot: 723974)									
EB0810422-021	ODXH4.1-10 (4)	EG020B-F: Bismuth	7440-69-9	0.001	mg/L	0.002	0.002	0.0	No Limit
		EG020B-F: Cerium	7440-45-1	0.001	mg/L	0.224	0.220	2.1	0% - 20%
		EG020B-F: Strontium	7440-24-6	0.001	mg/L	0.630	0.613	2.8	0% - 20%
		EG020B-F: Thorium	7440-29-1	0.001	mg/L	0.029	0.029	0.0	0% - 20%
		EG020B-F: Uranium	7440-61-1	0.001	mg/L	0.014	0.013	0.0	0% - 50%
		EG020B-F: Titanium	7440-32-6	0.01	mg/L	0.24	0.24	0.0	0% - 20%
EG020F: Dissolved Metals by ICP-MS (QC Lot: 723975)									
EB0810422-021	ODXH4.1-10 (4)	EG020D-F: Yttrium	7440-65-5	0.001	mg/L	0.038	0.037	3.1	0% - 20%
EG020F: Dissolved Metals by ICP-MS (QC Lot: 723976)									
EB0810422-021	ODXH4.1-10 (4)	EG020E-F: Tungsten	7440-33-7	0.001	mg/L	0.002	0.002	0.0	No Limit
EG035F: Dissolved Mercury by FIMS (QC Lot: 724189)									
EB0810365-023	Anonymous	EG035F: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EB0810422-007	ODXH3.2-05 (2)	EG035F: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EG035F: Dissolved Mercury by FIMS (QC Lot: 724190)									
EB0810422-017	Reagent Blank (3)	EG035F: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit

Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **WATER**

				Method Blank (MB) Report	*Laboratory Control Spike (LCS) Report*			
					Spike	*Spike Recovery (%)*	*Recovery Limits (%)*	
Method: Compound	*CAS Number*	*LOR*	*Unit*	*Result*	*Concentration*	*LCS*	*Low*	*High*
ED040F: Dissolved Major Anions (QCLot: 724826)								
ED040F: Silicon	7440-21-3	0.05	mg/L	<0.05	----	----	----	----
ED040F: Dissolved Major Anions (QCLot: 725612)								
ED040F: Silicon	7440-21-3	0.05	mg/L	<0.05	----	----	----	----
EG020F: Dissolved Metals by ICP-MS (QCLot: 723968)								
EG020A-F: Aluminium	7429-90-5	0.01	mg/L	<0.01	0.500 mg/L	108	76.1	130
EG020A-F: Antimony	7440-36-0	0.001	mg/L	<0.001	0.100 mg/L	107	87.7	114
EG020A-F: Arsenic	7440-38-2	0.001	mg/L	<0.001	0.100 mg/L	98.6	79.6	115
EG020A-F: Beryllium	7440-41-7	0.001	mg/L	<0.001	0.100 mg/L	121	80.8	130
EG020A-F: Barium	7440-39-3	0.001	mg/L	<0.001	----	----	----	----
EG020A-F: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.100 mg/L	108	86.6	113
EG020A-F: Chromium	7440-47-3	0.001	mg/L	<0.001	0.100 mg/L	114	84.4	128
EG020A-F: Cobalt	7440-48-4	0.001	mg/L	<0.001	0.100 mg/L	104	86.6	117
EG020A-F: Copper	7440-50-8	0.001	mg/L	<0.001	0.200 mg/L	102	85	117
EG020A-F: Lead	7439-92-1	0.001	mg/L	<0.001	0.100 mg/L	105	85.4	117
EG020A-F: Lithium	7439-93-2	0.001	mg/L	<0.001	----	----	----	----
EG020A-F: Manganese	7439-96-5	0.001	mg/L	<0.001	0.100 mg/L	109	84.1	122
EG020A-F: Molybdenum	7439-98-7	0.001	mg/L	<0.001	0.100 mg/L	101	89.6	110
EG020A-F: Nickel	7440-02-0	0.001	mg/L	<0.001	0.100 mg/L	106	86.3	118
EG020A-F: Selenium	7782-49-2	0.01	mg/L	----	0.100 mg/L	93.1	84.4	122
		0.010	mg/L	<0.010	----	----	----	----
EG020A-F: Thallium	7440-28-0	0.001	mg/L	<0.001	0.100 mg/L	108	83.4	119
EG020A-F: Tin	7440-31-5	0.001	mg/L	<0.001	0.100 mg/L	109	78.4	130
EG020A-F: Vanadium	7440-62-2	0.01	mg/L	<0.01	0.100 mg/L	96.8	76.9	117
EG020A-F: Zinc	7440-66-6	0.005	mg/L	<0.005	0.200 mg/L	109	84.2	130
EG020A-F: Boron	7440-42-8	0.05	mg/L	<0.05	0.50 mg/L	101	70	130
EG020F: Dissolved Metals by ICP-MS (QCLot: 723969)								
EG020B-F: Bismuth	7440-69-9	0.001	mg/L	<0.001	0.100 mg/L	116	85.2	119
EG020B-F: Cerium	7440-45-1	0.001	mg/L	<0.001	----	----	----	----
EG020B-F: Silver	7440-22-4	0.001	mg/L	<0.001	0.100 mg/L	83.8	70	120
EG020B-F: Strontium	7440-24-6	0.001	mg/L	<0.001	0.500 mg/L	103	84.1	116
EG020B-F: Thorium	7440-29-1	0.001	mg/L	<0.001	----	----	----	----
EG020B-F: Titanium	7440-32-6	0.01	mg/L	<0.01	0.100 mg/L	100	84.2	118
EG020B-F: Uranium	7440-61-1	0.001	mg/L	<0.001	----	----	----	----
EG020F: Dissolved Metals by ICP-MS (QCLot: 723970)								

Sub-Matrix: **WATER**

				Method Blank (MB) Report	*Laboratory Control Spike (LCS) Report*			
					Spike	*Spike Recovery (%)*	*Recovery Limits (%)*	
Method: Compound	*CAS Number*	*LOR*	*Unit*	*Result*	*Concentration*	*LCS*	*Low*	*High*
EG020F: Dissolved Metals by ICP-MS (QCLot: 723970) - continued								
EG020D-F: Yttrium	7440-65-5	0.001	mg/L	<0.001	----	----	----	----
EG020F: Dissolved Metals by ICP-MS (QCLot: 723971)								
EG020E-F: Tungsten	7440-33-7	0.001	mg/L	<0.001	----	----	----	----
EG020F: Dissolved Metals by ICP-MS (QCLot: 723972)								
EG020G-F: Rhenium	7440-15-5	0.001	mg/L	<0.001	----	----	----	----
EG020F: Dissolved Metals by ICP-MS (QCLot: 723973)								
EG020A-F: Aluminium	7429-90-5	0.01	mg/L	<0.01	0.500 mg/L	95.7	76.1	130
EG020A-F: Antimony	7440-36-0	0.001	mg/L	<0.001	0.100 mg/L	103	87.7	114
EG020A-F: Arsenic	7440-38-2	0.001	mg/L	<0.001	0.100 mg/L	100	79.6	115
EG020A-F: Beryllium	7440-41-7	0.001	mg/L	<0.001	0.100 mg/L	99.3	80.8	130
EG020A-F: Barium	7440-39-3	0.001	mg/L	<0.001	----	----	----	----
EG020A-F: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.100 mg/L	105	86.6	113
EG020A-F: Chromium	7440-47-3	0.001	mg/L	<0.001	0.100 mg/L	117	84.4	128
EG020A-F: Cobalt	7440-48-4	0.001	mg/L	<0.001	0.100 mg/L	102	86.6	117
EG020A-F: Copper	7440-50-8	0.001	mg/L	<0.001	0.200 mg/L	104	85	117
EG020A-F: Lead	7439-92-1	0.001	mg/L	<0.001	0.100 mg/L	103	85.4	117
EG020A-F: Lithium	7439-93-2	0.001	mg/L	<0.001	----	----	----	----
EG020A-F: Manganese	7439-96-5	0.001	mg/L	<0.001	0.100 mg/L	106	84.1	122
EG020A-F: Molybdenum	7439-98-7	0.001	mg/L	<0.001	0.100 mg/L	99.7	89.6	110
EG020A-F: Nickel	7440-02-0	0.001	mg/L	<0.001	0.100 mg/L	108	86.3	118
EG020A-F: Selenium	7782-49-2	0.01	mg/L	----	0.100 mg/L	106	84.4	122
		0.010	mg/L	<0.010	----	----	----	----
EG020A-F: Thallium	7440-28-0	0.001	mg/L	<0.001	0.100 mg/L	105	83.4	119
EG020A-F: Tin	7440-31-5	0.001	mg/L	<0.001	0.100 mg/L	105	78.4	130
EG020A-F: Vanadium	7440-62-2	0.01	mg/L	<0.01	0.100 mg/L	94.0	76.9	117
EG020A-F: Zinc	7440-66-6	0.005	mg/L	<0.005	0.200 mg/L	109	84.2	130
EG020A-F: Boron	7440-42-8	0.05	mg/L	<0.05	0.50 mg/L	84.7	70	130
EG020F: Dissolved Metals by ICP-MS (QCLot: 723974)								
EG020B-F: Bismuth	7440-69-9	0.001	mg/L	<0.001	0.100 mg/L	114	85.2	119
EG020B-F: Cerium	7440-45-1	0.001	mg/L	<0.001	----	----	----	----
EG020B-F: Silver	7440-22-4	0.001	mg/L	<0.001	0.100 mg/L	76.7	70	120
EG020B-F: Strontium	7440-24-6	0.001	mg/L	<0.001	0.500 mg/L	102	84.1	116
EG020B-F: Thorium	7440-29-1	0.001	mg/L	<0.001	----	----	----	----
EG020B-F: Titanium	7440-32-6	0.01	mg/L	<0.01	0.100 mg/L	104	84.2	118
EG020B-F: Uranium	7440-61-1	0.001	mg/L	<0.001	----	----	----	----
EG020F: Dissolved Metals by ICP-MS (QCLot: 723975)								
EG020D-F: Yttrium	7440-65-5	0.001	mg/L	<0.001	----	----	----	----
EG020F: Dissolved Metals by ICP-MS (QCLot: 723976)								

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report Result	Laboratory Control Spike (LCS) Report Spike Concentration	Spike Recovery (%) LCS	Recovery Limits (%) Low	High
EG020F: Dissolved Metals by ICP-MS (QCLot: 723976) - continued								
EG020E-F: Tungsten	7440-33-7	0.001	mg/L	<0.001	----	----	----	----
EG020F: Dissolved Metals by ICP-MS (QCLot: 723977)								
EG020G-F: Rhenium	7440-15-5	0.001	mg/L	<0.001	----	----	----	----
EG020F: Dissolved Metals by ICP-MS (QCLot: 728580)								
EG020A-F: Aluminium	7429-90-5	0.01	mg/L	<0.01	0.500 mg/L	102	76.1	130
EG020A-F: Antimony	7440-36-0	0.001	mg/L	<0.001	0.100 mg/L	94.9	87.7	114
EG020A-F: Arsenic	7440-38-2	0.001	mg/L	<0.001	0.100 mg/L	110	79.6	115
EG020A-F: Beryllium	7440-41-7	0.001	mg/L	<0.001	0.100 mg/L	109	80.8	130
EG020A-F: Barium	7440-39-3	0.001	mg/L	<0.001	----	----	----	----
EG020A-F: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.100 mg/L	111	86.6	113
EG020A-F: Chromium	7440-47-3	0.001	mg/L	<0.001	0.100 mg/L	117	84.4	128
EG020A-F: Cobalt	7440-48-4	0.001	mg/L	<0.001	0.100 mg/L	108	86.6	117
EG020A-F: Copper	7440-50-8	0.001	mg/L	<0.001	0.200 mg/L	106	85	117
EG020A-F: Lead	7439-92-1	0.001	mg/L	<0.001	0.100 mg/L	107	85.4	117
EG020A-F: Lithium	7439-93-2	0.001	mg/L	<0.001	----	----	----	----
EG020A-F: Manganese	7439-96-5	0.001	mg/L	<0.001	0.100 mg/L	106	84.1	122
EG020A-F: Molybdenum	7439-98-7	0.001	mg/L	<0.001	0.100 mg/L	99.8	89.6	110
EG020A-F: Nickel	7440-02-0	0.001	mg/L	<0.001	0.100 mg/L	112	86.3	118
EG020A-F: Selenium	7782-49-2	0.01	mg/L	----	0.100 mg/L	99.0	84.4	122
		0.010	mg/L	<0.010	----	----	----	----
EG020A-F: Thallium	7440-28-0	0.001	mg/L	<0.001	0.100 mg/L	106	83.4	119
EG020A-F: Tin	7440-31-5	0.001	mg/L	<0.001	0.100 mg/L	103	78.4	130
EG020A-F: Vanadium	7440-62-2	0.01	mg/L	<0.01	0.100 mg/L	103	76.9	117
EG020A-F: Zinc	7440-66-6	0.005	mg/L	<0.005	0.200 mg/L	102	84.2	130
EG020A-F: Boron	7440-42-8	0.05	mg/L	<0.05	0.50 mg/L	104	70	130
EG035F: Dissolved Mercury by FIMS (QCLot: 724189)								
EG035F: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.010 mg/L	99.6	85.3	117
EG035F: Dissolved Mercury by FIMS (QCLot: 724190)								
EG035F: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.010 mg/L	98.5	85.3	117

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **WATER**

				Matrix Spike (MS) Report			
				Spike	*Spike Recovery (%)*	*Recovery Limits (%)*	
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*Concentration*	*MS*	*Low*	*High*
EG020F: Dissolved Metals by ICP-MS (QCLot: 723968)							
EB0810422-002	ODXH4.1-04 (1)	EG020A-F: Aluminium	7429-90-5	0.100 mg/L	# Not Determined	70	130
		EG020A-F: Antimony	7440-36-0	.5 mg/L	77.7	70	130
		EG020A-F: Arsenic	7440-38-2	.5 mg/L	103	70	130
		EG020A-F: Beryllium	7440-41-7	.5 mg/L	98.7	70	130
		EG020A-F: Barium	7440-39-3	.5 mg/L	116	70	130
		EG020A-F: Cadmium	7440-43-9	.5 mg/L	104	70	130
		EG020A-F: Chromium	7440-47-3	.5 mg/L	101	70	130
		EG020A-F: Cobalt	7440-48-4	0.100 mg/L	# Not Determined	70	130
		EG020A-F: Copper	7440-50-8	.5 mg/L	102	70	130
		EG020A-F: Lead	7439-92-1	.5 mg/L	104	70	130
		EG020A-F: Manganese	7439-96-5	0.100 mg/L	# Not Determined	70	130
		EG020A-F: Molybdenum	7439-98-7	.5 mg/L	92.0	70	130
		EG020A-F: Nickel	7440-02-0	.5 mg/L	105	70	130
		EG020A-F: Selenium	7782-49-2	.5 mg/L	110	70	130
		EG020A-F: Thallium	7440-28-0	.5 mg/L	102	70	130
		EG020A-F: Tin	7440-31-5	.5 mg/L	85.0	70	130
		EG020A-F: Vanadium	7440-62-2	.5 mg/L	104	70	130
		EG020A-F: Zinc	7440-66-6	.5 mg/L	98.6	70	130
		EG020A-F: Boron	7440-42-8	.5 mg/L	95.0	70	130
EG020F: Dissolved Metals by ICP-MS (QCLot: 723973)							
EB0810422-022	Reagent Blank (4)	EG020A-F: Aluminium	7429-90-5	.5 mg/L	96.4	70	130
		EG020A-F: Antimony	7440-36-0	.5 mg/L	74.4	70	130
		EG020A-F: Arsenic	7440-38-2	.5 mg/L	111	70	130
		EG020A-F: Beryllium	7440-41-7	.5 mg/L	91.8	70	130
		EG020A-F: Barium	7440-39-3	.5 mg/L	100	70	130
		EG020A-F: Cadmium	7440-43-9	.5 mg/L	94.3	70	130
		EG020A-F: Chromium	7440-47-3	.5 mg/L	76.9	70	130
		EG020A-F: Cobalt	7440-48-4	.5 mg/L	94.1	70	130
		EG020A-F: Copper	7440-50-8	.5 mg/L	93.0	70	130
		EG020A-F: Lead	7439-92-1	.5 mg/L	92.9	70	130
		EG020A-F: Manganese	7439-96-5	.5 mg/L	93.0	70	130
		EG020A-F: Molybdenum	7439-98-7	.5 mg/L	87.0	70	130
		EG020A-F: Nickel	7440-02-0	.5 mg/L	94.0	70	130
		EG020A-F: Selenium	7782-49-2	.5 mg/L	120	70	130
		EG020A-F: Thallium	7440-28-0	.5 mg/L	96.5	70	130

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Matrix Spike (MS) Report Spike Concentration	Spike Recovery (%) MS	Recovery Limits (%) Low	High
EG020F: Dissolved Metals by ICP-MS (QCLot: 723973) - continued							
EB0810422-022	Reagent Blank (4)	EG020A-F: Tin	7440-31-5	.5 mg/L	85.6	70	130
		EG020A-F: Vanadium	7440-62-2	.5 mg/L	91.0	70	130
		EG020A-F: Zinc	7440-66-6	.5 mg/L	84.6	70	130
		EG020A-F: Boron	7440-42-8	.5 mg/L	98.6	70	130
EG035F: Dissolved Mercury by FIMS (QCLot: 724189)							
EB0810365-023	Anonymous	EG035F: Mercury	7439-97-6	0.01 mg/L	102	70	130
EG035F: Dissolved Mercury by FIMS (QCLot: 724190)							
EB0810422-017	Reagent Blank (3)	EG035F: Mercury	7439-97-6	0.01 mg/L	101	70	130

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES

Environmental Division

QUALITY CONTROL REPORT

Work Order : **EB0814044**
Client : **C S I R O AUSTRALIA**
Contact : DR STUART SIMPSON
Address : CENTRE FOR ENVIRONMENTAL CONTAMINANTS RESEARCH
CSIRO ENERGY TECHNOLOGY
NEW ILLAWARRA ROAD
LUCAS HEIGHTS NSW, AUSTRALIA 2234

E-mail : stuart.simpson@csiro.au
Telephone : +61 02 97106807
Facsimile : +61 02 97106837

Project : ----
Site : ----
C-O-C number : ----
Sampler : ----
Order number : ----

Quote number : BN/328/08

Page : 1 of 14

Laboratory : Environmental Division Brisbane
Contact : Tim Kilmister
Address : 32 Shand Street Stafford QLD Australia 4053

E-mail : Services.Brisbane@alsenviro.com
Telephone : +61-7-3243 7222
Facsimile : +61-7-3243 7218

QC Level : NEPM 1999 Schedule B(3) and ALS QCS3 requirement

Date Samples Received : 10-OCT-2008
Issue Date : 28-OCT-2008

No. of samples received : 50
No. of samples analysed : 50

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 Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

NATA
WORLD RECOGNISED
ACCREDITATION

NATA Accredited Laboratory 825

This document is issued in
accordance with NATA
accreditation requirements.

Accredited for compliance with
ISO/IEC 17025.

Signatories

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

Signatories	*Position*	*Accreditation Category*
Kim McCabe	Senior Inorganic Chemist	Inorganics
Phillip Kennedy	2IC Environmental Laboratory	Inorganics
Stephen Hislop	Senior Inorganic Chemist	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 preformed, 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 insuffient 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.

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = Chemistry Abstract Services number
LOR = Limit of reporting
RPD = Relative Percentage Difference
# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR:- No Limit; Result between 10 and 20 times LOR:- 0% - 50%; Result > 20 times LOR:- 0% - 20%.

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
ED037P: Alkalinity by PC Titrator (QC Lot: 783914)									
EB0814018-001	Anonymous	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	51	53	3.8	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	51	53	3.8	0% - 20%
EB0814044-016	3.2-05 W1 Unpreserved	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	<1	<1	0.0	No Limit
ED037P: Alkalinity by PC Titrator (QC Lot: 783916)									
EB0814044-028	3.2-01 W6 Unpreserved	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	91	91	0.0	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	91	91	0.0	0% - 20%
EB0814044-047	N2T W3 Unpreserved	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	115	110	4.4	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	115	110	4.4	0% - 20%
ED037P: Alkalinity by PC Titrator (QC Lot: 783934)									
EB0813958-001	Anonymous	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	5340	5340	0.0	0% - 20%
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	30700	30700	0.0	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	36000	36000	0.0	0% - 20%
EB0814067-012	Anonymous	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	247	247	0.0	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	247	247	0.0	0% - 20%
ED037P: Alkalinity by PC Titrator (QC Lot: 788780)									
EB0814044-026	3.2-01 W2 Unpreserved	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	156	156	0.0	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	156	156	0.0	0% - 20%
EB0814135-007	Anonymous	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	166	158	4.9	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	166	158	4.9	0% - 20%

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Laboratory Duplicate (DUP) Report					
				LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
ED038A: Acidity (QC Lot: 783613)									
EB0814044-016	3.2-05 W1 Unpreserved	ED038: Acidity as CaCO3	----	1	mg/L	18700	18700	0.3	0% - 20%
ED038A: Acidity (QC Lot: 787632)									
EB0814061-017	Anonymous	ED038: Acidity as CaCO3	----	1	mg/L	<1	<1	0.0	No Limit
EB0814061-009	Anonymous	ED038: Acidity as CaCO3	----	1	mg/L	<1	<1	0.0	No Limit
ED038A: Acidity (QC Lot: 789499)									
EB0814044-026	3.2-01 W2 Unpreserved	ED038: Acidity as CaCO3	----	1	mg/L	<1	2	66.7	No Limit
ED040F: Dissolved Major Anions (QC Lot: 784285)									
EB0813940-001	Anonymous	ED040F: Silicon	7440-21-3	0.05	mg/L	15.5	15.2	2.0	0% - 20%
		ED040F: Sulfate as SO4 2-	14808-79-8	1	mg/L	31	30	0.0	0% - 20%
EB0814044-018	3.2-05 W3 Unpreserved	ED040F: Silicon	7440-21-3	0.05	mg/L	29.3	30.1	2.8	0% - 20%
		ED040F: Sulfate as SO4 2-	14808-79-8	1	mg/L	2940	2970	1.0	0% - 20%
ED040F: Dissolved Major Anions (QC Lot: 784287)									
EB0814061-003	Anonymous	ED040F: Silicon	7440-21-3	0.05	mg/L	36.9	35.8	3.0	0% - 20%
		ED040F: Sulfate as SO4 2-	14808-79-8	1	mg/L	2020	2000	0.8	0% - 20%
EB0814061-010	Anonymous	ED040F: Silicon	7440-21-3	0.05	mg/L	50.9	57.3	11.8	0% - 20%
		ED040F: Sulfate as SO4 2-	14808-79-8	1	mg/L	6370	7240	12.8	0% - 20%
ED040F: Dissolved Major Anions (QC Lot: 784851)									
EB0814007-001	Anonymous	ED040F: Silicon	7440-21-3	0.05	mg/L	1.32	1.34	1.4	0% - 20%
		ED040F: Sulfate as SO4 2-	14808-79-8	1	mg/L	<1	<1	0.0	No Limit
EB0814071-002	Anonymous	ED040F: Silicon	7440-21-3	0.05	mg/L	20.2	20.0	1.0	0% - 20%
		ED040F: Sulfate as SO4 2-	14808-79-8	1	mg/L	5	4	0.0	No Limit
ED040F: Dissolved Major Anions (QC Lot: 785670)									
EB0814066-006	Anonymous	ED040F: Silicon	7440-21-3	0.05	mg/L	6.31	6.10	3.3	0% - 20%
		ED040F: Sulfate as SO4 2-	14808-79-8	1	mg/L	236	224	4.8	0% - 20%
EB0814117-001	Anonymous	ED040F: Silicon	7440-21-3	0.05	mg/L	0.14	0.12	16.7	No Limit
		ED040F: Sulfate as SO4 2-	14808-79-8	1	mg/L	<1	<1	0.0	No Limit
ED045P: Chloride by PC Titrator (QC Lot: 783915)									
EB0814018-001	Anonymous	ED045-P: Chloride	16887-00-6	1	mg/L	3	3	0.0	No Limit
EB0814044-016	3.2-05 W1 Unpreserved	ED045-P: Chloride	16887-00-6	1	mg/L	1090	1090	0.0	0% - 20%
ED045P: Chloride by PC Titrator (QC Lot: 783917)									
EB0814044-028	3.2-01 W6 Unpreserved	ED045-P: Chloride	16887-00-6	1	mg/L	258	258	0.0	0% - 20%
ED045P: Chloride by PC Titrator (QC Lot: 783936)									
EB0813958-001	Anonymous	ED045-P: Chloride	16887-00-6	1	mg/L	330	335	1.5	0% - 20%
EB0814067-012	Anonymous	ED045-P: Chloride	16887-00-6	1	mg/L	2780	2780	0.2	0% - 20%
ED045P: Chloride by PC Titrator (QC Lot: 788781)									
EB0814044-026	3.2-01 W2 Unpreserved	ED045-P: Chloride	16887-00-6	1	mg/L	4520	4500	0.6	0% - 20%
EB0814135-009	Anonymous	ED045-P: Chloride	16887-00-6	1	mg/L	9700	9750	0.5	0% - 20%
ED093F: Dissolved Major Cations (QC Lot: 784286)									

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
ED093F: Dissolved Major Cations (QC Lot: 784286) - continued									
EB0813940-001	Anonymous	ED093F: Calcium	7440-70-2	1	mg/L	81	80	0.0	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	21	21	0.0	0% - 20%
		ED093F: Sodium	7440-23-5	1	mg/L	168	164	2.2	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	81	80	0.0	0% - 20%
EB0814044-018	3.2-05 W3 Unpreserved	ED093F: Calcium	7440-70-2	1	mg/L	464	494	6.2	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	26	26	0.0	0% - 20%
		ED093F: Sodium	7440-23-5	1	mg/L	205	210	2.4	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	29	30	0.0	0% - 20%
ED093F: Dissolved Major Cations (QC Lot: 784852)									
EB0814007-001	Anonymous	ED093F: Calcium	7440-70-2	1	mg/L	90	94	3.8	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	6	6	0.0	No Limit
		ED093F: Sodium	7440-23-5	1	mg/L	1550	1610	3.6	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	8	7	0.0	No Limit
EB0814071-002	Anonymous	ED093F: Calcium	7440-70-2	1	mg/L	18	17	0.0	0% - 50%
		ED093F: Magnesium	7439-95-4	1	mg/L	5	5	0.0	No Limit
		ED093F: Sodium	7440-23-5	1	mg/L	9	8	0.0	No Limit
		ED093F: Potassium	7440-09-7	1	mg/L	2	2	0.0	No Limit
ED093F: Dissolved Major Cations (QC Lot: 785671)									
EB0814066-006	Anonymous	ED093F: Calcium	7440-70-2	1	mg/L	35	34	3.1	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	25	24	0.0	0% - 20%
		ED093F: Sodium	7440-23-5	1	mg/L	314	305	3.1	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	36	34	4.2	0% - 20%
EB0814117-001	Anonymous	ED093F: Calcium	7440-70-2	1	mg/L	<1	<1	0.0	No Limit
		ED093F: Magnesium	7439-95-4	1	mg/L	<1	<1	0.0	No Limit
		ED093F: Sodium	7440-23-5	1	mg/L	9	8	0.0	No Limit
		ED093F: Potassium	7440-09-7	1	mg/L	<1	<1	0.0	No Limit
EG020T: Total Metals by ICP-MS (QC Lot: 783669)									
EB0814044-001	3.2-05 W1 HNO3 Preserved	EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	0.0073	0.0068	7.0	0% - 20%
		EG020A-T: Antimony	7440-36-0	0.001	mg/L	0.006	0.006	0.0	No Limit
		EG020A-T: Arsenic	7440-38-2	0.001	mg/L	0.096	0.091	5.9	0% - 20%
		EG020A-T: Beryllium	7440-41-7	0.001	mg/L	0.169	0.161	4.4	0% - 20%
		EG020A-T: Barium	7440-39-3	0.001	mg/L	0.072	0.073	2.1	0% - 20%
		EG020A-T: Chromium	7440-47-3	0.001	mg/L	0.352	0.336	4.7	0% - 20%
		EG020A-T: Cobalt	7440-48-4	0.001	mg/L	17.9	17.2	4.2	0% - 20%
		EG020A-T: Copper	7440-50-8	0.001	mg/L	252	242	3.9	0% - 20%
		EG020A-T: Lead	7439-92-1	0.001	mg/L	0.048	0.046	4.3	0% - 20%
		EG020A-T: Lithium	7439-93-2	0.001	mg/L	4.67	4.41	5.8	0% - 20%
		EG020A-T: Manganese	7439-96-5	0.001	mg/L	45.3	43.8	3.3	0% - 20%

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	***Client sample ID***	***Method: Compound***	***CAS Number***	***LOR***	***Unit***	***Original Result***	***Duplicate Result***	***RPD (%)***	***Recovery Limits (%)***
EG020T: Total Metals by ICP-MS (QC Lot: 783669) - continued									
EB0814044-001	3.2-05 W1 HNO3 Preserved	EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	0.003	0.003	0.0	No Limit
		EG020A-T: Nickel	7440-02-0	0.001	mg/L	1.70	1.63	4.4	0% - 20%
		EG020A-T: Thallium	7440-28-0	0.001	mg/L	0.005	0.005	0.0	No Limit
		EG020A-T: Tin	7440-31-5	0.001	mg/L	0.001	<0.001	0.0	No Limit
		EG020A-T: Zinc	7440-66-6	0.005	mg/L	7.79	6.85	12.8	0% - 20%
		EG020A-T: Aluminium	7429-90-5	0.01	mg/L	3520	3900	10.2	0% - 20%
		EG020A-T: Vanadium	7440-62-2	0.01	mg/L	0.20	0.18	7.6	0% - 50%
		EG020A-T: Selenium	7782-49-2	0.010	mg/L	0.251	0.231	8.3	0% - 20%
		EG020A-T: Boron	7440-42-8	0.05	mg/L	0.42	0.41	0.0	No Limit
		EG020A-T: Iron	7439-89-6	0.05	mg/L	2270	2170	4.4	0% - 20%
EB0814044-008	4.1-04 W3 HNO3 Preserved	EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	0.0026	0.0026	0.0	0% - 20%
		EG020A-T: Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Arsenic	7440-38-2	0.001	mg/L	0.010	0.012	18.5	0% - 50%
		EG020A-T: Beryllium	7440-41-7	0.001	mg/L	0.015	0.016	0.0	0% - 50%
		EG020A-T: Barium	7440-39-3	0.001	mg/L	0.012	0.012	0.0	0% - 50%
		EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Cobalt	7440-48-4	0.001	mg/L	3.31	3.45	4.1	0% - 20%
		EG020A-T: Copper	7440-50-8	0.001	mg/L	0.024	0.024	0.0	0% - 20%
		EG020A-T: Lead	7439-92-1	0.001	mg/L	0.001	0.001	0.0	No Limit
		EG020A-T: Lithium	7439-93-2	0.001	mg/L	0.483	0.509	5.2	0% - 20%
		EG020A-T: Manganese	7439-96-5	0.001	mg/L	12.8	13.0	1.7	0% - 20%
		EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Nickel	7440-02-0	0.001	mg/L	0.284	0.291	2.5	0% - 20%
		EG020A-T: Thallium	7440-28-0	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Tin	7440-31-5	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Zinc	7440-66-6	0.005	mg/L	0.905	0.941	3.8	0% - 20%
		EG020A-T: Aluminium	7429-90-5	0.01	mg/L	67.0	68.4	2.0	0% - 20%
		EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	0.0	No Limit
		EG020A-T: Selenium	7782-49-2	0.010	mg/L	0.017	0.020	13.8	No Limit
		EG020A-T: Boron	7440-42-8	0.05	mg/L	0.23	0.25	5.6	No Limit
		EG020A-T: Iron	7439-89-6	0.05	mg/L	393	405	3.0	0% - 20%
EG020T: Total Metals by ICP-MS (QC Lot: 783670)									
EB0814044-001	3.2-05 W1 HNO3 Preserved	EG020B-T: Cerium	7440-45-1	0.001	mg/L	256	247	3.8	0% - 20%
		EG020B-T: Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020B-T: Strontium	7440-24-6	0.001	mg/L	6.20	6.00	3.4	0% - 20%
		EG020B-T: Thorium	7440-29-1	0.001	mg/L	2.34	2.28	2.4	0% - 20%
		EG020B-T: Uranium	7440-61-1	0.001	mg/L	77.4	75.6	2.4	0% - 20%

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EG020T: Total Metals by ICP-MS (QC Lot: 783670) - continued									
EB0814044-001	3.2-05 W1 HNO3 Preserved	EG020B-T: Titanium	7440-32-6	0.01	mg/L	0.06	0.06	0.0	No Limit
EB0814044-008	4.1-04 W3 HNO3 Preserved	EG020B-T: Cerium	7440-45-1	0.001	mg/L	16.3	16.3	0.05	0% - 20%
		EG020B-T: Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020B-T: Strontium	7440-24-6	0.001	mg/L	1.51	1.54	2.1	0% - 20%
		EG020B-T: Thorium	7440-29-1	0.001	mg/L	0.003	0.003	0.0	No Limit
		EG020B-T: Uranium	7440-61-1	0.001	mg/L	1.47	1.48	0.4	0% - 20%
		EG020B-T: Titanium	7440-32-6	0.01	mg/L	<0.01	<0.01	0.0	No Limit
EG020T: Total Metals by ICP-MS (QC Lot: 783671)									
EB0814044-001	3.2-05 W1 HNO3 Preserved	EG020D-T: Yttrium	7440-65-5	0.001	mg/L	30.7	29.9	2.6	0% - 20%
EB0814044-008	4.1-04 W3 HNO3 Preserved	EG020D-T: Yttrium	7440-65-5	0.001	mg/L	0.850	0.866	1.9	0% - 20%
EG020T: Total Metals by ICP-MS (QC Lot: 783672)									
EB0814044-001	3.2-05 W1 HNO3 Preserved	EG020E-T: Gold	7440-57-5	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020E-T: Tungsten	7440-33-7	0.001	mg/L	0.023	0.022	7.2	0% - 20%
EB0814044-008	4.1-04 W3 HNO3 Preserved	EG020E-T: Gold	7440-57-5	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020E-T: Tungsten	7440-33-7	0.001	mg/L	<0.001	<0.001	0.0	No Limit
EG020T: Total Metals by ICP-MS (QC Lot: 783673)									
EB0814044-008	4.1-04 W3 HNO3 Preserved	EG020G-T: Rhenium	7440-15-5	0.001	mg/L	0.003	0.004	0.0	No Limit
EB0814044-034	OX-T W4 HNO3 Preserved	EG020G-T: Rhenium	7440-15-5	0.001	mg/L	0.001	0.001	0.0	No Limit
EG020T: Total Metals by ICP-MS (QC Lot: 783674)									
EB0814044-034	OX-T W4 HNO3 Preserved	EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	0.0008	0.0008	0.0	No Limit
		EG020A-T: Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Arsenic	7440-38-2	0.001	mg/L	0.004	0.003	0.0	No Limit
		EG020A-T: Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Barium	7440-39-3	0.001	mg/L	0.052	0.051	0.0	0% - 20%
		EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Cobalt	7440-48-4	0.001	mg/L	0.059	0.060	0.0	0% - 20%
		EG020A-T: Copper	7440-50-8	0.001	mg/L	0.180	0.180	0.0	0% - 20%
		EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Lithium	7439-93-2	0.001	mg/L	0.282	0.287	1.7	0% - 20%
		EG020A-T: Manganese	7439-96-5	0.001	mg/L	1.62	1.64	1.5	0% - 20%
		EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	0.322	0.320	0.7	0% - 20%
		EG020A-T: Nickel	7440-02-0	0.001	mg/L	0.002	0.002	0.0	No Limit
		EG020A-T: Thallium	7440-28-0	0.001	mg/L	<0.001	<0.001	0.0	No Limit

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EG020T: Total Metals by ICP-MS (QC Lot: 783674) - continued									
EB0814044-034	OX-T W4 HNO3 Preserved	EG020A-T: Tin	7440-31-5	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Zinc	7440-66-6	0.005	mg/L	0.139	0.140	0.0	0% - 20%
		EG020A-T: Aluminium	7429-90-5	0.01	mg/L	0.08	0.08	0.0	No Limit
		EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	0.0	No Limit
		EG020A-T: Selenium	7782-49-2	0.010	mg/L	0.020	0.017	16.6	No Limit
		EG020A-T: Boron	7440-42-8	0.05	mg/L	2.59	2.59	0.0	0% - 20%
		EG020A-T: Iron	7439-89-6	0.05	mg/L	0.16	0.19	19.0	No Limit
EG020T: Total Metals by ICP-MS (QC Lot: 783675)									
EB0814044-034	OX-T W4 HNO3 Preserved	EG020B-T: Cerium	7440-45-1	0.001	mg/L	0.002	0.002	0.0	No Limit
		EG020B-T: Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020B-T: Strontium	7440-24-6	0.001	mg/L	3.46	3.50	1.0	0% - 20%
		EG020B-T: Thorium	7440-29-1	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020B-T: Uranium	7440-61-1	0.001	mg/L	2.67	2.68	0.5	0% - 20%
		EG020B-T: Titanium	7440-32-6	0.01	mg/L	<0.01	<0.01	0.0	No Limit
EG020T: Total Metals by ICP-MS (QC Lot: 783676)									
EB0814044-034	OX-T W4 HNO3 Preserved	EG020D-T: Yttrium	7440-65-5	0.001	mg/L	<0.001	<0.001	0.0	No Limit
EG020T: Total Metals by ICP-MS (QC Lot: 783677)									
EB0814044-034	OX-T W4 HNO3 Preserved	EG020E-T: Gold	7440-57-5	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020E-T: Tungsten	7440-33-7	0.001	mg/L	0.005	0.005	0.0	No Limit
EG035T: Total Recoverable Mercury by FIMS (QC Lot: 783392)									
EB0813880-010	Anonymous	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EB0814004-002	Anonymous	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EG035T: Total Recoverable Mercury by FIMS (QC Lot: 783393)									
EB0814044-011	3.2-01 W2 HNO3 Preserved	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EG035T: Total Recoverable Mercury by FIMS (QC Lot: 784519)									
EB0813972-017	Anonymous	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EB0814044-037	N2T W2 HNO3 Preserved	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EG035T: Total Recoverable Mercury by FIMS (QC Lot: 789120)									
EB0814002-001	Anonymous	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EB0814044-038	N2T W3 HNO3 Preserved	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EP006 Total Inorganic Carbon (QC Lot: 783597)									
EB0814044-016	3.2-05 W1 Unpreserved	EP006: Total Inorganic Carbon	----	1	mg/L	<1	<1	0.0	No Limit
EB0814044-025	3.2-01 W1 Unpreserved	EP006: Total Inorganic Carbon	----	1	mg/L	66	66	0.0	0% - 20%
EP006 Total Inorganic Carbon (QC Lot: 783598)									
EB0814044-046	N2T W2 Unpreserved	EP006: Total Inorganic Carbon	----	1	mg/L	<1	<1	0.0	No Limit
EB0814064-005	Anonymous	EP006: Total Inorganic Carbon	----	1	mg/L	9	8	0.0	No Limit

Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **WATER**

				Method Blank (MB) Report	*Laboratory Control Spike (LCS) Report*			
					Spike	*Spike Recovery (%)*	*Recovery Limits (%)*	
Method: Compound	*CAS Number*	*LOR*	*Unit*	*Result*	*Concentration*	*LCS*	*Low*	*High*
ED037P: Alkalinity by PC Titrator (QCLot: 783914)								
ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	----	200 mg/L	92.5	77.5	112
ED037P: Alkalinity by PC Titrator (QCLot: 783916)								
ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	----	200 mg/L	93.0	77.5	112
ED037P: Alkalinity by PC Titrator (QCLot: 783934)								
ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	----	500 mg/L	98.8	77.5	112
ED037P: Alkalinity by PC Titrator (QCLot: 788780)								
ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	----	200 mg/L	87.5	77.5	112
ED038A: Acidity (QCLot: 783613)								
ED038: Acidity as CaCO3	----	1	mg/L	----	100 mg/L	100	90.5	110
ED038A: Acidity (QCLot: 787632)								
ED038: Acidity as CaCO3	----	1	mg/L	----	100 mg/L	100	90.5	110
ED038A: Acidity (QCLot: 789499)								
ED038: Acidity as CaCO3	----	1	mg/L	----	100 mg/L	100	90.5	110
ED040F: Dissolved Major Anions (QCLot: 784285)								
ED040F: Sulfate as SO4 2-	14808-79-8	1	mg/L	<1	----	----	----	----
ED040F: Silicon	7440-21-3	0.05	mg/L	<0.05	----	----	----	----
ED040F: Dissolved Major Anions (QCLot: 784287)								
ED040F: Sulfate as SO4 2-	14808-79-8	1	mg/L	<1	----	----	----	----
ED040F: Silicon	7440-21-3	0.05	mg/L	<0.05	----	----	----	----
ED040F: Dissolved Major Anions (QCLot: 784851)								
ED040F: Sulfate as SO4 2-	14808-79-8	1	mg/L	<1	----	----	----	----
ED040F: Silicon	7440-21-3	0.05	mg/L	<0.05	----	----	----	----
ED040F: Dissolved Major Anions (QCLot: 785670)								
ED040F: Sulfate as SO4 2-	14808-79-8	1	mg/L	<1	----	----	----	----
ED040F: Silicon	7440-21-3	0.05	mg/L	<0.05	----	----	----	----
ED045P: Chloride by PC Titrator (QCLot: 783915)								
ED045-P: Chloride	16887-00-6	1	mg/L	<1	1000 mg/L	99.8	88.4	110
ED045P: Chloride by PC Titrator (QCLot: 783917)								
ED045-P: Chloride	16887-00-6	1	mg/L	<1	1000 mg/L	99.8	88.4	110
ED045P: Chloride by PC Titrator (QCLot: 783936)								
ED045-P: Chloride	16887-00-6	1	mg/L	<1	1000 mg/L	101	88.4	110
ED045P: Chloride by PC Titrator (QCLot: 788781)								

Sub-Matrix: **WATER**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result	Concentration	LCS	Low	High
ED045P: Chloride by PC Titrator (QCLot: 788781) - continued								
ED045-P: Chloride	16887-00-6	1	mg/L	<1	1000 mg/L	99.0	88.4	110
ED093F: Dissolved Major Cations (QCLot: 784286)								
ED093F: Calcium	7440-70-2	1	mg/L	<1	----	----	----	----
ED093F: Magnesium	7439-95-4	1	mg/L	<1	----	----	----	----
ED093F: Sodium	7440-23-5	1	mg/L	<1	----	----	----	----
ED093F: Potassium	7440-09-7	1	mg/L	<1	----	----	----	----
ED093F: Dissolved Major Cations (QCLot: 784852)								
ED093F: Calcium	7440-70-2	1	mg/L	<1	----	----	----	----
ED093F: Magnesium	7439-95-4	1	mg/L	<1	----	----	----	----
ED093F: Sodium	7440-23-5	1	mg/L	<1	----	----	----	----
ED093F: Potassium	7440-09-7	1	mg/L	<1	----	----	----	----
ED093F: Dissolved Major Cations (QCLot: 785671)								
ED093F: Calcium	7440-70-2	1	mg/L	<1	----	----	----	----
ED093F: Magnesium	7439-95-4	1	mg/L	<1	----	----	----	----
ED093F: Sodium	7440-23-5	1	mg/L	<1	----	----	----	----
ED093F: Potassium	7440-09-7	1	mg/L	<1	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 783669)								
EG020A-T: Aluminium	7429-90-5	0.01	mg/L	<0.01	0.500 mg/L	87.7	74	130
EG020A-T: Antimony	7440-36-0	0.001	mg/L	<0.001	0.100 mg/L	93.8	84.6	112
EG020A-T: Arsenic	7440-38-2	0.001	mg/L	<0.001	0.100 mg/L	95.6	75.7	110
EG020A-T: Beryllium	7440-41-7	0.001	mg/L	<0.001	0.100 mg/L	104	76.7	130
EG020A-T: Barium	7440-39-3	0.001	mg/L	<0.001	----	----	----	----
EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.100 mg/L	94.7	81.8	111
EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.001	0.100 mg/L	102	80.9	125
EG020A-T: Cobalt	7440-48-4	0.001	mg/L	<0.001	0.100 mg/L	106	81.3	117
EG020A-T: Copper	7440-50-8	0.001	mg/L	<0.001	0.200 mg/L	102	80.9	115
EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.001	0.100 mg/L	103	84.4	113
EG020A-T: Lithium	7439-93-2	0.001	mg/L	<0.001	----	----	----	----
EG020A-T: Manganese	7439-96-5	0.001	mg/L	<0.001	0.100 mg/L	111	76.8	123
EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	<0.001	0.100 mg/L	98.6	85.2	111
EG020A-T: Nickel	7440-02-0	0.001	mg/L	<0.001	0.100 mg/L	103	81.5	117
EG020A-T: Selenium	7782-49-2	0.01	mg/L	----	0.100 mg/L	96.0	78.9	113
		0.010	mg/L	<0.010	----	----	----	----
EG020A-T: Thallium	7440-28-0	0.001	mg/L	<0.001	0.100 mg/L	102	84.5	117
EG020A-T: Tin	7440-31-5	0.001	mg/L	<0.001	0.100 mg/L	97.7	70	130
EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.01	0.100 mg/L	109	70.5	119
EG020A-T: Zinc	7440-66-6	0.005	mg/L	<0.005	0.200 mg/L	106	81	127
EG020A-T: Boron	7440-42-8	0.05	mg/L	<0.05	0.500 mg/L	92.3	70	130
EG020A-T: Iron	7439-89-6	0.05	mg/L	<0.05	0.500 mg/L	114	70	130

Sub-Matrix: **WATER**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result	Concentration	LCS	Low	High
EG020T: Total Metals by ICP-MS (QCLot: 783670)								
EG020B-T: Cerium	7440-45-1	0.001	mg/L	<0.001	----	----	----	----
EG020B-T: Silver	7440-22-4	0.001	mg/L	<0.001	0.100 mg/L	84.0	70	120
EG020B-T: Strontium	7440-24-6	0.001	mg/L	<0.001	0.500 mg/L	97.4	81.2	115
EG020B-T: Thorium	7440-29-1	0.001	mg/L	<0.001	----	----	----	----
EG020B-T: Titanium	7440-32-6	0.01	mg/L	<0.01	0.100 mg/L	106	77.9	118
EG020B-T: Uranium	7440-61-1	0.001	mg/L	<0.001	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 783671)								
EG020D-T: Yttrium	7440-65-5	0.001	mg/L	<0.001	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 783672)								
EG020E-T: Gold	7440-57-5	0.001	mg/L	<0.001	----	----	----	----
EG020E-T: Tungsten	7440-33-7	0.001	mg/L	<0.001	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 783673)								
EG020G-T: Rhenium	7440-15-5	0.001	mg/L	<0.001	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 783674)								
EG020A-T: Aluminium	7429-90-5	0.01	mg/L	<0.01	0.500 mg/L	81.0	74	130
EG020A-T: Antimony	7440-36-0	0.001	mg/L	<0.001	0.100 mg/L	87.3	84.6	112
EG020A-T: Arsenic	7440-38-2	0.001	mg/L	<0.001	0.100 mg/L	82.2	75.7	110
EG020A-T: Beryllium	7440-41-7	0.001	mg/L	<0.001	0.100 mg/L	116	76.7	130
EG020A-T: Barium	7440-39-3	0.001	mg/L	<0.001	----	----	----	----
EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.100 mg/L	87.1	81.8	111
EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.001	0.100 mg/L	88.6	80.9	125
EG020A-T: Cobalt	7440-48-4	0.001	mg/L	<0.001	0.100 mg/L	90.7	81.3	117
EG020A-T: Copper	7440-50-8	0.001	mg/L	<0.001	0.200 mg/L	87.0	80.9	115
EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.001	0.100 mg/L	93.1	84.4	113
EG020A-T: Lithium	7439-93-2	0.001	mg/L	<0.001	----	----	----	----
EG020A-T: Manganese	7439-96-5	0.001	mg/L	<0.001	0.100 mg/L	93.9	76.8	123
EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	<0.001	0.100 mg/L	85.7	85.2	111
EG020A-T: Nickel	7440-02-0	0.001	mg/L	<0.001	0.100 mg/L	87.0	81.5	117
EG020A-T: Selenium	7782-49-2	0.01	mg/L	----	0.100 mg/L	83.1	78.9	113
		0.010	mg/L	<0.010	----	----	----	----
EG020A-T: Thallium	7440-28-0	0.001	mg/L	<0.001	0.100 mg/L	89.4	84.5	117
EG020A-T: Tin	7440-31-5	0.001	mg/L	<0.001	0.100 mg/L	88.3	70	130
EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.01	0.100 mg/L	95.1	70.5	119
EG020A-T: Zinc	7440-66-6	0.005	mg/L	<0.005	0.200 mg/L	91.1	81	127
EG020A-T: Boron	7440-42-8	0.05	mg/L	<0.05	0.500 mg/L	92.6	70	130
EG020A-T: Iron	7439-89-6	0.05	mg/L	<0.05	0.500 mg/L	94.4	70	130
EG020T: Total Metals by ICP-MS (QCLot: 783675)								
EG020B-T: Cerium	7440-45-1	0.001	mg/L	<0.001	----	----	----	----

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
				Result	Concentration	LCS	Low	High
EG020T: Total Metals by ICP-MS (QCLot: 783675) - continued								
EG020B-T: Strontium	7440-24-6	0.001	mg/L	<0.001	0.500 mg/L	88.9	81.2	115
EG020B-T: Thorium	7440-29-1	0.001	mg/L	<0.001	----	----	----	----
EG020B-T: Titanium	7440-32-6	0.01	mg/L	<0.01	0.100 mg/L	90.4	77.9	118
EG020B-T: Uranium	7440-61-1	0.001	mg/L	<0.001	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 783676)								
EG020D-T: Yttrium	7440-65-5	0.001	mg/L	<0.001	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 783677)								
EG020E-T: Gold	7440-57-5	0.001	mg/L	<0.001	----	----	----	----
EG020E-T: Tungsten	7440-33-7	0.001	mg/L	<0.001	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 783678)								
EG020G-T: Rhenium	7440-15-5	0.001	mg/L	<0.001	----	----	----	----
EG035T: Total Recoverable Mercury by FIMS (QCLot: 783392)								
EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.0100 mg/L	93.7	84.2	118
EG035T: Total Recoverable Mercury by FIMS (QCLot: 783393)								
EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.0100 mg/L	93.1	84.2	118
EG035T: Total Recoverable Mercury by FIMS (QCLot: 784519)								
EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.0100 mg/L	97.9	84.2	118
EG035T: Total Recoverable Mercury by FIMS (QCLot: 789120)								
EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.0100 mg/L	98.8	84.2	118

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **WATER**

				Matrix Spike (MS) Report			
				Spike	*Spike Recovery (%)*	*Recovery Limits (%)*	
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*Concentration*	*MS*	*Low*	*High*
ED045P: Chloride by PC Titrator (QCLot: 783915)							
EB0814018-002	Anonymous	ED045-P: Chloride	16887-00-6	20 mg/L	85.0	70	130
ED045P: Chloride by PC Titrator (QCLot: 783917)							
EB0814044-029	3.2-01 D21 Unpreserved	ED045-P: Chloride	16887-00-6	4000 mg/L	104	70	130
ED045P: Chloride by PC Titrator (QCLot: 783936)							
EB0813967-001	Anonymous	ED045-P: Chloride	16887-00-6	2000 mg/L	100	70	130
ED045P: Chloride by PC Titrator (QCLot: 788781)							
EB0814044-050	Reagent Blank (2) Unpreserved	ED045-P: Chloride	16887-00-6	20 mg/L	100	70	130
EG020T: Total Metals by ICP-MS (QCLot: 783669)							
EB0813958-002	Anonymous	EG020A-T: Arsenic	7440-38-2	1.000 mg/L	93.5	70	130
		EG020A-T: Beryllium	7440-41-7	0.100 mg/L	88.6	70	130
		EG020A-T: Barium	7440-39-3	1.000 mg/L	86.4	70	130
		EG020A-T: Cadmium	7440-43-9	0.500 mg/L	79.2	70	130
		EG020A-T: Chromium	7440-47-3	1.000 mg/L	88.3	70	130
		EG020A-T: Cobalt	7440-48-4	1.000 mg/L	94.5	70	130
		EG020A-T: Copper	7440-50-8	1.000 mg/L	93.5	70	130
		EG020A-T: Lead	7439-92-1	1.000 mg/L	93.1	70	130
		EG020A-T: Manganese	7439-96-5	1.000 mg/L	99.2	70	130
		EG020A-T: Nickel	7440-02-0	1.000 mg/L	93.4	70	130
		EG020A-T: Vanadium	7440-62-2	1.000 mg/L	102	70	130
		EG020A-T: Zinc	7440-66-6	1.000 mg/L	96.2	70	130
EG020T: Total Metals by ICP-MS (QCLot: 783674)							
EB0814044-035	OX-T W1(DX1) HNO3 Preserved	EG020A-T: Arsenic	7440-38-2	1.000 mg/L	91.6	70	130
		EG020A-T: Beryllium	7440-41-7	0.100 mg/L	102	70	130
		EG020A-T: Barium	7440-39-3	1.000 mg/L	86.9	70	130
		EG020A-T: Cadmium	7440-43-9	0.500 mg/L	73.0	70	130
		EG020A-T: Chromium	7440-47-3	1.000 mg/L	91.7	70	130
		EG020A-T: Cobalt	7440-48-4	1.000 mg/L	92.3	70	130
		EG020A-T: Copper	7440-50-8	1.000 mg/L	80.7	70	130
		EG020A-T: Lead	7439-92-1	1.000 mg/L	82.1	70	130
		EG020A-T: Manganese	7439-96-5	1.000 mg/L	99.8	70	130
		EG020A-T: Nickel	7440-02-0	1.000 mg/L	84.6	70	130
		EG020A-T: Vanadium	7440-62-2	1.000 mg/L	110	70	130
		EG020A-T: Zinc	7440-66-6	1.000 mg/L	89.2	70	130
EG035T: Total Recoverable Mercury by FIMS (QCLot: 783392)							

Sub-Matrix: **WATER**

				Matrix Spike (MS) Report			
				Spike	Spike Recovery (%)	Recovery Limits (%)	
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	Concentration	MS	Low	High
EG035T: Total Recoverable Mercury by FIMS (QCLot: 783392) - continued							
EB0813880-010	Anonymous	EG035T: Mercury	7439-97-6	0.0100 mg/L	91.0	70	130
EG035T: Total Recoverable Mercury by FIMS (QCLot: 783393)							
EB0814044-011	3.2-01 W2 HNO3 Preserved	EG035T: Mercury	7439-97-6	0.0100 mg/L	91.8	70	130
EG035T: Total Recoverable Mercury by FIMS (QCLot: 784519)							
EB0813972-017	Anonymous	EG035T: Mercury	7439-97-6	0.0100 mg/L	99.2	70	130
EG035T: Total Recoverable Mercury by FIMS (QCLot: 789120)							
EB0814002-001	Anonymous	EG035T: Mercury	7439-97-6	0.0100 mg/L	94.5	70	130

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES

Environmental Division

QUALITY CONTROL REPORT

Work Order : **EB0815577**

Client : **C S I R O AUSTRALIA**
Contact : DR STUART SIMPSON
Address : CENTRE FOR ENVIRONMENTAL CONTAMINANTS RESEARCH
CSIRO ENERGY TECHNOLOGY
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LUCAS HEIGHTS NSW, AUSTRALIA 2234

E-mail : stuart.simpson@csiro.au
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Project : ----
Site : ----
C-O-C number : ----
Sampler : ----
Order number : ----

Quote number : BN/328/08

Page : 1 of 9

Laboratory : Environmental Division Brisbane
Contact : Tim Kilmister
Address : 32 Shand Street Stafford QLD Australia 4053

E-mail : Services.Brisbane@alsenviro.com
Telephone : +61-7-3243 7222
Facsimile : +61-7-3243 7218

QC Level : NEPM 1999 Schedule B(3) and ALS QCS3 requirement

Date Samples Received : 11-NOV-2008
Issue Date : 19-NOV-2008

No. of samples received : 7
No. of samples analysed : 6

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 Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

NATA
WORLD RECOGNISED
ACCREDITATION

NATA Accredited Laboratory 825

This document is issued in
accordance with NATA
accreditation requirements.

Accredited for compliance with
ISO/IEC 17025.

Signatories

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

Signatories	*Position*	*Accreditation Category*
Kim McCabe	Senior Inorganic Chemist	Inorganics
Stephen Hislop	Senior Inorganic Chemist	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 insuffient 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.

Key :
Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = Chemistry Abstract Services number
LOR = Limit of reporting
RPD = Relative Percentage Difference
# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR:- No Limit; Result between 10 and 20 times LOR:- 0% - 50%; Result > 20 times LOR:- 0% - 20%.

