Acid, Metal and Nutrient Mobilisation Following Rewetting of Acid Sulfate Soils in the Lower Murray

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EXECUTIVE SUMMARY

The potential for mobilisation of acid, metals and nutrients following the rewetting of a wide range of dried acid sulfate soil (ASS) subtypes in the lower River Murray and Lakes region of South Australia was assessed. The 150 soil samples collected were classified as: (i) 29 sulfuric materials (pH <4), (ii) 73 sulfidic materials (high sulfide concentrations and potential to develop pH<4), (iii) 1 mono-sulfidic black ooze material (MBO), and (iv) 13 clays, 32 sands and 1 organic material, all containing some sulfides. Upon wetting of these soils with River Murray water using a rapid laboratory testing method, 6% had pH <3, 18% had pH <4, 25% had pH <5, 33% had pH <6, 67% had pH <7, and 95% had pH <8.

Upon resuspension of soils (100 g/L) in River Murray water, the water was effectively buffered to the pH of the soil. Releases of nutrients were generally not high. The dissolved metal concentrations exceeded water quality guidelines (WQGs) for all of the metals studied for which guidelines exist. The metals that most often exceeded the WQGs were Cu (87% of 47 samples tested), Zn (68%), Ni (64%), Co (60%), Cd (51%), Mn (51%) and Al (>49%). The number of WQG exceedances after applying a dilution factor (10×, 100×, 1000×), as would occur when these waters mix with river or lake water, was also calculated. Based on the maximum dissolved concentrations following dilution, the metals most greatly exceeding the WQGs by 10× were Ni (47%), Zn (43%), Cu (38%), and Al (34%), by 100× were Al (34%), Cu (11%), and Zn (11%), and by 1000× were Al (4%) and Zn (2%). The dilution of the acidic, metal-rich, waters with River Murray water resulted in neutralisation of pH and removal of many metals through precipitation and adsorption reactions. After accounting for the decreases in metal concentration due to 100-fold dilution, additional removal of metals from the dissolved phase was >99% for Al, Fe and Pb, >85% for As, Cr and Cu, >60% for Se and Zn, >40% for Cd, but less than 30% for Ag, Co, Mn, Ni and V. For most of these metals, there were significant relationships between the pH of the sulfidic/sulfuric soils and the concentrations of dissolved metals released. A combination of modelling and comparison of dissolved concentrations with WQGs indicated that for waters with pH 5 or less, significant impacts on the ecology of the River Murray system were likely.

All of the sulfuric (19% of total) and sulfidic soil samples (53%) were classified as high risk. The sulfidic soils may be expected to develop further acidity if suitable field conditions exist in the future for them to dry naturally. If this occurs, the results presented in this report may therefore be biased towards an underestimation of the acidification, dissolved metal concentrations and WQG exceedances.

1. INTRODUCTION

Previous research by CSIRO Land and Water has shown that the River Murray, adjacent wetlands and the Lower Lakes (Alexandrina and Albert) close to the Murray Mouth are being seriously impacted by a combination of low water levels and the presence of acid sulfate soils (ASS) (Fitzpatrick *et al.* 2008a; Appendix A). The Lower Lakes and the floodplains below Lock 1 at Blanchetown are undergoing their first major drying phase since the introduction of barrages more than 50 years ago. The isolation of lakes (e.g. Lake Bonney and Yatco Lagoon) and several wetlands from the River Murray is currently being used as an option to generate water savings and help mitigate drought-related problems in the Murray-Darling Basin (Fitzpatrick *et al.* 2008b). Field observations and chemical analyses confirm the presence of both sulfuric (pH < 4) and sulfidic materials (high sulfide concentrations and pH > 4) in a range of ASS subtypes (Figure 1).

Figure 1. Acid sulfate soil with sulfuric material in drained wetlands adjacent to the Murray River (from Fitzpatrick et al. 2008a).

The newly exposed ASS with sulfuric and sulfidic materials may lead to serious environmental impacts including acidification, mobilisation of heavy metals, anoxia, and the production of noxious gases. Further declining water levels (potentially >1.0 m below sea level) may expose large areas of ASS during 2009.

The acidity produced during oxidation of ASS can cause metals (e.g. Al, Cd, Cu, Fe, Mn, Ni, Pb, Zn) and metalloids (As, Se, Hg) to be dissolved and released. These constituents could subsequently be mobilised into the water column following sediment disturbance, mixing by surface wave action, or natural or artificial flooding. Phosphorus could also be released and may contribute to algal blooms. The findings of widespread ASS in the Lower Murray, along with the published scientific literature on acid and metal mobilisation, highlights a potential risk both to drinking water supplies and to ecosystem health. There are presently very limited data on the potential mobilisation and toxicity of metals and nutrients from ASS in the River Murray, Lower Lakes, and associated floodplains. There are also limited data on the net acidity of in-channel sediments and subaqueous ASS (Appendix A).

1.1 Project Scope

The major objective of this project was to assess the potential mobilisation of contaminants of concern (acid, metals, metalloids, and nutrients) to surface waters that may occur as a result the short-term inundation of ASS (rewetting) in the lower River Murray and associated lakes in South Australia.

Soil and sediment samples were collected from geographically representative locations in the Lower Murray region and characterised in terms of ASS properties (Appendix A). The samples were then subjected to accelerated drying in an attempt to mimic worse-case oxidation scenarios, and tests undertaken to assess the mobilisation of acid, metals and nutrients. The mobilisation results were interpreted in terms of sediment and soil properties and the information was summarised in a form suitable for the risk assessment of water quality issues associated with the drying and re-wetting of ASS in the Lower Murray region.

The study proposed to investigate two major types of ASS materials, namely sulfidic and sulfuric materials, with monosulfidic black ooze (MBO) materials being the focus of part of a separate sub-project (Sullivan et al., 2008). A variety of ASS subtypes were also selected, including cracking clay (clayey soils), and sandy, organic (peaty) and organic-rich soils. The sampling density was chosen to offer good spatial coverage of the study area. The depth to which samples were collected (through the profile) was determined from a detailed assessment of soil horizons, and varied from site to site. Samples collected comprised both water logged (hydrosols), submerged sediments (subaqueous soils) and air-exposed dry or semi-dry soils. The in-channel sample sites were located in areas of likely ASS exposure in the next 18 months (+0.7 to -1.5 m AHD areas) based on recently acquired bathymetry of the River Murray. The ASS samples were collected from representative locations from the main channel of River Murray, wetlands (open and managed), and Lakes Albert and Alexandrina. Selected samples were taken from sites before and after natural drying, and at each site up to five depths were sampled per site. Some samples were taken from archived samples collected previously and stored at 4℃. Water samples for baseline characterisation were collected from the River Murray, adjacent wetlands, and Lakes Albert and Alexandrina.

The ASS samples were photographed, described and characterised by physical and chemical analyses (e.g. sulfidic, sulfuric and MBO; e.g. Fitzpatrick *et al.* 2008). Analyses of sediment and soil properties included particle size or soil texture, organic matter content, wet chemistry (pH, EC), acid-base accounting (carbonate, total C and S, chromium-reducible sulfur (CRS or S_{cr}), potential acidity, acid neutralising capacity (ANC)). Trace metals were analysed in most samples. Sub-samples of each soils were archived in chip trays.

The rapid remobilisation of acidity, metals and nutrients from air-dried (40ºC) samples was evaluated by resuspending the samples in oxygenated, unfiltered Murray River water or synthetic rain water for 24 h. Water samples were analysed for pH, alkalinity, acidity, organic carbon, major and minor anions (Cl^-, NO_2^-, NO_3^-, PO_4^{3-}, SO_4^{2-}, HCO_3^-), the major cations (Na, K, Ca, Mg) and the trace metals and metalloids (Ag, Al, As, Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb, Se, V, Zn). The ability of the river system to buffer releases of acid, metals and nutrients was assessed for unfiltered water samples and waters containing varying amounts of suspended River Murray solids. The potential for low dissolved oxygen concentrations to arise from rewetting processes was determined and the possible environmental impacts assessed. The acid, metal and nutrient mobilisation dynamics (over 7 weeks) in response to suspensions of MBOs in freshwater and to freshwater inundation of dried MBO and sulfuric soil materials was investigated in a separate sub-project (Sullivan et al., 2008).

2. METHODS

2.1 Water Samples

Bulk River Murray water for the mobilisation tests (4× 20 L containers) was collected from a single location adjacent to Morgan's Lagoon (Easting 371015, Northing 618377). The containers were rinsed with river water before use.

Water samples were collected from seven sites in the River Murray system (

Table 1, Figure 2) to obtain information on background water quality parameters (e.g. pH, conductivity, alkalinity), and concentrations of trace metals and nutrients. These water samples were collected by the South Australian Environmental Protecion Agency (SA EPA) and handled using strict protocols (advised by CSIRO) to avoid sample contamination. This included the wearing of clean powder-free vinyl gloves for the handling of all sample bottles and sampling equipment. The plastic bottles and containers used to collect and store the waters were new and acid-washed before use.

To collect the waters, bottles were submerged quickly through the surface layer to approximately 20-50 cm depth (i.e. the surface layer was not collected). The collection bottle was filled and emptied twice with the site water before finally filling with the sample for analysis. Field blanks were prepared by opening an empty collection bottle in the field (e.g. on the river bank), and exposing it to the same conditions as the bottles used for sample collection. The field blank bottle was then filled with deionised water in the field. The water samples from the seven sites (

Table 1) were collected on 29th February, 2008.

Table 1. Locations of water samples collected from the River Murray and its associated wetlands

Site[a,b]	**Site Code**	**GPS Location (Easting,**	**Northing)**	**Description**
Swan Reach	SWR	371171	6174131	Swan Reach boat ramp
Mannum	MNM	345869	6135130	Adjacent Mannum township
Paiwalla Wetland	PA	351356	6122154	Wetland site was being filled at time of sample taken from on bird hide island
Riverglades Wetland	RGW	344814	6114561	Wetland almost dry taken from largest pool left
Wellington	WEL	353378	6089200	Wellington adjacent to ferry
Meningie	MNG	349791	6050241	Adjacent to Meningie Sailing club
Morgans Wetland	MOR	371015	6183985	Adjacent to wetland
Milang	MLG	316286	6079768	Milang jetty (Lake Alexandrina)

[a] Field blanks were collected at the Paiwalla Wetland and Milang sites

[b] Duplicate samples were collected from the Swan Reach and Meningie sites

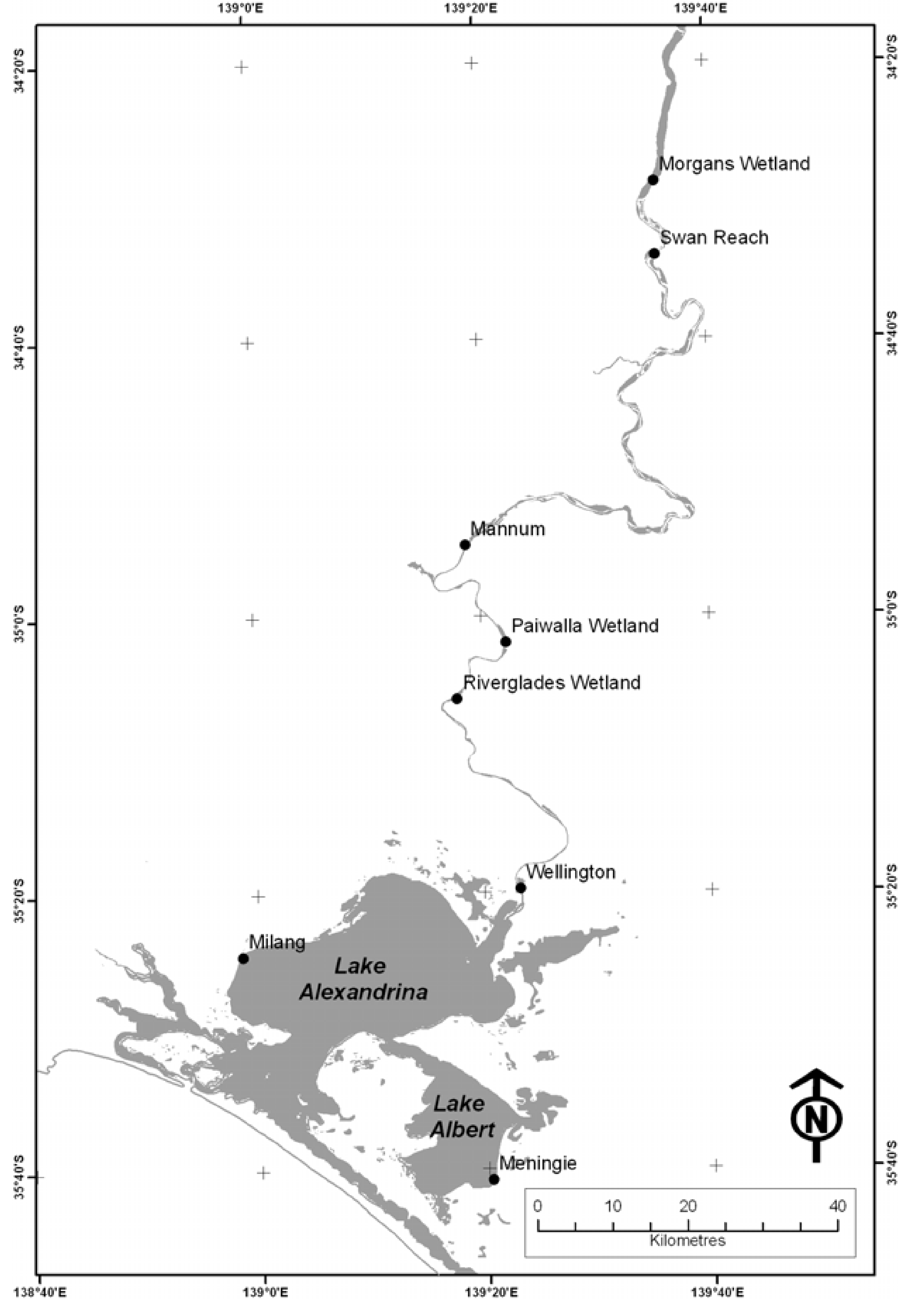


Figure 2. Water sampling sites in the River Murray system

2.2 Acid-sulfate Soil Samples

Approximately 150 samples of ASSs and were selected from 63 sites within the study regions and comprised 11 River Murray sites (29 samples), 5 Wellington Weir sites (10 samples), 16 Lake Albert sites (44 samples), 19 Lake Alexandrina sites (31 samples), and 12 wetland sites (36 samples) (Table 2). At each site, ASS samples were collected from up to five soil depths (horizons, layers).

A wide range of ASS (sulfidic, sulfuric, MBO materials) and associated (clayey, sandy and organic sulfide-containing) materials were sampled from several subtypes of ASS and non-ASS (Table 3 to Table 7). Samples were collected from a combination of new sites, sites sampled previously, and also from archived samples collected some time earlier and stored at 4 ℃. Sampling areas were classified as River Murray (encompassing all samples from the main river channel), Lake Albert, Lake Alexandrina, proposed Wellington Weir site (where the River enters into Lake Alexandrina), and the wetlands Jury Swamp, Murrundi, Paiwalla, Swanport, Ukee and Riverglades (Figure 3; Table 2).

Table 2. Regions and number of sites and acid sulfate soils locations collected from the River Murray (WL) between Wellington Weir and Lock (Figure 3)

Study Region	**Number of sites**	**Number of samples**	**Description**
River Murray	11	29	All samples from main river channel that did not ?
Wellington Weir	5	10	At proposed weir site
Lake Albert	16	44	Lake
Lake Alexandrina	19	31	Lake
Jury Swamp	2	4	Wetland
Murrundi	3	7	Wetland
Paiwalla	1	5	Wetland
Swanport	1	2	Wetland
Ukee	4	12	Wetland near boat club
Riverglades	2	6	Wetland
Total	63	150	

At each site, GPS co-ordinates (WGS84 datum), and brief descriptions of site locations and soil samples were recorded (Appendix A). Soil samples were collected to a maximum of about 60 cm depth by wading and using a range of implements, including spades, a D-auger and a gouge auger. Soil profiles were sampled by horizon or layers. For each sample, basic records were made using morphological descriptors and physical properties such as colour, consistency, structure and texture (Table 3 to Table 7), as described by McDonald et al. (1990). Chip tray samples were collected and archived at CSIRO in Adelaide – with recorded locations for long-term storage of the samples and air dried/moist samples kept in chip trays to allow for future analysis (Fitzpatrick et al. 2008b). Samples were collected in sealed bags or plastic containers and air was excluded as far as possible. On recept at the laboratory, samples were kept at 4 ºC until analysed.

The site codes, sampled layer depth ranges, and general descriptions of the samples collected are given in Table 3-7. The coordinates for each sample site are presented in Appendix A.

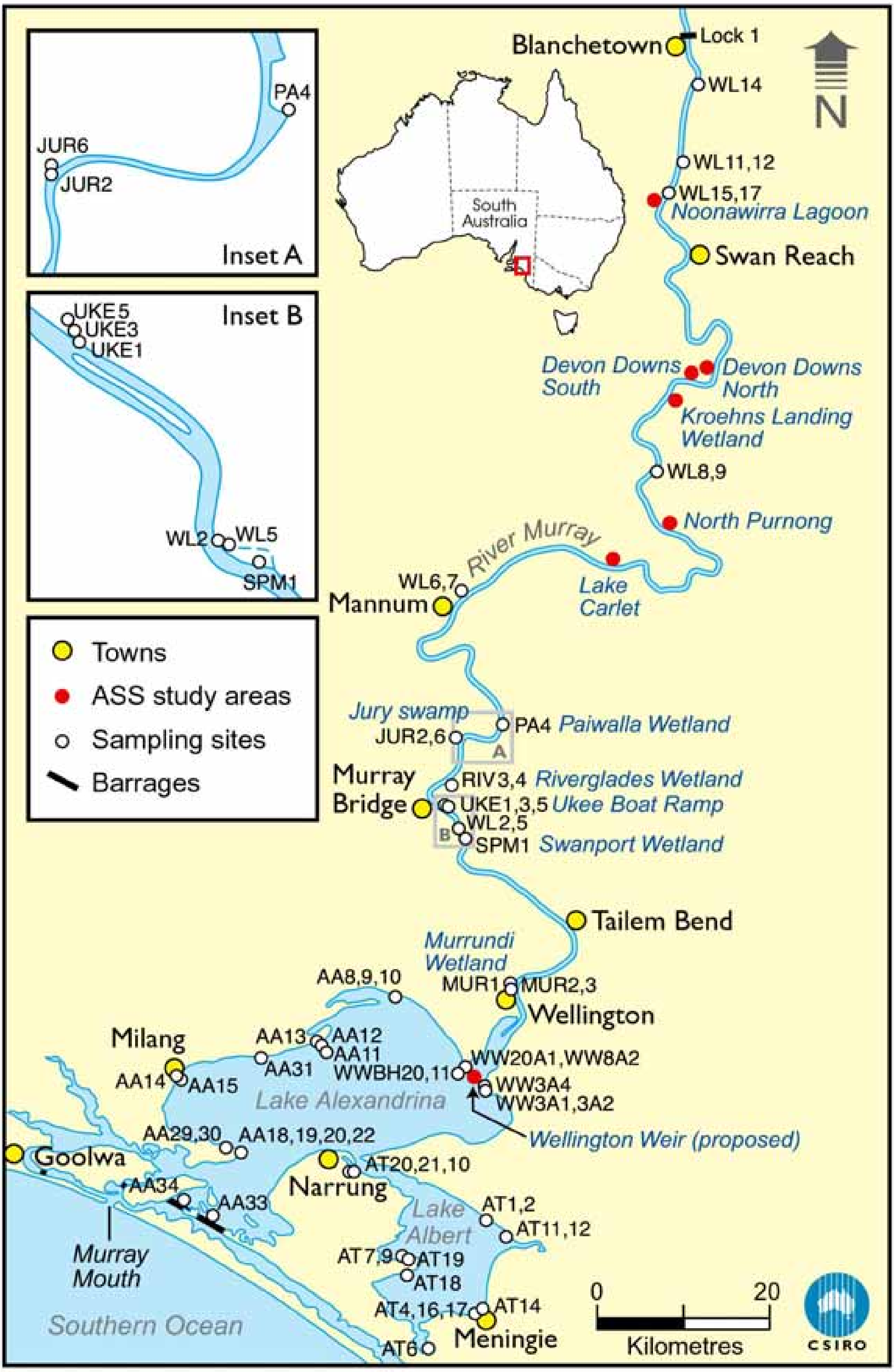


Figure 3. Sites of samples and areas in the River Murray system including River Murray (main channel), Wellington Weir, Lake Albert, Lake Alexandrina, and the wetlands Jury Swamp, Morgans, Murrundi, Paiwalla, Swanport, Ukee and Riverglades.

Table 3. Acid sulfate soils and associated materials collected from the River Murray (WL) and adjacent open wetlands between Wellington Weir and Lock 1 (see Appendix A for coordinates)

Site Code	Depth, cm	Material[a]	Description
WL 2.1	0-5	Sulfidic clayey	Grey sandy clay; top 1 cm algal mat; small fragments of calcrete; abrupt to
WL 2.2	5-20	Sulfidic clayey	Very dark grey heavy clay, black mottles; highly organic; orange mottles along old root channels; polyhedral structure (1 - 2 cm); probable old cracks filled with pale grey sand
WL 2.3	20-40	Clayey	Dark bluish grey heavy clay
WL 5.3	0-1	Sulfuric clayey organic-rich	Crust containing efflorescence and organic material
WL 5.4	1-5	Sulfuric clayey organic-rich	Brown organic loam, sapric, charcoal(?), common fine roots
WL 5.5	5-20	Sulfuric clayey organic-rich	Very dark brownish grey silty loam; pockets of sapric organic matter; mottled in top 5 cm
WL 6.3	0-1	Clayey	Brownish grey clay loam with crust
WL 6.4	1-8	Sulfidic clayey	Brownish grey clay loam; very sticky; lower 1 cm bleached; sharp, wavy to
WL 6.5	8-20	Clayey	Dark grey brown medium clay; sapric decomposing roots; some orange brown staining around old roots; clear, even to
WL 7.2	0-3	Sulfidic clayey	Dark brown medium heavy clay; sticky; porous and spongy; fine organic material; fine iron oxide mottles
WL 7.3	3-12	Clayey	Dark brown medium heavy clay; common, large orange brown coatings; clear boundary
WL 7.4	12.25	Clayey	Dark greyish brown heavy clay; sticky common orange brown mottles; appears porous along old root channels and oxygen probably enters along frequent, significant cracks
WL 8.2	0-1	Sulfidic clayey	Dark grey heavy clay; hard
WL 8.3	1-3	Sulfidic clayey	Very dark brownish grey heavy clay; sticky; organic material around pores
WL 8.4	3-6	Sulfidic clayey	As above but distinctly massive and 'sedimentary' not porous; diffuse pale orange mottles
WL 8.5	6-25	Sulfidic clayey	Grey heavy clay; organic; porous; granular structure (possibly).
WL 9.2	0-5	Sulfidic clayey	Dark grey heavy clay with sandy or silty, pale, horizontal layers a few mm thick
WL 9.3	5-30	Sulfidic clayey	Dark brownish grey heavy clay with some orange mottles on vertical crack planes as seen at other sites; also similar to material at site WL8
WL 11.1	0-5	Sulfidic clayey	Yellowish grey, gel-like
WL 11.2	5-10	Sulfidic clayey	Bluish grey heavy clay with common strong brown mottles along root channels; polyhedral structure
WL 11.3	10-20	Sulfidic sandy	Bluish grey fine sandy light clay, micaceous; distinct, strong orange mottles along root channels
WL 12.2	1-5	Sulfidic sandy	Dark grey fine sand; sulfidic
WL 12.3	5-15	Sulfidic clayey	As above, with clayey, black sulfidic mottles
WL 14.2	0-2	Sulfidic sandy	Grey loamy sand with distinct black and diffuse orange brown mottles
WL 14.4	2-7	Sulfidic sandy	Yellowish grey fine sand with occasional black and orange brown mottles along root channels
WL 15.1	0-5	Sulfidic sandy	Yellowish grey fine sand with some diffuse mottles; many roots
WL 15.2	5-10	Sulfidic sandy	Dark grey sand; soft iron rich nodules at ~ 10 cm; no roots
WL 17.1	0-15	Sulfidic sandy	Yellowish grey medium sand wit 20% orange mottles around weed root, dark grey at base; contains charcoal

[a] Sulfidic = sulfidic material; sulfuric = sulfuric material; MBO = mono sulfidic black ooze material (Appendix A); clayey = clayey material (>35% clay; light, medium and heavy clay texture); Sandy = Sandy materials (sand, loamy, sand, clayey sand texture groups); organic = organic material (>10 % organic carbon; Isbell, 1998); organic-rich (5 – 9% organic carbon).

Table 4. Acid sulfate soils and associated materials collected at Wellington Weir (WW) (see Appendix A for coordinates)

Site Code	Depth, cm	Material[a]	Description
WW3A 1.1	0-8	Sandy	Yellowish grey medium sand; stratified with yellow sand and sulfidic-like material
WW3A 1.2	8-20	Sandy	Greyish black; stratified with sulfidic-like material
WW3A 2.1	15-20	Sandy	Black medium sand; sulfidic-like; some shell
WW3A 4.1	0-5	Sandy	Yellow very coarse sand, pinkish in part; few shells
WW3A 4.2	15-25	Sandy	Black coarse sand; sulfidic-like; very shelly
WW3A 4.5	25-50	Clayey	Very dark grey with bluish green mottles; strongly gleyed; some decomposing carbonate; pH greater than 8, but 5.8 in places
WW8A 2.1	0-5	Sulfidic organic	Brownish litter, peat; highly decomposed organic matter; part fibric; pH 5.3-5.5
WW8A 2.2	5-15	Sulfidic organic	As above but more sapric; shiny crystals (gypsum?); pH 4.7
WW8A 2.3	15-30	Sulfidic organic	Light brown sapric peat; some decomposed plant remains; pH 4.4 - 4.7
WW20A 1.1	0-5	Organic	Peat; pH 5.5
WW20A 1.2	5-18	Sulfidic organic	Peat; pH 5.0
WW20C 1.1	30-40	Sulfidic clayey organic-rich	Black peat; sulfidic
WWBH20 11.1	0-5	Clayey	Brown clayey silty fine to medium sand; some roots and organic matter.
WWBH20 11.2	5-15	Sulfidic clayey	As above.

[a] Sulfidic = sulfidic material; sulfuric = sulfuric material; MBO = mono sulfidic black ooze material (Appendix A); clayey = clayey material (>35% clay; light, medium and heavy clay texture); Sandy = Sandy materials (sand, loamy, sand, clayey sand texture groups); organic = organic material (>10 % organic carbon; Isbell, 1998); organic-rich (5 – 9% organic carbon).

Table 5. Acid sulfate soil and associated materials collected from Lake Albert (see Appendix A for coordinates)

Site Code	Depth, cm	Material[a]	Description
AT 1.1	0-5	Sandy	Yellowish grey medium sand
AT 1.3	15-30	Sandy	Grey medium sand
AT 2.1	0-3	Sandy	Grey to brownish grey medium sand
AT 2.2	3-5	Sandy carbonate-rich	Yellowish grey medium sand; carbonate fragments or small shell to 2 mm
AT 2.3	5-20	Sulfidic organic	Rubbery, compressed organic remains; layered with blocky fracture; material known as ‘Coorongite’
AT 2.6	30-35	Sulfidic sandy	Brownish grey sand to clayey sand; residual concentrations of organic matter
AT 4.1	0-5	Sandy	Yellowish grey medium sand
AT 6.1	0-2	Sandy	Reddish brown to orange medium sand
AT 7.1	0-5	Sandy	Yellowish grey medium sand
AT 7.2	5-20	Sulfuric clayey organic-rich	Grey heavy clay; common decomposing roots
AT 7.3	20-40	Sulfidic clayey	Grey heavy clay; decomposing reeds

Table 5 (continued). Acid sulfate soil and associated materials collected from Lake Albert

Site Code	Depth, cm	Material[a]	Description
AT 9.1	0-5	Sulfuric clayey organic-rich	Dense root mat with brownish grey clay
AT 9.2	5-20	Sulfuric clayey organic-rich	Grey heavy clay; common fine roots
AT 10.1	0-5	Sulfidic clayey	Grey heavy clay
AT 10.2	5-15	Sulfidic clayey	Grey heavy clay; few fine roots
AT 11.1	0-5	Sandy	Yellowish grey medium sand (loose)
AT 11.2	5-50	Sulfidic sandy	Brownish grey medium sand with patches of grey silt or clay
AT 12.1	0-5	Sulfidic sandy	Yellowish grey medium sand (loose); pH 4 - 4.5.
AT 12.2	5-25	Sulfuric sandy	Pale grey medium sand; pH 4 - 3.9
AT 12.3	25-40	Sulfuric sandy	Grey medium sand to loamy sand; sulfidic.
AT 14.1	0-3	Sandy	Yellow oxidised sand, even under shallow water.
AT 14.2	3-15	Sandy	Greyish-brown sulfidic-like sand.
AT 14.3	5-25	Sulfidic clayey	Very dark greyish-black sticky clay. Black sulfidic mottles. Medium clay. N > 2.
AT 14.4	25-30	Sulfidic clayey	Greyish-olive clay (sticky) with many small shells. Medium-heavy clay. N > 2.
AT 14.5	30-60	Sulfidic clayey	Black sulfidic with patches of OM. n-value > 3.
AT 16.1	0-5	Sandy	Yellowish-grey oxidised sand.
AT 16.2	5-20	Sulfidic sandy	Light greyish-white sand
AT 16.3	20-45	Sulfidic sandy	Blackish-grey sand.
AT 16.4	45-75	Sulfidic sandy	Black sulfidic sandy clay with abundant very fine shells. Could be neutralising, but do not believe so.
AT 17.1	0-1	Sandy	Yellowish grey medium sand, loose
AT 17.2	1-10	Sandy	Brownish grey medium sand
AT 17.3	10-20	Sulfidic sandy	Dark grey sandy clay
AT 17.4	20-30	Sulfidic clayey	Bluish grey heavy clay (soft)
AT 18.1	0-8	Sandy	Greenish-yellow sand, pH 5.5.
AT 18.2	18-28	Sulfidic sandy	Dark greenish sand with black mottles in layers 2 cm think.
AT 18.3	28-40	Sandy	Dark greyish sand with thick 2 - 3 cm of sandy clay sulfidic-like material. Few shells.
AT 19.1	0-8	Sandy	Sand, greenish-yellow. pH 4.7
AT 19.2	8-18	Sulfuric clayey organic-rich	Sand (30%) in organic clay matrix. Jarosite in bright yellow mottles/streaks. Sulfuric pH 2.5.
AT 19.3	18-28	Sulfuric clayey	Sandy clay with many fossil roots and yellow mottles, especially along root pores (large) and orange mottles. Sulfuric, pH 3.3.
AT 20.1	0-2	Sulfidic clayey	Light grey hard flakes, cemented; hard with orange Fe-oxide; heavy clay.
AT 20.2	2-10	Sulfuric clayey	Very hard, massive clay; dark grey; white salt efflorescence on edges of cracks. Cracks 3 cm wide.
AT 20.3	10-20	Sulfidic clayey	Black heavy clay. Abrupt but wavy transition.
AT 21.1	0-1	Sulfidic clayey	Black flakes; heavy clay.
AT 21.2	1-10	Sulfidic clayey	Black heavy hard clay. Moist and friable and 20 cm.

[a] Sulfidic = sulfidic material; sulfuric = sulfuric material; MBO = mono sulfidic black ooze material (Appendix A); clayey = clayey material (>35% clay; light, medium and heavy clay texture); Sandy = Sandy materials (sand, loamy, sand, clayey sand texture groups); organic = organic material (>10 % organic carbon; Isbell, 1998); organic-rich (5 – 9% organic carbon).

Table 6. Acid sulfate soil and associated materials collected from Lake Alexandrina (see Appendix A for coordinates)

Site Code	Depth, cm	Material[a]	Description
AA 3 (AT3)	5-5.5	Sandy	Sandy with shells and sulfidic-like
AA 8.1	0-5	Sandy	Yellowish orange sand, small pale grey mottles areas.
AA 8.2	5-20	Sulfidic sandy	Grey fine sand; silty fine sand from 15 cm with black mottles; shiny mica flakes (about 1mm); few small shells
AA 9.1	0-5	Sulfidic sandy	Yellowish orange medium sand; sharp, irregular boundary
AA 10.1	0-10	Sulfidic sandy	Yellowish orange to grey fine sand becoming black with depth; few shells (3-5 mm)
AA10.2	10-30	Clayey	Grey silty fine sand with black and greenish mottles
AA 11.1	0-3	Sandy	Yellowish grey medium sand; mica flakes throughout
AA 11.2	3-10	Sulfidic sandy	Dark grey medium sand; sulfidic; black mottles
AA 12.1	0-5	Sandy	Yellowish grey medium to coarse sand; contains angular quartz to 2.5 cm
AA 12.2	5-20	Sandy	Dark grey medium sand; smelly (sulfidic-like); sharp wavy boundary.
AA 13.2	3-15	Sulfidic sandy	Grey sandy clay, black mottles
AA 14.2	2-7	Sulfidic sandy	Pale grey medium sand; sharp wavy boundary
AA 15.1	0-5	Sandy	Yellowish medium sand; abrupt boundary
AA 18.2	2-12	Sandy	Very dark grey sand with black mottles
AA 19.1	0-5	Sandy	Grey sand with pelican excreta; some shell; smelly (not sulfidic)
AA 20.1	0-5	Sandy	Yellowish grey sand; small pieces of calcrete
AA 20.2	5-20	Sulfidic sandy	Grey sand and clayey sand; abundant decomposing roots (~30%); strong sulfidic and other odours
AA 22.1	0-5	Clayey	Dark brownish grey heavy clay much organic matter and roots; moist; earth worms present
AA 29.5	0-3	Sulfuric sandy	Pale yellowish grey fine sand; slightly moist
AA 29.6	3-10	Sulfuric sandy	Pale yellowish brown to white medium to fine sand; few root remnants
AA 30.1	0-0.05	Sandy	Yellowish grey medium to fine sand
AA 30.2	0.05-20	Sandy	As above; saturated, black and sulfidic-like.
AA 31.2	0-10	Sulfidic sandy	Black sand with clay; old reed bed; sharp wavy boundary
AA 31.3	10-18	Sulfidic clayey	Olive grey and yellowish grey heavy clay; block to columnar structure; common remnant roots
AA 33.1	0-1	Sulfidic sandy	Black mono sulfidic black ooze, drying with a pale grey surface crust
AA 33.2	0-10	Sulfuric organic	Peaty with some grey clay; Phragmites root mat (pH 2.2)
AA 33.3	10-25	Sulfuric clayey organic-rich	Peaty with grey clay (pH 2.5)
AA 33.4	25-40	Sulfuric clayey	Yellowish grey sand; saturated; strong sulfidic smell; fresh reed roots.
AA 33.5	40-60	Sandy	Dark grey sand.
AA 34	0 -10	MBO	Mono sulfidic black ooze.

[a] Sulfidic = sulfidic material; sulfuric = sulfuric material; MBO = mono sulfidic black ooze material (Appendix A); clayey = clayey material (>35% clay; light, medium and heavy clay texture); Sandy = Sandy materials (sand, loamy, sand, clayey sand texture groups); organic = organic material (>10 % organic carbon; Isbell, 1998); organic-rich (5 – 9% organic carbon).

Table 7. Acid sulfate soil and associated materials collected from the River Murray off-river wetlands Jury Swamp, Murrundi, Paiwalla, Swanport, Ukee and Riverglades (see Appendix A for coordinates)

Site Code	Depth, cm	Material[a]	Description
UKE 1.1	0-10	Sulfidic clayey	Light grey clay (heavy clay), sticky, sulfidic with 20% Phragmites roots (fossil); few sandy lenses.
UKE 1.2	10-30	Sulfidic clayey	Dark grey clay (heavy) with n > 2. Sulfidic with 20% of relict Phragmites.
UKE 2.1	0-5	Sulfidic clayey	Organic-rich, with live roots plus 30% sapric (brown-olive colour). Rest is dark brown. Matrix mostly sandy.
UKE 2.2	5-20	Sulfidic clayey	Very dark grey heavy clay with few black sulfidic mottles. N > 2. 10 - 15% relict Phragmites roots. Sticky.
UKE 3.1	0-0.5	Sulfuric clayey	Salt efflorescence. pH 3.2. Bright yellow salts on upper edge of ped face. Bright yellow salts in middle of upper pad face. White salts at base of cracks between peds.
UKE 3.2	0.5-1	Sulfuric clayey	Black moist plus hard areas; heavy clay. Massive. Very few orange mottles.
UKE 3.3	1-8	Sulfuric clayey	Light grey; very hard and dry, heavy clay; massive, very few orange mottles.
UKE 3.4	8-12	Sulfuric clayey	Light grey heavy clay (cracked to 1 - 2 cm), with many mottles of orange colour in crack and root pores.
UKE 3.5	12-20	Sulfuric clayey	Sand. Abrupt transition. Moist.
UKE 5.1	0-0.5	Sulfuric clayey	Whitish - bright yellow salt efflorescent flakes and salts. Jarosite pH 3.9 - 4.2.
UKE 5.2	0.5-10	Sulfuric clayey	Organic-rich. Light grey peaty/clay with abundant root/plant material (fossil and remnant), much fibric material.
UKE 5.3	10-30	Sulfidic clayey	Black heavy clay. Abrupt transition. At interface abundant orange mottling in pores and fractures (Schwertmannite mottles) especially in pores at depth to 50 cm.
JUR 2.3	0-2	Sulfuric clayey organic-rich	Very hard with yellowish salt efflorescence.
JUR 2.4&5	2-10	Sulfuric clayey organic	As above but no salt efflorescence and more OM.
JUR 2.6&7	10-40	Sulfuric clayey	Brownish-black heavy clay; reddish to orange mottles on surface coatings. Dry to moist. Hard.
JUR 6.5	40-60	Sulfidic organic	Black, peaty / organic with clay. N-value above 2.
MUR 1.2	30-40	Sulfuric clayey organic	Very dark brown heavy clay strongly intermixed with 50% organic matter; common fine roots.
MUR 1.3	40-70	Sulfidic clayey organic-rich	Black to very dark brown heavy clay with few slickensides; thin coatings of reddish-brown iron oxide coatings on fractures and organic matter.
MUR 2.2	5-10	Sulfidic clayey	Black heavy clay; damp; very hard, with sand.
MUR 2.3	10-45	Sulfidic clayey	Black heavy clay, very hard; moist, n value > 0.8.
MUR 2.4	45-70	Sulfidic organic	Very dark brown to black with 30% sapric organic material; sulfidic with Typha and Phragmites roots.
MUR 3.1	0-15	Sulfidic clayey	Black heavy clay; subaqueous (Murray River); 10% plant remains, buried reed bed; n value >2
MUR 3.2	15-30	Sulfidic clayey	Dark olive grey clay; very organic, plant remains (30%)

[a] Sulfidic = sulfidic material; sulfuric = sulfuric material; MBO = mono sulfidic black ooze material (Appendix A); clayey = clayey material (>35% clay; light, medium and heavy clay texture); Sandy = Sandy materials (sand, loamy, sand, clayey sand texture groups); organic = organic material (>10 % organic carbon; Isbell, 1998); organic-rich (5 – 9% organic carbon).

Table 7 (continued). Acid sulfate soil and associated materials collected from the River Murray off-river wetlands Jury Swamp, Murrundi, Paiwalla, Swanport, Ukee and Riverglades

Site Code	Depth, cm	Material[a]	Description
PA 4.1	0-1	Organic	Black dry crust of old algal matting. Almost "coal-like" with shiny morphology.
PA 4.2	1-3	Clayey	Greyish-white silty clay, very hard. White shiny surfaces.
PA 4.3	3-8	Sulfidic clayey	Dark grey clay. Very hard.
PA 4.4	8-15	Sulfidic clayey	Dark greyish brown heavy clay with 20% yellowish orange mottles associated with roots; polyhedral (2-5mm) structure; very hard dry.
PA 4.5	15-50	Sulfidic clayey	Dark greyish brown heavy clay, similar to PA4.4 but with 10% orange mottle.
RIV 3.2	0-1	Sulfidic clayey	Hard greyish-white heavy clay with micro cracks.
RIV 3.4	1-10	Sulfidic clayey	To depth of cracking; very hard very heavy clay. Dark greyish with faint orange mottles.
RIV 3.5	10-20	Clayey	Very dark brown heavy clay. Moist, pliable, sticky.
RIV 4.2	0.02-2	Clayey	Blackish-brown, very fluffy flocculated MBO type material. Light clay with few reddish-brown mottle.
RIV 4.3	2-10	Sulfidic clayey	Medium to heavy clay. Brownish-black.
RIV 4.4	10-30	Clayey	Greenish-blue heavy clay with deep crotovina filled with brownish clayey sulfidic material. Few slickensides. Old remnant flattened Phragmites roots. Water sampled for buffering capacity.
SPM 1.1	0-0.5	Sulfuric clayey organic-rich	Yellow-white salt efflorescence. Very thin crust, which flakes. Mostly in centre of pad.
SPM1.3	5-10	Sulfuric clayey organic-rich	Sandy/silty loam. Hard to friable brownish with grey mottles and reddish-brown streaks. Massive. Very porous when dry. Many fine roots and decomposed organic matter.

[a] Sulfidic = sulfidic material; sulfuric = sulfuric material; MBO = mono sulfidic black ooze material (Appendix A); clayey = clayey material (>35% clay; light, medium and heavy clay texture); Sandy = Sandy materials (sand, loamy, sand, clayey sand texture groups); organic = organic material (>10 % organic carbon; Isbell, 1998); organic-rich (5 – 9% organic carbon).

2.3 Analytical Methods

For the majority of the chemical analyses (Table 8), NATA-accredited laboratories were used, including ALS Environmental (Brisbane) for water alkalinity and anions (including N and P nutrients), the Environmental Analysis Laboratory of Southern Cross University for selected ASS solid phase analyses, CSIRO Land and Water in Adelaide for pH in water and after peroxide treatment, and CSIRO Centre for Environmental Contaminants Research in Sydney for dissolved metals analyses in water and soils and also for the acid, metal and nutrient mobilisation tests. The majority of the methods used for soil analyses are described in detail in the "Acid Sulfate Soils Laboratory Methods Guidelines" (Ahern et al., 2004) (Table 9).

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

The QA/QC reports for all analyses are provided in Appendix B. The accuracy and precision of analytical data was checked using a number of standard laboratory and field QA procedures:

Blanks were collected for laboratory or field prepared samples to monitor the possible introduction of contaminants that were not present in the sample before collection. Reagent blanks and 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 used matrix-matched standards that comprised, as closely as possible, the same matrix as the test samples. These were analysed along with a concentration series (gradient) of the tested analytes. These are used to confirm linearity of the method and adequate functioning of instruments.

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

Replicate samples from the same field site or test taken to separate containers 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 were prepared by adding a known amount of test analyte and analysing along with the original sample. The percent recovery of each spiked analyte was calculated and reported.

In general, the frequency of QC samples processed was: 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 (one analysed within each process lot of 20 samples); and 5% matrix spikes (MS) (one analysed within each process lot of 20 samples).

Table 8. Methods used for analyses of water

Analyte	**Method**
Dissolved metals by ICP-AES	Dissolved metals were measured by ICP-AES (CIROS, SPECTRO). The Inductively Coupled Plasma (ICP-AES) consists of an argon gas ionised by an applied radio frequency. This field is inductively coupled to the ionised gas by a coil surrounding an axial aligned quartz torch that supports and confines the plasma. The sample is converted to an aerosol and transported into the plasma. Atoms and ions of the plasma are excited and emit light at characteristic wavelengths. The light emitted by the sample passes through the entrance slit of the spectrometer. The different wavelengths are measured and converted to a signal and quantified by comparison with standards.
Dissolved metals by ICP-MS	Dissolved metals were measured by ICP-MS (Agilent 7500 CE). The Inductively Coupled Plasma (ICP-MS) consists of an argon gas ionised by an applied radio frequency. This field is inductively coupled to the ionised gas by a water-cooled coil surrounding a Fassel torch shielded from the induction coil by a grounded metal plate. Analyte species originating in a liquid are nebulised by a Micromist nebuliser and a cooled double-pass spray chamber. The ions are extracted from a water cooled interface utilising sampler and skimmer cones and deflected from the sampler-skimmer axis by an ion lens stack into an off-axis reaction cell chamber (ORS cell) which contains an octopole ion guide. Ions exiting the reaction cell are introduced into the quadrupole via an ion lens arrangement. The ions are detected by an electron multiplier. The ions are quantified by comparison with prepared standards.
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. 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.
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 The ICP AES technique ionises filtered sample atoms emitting a characteristic spectrum. This spectrum is then compared against matrix matched standards for quantification.
Nitrite as N	APHA 21st ed., 4500 NO3- I. Nitrite is determined by direct colourimetry by FIA.
Nitrate as N	APHA 21st ed., 4500 NO3--I Nitrate is reduced to nitrite by way of a cadmium reduction column followed by quantification by FIA. Nitrite is determined separately 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 (NO2+NO3) is determined by Cadmium Reduction and direct colourimetry by FIA.
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.
Total organic carbon (TOC)	APHA 21st ed., 5310 B, The automated TOC analyzer determines Total and Inorganic Carbon by IR cell. TOC is calculated as the difference.
Total inorganic carbon (TOC) and dissolved inorganic carbon (TIC)	APHA 21st ed., 5310 B The automated carbon analyzer removes Inorganic carbon as CO_2, which is swept into an IR detector.

Table 9. Methods used for analyses of soils

Analyte	Method
Moisture content	A gravimetric procedure based on weight loss over a 12-24 h drying period at 110±5ºC.
Paste pH, conductivity	Paste pH (USEPA 600/2-78-054): pH determined on a saturated paste by ISE. Electrical Conductivity of Saturated Paste (USEPA 600/2-78-054) - conductivity determined on a saturated paste by ISE.
Potential Acidity	The latent acidity in ASS that will be released if the sulfide minerals they contain (e.g. pyrite) are fully oxidised. Total Potential Acidity in 1 M KCl peroxide digest titrated to pH 5.5 (Ahern et al., 2004).
Total actual acidity (TAA)	Actual acidity is a measure of the existing acidity in acid sulfate soil materials that have already oxidised. The method measures acidity stored in a number of forms in the soil such as iron and aluminium oxyhydroxides and oxyhydroxysulfate precipitates (e.g. jarosite, schwertmannite and alunite), which dissolve to produce acidity. However, it can be applied to the acid–base budget, which uses the total of actual and potential acidity to assess the acid generation potential of a soil. The TAA and oxidised sulfur methods are given by Ahern et al. (2004). Method Codes 23F and 23C respectively.
Acid neutralising capacity (ANC)	Soils with pH values > 6.5 may potentially have ANC in the form of (usually) carbonate minerals, principally of calcium, magnesium and sodium. The carbonate minerals present are estimated by titration (with 0.1 M acid). and alkalinity present expressed in $CaCO_3$ equivalents. By definition any soil with a pH < 6.5 has a zero ANC. Fine grinding of soil materials may lead to an over-estimate of ANC when carbonates are present in the form of hard nodules or shells. In the soil environment they may provide little effective ANC when exposure to acid may result in the formation of surface crusts (iron oxides or gypsum), preventing or slowing further neutralisation reactions. ANC (Ahern et al., 2004).
Particulate metals	Digestion of dried and ground sample in hot (microwave digestion) concentrated 2:1 $HCl:HNO_3$ ('aqua regia'), followed by dilution and filtration (<0.45 µm). Acids were high purity (Merck Suprapur). QA/QC included sample blanks and duplicates and a certified reference sediment (PACS-2, National Research Council, Canada). The concentrations of dissolved metals in extracted were determined by ICP-MS and ICP-AES (Spectroflame EOP, SPECTRO Analytical Instruments, Kleve, Germany).
Total S and C	Dried and pulverised sample is combusted in a LECO furnace at 1350ºC in the presence of strong oxidants / catalysts. The evolved S (as SO_2) and C (CO_2) is measured by infra-red detector (non-dispersive infrared (ndir) absorbtiometry).
Chromium-reducible sulfur (Scr)	A measure of reduced inorganic sulfur content using iodometric titration after an acidic chromium(II) chloride reduction (Ahern et al., 2004). (S_{Cr} or CRS: Method Code 22B).
pH in water and after hydrogen peroxide treatment	These methods (see Ahern et al., 2004) used field-sampled soil, measuring pH in an approximate 2:1 slurry of water to field moist soil and also after treatment with about 10 mL 30% w/v H_2O_2 (pH adjusted to between 5.0 and 5.2 using NaOH).
X-ray fluorescence spectrometry (XRF)	For trace elements. approximately 4 g of each oven dried sample (105℃) is accurately weighed with 1 g of Licowax binder and mixed using a test tube shaker. The mixtures are pressed in a 32 mm die at 12 tons pressure and the resulting pellets are analysed on a PANalytical Axios Advanced, wavelength dispersive XRF system using the in-house ProTrace calibration.

2.3.2 Soil drying

Soils, whether they were dry, moist or saturated when collected, were dried before use in the rapid (acid, metal and nutrient) mobilisation tests. Slow drying of soils in slightly humid conditions best resembles what may occur naturally in the field, however, due to the relatively short timeframe of the project, standard methods (e.g. Acid Sulfate Soils Laboratory Methods Guidelines) for soil drying and oxidation (e.g. 3 months) could not be used. Instead, the soils were air-dried in a temperature-controlled cabinet at 40ºC (not fan-forced) for five days.

2.3.3 Mobilisation experiments

The re-wetting of the soils by either River Murray water (re-flooding) or rainwater is expected to occur at different rates at each site and may involve slow or rapid wetting with large or small volumes of water. The fate of the water following re-wetting is unknown and is expected to be different at each site and be greatly affected by the soil properties, including the degree of surface cracking and sub-surface fissures, and land topography. Consequently, a large number of different mechanisms can be envisaged for substance (acid, metals, nutrients) substance mobilisation and transport from the soils. The substances considered in the current study were acid (pH, alkalinity and acidity changes), anions (chloride and sulfate), nutrients (N and P compounds), carbon, major cations and trace metals. In the different soil types, these substances will be present in different forms and will have differing mobility.

For the purpose of this study, the mobilisation of substances from soils through re-wetting was investigated using a test designed to represent a worst-case scenario for substance mobilisation from soils. Because of the large variety of possible re-wetting scenarios and the variety of soils being considered (surface versus sub-surface soils, desiccated/cracked versus uncracked), some real scenarios may, however, exist where great substance mobilisation occurs in certain areas.

The acidity, metal and nutrient metal mobilisation experiments were undertaken by shaking the dried soils in oxygenated River Murray water or synthetic rainwater to simulate the possible re-wetting of the soils.

The conceptual model for the mobilisation processes assumed:

(i) Soils in the field will be re-wetted by water resulting in release of substances from soil to the associated waters;

(ii) Substance release from soils resuspended in water will be greater than from soils in contact with near-stationary water (as occurs for saturated sub-surface soils);

(iii) A 24-h mixing period of soils in oxygenated water should provide sufficient time for the dissolution of the majority (e.g. >80%) of substances from most soils; and

(iv) Above a total suspended solids (TSS) concentration of 100 g/L, the substance release should become relatively independent of TSS concentration.

The tests were designed to provide a worst-case scenario for substance release. A TSS concentration of 100 g/L and mixing period of 24 h were used. The soils were resuspended (generally 24 g dry weight and 240 mL water in 250 mL Nalgene bottles) by rolling the bottles containing soils and water at ~60 rpm on a purpose-built bottle roller. The release of substances during shaking in water is expected to be partly dependent on the TSS concentration, with substance release generally increasing as TSS increases. However, the increase in substance release with increasing TSS is usually non-linear, and at TSS concentrations greater than 10-50 g/L the amount of substance release generally plateau's to become relatively independent of further increases in the TSS concentration. This generally occurs because there is a sufficiently large excess of solid material that can release substances to the dissolved phase that any additional solids do not significantly influence the release processes. For substances that are present as salts (e.g. $MgSO_4$) precipitate, concentrations of these substances will continue to increase with increasing TSS concentration, until saturation is reached. For most of the substances associated with the soils, however, the release is expected to become independent of TSS concentration at high TSS. For substances that are released through oxidation reactions (e.g. from sulfide phases), the kinetics of release may be important.

The 24-h time period was chosen based on the results from preliminary kinetics tests and past experience. In these tests, the kinetics of metal mobilisation was investigated for six soils with time-frames of 0.16, 1, 3, 6, and 24 h. These tests (Section 3.3.5) indicated that metal release was initially very rapid, with >50% of the metal released after 24 h generally occurring in the first 6 h and a plateau forming by 24 h. There may be some ongoing release of metals from some soil components, and oxidative release from sulfides, but this will occur much more slowly and was expected to comprise a less significant portion (e.g. <20%) of the total metal release. For some materials with high biological oxygen demand, at higher TSS concentrations, oxygen consumption by the solids may begin to limit oxidation reactions that release some substances, however, such materials are expected to comprise only a small percentage of the soil types investigated in this study (as indicated by measured dissolved oxygen concentrations reported in Section 3.3.1).

Acid-washed bottles were used for all tests. The water quality parameters, pH, redox potential (Eh), specific electrical conductivity (EC) and dissolved oxygen were measured at the start and finish of all tests and after 6 h for selected tests. After 24 h, the bottles were allowed to stand for 10 min to allow particle settling. The contents were then decanted into 250 mL Nalgene bottles and centrifuged at 8000 rpm for 5 min before sample collection. Alkalinity, nutrient (N and P), chloride and sulfate analyses were performed on unfiltered samples (centrifuged and no visible suspended solids present) and dissolved metals analyses (including major cations) were made on filtered samples so they could be appropriately compared to the water quality guidelines.

Synthetic rainwater used for some remobilisation tests had the formulation: 80 µM NaCl, 20 µM KCl, 50 µM $CaNO_3$, and 30 µM $MgSO_4$ dissolved in deionised water with µM H_2SO_4 additions to give pH 7.

2.3.4 Buffering and re-adsorption experiments

The ability of River Murray water to buffer the inputs of acidic water containing metals and nutrients was investigated by spiking known amounts of these substances into water, mixing for 3 h, then analysing the changes in acidity, nutrient and metal concentrations.

The conceptual model for the buffering and re-adsorption processes assumes:

(i) The River Murray water, depending on the location, will have varying alkalinity and concentrations and types of suspended solids (TSS);

(ii) The mixing of acidic, metal- and/or nutrient rich waters with River Murray water will occur at varying rates, depending on the input source and local flow conditions;

(iii) A 3-h mixing period of input water with River Murray water provides sufficient time for the neutralisation, precipitation and adsorption reactions of added substances to proceed; and

(iv) The buffering of pH and removal of substances would be greater for sub-surface transport than for surface water mixing.

The experiments were undertaken using unfiltered River Murray water containing no visible TSS and River Murray water containing eight different soils (as TSS). The variation in soils was expected to result in significant variation in water alkalinity. The ability of the River Murray water (and TSS) to buffer the inputs of acid, metals and nutrients was investigated by 100-fold dilution of a River Murray water sample acidified to pH 2.5, that had been spiked with 200 µg/L trace metals (2000 µg/L for Al, Fe and Mn) and 5 mg/L NO_3^- and 10 mg/L PO_4^{3-} nutrients. These tests were undertaken with added soil TSS concentrations of 10 and 100 g/L and for eight different non-acidic soils.

Additional tests were undertaken to investigate how acidity/metal load (added) influences the buffering capacity of suspended solids in River Murray water. These tests were undertaken by mixing of the acid and metal containing water (above) at dilutions of 1/100, 1/25 and 1/10 with River Murray water containing 10 g/L TSS (three soils types tested). Only pH and dissolved metals were analysed.

Acid-washed bottles were used for all tests. The water quality parameters, pH, redox potential (Eh), conductivity (EC) and dissolved oxygen were measured at the start and finish of all tests. After 3 h, filtered water samples were taken for dissolved metals analysis. Alkalinity and nutrients were measured for the first buffering/re-adsorption test only.

2.3.5 Potential for a soil to acidify on oxidation

The potential for a wetland or subaqueous soil to form acidity (as sulfuric acid) on moist oxidation can be estimated using two approaches:

i) measurement of net acid generation potential (NAGP, usually the difference between acid neutralising capacity (ANC, adjusted for a fineness factor for expected non-reactivity) and potential acid generation from chromium-reducible sulfur (Scr) + total actual acidity (TAA). NAGP can be expressed as mol H^+ per tonne dry weight of soil or converted to a $CaCO_3$ equivalent by dividing by 20.

ii) measurement of pH in water and after hydrogen peroxide treatment (Table 9). This method is useful as it is both quick and cheap.

These measures are important indicators of whether the soil is likely to acidify. A positive value for NAGP indicates likely acidification on drying and the peroxide pH gives an approximate indication of the final soil pH. Although peroxide pH values may be as low as 1, field observation indicates that the acidification attained on oxidation of drying soils usually goes no lower than about 2.0 to 2.5 pH units due to slow buffering reactions that are not simulated by this rapid laboratory method.

Both these measures are useful indicators of risk of soil acidification when wetland and subaqueous soils dry (e.g. Dear et al., 2002).

3. RESULTS

3.1 Waters

The bulk water sample collected from the River Murray had (mean ± standard deviation, n=5) pH 7.4 ± 0.05, conductivity 447 ± 7 µS/cm, redox potential (Eh) = 326 ± 14 mV, and dissolved oxygen concentration of 7.7 ± 0.2 mg/L. The water quality parameters for the additional seven locations, including wetlands, along the River Murray are provided in Table 10.

Table 10. Locations of water samples collected from the River Murray and its associated wetlands[a]

Site	Site Code	pH	Dissolved oxygen, mg/L	Conductivity, µS/cm
River Murray (at Morgan's Lagoon)	RM	7.4	7.70	450
Swan Reach	SWR	7.0	7.96	550
Mannum	MNM	7.6	7.55	920
Paiwalla Wetland	PWW	7.7	7.65	1000
Riverglades Wetland	RGW	6.5	6.54	5980
Wellington	WEL	7.7	7.68	840
Meningie	MNG	8.7	8.70	5620
Milang	MLG	8.8	8.83	4450

[a] The temperature of the waters ranged from 20 to 23 ºC.

For the River Murray, lake and wetland water samples, the alkalinity and concentrations of inorganic and organic carbon, nitrogen compounds (nitrite, nitrate), phosphate, major anions and cations, and trace metals are shown in Table 11 to Table 13. The water samples were collected primarily for analyses of alkalinity and trace metals, and were collected in acid-washed bottles (standard procedure for trace metals). The samples were filtered using 0.45 µm cellulose nitrate filters and for this reason dissolved nitrate concentrations are not reported..

The bulk River Murray water collected at Morgan's Lagoon had relatively low concentrations of alkalinity, acidity, sulfate, chloride, nitrite, nitrate, phosphate, total organic and inorganic carbon, and major and trace metals consistent with dilution processes.

All the waters were alkaline (40-230 mg/L $CaCO_3$), except the Riverglades wetland (a reflooded ASS wetland) that had a small amount of acidity (<1 mg/L alkalinity, 5 mg/L acidity as $CaCO_3$, Table 11). The Riverglades site also had high sulfate (2000 mg/L) and chloride (1000 mg/L) concentrations. The sulfate and chloride concentrations at the other sites ranged from 26 to 280 mg SO_4^{2-}/L and 117 to 1630 mg Cl^-/L, respectively. Nitrite concentrations were low, except in the total (unfiltered) Paiwalla (0.11 mg/L) and Riverglades (0.16 mg/L) wetland waters. Nitrate concentrations were similarly low, except in the unfiltered Paiwalla (0.07 mg/L) and Riverglades (0.28 mg/L) wetland waters. The highest filterable phosphate concentration was 0.094 mg/L at Paiwalla wetland. The TOC and TIC concentrations ranging from 3 to 60 mg/L and 1-38 mg/L, respectively. The Meningie water had the highest TOC and TIC concentrations.

Table 11. Concentrations of alkalinity, acidity, sulfate, chloride, nitrite, nitrate, phosphate, total organic carbon and inorganic carbon for River Murray water and wetlands[a]

Site	Type [a]	Alkalinity mg/L [b]	Acidity mg/L	Sulfate mg/L	Chloride mg/L	Nitrite-N mg/L	Nitrate-N mg/L	Phosphate mg/L [c]	TOC mg/L	TIC mg/L
River Murray [d]	Filtered	46±2	NA[f]	26±0.5	135±3	0.042±0.004	NA	<0.01	3.3±0.5	8.8±0.5
Swan Reach	Filtered	44	NA	26	117	<0.01	NA	<0.03	4	7
Swan Reach	Total	46	NA	26	140	<0.01	<0.01	<0.02	5	8
Mannum	Filtered	54	NA	46	234	<0.01	NA	<0.01	4	9
Mannum	Total	57	NA	44	225	<0.01	<0.01	<0.01	7	10
Paiwalla	Filtered	61	<1	53	244	<0.01	NA	0.059	5	9
Paiwalla	Total	63	<1	53	264	0.116	0.068	0.094	7	10
Riverglades	Filtered	<1	5	2090	984	0.057	NA	0.017	15	<1
Riverglades	Total	<1	5	2090	1150	0.157	0.28	0.032	18	1
Wellington	Filtered	59	NA	42	194	<0.01	NA	<0.01	4	9
Wellington	Total	62	NA	43	204	<0.01	0.013	0.098	6	9
Meningie	Filtered	213	NA	273	1810	<0.01	NA	<0.01	25	28
Meningie	Total	228	NA	279	1970	<0.01	<0.01	<0.01	59	38
Milang	Filtered	187	NA	197	1340	<0.01	NA	<0.01	11	30
Milang	Total	185	NA	196	1630	<0.01	<0.01	<0.01	23	31
FB (Paiwalla) [e]	Filtered	<1	NA	<1	<1	<0.01	NA	<0.01	<1	<1
FB (Paiwalla)	Total	<1	NA	<1	<1	<0.01	<0.01	<0.01	<1	<1
FB (Milang)	Filtered	<1	NA	<1	<1	<0.01	NA	<0.01	<1	<1
FB (Milang)	Total	<1	NA	<1	<1	<0.01	<0.01	<0.01	<1	<1

[a] Filtered (<0.45 µm). [b] Alkalinity (total) = bicarbonate alkalinity (hydroxide and carbonate alkalinity <1 mg/L). [c] Phosphate = reactive phosphorus. [d] River Murray at Morgan's Lagoon (mean of seven bulk sample). [e] FB = field blank (collection site). [f] NA = not analysed.

The concentrations of major cations (Na, K, Ca, Mg, Al and Fe) in the waters generally varied by a little more than an order of magnitude between the different sites, e.g. 60 to 870 mg Na/L, 13 to 260 mg Mg/L. The slightly acidic Riverglades water had the highest concentrations of Na, K, Ca and Mg. The Meningie site had the highest concentrations of dissolved Al (0.5 mg filterable Al/L) and dissolved Fe (0.6 mg filterable Fe/L) and these elevated dissolved concentrations are most likely to be a result of the high dissolved organic carbon concentration (25 mg/L, Table 11) of this water. There were significant positive relationships between dissolved organic carbon and dissolved Al and Fe (Figure 4).

Table 12. Concentrations of major cations in the River Murray and Wetland waters

Site	Type [a]	Na mg/L	K mg/L	Ca mg/L	Mg mg/L	Al mg/L	Fe mg/L
River Murray [b]	Filtered	71±1	4.5±1.3	13.6±0.5	12.7±0.5	<0.001	<0.001
Swan Reach	Filtered	63	3	13	13	0.012	0.011
Swan Reach	Total	66	3	14	13	0.155	0.34
Mannum	Filtered	122	4	-	-	-	-
Mannum	Total	123	4	20	19	0.33	0.43
Paiwalla	Filtered	136	4	23	20	0.008	0.013
Paiwalla	Total	138	5	22	20	0.13	0.27
Riverglades	Filtered	607	40	430	260	0.055	0.50
Riverglades	Total	602	39	420	260	0.13	2.1
Wellington	Filtered	109	4	21	18	0.05	0.033
Wellington	Total	108	4	22	18	0.230	0.32
Meningie	Filtered	848	40	66	145	0.515	0.635
Meningie	Total	868	42	84	150	2.1	3.5
Milang	Filtered	645	30	62	110	0.07	0.049
Milang	Total	648	30	69	110	0.37	0.55
FB (Paiwalla) [c]	Filtered	<1	<1	<1	<1	<0.001	<0.001
FB (Paiwalla)	Total	<1	<1	<1	<1	<0.001	<0.001
FB (Milang)	Filtered	<1	<1	<1	<1	<0.001	<0.001
FB (Milang)	Total	<1	<1	<1	<1	<0.001	<0.001

[a] Filtered (<0.45 µm). [b] River Murray at Morgan's Lagoon (mean of seven bulk sample).
[c] FB = field blank (collection site).

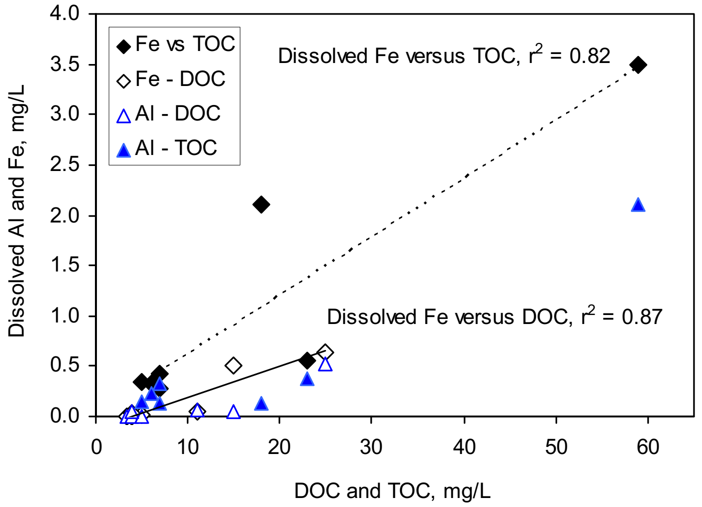


Figure 4. Relationships between dissolved aluminium and iron and dissolved (DOC) and total organic carbon (TOC)

Table 13. Concentrations of trace metals in the River Murray and Wetland waters

Site	Type [a]	Ag µg/L	As µg/L	Cd µg/L	Co µg/L	Cr µg/L	Cu µg/L	Mn µg/L	Ni µg/L	Pb µg/L	Sb µg/L	Se µg/L	V µg/L	Zn µg/L
River Murray [b]	Filtered	0.07	0.6	<0.05	<0.1	<0.1	6.2	2	0.6	<0.1	<0.5	<0.2	0.5	7.5
		±0.03	±0.2	NA	NA	NA	±7	±2	±0.1	NA	NA	NA	±0.1	±0.2
Swan Reach	Filtered	<0.02	0.6	<0.05	<0.1	<0.1	0.6	<1	0.4	<0.1	<0.5	<0.2	0.4	0.3
Swan Reach	Total	<0.02	0.9	<0.05	0.3	0.2	1	45	0.7	0.4	<0.5	<0.2	2.0	0.7
Mannum	Filtered	<0.02	0.7	<0.05	<0.1	<0.1	0.6	<1	0.6	<0.1	<0.5	<0.2	0.9	0.3
Mannum	Total	0.06	1.2	<0.05	0.5	0.3	1.2	75	1.0	0.9	<0.5	<0.2	2.9	1.6
Paiwalla	Filtered	0.14	1.9	<0.05	0.4	1.1	<0.2	<1	<0.1	<0.1	<0.5	<0.2	1.9	58
Paiwalla	Total	0.08	2.1	<0.05	1.8	170	<0.2	1.2	<0.1	0.3	<0.5	<0.2	3.2	63
Riverglades	Filtered	0.07	1.4	0.37	86	0.2	0.8	16300	54	<0.1	<0.5	<0.2	0.4	87
Riverglades	Total	0.05	2.0	0.36	85	0.3	1.2	16100	53	0.4	<0.5	<0.2	2.2	86
Wellington	Filtered	<0.02	0.8	<0.05	<0.1	<0.1	0.8	<1	0.6	<0.1	<0.5	<0.2	1.3	0.6
Wellington	Total	<0.02	1.0	<0.05	0.3	0.2	1.2	34	1.0	0.7	<0.5	<0.2	2.6	1.3
Meningie	Filtered	0.08	3.1	<0.05	0.6	0.8	2.5	38	3.1	1.1	<0.5	<0.2	5.6	2.8
Meningie	Total	0.06	6.3	0.05	3.4	2.8	13	280	7.9	6.4	<0.5	<0.2	28	8.0
Milang	Filtered	0.11	1.9	<0.05	0.1	0.2	0.5	1.7	1.2	<0.1	<0.5	<0.2	2.2	1.9
Milang	Total	0.09	2.6	<0.05	0.5	0.6	1.6	52	2.3	1.1	<0.5	<0.2	6.4	1.5
FB (Paiwalla) [c]	Filtered	<0.02	<0.2	<0.05	<0.1	<0.1	<0.2	<1	<0.1	<0.1	<0.5	<0.2	<0.1	<0.2
FB (Paiwalla)	Total	<0.02	<0.2	<0.05	<0.1	<0.1	<0.2	<1	<0.1	<0.1	<0.5	<0.2	<0.1	<0.2
FB (Milang)	Filtered	<0.02	<0.2	<0.05	<0.1	<0.1	<0.2	<1	<0.1	<0.1	<0.5	<0.2	<0.1	<0.2
FB (Milang)	Total	<0.02	<0.2	<0.05	<0.1	<0.1	<0.2	<1	<0.1	<0.1	<0.5	<0.2	<0.1	<0.2

[a] Filtered (<0.45 µm). [b] River Murray at Morgan's Lagoon (mean of seven bulk sample). [c] FB = field blank (collection site).

The concentrations of most trace metals in the collected waters were low (Table 13). The exceptions were metals in the Meningie, Paiwalla, and Riverglades waters. For example, manganese at the Riverglades site was 16.3 mg /L, vanadium at the Meningie site was 28 µg/L, and zinc at the Paiwalla and Riverglades sites were 60 and 85 µg/L, respectively.

The dissolved metal concentrations are compared to water quality guidelines (WQGs) in

Table 14. There were exceedances of guidelines for Ag, Cr, Zn in Paiwalla water, for Ag, Cd, Co, Mn and Zn in the Riverglades water, and Ag and Cu in the Meningie water.

The dissolved copper concentration also exceeded the WQG in the bulk River Murray water samples, however, this is possibly due in part to sample contamination (trace metal sample collection protocols were not used for the bulk water sample). The dissolved copper and zinc concentrations were variable (e.g. 6±7 µg Cu/L: 0.8, 0.8, 4.8, 4.1, 14, 18, 0.6 µg Cu/L in the seven 10 L containers) in these waters, consistent with this copper being contamination. For the metal remobilisation experiments, water was only sourced from the containers containing <1 µg/L copper.

Table 14. Comparison of metal concentrations to water quality guidelines: River Murray and Wetland waters

Site	Ag µg/L	As µg/L	Cd µg/L	Co µg/L	Cr µg/L	Cu µg/L	Mn µg/L	Ni µg/L	Pb µg/L	Se µg/L	V µg/L	Zn µg/L
River Murray	**0.07**	**0.6**	**<0.05**	**<0.1**	**<0.1**	**0.8**	**2**	**0.6**	**<0.1**	**<0.2**	**0.5**	**4.5**
Swan Reach	<0.02	0.6	<0.05	<0.1	<0.1	0.6	<1	0.4	<0.1	<0.2	0.4	<0.5
Mannum	<0.02	0.7	<0.05	<0.1	<0.1	0.6	<1	0.6	<0.1	<0.2	0.9	<0.5
Paiwalla	**0.14**	1.9	<0.05	0.4	1.1	<0.2	<1	<0.1	<0.1	<0.2	1.9	**58**
Riverglades	**0.07**	1.4	**0.37**	**86**	0.2	0.8	**16300**	54	<0.1	<0.2	0.4	**87**
Wellington	<0.02	0.8	<0.05	<0.1	<0.1	0.8	<1	0.6	<0.1	<0.2	1.3	0.6
Meningie	**0.08**	3.1	<0.05	0.6	0.8	**2.5**	38	3.1	1.1	<0.2	5.6	2.8
Milang	0.11	1.9	<0.05	0.1	0.2	0.5	1.7	1.2	<0.1	<0.2	2.2	1.9
WQG (95% PC) [a]	**0.05**	**13**	**0.2**	**1.4**	**1.0**	**1.4**	**1900**	**11**	**3.4**	**11**	**6.0**	**8.0**

[a] Water quality guideline, 95% level of ecosystem protection (without hardness corrections etc) in ANZECC/ARMCANZ (2000). The WQG for As assumes all is as As(V), which is less toxic than As(III) (WGQ = 24 µg/L). The WQG for Cr assumes all is as Cr(VI). The WQGs for Co and V are low reliability values. Exceedances of guidelines are in **bold**.

3.2 Soil Parameters

3.2.1 Soil properties

The soils had widely varying properties (

Table 15-19). As collected, the paste pH of the soils ranged from pH 2.1 to 9.3. Of the 150 soil samples, 9% were pH<3, 19% were pH<4, 30% were pH<5, 43% were pH<6, 58% were pH<7, and 87% were pH<9. The moisture content (% water) of the soils ranged from 1% (dry) to 86% (water-logged). The ranges for paste pH and moisture content were similar for each of the major sampling areas (Murray River, Wellington Weir, Lakes Albert and Alexandrina and the Wetlands). There was no significant relationship between soil paste pH and moisture content, or between paste pH and the soil depth samples (mid-range of profile sampled) (Figure 5).

