APPENDIX B1 – WETLAND DESCRIPTIONS FOR ASSESSMENT OF ACID SULFATE SOIL MATERIALS IN THE LOCK 1 TO WELLINGTON REGION OF THE MURRAY-DARLING BASIN

CONTENTS

1 POMANDA BAY WETLAND (WETLAND ID. 12700)

1.1 LOCATION AND SETTING DESCRIPTION

Pomanda Bay Wetland (Wetland ID. 12700) is situated on the northern side of the River Murray, where it widens before entering Lake Alexandrina. The wetland follows the curved shape of the bay. It is bounded to the north and west by farm land and on the southern side it essentially merges with the river in a series sandy bays, clay banks or dense reed areas. In some locations there are low-lying areas formed behind raised sandbars where water enters during elevated river levels from wind seiche events and is then dissconnected once river levels decrease. At the time of the survey in January 2010 the wetland was generally dry with some wetter indundated pools. Dense areas of reeds were growing throughout the area. Eight sites were described with four of those sites sampled (Figure 1-1).

Figure 1-1. Pomanda Bay Wetland and sample site locations.

1.2 SOIL PROFILE DESCRIPTION AND DISTRIBUTION

Eight sites were described with four of those sites sampled (PBY1, PBY2, PBY5 and PBY6). The acid sulfate soil subtype class and general location description are presented in Table 1-1. Sites were located along the bay area to characterise the variability in the landscape that included; in the water and sand of the shore (PBY1, PBY2), backwater areas behind a sandbar (PBY3, PBY4), amoungst reed beds and sandy beaches of former water lines (PBY5, PBY6), and large thick reed areas growing adjacent to the waters edge (PBY7, PBY8). The site and soil profile descriptions are presented in Table 1-2 and Table 1-3.

Site PBY1 (Figure 1-2) occurred in the river approximately 50 m from shore where the water depth was 20cm. The soil consisted of a thin layer of brown sand, over grey sand that contained many buried reed plant materials.

Site PBY2 (Figure 1-3) occurred on the shoreline where water would be expected to seiche across. The soil consisted of a loose brown sand that had red brown mottles down root channels, over a loose, black sand.

Site PBY3 (Figure 1-4) and PBY4 (Figure 1-5) occurred in a mid elevation area where a shallow backwater was separated from the river by a sandbar, the water was connected at one end by a narrow inlet channel to the river. The soil consisted of a thick (10 cm) layer of monosulfidic black ooze on the surface that was very soft over sand.

Site PBY5 (Figure 1-6) occurred on the edge of the shore in the raised area amongst *Phragmites australis* (Common Reed). The soil consisted of loose, grey sand with many reed roots.

Site PBY6 (Figure 1-7) occurred in a low elevation area on the shoreline between the water and step up to the reeds. The soil consisted of firm grey sand, over at a depth below 35cm a light grey clay.

Site PBY7 (Figure 1-8) and the profile PBY8 (Figure 1-9) occurred where there was at least a 60cm step up from the river onto a bank that the water had cut into and on the bank was very dense growth of *Phragmites australis* (Common Reed). The soil consisted of plant material and voids to more than 80 cm with some sand and clay.

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

Site ID	Easting m Zone 54H	Northing m Zone 54H	Acid sulfate soil subtype class	General location description
PBY1	352181	6087347	Subaqueous hypersulfidic soil	Low elevation, in water
PBY2	352229	6087451	Hypersulfidic soil	Low elevation, on sandy shoreline
PBY3	352353	6087548	Hypersulfidic soil with monosulfidic black ooze	Mid elevation, in backwater behind sand bar
PBY4	352363	6087520	Hypersulfidic soil with monosulfidic black ooze	Mid elevation, in backwater behind sand bar
PBY5	352947	6087132	Other acidic soil (sandy)	High elevation, on bank up from shore where reeds are growing
PBY6	352935	6087117	Hypersulfidic soil	Low elevation, on shore near water
PBY7	351094	6087067	Other acidic soil (sandy)	High elevation, on bank stepped up from shore where reeds are growing
PBY8	349766	6084310	Other acidic soil (sandy)	High elevation, on bank stepped up from shore where reeds are growing

Figure 1-2. Photographs of site PBY1, showing the landscape of shallow water in the bay, and the soil profile showing the upper horizons of thin loose brown sand to the left and grey sand with buried reed vegetation.

Figure 1-3. Photographs of site PBY2, showing the sand surface of the shoreline, and the soil profile of brownish grey sand with yellowish brown mottling over black sand.

Figure 1-4. Photograph of site PBY3, showing the shallow water behind a sand bank that has a layer of black monosulfidic material.

Figure 1-5. Photograph of site PBY4, adjacent to site PBY3 showing the deep pug holes made by cattle.

Figure 1-6. Photograph of site PBY5, showing the landscape from the site location to the sandy shoreline with reeds growing.

Figure 1-7. Photograph of site PBY6, showing thick reeds to the shore edge.

Figure 1-8. Photograph of site PBY7, showing tall thick reed vegetation.

Figure 1-9. Photograph of site PBY8, showing thick reeds growing down to the shore edge.

1.3 LABORATORY DATA ASSESSMENT

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

The pH data are provided in Table 1-4 and pH profiles are presented in Figure 1-10.

The pH_W data did not identify sulfuric materials with a pH_W <4. However, earlier ad hoc investigations had identified sulfuric soil materials amongst the reeds in the sandy surface soils.

The pH_{INC} data for subsoil layers of profiles PBY1 and PBY6 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 materials as a result of sulfide oxidation.

The pH_{OX} data for subsoil layers of profiles PBY1 and PBY6 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.

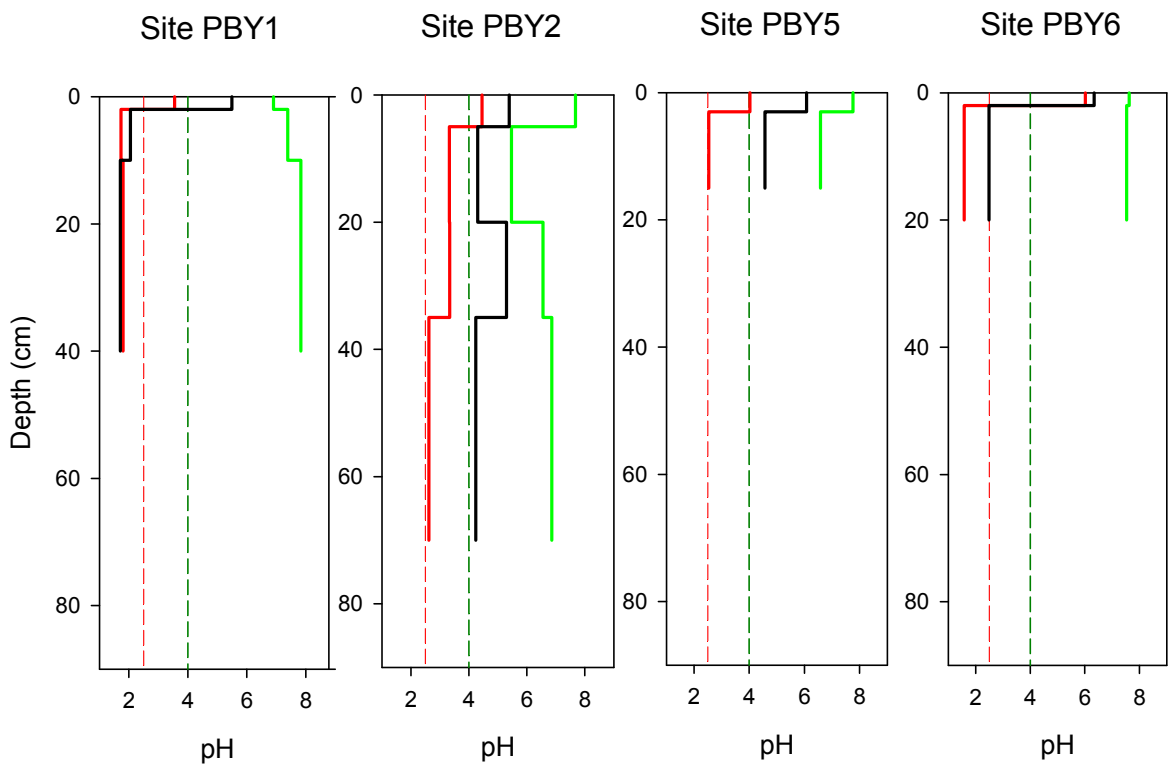

Figure 1-10. Depth profiles of soil pH for Pomanda Bay Wetland, showing soil pH (pH_W as green line), peroxide treated pH (pH_{OX} as red line) and ageing pH (pH_{INC} after 28 weeks as black line). Critical pH_W and pH_{INC} value of 4 (black dashed line) and critical pH_{OX} value of 2.5 (red dashed line).

Acid Base Accounting

The acid base accounting data is provided in Table 1-4 and summarised in Figure 1-11.

Chromium reducible sulfur values range from below the detection limit to 0.22 %S_{CR} and sulfidic materials were detected in subsoil layers for the sites that occurred on the sandy shoreline (PBY1, PBY2, and PBY6). For the surface layers values were below detection limits.

Titratable actual acidity values ranged from 0 to 3.30 mole H^+/tonne. With concentrations measured in the upper layers of profiles PBY1, PBY2 and PBY6.

Retained acidity was not measured in any of the samples, as all samples had a pH_{KCl} of greater than 4.5.

Acid neutralising capacity values ranged from 0 to 0.12 %$CaCO_3$, and were measured in at least one layer of each profile.

Net acidity values ranged from -10 to 138 mole H^+/tonne. The upper layers tended to have low or negative net acidity values and the subsoil layer of profiles that occurred near the shoreline (PBY1 and PBY6) were high values.

Water soluble sulfate

Water soluble sulfate data values were not measured.

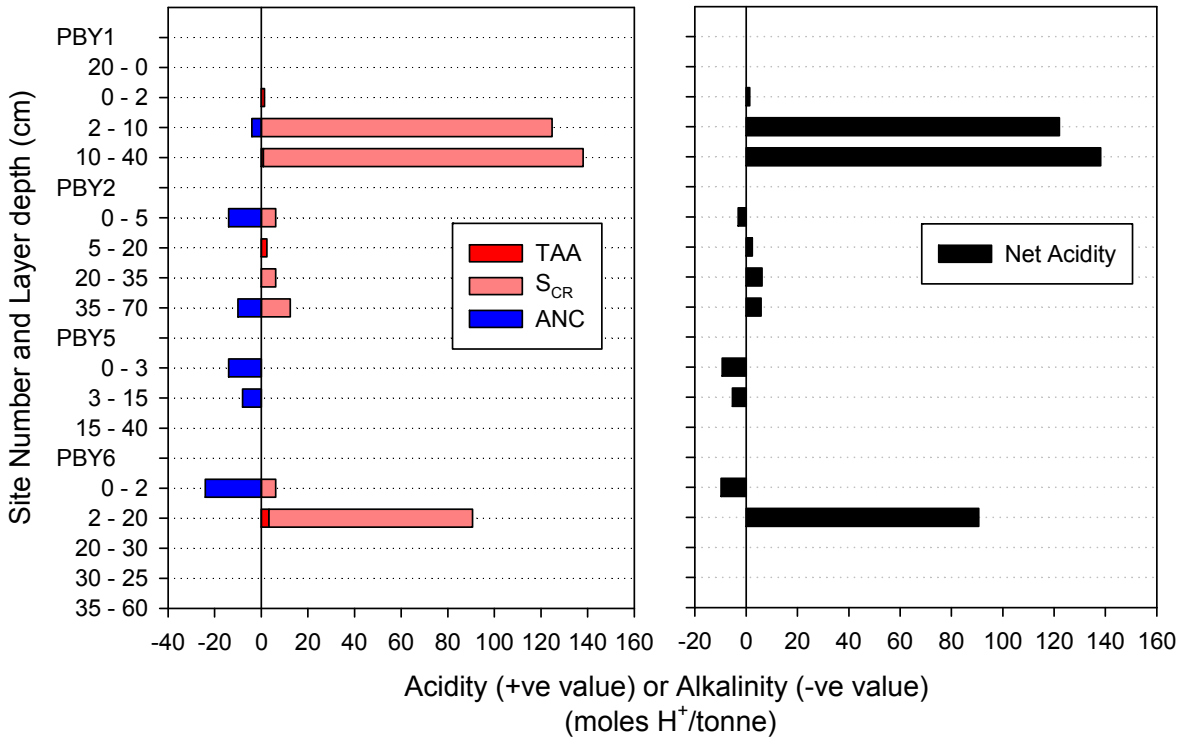

Figure 1-11. Acid base accounting depth profiles for Pomanda Bay Wetland. Left side shows the components: titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} -pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.

1.4 DISCUSSION

Acid sulfate soil materials at Pomanda Bay wetland were identified as hypersulfidic and hyposulfidic. They occurred generally in the subsoil layers of the sandy shoreline soils where the subsoil was below the water table and in some places there were many buried reed plant materials and roots.

At the higher elevation areas where there was a bank that was a step up from the shoreline into dense reeds, the soil was sandy but dominated by plant roots. The sandy soil was characterised as acidic and earlier ad hoc investigations indicated in some areas the surface was sulfuric. Where there were isolated backwater areas, the still water conditions and surrounding animal pug surfaces had thick surface layers of monosulfidic black ooze forming.

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

- Acidification hazard: The data identified hypersulfidic and hyposulfidic acid sulfate soil materials that occurred in the subsoil layers that were at the time saturated. These sandy shoreline soils had mottling patterns that indicated a reducing and oxidation environment in the upper layers probably due to the seiche of the water. If the water levels dropped and these hypersulfidic subsoils were oxidised then the sandy matrix would encourage a rapid release of acidity. There is a medium level of concern.
- De-oxygenation hazard: Along the sandy shoreline and step up to the reed banks there was continual renewal of water from wave and seiche action. For backwater areas where water was accumulating, field observations noted thick surface monosulfidic black ooze and would be of concern for these isolated areas. There is a low 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 Pomanda Bay Wetland:

Soil materials:	The soil materials were generally sandy along the shoreline areas and where the subsoils were below the water table these soils were hypersulfidic. For the higher elevation areas where thick reeds were growing, the soils were sandy throughout and in some areas the subsoil may be clay, however the soils were dominated by a thick mass of plant material from reed roots. These soils are characterised as acidic and previous investigations indicated that in some areas the sandy surface may be sulfuric.
Acid sulfate soil identification:	• Hypersulfidic Soil – that occurred throughout the area associated with the sandy shoreline. Dominant (>50%) in extent. • Subaqueous Hypersulfidic Soil – that occurred throughout the area below water adjacent to the shoreline. Minor (<25%) in extent. • Other Acidic Soil (sandy) – that occurred on the higher elevation areas where reeds were growing. Minor (<25%) in extent.
Hazard assessment	• Acidification hazard – medium level of concern, increasing to high if the water table drops for those areas associated with the shoreline. • De-oxygenation hazard – low level of concern, except for isolated backwater areas that would be high level of concern. • Metal mobilisation hazard – medium level of concern.

Table 1-2. Site data for Pomanda Island 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
PBY1	27-Jan-10	352181	6087347	Subaqueous hypersulfidic soil	-20	sandy	Water	low, in water 50m from shore,
PBY2	27-Jan-10	352229	6087451	Hypersulfidic soil	30	sandy	saltbush	mid, on shore about 10m up from water on step up,
PBY3	27-Jan-10	352353	6087548	Hypersulfidic soil with monosulfidic black ooze	-10	soft	water	mid, backwater behind sand bank, water connected to river by narrow inlet. No soil samples taken water measurement only,
PBY4	27-Jan-10	352363	6087520	Hypersulfidic soil with monosulfidic black ooze	-10	sandy	Water	mid, backwater behind sand bank, water connected to river by narrow inlet. No soil samples taken water measurement only,
PBY5	27-Jan-10	352947	6087132	Other acidic soil (sandy)	not reached	plant material	*Phragmites australis* (Common Reed)	high, step up into Reeds,
PBY6	27-Jan-10	352935	6087117	Hypersulfidic soil	not reached	sealed	sandy	high, on shore 2m from water2m from shore 5m from reeds,
PBY7	27-Jan-10	351094	6087067	Other acidic soil (sandy)	not reached	plant material	*Phragmites australis* (Common Reed)	high, step up into Reeds, 2m from water, no soil samples taken,
PBY8	27-Jan-10	349766	6084310	Other acidic soil (sandy)	not reached	plant material	*Phragmites australis* (Common Reed)	high, step up from water 60cm high, very thick reeds, soil samples taken but mainly plant roots

Table 1-3. Soil description data for Pomanda Island 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
PBY1.0	20	0	soil pit		water	wet						
PBY1.1	0	2	soil pit	brown	sand	wet	0			single grain	loose	thin black layer between brown and subsoil
PBY1.2	2	10	soil pit	grey	sand	wet	0			single grain	loose	many Reed roots,
PBY1.3	10	40	push tube	grey	sand	wet	0			single grain	loose	
PBY2.1	0	5	soil pit	brown	sand	moist	0			single grain	loose	
PBY2.2	5	20	soil pit	brown	sand	moist	5	reddish brown	in matrix along ped faces	single grain	loose	
PBY2.3	20	35	push tube	brownish grey	sand	wet	20	reddish brown	in matrix along ped faces	single grain	loose	mottles down root channels
PBY2.4	35	70	push tube	black	sand	wet	0			single grain	loose	
PBY3.0	10	0										water behind sandbar
PBY4.0	10	0										in 5cm of very soft MBO
PBY5.1	0	3	soil pit	brown	sand	dry	0			single grain	loose	
PBY5.2	3	15	soil pit	grey	sand	moist	25	reddish brown	in matrix	single grain	loose	
PBY5.3	15	40	push tube	grey	sand	dry	0			single grain	loose	not sampled
PBY6.1	0	2	soil pit	brown	sand	moist				single grain	loose	very thin coating of sand, windblown
PBY6.2	2	20	soil pit	greyish brown	sand	moist				single grain	loose	
PBY6.3	20	30	soil pit	dark grey	sand	moist				single grain	loose	not sampled
PBY6.4	30	25	soil pit	brown	peat	wet				massive	soft	not sampled
PBY6.5	35	60	push tube	light grey	clay	wet				massive	soft	not sampled

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
PBY7.1	0	5	push tube	brown	sand	dry				single grain	loose	amongst thick reeds, not sampled
PBY7.2	5	80	push tube	black	peat	dry				massive	firm	almost entirely Reed roots and organic material, not sampled
PBY8.1	0	10	push tube	brown	clay	dry				massive	hard	not sampled
PBY8.2	10	70	push tube	black	clayey peat	dry				massive	hard	almost entirely Reed roots and organic material

Table 1-4. Laboratory data for acid sulfate soil assessment of Pomanda Bay 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
PBY1.0	20 - 0	water											water
PBY1.1	0 - 2	coarse	100	6.91	3.55	5.49		6.34	1.40	< 0.01	0.00	1	other acidic
PBY1.2	2 - 10	coarse	120	7.39	1.73	2.05		6.56	0.00	0.20	0.02	122	hypersulfidic
PBY1.3	10 - 40	coarse	160	7.83	1.80	1.71		6.48	0.90	0.22	0.00	138	hypersulfidic
PBY2.1	0 - 5	coarse	170	7.68	4.45	5.39		6.69	0.00	< 0.01	0.07	-3	other acidic
PBY2.2	5 - 20	coarse	520	5.47	3.33	4.31		6.22	2.40	< 0.01	0.00	2	other acidic
PBY2.3	20 - 35	coarse	820	6.56	3.34	5.30		6.62	0.00	< 0.01	0.00	6	other acidic
PBY2.4	35 - 70	medium	220	6.86	2.62	4.24		6.83	0.00	0.02	0.05	6	hyposulfidic (S_{CR}<0.10%)
PBY3.0	10 - 0	water											-
PBY4.0	10 - 0	water											-
PBY5.1	0 - 3	medium	180	7.76	4.02	6.08		7.12	0.00	< 0.01	0.07	-9	other acidic
PBY5.2	3 - 15	medium	260	6.58	2.53	4.57		7.69	0.00	< 0.01	0.04	-5	other acidic
PBY5.3	15 - 40												-
PBY6.1	0 - 2	medium	260	7.63	6.02	6.34		8.76	0.00	< 0.01	0.12	-10	other acidic
PBY6.2	2 - 20	medium	230	7.53	1.58	2.49		5.72	3.30	0.14	0.00	91	hypersulfidic
PBY6.3	20 - 30	No sample											-
PBY6.4	30 - 25	No sample											-
PBY6.5	35 - 60	No sample											-
PBY7.1	0 - 5	No sample											-
PBY7.2	5 - 80	No sample											-
PBY8.1	0 - 10	No sample											-
PBY8.2	10 - 70	No sample											-

2 WELLINGTON SPIT WETLAND (WETLAND ID. 12701)

2.1 LOCATION AND SETTING DESCRIPTION

Wellington Spit Wetland (Wetland ID. 12701) is situated on the western side of the River Murray, forming a linear divide between the River Murray and Pomanda Bay before the river enters Lake Alexandrina. The wetland is linear in shape, approximately 3 kilometres in length and approximately 300 metres at its widest point, with a total surface area of 43 hectares. It is bounded to the east by an elevated bank supporting trees that separates it from the river and to the west by a slightly raised sand bar that grades into Pomanda Bay, the wetland occurs between these two raised areas. There are no obvious water connection channels with the river or bay, however the wetland is likely to be inundated at river levels at and above normal pool level of 0.75 m AHD. At the time when the soil survey was conducted in August 2008 the wetland was dry and there was no surface water. There was a thick cover of *Typha latifolia* (Bulrush) and *Phragmites australis* (Common Reed) vegetation throughout the wetland, with willow trees growing on the raised margin areas. Three sites were described and sampled and their locations are shown in Figure 2-1.

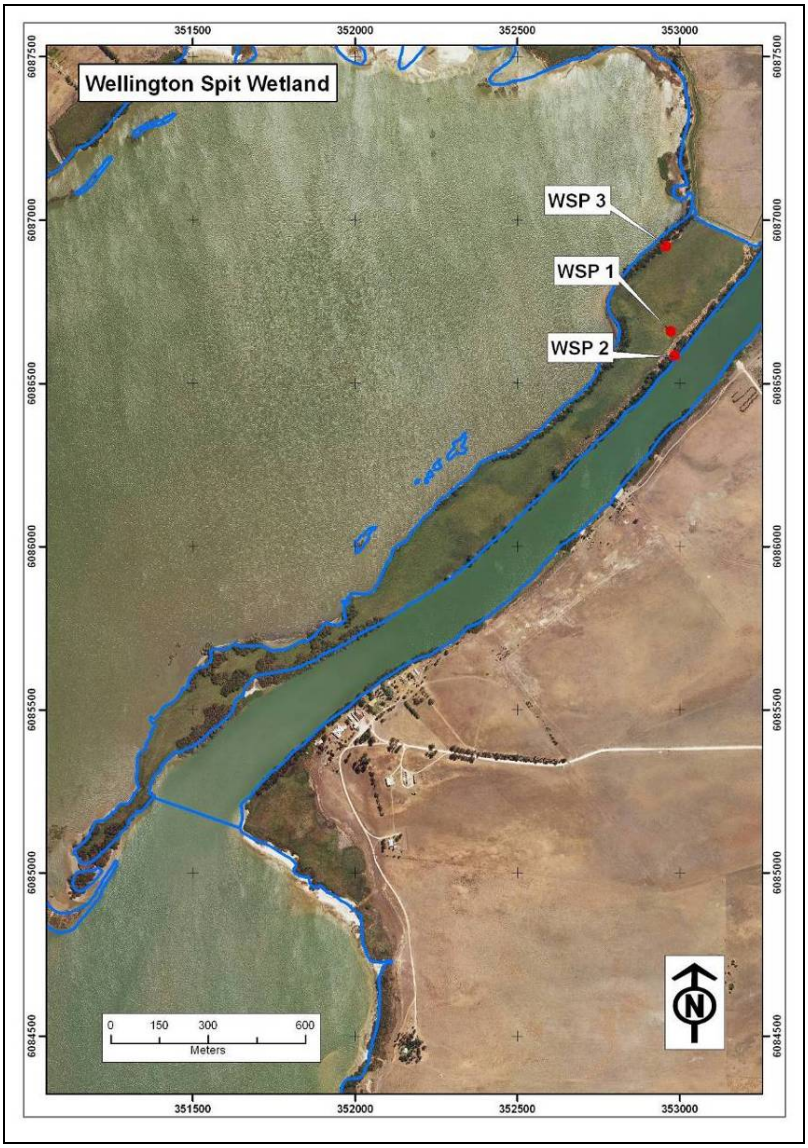

Figure 2-1. Wellington Spit Wetland and sample site locations.

2.2 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 2-1. Sites were located to form one transect through the northern area of the wetland, characterising the river side of the wetland (WSP1), the lower middle area of the wetland (WSP2), and the bay side of the wetland (WSP3). The site and soil profile descriptions are presented in Table 2-2 and Table 2-3.

Site WSP1 (Figure 2-2) occurred in lower middle area of the wetland amongst very thick reeds. The soil consisted of a thick (approximately 100 cm), black, friable, organic material, over dark grey, very firm, clay loam.

Site WSP2 (Figure 2-3) occurred on the shoreline of the river under willow trees in water approximately 25 centimetres deep. The soil consisted dark grey, very soft, loamy sand with clay lenses.

Site WSP3 (Figure 2-4) occurred on the bay side of the wetland in very thick reeds. The soil consisted of a black, friable, peaty clay, over clay.

Table 2-1. Soil identification, subtype and general location description of sites for Wellington Spit Wetland.

Site ID	Easting m Zone 54H	Northing m Zone 54H	Acid sulfate soil subtype class	General location description
WSP1	352974	6086658	Hyposulfidic soil	Low elevation, middle of the wetland amongst thick *Phragmites australis* (Common Reed)
WSP2	352986	6086584	Subaqueous Hyposulfidic soil	Low elevation, on the shoreline in the river water
WSP3	352959	6086920	Hyposulfidic soil	Low elevation, in thick *Phragmites australis* (Common Reed)

Figure 2-2. Photographs of site WSP1, showing the landscape with tall thick *Phragmites australis* (Common Reed), and the soil material extracted below a thick mat of plant material.

Figure 2-3. Photograph of site WSP2, showing the site location (marked by the shovel) adjacent to the bank and below willow trees that overhang into the river.

Figure 2-4. Photograph of site WSP3, showing the site location (marked by the shovel) located amongst thick *Phragmites australis* (Common Reed).

2.3 LABORATORY DATA ASSESSMENT

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

The pH data are provided in Table 2-4 and pH profiles are presented in Figure 2-5.

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 material as a result of sulfide oxidation.

The pH_{OX} data for the surface layer of WSP1 and the deep subsoil layer of WSP3 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 are provided in Table 2-4 and summarised in Figure 2-6.

Chromium reducible sulfur values ranged from below the detection limit to 0.02 $\%S_{CR}$ and sulfidic materials were detected in all soil profiles.

Titratable actual acidity values ranged from 7.28 to 82.02 mole H^+/tonne.

Analysis of retained acidity was not conducted on any of the samples, however retained acidity may be present in subsurface layer of profile WSP1 that was below the critical value of pH_{KCl} <4.5.

Acid neutralising capacity was not measured in any of the samples, as all samples had a pH_{KCl} of < 6.5.

Net acidity values ranged from 19 to 93 mole H^+/tonne. Moderate net acidity values were recorded in all soil layers.

Water soluble sulfate

Water soluble sulfate data values shown in Table 2-4 identified that surface layers in the three profiles were above the criteria trigger value of 100 mg/kg SO_4.

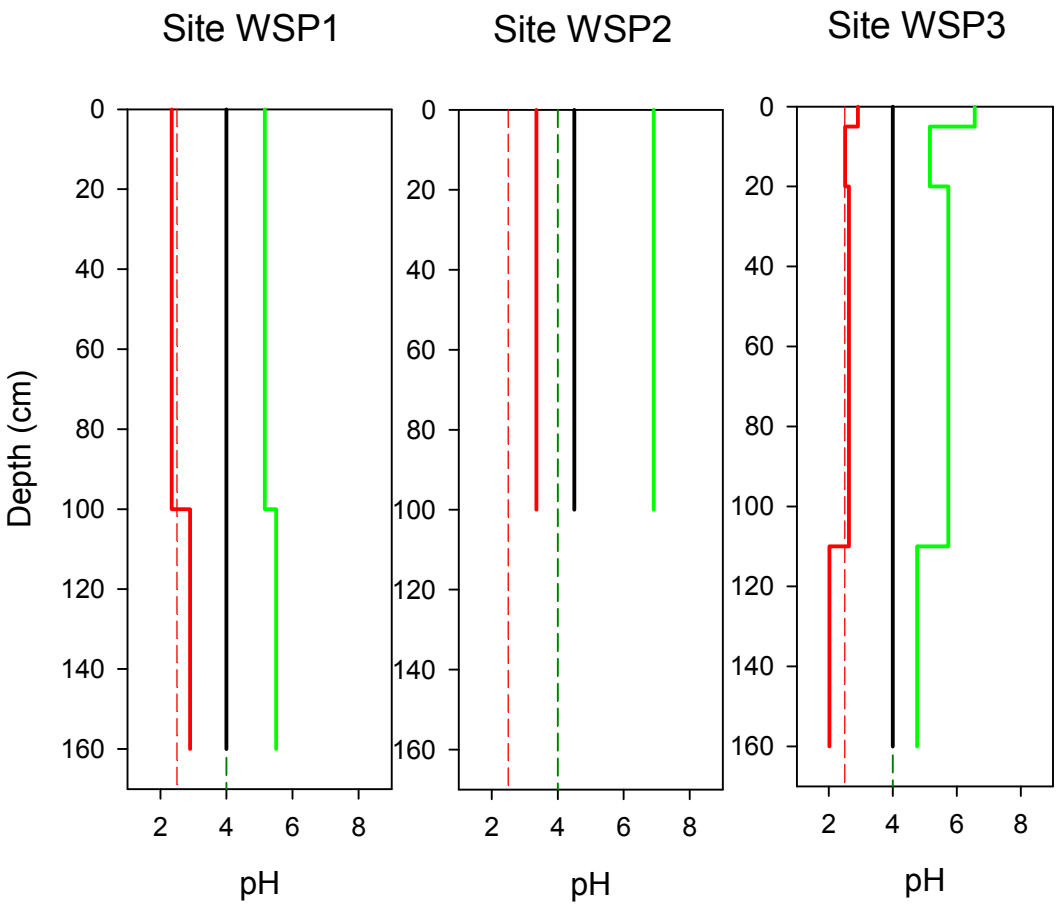

Figure 2-5. Depth profiles of soil pH for Wellington Spit Wetland, showing soil pH (pH_W as green line), peroxide treated pH (pH_{OX} as red line) and ageing pH (pH_{INC} after 28 weeks as black line). Critical pH_W and pH_{INC} value of 4 (black dashed line) and critical pH_{OX} value of 2.5 (red dashed line).

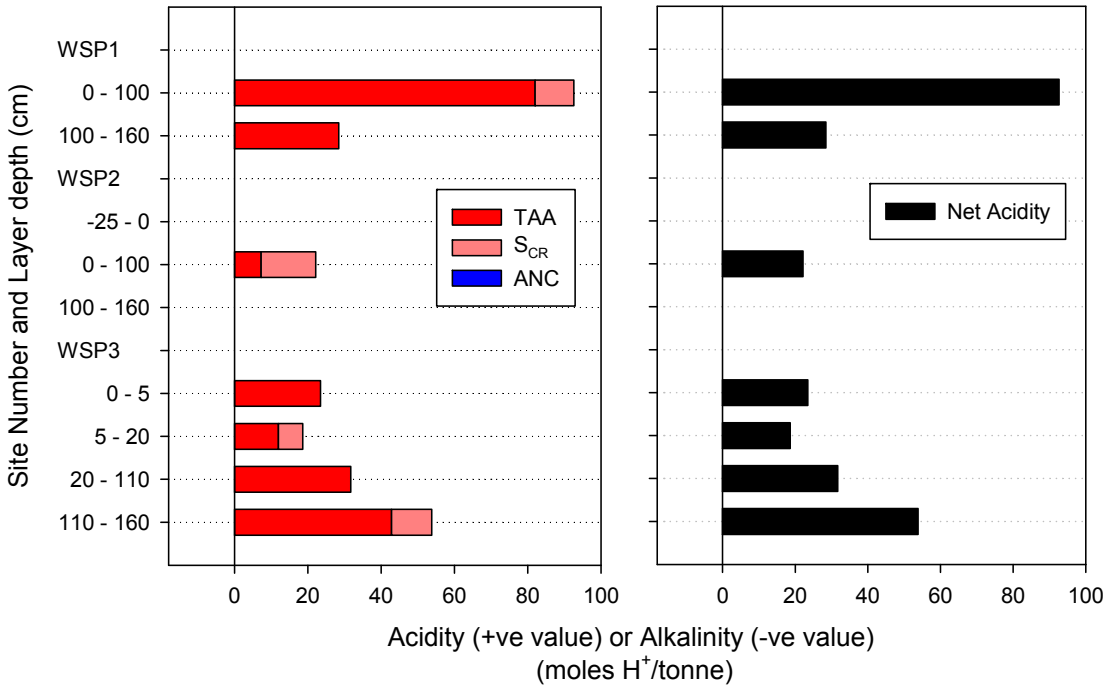

Figure 2-6. Acid base accounting depth profiles for Wellington Spit Wetland. Left side shows the components: titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} - pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.

2.4 DISCUSSION

Acid sulfate soil materials at Wellington Spit Wetland were identified as hyposulfidic and they occurred in the upper layers of all three soil profiles, some samples were characterised as other acidic soil materials. The acid sulfate soil subtype classes identified were Hyposulfidic Soil and Subaqueous Hyposulfidic Soil.

The soils in the main area of the wetland (WSP1, WSP3) consisted of a black, friable, thick peaty clay material over clay or clay loam soil at depth. Site WSP2 was placed in the river adjacent to the wetland and was a loamy sand texture.

