APPENDIX B3 – WETLAND DESCRIPTIONS FOR ASSESSMENT OF ACID SULFATE SOIL MATERIALS IN THE LOCK 1 TO WELLINGTON REGION OF THE MURRAY-DARLING BASIN

CONTENTS

41 TEAL FLAT (UPSTREAM) WETLAND (WETLAND ID. 12005)

41.1 LOCATION AND SETTING DESCRIPTION

Teal Flat (Upstream) wetland (Wetland ID. 12005) is situated on the eastern side of the River Murray. The wetland is geomorphically categorised as a Murray Gorge basin (Pressey 1986) and is formed on the inner side of the river bend, with a total surface area of 82 hectares. It is bounded to the east by a hill slope and to the west there is a floodplain that separates the wetland from the river. There are two narrow water connection channels one at the down river end and the other at the up river end of the wetland. At the time when the soil survey was conducted in September 2008, the wetland was dry. The wetland was dominated by bare cracking surface, and in some areas on the hill side the cracks were filled with sand moving across the wetland. Fringing the bare area at a slightly higher elevation was *Phragmites australis* (Common Reed) vegetation, and on the floodplain there were trees. Three sites were sampled and their locations are shown in Figure 41-1.

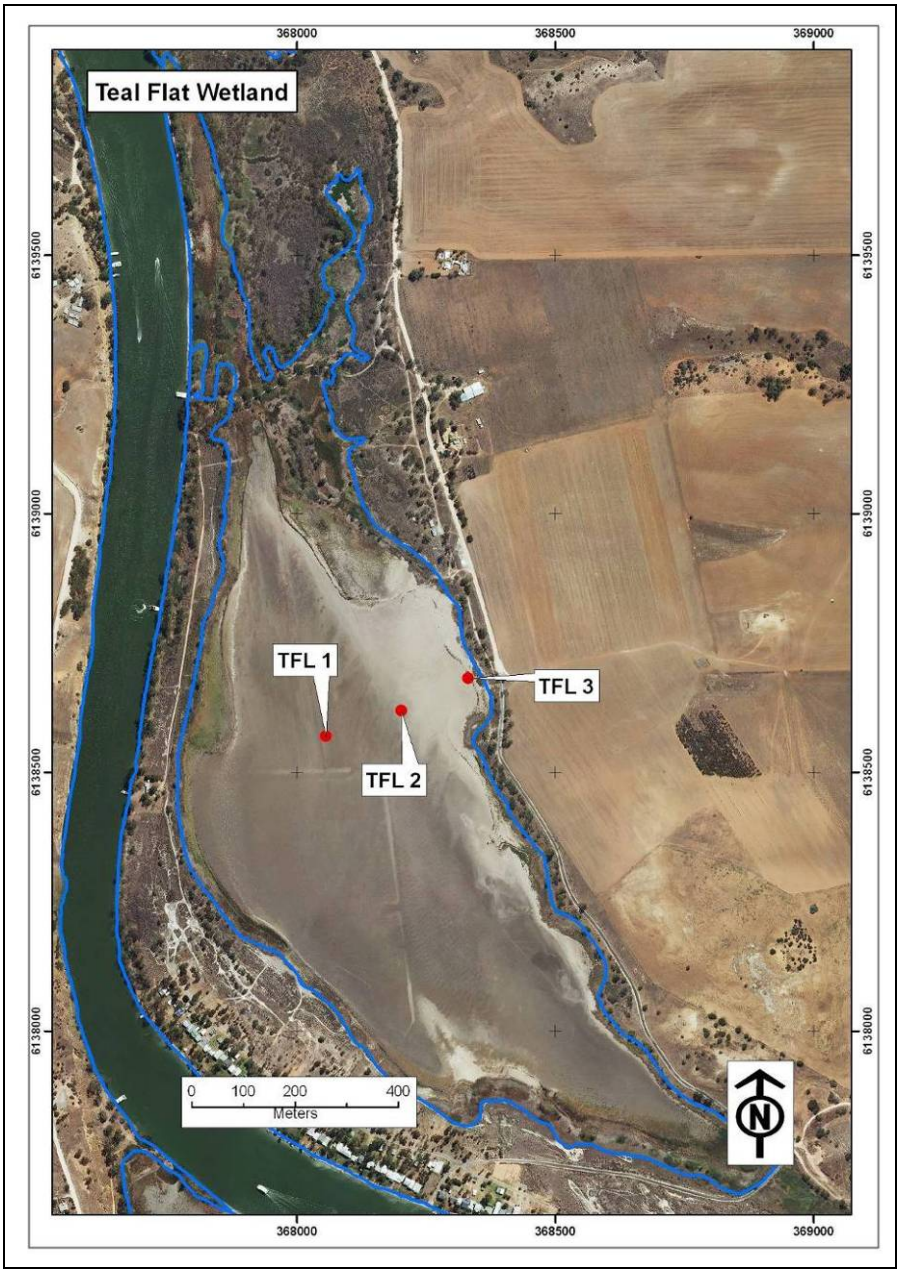

Figure 41-1. Teal Flat (Upstream) Wetland and sample site locations.

41.2 SOIL PROFILE DESCRIPTION AND DISTRIBUTION

Three sites were described and sampled. The acid sulfate soil subtype class and general location description are presented in Table 41-1. The sites were located to form a cross-section through the wetland, from the low main wetland area (TFL1), to the mid area where sand was encroaching (TFL2) on the higher wetland margin (TFL3). The site and profile descriptions are presented in Table 41-2 and Table 41-3.

Site TFL1 (Figure 41-2) occurred in the bare cracking clay surface area. The soil consisted of dark grey to black, very firm, clay that was too rigid to dig below 50 centimetres.

Site TFL2 (Figure 41-3) occurred in the bare cracking clay surface area where the cracks had been filled with sand to form a sealed surface. The soil consisted of dark grey, firm, clay that was too rigid to dig below 70 centimetres.

Site TFL3 (Figure 41-4) occurred near the edge of the wetland where sand was encroaching over the surface and *Phragmites australis* (Common Reed) were growing, the surface was bare with loose sand. The soil consisted of pale brown loose sand over black very firm clay.

Table 41-1. Soil identification, subtype and general location description for Teal Flat (Upstream) Wetland.

Site ID	Easting m Zone 54H	Northing m Zone 54H	Acid sulfate soil subtype class	General location description
TFL1	368056	6138570	Other soil (Cracking clay)	Low elevation, cracking clay soil areas
TFL2	368203	6138619	Other soil (Cracking clay)	Low elevation, filled cracks of cracking clay soil areas
TFL3	368332	6138682	Other soil (Sand)	High elevation, on margins of encroaching sand area

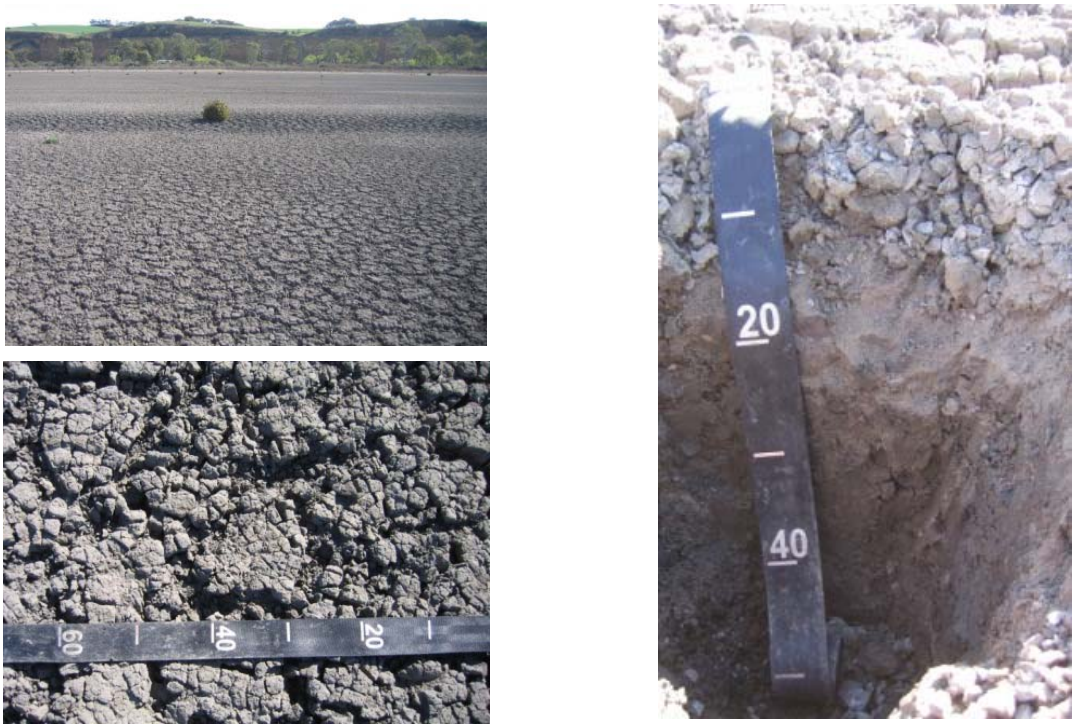

Figure 41-2. Photographs of site TFL1, showing the landscape across the wetland to the river in the background and the cracking clay surface that was breaking down into aggregates, and the soil profile of crumbling surface aggregates over a very firm clay.

Figure 41-3. Photographs of site TFL2, showing the soil cracks filled by windblown sand, and the soil profile with the sand filling cracks between the firm clay columns.

Figure 41-4. Photographs of site TFL3, showing the landscape along the wetland margin with sand encroaching onto the wetland surface, and the soil profile of loose sand over very firm clay.

41.3 LABORATORY DATA ASSESSMENT

Soil pH testing (pH_W, pH_{OX}, pH_{INC})

The pH data are provided in Table 41-4 and pH profiles are presented in Figure 41-5.

The pH_W data did not identify samples as sulfuric materials with a pH_W <4.

The pH_{INC} data for the subsurface sample of profile TFL1 identified that on incubation it declined below the critical value of pH<4. Samples that age to pH_{INC}<4 indicate that these soils potentially would form sulfuric material as a result of sulfide oxidation.

The pH_{OX} for the surface layer of profile TFL2 identified a sample below the critical value of pH_{OX} <2.5, the threshold value normally used to indicate a high likelihood of sulfuric material forming.

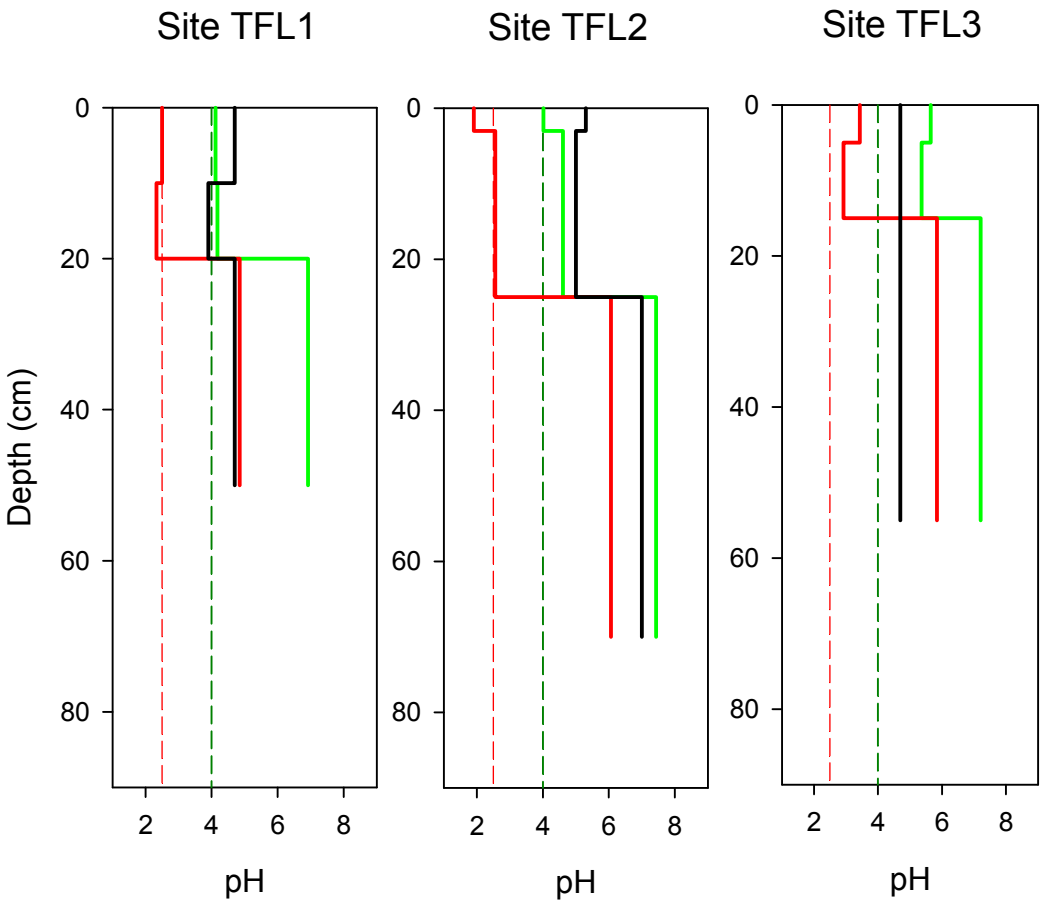

Figure 41-5. Depth profiles of soil pH for Teal Flat (Upstream) Wetland, showing soil pH (pH_W as green line), peroxide treated pH (pH_{OX} as red line) and ageing pH (pH_{INC} after 28 weeks as black line). Critical pH_W and pH_{INC} value of 4 (black dashed line) and critical pH_{OX} value of 2.5 (red dashed line).

Acid Base Accounting

The acid base accounting data is provided in Table 41-4 and summarised in Figure 41-6.

Chromium reducible sulfur values ranged from below the limit of detection to 0.02 $\%S_{CR}$. Sulfidic materials were detected in layers of profiles TFL2 and TFL3, and values were generally at or below detection limits for all sampled layers.

Titratable actual acidity values ranged from 0 to 35.39 mole H^+/tonne.

Analysis of retained acidity was not conducted on any of the samples, however retained acidity may be present in the surface layers of profiles TFL1, TFL2 and probably profile TFL3 that were below the critical value of pH_{KCl} <4.5.

Acid neutralising capacity values ranged from 0 to 0.86 $\%CaCO_3$, and were measured only in the subsoil layers of profile TFL2, and not measured in profiles TFL1 and TFL3.

Net acidity values ranged from -115 to 35 mole H^+/tonne. Low or moderate net acidity values occurred in layers for all profiles, and negative values occurred in the subsoil layers of profile TFL2.

Water Soluble Sulfate

Water soluble sulfate data values shown in Table 41-4 identified that surface layers were above the trigger value of 100 mg/kg SO_4.

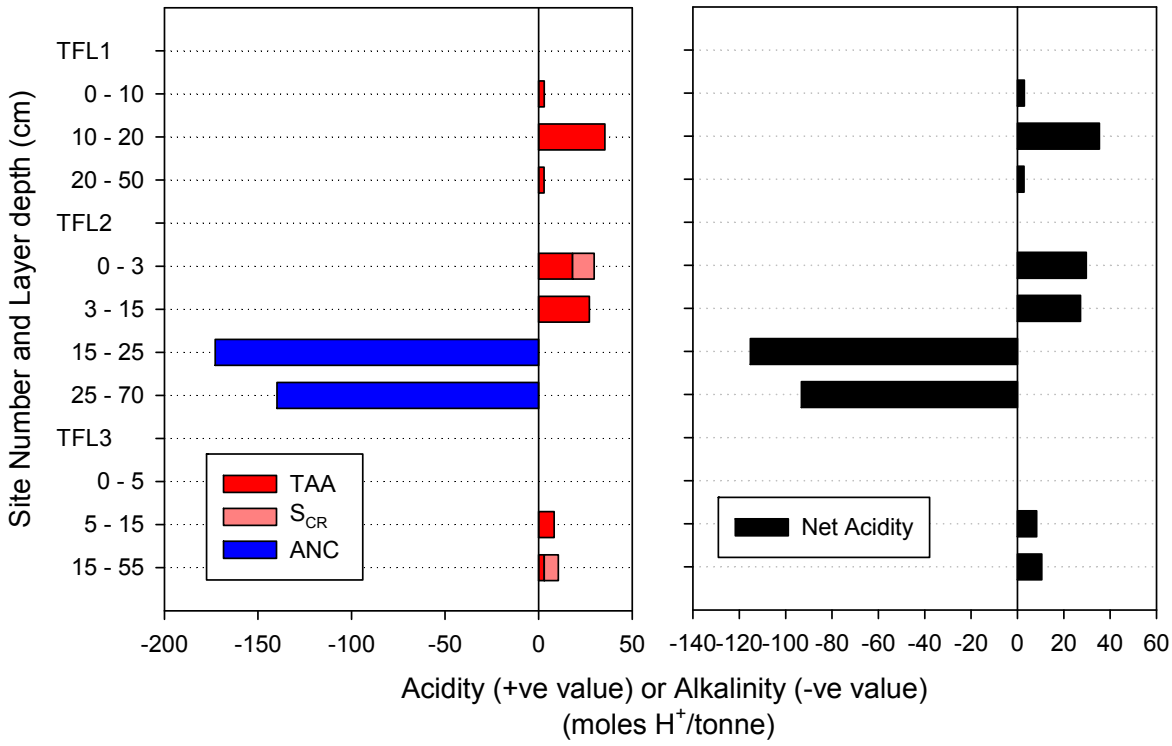

Figure 41-6. Acid base accounting depth profiles for Teal Flat (Upstream) Wetland. Left side shows the components: titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} -pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.

41.4 DISCUSSION

Acid sulfate soil materials at Teal Flat (Upstream) Wetland were identified as hyposulfidic that occurred in a subsoil layer of TFL3 and in the thin (3cm) surface soil layer of TFL2.. All the remaining layers were generally characterised as Other Acidic Soils because pH values were <5.0.

The soils throughout the main wetland area were cracking clay soils. On the hill-side side of the wetland these soil cracks have been filled with windblown sand to form a sealed surface, and at higher elevation these soils have been covered by encroaching sand.

The potential hazards posed by acid sulfate soil materials at Teal Flat (Upstream) Wetland are:

- Acidification hazard: The data identified low or moderate net acidity values, and pH data identified potential acidification due to oxidation for a few samples. There is a medium level of concern.
- De-oxygenation hazard: The water soluble sulfate data indicated a potential for monosulfidic materials to form in the surface layers of soils, monosulfidic material was not observed. There is a high level of concern.
- Metal mobilisation hazard: The medium acidification hazard indicates that soil acidification potential may increase the solubility of metals. There is a medium level of concern.

Summary of key findings for Teal Flat (Upstream) Wetland:

Soil materials:	The soils were cracking clays with sand encroaching and in-filling the soil cracks for areas near the hill slope margin side. There were isolated areas where the soil surface was hyposulfidic and the remaining soils were characterised as acidic.
Acid sulfate soil identification:	• Cracking Clay Soil – that occurred throughout the wetland. Dominant (>50%) in extent • Other soil (sandy) – that occurred on margins where sand was encroaching. Isolated (<10%) in extent.
Hazard assessment	• Acidification hazard - medium level of concern • De-oxygenation hazard – high level of concern • Metal mobilisation – medium level of concern

Table 41-2. Site data for Teal Flat (Upstream) Wetland.

Site Number	Sampled Date	Easting m Zone 54H	Northing m Zone 54H	Soil Classification	Water depth (+ve) Water table (-ve)	Surface Condition	Earth Cover (Vegetation)	Location Notes
TFL1	09-Sep-08	368056	6138570	Other soil (Cracking clay)	not reached	cracking	Bare	low,
TFL2	09-Sep-08	368203	6138619	Other soil (Cracking clay)	not reached	sealed	Bare	mid, on sandy surface,
TFL3	09-Sep-08	368332	6138682	Other soil (Sand)	not reached	loose aggregates	Bare	high, fringe of wetland,

Table 41-3. Soil description data for Teal Flat (Upstream) Wetland.

Site and Sample Number	Depth Upper (cm)	Depth Lower (cm)	Observation Method (kind)	Soil Colour (Munsell notation)	Texture (class)	Soil Water Status	Mottles Quantity (%)	Mottles Colour	Mottles Location	Structure Type (category)	Consistence (category)	Comments
TFL1.1	0	10	soil pit	2.5Y 5/2	clay	dry	5	10YR 8/1	on ped faces	angular blocky	rigid	white salts on surface
TFL1.2	10	20	soil pit	2.5Y 3/1	clay	moist	5	10YR 6/8	on ped faces	subangular blocky	very firm	
TFL1.3	20	50	soil pit	2.5Y 3/1	clay	moist	0			massive	very firm	too hard to dig below this layer
TFL2.1	0	3	soil pit	2.5Y 4/2	sandy loam	dry	0			platy	soft	
TFL2.2	3	15	soil pit	2.5Y 3/1	sandy clay loam	moist	0			columnar	firm	sand in cracks between columns
TFL2.3	15	25	soil pit	2.5Y 3/1	clay	moist	5	10YR 6/8	on ped faces	massive	firm	
TFL2.4	25	70	soil pit	2.5Y 3/1	clay	moist	0			massive	friable	too hard to dig below this layer
TFL3.1	0	5	soil pit	2.5Y 4/2	sand	dry	0			single grain	loose	
TFL3.2	5	15	soil pit	2.5Y 2.5/1	clay loam	moist	5	10YR 6/8	on ped faces	massive	firm	
TFL3.3	15	55	soil pit	2.5Y 2.5/1	clay	moist	0			massive	very firm	

Table 41-4. Laboratory data for acid sulfate soil assessment of Teal Flat (Upstream) Wetland.

(red printed values indicates data results of concern)

Site and Layer ID.	Depth Range (cm)	Soil Texture	EC (µS/cm)	pH water	pH peroxide	pH incubation	Sulfate (mg SO_4/kg)	pH KCl	Titratable Actual Acidity (mole H^+/ tonne)	Chromium Reducible Sulfur (%S_{CR})	Acid Neutralising Capacity (%$CaCO_3$)	Net Acidity (mole H^+/ tonne)	Acid Sulfate Soil Material Classification
TFL1.1	0 - 10	Fine	-	4.12	2.50	4.70	121	5.85	3.03	< 0.01	0.00	3	other acidic
TFL1.2	10 - 20	Fine	-	4.18	2.33	3.90	393	4.08	35.39	< 0.01	0.00	35	other acidic
TFL1.3	20 - 50	Fine	-	6.92	4.85	4.70	55	6.29	2.93	< 0.01	0.00	3	other acidic
TFL2.1	0 - 3	Medium	-	4.02	1.91	5.30	342	4.35	18.17	0.02	0.00	30	hyposulfidic (S_{CR}<0.10%)
TFL2.2	3 - 15	Medium	-	4.61	2.56	5.00	143	4.08	27.20	< 0.01	0.00	27	other acidic
TFL2.3	15 - 25	Fine	-	-	-	-	59	6.97	-	< 0.01	0.86	-115	other acidic
TFL2.4	25 - 70	Fine	-	7.43	6.06	7.00	87	6.91	-	< 0.01	0.70	-93	other soil material
TFL3.1	0 - 5	Coarse	-	5.65	3.43	4.70	-	-	-	< 0.01	0.00	0	other acidic
TFL3.2	5 - 15	Medium	-	5.36	2.92	4.70	172	5.37	8.34	< 0.01	0.00	8	other acidic
TFL3.3	15 - 55	Fine	-	7.21	5.84	4.70	109	6.10	3.04	0.01	0.00	11	hyposulfidic (S_{CR}<0.10%)

42 COOLCHA LAGOON WETLAND (WETLAND ID. 12004)

42.1 LOCATION AND SETTING DESCRIPTION

Coolcha Lagoon Wetland (Wetland ID. 12004) is situated on the southern side of the River Murray. The wetland is geomorphically categorised as a Murray Gorge basin (Pressey 1986) and is irregular in shape, over 3 kilometres long and approximately 500 metres at the widest point, with a total surface area of 128 hectares. It is bounded to the south by a hill slope and to the north by floodplain. There is fragmentation of the down river connection with the river channel due to raised river bank around trees such as *Eucalyptus camaldulensis* (River Red Gum) and Salix Spp. (willow trees). There are a total of six wide water connection channels with the river. At the time when the soil survey was conducted in September 2008, the wetland was dry. The area was dominated by bare cracking clay soil surfaces, surrounding at slightly higher elevations where sandy surfaces with *Typha latifolia* (Bulrush) and *Phragmites australis* (Common Reed) vegetation, and trees on the floodplain. Six sites were sampled and their locations are shown in Figure 42-1.

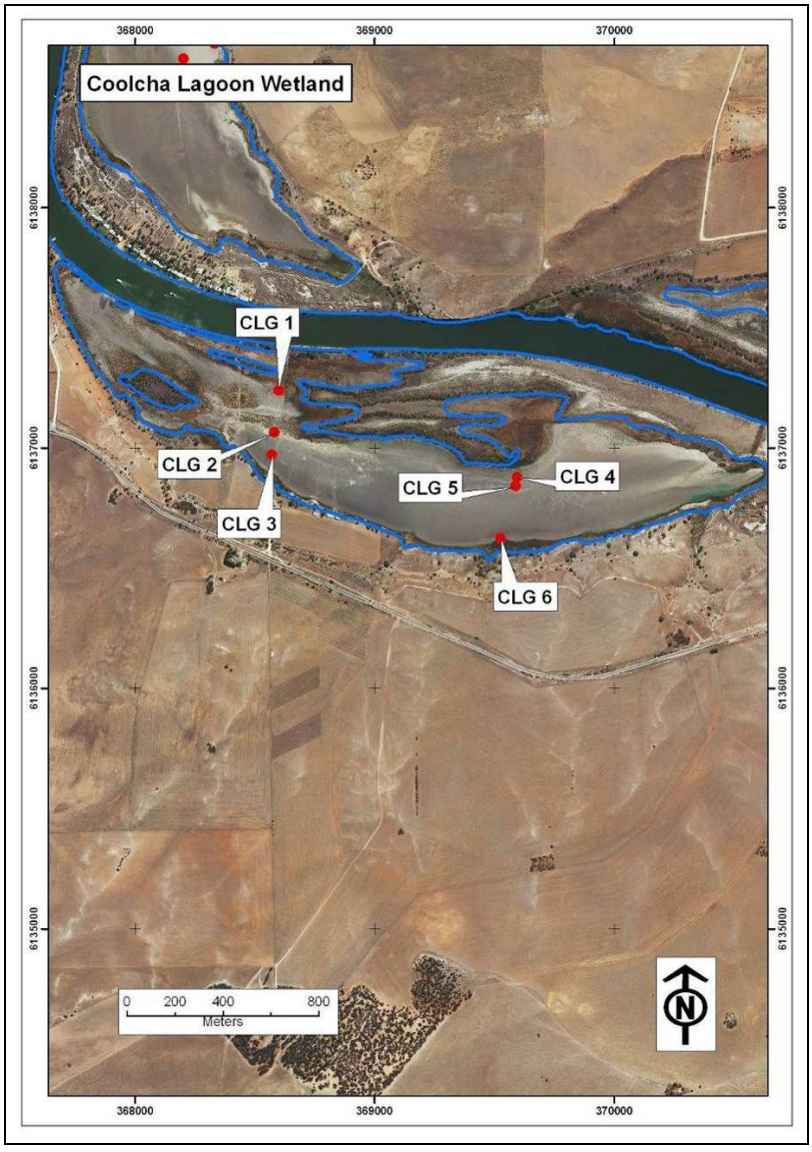

Figure 42-1. Coolcha Lagoon Wetland and sample site locations.

42.2 SOIL PROFILE DESCRIPTION AND DISTRIBUTION

Six sites were described and sampled. The acid sulfate soil subtype class and general location description are presented in Table 42-1. Sites were located to form two cross-sections through the wetland. The first transect characterised the high elevation position near the river (CLG1) to mid elevation (CLG2) and then the main wetland area (CLG3). The second transect characterised the main features of the wider area of the wetland from high elevation near the river (CLG4), to the dominant wetland area (CLG5) to the high elevation margin area near the hill slope (CLG6). The site and soil profile descriptions are presented in Table 42-2 and Table 42-3.

Site CLG1 (Figure 42-2) occurred on the river side of the wetland in the cracking clay area that had some plant growth that was at a high elevation grading up to the river bank. The soil consisted of black, slightly rigid clay over clay too hard to dig.

Site CLG2 (Figure 42-3) occurred mid elevation where there was a loose sandy surface with some plants growing. The soil consisted of a black, very firm, clay.

Site CLG3 (Figure 42-4) occurred in a bare area where the columns from the cracking clay had broken down into aggregates. The soil consisted of black, very firm, clay.

Site CLG4 (Figure 42-5) occurred on the river side at a high elevation where salt bush was growing on a crusted soil surface. The soil consisted of a black, firm clay.

Site CLG5 (Figure 42-6) occurred in the lowest area of the wetland where the surface was bare with loose aggregates from the broken columns formed when the surface cracked open. The soil consisted of a black, very firm clay.

Site CLG6 (Figure 42-7) occurred on the hill side of the wetland in the *Phragmites australis* (Common Reed) that grew on the margins of the wetland. The soil consisted of a dark grey, firm peaty clay, over a dark grey, very firm clay.

Table 42-1. Soil identification, subtype and general location description of sites for Coolcha Lagoon Wetland.

Site ID	Easting m Zone 54H	Northing m Zone 54H	Acid sulfate soil subtype class	General location description
CLG1	368600	6137239	Other soil (cracking clay)	High elevation, cracking clay soil area in the down river section
CLG2	368582	6137064	Other soil (sand over clay)	Mid elevation, sandy surface area
CLG3	368572	6136972	Hyposulfidic cracking clay soil	Low elevation, cracking clay soil area in the down river section
CLG4	369596	6136878	Sulfuric soil	High elevation, near flood plain areas
CLG5	369589	6136841	Sulfuric cracking clay soil	Low to mid elevation, cracking clay bare surface area in the up-river section
CLG6	369526	6136625	Sulfuric soil	High elevation, along margin areas where *Phragmites australis* (Common Reed) grows

Figure 42-2. Photographs of site CLG1, showing the cracking soil surface and vegetation growing on the surface, and the soil profile of black, slightly rigid clay.

Figure 42-3. Photographs of site CLG2, showing the wetland margin with sand encroaching onto the wetland surface, and the soil profile of black, very firm, clay.

Figure 42-4. Photographs of site CLG3, showing the main wetland area that had no vegetation growing on it and the breaking down of the surface layer into aggregates, and the soil profile of firm clay with the cracks filled with surface aggregates.

Figure 42-5. Photographs of site CLG4, showing the crusted surface of the wetland margin near the raised terrace adjacent to the river, and the soil profile of black firm clay.

Figure 42-6. Photographs of site CLG5, showing the main wetland area with columns breaking down into aggregates filling the cracks, and the soil profile of very firm clay.

Figure 42-7. Photographs of site CLG6, showing the landscape of the wetland margin where *Phragmites australis* (Common Reed) was growing, and the soil profile of dark grey, very firm clay.

42.3 LABORATORY DATA ASSESSMENT

Soil pH testing (pH_W, pH_{OX}, pH_{INC})

The pH data are provided in Table 42-4 and pH profiles are presented in Figure 42-8.

The pH_W data for the subsurface layers (about 5 to 20 cm depth) of profiles CLG4, CLG5 and CLG6, that occurred in the up-river section of the wetland identified samples as sulfuric materials with a pH_W <4.

The pH_{INC} data for soil layers of profiles CLG5 and CLG6 identified samples that on incubation declined below the critical value of pH<4. Samples that age to pH_{INC}<4 indicate that these soils potentially would form sulfuric material as a result of sulfide oxidation.

The pH_{OX} data for some layers in all profiles (except CLG1) identified samples below the critical value of pH_{OX} <2.5, the threshold value normally used to indicate a high likelihood of sulfuric material forming.

Acid Base Accounting

The acid base accounting data is provided in Table 42-4 and summarised in Figure 42-9.

Chromium reducible sulfur values ranged from below the limit of detection to 0.19 $\%S_{CR}$. Sulfidic materials were detected in at least one layer of all profiles. Concentrations were measured in all but one of the sampled layers.

Titratable actual acidity values ranged from 0 to 171.04 mole H^+/tonne.

Analysis of retained acidity was not conducted on any of the samples, however retained acidity may be present in the surface or subsurface layers of all profiles that were below the critical value of pH_{KCl} <4.5.

Acid neutralising capacity values ranged from 0 to 0.88 $\%CaCO_3$, and were measured in the lower subsoil layers of profiles CLG4, CL5 and CLG6, and all other sampled layers were zero.

Net acidity values ranged from -105 to 171 mole H^+/tonne. Low, moderate or high net acidity values occurred in most sampled layers, and negative values occurred in the lower subsoil layers of profiles CLG4, CL5 and CLG6.

Water Soluble Sulfate

Water soluble sulfate data values shown in Table 42-4 identified that surface layers were above the trigger value of 100 mg/kg SO_4.

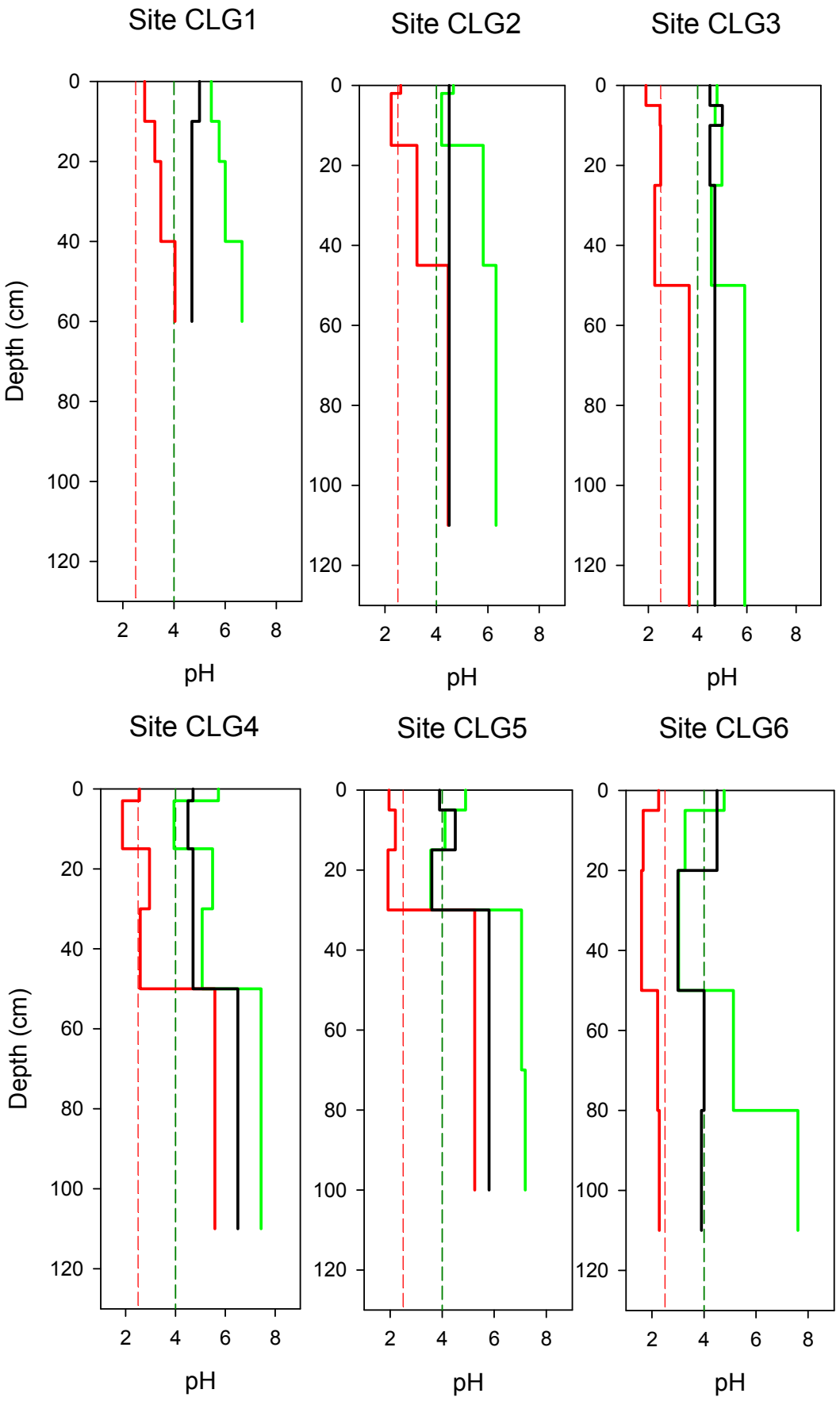

Figure 42-8. Depth profiles of soil pH for Coolcha Lagoon Wetland, showing soil pH (pH_W as green line), peroxide treated pH (pH_{OX} as red line) and ageing pH (pH_{INC} after 28 weeks as black line). Critical pH_W and pH_{INC} value of 4 (black dashed line) and critical pH_{OX} value of 2.5 (red dashed line).

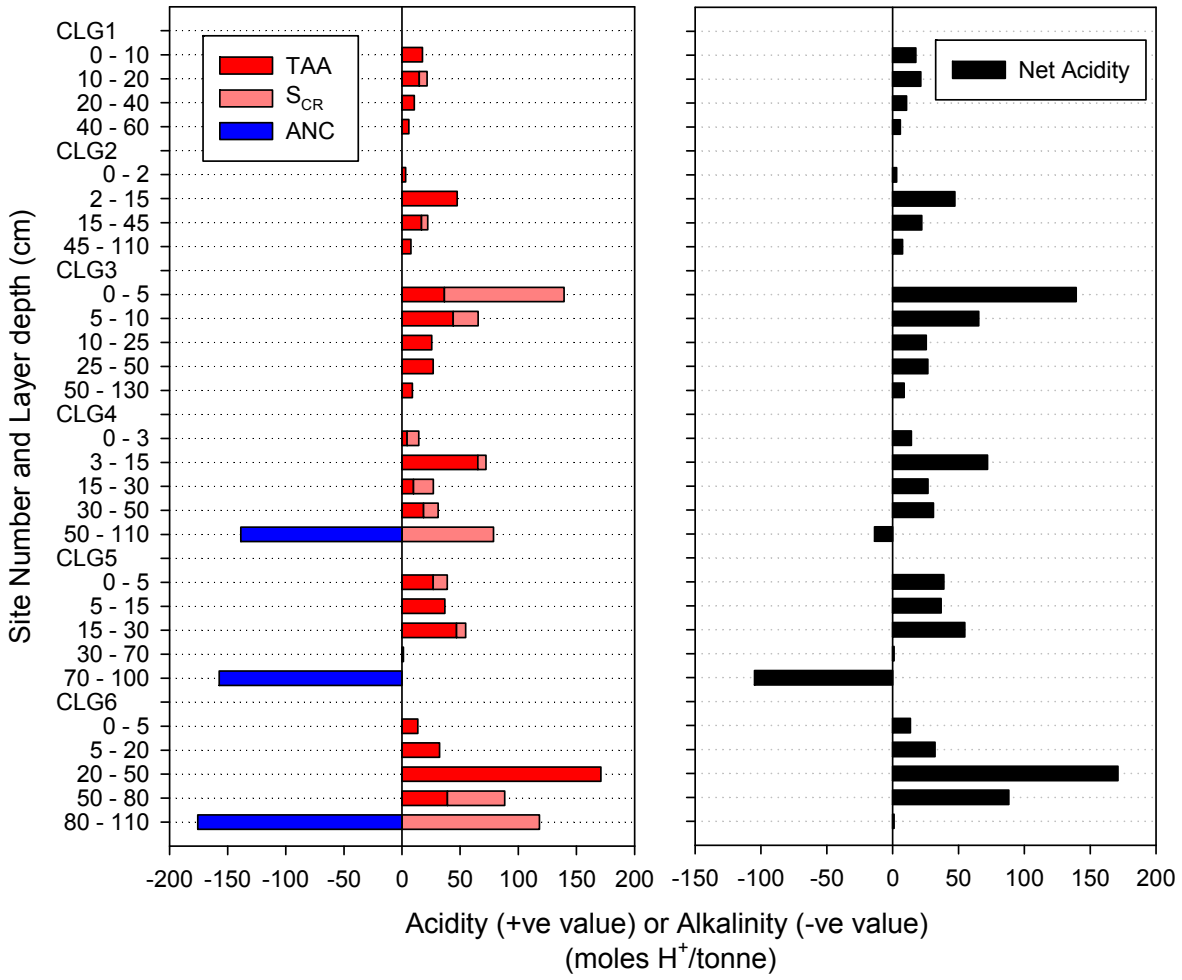

Figure 42-9. Acid base accounting depth profiles for Coolcha Lagoon Wetland. Left side shows the components: titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} -pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.