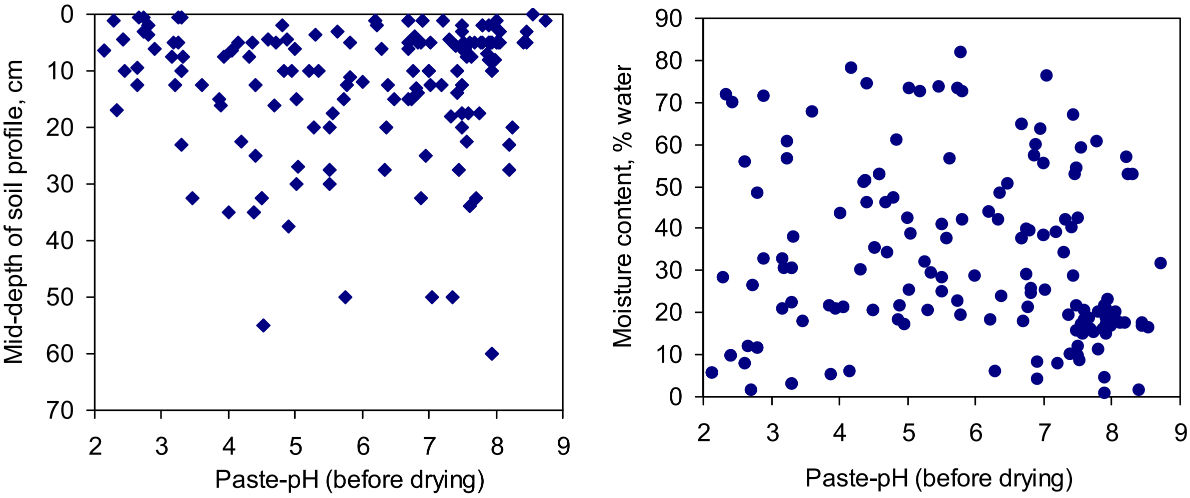


Figure 5. Relationship between paste pH (before drying and (i) soil depth (mid-range of profile sampled) and (ii) moisture content of soil (when collected)

In the natural situation, the slow drying of soils in the field is expect to cause oxidation of sulfide phases to form sulfuric acid, with air penetration supplying the oxygen and water (humidity) required for this reaction. In the present study, time constraints meant that soils could not be dried slowly under conditions similar to those that would occur naturally. Instead, the soils were air-dried at 40 °C for 5 days in an attempt to simulate the (accelerated) natural drying of the soils. There was a strong linear relationship between the paste pH measured before and after drying in the laboratory (Figure 6). This indicated that the laboratory drying procedure did not result in oxidation processes that produced significant amounts of acidity, as may be expected through natural drying. The consequence of this was that the sulfidic samples (as classified in Section 2.2.2), which comprised 53% of the total, remained less acidic after the accelerated drying procedure, but would likely go more acidic if dried in the natural situation.

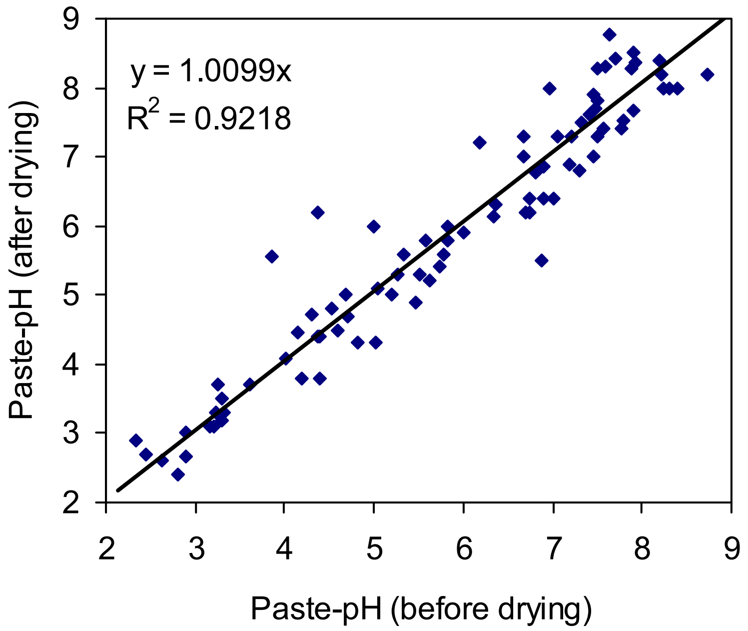


Figure 6. Comparison between paste pH measured before and after drying of the soils

There was a good relationship between the paste pH measured on the soil sub-samples taken by CSIRO Sydney for the mobilisation tests and the pH measurements (pH_W, $pH_{Peroxide}$, TAA) made on the separate soil subsamples taken by CSIRO Adelaide (Figure 7, Appendix C). Some of the samples were collected within weeks of this study, some were collected several months previously and some were from archived sample collections. Whilst the paste pH, measurements were all made at the same time (for the current study), the other measurements were made soon after sample collection. This will have contributed to the digressions from linearity of the paste pH versus pH_W relationship shown in Figure 7.

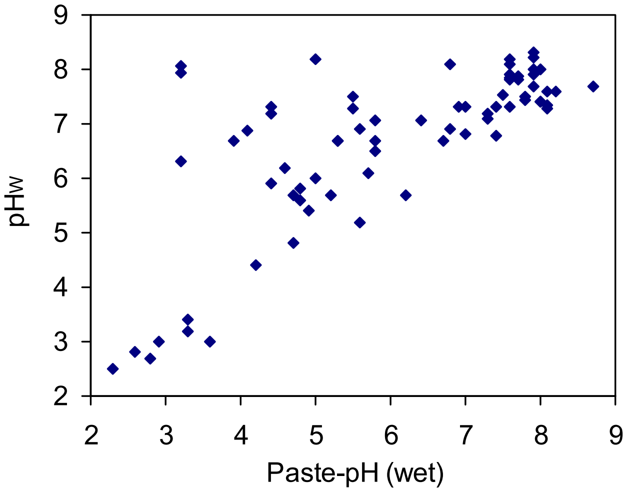


Figure 7. Comparison between paste pH and pH_w measurements on soil sub-samples from the same site.

Table 15. Soil properties of River Murray (main channel) and Wellington Weir samples

	Depth	Moisture	Paste pH [a]		pH_w [b]	pH_{Perox} [c]	TAA [d]	CRS [e]	ANC [f]
Sample	**cm**	**%**	**Wet**	**Dry**			**pH_{KCl}**	**%S**	**$\%CaCO_3$**
River Murray									
WL 2.1	0-5	51	4.4	6.2	7.2	2.1	5.65	0.046	
WL 2.2	5-20	25	7.0		6.8	3.2	6.50	0.043	0.01
WL 2.3	20-40	25	5.5		7.5	6.5	7.41	0.047	0.40
WL 5.3	0-1	28	2.3		2.5	1.0	3.24	0.069	0.00
WL 5.4	1-5	48	2.8	2.4	2.7	1.5	3.24	0.054	0.00
WL 5.5	5-20	56	2.6	2.6	2.8	1.2	3.33	0.180	0.00
WL 6.3	0-1	32	8.7	8.2	7.7	6.6	8.16	0.081	3.46
WL 6.4	1-8	34	7.3	6.8	7.2	4.5	8.10	0.191	1.63
WL 6.5	8-20	40	7.4	7.6	7.3	5.3	7.99	0.280	6.28
WL 7.2	0-3	57	5.6	5.2	6.9	3.0	5.40	0.023	0.00
WL 7.3	3-12	59	7.6	7.4	7.3	6.4	7.81	0.025	3.35
WL 7.4	12-25	42	7.3	7.5	7.1	6.4	7.87	0.059	3.87
WL 8.2	0-1	38	6.7	7.0	6.7	3.1	6.95	0.069	0.37
WL 8.3	1-3	47	4.8	4.3	5.6	2.0	5.55	0.118	0.00
WL 8.4	3-6	53	4.6	4.5	6.2	2.1	5.71	0.170	0.00
WL 8.5	6-25	46	4.7	5.0	5.7	2.4	4.93	0.077	0.00
WL 9.2	0-5	34	4.7	4.7	4.8	2.8	5.30	0.005	0.00
WL 9.3	5-30	37	5.6	5.8	5.2	3.1	5.25	0.008	0.00
WL 11.1	0-5	26	6.8		6.9	3.7	6.07	<0.005	0.00
WL 11.2	5-10				5.7	3.6	4.90	0.012	0.00
WL 11.3	10-20	25	5.0		6.0	3.8	5.17	0.010	0.00
WL 12.2	1-5	21	5.3		6.7	2.2	5.65	0.022	0.00
WL 12.3	5-15	29	5.3	5.6	6.7	1.8	5.80	0.046	0.00
WL 14.2	0-2	18	6.2		5.7	4.4	5.71	<0.005	0.00
WL 14.4	2-7	18	4.9		5.4	3.7	5.50	<0.005	0.00
WL 15.1	0-5	21	3.2		6.3	2.1	6.40	0.237	0.00
WL 15.2	5-10	21	3.9		6.7	1.8	5.78	0.182	0.00
WL 17.1	0-15	23	5.7		6.1	2.4	6.32	0.010	0.00
Mean		**35.3**	**5.4**	**5.7**	**6.1**	**3.3**	**5.9**	**0.1**	**0.7**
Proposed Wellington Weir Site									
WW3A 1.1	0-8	17	8.0		7.4	5.7			
WW3A 1.2	8-20	17	7.9	8.4	7.7	5.3			
WW3A2.1	15-20	15	7.7		7.8	6.6			
WW3A 4.1	0-5	15	7.9		8.3	7.7	9.72	0.003	1.23
WW3A 4.2	15-25	15	7.6		7.9	7.2	9.81	0.008	10.4
WW 3A 4.5	25-50	22	4.9				8.77	0.016	0.13
WW 8A 2.1	0-5	72	5.8	5.8	6.7	3.0	7.14	0.057	1.85
WW 8A 2.2	5-15	73	5.2	5.0	5.7	2.3	6.38	0.049	0.00
WW 8A 2.3	15-30	78	4.2	3.8	4.4	2.2	4.70	0.072	0.00
WW20A 1.1	0-5	57	6.9		7.3	3.5	6.70	0.031	1.49
WW20A 1.2	5-18	42	5.8	6.0	6.5	3.4	6.47	0.013	0.00
WW20C	30-40	51	4.4	4.4	5.9	1.7			
WWBH20B 1.1	0-5	19	8.0		7.6	5.4			
WWBH20B 1.2	5-15	17	5.0		7.1	3.6			
Mean		**36.4**	**6.4**	**5.6**	**6.9**	**4.4**	**7.5**	**0.0**	**1.9**

[a] Wet = as collected, Dry = after drying for 5 days at 40ºC (CSIRO, Sydney). [b] pH of approx. 2:1 water to soil slurry of field moist soil. [c] pH of field soil after peroxide treatment (Ahern et al. 2004) [d] TAA = total actual acidity. [e] CRS = chromium-reducible S, %S). [f] ANC = acid neutralising capacity, as $\%CaCO_3$. The calculated mean values for ANC and CRS assume <0.05 = 0.05.

Table 16. Soil properties of Lake Albert samples

Lake Albert	Depth	Moisture	Paste pH [a]		pH_w	pH_{Perox}	TAA [b]	CRS	ANC
Sample	cm	%	Wet	Dry			pH_{KCl}	%S	$\%CaCO_3$
AT 1.1*	0-5	18	7.6		8.2	7.4			
AT 1.3	15-30	17	7.6		8.1	6.9			
AT 2.1	0-3	20	8.1		7.6	7.3	9.19	0.015	2.09
AT 2.2	3-5	21	6.8		8.1	6.9	9.18	0.055	2.21
AT 2.3	5-20	74	4.4	3.8	7.3	1.9	7.25	0.769	0.95
AT 2.6	30-35	18	3.5				6.46	0.155	0.00
AT 3	5-5.5	9	7.5				6.46	0.155	0.00
AT 4.1 *	0-5	19	7.9		7.9	6.8	9.22	0.009	0.38
AT 6.1	0-2	17	8.0		7.4	7.3	9.21	0.024	0.63
AT 7.1	0-5	18	8.0		8.0	6.7	9.18	0.003	0.20
AT 7.2	5-20	68	3.6	3.7	3.0	1.5	7.23	1.079	1.50
AT 7.3	20-40	73	5.0	4.3	8.2	1.3	6.96	2.367	1.22
AT 9.1 *	0-5	60	3.3	3.7	3.2	1.7			
AT 9.2	5-10	72	2.9	3.0	3.0	1.8	3.12	0.044	0.00
AT 10.1	0-5	55	7.0	6.4	7.3	2.9	6.57	0.135	0.88
AT 10.2 *	5-15	61	4.8		5.8	2.9	7.14	0.140	1.24
AT 11.1	0-5	22	7.9	8.3	7.4	6.6	8.55	0.010	0.33
AT 11.2	5-50	42	6.3	6.2	6.8	2.6	5.49	0.178	<0.05
AT 12.1	0-5	6	4.2	4.5	4.9	3.3	7.98	0.821	2.70
AT 12.2	5-25	22	3.9	5.6	2.9	1.9	6.54	0.006	0.17
AT 12.3	25-40	60	6.9	5.5	4.4	1.9	4.82	0.004	<0.05
AT 14.1	0-3	17	8.5	9.5	7.6	7.2	8.89	0.008	3.65
AT 14.2	3-15	19	7.6	8.8	7.8	7.5	9.15	0.005	2.83
AT 14.3	15-25	54	7.5	7.7	7.8	4.6	7.98	0.289	1.83
AT 14.4	25-30	57	8.2	8.2	7.7	2.6	7.94	1.372	2.82
AT 14.5	30-60	67	7.5	7.0	7.6	1.6	7.52	1.231	1.93
AT 16.1	0-5	2	8.4	8.0	7.9	6.0	8.78	<0.005	0.25
AT 16.2	5-20	10	7.5	8.3	8.1	3.4	8.73	0.007	0.07
AT 16.3	20-45	16	7.7	8.4	7.1	2.2			
AT 16.4	45-70	23	8.0		8.1	4.3	6.24	0.014	<0.05
AT 17.1	0-1	19	8.0		7.7	7.4	9.52	0.006	1.19
AT 17.2	1-10	17	7.6		7.9	7.1	9.34	0.019	0.80
AT 17.3	10-20	65	6.7	7.3	7.2	4.0	8.12	0.141	1.29
AT 17.4	20-30	64	7.0	8.0			8.26	0.971	1.63
AT 18.1	0-8	11	9.1	9.5	8.6	7.0			
AT 18.2	18-28	18	8.2	8.4	8.0	3.4	8.46	0.013	0.00
AT 18.3	28-40	21	7.6	8.3	7.8	5.5	8.71	0.012	0.38
AT 19.1	0-8	1	7.9	8.5	8.0	6.7			
AT 19.2	8-18	39	6.8	6.8	2.5	1.4	7.97	0.370	0.85
AT 19.3	18-28	22	3.3		3.4	1.5	5.70	0.101	<0.05
AT 20.1	0-2	12	7.5	7.8	7.4	4.3	7.26	0.210	1.44
AT 20.2	2-10	6	6.3		6.2	2.5	6.48	0.180	0.61
AT 20.3	10-30	46	8.2	7.9	5.8	3.4	6.01	<0.005	0.56
AT 21.1	0-1	8	6.9	6.9	7.0	3.6	8.96	<0.005	35.2
AT 21.2	1-10	43	7.5	7.3			7.36	0.218	1.09
Mean		**32.3**	**6.8**	**6.9**	**6.7**	**4.3**	**7.7**	**0.3**	**1.9**

[a] Wet = as collected, Dry = after drying for 5 days at 40ºC (CSIRO, Sydney). [b] pH of approx. 2:1 water to soil slurry of field moist soil. [e] pH of field soil after peroxide treatment (Ahern *et al*. 2004) [d] TAA = total actual acidity. [e] CRS = chromium-reducible S (%S). [f] ANC = acid neutralising capacity, as $\%CaCO_3$. The calculated mean values for ANC assume <0.05 = 0.05.

Table 17. Soil properties of Lake Alexandrina samples

Lake Alexandrina	**Depth,**	**Moisture**	**Paste pH** [a]		**pH_w** [b]	**pH_{Perox}** [c]	**TAA** [d]	**CRS** [e]	**ANC** [f]
Sample	**cm**	**%**	**Wet**	**Dry**			**pH_{KCl}**	**%S**	**$\%CaCO_3$**
AA 8.1	0-5	19	7.7		7.9	5.4	5.90	0.010	0.00
AA 8.2	5-20	24	6.4		7.1	2.3	5.98	0.009	0.00
AA 9.1	0-5	18	8.1		7.3	4.3	6.65	<0.005	0.09
AA 10.1	0-10	29	7.4		6.8	4.4	8.36	0.024	0.61
AA10.2	10-30	28	5.5		7.3	5.4	5.66	0.022	0.00
AA 11.1	0-3	22	7.5		7.5	5.7	6.98	<0.005	0.10
AA 11.2	3-10	21	4.1		6.9	3.1	6.54	0.010	0.03
AA 12.1	0-5	21	8.2		7.6	6.7	8.11	<0.005	0.10
AA 12.2	5-20	20	5.8		7.1	4.9	7.03	0.008	0.03
AA 13.2	3-15	33	3.2	3.1	8.0	2.0	6.83	0.521	0.36
AA 14.2	1-4	18	7.6		7.8	3.9	6.76	0.010	0.12
AA 15.1	0-5	18	8.1		7.3	4.9	6.87	0.006	0.12
AA 18.2	2-12	16	7.9		8.2	6.2	9.25	0.016	0.19
AA 19.1	0-5	17	9.3		8.4	6.9	9.38	0.020	0.17
AA 20.1	0-5	20	7.8		7.4	5.8	9.37	0.016	0.69
AA 20.2	5-20	30	3.2	3.1	8.1	1.4	7.00	0.204	0.17
AA 22.1	0-5	60	7.8	7.4	7.5	6.1	8.12	0.047	7.18
AA 29.5	0-3	1	2.7		3.0	2.2	3.11	0.006	0.00
AA 29.6	3-10	6	2.1		2.8	1.5	5.24	<0.005	0.00
AA 30.1	0-0.05	16	8.6		8.8	7.2	9.01	0.020	1.01
AA 30.2	0.05-20	16	7.5		8.2	6.9	8.92	0.014	0.20
AA 31.2	0-10	29	6.8	6.2	7.2	2.9	6.31	0.028	<0.05
AA 31.3	10-18	25	6.8		7.3	3.9	6.60	0.060	<0.05
AA 33.1	0-1	44	6.2	7.2	7.1	3.4			
AA 33.2	0-10	70	2.4	2.7	2.75	1.6	3.19	0.076	<0.05
AA 33.3	10-25	72	2.3	2.9	2.6	1.7	3.15	0.105	<0.05
AA 33.4	25-40	20	4.5		3.7	2.0	6.02	0.065	<0.05
AA 33.5	40-60	19	7.4		7.6	6.6	8.63	0.076	7.19
AA 34 (MBO)	0-10	76	7.1	7.3	7.4	6.6	7.96	0.603	9.88
Mean		**27.2**	**6.3**	**5.0**	**6.8**	**4.3**	**6.9**	**0.1**	**1.0**

[a] Wet = as collected, Dry = after drying for 5 days at 40ºC (CSIRO, Sydney). [b] pH of approx. 2:1 water to soil slurry of field moist soil. [e] pH of field soil after peroxide treatment (Ahern *et al*. 2004) [d] TAA = total actual acidity. [e] CRS = chromium-reducible S (%S). [f] ANC = acid neutralising capacity, as $\%CaCO_3$. The calculated mean values for ANC assume <0.05 = 0.05.

Table 18. Soil properties of wetlands at Ukee, Jury Swamp, Murrundi, Paiwalla, Riverglades and , Swanport.

Wetlands	**Depth**	**Moisture**	**Paste pH [a]**		**pH_w [b]**	**pH_{Perox} [c]**	**TAA [d]**	**CRS [e]**	**ANC [f]**
Sample	**cm**	**%**	**Wet**	**Dry**			**pH_{KCl}**	**%S**	**$\%CaCO_3$**
UKE 1.1	0-10	38	7.0	0.0	6.5	1.6	4.64	0.051	<0.05
UKE 1.2	10-30	48	6.4	6.3	5.4	1.6	5.32	0.073	<0.05
UKE 2.1	0-5	65	6.7	6.2	6.5	2.9	5.60	0.120	<0.05
UKE 2.2	5-20	39	7.2	6.9	6.3	1.7	3.73	0.273	<0.05
UKE 3.1	0-0.5	57	3.2	3.3	3.4	1.6	3.71	0.105	<0.05
UKE 3.2	0.5-1	26	2.7		2.8	1.4	3.11	0.241	<0.05
UKE 3.3	1-8	10	2.4		2.6	1.2	2.76	0.034	<0.05
UKE 3.4	8-12	30	3.3	3.5	3.5	1.8	3.46	0.222	<0.05
UKE 3.5	12-20	5	3.9		4.0	1.3	4.61	0.590	<0.05
UKE 5.1	0-0.5	12	2.7		3.1	1.3	3.33	0.010	<0.05
UKE 5.2	0.5-10	8	2.6		3.0	1.4	3.11	0.045	<0.05
UKE 5.3	10-30	32	5.3	5.3	6.0	3.2	5.56	0.009	<0.05
JUR 2.3	0-2	11	2.8		2.6	1.3	3.00	0.242	<0.05
JUR 2.4&5	2-10	33	2.9	2.7	2.9	1.0			
JUR 2.6&7	10-40	46	4.4	4.4	4.2	2.3			
JUR 6.5	40-60	73	5.7	5.4	6.7	2.5	5.23	0.191	<0.05
MUR 1.2	30-40	44	4.0	4.1	4.0	1.5	4.21	0.067	<0.05
MUR 1.3	40-70	35	4.5	2.4	5.1	2.7	4.77	0.013	<0.05
MUR 2.2	5-10	30	4.3	4.7	5.0	2.5	4.23	0.015	<0.05
MUR 2.3	10-45	39	5.1	5.1	5.5	2.3	5.24	0.041	<0.05
MUR 2.4	45-60	74	5.5	4.9	4.9	1.2	5.07	1.373	<0.05
MUR 3.1	0-15	51	6.5		6.4	2.7	5.58	0.067	<0.05
MUR 3.2	15-30	82	5.8	5.6	5.5	1.3	4.38	1.385	<0.05
PA 4.1	0-1	4	6.9	6.4	7.0	5.5	7.15	0.263	8.94
PA 4.2	1-3	4	7.9	7.7	7.2	6.1	7.72	0.634	11.37
PA 4.3	3-8	10	7.4		6.6	3.5	7.59	0.616	10.45
PA 4.4	8-15	29	6.0	5.9	6.0	3.2	5.76	0.022	<0.05
PA 4.5	15-50	41	5.5	5.3	5.4	2.6	5.49	0.021	<0.05
RIV 3.2	0-1	8	7.2	7.3	6.7	3.2	6.46	0.273	<0.05
RIV 3.4	1-10	18	6.7		5.9	3.0	6.15	0.105	<0.05
RIV 3.5	10-20	53	7.5	7.9	7.7	4.7	6.18	0.101	<0.05
RIV 4.2	0.02-2	11	7.8	7.5	7.7	6.3	7.49	0.218	4.74
RIV 4.3	2-10	42	5.0	6.0	4.8	2.8	6.21	0.034	<0.05
RIV 4.4	10-30	53	8.2	8.0	7.5	5.2	6.58	0.222	<0.05
SPM 1.1	0-0.5	3	3.3	3.2	3.1	1.2			
SPM1.3	5-10	38	3.3	3.3	3.3	1.3	3.29	0.052	<0.05
Mean		**33.4**	**5.2**	**5.2**	**5.1**	**2.5**	**5.1**	**0.2**	**1.1**

[a] Wet = as collected, Dry = after drying for 5 days at 40ºC (CSIRO, Sydney). [b] pH of approx. 2:1 water to soil slurry of field moist soil. [e] pH of field soil after peroxide treatment (Ahern *et al*. 2004) [d] TAA = total actual acidity. [e] CRS = chromium-reducible S (%S). [f] ANC = acid neutralising capacity, as $\%CaCO_3$. The calculated mean values for ANC assume <0.05 = 0.05.

On the scale of the major sampling areas (Murray River, Wellington Weir, Lakes Albert and Alexandrina and the wetlands), there was little difference between the mean soil properties (Tables 15-18).

The pH values in water (pH_W) and after hydrogen peroxide treatment (pH_{Perox}) were measured on field soil (Tables 15-18). The distribution of pH_W values of the soils before and after oxidation is shown in Figure 8. Many samples (22% of 101) already had pH values less than 4 when sampled. At pH values below about 5.5, aluminium is usually released from soils as the acids dissolve clay minerals. Treatment with peroxide simulates oxidation of the soil samples and indicates potential acidification. Most soils showed some pH shift with peroxide treatment and approximately 60% (*c.f.* 22% in the untreated samples) reached pH values less than 4, which is regarded as a critical value below which the acidification is regarded as significant and potentially an environmental risk. Cumulative frequency plots of pH_w, pH_{Perox}, and TAA measured in the soils shows the relative portion of soils for which may shift lower pH if conditions suitable for their oxidation exists in the future (Figure 9).

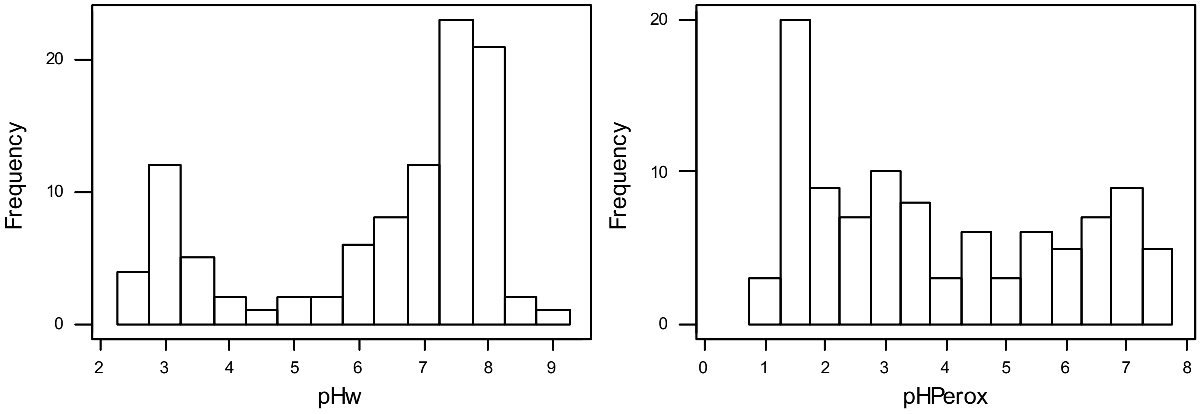


Figure 8. Histogram of soil pH measured (i) in water and (ii) after peroxide treatment of the field moist soils

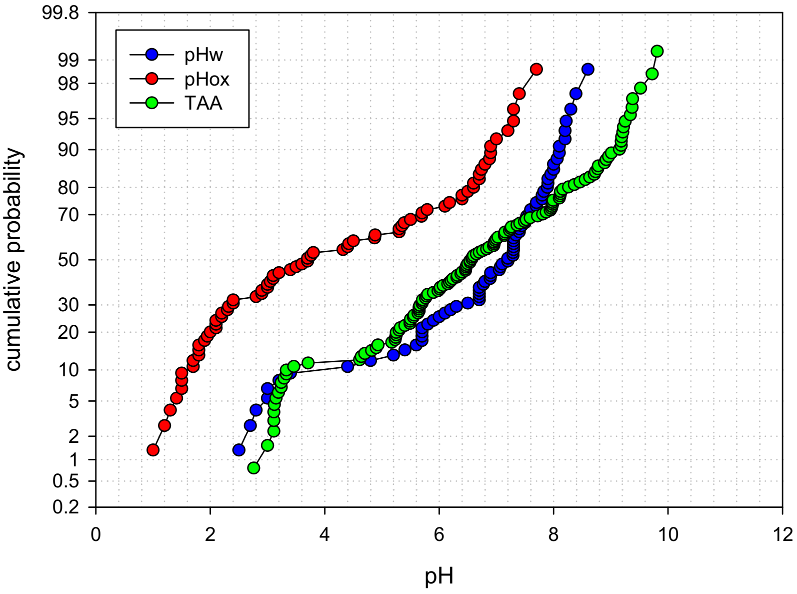


Figure 9. Cumulative frequency plot of pH_w, pH_{Perox} (= pH_{ox}) and TAA measured in the soil samples

Table 19. TAA, NAGP, Lime requirement and organic carbon content of the soils

Sample No	Titratable Actual (TAA) mole H^+/tonne (to pH 6.5)	Net Acid Generating Capacity (NAGP) mole H^+/tonne (based on %Scr)	Lime calculation[a] kg $CaCO_3$ / tonne dry weight (includes 1.5 safety factor)	Org C (%)
WL 2.1	5.5	34	1.70	5.41
WL 2.2	0	25	1.30	1.11
WL 2.3	0	-24	-1.20	1.40
WL 5.3	309	352	17.6	6.15
WL 5.4	220	254	12.7	5.93
WL 5.5	212	324	16.2	6.43
WL 6.3	0	-410	-20.5	1.91
WL 6.4	0	-98	-4.90	1.60
WL 6.5	0	-662	-33.1	2.34
WL 7.2	15	29	1.50	0.50
WL 7.3	0	-431	-21.6	3.10
WL 7.4	0	-479	-24.0	2.22
WL 8.2	0	-6	-0.30	2.41
WL 8.3	11	85	4.20	2.58
WL 8.4	9.5	116	5.80	3.22
WL 8.5	29	77	3.90	3.51
WL 9.2	10	13	0.70	1.97
WL 9.3	15	20	1.00	1.59
WL 11.1	2	2	0.10	
WL 11.2	18.5	26	1.30	0.30
WL 11.3	12.5	19	0.90	0.27
WL 12.2	3.5	17	0.90	0.35
WL 12.3	3	32	1.60	0.70
WL 14.2	3.5	4	0.20	0.24
WL 14.4	5	5	0.30	0.23
WL 15.1	0.5	148	7.40	0.07
WL 15.2	5	119	5.90	0.10
WL 17.1	1	7	0.40	0.45
WW3A 1.1				0.09
WW3A 1.2				0.07
WW3A2.1				0.08
WW 3A 4.1	0	-162	-8.10	0.03
WW 3A 4.2	0	-1380	-69.2	0.10
WW 3A 4.5	0	-7	-193	0.18
WW20A 1.1			-9.00	13.2
WW20A 1.2			0.50	9.05
WWBH20B			-1.00	0.16

–[a] Lime needed to neutralise acidity, based on net acidity/alkalinity. Includes a 1.5 times safety factor. Negative values have sufficient excess ANC and should not need additional lime.

Table 19 (continued). TAA, NAGP, Lime requirement and organic carbon content of the soils

Sample No	**Titratable Actual (TAA)**	**Net Acid Generating Capacity (NAGP))**	**Lime calculation**[a]	**Org C**
	mole H^+/tonne (to pH 6.5)	**mole H^+/tonne (based on %Scr)**	**kg $CaCO_3$ / tonne dry weight (includes 1.5 safety factor)**	**(%)**
AT 1.1				
AT 1.3				0.1
AT 1.5			-1.3	0.15
AT 1.7			23.7	5.49
AT 2.1	0	-268	-13.4	0.23
AT 2.2	0	-260	-13	0.18
AT 2.3	0	353	17.7	9.72
AT 2.6	1	98	4.9	0.24
AT 3				
AT 4.1	0	-45	-2.2	
AT 6.1	0	-68	-3.4	0.13
AT 7.3	0	1310	65.7	
AT 9.1 *				8.01
AT 9.2	281.5	309	15.5	6.12
AT 10.1	0	-33	-1.7	
AT 10.2 *	0	-78	-3.9	2.75
AT 11.1	5.2	-33	-1.7	
AT 11.2	0	111	5.6	
AT 12.1	5.2	152	-0.7	
AT 12.2	1.40	-14	0.2	
AT 12.3	0.4	4	2.1	
AT 14.1	0	-481	-24.1	
AT 14.2	0	-374	-18.7	
AT 14.3	0	-64	-3.2	
AT 14.4	0	480	24	
AT 14.5	0	511	25.6	
AT 16.1	0	-33	-1.7	
AT 16.2	0	-5	-0.2	
AT 16.3	17.8	27	1.35	
AT 16.4	0	-61	-3.05	
AT 17.1	4.7	-150	-7.5	
AT 17.2	9.5	-85	-3.05	
AT 17.3	0	-84	-4.2	
AT 17.4	0	388	19.4	
AT 18.1	0	-15		
AT 18.2	0	8	0.4	
AT 18.3	0		-1.8	
AT 19.1	0	-40		
AT 19.2	0	9	5.9	
AT 19.3	4.7	5	3.4	0.47
AT 20.1	0	-61	-3	
AT 20.2	0.5	31	1.6	
AT 20.3	7.6	-67	-3.4	
AT 21.1	0	-1	-0.5	2.86
AT 21.2				

[a] Lime needed to neutralise acidity, based on net acidity/alkalinity. Includes a 1.5 times safety factor. Negative values have sufficient excess ANC and should not need additional lime.

Table 19 (continued). TAA, NAGP, Lime requirement and organic carbon content of the soils

Sample No	**Titratable Actual (TAA)**	**Net Acid Generating Capacity (NAGP))**	**Lime calculation**[a]	**Org C**
	mole H^+/tonne (to pH 6.5)	**mole H^+/tonne (based on %Scr)**	**kg $CaCO_3$ / tonne dry weight (includes 1.5 safety factor)**	**(%)**
AA 8.1	3.5	10	0.5	
AA 8.2	3.5	9	0.5	
AA 9.1	0	-12	-0.6	
AA 10.1	0	-66	-3.3	
AA10.2	4.5	18	0.9	0.43
AA 11.1	0	-13	-0.6	
AA 11.2	0	2	0.1	
AA 12.1	0	-14	-0.7	0.08
AA 12.2	0	0		
AA 13.2	0	277	13.9	0.32
AA 14.2	0	-10	-0.5	0.17
AA 15.1	0	-12	-0.6	0.13
AA 18.2			0	
AA 19.1	0	-11	-0.5	0.13
AA 20.1	0	-82	-4.1	
AA 20.2	0	104	5.2	
AA 22.1				
AA 29.5	71.9	76	3.8	
AA 29.6	3.33	3	0.2	0.26
AA 30.1	0	-122	-6.1	0.44
AA 30.2	0	-18	-0.9	
AA 31.3	0	-23	0.9	
AA 31.5	0.47	18	1.9	
AA 33.1	0	230		
AA 33.2	286	354		12.8
AA 33.3	258	323	16.2	6.11
AA 33.4	8.19	49	2.5	
AA 33.5	0	-910	-45.5	
AA 34 (MBO)	0	-940		

[a] Lime needed to neutralise acidity, based on net acidity/alkalinity. Includes a 1.5 times safety factor. Negative values have sufficient excess ANC and should not need additional lime.

Table 19 (continued). TAA, NAGP, Lime requirement and organic carbon content of the soils.

Sample No	**Titratable Actual (TAA)**	**Net Acid Generating Capacity (NAGP))**	**Lime calculation[a]**	**Org C**
	mole H^+/tonne (to pH 6.5)	**mole H^+/tonne (based on %Scr)**	**kg $CaCO_3$ / tonne dry weight (includes 1.5 safety factor)**	**(%)**
UKE 1.1	26.7	59	2.9	2.24
UKE 1.2	13.4	59	2.9	6.75
UKE 2.1	8.1	8	4.2	4.06
UKE 2.2	17.6	18	9.4	2.38
UKE 3.1	670	670	36.8	5.12
UKE 3.2	702	702	42.7	0.23
UKE 3.3	452	452	23.7	7.95
UKE 3.4	183	183	16.1	3.49
UKE 3.5	11.4	11	19	0.28
UKE 5.1	56.3	183	9.5	
UKE 5.2	6.7	253	14.1	7.93
UKE 5.3	183	13	0.9	2.62
JUR 2.3	357	357	25.4	8.73
JUR 2.4&5	416	377		9.06
JUR 2.6&7	24.7	79		3.85
JUR 6.5	39.4	39	7.9	11.3
MUR 1.2	159	201	10.1	11.9
MUR 1.3	156	164	8.2	4.74
MUR 2.2	30.5	40	2	3.52
MUR 2.3	80.1	106	5.3	
MUR 2.4	48.7	905	45.3	11.1
MUR 3.1	21.5	63	3.2	
MUR 3.2	112	975	48.8	14
PA 4.1	0.0	-1030	-51.4	
PA 4.2	0.0	-1120	-56	
PA 4.3	0.0	-1010	-50.4	
PA 4.4	13.3	27		4.66
PA 4.5	11.9	25	1.3	
RIV 3.2	0.0	170	8.5	
RIV 3.4	4.3	70	3.5	
RIV 3.5		65	3.3	
RIV 4.2		-495	-24.8	
RIV 4.3	2.4	24	1.2	
RIV 4.4	0.0	138	6.9	
SPM 1.1			0	5.67
SPM 1.3	211	243	12.2	7.51

[a] Lime needed to neutralise acidity, based on net acidity/alkalinity. Includes a 1.5 times safety factor.
Negative values have sufficient excess ANC and should not need additional lime.

Figure 10 shows the relationship of net acid generation potential (NAGP) with pH after peroxide treatment. The relationship between NAGP and pH after peroxide treatment (pH_{Perox}) was significant and sigmoidal, and shows the poor buffering of pH where NAGP is close to zero. Negative NAGP values indicate residual acid neutralising capacity. pH values between about 6 and 8 are usually buffered by soil carbonate minerals and below about pH 3 are buffered by decomposition of clay and other soil minerals. Cumulative frequency plots of Scr and ANC indicated that nearly 90% of samples had Scr above the detection limit (dl: 0.005%) with the above dl data showing an approximately log-linear distribution (Figure 11).

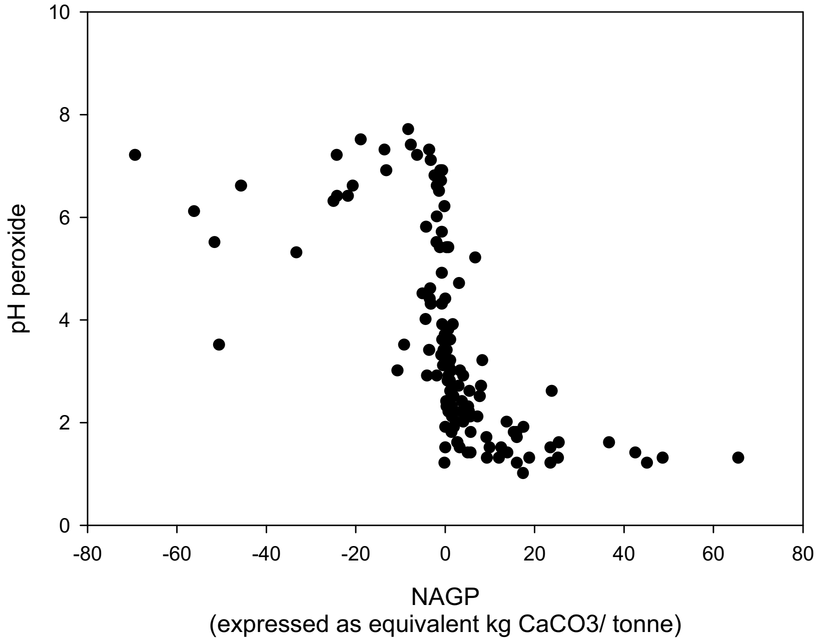


Figure 10. The relationship of NAGP (from liming calculation) and soil pH after peroxide treatment (pH_{Perox})

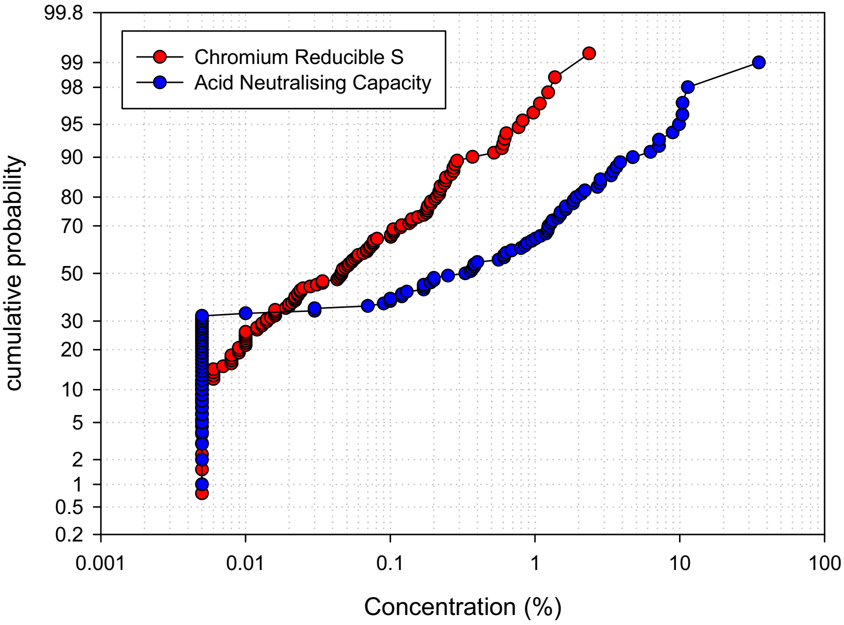


Figure 11. Cumulative frequency plots of chromium-reducible sulfur (Scr) and acid neutralising capacity (ANC).

3.2.2 Risk Associated with soils to being or becoming acidic (pH <4)

Out of the 150 soil samples, the following kinds of soil materials were identified in the ASS subtypes (Table 20): 29 sulfuric materials, 73 sulfidic materials, 2 MBO materials, 13 sulfide-rich clays, 32 sulfide-rich sands and sulfide-rich organic materials. These diagnostic materials and the soil identification key (Fitzpatrick et al., 2008a,b) were used to classify the full spectrum of ASS and non-ASS subtypes, which comprise subaqueous soils, hydrosols (i.e. in saline scalds and saline seepages with reeds), vertosols (cracking clay soils), organic soils, sandy soils and clayey soils (Table 20). In total, 102 of the 150 samples (68%) were classified as either sulfuric (pH<4) or sulfidic (would go to pH<4 if suitable conditions existed) (Appendix A). The single MBO sample tested had wet and dry paste pH values of 7.1 and 7.3 and a pH_{Perox} value of 6.6. The MBO sample had the highest ANC (9.9 % $CaCO_3$) and would be unlikely to become acidic.

Dear et al. (2002) have developed a “Risk categorisation to guide management planning” to assist in “evaluating the environmental risk” posed by ASS disturbance by identifying the level of treatment required to treat all existing and potential acidity resulting from such a disturbance. They defined the following five treatment categories: Low, Medium, High, Very High and Extra High based on laboratory results and the weight of material to be disturbed or exposed to air. According to Dear et al. (2002), there is a general correlation between the level of treatment required and the environmental risk. There are additional factors that will also influence the level of treatment required including the nature of the works to be undertaken, the staging and duration of construction, the soil characteristics (e.g. variability of sulfide concentrations, soil bulk density, physical characteristics such as texture, and self-neutralising capacity), surface and sub-surface hydrology, sensitivity of the surrounding environment, and the past history of the site.

Dear et al. (2002) have defined the total amount of fine agricultural lime required to neutralise the total existing plus potential acidity of a particular volume of soil, including the minimum industry safety factor of 1.5 (Table 20). Using the data presented in Table 20 and 20 and interpretation from Dear et al. (2002), the treatment category and risk class for each soil has been determined Table 20.

Table 20. Acid sulfate soil risk class and lime treatment category for sites sampled at Wellington to Lock 1, Wellington Weir

Site No	Depth, cm	Material	Soil subtypes	Treatment category[a]	Risk class
WL 2.1	0-5	Sulfidic clayey	Sulfidic subaqueous clayey soil	H	High
WL 2.2	5-20	Sulfidic clayey		H	High
WL 2.3	20-40	Clayey		L	Low
WL 5.3	0-1	Sulfuric clayey organic-rich	Sulfuric vertosol (clayey)	VH	Very High
WL 5.4	1-5	Sulfuric clayey organic-rich		VH	Very High
WL 5.5	5-20	Sulfuric clayey organic-rich		VH	Very High
WL 6.3	0-1	Clayey	Sulfidic clayey soil	L	Low
WL 6.4	1-8	Sulfidic clayey		M	Moderate
WL 6.5	8-20	Clayey		L	Low
WL 7.2	0-3	Sulfidic clayey	Sulfidic clayey soil	H	High
WL 7.3	3-12	Clayey		L	Low
WL 7.4	12-25	Clayey		VL	Very Low
WL 8.2	0-1	Sulfidic clayey	Sulfidic clayey soil	L	Low
WL 8.3	1-3	Sulfidic clayey		H	High
WL 8.4	3-6	Sulfidic clayey		H	High
WL 8.5	6-25	Sulfidic clayey		H	High
WL 9.2	0-5	Sulfidic clayey	Sulfidic subaqueous clayey soil	M	Moderate
WL 9.3	5-30	Sulfidic clayey		M	Moderate
WL 11.1	0-5	Sulfidic clayey	Sulfidic subaqueous clayey soil	L	Low
WL 11.2	5-10	Sulfidic clayey		M	Moderate
WL 11.3	10-20	Sulfidic sandy		M	Moderate
WL 12.2	1-5	Sulfidic sandy	Sulfidic subaqueous clayey soil	M	Moderate
WL 12.3	5-15	Sulfidic clayey		H	High
WL 14.2	0-2	Sulfidic sandy	Sulfidic subaqueous sandy soil	M	Moderate
WL 14.4	2-7	Sulfidic sandy		M	Moderate
WL 15.1	0-5	Sulfidic sandy	Sulfidic subaqueous sandy soil	VH	Very High
WL 15.2	5-10	Sulfidic sandy		VH	Very High
WL 17.1	0-15	Sulfidic sandy	Sulfidic sandy soil	M	Moderate
WW3A 1.1	0-8	Sandy	Sandy soil		
WW3A 1.2	8-20	Sandy			
WW3A 2.1	15-20	Sandy	Sandy soil		
WW3A 4.1	0-5	Sandy	Sandy soil	VL	Very Low
WW3A 4.2	15-25	Sandy		VL	Very Low
WW3A 4.5	25-50	Clayey		VL	Very Low
WW8A 2.1	0-5	Sulfidic organic	Sulfidic organic soil	L	Low
WW8A 2.2	5-15	Sulfidic organic		V	High
WW8A 2.3	15-30	Sulfidic organic		VH	Very High
WW20A 1.1	0-5	Organic	Sulfidic organic soil	VL	Very Low
WW20A 1.2	5-18	Sulfidic organic		L	Low
WW20C 1.1	30-40	Sulfidic clayey organic-rich	Sulfidic clayey soil	L	Low
WWBH20 11.1	0-5	Clayey	Sulfidic clayey soil	L	low
WWBH20 11.2	5-15	Sulfidic clayey		L	Low

[a] Treatment category: N = No treatment (no lime); L=Low level treatment; M = Medium level treatment, H = High level treatment, VH = Very high level treatment, XH = Extra High level treatment: based on data presented in Table 19, (Lime needed to neutralise acidity, based on net acidity/alkalinity, which includes a 1.5 times safety factor. Negative values have sufficient excess

Table 20 (continued). Acid sulfate soil risk class and lime treatment category for sites sampled at Lake Albert

Site No	Depth, cm	Material	Soil subtypes	Treatment category [a]	Risk class
AT 1.1	0-5	Sandy	Sandy hydrosol		
AT 1.3	15-30	Sandy			
AT 2.1	0-3	Sandy	Sulfidic hydrosol soil	L	Low
AT 2.2	3-5	Sandy carbonate-rich		L	Low
AT 2.3	5-20	Sulfidic organic		VH	Very High
AT 2.6	30-35	Sulfidic sandy		H	High
AT 4.1	0-5	Sandy	Sandy soil	L	Low
AT 6.1	0-2	Sandy	Sandy soil	L	Low
AT 7.1	0-5	Sandy	Sulfuric hydrosol (sandy) soil	XH	Very High
AT 7.2	5-20	Sulfuric clayey organic-rich		XH	Very High
AT 7.3	20-40	Sulfidic clayey		XH	Very High
AT 9.1	0-5	Sulfuric clayey organic-rich	Sulfuric hydrosol (clayey) soil	H	High
AT 9.2	5-20	Sulfuric clayey organic-rich		VH	High
AT 10.1	0-5	Sulfidic clayey	Sulfidic vertosol (clayey) soil	L	Low
AT 10.2	5-15	Sulfidic clayey		L	Low
AT 11.1	0-5	Sandy	Sulfuric hydrosol (sandy) soil	L	Low
AT 11.2	5-50	Sulfidic sandy		VH	Very High
AT 12.1	0-5	Sulfidic sandy	Sulfidic hydrosol (sandy) soil	M	Moderate
AT 12.2	5-25	Sulfuric sandy		M	Moderate
AT 12.3	25-40	Sulfuric sandy		H	High
AT 14.1	0-3	Sandy	Sulfidic hydrosol (sandy) soil	VL	Very Low
AT 14.2	3-15	Sandy		VL	Very Low
AT 14.3	5-25	Sulfidic clayey		L	Low
AT 14.4	25-30	Sulfidic clayey		XH	Ex High
AT 14.5	30-60	Sulfidic clayey		XH	Ex High
AT 16.1	0-5	Sandy	Sulfidic hydrosol (sandy) soil	L	Low
AT 16.2	5-20	Sulfidic sandy		L	Low
AT 16.3	20-45	Sulfidic sandy		H	High
AT 16.4	45-75	Sulfidic sandy		L	Low
AT 17.1	0-1	Sandy	Sulfidic vertosol (clayey) soil	L	Low
AT 17.2	1-10	Sandy		L:	Low
AT 17.3	10-20	Sulfidic sandy		L	Low
AT 17.4	20-30	Sulfidic clayey		VH	Very High
AT 18.1	0-8	Sandy	Sulfidic hydrosol (sandy) soil	L	Low
AT 18.2	18-28	Sulfidic sandy		M	Moderate
AT 18.3	28-40	Sandy			
AT 19.1	0-8	Sandy			
AT 19.2	8-18	Sulfuric clayey organic-rich	Sulfidic hydrosol (sandy) soil	VH	Very High
AT 19.3	18-28	Sulfuric clayey		H	High
AT 20.1	0-2	Sulfidic clayey	Sulfuric vertosol (clayey) soil	L	Low
AT 20.2	2-10	Sulfuric clayey		H	High
AT 20.3	10-20	Sulfidic clayey		L	Low
AT 21.1	0-1	Sulfidic clayey	Sulfuric vertosol (clayey) soil	L	Low
AT 21.2	1-10	Sulfidic clayey		L	Low

[a] Treatment category: N = No treatment (no lime); L=Low level treatment; M = Medium level treatment, H = High level treatment, VH = Very high level treatment, XH = Extra High level treatment: based on data presented in Table 19, (Lime needed to neutralise acidity, based on net acidity/alkalinity, which includes a 1.5 times safety factor. Negative values have sufficient excess

Table 20 (continued). Acid sulfate soil risk class and lime treatment category for sites sampled at Lake Alexandrina

Site No	Depth, cm	Material	Soil subtypes	Treatment category [a]	Risk class
AA 3	5-5.5	Sandy	-	-	
AA 8.1	0-5	Sandy	Sulfidic hydrosol (sandy) soil	M	Moderate
AA 8.2	5-20	Sulfidic sandy		M	Moderate
AA 9.1	0-5	Sulfidic sandy	Sulfidic hydrosol (sandy) soil	M	Moderate
AA 10.1	0-10	Sulfidic sandy			
AA10.2	10-30	Clayey			
AA 11.1	0-3	Sandy	Sulfidic hydrosol (sandy) soil	L	Low
AA 11.2	3-10	Sulfidic sandy		L	Low
AA 12.1	0-5	Sandy	Sulfidic hydrosol (sandy) soil	L	Low
AA 12.2	5-20	Sandy		L	Low
AA 13.2	3-15	Sulfidic sandy		VH	Very High
AA 14.2	2-7	Sulfidic sandy	Sulfidic hydrosol (sandy) soil	L	Low
AA 15.1	0-5	Sandy	Sulfidic hydrosol (sandy) soil	L	Low
AA 18.2	2-12	Sandy	Sulfidic hydrosol (sandy) soil	M	Moderate
AA 19.1	0-5	Sandy	Sulfidic hydrosol (sandy) soil	L	Low
AA 20.1	0-5	Sandy	Sulfidic hydrosol (sandy) soil	M	Moderate
AA 20.2	5-20	Sulfidic sandy		VH	Very High
AA 22.1	0-5	Clayey	Sulfidic vertosol (clayey) soil	L	Low
AA 29.5	0-3	Sulfuric sandy	Sulfuric hydrosol (clayey) soil	H	High
AA 29.6	3-10	Sulfuric sandy			
AA 30.1	0-0.05	Sandy	Sulfidic hydrosol (sandy) soil	L	Low
AA 30.2	0.05-20	Sandy		L	Low
AA 31.2	0-10	Sulfidic sandy	Sulfidic vertosol (clayey) soil	M	Moderate
AA 31.3	10-18	Sulfidic clayey		M	Moderate
AA 33.1	0-1	Sulfidic sandy	Sulfidic vertosol (clayey) soil	H	High
AA 33.2	0-10	Sulfuric organic		H	High
AA 33.3	10-25	Sulfuric clayey organic-rich		VH	Very High
AA 33.4	25-40	Sulfuric clayey		VH	Very High
AA 33.5	40-60	Sandy		VL	Very Low
AA 34	0 -10	MBO	MBO subaqueous (clayey) soil	VL	Very Low

[a] Treatment category: N = No treatment (no lime); L=Low level treatment; M = Medium level treatment, H = High level treatment, VH = Very high level treatment, XH = Extra High level treatment: based on data presented in Table 19, (Lime needed to neutralise acidity, based on net acidity/alkalinity, which includes a 1.5 times safety factor. Negative values have sufficient excess

Table 20 (continued). Acid sulfate soil risk class and lime treatment category for sites sampled at the wetlands Ukee Boat Ramp, Jury Swamp, Murrundi, Paiwalla, Riverglades and Swanport

Site No	Depth, cm	Material	Soil subtypes	Treatment category [a]	Risk class
UKE 1.1	0-10	Sulfidic clayey	Sulfidic subaqueous vertosol (clayey) soil	H	High
UKE 1.2	10-30	Sulfidic clayey		H	High
UKE 2.1	0-5	Sulfidic clayey	Sulfidic vertosol (clayey) soil	VH	Very High
UKE 2.2	5-20	Sulfidic clayey		VH	Very High
UKE 3.1	0-0.5	Sulfuric clayey	Sulfuric vertosol (sandy/clayey) soil	XH	X High
UKE 3.2	0.5-1	Sulfuric clayey		XH	X High
UKE 3.3	1-8	Sulfuric clayey		XH	X High
UKE 3.4	8-12	Sulfuric clayey		XH	X High
UKE 3.5	12-20	Sulfuric clayey		XH	X High
UKE 5.1	0-0.5	Sulfuric clayey	Sulfuric vertosol (clayey) soil	H	High
UKE 5.2	0.5-10	Sulfuric clayey		VH	Very High
UKE 5.3	10-30	Sulfidic clayey		H	High
JUR 2.3	0-2	Sulfuric clayey organic-rich	Sulfuric organic (clayey) soil	XH	X High
JUR 2.4&5	2-10	Sulfuric clayey organic		VH	X High
JUR 2.6&7	10-40	Sulfuric clayey		VH	X High
JUR 6.5	40-60	Sulfidic organic	Sulfuric organic (clayey) soil	VH	Very High
MUR 1.2	30-40	Sulfuric clayey organic	Sulfuric organic (clayey) soil	VH	Very High
MUR 1.3	40-70	Sulfidic clayey organic-rich		VH	Very High
MUR 2.2	5-10	Sulfidic clayey	Sulfidic vertosol (clayey) soil	H	High
MUR 2.3	10-45	Sulfidic clayey		VH	Very High
MUR 2.4	45-70	Sulfidic organic		XH	X High
MUR 3.1	0-15	Sulfidic clayey	Sulfidic subaqueous (clayey) soil	VH	Very High
MUR 3.2	15-30	Sulfidic clayey		XH	X High
PA 4.1	0-1	Organic	Sulfidic vertosol (clayey) soil	VL	Very Low
PA 4.2	1-3	Clayey		VL	Very Low
PA 4.3	3-8	Sulfidic clayey		VL	Very Low
PA 4.4	8-15	Sulfidic clayey		H	High
PA 4.5	15-50	Sulfidic clayey		H	High
RIV 3.2	0-1	Sulfidic clayey	Sulfidic vertosol (clayey) soil	VH	Very High
RIV 3.4	1-10	Sulfidic clayey		H	High
RIV 3.5	10-20	Clayey		H	High
RIV 4.2	0.02-2	Clayey	Sulfidic vertosol (clayey) soil	VL	Very Low
RIV 4.3	2-10	Sulfidic clayey		H	High
RIV 4.4	10-30	Clayey		VH	Very High
SPM 1.1	0-0.5	Sulfuric clayey organic-rich	Sulfuric vertosol (clayey) soil	H	High
SPM1.3	5-10	Sulfuric clayey organic-rich		VH	Very High

[a] Treatment category: N = No treatment (no lime); L=Low level treatment; M = Medium level treatment, H = High level treatment, VH = Very high level treatment, XH = Extra High level treatment: based on data presented in Table 19, (Lime needed to neutralise acidity, based on net acidity/alkalinity, which includes a 1.5 times safety factor. Negative values have sufficient excess

3.2.3 Particulate metal concentrations

The particulate metal concentrations of the soils are shown in Table 21-29. The mean and standard deviation of the metal concentrations for each area provide a useful summary of this information (Table 21). In general, the concentration of trace metals were low and below the ANZECC/ARMCANZ (2000) guideline concentrations for sediment and soil quality in waterways.

The wetlands generally had higher trace metal concentrations (e.g. Cr, Cu, Ni, Pb, V, Zn) than the River Murray and Lakes sites. The wetlands at Paiwalla and Rivergaldes had significantly higher manganese concentrations than the other wetlands and the River Murray and Lake sites. The Riverglades wetland had higher chromium concentrations than the other wetlands and the River Murray and Lake sites, and exceeded the guideline for chromium. The mean metal concentrations in the surface soils (i.e. those sampled from 0 to up to 10 cm depth), were very similar to those of the mean for each major study area (Table 21).

For many of the sampling sites, soil samples were collected from depth profiles (e.g. site WL 8.2 to 8.5 comprised for soils samples from 0-1, 1-3, 3-6, and 6-25 cm depth, respectively) (Table 29, Appendix C). For the River Murray (main channel) and Wellington Weir soils, none of the studied sites showed significant trends of particulate metals with soil depth, i.e. particulate metal concentrations did not consistently increase or decrease with soil depth (data shown in Appendix C). For some of the Lakes and wetlands sites, there were significant depth profiles for some metals (Table 29), for example, at UKE 3.1 to 3.5 particulate copper concentrations were 458, 537, 111, 83, and 11 mg/kg for soils at depths 0-0.5, 0.5-1, 1-8, 8-12, 12-20 cm.

Samples were also analysed for total trace element concentrations by XRF. In general, these were slightly greater than the aqua regia extracts, but correlate quite well for a number of trace elements (Appendix D). A few anomalously high concentrations for chromium are probably due to heterogeneity in the sub-samples.

Table 21. Particulate metal concentrations of soils[a]

	Trace metals, mg/kg									**Major metals, %**			
	As	**Co**	**Cr**	**Cu**	**Mn**	**Ni**	**Pb**	**V**	**Zn**	**Ca**	**Mg**	**Al**	**Fe**
River Murray													
Mean	4.5	8.9	6.5	10	170	8.1	7.1	19	17	0.41	0.18	0.24	0.59
SD	5.1	5.5	5.5	7	140	5.5	3.7	16	15	0.44	0.14	0.19	0.40
Wellington Weir													
Mean	3.6	5.0	3.2	8	180	5.5	3.7	13	8.2	0.31	0.13	0.12	0.41
SD	4.8	5.7	3.4	11	230	6.8	2.8	14	8.0	0.36	0.14	0.14	0.48
Lake Albert													
Mean	5.3	4.3	5.1	9	94	6.2	4.8	15	9.1	0.42	0.20	0.16	0.54
SD	5.8	5.2	6.4	8	110	7.2	5.0	14	9.1	0.41	0.19	0.15	0.55
Lake Alexandrina													
Mean	3.0	5.6	5.6	6	87	6.3	3.7	15	11	0.33	0.24	0.15	0.50
SD	2.9	6.5	10	7	85	7.3	4.2	18	12	0.47	0.33	0.14	0.62
Wetland at Ukee													
Mean	3.2	17	8.0	19	160	16	12	31	33	1.5	0.32	0.41	1.4
SD	1.5	20	2.5	11	170	18	7.6	14	36	2.4	0.33	0.24	1.1
Wetland at Jury Swamp													
Mean	6.2	5.4	9.1	22	96	13	15	41	17	1.6	0.31	0.49	1.6
SD	1.7	3.4	5.9	2	27	4.7	4.1	13	12	1.6	0.12	0.45	0.74
Wetland at Murrundi													
Mean	5.2	8.1	12	18	65	13	3.5	41	18	0.40	0.28	0.71	0.97
SD	2.8	3.1	2.6	4	26	4.1	3.0	11	6	0.20	0.08	0.51	0.28
Wetland at Paiwalla													
Mean	11	33	36	21	520	16	11	38	34	1.2	0.70	0.27	1.2
SD	3.3	50	57	7	390	3.3	6.0	15	10	1.1	0.29	0.04	0.38
Wetland at Riverglades													
Mean	6.9	13	172	22	750	18	12	33	22	0.81	0.72	0.33	1.3
SD	0.6	3.7	353	4	440	4.3	2.3	9	5	0.41	0.25	0.04	0.4
Wetland at Swanport													
Mean	7.9	12	10	27	32	14	24	42	24	0.6	0.1	0.2	0.8
SD	3.0	3.6	2.2	3	44	2.8	12	5	5	0.4	0.02	0.02	0.1
Concentrations in the surface soils (0-10 cm depth) (Appendix C)													
Mean	4.3	8.8	6.5	11	170	9.5	6.7	21	18	0.7	0.27	0.26	0.71
SD	4.2	12	6.5	9.9	220	130	7.1	18	23	1.3	0.30	0.30	0.78
Guideline concentrations													
Low	20	NA	80	65	NA	21	50	NA	200	NA	NA	NA	NA
High	70	NA	270	270	NA	52	200	NA	410	NA	NA	NA	NA

[a] Concentrations of silver (Ag), cadmium (Cd) and selenium (Se) were less than 0.4 mg/kg in all samples and less than the ANZECC/ARMCANZ (2000) guideline concentrations (low/high) for Ag and Cd are 1/3.7 and 1.5/10, respectively. There is no guideline for selenium (Se).

Table 22. Particulate metal concentrations of River Murray soils samples (above Wellington Weir)

River Murray Site	Depth, cm	Trace metal concentrations in mg/kg																
		Ag	As	Cd	Co	Cr	Cu	Mn	Ni	Pb	Se	V	Zn	K	Ca	Mg	Al	Fe
WL 2.1	0-5	<0.4	1.6	<0.4	6.3	1.6	3.7	120	3.3	2.3		6.2	7.4	510	1810	540	730	2210
WL 2.2	5-20	<0.4	2.6	<0.4	18	4.6	8.4	290	9.9	6.3		14	17	2340	4360	1550	1840	4970
WL 2.3	20-40	<0.4	2.7	<0.4	8.7	2.8	5.8	98	5.3	6.8		9.9	11	1060	1830	699	1330	3500
WL 5.3	0-1	<0.4	1.1	<0.4	9.1	4.8	15	44	9.3	11	<0.4	12	14	1440	5130	866	1770	9215
WL 5.4	1-5	<0.4	1.5	<0.4	4.3	4.5	11	25	4.1	8.1	<0.4	14	9.9	930	550	460	1570	7640
WL 5.5	5-20	<0.4	4.6	<0.4	8.3	8.3	19	51	8.2	9.6	<0.4	33	20	1380	1240	959	2980	9990
WL 6.3	0-1	<0.4	9.4	<0.4	9.8	8.8	8.1	200	12	6.4		20	20	3450	13800	3440	1700	7640
WL 6.4	1-8	<0.4	9.3	<0.4	14	10	10	73	11	8.0		21	18	2960	8900	2080	1870	7050
WL 6.5	8-20	<0.4	12	<0.4	15	13	11	130	12	8.7		29	75	3570	13400	2250	2150	9330
WL 7.2	0-3	<0.4	13	<0.4	14	19	20	150	16	13	<0.4	53	30	4950	4760	3650	8650	16200
WL 7.3	3-12	<0.4	21	<0.4	22	22	19	450	19	14		63	31	5500	13800	4820	3020	15400
WL 7.4	12.25	<0.4	4.8	<0.4	12	6.6	16	385	12	9.3		24	22	3270	8480	4330	2320	5580
WL 8.2	0-1	<0.4	6.0	<0.4	13	7.4	17	270	13	9.3	<0.4	26	22	2930	4440	3150	4710	6180
WL 8.3	1-3	<0.4	6.2	<0.4	16	8.4	19	260	14	11	<0.4	30	26	3550	5330	3250	5440	6570
WL 8.4	3-6	<0.4	4.8	<0.4	12	9.5	21	260	15	12	<0.4	34	27	4070	4700	3180	4570	7170
WL 8.5	6-25	<0.4	1.9	<0.4	7.4	6.0	11	205	9.2	7.0		17	15	2330	2340	2040	4590	4230
WL 9.2	0-5	<0.4	3.6	<0.4	4.5	9.5	21	160	12	11		32	22	3590	3810	3320	2920	5520
WL 9.3	5-30	<0.4	<0.4	<0.4	3.7	1.9	2.7	39	2.1	2.7		6.5	4.4	620	570	640	1110	2060
WL 11.1	0-5	<0.4	<0.4	<0.4	3.6	3.8	7.2	57	3.3	5.2		12	9.4	1380	1050	1310	1640	2830
WL 11.3	10-20	<0.4	1.0	<0.4	1.3	1.3	2.2	24	1.4	1.8		3.8	3.2	400	370	370	700	1190
WL 12.2	1-5																	
WL 12.3	5-15	<0.4	1.0	<0.4	4.9	2.5	2.9	550	3.2	3.3		5.4	6.6	900	870	960	1180	4770
WL 14.2	0-2	<0.4	<0.4	<0.4	1.8	2.2	2.7	72	1.7	2.9		4.9	5.8	710	350	680	1150	2020
WL 14.4	2-7																	
WL 15.1	0-5	<0.4	1.0	<0.4	4.4	0.9	1.1	230	1.9	2.1		2.7	3.3	340	390	340	610	3090
WL 15.2	5-10	<0.4	0.8	<0.4	3.4	1.3	1.5	22	1.5	2.5		3.5	4.3	460	370	330	700	1370
WL 17.1	0-15	<0.4	1.4	<0.4	4.8	1.7	2.3	33	1.9	2.9		5.0	5.5	490	390	390	810	1750

Table 23. Particulate metal concentrations of Wellington Weir soil samples

Wellington Weir Site	Depth, cm	Trace metal concentrations in mg/kg																
		Ag	As	Cd	Co	Cr	Cu	Mn	Ni	Pb	Se	V	Zn	K	Ca	Mg	Al	Fe
WW3A 1.1	0-8	<0.4	<0.4	<0.4	0.6	<0.4	<0.4	8.3	<0.4	<2		<2	<2	41	141	37	59	450
WW3A 1.2	8-20	<0.4	<0.4	<0.4	1.2	<0.4	<0.4	13	<0.4	<2		<2	<2	82	210	61	140	610
WW3A2.1	15-20	<0.4	<0.4	<0.4	0.8	<0.4	<0.3	9.0	<0.3	<2		<2	<2	47	304	43	76	450
WW3A 4.1	0-5	<0.4	1.0	<0.4	0.6	<0.4	0.4	14	<0.4	<2		<2	<2	40	486	45	60	440
WW3A 4.2	15-25	<0.4	<0.4	<0.4	1.1	<0.4	0.4	79	<0.4	<2		<2	<2	75	9800	376	110	660
WW 3A 4.5	25-50	<0.4	1.6	<0.4	0.9	0.4	0.7	16	<0.4	<2		<2	<2	150	254	123	255	330
WW 8A 2.1	0-5	<0.4	7.0	<0.4	10	5.6	15	540	11	4.0		24	21	4710	7380	2970	3040	9800
WW 8A 2.2	5-15	<0.4	9.8	<0.4	13	6.1	15	600	13	5.9		36	21	5960	9040	3560	2110	12300
WW 8A 2.3	15-30	<0.4	16	<0.4	19	8.4	32	210	19	12		37	20	4100	5880	3120	1920	13200
WW20A 1.1	0-5	<0.4	3.1	<0.4	6.4	5.8	9.4	590	7.2	2.7		17	13	3590	4430	2870	1920	4940
WW20A 1.2	5-18	<0.4	2.3	<0.4	5.5	7.2	12	210	8.0	4.7		22	8.8	2220	2720	2460	3880	5220
WW20C	30-40	<0.4	7.4	<0.4	9.2	8.1	32	160	17	7.0	0.5	28	15	2460	2670	1940	3400	7380
WWBH20 11.1	0-5	<0.4	<0.4	<0.4	1.4	<0.4	<0.4	12	0.5	<2		<2	<2	145	183	113	200	754
WWBH20 11.2	5-15	<0.4	<0.4	1.5	<0.4	<0.4	4.0	<0.4	<2		<2	<2	<2	140	110	46	136	446

Table 24. Particulate metal concentrations of Lake Albert soil samples (part 1)

Lake Albert	Depth,	Trace metal concentrations in mg/kg																
Site	**cm**	**Ag**	**As**	**Cd**	**Co**	**Cr**	**Cu**	**Mn**	**Ni**	**Pb**	**Se**	**V**	**Zn**	**K**	**Ca**	**Mg**	**Al**	**Fe**
AT 1.1	0-5																	
AT 1.3	15-30																	
AT 2.1	0-3																	
AT 2.2	3-5																	
AT 2.3	5-20	<0.4	28	0.7	2.9	2.2	17	57	15	0.8	0.7	22	6.2	620	2570	1970	992	4530
AT 2.6	30-35	<0.4	2.7	<0.4	0.2	1.4	0.9	17	0.8	1.2	<0.4	3.1	0.5	265	375	240	410	1040
AT 4.1	0-5																	
AT 6.1	0-2																	
AT 7.1	0-5																	
AT 7.2	5-20	<0.4	17	<0.4	26	7.0	18	150	29	11	<0.4	31	23	2000	3580	4540	4020	17000
AT 7.3	20-40																	
AT 9.1	0-5	<0.4	12	<0.4	5.9	6.9	16	150	11	12	<0.4	34	21	1610	8610	3510	4840	22000
AT 9.2	5-20	<0.4	8.3	<0.4	5.9	7.1	21	130	24	12	<0.4	32	27	1190	3440	5980	5180	13800
AT 10.1	0-5																	
AT 10.2	5-15	<0.4	7.4	<0.4	5.4	6.9	20	220	11	11	<0.4	30	20	1440	3510	2570	4010	6840
AT 11.1	0-5	<0.4	2.2	<0.4	1.5	34	0.7	34	0.8	1.5		3.2	1.0	230	760	250	305	1555
AT 11.2	5-50	<0.4	4.5	<0.4	<0.4	3.6	9.1	97	5.1	5.2		16	9.0	1770	1330	2580	1660	6200
AT 12.1	0-5	<0.4	0.5	<0.4	0.9	<0.3	0.5	5.1	0.4	<1		1.4	<1	160	140	120	200	610
AT 12.2	5-25	<0.4	0.6	<0.4	1.0	0.4	1.1	9.6	0.4	<1		2.3	<1	235	250	230	350	686
AT 12.3	25-40	<0.4	11	<0.4	8.4	4.9	23	240	10	7.8		20	13	2370	3800	2800	1740	9960
AT 14.1	0-3	<0.4	2.2	<0.4	0.7	0.8	0.6	20	0.3	<1		3.1	1.3	320	14000	830	290	950
AT 14.2	3-15	<0.4	2.1	<0.4	0.8	0.7	0.3	17	0.5	<1		2.5	0.6	190	9390	390	240	860
AT 14.3	15-25	<0.4	3.8	<0.4	4.6	5.7	12	110	6.6	7.0		20	14	2600	6650	3330	2070	6120
AT 14.4	25-30	<0.4	4.0	<0.4	7.3	4.5	8.4	170	4.7	5.5		14	9.0	2200	15600	2470	1830	6950
AT 14.5	25-30	<0.4	4.5	<0.4	7.4	6.7	11	135	7.6	7.6		20	12	3170	3740	4850	2250	9510

Table 25. Particulate metal concentrations of Lake Albert soil samples (part 2)

Lake Albert Site	Depth, cm	Trace metal concentrations in mg/kg																
		Ag	As	Cd	Co	Cr	Cu	Mn	Ni	Pb	Se	V	Zn	K	Ca	Mg	Al	Fe
AT 16.1	0-5	<0.3	1.5	<0.3	0.7	<0.3	0.4	7.3	<0.3	1.4		2.0	0.5	127	1160	180	180	660
AT 16.2	5-20	<0.3	0.6	<0.3	0.5	<0.3	<0.3	5.8	<0.3	<1		<1	<1	96	450	120	160	360
AT 16.3	20-45	<0.3	<0.3	<0.3	<0.3	4.6	<0.3	4.6	<0.3	<1		<1	<1	120	170	180	190	360
AT 16.4	45-75	<0.3	0.9	<0.3	1.9	1.5	2.8	37	1.6	<1		5.1	2.9	930	4720	990	930	2300
AT 17.1	0-1	<0.3	<0.3	<0.3	1.0	0.5	0.5	28	0.6	<1		2.9	1.1	360	3450	700	320	950
AT 17.2	1-10	<0.3	0.8	<0.3	0.9	<0.3	0.7	21	0.6	<1		2	<1	270	1820	365	350	815
AT 17.3	10-20	<0.3	4.1	<0.3	5.4	5.2	9.4	150	6.2	<1		19	13	2320	4190	2250	2030	5550
AT 17.4	20-30	<0.3	8.2	<0.3	9.9	6.8	12.3	170	8.6	<1		23	15	3500	9830	3370	2300	11400
AT 18.1	0-8	<0.3	0.7	<0.3	<0.3	<0.3	<0.3	16	<0.3	<1		<1	<1	110	930	160	110	370
AT 18.2	18-28	<0.3	0.5	<0.3	<0.3	<0.3	0.4	5.3	<0.3	<1		<1	<1	110	300	120	140	350
AT 18.3	28-40	<0.3	<0.3	<0.3	1.0	<0.3	0.4	12	<0.3	<1		1.5	<1	150	430	130	240	555
AT 19.1	0-8	<0.3	2.4	<0.3	0.7	<0.3	0.6	20	<0.3	1.3		2.7	<1	280	1630	360	280	840
AT 19.2	8-18	<0.3	5.5	<0.3	7.7	2.8	7.3	64	5.2	4.5		11.3	6.5	1070	11900	895	1260	5290
AT 19.3	18-28	<0.3	1.4	<0.3	2.1	0.4	0.7	13	1.1	<1	<0.4	1.9	1.0	230	550	280	308	1370
AT 20.1	0-2	<0.3	12	<0.3	15	10	22	545	15	14		39	29	4020	2830	3580	2700	11900
AT 20.2	2-10	<0.3	8.6	<0.3	11	9.3	20	170	12	12		34	24	3520	3930	2690	2610	7790
AT 20.3	10-20	<0.3	4.8	<0.3	3.3	14	27	56	7.4	14		45	15	5700	3510	5650	2960	4660
AT 21.1	0-1	<0.3	14	<0.3	8.1	12	22	195	17	13		36	20	6670	4430	5730	3440	13000
AT 21.2	1-10	<0.3	7.7	<0.3	5.4	14	20	155	14	14		41	19	6530	6230	5590	3470	8840