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

The potential hazards posed by acid sulfate soil materials at Wellington Spit Wetland are:

- Acidification hazard: The data identified moderate net acidity values in all layers of the profiles, and pH_{OX} data for layers in Sites WSP1 and WSP2 identified potential acidification due to oxidation. There is a medium level of concern.
- De-oxygenation hazard: The water soluble sulfate data indicated that there was potential for monosulfidic materials to form in the surface layers for all sites, 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 Wellington Spit Wetland:

Soil materials:	Hyposulfidic soil materials occurred in the upper layers of the soil profiles. Soils throughout the wetland area had a thick, peaty clay texture upper layer over clay. Soil samples had moderate net acidity values and pH_{OX} data for two layers indicated a potential for acidification due to oxidation.
Acid sulfate soil identification:	• Hyposulfidic soil – that occurred throughout the wetland. Dominant (>50%) in extent. • Subaqueous Hypersulfidic Soil – that occurred on the wetland margins where there was river or lake water. 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 2-2. Site data for Wellington Spit 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
WSP1	22-Aug-08	352974	6086658	Hyposulfidic soil	Not reached	plant material	*Phragmites australis* (Common Reed)	Low elevation, middle of the wetland amongst thick reeds
WSP2	22-Aug-08	352986	6086584	Subaqueous Hyposulfidic soil	-25	water	Water	Low elevation, on the shoreline adjacent to the river
WSP3	22-Aug-08	352959	6086920	Hyposulfidic soil	110	plant material	*Phragmites australis* (Common Reed)	Low elevation, in thick reeds

Table 2-3. Soil description data for Wellington Spit 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
WSP1.1	0	100	push tube	5YR 3/3	peat	moist	0			massive	soft	
WSP1.2	100	160	push tube	10YR 3/2	clay loam	moist	0			subangular blocky	friable	
WSP2.0	-25	0	water		water	wet	0					water
WSP2.1	0	100	push tube			wet	0					no recovery of material in core auger, soft and washed out
WSP2.2	100	160	push tube	5Y 7/1	loamy sand	wet	0			massive	soft	Contains lenses of clay. Material has low bearing strength
WSP3.1	0	5	soil pit	5YR 3/3	peaty clay	moist	0			granular	friable	
WSP3.2	5	20	soil pit	7.5YR 3/2	peaty clay	moist	0			subangular blocky	firm	10% fine and medium roots
WSP3.3	20	110	soil pit	2.5Y 3/2	clay	moist	0			subangular blocky	firm	5% fine roots
WSP3.4	110	160	push tube	2.5Y 2.5/1	clay	wet	0			massive	very friable	

Table 2-4. Laboratory data for acid sulfate soil assessment of Wellington Spit 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
WSP1.1	0 - 100	fine	-	5.16	2.34	4.00	3517	4.58	82.02	0.02	-	93	hyposulfidic (S_{CR}<0.10%)
WSP1.2	100 - 160	medium	-	5.51	2.90	4.00	3455	4.38	28.46	< 0.01	-	28	other acidic incubation
WSP2.0	-25 - 0	water	-	-	-	-	-	-	-	-	-	-	-
WSP2.1	0 - 100	medium	-	6.91	3.35	4.50	331	5.16	7.28	0.02	-	22	hyposulfidic (S_{CR}<0.10%)
WSP2.2	100 - 160	coarse	-	-	-	-	-	-	-	-	-	-	-
WSP3.1	0 - 5	fine	-	6.56	2.91	4.00	454	5.47	23.48	< 0.01	-	23	other acidic incubation
WSP3.2	5 - 20	fine	-	5.16	2.51	4.00	970	5.18	12.00	0.01	-	19	hyposulfidic (S_{CR}<0.10%)
WSP3.3	20 - 110	fine	-	5.73	2.63	4.00	659	4.86	31.75	< 0.01	-	32	other acidic incubation
WSP3.4	110 - 160	fine	-	4.76	2.02	4.00	1378	4.53	42.82	0.02	-	54	hyposulfidic (S_{CR}<0.10%)

3 WELLINGTON SOUTH WETLAND (WETLAND ID. 12008)

3.1 LOCATION AND SETTING DESCRIPTION

Wellington South Wetland (Wetland ID. 12008) is situated on the eastern side of the River Murray, down river from the Wellington car ferry. The wetland is triangular in shape, with a total surface area of 9 hectares. It is bounded to the east by hill slopes and to the west by river bank with trees growing on it, there were no levee banks. At the time when the soil survey was conducted in August 2008 there was surface water near the centre of the wetland. *Typha latifolia* (Bulrush) and *Phragmites australis* (Common Reed) vegetation were growing throughout the wetland, except in areas where there was surface water near the centre of the wetland and on the raised river bank which was dominated by willow trees. Two sites were described and sampled and their locations are shown in Figure 3-1.

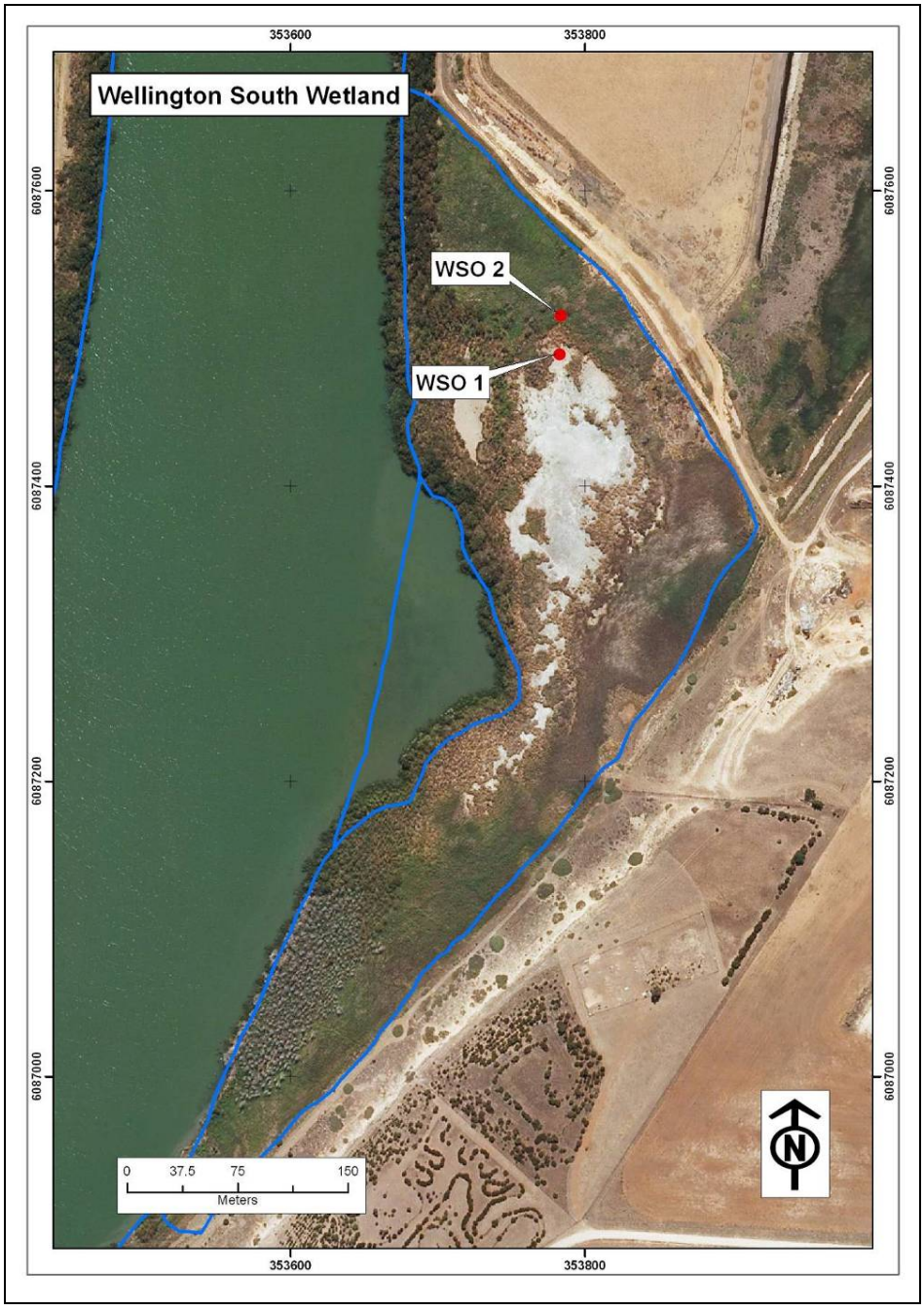

Figure 3-1. Wellington South Wetland and sample site locations.

3.2 SOIL PROFILE DESCRIPTION AND DISTRIBUTION

Two sites were described and sampled. The acid sulfate soil subtype class and general location description are presented in Table 3-1. Sites were located based on surface features, one site with surface water present (WSO1), and the other site amongst thick reeds on a raised area (WSO2). The site and soil profile descriptions are presented in Table 3-2 and Table 3-3.

Site WSO1 (Figure 3-2) occurred in an area of low elevation where there was surface water 10 centimetres deep. The soil consisted of black, very soft, peat material, over a grey, very soft, clay.

Site WSO2 (Figure 3-3) occurred on a raised area amongst thick reeds. The soil consisted of black, soft, peat, over brown grey, soft, peaty clay.

Table 3-1. Soil identification, subtype and general location description of sites for Wellington South Wetland.

Site ID	Easting m Zone 54H	Northing m Zone 54H	Acid sulfate soil subtype class	General location description
WSO1	353783	6087489	Subaqueous Hypersulfidic soil	Low elevation, where there was surface water
WSO2	353784	6087515	Hypersulfidic soil	High elevation, on a raised area with thick *Phragmites australis* (Common Reed) vegetation

Figure 3-2. Photographs of site WSO1, showing the site location (marked by the shovel), and the landscape with surface water in the low elevation position and isolated areas of *Phragmites australis* (Common Reed) vegetation.

Figure 3-3. Photographs of site WSO2, showing the site location amongst thick *Phragmites australis* (Common Reed) vegetation and plant material on the surface, and the soil profile of plant material, plant roots in a clayey soil.

3.3 LABORATORY DATA ASSESSMENT

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

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

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

The pH_{INC} data for all soil layers of profile WSO1 and one layer in WSO2 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 materials as a result of sulfide oxidation.

The pH_{OX} data for all soil layers in profile WSO1 and one layer in WSO2 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.

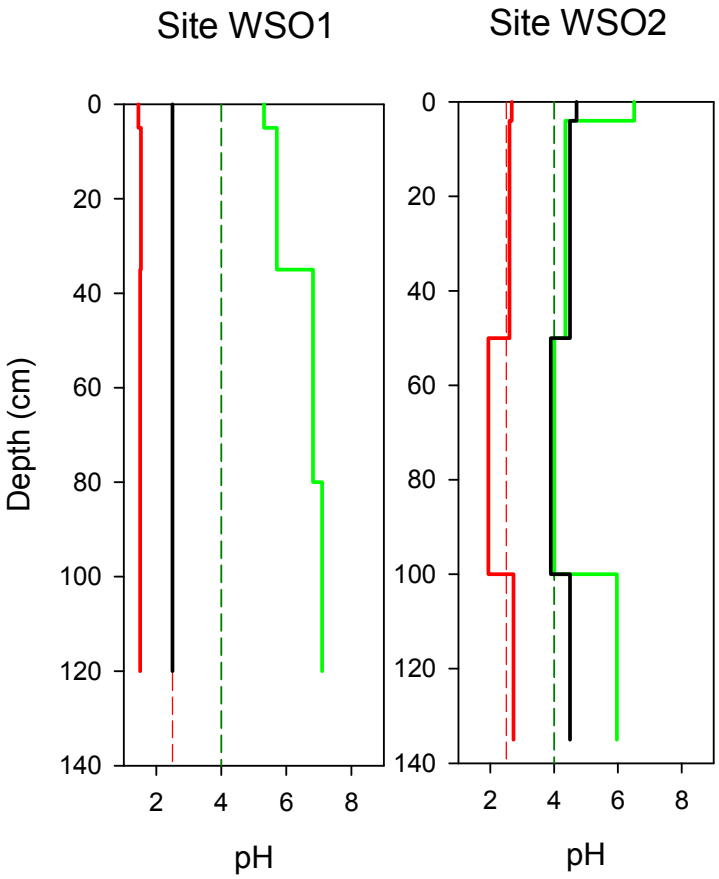

Figure 3-4. Depth profiles of soil pH for Wellington South Wetland, showing soil pH (pH_W as green line), peroxide treated pH (pH_{OX} as red line) and ageing pH (pH_{INC} after 28 weeks as black line). Critical pH_W and pH_{INC} value of 4 (black dashed line) and critical pH_{OX} value of 2.5 (red dashed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

Acid Base Accounting

The acid base accounting data are provided in Table 3-4 and summarised in Figure 3-5.

Chromium reducible sulfur values ranged from below the limit of detection to 1.58 %S_{CR}. Sulfidic materials were detected in all layers of profile WSO1 and all but the surface layer of WSO2.

Titratable actual acidity values ranged from 0 to 137.13 mole H^+/tonne.

Analysis of retained acidity was not conducted on any of the samples, however retained acidity may be present in upper layers of WSO1 and WSO2 that were below the critical value of pHK_{Cl} <4.5.

Acid neutralising capacity values ranged from 0 to 1.56 %$CaCO_3$, and were measured in the lower subsoil layers of profile WSO1.

Net acidity values ranged from 24 to 1033 mole H^+/tonne. Moderate or high net acidity values occurred in all layers of both soil profiles.

Water soluble sulfate

Water soluble sulfate data values shown in Table 3-4 identified that surface layers for both profiles were above the trigger value of 100 mg/kg SO_4.

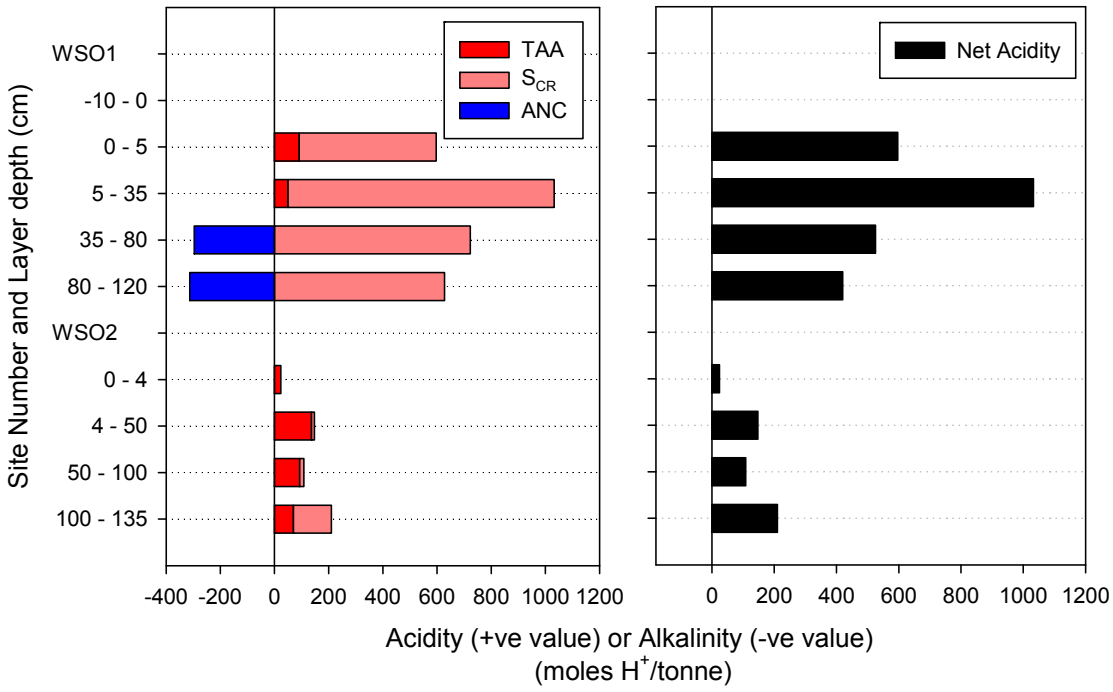

Figure 3-5. Acid base accounting depth profiles for Wellington South Wetland. Left side shows the components: titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} - pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.

3.4 DISCUSSION

Acid sulfate soil materials at Wellington South Wetland were identified as hypersulfidic throughout profile WSO1 and hyposulfidic and hypersulfidic for WSO2 except for the surface layer which was characterised as other acidic soil materials. The acid sulfate soil subtype classes identified were Subaqueous Hypersulfidic Soil and Hypersulfidic Soil.

The soils throughout the wetland were generally soft, peaty clay textured surface layers over clay. In low elevation areas there was shallow surface water.

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 Wellington South Wetland are:

- Acidification hazard: The data identified moderate or high net acidity values throughout both profiles, and pH data identified potential acidification due to oxidation. 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 Wellington South Wetland:

Soil materials:	Hypersulfidic and hyposulfidic soil materials were identified in most soil layers. The soils throughout were generally soft peaty clay and textured layers over clay. Generally both profiles had samples with moderate or high net acidity values and pH data identified potential acidification due to oxidation.
Acid sulfate soil identification:	• Subaqueous Hypersulfidic soil – that occurred in the lower elevation main areas of the wetland. Dominant (>50%) in extent. • Hypersulfidic Soil – that occurred on the margins of the wetland. Subdominant (<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 3-2. Site data for Wellington South 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
WSO1	22-Aug-08	353783	6087489	Hypersulfidic soil	-10	water	Water	Low elevation, where there was surface water
WSO2	22-Aug-08	353784	6087515	Hypersulfidic soil	65	plant material	*Phragmites australis* (Common Reed)	High elevation, on a raised area with thick *reed* vegetation

Table 3-3. Soil description data for Wellington South 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
WSO1.0	-10	0	water		water	Wet	0					water
WSO1.1	0	5	push tube	5Y 3/1	clayey peat	wet	0			massive	soft	
WSO1.2	5	35	push tube	5Y 2.5/1	peat	wet	0			massive	soft	
WSO1.3	35	80	push tube	5Y 5/1	clay	wet	0			massive	soft	20% root fibres
WSO1.4	80	120	push tube	5Y 5/1	clay	wet	0			massive	soft	
WSO2.1	0	4	soil pit	5YR 3/3	litter	moist	0			massive	soft	plant material
WSO2.2	4	50	soil pit	5YR 4/3	peaty clay	moist	0			massive	soft	plant material and roots
WSO2.3	50	100	push tube	5Y 5/1	clay	wet	0			massive	firm	
WSO2.4	100	135	push tube	5Y 2.5/1	peaty clay	wet	0			massive	soft	sulfurous odour

Table 3-4. Laboratory data for acid sulfate soil assessment of Wellington South 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
WSO1.0	-10 - 0	water	-	-	-	-	-	-	-	-	-	-	-
WSO1.1	0 - 5	fine	-	5.31	1.45	2.50	25085	4.38	91.46	0.81	-	597	hypersulfidic
WSO1.2	5 - 35	fine	-	5.71	1.53	2.50	29582	5.05	49.89	1.58	-	1033	hypersulfidic
WSO1.3	35 - 80	fine	-	6.82	1.50	2.50	3797	6.78	-	1.16	1.48	525	hypersulfidic
WSO1.4	80 - 120	fine	-	7.10	1.50	2.50	1516	6.87	-	1.01	1.56	420	hypersulfidic
WSO2.1	0 - 4	coarse	-	6.51	2.67	4.70	7453	5.28	23.87	< 0.01	-	24	other acidic incubation
WSO2.2	4 - 50	coarse	-	4.35	2.60	4.50	23364	3.97	137.13	0.02	-	147	hyposulfidic (S_{CR}<0.10%)
WSO2.3	50 - 100	fine	-	4.01	1.94	3.90	14596	3.90	93.60	0.02	-	108	hypersulfidic
WSO2.4	100 - 135	fine	-	5.97	2.73	4.50	6965	5.76	70.24	0.22	-	210	hyposulfidic (S_{CR}≥0.10%)

4 WELLINGTON WETLAND (WETLAND ID. 12007)

4.1 LOCATION AND SETTING DESCRIPTION

Wellington Wetland (Wetland ID. 12022) is situated on the western side of the River Murray, approximately 200 metres down river from the town of Wellington. The wetland is geomorphically categorised as a Murray Gorge basin (Pressey 1986) and is triangular in shape, with a total surface area of 6 hectares. It is bounded on the eastern river side by a levee bank and on the western side by a road and disused milking shed area up slope from the wetland. There are no obvious water connection channels with the river, except for an excavated channel on the southern boundary to provide water for irrigation. This is likely to overtop with high river levels. At the time when the soil survey was conducted in August 2008 the wetland surface was dry with large cracks (5 centimetres wide and down to 50 centimetres depth). *Typha latifolia* (Bulrush) was growing along the margins and below the willow trees that were growing adjacent to the levee bank. Two sites were described and sampled and their locations are shown in Figure 4-1.

Figure 4-1. Wellington Wetland and sample site locations.

4.2 SOIL PROFILE DESCRIPTION AND DISTRIBUTION

Two sites were described and sampled. The acid sulfate soil subtype class and general location description are presented in Table 4-1. Sites were located based on surface features, with one site in the low elevation area of the wetland where there were large deep cracks in the soil (WEL1), and the second in a slightly raised mid elevation area with reeds growing (WEL2). The site and soil profile descriptions are presented in Table 4-2 and Table 4-3.

Site WEL1 (Figure 4-2) occurred in a low area of the wetland where there were large deep cracks into the soil which consisted of grey, very hard, clay.

Site WEL2 (Figure 4-3) occurred in an area slightly raised before stepping up to the levee bank where thick stand of Bulrush vegetation was growing, and the soil consisted of a dark grey, firm, clay.

Table 4-1. Soil identification, subtype and general location description of sites for Wellington Wetland.

Site ID	Easting m Zone 54H	Northing m Zone 54H	Acid sulfate soil subtype class	General location description
WEL1	353154	6088620	Other acidic soil (cracking clay)	Low elevation, where there were soil cracks at the surface
WEL2	353253	6088637	Hypersulfidic cracking clay soil	Mid elevation, where there was Bulrush vegetation growing on the wetland margin

Figure 4-2. Photographs of site WEL1, showing the site location amongst the vegetation, and the soil profile of very hard cracking clay.

Figure 4-3. Photographs of site WEL 2, showing the site location amongst reeds, and the soil profile of firm clay.

4.3 LABORATORY DATA ASSESSMENT

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

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

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

The pH_{INC} data for subsoil layers of profile WEL2 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 surface layers of both profiles WEL1 and WEL2 identified samples that were below the critical value of pH_{OX} <2.5, the threshold value normally used to indicate a high likelihood of sulfuric material forming.

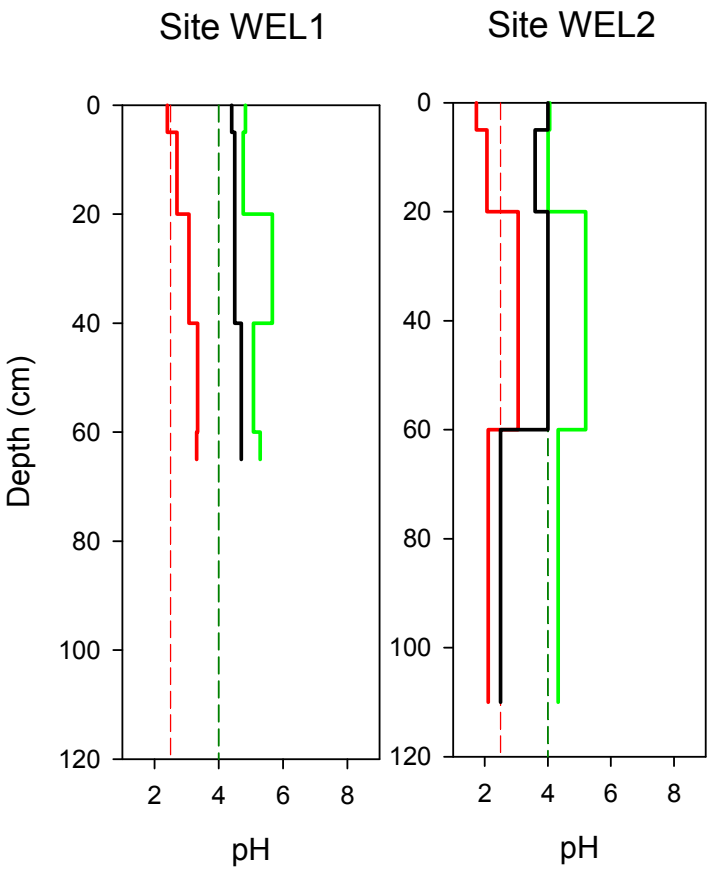

Figure 4-4. Depth profiles of soil pH for Wellington Wetland, showing soil pH (pH_W as green line), peroxide treated pH (pH_{OX} as red line) and ageing pH (pH_{INC} after 28 weeks as black line). Critical pH_W and pH_{INC} value of 4 (black dashed line) and critical pH_{OX} value of 2.5 (red dashed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

Acid Base Accounting

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

Chromium reducible sulfur values ranged from below the detection limit to 0.94%S_{CR}. Sulfidic materials were detected in the deep subsoil layer of profile WEL2.

Titratable actual acidity values ranged from 20.89 to 100.66 mole H^+/tonne.

Analysis for retained acidity was not conducted on any of the samples, however retained acidity may be present in the surface layer of WEL1 and the surface and subsoil layers of WEL2 that were below the critical value of pH_{KCl} <4.5.

Acid neutralising capacity was not measured in any of the samples, as all samples had a pH_{KCl} of < 6.5.

Net acidity values ranged from 21 to 685 mole H^+/tonne. Moderate net acidity values occurred in all layers of both profiles with a high net acidity value occurring at the bottom of profile WEL2 (60-110cm).

Water soluble sulfate

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

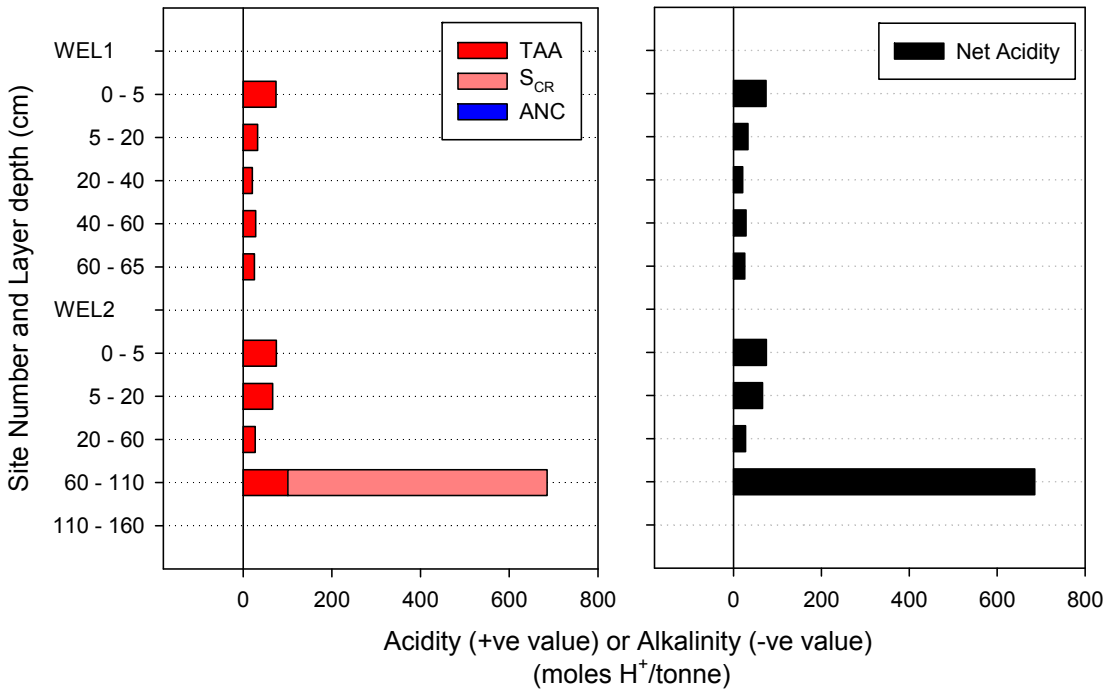

Figure 4-5. Acid base accounting depth profiles for Wellington Wetland. Left side shows the components: titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} - pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.

4.4 DISCUSSION

Acid sulfate soil materials at the Wellington Wetland were identified as hypersulfidic or hyposulfidic but most samples were generally characterised as other acidic soil materials. The acid sulfate soil subtype classes identified were Hypersulfidic Cracking Clay Soil that occurred on the higher elevation margin areas and Other Acidic Soil (cracking clay) that occurred in the lower elevation areas of the wetland.

The soils in the main wetland area were dominantly hard or firm clays and the surfaces were cracking.

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

- Acidification hazard: The data identified moderate net acidity values throughout both profiles with a high net acidity at the bottom of profile WEL2. pH data identified potential acidification due to oxidation. There is a high level of concern.
- De-oxygenation hazard: The water soluble sulfate data indicated that there was potential for monosulfidic materials to form in the surface layers of soils on re-flooding, although the wetland was dry at the time of sampling and 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 Wellington Wetland:

Soil materials:	Hypersulfidic and hyposulfidic soil materials were identified in a few subsoil soil layers. The soils were clayey textured throughout and the surface had wide and deep cracks. Samples had high or moderate net acidity values and pH data indicated potential acidification due to oxidation.
Acid sulfate soil identification:	• Other Acidic Soil (cracking clays) – that occurred throughout the main area of the wetland. Dominant (>50%) in extent. • Hypersulfidic Cracking Clay Soil – that occurred on the wetland margins. Sub-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 4-2. Site data for Wellington 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
WEL1	22-Aug-08	353154	6088620	Other acidic soil (cracking clay)	Not reached	cracking	weeds	Low elevation, where there were soil cracks at the surface
WEL2	22-Aug-08	353253	6088637	Hypersulfidic cracking clay soil	70	cracking	Bulrushes	Mid elevation, where there was *Typha latifolia* (Bulrush) vegetation growing on the wetland margin

Table 4-3. Soil description data for Wellington 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
WEL1.1	0	5	soil pit	2.5Y 4/1	clay	moist	0			cloddy	firm	
WEL1.2	5	20	soil pit	5Y 3/1	clay	moist	2	2.5Y 8/1	on ped faces	subangular blocky	extremely firm	white salts on surface
WEL1.3	20	40	soil pit	5Y 2.5/1	clay	moist	5	2.5Y 8/1	on ped faces	subangular blocky	slightly rigid	white salts on surface
WEL1.4	40	60	soil pit	5Y 2.5/1	clay	moist	2	2.5YR 5/8	in matrix adjacent to pores	subangular blocky	firm	
WEL1.5	60	65	push tube	5Y 3/2	clay	moist	5	2.5YR 5/8	in matrix adjacent to pores	subangular blocky	firm	
WEL2.1	0	5	soil pit	7.5YR 3/1	clay	moist	0			subangular blocky	very firm	
WEL2.2	5	20	soil pit	7.5YR 5/1	clay	moist	0			subangular blocky	very firm	
WEL2.3	20	60	soil pit	7.5YR 5/1	clay	moist	0			subangular blocky	firm	
WEL2.4	60	110	push tube	7.5YR 5/1	peaty clay	wet	0			massive	soft	
WEL2.5	110	160	push tube	2.5Y 4/2	peaty clay	wet	0			massive	soft	

Table 4-4. Laboratory data for acid sulfate soil assessment of Wellington 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
WEL1.1	0 - 5	fine	-	4.83	2.40	4.40	152	3.98	74.11	< 0.01	-	74	other acidic
WEL1.2	5 - 20	fine	-	4.76	2.70	4.50	71	4.64	32.65	< 0.01	-	33	other acidic
WEL1.3	20 - 40	fine	-	5.67	3.07	4.50	39	5.09	20.89	< 0.01	-	21	other acidic incubation
WEL1.4	40 - 60	fine	-	5.08	3.34	4.70	39	4.69	28.43	< 0.01	-	28	other acidic
WEL1.5	60 - 65	fine	-	5.29	3.31	4.70	31	4.64	25.58	< 0.01	-	26	other acidic incubation
WEL2.1	0 - 5	fine	-	4.06	1.74	4.00	138	3.92	74.82	< 0.01	-	75	other acidic
WEL2.2	5 - 20	fine	-	4.01	2.07	3.60	115	3.94	66.23	< 0.01	-	66	other acidic
WEL2.3	20 - 60	fine	-	5.20	3.06	4.00	99	4.95	27.26	< 0.01	-	27	other acidic incubation
WEL2.4	60 - 110	fine	-	4.33	2.11	2.50	707	3.78	100.66	0.94	-	685	hypersulfidic
WEL2.5	110 - 160	fine	-	-	-	-	-	-	-	-	-	-	-

5 EAST WELLINGTON WETLAND (WETLAND ID.12702)

5.1 LOCATION AND SETTING DESCRIPTION

East Wellington Wetland (Wetland ID. 12702) is situated on the eastern side of the River Murray, up river and adjacent to the Wellington car ferry ramp. The wetland is triangular in shape, with a total surface area of 12 hectares. It is bounded on the western side by a levee bank that separates the river from the wetland, and on the other sides by raised areas with the main road and a marina access road. There is no obvious water connection channel with the river. At the time when the soil survey was conducted in August 2008 the wetland was dry with large surface cracks (5 centimetres wide and down to more than 50 centimetres below the surface) throughout the wetland. *Phragmites australis* (Common Reed) vegetation was growing around the margins of the wetland, weeds were growing within the wetland area and there were a few isolated areas where there was no vegetation. Three sites were described and sampled and their locations are shown in Figure 5-1.

Figure 5-1. East Wellington Wetland and sample site locations.

5.2 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 5-1. Sites were located to represent the different surface features in the wetland, with one site amongst thick reeds near the levee bank (WEA1), a second at a low elevation near the centre of the wetland where there were large surface cracks (WEA2), and the third near the eastern side where there were surface cracks smaller in size (WEA3). The site and soil profile descriptions are presented in Table 5-2 and Table 5-3.

Site WEA1 (Figure 5-2) occurred in thick reeds near the levee bank. The soil consisted of black, friable, peat, over grey, very firm clay with red mottles on the soil ped faces.

Site WEA2 (Figure 5-3) occurred in an open vegetated area near the centre of the wetland where there were large cracks (5 to 10 centimetres wide and up to 120 centimetres deep). The soil consisted of grey, very hard, clay, with the exposed ped faces down the cracks almost entirely covered with red iron coatings.

Site WEA3 (Figure 5-4) occurred in an area similar to WEA2 but with smaller sized surface cracks. The soil consisted of grey, very hard, clay, with some red coatings on the exposed ped surfaces.

Table 5-1. Soil identification, subtype and general location description for East Wellington Wetland.

Site ID	Easting m Zone 54H	Northing m Zone 54H	Acid sulfate soil subtype class	General location description
WEA1	353195	6089508	Sulfuric soil	High elevation, amongst thick *Phragmites australis* (Common Reed) vegetation near the levee bank
WEA2	353270	6089513	Hyposulfidic cracking clay soil	Low elevation, where there were large surface cracks
WEA3	353327	6089584	Hyposulfidic cracking clay soil	Low elevation, where there were surface cracks

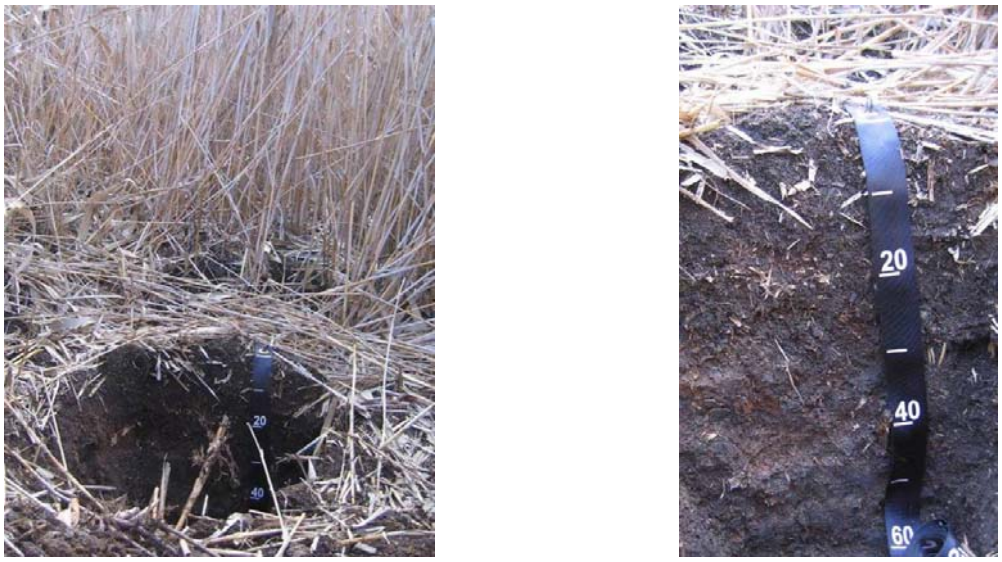

Figure 5-2. Photographs of site WEA1, showing the site location with thick *Phragmites australis* (Common Reed) growing and plant material on the surface, and the soil profile of peaty loam over clay loam.

