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Assessment of Acid Sulfate Soil materials in Ramsar wetlands of the Murray-Darling Basin: Kerang Wetlands

Water for a Healthy Country Flagship Report

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Cover Photograph:

Main: View of a drying Fosters Swamp; part of the Kerang Wetlands Ramsar site. Inset picture: subaqueous soil sample KER 4. Inset map: Regional location of Kerang Wetlands Ramsar site, northern Victoria.

Photographer: RH Merry © 2008 CSIRO.

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EXECUTIVE SUMMARY

The Kerang Wetlands Ramsar site comprising more than 100 wetlands covers an area of 9,419 ha on the western extremity of the Riverine Plain, northern Victoria. The Kerang Wetlands Ramsar site consists of permanent and temporary wetlands, including permanent freshwater lagoons, permanent open freshwater lakes, deep freshwater marshes, and saline and hypersaline lakes. The wetlands are locally significant in terms of agriculture, forming part of the local irrigation network and some are used in salt disposal. Regional groundwater levels have fallen in the past 100 years. Both factors have led to environmental and habitat decline of the wetland complex.

The Murray-Darling Basin Authority (MDBA), in partnership with its Partner Governments and scientists, instigated the Murray-Darling Basin Acid Sulfate Soils Risk Assessment Project (MDB ASSRAP), which aims to assess the spatial occurrence of, and risks posed by, acid sulfate soil materials at priority wetlands in the River Murray system, Ramsar wetlands and other key environmental sites in the Murray Darling Basin (MDB). The MDB ASSRAP project also aims to identify and assess broad management options.

Due to their ecological significance, a decision was made by the MDB Acid Sulfate Soil Risk Assessment Advisory Panel to prioritise the Ramsar-listed wetland complexes of the Murray-Darling Basin for immediate detailed acid sulfate soil assessment. This report provides the results of Phase 1 of a two-phased detailed acid sulfate soil assessment procedure for the Kerang Wetlands Ramsar site. This Phase 1 report is aimed solely at determining whether or not acid sulfate soil materials are present in the Kerang Wetlands Ramsar site.

In this study a total of 98 soil samples and 12 water samples were collected from 32 sites located along hydro-toposequences in 15 wetlands. Soil samples were analysed morphologically and chemically on a layer-by-layer basis for their acid sulfate soil properties. Field work was undertaken in late August 2008. Soil samples were analysed using a combination of standard methods: **(i)** soil morphology, **(ii)** pH testing, **(iii)** peroxide testing, **(iv)** acid-base accounting (ABA) and **(v)** soil incubation (ageing). Surface water and soil pit water samples were analysed for basic chemical properties, major and minor elements and nutrients.

The results indicated that acid sulfate soil materials were spatially extensive within the Kerang Wetlands Ramsar site. Sulfuric material was not identified at any of the sites assessed. Hypersulfidic material was only identified at 1 site. Hyposulfidic material was identified at 18 of the 32 sites assessed, and nine of these sites contained sulfidic material with contents >0.1 % S_{CR}. Other acidic soil materials, which had a pH_W or $pH_{INCUBATION}$ of less than 5.5, were identified at 13 sites. While monosulfidic material was observed at only four sites, near surface soil material at 19 sites contained water soluble sulfate concentrations which exceeded the trigger value of 100 mg kg^{-1} suggesting that monosulfides have potential to form on re-flooding of these soils.

The ASS hazards for specific wetlands within the Kerang Wetlands Ramsar site are listed below:

- *Acidification of sites with sulfidic materials (i.e. contained either hypersulfidic material or hyposulfidic material).* Based on net acidity data for soil layers, the degree of acidification hazard was high at one site with a net acidity of >100 mole H^+ t^{-1}. A moderate acidification hazard was identified at 9 sites with 19-100 mole H^+ t^{-1}. A low acidification hazard was identified at 5 sites with <19 mole H^+ t^{-1} and 14 sites contained an excess of acid neutralising capacity (net acidity was negative in all layers).

- *Acidification of sites with no sulfidic materials (i.e. do not contain either hypersulfidic material or hyposulfidic material).* Based on net acidity data for soil layers (i.e. in these soils due to total actual acidity), the degree of acidification hazard was high at two sites with a net acidity of >100 mole $H^+ t^{-1}$. A moderate acidification hazard was identified at 4 sites with 19-100 mole $H^+ t^{-1}$. A low acidification hazard was identified at 9 sites with <19 mole $H^+ t^{-1}$.
- *Deoxygenation*: The water soluble sulfate content of 19 near surface soil materials was over the trigger value for potential monosulfide formation indicating the possible development of an appreciable deoxygenation hazard after prolonged wet conditions. Monosulfidic material was observed at four of these sites.
- *Metal mobilisation*: The moderate and/or high acidification hazard at 14 sites indicates that soil acidification is likely to increase the solubility of metals at these sites. The widespread potential for monosulfide formation identified in the Kerang Wetlands Ramsar site may also result in an appreciable metal release hazard, depending on the metal loading in soils within a specific wetland.

It is recommended that further detailed examination (i.e. Phase 2) be undertaken of environmental hazards posed by the acid sulfate soil materials at the Kerang Wetlands Ramsar site and that the following representative soil materials be considered for Phase 2 work:

- One site based on the presence of hypersulfidic material.
- Nine sites based on the presence of hyposulfidic materials with S_{CR} > 0.10%.
- Five additional sites based on monosulfide formation hazard.

1. INTRODUCTION

1.1. Wetland overview

The majority of the wetlands within the Kerang Wetlands Ramsar site are located northwest of the township of Kerang in northern Victoria, 270 km from Melbourne and 480 km from Adelaide (Figure 1-1). The complex of more than 100 wetlands, covering an area of approximately 9,419 ha, falls in the Loddon-Murray Region on the western extremity of the Riverine Plain, and in the lower reaches of the Loddon and Avoca catchments. The wetland complex consists of a variety of permanent and temporary wetlands, including permanent freshwater lagoons, permanent open freshwater lakes, deep freshwater marshes, and saline and hypersaline lakes. Most of the wetlands are no longer in their natural state, as they lie in a region dominated by agriculture (typically irrigated grazing, horticulture, dairy farming and dryland cropping and grazing), and have been modified as a consequence of land and water management in the areas fringing the wetlands, and region at large.

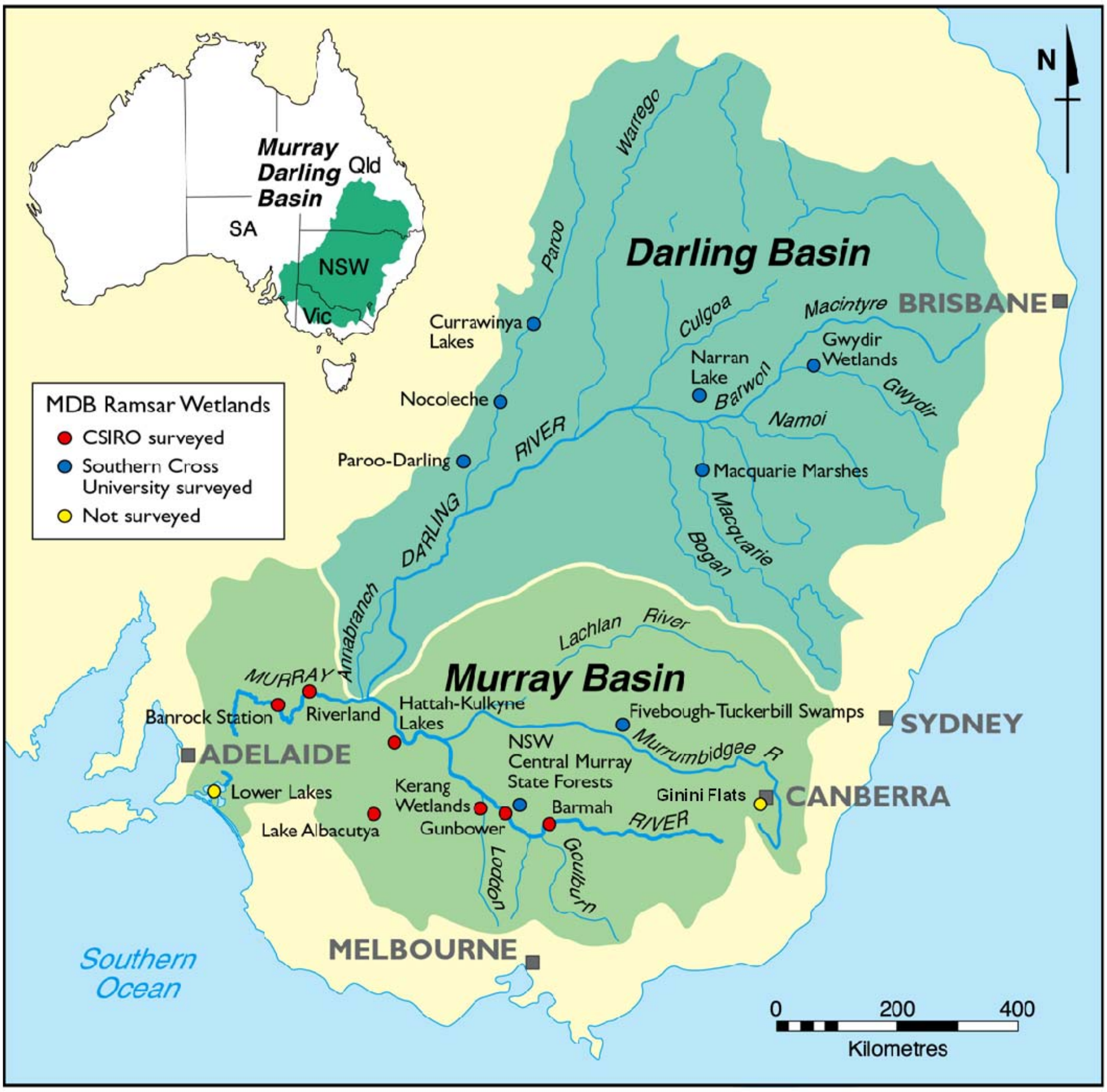


Figure 1-1 The Murray-Darling Basin contains 16 Ramsar-listed wetlands, 14 of which have received Phase 1 detailed assessment to determine whether or not ASS materials are present. The Kerang Wetlands Ramsar site is located in northern Victoria.

The Kerang Wetlands Ramsar site (Figure 1-2; Table 1-1) is managed by Parks Victoria, Goulburn-Murray Water, the Department of Sustainability and Environment, and the Shire of Goonawarra and Lower Murray. The wetlands are either managed for wildlife, water supply and saline disposal under various Acts.

Since European settlement and altered land use/floodplain management, the wetlands no longer receive replenishing regular floods from the Loddon, Avoca and Murray Rivers. A saline groundwater system fluctuates beneath the wetlands and can influence the soil salinity, water quality and vegetation health, depending on groundwater depth. Surface water in these wetlands is generally fresh. The management challenge under Ramsar designation, therefore, is to ensure that the ecological function and amenity of these wetlands are enhanced while sustainably maintaining their approved uses.

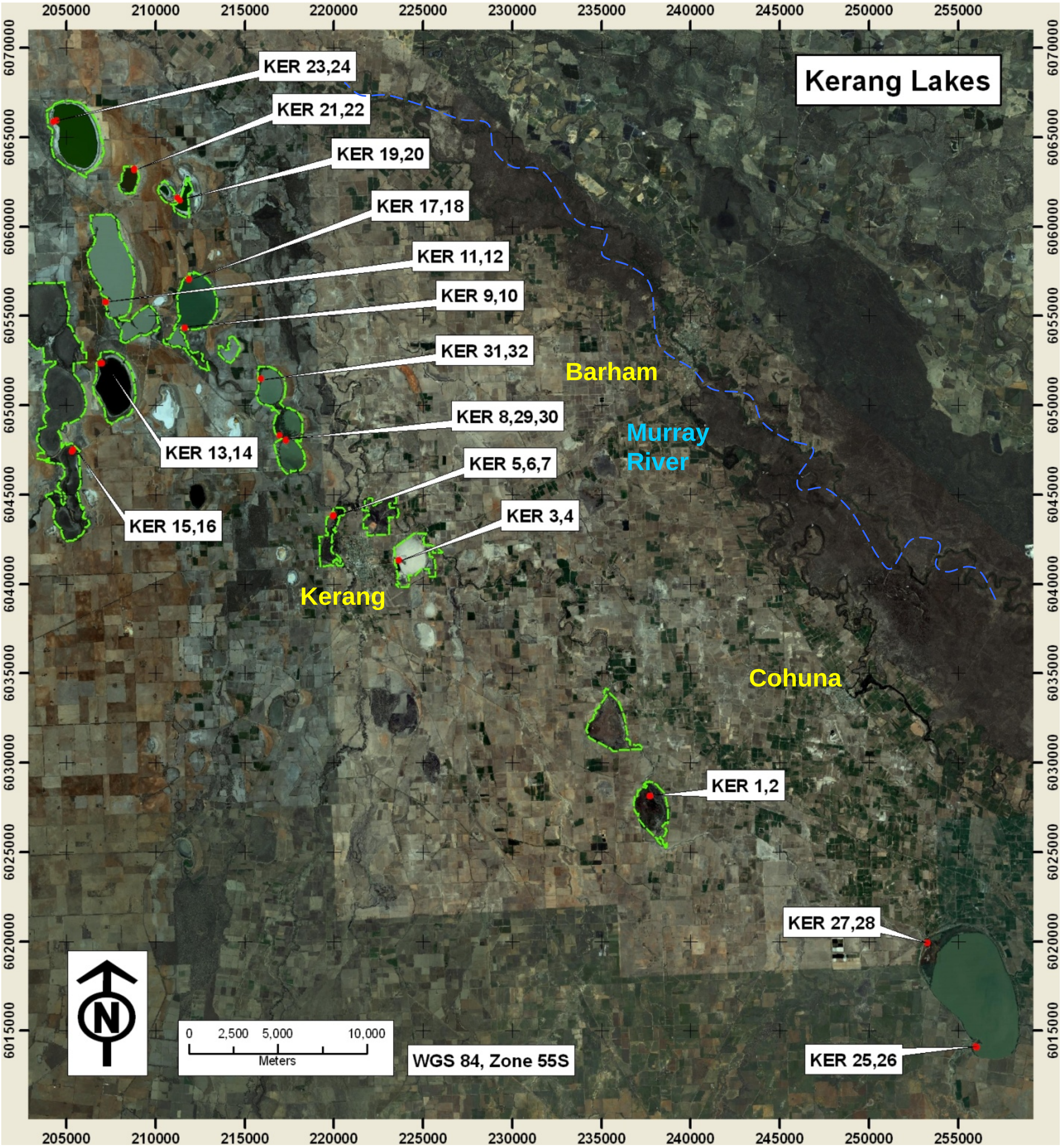


Figure 1-2 Sampling locations within the Kerang Wetlands Ramsar site, northern Victoria. Sites KER 25 to KER 28 were located at Kow Swamp which is not a Ramsar-listed wetland.

Table 1-1 The wetland classifications for the Kerang Wetlands Ramsar site, pre European settlement and current (from Department of Sustainability and Environment, 2010)

Wetland Name	Sampling sites	Wetland Classification pre Settlement	Wetland Classification (Type)	
			Category	**Sub category**
Kangaroo Lake	KER 11, 12	Permanent open freshwater	Permanent open freshwater	Shallow open water, reeds
Racecourse Lake	na	Permanent open freshwater	Permanent open freshwater	Shallow open water, reeds
Lake Charm	KER 17, 18	Permanent open freshwater	Permanent open freshwater	Shallow open water, dead timber
Little Lake Charm	KER 9, 10	Shallow freshwater marsh	Permanent open freshwater	Shallow open water, reeds
Third Lake	KER 31, 32	Deep freshwater marsh	Permanent open freshwater	Dead timber, reeds
Middle Lake	KER 7, 8	Deep freshwater marsh	Permanent open freshwater	Shallow open water, dead timber, lignum
Reedy Lake	KER 29, 30	Deep freshwater marsh	Permanent open freshwater	Shallow open water
First Marsh	na	Deep freshwater marsh	Permanent open freshwater	Shallow open water, red gum, dead timber
Lake Bael Bael	KER 15, 16	Permanent open freshwater	Permanent open freshwater	Shallow open water, red gum, dead timber, lignum
Third Marsh	na	Shallow freshwater marsh	Deep freshwater marsh	Open water, red gum, dead timber, black box
Second Marsh	na	Shallow freshwater marsh	Deep freshwater marsh	Open water, lignum, red gum, dead timber
Hird Swamp	KER 1, 2	Shallow freshwater marsh	Deep freshwater marsh	Reeds, open water, lignum
Johnson Swamp	na	Shallow freshwater marsh	Deep freshwater marsh	Reeds, open water, lignum
Town and Back Swamp	KER 5, 6	Shallow freshwater marsh	Shallow freshwater marsh	lignum
Cemetery Swamp	na	Shallow Freshwater Marsh	Shallow freshwater marsh	Herb/open water, lignum
Fosters Swamp	KER 3, 4	Shallow freshwater marsh	Semi-permanent saline	Salt pan
Stevenson Swamp	na	Semi permanent saline	Semi permanent saline	Salt pan
Lake Tutchewop	KER 23, 24	Permanent saline	Permanent saline	Shallow open water
Lake William	KER 21, 22	Semi permanent saline	Permanent saline	Shallow open water
Lake Kelly	KER 19, 20	Semi permanent saline	Permanent saline	Shallow open water
Little Lake Kelly	na	Semi permanent saline	Permanent saline	Shallow open water
Lake Cullen	KER 13, 14	Permanent saline	Permanent saline	Shallow open water
Racecourse Lake	na	Permanent open freshwater	Permanent open freshwater	Shallow open water, reeds
Kow Swamp (not Ramsar)	KER 25, 26, 27, 28	Permanent open freshwater	Permanent open freshwater	Shallow open water, reeds

Many of the wetlands in the irrigation district are underlain by highly saline regional groundwater systems. Groundwater levels are commonly higher than the beds of these wetlands, creating the potential for saline groundwater to seep into the wetlands. Surface water/groundwater interactions are complex. Irrigation supply lakes are however usually described as recharge wetlands where small quantities of lake water seep into the underlying groundwater system. This can freshen the groundwater beneath, in some cases creating a fresh groundwater lens which overlays the highly saline regional groundwater system. In irrigation supply wetlands, lowering the water levels can potentially increase the risk of saline groundwater intrusion which could result in degrading the water quality within the lakes.

Wetlands that receive water through the irrigation system may or may not be fresh as surface water salinity increases as they dry out. The wetlands have varying relationships with groundwater depending on their position in the landscape. Generally, while all interact with groundwater, they are not affected by groundwater intrusion. Where they are, management is being trialled to flush salt through the soil profile with management of water levels and drying cycles (Department of Sustainability and Environment, 2010).

Wetlands that are regulated as drainage supply wetlands are now no longer part of the floodplain and primarily receive saline water pumped from Barr Creek. In these wetlands the surrounding regional groundwater levels are higher than the wetland beds and have the potential to seep into them. The comparative lake levels and groundwater levels influence the rate of groundwater intrusion or seepage out of the lake (Department of Sustainability and Environment, 2010).

1.2. Acid sulfate soils in the Murray-Darling Basin

Acid sulfate soil is the term commonly given to soil and sediment that contain iron sulfides, or the products of sulfide oxidation. Pyrite (FeS_2) is the dominant sulfide in acid sulfate soil, although other sulfides including the iron disulfide marcasite (Sullivan and Bush 1997; Bush 2000) and iron monosulfides (Sullivan and Bush 1997, Bush *et al*. 2000) can also be found.

Sulfidic sediments accumulate under waterlogged conditions where there is a supply of sulfate, the presence of metabolisable organic matter and iron containing minerals (Dent 1986). Under reducing conditions, sulfate is bacterially reduced to sulfide, which reacts with reduced iron to form iron sulfide minerals. These sulfide minerals are generally stable under reducing conditions, however, on exposure to the atmosphere the acidity produced from sulfide oxidation can impact on water quality, crop production, and corrode concrete and steel structures (Dent 1986). In addition to the acidification of both ground and surface waters, a reduction in water quality may result from low dissolved oxygen levels (Sammut *et al*. 1993; Sullivan *et al*. 2002; Burton *et al*. 2006), high concentrations of aluminium and iron (Ferguson and Eyre 1999; Ward *et al*. 2002), and the release of other potentially toxic metals (Preda and Cox 2001; Sundstrom *et al*. 2002; Burton *et al*. 2008a; Sullivan *et al*. 2008a).

Acid sulfate soils form naturally when sulfate in the water is converted to sulfide by bacteria. Changes to the hydrology in regulated sections of the Murray-Darling Basin (MDB) system (due to higher weir pool levels), and the chemistry of rivers and wetlands have caused significant accumulation of sulfidic material in subaqueous and wetland margin soils (Fitzpatrick *et al*. 2009). If left undisturbed and covered with water, sulfidic material poses little or no threat of acidification. However, when sulfidic material is exposed to the air, the sulfides react with oxygen to form sulfuric acid (and sulfuric materials where soil pH < 4).

When these sulfuric materials are subsequently covered with water, significant amounts of sulfuric acid can be released into the water.

Other hazards associated with acid sulfate soil include: (i) mobilisation of metals, metalloids and non-metals, (ii) decrease in oxygen in the water column when monosulfidic materials are mobilised into the water column, and (iii) production of noxious gases. In severe cases, these risks can potentially lead to damage to the environment, and have impacts on water supplies, and human and livestock health.

Record low inflows and river levels in recent years have led to the drying of many wetlands in the MDB, resulting in the exposure of sulfidic material in acid sulfate soils, and soil acidification in many wetlands. The extent and potential threat posed by acid sulfate soils requires assessment.

Despite decades of scientific investigation of the ecological (e.g. Living Murray Icon Site Environmental Management Plan (Murray-Darling Basin Commission 2006a; Murray-Darling Basin Commission 2006b; Murray-Darling Basin Commission 2006c), hydrological, water quality (salinity) and pedological features of wetlands in the MDB, we have only recently advanced far enough to appreciate the wide spectrum of acid sulfate soil subtypes and processes that are operating in these contemporary environmental settings - especially from continued lowering of water levels (e.g. Lamontagne *et al*. 2006; Fitzpatrick *et al*. 2008c; Fitzpatrick *et al*. 2008; Shand and Edmunds 2008; Shand *et al*. 2008; Simpson *et al*. 2008; Sullivan *et al*. 2008a). Hence, the MDB Ministerial Council at its meeting in March 2008 directed the then Murray-Darling Basin Commission (MDBC) to undertake an assessment of acid sulfate soil risk at key wetlands in the MDB.

The MDBA, in partnership with its Partner Governments and scientists, designed the MDB ASS Risk Assessment Project, which aims to assess the spatial occurrence of, and risks posed by, acid sulfate soil materials at priority wetlands in the River Murray system, Ramsar wetlands and other key environmental sites in the Murray-Darling Basin. The project also aims to identify and assess broad management options.

The project established a list of more than 10,000 wetlands that were then assessed against a number of criteria aimed at identifying those that had potential for acid sulfate soil occurrence. Due to their ecological significance, the decision was made to prioritise Ramsar-listed wetland complexes of the Murray-Darling Basin (Figure 1-1) for immediate detailed acid sulfate soil assessment.

Wetlands within these complexes were then identified and selected for further assessment. CSIRO Land and Water carried out a detailed assessment at 32 representative sites within the Kerang Wetlands Ramsar site (Figure 1-2) in August 2008 to determine whether acid sulfate soils were present, or if there was a potential for acid sulfate soil to form within these wetlands.

This assessment included the determination of sulfide content within the soil profile at each site. Water soluble sulfate was used as an indicator of the potential of monosulfide (monosulfidic black ooze or MBO) formation in these wetland sites.

1.3. Detailed acid sulfate soil assessments using two phases

The detailed assessment stage of the MDB ASS Risk Assessment Project involves comprehensive analysis using a set of established and tested field and laboratory methods to determine the presence and extent of acid sulfate soil and associated hazards, including potential for acidification, metal mobilisation and deoxygenation.

In summary, the protocol developed by the MDB ASS Risk Assessment Project Scientific Reference Panel (MDBA 2010) requires a two-phase procedure.

Phase 1 aims to determine whether or not acid sulfate soil materials are present in each wetland by:

a. Consulting with relevant wetland managers.

b. Field descriptions of soils and sampling, including pH (e.g. using Merck test strips) and specific electrical conductance (SEC) testing.

c. Photographic record of sites and soil profiles.

d. Sampling and sub-sampling in chip trays.

e. Field testing of water quality parameters (pH, specific electrical conductance (SEC), redox potential (Eh), dissolved oxygen (DO), alkalinity by titration, and turbidity).

f. Laboratory analyses to conclusively identify the presence or absence of sulfuric, sulfidic or MBO acid sulfate soil materials using incubation ("ageing pH") in chip trays, pH peroxide testing and sulfur suite and partial acid base accounting: S_{CR} (sulfide % S), pH_{KCl}, and TAA (titratable actual acidity: moles H^+/tonne), acid neutralising capacity (ANC) where soil materials were sulfidic, acid volatile sulfur (S_{AV} or AVS) and water-soluble SO_4 (1:5 soil:water suspension).

g. Surface water and groundwater chemical and nutrient analyses.