Table 26. Particulate metal concentrations of Lake Alexandrina soil samples

Lake Alexandrina	Depth, cm	Trace metal concentrations in mg/kg																
Site		Ag	As	Cd	Co	Cr	Cu	Mn	Ni	Pb	Se	V	Zn	K	Ca	Mg	Al	Fe
AA 3	5-5.5	<0.4	<0.4	<0.4	0.6	0.4	0.4	6.6	0.4	<1		1.3	1.0	220	245	170	260	480
AA 8.1	0-5																	
AA 8.2	5-20	<0.4	1.3	<0.4	<0.4	1.6	1.9	44	1.5	<1		4.7	3.2	700	378	410	890	1350
AA 9.1	0-5																	
AA 10.1	0-10																	
AA10.2	10-30	<0.4	3.2	<0.4	12	4.1	6.7	270	9.3	3.5	<0.4	12	9.4	1010	17	950	1600	6750
AA 11.1	0-3																	
AA 11.2	3-10																	
AA 12.1	0-5																	
AA 12.2	5-20																	
AA 13.2	3-15	<0.4	3.9	<0.4	6.2	2	3.2	51	5.1	4.1	<0.4	7.0	5.8	540	52	873	1160	2880
AA 14.2	?																	
AA 15.1	?																	
AA 18.2	2-12																	
AA 19.1	?																	
AA 20.1	0-5																	
AA 20.2	5-20																	
AA 22.1	0-5																	
AA 29.5	0-3	<0.4	1.7	<0.4	9.0	0.8	0.9	94	4.2	1.1	<0.4	5.6	3.7	430	3330	666	544	3790
AA 29.6	3-10	<0.4	<0.3	<0.4	1.9	<0.4	0.4	9.6	0.5	<1	<0.4	1.7	0.5	100	180	62.0	162	1003
AA 30.1	0-0.05	<0.4	0.9	<0.4	1.4	<0.4	0.4	65	0.4	0.7		2.0	<1	440	3250	948	266	835
AA 30.2	0.05-20	<0.4	<0.3	<0.4	0.8	<0.4	<0.3	7.6	<0.3	<1		<1	<1	70	444	85.5	110	373
AA 31.3	0-10	<0.4	1.4	<0.4	0.4	4.7	8.3	54	4.1	4.2		10	13	1660	1170	1080	1720	3040
AA 31.5	10-18	<0.4	9.4	<0.4	3.1	42	19	150	24	17		62	40	15300	840	7900	3590	24400
AA 33.1	0-1	<0.4	5.9	<0.4	24	7.5	11	240	7.9	7.5		23	17	8290	11900	11200	2210	8110
AA 33.2	0-10	<0.4	7.3	<0.4	6.5	5.8	23	100	20	5.7	<0.4	41	27	5600	3540	4930	3570	6740
AA 33.3	10-25	<0.4	5.5	<0.4	15	7.3	13	76	12	7.5	<0.4	41	25	2680	2830	2670	4520	9900
AA 33.4	25-40	<0.4	0.6	<0.4	1.3	0.8	0.9	3.2	0.7	2.0		1.8	1.4	200	28	38	350	648
AA 33.5	40-60	<0.4	0.9	<0.4	1.1	1.4	0.8	21	0.7	<1		2.5	1.4	400	14000	1070	476	1030
AA 34(MBO)	40-60	<0.4	5.1	<0.4	7.6	11	12	180	8.9	<1		26	22	9330	10950	5610	2470	9440

Table 27. Particulate metal concentrations of Wetlands at Ukee and Jury Swamp soils

Ukee and Jury Swamp	**Depth, cm**	**Trace metal concentrations in mg/kg**																
Site		**Ag**	**As**	**Cd**	**Co**	**Cr**	**Cu**	**Mn**	**Ni**	**Pb**	**Se**	**V**	**Zn**	**K**	**Ca**	**Mg**	**Al**	**Fe**
UKE 1.1	0-10	<0.4	1.7	<0.4	5.7	8.3	8.5	76	6.1	7.0		23	12	1610	1350	1760	2270	6080
UKE 1.2	10-30	<0.4	3.7	<0.4	7.8	9.3	14	110	8.4	7.9		32	15	1850	1990	2340	2530	7860
UKE 2.1	0-5	<0.4	1.8	<0.4	4.8	5.2	9.5	63	5.9	10		22	10	1190	2820	1530	2900	2950
UKE 2.2	5-20	<0.4	2.4	<0.4	6.0	8.7	11	120	7.0	8.1		30	14	1910	2320	2100	2390	6840
UKE 3.1	0-0.5	<0.4	4.4	<0.4	47	8.0	37	460	42	25		49	88	9910	71400	7370	7140	41100
UKE 3.2	0.5-1	<0.4	3.9	<0.4	68	9.9	30	540	62	25	<0.4	55	125	6580	32500	12050	5590	23300
UKE 3.3	1-8	<0.4	4.5	<0.4	17	9.7	25	110	16	16	0.5	42	38	2350	2760	2300	4640	14400
UKE 3.4	8-12	<0.4	5.3	<0.4	11	8.6	14	83	10	6.8	<0.4	35	25	2630	5730	2000	5010	8850
UKE 3.5	12-20	<0.4	0.2	<0.4	24	15	12	1050	11	13	<0.4	35	34	3160	2170	2340	6120	9210
UKE 5.1	0-0.5	<0.4	2.2	<0.4	6.0	6.7	36	55	7.5	18	<0.4	24	15	8300	52600	830	2590	23000
UKE 5.2	0.5-10	<0.4	4.1	<0.4	8.9	9.5	21	95	9.7	6.1	<0.4	27	22	3170	1910	2230	4090	13000
UKE 5.3	10-30	<0.4	3.9	<0.4	16	11	19	230	18	13		32	31	4630	4040	3450	9290	14400
JUR 2.3	0-2	<0.4	5.1	<0.4	7.5	12	24	82	9.3	17	0.5	21	19	6120	12800	2580	2140	25200
JUR 2.4&5	2-10	<0.4	8.5	<0.4	6.3	11	23	65	9.1	17	<0.4	47	18	4170	5380	2010	2510	19700
JUR 2.6&7	10-40	<0.4	6.3	<0.4	7.1	12	22	120	18	17	<0.4	47	22	1440	5350	3120	11600	12300
JUR 6.5	40-60	<0.4	4.9	<0.4	7.5	13	20	120	16	9.0	<0.4	48	29	3230	38800	4830	3530	8720

Table 28. Particulate metal concentrations of Murrundi, Paiwalla, Riverglades, and Swanport wetland soils

Wetlands	**Depth,**	**Metal concentrations in mg/kg**																
Site	**cm**	**Ag**	**As**	**Cd**	**Co**	**Cr**	**Cu**	**Mn**	**Ni**	**Pb**	**Se**	**V**	**Zn**	**K**	**Ca**	**Mg**	**Al**	**Fe**
MUR 1.2	30-40	<0.4	5.9	<0.4	6.0	12	16	58	14	7.6	<0.4	37	27	2720	7410	2920	2960	10700
MUR 1.3	40-70	<0.4	5.4	<0.4	8.7	14	17	110	15	2.6	<0.4	44	25	3520	4910	3590	15600	14100
MUR 2.2	5-10	<0.4	1.8	<0.4	6.1	7.2	12	33	7.2	7.0	<0.4	21	13	1390	1780	1370	2410	6020
MUR 2.3	10-45	<0.4	3.2	<0.4	5.4	15	17	70	9.9	1.8		47	16	2540	3590	2870	3390	8500
MUR 2.4	45-60	<0.4	5.2	<0.4	9.0	12	22	67	13	<1	<0.4	44	13	1930	3610	3400	9310	7960
MUR 3.1	0-15																	
MUR 3.2	15-30	<0.4	9.9	<0.4	14	11	24	53	19	<1	<0.4	50	15	1870	2620	2840	8640	10800
PA 4.1	0-1	<0.4	5.5	<0.4	8.7	5.8	11	760	22	1.4		17	22	3530	21300	9440	2150	6460
PA 4.2	1-3	<0.4	12	0.42	13	9.8	19	1070	14	10		31	39	6180	27100	9820	2640	11400
PA 4.3	3-8	<0.4	14	0.49	13	9.9	20	460	15	11		38	47	5990	5200	8050	2560	13700
PA 4.4	8-15	<0.4	14	0.45	120	16	27	200	16	15		51	33	4130	4870	4100	3130	14400
PA 4.5	15-50	<0.4	11	<0.4	8.8	140	26	140	13	17	<0.4	54	28	3150	2910	3640	3125	16400
RIV 3.2	0-1	<0.4	7.9	<0.4	14	12	22	1490	17	12		30	29	4950	5690	5550	2920	13200
RIV 3.4	1-10	<0.4	6.9	<0.4	14	13	23	610	18	13		33	25	4560	12000	4600	3160	10600
RIV 3.5	10-20	<0.4	6.6	<0.4	13	16	24	485	19	15		44	21	6700	5980	6940	3780	18200
RIV 4.2	0.02-2																	
RIV 4.3	2-10	<0.4	6.2	<0.4	8.3	800	15	800	13	8.6		20	18	6050	13000	11000	2855	9160
RIV 4.4	10-30	<0.4	6.7	<0.4	19	15	26	360	24	14		39	16	7520	4000	7960	3680	13600
SPM 1.1	0-0.5	<0.4	5.7	<0.4	15	8.8	25	65	16	33	<0.4	46	27	7600	3220	1080	2060	7440
SPM1.3	5-10	<0.4	10	<0.4	9.8	12	29	63	12	16	<0.4	38	20	1650	9290	1420	2410	9010

Table 29. Particulate metal concentrations of soils at sampling sites where depth profiles were taken (others in Appendix C)

Site	Depth,	Trace metal concentrations in mg/kg													
	cm	As	Co	Cr	Cu	Mn	Ni	Pb	V	Zn	K	Ca	Mg	Al	Fe
AT 12.1	0-5	0.9	<0.3	0.5	5.1	0.4	<1	1.4	<1	<1	160	142	122	200	613
AT 12.2	5-25	1.0	0.4	1.1	10	0.4	<1	2.3	<1	<1	235	247	226	352	686
AT 12.3	25-40	8.4	4.9	23	240	10	7.8	20	13	13	2370	3800	2800	1740	9960
AT 14.1	0-3	0.7	0.8	0.6	20	0.3	<1	3.1	1.3	1.3	316	14000	832	292	952
AT 14.2	3-15	0.8	0.7	0.3	17	0.5	<1	2.5	0.6	0.6	192	9390	389	241	862
AT 14.3	15-25	4.6	5.7	12	110	6.6	7.0	20	14	14	2600	6650	3330	2070	6120
AT 14.4	25-30	7.3	4.5	8.4	170	4.7	5.5	14	9	9.0	2200	15600	2470	1830	6950
AT 14.5	25-30	7.4	6.7	11	135	7.6	7.6	20	12	12	3170	3740	4850	2250	9510
AT 17.1	0-1	1.0	0.5	0.5	28	0.6	<1	2.9	1.1	1.1	358	3450	704	320	950
AT 17.2	1-10	0.9	<0.3	0.7	21	0.6	<1	2.4	<1	<1	267	1820	365	347	815
AT 17.3	10-20	5.4	5.2	9.4	150	6.2	<1	19	13	15	2320	4190	2250	2030	5550
AT 17.4	20-30	10	6.8	12	170	8.6	<1	23	15	15	3500	9830	3370	2300	11400
AT 20.1	0-2	15	10	22	545	15	14	39	29	29	4020	2830	3580	2700	11900
AT 20.2	2-10	11	9.3	20	170	12	12	34	24	24	3520	3930	2690	2610	7790
AT 20.3	10-20	3.3	14	27	56	7.4	14	45	15	15	5700	3510	5650	2960	4660
AA 33.1	0-1	24	7.5	11	240	8	7.5	23	17	17	8290	11900	11200	2210	8110
AA 33.2	0-10	6.5	5.8	23	100	20	5.7	41	27	27	5600	3540	4930	3570	6740
AA 33.3	10-25	15	7.3	13	76	12	7.5	41	25	25	2680	2830	2670	4520	9900
AA 33.4	25-40	1.3	0.8	0.9	3.2	0.7	2.0	1.8	1.4	1.4	199	28	38	347	648
AA 33.5	40-60	1.1	1.4	0.8	21	0.7	<1	2.5	1.4	1.4	400	14000	1070	476	1030
UKE 3.1	0-0.5	47	8.0	37	460	42	25	49	88	88	9910	71400	7370	7140	41100
UKE 3.2	0.5-1	68	10	30	540	62	25	55	125	130	6580	32500	12050	5590	23300
UKE 3.3	1-8	17	10	25	111	16	16	42	38	38	2350	2760	2300	4640	14400
UKE 3.4	8-12	11	8.6	14	83	10	6.8	35	25	25	2630	5730	2000	5010	8850
UKE 3.5	12-20	2.4	1.5	1.1	11	1.1	<1.3	3.4	3.4	3.4	320	220	234	612	921
UKE 5.1	0-0.5	6.0	6.7	36	55	7	18	24	15	15	8300	52600	826	2590	23000
UKE 5.2	0.5-10	8.9	10	21	95	10	6.1	27	22	22	3170	1910	2230	4090	13000
UKE 5.3	10-30	16	11	19	230	18	13	32	31	31	4630	4040	3450	9290	14400
PA 4.1	0-1	8.7	5.8	11	760	22	1.4	17	22	22	3530	21300	9440	2150	6460
PA 4.2	1-3	13	10	19	1070	14	10	31	39	39	6180	27100	9820	2640	11400
PA 4.3	3-8	13	10	20	460	15	11	38	47	47	5990	5200	8050	2560	13700
PA 4.4	8-15	120	16	27	200	16	15	51	33	33	4130	4870	4100	3130	14400

3.3 River Murray Water Mobilisation Tests

3.3.1 Water quality during River Murray water acid-mobilisation tests

The water quality parameters, pH, redox potential, conductivity, and dissolved oxygen that were measured during the acid-mobilisation test using River Murray water are shown in Table 30-36. These tests were undertaken on 135 of the 150 soil samples. Upon wetting of these soils with River Murray water using a rapid laboratory testing method, 6% had pH <3, 18% had pH <4, 25% had pH <5, 33% had pH <6, 67% had pH <7, and 95% had pH <8.

There were strong relationships between the paste pH (before and after drying) and the initial (30 min) and final pH (24 h) measured in the test water in which the soils were resuspended (Figure 12). In 15% of the tests, the dissolved oxygen concentrations dropped below 2 mg/L and this was reflected by a drop in redox potential (Figure 13). For the waters for which dissolved oxygen remained high (e.g. above 4 mg/L), as expected, there was a significant negative relationship between water pH and redox potential.

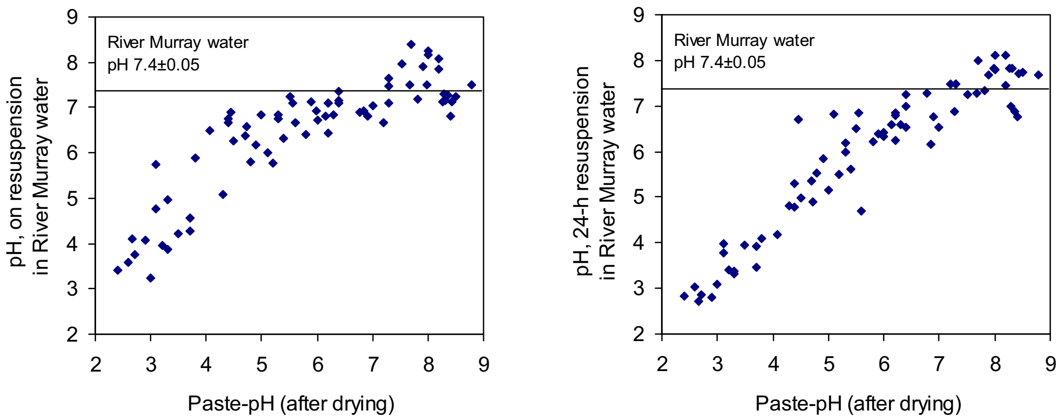


Figure 12. Comparison between paste pH and (i) pH of water following soil-resuspension (30 min) in River Murray water, and (ii) pH of water following 24-h resuspension of soil in River Murray water

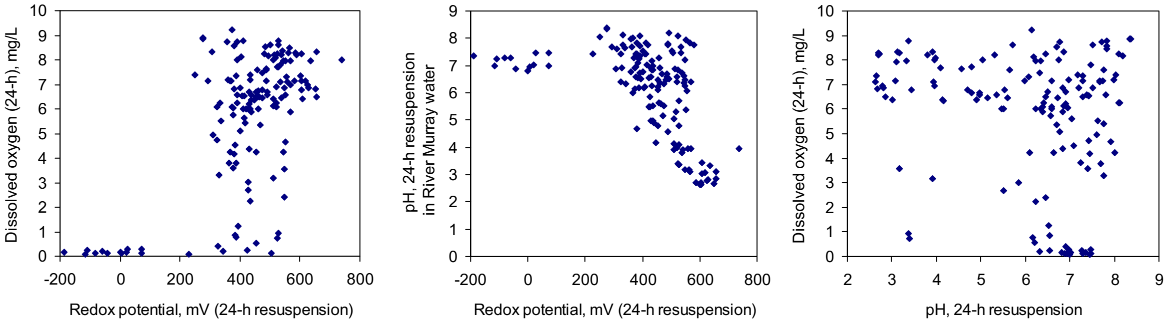


Figure 13. Comparison, following 24-h resuspension of soil in River Murray, between (i) water pH and redox potential, (ii) dissolved oxygen and pH, and (iii) dissolved oxygen and redox potential

Table 30. pH redox potential (Eh), conductivity and dissolved oxygen during the 24-h mobilisation experiments on River Murray samples (above Wellington Weir)

River Murray	Depth,	Soil properties			Parameters during 24-h mobilisation test									
(above Wellington)	cm	Paste pH		Moisture	t = 0.5 h (of mobilisation test)				t = 6 h		t = 24 h (of mobilisation test)			
Site		wet	dry	%	pH	Eh	EC	DO	pH	DO	pH	Eh	EC	D.O
WL 2.1	0-5	4.4	6.2	51	7.1	560	1000	10			6.8	430	1340	4.4
WL 2.2	5-20	7.0		25	7.2	530	780	10			7.1	390	951	4.5
WL 2.3	20-40	5.5		25	NT									
WL 5.3	0-1	2.3		28	3.0	760	1980	8.9			2.7	650	4160	6.8
WL 5.4	1-5	2.8	2.4	48	3.4	750	950	9.7			2.8	630	1820	6.9
WL 5.5	5-20	2.6	2.6	56	3.6	680	1150	11			3.0	610	1840	6.4
WL 6.3	0-1	8.7	8.2	32	7.9	500	6100	11			7.4	230	9.65	0.1
WL 6.4	1-8	7.3	6.8	34	NT									
WL 6.5	8-20	7.4	7.6	40	NT									
WL 7.2	0-3	5.6	5.2	57	5.8	470	1150	9.6	5.7	7.7	5.5	430	1290	2.7
WL 7.3	3-12	7.6	7.4	59	NT									
WL 7.4	12.25	7.3	7.5	42	NT									
WL 8.2	0-1	6.7	3.5	38	7.1	480	2500	9.8	6.8	8.1	6.5	390	3340	1.0
WL 8.3	1-3	4.8	4.3	47	5.1	510	1410	9.7	4.8	7.9	4.8	450	1540	6.7
WL 8.4	3-6	4.6	2.3	53	6.3	490	1230	9.6	5.1	7.9	5.0	430	1430	6.6
WL 8.5	6-25	4.7	5.0	46	6.9	570	804	11			5.2	470	1140	6.5
WL 9.2	0-5	4.7	4.7	34	6.4	590	1360	11			5.4	550	1900	6.6
WL 9.3	5-30	5.6	5.8	37	NT									
WL 11.1	0-5	6.8		26	7.0	580	572	10.6			6.7	470	575	5.4
WL 11.3	10-20	5.0		25	NT									
WL 12.2	1-5	5.3		21	6.8	610	587	10.3			6.5	450	578	6.5
WL 12.3	5-15	5.3	5.6	29	NT									
WL 14.2	0-2	6.2		18	6.9	500	850	9.6			7.3	460	1020	6.5
WL 14.4	2-7	4.9		18	6.6	600	577	10			6.3	480	569	7.5
WL 15.1	0-5	3.2		21	5.5	520	674	10			4.1	510	725	6.4
WL 15.2	5-10	3.9		21	6.5	580	669	10			6.1	450	709	4.2
WL 17.1	0-15	5.7		23	7.1	520	580	9.7			6.9	460	576	6.7

Table 31. pH redox potential (Eh), conductivity and dissolved oxygen during the 24-h mobilisation experiments on Wellington Weir samples

Wellington Weir Site	Depth, cm	Soil properties			Parameters during 24-h mobilisation test									
		Paste pH		Moisture	t = 0.5 h (of mobilisation test)				t = 6 h		t = 24 h (of mobilisation test)			
		wet	dry	%	pH	Eh	EC	D.O	pH	DO	pH	Eh	EC	D.O
WW3A 1.1	0-8	8.0		17	7.2	590	584	9.0			6.4	570	601	5.9
WW3A 1.2	8-15	7.9	8.4	17	7.3	580	585	9.4			6.9	510	613	6.1
WW3A2.1	15-20	7.7		15	7.0	510	597	9.7	8.0	8.9	6.6	520	664	6.1
WW3A 4.1	0-5	7.9		15	7.4	580	575	9.2			7.5	400	607	6.9
WW3A 4.2	15-25	7.6		15	7.9	560	598	9.2			8.0	360	644	7.2
WW 3A 4.5	25-50	4.9		22	7.4	580	611	9.3			7.2	430	626	7.4
WW 8A 2.1	0-5	5.8	5.8	72	6.4	450	1200	9.8	6.2	5.0	6.2	450	1640	0.6
WW 8A 2.2	5-15	5.2	5.0	73	NT									
WW 8A 2.3	15-30	4.2	3.8	78	NT									
WW20A 1.1	0-5	6.9		57	7.0	390	1640	9.3	7.0	5.4	6.9	330	2090	0.4
WW20A 1.2	5-18	5.8	6.0	42	6.7	570	2070	9.0			6.3	340	2670	0.2
WW20C	30-40	4.4	2.2	51	6.6	600	780	9.6	5.4	8.8	5.2	510	1350	8.1
WWBH20 11.1	0-5	8.0	0.0	19	7.5	560	601	8.9	0.0?	0.0?	7.4	410	629	6.5
WWBH20 11.2	5-15	5.0		17	7.1	610	666	9.8			6.1	560	663	7.3

Table 32. pH redox potential (Eh), conductivity and dissolved oxygen during the 24-h mobilisation experiments on Lake Albert samples (part 1)

Lake Albert	Depth,	Soil properties			Parameters during 24-h mobilisation test									
Site	cm	Paste pH		Moisture	t = 0.5 h (of mobilisation test)				t = 6 h		t = 24 h (of mobilisation test)			
		wet	dry	%	pH	Eh	EC	D.O	pH	DO	pH	Eh	EC	D.O
AT 1.1	0-5	7.6		18	7.5	580	627	11			7.4	320	739	4.7
AT 1.3	15-30	7.6		17	NT									
AT 2.1	0-3	8.1		20	8.0	500	674	11			7.8	330	802	3.3
AT 2.2	3-5	6.8		21	7.6	540	710	9.1			7.6	310	853	4.9
AT 2.3	5-20	4.4	3.8	74	5.9	560	1910	11			4.1	530	3490	7.7
AT 2.6	30-35	3.5		18	6.1	450	931	11			4.6	490	1010	7.6
AT 4.1	0-5	7.9		19	7.6	490	644	8.3			7.8	490	690	7.6
AT 6.1	0-2	8.0		17	NT									
AT 7.1	0-5	8.0		18	7.6	550	619	10.7			7.8	420	698	5.4
AT 7.2	5-20	3.6	3.7	68	4.3	540	1.82	9.8	4.0	7.0	3.9	510	2690	3.2
AT 7.3	20-40	5.0	4.3	73	NT									
AT 9.1	0-5	3.3	3.7	60	4.6	640	2290	8.3			3.5	610	5410	6.8
AT 9.2	5-20	2.9	3.0	72	3.2	610	1700	9.9	3.1	8.0	3.1	620	4.87	7.2
AT 10.1	0-5	7.0	6.4	55	7.2	600	1300	11			6.5	420	1730	0.2
AT 10.2	5-15	4.8		61	6.0	530	1420	9.7	5.6	8.0	5.5	480	1660	6.8
AT 11.1	0-5	7.9	4.1	22	7.3	440	739	10	0.0	0.0	7.0	50	931	0.2
AT 11.2	5-50	6.3	6.2	42	6.8	560	641	9.9	7.1	8.8	6.6	490	664	7.2
AT 12.1	0-5	4.2	4.5	6	6.9	590	902	10	7.4	8.8	6.7	480	974	8.5
AT 12.2	5-25	3.9	5.6	22	7.1	490	732	5.4			6.9	310	797	8.3
AT 12.3	25-40	6.9	5.5	60	7.2	580	904	9.8	7.3	8.5	6.5	490	1300	6.7
AT 14.1	0-3	8.5	9.5	17	8.4	460	2210	10	9.2	8.9	8.2	490	2.33	8.2
AT 14.2	3-15	7.6	8.8	19	7.5	510	851	5.2			7.7	290	918	7.2
AT 14.3	15-25	7.5	7.7	54	8.4	410	1750	9.9	8.3	8.2	8.0	370	1860	4.2
AT 14.3	25-30	7.5	3.8	54	7.2	560	726	11			7.0	440	749	7.2
AT 14.4	25-30	8.2	8.2	57	8.1	450	1950	10	8.3	8.2	8.1	390	2500	6.3
AT 14.5	25-30	7.5	7.0	67	NT									

Table 33. pH redox potential (Eh), conductivity and dissolved oxygen during the 24-h mobilisation experiments on Lake Albert samples (part 2)

Lake Albert	Depth,	Soil properties			Parameters during 24-h mobilisation test									
Site	cm	Paste pH		Moisture	t = 0.5 h (of mobilisation test)				t = 6 h		t = 24 h (of mobilisation test)			
		wet	dry	%	pH	Eh	EC	D.O	pH	DO	pH	Eh	EC	D.O
AT 16.1	0-5	8.4	8.0	2	7.5	540	815	10.1	8.3	8.8	7.8	570	868	8.5
AT 16.2	5-20	7.5	8.3	10	7.1	490	678	5.8			7.8	410	688	8.8
AT 16.3	20-45	7.7	8.4	16	7.1	490	899	5.6			7.7	390	913	8.7
AT 16.4	45-75	8.0	0.0	23	8.0	490	1380	10			8.4	280	1410	8.9
AT 17.1	0-1	8.0		19	8.8	490	1770	10			7.9	550	1830	4.7
AT 17.2	1-10	7.6		17	7.9	480	1000	10			8.0	250	1100	7.4
AT 17.3	10-20	6.7	7.3	65	NT									
AT 17.4	20-30	7.0	8.0	64	NT									
AT 18.1	0-8	9.1	9.5	11	7.2	480	417	5.6			7.4	390	973	6.6
AT 18.2	18-28	8.2	8.4	18	6.8	430	983	5.4			6.8	390	1010	8.0
AT 18.3	28-40	7.6	8.3	21	7.2	500	647	6.2			7.8	380	679	8.6
AT 19.1	0-8	7.9	8.5	1	7.2	550	1230	9.8	8.5	8.7	7.8	580	1540	7.1
AT 19.2	8-18	6.8	6.8	39	6.9	510	1070	7.3			7.3	390	1610	7.4
AT 19.3	18-28	3.3		22	5.3	520	874	5.8			4.0	740	992	8.0
AT 20.1	0-2	7.5	7.8	12	7.2	510	626	9.5			7.4	-190	1360	0.2
AT 20.2	2-10	6.3		6	6.7	490	1855	8.3			6.5	550	2650	2.4
AT 20.3	10-20		8.2	7.9	8.3	440	1130	8.4			8.1	530	1540	8.3
AT 21.1	0-1	6.9	6.9	8	6.9	540	4350	11			6.2	390	5300	0.8
AT 21.2	1-10	7.5	7.3	43	7.5	480	1380	8.2			7.5	540	1540	7.8

Table 34. pH redox potential (Eh), conductivity and dissolved oxygen during the 24-h mobilisation experiments on Lake Alexandrina samples

Lake Alexandrina	Depth,	Soil properties			Parameters during 24-h mobilisation test									
Site	cm	Paste pH		Moisture	t = 0.5 h (of mobilisation test)				t = 6 h		t = 24 h (of mobilisation test)			
		wet	dry	%	pH	Eh	EC	D.O	pH	DO	pH	Eh	EC	D.O
AA 3	5-5.5	7.5		9	7.4	600	944	10			7.2	550	1034	6.9
AA 8.1	0-5	7.7		19	7.3	530	587	11			6.9	520	602	6.9
AA 8.2	5-20	6.4		24	7.3	550	602	9.0			6.9	430	616	6.2
AA 9.1	0-5	8.1		18	7.3	510	585	8.6			6.7	540	602	6.5
AA10.2	10-30	5.5		28	6.5	600	678	11			5.7	530	713	8.6
AA 10.1	0-10	7.4		29	7.4	580	639	11			7.0	420	785	5.6
AA 11.1	0-3	7.5		22	7.1	570	618	11			6.4	460	629	6.0
AA 11.2	3-10	4.1		21	6.7	510	648	8.4			6.5	480	651	8.2
AA 12.1	0-5	7.9		21	7.3	580	610	11			6.6	430	637	6.0
AA 12.2	5-20	5.8		20	NT									
AA 13.2	3-15	3.2	3.1	33	4.8	600	1170	11			3.8	540	1290	8.2
AA 14.2	2-7	7.6		18	NT									
AA 15.1	0-3	8.1		18	NT									
AA 18.2	2-12	7.9		16	7.4	600	635	11			7.3	370	712	7.2
AA 19.1	0-5	9.3		17	7.6	540	700	11			8.1	330	823	6.3
AA 20.1	0-5	7.8		20	7.6	480	659	8.6			7.4	380	767	4.2
AA 20.2	5-20	3.2	3.1	30	5.8	450	903	8.3			4.0	520	1020	8.1
AA 22.1	0-5	7.8	7.4	60	NT									
AA 29.5	0-3	2.7		1	4.2	660	1570	6.3			3.9	540	1960	8.4
AA 29.6	3-10	2.1		6	4.9	680	863	10			4.4	560	905	8.0
AA 30.1	0-0.05	8.6		16	7.9	590	2330	11			7.7	360	2420	3.8
AA 30.2	0.05-20	7.5		16	7.8	580	755	11			7.6	340	822	5.5
AA 31.3	0-10	6.8	6.2	29	7.1	530	748	10			6.8	360	811	8.7
AA 31.5	10-18	6.8		25	7.6	440	750	10	7.3	8.1	7.4	380	765	3.6
AA 33.1	0-1	6.2	3.6	44	6.8	390	10700	10	6.9	5.7	7.5	50	14700	0.2
AA 33.2	0-10	2.4	2.7	70	3.8	650	4290	10			2.9	660	8700	6.5
AA 33.3	10-25	2.3	2.9	72	4.1	640	1540	9.7	2.9	8.3	2.8	630	3320	7.0
AA 33.4	25-40	4.5		20	6.8	560	672	10			6.3	550	738	8.0
AA 33.5	40-60	7.4		19	7.3	550	648	6.8	8.4	8.8	7.5	500	708	8.6
AA 34 (MBO)	0-10	7.1	7.3	76	7.6	490	5770	10			7.5	510	9910	0.1

Table 35. pH redox potential (Eh), conductivity and dissolved oxygen during the 24-h mobilisation experiments on wetland samples from Ukee and Jury Swamp

Wetland Sites at	Depth,	Soil properties			Parameters during 24-h mobilisation test									
Ukee and Jury Swamp	cm	Paste pH		Moisture	t = 0.5 h (of mobilisation test)				t = 6 h		t = 24 h (of mobilisation test)			
		wet	dry	%	pH	Eh	EC	D.O	pH	DO	pH	Eh	EC	D.O
UKE 1.1	0-10	7.0	6.9	38	7.1	500	642	9.9	7.0	8.0	6.9	380	699	6.1
UKE 1.2	10-30	6.4	6.3	48	6.8	510	622	9.7	6.6	8.0	6.6	380	698	5.8
UKE 2.1	0-5	6.7	6.2	65	6.4	540	654	9.7	6.3	7.9	6.2	430	696	2.3
UKE 2.2	5-20	7.2	6.9	39	6.8	500	643	9.5	6.9	7.5	6.8	400	709	5.1
UKE 3.1	0-0.5	3.2	3.3	57	3.9	640	733	10			3.4	530	8800	8.8
UKE 3.2	0.5-1	2.7		26	3.4	670	944	9.7	3.5	8.7	3.2	560	12540	8.3
UKE 3.3	1-8	2.4		10	2.7	630	2770	10	2.6	7.7	2.6	600	3820	7.2
UKE 3.4	8-12	3.3	1.8	30	4.2	530	1360	10	4.0	7.7	4.0	560	1820	7.0
UKE 3.5	12-20	3.9		5	6.9	570	601	10			6.1	370	610	9.2
UKE 5.1	0-0.5	2.7		12	4.3	590	1680	10	3.2	8.1	3.2	550	3840	3.6
UKE 5.2	0.5-10	2.6		8	4.1	680	1830	10			3.1	570	3890	7.9
UKE 5.3	10-30	5.3	5.3	32	6.7	590	617	10			6.2	410	720	8.1
JUR 2.3	0-2	2.8		11	3.3	730	1520	4.6			2.7	590	2920	8.3
JUR 2.4&5	2-10	2.9	2.7	33	4.1	650	937	11			2.7	600	2900	8.2
JUR 2.6&7	10-40	4.4	4.4	46	6.8	610	639	11			4.8	530	11.5	7.7
JUR 6.5	40-60	5.7	5.4	73	6.3	620	3030	11			5.6	470	4270	6.5

Table 36. pH redox potential (Eh), conductivity and dissolved oxygen during the 24-h mobilisation experiments on wetland samples from Murrundi, Paiwalla, Riverglades, Swanport

Wetlands	Depth,	Soil properties			Parameters during 24-h mobilisation test									
Site	cm	Paste pH		Moisture	t = 0.5 h (of mobilisation test)				t = 6 h		t = 24 h (of mobilisation test)			
		wet	dry	%	pH	Eh	EC	D.O	pH	DO	pH	Eh	EC	D.O
MUR 1.2	30-40	4.0	4.1	44	6.5	550	869	8.5			4.2	450	1987	6.4
MUR 1.3	40-70	4.5	2.4	35	5.9	530	997	9.9	5.5	8.1	5.5	430	1060	6.0
MUR 2.2	5-10	4.3	4.7	30	6.6	500	687	10			4.9	440	925	6.4
MUR 2.3	10-45	5.1	5.1	39	6.0	520	683	9.9	5.8	8.1	6.8	440	682	5.9
MUR 2.4	45-60	5.5	4.9	74	6.2	500	1092	9.5	6.1	7.2	5.8	430	1196	3.0
MUR 3.1	0-15	6.5		51	6.4	510	586	9.9	6.3	8.1	6.2	410	572	6.0
MUR 3.2	15-30	5.8	5.6	82	6.7	430	912	9.2	5.9	7.4	4.7	380	1044	6.8
PA 4.1	0-1	6.9	6.4	4	7.4	560	2100	11			7.0	-120	5970	0.1
PA 4.2	1-3	7.9	7.7	4	7.5	540	2400	11			7.3	-80	11070	0.1
PA 4.3	3-8	7.4	7.2	10	7.6	460	12940	10	7.3	8.0	6.9	0	16630	0.1
PA 4.4	8-15	6.0	5.9	29	7.1	550	1262	11			6.4	320	2500	6.1
PA 4.5	15-50	5.5	5.3	41	6.8	570	1289	11			6.0	370	1994	7.1
RIV 3.2	0-1	7.2	7.3	8	7.1	520	2700	11			6.9	-40	4030	0.1
RIV 3.4	1-10	6.7		18	6.7	500	3010	8.3			6.6	550	5220	4.2
RIV 3.5	10-20	7.5	7.9	53	7.9	490	1910	8.6			7.7	530	2510	7.1
RIV 4.2	0.02-2	7.8	3.8	11	8.0	480	38850	5.7			7.3	-80	239900	0.2
RIV 4.3	2-10	5.0	6.0	42	6.9	500	9020	6.1			6.4	520	13700	6.3
RIV 4.4	10-30	8.2	8.0	53	8.2	480	3	10	8.0	8.3	7.8	490	4080	6.6
SPM 1.1	0-0.5	3.3	1.6	3	4.0	640	1935	11			3.4	530	3405	0.8
SPM 1.3	5-10	3.3	3.3	38	5.0	630	786	8.9			3.3	630	1216	8.0

3.3.2 Selection of samples for investigating nutrient and metal remobilisation

The samples for investigation of nutrient and metal remobilisation were selected based on the pH decrease that occurred in the acid-mobilisation (pH, alkalinity/acidity) tests performed on the 135 samples (Table 30-36). Of these samples, the River Murray water pH (after 24 h) had dropped to pH≤ 3 for 6%, pH≤ 4 for 15%, pH≤ 5 for 24%, and pH≤ 6 for 32% of the samples, respectively. Because just one of the 150 soil samples collected was classified as an MBO material, it was not used in the nutrient and metal mobilisation assessment. The pH of the MBO material was greater than pH 7 when it was wet, dry or resuspended in River Murray water. Only sulfidic and sulfuric soils were used for the subsequent tests.

It is important to note that, as a consequence of the accelerated drying procedure not effectively mimicking the drying process that was expected to occur if the soils dried naturally, the pHs of all of the sulfidic samples (i.e. those that would go to pH<4 if suitable conditions existed, Table 20), were significantly greater (less acidic) than what would be expected if these soils had dried naturally over a longer period of time. Therefore, the results presented in this study are biased towards a low estimation of acidification, as the sulfidic samples comprised 53% of the total samples studied.

All soil samples that resulted in the pH of the River Murray water to drop below pH 6 after 24 h, were used for nutrient and metal remobilisation test (except for two Ukee samples, as there were many Ukee samples that gave pH<6). A total of 47 samples (35% of the total) were selected, including a few with pH 6-6.5 (Table 37).

3.3.3 pH, alkalinity and acidity during River Murray water mobilisation tests

The water alkalinity, concentrations of nitrate/nitrite, phosphate, chloride, sulfate and organic and inorganic carbon measured at the completion of the mobilisation tests using River Murray water are shown in Table 38-41). As the paste pH of the resuspended soils increased, the acidity decreased and the alkalinity increased in the water mixture (Figure 14).

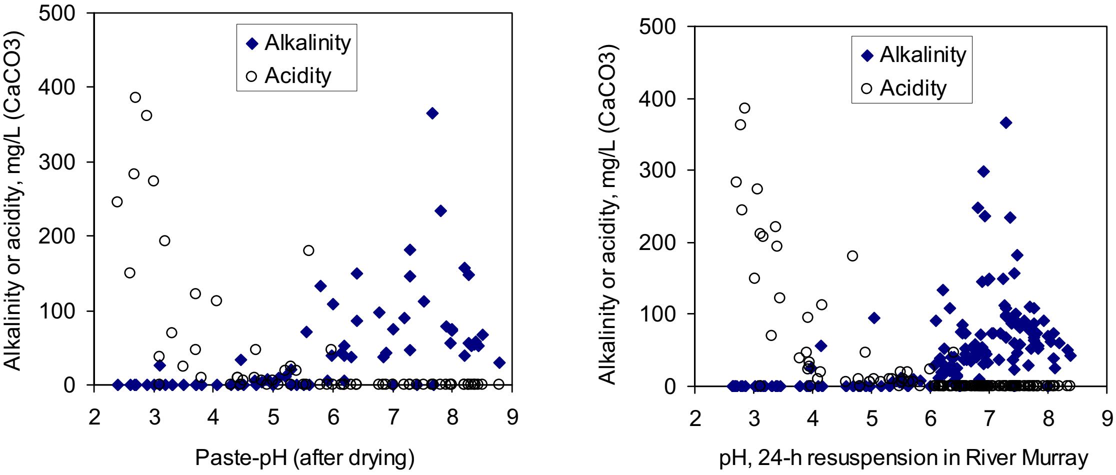


Figure 14. Comparison, of water alkalinity and acidity with (i) paste pH of soil and (ii) water pH, following 24-h resuspension of soil in River Murray.

The alkalinity of water collected from seven locations in the River Murray system (Figure 2) ranged from 40 to 230 mg/L $CaCO_3$, except for the Riverglades wetland which had a small amount of acidity (5 mg/L $CaCO_3$) (Table 11). The mobilisation tests indicated that mixing of River Murray water (alkalinity = 46±2 mg/L) with the various soils will result in large changes to the water alkalinity, in many cases making the water acidic. These data need to be evaluated in terms of the predicted volumes of input and receiving water, and net changes to the alkalinity of the river or lake water due to inputs of water from re-wetted soils.

Table 37. Samples selected for investigating metal and nutrient mobilisation based on water pH after 24 h

Area	Site	Depth, cm	GPS Location (Easting, Northing)		Paste pH	pH during mobilisation	
						0.5 h	24 h
Ukee	UKE 3.3	1-8	344455	6111878	2.4	2.7	2.6
Murray River	WL 5.3	0-1	346104	6109177	2.3	3.0	2.7
Jury Swamp	JUR 2.3	0-2	346469	6119696	2.8	3.3	2.7
Jury Swamp	JUR 2.4&5	2-10	346469	6119696	2.9	4.1	2.7
Lake Alexandrina	AA 33.3	10-25	319041	6060550	2.3	4.1	2.8
Murray River	WL 5.4	1-5	346104	6109177	2.8	3.4	2.8
Lake Alexandrina	AA 33.2	0-10	319041	6060550	2.4	3.8	2.9
Murray River	WL 5.5	5-20	346932	6136814	2.6	3.6	3.0
Lake Albert	AT 9.2	5-20	341289	6056481	2.9	3.2	3.1
Ukee	UKE 5.2	0.5-10	344415	6111993	2.6	4.1	3.1
Ukee	UKE 3.2	0.5-1	344455	6111878	2.7	3.4	3.2
Swanport	SPM1.3	5-10	346521	6109005	3.3	5.0	3.3
Ukee	UKE 3.1	0-0.5	344455	6111878	3.2	3.9	3.4
Swanport	SPM 1.1	0-0.5	346521	6109005	3.3	4.0	3.4
Lake Albert	AT 9.1	0-5	341289	6056481	3.3	4.6	3.5
Lake Alexandrina	AA 13.2	3-15	316052	6079413	3.2	4.8	3.8
Lake Albert	AT 7.2	5-20	341103	6056622	3.6	4.3	3.9
Lake Alexandrina	AA 29.5	0-3	321236	6070291	2.7	4.2	3.9
Lake Albert	AT 19.3	18-28	341105	6056636	3.3	5.3	4.0
Ukee	UKE 3.4	8-12	344455	6111878	3.3	4.1	4.0
Lake Alexandrina	AA 20.2	5-20	322798	6069894	3.2	5.8	4.0
Lake Albert	AT 2.3	5-20	349983	6061211	4.4	5.9	4.1
Murray River	WL 15.1	0-5	373632	6195697	3.2	5.5	4.1
Murrundi	MUR 1.2	30-40	352468	6091006	4.0	6.5	4.2
Lake Alexandrina	AA 29.6	3-10	321288	6070415	2.1	4.9	4.4
Lake Albert	AT 2.6	30-35	349983	6061211	3.5	6.1	4.6
Murrundi	MUR 3.2	15-30	371013	6184000	5.8	6.7	4.7
Jury Swamp	JUR 2.6&7	10-40	346469	6119696	4.4	6.8	4.8
Murray River	WL 8.3	1-3	368747	6150680	4.8	5.1	4.8
Murrundi	MUR 2.2	5-10	352564	6090525	4.3	6.6	4.9
Murray River	WL 8.4	3-6	368747	6150680	4.6	6.3	5.0
Murray River	WL 8.5	6-25	368740	6150647	4.7	6.9	5.2
Wellington Weir	WW20C	30-40	347191	6079348	4.4	6.6	5.2
Murray River	WL 9.2	0-5	368740	6150647	4.7	6.4	5.4
Murrundi	MUR 1.3	40-70	352468	6091006	4.5	5.9	5.5
Murray River	WL 7.2	0-3	347012	6136790	5.6	5.8	5.5
Lake Albert	AT 10.2	5-15	335000	6067500	4.8	6.0	5.5
Jury Swamp	JUR 6.5	40-60	346480	6119931	5.7	6.3	5.6
Lake Alexandrina	AA10.2	10-30	339385	6089959	5.5	6.5	5.7
Murrundi	MUR 2.4	45-60	352564	6090525	5.5	6.2	5.8
Wellington Weir	WWBH20B 1.2	5-15	347191	6080759	5.0	7.1	6.1
Murray River	WL 15.2	5-10	373472	6182897	3.9	6.5	6.1
Ukee	UKE 3.5	12-20	344455	6111878	3.9	6.9	6.1
Lake Albert	AT 21.1	0-1	335274	6067653	6.9	6.9	6.2
Ukee	UKE 5.3	10-30	344415	6111993	5.3	6.7	6.2
Wellington Weir	WW 8A 2.1	0-5	346419	6079832	5.8	6.4	6.2
Paiwalla	PA 4.4	8-15	351475	6121259	6.0	7.1	6.4

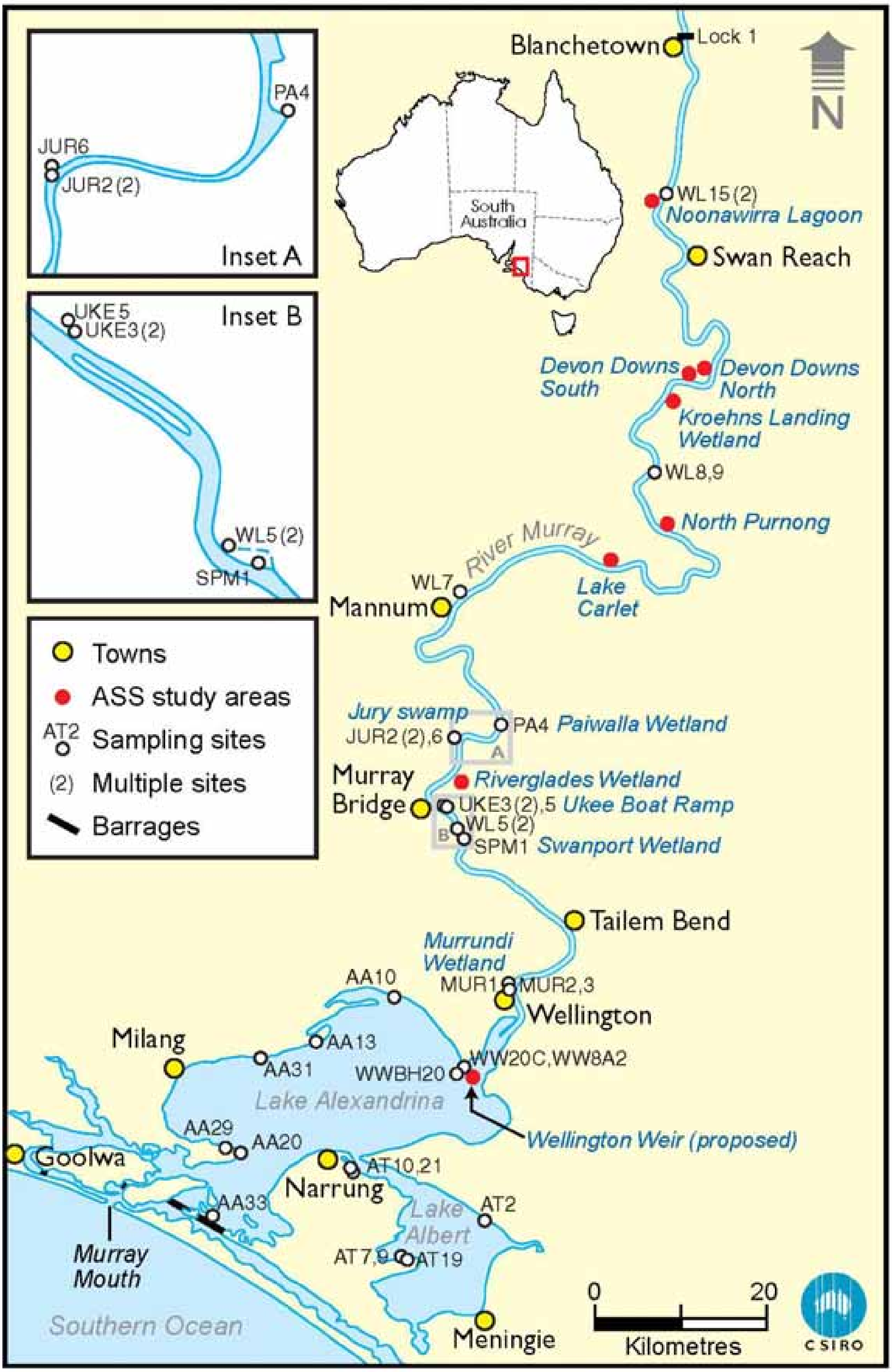


Figure 15. Sites of soil samples used for metal and nutrient mobilisation tests (Table 37)

3.3.4 Anions, nutrients, and carbon during River Murray water mobilisation tests

The chloride and sulfate concentrations of the initial River Murray water were 135 and 26 mg/L, respectively (Table 11). The highest concentrations of were chloride and sulfate measured in the mobilisation tests were (maximum, mean ± standard deviation) 5310 (470 ± 1100) mg/L and 2060 (710 ± 640) mg/L, respectively (Table 38-41). The greater than 30-fold increase in sulfate concentration (mobilised from the soils) may indicate this could be used to help trace inputs of water from oxidised soils. There was a weak relationship between sulfate concentration and the pH of the test water (Appendix C). It may be possible to utilise stable isotopes of sulfur to help trace the origin of the sulfate (river-derived or ASS-derived) in the River Murray system, provided that the end-members derived from different soils are established.

Table 38. Concentrations of alkalinity, acidity, sulfate, chloride, nitrite, nitrate, phosphate, total organic carbon and total organic carbon for the 24-h mobilisation experiments on River Murray and Wellington Weir samples

River Murray and Wellington Weir	Alkalinity mg/L [b]	Acidity mg/L	Sulfate mg/L	Chloride mg/L	Nitrite-N mg/L	Nitrate-N mg/L	Phosphate mg/L [c]	TOC mg/L	TIC mg/L
WL 2.1	5	---	---	---	---	---	---	---	---
WL 2.2	73	---	---	---	---	---	---	---	---
WL 5.3	---	508	2060	210	<0.010	0.011	0.012	87	2
WL 5.4	---	245	498	152	<0.010	0.027	0.031	64	1
WL 5.5	---	150	625	168	<0.010	0.03	<0.010	30	3
WL 6.3	157	---	---	---	---	---	---	---	---
WL 7.2	11	19	---	---	---	---	---	---	---
WL 8.2	74.5	---	---	---	---	---	---	---	---
WL 8.3	<1	<1	---	---	---	---	---	---	---
WL 8.4	---	5.0	---	---	---	---	---	---	---
WL 8.5	<1	5	---	---	---	---	---	---	---
WL 9.2	5	9	281	538	0.027	0.082	0.022	9	1
WL 11.1	41	---	---	---	---	---	---	---	---
WL 12.2	26	---	---	---	---	---	---	---	---
WL 14.2	96	---	---	---	---	---	---	---	---
WL 14.4	21	---	---	---	---	---	---	---	---
WL 15.1	57	19	134	134	0.011	0.015	0.018	2	8
WL 15.2	91	---	---	---	---	---	---	---	---
WL 17.1	31	---	---	---	---	---	---	---	---
WW3A 1.2	54	---	---	---	---	---	---	---	---
WW3A 2.1	73	---	---	---	---	---	---	---	---
WW3A 4.1	82	---	---	---	---	---	---	---	---
WW3A 4.2	70	---	---	---	---	---	---	---	---
WW3A 4.5	37	---	---	---	---	---	---	---	---
WW8A 2.1	133	---	---	---	---	---	---	---	---
WW20A 1.1	298	---	---	---	---	---	---	---	---
WW20A1.2	108	---	---	---	---	---	---	---	---
WW 20C	---	9.0	---	---	---	---	---	---	---
WWBH20 11.1	---	---	---	---	---	---	---	---	---
WWBH20 11.2	29	---	56	159	0.805	0.128	0.034	7	6

: [a] --- = not analysed. [b] Alkalinity (total) = bicarbonate alkalinity (hydroxide and carbonate alkalinity <1 mg/L). [c] Phosphate = reactive phosphorus. [d] River Murray at Morgan's Lagoon (mean of seven bulk sample). [e] FB = field blank (collection site).

Table 39. Concentrations of alkalinity, acidity, sulfate, chloride, nitrite, nitrate, phosphate, total organic carbon and total organic carbon for the 24-h mobilisation experiments on Lake Albert samples (part 1)

Lake Albert	Alkalinity mg/L [b]	Acidity mg/L	Sulfate mg/L	Chloride mg/L	Nitrite-N mg/L	Nitrate-N mg/L	Phosphate mg/L [c]	TOC mg/L	TIC mg/L
AT 1.1	99	---	---	---	---	---	---	---	---
AT 2.1	108	---	---	---	---	---	---	---	---
AT 2.2	91	---	---	---	---	---	---	---	---
AT 2.3	<1	9	---	---	---	---	---	---	---
AT 2.6	<1	5	210	168	<0.010	0.091	<0.010	3	<1
AT 4.1	64	---	---	---	---	---	---	---	---
AT 7.1	87	---	---	---	---	---	---	---	---
AT 7.2	---	47	1180	234	<0.010	0.036	<0.010	23	<1
AT 9.1	---	122	---	---	---	---	---	---	---
AT 9.2	---	273	---	---	---	---	---	---	---
AT 10.1	86	---	---	---	---	---	---	---	---
AT 10.2	6	9	---	---	---	---	---	---	---
AT 11.1	149	---	---	---	---	---	---	---	---
AT 14.4	44	---	---	---	---	---	---	---	---
AT 12.1	34	---	---	---	---	---	---	---	---
AT 12.2	72	---	---	---	---	---	---	---	---
AT 12.3	<1	---	---	---	---	---	---	---	---
AT 14.1	60	---	---	---	---	---	---	---	---
AT 14.2	30	---	---	---	---	---	---	---	---
AT 14.3	33	---	---	---	---	---	---	---	---
AT 14.3	39	---	---	---	---	---	---	---	---
AT 11.2	<1	---	---	---	---	---	---	---	---
AT 16.1	56	---	---	---	---	---	---	---	---
AT 16.2	56	---	---	---	---	---	---	---	---
AT 16.3	52	---	---	---	---	---	---	---	---
AT 16.4	46.5	---	---	---	---	---	---	---	---
AT 17.1	92	---	---	---	---	---	---	---	---
AT 17.2	62	---	---	---	---	---	---	---	---
AT 18.1	87	---	---	---	---	---	---	---	---
AT 18.2	58	---	---	---	---	---	---	---	---
AT 18.3	53	---	---	---	---	---	---	---	---
AT 19.1	68	---	---	---	---	---	---	---	---
AT 19.2	98	---	---	---	---	---	---	---	---
AT 19.3	---	28	---	---	---	---	---	---	---
AT 20.1	235	---	---	---	---	---	---	---	---
AT 20.2	14	---	---	---	---	---	---	---	---
AT 20.3	73	---	---	---	---	---	---	---	---
AT 20.3	150	---	---	---	---	---	---	---	---
AT 21.1	38	---	---	---	---	---	---	---	---
AT 21.2	47	---	---	---	---	---	---	---	---

: [a] --- = not analysed. [b] Alkalinity (total) = bicarbonate alkalinity (hydroxide and carbonate alkalinity <1 mg/L). [c] Phosphate = reactive phosphorus. [d] River Murray at Morgan's Lagoon (mean of seven bulk sample). [e] FB = field blank (collection site).

The total nitrate and phosphate concentrations of the initial River Murray water were <0.1 and <0.01 mg/L, respectively (Table 11). The highest concentrations of total nitrate and phosphate measured in the mobilisation tests were (maximum, mean ± standard deviation) 2.9 (0.3 ± 0.7) mg/L and 0.1 (0.02 ± 0.02) mg/L, respectively (Table 38-41).. The TOC and TIC concentrations of the initial River Murray water were 3-4 and 8-9 mg/L, respectively (Table 11). The highest concentrations of TOC and TIC measured in the mobilisation tests were (maximum, mean±standard deviation) 208 (46 ± 59) mg/L and 8 (2.8 ± 2.3) mg/L, respectively (Table 38-41). This indicates that there could be high inputs of TOC and DOC due to the re-wetting of some soils and these inputs could increase the biological oxygen demand and contribute to decreased dissolved oxygen concentrations in the waters. The dilution of the soil re-wetting water by River Murray water upon entry into the River Murray is likely to be quite significant (e.g. 10- to 100-fold) and the inputs of these anions at these concentrations are not likely to significantly affect water quality. The relationships between these parameters were not significant (Figure 16).

Table 40. Concentrations of alkalinity, acidity, sulfate, chloride, nitrite, nitrate, phosphate, total organic carbon and total organic carbon for the 24-h mobilisation experiments on Lake Albert (part 2) and Lake Alexandrina samples

Lake Albert	**Alkalinity**	**Acidity**	**Sulfate**	**Chloride**	**Nitrite-N**	**Nitrate-N**	**Phosphate**	**TOC**	**TIC**
	mg/L [b]	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L [c]**	**mg/L**	**mg/L**
Lake Alexandrina									
AA3	74	---	---	---	---	---	---	---	---
AA 8.1	48	---	---	---	---	---	---	---	---
AA 8.2	42	---	---	---	---	---	---	---	---
AA 9.1	54	---	---	---	---	---	---	---	---
AA 10.2	9	5	---	---	---	---	---	---	---
AA1 10.1	73	---	---	---	---	---	---	---	---
AA 11.1	41	---	---	---	---	---	---	---	---
AA 11.2	16	---	---	---	---	---	---	---	---
AA 12.1	52	---	---	---	---	---	---	---	---
AA 13.2	---	38	358	161	<0.010	0.046	<0.010	7	<1
AA 18.2	67	---	---	---	---	---	---	---	---
AA 19.1	25	---	---	---	---	---	---	---	---
AA 20.1	60	---	---	---	---	---	---	---	---
AA 20.2	---	---	---	---	0.156	0.146	---	7.5	---
AA 29.5	---	113	757	218	<0.010	0.317	<0.010	19	1
AA 29.6	---	---	---	---	---	0.036	---	13	---
AA 30.1	110	---	---	---	---	---	---	---	---
AA 30.2	85	---	---	---	---	---	---	---	---
AA 31.3	40	---	---	---	---	---	---	---	---
AA 31.5	37	---	---	---	---	---	---	---	---
AA 33.1	95	---	---	---	---	---	---	---	---
AA 33.2	---	386	---	---	---	---	---	---	---
AA 33.3	---	362	---	---	---	---	---	---	---
AA 33.4	29.5	---	---	---	---	---	---	---	---
AA 3.5	58	---	---	---	---	---	---	---	---
AA 34 (MBO)	182	---	---	---	---	---	---	---	---

: [a] --- = not analysed. [b] Alkalinity (total) = bicarbonate alkalinity (hydroxide and carbonate alkalinity <1 mg/L). [c] Phosphate = reactive phosphorus. [d] River Murray at Morgan's Lagoon (mean of seven bulk sample). [e] FB = field blank (collection site).

Table 41. Concentrations of alkalinity, acidity, sulfate, chloride, nitrite, nitrate, phosphate, total organic carbon and total organic carbon for the 24-h mobilisation experiments on wetlands samples from Ukee, Jury Swamp, Murrundi, Morgans, Paiwalla, Riverglades, and Swanport

Wetlands	Alkalinity mg/L [b]	Acidity mg/L	Sulfate mg/L	Chloride mg/L	Nitrite-N mg/L	Nitrate-N mg/L	Phosphate mg/L [c]	TOC mg/L	TIC mg/L
UKE 1.1	46	---	---	---	---	---	---	---	---
UKE 1.2	37	---	---	---	---	---	---	---	---
UKE 2.1	52	---	---	---	---	---	---	---	---
UKE 2.2	44	---	---	---	---	---	---	---	---
UKE 3.1	---	2130	---	---	---	---	---	---	---
UKE 3.2	---	3140	---	---	---	---	---	---	---
UKE 3.3	---	690	---	---	---	---	---	---	---
UKE 3.4	---	28.5	---	---	---	---	---	---	---
UKE 3.5	11	---	---	---	---	---	---	---	---
UKE 5.1	---	207	---	---	---	---	---	---	---
UKE 5.2	---	212	1360	565	0.01	2.91	0.02	208	5
UKE 5.3	20	---	---	---	---	---	---	---	---
JUR 2.3	---	628	---	---	---	---	---	---	---
JUR 2.4&5	---	282	791	476	<0.010	<0.010	0.022	95	3
JUR 2.6&7	<1	9	---	---	---	---	---	---	---
JUR 6.5	<1	19	---	---	---	---	---	---	---
MUR 1.3	5.0								
MUR 1.2	<1	47	---	---	---	---	---	---	---
MUR 2.2	<1	<1	212	192	0.012	0.153	0.013	12	<1
MUR 2.3	10	<1	---	---	---	---	---	---	---
MUR 2.4	8	<1	---	---	---	---	---	---	---
MUR 3.1	17	---	---	---	---	---	---	---	---
MUR 3.2	<1	180	---	---	---	---	---	---	---
PA 4.1	1710	---	---	---	---	---	---	---	---
PA 4.2	366	---	---	---	---	---	---	---	---
PA 4.3	243	---	---	---	---	---	---	---	---
PA 4.4	6	---	---	---	---	---	---	---	---
PA 4.5	<1	24	---	---	---	---	---	---	---
RIV 3.2	146	---	---	---	---	---	---	---	---
RIV 3.4	37	---	---	---	---	---	---	---	---
RIV 3.5	78	---	---	---	---	---	---	---	---
RIV 4.2	110.5	---	---	---	---	---	---	---	---
RIV 4.3	40	47	1130	5310	0.042	1.72	0.101	24	7
RIV 4.4	74	---	---	---	---	---	---	---	---
SPM1.1	---	207	1930	212	---	0.077	---	153	4.5
SPM 1.3	---	70	---	---	---	---	---	---	---

: [a] --- = not analysed. [b] Alkalinity (total) = bicarbonate alkalinity (hydroxide and carbonate alkalinity <1 mg/L). [c] Phosphate = reactive phosphorus. [d] River Murray at Morgan's Lagoon (mean of seven bulk sample). [e] FB = field blank (collection site).

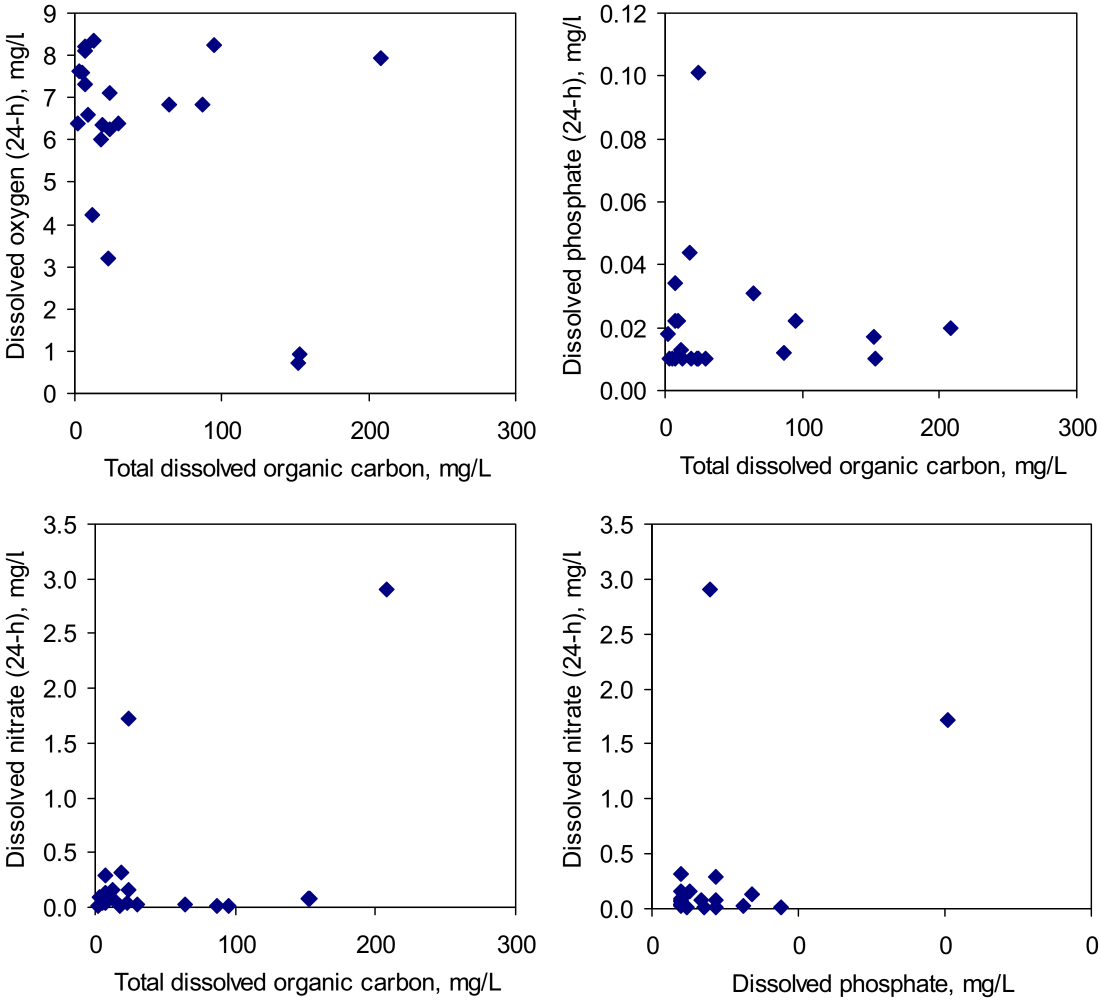


Figure 16. Comparison of water alkalinity and acidity with (i) paste pH of soil and (ii) water pH, following 24-h resuspension of soil in River Murray,

3.3.5 Kinetics of pH-change and metal release during mobilisation tests.

The kinetics of metal mobilisation was initially investigated for six soils over 0.1, 1, 6, and 24 h (Table 42). In general, more than 50% of the amount of each metal released after 24-h, was released within 10 min of contact of the soils with the River Murray water (shorter times were not investigated). After 6 h greater than 85% had been released (Figure 17, Appendix C). These tests indicated that the metal release is expected to be rapid initially, with a slower release continuing via a wide range of processes, i.e. a 2-step desorption process (Jenne, 1995). The initial, rapid, metal release was likely to involve significant amounts of re-dissolution of metal salts that had formed relatively recently at the soil surface through the re-precipitation of metals that had been from the soil matrix as the soils acidified over much longer time periods. The desorption of metals from soil phases that bind metals weakly will contribute more to both the rapid and the slower metal-release processes, and oxidative-dissolution of soil phases is expected to contribute only significantly to the slower metal-release processes.

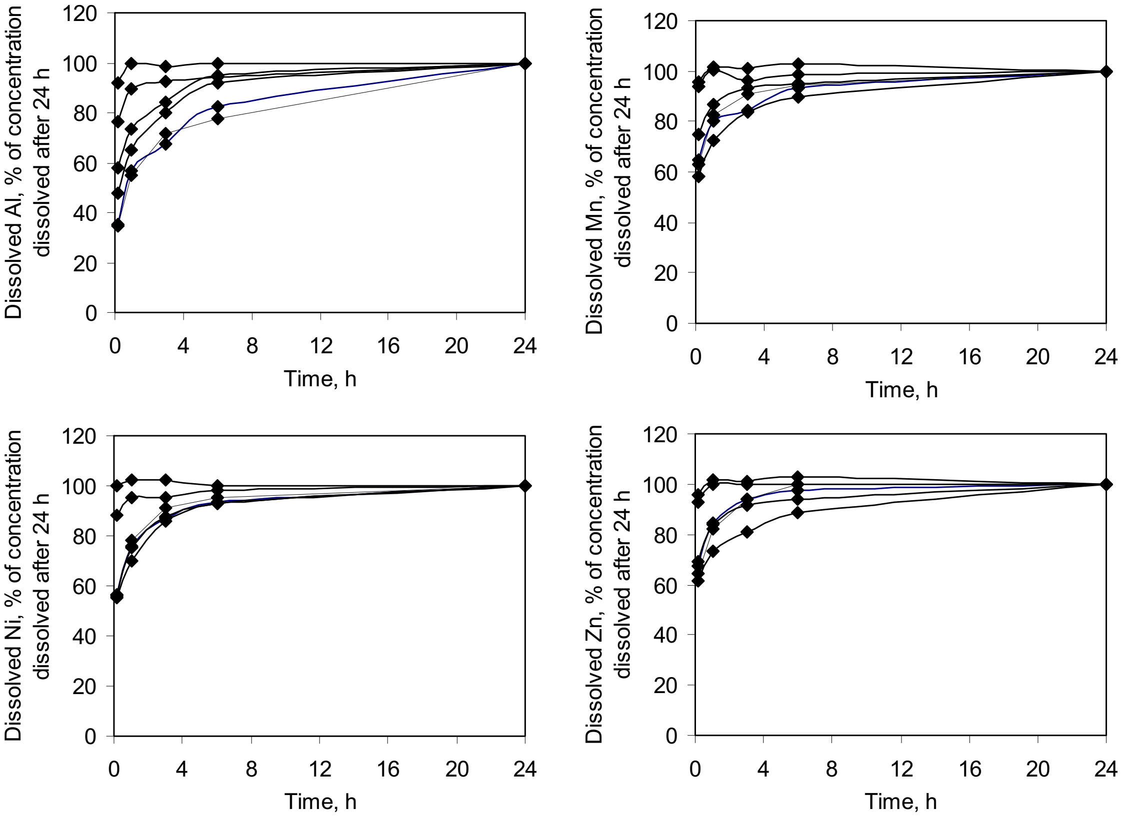


Figure 17. Kinetics of metal release as a percentage of dissolved metal concentration (Table 40) measured after 24 h.

3.3.6 Metal release during River Murray water mobilisation tests

For each soil tested, the concentrations of major and minor cations (Na, K, Ca, Mg, Al and Fe, in mg/L) and trace metals (µg/L) released from the soils to the River Murray waters are shown in Table 43-45. The concentrations of major and trace elements released varied over several orders of magnitude. The amount of metals released to the dissolved phase, as a percentage of the particulate metal concentrations measured in the soils (Tables 22-28), was (mean ± SD %) 2.2 ± 3.2 (for As), 5.2 ± 12 (Cd), 19 ± 22 (Co), 1.6 ± 3.6 (Cr), 3.5 ± 5.3 (Cu), 35 ± 32 (Mn), 22 ± 27 (Ni), 0.3 ± 0.4 (Pb), 2.1 ± 4.5 (V) and 16 ± 24% (Zn) (Appendix C). For some individual soils, the calculated percentage of metal released was very high, but this may be a result of heterogeneity of soils and the different sub-samples taken for the particulate metal analyses and for mobilisation tests. The ranges of concentrations, represented as a cumulative frequency plot, of major and trace elements released from the soils during the 24-h metal mobilisation tests are shown in Figure 18.