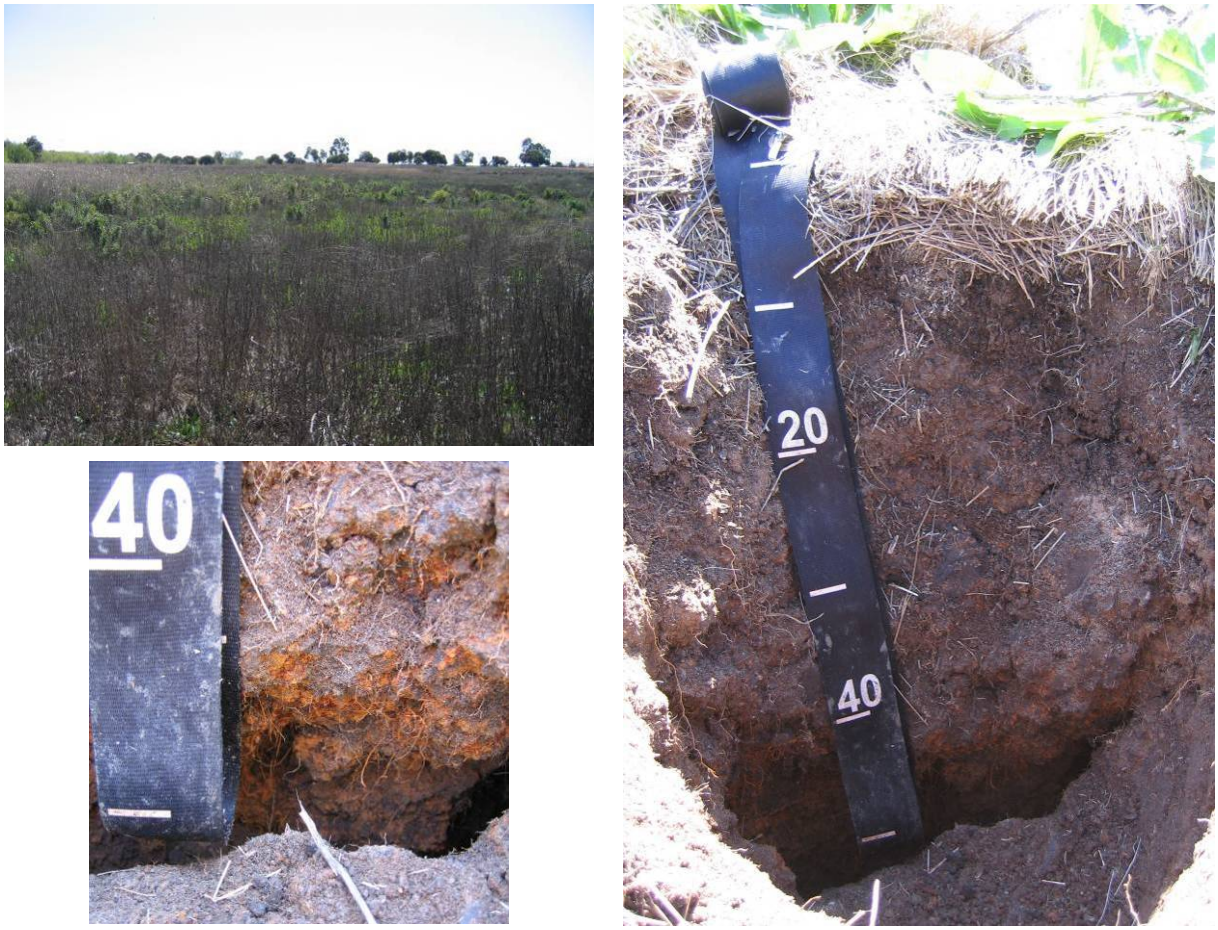

Figure 5-3. Photographs of site WEA2, showing the site location at the lowest elevation in the wetland, and the soil profile with deep cracks and the bright yellowish red coatings on the soil faces in the subsoil layers.

Figure 5-4. Photographs of site WEA3, showing the site location where established grasses and weeds were growing, and the soil profile with cracking clay upper layers.

5.3 LABORATORY DATA ASSESSMENT

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

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

The pH_W data for the subsoil layer of WEA1 identified samples that were sulfuric materials with a pH_W <4. The pH_{INC} data for the subsoil layers of profile WEA2 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 surface and/or subsurface layers of profiles WEA1, WEA2 and WEA3 identified samples that were below the critical value of pH_{OX} <2.5, the threshold value normally used to indicate a high likelihood of sulfuric material forming.

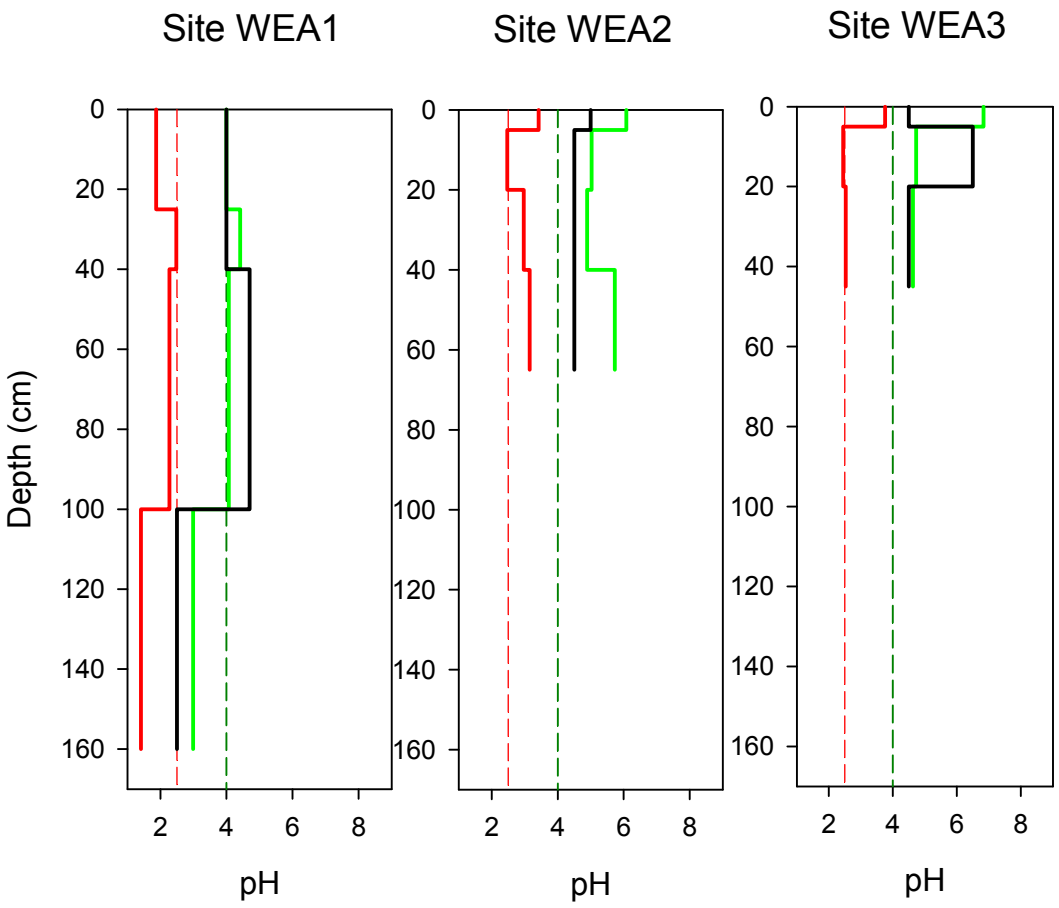

Figure 5-5. Depth profiles of soil pH for East Wellington Wetland, showing soil pH (pH_W as green line), peroxide treated pH (pH_{OX} as red line) and ageing pH (pH_{INC} after 28 weeks as black line). Critical pH_W and pH_{INC} value of 4 (black dashed line) and critical pH_{OX} value of 2.5 (red dashed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

Acid Base Accounting

The acid base accounting data are provided in Table 5-4 and summarised in Figure 5-6.

Chromium reducible sulfur values ranged from below the detection limit to 0.20%S_{CR}. Sulfidic materials were detected in the deep subsoil layer of profile WEA1 and the surface layers of profiles WEA2 and WEA3.

Titratable actual acidity values ranged from 4.77 to 425.25 mole H^+/tonne.

Analysis of retained acidity was not conducted on any of the samples, however retained acidity may be present in all layers of WEA1 and the subsoil layers of WEA3 that were below the critical value of pH_{KCl} <4.5.

Acid neutralising capacity was not measured in any of the samples, as all samples had a pH_{KCl} of < 6.5.

Net acidity values ranged from 17 to 549 mole H^+/tonne. Low, moderate or high net acidity values occurred in all of the sampled profiles.

Water Soluble Sulfate

Water soluble sulfate data values shown in Table 5-4 identified that surface layers in all profiles were above the criteria trigger value of 100 mg/kg SO_4.

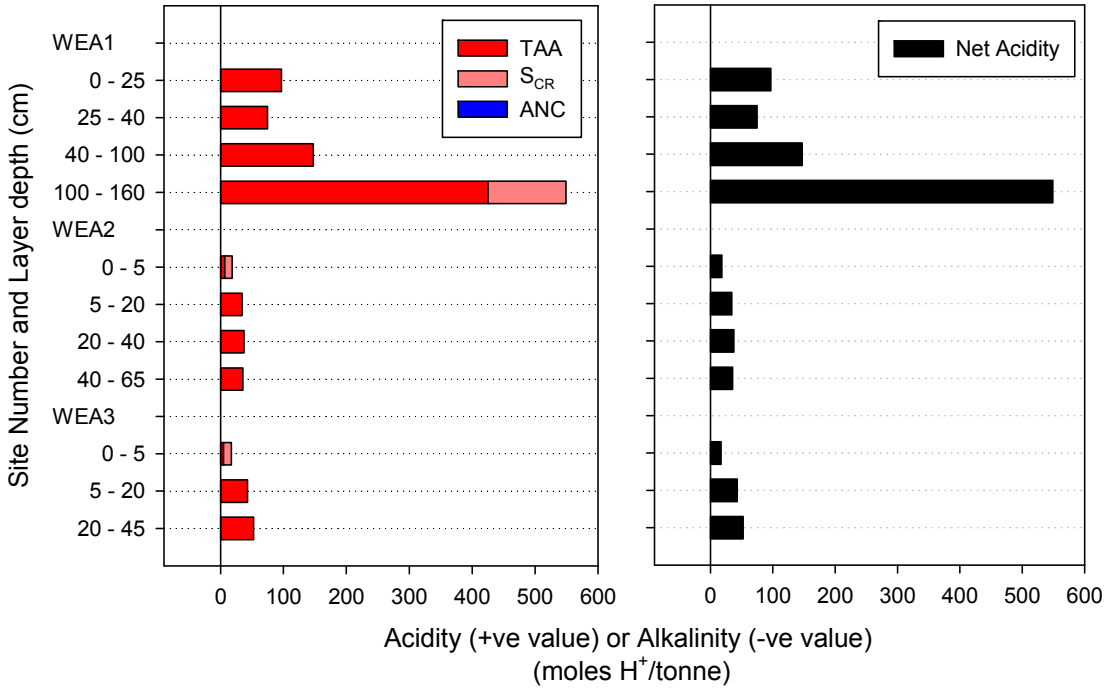

Figure 5-6. Acid base accounting depth profiles for East Wellington Wetland. Left side shows the components: titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} - pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.

5.4 DISCUSSION

Acid sulfate soil materials at East Wellington Wetland were identified as sulfuric in the lower subsoil layer of profile WEA1 that occurred on the wetland margin amongst thick *Phragmites australis* (Common Reed), hyposulfidic in the surface layers of profiles WEA2 and WEA3 that occurred in the low elevation main wetland area, and the remaining samples were characterised as other acidic soil materials. The acid sulfate soil subtype classes identified were Sulfuric Soil and Hyposulfidic Cracking Clay Soil.

The soils throughout the wetland were generally firm to rigid Consistence (category) and clay textured with large and deep cracks into the subsoil layers.

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 Wellington South Wetland are:

- Acidification hazard: The data identified generally moderate net acidity values throughout all of the profiles, and pH data identified potential acidification due to oxidation. There is a high level of concern.
- De-oxygenation hazard: The water soluble sulfate data indicated that there was potential for monosulfidic materials to form in the surface layers of soils on re-flooding, although the wetland was dry at the time of sampling and 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 East Wellington Wetland:

Soil materials:	Sulfuric soil materials were identified in a subsoil layer and hyposulfidic soil materials were identified in surface soil layers. The soils throughout were generally firm to rigid and clay textured with large cracks into the subsoil layers. Generally samples had moderate net acidity values and pH data identified potential acidification due to oxidation.
Acid sulfate soil identification:	• Hyposulfidic Cracking Clay Soil – that occurred throughout the wetland. Dominant (>50%) in extent. • Sulfuric Soil – that occurred on the elevation margins. Minor (<25%) 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 5-2. Site data for East Wellington 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
WEA1	20-Aug-08	353195	6089508	Sulfuric soil	90	plant material	*Phragmites australis* (Common Reed)	High elevation, amongst thick reed vegetation near the levee bank
WEA2	06-Sep-08	353270	6089513	Hyposulfidic cracking clay soil	Not reached	cracking	weeds	Low elevation, where there were large surface cracks
WEA3	06-Sep-08	353327	6089584	Hyposulfidic cracking clay soil	Not reached	cracking	weeds	Low elevation, where there were surface cracks

Table 5-3. Soil description data for East Wellington 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
WEA1.1	0	25	soil pit	5YR 3/1	peaty loam	moist	0			subangular blocky	very friable	
WEA1.2	25	40	soil pit	5YR 3/1	clay loam	moist	5	2.5YR 5/8	on ped faces	subangular blocky	firm	
WEA1.3	40	100	push tube	5YR 3/1	clay loam	moist	5	2.5YR 5/8	on ped faces	subangular blocky	firm	10% white concentrations in peds
WEA1.4	100	160	push tube	7.5YR 3/1	clay	wet	0			massive	soft	50% root fibres
WEA2.1	0	5	soil pit	7.5YR 2.5/2	clay loam	moist	0			subangular blocky	firm	
WEA2.2	5	20	soil pit	10YR 4/2	clay	moist	5	7.5YR 5/8	in matrix along ped faces	subangular blocky	very firm	
WEA2.3	20	40	soil pit	10YR 2/1	clay	moist	30	5YR 5/8	on ped faces	massive	extremely firm	
WEA2.4	40	65	soil pit	10YR 2/1	clay	moist	15	5YR 5/8	on ped faces	massive	rigid	too hard to dig below this layer
WEA3.1	0	5	soil pit	7.5YR 2.5/2	clay loam	moist	0			granular	friable	
WEA3.2	5	20	soil pit	10YR 4/2	clay	moist	30	5YR 5/8	on ped faces	subangular blocky	very firm	
WEA3.3	20	45	soil pit	10YR 2/1	clay	moist	15	5YR 5/8	on ped faces	massive	rigid	too hard to dig below this layer

Table 5-4. Laboratory data for acid sulfate soil assessment of East Wellington 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
WEA1.1	0 - 25	medium	-	4.00	1.87	4.00	818	4.00	96.79	< 0.01	-	97	other acidic
WEA1.2	25 - 40	medium	-	4.42	2.48	4.00	244	4.25	74.70	< 0.01	-	75	other acidic
WEA1.3	40 - 100	medium	-	4.07	2.27	4.70	475	3.88	147.23	< 0.01	-	147	other acidic
WEA1.4	100 - 160	fine	-	2.99	1.41	2.50	1090	2.95	425.25	0.20	-	549	sulfuric
WEA2.1	0 - 5	medium	-	6.08	3.42	5.00	579	6.06	6.80	0.02	-	18	hyposulfidic (S_{CR}<0.10%)
WEA2.2	5 - 20	fine	-	5.03	2.47	4.50	413	4.53	34.19	< 0.01	-	34	other acidic incubation
WEA2.3	20 - 40	fine	-	4.89	2.97	4.50	271	4.66	37.43	< 0.01	-	37	other acidic
WEA2.4	40 - 65	fine	-	5.73	3.15	4.50	189	4.60	35.48	< 0.01	-	35	other acidic incubation
WEA3.1	0 - 5	medium	-	6.83	3.76	4.50	194	6.21	4.77	0.02	-	17	hyposulfidic (S_{CR}<0.10%)
WEA3.2	5 - 20	fine	-	4.73	2.45	6.50	380	4.47	42.91	< 0.01	-	43	other acidic
WEA3.3	20 - 45	fine	-	4.63	2.53	4.50	406	4.50	52.53	< 0.01	-	53	other acidic

6 WELLINGTON MARINA WETLAND (WETLAND ID. 12703)

6.1 LOCATION AND SETTING DESCRIPTION

Wellington Marina Wetland (Wetland ID. 12703) is situated on the eastern side of the River Murray, up river from the Wellington car ferry. The wetland is rectangular in shape, with a total surface area of 191 hectares. The area is not typical of a wetland, there are two main sections, with the down river end dredged allowing water in for a marina development and the larger up-river section previously levelled for irrigated dairy fields but is no longer used. There is a levee bank between the wetland and river with willow trees on the river bank. The soil survey conducted in August 2008 investigated the dairy farm land which was dry with a water table at 60 centimetres, and one site was sampled. The soil survey conducted in January 2010 investigated the marina complex area, which was inundated with water and connected by two inlets to the river channel. A total of seven sites were sampled and their locations are shown in Figure 6-1.

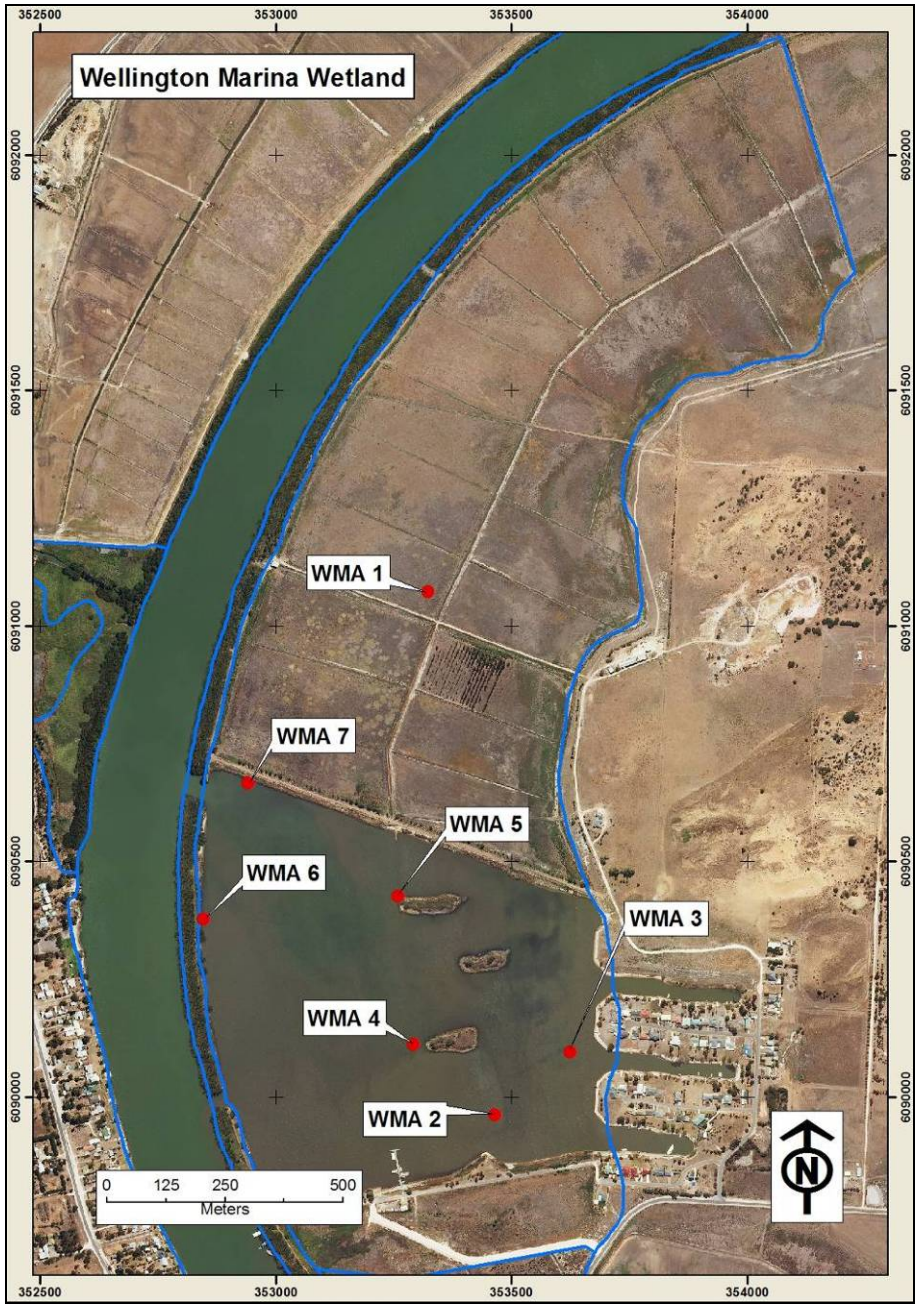

Figure 6-1. Wellington Marina Wetland and sample site locations.

6.2 SOIL PROFILE DESCRIPTION AND DISTRIBUTION

Seven sites were described and sampled. The acid sulfate soil subtype class and general location description are presented in Table 6-1. One site was located in the farmed pasture area that falls within the wetland boundary (WMA1). The other sites were located in the marina area to characterise different landscape positions that included mud islands surrounded by the marina water (WMA2, WMA3), subaqueous soil below the marina water (WMA4), mud islands with dredge spoils on the surface (WMA5), and shorelines adjacent to the levee banks that separate the marina waters from the river (WMA6) and from the up-river dairy farmed area (WMA7). The site and soil profile descriptions are presented in Table 6-2 and Table 6-3.

Site WMA1 (Figure 6-2) occurred in a low elevation area of the drained wetland that was used for growing pasture, the soil surface was cracking with cracks penetrating deep into the subsoil where the water table was at 60 cm, the soil consisted of black, friable, granular clay, with an upper subsoil of grey, extremely firm columnar clay, below approximately 50 cm the soil was an olive grey massive clay that graded from firm to soft with depth.

Site WMA2 (Figure 6-3) occurred in a low area of the wetland where a mud island area was just above the marina water. The soil consisted of grey clay with buried reed plant material, and below 10 cm there was a soft olive grey clay.

Site WMA3 (Figure 6-4) occurred in a low area of the wetland where the mud island area was just above the marina water at the house end of the wetland. The soil consisted of a thin, black aggregated clay, over a grey clay with buried reed material and below 20 cm a light grey, very soft clay.

Site WMA4 (Figure 6-5) occurred below the marina water near the centre of the marina approximately 20m from a mud island, the water was 30 cm deep and the sediment surface was very soft. The soil consisted of grey, soft, clay, with buried reed plant material, and in the subsoil an olive grey, clay.

Site WMA5 (Figure 6-6) occurred on the highest island area above the marina water where vegetation was growing, dredge clay material had been placed on the shoreline surface and was approximately 10 cm thick. The soil consisted of dredge grey clay material over the black aggregated clay surface layer, the subsoil was an olive grey, soft clay.

Site WMA6 (Figure 6-7) occurred in mid elevation on the shoreline next to the levee bank that separated the river from the marina wetland area. The soil consisted of black friable to soft clay, and at depth below approximately 40 cm an olive grey, firm clay with many buried reed plant material.

Site WMA7 (Figure 6-8) occurred on the shoreline next to the levee bank that separated the marina water from the pasture area of the wetland where new reeds were starting to grow. The soil consisted of black, soft clay, and at depth below approximately 40 cm an olive grey, soft clay with many buried reed plant material.

Table 6-1. Soil identification, subtype and general location description of sites for Wellington Marina Wetland.

Site ID	Easting m Zone 54H	Northing m Zone 54H	Acid sulfate soil subtype class	General location description
WMA1	353323	6091073	Sulfuric cracking clay soil	Low elevation, flat cracking surface pasture area
WMA2	353465	6089962	Hypersulfidic cracking clay soil	Low elevation, mud island in marina water
WMA3	353625	6090095	Hypersulfidic cracking clay soil	Low elevation, mud island in marina water
WMA4	353292	6090112	Subaqueous hypersulfidic cracking clay soil	Low elevation, below water adjacent to island
WMA5	353259	6090427	Hypersulfidic cracking clay soil	Low elevation, spoil on surface of island
WMA6	352847	6090378	Hypersulfidic cracking clay soil	Mid elevation, clay shore adjacent to levee bank with river
WMA7	352942	6090666	Hypersulfidic cracking clay soil	Mid elevation, clay shore adjacent to levee bank separating marina water from pasture area

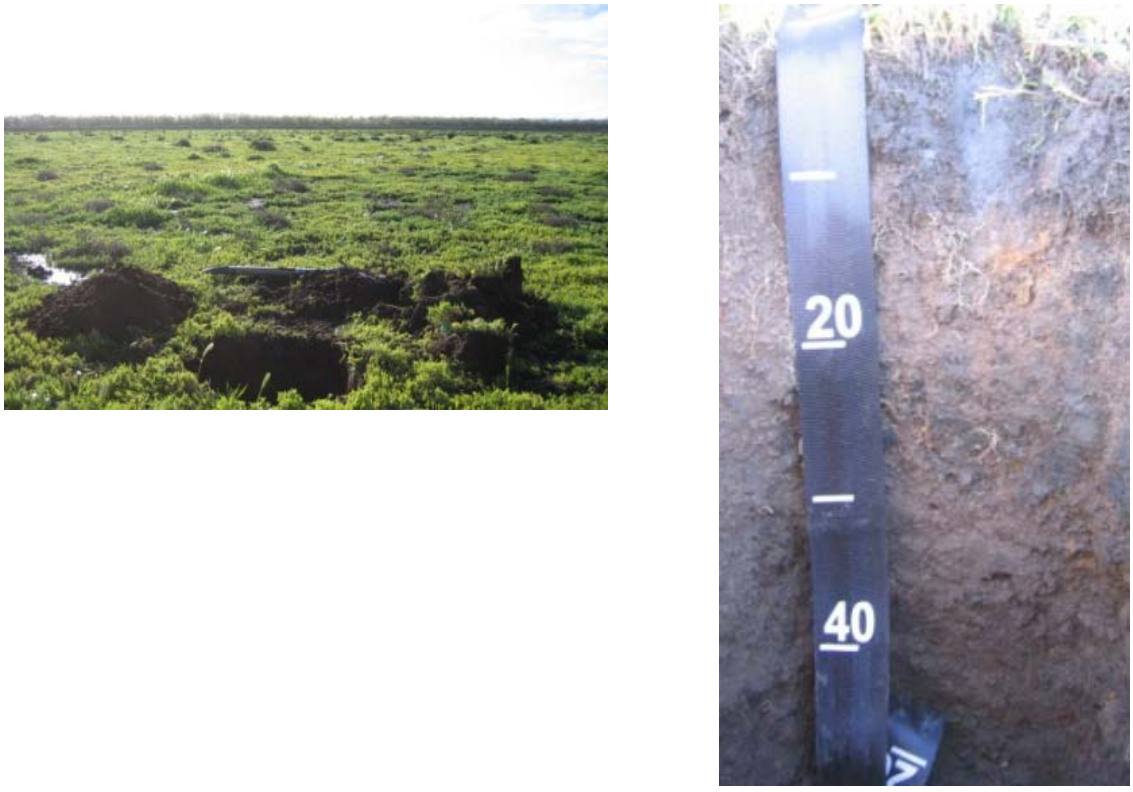

Figure 6-2. Photographs of site WMA1, showing the landscape of levelled land with the levee bank in the background and the soil profile of black 10cm topsoil over yellowish brown, clay.

Figure 6-3. Photographs of site WMA2, showing the site location on the mud island at the edge of the water in the marina, and the soil profile on the shovel showing grey clay with brown mottling.

Figure 6-4. Photographs of site WMA3, showing the landscape of a mud island that occurred in the marina waters, and the soil profile of grey clay with brown mottling.

Figure 6-5. Photographs of site WMA4, showing the landscape from the site in the water towards the island, and the soil profile core showing the black upper layers at the top and the lower subsoil layers containing reed plant material at the bottom of the photograph.

Figure 6-6. Photographs of site WMA5, showing the shoreline of an island in the marina waters that has had dredge spoil placed on the surface, and the soil profile of light grey clay dredge spoil material over a black granular clay.

Figure 6-7. Photographs of site WMA6, showing the shoreline adjacent to the levee bank with reeds growing, and the soil profile of grey clay.

Figure 6-8. Photographs of site WMA7, showing the levee bank that separates the marina area of the wetland from the farmed area of the wetland, and the soil profile of grey clay.

6.3 LABORATORY DATA ASSESSMENT

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

The pH data are provided in Table 6-4 and pH profiles are presented in Figure 6-9.

The pH_W data for subsoil layers of profile WMA1 identified sulfuric materials with a pH_W <4.

The pH_{INC} data for subsoil layers in all profiles (except for profiles WMA6 and WMA7) 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 materials as a result of sulfide oxidation. These layers were at or below the water table depth but if water levels dropped it is likely that they would oxidise.

The pH_{OX} data for subsoil layers in 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.

Acid Base Accounting

The acid base accounting data is provided in Table 6-4 and summarised in Figure 6-10.

Chromium reducible sulfur values ranged from below the limit of detection to 1.09%S_{CR}. Sulfidic materials were detected surface and subsoil layers, except for the upper layers of profile WMA1.

Titratable actual acidity ranged from 0 to 154.64 mole H^+/tonne.

Retained acidity was not measured in any of the samples, as all samples had a pH_{KCl} of greater than 4.5.

Acid neutralising capacity values ranged from 0 to 1.56 %$CaCO_3$. It was measured in only one upper layer of profile WMA4, and all other layers were zero.

Net acidity values ranged from -152 to 701 mole H^+/tonne. With the exception of the surface layer of the surface layer of profile WMA4 that was negative, all other layers had high net acidity values and a few with low or moderate values.

Water soluble sulfate

Water soluble sulfate data values shown in Table 6-4 identified that surface layers for profile WMA1 were above the trigger value of 100 mg/kg SO_4. Measurements for the other sites were not made but would be expected to be similar to WMA1

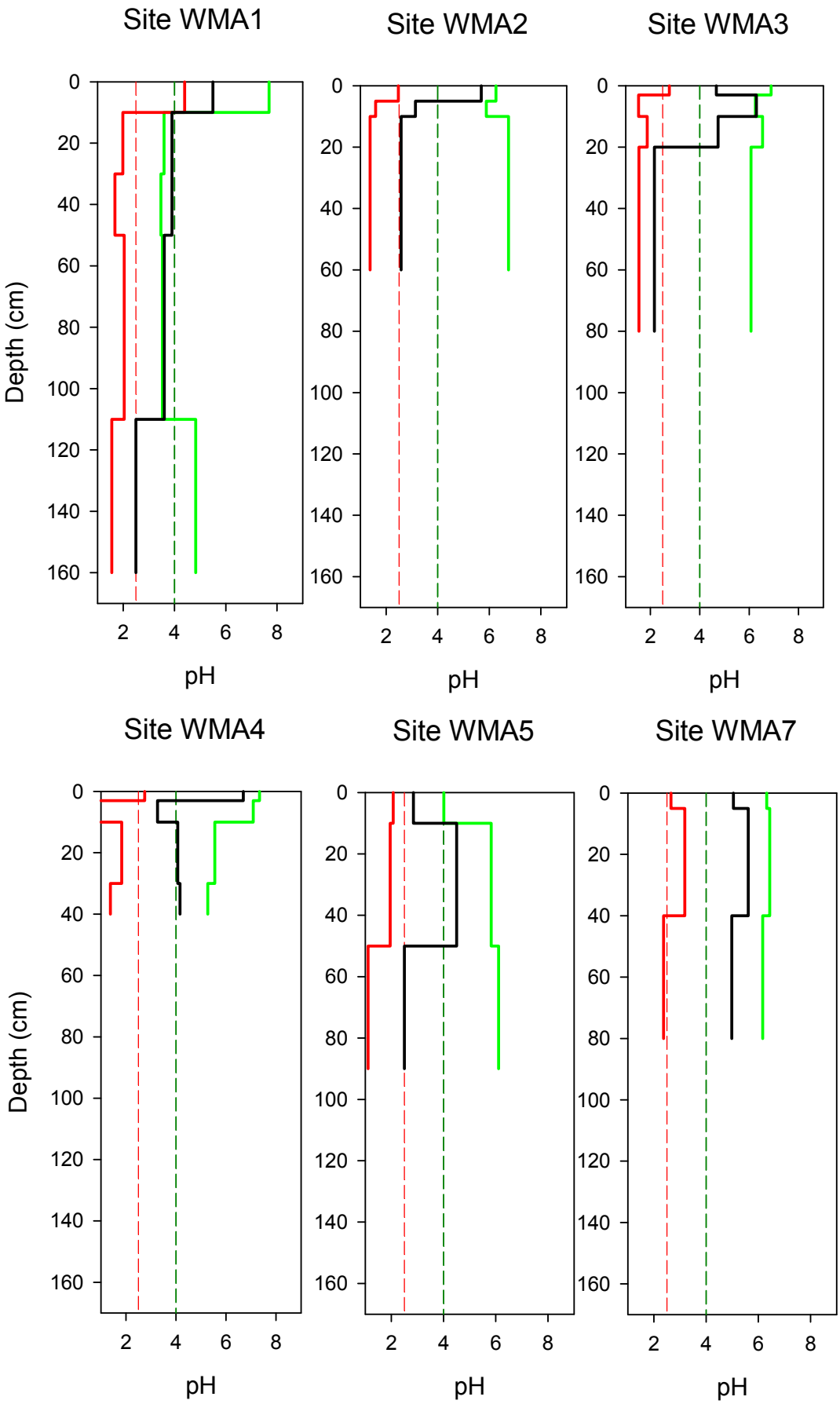

Figure 6-9. Depth profiles of soil pH for Wellington Marina Wetland, showing soil pH (pH_W as green line), peroxide treated pH (pH_{OX} as red line) and ageing pH (pH_{INC} after 28 weeks as black line). Critical pH_W and pH_{INC} value of 4 (black dashed line) and critical pH_{OX} value of 2.5 (red dashed line).