42.4 DISCUSSION

Acid sulfate soil materials at Coolcha Lagoon Wetland were identified as sulfuric in the subsurface layers of the up-river section of the wetland. For the down-river section the soil materials were characterised as hyposulfidic or other acidic.

The up-river section of the wetland describes the main extensive area of the wetland and was where the soils were cracking clays with sulfuric upper soil layers and hyposulfidic or hypersulfidic subsoils. The soil cracks extended deep into the subsoil and were partially filled with the degrading soil surface aggregates and windblown sand. The upper soil layers had low, moderate or high net acidity. The wetland had several connections with the river and the low elevation of these soils would suggest that they would most likely receive water that would then acidify.

The down-river section and around the margins of the wetland generally did not have acid sulfate soil materials except for some surface layers of hyposulfidic soil material. These areas because they were not directly connected to the river and were at higher elevation, suggest that they will have a low impact on acidification of the wetland.

The potential hazards posed by acid sulfate soil materials at the Coolcha Lagoon Wetland are:

- Acidification hazard: There were soil layers with sulfuric material or with moderate or high net acidity. There is a high level of concern.
- De-oxygenation hazard: The water soluble sulfate data indicated a potential for monosulfidic materials to form in the surface layers of soils, although monosulfidic material was not observed. There is a high level of concern.
- Metal mobilisation: The high acidification hazard indicates that soil acidification potential may increase the solubility of metals. There is a high level of concern.

Summary of key findings for Coolcha Lagoon Wetland:

Soil materials:	In the up-river section of the wetland the soils were cracking clays with sulfuric upper soil layers and the subsoils may be hypersulfidic, hyposulfidic or other acidic. The upper layers had high, moderate or low net acidity and the lower subsoil layers were negative. In the down-river section of the wetland acid sulfate soil materials were generally not identified except for isolated areas where subsoil layers were hyposulfidic.
Acid sulfate soil identification:	• Other Soil (cracking clay) – that occurred in the down-river section. Minor (<25 %) in extent. • Hyposulfidic Cracking Clay Soil – that occurred in the down-river section. Minor (<25 %) in extent. • Sulfuric Soil – That occurred in the up-river section on the higher elevations. Isolated (10%) in extent. • Sulfuric Cracking Clay Soil – that occurred in the up-river section throughout the low to mid elevation areas. Dominant (>50%) in extent.
Hazard assessment	• Acidification hazard – high level of concern • De-oxygenation hazard – high level of concern • Metal mobilisation hazard – high level of concern

Table 42-2. Site data for Coolcha Lagoon Wetland.

Site Number	Sampled Date	Easting m Zone 54H	Northing m Zone 54H	Soil Classification	Water depth (+ve) Water table (-ve)	Surface Condition	Earth Cover (Vegetation)	Location Notes
CLG1	09-Sep-08	368600	6137239	Other soil (cracking clay)	not reached	cracking	weeds	high, riverside,
CLG2	09-Sep-08	368582	6137064	Other soil (sand over clay)	90	Sealed, loose	weeds	mid, on sandy surface,
CLG3	09-Sep-08	368572	6136972	Hyposulfidic cracking clay soil	55	cracking, crumbling	Bare	low, water table pH5.5
CLG4	09-Sep-08	369596	6136878	Sulfuric soil	55	cracking, crumbling	salt bush	high, riverside,
CLG5	09-Sep-08	369589	6136841	Sulfuric cracking clay soil	55	cracking, crumbling	Bare	low, water table pH5.8
CLG6	09-Sep-08	369526	6136625	Sulfuric soil	60	cracking	*Phragmites australis* (Common Reed)	mid/high on fringe of wetland,

Table 42-3. Soil description data for Coolcha Lagoon Wetland.

Site and Sample Number	Depth Upper (cm)	Depth Lower (cm)	Observation Method (kind)	Soil Colour (Munsell notation)	Texture (class)	Soil Water Status	Mottles Quantity (%)	Mottles Colour	Mottles Location	Structure Type (category)	Consistence (category) (category)	Comments
CLG1.1	0	10	soil pit	2.5Y 5/2	clay	moist	0			subangular blocky	friable	
CLG1.2	10	20	soil pit	2.5Y 2.5/1	clay	moist	0			subangular blocky	firm	
CLG1.3	20	40	soil pit	2.5Y 2.5/1	clay	moist	10	10YR 6/8	on ped faces	subangular blocky	firm	
CLG1.4	40	60	soil pit	2.5Y 2.5/1	clay	moist	25	10YR 6/8	on ped faces	massive	very firm	
CLG2.1	0	2	soil pit	2.5Y 5/2	loamy sand	dry	3	5YR 5/8	in matrix	single grain	loose	
CLG2.2	2	15	soil pit	2.5Y 2.5/1	clay	dry	10	10YR 6/8		massive	soft	
CLG2.3	15	45	soil pit	2.5Y 2.5/1	peaty clay	moist	0			massive	very firm	
CLG2.4	45	110	push tube	2.5Y 2.5/1	clay	moist	0			massive	very firm	
CLG3.1	0	5	soil pit	2.5Y 4/2	clay	dry	3	5YR 5/8	on ped faces	angular blocky	rigid	
CLG3.2	5	10	soil pit	2.5Y 2.5/1	clay	moist	0			subangular blocky	very firm	
CLG3.3	10	25	soil pit	2.5Y 2.5/1	clay	moist	5	10YR 6/8	in matrix	massive	very firm	

Site and Sample Number	Depth Upper (cm)	Depth Lower (cm)	Observation Method (kind)	Soil Colour (Munsell notation)	Texture (class)	Soil Water Status	Mottles Quantity (%)	Mottles Colour	Mottles Location	Structure Type (category)	Consistence (category) (category)	Comments
CLG3.4	25	50	soil pit	2.5Y 2.5/1	peaty clay	moist	0			massive	very firm	
CLG3.5	50	130	push tube	2.5Y 2.5/1	clay loam	moist	0			massive	friable	
CLG3.6	130	140	push tube	2.5Y 2.5/1	clay	moist	0			massive	very firm	
CLG4.1	0	3	soil pit	2.5Y 4/2	sandy loam	moist	0			platy	friable	
CLG4.2	3	15	soil pit	2.5Y 2.5/1	clay	moist	0			massive	very firm	
CLG4.3	15	30	soil pit	2.5Y 2.5/1	peaty clay	moist	0			massive	firm	
CLG4.4	30	50	soil pit	2.5Y 2.5/1	clay	wet	0			massive	firm	
CLG4.5	50	110	push tube	2.5Y 3/1	clay	wet	0			massive	friable	
CLG4.6	110	120	push tube	5Y 5/2	clay	wet	0			massive	very firm	
CLG5.1	0	5	soil pit	2.5Y 5/1	clay	dry	3	5YR 5/8	on ped faces	angular blocky	rigid	
CLG5.2	5	15	soil pit	2.5Y 2.5/1	clay	moist	3	10YR 6/8	in matrix	subangular blocky	very firm	
CLG5.3	15	30	soil pit	2.5Y 2.5/1	clay	moist	3	10YR 6/8	in matrix	subangular blocky	very firm	
CLG5.4	30	70	soil pit	2.5Y 2.5/1	clay	wet	0			massive	firm	
CLG5.5	70	100	push tube	5Y 4/2	clay	wet	0			massive	very firm	
CLG6.1	0	5	soil pit	2.5Y 5/1	peaty sandy loam	moist	3	5YR 5/8	on ped faces	columnar	firm	
CLG6.2	5	20	soil pit	2.5Y 3/1	peaty clay	moist	0			columnar	firm	
CLG6.3	20	50	soil pit	2.5Y 2.5/1	peaty clay	moist	0			subangular blocky	firm	
CLG6.4	50	80	push tube	2.5Y 2.5/1	sandy clay loam	wet	0			massive	very firm	
CLG6.5	80	110	push tube	5Y 4/2	clay	wet	0			massive	very firm	

Table 42-4. Laboratory data for acid sulfate soil assessment of Coolcha Lagoon Wetland.

(red printed values indicates data results of concern)

Site and Layer ID.	Depth Range (cm)	Soil Texture	EC (µS/cm)	pH water	pH peroxide	pH incubation	Sulfate (mg SO_4/kg)	pH KCl	Titratable Actual Acidity (mole H^+/ tonne)	Chromium Reducible Sulfur (%S_{CR})	Acid Neutralising Capacity (%$CaCO_3$)	Net Acidity (mole H^+/ tonne)	Acid Sulfate Soil Material Classification
CLG1.1	0 - 10	Fine	-	5.46	2.85	5.00	486	5.01	17.61	< 0.01	0.00	18	other acidic
CLG1.2	10 - 20	Fine	-	5.77	3.25	4.70	972	5.37	14.78	0.01	0.00	22	hyposulfidic (S_{CR}<0.10%)
CLG1.3	20 - 40	Fine	-	6.01	3.48	4.70	731	5.69	10.53	< 0.01	0.00	11	other acidic
CLG1.4	40 - 60	Fine	-	6.66	4.04	4.70	192	5.85	5.81	< 0.01	0.00	6	other acidic
CLG2.1	0 - 2	Coarse	-	4.66	2.61	4.50	1525	5.11	3.11	< 0.01	0.00	3	other acidic
CLG2.2	2 - 15	Fine	-	4.20	2.24	4.50	3185	4.39	47.42	< 0.01	0.00	47	other acidic
CLG2.3	15 - 45	Fine	-	5.82	3.24	4.50	1688	5.53	16.66	0.01	0.00	22	other acidic
CLG2.4	45 - 110	Fine	-	6.32	4.46	4.50	800	5.70	7.63	< 0.01	0.00	8	other acidic
CLG3.1	0 - 5	Fine	-	4.79	1.90	4.50	4030	4.47	36.50	0.17	0.00	139	hyposulfidic (S_{CR}≥0.10%)
CLG3.2	5 - 10	Fine	-	4.71	2.47	5.00	6842	4.40	44.04	0.03	0.00	66	hyposulfidic (S_{CR}<0.10%)
CLG3.3	10 - 25	Fine	-	4.99	2.50	4.50	3733	5.07	25.54	< 0.01	0.00	26	other acidic
CLG3.4	25 - 50	Fine	-	4.56	2.26	4.70	4410	5.05	26.73	< 0.01	0.00	27	other acidic
CLG3.5	50 - 130	Medium	-	5.91	3.66	4.70	1142	5.67	8.82	< 0.01	0.00	9	other acidic
CLG3.6	130 - 140	Fine	-	-	-	-	-	-	-	-	-	-	-
CLG4.1	0 - 3	Fine	-	5.72	2.55	4.70	9742	5.68	4.32	0.02	0.00	14	hyposulfidic (S_{CR}<0.10%)
CLG4.2	3 - 15	Fine	-	3.94	1.87	4.50	10,636	4.22	65.12	0.01	0.00	72	sulfuric
CLG4.3	15 - 30	Fine	-	5.49	2.96	4.70	3026	5.68	9.92	0.03	0.00	27	hyposulfidic (S_{CR}<0.10%)
CLG4.4	30 - 50	Fine	-	5.07	2.59	4.70	2058	5.20	18.61	0.02	0.00	31	hyposulfidic (S_{CR}<0.10%)
CLG4.5	50 - 110	Fine	-	7.43	5.58	6.50	976	7.05		0.13	0.69	-14	hyposulfidic (S_{CR}≥0.10%)
CLG4.6	110 - 120	Fine	-	-	-	-	-	-	-	-	-	-	-

Site and Layer ID.	Depth Range (cm)	Soil Texture	EC (µS/cm)	pH water	pH peroxide	pH incubation	Sulfate (mg SO_4/kg)	pH KCl	Titratable Actual Acidity (mole H^+/ tonne)	Chromium Reducible Sulfur (%S_{CR})	Acid Neutralising Capacity (%$CaCO_3$)	Net Acidity (mole H^+/ tonne)	Acid Sulfate Soil Material Classification
CLG5.1	0 - 5	Fine	-	4.90	1.96	3.90	4148	4.64	26.69	0.02	0.00	39	hypersulfidic
CLG5.2	5 - 15	Fine	-	4.11	2.20	4.50	7498	4.34	36.83	< 0.01	0.00	37	other acidic
CLG5.3	15 - 30	Fine	-	3.56	1.92	3.60	8173	4.19	46.95	0.01	0.00	55	sulfuric
CLG5.4	30 - 70	Fine	-	7.05	5.25	5.80	1720	6.49	1.15	< 0.01	0.00	1	other soil material
CLG5.5	70 - 100	Fine	-	7.19	5.25	5.80	7807	6.62	0.00	< 0.01	0.79	-105	other soil material
CLG6.1	0 - 5	Medium	-	4.77	2.26	4.50	11,000	5.12	13.51	< 0.01	0.00	14	other acidic
CLG6.2	5 - 20	Fine	-	3.27	1.66	4.50	3384	4.03	32.29	< 0.01	0.00	32	sulfuric
CLG6.3	20 - 50	Fine	-	3.02	1.60	3.00	11674	3.45	171.04	< 0.01	0.00	171	sulfuric
CLG6.4	50 - 80	Medium	-	5.13	2.22	4.00	9397	4.53	39.02	0.08	0.00	88	hyposulfidic (S_{CR}<0.10%)
CLG6.5	80 - 110	Fine	-	7.61	2.28	3.90	4416	6.99	-	0.19	0.88	1	hypersulfidic

43 MAIDMENT LAGOON WETLAND (WETLAND ID. 12299)

43.1 LOCATION AND SETTING DESCRIPTION

Maidment Lagoon Wetland (Wetland ID. 12299) is situated on the northern side of the River Murray, on the inside of an elbow bend in the river. The wetland is geomorphically categorised as a Murray Gorge basin (Pressey 1986) and is triangular shape, with a total surface area of 67 hectares. The wetland is bounded to the north by hill slopes and on other sides by floodplain. There is a connection channel with the river at the north eastern end of the wetland and another as a culvert through a narrow area of the river bank at the south western end. At the time when the soil survey was conducted in September 2008 the wetland was dry and there was no surface water. A cereal crop was growing and the surface had been tilled into rough large aggregates. Surrounding at a slightly higher elevation was *Typha latifolia* (Bulrush) and *Phragmites australis* (Common Reed) vegetation, and trees were growing on the floodplain area. Three sites were described and sampled and their locations are shown in Figure 43-1.

Figure 43-1. Maidment Lagoon Wetland and sample site locations.

43.2 SOIL PROFILE DESCRIPTION AND DISTRIBUTION

Three sites were described and sampled. The acid sulfate soil subtype class and general location description are presented in Table 43-1. The sites were located to form a cross section from the lowest area of the wetland (MDT1), through the mid elevation area (MDT2), and the higher area of the wetland at the margin (MDT3). The site and soil profile descriptions are presented in Table 43-2 and Table 43-3.

Site MDT1 (Figure 43-2) occurred at the low elevation area that dominated the main area of the wetland where the cereal crop was growing. The soil consisted of grey, very firm, clay over clay that became too hard to dig.

Site MDT2 (Figure 43-4) occurred at mid elevation where there was a loose sandy surface with salt tolerant species were growing. The soil consisted of pale brown sandy loam, over a black, firm, clay.

Site MDT3 (Figure 43-4) occurred at a higher elevation on the wetland margin where *Typha latifolia* (Bulrush) was growing. The soil consisted of pale brown, loose, loamy sand, over grey, firm, clay.

Table 43-1. Soil identification, subtype and general location description for Maidment Lagoon Wetland.

Site ID	Easting m zone 54H	Northing m zone 54H	Acid sulfate soil subtype class	General location description
MDT1	371635	6137151	Hyposulfidic soil	Low elevation, site has been cultivated and cropped
MDT2	371691	6137009	Hyposulfidic soil	Mid elevation,
MDT3	371607	6136948	Other soil	High elevation

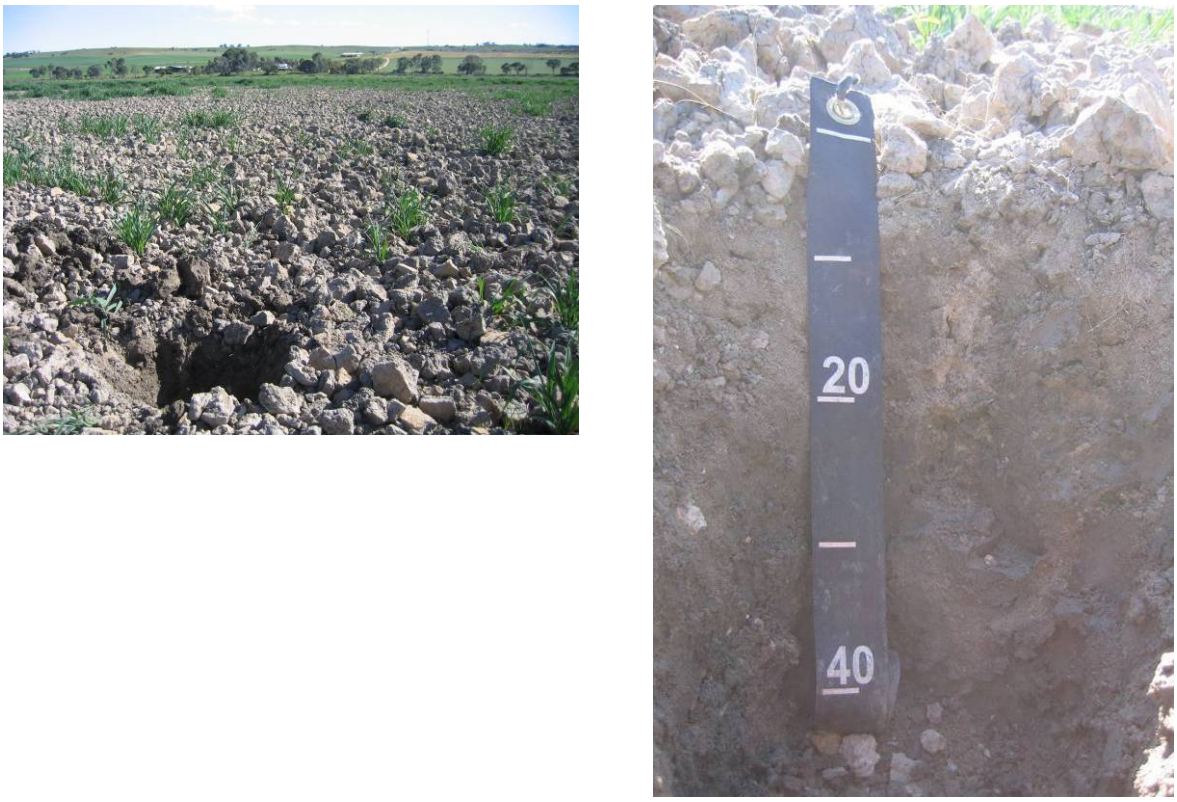

Figure 43-2. Photographs of site MDT1, showing the cultivated cloddy surface of the main wetland area, and the soil profile of rigid, cloddy, clay over very firm, clay.

Figure 43-3. Photographs of site MDT2, showing sandy surface at mid elevation, and the soil profile of friable, sandy loam, over firm clay.

Figure 43-4. Photographs of site MDT3, showing the wetland margin where reeds were growing, and the soil profile of loose sand, over firm clay.

43.3 LABORATORY DATA ASSESSMENT

Soil pH testing (pH_W, pH_{OX}, pH_{INC})

The pH data are provided in Table 43-4 and pH profiles are presented in Figure 43-5.

The pH_W data did not identify sulfuric materials with a pH_W <4.

The pH_{INC} data did not identify samples that on incubation declined below the critical value of pH <4. Samples that age to pH_{INC}<4 indicate that these soils potentially would form sulfuric materials as a result of sulfide oxidation.

The pH_{OX} data did not identify samples below the critical value of pH_{OX} <2.5, the threshold value normally used to indicate a high likelihood of sulfuric material forming.

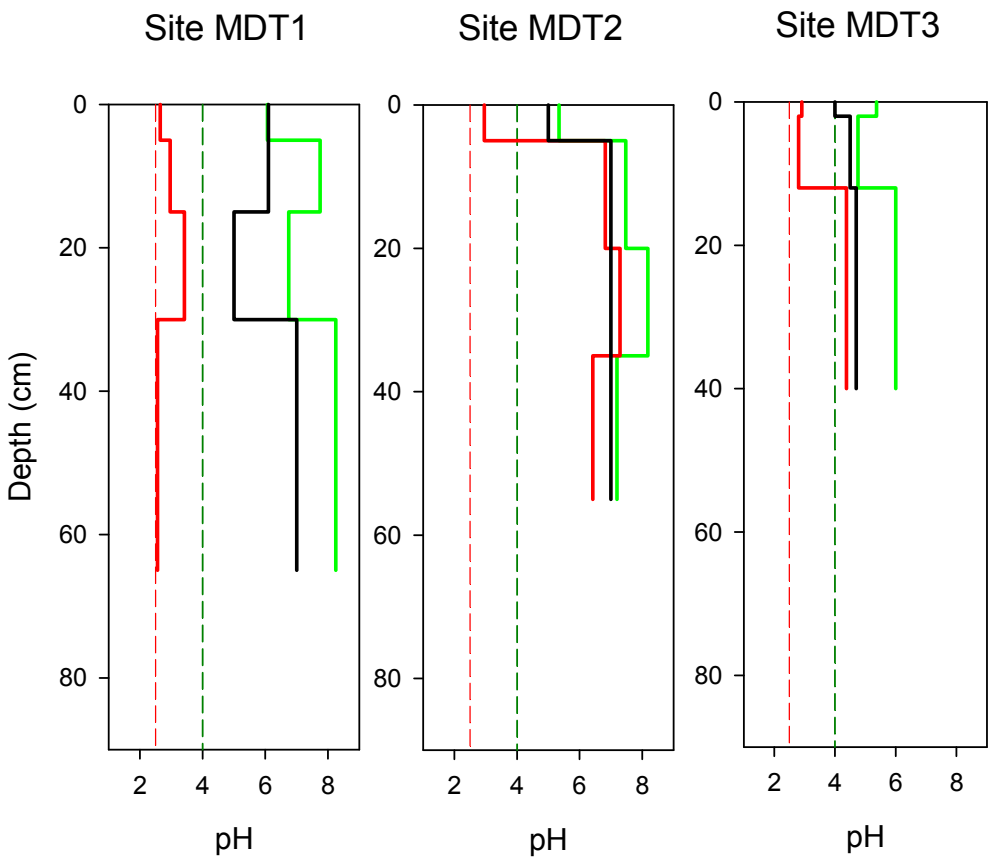

Figure 43-5. Depth profiles of soil pH for Maidment Lagoon Wetland, showing soil pH (pH_W as green line), peroxide treated pH (pH_{OX} as red line) and ageing pH (pH_{INC} after 28 weeks as black line). Critical pH_W and pH_{INC} value of 4 (black dashed line) and critical pH_{OX} value of 2.5 (red dashed line).

Acid Base Accounting

The acid base accounting data is provided in Table 43-4 and summarised in Figure 43-6.

Chromium reducible sulfur values ranged from below the limit of detection to 0.09 $\%S_{CR}$. Sulfidic materials were detected in the surface and lower subsoil layer of profile MDT1, and all other samples were at or below the limit of detection.

Titratable actual acidity values ranged from 0 to 9.97 mole H^+/tonne.

Analysis of retained acidity was not conducted on any of the samples, as all samples were above the critical value of pH_{KCl} <4.5.

Acid neutralising capacity values ranged from 0 to 1.17 $\%CaCO_3$, and were measured in the subsoil layers of profile MDT2 and the lower subsoil layer of MDT1.

Net acidity values ranged from -156 to 25 mole H^+/tonne. A moderate net acidity value occurred in the surface layer of MDT1, all other samples were low or negative net acidity values.

Water Soluble Sulfate

Water soluble sulfate data values shown in Table 43-4 identified that surface layers for all sampled profiles were above the trigger value of 100 mg/kg SO_4.

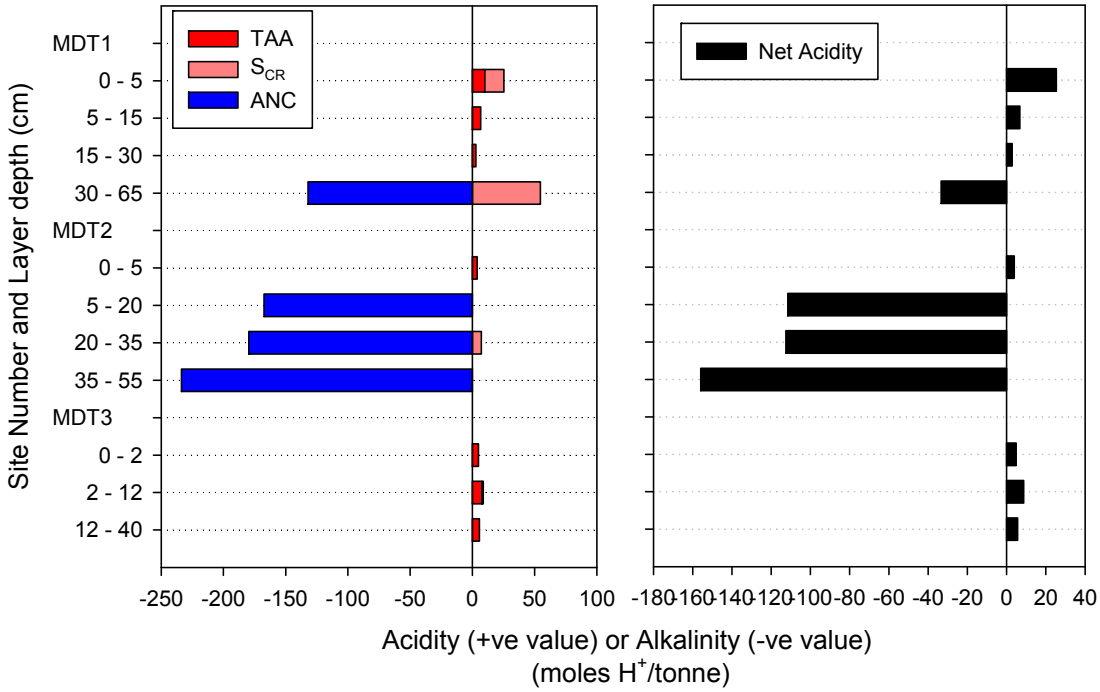

Figure 43-6. Acid base accounting depth profiles for Maidment Lagoon Wetland. Left side shows the components: titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} - pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.

43.4 DISCUSSION

Acid sulfate soil materials at Maidment Lagoon Wetland were identified as hyposulfidic for the lower subsoil layers of profiles MDT1 and MDT2 and the surface layer of MDT1, the remaining soils were characterised as other acidic or other soil materials. The acid sulfate soil subtype classes identified were Hyposulfidic Soil and Other Soil.

The soils throughout the main area of the wetland were generally cloddy, rigid clays over very firm clays, and nearer the wetland margins the surface layers were loose or friable sands over firm clay.

Monosulfidic material was not observed but water soluble sulfate data identified that surface layers for the profiles throughout the wetland were in excess of the 100 mg/kg trigger value for monosulfide formation potential.

The potential hazards posed by acid sulfate soil materials at the Maidment Lagoon Wetland are:

- Acidification hazard: The data identified moderate net acidity value in the surface layer of one profile characterising the main wetland area and all other samples in the wetland were low or negative net acidity, and pH data did not identify potential acidification due to oxidation. There is a medium level of concern.
- De-oxygenation hazard: The water soluble sulfate data indicated a potential for monosulfidic materials to form in the surface layers of soils, although monosulfidic material was not observed. There is a medium level of concern.
- Metal mobilisation: The medium acidification hazard indicates that soil acidification potential may increase the solubility of metals. There is a medium level of concern.

Summary of key findings for Maidment Lagoon Wetland:

Soil materials:	Hyposulfidic soil materials were identified in the main wetland area surface and subsoil samples. The soils throughout the main wetland area were generally clay textured and nearer the margins the surface layers were sandy over clay subsoil layers. One surface sample from the main wetland area had a moderate net acidity value and pH data did not identify potential acidification due to oxidation.
Acid sulfate soil identification:	• Hyposulfidic Soil – that occurred in the main area of the wetland. Dominant (>50%) in extent. • Other soil – that occurred in the higher elevation areas on the margins of the wetland. Minor (<25%) in extent.
Hazard assessment	• Acidification hazard – medium level of concern. • De-oxygenation hazard – medium level of concern. • Metal mobilisation hazard – medium level of concern.

Table 43-2. Site data for Maidment Lagoon Wetland.

Site Number	Sampled Date	Easting m zone 54H	Northing m zone 54H	Soil Classification	Water depth (+ve) Water table (-ve)	Surface Condition	Earth Cover (Vegetation)	Location Notes
MDT1	10-Sep-08	371635	6137151	Hyposulfidic soil	Not reached	cloddy	cropped	low elevation, site has been cultivated and cropped
MDT2	10-Sep-08	371691	6137009	Hyposulfidic soil	Not reached	sealed	salt bush	Mid elevation,
MDT3	10-Sep-08	371607	6136948	Other soil	Not reached	plant material	Bulrushes	High elevation

Table 43-3. Soil description data for Maidment Lagoon Wetland.

Site and Sample Number	Depth Upper (cm)	Depth Lower (cm)	Observation Method (kind)	Soil Colour (Munsell notation)	Texture (class)	Soil Water Status	Mottles Quantity (%)	Mottles Colour	Mottles Location	Structure Type (category)	Consistence (category)	Comments
MDT1.1	0	5	soil pit	2.5Y 7/2	clay	dry	15	5YR 5/8	on ped faces	cloddy	rigid	
MDT1.2	5	15	soil pit	2.5Y 5/3	sandy loam	moist	0			massive	very firm	
MDT1.3	15	30	soil pit	2.5Y 4/1	clay	moist	0			massive	very firm	
MDT1.4	30	65	soil pit	2.5Y 4/1	clay	moist	0			massive	very firm	too hard to dig below this layer
MDT2.1	0	5	soil pit	2.5Y 6/2	sandy loam	moist	15	5YR 5/8	in matrix	platy	friable	
MDT2.2	5	20	soil pit	2.5Y 2.5/1	clay	moist	5	10YR 6/8	in matrix adjacent to pores	subangular blocky	very firm	
MDT2.3	20	35	soil pit	2.5Y 2.5/1	clay	moist	5	10YR 6/8	in matrix adjacent to pores	massive	firm	
MDT2.4	35	55	soil pit	2.5Y 2.5/1	clay	moist	0			massive	firm	too hard to dig below this layer
MDT3.1	0	2	soil pit	2.5Y 5/3	sand	dry	0			single grain	loose	
MDT3.2	2	12	soil pit	2.5Y 5/2	loamy sand	moist	15	10YR 6/8	in matrix adjacent to pores	single grain	loose	
MDT3.3	12	40	soil pit	2.5Y 4/1	clay	moist	10	10YR 6/8	in matrix adjacent to pores	massive	firm	too hard to dig below this layer

Table 43-4. Laboratory data for acid sulfate soil assessment of Maidment Lagoon Wetland.

(red printed values indicate data results of concern)

Site and Layer ID.	Depth Range (cm)	Soil Texture	EC (µS/cm)	pH water	pH peroxide	pH incubation	Sulfate (mg SO_4/kg)	pH KCl	Titratable Actual Acidity (mole H^+/ tonne)	Chromium Reducible Sulfur (%S_{CR})	Acid Neutralising Capacity (%$CaCO_3$)	Net Acidity (mole H^+/ tonne)	Acid Sulfate Soil Material Classification
MDT1.1	0 - 5	fine	-	6.07	2.65	6.10	1304	5.41	9.97	0.02	-	25	hyposulfidic (S_{CR}<0.10%)
MDT1.2	5 - 15	medium	-	7.75	2.96	6.10	2667	5.40	6.74	< 0.01	-	7	other soil material
MDT1.3	15 - 30	fine	-	6.75	3.42	5.00	897	6.23	2.84	< 0.01	-	3	other acidic incubation
MDT1.4	30 - 65	fine	-	8.25	2.56	7.00	1171	7.21	-	0.09	0.66	-33	hyposulfidic (S_{CR}<0.10%)
MDT2.1	0 - 5	medium	-	5.34	2.96	5.00	266	5.23	3.90	< 0.01	-	4	other acidic
MDT2.2	5 - 20	fine	-	7.48	6.82	7.00	204	6.94	-	< 0.01	0.84	-112	other soil material
MDT2.3	20 - 35	fine	-	8.18	7.29	7.00	141	7.09	-	0.01	0.90	-112	hyposulfidic (S_{CR}<0.10%)
MDT2.4	35 - 55	fine	-	7.19	6.42	7.00	120	7.77	-	< 0.01	1.17	-156	other soil material
MDT3.1	0 - 2	coarse	-	5.37	2.91	4.00	101	5.28	4.93	< 0.01	-	5	other acidic incubation
MDT3.2	2 - 12	coarse	-	4.76	2.80	4.50	253	4.98	7.75	< 0.01	-	9	other acidic
MDT3.3	12 - 40	fine	-	6.00	4.38	4.70	612	5.56	5.62	< 0.01	-	6	other acidic incubation

44 BOW HILL WETLAND (WETLAND ID. 12067)

44.1 LOCATION AND SETTING DESCRIPTION

Bow Hill wetland (Wetland ID. 12067) is situated on the eastern side of the River Murray. The wetland is geomorphically categorised as a Murray Gorge basin (Pressey 1986) and is an irregular shape. It has a main wetland area in the down river section and an elongated channel in the up river section creating a total surface area of 48 hectares. It is bounded to the east by a hill slope and to the west by floodplain which separates the wetland from the river. There are two narrow water connection channels at the down-river end of the wetland. At the time when the soil survey was conducted in October 2008, the wetland was dry. The soil surface was bare with large columns forming cracks deep into the subsoil, *Typha latifolia* (Bulrush) and *Phragmites australis* (Common Reed) were growing in isolated areas along the margins. Three sites were described and sampled and their locations are shown in Figure 44-1.

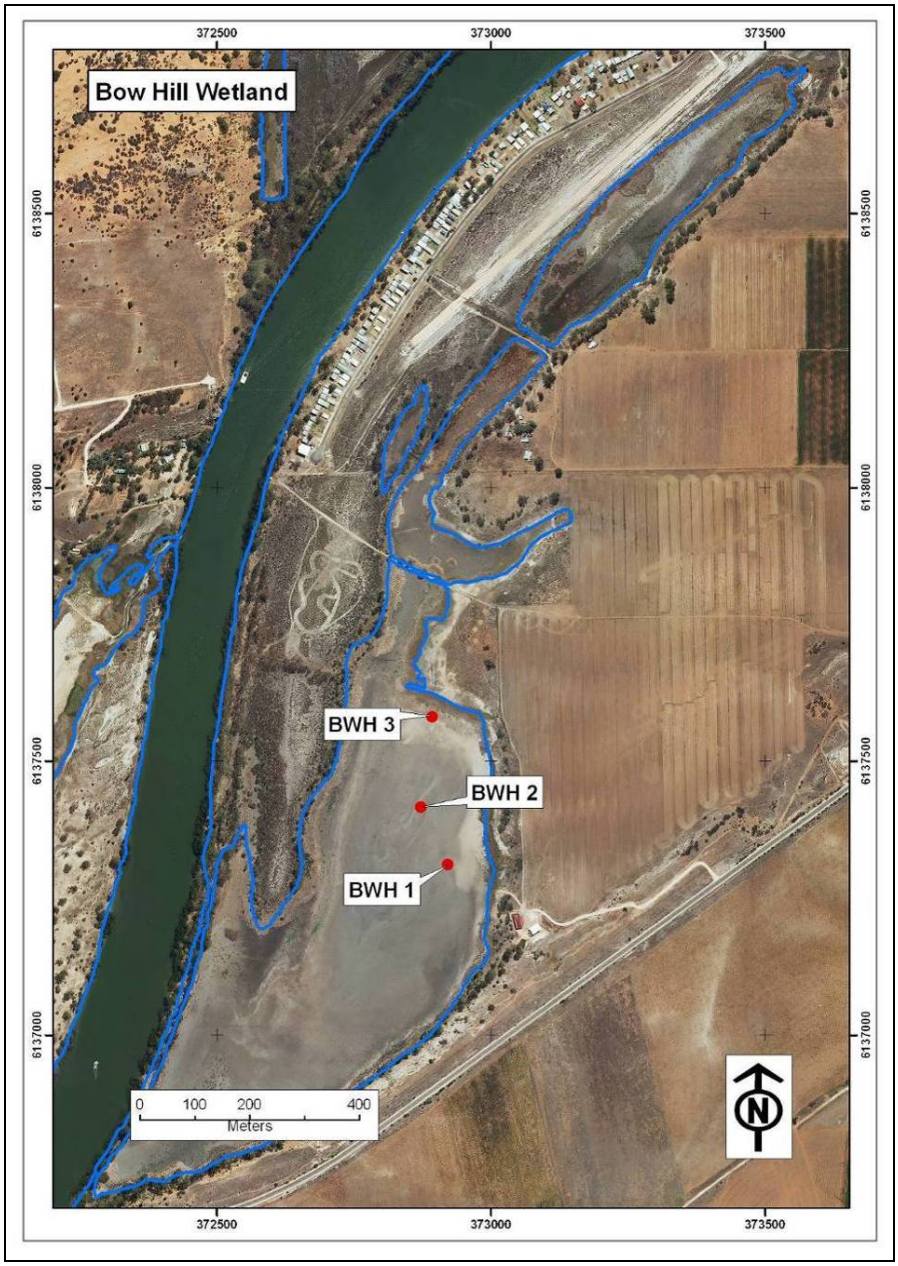

Figure 44-1. Bow Hill Wetland and sample site locations.

44.2 SOIL PROFILE DESCRIPTION AND DISTRIBUTION

Three sites were described and sampled. The acid sulfate soil subtype class and general location description are presented in Table 44-1. Sites characterised an area where salt occurred extensively across the soil surface (BWH1), the main low area of the wetland (BWH2) and the fringing margin area (BWH3). The site and soil profile descriptions are presented in Table 44-2 and Table 44-3.

Site BWH1 (Figure 44-2) occurred on a higher elevation area where significant quantities of salts were on the surface that were possibly related to a seep that may have formed at the base of the hill slope The soil consisted of dark grey, firm, clay, over black and then olive green, firm clay.

Site BWH2 (Figure 44-3) occurred in the low centre area of the wetland that was bare with large columns forming deep cracks extending into the subsoil. The soil consisted of light grey, extremely hard, clay with salts on the column faces, over black, firm, clay with red mottles in the soil matrix.

Site BWH3 (Figure 44-4) occurred where *Typha latifolia* (Bulrush) was growing on the higher elevation side of the wetland margin. The soil consisted of brown, loose, sand, over black, very firm, clay with red mottles on ped faces.

Table 44-1. Soil identification, subtype and general location description of sites for Bow Hill Wetland.