Table 42. Kinetics of mobilisation of metals from soils during 24-h mobilisation tests

	Soil (100 g/L) resuspended in River Murray water					
	JUR 2.3	**JUR 2.4**	**SPM 1.3**	**SPM 1.1**	**UKE 3.2**	**UKE 3.3**
Time, h	Dissolved Al concentration, mg/L					
0.16	22	5.7	1.7	11	560	52
1	35	7.8	2.7	14	610	61
3	42	9.6	3.5	16	600	63
6	51	11.0	3.8	18	610	64
24	62	12.0	4.9	19	610	68
Time, h	Dissolved Fe concentration, mg/L					
0.16	32	10	4	8	180	60
1	44	13	6	10	180	71
3	54	17	7	14	180	78
6	71	20	7	18	190	89
24	101	19	7	20	190	112
Time, h	Dissolved Mn concentration, mg/L					
0.16	3.8	0.9	1.2	2.7	44	4.2
1	4.7	1.1	1.6	3.1	47	4.5
3	5.0	1.3	1.8	3.3	47	4.3
6	5.5	1.3	1.9	3.4	48	4.4
24	5.9	1.5	2.0	3.6	46	4.5
Time, h	Dissolved Cr concentration, µg/L					
0.16	15	2.9	1.1	5.2	110	22
1	22	4.6	1.8	7.4	120	27
3	30	6.1	2.8	10	120	31
6	36	7.8	3.1	12	120	36
24	48	8.9	3.7	16	120	41
Time, h	Dissolved Co concentration, µg/L					
0.16	210	49	91	290	3300	460
1	260	62	120	360	3300	480
3	300	72	140	400	3300	480
6	310	78	140	410	3300	490
24	340	88	150	440	3300	510
Time, h	Dissolved Ni concentration, µg/L					
0.16	260	77	130	410	4700	600
1	350	98	180	550	4800	650
3	400	120	210	640	4800	650
6	430	130	220	680	4700	670
24	460	140	230	730	4700	680
Time, h	Dissolved Cu concentration, µg/L					
0.16	70	17	12	17	370	180
1	90	20	17	20	380	190
3	96	22	19	21	380	180
6	95	23	21	22	380	180
24	89	24	21	21	360	160
Time, h	Dissolved Zn concentration, µg/L					
0.16	560	160	110	340	9200	1300
1	700	190	140	410	9900	1400
3	780	210	160	450	9900	1400
6	810	230	170	460	10000	1400
24	830	260	170	490	9800	1400

Table 43. Concentrations of major cations mobilised by soils

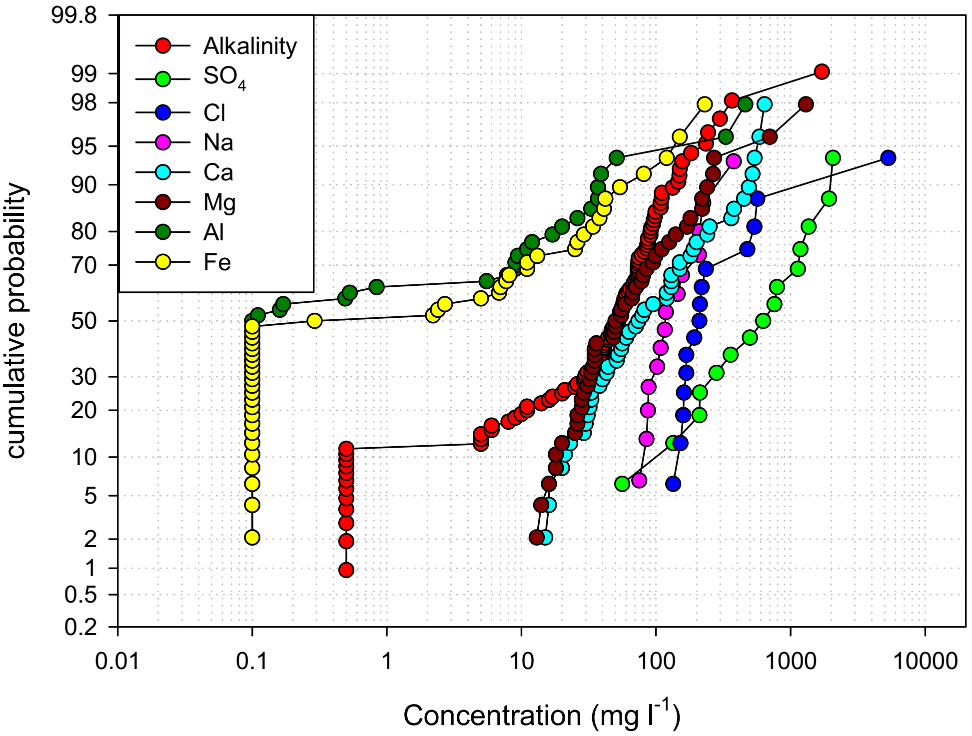
Site	Depth, cm	Na mg/L	K mg/L	Ca mg/L	Mg mg/L	Al mg/L	Fe mg/L
WL 5.3	0-1	145	5	540	95	37	54
WL 5.4	1-5	87	5	74	29	5.5	41
WL 5.5	5-20	88	25	130	50	9.4	29
WL 7.2	0-3	---	---	55	32	<0.1	<0.1
WL 8.3	1-3	---	---	63	50	<0.1	<0.1
WL 8.4	3-6	---	---	70.5	49	<0.1	<0.1
WL 8.5	6-25	---	---	51	33	0.17	<0.1
WL 9.2	0-5	208	16	79	67	0.16	<0.1
WL 15.1	0-5	75	5	23	20	0.11	5
WL 15.2	5-10	---	---	15	16	<0.1	<0.1
WW 8A 2.1	0-5	---	---	16	14	<0.1	<0.1
WW20C	30-40	---	---	60	48	<0.1	<0.1
WWBH20B 1.2	5-15	85	6	52	35	<0.1	<0.1
AT 2.3	5-20	---	---	150	140	<0.1	2.7
AT 2.6	30-35	108	11	38	28	<0.1	2.4
AT 7.2	5-20	210	53	190	180	<0.1	<0.1
AT 9.1	0-5	---	---	450	270	11	8.1
AT 9.2	5-20	---	---	250	220	26	25
AT 10.2	5-15	---	---	82	55	<0.1	<0.1
AT 19.3	18-28	---	---	43	35	0.53	2.2
AT 21.1	0-1	---	---	16	13	<0.1	<0.1
AA10.2	10-30	---	---	20	18	<0.1	<0.1
AA 13.2	3-15	102	19	56	55	<0.1	11
AA 20.2	5-20	---	---	40	34	0.49	7
AA 29.5	0-3	156	3	180	66	12	6.8
AA 29.6	3-10	---	---	33	26	<0.1	<0.1
AA 33.2	0-10	---	---	200	240	37	7.7
AA 33.3	10-25	---	---	130	110	33	34
UKE 3.1	0-0.5	---	---	520	700	330	150
UKE 3.2	0.5-1	---	---	490	1300	460	230
UKE 3.3	1-8	---	---	150	125	51	120
UKE 3.4	8-12	---	---	380	80	7.8	11
UKE 3.5	12-20	---	---	30	18	<0.1	<0.1
UKE 5.2	0.5-10	377	10	240	170	9	38
UKE 5.3	10-30	---	---	95	220	<0.1	<0.1
JUR 2.3	0-2	---	---	585	265	39	81
JUR 2.4&5	2-10	224	9	120	71	20	42
JUR 2.6&7	10-40	---	---	44	35	<0.1	<0.1
JUR 6.5	40-60	---	---	120	99	<0.1	<0.1
MUR 1.2	30-40	---	---	130	85	0.84	0.29
MUR 1.3	40-70	---	---	29	26	<0.1	<0.1
MUR 2.2	5-10	118	5	33	28	<0.1	<0.1
MUR 2.4	45-60	---	---	21	25	<0.1	<0.1
MUR 3.2	15-30	---	---	32	36	<0.1	<0.1
PA 4.4	8-15	---	---	31	31	<0.1	<0.1
SPM 1.1	0-0.5	116	---	640	78	17	26
SPM1.3	5-10	---	---	362	59	9.0	13.1

Table 44. Concentrations of trace metals mobilised by soils from River Murray (WL), Wellington Weir (WW) and Lakes Albert (AT) and Alexandrina (AA)

Site	Depth	Ag	As	Cd	Co	Cr	Cu	Mn	Ni	Pb	Sb	Se	V	Zn
	cm	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
WL 5.3	0-1	0.05	15	2.6	370	28	200	3800	710	2.8	<0.5	0.3	150	520
WL 5.4	1-5	<0.02	3.1	0.67	90	8.0	68	1100	150	2.6	<0.5	0.2	69	210
WL 5.5	5-20	<0.02	3.9	1.6	190	6.9	68	2600	280	17	<0.5	<0.2	22	380
WL 7.2	0-3	<0.02	4.0	0.05	3.8	0.36	2.8	270	4.7	<0.1	<0.5	0.4	1.1	3.9
WL 8.3	1-3	0.04	1.7	0.17	34	0.2	2.5	3600	18	0.1	<0.5	0.3	0.69	24
WL 8.4	3-6	<0.02	3.2	0.13	31	0.2	1.5	2650	15	0.2	<0.5	0.4	1.5	19
WL 8.5	6-25	<0.02	1.5	0.07	11	0.2	1.2	1700	6.8	<0.1	<0.5	0.2	1.1	6.9
WL 9.2	0-5	<0.02	1.1	<0.05	1.8	<0.1	1.5	710	4.4	<0.1	<0.5	<0.2	0.97	5.5
WL 15.1	0-5	<0.02	1.8	0.23	110	<0.1	12	3900	76	0.7	<0.5	<0.2	<0.1	60
WL 15.2	5-10	<0.02	1.5	<0.05	3.2	<0.1	11	46	3.6	<0.1	<0.5	<0.2	0.45	1.4
WW 8A 2.1	0-5	<0.02	1.5	0.07	0.4	0.3	2.0	56	2.3	0.2	<0.5	0.6	4.9	25
WW20C	30-40	<0.02	0.8	0.05	10	0.2	1.1	1950	9.9	0.1	<0.5	<0.2	1.0	9.2
WWBH20 11.2	5-15	<0.02	3.3	<0.05	1.5	3.8	9.0	150	6.4	0.3	0.6	0.4	7.3	1.8
AT 2.3	5-20	0.04	18	0.67	110	0.3	12	2100	180	0.8	<0.5	0.3	2.1	66
AT 2.6	30-35	0.03	3.0	0.13	12	0.2	2.1	1100	17	0.1	<0.5	<0.2	0.2	20
AT 7.2	5-20	0.05	19	3.0	1200	0.8	2.8	3800	780	6.2	<0.5	1.1	5.4	160
AT 9.1	0-5	0.03	5.5	2.1	190	1.3	19	7500	340	5.4	<0.5	0.3	0.4	270
AT 9.2	5-20	0.06	11	2.5	260	6.0	63	4100	510	8.5	<0.5	0.4	2.8	480
AT 10.2	5-15	0.04	1.7	0.15	6.1	0.1	2.7	1400	9.3	<0.1	<0.5	0.3	1.7	9.8
AT 19.3	18-28	<0.02	4.2	0.38	120	0.4	3.3	990	120	2.1	<0.5	<0.2	0.6	72
AT 21.1	0-1	<0.02	0.7	<0.05	6.7	0.1	1.4	200	4.8	<0.1	<0.5	<0.2	1.2	4.3
AA10.2	10-30	0.04	1.5	<0.05	28	<0.1	3.1	3200	13	<0.1	<0.5	0.2	0.9	6.1
AA 13.2	3-15	0.02	9.0	4.1	350	0.6	5.7	2500	220	8.5	<0.5	0.4	0.4	150
AA 20.2	5-20	0.02	3.0	1.3	170	0.3	3.3	560	150	0.5	<0.5	<0.2	0.9	120
AA 29.5	0-3	<0.02	7.1	0.6	97	1.1	17	6800	230	0.1	<0.5	0.2	0.3	160
AA 29.6	3-10	<0.02	2.7	0.08	14	2.2	23	690	24	0.6	<0.5	0.2	2.9	24
AA 33.2	0-10	0.04	32	5.0	290	17	170	4600	520	4.3	<0.5	0.7	120	950
AA 33.3	10-25	<0.02	16	2.6	210	20	110	2900	300	1.8	<0.5	0.2	230	370

Table 45. Concentrations of trace metals mobilised by soils from wetlands at Ukee, Jury Swamp, Murrundi, Paiwalla, Riverglades, and Swanport

Site	Depth	Ag	As	Cd	Co	Cr	Cu	Mn	Ni	Pb	Sb	Se	V	Zn
	cm	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
UKE 3.1	0-0.5	<0.02	51	18	2800	66	160	43000	4500	0.5	<0.5	1.1	97	7800
UKE 3.2	0.5-1	0.02	43	20	4400	120	220	60000	6900	3.2	<0.5	0.9	1130	14000
UKE 3.3	1-8	0.06	10	4.5	445	43.5	160	5350	660	7.4	<0.5	0.4	660	1700
UKE 3.4	8-12	<0.02	13	1.2	155	12	51	3550	235	1.9	<0.5	0.5	56	240
UKE 3.5	12-20	<0.02	0.7	<0.05	26	<0.1	1.6	7800	22	<0.1	<0.5	<0.2	<0.1	4.7
UKE 5.2	0.5-10	<0.02	5.4	1.3	210	16	31	6800	250	1.5	0.6	0.5	110	670
UKE 5.3	10-30	<0.02	3.2	<0.05	0.6	<0.1	4.5	380	2.3	<0.1	<0.5	4.9	2.8	0.4
JUR 2.3	0-2	0.12	15	2.4	310	42	67	7500	400	0.6	0.8	0.8	260	1040
JUR 2.4&5	2-10	<0.02	6.7	0.53	90	17	52	1900	160	3.6	<0.5	0.3	200	300
JUR 2.6&7	10-40	<0.02	1.1	0.08	15	0.4	0.6	740	11	0.1	<0.5	<0.2	1.4	9.8
JUR 6.5	40-60	<0.02	2.1	<0.05	1.8	0.4	1.4	740	1.4	<0.1	0.6	0.3	7.4	2.4
MUR 1.2	30-40	0.03	2.5	0.24	27	1.2	2.3	970	22	0.6	<0.5	<0.2	4.8	52
MUR 1.3	40-70	<0.02	1.0	<0.05	0.6	0.4	1	74	1.2	<0.1	<0.5	0.2	2.7	1.4
MUR 2.2	5-10	<0.02	0.8	<0.05	5.8	0.4	0.5	220	5.1	<0.1	<0.5	<0.2	1.0	4.7
MUR 2.4	45-60	<0.02	2.1	<0.05	8.3	<0.1	11	740	8.8	<0.1	<0.5	<0.2	1.3	4.7
MUR 3.2	15-30	<0.02	2.0	<0.05	5.7	0.2	1.8	210	3.7	<0.1	0.8	1.6	7.8	1.7
PA 4.4	8-15	<0.02	4.7	<0.05	6.6	0.4	4.3	180	5.3	<0.1	0.9	1.6	15	2.2
SPM 1.1	0-0.5	<0.02	16	3.3	440	16	44	4600	700	0.1	0.6	0.7	97	460
SPM1.3	5-10	0.02	9.6	2.1	280	9.6	20	3300	430	2.7	<0.5	0.4	52	300



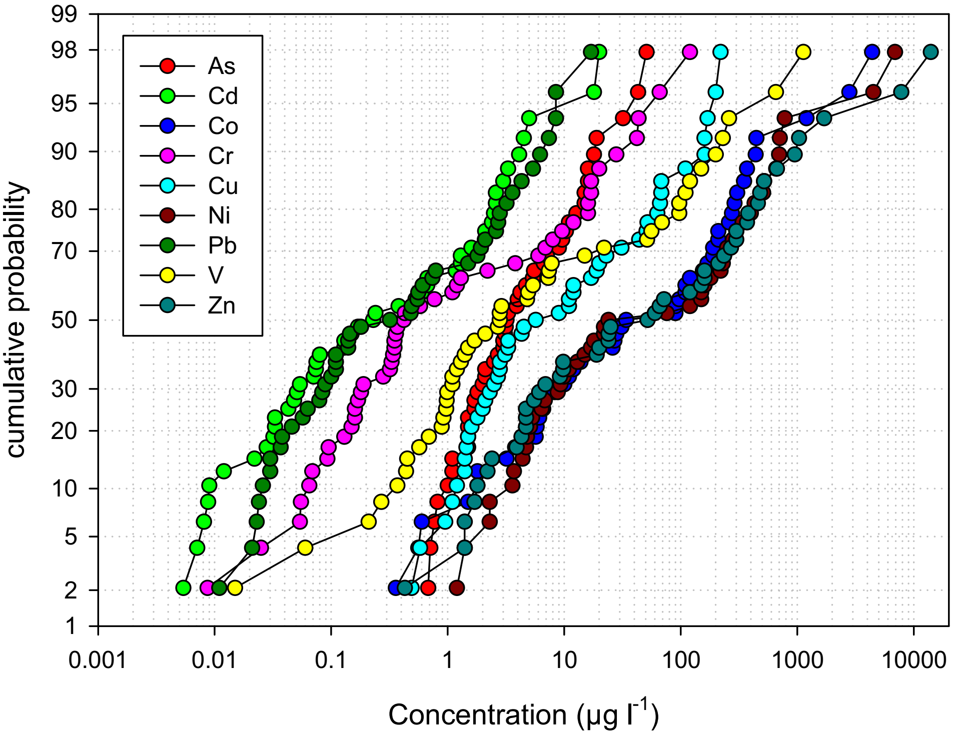


Figure 18. Range of concentrations of major and trace elements released during water extractions

3.4 Synthetic Rainwater Mobilisation Tests

3.4.1 Comparison of water quality parameters for tests with synthetic rain water and River Murray water

After 24 h of resuspension of soils in synthetic rainwater, the pH values (Table 46, Figure 19) were slightly more acidic than those using River Murray water (Table 47). The pH values were more similar after 24 h than after 0.5 h resuspension of soil in each water, indicating that some of the initial buffering by River Murray water is slowly lost. Because the pH results and alkalinity/acidity were reasonably similar for the tests with the two water types after mixing for 24 h, no comparisons were made of dissolved metal or nutrient concentrations.

Table 46. Comparison of pH, redox potential (Eh), conductivity and dissolved oxygen during the 24-h mobilisation experiments using synthetic rainwater and River Murray water

Test Water	Sample	Parameters during 24-h mobilisation test							
		t = 0.5 h (of mobilisation test)				t = 24 h (of mobilisation test)			
		pH	Eh, mV	EC, µS/cm	DO, mg/L	pH	Eh, mV	EC, µS/cm	DO, mg/L
Synthetic Rainwater	WL 15.1	3.9	572	297	11.6	3.6	567	376	9.3
River Murray Water	WL 15.1	5.5	517	674	10.3	4.1	510	725	6.4
Synthetic Rainwater	WL 5.4	3.0	650	727	11.3	2.7	631	1625	9.3
River Murray Water	WL 5.4	3.4	745	950	9.7	2.8	629	1822	6.9
Synthetic Rainwater	WL 9.2	5.4	565	1270	11.2	5.1	562	1837	8.9
River Murray Water	WL 9.2	6.4	593	1360	10.7	5.4	551	1900	6.6
Synthetic Rainwater	WWBH20 11.2	6.9	454	200	11.7	5.8	505	212	9.3
River Murray Water	WWBH20 11.2	7.1	613	666	9.8	6.1	556	663	7.3
Synthetic Rainwater	AT 19.3	3.6	600	508	10.8	3.6	564	662	9.4
River Murray Water	AT 19.3	5.3	522	874	5.8	4.0	738	992	8.0
Synthetic Rainwater	AA 29.5	3.4	684	1408	10.7	3.3	623	1825	9.5
River Murray Water	AA 29.5	4.2	658	1565	6.3	3.9	541	1957	8.4
Synthetic Rainwater	AA 29.6	3.2	701	525	10.8	3.0	680	705	9.5
River Murray Water	AA 29.6	3.5	765	971	10.4	3.1	655	1106	8.3
Synthetic Rainwater	AA 29.9	4.8	502	301	10.9	4.6	524	332	9.3
River Murray Water	AA 29.6	6.4	591	756	10.4	5.7	457	705	7.6
Synthetic Rainwater	UKE 5.2	3.2	599	2290	11.5	3.0	568	4010	9.4
River Murray Water	UKE 5.2	4.1	683	1831	10.0	3.1	567	3889	7.9
Synthetic Rainwater	JUR 2.3	3.1	620	2020	11.6	2.6	590	5880	9.4
River Murray Water	JUR 2.3	3.3	728	1506	4.6	2.7	587	2918	8.3
Synthetic Rainwater	JUR 2.6&7	5.0	563	449	12.0	4.6	559	1097	9.3
River Murray Water	JUR 2.6&7	6.8	608	639	11.1	4.8	526	1153	7.7
Synthetic Rainwater	MUR 1.3	6.0	529	365	11.8	5.7	547	694	9.0
River Murray Water	MUR 1.3	5.9	534	997	9.9	5.5	429	1060	6.0
Synthetic Rainwater	MUR 2.2	5.1	746	243	11.3	4.7	543	580	8.7
River Murray Water	MUR 2.2	6.6	497	687	10.3	4.9	439	925	6.4
Synthetic Rainwater	PA 4.5	6.1	486	675	11.0	5.8	466	1591	9.0
River Murray Water	PA 4.5	6.8	566	1289	11.4	6.0	367	1994	7.1
Synthetic Rainwater	SPM 1.1	3.4	570	1382	11.0	3.3	544	3020	6.8
River Murray Water	SPM 1.1	4.0	639	1935	11.2	3.4	527	3405	0.8
Synthetic Rainwater	SPM1.3	3.4	597	566	11.4	3.3	644	1239	9.2
River Murray Water	SPM1.3	5.0	626	786	8.9	3.3	634	1216	8.0

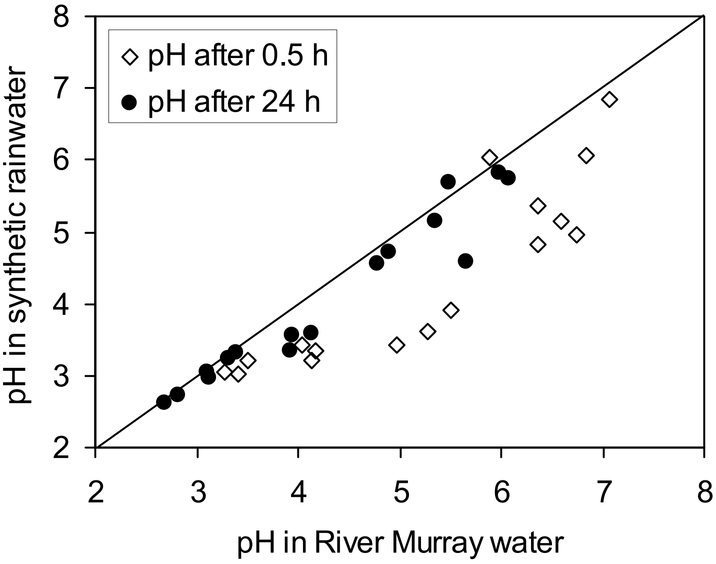


Figure 19. Comparison of Release Test results using River Murray water and synthetic rainwater.

Table 47. Concentrations of alkalinity and acidity for the 24-h mobilisation experiments

	Alkalinity mg/L		Acidity, mg/L	
Sample	**River Murray water**	**Synthetic rainwater**	**River Murray water**	**Synthetic rainwater**
WL 15.1	57	---	19	47
WL 5.4	---	---	245	263
WL 9.2	5	<1	9	<1
WW 20C	---	<1	9	9
WWBH20 11.2	29	5	---	<1
AT 19.3	---	---	28	38
AA 29.5	---	---	113	169
AA 33.3	---	---	362	508
UKE 3.3	---	---	690	678
UKE 3.4	---	---	29	38
UKE 5.2	---	---	212	268
JUR 2.3	---	---	628	734
JUR 2.6&7	---	<1	9	5
MUR 1.3	5	---	---	9
MUR 2.2	<1	<1	---	<1
PA 4.5	<1	4	24	5
SPM 1.1	---	---	207	207
SPM 1.3	---	---	70	85

3.4.2 Comparison of metal mobilisation in the different sampling areas

A comparison of mean dissolved metal concentrations measured in the water from the mobilisation tests for each of the major sampling areas (Murray River, Wellington Weir, Lakes Albert and Alexandrina and the wetlands) is shown in Table 48. Thirteen of the samples tested may be considered as surface soils, although the sampling depth varied considerably in each case. The metal mobilisation only for surface soils is shown in Table 49. In general, little can be interpreted from data summaries of this type, because the soil properties (e.g. pH), rather than the sample location most strongly influence metal releases (see Section 3.6).

Table 48. Maximum and mean ± standard deviation (SD) concentrations of dissolved metals mobilised from soils for each sampling area.

		Ag µg/L	As µg/L	Cd µg/L	Co µg/L	Cr µg/L	Cu µg/L	Mn µg/L	Ni µg/L	Pb µg/L	Sb µg/L	Se µg/L	V µg/L	Zn µg/L	Al mg/L	Fe mg/L
Maximum (All)	n =47	0.12	51	20	4400	120	220	60000	6900	17	0.9	4.9	1130	14000	460	230
Mean (All soils)	n =47	<0.02	7.8	1.7	280	9.5	35	4531	410	1.8	<0.5	0.5	71	650	49	39
SD (All soils)	n =47	0.02	11	3.9	760	21	57	10406	1200	3.2	<0.5	0.8	190	2300	110	55
Area																
Murray River	Mean (11)	<0.02	3.6	**0.52**	**80**	**4.0**	**34**	**2090**	**120**	2.2	<0.5	0.5	**23**	**110**	**8.7**	32
	±SD	NA	3.9	0.83	110	8.5	61	1400	220	5	NA	NA	47	180	14	21
Wellington Weir	Mean (4)	<0.02	1.6	**0.05**	**5.6**	**1.1**	**3.3**	**1000**	7.1	0.18	<0.5	0.3	3.5	**11**	**<0.1**	<0.1
	±SD	NA	1.2	0.03	5.8	1.8	3.8	1100	4	0.1	NA	NA	3.1	9	NA	NA
Lake Albert	Mean (8)	0.03	7.9	**1.1**	**240**	**1.1**	**13**	**2600**	**250**	2.9	<0.5	0.3	1.8	**140**	**13**	8.1
	±SD	0.02	7.3	1.2	400	2.0	21	2400	280	3.3	NA	NA	1.7	170	13	9.8
Lake Alexandrina	Mean (8)	<0.02	9.0	**1.7**	**150**	**5.4**	**45**	**2700**	**190**	2	<0.5	0.3	**45**	**230**	**18**	14
	±SD	NA	10	2.0	130	8.2	63	2200	170	3	NA	NA	86	320	17	11
Ukee	Mean (10)	<0.02	**15**	**5.2**	**880**	**32**	**84**	**14000**	**1360**	2.7	<0.5	0.9	**280**	**2600**	**120**	85
	±SD	NA	18	7.5	1500	39	84	20000	2400	2.8	NA	1.4	400	4600	180	83
Jury Swamp	Mean (5)	0.05	8.0	**1.1**	**140**	**20**	**37**	**3700**	**190**	1	0.5	0.4	**150**	**476**	**33**	68
	±SD	0.07	6.7	1.2	150	21	34	3500	200	1.5	NA	NA	130	526	11	23
Murrinda	Mean (6)	<0.02	1.6	**0.05**	**8.0**	0.4	**2.9**	380	7.0	0.14	<0.5	0.4	3.4	**11**	**0.48**	<0.3
	±SD	NA	0.7	0.09	9.8	0.4	4.0	380	7.9	0.2	NA	NA	2.6	20	0.52	NA
Paiwailla	Mean (1)	<0.02	4.7	**0.05**	**6.6**	0.4	**4.3**	180	**5.3**	0.06	0.9	1.6	**15**	2	**<0.1**	<0.1
	±SD	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Swanport	Mean (3)	<0.02	12	**2.5**	**330**	**11**	**28**	**3700**	**520**	1.86	<0.5	0.5	**67**	**350**	**12**	17.4
	±SD	NA	7.4	1.5	190	7.0	14.7	1600	320	2.98	NA	NA	47	190	8.3	14
WQG (95% PC) [a]	n =47	0.05	13	0.2	1.4	1.0	1.4	1900	11	3.4	NA	11	6	8.0	0.055	NA

[a] WQG, 95% level of protection (without hardness corrections etc). The WQG for As assumes all is As(V), which is more toxic the As(III) (WGQ = 24 µg/L). The WQG for Cr assumes all is as Cr(VI). The WQGs for Co and V are a low reliability values. Exceedances of guidelines are in **bold**.

Table 49. Concentrations of trace metals mobilised from surface soils (all in µg/L, except Al and Fe in mg/L): Maximum and mean ± standard deviation (SD)

Surface soils	Depth cm	Ag µg/L	As µg/L	Cd µg/L	Co µg/L	Cr µg/L	Cu µg/L	Mn µg/L	Ni µg/L	Pb µg/L	Sb µg/L	Se µg/L	V µg/L	Zn µg/L	Al mg/L	Fe mg/L
WL 5.3	0-1	0.05	15	2.6	370	28	200	3800	710	2.8	<0.5	0.3	150	520	37	54
WL 15.1	0-5	<0.02	1.8	0.23	110	<0.1	12	3900	76	0.7	<0.5	<0.2	<0.1	60	0.11	5
WL 9.2	0-5	<0.02	1.1	<0.05	1.8	<0.1	1.5	710	4.4	<0.1	<0.5	<0.2	1.0	5.5	0.16	<0.1
WL 7.2	0-3	<0.02	4	0.05	3.8	0.4	2.8	270	4.7	<0.1	<0.5	0.4	1.1	3.9	<0.1	<0.1
WW 8A 2.1	0-5	<0.02	1.5	0.07	0.4	0.3	2	56	2.3	0.2	<0.5	0.6	4.9	25	<0.1	<0.1
AT 21.1	0-1	<0.02	0.7	<0.05	6.7	0.1	1.4	200	4.8	<0.1	<0.5	<0.2	1.2	4.3	<0.1	<0.1
AT 9.1	0-5	0.03	5.5	2.1	190	1.3	19	7500	340	5.4	<0.5	0.3	0.4	270	11	8.1
AA 29.5	0-3	<0.02	7.1	0.6	97	1.1	17	6800	230	0.1	<0.5	0.2	0.3	160	12	6.8
AA 33.2	0-10	0.04	32	5	290	17	170	4600	520	4.3	<0.5	0.7	120	950	37	7.7
UKE 3.1	0-0.5	<0.02	51	18	2800	66	160	43000	4500	0.5	<0.5	1.1	97	7800	330	150
JUR 2.3	0-2	0.16	15	2.4	300	43	67	7400	390	0.3	1	0.8	270	970	38	81
JUR 2.3	0-2	0.08	15	2.3	310	41	66	7600	410	0.9	0.7	0.8	250	1100	40	81
SPM 1.1	0-0.5	<0.02	16	3.3	440	16	44	4600	700	0.1	0.6	0.7	97	460	17	26
Surface soils	Mean	0.03	13	2.8	380	17	59	7000	607	1.2	<0.5	0.5	76	950	52	47
Surface soils	SD	0.05	15	4.8	740	22	71	11000	1200	1.8	NA	0.3	98	2100	99	50

3.5 Water Quality Guidelines for Dissolved Metals

There were exceedances of the guidelines in the metal mobilisation tests for all metals for which Australian WQGs) exist (Table 50). It is important to note that the metal mobilisation tests were only undertaken on soils that caused the pH of the River Murray waters to drop below pH ~6. Furthermore, the mobilisation tests were expected to result in a worst case scenario for rapid metal release from most of these soils (undertaken using high concentrations of suspended solids (100 g/L) with the soils shaken for 24 h). For these reasons, calculations of maximum and mean (± standard deviations) concentrations for metal release are based on the most acidic soils from each of the study areas (Figure 3) within the River Murray system. As noted earlier, further generation of acid may occur in the field for soil samples that were incompletely oxidised at the time of sample collection (i.e. the sulfide samples) and this may result in greater dissolved metal concentrations and more exceedances of the WQGs.

Table 50. Water quality guidelines (WQG) and number of exceedances of WQG for each area

Site	**Al**	**Ag**	**As**	**Cd**	**Co**	**Cr**	**Cu**	**Mn**	**Ni**	**Pb**	**Se**	**V**	**Zn**
WQG (95% PC), µg/L [a]	**55**	**0.05**	**13**	**0.2**	**1.4**	**1**	**1.4**	**1900**	**11**	**3.4**	**11**	**6**	**8**
All samples													
# exceeding WQG	23	4	9	24	28	20	41	24	30	8	0	18	32
% of total (of 47)	49 [b]	9	19	51	60	43	87	51	64	17	0	38	68
# exceed 10× WQG	16	0	0	2	11	11	18	2	22	1	0	11	20
% of total (of 47)	34	0	0	4	23	23	38	4	47	2	0	23	43
# exceed 100× WQG	16	0	0	0	2	1	5	0	2	0	0	2	5
% of total (of 47)	34	0	0	0	4	2	11	0	4	0	0	4	11
# exceed 1000× WQG	2	0	0	0	0	0	0	0	0	0	0	0	1
% of total (of 47)	4	0	0	0	0	0	0	0	0	0	0	0	2
River Murray													
# exceeding WGQ	6	0	1	4	6	3	9	5	6	1	0	2	6
% of total (of 10)	60	0	10	40	60	30	90	50	60	10	0	20	60
Wellington Weir													
# exceeding WGQ	0	0	0	0	0	1	2	1	0	0	0	1	2
% of total (of 3)	0	0	0	0	0	33	67	33	0	0	0	33	67
Lake Albert													
# exceeding WGQ	3	2	2	5	5	2	7	4	6	3	0	0	7
% of total (of 8)	38	25	25	63	63	25	88	50	75	38	0	0	88
Lake Alexandrina													
# exceeding WGQ	4	0	2	5	6	4	7	5	7	2	0	2	6
% of total (of 7)	57	0	29	71	86	57	100	71	100	29	0	29	86
Wetlands (all)													
# exceeding WGQ	10	2	4	10	11	10	16	9	11	2	0	12	11
% of total (of 19)	53	11	22	53	58	53	84	48	58	11	0	63	58
Ukee (wetland)													
# exceeding WGQ	5	1	2	5	6	5	7	6	6	1	0	5	5
% of total (of 7)	71	14	11	71	86	71	100	86	86	14	0	71	71

[a] WQG, 95% level of protection (without hardness corrections etc) as per earlier Table. [b] For Al, the limit of reporting (LOR) was 100 µg/L and above the WQG of 55 µg/L. Where the dissolved Al concentration was <LOR, it is considered <WQG, although in some case sit may exceed the WQG.

The metals that most often exceeded the WQGs were Cu (87% of 47 samples), Zn (68%), Ni (64%), Co (60%), Cd (51%), and Mn (51%) (Table 50). For aluminium, the limit of reporting (LOR) was 100 µg/L and above the WQG of 55 µg/L. It is possible that all (100%) of the mobilisation waters exceeded the WQG for aluminium (49% of samples definitely exceeded the WQG). The number of WQG exceedances after applying a dilution factor (10×, 100×, 1000×), expected for these waters mixing with river or lake water, has also been calculated. Based on the maximum dissolved concentrations following dilution, the metals most greatly exceeding the WQGs by 10× were Ni (47% of 47 samples), Zn (43%), Cu (38%), and Al (34%). The metals exceeding the WQGs by 100× were Al (34% of 47 samples), Cu (11%), and Zn (11%). The metals exceeding the WQGs by 1000× were Al (4% of 47 samples) and Zn (2%).

3.6 Dissolved Metal - pH Relationships

There was no significant relationship between the soil depth and the paste pH of the soil (Figure 5). However, there were significant relationships between the pH of the soils (paste pH) and (i) the final pH of the water in which they were resuspended for mobilisation experiments (Figure 12), and (ii) the release of many of the major metals (Figure 20 and 21, see Appendix C for Ag, Cd, Co. Pb Sb and Se).

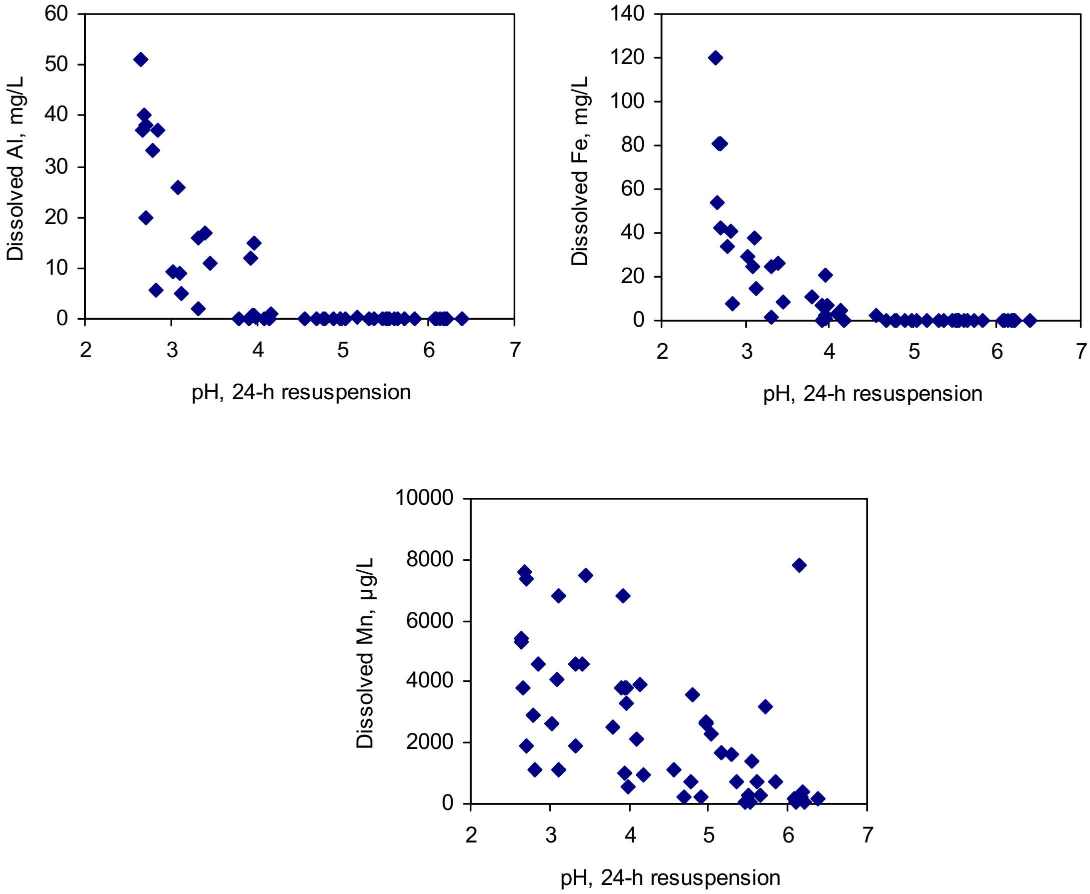


Figure 20. Release of dissolved Al, Fe, and Mn versus pH following 24-h resuspension in River Murray water

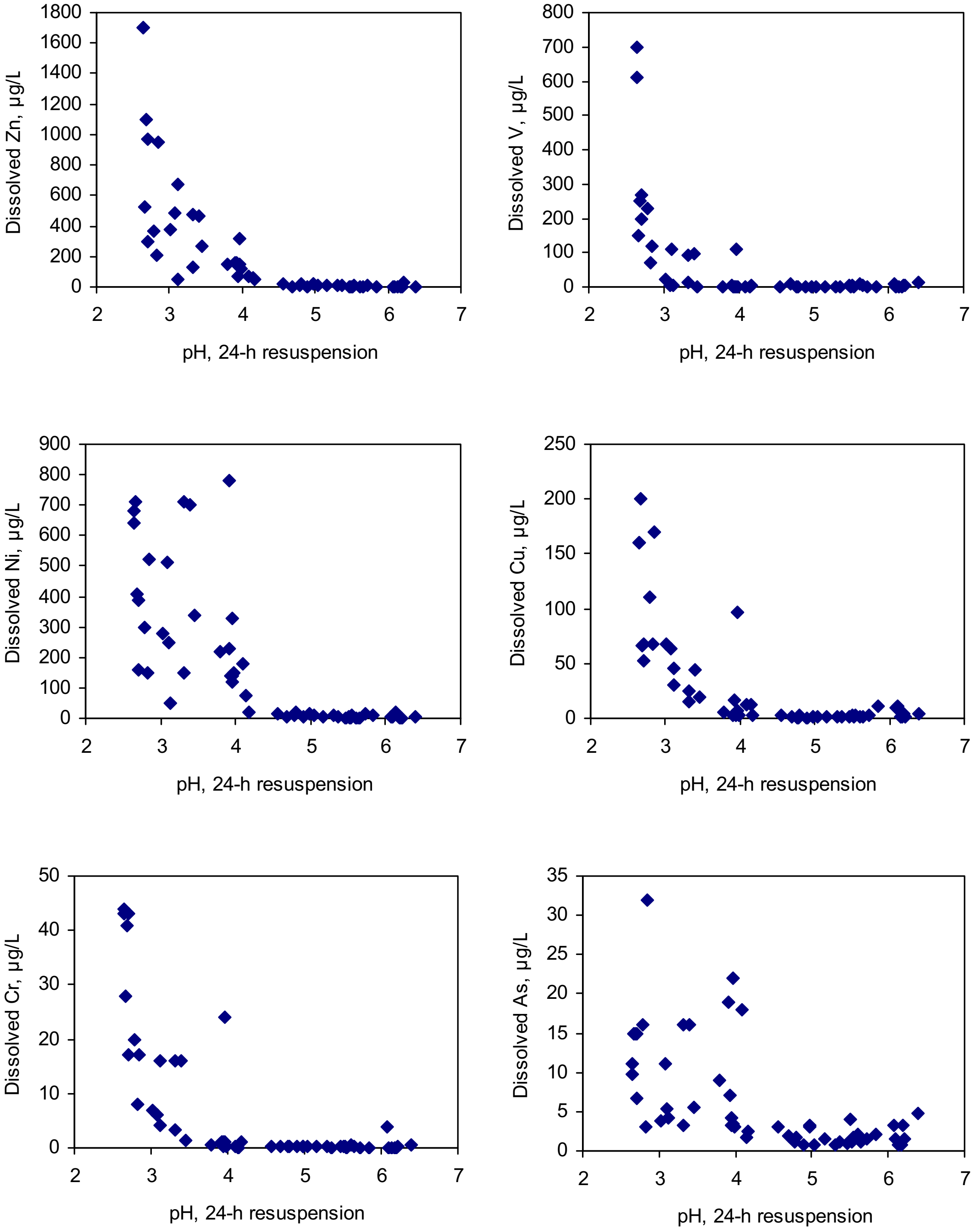


Figure 21. Release of dissolved Zn, V, Ni, Cu, Cr and As versus pH following 24-h resuspension in River Murray water

The concentrations of aluminium and iron and were in the mg/L range. Modelling calculations (MINEQL+, version 4.5) indicate saturation of the waters with respect to $Fe(OH)_3$ (ferrihydrite), but not with respect to aluminium precipitates (e.g. $Al(OH)_3$, gibbsite, diaspore) (Appendix C). Aluminium concentrations in one mobilisation test water were greater than 8,000 × WQG for the protection of ecosystem health (95% protection value = 0.055 mg Al/L). The high manganese concentrations (mean of 4.5 mg/L) may be of concern for water treatment. The trace metals Zn, V, Ni, Cu, Cr and As were at medium to high µg/L concentrations and in some cases greater than 1,000 × WQGs. The concentrations of Ag, Cd, Sb, Se, Pb also increased with decreasing pH, but their concentrations did not greatly exceed WQGs, especially considering the possible dilutions when mixed with receiving waters.

The concentrations of calcium and magnesium also increased with increasing pH, increasing water hardness and possibly providing some ‘protection’ from the toxic effects (competition for binding sites on organism receptors) (Figure 22). For waters with pH <4, increases in calcium and magnesium concentrations of 2- to 3-fold were often observed.

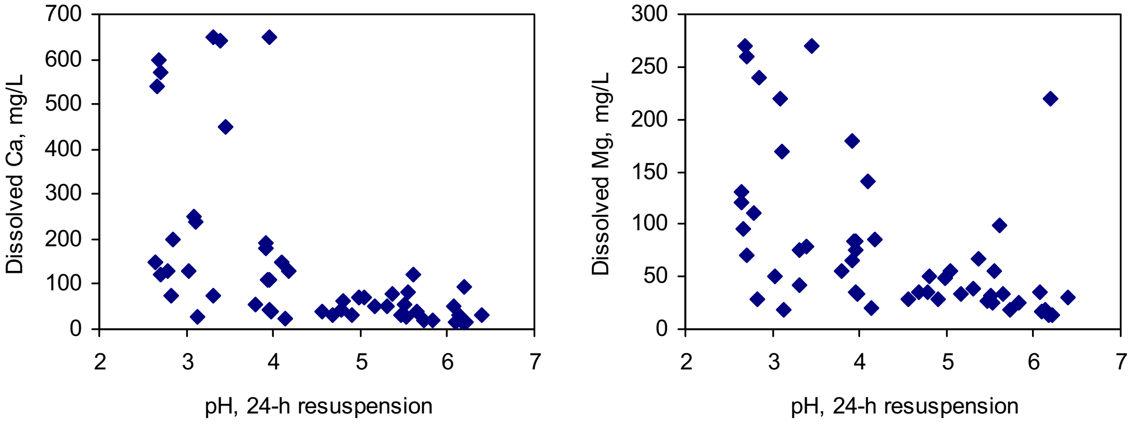


Figure 22. Release of dissolved Ca and Mg versus pH following 24-h resuspension in River Murray water

3.6.1 Modelling dissolved metal - pH relationships

The dissolved metal concentrations versus soil- and water-pH relationships may be useful for estimating the maximum input of metals expected from the various soils to the River Murray system. Considerable data are available (beyond that provided in this study) on the pH of soils throughout the River Murray system. This study has shown that the pH of the water with which the soils are in contact (through resuspension) is closely related to the soil paste pH (Figure 12).

Of the metals, Al, Cu, Co, Mn, Ni, V and Zn, whose concentrations most greatly exceeded the WQGs, there were strong relationships between concentration and pH for Al, Cu, Ni, V and Zn. The concentration-pH relationships were poor for Co and Mn.

Can concentration-pH relationships be used to predict the worst-case metal release as a function of soil pH? Plots of log-dissolved metal concentration versus pH are shown in Figure 23 for Al, Fe, Zn, V, Cu, and Cr. These relationships are non-linear over the pH range of the samples and indicate that a number of different processes are affecting the metal-release as a function of pH. This is not surprising as the soils had varying properties (depending on site locations), and represented a range of soil depths and degrees of drying and oxidation.

For the metals, Al, Zn, V, Cu, and Cr, the data are modelled assuming that three major (undefined) processes/reactions control the metal mobilisation as a function of pH (Figure 24, Appendix C). The data were not adequate for calculating confidence limits.

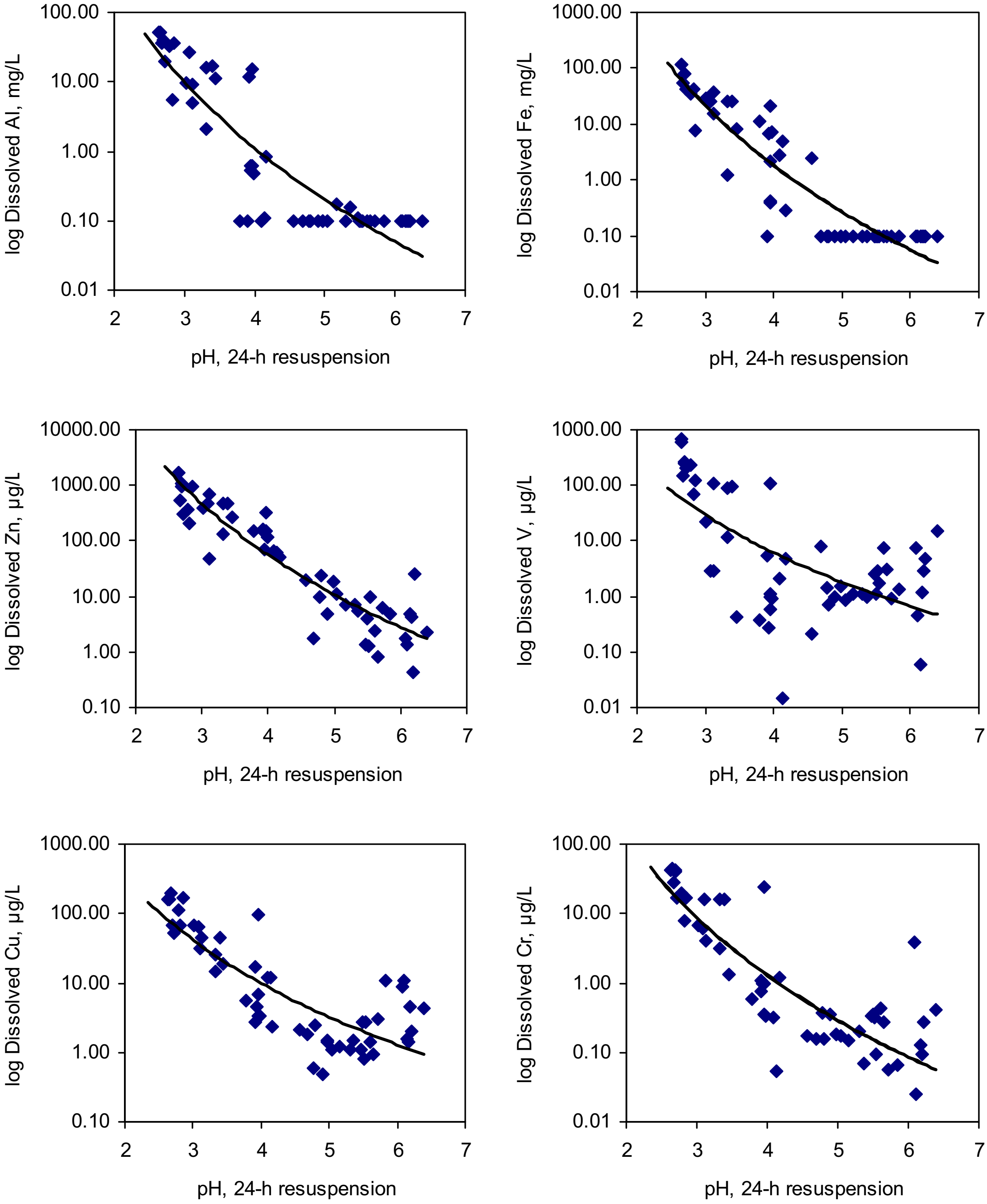


Figure 23. Released dissolved Al, Fe, Zn, V, Cu, and Cr concentrations versus suspension pH

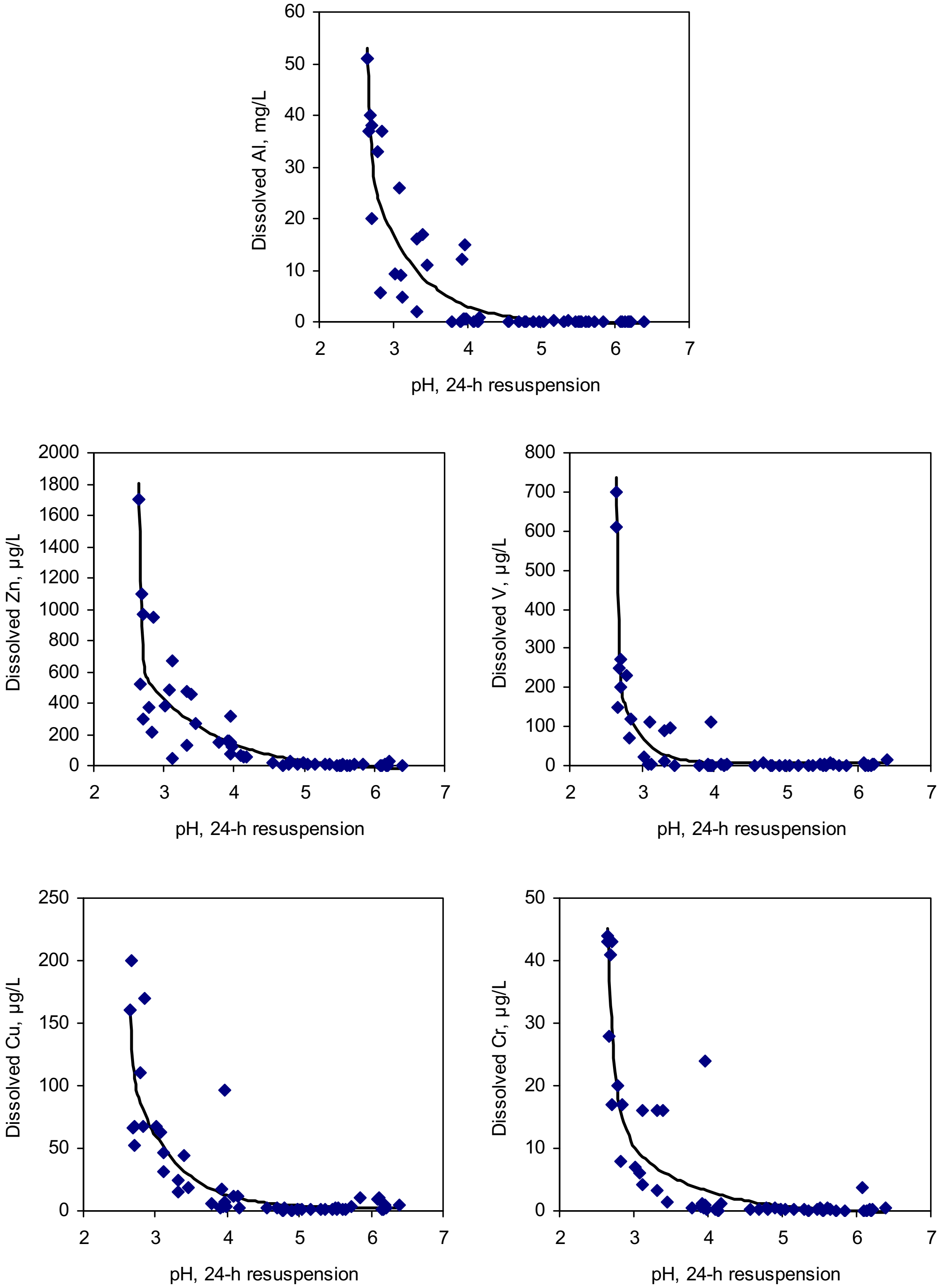


Figure 24. Released dissolved Al, Zn, V, Cu, and Cr as a function of pH represented by power relationships (Dissolved metal (µg/L) = y0 + A1*exp(-(pH-B1)/C1) + A2*exp(-(pH-B1)/C2) + A3*exp(-(pH-B1)/C3) (calculated using Microcal Origin Pro 7.5))

3.6.2 Soil pH for field samples from each study area

Based on the significant relationships between the pH of the soils (paste pH) and the final pH of the water in which they were resuspended for mobilisation experiments (Figure 12), the soil pH data (Table 51) for each of the study areas (River Murray, Wellington Weir, Lake Albert, Lake Alexandrina, wetlands) may be used to predict worst-case scenarios for the pH of the remobilisation water (i.e. the water that mixes with the soils and remobilises acidity and metals) (Table 52, Appendix C for statistics).

Table 51. Paste pH of soils (as collected) for each area

Area	**Number of samples**	**Paste pH of soils**			
		Min	**Max**	**Mean**	**SD**
River Murray (main channel)	27	2.3	8.7	5.4	1.6
Wellington Weir	14	4.2	8.0	6.5	1.5
Lake Albert	46	2.9	9.1	6.8	1.7
Lake Alexandrina	31	2.1	9.3	6.3	2.1
Wetlands (all)	35	2.4	7.9	5.1	1.7
Ukee (wetland)	14	2.4	7.2	4.6	1.9

Table 52. Model pH (Figure 24) and dissolved metal concentration predictions in relation to exceedances of WQGs

		Model metal (pH of WQG exceedances)				
		Cr	**Cu**	**V**	**Zn**	**Al**
pH when dissolved metal = WQG	pH =	4.9	10	4.5	5.4	<5.5
pH when dissolved metal = 10× WQG	pH =	3.0	3.9	3.0	4.4	4.9
pH when dissolved metal = 100× WQG	pH =	2.5	2.6	2.6	3.0	3.8
WQG (95% PC) in µg/L [a]		1	1.4	6	8	40
Site	Mean pH	Model predicts guideline exceeded ?				
River Murray	5.4	No	Yes	No	Yes	Yes
Wellington Weir	6.5	No	Yes	No	No	No
Lake Albert	6.8	No	Yes	No	No	No
Lake Alexandrina	6.3	No	Yes	No	No	No
Wetlands (all)	5.1	No	Yes	No	No	Yes
Ukee (wetland)	4.6	Yes	Yes	No	Yes	Yes

[a] Water quality guideline, 95% level of protection (without hardness corrections etc).

[b] pH estimated for Mn based on scattered data in Figure 20.

The accuracy of the model predictions is not expected to be very high for individual samples, however, calculations of this type may be useful for predicting pH thresholds for major areas and water bodies (e.g. wetlands), below which pH the dissolved metal concentrations are predicted to exceed guideline concentrations and may cause ecological effects.

Based on these simple calculations, if a defined area (e.g. a wetland) contains soils having a mean pH <5, then from the results in this study, the mean water pH in the re-wetted area is predicted to be pH <5. Should this scenario eventuate (i.e. a pH <5), the WQGs are expected to be exceeded for some metals (Table 50).

3.7 Buffering and Re-adsorption Tests

Following re-wetting and mobilisation of substances from soils, the water containing the mobilised substances may be transported either through soils (sub-surface) or in surface waters. During sub-surface transport, the water can effectively be considered as groundwater and will interact with a range of different soil materials which may buffer the acidity and adsorb many of the substances that were mobilised during re-wetting. During transport in surface waters, mixing with other waters will occur (e.g. with River and Lake water that have differing pH, alkalinity and concentration of TSS). The buffering of acidify and re-adsorption of metals through mixing with River Murray water is investigated in this section.

3.7.1 Influence of soil type and concentration on buffering of metal release

The ability of the River Murray water to buffer the inputs of acid, metals and nutrients was investigated by 100-fold dilution of an artificial, laboratory-prepared water that contained known amounts of acid, nutrients and metals. The artificial water had a pH of 2.5 and contained 20 mg/L of Ag, As, Cd, Co, Cr, Cu, Mn, Ni, Pb, Sb, Se, V, and Zn, 2000 mg/L Al, Fe, and Mn, 500 mg/L NO_3^- and 1000 mg/L PO_4^{3-}. These concentrations were higher than the highest concentrations measured during the mobilisation tests, but allowed easy measurement of dissolved concentrations in the mixed water (e.g. 200 µg/L total, of the each trace metal). The 100-fold dilutions were made with unfiltered River Murray water containing 0, 1 or 10 g/L of added soil TSS, with eight different non-acidic soil TSS concentrations tested (

Table 53-55).

The 100-fold dilution of the artificial water with River Murray water was sufficient to raise the pH from 2.5 to 6.4-6.5. In general, the presence of the River Murray water derived suspended soils caused the River Murray water pH to increase (from pH 6.4 to pH 6.6-7.2), with slightly greater increases when the TSS concentration was increased from 1 to 10 mg/L (

Table 53). The presence of the suspended soils generally had only small effects of alkalinity and nutrients (nitrate and phosphate) in the waters (Table 54). The alkalinity of the water was increased slightly by releases from the Riverglades and River Murray (WL11.1) soils and significantly alkalinity inputs from the Paiwalla soil. The Paiwalla and Riverglades soils also released significant amounts of nitrate and phosphate.

The dilution of the artificial water with the alkaline River Murray water resulted in a decrease in nitrate by ~10% and phosphate by ~95% (after considering the 100-fold dilution) (Table 54). The removal of nutrients, particularly phosphate, is believed to be due to adsorption onto iron hydroxide phases (possibly aluminium and manganese also) that precipitated as the pH increased.

Table 53. Effect of soil type and solid concentration on pH, Eh, EC and DO in mobilisation tests

Soil	Depth, cm	TSS, mg/L	t = 0.5 h (of mobilisation test)				t = 3 h (of mobilisation test)			
			pH	Eh, mV	EC, µS/cm	DO, mg/L	pH	Eh, mV	EC, µS/cm	DO, mg/L
Deionised Water (Milli-Q) (measured)										
No soil	NA	0	2.7	NA	NA	NA	2.7	NA	NA	NA
River Murray Water										
No soil	NA	0	6.5	460	540	11.0	6.4	540	920	8.9
AT 16.1	0-5	1000	6.6	460	550	10.6	6.5	600	920	9.0
AT 16.1	0-5	10000	6.7	480	570	10.6	6.5	610	950	8.8
AT 16.2	5-20	1000	6.7	500	550	10.7	6.5	630	920	9.0
AT 16.2	5-20	10000	6.8	490	560	10.6	6.5	630	930	9.0
AT 16.3	20-45	1000	6.9	510	550	10.7	6.5	650	920	8.9
AT 16.3	20-45	10000	6.9	510	550	10.6	6.5	640	950	8.9
PA 4.2	1-3	1000	7.0	520	720	10.5	6.8	600	1100	8.9
PA 4.2	1-3	10000	6.9	520	1850	10.4	7.1	530	2330	8.5
RIV 3.5	10-20	1000	7.1	520	570	10.6	6.4	470	940	8.7
RIV 3.5	10-20	10000	7.2	520	750	10.7	6.7	500	1440	8.7
UKE 1.1	0-10	1000	7.1	520	550	10.7	6.5	470	920	8.8
UKE 1.1	0-10	10000	7.1	530	560	10.7	6.5	510	930	8.7
WL 2.2	5-20	1000	7.1	520	550	10.4	6.2	470	920	8.6
WL 2.2	5-20	10000	7.0	530	590	10.5	6.4	490	970	8.6
WL 11.1	0-5	1000	7.1	520	540	10.4	6.5	510	910	8.6
WL 11.1	0-5	10000	7.1	530	550	10.5	6.5	520	920	8.5

Table 54. Effect of soil type and solid concentration on alkalinity and nutrients in mobilisation tests

Soil	Depth cm	TSS, mg/L	Alkalinity mg/L [b]	Nitrite-N mg/L	Nitrate-N mg/L	Phosphate mg/L [c]
No soil 1	NA	0	34	0.064	4.0	0.39
No soil 2	NA	0	35	0.061	4.1	0.37
AT 16.1	0-5	1000	34	0.075	4.3	0.37
AT 16.1	0-5	10000	35	0.077	4.3	0.42
AT 16.2	5-20	1000	34	0.084	4.3	0.36
AT 16.2	5-20	10000	35	0.061	4.3	0.40
AT 16.3	20-45	1000	34	0.070	4.3	0.36
AT 16.3	20-45	10000	35	0.072	4.2	0.43
PA 4.2	1-3	1000	53	0.075	4.2	0.66
PA 4.2	1-3	10000	76	0.12	4.0	1.8
RIV 3.5	10-20	1000	37	0.069	4.0	0.50
RIV 3.5	10-20	10000	48	0.077	3.9	0.93
UKE 1.1	0-10	1000	34	0.065	4.0	0.39
UKE 1.1	0-10	10000	35	0.070	3.9	0.50
WL 2.2	5-20	1000	35	0.081	4.0	0.39
WL 2.2	5-20	10000	42	0.074	4.0	0.53
WL 11.1	0-5	1000	34	0.071	3.5	0.37
WL 11.1	0-5	10000	34	0.073	4.0	0.39

Even at pH 2.5, there was much precipitation of iron (99%) and aluminium (~50%) when spiked into deionised water (pH 2.5-2.7 on dilution) (Table 55). This was in part due to the very high initial concentrations. The precipitation of iron and aluminium (oxy)hydroxide phases resulted in some co-precipitation and adsorptive losses of some of the other metals that have low solubility or have a preference for adsorption to the iron and aluminium solid phases (e.g. Pb, As, V, Cr). The dilution into River Murray water (no added TSS) caused greater removal of dissolved metals because of the increase in alkalinity that did not exist in the deionised water. The 100-fold dilution of the pH 2.5 metal-spiked water in River Murray water gave a final pH of 6.5. At this pH, the removal of metals from the dissolved phases was >99% for Al, Fe and Pb, >85% for As, Cr and Cu, >60% for Se and Zn, >40% for Cd, but less than 30% for Ag, Co, Mn, Ni and V.

The effectiveness of the added TSS in removing metals was different for the different soil TSS types added and the removal increased as the TSS concentration increased (from 1 to 10 g/L) (Table 55). The Paiwalla and Riverglades soils (PA4.2 and RIV3.5) released significant amounts of dissolved Al and Fe which is likely to be colloidal or complexed by dissolved organic matter (DOC) to remain in solution at this pH. This additional iron and aluminium may have contributed to additional scavenging of some trace metals (e.g. As, Cd, Ni, and Pb).

Table 55. Effect of soil type and solid concentration on 3-h buffering of metal release in mobilisation tests

Soil	**Depth Cm**	**TSS mg/L**	**Ag µg/L**	**As µg/L**	**Cd µg/L**	**Co µg/L**	**Cr µg/L**	**Cu µg/L**	**Mn µg/L**	**Ni µg/L**	**Pb µg/L**	**Sb µg/L**	**Se µg/L**	**V µg/L**	**Zn µg/L**	**Al µg/L**	**Fe µg/L**
Nominal [a]	NA	0	100	200	200	200	200	200	2000	200	200	200	200	200	200	2000	2000
Deionised Water (Milli-Q) (measured)																	
No soil	NA	0	54	110	206	202	147	203	1960	201	<1	NA	230	124	211	1320	4.7
River Murray Water (measured)																	
No soil	NA	0	78	18	120	175	12	28	1700	165	0.3	0.18	86	140	88	6.0	5.2
AT 16.1	0-5	1000	82	21	120	170	12	26	1700	170	<0.3	0.16	86	140	85	2.7	1.3
AT 16.1	0-5	10000	82	12	93	150	12	23	1600	150	<0.3	0.14	87	130	66	1.4	1.4
AT 16.2	5-20	1000	85	21	120	180	14	27	1700	180	0.5	0.13	89	140	90	7.5	6.2
AT 16.2	5-20	10000	84	19	100	160	13	21	1600	160	<0.3	0.18	89	140	74	1.6	1.5
AT 16.3	20-45	1000	84	20	115	170	13	30	1700	175	<0.3	0.13	90	140	86	5.1	1.2
AT 16.3	20-45	10000	86	14	100	150	13	21	1600	160	<0.3	0.14	91	140	69	1.6	1.9
PA 4.2	1-3	1000	84	1.1	18	54	14	45	1200	54	0.5	0.13	85	120	14	21	6.7
PA 4.2	1-3	10000	73	2.4	3.7	15	26	48	650	36	6.7	0.25	66	55	7.9	80	120
RIV 3.5	10-20	1000	71	0.16	29	63	13	11	990	60	0.5	0.15	87	110	22	7.2	6.5
RIV 3.5	10-20	10000	45	0.05	1.5	4.1	13	6.7	130	7.4	0.5	0.36	79	51	3.7	200	93
UKE 1.1	0-10	1000	81	1.2	63	130	12	14	1500	130	<0.3	0.14	88	140	56	4.7	1.5
UKE 1.1	0-10	10000	73	0.06	12	36	12	5.2	830	27	<0.3	0.18	88	120	12	<1	1.7
WL 2.2	5-20	1000	82	2.5	54	120	13	14	1400	110	<0.3	0.17	87	120	54	2.8	2.4
WL 2.2	5-20	10000	64	0.12	6.1	18	13	5.6	580	16	<0.3	0.19	76	69	6.7	3.6	1.0
WL 11.1	0-5	1000	83	22	110	160	13	25	1600	180	0.3	0.14	87	130	82	3.8	4.0
WL 11.1	0-5	10000	62	5.5	55	92	13	23	1200	110	<0.3	0.15	80	71	39	<1	1.0

[a] The nominal concentrations are for metals in the spiked and 100-fold diluted waters.

3.7.2 Influence of metal-load (added) on buffering capacity of suspended solids in River Murray water

The buffering capacity of River Murray water (pH 7.0) was investigated for 10-, 25-, and 100-fold dilutions of acidic, metal-enriched, water with River Murray water (containing no added TSS or 10 g/L of three different soils) (Table 56-58, Appendix C).

Table 56. Effect of dilution factor for acid, metal-rich water on pH, Eh, EC and DO in mobilisation tests

Soil	TSS, mg/L	Dilution	T = 0.5 h (of mobilisation test)				t = 3 h (of mobilisation test)			
			pH	Eh, mV	EC, µS/cm	DO, mg/L	pH	Eh, mV	EC, µS/cm	DO, mg/L
No soil	0	No spike[a]	6.9	564	534	9.6	6.7	524	540	8.5
No soil	0	100-fold	6.9	574	537	9.5	6.7	563	910	8.5
No soil	0	25-fold	7.0	584	535	9.5	5.7	620	2000	8.5
No soil	0	10-fold	7.1	577	537	9.5	3.8	672	4210	8.4
AT 16.1	10	No spike	7.1	579	568	9.7	6.6	478	570	8.2
AT 16.1	10	100-fold	7.1	567	566	9.7	6.6	497	940	8.3
AT 16.1	10	25-fold	7.2	561	568	9.7	5.9	532	2020	8.3
AT 16.1	10	10-fold	7.2	565	570	9.8	4.0	580	4220	8.4
UKE 1.1	10	No spike	7.2	541	550	9.7	6.6	513	550	8.3
UKE 1.1	10	100-fold	7.2	520	550	9.6	6.5	510	920	8.3
UKE 1.1	10	25-fold	7.2	510	552	9.4	6.0	529	2010	8.2
UKE 1.1	10	10-fold	7.1	497	550	9.3	4.3	576	4160	8.2

[a] No spike = no acidic, metal-enriched, water spiked into the River Murray water.

The final (3-h) pH of the diluted waters reflected the buffering capacity of the River Murray water (initially pH ~7) being exceeded at lowest dilution, i.e. pH ~6.7 (100-fold), pH ~5.8 (25-fold) and pH ~4 (10-fold) (Table 56). For all metals, the %-removal efficiency decreased as the dilution factor decreased and is likely to be a result of the lower pH of the less diluted waters having less aluminium and iron precipitation (as phases which adsorb metals). This reflects the lower final pH of the less diluted waters, but may also be influenced by saturation of metal-binding sites on the TSS (added soil TSS or TSS existing in the unfiltered River Murray water). For tests with added soil TSS, at the higher dilution (100-fold), there was an input of metals (e.g. Al, Fe, Cu, Mn, V, and Zn) from some soils rather than removal (Table 57). This is consistent for some desorption of metals from soil particles at the resulting water pH.

Table 57. Effect of dilution factor for acid, metal-rich water on 3-h buffering of metal release: dissolved metal concentrations.

Soil	TSS, mg/L	Dilution factor	Ag µg/L	As µg/L	Cd µg/L	Co µg/L	Cr µg/L	Cu µg/L	Mn µg/L	Ni µg/L	Pb µg/L	Se µg/L	V µg/L	Zn µg/L	Al µg/L	Fe µg/L
Nominal	NA	No spike	<2	<5	<2	<2	<2	<3	<2	<2	<10	<5	<5	<5	<10	<10
Nominal	NA	100-fold	50	200	200	200	200	200	2000	200	200	200	200	200	2000	2000
Nominal	NA	25-fold	200	800	800	800	800	800	8000	800	800	800	800	800	8000	9000
Nominal	NA	10-fold	500	2000	2000	2000	2000	2000	20000	2000	2000	2000	2000	2000	20000	20000
Deionised Water (Milli-Q) (measured)																
No soil 1	NA	100-fold	50	110	210	200	150	200	1960	200	<10	230	140	210	1320	5
No soil 2	NA	25-fold	210	440	770	760	580	770	7340	780	<10	850	440	770	5090	60
No soil 2	NA	10-fold	520	1100	1900	1860	1430	1910	17270	1860	<10	2070	920	1920	11300	130
River Murray Water																
No soil	0	No spike	<2	<5	<2	<2	<2	<3	<2	<2	<10	<5	<5	<5	<10	<10
No soil	0	100-fold	0	73	93	180	12	16	1760	180	<10	170	120	34	26	<10
No soil	0	25-fold	22	180	700	750	46	352	7020	760	<10	610	400	760	10	<10
No soil	0	10-fold	18	910	1860	1810	1350	1860	16800	1820	<10	1970	685	1920	6250	15
AT 16.1	10	No spike	<2	<5	<2	<2	<2	7	80	<2	<10	<5	24	130	34	25
AT 16.1	10	100-fold	<2	70	9	27	11	9	760	18	<10	120	130	49	<10	<10
AT 16.1	10	25-fold	<2	230	160	350	35	14	4500	270	<10	460	360	180	<10	<10
AT 16.1	10	10-fold	3	720	1470	1520	130	532	14900	1530	<10	1380	330	1650	600	27
UKE 1.1	10	No spike	<2	<5	3	<2	<2	13	10	<2	<10	<5	<5	<5	<10	<10
UKE 1.1	10	100-fold	<2	78	2	150	11	24	1650	150	<10	10	140	22	24	<10
UKE 1.1	10	25-fold	5	200	350	720	45	147	6900	730	<10	401	440	620	<10	<10
UKE 1.1	10	10-fold	16	810	650	1800	1180	1770	16800	1820	<10	613	610	1900	4150	<10

No spike = no acidic, metal-enriched, water spiked into the River Murray water.

Table 58. Removal of metal by River Murray Water or River Murray water plus soils TSS, calculated as a % of metal remaining in the deionised water.

Soil	TSS, mg/L	Dilution factor	Dissolved metal concentrations in remobilisation test waters, µg/L													
			Ag	**As**	**Cd**	**Co**	**Cr**	**Cu**	**Mn**	**Ni**	**Pb**	**Se**	**V**	**Zn**	**Al**	**Fe**
Nominal	NA	No spike	<2	<5	<2	<2	<2	<3	<2	<2	<10	<5	<5	<5	<10	<10
Nominal	NA	100-fold	50	200	200	200	200	200	2000	200	200	200	200	200	2000	2000
Nominal	NA	25-fold	200	800	800	800	800	800	8000	800	800	800	800	800	8000	9000
Nominal	NA	10-fold	500	2000	2000	2000	2000	2000	20000	2000	2000	2000	2000	2000	20000	20000
			Deionised Water (Milli-Q) (measured)													
No soil 1	NA	100-fold	54	110	206	200	150	200	1960	200	<10	228	140	208	1320	5
No soil 2	NA	25-fold	210	440	780	760	580	770	7340	780	<10	850	440	770	5090	60
No soil 2	NA	10-fold	520	1100	1900	1860	1430	1910	17300	1860	<10	2070	920	1920	11300	130
Soil	**TSS, mg/L**	**Dilution factor**	**% removal of metals [a]**													
			Ag	**As**	**Cd**	**Co**	**Cr**	**Cu**	**Mn**	**Ni**	**Pb**	**Se**	**V**	**Zn**	**Al**	**Fe**
No soil	0	No spike	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
No soil	0	100-fold	99	33	55	13	92	92	10	11	0	27	72	83	98	NC
No soil	0	25-fold	89	59	10	2	92	54	4	3	0	27	41	1	100	84
No soil	0	10-fold	97	17	2	3	6	3	3	2	0	5	26	0	45	88
AT 16.1	10	No spike	NC	NC	NC	NC	NC	-130	-4000	NC	NC	NC	-370	-2600	-240	-150
AT 16.1	10	100-fold	100	36	96	86	93	96	61	91	0	49	69	77	99	NC
AT 16.1	10	25-fold	100	47	80	54	94	98	39	65	0	46	47	76	100	84
AT 16.1	10	10-fold	100	34	23	18	91	72	13	18	0	33	64	14	95	79
UKE 1.1	10	No spike	NC	NC	NC	NC	NC	-340	-460	NC	NC	NC	60	NC	NC	NC
UKE 1.1	10	100-fold	100	29	99	27	92	88	16	25	0	96	69	90	98	109
UKE 1.1	10	25-fold	97	55	55	6	92	81	6	7	0	53	35	20	100	97
UKE 1.1	10	10-fold	97	26	66	3	17	7	3	2	0	70	34	1	63	94

[a] Removal of metal by River Murray Water or River Murray water plus soils TSS, calculated as a % of metal remaining in the deionised water (not as % of nominal metal concentration). Negative numbers for removal indicate metal inputs from the soil TSS. NC = not calculated due to concentrations being below detection limits. No spike = no acidic, metal-enriched, water spiked into the River Murray water.