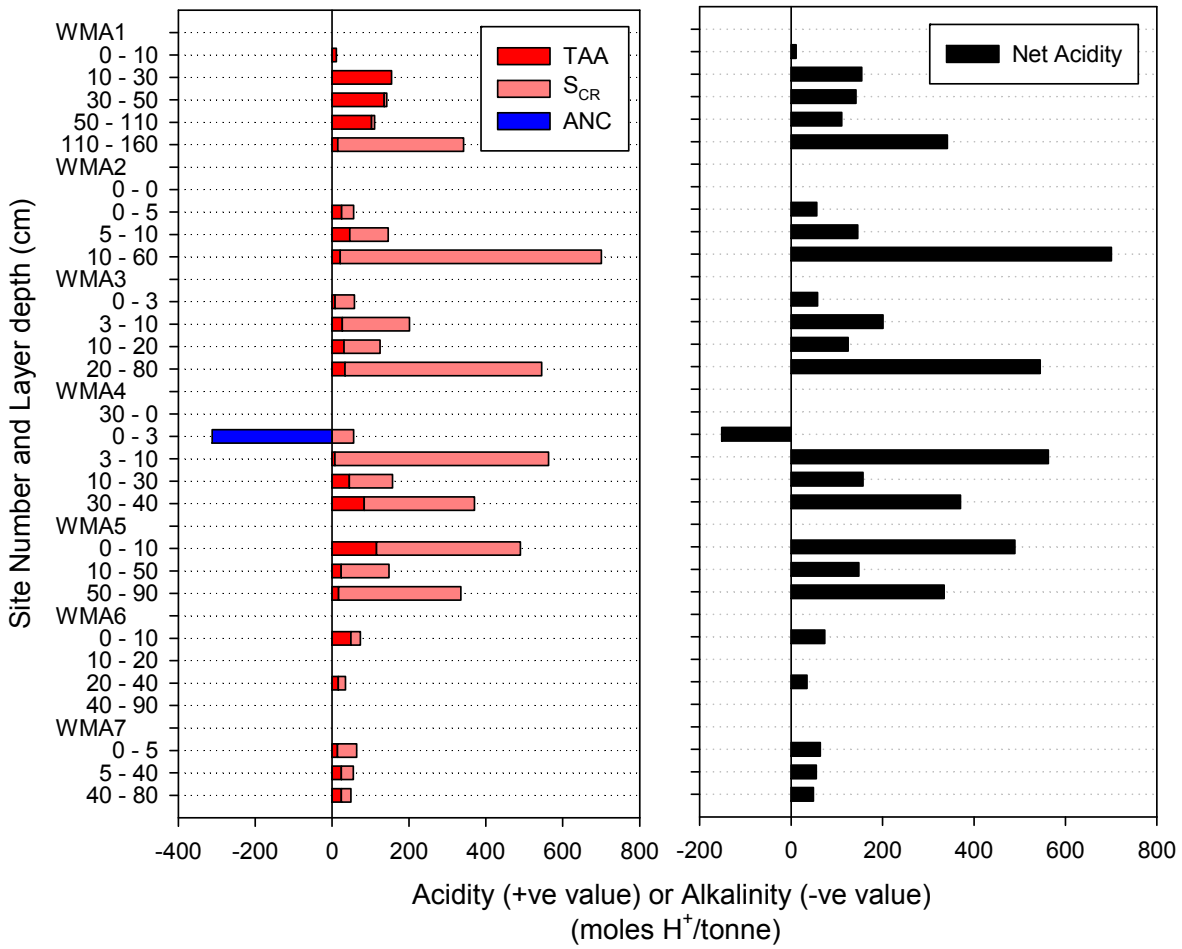

Figure 6-10. Acid base accounting depth profiles for Wellington Marina Wetland. Left side shows the components: titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} -pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.

6.4 DISCUSSION

Acid sulfate soil materials at the Wellington Marina Wetland were identified as sulfuric in the pasture area of the wetland where the soil was above the water table (Site WMA1), hypersulfidic or hyposulfidic in the marina area of the wetland where the soil layers were at or below the water level (Sites WMA2, WMA3, WMA4, WMA5, WMA6, WMA7).

The soils in the marina area of the wetland were reasonably uniform throughout, with surface layers of grey, firm to soft clays that may contain buried reed plant material over deeper subsoils of soft, olive grey clay. The soils in the pasture land area of the wetland that was levelled for drainage and irrigation have dried and the upper layers have formed large and deep cracks extending into the subsoil. These soils were somewhat similar to those in the marina section suggesting that if the water level in the marina dropped the soils would also dry, crack and form sulfuric acid sulfate soil material.

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

- Acidification hazard: The acid sulfate soil materials in the pasture area of the wetland are sulfuric and in the marina area they were hypersulfidic with high net acidity values. This suggests the potential that if the water table lowers in the marina area then these soils are likely to also become sulfuric. 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, monosulfidic material was observed at one site. 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 Wellington Marina Wetland:

Soil materials:	The soils throughout were generally grey clays to approximately 20 to 40 cm over soft olive grey clays. Where the soil layers have dried, as has occurred in the pasture area of the wetland, sulfuric acid sulfate soil material has formed. Where the soils remain inundated and at or below the water level they were hypersulfidic or hyposulfidic.
Acid sulfate soil identification:	• Sulfuric Cracking Clay Soil – that occurred throughout the pasture area of the wetland section were the soils have been drained. Dominant (>50%) in extent. • Hypersulfidic Cracking Clay Soil – that occurred throughout the wetland. Subdominant (<50%) in extent. • Subaqueous Hypersulfidic clay soil – that occurred throughout the marina area of the wetland. Minor (<25%) 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 6-2. Site data for Wellington Marina 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
WMA1	22-Aug-08	353323	6091073	Sulfuric cracking clay soil	60	cracking	grasses, weeds	lower, mid way between river and high,
WMA2	27-Jan-10	353465	6089962	Hypersulfidic cracking clay soil	0	sealed, wet	bare	low, on high area mud surface of raised area in marina water area,
WMA3	27-Jan-10	353625	6090095	Hypersulfidic cracking clay soil	0	sealed, wet	bare	low, flat mud island at house end of marina waters,
WMA4	27-Jan-10	353292	6090112	Subaqueous hypersulfidic clay soil	-30	soft	water	low, 20m from mud island with tree on it,
WMA5	27-Jan-10	353259	6090427	Hypersulfidic cracking clay soil	20	hard, clay spoil dredged material	bare	low to mid, island beach about 2m up from shore,
WMA6	27-Jan-10	352847	6090378	Hypersulfidic cracking clay soil	20	sealed	bare	mid, adjacent to levee bank with river on the side of marina,
WMA7	27-Jan-10	352942	6090666	Hypersulfidic cracking clay soil	25	sealed	*Phragmites australis* (Common Reed)	mid, on side of marina waters adjacent to levee bank with dairy land, amongst new reeds growing,

Table 6-3. Soil description data for Wellington Marina 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
WMA1.1	0	10	soil pit	7.5YR 3/1	clay	moist	0			granular	friable	
WMA1.2	10	30	soil pit	7.5YR 4/3	clay	moist	0			subangular blocky	extremely firm	
WMA1.3	30	50	soil pit	7.5YR 4/2	clay	moist	0			subangular blocky	very firm	
WMA1.4	50	110	push tube	7.5YR 4/2	peaty clay	wet	0			massive	firm	
WMA1.5	110	160	push tube	5Y 5/2	peaty clay	wet	0			massive	soft	
WMA2.0	0	0	soil pit		water							water sampled adjacent to mud island
WMA2.1	0	5	push tube	grey	clay	wet	0			granular	firm	
WMA2.2	5	10	push tube	brownish grey	clay	wet	0			massive	firm	many *Phragmites australis* (Common Reed plant materials
WMA2.3	10	60	push tube	olive grey	clay	wet	0			massive	soft	
WMA3.1	0	3	soil pit	black	clay	wet	0			granular	friable	
WMA3.2	3	10	soil pit	grey	clay	wet	0			granular	soft	common Reed roots
WMA3.3	10	20	soil pit	grey	clay	wet	0			massive	soft	
WMA3.4	20	80	push tube	light grey	clay	wet	0			massive	very soft	
WMA4.0	30	0	soil pit		water							Water
WMA4.1	0	3	soil pit	black	clay	wet	0			granular	friable	possibly MBO
WMA4.2	3	10	soil pit	grey brown	clay	wet	0			angular blocky	firm	many Reed roots and plant material
WMA4.3	10	30	push tube	light grey	clay	wet	0			massive	firm	
WMA4.4	30	40	push tube	olive grey	clay	wet	0			massive	soft	

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
WMA5.1	0	10	soil pit	grey	clay	wet	0			angular blocky	hard	spoil overburden probably from dredging, brown stains on ped faces, sharp boundary with underlying
WMA5.2	10	50	soil pit	black	clay	wet	0			granular	soft	possibly Monosulfidic material
WMA5.3	50	90	push tube	olive grey	clay	wet	0			massive	soft	
WMA6.1	0	10	soil pit	black	clay	moist	0			angular blocky	friable	
WMA6.2	10	20	soil pit	black	clay	moist	0			massive	soft	not sampled
WMA6.3	20	40	push tube	grey	clay	wet	0			massive	firm	
WMA6.4	40	90	push tube	olive grey	clay	wet	0			massive	firm	not sampled, many reed roots and plant material
WMA7.1	0	5	soil pit	black	clay	moist	0			angular blocky	soft	
WMA7.2	5	40	soil pit	olive grey	clay	moist	0			massive	firm	
WMA7.3	40	80	push tube	olive grey	clay	wet	0			massive	firm	many Reed roots, sulfurous odour

Table 6-4. Laboratory data for acid sulfate soil assessment of Wellington Marina 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
WMA1.1	0 - 10			7.69	4.40	5.50	141	5.45	11.09	< 0.01	0.00	11	other soil material
WMA1.2	10 - 30			3.59	1.99	3.90	1043	3.86	154.64	< 0.01	0.00	155	sulfuric
WMA1.3	30 - 50			3.47	1.68	3.90	462	3.66	135.43	0.01	0.00	142	sulfuric
WMA1.4	50 - 110			3.53	2.04	3.60	370	3.68	102.69	0.01	0.00	111	sulfuric
WMA1.5	110 - 160			4.83	1.55	2.50	343	5.08	14.89	0.52	0.00	342	hypersulfidic
WMA2.0	0 - 0	water											water
WMA2.1	0 - 5	fine	200	6.26	2.47	5.69		6.11	25.00	0.05	0.00	56	hyposulfidic (S_{CR}<0.10%)
WMA2.2	5 - 10	fine	360	5.88	1.59	3.14		5.30	46.30	0.16	0.00	146	hypersulfidic
WMA2.3	10 - 60	fine	930	6.75	1.38	2.58		5.86	20.80	1.09	0.00	701	hypersulfidic
WMA3.1	0 - 3	fine	190	6.89	2.77	4.67		6.35	8.00	0.08	0.00	58	hyposulfidic (S_{CR}<0.10%)
WMA3.2	3 - 10	fine	270	6.25	1.52	6.29		5.67	26.50	0.28	0.00	201	hyposulfidic (S_{CR}≥0.10%)
WMA3.3	10 - 20	fine	370	6.54	1.87	4.74		5.71	31.20	0.15	0.00	125	hyposulfidic (S_{CR}≥0.10%)
WMA3.4	20 - 80	fine	940	6.07	1.54	2.16		5.50	33.60	0.82	0.00	545	hypersulfidic
WMA4.0	30 - 0	water											water
WMA4.1	0 - 3	fine	220	7.34	2.75	6.69		6.56	0.00	0.09	1.56	-152	hyposulfidic (S_{CR}<0.10%)
WMA4.2	3 - 10	fine	310	7.09	0.92	3.26		6.29	7.60	0.89	0.00	563	hypersulfidic
WMA4.3	10 - 30	fine	1,250	5.55	1.83	4.07		5.20	44.90	0.18	0.00	157	hyposulfidic (S_{CR}≥0.10%)
WMA4.4	30 - 40	fine	1,290	5.27	1.38	4.16		4.46	83.60	0.46	0.00	371	hyposulfidic (S_{CR}≥0.10%)
WMA5.1	0 - 10	fine	400	4.01	2.07	2.85		3.96	115.30	0.60	0.00	490	hypersulfidic
WMA5.2	10 - 50	fine	500	5.83	1.96	4.50		5.27	23.60	0.20	0.00	148	hyposulfidic (S_{CR}≥0.10%)
WMA5.3	50 - 90	fine	910	6.11	1.11	2.50		5.37	17.00	0.51	0.00	335	hypersulfidic
WMA6.1	0 - 10	fine	150	5.67	2.20	4.72		4.84	48.70	0.04	0.00	74	hyposulfidic (S_{CR}<0.10%)
WMA6.2	10 - 20	fine											-
WMA6.3	20 - 40	fine	250	6.62	2.68	4.70		5.74	16.10	0.03	0.00	35	hyposulfidic (S_{CR}<0.10%)
WMA6.4	40 - 90	fine											-
WMA7.1	0 - 5	fine	180	6.32	2.65	5.04		5.68	14.20	0.08	0.00	64	hyposulfidic (S_{CR}<0.10%)
WMA7.2	5 - 40	fine	190	6.44	3.18	5.61		5.35	24.10	0.05	0.00	55	hyposulfidic (S_{CR}<0.10%)
WMA7.3	40 - 80	fine	210	6.17	2.37	4.98		5.51	24.10	0.04	0.00	49	hyposulfidic (S_{CR}<0.10%)

7 WELLINGTON NORTH (MURRUNDI) WETLAND (WETLAND ID. 12704)

7.1 BACKGROUND

Wellington North (Murrundi) Wetland (Wetland ID. 12704) is situated up-river from the Wellington ferry on the western side of the River Murray. The wetland is geomorphically categorised as a Murray Gorge basin (Pressey 1986) and is somewhat triangular in shape, approximately 600 metres in length and 200 metres at its widest, with a total surface area of approximately 9 hectares. It is bounded to the east by a river bank that is lined with willow trees that separates it from the river and to the west by a hill slope that is eroding and in some areas it has been modified by quarrying and other human activity. The wetland area has dense tall *Typha latifolia* (Bulrush) and *Phragmites australis* (Common Reed). There were excavated channels cut through the wetland and on the western hill slope side to facilitate the movement of water in the wetland.

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. Three sites were sampled (MUR1, MUR2, and MUR3) and their locations are shown in Figure 7-1. A follow-up survey was conducted in August 2009 to observe the condition of the wetland.

Figure 7-1. Wellington North (Murrundi) Wetland and sample site locations.

7.2 DISCUSSION

Acid sulfate soil materials at the Wellington North Wetland were identified as sulfuric in areas where the surface layers were above the water level and hypersulfidic elsewhere in the surface layers and throughout the wetland subsoil layers.

The dominant soil that occurred throughout the lower elevation areas of the wetland had large and deep cracks that in some areas were becoming filled by collapsing surface soil materials; the soil materials were hypersulfidic and have a high net acidity. The water table was within 20 cm of the soil surface and the water between the soil cracks was acidic with pH values between 2 and 3 (follow-up site visit in August 2009), indicating that acidification of the waters in contact with the soil was occurring and would continue.

Soils on the river side margins of the wetland were peaty in texture, and were observed near the downstream inlet. The soil material in the surface was sulfuric with low pH values and a high net acidity, the subsoils were characterised as hypersulfidic soil materials. The low buffering capacity of the peat material and current sulfuric soil material status indicates that waters entering the in-let over these soils may acidify.

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

- Acidification hazard: Sulfuric soil material was detected in the wetland and waters between soil cracks had strongly acidic pH values. Hypersulfidic soil material occurred through the subsoils in the wetland and if oxidised could form sulfuric material. There is a high level of concern.
- De-oxygenation hazard: No data was available, but a judgement made based on similar soils from the area would suggest 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 high level of concern.

Summary of key findings for Wellington North (Murrundi) Wetland:

Soil materials:	The soils were generally clays that had deep cracks into the subsoil. Throughout the wetland, especially where dense tall Typha latifolia (Bulrush) and Phragmities australis (Common Reed) occurred, sulfuric organic clayey soils with thick organic and peaty surface soil layers were present. The surface layers above the water table were sulfuric in some areas, and elsewhere hypersulfidic soil materials occurred throughout the wetland.
Acid sulfate soil identification:	• Hypersulfidic Cracking Clay Soil – that occurred throughout. Dominant (>50%) in extent. • Sulfuric Organic Soil –that occurred throughout the wetland and near the inlets and margins. Subdominant (<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

8 FRED'S LANDING WETLAND (WETLAND ID.12705)

8.1 LOCATION AND SETTING DESCRIPTION

Fred's Landing Wetland (Wetland ID. 12705) is situated on the south eastern side of the River Murray. The wetland is geomorphically categorised as a Murray Gorge basin (Pressey 1986) and is narrow and elongated in shape, and at the location it was very difficult to identify the wetland boundary. The wetland has a total surface area of approximately 0.3 hectares and is bounded to the north-west by a slightly raised river bank formed by willow trees that separate it from the river and to the south-east by a steep cliff. There are no obvious water connection channels with the river. At the time when the soil survey was conducted in September 2008 the wetland was dry with a water table at approximately 80 centimetres depth. One site was described and sampled and their locations are shown in Figure 8-1.

Figure 8-1. Fred's Landing Wetland and sample site locations.

8.2 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 8-1. The site was located in what appeared to be the lowest elevation area of the wetland depression (FLA5). Only one site was sampled because of the small wetland size and the difficulty in recognising the wetland location. The site and soil profile descriptions are presented in Table 8-2 and Table 8-3.

Site FLA5 (Figure 8-2) occurred on the margin of the wetland near the river in open land that was highly disturbed. The soil consisted of black, peaty clay, and at depth an olive grey, soft peaty clay with a strong sulfurous odour.

Table 8-1. Soil identification, subtype and general location description of sites for Fred's Landing Wetland.

Site ID	Easting m Zone 54H	Northing m Zone 54H	Acid sulfate soil subtype class	General location description
FLA5	357138	6092851	Hyposulfidic soil (clayey)	Low elevation, very difficult to identify wetland location

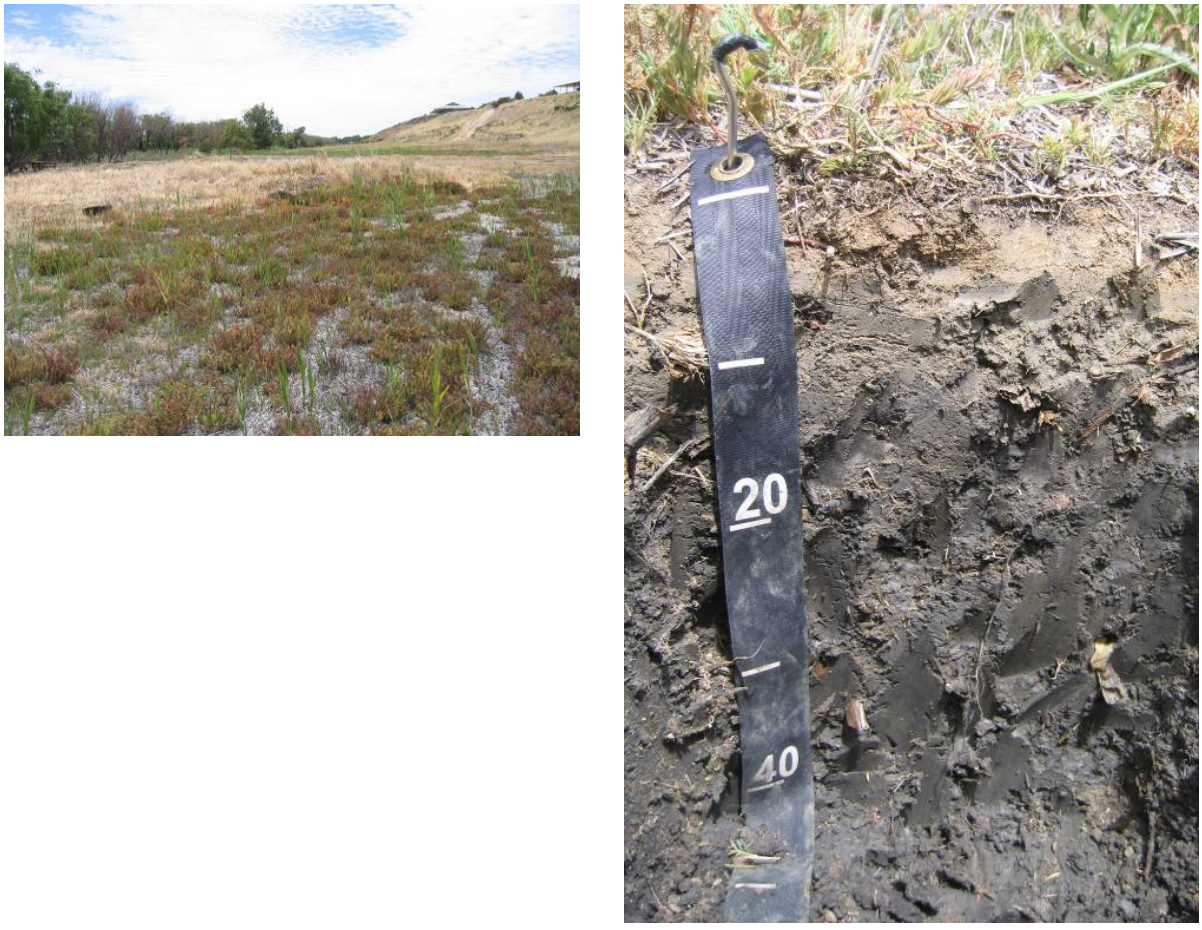

Figure 8-2. Photographs of site FLA5, showing the site landscape with grasses growing and the area bounded by willows to the west and a steep cliff to the east, and the soil profile of firm clay.

8.3 LABORATORY DATA ASSESSMENT

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

The pH data are presented in Table 8-4 and pH profiles are presented in Figure 8-3.

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 the lower subsoil layer of profile FLA5 identified samples that were below the critical value of pH_{OX} <2.5, the threshold value normally used to indicate a high likelihood of sulfuric material forming.

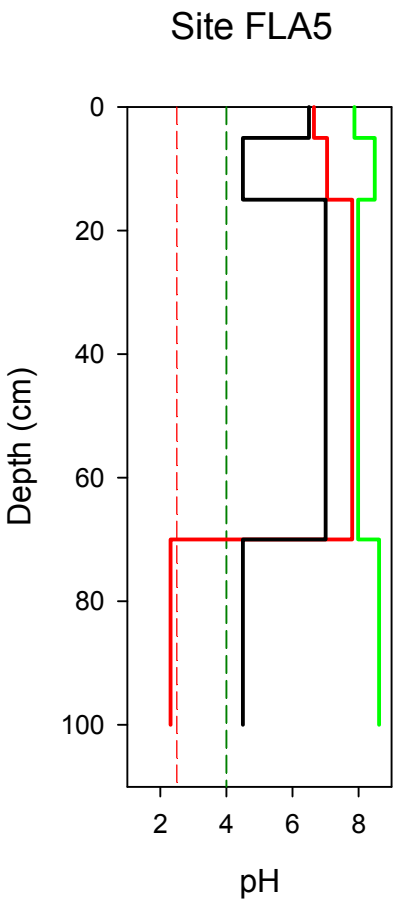

Figure 8-3. Depth profiles of soil pH for Fred's Landing Wetland, showing soil pH (pH_W as green line), peroxide treated pH (pH_{OX} as red line) and ageing pH (pH_{INC} after 28 weeks as black line). Critical pH_W and pH_{INC} value of 4 (black dashed line) and critical pH_{OX} value of 2.5 (red dashed line).

Acid Base Accounting

The acid base accounting data are provided in Table 8-4 and summarised in Figure 8-4.

Chromium reducible sulfur values ranged from 0.01 to 0.25%S_{CR}. Sulfidic materials were detected in all layers.

Titratable actual acidity was not detected in samples analysed.

Retained acidity was not measured in any of the samples, as all samples had a pH_{KCl} of greater than 4.5.

Acid neutralising capacity values ranged from 0.55 to 7.96 %$CaCO_3$, and were measured in all sampled layers.

Net acidity values ranged from -1054 to 83 mole H^+/tonne. The upper layers had negative net acidity values and the deeper subsoil layer had a moderate value.

Water Soluble Sulfate

Water soluble sulfate data values shown in Table 8-4 identified that surface layers were above the critical trigger value of 100 mg/kg SO_4.

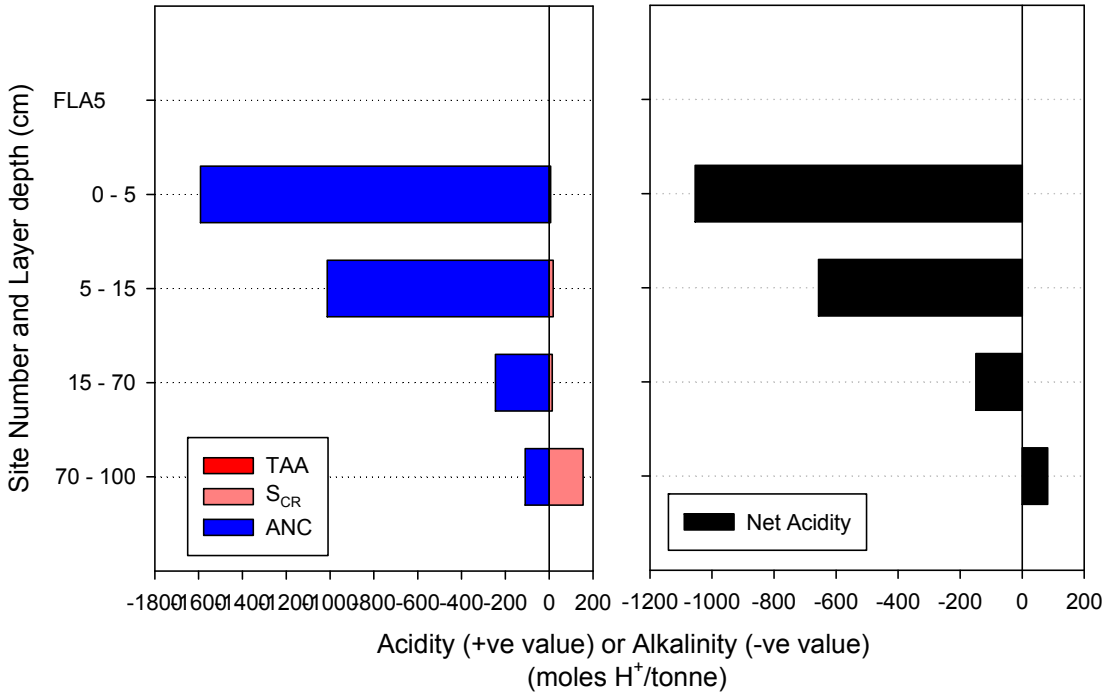

Figure 8-4. Acid base accounting depth profiles for Fred's Landing Wetland. Left side shows the components: titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} - pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.

8.4 DISCUSSION

Acid sulfate soil materials at Fred's Landing Wetland were identified as hyposulfidic for all layers of the sampled profile. The acid sulfate soil subtype class identified was Hyposulfidic Soil (clayey).

The soils throughout the wetland were generally firm and clay textured surface layers over soft 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 Fred's Landing Wetland are:

- Acidification hazard: The data identified negative net acidity values throughout most of the profile, and pH data identified the deeper subsoil sample with a value that was a potential acidification hazard due to oxidation. There is a low to medium level of concern.
- De-oxygenation hazard: The water soluble sulfate data indicated that there was potential for monosulfidic materials to form in the surface layers of soils on re-flooding, although the wetland was dry at the time of sampling and monosulfidic material was not observed. There is a medium level of concern.
- Metal mobilisation: 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 Fred's Landing Wetland:

Soil materials:	Hyposulfidic soil materials were identified in all soil layers. The soils throughout were generally clay textured layers. Samples had negative net acidity values and pH data identified the deepest subsoil layer with a value that indicated potential acidification due to oxidation.
Acid sulfate soil identification:	• Hyposulfidic Soil (clayey) – that occurred throughout the wetland. Dominant (>50%) in extent.
Hazard assessment	• Acidification hazard – low to medium of concern • De-oxygenation hazard – medium level of concern • Metal mobilisation hazard – low level of concern

Table 8-2. Site data for Fred's Landing 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
FLA5	24-Nov-08	357138	6092851	Hyposulfidic soil (clayey)	90	cracking, plant litter	saltbush	Low elevation, very difficult to identify wetland location

Table 8-3. Soil description data for Fred's Landing 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
FLA5.1	0	5	soil pit	10YR 6/2	clay	dry	0			subangular blocky	loose	
FLA5.2	5	15	soil pit	10YR 5/1	clay	moist	0			subangular blocky	firm	
FLA5.3	15	70	soil pit	10YR 2/1	clay	moist	0			massive	firm	
FLA5.4	70	100	soil pit	2.5Y 5/2	clay	moist	0			massive	soft	
FLA5.5	100	140	push tube	5Y 5/1	peaty sand	wet	0			massive	soft	sulfurous smell, not sampled due to insufficient recovery

Table 8-4. Laboratory data for acid sulfate soil assessment of Fred's Landing 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
FLA5.1	0 - 5	fine	-	7.88	6.65	6.50	2550	8.72	0.00	0.01	7.96	-1054	hyposulfidic (S_{CR}<0.10%)
FLA5.2	5 - 15	fine	-	8.49	7.05	4.50	1665	8.53	0.00	0.03	5.07	-655	hyposulfidic (S_{CR}<0.10%)
FLA5.3	15 - 70	fine	-	7.99	7.81	7.00	1113	7.85	0.00	0.02	1.23	-149	hyposulfidic (S_{CR}<0.10%)
FLA5.4	70 - 100	fine	-	8.62	2.31	4.50	517	8.08	0.00	0.25	0.55	82	hyposulfidic (S_{CR}≥0.10%)
FLA5.5	100 - 140	coarse	-	-	-	-	-	-	-	-	-	-	-

9 TAILEM BEND WETLAND (WETLAND ID. 12022)

9.1 LOCATION AND SETTING DESCRIPTION

Tailem Bend Wetland (Wetland ID. 12022) is situated on the north-eastern side of the River Murray, up river from the town of Tailem Bend. The wetland is geomorphically categorised as a Murray Gorge basin (Pressey 1986) and is somewhat rectangular in shape, with a total surface area of 96 hectares. It is bounded to the north-east by steep cliffs and to the south-west it is separated from the river by a levee bank. There are a few water connection channels with the river. The wetland was previously fenced into large paddocks, but now occurs in multiple sections separated by causeways. At the time of the survey in September 2008 the wetland had surface water over approximately one third of the wetland area and the water table was at or near the surface for the remaining area. Five sites were sampled and their locations are shown in Figure 9-1.

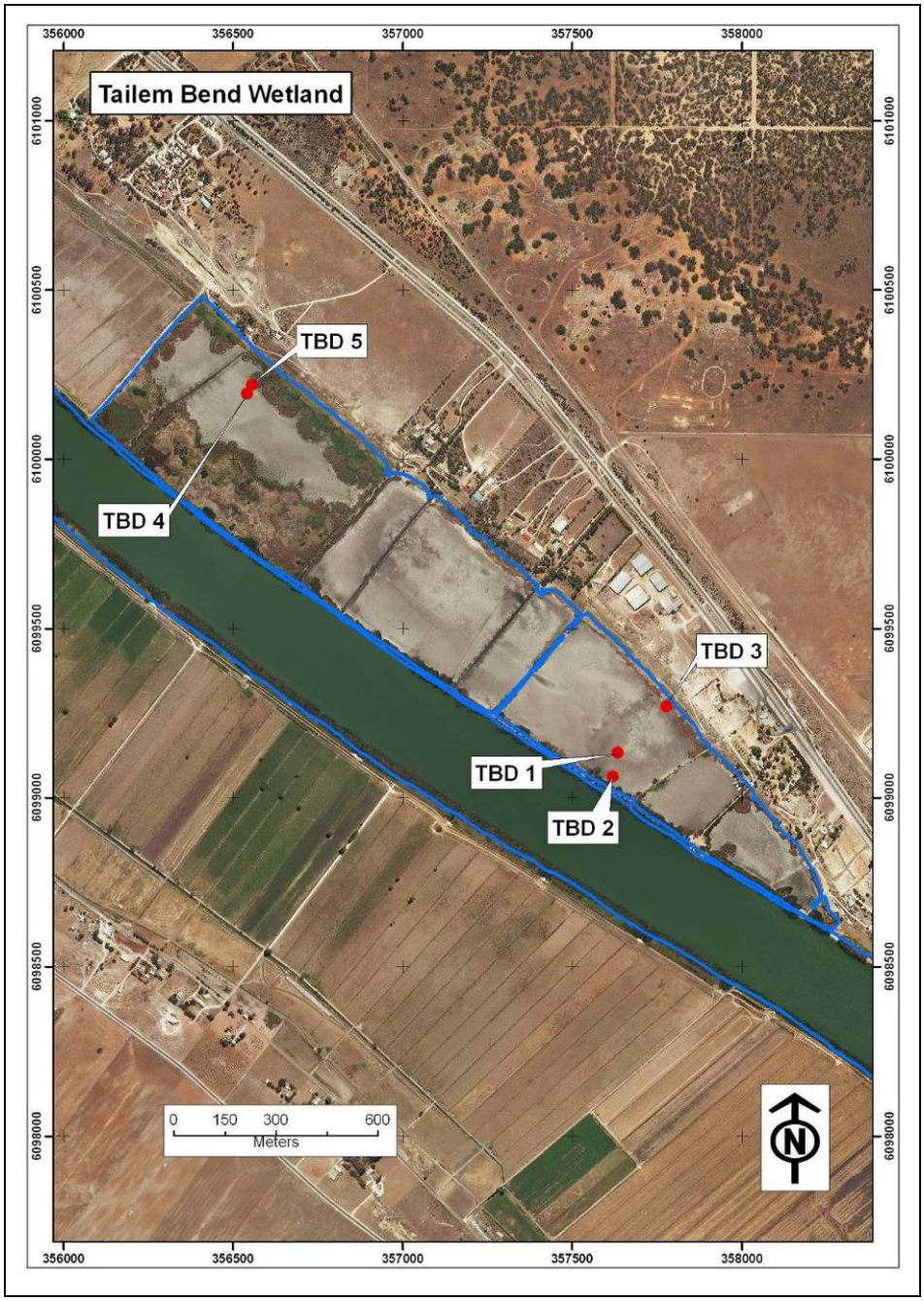

Figure 9-1. Tailem Bend Wetland and sample site locations.

9.2 SOIL PROFILE DESCRIPTION AND DISTRIBUTION

Five sites were described and sampled. The acid sulfate soil subtype class and general location description are presented in Table 9-1. There was no obvious difference in elevation; therefore one transect was located to obtain a cross-section through the wetland sites where located on the hill side (TBD3), in the middle low elevation area (TBD1) and near the levee bank (TBD2). At the other end of the wetland sites where located at a low elevation area (TBD4) and nearby where the vegetation was growing (TBD5). The site and soil profile descriptions are presented in Table 9-2 and Table 9-3.

Site TBD1 (Figure 9-2) occurred in a low area of the wetland where surface water was present. The soil consisted of grey clay, and at depth below 60 centimetres there were many reeds and other plant material buried with clay.

Site TBD2 (Figure 9-3) occurred between the surface water area and the levee bank. The soil consisted of a firm, black, clay, and at depth a brown, soft, peaty clay.

Site TBD3 (Figure 9-4) occurred on the cliff side of the wetland amongst *Typha latifolia* (Bulrush) latifolia (Bulrush). The soil consisted of a black, clay.

Site TBD4 (Figure 9-5) occurred in a low area of the wetland where water was on the soil surface and in soil cracks. The soil consisted of friable, black, peaty clay, and at depth an olive grey, firm clay.

Site TBD5 (Figure 9-6) occurred on the edge of the wetland amongst *Phragmites australis* (Common Reed). The soil consisted of friable, black, peaty clay, and at depth an olive grey, soft peaty clay.

Table 9-1. Soil identification, subtype and general location description of sites for Tailem Bend Wetland.