Phase 2 is only pursued if results of Phase 1 dictate, and the MDB ASS Risk Assessment Advisory Panel recommend further detailed investigation. Phase 2 aims to determine the nature and severity of the environmental hazards posed by the acid sulfate soil materials, if present, by:

a. Continued incubation of samples in chip trays.

b. More detailed acid/base accounting (e.g. elemental sulfur).

c. Rapid metal release.

d. Contaminant and metalloid dynamics.

e. MBO formation potential.

f. Mineralogy by X-ray diffraction (XRD).

g. Major and trace elements by X-ray fluorescence spectroscopy (XRF).

h. Archiving of all soil samples in CSIRO archive (as chip trays and bulk samples).

Following a request from the Murray-Darling Basin Authority (MDBA), CSIRO Land and Water were engaged to conduct a Phase 1 detailed assessment of acid sulfate soils at the Kerang Wetlands Ramsar site (Figure 1-1).

1.4. Methods used to assess acid generation potential

As detailed previously, sulfide minerals are generally stable under reducing conditions, however, on exposure to the atmosphere the acidity produced from sulfide oxidation can impact on water quality, crop production, and corrode concrete and steel structures (Dent 1986). In addition to the acidification of both ground and surface waters, a reduction in water quality may result from low dissolved oxygen levels (Sammut *et al*. 1993; Sullivan *et al*. 2002; Burton *et al*. 2006), high concentrations of aluminium and iron (Ferguson and Eyre 1999; Ward *et al*. 2002), and the release of other potentially toxic metals (Preda and Cox 2001; Sundstrom *et al*. 2002; Burton *et al*. 2008a; Sullivan *et al*. 2008a).

In nature, a number of oxidation reactions of sulfide minerals (principally pyrite: FeS_2) may occur which produce acidity, including:

$$2FeS_2 + 7O_2 + 2H_2O \text{ ---> } 2Fe^{2+} + 4SO_4^{2-} + 4H^+$$

$$4FeS_2 + 15O_2 + 10H_2O \text{ ---> } 4FeOOH + 8H_2SO_4$$

A range of secondary minerals, such as jarosite, sideronatrite and schwertmannite may also form, which act as stores of acidity i.e. they may produce acidity upon dissolution (rewetting).

Acid-base accounting (ABA)

Acid-base accounting (ABA) is used to assess both the potential of a soil material to produce acidity from sulfide oxidation and also its ability to neutralise any acid formed (e.g. Sullivan *et al*. 2001; Sullivan *et al*. 2002).

The standard ABA applicable to acid sulfate soil is as described in Ahern *et al.* (2004) and summarised here. The equation below shows the calculation of Net Acidity (NA).

Net Acidity = Potential Sulfidic Acidity + Existing Acidity – ANC*/Fineness Factor

***ANC = Acid Neutralising Capacity**

The components in this ABA are further discussed below and by Ahern *et al.* (2004).

Potential Sulfidic Acidity (PSA)

The Potential Sulfidic Acidity is most easily and accurately determined by assessing the Chromium Reducible Sulfur. This method was developed specifically for analysing acid sulfate soil materials (Sullivan *et al*. 2000) to, *inter alia*, assess their Potential Sulfidic Acidity (PSA) also known as the 'acid generation potential' (AGP). The method is also described in Ahern *et al.* (2004), which includes the chromium reducible sulfur method (S_{CR} or CRS: Method Code 22B) and its conversion to PSA.

Existing Acidity

Existing acidity is the sum of the Actual Acidity and the Retained Acidity (Ahern *et al*. 2004). Titratable actual acidity (TAA) is a measure of the actual acidity in acid sulfate soil material that has already oxidised. TAA measures the sum of both soluble and exchangeable acidity present in a soil. The Retained Acidity (RA) is the acidity 'stored' in minerals such as jarosite, schwertmannite and other hydroxysulfate minerals. Although these minerals may be stable under acidic conditions, they can release acidity to the environment when these conditions change. The methods for determining both TAA and RA are given by Ahern *et al.* (2004).

Acid Neutralising Capacity (ANC)

Soils with pH_{KCl} values > 6.5 may potentially have ANC in the form of (usually) carbonate minerals, principally of calcium, magnesium and sodium. The carbonate minerals present are estimated by titration, and alkalinity present is expressed in $CaCO_3$ equivalents. By accepted definition (Ahern *et al*. 2004), any acid sulfate soil material with a pH_{KCl} < 6.5 has a zero ANC. The methods for determining ANC are given by Ahern *et al.* (2004).

Fineness Factor (FF)

This is defined by Ahern *et al.* (2004) as "A factor applied to the acid neutralising capacity result in the acid base account to allow for the poor reactivity of coarser carbonate or other acid neutralising material. The minimum factor is 1.5 for finely divided pure agricultural lime, but may be as high as 3.0 for coarser shell material". Fine grinding of soil materials may lead to an over-estimate of ANC when carbonates are present in the form of hard nodules or shells. In the soil environment, they may provide little effective ANC when exposure to acid may result in the formation of surface crusts (iron oxides or gypsum), preventing or slowing further neutralisation reactions. For reasons including those above, the use of the "Fineness Factor" also applies to those naturally occurring alkalinity sources in soil materials as measured by the ANC methods.

1.5. Classification of soil materials

Recently, the Acid Sulfate Soils Working Group of the International Union of Soil Sciences agreed to adopt in principle the following new descriptive terminology and classification definitions of acid sulfate soil materials proposed by Sullivan *et al.* (2008b) at the 6th International Acid Sulfate Soil and Acid Rock Drainage Conference in September 2008 in Guangzhou, China. This new classification system for acid sulfate soil materials (Sullivan *et al*. 2009) has also been recently (October 2008) adopted by the Scientific Reference Panel of the Murray-Darling Basin Acid Sulfate Soils Risk Assessment Project for use in the detailed assessment of acid sulfate soil in the Murray-Darling Basin.

The criteria to define the soil materials are as follows:

1) Sulfuric material - soil materials currently defined as sulfuric by the Australian Soil Classification (Isbell 1996). Essentially, these are soil materials with a pH_w < 4 as a result of sulfide oxidation.

2) *Sulfidic material – soil materials containing detectable sulfide minerals (defined as containing ≥ 0.01% sulfidic S). The intent is for this term to be used in a descriptive context (e.g. sulfidic soil material or sulfidic sediment) and to align with general definitions applied by other scientific disciplines such as geology and ecology (e.g. sulfidic sediment). The method with the lowest detection limit is the Cr-reducible sulfide method, which currently has a detection limit of 0.01%; other methods (e.g. X-ray diffraction, visual identification, Raman spectroscopy or infra red spectroscopy) can also be used to identify sulfidic materials.

**This term differs from previously published definitions in various soil classifications (e.g. Isbell 1996).*

3) Hypersulfidic material - Hypersulfidic material is a sulfidic material that is identified by having a field pH of 4 or more and by experiencing a substantial* drop in pH by at least 0.5 unit to 4 or less (1:1 by weight in water, or in a minimum of water to permit measurement) when a 2-10 mm thick layer is incubated aerobically at field capacity. The duration of the incubation is either: a) until the soil pH changes by at least 0.5 pH unit to below 4, or b) until a stable** pH is reached after at least 8 weeks of incubation.

> **A substantial drop in pH arising from incubation is regarded as an overall decrease of at least 0.5 pH unit.*
> ***A stable pH is assumed to have been reached after at least 8 weeks of incubation when either the decrease in pH is < 0.1 pH unit over at least a 14 day period, or the pH begins to increase.*

4) Hyposulfidic material - Hyposulfidic material is a sulfidic material that is identified by having a field pH of 4 or more and by not experiencing a substantial* drop in pH by at least 0.5 unit to 4 or less (1:1 by weight in water, or in a minimum of water to permit measurement) when a 2-10 mm thick layer is incubated aerobically at field capacity. The duration of the incubation is until a stable** pH is reached after at least 8 weeks of incubation.

> **A substantial drop in pH arising from incubation is regarded as an overall decrease of at least 0.5 pH unit.*
> ***A stable pH is assumed to have been reached after at least 8 weeks of incubation when either the decrease in pH is < 0.1 pH unit over at least a 14 day period, or the pH begins to increase.*

5) Monosulfidic material - soil materials with an acid volatile sulfide content ≥ 0.01% S.

Non-Acid Sulfate Soil material

In addition the Scientific Reference Panel of the Murray-Darling Basin Acid Sulfate Soils Risk Assessment Project agreed to identify the other acidic soil materials arising from the detailed assessment of wetland soils in the Murray-Darling Basin even though these materials may not be the result of acid sulfate soil processes (e.g. the acidity developed during ageing may be the result of Fe^{2+} hydrolysis, which may or may not be associated with acid sulfate soil processes). The acidity present in field soils may also be due to the accumulation of acidic organic matter and/or the leaching of bases. Of course, these acidic soil materials may also pose a risk to the environment and would be identified during the present course of the Phase 1 detailed assessment.

The definition of these *other acidic soil materials* for the detailed assessment of acid sulfate soils in the Murray-Darling Basin is as follows:

1. Other acidic soil material – either:

a. non-sulfidic soil materials that acidify by at least a 0.5 pH_w unit to a pH_w of <5.5 during moist aerobic incubation, or

b. soil materials with a $pH_w \geq 4$ but < 5.5 in the field.

2. Other soil material – soils that do not have acid sulfate soil (or other acidic) characteristics.

2. METHODS AND MATERIALS

2.1. Kerang Wetlands Ramsar Site Characteristics

The field survey (Phase 1) was conducted during August 2008 in a selection of 15 wetlands (14 wetlands within the Kerang Wetlands Ramsar site plus Kow Swamp) (Table 1-1). At the time of the survey, the wetlands were either dry lakes (Figure 2-1), freshwater or saline lakes (Figure 2-2).

Most of the soils encountered typically fall into one of three categories:

(i) grey heavy clay, typically with prominent red-brown mottles, and often cracking and self-mulching when dry (Vertosols and Hydrosols) (e.g. Figure 2-1 , Figure 7-21);

(ii) sands (Tenosols and Hydrosols) (e.g. Figure 7-17, Figure 7-30), and

(iii) bluish-grey medium to heavy clays (e.g. Figure 7-8, Figure 7-9) often overlain by a peaty or gel layer (Vertosols and Hydrosols) (e.g. Figure 7-7, Figure 7-11). Along the shores of the saline lakes, surface salt crusts (varying in thickness from a few mm to 200 mm) were common above a sandy upper layer. Monosulfidic material was commonly observed in saline lake profiles, occurring beneath a surface crust of halite (Figure 2-2).

Site descriptions are provided in Appendix 1. Detailed descriptions of soil sample layers are provided in Appendix 2.

Figure 2-1 (left) Landscape photo showing the dry lake bed of Lake Cullen (sites KER 13 and KER 14) (right) Soil profile KER 13. Strong brown mottles in the upper 15 cm of the profile indicate that iron sulfide minerals were likely present prior to drying out and oxidising to form iron oxides.

Figure 2-2 (left) Landscape photo of Lake William (sites KER 21 and KER 22), a hypersaline lake with the shore encrusted with windblown salt up to 20 cm thick. (right) Soil profile KER 22 sampled from near the waterline. Dark grey to black layers indicate the presence of monosulfidic material.

2.2. Field sampling of soils and waters

A detailed field investigation was undertaken during August 2008 to assess the current and potential environmental hazards due to the presence of acid sulfate soils at the Ramsar site. In this study, a total of 32 sites (soil profiles) were assessed. The soil profiles were located on toposequences that traversed across 15 individual wetlands. Sites were selected to represent the various aquatic states and wetland morphologies (Figure 1-2). Typically two or three soil profiles were sampled along each toposequence transect; one at the lowest point in the landscape and at least one on the mid to high point at the edge of the wetland feature (e.g. Figure 2-2).

At each survey site (i.e. the soil profile location), global positioning system coordinates, site locations and soil sample descriptions were recorded on a layer-by-layer basis. Site coordinates are presented in Appendix 1. Site and soil morphological descriptions are presented in Appendix 1 and Appendix 2 respectively.

Soil morphology was described in the field (e.g. colour, consistency, structure and texture) according to McDonald *et al*. (1998). Multiple samples from each layer were taken, including:

- Two sets of chip tray samples placed in individual tray compartments; one for desk top morphological reference and storage, and the other for incubation (ageing) experiments;
- Bulk (~500 g) samples for peroxide pH analysis and bulk storage, placed in thick sealable plastic bags;
- Two samples, each placed in 70 ml screw top plastic jars, one for XRD (X-ray diffraction) and XRF (X-ray fluorescence spectrometry) analyses, and the other for chromium reducible sulfur (S_{CR}) and acid neutralisation (ANC) analyses.

Descriptions were made for each site and each layer in the soil profiles. Soil colour, texture, structure and consistence were valuable field indicators for soil identification and appraisal, indicating soil type and potential impacts of ASS formation during inundation, and likely products of oxidation based on acid generating and acid neutralising characteristics. For example, quartz-rich, sandy soils often present higher acidification hazards as they contain little acid neutralising capacity (ANC), whereas clay-rich soils have ability to neutralise acidity through dissolution of clay minerals. Individual soil profiles of alluvial origin often show variations in layer textures, contributing to the complexity of interpreting likely ASS behaviour at each site.

Surface water and groundwater samples were collected for hydrochemical analyses. The parameters pH, dissolved oxygen (DO) and redox potential (Eh) were measured on-site using a calibrated YSI multi-parameter meter and electrodes. Other on-site measurements included temperature (T °C), specific electrical conductance (SEC) and alkalinity (as HCO_3 by titration). Samples were collected for major and trace chemical analysis in 125 ml polyethylene bottles. Those for major and trace element analyses were filtered through 0.45 µm filters, and the aliquot for cation and trace elements was acidified to ca. 0.2 % v/v HCl to stabilise solute concentrations and minimise adsorption onto container walls.

2.3. Laboratory soil analysis methods

All soil samples were oven-dried at 80°C prior to analysis. Any coarse material (> 2 mm) present was removed by sieving, and then samples were ring mill ground.

Several parameters were examined to determine whether acid sulfate soil materials were likely to be present, or if there was a potential for acid sulfate soil materials to form. The parameters measured in this study included pH (pH_W, pH_{OX}, pH_{KCl} and $pH_{INCUBATION}$), titratable actual acidity (TAA), water soluble sulfate, chromium reducible sulfur (S_{CR}) and acid neutralising capacity (ANC).

The existing acidity of each soil layer (pH_W) was assessed by measuring the pH in a saturated paste (1:1 soil:water mixture). The pH_{OX} was determined following oxidation with 30 % hydrogen peroxide (H_2O_2) (Method Code 23Bf) (Ahern *et al*. 2004). The KCl extractable pH (pH_{KCl}) was measured in a 1:40 1.0 M KCl extract (Method Code 23A), and the titratable actual acidity (TAA) (i.e. sum of soluble and exchangeable acidity) was determined by titration of the KCl extract to pH 6.5 (Method Code 23F) (Ahern *et al*. 2004). TAA is a measure of the actual acidity in soil materials. The pH following incubation ($pH_{INCUBATION}$) was determined on duplicate moistened sulfidic soil materials (i.e. $S_{CR} \geq 0.01\%$ S) placed in chip trays using pH indicator strips. The duration of the incubation was until a stable pH was reached after at least 8 weeks of incubation.

Water soluble sulfate (1:5 soil:water extract) was prepared following the procedures described in Rayment and Higginson (1992), and analysed by ICP-OES (Inductively Coupled Plasma - Optical Emission Spectrometry). The pyritic sulfur content was quantified using the chromium reduction analysis method of Burton *et al.* (2008).

Acid neutralising capacity, measured by the ANC_{BT} method (Method Code 19A2) (Ahern et al. 2004) was determined for sulfidic samples to enable Net Acidity to be estimated by the Acid Base Account method of Ahern *et al.* (2004).

Standard quality assurance (QA) procedures were followed including the monitoring of blanks, duplicates and standards in each batch.

2.4. Criteria for ranking soil materials for inclusion in Phase 2 of the detailed assessment process

The Scientific Reference Panel of the Murray-Darling Basin Acid Sulfate Soils Risk Assessment Project agreed to recommend that soil materials be assigned the following priorities to undertake the Phase 2 detailed assessment:

High Priority

1. All sulfuric materials.
2. All hypersulfidic materials as recognised by either:
   i) incubation of sulfidic materials or
   ii) a positive net acidity result with a Fineness Factor of 1.5 being used.
3. All hyposulfidic materials with S_{CR} contents ≥ 0.10% S.
4. All surface soil materials (i.e. within 0-20 cm) with water soluble sulfate (1:5 soil:water) contents ≥100 mg SO_4 kg^{-1}.
5. All monosulfidic materials.

Moderate Priority

1. All hyposulfidic materials with S_{CR} contents < 0.10% S.
2. Other acidic soil materials.

No Further Assessment

All other soil materials.

It is important to note, while the criteria identifying samples for Phase 2 analysis is clearly defined, samples only go through to Phase 2 when consideration is given to the wetland as a whole.

3. RESULTS

3.1. Summary of Kerang Wetlands Ramsar site field and laboratory data

Soil features were influenced by the morphology of the wetland, the wetting regime, and salinity. Lakes typically had sandy soils on the shoreline and more clayey soils within the lake bed. Sub-aqueous soils, whether clayey or sandy, were generally grey or dark brown with a grey gel-like surface layer. Black layering and gleyed coloured, mottled clays were evident in some dried and partly dried lakebeds, suggesting reducing conditions. Monosulfidic material was observed at four locations with wet or subaqueous soils. Orange mottles were common in soils surrounding wetlands and in the clayey, cracked beds of dried wetlands.

From the 32 sites assessed, 98 soil samples were tested for routine laboratory analyses. These results are summarised in Table 3-1. A detailed list of laboratory results is presented in Appendix 3.

Surface water chemistry is presented in Section 3.2 and Appendix 4.

The down profile distribution of acid base accounting parameters are shown for each soil profile in graphs presented in Appendix 5.

Table 3-1 Summary data for pH testing, sulfur chemistry and ABA

Parameter	Units	Minimum	Median	Maximum	[1]n
[2]**pH_W**		4.8	7.1	8.8	98
[3]**pH_{OX}**		1.9	6.1	8.3	98
[4]**pH_{KCl}**		4.2	6.9	9.7	95
[5]**$pH_{INCUBATION}$**		2.5	7.0	>7.0	98
[6]**TAA**	mole H^+ t^{-1}	0.0	2.0	176	44
[7]**SO_4** (Water soluble)	mg SO_4 kg^{-1}	11	99	6056	95
[8]**S_{CR}**	%S	< 0.01	< 0.01	0.22	95
[9]**ANC**	$\%CaCO_3$	0.0	0.1	25.7	95
[10]**Net Acidity**	mole H^+ t^{-1}	-3425	-54	176	95

[1]n: number of samples. [2]pH_W: pH water. [3]pH_{OX} after peroxide treatment. [4]pH_{KCl}: pH in KCl [5]$pH_{INCUBATION}$ at 19 weeks of ageing. [6]TAA: titratable actual acidity . [7]SO_4: Water Soluble Sulfate in 1:5 soil:water extract. [8]S_{CR}: Cr-reducible sulfur. [9]ANC: Acid Neutralising Capacity – by definition, where pH_{KCl} < 6.5 ANC = 0. [10]Net Acidity - here does not include allowance for retained acidity.

3.1.1. Soil pH testing (pH_W, pH_{OX}, $pH_{INCUBATION}$ and pH_{KCl})

Soil-water pH_W values ranged from 4.8 to 8.8, with a median value of 7.1 (Table 3-1). The pH_W results indicated that no sites contained sulfuric material (pH <4). Six soil layers (from 3 sites) contained one or more soil layers with a pH_W value less than 5.5, classifying as 'other acidic soil material'.

Peroxide oxidation testing (pH_{OX}) was performed on all samples as a guide to soil pH following oxidation. The pH_{OX} values ranged from 1.9 to 8.3 with a median value of 6.1 (Table 3-1). The pH_{OX} results suggest that 15 soil samples were likely to contain sulfidic material in sufficient concentrations to acidify the soil if oxidised fully (indicated by pH_{OX} <2.5) (e.g. Figure 3-1). Peroxide treatment results generally support the same general downward trend in pH as the incubation experiments, which in turn support the S_{CR} data.

The $pH_{INCUBATION}$ values ranged from 2.5 to >7.0 with a median value of 7.0 (Table 3-1). The pH incubation ($pH_{INCUBATION}$) experiments showed that the pH of only one soil sample dropped to less than pH 4 within 19 weeks, and classified as hypersulfidic material. Nine other soil samples measured a $pH_{INCUBATION}$ value of 4.0 within the 19 weeks of incubation. It is possible that the $pH_{INCUBATION}$ of these samples dropped to below 4 at some stage during the testing period, but was not observed.

The pH_{KCl} values ranged between 4.2 and 9.7 with a median value of 6.9 (Table 3-1). The results indicate that 44 soil samples (45% of samples tested) were likely to contain titratable actual acidity (TAA) as they had a pH_{KCl} < 6.5. Two samples (KER 7.1 and KER 31.1) were also likely to contain retained acidity (RA) as they had a pH_{KCl} value < 4.5.

3.1.2. Chromium Reducible Sulfur (S_{CR})

Reduced inorganic sulfur was detected in soil from 42% of sites, indicating that sulfidic material was spatially extensive in wetlands at the Kerang Wetlands Ramsar site, during the time of sampling. Forty one soil samples contained detectable $S_{CR,}$ ranging from 0.01 to 0.22 wt. %, and a median value of <0.01% (Table 3-1). Generally, the highest S_{CR} values were found in moist or wet (often saline) lakebed soils with high organic matter content (e.g. see overall summary in Table 4-2). The S_{CR} results were generally supported by the pH_{OX} testing.

3.1.3. Titratable actual acidity (TAA)

The titratable actual acidity (TAA) data is presented in Appendix 3 and summarised in Table 3-1. The TAA values ranged between zero and 176 mole $H^+ t^{-1}$, with a median of 2.0 mole $H^+ t^{-1}$. TAA was assumed to be zero in soil layers that had a pH_{KCl} ≥ 6.5 (51 samples). The TAA of 17 samples represented a moderate, existing, acidity hazard due to TAA values measuring between 19 and 100 mole $H^+ t^{-1}$. Two samples presented a high acidity hazard due to values of TAA measuring >100 mole $H^+ t^{-1}$ (e.g. Figure 3-1, 0-3 cm).

3.1.4. Acid Neutralising Capacity (ANC)

The acid neutralising capacity (ANC) data for all Kerang Wetlands Ramsar site samples are presented in Appendix 3 and summarised in Table 3-1. The ANC was determined for 95 samples to enable the net acidity to be estimated by the acid-base accounting method. The ANC values ranged from zero and 25.7% $CaCO_3$ equivalent, with a median value of 0.1%. The effective ANC was determined to be zero where pH_{KCl} was below 6.5 (i.e. for 46 % of the samples). Samples with high S_{CR} values often also contained high ANC especially in saline wetlands (e.g. Figure 3-2).

3.1.5. Net Acidity

Net acidity data for the all Kerang Wetlands Ramsar site samples analysed are presented in Appendix 3 and summarised in Table 3-1. Acid-base accounting calculations showed the net acidity ranged between -3425 and 176 mole $H^+ t^{-1}$, with a median net acidity of -54 mole $H^+ t^{-1}$ (Table 3-1).

The net acidity thresholds used to characterise the acid sulfate soil materials of 95 samples in this assessment include; (i) low net acidity (< 19 mole $H^+ t^{-1}$), (ii) moderate net acidity (19-100 mole $H^+ t^{-1}$) and (iii) high net acidity (> 100 mole $H^+ t^{-1}$).

- Low net acidity values were measured in 67 soil samples. Seventeen profiles contained only low or negative net acidity values. A negative net acidity value was measured in 45 samples.

- Moderate net acidity values (19-100 mole H^+ t^{-1}) were measured in soil 21 samples. Thirteen soil profiles contained at least one soil sample with a moderate net acidity value.

- High net acidity values (>100 mole H^+ t^{-1}) were measured in three soils samples. The three soil profiles that contained one soil sample with a high net acidity value were: KER 31 (between 0-3 cm depths), KER 7 (between 0-8 cm depth) and KER 5 (between 15-30 cm depth). These three soil profiles contained organic rich topsoils, which were located on the shoreline of wet, moderately freshwater lakes (e.g. Figure 3-1; Figure 7-1; Figure 7-5; Figure 7-7). The down profile distribution of soil pH and acid base accounting parameters for all profiles are presented in Appendix 5.