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
ED037P: Alkalinity by PC Titrator (QC Lot: 813200)									
EB0815577-001	3.2-05 W9	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	<1	<1	0.0	No Limit
ED037P: Alkalinity by PC Titrator (QC Lot: 814721)									
EB0815400-001	Anonymous	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	74	74	0.0	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	74	74	0.0	0% - 20%
EB0815570-006	Anonymous	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	<1	<1	0.0	No Limit
ED038A: Acidity (QC Lot: 814752)									
EB0815577-002	3.2-05 W12	ED038: Acidity as CaCO3	----	1	mg/L	77	77	0.0	0% - 20%
EB0815582-007	Anonymous	ED038: Acidity as CaCO3	----	1	mg/L	<1	<1	0.0	No Limit
ED040F: Dissolved Major Anions (QC Lot: 814085)									
EB0815577-001	3.2-05 W9	ED040F: Silicon	7440-21-3	0.05	mg/L	28.5	28.6	0.6	0% - 20%
		ED040F: Sulfate as SO4 2-	14808-79-8	1	mg/L	1680	1670	0.4	0% - 20%
EB0815578-010	Anonymous	ED040F: Silicon	7440-21-3	0.05	mg/L	7.10	7.31	2.8	0% - 20%
		ED040F: Sulfate as SO4 2-	14808-79-8	1	mg/L	1280	1330	3.3	0% - 20%
ED045P: Chloride by PC Titrator (QC Lot: 813201)									
EB0815577-001	3.2-05 W9	ED045-P: Chloride	16887-00-6	1	mg/L	<1	<1	0.0	No Limit
ED045P: Chloride by PC Titrator (QC Lot: 814723)									
EB0815400-001	Anonymous	ED045-P: Chloride	16887-00-6	1	mg/L	104	104	0.0	0% - 20%
EB0815577-004	4.1-04 W12	ED045-P: Chloride	16887-00-6	1	mg/L	7	9	25.0	No Limit
ED093F: Dissolved Major Cations (QC Lot: 814084)									
EB0815447-003	Anonymous	ED093F: Calcium	7440-70-2	1	mg/L	90	90	0.0	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	320	331	3.5	0% - 20%
		ED093F: Sodium	7440-23-5	1	mg/L	1020	1060	4.3	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	447	461	3.1	0% - 20%
EB0815462-002	Anonymous	ED093F: Calcium	7440-70-2	1	mg/L	10	9	0.0	No Limit
		ED093F: Magnesium	7439-95-4	1	mg/L	<1	<1	0.0	No Limit
		ED093F: Sodium	7440-23-5	1	mg/L	<1	<1	0.0	No Limit

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
ED093F: Dissolved Major Cations (QC Lot: 814084) - continued									
EB0815462-002	Anonymous	ED093F: Potassium	7440-09-7	1	mg/L	<1	<1	0.0	No Limit
ED093F: Dissolved Major Cations (QC Lot: 814086)									
EB0815577-001	3.2-05 W9	ED093F: Calcium	7440-70-2	1	mg/L	644	638	0.8	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	<1	<1	0.0	No Limit
		ED093F: Sodium	7440-23-5	1	mg/L	2	2	0.0	No Limit
		ED093F: Potassium	7440-09-7	1	mg/L	8	8	0.0	No Limit
EB0815578-010	Anonymous	ED093F: Calcium	7440-70-2	1	mg/L	441	452	2.3	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	83	84	1.5	0% - 20%
		ED093F: Sodium	7440-23-5	1	mg/L	58	61	4.2	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	30	31	0.0	0% - 20%
EG020T: Total Metals by ICP-MS (QC Lot: 812569)									
EB0815577-001	3.2-05 W9	EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	0.0019	0.0018	5.3	0% - 50%
		EG020A-T: Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Arsenic	7440-38-2	0.001	mg/L	0.033	0.032	0.0	0% - 20%
		EG020A-T: Beryllium	7440-41-7	0.001	mg/L	<0.001	0.001	0.0	No Limit
		EG020A-T: Barium	7440-39-3	0.001	mg/L	0.031	0.030	0.0	0% - 20%
		EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Cobalt	7440-48-4	0.001	mg/L	0.743	0.748	0.8	0% - 20%
		EG020A-T: Copper	7440-50-8	0.001	mg/L	25.4	26.5	4.2	0% - 20%
		EG020A-T: Lead	7439-92-1	0.001	mg/L	0.007	0.006	0.0	No Limit
		EG020A-T: Lithium	7439-93-2	0.001	mg/L	0.009	0.010	0.0	0% - 50%
		EG020A-T: Manganese	7439-96-5	0.001	mg/L	0.136	0.137	0.0	0% - 20%
		EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Nickel	7440-02-0	0.001	mg/L	0.048	0.048	0.0	0% - 20%
		EG020A-T: Thallium	7440-28-0	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Tin	7440-31-5	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Zinc	7440-66-6	0.005	mg/L	0.062	0.062	0.0	0% - 50%
		EG020A-T: Aluminium	7429-90-5	0.01	mg/L	4.29	4.29	0.0	0% - 20%
		EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	0.0	No Limit
		EG020A-T: Selenium	7782-49-2	0.010	mg/L	0.018	0.018	0.0	No Limit
		EG020A-T: Boron	7440-42-8	0.05	mg/L	0.10	0.11	0.0	No Limit
		EG020A-T: Iron	7439-89-6	0.05	mg/L	4.87	4.76	2.4	0% - 20%
EB0815578-004	Anonymous	EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
		EG020A-T: Antimony	7440-36-0	0.001	mg/L	0.002	0.002	0.0	No Limit
		EG020A-T: Arsenic	7440-38-2	0.001	mg/L	0.005	0.004	0.0	No Limit
		EG020A-T: Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Barium	7440-39-3	0.001	mg/L	0.037	0.038	0.0	0% - 20%
		EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.001	0.002	75.5	No Limit
		EG020A-T: Cobalt	7440-48-4	0.001	mg/L	0.322	0.330	2.5	0% - 20%

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EG020T: Total Metals by ICP-MS (QC Lot: 812569) - continued									
EB0815578-004	Anonymous	EG020A-T: Copper	7440-50-8	0.001	mg/L	0.221	0.228	3.4	0% - 20%
		EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Lithium	7439-93-2	0.001	mg/L	0.500	0.544	8.5	0% - 20%
		EG020A-T: Manganese	7439-96-5	0.001	mg/L	6.55	6.89	5.1	0% - 20%
		EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	0.618	0.650	5.1	0% - 20%
		EG020A-T: Nickel	7440-02-0	0.001	mg/L	0.006	0.006	0.0	No Limit
		EG020A-T: Thallium	7440-28-0	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Tin	7440-31-5	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Zinc	7440-66-6	0.005	mg/L	0.028	0.027	0.0	No Limit
		EG020A-T: Aluminium	7429-90-5	0.01	mg/L	0.05	0.05	0.0	No Limit
		EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	0.0	No Limit
		EG020A-T: Selenium	7782-49-2	0.010	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-T: Boron	7440-42-8	0.05	mg/L	3.05	3.12	2.4	0% - 20%
		EG020A-T: Iron	7439-89-6	0.05	mg/L	0.85	0.85	0.0	0% - 50%
EG020T: Total Metals by ICP-MS (QC Lot: 812570)									
EB0815577-001	3.2-05 W9	EG020B-T: Bismuth	7440-69-9	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020B-T: Cerium	7440-45-1	0.001	mg/L	9.77	9.68	0.8	0% - 20%
		EG020B-T: Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020B-T: Strontium	7440-24-6	0.001	mg/L	1.17	1.16	1.2	0% - 20%
		EG020B-T: Thorium	7440-29-1	0.001	mg/L	0.024	0.025	0.0	0% - 20%
		EG020B-T: Uranium	7440-61-1	0.001	mg/L	0.324	0.318	1.6	0% - 20%
		EG020B-T: Titanium	7440-32-6	0.01	mg/L	<0.01	<0.01	0.0	No Limit
EB0815578-004	Anonymous	EG020B-T: Bismuth	7440-69-9	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020B-T: Cerium	7440-45-1	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020B-T: Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020B-T: Strontium	7440-24-6	0.001	mg/L	8.43	8.86	5.0	0% - 20%
		EG020B-T: Thorium	7440-29-1	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020B-T: Uranium	7440-61-1	0.001	mg/L	4.84	5.08	4.9	0% - 20%
		EG020B-T: Titanium	7440-32-6	0.01	mg/L	<0.01	<0.01	0.0	No Limit
EG020T: Total Metals by ICP-MS (QC Lot: 812571)									
EB0815577-001	3.2-05 W9	EG020D-T: Yttrium	7440-65-5	0.001	mg/L	0.536	0.535	0.0	0% - 20%
EB0815578-004	Anonymous	EG020D-T: Yttrium	7440-65-5	0.001	mg/L	<0.001	<0.001	0.0	No Limit
EG020T: Total Metals by ICP-MS (QC Lot: 812572)									
EB0815577-001	3.2-05 W9	EG020E-T: Gold	7440-57-5	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020E-T: Tungsten	7440-33-7	0.001	mg/L	<0.001	<0.001	0.0	No Limit
EB0815578-004	Anonymous	EG020E-T: Gold	7440-57-5	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020E-T: Tungsten	7440-33-7	0.001	mg/L	0.006	0.006	0.0	No Limit
EG020T: Total Metals by ICP-MS (QC Lot: 812573)									
EB0815578-004	Anonymous	EG020G-T: Rhenium	7440-15-5	0.001	mg/L	<0.001	<0.001	0.0	No Limit

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Laboratory Duplicate (DUP) Report					
				LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EG035T: Total Recoverable Mercury by FIMS (QC Lot: 812173)									
EB0815369-010	Anonymous	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EB0815577-001	3.2-05 W9	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EG035T: Total Recoverable Mercury by FIMS (QC Lot: 813449)									
EB0815489-003	Anonymous	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EB0815524-019	Anonymous	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EP006 Total Inorganic Carbon (QC Lot: 813210)									
EB0815577-001	3.2-05 W9	EP006: Total Inorganic Carbon	----	1	mg/L	<1	<1	0.0	No Limit
EB0815578-010	Anonymous	EP006: Total Inorganic Carbon	----	1	mg/L	12	12	0.0	0% - 50%

Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **WATER**

				Method Blank (MB) Report	*Laboratory Control Spike (LCS) Report*			
					Spike	*Spike Recovery (%)*	*Recovery Limits (%)*	
Method: Compound	*CAS Number*	*LOR*	*Unit*	*Result*	*Concentration*	*LCS*	*Low*	*High*
ED037P: Alkalinity by PC Titrator (QCLot: 813200)								
ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	----	500 mg/L	103	77.5	112
ED037P: Alkalinity by PC Titrator (QCLot: 814721)								
ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	----	200 mg/L	101	77.5	112
ED038A: Acidity (QCLot: 813206)								
ED038: Acidity as CaCO3	----	1	mg/L	----	100 mg/L	95.0	90.5	110
ED038A: Acidity (QCLot: 814752)								
ED038: Acidity as CaCO3	----	1	mg/L	----	100 mg/L	95.0	90.5	110
ED040F: Dissolved Major Anions (QCLot: 814085)								
ED040F: Sulfate as SO4 2-	14808-79-8	1	mg/L	<1	----	----	----	----
ED040F: Silicon	7440-21-3	0.05	mg/L	<0.05	----	----	----	----
ED045P: Chloride by PC Titrator (QCLot: 813201)								
ED045-P: Chloride	16887-00-6	1	mg/L	<1	1000 mg/L	94.1	88.4	110
ED045P: Chloride by PC Titrator (QCLot: 814723)								
ED045-P: Chloride	16887-00-6	1	mg/L	<1	1000 mg/L	97.3	88.4	110
ED093F: Dissolved Major Cations (QCLot: 814084)								
ED093F: Calcium	7440-70-2	1	mg/L	<1	----	----	----	----
ED093F: Magnesium	7439-95-4	1	mg/L	<1	----	----	----	----
ED093F: Sodium	7440-23-5	1	mg/L	<1	----	----	----	----
ED093F: Potassium	7440-09-7	1	mg/L	<1	----	----	----	----
ED093F: Dissolved Major Cations (QCLot: 814086)								
ED093F: Calcium	7440-70-2	1	mg/L	<1	----	----	----	----
ED093F: Magnesium	7439-95-4	1	mg/L	<1	----	----	----	----
ED093F: Sodium	7440-23-5	1	mg/L	<1	----	----	----	----
ED093F: Potassium	7440-09-7	1	mg/L	<1	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 812569)								
EG020A-T: Aluminium	7429-90-5	0.01	mg/L	<0.01	0.500 mg/L	99.5	74	130
EG020A-T: Antimony	7440-36-0	0.001	mg/L	<0.001	0.100 mg/L	95.9	84.6	112
EG020A-T: Arsenic	7440-38-2	0.001	mg/L	<0.001	0.100 mg/L	99.9	75.7	110
EG020A-T: Beryllium	7440-41-7	0.001	mg/L	<0.001	0.100 mg/L	106	76.7	130
EG020A-T: Barium	7440-39-3	0.001	mg/L	<0.001	----	----	----	----
EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.100 mg/L	94.5	81.8	111
EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.001	0.100 mg/L	105	80.9	125
EG020A-T: Cobalt	7440-48-4	0.001	mg/L	<0.001	0.100 mg/L	99.5	81.3	117

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
				Result	Concentration	LCS	Low	High
EG020T: Total Metals by ICP-MS (QCLot: 812569) - continued								
EG020A-T: Copper	7440-50-8	0.001	mg/L	<0.001	0.200 mg/L	99.6	80.9	115
EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.001	0.100 mg/L	97.2	84.4	113
EG020A-T: Lithium	7439-93-2	0.001	mg/L	<0.001	----	----	----	----
EG020A-T: Manganese	7439-96-5	0.001	mg/L	<0.001	0.100 mg/L	97.2	76.8	123
EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	<0.001	0.100 mg/L	93.9	85.2	111
EG020A-T: Nickel	7440-02-0	0.001	mg/L	<0.001	0.100 mg/L	101	81.5	117
EG020A-T: Selenium	7782-49-2	0.01	mg/L	----	0.100 mg/L	90.4	78.9	113
		0.010	mg/L	<0.010	----	----	----	----
EG020A-T: Thallium	7440-28-0	0.001	mg/L	<0.001	0.100 mg/L	95.2	84.5	117
EG020A-T: Tin	7440-31-5	0.001	mg/L	<0.001	0.100 mg/L	96.2	70	130
EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.01	0.100 mg/L	98.8	70.5	119
EG020A-T: Zinc	7440-66-6	0.005	mg/L	<0.005	0.200 mg/L	89.5	81	127
EG020A-T: Boron	7440-42-8	0.05	mg/L	<0.05	0.500 mg/L	95.8	70	130
EG020A-T: Iron	7439-89-6	0.05	mg/L	<0.05	0.500 mg/L	112	70	130
EG020T: Total Metals by ICP-MS (QCLot: 812570)								
EG020B-T: Bismuth	7440-69-9	0.001	mg/L	<0.001	0.100 mg/L	99.4	80.4	118
EG020B-T: Cerium	7440-45-1	0.001	mg/L	<0.001	----	----	----	----
EG020B-T: Silver	7440-22-4	0.001	mg/L	<0.001	0.100 mg/L	77.1	70	120
EG020B-T: Strontium	7440-24-6	0.001	mg/L	<0.001	0.500 mg/L	98.0	81.2	115
EG020B-T: Thorium	7440-29-1	0.001	mg/L	<0.001	----	----	----	----
EG020B-T: Titanium	7440-32-6	0.01	mg/L	<0.01	0.100 mg/L	99.2	77.9	118
EG020B-T: Uranium	7440-61-1	0.001	mg/L	<0.001	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 812571)								
EG020D-T: Yttrium	7440-65-5	0.001	mg/L	<0.001	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 812572)								
EG020E-T: Gold	7440-57-5	0.001	mg/L	<0.001	----	----	----	----
EG020E-T: Tungsten	7440-33-7	0.001	mg/L	<0.001	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 812573)								
EG020G-T: Rhenium	7440-15-5	0.001	mg/L	<0.001	----	----	----	----
EG035T: Total Recoverable Mercury by FIMS (QCLot: 812173)								
EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.0100 mg/L	93.5	84.2	118
EG035T: Total Recoverable Mercury by FIMS (QCLot: 813449)								
EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.0100 mg/L	91.0	84.2	118

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **WATER**

				Matrix Spike (MS) Report			
				Spike	*Spike Recovery (%)*	*Recovery Limits (%)*	
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*Concentration*	*MS*	*Low*	*High*
ED045P: Chloride by PC Titrator (QCLot: 813201)							
EB0815577-003	4.1-04 W9	ED045-P: Chloride	16887-00-6	80 mg/L	92.5	70	130
ED045P: Chloride by PC Titrator (QCLot: 814723)							
EB0815400-002	Anonymous	ED045-P: Chloride	16887-00-6	20 mg/L	105	70	130
EG020T: Total Metals by ICP-MS (QCLot: 812569)							
EB0815577-002	3.2-05 W12	EG020A-T: Arsenic	7440-38-2	1.000 mg/L	103	70	130
		EG020A-T: Beryllium	7440-41-7	0.100 mg/L	121	70	130
		EG020A-T: Barium	7440-39-3	1.000 mg/L	105	70	130
		EG020A-T: Cadmium	7440-43-9	0.500 mg/L	99.4	70	130
		EG020A-T: Chromium	7440-47-3	1.000 mg/L	109	70	130
		EG020A-T: Cobalt	7440-48-4	1.000 mg/L	110	70	130
		EG020A-T: Copper	7440-50-8	1.000 mg/L	# Not Determined	70	130
		EG020A-T: Lead	7439-92-1	1.000 mg/L	102	70	130
		EG020A-T: Manganese	7439-96-5	1.000 mg/L	104	70	130
		EG020A-T: Nickel	7440-02-0	1.000 mg/L	102	70	130
		EG020A-T: Vanadium	7440-62-2	1.000 mg/L	115	70	130
		EG020A-T: Zinc	7440-66-6	1.000 mg/L	91.0	70	130
EG035T: Total Recoverable Mercury by FIMS (QCLot: 812173)							
EB0815369-010	Anonymous	EG035T: Mercury	7439-97-6	0.0100 mg/L	81.3	70	130
EG035T: Total Recoverable Mercury by FIMS (QCLot: 813449)							
EB0815489-003	Anonymous	EG035T: Mercury	7439-97-6	0.0100 mg/L	86.7	70	130

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES

Environmental Division

QUALITY CONTROL REPORT

Work Order	: **EB0815578**	Page	: 1 of 8
Client	: **C S I R O AUSTRALIA**	Laboratory	: Environmental Division Brisbane
Contact	: DR STUART SIMPSON	Contact	: Tim Kilmister
Address	: CENTRE FOR ENVIRONMENTAL CONTAMINANTS RESEARCH CSIRO ENERGY TECHNOLOGY NEW ILLAWARRA ROAD LUCAS HEIGHTS NSW, AUSTRALIA 2234	Address	: 32 Shand Street Stafford QLD Australia 4053
E-mail	: stuart.simpson@csiro.au	E-mail	: Services.Brisbane@alsenviro.com
Telephone	: +61 02 97106807	Telephone	: +61-7-3243 7222
Facsimile	: +61 02 97106837	Facsimile	: +61-7-3243 7218
Project	: ----	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Site	: ----		
C-O-C number	: ----	Date Samples Received	: 11-NOV-2008
Sampler	: ----	Issue Date	: 19-NOV-2008
Order number	: ----		
		No. of samples received	: 12
Quote number	: BN/328/08	No. of samples analysed	: 12

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 Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

NATA Accredited Laboratory 825

This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

Signatories

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

Signatories	*Position*	*Accreditation Category*
Kim McCabe	Senior Inorganic Chemist	Inorganics
Stephen Hislop	Senior Inorganic Chemist	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 insuffient 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.

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = Chemistry Abstract Services number
LOR = Limit of reporting
RPD = Relative Percentage Difference
# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR:- No Limit; Result between 10 and 20 times LOR:- 0% - 50%; Result > 20 times LOR:- 0% - 20%.

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
ED037P: Alkalinity by PC Titrator (QC Lot: 813200)									
EB0815577-001	Anonymous	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	<1	<1	0.0	No Limit
ED040F: Dissolved Major Anions (QC Lot: 814085)									
EB0815577-001	Anonymous	ED040F: Sulfate as SO4 2-	14808-79-8	1	mg/L	1680	1670	0.4	0% - 20%
EB0815578-010	N2T W5D/2	ED040F: Sulfate as SO4 2-	14808-79-8	1	mg/L	1280	1330	3.3	0% - 20%
ED045P: Chloride by PC Titrator (QC Lot: 813201)									
EB0815577-001	Anonymous	ED045-P: Chloride	16887-00-6	1	mg/L	<1	<1	0.0	No Limit
ED093F: Dissolved Major Cations (QC Lot: 814086)									
EB0815577-001	Anonymous	ED093F: Calcium	7440-70-2	1	mg/L	644	638	0.8	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	<1	<1	0.0	No Limit
		ED093F: Sodium	7440-23-5	1	mg/L	2	2	0.0	No Limit
		ED093F: Potassium	7440-09-7	1	mg/L	8	8	0.0	No Limit
EB0815578-010	N2T W5D/2	ED093F: Calcium	7440-70-2	1	mg/L	441	452	2.3	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	83	84	1.5	0% - 20%
		ED093F: Sodium	7440-23-5	1	mg/L	58	61	4.2	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	30	31	0.0	0% - 20%
EG020T: Total Metals by ICP-MS (QC Lot: 812569)									
EB0815577-001	Anonymous	EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	0.0019	0.0018	5.3	0% - 50%
		EG020A-T: Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Arsenic	7440-38-2	0.001	mg/L	0.033	0.032	0.0	0% - 20%
		EG020A-T: Beryllium	7440-41-7	0.001	mg/L	<0.001	0.001	0.0	No Limit
		EG020A-T: Barium	7440-39-3	0.001	mg/L	0.031	0.030	0.0	0% - 20%
		EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Cobalt	7440-48-4	0.001	mg/L	0.743	0.748	0.8	0% - 20%
		EG020A-T: Copper	7440-50-8	0.001	mg/L	25.4	26.5	4.2	0% - 20%
		EG020A-T: Lead	7439-92-1	0.001	mg/L	0.007	0.006	0.0	No Limit
		EG020A-T: Lithium	7439-93-2	0.001	mg/L	0.009	0.010	0.0	0% - 50%
		EG020A-T: Manganese	7439-96-5	0.001	mg/L	0.136	0.137	0.0	0% - 20%
		EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Nickel	7440-02-0	0.001	mg/L	0.048	0.048	0.0	0% - 20%
		EG020A-T: Thallium	7440-28-0	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Tin	7440-31-5	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Zinc	7440-66-6	0.005	mg/L	0.062	0.062	0.0	0% - 50%

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EG020T: Total Metals by ICP-MS (QC Lot: 812569) - continued									
EB0815577-001	Anonymous	EG020A-T: Aluminium	7429-90-5	0.01	mg/L	4.29	4.29	0.0	0% - 20%
		EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	0.0	No Limit
		EG020A-T: Selenium	7782-49-2	0.010	mg/L	0.018	0.018	0.0	No Limit
		EG020A-T: Boron	7440-42-8	0.05	mg/L	0.10	0.11	0.0	No Limit
EB0815578-004	N2T W5	EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
		EG020A-T: Antimony	7440-36-0	0.001	mg/L	0.002	0.002	0.0	No Limit
		EG020A-T: Arsenic	7440-38-2	0.001	mg/L	0.005	0.004	0.0	No Limit
		EG020A-T: Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Barium	7440-39-3	0.001	mg/L	0.037	0.038	0.0	0% - 20%
		EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.001	0.002	75.5	No Limit
		EG020A-T: Cobalt	7440-48-4	0.001	mg/L	0.322	0.330	2.5	0% - 20%
		EG020A-T: Copper	7440-50-8	0.001	mg/L	0.221	0.228	3.4	0% - 20%
		EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Lithium	7439-93-2	0.001	mg/L	0.500	0.544	8.5	0% - 20%
		EG020A-T: Manganese	7439-96-5	0.001	mg/L	6.55	6.89	5.1	0% - 20%
		EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	0.618	0.650	5.1	0% - 20%
		EG020A-T: Nickel	7440-02-0	0.001	mg/L	0.006	0.006	0.0	No Limit
		EG020A-T: Thallium	7440-28-0	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Tin	7440-31-5	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Zinc	7440-66-6	0.005	mg/L	0.028	0.027	0.0	No Limit
		EG020A-T: Aluminium	7429-90-5	0.01	mg/L	0.05	0.05	0.0	No Limit
		EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	0.0	No Limit
		EG020A-T: Selenium	7782-49-2	0.010	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-T: Boron	7440-42-8	0.05	mg/L	3.05	3.12	2.4	0% - 20%
EG020T: Total Metals by ICP-MS (QC Lot: 812570)									
EB0815577-001	Anonymous	EG020B-T: Bismuth	7440-69-9	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020B-T: Cerium	7440-45-1	0.001	mg/L	9.77	9.68	0.8	0% - 20%
		EG020B-T: Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020B-T: Strontium	7440-24-6	0.001	mg/L	1.17	1.16	1.2	0% - 20%
		EG020B-T: Thorium	7440-29-1	0.001	mg/L	0.024	0.025	0.0	0% - 20%
		EG020B-T: Uranium	7440-61-1	0.001	mg/L	0.324	0.318	1.6	0% - 20%
		EG020B-T: Titanium	7440-32-6	0.01	mg/L	<0.01	<0.01	0.0	No Limit
EB0815578-004	N2T W5	EG020B-T: Bismuth	7440-69-9	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020B-T: Cerium	7440-45-1	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020B-T: Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020B-T: Strontium	7440-24-6	0.001	mg/L	8.43	8.86	5.0	0% - 20%
		EG020B-T: Thorium	7440-29-1	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020B-T: Uranium	7440-61-1	0.001	mg/L	4.84	5.08	4.9	0% - 20%
		EG020B-T: Titanium	7440-32-6	0.01	mg/L	<0.01	<0.01	0.0	No Limit

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Laboratory Duplicate (DUP) Report					
				LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EG020T: Total Metals by ICP-MS (QC Lot: 812571)									
EB0815577-001	Anonymous	EG020D-T: Yttrium	7440-65-5	0.001	mg/L	0.536	0.535	0.0	0% - 20%
EB0815578-004	N2T W5	EG020D-T: Yttrium	7440-65-5	0.001	mg/L	<0.001	<0.001	0.0	No Limit
EG020T: Total Metals by ICP-MS (QC Lot: 812572)									
EB0815577-001	Anonymous	EG020E-T: Tungsten	7440-33-7	0.001	mg/L	<0.001	<0.001	0.0	No Limit
EB0815578-004	N2T W5	EG020E-T: Tungsten	7440-33-7	0.001	mg/L	0.006	0.006	0.0	No Limit
EG020T: Total Metals by ICP-MS (QC Lot: 812573)									
EB0815578-004	N2T W5	EG020G-T: Rhenium	7440-15-5	0.001	mg/L	<0.001	<0.001	0.0	No Limit
EG020T: Total Metals by ICP-MS (QC Lot: 813096)									
EB0815523-007	Anonymous	EG020A-T: Iron	7439-89-6	0.05	mg/L	0.08	0.08	0.0	No Limit
EB0815585-001	Anonymous	EG020A-T: Iron	7439-89-6	0.05	mg/L	0.25	0.26	0.0	No Limit
EG035T: Total Recoverable Mercury by FIMS (QC Lot: 812173)									
EB0815369-010	Anonymous	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EB0815577-001	Anonymous	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EG035T: Total Recoverable Mercury by FIMS (QC Lot: 813450)									
EB0815578-003	OX-T W8	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EB0815590-009	Anonymous	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EP006 Total Inorganic Carbon (QC Lot: 813210)									
EB0815577-001	Anonymous	EP006: Total Inorganic Carbon	----	1	mg/L	<1	<1	0.0	No Limit
EB0815578-010	N2T W5D/2	EP006: Total Inorganic Carbon	----	1	mg/L	12	12	0.0	0% - 50%

Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **WATER**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	*CAS Number*	*LOR*	*Unit*	*Result*	*Concentration*	*LCS*	*Low*	*High*
ED037P: Alkalinity by PC Titrator (QCLot: 813200)								
ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	----	500 mg/L	103	77.5	112
ED038A: Acidity (QCLot: 813206)								
ED038: Acidity as CaCO3	----	1	mg/L	----	100 mg/L	95.0	90.5	110
ED040F: Dissolved Major Anions (QCLot: 814085)								
ED040F: Sulfate as SO4 2-	14808-79-8	1	mg/L	<1	----	----	----	----
ED045P: Chloride by PC Titrator (QCLot: 813201)								
ED045-P: Chloride	16887-00-6	1	mg/L	<1	1000 mg/L	94.1	88.4	110
ED093F: Dissolved Major Cations (QCLot: 814086)								
ED093F: Calcium	7440-70-2	1	mg/L	<1	----	----	----	----
ED093F: Magnesium	7439-95-4	1	mg/L	<1	----	----	----	----
ED093F: Sodium	7440-23-5	1	mg/L	<1	----	----	----	----
ED093F: Potassium	7440-09-7	1	mg/L	<1	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 812569)								
EG020A-T: Aluminium	7429-90-5	0.01	mg/L	<0.01	0.500 mg/L	99.5	74	130
EG020A-T: Antimony	7440-36-0	0.001	mg/L	<0.001	0.100 mg/L	95.9	84.6	112
EG020A-T: Arsenic	7440-38-2	0.001	mg/L	<0.001	0.100 mg/L	99.9	75.7	110
EG020A-T: Beryllium	7440-41-7	0.001	mg/L	<0.001	0.100 mg/L	106	76.7	130
EG020A-T: Barium	7440-39-3	0.001	mg/L	<0.001	----	----	----	----
EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.100 mg/L	94.5	81.8	111
EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.001	0.100 mg/L	105	80.9	125
EG020A-T: Cobalt	7440-48-4	0.001	mg/L	<0.001	0.100 mg/L	99.5	81.3	117
EG020A-T: Copper	7440-50-8	0.001	mg/L	<0.001	0.200 mg/L	99.6	80.9	115
EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.001	0.100 mg/L	97.2	84.4	113
EG020A-T: Lithium	7439-93-2	0.001	mg/L	<0.001	----	----	----	----
EG020A-T: Manganese	7439-96-5	0.001	mg/L	<0.001	0.100 mg/L	97.2	76.8	123
EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	<0.001	0.100 mg/L	93.9	85.2	111
EG020A-T: Nickel	7440-02-0	0.001	mg/L	<0.001	0.100 mg/L	101	81.5	117
EG020A-T: Selenium	7782-49-2	0.01	mg/L	----	0.100 mg/L	90.4	78.9	113
		0.010	mg/L	<0.010	----	----	----	----
EG020A-T: Thallium	7440-28-0	0.001	mg/L	<0.001	0.100 mg/L	95.2	84.5	117
EG020A-T: Tin	7440-31-5	0.001	mg/L	<0.001	0.100 mg/L	96.2	70	130
EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.01	0.100 mg/L	98.8	70.5	119
EG020A-T: Zinc	7440-66-6	0.005	mg/L	<0.005	0.200 mg/L	89.5	81	127
EG020A-T: Boron	7440-42-8	0.05	mg/L	<0.05	0.500 mg/L	95.8	70	130

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report Result	Laboratory Control Spike (LCS) Report Spike Concentration	Spike Recovery (%) LCS	Recovery Limits (%) Low	High
EG020T: Total Metals by ICP-MS (QCLot: 812570)								
EG020B-T: Bismuth	7440-69-9	0.001	mg/L	<0.001	0.100 mg/L	99.4	80.4	118
EG020B-T: Cerium	7440-45-1	0.001	mg/L	<0.001	----	----	----	----
EG020B-T: Silver	7440-22-4	0.001	mg/L	<0.001	0.100 mg/L	77.1	70	120
EG020B-T: Strontium	7440-24-6	0.001	mg/L	<0.001	0.500 mg/L	98.0	81.2	115
EG020B-T: Thorium	7440-29-1	0.001	mg/L	<0.001	----	----	----	----
EG020B-T: Titanium	7440-32-6	0.01	mg/L	<0.01	0.100 mg/L	99.2	77.9	118
EG020B-T: Uranium	7440-61-1	0.001	mg/L	<0.001	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 812571)								
EG020D-T: Yttrium	7440-65-5	0.001	mg/L	<0.001	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 812572)								
EG020E-T: Tungsten	7440-33-7	0.001	mg/L	<0.001	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 812573)								
EG020G-T: Rhenium	7440-15-5	0.001	mg/L	<0.001	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 813096)								
EG020A-T: Iron	7439-89-6	0.05	mg/L	<0.05	0.500 mg/L	107	70	130
EG035T: Total Recoverable Mercury by FIMS (QCLot: 812173)								
EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.0100 mg/L	93.5	84.2	118
EG035T: Total Recoverable Mercury by FIMS (QCLot: 813450)								
EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.0100 mg/L	87.9	84.2	118

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **WATER**

				Matrix Spike (MS) Report			
				Spike	*Spike Recovery (%)*	*Recovery Limits (%)*	
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*Concentration*	*MS*	*Low*	*High*
ED045P: Chloride by PC Titrator (QCLot: 813201)							
EB0815577-003	Anonymous	ED045-P: Chloride	16887-00-6	80 mg/L	92.5	70	130
EG020T: Total Metals by ICP-MS (QCLot: 812569)							
EB0815577-002	Anonymous	EG020A-T: Arsenic	7440-38-2	1.000 mg/L	103	70	130
		EG020A-T: Beryllium	7440-41-7	0.100 mg/L	121	70	130
		EG020A-T: Barium	7440-39-3	1.000 mg/L	105	70	130
		EG020A-T: Cadmium	7440-43-9	0.500 mg/L	99.4	70	130
		EG020A-T: Chromium	7440-47-3	1.000 mg/L	109	70	130
		EG020A-T: Cobalt	7440-48-4	1.000 mg/L	110	70	130
		EG020A-T: Copper	7440-50-8	1.000 mg/L	# Not Determined	70	130
		EG020A-T: Lead	7439-92-1	1.000 mg/L	102	70	130
		EG020A-T: Manganese	7439-96-5	1.000 mg/L	104	70	130
		EG020A-T: Nickel	7440-02-0	1.000 mg/L	102	70	130
		EG020A-T: Vanadium	7440-62-2	1.000 mg/L	115	70	130
		EG020A-T: Zinc	7440-66-6	1.000 mg/L	91.0	70	130
EG035T: Total Recoverable Mercury by FIMS (QCLot: 812173)							
EB0815369-010	Anonymous	EG035T: Mercury	7439-97-6	0.0100 mg/L	81.3	70	130
EG035T: Total Recoverable Mercury by FIMS (QCLot: 813450)							
EB0815578-003	OX-T W8	EG035T: Mercury	7439-97-6	0.0100 mg/L	83.2	70	130

QUALITY CONTROL REPORT

Work Order	: **EM0810682**	Page	: 1 of 13
Client	: **C S I R O AUSTRALIA**	Laboratory	: Environmental Division Melbourne
Contact	: DR STUART SIMPSON	Contact	: Steven McGrath
Address	: CENTRE FOR ENVIRONMENTAL CONTAMINANTS RESEARCH CSIRO ENERGY TECHNOLOGY NEW ILLAWARRA ROAD LUCAS HEIGHTS NSW, AUSTRALIA 2234	Address	: 4 Westall Rd Springvale VIC Australia 3171
E-mail	: stuart.simpson@csiro.au	E-mail	: steven.mcgrath@alsenviro.com
Telephone	: +61 02 97106807	Telephone	: +61-3-8549 9600
Facsimile	: +61 02 97106837	Facsimile	: +61-3-8549 9601
Project	: ----	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Site	: ----		
C-O-C number	: ----	Date Samples Received	: 11-DEC-2008
Sampler	: STUART SIMPSON	Issue Date	: 31-DEC-2008
Order number	: ----		
		No. of samples received	: 49
Quote number	: BN/328/08	No. of samples analysed	: 49

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 Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

NATA
WORLD RECOGNISED
ACCREDITATION

NATA Accredited Laboratory 825

This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

Signatories

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

Signatories	*Position*	*Accreditation Category*
Herman Lin	Senior Inorganic Chemist	Inorganics
Kim McCabe	Senior Inorganic Chemist	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 insuffient 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.

Key :
Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = Chemistry Abstract Services number
LOR = Limit of reporting
RPD = Relative Percentage Difference
# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR:- No Limit; Result between 10 and 20 times LOR:- 0% - 50%; Result > 20 times LOR:- 0% - 20%.

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
ED037P: Alkalinity by PC Titrator (QC Lot: 845738)									
EM0810622-001	Anonymous	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	1110	1110	0.3	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	1110	1110	0.3	0% - 20%
EM0810682-025	3.2_12 R2 W1LD/2	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	<1	<1	0.0	No Limit
ED037P: Alkalinity by PC Titrator (QC Lot: 845740)									
EM0810682-048	4.1-04 W15	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	30	32	4.1	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	30	32	4.1	0% - 20%
ED038A: Acidity (QC Lot: 844154)									
EM0810682-007	CORE 1A_N2LW1	ED038: Acidity as CaCO3	----	1	mg/L	14500	14700	1.4	0% - 20%
EM0810682-026	3.2_12 R2 0W1LD/2	ED038: Acidity as CaCO3	----	1	mg/L	12800	12000	6.4	0% - 20%
ED038A: Acidity (QC Lot: 844155)									
EM0810682-049	3.2-01 W15	ED038: Acidity as CaCO3	----	1	mg/L	6	6	0.0	No Limit
ED040F: Dissolved Major Anions (QC Lot: 843700)									
EM0810550-010	Anonymous	ED040F: Silicon	7440-21-3	0.05	mg/L	5.27	5.92	11.5	0% - 20%
ED040F: Dissolved Major Anions (QC Lot: 843702)									
EM0810682-014	3.1_09 R2 W1 LD/10	ED040F: Silicon	7440-21-3	0.05	mg/L	2.88	2.53	12.8	0% - 20%
		ED040F: Sulfate as SO4 2-	14808-79-8	1	mg/L	2130	1760	19.3	0% - 20%
EM0810682-019	CORE 4A_N2LW1D/10	ED040F: Silicon	7440-21-3	0.05	mg/L	3.68	3.69	0.0	0% - 20%
		ED040F: Sulfate as SO4 2-	14808-79-8	1	mg/L	2880	2840	1.6	0% - 20%
ED040F: Dissolved Major Anions (QC Lot: 846011)									
EM0810649-001	Anonymous	ED040F: Silicon	7440-21-3	0.05	mg/L	20.1	20.0	0.2	0% - 20%
		ED040F: Sulfate as SO4 2-	14808-79-8	1	mg/L	3	3	0.0	No Limit
EM0810682-040	CORE 4B_DOLCO2W1D/10	ED040F: Silicon	7440-21-3	0.05	mg/L	1.16	1.26	8.1	0% - 20%
		ED040F: Sulfate as SO4 2-	14808-79-8	1	mg/L	418	412	1.4	0% - 20%
ED045P: Chloride by PC Titrator (QC Lot: 845739)									
EM0810622-001	Anonymous	ED045-P: Chloride	16887-00-6	1	mg/L	3800	4020	5.7	0% - 20%
EM0810682-019	CORE 4A_N2LW1D/10	ED045-P: Chloride	16887-00-6	1	mg/L	248	255	2.7	0% - 20%
ED045P: Chloride by PC Titrator (QC Lot: 845741)									

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
ED045P: Chloride by PC Titrator (QC Lot: 845741) - continued									
EM0810682-048	4.1-04 W15	ED045-P: Chloride	16887-00-6	1	mg/L	<5	<5	0.0	No Limit
ED093F: Dissolved Major Cations (QC Lot: 843701)									
EM0810550-001	Anonymous	ED093F: Calcium	7440-70-2	1	mg/L	5	6	19.5	No Limit
		ED093F: Magnesium	7439-95-4	1	mg/L	6	7	18.0	No Limit
		ED093F: Sodium	7440-23-5	1	mg/L	10	12	17.0	0% - 50%
		ED093F: Potassium	7440-09-7	1	mg/L	2	3	0.0	No Limit
EM0810550-010	Anonymous	ED093F: Calcium	7440-70-2	1	mg/L	2	3	0.0	No Limit
		ED093F: Magnesium	7439-95-4	1	mg/L	2	2	0.0	No Limit
		ED093F: Sodium	7440-23-5	1	mg/L	10	11	10.4	0% - 50%
		ED093F: Potassium	7440-09-7	1	mg/L	2	2	0.0	No Limit
ED093F: Dissolved Major Cations (QC Lot: 843703)									
EM0810682-014	3.1_09 R2 W1 LD/10	ED093F: Calcium	7440-70-2	1	mg/L	47	41	13.6	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	73	63	14.7	0% - 20%
		ED093F: Sodium	7440-23-5	1	mg/L	194	176	9.5	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	56	52	6.8	0% - 20%
ED093F: Dissolved Major Cations (QC Lot: 846012)									
EM0810649-001	Anonymous	ED093F: Calcium	7440-70-2	1	mg/L	30	29	0.0	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	25	25	0.0	0% - 20%
		ED093F: Sodium	7440-23-5	1	mg/L	83	83	0.0	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	6	6	0.0	No Limit
EM0810682-040	CORE 4B_DOLCO2W1D/10	ED093F: Calcium	7440-70-2	1	mg/L	58	58	0.0	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	26	26	0.0	0% - 20%
		ED093F: Sodium	7440-23-5	1	mg/L	162	161	0.0	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	20	20	0.0	0% - 20%
ED093T: Total Major Cations (QC Lot: 846136)									
EM0810682-035	N2T-W2_D10	ED093T: Calcium	7440-70-2	1	mg/L	56	60	6.8	0% - 20%
		ED093T: Magnesium	7439-95-4	1	mg/L	208	214	2.9	0% - 20%
		ED093T: Sodium	7440-23-5	1	mg/L	1180	1210	2.4	0% - 20%
		ED093T: Potassium	7440-09-7	1	mg/L	34	36	5.6	0% - 20%
EG005T: Total Metals by ICP-AES (QC Lot: 845116)									
EM0810682-011	3.1_04 R1 W1 LD/10	EG005T: Iron	7439-89-6	0.01	mg/L	625	669	6.8	0% - 20%
EM0810682-020	CORE4B_CO2LW1D/10	EG005T: Iron	7439-89-6	0.01	mg/L	992	1050	5.7	0% - 20%
EG020T: Total Metals by ICP-MS (QC Lot: 846131)									
EM0810682-001	3.1_04 R1 W1L	EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	0.0033	0.0032	0.0	0% - 20%
		EG020A-T: Antimony	7440-36-0	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-T: Arsenic	7440-38-2	0.001	mg/L	<0.010	0.010	0.0	0% - 50%
		EG020A-T: Beryllium	7440-41-7	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-T: Barium	7440-39-3	0.001	mg/L	0.042	0.046	9.7	0% - 20%
		EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.010	<0.010	0.0	No Limit

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	***Client sample ID***	***Method: Compound***	***CAS Number***	***LOR***	***Unit***	***Original Result***	***Duplicate Result***	***RPD (%)***	***Recovery Limits (%)***
EG020T: Total Metals by ICP-MS (QC Lot: 846131) - continued									
EM0810682-001	3.1_04 R1 W1L	EG020A-T: Cobalt	7440-48-4	0.001	mg/L	35.0	39.3	11.8	0% - 20%
		EG020A-T: Copper	7440-50-8	0.001	mg/L	0.375	0.426	12.7	0% - 20%
		EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-T: Lithium	7439-93-2	0.001	mg/L	2.52	2.86	12.7	0% - 20%
		EG020A-T: Manganese	7439-96-5	0.001	mg/L	115	130	12.4	0% - 20%
		EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-T: Nickel	7440-02-0	0.001	mg/L	2.77	3.08	10.5	0% - 20%
		EG020A-T: Thallium	7440-28-0	0.001	mg/L	0.011	0.011	0.0	0% - 50%
		EG020A-T: Tin	7440-31-5	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-T: Zinc	7440-66-6	0.005	mg/L	5.57	6.11	9.3	0% - 20%
		EG020A-T: Aluminium	7429-90-5	0.01	mg/L	12.2	14.0	13.7	0% - 20%
		EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.10	<0.10	0.0	No Limit
		EG020A-T: Selenium	7782-49-2	0.010	mg/L	0.084	0.093	10.5	No Limit
		EG020A-T: Boron	7440-42-8	0.05	mg/L	2.21	2.54	13.8	0% - 20%
EM0810682-010	CORE4B_CO2LW1	EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	0.0342	0.0326	4.8	0% - 20%
		EG020A-T: Antimony	7440-36-0	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-T: Arsenic	7440-38-2	0.001	mg/L	0.028	0.037	29.9	0% - 20%
		EG020A-T: Beryllium	7440-41-7	0.001	mg/L	0.338	0.321	5.1	0% - 20%
		EG020A-T: Barium	7440-39-3	0.001	mg/L	0.290	0.271	6.8	0% - 20%
		EG020A-T: Chromium	7440-47-3	0.001	mg/L	0.588	0.549	6.8	0% - 20%
		EG020A-T: Cobalt	7440-48-4	0.001	mg/L	73.6	68.2	7.6	0% - 20%
		EG020A-T: Copper	7440-50-8	0.001	mg/L	744	690	7.4	0% - 20%
		EG020A-T: Lead	7439-92-1	0.001	mg/L	0.021	0.019	7.1	0% - 50%
		EG020A-T: Lithium	7439-93-2	0.001	mg/L	6.01	5.61	6.9	0% - 20%
		EG020A-T: Manganese	7439-96-5	0.001	mg/L	201	187	6.8	0% - 20%
		EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	0.017	0.016	0.0	0% - 50%
		EG020A-T: Nickel	7440-02-0	0.001	mg/L	7.49	6.94	7.7	0% - 20%
		EG020A-T: Thallium	7440-28-0	0.001	mg/L	0.036	0.033	7.5	0% - 20%
		EG020A-T: Tin	7440-31-5	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-T: Zinc	7440-66-6	0.005	mg/L	34.1	31.8	7.0	0% - 20%
		EG020A-T: Aluminium	7429-90-5	0.01	mg/L	3680	3400	7.8	0% - 20%
		EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.10	<0.10	0.0	No Limit
		EG020A-T: Selenium	7782-49-2	0.010	mg/L	0.269	0.282	4.8	0% - 20%
		EG020A-T: Boron	7440-42-8	0.05	mg/L	3.06	2.87	6.4	0% - 20%
EG020T: Total Metals by ICP-MS (QC Lot: 846132)									
EM0810682-001	3.1_04 R1 W1L	EG020B-T: Bismuth	7440-69-9	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020B-T: Cerium	7440-45-1	0.001	mg/L	0.170	0.185	8.3	0% - 20%
		EG020B-T: Silver	7440-22-4	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020B-T: Strontium	7440-24-6	0.001	mg/L	2.49	2.73	9.2	0% - 20%

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EG020T: Total Metals by ICP-MS (QC Lot: 846132) - continued									
EM0810682-001	3.1_04 R1 W1L	EG020B-T: Thorium	7440-29-1	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020B-T: Uranium	7440-61-1	0.001	mg/L	6.61	7.14	7.7	0% - 20%
		EG020B-T: Titanium	7440-32-6	0.01	mg/L	<0.10	<0.10	0.0	No Limit
EM0810682-010	CORE4B_CO2LW1	EG020B-T: Bismuth	7440-69-9	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020B-T: Cerium	7440-45-1	0.001	mg/L	71.5	66.6	7.2	0% - 20%
		EG020B-T: Silver	7440-22-4	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020B-T: Strontium	7440-24-6	0.001	mg/L	4.18	3.86	8.2	0% - 20%
		EG020B-T: Thorium	7440-29-1	0.001	mg/L	0.032	0.030	7.8	0% - 20%
		EG020B-T: Uranium	7440-61-1	0.001	mg/L	33.0	30.8	6.7	0% - 20%
		EG020B-T: Titanium	7440-32-6	0.01	mg/L	<0.10	<0.10	0.0	No Limit
EG020T: Total Metals by ICP-MS (QC Lot: 846133)									
EM0810682-001	3.1_04 R1 W1L	EG020D-T: Yttrium	7440-65-5	0.001	mg/L	0.082	0.088	8.2	0% - 20%
EM0810682-010	CORE4B_CO2LW1	EG020D-T: Yttrium	7440-65-5	0.001	mg/L	23.3	21.6	7.6	0% - 20%
EG020T: Total Metals by ICP-MS (QC Lot: 846134)									
EM0810682-001	3.1_04 R1 W1L	EG020E-T: Tungsten	7440-33-7	0.001	mg/L	<0.010	<0.010	0.0	No Limit
EM0810682-010	CORE4B_CO2LW1	EG020E-T: Tungsten	7440-33-7	0.001	mg/L	0.020	0.018	8.1	0% - 50%
EG020T: Total Metals by ICP-MS (QC Lot: 846135)									
EM0810682-010	CORE4B_CO2LW1	EG020G-T: Rhenium	7440-15-5	0.001	mg/L	0.002	0.002	0.0	No Limit
EM0810682-035	N2T-W2_D10	EG020G-T: Rhenium	7440-15-5	0.001	mg/L	<0.001	<0.001	0.0	No Limit
EG020T: Total Metals by ICP-MS (QC Lot: 846137)									
EM0810682-035	N2T-W2_D10	EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	0.0017	0.0014	19.7	0% - 50%
		EG020A-T: Antimony	7440-36-0	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-T: Arsenic	7440-38-2	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-T: Beryllium	7440-41-7	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-T: Barium	7440-39-3	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-T: Cobalt	7440-48-4	0.001	mg/L	0.027	<0.010	92.5	No Limit
		EG020A-T: Copper	7440-50-8	0.001	mg/L	0.024	0.026	7.9	0% - 20%
		EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-T: Lithium	7439-93-2	0.001	mg/L	0.230	0.208	9.8	0% - 20%
		EG020A-T: Manganese	7439-96-5	0.001	mg/L	0.568	0.564	0.6	0% - 20%
		EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	0.344	0.322	6.8	0% - 20%
		EG020A-T: Nickel	7440-02-0	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-T: Thallium	7440-28-0	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-T: Tin	7440-31-5	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-T: Zinc	7440-66-6	0.005	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-T: Aluminium	7429-90-5	0.01	mg/L	<0.10	<0.10	0.0	No Limit
		EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.10	<0.10	0.0	No Limit
		EG020A-T: Selenium	7782-49-2	0.010	mg/L	<0.050	<0.050	0.0	No Limit

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EG020T: Total Metals by ICP-MS (QC Lot: 846137) - continued									
EM0810682-035	N2T-W2_D10	EG020A-T: Boron	7440-42-8	0.05	mg/L	2.24	2.11	5.9	0% - 20%
		EG020A-T: Iron	7439-89-6	0.05	mg/L	<0.50	<0.50	0.0	No Limit
EG020T: Total Metals by ICP-MS (QC Lot: 846138)									
EM0810682-035	N2T-W2_D10	EG020B-T: Bismuth	7440-69-9	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020B-T: Cerium	7440-45-1	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020B-T: Silver	7440-22-4	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020B-T: Strontium	7440-24-6	0.001	mg/L	1.60	1.47	8.3	0% - 20%
		EG020B-T: Thorium	7440-29-1	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020B-T: Uranium	7440-61-1	0.001	mg/L	3.18	2.91	8.9	0% - 20%
		EG020B-T: Titanium	7440-32-6	0.01	mg/L	<0.10	<0.10	0.0	No Limit
EG020T: Total Metals by ICP-MS (QC Lot: 846139)									
EM0810682-035	N2T-W2_D10	EG020D-T: Yttrium	7440-65-5	0.001	mg/L	<0.010	<0.010	0.0	No Limit
EG020T: Total Metals by ICP-MS (QC Lot: 846140)									
EM0810682-035	N2T-W2_D10	EG020E-T: Gold	7440-57-5	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020E-T: Tungsten	7440-33-7	0.001	mg/L	<0.010	<0.010	0.0	No Limit
EG035T: Total Recoverable Mercury by FIMS (QC Lot: 846164)									
EM0810682-001	3.1_04 R1 W1L	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EM0810682-027	OX-T W10	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EG035T: Total Recoverable Mercury by FIMS (QC Lot: 846165)									
EM0810682-047	3.2-05 W15	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EP006 Total Inorganic Carbon (QC Lot: 848883)									
EM0810682-007	CORE 1A_N2LW1	EP006: Total Inorganic Carbon	----	1	mg/L	<1	<1	0.0	No Limit
EM0810682-026	3.2_12 R2 0W1LD/2	EP006: Total Inorganic Carbon	----	1	mg/L	1	2	0.0	No Limit
EP006 Total Inorganic Carbon (QC Lot: 848884)									
EM0810682-049	3.2-01 W15	EP006: Total Inorganic Carbon	----	1	mg/L	26	25	4.0	0% - 20%

Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **WATER**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result	Concentration	LCS	Low	High
ED037P: Alkalinity by PC Titrator (QCLot: 845738)								
ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	----	200 mg/L	98.5	80	120
ED037P: Alkalinity by PC Titrator (QCLot: 845740)								
ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	----	200 mg/L	92.9	80	120
ED038A: Acidity (QCLot: 844154)								
ED038: Acidity as CaCO3	----	1	mg/L	----	1000 mg/L	96.2	88.3	111
ED038A: Acidity (QCLot: 844155)								
ED038: Acidity as CaCO3	----	1	mg/L	----	1000 mg/L	96.2	88.3	111
ED040F: Dissolved Major Anions (QCLot: 843700)								
ED040F: Silicon	7440-21-3	0.05	mg/L	<0.05	----	----	----	----
ED040F: Dissolved Major Anions (QCLot: 843702)								
ED040F: Sulfate as SO4 2-	14808-79-8	1	mg/L	<1	300 mg/L	95.6	86.4	118
ED040F: Silicon	7440-21-3	0.05	mg/L	<0.05	----	----	----	----
ED040F: Dissolved Major Anions (QCLot: 846011)								
ED040F: Sulfate as SO4 2-	14808-79-8	1	mg/L	<1	300 mg/L	101	86.4	118
ED040F: Silicon	7440-21-3	0.05	mg/L	<0.05	----	----	----	----
ED045P: Chloride by PC Titrator (QCLot: 845739)								
ED045-P: Chloride	16887-00-6	1	mg/L	<1	1000 mg/L	94.8	81.7	120
ED045P: Chloride by PC Titrator (QCLot: 845741)								
ED045-P: Chloride	16887-00-6	1	mg/L	<1	1000 mg/L	86.5	81.7	120
ED093F: Dissolved Major Cations (QCLot: 843701)								
ED093F: Calcium	7440-70-2	1	mg/L	<1	5 mg/L	102	91.4	121
ED093F: Magnesium	7439-95-4	1	mg/L	<1	5 mg/L	97.1	86.9	121
ED093F: Sodium	7440-23-5	1	mg/L	<1	50 mg/L	98.8	85.2	113
ED093F: Potassium	7440-09-7	1	mg/L	<1	50 mg/L	96.7	82.1	118
ED093F: Dissolved Major Cations (QCLot: 843703)								
ED093F: Calcium	7440-70-2	1	mg/L	<1	5 mg/L	104	91.4	121
ED093F: Magnesium	7439-95-4	1	mg/L	<1	5 mg/L	101	86.9	121
ED093F: Sodium	7440-23-5	1	mg/L	<1	50 mg/L	99.9	85.2	113
ED093F: Potassium	7440-09-7	1	mg/L	<1	50 mg/L	93.3	82.1	118
ED093F: Dissolved Major Cations (QCLot: 846012)								
ED093F: Calcium	7440-70-2	1	mg/L	<1	5 mg/L	110	91.4	121
ED093F: Magnesium	7439-95-4	1	mg/L	<1	5 mg/L	101	86.9	121
ED093F: Sodium	7440-23-5	1	mg/L	<1	50 mg/L	99.5	85.2	113

Sub-Matrix: **WATER**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	*CAS Number*	*LOR*	*Unit*	*Result*	*Concentration*	*LCS*	*Low*	*High*
ED093F: Dissolved Major Cations (QCLot: 846012) - continued								
ED093F: Potassium	7440-09-7	1	mg/L	<1	50 mg/L	100	82.1	118
ED093T: Total Major Cations (QCLot: 846136)								
ED093T: Calcium	7440-70-2	1	mg/L	<1	----	----	----	----
ED093T: Magnesium	7439-95-4	1	mg/L	<1	----	----	----	----
ED093T: Sodium	7440-23-5	1	mg/L	<1	----	----	----	----
ED093T: Potassium	7440-09-7	1	mg/L	<1	----	----	----	----
EG005T: Total Metals by ICP-AES (QCLot: 845116)								
EG005T: Iron	7439-89-6	0.01	mg/L	<0.01	1.00 mg/L	99.0	80	120
EG020T: Total Metals by ICP-MS (QCLot: 846131)								
EG020A-T: Aluminium	7429-90-5	0.01	mg/L	<0.01	0.500 mg/L	107	74	128
EG020A-T: Antimony	7440-36-0	0.001	mg/L	<0.001	0.100 mg/L	113	80	114
EG020A-T: Arsenic	7440-38-2	0.001	mg/L	<0.001	0.100 mg/L	# 119	74	114
EG020A-T: Beryllium	7440-41-7	0.001	mg/L	<0.001	0.100 mg/L	128	77	130
EG020A-T: Barium	7440-39-3	0.001	mg/L	<0.001	----	----	----	----
EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.100 mg/L	106	74	118
EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.001	0.100 mg/L	# 128	81	127
EG020A-T: Cobalt	7440-48-4	0.001	mg/L	<0.001	0.100 mg/L	# 123	74	122
EG020A-T: Copper	7440-50-8	0.001	mg/L	<0.001	0.200 mg/L	# 124	75	119
EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.001	0.100 mg/L	110	80	116
EG020A-T: Lithium	7439-93-2	0.001	mg/L	<0.001	----	----	----	----
EG020A-T: Manganese	7439-96-5	0.001	mg/L	<0.001	0.100 mg/L	120	72	124
EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	<0.001	0.100 mg/L	112	80	112
EG020A-T: Nickel	7440-02-0	0.001	mg/L	<0.001	0.100 mg/L	# 126	75	121
EG020A-T: Selenium	7782-49-2	0.01	mg/L	----	0.100 mg/L	114	73	119
		0.010	mg/L	<0.010	----	----	----	----
EG020A-T: Thallium	7440-28-0	0.001	mg/L	<0.001	0.100 mg/L	110	80	116
EG020A-T: Tin	7440-31-5	0.001	mg/L	<0.001	0.100 mg/L	111	70	130
EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.01	0.100 mg/L	# 121	70.5	118
EG020A-T: Zinc	7440-66-6	0.005	mg/L	<0.005	0.200 mg/L	123	73	127
EG020A-T: Boron	7440-42-8	0.05	mg/L	<0.05	0.500 mg/L	116	70	128
EG020T: Total Metals by ICP-MS (QCLot: 846132)								
EG020B-T: Bismuth	7440-69-9	0.001	mg/L	<0.001	0.100 mg/L	111	73	123
EG020B-T: Cerium	7440-45-1	0.001	mg/L	<0.001	----	----	----	----
EG020B-T: Silver	7440-22-4	0.001	mg/L	<0.001	0.100 mg/L	93.9	70	118
EG020B-T: Strontium	7440-24-6	0.001	mg/L	<0.001	0.500 mg/L	113	73	119
EG020B-T: Thorium	7440-29-1	0.001	mg/L	<0.001	----	----	----	----
EG020B-T: Titanium	7440-32-6	0.01	mg/L	<0.01	0.100 mg/L	# 123	74	120
EG020B-T: Uranium	7440-61-1	0.001	mg/L	<0.001	----	----	----	----

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
				Result	Concentration	LCS	Low	High
EG020T: Total Metals by ICP-MS (QCLot: 846133)								
EG020D-T: Yttrium	7440-65-5	0.001	mg/L	<0.001	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 846134)								
EG020E-T: Tungsten	7440-33-7	0.001	mg/L	<0.001	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 846135)								
EG020G-T: Rhenium	7440-15-5	0.001	mg/L	<0.001	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 846137)								
EG020A-T: Aluminium	7429-90-5	0.01	mg/L	<0.01	0.500 mg/L	102	74	128
EG020A-T: Antimony	7440-36-0	0.001	mg/L	<0.001	0.100 mg/L	109	80	114
EG020A-T: Arsenic	7440-38-2	0.001	mg/L	<0.001	0.100 mg/L	110	74	114
EG020A-T: Beryllium	7440-41-7	0.001	mg/L	<0.001	0.100 mg/L	124	77	130
EG020A-T: Barium	7440-39-3	0.001	mg/L	<0.001	----	----	----	----
EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.100 mg/L	102	74	118
EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.001	0.100 mg/L	117	81	127
EG020A-T: Cobalt	7440-48-4	0.001	mg/L	<0.001	0.100 mg/L	114	74	122
EG020A-T: Copper	7440-50-8	0.001	mg/L	<0.001	0.200 mg/L	112	75	119
EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.001	0.100 mg/L	107	80	116
EG020A-T: Lithium	7439-93-2	0.001	mg/L	<0.001	----	----	----	----
EG020A-T: Manganese	7439-96-5	0.001	mg/L	<0.001	0.100 mg/L	88.9	72	124
EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	<0.001	0.100 mg/L	109	80	112
EG020A-T: Nickel	7440-02-0	0.001	mg/L	<0.001	0.100 mg/L	116	75	121
EG020A-T: Selenium	7782-49-2	0.01	mg/L	----	0.100 mg/L	105	73	119
		0.010	mg/L	<0.010	----	----	----	----
EG020A-T: Thallium	7440-28-0	0.001	mg/L	<0.001	0.100 mg/L	107	80	116
EG020A-T: Tin	7440-31-5	0.001	mg/L	<0.001	0.100 mg/L	109	70	130
EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.01	0.1 mg/L	112	70.5	118
EG020A-T: Zinc	7440-66-6	0.005	mg/L	<0.005	0.2 mg/L	115	73	127
EG020A-T: Boron	7440-42-8	0.05	mg/L	<0.05	0.500 mg/L	110	70	128
EG020T: Total Metals by ICP-MS (QCLot: 846138)								
EG020B-T: Bismuth	7440-69-9	0.001	mg/L	<0.001	0.100 mg/L	108	73	123
EG020B-T: Cerium	7440-45-1	0.001	mg/L	<0.001	----	----	----	----
EG020B-T: Silver	7440-22-4	0.001	mg/L	<0.001	0.100 mg/L	88.9	70	118
EG020B-T: Strontium	7440-24-6	0.001	mg/L	<0.001	0.500 mg/L	110	73	119
EG020B-T: Thorium	7440-29-1	0.001	mg/L	<0.001	----	----	----	----
EG020B-T: Titanium	7440-32-6	0.01	mg/L	<0.01	0.100 mg/L	112	74	120
EG020B-T: Uranium	7440-61-1	0.001	mg/L	<0.001	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 846139)								
EG020D-T: Yttrium	7440-65-5	0.001	mg/L	<0.001	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 846140)								

Sub-Matrix: **WATER**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result	Concentration	LCS	Low	High
EG020T: Total Metals by ICP-MS (QCLot: 846140) - continued								
EG020E-T: Gold	7440-57-5	0.001	mg/L	<0.001	----	----	----	----
EG020E-T: Tungsten	7440-33-7	0.001	mg/L	<0.001	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 846141)								
EG020G-T: Rhenium	7440-15-5	0.001	mg/L	<0.001	----	----	----	----
EG035T: Total Recoverable Mercury by FIMS (QCLot: 846164)								
EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.0100 mg/L	99.4	82	122
EG035T: Total Recoverable Mercury by FIMS (QCLot: 846165)								
EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.0100 mg/L	97.5	82	122
EP006 Total Inorganic Carbon (QCLot: 848883)								
EP006: Total Inorganic Carbon	----	1	mg/L	<1	100 mg/L	113	83.2	121
EP006 Total Inorganic Carbon (QCLot: 848884)								
EP006: Total Inorganic Carbon	----	1	mg/L	<1	100 mg/L	109	83.2	121

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **WATER**

				Matrix Spike (MS) Report			
				Spike	Spike Recovery (%)	Recovery Limits (%)	
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*Concentration*	*MS*	*Low*	*High*
ED045P: Chloride by PC Titrator (QCLot: 845739)							
EM0810682-011	3.1_04 R1 W1 LD/10	ED045-P: Chloride	16887-00-6	2500 mg/L	108	70	130
ED045P: Chloride by PC Titrator (QCLot: 845741)							
EM0810682-049	3.2-01 W15	ED045-P: Chloride	16887-00-6	490 mg/L	129	70	130
EG005T: Total Metals by ICP-AES (QCLot: 845116)							
EM0810682-012	3.1_04 R2 W1LD/10	EG005T: Iron	7439-89-6	1.00 mg/L	# Not Determined	70	130
EG020T: Total Metals by ICP-MS (QCLot: 846131)							
EM0810682-002	3.1_04 R2 W1L	EG020A-T: Arsenic	7440-38-2	1.000 mg/L	118	70	130
		EG020A-T: Beryllium	7440-41-7	0.100 mg/L	128	70	130
		EG020A-T: Barium	7440-39-3	1.000 mg/L	127	70	130
		EG020A-T: Cadmium	7440-43-9	0.500 mg/L	112	70	130
		EG020A-T: Chromium	7440-47-3	1.000 mg/L	124	70	130
		EG020A-T: Cobalt	7440-48-4	1.000 mg/L	# Not Determined	70	130
		EG020A-T: Copper	7440-50-8	1.000 mg/L	114	70	130
		EG020A-T: Lead	7439-92-1	1.000 mg/L	125	70	130
		EG020A-T: Manganese	7439-96-5	1.000 mg/L	# Not Determined	70	130
		EG020A-T: Nickel	7440-02-0	1.000 mg/L	115	70	130
		EG020A-T: Vanadium	7440-62-2	1.000 mg/L	120	70	130
		EG020A-T: Zinc	7440-66-6	1.000 mg/L	# Not Determined	70	130
EG020T: Total Metals by ICP-MS (QCLot: 846137)							
EM0810682-048	4.1-04 W15	EG020A-T: Arsenic	7440-38-2	1.000 mg/L	126	70	130
		EG020A-T: Beryllium	7440-41-7	0.100 mg/L	120	70	130
		EG020A-T: Barium	7440-39-3	1.000 mg/L	123	70	130
		EG020A-T: Cadmium	7440-43-9	0.500 mg/L	109	70	130
		EG020A-T: Chromium	7440-47-3	1.000 mg/L	128	70	130
		EG020A-T: Cobalt	7440-48-4	1.000 mg/L	113	70	130
		EG020A-T: Copper	7440-50-8	1.000 mg/L	128	70	130
		EG020A-T: Lead	7439-92-1	1.000 mg/L	126	70	130
		EG020A-T: Manganese	7439-96-5	1.000 mg/L	128	70	130
		EG020A-T: Nickel	7440-02-0	1.000 mg/L	124	70	130
		EG020A-T: Vanadium	7440-62-2	1.000 mg/L	128	70	130
		EG020A-T: Zinc	7440-66-6	1.000 mg/L	119	70	130
EG035T: Total Recoverable Mercury by FIMS (QCLot: 846164)							
EM0810682-001	3.1_04 R1 W1L	EG035T: Mercury	7439-97-6	0.0100 mg/L	115	70	130
EG035T: Total Recoverable Mercury by FIMS (QCLot: 846165)							

Sub-Matrix**: WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Matrix Spike (MS) Report Spike Concentration	Spike Recovery (%) MS	Recovery Limits (%) Low	High
EG035T: Total Recoverable Mercury by FIMS (QCLot: 846165) - continued							
EM0810682-047	3.2-05 W15	EG035T: Mercury	7439-97-6	0.0100 mg/L	106	70	130
EP006 Total Inorganic Carbon (QCLot: 848883)							
EM0810682-008	CORE 1B_CO2LW1	EP006: Total Inorganic Carbon	----	100 mg/L	93.7	70	130

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES

Environmental Division

QUALITY CONTROL REPORT

Work Order	: **EB0900693**	Page	: 1 of 9
Client	: **C S I R O AUSTRALIA**	Laboratory	: Environmental Division Brisbane
Contact	: DR STUART SIMPSON	Contact	: Tim Kilmister
Address	: CENTRE FOR ENVIRONMENTAL CONTAMINANTS RESEARCH CSIRO ENERGY TECHNOLOGY NEW ILLAWARRA ROAD LUCAS HEIGHTS NSW, AUSTRALIA 2234	Address	: 32 Shand Street Stafford QLD Australia 4053
E-mail	: stuart.simpson@csiro.au	E-mail	: Services.Brisbane@alsenviro.com
Telephone	: +61 02 97106807	Telephone	: +61-7-3243 7222
Facsimile	: +61 02 97106837	Facsimile	: +61-7-3243 7218
Project	: ----	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Site	: ----		
C-O-C number	: ----	Date Samples Received	: 13-JAN-2009
Sampler	: ----	Issue Date	: 29-JAN-2009
Order number	: ----		
		No. of samples received	: 6
Quote number	: BN/328/08	No. of samples analysed	: 6

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 Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

NATA
WORLD RECOGNISED
ACCREDITATION

NATA Accredited Laboratory 825

This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

Signatories

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

Signatories	*Position*	*Accreditation Category*
Kim McCabe	Senior Inorganic Chemist	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 insuffient 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.

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = Chemistry Abstract Services number
LOR = Limit of reporting
RPD = Relative Percentage Difference
# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR:- No Limit; Result between 10 and 20 times LOR:- 0% - 50%; Result > 20 times LOR:- 0% - 20%.