Site ID	Easting m Zone 54H	Northing m Zone 54H	Acid sulfate soil subtype class	General location description
TBD1	357636	6099131	Hypersulfidic cracking clay soil	Low elevation, cracking clay soil areas
TBD2	357621	6099062	Hypersulfidic cracking clay soil	Low elevation, cracking clay soil areas
TBD3	357779	6099268	Hyposulfidic cracking clay soil	Mid to high elevation, margins on the cliff side where *Typha latifolia* (Bulrush) latifolia (Bulrush) was growing.
TBD4	356542	6100193	Hypersulfidic cracking clay soil	Low elevation, cracking clay soil areas
TBD5	356557	6100219	Hypersulfidic cracking clay soil	Mid elevation, margins where *Phragmites australis* (Common Reed) was growing

Figure 9-2. Photographs of site TBD1, showing the landscape with surface water, and the soil profile core with the upper horizon on the left and lower clay subsoil on the right.

Figure 9-3. Photographs of site TBD 2, showing the surface with isolated water and vegetation, and the soil profile core with the upper horizon on the left and lower clay horizons on the right.

Figure 9-4. Photograph of site TBD3, showing the soil profile core with the upper horizons on the left and lower on the right.

Figure 9-5. Photographs of site TBD4, showing the landscape from the site towards the hillside of the wetland with vegetation encroaching onto the cracking clay surface soils and the fringing brown *Typha latifolia* (Bulrush) in the background before the rise to the hills, and the soil profile core with the surface horizon on the left and the lower clay subsoil on the right.

Figure 9-6. Photographs of site TBD5, showing the landscape towards the levee bank, and the soil profile core with the surface horizon on the left and subsoil on the right.

9.3 LABORATORY DATA ASSESSMENT

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

The pH data are provided in Table 9-4 and pH profiles are presented in Figure 9-7.

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

The pH_{INC} data for the lower subsoil layer (below about 50 cm depth) of profiles TBD1, TBD2, TBD4, and TBD5 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 materials as a result of sulfide oxidation.

The pH_{OX} data for the lower subsoil layers of profiles TBD1 and TBD2 and the surface and subsoil layers of profiles TBD4 and TBD5 identified samples that were 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 9-4 and summarised in Figure 9-8.

Chromium reducible sulfur values ranged from below the detection limit to 2.21%S_{CR}. Sulfidic materials were detected in subsoil layers below about 50 cm depth for all profiles.

Titratable actual acidity ranged from 3.23 to 100.27 mole H^+/tonne. It was measured in all layers for profiles TBD1, TBD2, TBD4, TBD5, and for the surface layer of TBD3.

Analysis of retained acidity was not conducted on any of the samples, however retained acidity may be present in the subsurface layer of profile TBD5 that was below the critical value of pH_{KCl} <4.5.

Acid neutralising capacity values ranged from 0 to 3.08 %$CaCO_3$, and were measured in the layers of profile TBD3 and not measured in the other soil profile layers. The acid neutralising capacity at profile TBD3 may be due to inputs of carbonate from the nearby cliffs or possibly associated with a ground water seep.

Net acidity values ranged from -229 to 1402 mole H^+/tonne. Moderate or high net acidity values occurred in layers of all profiles, with the exception of TBD3 where there were negative and low values. The higher values tend to be associated with the deeper subsoil layers below about 50 cm.

Water soluble sulfate

Water soluble sulfate data values shown in Table 9-4 identified that surface layers for profiles TBD4 and TBD5 were above the trigger value of 100 mg/kg SO_4.

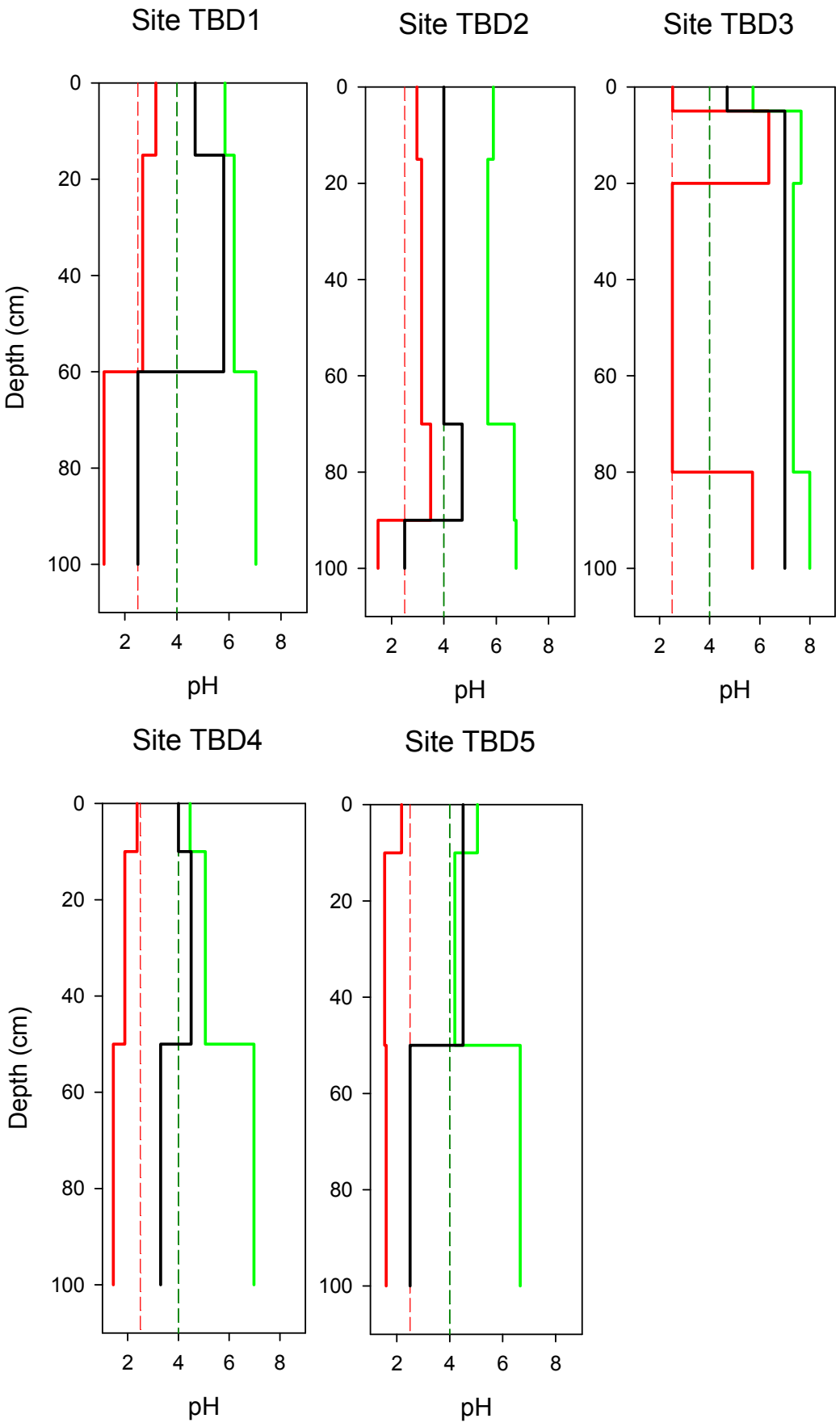

Figure 9-7. Depth profiles of soil pH for Tailem Bend Wetland, showing soil pH (pH_W as green line), peroxide treated pH (pH_{OX} as red line) and ageing pH (pH_{INC} after 28 weeks as black line). Critical pH_W and pH_{INC} value of 4 (black dashed line) and critical pH_{OX} value of 2.5 (red dashed line).

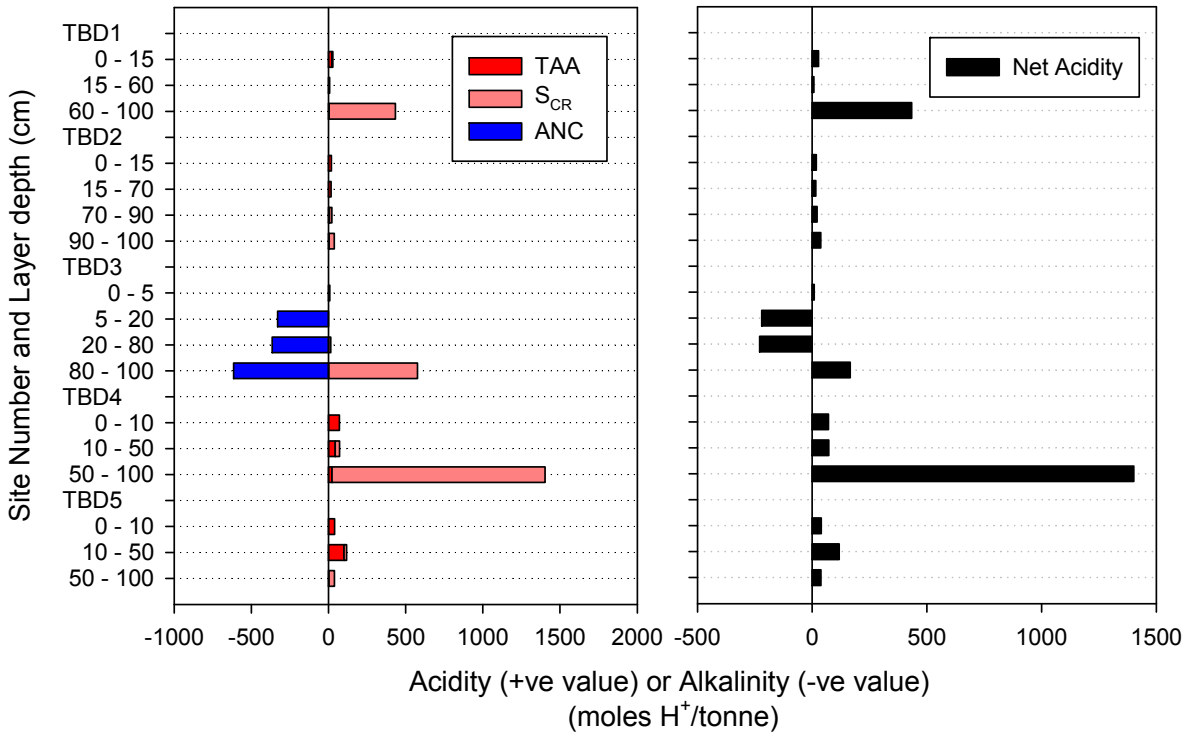

Figure 9-8. Acid base accounting depth profiles for Tailem Bend Wetland. Left side shows the components: titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} - pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.

9.4 DISCUSSION

Acid sulfate soil materials at Tailem Bend Wetland were identified as hypersulfidic or hyposulfidic, they occurred throughout the wetland generally associated with the subsoil below about 50 cm depth. The surface soil layers (to about 10 cm depths) were generally not identified as acid sulfate soil material.

The soils in the wetland were reasonably uniform throughout as reflected by the similarly described soils and the soil surface features which were relatively flat with cracking clay surfaces. The soils on the cliff side margin were somewhat similar to the soils within the main wetland area but they tended to be less acidic possibly due to ground water seepage.

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

- Acidification hazard: The acid sulfate soil materials were generally in the subsoil and below the water table (at the time of sampling in September 2008). However, if the water table lowers then the soil will oxidise and deep soil cracks will expose the soil raising the acidification hazard to a high level of concern. There is a medium level of concern.
- De-oxygenation hazard: The water soluble sulfate data indicated no potential for monosulfidic materials to form in the surface layers of soils at the south eastern end of the wetland but there is potential at the up river north western end, monosulfidic material was not observed. There is a low and high 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 Tailem Bend Wetland:

Soil materials:	The surface soil layers were generally not identified as acid sulfate soil materials but they were acidic with low or moderate net acidity values and were a clay textured cracking soil surface. The lower subsoil layers (below about 50cm) were hypersulfidic throughout the wetland with moderate or high net acidity values. These clay textured layers at the time of sampling were submerged but if the water table declined they could dry causing the crack to extend deeper, oxidising the soil and sulfuric material could form.
Acid sulfate soil identification:	• Hypersulfidic Cracking Clay Soil – that occurred throughout the wetland. Dominant (>50%) in extent. • Hyposulfidic Cracking Clay Soil – that occurred on the cliff side wetland margins. Isolated (10%) in extent.
Hazard assessment	• Acidification hazard – medium level of concern, increasing to high if the water table drops below 50 cm depth. • De-oxygenation hazard – high level of concern for the upper river end, and low level of concern elsewhere. • Metal mobilisation hazard – medium level of concern.

Table 9-2. Site data for Tailem Bend 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
TBD1	02-Sep-08	357636	6099131	Hypersulfidic cracking clay soil	0	firm	Bare	mid way into wetland,
TBD2	02-Sep-08	357621	6099062	Hypersulfidic cracking clay soil	70	very firm	weeds	high, near levee,
TBD3	02-Sep-08	357779	6099268	Hyposulfidic cracking clay soil	0	very firm	Bulrushes	mid, edge of wetland near cliffs,
TBD4	02-Sep-08	356542	6100193	Hypersulfidic cracking clay soil	0	cracking, filled with water	weeds	mid, centre, part of inlet channel,
TBD5	02-Sep-08	356557	6100219	Hypersulfidic cracking clay soil	5	cracking	*Phragmites australis* (Common Reed)	low, near edge of wetland below cliff,

Table 9-3. Soil description data for Tailem Bend 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
TBD1.1	0	15	push tube	2.5Y 3/1	clay	wet	0			subangular blocky	firm	
TBD1.2	15	60	push tube	2.5Y 2.5/1	clay	wet	0			massive	firm	
TBD1.3	60	100	push tube	2.5Y 3/2	peaty clay	wet	0			massive	firm	plant material, many old buried reeds
TBD2.1	0	15	push tube	2.5Y 3/1	peaty clay	moist	0			subangular blocky	very firm	
TBD2.2	15	70	push tube	2.5Y 2.5/1	clay	moist	0			subangular blocky	very firm	
TBD2.3	70	90	push tube	2.5Y 3/1	clay	wet	0			massive	firm	
TBD2.4	90	100	push tube	2.5Y 3/2	peat	wet	0			massive	soft	
TBD3.1	0	5	push tube	2.5Y 3/1	peaty clay	wet	0			massive	soft	
TBD3.2	5	20	push tube	2.5Y 2.5/1	clay	wet	0			subangular blocky	very firm	
TBD3.3	20	80	push tube	2.5Y 2.5/1	clay	wet	0			subangular blocky	very firm	
TBD3.4	80	100	push tube	5Y 3/2	clay	wet	0			massive	firm	
TBD4.1	0	10	push tube	2.5Y 2.5/1	peaty clay	wet	0			subangular blocky	firm	contains plant material
TBD4.2	10	50	push tube	2.5Y 2.5/1	clay	wet	0			subangular blocky	friable	contains plant material
TBD4.3	50	100	push tube	5Y 3/2	clay	wet	0			massive	firm	contains plant material
TBD5.1	0	10	push tube	2.5Y 2.5/1	peaty clay	wet	0			subangular blocky	firm	
TBD5.2	10	50	push tube	2.5Y 2.5/1	clay	wet	0			subangular blocky	friable	contains plant material
TBD5.3	50	100	push tube	5Y 3/2	clay	wet	0			massive	firm	contains plant material

Table 9-4. Laboratory data for acid sulfate soil assessment of Tailem Bend 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
TBD1.1	0 - 15	Fine	-	5.85	3.19	4.70	44	5.11	21.88	0.01	0.00	28	hyposulfidic (S_{CR}<0.10%)
TBD1.2	15 - 60	Fine	-	6.20	2.68	5.80	22	5.64	7.79	< 0.01	0.00	8	other soil material
TBD1.3	60 - 100	Fine	-	7.04	1.20	2.50	57	5.99	4.06	0.69	0.00	434	hypersulfidic
TBD2.1	0 - 15	Fine	-	5.89	2.97	4.00	31	5.02	18.39	< 0.01	0.00	18	other acidic
TBD2.2	15 - 70	Fine	-	5.68	3.15	4.00	22	5.18	16.31	< 0.01	0.00	16	other acidic
TBD2.3	70 - 90	Fine	-	6.69	3.49	4.70	15	5.80	6.18	0.02	0.00	22	hyposulfidic (S_{CR}<0.10%)
TBD2.4	90 - 100	Peat	-	6.76	1.48	2.50	33	5.86	4.19	0.05	0.00	37	hypersulfidic
TBD3.1	0 - 5	Fine	-	5.73	2.52	4.70	49	5.63	8.43	< 0.01	0.00	8	other acidic
TBD3.2	5 - 20	Fine	-	7.65	6.36	7.00	42	6.93	-	< 0.01	1.65	-220	other soil material
TBD3.3	20 - 80	Fine	-	7.34	2.51	7.00	74	6.80	-	0.02	1.83	-229	hyposulfidic (S_{CR}<0.10%)
TBD3.4	80 - 100	Fine	-	7.99	5.71	7.00	71	7.98	-	0.92	3.08	166	hyposulfidic (S_{CR}≥0.10%)
TBD4.1	0 - 10	Fine	-	4.46	2.37	4.00	207	4.57	70.91	< 0.01	0.00	74	other acidic
TBD4.2	10 - 50	Fine	-	5.06	1.89	4.50	221	5.05	43.23	0.05	0.00	72	hyposulfidic (S_{CR}<0.10%)
TBD4.3	50 - 100	Fine	-	6.98	1.43	3.30	452	4.94	23.36	2.21	0.00	1402	hypersulfidic
TBD5.1	0 - 10	Fine	-	5.05	2.18	4.50	279	4.82	39.59	< 0.01	0.00	40	other acidic
TBD5.2	10 - 50	Fine	-	4.19	1.54	4.50	328	4.00	100.27	0.03	0.00	118	hyposulfidic (S_{CR}<0.10%)
TBD5.3	50 - 100	Fine	-	6.66	1.60	2.50	390	6.16	3.23	0.06	0.00	38	hypersulfidic

10 MASON ROCK WETLAND (WETLAND ID. 12121)

10.1 LOCATION AND SETTING DESCRIPTION

Mason Rock wetland (Wetland ID. 12121) is situated on the eastern side of the River Murray, down river from the town of Murray Bridge. The wetland is geomorphically categorised as a Murray Gorge basin (Pressey 1986) and is a narrow elongated shape, with a total surface area of 26 hectares. It is bounded to the north-east by raised land and to the south-west it is separated from the river by a river bank, there were no levee banks and the wetland has formed on slightly higher land that grades down into the adjacent river. There are seven wide connection channels with the river. At the time when the soil survey was conducted in September 2008 the wetland surface was moist but there was no surface water. Two sites were sampled and their locations are shown in Figure 10-1.

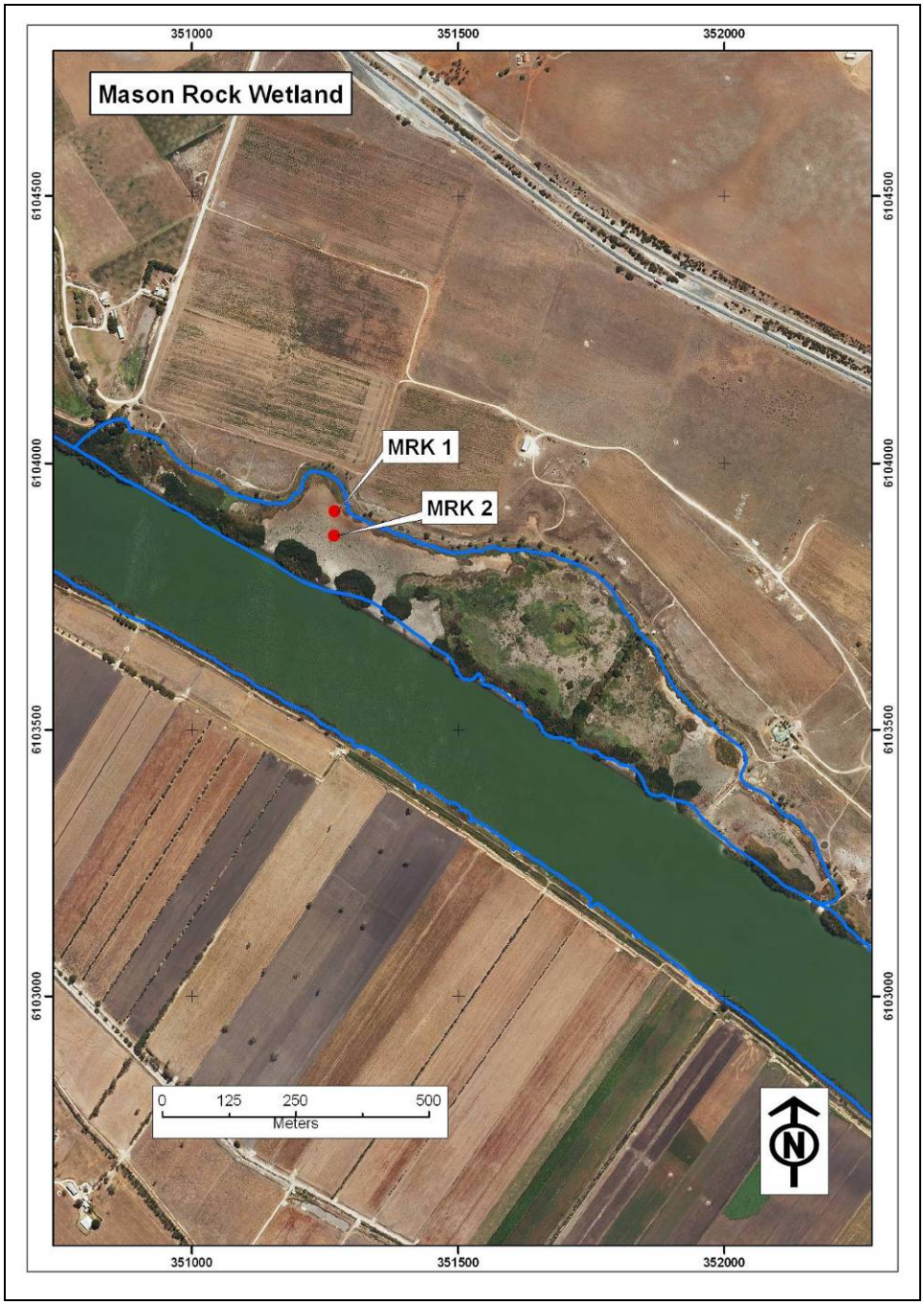

Figure 10-1. Mason Rock Wetland and sample site locations.

10.2 SOIL PROFILE DESCRIPTION AND DISTRIBUTION

Two sites were described and sampled. The acid sulfate soil subtype class and general location description are presented in Table 10-1. The two sites form a cross section through the up river area of the wetland, selected to characterise the higher elevation fringing area (MRK1) and the main area of the wetland that was at low elevation with a relatively flat surface (MRK2). The site and soil profile descriptions are presented in Table 10-2 and Table 10-3.

Site MRK1 (Figure 10-2) occurred in *Phragmites australis* (Common Reed) that fringe the bare surface areas around the wetland margins, the water table was at 25 cm depth. The soil consisted of grey, soft, clay, and at depth below 50 centimetres there was plant material buried with olive grey, firm, clay.

Site MRK2 (Figure 10-3) occurred in a low area of the wetland that had a bare soil surface, the water table was at 25 cm depth. The soil consisted of grey, soft, clay, and at depth below 50 centimetres there was plant material buried with olive grey, firm, clay.

A site visit in August 2009 identified the surface soil layer along the length of the wetland river bank was sulfuric with pH values at several locations approximately pH3.5, in addition to orange and yellow staining, indicating the presence of iron oxide and jarosite. Although there were no reeds along the bank, there was a dense mat of root material similar to that seen around *Phragmites australis* (Common Reed) and the soil material would probably have a low buffering capacity.

Table 10-1. Soil identification, subtype and general location description for Mason Rock Wetland.

Site ID	Easting m Zone 54H	Northing m Zone 54H	Acid sulfate soil subtype class	General location description
MRK1	351269	6103909	Hypersulfidic soil	Higher elevation, on the margins of the wetland
MRK2	351268	6103863	Hypersulfidic soil	Low to mid elevation, in the middle main flat area of the wetland

Figure 10-2. Photographs of site MRK1, showing the fringing vegetation on the hillside of the wetland, and the soil profile of structured clay surface layer with water table at approximately 25 cm.

Figure 10-3. Photographs of site MRK2, showing moist bare surfaced wetland landscape, and the soil profile of sticky clay and water table at approximately 25cm.

10.3 LABORATORY DATA ASSESSMENT

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

The pH data are provided in Table 10-4 and pH profiles are presented in Figure 10-4.

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

The pH_{INC} data for the lower subsoil layers (below about 50 cm depth) of profiles MRK1 and MRK2 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 subsoil layers of profiles MRK1 and MRK2 identified samples that were 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 10-4 and summarised in Figure 10-5.

Chromium reducible sulfur values ranged from below the detection limit to 1.08%S_{CR}. Sulfidic materials were detected in the lower subsoil layers for both profiles and in the surface layers for profile MRK2.

Titratable actual acidity values ranged from 0 to 27.05 mole H^+/tonne. Concentrations were measured in all layers of profile MRK2 and not in MRK1.

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 1.60 %$CaCO_3$ and were measured in profile MRK1 but not in MRK2.

Net acidity values ranged from -212 to 678 mole H^+/tonne. High net acidity values occurred in the deeper subsoil clay layer for both profiles. For profile MRK2 that would be indicative of the main area of the wetland, the net acidity values were high, moderate or low. For profile MRK1 the net acidity values were negative in the upper soil layers.

Water Soluble Sulfate

Water soluble sulfate data values shown in Table 10-4 identified that surface layers in both profiles were above the trigger value of 100 mg/kg SO_4.

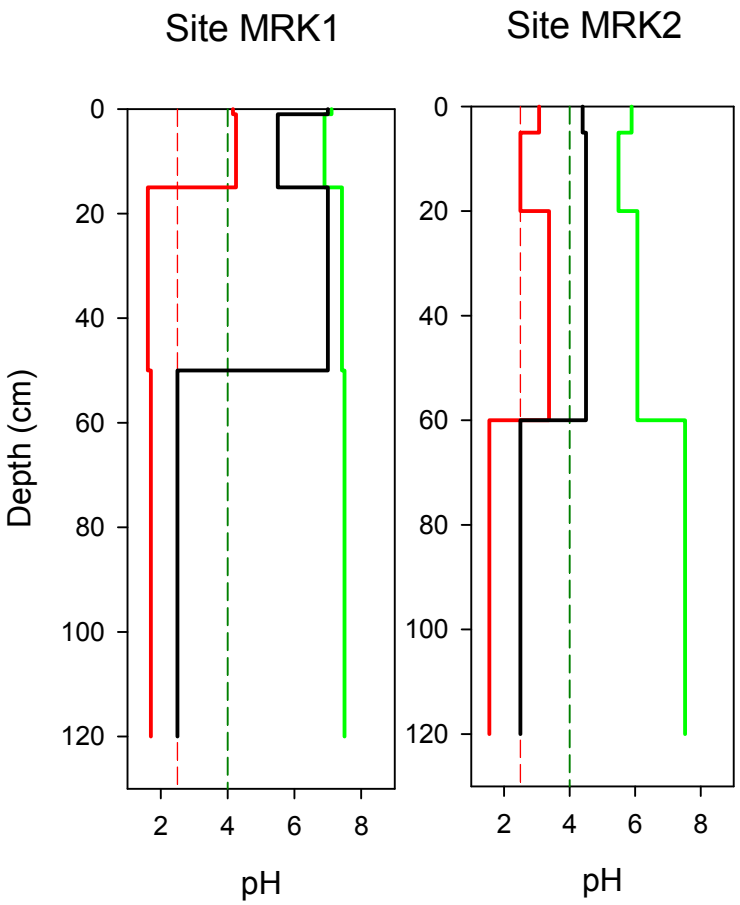

Figure 10-4. Depth profiles of soil pH for Mason Rock Wetland, showing soil pH (pH_W as green line), peroxide treated pH (pH_{OX} as red line) and ageing pH (pH_{INC} after 28 weeks as black line). Critical pH_W and pH_{INC} value of 4 (black dashed line) and critical pH_{OX} value of 2.5 (red dashed line).

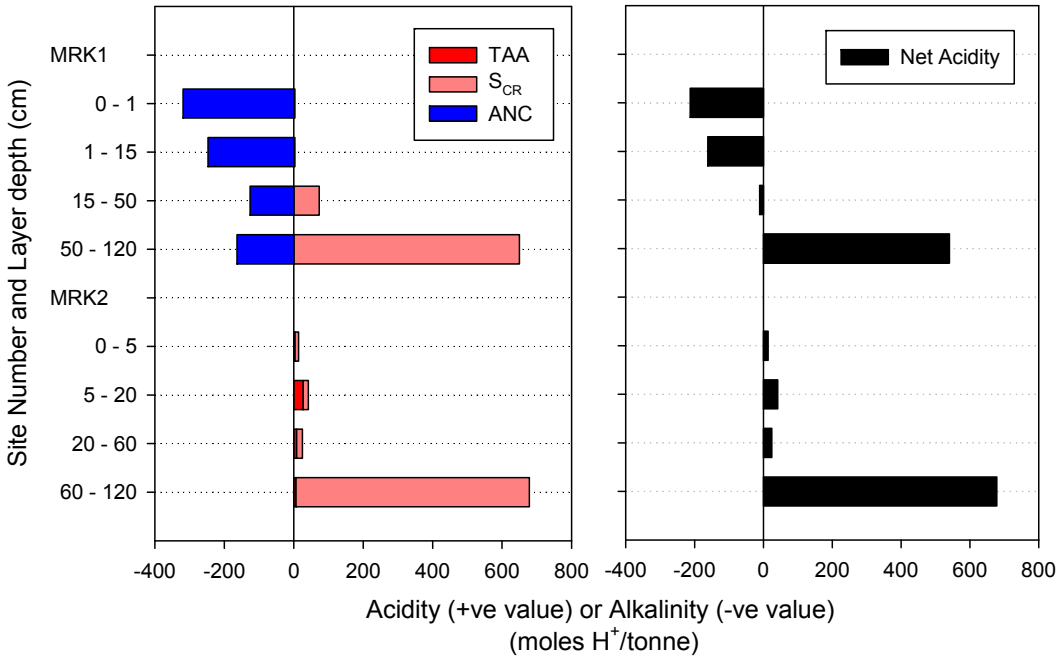

Figure 10-5. Acid base accounting depth profiles for Mason Rock Wetland. Left side shows the components: titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} -pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.

10.4 DISCUSSION

Acid sulfate soil materials at Mason Rock Wetland were identified as hypersulfidic in the lower subsoil layers (below about 50 cm) throughout the wetland. These layers at the time of survey in September 2008 were submerged below the water table, however if the water table drops then they would potentially oxidise and have more influence on the acidification of the wetland. Hyposulfidic soil materials were identified in the surface soil layers throughout the main area of the wetland.

The sulfuric soil materials observed on the river banks (in August 2009) present a risk not only to the river channel but also the wetland. As river levels rise, water will eventually lap over the bank and enter the wetland. This water movement will be shallow and slow until river level rises sufficiently and, as such, the acidic banks are likely to reduce the buffering capacity of the water as it passes over and enters the wetland, reducing the ability of the water to buffer any acidity produced within the wetland. Until the banks are permanently and fully submerged the constant exposure and rewetting with wave action will continue to create acidity in these river banks.

Isolated areas of sulfuric material were observed (in August 2009) on the hillside margin areas where the surface layers were sandy.

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

- Acidification hazard: The data identified the subsoils of the main area of the wetland as hypersulfidic and if they remain below the water table would be a low level of concern, but if the water table drops to allow the subsoil to be oxidised then it would become a medium to high level of concern. There is high level of concern for the river bank where sulfuric material has been identified and would impact on both the wetland and river channel. Overall 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 the soils, 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 may increase the solubility of metals. There is a low level of concern.

Summary of key findings for Mason Rock Wetland:

Soil materials:	The surface soil layers that occurred throughout the main areas of the wetland were identified as acid sulfate soil materials and the surface soil layers that occurred on the river bank and elevation sandy margins were sulfuric. The lower subsoil layers (below about 50cm depth) throughout the wetland were hypersulfidic.
Acid sulfate soil identification:	• Hypersulfidic Soil – that occurred throughout the wetland. Dominant (>50%) in extent. • Sulfuric Soil – that occurred on the elevated sandy margins and along the river bank. Isolated (<10%) in extent.
Hazard assessment	• Acidification hazard – low to medium level of concern, would increase if water table drops. • De-oxygenation hazard – high level of concern • Metal mobilisation hazard – low level of concern, would increase if water table drops.

Table 10-2. Site data for Mason Rock 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
MRK1	02-Sep-08	351269	6103909	Hypersulfidic soil	30	sealed	Bare	low, depression spot of wetland, near inlet channel,
MRK2	02-Sep-08	351268	6103863	Hypersulfidic soil	25	sealed, firm	*Phragmites australis* (Common Reed)	mid, near river on slight rise,

Table 10-3. Soil description data for Mason Rock 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
MRK1.1	0	1	soil pit	10YR 3/2	loam	moist	0			platy	very friable	
MRK1.2	1	15	soil pit	10YR 3/1	clay loam	wet	3	5YR 6/8	in matrix along ped faces	subangular blocky	firm	
MRK1.3	15	50	soil pit	2.5Y 4/1	clay	wet	0			massive	soft	contains plant material
MRK1.4	50	120	push tube	5Y 3/2	clay	wet	0			massive	firm	contains plant material
MRK2.1	0	5	soil pit	10YR 3/1	clay loam	moist	0			subangular blocky	friable	
MRK2.2	5	20	soil pit	10YR 3/1	clay	wet	0			subangular blocky	friable	
MRK2.3	20	60	soil pit	10YR 3/1	clay	wet	0			massive	firm	
MRK2.4	60	120	push tube	10YR 3/2	clay	wet	0			massive	firm	decomposed plant material

Table 10-4. Laboratory data for acid sulfate soil assessment of Mason Rock 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
MRK1.1	0 - 1	Medium	-	7.11	4.16	7.00	1660	7.85	-	< 0.01	1.60	-212	other soil material
MRK1.2	1 - 15	Medium	-	6.90	4.25	5.50	441	6.86	-	< 0.01	1.24	-165	other soil material
MRK1.3	15 - 50	Fine	-	7.42	1.61	7.00	537	6.98	-	0.12	0.63	-11	hyposulfidic (S_{CR}≥0.10%)
MRK1.4	50 - 120	Fine	-	7.50	1.70	2.50	1429	6.89	-	1.04	0.82	541	hypersulfidic
MRK2.1	0 - 5	Medium	-	5.89	3.07	4.40	407	5.62	3.82	0.02	0.00	14	hyposulfidic (S_{CR}<0.10%)
MRK2.2	5 - 20	Fine	-	5.49	2.50	4.50	529	4.80	27.05	0.02	0.00	42	hyposulfidic (S_{CR}<0.10%)
MRK2.3	20 - 60	Fine	-	6.07	3.37	4.50	226	5.76	8.14	0.03	0.00	25	hyposulfidic (S_{CR}<0.10%)
MRK2.4	60 - 120	Fine	-	7.52	1.55	2.50	2199	5.81	6.71	1.08	0.00	678	hypersulfidic

11 TOBALONG WETLAND (WETLAND ID. 12011)

11.1 LOCATION AND SETTING DESCRIPTION

Tobalong Wetland (Wetland ID. 12011) is situated on the southern side of the River Murray, down river from the town of Murray Bridge. The wetland is geomorphically categorised as a Murray Gorge basin (Pressey 1986) and is rectangular in shape, with a total surface area of 20 hectares. It is bounded to the north by a levee bank and to the south by a slope that separates it from farmed land on the highlands above. There are multiple connections with the river, via leaks in the levee, excavated channel and open area of riverbank. At the time when the soil survey was conducted in September 2008 the wetland had no surface water. There was very thick and tall *Phragmites australis* (Common Reed) vegetation growing throughout the wetland. One site was described and sampled and the location is shown in Figure 11-1.