3.7.3 Comparison of pH versus metal relationships during mobilisation, model and buffering re-adsorption tests

The changes in dissolved metal concentrations with dilution, neutralisation and increasing pH that occurred in the buffering/re-adsorption tests (Table 55 and 57) can be compared with the dissolved metal concentration versus pH relationships developed from the mobilisation tests (modelled in Figure 24). These two scenarios are different in one major aspect, the concentration of the soil (soil TSS) phase. For the 24-h mobilisation tests, the solid phase was 100 g/L of soil TSS and the different soils were expected to contain a wide variety of different metal-binding phases (binding strength and density of sites) and an overall excess of binding sites relative to the concentration of trace metals. In contrast, the 3-h buffering/re-adsorption tests were designed to simulate the mixing of acid, metal-rich, water with an alkaline river water that contained varying, but much lower, concentrations of soil TSS and artificially high (spiked) dissolved metal concentrations (note that 1-10 g TSS/L is likely to be much higher than would exist in many parts of the River Murray).

Due to the very high artificial metal concentrations used in the buffering/re-adsorption tests relative to the metal-release from the soils, caution is required when comparing the two metal concentration–pH relationships. However, the comparison indicates that, at the same water pH, dissolved metal concentrations may be much higher for acidic, metal-rich waters that are neutralised by dilution in the presence of low concentrations of TSS, then for water-soil suspensions containing high TSS concentrations (Figure 25). The positive aspect of this comparison is that the inputs of dissolved metals from re-wetted acidic soil systems to the River Murray may be expected to be lower if the neutralisation of pH occurs when the waters are in close association with high concentrations of soil TSS. This scenario could be the case for groundwater, which is expected to travel through large masses of soil to reach the river system. For areas which contain soils with a range of different pH values, metals released from the most acidic soils may be expected to be re-adsorbed to soils that have a higher pH due to water neutralisation reactions. In most areas the mean soil pH may be much higher than the minimum soil pH (with the greatest metal release) in that same area (e.g. Table 51). For these areas, the modelling of pH-metal relationships indicates that the critical mean pH for these systems is about pH 5 (i.e. metal concentrations above WQGs), however, these metal concentrations are likely to decrease even further when this water mixes and is diluted by the more alkaline River Murray and lake waters that contain additional sources of soil TSS. However, caution needs to be applied when making these assumptions as the accelerated drying method used in this study did not replicate what would be expected if the soils had dried naturally in the field. Only 29 of the 150 soil samples were sulphuric (i.e. with pH<4), but further development of acidity would be expected to occur in all the 73 sulfidic samples (i.e. those having the potential to go below pH 4) if suitable field conditions existed.

3.8 Toxicity and Remobilisation of Metal Associated with Precipitates

The buffering/re-adsorption tests indicated that there would be considerable precipitation of Al, Fe and Mn as (oxy)hydroxide phases (e.g. $Al(OH)_3$, FeOOH and MnOOH) with the simultaneous removal of large amounts of the mobilised trace metals through adsorption/co-precipitation by these fresh precipitates. Although metals may be removed from the dissolved phase, it is well known that flocculation of aluminium at high concentrations is likely to cause toxicity to a range of aquatic aquatic fish, particularly for waters in the pH 5-6 range (Sparling et al., 1997). The precipitates that form (through the neutralisation of the acidic, metal-rich water) will also contain high concentrations of trace metals which may be toxic to a variety of organisms, e.g. aquatic organisms exposed to suspended solids through filter feeding or benthic organisms that graze on materials at the sediment-water interface. The metals associated with the iron and manganese precipitates may also be easily remobilised to the dissolved phase if these phases undergo reductive dissolution to form Fe(II) and Mn(II), which is likely to commence shortly after the precipitated materials are deposited as sediments. The ongoing cycling of these metals through oxidative-precipitation and reductive-dissolution reactions may result in the metal remaining labile and highly bioavailable for long periods of time (following the initial mobilisation). The potential toxicity and long-term fate of precipitates that may form as a result of neutralisation of the acidic, metal-rich, water need to be investigated. In reducing environments (low dissolved oxygen), the bacterially-mediated reduction of sulfate to sulfide may result in the formation of relative insoluble metal-sulfide phases, however, these phases may be re-oxidised with water conditions change, resulting in re-release of the metals to the water column.

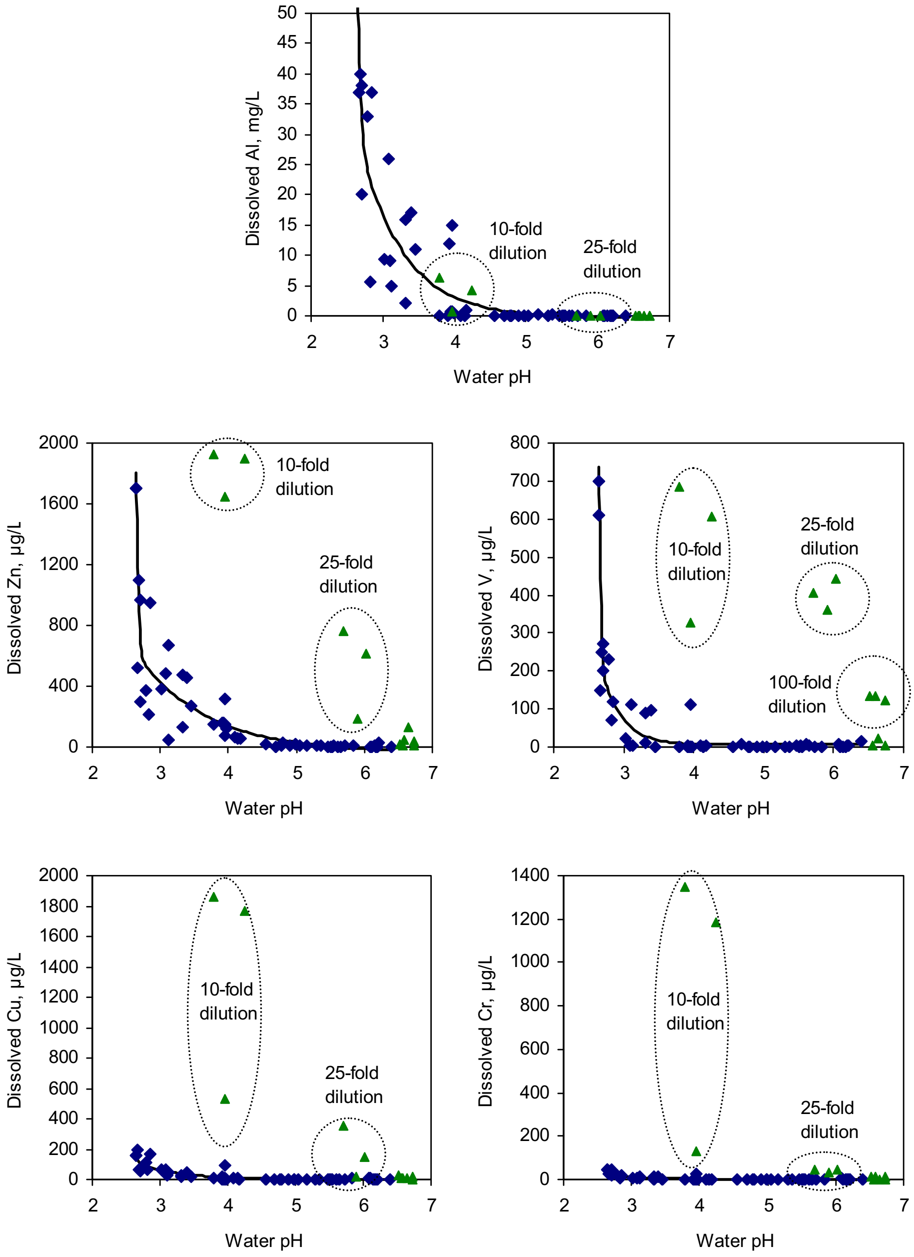


Figure 25. Concentration (Al, Zn, V, Cu, and Cr) versus pH relationships for (i) the 24-h mobilisation tests (◆) (soil TSS = 100 g/L) and (ii) for the 3-h buffering/re-adsorption tests (▲) (0-10 g/L soil TSS)

4. SUMMARY

Soils in the River Murray system (River Murray, adjacent wetlands and Lakes Alexandrina and Albert) are being impacted by a combination of low water levels and the presence of acid sulfate soils (ASS). As water levels recede, surface soils may dry out, desiccate (lose water) and crack, resulting in the exposure of deeper soils to air and drying. Such exposure of ASS may cause oxidation of soil constituents (e.g. sulfide) which releases acidity and can cause significant decreases in soil pH. Field observations and chemical analyses confirm the presence of both sulfuric materials (19% of samples with pH < 4) and sulfidic materials (53% of samples high sulfide concentrations and pH > 4, but potential to develop pH<4) in a range of ASS sub-types in the River Murray system. The re-wetting of ASS that has dried and oxidised as a result of lowered water levels may result in high concentrations of trace metals being dissolved and released to waterways. The mobilisation of acidity and metals may have significant impacts on the ecology of the River Murray system as well as on water quality.

150 soil samples were collected from 63 sites at locations in the main channel of River Murray, adjacent wetlands, and Lakes Albert and Alexandrina. The samples comprised both water logged, submerged sediments and air-exposed dry or semi-dry soils. The sites were located in the areas that have, or potentially will likely to be exposed to the atmosphere before mid-2009 (+0.7 to -1.5 m AHD areas). Samples were collected from sites before and after natural drying, and at each site up to five depths were sampled (depending on the soil horizons present). Some samples were taken from archived samples collected previously. Water samples for baseline characterisation were collected from the River Murray, adjacent wetlands, and Lakes Albert and Alexandrina. Soil properties were characterised and tests undertaken to assess the mobilisation of acid and metals.

The waters collected from the River Murray, wetlands and lakes had pH ranging from 6.0 to 8.8 and alkalinity ranging from 40 to 230 mg/L $CaCO_3$, except for the Riverglades wetland which contained a small amount of actual acidity (pH 6, alkalinity = 5 mg/L $CaCO_3$). Concentrations of the nutrients were low, with total (unfiltered waters) nitrate and phosphate generally <0.1 and <0.01 mg/L, respectively. The highest total nitrate and phosphate concentrations were 0.28 mg/L (Riverglades wetland) and 0.094 mg/L (Paiwalla wetland), respectively. Dissolved oxygen concentrations in the waters ranged from 6.5 to 8.8 mg/L and specific electrical conductance (SEC) ranged from 450 to 6000 µS/cm. Trace metal concentrations in waters were generally low, except for waters from a few of the wetlands sites, where concentrations of some metals (e.g. 50-90 µg/L Co and Zn) were above Australia's water quality guidelines (WQGs) for protection of ecosystem health (ANZECC/ARMCANZ, 2000).

The soils and ASS subtypes were classified as; (i) 29 sulfuric materials (pH <4), (ii) 73 sulfidic materials (high sulfide concentrations and potential to develop pH<4), (iii) 1 mono-sulfidic black ooze material (MBO), and (iv) 13 clays, 32 sands and 1 organic material, all containing some sulfides. Of these soils, 9% had pH <3, 19% had pH <4, 30% had pH <5, 43% had pH <6, 58% had pH <7, 68% had pH <8, and 87% had pH <9. In the natural situation, the slow drying of soils is expected to cause the oxidation of sulfides to form sulfuric acid, with air penetration supplying the oxygen and water (humidity) required for this reaction. Although a process of accelerated drying of the soils at 40 ºC was anticipated to result in soil oxidation resembling what may occur naturally to the soils in the field, this was not achieved. The consequence of this was that the sulfidic samples, which comprised 53% of the total, remained less acidic than would be expected if suitable field conditions existed for them to dry naturally. The results presented in this report may therefore be biased towards a low estimation of the acidification that may occur if the soils are dried naturally.

The potential for mobilisation of substances from soils was quantified using tests that mixed 50 g of soil with 500 mL of test water for 24 h before measurement of substance release to the dissolved phase. In samples re-wetted with River Murray water, the mobilisation of alkalinity and acidity was quantified for 135 soils, the mobilisation of nutrients (N and P) quantified for 21 soils and the mobilisation of metal quantified for 47 soils.

Upon wetting of these soils with River Murray water using a rapid laboratory testing method, 6% had pH <3, 18% had pH <4, 25% had pH <5, 33% had pH <6, 67% had pH <7, and 95% had pH <8. As expected, the single MBO material tested had a pH greater than pH 7, whether wet, dry, or resuspended in River Murray water. There were strong relationships between the paste pH of the soils and the pH of soils resuspended in the River Murray water. As the paste pH of the soils decreased, the test water alkalinity decreased (and acidity increased). The test water pH dropped from pH 6.5 to pH <3 for 6%, to pH <4 for 15%, to pH <5 for 24%, and to pH <6 for 32% of the soils tested (resuspended for 24 h in River Murray water). For 15% of the 135 soils tested, the dissolved oxygen concentrations dropped below 2 mg/L when the soils were resuspended in River Murray water. There may be possible environmental impacts associated with the release of large volumes of water with low dissolved oxygen concentrations. The highest concentrations of were total nitrate and phosphate measured in the mobilisation tests were 2.9 mg/L and 0.1 mg/L, respectively.

In general, the concentration of trace metal contaminants in the soils were low and well below the ANZECC/ARMCANZ (2000) guideline concentrations for sediment/soil quality. The soils were ranked on the basis of their pH, and metal-mobilisation tests were undertaken for all soils having pH <6 (approximately 35% of the 135 acid-mobilisation test soils). No MBO samples were included in the rapid nutrient and metal mobilisation tests. The mobilisation of nutrients and metals from MBO materials was assessed in a separate sub-project (Sullivan et al., 2008). Dissolved metal concentrations were measured in the metal-mobilisation test waters (River Murray water in which the soils were resuspended) after 24 h. As a percentage of the total metal concentrations measured in the soils, the amount of metal release to the dissolved phase was quite high, being (mean±SD, %) 2.2±3.2 (for As), 5.2±12 (Cd), 19±22 (Co), 1.6±3.6 (Cr), 3.5±5.3 (Cu), 35±32 (Mn), 22±27 (Ni), 0.3±0.4 (Pb), 2.1±4.5 (V) and 16±24% (Zn). The metal release was rapid and most likely involves rapid dissolution and desorption reactions. In general, more than 50% of the metal was released from the soils within 10 min of contact with the River Murray water and after 6 h greater than 85% had been released (percentage of dissolved metal concentration after 24 h).

The ongoing release of metals from soil inundated with water for time periods longer than 24 h (before being released into, and mixed with, receiving water) may be significantly greater for redox-active metals such as arsenic (As(III)/As(V)) and manganese (Mn(II)/Mn(IV)). However, appreciable amounts of additional metal release (i.e. greater than that measured after 24 h) may not necessarily occur for other metals. In 7-week mobilisation experiments undertaken on wet and dried MBO and dried sulfuric materials by Sullivan et al. (2008), the mean/max concentrations of major metals (Al, Fe, and Mn) and of trace metals (Ag, As, Cd, Co, Cr, Cu, Ni, Pb, Zn) were generally observed to be of a similar magnitude as that observed for the rapid 24-h release from the sulfidic/sulfuric samples reported here. Sullivan et al. (2008) observed that after the first 24-h release period, the concentrations of most metals remained fairly constant – generally increasing or decreasing by a factor of 2. The only notable exceptions to this were Mn and As, where significant increases in their concentrations were measured in some samples.

The dissolved metal concentrations exceeded WQGs for all of the metals studied for which guidelines exist. The metals which most often exceeded the WQGs were Cu (87% of 47 samples), Zn (68%), Ni (64%), Co (60%), Cd (51%), and Mn (51%). For aluminium, the limit of reporting (LOR) was 100 µg/L which is and above the WQG of 55 µg/L. It is possible that all (100%) of the mobilisation waters exceeded the WQG for aluminium (49% of samples definitely exceeded the WQG). The number of WQG exceedances after applying a dilution factor (10×, 100×, 1000×), as expected for these waters mixing with river or lake water, has also been calculated. Based on the maximum dissolved concentrations following dilution, the metals most greatly exceeding the WQGs by 10× were Ni (47% of 47 samples), Zn (43%), Cu (38%), and Al (34%). The metals exceeding the WQGs by 100× were Al (34% of 47 samples), Cu (11%), and Zn (11%). The metals exceeding the WQGs by 1000× were Al (4% of 47 samples) and Zn (2%). It should be noted here that these results may be biased towards a low estimation dissolved metal concentrations and WQG exceedances due to the tests of sulfidic samples that may oxidise further to develop greater acidity and release further metals if they had dried naturally before the test undertaken in this study.

Although there was no significant relationship between the soil depth and the paste pH of the soils, there were significant relationships between the pH of the sulfidic/sulfuric soils (paste pH) and (i) the final pH of the water in which the soils were resuspended for mobilisation tests, and (ii) the concentrations of dissolved metals being most greatly released from the soils. The dissolved metal concentration versus soil-pH/water-pH relationships may be useful for estimating the maximum input of metals from sulfidic/sulfuric soil materials to the River Murray system that may occur as a result of waters inundating these soil types, then being released to mix with receiving water soon after (i.e. within 24 h). Of the metals whose dissolved concentrations most greatly exceeded the WQGs, there were strong relationships between the pH of the sulfidic/sulfuric soil materials and the dissolved concentrations of Al, Cu, Ni, V and Zn. The concentration-pH relationships were poor for cobalt and manganese. Modelling calculations indicated that for areas containing sulfuric soils, waters with pH <5 are likely to contain concentrations of metals that exceed water quality guideline concentrations for protection of ecosystem heath.

The ability of the River Murray water to buffer the inputs of acid, metals and nutrients was investigated by dilution of an acidic (pH 2.5), metal-spiked artificial water, with unfiltered River Murray water (pH 6.5). The buffering tests were undertaken at various dilutions and with varying amounts and types of added soil (as suspended solids, TSS. For 100-fold, 25-fold and 10-fold dilutions, after 3 h the pH of the mixed waters were approximately 6.5, 5.8 and pH 4.0, respectively. The buffering/re-adsorption tests indicated that neutralisation of the acidic, metal-spiked water with River Murray water will cause considerable precipitation of Al, Fe and Mn as (oxy)hydroxide phases (e.g. as $Al(OH)_3$, FeOOH and MnO_2) and the simultaneous removal of large amounts of the mobilised trace metals through adsorption/co-precipitation by these fresh precipitates. At pH 6.5 (100-fold dilution), the removal of metals from the dissolved phase was >99% for Al, Fe (by precipitation as the pH neutralises) and the metals (through adsorption/co-precipitation with Al and Fe precipitates) Pb, >85% for As, Cr and Cu, >60% for Se and Zn, >40% for Cd, but less than 30% for Ag, Co, Mn, Ni and V (after accounting for the decreases due to dilution alone). The addition of soil TSS (1-10 g/L) increased the pH to 6.6-7.2 and resulted in significantly greater removal of many of the metals from the dissolved phase. The removal of trace metals was different for the different soil TSS types and greater at higher TSS concentration.

It is well known that flocculation of aluminium at high concentrations is likely to cause toxicity to a range of aquatic fish, particularly for waters in the pH 5-6 range. The precipitates that form through the neutralisation of the acidic, metal-rich water will also contain high concentration of trace metals which may be toxic to a variety of organisms, e.g. organisms exposed to suspended solids through filter feeding or benthic organisms that graze on materials at the sediment-water interface. The metals associated with the iron and manganese precipitates may also be easily remobilised to the dissolved phase if these phases undergo reduction to form Fe(II) and Mn(II), which is likely to commence shortly after the precipitated materials are deposited as sediments. The ongoing cycling of these metals through oxidative-precipitation and reductive-dissolution reactions may result in the metal remaining highly bio-available for long periods of time (following the initial mobilisation).

5. RECOMMENDATIONS

This study has important implications for risk assessment of acid, metal and nutrient inputs to the aquatic environment of the River Murray system:

(i) The soil pH influences metal release from the sulfidic/sulfuric soil materials more than any other parameter and detailed mapping of soil pH in the River Murray system is recommended. Heterogeneity of the soil landscapes is expected to significantly affect soil pH and the influence of heterogeneity of soil types, topography, plant coverage, extent and rate of drying, and soil desiccation needs to be evaluated when mapping soil pH.

(ii) The alkalinity (or acidity) mobilised from re-wetted soils was not well predicted based on the measured soil parameters. Models are needed to predict the alkalinity of the water associated with re-wetted soils.

(iii) Metal concentrations in the waters in close association with the more acidic soils are likely to greatly exceed WQG concentrations for protection of ecosystem heath. Numerical models need to be developed and tested to provide prediction of water dilutions expected under a number of soil re-wetting (metal mobilisation) and mixing scenarios.

(iv) Simple numerical metal-mobilisation models that utilise the pH of sulfidic/sulfuric soil material to predict the degree of metal mobilisation appear useful for predicting metal release for individual soils likely to occur as a result of waters inundating the soil materials, then being released to mix with receiving water soon after (i.e. within 24 h). The 24-h pH of the water in which the soils were resuspended closely matched the pH of the soil. These models should be refined and tested for mixtures of soils (different pH and properties). For the purpose of risk assessment of 'areas' being re-wetted, an input as simple as the 'mean soil pH' (for the area) may be adequate for prediction of worst case dissolved metal concentration and WQG exceedances.

(v) The dilution of acidic, metal-rich waters (associated with the re-wetting of soils in degraded areas) with more alkaline waters from the River Murray and lakes will cause rapid pH-neutralisation and the precipitation of aluminium and iron (slower for manganese) and subsequent removal of trace metals. As the extent of removal of many of the trace metals may be greater than 90%, quantifying these processes is vital to the risk assessment for metal mobilisation. Experiments should be undertaken to provide information suitable for incorporation into water-mixing models. These experiments should quantify the kinetics of pH-neutralisation and trace metal removal processes as a function of dilution, TSS concentration and metal concentration. Numerical models of the mixing zones (where acidic, metal-rich waters mix with River Murray and lake waters) need to be developed to complement the numerical models of substance mobilisation.

(vi) The potential toxicity and long term fate of precipitates that may form as a result of neutralisation of the acidic, metal-rich, water needs to be assessed. These phases may cause significant toxicity to a range of aquatic and benthic organisms. Metals may be easily re-mobilised from these phases.

(vii) Flow pathways and interactions with sub-surface waters in the river, wetlands, ground waters (that usually have high alkalinity) and lakes are poorly defined, but may have a significant effect on the degree to which soil waters are neutralised. Detailed studies are recommended for those wetlands likely to be at risk from acidification by ASS.

(viii) The mobilisation of nutrients and metals from mono-sulfidic black ooze (MBO) materials was the subject of a separate sub-project undertaken by Sullivan et al. (2008). For the four MBO samples studied the pH of water in which they were resuspended remained above pH 7 and there was significant release of nutrients and metals (exceeding guideline concentrations) that was not mediated by low water pH. Metal release was greater for dried MBO materials than from MBO materials that had not been dried. The metal release from the MBO materials was similar in magnitude to that measured for the sulfidic/sulfuric soil materials (this report). Much greater release of N and P compounds (nutrients) was observed for the MBO materials than from the sulfidic/sulfuric soil materials.

(ix) The acid, metal and nutrient mobilisation dynamics (over 7 weeks) in response to suspensions of MBOs in freshwater and to freshwater inundation of dried MBO and sulfuric soil materials was investigated in a separate sub-project (Sullivan et al., 2008). The study, undertaken on four MBO materials and four sulfidic materials, highlighted the complexities of long-term mobilisation processes and the inability to make accurate predictions (based on simple soils properties) of long-term nutrient and metal mobilisation from laboratory-based tests. For soils inundated with water for up to 7-weeks, the mean/max concentrations of major metals (Al, Fe, and Mn) and of trace metals (Ag, As, Cd, Co, Cr, Cu, Ni, Pb, Zn) were generally observed to be of a similar magnitude as that observed for the rapid 24-h release from the sulfidic/sulfuric samples reported here. After the first 24-h release period, the concentrations of most metals remained fairly constant – generally increasing or decreasing by a factor of 2. The only notable exceptions to this were Mn and As, where significant increases in their concentrations were measured in some samples.

(x) For the purposes of the screening level risk assessment undertaken by Stauber et al. (2008), the maximum metal concentrations reported in the current study appear appropriate for assessing the immediate risks associated with re-wetting of ASS materials in the River Murray system.

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APPENDIX A: SOIL LOCALITY AND SOIL ANALYSES

A1 What are Subaqueous Soils?

In the last decade, the USDA's definition of soils has completely changed to include environments that are permanently submerged (Soil Survey Staff, 1999). Subaqueous soils form in sediments found in shallow permanently flooded environments. Excluded from the definition of subaqueous soils are any areas permanently covered by water too deep (typically greater than 2.5m) for the growth of rooted plants (Stolt, 2006). Soil scientists (mainly pedologists) have been studying these subaqueous soils in shallow subtidal lagoons and described them from a pedological perspective. The pedological approach involves characterising the morphological (colour, structure), physical (texture, compressibility), chemical (pH, salinity), mineralogical (layer silicates, iron oxides) and biological (roots, plants) properties of the benthic substrates and describing them using the terminology commonly used for soils. Once the benthic materials and underlying sediments are described as soils, investigators can easily identify the relationship between the soils and their position on the landscape (e.g. Bradley and Stolt, 2002; 2003). An understanding of these relationships enables land managers to identify the best location for specific land uses and to better predict the potential impact of proposed changes (e.g. dredging or drainage) on subaqueous soils and ecosystems they support.

A2 What are Acid Sulfate Soils?

Acid sulfate soils are all those soils in which sulfuric acid may be produced, is being produced, or has been produced in amounts that have a lasting effect on main soil characteristics (Pons, 1973). This general definition includes: (i) potential, (ii) actual (or active), and (iii) post-active ASS, three broad genetic soil types that continue to be recognised (e.g. Fanning, 2002). ASS form in coastal, estuarine, mangrove swamp, coastal back swamp/marsh environments and in inland saline wetlands (e.g. Fitzpatrick 1996) because these waterlogged or highly reducing environments are ideal for the formation of sulfide minerals, predominantly iron pyrite (FeS_2). Iron sulfide minerals are one of the end products that form as part of the process of sulfate reduction (i.e. the use of SO_4^{2-} instead of O_2 during microbial respiration). Sulfate reduction is a natural process that occurs virtually in all subaqueous soils in oceans, estuaries, lakes, rivers and wetlands. However, the quantities of sulfidic material that will accumulate in a given environment are a function of many factors. The key requirements for high rates of sulfate reduction and sulfide accumulation are:

(i) high concentrations of sulfate in surface or groundwater,

(ii) saturation of soils and sediments for periods long enough to favour anaerobic conditions,

(iii) availability of labile carbon to fuel microbial activity and

(iv) availability of iron minerals (Figure A1).

To form sulfidic materials, the bicarbonate produced by the reduction reactions must be flushed from the sediment, for example by tides or seiches (standing waves) caused by wind in lakes and rivers.

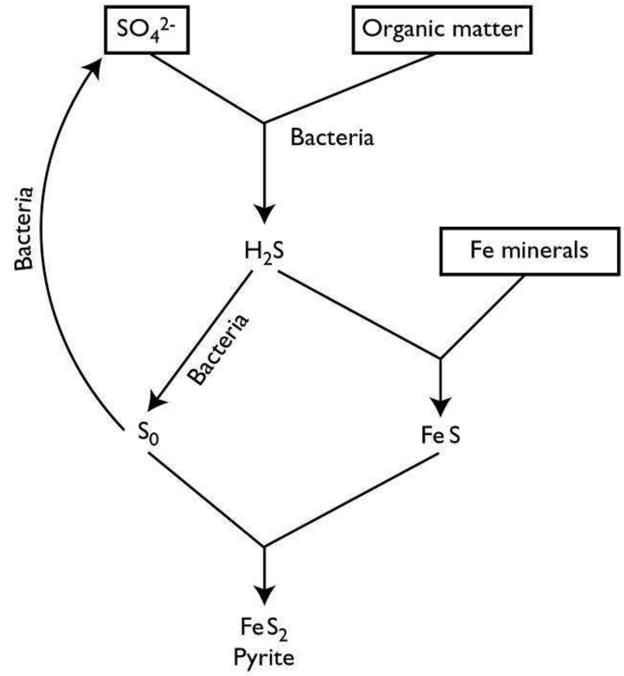


Figure A1. Schematic diagram for the formation of pyrite in anoxic sediments (after Berner, 1984)

Soil horizons that contain sulfides are called sulfidic materials (Isbell, 1996; Soil Survey Staff, 2003) and can be environmentally damaging if exposed to air by disturbance.

In summary, sulfidic materials contain oxidisable sulfur compounds. They may be mineral or organic soil materials, have a natural pH value >4, and when incubated as a layer 1 cm thick under moist conditions, while maintaining contact with the air at room temperature, they show a drop in pH of 0.5 units or more to a value of 4.0 or less within 8 weeks (Soil Survey Staff 2003).

Exposure of sulfidic material results in the oxidation of pyrite, with each mole of pyrite yielding 4 moles of protons (i.e. 2 moles of sulfuric acid). This process transforms sulfidic material to sulfuric material when, on oxidation, the material develops a pH of 4 or less (Isbell, 1996); note that a sulfuric horizon has a pH of 3.5 or less according to Soil Survey Staff (2003). If disturbed, the time required for the transition from sulfidic materials to sulfuric material ranges from weeks to years.

Monosulfidic black ooze (MBO) material is a subaqueous or waterlogged mineral or organic material that contains mainly oxidisable monosulfides that have a field pH of 4 or more but which will not become extremely acid (pH <4) when drained.

The recognition of the occurrence and importance of monosulfides in soil materials led in 2005 to the inclusion of monosulfidic materials as a distinguishing property within mapping units of the Australian National Atlas of Acid Sulfate Soils (Fitzpatrick et al., 2006). High nutrient environments together with the activity of algae and micro-organisms generate redoximorphic conditions, which result in the formation of black, smelly, iron monosulfides. When subaqueous materials rich in monosulfides are resuspended, for example during the flushing of drains by high runoff events, they rapidly oxidise, potentially removing most of the oxygen from the water column (Sullivan et al., 2002). This can lead to fish kills, especially in enclosed areas such as aquaculture ponds or estuaries. Hence, MBO is reactive if exposed to oxygen but is harmless if left undisturbed.

Monosulfidic soil materials have the ability to favourably affect surrounding environments by immobilizing potential metal pollutants (e.g. Simpson *et al.* 1998). However, when a drain is cleaned, iron and alumino-sulfo salts (e.g. jarosite and alunite), iron oxyhydroxy-sulfate salts (e.g. schwertmannite) precipitate on the soil surface along the drain edges. These soluble salts dissolve during rain events and contribute to MBO formation, acidity and metal content in drainage waters.

A3 Soil Cracks, Slickensides and Cracking Clay Soils

Soil cracks are features that are difficult to observe because they occur mostly at the soil surface only when the soil is dry and often in soil layers below the surface. Knowledge about soil behaviour during seasonal changes is required to determine if these features exist.

Slickensides: are polished and grooved surfaces that are produced when one soil mass slides past another (Isbell, 1996; Soil Survey Staff, 2003). Slickensides result directly from the swelling of clay minerals and shear failure. They are common in swelling clays that undergo marked changes in moisture content. All cracking clay soils contain slickensides and crack when dry. In many landscapes across Australia, this group of soil material contains both acid sulfate materials and non–acid sulfate members. Cracking clay soils are characterised by swelling on wetting and shrinking on drying with consequent crack formation. This behaviour is caused by the presence of interlayered clay minerals such as smectite.

A4 n Value

n value characterises the relation between the percentage of water in a soil under field conditions and its percentages of inorganic clay and humus. It is used to predict whether a soil can support loads and what degree of subsidence would occur after drainage. It is defined as $(A - 0.2R)/(L + 3H)$, where A is the percentage field water content, R the percentage of silt plus sand, L the percentage clay and H the percentage of organic matter (or organic carbon × 1.724).

A value of 0.7 or greater indicates that the soil is soft and would subside under a load.

Table A1 Location of soil sampling sites (WGS 84, Zone 54 S)

Site No	Easting	Northing
WL 2	346070	6109189
WL 5	346104	6109177
WL 6	346932	6136814
WL 7	347012	6136790
WL 8	368747	6150680
WL 9	368740	6150647
WL 11	372164	6186558
WL 12	372126	6186559
WL 14	373628	6195697
WL 15	373632	6195697
WL 17	370591	6182897
WW 3A 1	349450	6078069
WW 8A 2	349629	6077853
WW 20A 1	346419	6079832
WW 20C 1	347191	6080759
WWBH 20 11	347230	6080756
AT 1	349981	6061209
AT 2	349983	6061211
AT 4	349069	6049329
AT 6	343823	6044780
AT 7	341103	6056622
AT 9	341289	6056481
AT 10	335000	6067500
AT 11	352256	6059052
AT 12	352352	6059098
AT 14	349689	6049871
AT 16	349068	6049358
AT 17	349053	6049396
AT 18	341376	6054362
AT 19	341105	6056636
AT 20	335099	6067460
AT 21	335274	6067653
AT 3	339455	6089879
AA 8	339455	6089879
AA 9	339425	6089921
AA 10	339385	6089959
AA 11	332005	6083476
AA 12	331870	6083750
AA 13	331882	6083695
AA 14	316052	6079413
AA 15	316461	6079066
AA 18	322859	6069941
AA 19	322823	6069916
AA 20	322835	6069901
AA 22	322810	6069846
AA 29	321236	6070291
AA 30	321288	6070415
AA 31	325403	6081831
AA 33	319041	6060550
AA 34	315500	6062595
UKE 1	344545	6111773
UKE 2	344544	6111775
UKE 3	344455	6111878
UKE 5	344415	6111993
JUR 2	346469	6119696
JUR 6	346480	6119931
MUR 1	352468	6091006
MUR 2	352564	6090525
MUR 3	352581	6090527
PA 4	351475	6121259
RIV 3	345243	6115055
RIV 4	345258	6115038
SPM 1	346521	6109005

APPENDIX B: QUALITY ASSURANCE/ QUALITY CONTROL (QA/QC)

B1 QA/QC for Moisture and Paste pH Measurements at CSIRO (Sydney)

Table B1. Paste pH and moisture measurements of soils (Includes duplicates)

Paste-pH and moisture measurements of soils

Murray River (above WW)

Sample	Depth	Paste pH		Moisture
Name	cm	Wet	Dry	%
WL 2.1	0-5	4.4	6.2	51
WL 2.2	5-20	7.0		25
WL 2.3	20-40	5.5		25
WL 5.3	0-1	2.3		28
WL 5.4	1-5	2.8	2.4	48
WL 5.5	5-20	2.6	2.6	56
WL 6.3	0-1	8.7	8.2	32
WL 6.4	1-8	7.3	6.8	34
WL 6.5	8-20	7.4	7.6	40
WL 7.2	0-3	5.6	5.2	57
WL 7.3	3-12	7.6	7.4	59
WL 7.4	12.25	7.3	7.5	42
WL 8.2	0-1	6.7	3.5	38
WL 8.3	1-3	4.8	4.3	47
WL 8.4	3-6	4.6	2.3	53
WL 8.5	6-25	4.7	5.0	46
WL 9.2	0-5	4.7	4.7	34
WL 9.3	5-30	5.6	5.8	37
WL 11.1	0-5	6.8		26
WL 11.3	10-20	5.0		25
WL 12.2	1-5	5.3		21
WL 12.3	5-15	5.3	5.6	29
WL 14.2	0-2	6.2		18
WL 14.4	2-7	4.9		18
WL 15.1	0-5	3.2		21
WL 15.2	5-10	3.9		21
WL 17.1	0-15	5.7		23

Wellington Weir

Sample	Depth	Paste pH		Moisture
Name	cm	Wet	Dry	%
WW3A 1.1	0-8	8.0		17
WW3A 1.2	8-?	7.9	8.4	17
WW3A2.1	15-20	7.7		15
WW3A 4.1	0-5	7.9		15
WW3A 4.2	15-25	7.6		15
WW 3A 4.5	25-50	4.9		22
WW 8A 2.1	0-5	5.8	5.8	72
WW 8A 2.2	5-15	5.2	5.0	73
WW 8A 2.3	15-30	4.2	3.8	78
WW20A 1.1	0-5	6.9		57
WW20A 1.2	5-18	5.8	6.0	42
WW20C	30-40	4.4	2.2	51
WWBH20 11.1	0-5	8.0	0.0	19
WWBH20 11.2	5-15	5.0		17

Lake Albert

Sample	Depth	Paste pH		Moisture
Name	cm	Wet	Dry	%
AT 1.1*	0-5	7.6		18
AT 1.3	15-30	7.6		17
AT 2.1	0-3	8.1		20
AT 2.2	3-5	6.8		21
AT 2.3	5-20	4.4	3.8	74
AT 2.6	30-35	3.5		18
AT 4.1 *	0-5	7.9		19
AT 6.1	0-2	8.0		17
AT 7.1	0-5	8.0		18
AT 7.2	5-20	3.6	3.7	68
AT 7.3	20-40	5.0	4.3	73
AT 9.1 *	0-5	3.3	3.7	60
AT 9.2		2.9	3.0	72
AT 10.1	0-5	7.0	6.4	55
AT 10.2 *	5-15	4.8		61
AT 11.1	0-5	7.9	4.1	22
AT 11.2	5-50	6.3	6.2	42
AT 12.1	0-5	4.2	4.5	6
AT 12.2	5-25	3.9	5.6	22
AT 12.3	25-40	6.9	5.5	60
AT 14.1	0-3	8.5	9.5	17
AT 14.2	3-15	7.6	8.8	19
AT 14.3	15-25	7.5	7.7	54
AT 14.3	15-25	7.5	3.8	54
AT 14.4	25-30	8.2	8.2	57
AT 14.5	25-30	7.5	7.0	67
AT 16.1	0-5	8.4	8.0	2
AT 16.2	5-20	7.5	8.3	10
AT 16.3	20-45	7.7	8.4	16
AT 16.4	45-75	8.0	0.0	23
AT 17.1	0-1	8.0		19
AT 17.2	1-10	7.6		17
AT 17.3	10-20	6.7	7.3	65
AT 17.4	20-30	7.0	8.0	64
AT 18.1	0-8	9.1	9.5	11
AT 18.2	18-28	8.2	8.4	18
AT 18.3	28-40	7.6	8.3	21
AT 19.1	0-8	7.9	8.5	1
AT 19.2	8-18	6.8	6.8	39
AT 19.3	18-28	3.3		22
AT 20.1	0-2	7.5	7.8	12
AT 20.2	2-10	6.3		6
AT 20.3	?	8.3	8.0	53
AT 20.3	10-?	6.7	6.4	40
AT 21.1	0-1	6.9	6.9	8
AT 21.2	1-10	7.5	7.3	43

Table B2. Paste pH and moisture measurements of soils

Paste-pH and moisture measurements of soils

Lake Alexandrina

Sample	Depth	Paste pH		Moisture
Name	**cm**	**Wet**	**Dry**	**%**
AA 3	5-5.5	7.5		9
AA 8.1 *	0-5	7.7		19
AA 8.2	5-20	6.4		24
AA 9.1	0-5	8.1		18
AA10.2 *	10-30	5.5		28
AA 10.1	0-10	7.4		29
AA 11.1	0-3	7.5		22
AA 11.2	3-10	4.1		21
AA 12.1	0-5	7.9		21
AA 12.1*	0-5	8.5		17
AA 12.2	5-20	5.8		20
AA 13.2	3-15	3.2	3.1	33
AA 14.2*	?	7.6		18
AA 15.1*	?	8.1		18
AA 18.2	2-12	7.9		16
AA 19.1	?	9.3		17
AA 19.3	?			
AA 20.1*	0-5	7.8		20
AA 20.2	5-20	3.2	3.1	30
AA 22.1*	0-5	7.8	7.4	60
AA 29.5	0-3	2.7		1
AA 29.6	3-10	2.1	0.0	6
AA 30.1	0-0.05	8.6		16
AA 30.2	0.05-20	7.5		16
AA 31.3	0-10	6.8	6.2	29
AA 31.5	10-18	6.8		25
AA 33.1	0-1	6.2	3.6	44
AA 33.2	0-10	2.4	2.7	70
AA 33.3	10-25	2.3	2.9	72
AA 33.4	25-40	4.5	0.0	20
AA 33.5	40-60	7.4		19
AA 34 (MBC	40-60	7.1	7.3	76

Wetland: Ekee

Sample	Depth	Paste pH		Moisture
Name	**cm**	**Wet**	**Dry**	**%**
UKE 1.1	0-10	7.0	0.0	38
UKE 1.1	0-10	7.0		38
UKE 1.2	10-30	6.4	6.3	48
UKE 2.1	0-5	6.7	6.2	65
UKE 2.2	5-20	7.2	6.9	39
UKE 3.1	0-0.5	3.2	3.3	57
UKE 3.2	0.5-1	2.7		26
UKE 3.3	1-8	2.4	0.0	10
UKE 3.4	8-12	3.3	1.8	30
UKE 3.4	8-12	3.3		30
UKE 3.5	12-20	3.9		5
UKE 5.1	0-0.5	2.7		12
UKE 5.2	0.5-10	2.6		8
UKE 5.3	10-30	5.3	5.3	32

Wetland: Jury Swamp

Sample	Depth	Paste pH		Moisture
Name	**cm**	**Wet**	**Dry**	**%**
JUR 2.3	0-2	2.8	0.0	11
JUR 2.4.5	2-10	2.9	2.7	33
JUR 2.6-7	10-40	4.4	4.4	46
JUR 6.5	40-60	5.7	5.4	73

Wetland: Morgan

Sample	Depth	Paste pH		Moisture
Name	**cm**	**Wet**	**Dry**	**%**
MOR 1.2	30-40	4.0	4.1	44
MOR 1.3	40-70	4.5	2.4	35
MOR 2.2	5-10	4.3	4.7	30
MOR 2.3	10-45	5.1	5.1	39
MOR 2.4	?	5.5	4.9	74
MOR 3.1	0-15	6.5		51
MOR 3.2	?	5.8	5.6	82
PA 4.1	0-1	6.9	6.4	4
PA 4.2	1-3	7.9	7.7	4

Wetland: Paiwilla

Sample	Depth	Paste pH		Moisture
Name	**cm**	**Wet**	**Dry**	**%**
PA 4.3	3-8	7.4	0.0	10
PA 4.4	8-15	6.0	5.9	29
PA 4.5	15-50	5.5	5.3	41
RIV 3.2	0-1	7.2	7.3	8
RIV 3.4	1-10	6.7		18
RIV 3.5	?	7.5	7.9	53

Wetland: Riverglades

Sample	Depth	Paste pH		Moisture
Name	**cm**	**Wet**	**Dry**	**%**
RIV 4.2	0.02-2	7.8	3.8	11
RIV 4.3	2-10	5.0	6.0	42
RIV 4.4	10-30	8.2	8.0	53

Wetland: Swanport

Sample	Depth	Paste pH		Moisture
Name	**cm**	**Wet**	**Dry**	**%**
SPM 1.1	0-0.5	3.3	1.6	3
SPM1.3	5-10	3.3	3.3	38

B2. QA/QC for Particulate Metals

Table B3. Analyses of Certified Reference Material (PACS-2) (mg/kg)

Batch No.	Ag	Al	As	Ba	Ca	Cd	Co	Cr	Cu	Fe	K	Mg	Mn	Ni	Pb	V	Zn
TPM 1	<0.3	3740	23.3	91.2	5710	2.48	12.81	40.5	295	22300	5990	8240	207	26.6	153	65.1	334
TPM 1	<0.3	3640	24.4	90.8	6220	2.46	12.54	40.3	296	22300	5980	8250	205	25.1	163	63.0	334
TPM 1	<0.3	4020	23.2	103	4790	2.51	13.23	40.6	307	23000	6090	8330	213	25.2	165	64.0	344
TPM 1	<0.3	3800	24.9	97.5	5820	2.63	13.15	41.4	304	23100	6120	8560	212	26.2	160	64.0	341
TPM 2	<0.3	3410	22.3	48.6	5520	2.31	14.9	37.9	276	21200	6020	8080	200	24.5	152	59.8	320
TPM 2	<0.3	3710	21.9	52.2	5530	2.22	10.20	37.3	283	21600	5930	8000	198	23.5	161	60.2	308
TPM 2	<0.3	3710	21.2	129.0	5680	2.37	10.60	36.8	282	21200	5970	7930	192	23.9	143	59.7	310
TPM 2	<0.3	3870	22.2	118.0	6230	2.51	14.60	41.5	311.0	23200	6790	8940	214	26.4	160	67.1	334
TPM 3	<0.375	3640	20.5	50.0	5530	<0.375	13.3	35.9	265	19900	5940	7790	198	24.7	143	56.2	325
TPM 3	<0.375	3770	22.1	57.9	5590	<0.375	13.8	37.1	277	21100	6120	7990	203	24.5	150	60.8	316
TPM 3	<0.375	3550	22.0	50.8	5410	<0.375	13.4	36.1	281	20200	6130	7820	198	24.9	152	57.0	325
TPM 4	<0.375	3280	21.5	320	4940	2.32	8.22	34.1	276	19600	5520	7250	184	22.6	148	54.5	299
TPM 4	<0.375	3240	21.5	68.2	5040	2.34	6.68	34.9	276	20000	5580	7390	186	23.1	146	54.3	300
TPM 4	<0.375	3700	20.9	184	4930	2.36	6.79	35.7	279	20500	5620	7450	183	23.2	153	55.1	304
Ave	<0.375	3649	22.3	104	5496	2.41	11.73	37.9	286	21371	5986	8001	200	24.6	154	60.1	321
Std Dev	241	217	1.27	72.9	447	0.118	2.77	2.5	13.8	1247	308	460	10.4	1.25	7.27	4.19	15.2

	Ag	As	Cd	Co	Cr	Cu	Mn	Ni	Pb	Zn
Certified	1.10	26.2	2.11	11.5	90.7	310	440	39.5	183	364
% recovery		85	114	102	42	92	45	62	84	88
In house ave (n=31)	1.59	23.3	2.30	10.8	39.7	302	203	25.0	154	329
% recovery		96	105	108	95	95	98	98	100	98

Table B4. Method blanks (mg/kg)

Batch	Ag	Al	As	Ba	Ca	Cd	Co	Cr	Cu	Fe	K	Mg	Mn	Ni	Pb	V	Zn
TPM 1	<0.3	0.94	<0.3	<0.3	16.3	<0.3	<0.3	0.02	<0.3	<0.5	<0.3	<1	<0.3	<0.3	<1	<1	0
TPM 1	<0.3	0.62	0.37	<0.3	37.1	<0.3	<0.3	0.02	<0.3	<0.5	<0.3	<1	<0.3	<0.3	<1	<1	<1
TPM 2	<0.3	<0.5	<0.3	<0.3	44.0	<0.3	13.1	<0.3	<0.3	<0.5	<0.3	<1	<0.3	<0.3	<1	<1	<1
TPM 2	<0.3	<0.5	<0.3	<0.3	60.1	<0.3	<0.3	<0.3	<0.3	<0.5	<0.3	<1	<0.3	<0.3	<1	<1	<1
TPM 2	<0.3	<0.5	<0.3	<0.3	78.4	<0.3	<0.3	<0.3	<0.3	<0.5	<0.3	<1	<0.3	<0.3	<1	<1	<1
TPM 2	<0.3	<0.5	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	3.28	<0.3	<1	<0.3	<0.3	<1	<1	<1
TPM 2	<0.3	<0.5	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.5	<0.3	<1	<0.3	<0.3	<1	<1	<1
TPM 3	<0.3	<0.5	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.5	<0.3	<1	<0.3	<0.3	<1	<1	<1
TPM 3	<0.3	<0.5	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.5	<0.3	<1	<0.3	<0.3	<1	<1	<1
TPM 3	<0.3	<0.5	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.5	<0.3	<1	<0.3	<0.3	<1	<1	<1
TPM 4	<0.375	<0.5	<0.375	<0.375	10.9	<0.375	<0.375	<0.375	<0.375	1.66	<0.375	<0.375	<0.375	<0.375	<1.25	<1.25	<1.25
TPM 4	<0.375	<0.5	<0.375	<0.375	50.8	<0.375	<0.375	<0.375	<0.375	3.01	<0.375	<0.375	<0.375	<0.375	<1.25	<1.25	<1.25
TPM 4	<0.375	<0.5	<0.375	<0.375	55.0	<0.375	<0.375	<0.375	<0.375	1.72	<0.375	<0.375	<0.375	<0.375	<1.25	<1.25	<1.25

Table B4. Analyses of sample duplicates (mg/kg)

Batch no.	Site Name	Ag	Al	As	Ba	Ca	Cd	Co	Cr	Cu	Fe	K	Mg	Mn	Ni	Pb	V	Zn
TPM 1	PA 4.5	<0.3	3090	9.68	285	4500	<0.3	12.5	136	26.1	15300	3190	3650	136	13.7	16.4	51.5	27.7
TPM 1	PA 4.5	<0.3	3160	12.1	293	1310	<0.3	12.4	138	26.3	17500	3100	3630	138	13.1	17.8	56.3	27.2
TPM 1	AT 16.3	<0.3	186	<0.3	2.83	146	<0.3	8.32	4.55	<0.3	393	121	175	4.55	<0.3	<1	<1	<1
TPM 1	AT 16.3	<0.3	188	<0.3	3.12	195	<0.3	8.25	4.60	<0.3	364	121	177	4.60	<0.3	<1	<1	<1
TPM 1	RIV 4.3	<0.3	2630	5.42	91.8	20400	<0.3	14.3	1280	12.5	8770	6370	13900	1280	9.87	6.89	16.8	16.7
TPM 1	RIV 4.3	<0.3	3080	6.89	111	5530	<0.3	8.95	327	17.8	9540	5720	8070	327	15.3	10.3	23.1	18.8
TPM 1	AT 11.1	<0.3	294	2.21	9.58	787	<0.3	6.36	34.2	0.69	1530	228	245	34.2	0.73	1.5	3.26	0.87
TPM 1	AT 11.1	<0.3	315	2.25	9.62	733	<0.3	5.15	34.2	0.71	1580	233	251	34.2	0.78	<1	3.17	1.06
TPM2	AA 29.6	<0.3	155	<0.3	2.52	172	<0.3	3.08	<0.3	0.34	966	96.4	60.1	9.07	<0.3	<1	1.64	0.48
TPM2	AA 29.6	<0.3	169	<0.3	2.71	189	<0.3	0.64	<0.3	0.38	1040	103	63.9	10.1	0.49	<1	1.73	0.59
TPM2	AA 33.4	<0.3	335	0.35	2.95	27.6	<0.3	1.40	0.73	0.75	633	195	26.9	3.70	0.68	<1	1.77	1.49
TPM2	AA 33.4	<0.3	358	0.81	3.12	27.6	<0.3	1.28	0.86	0.95	662	203	49.1	2.78	0.61	2.02	1.87	1.38
TPM2	AT 20.3	<0.3	2350	7.20	44.1	11600	<0.3	6.20	6.70	9.56	9020	5030	3020	164	7.02	<1	17.2	11.9
TPM2	AT 20.3	<0.3	2390	6.42	44.5	10300	<0.3	6.05	6.79	9.76	9680	5140	3010	160	7.14	<1	17.4	12.6
TPM2	UKE 3.2	<0.3	8460	3.60	31.7	32500	<0.3	67.2	9.78	29.8	26800	6620	12400	571	61.5	25.6	55.0	124
TPM2	UKE 3.2	<0.3	2720	4.09	31.0	32500	<0.3	68.6	9.97	29.9	19800	6540	11700	502	63.1	24.6	55.1	125
TPM 3	WL 5.3	<0.375	1710	1.43	40.0	5190	<0.375	8.70	4.64	14.4	8740	1370	834	42.6	8.80	10.8	11.2	14.0
TPM 3	WL 5.3	<0.375	1830	0.660	42.3	5070	<0.375	9.55	5.01	15.8	9690	1500	898	45.5	9.77	10.9	12.1	14.0
TPM 3	WW3A2.1	<0.375	79.6	<0.375	2.28	313	<0.375	0.88	<0.375	<0.375	474	50.1	45.7	9.4	<0.375	<1.25	<1.25	<1.25
TPM 3	WW3A2.1	<0.375	71.7	<0.375	2.07	294	<0.375	0.73	<0.375	<0.375	434	44.5	40.7	8.57	<0.375	<1.25	<1.25	<1.25
TPM 3	WW20C	<0.375	3410	7.27	120	2640	<0.375	9.24	8.05	32.5	7400	2450	1940	163	16.8	7.19	28.7	15
TPM 3	WW20C	<0.375	3400	7.44	117	2700	<0.375	9.17	8.04	31.2	7360	2400	1940	161	16.8	6.82	27.4	14.4
TPM 3	WL 11.3	<0.375	1660	<0.375	64.6	1060	<0.375	3.58	3.73	7.36	2900	1400	1320	56.2	3.29	4.88	12.1	9.71
TPM 3	WL 11.3	<0.375	1620	<0.375	64.7	1040	<0.375	3.51	3.77	7.00	2750	1360	1300	56.7	3.34	5.43	11.5	9.05
TPM 3	WL 14.4	<0.375	1270	<0.375	18.5	144	<0.375	2.38	2.13	2.64	1930	728	645	66.6	1.74	2.95	4.96	5.86
TPM 4	WL 14.4	<0.375	1030	<0.375	26.8	555	<0.375	1.11	2.28	2.76	2110	699	712	77.3	1.59	2.81	4.82	5.72
TPM 3	WL 8.5	<0.375	6460	4.38	86.9	4660	<0.375	15.3	9.38	20.4	7310	4140	3160	258	15.2	11.7	34.1	26.8
TPM 4	WL 8.5	<0.375	2680	5.15	232	4750	<0.375	8.12	9.54	20.8	7020	4000	3200	256	15.2	11.8	34.1	27.4
TPM 4	AA 20.2	<0.375	296	1.54	125	353	<0.375	2.10	0.740	1.72	1280	85.0	248	10.9	2.68	0.68	3.59	2.77
TPM 4	AA 20.2	<0.375	315	1.41	125	332	<0.375	2.16	0.760	1.78	1350	55.2	275	11.0	2.57	0.800	3.79	2.59

B3. QA/QC for Mobilisation Tests: Replicated Tests

Table B5.

All Replicated Tests for 1st and 2nd River Murray release tests and Synthetic Rainwater Tests

Replicates of 1st River Murray release tests

Sample	Depth	Paste	Moisture	Start of Resuspension				Middle		End of Resuspension			
Name	cm	pH	%	pH	Redox	EC	D.O	pH	DO	pH	Redox	EC	D.O
JUR 2.3	0-2	2.8	11	3.2	737	3010	6.7			2.7	588	6.13	8.2
JUR 2.3	0-2	2.8	11	3.4	718	2.59	2.6			2.7	585	5830	8.3
PA 4.3	3-8	7.4	10	7.7	494	14000	10.1	7.3	8.0	6.8	1	16930	0.2
PA 4.3	3-8	7.4	10	7.5	429	11880	10.0	7.4	7.9	6.9	5	16330	0.1
SPM 1.1	0-0.5	3.3	3	4.0	646	2170	11.2			3.4	525	3400	0.7
SPM 1.1	0-0.5	3.3	3	4.1	632	1700	11.2			3.4	528	3410	0.9
RIV 4.2	0.02-2	7.8	11	8.0	488	37500	5.8			7.3	-109	443600	0.3
RIV 4.2	0.02-2	7.8	11	8.0	478	40200	5.6			7.3	-60	36200	0.2
AT 11.1	0-5	7.9	22	7.3	428	741	10.2			7.0	73	947	0.3
AT 11.1	0-5	7.9	22	7.3	449	738	10.2			7.0	20	915	0.2
AA 33.1	0-1	6.2	44	6.7	392	11350	10.3	6.9	5.8	7.5	73	14770	0.1
AA 33.1	0-1	6.2	44	6.9	394	10007	10.4	6.8	5.6	7.5	26	14680	0.3
AT 16.4	45-75	8.0	23	8.0	484	1297	10.6			8.3	277	1320	8.9
AT 16.4	45-75	8.0	23	8.0	489	1460	10.5			8.4	276	1490	8.9
MOR 1.3	0-3 or 40-70	4.5	35	5.8	532	1001	10.0	5.6	8.1	5.5	435	1056	6.0
MOR 1.3	0-3 or 40-70	4.5	35	6.0	535	993	9.8	5.4	8.1	5.5	422	1063	6.0
UKE 3.4	8-12	3.3	30	4.2	523	1270	10.3	4.0	7.7	3.9	557	1846	7.1
UKE 3.4	8-12	3.3	30	4.1	534	1456	10.1	4.0	7.6	4.0	568	1784	7.0
UKE 3.3	1-8	2.4	10	2.6	629	2740	10.4	2.6	7.7	2.7	602	3830	7.3
UKE 3.3	1-8	2.4	10	2.7	627	2800	10.4	2.6	7.8	2.6	604	3800	7.1
UKE 1.1	0-10	7.0	38	7.0	491	640	9.9	7.0	8.0	7.0	377	701	6.1
UKE 1.1	0-10	7.0	38	7.2	503	643	9.9	7.0	7.9	6.9	375	697	6.1
WW20C	30-40	4.4	51	6.7	593	744	9.7	5.5	8.7	5.3	516	1217	8.2
WW20C	30-40	4.4	51	6.6	598	817	9.6	5.4	8.8	5.0	511	1475	8.0
WWBH20 11.1	0-5	8.0	19	7.5	566	601	8.8			7.4	413	630	6.6
WWBH20 11.1	0-5	8.0	19	7.5	557	602	9.0			7.4	407	628	6.5
WL 8.2	0-1	6.7	38	7.0	488	2730	9.7	6.9	8.1	6.5	394	3320	1.2
WL 8.2	0-1	6.7	38	7.2	461	2280	10.0	6.8	8.0	6.5	384	3350	0.8
WL 8.4	3-6	4.6	53	6.3	484	1260	9.5	5.1	7.9	5.0	431	1440	6.7
WL 8.4	3-6	4.6	53	6.4	502	1190	9.7	5.1	8.0	5.0	438	1420	6.6

Replicates of Synthetic Rain Water release tests

Sample	Depth	Paste	Moisture	Start of Resuspension				Middle		End of Resuspension			
Name	cm	pH	%	pH	Redox	EC	D.O	pH	DO	pH	Redox	EC	D.O
AA 29.6	3-10	2.1	6	3.2	701	541	10.7			3.0	681	725	9.5
AA 29.6	3-10	2.1	6	3.2	701	508	10.8			3.0	679	684	9.4
MUR 1.3	0-3 or 40-70	4.5	35	6.0	533	319	11.9			5.9	552	692	8.9
MUR 1.3	0-3 or 40-70	4.5	35	6.0	524	411	11.7			5.5	541	695	9.1
WL 15.1	0-5	3.2	21	3.9	579	295	11.6			3.6	571	371	9.3
WL 15.1	0-5	3.2	21	3.9	565	299	11.7			3.6	563	380	9.3

Replicates of 2nd River Murray release tests (a week later)

Sample	Depth	Paste	Moisture	Start of Resuspension				Middle		End of Resuspension			
Name	cm	pH	%	pH	Redox	EC	D.O	pH	DO	pH	Redox	EC	D.O
AA 29.6	3-10	2.1	6	3.7	646	803	12.9			3.3	548	1001	9.5
AA 29.6	3-10	2.1	6	3.8	624	771	13.3			3.4	624	964	9.7
AA 20.2	5-20	3.2	30	5.1	547	888	11.7			3.9	527	1001	9.2
AA 20.2	5-20	3.2	30	5.3	544	902	11.9			4.0	516	1001	9.2

Table B6.

Averages of Replicated Tests for 1st and 2nd River Murray release tests and Synthetic Rainwater Tests

Averages of replicates of 1st River Murray release tests

Sample	Depth	Paste	Moisture	Start of Resuspension				Middle		End of Resuspension			
Name	**cm**	**pH**	**%**	**pH**	**Redox**	**EC**	**D.O**	**pH**	**DO**	**pH**	**Redox**	**EC**	**D.O**
JUR 2.3	0-2	2.8	11	3.3	728	1506	4.6			2.7	587	2918	8.3
PA 4.3	3-8	7.4	10	7.6	462	12940	10.0	7.3	8.0	6.9	3	16630	0.1
SPM 1.1	0-0.5	3.3	3	4.0	639	1935	11.2			3.4	527	3405	0.8
RIV 4.2	0.02-2	7.8	11	8.0	483	38850	5.7			7.3	-85	239900	0.2
AT 11.1	0-5	7.89	22	7.3	439	740	10.2			7.0	47	931	0.2
AA 33.1	0-1	6.19	44	6.8	393	10679	10.3	6.9	5.7	7.5	50	14725	0.2
AT 16.4	45-75	7.95	23	8.0	487	1379	10.5			8.4	277	1405	8.9
MOR 1.3	0-3 or 40-70	4.53	35	5.9	534	997	9.9	5.5	8.1	5.5	429	1060	6.0
UKE 3.4	8-12	3.3	30	4.2	529	1363	10.2	4.0	7.7	4.0	563	1815	7.0
UKE 3.3	1-8	2.42	10	2.7	628	2770	10.4	2.6	7.7	2.6	603	3815	7.2
UKE 1.1	0-10	7	38	7.1	497	642	9.9	7.0	8.0	6.9	376	699	6.1
WW20C	30-40	4.38	51	6.6	596	781	9.6	5.4	8.8	5.2	514	1346	8.1
WWBH20 11.1	0-5	8	19	7.5	562	602	8.9			7.4	410	629	6.5
WL 8.2	0-1	6.68	38	7.1	475	2505	9.8	6.8	8.1	6.5	389	3335	1.0
WL 8.4	3-6	4.6	53	6.3	493	1225	9.6	5.1	7.9	5.0	435	1430	6.6

Averages of replicates of Synthetic Rain Water release tests

Sample	Depth	Paste	Moisture	Start of Resuspension				Middle		End of Resuspension			
Name	**cm**	**pH**	**%**	**pH**	**Redox**	**EC**	**D.O**	**pH**	**DO**	**pH**	**Redox**	**EC**	**D.O**
AA 29.6	3-10	2.1	5.5	3.2	701	525	11			3.0	680	705	9.5
MUR 1.3	0-3 or 40-70	4.5	35.3	6.025	528.5	365	12			5.7	546.5	694	9.0
WL 15.1	0-5	3.2	20.6	3.905	572	297	12			3.6	567	376	9.3

Averages of replicates of 2nd River Murray release tests (a week later)

Sample	Depth	Paste	Moisture	Start of Resuspension				Middle		End of Resuspension			
Name	**cm**	**pH**	**%**	**pH**	**Redox**	**EC**	**D.O**	**pH**	**DO**	**pH**	**Redox**	**EC**	**D.O**
AA 29.6	3-10	2.14	6	3.8	635.0	787.0	13.1			3.3	586.0	982.5	9.6
AA 20.2	5-20	3.2	30	5.2	545.5	895.0	11.8			3.9	521.5	1001.0	9.2

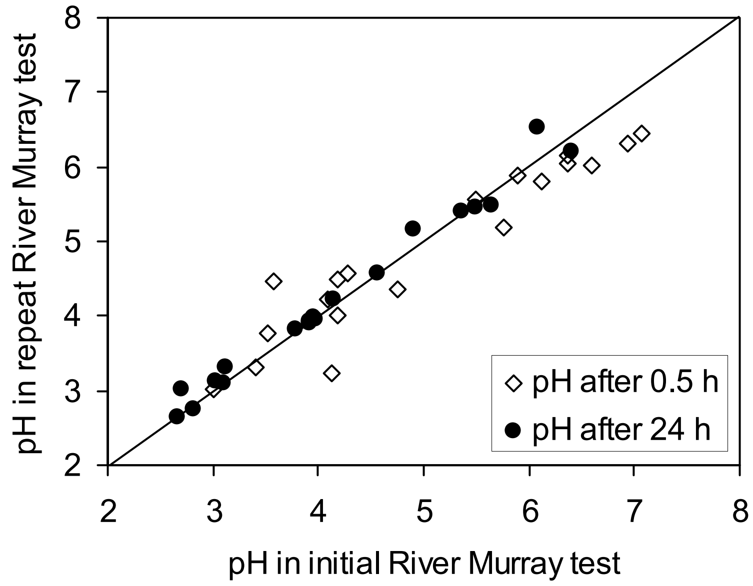


Table B7. Comparison of release test results for repeated remobilisation tests with River Murray water.