Site ID	Easting m Zone 54H	Northing m Zone 54H	Acid sulfate soil subtype class	General location description
BWH1	372921	6137311	Sulfuric cracking clay soil	Higher elevation, on margin where there was a ground water seep
BWH2	372872	6137416	Hyposulfidic cracking clay soil	Low to mid elevation, throughout where cracking clay and no vegetation
BWH3	372893	6137581	Hyposulfidic soil	High elevation, on margins where *Typha latifolia* (Bulrush) grows

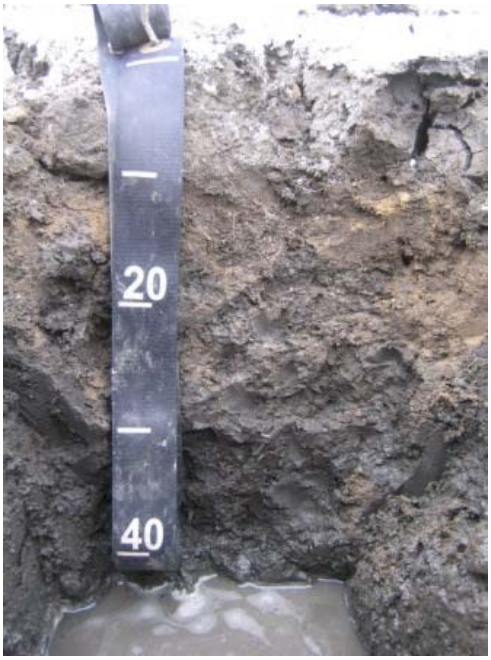

Figure 44-2. Photographs of site BWH1, showing the salt crust on the cracking clay surface, and the soil profile with the water table at about 45 cm.

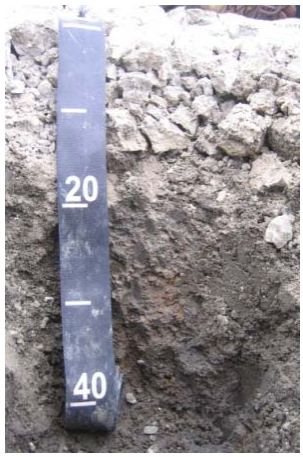

Figure 44-3. Photographs of site BWH2, showing the very hard clay surface with deep cracks, and the soil profile with a surface layer of extremely hard clay aggregates over a very firm clay.

Figure 44-4. Photograph of site BWH3, showing the soil profile of the encroaching surface sand over very firm clay.

44.3 LABORATORY DATA ASSESSMENT

Soil pH testing (pH_W, pH_{OX}, pH_{INC})

The pH data are provided in Table 44-4 and pH profiles are presented in Figure 44-5.

The pH_W data for the surface layer of profile BWH1 that was associated with the salt accumulations identified a sample as sulfuric materials with a pH_W <4.

The pH_{INC} data for some layers of profile BWH1 identified samples that on incubation declined below the critical value of pH<4. Samples that age to pH_{INC}<4 indicate that these soils potentially would form sulfuric material as a result of sulfide oxidation.

The pH_{OX} data for the surface layers of profiles BWH1 and BWH2 identified samples below the critical value of pH_{OX} <2.5, the threshold value normally used to indicate a high likelihood of sulfuric material forming.

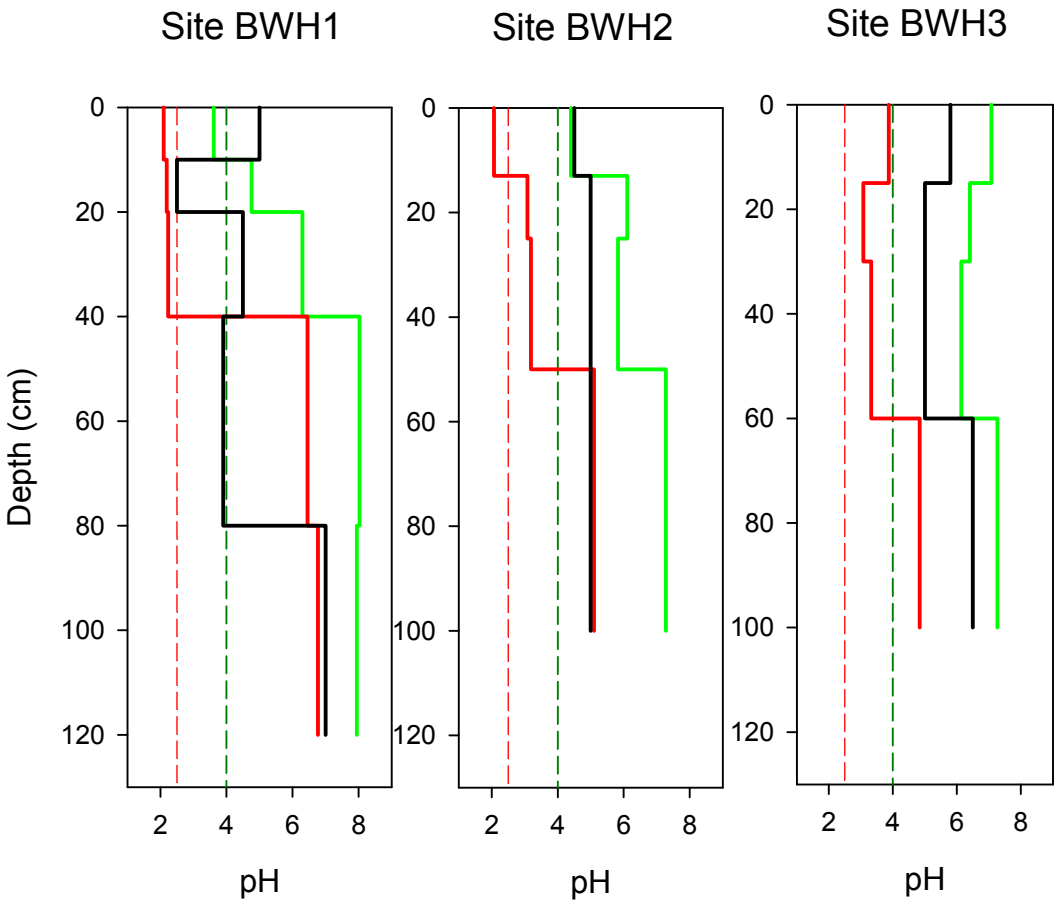

Figure 44-5. Depth profiles of soil pH for Bow Hill wetland, showing soil pH (pH_W as green line), and peroxide treated pH (pH_{OX} as red line) and ageing pH (pH_{INC} after 28 weeks as black line). Critical pH_W and pH_{INC} value of 4 (black dashed line) and critical pH_{OX} value of 2.5 (red dashed line).

Acid Base Accounting

The acid base accounting data is provided in Table 44-4 and summarised in Figure 44-6.

Chromium reducible sulfur values ranged from below the detection limit to 0.18 %S_{CR}. Sulfidic materials were detected in the surface layers of profiles BWH1 and BWH2, and the deeper subsoil layers of BWH2 and BWH3.

Titratable actual acidity values ranged from 0 to 63.69 mole H^+/tonne. Concentrations were measured in nearly all sampled layers.

Analysis of retained acidity was not conducted on any of the samples, however retained acidity may be present in the surface layers of profiles BWH1 and BWH2 that were below the critical value of pH_{KCl} <4.5.

Acid neutralising capacity values ranged from 0 to 1.25 %$CaCO_3$, and were measured in the lower subsoil layers of profile BWH1.

Net acidity values ranged from -166 to 123 mole H^+/tonne. Low or moderate net acidity values occurred in most layers, with a high value in the subsoil layer of profile BWH1 and negative values occurred in the lower subsoil layers of profile BWH1.

Water Soluble Sulfate

Water soluble sulfate data values shown in Table 44-4 identified that surface layers were above the trigger value of 100 mg/kg SO_4.

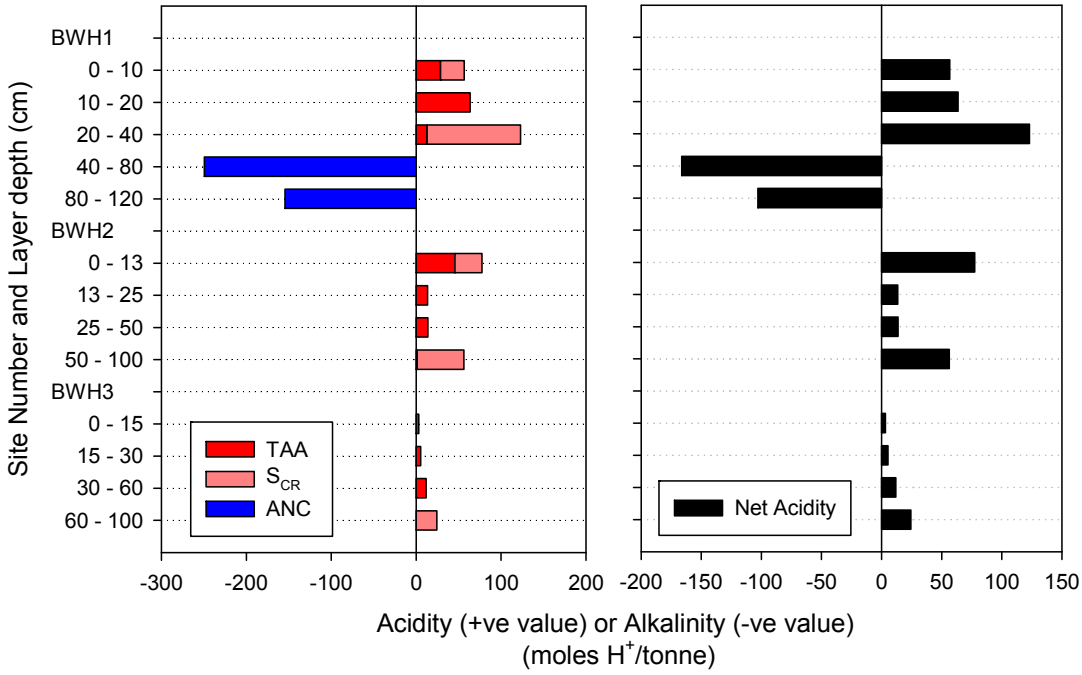

Figure 44-6. Acid base accounting depth profiles for Bow Hill Wetland. Left side shows the components: titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} - pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.

44.4 DISCUSSION

Acid sulfate soil materials at Bow Hill Wetland were identified as sulfuric that occurred at an isolated area on the hill-side of the wetland associated with a ground water seep, and hyposulfidic that occurred generally in the deeper subsoil layers throughout the wetland and in the surface layer for profile BWH2.

The area where the sulfuric material occurs would be a high level of concern, but because of its high elevation in the wetland it probably would be one of the last areas to receive water as the wetland refills.

The main wetland area was dominated by cracking clay soils with very hard surface aggregates, the cracks were deep extending down to the subsoil. The clay soil layers were hyposulfidic or acidic.

The potential hazards posed by acid sulfate soil materials at the Bow Hill Wetland are:

- Acidification hazard: The main wetland area had hyposulfidic soil material on the surface and the pH data did not identify values of concern, the sulfuric material occurred high up in the wetland but would be unlikely (or the last) to receive water if the wetland water levels increased on refilling and therefore probably having a minimal impact. There is a low to medium level of concern.
- De-oxygenation hazard: The water soluble sulfate data indicated a potential for monosulfidic materials to form in the surface layers of soils, although monosulfidic material was not observed. There is a high level of concern.
- Metal mobilisation hazard: The low to medium acidification hazard indicates that soil acidification potential is not likely to increase the solubility of metals. There is a low level of concern

Summary of key findings for Bow Hill Wetland:

Soil materials:	Throughout the main wetland area the surface soils were very hard clay aggregates with deep cracks extending into the clay subsoil, the deeper subsoil layers were generally hyposulfidic or other acidic with a low or moderate net acidity. Sulfuric soil materials occurred at an isolated area where there were many salts on the surface associated with a ground water seep.
Acid sulfate soil identification:	• Sulfuric Cracking Clay Soil – that occurred where there was a ground water seep. Isolated (<10%) in extent. • Hyposulfidic cracking clay soils – that occurred throughout the wetland. Dominant (>50%) in extent. • Hyposulfidic soils – that occurred around the margins. Isolated (<10%) in extent.
Hazard assessment	• Acidification hazard – low to medium level of concern • De-oxygenation hazard – high level of concern • Metal mobilisation hazard – low level of concern

Table 44-2. Site data for Bow Hill Wetland.

Site Number	Sampled Date	Easting m Zone 54H	Northing m Zone 54H	Soil Classification	Water depth (+ve) Water table (-ve)	Surface Condition	Earth Cover (Vegetation)	Location Notes
BWH1	23-Oct-08	372921	6137311	Sulfuric cracking clay soil	50	cracking, salts	Bare	mid, probable seepage area,
BWH2	23-Oct-08	372872	6137416	Hyposulfidic cracking clay soil	70	cracking	Bare	low, centre,
BWH3	23-Oct-08	372893	6137581	Hyposulfidic soil	90	loose, sand	*Typha latifolia* (Bulrush)	high,

Table 44-3. Soil description data for Bow Hill Wetland.

Site and Sample Number	Depth Upper (cm)	Depth Lower (cm)	Observation Method (kind)	Soil Colour (Munsell notation)	Texture (class)	Soil Water Status	Mottles Quantity (%)	Mottles Colour	Mottles Location	Structure Type (category)	Consistence (category)	Comments
BWH1.0	0	0	soil pit	2.5Y 8/1	SALTS	dry	0					white salts on the surface
BWH1.1	0	10	soil pit	2.5Y 2.5/1	clay	moist	0			columnar	very firm	
BWH1.2	10	20	soil pit	2.5Y 2.5/1	sandy clay loam	moist	0			subangular blocky	firm	
BWH1.3	20	40	soil pit	2.5Y 2.5/1	clay	moist	0			subangular blocky	firm	
BWH1.4	40	80	push tube	2.5Y 2.5/1	clay	wet	0			massive	firm	
BWH1.5	80	120	push tube	5Y 5/2	clay	wet	0			massive	friable	
BWH2.1	0	13	soil pit	2.5Y 6/2	clay	dry	0			columnar	extremely hard	contains salts on column faces
BWH2.2	13	25	soil pit	2.5Y 2.5/1	clay	moist	5	5YR 6/8	in matrix adjacent to pores	subangular blocky	firm	
BWH2.3	25	50	soil pit	2.5Y 2.5/1	clay	moist	10	5YR 6/8	in matrix	subangular blocky	firm	
BWH2.4	50	100	push tube	2.5Y 2.5/1	clay	moist	0			massive	firm	
BWH3.1	0	15	soil pit	2.5Y 6/3	sand	dry	0			single grain	loose	
BWH3.2	15	30	soil pit	2.5Y 2.5/1	sandy clay loam	moist	20	5YR 6/8	in matrix adjacent to pores	subangular blocky	firm	
BWH3.3	30	60	soil pit	2.5Y 2.5/1	clay	moist	20	5YR 6/8	in matrix along ped faces	subangular blocky	very firm	
BWH3.4	60	100	push tube	2.5Y 2.5/1	clay	moist	0			massive	firm	

Table 44-4. Laboratory data for acid sulfate soil assessment of Bow Hill Wetland.

(red printed values indicates data results of concern)

Site and Layer ID.	Depth Range (cm)	Soil Texture	EC (µS/cm)	pH water	pH peroxide	pH incubation	Sulfate (mg SO_4/kg)	pH KCl	Titratable Actual Acidity (mole H^+/ tonne)	Chromium Reducible Sulfur (%S_{CR})	Acid Neutralising Capacity (%$CaCO_3$)	Net Acidity (mole H^+/ tonne)	Acid Sulfate Soil Material Classification
BWH1.0	0 - 0	Salts		-	-	-	-	-	-	-	-	-	-
BWH1.1	0 - 10	Fine	13,090	3.62	2.10	5.00	18698	4.56	28.78	0.04	0.00	57	sulfuric
BWH1.2	10 - 20	Medium	2,770	4.76	2.19	2.50	3071	4.03	63.69	< 0.01	0.00	64	other acidic
BWH1.3	20 - 40	Fine	1,680	6.30	2.23	4.50	3127	5.51	12.89	0.18	0.00	123	hyposulfidic (S_{CR}≥0.10%)
BWH1.4	40 - 80	Fine	580	8.03	6.46	3.90	1158	6.63	0.00	< 0.01	1.25	-166	other acidic
BWH1.5	80 - 120	Fine	140	7.95	6.77	7.00	922	6.64	0.00	< 0.01	0.77	-103	other soil material
BWH2.1	0 - 13	Fine	9,30	4.40	2.07	4.50	6669	4.25	45.81	0.05	0.00	78	hyposulfidic (S_{CR}<0.10%)
BWH2.2	13 - 25	Fine	420	6.11	3.08	5.00	1448	5.55	13.51	< 0.01	0.00	14	other acidic
BWH2.3	25 - 50	Fine	2,970	5.83	3.19	5.00	2085	5.51	13.83	< 0.01	0.00	14	other acidic
BWH2.4	50 - 100	Fine	3,440	7.28	5.10	5.00	1849	6.36	1.10	0.09	0.00	56	hyposulfidic (S_{CR}<0.10%)
BWH3.1	0 - 15	Coarse	8,090	7.08	3.87	5.80	8068	6.29	3.26	< 0.01	0.00	3	other soil material
BWH3.2	15 - 30	Medium	650	6.41	3.08	5.00	1184	5.62	5.33	< 0.01	0.00	5	other acidic
BWH3.3	30 - 60	Fine	1,920	6.14	3.32	5.00	1620	5.53	11.87	< 0.01	0.00	12	other acidic
BWH3.4	60 - 100	Fine	2,200	7.27	4.84	6.50	1057	6.49	0.14	0.04	0.00	24	hyposulfidic (S_{CR}<0.10%)

45 CRAIGNOOK WETLAND (WETLAND ID. 12332)

45.1 LOCATION AND SETTING DESCRIPTION

Craignook Wetland (Wetland ID. 12332) is situated on the northern side of the River Murray. The wetland is geomorphically categorised as a Murray Gorge basin (Pressey 1986) and is a sliver that follows the river shape and is separated into two sections, a total length of about 3 kilometres and about 300 metres at the widest, with a total surface area of 55 hectares. It is bounded to the north by a cliff and hill slope and to the south by a floodplain 100 to 200 metres wide. There is an excavated channel across the floodplain connecting the river with the midpoint of the wetland, close to the divide between the up and down river sections of the wetland.This channel connects the down-river end of the wetland. There also appeared to be a second connection at the most downstream end of the wetland however it's elevation appeared to be too high for connectivity at normal pool level of 0.75 m AHD.

At the time when the soil survey was conducted in September 2008, a depression area had shallow water above the water filled cracked soil, probably from ground water upwelling, the remainder of the wetland surface was dry. Surrounding the wetland at a slightly higher elevation was *Typha latifolia* (Bulrush) and *Phragmites australis* (Common Reed) vegetation often growing on a sandy surface, and trees on the raised bank that separates the wetland from the river. Three sites were described and sampled and their locations are shown in Figure 45-1.

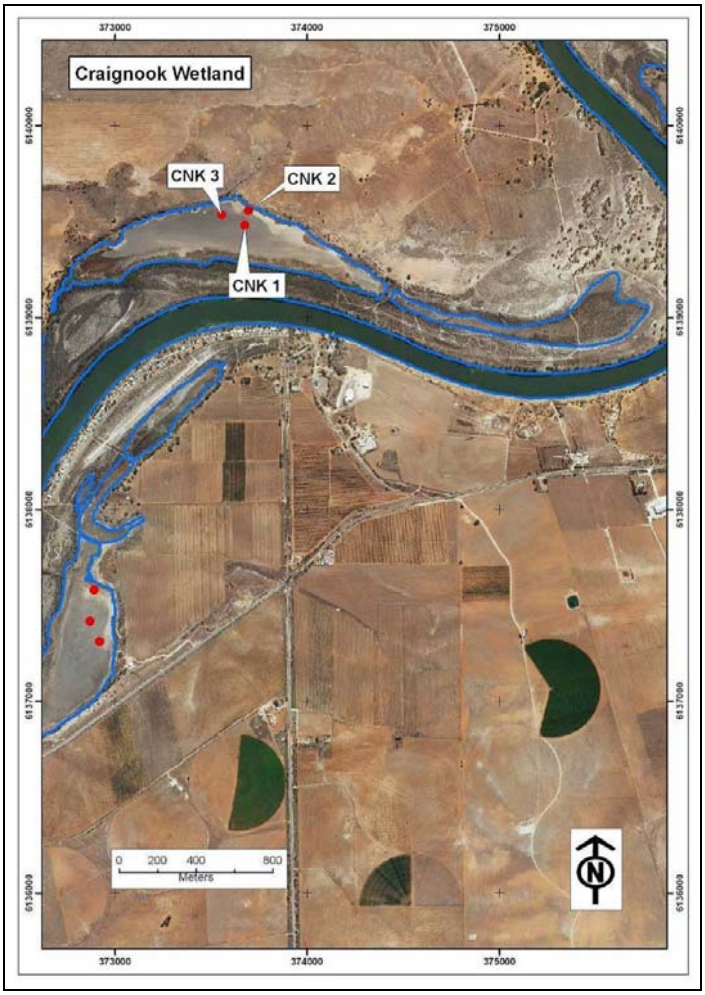

Figure 45-1. Craignook Wetland and sample site locations.

45.2 SOIL PROFILE DESCRIPTION AND DISTRIBUTIONS

Three sites were sampled and described. The acid sulfate soil subtype class and general location description are presented in Table 45-1. The sites were located to characterise the main area of the wetland at low elevation (CNK1), the higher elevation margin area where sand was encroaching (CNK2), and an area of surface water (CNK3). The site and profile descriptions are presented in Table 45-2 and Table 45-3.

Site CNK1 (Figure 45-2) occurred where the bare vegetation cracking surface area that was in the low to mid elevation area of the wetland that was the dominant area of the wetland. Water filled the cracks but was not on the surface. The soil consisted of dark grey, firm, clay over black, firm clay.

Site CNK2 (Figure 45-3) occurred mid to high elevation where sand had encroached over the wetland from the surrounding hill slopes, the surface was sandy and loose with no vegetation.. Nearby towards the fringing area there were *Phragmites australis* (Common Reed), the soil consisted of a pale brown, loose sand, over a black, firm, sandy clay loam.

Site CNK3 (Figure 45-4) occurred in the low depression area where there was surface water probably as a result of ground water discharge. The water was 5 centimetres above the surface and in the soil cracks, there was no vegetation growing. The soil consisted of dark grey friable clay, over dark grey, firm clay.

Table 45-1. Soil identification, subtype and general location description of sites for Craignook Wetland.

Site ID	Easting m Zone 54H	Northing m Zone 54H	Acid sulfate soil subtype class	General location description
CNK1	373677	6139479	Hypersulfidic cracking clay soil	Low to mid elevation, cracking clay soil areas
CNK2	373696	6139555	Sulfuric soil	Higher elevation, on the margins of the wetland where sand encroaches and where *Phragmites australis* (Common Reed) and *Typha latifolia* (Bulrush) grow
CNK3	373557	6139533	Hyposulfidic cracking clay soil	Low elevation, near cliff side, where ground water upwelling probably occurred

Figure 45-2. Photographs of site CNK1, showing the main wetland area with the tops of the soil columns breaking down and the aggregates filling cracks, and the soil profile with the water level near the surface.

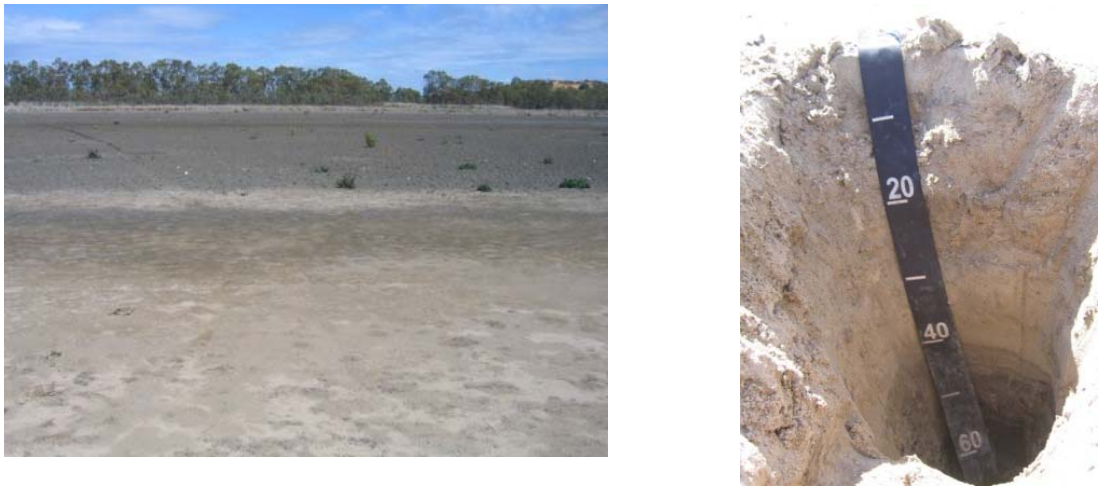

Figure 45-3. Photographs of site CNK2, showing the sand encroaching from the margins over the cracking clay soils of the wetland, and the soil profile of deep loose sand.

Figure 45-4. Photograph of site CNK3, showing the shallow surface water probably from upwelling of ground water seep.

45.3 LABORATORY DATA ASSESSMENT

Soil pH testing (pH_W, pH_{OX}, pH_{INC})

The pH data are provided in Table 45-4 and pH profiles are presented in Figure 45-5.

The pH_W data for the surface layers of profile CNK2 identified samples as sulfuric materials with a pH_W <4.

The pH_{INC} data for the subsoil layers of profile CNK1 and most of the soil layers throughout profile CNK2 identified samples that on incubation declined below the critical value of pH<4. Samples that age to pH_{INC}<4 indicate that these soils potentially would form sulfuric material as a result of sulfide oxidation.

The pH_{OX} data for the surface layers of all profiles identified samples below the critical value of pH_{OX} <2.5, the threshold value normally used to indicate a high likelihood of sulfuric material forming.

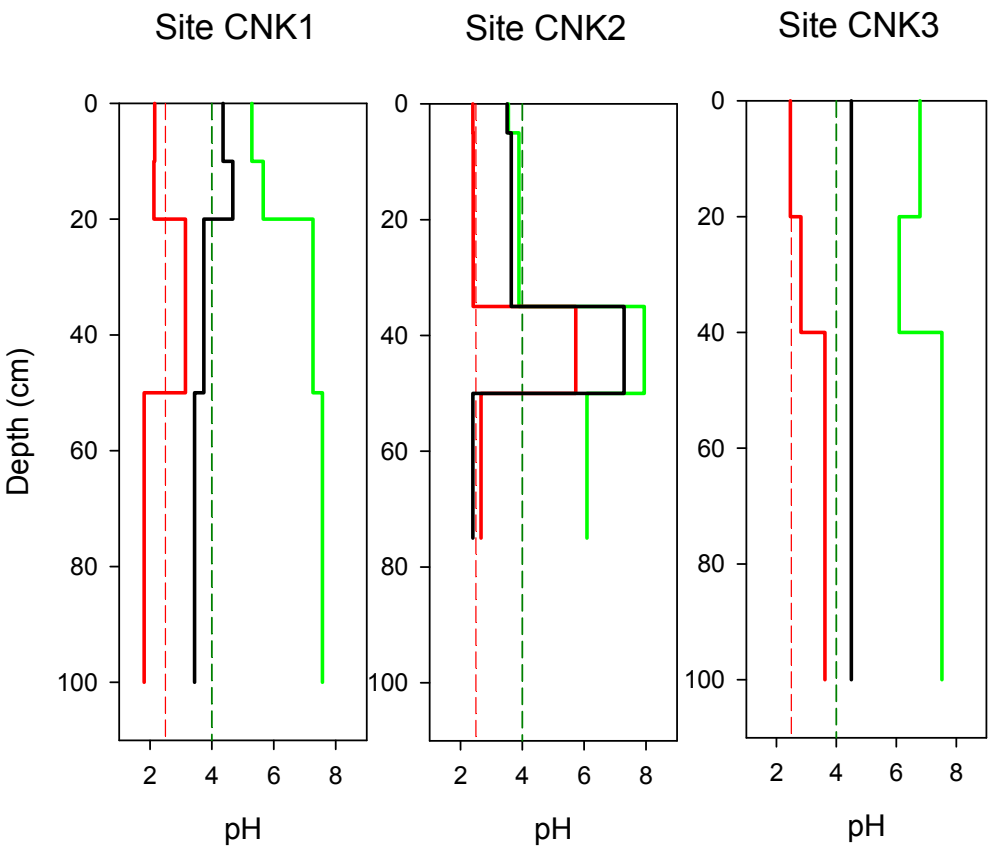

Figure 45-5. Depth profiles of soil pH for Craignook Wetland, showing soil pH (pH_W as green line), peroxide treated pH (pH_{OX} as red line) and ageing pH (pH_{INC} after 28 weeks as black line). Critical pH_W and pH_{INC} value of 4 (black dashed line) and critical pH_{OX} value of 2.5 (red dashed line).

Acid Base Accounting

The acid base accounting data is provided in Table 45-4 and summarised in Figure 45-6.

Chromium reducible sulfur values ranged from below the detection limit to 0.42 %S_{CR}. Sulfidic materials were detected in all layers of profiles CNK1 and CNK3 that occurred in the low area of the wetland and also in the deep subsoil layer of CNK2 that corresponded with the clay wetland surface. For profile CNK2 values were below detection limits for the encroaching sandy soil material in the upper layers.

Titratable actual acidity values ranged from 0 to 4.67 mole H^+/tonne. Concentrations were measured in the upper layers for all profiles.

Analysis of retained acidity was not conducted on any of the samples, as all samples were above the critical value of pHK_{Cl} <4.5.

Acid neutralising capacity values ranged from 0 to 1.74 %$CaCO_3$, and were measured in the lower subsoil layers of all three profiles.

Net acidity values ranged from -65 to 84 mole H^+/tonne. Moderate and low net acidity values occurred in most layers of all profiles, and negative values occurred in the subsoil layers

Water Soluble Sulfate

Water soluble sulfate data values shown in Table 45-4 identified that surface layers were above the trigger value of 100 mg/kg SO_4.

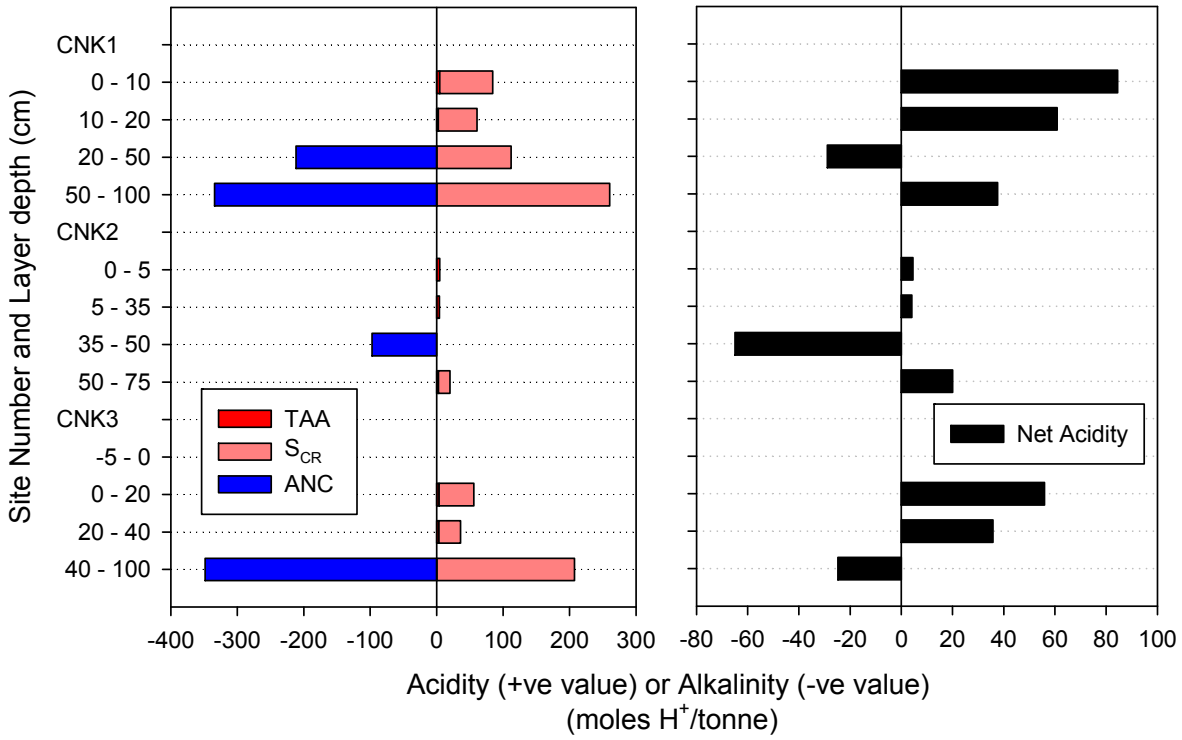

Figure 45-6. Acid base accounting depth profiles for Craignook wetland. Left side shows the components: titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} - pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.

45.4 DISCUSSION

Acid sulfate soil materials at Craignook Wetland were identified as sulfuric that were associated with the sandy soil layers on the margins of the wetland. Hypersulfidic soil materials were identified in the lower subsoil clays that occurred in the main area of the wetland. Hyposulfidic soil materials occurred where there was surface and soil water present and in the surface clay layers for the main area of the wetland

The main lower elevation area of the wetland was clay with cracks that extended deep into the subsoil. At the time of the survey (September 2008) the soil cracks were almost filled with water to the surface. The hypersulfidic subsoil layers were probably prevented from forming sulfuric material by the high water table, but if the water table lowered then it is likely that sulfuric material would form. The ground water seep that occurred in an isolated area of the wetland had subsoils with a high acid neutralising capacity probably due to the ground water influence.

Surrounding the wetland at higher elevations on the margins was sand encroaching onto the wetland. The upper layers of these soils were sulfuric. These areas would be the last to inundate when the wetland water levels rise, but before then they would likely contribute to acidification hazard through rainfall and runoff.

The potential hazards posed by acid sulfate soil materials at the Craignook Wetland are:

- Acidification hazard: Sulfuric soil material was identified on the wetland margins and if the water level drops in the main area of the wetland then the hypersulfidic soil layers would potentially oxidise to form sulfuric material. There is a medium to high level of concern.
- De-oxygenation hazard: The water soluble sulfate data indicated a potential for monosulfidic materials to form in the surface layers of soils, although monosulfidic material was not observed. There is a high level of concern.
- Metal mobilisation hazard: The medium to high acidification hazard indicates that soil acidification potential may increase the solubility of metals. There is a medium level of concern.

Summary of key findings for Craignook Wetland:

Soil materials:	The main area of the wetland had cracking clay soils that were hard with surface and subsoil layers identified as hyposulfidic or hypersulfidic. On the wetland margins where sand had encroached over the wetland there were sandy layers identified as sulfuric over a subsoil layer that was similar to the clayey hypersulfidic soil materials of the main wetland area.
Acid sulfate soil identification:	• Hypersulfidic Cracking Clay Soil – that occurred throughout at low to mid elevation. Dominant (>50%) in extent. • Sulfuric Soil – that occurred on the margins of the wetland at the higher elevation. Minor (<25%) in extent. • Hyposulfidic Cracking Clay Soil – that occurred at low elevation near cliff side where ground water seeps probably occurred. Isolated (<10%) in extent.
Hazard assessment	• Acidification hazard – medium to high level of concern • De-oxygenation hazard – high level of concern • Metal mobilisation hazard – medium level of concern

Table 45-2. Site data for Craignook Wetland.

Site Number	Sampled Date	Easting m Zone 54H	Northing m Zone 54H	Soil Classification	Water depth (+ve) Water table (-ve)	Surface Condition	Earth Cover (Vegetation)	Location Notes
CNK1	10-Sep-08	373677	6139479	Hypersulfidic cracking clay soil	10	cracking, crumbling	Bare	low, middle of wetland, water table pH5.8
CNK2	10-Sep-08	373696	6139555	Sulfuric soil	not reached	sealed	Bare	high,
CNK3	10-Sep-08	373557	6139533	Hyposulfidic cracking clay soil	-5	water	Water	low,

Table 45-3. Soil description data for Craignook Wetland.

Site and Sample Number	Depth Upper (cm)	Depth Lower (cm)	Observation Method (kind)	Soil Colour (Munsell notation)	Texture (class)	Soil Water Status	Mottles Quantity (%)	Mottles Colour	Mottles Location	Structure Type (category)	Consistence (category)	Comments
CNK1.1	0	10	soil pit	2.5Y 3/1	clay	moist	0			angular blocky	friable	
CNK1.2	10	20	soil pit	2.5Y 3/1	clay	wet	0			angular blocky	friable	
CNK1.3	20	50	soil pit	2.5Y 3/1	clay	wet	0			massive	firm	contains sand lenses
CNK1.4	50	100	push tube	2.5Y 2.5/1	clay	wet	0			massive	firm	
CNK2.1	0	5	soil pit	2.5Y 6/2	sand	dry	3	10YR 6/8	in matrix	single grain	loose	
CNK2.2	5	35	soil pit	2.5Y 6/2	sand	dry	3	10YR 6/8	in matrix	single grain	friable	
CNK2.3	35	50	soil pit	2.5Y 5/2	sand	moist	0			single grain	friable	
CNK2.4	50	75	push tube	2.5Y 4/1	sandy clay loam	moist	0			massive	firm	too hard to auger below this layer
CNK3.0	-5	0	water		water	wet	0					
CNK3.1	0	20	soil pit	2.5Y 2.5/1	clay	wet	10	5YR 6/8	on ped faces	subangular blocky	friable	
CNK3.2	20	40	push tube	2.5Y 2.5/1	clay	wet	10	5YR 6/8	in matrix	massive	firm	
CNK3.3	40	100	push tube	2.5Y 2.5/1	clay	wet	0			massive	firm	

Table 45-4. Laboratory data for acid sulfate soil assessment of Craignook Wetland.

(red printed values indicates data results of concern)

Site and Layer ID.	Depth Range (cm)	Soil Texture	EC (µS/cm)	pH water	pH peroxide	pH incubation	Sulfate (mg SO_4/kg)	pH KCl	Titratable Actual Acidity (mole H^+/ tonne)	Chromium Reducible Sulfur (%S_{CR})	Acid Neutralising Capacity (%$CaCO_3$)	Net Acidity (mole H^+/ tonne)	Acid Sulfate Soil Material Classification
CNK1.1	0 - 10	Fine	-	5.29	2.15	4.36	5905	5.78	4.67	0.13	0.00	84	hyposulfidic (S_{CR}≥0.10%)
CNK1.2	10 - 20	Fine	-	5.66	2.13	4.68	5789	5.92	2.52	0.09	0.00	61	hyposulfidic (S_{CR}<0.10%)
CNK1.3	20 - 50	Fine	-	7.27	3.15	3.74	2478	6.97	-	0.18	1.06	-29	hypersulfidic
CNK1.4	50 - 100	Fine	-	7.57	1.81	3.44	1356	7.70	-	0.42	1.67	38	hypersulfidic
CNK2.1	0 - 5	Coarse	-	3.55	2.40	3.51	272	4.89	4.57	< 0.01	0.00	5	sulfuric
CNK2.2	5 - 35	Coarse	-	3.89	2.41	3.64	206	4.95	4.09	< 0.01	0.00	4	sulfuric
CNK2.3	35 - 50	Coarse	-	7.94	5.73	7.29	540	9.63	-	< 0.01	0.49	-65	other soil material
CNK2.4	50 - 75	Medium	-	6.09	2.66	2.40	920	6.26	2.93	0.03	0.00	20	hypersulfidic
CNK3.0	-5 - 0	Water	-	-	-	-	-	-	-	-	-	-	water
CNK3.1	0 - 20	Fine	-	6.79	2.47	4.50	1141	6.16	3.70	0.08	0.00	56	hyposulfidic (S_{CR}<0.10%)
CNK3.2	20 - 40	Fine	-	6.10	2.82	4.50	2277	6.07	3.26	0.05	0.00	36	hyposulfidic (S_{CR}<0.10%)
CNK3.3	40 - 100	Fine	-	7.52	3.62	4.50	732	8.25	-	0.33	1.74	-25	hyposulfidic (S_{CR}≥0.10%)

46 SALTBUSH FLAT WETLAND (WETLAND ID. 12105, 12106, 12107)

46.1 LOCATION AND SETTING DESCRIPTION

Saltbush Flat Wetland (Wetland ID. 12105, 12106, 12107) is situated on the north-eastern side of the River Murray, down river from the Purnong car ferry. The wetland is geomorphically categorised as a Murray Gorge basin (Pressey 1986) and is an irregular shape with one large area that then forms a long channel against the cliff at the down river end. There is another separate wetland isolated between this channel and the main river bank, with a total surface area of 102 hectares. It is bounded to the north-east by a cliff and hill slope and to the south-west there is a floodplain 100 to 200 metres wide that separates the wetland from the river. There is one narrow water connection channel with the river at the down-river end and another channel approximately midway that goes through the river bank. At the time when the soil survey was conducted in August 2008, the wetland was generally dry. Surrounding the wetland and in the channels at a slightly higher elevation were *Typha latifolia* (Bulrush) and *Phragmites australis* (Common Reed) vegetation often associated with a sandy soil surface, and trees on the raised floodplain. Four sites were described and sampled and their locations are shown in Figure 46-1.