Figure 11-1. Tobalong Wetland and sample site locations.

11.2 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 11-1. The site was located at the eastern end of the wetland, additional sites would be required to better characterise this wetland, but difficult access through dense vegetation meant that this was not possible because of time restrictions during this survey. The site and soil profile descriptions are presented in Table 11-2 and Table 11-3.

Site TOB1 (Figure 11-2) occurred in thick reeds that occurred throughout this area of the wetland. The soil consisted of brown peaty, friable, clay, over a grey brown, very firm, clay.

Table 11-1. Soil identification, subtype and general location description of sites for Tobalong Wetland.

Site ID	Easting m Zone 54H	Northing m Zone 54H	Acid sulfate soil subtype class	General location description
TOB1	349828	6104067	Other acidic soil	Mid elevation, amongst very thick and tall *Phragmites australis* (Common Reed) vegetation

Figure 11-2. Photographs of site TOB1, showing the site location with thick reeds growing.

11.3 LABORATORY DATA ASSESSMENT

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

The pH data are provided in Table 11-4 and pH profiles are presented in Figure 11-3.

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 the surface layer of profile TOB1 identified a sample that was below the critical value of pH_{OX} <2.5, the threshold value normally used to indicate a high likelihood of sulfuric material forming.

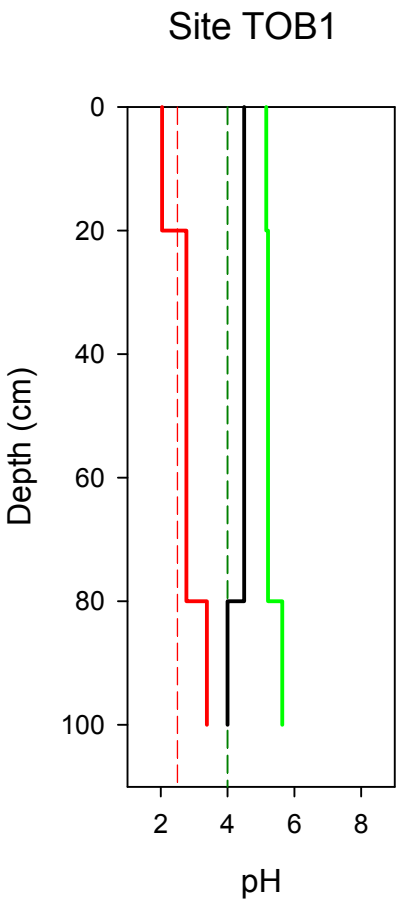

Figure 11-3. Depth profiles of soil pH for Tobalong Wetland, showing soil pH (pH_W as green line), peroxide treated pH (pH_{OX} as red line) and ageing pH (pH_{INC} after 28 weeks as black line). Critical pH_W and pH_{INC} value of 4 (black dashed line) and critical pH_{OX} value of 2.5 (red dashed line).

Acid Base Accounting

The acid base accounting data are provided in Table 11-4 and summarised in Figure 11-4.

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

Titratable actual acidity ranged from 16.39 to 49.11 mole H^+/tonne.

Retained acidity was not measured in any of the samples, as all samples had a pH_{KCl} of greater than 4.5.

Acid neutralising capacity was not measured in any of the samples, as all samples had a pH_{KCl} of <6.5.

Net acidity values ranged from 16 to 49 mole H^+/tonne. The upper layers had moderate net acidity values and the deeper subsoil layer was a low value.

Water Soluble Sulfate

Water soluble sulfate data values shown in Table 11-4 identified that surface layers were above the critical trigger value of 100 mg/kg SO_4.

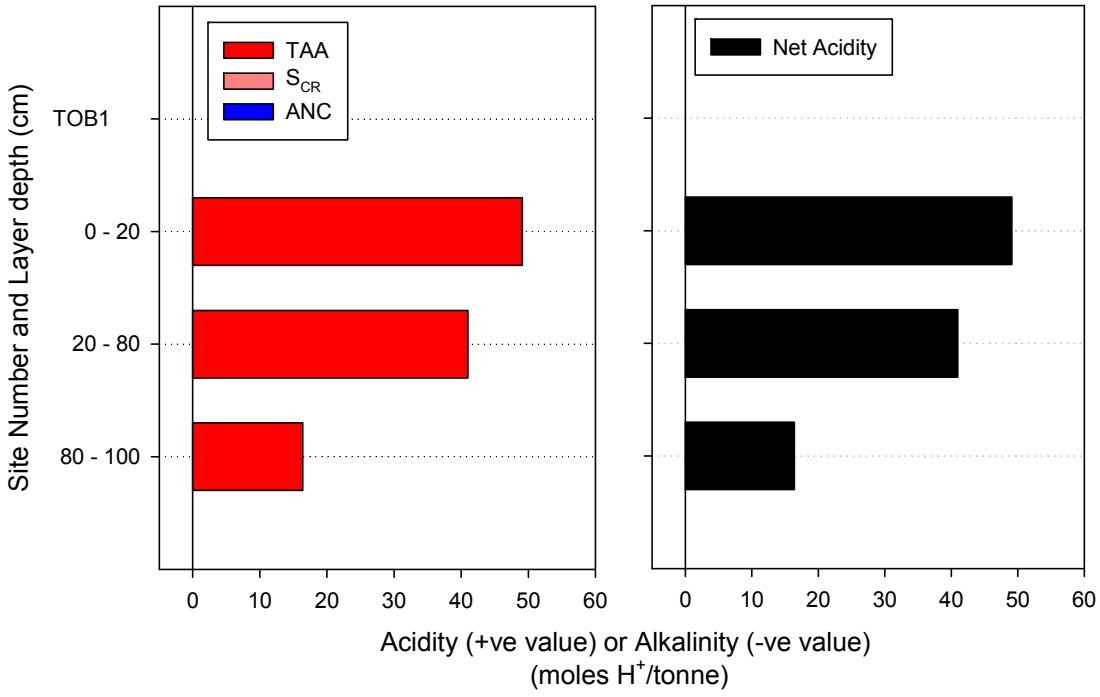

Figure 11-4. Acid base accounting depth profiles for Tobalong Wetland. Left side shows the components: titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} - pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.

11.4 DISCUSSION

Acid sulfate soil materials at Tobalong Wetland were not identified, and all layers were characterised as other acidic soil materials. The acid sulfate soil subtype class identified was Other Acidic Soil (clayey).

The soils throughout the wetland were generally very firm and clay textured.

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

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

- Acidification hazard: The data identified moderate or low net acidity values throughout the profile, and pH_{OX} data identified the surface layer with a value that was a potential acidification hazard due to oxidation. There is a medium level of concern.
- De-oxygenation hazard: The water soluble sulfate data indicated that there was potential for monosulfidic materials to form in the surface layers of soils on re-flooding, although the wetland was dry at the time of sampling and 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 Tobalong Wetland:

Soil materials:	Acid sulfate soil materials were not identified. The soils throughout were generally clay textured layers. Samples had moderate or low net acidity values and pH_{OX} data identified the surface layer with a value that indicated potential acidification due to oxidation.
Acid sulfate soil identification:	• Other acidic soil (clayey) – that occurred throughout the wetland. Dominant (>50%).
Hazard assessment:	• Acidification hazard – medium of concern • De-oxygenation hazard – medium level of concern • Metal mobilisation hazard – medium level of concern

Table 11-2. Site data for Tobalong 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
TOB1	02-Sep-08	349828	6104067	Other acidic soil	Not reached	plant material	*Phragmites australis* (Common Reed)	Mid elevation, amongst very thick and tall reed vegetation

Table 11-3. Soil description data for Tobalong 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
TOB1.1	0	20	push tube	7.5YR 3/2	peat	moist	0			granular	very friable	many plant roots
TOB1.2	20	80	push tube	10YR 2/1	clay	moist	5	5YR 6/8	in matrix along ped faces	subangular blocky	very firm	
TOB1.3	80	100	push tube	10YR 2/1	clay	moist	0			massive	very firm	

Table 11-4. Laboratory data for acid sulfate soil assessment of Tobalong 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
TOB1.1	0 - 20	fine	-	5.16	2.04	4.50	147	4.51	49.11	< 0.01	-	49	other acidic incubation
TOB1.2	20 - 80	fine	-	5.21	2.77	4.50	230	4.51	40.99	< 0.01	-	41	other acidic incubation
TOB1.3	80 - 100	fine	-	5.64	3.38	4.00	113	5.13	16.39	< 0.01	-	16	other acidic incubation

12 SWANPORT WETLAND (WETLAND ID. 12706)

12.1 BACKGROUND

Swanport Wetland is situated immediately down river from the Swanport Bridge near the town of Murray Bridge on the northern side of the River Murray. The wetland follows the curve of the river and is approximately 700 metres long, 300 metres at the widest point, and with a total surface area of 13 hectares. The wetland consists of one lagoon bisected by an old causeway, and is bounded to the east by a large sand hill and to the south and east it is separated from the river by a levee bank. There are two connections with the river at the northern end and one at the south-eastern end of the wetland. The wetland occurs on crown reserve and is a popular place for outdoor education and recreational activities.

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 two reports: i) '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) and ii) 'Acid Sulfate Soil Investigations of Vertical and Lateral Changes with Time in five Managed Wetlands Between Lock 1 and Wellington' (Fitzpatrick, Shand, Thomas, Grealish, McClure, Merry and Baker. CSIRO Land and Water Science Report 03/10). Readers are referred to these reports for detailed information, and here a summary of the findings are presented.

At the time of field sampling the wetland was dry. Six sites were sampled (WL1, WL2, WL5, SPM1, SPM2 and SPM3) and their locations are shown in Figure 12-1.

Figure 12-1. Swanport Wetland and sample site locations.

12.2 DISCUSSION

Acid sulfate soil materials at Swanport Wetland were identified as sulfuric that occurred in the surface and subsurface layers throughout the wetland where the soil material was above the water table, and hypersulfidic or hyposulfidic in the subsoil layers below the water table and in upper layers where the soil was below surface water (subaqueous).

The soil textures throughout the wetland were clays, with soil cracks that extend from the surface down into the upper subsoil. In some areas these cracks had been filled with aggregates from the break down of the surface soil material.

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

- Acidification hazard: Sulfuric, hypersulfidic and hyposulfidic soil materials occur throughout the wetland, the clay soils have deep cracks that extend into the subsoil clays and observations indicate that water in these cracks were acidic. There is a 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, 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 high level of concern.

Summary of key findings for Swanport Wetland:

Soil materials:	The soils were clays with deep cracks into the subsoil. The surface and subsurface layers throughout the wetland were sulfuric and the subsoil layers were hypersulfidic and hyposulfidic.
Acid sulfate soil identification:	• Sulfuric Cracking Clay Soils – occurring throughout the wetland. Dominant (>50%) in extent. • Subaqueous Hypersulfidic Soils (clayey) – occurring on the wetland margins adjacent to the river. Isolated (<10%) in extent. • Hypersulfidic Cracking Clay Soils – occurring on the wetland margins. 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

13 UKEE BOAT CLUB WETLAND (WETLAND ID. 12707)

13.1 BACKGROUND

Ukee Boat Club Wetland is situated up-river from the town of Murray Bridge on the north-eastern side of the River Murray. The wetland is approximately 450 metres long, and 100 metres at the widest point. It is a remnant of a much larger wetland that included land to the west now used for agriculture. It is maintained behind a man-made levee, with a single connection to the river channel, forming a complex of small lagoons connected by channels within the wetland.

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, three sites were sampled in the wetland (UKE3, UKE5, and UKE6) and three sites (UKE1, UKE2 and UKE4) were located in the river channel, and their locations are shown in Figure 13-1.

Figure 13-1. Ukee Boat Club Wetland and sample site locations.

13.2 DISCUSSION

Acid sulfate soil materials at Ukee Boat Club Wetland were identified as sulfuric that occurred in the surface and subsurface layers throughout the wetland where the soil material was above the water table, and hypersulfidic or hyposulfidic in the subsoil layers below the water table and in upper layers where the soil was below surface water (subaqueous).

The soils throughout the wetland were clays with soil cracks extending down 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 Ukee Boat Club Wetland are:

- Acidification hazard: Sulfuric, hypersulfidic and hyposulfidic soil materials occur throughout the wetland, the clay soils have deep cracks that extend into the subsoil clays. There is a 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 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 Ukee Boat Club Wetland:

Soil materials:	The soils were clays with deep cracks extending into the subsoil. The surface and subsurface layers throughout the wetland above the water table were sulfuric. Below the water table in the subsoil layers the soils were hypersulfidic and hyposulfidic and throughout the soil profile in areas where water was above the soil surface.
Acid sulfate soil identification:	• Sulfuric Cracking Clay Soils – occurring throughout the wetland. Dominant (>50%) in extent. • Subaqueous Hypersulfidic Soils (clayey) – occurring on the wetland margins adjacent to the river. 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

14 MOBILONG SWAMP (ROCKY GULLY) WETLAND (WETLAND ID. 12708)

14.1 LOCATION AND SETTING DESCRIPTION

Mobilong Swamp (Rocky Gully) Wetland (Wetland ID. 12708) is situated on the western side of the River Murray, up river and adjacent to the town of Murray Bridge. The wetland is geomorphically categorised as a Murray Gorge basin (Pressey 1986) and is irregular in shape, with a total surface area of 28 hectares. The wetland is situated away from the river beyond farmland behind a levee bank along the river. There was an up-stream water connection channel and a major outlet channel to the river. The wetland receives surface water from stormwater in the surrounding area that includes dairy farms, an abattoir, and residential housing. Water is held in the wetland by a structure in the outlet channel and water can become extremely saline during the summer months. Additionally nutrients from run off may also deteriorate water quality. At the time when the soil survey was conducted in October 2008, the wetland had surface water in the centre and along the channels. On the wetland margins at a slightly higher elevation *Typha latifolia* (Bulrush) and *Phragmites australis* (Common Reed) were growing. Three sites were described and sampled and their locations are shown in Figure 14-1.

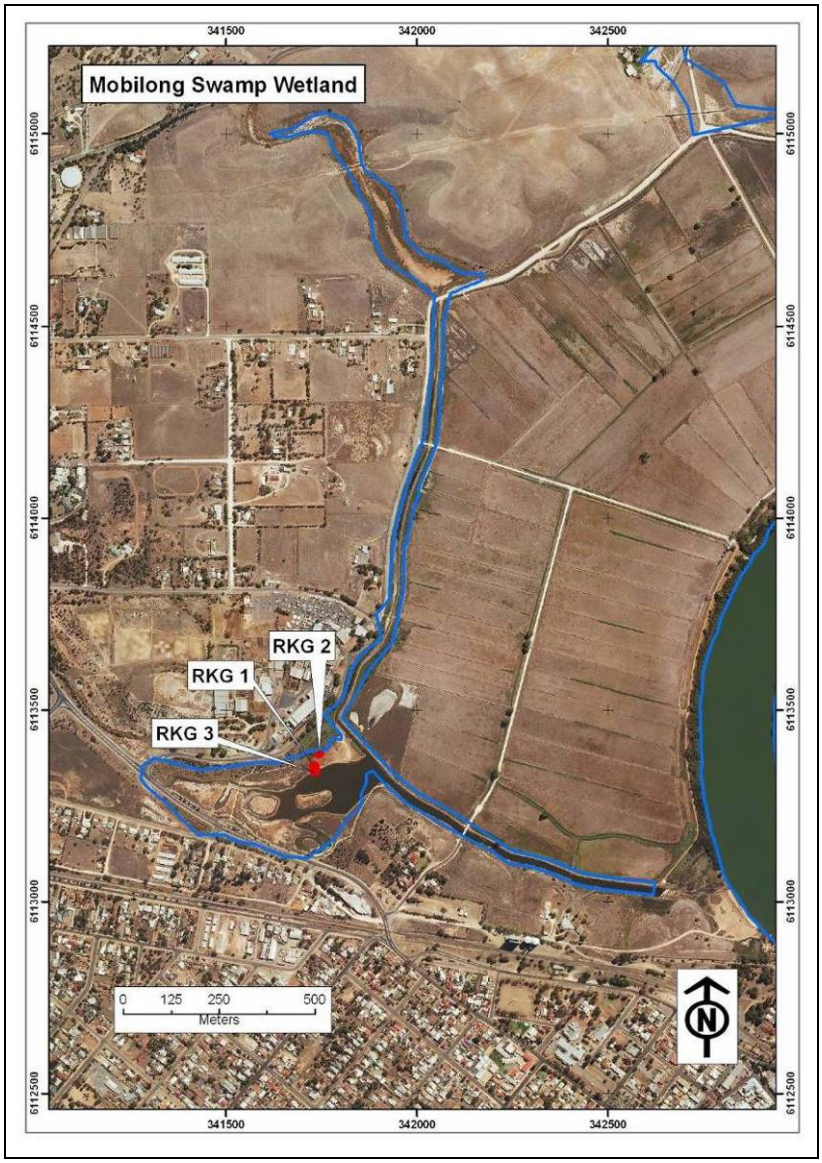

Figure 14-1. Mobilong Swamp (Rocky Gully) Wetland and sample site locations.

14.2 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 14-1. Sites were located along one transect, from the wetland margin (RKG2) to the water edge (RKG1) and in the surface water area (RKG3). Site and soil profile descriptions are presented in Table 14-2 and Table 14-3.

Site RKG1 (Figure 14-2) occurred 3 metres from the waters edge where Samphire (*Sarcocornia globosa)* was growing. The soil consisted of brown, clay, over a black, soft, peaty clay.

Site RKG2 (Figure 14-3) occurred in the higher elevation wetland margin where reeds were growing. The soil consisted of a red-brown, blocky, clay, over a black, firm, clay.

Site RKG3 (Figure 14-4) occurred in the water area of the wetland approximately 4 metres from the waters edge. The soil consisted of a thin, black, very soft, peaty clay monosulfidic material, over a dark grey soft sandy clay, over a black, firm, clay.

Table 14-1. Soil identification, subtype and general location description for Mobilong Swamp - Rocky Gully Wetland.

Site ID	Easting m Zone 54H	Northing m Zone 54H	Acid sulfate soil subtype class	General location description
RKG1	341732	6113351	Hyposulfidic soil	Low elevation, 3m from water edge
RKG2	341744	6113386	Hyposulfidic soil	High elevation, adjacent to reed vegetation
RKG3	341734	6113340	Subaqueous hyposulfidic soil	Low elevation, 4m from edge of water

Figure 14-2: Photographs of site RKG1, showing site location above the surface water level where *Sarcocornia globosa* (Samphire) vegetation was growing and a sealed clay surface, and the soil profile of clay.

Figure 14-3. Photographs of site RKG2, showing the site landscape adjacent to reeds growing on the wetland margin.

Figure 14-4. Photographs of site RKG3, showing the site location (marked by the person) in shallow surface water, and the soil profile of the upper layers of black monosulfidic material over sandy clay.

14.3 LABORATORY DATA ASSESSMENT

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

The pH data are provided in Table 14-4 and pH profiles are presented in Figure 14-5.

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.

Acid Base Accounting

The acid base accounting data are provided in Table 14-4 and summarised in Figure 14-6.

Chromium reducible sulfur values ranged from below the detection limit to 0.56%S_{CR}. Sulfidic materials were detected in all subsoil layers.

Titratable actual acidity was not detected in samples analysed.

Retained acidity was not measured in any of the samples, as all samples had a pH_{KCl} of greater than 4.5.

Acid neutralising capacity ranged from 2.06 to 9.92 %$CaCO_3$, and was measured in all sampled layers.

Net acidity values ranged from -1321 to -171 mole H^+/tonne. All samples had negative net acidity values.

Water Soluble Sulfate

Water soluble sulfate data values shown in Table 14-4 identified that surface layers in all profiles were above the critical trigger value of 100 mg/kg SO_4.

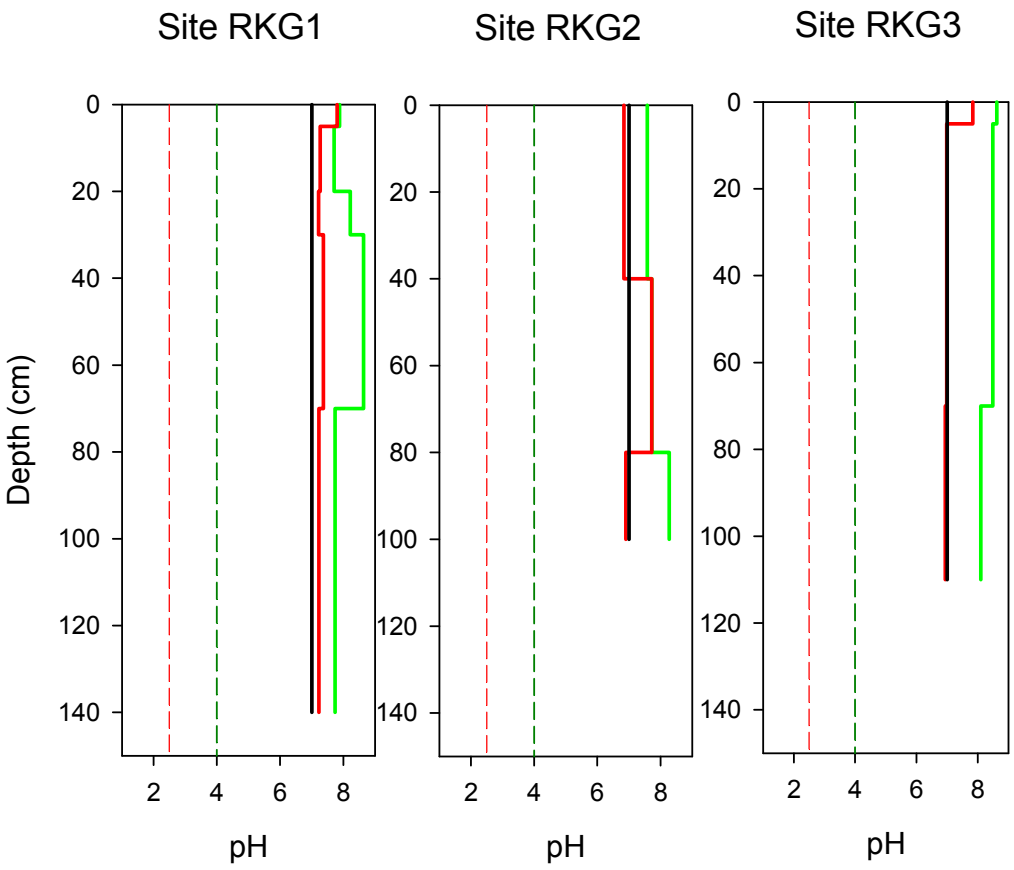

Figure 14-5. Depth profiles of soil pH for Mobilong Swamp - Rocky Gully Wetland, showing soil pH (pH_W as green line), peroxide treated pH (pH_{OX} as red line) and ageing pH (pH_{INC} after 28 weeks as black line). Critical pH_W and pH_{INC} value of 4 (black dashed line) and critical pH_{OX} value of 2.5 (red dashed line).

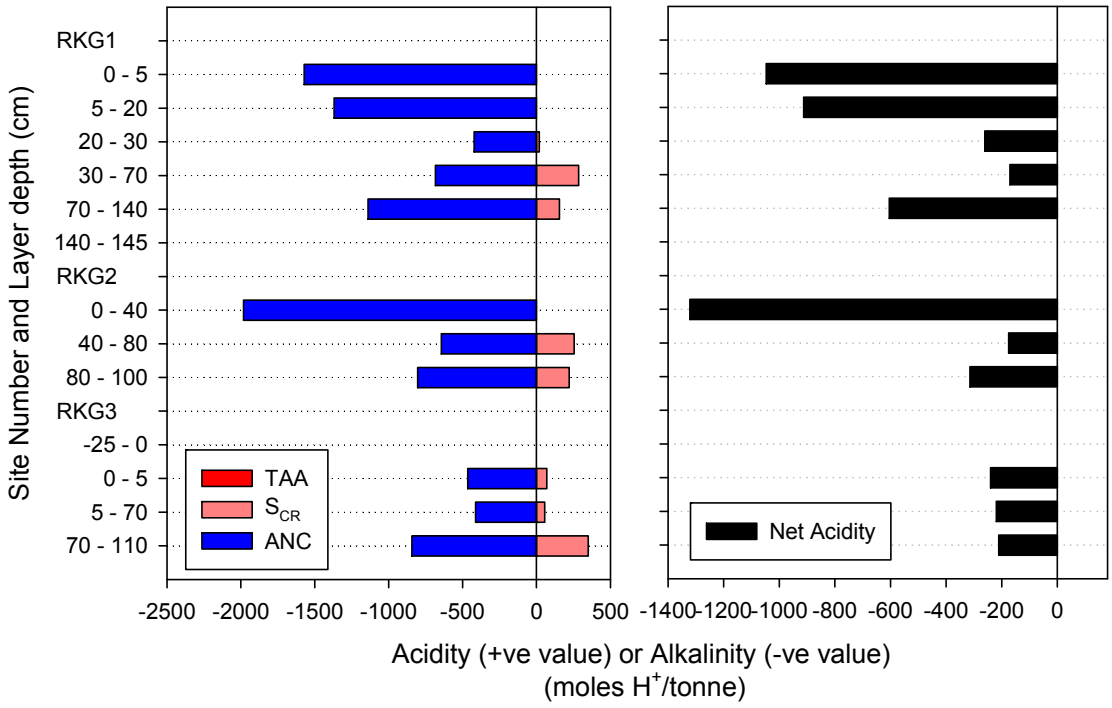

Figure 14-6. Acid base accounting depth profiles for Mobilong Swamp - Rocky Gully Wetland. Left side shows the components: titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} - pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.

14.4 DISCUSSION

Acid sulfate soil materials at Mobilong Swamp Wetland were identified as hyposulfidic and some surface samples were characterised as other soil materials. The acid sulfate soil subtype class identified was Hyposulfidic Soil (clayey).

The soils throughout the wetland were generally firm and clayey textured surface layers over soft peaty clays in the subsoil.

Monosulfidic material was observed in the channel areas of the wetland but not sampled and 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 Mobilong Swamp Wetland are:

- Acidification hazard: The data identified negative net acidity values throughout all of the profile, and pH data did not identify samples with values that were potential acidification hazard due to oxidation. There is a low level of concern.
- De-oxygenation hazard: The water soluble sulfate data indicated that there was potential for monosulfidic materials to form in the surface layers of soils, although monosulfidic material was observed. There is a high 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 Mobilong Swamp - Rocky Gully Wetland:

Soil materials:	Hyposulfidic soil materials were identified in some surface layers. The soils throughout were generally clay textured layers at the surface and soft peaty clays in the subsoil. Samples had negative net acidity values and pH data did not identify samples with values that indicated potential acidification due to oxidation.
Acid sulfate soil identification:	• Hyposulfidic Soil – that occurred throughout the wetland. Dominant (>50%) in extent.
Hazard assessment	• Acidification hazard – low level of concern • De-oxygenation hazard – high level of concern • Metal mobilisation hazard – low level of concern

Table 14-2. Site data for Mobilong Swamp - Rocky Gully 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
RKG1	09-Oct-08	341732	6113351	Hyposulfidic soil	40	sealed, soft	*Sarcocornia globosa* (Samphire)	Low elevation, 3m from water edge
RKG2	09-Oct-08	341744	6113386	Hyposulfidic soil	50	plant material	*Phragmites australis* (Common Reed)	High elevation, adjacent to reed vegetation
RKG3	09-Oct-08	341734	6113340	Subaqueous hyposulfidic soil	-25	water	Water	Low elevation, 4m from edge of water

Table 14-3. Soil description data for Mobilong Swamp - Rocky Gully 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
RKG1.1	0	5	soil pit	5YR 3/3	clay	moist	0			platy	firm	
RKG1.2	5	20	soil pit	5YR 3/3	clay	moist	0			subangular blocky	firm	
RKG1.3	20	30	soil pit	10YR 3/2	clay	moist	0			massive	firm	
RKG1.4	30	70	soil pit	10YR 3/1	peaty clay	wet	0			massive	soft	
RKG1.5	70	140	push tube	10YR 3/1	peaty clay	wet	0			massive	soft	
RKG1.6	140	145	push tube	10YR 2/1	peat	wet	0			massive	very soft	
RKG2.1	0	40	soil pit	7.5YR 3/2	clay	moist	0			subangular blocky	firm	
RKG2.2	40	80	soil pit	10YR 3/1	sandy clay loam	wet	0			massive	soft	
RKG2.3	80	100	push tube	10YR 3/1	peaty clay	wet	0			massive	firm	
RKG3.0	-25	0	water		water	wet	0					
RKG3.1	0	5	push tube	10YR 4/2	peaty clay	wet	0			massive	very soft	
RKG3.2	5	70	push tube	10YR 3/2	sandy clay loam	wet	0			massive	soft	
RKG3.3	70	110	push tube	10YR 2/2	clay	wet	0			massive	firm	

Table 14-4. Laboratory data for acid sulfate soil assessment of Mobilong Swamp - Rocky Gully 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
RKG1.1	0 - 5	fine	20,480	7.88	7.80	7.00	1690	9.11	0.00	< 0.01	7.86	-1047	other soil material
RKG1.2	5 - 20	fine	14,880	7.71	7.27	7.00	667	8.95	0.00	< 0.01	6.85	-912	other soil material
RKG1.3	20 - 30	fine	5,730	8.22	7.22	7.00	164	8.93	0.00	0.03	2.11	-261	hyposulfidic (S_{CR}<0.10%)
RKG1.4	30 - 70	fine	4,090	8.64	7.37	7.00	500	8.94	0.00	0.46	3.43	-171	hyposulfidic (S_{CR}≥0.10%)
RKG1.5	70 - 140	fine	7,860	7.74	7.23	7.00	1548	8.80	0.00	0.25	5.70	-604	hyposulfidic (S_{CR}≥0.10%)
RKG1.6	140 - 145	fine	-	-	-	-	-	-	-	-	-	-	-
RKG2.1	0 - 40	fine	4,240	7.58	6.84	7.00	230	8.95	0.00	< 0.01	9.92	-1321	other soil material
RKG2.2	40 - 80	medium	5,060	7.72	7.72	7.00	1889	8.66	0.00	0.41	3.22	-175	hyposulfidic (S_{CR}≥0.10%)
RKG2.3	80 - 100	fine	4,160	8.27	6.90	7.00	1808	8.45	0.00	0.36	4.03	-314	hyposulfidic (S_{CR}≥0.10%)
RKG3.0	-25 - 0	water	-	-	-	-	-	-	-	-	-	-	-
RKG3.1	0 - 5	fine	4,290	8.62	7.84	7.00	999	9.22	0.00	0.11	2.33	-240	hyposulfidic (S_{CR}≥0.10%)
RKG3.2	5 - 70	medium	5,250	8.49	6.99	7.00	995	8.94	0.00	0.09	2.06	-220	hyposulfidic (S_{CR}<0.10%)
RKG3.3	70 - 110	fine	9,540	8.10	6.94	7.00	3110	8.53	0.00	0.56	4.22	-211	hyposulfidic (S_{CR}≥0.10%)

15 RIVERGLADES WETLAND (WETLAND ID. 12119)

15.1 BACKGROUND

Riverglades Wetland (Wetland ID. 12119) is situated on the eastern side of the River Murray and north of the town of Murray Bridge. The majority of the wetland is situated within a residential development known as 'Riverglades' except for an area of council reserve and a caravan park at the up river end. The wetland and surrounds are used for recreational pursuits such as bushwalking and bird watching.

This wetland was studied in 2008 and 2009 as part of a separate monitoring investigation of acid sulfate soils, the work and data was presented in the report 'Acid Sulfate Soil Investigations of Vertical and Lateral Changes with Time in five Managed Wetlands Between Lock 1 and Wellington' (Fitzpatrick, Shand, Thomas, Grealish, McClure, Merry and Baker. CSIRO Land and Water Science Report 03/10). Readers are referred to this report for detailed information, and here a summary of the findings are presented.

The Riverglades wetland complex is geomorphically categorised as a Murray Gorge basin (Pressey 1986) and consists of two permanent wetlands referred to as North Lagoon and South Lagoon with a combined surface area of 44.6 ha. The North Lagoon is separated from the River Murray by a levee bank to the west and from the South Lagoon by a causeway. The North Lagoon has a narrow inlet / outlet to the northwith fish screens and control gates and two inlet / outlets to the south with fish screens and control gates. The wetland is long and narrow and shallow (< 1 m) for the majority of its surface area with several island habitats.

Three survey sites along one transect were located in the northern lagoon (Sites RIV 3, 4 and 5). The cross section spanned the deepest area of the wetland (RIV 3), mid (RIV4), and near the high water mark (RIV 5). The wetland and sample site locations are shown in Figure 15-1.

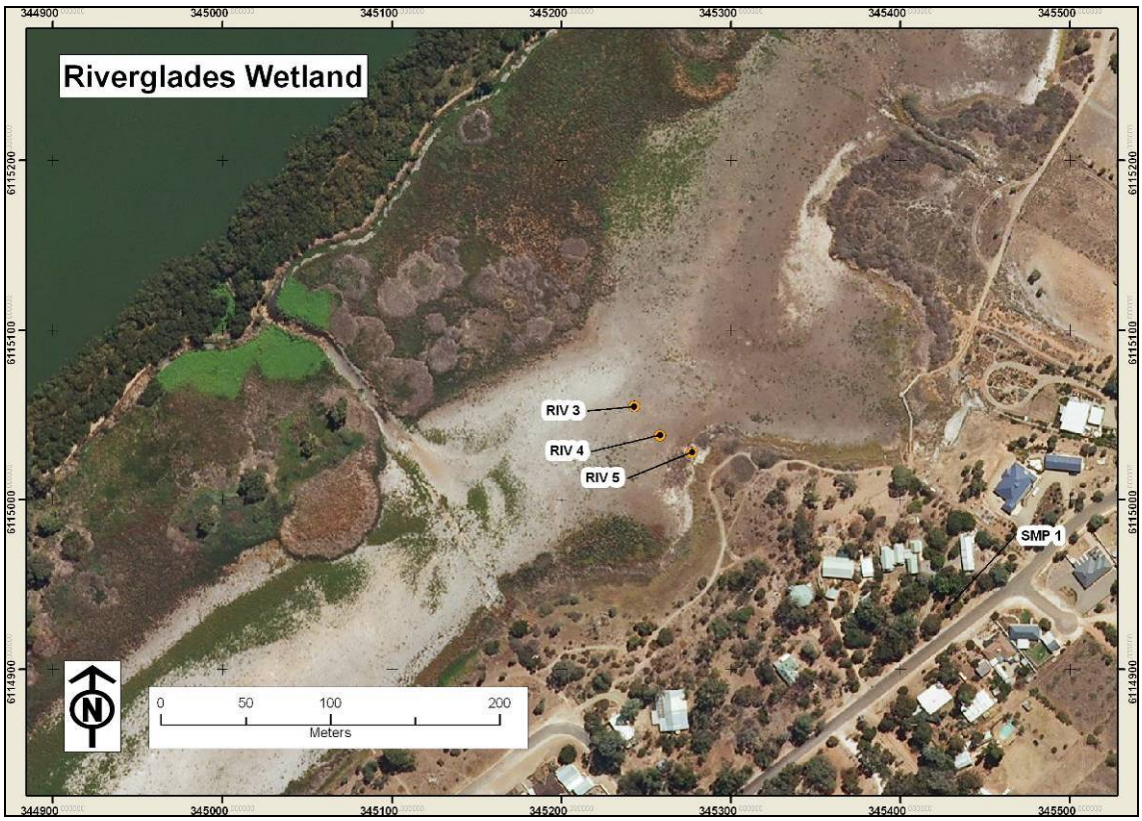

Figure 15-1. Riverglades wetland and site locations.