Comparison of Repeat RM test (week later) with initial RM tests (averages or otherwise) of 1st RN release tests

Sample	Depth	Paste	Moisture	Start of Resuspension				End of Resuspension			
Name	**cm**	**pH**	**%**	**pH**	**Redox**	**EC**	**D.O**	**pH**	**Redox**	**EC**	**D.O**
RIV 4.3	2-10	5.0	42	6.3	209	10750	13.2	6.2	455	14060	8.2
RIV 4.3	2-10	5.0	42	6.9	502	9020	6.1	6.4	522	13700	6.3
MUR 2.2				6.0	507	703	11.3	5.2	523	933	7.8
MOR 2.2	5-10	4.3	30	6.6	497	687	10.3	4.9	439	925	6.4
AA 29.5	0-3	2.7	1	4.0	664	1587	12.7	3.9	560	2030	9.7
AA 29.5	0-3	2.7	1	4.2	658	1565	6.3	3.9	541	1957	8.4
AA 29.6	3-10	2.1	6	3.8	635	787	13.1	3.3	586	983	9.6
AA 29.6	3-10	2.1	6	3.5	765	971	10.4	3.1	655	1106	8.3
AA 29.9	3-10	2.1	6	6.1	460	742	13.1	5.5	482	748	9.4
AA 29.6	3-10	2.1	6	6.4	591	756	10.4	5.7	457	705	7.6
MUR 1.3	0-3 or 40-70	4.5	35	5.9	496	798	13.2	5.5	532	1078	8.4
MOR 1.3	0-3 or 40-70	4.5	35	5.9	534	997	9.9	5.5	429	1060	6.0
UKE 3.4	8-12	3.3	30	4.5	561	1368	13.1	4.0	579	1809	9.1
UKE 3.4	8-12	3.3	30	4.2	529	1363	10.2	4.0	563	1815	7.0
UKE 5.2	0.5-10	2.6	8	3.2	593	2330	12.6	3.1	623	4510	9.4
UKE 5.2	0.5-10	2.6	8	4.1	683	1831	1002	3.1	567	3889	7.9
WL 5.3	0-1	2.3	28	3.0	665	2150	13.2	2.6	646	4290	9.3
WL 5.3	0-1	2.3	28	3.0	762	1978	8.9	2.7	651	4160	6.8
WL 5.4	1-5	2.8	48	3.3	637	1207	12.9	2.8	625	1963	9.2
WL 5.4	1-5	2.8	48	3.4	745	950	9.7	2.8	629	1822	6.9
WL 9.2	0-5	4.7	34	6.2	488	1539	11.4	5.4	523	2090	8.4
WL 9.2	0-5	4.7	34	6.4	593	1360	10.7	5.4	551	1900	6.6
WWBH20 11.2	5-15	5.0	17	6.4	409	660	11.3	6.5	466	665	7.5
WWBH20 11.2	5-15	5.0	17	7.1	613	666	9.8	6.1	556	663	7.3
WL 15.1	0-5	3.2	21	5.6	363	670	12.1	4.2	504	715	9.2
WL 15.1	0-5	3.2	21	5.5	517	674	10.3	4.1	510	725	6.4
WL 5.5	5-20	2.6	56	4.5	557	737	11.7	3.1	603	1467	8.8
WL 5.5	5-20	2.6	56	3.6	677	1150	10.7	3.0	608	1837	6.4
AT 7.2	5-20	3.6	68	4.6	516	1910	11.4	3.9	519	2720	6.3
AT 7.2	5-20	3.6	68	4.3	538	2	9.8	3.9	511	2690	3.2
AA 13.2	3-15	3.2	33	4.4	551	1075	11.4	3.8	529	1193	8.9
AA 13.2	3-15	3.2	33	4.8	598	1167	10.8	3.8	538	1290	8.2
AT 2.6	30-35	3.5	18	5.8	365	844	12.0	4.6	474	927	9.0
AT 2.6	30-35	3.5	18	6.1	448	931	10	4.6	488	1006	7.6
JUR 2.4.5	2-10	2.9	33	4.2	564	860	11.4	3.0	599	2020	8.9
JUR 2.4.5	2-10	2.9	33	4.1	645	937	11.2	2.7	604	2900	8.2
AA 20.2	5-20	3.2	30	5.2	546	895	11.8	3.9	522	1001	9.2
AA 20.2	5-20	3.2	30	5.8	453	903	8.3	4.0	519	1019	8.1

Table B8. Alkalinity/acidity, anions, nutrients, TOC

Replicates of 1st River Murray release tests

Sample	Depth	Alkalinity	Acidity	Sulfate	Chloride	Nitrite-N	Nitrate-N	Phosphate	TOC	TIC
Name	cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
JUR 2.3	0-2	---	630	---	---	---	---	---	---	---
JUR 2.3	0-2	---	626	---	---	---	---	---	---	---
PA 4.3	3-8	249	---	---	---	---	---	---	---	---
PA 4.3	3-8	236	---	---	---	---	---	---	---	---
SPM1.1	0-0.5	---	221	1910	213	<0.010	0.073	<0.010	153	5
SPM1.1	0-0.5	---	193	1950	211	<0.010	0.08	0.017	152	4
RIV 4.2	0.02-2	112	---	---	---	---	---	---	---	---
RIV 4.2	0.02-2	109	---	---	---	---	---	---	---	---
AT 11.1	0-5	148	---	---	---	---	---	---	---	---
AT 11.1	0-5	149	---	---	---	---	---	---	---	---
AA 29.6	3-10	---	94	220	145	<0.010	0.072	<0.010	13	1
AA 29.6	3-10	---	---	---	---			---	13	---
AA 33.1	0-1	101	---	---	---	---	---	---	---	---
AA 33.1	0-1	89	---	---	---	---	---	---	---	---
AA 33.4	25-40	29	---	---	---	---	---	---	---	---
AA 33.4	25-40	30	---	---	---	---	---	---	---	---
AT 16.4	45-75	50	---	---	---	---	---	---	---	---
AT 16.4	45-75	43	---	---	---	---	---	---	---	---
MUR 1.3	-3 or 40-7	6	<1	256	162	0.027	<0.010	0.044	18	1
MUR 1.3	-3 or 40-7	4	5	---	---	---	---	---	---	---
AA 20.2	8-12	26	<1	164	149	0.311	0.292	0.022	7	5
AA 20.2	8-12	---	---	---	---			---	8	---
UKE 3.4	1-8	---	24	645	222	<0.010	0.156	<0.010	24	<1
UKE 3.4	1-8	---	33	---	---	---	---	---	---	---
UKE 3.3	0-10	---	692	---	---	---	---	---	---	---
UKE 3.3	0-10	---	687	---	---	---	---	---	---	---
UKE 1.1	30-40	48	---	---	---	---	---	---	---	---
UKE 1.1	30-40	44	---	---	---	---	---	---	---	---
WW 20C	0-5	94	9	---	---	---	---	---	---	---
WW 20C	0-5	<1	9	---	---	---	---	---	---	---
WWBH20 11.1	0-1	<1	---	---	---	---	---	---	---	---
WWBH20 11.1	0-1	23	---	---	---	---	---	---	---	---
WL 8.2	3-6	75	---	---	---	---	---	---	---	---
WL 8.2	3-6	74	---	---	---	---	---	---	---	---
WL 8.4	WL 8.4	<1	5	---	---	---	---	---	---	---
WL 8.4	WL 8.4	<1	5	---	---	---	---	---	---	---

Table B9. QA/QC for mobilisation tests: alkalinity/acidity, anions, nutrients, TOC

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: 618488)									
ES0803750-001	SWAN REACH, SITE DUP 1 O...	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	44	44	0.0	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	44	44	0.0	0% - 20%
ES0803750-010	FILED BLANK 1 (PALWALLA...	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: 618577)									
ES0803750-011	FIELD BLANK 2 (MILANG),...	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
ES0803750-020	MILANG, TOTAL	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	185	184	0.8	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	185	184	0.8	0% - 20%
ED037P: Alkalinity by PC Titrator (QC Lot: 618578)									
ES0803750-043	SR: WWBH20 11.2	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	5	5	0.0	No Limit
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	5	5	0.0	No Limit
ES0803750-057	PA 4.3, METHOD DUP 1 OF 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	249	249	0.0	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	249	249	0.0	0% - 20%
ED037P: Alkalinity by PC Titrator (QC Lot: 618617)									
ES0803750-058	PA 4.3, METHOD DUP 2 OF 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	236	236	0.0	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	236	236	0.0	0% - 20%
ES0803750-071	AT 16.2	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	56	56	0.0	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	56	56	0.0	0% - 20%
ED038A: Acidity (QC Lot: 618593)									
ES0803750-004	PALWALLA WETLAND, FILTER...	ED038: Acidity as CaCO3	----	1	mg/L	<1	<1	0.0	No Limit
ES0803795-025	Anonymous	ED038: Acidity as CaCO3	----	1	mg/L	5	5	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 (%)*
ED038A: Acidity (QC Lot: 619234)									
ES0803750-015	PALWALLA WETLAND, TOTAL	ED038: Acidity as CaCO3	----	1	mg/L	<1	<1	0.0	No Limit
ES0803750-030	SR: AA 29.5	ED038: Acidity as CaCO3	----	1	mg/L	169	188	10.5	0% - 20%
ED038A: Acidity (QC Lot: 619235)									
ES0803750-044	SR: WL 15.1, METHOD DUP ...	ED038: Acidity as CaCO3	----	1	mg/L	38	38	0.0	0% - 20%
ES0803750-050	JUR 2.3, METHOD DUP 1 OF...	ED038: Acidity as CaCO3	----	1	mg/L	630	602	4.6	0% - 20%
ED041: Sulphate (Turbidimetric) as SO4 2- (QC Lot: 620491)									
ES0803750-001	SWAN REACH, SITE DUP 1 O...	ED041: Sulphate as SO4 - Turbidimetric	----	1	mg/L	26	26	0.0	0% - 20%
ES0803750-010	FILED BLANK 1 (PALWALLA...	ED041: Sulphate as SO4 - Turbidimetric	----	1	mg/L	<1	<1	0.0	No Limit
ED041: Sulphate (Turbidimetric) as SO4 2- (QC Lot: 620492)									
ES0803750-021	FIELD BLANK 1(PALWALLA),...	ED041: Sulphate as SO4 - Turbidimetric	----	1	mg/L	<1	<1	0.0	No Limit
ES0803795-014	Anonymous	ED041: Sulphate as SO4 - Turbidimetric	----	1	mg/L	1180	1180	0.2	0% - 20%
ED045G: Chloride Discrete analyser (QC Lot: 618452)									
ES0803750-001	SWAN REACH, SITE DUP 1 O...	ED045G: Chloride	16887-00-6	1.0	mg/L	109	109	0.6	0% - 20%
ES0803750-010	FILED BLANK 1 (PALWALLA...	ED045G: Chloride	16887-00-6	1.0	mg/L	<1.0	1.5	40.0	No Limit
ED045G: Chloride Discrete analyser (QC Lot: 618453)									
ES0803750-021	FIELD BLANK 1(PALWALLA),...	ED045G: Chloride	16887-00-6	1.0	mg/L	<1.0	<1.0	0.0	No Limit
ES0803794-028	Anonymous	ED045G: Chloride	16887-00-6	1.0	mg/L	141	135	4.3	0% - 20%
ED093F: Dissolved Major Cations (QC Lot: 619602)									
ES0803750-001	SWAN REACH, SITE DUP 1 O...	ED093F: Sodium	7440-23-5	1	mg/L	63	64	0.0	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	3	3	0.0	No Limit
ES0803750-011	FIELD BLANK 2 (MILANG),...	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
ED093F: Dissolved Major Cations (QC Lot: 619603)									
ES0803750-021	FIELD BLANK 1(PALWALLA),...	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
ES0803884-001	Anonymous	ED093F: Sodium	7440-23-5	1	mg/L	9	9	0.0	No Limit
		ED093F: Potassium	7440-09-7	1	mg/L	<1	<1	0.0	No Limit
EK057G: Nitrite as N by Discrete Analyser (QC Lot: 618213)									
ES0803747-001	Anonymous	EK057G: Nitrite as N	----	0.010	mg/L	<0.010	<0.010	0.0	No Limit
ES0803750-001	SWAN REACH, SITE DUP 1 O...	EK057G: Nitrite as N	----	0.010	mg/L	<0.010	<0.010	0.0	No Limit
EK057G: Nitrite as N by Discrete Analyser (QC Lot: 618214)									
ES0803750-012	SWAN REACH, SITE DUP 1 O...	EK057G: Nitrite as N	----	0.010	mg/L	0.028	0.027	3.6	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 (%)*
EK057G: Nitrite as N by Discrete Analyser (QC Lot: 618214) - continued									
ES0803750-021	FIELD BLANK 1(PALWALLA),...	EK057G: Nitrite as N	----	0.010	mg/L	<0.010	<0.010	0.0	No Limit
EK059G: NOX as N by Discrete Analyser (QC Lot: 618455)									
ES0803750-001	SWAN REACH, SITE DUP 1 O...	EK059G: Nitrite + Nitrate as N	----	0.010	mg/L	0.462	0.458	0.9	0% - 20%
ES0803750-010	FILED BLANK 1 (PALWALLA...	EK059G: Nitrite + Nitrate as N	----	0.010	mg/L	0.058	0.081	33.1	No Limit
EK059G: NOX as N by Discrete Analyser (QC Lot: 618456)									
ES0803750-021	FIELD BLANK 1(PALWALLA),...	EK059G: Nitrite + Nitrate as N	----	0.010	mg/L	<0.010	<0.010	0.0	No Limit
ES0803794-028	Anonymous	EK059G: Nitrite + Nitrate as N	----	0.010	mg/L	0.054	0.054	0.0	No Limit
EK071G: Reactive Phosphorus as P by discrete analyser (QC Lot: 618217)									
ES0803750-022	FIEDL BLANK2 (MIILANG),...	EK071G: Reactive Phosphorus as P	----	0.010	mg/L	<0.010	<0.010	0.0	No Limit
ES0803750-010	FILED BLANK 1 (PALWALLA...	EK071G: Reactive Phosphorus as P	----	0.010	mg/L	<0.010	0.014	33.3	No Limit
EK071G: Reactive Phosphorus as P by discrete analyser (QC Lot: 618218)									
ES0803825-001	Anonymous	EK071G: Reactive Phosphorus as P	----	0.010	mg/L	<0.010	0.015	40.0	No Limit
ES0803797-023	Anonymous	EK071G: Reactive Phosphorus as P	----	0.010	mg/L	0.022	0.012	58.8	No Limit
EP005: Total Organic Carbon (TOC) (QC Lot: 619156)									
ES0803717-001	Anonymous	EP005: Total Organic Carbon	----	1	mg/L	3	3	0.0	No Limit
ES0803724-002	Anonymous	EP005: Total Organic Carbon	----	1	mg/L	4	4	0.0	No Limit
EP005: Total Organic Carbon (TOC) (QC Lot: 619157)									
ES0803750-007	MENINGLE, SITE DUP 1 OF ...	EP005: Total Organic Carbon	----	1	mg/L	20	22	8.7	0% - 20%
ES0803750-020	MILANG, TOTAL	EP005: Total Organic Carbon	----	1	mg/L	23	28	16.8	0% - 20%
EP006 Total Inorganic Carbon (QC Lot: 620441)									
ES0803750-001	SWAN REACH, SITE DUP 1 O...	EP006: Total Inorganic Carbon	----	1	mg/L	8	7	0.0	No Limit
ES0803750-010	FILED BLANK 1 (PALWALLA...	EP006: Total Inorganic Carbon	----	1	mg/L	<1	<1	0.0	No Limit
EP006 Total Inorganic Carbon (QC Lot: 620442)									
ES0803750-021	FIELD BLANK 1(PALWALLA),...	EP006: Total Inorganic Carbon	----	1	mg/L	<1	<1	0.0	No Limit
ES0803794-028	Anonymous	EP006: Total Inorganic Carbon	----	1	mg/L	<1	<1	0.0	No Limit

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

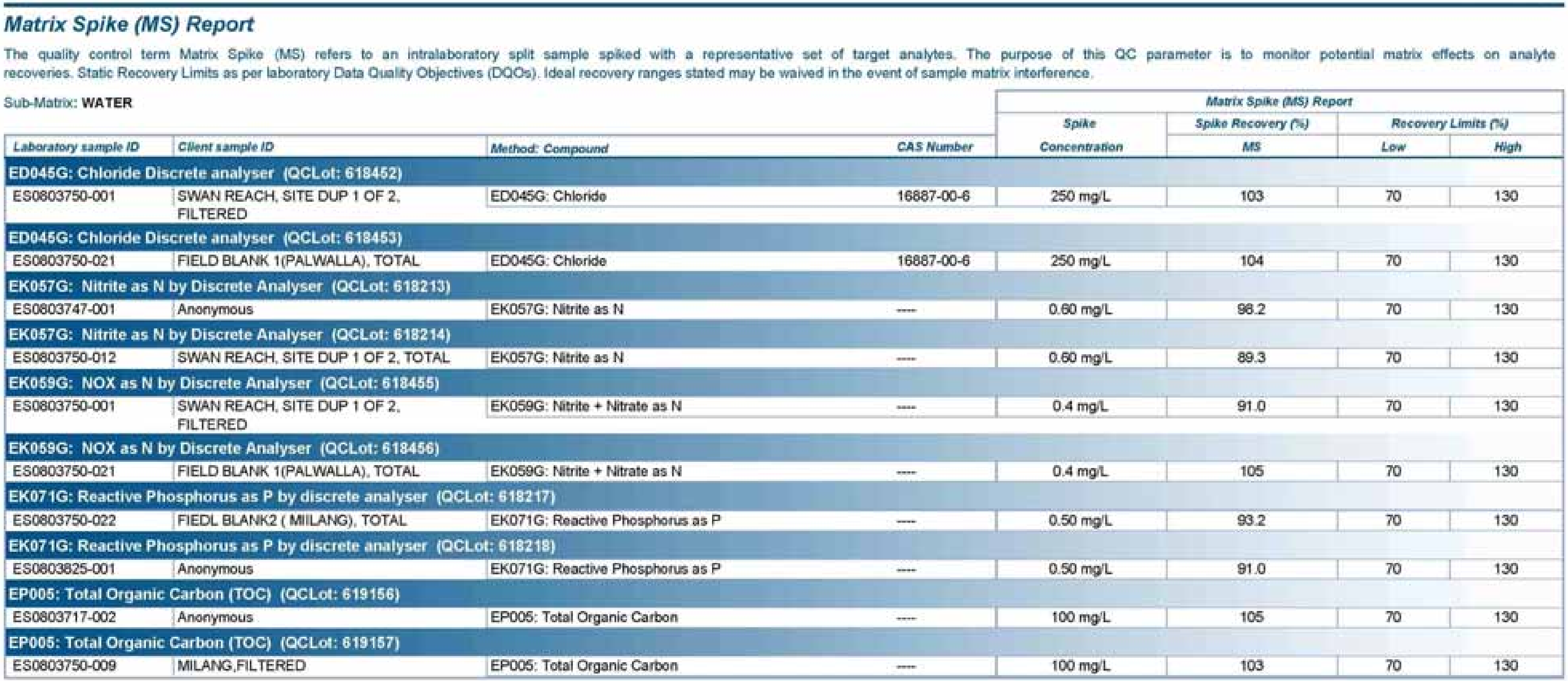
The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory 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: 618488)								
ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	----	200 mg/L	85.2	80.2	108
ED037P: Alkalinity by PC Titrator (QCLot: 618577)								
ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	----	200 mg/L	91.6	80.2	108
ED037P: Alkalinity by PC Titrator (QCLot: 618578)								
ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	----	200 mg/L	88.5	80.2	108
ED037P: Alkalinity by PC Titrator (QCLot: 618617)								
ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	----	200 mg/L	85.9	80.2	108
ED038A: Acidity (QCLot: 618593)								
ED038: Acidity as CaCO3	----	1	mg/L	<1	20 mg/L	94.1	89.8	103
ED038A: Acidity (QCLot: 619234)								
ED038: Acidity as CaCO3	----	1	mg/L	<1	20 mg/L	94.1	89.8	103
ED038A: Acidity (QCLot: 619235)								
ED038: Acidity as CaCO3	----	1	mg/L	<1	20 mg/L	94.1	89.8	103
ED041: Sulphate (Turbidimetric) as SO4 2- (QCLot: 620491)								
ED041: Sulphate as SO4 - Turbidimetric	----	1	mg/L	<1	150 mg/L	100	76.1	126
ED041: Sulphate (Turbidimetric) as SO4 2- (QCLot: 620492)								
ED041: Sulphate as SO4 - Turbidimetric	----	1	mg/L	<1	150 mg/L	102	76.1	126
ED045G: Chloride Discrete analyser (QCLot: 618452)								
ED045G: Chloride	16887-00-6	1 1.0	mg/L mg/L	---- <1.0	50 mg/L ----	98.1 ----	83.7 ----	124 ----
ED045G: Chloride Discrete analyser (QCLot: 618453)								
ED045G: Chloride	16887-00-6	1 1.0	mg/L mg/L	---- <1.0	50 mg/L ----	106 ----	83.7 ----	124 ----
ED093F: Dissolved Major Cations (QCLot: 619602)								
ED093F: Sodium	7440-23-5	1	mg/L	<1	50 mg/L	93.8	77.4	113
ED093F: Potassium	7440-09-7	1	mg/L	<1	50 mg/L	98.0	84.3	118
ED093F: Dissolved Major Cations (QCLot: 619603)								
ED093F: Sodium	7440-23-5	1	mg/L	<1	50 mg/L	93.9	77.4	113
ED093F: Potassium	7440-09-7	1	mg/L	<1	50 mg/L	96.9	84.3	118
EK057G: Nitrite as N by Discrete Analyser (QCLot: 618213)								
EK057G: Nitrite as N	----	0.01 0.010	mg/L mg/L	---- <0.010	0.96 mg/L ----	93.0 ----	66.6 ----	131 ----
EK057G: Nitrite as N by Discrete Analyser (QCLot: 618214)								

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*
EK057G: Nitrite as N by Discrete Analyser (QCLot: 618214) - continued								
EK057G: Nitrite as N	----	0.01	mg/L	----	0.96 mg/L	110	66.6	131
		0.010	mg/L	<0.010	----	----	----	----
EK059G: NOX as N by Discrete Analyser (QCLot: 618455)								
EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	----	0.5 mg/L	121	76.9	122
		0.010	mg/L	<0.010	----	----	----	----
EK059G: NOX as N by Discrete Analyser (QCLot: 618456)								
EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	----	0.5 mg/L	122	76.9	122
		0.010	mg/L	<0.010	----	----	----	----
EK071G: Reactive Phosphorus as P by discrete analyser (QCLot: 618217)								
EK071G: Reactive Phosphorus as P	----	0.01	mg/L	----	0.50 mg/L	# 126	83.8	122
		0.010	mg/L	<0.010	----	----	----	----
EK071G: Reactive Phosphorus as P by discrete analyser (QCLot: 618218)								
EK071G: Reactive Phosphorus as P	----	0.01	mg/L	----	0.50 mg/L	103	83.8	122
		0.010	mg/L	<0.010	----	----	----	----
EP005: Total Organic Carbon (TOC) (QCLot: 619156)								
EP005: Total Organic Carbon	----	1	mg/L	<1	10 mg/L	105	86.9	125
EP005: Total Organic Carbon (TOC) (QCLot: 619157)								
EP005: Total Organic Carbon	----	1	mg/L	<1	10 mg/L	103	86.9	125
EP006 Total Inorganic Carbon (QCLot: 620441)								
EP006: Total Inorganic Carbon	----	1	mg/L	<1	50 mg/L	82.3	70	130
EP006 Total Inorganic Carbon (QCLot: 620442)								
EP006: Total Inorganic Carbon	----	1	mg/L	<1	50 mg/L	87.1	70	130

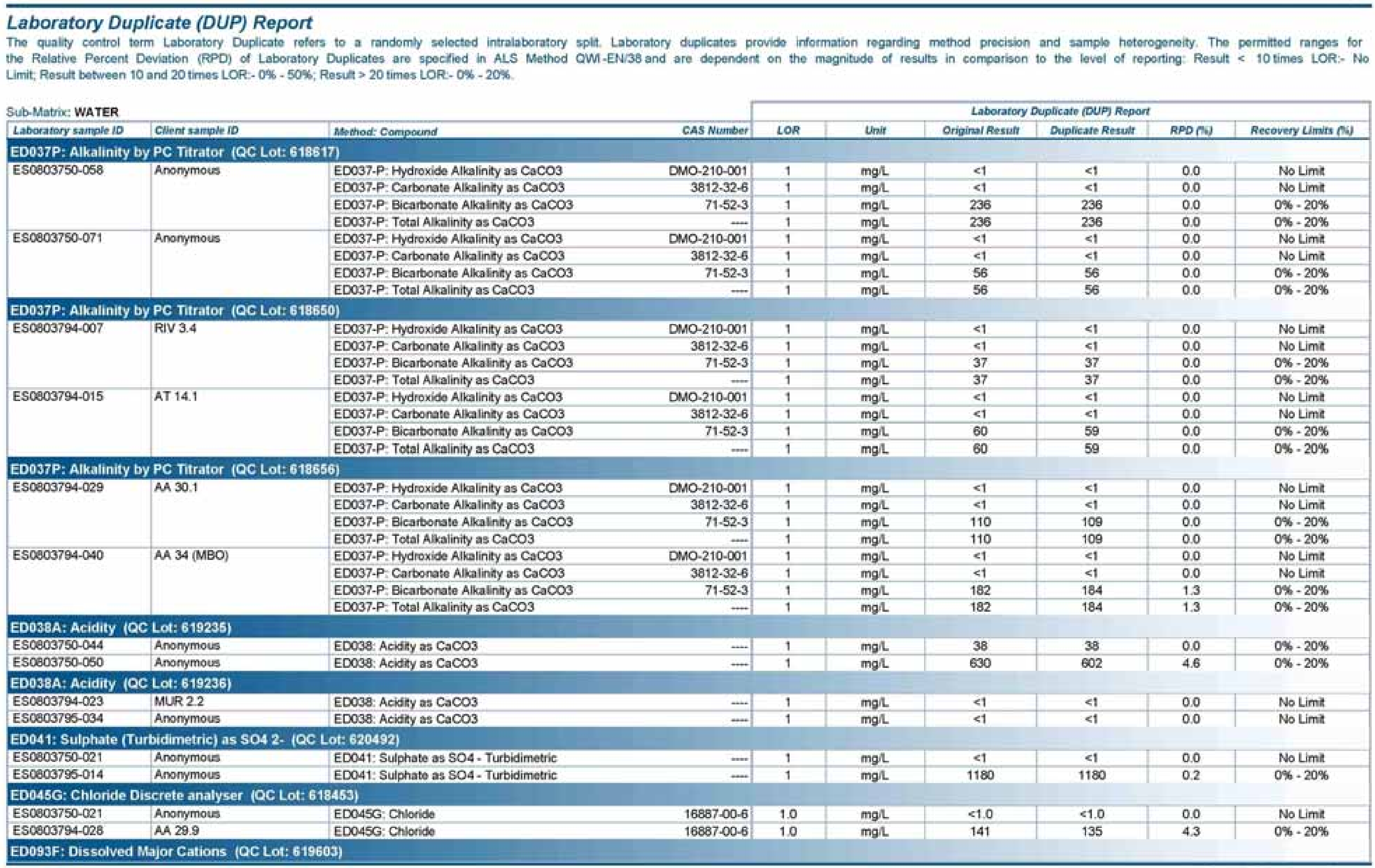


Matrix Spike (MS) Report

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: 618452)							
ES0803750-001	SWAN REACH, SITE DUP 1 OF 2, FILTERED	ED045G: Chloride	16887-00-6	250 mg/L	103	70	130
ED045G: Chloride Discrete analyser (QCLot: 618453)							
ES0803750-021	FIELD BLANK 1(PALWALLA), TOTAL	ED045G: Chloride	16887-00-6	250 mg/L	104	70	130
EK057G: Nitrite as N by Discrete Analyser (QCLot: 618213)							
ES0803747-001	Anonymous	EK057G: Nitrite as N	----	0.60 mg/L	98.2	70	130
EK057G: Nitrite as N by Discrete Analyser (QCLot: 618214)							
ES0803750-012	SWAN REACH, SITE DUP 1 OF 2, TOTAL	EK057G: Nitrite as N	----	0.60 mg/L	89.3	70	130
EK059G: NOX as N by Discrete Analyser (QCLot: 618455)							
ES0803750-001	SWAN REACH, SITE DUP 1 OF 2, FILTERED	EK059G: Nitrite + Nitrate as N	----	0.4 mg/L	91.0	70	130
EK059G: NOX as N by Discrete Analyser (QCLot: 618456)							
ES0803750-021	FIELD BLANK 1(PALWALLA), TOTAL	EK059G: Nitrite + Nitrate as N	----	0.4 mg/L	105	70	130
EK071G: Reactive Phosphorus as P by discrete analyser (QCLot: 618217)							
ES0803750-022	FIEDL BLANK2 (MIILANG), TOTAL	EK071G: Reactive Phosphorus as P	----	0.50 mg/L	93.2	70	130
EK071G: Reactive Phosphorus as P by discrete analyser (QCLot: 618218)							
ES0803825-001	Anonymous	EK071G: Reactive Phosphorus as P	----	0.50 mg/L	91.0	70	130
EP005: Total Organic Carbon (TOC) (QCLot: 619156)							
ES0803717-002	Anonymous	EP005: Total Organic Carbon	----	100 mg/L	105	70	130
EP005: Total Organic Carbon (TOC) (QCLot: 619157)							
ES0803750-009	MILANG,FILTERED	EP005: Total Organic Carbon	----	100 mg/L	103	70	130

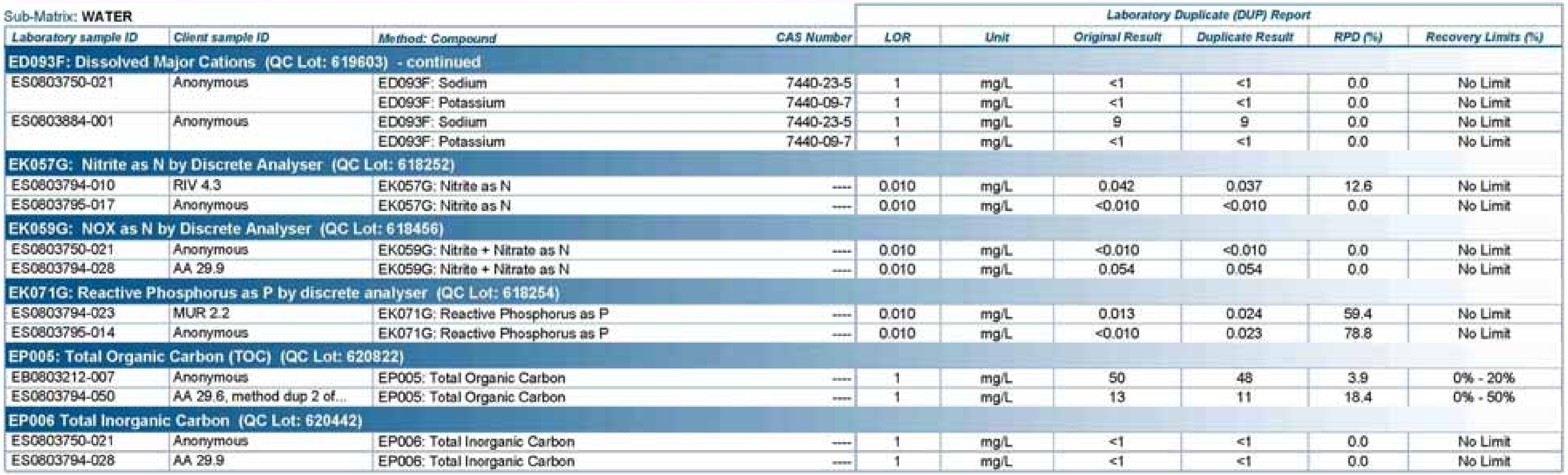


Laboratory Duplicate (DUP) Report

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: 618617)									
ES0803750-058	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	236	236	0.0	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	236	236	0.0	0% - 20%
ES0803750-071	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	56	0.0	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	56	56	0.0	0% - 20%
ED037P: Alkalinity by PC Titrator (QC Lot: 618650)									
ES0803794-007	RIV 3.4	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	37	37	0.0	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	37	37	0.0	0% - 20%
ES0803794-015	AT 14.1	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	60	59	0.0	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	60	59	0.0	0% - 20%
ED037P: Alkalinity by PC Titrator (QC Lot: 618656)									
ES0803794-029	AA 30.1	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	110	109	0.0	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	110	109	0.0	0% - 20%
ES0803794-040	AA 34 (MBO)	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	182	184	1.3	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	182	184	1.3	0% - 20%
ED038A: Acidity (QC Lot: 619235)									
ES0803750-044	Anonymous	ED038: Acidity as CaCO3	----	1	mg/L	38	38	0.0	0% - 20%
ES0803750-050	Anonymous	ED038: Acidity as CaCO3	----	1	mg/L	630	602	4.6	0% - 20%
ED038A: Acidity (QC Lot: 619236)									
ES0803794-023	MUR 2.2	ED038: Acidity as CaCO3	----	1	mg/L	<1	<1	0.0	No Limit
ES0803795-034	Anonymous	ED038: Acidity as CaCO3	----	1	mg/L	<1	<1	0.0	No Limit
ED041: Sulphate (Turbidimetric) as SO4 2- (QC Lot: 620492)									
ES0803750-021	Anonymous	ED041: Sulphate as SO4 - Turbidimetric	----	1	mg/L	<1	<1	0.0	No Limit
ES0803795-014	Anonymous	ED041: Sulphate as SO4 - Turbidimetric	----	1	mg/L	1180	1180	0.2	0% - 20%
ED045G: Chloride Discrete analyser (QC Lot: 618453)									
ES0803750-021	Anonymous	ED045G: Chloride	16887-00-6	1.0	mg/L	<1.0	<1.0	0.0	No Limit
ES0803794-028	AA 29.9	ED045G: Chloride	16887-00-6	1.0	mg/L	141	135	4.3	0% - 20%
ED093F: Dissolved Major Cations (QC Lot: 619603)									



Sub-Matrix: **WATER**

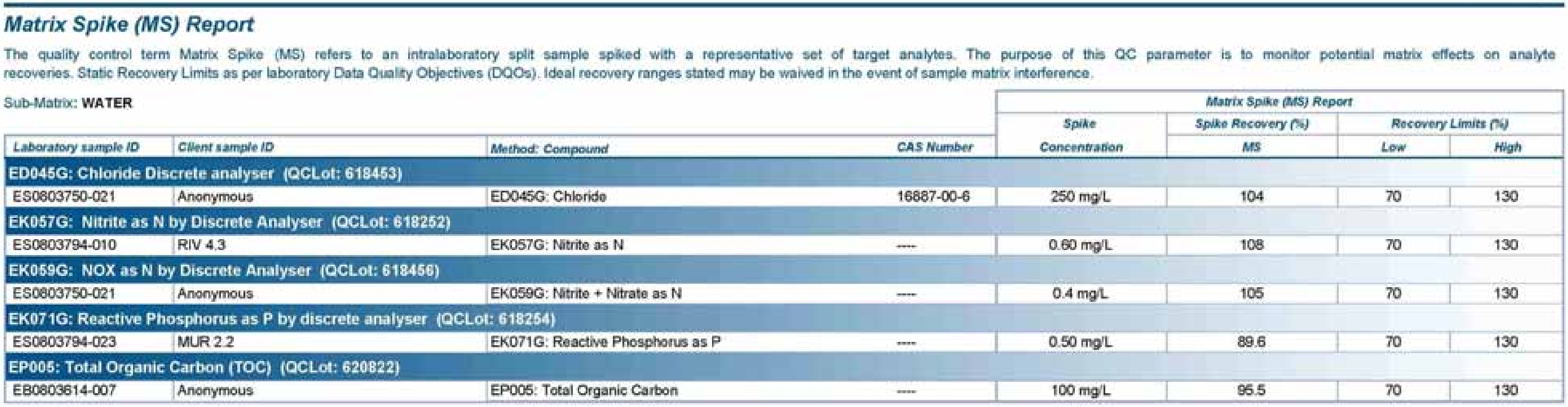
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
				Laboratory Duplicate (DUP) Report					
ED093F: Dissolved Major Cations (QC Lot: 619603) - continued									
ES0803750-021	Anonymous	ED093F: Sodium	7440-23-5	1	mg/L	<1	<1	0.0	No Limit
		ED093F: Potassium	7440-09-7	1	mg/L	<1	<1	0.0	No Limit
ES0803884-001	Anonymous	ED093F: Sodium	7440-23-5	1	mg/L	9	9	0.0	No Limit
		ED093F: Potassium	7440-09-7	1	mg/L	<1	<1	0.0	No Limit
EK057G: Nitrite as N by Discrete Analyser (QC Lot: 618252)									
ES0803794-010	RIV 4.3	EK057G: Nitrite as N	----	0.010	mg/L	0.042	0.037	12.6	No Limit
ES0803795-017	Anonymous	EK057G: Nitrite as N	----	0.010	mg/L	<0.010	<0.010	0.0	No Limit
EK059G: NOX as N by Discrete Analyser (QC Lot: 618456)									
ES0803750-021	Anonymous	EK059G: Nitrite + Nitrate as N	----	0.010	mg/L	<0.010	<0.010	0.0	No Limit
ES0803794-028	AA 29.9	EK059G: Nitrite + Nitrate as N	----	0.010	mg/L	0.054	0.054	0.0	No Limit
EK071G: Reactive Phosphorus as P by discrete analyser (QC Lot: 618254)									
ES0803794-023	MUR 2.2	EK071G: Reactive Phosphorus as P	----	0.010	mg/L	0.013	0.024	59.4	No Limit
ES0803795-014	Anonymous	EK071G: Reactive Phosphorus as P	----	0.010	mg/L	<0.010	0.023	78.8	No Limit
EP005: Total Organic Carbon (TOC) (QC Lot: 620822)									
EB0803212-007	Anonymous	EP005: Total Organic Carbon	----	1	mg/L	50	48	3.9	0% - 20%
ES0803794-050	AA 29.6, method dup 2 of...	EP005: Total Organic Carbon	----	1	mg/L	13	11	18.4	0% - 50%
EP006 Total Inorganic Carbon (QC Lot: 620442)									
ES0803750-021	Anonymous	EP006: Total Inorganic Carbon	----	1	mg/L	<1	<1	0.0	No Limit
ES0803794-028	AA 29.9	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: 618617)								
ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	----	200 mg/L	85.9	80.2	108
ED037P: Alkalinity by PC Titrator (QCLot: 618650)								
ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	----	200 mg/L	84.3	80.2	108
ED037P: Alkalinity by PC Titrator (QCLot: 618656)								
ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	----	200 mg/L	85.2	80.2	108
ED038A: Acidity (QCLot: 619235)								
ED038: Acidity as CaCO3	----	1	mg/L	<1	20 mg/L	94.1	89.8	103
ED038A: Acidity (QCLot: 619236)								
ED038: Acidity as CaCO3	----	1	mg/L	<1	20 mg/L	94.1	89.8	103
ED041: Sulphate (Turbidimetric) as SO4 2- (QCLot: 620492)								
ED041: Sulphate as SO4 - Turbidimetric	----	1	mg/L	<1	150 mg/L	102	76.1	126
ED045G: Chloride Discrete analyser (QCLot: 618453)								
ED045G: Chloride	16887-00-6	1	mg/L	----	50 mg/L	106	83.7	124
		1.0	mg/L	<1.0	----	----	----	----
ED093F: Dissolved Major Cations (QCLot: 619603)								
ED093F: Sodium	7440-23-5	1	mg/L	<1	50 mg/L	93.9	77.4	113
ED093F: Potassium	7440-09-7	1	mg/L	<1	50 mg/L	96.9	84.3	118
EK057G: Nitrite as N by Discrete Analyser (QCLot: 618252)								
EK057G: Nitrite as N	----	0.01	mg/L	----	0.96 mg/L	92.3	66.6	131
		0.010	mg/L	<0.010	----	----	----	----
EK059G: NOX as N by Discrete Analyser (QCLot: 618456)								
EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	----	0.5 mg/L	122	76.9	122
		0.010	mg/L	<0.010	----	----	----	----
EK071G: Reactive Phosphorus as P by discrete analyser (QCLot: 618254)								
EK071G: Reactive Phosphorus as P	----	0.01	mg/L	----	0.50 mg/L	111	83.8	122
		0.010	mg/L	<0.010	----	----	----	----
EP005: Total Organic Carbon (TOC) (QCLot: 620822)								
EP005: Total Organic Carbon	----	1	mg/L	<1	10 mg/L	118	86.9	125
EP006 Total Inorganic Carbon (QCLot: 620442)								
EP006: Total Inorganic Carbon	----	1	mg/L	<1	50 mg/L	87.1	70	130

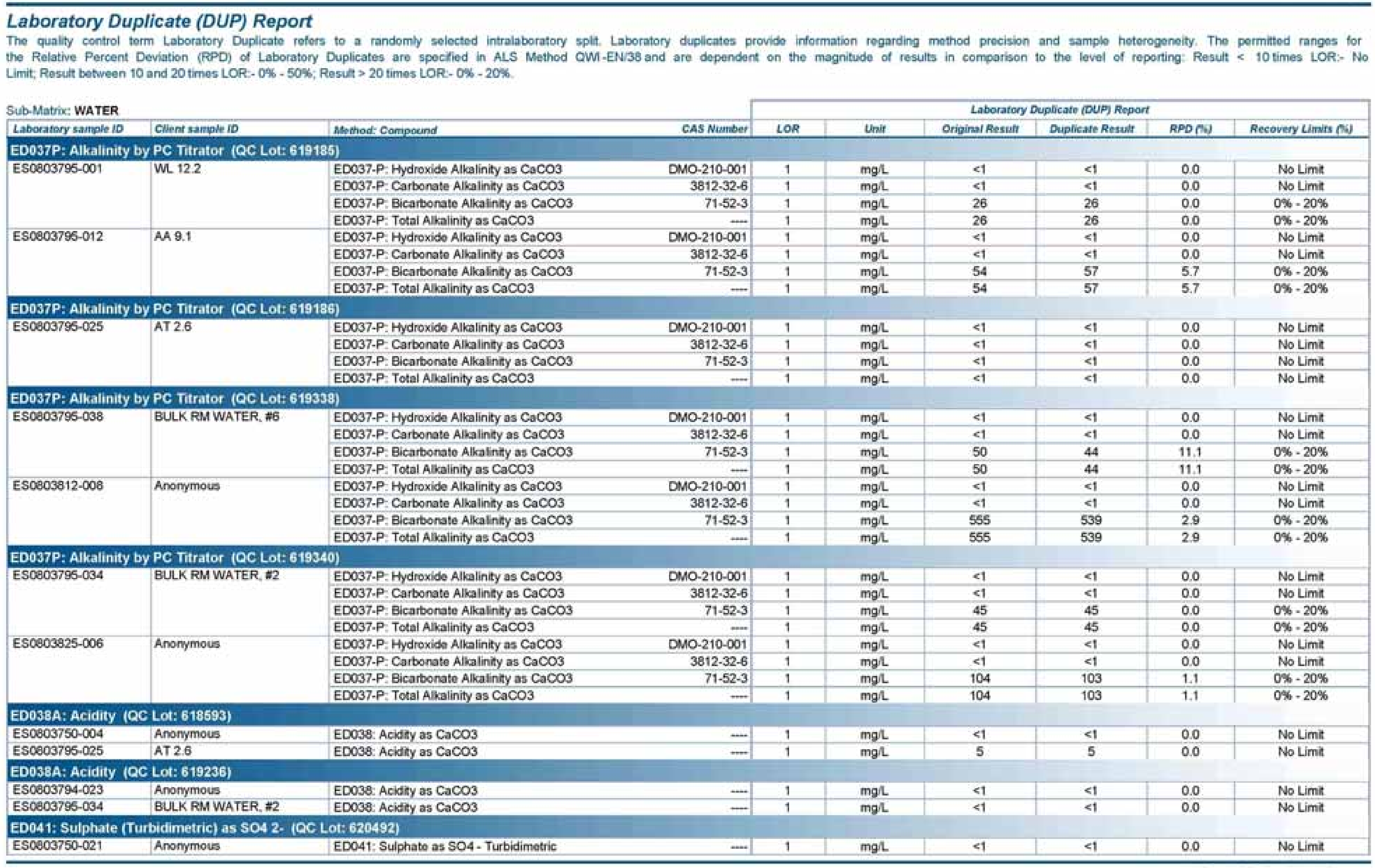


Matrix Spike (MS) Report

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: 618453)							
ES0803750-021	Anonymous	ED045G: Chloride	16887-00-6	250 mg/L	104	70	130
EK057G: Nitrite as N by Discrete Analyser (QCLot: 618252)							
ES0803794-010	RIV 4.3	EK057G: Nitrite as N	----	0.60 mg/L	108	70	130
EK059G: NOX as N by Discrete Analyser (QCLot: 618456)							
ES0803750-021	Anonymous	EK059G: Nitrite + Nitrate as N	----	0.4 mg/L	105	70	130
EK071G: Reactive Phosphorus as P by discrete analyser (QCLot: 618254)							
ES0803794-023	MUR 2.2	EK071G: Reactive Phosphorus as P	----	0.50 mg/L	89.6	70	130
EP005: Total Organic Carbon (TOC) (QCLot: 620822)							
EB0803614-007	Anonymous	EP005: Total Organic Carbon	----	100 mg/L	95.5	70	130



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: 619185)									
ES0803795-001	WL 12.2	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	26	26	0.0	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	26	26	0.0	0% - 20%
ES0803795-012	AA 9.1	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	54	57	5.7	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	54	57	5.7	0% - 20%
ED037P: Alkalinity by PC Titrator (QC Lot: 619186)									
ES0803795-025	AT 2.6	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: 619338)									
ES0803795-038	BULK RM WATER, #6	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	50	44	11.1	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	50	44	11.1	0% - 20%
ES0803812-008	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	555	539	2.9	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	555	539	2.9	0% - 20%
ED037P: Alkalinity by PC Titrator (QC Lot: 619340)									
ES0803795-034	BULK RM WATER, #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	45	45	0.0	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	45	45	0.0	0% - 20%
ES0803825-006	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	104	103	1.1	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	104	103	1.1	0% - 20%
ED038A: Acidity (QC Lot: 618593)									
ES0803750-004	Anonymous	ED038: Acidity as CaCO3	----	1	mg/L	<1	<1	0.0	No Limit
ES0803795-025	AT 2.6	ED038: Acidity as CaCO3	----	1	mg/L	5	5	0.0	No Limit
ED038A: Acidity (QC Lot: 619236)									
ES0803794-023	Anonymous	ED038: Acidity as CaCO3	----	1	mg/L	<1	<1	0.0	No Limit
ES0803795-034	BULK RM WATER, #2	ED038: Acidity as CaCO3	----	1	mg/L	<1	<1	0.0	No Limit
ED041: Sulphate (Turbidimetric) as SO4 2- (QC Lot: 620492)									
ES0803750-021	Anonymous	ED041: Sulphate as SO4 - Turbidimetric	----	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 (%)*
ED041: Sulphate (Turbidimetric) as SO4 2- (QC Lot: 620492) - continued									
ES0803795-014	AT 7.2	ED041: Sulphate as SO4 - Turbidimetric	----	1	mg/L	1180	1180	0.2	0% - 20%
ED045G: Chloride Discrete analyser (QC Lot: 618453)									
ES0803750-021	Anonymous	ED045G: Chloride	16887-00-6	1.0	mg/L	<1.0	<1.0	0.0	No Limit
ES0803794-028	Anonymous	ED045G: Chloride	16887-00-6	1.0	mg/L	141	135	4.3	0% - 20%
ED093F: Dissolved Major Cations (QC Lot: 619603)									
ES0803750-021	Anonymous	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
ES0803884-001	Anonymous	ED093F: Sodium	7440-23-5	1	mg/L	9	9	0.0	No Limit
		ED093F: Potassium	7440-09-7	1	mg/L	<1	<1	0.0	No Limit
ED093F: Dissolved Major Cations (QC Lot: 619605)									
ES0803795-014	AT 7.2	ED093F: Sodium	7440-23-5	1	mg/L	210	214	2.1	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	53	54	2.2	0% - 20%
ES0803797-019	Anonymous	ED093F: Sodium	7440-23-5	1	mg/L	145	146	0.0	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	5	5	0.0	No Limit
EK057G: Nitrite as N by Discrete Analyser (QC Lot: 618252)									
ES0803794-010	Anonymous	EK057G: Nitrite as N	----	0.010	mg/L	0.042	0.037	12.6	No Limit
ES0803795-017	AA 13.2	EK057G: Nitrite as N	----	0.010	mg/L	<0.010	<0.010	0.0	No Limit
EK059G: NOX as N by Discrete Analyser (QC Lot: 618456)									
ES0803750-021	Anonymous	EK059G: Nitrite + Nitrate as N	----	0.010	mg/L	<0.010	<0.010	0.0	No Limit
ES0803794-028	Anonymous	EK059G: Nitrite + Nitrate as N	----	0.010	mg/L	0.054	0.054	0.0	No Limit
EK059G: NOX as N by Discrete Analyser (QC Lot: 618461)									
ES0803748-001	Anonymous	EK059G: Nitrite + Nitrate as N	----	0.010	mg/L	0.082	0.082	0.0	No Limit
ES0803797-022	Anonymous	EK059G: Nitrite + Nitrate as N	----	0.010	mg/L	0.027	0.026	3.8	No Limit
EK071G: Reactive Phosphorus as P by discrete analyser (QC Lot: 618254)									
ES0803794-023	Anonymous	EK071G: Reactive Phosphorus as P	----	0.010	mg/L	0.013	0.024	59.4	No Limit
ES0803795-014	AT 7.2	EK071G: Reactive Phosphorus as P	----	0.010	mg/L	<0.010	0.023	78.8	No Limit
EP005: Total Organic Carbon (TOC) (QC Lot: 621564)									
EB0803629-002	Anonymous	EP005: Total Organic Carbon	----	1	mg/L	11	11	0.0	0% - 50%
ES0803795-003	WL 5.5	EP005: Total Organic Carbon	----	1	mg/L	30	33	8.6	0% - 20%
EP006 Total Inorganic Carbon (QC Lot: 619187)									
ES0803795-003	WL 5.5	EP006: Total Inorganic Carbon	----	1	mg/L	3	3	0.0	No Limit
ES0803797-038	Anonymous	EP006: Total Inorganic Carbon	----	1	mg/L	6	6	0.0	No Limit
EP006 Total Inorganic Carbon (QC Lot: 620442)									
ES0803750-021	Anonymous	EP006: Total Inorganic Carbon	----	1	mg/L	<1	<1	0.0	No Limit
ES0803794-028	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: 619185)								
ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	----	200 mg/L	90.4	80.2	108
ED037P: Alkalinity by PC Titrator (QCLot: 619186)								
ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	----	200 mg/L	90.2	80.2	108
ED037P: Alkalinity by PC Titrator (QCLot: 619338)								
ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	----	200 mg/L	85.2	80.2	108
ED037P: Alkalinity by PC Titrator (QCLot: 619340)								
ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	----	200 mg/L	85.0	80.2	108
ED038A: Acidity (QCLot: 618593)								
ED038: Acidity as CaCO3	----	1	mg/L	<1	20 mg/L	94.1	89.8	103
ED038A: Acidity (QCLot: 619236)								
ED038: Acidity as CaCO3	----	1	mg/L	<1	20 mg/L	94.1	89.8	103
ED041: Sulphate (Turbidimetric) as SO4 2- (QCLot: 620492)								
ED041: Sulphate as SO4 - Turbidimetric	----	1	mg/L	<1	150 mg/L	102	76.1	126
ED045G: Chloride Discrete analyser (QCLot: 618453)								
ED045G: Chloride	16887-00-6	1 1.0	mg/L mg/L	---- <1.0	50 mg/L ----	106 ----	83.7 ----	124 ----
ED093F: Dissolved Major Cations (QCLot: 619603)								
ED093F: Sodium	7440-23-5	1	mg/L	<1	50 mg/L	93.9	77.4	113
ED093F: Potassium	7440-09-7	1	mg/L	<1	50 mg/L	96.9	84.3	118
ED093F: Dissolved Major Cations (QCLot: 619605)								
ED093F: Sodium	7440-23-5	1	mg/L	<1	50 mg/L	100	77.4	113
ED093F: Potassium	7440-09-7	1	mg/L	<1	50 mg/L	105	84.3	118
EK057G: Nitrite as N by Discrete Analyser (QCLot: 618252)								
EK057G: Nitrite as N	----	0.01 0.010	mg/L mg/L	---- <0.010	0.96 mg/L ----	92.3 ----	66.6 ----	131 ----
EK059G: NOX as N by Discrete Analyser (QCLot: 618456)								
EK059G: Nitrite + Nitrate as N	----	0.01 0.010	mg/L mg/L	---- <0.010	0.5 mg/L ----	122 ----	76.9 ----	122 ----
EK059G: NOX as N by Discrete Analyser (QCLot: 618461)								
EK059G: Nitrite + Nitrate as N	----	0.01 0.010	mg/L mg/L	---- <0.010	0.5 mg/L ----	105 ----	76.9 ----	122 ----
EK071G: Reactive Phosphorus as P by discrete analyser (QCLot: 618254)								
EK071G: Reactive Phosphorus as P	----	0.01 0.010	mg/L mg/L	---- <0.010	0.50 mg/L ----	111 ----	83.8 ----	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*
EP005: Total Organic Carbon (TOC) (QCLot: 621564)								
EP005: Total Organic Carbon	----	1	mg/L	<1	10 mg/L	105	86.9	125
EP006 Total Inorganic Carbon (QCLot: 619187)								
EP006: Total Inorganic Carbon	----	1	mg/L	<1	50 mg/L	86.0	70	130
EP006 Total Inorganic Carbon (QCLot: 620442)								
EP006: Total Inorganic Carbon	----	1	mg/L	<1	50 mg/L	87.1	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: 618453)							
ES0803750-021	Anonymous	ED045G: Chloride	16887-00-6	250 mg/L	104	70	130
EK057G: Nitrite as N by Discrete Analyser (QCLot: 618252)							
ES0803794-010	Anonymous	EK057G: Nitrite as N	----	0.60 mg/L	108	70	130
EK059G: NOX as N by Discrete Analyser (QCLot: 618456)							
ES0803750-021	Anonymous	EK059G: Nitrite + Nitrate as N	----	0.4 mg/L	105	70	130
EK059G: NOX as N by Discrete Analyser (QCLot: 618461)							
ES0803748-001	Anonymous	EK059G: Nitrite + Nitrate as N	----	0.4 mg/L	70.8	70	130
EK071G: Reactive Phosphorus as P by discrete analyser (QCLot: 618254)							
ES0803794-023	Anonymous	EK071G: Reactive Phosphorus as P	----	0.50 mg/L	89.6	70	130
EP005: Total Organic Carbon (TOC) (QCLot: 621564)							
EB0803686-001	Anonymous	EP005: Total Organic Carbon	----	100 mg/L	87.9	70	130

Laboratory Duplicate (DUP) Report

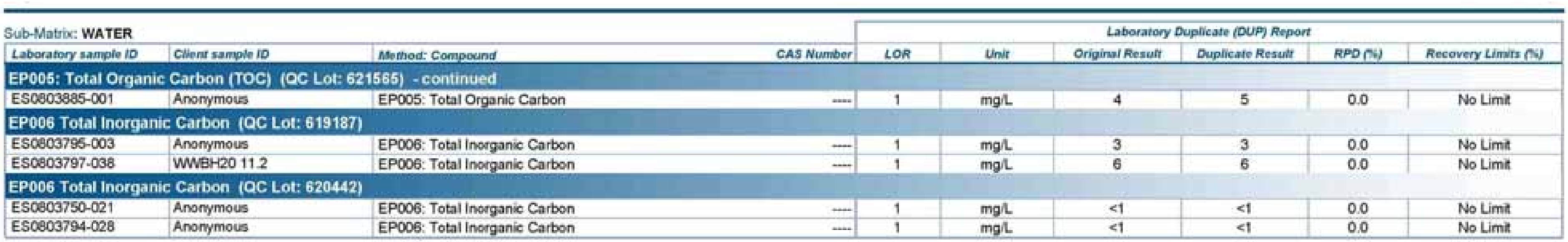
The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS 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: 618488)									
ES0803750-001	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	44	44	0.0	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	44	44	0.0	0% - 20%
ES0803750-010	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: 618491)									
ES0803797-030	WW3A 4.5	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	37	36	0.0	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	37	36	0.0	0% - 20%
ES0803797-042	WL 15.2	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	91	92	0.0	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	91	92	0.0	0% - 20%
ED037P: Alkalinity by PC Titrator (QC Lot: 618617)									
ES0803750-058	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	236	236	0.0	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	236	236	0.0	0% - 20%
ES0803750-071	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	56	0.0	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	56	56	0.0	0% - 20%
ED037P: Alkalinity by PC Titrator (QC Lot: 618618)									
ES0803797-016	UKE 2.2	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	44	44	0.0	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	44	44	0.0	0% - 20%
ES0803797-048	WL 8.3	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: 618656)									
ES0803794-029	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	110	109	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 (%)*
ED037P: Alkalinity by PC Titrator (QC Lot: 618656) - continued									
ES0803794-029	Anonymous	ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	110	109	0.0	0% - 20%
ES0803794-040	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	182	184	1.3	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	182	184	1.3	0% - 20%
ED037P: Alkalinity by PC Titrator (QC Lot: 618657)									
ES0803824-003	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	5	8	32.4	No Limit
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	5	8	32.4	No Limit
ED038A: Acidity (QC Lot: 618593)									
ES0803750-004	Anonymous	ED038: Acidity as CaCO3	----	1	mg/L	<1	<1	0.0	No Limit
ES0803795-025	Anonymous	ED038: Acidity as CaCO3	----	1	mg/L	5	5	0.0	No Limit
ED038A: Acidity (QC Lot: 619236)									
ES0803794-023	Anonymous	ED038: Acidity as CaCO3	----	1	mg/L	<1	<1	0.0	No Limit
ES0803795-034	Anonymous	ED038: Acidity as CaCO3	----	1	mg/L	<1	<1	0.0	No Limit
ED038A: Acidity (QC Lot: 619237)									
ES0803797-006	UKE 5.1	ED038: Acidity as CaCO3	----	1	mg/L	207	188	9.5	0% - 20%
ED041: Sulphate (Turbidimetric) as SO4 2- (QC Lot: 620493)									
ES0803797-019	WL 5.3	ED041: Sulphate as SO4 - Turbidimetric	----	1	mg/L	2060	2020	1.8	0% - 20%
ED045G: Chloride Discrete analyser (QC Lot: 618457)									
ES0803748-001	Anonymous	ED045G: Chloride	16887-00-6	1.0	mg/L	46.7	46.7	0.0	0% - 20%
ES0803797-038	WWBH20 11.2	ED045G: Chloride	16887-00-6	1.0	mg/L	159	151	4.9	0% - 20%
ED093F: Dissolved Major Cations (QC Lot: 619605)									
ES0803795-014	Anonymous	ED093F: Sodium	7440-23-5	1	mg/L	210	214	2.1	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	53	54	2.2	0% - 20%
ES0803797-019	WL 5.3	ED093F: Sodium	7440-23-5	1	mg/L	145	146	0.0	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	5	5	0.0	No Limit
EK057G: Nitrite as N by Discrete Analyser (QC Lot: 618214)									
ES0803750-012	Anonymous	EK057G: Nitrite as N	----	0.010	mg/L	0.028	0.027	3.6	No Limit
ES0803750-021	Anonymous	EK057G: Nitrite as N	----	0.010	mg/L	<0.010	<0.010	0.0	No Limit
EK057G: Nitrite as N by Discrete Analyser (QC Lot: 618215)									
ES0803797-039	WL 15.1	EK057G: Nitrite as N	----	0.010	mg/L	0.011	<0.010	9.5	No Limit
EK059G: NOX as N by Discrete Analyser (QC Lot: 618461)									
ES0803748-001	Anonymous	EK059G: Nitrite + Nitrate as N	----	0.010	mg/L	0.082	0.082	0.0	No Limit
ES0803797-022	WL 5.4	EK059G: Nitrite + Nitrate as N	----	0.010	mg/L	0.027	0.026	3.8	No Limit
EK071G: Reactive Phosphorus as P by discrete analyser (QC Lot: 618218)									
ES0803825-001	Anonymous	EK071G: Reactive Phosphorus as P	----	0.010	mg/L	<0.010	0.015	40.0	No Limit
ES0803797-023	WL 9.2	EK071G: Reactive Phosphorus as P	----	0.010	mg/L	0.022	0.012	58.8	No Limit
EP005: Total Organic Carbon (TOC) (QC Lot: 621565)									
ES0803797-004	UKE 3.4, METHOD DUP 1 OF...	EP005: Total Organic Carbon	----	1	mg/L	24	20	19.4	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 (%)*
EP005: Total Organic Carbon (TOC) (QC Lot: 621565) - continued									
ES0803885-001	Anonymous	EP005: Total Organic Carbon	----	1	mg/L	4	5	0.0	No Limit
EP006 Total Inorganic Carbon (QC Lot: 619187)									
ES0803795-003	Anonymous	EP006: Total Inorganic Carbon	----	1	mg/L	3	3	0.0	No Limit
ES0803797-038	WWBH20 11.2	EP006: Total Inorganic Carbon	----	1	mg/L	6	6	0.0	No Limit
EP006 Total Inorganic Carbon (QC Lot: 620442)									
ES0803750-021	Anonymous	EP006: Total Inorganic Carbon	----	1	mg/L	<1	<1	0.0	No Limit
ES0803794-028	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: 618488)								
ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	----	200 mg/L	85.2	80.2	108
ED037P: Alkalinity by PC Titrator (QCLot: 618491)								
ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	----	200 mg/L	90.1	80.2	108
ED037P: Alkalinity by PC Titrator (QCLot: 618617)								
ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	----	200 mg/L	85.9	80.2	108
ED037P: Alkalinity by PC Titrator (QCLot: 618618)								
ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	----	200 mg/L	90.0	80.2	108
ED037P: Alkalinity by PC Titrator (QCLot: 618656)								
ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	----	200 mg/L	85.2	80.2	108
ED037P: Alkalinity by PC Titrator (QCLot: 618657)								
ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	----	200 mg/L	84.5	80.2	108
ED038A: Acidity (QCLot: 618593)								
ED038: Acidity as CaCO3	----	1	mg/L	<1	20 mg/L	94.1	89.8	103
ED038A: Acidity (QCLot: 619236)								
ED038: Acidity as CaCO3	----	1	mg/L	<1	20 mg/L	94.1	89.8	103
ED038A: Acidity (QCLot: 619237)								
ED038: Acidity as CaCO3	----	1	mg/L	<1	20 mg/L	94.1	89.8	103
ED041: Sulphate (Turbidimetric) as SO4 2- (QCLot: 620493)								
ED041: Sulphate as SO4 - Turbidimetric	----	1	mg/L	<1	150 mg/L	101	76.1	126
ED045G: Chloride Discrete analyser (QCLot: 618457)								
ED045G: Chloride	16887-00-6	1 1.0	mg/L mg/L	---- <1.0	50 mg/L ----	103 ----	83.7 ----	124 ----
ED093F: Dissolved Major Cations (QCLot: 619605)								
ED093F: Sodium	7440-23-5	1	mg/L	<1	50 mg/L	100	77.4	113
ED093F: Potassium	7440-09-7	1	mg/L	<1	50 mg/L	105	84.3	118
EK057G: Nitrite as N by Discrete Analyser (QCLot: 618214)								
EK057G: Nitrite as N	----	0.01 0.010	mg/L mg/L	---- <0.010	0.96 mg/L ----	110 ----	66.6 ----	131 ----
EK057G: Nitrite as N by Discrete Analyser (QCLot: 618215)								
EK057G: Nitrite as N	----	0.01 0.010	mg/L mg/L	---- <0.010	0.96 mg/L ----	98.0 ----	66.6 ----	131 ----
EK059G: NOX as N by Discrete Analyser (QCLot: 618461)								
EK059G: Nitrite + Nitrate as N	----	0.01 0.010	mg/L mg/L	---- <0.010	0.5 mg/L ----	105 ----	76.9 ----	122 ----

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 (%)*
EP005: Total Organic Carbon (TOC) (QC Lot: 621565) - continued									
ES0803885-001	Anonymous	EP005: Total Organic Carbon	----	1	mg/L	4	5	0.0	No Limit
EP006 Total Inorganic Carbon (QC Lot: 619187)									
ES0803795-003	Anonymous	EP006: Total Inorganic Carbon	----	1	mg/L	3	3	0.0	No Limit
ES0803797-038	WWBH20 11.2	EP006: Total Inorganic Carbon	----	1	mg/L	6	6	0.0	No Limit
EP006 Total Inorganic Carbon (QC Lot: 620442)									
ES0803750-021	Anonymous	EP006: Total Inorganic Carbon	----	1	mg/L	<1	<1	0.0	No Limit
ES0803794-028	Anonymous	EP006: Total Inorganic Carbon	----	1	mg/L	<1	<1	0.0	No Limit

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*
EK071G: Reactive Phosphorus as P by discrete analyser (QCLot: 618218)								
EK071G: Reactive Phosphorus as P	----	0.01 0.010	mg/L mg/L	---- <0.010	0.50 mg/L ----	103 ----	83.8 ----	122 ----
EP005: Total Organic Carbon (TOC) (QCLot: 621565)								
EP005: Total Organic Carbon	----	1	mg/L	<1	10 mg/L	98.7	86.9	125
EP006 Total Inorganic Carbon (QCLot: 619187)								
EP006: Total Inorganic Carbon	----	1	mg/L	<1	50 mg/L	86.0	70	130
EP006 Total Inorganic Carbon (QCLot: 620442)								
EP006: Total Inorganic Carbon	----	1	mg/L	<1	50 mg/L	87.1	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: 618457)							
ES0803748-001	Anonymous	ED045G: Chloride	16887-00-6	250 mg/L	102	70	130
EK057G: Nitrite as N by Discrete Analyser (QCLot: 618214)							
ES0803750-012	Anonymous	EK057G: Nitrite as N	----	0.60 mg/L	89.3	70	130
EK057G: Nitrite as N by Discrete Analyser (QCLot: 618215)							
ES0803797-039	WL 15.1	EK057G: Nitrite as N	----	0.60 mg/L	95.5	70	130
EK059G: NOX as N by Discrete Analyser (QCLot: 618461)							
ES0803748-001	Anonymous	EK059G: Nitrite + Nitrate as N	----	0.4 mg/L	70.8	70	130
EK071G: Reactive Phosphorus as P by discrete analyser (QCLot: 618218)							
ES0803825-001	Anonymous	EK071G: Reactive Phosphorus as P	----	0.50 mg/L	91.0	70	130
EP005: Total Organic Carbon (TOC) (QCLot: 621565)							
ES0803797-039	WL 15.1	EP005: Total Organic Carbon	----	100 mg/L	80.5	70	130

Table B10. QA/QC for mobilisation tests: dissolved metals

Quality Control Summary for Dissolved Metals Analyses

Replicates	Ag	As	Cd	Co	Cr	Cu	Mn	Ni	Pb	Sb	Se	V	Zn
Sample	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µgL
10	0.015	4.3	0.15	27	4.1	46	1100	48	0.94	0.074	0.091	2.8	48
10 Dup	0.004	4.1	0.16	27	4.0	46	1100	47	0.94	0.065	0.077	2.7	47
10 Average	0.009	4.2	0.16	27	4.1	46	1100	48	0.94	0.069	0.084	2.8	47
20	0.043	2.6	0.24	27	1.1	2.3	970	22	0.55	0.26	0.15	4.8	52
20 Dup	0.016	2.5	0.24	27	1.2	2.3	970	23	0.54	0.27	0.16	4.8	52
20 Average	0.03	2.5	0.24	27	1.2	2.3	970	22	0.55	0.26	0.15	4.8	52
30	0.003	4.1	0.052	3.9	0.36	2.8	260	4.8	0.027	0.38	0.36	1.1	3.9
30 Dup	0.002	4.0	0.05	3.8	0.35	2.7	270	4.7	0.025	0.32	0.37	1.1	3.9
30 Average	0.002	4.0	0.051	3.8	0.36	2.8	270	4.7	0.026	0.35	0.36	1.1	3.9
34	6E-04	4.5	0.049	6.5	0.41	4.2	190	5.2	0.065	0.93	1.6	14	2.1
34 Dup	0.002	4.9	0.047	6.7	0.42	4.4	180	5.4	0.062	0.95	1.6	15	2.2
34 Average	1E-03	4.7	0.048	6.6	0.42	4.3	180	5.3	0.063	0.94	1.6	15	2.2
Mannum Filt	0.004	0.80	0.005	0.042	0.031	0.64	0.42	0.56	0.021	0.14	0.12	0.89	0.26
Mannum Filt Replicate	0.006	0.66	0.004	0.041	0.034	0.60	0.43	0.55	0.016	0.13	0.11	0.85	0.26
Mannum Filt Average	0.005	0.73	0.005	0.042	0.033	0.62	0.43	0.56	0.018	0.14	0.11	0.87	0.26
Average DL	6E-04	0.003	0.003	7E-04	0.003	0.005	0.032	0.007	0.001	0.003	0.011	0.001	0.052

% Spike Recovery	Ag	As	Cd	Co	Cr	Cu	Mn	Ni	Pb	Sb	Se	V	Zn
Sample	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µgL
2 % Spike Recovery	66	108	87	NA	89	NA	NA	NA	94	102	86	102	NA
15 % Spike Recovery	48	114	76	110	72	NA	NA	NA	104	93	94	72	NA
13 % Spike Recovery	77	103	98	NA	96	90	NA	NA	104	111	83	98	NA
1 R % Spike Recovery	64	88	82	NA	NA	NA	NA	NA	98	99	81	NA	NA
Bulk Murray river water % Spike Recovery	86	119	110	112	110	105	NA	107	114	120	90	117	104
147 % Spike Recovery	34	110	104	NA	103	96	NA	121	106	118	87	109	102
Mannum % Spike Recovery	77	110	98	105	108	99	115	101	101	102	99	113	97

	Ag	As	Cd	Co	Cr	Cu	Mn	Ni	Pb	Sb	Se	V	Zn
Certified Reference Material	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µgL
TM28.3 Replicate-1	3.73	6.02	1.86	3.46	4.82	5.99	6.93	9.42	3.90	3.43	4.03	3.04	24.35
TM28.3 Replicate-2	3.88	6.47	2.03	3.66	5.04	6.28	6.84	10.02	3.84	3.65	3.92	3.23	25.44
TM28.3 Average	3.80	6.24	1.94	3.56	4.93	6.13	6.89	9.72	3.87	3.54	3.97	3.13	24.90
TM28.3 Certified Reference Material Values	3.79±0.436	6.22±0.85	1.91±0.23	3.53±0.52	4.83±0.768	6.15±0.863	6.90±0.521	9.80±1.16	3.97±0.567	3.38±0.667	4.31±0.915	3.07±0.394	27.5±3.37
% Recovery	100	100	102	101	102	100	100	99	97	105	92	102	91

Table B11 QA/QC for mobilisation tests: dissolved metals

Metal concentrations in bulk Murray River waters used for remobilisation tests

		Ag	As	Cd	Co	Cr	Cu	Mn	Ni	Pb	Sb	Se	V	Zn	Na	K	Ca	Mg	Al	Fe
RM water		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Bulk Murray River Water 1		0.028	0.62	0.008	0.071	0.042	0.81	1.5	0.67	0.014	0.15	0.06	0.54	1.5	69	6	13	12	<0.1	<0.1
Bulk Murray River Water 2		0.055	0.62	0.007	0.11	0.13	0.77	4.2	0.78	0.017	0.21	0.05	0.45	6.5	71	5	14	13	<0.1	<0.1
Bulk Murray River Water 3		0.06	0.53	0.01	0.053	0.065	4.8	0.27	0.65	0.011	0.21	0.04	0.48	4.7	71	4	14	13	<0.1	<0.1
Bulk Murray River Water 4		0.047	0.57	0.001	0.064	0.037	4.1	0.78	0.55	0.008	0.13	0.06	0.44	5.5	71	3	14	13	<0.1	<0.1
Bulk Murray River Water 5		0.086	0.51	0.017	0.072	0.026	14	2.1	0.71	0.019	0.13	0.06	0.45	16			14	13	<0.1	<0.1
Bulk Murray River Water 6		0.085	0.58	0.014	0.05	0.029	18	0.49	0.53	0.015	0.15	0.06	0.56	12			13	12	<0.1	<0.1
Bulk Murray River Water 7		0.091	0.65	0.006	0.045	0.073	0.62	0.34	0.52	0.007	0.14	0.05	0.50	6.3			13	13	<0.1	<0.1
Mean		**0.065**	**0.58**	**0.009**	**0.066**	**0.057**	**6.2**	**1.4**	**0.63**	**0.013**	**0.16**	**0.05**	**0.49**	**7.5**	**71**	**4.5**	**14**	**13**	**<0.1**	**<0.1**
S.D.		**0.024**	**0.051**	**0.005**	**0.022**	**0.037**	**7.0**	**1.4**	**0.10**	**0.005**	**0.035**	**0.01**	**0.05**	**4.9**	**1.0**	**1.3**	**0.5**	**0.5**	**<0.1**	**<0.1**

QA/QC

		Ag	As	Cd	Co	Cr	Cu	Mn	Ni	Pb	Sb	Se	V	Zn	Na	K	Ca	Mg	Al	Fe
Metal concentrations in field blanks		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
FILED BLANK 1 (PALWALLA)	FILTERED	<0.001	<0.003	<0.003	<0.001	<0.003	0.078	<0.03	<0.007	<0.001	<0.003	<0.01	0.0019	0.12	<1	<1	<1	<1	<0.001	<0.001
FIELD BLANK 2 (MILANG)	FILTERED	<0.0006	0.0075	<0.003	<0.001	<0.003	<0.005	<0.03	<0.007	<0.001	<0.003	<0.01	<0.001	<0.052	<1	<1	<1	<1	<0.001	<0.001
FIELD BLANK 1(PALWALLA)	TOTAL	<0.001	0.0055	<0.003	<0.001	<0.003	0.011	<0.03	<0.007	<0.001	<0.003	<0.01	<0.001	<0.052	<1	<1	<1	<1	<0.001	<0.001
FIEDL BLANK2 (MIILANG)	TOTAL	<0.001	<0.003	<0.003	<0.001	<0.003	<0.005	<0.03	<0.007	<0.001	<0.003	<0.01	<0.001	<0.052	<1	<1	<1	<1	<0.001	<0.001

		Ag	As	Cd	Co	Cr	Cu	Mn	Ni	Pb	Sb	Se	V	Zn	Na	K	Ca	Mg	Al	Fe
Site Duplicates		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	mg/L	mg/L	mg/L	mg/L	µg/L	mg/L
Swan Reach Site Dup 1	FILTERED	0.010	0.53	0.008	0.04	0.038	0.59	0.22	0.41	0.029	0.13	0.06	0.4	0.32	63	3	13	13	0.014	0.013
Swan Reach Site Dup 2	FILTERED	0.010	0.58	0.006	0.045	0.047	0.64	0.24	0.44	0.026	0.13	0.06	0.44	0.29	63	3	13	13	0	0
Meningle Site Dup 1	FILTERED	0.092	2.7	0.012	0.36	0.50	1.7	18	2.6	0.59	0.45	0.08	3.4	2.0	829	39	61	140	0.34	0.36
Meningle Site Dup 2	FILTERED	0.062	3.5	0.023	0.85	1.1	3.2	57	3.6	1.7	0.4	0.04	7.8	3.5	866	41	71	150	0.69	0.91
Swan Reach Site Dup 1	TOTAL	0.003	0.97	0.006	0.29	0.18	1.1	44	0.71	0.42	0.12	0.02	1.9	0.78	65	3	14	13	0.15	0.33
Swan Reach Site Dup 2	TOTAL	0.002	0.9	0.004	0.31	0.22	0.97	45	0.73	0.43	0.11	0.02	2	0.66	66	3	14	13	0.16	0.35
Meningle Site Dup 1	TOTAL	0.055	6.3	0.048	3.2	2.7	11	260	7.4	6	0.19	<0.01	27	7.2	873	42	87	150	2	3.3
Meningle Site Dup 2	TOTAL	0.054	6.3	0.052	3.5	2.8	14	300	8.4	6.8	0.17	<0.01	30	8.8	862	41	81	150	2.2	3.7

		Ag	As	Cd	Co	Cr	Cu	Mn	Ni	Pb	Sb	Se	V	Zn	Na	K	Ca	Mg	Al	Fe
Mean of Site Duplicates		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	mg/L	mg/L	mg/L	mg/L	µg/L	mg/L
Swan Reach	FILTERED	0.0098	0.555	0.0069	0.0425	0.0425	0.615	0.23	0.425	0.0275	0.13	0.0605	0.42	0.305	63	3	13	13	0.0117	0.0112
Meningle	FILTERED	0.077	3.1	0.0175	0.605	0.8	2.45	37.5	3.1	1.145	0.425	0.0585	5.6	2.75	848	40	66	145	0.515	0.635
Swan Reach	TOTAL	0.0024	0.935	0.005	0.3	0.2	1.035	44.5	0.72	0.425	0.115	0.023	1.95	0.72	66	3	14	13	0.155	0.34
Meningle	TOTAL	0.0545	6.3	0.05	3.35	2.75	12.5	280	7.9	6.4	0.18	<0.01	28.5	8	868	42	84	150	2.1	3.5

		Ag	As	Cd	Co	Cr	Cu	Mn	Ni	Pb	Sb	Se	V	Zn	Na	K	Ca	Mg	Al	Fe
Sample Duplicates (same bottle)		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	mg/L	mg/L	mg/L	mg/L	µg/L	mg/L
Mannum Filt	FILTERED	0.004	0.80	0.005	0.042	0.031	0.64	0.42	0.56	0.021	0.14	0.12	0.89	0.26			20	19	0.021	0.0069
Mannum Filt Replicate	FILTERED	0.006	0.66	0.004	0.041	0.034	0.60	0.43	0.55	0.016	0.13	0.11	0.85	0.26			-	-	-	-
Mannum Filt Average	FILTERED	0.005	0.73	0.005	0.042	0.033	0.62	0.43	0.56	0.018	0.14	0.11	0.87	0.26			-	-	-	-

Table B12 QA/QC for Mobilisation Tests: Dissolved Metals (CSIRO – Sydney)

All Replicated Tests for River Murray metal-mobilisation tests

Replicates of River Murray metal-release tests (same soil, repeated test)

Sample	**Depth**	**Ag**	**As**	**Cd**	**Co**	**Cr**	**Cu**	**Mn**	**Ni**	**Pb**	**Sb**	**Se**	**V**	**Zn**	**Ca**	**Mg**	**Al**	**Fe**
Name	**cm**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**mg/L**	**mg/L**	**µg/L**	**mg/L**
WL 8.4	3-6	0.004	3.1	0.13	31	0.18	1.5	2700	15	0.14	0.18	0.36	1.5	19	70	49	<0.1	<0.1
WL 8.4	3-6	0.007	3.2	0.13	31	0.18	1.4	2600	15	0.15	0.2	0.36	1.5	19	71	49	<0.1	<0.1
WW20C	30-40	0.002	0.86	0.06	13	0.17	1.1	2300	12	0.12	0.24	0.14	0.86	11	71	56	<0.1	<0.1
WW20C	30-40	0.002	0.78	0.047	7.5	0.2	1.1	1600	7.7	0.095	0.25	0.13	1.1	7.3	49	39	<0.1	<0.1
AA 29.6	3-10	9E-04	1.2	0.007	0.67	0.27	0.94	280	0.79	0.18	0.22	0.36	3.0	0.82	39	34	<0.1	<0.1
AA 29.6	3-10	0.009	4.2	0.16	27	4.1	46	1100	48	0.94	0.069	0.08	2.8	47	27	18	4.9	15
UKE 3.3	1-8	0.045	11	4.7	460	44	160	5300	680	7.5	0.3	0.36	610	1700	150	120	51	120
UKE 3.3	1-8	0.07	9.7	4.3	430	43	160	5400	640	7.3	0.28	0.37	700	1700	150	130	51	120
UKE 3.4	8-12	0.012	22	0.94	170	24	96	3300	330	0.46	0.6	0.75	110	320	650	76	15	21
UKE 3.4	8-12	0.004	3.4	1.4	140	0.97	6.9	3800	140	3.4	0.12	0.21	1.1	150	110	83	0.63	0.42
JUR 2.3	0-2	0.16	15	2.4	300	43	67	7400	390	0.29	0.98	0.78	270	970	570	260	38	81
JUR 2.3	0-2	0.083	15	2.3	310	41	66	7600	410	0.92	0.66	0.76	250	1100	600	270	40	81
MOR 1.3	-3 or 40-7	1E-03	1.1	0.007	0.59	0.32	0.79	71	1.1	0.03	0.31	0.21	2.8	1.3	28	25	<0.1	<0.1
MOR 1.3	-3 or 40-7	9E-04	0.97	0.011	0.61	0.33	1.1	77	1.2	0.029	0.29	0.22	2.6	1.4	30	26	0.11	<0.1
SPM1.3	5-10	0.002	3.2	0.77	110	3.2	15	1900	150	5.3	0.22	0.19	12	130	75	42	2.1	1.2
SPM1.3	5-10	0.029	16	3.4	440	16	25	4600	710	0.13	0.59	0.7	91	470	650	76	16	25
Sample	**Depth**	Ag	As	Cd	Co	Cr	Cu	Mn	Ni	Pb	Sb	Se	V	Zn	Ca	Mg	Al	Fe

Averages of replicates of River Murray metal-release tests (same soil, repeated test)

Sample	**Depth**	Ag	As	Cd	Co	Cr	Cu	Mn	Ni	Pb	Sb	Se	V	Zn	Ca	Mg	Al	Fe
Name	**cm**	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	mg/L	mg/L	µg/L	mg/L
WL 8.4	3-6	0.006	3.15	0.13	31	0.18	1.45	2650	15	0.145	0.19	0.36	2	19	70.5	49	<0.1	<0.1
WW20C	30-40	0.002	0.82	0.054	10.25	0.185	1.1	1950	9.85	0.108	0.245	0.135	1	9.15	60	47.5	<0.1	<0.1
AA 29.6	3-10	0.005	2.7	0.084	13.84	2.185	23.47	690	24.4	0.56	0.145	0.222	3	23.91	33	26	<0.1	<0.1
UKE 3.3	1-8	0.058	10.35	4.5	445	43.5	160	5350	660	7.4	0.29	0.365	655	1700	150	125	51	120
UKE 3.4	8-12	0.008	12.7	1.17	155	12.5	51.45	3550	235	1.93	0.36	0.48	56	235	380	79.5	7.815	10.71
JUR 2.3	0-2	0.122	15	2.35	305	42	66.5	7500	400	0.605	0.82	0.77	260	1035	585	265	39	81
MOR 1.3	40-70	9E-04	1.035	0.009	0.6	0.325	0.945	74	1.15	0.03	0.3	0.215	3	1.35	29	25.5	<0.1	<0.1
SPM1.3	5-10	0.016	9.6	2.085	275	9.6	20	3250	430	2.715	0.405	0.445	52	300	362.5	59	9.05	13.1

Table B13 QA/QC for Mobilisation Tests: Dissolved Metals (CSIRO – Sydney)

Replicates of River Murray metal-release tests (same test, repeat sample and analysis)