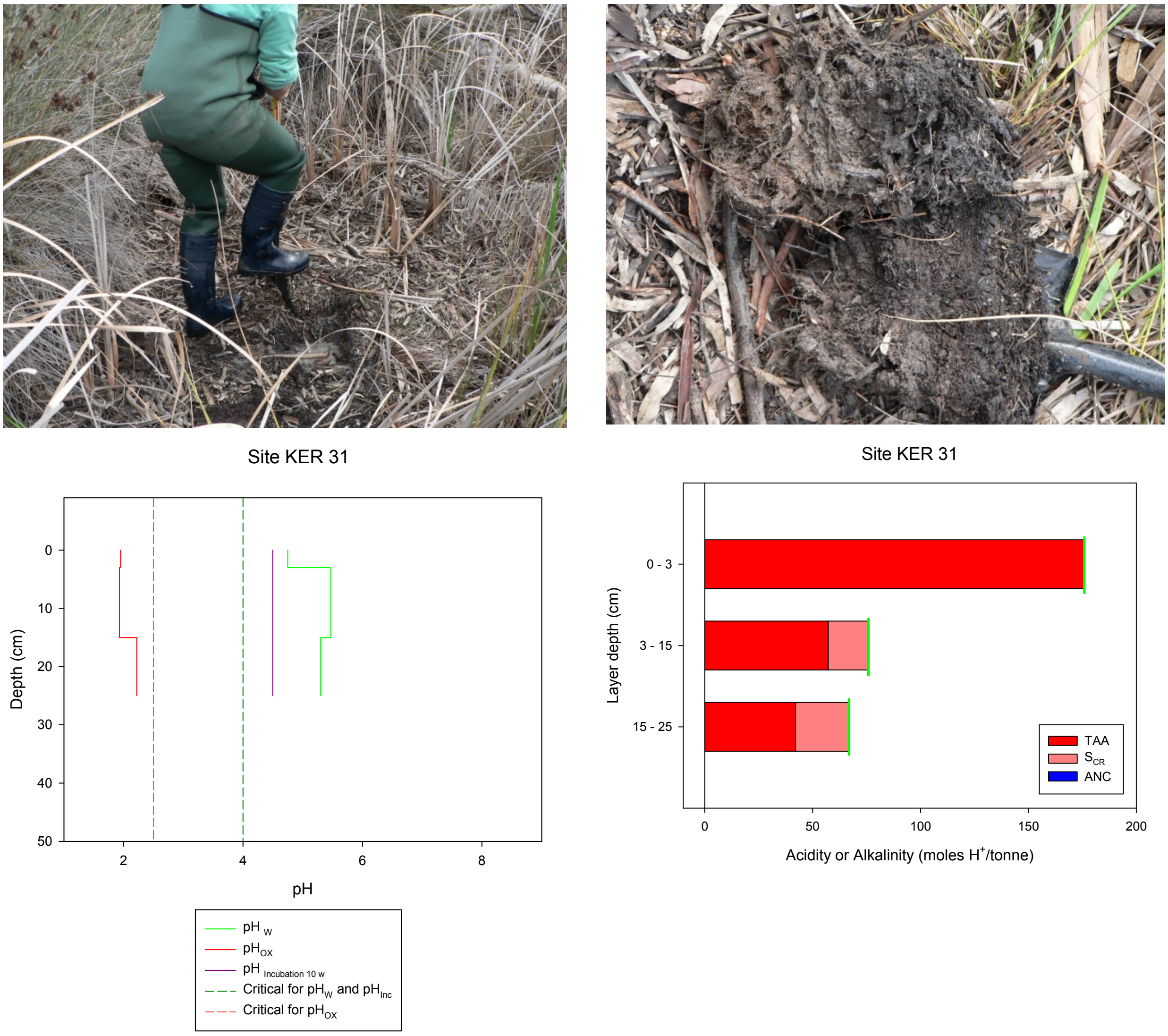
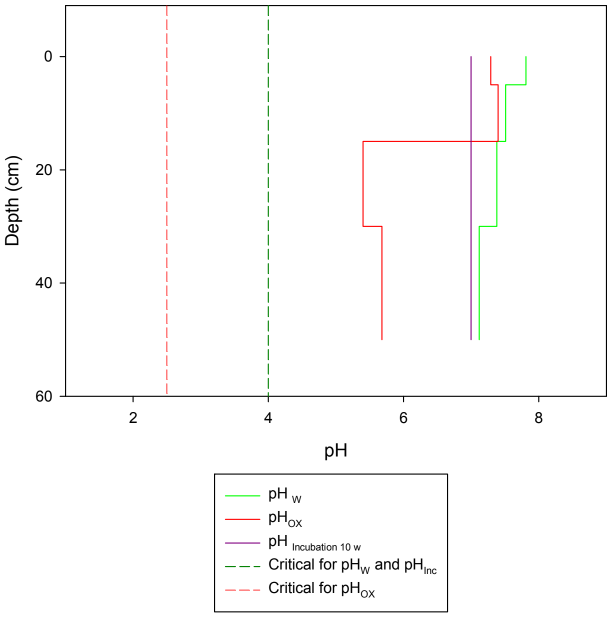


Figure 3-1 Acid sulfate soil characteristics for site KER 31. Soil pH (pH_W, solid green line), peroxide pH (pH_{OX}, solid red line) and incubation pH ($pH_{INCUBATION}$ after 19 weeks, solid purple line). Dashed lines show the critical values for pH_W/$pH_{INCUBATION}$ and pH_{OX}. Right Plot: TAA (red bar), S_{CR} (pink bar), ANC (blue bar) and Net Acidity (green line).

Site KER 3



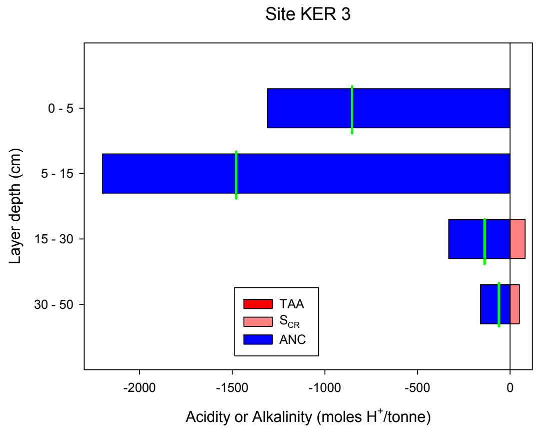


Figure 3-2 Site KER 3. Soil pH (pH_W, solid green line), peroxide pH (pH_{OX}, solid red line) and incubation pH ($pH_{INCUBATION}$ after 19 weeks, solid purple line)). Dashed lines show the critical values for pH_W/$pH_{INCUBATION}$and pH_{OX}. Right Plot: TAA (red bar), S_{CR} (pink bar), ANC (blue bar) and Net Acidity (green line).

Representative photographs are provided in Appendix 5 for the wetlands targeted during this study. Graphs showing the down profile distribution of acid sulfate soil characteristics are also provided in Appendix 5 (refer to Figure 7-1 to Figure 7-32).

3.1.6. Water Soluble SO_4

Water soluble sulfate data for the Kerang Wetlands Ramsar sites is presented in Appendix 4 and summarised in Table 3-21. The water soluble sulfate values were measured on 95 soil samples and values ranged between 11 and 6056 mg kg^{-1} SO_4, with a median value of 99 mg kg^{-1} SO_4. Concentrations were generally highest at or near the surface of soil profiles and decreased with increasing depth. The water soluble sulfate content of near surface soils exceeded the trigger value of 100 mg kg^{-1} SO_4 in 19 profiles. These results suggest that the formation of monosulfides is likely to occur upon rewetting dry wetlands within the Kerang Wetlands Ramsar site.

3.2. Hydrogeochemistry

Surface water samples were collected from 13 wetlands within the Kerang Wetlands Ramsar site. All field and laboratory hydrochemical measurements are provided in Appendix 4. A summary of the field hydrochemical characteristics are shown on Table 3-2.

Surface water samples were slightly alkaline to neutral (median pH 8.5) and slightly saline (median SEC of 303 µS cm^{-1}) (Table 3-2). Salinity measurements however, varied greatly across the site and ranged from 83 µS m^{-1} at site KER 26 to 146,600 µS cm^{-1} at site KER 20 (refer to Appendix 4). The dissolved oxygen (DO) and redox potential (Eh) indicated surface waters conditions range from slightly reducing to oxidising conditions (median DO of 11.3 mg L^{-1} and Eh of 300 mV). All surface waters contained a moderate amount of alkalinity (median value of 57 mg L^{-1} as HCO_3). Turbidity values ranged from 45 to 91 NTU (Table 3-2).

Table 3-2 Summary of surface water data

	pH	SEC µS cm^{-1}	DO mg L^{-1}	Eh mV	Turbidity NTU	Alkalinity mg L^{-1} as HCO_3
minimum	7.1	83	4.1	43	45	28
median	8.5	303	11.3	300	68	57
maximum	9.0	146,600	13.6	377	91	341
[1]**n**	12	13	12	12	4	11

[1]n: number of samples.

Surface water quality data for major elements and nutrients were determined for 13 sites, and are summarised in Table 3-3. A full list of the data is presented in Appendix 4. The major element hydrochemistry shows that calcium and bicarbonate were enriched at hypersaline sites. Sulfate was slightly depleted relative to a dilute seawater for all sites (i.e. all SO_4/Cl^- values were below 0.5).

Nutrient concentrations vary, with total and reactive phosphorus as well as ammonium above guideline trigger values for physical and chemical stressors (ANZECC and ARMCANZ 2000) at sites KER 4, KER 20, KER 22, KER 24 and KER 28 (Table 3-3). Ammonium was also above guideline trigger values for sites KER 6, KER 8, KER 12 and KER 26. Nitrate was below guideline values in all samples.

Selected minor elements are shown in Table 3-4. Concentrations are above ANZECC and ARMCANZ (2000) guideline trigger values for the protection of aquatic ecosystems (99% of species value) for aluminium, boron, manganese, silver, chromium, nickel, copper, zinc, arsenic, lead and cadmium. Aluminium exceeded the trigger value at all but three sites (KER 4, KER 22 and KER 24). However the solubility of aluminium at the measured pH values (near neutral) is much lower than the measured concentration and the elevated value must result from either colloidal or organically-complexed aluminium that passed through the 0.45 µm membrane filter. Boron, manganese, silver, nickel, copper, zinc, arsenic and lead significantly exceeded guideline values at sites KER 20, KER 22 and KER 24. Manganese and zinc exceeded guideline values at all sites sampled (Table 3-4). These wetlands also contained the highest concentration of nutrients, sulfate and EC. Cadmium concentrations were above guideline vales for sites KER 22, KER 28 and KER 30. The exceedances may be a result of the drying or rewetting events that disturb bottom sediments (i.e. monosulfides). They may also be related to metal complexation with the high level of dissolved organic carbon in the water bodies.

Table 3-3 Major element and nutrient laboratory data for the surface water samples from Kerang Wetlands Ramsar site

Parameter	Unit	[1] Trigger values		Site ID										
		Rivers	Lakes	KER 4	KER 6	KER 8	KER 10	KER 12	KER 18	KER 20	KER 22	KER 24	KER 26	KER 28
pH		6.5–9.0	6.5–9.0	8.3	7.2	7.0	8.4	7.1	8.3	8.0	7.0	7.1	6.9	7.2
E.C.	dS m^{-1}			13.1	0.40	0.36	3.4	0.30	3.4	112	59	66	0.18	0.23
Alkalinity	meq L^{-1}			4.9	0.9	0.5	3.7	0.8	3.7	5.4	33	28	0.5	0.8
NH_4-N	mg L^{-1}	0.1	0.025	16	0.060	0.050	0.015	0.078	0.012	4.3	19	15	0.036	0.33
NO_x-N	mg L^{-1}	0.1	0.1	1.17	0.14	0.070	0.008	0.28	<0.005	<0.05	<0.05	<0.05	0.031	0.77
NO_2-N	mg L^{-1}			0.205	0.007	0.008	<0.005	0.039	<0.005	0.008	0.042	0.067	0.017	0.013
PO_4-P	mg L^{-1}	0.04	0.01	4.7	<0.002	0.021	0.015	0.10	0.006	0.039	2.8	1.6	0.070	0.21
F^-	mg L^{-1}			<1	0.08	0.07	0.3	0.10	0.2	<25	<25	<25	0.07	0.12
Cl^-	mg L^{-1}			4810	85	74	939	48	938	125000	176000	174000	10	52
Br^-	mg L^{-1}			15	0.24	0.19	2.9	0.12	2.8	325	2026	1258	<0.05	0.31
$SO_4^=$	mg L^{-1}			890	13	16	252	13	253	12700	54400	42200	3.7	2.7
Ca	mg L^{-1}			280	11	10	62	12	63	930	139	166	4.3	13.7
K	mg L^{-1}			15	3.2	2.0	12	2.8	12	171	1090	1640	1.8	3.8
Mg	mg L^{-1}			490	13	9.2	83	8.7	84	10600	51000	40000	3.7	10.5
Na	mg L^{-1}			2400	48	45	580	40	620	65000	44000	57000	12	40.4
S	mg L^{-1}			310	4.9	5.9	87	5.3	89	4200	17400	13600	1.7	3.3
NPOC	mg L^{-1}			17	11	6.9	14	11	14	24	6.2	5.3	14	104
TN	mg L^{-1}	1	1	14	0.80	0.40	1.0	1.1	1.0	12	21	23	1.3	6.6
P	mg L^{-1}	0.1	0.025	4.5	< 0.03	0.16	< 0.03	0.04	< 0.03	9.8	3.9	8.8	< 0.03	0.24

[1] Trigger values are the default for physical and chemical stressors for the low rainfall areas south central Australia lowland lakes and rivers (ANZECC and ARMCANZ, 2000). There are no trigger values for wetlands. Units are mg L^{-1} unless otherwise indicated.

Table 3-4 Minor element laboratory data for surface water samples from Kerang Wetlands Ramsar sites.

Site ID		[1]Trigger value	KER 4	KER 6	KER 8	KER 10	KER 12	KER 18	KER 20	KER 22	KER 24	KER 26	KER 28	KER 30	KER 32
Al	mg L^{-1}	**0.027**	< 0.01	0.10	0.17	0.11	0.62	0.08	0.50	< 0.2	< 0.2	0.30	0.15	0.13	0.28
B	mg L^{-1}	**0.09**	0.55	0.02	0.03	0.26	0.04	0.25	12	67	47	0.02	0.03	0.02	0.03
Fe	mg L^{-1}		0.03	0.26	0.28	0.08	1.1	0.05	0.88	< 0.4	< 0.4	0.54	1.3	0.22	0.43
Mn	mg L^{-1}	**1.2**	57	32	8.2	3	25	2.2	1572		1024	9.4		4.0	8.3
Ag	µg L^{-1}	**0.02**	0.04	<0.01	<0.01	<0.04	<0.01	<0.01	0.6	1.4	0.8	<0.01	<0.01	<0.01	<0.01
Zr	µg L^{-1}		0.35	0.22	0.10	0.5	0.49	0.81	5.8	14	8.8	0.13	2.3	0.14	0.26
Sn	µg L^{-1}		3.0	1.0	3.0	21	3.4	5.5	24	20	12	7.8	37	41	5.2
V	µg L^{-1}		0.6	0.5	0.9	3.6	5.3	5.9	2.4	27	7.2	1.9	2.6	0.8	1.7
Cr	µg L^{-1}	**0.01**	<0.3	0.10	0.25	<0.5	1.2	0.16	<2	1	<2	0.45	1.1	0.25	0.55
Co	µg L^{-1}		0.36	0.16	0.16	0.11	0.58	0.17	6	7.8	6	0.32	3.7	0.13	0.24
Ni	µg L^{-1}	**8**	1.8	1.0	0.81	1.2	2.1	1.6	21	53	64	1.1	15	0.84	1.2
Cu	µg L^{-1}	**1**	0.9	0.72	1.3	0.8	2.7	1.2	4.0	6.5	8.0	2.0	9.2	1.4	1.7
Zn	µg L^{-1}	**2.4**	20	5.4	32	33	27	8.7	30	24	30	23	23	25	40
As	µg L^{-1}	[2] **1 or 0.8**	1	0.8	0.6	2	1.4	4.4	80	315	192	0.8	3.8	0.4	0.8
Pb	µg L^{-1}	**1.0**	0.1	<0.02	<0.02	<0.2	<0.02	0.06	1.6	6.0	6.4	<0.02	0.02	<0.02	<0.02
Se	µg L^{-1}		<0.5	<0.1	<0.1	<1	<0.1	0.1	<4	30	8	<0.1	0.5	<0.1	<0.1
Mo	µg L^{-1}		<2	<0.3	<0.3	<3	<0.3	0.9	<10	<8	<10	<0.3	<0.3	<0.3	<0.3
Cd	µg L^{-1}	**0.06**	<0.5	<0.1	<0.1	<1	<0.1	<0.1	<4	6	<4	<0.1	0.5	0.6	<0.1

[1] Trigger values are the default for physical and chemical stressors for the low rainfall areas south central Australia lowland lakes and rivers (ANZECC and ARMCANZ 2000). There are no trigger values for wetlands. [2] Values for As^{III} and As^{V}, respectively.

4. HAZARD ASSESSMENT

4.1. Interpretation of soil and water data

Table 4-1 provides a summary of acid sulfate soil materials identified within soil profiles assessed at the Kerang Wetlands Ramsar site.

Table 4-1 Summary of acid sulfate soil types in the Kerang Wetlands Ramsar site

Type of acid sulfate soil material	Number of sampling sites containing acid sulfate soil material (Total sites = 32 but some sites have more than one material)	Portion of total sampling sites (%)
Sulfuric	0	0
Hypersulfidic	1	3%
Hyposulfidic ($S_{CR} \geq 0.10\%$)	9	28%
Monosulfidic (observed)	4	13%
Monosulfidic (potential)	19	59%
Hyposulfidic ($S_{CR} < 0.10\%$)	17	53%
Other acidic (pH_w &/or $pH_{INCUBATION}$ 4 – 5.5)	14	44%
Other soil materials ($pH_w > 5.5$)	18	56%

The actual and potential acidity within the Kerang Wetlands Ramsar site is substantial, and spatially extensive. However, in the Kerang Wetland Ramsar site, soils that classified as 'other acidic soil materials' generally contained the higher actual acidity (as TAA) and net acidity values than the acid sulfate soil materials and therefore present a higher acidity hazard.

Soil pH_W measurements indicated that no soils contained sulfuric material. The single site that contained hypersulfidic material had an initial S_{CR} value of 0.03%, and presents a moderate acidity hazard. Soil pH incubation experiments indicated that the majority of sulfidic soils classified as hyposulfidic, as $pH_{INCUBATION}$ remained above 4. Nine soil profiles at six of the lakes sampled contained hyposulfidic material (S_{CR}>0.1%) (Table 4-2). However, only two of the nine soil profiles which contained hyposulfidic materials (S_{CR}>0.1%) had a positive net acidity (KER 5 and KER 6). Respectively, these two soil profiles present a high and moderate acidity hazard (Table 4-2).

Four sites were found to contain observable monosulfidic materials and 19 soil profiles had a significant monosulfide formation potential.

The potential hazards at a wetland-scale posed by sulfidic acid sulfate soil materials at the Kerang Wetlands Ramsar site are as below:

- **Acidification:** Based on net acidity data the degree of acidification hazard was high at three sites, which contained sulfidic materials with a net acidity of >100 mole H^+/tonne. A moderate sulfidic acidification hazard was identified at 7 sulfidic sites which contained either hypersulfidic material or hyposulfidic material with 19-100 mole H^+/tonne. There are also 5 non-sulfidic sites with "Other acidic material" with 19-100 mole H^+/tonne, where all sulfidic material may have been oxidised. Seventeen profiles contained only low or negative net acidity values.
  In summary soil pH and net acidity data suggests that:
  - Soil profiles KER 1, 2, 5, 6, 7, 8, 16, 27, 28, 29, 30, 31 and 32 have acidified or would likely acidify if oxidised fully.
  - Soil layers within soil profiles KER 15, 17, 18, 25 and 26 may acidify slightly if oxidised fully.
  - Soil profiles KER 3, 4, 9, 10, 11, 12, 13, 14, 19, 20, 21, 22, 23 and 24 would be expected to remain alkaline if oxidised fully.

- **Deoxygenation:** The water soluble sulfate contents of 19 near surface soil materials were over the trigger value for potential monosulfide formation indicating the possible development of an appreciable deoxygenation hazard after prolonged wet conditions. In addition MBOs were observed at 4 of these sites.
- **Metal mobilisation:** The moderate to high acidification hazard indicates that soil acidification is likely to increase the solubility of metals. The widespread potential for monosulfide formation and presence of MBO observed in the Kerang Wetlands Ramsar site may also result in an appreciable metal release hazard, depending on the metal loading within the soils and water at a particular wetland.

The association between hazard type, soil materials and wetland type are summarised in Table 4-2.

Table 4-2 **Hazard characterisation for the Kerang Wetlands Ramsar site for each wetland surveyed.**

Wetland Name	Sampling sites	Water status at time of sampling	Acid sulfate soil subtype class	Hazard			Wetland Category
				Acidification	Metal mobilisation	De-oxygenation of water	
Town and Back Swamp	KER 5, 6	Wet	***Hyposulfidic (S_{CR}% >0.1)*** – clay	H	H	H	Shallow freshwater marsh
Third Lake	KER 31, 32	Wet	***Hyposulfidic*** – clay	H	H	H	Permanent open freshwater
Middle Lake	KER 7, 8	Wet	***Other acidic soil*** – clay	H	H	H	Permanent open freshwater
Reedy Lake	KER 29, 30	Wet	***Hyposulfidic*** – sand	M	H	H	Permanent open freshwater
Lake Bael Bael	KER 15, 16	Dry	***Hyposulfidic*** – clay	M	H	H	Permanent open freshwater
Hird Swamp	KER 1, 2	Dry	***Other acidic soil*** – clay	M	M	H	Deep freshwater marsh
Lake Charm	KER 17	Wet	***Hypersulfidic*** – sand	M	M	L	Permanent open freshwater
Lake Charm	KER 18	Wet	***Hyposulfidic*** – clay	M	L	L	Permanent open freshwater
Kow Swamp	KER 25, 26, 27, 28	Wet	***Hyposulfidic*** – clay	M	M	L	Permanent open freshwater
Little Lake Charm	KER 9, 10	Wet	***Hyposulfidic*** – clay	L	M	H	Permanent open freshwater
Fosters Swamp	KER 3, 4	Wet	***Hyposulfidic (S_{CR}% >0.1)*** – clay	L	M	H	Semi-perm saline
Lake Tutchewop	KER 23, 24	Wet	***Hyposulfidic (S_{CR}% >0.1)*** – clay	L	M	H	Permanent saline
Lake William	KER 21, 22	Wet	***Hyposulfidic (S_{CR}% >0.1)*** – clay	L	M	H	Permanent saline
Lake Kelly	KER 19,	Wet	***Other soil material – clay***	L	M	L	Permanent saline
Lake Kelly	KER 20	Wet	***Hyposulfidic (S_{CR}% >0.1)*** – clay	L	M	L	Permanent saline
Lake Cullen	KER 13, 14	Dry	***Hyposulfidic (S_{CR}% >0.1)*** – clay	L	M	H	Permanent saline
Kangaroo Lake	KER 11, 12	Wet	***Other soil materials*** – clay	L	L	L	Permanent open freshwater

5. CONCLUSIONS

This report provides the results of Phase 1 of a two-phase assessment procedure to determine whether or not acid sulfate soil materials are present at the Kerang Wetlands Ramsar site, and to discuss the hazards posed by the various soil materials identified. In this study, 98 soil layer and mineral samples were analysed from 32 geographically well-distributed and locally representative sites. Soil samples were analysed using standard methods;

i. soil morphology,
ii. field pH testing,
iii. peroxide testing,
iv. acid-base accounting (ABA), and
v. soil incubation (ageing).

Thirteen surface water samples were collected from lakes and analysed to assess water quality.

Sulfuric material was not identified at any of the sites assessed and only one hypersulfidic material was identified.

Hyposulfidic material was identified at 18 of the 32 sites assessed, and nine of these sites contained sulfidic material with contents of S_{CR} >0.10%.

Only 12 of the 32 sites assessed did not contain acid sulfate soils with sulfidic material.

In summary, the overall results indicate that acid sulfate soil materials with sulfidic materials were spatially extensive within the Kerang Wetlands Ramsar site at the time of sampling. However, most of the 12 soils that classified as 'other acidic soil materials' generally contained higher actual acidity (as TAA) and net acidity values than the sulfidic acid sulfate soil materials and therefore present a higher acidity hazard within the Kerang Wetlands Ramsar site. The TAA and net acidity was:

- high at one site with a net acidity of >100 mole $H^+ t^{-1}$,
- moderate at 4 sites with 19-100 mole $H^+ t^{-1}$, and
- low at 7 sites with <19 mole $H^+ t^{-1}$.

Slightly acidic soils, which had a pH_W or $pH_{INCUBATION}$ of less than 5.5, were identified at eight sites, however these soils contained moderate to high net acidity contents.

While monosulfidic material was observed at only four sites, near surface soil material at 19 sites contained water soluble sulfate concentrations exceeded the trigger value of 100 mg kg^{-1} suggesting that monosulfides have potential to form on re-flooding of these soils.

It is recommended that further detailed examination (i.e. Phase 2) be undertaken of environmental hazards posed by the acid sulfate soil materials at the Kerang Wetlands Ramsar site and that the following representative soil materials be considered for Phase 2 work:

- One site based on the presence of hypersulfidic material.
- Nine sites based on the presence of hyposulfidic materials with S_{CR} > 0.10%.

- Eleven additional sites based on monosulfide formation hazard.

Trace metal and metalloid concentrations are elevated relative to guideline values for the protection of freshwater ecosystems. This may be related to the elevated dissolved organic carbon and metal or metalloid complexation and warrants further investigation.