15.2 DISCUSSION

Acid sulfate soil materials at Riverglades Wetland were identified as hypersulfidic materials that occurred in the surface soil layers below surface water and in the subsoil layers throughout the wetland. Hyposulfidic soil materials were also identified in subsoil layers. Sulfuric material was observed in the field at isolated areas where the surface soil materials had dried near the river side of the wetland.

The soils throughout the wetland were dominantly clays that have cracking soil surfaces. On the margin areas adjacent to the hill slopes there were sandy surface layers and sand filled the soil cracks.

The potential hazards posed by acid sulfate soil materials at the Riverglades wetland are:

- Acidification hazard: Hypersulfidic and hyposulfidic materials occur throughout the main area of the wetland. Sulfuric material occurred in isolated areas. 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, and monosulfidic material was observed in the field. 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 Riverglades Wetland:

Soil materials:	The soils were dominantly clay textured, with sandy surface layers near the wetland margins. The surface soil layers throughout the wetland were hypersulfidic below the water and sulfuric where the soil was above the water level. The subsoil layers were mostly hypersulfidic or hyposulfidic.
Acid sulfate soil identification:	• Hypersulfidic Subaqueous Soils (clayey) – that occurred in areas below surface water. Dominant (>50%) in extent. • Sulfuric Cracking Clay Soils – that occurred in isolated areas on the river side of the wetland above the water. Isolated (<10%) in extent. • Cracking Clay Soils – that occurred on the margins. Minor (<25%) in extent.
Hazard assessment	• Acidification hazard – high level of concern • De-oxygenation hazard – high level of concern • Metal mobilisation hazard – high level of concern

16 JURY SWAMP WETLAND (WETLAND ID. 12710)

16.1 BACKGROUND

Jury Swamp Wetland is situated on the western side of the River Murray north of the town of Murray Bridge. The wetland is somewhat triangular in shape, approximately 600 metres in length, 300 metres at its widest, and with a total surface area of 6 hectares. It is bounded to the west by hills and a road, to the north by a bank with a track on it, and to the east it is separated from the river by a bank and willow trees.

This wetland was studied as part of a separate monitoring investigation of acid sulfate soils, the work and data was presented in the report 'Acid Sulfate Soil Investigations of Vertical and Lateral Changes with Time in five Managed Wetlands Between Lock 1 and Wellington' (Fitzpatrick, Shand, Thomas, Grealish, McClure, Merry and Baker. CSIRO Land and Water Science Report 03/10). Readers are referred to this report for detailed information, and here a summary of the findings are presented.

The wetland was dry at the time of sampling. Eight sites were sampled and their locations are shown in Figure 16-1.

Figure 16-1. Jury Swamp wetland and site locations.

16.2 DISCUSSION

Acid sulfate soil materials at Jury Swamp Wetland were identified as sulfuric within the surface layers of the low areas and hypersulfidic in the surface layers below surface water and in the subsoil layers throughout the wetland.

The soils throughout the wetland were dominantly clays that have cracking soil surfaces. On the margin areas adjacent to the hill slopes the cracks were filled with aggregates and sand.

The potential hazards posed by acid sulfate soil materials at the Jury Swamp wetland are:

- Acidification hazard: Sulfuric materials had formed and hypersulfidic materials occur throughout the main area of the wetland. There is a high level of concern.
- De-oxygenation hazard: Monosulfidic material was observed in the area near the inlet channel to the river and adjacent to where water is piped in. 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 Jury Swamp Wetland:

Soil materials:	The surface soil layers in the lower areas of the wetland were sulfuric, elsewhere and on the margins they were hypersulfidic. The subsoil layers throughout the wetland were hypersulfidic.
Acid sulfate soil identification:	• Sulfuric Cracking Clay – occurring in more than half of the wetland area. Dominant (>50%) in extent. • Sulfuric Organic Clay – occurring near hillside and dairy pasture side of the wetland. Minor (<25%) in extent. • Sulfuric Crack Clay with Monosulfidic material – occurring in lower elevated areas near the hillside side of the wetland. Minor (<25%) in extent. • Hypersulfidic Subaqueous Clay with Monosulfidic Material – occurring near the pump and inflow channel to the river. 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

17 TOORA LEVEE WETLAND (WETLAND ID. 12041)

17.1 LOCATION AND SETTING DESCRIPTION

Toora Levee Wetland (Wetland ID. 12041) is situated on the northern side of the River Murray, up-river from the town of Murray Bridge. The wetland is geomorphically categorised as a channel-margin swale (Pressey 1986) and is linear in shape, with a total surface area of approximately 3 hectares. The wetland is bounded to the north by a levee bank and to the south separated from the river by a raised bank with *Salix* Spp. (Willow trees) trees. There are a few water connection channels with the river through the raised bank. At the time when the soil survey was conducted in October 2008, the wetland was dry and there was no surface water. There is a mosaic of tall and dense *Phragmites australis* (Common Reed), *Typha latifolia* (Bulrush), and sedges throughout the main area of the wetland with trees on the raised bank/floodplain. Two sites were described and sampled and their locations are shown in Figure 17-1.

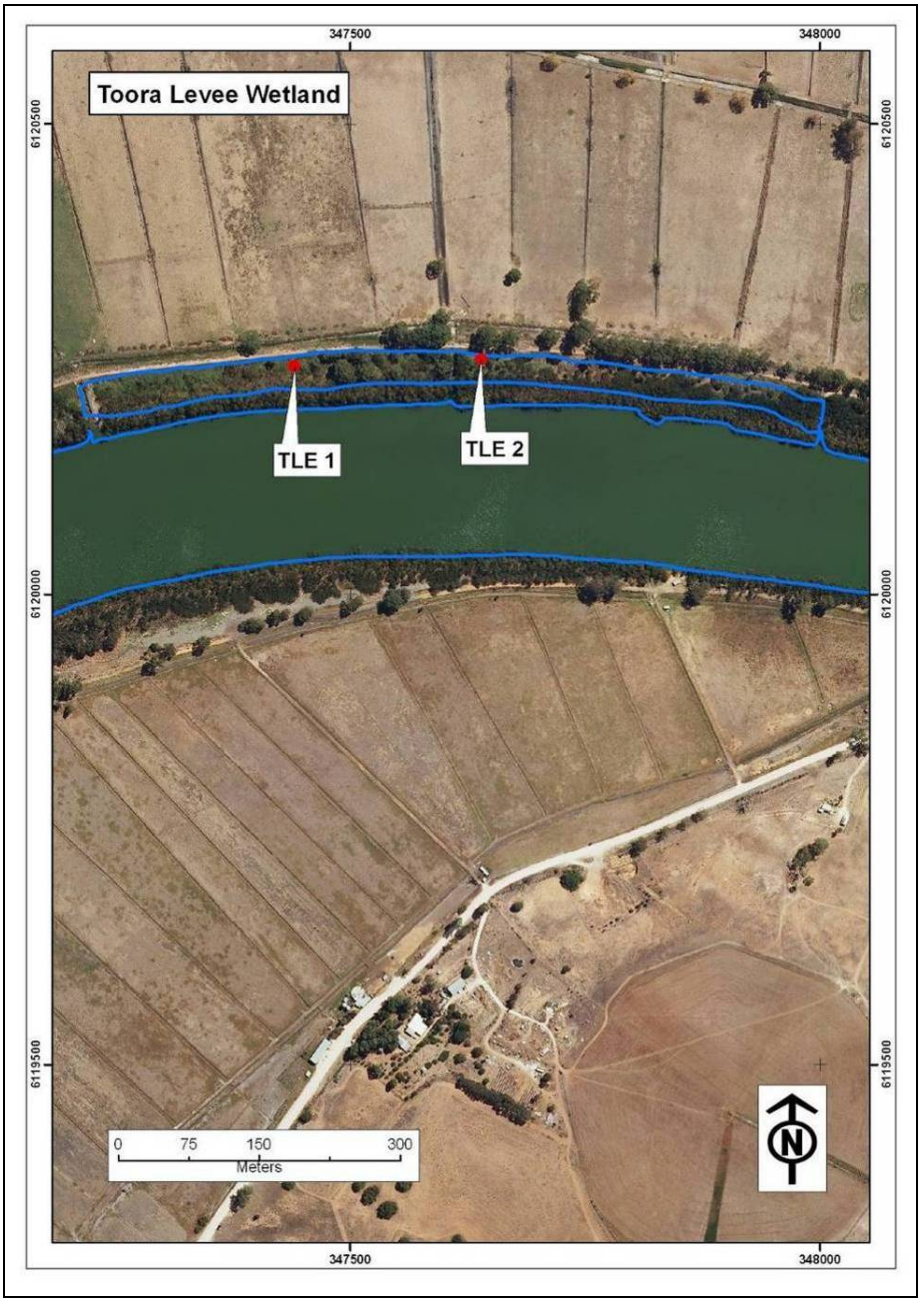

Figure 17-1. Toora Levee Wetland and sample site locations.

17.2 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 17-1. Sites were located to characterise a low elevation position (TLE1) and mid elevation position (TLE2). The site and soil profile descriptions are presented in Table 17-2 and Table 17-3.

Site TLE1 (Figure 17-2) occurred in the low elevation area of the wetland where tall and thick reeds and sedges were growing. The soil consisted of dark brown, clay, over a black, very hard, clay that was too difficult to dig.

Site TLE2 (Figure 17-3) occurred where there were reeds growing on slightly elevated areas. The soil consisted of a dark brown, clayey peat, over grey, very firm, clay.

Table 17-1. Soil identification, subtype and general location description for Toora Levee Wetland.

Site ID	Easting m Zone 54H	Northing m Zone 54H	Acid sulfate soil subtype class	General location description
TLE1	347441	6120242	Other soil	Low elevation, near centre of wetland
TLE2	347640	6120249	Other acidic soil	Mid elevation, near the wetland margin

Figure 17-2. Photograph of site TLE1, showing the site location (marked by the shovel handle) amongst tall and thick *Phragmites australis* (Common Reed) vegetation.

Figure 17-3. Photograph of site TLE2, showing the site location (marked by yellow shovel handle) amongst tall *Phragmites australis* (Common Reed) vegetation.

17.3 LABORATORY DATA ASSESSMENT

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

The pH data are provided in Table 17-4 and pH profiles are presented in Figure 17-4.

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 the surface and subsoil layers of profile TLE2 identified samples that were below the critical value of pH_{OX} <2.5, the threshold value normally used to indicate a high likelihood of sulfuric material forming.

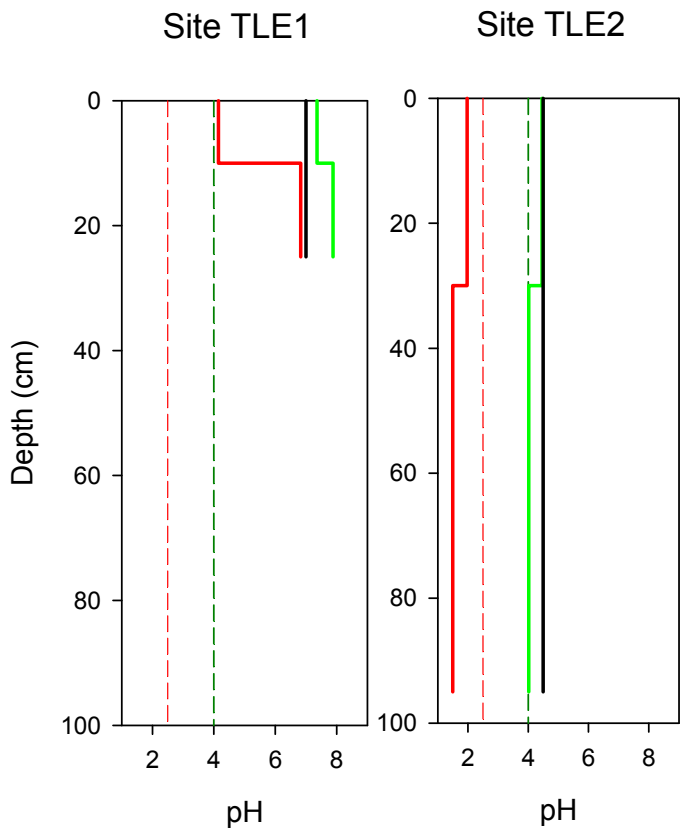

Figure 17-4. Depth profiles of soil pH for Toora Levee Wetland, showing soil pH (pH_W as green line), peroxide treated pH (pH_{OX} as red line) and ageing pH (pH_{INC} after 28 weeks as black line). Critical pH_W and pH_{INC} value of 4 (black dashed line) and critical pH_{OX} value of 2.5 (red dashed line).

Acid Base Accounting

The acid base accounting data are provided in Table 17-4 and summarised in Figure 17-5.

Chromium reducible sulfur values were below the limit of detection. Sulfidic materials were not detected in the profile samples.

Titratable actual acidity ranged from 0 to 119.75 mole H^+/tonne.

Analysis of retained acidity was not conducted on any of the samples, however retained acidity may be present in the subsoil layer of profile TLE2 that was below the critical value of pH_{KCl} <4.5.

Acid neutralising capacity values ranged from 0 to 23.51 %$CaCO_3$, and were measured in sampled layers from profile TLE1.

Net acidity values ranged from -3132 to 120 mole H^+/tonne. Profile TLE1 samples had negative net acidity values and profile TLE2 had moderate or high values.

Water Soluble Sulfate

Water soluble sulfate data values shown in Table 17-4 identified that surface layers in both profiles were above the critical trigger value of 100 mg/kg SO_4.

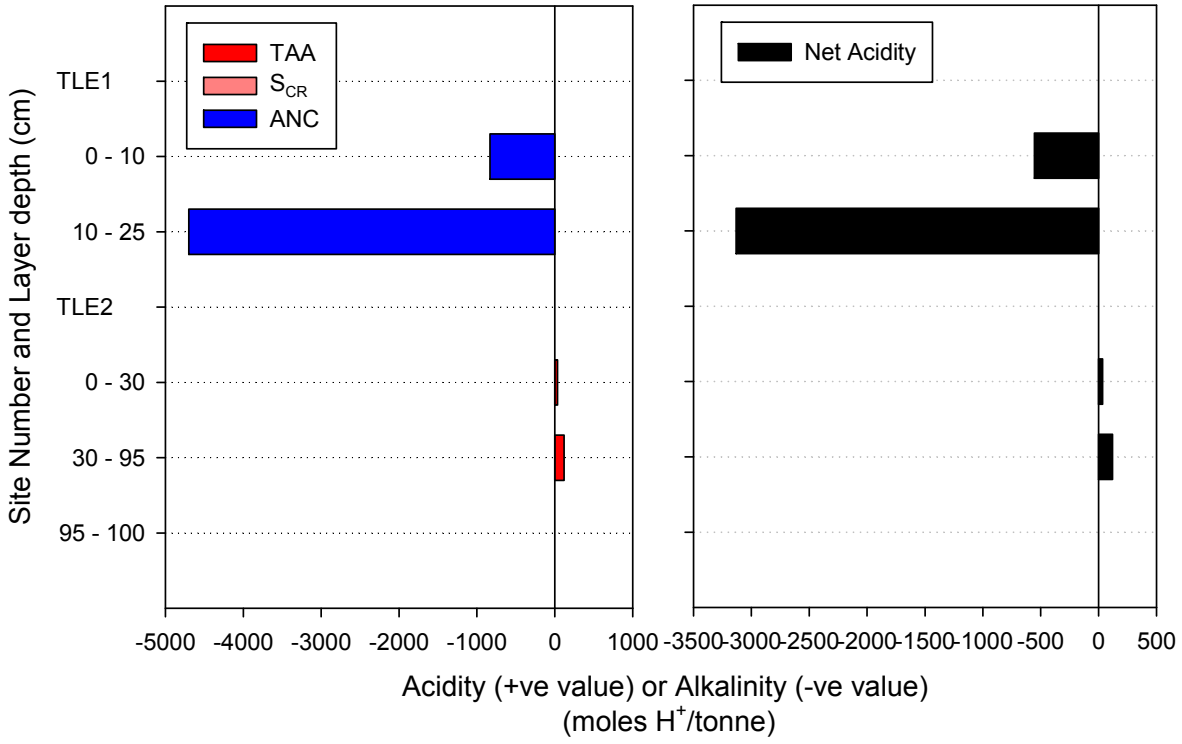

Figure 17-5. Acid base accounting depth profiles for Toora Levee Wetland. Left side shows the components: titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} - pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.

17.4 DISCUSSION

Acid sulfate soil materials at Toora Levee Wetland were not identified, and the soil layers were characterised as other acidic or other soil materials. The acid sulfate soil subtype class identified was Other Soil (clayey) and Other Acidic Soil (clayey).

The soils throughout the wetland were generally friable clays at the surface and very firm clays in the subsoil.

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 Toora Levee Wetland are:

- Acidification hazard: The data identified negative net acidity values in the lower elevation profile, and in the profile at mid elevation there were moderate or high sample values, and pH_{OX} data identified the subsoil samples with values that were potential acidification hazard due to oxidation. There is a medium level of concern.
- De-oxygenation hazard: The water soluble sulfate data indicated that there was potential for monosulfidic materials to form in the surface layers of soils on re-flooding, although the wetland was dry at the time of sampling and 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 Toora Levee Wetland:

Soil materials:	Acid sulfate soil materials were not identified. The soils throughout were generally clay textured layers. Samples in the lower elevation position of the wetland had negative net acidity values and for the mid elevation profile the samples were moderate or high net acidity values, pH_{OX} data identified samples in the mid elevation position with values that indicated potential acidification due to oxidation.
Acid sulfate soil identification:	• Other Soil (clayey) – that occurred throughout the lower elevation areas of the wetland. Dominant (>50%) in extent. • Other Acidic Soil (clayey) – that occurred on the elevation 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 17-2. Site data for Toora Levee 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
TLE1	10-Oct-08	347441	6120242	Other soil	Not reached	plant material	*Phragmites australis* (Common Reed)	Low elevation, near centre of wetland
TLE2	10-Oct-08	347640	6120249	Other acidic soil	70	plant material	*Phragmites australis* (Common Reed)	Mid elevation, near the wetland margin

Table 17-3. Soil description data for Toora Levee 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
TLE1.1	0	10	soil pit	10YR 3/1	clay	moist	0			subangular blocky	friable	
TLE1.2	10	25	soil pit	10YR 3/1	clay	moist	0			subangular blocky	very firm	too hard to dig below this layer
TLE2.1	0	30	soil pit	10YR 3/2	clayey peat	moist	0			granular	friable	
TLE2.2	30	95	soil pit	10YR 3/1	clay	moist	0			massive	very firm	
TLE2.3	95	100	push tube	10YR 4/1	sand	wet	0			massive	loose	

Table 17-4. Laboratory data for acid sulfate soil assessment of Toora Levee 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
TLE1.1	0 - 10	fine	290	7.36	4.15	7.00	271	7.73	0.00	< 0.01	4.16	-555	other soil material
TLE1.2	10 - 25	fine	300	7.88	6.83	7.00	135	8.24	0.00	< 0.01	23.51	-3132	other soil material
TLE2.1	0 - 30	fine	2,330	4.46	1.98	4.50	3247	4.51	35.12	< 0.01	-	35	other acidic
TLE2.2	30 - 95	fine	1,090	4.02	1.50	4.50	1506	4.03	119.75	< 0.01	-	120	other acidic
TLE2.3	95 - 100	coarse	-	-	-	-	-	-	-	-	-	-	-

18 SUNNYSIDE - SUNNYSIDE SWAMP (DOWNSTREAM) WETLAND (WETLAND ID. 12709)

18.1 LOCATION AND SETTING DESCRIPTION

Sunnyside - Sunnyside Swamp (Downstream) wetland (Wetland ID. 12709) is situated on the eastern side of the River Murray. The wetland is geomorphically categorised as a Murray Gorge basin (Pressey 1986) and is somewhat triangular in shape, with a total surface area of 28 hectares. The wetland is bounded to the east by a cliff slope, to the north by a bank that separates it from the Sunnyside – Paiwala Managed Wetland, and to the west it slopes gradually down to the river as there is no levee or river bank. The wetland is open to the river along almost the entire length of the wetland. At the time when the soil survey was conducted in October 2008, the wetland was dry and there was no surface water. A few willow trees were growing along the margin of the wetland with the river, on the cliff side of the wetland there were trees and areas with thick *Phragmites australis* (Common Reed), in the wetland area there was generally no vegetation except for isolated areas of *Sarcocornia globosa* (Samphire) and reeds. Five sites were described and sampled and their locations are shown in Figure 18-1.

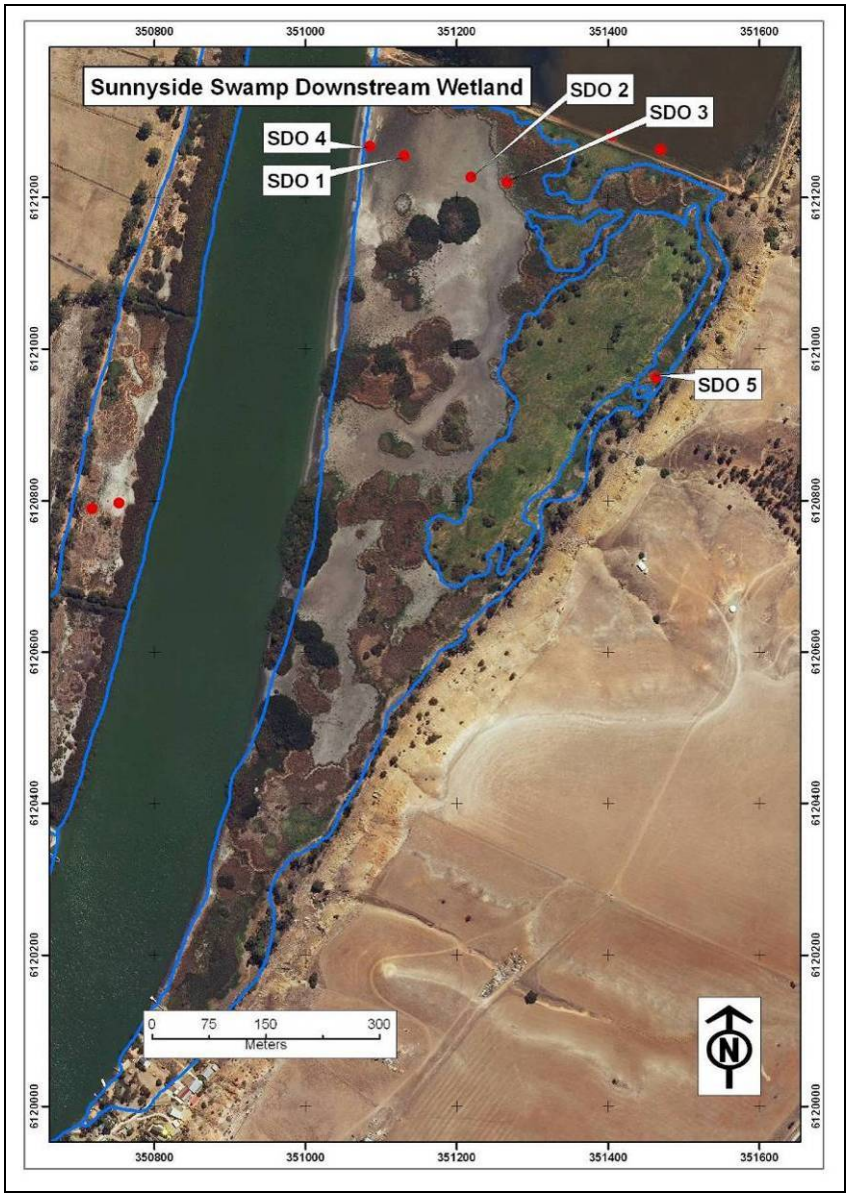

Figure 18-1. Sunnyside - Sunnyside Swamp (Downstream) Wetland and sample site locations.

18.2 SOIL PROFILE DESCRIPTION AND DISTRIBUTION

Five sites were described and sampled. The acid sulfate soil subtype class and general location description are presented in Table 18-1. Sites were located to form one transect from the river side of the wetland through to the cliff side. The site and soil profile descriptions are presented in Table 18-2 and Table 18-3.

Site SDO1 (Figure 18-2) occurred in an area that had no vegetation growing and a few mussel shells on the black crusted surface that possibly was dry monosulfidic material, and the soil consisted of black, firm, clay with orange mottles along root channels between 5 and 70 centimetres in depth, over an olive grey, soft, clay.

Site SDO2 (Figure 18-3) occurred where the surface was cracking. The soil consisted of black, firm, clay with orange mottles on ped surfaces and then along root channels, over an olive grey, soft, clay.

Site SDO3 (Figure 18-4) occurred near reed vegetation. The soil consisted of black, firm, clay.

Site SDO4 **(**no photograph available**)** occurred in the river where the water depth was approximately 15 centimetres deep. The soil consisted of grey, firm, clay, over an olive grey, firm, clay.

Site SDO5 (Figure 18-5) occurred on the cliff side of the wetland amongst thick reed vegetation. The soil consisted of red brown, friable, peaty clay, over a dark grey, firm, clay.

Table 18-1. Soil identification, subtype and general location description for Sunnyside - Sunnyside Swamp (Downstream) Wetland.

Site ID	Easting m Zone 54H	Northing m Zone 54H	Acid sulfate soil subtype class	General location description
SDO1	351131	6121255	Other acidic soil	Low elevation
SDO2	351219	6121227	Hyposulfidic cracking clay soil	Mid elevation
SDO3	351267	6121220	Sulfuric cracking clay soil	High elevation
SDO4	351085	6121268	Subaqueous hyposulfidic soil	Low elevation, in surface water of the river
SDO5	351464	6120962	Sulfuric soil	High elevation

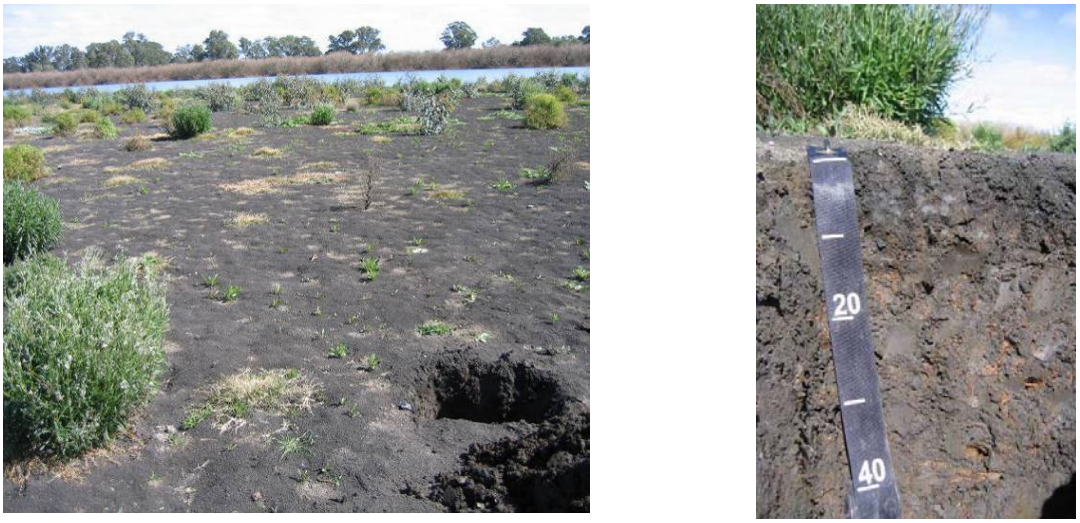

Figure 18-2. Photographs of site SDO1, showing the site location where the surface was black and friable, and the soil profile that was firm clay with bright orange mottles in root channels.

Figure 18-3. Photograph of site SDO2 showing the site landscape with large surface cracks, and the soil profile with firm, blocky structure with cracks in the soil.

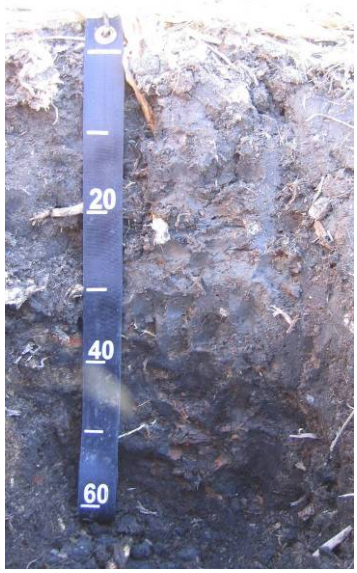

Figure 18-4. Photograph of site SDO3, showing the site landscape adjacent to *Phragmites australis* (Common Reed) vegetation, and the soil profile with firm clay.

Figure 18-5. Photograph of site SDO5, showing the site landscape (near where the person is standing) and the site location amongst tall thick *Phragmites australis* (Common Reed) vegetation.

18.3 LABORATORY DATA ASSESSMENT

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

The pH data are provided in Table 18-4 and pH profiles are presented in Figure 18-6.

The pH_W data for the surface layer of profile SDO3 and the subsoil layer of SDO5 identified samples that were sulfuric materials with a pH_W <4.

The pH_{INC} data for the subsoil layer of profile SDO5 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 material as a result of sulfide oxidation.

The pH_{OX} data for all layers of profile SDO3 and the deepest subsoil layers of profiles SDO4 and SDO5 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 are provided in Table 18-4 and summarised in Figure 19-7.

Chromium reducible sulfur values ranged from below the limit of detection to 0.85%S_{CR}. Sulfidic materials were detected in the surface layers of profiles SDO2 and SDO3 and the subsoil layers of profiles SDO4 and SDO5.

Titratable actual acidity ranged from 0 to 181.22 moles H^+/tonne.

Analysis of retained acidity was not conducted on any of the samples; however retained acidity may be present in the subsoil layer of profile SDO5 as the sample had a pH_{KCl} of greater than 4.5.

Acid neutralising capacity values ranged from 0 to 0.84 %$CaCO_3$, and were measured only in layers of profile SDO4 that occurred in the river bank area.

Net acidity values ranged from -102 to 619 mole H^+/tonne. Profile SDO4 had negative net acidity values in all layers and for the other four profiles the values were low, moderate or high.

Water Soluble Sulfate

Water soluble sulfate data values shown in Table 18-4 identified that surface layers in all profiles were above the critical trigger value of 100 mg/kg SO_4.

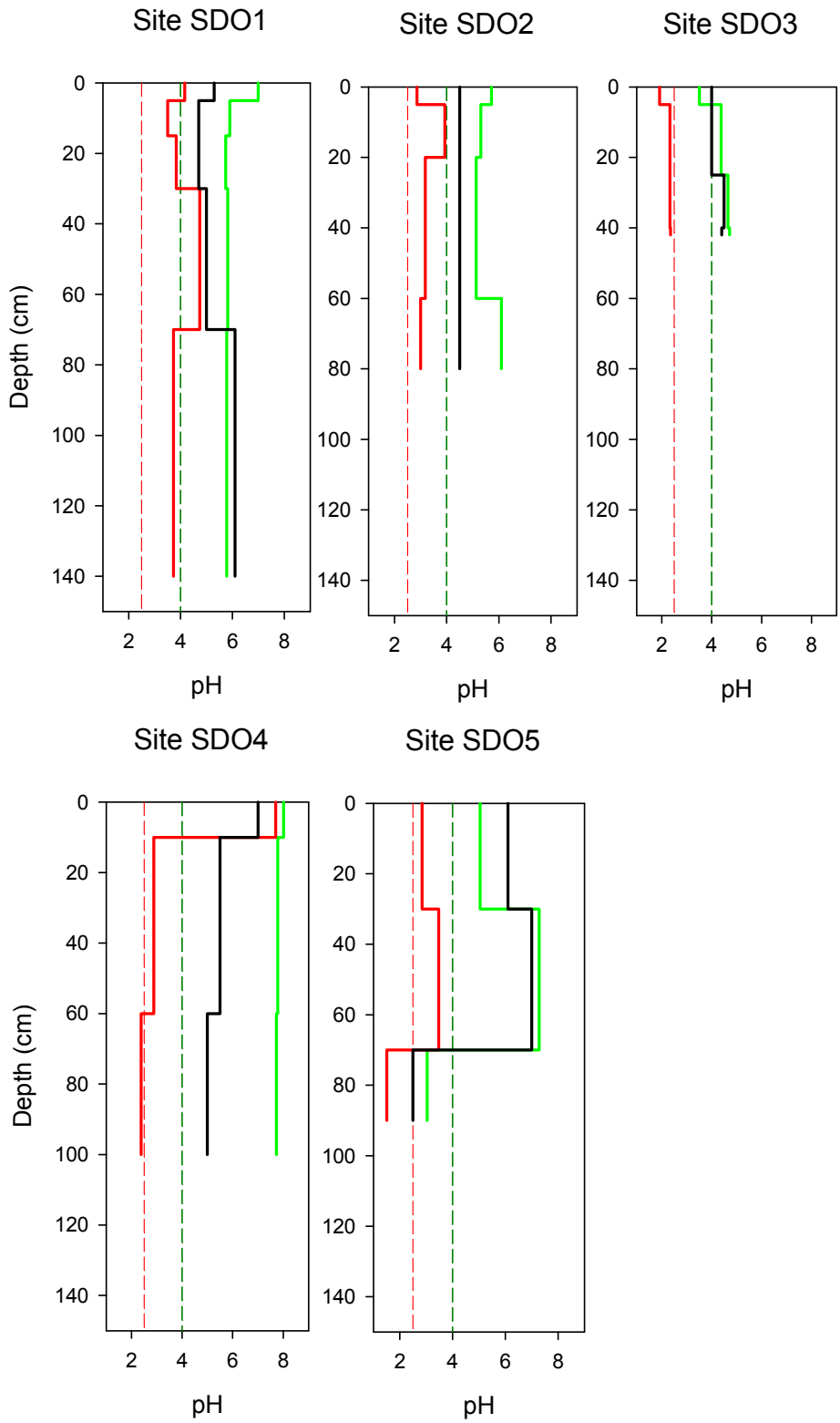

Figure 18-6. Depth profiles of soil pH for Sunnyside - Sunnyside Swamp (Downstream) Wetland, showing soil pH (pH_W as green line), peroxide treated pH (pH_{OX} as red line) and ageing pH (pH_{INC} after 28 weeks as black line). Critical pH_W and pH_{INC} value of 4 (black dashed line) and critical pH_{OX} value of 2.5 (red dashed line).