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
ED037P: Alkalinity by PC Titrator (QC Lot: 866636)									
EB0900685-001	Anonymous	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	<1	<1	0.0	No Limit
EB0900685-021	Anonymous	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	<1	<1	0.0	No Limit
ED037P: Alkalinity by PC Titrator (QC Lot: 869716)									
EB0900683-001	Anonymous	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	1	<1	0.0	No Limit
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	1	<1	0.0	No Limit
EB0900697-002	Anonymous	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	175	174	0.0	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	175	174	0.0	0% - 20%
ED038A: Acidity (QC Lot: 868272)									
EB0900685-001	Anonymous	ED038: Acidity as CaCO3	----	1	mg/L	34000	34100	0.2	0% - 20%
ED040F: Dissolved Major Anions (QC Lot: 867357)									
EB0900632-001	Anonymous	ED040F: Silicon	7440-21-3	0.05	mg/L	16.6	16.8	1.2	0% - 20%
		ED040F: Sulfate as SO4 2-	14808-79-8	1	mg/L	3850	3920	1.8	0% - 20%
ED040F: Dissolved Major Anions (QC Lot: 869014)									
EB0900668-011	Anonymous	ED040F: Silicon	7440-21-3	0.05	mg/L	36.9	37.8	2.4	0% - 20%
		ED040F: Sulfate as SO4 2-	14808-79-8	1	mg/L	2310	2350	1.7	0% - 20%
EB0900704-001	Anonymous	ED040F: Silicon	7440-21-3	0.05	mg/L	26.1	25.7	1.2	0% - 20%
		ED040F: Sulfate as SO4 2-	14808-79-8	1	mg/L	7	4	53.8	No Limit
ED045P: Chloride by PC Titrator (QC Lot: 866637)									
EB0900693-005	3.2-01 W18	ED045-P: Chloride	16887-00-6	1	mg/L	66	66	0.0	0% - 20%
ED045P: Chloride by PC Titrator (QC Lot: 869717)									
EB0900685-011	Anonymous	ED045-P: Chloride	16887-00-6	1	mg/L	333	337	1.2	0% - 20%
EB0900685-020	Anonymous	ED045-P: Chloride	16887-00-6	1	mg/L	309	309	0.0	0% - 20%
ED093F: Dissolved Major Cations (QC Lot: 867358)									
EB0900632-001	Anonymous	ED093F: Calcium	7440-70-2	1	mg/L	670	672	0.3	0% - 20%

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
ED093F: Dissolved Major Cations (QC Lot: 867358) - continued									
EB0900632-001	Anonymous	ED093F: Magnesium	7439-95-4	1	mg/L	252	253	0.4	0% - 20%
		ED093F: Sodium	7440-23-5	1	mg/L	944	948	0.4	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	80	76	5.1	0% - 20%
EB0900685-014	Anonymous	ED093F: Calcium	7440-70-2	1	mg/L	54	55	2.3	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	200	205	2.3	0% - 20%
		ED093F: Sodium	7440-23-5	1	mg/L	212	220	3.3	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	77	80	3.5	0% - 20%
ED093F: Dissolved Major Cations (QC Lot: 869015)									
EB0900668-011	Anonymous	ED093F: Calcium	7440-70-2	1	mg/L	326	334	2.3	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	416	423	1.6	0% - 20%
		ED093F: Sodium	7440-23-5	1	mg/L	361	366	1.3	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	8	8	0.0	No Limit
EB0900704-001	Anonymous	ED093F: Calcium	7440-70-2	1	mg/L	39	37	5.2	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	21	21	0.0	0% - 20%
		ED093F: Sodium	7440-23-5	1	mg/L	23	23	0.0	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	1	1	0.0	No Limit
EG020T: Total Metals by ICP-MS (QC Lot: 866779)									
EB0900685-001	Anonymous	EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	0.0175	0.0186	6.1	0% - 20%
		EG020A-T: Antimony	7440-36-0	0.001	mg/L	<0.100	<0.100	0.0	No Limit
		EG020A-T: Arsenic	7440-38-2	0.001	mg/L	0.103	<0.100	3.0	No Limit
		EG020A-T: Beryllium	7440-41-7	0.001	mg/L	0.263	0.219	18.3	0% - 20%
		EG020A-T: Barium	7440-39-3	0.001	mg/L	<0.100	<0.100	0.0	No Limit
		EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.100	<0.100	0.0	No Limit
		EG020A-T: Cobalt	7440-48-4	0.001	mg/L	52.3	50.7	3.1	0% - 20%
		EG020A-T: Copper	7440-50-8	0.001	mg/L	566	564	0.4	0% - 20%
		EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.100	<0.100	0.0	No Limit
		EG020A-T: Lithium	7439-93-2	0.001	mg/L	4.74	4.61	2.6	0% - 20%
		EG020A-T: Manganese	7439-96-5	0.001	mg/L	123	122	0.5	0% - 20%
		EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	<0.100	<0.100	0.0	No Limit
		EG020A-T: Nickel	7440-02-0	0.001	mg/L	5.13	4.89	4.8	0% - 20%
		EG020A-T: Thallium	7440-28-0	0.001	mg/L	<0.100	<0.100	0.0	No Limit
		EG020A-T: Tin	7440-31-5	0.001	mg/L	<0.100	<0.100	0.0	No Limit
		EG020A-T: Zinc	7440-66-6	0.005	mg/L	19.5	19.0	2.8	0% - 20%
		EG020A-T: Aluminium	7429-90-5	0.01	mg/L	2850	2780	2.7	0% - 20%
		EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<1.00	<1.00	0.0	No Limit
		EG020A-T: Selenium	7782-49-2	0.010	mg/L	0.517	<0.500	3.4	No Limit
		EG020A-T: Boron	7440-42-8	0.05	mg/L	2.14	1.85	14.6	0% - 20%
		EG020A-T: Iron	7439-89-6	0.05	mg/L	12400	12300	0.7	0% - 20%
EB0900685-010	Anonymous	EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	0.0188	0.0152	21.2	0% - 20%

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EG020T: Total Metals by ICP-MS (QC Lot: 866779) - continued									
EB0900685-010	Anonymous	EG020A-T: Antimony	7440-36-0	0.001	mg/L	<0.100	<0.100	0.0	No Limit
		EG020A-T: Arsenic	7440-38-2	0.001	mg/L	0.106	0.103	3.1	0% - 20%
		EG020A-T: Beryllium	7440-41-7	0.001	mg/L	0.247	0.232	6.6	0% - 20%
		EG020A-T: Barium	7440-39-3	0.001	mg/L	<0.100	<0.100	0.0	No Limit
		EG020A-T: Chromium	7440-47-3	0.001	mg/L	0.176	0.137	24.9	0% - 20%
		EG020A-T: Cobalt	7440-48-4	0.001	mg/L	51.2	48.7	5.1	0% - 20%
		EG020A-T: Copper	7440-50-8	0.001	mg/L	586	556	5.2	0% - 20%
		EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.100	<0.100	0.0	No Limit
		EG020A-T: Lithium	7439-93-2	0.001	mg/L	5.35	5.09	5.1	0% - 20%
		EG020A-T: Manganese	7439-96-5	0.001	mg/L	126	118	5.9	0% - 20%
		EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	<0.100	<0.100	0.0	No Limit
		EG020A-T: Nickel	7440-02-0	0.001	mg/L	5.03	4.84	3.8	0% - 20%
		EG020A-T: Thallium	7440-28-0	0.001	mg/L	<0.100	<0.100	0.0	No Limit
		EG020A-T: Tin	7440-31-5	0.001	mg/L	<0.100	<0.100	0.0	No Limit
		EG020A-T: Zinc	7440-66-6	0.005	mg/L	19.6	18.5	5.9	0% - 20%
		EG020A-T: Aluminium	7429-90-5	0.01	mg/L	2600	2490	4.4	0% - 20%
		EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<1.00	<1.00	0.0	No Limit
		EG020A-T: Selenium	7782-49-2	0.010	mg/L	<0.500	<0.500	0.0	No Limit
		EG020A-T: Boron	7440-42-8	0.05	mg/L	2.20	2.47	11.8	0% - 20%
		EG020A-T: Iron	7439-89-6	0.05	mg/L	13300	12600	5.7	0% - 20%
EG020T: Total Metals by ICP-MS (QC Lot: 866780)									
EB0900685-001	Anonymous	EG020B-T: Bismuth	7440-69-9	0.001	mg/L	<0.100	<0.100	0.0	No Limit
		EG020B-T: Cerium	7440-45-1	0.001	mg/L	58.2	56.1	3.6	0% - 20%
		EG020B-T: Silver	7440-22-4	0.001	mg/L	<0.100	<0.100	0.0	No Limit
		EG020B-T: Strontium	7440-24-6	0.001	mg/L	2.28	2.23	2.3	0% - 20%
		EG020B-T: Thorium	7440-29-1	0.001	mg/L	<0.100	<0.100	0.0	No Limit
		EG020B-T: Uranium	7440-61-1	0.001	mg/L	29.3	29.6	0.9	0% - 20%
		EG020B-T: Titanium	7440-32-6	0.01	mg/L	<1.00	<1.00	0.0	No Limit
EB0900685-010	Anonymous	EG020B-T: Bismuth	7440-69-9	0.001	mg/L	<0.100	<0.100	0.0	No Limit
		EG020B-T: Cerium	7440-45-1	0.001	mg/L	54.1	51.0	5.8	0% - 20%
		EG020B-T: Silver	7440-22-4	0.001	mg/L	<0.100	<0.100	0.0	No Limit
		EG020B-T: Strontium	7440-24-6	0.001	mg/L	2.58	2.42	6.4	0% - 20%
		EG020B-T: Thorium	7440-29-1	0.001	mg/L	<0.100	<0.100	0.0	No Limit
		EG020B-T: Uranium	7440-61-1	0.001	mg/L	27.6	26.4	4.4	0% - 20%
		EG020B-T: Titanium	7440-32-6	0.01	mg/L	<1.00	<1.00	0.0	No Limit
EG020T: Total Metals by ICP-MS (QC Lot: 866781)									
EB0900685-001	Anonymous	EG020D-T: Yttrium	7440-65-5	0.001	mg/L	18.8	18.1	3.7	0% - 20%
EB0900685-010	Anonymous	EG020D-T: Yttrium	7440-65-5	0.001	mg/L	16.4	15.1	8.3	0% - 20%
EG020T: Total Metals by ICP-MS (QC Lot: 866782)									

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Laboratory Duplicate (DUP) Report LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EG020T: Total Metals by ICP-MS (QC Lot: 866782) - continued									
EB0900685-001	Anonymous	EG020E-T: Gold	7440-57-5	0.001	mg/L	<0.100	<0.100	0.0	No Limit
		EG020E-T: Tungsten	7440-33-7	0.001	mg/L	<0.100	<0.100	0.0	No Limit
EB0900685-010	Anonymous	EG020E-T: Gold	7440-57-5	0.001	mg/L	<0.100	<0.100	0.0	No Limit
		EG020E-T: Tungsten	7440-33-7	0.001	mg/L	<0.100	<0.100	0.0	No Limit
EG020T: Total Metals by ICP-MS (QC Lot: 866783)									
EB0900685-010	Anonymous	EG020G-T: Rhenium	7440-15-5	0.001	mg/L	<0.100	<0.100	0.0	No Limit
EG035T: Total Recoverable Mercury by FIMS (QC Lot: 866757)									
EB0900456-006	Anonymous	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EG035T: Total Recoverable Mercury by FIMS (QC Lot: 869298)									
EB0900690-001	Anonymous	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EB0900741-002	Anonymous	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EP006 Total Inorganic Carbon (QC Lot: 871535)									
EB0900685-001	Anonymous	EP006: Total Inorganic Carbon	----	1	mg/L	10	10	0.0	0% - 50%
EB0900685-010	Anonymous	EP006: Total Inorganic Carbon	----	1	mg/L	11	11	0.0	0% - 50%

Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **WATER**

				Method Blank (MB) Report	*Laboratory Control Spike (LCS) Report*			
					Spike	*Spike Recovery (%)*	*Recovery Limits (%)*	
Method: Compound	*CAS Number*	*LOR*	*Unit*	*Result*	*Concentration*	*LCS*	*Low*	*High*
ED037P: Alkalinity by PC Titrator (QCLot: 866636)								
ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	----	500 mg/L	95.2	80	114
ED037P: Alkalinity by PC Titrator (QCLot: 869716)								
ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	----	200 mg/L	97.7	80	114
ED038A: Acidity (QCLot: 868272)								
ED038: Acidity as CaCO3	----	1	mg/L	----	100 mg/L	99.0	95	105
ED040F: Dissolved Major Anions (QCLot: 867357)								
ED040F: Sulfate as SO4 2-	14808-79-8	1	mg/L	<1	----	----	----	----
ED040F: Silicon	7440-21-3	0.05	mg/L	<0.05	----	----	----	----
ED040F: Dissolved Major Anions (QCLot: 869014)								
ED040F: Sulfate as SO4 2-	14808-79-8	1	mg/L	<1	----	----	----	----
ED040F: Silicon	7440-21-3	0.05	mg/L	<0.05	----	----	----	----
ED045P: Chloride by PC Titrator (QCLot: 866637)								
ED045-P: Chloride	16887-00-6	1	mg/L	<1	1000 mg/L	93.6	90	110
ED045P: Chloride by PC Titrator (QCLot: 869717)								
ED045-P: Chloride	16887-00-6	1	mg/L	<1	1000 mg/L	94.1	90	110
ED093F: Dissolved Major Cations (QCLot: 867358)								
ED093F: Calcium	7440-70-2	1	mg/L	<1	----	----	----	----
ED093F: Magnesium	7439-95-4	1	mg/L	<1	----	----	----	----
ED093F: Sodium	7440-23-5	1	mg/L	<1	----	----	----	----
ED093F: Potassium	7440-09-7	1	mg/L	<1	----	----	----	----
ED093F: Dissolved Major Cations (QCLot: 869015)								
ED093F: Calcium	7440-70-2	1	mg/L	<1	----	----	----	----
ED093F: Magnesium	7439-95-4	1	mg/L	<1	----	----	----	----
ED093F: Sodium	7440-23-5	1	mg/L	<1	----	----	----	----
ED093F: Potassium	7440-09-7	1	mg/L	<1	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 866779)								
EG020A-T: Aluminium	7429-90-5	0.01	mg/L	<0.01	0.500 mg/L	96.8	74	128
EG020A-T: Antimony	7440-36-0	0.001	mg/L	<0.001	0.100 mg/L	101	80	114
EG020A-T: Arsenic	7440-38-2	0.001	mg/L	<0.001	0.100 mg/L	112	74	114
EG020A-T: Beryllium	7440-41-7	0.001	mg/L	<0.001	0.100 mg/L	101	77	130
EG020A-T: Barium	7440-39-3	0.001	mg/L	<0.001	----	----	----	----
EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.100 mg/L	100	74	118
EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.001	0.100 mg/L	101	81	127

Sub-Matrix: **WATER**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result	Concentration	LCS	Low	High
EG020T: Total Metals by ICP-MS (QCLot: 866779) - continued								
EG020A-T: Cobalt	7440-48-4	0.001	mg/L	<0.001	0.100 mg/L	99.5	74	122
EG020A-T: Copper	7440-50-8	0.001	mg/L	<0.001	0.200 mg/L	100	75	119
EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.001	0.100 mg/L	99.6	80	116
EG020A-T: Lithium	7439-93-2	0.001	mg/L	<0.001	----	----	----	----
EG020A-T: Manganese	7439-96-5	0.001	mg/L	<0.001	0.100 mg/L	101	72	124
EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	<0.001	0.100 mg/L	99.9	80	112
EG020A-T: Nickel	7440-02-0	0.001	mg/L	<0.001	0.100 mg/L	98.1	75	121
EG020A-T: Selenium	7782-49-2	0.01	mg/L	----	0.100 mg/L	108	73	119
		0.010	mg/L	<0.010	----	----	----	----
EG020A-T: Thallium	7440-28-0	0.001	mg/L	<0.001	0.100 mg/L	102	80	116
EG020A-T: Tin	7440-31-5	0.001	mg/L	<0.001	0.100 mg/L	110	70	130
EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.01	0.100 mg/L	106	70.5	118
EG020A-T: Zinc	7440-66-6	0.005	mg/L	<0.005	0.200 mg/L	94.6	73	127
EG020A-T: Boron	7440-42-8	0.05	mg/L	<0.05	0.500 mg/L	84.0	70	128
EG020A-T: Iron	7439-89-6	0.05	mg/L	<0.05	0.500 mg/L	110	70	130
EG020T: Total Metals by ICP-MS (QCLot: 866780)								
EG020B-T: Bismuth	7440-69-9	0.001	mg/L	<0.001	0.100 mg/L	100	73	123
EG020B-T: Cerium	7440-45-1	0.001	mg/L	<0.001	----	----	----	----
EG020B-T: Silver	7440-22-4	0.001	mg/L	<0.001	0.100 mg/L	84.0	70	118
EG020B-T: Strontium	7440-24-6	0.001	mg/L	<0.001	0.500 mg/L	98.6	73	119
EG020B-T: Thorium	7440-29-1	0.001	mg/L	<0.001	----	----	----	----
EG020B-T: Titanium	7440-32-6	0.01	mg/L	<0.01	0.100 mg/L	105	74	120
EG020B-T: Uranium	7440-61-1	0.001	mg/L	<0.001	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 866781)								
EG020D-T: Yttrium	7440-65-5	0.001	mg/L	<0.001	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 866782)								
EG020E-T: Gold	7440-57-5	0.001	mg/L	<0.001	----	----	----	----
EG020E-T: Tungsten	7440-33-7	0.001	mg/L	<0.001	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 866783)								
EG020G-T: Rhenium	7440-15-5	0.001	mg/L	<0.001	----	----	----	----
EG035T: Total Recoverable Mercury by FIMS (QCLot: 866757)								
EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.0100 mg/L	99.2	82	122
EG035T: Total Recoverable Mercury by FIMS (QCLot: 869298)								
EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.0100 mg/L	96.1	82	122

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **WATER**

				Matrix Spike (MS) Report			
				Spike	Spike Recovery (%)	Recovery Limits (%)	
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	Concentration	MS	Low	High
ED045P: Chloride by PC Titrator (QCLot: 866637)							
EB0900685-013	Anonymous	ED045-P: Chloride	16887-00-6	400 mg/L	111	70	130
ED045P: Chloride by PC Titrator (QCLot: 869717)							
EB0900685-012	Anonymous	ED045-P: Chloride	16887-00-6	2000 mg/L	86.7	70	130
EG020T: Total Metals by ICP-MS (QCLot: 866779)							
EB0900685-002	Anonymous	EG020A-T: Arsenic	7440-38-2	1.000 mg/L	117	70	130
		EG020A-T: Beryllium	7440-41-7	0.100 mg/L	110	70	130
		EG020A-T: Barium	7440-39-3	1.000 mg/L	104	70	130
		EG020A-T: Cadmium	7440-43-9	0.500 mg/L	88.2	70	130
		EG020A-T: Chromium	7440-47-3	1.000 mg/L	95.0	70	130
		EG020A-T: Cobalt	7440-48-4	1.000 mg/L	# Not Determined	70	130
		EG020A-T: Copper	7440-50-8	1.000 mg/L	# Not Determined	70	130
		EG020A-T: Lead	7439-92-1	1.000 mg/L	100	70	130
		EG020A-T: Manganese	7439-96-5	1.000 mg/L	# Not Determined	70	130
		EG020A-T: Nickel	7440-02-0	1.000 mg/L	# Not Determined	70	130
		EG020A-T: Vanadium	7440-62-2	1.000 mg/L	111	70	130
		EG020A-T: Zinc	7440-66-6	1.000 mg/L	# Not Determined	70	130
EG035T: Total Recoverable Mercury by FIMS (QCLot: 866757)							
EB0900456-006	Anonymous	EG035T: Mercury	7439-97-6	0.0100 mg/L	93.6	70	130
EG035T: Total Recoverable Mercury by FIMS (QCLot: 869298)							
EB0900690-001	Anonymous	EG035T: Mercury	7439-97-6	0.0100 mg/L	77.4	70	130

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES

Environmental Division

QUALITY CONTROL REPORT

Work Order	: **EB0900685**	Page	: 1 of 10
Client	: **C S I R O AUSTRALIA**	Laboratory	: Environmental Division Brisbane
Contact	: DR STUART SIMPSON	Contact	: Tim Kilmister
Address	: CENTRE FOR ENVIRONMENTAL CONTAMINANTS RESEARCH CSIRO ENERGY TECHNOLOGY NEW ILLAWARRA ROAD LUCAS HEIGHTS NSW, AUSTRALIA 2234	Address	: 32 Shand Street Stafford QLD Australia 4053
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Telephone	: +61 02 97106807	Telephone	: +61-7-3243 7222
Facsimile	: +61 02 97106837	Facsimile	: +61-7-3243 7218
Project	: ----	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Site	: ----		
C-O-C number	: ----	Date Samples Received	: 13-JAN-2009
Sampler	: ----	Issue Date	: 29-JAN-2009
Order number	: ----		
		No. of samples received	: 22
Quote number	: BN/328/08	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 Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

NATA Accredited Laboratory 825

This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

Signatories

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

Signatories	*Position*	*Accreditation Category*
Kim McCabe	Senior Inorganic Chemist	Inorganics
Stephen Hislop	Senior Inorganic Chemist	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 insuffient 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.

Key :
Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = Chemistry Abstract Services number
LOR = Limit of reporting
RPD = Relative Percentage Difference
\# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR:- No Limit; Result between 10 and 20 times LOR:- 0% - 50%; Result > 20 times LOR:- 0% - 20%.

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
ED037P: Alkalinity by PC Titrator (QC Lot: 866636)									
EB0900685-001	RBLK_N2LW2	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	<1	<1	0.0	No Limit
EB0900685-021	RBLK_N2LW2D/100	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	<1	<1	0.0	No Limit
ED037P: Alkalinity by PC Titrator (QC Lot: 869716)									
EB0900683-001	Anonymous	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	1	<1	0.0	No Limit
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	1	<1	0.0	No Limit
EB0900697-002	Anonymous	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	175	174	0.0	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	175	174	0.0	0% - 20%
ED038A: Acidity (QC Lot: 868272)									
EB0900685-001	RBLK_N2LW2	ED038: Acidity as CaCO3	----	1	mg/L	34000	34100	0.2	0% - 20%
ED038A: Acidity (QC Lot: 869654)									
EB0900685-002	RBLK_N2LW3	ED038: Acidity as CaCO3	----	1	mg/L	31900	33700	5.6	0% - 20%
EB0900849-011	Anonymous	ED038: Acidity as CaCO3	----	1	mg/L	12	12	0.0	0% - 50%
ED040F: Dissolved Major Anions (QC Lot: 867357)									
EB0900632-001	Anonymous	ED040F: Silicon	7440-21-3	0.05	mg/L	16.6	16.8	1.2	0% - 20%
ED040F: Dissolved Major Anions (QC Lot: 869014)									
EB0900668-011	Anonymous	ED040F: Silicon	7440-21-3	0.05	mg/L	36.9	37.8	2.4	0% - 20%
EB0900704-001	Anonymous	ED040F: Silicon	7440-21-3	0.05	mg/L	26.1	25.7	1.2	0% - 20%
ED040T: Total Major Anions (QC Lot: 867364)									
EB0900685-011	RBLK_N2LW2D/10	ED040T: Sulfate as SO4 2-	14808-79-8	1	mg/L	3490	3460	0.7	0% - 20%
EB0900685-020	Core 4B_CO2LW3D/10	ED040T: Sulfate as SO4 2-	14808-79-8	1	mg/L	3310	3280	0.8	0% - 20%
ED045P: Chloride by PC Titrator (QC Lot: 866637)									
EB0900693-005	Anonymous	ED045-P: Chloride	16887-00-6	1	mg/L	66	66	0.0	0% - 20%
ED045P: Chloride by PC Titrator (QC Lot: 869717)									
EB0900685-011	RBLK_N2LW2D/10	ED045-P: Chloride	16887-00-6	1	mg/L	333	337	1.2	0% - 20%

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
ED045P: Chloride by PC Titrator (QC Lot: 869717) - continued									
EB0900685-020	Core 4B_CO2LW3D/10	ED045-P: Chloride	16887-00-6	1	mg/L	309	309	0.0	0% - 20%
ED093F: Dissolved Major Cations (QC Lot: 867358)									
EB0900632-001	Anonymous	ED093F: Calcium	7440-70-2	1	mg/L	670	672	0.3	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	252	253	0.4	0% - 20%
		ED093F: Sodium	7440-23-5	1	mg/L	944	948	0.4	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	80	76	5.1	0% - 20%
EB0900685-014	Core 1B_CO2LW2D/10	ED093F: Calcium	7440-70-2	1	mg/L	54	55	2.3	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	200	205	2.3	0% - 20%
		ED093F: Sodium	7440-23-5	1	mg/L	212	220	3.3	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	77	80	3.5	0% - 20%
ED093F: Dissolved Major Cations (QC Lot: 869015)									
EB0900668-011	Anonymous	ED093F: Calcium	7440-70-2	1	mg/L	326	334	2.3	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	416	423	1.6	0% - 20%
		ED093F: Sodium	7440-23-5	1	mg/L	361	366	1.3	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	8	8	0.0	No Limit
EB0900704-001	Anonymous	ED093F: Calcium	7440-70-2	1	mg/L	39	37	5.2	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	21	21	0.0	0% - 20%
		ED093F: Sodium	7440-23-5	1	mg/L	23	23	0.0	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	1	1	0.0	No Limit
EG020T: Total Metals by ICP-MS (QC Lot: 866779)									
EB0900685-001	RBLK_N2LW2	EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	0.0175	0.0186	6.1	0% - 20%
		EG020A-T: Antimony	7440-36-0	0.001	mg/L	<0.100	<0.100	0.0	No Limit
		EG020A-T: Arsenic	7440-38-2	0.001	mg/L	0.103	<0.100	3.0	No Limit
		EG020A-T: Beryllium	7440-41-7	0.001	mg/L	0.263	0.219	18.3	0% - 20%
		EG020A-T: Barium	7440-39-3	0.001	mg/L	<0.100	<0.100	0.0	No Limit
		EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.100	<0.100	0.0	No Limit
		EG020A-T: Cobalt	7440-48-4	0.001	mg/L	52.3	50.7	3.1	0% - 20%
		EG020A-T: Copper	7440-50-8	0.001	mg/L	566	564	0.4	0% - 20%
		EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.100	<0.100	0.0	No Limit
		EG020A-T: Lithium	7439-93-2	0.001	mg/L	4.74	4.61	2.6	0% - 20%
		EG020A-T: Manganese	7439-96-5	0.001	mg/L	123	122	0.5	0% - 20%
		EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	<0.100	<0.100	0.0	No Limit
		EG020A-T: Nickel	7440-02-0	0.001	mg/L	5.13	4.89	4.8	0% - 20%
		EG020A-T: Thallium	7440-28-0	0.001	mg/L	<0.100	<0.100	0.0	No Limit
		EG020A-T: Tin	7440-31-5	0.001	mg/L	<0.100	<0.100	0.0	No Limit
		EG020A-T: Zinc	7440-66-6	0.005	mg/L	19.5	19.0	2.8	0% - 20%
		EG020A-T: Aluminium	7429-90-5	0.01	mg/L	2850	2780	2.7	0% - 20%
		EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<1.00	<1.00	0.0	No Limit
		EG020A-T: Selenium	7782-49-2	0.010	mg/L	0.517	<0.500	3.4	No Limit

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EG020T: Total Metals by ICP-MS (QC Lot: 866779) - continued									
EB0900685-001	RBLK_N2LW2	EG020A-T: Boron	7440-42-8	0.05	mg/L	2.14	1.85	14.6	0% - 20%
EB0900685-010	Core 4B_CO2LW3	EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	0.0188	0.0152	21.2	0% - 20%
		EG020A-T: Antimony	7440-36-0	0.001	mg/L	<0.100	<0.100	0.0	No Limit
		EG020A-T: Arsenic	7440-38-2	0.001	mg/L	0.106	0.103	3.1	0% - 20%
		EG020A-T: Beryllium	7440-41-7	0.001	mg/L	0.247	0.232	6.6	0% - 20%
		EG020A-T: Barium	7440-39-3	0.001	mg/L	<0.100	<0.100	0.0	No Limit
		EG020A-T: Chromium	7440-47-3	0.001	mg/L	0.176	0.137	24.9	0% - 20%
		EG020A-T: Cobalt	7440-48-4	0.001	mg/L	51.2	48.7	5.1	0% - 20%
		EG020A-T: Copper	7440-50-8	0.001	mg/L	586	556	5.2	0% - 20%
		EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.100	<0.100	0.0	No Limit
		EG020A-T: Lithium	7439-93-2	0.001	mg/L	5.35	5.09	5.1	0% - 20%
		EG020A-T: Manganese	7439-96-5	0.001	mg/L	126	118	5.9	0% - 20%
		EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	<0.100	<0.100	0.0	No Limit
		EG020A-T: Nickel	7440-02-0	0.001	mg/L	5.03	4.84	3.8	0% - 20%
		EG020A-T: Thallium	7440-28-0	0.001	mg/L	<0.100	<0.100	0.0	No Limit
		EG020A-T: Tin	7440-31-5	0.001	mg/L	<0.100	<0.100	0.0	No Limit
		EG020A-T: Zinc	7440-66-6	0.005	mg/L	19.6	18.5	5.9	0% - 20%
		EG020A-T: Aluminium	7429-90-5	0.01	mg/L	2600	2490	4.4	0% - 20%
		EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<1.00	<1.00	0.0	No Limit
		EG020A-T: Selenium	7782-49-2	0.010	mg/L	<0.500	<0.500	0.0	No Limit
		EG020A-T: Boron	7440-42-8	0.05	mg/L	2.20	2.47	11.8	0% - 20%
EG020T: Total Metals by ICP-MS (QC Lot: 866780)									
EB0900685-001	RBLK_N2LW2	EG020B-T: Bismuth	7440-69-9	0.001	mg/L	<0.100	<0.100	0.0	No Limit
		EG020B-T: Cerium	7440-45-1	0.001	mg/L	58.2	56.1	3.6	0% - 20%
		EG020B-T: Silver	7440-22-4	0.001	mg/L	<0.100	<0.100	0.0	No Limit
		EG020B-T: Strontium	7440-24-6	0.001	mg/L	2.28	2.23	2.3	0% - 20%
		EG020B-T: Thorium	7440-29-1	0.001	mg/L	<0.100	<0.100	0.0	No Limit
		EG020B-T: Uranium	7440-61-1	0.001	mg/L	29.3	29.6	0.9	0% - 20%
		EG020B-T: Titanium	7440-32-6	0.01	mg/L	<1.00	<1.00	0.0	No Limit
EB0900685-010	Core 4B_CO2LW3	EG020B-T: Bismuth	7440-69-9	0.001	mg/L	<0.100	<0.100	0.0	No Limit
		EG020B-T: Cerium	7440-45-1	0.001	mg/L	54.1	51.0	5.8	0% - 20%
		EG020B-T: Silver	7440-22-4	0.001	mg/L	<0.100	<0.100	0.0	No Limit
		EG020B-T: Strontium	7440-24-6	0.001	mg/L	2.58	2.42	6.4	0% - 20%
		EG020B-T: Thorium	7440-29-1	0.001	mg/L	<0.100	<0.100	0.0	No Limit
		EG020B-T: Uranium	7440-61-1	0.001	mg/L	27.6	26.4	4.4	0% - 20%
		EG020B-T: Titanium	7440-32-6	0.01	mg/L	<1.00	<1.00	0.0	No Limit
EG020T: Total Metals by ICP-MS (QC Lot: 866781)									
EB0900685-001	RBLK_N2LW2	EG020D-T: Yttrium	7440-65-5	0.001	mg/L	18.8	18.1	3.7	0% - 20%
EB0900685-010	Core 4B_CO2LW3	EG020D-T: Yttrium	7440-65-5	0.001	mg/L	16.4	15.1	8.3	0% - 20%

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EG020T: Total Metals by ICP-MS (QC Lot: 866782)									
EB0900685-001	RBLK_N2LW2	EG020E-T: Tungsten	7440-33-7	0.001	mg/L	<0.100	<0.100	0.0	No Limit
EB0900685-010	Core 4B_CO2LW3	EG020E-T: Tungsten	7440-33-7	0.001	mg/L	<0.100	<0.100	0.0	No Limit
EG020T: Total Metals by ICP-MS (QC Lot: 866783)									
EB0900685-010	Core 4B_CO2LW3	EG020G-T: Rhenium	7440-15-5	0.001	mg/L	<0.100	<0.100	0.0	No Limit
EG020T: Total Metals by ICP-MS (QC Lot: 867365)									
EB0900685-011	RBLK_N2LW2D/10	EG020A-T: Iron	7439-89-6	0.05	mg/L	1210	1220	1.1	0% - 20%
EB0900685-020	Core 4B_CO2LW3D/10	EG020A-T: Iron	7439-89-6	0.05	mg/L	1290	1240	4.2	0% - 20%
EG035T: Total Recoverable Mercury by FIMS (QC Lot: 866757)									
EB0900456-006	Anonymous	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EG035T: Total Recoverable Mercury by FIMS (QC Lot: 869297)									
EB0900563-001	Anonymous	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EB0900668-008	Anonymous	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EG035T: Total Recoverable Mercury by FIMS (QC Lot: 869298)									
EB0900690-001	Anonymous	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EB0900741-002	Anonymous	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EP006 Total Inorganic Carbon (QC Lot: 871535)									
EB0900685-001	RBLK_N2LW2	EP006: Total Inorganic Carbon	----	1	mg/L	10	10	0.0	0% - 50%
EB0900685-010	Core 4B_CO2LW3	EP006: Total Inorganic Carbon	----	1	mg/L	11	11	0.0	0% - 50%

Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **WATER**

				Method Blank (MB) Report	*Laboratory Control Spike (LCS) Report*			
					Spike	*Spike Recovery (%)*	*Recovery Limits (%)*	
Method: Compound	*CAS Number*	*LOR*	*Unit*	*Result*	*Concentration*	*LCS*	*Low*	*High*
ED037P: Alkalinity by PC Titrator (QCLot: 866636)								
ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	----	500 mg/L	95.2	80	114
ED037P: Alkalinity by PC Titrator (QCLot: 869716)								
ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	----	200 mg/L	97.7	80	114
ED038A: Acidity (QCLot: 868272)								
ED038: Acidity as CaCO3	----	1	mg/L	----	100 mg/L	99.0	95	105
ED038A: Acidity (QCLot: 869654)								
ED038: Acidity as CaCO3	----	1	mg/L	----	100 mg/L	99.0	95	105
ED040F: Dissolved Major Anions (QCLot: 867357)								
ED040F: Silicon	7440-21-3	0.05	mg/L	<0.05	----	----	----	----
ED040F: Dissolved Major Anions (QCLot: 869014)								
ED040F: Silicon	7440-21-3	0.05	mg/L	<0.05	----	----	----	----
ED040T: Total Major Anions (QCLot: 867364)								
ED040T: Sulfate as SO4 2-	14808-79-8	1	mg/L	<1	----	----	----	----
ED045P: Chloride by PC Titrator (QCLot: 866637)								
ED045-P: Chloride	16887-00-6	1	mg/L	<1	1000 mg/L	93.6	90	110
ED045P: Chloride by PC Titrator (QCLot: 869717)								
ED045-P: Chloride	16887-00-6	1	mg/L	<1	1000 mg/L	94.1	90	110
ED093F: Dissolved Major Cations (QCLot: 867358)								
ED093F: Calcium	7440-70-2	1	mg/L	<1	----	----	----	----
ED093F: Magnesium	7439-95-4	1	mg/L	<1	----	----	----	----
ED093F: Sodium	7440-23-5	1	mg/L	<1	----	----	----	----
ED093F: Potassium	7440-09-7	1	mg/L	<1	----	----	----	----
ED093F: Dissolved Major Cations (QCLot: 869015)								
ED093F: Calcium	7440-70-2	1	mg/L	<1	----	----	----	----
ED093F: Magnesium	7439-95-4	1	mg/L	<1	----	----	----	----
ED093F: Sodium	7440-23-5	1	mg/L	<1	----	----	----	----
ED093F: Potassium	7440-09-7	1	mg/L	<1	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 866779)								
EG020A-T: Aluminium	7429-90-5	0.01	mg/L	<0.01	0.500 mg/L	96.8	74	128
EG020A-T: Antimony	7440-36-0	0.001	mg/L	<0.001	0.100 mg/L	101	80	114
EG020A-T: Arsenic	7440-38-2	0.001	mg/L	<0.001	0.100 mg/L	112	74	114
EG020A-T: Beryllium	7440-41-7	0.001	mg/L	<0.001	0.100 mg/L	101	77	130
EG020A-T: Barium	7440-39-3	0.001	mg/L	<0.001	----	----	----	----

Sub-Matrix: **WATER**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result	Concentration	LCS	Low	High
EG020T: Total Metals by ICP-MS (QCLot: 866779) - continued								
EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.100 mg/L	100	74	118
EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.001	0.100 mg/L	101	81	127
EG020A-T: Cobalt	7440-48-4	0.001	mg/L	<0.001	0.100 mg/L	99.5	74	122
EG020A-T: Copper	7440-50-8	0.001	mg/L	<0.001	0.200 mg/L	100	75	119
EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.001	0.100 mg/L	99.6	80	116
EG020A-T: Lithium	7439-93-2	0.001	mg/L	<0.001	----	----	----	----
EG020A-T: Manganese	7439-96-5	0.001	mg/L	<0.001	0.100 mg/L	101	72	124
EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	<0.001	0.100 mg/L	99.9	80	112
EG020A-T: Nickel	7440-02-0	0.001	mg/L	<0.001	0.100 mg/L	98.1	75	121
EG020A-T: Selenium	7782-49-2	0.01	mg/L	----	0.100 mg/L	108	73	119
		0.010	mg/L	<0.010	----	----	----	----
EG020A-T: Thallium	7440-28-0	0.001	mg/L	<0.001	0.100 mg/L	102	80	116
EG020A-T: Tin	7440-31-5	0.001	mg/L	<0.001	0.100 mg/L	110	70	130
EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.01	0.100 mg/L	106	70.5	118
EG020A-T: Zinc	7440-66-6	0.005	mg/L	<0.005	0.200 mg/L	94.6	73	127
EG020A-T: Boron	7440-42-8	0.05	mg/L	<0.05	0.500 mg/L	84.0	70	128
EG020T: Total Metals by ICP-MS (QCLot: 866780)								
EG020B-T: Bismuth	7440-69-9	0.001	mg/L	<0.001	0.100 mg/L	100	73	123
EG020B-T: Cerium	7440-45-1	0.001	mg/L	<0.001	----	----	----	----
EG020B-T: Silver	7440-22-4	0.001	mg/L	<0.001	0.100 mg/L	84.0	70	118
EG020B-T: Strontium	7440-24-6	0.001	mg/L	<0.001	0.500 mg/L	98.6	73	119
EG020B-T: Thorium	7440-29-1	0.001	mg/L	<0.001	----	----	----	----
EG020B-T: Titanium	7440-32-6	0.01	mg/L	<0.01	0.100 mg/L	105	74	120
EG020B-T: Uranium	7440-61-1	0.001	mg/L	<0.001	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 866781)								
EG020D-T: Yttrium	7440-65-5	0.001	mg/L	<0.001	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 866782)								
EG020E-T: Tungsten	7440-33-7	0.001	mg/L	<0.001	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 866783)								
EG020G-T: Rhenium	7440-15-5	0.001	mg/L	<0.001	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 867365)								
EG020A-T: Iron	7439-89-6	0.05	mg/L	<0.05	0.500 mg/L	125	70	130
EG035T: Total Recoverable Mercury by FIMS (QCLot: 866757)								
EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.0100 mg/L	99.2	82	122
EG035T: Total Recoverable Mercury by FIMS (QCLot: 869297)								
EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.0100 mg/L	98.3	82	122
EG035T: Total Recoverable Mercury by FIMS (QCLot: 869298)								
EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.0100 mg/L	96.1	82	122

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **WATER**

				Matrix Spike (MS) Report			
				Spike	*Spike Recovery (%)*	*Recovery Limits (%)*	
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*Concentration*	*MS*	*Low*	*High*
ED045P: Chloride by PC Titrator (QCLot: 866637)							
EB0900685-013	Core 1A_N2LW2D/10	ED045-P: Chloride	16887-00-6	400 mg/L	111	70	130
ED045P: Chloride by PC Titrator (QCLot: 869717)							
EB0900685-012	RBLK_N2LW3D/10	ED045-P: Chloride	16887-00-6	2000 mg/L	86.7	70	130
EG020T: Total Metals by ICP-MS (QCLot: 866779)							
EB0900685-002	RBLK_N2LW3	EG020A-T: Arsenic	7440-38-2	1.000 mg/L	117	70	130
		EG020A-T: Beryllium	7440-41-7	0.100 mg/L	110	70	130
		EG020A-T: Barium	7440-39-3	1.000 mg/L	104	70	130
		EG020A-T: Cadmium	7440-43-9	0.500 mg/L	88.2	70	130
		EG020A-T: Chromium	7440-47-3	1.000 mg/L	95.0	70	130
		EG020A-T: Cobalt	7440-48-4	1.000 mg/L	# Not Determined	70	130
		EG020A-T: Copper	7440-50-8	1.000 mg/L	# Not Determined	70	130
		EG020A-T: Lead	7439-92-1	1.000 mg/L	100	70	130
		EG020A-T: Manganese	7439-96-5	1.000 mg/L	# Not Determined	70	130
		EG020A-T: Nickel	7440-02-0	1.000 mg/L	# Not Determined	70	130
		EG020A-T: Vanadium	7440-62-2	1.000 mg/L	111	70	130
		EG020A-T: Zinc	7440-66-6	1.000 mg/L	# Not Determined	70	130
EG035T: Total Recoverable Mercury by FIMS (QCLot: 866757)							
EB0900456-006	Anonymous	EG035T: Mercury	7439-97-6	0.0100 mg/L	93.6	70	130
EG035T: Total Recoverable Mercury by FIMS (QCLot: 869297)							
EB0900563-001	Anonymous	EG035T: Mercury	7439-97-6	0.0100 mg/L	91.9	70	130
EG035T: Total Recoverable Mercury by FIMS (QCLot: 869298)							
EB0900690-001	Anonymous	EG035T: Mercury	7439-97-6	0.0100 mg/L	77.4	70	130

QUALITY CONTROL REPORT

Work Order	: **EB0901048**	Page	: 1 of 8
Client	: **C S I R O AUSTRALIA**	Laboratory	: Environmental Division Brisbane
Contact	: DR STUART SIMPSON	Contact	: Tim Kilmister
Address	: CENTRE FOR ENVIRONMENTAL CONTAMINANTS RESEARCH CSIRO ENERGY TECHNOLOGY NEW ILLAWARRA ROAD LUCAS HEIGHTS NSW, AUSTRALIA 2234	Address	: 32 Shand Street Stafford QLD Australia 4053
E-mail	: stuart.simpson@csiro.au	E-mail	: Services.Brisbane@alsenviro.com
Telephone	: +61 02 97106807	Telephone	: +61-7-3243 7222
Facsimile	: +61 02 97106837	Facsimile	: +61-7-3243 7218
Project	: ----	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Site	: ----		
C-O-C number	: ----	Date Samples Received	: 22-JAN-2009
Sampler	: ----	Issue Date	: 04-FEB-2009
Order number	: ----		
		No. of samples received	: 46
Quote number	: BN/328/08	No. of samples analysed	: 46

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 Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

NATA
WORLD RECOGNISED
ACCREDITATION

NATA Accredited Laboratory 825

This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

Signatories

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

Signatories	*Position*	*Accreditation Category*
Celine Conceicao	Spectroscopist	Inorganics
Hoa Nguyen	Inorganic Chemist	Inorganics
Stephen Hislop	Senior Inorganic Chemist	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 insuffient 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.

Key :
Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
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
RPD = Relative Percentage Difference
# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR:- No Limit; Result between 10 and 20 times LOR:- 0% - 50%; Result > 20 times LOR:- 0% - 20%.

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
ED037P: Alkalinity by PC Titrator (QC Lot: 875140)									
EB0901048-038	3.1_09 R2 W2 L	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	<1	<1	0.0	No Limit
EB0901049-042	Anonymous	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	<1	<1	0.0	No Limit
ED038A: Acidity (QC Lot: 875002)									
EB0901048-035	3.1_04 R1 W2 LD/2	ED038: Acidity as CaCO3	----	1	mg/L	4300	4310	0.2	0% - 20%
EB0901048-044	3.1_09 R2 W3 L	ED038: Acidity as CaCO3	----	1	mg/L	24600	24600	0.1	0% - 20%
ED040F: Dissolved Major Anions (QC Lot: 876424)									
EB0901048-001	3.1_04 R1 W2 L	ED040F: Silicon	7440-21-3	0.05	mg/L	2.97	2.80	6.1	0% - 20%
EB0901048-010	3.1_09 R2 W3 L	ED040F: Silicon	7440-21-3	0.05	mg/L	64.5	66.2	2.6	0% - 20%
ED093F: Dissolved Major Cations (QC Lot: 875731)									
EB0901048-018	3.1_04 R1 W2 LD/10	ED093F: Calcium	7440-70-2	1	mg/L	49	49	0.0	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	68	68	0.0	0% - 20%
		ED093F: Sodium	7440-23-5	1	mg/L	183	182	0.7	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	48	47	0.0	0% - 20%
EB0901048-028	3.2_12 R2 W3 LD/10	ED093F: Calcium	7440-70-2	1	mg/L	48	50	3.8	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	174	180	3.7	0% - 20%
		ED093F: Sodium	7440-23-5	1	mg/L	198	198	0.0	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	66	65	1.8	0% - 20%
EG020T: Total Metals by ICP-MS (QC Lot: 878523)									
EB0901048-001	3.1_04 R1 W2 L	EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	0.0078	0.0080	3.5	0% - 20%
		EG020A-T: Antimony	7440-36-0	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-T: Arsenic	7440-38-2	0.001	mg/L	<0.010	0.011	0.0	0% - 50%
		EG020A-T: Beryllium	7440-41-7	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-T: Barium	7440-39-3	0.001	mg/L	0.029	0.027	8.4	0% - 20%
		EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-T: Cobalt	7440-48-4	0.001	mg/L	34.0	34.5	1.3	0% - 20%
		EG020A-T: Copper	7440-50-8	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-T: Lithium	7439-93-2	0.001	mg/L	2.74	2.82	2.7	0% - 20%
		EG020A-T: Manganese	7439-96-5	0.001	mg/L	103	103	0.2	0% - 20%

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EG020T: Total Metals by ICP-MS (QC Lot: 878523) - continued									
EB0901048-001	3.1_04 R1 W2 L	EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-T: Nickel	7440-02-0	0.001	mg/L	1.92	1.90	0.8	0% - 20%
		EG020A-T: Thallium	7440-28-0	0.001	mg/L	0.014	0.014	0.0	0% - 50%
		EG020A-T: Tin	7440-31-5	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-T: Zinc	7440-66-6	0.005	mg/L	4.57	4.54	0.6	0% - 20%
		EG020A-T: Aluminium	7429-90-5	0.01	mg/L	2.07	1.99	4.0	0% - 20%
		EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.10	<0.10	0.0	No Limit
		EG020A-T: Selenium	7782-49-2	0.010	mg/L	0.059	0.068	15.4	No Limit
		EG020A-T: Boron	7440-42-8	0.05	mg/L	1.52	1.46	4.5	0% - 20%
EB0901048-010	3.1_09 R2 W3 L	EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	0.0235	0.0220	7.0	0% - 20%
		EG020A-T: Antimony	7440-36-0	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-T: Arsenic	7440-38-2	0.001	mg/L	0.028	0.040	33.7	0% - 20%
		EG020A-T: Beryllium	7440-41-7	0.001	mg/L	0.310	0.298	3.9	0% - 20%
		EG020A-T: Barium	7440-39-3	0.001	mg/L	0.077	0.077	0.0	0% - 20%
		EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-T: Cobalt	7440-48-4	0.001	mg/L	54.7	52.5	4.2	0% - 20%
		EG020A-T: Copper	7440-50-8	0.001	mg/L	710	697	1.8	0% - 20%
		EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-T: Lithium	7439-93-2	0.001	mg/L	6.21	6.20	0.1	0% - 20%
		EG020A-T: Manganese	7439-96-5	0.001	mg/L	131	127	3.0	0% - 20%
		EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-T: Nickel	7440-02-0	0.001	mg/L	5.11	5.00	2.3	0% - 20%
		EG020A-T: Thallium	7440-28-0	0.001	mg/L	0.031	0.032	0.0	0% - 20%
		EG020A-T: Tin	7440-31-5	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-T: Zinc	7440-66-6	0.005	mg/L	22.5	21.8	2.9	0% - 20%
		EG020A-T: Aluminium	7429-90-5	0.01	mg/L	2120	2030	4.1	0% - 20%
		EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.10	<0.10	0.0	No Limit
		EG020A-T: Selenium	7782-49-2	0.010	mg/L	0.308	0.306	0.6	0% - 20%
		EG020A-T: Boron	7440-42-8	0.05	mg/L	2.36	2.32	1.7	0% - 20%
EG020T: Total Metals by ICP-MS (QC Lot: 878524)									
EB0901048-001	3.1_04 R1 W2 L	EG020B-T: Bismuth	7440-69-9	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020B-T: Cerium	7440-45-1	0.001	mg/L	0.211	0.212	0.0	0% - 20%
		EG020B-T: Silver	7440-22-4	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020B-T: Strontium	7440-24-6	0.001	mg/L	2.18	2.21	1.3	0% - 20%
		EG020B-T: Thorium	7440-29-1	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020B-T: Uranium	7440-61-1	0.001	mg/L	5.00	4.98	0.4	0% - 20%
		EG020B-T: Titanium	7440-32-6	0.01	mg/L	<0.10	<0.10	0.0	No Limit
EB0901048-010	3.1_09 R2 W3 L	EG020B-T: Bismuth	7440-69-9	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020B-T: Cerium	7440-45-1	0.001	mg/L	58.5	56.8	2.9	0% - 20%

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EG020T: Total Metals by ICP-MS (QC Lot: 878524) - continued									
EB0901048-010	3.1_09 R2 W3 L	EG020B-T: Silver	7440-22-4	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020B-T: Strontium	7440-24-6	0.001	mg/L	2.95	2.88	2.4	0% - 20%
		EG020B-T: Thorium	7440-29-1	0.001	mg/L	0.015	0.014	7.5	0% - 50%
		EG020B-T: Uranium	7440-61-1	0.001	mg/L	34.9	34.6	1.0	0% - 20%
		EG020B-T: Titanium	7440-32-6	0.01	mg/L	<0.10	<0.10	0.0	No Limit
EG020T: Total Metals by ICP-MS (QC Lot: 878525)									
EB0901048-001	3.1_04 R1 W2 L	EG020D-T: Yttrium	7440-65-5	0.001	mg/L	0.078	0.080	1.7	0% - 20%
EB0901048-010	3.1_09 R2 W3 L	EG020D-T: Yttrium	7440-65-5	0.001	mg/L	15.1	14.5	3.7	0% - 20%
EG020T: Total Metals by ICP-MS (QC Lot: 878526)									
EB0901048-001	3.1_04 R1 W2 L	EG020E-T: Tungsten	7440-33-7	0.001	mg/L	<0.010	<0.010	0.0	No Limit
EB0901048-010	3.1_09 R2 W3 L	EG020E-T: Tungsten	7440-33-7	0.001	mg/L	0.014	0.014	0.0	0% - 50%
EG020T: Total Metals by ICP-MS (QC Lot: 878527)									
EB0901048-010	3.1_09 R2 W3 L	EG020G-T: Rhenium	7440-15-5	0.001	mg/L	0.002	0.002	0.0	No Limit
EB0901049-003	Anonymous	EG020G-T: Rhenium	7440-15-5	0.001	mg/L	0.002	0.002	0.0	No Limit
EG035T: Total Recoverable Mercury by FIMS (QC Lot: 876034)									
EB0901048-002	3.1_04 R2 W2 L	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EB0901048-011	3.2_12 R2 W3 L	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EP006 Total Inorganic Carbon (QC Lot: 875135)									
EB0901048-035	3.1_04 R1 W2 LD/2	EP006: Total Inorganic Carbon	----	1	mg/L	<1	<1	0.0	No Limit
EB0901048-044	3.1_09 R2 W3 L	EP006: Total Inorganic Carbon	----	1	mg/L	<1	<1	0.0	No Limit

Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **WATER**

				Method Blank (MB) Report	*Laboratory Control Spike (LCS) Report*			
					Spike	*Spike Recovery (%)*	*Recovery Limits (%)*	
Method: Compound	*CAS Number*	*LOR*	*Unit*	*Result*	*Concentration*	*LCS*	*Low*	*High*
ED037P: Alkalinity by PC Titrator (QCLot: 875138)								
ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	----	200 mg/L	103	80.2	108
ED037P: Alkalinity by PC Titrator (QCLot: 875140)								
ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	----	200 mg/L	92.0	80.2	108
ED038A: Acidity (QCLot: 875002)								
ED038: Acidity as CaCO3	----	1	mg/L	<1	20 mg/L	93.3	89.8	103
ED040F: Dissolved Major Anions (QCLot: 876424)								
ED040F: Silicon	7440-21-3	0.05	mg/L	<0.05	----	----	----	----
ED093F: Dissolved Major Cations (QCLot: 875731)								
ED093F: Calcium	7440-70-2	1	mg/L	<1	50 mg/L	99.4	82.9	121
ED093F: Magnesium	7439-95-4	1	mg/L	<1	50 mg/L	98.1	82.7	114
ED093F: Sodium	7440-23-5	1	mg/L	<1	50 mg/L	95.1	77.4	113
ED093F: Potassium	7440-09-7	1	mg/L	<1	50 mg/L	96.7	84.3	118
EG020T: Total Metals by ICP-MS (QCLot: 878523)								
EG020A-T: Aluminium	7429-90-5	0.01	mg/L	<0.01	0.500 mg/L	78.5	74	128
EG020A-T: Antimony	7440-36-0	0.001	mg/L	<0.001	0.100 mg/L	95.2	80	114
EG020A-T: Arsenic	7440-38-2	0.001	mg/L	<0.001	0.100 mg/L	103	74	114
EG020A-T: Beryllium	7440-41-7	0.001	mg/L	<0.001	0.100 mg/L	94.1	77	130
EG020A-T: Barium	7440-39-3	0.001	mg/L	<0.001	----	----	----	----
EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.100 mg/L	94.6	74	118
EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.001	0.100 mg/L	98.0	81	127
EG020A-T: Cobalt	7440-48-4	0.001	mg/L	<0.001	0.100 mg/L	96.6	74	122
EG020A-T: Copper	7440-50-8	0.001	mg/L	<0.001	0.200 mg/L	86.2	75	119
EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.001	0.100 mg/L	97.2	80	116
EG020A-T: Lithium	7439-93-2	0.001	mg/L	<0.001	----	----	----	----
EG020A-T: Manganese	7439-96-5	0.001	mg/L	<0.001	0.100 mg/L	93.9	72	124
EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	<0.001	0.100 mg/L	94.9	80	112
EG020A-T: Nickel	7440-02-0	0.001	mg/L	<0.001	0.100 mg/L	91.9	75	121
EG020A-T: Selenium	7782-49-2	0.01	mg/L	----	0.100 mg/L	90.0	73	119
		0.010	mg/L	<0.010	----	----	----	----
EG020A-T: Thallium	7440-28-0	0.001	mg/L	<0.001	0.100 mg/L	99.0	80	116
EG020A-T: Tin	7440-31-5	0.001	mg/L	<0.001	0.100 mg/L	115	70	130
EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.01	0.100 mg/L	90.6	70.5	118
EG020A-T: Zinc	7440-66-6	0.005	mg/L	<0.005	0.200 mg/L	98.5	73	127
EG020A-T: Boron	7440-42-8	0.05	mg/L	<0.05	0.500 mg/L	94.4	70	128

Sub-Matrix: **WATER**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result	Concentration	LCS	Low	High
EG020T: Total Metals by ICP-MS (QCLot: 878524)								
EG020B-T: Bismuth	7440-69-9	0.001	mg/L	<0.001	0.100 mg/L	98.8	73	123
EG020B-T: Cerium	7440-45-1	0.001	mg/L	<0.001	----	----	----	----
EG020B-T: Silver	7440-22-4	0.001	mg/L	<0.001	0.100 mg/L	80.2	70	118
EG020B-T: Strontium	7440-24-6	0.001	mg/L	<0.001	0.500 mg/L	94.3	73	119
EG020B-T: Thorium	7440-29-1	0.001	mg/L	<0.001	----	----	----	----
EG020B-T: Titanium	7440-32-6	0.01	mg/L	<0.01	0.100 mg/L	95.7	74	120
EG020B-T: Uranium	7440-61-1	0.001	mg/L	<0.001	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 878525)								
EG020D-T: Yttrium	7440-65-5	0.001	mg/L	<0.001	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 878526)								
EG020E-T: Tungsten	7440-33-7	0.001	mg/L	<0.001	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 878527)								
EG020G-T: Rhenium	7440-15-5	0.001	mg/L	<0.001	----	----	----	----
EG035T: Total Recoverable Mercury by FIMS (QCLot: 876034)								
EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.0100 mg/L	96.5	82	122
EP006 Total Inorganic Carbon (QCLot: 875135)								
EP006: Total Inorganic Carbon	----	1	mg/L	<1	50 mg/L	126	70	130

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **WATER**

				Matrix Spike (MS) Report			
				Spike	Spike Recovery (%)	Recovery Limits (%)	
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
EG020T: Total Metals by ICP-MS (QCLot: 878523)							
EB0901048-002	3.1_04 R2 W2 L	EG020A-T: Arsenic	7440-38-2	1.000 mg/L	128	70	130
		EG020A-T: Beryllium	7440-41-7	0.100 mg/L	117	70	130
		EG020A-T: Barium	7440-39-3	1.000 mg/L	110	70	130
		EG020A-T: Cadmium	7440-43-9	0.500 mg/L	110	70	130
		EG020A-T: Chromium	7440-47-3	1.000 mg/L	109	70	130
		EG020A-T: Cobalt	7440-48-4	1.000 mg/L	# Not Determined	70	130
		EG020A-T: Copper	7440-50-8	1.000 mg/L	88.2	70	130
		EG020A-T: Lead	7439-92-1	1.000 mg/L	106	70	130
		EG020A-T: Manganese	7439-96-5	1.000 mg/L	# Not Determined	70	130
		EG020A-T: Nickel	7440-02-0	1.000 mg/L	103	70	130
		EG020A-T: Vanadium	7440-62-2	1.000 mg/L	106	70	130
		EG020A-T: Zinc	7440-66-6	1.000 mg/L	# Not Determined	70	130
EG035T: Total Recoverable Mercury by FIMS (QCLot: 876034)							
EB0901048-001	3.1_04 R1 W2 L	EG035T: Mercury	7439-97-6	0.0100 mg/L	95.7	70	130

INTERPRETIVE QUALITY CONTROL REPORT

Work Order	: **EB0901049**	Page	: 1 of 11
Client	: C S I R O AUSTRALIA	Laboratory	: Environmental Division Brisbane
Contact	: DR STUART SIMPSON	Contact	: Tim Kilmister
Address	: CENTRE FOR ENVIRONMENTAL CONTAMINANTS RESEARCH CSIRO ENERGY TECHNOLOGY NEW ILLAWARRA ROAD LUCAS HEIGHTS NSW, AUSTRALIA 2234	Address	: 32 Shand Street Stafford QLD Australia 4053
E-mail	: stuart.simpson@csiro.au	E-mail	: Services.Brisbane@alsenviro.com
Telephone	: +61 02 97106807	Telephone	: +61-7-3243 7222
Facsimile	: +61 02 97106837	Facsimile	: +61-7-3243 7218
Project	: ----	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Site	: ----		
C-O-C number	: ----	Date Samples Received	: 22-JAN-2009
Sampler	: ----	Issue Date	: 05-FEB-2009
Order number	: ----		
		No. of samples received	: 52
Quote number	: BN/328/08	No. of samples analysed	: 52

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 Interpretive Quality Control Report contains the following information:

- Analysis Holding Time Compliance
- Quality Control Parameter Frequency Compliance
- Brief Method Summaries
- Summary of Outliers

Analysis Holding Time Compliance

The following report summarises extraction / preparation and analysis times and compares with recommended holding times. Dates reported represent first date of extraction or analysis and precludes subsequent dilutions and reruns. Information is also provided re the sample container (preservative) from which the analysis aliquot was taken. Elapsed period to analysis represents number of days from sampling where no extraction / digestion is involved or period from extraction / digestion where this is present. For composite samples, sampling date is assumed to be that of the oldest sample contributing to the composite. Sample date for laboratory produced leachates is assumed as the completion date of the leaching process. Outliers for holding time are based on USEPA SW 846, APHA, AS and NEPM (1999). A listing of breaches is provided in the Summary of Outliers.

Holding times for leachate methods (excluding elutriates) vary according to the analytes being determined on the resulting solution. For non -volatile analytes, the holding time compliance assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These soil holding times are: Organics (14 days); Mercury (28 days) & other metals (180 days). A recorded breach therefore does not guarantee a breach for all non-volatile parameters.

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method		Sample Date	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)			**Date extracted**	Due for extraction	Evaluation	**Date analysed**	Due for analysis	Evaluation
ED037P: Alkalinity by PC Titrator								
Clear Plastic Bottle - Natural pH4.5_TL2W3 D/100, Core 1A_CO2W3 D/3, Core 4A_DOLCO2W3,	pH6.0_TLDOLW3 D/100, Core 1B_N2W3 D/3, Core 4B_DOLCO2W3	**14-JAN-2009**	**---**	---	----	**28-JAN-2009**	28-JAN-2009	✓
Clear Plastic Bottle - Natural O.D._TL2 D/100,	O.D._PW No. 1D/100	**15-JAN-2009**	**---**	---	----	**28-JAN-2009**	29-JAN-2009	✓
Clear Plastic Bottle - Natural pH4.5_TL2W2 D/100, Core 1A_CO2W2, Core 4A_DOLCO2W2,	pH6.0_TLDOLW2 D/100, Core 1B_N2W2, Core 4B_DOLCO2W2	**17-JAN-2009**	**---**	---	----	**28-JAN-2009**	31-JAN-2009	✓
ED038A: Acidity								
Clear Plastic Bottle - Natural pH4.5_TL2W3 D/100, Core 1A_CO2W3 D/3, Core 4A_DOLCO2W3,	pH6.0_TLDOLW3 D/100, Core 1B_N2W3 D/3, Core 4B_DOLCO2W3	**14-JAN-2009**	**----**	----	----	**28-JAN-2009**	28-JAN-2009	✓
Clear Plastic Bottle - Natural O.D._TL2 D/100,	O.D._PW No. 1D/100	**15-JAN-2009**	**----**	----	----	**28-JAN-2009**	29-JAN-2009	✓
Clear Plastic Bottle - Natural pH4.5_TL2W2 D/100, Core 1A_CO2W2, Core 4A_DOLCO2W2,	pH6.0_TLDOLW2 D/100, Core 1B_N2W2, Core 4B_DOLCO2W2	**17-JAN-2009**	**----**	----	----	**30-JAN-2009**	31-JAN-2009	✓

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method **Container** / Client Sample ID(s)	**Sample Date**	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	**Date analysed**	Due for analysis	Evaluation
ED040F: Dissolved Major Anions							
Clear Plastic Bottle - Natural O.D._TL2 D/100, O.D._PW No. 1D/100	**15-JAN-2009**	**---**	---	----	**29-JAN-2009**	12-FEB-2009	✓
Clear Plastic Bottle - Nitric Acid; Unfiltered R_N2TW5	**09-JAN-2009**	**---**	---	----	**02-FEB-2009**	06-FEB-2009	✓
Clear Plastic Bottle - Nitric Acid; Unfiltered R_OW-TW 10	**11-JAN-2009**	**---**	---	----	**02-FEB-2009**	08-FEB-2009	✓
Clear Plastic Bottle - Nitric Acid; Unfiltered pH4.5_TL2W3, pH6.0_TLDOLW3, Core 1A_CO2W3, Core 1B_N2W3, Core 4A_DOLCO2W3, Core 4B_DOLCO2W3, R-pH4.5_TL2W3, R-Core 1B_N2W3	**14-JAN-2009**	**---**	---	----	**02-FEB-2009**	11-FEB-2009	✓
Clear Plastic Bottle - Nitric Acid; Unfiltered O.D._TL2, O.D._PW No1	**15-JAN-2009**	**---**	---	----	**02-FEB-2009**	12-FEB-2009	✓
Clear Plastic Bottle - Nitric Acid; Unfiltered pH4.5_TL2W2, pH6.0_TLDOLW2, Core 1A_CO2W2, Core 1B_N2W2, Core 4A_DOLCO2W2, Core 4B_DOLCO2W2, R-Core 1B_N2W2	**17-JAN-2009**	**---**	---	----	**02-FEB-2009**	14-FEB-2009	✓
Miscellaneous Nitric Preserved - unspecified O.D._TL2D/10, O.D.-PWNo. 1D/10	**15-JAN-2009**	**---**	---	----	**02-FEB-2009**	12-FEB-2009	✓
ED045G: Chloride Discrete analyser							
Clear Plastic Bottle - Natural O.D._TL2 D/100, O.D._PW No. 1D/100	**15-JAN-2009**	**----**	----	----	**03-FEB-2009**	12-FEB-2009	✓

Matrix: **WATER**

Evaluation: ✘ = Holding time breach ; ✓ = Within holding time.

Method ***Container** / Client Sample ID(s)*	***Sample Date***	*Extraction / Preparation*			*Analysis*		
		Date extracted	*Due for extraction*	*Evaluation*	***Date analysed***	*Due for analysis*	*Evaluation*
ED093F: Dissolved Major Cations							
Clear Plastic Bottle - Natural O.D._TL2 D/100, O.D._PW No. 1D/100	**15-JAN-2009**	**---**	---	----	**29-JAN-2009**	12-FEB-2009	✓
Miscellaneous Nitric Preserved - unspecified R_N2TW5D/10	**09-JAN-2009**	**---**	---	----	**29-JAN-2009**	06-FEB-2009	✓
Miscellaneous Nitric Preserved - unspecified R_OW-TW10D/10	**11-JAN-2009**	**---**	---	----	**29-JAN-2009**	08-FEB-2009	✓
Miscellaneous Nitric Preserved - unspecified pH4.5_TL2W3D/10, pH6.0_TLDOLW3D/10, Core 1A_CO2W3D/10, Core 1B_N2W3D/10, Core 4A_DOLCO2W3D/10, Core 4B_DOLCO2W3D/10, R_pH4.5_TL2W3, R-Core 1B_N2W3D/10	**14-JAN-2009**	**---**	---	----	**29-JAN-2009**	11-FEB-2009	✓
Miscellaneous Nitric Preserved - unspecified O.D._TL2D/10, O.D.-PWNo. 1D/10	**15-JAN-2009**	**---**	---	----	**02-FEB-2009**	12-FEB-2009	✓
Miscellaneous Nitric Preserved - unspecified pH4.5_TL2W2D/10, pH6.0_TLDOLW2D/10, Core 1A_CO2W2D/10, Core 1B_N2W2D/10, Core 4A_DOLCO2WD/10, Core 4B_DOLCO2WD/10, R-Core 1B_N2W2D/10	**17-JAN-2009**	**---**	---	----	**29-JAN-2009**	14-FEB-2009	✓
EG020T: Total Metals by ICP-MS							
Clear Plastic Bottle - Nitric Acid; Unfiltered R_N2TW5	**09-JAN-2009**	**02-FEB-2009**	09-JAN-2009	✘	**02-FEB-2009**	08-JUL-2009	✓
Clear Plastic Bottle - Nitric Acid; Unfiltered R_OW-TW 10	**11-JAN-2009**	**02-FEB-2009**	11-JAN-2009	✘	**02-FEB-2009**	10-JUL-2009	✓
Clear Plastic Bottle - Nitric Acid; Unfiltered pH4.5_TL2W3, pH6.0_TLDOLW3, Core 1A_CO2W3, Core 1B_N2W3, Core 4A_DOLCO2W3, Core 4B_DOLCO2W3, R-pH4.5_TL2W3, R-Core 1B_N2W3	**14-JAN-2009**	**02-FEB-2009**	14-JAN-2009	✘	**02-FEB-2009**	13-JUL-2009	✓
Clear Plastic Bottle - Nitric Acid; Unfiltered O.D._TL2, O.D._PW No1	**15-JAN-2009**	**02-FEB-2009**	15-JAN-2009	✘	**02-FEB-2009**	14-JUL-2009	✓
Clear Plastic Bottle - Nitric Acid; Unfiltered pH4.5_TL2W2, pH6.0_TLDOLW2, Core 1A_CO2W2, Core 1B_N2W2, Core 4A_DOLCO2W2, Core 4B_DOLCO2W2, R-Core 1B_N2W2	**17-JAN-2009**	**02-FEB-2009**	17-JAN-2009	✘	**02-FEB-2009**	16-JUL-2009	✓
Miscellaneous Nitric Preserved - unspecified O.D._TL2D/10, O.D.-PWNo. 1D/10	**15-JAN-2009**	**02-FEB-2009**	15-JAN-2009	✘	**02-FEB-2009**	15-JAN-2009	✘

Matrix: **WATER**

Evaluation: ✗ = Holding time breach ; ✓ = Within holding time.