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7. APPENDICES

There are

Appendix 1. Site descriptions

Appendix 2. Soil sample descriptions

Appendix 3. Soil laboratory analytical data

Appendix 4. Hydrochemical data

Appendix 5. Soil pH and net acidity plots, and site photos

APPENDIX 1. SITE DESCRIPTIONS

GENERAL				POSITION			LOCALITY					
Location name	Sampling date (dd/mm/yyyy)	Site code	Layer code	Zone	X	Y	Toposequence Locality (position)	Obs. method	Site (Local name)	Site Water Status	Site Description
Kerang	21/08/2008	KER 1	**KER 1.1**	55H	237712	6028122	2	Field	Macorna North (Lake)	D	Hird Swamp. Totally dry; sampled W of central drain. Two vegetation types - open weedy on lower parts and *Typha/ Phragmites* on higher. Sampled in middle of patch of Typha approx 20m across. Dry and semi flattened.
Kerang	21/08/2008	KER 1	**KER 1.2**	55H	237712	6028122					
Kerang	21/08/2008	KER 2	**KER 2.1**	55H	237745	6028155	3	Field	Macorna North (Lake)	D	Hird Swamp. Totally dry sampled W of central drain. Two vegetation types - open weedy on lower parts and *Typha/ Phragmites* on higher. Sampled about 40m east of KER 1 in lower lying ground; weedy; coarse polygonal cracking evident at surface; approx 10m S of tall Phragmites
Kerang	21/08/2008	KER 2	**KER 2.2**	55H	237745	6028155					
Kerang	21/08/2008	KER 2	**KER 2.3**	55H	237745	6028155					
Kerang	23/08/2008	KER 3	**KER 3.1**	54H	766278	6041634	2	Field	Fosters Swamp (Lake)	D	Occasional samphire, 30 cm from outlet of ponds. No vegetation at site.
Kerang	23/08/2008	KER 3	**KER 3.2**	54H	766278	6041634					
Kerang	23/08/2008	KER 3	**KER 3.3**	54H	766278	6041634					
Kerang	23/08/2008	KER 3	**KER 3.4**	54H	766278	6041634					
Kerang	23/08/2008	KER 3	**KER 3.5**	54H	766278	6041634					
Kerang	23/08/2008	KER 4	**KER 4.1**	54H	766343	6041636	3	Field	Fosters Swamp (Lake)	S	Site ~ 25 m NW of outlet draw from ponds. Smell site.
Kerang	23/08/2008	KER 4	**KER 4.2**	54H	766343	6041636					
Kerang	23/08/2008	KER 4	**KER 4.3**	54H	766343	6041636					
Kerang	22/08/2008	KER 5	**KER 5.1**	54H	762798	6044362	2	Field	Back Swamp (Loddon River)	D	Site in *Juncus*/sedges in dense stands, knee high, 3 m from open water. Surface damp.
Kerang	22/08/2008	KER 5	**KER 5.2**	54H	762798	6044362					
Kerang	22/08/2008	KER 5	**KER 5.3**	54H	762798	6044362					
Kerang	22/08/2008	KER 6	**KER 6.1**	54H	762794	6044351	3	Field	Back Swamp (Loddon River)	M	In Loddon River, 6 m from bank in 60 cm water. Much red floating aquatic plants present.
Kerang	22/08/2008	KER 6	**KER 6.2**	54H	762794	6044351					
Kerang	22/08/2008	KER 6	**KER 6.3**	54H	762794	6044351					

Site water status: D = Dry; M = Moist; S = saturated

GENERAL				POSITION			LOCALITY				
Location name	**Sampling date (dd/mm/ yyyy)**	**Site code**	**Layer code**	**Zone**	**X**	**Y**	**Toposequence Locality (position)**	**Obs. method**	**Site (Local name)**	**Site Water Status**	**Site Description**
Kerang	22/08/2008	KER 7	**KER 7.1**	54H	762791	6044345	1	Field	Middle Lake (south)	D	North of ibis rookery on Middle Lake. Usual sequence of rushes, reeds (*Typha*?) and water. Check a further 50m from reeds shows same soil. Just on reed side of boundary between reeds and rushes; red gums to landward side.
Kerang	22/08/2008	KER 7	**KER 7.2**	54H	762791	6044345					
Kerang	22/08/2008	KER 7	**KER 7.3**	54H	762791	6044345					
Kerang	22/08/2008	KER 8	**KER 8.1**	54H	760060	6048999	2	Field	Middle Lake (south)	M	North of ibis rookery on Middle Lake. Usual sequence of rushes, reeds (*Typha*?) and water. Water sampled 10m beyond reeds. Check a further 50m out from reeds shows same soil. Sampled just beyond reeds.
Kerang	22/08/2008	KER 8	**KER 8.2**	54H	760060	6048999					
Kerang	22/08/2008	KER 8	**KER 8.3**	54H	760060	6048999					
Kerang	21/08/2008	KER 9	**KER 9.1**	54H	755131	6055345	2	Field	Lake Charm (south)	D	Taken 200-300m E of pre-designated site which was on a causeway and disturbed. On S bank of Lake Charm. About 20m SE of KER 10 in middle of patch of *Typha* (?). A bit unusual, compared to adjoining lakes as there are not many reeds around the lake, except on the W and SW sides. Water table at 50cm depth in profile.
Kerang	21/08/2008	KER 9	**KER 9.2**	54H	755131	6055345					
Kerang	21/08/2008	KER 9	**KER 9.3**	54H	755131	6055345					
Kerang	21/08/2008	KER 10	**KER 10.1**	54H	755127	6055354	3	Field	Lake Charm (south)	W	Taken 200-300m E of pre-designated site which was on a causeway and disturbed. On S bank of Lake Charm. Approx 1m on lake side of reeds in 40cm of water.
Kerang	21/08/2008	KER 10	**KER 10.2**	54H	755127	6055354					
Kerang	21/08/2008	KER 10	**KER 10.3**	54H	755127	6055354					
Kerang	22/08/2008	KER 11	**KER 11.1**	54H	750793	6057035	1	Field	Kangaroo Lake	M	At Kangaroo Lake, western side. 20m of rushes in from road then 25m of Phragmites. Difficult to sample. Water starts at boundary of *Phragmites* and rushes. Water samples off shore beyond reeds. Among large rush plants about 15m W of KER 12
Kerang	22/08/2008	KER 11	**KER 11.2**	54H	750793	6057035					
Kerang	22/08/2008	KER 11	**KER 11.3**	54H	750793	6057035					
Kerang	22/08/2008	KER 12	**KER 12.1**	54H	750800	6057032	2	Field	Kangaroo Lake	S	At Kangaroo Lake, western side. 20m of rushes in from road then 25m of Phragmites. Very difficult to sample. Water starts at boundary of *Phragmites* and rushes. Water samples off shore beyond reeds. Sampled at edge of water and where reeds and rushes meet.
Kerang	22/08/2008	KER 12	**KER 12.2**	54H	750800	6057032					
Kerang	22/08/2008	KER 13	**KER 13.1**	54H	750270	6053654	2	Field	Lake Cullen	D	Lake Cullen, western side.
Kerang	22/08/2008	KER 13	**KER 13.2**	54H	750270	6053654					
Kerang	22/08/2008	KER 13	**KER 13.3**	54H	750270	6053654					
Kerang	22/08/2008	KER 13	**KER 13.4**	54H	750270	6053654					
Kerang	22/08/2008	KER 14	**KER 14.1**	54H	750384	6053658	3	Field	Lake Cullen	M	Lake Cullen, western side.
Kerang	22/08/2008	KER 14	**KER 14.2**	54H	750384	6053658					
Kerang	22/08/2008	KER 14	**KER 14.3**	54H	750384	6053658					

GENERAL				POSITION			LOCALITY				
Location name	Sampling date (dd/mm/ yyyy)	Site code	Layer code	Zone	X	Y	Toposequence Locality (position)	Obs. method	Site (Local name)	Site Water Status	Site Description
Kerang	22/08/2008	KER 15	**KER 15.1**	54H	748463	6048919	2	Field	Lake Bael Bael	D	Site 2 m from previous shoreline. Surface covered in abundant self-mulching aggregates over small polyhedral crust plates, 1 - 3 cm thick.
Kerang	22/08/2008	KER 15	**KER 15.2**	54H	748463	6048919					
Kerang	22/08/2008	KER 15	**KER 15.3**	54H	748463	6048919					
Kerang	22/08/2008	KER 16	**KER 16.1**	54H	748383	6048809	3	Field	Lake Bael Bael	D	Located approximately 200 m from KER 15 in flat dry lake bed. Surface flakes approximately 5 mm thick, polyhedral, 1 - 4 cm area.
Kerang	22/08/2008	KER 16	**KER 16.2**	54H	748383	6048809					
Kerang	22/08/2008	KER 16	**KER 16.3**	54H	748383	6048809					
Kerang	22/08/2008	KER 17	**KER 17.1**	54H	755525	6058042	2	Field	Lake Charm (north)	M	Lake Charm NW corner. Sampled on beach approx 3m from water edge. Note a 2m high sand hill behind beach with some rushes and reeds. Further inland is samphire supported by ground water
Kerang	22/08/2008	KER 17	**KER 17.2**	54H	755525	6058042					
Kerang	22/08/2008	KER 18	**KER 18.1**	54H	755525	6058032	3	Field	Lake Charm (north)	S	Lake Charm, NW corner. Sampled 10m off shore in 60cm of water.
Kerang	22/08/2008	KER 18	**KER 18.2**	54H	755525	6058032					
Kerang	22/08/2008	KER 19	**KER 19.1**	54H	755154	6062621	2	Field	Lake Kelly	M	Located on shallow beach. Site approximately 30 m from upper high water mark. Within 5 m of stands of samphire. Thin (2 mm) salt crust on surface. Noted 20 m to east a canal connecting the two lakes containing red precipitate and MBO.
Kerang	22/08/2008	KER 19	**KER 19.2**	54H	755154	6062621					
Kerang	22/08/2008	KER 19	**KER 19.3**	54H	755154	6062621					
Kerang	22/08/2008	KER 19	**KER 19.4**	54H	755154	6062621					
Kerang	22/08/2008	KER 20	**KER 20.1**	54H	755286	6062472	3	Field	Lake Kelly	S	Site approximately 2 m from current shoreline. Down-wind there is a build-up of foam contributing to salt crust formation. Below water line salt has encrusted on filamentous algae, causing "petrified" algae. Water depth 15 cm.
Kerang	22/08/2008	KER 20	**KER 20.2**	54H	755286	6062472					
Kerang	22/08/2008	KER 20	**KER 20.3**	54H	755286	6062472					
Kerang	22/08/2008	KER 21	**KER 21.1**	54H	752844	6064389	2	Field	Lake William	M	Site approximately 15 m from upper shoreline, which is evident by samphire growth. Approximately 30 m north of KER 22.
Kerang	22/08/2008	KER 21	**KER 21.2**	54H	752844	6064389					
Kerang	22/08/2008	KER 21	**KER 21.3**	54H	752844	6064389					

Site water status: D = Dry; M = Moist; S = saturated

GENERAL				POSITION			LOCALITY				
Location name	Sampling date (dd/mm yyyy)	Site code	Layer code	Zone	X	Y	Toposequence Locality (position)	Obs. method	Site (Local name)	Site Water Status	Site Description
Kerang	22/08/2008	KER 22	**KER 22.1**	54H	752831	6064336	3	Field	Lake William	S	Lower of the two sites of KER 21-22 toposequence. Approximately 8 m from present shoreline, salt foam blown from lake crystallised at site.
Kerang	22/08/2008	KER 22	**KER 22.2**	54H	752831	6064336					
Kerang	22/08/2008	KER 22	**KER 22.3**	54H	752831	6064336					
Kerang	22/08/2008	KER 22	**KER 22.4**	54H	752831	6064336					
Kerang	22/08/2008	KER 23	**KER 23.1**	54H	748466	6067305	2	Field	Lake Tutchewop	M	Lake Tutchewop shore, approximately 400 m from current shoreline, 30 m from high water mark. Site dry, surface cover of intact large light Grey-white crusts (1-2 m), 2 mm thick.
Kerang	22/08/2008	KER 23	**KER 23.2**	54H	748466	6067305					
Kerang	22/08/2008	KER 23	**KER 23.3**	54H	748466	6067305					
Kerang	22/08/2008	KER 23	**KER 23.4**	54H	748466	6067305					
Kerang	22/08/2008	KER 24	**KER 24.1**	54H	748652	6067353	3	Field	Lake Tutchewop	M	Site 200 m from high water mark.
Kerang	22/08/2008	KER 24	**KER 24.2**	54H	748652	6067353					
Kerang	22/08/2008	KER 24	**KER 24.3**	54H	748652	6067353					
Kerang	22/08/2008	KER 24	**KER 24.4**	54H	748652	6067353					
Kerang	22/08/2008	KER 25	**KER 25.1**	55H	255987	6014118	2	Field	Kow Swamp (south)	M	At SE corner of Kow Swamp through on private property. Old lake edge is approx 60m to SW, water 30m to NE. Sampled at edge of area where rushes are starting to grow and approx 30m from current water's edge
Kerang	21/08/2008	KER 25	**KER 25.2**	55H	255987	6014118					
Kerang	21/08/2008	KER 25	**KER 25.3**	55H	255987	6014118					
Kerang	21/08/2008	KER 25	**KER 25.4**	55H	255987	6014118					
Kerang	21/08/2008	KER 26	**KER 26.1**	55H	256067	6014096	3	Field	Kow Swamp (south)	S	At SE corner of Kow Swamp through on private property. Old lake edge is approx 60m to SW, water 30m to NE. 10-15m from current lake edge in 5cm deep water
Kerang	21/08/2008	KER 26	**KER 26.2**	55H	256067	6014096					
Kerang	21/08/2008	KER 26	**KER 26.3**	55H	256067	6014096					

Site water status: D = Dry; M = Moist; S = saturated

GENERAL				POSITION			LOCALITY				
Location name	Sampling date (dd/mm/ yyyy)	Site code	Layer code	Zone	X	Y	Toposequence Locality (position)	Obs. method	Site (Local name)	Site Water Status	Site Description
Kerang	20/08/2008	KER 27	**KER 27.1**	55H	253293	6019922	2	Field	Kow Swamp (north)	M	At Kow Swamp NE side near water outlets (and to SE of them). About 5m into Phragmites from edge of water; area trampled by cattle
Kerang	20/08/2008	KER 27	**KER 27.2**	55H	253293	6019922					
Kerang	20/08/2008	KER 27	**KER 27.3**	55H	253293	6019922					
Kerang	20/08/2008	KER 28	**KER 28.1**	55H	253283	6019919	3	Field	Kow Swamp (north)	S	At Kow Swamp, NE side near water outlets (and to SE of them). About 10m out into shallow water no more than 10cm deep. Degraded Phragmites and many logs
Kerang	20/08/2008	KER 28	**KER 28.2**	55H	253283	6019919					
Kerang	20/08/2008	KER 28	**KER 28.3**	55H	253283	6019919					
Kerang	21/08/2008	KER 29	**KER 29.1**	54H	760412	6048727	2	Field	Reedy Lake (north)	M	On N side of Reedy Lake. A kind of causeway exists between Reedy and Middle Lakes. Approx 1m from water edge among rushes. Two species present, one in water, one on land with finer spiked leaf. Smells sulfidic on digging. Water table at 15cm.
Kerang	21/08/2008	KER 29	**KER 29.2**	54H	760412	6048727					
Kerang	21/08/2008	KER 30	**KER 30.1**	54H	760420	6048714	3	Field	Reedy Lake (north)	S	On N side of Reedy Lake. A kind of causeway exists between Reedy and Middle Lakes. Approx 20m S of KER 29 in 100mm of water
Kerang	21/08/2008	KER 30	**KER 30.2**	54H	760420	6048714					
Kerang	22/08/2008	KER 31	**KER 31.1**	54H	759231	6052225	2	Field	Third Lake	M	Third Lake, western side. Approx 1m E of shore line in Typha, many roots of eucalypts making sampling difficult.
Kerang	22/08/2008	KER 31	**KER 31.2**	54H	759231	6052225					
Kerang	22/08/2008	KER 31	**KER 31.3**	54H	759231	6052225					
Kerang	22/08/2008	KER 32	**KER 32.1**	54H	759225	6052247	3	Field	Third Lake	S	Third Lake, western side. Sampled at outer edge of Typha in 50cm of water
Kerang	22/08/2008	KER 32	**KER 32.2**	54H	759225	6052247					
Kerang	22/08/2008	KER 32	**KER 32.3**	54H	759225	6052247					

Site water status: D = Dry; M = Moist; S = saturated

APPENDIX 2. SOIL SAMPLE DESCRIPTIONS

	DEPTH			TEXTURE	SOIL COLOUR					
Layer code	Upper depth	Lower depth	Depth to water	Class	Moisture Status	Soil Colour	Hue	Value	Chroma	Munsell
KER 1.1	0	18	?	Medium	M	Very Dark Grey	N	2.5	0	N 2.5/0
KER 1.2	18	40		Fine	M	Dark Grey	5Y	4	1	5Y 4/1
KER 2.1	0	8	?	Medium	M	Very Dark Grey	N	2.5	0	N 2.5/0
KER 2.2	8	30		Coarse	M	Dark Grey	5Y	4	1	5Y 4/1
KER 2.3	30	45		Coarse	M	Dark Grey	5Y	4	1	5Y 4/1
KER 3.1	0	5	?	Fine	M	Dark Grey	2.5Y	4	1	2.5Y 4/1
KER 3.2	5	15		Fine	M	Olive Grey	5Y	5	2	5Y 5/2
KER 3.3	15	30		Fine	M	Dark Grey	2.5Y	4	1	2.5Y 4/1
KER 3.4	30	50		Fine	M	Dark Grey	2.5Y	4	1	2.5Y 4/1
KER 3.5	0	1.5		Fine	M	Olive Grey	5Y	5	2	5Y 5/2
KER 4.1	0	3	?	Fine	M	Olive Grey	5Y	5	2	5Y 5/2
KER 4.2	3	20		Fine	M	Dark Grey	2.5Y	4	1	2.5Y 4/1
KER 4.3	20	30		Fine	M	Dark Grey	2.5Y	4	1	2.5Y 4/1
KER 5.1	0	15	?	Medium	M	Dark Grey Brown	10YR	4	2	10YR 4/2
KER 5.2	15	30		Medium	M	Dark Grey Brown	10YR	4	2	10YR 4/2
KER 5.3	30	45		Fine	M	Dark Grey Brown	10YR	4	2	10YR 4/2
KER 6.1	0	15	-60	Fine	M	Dark Grey Brown	10YR	4	2	10YR 4/2
KER 6.2	15	30		Fine	M	Dark Grey Brown	10YR	4	2	10YR 4/2
KER 6.3	30	60		Fine	M	Dark Grey	10YR	4	1	10YR 4/1
KER 7.1	0	8	?	Medium	M					
KER 7.2	8	16		Medium	M					
KER 7.3	16	30		Fine	M					

	DEPTH			TEXTURE	SOIL COLOUR					
Layer code	Upper depth	Lower depth	Depth to water	Class	Moisture Status	Soil Colour	Hue	Value	Chroma	Munsell
KER 8.1	0	8	?	Fine	M					
KER 8.2	8	15		Fine	M					
KER 8.3	15	30		Fine	M					
KER 9.1	0	20	50	Fine	M	Olive Grey	5Y	5	2	5Y 5/2
KER 9.2	20	40		Fine	M	Light Brown Grey	2.5Y	6	2	2.5Y 6/2
KER 9.3	40	50		Fine	M	Light Brown Grey	2.5Y	6	2	2.5Y 6/2
KER 10.1	0	10	-40	Medium	M	Light Brown Grey	2.5Y	6	2	2.5Y 6/2
KER 10.2	10	20		Medium	M	Light Brown Grey	2.5Y	6	2	2.5Y 6/2
KER 10.3	20	30		Fine	M	Light Yellow Brown	2.5Y	6	3	2.5Y 6/3
KER 11.1	0	8	?	Medium	M	Very Dark Brown	10YR	2	2	10YR 2/2
KER 11.2	8	12		Coarse	M	Pale Brown	10YR	6	3	10YR 6/3
KER 11.3	12	25		Medium	M	Very Dark Grey	10YR	3	1	10YR 3/1
KER 12.1	0	10	?	Medium	M	Very Dark Brown	10YR	2	2	10YR 2/2
KER 12.2	10	20		Medium	M	Very Dark Brown	10YR	2	2	10YR 2/2
KER 13.1	0	2	?	Fine	M	Greyish Brown	2.5Y	5	2	2.5Y 5/2
KER 13.2	2	12		Fine	M	Grey	2.5Y	5	1	2.5Y 5/1
KER 13.3	12	25		Fine	M	Olive Grey	5Y	5	2	5Y 5/2
KER 13.4	25	45		Fine	M	Olive Grey	5Y	5	2	5Y 5/2
KER 14.1	0	5	?	Medium	M	Dark Grey Brown	2.5Y	4	2	2.5Y 4/2
KER 14.2	5	15		Fine	M	Dark Grey	2.5Y	4	1	2.5Y 4/1
KER 14.3	15	25		Fine	M	Dark Grey	2.5Y	4	1	2.5Y 4/1

	DEPTH			TEXTURE	SOIL COLOUR					
Layer code	Upper depth	Lower depth	Depth to water	Class	Moisture Status	Soil Colour	Hue	Value	Chroma	Munsell
KER 15.1	0	10	?	Fine	M	Very Dark Grey Brown	10YR	3	2	10YR 3/2
KER 15.2	10	30		Fine	M	Very Dark Grey Brown	10YR	3	2	10YR 3/2
KER 15.3	30	40		Fine	M	Light Yellow Brown	2.5Y	6	3	2.5Y 6/3
KER 16.1	0	10	?	Fine	M	Very Dark Grey	10YR	3	1	10YR 3/1
KER 16.2	10	20		Fine	M	Dark Grey	10YR	4	1	10YR 4/1
KER 16.3	20	30		Fine	M	Dark Grey	10YR	4	1	10YR 4/1
KER 17.1	0	20	?	Coarse	M	Pink	7.5YR	7	4	7.5YR 7/4
KER 17.2	20	40		Coarse	M	Very Dark Grey Brown	10YR	3	2	10YR 3/2
KER 18.1	0	8	-60	Medium	M	Very Dark Grey Brown	10YR	3	2	10YR 3/2
KER 18.2	8	25		Medium	M	Very Dark Grey Brown	10YR	3	2	10YR 3/2
KER 19.1	0	5	?	Medium	M	Very Dark Grey Brown	2.5Y	3	2	2.5Y 3/2
KER 19.2	5	18		Medium	M	Greyish Brown	2.5Y	5	2	2.5Y 5/2
KER 19.3	18	28		Medium	M	Dark Grey Brown	2.5Y	4	2	2.5Y 4/2
KER 19.4	28	40		Fine	M	Olive Grey	5Y	4	2	5Y 4/2
KER 20.1	0	1	-15	Fine	M	Pale Yellow	5Y	8	4	5Y 8/4
KER 20.2	1	5		Fine	M	Olive	5Y	5	3	5Y 5/3
KER 20.3	5	25		Fine	M	Olive	5Y	5	3	5Y 5/3
KER 21.1	0	10	?	Fine	M	Light Olive Brown	2.5Y	5	3	2.5Y 5/3
KER 21.2	10	40		Fine	M	Light Yellow Brown	2.5Y	6	3	2.5Y 6/3
KER 21.3	40	55		Medium	M	Light Yellow Brown	2.5Y	6	3	2.5Y 6/3

	DEPTH			TEXTURE	SOIL COLOUR					
Layer code	Upper depth	Lower depth	Depth to water	Class	Moisture Status	Soil Colour	Hue	Value	Chroma	Munsell
KER 22.1	0	10	?	Fine	M	White	N	8	0	N 8/0
KER 22.2	10	30		Fine	M	Olive Grey	5Y	5	2	5Y 5/2
KER 22.3	30	50		Medium	M	Very Dark Grey	N	2.5	0	N 2.5/0
KER 22.4	50	70		Coarse	M	Greenish Grey	5GY	5	1	5GY 5/1
KER 23.1	0	5	?	Medium	M	Light Yellow Brown	2.5Y	6	3	2.5Y 6/3
KER 23.2	5	15		Fine	M	Dark Grey	2.5Y	4	1	2.5Y 4/1
KER 23.3	15	35		Fine	M	Light Olive Grey	5Y	6	2	5Y 6/2
KER 23.4	0	0.5		Fine	M	White	N	8	0	N 8/0
KER 24.1	0	2	?	Fine	M	Greyish Brown	2.5Y	5	2	2.5Y 5/2
KER 24.2	2	18		Fine	M	Dark Grey	10YR	4	1	10YR 4/1
KER 24.3	18	25		Fine	M	Olive Grey	5Y	5	2	5Y 5/2
KER 24.4	25	40		Fine	M	Olive Grey	5Y	5	2	5Y 5/2
KER 25.1	0	2	?	Medium	M	Greyish Brown	2.5Y	5	2	2.5Y 5/2
KER 25.2	2	15		Fine	M	Grey	2.5Y	5	1	2.5Y 5/1
KER 25.3	15	30		Fine	M	Grey	2.5Y	5	1	2.5Y 5/1
KER 25.4	30	45		Fine	M	Grey	2.5Y	5	1	2.5Y 5/1
KER 26.1	0	10	?	Fine	M	Dark Greyish Brown	2.5Y	4	2	2.5Y 4/2
KER 26.2	10	25		Fine	M	Grey	2.5Y	5	1	2.5Y 5/1
KER 26.3	25	55		Fine	M	Grey	2.5Y	5	1	2.5Y 5/1