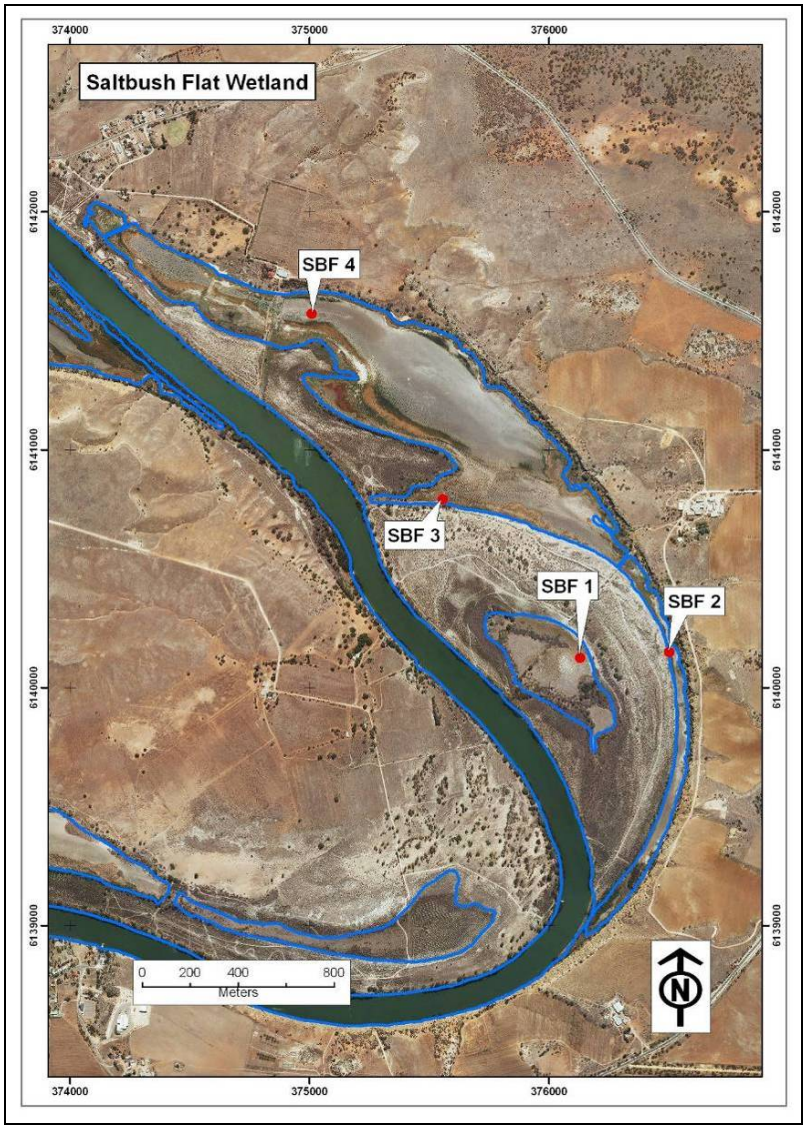

Figure 46-1. Saltbush Flat Wetland and sample site locations.

46.2 SOIL PROFILE DESCRIPTION AND DISTRIBUTION

Four sites were described and sampled. The acid sulfate soil subtype class and general location description are presented in Table 46-1. The sites were located to characterise different landscape position observed in the different areas of the wetland. The site and soil profile descriptions are presented in Table 46-2 and Table 46-3.

Site SBF1 (Figure 46-2) occurred in a salt flat with salt tolerant species and grasses covering the entire area, the soil consisted of black, firm, clay over clay too hard to dig.

Site SBF2 (Figure 46-3) occurred in a water pond at the base of the cliff, surrounded by *Phragmites australis* (Common Reed) and was part of the narrow channel to the downstream outlet, the water was probably from a spring or seepage from the cliffs, the water was about 10 centimetres deep, and the soil consisted of black, soft peaty clay over olive grey, firm clay.

Site SBF3 (Figure 46-4) occurred in the mid to high elevation near the river and on the side of an inlet which had dense growth of *Phragmites australis* (Common Reed). The soil consisted of dark brown friable clay, over grey firm clay.

Site SBF4 (Figure 46-5) occurred in a relatively bare area where the surface was cracking and had broken into aggregates. The soil consisted of dark grey friable clay, over olive grey, firm clay

Table 46-1. Soil identification, subtype and general location description of sites for Saltbush Flat Wetland.

Site ID	Easting m Zone 54H	Northing m Zone 54H	Acid sulfate soil subtype class	General location description
SBF1	376132	6140125	Other soil (clay)	High elevation, salt flat and high flood plain
SBF2	376503	6140150	Hypersulfidic soil	Low elevation, near cliff side where there was ground water seep
SBF3	375557	6140791	Hyposulfidic soil	Mid to high elevation, on the margins of the wetland where *Phragmites australis* (Common Reed) grow
SBF4	375010	6141573	Hypersulfidic cracking clay soil	Low elevation, throughout where there were cracking soils

Figure 46-2. Photograph of site SBF1, showing the soil profile of a well structured firm clay soil.

Figure 46-3. Photograph of site SBF2, showing surface water near the base of the cliff.

Figure 46-4. Photograph of site SBF3, showing the soil profile core with upper soil of brown friable clay on the left and grey firm clay on the right.

Figure 46-5. Photographs of site SBF4, showing the main wetland landscape of cracking clay surface, and the soil profile of friable, grey clay and the water table at about 35 cm.

46.3 LABORATORY DATA ASSESSMENT

Soil pH testing (pH_W, pH_{OX}, pH_{INC})

The pH data are provided in Table 46-4 and pH profiles are presented in Figure 46-6.

The pH_W data did not identify samples as sulfuric materials with a pH_W <4.

The pH_{INC} data for the subsoil layer of profile SBF2 and the surface layer of profile SBF4 identified samples that on incubation declined below the critical value of pH<4. Samples that age to pH_{INC}<4 indicate that these soils potentially would form sulfuric material as a result of sulfide oxidation.

The pH_{OX} data for all layers of profile SBF2 and the surface layers of profiles SBF3 and SBF4 identified samples below the critical value of pH_{OX} <2.5, the threshold value normally used to indicate a high likelihood of sulfuric material forming.

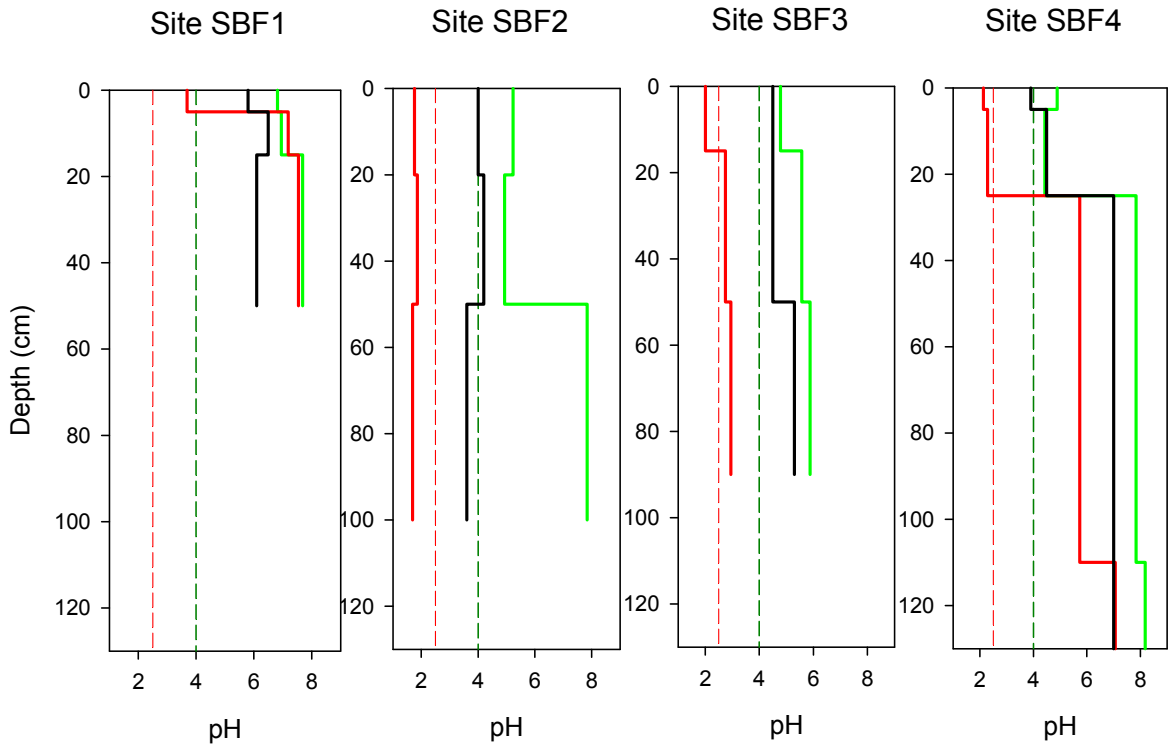

Figure 46-6. Depth profiles of soil pH for Salt Bush Flat Wetland, showing soil pH (pH_W as green line), peroxide treated pH (pH_{OX} as red line) and ageing pH (pH_{INC} after 28 weeks as black line). Critical pH_W and pH_{INC} value of 4 (black dashed line) and critical pH_{OX} value of 2.5 (red dashed line).

Acid Base Accounting

The acid base accounting data is provided in Table 46-4 and summarised in Figure 46-7.

Chromium reducible sulfur values ranged from below the detection limit to 0.23 %S_{CR}. Sulfidic materials were detected in all layers of profile SBF2, in the upper soil layers of profile SBF4. All layers of profiles SBF1 and SBF3 were at or below the detection limit.

Titratable actual acidity values ranged from 0 to 40.08 mole H^+/tonne. Concentrations were measured in most of the sampled layers.

Analysis of retained acidity was not conducted on any of the samples, however retained acidity may be present in the surface layers of profiles SBF2 and SBF4 that were below the critical value of pH_{KCl} <4.5.

Acid neutralising capacity values ranged from 0 to 0.98 %$CaCO_3$, and were measured in the lower subsoil layers of profiles SBF1, SBF2, and SBF4.

Net acidity values ranged from -130 to 111 mole H^+/tonne. High, net acidity values occurred in the upper layers of profile SBF2 while negative net acidity values occurred in the lower layers of profiles SBF1 and SBF4. Moderate and low net acidity values occurred in profiles SBF3 and upper layers of SBF1.

Water Soluble Sulfate

Water soluble sulfate data values shown in Table 46-4 identified that surface layers were above the trigger value of 100 mg/kg SO_4.

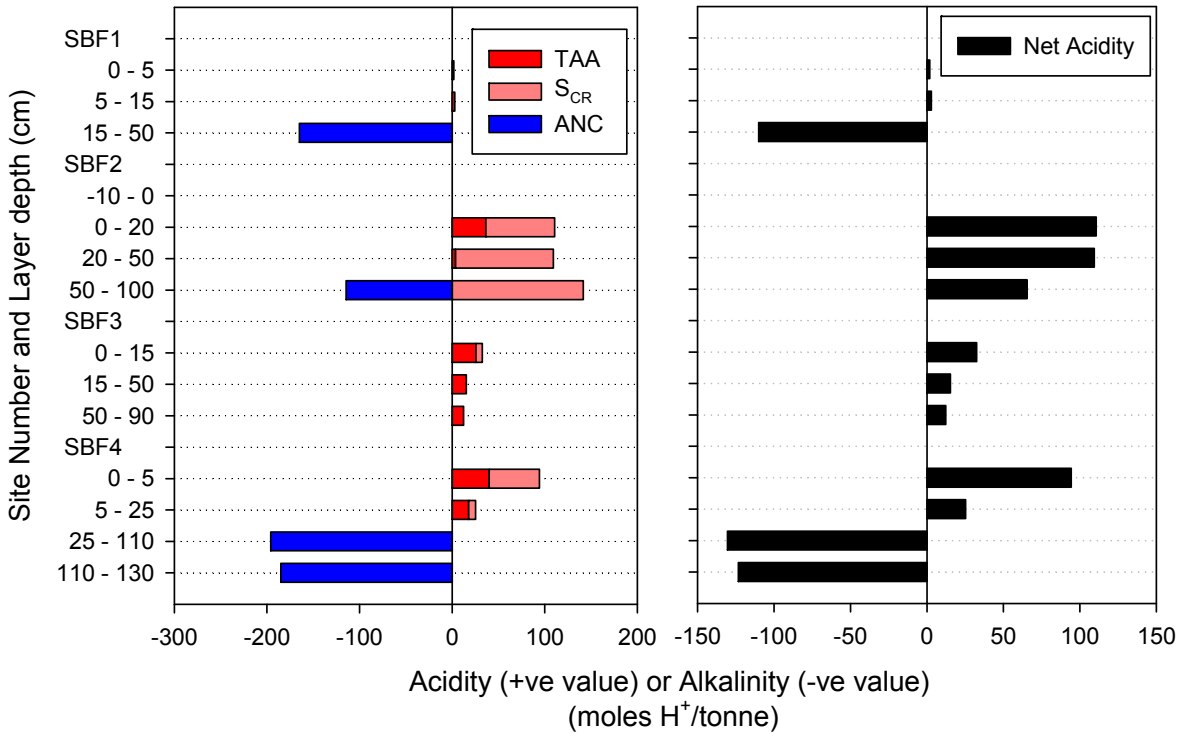

Figure 46-7. Acid base accounting depth profiles for Salt Bush Flat Wetland. Left side shows the components: titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} -pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.

46.4 DISCUSSION

Acid sulfate soil materials at Saltbush Flat Wetland were identified as hypersulfidic that occurred in the surface soil layer through the low elevation main area of the wetland and in the subsoil near the cliff water seep area. Hyposulfidic soil material occurred in the surface or upper layers for the profiles in the main area of the wetland. Elsewhere the soil materials were acidic or not of concern.

The main lower elevation areas of the wetland were clayey with shallow cracks and a thin (5 cm) hypersulfidic surface layer. Below this layer were hyposulfidic and other soil materials.

The inlet channel from the river into the middle section of the wetland had dense *Phragmites australis* (Common Reed) vegetation over hyposulfidic soil material. The soil was wet at the time of sampling but could become a concern if it dried allowing oxidation to occur.

The potential hazards posed by acid sulfate soil materials at the Saltbush Flat Wetland are:

- Acidification hazard: The main area of the wetland at the surface was hypersulfidic and elsewhere hyposulfidic. There is a medium to high level of concern.
- De-oxygenation Hazard: The water soluble sulfate data indicated a potential for monosulfidic materials to form in the surface layers of soils, although monosulfidic material was not observed. There is a high level of concern.
- Metal mobilisation hazard: The medium to high acidification hazard indicates that soil acidification potential may increase the solubility of metals. There is a medium level of concern.

Summary of key findings for Saltbush Flat Wetland:

Soil materials:	The soils through the main area of the wetland were clays with cracking soil surface that were generally hypersulfidic and in some areas hyposulfidic. The subsoil materials were clayey, and hypersulfidic material identified in one profile but generally would not be considered to be of concern.
Acid sulfate soil identification:	• Hypersulfidic Cracking Cay Soil – that occurred throughout. Dominant (>50%) in extent. • Other Soil (clayey) – that occurred on elevated salt flat. Minor (<25%) in extent. • Hyposulfidic Soil – that occurred on margins. Minor (<25%) in extent.
Hazard assessment	• Acidification hazard – medium to high level of concern • De-oxygenation hazard – high level of concern • Metal mobilisation hazard – medium level of concern

Table 46-2. Site data for Saltbush Flat Wetland.

Site Number	Sampled Date	Easting m Zone 54H	Northing m Zone 54H	Soil Classification	Water depth (+ve) Water table (-ve)	Surface Condition	Earth Cover (Vegetation)	Location Notes
SBF1	29-Aug-08	376132	6140125	Other soil (clay)	not reached	sealed, cracking	grasses, weeds	low,
SBF2	29-Aug-08	376503	6140150	Hyposulfidic soil	-10	water	Water	low,
SBF3	29-Aug-08	375557	6140791	Hyposulfidic soil	not reached	plant material	*Phragmites australis* (Common Reed)	low, in channel,
SBF4	29-Aug-08	375010	6141573	Hypersulfidic cracking clay soil	35	crumbling	Bare	low,

Table 46-3. Soil description data for Saltbush Flat Wetland.

Site and Sample Number	Depth Upper (cm)	Depth Lower (cm)	Observation Method (kind)	Soil Colour (Munsell notation)	Texture (class)	Soil Water Status	Mottles Quantity (%)	Mottles Colour	Mottles Location	Structure Type (category)	Consistence (category)	Comments
SBF1.1	0	5	soil pit	2.5Y 5/2	sandy clay loam	dry	0			massive	loose	
SBF1.2	5	15	soil pit	2.5Y 3/1	clay	moist	0			massive	firm	
SBF1.3	15	50	soil pit	2.5Y 2.5/1	clay	moist	0			subangular blocky	very firm	too hard to dig below this layer
SBF2.0	-10	0	water		water	wet	0					
SBF2.1	0	20	push tube	2.5Y 2.5/1	peaty clay	wet	0			massive	soft	
SBF2.2	20	50	push tube	5Y 3/1	clay	wet	2	10YR 6/8	in matrix	massive	firm	
SBF2.3	50	100	push tube	5Y 3/2	clay	wet	2	10YR 6/8	in matrix	massive	firm	
SBF3.1	0	15	soil pit	10YR 3/2	clay	moist	0			massive	friable	contains plant material
SBF3.2	15	50	soil pit	10YR 3/1	clay	moist	15	10YR 6/8	in matrix adjacent to pores	subangular blocky	firm	
SBF3.3	50	90	push tube	10YR 2/1	clay	moist	15	10YR 6/8	in matrix adjacent to pores	massive	firm	
SBF4.1	0	5	soil pit	10YR 6/1	clay	moist	0			cloddy	friable	
SBF4.2	5	25	soil pit	10YR 4/1	clay	moist	15	10YR 6/8	in matrix along ped faces	subangular blocky	very firm	
SBF4.3	25	110	soil pit	5Y 4/1	clay	wet	0			subangular blocky	friable	
SBF4.4	110	130	push tube	5Y 4/2	clay	wet	0			massive	firm	
SBF4.5	130	135	push tube	5Y 2.5/1	peaty clay	wet	0			massive	firm	

Table 46-4. Laboratory data for acid sulfate soil assessment of Saltbush Flat Wetland.

(red printed values indicates data results of concern)

Site and Layer ID.	Depth Range (cm)	Soil Texture	EC (µS/cm)	pH water	pH peroxide	pH incubation	Sulfate (mg SO_4/kg)	pH KCl	Titratable Actual Acidity (mole H^+/ tonne)	Chromium Reducible Sulfur (%S_{CR})	Acid Neutralising Capacity (%$CaCO_3$)	Net Acidity (mole H^+/ tonne)	Acid Sulfate Soil Material Classification
SBF1.1	0 - 5	Medium	-	6.82	3.69	5.80	184	6.04	1.89	< 0.01	0.00	2	other soil material
SBF1.2	5 - 15	Fine	-	6.95	7.19	6.50	834	6.17	2.92	< 0.01	0.00	3	other soil material
SBF1.3	15 - 50	Fine	-	7.69	7.54	6.10	698	6.75	-	< 0.01	0.83	-110	other soil material
SBF2.0	-10 - 0	Water	-	-	-	-	-	-	-	-	-	-	water
SBF2.1	0 - 20	Fine	-	5.23	1.76	4.00	6531	4.39	36.32	0.12	0.00	111	hyposulfidic (S_{CR}≥0.10%)
SBF2.2	20 - 50	Fine	-	4.93	1.86	4.20	3804	5.83	3.65	0.17	0.00	109	hyposulfidic (S_{CR}≥0.10%)
SBF2.3	50 - 100	Fine	-	7.84	1.69	3.60	1833	7.28	0.00	0.23	0.57	65	hypersulfidic
SBF3.1	0 - 15	Fine	-	4.78	2.01	4.50	5169	4.66	25.75	0.01	0.00	33	hyposulfidic (S_{CR}<0.10%)
SBF3.2	15 - 50	Fine	-	5.57	2.75	4.50	1215	4.99	15.30	< 0.01	0.00	15	other acidic
SBF3.3	50 - 90	Fine	-	5.88	2.95	5.30	1428	5.44	12.35	< 0.01	0.00	12	other acidic
SBF4.1	0 - 5	Fine	-	4.89	2.13	3.90	3895	4.11	40.08	0.09	0.00	94	hypersulfidic
SBF4.2	5 - 25	Fine	-	4.43	2.29	4.50	3754	4.89	17.96	0.01	0.00	25	hyposulfidic (S_{CR}<0.10%)
SBF4.3	25 - 110	Fine	-	7.84	5.73	7.00	954	7.20	-	< 0.01	0.98	-130	other soil material
SBF4.4	110 - 130	Fine	-	8.18	7.06	7.00	878	7.22	-	< 0.01	0.92	-123	other soil material
SBF4.5	130 - 135	Fine	-	-	-	-	-	-	-	-	-	-	-

47 CAURNAMONT WETLAND (WETLAND ID. 12015)

47.1 LOCATION AND SETTING DESCRIPTION

Caurnamont Wetland (Wetland ID. 12015) is situated on the south western side of the River Murray, adjacent to the Purnong car ferry ramp. The wetland is geomorphically categorised as a Murray Gorge basin (Pressey 1986) and is an irregular shape that is divided by a raised spit, approximately 4 kilometres in length and varies greatly in width, with a total surface area of 90 hectares. It is bounded to the south-west by a cliff and hill slope and to the northwest it is separated from the river by a 100 to 200 metre wide floodplain with a road and buildings on it. The wetland has two water connections to the river channel, one at the up river end and the other at the down river end. At the time when the soil survey was conducted in September 2008, the wetland was generally dry and there was no surface water. The wetland was predominantly bare with cracking clay surfaces that had broken down to crumbly aggregates, fringing the bare area were isolated areas of *Typha latifolia* (Bulrush) and *Phragmites australis* (Common Reed) vegetation, and trees on the floodplain area. Three sites were described and sampled and their locations are shown in Figure 47-1.

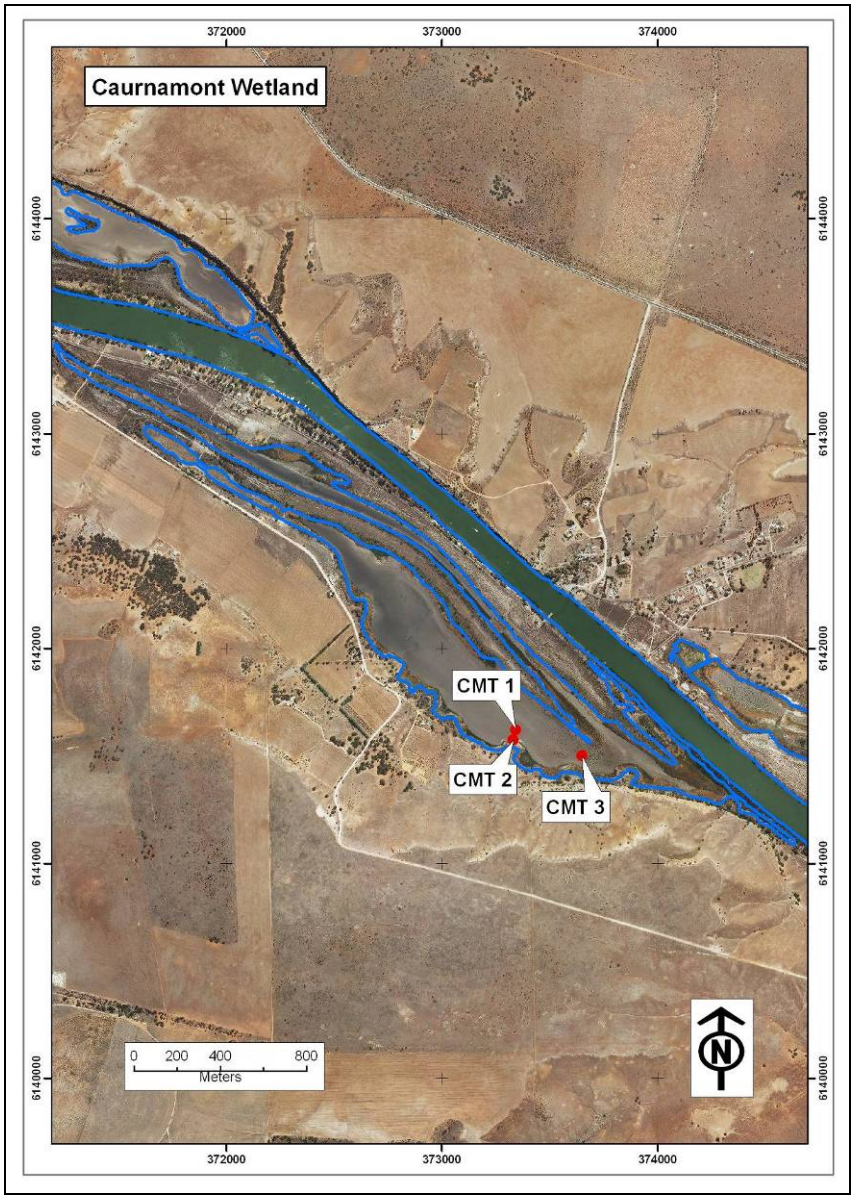

Figure 47-1. Caurnamont Wetland and sample site locations.

47.2 SOIL PROFILE DESCRIPTION AND DISTRIBUTION

Three sites were described and sampled. The acid sulfate soil subtype class and general landscape description are presented in Table 47-1. Sites where located to form a transect that characterised the low to mid area (CMT1) and the higher area (CMT2), and another low area where vegetation was encroaching (CMT3). The site and soil profile descriptions are presented in Table 47-2 and Table 47-3.

Site CMT1 (Figure 47-2) occurred in the mid to low elevation area and was typical of most of the wetland. The soil consisted of dark grey, very firm, clay over clay too hard to dig.

Site CMT2 (Figure 47-3) occurred on the higher edge of the wetland where sand has encroached from the surrounding hill slopes. The soil consisted of reddish brown, loose sandy over dark grey very firm clay.

Site CMT3 (Figure 47-4) occurred in the low area of the wetland where Persicaria lapathifolium (Pale Knotweed) was growing on the cracking clay surface that had broken down into aggregates. The soil consisted of black, slightly rigid clay over dark grey slightly rigid clay that became too hard to dig.

Table 47-1. Site ID, subtype and general landscape description of sites for Caurnamont Wetland.

Site ID	Easting m Zone 54H	Northing m Zone 54H	Acid sulfate soil subtype class	General landscape description
CMT1	373342	6141621	Hyposulfidic cracking clay soil	Low to mid elevation, cracking clay soil area
CMT2	373330	6141575	Other acidic (sand over clay)	Higher elevation, on the margins of the wetland where sand encroaches
CMT3	373651	6141500	Other acidic (cracking clay)	Low elevation, cracking clay area

Figure 47-2: Photographs of site CMT1, showing the wetland landscape to the northwest from the profile location with broken surface aggregates that filled the cracking clay surface, and the soil profile with very hard grey clay below about 30cm.

Figure 47-3. Photograph of profile CMT2, showing the soil profile with loose sand to about 15 cm over the grey clay.

Figure 47-4. Photograph of profile CMT3, showing the soil profile with aggregates in-filling the surface cracks and subsoil of rigid clay that was too hard to dig below 40 cm.

47.3 LABORATORY DATA ASSESSMENT

Soil pH testing (pH_W, pH_{OX}, pH_{INC})

The pH data are provided in Table 47-4 and pH profiles are presented in Figure 47-5.

The pH_W data did not identify samples as sulfuric materials with a pH_W <4.

The pH_{INC} data did not identify samples that on incubation declined below the critical value of pH<4. Samples that age to pH_{INC}<4 indicate that these soils potentially would form sulfuric material as a result of sulfide oxidation.

The pH_{OX} data for all layers in profile CMT1 identified samples below the critical value of pH_{OX} <2.5, the threshold value normally used to indicate a high likelihood of sulfuric material forming.

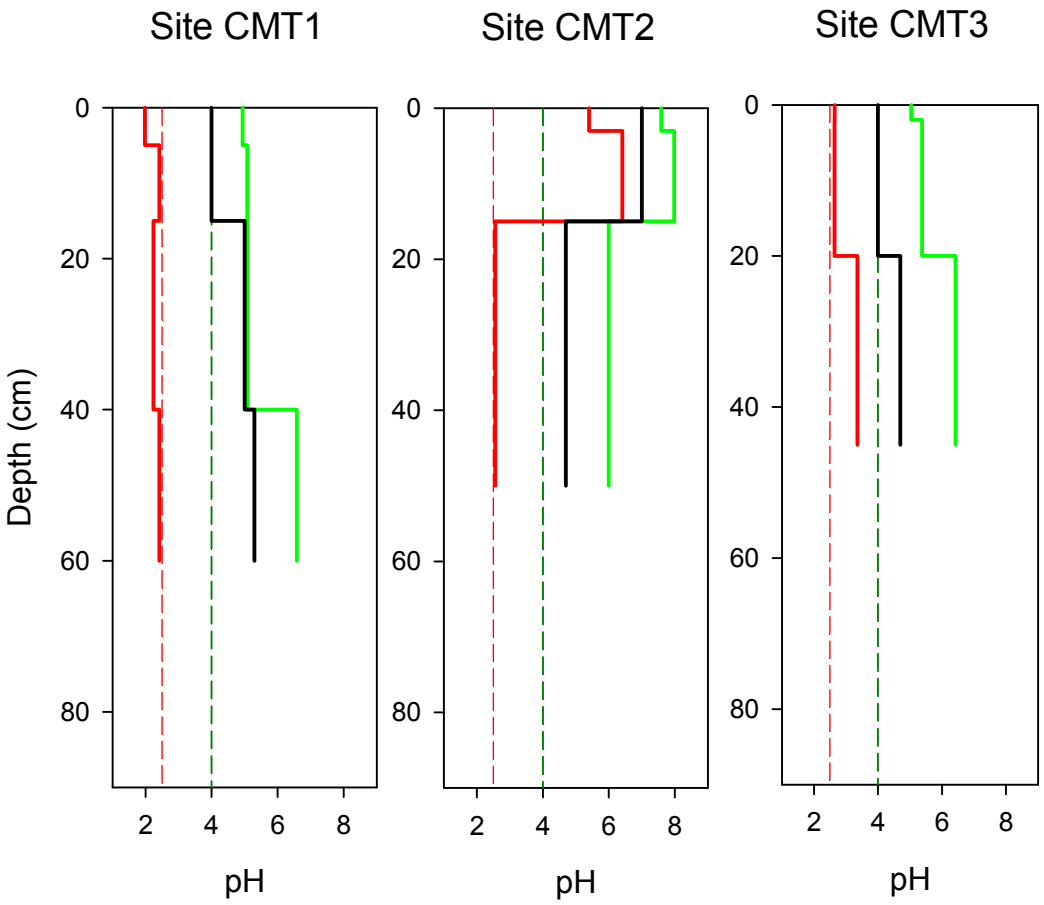

Figure 47-5. Depth profiles of soil pH for Caurnamont Wetland, showing soil pH (pH_W as green line), peroxide treated pH (pH_{OX} as red line) and ageing pH (pH_{INC} after 28 weeks as black line). Critical pH_W and pH_{INC} value of 4 (black dashed line) and critical pH_{OX} value of 2.5 (red dashed line).

Acid Base Accounting

The acid base accounting data is provided in Table 47-4 and summarised in Figure 47-6.

Chromium reducible sulfur values ranged from below the limit of detection to 0.01 $\%S_{CR}$. Sulfidic materials were detected in layers of profile CMT1, and for all other sampled layers sulfidic materials were not detected.

Titratable actual acidity values ranged from 0 to 26.95 mole H^+/tonne. Concentrations were measured in all layers, except for the surface layers of profile CMT2 that corresponded with the over sandy soil material

Analysis of retained acidity was not conducted on any of the samples, as all samples were above the critical value of pHK_{Cl} <4.5.

Acid neutralising capacity values ranged from 0 to 4.89 $\%CaCO_3$, and were measured in the upper layers of profile CMT2 which corresponded with the over sandy soil material. All other profile layers did not have measurable acid neutralising capacity.

Net acidity results ranged from -651 to 72 mole H^+/tonne. Low or moderate net acidity values occurred in most sampled layers, and negative values occurred in the sandy upper layers of profile CMT2.

Water Soluble Sulfate

Water soluble sulfate data values shown in Table 47-4 identified that surface layers were above the trigger value of 100 mg/kg SO_4.

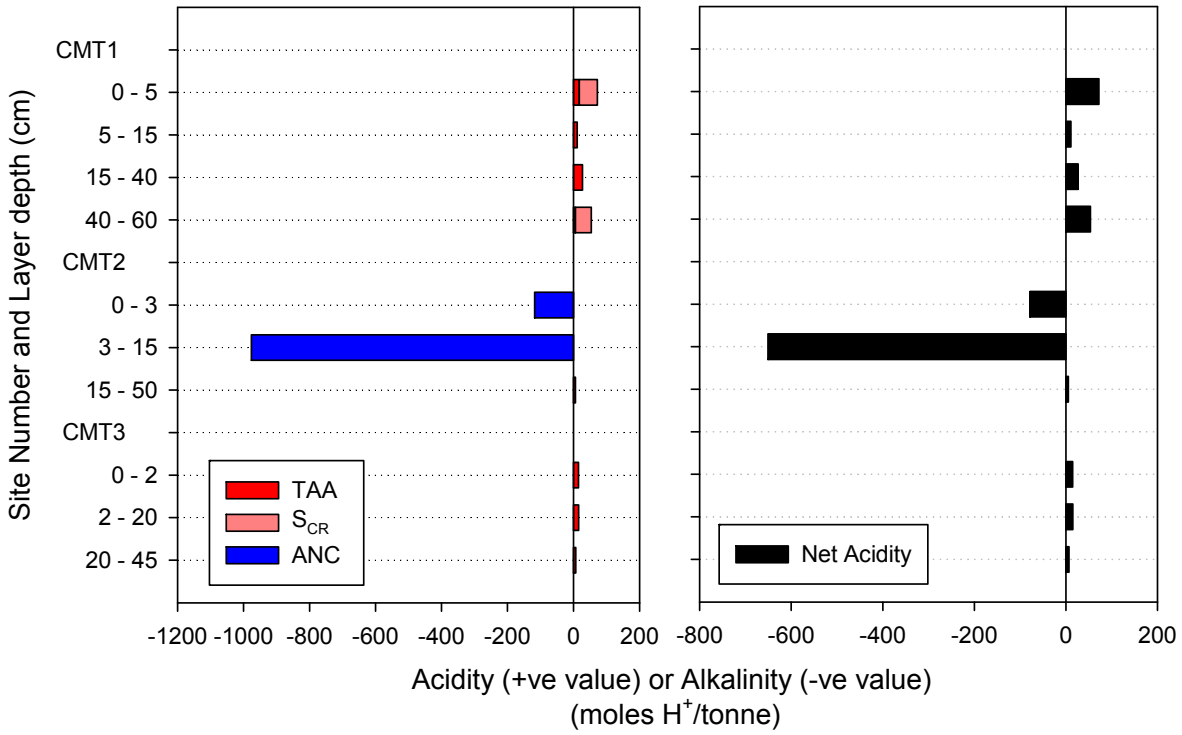

Figure 47-6. Acid base accounting depth profiles for Caurnamont Wetland. Left side shows the components: titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} -pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.

47.4 DISCUSSION

Acid sulfate soil materials at Caurnamont Wetland were identified as hyposulfidic that occurred as a surface soil layer associated with the cracking clay surface areas found throughout most of the low to mid elevation areas. The clay subsoils were characterised as other acidic soil materials, and the encroaching sand layers that occurred on the high margin areas on the hill slope side of the wetland were characterised as other soil materials.

The potential hazards posed by acid sulfate soil materials at the Caurnamont Wetland are:

- Acidification hazard: The acid sulfate soil materials identified were hyposulfidic that occurred as a surface soil layer. There is a low to medium level of concern.
- De-oxygenation hazard: The water soluble sulfate data indicated a potential for monosulfidic materials to form in the surface layers of soils, although monosulfidic material was not observed. There is a high level of concern.
- Metal mobilisation: The low to medium level acidification hazard indicates that soil acidification potential is not likely to increase the solubility of metals. There is a low level of concern.

Summary of key findings for Caurnamont Wetland:

Soil materials:	The surface soil layers throughout most of the wetland were hyposulfidic, often associated with the clay textured cracking surface. In some areas where sand was encroaching at higher elevations the surface sand layers were not identified as acidic soils. The subsoil layers throughout the wetland were generally clayey and identified as other acidic soil material.
Acid sulfate soil type identification:	• Hyposulfidic Cracking Clay Soil – that occurred in the low to mid elevations areas of the wetland where the surface was cracking. Dominant (>50%) in extent. • Other Acidic Soil (sandy over clayey) – that occurred at high elevation on the wetland margins where sand was encroaching. Minor (<25%) in extent. • Other Acidic Soil (clayey) – that occurred at low elevation near water channels. Isolated (<10%) in extent.
Hazard assessment	• Acidification hazard – low to medium level of concern • De-oxygenation hazard – high level of concern • Metal mobilisation hazard – low level of concern

Table 47-2. Site data for Caurnamont Wetland.

Site Number	Sampled Date	Easting m Zone 54H	Northing m Zone 54H	Soil Classification	Water depth (+ve) Water table (-ve)	Surface Condition	Earth Cover (Vegetation)	Location Notes
CMT1	10-Sep-08	373342	6141621	Hyposulfidic cracking clay soil	not reached	cracking, crumbling	Bare	mid, mid area of wetland,
CMT2	10-Sep-08	373330	6141575	Other acidic (sand over clay)	not reached	loose aggregates	Bare	high, vegetation fringe,
CMT3	10-Sep-08	373651	6141500	Other acidic (cracking clay)	not reached	cracking, crumbling	Persicaria lapathifolium (Pale Knotweed)	low, mid area of wetland,

Table 47-3. Soil description data for Caurnamont Wetland.