Sample	**Depth**	Ag	As	Cd	Co	Cr	Cu	Mn	Ni	Pb	Sb	Se	V	Zn	Ca	Mg	Al	Fe
Name	**cm**	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	mg/L	mg/L	µg/L	mg/L
PA 4.4	8-15	6E-04	4.5	0.049	6.5	0.41	4.2	190	5.2	0.065	0.93	1.6	14	2.1	31	34	<0.1	<0.1
PA 4.4	8-15	0.002	4.9	0.047	6.7	0.42	4.4	180	5.4	0.062	0.95	1.6	15	2.2	31	34	<0.1	<0.1
MOR 1.2	30-40	0.043	2.6	0.24	27	1.1	2.3	970	22	0.55	0.26	0.15	4.8	52	130	85	0.86	0.28
MOR 1.2	30-40	0.016	2.5	0.24	27	1.2	2.3	970	23	0.54	0.27	0.16	4.8	52	130	86	0.82	0.29
AA 29.6	3-10	0.015	4.3	0.15	27	4.1	46	1100	48	0.94	0.074	0.09	2.8	48	27	18	5	15
AA 29.6	3-10	0.004	4.1	0.16	27	4	46	1100	47	0.94	0.065	0.08	2.7	47	27	18	4.9	15
WL 7.2	0-3	0.003	4.1	0.052	3.9	0.36	2.8	260	4.8	0.027	0.38	0.36	1.1	3.9	55	32	<0.1	<0.1
WL 7.2	0-3	0.002	4.0	0.05	3.8	0.35	2.7	270	4.7	0.025	0.32	0.37	1.1	3.9	55	32	<0.1	<0.1

Averages of replicates of River Murray metal-release tests (same test, repeat sample and analysis)

Sample	**Depth**	Ag	As	Cd	Co	Cr	Cu	Mn	Ni	Pb	Sb	Se	V	Zn	Ca	Mg	Al	Fe
Name	**cm**	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	mg/L	mg/L	µg/L	mg/L
PA 4.4	8-15	1E-03	4.7	0.048	6.6	0.42	4.3	180	5.3	0.063	0.94	1.6	15	2.2	31	31	<0.1	<0.1
MOR 1.2	30-40	0.03	2.5	0.24	27	1.2	2.3	970	22	0.55	0.26	0.15	4.8	52	130	85	0.84	0.29
AA 29.6	3-10	0.009	4.2	0.16	27	4.1	46	1100	48	0.94	0.069	0.08	2.8	47	27	18	4.9	15
WL 7.2	0-3	0.002	4.0	0.051	3.8	0.36	2.8	270	4.7	0.026	0.35	0.36	1.1	3.9	55	32	<0.1	<0.1

Table B14 QA/QC for Buffering / Re-adsorption Tests

Buffering and Re-adsorption test 1

Influence of soil type and solid concentration on buffering of metal release

Method duplicates

Sample	Start of Resuspension				End of Resuspension			
Number	**pH**	**Eh, mV**	**EC, µS**	**DO, mg/L**	**pH**	**Eh, mV**	**EC, µS**	**DO, mg/L**
AT 16.3 (1000 mg/L)	6.9	299	549	10.7	6.5	442	918	8.9
AT 16.3 (1000 mg/L)	6.9	303	549	10.7	6.5	444	918	9.0
WL 2.2(10000 mg/L)	7.1	325	584	10.4	6.4	280	963	8.6
WL 2.2 (10000 mg/L)	7.0	316	589	10.5	6.5	290	967	8.6

Average of method duplicates

Sample	Start of Resuspension				End of Resuspension			
Number	**pH**	**Eh, mV**	**EC, µS**	**DO, mg/L**	**pH**	**Eh, mV**	**EC, µS**	**DO, mg/L**
AT 16.3 (1000 mg/L)	6.9	506	549	10.7	6.5	648	918	8.93
WL 2.2 (10000 mg/L)	7.0	526	587	10.5	6.4	490	965	8.59

	Ag	As	Cd	Co	Cr	Cu	Mn	Ni	Pb	Sb	Se	V	Zn	Al	Fe
Method duplicates	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
AT 16.3 Meth Dup 1 (100)	84	20	120	170	13	26	1700	180	<0.3	0.13	90	140	87	1.4	1.3
AT 16.3 Meth Dup 2 (100)	83	20	110	170	13	33	1700	170	<0.3	0.12	89	140	85	8.8	1.0
WL 2.2 Meth Dup 1 (1000)	64	0.12	6.1	18	13	5.6	580	16	<0.3	0.19	76	69	6.7	3.6	1.0
WL 2.2 Meth Dup 2 (1000)	56	0.09	5.5	15	13	5.5	550	17	<0.3	0.22	73	54	5.4	1.3	1.2

Average of method duplicates

AT 16.3 Average (100)	83.5	20	115	170	13	29.5	1700	175	<0.3	0.13	90	140	86	5.1	1.2
WL 2.2 Average (1000)	64	0.12	6.1	18	13	5.6	580	16	<0.3	0.19	76	69	6.7	3.6	1.0

	Total Alkalinity	**Nitrite as N**	**Nitrate as N**	**Reactive Phosphorus**
Method duplicates	mg/L	mg/L	mg/L	mg/L
AT 16.3 Meth Dup 1 (100)	34	0.073	41.7	0.38
AT 16.3 Meth Dup 2 (100)	34	0.066	43.9	0.35
WL 2.2 Meth Dup 1 (1000)	40	0.069	40.8	0.55
WL 2.2 Meth Dup 2 (1000)	43	0.078	40.1	0.52

	Total Alkalinity	**Nitrite as N**	**Nitrate as N**	**Reactive Phosphorus**
Average of duplicates	mg/L	mg/L	mg/L	mg/L
AT 16.3 Average (100)	34.0	0.070	42.8	0.36
WL 2.2 Average (1000)	41.5	0.074	40.5	0.53

Table B15 QA/QC for Buffering / Re-adsorption Tests: Replicated Tests

Buffering and Re-adsorption test 2

Influence of metal-load (added) on buffering capacity of suspended solids in River Murray water

Method duplicates

			Before metal-spiking				After metal-spiking			
Sample	TSS g/L	Dilution	Start of Resuspension				End of Resuspension			
Number		Factor	Eh, mV	EC, µS	DO, mg/L	D.O	pH	Eh, mV	EC, µS	DO, mg/L
No soil	0	25-fold	7.0	587	536	9.5	5.8	606	1997	8.5
No soil	0	25-fold	7.0	581	534	9.6	5.6	634	2000	8.5
AT 16.1	10	25-fold	7.2	562	567	9.6	6.0	523	2020	8.3
AT 16.1	10	25-fold	7.2	560	568	9.7	5.8	540	2020	8.3
UKE 1.1	10	25-fold	7.2	513	553	9.5	6.1	527	2010	8.2
UKE 1.1	10	25-fold	7.2	507	550	9.3	6.0	531	2010	8.2

Average of method duplicates

Sample	TSS g/L		Start of Resuspension				End of Resuspension			
Number			pH	Eh, mV	EC, µS	DO, mg/L	pH	Eh, mV	EC, µS	DO, mg/L
No soil	0	25-fold	7.0	584	535	9.5	5.7	620	1999	8.5
AT 16.1	10	25-fold	7.2	561	568	9.7	5.9	532	2020	8.3
UKE 1.1	10	25-fold	7.2	510	552	9.4	6.0	529	2010	8.2

Table B16 QA/QC for Buffering / Re-adsorption Tests: Replicated Tests

Buffering and Re-adsorption test 2

Influence of metal-load (added) on buffering capacity of suspended solids in River Murray water

	Ag	As	Cd	Co	Cr	Cu	Mn	Ni	Pb	Se	V	Zn	Al	Fe
Blanks	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**
Blank 1	<2	<5	<2	<2	<2	<3	<2	<2	<10	<5	<5	<5	<10	<10
Blank 2	<2	<5	<2	<2	<2	<3	<2	<2	<10	<5	<5	<5	<10	<10

Duplicate Tests

RM-4 Dup 1	20	174	692	743	45	327	6930	748	<10	605	438	813	<10	<10
RM-4 Dup 2	25	186	707	748	47	377	7110	767	<10	622	436	709	13	<10
UKE1.1-4 Dup 1	<2	225	156	352	36	13	4477	264	<10	466	361	179	<10	<10
UKE1.1-4 Dup 2	<2	240	161	354	34	15	4514	277	<10	454	358	188	<10	<10
AT16.1-4 Dup 1	<2	199	72	710	44	134	6920	730	<10	170	448	594	<10	<10
AT16.1-4 Dup 2	11	200	626	729	45	160	6870	719	<10	632	440	637	11	<10
100-fold Deionised water	52	112	203	198	147	204	1959	201	<10	225	122	206	1315	<10
100-fold Deionised water	55	108	208	205	146	202	1961	200	<10	230	124	211	1316	<10
26-fold Deionised water	204	439	779	769	581	776	7300	790	<10	832	404	779	5150	63
26-fold Deionised water	207	445	772	760	581	770	7380	773	<10	857	404	760	5030	65
10-fold Deionised water	526	1103	1901	1867	1434	1914	17470	1857	<10	2092	925	1911	11420	126
10-fold Deionised water	514	1095	1898	1860	1430	1915	17070	1858	<10	2052	916	1925	11230	129

Average of Duplicate Tests

RM-4	22	180	699	745	46	352	7020	758	<10	613	437	761	<10	-1
UKE1.1-4	<2	233	158	353	35	14	4496	271	<10	460	360	184	<10	0
AT16.1-4	5	199	349	719	45	147	6895	725	<10	401	444	616	<10	2
100-fold Deionised water	54	110	206	201	146	203	1960	200	<10	228	123	208	1316	5
26-fold Deionised water	206	442	775	764	581	773	7340	782	<10	845	404	769	5090	64
10-fold Deionised water	520	1099	1900	1863	1432	1914	17270	1858	<10	2072	921	1918	11325	128

Spike Control (40 µg/L) was 90-100% for all metals

APPENDIX C: DATA INTERPRETATION

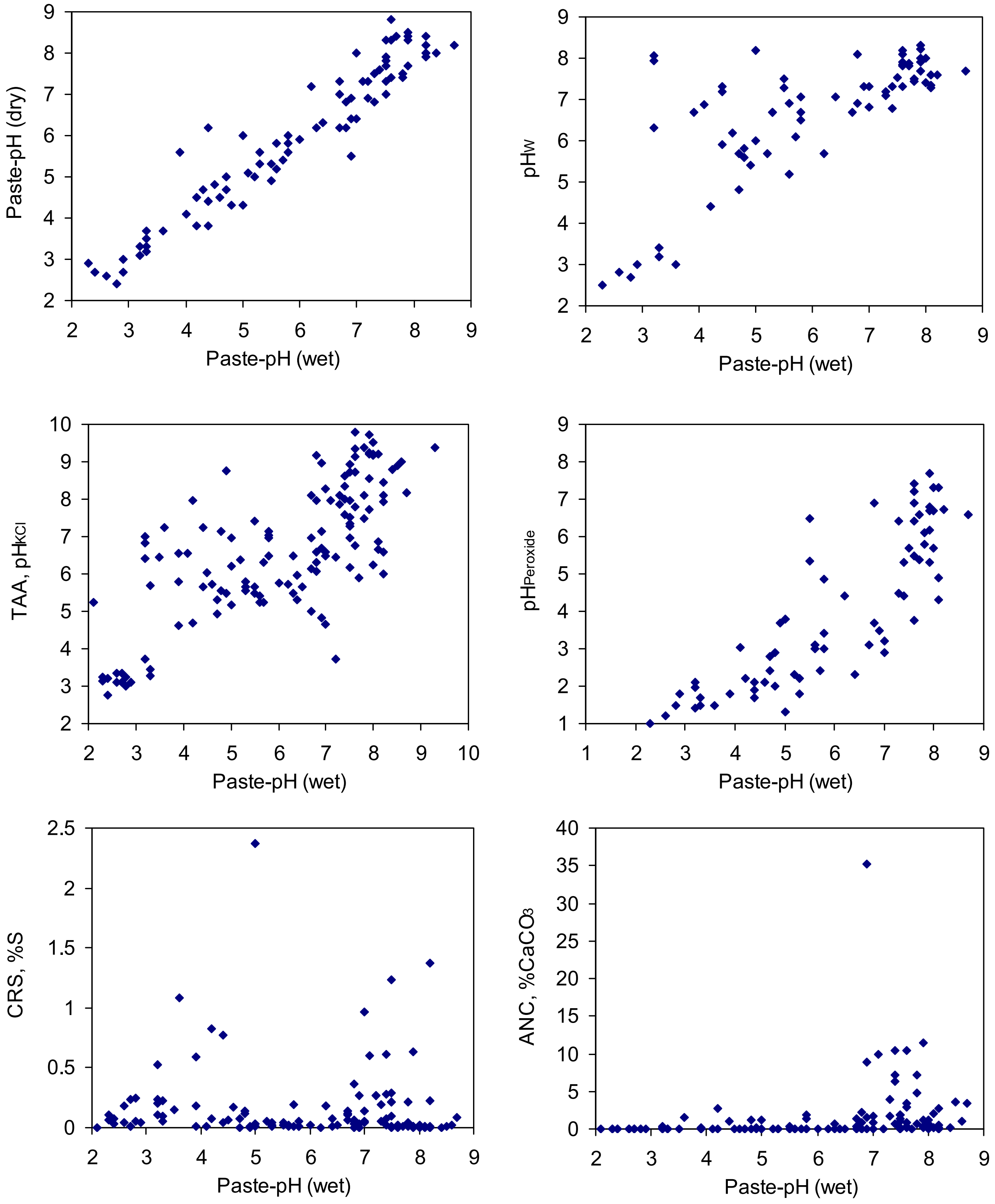


Figure C1. Relationships between soils properties (solid phases)

Table C1. Soil properties (by area)

Soil Properties (by area): pH, TAA, ANC, CRS: Min, Max, Mean±standard deviatiation

River Murray

	Moisture	Paste pH [a]		pH_w	pH_{Perox}	TAA [b]	CRS	ANC
Site	%	Wet	Dry			pH_{KCl}	%S	$\%CaCO_3$
Count	27	27	16	28	28	28	25	27
Minimum	18.0	2.3	2.4	2.5	1.0	3.2	0.0	0.0
Maximum	59.0	8.7	8.2	7.7	6.6	8.2	0.3	6.3
Mean	35.3	5.4	5.7	6.1	3.3	5.9	0.1	0.7
SD	13.0	1.6	1.7	1.4	1.7	1.4	0.1	1.6

Wellington Weir

	Moisture	Paste pH [a]		pH_w	pH_{Perox}	TAA [b]	CRS	ANC
Site	%	Wet	Dry			pH_{KCl}	%S	$\%CaCO_3$
Count	14	14	6	11	11	8	8	8
Minimum	15.0	4.2	3.8	4.4	1.7	4.7	0.0	0.0
Maximum	78.0	8.0	8.4	8.3	7.7	9.8	0.1	10.4
Mean	36.4	6.4	5.6	6.9	4.4	7.5	0.0	1.9
SD	24.8	1.5	1.6	1.2	2.2	1.8	0.0	3.5

Lake Albert

	Moisture	Paste pH [a]		pH_w	pH_{Perox}	TAA [b]	CRS	ANC
Site	%	Wet	Dry			pH_{KCl}	%S	$\%CaCO_3$
Count	44	44	30	18	18	38	35	34
Minimum	1.0	2.9	3.0	3.0	1.3	3.1	0.0	0.0
Maximum	74.0	9.1	9.5	8.6	7.4	9.5	2.4	35.2
Mean	32.3	6.8	6.9	6.7	4.7	7.7	0.3	2.1
SD	22.9	1.7	1.8	2.0	2.6	1.5	0.5	5.9

Lake Alexandrina

	Moisture	Paste pH [a]		pH_w	pH_{Perox}	TAA [b]	CRS	ANC
	%	Wet	Dry			pH_{KCl}	%S	$\%CaCO_3$
Count	30	30	8	17	17	28	24	23
Minimum	1.0	2.1	2.7	6.8	1.4	3.1	0.0	0.0
Maximum	76.0	9.3	7.4	8.4	6.9	9.4	0.6	9.9
Mean	27.2	6.3	5.0	7.5	4.7	6.9	0.1	1.2
SD	18.8	2.1	2.2	0.5	1.7	1.8	0.2	2.8

Welands

	Moisture	Paste pH [a]		pH_w	pH_{Perox}	TAA [b]	CRS	ANC
Site	%	Wet	Dry			pH_{KCl}	%S	$\%CaCO_3$
Count	36	36	26			28	28	5
Minimum	3.0	2.4	2.7			2.8	0.0	1.3
Maximum	82.0	8.2	8.0			7.7	0.6	11.4
Mean	33.4	5.2	5.5			5.2	0.2	7.4
SD	21.8	1.8	1.6			1.6	0.2	4.2

Table C1 (continued). Soil properties (by area)

Soil Properties (Wetlands): pH, TAA, ANC, CRS: Min, Max, Mean±standard deviatiation

Ukee

	Moisture	Paste pH [a]		pH$_w$	pH$_{Perox}$	TAA [b]	CRS	ANC
Site	%	Wet	Dry			pH$_{KCl}$	%S	%CaCO$_3$
Count	12	12	6			12	12	0
Minimum	5.0	2.4	3.3			2.8	0.0	0.0
Maximum	65.0	7.2	6.9			5.6	0.6	0.0
Mean	30.8	4.5	5.3			4.0	0.1	#DIV/0!
SD	19.7	1.9	1.5			1.0	0.2	#DIV/0!

Jury Swamp

	Moisture	Paste pH [a]		pH$_w$	pH$_{Perox}$	TAA [b]	CRS	ANC
Site	%	Wet	Dry			pH$_{KCl}$	%S	%CaCO$_3$
Count	4	4	3			2	2	0
Minimum	11.0	2.8	2.7			3.0	0.2	0.0
Maximum	73.0	5.7	5.4			5.2	0.2	0.0
Mean	40.8	4.0	4.2			4.1	0.2	
SD	25.9	1.4	1.4			1.6	0.0	

Morgan

	Moisture	Paste pH [a]		pH$_w$	pH$_{Perox}$	TAA [b]	CRS	ANC
Site	%	Wet	Dry			pH$_{KCl}$	%S	%CaCO$_3$
Count	7	7	6			2	2	1
Minimum	30.0	4.0	4.1			5.7	0.0	1.3
Maximum	82.0	6.5	5.6			7.0	0.0	1.3
Mean	50.7	5.1	4.9			6.3	0.0	1.3
SD	19.9	0.9	0.5			0.9	0.0	

Paiwella

	Moisture	Paste pH [a]		pH$_w$	pH$_{Perox}$	TAA [b]	CRS	ANC
Site	%	Wet	Dry			pH$_{KCl}$	%S	%CaCO$_3$
Count	5	5	4			5	5	3
Minimum	4.0	5.5	5.3			5.5	0.0	8.9
Maximum	41.0	7.9	7.7			7.7	0.6	11.4
Mean	17.6	6.7	6.3			6.7	0.3	10.3
SD	16.6	1.0	1.0			1.0	0.3	1.2

Riverglades

	Moisture	Paste pH [a]		pH$_w$	pH$_{Perox}$	TAA [b]	CRS	ANC
Site	%	Wet	Dry			pH$_{KCl}$	%S	%CaCO$_3$
Count	8	8	7			7	7	1
Minimum	3.0	3.3	3.2			3.3	0.0	4.7
Maximum	53.0	8.2	8.0			7.5	0.3	4.7
Mean	28.3	6.1	6.2			6.1	0.1	4.7
SD	20.6	2.0	2.1			1.3	0.1	

Swanport

	Moisture	Paste pH [a]		pH$_w$	pH$_{Perox}$	TAA [b]	CRS	ANC
Site	%	Wet	Dry			pH$_{KCl}$	%S	%CaCO$_3$
Count	2	2	2			1	1	0
Minimum	3.0	3.3	3.2			3.3	0.1	0.0
Maximum	38.0	3.3	3.3			3.3	0.1	0.0
Mean	20.5	3.3	3.3			3.3	0.1	
SD	24.7	0.0	0.1					

Table C2. Particulate metal concentrations

Concentrations of particulate metals in surface soils (comprising those collected from 0 to up to 10 CM soil depth)

Metal Concentrations in Surface Soils

	Depth	Trace metal concentrations in µg/L (ppb)												Trace metal concentrations in mg/L (ppm)				
Site	cm	Ag	As	Cd	Co	Cr	Cu	Mn	Ni	Pb	Se	V	Zn	K	Ca	Mg	Al	Fe
WL 2.1	0-5	0.4	1.61	0.4	6.3	1.56	3.67	120	3.28	2.34		6.22	7.35	506	1810	543	731	2210
WL 5.3	0-1	0.4	1.05	0.4	9.13	4.83	15.1	44.1	9.29	10.9	0.4	11.7	14	1435	5130	866	1770	9215
WL 6.3	0-1	0.4	9.4	0.4	9.79	8.82	8.09	199	11.9	6.35		19.8	19.7	3450	13800	3440	1700	7640
WL 7.2	0-3	0.4	12.8	0.4	13.9	19.4	20.1	151	16.3	13.1	0.4	53.2	30	4950	4760	3650	8650	16200
WL 8.2	0-1	0.4	5.95	0.4	13	7.41	17	274	12.8	9.33	0.4	26.4	21.7	2930	4440	3150	4710	6180
WL 9.2	0-5	0.4	3.55	0.4	4.54	9.5	20.8	159	11.9	11.2		32.2	21.5	3590	3810	3320	2920	5520
WL 11.1	0-5	0.4	0.4	0.4	3.55	3.75	7.18	56.5	3.32	5.16		11.8	9.38	1380	1050	1310	1640	2830
WL 14.2	0-2	0.4	0.4	0.4	1.75	2.21	2.7	72	1.67	2.88		4.89	5.79	714	350	679	1150	2020
WL 15.1	0-5	0.4	1.01	0.4	4.38	0.92	1.07	228	1.9	2.14		2.7	3.25	342	387	340	613	3090
WL 17.1	0-15	0.4	1.44	0.4	4.75	1.65	2.34	32.5	1.93	2.91		5.01	5.53	487	394	394	812	1750
WW3A 1.1	0-8	0.4	0.4	0.4	0.64	0.4	0.4	8.27	0.4	2		2	2	41.4	141	36.7	59.3	453
WW3A 4.1	0-5	0.4	0.95	0.4	0.63	0.4	0.26	13.9	0.4	2		2	2	40.3	486	45.1	61.8	443
WW 8A 2.1	0-5	0.4	6.99	0.4	9.96	5.62	14.6	544	10.6	3.97		24.4	20.8	4710	7380	2970	3040	9800
WW20A 1.1	0-5	0.4	3.09	0.4	6.37	5.84	9.43	591	7.24	2.73		16.7	13.3	3590	4430	2870	1920	4940
WWBH20 11.1	0-5	0.4	0.4	0.4	1.41	0.4	0.4	11.9	0.47	2		2	2	145	183	113	202	754
AT 9.1 *	0-5	0.4	11.8	0.4	5.94	6.85	15.8	147	10.9	11.9	0.4	34.2	21.3	1610	8610	3510	4840	22000
AT 11.1	0-5	0.4	2.23	0.4	1.47	34.2	0.7	34.2	0.76	1.5		3.22	0.97	231	760	248	305	1555
AT 12.1	0-5	0.4	0.48	0.4	0.92	0.3	0.54	5.09	0.35	1		1.39	1	157	142	122	200	613
AT 14.1	0-3	0.4	2.2	0.4	0.7	0.83	0.55	19.6	0.31	1		3.06	1.32	316	14000	832	292	952
AT 16.1	0-5	0.3	1.49	0.3	0.69	0.3	0.36	7.27	0.3	1.36		2.02	0.53	127	1160	181	182	661
AT 17.1	0-1	0.3	0.3	0.3	0.99	0.53	0.51	28.2	0.64	1		2.85	1.1	358	3450	704	322	950
AT 18.1	0-8	0.3	0.73	0.3	0.3	0.3	0.3	15.5	0.3	1		1	1	113	928	157	114	374
AT 19.1	0-8	0.3	2.35	0.3	0.71	0.3	0.57	19.5	0.3	1.25		2.73	1	278	1630	363	278	844
AT 20.1	0-2	0.3	11.8	0.3	14.5	10.3	22.1	545	14.5	13.8		39.4	29.2	4020	2830	3580	2700	11900
AT 21.1	0-1	0.3	14	0.3	8.06	11.7	22.1	196	17.4	13.2		35.8	20.4	6670	4430	5730	3440	13000
AA 29.5	0-3	0.4	1.69	0.4	8.97	0.75	0.9	94.1	4.15	1.1	0.4	5.6	3.7	432	3330	666	544	3790
AA 30.1	0-0.05	0.4	0.92	0.4	1.4	0.4	0.4	65	0.4	0.7		2.03	1	442	3250	948	266	835
AA 30.2	0.05-20	0.4	0.3	0.4	0.78	0.4	0.3	7.63	0.3	1		1	1	71.7	444	85.5	108	373
AA 31.3	0-10	0.4	1.42	0.4	0.4	4.73	8.33	53.9	4.11	4.15		10.2	13.2	1660	1170	1080	1720	3040
AA 33.1	0-1	0.4	5.94	0.4	23.8	7.53	10.7	244	7.88	7.53		23.4	17	8290	11900	11200	2210	8110
AA 33.2	0-10	0.4	7.25	0.4	6.46	5.84	23.1	104	20.4	5.72	0.4	41.4	27.4	5600	3540	4930	3570	6740
UKE 1.1	0-10	0.4	1.74	0.4	5.74	8.27	8.54	76	6.13	7.02		22.9	11.5	1610	1350	1760	2270	6080
UKE 2.1	0-5	0.4	1.82	0.4	4.75	5.16	9.46	62.7	5.91	10		22.3	10.3	1190	2820	1530	2900	2950
UKE 3.1	0-10	0.4	4.39	0.4	47.1	8.01	37	458	42.4	24.8		49.1	88.3	9910	71400	7370	7140	41100
UKE 3.2	0-3	0.4	3.85	0.4	67.9	9.88	29.9	537	62.3	25.1	0.4	55.1	125	6580	32500	12050	5590	23300
UKE 3.4	0-5	0.4	5.33	0.4	11.2	8.61	13.7	83.2	10.1	6.75	0.4	34.7	25.1	2630	5730	2000	5010	8850
JUR 6.5	0-5	0.4	4.86	0.4	7.47	13.2	20	116	15.9	9.03	0.4	47.5	28.8	3230	38800	4830	3530	8720
MOR 1.3	0-5	0.4	5.35	0.4	8.67	13.9	17.2	112	15.4	2.6	0.4	44.3	24.5	3520	4910	3590	15600	14100
MOR 2.3	0-5	0.4	3.22	0.4	5.38	14.7	16.5	70.3	9.88	1.8		46.5	15.8	2540	3590	2870	3390	8500
MOR 3.2	0-3	0.4	9.92	0.4	13.7	11.2	23.6	52.5	18.9	1	0.4	50.3	14.6	1870	2620	2840	8640	10800
PA 4.2	0-5	0.4	11.9	0.42	12.8	9.84	19.3	1070	14.3	10.1		31.1	39.3	6180	27100	9820	2640	11400
PA 4.3	0-5	0.4	13.6	0.49	12.9	9.9	20	457	14.8	11.1		37.6	47.4	5990	5200	8050	2560	13700
SPM 1.1	0-0.5	0.4	5.74	0.4	15	8.79	24.5	0.3	16.2	32.6	0.4	45.8	27.2	7600	3220	1080	2060	7440
Mean		**0.4**	**4.3**	**0.4**	**8.8**	**6.5**	**10.9**	**167**	**9.5**	**6.7**	**0.4**	**21.3**	**18.1**	**2594**	**7195**	**2694**	**2614**	**7110**
SD		**0.0**	**4.2**	**0.0**	**12.3**	**6.5**	**9.9**	**220**	**11.7**	**7.1**	**0.0**	**18.4**	**23.3**	**2640**	**13036**	**3048**	**3011**	**7839**

Table C3. Depth profiles of particulate metals, mg/kg

	Depth	Trace metal concentrations in mg/kg													
Site	cm	As	Co	Cr	Cu	Mn	Ni	Pb	V	Zn	K	Ca	Mg	Al	Fe
WL 2.1	0-5	1.61	6.3	1.56	3.67	120	3.28	2.34	6.22	7.35	506	1810	543	731	2210
WL 2.2	5-20	2.6	18.3	4.62	8.35	292	9.88	6.28	13.8	16.9	2340	4360	1550	1840	4970
WL 2.3	20-40	2.71	8.72	2.77	5.83	98	5.25	6.77	9.94	10.5	1060	1830	699	1330	3500
WL 5.3	0-1	1.05	9.13	4.83	15.1	44.1	9.29	10.9	11.7	14	1435	5130	866	1770	9215
WL 5.4	1-5	1.53	4.3	4.47	11.2	24.5	4.11	8.07	14.3	9.93	932	549	459	1570	7640
WL 5.5	5-20	4.55	8.31	8.26	19.2	51	8.17	9.61	33	19.6	1380	1240	959	2980	9990
WL 6.3	0-1	9.40	9.79	8.82	8.09	199	11.9	6.35	19.8	19.7	3450	13800	3440	1700	7640
WL 6.4	1-8	9.27	13.6	10.1	10.4	72.6	11	7.97	21	17.8	2960	8900	2080	1870	7050
WL 6.5	8-20	12.4	14.6	12.7	11.2	133	12.4	8.72	28.7	75.4	3570	13400	2250	2150	9330
WL 7.2	0-3	12.8	13.9	19.4	20.1	151	16.3	13.1	53.2	30	4950	4760	3650	8650	16200
WL 7.3	3-12	21.4	22.2	22.3	19.1	447	19.3	13.5	62.7	31.2	5500	13800	4820	3020	15400
WL 7.4	12.25	4.79	11.8	6.58	15.8	385	12.4	9.31	23.8	21.6	3270	8480	4330	2320	5580
WL 8.2	0-1	5.95	13	7.41	17	274	12.8	9.33	26.4	21.7	2930	4440	3150	4710	6180
WL 8.3	1-3	6.16	16.1	8.41	19.2	263	13.8	11	30.2	26.3	3550	5330	3250	5440	6570
WL 8.4	3-6	4.77	11.7	9.46	20.6	257	15.2	11.8	34.1	27.1	4070	4700	3180	4570	7170
WL 8.5	6-25	1.86	7.37	6.03	11	205	9.16	7	16.7	14.9	2330	2340	2040	4590	4230
WW 8A 2.1	0-5	6.99	9.96	5.62	14.6	544	10.6	3.97	24.4	20.8	4710	7380	2970	3040	9800
WW 8A 2.2	5-15	9.8	12.6	6.07	14.8	600	13	5.86	36.4	21.1	5960	9040	3560	2110	12300
WW 8A 2.3	15-30	16.1	18.6	8.41	32.2	210	18.5	11.6	36.8	19.9	4100	5880	3120	1920	13200
AT 12.1	0-5	0.48	0.92	<0.3	0.54	5.09	0.35	<1	1.39	<1	157	142	122	200	613
AT 12.2	5-25	0.58	1.03	0.41	1.13	9.62	0.41	<1	2.26	<1	235	247	226	352	686
AT 12.3	25-40	11.4	8.43	4.88	22.5	244	10.0	7.81	20.2	13.3	2370	3800	2800	1740	9960
AT 14.1	0-3	2.20	0.70	0.83	0.55	19.6	0.31	<1	3.06	1.32	316	14000	832	292	952
AT 14.2	3-15	2.07	0.82	0.70	0.29	16.5	0.45	<1	2.52	0.61	192	9390	389	241	862
AT 14.3	15-25	3.75	4.60	5.65	11.8	108	6.61	6.95	19.7	13.7	2600	6650	3330	2070	6120
AT 14.4	25-30	4.01	7.30	4.54	8.36	174	4.67	5.47	13.8	9.00	2200	15600	2470	1830	6950
AT 14.5	25-30	4.46	7.35	6.66	11.4	135	7.57	7.6	20.4	12.2	3170	3740	4850	2250	9510

Table C3 (continued). Depth profiles of particulate metals, mg/kg

	Depth	Trace metal concentrations in mg/kg													
Site	cm	As	Co	Cr	Cu	Mn	Ni	Pb	V	Zn	K	Ca	Mg	Al	Fe
AT 16.1	0-5	1.49	0.69	<0.3	0.36	7.27	<0.3	1.36	2.02	0.53	127	1160	181	182	661
AT 16.2	5-20	0.64	0.50	<0.3	<0.3	5.8	<0.3	<1	<1	<1	95.9	452	117	161	360
AT 16.3	20-45	<0.3	<0.3	4.58	<0.3	4.58	<0.3	<1	<1	<1	121	171	176	187	379
AT 16.4	45-75	0.94	1.93	1.47	2.82	37.3	1.59	<1	5.13	2.87	928	4720	987	927	2300
AT 17.1	0-1	<0.3	0.99	0.53	0.51	28.2	0.64	<1	2.85	1.1	358	3450	704	322	950
AT 17.2	1-10	0.82	0.89	<0.3	0.71	20.5	0.61	<1	2.44	<1	267	1820	365	347	815
AT 17.3	10-20	4.06	5.42	5.24	9.38	148	6.17	<1	19.3	12.5	2320	4190	2250	2030	5550
AT 17.4	20-30	8.19	9.87	6.77	12.3	169	8.56	<1	22.8	14.6	3500	9830	3370	2300	11400
AT 18.1	0-8	0.73	<0.3	<0.3	<0.3	15.5	<0.3	<1	<1	<1	113	928	157	114	374
AT 18.2	18-28	0.52	<0.3	<0.3	0.42	5.32	<0.3	<1	<1	<1	107	304	120	138	350
AT 18.3	28-40	<0.3	1.04	<0.3	0.40	11.6	<0.3	<1	1.48	<1	155	433	132	244	555
AT 19.1	0-8	2.35	0.71	<0.3	0.57	19.5	<0.3	1.25	2.73	<1	278	1630	363	278	844
AT 19.2	8-18	5.48	7.74	2.79	7.27	63.7	5.15	4.50	11.3	6.54	1070	11900	895	1260	5290
AT 19.3	18-28	1.41	2.12	0.39	0.69	12.9	1.06	<1	1.85	1.01	234	550	279	308	1370
AT 20.1	0-2	11.8	14.5	10.3	22.1	545	14.5	13.8	39.4	29.2	4020	2830	3580	2700	11900
AT 20.2	2-10	8.63	10.5	9.32	19.7	168	12.3	12	33.9	24.3	3520	3930	2690	2610	7790
AT 20.3	10-20	4.79	3.28	14.0	26.5	55.6	7.38	13.5	45.4	14.7	5700	3510	5650	2960	4660
AA 33.1	0-1	5.94	23.8	7.53	10.7	244	7.88	7.53	23.4	17.0	8290	11900	11200	2210	8110
AA 33.2	0-10	7.25	6.46	5.84	23.1	104	20.4	5.72	41.4	27.4	5600	3540	4930	3570	6740
AA 33.3	10-25	5.47	14.6	7.31	13.1	76.2	12.2	7.45	40.7	24.6	2680	2830	2670	4520	9900
AA 33.4	25-40	0.58	1.34	0.80	0.85	3.24	0.65	2.02	1.82	1.44	199	27.6	38.0	347	648
AA 33.5	40-60	0.91	1.07	1.4	0.78	20.7	0.7	<1	2.48	1.44	400	14000	1070	476	1030
UKE 3.1	0-0.5	4.39	47.1	8.01	37	458	42.4	24.8	49.1	88.3	9910	71400	7370	7140	41100
UKE 3.2	0.5-1	3.85	67.9	9.88	29.9	537	62.3	25.1	55.1	125	6580	32500	12050	5590	23300
UKE 3.3	1-8	4.49	17.1	9.66	24.5	111	16.2	16.3	41.8	38.2	2350	2760	2300	4640	14400
UKE 3.4	8-12	5.33	11.2	8.61	13.7	83.2	10.1	6.75	34.7	25.1	2630	5730	2000	5010	8850
UKE 3.5	12-20	0.19	2.44	1.49	1.15	10.5	1.13	<1.3	3.45	3.41	316	217	234	612	921
UKE 5.1	0-0.5	2.23	6.03	6.68	36.3	55	7.48	18.2	23.9	15.0	8300	52600	826	2590	23000
UKE 5.2	0.5-10	4.10	8.88	9.52	21.0	94.5	9.71	6.12	26.6	21.8	3170	1910	2230	4090	13000
UKE 5.3	10-30	3.87	16.2	10.5	18.8	229	17.9	12.6	32.4	30.9	4630	4040	3450	9290	14400
PA 4.1	0-1	5.47	8.72	5.78	10.5	759	21.6	1.35	16.5	22.1	3530	21300	9440	2150	6460
PA 4.2	1-3	11.9	12.8	9.84	19.3	1070	14.3	10.1	31.1	39.3	6180	27100	9820	2640	11400
PA 4.3	3-8	13.6	12.9	9.90	20.0	457	14.8	11.1	37.6	47.4	5990	5200	8050	2560	13700
PA 4.4	8-15	13.5	122	16.3	27.3	196	15.7	14.5	51	33.3	4130	4870	4100	3130	14400

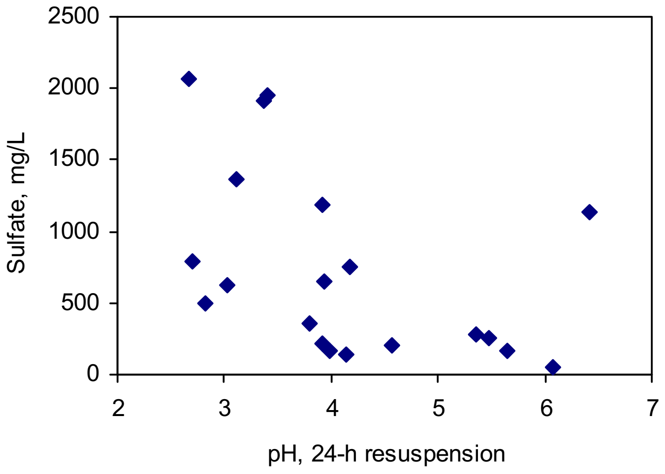


Figure C2. Dissolved sulfate versus water pH (24-H mobilisation)

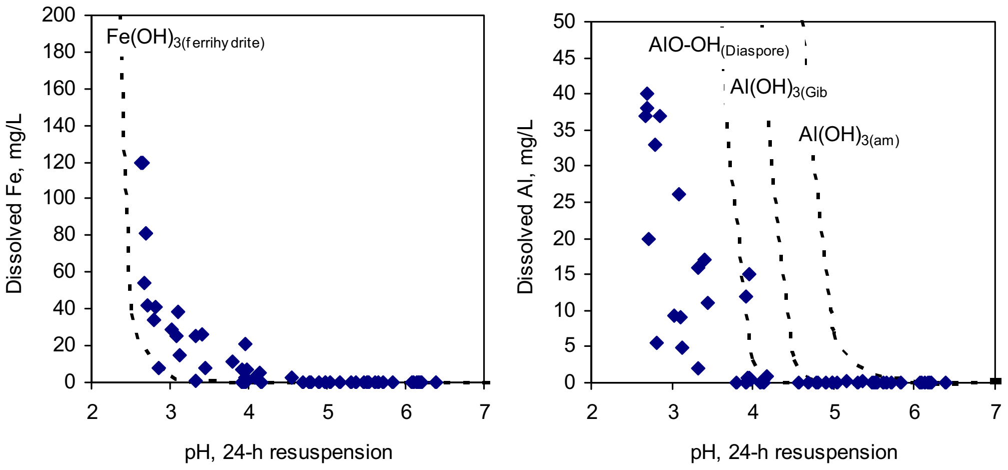


Figure C3. Mineql+ model calculations of aluminium and iron solubility versus water PH (24-H mobilisation)

Table C4. Kinetics of mobilisation of metals from soils during 24-h mobilisation tests (% release)

	Soil (100 g/L) resuspended in River Murray water.					
	JUR 2.3	JUR 2.4&5	SPM 1.3	SPM 1.1	UKE 3.2	UKE 3.3
Time, h	Dissolved Al as a percentage of concentration (Table 40) after 24-h					
0.16	35	48	35	58	92	76
1	56	65	55	74	100	90
3	68	80	71	84	98	93
6	82	92	78	95	100	94
24	100	100	100	100	100	100
Time, h	Dissolved Fe as a percentage of concentration (Table 40) after 24-h					
0.16	31	52	190	37	95	53
1	43	67	275	51	95	63
3	54	88	320	69	95	69
6	70	101	251	86	100	79
24	100	100	100	100	100	100
Time, h	Dissolved Mn as a percentage of concentration (Table 40) after 24-h					
0.16	65	58	63	75	96	94
1	80	72	82	86	102	100
3	84	84	91	93	101	96
6	94	90	94	95	103	98
24	100	100	100	100	100	100
Time, h	Dissolved Cr as a percentage of concentration (Table 40) after 24-h					
0.16	32	33	31	32	92	54
1	47	52	47	45	100	66
3	64	69	75	61	100	77
6	76	88	84	75	100	87
24	100	100	100	100	100	100
Time, h	Dissolved Co as a percentage of concentration (Table 40) after 24-h					
0.16	62	56	61	66	100	90
1	76	71	80	82	100	94
3	88	82	93	91	100	94
6	91	89	93	93	100	96
24	100	100	100	100	100	100
Time, h	Dissolved Ni as a percentage of concentration (Table 40) after 24-h					
0.16	57	55	57	56	100	88
1	76	70	78	75	102	96
3	87	86	91	88	102	96
6	93	93	95	93	100	99
24	100	100	100	100	100	100
Time, h	Dissolved Cu as a percentage of concentration (Table 40) after 24-h					
0.16	78	72	60	80	103	113
1	101	86	80	93	106	119
3	107	92	93	101	106	113
6	106	97	101	103	106	113
24	100	100	100	100	100	100
Time, h	Dissolved Zn as a percentage of concentration (Table 40) after 24-h					
0.16	67	62	65	69	94	93
1	84	73	82	84	101	100
3	94	81	94	92	101	100
6	98	88	100	94	102	100
24	100	100	100	100	100	100

Table C5. Percentage of each metal released from the soils during the 24-h mobilisation tests in River Murray water

Metal release, as a percentatge of the metal concentration in the soils

Sample	As	Cd	Co	Cr	Cu	Mn	Ni	Pb	V	Zn
Name	%	%	%	%	%	%	%	%	%	%
WL 5.3	14.4	6.9	40.5	5.8	13.2	86.3	76.5	0.3	12.9	37.1
WL 5.4	2.0	1.8	20.9	1.8	6.1	44.9	36.5	0.3	4.8	21.1
WL 5.5	0.9	4.3	22.9	0.8	3.5	51.0	34.3	1.8	0.7	19.4
WL 7.2	0.3	0.1	0.3	0.0	0.1	1.8	0.3	0.0	0.0	0.1
WL 8.3	0.3	0.5	2.6	0.0	0.1	13.1	1.4	0.0	0.0	1.1
WL 8.4	0.5	0.3	1.9	0.0	0.1	10.1	1.1	0.0	0.0	0.7
WL 8.5	0.3	0.2	0.9	0.0	0.1	6.6	0.4	0.0	0.0	0.3
WL 9.2	0.6	0.1	0.2	0.0	0.1	3.5	0.5	0.0	0.1	0.4
WL 15.1	4.8	0.6	24.6	0.1	14.3	77.4	35.0	0.4	0.0	18.9
WL 15.2	1.5	0.0	0.7	0.0	10.3	0.2	1.9	0.0	0.2	0.4
WW 8A 2.1	0.2	0.2	0.0	0.0	0.1	0.1	0.2	0.0	0.2	1.2
WW20C	0.1	0.1	1.1	0.0	0.0	12.0	0.6	0.0	0.0	0.6
WWBH20 11.2	8.8	0.0	1.0	20.0	23.1	37.7	17.1	0.3	5.8	1.4
AT 2.3	0.7	1.0	38.3	0.1	0.7	37.2	12.2	1.0	0.1	10.6
AT 2.6	1.1	0.3	52.2	0.1	2.3	64.3	21.0	0.1	0.1	44.4
AT 7.2	1.1	8.0	45.8	0.1	0.2	25.7	27.1	0.6	0.2	7.0
AT 9.1 *	0.5	5.6	32.0	0.2	1.2	51.0	31.2	0.5	0.0	12.7
AT 9.2	1.3	6.7	44.1	0.9	3.0	31.1	21.6	0.7	0.1	17.6
AT 19.3	0.6	1.0	22.2	0.1	0.2	4.4	11.3	0.2	0.0	3.6
AT 10.2 *	1.2	0.5	2.9	0.2	3.9	108.5	8.8	0.0	0.9	9.7
AT 21.1	0.1	0.1	0.8	0.0	0.1	1.0	0.3	0.0	0.0	0.2
AA10.2 *	0.5	0.1	2.4	0.0	0.5	11.8	1.4	0.0	0.1	0.7
AA 13.2	2.3	10.9	56.6	0.3	1.8	48.9	43.6	2.1	0.1	26.0
AA 20.2	1.9	3.5	81.0	0.5	1.9	51.4	56.0	0.7	0.2	43.3
AA 29.5	4.2	2.0	10.8	1.5	18.5	72.3	55.4	0.1	0.0	43.4
AA 29.6	2.1	0.3	46.1	1.4	12.4	15.6	16.5	0.6	0.6	7.5
AA 33.2	4.4	16.7	44.9	2.9	7.4	44.2	25.5	0.8	2.9	34.7
AA 33.3	2.9	8.7	14.4	2.7	8.4	38.1	24.6	0.2	5.7	15.0
UKE 3.1	11.6	48.0	59.4	8.2	4.3	93.9	106.1	0.0	2.0	88.3
UKE 3.2	11.2	66.7	64.8	12.2	7.4	111.8	110.8	0.1	20.5	112.4
UKE 3.3	2.3	12.0	26.0	4.5	6.5	48.2	40.7	0.5	15.7	44.5
UKE 3.4	2.4	3.9	13.8	1.5	3.8	42.7	23.3	0.3	1.6	9.4
UKE 3.5	3.6	0.1	1.1	0.0	0.1	7.4	1.9	0.0	0.0	0.1
UKE 5.2	1.3	4.3	23.6	1.7	1.5	72.0	25.7	0.2	4.1	30.7
UKE 5.3	0.8	0.0	0.0	0.0	0.2	1.7	0.1	0.0	0.1	0.0
JUR 2.3	2.9	7.8	40.5	3.5	2.8	91.0	43.1	0.0	12.2	55.3
JUR 2.4.5	0.8	1.8	14.2	1.6	2.2	29.5	17.6	0.2	4.3	16.6
JUR 2.6-7	0.2	0.3	2.1	0.0	0.0	6.1	0.6	0.0	0.0	0.5
JUR 6.5	0.4	0.0	0.2	0.0	0.1	6.4	0.1	0.0	0.2	0.1
MOR 1.2	0.4	0.8	4.5	0.1	0.1	16.8	1.6	0.1	0.1	1.9
MOR 1.3	0.2	0.0	0.1	0.0	0.1	0.7	0.1	0.0	0.1	0.1
MOR 2.2	0.4	0.1	1.0	0.0	0.0	6.6	0.7	0.0	0.0	0.4
MOR 2.4	0.4	0.1	0.9	0.0	0.5	11.1	0.7	0.0	0.0	0.4
MOR 3.2	0.2	0.0	0.4	0.0	0.1	4.0	0.2	0.1	0.2	0.1
PA 4.4	0.3	0.1	0.5	0.0	0.2	0.9	0.3	0.0	0.3	0.1
SPM 1.1	2.8	11.0	29.3	1.8	1.8	70.4	43.2	0.0	2.1	16.9
SPM1.3	1.0	7.0	28.0	0.8	0.7	51.5	35.0	0.2	1.3	14.9
Mean	**2.2**	**5.2**	**19.6**	**1.6**	**3.5**	**34.5**	**21.6**	**0.3**	**2.1**	**16.4**
SD	**3.2**	**12.0**	**21.8**	**3.6**	**5.3**	**32.1**	**26.5**	**0.4**	**4.5**	**23.7**

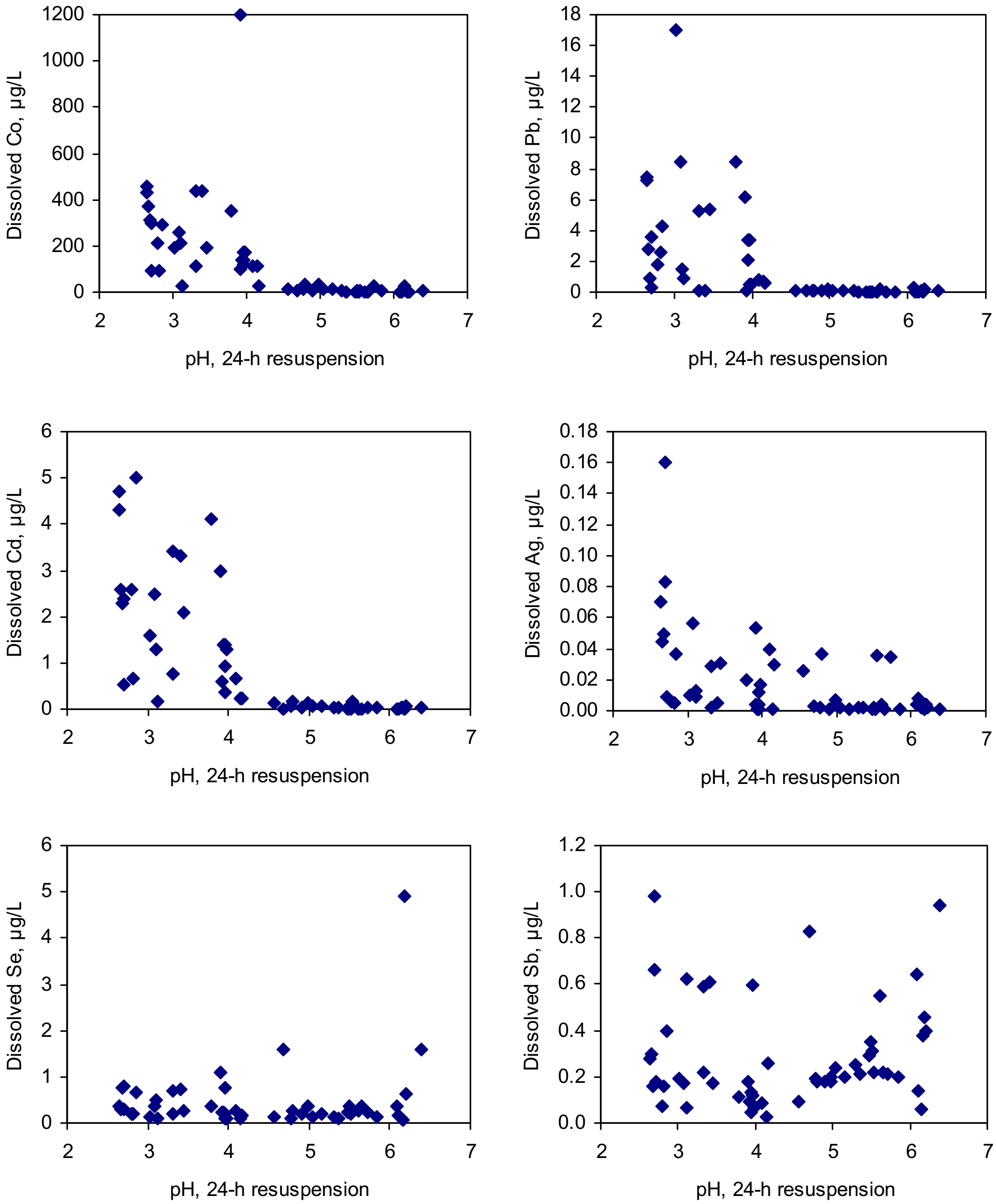


Figure C4. Dissolved metals versus water pH (24-h mobilisation). Dissolved antinomy, cadmium, cobalt, lead, selenium and silver vs pH after 24 h resuspension in River Murray water.

Table C6.Models of pH-dissolved metal release relationships

Al

Model: ExpDecay3

Equation: y = y0 + A1*exp(-(x-x0)/t1) + A2*exp(-(x-x0)/t2) + A3*exp(-(x-x0)/t3)

Weighting:

y	No weighting	
Chi^2/DoF	33.9	
R^2	0.9	
y0	-0.34	1.47
x0	2.62	--
A1	23.57	--
t1	0.04	1074
A2	13.77	--
t2	0.04	1838
A3	31.80	--
t3	0.62	0.2

Zn

Model: ExpDecay3

Equation: y = y0 + A1*exp(-(x-x0)/t1) + A2*exp(-(x-x0)/t2) + A3*exp(-(x-x0)/t3)

Weighting:

y	No weighting	
Chi^2/DoF	27972.5	
R^2	0.8	
y0	-37.21	68.3
x0	2.63	--
A1	879.27	20796866682
t1	0.03	270
A2	1031.12	21106376835
t2	0.03	230
A3	668.75	--
t3	1.02	0.45

Cu

Model: ExpDecay3

Equation: y = y0 + A1*exp(-(x-x0)/t1) + A2*exp(-(x-x0)/t2) + A3*exp(-(x-x0)/t3)

Weighting:

y	No weighting	
Chi^2/DoF	637.3	
R^2	0.8	
y0	2.37	5.756
x0	2.64	--
A1	-76.48	--
t1	0.01	0.049
A2	122.39	--
t2	0.02	0.064
A3	110.06	--
t3	0.57	0.212

Table C6 (continued).Models of pH-dissolved metal release relationships

Cr
Model: ExpDecay3
Equation: y = y0 + A1*exp(-(x-x0)/t1) + A2*exp(-(x-x0)/t2) + A3*exp(-(x-x0)/t3)
Weighting:
y No weighting

Chi^2/DoF	29.6
R^2	0.8

y0	-0.46	2.5
x0	2.61	117064
A1	16.27	--
t1	0.10	19382
A2	24.98	--
t2	0.10	12628
A3	15.14	1864467
t3	0.95	1.0

V
Model: ExpDecay3
Equation: y = y0 + A1*exp(-(x-x0)/t1) + A2*exp(-(x-x0)/t2) + A3*exp(-(x-x0)/t3)
Weighting:
y No weighting

Chi^2/DoF	1784.7
R^2	0.9

y0	5.61	7.30
x0	2.63	--
A1	331.23	--
t1	0.02	53.69
A2	406.84	--
t2	0.02	43.71
A3	245.03	--
t3	0.28	0.11

Table C7 Statistics on soil paste pH (wet) for all samples

Summary Section of Murray_River

Count	Mean	Standard Deviation	Standard Error	Minimum	Maximum	Range
27	5.403704	1.625395	0.3128074	2.3	8.7	6.4

Counts Section of Murray_River

Rows	Sum of Frequencies	Missing Values	Distinct Values	Sum	Total Sum Squares	Adjusted Sum Squares
46	27	19	23	145.9	857.09	68.68963

Means Section of Murray_River

Parameter	Mean	Median	Geometric Mean	Harmonic Mean	Sum	Mode
Value	5.403704	5.3	5.139269	4.842259	145.9	
Std Error	0.3128074				8.4458	
95% LCL	4.760719	4.7	4.49701	4.198879	128.5394	
95% UCL	6.046689	6.2	5.873255	5.718485	163.2606	
T-Value	17.27486					
Prob Level	8.881784E-16					
Count	27		27	27		0

The geometric mean confidence interval assumes that the ln(y) are normally distributed.
The harmonic mean confidence interval assumes that the 1/y are normally distributed.

Variation Section of Murray_River

Parameter	Variance	Standard Deviation	Unbiased Std Dev	Std Error of Mean	Interquartile Range	Range
Value	2.641909	1.625395	1.641095	0.3128074	2.2	6.4
Std Error	0.6120579	0.2662678		5.124326E-02		
95% LCL	1.638465	1.280025		0.246341		
95% UCL	4.961724	2.227493		0.4286812		

Percentile Section of Murray_River

Percentile	Value	95% LCL	95% UCL	Exact Conf. Level
99	8.7			
95	8.26			
90	7.44			
85	7.3	6.2	8.7	97.37556
80	7.12	5.7	7.6	95.08366
75	6.8	5.6	7.4	95.76357
70	6.5	5.3	7.3	96.55508
65	5.8	5.3	7.3	95.88674
60	5.6	5	7	95.0808
55	5.54	4.7	6.7	95.9296
50	5.3	4.7	6.2	96.43018
45	5.18	4.6	5.7	96.82272
40	4.92	4.4	5.6	95.0808
35	4.78	3.9	5.5	95.88674
30	4.7	3.2	5.3	96.55508
25	4.6	2.8	5	95.76357
20	4.2	2.6	4.8	95.08366
15	3.34	2.3	4.7	97.37556
10	2.76			
5	2.42			
1	2.3			

Table C7 (continued) Statistics on soil paste pH (wet) for all samples

Summary Section of Wellington_Weir

Count	Mean	Standard Deviation	Standard Error	Minimum	Maximum	Range
14	6.378572	1.472924	0.3936555	4.2	8	3.8

Counts Section of Wellington_Weir

Rows	Sum of Frequencies	Missing Values	Distinct Values	Sum	Total Sum Squares	Adjusted Sum Squares
46	14	32	11	89.3	597.81	28.20357

Means Section of Wellington_Weir

Parameter	Mean	Median	Geometric Mean	Harmonic Mean	Sum	Mode
Value	6.378572	6.35	6.213098	6.044576	89.3	
Std Error	0.3936555				5.511178	
95% LCL	5.528131	4.9	5.404577	5.289756	77.39382	
95% UCL	7.229012	7.9	7.142574	7.050668	101.2062	
T-Value	16.20343					
Prob Level	5.308984E-10					
Count	14		14	14		0

The geometric mean confidence interval assumes that the ln(y) are normally distributed.
The harmonic mean confidence interval assumes that the 1/y are normally distributed.

Variation Section of Wellington_Weir

Parameter	Variance	Standard Deviation	Unbiased Std Dev	Std Error of Mean	Interquartile Range	Range
Value	2.169506	1.472924	1.501495	0.3936555	2.925	3.8
Std Error	0.3564056	0.1710997		4.572831E-02		
95% LCL	1.140201	1.067802		0.2853821		
95% UCL	5.63086	2.372943		0.6341957		

Percentile Section of Wellington_Weir

Percentile	Value	95% LCL	95% UCL	Exact Conf. Level
99	8			
95	8			
90	8			
85	7.975			
80	7.9	5.8	8	95.36224
75	7.9	5.8	8	97.18725
70	7.8	5.8	8	96.17493
65	7.675	5.8	8	95.51371
60	7.6	5.2	8	97.43929
55	7.075	5	7.9	97.15633
50	6.35	4.9	7.9	96.48438
45	5.8	4.9	7.9	97.15633
40	5.8	4.4	7.7	97.43929
35	5.35	4.4	7.6	95.51371
30	5.1	4.2	6.9	96.17493
25	4.975	4.2	6.9	97.18725
20	4.9	4.2	6.9	95.36224
15	4.525			
10	4.3			
5	4.2			
1	4.2			

Table C7 (continued). Statistics on soil paste pH (wet) for all samples

Summary Section of Lake_Alexandrina

Count	Mean	Standard Deviation	Standard Error	Minimum	Maximum	Range
31	6.312903	2.135219	0.3834967	2.1	9.3	7.2

Counts Section of Lake_Alexandrina

Rows	Sum of Frequencies	Missing Values	Distinct Values	Sum	Total Sum Squares	Adjusted Sum Squares
46	31	15	23	195.7	1372.21	136.7748

Means Section of Lake_Alexandrina

Parameter	Mean	Median	Geometric Mean	Harmonic Mean	Sum	Mode
Value	6.312903	7.4	5.836281	5.231599	195.7	7.5
Std Error	0.3834967				11.8884	
95% LCL	5.529698	5.8	4.964615	4.352013	171.4207	
95% UCL	7.096108	7.7	6.86099	6.556794	219.9793	
T-Value	16.46143					
Prob Level	2.220446E-16					
Count	31		31	31		3

The geometric mean confidence interval assumes that the ln(y) are normally distributed.
The harmonic mean confidence interval assumes that the 1/y are normally distributed.

Variation Section of Lake_Alexandrina

Parameter	Variance	Standard Deviation	Unbiased Std Dev	Std Error of Mean	Interquartile Range	Range
Value	4.559161	2.135219	2.153084	0.3834967	3.3	7.2
Std Error	0.9352235	0.3097119		5.562591E-02		
95% LCL	2.911389	1.706279		0.3064568		
95% UCL	8.145834	2.854091		0.5126098		

Percentile Section of Lake_Alexandrina

Percentile	Value	95% LCL	95% UCL	Exact Conf. Level
99	9.3			
95	8.88			
90	8.42	7.8	9.3	95.22601
85	8.1	7.8	9.3	95.94347
80	7.9	7.6	8.6	95.8624
75	7.8	7.5	8.5	96.27022
70	7.74	7.4	8.1	95.22247
65	7.58	7.1	7.9	96.36867
60	7.5	6.8	7.8	95.35354
55	7.46	6.4	7.8	95.47302
50	7.4	5.8	7.7	97.05506
45	6.92	5.5	7.5	95.47302
40	6.72	4.1	7.5	95.54381
35	6.24	3.2	7.4	95.2079
30	5.68	3.2	7.1	95.22247
25	4.5	2.4	6.8	96.27022
20	3.56	2.3	6.2	95.8624
15	3.1	2.1	5.5	95.94347
10	2.46	2.1	4.5	95.22601
5	2.22			
1	2.1			

Table C7 (continued) Statistics on soil paste pH (wet) for all samples

Summary Section of Lake_Albert

Count	Mean	Standard Deviation	Standard Error	Minimum	Maximum	Range
46	6.771739	1.663552	0.2452774	2.9	9.1	6.2

Counts Section of Lake_Albert

Rows	Sum of Frequencies	Missing Values	Distinct Values	Sum	Total Sum Squares	Adjusted Sum Squares
46	46	0	25	311.5	2233.93	124.5333

Means Section of Lake_Albert

Parameter	Mean	Median	Geometric Mean	Harmonic Mean	Sum	Mode
Value	6.771739	7.5	6.513549	6.189381	311.5	7.5
Std Error	0.2452774				11.28276	
95% LCL	6.277725	6.8	5.95375	5.579168	288.7754	
95% UCL	7.265753	7.6	7.125984	6.949468	334.2246	
T-Value	27.60849					
Prob Level	0					
Count	46		46	46		6

The geometric mean confidence interval assumes that the ln(y) are normally distributed.
The harmonic mean confidence interval assumes that the 1/y are normally distributed.

Variation Section of Lake_Albert

Parameter	Variance	Standard Deviation	Unbiased Std Dev	Std Error of Mean	Interquartile Range	Range
Value	2.767406	1.663552	1.672819	0.2452774	1.625	6.2
Std Error	0.5636499	0.2395841		3.532475E-02		
95% LCL	1.903883	1.379812		0.2034423		
95% UCL	4.390206	2.095282		0.3089325		

Percentile Section of Lake_Albert

Percentile	Value	95% LCL	95% UCL	Exact Conf. Level
99	9.1			
95	8.465			
90	8.23	8	9.1	95.57803
85	8.095	7.9	8.4	96.12654
80	8	7.6	8.2	95.30316
75	7.925	7.6	8.2	96.0892
70	7.88	7.5	8	96.50339
65	7.6	7.5	8	95.67103
60	7.6	7.5	7.9	96.60972
55	7.5	7	7.9	96.27471
50	7.5	6.8	7.6	96.0014
45	7.5	6.7	7.6	96.27471
40	6.98	6.3	7.5	96.60972
35	6.845	5	7.5	95.67103
30	6.71	4.2	7	95.73239
25	6.3	3.9	6.9	96.0892
20	4.88	3.5	6.8	95.86363
15	4.21	3.3	6.3	95.9418
10	3.57	2.9	4.8	95.57803
5	3.3			
1	2.9			

Table C7 (continued) Statistics on soil paste pH (wet) for all samples

Summary Section of All_Wetlands

Count	Mean	Standard Deviation	Standard Error	Minimum	Maximum	Range
35	5.054286	1.755553	0.2967426	2.4	7.9	5.5

Counts Section of All_Wetlands

Rows	Sum of Frequencies	Missing Values	Distinct Values	Sum	Total Sum Squares	Adjusted Sum Squares
46	35	11	27	176.9	998.89	104.7869

Means Section of All_Wetlands

Parameter	Mean	Median	Geometric Mean	Harmonic Mean	Sum	Mode
Value	5.054286	5.3	4.735197	4.41247	176.9	3.3
Std Error	0.2967426				10.38599	
95% LCL	4.451232	3.9	4.160407	3.890338	155.7931	
95% UCL	5.657339	6.4	5.389398	5.096481	198.0069	
T-Value	17.03256					
Prob Level	0					
Count	35		35	35		4

The geometric mean confidence interval assumes that the ln(y) are normally distributed.
The harmonic mean confidence interval assumes that the 1/y are normally distributed.

Variation Section of All_Wetlands

Parameter	Variance	Standard Deviation	Unbiased Std Dev	Std Error of Mean	Interquartile Range	Range
Value	3.081966	1.755553	1.768507	0.2967426	3.4	5.5
Std Error	0.3860714	0.155503		0.0262848		
95% LCL	2.01645	1.420018		0.2400268		
95% UCL	5.290595	2.300129		0.3887928		

Percentile Section of All_Wetlands

Percentile	Value	95% LCL	95% UCL	Exact Conf. Level
99	7.9			
95	7.58			
90	7.28	6.9	7.9	95.49782
85	7.12	6.5	7.5	96.4725
80	6.98	6	7.4	96.67783
75	6.7	5.8	7.2	95.00591
70	6.54	5.5	7	95.71412
65	6.16	5.1	7	96.80229
60	5.76	4.4	6.7	96.0789
55	5.5	4.3	6.7	95.92338
50	5.3	3.9	6.4	95.90404
45	4.62	3.3	5.8	95.92338
40	4.34	3.3	5.5	95.97847
35	3.96	3.2	5.5	96.80229
30	3.3	2.8	4.5	95.5
25	3.3	2.7	4.3	95.00591
20	3.22	2.6	3.9	96.16875
15	2.84	2.4	3.3	96.74316
10	2.7	2.4	3.3	95.49782
5	2.56			
1	2.4			

Table C7 (continued) Statistics on soil paste pH (wet) for all samples

Summary Section of Wetland_Ekee

Count	Mean	Standard Deviation	Standard Error	Minimum	Maximum	Range
14	4.55	1.927034	0.5150216	2.4	7.2	4.8

Counts Section of Wetland_Ekee

Rows	Sum of Frequencies	Missing Values	Distinct Values	Sum	Total Sum Squares	Adjusted Sum Squares
46	14	32	11	63.7	338.11	48.275

Means Section of Wetland_Ekee

Parameter	Mean	Median	Geometric Mean	Harmonic Mean	Sum	Mode
Value	4.55	3.6	4.179138	3.850618	63.7	
Std Error	0.5150216				7.210302	
95% LCL	3.437363	2.7	3.26247	3.126378	48.12309	
95% UCL	5.662637	6.7	5.353366	5.011574	79.27691	
T-Value	8.83458					
Prob Level	7.424788E-07					
Count	14		14	14		0

The geometric mean confidence interval assumes that the ln(y) are normally distributed.
The harmonic mean confidence interval assumes that the 1/y are normally distributed.