	DEPTH			TEXTURE	SOIL COLOUR					
Layer code	Upper depth	Lower depth	Depth to water	Class	Moisture Status	Soil Colour	Hue	Value	Chroma	Munsell
KER 27.1	0	3	?	Medium	M	Dark Brown	10YR	3	3	10YR 3/3
KER 27.2	3	15		Fine	M	Dark Grey	2.5Y	4	1	2.5Y 4/1
KER 27.3	15	30		Fine	M	Dark Grey	2.5Y	4	1	2.5Y 4/1
KER 28.1	0	3	-10	Medium	M	Very Dark Grey	7.5YR	2.5	1	7.5YR 2.5/1
KER 28.2	3	15		Fine	M	Dark Grey	2.5Y	4	1	2.5Y 4/1
KER 28.3	15	25		Fine	M	Dark Grey	2.5Y	4	1	2.5Y 4/1
KER 29.1	0	18	15	Coarse	M					
KER 29.2	18	40		Fine	M					
KER 30.1	0	5	?-100	Fine	M					
KER 30.2	5	30		Coarse	M					
KER 31.1	0	3	?	Medium	M	Very Dark Brown	10YR	2	2	10YR 2/2
KER 31.2	3	15		Medium	M	Very Dark Grey Brown	10YR	3	2	10YR 3/2
KER 31.3	15	25		Medium	M	Dark Greyish Brown	10YR	4	2	10YR 4/2
KER 32.1	0	2	-50	Medium	M	Pale Brown	10YR	6	3	10YR 6/3
KER 32.2	2	15		Medium	M	Very Dark Grey	10YR	3	1	10YR 3/1
KER 32.3	15	25		Medium	M	Very Dark Greyish Brown	10YR	3	2	10YR 3/2

	LAYER MORPHOLOGY
Layer code	Description
KER 1.1	Soft dark brown to black peat; hemic or sapric; some small pellets (5-10%); many fine and medium roots; sharp to
KER 1.2	Grey clay; 5-10% diffuse orange brown mottles; common fine and medium roots at least at top; medium polyhedral;/ breaking to fine granular
KER 2.1	Soft brown (dry) peaty surface layer; sapric; coarse columnar cracking to at least 40cm with peaty material falling down; clear to
KER 2.2	Brownish grey organic clay; many fine roots with orange brown mottles and flecks of MnO_2; firm to hard breaking to fine blocky
KER 2.3	Dark grey clay; hard; ped surfaces with coatings of very pale grey sand
KER 3.1	Pale grey surface (dry); olive-grey medium heavy clay, moderate polyhedral; no smell; no roots; few fine voids; moist reddish brown mottles on channels (1%). Fine stable fragments.
KER 3.2	Paler light olive-grey medium heavy clay; medium to coarse sub angular blocky "pellets"; diffuse brown mottles (1-2%); about 2-3 cm of bleach above boundary. Abrupt boundary to.
KER 3.3	Dark grey heavy clay; medium to strong coarse prismatic breaking to medium blocky; many decomposing charcoal and fine roots; coarse black mottles on surface and within peds; this layer is wet with water passing through coarser voids.
KER 3.4	Dark grey heavy clay; coarse black mottles, common medium to fine roots (old). Slight smell; strong medium possible lenticular structure.
KER 3.5	Separated crust.
KER 4.1	Black MBO (N>2), abrupt boundary to
KER 4.2	Very dark grey medium heavy clay of heavy clay; strong sub angular blocky or lenticular; few fine roots; common brown decaying wood; few medium black mottles; clear boundary to.
KER 4.3	Grey to slightly olive grey heavy clay; common diffuse brown mottles; common fine root (relict); weak sulfidic smell.
KER 5.1	Grey-brown fibric peat, massive structure. Many very coarse live and decomposing roots.
KER 5.2	Grey-brown clayey fibric peat, massive structure. Very coarse roots, live and dead.
KER 5.3	Bluish-grey heavy clay, massive structure. Many fine roots, coarse decaying woody material. Few coarse diffuse dark mottles.
KER 6.1	Olive-grey sapric gel, N>2. Few coarse decaying plant matter, generally composed of leaves. Few fine roots. Few fine charcoal fragments.
KER 6.2	Olive grey heavy clay, weak structure, almost a gel. Pellet-like peds present. Few medium roots. Few coarse decaying woody material.
KER 6.3	Dark grey heavy clay, massive. Breaks down into small (5 mm) aggregates in hand. Many coarse decaying woody material.
KER 7.1	Dark brown peat; many medium roots; hemic or sapric; water table at 8cm; clear boundary to
KER 7.2	Dark greyish brown peat with some clay
KER 7.3	Brownish grey heavy clay

	LAYER MORPHOLOGY
Layer code	Description
KER 8.1	Thin algal gel then brownish grey soft clay with 5% diffuse brown mottles; some small aquatic plants growing roots; clear boundary to
KER 8.2	Grey clay soft and 'pellety'; abrupt boundary to
KER 8.3	Grey clay; columnar structure with “pellet” material down cracks; common (15%) orange brown mottling around fine roots
KER 9.1	Grey brown clay with small flecks of what could be $CaCO_3$; organic with many fine roots of *Typha* and decomposing root sheaths; grades to
KER 9.2	Grey gritty clay with $CaCO_3$; 10% orange brown mottles on root channels; 20% pale soft calcareous material; patches of bluish Grey clay; gradual boundary to
KER 9.3	Bluish grey gritty clay with brownish mottles along root channels. Gritty material is $CaCO_3$
KER 10.1	Thin surface coating of algae and sand (3mm) overlying greenish grey clay with much gritty carbonate; patches of near black soft MBO material; boundary clear to
KER 10.2	Simular to above but with few orange brown mottles (1-3%); greenish grey gritty clay; perhaps less gritty but approx 20% pale patches of soft carbonate; clear to
KER 10.3	More yellowish grey clay with calcareous grit and few browner mottles
KER 11.1	Brown peaty material with some fine sand; many fine roots; abrupt boundary to
KER 11.2	Pale pinkish/reddish coarse sand; common medium roots; clear boundary to
KER 11.3	Grey to olive grey clay. Sandy towards top and very little at 25cm
KER 12.1	Brown organic peaty material; may be hemic; coarse roots and decomposing litter
KER 12.2	Very dark grey sandy loam to loamy sand; organic; with some pale grey patches
KER 13.1	Greyish yellow crust, hard on surface (top 2mm) breaking to fine crumb; sparse vegetation
KER 13.2	Grey heavy clay with large brown mottles on ped surfaces; friable sub angular blocky structure; bleached layer at 12cm; sharp wavy boundary to
KER 13.3	Olive grey heavy clay with brown mottles along root channels (uncommon); soft crystals of possibly gypsum; coarse columnar structure
KER 13.4	Olive brown heavy clay; small (1-2mm) brown mottles around roots channels
KER 14.1	Peaty surface with very many fine roots grading to granular Grey clay; very few (<5%) diffuse orange mottles around root channels
KER 14.2	Grey clay; granular to subangular blocky with fine roots (fewer than above)
KER 14.3	Grey clay with few roots; massive or coarsely structured

	LAYER MORPHOLOGY
Layer code	**Description**
KER 15.1	Grey-brown clay, weak structure. Many fine and medium orange-brown mottles. Polyhedral surface crust, cracked. Crust approximately 1-3 cm thick. Self-mulching surface aggregates (2 cm) blown by wind in areas.
KER 15.2	Light grey heavy clay, medium structure. Many orange-brown prominent mottles. Few diffused coarse dark mottles.
KER 15.3	Light grey heavy clay, strong structure. Distinct orange to red mottles on faces. Few fine roots with orange mottles along channels. Otherwise few large diffuse dark mottles in matrix.
KER 16.1	Very dark grey heavy clay, weak structure. Common brown mottles. White precipitate, very fine (likely calcrete).
KER 16.2	Dark grey heavy clay, strong structure. Common orange-brown mottles along root voids. Very fine white precipitate forms as ped faces dry on exposure to wind.
KER 16.3	Dark grey heavy clay, strong structure. Many orange-brown mottles on faces and voids, voids few.
KER 17.1	Pale yellowish speckled beach sand. Clear boundary to
KER 17.2	Greenish grey medium to coarse clayey sand; some darker patches which are organic matter associated with old eucalyptus roots; sulfidic smell is strong; diffuse bleached mottles near 20-30cm (5%)
KER 18.1	Dark olive grey clay with paler algal crust of 2-4mm on surface; layered with coarse organic matter (eucalyptus roots) and some coarse sandy clay
KER 18.2	Dark olive grey clayey sand; diffuse black mottles approx 10-15mm; sulfidic smell
KER 19.1	Brown silty loam, strong structure. Many orange-brown mottles with root voids.
KER 19.2	Grey silky loam, strong structure. Common medium and fine roots with prominent orange-brown mottles in root channels.
KER 19.3	Grey silty loam, moderate structure. Many fine roots. Few coarse decaying material.
KER 19.4	Bluish-grey light clay, medium structure. Few orange-brown mottles, fine. Few coarse dead root material, with mottles associated.
KER 20.1	Salt encrusted filamentous algae, hard platy, with sharp boundary to
KER 20.2	Greenish olive gel, sapric material (roots). Few decaying medium roots.
KER 20.3	Bluish grey heavy clay, massive structure. Few coarse fragments of decomposing woody material.
KER 21.1	Light brown light clay, strongly structured. Few fine white efflorescence in voids (gypsum?). Few orange-brown mottles in voids and root channels.
KER 21.2	Light brown medium clay, strong structure. Few coarse darker brown mottles, diffuse. Common very fine roots. Apparent low bulk density.
KER 21.3	Light brown silty clay loam, strong structure. Very "pasty" to the feel. Few fine to medium roots. Few medium dark brown mottles (round). Water table at 55 cm.

	LAYER MORPHOLOGY
Layer code	Description
KER 22.1	Continuous salt crust, hard, concreted. White platy and granular structure.
KER 22.2	Black light clay, massive. MBO. Few coarse roots, N > 2.
KER 22.3	Black clayey sand, massive. Few diffuse large dark Grey mottles.
KER 22.4	Dark green grey medium clay, massive. Coarse sand grains to the feel. N > 2.
KER 23.1	Top layer salt crust with green algae growing on underside. Below, light brown sand, further below, reddish sand. Damp. See chip tray.
KER 23.2	Dark grey medium clay, medium structure. Many small and large cobble-sized nodules throughout the layer. Few medium roots, orange mottles among root channels.
KER 23.3	Light grey-yellow heavy clay, massive structure. Few large cobbles (as above). Few large dark diffuse mottles.
KER 23.4	As above.
KER 24.1	Thick light grey salt crust (1 cm) with pink underside overlaying olive-Grey sand.
KER 24.2	Very dark grey / black light clay, massive (almost gel-like) MBO layer. Strong sulfidic smell.
KER 24.3	Olive grey heavy clay, massive structure. Strong sulfidic smell. Few diffuse large dark mottles.
KER 24.4	Olive grey heavy clay, massive structure. Large diffuse light yellow mottles.
KER 25.1	Pale yellowish grey fine sandy crust, hard to firm on upper 2mm; diffuse orange mottles approx 10%; sharp boundary to
KER 25.2	Grey heavy clay with few roots and 5% orange red mottles, brown ped faces near top; common MnO2 flecks; gradual boundary to
KER 25.3	Grey heavy clay as above with fewer roots
KER 25.4	Bluish Grey heavy clay; no roots; few orange brown mottles near top
KER 26.1	Approx 1cm brownish grey algal gel (some sand) overlying Grey heavy clay; <5% red brown mottles; few fine roots; grades to
KER 26.2	As above; but increasing large bluish grey mottles with depth
KER 26.3	Grey heavy clay, becomes more bluish grey with depth; drier; about 5% mottles more distinct than above to 35cm, below which there are only few (chip tray and bottle only)

	LAYER MORPHOLOGY
Layer code	**Description**
KER 27.1	Fibric peat; browner colour than KER28.1
KER 27.2	Grey heavy clay; much fibric material down cracks (as KER 28.2)
KER 27.3	Grey heavy clay as above; no mottling observed
KER 28.1	Fibric peaty material; abrupt boundary to
KER 28.2	Olive grey heavy clay; coarse structured (columnar) with much organic matter in cracks
KER 28.3	As above; approx 10% orange brown mottles in 20-25cm
KER 29.1	Coarse reddish sand perhaps redder at base; few fine and coarse roots; abrupt boundary to
KER 29.2	Greenish grey heavy clay, not saturated but wet; no mottles except near surface where roots occur
KER 30.1	Green algal gel surface with orange band at about 3-4mm. Green medium sand grading to grey sand; wavy sharp boundary
KER 30.2	Very dark grey or black coarse sand; some inclusions of blue clay, but not common. No smells were noticed.
KER 31.1	Very dark brownish black peat (sapric); clear boundary to
KER 31.2	Dark brown organic matter with heavy clay; many medium roots; sulfidic
KER 31.3	Brown organic matter with some heavy clay; many medium roots; mainly organic matter and roots; sulfidic
KER 32.1	Brown sandy algal surface wavy to irregular but sharp boundary to
KER 32.2	Dark grey coarse sandy clay; probably cracked with sand falling into cracks; coarse roots of reeds at 10-20cm; continues
KER 32.3	As above.

APPENDIX 3. SOIL LABORATORY ANALYTICAL DATA

	Layer depth		$pH_{Incubation}$	pH		S - Suite								
Layer code	Upper depth	Lower depth	19 weeks	pHw	pH_{OX}	Texture	Sulfate* ($mgSO_4$ kg^{-1})	pH_{KCl}	TAA (to pH 6.5) (mole H^+ t^{-1})	Reduced Inorganic Sulfur ($\%S_{CR}$)	$\%S_{CR}$ (as mole H^+ t^{-1})	ANC ($\%CaCO_3$)	NET ACIDITY (based on $\%S_{CR}$) (mole H^+ t^{-1})	ASS Classification
KER 1.1	0	18	4	5.6	2.46	Medium	217	5.21	35.99	0.00	0.00	0.00	35.99	Other Acidic
KER 1.2	18	40	7	7.29	7.54	Fine	69	6.27	3.15	0.00	0.00	0.00	3.15	Other soil material
KER 2.1	0	8	5	5.74	2.64	Medium	114	5.54	28.64	0.00	0.00	0.00	28.64	Other Acidic
KER 2.2	8	30	5	5.65	2.60	Coarse	87	5.36	14.81	0.00	0.00	0.00	14.81	Other Acidic
KER 2.3	30	45	5	6.69	7.41	Coarse	66	5.74	7.30	0.00	0.00	0.00	7.30	Other Acidic
KER 3.1	0	5	7	7.81	7.29	Fine	1078	8.83	0.00	0.00	0.00	6.55	-872.89	Other soil material
KER 3.2	5	15	7	7.51	7.40	Fine	1086	8.71	0.00	0.00	0.00	11.01	-1466.63	Other soil material
KER 3.3	15	30	7	7.38	5.40	Fine	1203	8.44	0.00	0.13	81.08	1.66	-139.61	Hyposulfidic (SCR >0.1%)
KER 3.4	30	50	7	7.12	5.68	Fine	704	7.75	0.00	0.08	49.90	0.80	-56.95	Hyposulfidic
KER 3.5	0	1.5	7			Fine								Other soil material
KER 4.1	0	3	7	7.78	7.27	Fine	488	9.18	0.00	0.14	87.32	13.13	-1661.29	Hyposulfidic (SCR >0.1%)
KER 4.2	3	20	7	8.72	3.95	Fine	287	8.28	0.00	0.15	93.56	0.89	-25.23	Hyposulfidic (SCR >0.1%)
KER 4.3	20	30	7	7.68	8.08	Fine	148	7.42	0.00	0.00	0.00	0.84	-112.26	Other soil material
KER 5.1	0	15	4	6.44	1.89	Medium	113	4.97	50.55	0.04	24.95	0.00	75.50	Hyposulfidic
KER 5.2	15	30	4	6.41	2.28	Medium	99	4.83	52.74	0.11	68.61	0.00	121.35	Hyposulfidic (SCR >0.1%)
KER 5.3	30	45	4	6.44	3.28	Fine	74	4.54	54.46	0.03	18.71	0.00	73.17	Hyposulfidic
KER 6.1	0	15	4	6.85	2.39	Fine	92	5.44	2.03	0.04	24.95	0.00	26.98	Hyposulfidic
KER 6.2	15	30	4	6.67	2.35	Fine	117	5.28	27.58	0.11	68.61	0.00	96.19	Hyposulfidic (SCR >0.1%)
KER 6.3	30	60	4	6.78	2.86	Fine	37	4.84	29.41	0.00	0.00	0.00	29.41	Other Acidic
KER 7.1	0	8	4.5	4.82	2.50	Medium	135	4.23	142.67	0.00	0.00	0.00	142.67	Other Acidic
KER 7.2	8	16	4.5	5.58	2.02	Medium	61	4.64	60.51	0.00	0.00	0.00	60.51	Other Acidic
KER 7.3	16	30	4.7	5.41	2.80	Fine	23	4.62	25.92	0.00	0.00	0.00	25.92	Other Acidic

	Layer depth		$pH_{Incubation}$	pH		S - Suite									
Layer code	Upper depth	Lower depth	19 weeks	pHw	pH_{OX}	Texture	Sulfate* ($mgSO_4$ kg^{-1})	pH_{KCl}	TAA (to pH 6.5) (mole H^+ t^{-1})	Reduced Inorganic Sulfur ($\%S_{CR}$)	$\%S_{CR}$ (as mole H^+ t^{-1})	ANC ($\%CaCO_3$)	NET ACIDITY (based on $\%S_{CR}$) (mole H^+ t^{-1})	ASS Classification
KER 8.1	0	8	4.7	6.25	3.15	Fine	20	5.65	9.44	0.00	0.00	0.00	9.44	Other Acidic
KER 8.2	8	15	4.7	6.35	3.44	Fine	25	5.24	13.47	0.00	0.00	0.00	13.47	Other Acidic
KER 8.3	15	30	5	6.61	5.02	Fine	30	5.40	16.17	0.00	0.00	0.00	16.17	Other Acidic
KER 9.1	0	20	7	6.97	6.07	Fine	1349	8.80	0.00	0.11	68.61	5.47	-659.38	Hyposulfidic (SCR >0.1%)
KER 9.2	20	40	7	7.22	7.82	Fine	291	8.77	0.00	0.08	49.90	16.31	-2121.93	Hyposulfidic
KER 9.3	40	50	7	7.46	7.44	Fine	156	8.59	0.00	0.03	18.71	5.15	-667.27	Hyposulfidic
KER 10.1	0	10	7	8	7.82	Medium	96	8.61	0.00	0.06	37.42	10.04	-1299.91	Hyposulfidic
KER 10.2	10	20	7	7.89	8.08	Medium	63	8.61	0.00	0.03	18.71	13.28	-1750.19	Hyposulfidic
KER 10.3	20	30	7	7.78	7.93	Fine	53	8.67	0.00	0.02	12.47	15.52	-2054.12	Hyposulfidic
KER 11.1	0	8	7	7.13	4.08	Medium	25	7.32	0.00	0.00	0.00	0.40	-53.17	Other soil material
KER 11.2	8	12	7	8	4.47	Coarse	12	7.52	0.00	0.00	0.00	0.08	-11.30	Other soil material
KER 11.3	12	25	7	7.65	6.24	Medium	11	6.93	0.00	0.00	0.00	0.46	-60.68	Other soil material
KER 12.1	0	10	7	7	3.71	Medium	32	6.51	0.00	0.00	0.00	0.34	-45.19	Other soil material
KER 12.2	10	20	7	7.29	4.93	Medium	21	6.50	0.00	0.00	0.00	2.03	-269.87	Other soil material
KER 13.1	0	2	7	7.85	7.58	Fine	6056	8.51	0.00	0.06	37.42	5.28	-665.87	Hyposulfidic
KER 13.2	2	12	7	7.89	7.20	Fine	1223	8.73	0.00	0.12	74.84	2.95	-318.56	Hyposulfidic (SCR >0.1%)
KER 13.3	12	25	7	7.71	6.94	Fine	578	7.69	0.00	0.00	0.00	0.75	-99.90	Other soil material
KER 13.4	25	45	7	7.68	7.78	Fine	516	7.15	0.00	0.00	0.00	1.07	-142.52	Other soil material
KER 14.1	0	5	7	7.3	6.90	Medium	106	8.07	0.00	0.07	43.66	3.25	-389.06	Hyposulfidic
KER 14.2	5	15	7	7.52	6.91	Fine	80	8.24	0.00	0.10	62.37	2.97	-332.99	Hyposulfidic
KER 14.3	15	25	7	7.88	7.15	Fine	28	8.57	0.00	0.00	0.00	0.78	-103.59	Other soil material

	Layer depth		$pH_{Incubation}$	pH		S - Suite								
Layer code	Upper depth	Lower depth	19 weeks	pHw	pH_{OX}	Texture	Sulfate* ($mgSO_4$ kg^{-1})	pH_{KCl}	TAA (to pH 6.5) (mole H^+ t^{-1})	Reduced Inorganic Sulfur ($\%S_{CR}$)	$\%S_{CR}$ (as mole H^+ t^{-1})	ANC ($\%CaCO_3$)	NET ACIDITY (based on $\%S_{CR}$) (mole H^+ t^{-1})	ASS Classification
KER 15.1	0	10	5.3	7.04	4.69	Fine	86	7.64	0.00	0.04	24.95	1.00	-108.17	Hyposulfidic
KER 15.2	10	30	5.3	5.88	3.51	Fine	125	5.58	11.15	0.00	0.00	0.00	11.15	Other Acidic
KER 15.3	30	40	6.1	6.72	5.31	Fine	109	5.93	49.15	0.00	0.00	0.00	49.15	Other soil material
KER 16.1	0	10	7	6.4	3.83	Fine	477	6.37	3.23	0.02	12.47	0.00	15.70	Hyposulfidic
KER 16.2	10	20	5.3	5.72	3.56	Fine	266	5.40	11.10	0.02	12.47	0.00	23.58	Hyposulfidic
KER 16.3	20	30	5.3	6.63	4.45	Fine	150	5.61	12.39	0.02	12.47	0.00	24.86	Hyposulfidic
KER 17.1	0	20	7	8.14	6.60	Coarse								Other soil material
KER 17.2	20	40	2.5	8	6.32	Coarse	43	6.39	2.80	0.03	18.71	0.02	19.26	Hypersulfidic
KER 18.1	0	8	7	8.53	7.33	Medium	98	8.79	0.00	0.08	49.90	2.97	-346.18	Hyposulfidic
KER 18.2	8	25	7	8.84	4.18	Medium	40	7.56	0.00	0.04	24.95	0.05	18.69	Hyposulfidic
KER 19.1	0	5	7	8.05	6.79	Medium	2866	9.09	0.00	0.00	0.00	1.36	-180.73	Other soil material
KER 19.2	5	18	7	7.61	6.36	Medium	876	8.77	0.00	0.00	0.00	1.84	-244.67	Other soil material
KER 19.3	18	28	7	7.91	6.38	Medium	294	8.89	0.00	0.00	0.00	0.41	-54.17	Other soil material
KER 19.4	28	40	7	7.61	7.58	Fine	634	7.79	0.00	0.00	0.00	0.86	-115.17	Other soil material
KER 20.1	0	1	7	7.51	7.36	Fine	2946	9.34	0.00	0.00	0.00	8.10	-1078.32	Other soil material
KER 20.2	1	5	7	7.19	6.29	Fine	4536	9.08	0.00	0.11	68.61	14.19	-1821.50	Hyposulfidic (SCR >0.1%)
KER 20.3	5	25	7	7.26	7.46	Fine	959	9.07	0.00	0.11	68.61	6.65	-817.72	Hyposulfidic (SCR >0.1%)
KER 21.1	0	10	7	8.1	7.39	Fine	5472	9.08	0.00	0.00	0.00	10.13	-1349.76	Other soil material
KER 21.2	10	40	7	7.72	7.86	Fine	3528	8.86	0.00	0.00	0.00	11.46	-1525.94	Other soil material
KER 21.3	40	55	7	7.61	7.80	Medium	3004	8.75	0.00	0.00	0.00	5.53	-736.06	Other soil material