Site and Sample Number	Depth Upper (cm)	Depth Lower (cm)	Observation Method (kind)	Soil Colour (Munsell notation)	Texture (class)	Soil Water Status	Mottles Quantity (%)	Mottles Colour	Mottles Location	Structure Type (category)	Consistence (category)	Comments
CMT1.1	0	5	soil pit	2.5Y 4/1	clay	moist	3	10YR 8/1	on ped faces	angular blocky	friable	white salts on surface
CMT1.2	5	15	soil pit	2.5Y 4/1	clay	moist	3	10YR 6/8	on ped faces	subangular blocky	very firm	
CMT1.3	15	40	soil pit	2.5Y 3/1	clay	moist	10	10YR 6/8	in matrix	massive	very firm	
CMT1.4	40	60	push tube	2.5Y 3/1	clay	moist	0			massive	very firm	too hard to auger below this layer
CMT2.1	0	3	soil pit	10YR 5/6	sand	dry	0			single grain	loose	
CMT2.2	3	15	soil pit	10YR 5/6	sand	dry	10	5YR 6/8	in matrix	single grain	loose	
CMT2.3	15	50	soil pit	2.5Y 4/1	clay	moist	0			columnar	very firm	sand down cracks, too hard to auger below this layer
CMT3.1	0	2	soil pit	2.5Y 4/1	clay	dry	0			angular blocky	loose	
CMT3.2	2	20	soil pit	2.5Y 2.5/1	peaty clay	moist	0			massive	extremely firm	contains plant material
CMT3.3	20	45	soil pit	2.5Y 2.5/1	clay	moist	3	10YR 6/8	in matrix adjacent to pores	massive	extremely firm	too hard to dig below this layer

Table 47-4. Laboratory data for acid sulfate soil assessment of Caurnamont Wetland.

(red printed values indicates data results of concern)

Site and Layer ID.	Depth Range (cm)	Soil Texture	EC (µS/cm)	pH water	pH peroxide	pH incubation	Sulfate (mg SO_4/kg)	pH KCl	Titratable Actual Acidity (mole H^+/ tonne)	Chromium Reducible Sulfur (%S_{CR})	Acid Neutralising Capacity (%$CaCO_3$)	Net Acidity (mole H^+/ tonne)	Acid Sulfate Soil Material Classification
CMT1.1	0 - 5	Fine	-	4.94	1.98	4.00	1854	4.97	17.40	0.09	0.00	72	hyposulfidic (S_{CR}<0.10%)
CMT1.2	5 - 15	Fine	-	5.08	2.42	4.00	2776	5.35	11.34	< 0.01	0.00	12	other acidic
CMT1.3	15 - 40	Fine	-	5.09	2.24	5.00	1732	4.93	26.95	< 0.01	0.00	27	other acidic
CMT1.4	40 - 60	Fine	-	6.58	2.42	5.30	1032	6.03	5.69	0.08	0.00	54	hyposulfidic (S_{CR}<0.10%)
CMT2.1	0 - 3	Coarse	-	7.59	5.40	7.00	3130	9.18	-	< 0.01	0.59	-78	other soil material
CMT2.2	3 - 15	Coarse	-	7.98	6.41	7.00	526	9.78	-	< 0.01	4.89	-651	other soil material
CMT2.3	15 - 50	Fine	-	6.00	2.56	4.70	1097	5.98	5.47	< 0.01	0.00	5	other acidic
CMT3.1	0 - 2	Fine	-	5.04	2.65	4.00	1888	5.20	14.79	< 0.01	0.00	15	other acidic
CMT3.2	2 - 20	Fine	-	5.38	2.64	4.00	1085	5.43	15.14	< 0.01	0.00	15	other acidic
CMT3.3	20 - 45	Fine	-	6.42	3.36	4.70	413	5.87	6.74	< 0.01	0.00	7	other acidic

48 NORTH PURNONG WETLAND (WETLAND ID. 12718)

48.1 BACKGROUND

North Purnong Wetland is located on a bend on the northern side of the River Murray. The wetland is somewhat linear in shape, approximately 3.5 kilometres long, and 450 metres at the widest point. The wetland is bounded to the north by an eroded cliff, to the east by a steep cliff face and to the south and west by floodplain that separates it from the river. The wetland contains four islands. There are channels at the northern and southern ends connecting the wetland with the river.

This wetland was studied in 2007/08 as part of a separate monitoring investigation of acid sulfate soils, the work and data was presented in the report 'Acid sulfate soils in subaqueous, waterlogged and drained soil environments of nine wetlands below Blanchetown (Lock 1), South Australia: properties, genesis, risks and management' (Fitzpatrick, Shand, Thomas, Merry, Raven and Simpson, November 2008. Report prepared for South Australian Murray-Darling Basin Natural Resources Management Board. CSIRO Land and Water Science Report 42/08). Readers are referred to this report for detailed information, and here a summary of the findings are presented.

At the time of field sampling the wetland was dry. Sites were located along one transect from the north bank to the largest island 120 metres away. Site NPU2 was near the north shore, Sites NPU3 was half way between the north shore and the island in a locally low lying area, and NPU4 was located on the island amongst reeds. Four sites were located with the listed three sampled and their locations are shown in Figure 48-1.

Figure 48-1. North Purnong Wetland and sample site locations.

48.2 DISCUSSION

Acid sulfate soil materials at North Purnong Wetland were identified as sulfuric that occurred amongst reeds on the island, and hypersulfidic or hyposulfidic in the surface and subsoil layers throughout the main area of the wetland. The sandy soil material at the surface near the shore (Site NPU2) was characterised as other soil material.

The soils throughout the wetland were clays with wide soil cracks extending into the upper subsoil. In some areas these cracks had been filled with the break down of the surface soil material.

The potential hazards posed by acid sulfate soil materials at the North Purnong Wetland are:

- Acidification hazard: Sulfuric materials occur in isolated areas, hypersulfidic and hyposulfidic soil materials occur throughout the wetland. There is a medium to high level of concern.
- De-oxygenation hazard: No data was available, but based on judgement and comparison with other similar soils in the area there would be potential for monosulfidic materials to form in the surface layers of soils, although monosulfidic material was not observed. There is a high level of concern.
- Metal mobilisation hazard: The medium to high acidification hazard indicates that soil acidification potential may increase the solubility of metals. There is a medium level of concern.

Summary of key findings for North Purnong Wetland:

Soil materials:	The soils were clays with deep cracks into the subsoil, the surface and subsurface layers throughout the wetland were hypersulfidic and hyposulfidic. Soil layers on the island were sulfuric.
Acid sulfate soil identification:	• Hypersulfidic Cracking Clay Soils – occurring throughout the wetland. Dominant (>50%) in extent. • Cracking Clay Soils – occurring on the northern and eastern margins of the wetland. Isolated (<10%) in extent. • Sulfuric Cracking Clay Soils – occurring on sandy islands and areas where reeds are growing. (Isolated (<10%) in extent.
Hazard assessment	• Acidification hazard – medium to high level of concern • De-oxygenation hazard – high level of concern • Metal mobilisation hazard – medium level of concern

49 NORTH CAURNAMONT WETLAND (WETLAND ID. 12112)

49.1 LOCATION AND SETTING DESCRIPTION

North Caurnamont Wetland (Wetland ID. 12112) is situated on the western side of the River Murray, up river from the Purnong car ferry. The wetland is geomorphically categorised as a Murray Gorge basin (Pressey 1986) and is irregular in shape. It is over 3 kilometres in length and varies greatly in width up to 500 metres at the widest, with a total surface area of 73 hectares. The wetland is bounded on the western side by a cliff and on the eastern side by floodplain approximately 100 metres wide. There are narrow water connection channels with the river at the southern end of the wetland. At the time when the soil survey was conducted in September 2008 the wetland was dry and there was no surface water. The wetland had a cracking clay surface but was dry long enough for plants to start regrowing in some areas and in other areas a cereal crop had been planted. On the wetland margins there were isolated areas of *Typha latifolia* (Bulrush) and *Phragmites australis* (Common Reed) vegetation and trees growing on the floodplain area. Four sites were described and sampled and their locations are shown in Figure 49-1.

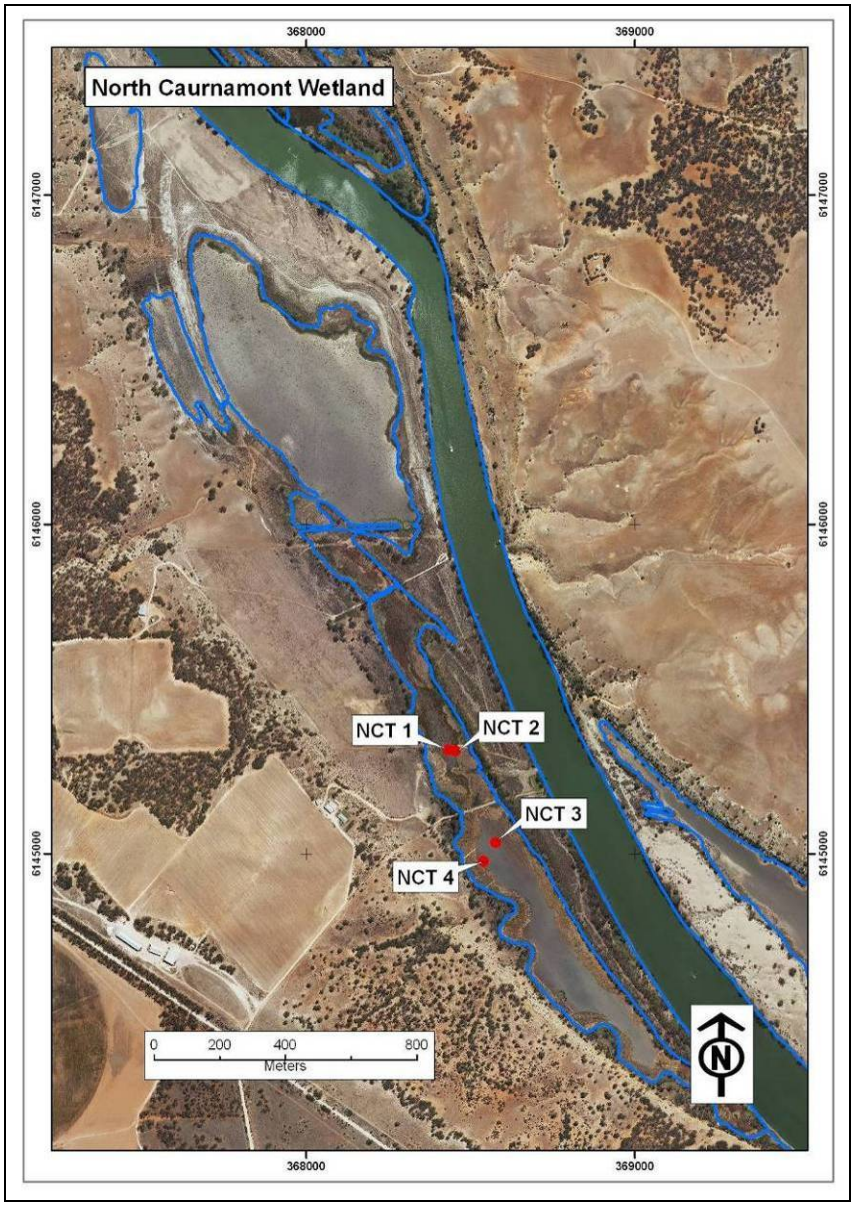

Figure 49-1. North Caurnamont Wetland and sample site locations.

49.2 SOIL PROFILE DESCRIPTION AND DISTRIBUTION

Four sites were described and sampled. The acid sulfate soil subtype class and general location description are presented in Table 49-1. The sites were paired to characterise the northern end of the wetland (NCT1 and NCT2) and the main area of the wetland (NCT3 and NCT4). The site and soil profile descriptions are presented in Table 49-2 and Table 49-3.

Site NCT1 (Figure 49-2) occurred in a bare area mid way across the wetland. The soil consisted of black, slightly rigid, clay, over clay that was too hard to dig.

Site NCT2 (Figure 49-3) occurred on the wetland margin where *Typha latifolia* (Bulrush) was growing. The soil consisted of black, very firm, clay, over clay that was too hard to dig.

Site NCT3 (Figure 49-4) occurred in the low elevation area of the wetland that was characteristic of a large portion of the wetland. A cereal crop was growing on the cracking clay surface that had been tilled into large clods. The soil consisted of black, rigid, clay, over clay that was too hard to dig.

Site NCT4 (Figure 49-5) occurred at a higher elevation where *Typha latifolia* (Bulrush) was growing on the wetland margins. The soil consisted of dark grey, rigid, clay, over clay that was too hard to dig.

Table 49-1. Soil identification, subtype and general location description of sites for North Caurnamont Wetland.

Site ID	Easting m zone 54H	Northing m zone 54H	Acid sulfate soil subtype class	General location description
NCT1	368434	6145316	Hyposulfidic cracking clay soil	Low elevation, near centre of wetland
NCT2	368455	6145312	Hyposulfidic soil	Mid elevation, adjacent to vegetation on wetland margin
NCT3	368578	6145035	Hyposulfidic soil	Low elevation, near centre of wetland
NCT4	368541	6144977	Hyposulfidic cracking clay soil	High elevation, adjacent to vegetation on wetland margin

Figure 49-2. Photographs of site NCT1, showing the site location where the surface was bare, and the soil profile of black, slightly rigid, clay.

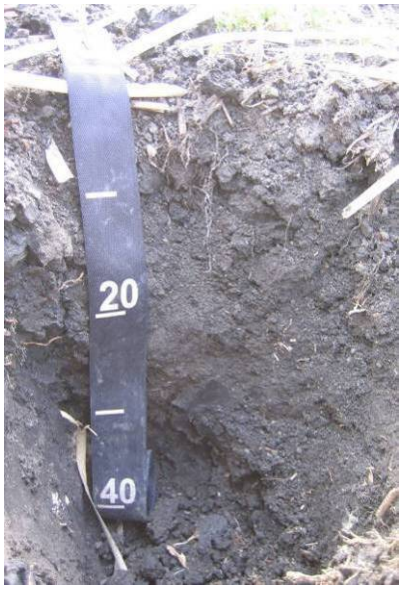

Figure 49-3. Photographs of site NCT2, showing the wetland margin where bulrushes were growing, and the soil profile of black, very firm, clay.

Figure 49-4. Photographs of site NCT3, showing the main wetland area where cereal crop was growing in the cloddy surface, and the soil profile of black, rigid, clay.

Figure 49-5. Photographs of site NCT4, showing the wetland margin, and the soil profile of rigid, clay.

49.3 LABORATORY DATA ASSESSMENT

Soil pH testing (pH_W, pH_{OX}, pH_{INC})

The pH data is presented in Table 49-4 and pH profiles are presented in Figure 49-6.

The pH_W data did not identify sulfuric materials with a pH_W <4.

The pH_{INC} data did not identify samples that on incubation declined below the critical value of pH <4. Samples that age to pH_{INC}<4 indicate that these soils potentially would form sulfuric materials as a result of sulfide oxidation.

The pH_{OX} data for the surface layers of profiles NCT1, NCT2, and NCT3 and subsoil layers of NCT4 identified samples below the critical value of pH_{OX} <2.5, the threshold value normally used to indicate a high likelihood of sulfuric material forming.

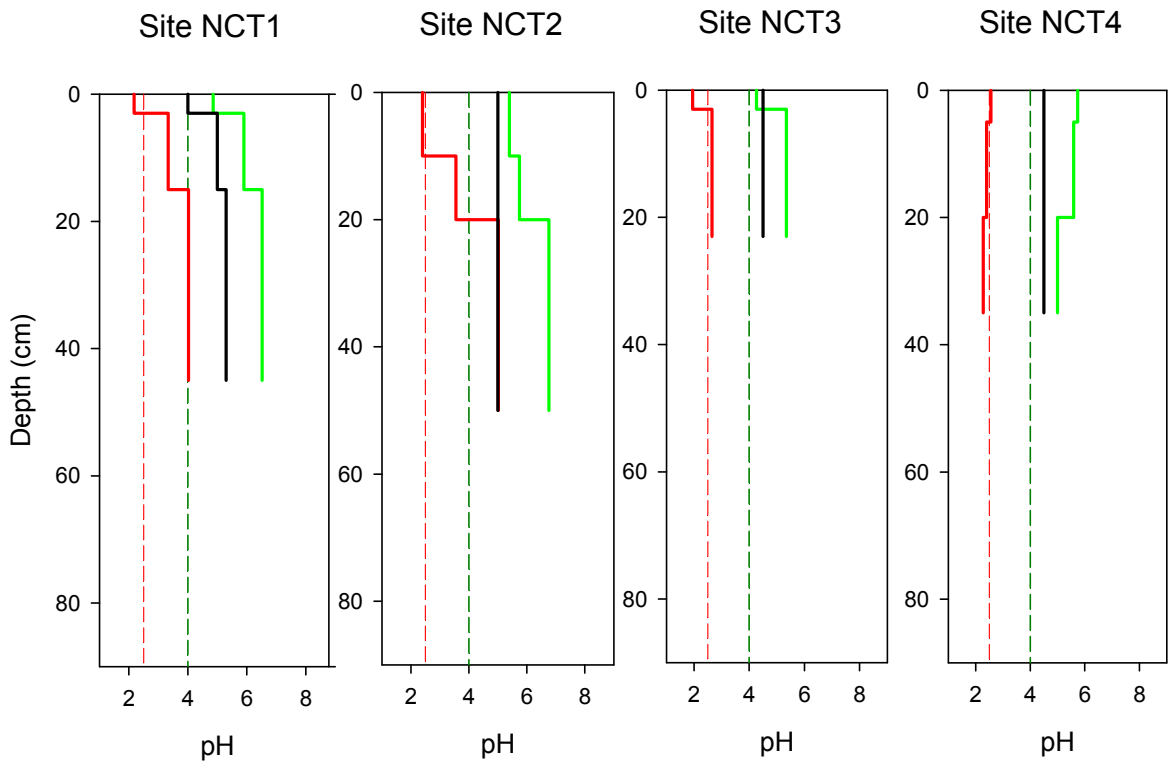

Figure 49-6. Depth profiles of soil pH for North Caurnamont Wetland, showing soil pH (pH_W as green line), peroxide treated pH (pH_{OX} as red line) and ageing pH (pH_{INC} after 28 weeks as black line). Critical pH_W and pH_{INC} value of 4 (black dashed line) and critical pH_{OX} value of 2.5 (red dashed line).

Acid Base Accounting

The acid base accounting data is provided in Table 49-4 and summarised in Figure 49-7.

Chromium reducible sulfur values ranged from below the limit of detection to 0.06 $\%S_{CR}$. Sulfidic materials were detected in the surface layers for all profiles.

Titratable actual acidity values ranged from 2.58 to 53.80 mole H^+/tonne.

Analysis of retained acidity was not conducted on any of the samples, however retained acidity may be present in surface layer of profile NCT3 and the subsoil layer of profile NCT4 that were below the critical value of pH_{KCl} <4.5.

Acid neutralising capacity was not detected in any of the samples.

Net acidity values ranged from 4 to 87 mole H^+/tonne. Moderate net acidity values occurred in all surface layers and in the subsoil layers of profiles NCT3 and NCT4.

Water Soluble Sulfate

Water soluble sulfate data values shown in Table 49-4 were identified that that surface layers for all profiles were above the trigger value of 100 mg/kg SO_4.

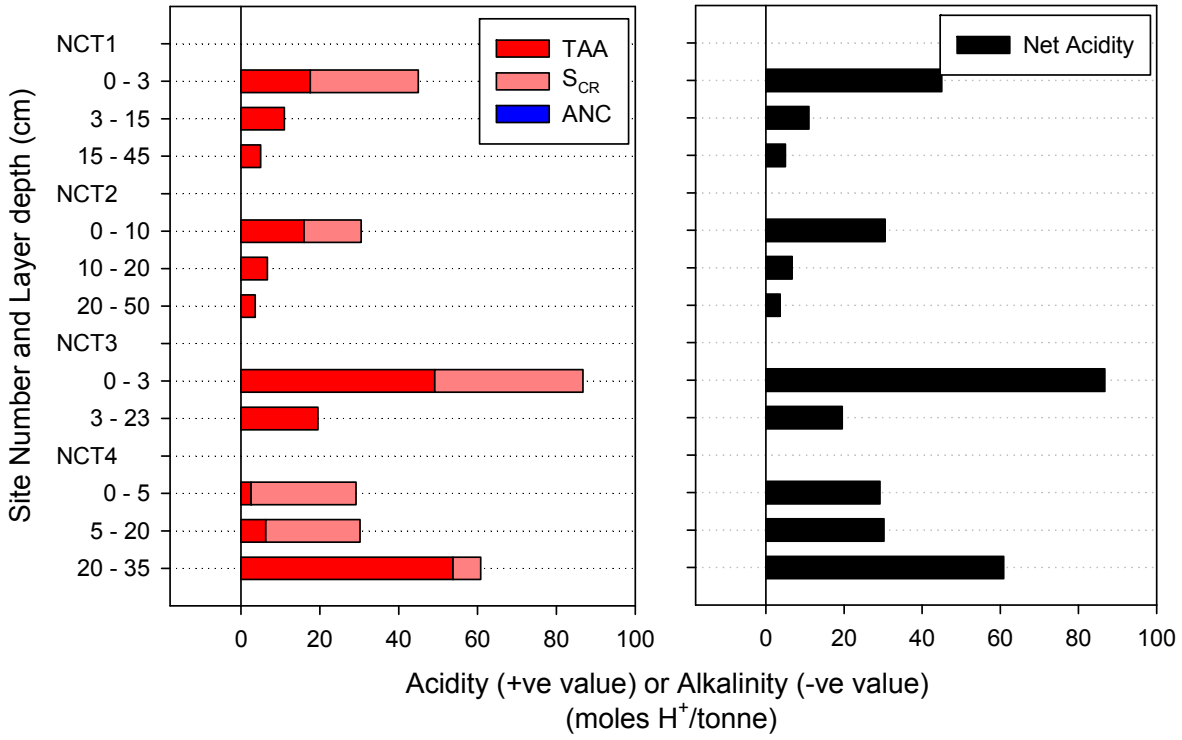

Figure 49-7. Acid base accounting depth profiles for North Caurnamont Wetland. Left side shows the components: titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} - pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.

49.4 DISCUSSION

Acid sulfate soil materials at North Caurnamont Wetland were identified as hyposulfidic that occurred in all surface layers and the subsoil layers for profile NCT4, the remaining subsoil layers were characterised as other acidic soil materials. The acid sulfate soil subtype classes identified were Hyposulfidic Soil and Hyposulfidic Cracking Clay Soil.

The soils throughout the wetland were generally friable, cloddy, clay over extremely firm or rigid subsoil clays that became too hard to dig.

Monosulfidic material was not observed but water soluble sulfate data identified that surface layers for the profiles throughout the wetland were in excess of the 100 mg/kg trigger value for monosulfide formation potential.

The potential hazards posed by acid sulfate soil materials at the North Caurnamont Wetland are:

- Acidification hazard: The data identified moderate net acidity values in some layers of all profiles, and pH_{OX} data identified potential acidification due to oxidation. There is a medium to high level of concern.
- De-oxygenation hazard: The water soluble sulfate data indicated a potential for monosulfidic materials to form in the surface layers of soils, although monosulfidic material was not observed. There is a medium level of concern.
- Metal mobilisation: The medium to high acidification hazard indicates that soil acidification potential may increase the solubility of metals. There is a medium level of concern.

Summary of key findings for North Caurnamont Wetland:

Soil materials:	Hyposulfidic soil materials were identified in all surface soil layers and the subsoil layers for the profiles in the main area of the wetland. The soils throughout were generally friable, clay over slightly rigid clay. Generally some layers of all profiles had samples with moderate net acidity values and pH_{OX} data identified potential acidification due to oxidation.
Acid sulfate soil identification:	• Hyposulfidic Soil – that occurred in the main areas of the wetland. Dominant (>50%) in extent. • Hyposulfidic Cracking Clay Soil – that occurred in the mid elevation and margin areas of the wetland. Minor (<25%) in extent.
Hazard assessment	• Acidification hazard – medium to high level of concern. • De-oxygenation hazard – medium level of concern. • Metal mobilisation hazard – medium level of concern.

Table 49-2. Site data for North Caurnamont Wetland

Site Number	Sampled Date	Easting m zone 54H	Northing m zone 54H	Soil Classification	Water depth (+ve) Water table (-ve)	Surface Condition	Earth Cover (Vegetation)	Location Notes
NCT1	10-Sep-08	368434	6145316	Hyposulfidic cracking clay soil	Not reached	cracking, crumbling	hare	Low elevation, near centre of wetland
NCT2	10-Sep-08	368455	6145312	Hyposulfidic soil	Not reached	loose	Bulrushes	Mid elevation, adjacent to vegetation on wetland margin
NCT3	10-Sep-08	368578	6145035	Hyposulfidic soil	Not reached	loose	cropped	Low elevation, near centre of wetland
NCT4	10-Sep-08	368541	6144977	Hyposulfidic cracking clay soil	Not reached	cracking, crumbling	Bulrushes	High elevation, adjacent to vegetation on wetland margin

Table 49-3. Soil description data for North Caurnamont Wetland

Site and Sample Number	Depth Upper (cm)	Depth Lower (cm)	Observation Method (kind)	Soil Colour (Munsell notation)	Texture (class)	Soil Water Status	Mottles Quantity (%)	Mottles Colour	Mottles Location	Structure Type (category)	Consistence (category)	Comments
NCT1.1	0	3	soil pit	2.5Y 3/1	clay	moist	3	10YR 8/1	on ped faces	cloddy	friable	
NCT1.2	3	15	soil pit	2.5Y 2.5/1	clay	moist	3	10YR 6/8	on ped faces	subangular blocky	extremely firm	
NCT1.3	15	45	soil pit	2.5Y 2.5/1	clay	moist	0			massive	extremely firm	too hard to dig below this layer
NCT2.1	0	10	soil pit	2.5Y 3/1	clay	moist	0			subangular blocky	friable	
NCT2.2	10	20	soil pit	2.5Y 2.5/1	clay	moist	0			columnar	very firm	
NCT2.3	20	50	soil pit	2.5Y 2.5/1	clay	moist	3	10YR 6/8	on ped faces	massive	very firm	too hard to dig below this layer
NCT3.1	0	3	soil pit	2.5Y 4/2	clay	dry	0			cloddy	friable	
NCT3.2	3	23	soil pit	2.5Y 3/1	clay	dry	3	10YR 6/8	on ped faces	columnar	rigid	too hard to dig below this layer
NCT4.1	0	5	soil pit	2.5Y 3/1	clay	dry	3	10YR 6/8	on ped faces	angular blocky	friable	
NCT4.2	5	20	soil pit	2.5Y 3/1	clay	moist	3	10YR 6/8	on ped faces	columnar	rigid	too hard to dig below this layer
NCT4.3	20	35	soil pit	2.5Y 3/1	clay	moist	0			columnar	extremely firm	

Table 49-4. Laboratory data for acid sulfate soil assessment of North Caurnamont Wetland.

(red printed values indicate data results of concern)

Site and Layer ID.	Depth Range (cm)	Soil Texture	EC (µS/cm)	pH water	pH peroxide	pH incubation	Sulfate (mg SO_4/kg)	pH KCl	Titratable Actual Acidity (mole H^+/ tonne)	Chromium Reducible Sulfur (%S_{CR})	Acid Neutralising Capacity (%$CaCO_3$)	Net Acidity (mole H^+/ tonne)	Acid Sulfate Soil Material Classification
NCT1.1	0 - 3	fine	-	4.86	2.18	4.00	3923	4.82	17.59	0.04	-	45	hyposulfidic (S_{CR}<0.10%)
NCT1.2	3 - 15	fine	-	5.90	3.33	5.00	1549	5.37	11.01	< 0.01	-	11	other acidic incubation
NCT1.3	15 - 45	fine	-	6.52	4.02	5.30	389	5.83	4.99	< 0.01	-	5	other acidic incubation
NCT2.1	0 - 10	fine	-	5.40	2.40	5.00	2662	5.04	16.00	0.02	-	31	hyposulfidic (S_{CR}<0.10%)
NCT2.2	10 - 20	fine	-	5.75	3.55	5.00	1253	5.66	6.69	< 0.01	-	7	other acidic incubation
NCT2.3	20 - 50	fine	-	6.76	5.02	5.00	432	5.93	3.61	< 0.01	-	4	other acidic incubation
NCT3.1	0 - 3	fine	-	4.26	1.95	4.50	5481	4.11	49.19	0.06	-	87	hyposulfidic (S_{CR}<0.10%)
NCT3.2	3 - 23	fine	-	5.35	2.65	4.50	1256	4.89	19.52	< 0.01	-	20	other acidic incubation
NCT4.1	0 - 5	fine	-	5.74	2.56	4.50	3385	6.30	2.58	0.04	-	29	hyposulfidic (S_{CR}<0.10%)
NCT4.2	5 - 20	fine	-	5.59	2.40	4.50	3230	5.60	6.32	0.04	-	30	hyposulfidic (S_{CR}<0.10%)
NCT4.3	20 - 35	fine	-	5.00	2.28	4.50	6317	4.01	53.80	0.01	-	61	hyposulfidic (S_{CR}<0.10%)

50 SCRUBBY FLAT WETLAND (WETLAND ID. 12306)

50.1 LOCATION AND SETTING DESCRIPTION

Scrubby Flat Wetland (Wetland ID. 12306) is situated on the eastern side of the River Murray. The wetland is geomorphically categorised as a Murray Gorge basin (Pressey 1986) with a total surface area of 49 hectares and is formed by a number of inter-connected irregularly shaped wetlands. The wetland is bounded to the east by hill slopes and to the west by a floodplain area that separates it from the river. There is a narrow water connection channel at the down river southern end of the wetland. The wetland occurs in association with Scrubby Flat Creek Wetland. At the time when the soil survey was conducted in August 2008 the wetland was dry and the landholder indicated that it was last inundated in 1996. The wetland location was difficult to identify in the field with grasses and Muehlenbeckia florulenta (Lignum) growing throughout the wetland and on the higher floodplain area trees were growing. One site (SCF1) was described and sampled and the location is shown in Figure 50-1.

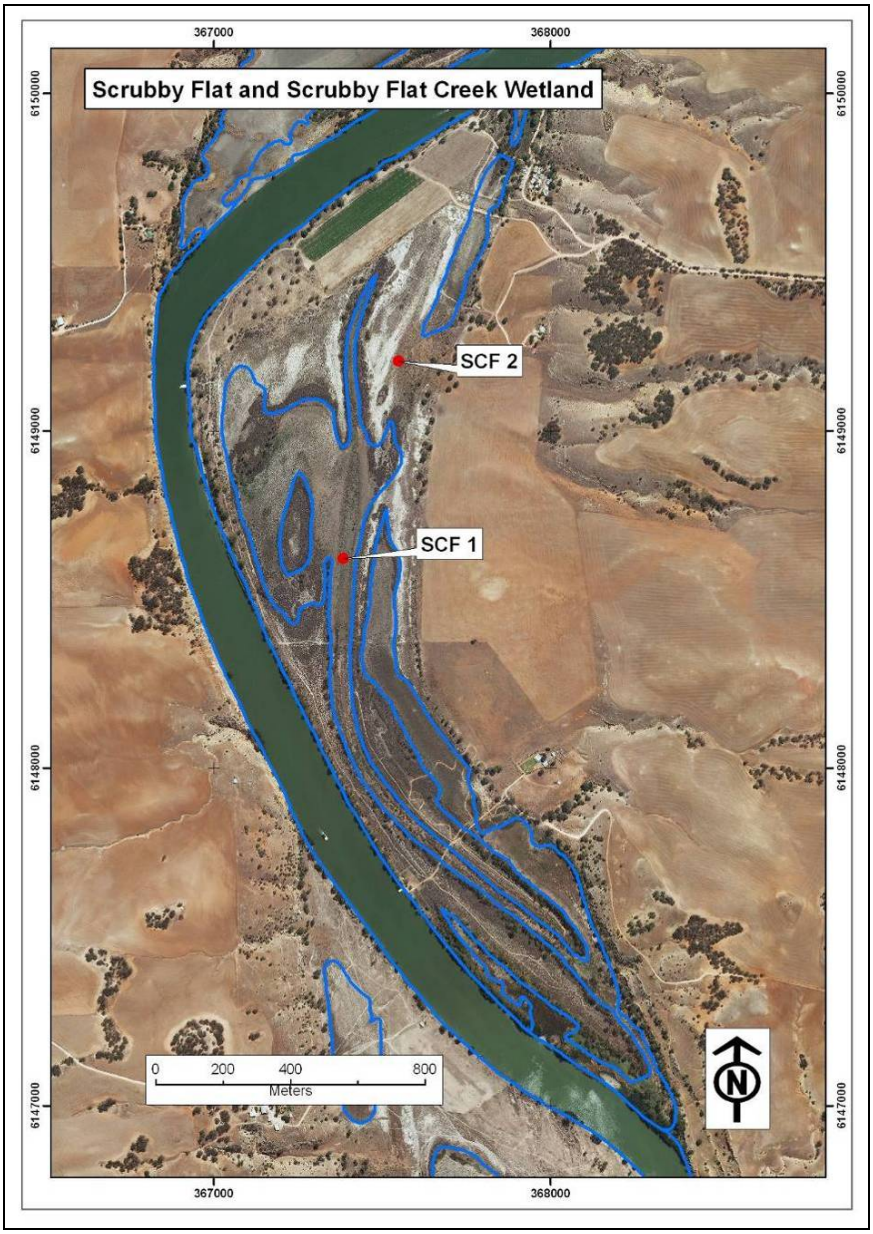

Figure 50-1. Scrubby Flat Wetland and sample site location.

50.2 SOIL PROFILE DESCRIPTION AND DISTRIBUTION

One site described and sampled. The acid sulfate soil subtype class and general location description are presented in Table 50-1. No other sites were located as the wetland location was difficult to identify as it formed part of the grazed farm area. The site was located in the lowest observed location that probably was a channel depression. The site and soil profile descriptions are presented in Table 50-2 and Table 50-3.

Site SCF1 (Figure 50-2) occurred in a low elevation channel depression, and the soil consisted of black, slightly rigid, clay, over clay that became too hard to dig below 30 centimetres depth.

Table 50-1. Soil identification, subtype and general location description of sites for Scrubby Flat Wetland.

Site ID	Easting m zone 54H	Northing m zone 54H	Acid sulfate soil subtype class	General location description
SCF1	367385	6148622	Other soil	Low elevation, near centre of channel

Figure 50-2. Photographs of site SCF1, showing the site location in an area with grasses and Muehlenbeckia florulenta (Lignum) growing, and the soil profile of very hard, blocky structured, clay.

50.3 LABORATORY DATA ASSESSMENT

Soil pH testing (pH_W, pH_{OX}, pH_{INC})

The pH data are provided in Table 50-4 and pH profiles are presented in Figure 50-3.

The pH_W data did not identify sulfuric materials with a pH_W <4.

The pH_{INC} data did not identify samples that on incubation declined below the critical value of pH <4. Samples that age to pH_{INC}<4 indicate that these soils potentially would form sulfuric materials as a result of sulfide oxidation.

The pH_{OX} data did not identify samples below the critical value of pH_{OX} <2.5, the threshold value normally used to indicate a high likelihood of sulfuric material forming.

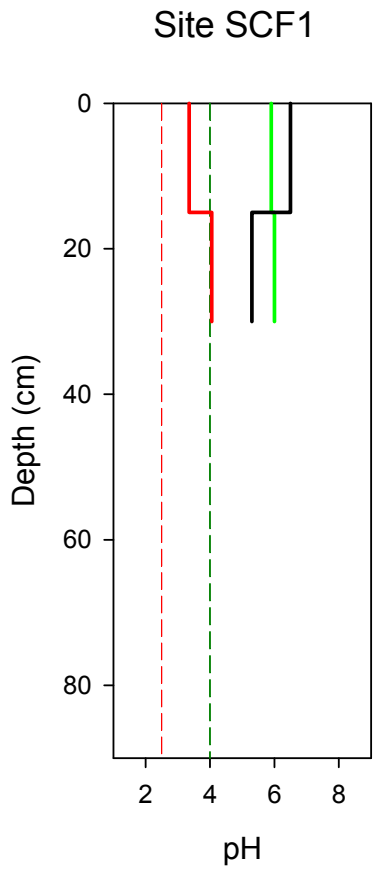

Figure 50-3. Depth profiles of soil pH for Scrubby Flat Wetland, showing soil pH (pH_W as green line), peroxide treated pH (pH_{OX} as red line) and ageing pH (pH_{INC} after 28 weeks as black line). Critical pH_W and pH_{INC} value of 4 (black dashed line) and critical pH_{OX} value of 2.5 (red dashed line).

Acid Base Accounting

The acid base accounting data is provided in Table 50-4 and summarised in Figure 50-4.

Chromium reducible sulfur values were below the limit of detection. Sulfidic materials were not detected in any of the soil layers sampled.

Titratable actual acidity values ranged from 4.46 to 5.73 mole H^+/tonne.

Analysis of retained acidity was not conducted on any of the samples, as all samples were above the critical value of pH_{KCl} <4.5.

Acid neutralising capacity was not detected in any of the samples.

Net acidity values ranged from 4 to 6 mole H^+/tonne. Low net acidity values occurred in both sampled layers of the soil profile.

Water Soluble Sulfate

Water soluble sulfate data values shown in Table 50-4 identified that surface layers for the profile were above the critical trigger value of 100 mg/kg SO_4.

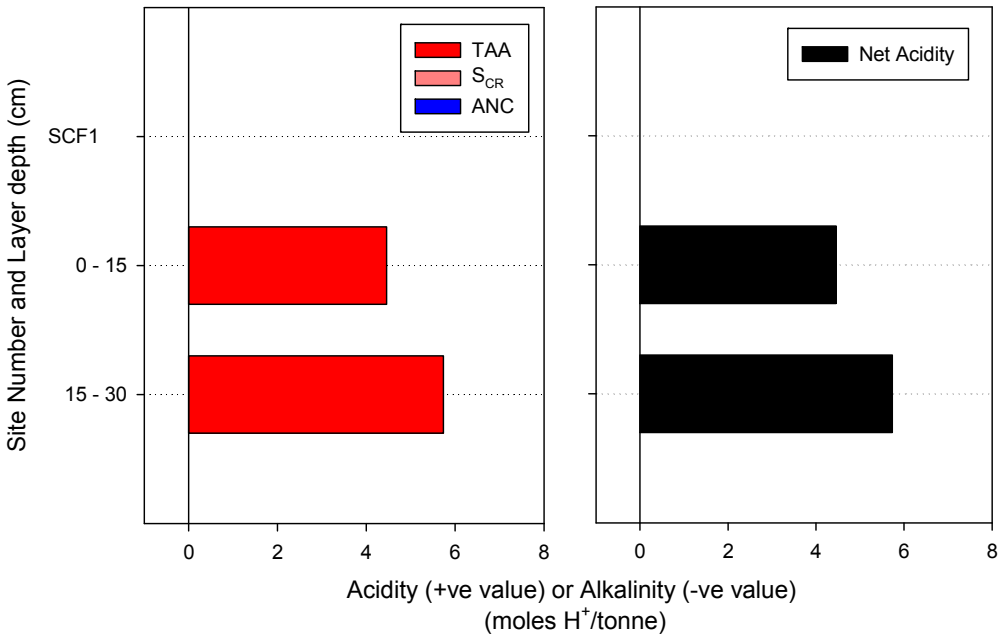

Figure 50-4. Acid base accounting depth profiles for Scrubby Flat Wetland. Left side shows the components: titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} - pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.

50.4 DISCUSSION

Acid sulfate soil materials at Scrubby Flat Wetland were not identified, samples were characterised as other acidic soil materials or other soil materials. The acid sulfate soil subtype class identified was Other Soil.

The soils throughout the wetland were generally slightly hard to very hard, blocky structured, clays that had subsoils too hard to dig.

Monosulfidic material was not observed but water soluble sulfate data identified that surface layers for the profile were in excess of the 100 mg/kg trigger value for monosulfide formation potential.

The potential hazards posed by acid sulfate soil materials at the Scrubby Flat Wetland are:

- Acidification hazard: The data identified low net acidity values throughout the profile, and pH data did not identify potential acidification due to oxidation. There is a low level of concern.
- De-oxygenation hazard: The water soluble sulfate data indicated a potential for monosulfidic materials to form in the surface layers of soils, although monosulfidic material was not observed. There is a medium level of concern.
- Metal mobilisation: The low acidification hazard indicates that soil acidification potential is not likely to increase the solubility of metals. There is a low level of concern.