Method	***Sample Date***	*Extraction / Preparation*			*Analysis*		
***Container** / Client Sample ID(s)*		***Date extracted***	*Due for extraction*	*Evaluation*	***Date analysed***	*Due for analysis*	*Evaluation*
EG035T: Total Recoverable Mercury by FIMS							
Clear Plastic Bottle - Nitric Acid; Unfiltered R_N2TW5	**09-JAN-2009**	**----**	----	----	**02-FEB-2009**	06-FEB-2009	✓
Clear Plastic Bottle - Nitric Acid; Unfiltered R_OW-TW 10	**11-JAN-2009**	**----**	----	----	**02-FEB-2009**	08-FEB-2009	✓
Clear Plastic Bottle - Nitric Acid; Unfiltered pH4.5_TL2W3, pH6.0_TLDOLW3, Core 1A_CO2W3, Core 1B_N2W3, Core 4A_DOLCO2W3, Core 4B_DOLCO2W3, R-pH4.5_TL2W3, R-Core 1B_N2W3	**14-JAN-2009**	**----**	----	----	**02-FEB-2009**	11-FEB-2009	✓
Clear Plastic Bottle - Nitric Acid; Unfiltered O.D._TL2, O.D._PW No1	**15-JAN-2009**	**----**	----	----	**02-FEB-2009**	12-FEB-2009	✓
Clear Plastic Bottle - Nitric Acid; Unfiltered pH4.5_TL2W2, pH6.0_TLDOLW2, Core 1A_CO2W2, Core 1B_N2W2, Core 4A_DOLCO2W2, Core 4B_DOLCO2W2, R-Core 1B_N2W2	**17-JAN-2009**	**----**	----	----	**02-FEB-2009**	14-FEB-2009	✓
Miscellaneous Nitric Preserved - unspecified O.D._TL2D/10, O.D.-PWNo. 1D/10	**15-JAN-2009**	**----**	----	----	**02-FEB-2009**	29-JAN-2009	✗
EP006 Total Inorganic Carbon							
Clear Plastic Bottle - Natural pH4.5_TL2W3 D/100, pH6.0_TLDOLW3 D/100, Core 1A_CO2W3 D/3, Core 1B_N2W3 D/3, Core 4A_DOLCO2W3, Core 4B_DOLCO2W3	**14-JAN-2009**	**---**	---	----	**28-JAN-2009**	28-JAN-2009	✓
Clear Plastic Bottle - Natural O.D._TL2 D/100, O.D._PW No. 1D/100	**15-JAN-2009**	**---**	---	----	**28-JAN-2009**	29-JAN-2009	✓
Clear Plastic Bottle - Natural pH4.5_TL2W2 D/100, pH6.0_TLDOLW2 D/100, Core 1A_CO2W2, Core 1B_N2W2, Core 4A_DOLCO2W2, Core 4B_DOLCO2W2	**17-JAN-2009**	**---**	---	----	**28-JAN-2009**	31-JAN-2009	✓

Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(where) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **WATER**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			*Quality Control Specification*
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Duplicates (DUP)							
Acidity as Calcium Carbonate	ED038	4	40	**10.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Alkalinity by PC Titrator	ED037-P	5	24	**20.8**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Chloride by Discrete Analyser	ED045G	1	2	**50.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Chloride by PC Titrator	ED045-P	2	18	**11.1**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Major Anions - Filtered	ED040F	3	21	**14.3**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Major Cations - Filtered	ED093F	5	38	**13.2**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Inorganic Carbon & Dissolved Inorganic Carbon	EP006	3	26	**11.5**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Mercury by FIMS	EG035T	4	38	**10.5**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-MS - Suite A	EG020A-T	4	37	**10.8**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-MS - Suite B	EG020B-T	4	38	**10.5**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-MS - Suite D	EG020D-T	4	38	**10.5**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-MS - Suite E	EG020E-T	4	38	**10.5**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-MS - Suite G	EG020G-T	3	38	**7.9**	**10.0**	×	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Laboratory Control Samples (LCS)							
Acidity as Calcium Carbonate	ED038	2	40	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Alkalinity by PC Titrator	ED037-P	3	24	**12.5**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Chloride by Discrete Analyser	ED045G	2	2	**100.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Chloride by PC Titrator	ED045-P	1	18	**5.6**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Major Anions - Filtered	ED040F	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Major Cations - Filtered	ED093F	2	36	**5.6**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Inorganic Carbon & Dissolved Inorganic Carbon	EP006	2	26	**7.7**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Mercury by FIMS	EG035T	2	38	**5.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-MS - Suite A	EG020A-T	3	38	**7.9**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-MS - Suite B	EG020B-T	2	38	**5.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Method Blanks (MB)							
Acidity as Calcium Carbonate	ED038	2	40	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Chloride by Discrete Analyser	ED045G	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Chloride by PC Titrator	ED045-P	1	18	**5.6**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Major Anions - Filtered	ED040F	3	23	**13.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Major Cations - Filtered	ED093F	3	38	**7.9**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Inorganic Carbon & Dissolved Inorganic Carbon	EP006	2	26	**7.7**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Mercury by FIMS	EG035T	2	38	**5.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-MS - Suite A	EG020A-T	3	38	**7.9**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-MS - Suite B	EG020B-T	2	38	**5.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-MS - Suite D	EG020D-T	2	38	**5.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement

Matrix: **WATER**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Method Blanks (MB) - Continued							
Total Metals by ICP-MS - Suite E	EG020E-T	2	38	**5.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-MS - Suite G	EG020G-T	2	38	**5.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Matrix Spikes (MS)							
Chloride by Discrete Analyser	ED045G	1	2	**50.0**	**5.0**	✓	ALS QCS3 requirement
Chloride by PC Titrator	ED045-P	1	18	**5.6**	**5.0**	✓	ALS QCS3 requirement
Total Mercury by FIMS	EG035T	2	38	**5.3**	**5.0**	✓	ALS QCS3 requirement
Total Metals by ICP-MS - Suite A	EG020A-T	2	37	**5.4**	**5.0**	✓	ALS QCS3 requirement

Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	*Method*	*Matrix*	*Method Descriptions*
Alkalinity by PC Titrator	ED037-P	WATER	APHA 21st ed., 2320 B This procedure determines alkalinity by both manual measurement and automated measurement (e.g. PC Titrate) using pH 4.5 for indicating the total alkalinity end-point. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Acidity as Calcium Carbonate	ED038	WATER	APHA 21st ed., 2310 B Acidity is determined by titration with a standardised alkali to an end-point pH of 8.3. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Major Anions - Filtered	ED040F	WATER	APHA 21st ed., 3120 Sulfur and/or Silcon content is determined by ICP/AES and reported as Sulfate and/or Silica after conversion by gravimetric factor.
Chloride by Discrete Analyser	ED045G	WATER	The thiocyanate ion is liberated from mercuric thiocyanate through sequestration of mercury by the chloride ion to form non-ionised mercuric chloride.in the presence of ferric ions the librated thiocynate forms highly-coloured ferric thiocynate which is measured at 480 nm APHA 21st edition seal method 2 017-1-L april 2003
Chloride by PC Titrator	ED045-P	WATER	APHA 21st ed., 4500 Cl - B. Automated Silver Nitrate titration.
Major Cations - Filtered	ED093F	WATER	APHA 21st ed., 3120; USEPA SW 846 - 6010 The ICPAES technique ionises filtered sample atoms emitting a characteristic spectrum. This spectrum is then compared against matrix matched standards for quantification. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Total Metals by ICP-MS - Suite A	EG020A-T	WATER	(APHA 21st ed., 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020): The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Total Metals by ICP-MS - Suite B	EG020B-T	WATER	(APHA 21st ed., 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020): The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Total Metals by ICP-MS - Suite D	EG020D-T	WATER	(APHA 21st ed., 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020): The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Total Metals by ICP-MS - Suite E	EG020E-T	WATER	(APHA 21st ed., 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020): The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Total Metals by ICP-MS - Suite G	EG020G-T	WATER	(APHA 21st ed., 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020): The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.

Analytical Methods	Method	Matrix	Method Descriptions
Total Mercury by FIMS	EG035T	WATER	AS 3550, APHA 21st ed. 3112 Hg - B (Flow-injection (SnCl2)(Cold Vapour generation) AAS) FIM-AAS is an automated flameless atomic absorption technique. A bromate/bromide reagent is used to oxidise any organic mercury compounds in the unfiltered sample. The ionic mercury is reduced online to atomic mercury vapour by SnCl2 which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Silica (Total Dissolved) by ICPAES	EG052	WATER	APHA 21st ed., 4500-SiO2. Silica (Total) determined by calculation from Silicon by ICPAES.
Ionic Balance by PCT and ICPAES	EN055	WATER	APHA 21st Ed. 1030F. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Total Inorganic Carbon & Dissolved Inorganic Carbon	EP006	WATER	APHA 21st ed., 5310 B The automated carbon analyzer removes Inorganic carbon as CO2, which is swept into an IR detector. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)

Preparation Methods	Method	Matrix	Method Descriptions
Digestion for Total Recoverable Metals	EN25	WATER	USEPA SW846-3005 Method 3005 is a Nitric/Hydrochloric acid digestion procedure used to prepare surface and ground water samples for analysis by ICPAES or ICPMS. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)

Summary of Outliers

Outliers : Quality Control Samples

The following report highlights outliers flagged in the Quality Control (QC) Report. Surrogate recovery limits are static and based on USEPA SW846 or ALS-QWI/EN/38 (in the absence of specific USEPA limits). This report displays QC Outliers (breaches) only.

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Matrix: **WATER**

Compound Group Name	Laboratory Sample ID	Client Sample ID	Analyte	CAS Number	Data	Limits	Comment
Duplicate (DUP) RPDs							
ED037P: Alkalinity by PC Titrator	EB0901049-033	Core 4B_DOLCO2W3D/10	**Hydroxide Alkalinity as CaCO3**	DMO-210-001	Not Determined		**Analyte not determined in allocated original sample.**
ED037P: Alkalinity by PC Titrator	EB0901049-033	Core 4B_DOLCO2W3D/10	**Carbonate Alkalinity as CaCO3**	3812-32-6	Not Determined		**Analyte not determined in allocated original sample.**
ED037P: Alkalinity by PC Titrator	EB0901049-033	Core 4B_DOLCO2W3D/10	**Total Alkalinity as CaCO3**	----	Not Determined		**Analyte not determined in allocated original sample.**
Matrix Spike (MS) Recoveries							
EG020T: Total Metals by ICP-MS	EB0901049-005	pH6.0_TLDOLW2	**Arsenic**	7440-38-2	Not Determined	----	**Background level of analyte not determined in original.**
EG020T: Total Metals by ICP-MS	EB0901049-005	pH6.0_TLDOLW2	**Beryllium**	7440-41-7	Not Determined	----	**Background level of analyte not determined in original.**
EG020T: Total Metals by ICP-MS	EB0901048-002	Anonymous	**Cobalt**	7440-48-4	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
EG020T: Total Metals by ICP-MS	EB0901049-005	pH6.0_TLDOLW2	**Copper**	7440-50-8	Not Determined	----	**Matrix spike recovery not determined due to sample matrix interference.**
EG020T: Total Metals by ICP-MS	EB0901049-005	pH6.0_TLDOLW2	**Lead**	7439-92-1	Not Determined	----	**Background level of analyte not determined in original.**
EG020T: Total Metals by ICP-MS	EB0901049-005	pH6.0_TLDOLW2	**Manganese**	7439-96-5	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
EG020T: Total Metals by ICP-MS	EB0901048-002	Anonymous	**Manganese**	7439-96-5	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
EG020T: Total Metals by ICP-MS	EB0901049-005	pH6.0_TLDOLW2	**Vanadium**	7440-62-2	Not Determined	----	**Background level of analyte not determined in original.**
EG020T: Total Metals by ICP-MS	EB0901048-002	Anonymous	**Zinc**	7440-66-6	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**

- **For all matrices, no Method Blank value outliers occur.**
- **For all matrices, no Laboratory Control outliers occur.**

Regular Sample Surrogates

- **For all regular sample matrices, no surrogate recovery outliers occur.**

Outliers : Analysis Holding Time Compliance

This report displays Holding Time breaches only. Only the respective Extraction / Preparation and/or Analysis component is/are displayed.

Matrix: **WATER**

Method	*Extraction / Preparation*			*Analysis*		
Container / Client Sample ID(s)	*Date extracted*	*Due for extraction*	**Days overdue**	*Date analysed*	*Due for analysis*	**Days overdue**
EG020T: Total Metals by ICP-MS						
Clear Plastic Bottle - Nitric Acid; Unfiltered R_N2TW5	02-FEB-2009	09-JAN-2009	**24**	----	----	----
Clear Plastic Bottle - Nitric Acid; Unfiltered R_OW-TW 10	02-FEB-2009	11-JAN-2009	**22**	----	----	----
Clear Plastic Bottle - Nitric Acid; Unfiltered pH4.5_TL2W3, pH6.0_TLDOLW3, Core 1A_CO2W3, Core 1B_N2W3, Core 4A_DOLCO2W3, Core 4B_DOLCO2W3, R-pH4.5_TL2W3, R-Core 1B_N2W3	02-FEB-2009	14-JAN-2009	**19**	----	----	----
Clear Plastic Bottle - Nitric Acid; Unfiltered O.D._TL2, O.D._PW No1	02-FEB-2009	15-JAN-2009	**18**	----	----	----
Clear Plastic Bottle - Nitric Acid; Unfiltered pH4.5_TL2W2, pH6.0_TLDOLW2, Core 1A_CO2W2, Core 1B_N2W2, Core 4A_DOLCO2W2, Core 4B_DOLCO2W2, R-Core 1B_N2W2	02-FEB-2009	17-JAN-2009	**16**	----	----	----
Miscellaneous Nitric Preserved - unspecified O.D._TL2D/10, O.D.-PWNo. 1D/10	02-FEB-2009	15-JAN-2009	**18**	02-FEB-2009	15-JAN-2009	**18**
EG035T: Total Recoverable Mercury by FIMS						
Miscellaneous Nitric Preserved - unspecified O.D._TL2D/10, O.D.-PWNo. 1D/10	----	----	----	02-FEB-2009	29-JAN-2009	**4**

Outliers : Frequency of Quality Control Samples

The following report highlights breaches in the Frequency of Quality Control Samples.

Matrix: **WATER**

Quality Control Sample Type	Count		Rate (%)		Quality Control Specification
Method	QC	Regular	Actual	Expected	
Laboratory Duplicates (DUP)					
Total Metals by ICP-MS - Suite G	3	38	7.9	10.0	NEPM 1999 Schedule B(3) and ALS QCS3 requirement

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES

Environmental Division

QUALITY CONTROL REPORT

Work Order : **EB0901049**

Client : **C S I R O AUSTRALIA**
Contact : DR STUART SIMPSON
Address : CENTRE FOR ENVIRONMENTAL CONTAMINANTS RESEARCH
CSIRO ENERGY TECHNOLOGY
NEW ILLAWARRA ROAD
LUCAS HEIGHTS NSW, AUSTRALIA 2234

E-mail : stuart.simpson@csiro.au
Telephone : +61 02 97106807
Facsimile : +61 02 97106837

Project : ----
Site : ----
C-O-C number : ----
Sampler : ----
Order number : ----

Quote number : BN/328/08

Page : 1 of 12

Laboratory : Environmental Division Brisbane
Contact : Tim Kilmister
Address : 32 Shand Street Stafford QLD Australia 4053

E-mail : Services.Brisbane@alsenviro.com
Telephone : +61-7-3243 7222
Facsimile : +61-7-3243 7218

QC Level : NEPM 1999 Schedule B(3) and ALS QCS3 requirement

Date Samples Received : 22-JAN-2009
Issue Date : 05-FEB-2009

No. of samples received : 52
No. of samples analysed : 52

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 Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

NATA
WORLD RECOGNISED ACCREDITATION

NATA Accredited Laboratory 825

This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

Signatories

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

Signatories	*Position*	*Accreditation Category*
Celine Conceicao	Spectroscopist	Inorganics
Hoa Nguyen	Inorganic Chemist	Inorganics
Stephen Hislop	Senior Inorganic Chemist	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 insuffient 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.

Key :
Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
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
RPD = Relative Percentage Difference
# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR:- No Limit; Result between 10 and 20 times LOR:- 0% - 50%; Result > 20 times LOR:- 0% - 20%.

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
ED037P: Alkalinity by PC Titrator (QC Lot: 875142)									
EB0901049-033	Core 4B_DOLCO2W3D/10	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	----	<1	# Not Determined	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	----	<1	# Not Determined	No Limit
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	----	<1	# Not Determined	No Limit
EB0901049-042	pH4.5_TL2W3 D/100	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	<1	<1	0.0	No Limit
ED038A: Acidity (QC Lot: 875002)									
EB0901048-035	Anonymous	ED038: Acidity as CaCO3	----	1	mg/L	4300	4310	0.2	0% - 20%
EB0901048-044	Anonymous	ED038: Acidity as CaCO3	----	1	mg/L	24600	24600	0.1	0% - 20%
ED038A: Acidity (QC Lot: 877071)									
EB0901049-041	pH4.5_TL2W2 D/100	ED038: Acidity as CaCO3	----	1	mg/L	491	501	2.1	0% - 20%
ES0901072-004	Anonymous	ED038: Acidity as CaCO3	----	1	mg/L	982	982	0.0	0% - 20%
ED040F: Dissolved Major Anions (QC Lot: 877352)									
EB0901049-001	O.D._TL2	ED040F: Silicon	7440-21-3	0.05	mg/L	40.2	45.6	12.4	0% - 20%
EB0901049-020	O.D._TL2D/10	ED040F: Silicon	7440-21-3	0.05	mg/L	4.39	4.92	11.3	0% - 20%
ED040F: Dissolved Major Anions (QC Lot: 877354)									
EB0901049-021	O.D.-PWNo. 1D/10	ED040F: Silicon	7440-21-3	0.05	mg/L	3.88	4.02	3.4	0% - 20%
ED045G: Chloride Discrete analyser (QC Lot: 879575)									
EB0901049-039	O.D._TL2 D/100	ED045G: Chloride	16887-00-6	1	mg/L	62	62	0.0	0% - 20%
ED093F: Dissolved Major Cations (QC Lot: 875731)									
EB0901048-018	Anonymous	ED093F: Calcium	7440-70-2	1	mg/L	49	49	0.0	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	68	68	0.0	0% - 20%
		ED093F: Sodium	7440-23-5	1	mg/L	183	182	0.7	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	48	47	0.0	0% - 20%
EB0901048-028	Anonymous	ED093F: Calcium	7440-70-2	1	mg/L	48	50	3.8	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	174	180	3.7	0% - 20%
		ED093F: Sodium	7440-23-5	1	mg/L	198	198	0.0	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	66	65	1.8	0% - 20%
ED093F: Dissolved Major Cations (QC Lot: 875733)									
EB0901049-025	pH6.0_TLDOLW3D/10	ED093F: Calcium	7440-70-2	1	mg/L	55	54	0.0	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	16	16	0.0	0% - 50%

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
ED093F: Dissolved Major Cations (QC Lot: 875733) - continued									
EB0901049-025	pH6.0_TLDOLW3D/10	ED093F: Sodium	7440-23-5	1	mg/L	210	204	2.6	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	34	34	0.0	0% - 20%
EB0901049-036	R_pH4.5_TL2W3	ED093F: Calcium	7440-70-2	1	mg/L	76	74	1.7	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	104	103	1.0	0% - 20%
		ED093F: Sodium	7440-23-5	1	mg/L	222	232	4.4	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	69	72	4.2	0% - 20%
ED093F: Dissolved Major Cations (QC Lot: 877353)									
EB0901049-020	O.D._TL2D/10	ED093F: Calcium	7440-70-2	1	mg/L	77	86	11.0	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	303	316	4.1	0% - 20%
		ED093F: Sodium	7440-23-5	1	mg/L	701	799	13.0	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	229	258	11.9	0% - 20%
EG020T: Total Metals by ICP-MS (QC Lot: 878523)									
EB0901048-001	Anonymous	EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	0.0078	0.0080	3.5	0% - 20%
		EG020A-T: Antimony	7440-36-0	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-T: Arsenic	7440-38-2	0.001	mg/L	<0.010	0.011	0.0	0% - 50%
		EG020A-T: Beryllium	7440-41-7	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-T: Barium	7440-39-3	0.001	mg/L	0.029	0.027	8.4	0% - 20%
		EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-T: Cobalt	7440-48-4	0.001	mg/L	34.0	34.5	1.3	0% - 20%
		EG020A-T: Copper	7440-50-8	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-T: Lithium	7439-93-2	0.001	mg/L	2.74	2.82	2.7	0% - 20%
		EG020A-T: Manganese	7439-96-5	0.001	mg/L	103	103	0.2	0% - 20%
		EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-T: Nickel	7440-02-0	0.001	mg/L	1.92	1.90	0.8	0% - 20%
		EG020A-T: Thallium	7440-28-0	0.001	mg/L	0.014	0.014	0.0	0% - 50%
		EG020A-T: Tin	7440-31-5	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-T: Zinc	7440-66-6	0.005	mg/L	4.57	4.54	0.6	0% - 20%
		EG020A-T: Aluminium	7429-90-5	0.01	mg/L	2.07	1.99	4.0	0% - 20%
		EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.10	<0.10	0.0	No Limit
		EG020A-T: Selenium	7782-49-2	0.010	mg/L	0.059	0.068	15.4	No Limit
		EG020A-T: Boron	7440-42-8	0.05	mg/L	1.52	1.46	4.5	0% - 20%
EB0901048-010	Anonymous	EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	0.0235	0.0220	7.0	0% - 20%
		EG020A-T: Antimony	7440-36-0	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-T: Arsenic	7440-38-2	0.001	mg/L	0.028	0.040	33.7	0% - 20%
		EG020A-T: Beryllium	7440-41-7	0.001	mg/L	0.310	0.298	3.9	0% - 20%
		EG020A-T: Barium	7440-39-3	0.001	mg/L	0.077	0.077	0.0	0% - 20%
		EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-T: Cobalt	7440-48-4	0.001	mg/L	54.7	52.5	4.2	0% - 20%

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EG020T: Total Metals by ICP-MS (QC Lot: 878523) - continued									
EB0901048-010	Anonymous	EG020A-T: Copper	7440-50-8	0.001	mg/L	710	697	1.8	0% - 20%
		EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-T: Lithium	7439-93-2	0.001	mg/L	6.21	6.20	0.1	0% - 20%
		EG020A-T: Manganese	7439-96-5	0.001	mg/L	131	127	3.0	0% - 20%
		EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-T: Nickel	7440-02-0	0.001	mg/L	5.11	5.00	2.3	0% - 20%
		EG020A-T: Thallium	7440-28-0	0.001	mg/L	0.031	0.032	0.0	0% - 20%
		EG020A-T: Tin	7440-31-5	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-T: Zinc	7440-66-6	0.005	mg/L	22.5	21.8	2.9	0% - 20%
		EG020A-T: Aluminium	7429-90-5	0.01	mg/L	2120	2030	4.1	0% - 20%
		EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.10	<0.10	0.0	No Limit
		EG020A-T: Selenium	7782-49-2	0.010	mg/L	0.308	0.306	0.6	0% - 20%
		EG020A-T: Boron	7440-42-8	0.05	mg/L	2.36	2.32	1.7	0% - 20%
EG020T: Total Metals by ICP-MS (QC Lot: 878524)									
EB0901048-001	Anonymous	EG020B-T: Bismuth	7440-69-9	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020B-T: Cerium	7440-45-1	0.001	mg/L	0.211	0.212	0.0	0% - 20%
		EG020B-T: Silver	7440-22-4	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020B-T: Strontium	7440-24-6	0.001	mg/L	2.18	2.21	1.3	0% - 20%
		EG020B-T: Thorium	7440-29-1	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020B-T: Uranium	7440-61-1	0.001	mg/L	5.00	4.98	0.4	0% - 20%
		EG020B-T: Titanium	7440-32-6	0.01	mg/L	<0.10	<0.10	0.0	No Limit
EB0901048-010	Anonymous	EG020B-T: Bismuth	7440-69-9	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020B-T: Cerium	7440-45-1	0.001	mg/L	58.5	56.8	2.9	0% - 20%
		EG020B-T: Silver	7440-22-4	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020B-T: Strontium	7440-24-6	0.001	mg/L	2.95	2.88	2.4	0% - 20%
		EG020B-T: Thorium	7440-29-1	0.001	mg/L	0.015	0.014	7.5	0% - 50%
		EG020B-T: Uranium	7440-61-1	0.001	mg/L	34.9	34.6	1.0	0% - 20%
		EG020B-T: Titanium	7440-32-6	0.01	mg/L	<0.10	<0.10	0.0	No Limit
EG020T: Total Metals by ICP-MS (QC Lot: 878525)									
EB0901048-001	Anonymous	EG020D-T: Yttrium	7440-65-5	0.001	mg/L	0.078	0.080	1.7	0% - 20%
EB0901048-010	Anonymous	EG020D-T: Yttrium	7440-65-5	0.001	mg/L	15.1	14.5	3.7	0% - 20%
EG020T: Total Metals by ICP-MS (QC Lot: 878526)									
EB0901048-001	Anonymous	EG020E-T: Tungsten	7440-33-7	0.001	mg/L	<0.010	<0.010	0.0	No Limit
EB0901048-010	Anonymous	EG020E-T: Tungsten	7440-33-7	0.001	mg/L	0.014	0.014	0.0	0% - 50%
EG020T: Total Metals by ICP-MS (QC Lot: 878527)									
EB0901048-010	Anonymous	EG020G-T: Rhenium	7440-15-5	0.001	mg/L	0.002	0.002	0.0	No Limit
EB0901049-003	pH4.5_TL2W2	EG020G-T: Rhenium	7440-15-5	0.001	mg/L	0.002	0.002	0.0	No Limit
EG020T: Total Metals by ICP-MS (QC Lot: 878528)									
EB0901049-003	pH4.5_TL2W2	EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	0.0182	0.0198	8.7	0% - 20%

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EG020T: Total Metals by ICP-MS (QC Lot: 878528) - continued									
EB0901049-003	pH4.5_TL2W2	EG020A-T: Antimony	7440-36-0	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-T: Arsenic	7440-38-2	0.001	mg/L	0.023	0.037	47.3	0% - 20%
		EG020A-T: Beryllium	7440-41-7	0.001	mg/L	0.272	0.267	2.0	0% - 20%
		EG020A-T: Barium	7440-39-3	0.001	mg/L	0.064	0.065	1.9	0% - 20%
		EG020A-T: Chromium	7440-47-3	0.001	mg/L	0.016	0.029	59.1	0% - 20%
		EG020A-T: Cobalt	7440-48-4	0.001	mg/L	52.4	52.6	0.2	0% - 20%
		EG020A-T: Copper	7440-50-8	0.001	mg/L	575	582	1.2	0% - 20%
		EG020A-T: Lead	7439-92-1	0.001	mg/L	0.048	0.046	0.0	0% - 20%
		EG020A-T: Lithium	7439-93-2	0.001	mg/L	6.37	6.48	1.7	0% - 20%
		EG020A-T: Manganese	7439-96-5	0.001	mg/L	126	128	1.7	0% - 20%
		EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	0.013	0.011	16.6	0% - 50%
		EG020A-T: Nickel	7440-02-0	0.001	mg/L	4.67	4.72	1.2	0% - 20%
		EG020A-T: Thallium	7440-28-0	0.001	mg/L	0.033	0.032	0.0	0% - 20%
		EG020A-T: Tin	7440-31-5	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-T: Zinc	7440-66-6	0.005	mg/L	21.0	21.0	0.1	0% - 20%
		EG020A-T: Aluminium	7429-90-5	0.01	mg/L	2620	2620	0.09	0% - 20%
		EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.10	<0.10	0.0	No Limit
		EG020A-T: Selenium	7782-49-2	0.010	mg/L	0.229	0.287	22.6	0% - 20%
		EG020A-T: Boron	7440-42-8	0.05	mg/L	2.28	2.22	2.5	0% - 20%
EB0901049-013	Core 4A_DOLCO2W3	EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	0.0025	0.0024	5.0	0% - 20%
		EG020A-T: Antimony	7440-36-0	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-T: Arsenic	7440-38-2	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-T: Beryllium	7440-41-7	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-T: Barium	7440-39-3	0.001	mg/L	0.074	0.069	6.5	0% - 20%
		EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-T: Cobalt	7440-48-4	0.001	mg/L	2.21	2.15	2.6	0% - 20%
		EG020A-T: Copper	7440-50-8	0.001	mg/L	0.039	0.037	4.4	0% - 20%
		EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-T: Lithium	7439-93-2	0.001	mg/L	2.92	2.93	0.2	0% - 20%
		EG020A-T: Manganese	7439-96-5	0.001	mg/L	56.8	55.3	2.6	0% - 20%
		EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-T: Nickel	7440-02-0	0.001	mg/L	0.103	0.101	2.2	0% - 20%
		EG020A-T: Thallium	7440-28-0	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-T: Tin	7440-31-5	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-T: Zinc	7440-66-6	0.005	mg/L	0.386	0.382	1.1	0% - 20%
		EG020A-T: Aluminium	7429-90-5	0.01	mg/L	0.30	0.27	12.4	0% - 20%
		EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.10	<0.10	0.0	No Limit
		EG020A-T: Selenium	7782-49-2	0.010	mg/L	<0.050	<0.050	0.0	No Limit
		EG020A-T: Boron	7440-42-8	0.05	mg/L	0.65	0.63	2.2	0% - 50%

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EG020T: Total Metals by ICP-MS (QC Lot: 878530)									
EB0901049-003	pH4.5_TL2W2	EG020B-T: Bismuth	7440-69-9	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020B-T: Cerium	7440-45-1	0.001	mg/L	59.6	59.2	0.6	0% - 20%
		EG020B-T: Silver	7440-22-4	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020B-T: Strontium	7440-24-6	0.001	mg/L	2.68	2.64	1.8	0% - 20%
		EG020B-T: Thorium	7440-29-1	0.001	mg/L	0.037	0.025	39.1	0% - 20%
		EG020B-T: Uranium	7440-61-1	0.001	mg/L	29.0	27.6	5.0	0% - 20%
		EG020B-T: Titanium	7440-32-6	0.01	mg/L	<0.10	<0.10	0.0	No Limit
EB0901049-013	Core 4A_DOLCO2W3	EG020B-T: Bismuth	7440-69-9	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020B-T: Cerium	7440-45-1	0.001	mg/L	0.093	<0.010	161	No Limit
		EG020B-T: Silver	7440-22-4	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020B-T: Strontium	7440-24-6	0.001	mg/L	1.46	1.46	0.2	0% - 20%
		EG020B-T: Thorium	7440-29-1	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020B-T: Uranium	7440-61-1	0.001	mg/L	0.091	0.014	147	0% - 50%
		EG020B-T: Titanium	7440-32-6	0.01	mg/L	<0.10	<0.10	0.0	No Limit
EG020T: Total Metals by ICP-MS (QC Lot: 878533)									
EB0901049-003	pH4.5_TL2W2	EG020D-T: Yttrium	7440-65-5	0.001	mg/L	18.3	18.1	1.3	0% - 20%
EB0901049-013	Core 4A_DOLCO2W3	EG020D-T: Yttrium	7440-65-5	0.001	mg/L	0.025	<0.010	85.9	No Limit
EG020T: Total Metals by ICP-MS (QC Lot: 878535)									
EB0901049-003	pH4.5_TL2W2	EG020E-T: Tungsten	7440-33-7	0.001	mg/L	0.013	0.013	0.0	0% - 50%
EB0901049-013	Core 4A_DOLCO2W3	EG020E-T: Tungsten	7440-33-7	0.001	mg/L	<0.010	<0.010	0.0	No Limit
EG020T: Total Metals by ICP-MS (QC Lot: 878536)									
EB0901049-013	Core 4A_DOLCO2W3	EG020G-T: Rhenium	7440-15-5	0.001	mg/L	<0.001	<0.001	0.0	No Limit
EG035T: Total Recoverable Mercury by FIMS (QC Lot: 876034)									
EB0901048-002	Anonymous	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EB0901048-011	Anonymous	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EG035T: Total Recoverable Mercury by FIMS (QC Lot: 876035)									
EB0901049-005	pH6.0_TLDOLW2	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EB0901049-014	Core 4B_DOLCO2W3	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EP006 Total Inorganic Carbon (QC Lot: 875135)									
EB0901048-035	Anonymous	EP006: Total Inorganic Carbon	----	1	mg/L	<1	<1	0.0	No Limit
EB0901048-044	Anonymous	EP006: Total Inorganic Carbon	----	1	mg/L	<1	<1	0.0	No Limit
EP006 Total Inorganic Carbon (QC Lot: 875136)									
EB0901049-047	Core 4A_DOLCO2W2	EP006: Total Inorganic Carbon	----	1	mg/L	<1	<1	0.0	No Limit
Sample Preparation Method (QC Lot: 875141)									
EB0901049-025	pH6.0_TLDOLW3D/10	PCT-DP: Dummy Analyte	----	----	-	----	----	----	0% - 20%

Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **WATER**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result	Concentration	LCS	Low	High
ED037P: Alkalinity by PC Titrator (QCLot: 875142)								
ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	----	200 mg/L	103	80.2	108
ED038A: Acidity (QCLot: 875002)								
ED038: Acidity as CaCO3	----	1	mg/L	<1	20 mg/L	93.3	89.8	103
ED038A: Acidity (QCLot: 877071)								
ED038: Acidity as CaCO3	----	1	mg/L	<1	20 mg/L	102	89.8	103
ED040F: Dissolved Major Anions (QCLot: 875732)								
ED040F: Sulfate as SO4 2-	14808-79-8	1	mg/L	<1	150 mg/L	96.8	82.9	114
ED040F: Dissolved Major Anions (QCLot: 877352)								
ED040F: Silicon	7440-21-3	0.05	mg/L	<0.05	----	----	----	----
ED040F: Dissolved Major Anions (QCLot: 877354)								
ED040F: Silicon	7440-21-3	0.05	mg/L	<0.05	----	----	----	----
ED045G: Chloride Discrete analyser (QCLot: 879575)								
ED045G: Chloride	16887-00-6	1	mg/L	<1	50 mg/L	109	83.7	124
ED093F: Dissolved Major Cations (QCLot: 875731)								
ED093F: Calcium	7440-70-2	1	mg/L	<1	50 mg/L	99.4	82.9	121
ED093F: Magnesium	7439-95-4	1	mg/L	<1	50 mg/L	98.1	82.7	114
ED093F: Sodium	7440-23-5	1	mg/L	<1	50 mg/L	95.1	77.4	113
ED093F: Potassium	7440-09-7	1	mg/L	<1	50 mg/L	96.7	84.3	118
ED093F: Dissolved Major Cations (QCLot: 875733)								
ED093F: Calcium	7440-70-2	1	mg/L	<1	50 mg/L	97.5	82.9	121
ED093F: Magnesium	7439-95-4	1	mg/L	<1	50 mg/L	97.2	82.7	114
ED093F: Sodium	7440-23-5	1	mg/L	<1	50 mg/L	94.5	77.4	113
ED093F: Potassium	7440-09-7	1	mg/L	<1	50 mg/L	96.7	84.3	118
ED093F: Dissolved Major Cations (QCLot: 877353)								
ED093F: Calcium	7440-70-2	1	mg/L	<1	----	----	----	----
ED093F: Magnesium	7439-95-4	1	mg/L	<1	----	----	----	----
ED093F: Sodium	7440-23-5	1	mg/L	<1	----	----	----	----
ED093F: Potassium	7440-09-7	1	mg/L	<1	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 878523)								
EG020A-T: Aluminium	7429-90-5	0.01	mg/L	<0.01	0.500 mg/L	78.5	74	128
EG020A-T: Antimony	7440-36-0	0.001	mg/L	<0.001	0.100 mg/L	95.2	80	114
EG020A-T: Arsenic	7440-38-2	0.001	mg/L	<0.001	0.100 mg/L	103	74	114
EG020A-T: Beryllium	7440-41-7	0.001	mg/L	<0.001	0.100 mg/L	94.1	77	130

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
				Result	Concentration	LCS	Low	High
EG020T: Total Metals by ICP-MS (QCLot: 878523) - continued								
EG020A-T: Barium	7440-39-3	0.001	mg/L	<0.001	----	----	----	----
EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.100 mg/L	94.6	74	118
EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.001	0.100 mg/L	98.0	81	127
EG020A-T: Cobalt	7440-48-4	0.001	mg/L	<0.001	0.100 mg/L	96.6	74	122
EG020A-T: Copper	7440-50-8	0.001	mg/L	<0.001	0.200 mg/L	86.2	75	119
EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.001	0.100 mg/L	97.2	80	116
EG020A-T: Lithium	7439-93-2	0.001	mg/L	<0.001	----	----	----	----
EG020A-T: Manganese	7439-96-5	0.001	mg/L	<0.001	0.100 mg/L	93.9	72	124
EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	<0.001	0.100 mg/L	94.9	80	112
EG020A-T: Nickel	7440-02-0	0.001	mg/L	<0.001	0.100 mg/L	91.9	75	121
EG020A-T: Selenium	7782-49-2	0.01	mg/L	----	0.100 mg/L	90.0	73	119
		0.010	mg/L	<0.010	----	----	----	----
EG020A-T: Thallium	7440-28-0	0.001	mg/L	<0.001	0.100 mg/L	99.0	80	116
EG020A-T: Tin	7440-31-5	0.001	mg/L	<0.001	0.100 mg/L	115	70	130
EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.01	0.100 mg/L	90.6	70.5	118
EG020A-T: Zinc	7440-66-6	0.005	mg/L	<0.005	0.200 mg/L	98.5	73	127
EG020A-T: Boron	7440-42-8	0.05	mg/L	<0.05	0.500 mg/L	94.4	70	128
EG020T: Total Metals by ICP-MS (QCLot: 878524)								
EG020B-T: Bismuth	7440-69-9	0.001	mg/L	<0.001	0.100 mg/L	98.8	73	123
EG020B-T: Cerium	7440-45-1	0.001	mg/L	<0.001	----	----	----	----
EG020B-T: Silver	7440-22-4	0.001	mg/L	<0.001	0.100 mg/L	80.2	70	118
EG020B-T: Strontium	7440-24-6	0.001	mg/L	<0.001	0.500 mg/L	94.3	73	119
EG020B-T: Thorium	7440-29-1	0.001	mg/L	<0.001	----	----	----	----
EG020B-T: Titanium	7440-32-6	0.01	mg/L	<0.01	0.100 mg/L	95.7	74	120
EG020B-T: Uranium	7440-61-1	0.001	mg/L	<0.001	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 878525)								
EG020D-T: Yttrium	7440-65-5	0.001	mg/L	<0.001	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 878526)								
EG020E-T: Tungsten	7440-33-7	0.001	mg/L	<0.001	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 878527)								
EG020G-T: Rhenium	7440-15-5	0.001	mg/L	<0.001	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 878528)								
EG020A-T: Aluminium	7429-90-5	0.01	mg/L	<0.01	0.500 mg/L	79.3	74	128
EG020A-T: Antimony	7440-36-0	0.001	mg/L	<0.001	0.100 mg/L	98.9	80	114
EG020A-T: Arsenic	7440-38-2	0.001	mg/L	<0.001	0.100 mg/L	106	74	114
EG020A-T: Beryllium	7440-41-7	0.001	mg/L	<0.001	0.100 mg/L	112	77	130
EG020A-T: Barium	7440-39-3	0.001	mg/L	<0.001	----	----	----	----
EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.100 mg/L	97.5	74	118

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
				Result	Concentration	LCS	Low	High
EG020T: Total Metals by ICP-MS (QCLot: 878528) - continued								
EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.001	0.100 mg/L	94.1	81	127
EG020A-T: Cobalt	7440-48-4	0.001	mg/L	<0.001	0.100 mg/L	95.3	74	122
EG020A-T: Copper	7440-50-8	0.001	mg/L	<0.001	0.200 mg/L	92.8	75	119
EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.001	0.100 mg/L	95.6	80	116
EG020A-T: Lithium	7439-93-2	0.001	mg/L	<0.001	----	----	----	----
EG020A-T: Manganese	7439-96-5	0.001	mg/L	<0.001	0.100 mg/L	93.9	72	124
EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	<0.001	0.100 mg/L	96.2	80	112
EG020A-T: Nickel	7440-02-0	0.001	mg/L	<0.001	0.100 mg/L	87.8	75	121
EG020A-T: Selenium	7782-49-2	0.01	mg/L	----	0.100 mg/L	96.7	73	119
		0.010	mg/L	<0.010	----	----	----	----
EG020A-T: Thallium	7440-28-0	0.001	mg/L	<0.001	0.100 mg/L	97.3	80	116
EG020A-T: Tin	7440-31-5	0.001	mg/L	<0.001	0.100 mg/L	118	70	130
EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.01	0.100 mg/L	90.9	70.5	118
EG020A-T: Zinc	7440-66-6	0.005	mg/L	<0.005	0.200 mg/L	99.2	73	127
EG020A-T: Boron	7440-42-8	0.05	mg/L	<0.05	0.500 mg/L	104	70	128
EG020T: Total Metals by ICP-MS (QCLot: 878530)								
EG020B-T: Bismuth	7440-69-9	0.001	mg/L	<0.001	0.100 mg/L	97.2	73	123
EG020B-T: Cerium	7440-45-1	0.001	mg/L	<0.001	----	----	----	----
EG020B-T: Silver	7440-22-4	0.001	mg/L	<0.001	0.100 mg/L	79.2	70	118
EG020B-T: Strontium	7440-24-6	0.001	mg/L	<0.001	0.500 mg/L	96.4	73	119
EG020B-T: Thorium	7440-29-1	0.001	mg/L	<0.001	----	----	----	----
EG020B-T: Titanium	7440-32-6	0.01	mg/L	<0.01	0.100 mg/L	90.1	74	120
EG020B-T: Uranium	7440-61-1	0.001	mg/L	<0.001	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 878533)								
EG020D-T: Yttrium	7440-65-5	0.001	mg/L	<0.001	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 878535)								
EG020E-T: Tungsten	7440-33-7	0.001	mg/L	<0.001	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 878536)								
EG020G-T: Rhenium	7440-15-5	0.001	mg/L	<0.001	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 880363)								
EG020A-T: Aluminium	7429-90-5	0.01	mg/L	<0.01	0.500 mg/L	98.1	74	128
EG020A-T: Antimony	7440-36-0	0.001	mg/L	<0.001	0.100 mg/L	102	80	114
EG020A-T: Arsenic	7440-38-2	0.001	mg/L	<0.001	0.100 mg/L	95.2	74	114
EG020A-T: Beryllium	7440-41-7	0.001	mg/L	<0.001	0.100 mg/L	110	77	130
EG020A-T: Barium	7440-39-3	0.001	mg/L	<0.001	----	----	----	----
EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.100 mg/L	102	74	118
EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.001	0.100 mg/L	101	81	127
EG020A-T: Cobalt	7440-48-4	0.001	mg/L	<0.001	0.100 mg/L	100	74	122

Sub-Matrix: **WATER**

				Method Blank (MB) Report	*Laboratory Control Spike (LCS) Report*			
					Spike	*Spike Recovery (%)*	*Recovery Limits (%)*	
Method: Compound	*CAS Number*	*LOR*	*Unit*	*Result*	*Concentration*	*LCS*	*Low*	*High*
EG020T: Total Metals by ICP-MS (QCLot: 880363) - continued								
EG020A-T: Copper	7440-50-8	0.001	mg/L	<0.001	0.200 mg/L	100	75	119
EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.001	0.100 mg/L	102	80	116
EG020A-T: Lithium	7439-93-2	0.001	mg/L	<0.001	----	----	----	----
EG020A-T: Manganese	7439-96-5	0.001	mg/L	<0.001	0.100 mg/L	99.0	72	124
EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	<0.001	0.100 mg/L	98.2	80	112
EG020A-T: Nickel	7440-02-0	0.001	mg/L	<0.001	0.100 mg/L	102	75	121
EG020A-T: Selenium	7782-49-2	0.01	mg/L	----	0.100 mg/L	97.1	73	119
		0.010	mg/L	<0.010	----	----	----	----
EG020A-T: Thallium	7440-28-0	0.001	mg/L	<0.001	0.100 mg/L	99.7	80	116
EG020A-T: Tin	7440-31-5	0.001	mg/L	<0.001	0.100 mg/L	111	70	130
EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.01	0.100 mg/L	95.4	70.5	118
EG020A-T: Zinc	7440-66-6	0.005	mg/L	<0.005	0.200 mg/L	99.0	73	127
EG020A-T: Boron	7440-42-8	0.05	mg/L	<0.05	0.500 mg/L	95.5	70	128
EG035T: Total Recoverable Mercury by FIMS (QCLot: 876034)								
EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.0100 mg/L	96.5	82	122
EG035T: Total Recoverable Mercury by FIMS (QCLot: 876035)								
EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.0100 mg/L	97.2	82	122
EP006 Total Inorganic Carbon (QCLot: 875135)								
EP006: Total Inorganic Carbon	----	1	mg/L	<1	50 mg/L	126	70	130
EP006 Total Inorganic Carbon (QCLot: 875136)								
EP006: Total Inorganic Carbon	----	1	mg/L	<1	50 mg/L	120	70	130

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix**: WATER**

				Matrix Spike (MS) Report			
				Spike	*Spike Recovery (%)*	*Recovery Limits (%)*	
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*Concentration*	*MS*	*Low*	*High*
ED045G: Chloride Discrete analyser (QCLot: 879575)							
EB0901049-039	O.D._TL2 D/100	ED045G: Chloride	16887-00-6	250 mg/L	110	70	130
EG020T: Total Metals by ICP-MS (QCLot: 878523)							
EB0901048-002	Anonymous	EG020A-T: Arsenic	7440-38-2	1.000 mg/L	128	70	130
		EG020A-T: Beryllium	7440-41-7	0.100 mg/L	117	70	130
		EG020A-T: Barium	7440-39-3	1.000 mg/L	110	70	130
		EG020A-T: Cadmium	7440-43-9	0.500 mg/L	110	70	130
		EG020A-T: Chromium	7440-47-3	1.000 mg/L	109	70	130
		EG020A-T: Cobalt	7440-48-4	1.000 mg/L	# Not Determined	70	130
		EG020A-T: Copper	7440-50-8	1.000 mg/L	88.2	70	130
		EG020A-T: Lead	7439-92-1	1.000 mg/L	106	70	130
		EG020A-T: Manganese	7439-96-5	1.000 mg/L	# Not Determined	70	130
		EG020A-T: Nickel	7440-02-0	1.000 mg/L	103	70	130
		EG020A-T: Vanadium	7440-62-2	1.000 mg/L	106	70	130
		EG020A-T: Zinc	7440-66-6	1.000 mg/L	# Not Determined	70	130
EG020T: Total Metals by ICP-MS (QCLot: 878528)							
EB0901049-005	pH6.0_TLDOLW2	EG020A-T: Arsenic	7440-38-2	1.000 mg/L	# Not Determined	70	130
		EG020A-T: Beryllium	7440-41-7	0.100 mg/L	# Not Determined	70	130
		EG020A-T: Barium	7440-39-3	1.000 mg/L	107	70	130
		EG020A-T: Cadmium	7440-43-9	0.500 mg/L	111	70	130
		EG020A-T: Chromium	7440-47-3	1.000 mg/L	106	70	130
		EG020A-T: Cobalt	7440-48-4	1.000 mg/L	81.6	70	130
		EG020A-T: Copper	7440-50-8	1.000 mg/L	# Not Determined	70	130
		EG020A-T: Lead	7439-92-1	1.000 mg/L	# Not Determined	70	130
		EG020A-T: Manganese	7439-96-5	1.000 mg/L	# Not Determined	70	130
		EG020A-T: Nickel	7440-02-0	1.000 mg/L	97.1	70	130
		EG020A-T: Vanadium	7440-62-2	1.000 mg/L	# Not Determined	70	130
		EG020A-T: Zinc	7440-66-6	1.000 mg/L	99.4	70	130
EG035T: Total Recoverable Mercury by FIMS (QCLot: 876034)							
EB0901048-001	Anonymous	EG035T: Mercury	7439-97-6	0.0100 mg/L	95.7	70	130
EG035T: Total Recoverable Mercury by FIMS (QCLot: 876035)							
EB0901049-004	pH4.5_TL2W3	EG035T: Mercury	7439-97-6	0.0100 mg/L	76.7	70	130
Sample Preparation Method (QCLot: 875141)							
EB0901049-025	pH6.0_TLDOLW3D/10	PCT-DP: Dummy Analyte	----	----	----	----	----

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES

Environmental Division

QUALITY CONTROL REPORT

Work Order	: **EB0902458**	Page	: 1 of 8
Client	: **C S I R O AUSTRALIA**	Laboratory	: Environmental Division Brisbane
Contact	: DR STUART SIMPSON	Contact	: Tim Kilmister
Address	: CENTRE FOR ENVIRONMENTAL CONTAMINANTS RESEARCH CSIRO ENERGY TECHNOLOGY NEW ILLAWARRA ROAD LUCAS HEIGHTS NSW, AUSTRALIA 2234	Address	: 32 Shand Street Stafford QLD Australia 4053
E-mail	: stuart.simpson@csiro.au	E-mail	: Services.Brisbane@alsenviro.com
Telephone	: +61 02 97106807	Telephone	: +61-7-3243 7222
Facsimile	: +61 02 97106837	Facsimile	: +61-7-3243 7218
Project	: Olympic Dam Analysis	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Site	: ----		
C-O-C number	: ----	Date Samples Received	: 13-FEB-2009
Sampler	: ----	Issue Date	: 24-FEB-2009
Order number	: ----		
		No. of samples received	: 15
Quote number	: BN/328/08	No. of samples analysed	: 15

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 Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

NATA

WORLD RECOGNISED ACCREDITATION

NATA Accredited Laboratory 825

This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

Signatories

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

Signatories	*Position*	*Accreditation Category*
		Inorganics
Kim McCabe	Senior Inorganic Chemist	Inorganics
Stephen Hislop	Senior Inorganic Chemist	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 insuffient 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.

Key :
Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
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
RPD = Relative Percentage Difference
# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR:- No Limit; Result between 10 and 20 times LOR:- 0% - 50%; Result > 20 times LOR:- 0% - 20%.

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
ED037P: Alkalinity by PC Titrator (QC Lot: 893943)									
EB0902435-001	Anonymous	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	219	218	0.0	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	219	218	0.0	0% - 20%
EB0902436-009	Anonymous	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	56	55	0.0	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	56	55	0.0	0% - 20%
ED037P: Alkalinity by PC Titrator (QC Lot: 897531)									
EB0902368-001	Anonymous	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	24	23	4.4	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	24	23	4.4	0% - 20%
EB0902459-001	Anonymous	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	<1	<1	0.0	No Limit
ED038A: Acidity (QC Lot: 894675)									
EB0902163-001	Anonymous	ED038: Acidity as CaCO3	----	1	mg/L	6	6	0.0	No Limit
EB0902163-010	Anonymous	ED038: Acidity as CaCO3	----	1	mg/L	4	4	0.0	No Limit
ED038A: Acidity (QC Lot: 896824)									
EB0902433-001	Anonymous	ED038: Acidity as CaCO3	----	1	mg/L	56	48	15.4	0% - 20%
ED040F: Dissolved Major Anions (QC Lot: 894636)									
EB0902458-011	CORE 1A_CO2W4 D/2	ED040F: Sulfate as SO4 2-	14808-79-8	1	mg/L	67000	68100	1.7	0% - 20%
EB0902482-005	Anonymous	ED040F: Sulfate as SO4 2-	14808-79-8	1	mg/L	32	32	0.0	0% - 20%
ED045P: Chloride by PC Titrator (QC Lot: 893944)									
EB0902435-001	Anonymous	ED045-P: Chloride	16887-00-6	1	mg/L	458	460	0.4	0% - 20%
EB0902436-009	Anonymous	ED045-P: Chloride	16887-00-6	1	mg/L	9	8	11.8	No Limit
ED045P: Chloride by PC Titrator (QC Lot: 897533)									
EB0902368-001	Anonymous	ED045-P: Chloride	16887-00-6	1	mg/L	980	985	0.5	0% - 20%
EB0902458-011	CORE 1A_CO2W4 D/2	ED045-P: Chloride	16887-00-6	1	mg/L	1550	1550	0.0	0% - 20%
ED093F: Dissolved Major Cations (QC Lot: 894635)									
EB0902458-006	CORE 1A_CO2W4 D/10	ED093F: Calcium	7440-70-2	1	mg/L	60	61	2.3	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	164	167	1.6	0% - 20%

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
ED093F: Dissolved Major Cations (QC Lot: 894635) - continued									
EB0902458-006	CORE 1A_CO2W4 D/10	ED093F: Sodium	7440-23-5	1	mg/L	183	188	2.7	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	66	73	9.4	0% - 20%
EB0902478-005	Anonymous	ED093F: Calcium	7440-70-2	1	mg/L	365	361	1.2	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	1200	1180	1.5	0% - 20%
		ED093F: Sodium	7440-23-5	1	mg/L	9670	9460	2.2	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	427	405	5.2	0% - 20%
EG020T: Total Metals by ICP-MS (QC Lot: 893972)									
EB0902458-001	CORE 1A_CO2W4	EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	0.0182	0.0175	3.4	0% - 20%
		EG020A-T: Antimony	7440-36-0	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-T: Arsenic	7440-38-2	0.001	mg/L	0.043	0.034	24.0	0% - 20%
		EG020A-T: Beryllium	7440-41-7	0.001	mg/L	0.072	0.066	8.4	0% - 20%
		EG020A-T: Barium	7440-39-3	0.001	mg/L	0.099	0.094	4.4	0% - 20%
		EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-T: Cobalt	7440-48-4	0.001	mg/L	52.4	51.1	2.4	0% - 20%
		EG020A-T: Copper	7440-50-8	0.001	mg/L	84.0	81.9	2.5	0% - 20%
		EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-T: Lithium	7439-93-2	0.001	mg/L	4.13	4.21	1.8	0% - 20%
		EG020A-T: Manganese	7439-96-5	0.001	mg/L	177	175	1.4	0% - 20%
		EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-T: Nickel	7440-02-0	0.001	mg/L	5.04	4.92	2.4	0% - 20%
		EG020A-T: Thallium	7440-28-0	0.001	mg/L	0.026	0.025	0.0	0% - 20%
		EG020A-T: Tin	7440-31-5	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-T: Zinc	7440-66-6	0.005	mg/L	20.7	20.6	0.5	0% - 20%
		EG020A-T: Aluminium	7429-90-5	0.01	mg/L	561	554	1.2	0% - 20%
		EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.10	<0.10	0.0	No Limit
		EG020A-T: Selenium	7782-49-2	0.010	mg/L	0.170	0.176	3.6	0% - 50%
		EG020A-T: Boron	7440-42-8	0.05	mg/L	2.29	2.37	3.3	0% - 20%
EG020T: Total Metals by ICP-MS (QC Lot: 893973)									
EB0902458-001	CORE 1A_CO2W4	EG020B-T: Bismuth	7440-69-9	0.001	mg/L	0.018	<0.010	60.0	No Limit
		EG020B-T: Cerium	7440-45-1	0.001	mg/L	19.9	19.5	2.2	0% - 20%
		EG020B-T: Silver	7440-22-4	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020B-T: Strontium	7440-24-6	0.001	mg/L	1.90	1.87	1.8	0% - 20%
		EG020B-T: Thorium	7440-29-1	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020B-T: Uranium	7440-61-1	0.001	mg/L	15.0	15.0	0.6	0% - 20%
		EG020B-T: Titanium	7440-32-6	0.01	mg/L	<0.10	<0.10	0.0	No Limit
EG020T: Total Metals by ICP-MS (QC Lot: 893974)									
EB0902458-001	CORE 1A_CO2W4	EG020D-T: Yttrium	7440-65-5	0.001	mg/L	4.59	4.54	1.3	0% - 20%
EG020T: Total Metals by ICP-MS (QC Lot: 893975)									
EB0902458-001	CORE 1A_CO2W4	EG020E-T: Tungsten	7440-33-7	0.001	mg/L	<0.010	<0.010	0.0	No Limit

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Laboratory Duplicate (DUP) Report					
				LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EG020T: Total Metals by ICP-MS (QC Lot: 894747)									
EB0902424-001	Anonymous	EG020A-T: Iron	7439-89-6	0.05	mg/L	0.06	0.08	31.6	No Limit
EB0902458-009	pH4.5_TL2 N2 W4 D/10	EG020A-T: Iron	7439-89-6	0.05	mg/L	1070	1150	7.2	0% - 20%
EG035T: Total Recoverable Mercury by FIMS (QC Lot: 894178)									
EB0902235-002	Anonymous	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EB0902436-009	Anonymous	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EG035T: Total Recoverable Mercury by FIMS (QC Lot: 894179)									
EB0902458-005	pH4.5_TL2 CO2 W4	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EB0902497-001	Anonymous	EG035T: Mercury	7439-97-6	0.0001	mg/L	0.0001	<0.0001	0.0	No Limit
EP006 Total Inorganic Carbon (QC Lot: 899000)									
EB0902458-015	pH4.5_TL2 CO2 W4 D/100	EP006: Total Inorganic Carbon	----	1	mg/L	<1	<1	0.0	No Limit

Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **WATER**

				Method Blank (MB) Report	*Laboratory Control Spike (LCS) Report*			
					Spike	*Spike Recovery (%)*	*Recovery Limits (%)*	
Method: Compound	*CAS Number*	*LOR*	*Unit*	*Result*	*Concentration*	*LCS*	*Low*	*High*
ED037P: Alkalinity by PC Titrator (QCLot: 893943)								
ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	----	200 mg/L	99.7	80	114
ED037P: Alkalinity by PC Titrator (QCLot: 897531)								
ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	----	200 mg/L	101	80	114
ED038A: Acidity (QCLot: 894675)								
ED038: Acidity as CaCO3	----	1	mg/L	----	100 mg/L	98.0	95	105
ED038A: Acidity (QCLot: 896824)								
ED038: Acidity as CaCO3	----	1	mg/L	----	100 mg/L	101	95	105
ED040F: Dissolved Major Anions (QCLot: 894636)								
ED040F: Sulfate as SO4 2-	14808-79-8	1	mg/L	<1	----	----	----	----
ED045P: Chloride by PC Titrator (QCLot: 893944)								
ED045-P: Chloride	16887-00-6	1	mg/L	<1	1000 mg/L	99.0	90	110
ED045P: Chloride by PC Titrator (QCLot: 897533)								
ED045-P: Chloride	16887-00-6	1	mg/L	<1	1000 mg/L	99.9	90	110
ED093F: Dissolved Major Cations (QCLot: 894635)								
ED093F: Calcium	7440-70-2	1	mg/L	<1	----	----	----	----
ED093F: Magnesium	7439-95-4	1	mg/L	<1	----	----	----	----
ED093F: Sodium	7440-23-5	1	mg/L	<1	----	----	----	----
ED093F: Potassium	7440-09-7	1	mg/L	<1	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 893972)								
EG020A-T: Aluminium	7429-90-5	0.01	mg/L	<0.01	0.500 mg/L	108	74	128
EG020A-T: Antimony	7440-36-0	0.001	mg/L	<0.001	0.100 mg/L	98.5	80	114
EG020A-T: Arsenic	7440-38-2	0.001	mg/L	<0.001	0.100 mg/L	108	74	114
EG020A-T: Beryllium	7440-41-7	0.001	mg/L	<0.001	0.100 mg/L	94.6	77	130
EG020A-T: Barium	7440-39-3	0.001	mg/L	<0.001	----	----	----	----
EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.100 mg/L	95.8	74	118
EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.001	0.100 mg/L	99.4	81	127
EG020A-T: Cobalt	7440-48-4	0.001	mg/L	<0.001	0.100 mg/L	97.4	74	122
EG020A-T: Copper	7440-50-8	0.001	mg/L	<0.001	0.200 mg/L	93.8	75	119
EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.001	0.100 mg/L	96.9	80	116
EG020A-T: Lithium	7439-93-2	0.001	mg/L	<0.001	----	----	----	----
EG020A-T: Manganese	7439-96-5	0.001	mg/L	<0.001	0.100 mg/L	97.1	72	124
EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	<0.001	0.100 mg/L	97.8	80	112
EG020A-T: Nickel	7440-02-0	0.001	mg/L	<0.001	0.100 mg/L	96.5	75	121

Sub-Matrix: **WATER**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	**CAS Number**	**LOR**	**Unit**	**Result**	**Concentration**	**LCS**	**Low**	**High**
EG020T: Total Metals by ICP-MS (QCLot: 893972) - continued								
EG020A-T: Selenium	7782-49-2	0.01	mg/L	----	0.100 mg/L	95.7	73	119
		0.010	mg/L	<0.010	----	----	----	----
EG020A-T: Thallium	7440-28-0	0.001	mg/L	<0.001	0.100 mg/L	98.8	80	116
EG020A-T: Tin	7440-31-5	0.001	mg/L	<0.001	0.100 mg/L	95.3	70	130
EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.01	0.100 mg/L	95.5	70.5	118
EG020A-T: Zinc	7440-66-6	0.005	mg/L	<0.005	0.200 mg/L	97.0	73	127
EG020A-T: Boron	7440-42-8	0.05	mg/L	<0.05	0.500 mg/L	91.8	70	128
EG020T: Total Metals by ICP-MS (QCLot: 893973)								
EG020B-T: Bismuth	7440-69-9	0.001	mg/L	<0.001	0.100 mg/L	97.4	73	123
EG020B-T: Cerium	7440-45-1	0.001	mg/L	<0.001	----	----	----	----
EG020B-T: Silver	7440-22-4	0.001	mg/L	<0.001	0.100 mg/L	87.1	70	118
EG020B-T: Strontium	7440-24-6	0.001	mg/L	<0.001	0.500 mg/L	94.8	73	119
EG020B-T: Thorium	7440-29-1	0.001	mg/L	<0.001	----	----	----	----
EG020B-T: Titanium	7440-32-6	0.01	mg/L	<0.01	0.100 mg/L	97.9	74	120
EG020B-T: Uranium	7440-61-1	0.001	mg/L	<0.001	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 893974)								
EG020D-T: Yttrium	7440-65-5	0.001	mg/L	<0.001	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 893975)								
EG020E-T: Tungsten	7440-33-7	0.001	mg/L	<0.001	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 893976)								
EG020G-T: Rhenium	7440-15-5	0.001	mg/L	<0.001	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 894747)								
EG020A-T: Iron	7439-89-6	0.05	mg/L	<0.05	0.500 mg/L	111	70	130
EG035T: Total Recoverable Mercury by FIMS (QCLot: 894178)								
EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.0100 mg/L	97.0	82	122
EG035T: Total Recoverable Mercury by FIMS (QCLot: 894179)								
EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.0100 mg/L	94.3	82	122

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **WATER**

				Matrix Spike (MS) Report			
				Spike	Spike Recovery (%)	Recovery Limits (%)	
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*Concentration*	*MS*	*Low*	*High*
ED045P: Chloride by PC Titrator (QCLot: 893944)							
EB0902436-001	Anonymous	ED045-P: Chloride	16887-00-6	20 mg/L	100	70	130
ED045P: Chloride by PC Titrator (QCLot: 897533)							
EB0902368-002	Anonymous	ED045-P: Chloride	16887-00-6	80 mg/L	100	70	130
EG020T: Total Metals by ICP-MS (QCLot: 893972)							
EB0902458-002	CORE 1B_N2W4	EG020A-T: Arsenic	7440-38-2	1.000 mg/L	118	70	130
		EG020A-T: Beryllium	7440-41-7	0.100 mg/L	108	70	130
		EG020A-T: Barium	7440-39-3	1.000 mg/L	104	70	130
		EG020A-T: Cadmium	7440-43-9	0.500 mg/L	104	70	130
		EG020A-T: Chromium	7440-47-3	1.000 mg/L	102	70	130
		EG020A-T: Cobalt	7440-48-4	1.000 mg/L	# Not Determined	70	130
		EG020A-T: Copper	7440-50-8	1.000 mg/L	# Not Determined	70	130
		EG020A-T: Lead	7439-92-1	1.000 mg/L	99.1	70	130
		EG020A-T: Manganese	7439-96-5	1.000 mg/L	# Not Determined	70	130
		EG020A-T: Nickel	7440-02-0	1.000 mg/L	# Not Determined	70	130
		EG020A-T: Vanadium	7440-62-2	1.000 mg/L	106	70	130
		EG020A-T: Zinc	7440-66-6	1.000 mg/L	# Not Determined	70	130
EG035T: Total Recoverable Mercury by FIMS (QCLot: 894178)							
EB0902424-001	Anonymous	EG035T: Mercury	7439-97-6	0.010 mg/L	120	70	130
EG035T: Total Recoverable Mercury by FIMS (QCLot: 894179)							
EB0902459-001	Anonymous	EG035T: Mercury	7439-97-6	0.010 mg/L	91.2	70	130

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES

Environmental Division

QUALITY CONTROL REPORT

Work Order	: **EB0902459**	Page	: 1 of 7
Client	: **C S I R O AUSTRALIA**	Laboratory	: Environmental Division Brisbane
Contact	: DR STUART SIMPSON	Contact	: Tim Kilmister
Address	: CENTRE FOR ENVIRONMENTAL CONTAMINANTS RESEARCH CSIRO ENERGY TECHNOLOGY NEW ILLAWARRA ROAD LUCAS HEIGHTS NSW, AUSTRALIA 2234	Address	: 32 Shand Street Stafford QLD Australia 4053
E-mail	: stuart.simpson@csiro.au	E-mail	: Services.Brisbane@alsenviro.com
Telephone	: +61 02 97106807	Telephone	: +61-7-3243 7222
Facsimile	: +61 02 97106837	Facsimile	: +61-7-3243 7218
Project	: Olympic Dam Analysis	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Site	: ----		
C-O-C number	: ----	Date Samples Received	: 13-FEB-2009
Sampler	: ----	Issue Date	: 24-FEB-2009
Order number	: ----		
		No. of samples received	: 6
Quote number	: BN/328/08	No. of samples analysed	: 6

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 Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

NATA
WORLD RECOGNISED ACCREDITATION

NATA Accredited Laboratory 825

This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

Signatories

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

Signatories	*Position*	*Accreditation Category*
		Inorganics
Kim McCabe	Senior Inorganic Chemist	Inorganics
Stephen Hislop	Senior Inorganic Chemist	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 insuffient 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.