	Layer depth		$pH_{Incubation}$	pH		S - Suite								
Layer code	Upper depth	Lower depth	19 weeks	pHw	pH_{OX}	Texture	Sulfate* ($mgSO_4$ kg^{-1})	pH_{KCl}	TAA (to pH 6.5) (mole H^+ t^{-1})	Reduced Inorganic Sulfur ($\%S_{CR}$)	$\%S_{CR}$ (as mole H^+ t^{-1})	ANC ($\%CaCO_3$)	NET ACIDITY (based on $\%S_{CR}$) (mole H^+ t^{-1})	ASS Classification
KER 22.1	0	10	6.5	6.13	4.73	Fine	99	8.11	0.00	0.00	0.00	0.00	0.00	Other soil material
KER 22.2	10	30	7	7.4	7.20	Fine	5070	8.88	0.00	0.20	124.74	4.65	-494.47	Hyposulfidic (SCR >0.1%)
KER 22.3	30	50	7	7.07	7.62	Medium	4260	8.97	0.00	0.20	124.74	5.11	-555.57	Hyposulfidic (SCR >0.1%)
KER 22.4	50	70	7	7.17	7.33	Coarse	5027	8.66	0.00	0.02	12.47	5.36	-702.14	Hyposulfidic
KER 23.1	0	5	7	7.78	7.26	Medium	2241	8.86	0.00	0.03	18.71	19.55	-2585.35	Hyposulfidic
KER 23.2	5	15	7	7.86	7.59	Fine	2257	8.88	0.00	0.05	31.19	12.67	-1656.46	Hyposulfidic
KER 23.3	15	35	7	6.28	7.28	Fine	371	9.09	0.00	0.00	0.00	25.71	-3424.57	Other soil material
KER 23.4	0	0.5	7			Fine								Other soil material
KER 24.1	0	2	7	7.22	6.64	Fine	4798	9.70	0.00	0.02	12.47	6.24	-818.07	Hyposulfidic
KER 24.2	2	18	7	6.89	6.82	Fine	2187	8.92	0.00	0.22	137.21	13.44	-1652.99	Hyposulfidic (SCR >0.1%)
KER 24.3	18	25	7	7.19	6.49	Fine	755	8.46	0.00	0.09	56.13	0.79	-49.41	Hyposulfidic
KER 24.4	25	40	7	8.73	7.42	Fine	956	8.88	0.00	0.03	18.71	8.46	-1108.47	Hyposulfidic
KER 25.1	0	2	5	6.37	3.28	Medium	28	6.10	3.87	0.00	0.00	0.00	3.87	Other Acidic
KER 25.2	2	15	5	6.58	6.63	Fine	28	5.46	8.98	0.00	0.00	0.00	8.98	Other Acidic
KER 25.3	15	30	5.8	7.16	7.07	Fine	38	5.90	6.62	0.00	0.00	0.00	6.62	Other soil material
KER 25.4	30	45	7	8.22	8.36	Fine	59	6.78	0.00	0.00	0.00	0.38	-50.63	Other soil material
KER 26.1	0	10	5	5.85	4.00	Fine	19	4.89	20.47	0.00	0.00	0.00	20.47	Other Acidic
KER 26.2	10	25	7	7.25	6.80	Fine	28	5.69	6.16	0.00	0.00	0.00	6.16	Other soil material
KER 26.3	25	55	7	7.06	8.02	Fine	56	7.93	0.00	0.00	0.00	0.97	-128.68	Other soil material

	Layer depth		$pH_{Incubation}$	pH		S - Suite								
Layer code	Upper depth	Lower depth	19 weeks	pHw	pH_{OX}	Texture	Sulfate* ($mgSO_4$ kg^{-1})	pH_{KCl}	TAA (to pH 6.5) (mole $H^+ t^{-1}$)	Reduced Inorganic Sulfur ($\%S_{CR}$)	$\%S_{CR}$ (as mole H^+t^{-1})	ANC ($\%CaCO_3$)	NET ACIDITY (based on $\%S_{CR}$) (mole $H^+ t^{-1}$)	ASS Classification
KER 27.1	0	3	4.5	5.96	2.05	Medium	71	4.91	48.4	0.00	0.00	0.00	48.35	Other Acidic
KER 27.2	3	15	4.5	5.19	2.58	Fine	27	4.72	27.6	0.00	0.00	0.00	27.57	Other Acidic
KER 27.3	15	30	4.5	5.96	2.78	Fine	31	4.82	24.2	0.00	0.00	0.00	24.20	Other Acidic
KER 28.1	0	3	5	6.68	2.32	Medium	33	5.54	22.5	0.03	18.71	0.00	41.18	Hyposulfidic
KER 28.2	3	15	5	6.45	4.05	Fine	92	5.29	12.7	0.00	0.00	0.00	12.74	Other Acidic
KER 28.3	15	25	4.7	6.63	2.84	Fine	30	5.62	7.07	0.00	0.00	0.00	7.07	Other Acidic
KER 29.1	0	18	5	6.38	3.17	Coarse	27	5.67	3.19	0.00	0.00	0.00	3.19	Other Acidic
KER 29.2	18	40	4	6.79	6.09	Fine	14	5.63	8.04	0.00	0.00	0.00	8.04	Other Acidic
KER 30.1	0	5	4	6.34	1.93	Fine	24	5.69	2.05	0.03	18.71	0.00	20.76	Hyposulfidic
KER 30.2	5	30	7	6.85	2.26	Coarse	16	5.77	5.65	0.00	0.00	0.00	5.65	Other Acidic
KER 31.1	0	3	4.5	4.75	1.95	Medium	17	4.31	176.1	0.00	0.00	0.00	176.07	Other Acidic
KER 31.2	3	15	4.5	5.47	1.93	Medium	197	4.74	57.3	0.03	18.71	0.00	76.00	Hyposulfidic
KER 31.3	15	25	4.5	5.3	2.22	Medium	64	5.08	42.14	0.04	24.95	0.00	67.09	Hyposulfidic
KER 32.1	0	2	4.2	6.12	2.20	Medium	104	5.32	3.64	0.03	18.71	0.00	22.35	Hyposulfidic
KER 32.2	2	15	4.5	7.01	5.97	Medium	37	5.70	11.68	0.00	0.00	0.00	11.68	Other Acidic
KER 32.3	15	25	7	7.26	6.12	Medium	31	5.98	8.34	0.00	0.00	0.00	8.34	Other soil material

APPENDIX 4. HYDROCHEMICAL DATA

			FIELD SURFACE WATER DATA								
Date sampled	Site ID	GW/SW	Alkalinity (µL)	Alkalinity mg L^{-1} (x 1.2192)	Temp (°C)	EC (µS cm^{-1})	DO (%)	DO (mg L^{-1})	pH	ORP (mV)	Turbidity (NTU)
22/08/2008	KER 4	SW	na	na	na	na	na	na	na	na	na
22/08/2008	KER 6	SW	46	56	11.02	282	116	12.78	7.64	9	78
22/08/2008	KER 8	SW	32	39	12.01	295	107	11.53	8.58	98.1	na
21/08/2008	KER 10	SW	227	277	10.46	30000	110	12.33	8.53	101	na
22/08/2008	KER 12	SW	47	57	7.93	252	92.4	10.99	8.73	97.5	na
22/08/2008	KER 18	SW	212	258	10.21	3068	99	11.01	8.74	113	na
22/08/2008	KER 20	SW	264	322	12.3	146600	120	6.3	8.15	137	57
22/08/2008	KER 22	SW	1359	1657	14.35	103807	64	4.08	7.05	177	44.5
22/08/2008	KER 24	SW	na	na	na	na	na	na	na	na	na
21/08/2008	KER 26	SW	26	32	10.75	83	95.2	10.55	8.27	88	na
20/08/2008	KER 28	SW	63	77	16.6	282	115	10.8	8.38	118	na
21/08/2008	KER 30	SW	31	38	11.75	303	110	12.1	8.27	105	na
22/08/2008	KER 32	SW	23	28	10.7	146	116	12.7	8.99	91.3	na

						LAB WATER DATA						
Site ID	Li (µgL^{-1})	Be (µgL^{-1})	Sc (µgL^{-1})	Ti (µgL^{-1})	V (µgL^{-1})	Cr (µgL^{-1})	Mn (µgL^{-1})	Co (µgL^{-1})	Ni (µgL^{-1})	Cu (µgL^{-1})	Zn (µgL^{-1})	As (µgL^{-1})
KER 4	<10	<0.3	<2	50	0.6	<0.3	57	0.36	1.8	0.9	20	1
KER 6	<2	<0.1	<0.3	<10	0.5	0.10	32	0.16	1.0	0.72	5.4	0.8
KER 8	<2	<0.1	<0.3	<10	0.9	0.25	8.2	0.16	0.81	1.3	32	0.6
KER 10	<20	<0.6	<3	<100	3.6	<0.5	3	0.11	1.2	0.8	33	2
KER 12	<2	0.2	<0.3	<10	5.3	1.2	25	0.58	2.1	2.7	27	1.4
KER 18	<2	<0.1	0.3	20	5.9	0.16	2.2	0.17	1.6	1.2	8.7	4.4
KER 20	320	2	50	<400	2.4	<2	1572	6	21	4.0	30	80
KER 22	4000	16	112	<250	27	1		7.8	53	6.5	24	315
KER 24	3040	6	70	<400	7.2	<2	1024	6	64	8.0	30	192
KER 26	<2	0.1	<0.3	<10	1.9	0.45	9.4	0.32	1.1	2.0	23	0.8
KER 28	<2	<0.1	<0.3	<10	2.6	1.1		3.7	15	9.2	23	3.8
KER 30	<2	<0.1	<0.3	<10	0.8	0.25	4.0	0.13	0.84	1.4	25	0.4
KER 32	<2	<0.1	<0.3	<10	1.7	0.55	8.3	0.24	1.2	1.7	40	0.8

						LAB WATER DATA						
Site ID	Se (µg/L)	Rb (µg/L)	Y (µg/L)	Zr (µg/L)	Nb (µg/L)	Mo (µg/L)	Ru (µg/L)	Pd (µg/L)	Ag (µg/L)	Cd (µg/L)	Sn (µg/L)	Sb (µg/L)
KER 4	<0.5	<5	<0.3	0.35	<1	<2	<0.04	0.1	0.04	<0.5	3.0	<0.4
KER 6	<0.1	<1	0.12	0.22	<0.2	<0.3	<0.01	<0.02	<0.01	<0.1	1.0	<0.08
KER 8	<0.1	<1	0.27	0.10	<0.2	<0.3	<0.01	<0.02	<0.01	<0.1	3.0	<0.08
KER 10	<1	<10	<0.5	0.5	<2	<3	<0.08	<0.2	<0.04	<1	21	<0.8
KER 12	<0.1	<1	1.3	0.49	<0.2	<0.3	<0.01	<0.02	<0.01	<0.1	3.4	<0.08
KER 18	0.1	<1	0.15	0.81	0.4	0.9	<0.01	0.06	<0.01	<0.1	5.5	1.2
KER 20	<4	<40	<2	5.8	32	<10	1.2	1.6	0.6	<4	24	18
KER 22	30	180	4.2	14	60	<8	2.0	6.0	1.4	6	20	50
KER 24	8	<40	<2	8.8	32	<10	1.5	6.4	0.8	<4	12	33
KER 26	<0.1	<1	0.50	0.13	<0.2	<0.3	<0.01	<0.02	<0.01	<0.1	7.8	<0.08
KER 28	0.5	<1	1.3	2.3	<0.2	<0.3	<0.01	0.02	<0.01	0.5	37	0.32
KER 30	<0.1	<1	0.20	0.14	<0.2	<0.3	<0.01	<0.02	<0.01	0.6	41	<0.08
KER 32	<0.1	<1	0.40	0.26	<0.2	<0.3	<0.01	<0.02	<0.01	<0.1	5.2	<0.08

						LAB WATER DATA						
Site ID	Cs (µg/L)	Ba (µg/L)	La (µg/L)	Ce (µg/L)	Pr (µg/L)	Nd (µg/L)	Sm (µg/L)	Eu (µg/L)	Gd (µg/L)	Tb (µg/L)	Dy (µg/L)	Ho (µg/L)
KER 4	<0.05	44	<0.02	0.06	<0.02	<0.5	<0.1	<0.05	<0.04	<0.03	<0.1	0.01
KER 6	<0.01	45	0.17	0.45	0.05	0.2	<0.02	<0.01	0.01	<0.01	0.02	<0.01
KER 8	<0.01	83	0.35	0.82	0.10	0.3	0.06	0.02	0.06	0.01	0.06	0.01
KER 10	<0.1	210	<0.03	0.06	<0.04	<1	<0.2	<0.1	<0.07	<0.06	<0.2	<0.08
KER 12	<0.01	77	1.8	4.0	0.54	2.0	0.40	0.10	0.39	0.05	0.30	0.06
KER 18	0.02	200	0.06	0.13	0.02	<0.1	0.04	0.02	0.01	<0.01	0.02	<0.01
KER 20	2.4	160	0.7	0.7	0.6	<4	3.2	1.6	0.9	0.4	1.6	0.3
KER 22	9.9	40	2.3	3.0	1.8	8	11	2.7	3.4	1.2	4.5	1.2
KER 24	3.6	140	0.9	1.4	1.0	<4	4.0	1.6	1.5	0.4	2.4	0.6
KER 26	<0.01	52	0.69	1.7	0.21	0.7	0.14	0.04	0.14	0.02	0.14	0.02
KER 28	<0.01	57	1.2	2.9	0.35	1.4	0.34	0.08	0.33	0.05	0.30	0.05
KER 30	<0.01	76	0.26	0.60	0.07	0.3	0.04	0.01	0.04	<0.01	0.04	<0.01
KER 32	<0.01	78	0.59	1.4	0.17	0.6	0.10	0.02	0.12	0.01	0.10	0.02

Site ID	Er (µgL^{-1})	Tm (µg L^{-1})	Yb (µg L^{-1})	Lu (µg L^{-1})	Hf (µg L^{-1})	W (µg L^{-1})	Tl (µg L^{-1})	Pb (µg L^{-1})	Th (µg L^{-1})	U (µgL^{-1})
					LAB WATER DATA					
KER 4	<0.05	<0.03	<0.05	<0.03	0.4	<0.3	<0.02	<0.4	0.20	4.2
KER 6	<0.01	<0.01	<0.01	<0.01	0.09	<0.06	<0.01	0.24	0.06	<0.04
KER 8	0.02	<0.01	<0.01	<0.01	0.06	<0.06	<0.01	0.48	0.07	<0.04
KER 10	<0.09	<0.05	<0.1	<0.06	0.3	<0.6	<0.04	<0.8	0.2	<0.4
KER 12	0.14	0.02	0.11	<0.01	0.06	<0.06	<0.01	2.6	0.26	<0.04
KER 18	0.02	<0.01	<0.01	<0.01	0.87	<0.06	<0.01	<0.08	0.30	2.7
KER 20	0.8	0.4	1.2	1.0	8	4	0.8	3	5.2	4
KER 22	3.6	0.9	5.7	4.6	23	26	2.6	4	8.1	118
KER 24	1.6	0.4	2.4	1.4	15	14	1.4	<3	5.2	8
KER 26	0.06	<0.01	0.04	<0.01	0.09	<0.06	<0.01	1.0	0.14	<0.04
KER 28	0.15	0.02	0.09	<0.01	0.66	0.06	<0.01	1.4	0.50	<0.04
KER 30	0.01	<0.01	<0.01	<0.01	0.09	<0.06	<0.01	0.32	0.08	<0.04
KER 32	0.04	<0.01	0.02	<0.01	0.06	<0.06	<0.01	0.80	0.11	<0.04

					LAB WATER DATA						
	pH	EC	Alkalinity	NH_4-N	NO_x-N	NO_2-N	PO_4-P	F^-	Cl^-	Br^-	$SO_4^=$
Site ID		dS m^{-1}	meq L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}
KER 4	8.3	13.1	4.9	16	1.17	0.205	4.7	<1	4810	15	890
KER 6	7.2	0.40	0.9	0.060	0.14	0.007	<0.002	0.08	85	0.24	13
KER 8	7.0	0.36	0.5	0.050	0.070	0.008	0.021	0.07	74	0.19	16
KER 10	8.4	3.4	3.7	0.015	0.008	<0.005	0.015	0.3	939	2.9	252
KER 12	7.1	0.30	0.8	0.078	0.28	0.039	0.10	0.10	48	0.12	13
KER 18	8.3	3.4	3.7	0.012	<0.005	<0.005	0.006	0.2	938	2.8	253
KER 20	8.0	112	5.4	4.3	<0.05	0.008	0.039	<25	125000	325	12700
KER 22	7.0	59	33	19	<0.05	0.042	2.8	<25	176000	2026	54400
KER 24	7.1	66	28	15	<0.05	0.067	1.6	<25	174000	1258	42200
KER 26	6.9	0.18	0.5	0.036	0.031	0.017	0.070	0.07	10	<0.05	3.7
KER 28	7.2	0.23	0.8	0.33	0.77	0.013	0.21	0.12	52	0.31	2.7
KER 30	7.0	0.37	0.5	0.18	0.080	0.007	0.009	<0.05	76	0.19	16
KER 32	7.0	0.21	0.6	0.11	0.077	0.016	0.016	0.09	31	0.08	10

	LAB WATER DATA											
	Ca	K	Mg	Na	S	NPOC	TN	Al	B	Cu	Fe	Mn
Site ID	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}
KER 4	280	15	490	2400	310	17	14	< 0.01	0.55	< 0.03	0.03	0.06
KER 6	11	3.2	13	48	4.9	11	0.80	0.10	0.02	< 0.005	0.26	0.04
KER 8	10	2.0	9.2	45	5.9	6.9	0.40	0.17	0.03	< 0.005	0.28	0.02
KER 10	62	12	83	580	87	14	1.0	0.11	0.26	< 0.005	0.08	< 0.006
KER 12	12	2.8	8.7	40	5.3	11	1.1	0.62	0.04	< 0.005	1.1	0.03
KER 18	63	12	84	620	89	14	1.0	0.08	0.25	< 0.005	0.05	< 0.006
KER 20	930	171	10600	65000	4200	24	12	0.50	12	< 0.5	0.88	1.5
KER 22	139	1090	51000	44000	17400	6.2	21	< 0.2	67	< 0.5	< 0.4	2.4
KER 24	166	1640	40000	57000	13600	5.3	23	< 0.2	47	< 0.5	< 0.4	1.0
KER 26	4.3	1.8	3.7	12	1.7	14	1.3	0.30	0.02	< 0.005	0.54	0.01
KER 28	13.7	3.8	10.5	40.4	3.3	104	6.6	0.15	0.03	0.009	1.3	0.23
KER 30	10	1.8	9.4	46	5.9	6.4	0.42	0.13	0.02	< 0.005	0.22	< 0.006
KER 32	6.3	2.0	5.2	19	3.1	6.9	0.42	0.28	0.03	< 0.005	0.43	0.01

	LAB WATER DATA									
	P	Zn	Mo	Co	Ni	Ti	Cr	Cd	Pb	Se
Site ID	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}
KER 4	4.5	0.07	< 0.06	< 0.06	< 0.07	< 0.009	< 0.04	< 0.02	< 0.2	< 0.6
KER 6	< 0.03	< 0.003	< 0.01	< 0.01	< 0.01	< 0.002	< 0.008	< 0.003	< 0.03	< 0.1
KER 8	0.16	0.02	< 0.01	< 0.01	< 0.01	< 0.002	< 0.008	< 0.003	< 0.03	< 0.1
KER 10	< 0.03	0.01	< 0.01	< 0.01	< 0.01	< 0.002	< 0.008	< 0.003	< 0.03	< 0.1
KER 12	0.04	0.02	< 0.01	< 0.01	< 0.01	< 0.002	< 0.008	< 0.003	< 0.03	< 0.1
KER 18	< 0.03	< 0.003	< 0.01	< 0.01	< 0.01	< 0.002	< 0.008	< 0.003	< 0.03	< 0.1
KER 20	9.8	< 0.3	< 1	< 1	< 1	< 0.2	< 0.8	< 0.3	< 3	< 10
KER 22	3.9	< 0.3	< 1	< 1	< 1	< 0.2	< 0.8	< 0.3	< 3	< 10
KER 24	8.8	< 0.3	< 1	< 1	< 1	< 0.2	< 0.8	< 0.3	< 3	< 10
KER 26	< 0.03	0.01	< 0.01	< 0.01	< 0.01	< 0.002	< 0.008	< 0.003	< 0.03	< 0.1
KER 28	0.24	0.01	< 0.01	< 0.01	0.02	0.003	< 0.008	< 0.003	< 0.03	< 0.1
KER 30	< 0.03	0.01	< 0.01	< 0.01	< 0.01	< 0.002	< 0.008	< 0.003	< 0.03	< 0.1
KER 32	< 0.03	0.02	< 0.01	< 0.01	< 0.01	< 0.002	< 0.008	< 0.003	< 0.03	< 0.1

APPENDIX 5. SOIL pH AND NET ACIDITY PLOTS AND SITE PHOTOS

Hird Swamp (sites KER 1-2)

Site KER 1

Site KER 1

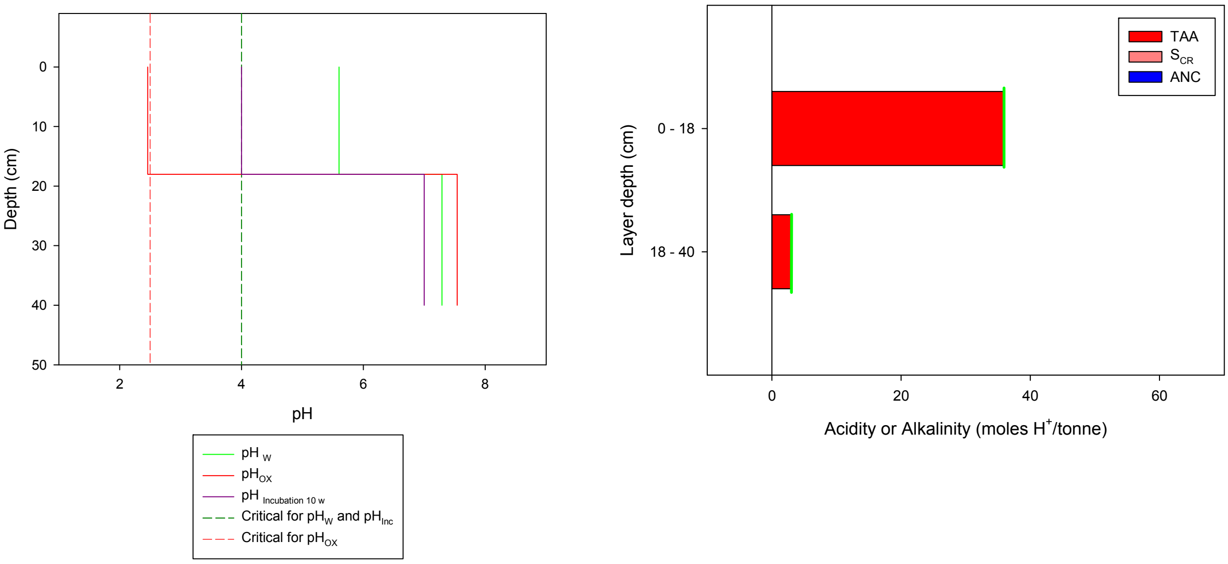


Figure 7-1 Site KER 1. Soil pH (pH_W, solid green line), peroxide pH (pH_{OX}, solid red line) and incubation pH ($pH_{INCUBATION}$ after 19 weeks, solid purple line). Dashed lines show the critical values for pH_W/$pH_{INCUBATION}$ and pH_{OX}. Right Plot: TAA (red bar), S_{CR} (pink bar), ANC (blue bar) and Net Acidity (green line).

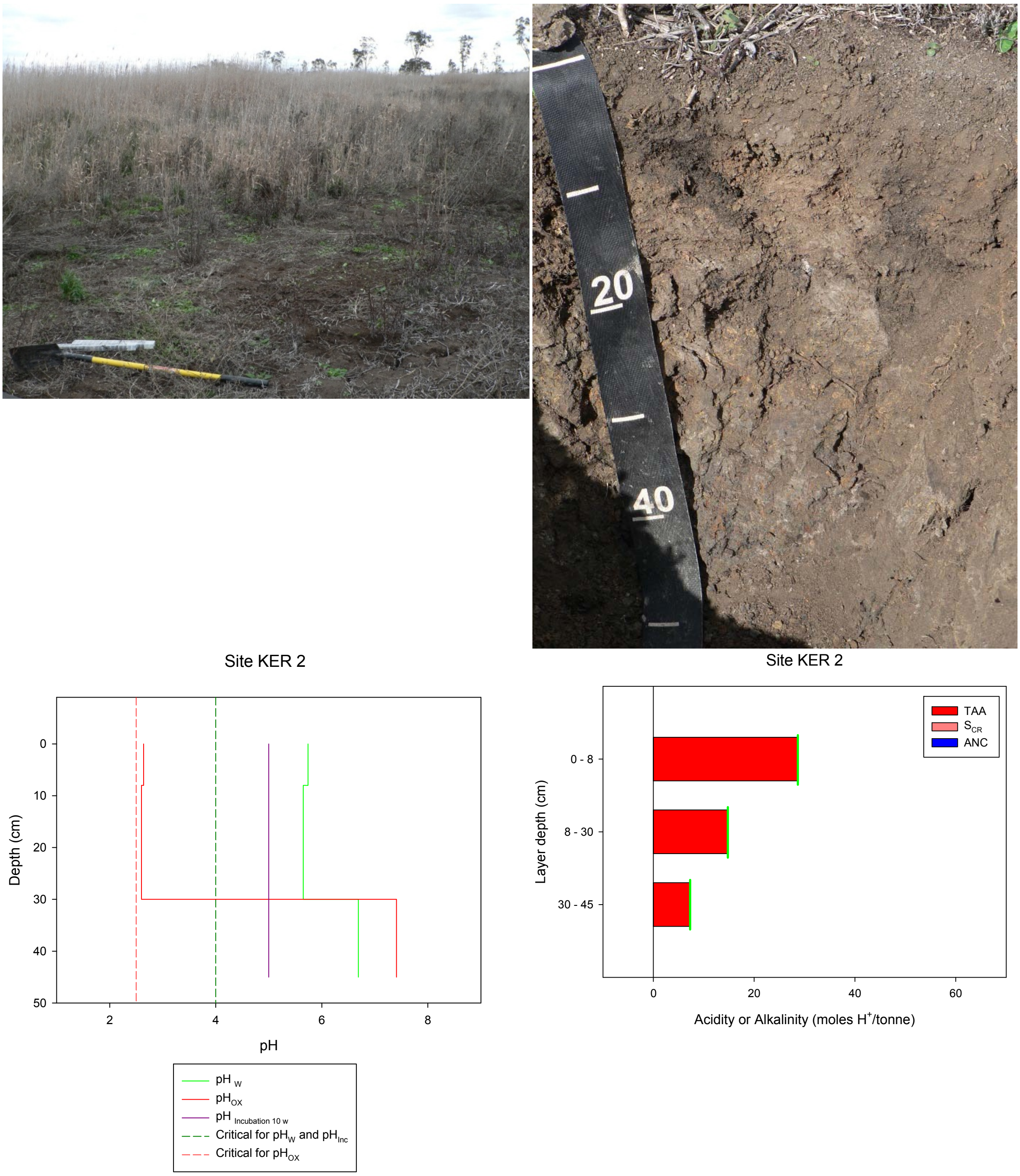
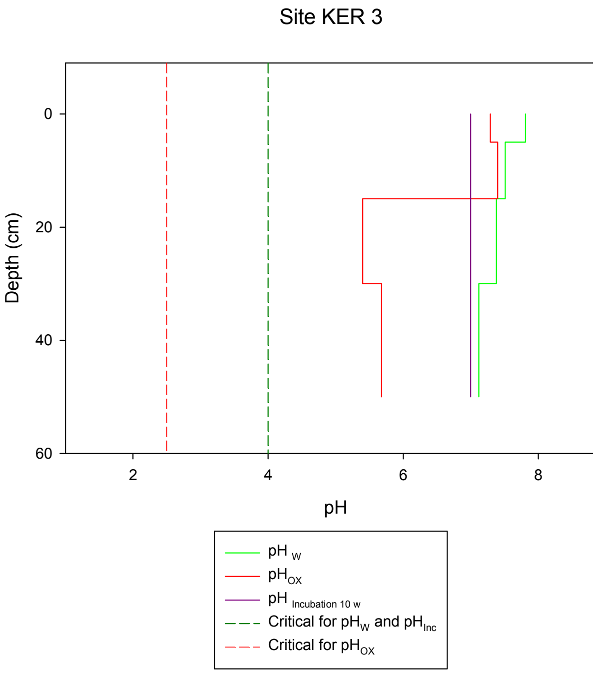


Figure 7-2 Site KER 2. Soil pH (pH_W, solid green line), peroxide pH (pH_{OX}, solid red line) and incubation pH ($pH_{INCUBATION}$ after 19 weeks, solid purple line). Dashed lines show the critical values for $pH_W/pH_{INCUBATION}$ and pH_{OX}. Right Plot: TAA (red bar), S_{CR} (pink bar), ANC (blue bar) and Net Acidity (green line).