Summary of key findings for Scrubby Flat Wetland:

Soil materials:	Other acidic and other soil materials were identified and acid sulfate soil materials were not identified in the soil layers. The soils throughout were generally very hard, blocky structured, clay. The profile had samples with low net acidity values and pH data did not identify potential acidification due to oxidation.
Acid sulfate soil identification:	• Other Soil – that occurred in the lower elevation main areas of the wetland. Dominant (>50%) in extent.
Hazard assessment	• Acidification hazard – low level of concern. • De-oxygenation hazard – medium level of concern. • Metal mobilisation hazard – low level of concern.

Table 50-2. Site data for Scrubby Flat Wetland

Site Number	Sampled Date	Easting m zone 54H	Northing m zone 54H	Soil Classification	Water depth (+ve) Water table (-ve)	Surface Condition	Earth Cover (Vegetation)	Location Notes
SCF1	29-Aug-08	367385	6148622	Other soil	Not reached	Sealed	Muehlenbeckia florulenta (Lignum) and grasses	Low elevation, centre of channel

Table 50-3. Soil description data for Scrubby Flat Wetland.

Site and Sample Number	Depth Upper (cm)	Depth Lower (cm)	Observation Method (kind)	Soil Colour (Munsell notation)	Texture (class)	Soil Water Status	Mottles Quantity (%)	Mottles Colour	Mottles Location	Structure Type (category)	Consistence (category)	Comments
SCF1.1	0	15	soil pit	2.5Y 4/1	clay loam	dry	0			subangular blocky	slightly hard	
SCF1.2	15	30	soil pit	2.5Y 3/1	clay	dry	3	10YR 6/8	in matrix	subangular blocky	very hard	

Table 50-4. Laboratory data for acid sulfate soil assessment of Scrubby Flat Wetland.

(red printed values indicate data results of concern)

Site and Layer ID.	Depth Range (cm)	Soil Texture	EC (µS/cm)	pH water	pH peroxide	pH incubation	Sulfate (mg SO_4/kg)	pH KCl	Titratable Actual Acidity (mole H^+/ tonne)	Chromium Reducible Sulfur (%S_{CR})	Acid Neutralising Capacity (%$CaCO_3$)	Net Acidity (mole H^+/ tonne)	Acid Sulfate Soil Material Classification
SCF1.1	0 - 15	medium	-	5.90	3.35	6.50	1246	6.01	4.46	< 0.01	-	4	other soil material
SCF1.2	15 - 30	fine	-	6.00	4.05	5.30	276	5.45	5.73	< 0.01	-	6	other acidic incubation

51 SCRUBBY FLAT CREEK WETLAND (WETLAND ID. 12719)

51.1 LOCATION AND SETTING DESCRIPTION

Scrubby Flat Creek wetland (Wetland ID. 12719) is situated on the eastern side of the River Murray, up river and adjacent to Scrubby Flat Wetland. The wetland is geomorphically categorised as a miscellaneous floodplain depression (Pressey 1986) and is rectangular in shape, approximately 100 metres long and 50 metres wide, with a total surface area of 4 hectares. The wetland is part of an old channel depression where sand has accumulated. There are no obvious water connection channels with the river. At the time when the soil survey was conducted in August 2008 the wetland was dry with no surface water. The wetland was difficult to identify in the field with grasses and Muehlenbeckia florulenta (Lignum) growing throughout. One site (SCF2) was described and sampled and the location is shown in Figure 51-1.

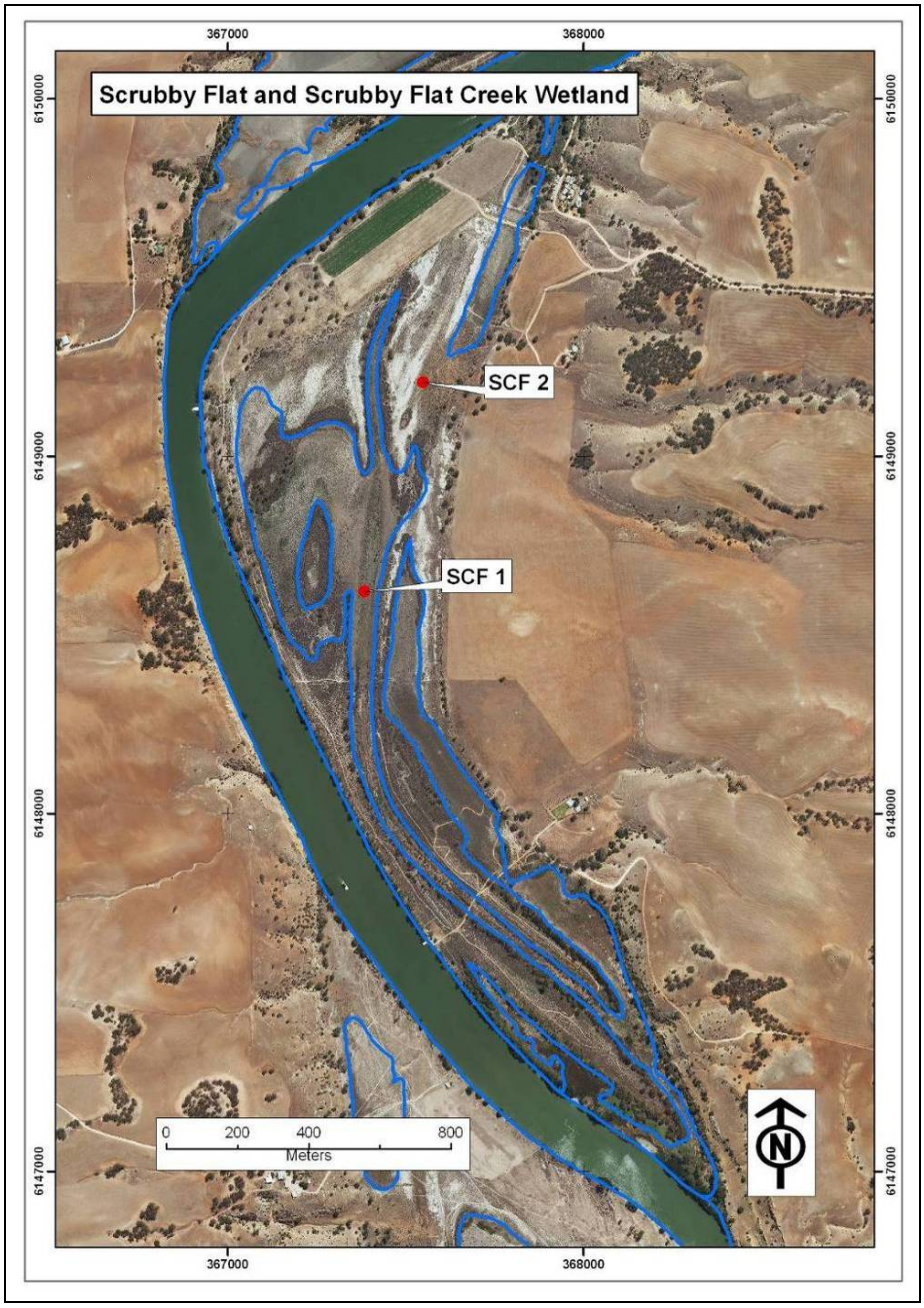

Figure 51-1. Scrubby Flat Creek Wetland and sample site location.

51.2 SOIL PROFILE DESCRIPTION AND DISTRIBUTION

One site was described and sampled. The acid sulfate soil subtype class and general location description are presented in Table 51-1. No other sites were located as the wetland location was difficult to identify in the field as it formed part of the grazed farm area. The site was located in the lower observed location that probably was a channel depression. Site and soil profile descriptions are presented in Table 51-2 and Table 51-3.

Site SCF2 (Figure 51-2) occurred in a channel depression that probably is where the wetland would be located, and the soil consisted of red brown to whitish grey, loose, sand, over black, extremely hard, clay, too hard to dig below 40 centimetres depth.

Table 51-1. Soil identification, subtype and general location description for Scrubby Flat Creek Wetland.

Site ID	Easting m zone 54H	Northing m zone 54H	Acid sulfate soil subtype class	General location description
SCF2	367550	6149206	Other soil	Mid elevation, on side of channel

Figure 51-2. Photographs of site SCF2, showing the sandy surface and Muehlenbeckia florulenta (Lignum) growing, and the soil profile of loose sand over extremely hard clay below approximately 20 centimetres depth.

51.3 LABORATORY DATA ASSESSMENT

Soil pH testing (pH_W, pH_{OX}, pH_{INC})

The pH data are provided in Table 51-4 profiles for the sites are presented in Figure 51-3.

The pH_W data did not identify sulfuric materials with a pH_W <4.

The pH_{INC} data did not identify samples that on incubation declined below the critical value of pH <4. Samples that age to pH_{INC}<4 indicate that these soils potentially would form sulfuric materials as a result of sulfide oxidation.

The pH_{OX} data did not identify samples below the critical value of pH_{OX} <2.5, the threshold value normally used to indicate a high likelihood of sulfuric material forming.

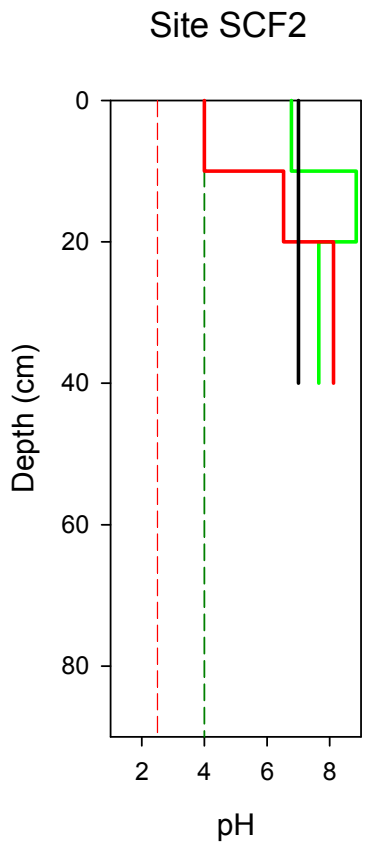

Figure 51-3. Depth profiles of soil pH for Scrubby Flat Creek Wetland, showing soil pH (pH_W as green line), peroxide treated pH (pH_{OX} as red line) and ageing pH (pH_{INC} after 28 weeks as black line). Critical pH_W and pH_{INC} value of 4 (black dashed line) and critical pH_{OX} value of 2.5 (red dashed line).

Acid Base Accounting

The acid base accounting data is provided in Table 51-4 and summarised in Figure 51-4.

Chromium reducible sulfur values were all below the limit of detection. Sulfidic materials were not detected in any of the soil layers.

Titratable actual acidity was not detected in any of the samples.

Analysis of retained acidity was not conducted on any of the samples, as all samples were above the critical value of pH_{KCl} <4.5.

Acid neutralising capacity values ranged from 0.44 to 0.91 $\%CaCO_3$, and were measured in the all samples of the profile.

Net acidity values ranged from -121 to -58 mole H^+/tonne. Negative net acidity values occurred in all layers of the soil profile.

Water Soluble Sulfate

Water soluble sulfate data values shown in Table 51-4 identified that surface layers in the sampled profile were below the critical trigger value of 100 mg/kg SO_4.

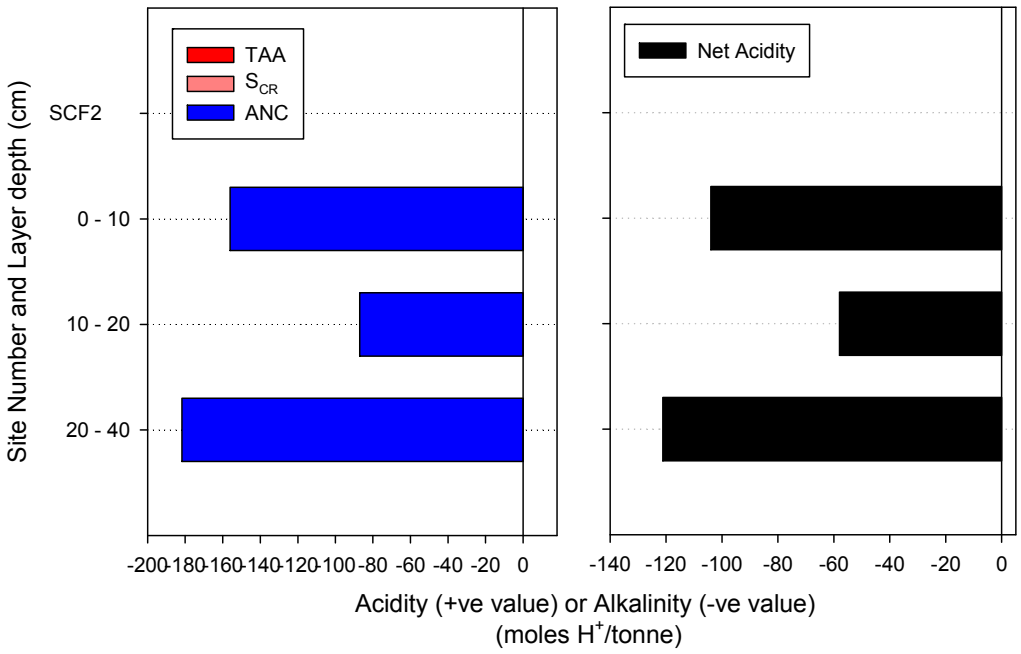

Figure 51-4. Acid base accounting depth profiles for Scrubby Flat Creek Wetland. Left side shows the components: titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} - pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.

51.4 DISCUSSION

Acid sulfate soil materials at Scrubby Flat Creek Wetland were not identified, the samples were characterised as other soil materials. The acid sulfate soil subtype class identified was Other Soil.

The soils throughout the wetland were generally loose, sandy surface layers over an extremely hard, clay subsoil layer.

Monosulfidic material was not observed but water soluble sulfate data identified that surface layers for the profiles throughout the wetland were below the 100 mg/kg trigger value for monosulfide formation potential.

The potential hazards posed by acid sulfate soil materials at the Scrubby Flat Creek Wetland are:

- Acidification hazard: The data identified negative net acidity values throughout the soil profile, and pH data did not identify potential acidification due to oxidation. There is a low level of concern.
- De-oxygenation hazard: The water soluble sulfate data did not indicate a potential for monosulfidic materials to form in the surface layers of soils, and monosulfidic material was not observed. There is a low level of concern.
- Metal mobilisation: The low acidification hazard indicates that soil acidification potential is not likely to increase the solubility of metals. There is a low level of concern.

Summary of key findings for Scrubby Flat Creek Wetland:

Soil materials:	Other soil materials were identified in all soil layers, and acid sulfate soil materials were not identified. The soils had a loose sandy surface layer over extremely hard, clay subsoil. All layers of the soil profile had negative net acidity values and pH data did not identify potential acidification due to oxidation.
Acid sulfate soil identification:	• Other Soil – that occurred in the main channel area of the wetland. Dominant (>50%) in extent.
Hazard assessment	• Acidification hazard – low level of concern. • De-oxygenation hazard – low level of concern. • Metal mobilisation hazard – low level of concern.

Table 51-2. Site data for Scrubby Flat Creek Wetland.

Site Number	Sampled Date	Easting m zone 54H	Northing m zone 54H	Soil Classification	Water depth (+ve) Water table (-ve)	Surface Condition	Earth Cover (Vegetation)	Location Notes
SCF2	29-Aug-08	367550	6149206	Other soil	Not reached	sealed, soft	grasses, weeds	Mid elevation, on side of channel

Table 51-3. Soil description data for Scrubby Flat Creek Wetland

Site and Sample Number	Observation Method (kind)	Depth Upper (cm)	Depth Lower (cm)	Soil Colour (Munsell notation)	Texture (class)	Soil Water Status	Mottles Quantity (%)	Mottles Colour	Mottles Location	Structure Type (category)	Consistence (category)	Comments
SCF2.1	soil pit	0	10	10YR 5/3	loamy sand	dry	0			single grain	loose	
SCF2.2	soil pit	10	20	2.5Y 6/3	sand	dry	0			single grain	loose	
SCF2.3	soil pit	20	40	2.5Y 3/1	clay	dry	3	10YR 6/8	in matrix adjacent to pores	subangular blocky	extremely hard	

Table 51-4. Laboratory data for acid sulfate soil assessment of Scrubby Flat Creek Wetland.

(red printed values indicate data results of concern)

Site and Layer ID.	Depth Range (cm)	Soil Texture	EC (µS/cm)	pH water	pH peroxide	pH incubation	Sulfate (mg SO_4/kg)	pH KCl	Titratable Actual Acidity (mole H^+/ tonne)	Chromium Reducible Sulfur (%S_{CR})	Acid Neutralising Capacity (%$CaCO_3$)	Net Acidity (mole H^+/ tonne)	Acid Sulfate Soil Material Classification
SCF2.1	0 - 10	coarse	-	6.78	4.00	7.00	31	8.79	-	< 0.01	0.78	-104	other soil material
SCF2.2	10 - 20	coarse	-	8.85	6.53	7.00	50	9.19	-	< 0.01	0.44	-58	other soil material
SCF2.3	20 - 40	fine	-	7.65	8.12	7.00	873	7.65	-	< 0.01	0.91	-121	other soil material

52 WALKER FLAT SOUTH LAGOON WETLAND (WETLAND ID. 12029)

52.1 BACKGROUND

Walker Flat South Lagoon Wetland (Wetland ID. 12029) is situated down-river from the Walker Flat ferry on the south-western side of the River Murray. The wetland is geomorphically categorised as a Murray Gorge basin (Pressey 1986).

This wetland was studied in 2007 as part of a separate monitoring investigation of acid sulfate soils, the work and data was presented in the report 'Acid sulfate soils in subaqueous, waterlogged and drained soil environments in Lake Albert, Lake Alexandrina and River Murray below Blanchetown (Lock 1): properties, distribution, genesis, risks and management' (Fitzpatrick, Shand, Marvanek, Merry, Thomas, Raven, Simpson and McClure. November 2008. Report prepared for Department of Environment and Heritage SA. CSIRO Land and Water Science Report 46/08). Readers are referred to this report for detailed information. A summary of the findings from this report are presented including a follow-up site visit that was conducted in August 2009.

At the time of field sampling the wetland had some surface water and the sites were located near the wetland margin. Two sites were sampled (Sites WL8 and WL9) and the wetland is shown in Figure 52-1.

Figure 52-1. Walker Flat South Lagoon Wetland.

52.2 DISCUSSION

Acid sulfate soil materials at Walker Flat South Lagoon Wetland were identified as hypersulfidic that occurred as a surface soil layer (0 to about 10 cm) throughout the wetland and in some areas near the inlet channels to the river the subsoils were characterised as hypersulfidic. The subsoils throughout the rest of the wetland were hyposulfidic, with low or moderate net acidity values and pH values of <5.0.

The soils were clays with open deep cracks that extended down into the subsoil. The up-river section of the wetland had been cultivated and planted with grasses for cattle and stock trampling had broken the surface and filled the cracks with aggregates (August 2009 site visit). The down-river section of the wetland was somewhat similar, but near the inlet channel area the soils were characterised as hypersulfidic and would be of concern as this was the most likely area to wet up first as water levels rise in the wetland.

The potential hazards posed by acid sulfate soil materials at the Walker Flat South Wetland are:

- Acidification hazard: Hypersulfidic soil material occurred in the soil surface layer throughout the wetland and the subsoils were generally hyposulfidic or hypersulfidic in isolated areas near the inlet channels. There is a medium level of concern.
- De-oxygenation hazard: No data was available, but a judgement was made based on similar wetland soils in the area, there would be a potential for monosulfidic materials to form in the surface layers of soils, although monosulfidic material was not observed. There is a high level of concern.
- Metal mobilisation hazard: The high acidification hazard indicates that soil acidification potential may increase the solubility of metals. There is a medium level of concern.

Summary of key findings for Walker Flat South Lagoon Wetland:

Soil materials:	The soils were dominantly clays with a cracking surface and in some areas the cracks were filled with aggregates. Surface soil layers were generally hypersulfidic and in some areas acidic. Subsoil soil layers were hypersulfidic near the inlet channels and elsewhere they were hyposulfidic.
Acid sulfate soil identification:	• Hypersulfidic Cracking Clay Soil – that occurred throughout the wetland. Dominant (>50%) in extent. • Other Acidic Soil (clayey) – that occurred throughout on the wetland margins. Isolated (<25%) in extent.
Hazard assessment	• Acidification hazard – medium level of concern • De-oxygenation hazard – high level of concern • Metal mobilisation hazard – medium level of concern

53 LAKE BYWATERS WETLAND (WETLAND ID. 12028)

53.1 LOCATION AND SETTING DESCRIPTION

Lake Bywaters Wetland (Wetland ID. 12028) is situated on the south western side of the River Murray, adjacent to Walker Flat car ferry ramp. The wetland is geomorphically categorised as a Murray Gorge basin (Pressey 1986) and is a triangular shape, approximately 1.5 kilometres in length and up to 400 metres at the widest, with a total surface area of 39 hectares. It is bounded on three-sides by a road and there is a raised terrace bank approximately 50 to 100 metres wide that separates the wetland from the river. There are two narrow water connection channels, one with the river at the most up-river end and at the down-river end there is a culvert under the road connecting it with Walker Flat Wetland. At the time when the soil survey was conducted in August 2008, the wetland was generally dry. The wetland had cracking clay surface that was breaking down into aggregates, and in some areas cracks were filling with wind blown sand. Around the margins there were isolated areas of *Typha latifolia* (Bulrush) and *Phragmites australis* (Common Reed) vegetation, and trees on the raised bank. Three sites were described and sampled and their locations are shown in Figure 53-1.

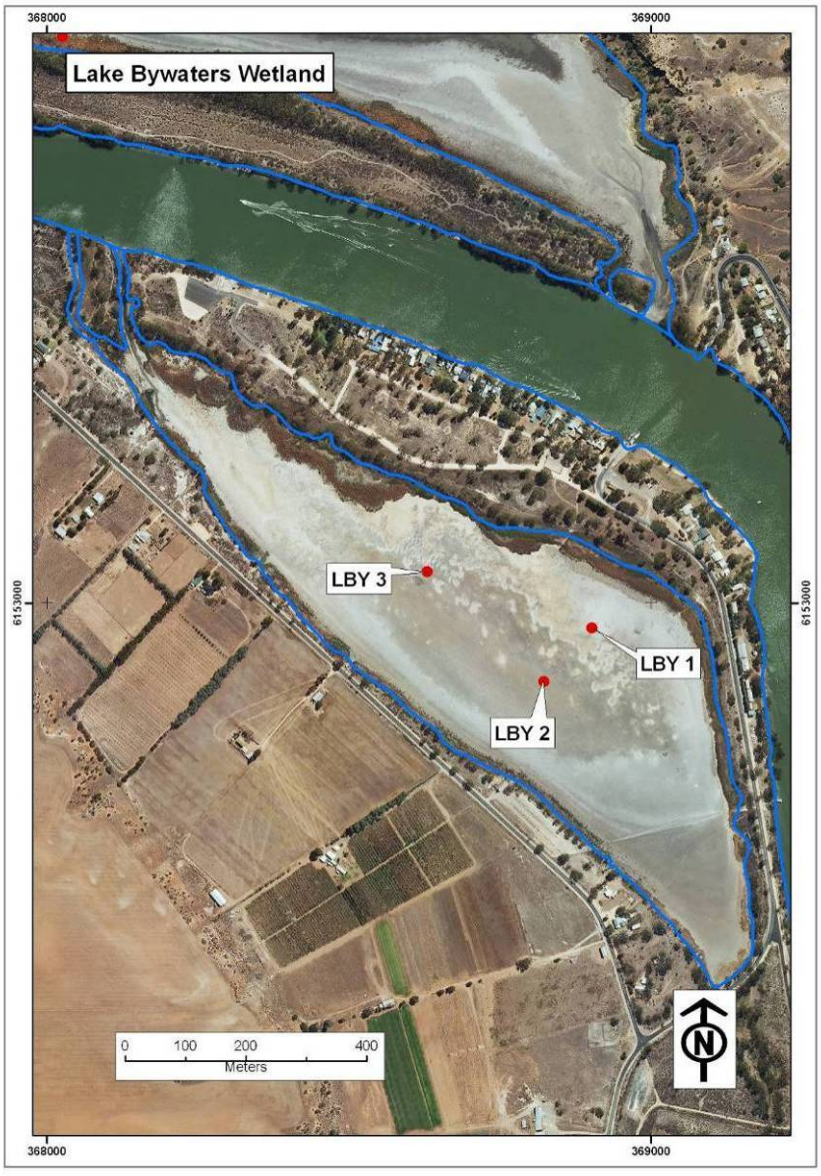

Figure 53-1. Lake Bywaters Wetland and sample site locations.

53.2 SOIL PROFILE DESCRIPTION AND DISTRIBUTION

Three sites were described and sampled. The acid sulfate soil subtype class and general location description are presented in Table 53-1. The sites were located to characterise the dominant wetland features that included the cracking clay surface where the cracks have been filled with sand (LBY1), the cracking clay area (LBY2), and cracking clay area near the channel through the wetland (LBY3). The site and soil profile descriptions are presented in Table 53-2 and Table 53-3.

Site LBY1 (Figure 53-2) occurred on the river side of the wetland where sand had filled the surface cracks and no vegetation was growing. The soil consisted of grey, loose sand, over black, firm, sandy loam, and at depth olive grey, very firm, sandy loam.

Site LBY2 (Figure 53-3) occurred near the centre and low point of the wetland where the surface was cracking and no vegetation was growing. The soil consisted of grey, firm clay, over black, very firm clay, and at depth olive grey, firm clay.

Site LBY3 (Figure 53-4) occurred in the low area of the wetland nearer the channel and has a slightly wet cracking clay surface. The soil consisted of dark grey, firm clay over black, very firm clay, and at depth olive, very firm clay.

Table 53-1. Soil identification, subtype and general location description of sites for Lake Bywaters Wetland.

Site ID	Easting m Zone 54H	Northing m Zone 54H	Acid sulfate soil subtype class	General location description
LBY1	368903	6152958	Sulfuric cracking clay soil	Mid elevation, cracking clay soil areas
LBY2	368823	6152869	Sulfuric cracking clay soil	Low elevation, cracking clay soil area
LBY3	368630	6153051	Sulfuric cracking clay soil	Low elevation, cracking clay soil area near the channel through the wetland

Figure 53-2. Photographs of site LBY1, showing the wind blown sand encroaching onto the wetland surface, and the soil profile of sand over clay.

Figure 53-3. Photographs of site LBY2, showing the cracking clay surface with the windblown sand on the wetland surface in the background, and the soil profile of firm clay.

Figure 53-4. Photographs of site LBY3, showing the cracking clay surface, and the soil profile with the water table at about 50 cm.

53.3 LABORATORY DATA ASSESSMENT

Soil pH testing (pH_W, pH_{OX}, pH_{INC})

The pH data are provided in Table 53-4 and pH profiles in Figure 53-5.

The pH_W data for the surface layer of profile LBY1 and the subsurface layers of profile LBY2 and LBY3 identified samples as sulfuric materials with a pH_W <4.

The pH_{INC} data for he surface layers of all three profiles identified samples that on incubation declined below the critical value of pH<4. Samples that age to pH_{INC}<4 indicate that these soils potentially would form sulfuric material as a result of sulfide oxidation.

The pH_{OX} data for some layers of all three profiles identified samples below the critical value of pH_{OX} <2.5, the threshold value normally used to indicate a high likelihood of sulfuric material forming.

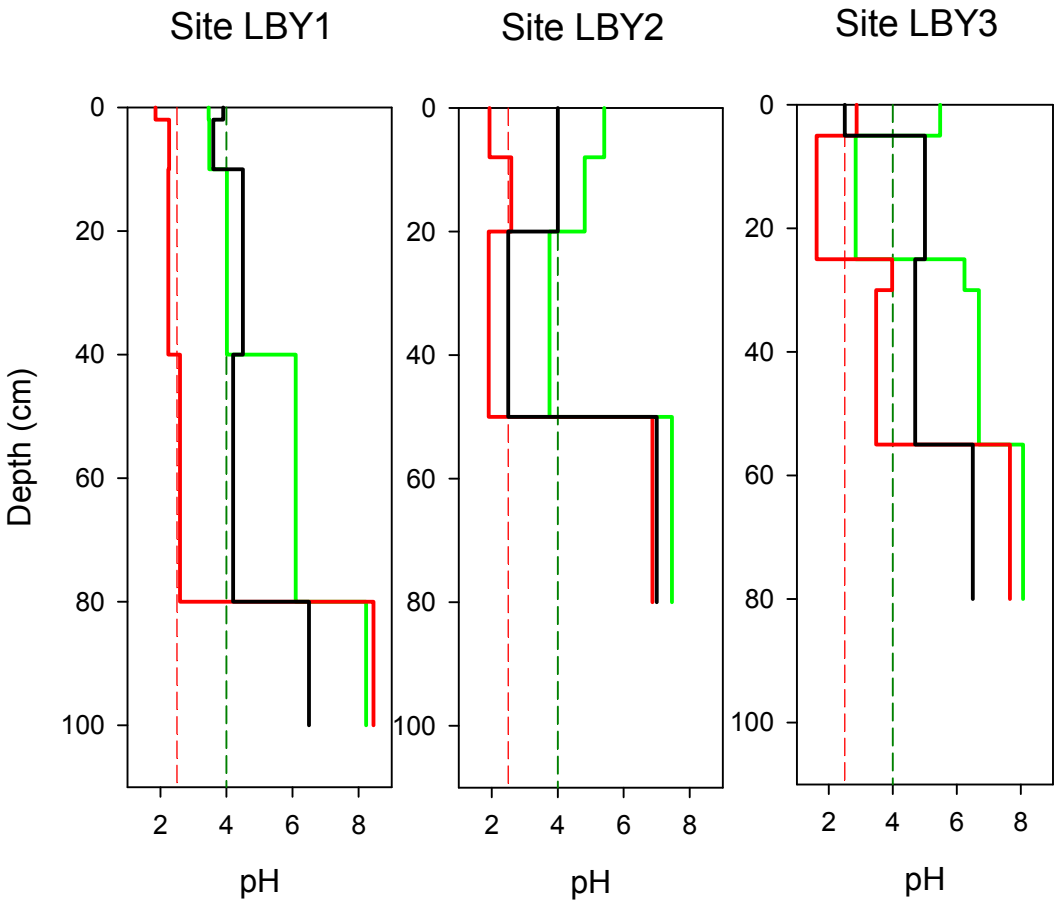

Figure 53-5. Depth profiles of soil pH for Lake Bywaters Wetland, showing soil pH (pH_W as green line), peroxide treated pH (pH_{OX} as red line) and ageing pH (pH_{INC} after 28 weeks as black line). Critical pH_W and pH_{INC} value of 4 (black dashed line) and critical pH_{OX} value of 2.5 (red dashed line).

Acid Base Accounting

The acid base accounting data is provided in Table 53-4 and summarised in Figure 53-6.

Chromium reducible sulfur values ranged from below the limit of detection to 0.11 %S_{CR}. Sulfidic materials were detected in at least one layer for each of the three profiles.

Titratable actual acidity values ranged from 0 to 51.26 mole H^+/tonne.

Analysis of retained acidity was not conducted on any of the samples, however retained acidity may be present in the surface layers of profiles LBY1 and LBY3 that were below the critical value of pH_{KCl} <4.5.

Acid neutralising capacity values ranged from 0 to 2.43 %$CaCO_3$, and were measured in the deepest subsoil layers of all profiles.

Net acidity values ranged from -324 to 107 mole H^+/tonne. Moderate net acidity values occurred in most sampled layers, with a high value in the surface layer of profile LBY3 and negative values in the lower subsoil layers for all profiles.

Water Soluble Sulfate

Water soluble sulfate data values shown in Table 53-4 identified that surface layers in all profiles were above the trigger value of 100 mg/kg SO_4.

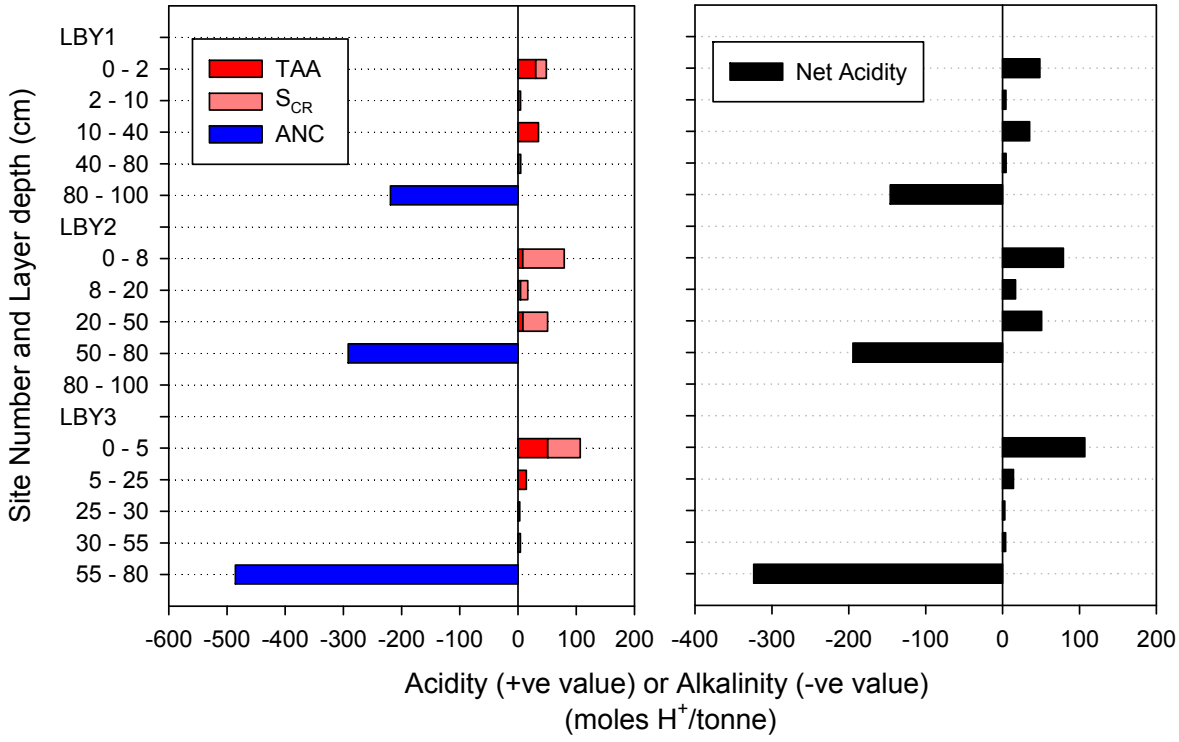

Figure 53-6. Acid base accounting depth profiles for Lake Bywaters Wetland. Left side shows the components: titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} -pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.

53.4 DISCUSSION

Acid sulfate soil materials at Lake Bywaters Wetland were identified as sulfuric that occurred as a thick (25 to 50 cm) surface or upper subsoil layers. In some areas the soils were hypersulfidic or hyposulfidic with the deepest subsoil layers characterised as other soil material.

Soils throughout this wetland were clays with deep cracks into the subsoil. More than half of the area where these soils occurred had filled cracks from wind-blown sand and on the margins the sand was encroaching over the wetland surface. Sulfuric material was identified both in the sandy filled cracks and in the clay soils.

Subsoils throughout were not identified as acid sulfate soil materials and generally were below the water table at the time of sampling (August 2008) and had a negative net acidity.

The potential hazards posed by acid sulfate soil materials in Lake Bywaters Wetland are:

- Acidification hazard: There was a thick surface sulfuric layer throughout the wetland and sulfidic materials identified in the upper soil layers. There is a high level of concern.
- De-oxygenation hazard: The water soluble sulfate data indicated a potential for monosulfidic materials to form in the surface layers of soils, although monosulfidic material was not observed. There is a high level of concern.
- Metal mobilisation hazard: The high acidification hazard indicates that soil acidification potential may increase the solubility of metals. There is a level of concern.

Summary of key findings for Lake Bywaters Wetland:

Soil materials:	The soils were cracking clay soils throughout, with deep cracks that may be filled with sand near the margins of the wetland. The upper soil layers (down to about 25cm and in some areas 50 cm) were sulfuric. The subsoil layers (below 50 cm) generally were not identified as acid sulfate soil material and had a negative net acidity.
Acid sulfate soil identification:	• Sulfuric cracking clay soil – that occurred throughout the wetland. Dominant (>50%) in extent.
Hazard assessment	• Acidification hazard – high level of concern • De-oxygenation hazard – high level of concern • Metal mobilisation hazard – high level of concern

Table 53-2. Site data for Lake Bywaters Wetland.

Site Number	Sampled Date	Easting m Zone 54H	Northing m Zone 54H	Soil Classification	Water depth (+ve) Water table (-ve)	Surface Condition	Earth Cover (Vegetation)	Location Notes
LBY1	23-Aug-08	368903	6152958	Sulfuric cracking clay soil	55	cracking, filled with sand	Bare	mid to high in sand area,
LBY2	23-Aug-08	368823	6152869	Sulfuric cracking clay soil	80	cracking	Bare	low,
LBY3	23-Aug-08	368630	6153051	Sulfuric cracking clay soil	45	cracking	Bare	low,

Table 53-3. Soil description data for Lake Bywaters Wetland.

Site and Sample Number	Depth Upper (cm)	Depth Lower (cm)	Observation Method (kind)	Soil Colour (Munsell notation)	Texture (class)	Soil Water Status	Mottles Quantity (%)	Mottles Colour	Mottles Location	Structure Type (category)	Consistence (category)	Comments
LBY1.1	0	2	soil pit	10YR 7/1	loamy sand	dry	0			platy	firm	
LBY1.2	2	10	soil pit	10YR 7/1	Sand	dry	0			subangular blocky	loose	
LBY1.3	10	40	soil pit	2.5Y 4/2	CS	moist	10	2.5YR 5/8	in matrix adjacent to pores	massive	firm	
LBY1.4	40	80	soil pit	2.5Y 5/2	sandy loam	moist	5	2.5YR 5/8	in matrix adjacent to pores	massive	very firm	
LBY1.5	80	100	push tube	5Y 5/2	sandy loam	moist	0			massive	very firm	
LBY2.1	0	8	soil pit	10YR 5/1	Clay	moist	3	2.5Y 8/1	on ped faces	massive	rigid	white salts on surface
LBY2.2	8	20	soil pit	10YR 5/1	Clay	moist	0			subangular blocky	firm	contains sand lenses
LBY2.3	20	50	soil pit	10YR 3/1	Clay	moist	10	2.5YR 5/8	in matrix adjacent to pores	massive	firm	
LBY2.4	50	80	push tube	10YR 3/1	Clay	moist	0			massive	firm	
LBY2.5	80	100	push tube	2.5Y 5/1	sandy clay loam	moist	0			massive	firm	
LBY3.1	0	5	soil pit	10YR 6/1	clay loam	dry	0			platy	very firm	
LBY3.2	5	25	soil pit	10YR 5/1	clay loam	moist	15	2.5YR 5/8	in matrix adjacent to pores	massive	firm	
LBY3.3	25	30	soil pit	10YR 6/2	Sand	moist	0			single grain	loose	
LBY3.4	30	55	soil pit	10YR 3/1	Clay	moist	10	2.5YR 5/8	in matrix adjacent to pores	massive	firm	
LBY3.5	55	80	push tube	10YR 3/1	Clay	moist	0			massive	firm	

Table 53-4. Laboratory data for acid sulfate soil assessment of Lake Bywaters Wetland.