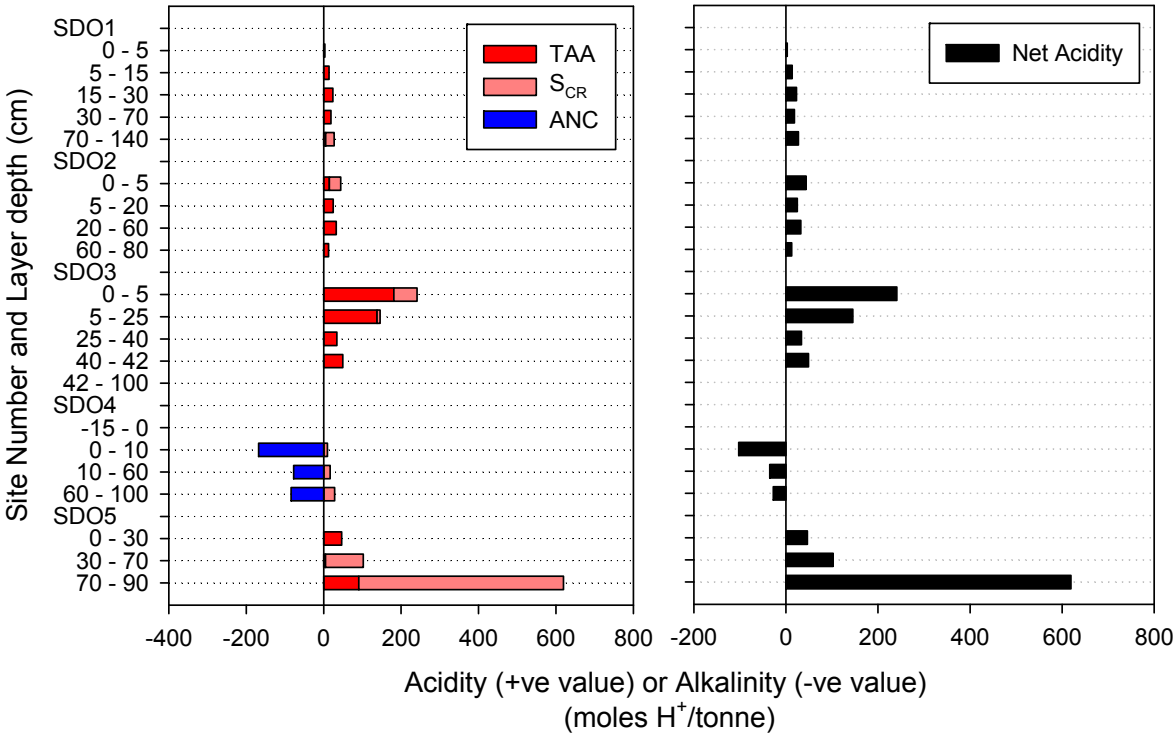

Figure 18-7. Acid base accounting depth profiles for Sunnyside - Sunnyside Swamp (Downstream) Wetland. Left side shows the components: titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} - pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.

18.4 DISCUSSION

Acid sulfate soil materials at Sunnyside Swamp (Downstream) Wetland were identified as sulfuric in the surface layer of profile SDO3 and the deeper subsoil layer of profile SDO5, and hyposulfidic material in at least one layer of each of the five profiles, and some layers were characterised as other acidic soil materials. The acid sulfate soil subtype classes identified were Sulfuric Soil, Sulfuric Cracking Clay Soil, Hyposulfidic Cracking Clay Soil, Subaqueous Hyposulfidic Soil, and Other Acidic Soil.

The soils throughout the wetland were generally firm and clay textured.

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 Sunnyside – Sunnyside Swamp (Downstream) Wetland are:

- Acidification hazard: The data identified negative net acidity values in samples from the profile in river water and low, moderate or high net acidity values throughout profiles in other locations, and pH data identified sample values that indicated potential acidification hazard due to oxidation. There is a high level of concern.
- De-oxygenation hazard: The water soluble sulfate data indicated that there was potential for monosulfidic materials to form in the surface layers of soils on re-flooding, although the wetland was dry at the time of sampling and 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 Sunnyside - Sunnyside Swamp (Downstream) Wetland:

Soil materials:	Sulfuric soil materials were identified in surface and deep subsoil layers, and hyposulfidic materials occurred in surface and subsoil layers. The soils throughout were generally clay textured layers. Sites in the main area of the wetland had samples with low, moderate or high net acidity values and pH data identified some samples with values that indicated potential acidification due to oxidation.
Acid sulfate soil identification:	• Sulfuric Cracking Clay Soil – that occurred at high elevation position in the wetland. Minor (<25%) in extent • Sulfuric Soil – that occurred at high elevation positions amongst reed vegetation near the cliff side of the wetland. Minor (<25%) in extent • Hyposulfidic Cracking Clay Soil – that occurred throughout the mid elevation positions of the wetland where the surface was cracking. Sub-dominant (<50%) in extent • Other Acidic Soil – that occurred through the main low elevation position of the wetland. Sub-dominant (<50%) in extent • Subaqueous Hyposulfidic Soil – that occurred on the river bank area. 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

Table 18-2. Site data for Sunnyside - Sunnyside Swamp (Downstream) 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
SDO1	27-Aug-08	351131	6121255	Other acidic soil	120	crust, crumbling	Bare	Low elevation
SDO2	27-Aug-08	351219	6121227	Hyposulfidic cracking clay soil	Not reached	cracking	Bare	Mid elevation
SDO3	27-Aug-08	351267	6121220	Sulfuric cracking clay soil	Not reached	cracking	Bare	High elevation
SDO4	27-Aug-08	351085	6121268	Subaqueous hyposulfidic soil	-15	water	Water	Low elevation, in surface water
SDO5	14-Oct-08	351464	6120962	Sulfuric soil	80	plant material	*Phragmites australis* (Common Reed)	High elevation

Table 18-3. Soil description data for Sunnyside - Sunnyside Swamp (Downstream) 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
SDO1.1	0	5	soil pit	10YR 2/1	clay	moist	0			platy	friable	
SDO1.2	5	15	soil pit	10YR 2/1	clay	moist	10	5YR 5/8	in matrix along ped faces	subangular blocky	firm	
SDO1.3	15	30	soil pit	10YR 2/1	clay	moist	20	5YR 5/8	in matrix adjacent to pores	subangular blocky	firm	
SDO1.4	30	70	soil pit	10YR 2/1	clay	moist	20	5YR 5/8	in matrix	subangular blocky	very firm	
SDO1.5	70	140	push tube	10YR 4/1	clay	moist	0			massive	firm	
SDO2.1	0	5	soil pit	10YR 4/1	clay loam	dry	2	2.5Y 7/1	on ped faces	subangular blocky	very firm	white salts on surface
SDO2.2	5	20	soil pit	10YR 2/1	clay	moist	10	7.5YR 5/8	in matrix	subangular blocky	firm	
SDO2.3	20	60	soil pit	10YR 2/1	clay	moist	25	7.5YR 5/8	in matrix	subangular blocky	firm	
SDO2.4	60	80	push tube	2.5Y 5/2	clay	moist	0			massive	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)	Comments
SDO3.1	0	5	soil pit	10YR 4/1	clay loam	dry	0			subangular blocky	firm	
SDO3.2	5	25	soil pit	10YR 2/1	clay	moist	0			subangular blocky	firm	
SDO3.3	25	40	soil pit	10YR 3/1	clay	moist	0			subangular blocky	very firm	
SDO3.4	40	42	soil pit	2.5YR 4/6	sandy loam	moist	0			single grain	loose	
SDO3.5	42	100	soil pit	10YR 2/1	clay	moist	0			massive	very firm	
SDO4.0	-15	0	water		water	wet	0					
SDO4.1	0	10	soil pit	2.5Y 5/1	clay	wet	0			subangular blocky	friable	
SDO4.2	10	60	soil pit	2.5Y 4/2	clay	wet	0			massive	firm	
SDO4.3	60	100	push tube	2.5Y 4/1	clay	wet	0			massive	firm	
SDO5.1	0	30	soil pit	10YR 4/3	peaty clay	moist	0			granular	friable	
SDO5.2	30	70	soil pit	2.5Y 4/1	clay	moist	0			massive	firm	
SDO5.3	70	90	push tube	2.5Y 4/2	clay	wet	0			massive	firm	

Table 18-4. Laboratory data for acid sulfate soil assessment of Sunnyside - Sunnyside Swamp (Downstream) 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
SDO1.1	0 - 5	fine	-	6.99	4.16	5.30	183	6.07	3.10	< 0.01	-	3	other acidic incubation
SDO1.2	5 - 15	fine	-	5.90	3.50	4.70	705	5.18	13.80	< 0.01	-	14	other acidic incubation
SDO1.3	15 - 30	fine	-	5.74	3.83	4.70	335	4.74	23.38	< 0.01	-	23	other acidic incubation
SDO1.4	30 - 70	fine	-	5.82	4.74	5.00	768	4.90	18.67	< 0.01	-	19	other acidic incubation
SDO1.5	70 - 140	fine	-	5.78	3.73	6.10	1017	5.76	5.50	0.03	-	27	hyposulfidic (S_{CR}<0.10%)
SDO2.1	0 - 5	medium	-	5.72	2.86	4.50	4519	5.18	14.76	0.05	-	44	hyposulfidic (S_{CR}<0.10%)
SDO2.2	5 - 20	fine	-	5.31	3.93	4.50	1463	4.88	24.64	< 0.01	-	25	other acidic incubation
SDO2.3	20 - 60	fine	-	5.13	3.18	4.50	2232	4.73	32.49	< 0.01	-	32	other acidic incubation
SDO2.4	60 - 80	fine	-	6.10	3.00	4.50	1063	4.96	12.71	< 0.01	-	13	other acidic incubation
SDO3.1	0 - 5	medium	-	3.51	1.92	4.00	14672	3.50	181.22	0.10	-	241	sulfuric
SDO3.2	5 - 25	fine	-	4.38	2.33	4.00	4356	3.79	137.87	0.01	-	146	hyposulfidic (S_{CR}<0.10%)
SDO3.3	25 - 40	fine	-	4.65	2.33	4.50	2905	4.52	34.04	< 0.01	-	34	other acidic
SDO3.4	40 - 42	medium	-	4.72	2.35	4.40	2761	4.56	49.21	< 0.01	-	49	other acidic
SDO3.5	42 - 100	fine	-	-	-	-	-	-	-	-	-	-	no sample
SDO4.0	-15 - 0	water	-	-	-	-	-	-	-	-	-	-	-
SDO4.1	0 - 10	fine	-	8.01	7.70	7.00	174	6.85	-	0.02	0.84	-102	hyposulfidic (S_{CR}<0.10%)
SDO4.2	10 - 60	fine	-	7.78	2.88	5.50	166	6.55	-	0.03	0.39	-35	hyposulfidic (S_{CR}<0.10%)
SDO4.3	60 - 100	fine	-	7.73	2.38	5.00	197	6.76	-	0.05	0.42	-27	hyposulfidic (S_{CR}<0.10%)
SDO5.1	0 - 30	fine	2,110	5.05	2.85	6.10	4657	4.53	46.53	< 0.01	-	47	other acidic
SDO5.2	30 - 70	fine	2,550	7.28	3.48	7.00	4946	6.06	4.82	0.16	-	103	hyposulfidic (S_{CR}≥0.10%)
SDO5.3	70 - 90	fine	2,770	3.04	1.51	2.50	4088	3.85	90.85	0.85	-	619	sulfuric

19 MYPOLONGA LEVEE WETLAND (WETLAND ID. 12066)

19.1 LOCATION AND SETTING DESCRIPTION

Mypolonga Levee wetland (Wetland ID. 12066) is situated on the western side of the River Murray, across the river from the Sunnyside – Paiwalla wetlands. The wetland is geomorphically categorised as a channel-margin swale (Pressey 1986) and is narrow and follows the curve of the river. It is approximately 4 kilometres in length and approximately 100 metres at its widest, with a total surface area of 33 hectares. The wetland is bounded to the west by a levee bank that separates it from the farmland and to the east by a raised river bank area with willow trees growing on it. There are a number of connection channels with the river along the length of the wetland. At the time when the soil survey was conducted in October 2008, the wetland was dry. *Typha latifolia* (Bulrush) and *Phragmites australis* (Common Reed) vegetation was growing throughout the wetland, and on the raised bank/floodplain there were trees. Four sites were described and sampled and their locations are shown in Figure 19-1.

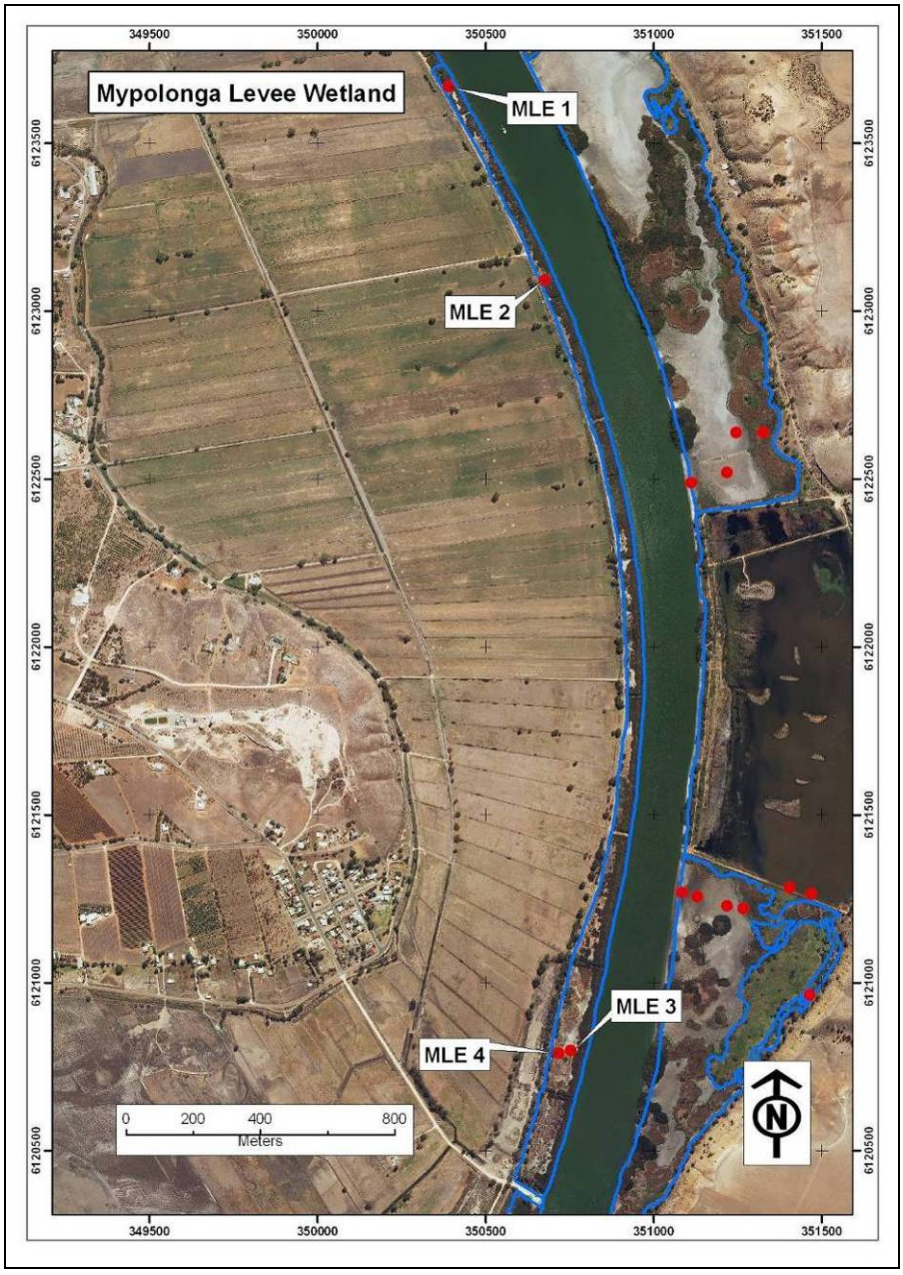

Figure 19-1. Mypolonga Levee Wetland and sample site locations.

19.2 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 19-1. Sites were located in the north of the wetland (MLE1 and MLE2) and the south of the wetland (MLE3 and MLE4). The site and profile descriptions are presented in Table 19-2 and Table 19-3.

Site MLE1 (Figure 19-2) occurred where rushes were growing with an extremely hard and cracking soil surface. The soil consisted of grey, extremely hard, clay, over a black, firm, clay.

Site MLE2 (Figure 19-3) occurred where reeds were growing. The soil consisted of red-brown, friable, clayey peat, over a dark grey, very firm, clay.

Site MLE3 (Figure 19-4) occurred where the surface was cracking with some isolated Eucalyptus vegetation. The soil consisted of grey, very firm, clay, over a dark grey, very firm, clay that contained sand lenses.

Site MLE4 (Figure 19-5) occurred where reeds were growing at a higher elevation. The soil consisted of dark brown, very firm, clay, over clay that was too hard to dig.

Table 19-1. Soil identification, subtype and general location description for Mypolonga Levee Wetland.

Site ID	Easting m Zone 54H	Northing m Zone 54H	Acid sulfate soil subtype class	General location description
MLE1	350391	6123669	Sulfuric cracking clay soil	Low elevation, cracking clay soil areas
MLE2	350675	6123091	Sulfuric soil	Low elevation, cracks filled with soil material in cracking clay soil areas
MLE3	350754	6120796	Sulfuric cracking clay soil	Low elevation, where the surface was cracking
MLE4	350718	6120789	Sulfuric soil	High elevation

Figure 19-2. Photographs of site MLE1, showing the site landscape adjacent to reeds with a hard cracking surface, and the soil profile with a columnar structure, extremely hard, clay, over firm clay.

Figure 19-3. Photographs of site MLE2, showing the site location (marked by the auger) amongst *Phragmites australis* (Common Reed) vegetation.

Figure 19-4. Photographs of site MLE3, showing the site landscape where there were few plants growing and the hard cracking clay surface, and the soil profile of blocky clay at the surface over clay with isolated red mottles in the soil matrix.

Figure 19-5. Photographs of site MLE4, showing the site location on the side slopes of the wetland, and the soil profile with friable, blocky structured, clay.

19.3 LABORATORY DATA ASSESSMENT

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

The pH data are provided in Table 19-4 and pH profiles are presented in Figure 19-6.

The pH_W data for the upper layers of all profiles identified samples that were sulfuric materials with a pH_W <4.

The pH_{INC} data for all 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 all profiles identified samples that were 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 are provided in Table 19-4 and summarised in Figure 19-7.

Chromium reducible sulfur values ranged from below the detection limit to 0.03%S_{CR}. Sulfidic materials were detected in profiles MLE1 and MLE3.

Titratable actual acidity values ranged from 25.45 to 213.42 mole H^+/tonne.

Analysis of retained acidity was not conducted on any of the samples, however retained acidity could be present in the upper layers of all profiles as the samples were below the critical value of pH_{KCl} <4.5.

Acid neutralising capacity was not measured in any of the samples, as all samples had a pH_{KCl} of < 6.5.

Net acidity values ranged from 25 to 231 mole H^+/tonne. All samples had moderate or high net acidity values with the higher values in each profile occurring in the surface layers.

Water Soluble Sulfate

Water soluble sulfate data values shown in Table 19-4 identified that surface layers in all profiles were above the critical trigger value of 100 mg/kg SO_4.

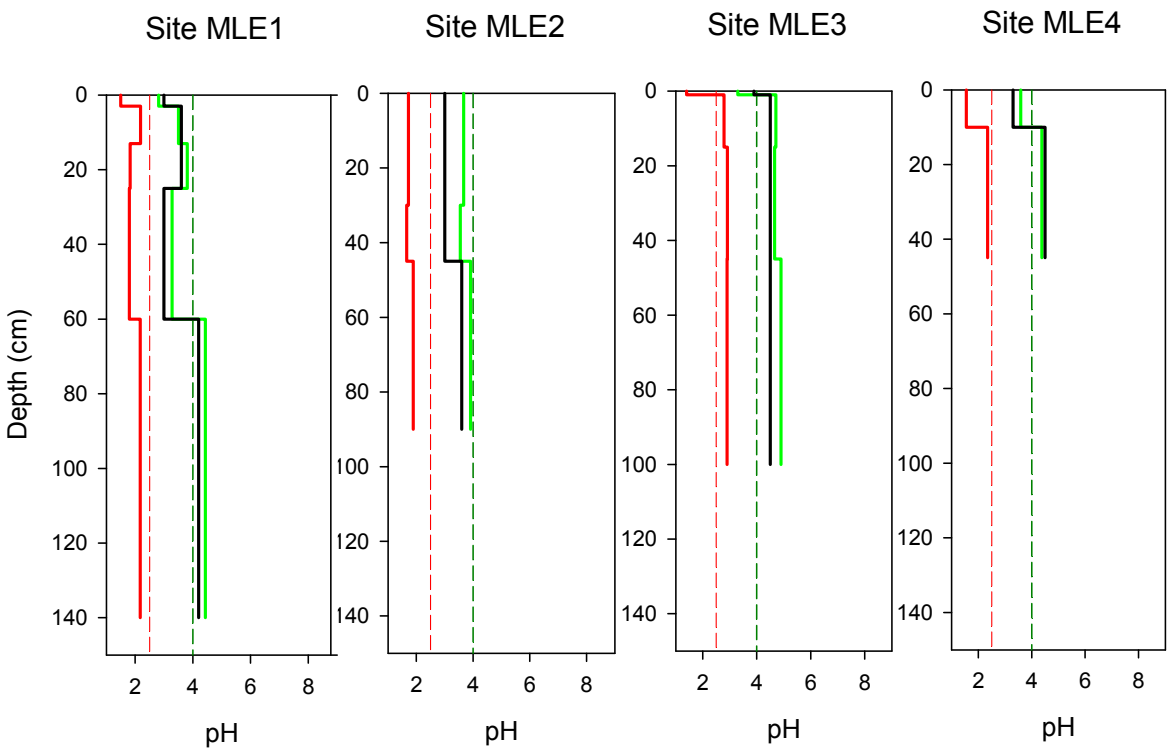

Figure 19-6. Depth profiles of soil pH for Mypolonga Levee Wetland, showing soil pH (pH_W as green line), peroxide treated pH (pH_{OX} as red line) and ageing pH (pH_{INC} after 28 weeks as black line). Critical pH_W and pH_{INC} value of 4 (black dashed line) and critical pH_{OX} value of 2.5 (red dashed line).

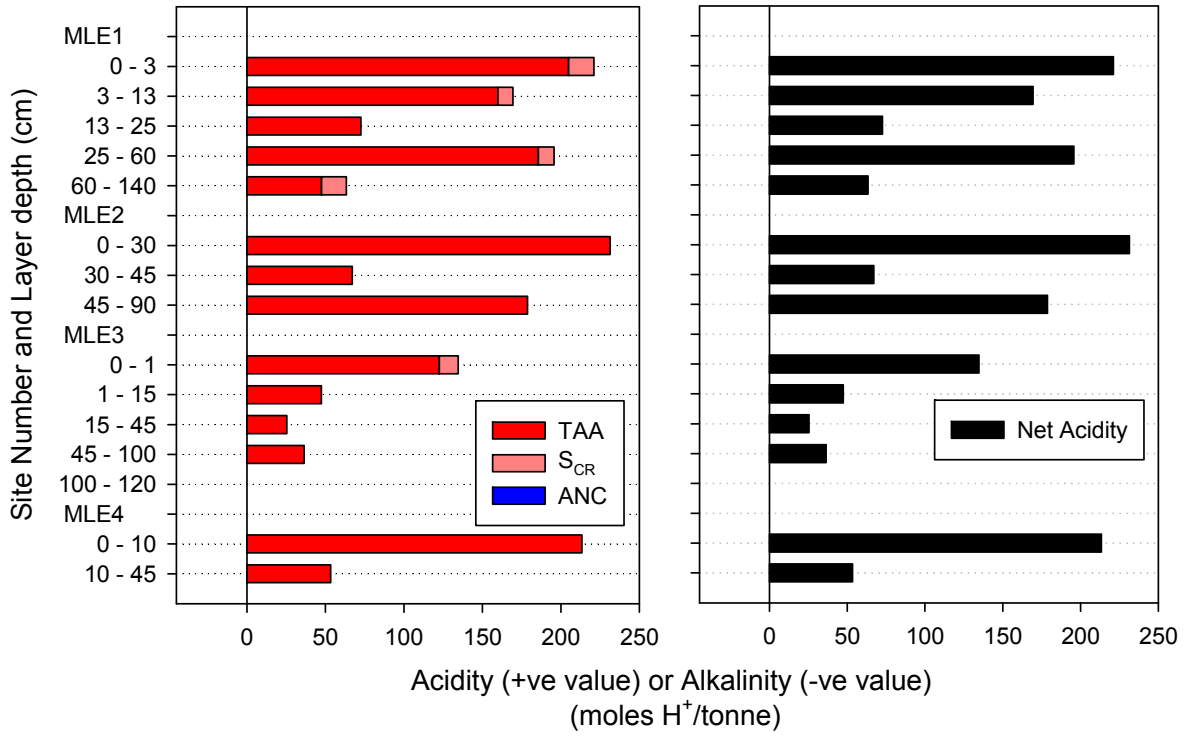

Figure 19-7. Acid base accounting depth profiles for Mypolonga Levee Wetland. Left side shows the components: titratable actual acidity (TAA - red bar), acid generating potential (AGP as S_{CR} - pink bar), and acid neutralising capacity (ANC - blue bar), and right side shows net acidity.

19.4 DISCUSSION

Acid sulfate soil materials at Mypolonga Levee Wetland were identified as sulfuric that occurred in the upper soil layers of all profiles and hyposulfidic in the subsoil of profile MLE1, and the subsoils of profiles MLE3 and MLE4 were characterised as other acidic soil materials. The acid sulfate soil subtype classes identified were Sulfuric Soil and Sulfuric Cracking Clay Soil.

The soils throughout the wetland were generally firm and clayey textured surface layers over clayey subsoils, and where the surface was cracking the clays were extremely hard or rigid.

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 Mypolonga Levee Wetland are:

- Acidification hazard: The data identified moderate or high net acidity values for all profile samples, and pH data identified samples with values that were potential acidification hazard due to oxidation. There is a high level of concern.
- De-oxygenation hazard: The water soluble sulfate data indicated that there was potential for monosulfidic materials to form in the surface layers of soils on re-flooding, although the wetland was dry at the time of sampling and 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 Mypolonga Levee Wetland:

Soil materials:	Sulfuric soil materials were identified in the surface layers and hyposulfidic soil materials were identified in a subsoil layer. The soils throughout were generally clay textured with extremely hard surface layers where the soil was cracking. Samples had moderate or high net acidity values and pH data identified samples with values that indicated potential acidification due to oxidation.
Acid sulfate soil identification:	• Sulfuric Soil – that occurred throughout the wetland. Dominant (>50%) in extent • Sulfuric Cracking Clay Soil – that occurred at the low elevation middle areas of the wetland. Sub-dominant (<50%) in extent.
Hazard assessment	• Acidification hazard - high level of concern • De-oxygenation hazard – high level of concern • Metal mobilisation – high level of concern

Table 19-2. Site data for Mypolonga Levee 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
MLE1	10-Oct-08	350391	6123669	Sulfuric soil	45	cracking, hard	Bare	Low elevation, adjacent to reeds
MLE2	10-Oct-08	350675	6123091	Sulfuric soil	60	plant material	*Phragmites australis* (Common Reed)	Low elevation,
MLE3	10-Oct-08	350754	6120796	Sulfuric cracking clay soil	Not reached	cracking	Bare	Low elevation
MLE4	10-Oct-08	350718	6120789	Sulfuric soil	Not reached	plant material	Spikebrush	High elevation

Table 19-3. Soil description data for Mypolonga Levee 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
MLE1.1	0	3	soil pit	2.5Y 7/2	clay	dry	0			columnar	extremely hard	
MLE1.2	3	13	soil pit	2.5Y 6/2	clay	dry	0			columnar	extremely hard	
MLE1.3	13	25	soil pit	2.5Y 6/1	sandy clay loam	moist	0			massive	rigid	
MLE1.4	25	60	push tube	10YR 5/3	peaty clay	wet	0			massive	firm	
MLE1.5	60	140	push tube	10YR 3/1	clay	wet	0			massive	firm	contains some plant material
MLE2.1	0	30	soil pit	10YR 2/2	peaty clay	moist	0			massive	friable	
MLE2.2	30	45	soil pit	10YR 3/2	sandy clay loam	moist	0			massive	firm	
MLE2.3	45	90	push tube	10YR 3/1	clay	wet	5	10YR 6/8	in matrix adjacent to pores	massive	very firm	
MLE3.1	0	1	soil pit	10YR 5/2	clay loam	moist	0			platy	firm	
MLE3.2	1	15	soil pit	10YR 3/3	clay	moist	0			subangular blocky	very firm	dominated by plant roots
MLE3.3	15	45	soil pit	2.5Y 2.5/1	clay	moist	5	5YR 5/8	in matrix adjacent to pores	massive	very firm	
MLE3.4	45	100	push tube	2.5Y 2.5/1	clay	moist	5	5YR 5/8	in matrix adjacent to pores	massive	very firm	contains lenses of sand
MLE3.5	100	120	push tube	2.5Y 4/1	clay	moist	0			massive	firm	
MLE4.1	0	10	soil pit	10YR 3/2	clay	moist	0			cloddy	friable	
MLE4.2	10	45	push tube	10YR 3/2	clay	moist	0			subangular blocky	very firm	too hard to dig below this layer

Table 19-4. Laboratory data for acid sulfate soil assessment of Mypolonga Levee 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
MLE1.1	0 - 3	fine	3,020	2.81	1.50	3.00	8264	3.11	204.94	0.03	-	221	sulfuric
MLE1.2	3 - 13	fine	1,450	3.50	2.19	3.60	4459	3.54	159.88	0.02	-	169	sulfuric
MLE1.3	13 - 25	medium	1,430	3.81	1.83	3.60	3537	3.80	72.61	< 0.01	-	73	sulfuric
MLE1.4	25 - 60	fine	2,200	3.28	1.80	3.00	7562	3.39	185.71	0.02	-	196	sulfuric
MLE1.5	60 - 140	fine	830	4.43	2.18	4.20	3030	4.32	47.57	0.03	-	63	hyposulfidic (S_{CR}<0.10%)
MLE2.1	0 - 30	fine	2,080	3.67	1.72	3.00	7286	3.33	231.38	< 0.01	-	231	sulfuric
MLE2.2	30 - 45	medium	1,620	3.55	1.66	3.00	2771	3.86	67.15	< 0.01	-	67	sulfuric
MLE2.3	45 - 90	fine	670	3.91	1.89	3.60	7607	3.63	178.79	< 0.01	-	179	sulfuric
MLE3.1	0 - 1	medium	1,810	3.30	1.40	3.90	7117	3.67	122.65	0.02	-	135	sulfuric
MLE3.2	1 - 15	fine	660	4.71	2.79	4.50	716	4.36	47.42	< 0.01	-	47	other acidic
MLE3.3	15 - 45	fine	770	4.66	2.91	4.50	442	4.45	25.45	< 0.01	-	25	other acidic
MLE3.4	45 - 100	fine	78,200	4.90	2.90	4.50	226	4.35	36.43	< 0.01	-	36	other acidic
MLE3.5	100 - 120	fine	-	-	-	-	-	-	-	-	-	-	-
MLE4.1	0 - 10	fine	870	3.59	1.55	3.30	3003	3.37	213.42	< 0.01	-	213	sulfuric
MLE4.2	10 - 45	fine	1,090	4.38	2.35	4.50	2748	4.32	53.39	< 0.01	-	53	other acidic

20 SUNNYSIDE - PAIWALLA MANAGED WETLAND (WETLAND ID. 12715)

20.1 LOCATION AND SETTING DESCRIPTION

Sunnyside - Paiwalla Managed Wetland (Wetland ID. 12715) is situated on the eastern side of the River Murray up-river from the town of Murray Bridge. The wetland is the centre wetland in a continuum of three that form the Sunnyside complex and is named Sunnyside – Paiwalla Swamp. The wetland is former dairy swamp land and has a total surface area of 60 hectares. It is bound to the east by a cliff, to the west by a levee bank that separates it from the river and to the north and south there are raised banks that separate it from the adjacent wetland areas. The wetland is connected to the river channel by a managed culvert with gate and carp screen. There were many species of reed and sedge growing on the wetland margin dominated by *Typha latifolia* (Bulrush) and *Phragmites australis* (Common Reed). The wetland is managed and in 2007 it dried due to receding water levels, in February 2008 it was again flooded and monitoring was conducted to observe the change with time.

This wetland was studied as part of a separate monitoring investigation of acid sulfate soils, the work and data was presented in the report 'Acid Sulfate Soil Investigations of Vertical and Lateral Changes with Time in five Managed Wetlands Between Lock 1 and Wellington' (Fitzpatrick, Shand, Thomas, Grealish, McClure, Merry and Baker. CSIRO Land and Water Science Report 03/10). Readers are referred to this report for detailed information, and here a summary of the findings are presented.

Two locations were sampled PAI 1 and the collection of sites that are associated with PAI 4. The sites sampled and their location is shown in Figure 20-1.

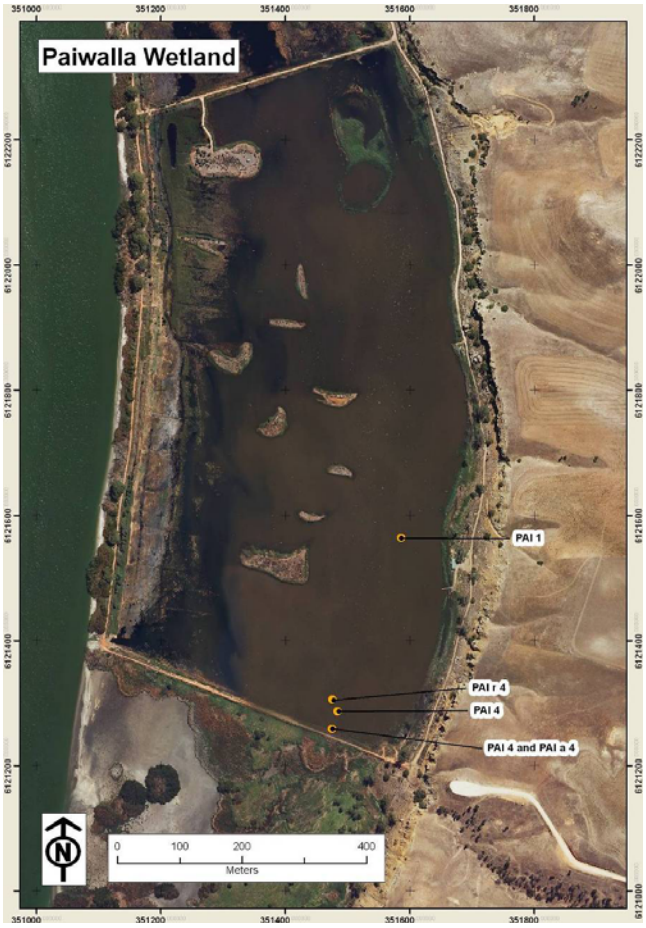

Figure 20-1. Sunnyside - Paiwalla Managed Wetland and sample site locations.

20.2 DISCUSSION

Acid sulfate soil materials at Sunnyside - Paiwalla Managed Wetland were identified as hyposulfidic that occurred in the subsoil layers and in some areas hypersulfidic. The acid sulfate soil subtype class identified was Subaqueous Hyposulfidic Soil (clayey).

The soils throughout the wetland were below water after the wetland was flooded, with a soft peaty surface layer over firm massive clay subsoil. Monosulfidic material was observed throughout the wetland.

The potential hazards posed by acid sulfate soil materials at the Sunnyside - Paiwalla Managed Wetland are:

- Acidification hazard: The data identified negative or low net acidity values, and pH_{OX} data indicated a potential acidification hazard due to oxidation. There is a low to medium level of concern.
- De-oxygenation hazard: The water soluble sulfate data indicated that there was potential for monosulfidic materials to form in the surface layers of soils, and monosulfidic material was observed in areas sampled where the wetland contained water. There is a high level of concern.
- Metal mobilisation: 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 Sunnyside - Paiwalla Managed Wetland:

Soil materials:	The soils were generally soft and peaty at the surface and firm clays in the subsoil layers. Hyposulfidic soil materials were identified.
Acid sulfate soil identification:	• Subaqueous Hyposulfidic Soil (clayey) – that occurred throughout the wetland below water. Dominant (>50%) 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

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