Variation Section of Wetland_Ekee

Parameter	Variance	Standard Deviation	Unbiased Std Dev	Std Error of Mean	Interquartile Range	Range
Value	3.713462	1.927034	1.964414	0.5150216	4.075	4.8
Std Error	0.5753658	0.211125		5.642552E-02		
95% LCL	1.95164	1.397011		0.3733669		
95% UCL	9.638132	3.104534		0.8297216		

Percentile Section of Wetland_Ekee

Percentile	Value	95% LCL	95% UCL	Exact Conf. Level
99	7.2			
95	7.2			
90	7.1			
85	7			
80	7	3.3	7.2	95.36224
75	6.775	3.3	7.2	97.18725
70	6.55	3.3	7.2	96.17493
65	6.125	3.3	7	95.51371
60	5.3	3.2	7	97.43929
55	4.25	2.7	7	97.15633
50	3.6	2.7	6.7	96.48438
45	3.3	2.7	6.7	97.15633
40	3.3	2.6	6.4	97.43929
35	3.225	2.6	5.3	95.51371
30	2.95	2.4	3.9	96.17493
25	2.7	2.4	3.9	97.18725
20	2.7	2.4	3.9	95.36224
15	2.625			
10	2.5			
5	2.4			
1	2.4			

APPENDIX D: XRF TOTAL METAL DATA

Table D1. XRF Data for River Murray and Lake Albert soils

	Ag (ppm)	As (ppm)	Ba (ppm)	Bi (ppm)	Br (ppm)	Cd (ppm)	Ce (ppm)	Co (ppm)	Cr (ppm)	Cs (ppm)	Cu (ppm)	Ga (ppm)	Ge (ppm)	Hf (ppm)	Hg (ppm)	I (ppm)	La (ppm)
WW3A 1.2	<2	4	100	<3	<1	<2	<15	49	0	8	<1	1	2	<7	20	<6	<13
WW3A 2.1	<2	5	79	<3	<1	<2	<15	20	3	<8	<1	1	2	<7	<11	<6	<13
WW3A 4.1	<2	4	64	<3	<1	<2	<15	41	7	<8	<1	<1	1	<7	<11	<6	<13
WW3A 4.2	<2	4	105	<3	<1	<2	<15	15	3	<8	<1	<1	2	<7	17	<6	<13
WW3A 4.5	<2	6	274	<3	3	<2	<15	5	7	14	2	3	2	<7	22	7	<13
WW8A 2.1	<2	13	281	<3	206	<2	38	12	31	<8	18	9	2	<7	20	36	<13
WW8A 2.2	<2	17	177	<3	160	<2	22	13	26	11	20	7	2	<7	28	15	20
WW8A 2.3	<2	23	242	<3	234	<2	61	19	31	10	45	8	2	<7	18	60	22
WW20A 1.1	<2	10	310	<3	312	2	28	34	27	<8	13	8	2	<7	12	83	24
WW20A 1.2	<2	9	273	<3	176	2	34	17	33	<8	18	9	2	<7	14	43	<13
WW20C 1.1	<2	10	374	<3	64	2	56	16	40	8	34	10	3	8	25	9	18
AT2.3	<2	35	104	<3	49	<2	19	11	22	11	31	6	2	<7	19	14	<13
AT2.6	<2	8	156	<3	3	<2	16	3	13	<8	1	3	3	7	12	<6	<13
AT4.1	<2	4	108	<3	<1	<2	<15	12	6	13	1	3	3	<7	18	<6	<13
AT6.1	<2	6	136	<3	27	<2	22	6	4	8	<1	1	2	<7	15	8	<13
AT7.2	<2	32	185	<3	37	<2	68	40	60	12	28	15	1	<7	12	12	42
AT9.2	<2	17	261	<3	62	2	57	18	64	12	28	18	3	<7	13	32	27
AT10.1	<2	13	276	4	26	<2	51	13	54	13	27	15	4	7	18	9	39
AT12.1	<2	17	282	<3	133	<2	66	14	70	9	33	21	3	9	17	10	31
AT16.1	<2	4	134	3	2	<2	<15	6	18	9	1	1	2	<7	22	<6	<13
AT16.2	<2	4	131	<3	1	<2	<15	14	11	10	1	1	3	<7	26	<6	<13
AT16.3	<2	3	137	<3	13	<2	<15	<4	5	12	1	1	2	<7	22	<6	<13
AT16.4	<2	5	172	3	12	<2	15	<4	17	<8	6	4	3	<7	27	<6	<13
AT17.1	<2	4	131	<3	6	2	<15	<4	35	<8	1	<1	1	14	<11	7	<13
AT17.2	<2	5	122	<3	2	<2	<15	<4	31	16	1	1	2	<7	16	<6	<13
AT17.3	<2	13	234	<3	22	<2	55	10	57	8	26	15	3	<7	18	9	17
AT17.4	<2	16	178	3	31	<2	41	11	45	8	18	12	3	7	26	<6	23
AT18.1	<2	4	85	<3	5	<2	<15	<4	3	9	1	2	3	<7	19	<6	<13
AT18.2	<2	4	135	<3	10	<2	<15	<4	24	13	1	<1	2	<7	12	<6	<13

Table D1 (continued). XRF Data for River Murray and Lake Albert soils

	Mn (ppm)	Mo (ppm)	Nb (ppm)	Nd (ppm)	Ni (ppm)	Pb (ppm)	Rb (ppm)	Sb (ppm)	Sc (ppm)	Se (ppm)	Sm (ppm)	Sn (ppm)	Sr (ppm)	Ta (ppm)	Th (ppm)	Tl (ppm)	U (ppm)
WW3A 1.2	18	1	3	<8	5	<2	14	<6	<3	1	<9	<2	18	<6	5	11	<2
WW3A 2.1	18	<1	2	<8	<2	<2	8	<6	<3	1	<9	<2	10	<6	3	10	<2
WW3A 4.1	46	1	2	<8	2	<2	7	<6	<3	<1	<9	<2	47	<6	3	10	<2
WW3A 4.2	148	<1	2	<8	3	<2	9	<6	<3	1	<9	<2	88	<6	<3	9	<2
WW3A 4.5	38	1	4	<8	4	<2	39	<6	<3	1	<9	<2	43	<6	5	9	2
WW8A 2.1	538	<1	8	15	19	5	58	<6	8	2	<9	<2	134	<6	8	10	3
WW8A 2.2	414	<1	5	13	19	4	42	<6	6	2	<9	<2	92	<6	5	13	4
WW8A 2.3	273	<1	7	26	31	13	50	<6	9	2	11	<2	104	<6	8	12	6
WW20A 1.1	1745	1	7	14	16	2	52	<6	7	2	9	<2	149	<6	8	8	2
WW20A 1.2	286	1	10	20	20	7	62	<6	8	1	<9	<2	115	<6	11	10	5
WW20C 1.1	244	2	11	31	29	9	74	<6	7	2	<9	<2	98	<6	13	11	5
AT2.3	131	23	5	8	32	<2	36	<6	5	2	<9	<2	95	<6	4	10	10
AT2.6	68	1	4	<8	4	<2	32	<6	3	2	<9	<2	37	<6	5	12	<2
AT4.1	20	1	3	<8	2	<2	20	<6	3	1	<9	<2	21	<6	5	8	<2
AT6.1	133	<1	3	<8	3	<2	21	<6	<3	<1	<9	<2	41	<6	6	7	<2
AT7.2	235	4	12	30	52	11	91	<6	11	1	<9	<2	83	<6	13	9	5
AT9.2	168	2	13	30	33	13	103	<6	14	2	<9	<2	91	<6	16	10	4
AT10.1	379	<1	13	24	27	11	93	<6	12	2	<9	<2	96	<6	15	11	<2
AT12.1	285	3	13	33	41	11	123	<6	15	1	<9	<2	132	<6	15	10	9
AT16.1	34	<1	5	<8	3	<2	21	<6	4	1	<9	<2	23	<6	5	10	<2
AT16.2	22	1	4	<8	<2	<2	22	<6	3	1	<9	<2	23	<6	5	8	<2
AT16.3	19	<1	3	<8	<2	<2	24	<6	<3	1	<9	<2	28	<6	4	10	<2
AT16.4	102	<1	4	8	7	<2	39	<6	4	1	11	<2	65	<6	5	10	2
AT17.1	80	1	7	<8	3	<2	23	<6	3	1	<9	<2	57	<6	7	11	<2
AT17.2	69	1	4	<8	3	<2	23	<6	3	1	<9	<2	34	<6	4	7	<2
AT17.3	278	<1	12	28	28	10	93	<6	13	1	9	4	92	<6	13	8	2
AT17.4	298	<1	10	24	21	8	73	<6	9	2	<9	<2	94	<6	12	11	<2
AT18.1	23	<1	2	<8	<2	<2	16	<6	4	1	<9	<2	18	<6	4	10	<2
AT18.2	47	1	7	<8	2	<2	23	<6	<3	1	<9	<2	28	<6	5	8	<2

Table D2. XRF Data for River Murray and Lake Albert, Lake Alexandrina and Ukee wetland soils

	Ag (ppm)	As (ppm)	Ba (ppm)	Bi (ppm)	Br (ppm)	Cd (ppm)	Ce (ppm)	Co (ppm)	Cr (ppm)	Cs (ppm)	Cu (ppm)	Ga (ppm)	Ge (ppm)	Hf (ppm)	Hg (ppm)	I (ppm)	La (ppm)
AT18.3	<2	5	144	<3	2	<2	<15	<4	15	10	1	1	2	<7	<11	<6	<13
AT19.1	<2	4	115	<3	3	<2	<15	<4	11	10	1	1	3	9	12	7	<13
AT19.2	<2	9	151	<3	10	<2	<15	9	19	8	7	6	3	<7	19	7	13
AT19.3	<2	5	115	<3	<1	<2	<15	4	8	8	1	2	2	<7	16	<6	<13
AT20.1	<2	16	262	<3	29	<2	53	18	52	8	28	13	2	<7	<11	23	27
AT20.2	<2	13	266	<3	34	<2	49	16	53	<8	27	14	3	9	18	12	23
AT20.3	<2	10	206	<3	55	<2	38	10	56	8	22	16	3	<7	14	<6	12
AA8.2	<2	6	377	<3	<1	<2	22	6	12	9	2	6	2	<7	<11	8	19
AA11.1	<2	3	221	<3	<1	<2	16	17	5	<8	<1	3	2	11	15	7	22
AA12.1	<2	3	162	<3	<1	<2	15	12	7	9	<1	3	3	<7	<11	<6	<13
AA12.2	<2	4	155	<3	<1	<2	17	64	7	<8	1	1	2	<7	11	<6	<13
AA13.2	<2	8	218	<3	3	<2	31	21	25	<8	5	5	3	<7	12	<6	<13
AA14.2	<2	4	75	<3	1	<2	<15	20	7	<8	1	<1	1	<7	<11	<6	<13
AA15.1	<2	3	48	<3	2	<2	<15	9	3	8	<1	<1	2	<7	12	<6	<13
AA29.5	<2	5	135	<3	8	<2	23	8	19	<8	3	2	2	10	<11	<6	14
AA29.6	<2	5	71	<3	<1	3	<15	43	7	<8	<1	2	3	<7	15	6	<13
AA30.1	<2	6	148	<3	46	<2	<15	17	8	<8	<1	2	2	9	12	6	<13
AA30.2	<2	4	139	<3	<1	<2	<15	17	9	<8	1	1	2	<7	<11	<6	<13
UKE1.1	<2	7	297	3	2	<2	46	10	43	6	13	13	3	10	24	<6	30
UKE1.2	<2	8	277	<3	5	<2	51	11	47	6	18	14	3	8	22	<6	20
UKE2.1	<2	7	290	<3	27	2	41	4	36	7	13	8	2	<7	22	12	30
UKE2.2	<2	7	300	<3	3	<2	52	9	52	9	15	12	3	10	21	<6	30
UKE3.1	<2	8	128	3	29	<2	112	52	19	12	21	4	2	<7	25	15	53
UKE3.2	<2	7	217	<3	38	3	72	46	34	11	38	6	1	<7	24	18	35
UKE3.3	<2	9	281	3	35	<2	55	17	47	12	29	10	2	<7	18	14	30
UKE3.4	<2	11	298	<3	23	<2	53	14	57	15	27	17	3	11	26	17	32
UKE3.5	<2	5	230	<3	<1	<2	15	2	10	9	2	3	2	<7	26	<6	<13
UKE5.1	<2	8	297	<3	33	<2	52	13	34	8	42	7	2	9	17	10	15
UKE5.2	<2	9	311	<3	48	<2	40	11	42	13	30	11	3	8	20	10	22
UKE5.3	<2	9	392	<3	23	<2	61	17	63	9	27	17	4	11	30	10	27

Table D2 (continued). XRF Data for River Murray and Lake Albert, Lake Alexandrina and Ukee wetland soils

	Mn (ppm)	Mo (ppm)	Nb (ppm)	Nd (ppm)	Ni (ppm)	Pb (ppm)	Rb (ppm)	Sb (ppm)	Sc (ppm)	Se (ppm)	Sm (ppm)	Sn (ppm)	Sr (ppm)	Ta (ppm)	Th (ppm)	Tl (ppm)	U (ppm)
AT18.3	35	1	4	<8	2	<2	26	<6	5	1	10	<2	30	<6	5	8	4
AT19.1	54	1	6	<8	3	<2	21	<6	<3	1	<9	<2	30	<6	6	9	<2
AT19.2	93	<1	4	10	8	<2	39	<6	6	1	<9	<2	38	<6	5	9	<2
AT19.3	39	1	3	<8	2	<2	21	<6	3	1	<9	<2	17	<6	5	10	<2
AT20.1	583	<1	13	27	36	12	93	<6	12	1	<9	2	118	<6	15	7	<2
AT20.2	352	1	14	24	28	14	94	<6	13	1	<9	<2	97	<6	16	11	3
AT20.3	287	1	10	21	26	6	102	<6	12	1	<9	<2	71	<6	14	9	2
AA8.2	86	<1	6	9	6	2	52	<6	5	<1	<9	<2	126	<6	8	7	<2
AA11.1	99	1	5	9	2	<2	15	<6	3	<1	<9	<2	33	<6	8	10	<2
AA12.1	50	<1	4	<8	<2	<2	16	<6	3	1	<9	<2	40	<6	7	8	<2
AA12.2	47	<1	3	<8	2	<2	12	<6	<3	<1	<9	<2	25	<6	6	12	<2
AA13.2	159	1	6	9	12	<2	36	<6	7	1	<9	<2	44	<6	9	8	2
AA14.2	21	1	3	<8	<2	<2	6	<6	<3	2	<9	<2	10	<6	6	10	<2
AA15.1	33	1	2	<8	<2	<2	4	<6	4	1	<9	<2	6	<6	3	11	<2
AA29.5	234	1	6	9	7	<2	17	<6	4	1	<9	<2	35	<6	8	9	3
AA29.6	86	1	5	<8	<2	<2	10	<6	<3	1	<9	<2	11	<6	5	11	<2
AA30.1	160	1	6	<8	<2	<2	20	<6	<3	<1	<9	<2	51	<6	6	7	<2
AA30.2	79	1	4	<8	<2	<2	11	<6	3	<1	9	<2	17	<6	5	8	<2
UKE1.1	168	1	15	24	15	7	92	<6	9	1	<9	<2	77	<6	16	10	5
UKE1.2	181	<1	15	29	21	8	96	<6	8	<1	<9	<2	81	<6	16	11	5
UKE2.1	113	2	10	21	14	11	67	<6	7	1	13	<2	93	<6	12	10	4
UKE2.2	191	2	16	23	16	9	99	<6	10	1	9	<2	86	<6	18	11	6
UKE3.1	944	<1	5	54	70	7	32	<6	<3	1	11	<2	900	<6	9	11	12
UKE3.2	609	<1	8	41	66	24	51	<6	5	2	14	<2	260	<6	12	10	9
UKE3.3	168	<1	11	25	24	15	77	<6	8	2	<9	<2	79	<6	14	11	5
UKE3.4	212	1	13	32	29	17	101	<6	12	1	<9	<2	87	<6	15	10	7
UKE3.5	44	1	4	9	2	<2	45	<6	8	1	<9	<2	42	<6	6	12	<2
UKE5.1	120	<1	9	29	16	19	62	<6	5	1	12	<2	350	<6	12	11	6
UKE5.2	197	<1	12	17	19	13	83	<6	10	1	<9	<2	101	<6	15	11	6
UKE5.3	393	<1	16	33	36	13	125	<6	12	1	10	<2	103	<6	17	11	4

Table D3. XRF Data for wetland soils

	Ag (ppm)	As (ppm)	Ba (ppm)	Bi (ppm)	Br (ppm)	Cd (ppm)	Ce (ppm)	Co (ppm)	Cr (ppm)	Cs (ppm)	Cu (ppm)	Ga (ppm)	Ge (ppm)	Hf (ppm)	Hg (ppm)	I (ppm)	La (ppm)
JUR2.3	<2	11	253	<3	47	<3	40	12	38	9	28	9	2	<7	<11	10	20
JUR6.5	<2	11	269	<3	66	<3	37	13	52	10	27	15	1	<7	<11	12	26
MUR3.1	<2	7	364	<3	3	<3	60	18	53	15	20	12	3	7	11	6	27
MUR3.2	<2	10	667	<3	7	<3	65	19	58	10	22	16	3	7	<11	6	43
PA4.1	<2	13	185	<3	102	<3	<15	8	20	<7	11	5	1	<7	11	39	<13
PA4.2	<2	19	280	<3	228	<3	38	15	42	11	22	12	2	<7	<11	85	22
PA4.3	<2	17	235	<3	588	<3	36	12	40	11	23	11	2	<7	<11	69	18
PA4.4	<2	15	320	<3	46	<3	57	16	69	<7	33	18	3	<7	<11	10	28
PA4.5	<2	14	292	<3	46	<3	57	15	71	10	36	19	2	<7	<11	8	19
RIV3.2	<2	13	346	<3	51	<3	56	16	56	10	31	14	2	<7	<11	21	26
RIV3.4	<2	13	380	<3	83	<3	54	15	55	12	30	16	3	<7	<11	17	30
RIV3.5	<2	16	387	<3	35	<3	63	21	66	8	36	19	3	<7	<11	12	28
RIV4.2	<2	10	272	<3	259	<3	23	10	34	11	16	9	2	<7	<11	23	<13
RIV4.3	<2	13	351	<3	165	<3	51	11	45	9	24	12	3	<7	13	21	21
RIV4.4	<2	15	303	<3	57	<3	59	23	68	<7	35	18	2	<7	<11	13	14
SPM1.3	<2	14	312	<3	21	<3	43	15	47	7	35	12	2	10	<11	13	22

Table D3 (continued). XRF Data for wetland soils

	Mn (ppm)	Mo (ppm)	Nb (ppm)	Nd (ppm)	Ni (ppm)	Pb (ppm)	Rb (ppm)	Sb (ppm)	Sc (ppm)	Se (ppm)	Sm (ppm)	Sn (ppm)	Sr (ppm)	Ta (ppm)	Th (ppm)	Tl (ppm)	U (ppm)
JUR2.3	137	<1	9	21	17	9	64	<6	7	2	<9	<2	164	<6	11	9	4
JUR6.5	181	<1	11	27	31	7	99	<6	12	<1	<9	<2	100	<6	12	6	3
MUR3.1	375	<1	14	27	21	12	104	<6	10	1	14	<2	88	<6	15	8	5
MUR3.2	1761	<1	15	28	24	12	109	<6	13	1	<9	<2	157	<6	15	10	4
PA4.1	1002	<1	4	10	21	<2	34	<6	3	1	<9	<2	372	<6	6	7	6
PA4.2	1311	1	9	23	27	4	71	<6	6	1	<9	<2	362	<6	13	7	4
PA4.3	1043	1	8	20	26	3	66	<6	11	2	<9	<2	287	<6	10	10	2
PA4.4	252	1	13	31	37	16	111	<6	16	1	<9	<2	99	<6	14	10	5
PA4.5	196	1	13	30	33	12	112	<6	16	1	<9	<2	90	<6	13	8	4
RIV3.2	718	1	12	21	33	10	92	<6	10	1	9	<2	126	<6	15	7	5
RIV3.4	592	<1	11	20	34	11	90	<6	13	1	13	<2	114	<6	13	9	5
RIV3.5	442	<1	13	33	46	9	99	<6	17	1	<9	<2	104	<6	16	7	3
RIV4.2	2236	<1	7	18	20	<2	51	<6	6	2	<9	<2	396	<6	10	10	3
RIV4.3	528	<1	9	24	27	8	76	<6	10	2	<9	<2	127	<6	11	9	3
RIV4.4	514	<1	12	35	40	9	104	<6	14	1	<9	<2	115	<6	14	7	3
SPM1.3	132	<1	12	22	20	16	83	<6	10	1	<9	<2	81	<6	15	7	4

Table D4. XRF Data for metals V, Y, Yb, Zn and Zr

Soil Sample	**V** (ppm)	**Y** (ppm)	**Yb** (ppm)	**Zn** (ppm)	**Zr** (ppm)	Soil Sample	**V** (ppm)	**Y** (ppm)	**Yb** (ppm)	**Zn** (ppm)	**Zr** (ppm)	Soil Sample	**V** (ppm)	**Y** (ppm)	**Yb** (ppm)	**Zn** (ppm)	**Zr** (ppm)
WW3A 1.2	<5	2	10	<2	58	AT18.3	8	3	<8	<2	67	UKE5.3	103	30	<8	77	217
WW3A 2.1	<5	1	<8	<2	43	AT19.1	11	5	<8	2	269	JUR2.3	53	18	<8	37	193
WW3A 4.1	<5	1	<8	<2	21	AT19.2	41	6	<8	25	65	JUR6.5	106	22	<8	67	103
WW3A 4.2	7	1	<8	<2	26	AT19.3	15	3	<8	2	70	MUR3.1	80	31	<8	53	329
WW3A 4.5	8	4	<8	<2	50	AT20.1	99	29	<8	69	169	MUR3.2	92	31	<8	90	266
WW8A 2.1	55	16	<8	39	159	AT20.2	94	26	<8	63	181	PA4.1	38	8	<8	38	43
WW8A 2.2	57	8	<8	36	51	AT20.3	91	21	<8	66	138	PA4.2	76	18	<8	71	87
WW8A 2.3	74	29	<8	37	174	AA8.2	14	10	<8	6	180	PA4.3	74	15	<8	72	81
WW20A 1.1	44	14	<8	31	146	AA11.1	9	9	<8	9	317	PA4.4	123	25	<8	89	147
WW20A 1.2	55	19	<8	29	180	AA12.1	<5	8	<8	7	182	PA4.5	125	25	<8	81	128
WW20C 1.1	67	31	<8	35	232	AA12.2	6	6	<8	10	138	RIV3.2	91	27	<8	68	179
AT2.3	54	8	<8	21	93	AA13.2	44	11	<8	26	139	RIV3.4	93	27	<8	58	181
AT2.6	19	5	<8	<2	194	AA14.2	<5	4	<8	<2	252	RIV3.5	136	27	<8	56	130
AT4.1	5	3	<8	<2	70	AA15.1	6	1	<8	<2	63	RIV4.2	53	13	<8	35	92
AT6.1	12	2	<8	<2	55	AA29.5	17	11	<8	2	420	RIV4.3	71	23	<8	43	176
AT7.2	119	30	<8	79	127	AA29.6	<5	5	<8	<2	230	RIV4.4	128	27	<8	55	139
AT9.2	118	26	<8	82	135	AA30.1	8	7	<8	2	378	SPM1.3	83	26	<8	48	280
AT10.1	88	27	<8	63	203	AA30.2	5	5	<8	<2	225						
AT12.1	125	27	<8	79	140	UKE1.1	80	26	<8	34	306						
AT16.1	10	3	<8	<2	268	UKE1.2	82	31	<8	42	330						
AT16.2	5	1	<8	<2	87	UKE2.1	67	18	<8	27	236						
AT16.3	6	2	<8	<2	55	UKE2.2	87	32	<8	42	303						
AT16.4	33	6	<8	9	67	UKE3.1	64	65	<8	147	68						
AT17.1	15	5	<8	<2	471	UKE3.2	86	52	<8	159	135						
AT17.2	10	2	<8	4	125	UKE3.3	82	23	<8	61	241						
AT17.3	102	24	<8	66	174	UKE3.4	102	25	<8	82	171						
AT17.4	80	20	<8	48	149	UKE3.5	21	7	<8	7	80						
AT18.1	<5	2	<8	<2	29	UKE5.1	64	27	<8	31	211						
AT18.2	11	4	<8	<2	311	UKE5.2	77	20	<8	53	243						

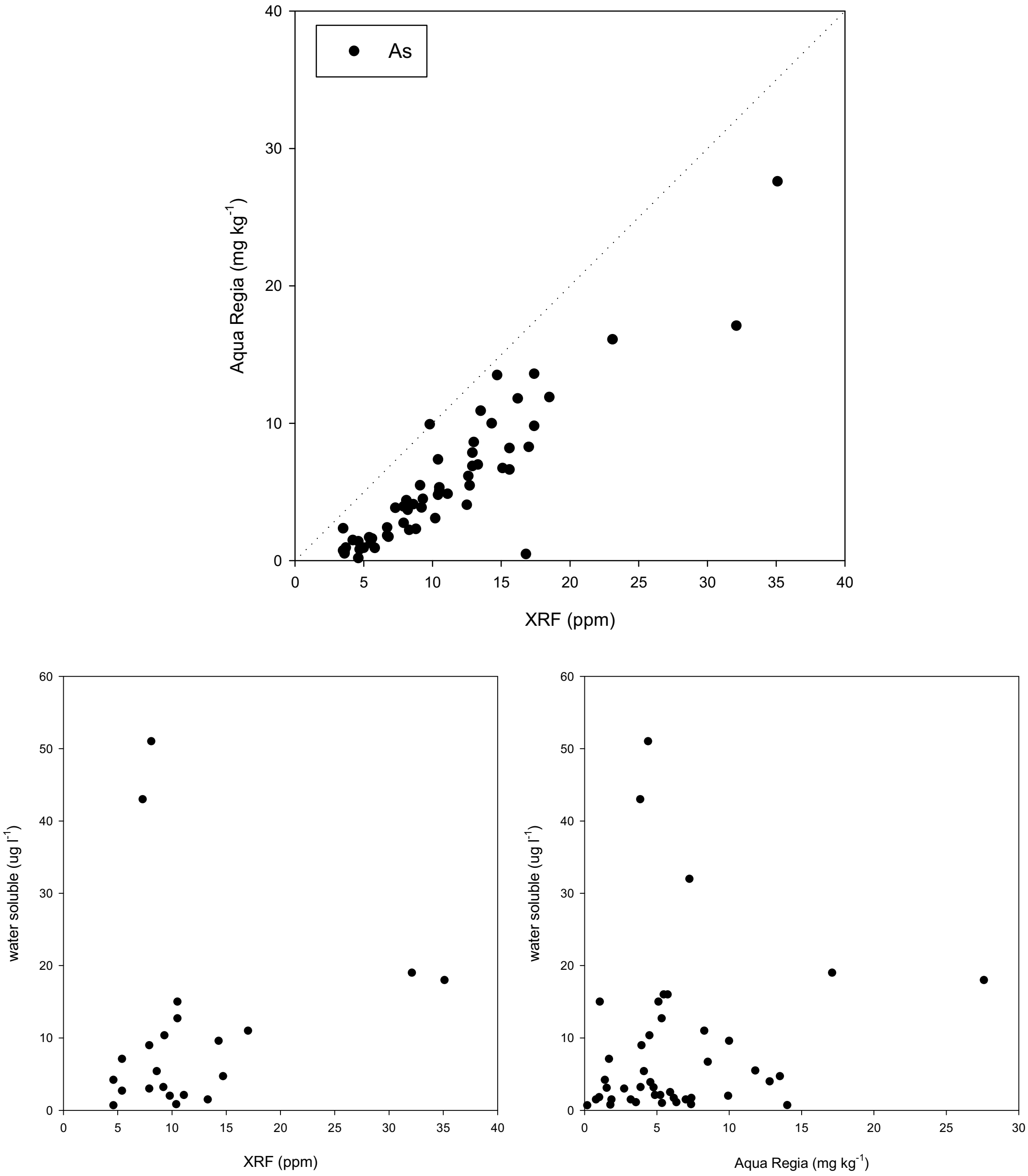


Figure D1. Relationship between total metals analyses by acid digestion and XRF (Arsenic).

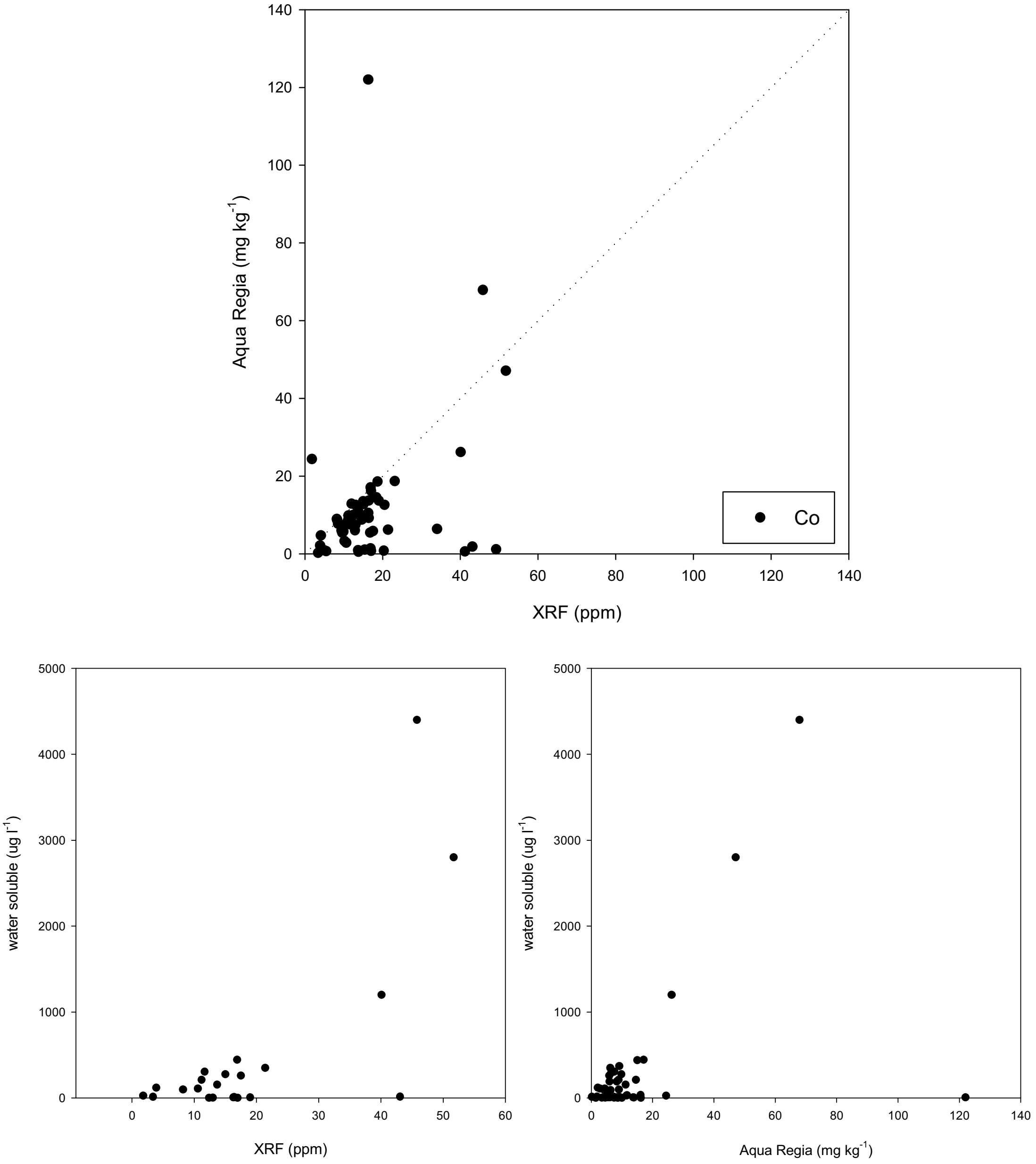


Figure D2. Relationship between total metals analyses by acid digestion and XRF (Cobalt).

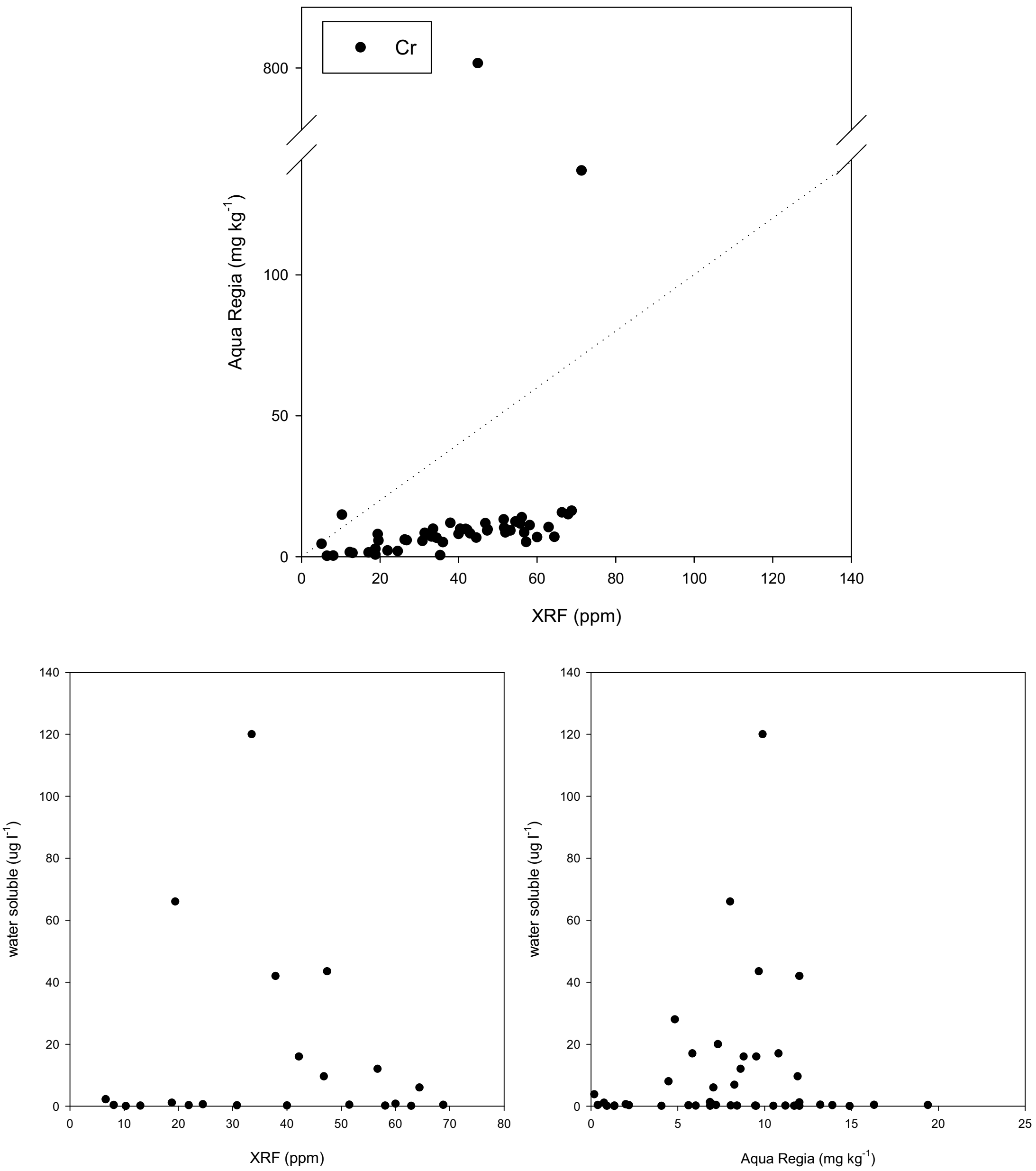


Figure D3. Relationship between total metals analyses by acid digestion and XRF (Chromium)..

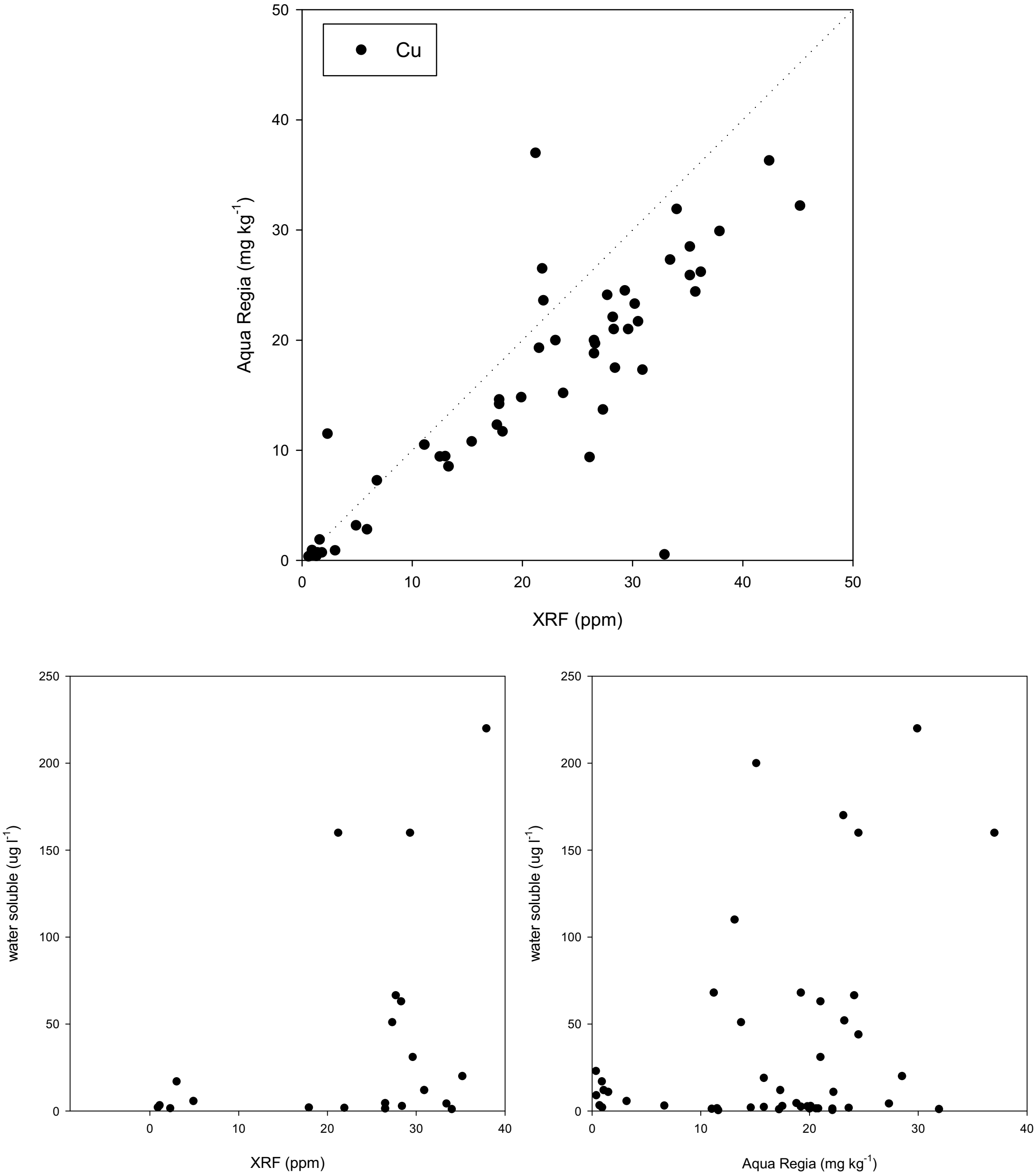


Figure D4. Relationship between total metals analyses by acid digestion and XRF (Copper).

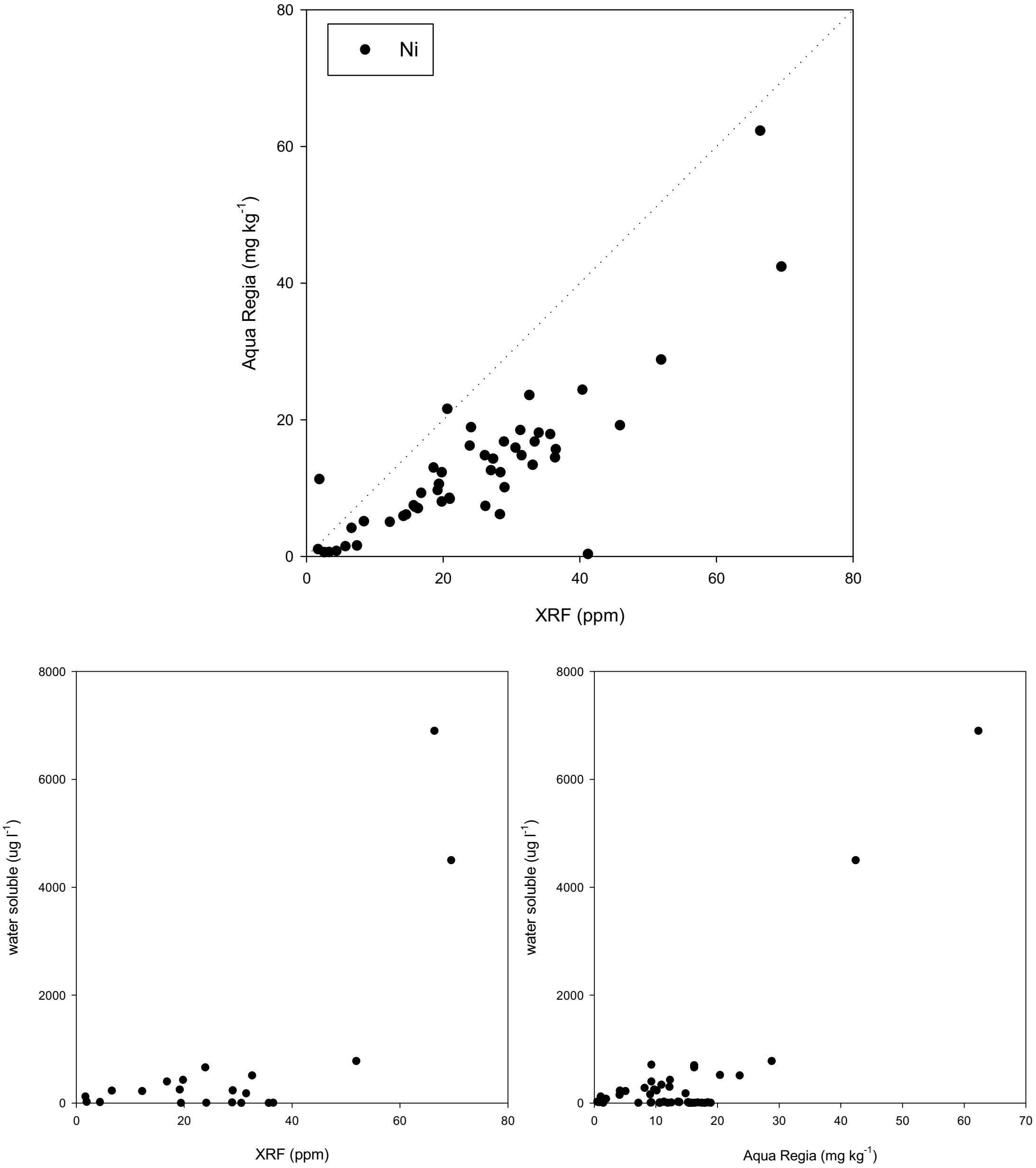


Figure D5. Relationship between total metals analyses by acid digestion and XRF (Nickel).

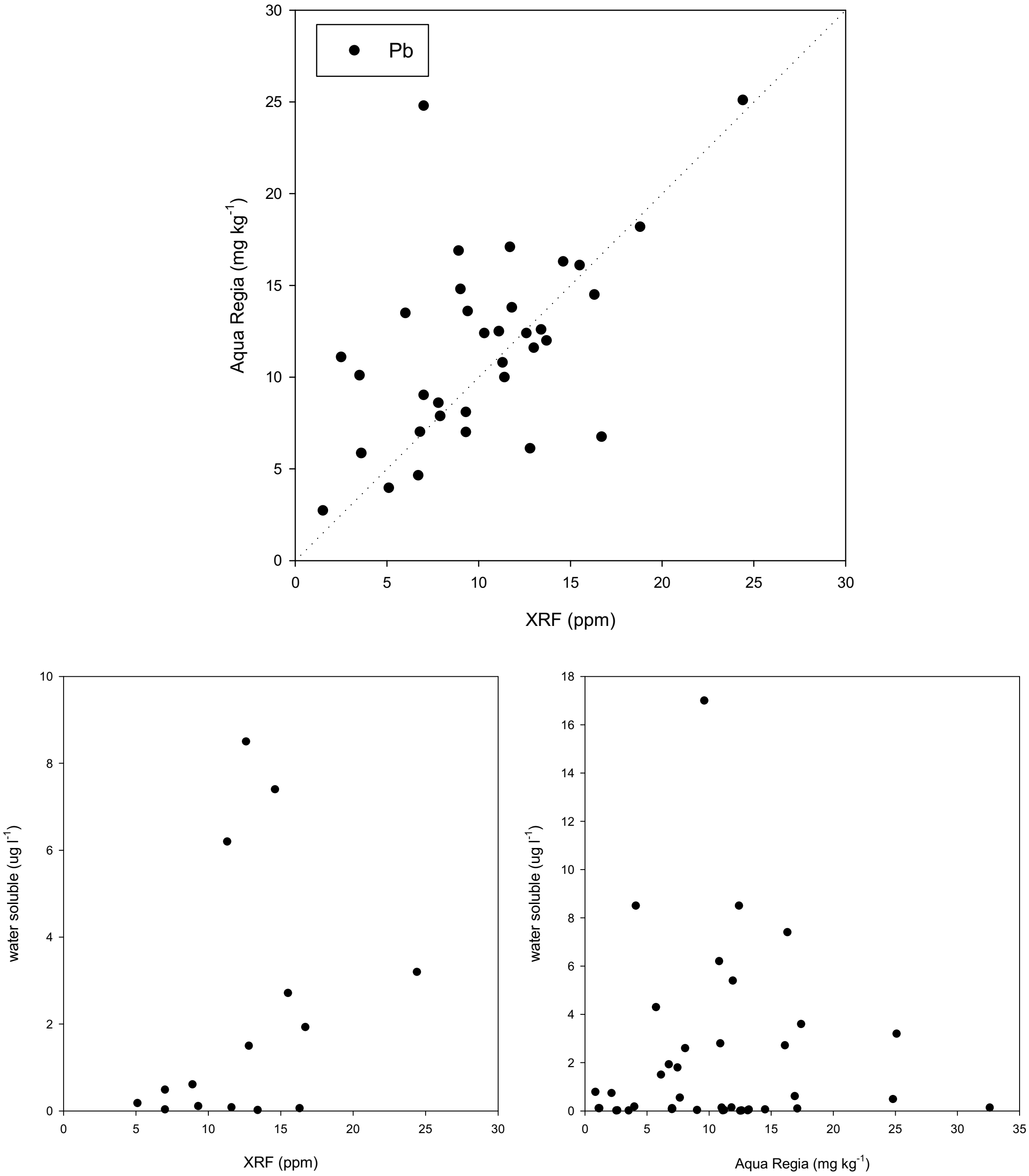


Figure D6. Relationship between total metals analyses by acid digestion and XRF (Lead).

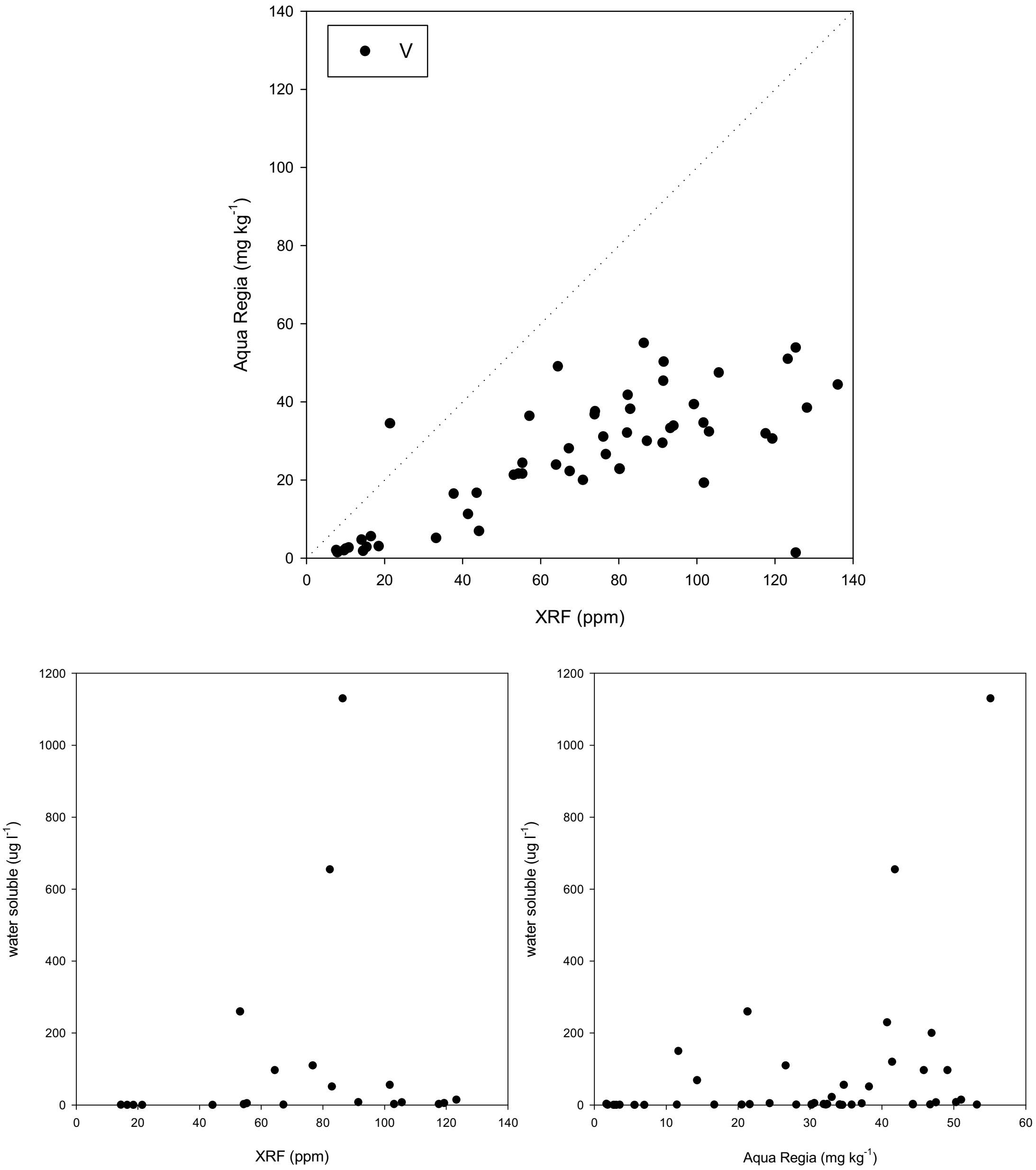


Figure D7. Relationship between total metals analyses by acid digestion and XRF (Vanadium).

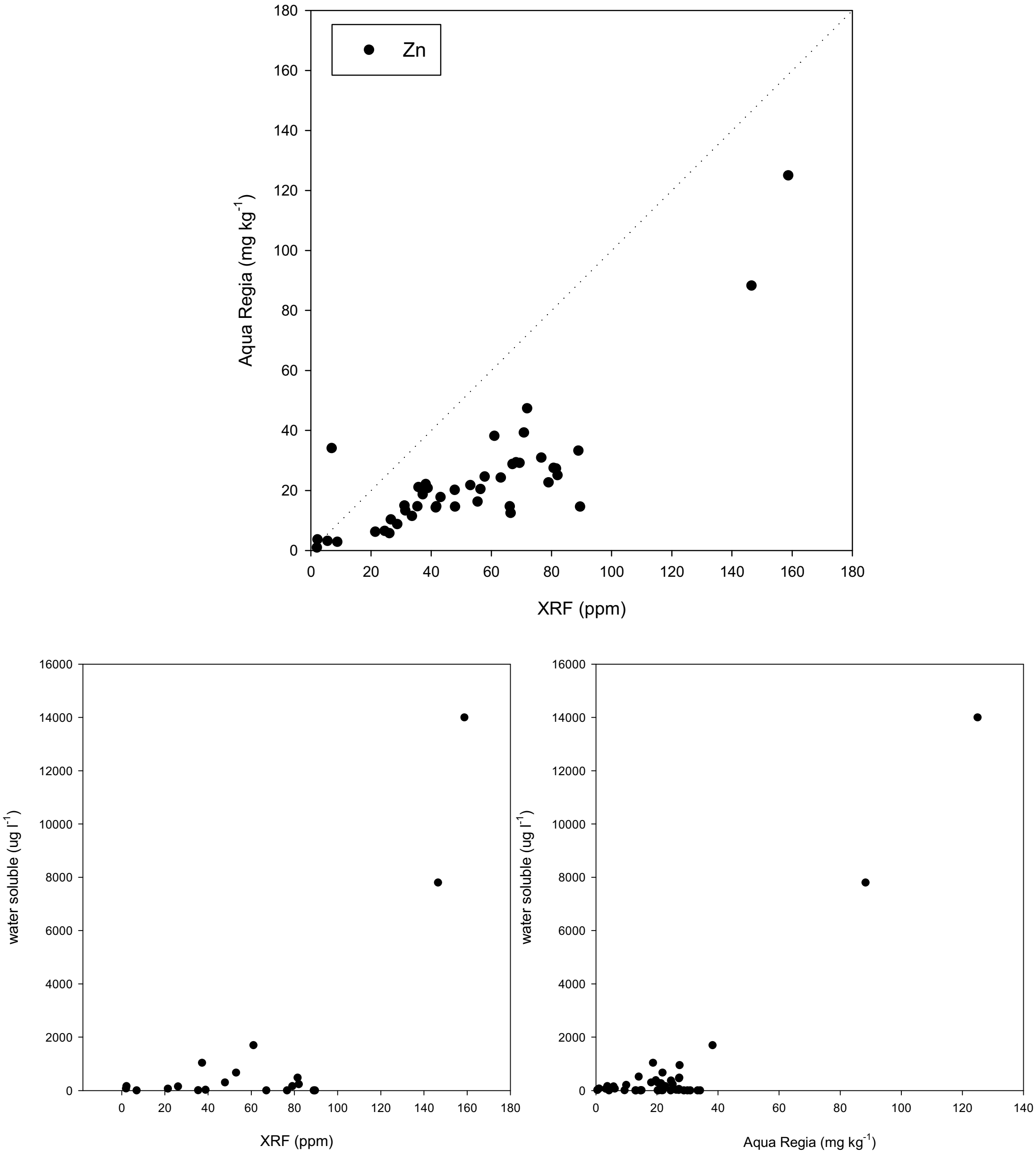


Figure D8. Relationship between total metals analyses by acid digestion and XRF (Zinc).

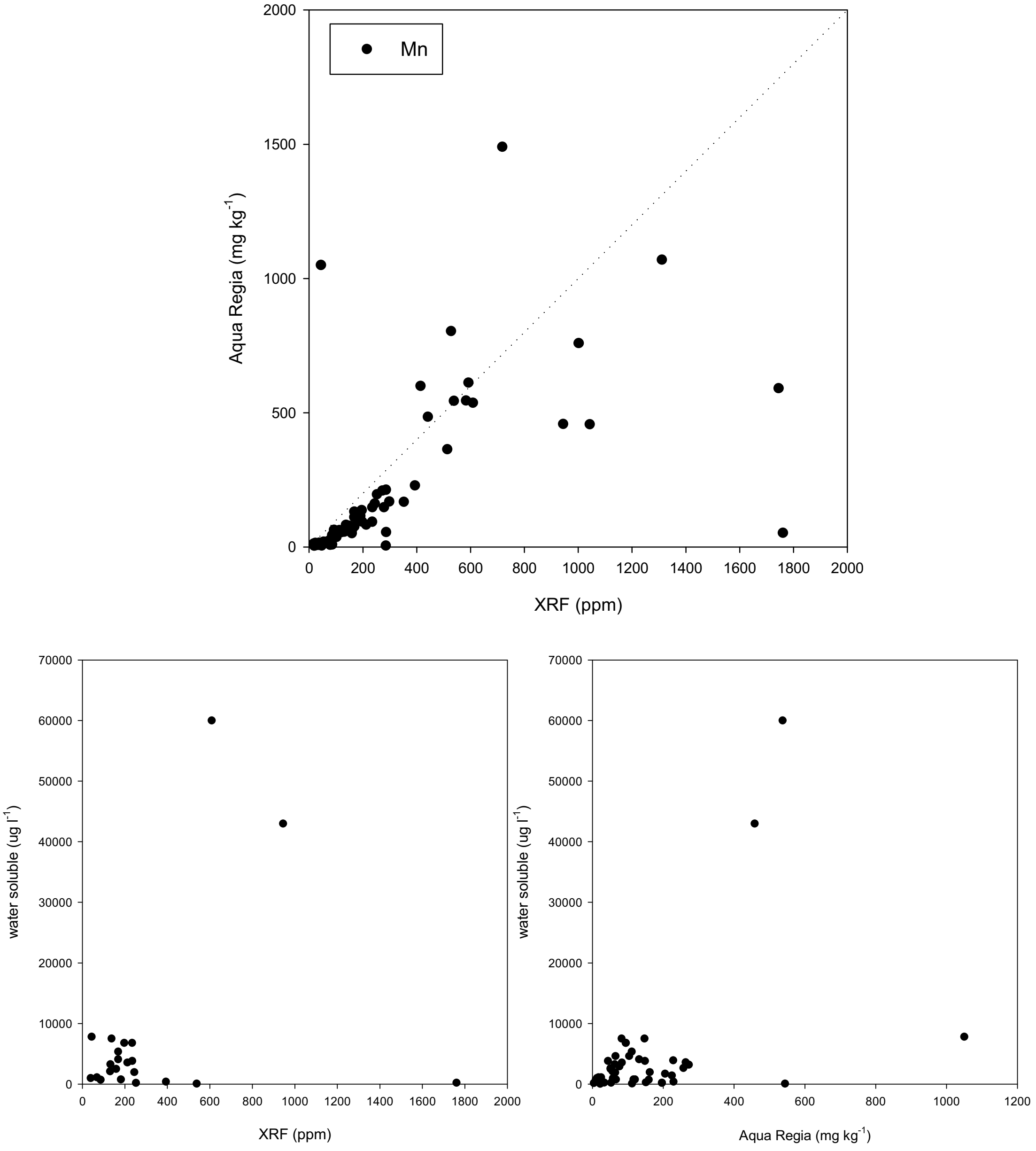


Figure D9. Relationship between total metals analyses by acid digestion and XRF (Manganese).

APPENDIX E: CORRELATIONS BETWEEN SOLID PHASE AND WATER SOLUBLE TRACE ELEMENT CONCENTRATIONS.

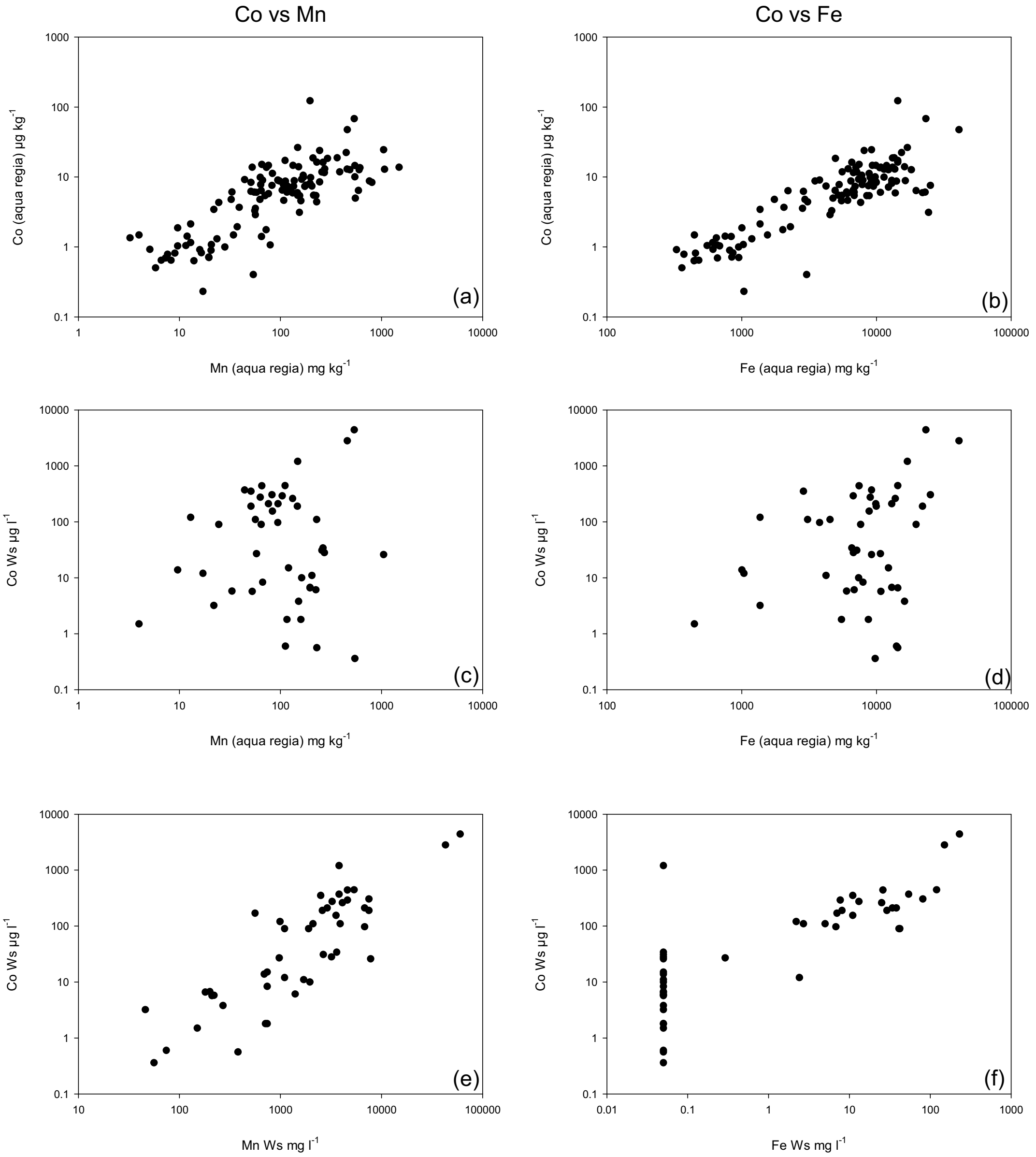


Figure E1. Correlations between solid phase and water soluble trace element concentrations (Cobalt).

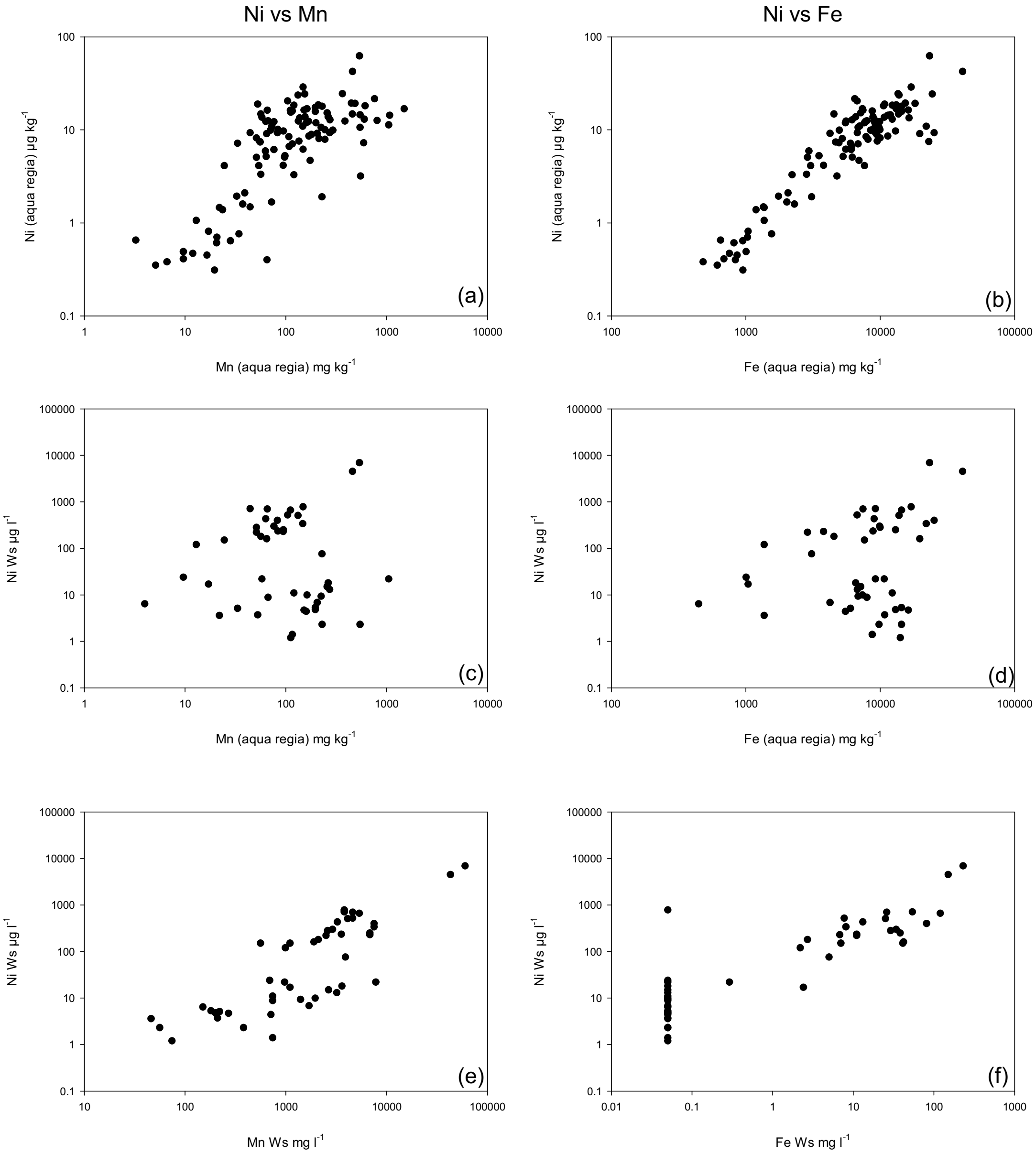


Figure E2. Correlations between solid phase and water soluble trace element concentrations (Nickel).

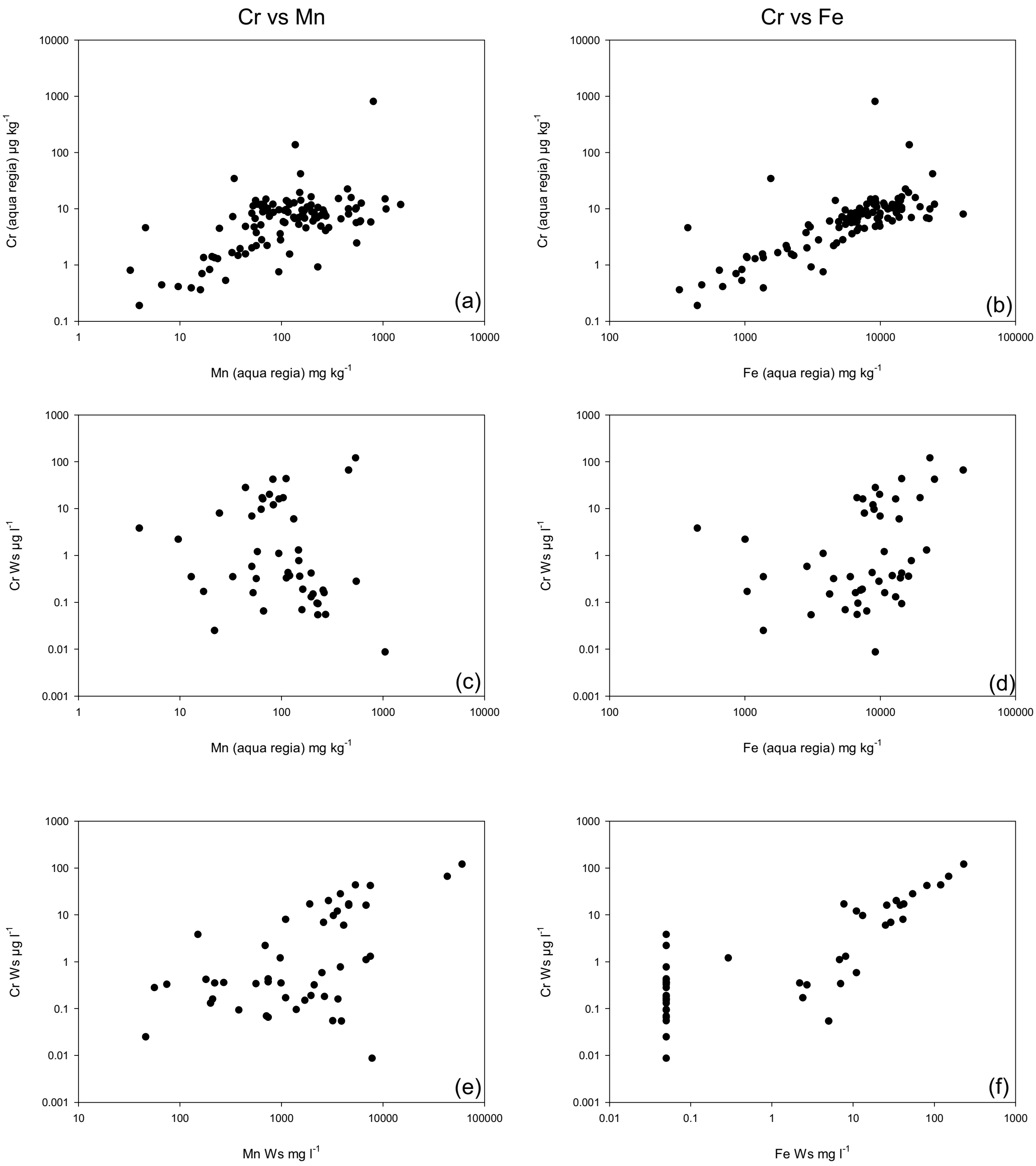


Figure E3. Correlations between solid phase and water soluble trace element concentrations (Chromium).

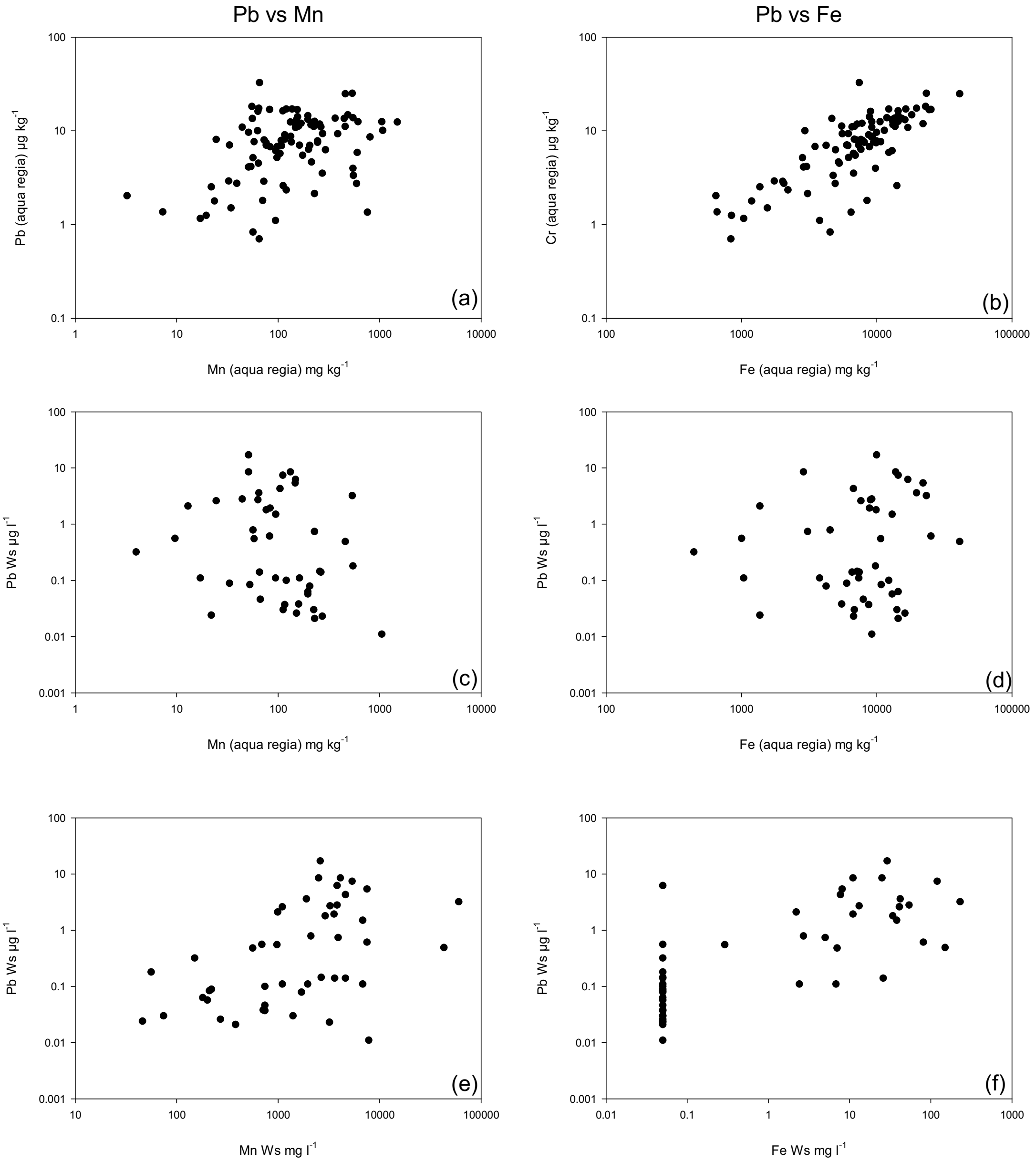


Figure E4. Correlations between solid phase and water soluble trace element concentrations (Lead).

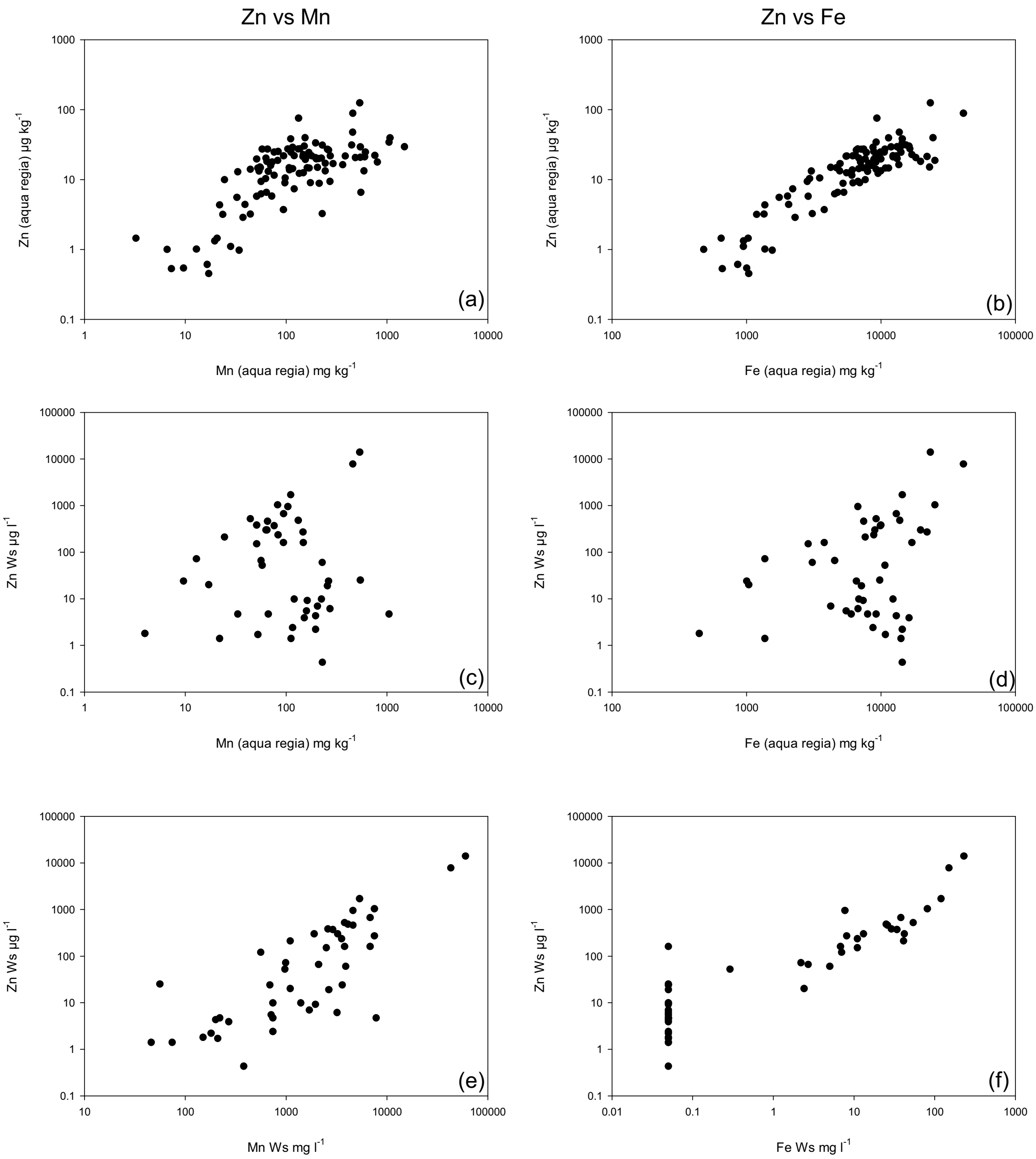


Figure E5. Correlations between solid phase and water soluble trace element concentrations (Zinc).

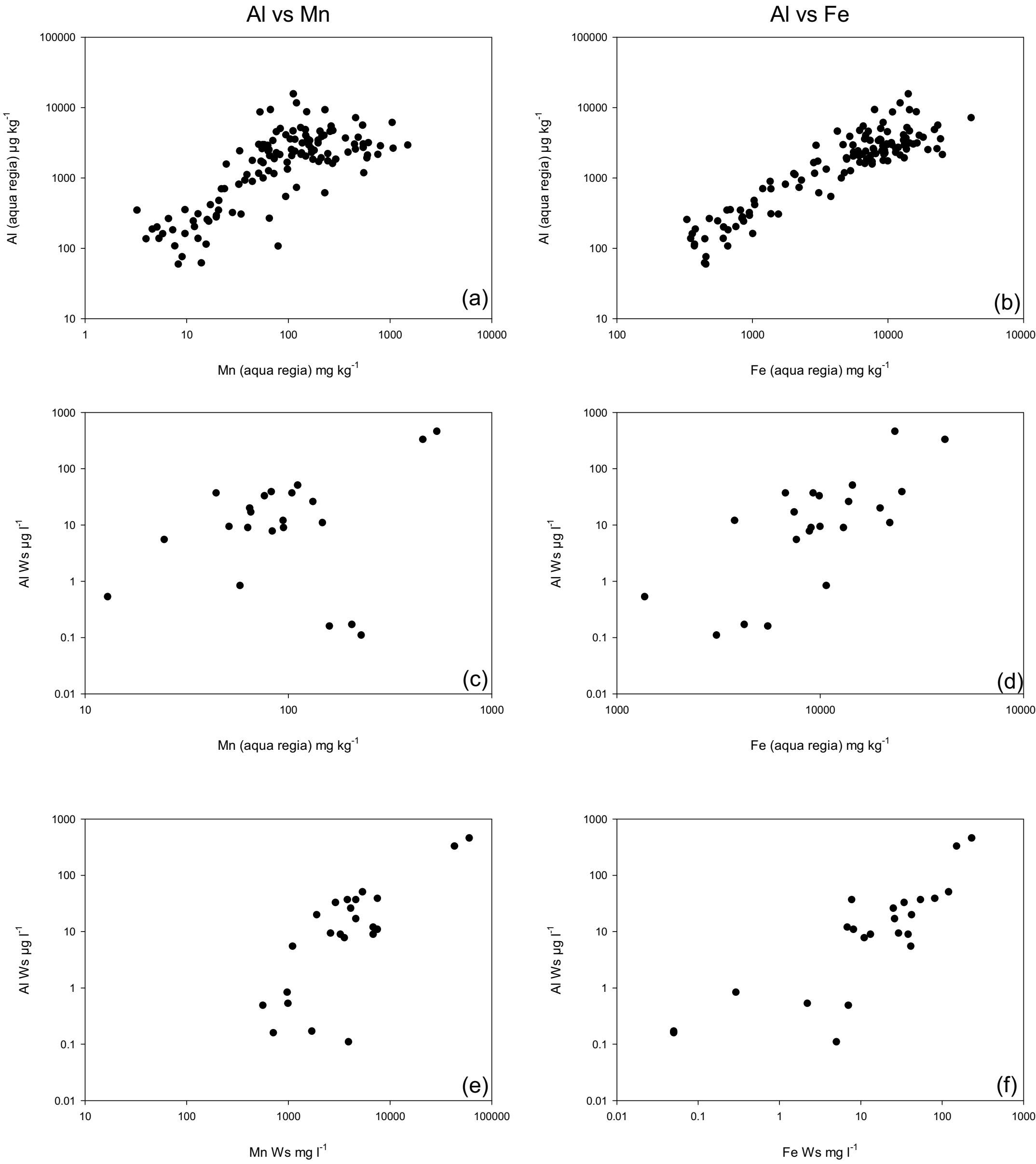


Figure E6. Correlations between solid phase and water soluble trace element concentrations (Aluminium)

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