(red printed values indicates data results of concern)

Site and Layer ID.	Depth Range (cm)	Soil Texture	EC (µS/cm)	pH water	pH peroxide	pH incubation	Sulfate (mg SO_4/kg)	pH KCl	Titratable Actual Acidity (mole H^+/ tonne)	Chromium Reducible Sulfur (%S_{CR})	Acid Neutralising Capacity (%$CaCO_3$)	Net Acidity (mole H^+/ tonne)	Acid Sulfate Soil Material Classification
LBY1.1	0 - 2	Coarse	-	3.46	1.85	3.90	3991	4.04	30.60	0.03	0.00	48	sulfuric
LBY1.2	2 - 10	Coarse	-	3.48	2.26	3.60	684	5.18	4.53	< 0.01	0.00	5	sulfuric
LBY1.3	10 - 40	Coarse	-	4.01	2.24	4.50	2396	4.26	35.18	< 0.01	0.00	35	other acidic
LBY1.4	40 - 80	Medium	-	6.10	2.59	4.20	303	5.83	4.65	< 0.01	0.00	5	other acidic
LBY1.5	80 - 100	Medium	-	8.23	8.45	6.50	97	7.54	-	< 0.01	1.10	-146	other soil material
LBY2.1	0 - 8	Fine	-	5.41	1.93	4.00	5213	5.03	8.13	0.11	0.00	79	hyposulfidic (S_{CR}≥0.10%)
LBY2.2	8 - 20	Fine	-	4.82	2.59	4.00	2124	5.65	4.31	0.02	0.00	17	hyposulfidic (S_{CR}<0.10%)
LBY2.3	20 - 50	Fine	-	3.75	1.91	2.50	2520	5.17	8.48	0.07	0.00	51	sulfuric
LBY2.4	50 - 80	Fine	-	7.46	6.87	7.00	735	8.58	-	< 0.01	1.46	-195	other soil material
LBY2.5	80 - 100	Medium	-	-	-	-	-	-	-	-	-	-	-
LBY3.1	0 - 5	Medium	-	5.48	2.87	2.50	7165	3.76	51.26	0.09	0.00	107	hypersulfidic
LBY3.2	5 - 25	Medium	-	2.84	1.62	5.00	933	4.98	14.26	< 0.01	0.00	14	sulfuric
LBY3.3	25 - 30	Coarse	-	6.24	3.98	4.70	379	6.13	3.01	< 0.01	0.00	3	other acidic
LBY3.4	30 - 55	Fine	-	6.69	3.48	4.70	1035	6.18	4.02	< 0.01	0.00	4	other acidic
LBY3.5	55 - 80	Fine	-	8.07	7.66	6.50	407	8.54	-	< 0.01	2.43	-324	other soil material

54 FORSTER LAGOON WETLAND (WETLAND ID. 12027)

54.1 LOCATION AND SETTING DESCRIPTION

Forster Lagoon Wetland (Wetland ID. 12027) is situated on the north eastern side of the River Murray, up river from the Walker Flat car ferry ramp. The wetland is geomorphically categorised as a Murray Gorge basin (Pressey 1986) and is a sinuous shape following the river bend, approximately 4 kilometres in length and up to 350 metres at the widest, with a total surface area of 79 hectares. It is bounded to the north and east by hill slopes and to the south and west there is a raised bank and floodplain approximately 100 metres wide. There are two narrow water connection channels with the river at the up and down river ends of the wetland. At the time when the soil survey was conducted in September 2008, the wetland was generally dry and there was surface water in a low depression area, possibly from recent rain. The wetland had cracking clay surfaces with no vegetation growth, fringing the area and in the channels were isolated areas of *Phragmites australis* (Common Reed) vegetation, and trees on the raised bank. Four sites were described and sampled and their locations are shown in Figure 54-1.

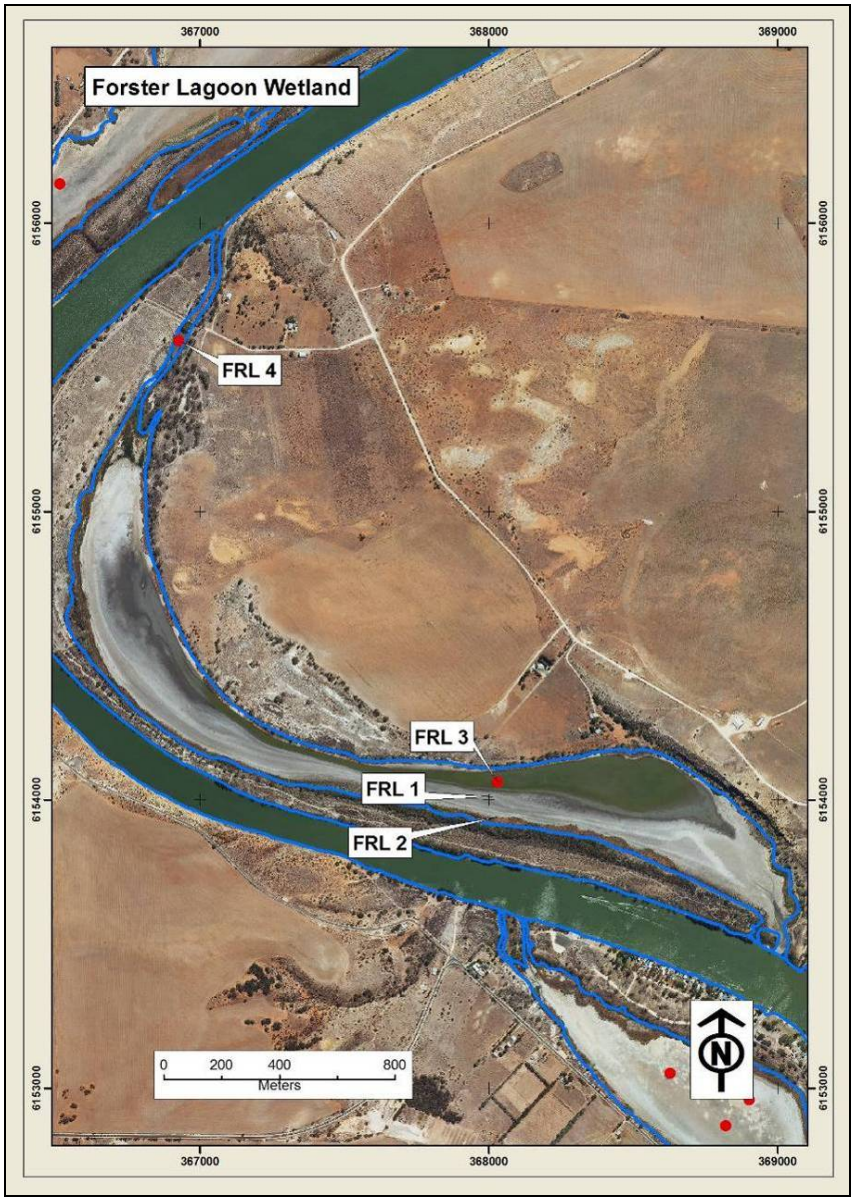

Figure 54-1. Forster Lagoon Wetland and sample site locations.

54.2 SOIL PROFILE DESCRIPTION AND DISTRIBUTION

Four sites were described and sampled. The acid sulfate soil subtype class and general location description are presented in Table 54-1. Sites were located to form a cross-section across the wetland from the wetland margin near the river (FRL2), main area of the wetland at low elevation (FRL1) and in the channel depression (FRL3). Site FRL4 was located in the up-river channel entering the wetland. The site and soil profile descriptions are presented in Table 54-2 and Table 54-3.

Site FRL1 (Figure 54-2) occurred in the middle of the wetland, the surface was cracking and no vegetation was growing. The soil consisted of black, very firm clay over dark grey, firm clay.

Site FRL2 (Figure 54-3) occurred on the river side of the wetland amongst *Typha latifolia* (Bulrush) that fringed the slightly higher elevation areas. The soil consisted of black, slightly rigid clay, over black, very firm clay.

Site FRL3 (Figure 54-4) occurred on the hill slope side of the wetland in a channel depression that had shallow surface water and in-filling of the surface cracks. The soil consisted of a thin grey, firm clay over a dark grey, very soft, almost peaty clay, and at depth black, firm clay.

Site FRL4 (Figure 54-5) occurred in the up river channel connection of the wetland with the river; the surface was bare with friable clay aggregates and on the channel margins *Typha latifolia* (Bulrush) was growing. The soil consisted of grey, firm clay over pale grey, firm, very sticky clay.

Table 54-1. Soil identification, subtype and general location description of sites for Forster Lagoon Wetland.

Site ID	Easting m Zone 54H	Northing m Zone 54H	Acid sulfate soil subtype class	General location description
FRL1	368013	6154010	Hypersulfidic cracking clay soil	Low to mid elevation, cracking clay areas
FRL2	368027	6153938	Other soil (clay)	Mid elevation, cracking clay areas
FRL3	368031	6154061	Hypersulfidic cracking clay soil	Low elevation, cracking clay areas
FRL4	366928	6155592	Hypersulfidic cracking clay soil	Low elevation, in channel

Figure 54-2. Photographs of site FRL1, showing the cracking clay surface of the main wetland area, and the soil profile of very firm clay.

Figure 54-3. Photograph of site FRL2, showing the soil profile of rigid clay and *Phragmites australis* (Common Reed) roots.

Figure 54-4. Photograph of site FRL3, showing the shallow surface water in soil cracks and the low depression located near the hill slope.

Figure 54-5. Photograph of site FRL4, showing the soil profile of friable clay aggregates to about 20 cm over a firm clay.

54.3 LABORATORY DATA ASSESSMENT

Soil pH testing (pH_W, pH_{OX}, pH_{INC})

The pH data are provided in Table 54-4 and pH profiles are presented in Figure 54-6.

The pH_W data did not identify samples as sulfuric materials with a pH_W <4.

The pH_{INC} data for some layers in profiles FRL1, FRL3 and FRL4 identified samples that on incubation declined below the critical value of pH<4. Samples that age to pH_{INC}<4 indicate that these soils potentially would form sulfuric material as a result of sulfide oxidation.

The pH_{OX} data for the surface layers of profiles FRL1 and FRL2 identified samples below the critical value of pH_{OX} <2.5, the threshold value normally used to indicate a high likelihood of sulfuric material forming.

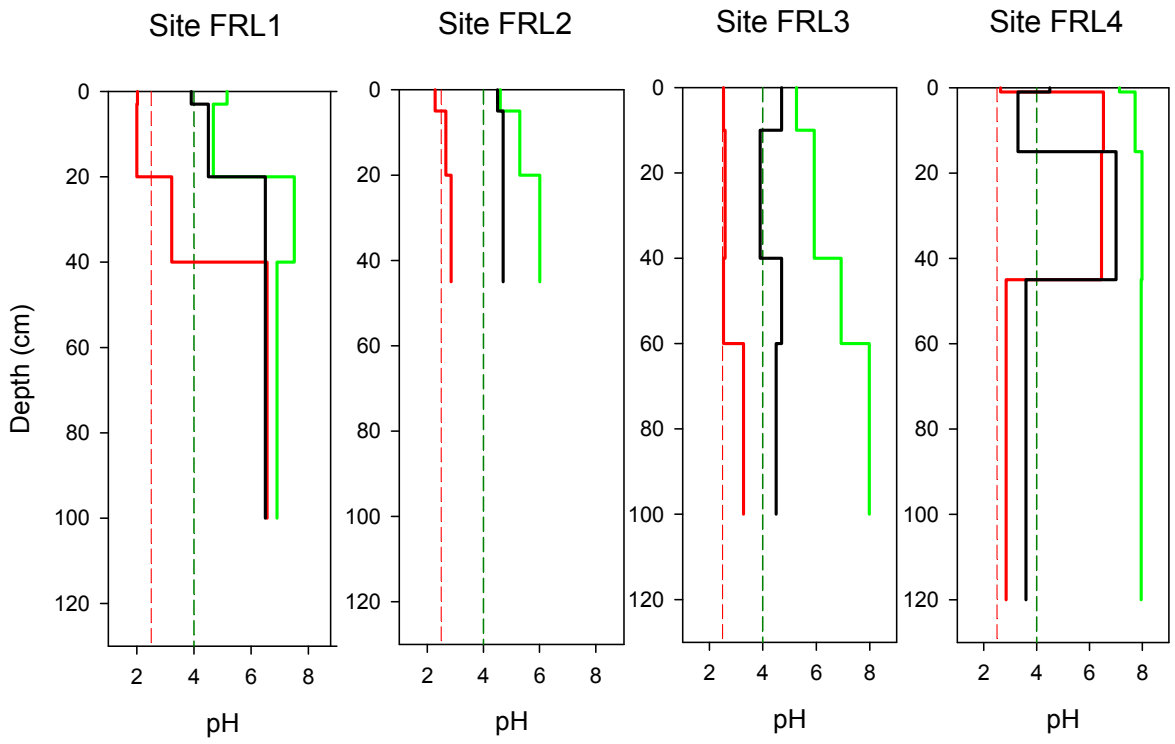

Figure 54-6. Depth profiles of soil pH for Forster Lagoon Wetland, showing soil pH (pH_W as green line), peroxide treated pH (pH_{OX} as red line) and ageing pH (pH_{INC} after 28 weeks as black line). Critical pH_W and pH_{INC} value of 4 (black dashed line) and critical pH_{OX} value of 2.5 (red dashed line).

Acid Base Accounting

The acid base accounting data is provided in Table 54-4 and summarised in Figure 54-7.

Chromium reducible sulfur values ranged from below the limit of detection to 0.17 $\%S_{CR}$. Sulfidic materials were detected in most soil layers of FRL1, FRL3, and FRL4, and no sulfidic materials were detected in layers of profile FRL2.

Titratable actual acidity values ranged from 0 to 26.36 mole H^+/tonne. Concentrations were measured in most layers of profiles FRL1, FRL2 and FRL3.

Analysis of retained acidity was not conducted on any of the samples, as all samples were above the critical value of pHK_{Cl} <4.5.

Acid neutralising capacity values ranged from 0 to 0.90 $\%CaCO_3$, and were measured in the subsoil layers of profiles FRL1 and FRL3, and in all layers of profile FRL4. For layers of profile FRL2 it was not measured.

Net acidity values ranged from -71 to 67 mole H^+/tonne. Moderate and low net acidity values occurred in layers of profiles FRL1, FRL2, and FRL3 and negative values for the lower subsoil layers of profiles FRL1 and FRL3, possibly due to the ground water influence. Low and negative values occurred in profile FRL 4.

Water Soluble Sulfate

Water soluble sulfate data values shown in Table 54-4 identified that surface layers were above the trigger value of 100 mg/kg SO_4.

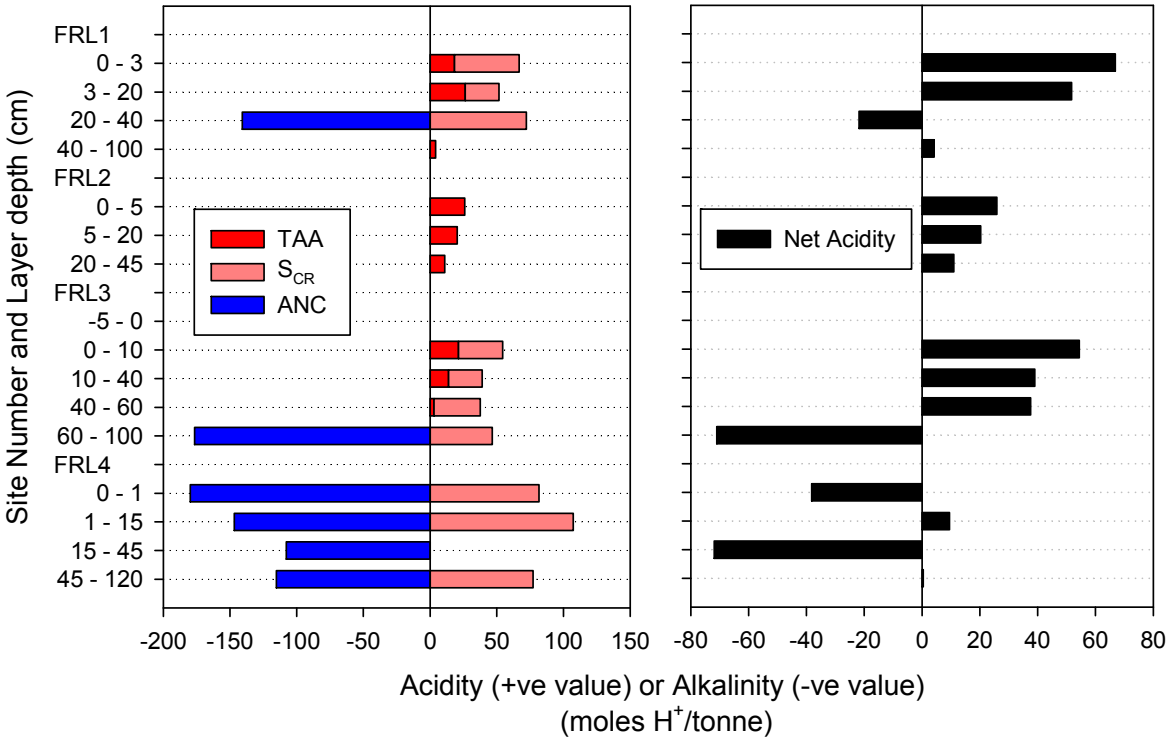

Figure 54-7. Acid base accounting depth profiles for Forster Lagoon Wetland. Left side shows the components: titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} -pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.

54.4 DISCUSSION

Acid sulfate soil materials at Forster Lagoon Wetland were identified as hypersulfidic that occurred throughout the main area of the wetland in surface soil layers, and hyposulfidic that occurred throughout the wetland in surface and subsurface layers. In areas around the margins of the wetland, acid sulfate soil materials were not identified but were characterised as acidic because the pH values were <5.

The soils were clayey and cracking, the soil cracks in some areas were filled with the break down of the surface soils into aggregates and wind-blown sand. Near the hill slope side of the wetland there was surface water probably from a ground-water seep that filled soil cracks, the water pH was acidic but not sulfuric. The lower clay subsoils had negative net acidity indicating that the subsoil had acid neutralising capacity.

The potential hazards posed by acid sulfate soil materials at the Forster Lagoon Wetland are:

- Acidification hazard: The hypersulfidic soil materials occurred in the surface and near surface soil layers, and they indicate a potential acidification hazard due to oxidation. There is a medium to high level of concern.
- De-oxygenation hazard: The water soluble sulfate data indicates a potential for monosulfidic materials to form in the surface layers of soils, monosulfidic material was not observed. There is a high level of concern.
- Metal mobilisation hazard: The medium to high level acidification hazard indicates that soil acidification may increase the solubility of metals. There is a medium level of concern.

Summary of key findings for Forster Lagoon Wetland:

Soil materials:	The soils throughout the main area of the wetland were clays with deep cracks that were filled by surface aggregates, sand or water. The upper soil layers were hypersulfidic, and the subsoil layers were hyposulfidic and in some areas hypersulfidic. In some areas of the wetland margin, acid sulfate soil materials were not identified but they were acidic.
Acid sulfate soil identification:	• Hypersulfidic Cracking Clay Soil – that occurred throughout the wetland. Dominant (>50%) in extent. • Other Soil (clayey) – that occurred on the margins of the wetland. Minor (<25%) in extent.
Hazard assessment	• Acidification hazard: medium to high level of concern • De-oxygenation hazard: high level of concern • Metal mobilisation: medium level of concern

Table 54-2. Site data for Forster Lagoon Wetland.

Site Number	Sampled Date	Easting m Zone 54H	Northing m Zone 54H	Soil Classification	Water depth (+ve) Water table (-ve)	Surface Condition	Earth Cover (Vegetation)	Location Notes
FRL1	03-Sep-08	368013	6154010	Hypersulfidic cracking clay soil	not reached	cracking	Bare	mid,
FRL2	03-Sep-08	368027	6153938	Other soil (clay)	not reached	cracking, plant litter	Bulrushes	low, edge of wetland river side,
FRL3	03-Sep-08	368031	6154061	Hypersulfidic cracking clay soil	-5	cracking, filled with water	Bare	low, with water,
FRL4	03-Sep-08	366928	6155592	Hypersulfidic cracking clay soil	80	loose aggregates	Bare	low, channel,

Table 54-3. Soil description data for Forster Lagoon Wetland.

Site and Sample Number	Depth Upper (cm)	Depth Lower (cm)	Observation Method (kind)	Soil Colour (Munsell notation)	Texture (class)	Soil Water Status	Mottles Quantity (%)	Mottles Colour	Mottles Location	Structure Type (category)	Consistence (category)	Comments
FRL1.1	0	3	soil pit	10YR 5/1	clay	moist	2	10YR 8/1	in matrix along ped faces	cloddy	slightly rigid	white salts on surface
FRL1.2	3	20	soil pit	2.5Y 2.5/1	clay	moist	2	5YR 5/8	in matrix	subangular blocky	very firm	
FRL1.3	20	40	soil pit	2.5Y 2.5/1	clay	moist	2	10YR 8/1	in matrix along ped faces	massive	very firm	white salts on surface
FRL1.4	40	100	push tube	2.5Y 2.5/1	clay	moist	0			massive	firm	
FRL2.1	0	5	soil pit	2.5Y 5/2	clay	moist	2	5YR 5/6	on ped faces	angular blocky	slightly rigid	
FRL2.2	5	20	soil pit	2.5Y 2.5/1	clay	moist	2	10YR 8/1	in matrix along ped faces	subangular blocky	slightly rigid	white salts on surface
FRL2.3	20	45	soil pit	2.5Y 2.5/1	clay	moist	0			massive	very firm	
FRL3.0	-5	0	water		water	wet	0					water, mainly in cracks
FRL3.1	0	10	soil pit	5Y 4/1	clay	wet	0			subangular blocky	firm	algae on the surface
FRL3.2	10	40	push tube	5Y 4/1	clay	wet	5	5YR 5/8	in matrix	subangular blocky	very soft	
FRL3.3	40	60	push tube	5Y 2.5/2	peaty clay	wet	0			massive	very soft	
FRL3.4	60	100	push tube	5Y 2.5/2	clay	wet	0			massive	firm	
FRL4.1	0	1	soil pit	5Y 4/1	clay	dry	0			cloddy	friable	
FRL4.2	1	15	soil pit	5Y 5/2	clay	moist	0			subangular blocky	firm	mixed layer with grey/black/red material
FRL4.3	15	45	soil pit	5Y 5/2	clay	moist	5	5YR 5/8	in matrix	massive	very firm	
FRL4.4	45	120	push tube	5Y 3/2	clay	moist	0			massive	firm	very sticky

Table 54-4. Laboratory data for acid sulfate soil assessment of Forster Lagoon Wetland.

(red printed values indicates data results of concern)

Site and Layer ID.	Depth Range (cm)	Soil Texture	EC (µS/cm)	pH water	pH peroxide	pH incubation	Sulfate (mg SO_4/kg)	pH KCl	Titratable Actual Acidity (mole H^+/ tonne)	Chromium Reducible Sulfur (%S_{CR})	Acid Neutralising Capacity (%$CaCO_3$)	Net Acidity (mole H^+/ tonne)	Acid Sulfate Soil Material Classification
FRL1.1	0 - 3	Fine	-	5.16	2.02	3.90	5085	4.68	18.30	0.08	0.00	67	hypersulfidic
FRL1.2	3 - 20	Fine	-	4.68	2.00	4.50	4075	4.55	26.36	0.04	0.00	52	hyposulfidic (S_{CR}<0.10%)
FRL1.3	20 - 40	Fine	-	7.51	3.22	6.50	1579	6.51	-	0.12	0.71	-22	hyposulfidic (S_{CR}≥0.10%)
FRL1.4	40 - 100	Fine	-	6.91	6.56	6.50	1267	5.93	4.18	< 0.01	0.00	3	other soil material
FRL2.1	0 - 5	Fine	-	4.60	2.28	4.50	3705	4.77	25.89	< 0.01	0.00	26	other acidic
FRL2.2	5 - 20	Fine	-	5.30	2.66	4.70	1423	5.11	20.30	< 0.01	0.00	20	other acidic
FRL2.3	20 - 45	Fine	-	6.01	2.85	4.70	386	5.41	10.96	< 0.01	0.00	11	other acidic
FRL3.0	-5 - 0	Water	-	-	-	-	-	-	-	-	-	-	water
FRL3.1	0 - 10	Fine	-	5.26	2.53	4.70	1601	4.75	21.42	0.05	0.00	54	hyposulfidic (S_{CR}<0.10%)
FRL3.2	10 - 40	Fine	-	5.92	2.59	3.90	1226	5.07	13.89	0.04	0.00	39	hypersulfidic
FRL3.3	40 - 60	Fine	-	6.93	2.53	4.70	571	6.11	2.99	0.06	0.00	38	hyposulfidic (S_{CR}<0.10%)
FRL3.4	60 - 100	Fine	-	7.98	3.28	4.50	392	6.67	-	0.07	0.88	-71	hyposulfidic (S_{CR}<0.10%)
FRL4.1	0 - 1	Fine	-	7.13	2.64	4.50	1538	6.78	-	0.13	0.90	-38	hyposulfidic (S_{CR}≥0.10%)
FRL4.2	1 - 15	Fine	-	7.72	6.53	3.30	10,392	6.80	-	0.17	0.73	10	hypersulfidic
FRL4.3	15 - 45	Fine	-	7.98	6.45	7.00	164	6.92	-	< 0.01	0.54	-72	other soil material
FRL4.4	45 - 120	Fine	-	7.95	2.85	3.60	394	6.77	-	0.12	0.58	1	hypersulfidic

55 WONGULLA LAGOON WETLAND (WETLAND ID. 12026)

55.1 LOCATION AND SETTING DESCRIPTION

Wongulla Lagoon Wetland (Wetland ID. 12026) is situated on the western side of the River Murray. The wetland is geomorphically categorised as a Murray Gorge basin (Pressey 1986) and is a somewhat linear shape, more than 3.5 kilometres in length and up to 400 metres at the widest, with a total surface area of 124 hectares. It is bounded to the north west by hill slopes and a road and to the south east there is a raised bank/terrace approximately 100 to 200 metres wide that separates the wetland from the river. There are four narrow water connection channels with the river at both ends of the wetland and mid way. At the time when the soil survey was conducted in August 2008, the wetland was generally dry and there was surface water in a low depression at the down river end near cliffs. The wetland has cracking clay surfaces, fringing the wetland and in the channels were *Phragmites australis* (Common Reed) vegetation. Three sites were described and sampled and their locations are shown in Figure 55-1.

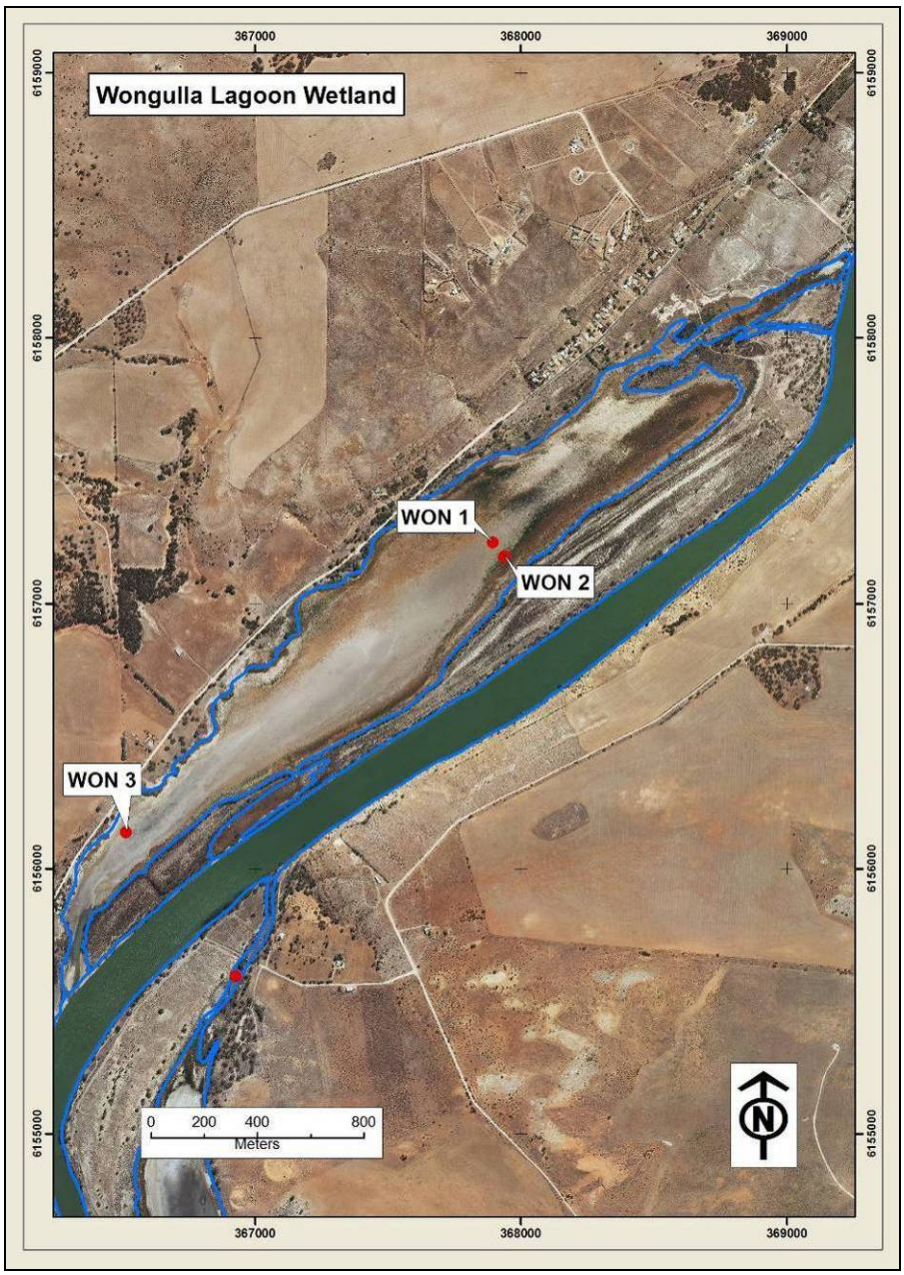

Figure 55-1. Wongulla Lagoon Wetland and sample site locations.

55.2 SOIL PROFILE DESCRIPTION AND DISTRIBUTION

Three sites were described and sampled. The acid sulfate soil subtype class and general location description are presented in Table 55-1. Sites were located to characterise the dominant wetland features that included the main wetland area (WON1), elevated margins (WON2) and the inlet channel (WON3). The site and soil profile descriptions are presented in Table 55-2 and Table 55-3.

Site WON1 (Figure 55-2) occurred near the middle of the wetland, the surface was cracking and no vegetation was growing. The soil consisted of grey, very firm clay over black, firm clay.

Site WON2 (Figure 55-3) occurred on the river side of the wetland amongst *Phragmites australis* (Common Reed) that fringed the slightly higher elevation areas. The soil consisted of dark grey, firm clay, over black, very firm clay.

Site WON3 (Figure 55-4) occurred near the down river channel and close to where water was on the surface in a depression. The soil consisted of a thin grey, soft clay over a black, firm, and at depth, olive grey, firm clay.

Table 55-1. Soil identification, subtype and general location description of sites for Wongulla Lagoon Wetland.

Site ID	Easting m Zone 54H	Northing m Zone 54H	Acid sulfate soil subtype class	General location description
WON1	367896	6157229	Cracking clay soil	Low to mid elevation, cracking clay soil areas
WON2	367938	6157176	Other soil (clay)	Higher elevation, on the margins of the wetland where *Phragmites australis* (Common Reed) and *Typha latifolia* (Bulrush) grow
WON3	366516	6156137	Other soil (cracking clay)	Low elevation, near down-river inlet

Figure 55-2. Photographs of site WON1, showing the main wetland area of cracking clay soils, and the soil profile of very firm clay.

Figure 55-3. Photograph of site WON2, showing the soil profile of grey clay and *Phragmites australis* (Common Reed) roots.

Figure 55-4. Photographs of site WON3, showing the soft clay surface, and the soil profile of olive grey clay.

55.3 LABORATORY DATA ASSESSMENT

Soil pH testing (pH_W, pH_{OX}, pH_{INC})

The pH data are provided in Table 55-4 and pH profiles are presented in Figure 55-5.

The pH_W data did not identify samples as sulfuric materials with a pH_W <4.

The pH_{INC} data did not identify samples that on incubation declined below the critical value of pH<4. Samples that age to pH_{INC}<4 indicate that these soils potentially would form sulfuric material as a result of sulfide oxidation.

The pH_{OX} data did not identify samples below the critical value of pH_{OX} <2.5, the threshold value normally used to indicate a high likelihood of sulfuric material forming.

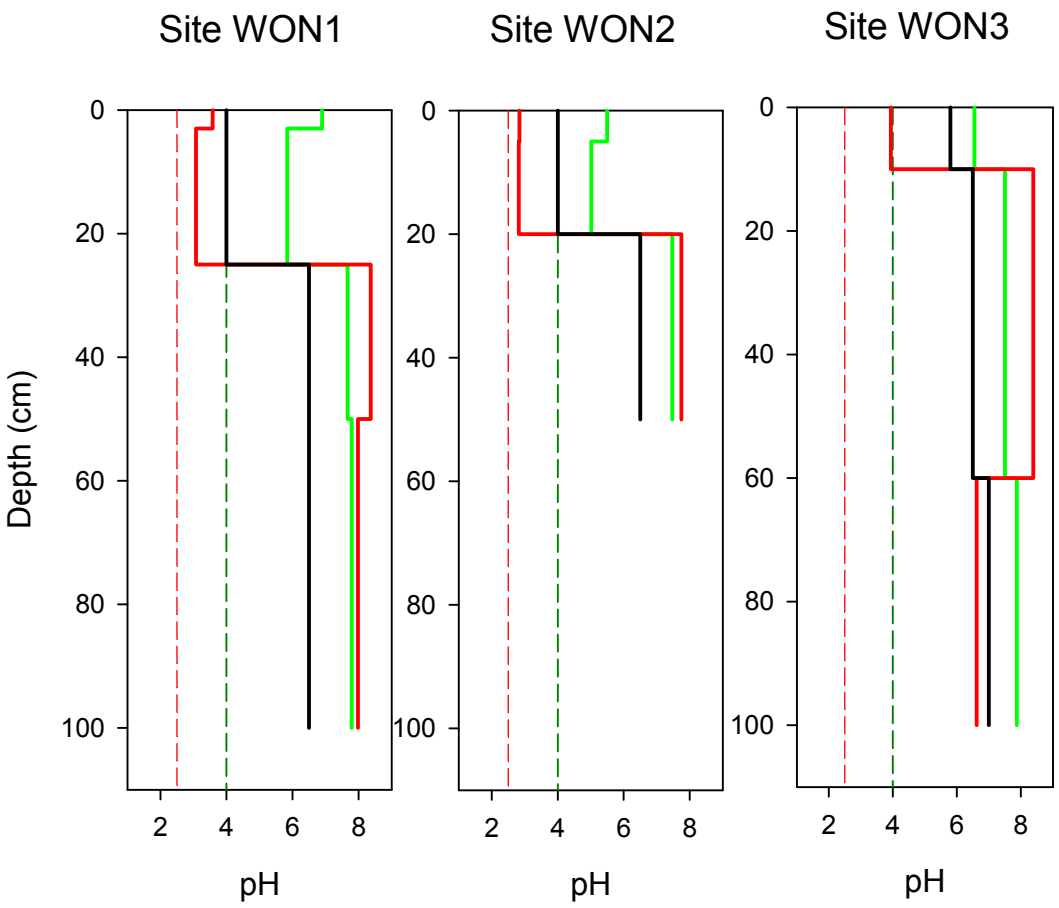

Figure 55-5. Depth profiles of soil pH for Wongulla Lagoon Wetland, showing soil pH (pH_W as green line), peroxide treated pH (pH_{OX} as red line) and ageing pH (pH_{INC} after 28 weeks as black line). Critical pH_W and pH_{INC} value of 4 (black dashed line) and critical pH_{OX} value of 2.5 (red dashed line).

Acid Base Accounting

Acid base accounting data is provided in Table 55-4 and summarised in Figure 55-6.

Chromium reducible sulfur values were all below detection limits. Sulfidic materials were not detected in the three profiles.

Titratable actual acidity values ranged from 0 to 29.36 mole H^+/tonne. Concentrations were measured in the upper soil layers for the three profiles.

Analysis of retained acidity was not conducted on any of the samples, however retained acidity may be present in the subsurface layer of profile WON2 that was below the critical value of pH_{KCl} <4.5.

Acid neutralising capacity values ranged from 0 to 1.02 %$CaCO_3$, and were measured in the lower subsoil layers for all three profiles.

Net acidity values ranged from -136 to 29 mole H^+/tonne. Low net acidity values occurred in the upper soil layers with the exception of 5 to 20 cm in profile WON2 which was moderate. The lower subsoil layers were negative.

Water Soluble Sulfate

Water soluble sulfate data values shown in Table 55-4 identified surface layers in profiles WON1 and WON2 were above the trigger value of 100 mg/kg of SO_4.

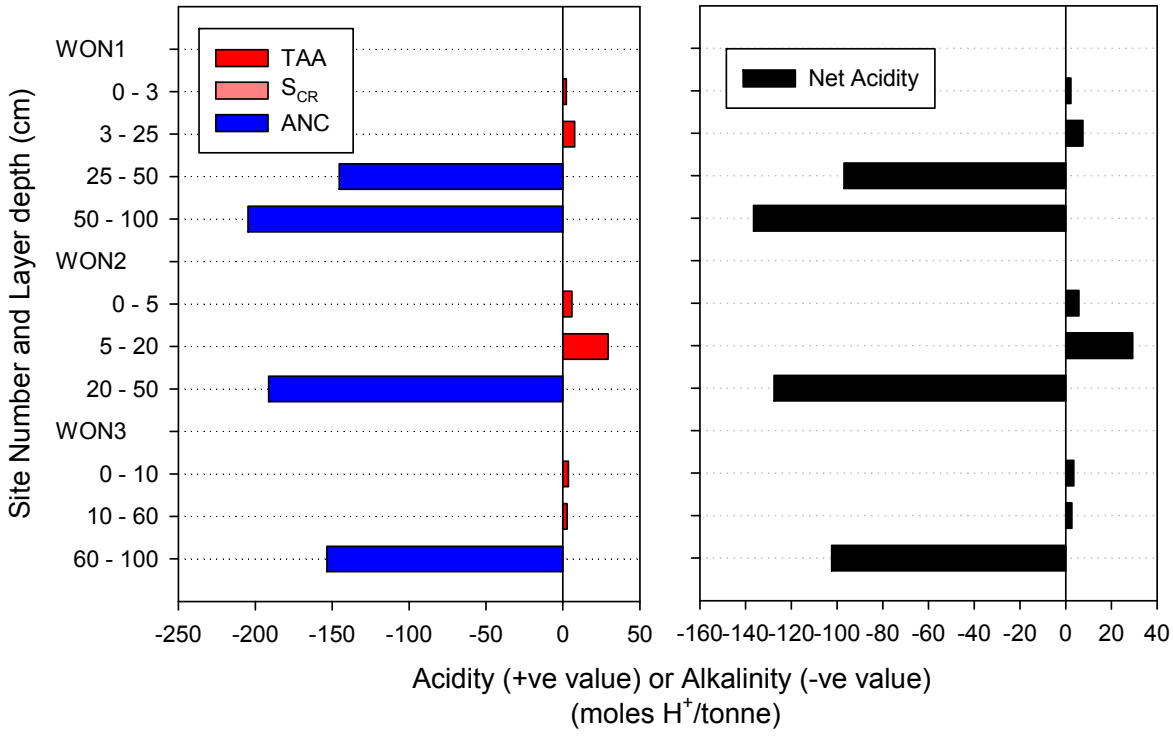

Figure 55-6. Acid base accounting depth profiles for Wongulla Lagoon Wetland. Left side shows the components: titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} -pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.

55.4 DISCUSSION

Acid sulfate soils materials at Wongulla Lagoon Wetland were not identified. Soil materials were characterised as other acidic in the surface layers or other soil materials in the subsoils.

The soils throughout the main lower area of the wetland were cracking clays that had cracks extending into the subsoil, often the cracks had filled with the breakdown of surface soil layers or wind-blown sand. On the margins of the wetland the soils were clays but they were not cracking and in some areas sand was accumulating on the surface when trapped amongst the *Phragmites australis* (Common Reed) vegetation.