Key :
Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
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
RPD = Relative Percentage Difference
# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR:- No Limit; Result between 10 and 20 times LOR:- 0% - 50%; Result > 20 times LOR:- 0% - 20%.

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
ED037P: Alkalinity by PC Titrator (QC Lot: 897531)									
EB0902368-001	Anonymous	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	24	23	4.4	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	24	23	4.4	0% - 20%
EB0902459-001	3.1_04 R2 W4 L	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	<1	<1	0.0	No Limit
ED038A: Acidity (QC Lot: 896824)									
EB0902433-001	Anonymous	ED038: Acidity as CaCO3	----	1	mg/L	56	48	15.4	0% - 20%
ED040F: Dissolved Major Anions (QC Lot: 893856)									
EB0902235-002	Anonymous	ED040F: Silicon	7440-21-3	0.05	mg/L	0.17	0.18	0.0	No Limit
		ED040F: Sulfate as SO4 2-	14808-79-8	1	mg/L	8	8	0.0	No Limit
EB0902455-002	Anonymous	ED040F: Silicon	7440-21-3	0.05	mg/L	8.46	8.48	0.1	0% - 20%
		ED040F: Sulfate as SO4 2-	14808-79-8	1	mg/L	152	153	1.0	0% - 20%
ED045P: Chloride by PC Titrator (QC Lot: 897533)									
EB0902368-001	Anonymous	ED045-P: Chloride	16887-00-6	1	mg/L	980	985	0.5	0% - 20%
EB0902458-011	Anonymous	ED045-P: Chloride	16887-00-6	1	mg/L	1550	1550	0.0	0% - 20%
ED093F: Dissolved Major Cations (QC Lot: 893857)									
EB0902235-002	Anonymous	ED093F: Calcium	7440-70-2	1	mg/L	21	22	0.0	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	<1	<1	0.0	No Limit
		ED093F: Sodium	7440-23-5	1	mg/L	10	10	0.0	0% - 50%
		ED093F: Potassium	7440-09-7	1	mg/L	<1	<1	0.0	No Limit
EB0902455-002	Anonymous	ED093F: Calcium	7440-70-2	1	mg/L	23	23	0.0	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	10	10	0.0	0% - 50%
		ED093F: Sodium	7440-23-5	1	mg/L	142	142	0.0	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	4	4	0.0	No Limit
EG020T: Total Metals by ICP-MS (QC Lot: 893972)									
EB0902458-001	Anonymous	EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	0.0182	0.0175	3.4	0% - 20%
		EG020A-T: Antimony	7440-36-0	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-T: Arsenic	7440-38-2	0.001	mg/L	0.043	0.034	24.0	0% - 20%
		EG020A-T: Beryllium	7440-41-7	0.001	mg/L	0.072	0.066	8.4	0% - 20%
		EG020A-T: Barium	7440-39-3	0.001	mg/L	0.099	0.094	4.4	0% - 20%
		EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-T: Cobalt	7440-48-4	0.001	mg/L	52.4	51.1	2.4	0% - 20%

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EG020T: Total Metals by ICP-MS (QC Lot: 893972) - continued									
EB0902458-001	Anonymous	EG020A-T: Copper	7440-50-8	0.001	mg/L	84.0	81.9	2.5	0% - 20%
		EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-T: Lithium	7439-93-2	0.001	mg/L	4.13	4.21	1.8	0% - 20%
		EG020A-T: Manganese	7439-96-5	0.001	mg/L	177	175	1.4	0% - 20%
		EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-T: Nickel	7440-02-0	0.001	mg/L	5.04	4.92	2.4	0% - 20%
		EG020A-T: Thallium	7440-28-0	0.001	mg/L	0.026	0.025	0.0	0% - 20%
		EG020A-T: Tin	7440-31-5	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020A-T: Zinc	7440-66-6	0.005	mg/L	20.7	20.6	0.5	0% - 20%
		EG020A-T: Aluminium	7429-90-5	0.01	mg/L	561	554	1.2	0% - 20%
		EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.10	<0.10	0.0	No Limit
		EG020A-T: Selenium	7782-49-2	0.010	mg/L	0.170	0.176	3.6	0% - 50%
		EG020A-T: Boron	7440-42-8	0.05	mg/L	2.29	2.37	3.3	0% - 20%
EG020T: Total Metals by ICP-MS (QC Lot: 893973)									
EB0902458-001	Anonymous	EG020B-T: Bismuth	7440-69-9	0.001	mg/L	0.018	<0.010	60.0	No Limit
		EG020B-T: Cerium	7440-45-1	0.001	mg/L	19.9	19.5	2.2	0% - 20%
		EG020B-T: Silver	7440-22-4	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020B-T: Strontium	7440-24-6	0.001	mg/L	1.90	1.87	1.8	0% - 20%
		EG020B-T: Thorium	7440-29-1	0.001	mg/L	<0.010	<0.010	0.0	No Limit
		EG020B-T: Uranium	7440-61-1	0.001	mg/L	15.0	15.0	0.6	0% - 20%
		EG020B-T: Titanium	7440-32-6	0.01	mg/L	<0.10	<0.10	0.0	No Limit
EG020T: Total Metals by ICP-MS (QC Lot: 893974)									
EB0902458-001	Anonymous	EG020D-T: Yttrium	7440-65-5	0.001	mg/L	4.59	4.54	1.3	0% - 20%
EG020T: Total Metals by ICP-MS (QC Lot: 893975)									
EB0902458-001	Anonymous	EG020E-T: Tungsten	7440-33-7	0.001	mg/L	<0.010	<0.010	0.0	No Limit
EG020T: Total Metals by ICP-MS (QC Lot: 894747)									
EB0902424-001	Anonymous	EG020A-T: Iron	7439-89-6	0.05	mg/L	0.06	0.08	31.6	No Limit
EB0902458-009	Anonymous	EG020A-T: Iron	7439-89-6	0.05	mg/L	1070	1150	7.2	0% - 20%
EG035T: Total Recoverable Mercury by FIMS (QC Lot: 894179)									
EB0902458-005	Anonymous	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EB0902497-001	Anonymous	EG035T: Mercury	7439-97-6	0.0001	mg/L	0.0001	<0.0001	0.0	No Limit
EP006 Total Inorganic Carbon (QC Lot: 899000)									
EB0902458-015	Anonymous	EP006: Total Inorganic Carbon	----	1	mg/L	<1	<1	0.0	No Limit

Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **WATER**

				Method Blank (MB) Report	*Laboratory Control Spike (LCS) Report*			
					Spike	*Spike Recovery (%)*	*Recovery Limits (%)*	
Method: Compound	*CAS Number*	*LOR*	*Unit*	*Result*	*Concentration*	*LCS*	*Low*	*High*
ED037P: Alkalinity by PC Titrator (QCLot: 897531)								
ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	----	200 mg/L	101	80	114
ED038A: Acidity (QCLot: 896824)								
ED038: Acidity as CaCO3	----	1	mg/L	----	100 mg/L	101	95	105
ED040F: Dissolved Major Anions (QCLot: 893856)								
ED040F: Sulfate as SO4 2-	14808-79-8	1	mg/L	<1	----	----	----	----
ED040F: Silicon	7440-21-3	0.05	mg/L	<0.05	----	----	----	----
ED045P: Chloride by PC Titrator (QCLot: 897533)								
ED045-P: Chloride	16887-00-6	1	mg/L	<1	1000 mg/L	99.9	90	110
ED093F: Dissolved Major Cations (QCLot: 893857)								
ED093F: Calcium	7440-70-2	1	mg/L	<1	----	----	----	----
ED093F: Magnesium	7439-95-4	1	mg/L	<1	----	----	----	----
ED093F: Sodium	7440-23-5	1	mg/L	<1	----	----	----	----
ED093F: Potassium	7440-09-7	1	mg/L	<1	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 893972)								
EG020A-T: Aluminium	7429-90-5	0.01	mg/L	<0.01	0.500 mg/L	108	74	128
EG020A-T: Antimony	7440-36-0	0.001	mg/L	<0.001	0.100 mg/L	98.5	80	114
EG020A-T: Arsenic	7440-38-2	0.001	mg/L	<0.001	0.100 mg/L	108	74	114
EG020A-T: Beryllium	7440-41-7	0.001	mg/L	<0.001	0.100 mg/L	94.6	77	130
EG020A-T: Barium	7440-39-3	0.001	mg/L	<0.001	----	----	----	----
EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.100 mg/L	95.8	74	118
EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.001	0.100 mg/L	99.4	81	127
EG020A-T: Cobalt	7440-48-4	0.001	mg/L	<0.001	0.100 mg/L	97.4	74	122
EG020A-T: Copper	7440-50-8	0.001	mg/L	<0.001	0.200 mg/L	93.8	75	119
EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.001	0.100 mg/L	96.9	80	116
EG020A-T: Lithium	7439-93-2	0.001	mg/L	<0.001	----	----	----	----
EG020A-T: Manganese	7439-96-5	0.001	mg/L	<0.001	0.100 mg/L	97.1	72	124
EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	<0.001	0.100 mg/L	97.8	80	112
EG020A-T: Nickel	7440-02-0	0.001	mg/L	<0.001	0.100 mg/L	96.5	75	121
EG020A-T: Selenium	7782-49-2	0.01	mg/L	----	0.100 mg/L	95.7	73	119
		0.010	mg/L	<0.010	----	----	----	----
EG020A-T: Thallium	7440-28-0	0.001	mg/L	<0.001	0.100 mg/L	98.8	80	116
EG020A-T: Tin	7440-31-5	0.001	mg/L	<0.001	0.100 mg/L	95.3	70	130
EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.01	0.100 mg/L	95.5	70.5	118
EG020A-T: Zinc	7440-66-6	0.005	mg/L	<0.005	0.200 mg/L	97.0	73	127

Sub-Matrix: **WATER**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	*CAS Number*	*LOR*	*Unit*	*Result*	*Concentration*	*LCS*	*Low*	*High*
EG020T: Total Metals by ICP-MS (QCLot: 893972) - continued								
EG020A-T: Boron	7440-42-8	0.05	mg/L	<0.05	0.500 mg/L	91.8	70	128
EG020T: Total Metals by ICP-MS (QCLot: 893973)								
EG020B-T: Bismuth	7440-69-9	0.001	mg/L	<0.001	0.100 mg/L	97.4	73	123
EG020B-T: Cerium	7440-45-1	0.001	mg/L	<0.001	----	----	----	----
EG020B-T: Silver	7440-22-4	0.001	mg/L	<0.001	0.100 mg/L	87.1	70	118
EG020B-T: Strontium	7440-24-6	0.001	mg/L	<0.001	0.500 mg/L	94.8	73	119
EG020B-T: Thorium	7440-29-1	0.001	mg/L	<0.001	----	----	----	----
EG020B-T: Titanium	7440-32-6	0.01	mg/L	<0.01	0.100 mg/L	97.9	74	120
EG020B-T: Uranium	7440-61-1	0.001	mg/L	<0.001	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 893974)								
EG020D-T: Yttrium	7440-65-5	0.001	mg/L	<0.001	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 893975)								
EG020E-T: Tungsten	7440-33-7	0.001	mg/L	<0.001	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 893976)								
EG020G-T: Rhenium	7440-15-5	0.001	mg/L	<0.001	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 894747)								
EG020A-T: Iron	7439-89-6	0.05	mg/L	<0.05	0.500 mg/L	111	70	130
EG035T: Total Recoverable Mercury by FIMS (QCLot: 894179)								
EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.0100 mg/L	94.3	82	122

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix**: WATER**

				Matrix Spike (MS) Report			
				Spike Concentration	*Spike Recovery (%)*	*Recovery Limits (%)*	
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*		*MS*	*Low*	*High*
ED045P: Chloride by PC Titrator (QCLot: 897533)							
EB0902368-002	Anonymous	ED045-P: Chloride	16887-00-6	80 mg/L	100	70	130
EG020T: Total Metals by ICP-MS (QCLot: 893972)							
EB0902458-002	Anonymous	EG020A-T: Arsenic	7440-38-2	1.000 mg/L	118	70	130
		EG020A-T: Beryllium	7440-41-7	0.100 mg/L	108	70	130
		EG020A-T: Barium	7440-39-3	1.000 mg/L	104	70	130
		EG020A-T: Cadmium	7440-43-9	0.500 mg/L	104	70	130
		EG020A-T: Chromium	7440-47-3	1.000 mg/L	102	70	130
		EG020A-T: Cobalt	7440-48-4	1.000 mg/L	# Not Determined	70	130
		EG020A-T: Copper	7440-50-8	1.000 mg/L	# Not Determined	70	130
		EG020A-T: Lead	7439-92-1	1.000 mg/L	99.1	70	130
		EG020A-T: Manganese	7439-96-5	1.000 mg/L	# Not Determined	70	130
		EG020A-T: Nickel	7440-02-0	1.000 mg/L	# Not Determined	70	130
		EG020A-T: Vanadium	7440-62-2	1.000 mg/L	106	70	130
		EG020A-T: Zinc	7440-66-6	1.000 mg/L	# Not Determined	70	130
EG035T: Total Recoverable Mercury by FIMS (QCLot: 894179)							
EB0902459-001	3.1_04 R2 W4 L	EG035T: Mercury	7439-97-6	0.010 mg/L	91.2	70	130

QUALITY CONTROL REPORT

Work Order	: **EB0902432**	Page	: 1 of 5
Client	: **C S I R O AUSTRALIA**	Laboratory	: Environmental Division Brisbane
Contact	: DR STUART SIMPSON	Contact	: Tim Kilmister
Address	: CENTRE FOR ENVIRONMENTAL CONTAMINANTS RESEARCH CSIRO ENERGY TECHNOLOGY NEW ILLAWARRA ROAD LUCAS HEIGHTS NSW, AUSTRALIA 2234	Address	: 32 Shand Street Stafford QLD Australia 4053
E-mail	: stuart.simpson@csiro.au	E-mail	: Services.Brisbane@alsenviro.com
Telephone	: +61 02 97106807	Telephone	: +61-7-3243 7222
Facsimile	: +61 02 97106837	Facsimile	: +61-7-3243 7218
Project	: ----	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Site	: ----		
C-O-C number	: ----	Date Samples Received	: 13-FEB-2009
Sampler	: ----	Issue Date	: 23-FEB-2009
Order number	: ----		
		No. of samples received	: 3
Quote number	: BN/032/09	No. of samples analysed	: 3

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 Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

NATA

WORLD RECOGNISED ACCREDITATION

NATA Accredited Laboratory 825

This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

Signatories

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

Signatories	*Position*	*Accreditation Category*
Kim McCabe	Senior Inorganic Chemist	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 insuffient 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.

Key :
Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
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
RPD = Relative Percentage Difference
# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR:- No Limit; Result between 10 and 20 times LOR:- 0% - 50%; Result > 20 times LOR:- 0% - 20%.

Sub-Matrix: **SOIL**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
ED008: Exchangeable Cations (QC Lot: 894998)									
EB0902432-001	Core 1	ED008: Exchangeable Calcium	----	0.1	meq/100g	16.2	16.5	1.8	0% - 20%
		ED008: Exchangeable Magnesium	----	0.1	meq/100g	10.2	10.6	4.1	0% - 20%
		ED008: Exchangeable Potassium	----	0.1	meq/100g	<0.1	<0.1	0.0	No Limit
		ED008: Exchangeable Sodium	----	0.1	meq/100g	<0.1	<0.1	0.0	No Limit
		ED008: Cation Exchange Capacity	----	0.1	meq/100g	26.6	27.3	2.6	0% - 20%

Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **SOIL**

				Method Blank (MB) Report	*Laboratory Control Spike (LCS) Report*			
					Spike	*Spike Recovery (%)*	*Recovery Limits (%)*	
Method: Compound	*CAS Number*	*LOR*	*Unit*	*Result*	*Concentration*	*LCS*	*Low*	*High*
ED008: Exchangeable Cations (QCLot: 894998)								
ED008: Exchangeable Calcium	----	0.1	meq/100g	<0.1	1.47 meq/100g	81.1	70.2	105
ED008: Exchangeable Magnesium	----	0.1	meq/100g	<0.1	----	----	----	----
ED008: Exchangeable Potassium	----	0.1	meq/100g	<0.1	----	----	----	----
ED008: Exchangeable Sodium	----	0.1	meq/100g	<0.1	----	----	----	----
ED008: Cation Exchange Capacity	----	0.1	meq/100g	<0.1	----	----	----	----

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

- **No Matrix Spike (MS) Results are required to be reported.**

APPENDIX E. Mineralogical examination of leach residues

CSIRO RESTRICTED INVESTIGATION REPORT
ET/IR1135

Mineralogical Investigation of Olympic Dam Leach Samples

by

D.H. French

Prepared for SRK Consulting

June 2009

CSIRO Energy Technology:
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Pinjarra Hills Laboratory: PO Box 883, Kenmore, Qld 4069 Australia
Lucas Heights Laboratory: PMB 7, Bangor, NSW 2233 Australia

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Report to SRK Consulting

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EXECUTIVE SUMMARY

CSIRO, Energy Technology was requested by Dr. S. Simpson of CSIRO, Land and Water to undertake a mineralogical examination of 10 samples of residues from leaching experiments conducted on a range of materials from the Olympic Dam mine site to identify possible mineralogical changes arising from the experiments. The samples were examined using a combination of binocular microscopy and reflected polarised light microscopy.

Although a detailed optical examination was conducted, very little evidence was found of dissolution of primary phases or precipitation of secondary phases as a result of leaching. The only definitive evidence of precipitation was found in the quartz rich sediment (sample 7) and quartz rich tailing (samples 3 and 4) in which coatings of malachite/azurite were present on some grains, being more common in sample 7. Traces of copper sulphides (bornite and covellite) were found in sample 4, some of which showed signs of oxidation although the oxidation could not be confirmed as being due to leaching. These sulphides probably account for the occurrence of copper in the bulk analysis of the pre leach sample.

1. INTRODUCTION

CSIRO, Energy Technology was requested by Dr. S. Simpson of CSIRO, Land and Water to undertake a mineralogical examination of 10 samples of residues from leaching experiments conducted on a range of materials from the Olympic Dam mine site to identify possible mineralogical changes arising from the experiments. The samples were examined using a combination of binocular microscopy and reflected polarised light microscopy.

2. SAMPLING AND ANALYTICAL PROCEDURES

Ten samples of leach residue materials were supplied for mineralogical analysis (see Table 2.1 for details) from which polished grain mounts were prepared. Subsequently, further samples of pre and post leach materials were provided but, due to time constraints, only a binocular microscope examination was carried out. The polished grain mounts were examined using reflected polarised light microscopy.

Table 2.1. Details of leach residue materials provided for analysis.

CSIRO Petrographic No.	SRK Sample No.	Sample	Source	Lithology	Mineral Assemblage	Leach solution
56715	8	Core 1 Andamooka limestone	Residue from 2:1 bottle roll sorption tests	Dolostone	Dolomite	Simulated acid percolate
56716	10	Core-4 Andamooka quartzite	Unreacted parent sample	Quartzite	Qtz+mica+kspar	Neutralised percolate
56717	9	Core-4 Andamooka quartzite	Residue from saturated column test	Quartzite	Qtz+mica+kspar	Core-4 Andamooka quartzite saturated column
56718	5	ODXH 3.1-04	Residue from 2:1 bottle roll sorption tests	Sediment	Dol+cal+qtz	Simulated acid percolate
56719	7	ODXH 3.1-09	Residue from 2:1 bottle roll sorption tests	Sediment	Quartz	Simulated acid percolate
56720	1	ODXH 3.2-05	Residue from unsaturated column test	Tailings	Hem+ill+qtz	De-ionised water
56721	6	ODXH 3.2-12	Residue from 2:1 bottle roll sorption tests	Sediment	Dolomite	Simulated acid percolate
56722	4	ODXH 3.2-01	Residue from saturated column test	Tailings	Qtz+ill+hem	De-ionised water
56723	3	ODXH 3.2-01	Residue from unsaturated column test	Tailings	Qtz+ill+hem	De-ionised water
56724	2	ODXH 4.1-04	Residue from unsaturated column test	Tailings	Hem+ill+qtz	De-ionised water

Note: Abbreviations used

Cal	calcite
Dol	dolomite
Hem	hematite
Ill	illite
Kspar	potassium feldspar
Mica	muscovite
Qtz	quartz

3. RESULTS AND DISCUSSION

3.1 Basement Lithologies

3.1.1 Andamooka Limestone

The post leach sample of the Andamooka Limestone varies in particle size from 400 to 10µm with most particles falling within the range of 100 to 300µm (Figure 3.1). Sub angular polycrystalline aggregates of carbonate (indentified as dolomite by X-ray diffraction) are common, occurring in association with sub-angular quartz grains. No evidence for dissolution or precipitation of phases was found either in the polished block or in a comparison of the pre and post leach samples under a binocular microscope. Although the leaching data suggest that copper has been absorbed/precipitated no evidence was found in the optical examination of any copper compound.

3.1.2 Arcoona Quartzite

Pre and post-leach samples of the Arcoona Quartzite were available for detailed petrographic examination. The grain size of both samples varies from 10 to 300µm and both are dominated by equant to sub equant sub angular to rounded quartz grains (Figures 3.2 and 3.3). Potash feldspar and micaceous grains (identified as mica/illite by X-ray diffraction) are also present. Rare, anhedral grains of hematite are also present, varying in size from 10 to 100µm, although most are less than 50µm in size. Although the leaching data indicate that iron may have been deposited there is no indication, in fact the reverse as a binocular microscope examination suggest that the colouring on the grains (most likely due to iron) is less intense in the post leach sample.

3.2 Sediments

3.2.1 Carbonate rich

Sample 6 is comprised largely of equant to subequant sub angular grains varying in size from 10 to 300µm although most grains are less than 100µm (Figure 3.4). Carbonate (identified as dolomite by X-ray diffraction) is the dominant phase, occurring as polycrystalline aggregates in the larger particles. Rare quartz and clay (? smectite) are also present. Binocular microscope examination of pre and post leach samples indicates that some grains have a thin coating of iron oxide which is at variance with the leaching results which indicate very little change in the iron content of the leach liquor. No other indication of dissolution or reprecipitation was identified.

Sample 5 is similar, although polycrystalline aggregates up to 600µm in size are present (Figure 3.5). Carbonate grains are dominant (calcite and dolomite by X-ray diffraction) but angular grains of quartz are common and clay rich aggregates are also present. Although the leaching data indicate that aluminium and copper were precipitated/absorbed no clear evidence for precipitation was found. However, some clay rich grains appear to have a distinct partial rim (Figure 3.5) although it is unclear as to if this is a primary or a secondary feature as no sample of the pre-leach material was available for a detailed optical examination.

3.2.2 Quartz rich

Sample 7 has a distinctive mineralogy in comparison to the other two sediment samples, consisting almost exclusively of quartz with only minor carbonate (calcite by X-ray diffraction) (Figure 3.6). Quartz occurs as sub-equant to equant sub-angular grains varying in size from 10µm to 300µm with 100 to 200µm grains being abundant. Although only one leach experiment suggested that copper precipitation had occurred, films of malachite/azurite were observed in a binocular microscope examination of the post leach sample which were absent in the pre-leach material.

3.3 Tailings

3.3.1 Hematite Rich

Sample 1 and 2 have a similar mineralogy, containing abundant hematite, mica/illite and quartz. The particle size varies from <5µm to 100µm. Quartz occurs as angular, subequant to equant grains and mica/illite as large granular aggregates (Figures 3.7 and 3.8). Hematite is common, occurring either as 10 to 100µm angular grains or as complex intergrowths with other phases (Figure 3.7). Although elements such as copper appear to have been leached from sample 1 no evidence was found in the optical examination of dissolution. There is some evidence that iron may have been leached from sample 2 as the post leach material is slightly paler than the pre-leach material. However, the leaching data indicates that iron was only removed in the initial leach experiments.

3.3.2 Quartz rich

Samples 3 and 4 are of the same tailings material leached under unsaturated and saturated conditions respectively. The tailings sample differs from samples 1 and 2 in containing more abundant quartz and mica/illite as shown by X-ray diffraction analysis. Quartz grains are common, ranging in size up to nearly 400µm (Figures 3.9 and 3.10). In a binocular microscope examination of the pre and post leach material, sparse coatings of malachite/azurite were observed to be present on some grains in the post leach material that are absent in the pre-leach sample. Minor copper sulphides are present in sample 4 as shown in Figure 3.11. Whereas covellite appears to be unaffected, some bornite grains have a rim of secondary oxidation products (malachite/azurite). It is unclear as to if the sulphide oxidation is a primary or secondary feature as samples of the pre-leach material were unavailable for a detailed optical examination.

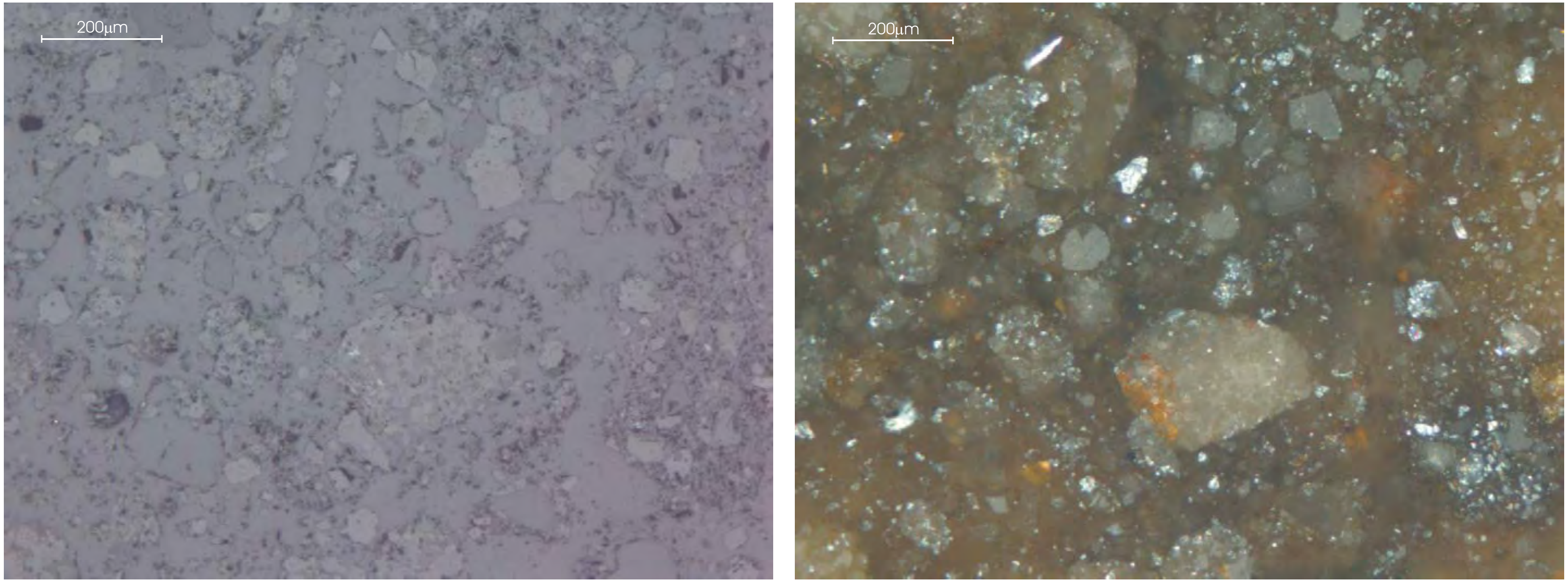

Figure 3.1. Photomicrographs of Core 1 Andamooka Limestone post-leach sample plain light (left) and crossed nicols (right) showing mottled granular carbonate aggregates and anhedral mid-grey quartz grains.

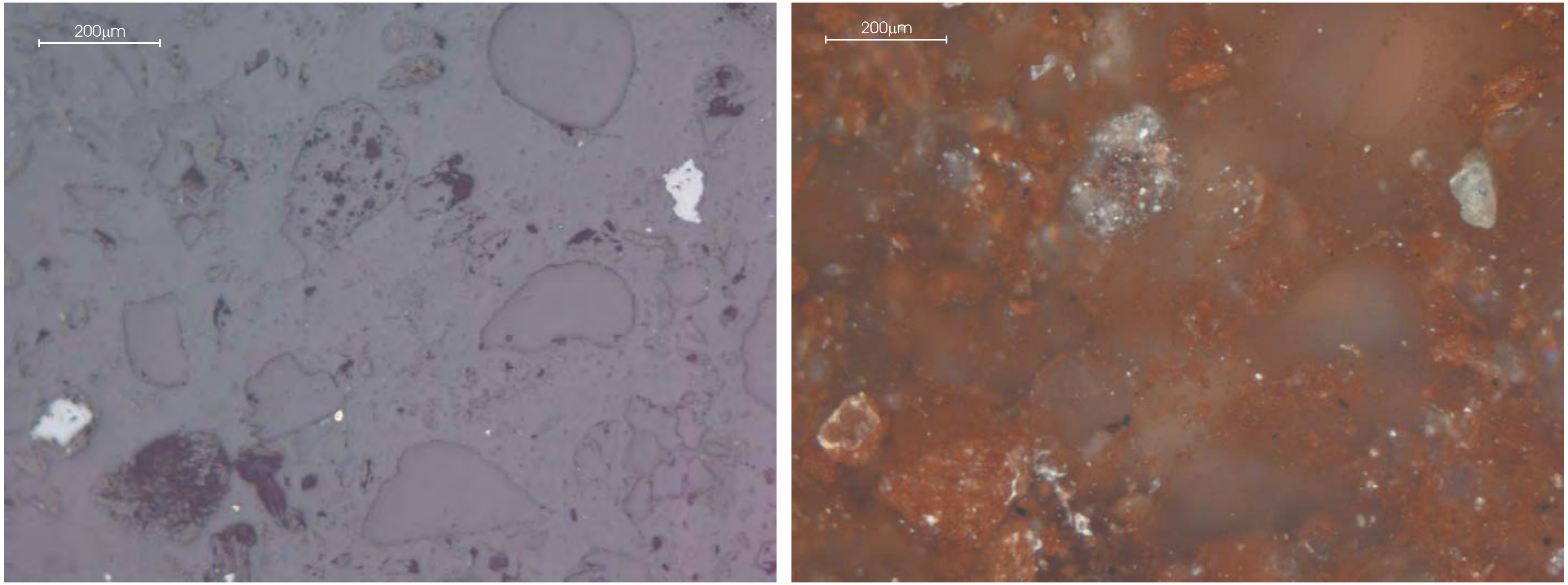

Figure 3.2. Photomicrographs of unreacted Arcoona Quartzite plain light (left) and crossed nicols (right) showing abundant rounded to sub-angular quartz grains, darker illite (bottom left) and bright hematite.

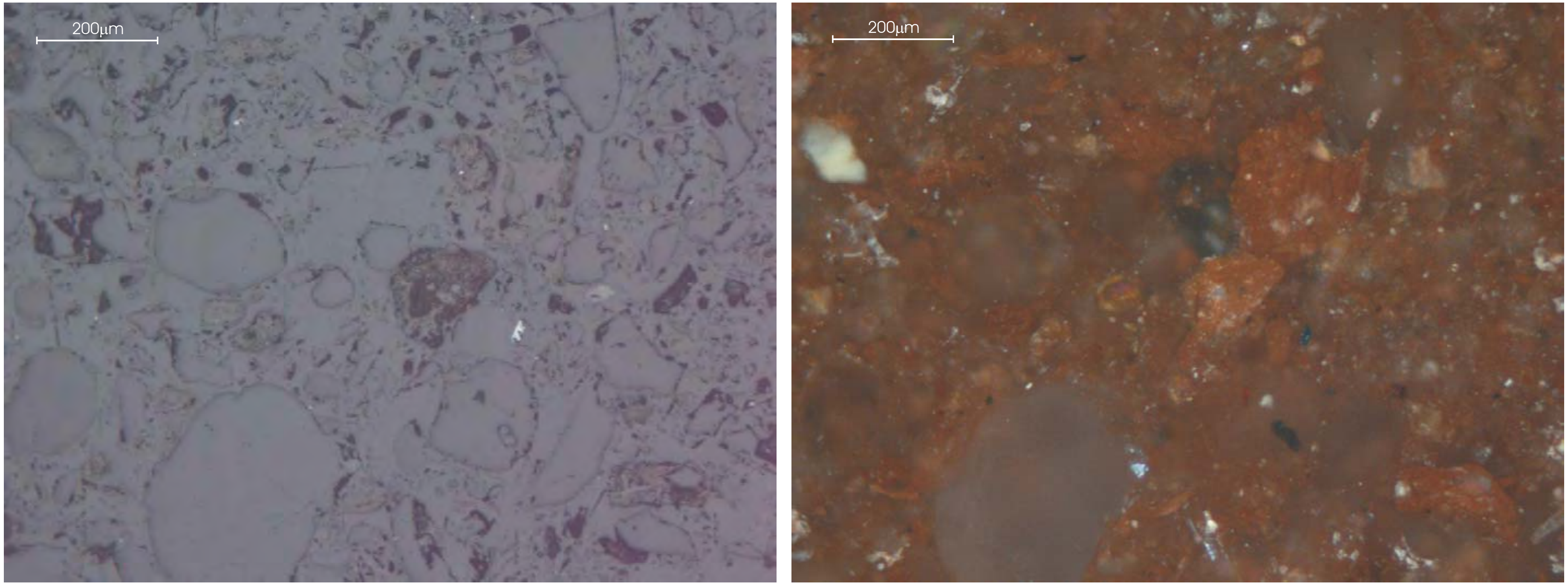

Figure 3.3. Photomicrographs of reacted Arcoona Quartzite plain light (left) and crossed nicols (right) showing abundant rounded to sub-angular quartz grains, darker illite (centre) and rare bright hematite.

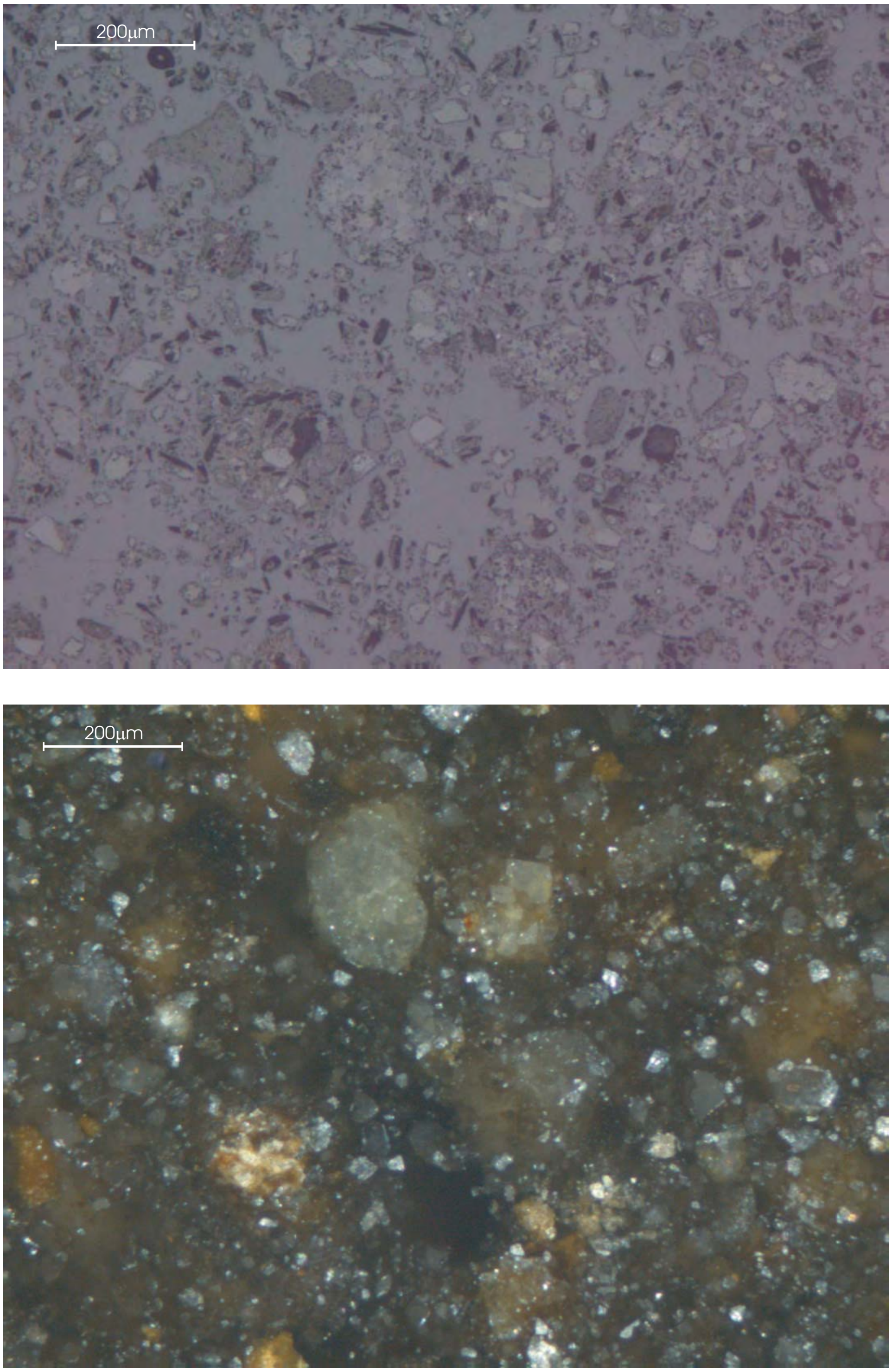

Figure 3.4. Photomicrographs of carbonate rich sediment (sample 6) plain light top and crossed nicols bottom showing polycrystalline aggregates of carbonate (top centre) and darker clay rich aggregates (top left).

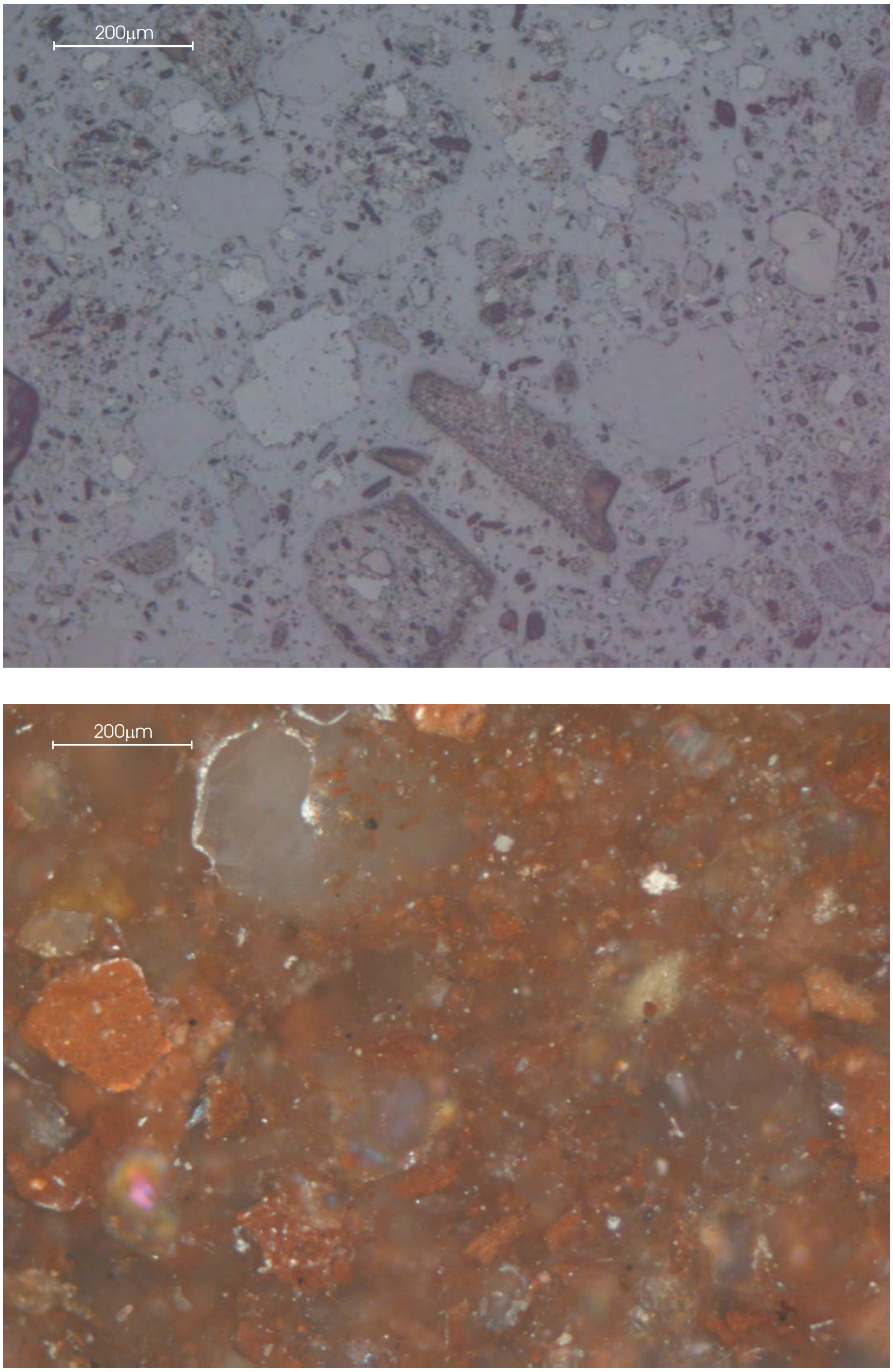

Figure 3.5. Photomicrographs of quartzose carbonate sediment (sample 5) plain light top and crossed nicols bottom containing polycrystalline carbonate aggregates, angular quartz grains and clay rich aggregates. Some clay aggregates (bottom centre) have distinctive partial rims of an unidentified phase.

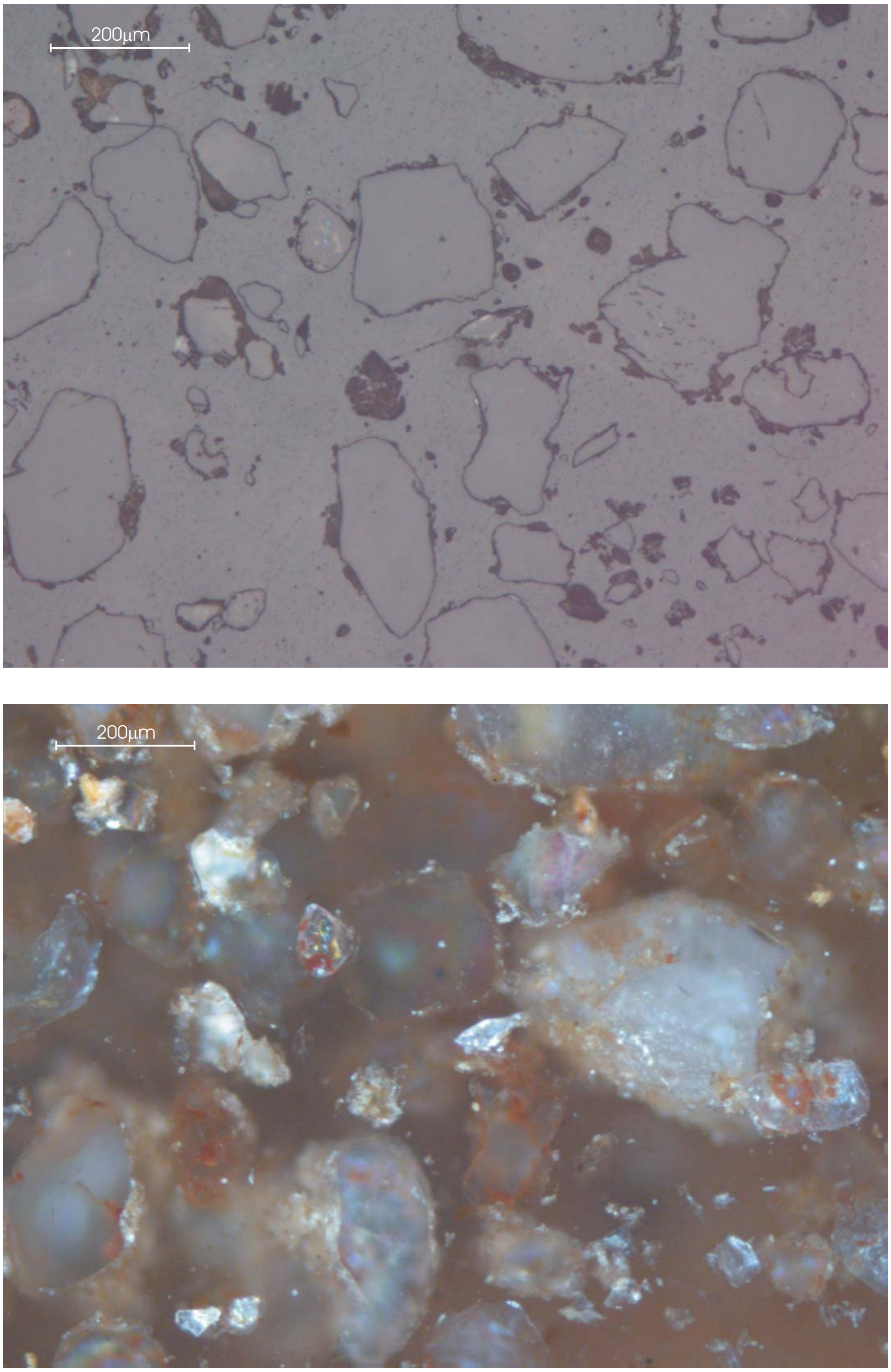

Figure 3.6. Photomicrographs of quartz rich sediment (sample 7) plain light top and crossed nicols bottom containing abundant coarse angular quartz grains and fine clay aggregates (dark).

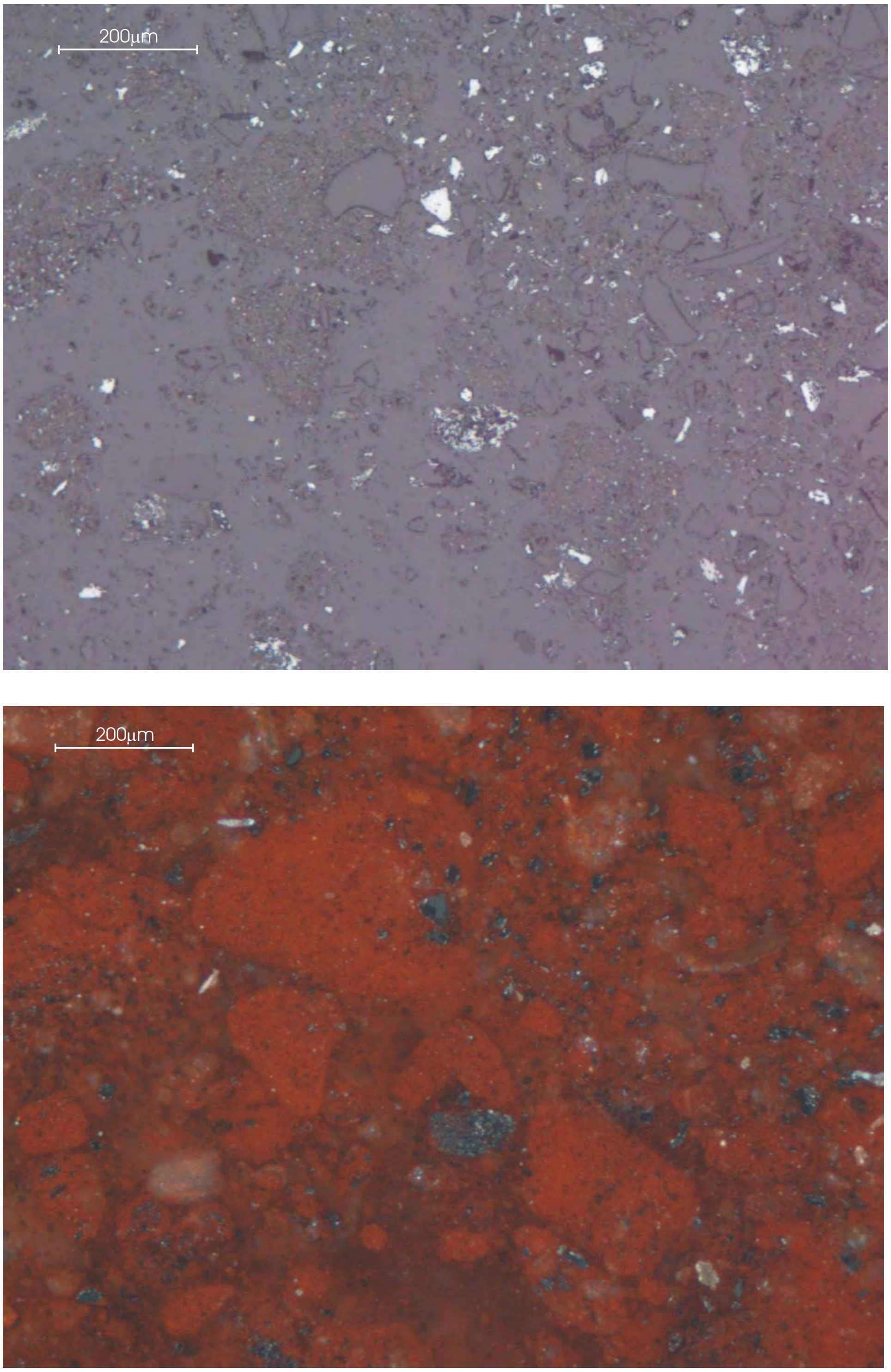

Figure 3.7. Photomicrographs of hematite rich tailings (sample 1) plain light top and crossed nicols bottom. Angular grains of quartz and clay rich aggregates occur in association with bright hematite which occurs as angular grains or complex intergrowths with other phases (lower centre).

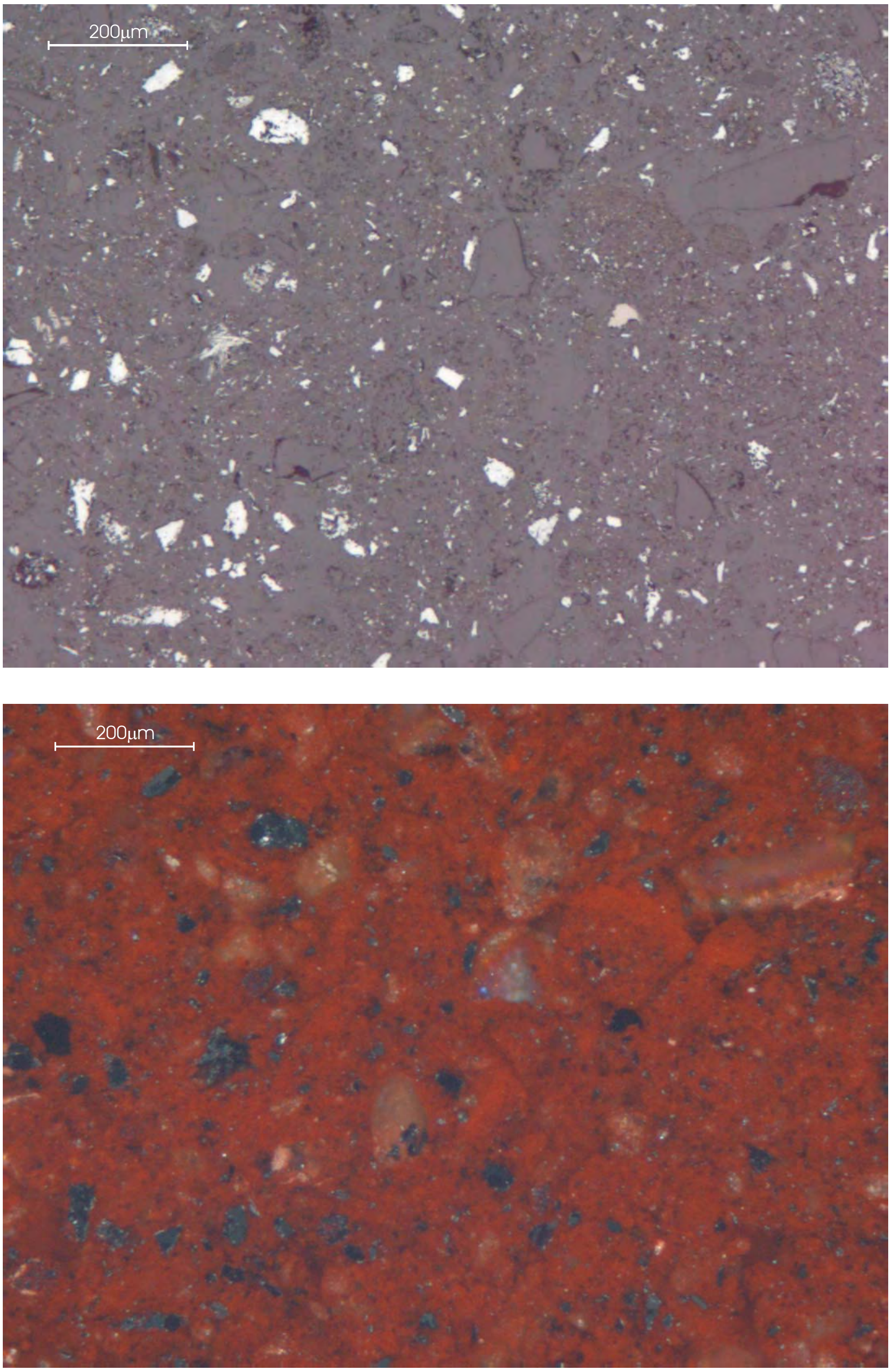

Figure 3.8. Photomicrographs of hematite rich tailings (sample 2) plain light top and crossed nicols bottom, showing the similarity to sample 1.

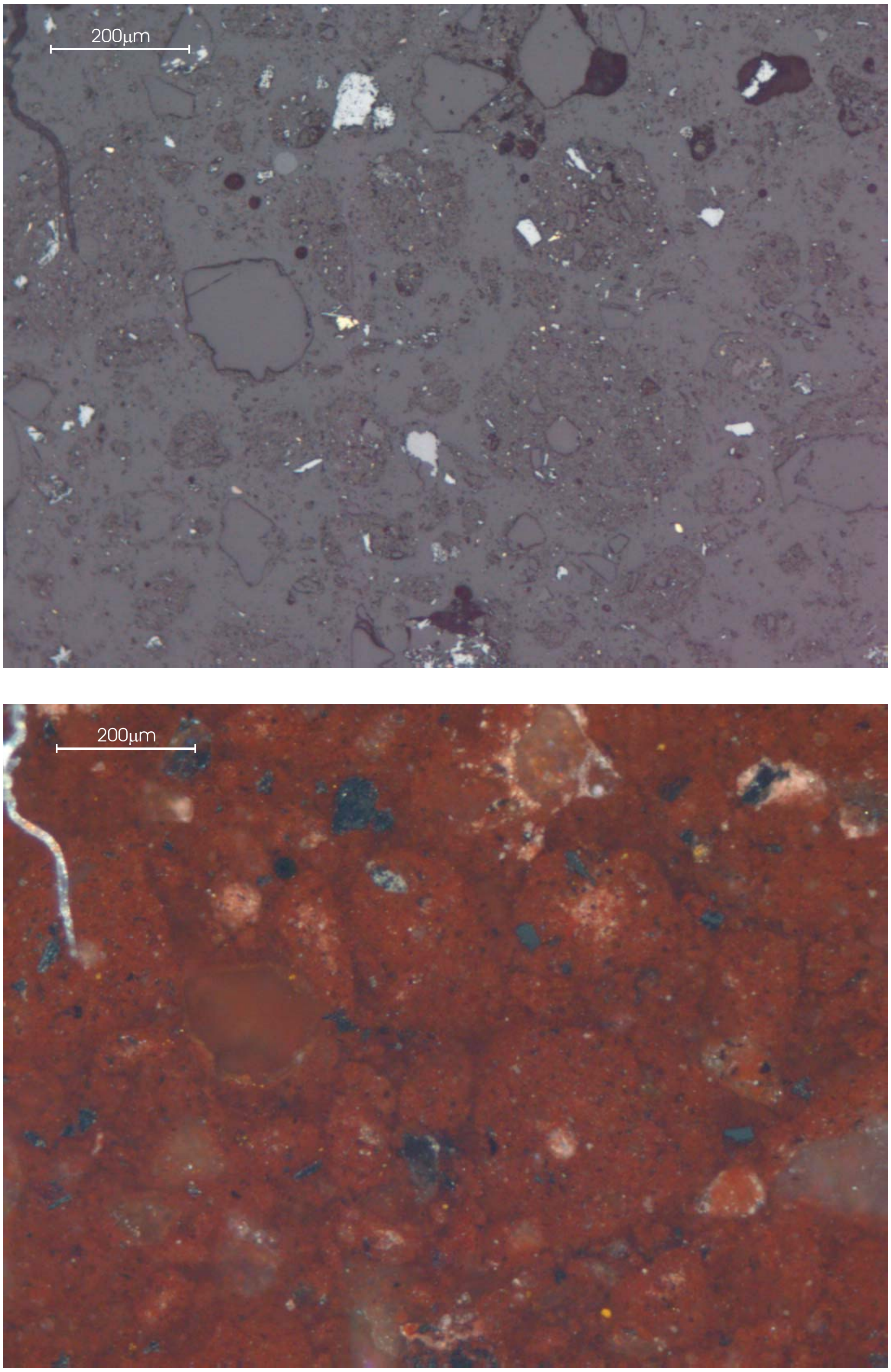

Figure 3.9. Photomicrographs of quartz rich tailings (sample 3) plain light top and crossed nicols bottom. Coarse, pale grey quartz grains, clay-rich fine grained aggregates and bright hematite are present

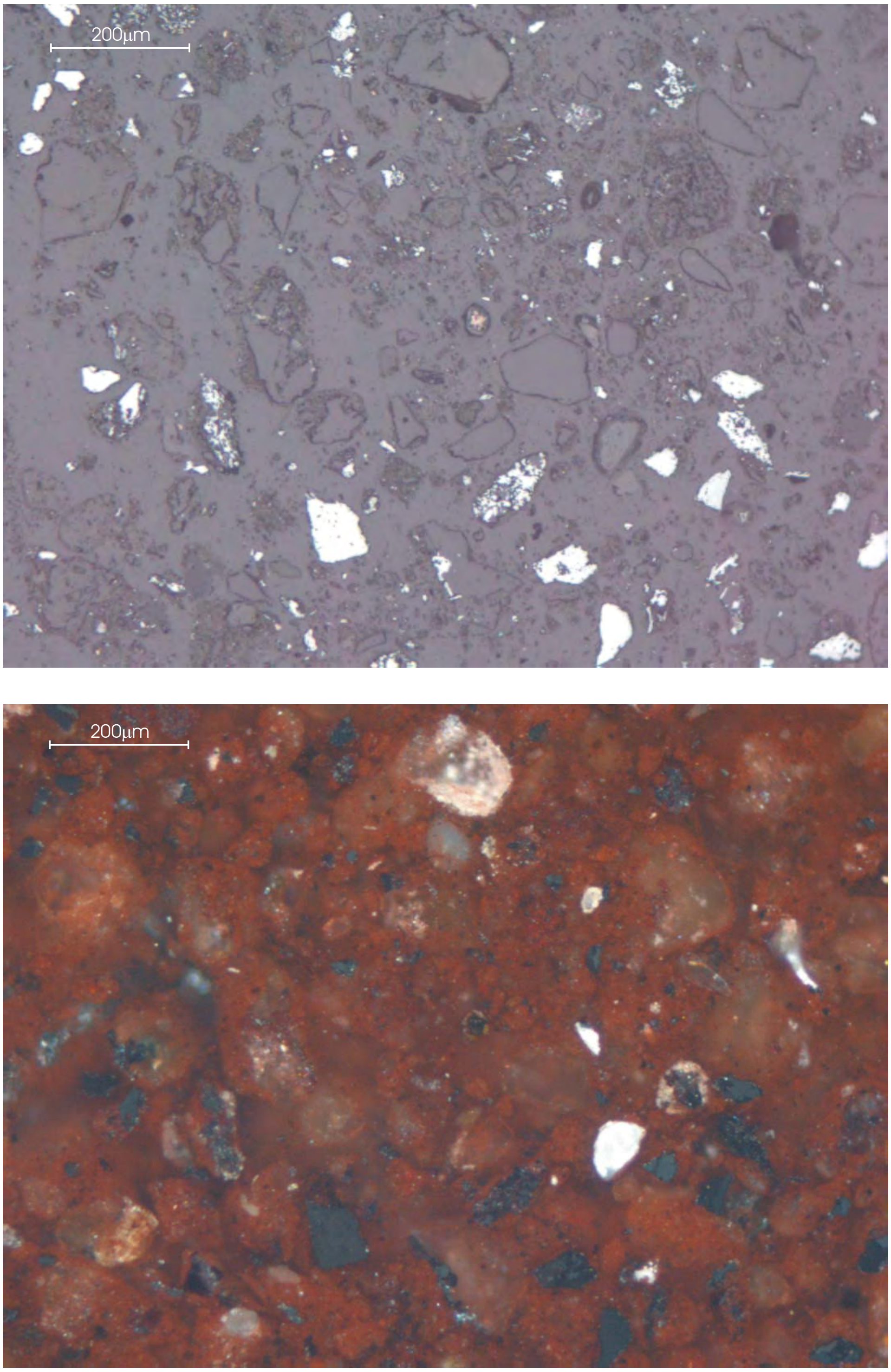

Figure 3.10. Photomicrographs of quartz rich tailings (sample 4) plain light top and crossed nicols bottom showing the similarity to sample 3.