Fosters Swamp (sites KER 3-4)



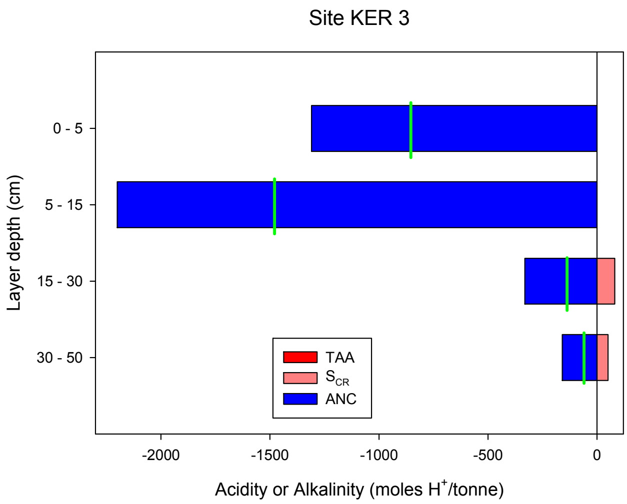
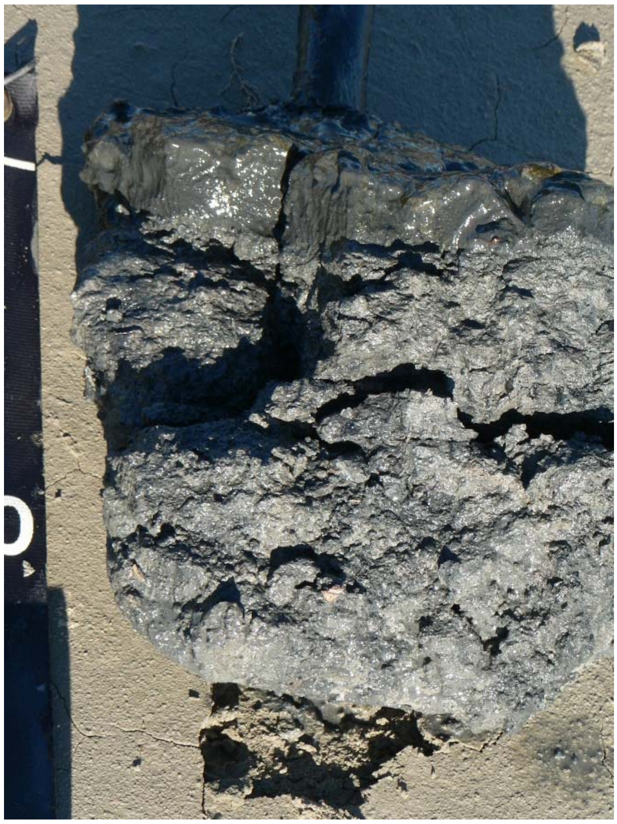
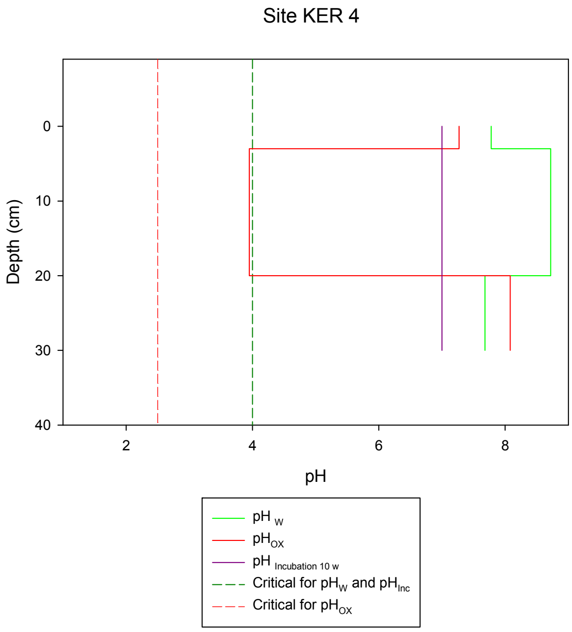


Figure 7-3 Site KER 3. Soil pH (pH_W, solid green line), peroxide pH (pH_{OX}, solid red line) and incubation pH ($pH_{INCUBATION}$ after 19 weeks, solid purple line). Dashed lines show the critical values for pH_W/$pH_{INCUBATION}$ and pH_{OX}. Right Plot: TAA (red bar), S_{CR} (pink bar), ANC (blue bar) and Net Acidity (green line).





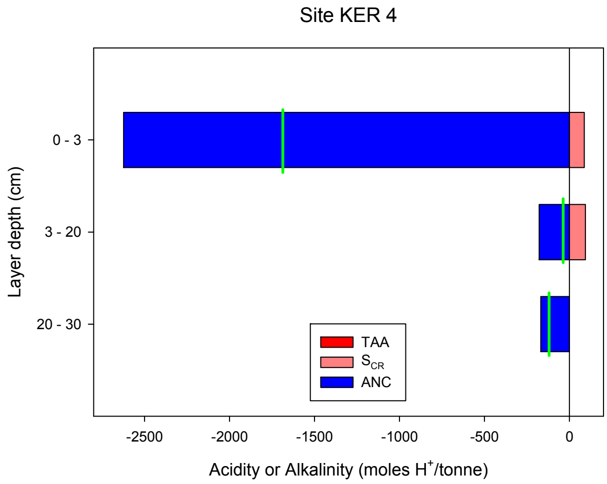


Figure 7-4 Site KER 4. Soil pH (pH_W, solid green line), peroxide pH (pH_{OX}, solid red line) and incubation pH ($pH_{INCUBATION}$ after 19 weeks, solid purple line). Dashed lines show the critical values for pH_W/$pH_{INCUBATION}$ and pH_{OX}. Right Plot: TAA (red bar), S_{CR} (pink bar), ANC (blue bar) and Net Acidity (green line).

Town and Back Swamp (sites KER 5-6)

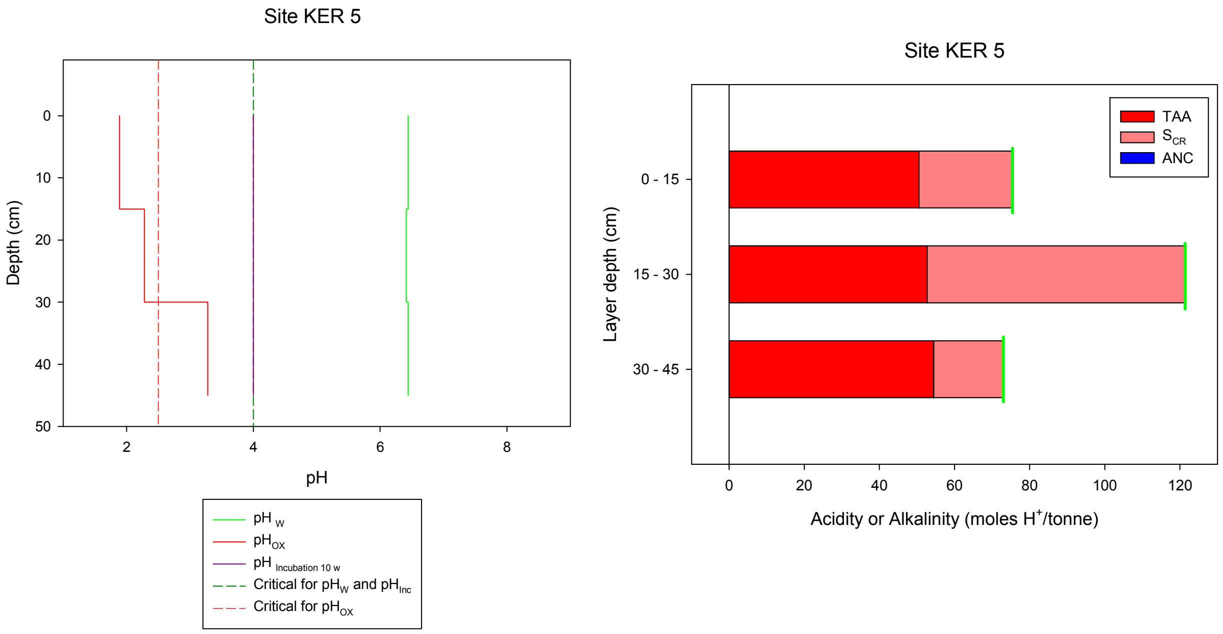


Figure 7-5 Site KER 5. Soil pH (pH_W, solid green line), peroxide pH (pH_{OX}, solid red line) and incubation pH ($pH_{INCUBATION}$ after 19 weeks, solid purple line). Dashed lines show the critical values for $pH_W/pH_{INCUBATION}$ and pH_{OX}. Right Plot: TAA (red bar), S_{CR} (pink bar), ANC (blue bar) and Net Acidity (green line).

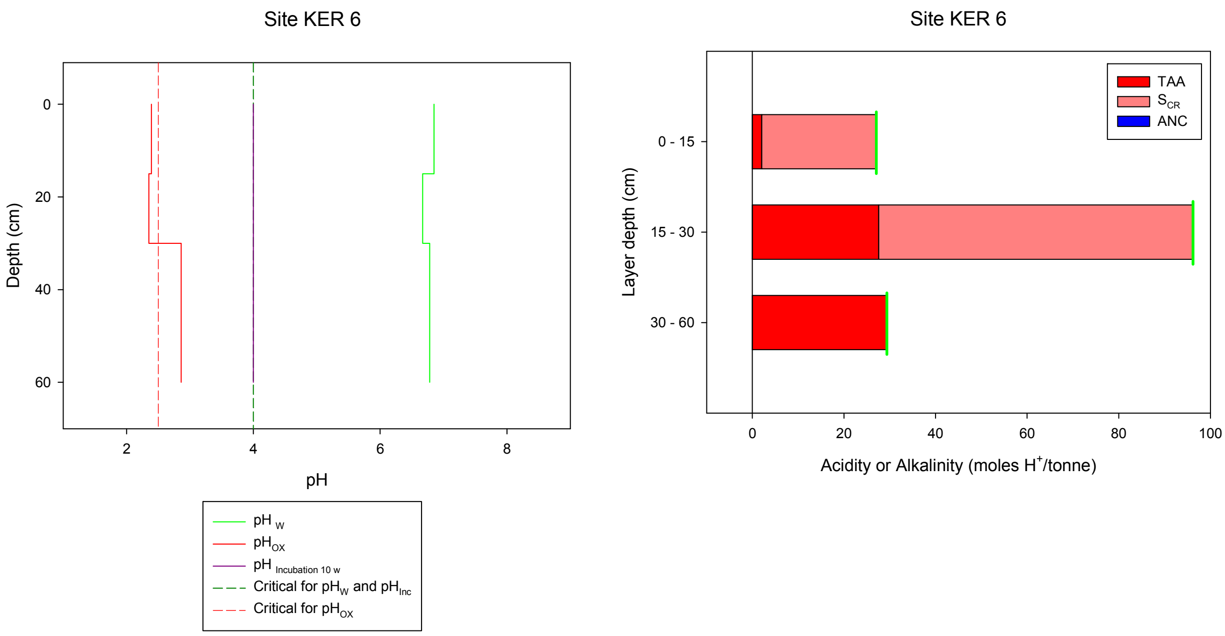
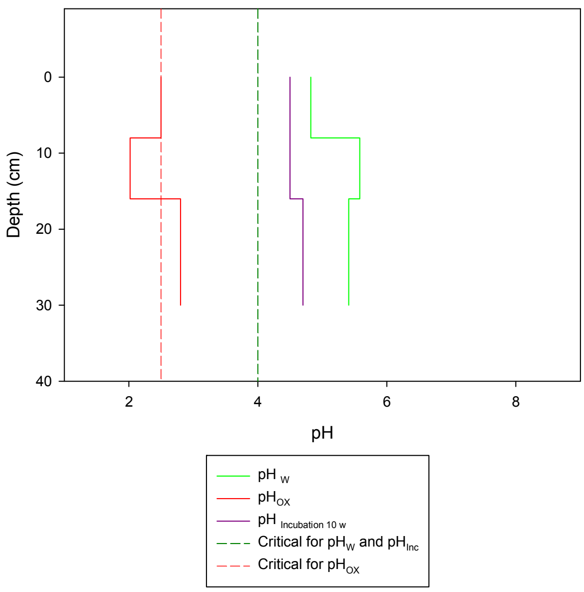


Figure 7-6 Site KER 6. Soil pH (pH_W, solid green line), peroxide pH (pH_{OX}, solid red line) and incubation pH ($pH_{INCUBATION}$ after 19 weeks, solid purple line). Dashed lines show the critical values for $pH_W/pH_{INCUBATION}$ and pH_{OX}. Right Plot: TAA (red bar), S_{CR} (pink bar), ANC (blue bar) and Net Acidity (green line).

Middle Lake (sites KER 7-8)

Site KER 7

Site KER 7



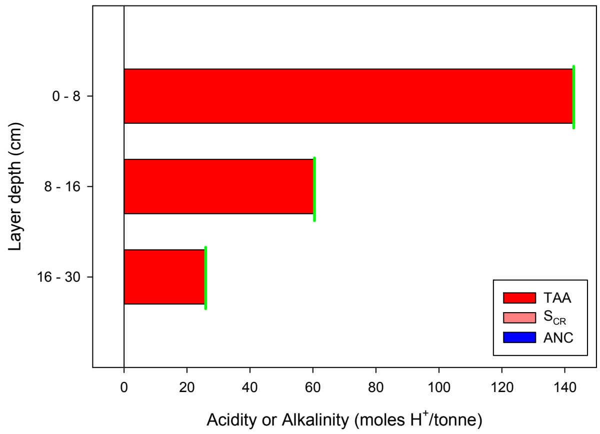
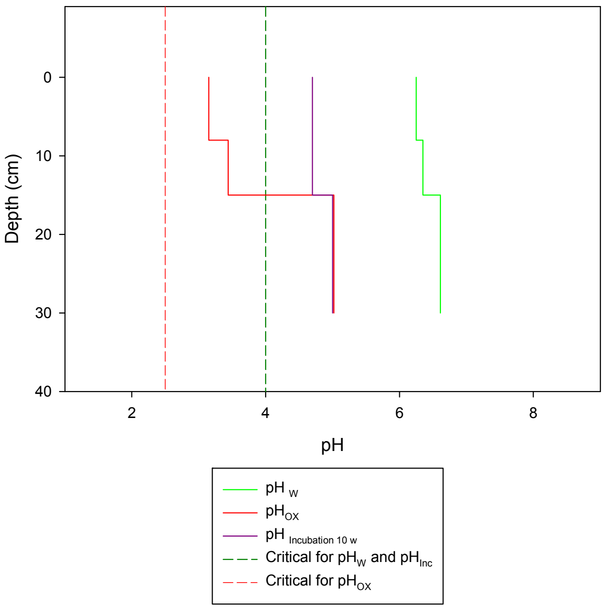


Figure 7-7 Site KER 7. Soil pH (pH_W, solid green line), peroxide pH (pH_{OX}, solid red line) and incubation pH ($pH_{INCUBATION}$ after 19 weeks, solid purple line). Dashed lines show the critical values for $pH_W/pH_{INCUBATION}$ and pH_{OX}. Right Plot: TAA (red bar), S_{CR} (pink bar), ANC (blue bar) and Net Acidity (green line).

Site KER 8



Site KER 8

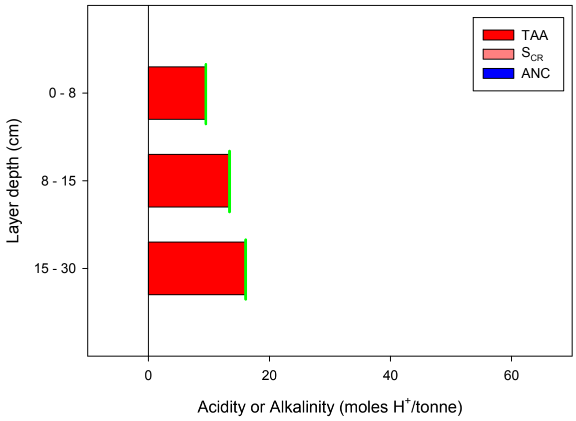
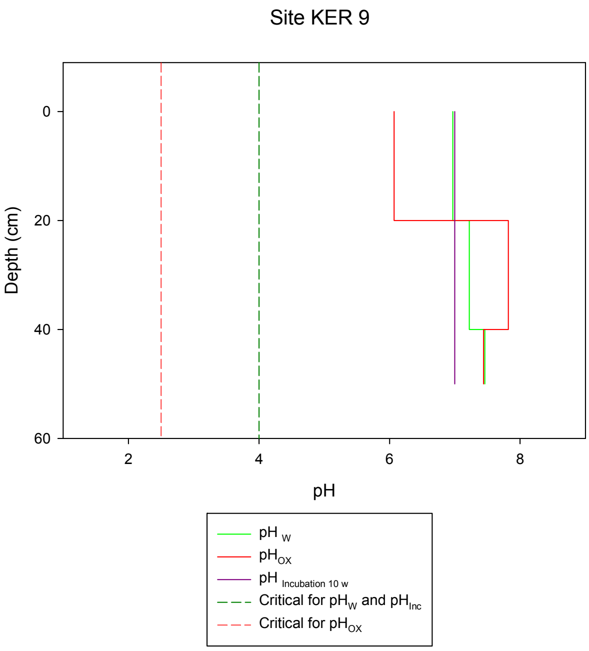


Figure 7-8 Site KER 8. Soil pH (pH_W, solid green line), peroxide pH (pH_{OX}, solid red line) and incubation pH ($pH_{INCUBATION}$ after 19 weeks, solid purple line). Dashed lines show the critical values for pH_W/$pH_{INCUBATION}$ and pH_{OX}. Right Plot: TAA (red bar), S_{CR} (pink bar), ANC (blue bar) and Net Acidity (green line).

Little Lake Charm (sites KER 9-10)



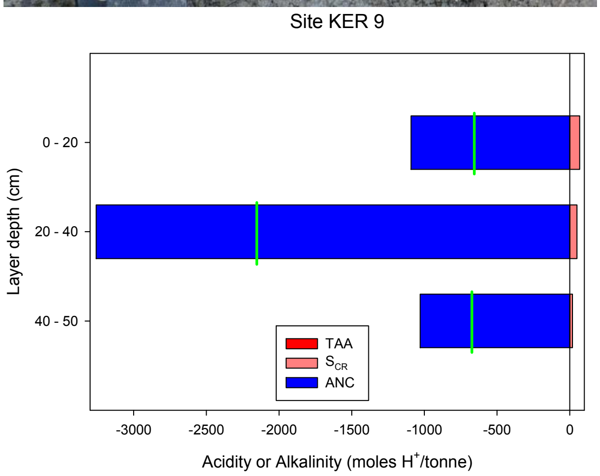
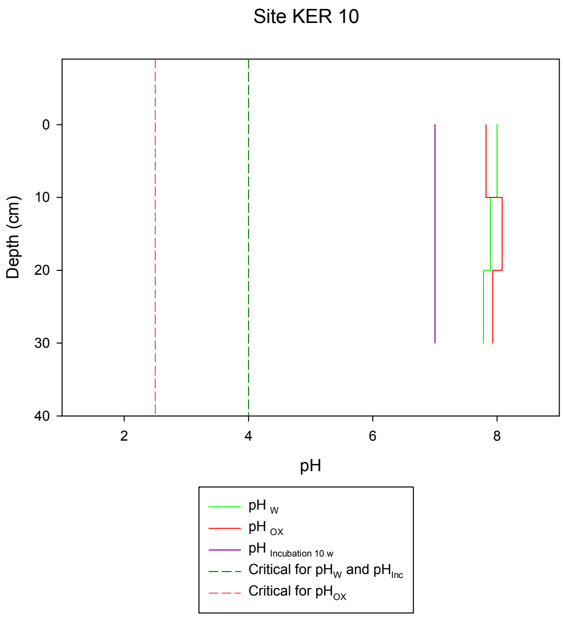


Figure 7-9 Site KER 9. Soil pH (pH_W, solid green line), peroxide pH (pH_{OX}, solid red line) and incubation pH ($pH_{INCUBATION}$ after 19 weeks, solid purple line). Dashed lines show the critical values for $pH_W/pH_{INCUBATION}$ and pH_{OX}. Right Plot: TAA (red bar), S_{CR} (pink bar), ANC (blue bar) and Net Acidity (green line).



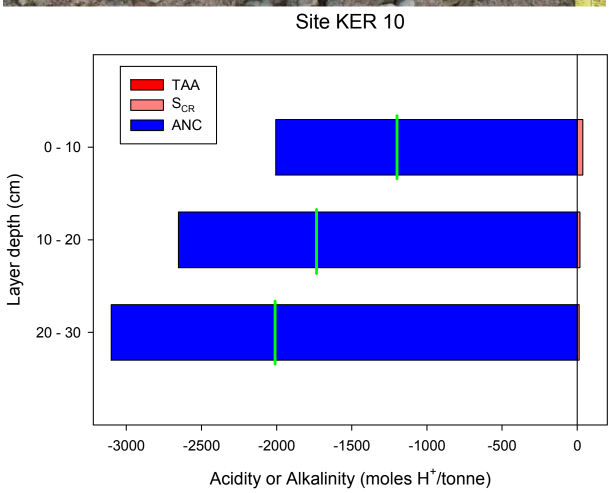
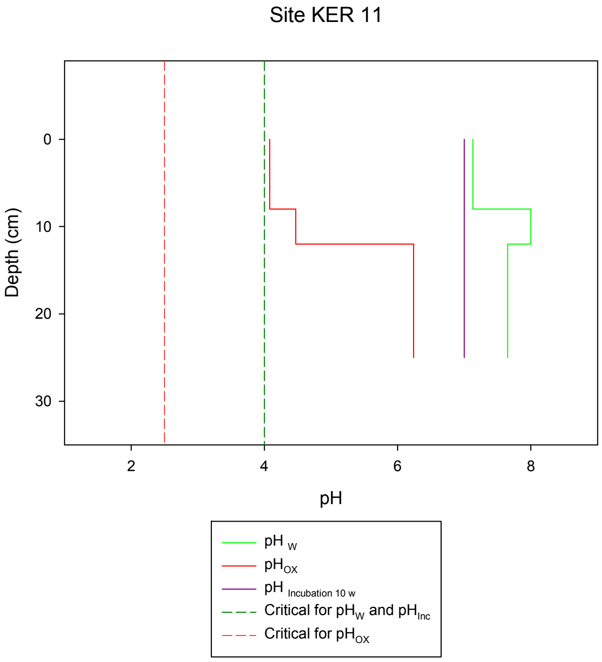


Figure 7-10 Site KER 10. Soil pH (pH_W, solid green line), peroxide pH (pH_{OX}, solid red line) and incubation pH ($pH_{INCUBATION}$ after 19 weeks, solid purple line). Dashed lines show the critical values for pH_W/$pH_{INCUBATION}$ and pH_{OX}. Right Plot: TAA (red bar), S_{CR} (pink bar), ANC (blue bar) and Net Acidity (green line).