The potential hazards posed by acid sulfate soil materials at the Wongulla Lagoon Wetland are:

- Acidification hazard: Acid sulfate soil materials were not identified, however some of the upper soil layers were characterised as acidic. There is a low level of concern.
- De-oxygenation hazard: The water soluble sulfate data indicated that there was no potential for monosulfidic materials to form in the surface layers of the soils, except for Site WON2 that was above the trigger value but this site was at a high elevation and unlikely to be inundated until the wetland water level was near maximum height. There is a low level of concern.
- Metal mobilisation hazard: The low acidification hazard indicates that soil acidification potential is not likely to increase the solubility of metals, however the pH values were <5.0 suggesting that aluminium may be mobilised. There is a low level of concern.

Summary of key findings for Wongulla Lagoon Wetland:

Soil materials:	The soils were cracking clay soils throughout the wetland and acid sulfate soil materials were not identified. Some surface soil samples had a pH_{INC} <5 indicating aluminium may potentially mobilise.
Acid sulfate soil identification:	• Cracking Clay Soil – that occurred throughout the wetland. Dominant (>50%) in extent. • Clay Soil – that occurred on the wetland margins at high elevation. Isolated (<10%) in extent.
Hazard assessment	• Acidification hazard – low level of concern • De-oxygenation hazard – low level of concern • Metal mobilisation hazard – low level of concern

Table 55-2. Site data for Wongulla Lagoon Wetland.

Site Number	Sampled Date	Easting m Zone 54H	Northing m Zone 54H	Soil Classification	Water depth (+ve) Water table (-ve)	Surface Condition	Earth Cover (Vegetation)	Location Notes
WON1	28-Aug-08	367896	6157229	Cracking clay soil	not reached	cracking, very hard	Bare	mid,
WON2	28-Aug-08	367938	6157176	Other soil (clay)	not reached	cracking	*Phragmites australis* (Common Reed)	high, on edge,
WON3	28-Aug-08	366516	6156137	Other soil (cracking clay)	35	sealed	Bare	low,

Table 55-3. Soil description data for Wongulla Lagoon Wetland.

Site and Sample Number	Depth Upper (cm)	Depth Lower (cm)	Observation Method (kind)	Soil Colour (Munsell notation)	Texture (class)	Soil Water Status	Mottles Quantity (%)	Mottles Colour	Mottles Location	Structure Type (category)	Consistence (category)	Comments
WON1.1	0	3	soil pit	2.5Y 5/2	clay	dry	3	2.5YR 5/6	in matrix along ped faces	subangular blocky	extremely hard	white salts on surface
WON1.2	3	25	soil pit	2.5Y 5/2	clay	dry	2	2.5Y 6/6	in matrix	subangular blocky	hard	
WON1.3	25	50	soil pit	2.5Y 3/1	clay	moist	0			subangular blocky	very firm	
WON1.4	50	100	push tube	2.5Y 2.5/1	clay	moist	0			massive	firm	
WON2.1	0	5	soil pit	2.5Y 4/2	clay loam	moist	3	10YR 6/6	in matrix	subangular blocky	firm	
WON2.2	5	20	soil pit	2.5Y 3/1	clay	moist	3	10YR 6/6	in matrix	subangular blocky	firm	
WON2.3	20	50	soil pit	2.5Y 2.5/1	clay	moist	0			massive	very firm	
WON3.1	0	10	soil pit	2.5Y 4/1	sandy clay loam	moist	0			massive	very friable	
WON3.2	10	60	soil pit	2.5Y 2.5/1	clay	moist	0			subangular blocky	firm	
WON3.3	60	100	push tube	2.5Y 4/2	clay	wet	0			massive	very firm	contains patches of black clay

Table 55-4. Laboratory data for acid sulfate soil assessment of Wongulla Lagoon Wetland.

(red printed values indicates data results of concern)

Site and Layer ID.	Depth Range (cm)	Soil Texture	EC (µS/cm)	pH water	pH peroxide	pH incubation	Sulfate (mg SO_4/kg)	pH KCl	Titratable Actual Acidity (mole H^+/ tonne)	Chromium Reducible Sulfur (%S_{CR})	Acid Neutralising Capacity (%$CaCO_3$)	Net Acidity (mole H^+/ tonne)	Acid Sulfate Soil Material Classification
WON1.1	0 - 3	Fine	-	6.90	3.58	4.00	41	6.13	2.29	< 0.01	0.00	2	other acidic
WON1.2	3 - 25	Fine	-	5.84	3.08	4.00	170	5.44	7.56	< 0.01	0.00	8	other acidic
WON1.3	25 - 50	Fine	-	7.67	8.37	6.50	22	6.50	-	< 0.01	0.73	-97	other soil material
WON1.4	50 - 100	Fine	-	7.79	7.98	6.50	17	6.85	-	< 0.01	1.02	-136	other soil material
WON2.1	0 - 5	Medium	-	5.50	2.84	4.00	129	5.56	5.86	< 0.01	0.00	6	other acidic
WON2.2	5 - 20	Fine	-	5.02	2.82	4.00	313	4.21	29.36	< 0.01	0.00	29	other acidic
WON2.3	20 - 50	Fine	-	7.47	7.75	6.50	65	6.64	-	< 0.01	0.96	-128	other soil material
WON3.1	0 - 10	Medium	-	6.55	3.94	5.80	85	5.83	3.55	< 0.01	0.00	4	other soil material
WON3.2	10 - 60	Fine	-	7.50	8.39	6.50	40	6.22	2.71	< 0.01	0.00	3	other soil material
WON3.3	60 - 100	Fine	-	7.87	6.62	7.00	38	6.70	-	< 0.01	0.77	-102	other soil material

56 KROEHNS LANDING WETLAND (WETLAND ID. 12489)

56.1 BACKGROUND

Kroehns Landing Wetland is located on the eastern side of the River Murray. The wetland is oval in shape, approximately 1100 metres long, and 600 metres at the widest point. The wetland is bounded to the east by a steep cliff and to the west by a levee bank that separates it from the river. A small island (< 1 ha) is located towards the western shore. There are channels at the northern and southern ends connecting the wetland with the river.

This wetland was studied in 2007/08 as part of a separate monitoring investigation of acid sulfate soils, the work and data was presented in the report 'Acid sulfate soils in subaqueous, waterlogged and drained soil environments of nine wetlands below Blanchetown (Lock 1), South Australia: properties, genesis, risks and management' (Fitzpatrick, Shand, Thomas, Merry, Raven and Simpson, November 2008. Report prepared for South Australian Murray-Darling Basin Natural Resources Management Board. CSIRO Land and Water Science Report 42/08). Readers are referred to this report for detailed information, and here a summary of the findings are presented.

At the time of field sampling the wetland was dry. Sites were located near the island in the wetland (Sites KRL1 and KRL 2), and towards the eastern bank of the wetland (Sites KRL3 and KRL4). Four sites were sampled and their locations are shown in Figure 56-1.

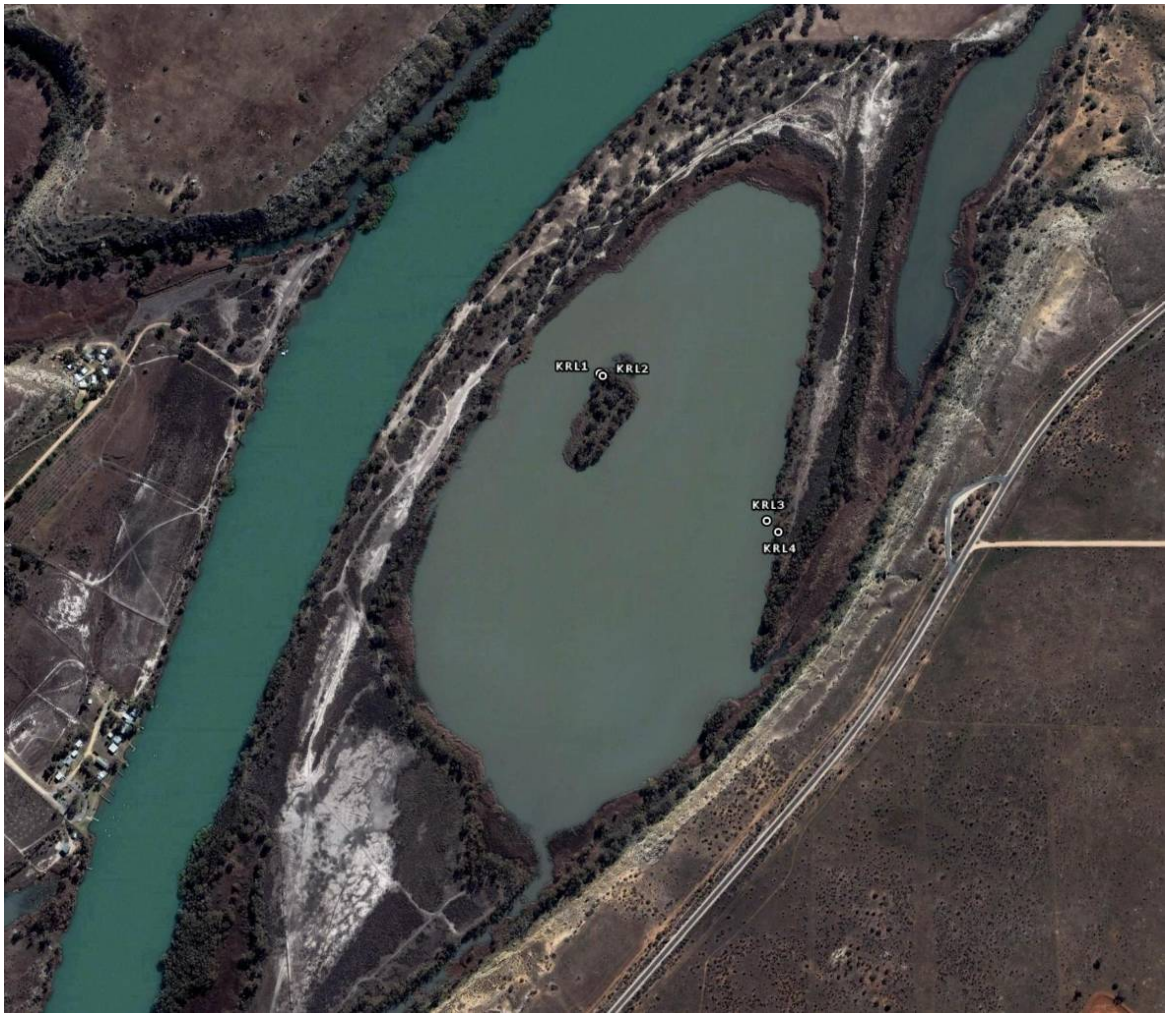

Figure 56-1. Kroehns Landing Wetland and sample site locations.

56.2 DISCUSSION

Acid sulfate soil materials at Kroehns Landing Wetland were identified as hypersulfidic or hyposulfidic in the surface and subsoil layers.

The soils throughout the wetland were clays with wide soil cracks that extended into the upper subsoil. In some areas these cracks had been filled with the break down of the surface soil material.

The potential hazards posed by acid sulfate soil materials at the Kroehns Landing Wetland are:

- Acidification hazard: Hypersulfidic and hyposulfidic soil materials occur throughout the wetland. There is a medium to high level of concern.
- De-oxygenation hazard: No data was available, but based on judgement and comparison with other similar soils in the area there would be potential for monosulfidic materials to form in the surface layers of soils, although monosulfidic material was not observed. There is a high level of concern.
- Metal mobilisation hazard: The medium to high acidification hazard indicates that soil acidification potential may increase the solubility of metals. There is a medium level of concern.

Summary of key findings for Kroehns Landing Wetland:

Soil materials:	The soils were clays with deep cracks that extended into the subsoil. The surface and subsurface layers throughout the wetland were hypersulfidic or hyposulfidic.
Acid sulfate soil identification:	• Hypersulfidic Cracking Clay Soils – occurring throughout the wetland. Dominant (>50%) in extent.
Hazard assessment	• Acidification hazard – medium to high level of concern • De-oxygenation hazard – high level of concern • Metal mobilisation hazard – medium level of concern

57 MARNE RIVER MOUTH WETLAND (WETLAND ID. 12490)

57.1 LOCATION AND SETTING DESCRIPTION

Marne River Mouth Wetland (Wetland ID. 12490) is situated on the western side of the River Murray, where the Marne River enters the river channel. The wetland is geomorphically categorised as a lentic (non-flowing) tributary (Pressey 1986) and is a sinuous shape that follows the lower area of the Marne River valley and water channel, with a total surface area of 17 hectares. The wetland is bounded by the slopes on either side of the river valley and a sand bar that separates it from the river. There is a water connection channel with the river at eastern end. At the time when the soil survey was conducted in August 2008, the wetland was generally dry with a few isolated areas of water on the surface. The surface was bare and cracking, and on the margins and in the channel there were thick isolated areas of *Phragmites australis* (Common Reed). Two sites were described and sampled and their locations are shown in Figure 57-1.

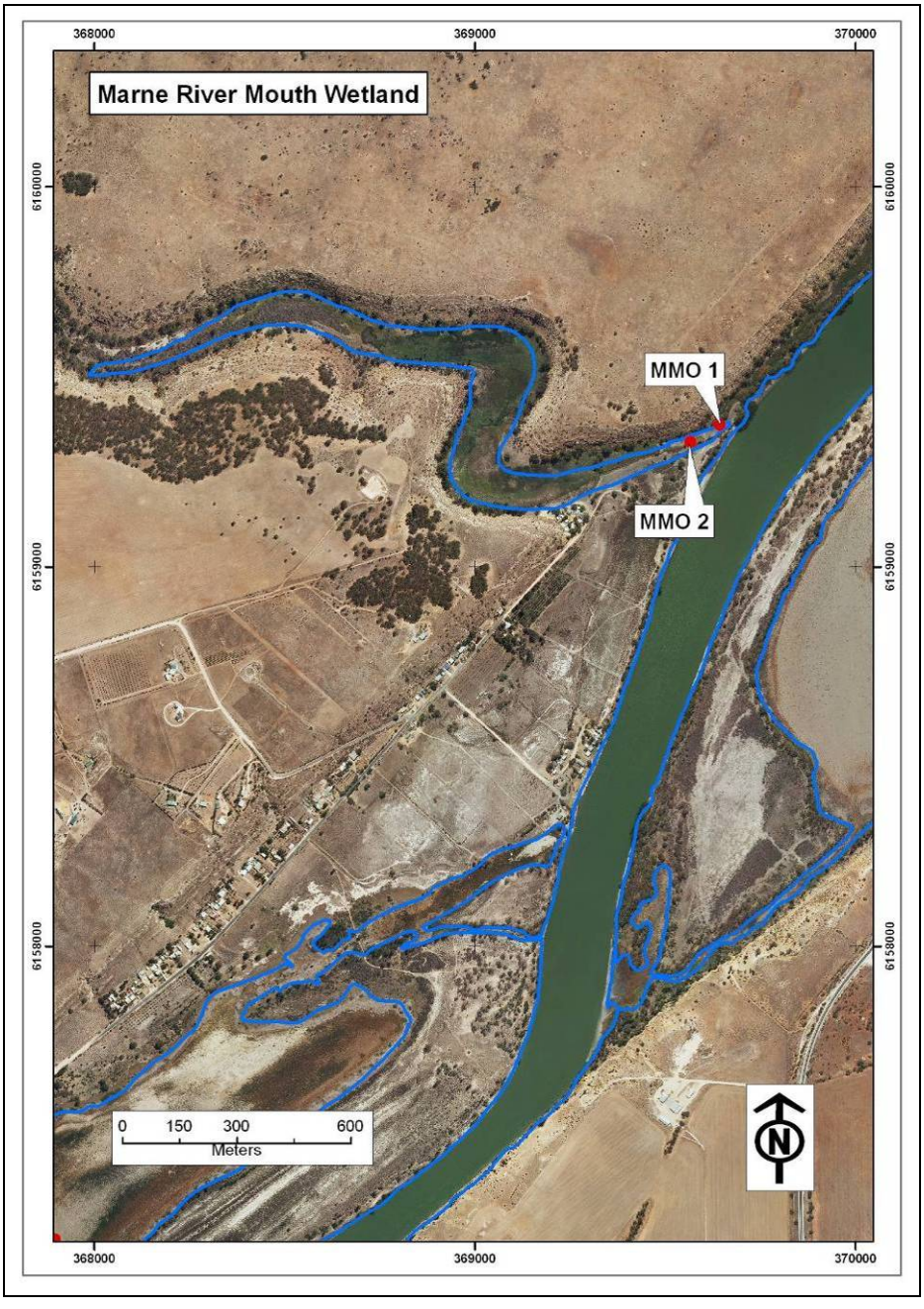

Figure 57-1. Marne River Mouth Wetland and sample site locations.

57.2 SOIL PROFILE DESCRIPTION AND DISTRIBUTIONS

Two sites were described and sampled. The acid sulfate soil subtype class and general location description are presented in Table 57-1. Sites were located at the river end of the wetland to characterise the main surface features. The site and soil profile descriptions are presented in Table 57-2 and Table 57-3.

Site MMO1 (Figure 57-2) occurred near the middle of the wetland where it connects with the river, there was no vegetation growing and the surface had crumbled into aggregates. The soil consisted of a thin surface layer of slightly rigid, blocky aggregates, over dark grey, soft, clay, over a brown to black, soft, peaty clay, and at depth olive grey, soft, peaty clay.

Site MMO2 (Figure 57-3) occurred amongst *Phragmites australis* (Common Reed) at a higher elevation on the wetland margin. The soil consisted of grey, friable, peaty clay over very firm, clay with many plant roots.

Table 57-1. Soil identification, subtype and general location description for Marne River Mouth Wetland.

Site ID	Easting m zone 54H	Northing m zone 54H	Acid sulfate soil subtype class	General location description
MMO1	369644	6159373	Hyposulfidic soil	Low elevation, in channel
MMO2	369567	6159328	Hyposulfidic soil	Mid elevation, on side of channel

Figure 57-2. Photographs of site MMO1, showing the main wetland area in the channel with no vegetation growing, and the soil profile of a thin layer of slightly rigid, clay aggregates over soft clay.

Figure 57-3. Photograph of site MMO2, showing the site location on the wetland margin marked by auger handle amongst tall *Phragmites australis* (Common Reed).

57.3 LABORATORY DATA ASSESSMENT

Soil pH testing (pH_W, pH_{OX}, pH_{INC})

The pH data are provided in Table 57-4 and pH profiles are presented in Figure 57-4.

The pH_W data did not identify sulfuric materials with a pH_W <4.

The pH_{INC} data for the deepest subsoil layer of profile MMO1 identified a sample that on incubation declined below the critical value of pH <4. Samples that age to pH_{INC}<4 indicate that these soils potentially would form sulfuric materials as a result of sulfide oxidation.

The pH_{OX} data for the deeper subsoil layers in profile MMO1 identified samples below the critical value of pH_{OX} <2.5, the threshold value normally used to indicate a high likelihood of sulfuric material forming.

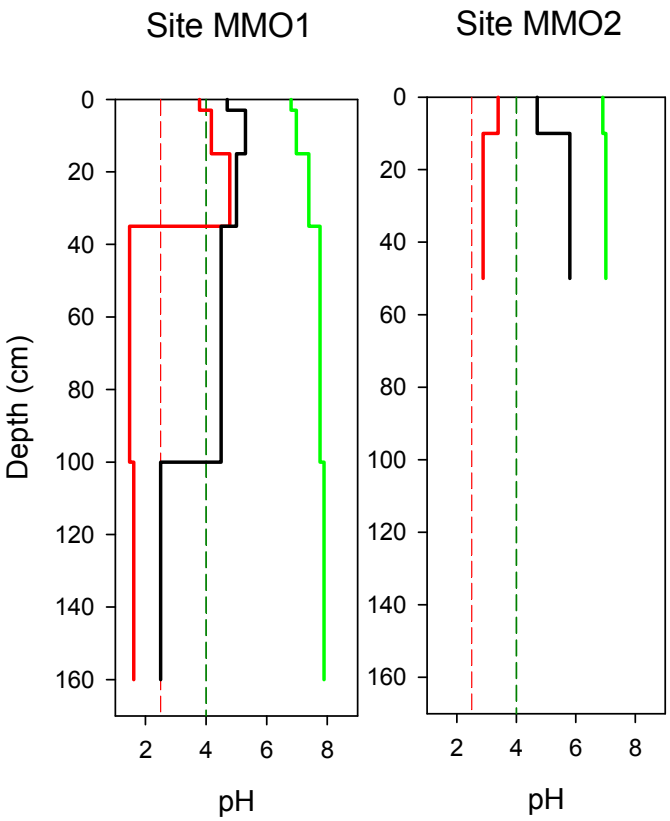

Figure 57-4. Depth profiles of soil pH for Marne River Mouth Wetland, showing soil pH (pH_W as green line), peroxide treated pH (pH_{OX} as red line) and ageing pH (pH_{INC} after 28 weeks as black line). Critical pH_W and pH_{INC} value of 4 (black dashed line) and critical pH_{OX} value of 2.5 (red dashed line).

Acid Base Accounting

The acid base accounting data is provided in Table 57-4 and summarised in Figure 57-5.

Chromium reducible sulfur values ranged from 0.02 to 0.85 $\%S_{CR}$. Sulfidic materials were detected in all layers of both profiles.

Titratable actual acidity was detected in one sample of profile MMO1 with a value of 1.61 mole H^+/tonne.

Analysis of retained acidity was not conducted on any of the samples, as all samples were above the critical value of pH_{KCl} <4.5.

Acid neutralising capacity values ranged from 0 to 1.52 $\%CaCO_3$, and were measured in nearly all samples of both profiles.

Net acidity values ranged from -153 to 427 mole H^+/tonne. High and low net acidity values occurred in the subsoil layers of profile MMO1 and the surface and upper subsoil layers for both profiles were negative.

Water Soluble Sulfate

Water soluble sulfate data values shown in Table 57-4 identified that surface layers were above the critical trigger value of 100 mg/kg SO_4.

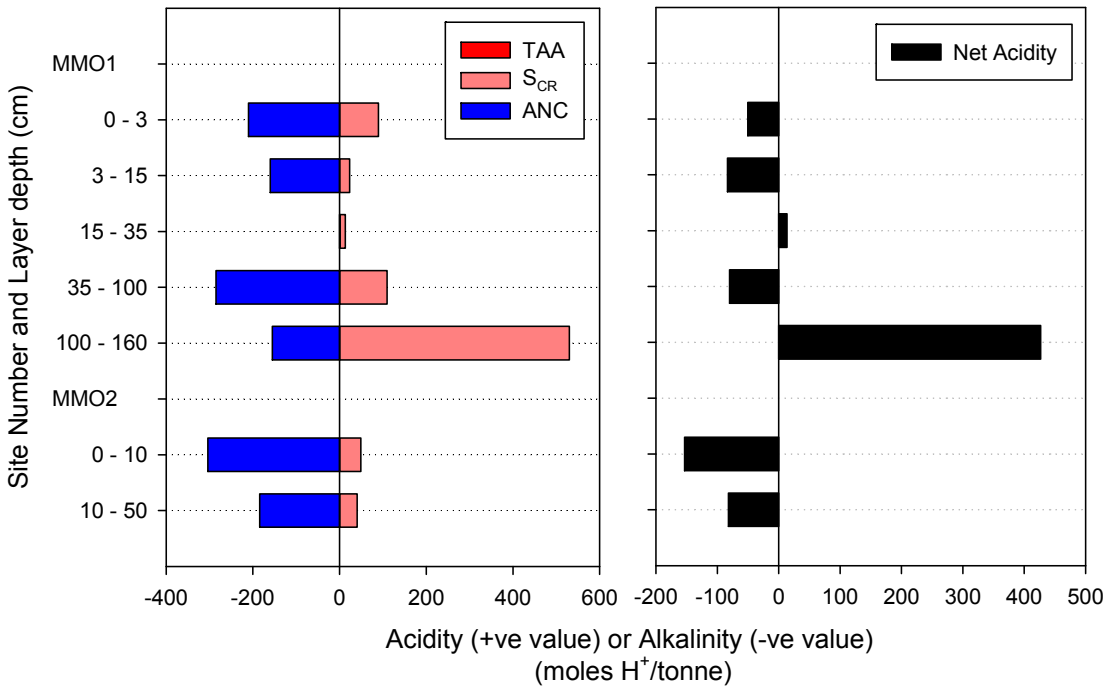

Figure 57-5. Acid base accounting depth profiles for Marne River Mouth Wetland. Left side shows the components: titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} - pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.

57.4 DISCUSSION

Acid sulfate soil materials at Marne River Mouth Wetland were identified as hypersulfidic in the deeper subsoil layer below 100 centimetres in profile MMO1 and hyposulfidic in all other layers. The acid sulfate soil subtype classes identified was Hyposulfidic Soil. It was considered that the hypersulfidic layer identified below 100 centimetres was deeper than the depth range used for soil classification.

The soils throughout the main wetland areas were generally a thin layer of slightly rigid clay aggregates over soft clay that became peaty clay at depth. The soils on the wetland margins were friable peaty clay over very firm clay with many plant roots.

Monosulfidic material was not observed but water soluble sulfate data identified that surface layers for the profiles throughout the wetland were in excess of the 100 mg/kg trigger value for monosulfide formation potential.

The potential hazards posed by acid sulfate soil materials at the Marne River Mouth Wetland are:

- Acidification hazard: The data identified moderate or high net acidity values in the subsoil layers, and pH data identified potential acidification due to oxidation. There is a medium level of concern.
- De-oxygenation hazard: The water soluble sulfate data indicated a potential for monosulfidic materials to form in the surface layers of soils, although monosulfidic material was not observed. There is a medium level of concern.
- Metal mobilisation: The medium acidification hazard indicates that soil acidification potential may increase the solubility of metals. There is a medium level of concern.

Summary of key findings for Marne River Mouth Wetland:

Soil materials:	Hyposulfidic soil materials were identified in most soil layers and one deeper subsoil layer was hypersulfidic. The soils throughout were generally soft clays over soft peaty clays Generally both profiles had negative net acidity values for the surface layers and the deeper subsoil layer of profile in the main wetland area was high and pH data identified potential acidification due to oxidation.
Acid sulfate soil identification:	• Hyposulfidic Soil – that occurred throughout the wetland. Dominant (>50%) in extent.
Hazard assessment	• Acidification hazard – medium level of concern. • De-oxygenation hazard – medium level of concern. • Metal mobilisation hazard – medium level of concern.

Table 57-2. Site data for Marne River Mouth Wetland.

Site Number	Sampled Date	Easting m zone 54H	Northing m zone 54H	Soil Classification	Water depth (+ve) Water table (-ve)	Surface Condition	Earth Cover (Vegetation)	Location Notes
MMO1	28-Aug-08	369644	6159373	Hyposulfidic soil	50	crumbling, hard	Bare	Low elevation, in channel
MMO2	28-Aug-08	369567	6159328	Hyposulfidic soil	50	plant material	*Phragmites australis* (Common Reed)	Mid elevation, on side of channel

Table 57-3. Soil description data for Marne River Mouth Wetland.

Site and Sample Number	Depth Upper (cm)	Depth Lower (cm)	Observation Method (kind)	Soil Colour (Munsell notation)	Texture (class)	Soil Water Status	Mottles Quantity (%)	Mottles Colour	Mottles Location	Structure Type (category)	Consistence (category)	Comments
MMO1.1	0	3	soil pit	2.5Y 4/1	clay	moist	3	2.5Y 8/1		subangular blocky	slightly rigid	white salts on surface
MMO1.2	3	15	soil pit	2.5Y 3/1	clay	moist	10	2.5Y 6/6	in matrix adjacent to pores	massive	soft	
MMO1.3	15	35	soil pit	2.5Y 3/1	clay	moist	10	2.5Y 6/6	in matrix along ped faces	massive	very firm	
MMO1.4	35	100	soil pit	2.5Y 2.5/1	peaty clay	wet	0			massive	soft	contains plant material
MMO1.5	100	160	push tube	2.5Y 3/2	peaty clay	wet	0			massive	soft	contains plant material
MMO2.1	0	10	soil pit	10YR 4/2	peaty clay	moist	0			granular	friable	plant and root material
MMO2.2	10	50	soil pit	10YR 4/1	clay	moist	0			massive	very firm	plant roots, too hard to auger below this layer

Table 57-4. Laboratory data for acid sulfate soil assessment of Marne River Mouth Wetland.

(red printed values indicate data results of concern)

Site and Layer ID.	Depth Range (cm)	Soil Texture	EC (µS/cm)	pH water	pH peroxide	pH incubation	Sulfate (mg SO_4/kg)	pH KCl	Titratable Actual Acidity (mole H^+/ tonne)	Chromium Reducible Sulfur (%S_{CR})	Acid Neutralising Capacity (%$CaCO_3$)	Net Acidity (mole H^+/ tonne)	Acid Sulfate Soil Material Classification
MMO1.1	0 - 3	fine	-	6.80	3.78	4.70	2808	6.55	-	0.14	1.05	-50	hyposulfidic (S_{CR}≥0.10%)
MMO1.2	3 - 15	fine	-	6.98	4.17	5.30	3383	6.93	-	0.04	0.80	-83	hyposulfidic (S_{CR}<0.10%)
MMO1.3	15 - 35	fine	-	7.39	4.78	5.00	351	6.13	1.61	0.02	-	13	hyposulfidic (S_{CR}<0.10%)
MMO1.4	35 - 100	fine	-	7.76	1.47	4.50	644	6.59	-	0.18	1.43	-80	hyposulfidic (S_{CR}≥0.10%)
MMO1.5	100 - 160	fine	-	7.89	1.61	2.50	597	6.84	-	0.85	0.77	427	hypersulfidic
MMO2.1	0 - 10	fine	-	6.91	3.39	4.70	4204	7.26	-	0.08	1.52	-153	hyposulfidic (S_{CR}<0.10%)
MMO2.2	10 - 50	fine	-	7.01	2.88	5.80	1966	6.93	-	0.07	0.92	-82	hyposulfidic (S_{CR}<0.10%)

58 DEVON DOWNS SOUTH WETLAND (WETLAND ID. 12014)

58.1 BACKGROUND

Devon Downs South Wetland is located on the northern side of the River Murray. The wetland is somewhat oval in shape, approximately 1600 metres long, and 450 metres at the widest point. The wetland is bounded to the north by a steep cliff at the north-eastern end of the wetland and towards the north-western end a low graded slope to farm land, and to the south by a floodplain that separates it from the river. The wetland is connected by a channel to the river at the western end.

This wetland was studied in 2007/08 as part of a separate monitoring investigation of acid sulfate soils, the work and data was presented in the report 'Acid sulfate soils in subaqueous, waterlogged and drained soil environments of nine wetlands below Blanchetown (Lock 1), South Australia: properties, genesis, risks and management' (Fitzpatrick, Shand, Thomas, Merry, Raven and Simpson, November 2008. Report prepared for South Australian Murray-Darling Basin Natural Resources Management Board. CSIRO Land and Water Science Report 42/08). Readers are referred to this report for detailed information, and here a summary of the findings are presented.

At the time of field sampling the wetland was dry. Sites were located along one transect across the wetland (Sites DD51, DD52, DD53 and DD54) and at the eastern margin (Site DD55). Five sites were sampled and their locations are shown in Figure 58-1.

Figure 58-1. Devon Downs South Wetland and sample site locations.

58.2 DISCUSSION

Acid sulfate soil materials at Devon Downs South Wetland were identified as hyposulfidic in the surface layers of the site located on the sandy margin (Site DD51). All other surface and subsoil layers were characterised as other soil materials.

The soils throughout the wetland were dominantly clays, with broken down surface layers that have filled the soil cracks. Along the wetland margins the surface layers were sandy.

The potential hazards posed by acid sulfate soil materials at the Devon Downs South Wetland are:

- Acidification hazard: Hyposulfidic soil materials occur on the wetland margins. There is a low to medium level of concern.
- De-oxygenation hazard: No data was available, but based on judgement and comparison with other similar soils in the area there may be potential for monosulfidic materials to form in the surface layers of soils, although monosulfidic material was not observed. There is a medium level of concern.
- Metal mobilisation hazard: The low to medium acidification hazard indicates that soil acidification potential is unlikely to increase the solubility of metals. There is a low level of concern.

Summary of key findings for Devon Downs South Wetland:

Soil materials:	The soils throughout the wetland were clays in the surface and subsoil layers. On the margins the surface layers were sandy and characterised as Hyposulfidic.
Acid sulfate soil identification:	• Cracking Clay Soils – occurring throughout the wetland. Dominant (>50%) in extent. • Hyposulfidic Cracking Clay Soils – occurring on the margins of the wetland. Minor (<25%) in extent.
Hazard assessment	• Acidification hazard – low to medium level of concern • De-oxygenation hazard – medium level of concern • Metal mobilisation hazard – low level of concern

59 DEVON DOWNS NORTH WETLAND (WETLAND ID. 12019)

59.1 BACKGROUND

Devon Downs North Wetland (Wetland ID. 12019) is situated on the western side of the River Murray. The wetland is geomorphically categorised as a Murray Gorge basin (Pressey 1986) and is approximately 6.5 km long and approximately 800 m at the widest (southern end), with a total surface area of 273 hectares. It is bounded to the east by a narrow flood plain that separates it from the river and to the west by cliffs. At the time of sampling the wetland was dry with a cracking clay surface and in some areas a continuous cover of *Phragmites australis* (Common Reed).

This wetland was studied in 2007/08 as part of a separate monitoring investigation of acid sulfate soils, the work and data was presented in the report 'Acid sulfate soils in subaqueous, waterlogged and drained soil environments of nine wetlands below Blanchetown (Lock 1), South Australia: properties, genesis, risks and management' (Fitzpatrick, Shand, Thomas, Merry, Raven and Simpson, November 2008. Report prepared for South Australian Murray-Darling Basin Natural Resources Management Board. CSIRO Land and Water Science Report 42/08). Readers are referred to this report for detailed information, and here a summary of the findings are presented. Four sites were described and sampled (DD1, DD2, DD3 and DD4) and their locations are shown in Figure 59-1. A follow-up survey was conducted in August 2009 to observe the condition of the wetland.

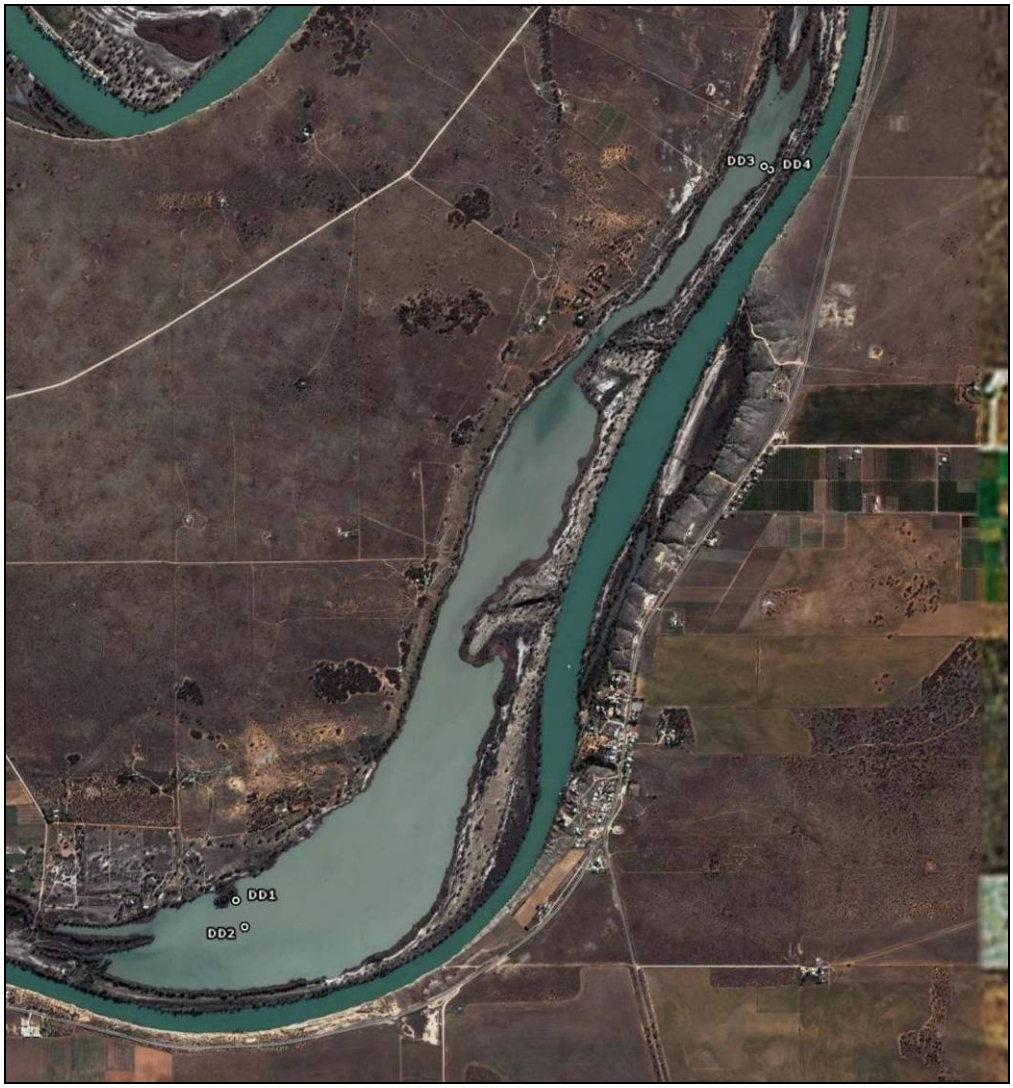

Figure 59-1. Devon Down North Wetland and sample site locations.

59.2 DISCUSSION

Acid sulfate soil materials at Devon Downs Wetland were identified as hypersulfidic that occurred throughout the main area of the wetland in the surface and subsoil layers. Sulfuric soil materials occurred in the surface layers on the elevated margin areas where sand material had accumulated amongst the reeds.

The soils were clays with cracks extending down into the subsoil, the upper soil layers were hypersulfidic to about 40 cm depth with a high net acidity. These soils occurred throughout the main area of the wetland. On the hill-side and up-river section of the wetland, the cracks were being filled with wind-blown sand to form a sealed surface. On the wetland margins where the soils were not cracking they were hypersulfidic to about 10 cm. Where *Phragmites australis* (Common Reed) vegetation was growing on the river-side of the wetland the soils were sandy and sulfuric soil materials were identified.

The potential hazards posed by acid sulfate soil materials at the Devon Downs Wetland are:

- Acidification hazard: Hypersulfidic soil materials occurred throughout the wetland, and sulfuric material was identified on the wetland margins. There is a high level of concern.
- De-oxygenation hazard: No data was available but based on judgement and data from similar soils in the area, indicated a potential for monosulfidic materials to form in the surface layers of soils. There is a high level of concern.
- Metal mobilisation hazard: The high acidification hazard indicates that soil acidification potential may increase the solubility of metals. There is a high level of concern.

Summary of key findings for Devon Downs North Wetland:

Soil materials:	The soils throughout the main area of the wetland were clays with deep cracks and the surface and subsoil layers were hypersulfidic. On the margins of the river-side of the wetland *Phragmites australis* (Common Reed) were growing, the surface layers were sulfuric. On the cliff-side margins of the wetland the surface layers were hypersulfidic and the cracks had been filled with wind blown sand.
Acid sulfate soil identification:	• Hypersulfidic Cracking Clay Soil – that occurred throughout the main area of the wetland at low to mid elevations. Dominant (>50%) in extent. • Hypersulfidic Soil – that occurred along the margins mainly on the cliff side at mid to high elevations. Minor (<25%) in extent. • Sulfuric Soil – that occurred along the margins mainly on the river side at mid to high elevations. Isolated (<10%) in extent.
Hazard assessment	• Acidification hazard – high level of concern • De-oxygenation hazard – high level of concern • Metal mobilisation hazard – high level of concern

60 DEVON DOWNS SWAMP WETLAND (WETLAND ID. 12723)

No field survey or assessment conducted at this wetland.

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