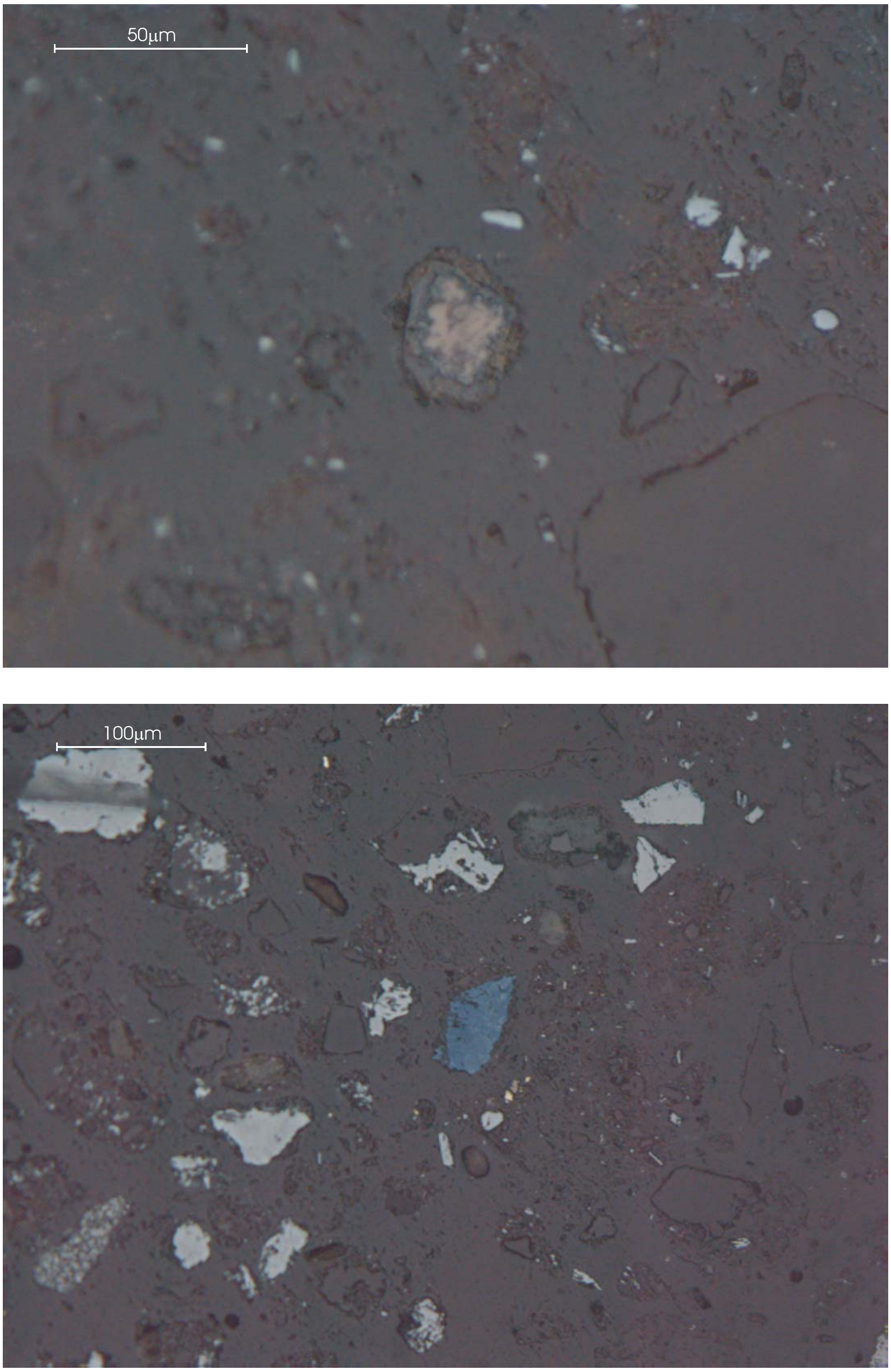

Figure 3.11. Photomicrograph of (top) pale bornite enclosed in a rim of malachite/azurite and (bottom) unaltered blue covellite.

4. CONCLUSIONS

Although a detailed optical examination was conducted very little evidence was found of dissolution of primary phases or precipitation of secondary phases as a result of leaching. The only definitive evidence of precipitation was found in the quartz rich sediment (sample 7) and quartz rich tailing (samples 3 and 4) in which coatings of malachite/azurite were present on some grains, being more common in sample 7. Traces of copper sulphides (bornite and covellite) were found in sample 4, some of which showed signs of oxidation although the oxidation could not be confirmed as being due to leaching. These sulphides probably account for the occurrence of copper in the bulk analysis of the pre leach sample.

Appendix 6: Results of Characterisation of RSF Sediments

Profile for Drillhole

Profile for Drillhole		page	of
SRK Consulting Engineers and Scientists	Client: BHP Billiton ODX	Drillhole No. RD 3469 (adj to RD2324)	
	Project:	Project No.	

Drill Rig	Inclination 90	Easting	682287 (proposed)	Bedrock depth [m]
Location	Type/Diameter	Northing	6633885 (proposed)	Depth to water [m]
Geologist TMc (REM)	Final Depth [m] 16.8	Elevation [m]		Date Drilled 12/1/2008	Date profiled

Depth [m]	Pictorial Log		Description	Material	Comments	Sample(s) Depth [m]	Sample(s) Type	SPT Blows
0.00			Sandy gravely silt: brown gravels up to 50mm, fine grained					
1.50			sandy Silt: brown/light brown, medium to fine grained, white calcareous bands throughout (weathered)		Photo 1.5 - 3.0m			
4.00			Sandy Silt (Shale): light brown/creamy, yellow and orange mottling, fine grained, calcareous		LEKT 3.0m			
4.50			Shale (Bulldog?): green/pink, clear quartz grains throughout, green mottling, fine grained, weathered		Photo 4.5 - 6.0m			
7.50			Shale (Bulldog?): Purple with some black bands, highly weathered, fine grained, calcareous		LEX 6.0m lost sample 6.0-6.75			
8.00			Silty Sandy Clay: cream/white/pink, fine grained, calcareous, some clay bands throughout.		Photo 7.5 - 8.0m			
8.50			Silty Sandy Clay: cream/white/pink, fine grained, calcareous, some clay bands throughout.					
9.00			Silty Sandy Clay: dark tan, fine grained, calcareous, less sand, gritty.		Photo 8.0 - 9.0m			
10.00			Silcrete (silty sand): cream/light brown, calcareous, consolidated silcrete/shale, gravels with orange to green and yellow banding		Photo 9.0 - 9.3m Photo 9.3 - 10.5m			
12.75			Sand/Clayey sand: cream, fine grained, low plasticity, minor gravels throughout (silcrete)		LEX 12.0 Photo 10.5 - 12.0m			
14.00			Mudstone/Silty sand: consolidated, brown/black/maroon, fine grained		Photo 13.5 - 15.0m			
14.50			Silcrete/Shale: light brown. Consolidated, slightly calcareous					
14.70			Clay/Mudstone: pale yellow/olive green, some fine sand					
16.00			Dolomite/consolidated clay: light brown, minor brown/black banding, slightly calcareous		15.0 - 15.8 (tube) Photo 15.0 - 15.9m			
			EoH		refusal at 16.8m			

Notes:

Profile for Drillhole

page		of	
SRK Consulting Engineers and Scientists	Client: BHP Billiton ODX	Drillhole No. RD 3469 (adj to RD2324)	
	Project:	Project No.	
Drill Rig	Inclination 90	Easting 682287 (proposed)	Bedrock depth [m] 16.8
Location	Type/Diameter	Northing 6633885 (proposed)	Depth to water [m]
Geologist	Final Depth [m] 16.8	Elevation [m]	Date Drilled 12/1/2008 / Date profiled 12/1/2008

Depth [m] from	to	Mid-Point (m)	Description		Paste Result pH	EC (mS)	Eh (mV)	Comments
	1.50	1.50	Cup	1	8.04	5.97	133	38.6 °C
	2.00	2.00		2	8.87	2.11	115	38.4
	2.50	2.50		3	8.47	1.83	124	37.8
	3.00	3.00		4	8.38	2.08	122	36.6
	3.75	3.75		5	8.87	1.645	123	33.7
	4.50	4.50		6	8.58	1.679	125	34.0
	5.00	5.00		1	7.87	3.09	158	37.1
	5.50	5.50		2	7.71	3.42	151	38.4
	6.00	6.00		4	7.61	3.45	145	37.1
	6.75	6.75		4	7.50	4.67	76	36.6
	7.50	7.50		6	7.34	4.86	67	35.9
	8.00	8.00		4	8.85	1.46	118	37.0
	8.50	8.50		6	9.22	0.94	96	36.5
	9.00	9.00		2	8.78	1.55	78	33.7
	9.50	9.50		**2**	9.08	1	77	37.8
	10.00	10.00		5	9.69	1.7	74	37.1
	10.50	10.50		6	9.69	1.62	76	37.4
	11.00	11.00		2	9.45	0.7	126	36.1
	11.50	11.50		5	9.44	0.93	121	35.9
	12.00	12.00		6	9.77	0.55	98	35.5
	12.75	12.75		2	9.7	0.13	130	35.6
	13.50	13.50		5	9.46	0.19	117	36.6
	14.00	14.00		**1**	8.56	1.6	146	35.2
	14.50	14.50		2	9.11	0.82	130	36.6
	15.00	15.00		3	8.87	2.7	125	35.9
	15.20	15.20		3	9.56	0.74	135	20.6
	16.00	16.00		4	9.95	0.325	133	19.4
	16.80	16.80		7	10.19	0.41	111	20.4
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Profile for Drillhole

page 1	of		
SRK Consulting Engineers and Scientists	Client: BHP Billiton ODX	Drillhole No. RD 3470 (PT-15)	
	Project:	Project No.	
Drill Rig	Inclination 90	Easting MGA 678297 (proposed)	Bedrock depth [m]
Location	Type/Diameter	Northing MGA 6627345 (proposed)	Depth to water [m]
Geologist SM (BHP)	Final Depth [m] 17	Elevation [m]	Date Drilled 13/1/2008
			Date profiled

Depth [m]	Pictorial Log		Description	Material	Comments	Sample(s) Depth [m]	Sample(s) Type	SPT Blows
1.30			Clayey sand: red/brown. Fine, calcareous nodules, gravel up to 30mm					
2.30			Sandy Silt:, layered white/tan/pink/brown		sample mostly powdered			
2.80			Sandstone/conglomerate: crystalline matrix, calcareous					
3.00			Sandy Silt:, layered white/tan/pink/brown					
6.30			Silty sand: tan/brown/red, coarse sand grains					
6.50			Clay: white/grey, firm, calcareous					
6.70			Silty sand: white/grey, soft					
8.00			Silty sand: fine to medium, rounded quartz grains up to 10mm, very large pebbles to 50 mm rounded and smooth (7.2-7.5m), Sandstone & Quartzite chips to 30mm, grading to coarser sand 7.5 to 8.0m					
8.30			Clay: white, firm, waxy surface					
8.60			Silty sand: white/purple, medium to coarse grained, thick layer medium to coarse sand at base					
9.00			Clay: firm, some sand layers, tan and red mottling					
9.75			Clay: firm, some sand layers, tan and red mottling		tube			
10.50			Clayey sand: tan/olive		tube			
13.50			Clay: olive/tan, hard, mottled red/white sand layers		bagged 13.1 to 13.5m			
15.00					13.5-15.0 tube			
15.30			Sandy Clay: yellow/tan					
15.75			Clay: light green/blue, hard with sandy layers, some gypsum					
17.00			Limestone: light beige/tan/white clayey (powdered)		EoH Refusal			

Notes:

Profile for Drillhole

page 2 of

SRK Consulting
Engineers and Scientists

Client: BHP Billiton ODX		Drillhole No. RD 3470 (PT-15)	
Project:		Project No.	
Drill Rig	Inclination 90	Easting 678297 (proposed)	Bedrock depth [m] 17.0
Location	Type/Diameter	Northing 6627345 (proposed)	Depth to water [m]
Geologist SM (BHP)	Final Depth [m] 17	Elevation [m]	Date Drilled 12/1/2008 / Date profiled 12/1/2008

Depth [m]			Description	Paste Result			Comments
from	to	Mid-Point (m)		pH	EC (mS)	Eh (mV)	
	1.00	1.00	Cup	8.64	3.19	122	23.3 °C
	1.50	1.50		8.55	5.14	105	25.1
	2.00	2.00		8.42	3.34	-275	25.0
	2.50	2.50		8.41	3.56	82	25.3
	3.25	3.25		8.68	2.92	77	27.0
	4.00	4.00		9.21	1.71	63	25.8
	4.50	4.50		8.93	0.955	113	27.1
	5.20	5.20		8.73	1.375	119	27.0
	6.00	6.00		8.57	1.98	124	23.9
	6.50	6.50		7.82	3.14	133	28.4
	7.00	7.00		7.45	3.34	181	28.2
	7.50	7.50		7.53	2.92	154	28.7
	8.00	8.00		7.89	2.54	168	28.1
	8.50	8.50		8.05	1.98	197	28.1
	9.00	9.00		7.92	2.62	193	27.2
	9.75	9.75		8.21	1.651	143	29.7
	10.50	10.50		7.35	1.96	182	30.2
	11.00	11.00		7.71	3.91	153	30.2
	11.50	11.50		7.51	2.27	122	30.1
	12.00	12.00		7.21	3.03	123	27.8
	12.50	12.50		7.13	2.24	146	29.3
	13.00	13.00		6.95	3.76	73	29.5
	13.50	13.50		7.13	2.02	61	30.1
	14.25	14.25		6.8	3.17	73	31.4
	15.00	15.00		7.75	1.349	120	28.4
	15.50	15.50		7.97	2.04	129	32.7
	16.00	16.00		8.67	1.575	111	33.3
	17.00	17.00		9.26	2.63	112	34.1
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Profile for Drillhole

page		of	
SRK Consulting Engineers and Scientists	Client: BHP Billiton ODX	Drillhole No.	RD3471 (PT-17)
	Project:	Project No.	

Drill Rig	Inclination 90	Easting 684465 (proposed)	Bedrock depth [m] 9.3
Location	Type/Diameter	Northing 6631390 (proposed)	Depth to water [m]
Geologist T Mc (REM)	Final Depth [m] 9.3 m	Elevation [m]	Date Drilled 10/1/2008
			Date profiled

Depth [m]	Pictorial Log		Description	Material	Comments	Sample(s)		SPT Blows
						Depth [m]	Type	
0.00			Gravely sandy silt: red brown, fine grained, grain size up to 2 mm					
0.50			Shale: (Bulldog?), grey/green white					
1.00					tube melted lost sample			
2.50			Silt/Shale: brown/green, consolidated with limestone nodules throughout					
3.00			Siltstone/Clay: brown, moderate plasticity, limestone and gravels throughout		LEX 3.0 - 3.25			
3.75			Silt: Cream light brown, moderate plasticity, limestone gravels throughout					
4.50			Limestone: light brown/white, some clay fines, increasing clay to 6.25m		LEX 3.75 - 4.5			
6.25			Sand: white, clean, increasing to pale brown/yellow with depth, minor clay layers with iron banding and staining					
7.50			Sand: light brown/white, clean, medium grained some clay fines					
7.75			Limestone: fine grained sands					
8.00			Sand: Light brown/white, fine grained, silcrete gravels, quartz fines(?)					
9.00			Limestone: cream/white, some quartz fines, clay fines throughout					
9.20			Clayey sand: grey/cream, moderately hard, medium grained, largely plastic, white limestone mottling & quartz gravels					
9.30			EoH		refusal on quartzite			

Notes:

Profile for Drillhole

		page	of
SRK Consulting Engineers and Scientists	Client: BHP Billiton ODX	Drillhole No. RD3471 (PT-17)	
	Project:	Project No.	

Drill Rig	Inclination 90	Easting 684465 (proposed)	Bedrock depth [m] 9.3	
Location	Type/Diameter	Northing 6631390 (proposed)	Depth to water [m]	
Geologist	Final Depth [m] 9.3	Elevation [m]	Date Drilled 10/1/2008	Date profiled

Depth [m] from	to	Mid-Point (m)	Description	Paste Result pH	EC (mS)	Eh (mV)	Comments
	1	1.00	Cup 1	8.01	3.94	160	35.8 °C
	1.75	1.75	2	8.63	3.77	138	33.5
	2.5	2.50	3	8.53	4.61	139	32.0
	2.75	2.75	1	9.03	2.14	131	34.3
	3	3.00	2	10.50	1.372	57	33.9
	3.75	3.75	1	10.38	1.519	81	25.2
	4.5	4.50	1	8.58	3.15	174	36.6
	5	5.00	2	8.39	3.36	173	36.0
	5.5	5.50	3	8.18	2.63	212	36.8
	6	6.00	4	8.04	2.63	174	36.9
	6.1	6.10	1	4.80	2.59	140	38.6
	6.5	6.50	2	5.00	0.397	130	36.8
	7	7.00	3		4.73	168	38.3
	7.5	7.50	4		2.41	151	38.1
	8	8.00	5	7.79	0.89	196	42.3
	8.5	8.50	6	7.35	2.32	201	40.6
	9	9.00	7	8.11	1.267	151	34.8
	9.2	9.20	8	8.52	0.59	36	38.8
		0.00					
		0.00					
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Profile for Drillhole

SRK Consulting Engineers and Scientists	Client:	BHP Billiton ODX		Drillhole No.	RD 3472 (adj to RT16)	
	Project:			Project No.		
Drill Rig	Inclination	90	Easting	677880 (proposed)	Bedrock depth [m]	24.1
Location	Type/Diameter		Northing	6634873 (proposed)	Depth to water [m]	
Geologist	T Mc (REM)	Final Depth [m]	24.1	Elevation [m]	Date Drilled 10/1/2008	Date profiled

page of

Depth [m]	Pictorial Log		Description	Material	Comments	Sample(s) Depth [m]	Sample(s) Type	SPT Blows
0.00			Gravely sandy silt: red/brown, fine grained grading up to 20 mm					
0.20			Sandy silt: red/brown, fine grained, with some gravels throughout					
3.00			Clayey silt: brown, low plasticity, some gravels up to 10 mm throughout		LEX 1.5 - 2.25 LEX 2.25 - 3.0			
3.50			Sandy Gravely Silt: cream, gravels up to 30 mm, fine grained, silcrete gravels		iron staining on gravels			
4.00			Siltstone (Shale?): white/cream, some gravels up to 50 mm throughout, silt fine grained					
4.50			Clayey Siltstone: brown, cream, moderate plasticity, orange (FeO_2) banding throughout					
5.00			Siltstone: light brown/cream, gravely throughout					
5.20			Siltstone: cream, gravels throughout					
6.00			Limestone/Siltstone: light brown, cream, minor gravels throughout, calcareous		Dolomite chips throughout at 7.0m			
8.20			Dolomite: brown, light brown, some orange banding, some quartzite throughout, calcareous, hard		hard bar at 8.9m			
9.20			Clayey Sand: light brown, medium to fine grained, low plasticity, dolomite gravels up to 50mm throughout, calcareous		photo 9.0 - 10.0			
11.00			Clayey Sand: light brown, medium to fine grained, low plasticity, dolomite/silcrete gravels (calcareous) some limestone bands throughout		photo 10.0 - 12m			
13.00			Clayey Sand: cream/white/light brown, medium to fine grained, low plasticity, purple/green & white banding through					
13.90			Dolomite/Siltstone/Limestone: cream/white/brown/light brown, dolomite with orange and black streaks, quartzite fines throughout, fine grained		photo 13.5 - 15.0m photo 15.0 - 15.6m			
16.00			Limestone/Dolomite: grey/purple, large dolomite grains, light black/brown gravels with purple streaks, fine grained, calcareous, some quartzite with silcrete in dolomite		hard bar at 17.5m photo 15.6 - 16.5 photo 15.6 - 17.2			
18.00			Limestone/dolomite: white/cream, dolomite gravels throughout, fine grained brown gravels		photo 17.2 - 18.0m			
20.00			Clay: tan/brown, moderate plasticity, some green banding throughout, gravels throughout		hard bar at 21m lost sample photo 18.0 - 19.0			
23.70			Clay: tan/brown, moderate plasticity, some green mottling/banding throughout		photo 19.0 - 19.6m photo 19.6 - 20.5m photo 22.5 - 23.75			
24.00			Dolomite: light brown/cream, minor purple/pink bands, calcareous					
24.10			EoH		Refusal on Dolomite			

Notes:

Profile for Drillhole

SRK Consulting Engineers and Scientists	Client: BHP Billiton ODX		Drillhole No. RD 3472 (adj to RT16)	page	of
	Project:		Project No.		
Drill Rig	Inclination 90	Easting 677880 (proposed)	Bedrock depth [m] 24.1		
Location	Type/Diameter	Northing 6634873 (proposed)	Depth to water [m]		
Geologist	Final Depth [m] 24.1	Elevation [m]	Date Drilled 10/1/2008	Date profiled 12/1/2008	

Depth [m]			Description	Paste Result			Comments
from	to	Mid-Point (m)		pH	EC (mS)	Eh (mV)	
	1.50	1.50	Cup 1	7.98	6.78	110	39.6 °C
	2.25	2.25	2	7.86	9.12	110	38.8
	3.00	3.00	3	8.49	3.03	80	38.1
	3.50	3.50	1	8.69	1.1128	86	39.7
	4.00	4.00	2	9.16	0.416	83	39.8
	4.50	4.50	4	9.32	0.646	77	39.9
	4.50	4.50	1	9.60	1.853	110	40.9
	5.00	5.00	2	9.26	15.04µS	117	41.8
	6.00	6.00	3	9.28	15.29µS	101	43.0
	6.50	6.50	2	9.39	0.972	120	30.5
	7.00	7.00	3	9.60	1.012	116	30.8
	7.50	7.50	1	9.63	1.208	92	32.7
	8.00	8.00	2	9.38	1.156	95	32.6
	9.00	9.00	**No sample**				
	9.50	9.50	1	9.11	1.92	156	35.1
	10.00	10.00	2	8.87	2.94	153	34.8
	10.50	10.50	3	8.83	3.11	146	32.8
	11.00	11.00	4	9.06	2.26	135	32.1
	11.50	11.50	5	8.87	2.13	135	32
	12.00	12.00	6	8.76	2.18	134	31.7
	12.75	12.75	7	9.06	2.24	112	33.3
	13.25	13.25	**No sample (wind knocked cup over)**				
	13.50	13.50	1	9.03	1.296	180	34.5
	14.00	14.00	2	9.09	1.012	166	33.5
	14.50	14.50	3	9.21	0.868	166	32.2
	15.00	15.00	4	9.37	1.268	153	32.2
	15.50	15.50		9.38	0.64	149	32.7
	16.00	16.00	1	8.93	1.082	148	41.5
	16.50	16.50	2	9.16	0.709	140	39.7
	17.00	17.00	3	9.15	0.863	132	41.4
	18.50	18.50	1	9.78	1.051	118	24.7
	19.00	19.00	2	9.92	0.783	113	24.7
	19.50	19.50	1	9.96	0.509	110	27.5
	20.20	20.20	1	9.62	0.356	76	28.3
	20.95	20.95	2	10.03	0.032	89	29.1
	21.70	21.70	3	10	0.366	77	29.5
	22.00	22.00	3	10.06	0.35	113	29.3
	22.50	22.50	1	9.6	0.707	89	31.4
	23.70	23.70	2	9.54	0.623	92	31.3
		0.00					

Notes:

Table A6.1 Total sulfur, sulfate sulfur, total carbon and acid neutralizing capacity (RSF sediment samples)

Sample	Total S	Sulphate S	Total C	ANC as H2SO4
Units	**%**	**%**	**%**	**kgH2SO4/tonne**
LOD	**0.01**	**0.01**	**0.02**	**0.5**
ODXPT15-1	0.07	0.08	0.36	26.3
ODXPT15-3	0.04	0.02	0.03	3.5
ODXPT15-5	0.96	0.85	0.03	<0.5
ODXPT15-7	1.93	1.78	0.03	0.5
ODXPT15-9a	0.37	0.41	0.03	-
ODXPT15-9c	0.04	-	0.02	-
ODXPT15-9f	0.01	-	12	959
ODXPT17-1	0.08	0.15	1.07	554
ODXPT17-2	0.09	0.09	1.31	-
ODXPT17-3d	0.03	-	0.06	-
ODXPT17-3f	0.04	-	<0.02	-
ODXPT17-3h	0.01	-	0.06	-
ODXRD2324-1	0.09	0.06	0.2	51.4
ODXRD2324-3	4.27	6.47	0.02	<0.5
ODXRD2324-5	<0.01	-	12	941
ODXRD2324-6	<0.01	-	11.8	760
ODXRD2324-7b	0.01	-	12	-
ODXRD2324-7e	<0.01	-	12	-
ODXRD2324-7g	<0.01	-	1.1	-
ODXRt16a-1	0.49	0.21	0.44	55
ODXRt16a-10	<0.01	-	11.8	-
ODXRt16a-11	<0.01	-	12	454
ODXRt16a-12b	0.02	-	11.7	-
ODXRt16a-12d	0.01	-	11.1	-
ODXRt16a-12g	0.03	-	4.73	-
ODXRt16a-12j	<0.01	-	12	-
ODXRt16a-12k	<0.01	-	11.7	-
ODXRt16a-2	1.66	1.58	3.66	-
ODXRt16a-3	<0.01	-	11.6	914
ODXRt16a-4	<0.01	-	11.6	-
ODXRt16a-5	0.01	-	9.32	790
ODXRt16a-7	<0.01	0.01	12.1	931
ODXRt16a-8	<0.01	-	11.9	-
ODXRt16a-9	<0.01	-	11.5	937

Table A6.2 Cation exchange capacity (RSF sediment samples)

Sample #	Exch Ca	Exch Mg	Exch K	Exch Na	Exch Al	CEC
Units	meq/100g	meq/100g	meq/100g	meq/100g	meq/100g	meq/100g
LOD	0.1	0.1	0.1	0.1	0.1	0.1
ODXPT15-1	28.4	1.5	0.2	1	<0.1	31.1
ODXPT15-3	5.6	0.6	<0.1	0.4	<0.1	6.6
ODXPT15-5	27.6	2.1	1.5	2	<0.1	33.2
ODXPT15-7	99.8	4.7	1	7	<0.1	112
ODXPT15-9a	22.3	1.7	<0.1	1.6	<0.1	25.7
ODXPT15-9c	2.2	0.4	<0.1	0.3	<0.1	2.9
ODXPT15-9f	16.4	12.5	<0.1	0.1	<0.1	29.1
ODXPT17-1	54.1	1	0.8	1.3	<0.1	57.3
ODXPT17-2	38.5	1.6	0.6	1.6	<0.1	42.3
ODXPT17-3d	8.1	2.6	0.2	3.7	<0.1	14.6
ODXPT17-3f	2	1.6	<0.1	1.3	<0.1	5
ODXPT17-3h	9.8	0.3	<0.1	0.2	<0.1	10.4
ODXRD2324-1	27	1.2	0.2	1.3	<0.1	29.8
ODXRD2324-3	200	2.3	0.4	4.8	<0.1	207
ODXRD2324-5	16.8	14.3	<0.1	0.1	<0.1	31.2
ODXRD2324-6	19.9	16.2	<0.1	0.6	<0.1	36.8
ODXRD2324-7b	18.5	14.7	<0.1	0.2	<0.1	33.4
ODXRD2324-7e	17.8	15.1	<0.1	0.2	<0.1	33.1
ODXRD2324-7g	13.2	10.6	<0.1	0.2	<0.1	24.1
ODXRt16a-1	56.8	5.4	1.6	5.5	<0.1	69.3
ODXRt16a-10	17	13.4	<0.1	0.4	<0.1	30.9
ODXRt16a-11	18	15.1	<0.1	0.2	<0.1	33.3
ODXRt16a-12b	17.8	11.6	0.1	0.5	<0.1	30
ODXRt16a-12d	17.8	11.3	0.2	1.2	<0.1	30.5
ODXRt16a-12g	26.4	5.3	0.5	4.5	<0.1	36.8
ODXRt16a-12j	18.8	16.2	<0.1	0.2	<0.1	35.3
ODXRt16a-12k	17.3	13.7	<0.1	1	<0.1	32.1
ODXRt16a-2	144	6.1	0.8	7	<0.1	157
ODXRt16a-3	15.4	12	0.1	0.9	<0.1	28.4
ODXRt16a-4	16.2	12.8	0.1	1	<0.1	30
ODXRt16a-5	13.7	10.2	0.3	2.6	<0.1	26.9
ODXRt16a-7	15.2	12.2	<0.1	0.4	<0.1	27.8
ODXRt16a-8	17.8	15.1	<0.1	0.4	<0.1	33.4
ODXRt16a-9	16.4	13.2	<0.1	0.5	<0.1	30.2

Table A6.3 **Mineralogy of RSF sediments**

Sample #	Bottom, m	Top, m	Hematite, wt%	Quartz, wt%	Chlorite, wt%	Mica/Illite, wt%	Calcite, wt%	Halite, wt%	Kaolin, wt%	Gypsum, wt%	Jarosite, wt%	Dolomite, wt%
ODXPT15-1	3.25	3		96		1	3	<1				
ODXPT15-3	4.5	4	<1	85				<1	15			
ODXPT15-5	9.75	9		3	<1	80		<1	8	9		
ODXPT15-7	14.25	13.5		17		48		<1	8	11	15	
ODXPT15-9f		16		<1								99
ODXPT17-1	3.75	3	1	92			4		3			
ODXRD2324-1	3.75	3		89		2	1		5	1		
ODXRD2324-3	7.5	6.75		10		31		<1	13	42		
ODXRD2324-5	13.5	12.75	<1	1								98
ODXRD2324-6	15.8	15.2		2								98
ODXRt16a-1	2.25	1.5	1	62		25	3	<1	7	1		
ODXRt16a-11	24.1	23.7	<1	1								99
ODXRt16a-3	6.75	6		2								98
ODXRt16a-5	12.75	12		4		7		<1				89
ODXRt16a-7	20.95	20.2		2								98
ODXRt16a-9	22.5	21.75		1		4						95

Table A6.4 **Major element composition of RSF sediments**

SAMPLE	Al2O3	BaO	CaO	Cr2O3	Fe2O3	K2O	MgO	MnO	Na2O	SiO2	SrO	TiO2	LOI
DESCRIPTION	%	%	%	%	%	%	%	%	%	%	%	%	%
LOD	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
ODXPT15-1	1.4	0.01	1.81	0.01	0.61	0.1	0.32	0.01	0.18	92.7	0.01	0.39	2.24
ODXPT15-3	2.78	0.01	0.14	0.03	0.59	0.1	0.08	0.01	0.15	94.6	0.01	0.26	1.13
ODXPT15-9a	11.55	0.02	0.85	0.01	0.63	0.28	0.23	<0.01	0.35	79.7	0.01	0.81	4.76
ODXPT15-9c	5.46	0.01	0.07	0.03	0.56	0.13	0.07	0.01	0.17	90.9	0.01	0.36	2.11
ODXPT15-5	22.3	0.02	1.6	0.01	5.01	6.91	3.32	0.01	0.72	51.6	0.02	0.9	6.57
ODXPT15-7	16.85	0.02	3.35	0.02	4.35	3.95	1.99	0.01	0.76	56.8	0.32	0.7	7.47
ODXPT15-9f	0.43	0.01	29.2	<0.01	0.44	0.09	21.7	0.05	0.11	1.19	0.01	0.02	46.64
ODXPT17-1	2.61	0.03	7.72	0.02	1.49	0.36	0.54	0.03	0.2	80	0.02	0.22	6.54
ODXPT17-2	4.34	0.04	6.75	0.01	1.29	0.23	1.54	0.01	0.24	76.1	0.02	0.27	9
ODXPT17-3d	8.03	0.01	1.04	0.01	0.57	0.29	0.73	0.01	0.43	83.8	0.01	0.94	3.99
ODXPT17-3f	4.02	0.01	2.94	0.02	0.57	0.08	2.17	0.01	0.33	83	0.01	0.52	6.08
ODXPT17-3h	0.44	0.01	0.26	0.02	0.44	0.02	0.09	0.01	0.07	97.8	0.01	0.07	0.48
ODXRD2324-1	2.44	0.02	2.16	0.01	1.66	0.14	0.45	0.06	0.17	89.6	0.01	0.12	2.92
ODXRD2324-3	13.6	0.02	14.25	0.01	5.68	2.52	1.06	0.01	0.48	33.2	0.02	0.69	9.94
ODXRD2324-7b	0.54	0.01	28.8	<0.01	0.98	0.02	20.9	0.1	0.08	2.74	0.01	0.03	45.64
ODXRD2324-5	0.38	0.01	29.2	<0.01	1.18	0.06	21.4	0.16	0.06	1.46	0.02	0.03	45.99
ODXRD2324-7e	0.32	0.01	28.4	<0.01	1.63	0.06	20.5	0.08	0.07	4.46	0.02	0.03	44.55
ODXRD2324-6	0.65	0.01	29.1	<0.01	0.7	0.03	20.8	0.12	0.1	2.6	0.01	0.03	45.94
ODXRD2324-7g	0.58	0.01	29	<0.01	0.86	0.01	20.8	0.1	0.06	2.58	0.01	0.03	45.86
ODXRt16a-1	7.22	0.02	3.25	0.01	3.1	0.81	2.05	0.04	0.58	75.3	0.02	0.32	6.72
ODXRt16a-2	8.98	0.08	15.2	0.01	4.63	1.22	5	0.14	0.69	45.3	0.05	0.39	17.02
ODXRt16a-12b	1.08	0.01	27.5	<0.01	0.69	0.17	20.3	0.09	0.17	5.79	0.02	0.05	44.01
ODXRt16a-12d	2.28	0.01	26.8	<0.01	0.81	0.6	18.75	0.13	0.23	8.31	0.01	0.13	41.65
ODXRt16a-3	0.82	0.01	28.5	<0.01	0.42	0.19	21.1	0.1	0.16	2.99	0.01	0.03	45.48
ODXRt16a-4	0.88	0.01	28.6	<0.01	0.35	0.19	21	0.09	0.15	3.18	0.01	0.05	45.4
ODXRt16a-12g	4.98	0.03	13.95	0.01	2.2	0.73	9.47	0.25	0.44	44.9	0.02	0.29	22.57
ODXRt16a-5	3.72	0.01	23.9	<0.01	1.28	0.72	17.6	0.17	0.36	13.25	0.01	0.17	38.55
ODXRt16a-12j	0.81	0.01	28.2	<0.01	1.2	0.1	20.5	0.22	0.1	4.15	0.01	0.05	44.64
ODXRt16a-12k	0.98	0.01	28.5	<0.01	0.61	0.1	20.7	0.08	0.1	3.62	0.01	0.05	45.14
ODXRt16a-8	0.15	0.01	29.9	<0.01	1.02	<0.01	21.2	0.11	0.12	0.69	0.01	0.02	46.86
ODXRt16a-10	0.56	0.01	29	<0.01	0.74	0.08	21.4	0.12	0.08	1.98	0.01	0.03	46.04
ODXRt16a-9	0.58	0.01	29	<0.01	0.89	0.04	21.1	0.08	0.08	2.23	0.02	0.03	46.08
ODXRt16a-7	0.15	<0.01	29.7	<0.01	0.99	<0.01	21.1	0.1	0.06	0.63	0.01	0.01	47.25
ODXRt16a-11	0.77	0.01	28.7	<0.01	0.54	0.21	21.2	0.15	0.08	2.6	0.01	0.03	45.65

Table A6.5 Minor and trace element composition of RSF sediments

SAMPLE	Ag	As	B	Be	Bi	Cd	Ce	Co	Cu	Hg	Li	Mn	Mo	Ni
Units	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
LOD	0.01	5	10	0.05	0.01	0.02	0.01	0.1	0.2	0.005	0.2	5	0.05	0.2
ODXPT15-1	0.08	3.5	10	0.15	0.41	<0.02	7.57	1.9	3.7	0.005	8.3	32	2.61	3.8
ODXPT15-3	0.05	3.7	10	0.1	0.35	<0.02	6.73	1.5	3.1	0.005	14.8	30	4.19	3.9
ODXPT15-9a	0.05	7.4	40	0.41	0.56	<0.02	20.2	2.1	1.2	0.006	29.3	24	1.94	10.7
ODXPT15-9c	0.06	3.4	20	0.23	0.54	<0.02	39.7	1.3	2.3	0.006	18.4	34	4.02	5.5
ODXPT15-5	0.12	45	170	4.12	1.5	<0.02	101	3.9	1.3	0.058	80.9	78	4.75	26.9
ODXPT15-7	0.09	18.1	120	2.65	1.68	<0.02	>500	3.3	2.2	0.005	41.3	64	2.89	18.9
ODXPT15-9f	0.04	<5	20	0.22	1.16	0.12	4.44	35.5	1.5	<0.005	1.6	383	0.62	22.4
ODXPT17-1	0.07	4.9	80	0.39	0.47	0.05	35.7	2.8	11.3	0.01	12	127	3.21	7.2
ODXPT17-2	0.05	5.4	60	0.27	0.35	0.03	11.9	4.2	8.8	0.006	27.5	77	7.52	8.5
ODXPT17-3d	0.06	5.6	80	0.23	2.75	<0.02	22.7	1.2	3.3	0.006	48.2	26	3.78	11.6
ODXPT17-3f	0.05	5.7	60	0.23	0.69	<0.02	11.35	0.9	2.4	0.005	31.5	89	2.52	4.3
ODXPT17-3h	0.05	1.7	80	0.09	1.77	<0.02	2.3	8.9	9.7	0.046	7.5	45	5.2	4.1
ODXRD2324-1	0.04	11.9	60	0.36	0.34	0.03	18.6	5.2	5.1	<0.005	11.7	377	2.84	8.2
ODXRD2324-3	0.09	5.2	110	2.67	1.05	0.02	77	3	3.8	0.005	24.4	34	1.78	22.7
ODXRD2324-7b	0.04	<5	50	0.45	0.23	0.21	5.1	2.9	1.5	0.006	2.3	757	0.65	4.3
ODXRD2324-5	0.03	<5	10	0.82	0.8	0.17	5.1	3.9	1	<0.005	1.3	1070	0.58	5.4
ODXRD2324-7e	0.04	<5	20	0.87	13.65	0.13	6.53	3.2	2.1	<0.005	1.5	614	1.11	6.2
ODXRD2324-6	0.04	<5	60	0.19	0.27	0.05	7.68	2.6	0.9	<0.005	2	905	0.59	2.4
ODXRD2324-7g	0.03	<5	60	0.46	0.53	0.04	7.61	4.3	0.6	<0.005	1.8	671	0.36	7.8
ODXRt16a-1	0.13	5.5	150	1.01	0.3	0.04	32	7	16.7	0.006	19.4	321	2.34	17.1
ODXRt16a-2	0.09	18.8	150	2.64	1.52	0.03	57.3	14.7	13.5	<0.005	26.8	969	6.76	45.4
ODXRt16a-12b	0.05	6	80	0.28	0.36	<0.02	10.7	2.6	2.7	0.006	2.7	633	0.62	3
ODXRt16a-12d	0.04	<5	130	0.6	0.05	0.02	26.2	3.5	3.1	<0.005	5.4	954	1.04	6.8
ODXRt16a-3	0.04	8	130	0.26	0.09	<0.02	10.5	4.1	3.6	0.006	2	774	1.37	3.6
ODXRt16a-4	0.07	<5	140	0.23	0.13	<0.02	10.4	2.6	3.4	<0.005	2.2	651	3.56	2.8
ODXRt16a-12g	0.05	8.2	200	1.59	0.15	0.02	43.7	10.3	21.3	<0.005	14	1850	2.74	15.5
ODXRt16a-5	0.06	<5	160	1.02	0.12	0.07	37.5	26	50.3	<0.005	8.1	1220	0.95	17.1
ODXRt16a-12j	0.04	<5	120	0.41	1.2	0.04	7.48	5.4	12.2	<0.005	2.4	1510	1.33	5.9
ODXRt16a-12k	0.04	<5	150	0.26	0.62	0.02	6.12	3.2	3.8	<0.005	1.9	539	0.72	4.5
ODXRt16a-8	0.05	5	160	0.26	6.01	0.07	2.55	3.7	3.1	<0.005	1.5	771	3.73	3.1
ODXRt16a-10	0.03	6	120	0.25	2.37	0.02	5.09	3.9	2.3	<0.005	1.5	765	2.02	4.2
ODXRt16a-9	0.04	5	140	0.27	0.41	0.06	4.49	3.5	1.8	0.005	1.8	561	0.84	4.2
ODXRt16a-7	0.41	<5	10	0.24	0.06	0.07	2.39	3.8	25.1	0.018	1.3	730	1.67	3.3
ODXRt16a-11	0.05	<5	160	0.24	0.34	0.02	5.54	2.8	1.4	<0.005	1.8	907	0.68	2.8

Table A6.5 (cont'd) Minor and trace element composition of RSF sediments

SAMPLE	Pb	Re	Sb	Sc	Se	Sn	Th	Tl	U	V	W	Y	Zn	-
Units	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	-
LOD	0.5	0.002	0.05	0.1	1	0.2	0.2	0.02	0.1	1	0.1	0.1	2	-
ODXPT15-1	2.4	<0.002	0.28	2.1	<1	0.8	2.1	0.03	0.6	36	2.9	3.5	6	-
ODXPT15-3	3.2	<0.002	0.27	2.4	<1	0.8	2.1	0.03	0.4	40	3.2	2.4	3	-
ODXPT15-9a	7.8	<0.002	0.46	5.3	<1	1.7	4.6	0.15	1.4	150	2.9	6.2	8	-
ODXPT15-9c	6.1	<0.002	0.36	1.4	<1	0.9	7.1	0.02	1.3	34	2.1	4.4	4	-
ODXPT15-5	34.2	<0.002	1.48	15.4	10	7.1	27.6	0.93	5.8	140	4.5	15.8	45	-
ODXPT15-7	33.6	0.002	1.15	15.3	6	5	39.9	0.66	10.6	88	6	19.2	32	-
ODXPT15-9f	1.5	<0.002	0.07	0.5	<1	0.2	0.8	0.03	0.7	5	1.4	2	80	-
ODXPT17-1	6.4	<0.002	0.47	2.5	<1	0.9	3.6	0.07	1	38	2	5.4	16	-
ODXPT17-2	5	0.002	0.29	2.1	<1	0.9	2.1	0.04	0.8	56	2.8	4.6	13	-
ODXPT17-3d	4.4	<0.002	0.55	4	<1	1.7	4.1	0.04	2.2	159	9	8.8	4	-
ODXPT17-3f	2.7	<0.002	0.36	2.3	<1	0.9	2	<0.02	1.4	92	3.1	5	8	-
ODXPT17-3h	0.8	0.003	0.3	0.3	<1	0.4	0.4	<0.02	0.7	14	111	0.9	3	-
ODXRD2324-1	6.8	<0.002	0.29	1.9	2	0.5	2	0.28	1.2	92	2.7	6.2	14	-
ODXRD2324-3	18	0.002	0.79	9.3	6	4.4	18.3	0.42	9.3	59	4.7	32	34	-
ODXRD2324-7b	4.2	<0.002	0.1	0.9	<1	<0.2	0.7	0.03	1.2	8	0.4	3.8	30	-
ODXRD2324-5	4.8	<0.002	0.07	1	<1	0.2	1.1	0.02	1.8	4	0.9	4.6	57	-
ODXRD2324-7e	3.9	<0.002	0.11	0.8	<1	0.2	0.6	<0.02	2.1	6	1.5	3.1	61	-
ODXRD2324-6	3.5	0.003	0.13	1	<1	0.2	1.1	<0.02	1.8	9	0.5	2.6	9	-
ODXRD2324-7g	1.2	0.002	0.08	1.2	<1	0.2	1.1	<0.02	1.5	4	0.9	3.6	10	-
ODXRt16a-1	8.8	0.002	0.37	7.1	<1	1.2	4.9	0.15	0.8	68	1.6	11.2	39	-
ODXRt16a-2	10.7	<0.002	0.81	8.1	1	1.9	7.9	0.25	2.7	197	4.4	21.3	43	-
ODXRt16a-12b	1.7	<0.002	1.89	2.1	<1	0.3	2	0.02	0.6	20	0.8	4.3	14	-
ODXRt16a-12d	2.6	<0.002	0.24	4.2	<1	0.8	4.3	0.08	1	36	0.7	9.3	16	-
ODXRt16a-3	1.1	<0.002	0.14	2.1	<1	0.3	1.9	0.03	0.5	15	11.2	3.8	14	-
ODXRt16a-4	0.9	<0.002	0.2	2.1	<1	0.3	1.9	0.05	0.5	13	0.7	3.8	13	-
ODXRt16a-12g	9	<0.002	0.43	5.9	1	1.3	7.2	0.21	2.1	79	1.6	14.1	35	-
ODXRt16a-5	22.9	<0.002	0.6	5.2	1	1.4	7.8	0.31	1.5	36	0.6	10.8	60	-
ODXRt16a-12j	11.1	0.002	0.14	1.3	<1	0.3	1.3	0.04	0.8	11	8.2	3.5	18	-
ODXRt16a-12k	2.8	<0.002	0.11	1.5	<1	0.2	1.4	0.03	1.1	5	4.2	3.1	7	-
ODXRt16a-8	3.2	0.002	0.06	0.4	1	0.2	0.4	0.07	1.1	3	48.4	1.5	11	-
ODXRt16a-10	3.1	<0.002	0.1	1.2	<1	0.3	1.2	0.03	1	6	16.6	3	11	-
ODXRt16a-9	2.8	<0.002	0.11	1.3	<1	0.2	1.2	0.03	1.3	4	2	2.3	9	-
ODXRt16a-7	2.1	<0.002	0.06	0.4	NM	<0.2	0.3	0.15	1	4	6.7	1.2	12	
ODXRt16a-11	3	<0.002	0.09	1.3	1	0.3	1.3	0.03	0.7	5	2.4	2.8	10	-

Table A6.6 **Concentrations of major elements leached from RSF sediments (3:1 water-to-rock ratio, aerobic conditions)**

Sample	pH	Total Alkalinity	Cl-	F	SO42-	Ca	Fe	K	Mg	Na
Units	-	mg/L (CaCO3)	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
LOD	0.01	1	1	0.1	1	1	0.05	1	1	1
ODXPT15-1	2.02	31	320	1.9	1710	607	<0.05	7	32	297
ODXPT15-3	2.95	31	250	2.2	237	100	<0.05	6	12	154
ODXPT15-5	5.35	10	1220	0.6	2450	662	0.1	7	103	1050
ODXPT15-7	3.89	26	900	1.1	2180	602	<0.05	37	70	712
ODXPT15-9f	7.10	38	158	0.5	338	67	<0.05	48	43	105
ODXPT17-1	11.30	12	1310	0.6	90	4	<0.05	18	<1	147
ODXRD2324-1	7.54	45	208	2.0	607	138	<0.05	3	12	262
ODXRD2324-3	7.48	16	1030	4.9	1990	616	<0.05	6	46	724
ODXRD2324-5	8.96	71	76	0.4	37	9	<0.05	48	25	52
ODXRD2324-6	7.38	114	139	0.5	57	7	<0.05	7	14	137
ODXRt16a-1	6.98	46	1040	0.9	1990	576	<0.05	20	62	881
ODXRt16a-11	9.16	73	72	0.2	15	5	<0.05	3	23	73
ODXRt16a-3	8.65	123	309	1.3	35	6	<0.05	4	12	256
ODXRt16a-5	8.35	76	520	3.3	76	8	<0.05	6	4	389
ODXRt16a-7	9.05	107	146	0.6	29	5	<0.05	35	14	105
ODXRt16a-9	8.86	103	148	0.6	25	5	<0.05	15	11	124

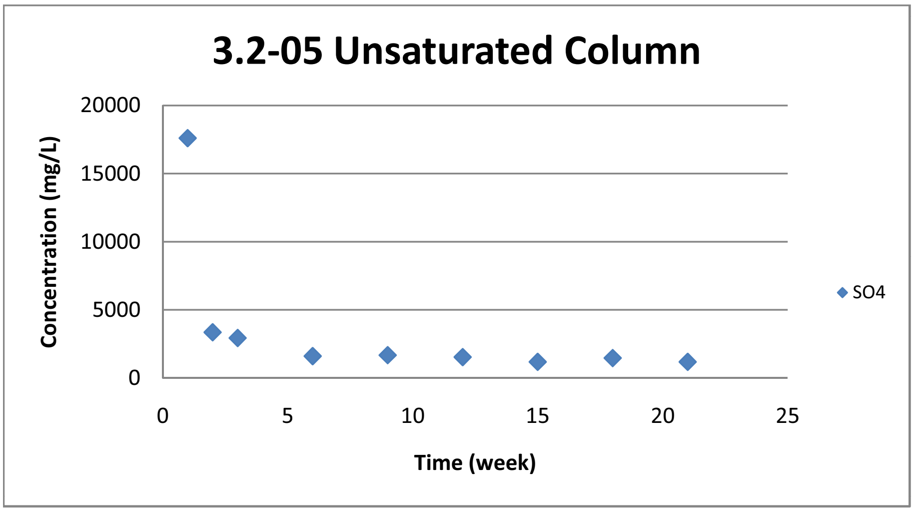
Table A6.7 Concentrations of minor and trace elements leached from RSF sediments (3:1 water-to-rock ratio, aerobic conditions)

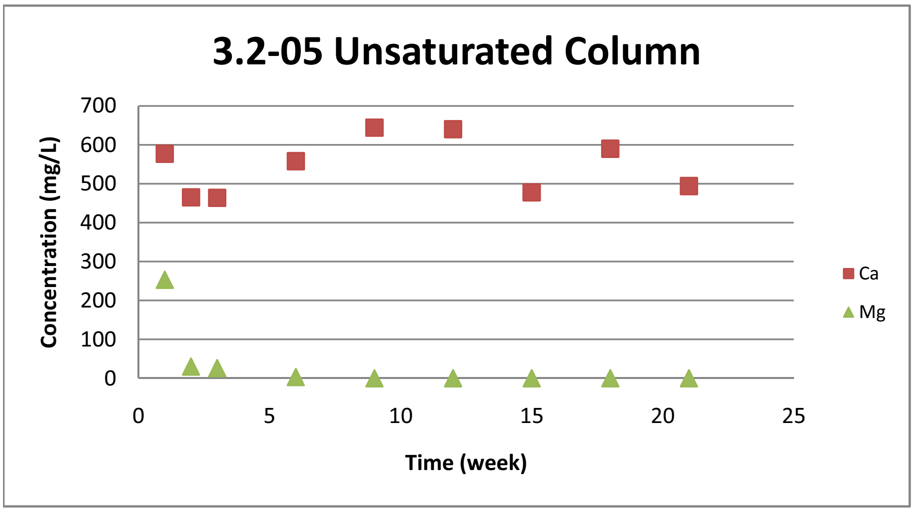
Sample	Ag	Al	As	B	Ba	Be	Bi	Cd	Ce	Co	Cr	Cu	Hg	Li	Mn	Mo
Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
LOD	0.001	0.01	0.001	0.1	0.001	0.001	0.001	0.0001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
ODXPT15-1	<0.001	0.03	0.005	2.2	0.383	<0.001	<0.001	<0.0001	<0.001	<0.001	<0.001	0.002	<0.001	0.02	0.056	0.054
ODXPT15-3	<0.001	0.09	0.01	1.2	0.289	<0.001	<0.001	<0.0001	<0.001	<0.001	<0.001	0.006	<0.001	0.02	0.013	0.03
ODXPT15-5	<0.001	0.1	<0.001	1.2	0.065	<0.001	<0.001	0.0035	<0.001	0.001	0.01	0.061	<0.001	0.025	0.084	<0.001
ODXPT15-7	<0.001	0.11	<0.001	1.1	0.114	<0.001	<0.001	0.0008	0.001	0.002	<0.001	0.005	<0.001	0.046	0.101	0.001
ODXPT15-9f	<0.001	0.11	0.001	0.3	0.12	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	0.05	<0.001	0.005	0.002	0.006
ODXPT17-1	<0.001	1.72	0.002	0.4	0.25	<0.001	<0.001	0.0024	<0.001	0.002	0.1	0.059	<0.001	0.01	0.002	0.015
ODXRD2324-1	<0.001	0.03	0.006	1.4	0.067	<0.001	<0.001	0.0007	<0.001	<0.001	<0.001	0.001	<0.001	0.014	0.002	0.029
ODXRD2324-3	<0.001	0.09	<0.001	1.4	0.119	<0.001	<0.001	0.004	<0.001	<0.001	0.004	0.05	<0.001	0.012	0.037	0.002
ODXRD2324-5	<0.001	0.08	<0.001	0.2	0.24	<0.001	<0.001	0.0031	<0.001	<0.001	0.002	0.003	<0.001	0.005	0.001	0.006
ODXRD2324-6	<0.001	0.14	<0.001	0.6	0.246	<0.001	<0.001	0.0011	<0.001	<0.001	0.001	0.009	<0.001	0.011	0.001	0.025
ODXRt16a-1	<0.001	0.08	0.002	1	0.072	<0.001	<0.001	0.0011	<0.001	<0.001	0.004	0.005	<0.001	0.031	0.001	0.042
ODXRt16a-11	<0.001	0.09	<0.001	0.3	0.318	<0.001	<0.001	0.0009	<0.001	<0.001	<0.001	0.004	<0.001	0.086	0.004	0.097
ODXRt16a-3	<0.001	0.08	0.001	0.4	0.377	<0.001	<0.001	0.0013	<0.001	<0.001	<0.001	0.007	<0.001	0.029	0.002	0.141
ODXRt16a-5	<0.001	0.15	0.002	1	0.362	<0.001	<0.001	0.0048	<0.001	<0.001	0.007	0.009	<0.001	0.035	0.007	0.043
ODXRt16a-7	<0.001	0.08	0.001	0.3	0.453	<0.001	<0.001	0.0006	<0.001	<0.001	0.001	0.002	<0.001	0.021	0.001	0.072
ODXRt16a-9	<0.001	0.07	0.001	0.4	0.356	<0.001	<0.001	0.0009	<0.001	<0.001	<0.001	0.005	<0.001	0.007	<0.001	0.049

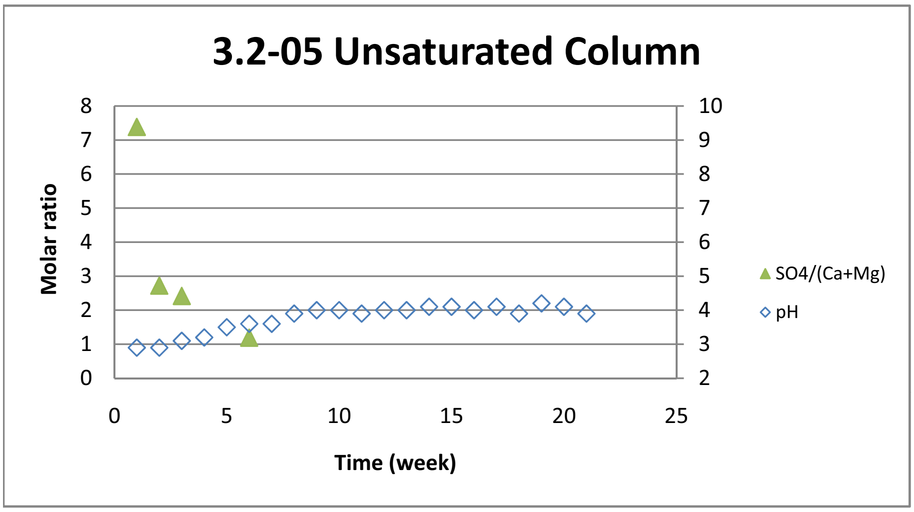
Table A6.7 (cont’d) Concentrations of minor and trace elements leached from RSF sediments (3:1 water-to-rock ratio, aerobic conditions)

Sample	Ni	Pb	Sb	Se	Si	Sn	Sr	Th	Ti	Tl	U	V	W	Y	Zn
Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
LOD	0.001	0.001	0.001	0.01	0.05	0.001	0.001	0.001	0.01	0.001	0.001	0.01	0.001	0.001	0.005
ODXPT15-1	0.005	<0.001	<0.001	<0.01	8.36	<0.001	1.85	<0.001	<0.01	<0.001	0.001	0.07	<0.001	<0.001	0.368
ODXPT15-3	0.002	<0.001	<0.001	<0.01	8.08	<0.001	0.57	<0.001	<0.01	<0.001	<0.001	0.12	<0.001	<0.001	0.544
ODXPT15-5	0.012	0.002	<0.001	<0.01	8.6	<0.001	2.27	<0.001	<0.01	<0.001	<0.001	<0.01	<0.001	<0.001	0.846
ODXPT15-7	0.007	<0.001	<0.001	<0.01	10.9	<0.001	1.89	<0.001	<0.01	<0.001	<0.001	<0.01	<0.001	<0.001	0.83
ODXPT15-9f	0.003	0.002	<0.001	<0.01	3.02	<0.001	0.192	<0.001	<0.01	<0.001	0.001	<0.01	<0.001	<0.001	0.07
ODXPT17-1	0.004	<0.001	<0.001	<0.01	9.1	<0.001	0.562	<0.001	<0.01	<0.001	<0.001	0.05	<0.001	<0.001	0.057
ODXRD2324-1	<0.001	<0.001	<0.001	<0.01	5.97	<0.001	0.834	<0.001	<0.01	<0.001	0.001	0.06	<0.001	<0.001	0.057
ODXRD2324-3	0.004	<0.001	<0.001	<0.01	5.49	<0.001	2.88	<0.001	<0.01	<0.001	<0.001	<0.01	<0.001	<0.001	0.184
ODXRD2324-5	0.001	<0.001	<0.001	<0.01	2.88	<0.001	0.061	<0.001	<0.01	<0.001	<0.001	<0.01	<0.001	<0.001	0.03
ODXRD2324-6	0.002	<0.001	<0.001	<0.01	4.87	<0.001	0.042	<0.001	<0.01	<0.001	<0.001	<0.01	<0.001	<0.001	0.576
ODXRt16a-1	<0.001	<0.001	<0.001	<0.01	7.44	<0.001	2.66	<0.001	<0.01	<0.001	0.002	0.02	<0.001	<0.001	0.272
ODXRt16a-11	0.078	<0.001	<0.001	<0.01	2.04	<0.001	0.046	<0.001	<0.01	<0.001	<0.001	<0.01	<0.001	<0.001	0.022
ODXRt16a-3	0.014	<0.001	<0.001	<0.01	3.27	<0.001	0.067	<0.001	<0.01	<0.001	0.001	0.1	<0.001	<0.001	0.042
ODXRt16a-5	0.015	<0.001	<0.001	<0.01	3.45	0.001	0.099	<0.001	<0.01	<0.001	<0.001	<0.01	<0.001	<0.001	0.145
ODXRt16a-7	0.001	<0.001	<0.001	<0.01	4.53	<0.001	0.05	<0.001	<0.01	<0.001	<0.001	<0.01	<0.001	<0.001	0.04
ODXRt16a-9	<0.001	<0.001	0.001	<0.01	4.45	<0.001	0.058	<0.001	<0.01	<0.001	<0.001	<0.01	<0.001	<0.001	0.122

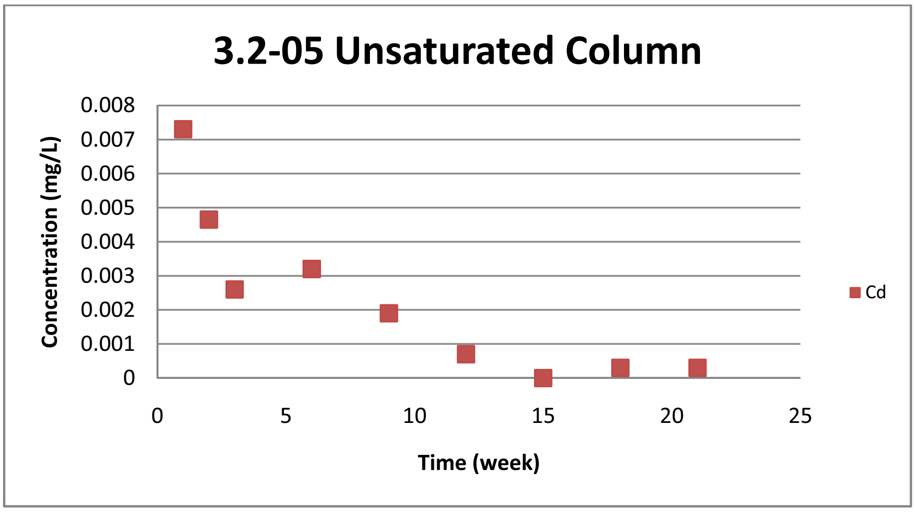
Appendix 7: Graphs Showing Results of CSIRO Column Testwork

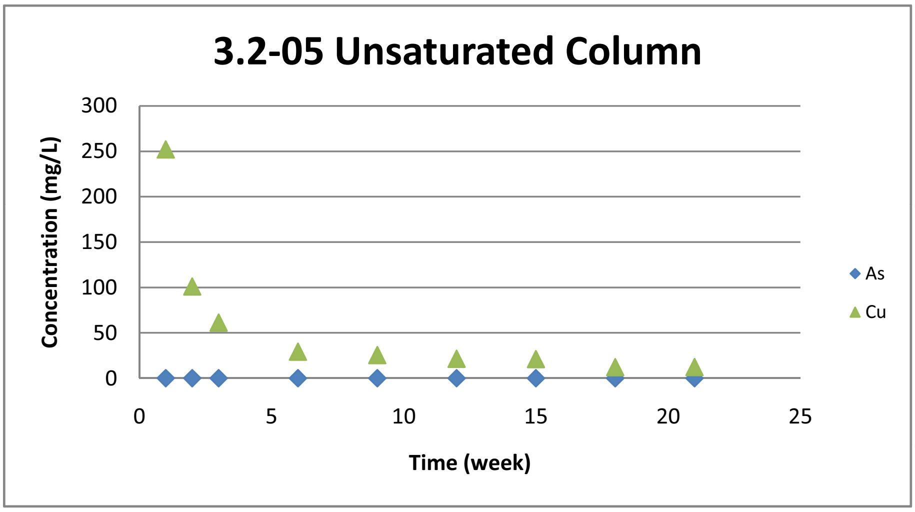

3.2-05 Unsaturated Column
Concentration (mg/L)
20000
15000
10000
5000
0
0
5
10
15
20
25
Time (week)
SO4

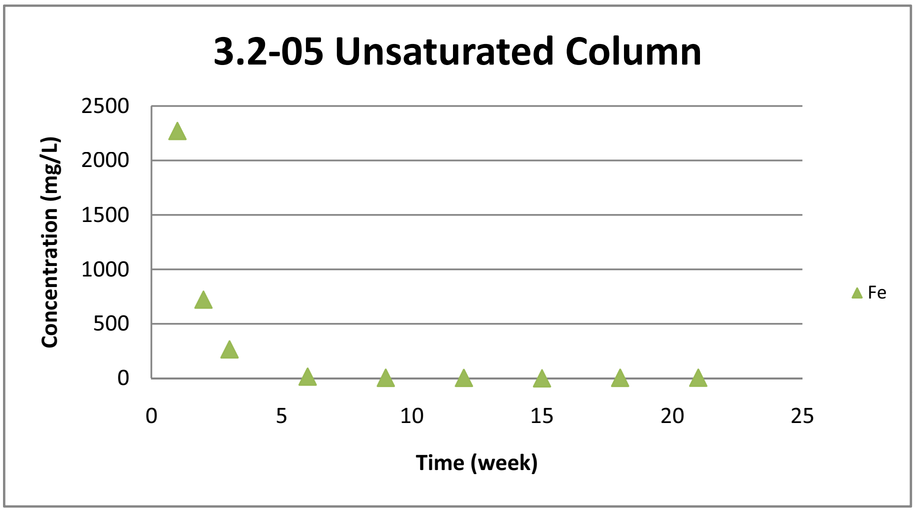

3.2-05 Unsaturated Column
Concentration (mg/L)
700
600
500
400
300
200
100
0
0
5
10
15
20
25
Time (week)
Ca
Mg

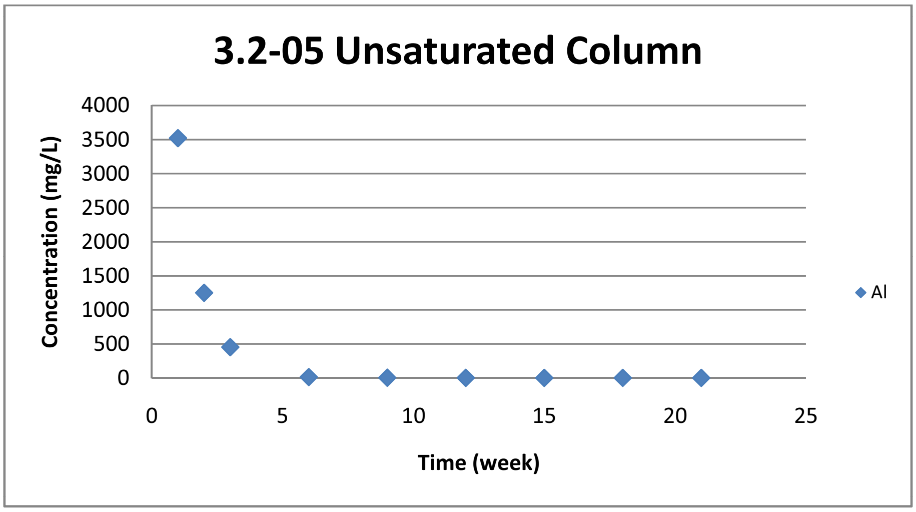

3.2-05 Unsaturated Column
Molar ratio
8
7
6
5
4
3
2
1
0
10
9
8
7
6
5
4
3
2
0
5
10
15
20
25
Time (week)
SO4/(Ca+Mg)
pH

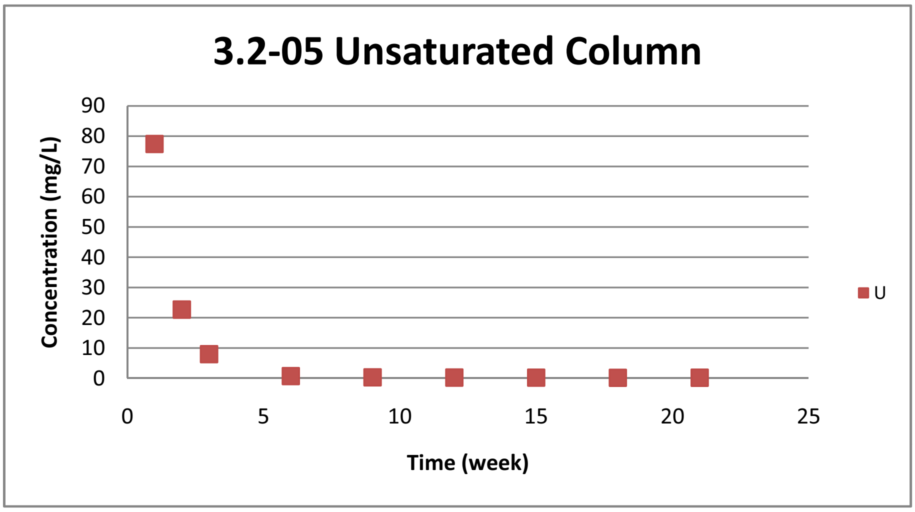
Appendix 7

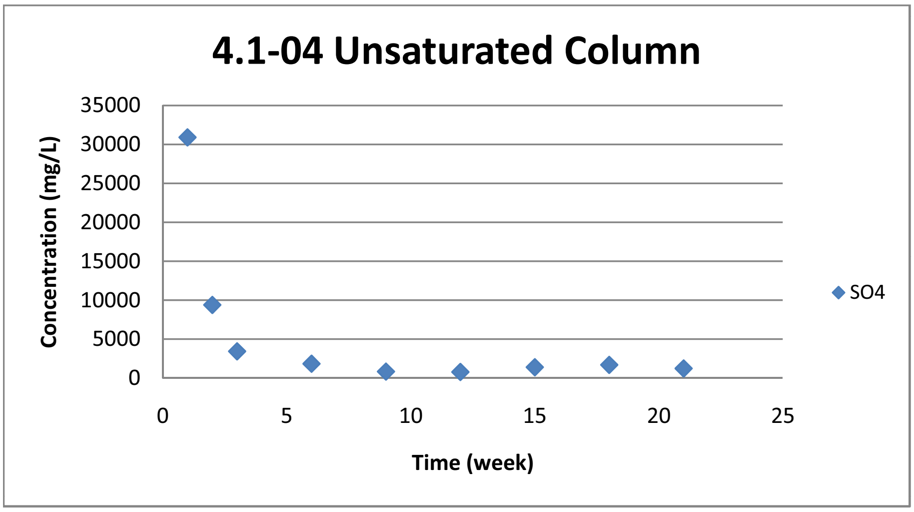

3.2-05 Unsaturated Column
Concentration (mg/L)
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0
0
5
10
15
20
25
Time (week)
Cd

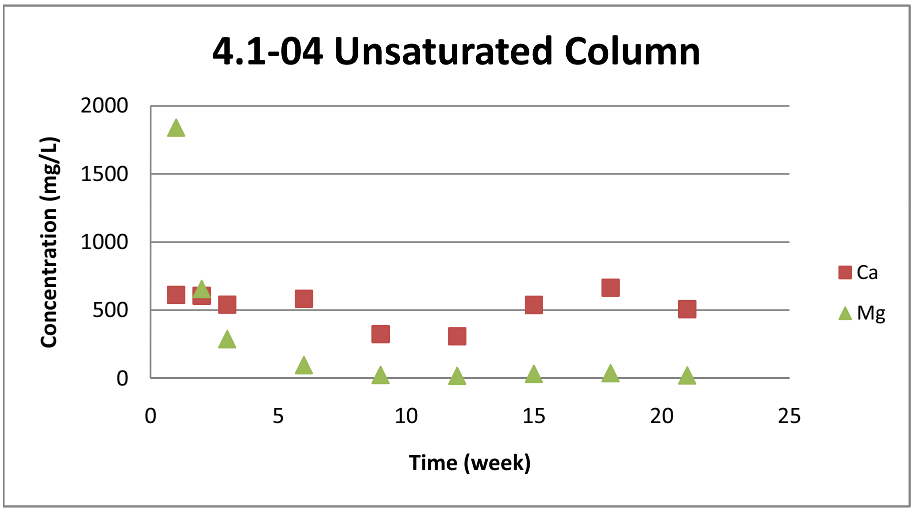

3.2-05 Unsaturated Column
Concentration (mg/L)
300
250
200
150
100
50
0
0
5
10
15
20
25
Time (week)
As
Cu

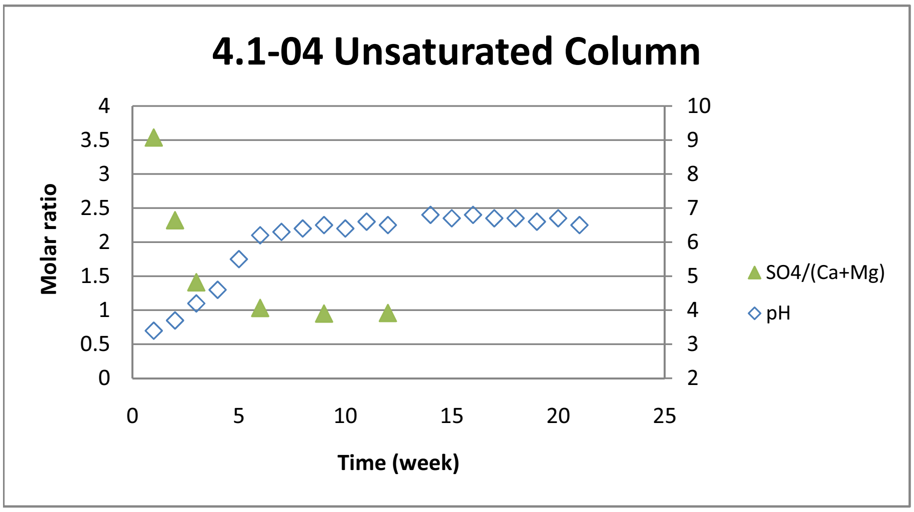

3.2-05 Unsaturated Column
Concentration (mg/L)
2500
2000
1500
1000
500
0
0
5
10
15
20
25
Time (week)
Fe

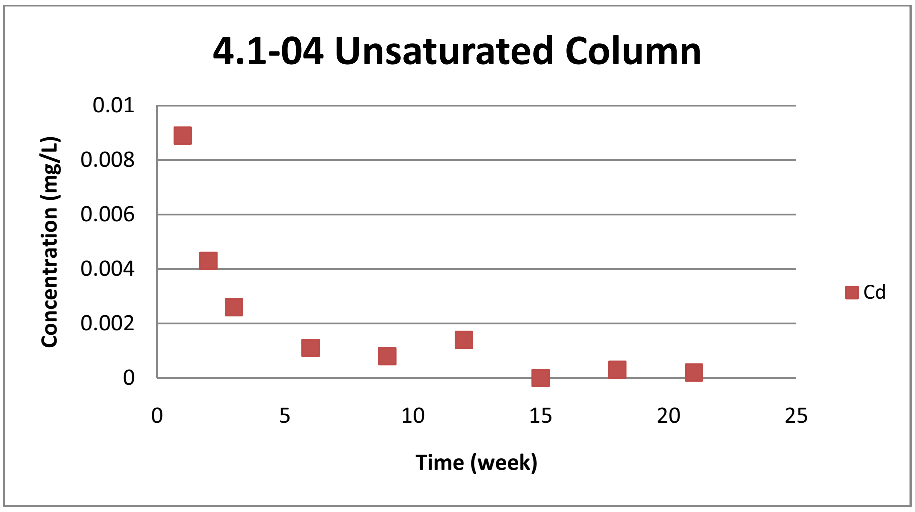

3.2-05 Unsaturated Column
Concentration (mg/L)
4000
3500
3000
2500
2000
1500
1000
500
0
0
5
10
15
20
25
Time (week)
◆ Al

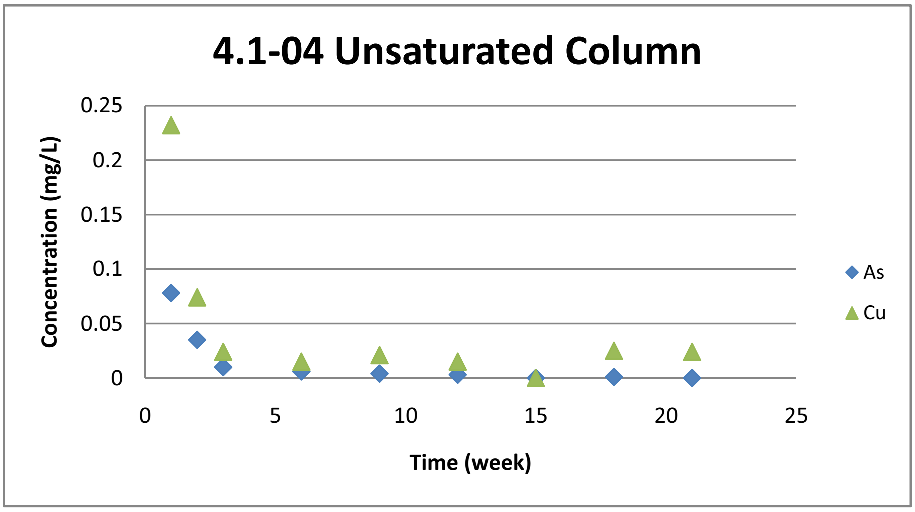

3.2-05 Unsaturated Column
Concentration (mg/L)
90
80
70
60
50
40
30
20
10
0
0
5
10
15
20
25
Time (week)
■ U

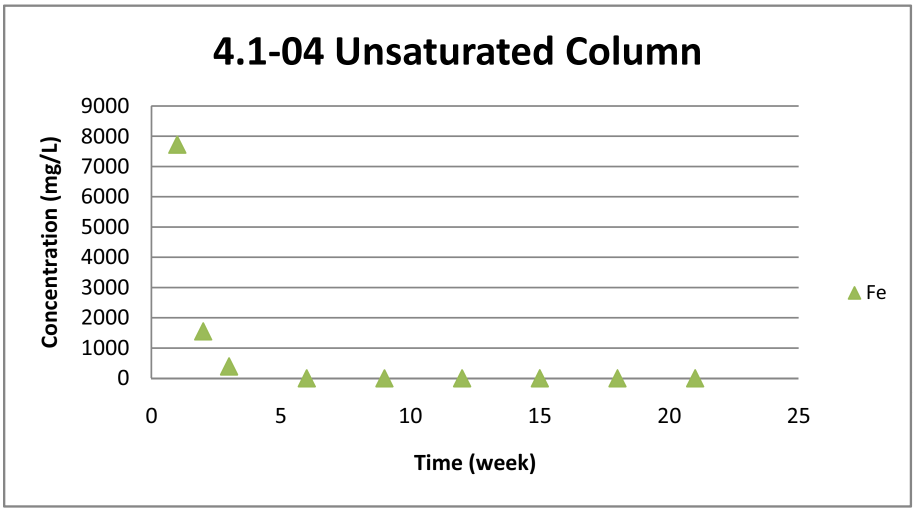

4.1-04 Unsaturated Column
Concentration (mg/L)
35000
30000
25000
20000
15000
10000
5000
0
0
5
10
15
20
25
Time (week)
SO4

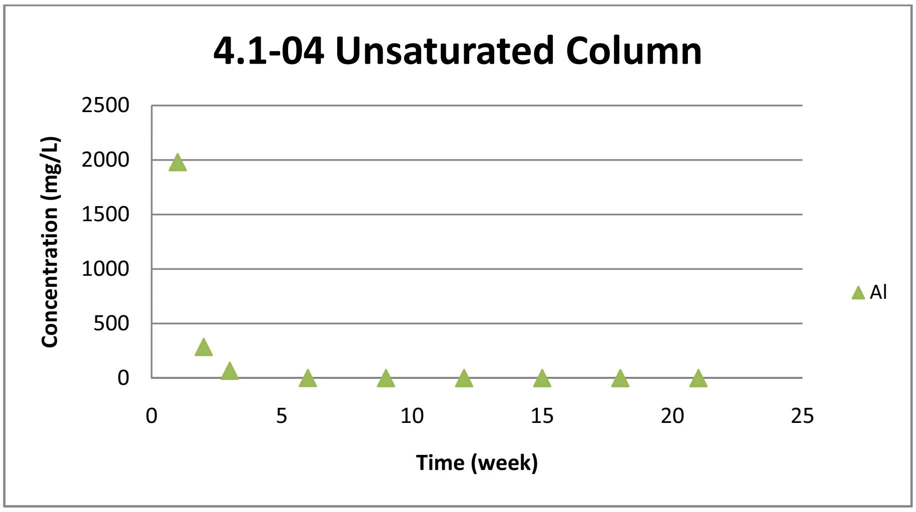

4.1-04 Unsaturated Column
Concentration (mg/L)
2000
1500
1000
500
0
0
5
10
15
20
25
Time (week)
Ca
Mg

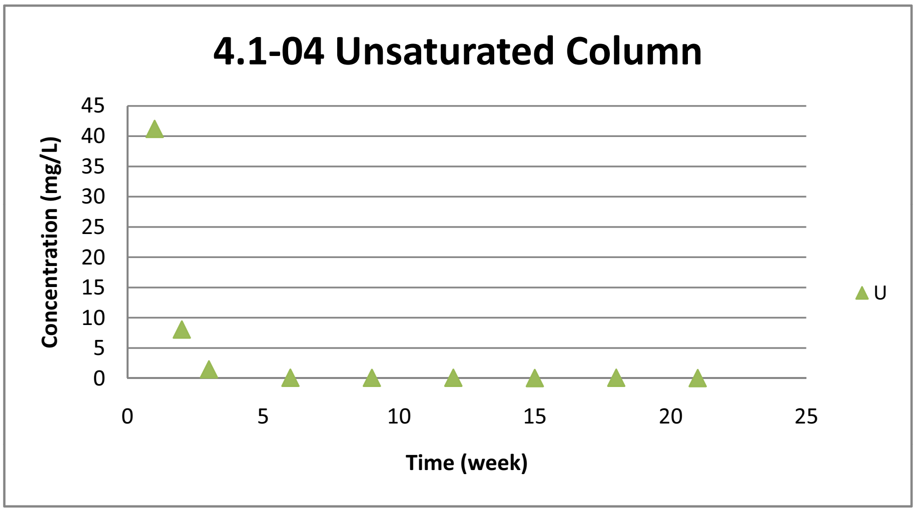

4.1-04 Unsaturated Column
Molar ratio
4
3.5
3
2.5
2
1.5
1
0.5
0
10
9
8
7
6
5
4
3
2
0
5
10
15
20
25
Time (week)
SO4/(Ca+Mg)
pH

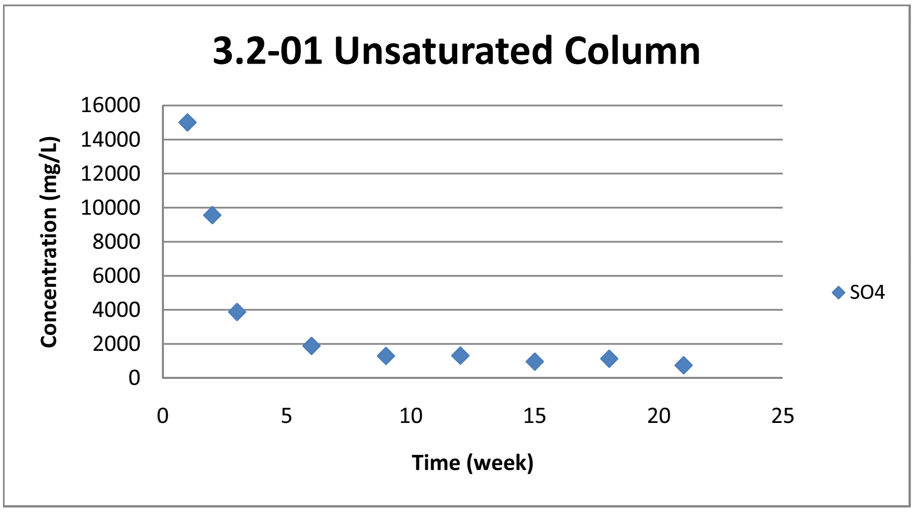

4.1-04 Unsaturated Column
Concentration (mg/L)
0.01
0.008
0.006
0.004
0.002
0
0
5
10
15
20
25
Time (week)
Cd

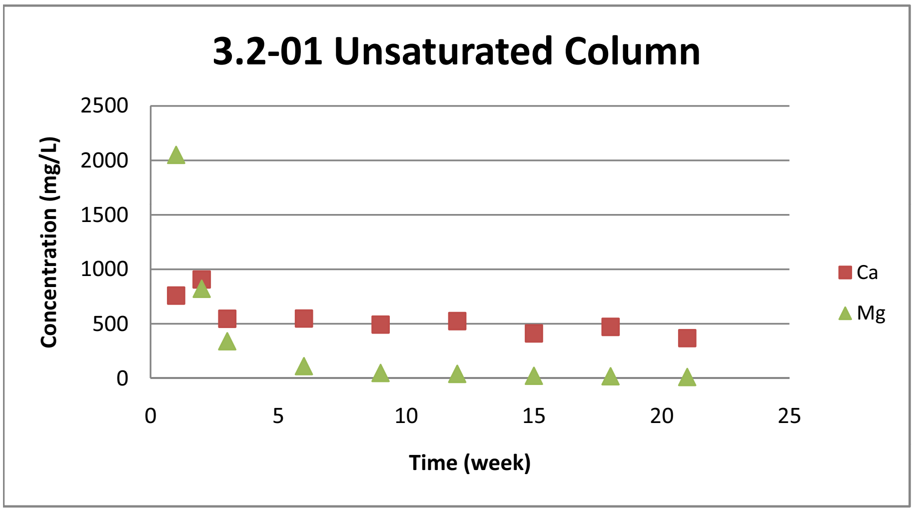

4.1-04 Unsaturated Column
Concentration (mg/L)
0.25
0.2
0.15
0.1
0.05
0
0
5
10
15
20
25
Time (week)
As
Cu

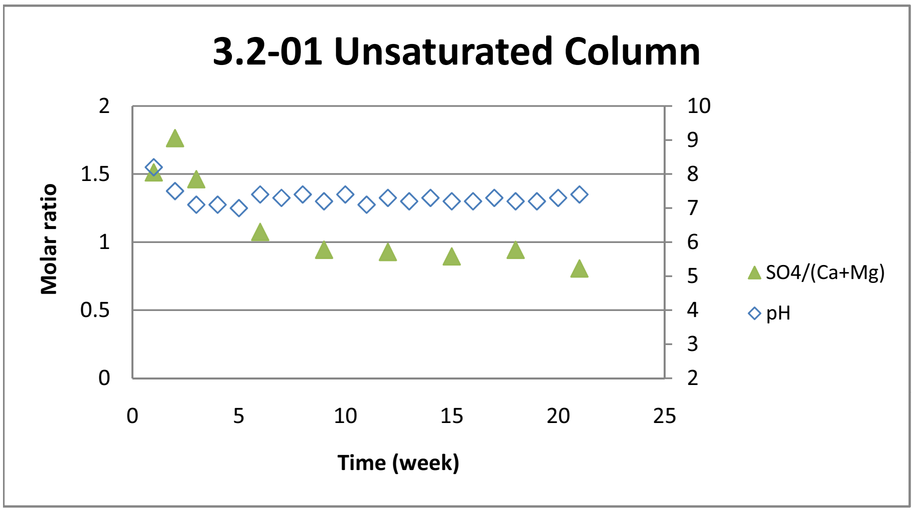

4.1-04 Unsaturated Column
Concentration (mg/L)
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
5
10
15
20
25
Time (week)
Fe

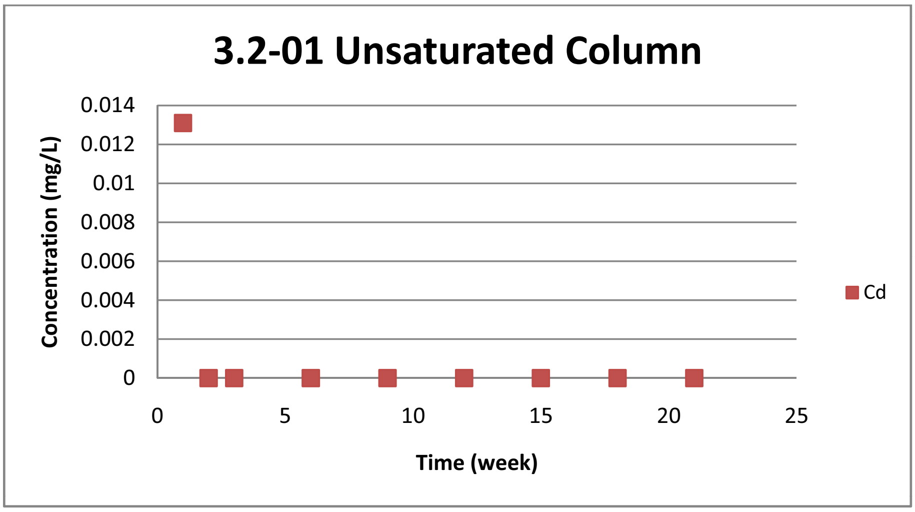

4.1-04 Unsaturated Column
Concentration (mg/L)
2500
2000
1500
1000
500
0
0
5
10
15
20
25
Time (week)
Al

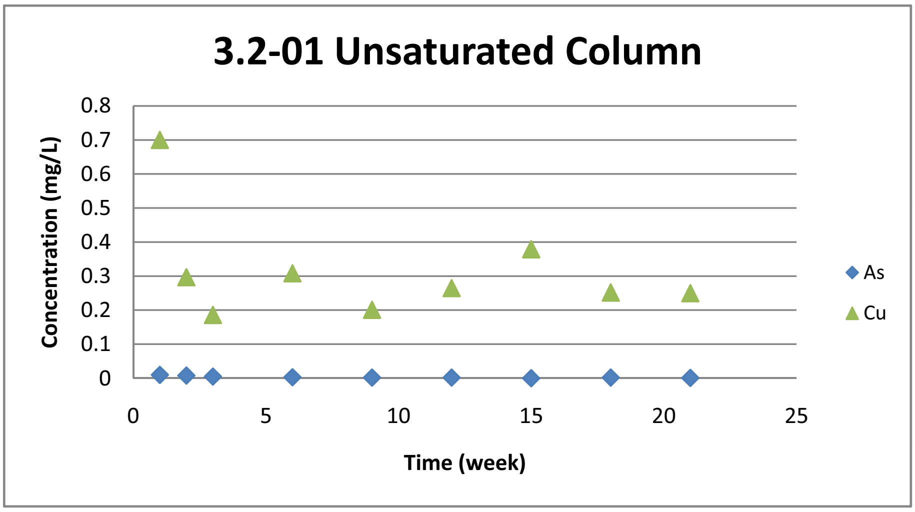

4.1-04 Unsaturated Column
Concentration (mg/L)
45
40
35
30
25
20
15
10
5
0
0
5
10
15
20
25
Time (week)
U

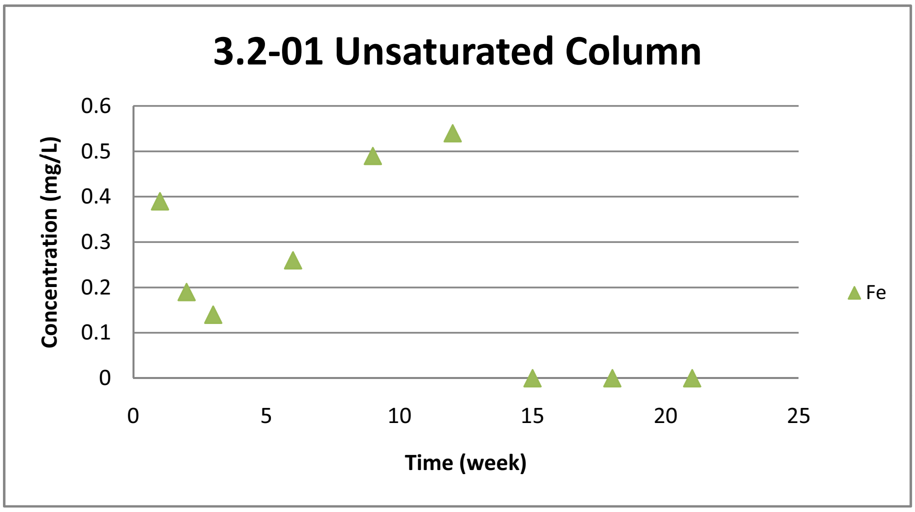

3.2-01 Unsaturated Column
Concentration (mg/L)
16000
14000
12000
10000
8000
6000
4000
2000
0
0
5
10
15
20
25
Time (week)
SO4

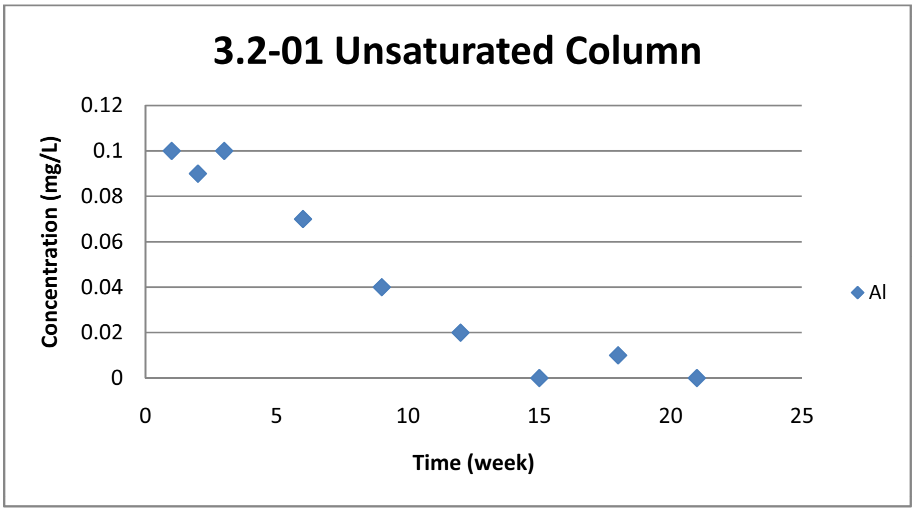

3.2-01 Unsaturated Column
Concentration (mg/L)
2500
2000
1500
1000
500
0
0
5
10
15
20
25
Time (week)
Ca
Mg

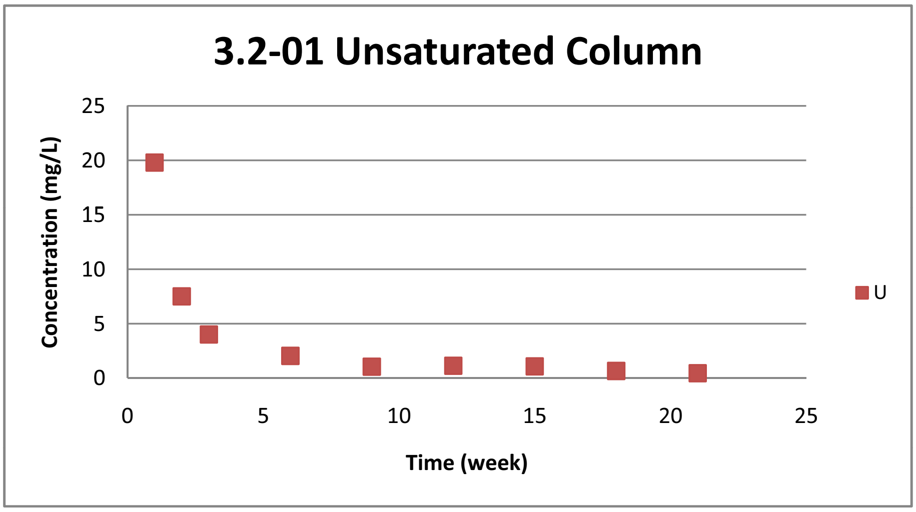

3.2-01 Unsaturated Column
Molar ratio
2
1.5
1
0.5
0
10
9
8
7
6
5
4
3
2
0
5
10
15
20
25
Time (week)
SO4/(Ca+Mg)
pH

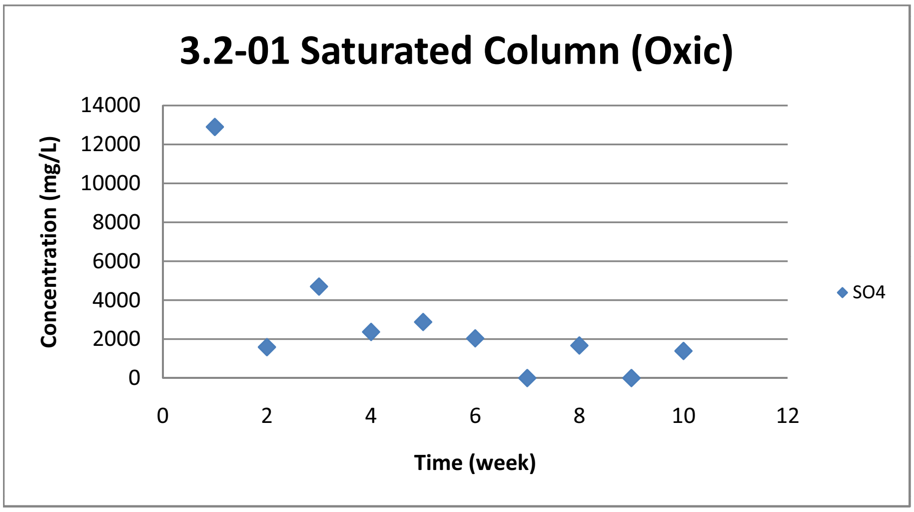

3.2-01 Unsaturated Column
Concentration (mg/L)
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
0
5
10
15
20
25
Time (week)
Cd

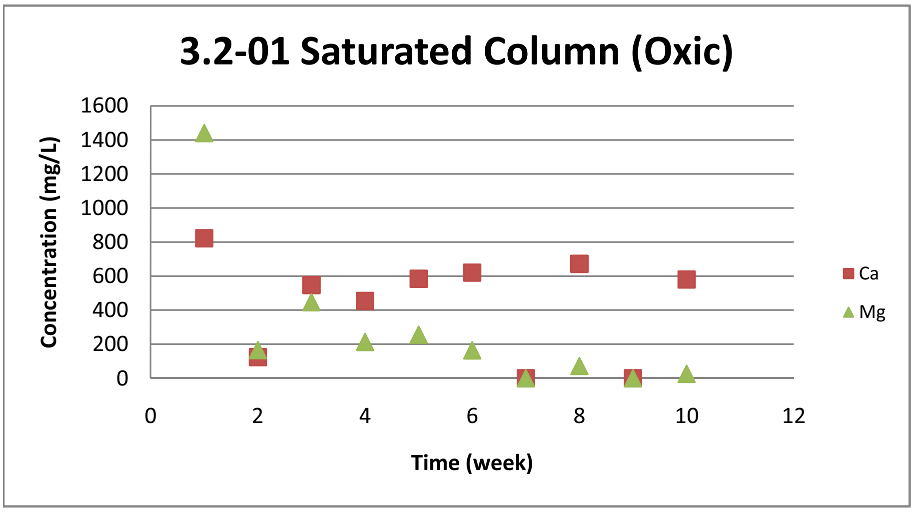

3.2-01 Unsaturated Column
Concentration (mg/L)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
5
10
15
20
25
Time (week)
As
Cu

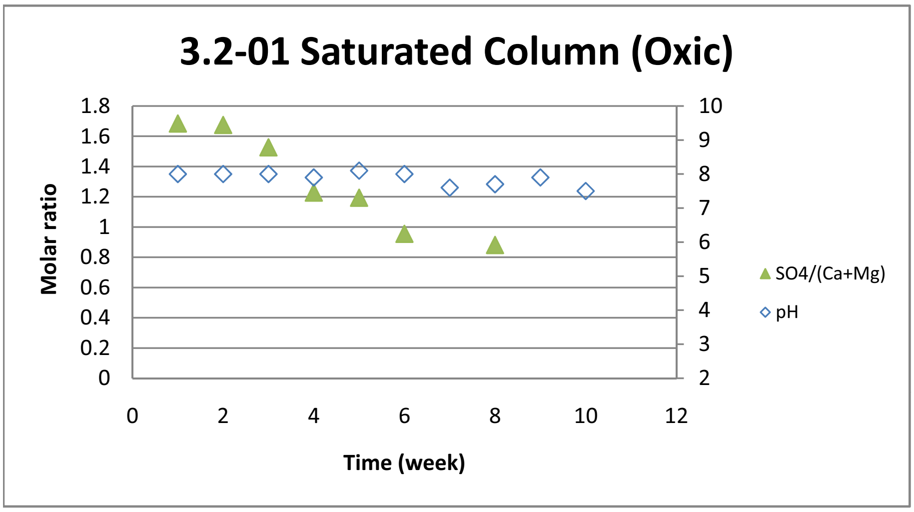

3.2-01 Unsaturated Column
Concentration (mg/L)
0.6
0.5
0.4
0.3
0.2
0.1
0
0
5
10
15
20
25
Time (week)
Fe

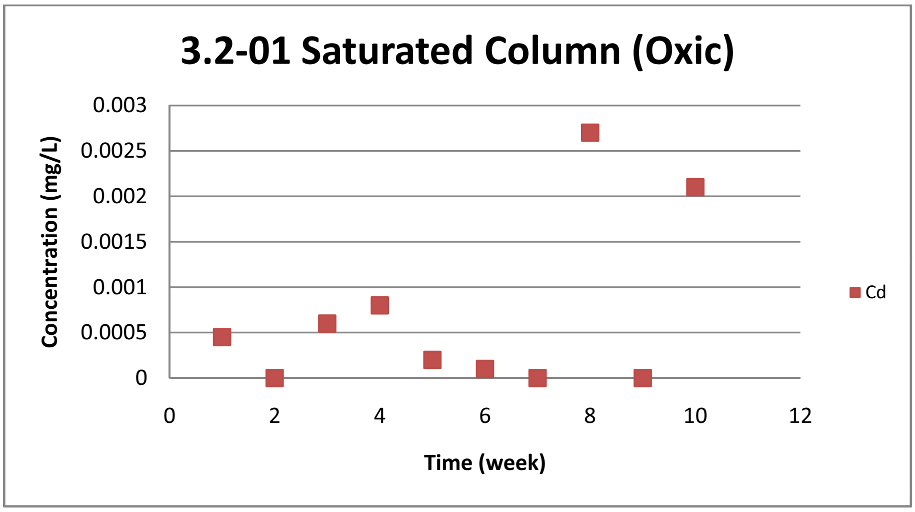

3.2-01 Unsaturated Column
Concentration (mg/L)
0.12
0.1
0.08
0.06
0.04
0.02
0
0
5
10
15
20
25
Time (week)
Al

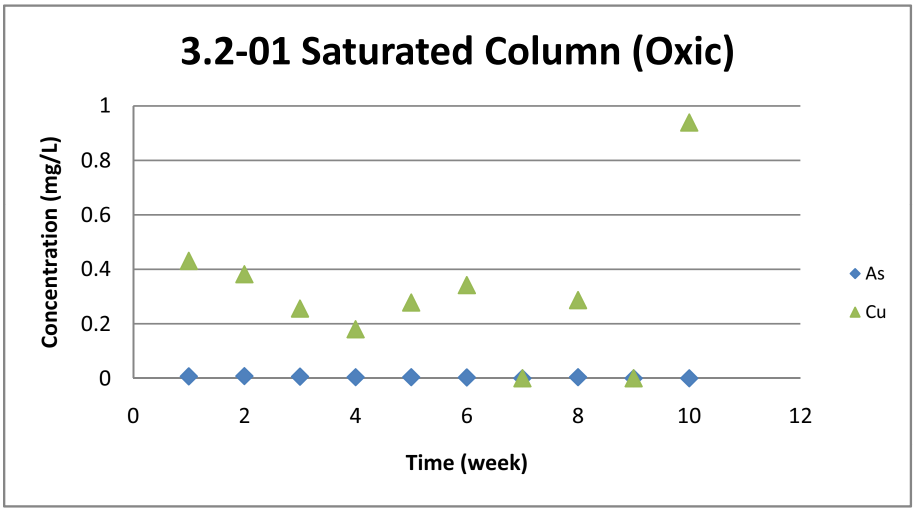

3.2-01 Unsaturated Column
Concentration (mg/L)
25
20
15
10
5
0
0
5
10
15
20
25
Time (week)
U

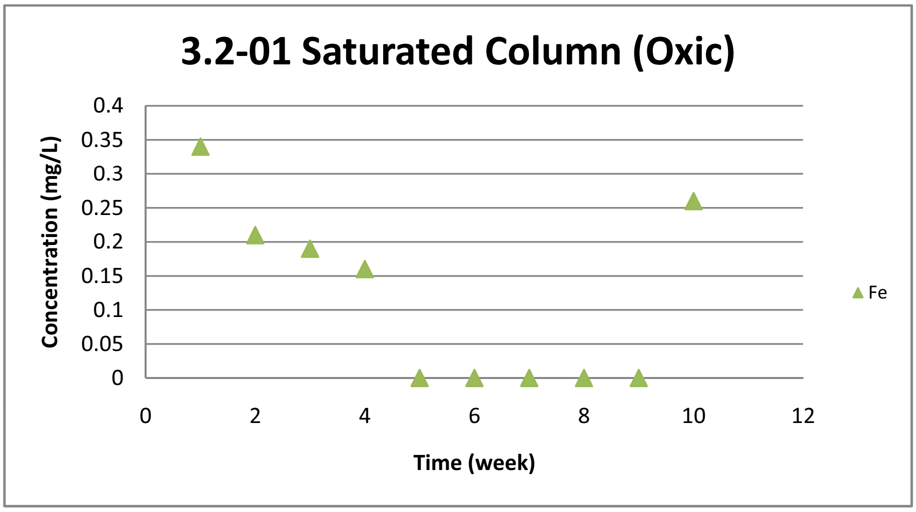

3.2-01 Saturated Column (Oxic)
Concentration (mg/L)
14000
12000
10000
8000
6000
4000
2000
0
0
2
4
6
8
10
12
Time (week)
SO4

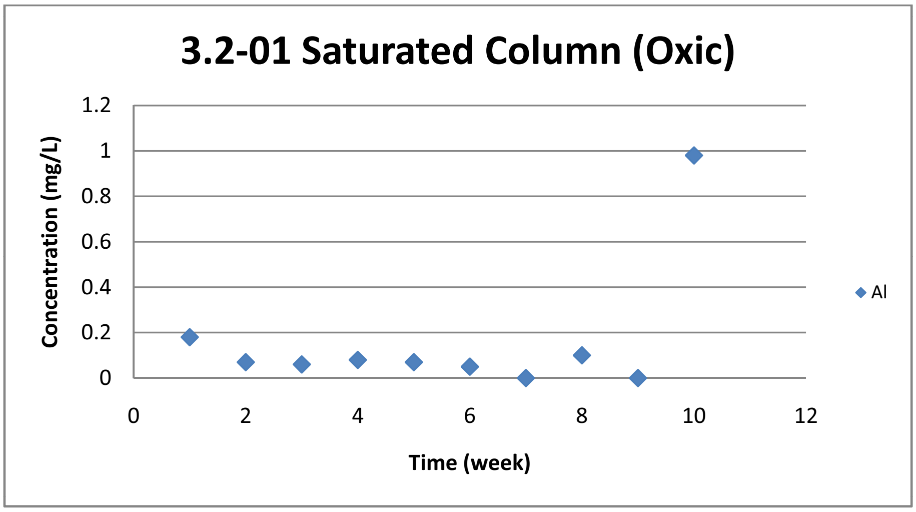

3.2-01 Saturated Column (Oxic)
Concentration (mg/L)
1600
1400
1200
1000
800
600
400
200
0
0
2
4
6
8
10
12
Time (week)
Ca
Mg

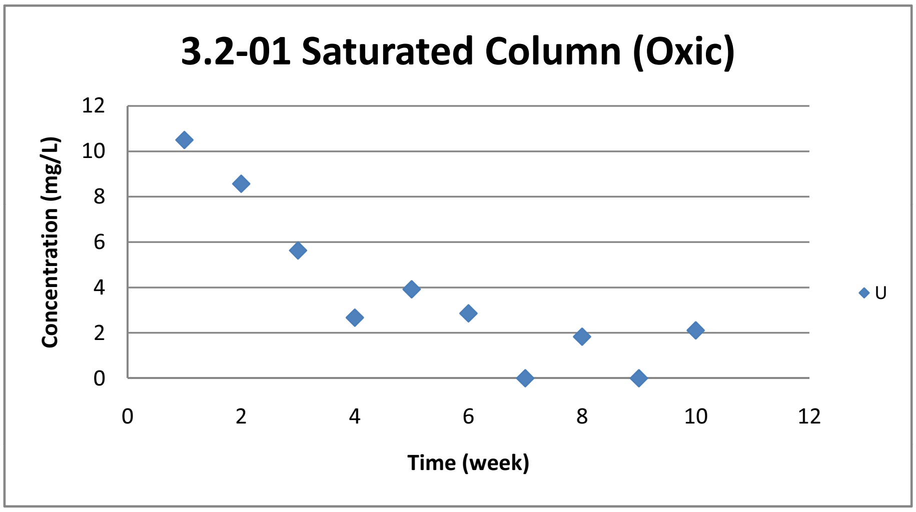

3.2-01 Saturated Column (Oxic)
Molar ratio
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
10
9
8
7
6
5
4
3
2
0
2
4
6
8
10
12
Time (week)
SO4/(Ca+Mg)
pH

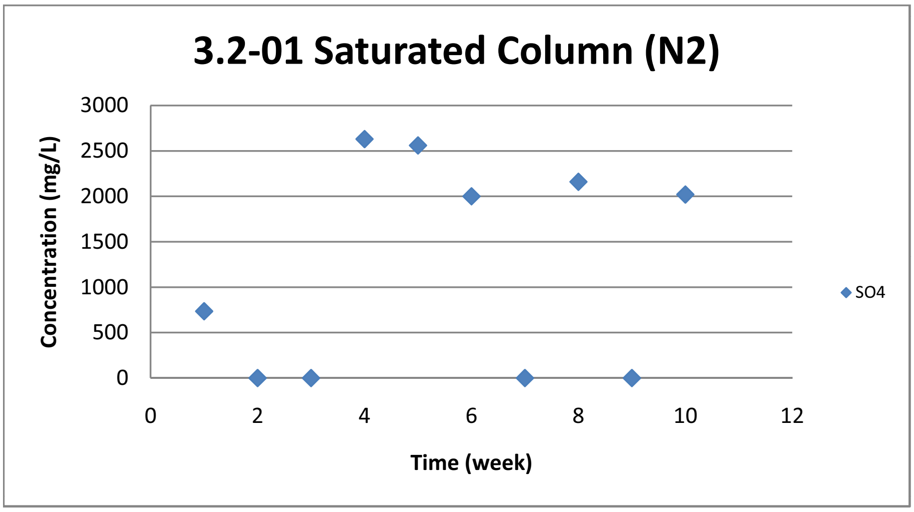

3.2-01 Saturated Column (Oxic)
Concentration (mg/L)
0.003
0.0025
0.002
0.0015
0.001
0.0005
0
0
2
4
6
8
10
12
Time (week)
Cd

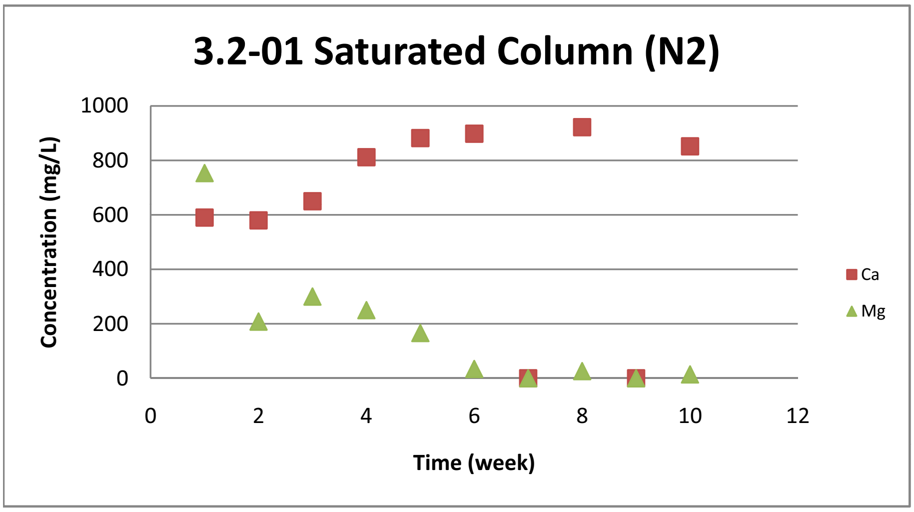

3.2-01 Saturated Column (Oxic)
Concentration (mg/L)
1
0.8
0.6
0.4
0.2
0
0
2
4
6
8
10
12
Time (week)
As
Cu

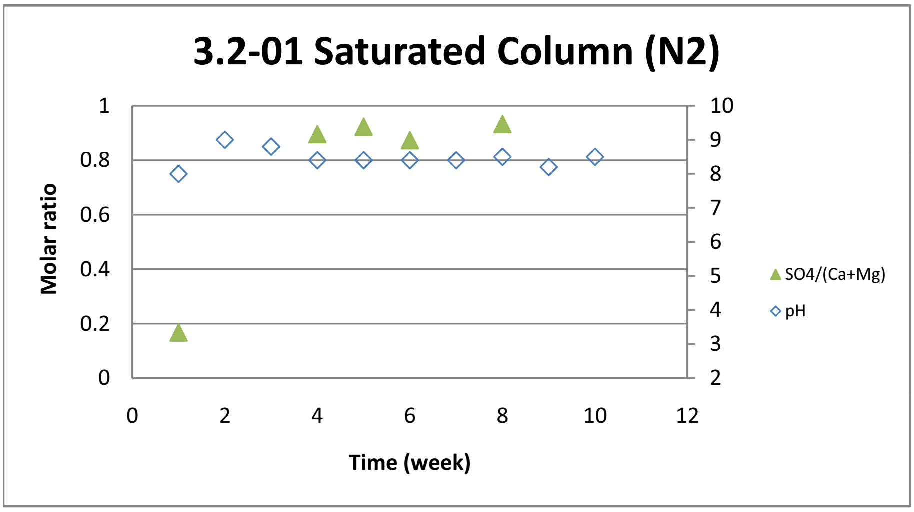

3.2-01 Saturated Column (Oxic)
Concentration (mg/L)
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
2
4
6
8
10
12
Time (week)
Fe

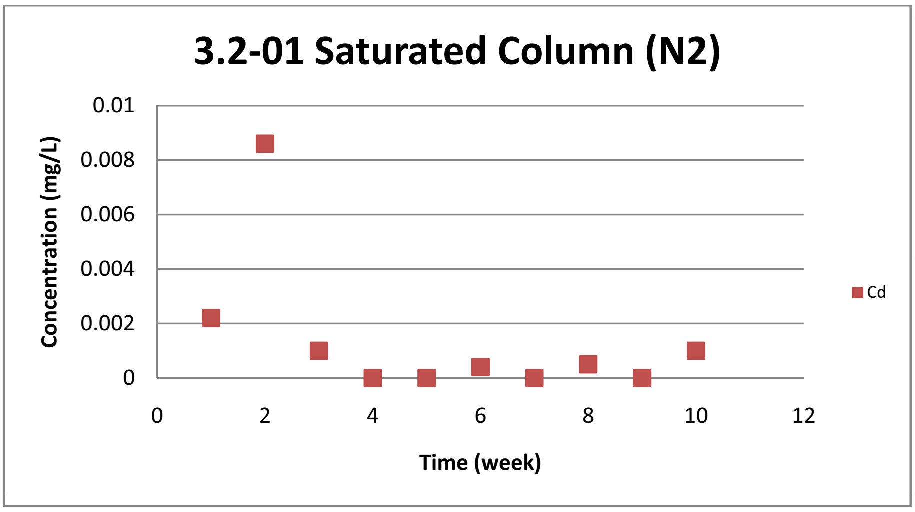

3.2-01 Saturated Column (Oxic)
Concentration (mg/L)
1.2
1
0.8
0.6
0.4
0.2
0
0
2
4
6
8
10
12
Time (week)
Al

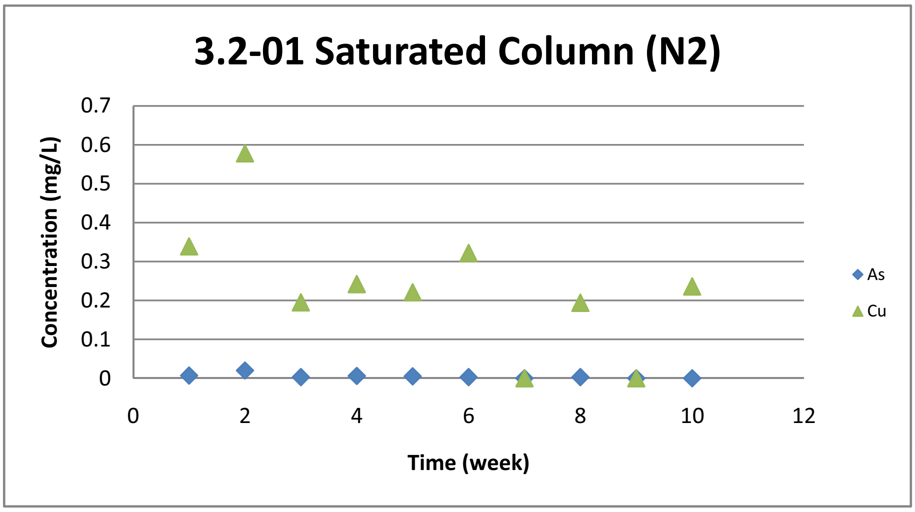

3.2-01 Saturated Column (Oxic)
Concentration (mg/L)
12
10
8
6
4
2
0
0
2
4
6
8
10
12
Time (week)
U

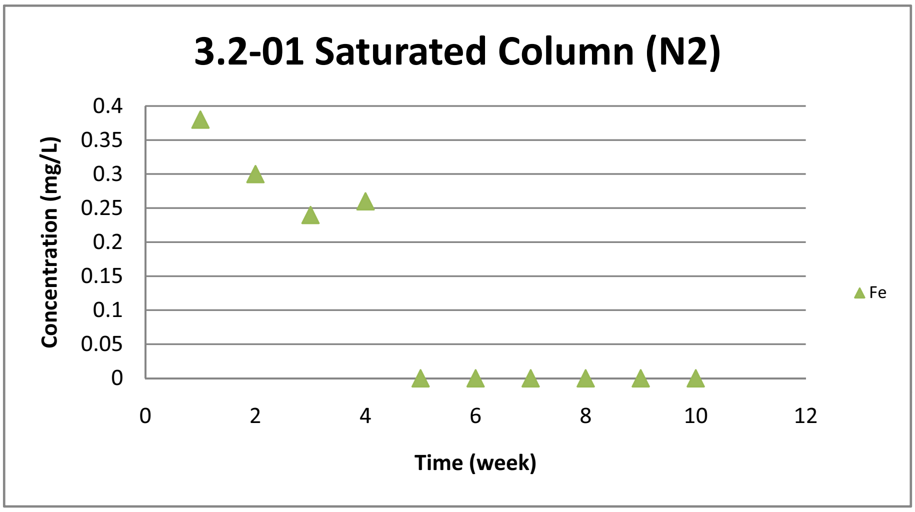

3.2-01 Saturated Column (N2)
Concentration (mg/L)
3000
2500
2000
1500
1000
500
0
0
2
4
6
8
10
12
Time (week)
SO4

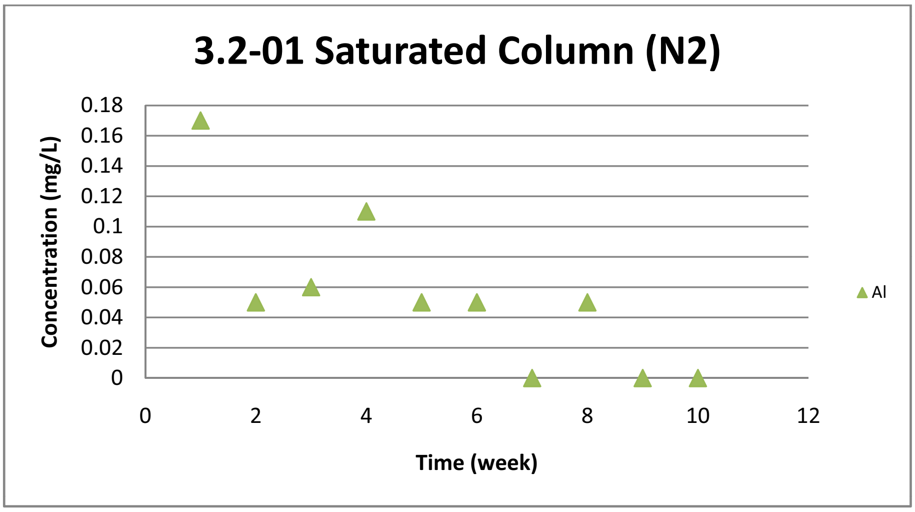

3.2-01 Saturated Column (N2)
Concentration (mg/L)
1000
800
600
400
200
0
0
2
4
6
8
10
12
Time (week)
Ca
Mg

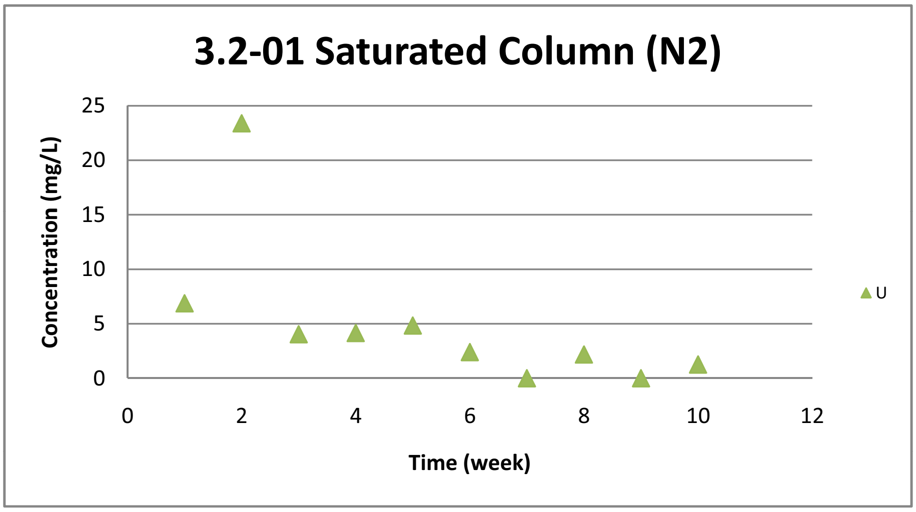

3.2-01 Saturated Column (N2)
Molar ratio
1
0.8
0.6
0.4
0.2
0
10
9
8
7
6
5
4
3
2
0
2
4
6
8
10
12
Time (week)
SO4/(Ca+Mg)
pH


3.2-01 Saturated Column (N2)
Concentration (mg/L)
0.01
0.008
0.006
0.004
0.002
0
0
2
4
6
8
10
12
Time (week)
Cd


3.2-01 Saturated Column (N2)
Concentration (mg/L)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
2
4
6
8
10
12
Time (week)
As
Cu


3.2-01 Saturated Column (N2)
Concentration (mg/L)
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
2
4
6
8
10
12
Time (week)
Fe


3.2-01 Saturated Column (N2)
Concentration (mg/L)
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
2
4
6
8
10
12
Time (week)
Al


3.2-01 Saturated Column (N2)
Concentration (mg/L)
25
20
15
10
5
0
0
2
4
6
8
10
12
Time (week)
U

Appendix 8: ABCC Test Results

Australian Government

ansto
Nuclear-based science benefiting all Australians

Institute for Environmental Research Analytical Report

Client: **SRK Consulting (Geoenvironmental)**
Principal Consultant
Level 6, 44 Market St.,
Sydney
NSW 2000
Contact: **Claire Linklater**
Tel:

Report Number: **2008/0318**
Batch Description: **ABCC**
Samples Received: **3**
Registration Date: **25-Nov-2008**
Report Date: **23-Dec-2008**
Logged By: **Henri Wong**
ANSTO Major Topic: **0206V**
ANSTO Cost Code: **0206v-2-3-1**
Funds Type: **ATLAS - Commercial**
Supervising Analyst: **Henri Wong**
Inorganic lab analyses required:
Inorganic lab special requests:

Signature:________________________ Date: 23/12/2008
Henri Wong

Institute for Environmental Research
Analytical Report

Report Number: 2008/0318

ABCC

Sample#	Client Identification	Sample Description
2008/0318-1	Core 1	Olympic Dam
2008/0318-2	H3.2-12	Olympic Dam
2008/0318-3	H3.1-09	Olympic Dam

See attached spreadsheet for complete data points.

23/12/08

MULTITRATOR®
multi-mode titration systems

Acid Base Characteristic Curve

Operator:	Henri Wong
HCl (M):	0.5148
Sample mass (g):	1.8390
Equilbration time (sec):	1000
Initial pH:	9.870

Client's ID:	Core1- Olympic Dam
Sample ID:	2008/0318-1(2)

Date analysed	Vol of acid added (ml)	Total acid added (ml)	pH (after acid addition)	pH (after equilbration)
19/12/2008 17:54	0.405	0.405	5.8686	7.723
19/12/2008 18:11	0.405	0.810	5.5301	7.027
19/12/2008 18:29	0.405	1.215	5.2560	6.823
19/12/2008 18:46	0.405	1.620	5.1214	6.727
19/12/2008 19:04	0.405	2.025	4.9974	6.677
19/12/2008 19:21	0.405	2.430	4.9571	6.643
19/12/2008 19:39	0.405	2.835	4.9192	6.622
19/12/2008 19:56	0.405	3.240	4.8901	6.602
19/12/2008 20:14	0.405	3.645	4.8428	6.577
19/12/2008 20:31	0.405	4.050	4.8042	6.543
19/12/2008 20:49	0.405	4.455	4.7180	6.497
19/12/2008 21:06	0.405	4.860	4.6320	6.437
19/12/2008 21:24	0.405	5.265	4.6322	6.375
19/12/2008 21:41	0.405	5.670	4.5622	6.344
19/12/2008 21:59	0.405	6.075	4.5297	6.333
19/12/2008 22:16	0.405	6.480	4.5324	6.337
19/12/2008 22:34	0.405	6.885	4.4922	6.345
19/12/2008 22:51	0.405	7.290	4.4654	6.350
19/12/2008 23:09	0.405	7.695	4.4861	6.355
19/12/2008 23:26	0.405	8.100	4.5130	6.357
19/12/2008 23:43	0.405	8.505	4.4944	6.354
20/12/2008 0:01	0.405	8.910	4.4558	6.347
20/12/2008 0:18	0.405	9.315	4.4259	6.341
20/12/2008 0:36	0.405	9.720	4.4159	6.339
20/12/2008 0:53	0.405	10.125	4.3939	6.329
20/12/2008 1:11	0.405	10.530	4.3822	6.325
20/12/2008 1:28	0.405	10.935	4.3873	6.321
20/12/2008 1:46	0.405	11.340	4.3371	6.311
20/12/2008 2:03	0.405	11.745	4.3482	6.310
20/12/2008 2:21	0.405	12.150	4.3296	6.304
20/12/2008 2:38	0.405	12.555	4.3165	6.297
20/12/2008 2:56	0.405	12.960	4.2964	6.290
20/12/2008 3:13	0.405	13.365	4.2749	6.286
20/12/2008 3:31	0.405	13.770	4.2633	6.283
20/12/2008 3:48	0.405	14.175	4.2469	6.276
20/12/2008 4:06	0.405	14.580	4.2172	6.270
20/12/2008 4:23	0.405	14.985	4.2125	6.266
20/12/2008 4:41	0.405	15.390	4.2095	6.265
20/12/2008 4:58	0.405	15.795	4.1671	6.262
20/12/2008 5:15	0.405	16.200	4.2043	6.255
20/12/2008 5:33	0.405	16.605	4.1537	6.251
20/12/2008 5:50	0.405	17.010	4.1478	6.250
20/12/2008 6:08	0.405	17.415	4.1339	6.244
20/12/2008 6:25	0.405	17.820	4.1213	6.238

23/12/08

Sample ID: 2008/0318-1(2)

Date analysed	Vol of acid added (ml)	Total acid added (ml)	pH (after acid addition)	pH (after equilbration)
20/12/2008 6:43	0.405	18.225	4.0570	6.229
20/12/2008 7:00	0.405	18.630	4.0999	6.222
20/12/2008 7:18	0.405	19.035	4.0639	6.215
20/12/2008 7:35	0.405	19.440	4.0784	6.211
20/12/2008 7:53	0.405	19.845	4.0866	6.209
20/12/2008 8:10	0.405	20.250	4.0666	6.210
20/12/2008 8:28	0.405	20.655	4.0755	6.222
20/12/2008 8:45	0.405	21.060	4.0898	6.229
20/12/2008 9:03	0.405	21.465	4.1146	6.223
20/12/2008 9:20	0.405	21.870	4.1021	6.201
20/12/2008 9:38	0.405	22.275	4.0926	6.191
20/12/2008 9:55	0.405	22.680	4.0980	6.187
20/12/2008 10:13	0.405	23.085	4.1029	6.181
20/12/2008 10:30	0.405	23.490	4.0735	6.175
20/12/2008 10:48	0.405	23.895	4.0880	6.174
20/12/2008 11:05	0.405	24.300	4.0465	6.168
20/12/2008 11:22	0.405	24.705	4.0287	6.164
20/12/2008 11:40	0.405	25.110	4.0449	6.161
20/12/2008 11:57	0.405	25.515	4.0443	6.159
20/12/2008 12:15	0.405	25.920	4.0396	6.156
20/12/2008 12:32	0.405	26.325	4.0231	6.153
20/12/2008 12:50	0.405	26.730	4.0355	6.150
20/12/2008 13:07	0.405	27.135	4.0290	6.148
20/12/2008 13:25	0.405	27.540	4.0552	6.145
20/12/2008 13:42	0.405	27.945	4.0533	6.143
20/12/2008 14:00	0.405	28.350	4.0121	6.140
20/12/2008 14:17	0.405	28.755	4.0228	6.136
20/12/2008 14:35	0.405	29.160	4.0285	6.134
20/12/2008 14:52	0.405	29.565	4.0472	6.131
20/12/2008 15:10	0.405	29.970	4.0303	6.126
20/12/2008 15:27	0.405	30.375	4.0253	6.123
20/12/2008 15:45	0.405	30.780	4.0000	6.115
20/12/2008 16:02	0.405	31.185	3.9851	6.105
20/12/2008 16:20	0.405	31.590	3.9646	6.104
20/12/2008 16:37	0.405	31.995	3.9788	6.102
20/12/2008 16:54	0.405	32.400	3.9703	6.100
20/12/2008 17:12	0.405	32.805	3.9836	6.095
20/12/2008 17:29	0.405	33.210	3.9497	6.087
20/12/2008 17:47	0.405	33.615	3.9350	6.070
20/12/2008 18:04	0.405	34.020	3.8891	6.048
20/12/2008 18:22	0.405	34.425	3.8656	6.038
20/12/2008 18:39	0.405	34.830	3.8633	6.035
20/12/2008 18:57	0.405	35.235	3.8605	6.033
20/12/2008 19:14	0.405	35.640	3.8336	6.033
20/12/2008 19:32	0.405	36.045	3.8156	6.035
20/12/2008 19:49	0.405	36.450	3.8251	6.034
20/12/2008 20:07	0.405	36.855	3.8071	6.033
20/12/2008 20:24	0.405	37.260	3.7900	6.030
20/12/2008 20:42	0.405	37.665	3.7787	6.023
20/12/2008 20:59	0.405	38.070	3.7711	6.018
20/12/2008 21:17	0.405	38.475	3.7584	6.008
20/12/2008 21:34	0.405	38.880	3.7546	6.002

23/12/08

Sample ID: 2008/0318-1(2)

Date analysed	Vol of acid added (ml)	Total acid added (ml)	pH (after acid addition)	pH (after equilbration)
20/12/2008 21:52	0.405	39.285	3.7402	5.995
20/12/2008 22:09	0.405	39.690	3.7284	5.991
20/12/2008 22:27	0.405	40.095	3.7035	5.985
20/12/2008 22:44	0.405	40.500	3.6960	5.978
20/12/2008 23:01	0.405	40.905	3.6853	5.974
20/12/2008 23:19	0.405	41.310	3.6711	5.967
20/12/2008 23:36	0.405	41.715	3.6632	5.962
20/12/2008 23:54	0.405	42.120	3.6474	5.956
21/12/2008 0:11	0.405	42.525	3.6267	5.952
21/12/2008 0:29	0.405	42.930	3.6301	5.945
21/12/2008 0:46	0.405	43.335	3.6144	5.939
21/12/2008 1:04	0.405	43.740	3.5988	5.930
21/12/2008 1:21	0.405	44.145	3.5884	5.924
21/12/2008 1:39	0.405	44.550	3.5868	5.917
21/12/2008 1:56	0.405	44.955	3.5608	5.910
21/12/2008 2:14	0.405	45.360	3.5485	5.901
21/12/2008 2:31	0.405	45.765	3.5357	5.896
21/12/2008 2:49	0.405	46.170	3.5228	5.887
21/12/2008 3:06	0.405	46.575	3.5172	5.880
21/12/2008 3:24	0.405	46.980	3.5050	5.873
21/12/2008 3:41	0.405	47.385	3.4929	5.866
21/12/2008 3:59	0.405	47.790	3.4826	5.855
21/12/2008 4:16	0.405	48.195	3.4650	5.848
21/12/2008 4:33	0.405	48.600	3.4581	5.838
21/12/2008 4:51	0.405	49.005	3.4403	5.831
21/12/2008 5:08	0.405	49.410	3.4358	5.823
21/12/2008 5:26	0.405	49.815	3.4312	5.813
21/12/2008 5:43	0.405	50.220	3.4158	5.805
21/12/2008 6:01	0.405	50.625	3.4073	5.796
21/12/2008 6:18	0.405	51.030	3.3961	5.788
21/12/2008 6:36	0.405	51.435	3.3920	5.774
21/12/2008 6:53	0.405	51.840	3.3797	5.765
21/12/2008 7:11	0.405	52.245	3.3810	5.764
21/12/2008 7:28	0.405	52.650	3.3745	5.777
21/12/2008 7:46	0.405	53.055	3.4043	5.766
21/12/2008 8:03	0.405	53.460	3.3911	5.733
21/12/2008 8:21	0.405	53.865	3.3558	5.715
21/12/2008 8:38	0.405	54.270	3.3520	5.704
21/12/2008 8:56	0.405	54.675	3.3399	5.692
21/12/2008 9:13	0.405	55.080	3.3245	5.683
21/12/2008 9:31	0.405	55.485	3.3240	5.674
21/12/2008 9:48	0.405	55.890	3.3155	5.661
21/12/2008 10:06	0.405	56.295	3.2985	5.647
21/12/2008 10:23	0.405	56.700	3.3012	5.634
21/12/2008 10:40	0.405	57.105	3.2877	5.622
21/12/2008 10:58	0.405	57.510	3.2756	5.608
21/12/2008 11:15	0.405	57.915	3.2710	5.592
21/12/2008 11:33	0.405	58.320	3.2519	5.567
21/12/2008 11:50	0.405	58.725	3.2351	5.552
21/12/2008 12:08	0.405	59.130	3.2291	5.531
21/12/2008 12:25	0.405	59.535	3.2167	5.508
21/12/2008 12:43	0.405	59.940	3.1972	5.482

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Sample ID: 2008/0318-1(2)

Date analysed	Vol of acid added (ml)	Total acid added (ml)	pH (after acid addition)	pH (after equilbration)
21/12/2008 13:00	0.405	60.345	3.1890	5.453
21/12/2008 13:18	0.405	60.750	3.1755	5.424
21/12/2008 13:35	0.405	61.155	3.1585	5.390
21/12/2008 13:53	0.405	61.560	3.1433	5.352
21/12/2008 14:10	0.405	61.965	3.1263	5.305
21/12/2008 14:28	0.405	62.370	3.1062	5.246
21/12/2008 14:45	0.405	62.775	3.0841	5.169
21/12/2008 15:03	0.405	63.180	3.0654	5.062
21/12/2008 15:20	0.405	63.585	3.0406	4.882
21/12/2008 15:38	0.405	63.990	3.0083	4.465
21/12/2008 15:55	0.405	64.395	2.9645	3.702
21/12/2008 16:12	0.405	64.800	2.8846	3.184
21/12/2008 16:30	0.405	65.205	2.7453	2.849
21/12/2008 16:47	0.405	65.610	2.5876	2.616
21/12/2008 17:05	0.405	66.015	2.4427	2.450
21/12/2008 17:22	0.405	66.420	2.3239	2.324
21/12/2008 17:40	0.405	66.825	2.2281	2.226
21/12/2008 17:57	0.405	67.230	2.1485	2.147
21/12/2008 18:15	0.405	67.635	2.0819	2.080
21/12/2008 18:32	0.405	68.040	2.0247	2.027
21/12/2008 18:50	0.405	68.445	1.9792	

23/12/08

MULTITRATOR®
multi-mode titration systems

Acid Base Characteristic Curve

Operator: Henri Wong
HCl (M): 0.5148
Sample mass (g): 2.0267
Equilibration time (sec): 1000
Initial pH: 9.750

Client's ID: H3.1-12- Olympic Dam
Sample ID: 2008-0318-2

Date analysed	Vol of acid added (ml)	Total acid added (ml)	pH (after acid addition)	pH (after equilibration)
5/12/2008 17:18	0.405	0.405	7.2909	8.102
5/12/2008 17:35	0.405	0.810	6.5413	7.654
5/12/2008 17:53	0.405	1.215	6.2642	7.472
5/12/2008 18:10	0.405	1.620	6.1229	7.367
5/12/2008 18:28	0.405	2.025	6.0155	7.303
5/12/2008 18:45	0.405	2.430	5.9233	7.270
5/12/2008 19:03	0.405	2.835	5.8484	7.216
5/12/2008 19:20	0.405	3.240	5.7806	7.159
5/12/2008 19:38	0.405	3.645	5.7426	7.123
5/12/2008 19:55	0.405	4.050	5.6963	7.099
5/12/2008 20:13	0.405	4.455	5.6449	7.073
5/12/2008 20:30	0.405	4.860	5.6249	7.049
5/12/2008 20:48	0.405	5.265	5.5823	7.023
5/12/2008 21:05	0.405	5.670	5.5601	6.999
5/12/2008 21:23	0.405	6.075	5.5242	6.977
5/12/2008 21:40	0.405	6.480	5.5034	6.955
5/12/2008 21:58	0.405	6.885	5.4581	6.922
5/12/2008 22:15	0.405	7.290	5.4466	6.915
5/12/2008 22:33	0.405	7.695	5.4043	6.909
5/12/2008 22:50	0.405	8.100	5.3794	6.896
5/12/2008 23:07	0.405	8.505	5.3632	6.894
5/12/2008 23:25	0.405	8.910	5.3648	6.883
5/12/2008 23:42	0.405	9.315	5.3510	6.852
6/12/2008 0:00	0.405	9.720	5.3200	6.836
6/12/2008 0:17	0.405	10.125	5.2791	6.819
6/12/2008 0:35	0.405	10.530	5.2853	6.823
6/12/2008 0:52	0.405	10.935	5.2890	6.796
6/12/2008 1:10	0.405	11.340	5.2498	6.776
6/12/2008 1:27	0.405	11.745	5.2321	6.755
6/12/2008 1:45	0.405	12.150	5.2321	6.732
6/12/2008 2:02	0.405	12.555	5.2182	6.717
6/12/2008 2:20	0.405	12.960	5.1838	6.696
6/12/2008 2:37	0.405	13.365	5.1962	6.677
6/12/2008 2:55	0.405	13.770	5.1996	6.660
6/12/2008 3:12	0.405	14.175	5.1885	6.636
6/12/2008 3:30	0.405	14.580	5.1745	6.615
6/12/2008 3:47	0.405	14.985	5.1648	6.597
6/12/2008 4:05	0.405	15.390	5.1621	6.580
6/12/2008 4:22	0.405	15.795	5.1602	6.570
6/12/2008 4:40	0.405	16.200	5.1437	6.557
6/12/2008 4:57	0.405	16.605	5.1107	6.542
6/12/2008 5:14	0.405	17.010	5.1284	6.530
6/12/2008 5:32	0.405	17.415	5.1112	6.529
6/12/2008 5:49	0.405	17.820	5.0803	6.515
6/12/2008 6:07	0.405	18.225	5.0882	6.485
6/12/2008 6:24	0.405	18.630	5.0556	6.466
6/12/2008 6:42	0.405	19.035	5.0164	6.447

23/12/08

Sample ID: 2008-0318-2

Date analysed	Vol of acid added (ml)	Total acid added (ml)	pH (after acid addition)	pH (after equilbration)
6/12/2008 6:59	0.405	19.440	5.0311	6.437
6/12/2008 7:17	0.405	19.845	5.0112	6.430
6/12/2008 7:34	0.405	20.250	5.0164	6.416
6/12/2008 7:52	0.405	20.655	4.9858	6.411
6/12/2008 8:09	0.405	21.060	4.9665	6.416
6/12/2008 8:27	0.405	21.465	4.9305	6.405
6/12/2008 8:44	0.405	21.870	4.9416	6.407
6/12/2008 9:02	0.405	22.275	4.9164	6.402
6/12/2008 9:19	0.405	22.680	4.9297	6.406
6/12/2008 9:37	0.405	23.085	4.9150	6.405
6/12/2008 9:54	0.405	23.490	4.9170	6.399
6/12/2008 10:12	0.405	23.895	4.9043	6.395
6/12/2008 10:29	0.405	24.300	4.9085	6.388
6/12/2008 10:46	0.405	24.705	4.8704	6.378
6/12/2008 11:04	0.405	25.110	4.8651	6.365
6/12/2008 11:21	0.405	25.515	4.8532	6.354
6/12/2008 11:39	0.405	25.920	4.8612	6.355
6/12/2008 11:56	0.405	26.325	4.8179	6.348
6/12/2008 12:14	0.405	26.730	4.8365	6.345
6/12/2008 12:31	0.405	27.135	4.8308	6.340
6/12/2008 12:49	0.405	27.540	4.8009	6.339
6/12/2008 13:06	0.405	27.945	4.8225	6.339
6/12/2008 13:24	0.405	28.350	4.8058	6.345
6/12/2008 13:41	0.405	28.755	4.7812	6.336
6/12/2008 13:59	0.405	29.160	4.7861	6.331
6/12/2008 14:16	0.405	29.565	4.7770	6.330
6/12/2008 14:34	0.405	29.970	4.7662	6.292
6/12/2008 14:51	0.405	30.375	4.7654	6.299
6/12/2008 15:09	0.405	30.780	4.7531	6.305
6/12/2008 15:26	0.405	31.185	4.7526	6.307
6/12/2008 15:44	0.405	31.590	4.7265	6.300
6/12/2008 16:01	0.405	31.995	4.7181	6.298
6/12/2008 16:18	0.405	32.400	4.7041	6.291
6/12/2008 16:36	0.405	32.805	4.6766	6.300
6/12/2008 16:53	0.405	33.210	4.7076	6.291
6/12/2008 17:11	0.405	33.615	4.6970	6.291
6/12/2008 17:28	0.405	34.020	4.6714	6.275
6/12/2008 17:46	0.405	34.425	4.6751	6.263
6/12/2008 18:03	0.405	34.830	4.6481	6.264
6/12/2008 18:21	0.405	35.235	4.6302	6.264
6/12/2008 18:38	0.405	35.640	4.6116	6.243
6/12/2008 18:56	0.405	36.045	4.6240	6.221
6/12/2008 19:13	0.405	36.450	4.5608	6.193
6/12/2008 19:31	0.405	36.855	4.5812	6.180
6/12/2008 19:48	0.405	37.260	4.5683	6.186
6/12/2008 20:06	0.405	37.665	4.5337	6.194
6/12/2008 20:23	0.405	38.070	4.5297	6.194
6/12/2008 20:41	0.405	38.475	4.5115	6.202
6/12/2008 20:58	0.405	38.880	4.5099	6.199
6/12/2008 21:16	0.405	39.285	4.5093	6.192
6/12/2008 21:33	0.405	39.690	4.4911	6.181
6/12/2008 21:50	0.405	40.095	4.4806	6.179
6/12/2008 22:08	0.405	40.500	4.4637	6.175
6/12/2008 22:25	0.405	40.905	4.4458	6.170
6/12/2008 22:43	0.405	41.310	4.4471	6.161

23/12/08

Sample ID: 2008-0318-2

Date analysed	Vol of acid added (ml)	Total acid added (ml)	pH (after acid addition)	pH (after equilbration)
6/12/2008 23:00	0.405	41.715	4.4190	6.148
6/12/2008 23:18	0.405	42.120	4.3860	6.141
6/12/2008 23:35	0.405	42.525	4.3753	6.141
6/12/2008 23:53	0.405	42.930	4.3585	6.135
7/12/2008 0:10	0.405	43.335	4.3566	6.130
7/12/2008 0:28	0.405	43.740	4.3446	6.121
7/12/2008 0:45	0.405	44.145	4.3280	6.118
7/12/2008 1:03	0.405	44.550	4.3003	6.117
7/12/2008 1:20	0.405	44.955	4.3047	6.113
7/12/2008 1:38	0.405	45.360	4.2658	6.101
7/12/2008 1:55	0.405	45.765	4.2692	6.101
7/12/2008 2:13	0.405	46.170	4.2337	6.099
7/12/2008 2:30	0.405	46.575	4.2345	6.091
7/12/2008 2:48	0.405	46.980	4.2143	6.084
7/12/2008 3:05	0.405	47.385	4.1964	6.081
7/12/2008 3:23	0.405	47.790	4.1920	6.069
7/12/2008 3:40	0.405	48.195	4.1735	6.067
7/12/2008 3:57	0.405	48.600	4.1638	6.067
7/12/2008 4:15	0.405	49.005	4.1630	6.059
7/12/2008 4:32	0.405	49.410	4.1220	6.053
7/12/2008 4:50	0.405	49.815	4.1397	6.046
7/12/2008 5:07	0.405	50.220	4.1234	6.047
7/12/2008 5:25	0.405	50.625	4.1236	6.007
7/12/2008 5:42	0.405	51.030	4.1016	6.002
7/12/2008 6:00	0.405	51.435	4.0790	6.003
7/12/2008 6:17	0.405	51.840	4.0726	5.999
7/12/2008 6:35	0.405	52.245	4.0508	6.006
7/12/2008 6:52	0.405	52.650	4.0445	6.006
7/12/2008 7:10	0.405	53.055	4.0443	6.008
7/12/2008 7:27	0.405	53.460	4.0124	6.008
7/12/2008 7:45	0.405	53.865	4.0087	6.007
7/12/2008 8:02	0.405	54.270	3.9828	6.008
7/12/2008 8:20	0.405	54.675	3.9665	6.002
7/12/2008 8:37	0.405	55.080	3.9588	5.995
7/12/2008 8:55	0.405	55.485	3.9401	5.992
7/12/2008 9:12	0.405	55.890	3.9293	5.990
7/12/2008 9:29	0.405	56.295	3.9169	5.987
7/12/2008 9:47	0.405	56.700	3.8952	5.985
7/12/2008 10:04	0.405	57.105	3.8854	5.979
7/12/2008 10:22	0.405	57.510	3.8588	5.975
7/12/2008 10:39	0.405	57.915	3.8549	5.972
7/12/2008 10:57	0.405	58.320	3.8382	5.964
7/12/2008 11:14	0.405	58.725	3.8212	5.957
7/12/2008 11:32	0.405	59.130	3.8138	5.946
7/12/2008 11:49	0.405	59.535	3.8072	5.942
7/12/2008 12:07	0.405	59.940	3.7879	5.941
7/12/2008 12:24	0.405	60.345	3.7823	5.941
7/12/2008 12:42	0.405	60.750	3.7721	5.934
7/12/2008 12:59	0.405	61.155	3.7629	5.932
7/12/2008 13:17	0.405	61.560	3.7474	5.925
7/12/2008 13:34	0.405	61.965	3.7233	5.921
7/12/2008 13:52	0.405	62.370	3.7212	5.913
7/12/2008 14:09	0.405	62.775	3.7144	5.907
7/12/2008 14:27	0.405	63.180	3.7064	5.902
7/12/2008 14:44	0.405	63.585	3.6857	5.900

23/12/08

Sample ID: 2008-0318-2

Date analysed	Vol of acid added (ml)	Total acid added (ml)	pH (after acid addition)	pH (after equilbration)
7/12/2008 15:01	0.405	63.990	3.6711	5.895
7/12/2008 15:19	0.405	64.395	3.6610	5.892
7/12/2008 15:36	0.405	64.800	3.6491	5.887
7/12/2008 15:54	0.405	65.205	3.6385	5.886
7/12/2008 16:11	0.405	65.610	3.6211	5.878
7/12/2008 16:29	0.405	66.015	3.6041	5.871
7/12/2008 16:46	0.405	66.420	3.5953	5.861
7/12/2008 17:04	0.405	66.825	3.5917	5.855
7/12/2008 17:21	0.405	67.230	3.5702	5.848
7/12/2008 17:39	0.405	67.635	3.5541	5.840
7/12/2008 17:56	0.405	68.040	3.5447	5.836
7/12/2008 18:14	0.405	68.445	3.5258	5.831
7/12/2008 18:31	0.405	68.850	3.5224	5.827
7/12/2008 18:49	0.405	69.255	3.5034	5.817
7/12/2008 19:06	0.405	69.660	3.4871	5.805
7/12/2008 19:24	0.405	70.065	3.4743	5.801
7/12/2008 19:41	0.405	70.470	3.4606	5.794
7/12/2008 19:59	0.405	70.875	3.4458	5.784
7/12/2008 20:16	0.405	71.280	3.4327	5.776
7/12/2008 20:33	0.405	71.685	3.4135	5.767
7/12/2008 20:51	0.405	72.090	3.3981	5.756
7/12/2008 21:08	0.405	72.495	3.3773	5.747
7/12/2008 21:26	0.405	72.900	3.3632	5.736
7/12/2008 21:43	0.405	73.305	3.3442	5.724
7/12/2008 22:01	0.405	73.710	3.3366	5.712
7/12/2008 22:18	0.405	74.115	3.3194	5.698
7/12/2008 22:36	0.405	74.520	3.2973	5.678
7/12/2008 22:53	0.405	74.925	3.2794	5.665
7/12/2008 23:11	0.405	75.330	3.2575	5.648
7/12/2008 23:28	0.405	75.735	3.2432	5.630
7/12/2008 23:46	0.405	76.140	3.2240	5.607
8/12/2008 0:03	0.405	76.545	3.2026	5.581
8/12/2008 0:21	0.405	76.950	3.1850	5.548
8/12/2008 0:38	0.405	77.355	3.1618	5.512
8/12/2008 0:56	0.405	77.760	3.1386	5.467
8/12/2008 1:13	0.405	78.165	3.1126	5.404
8/12/2008 1:31	0.405	78.570	3.0873	5.322
8/12/2008 1:48	0.405	78.975	3.0577	5.197
8/12/2008 2:05	0.405	79.380	3.0215	4.957
8/12/2008 2:23	0.405	79.785	2.9796	4.160
8/12/2008 2:40	0.405	80.190	2.9071	3.284
8/12/2008 2:58	0.405	80.595	2.7521	2.853
8/12/2008 3:15	0.405	81.000	2.5682	2.595
8/12/2008 3:33	0.405	81.405	2.4131	2.422
8/12/2008 3:50	0.405	81.810	2.2911	2.295
8/12/2008 4:08	0.405	82.215	2.1938	2.196
8/12/2008 4:25	0.405	82.620	2.1130	2.114
8/12/2008 4:43	0.405	83.025	2.0453	2.046
8/12/2008 5:00	0.405	83.430	1.9860	

23/12/08

MULTITRATOR®
multi-mode titration systems

Acid Base Characteristic Curve

Operator:	Henri Wong
HCl (M):	0.1149
Sample mass (g):	1.9954
Equilbration time (sec):	1000
Initial pH:	9.600

Client's ID: H3.1-09- Olympic Dam
Sample ID: 2008-0318-3

Date analysed	Vol of acid added (ml)	Total acid added (ml)	pH (after acid addition)	pH (after equilbration)
2/12/2008 12:25	0.508	0.508	8.3402	8.654
2/12/2008 12:43	0.508	1.016	7.7560	8.239
2/12/2008 13:00	0.508	1.524	7.4207	8.035
2/12/2008 13:17	0.508	2.032	7.2151	7.881
2/12/2008 13:35	0.508	2.540	7.0829	7.789
2/12/2008 13:52	0.508	3.048	6.9969	7.736
2/12/2008 14:10	0.508	3.556	6.9390	7.654
2/12/2008 14:27	0.508	4.064	6.8789	7.595
2/12/2008 14:45	0.508	4.572	6.8247	7.535
2/12/2008 15:02	0.508	5.080	6.7657	7.480
2/12/2008 15:20	0.508	5.588	6.7039	7.412
2/12/2008 15:37	0.508	6.096	6.6256	7.319
2/12/2008 15:55	0.508	6.604	6.5156	7.183
2/12/2008 16:12	0.508	7.112	6.3445	7.001
2/12/2008 16:30	0.508	7.620	6.0559	6.758
2/12/2008 16:47	0.508	8.128	5.4133	6.453
2/12/2008 17:05	0.508	8.636	4.4156	5.996
2/12/2008 17:22	0.508	9.144	3.9316	5.261
2/12/2008 17:40	0.508	9.652	3.6596	4.485
2/12/2008 17:57	0.508	10.160	3.4973	3.946
2/12/2008 18:15	0.508	10.668	3.3418	3.553
2/12/2008 18:32	0.508	11.176	3.1829	3.280
2/12/2008 18:49	0.508	11.684	3.0388	3.089
2/12/2008 19:07	0.508	12.192	2.9183	2.947
2/12/2008 19:24	0.508	12.700	2.8183	2.818
2/12/2008 19:42	0.508	13.208	2.7185	2.738
2/12/2008 19:59	0.508	13.716	2.6583	2.662
2/12/2008 20:17	0.508	14.224	2.5950	2.564
2/12/2008 20:34	0.508	14.732	2.5075	2.461
2/12/2008 20:52	0.508	15.240	2.4154	2.415
2/12/2008 21:09	0.508	15.748	2.3771	2.398
2/12/2008 21:27	0.508	16.256	2.3671	2.388
2/12/2008 21:44	0.508	16.764	2.3583	2.433
2/12/2008 22:02	0.508	17.272	2.4096	2.419
2/12/2008 22:19	0.508	17.780	2.3912	2.393
2/12/2008 22:37	0.508	18.288	2.3726	2.381
2/12/2008 22:54	0.508	18.796	2.3552	2.330
2/12/2008 23:12	0.508	19.304	2.3053	2.296
2/12/2008 23:29	0.508	19.812	2.2747	2.269
2/12/2008 23:47	0.508	20.320	2.2484	2.242
3/12/2008 0:04	0.508	20.828	2.2214	2.207
3/12/2008 0:21	0.508	21.336	2.1874	2.177
3/12/2008 0:39	0.508	21.844	2.1583	2.150
3/12/2008 0:56	0.508	22.352	2.1321	2.139
3/12/2008 1:14	0.508	22.860	2.1241	2.130
3/12/2008 1:31	0.508	23.368	2.1157	2.126
3/12/2008 1:49	0.508	23.876	2.1136	2.143
3/12/2008 2:06	0.508	24.384	2.1337	2.156
3/12/2008 2:24	0.508	24.892	2.1479	2.176
3/12/2008 2:41	0.508	25.400	2.1723	2.218
3/12/2008 2:59	0.508	25.908	2.2105	2.220

28/12/08

Sample ID: 2008-0318-3

Date analysed	Vol of acid added (ml)	Total acid added (ml)	pH (after acid addition)	pH (after equilbration)
3/12/2008 3:16	0.508	26.416	2.2143	2.241
3/12/2008 3:34	0.508	26.924	2.2354	2.244
3/12/2008 3:51	0.508	27.432	2.2386	2.241
3/12/2008 4:09	0.508	27.940	2.2335	2.249
3/12/2008 4:26	0.508	28.448	2.2451	2.235
3/12/2008 4:44	0.508	28.956	2.2278	2.222
3/12/2008 5:01	0.508	29.464	2.2151	2.208
3/12/2008 5:18	0.508	29.972	2.2029	2.221
3/12/2008 5:36	0.508	30.480	2.2169	2.167
3/12/2008 5:53	0.508	30.988	2.1529	2.055
3/12/2008 6:11	0.508	31.496	2.0450	2.051
3/12/2008 6:28	0.508	32.004	2.0509	2.120
3/12/2008 6:46	0.508	32.512	2.1176	2.151
3/12/2008 7:03	0.508	33.020	2.1488	2.188
3/12/2008 7:21	0.508	33.528	2.1893	2.116
3/12/2008 7:38	0.508	34.036	2.1021	2.032
3/12/2008 7:56	0.508	34.544	2.0253	2.000
3/12/2008 8:04	0.508	35.052	1.9891	1.988
3/12/2008 9:23	0.205	35.257	1.8602	

23/12/08

Addendum 1
Olympic Dam Expansion
TSF Supplemental Geochemical Investigations

Addendum 1
Olympic Dam Expansion TSF Supplemental Geochemical Investigations

Introduction

This addendum has been prepared in response to additional information requests following the review of the Supplementary EIS.

Discussion

Issue: Capacity for neutralisation of acidic seepage from the TSF, RSF and low grade stockpile

Information Requirement #1:

- ***Justification of the sample selection criteria, particularly demonstrating that the samples are representative of the materials likely to be in the waste rock and that the low grade material can be adequately defined by the average data.***

Supplemental verbal requests included:

- ***An explanation of sample source and sampling method.***
- ***Specific reference was made to Table 12.10 in the SEIS, where the representativeness of sample OD_11/HEMH was raised when compared to the average content reported for this lithological unit in Table 12.9 of the SEIS.***
- ***Explanation for early termination of six of the nineteen kinetic tests was requested.***

The sample selection for kinetic testing has to be viewed in the context of the:

i) overall acidity balance for the RSF,
ii) expected interaction with the underlying calcareous sediments and Andamooka Limestone, and,
iii) groundwater flow modelling.

First, as discussed in the Draft EIS and the Supplementary EIS (SEIS), the overall risk for acid generation is low, especially when it is considered that the total sulphur content was used to estimate the potential for acid generation, and the ANC far exceeds the MPA (as shown in Table 12.9 of the SEIS, mass weighted average MPA = 5 kg H2SO4 per tonne, and the mass weighted ANC = 62 kgH2SO4 per tonne respectively for the entire RSF). Even considered in isolation, the basement sequence which constituents a third of the RSF has a mass weighted average sulphur content of about 0.38 % (or an MPA of only 11 kg H2SO4 per tonne). Importantly, the overall potential for acid release is lower for the RSF than for the TSF. Second, similar to the TSF, the RSF is underlain by calcareous sediments up to 15 m thick, which is underlain by Andamooka Limestone averaging 32 m thick. As discussed for the TSF, the sediments and the Andamooka Limestone formation provide a large excess of neutralisation capacity so that even if acid was to be released from the RSF, it would be neutralised almost completely within the sediments and the balance within the Andamooka

Limestone. Third, the groundwater transport modelling showed that percolate from the RSF will ultimately report to the open pit. Therefore the solutes released from the RSF are expected to report to the open pit in the long term and releases off-site are unlikely to occur. The potential for impacts from the RSF is therefore considered to be very low.

In the light of the low risk environment, the primary objectives of the kinetic tests were to obtain indicative estimates of steady state oxidation rates, and concurrent solute release rates, from each of the major lithological units which then could be used to derive estimates of solute releases from the RSF. The sample selection was therefore undertaken to obtain samples that approximately correlated with the average sulphur content of each lithological unit, as indicated by the large exploration database. Samples were obtained from both drill core and underground bulk samples. The drill core samples represented discrete core intervals as shown in Table 1. The likely sulphur content for the samples selected was inferred from existing data.

Table 1 Kinetic Test Sample Sources

Column ID	Rock Code Hole	Source	Drill Hole	Sampling Interval (m)
OD_1	HEMH (148187)	Basement	UG1*	n / a
OD_2	GRNL (148207)	Basement	UG2*	n / a
OD_3	HEM (148194)	Basement	UG3*	n / a
OD_4	ZWAW	Cover Sequence	RD2744	174-175
OD_5	ZWA	Cover Sequence	RD2744	45-46
OD_6	ZWC	Cover Sequence	RD2744	193-194
OD_7	ZWT	Cover Sequence	RD2744	230-231
OD_8	ZWAR	Cover Sequence	RD2744	103-104
OD_9	ZAL	Cover Sequence	RD2744	24-25
OD_10	HEMQ	Basement	RD2741	793-794
OD_11	HEMH	Basement	RD1638	530-531
OD_12	GRNH	Basement	RD1625	583-594
OD_13	GRNB	Basement	RD2731	754-755
OD_14	GRNL	Basement	RD2730	719-720
OD_15	KASH	Basement	RD1638	651-652
OD_16	KASH Laminated	Basement	RD2748	582-586
OD_17	VHEM	Basement	RD2741	650-651
OD_18	KHEMQ-VASH	Basement	RD2748	730-731
D_19	CONGLO	Basement	RD1638	374-376

Notes: Mine rock collected underground: UG1* = sample collected 10May06 from '32 Purple 311 EXT DRV'' UG2* = sample collected11May06 from '39 LJ55 S / PILE'; UG3* = sample collected 10May06 from '45 MJ55 STH PER'.

Table 2 provides a direct comparison between the average sulphur content for the respective lithological units and the sulphur content of the samples selected for testing in the kinetic tests. As discussed later, the overburden units do not represent a risk of acid generation as they have excess neutralisation capacity, the sulphur content is low and occurs predominantly as sulphate. These units also represent minor sources of sulphur in the RSF based on sulphur content and abundance of material (i.e. mass weighted sulphur content) to be placed in the RSF. Comments with respect to the most significant lithological units (in terms of both abundance and sulphur content) are as follows:

HEMQ, Hematite >90 % + quartz, proportionally represents the highest mass source of sulphur in the RSF. The sample sulphur content is approximately 80% of the lithological unit which is considered to be within reasonable agreement.

GRNB, Granite >90 %, Hematite <10 %, represents the second most highest mass source of sulphur in the RSF, the sample sulphur content exceeds the lithological average by about 60 %.

GRNH, Granite 70–90 %, Hematite 10–30%, the sample sulphur content exceeds the average lithological content by 23 %.

Combined, the above units account for the majority of the sulphur. Whilst the **HEMH** (Granite 10–40 %, Hematite 60–90 %) represents a minor source of sulphur, the sample represented in Test Column 11 does not reflect the lithological average; however a second sample which had a sulphur content almost double the target value was tested in Column 1, therefore this unit too has reasonable representation.

Table 2 Kinetic Test Sample Sulphur Comparison

Column Test#	Sample/Unit	Proportion of RSF %	Lithological Average S(T) %	Sample S(T) %
1	HEMH 148187	0.92	0.51	1.2
11	HEMH		0.66	0.04
2	GRNL 148207	0.89	0.45	0.17
14	GRNL		0.45	0.16
3	HEM 148194	0.52	0.51	0.72
4	ZWAW	6.00	0.05	0.02
5	ZWA	-	0.04	0.06
6	ZWC	2.57	0.05	0.02
7	ZWT	13.34	0.08	0.02
8	ZWAR	25.88	0.04	0.02
9	ZAL	9.52	0.12	<0.01
10	HEMQ	7.64	0.73	0.59
12	GRNH	3.49	0.31	0.38
13	GRNB	12.54	0.22	0.35
15	KASH	-	-	0.01
16	KASH LAM	-	-	0.04
17	KEMQ VASH	2.49	0.37	0.52
18	VHEM	1.35	0.02	0.86
19	CONGLO	0.19	0.26	1.03

The column tests that were terminated early comprised those tests from the ‘cover sequence’ (i.e. tests 4 to 9 inclusive). The ‘cover sequence’ is a term used at Olympic Dam to describe the flat-lying, undeformed Late Proterozoic to Cambrian age chemically homogeneous shales, quartzites, and limestones which unconformably overlie the Gawler Craton (ie ‘basement’) sequence. The cover sequence is approximately 350 metres thick. Lithological units (and average thickness) comprising the cover sequence are listed in Table 3.

Table 3 Cover Sequence Stratigraphy

Lithological Unit	Unit Code	Average Thickness (m)
Cainozoic sands and clays	ZRS	10
Andamooka Limestone	ZAL	32
Arcoona Quartzite - Transition	ZWA	5
Arcoona Quartzite - Red	ZWAR	111
Arcoona Quartzite - White	ZWAW	30
Corraberra Sandstone	ZWC	20
Tregolana Shale	ZWT	125
Pebble Conglomerate	ZWP	9

Detailed geological descriptions of the cover sequence are provided in Ehrig (2002), EIS (2008), Scott (HLA, 2007), Kinhill and Stearns (1982), KBR (1997), Golder (1995), Woodward-Clyde (1996). Lithological units within the cover sequence which occur over the top and immediately adjacent to the Olympic Dam deposit are noted for their relatively uniform geology and chemical compositions across the entire deposit. Detailed chemical analyses (Cu, U3O8, CO2, S, Fe, K, Al, Ba, Ca, Mg, Si, Mn, P, Ti, As, Ce, Co, La, Mo, Na, Ni, Pb, Zn, Zr, Bi, Cd, Cr, Sb, V, Y) of the cover sequence were completed on 5m core samples from 20 diamond drill holes. The total number of samples analysed from each unit are listed in Table 4. Drill holes were selected from the cover sequence within the open-pit.

Table 4 Number of Geochemical Samples

Lithological Unit	Number of Samples
Andamooka Limestone	117
Arcoona Quartzite - Transition	41
Arcoona Quartzite - Red	459
Arcoona Quartzite - White	90
Corraberra Sandstone	94
Tregolana Shale	546
Pebble Conglomerate	15

Detailed assaying of the cover sequence was obtained for 20 diamond drill holes. The drill hole coordinates are provided in Table 5. The overall geology and chemical composition of each of the units did not vary significantly from drill hole to drill hole. Figure 1 to Figure 6 illustrate the similarity of the concentrations of CO2, and S amongst the different drill holes for each of the lithological units. The graphs were constructed by:

- Grouping all assays together for each unit based on the lithological code (i.e. ZAL, ZWAR, ZWAW, ZWC, ZWT). The average, minimum, and maximum values were extracted for all samples of a unit across the 20 drill holes. These results were plotted as ALL on each graph. (Note that the total number of samples for ZWA and ZWP were very low, so their graphs are not displayed.)

- For each lithological unit, the average, minimum, and maximum values were extracted separately for each drill hole. These values are plotted against the drill hole number (i.e. RD1470, RD1482, etc).

For example, Figure 1 shows the average, minimum, and maximum CO2 and S concentrations of the Andamooka Limestone (ZAL) for all ZAL samples within the 20 holes. The average, minimum, and maximum concentrations of the ZAL samples which occur in each drill hole are also plotted. Figure 2 shows the same but for Ca and Mg.

The major conclusion from the figures for the Andamooka Limestone is that the average chemical composition of the Andamooka Limestone is the same for all of the drill holes. The CO2 analyses also indicate that the carbonate content is very high, and is expected to be readily available for neutralisation reactions. The Ca and Mg results confirm that the Andamooka Limestone is predominantly dolomite rather than calcite. Clearly the Andamooka Limestone has no potential to generate acid with an average S content of less than 0.1 %.

The remainder of the figures indicate that the sulphur content for the remainder of the cover sequence, comprising the Arcoona Quartzite – Red (ZWAR), Arcoona Quartzite – White (ZWAW), Corraberra Sandstone (ZWC) and the Tregolana Shale (ZWT), varied little and that the average sulphur content was at or below 0.1 %. Based on the sulphur content alone these units would be considered as non-acid forming. However, all of these units contained some neutralising capacity, as inferred from the CO2 results, with an ANC equivalent that exceeds the MPA inferred from the total sulphur contents. The measured ANC values (as presented in Table 12.9 of the SEIS) confirm this conclusion. The kinetic tests of the cover sequence were terminated early because these materials are clearly non-acid forming, with very low sulphur contents, and early termination of these tests had no implication on the assessment of acid generation from the RSF.

Table 5 Drill Hole Collar Coordinates (MGA94-53)

Drill Hole	Easting	Northing	RL (m)	Mine Area
RD1470	682234.9	6630481.0	104.7	A
RD1482	682842.4	6630514.1	113.9	A
RD1519A	681969.9	6630586.2	102.3	A
RD1637	682234.5	6629557.5	107.0	E
RD1680	681249.0	6630291.1	95.3	H
RD1683	681632.1	6629797.9	101.8	B
RD1684	681519.4	6629620.6	98.7	E
RD1685	681897.6	6629653.1	103.4	E
RD1688	682371.7	6629709.3	106.7	E
RD1691	682419.0	6630732.5	106.2	A
RD1694	681967.3	6631257.5	97.5	A
RD1695	681375.1	6630654.8	98.6	CC
RD1698	682029.8	6630422.5	101.2	A
RD1705	682270.8	6630660.8	103.0	A
RD1711	682527.3	6630716.2	107.9	A
RD1711A	682527.3	6630716.2	107.9	A
RD1716	682175.0	6630518.9	104.5	A
RD1739	681578.5	6629977.3	102.2	B
RD1842	680700.0	6630444.0	101.0	DSE
RD1913	682227.2	6629136.5	106.0	E
RD1914	682428.3	6629198.4	102.9	E

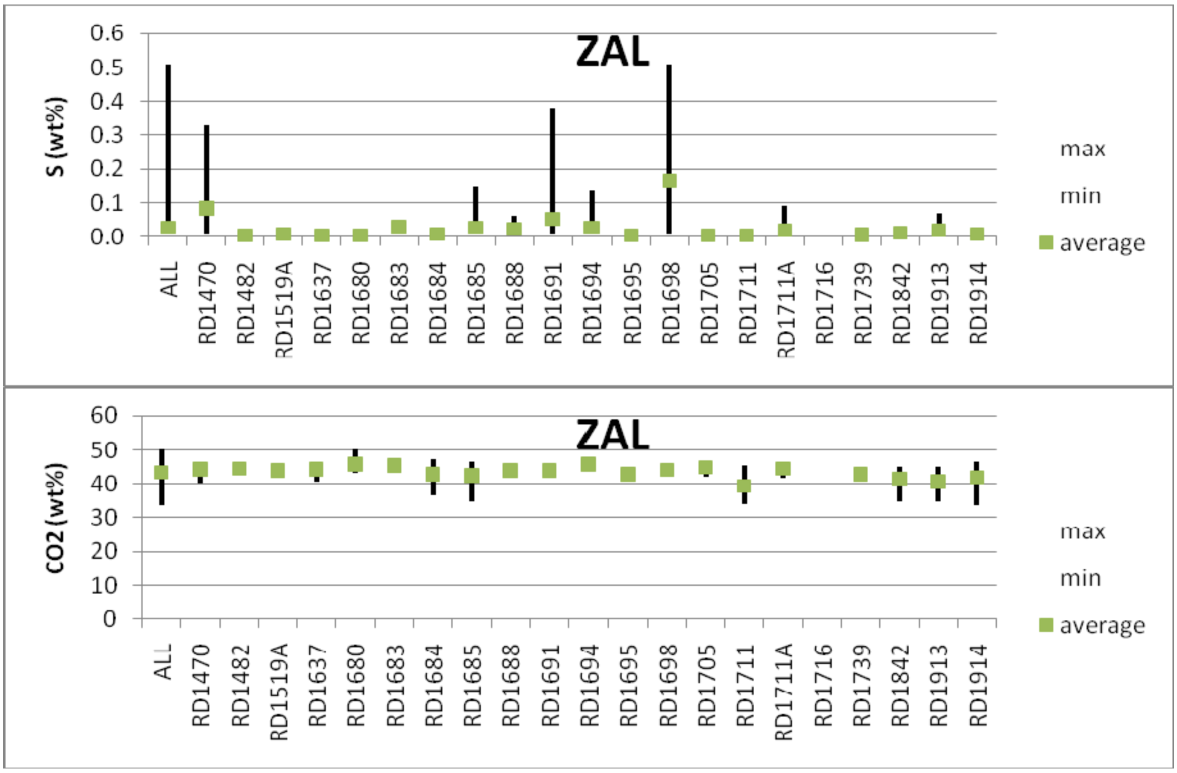

Figure 1 Andamooka Limestone (ZAL) Sulphur and CO2 content.

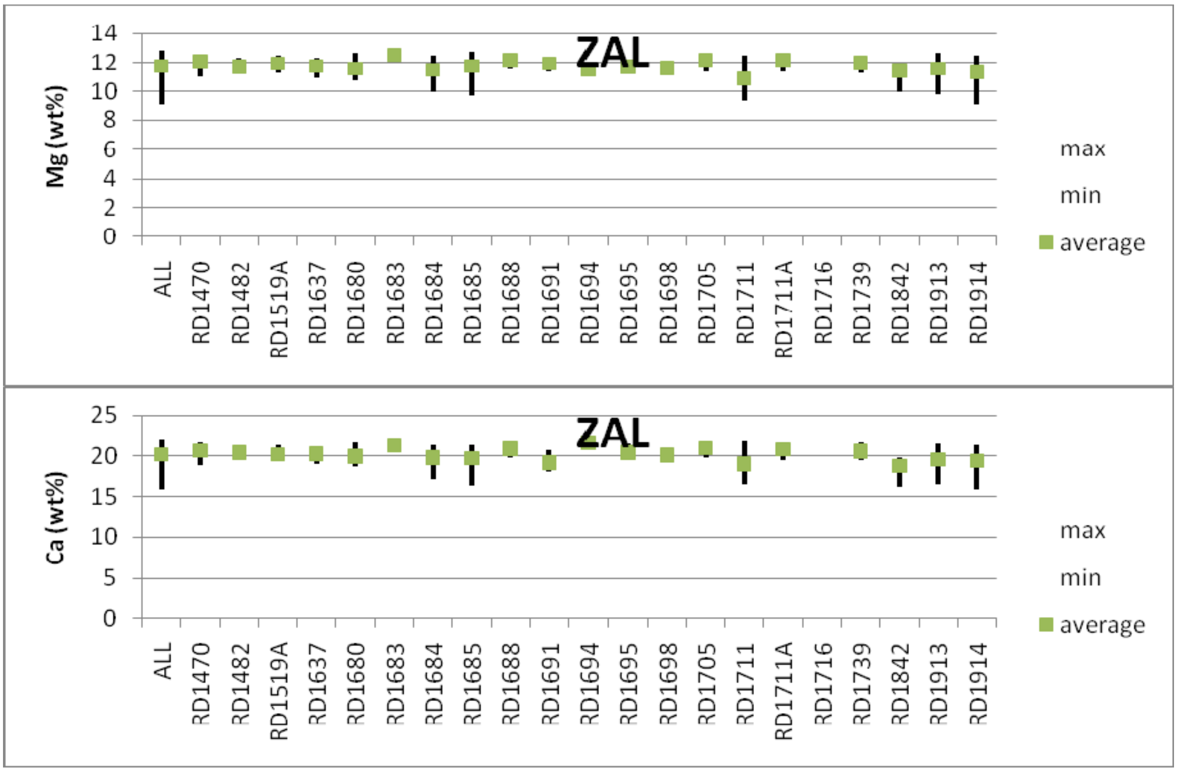

Figure 2 Andamooka Limestone (ZAL) Ca and Mg Content

Figure 3 **Arcoona Quartzite - Red (ZWAR) Sulphur and CO2 Content.**

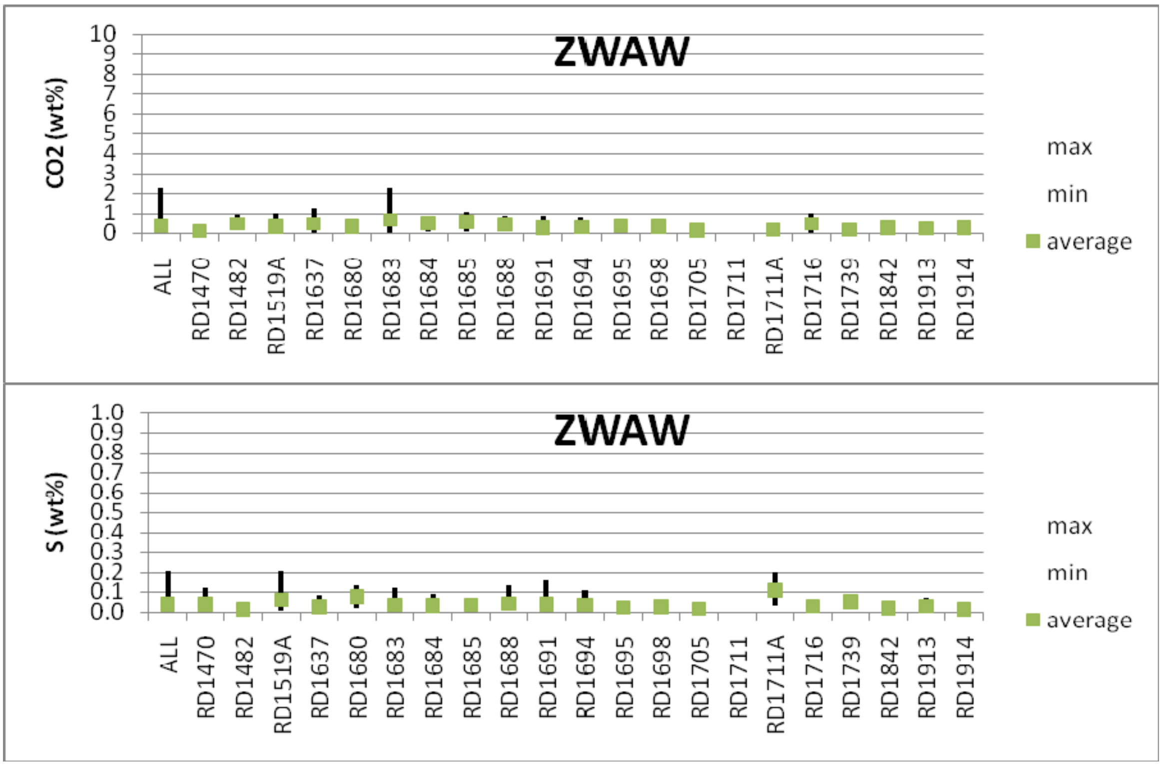

Figure 4 **Arcoona Quartzite - White (ZWAW) CO2 and S Contents**

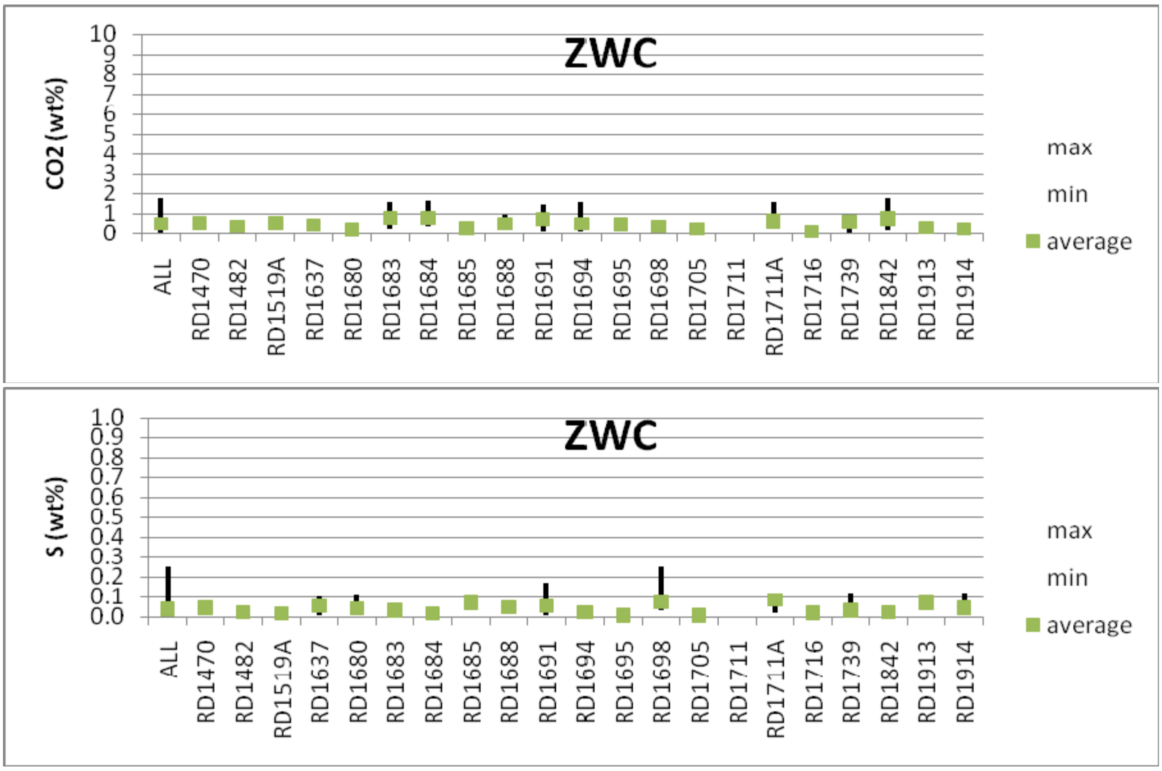

Figure 5 Corraberra Sandstone (ZWC) CO2 and S Content.

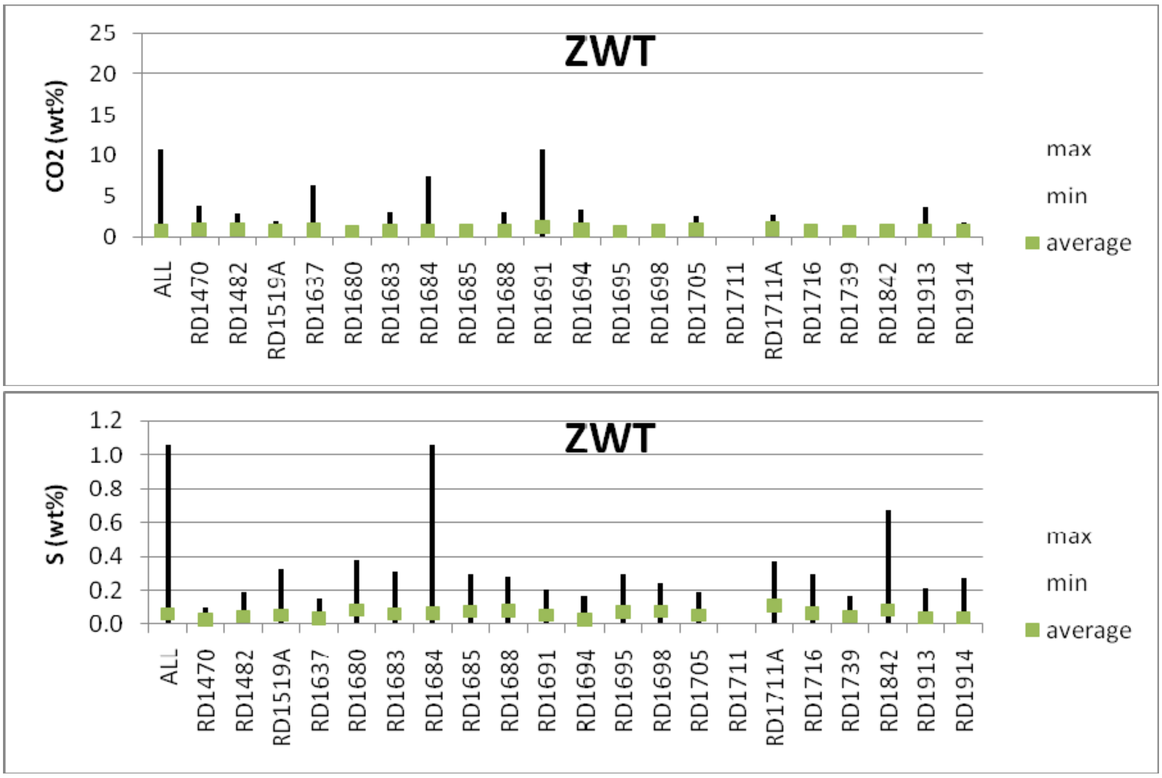

Figure 6 Tregolana Shale (ZWT) CO2 and S content.

Information Requirement #2:

Explanation of the test method(s) used for determination of the amount of sulphate in the rock samples.

The total sulphur was determined using a Leco High temperature Induction Furnace Analysis. As clarification the MPA was calculated from the total sulphur analyses and reported as kg H_2SO_4/tonne. This was used in the overall acid balance calculations for the RSF.

Limited sulphate analyses were completed. The method utilised comprised a dilute hydrochloric acid digestion and ICP-AES analysis.

The kinetic test samples were also analysed for sulphide sulphur content by using a chromium reducible sulphur method, as reported in Table 12.10 of the SEIS.

Information Requirement #3:

Further explanation of the modelled groundwater/percolate flow through the TSF and RSF subsurface to provide confidence that full neutralisation will occur, given impacts of: distribution of clay soils, preferential fracture flow in the limestone, precipitation of secondary minerals, residual silica or insoluble residues and silica.

Supplemental verbal requests included:

Explain the use of the tailings percolate in the overall acidity balance with specific reference to the data provided in Table 4.5 of the supplemental geochemical assessment of the tailings.

Confidence in the analysis is drawn from the existing TSF which represents a full scale test or analogue of the proposed TSF that has been in operation for over 20 years. Monitoring of groundwater levels and quality over that period provide a sound basis for predicting the likely response of the Andamooka Limestone aquifer to the operation of new TSF cells. In particular, the subsurface flow from the existing TSF cells has resulted in a mound of the water table beneath the TSF within the Andamooka Limestone, and the water has remained circum neutral in pH.

Since the percolate from the existing TSF reports to the groundwater mound located in the Andamooka Limestone in the vicinity of the TSF, two key conclusions can be made. First, the majority of the flow is passing vertically through the subsoils and sediments, and, this flow is entering the Andamooka Limestone formation. This means that even though there may be clays beneath the TSF, the vast majority of the flow remains vertical. Second, the fact that the water is mounding high above the water table (and not dissipating laterally) further confirms that lateral conductivity of the Andamooka Limestone is low.

The water quality monitoring results for water within the mound that has formed in the Andamooka Limestone aquifer below and adjacent to the TSF has remained circum neutral in pH indicating that the subsurface flows from the TSF are being neutralised effectively. These neutralisation processes have maintained near neutral pH conditions throughout the period of higher flow that occurred during the early stages of tailings deposition, and continues almost completely through the operational phase of the initial TSF. Flows from the existing TSF have decreased over time so that the highest 'stress' period has already passed. Flows are expected to further decrease when the TSF is taken out of service and then decommissioned and covered in accordance with the Closure Plan.

Since the neutralisation processes have coped with these maximum acidity loadings there is confidence that the system will cope with future loadings over the remaining operational period and after closure of the existing TSF.

The proposed TSF cells will proceed through the same life cycle as the existing TSF, with flows similar to or less than those that had occurred from the existing system. Therefore the response to the percolate from the proposed system is expected to be the same as that observed for the existing TSF.

The field and laboratory testing on samples from beneath the existing TSF cells indicate that neutralisation continues to occur within the near-zone of the tailings-soils contact. The drilling completed to date suggests that the depth of acid migration beneath the TSF is limited to less than a meter ranging up to a few meters. This indicates that irrespective of the distribution of the soil types, neutralisation occurs effectively within these soils.

Neutralisation reactions within the soils occur as a result of calcite and dolomite that are present in the soils. Where calcite is present, the volume of gypsum that may be formed is sufficiently high that neutralisation reactions with calcite could result in a net reduction of porosity, i.e. the calcareous clays containing calcite could become less permeable. Should the clays become less permeable, the neutralising capacity would be isolated and no longer as available as before (since the proportion of flow through the clays would decrease. Nevertheless, percolate would tend to flow across and then down to the Andamooka Limestone, rather than through the zone.

The Andamooka Limestone has been shown to contain excess neutralisation capacity and consists mainly of dolomite [$CaMg(CO_3)_2$]. As discussed in SEIS Appendix F5, there is sufficient neutralisation capacity in the Andamooka Limestone to neutralise all of the acidity that could be released from the TSF (and the RSF). Furthermore, the results from the geochemical assessment indicated that the volume of precipitates that would be formed, when dolomite reacts under anoxic conditions with the percolate from the TSF, would be less than the volume of the dolomite dissolved by the reactions. This is mainly due to the presence of magnesium in the dolomite which is soluble and therefore does not precipitate (unlike calcium which would form gypsum and reduce the pore space). Therefore, rather than limiting or reducing the availability of the dolomite, the neutralisation reactions would tend to lead to the formation of cavities which would create new surfaces so that reactions would continue to proceed.

The results contained in Table 4.5 as reported in the supplemental geochemical characterisation program show differences between the extracted porewater, the leach extracted porewater and the in situ porewater. The extracted porewater represent water that was recovered directly from saturated tailings samples. The leach extracted porewater (middle series of results in the table) represent unsaturated tailings contacted with water at a solids to liquid mass ratio of 1:1. The in situ or piezometer results represent water samples obtained by disposable bailer, with the standpipe purged prior to sampling.

The results for the leach extracted porewater cannot be compared directly to the extracted or in situ results as additional water was added to the tailings to recover the solutes. This means that if the tailings were saturated, the extraction would represent a dilution of about 3 or more. However, since the tailings were unsaturated, the dilution rate could be substantially higher, hence the relatively low concentrations reported for this series of extractions.

The extracted porewater sourced from saturated or near saturated tailings generally has higher chloride and sulphate concentrations. Whilst the acidity was not measured for the in situ porewater samples, the acidity of the extracted porewater also is higher than the back calculated acidity of the in situ porewater. The extracted porewater more closely approximate process water concentrations whereas the lower concentrations measured for the in situ porewater suggest that some of the solutes had been lost to secondary minerals precipitated from solution, such as jarosite etc. Other factors that could also have contributed to the lower concentrations in the in situ porewater is historic periods of high rainfall that could have diluted the porewater.

Nevertheless, for the overall acidity balance, and to evaluate the potential interaction with the Andamooka Limestone, the highest acidity value obtained from all the tests and monitoring results was used to calculate the maximum possible acidity release that could occur from the tailings. As noted in Chapter 8 of the supplemental geochemical assessment, an acidity loading of 70 g/L $CaCO_3$ eq. (compared to the maximum measured value of 66.7 g/L $CaCO_3$ eq.) was used. Furthermore, it was assumed that all of the acidity would report to the tailings percolate; the in situ measurements suggest that some of the acidity could be taken up in secondary minerals and may not report to the percolate. Nevertheless, as explained in the report the total acidity loadings from the tailings (including that from the oxidation of any residual sulphide minerals) could be in the order of about 2000 kg CaCO3 eq./tonne. The average ANC of the Andamooka Limestone has been measured to be about 430 kg CaCO3 eq./tonne, ranging up to 930 kg CaCO3 eq./tonne. Not accounting for any neutralisation to occur within the sediments and soils the interaction of the acidity with the Andamooka Limestone could be in the order of about 4 to 5 m. At the maximum measured ANC, the interaction could be as low as 2m.

The sediments have clearly been shown to effectively neutralise acidity in the percolate; depending on the actual availability of the ANC in the sediments, the interaction with the Andamooka Limestone could be less than 2 m, but more likely to be in the order of about 3 m (assuming an average ANC of 50 kg CaCO3 eq./tonne and an average thickness of about 10 m for the sediments and soils, and an average ANC of 480 kg CaCO3 eq./tonne for the Andamooka Limestone).

Information Requirement #4:

Provide omitted data from the first 25 weeks of leachable salt tests, and assessment of nitrate residues.

All kinetic test data are provided in SEIS Appendix F6. However, whilst we concur that discounting the first 25 weeks of kinetic test results neglects the potential for salinity release that may occur from the RSF materials, we disagree that the results from the first 25 weeks are appropriate for such an assessment. The reasons are manyfold. First, the samples represent cores that have been drilled with drilling fluids that likely were saline and may have biased the actual salinity associated with the samples. Second, the samples will have been logged and likely washed with saline water (considering the site location and water sources) and evaporites would have formed as the samples dried. Again, the salinity load would have been biased. Third, the samples represent very finely crushed material which results in very high surface areas and would release occluded porewater that would otherwise not be available for release. (Reasons for excluding the first 25 weeks of testing for solutes that are released due to oxidation are discussed in SEIS Appendix F7 and are not repeated here.)

An appropriate method to assess the salt release from the waste rock materials is to consider the groundwater content together with the groundwater quality. The moisture content at the time of placement multiplied with the salt concentration would yield the total mass of salt contained in the waste rock. The mass available for transport, and resultant concentrations, can then be assessed as described in SEIS Appendix F7.

A statistical summary of the major ion concentrations present in the Andamooka Limestone Aquifer is provided in Table 6 (source: Appendix F2 Attachment C).

Table 6 Summary of Average Major Ion Concentrations in the Andamooka Limestone Aquifer within the Mining Area

Parameter	Units	Minimum	Maximum	Geometric Mean
Calcium	mg/L	777	1360	965
Magnesium	mg/L	93	1050	569
Sodium	mg/L	7120	9360	7981
Potassium	mg/L	56	217	90
Sulphate	mg/L	2300	5680	3869
Chloride	mg/L	8200	11000	9860
Fluoride	mg/L	0.2	3.2	1.25

Table 7 provides a summary of the initial and estimated final residual porewater content of the various rock types. The residual water content represent the amount of water that would remain within the waste rock after dewatering and would be present at the time it is placed in the RSF.

Table 7 Summary of Estimated Water Content Prior to and After Dewatering

Symbol	Unit	Average Rock water content post blasting (mass %)		Vol water
		Non dewatered rock water content	Dewatered (residual) rock water content	L/tonne
ZAL	Andamooka Limestone	7.5	1	10
ZWAR	Arcoona Red Quartzite	2.5	0.5	5
ZWAW	Arcoona White Quartzite	2.5	0.5	5
ZWC	Corraberra Sandstone	7.5	2	20
ZWTT	Tregolana Shale / Corraberra transition	7.5	5	50
ZWT	Tregolana Shale	2	1	10
ODBC	basement complex	2	1	10

The information in the above tables can then be used to estimate the total solute loading that would be present in the RSF. The results are shown in Table 8. The table also shows the equivalent mass weighted solute loadings for the RSF as a whole and the estimated maximum solute concentrations. The calculations adopted the same assumption and scaling factors described for the RSF assessment. The calculations further assumed that all of the available salts are flushed from the RSF in a single flush; in reality the displacement will occur over time with lower peak concentrations.

Table 8 Summary of Estimated RSF loadings and Concentrations

Symbol	Distribution %	Vol water	Ca	Mg	Na	K	SO4	Cl	F
		L/t	g/t	g/t	g/t	g/t	g/t	g/t	g/t
ZAL	9.5	10	9.65	5.7	79.8	0.9	38.7	98.6	0.013
ZWAR	25.9	5	4.83	2.8	39.9	0.5	19.3	49.3	0.006
ZWAW	6.0	5	4.83	2.8	39.9	0.5	19.3	49.3	0.006
ZWC	2.6	20	19.30	11.4	159.6	1.8	77.4	197.2	0.025
ZWTT	7.8	50	48.25	28.5	399.1	4.5	193.5	493.0	0.063
ZWT	13.3	10	9.65	5.7	79.8	0.9	38.7	98.6	0.013
ODBC	34.9	10	9.65	5.7	79.8	0.9	38.7	98.6	0.013
RSF Mass Weighted Load (g/tonne)			**11.37**	**6.70**	**94.04**	**1.06**	**45.59**	**116.18**	**0.015**
RSF average concentration (mg/L)			**400**	**1341**	**18808**	**212**	**4620**	**23236**	**2.95**

As to the second part of the request, the ammonium and nitrate release from the waste rock can be calculated from the powder factors for waste rock blasting and adopting a proportion of 'losses' that could occur as a result of missed rounds, spillage etc. ANFO consumption for waste rock blasting is expected to be in the order of about 0.28 kg/tonne. Formal advice from Orica indicated that losses can be expected to be between 0.6% and 1.3% losses on total ANFO emplaced. Losses reported elsewhere in the literature indicate that on average losses of about 1 % can be expected.

Therefore the total mass of ammonium nitrate that would be present in the waste rock would be approximately 0.28 *(1/100) = 0.0028 kg/tonne, or about 2.8 g/tonne, as NH_4NO_3. The ammonium and nitrate concentrations were then calculated for the porewater content of the waste rock, assuming a field moisture content of about 15 % (vol/vol). The estimated concentrations in the percolate from the RSF are estimated to be about 17 mg/L ammonium and about 58 mg/L nitrate (or 13 mg/L as N, respectively). The ammonium and nitrate would be expected to be displaced from the RSF within the first pore volume displacement. Generally, since the RSF is expected to remain oxygenated, the ammonium is expected to be oxidised to nitrate before it is displaced from the RSF. The nitrate concentration would increase inversely with the proportion of ammonium oxidised. As indicated by the groundwater modelling the nitrate would ultimately end up in the pit lake, where, under anoxic conditions it could potentially be reduced through denitrification.

Issue: Geochemical Modelling of Tailings Storage Facility

Information Requirement:

Provide data for estimated annual ammonia percolate loading in Tables 8.1 and 8.2 of the supplemental geochemical assessment, and comment on the fate of this ammonia.

The tailings porewater contain ammonium (rather than ammonia, since the tailings porewater is acidic). The equivalent ammonium-nitrogen loadings for the tailings area are given in Table 9 (equivalent to loadings provided in *Tables 8.1).* After closure the ammonium loadings are expected to decrease to very low concentrations since the ammonium will be readily flushed from the tailings.

Table 9 Estimated Ammonium Loadings from TSF

Parameter	**Contaminant loading, kg/ha/yr***					
	Based on extracted porewater chemistry			**Based on data from piezometer-sourced samples**		
	min	p50	max	min	p50	max
NH4-N	23	107	135	n/a	n/a	n/a

The fate of the ammonium will depend on the conditions under which the porewater is flushed from the tailings. Where tailings porewater is displaced under saturated conditions (i.e. anoxic conditions) the ammonium ion will prevail. However, as soon as conditions become oxidising (i.e. excess oxygen becomes available) the ammonium is expected to be oxidised to nitrate. The ammonium, and if oxidised in transit, will end up in the open pit as indicated by the groundwater transport modelling. Within the pit lake, it is possible that the nitrate could be reduced to nitrogen through denitrification reactions.