Kangaroo Lake (sites KER 11-12)



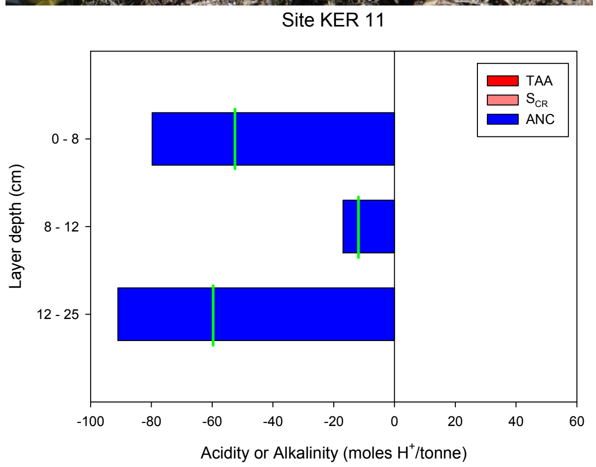
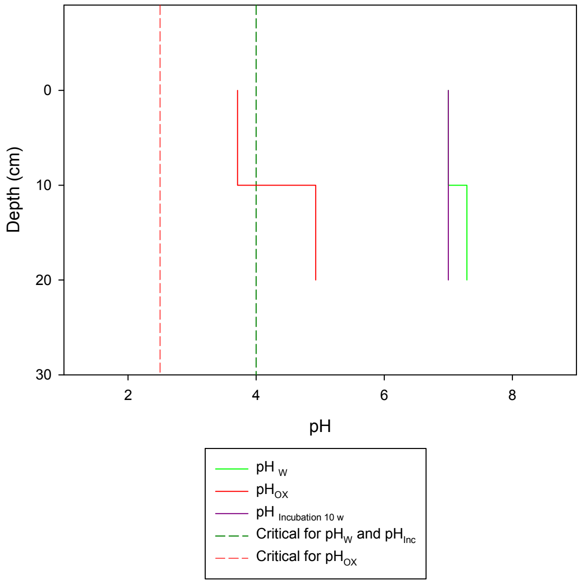


Figure 7-11 Site KER 11. Soil pH (pH_W, solid green line), peroxide pH (pH_{OX}, solid red line) and incubation pH ($pH_{INCUBATION}$ after 19 weeks, solid purple line). Dashed lines show the critical values for pH_W/$pH_{INCUBATION}$ and pH_{OX}. Right Plot: TAA (red bar), S_{CR} (pink bar), ANC (blue bar) and Net Acidity (green line).

Site KER 12

Site KER 12



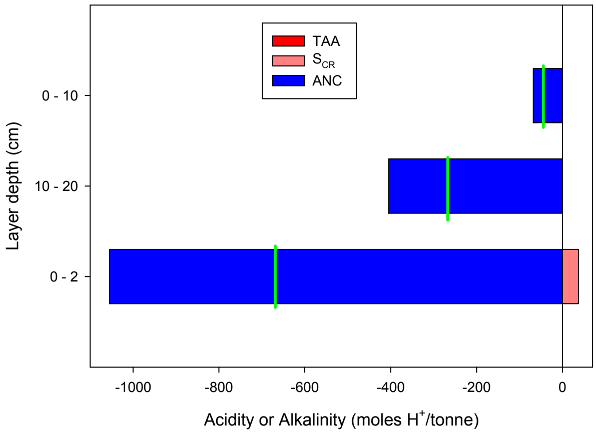
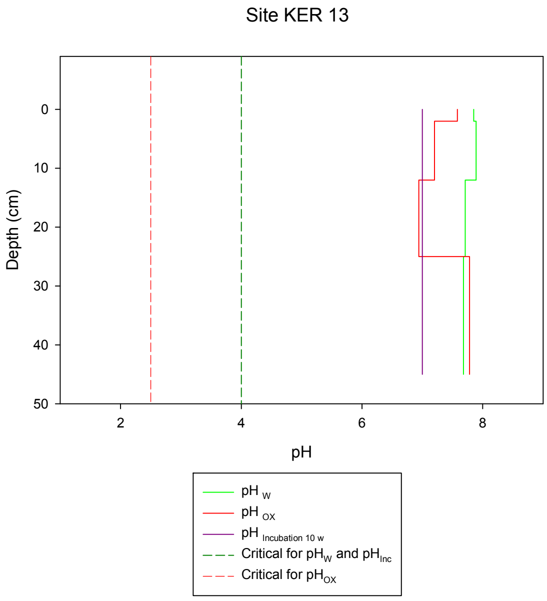


Figure 7-12 Site KER 12. Soil pH (pH_W, solid green line), peroxide pH (pH_{OX}, solid red line) and incubation pH ($pH_{INCUBATION}$ after 19 weeks, solid purple line). Dashed lines show the critical values for pH_W/$pH_{INCUBATION}$ and pH_{OX}. Right Plot: TAA (red bar), S_{CR} (pink bar), ANC (blue bar) and Net Acidity (green line).

Lake Cullen (sites KER 13-14)



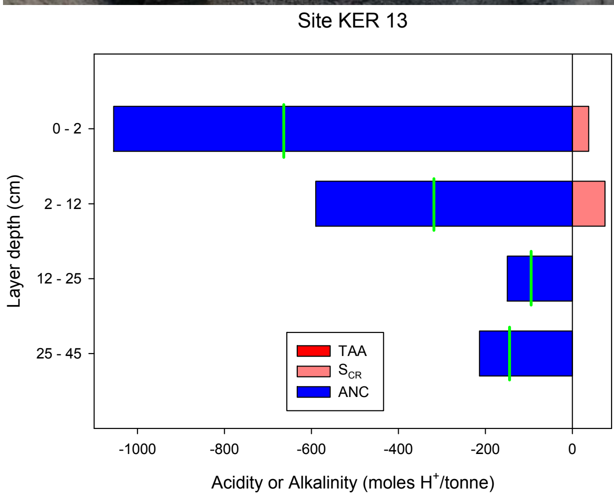
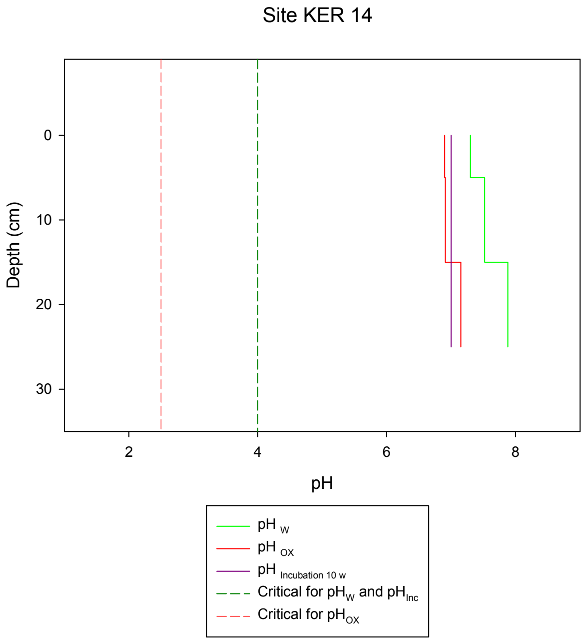


Figure 7-13 Site KER 13. Soil pH (pH_W, solid green line), peroxide pH (pH_{OX}, solid red line) and incubation pH ($pH_{INCUBATION}$ after 19 weeks, solid purple line). Dashed lines show the critical values for pH_W/$pH_{INCUBATION}$ and pH_{OX}. Right Plot: TAA (red bar), S_{CR} (pink bar), ANC (blue bar) and Net Acidity (green line).



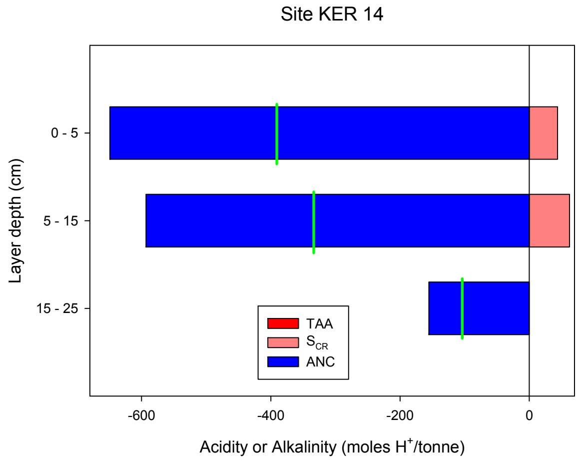
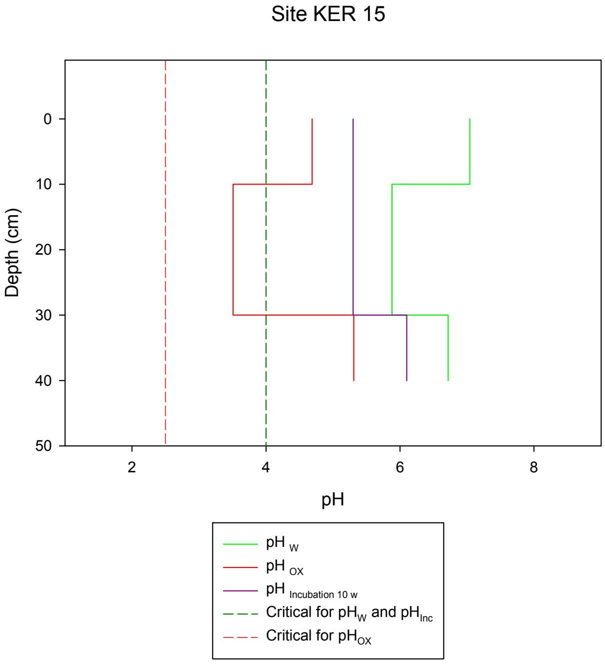


Figure 7-14 Site KER 14. Soil pH (pH_W, solid green line), peroxide pH (pH_{OX}, solid red line) and incubation pH ($pH_{INCUBATION}$ after 19 weeks, solid purple line). Dashed lines show the critical values for $pH_W/pH_{INCUBATION}$ and pH_{OX}. Right Plot: TAA (red bar), S_{CR} (pink bar), ANC (blue bar) and Net Acidity (green line).

Lake Bael Bael (sites KER 15-16)



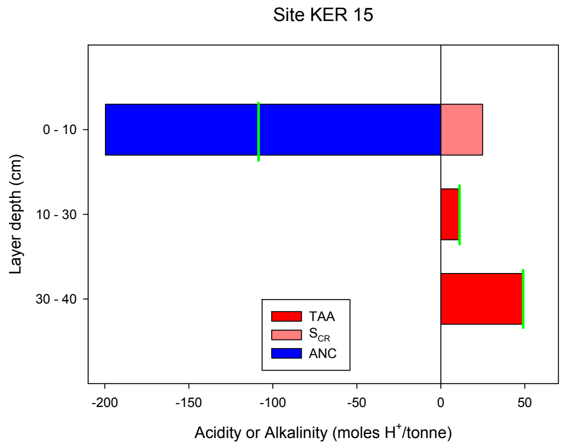
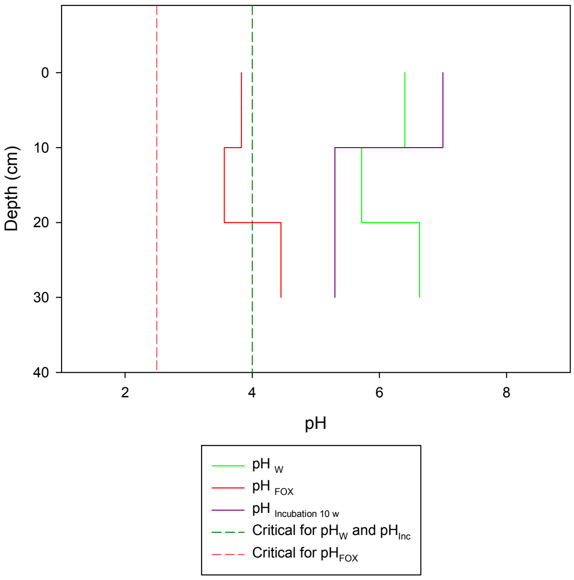


Figure 7-15 Site KER 15. Soil pH (pH_W, solid green line), peroxide pH (pH_{OX}, solid red line) and incubation pH ($pH_{INCUBATION}$ after 19 weeks, solid purple line). Dashed lines show the critical values for $pH_W/pH_{INCUBATION}$ and pH_{OX}. Right Plot: TAA (red bar), S_{CR} (pink bar), ANC (blue bar) and Net Acidity (green line).

Site KER 16



Site KER 16

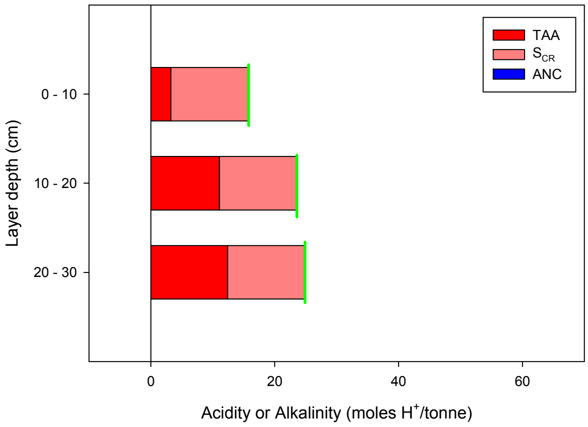
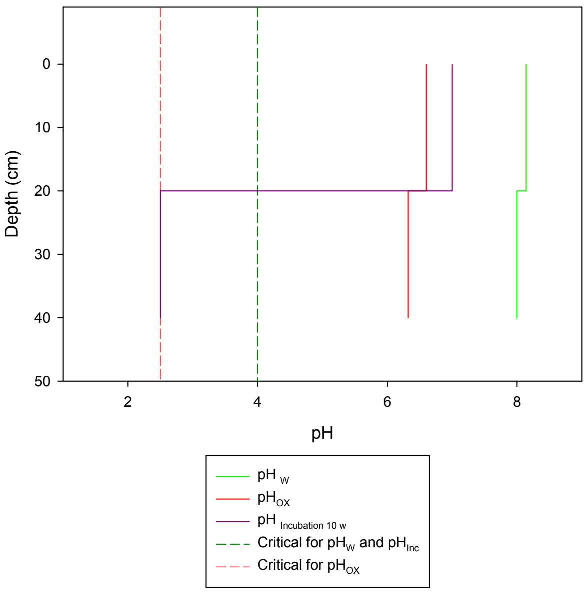


Figure 7-16 Site KER 16. Soil pH (pH_W, solid green line), peroxide pH (pH_{OX}, solid red line) and incubation pH ($pH_{INCUBATION}$ after 19 weeks, solid purple line). Dashed lines show the critical values for $pH_W/pH_{INCUBATION}$ and pH_{OX}. Right Plot: TAA (red bar), S_{CR} (pink bar), ANC (blue bar) and Net Acidity (green line).

Lake Charm (sites KER 17-18)

Site KER 17

Site KER 17



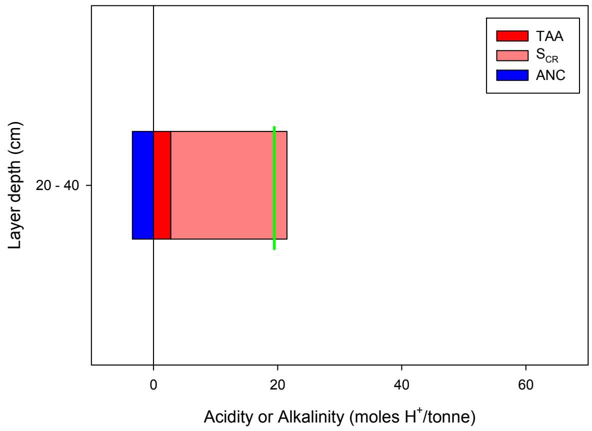
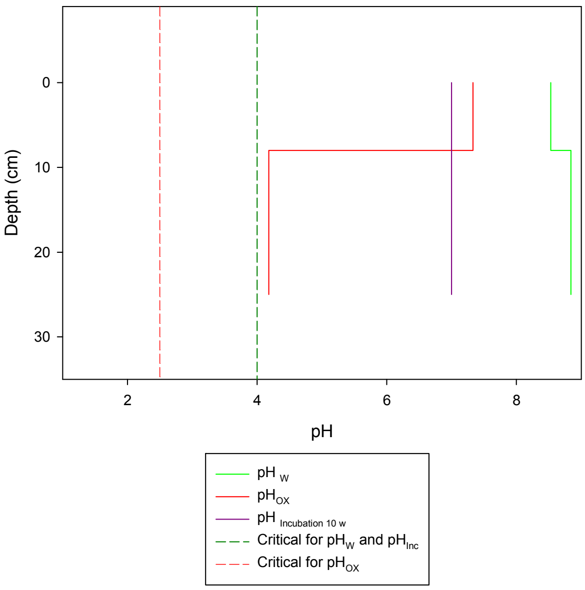


Figure 7-17 Site KER 17. Soil pH (pH_W, solid green line), peroxide pH (pH_{OX}, solid red line) and incubation pH ($pH_{INCUBATION}$ after 19 weeks, solid purple line). Dashed lines show the critical values for pH_W/$pH_{INCUBATION}$ and pH_{OX}. Right Plot: TAA (red bar), S_{CR} (pink bar), ANC (blue bar) and Net Acidity (green line).

Site KER 18

Site KER 18



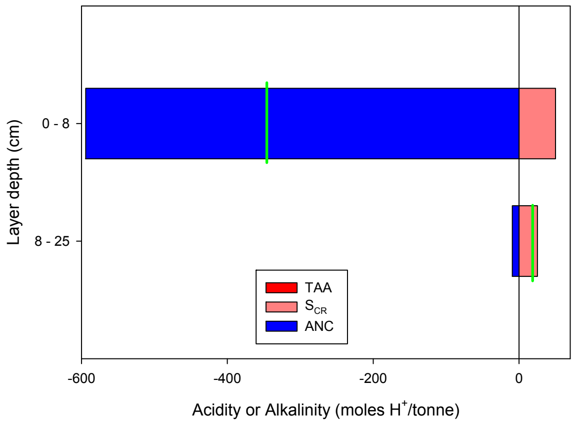


Figure 7-18 Site KER 18. Soil pH (pH_W, solid green line), peroxide pH (pH_{OX}, solid red line) and incubation pH ($pH_{INCUBATION}$ after 19 weeks, solid purple line). Dashed lines show the critical values for pH_W/$pH_{INCUBATION}$ and pH_{OX}. Right Plot: TAA (red bar), S_{CR} (pink bar), ANC (blue bar) and Net Acidity (green line).

Lake Kelly (sites KER 19-20)

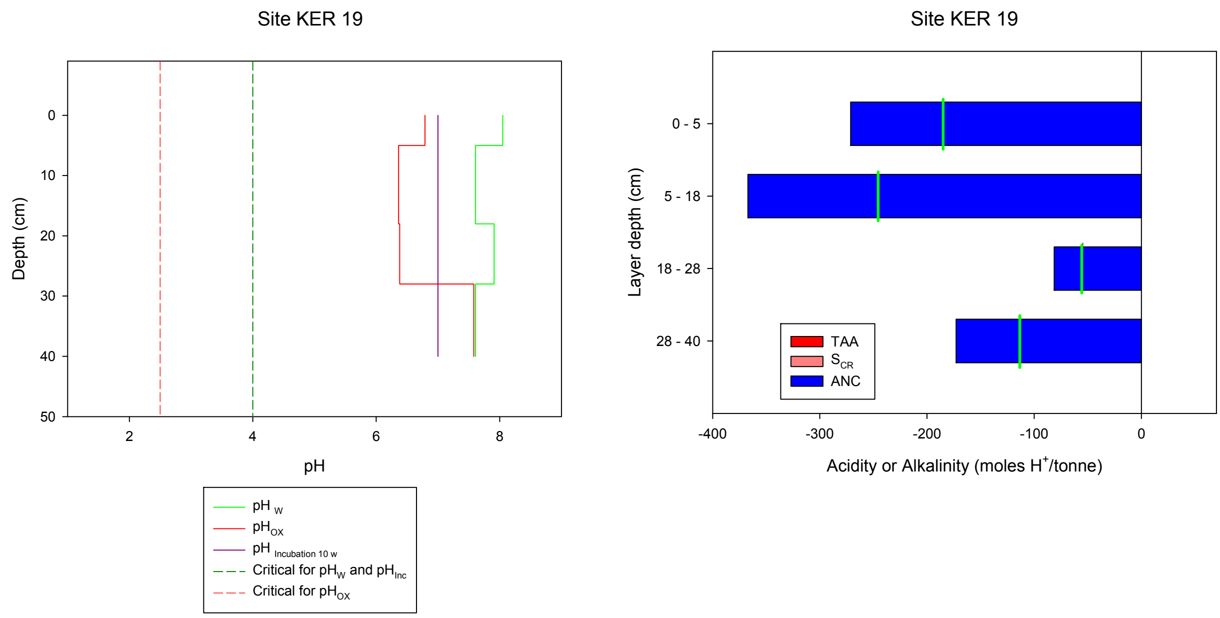


Figure 7-19 Site KER 19. Soil pH (pH_W, solid green line), peroxide pH (pH_{OX}, solid red line) and incubation pH ($pH_{INCUBATION}$ after 19 weeks, solid purple line). Dashed lines show the critical values for pH_W/$pH_{INCUBATION}$ and pH_{OX}. Right Plot: TAA (red bar), S_{CR} (pink bar), ANC (blue bar) and Net Acidity (green line).

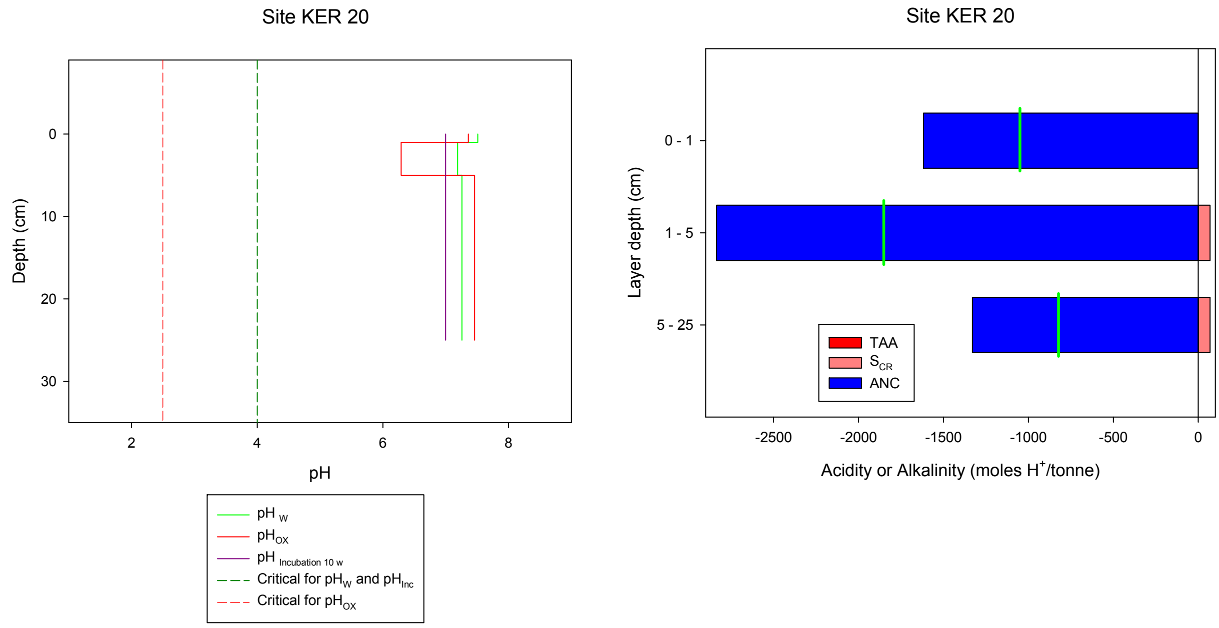
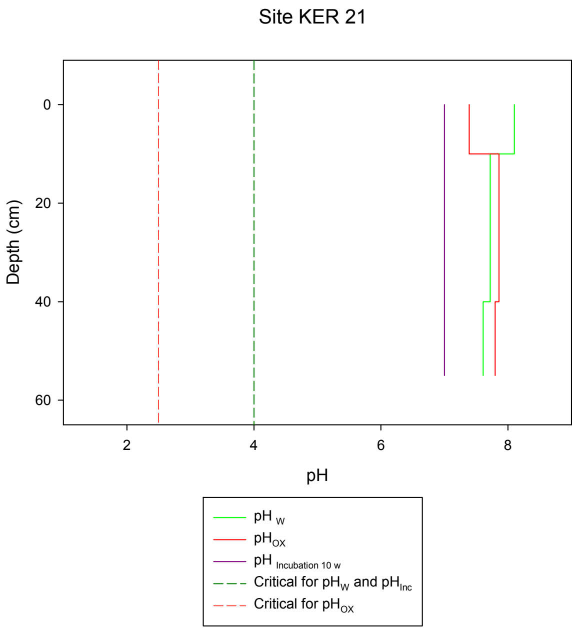


Figure 7-20 Site KER 20. Soil pH (pH_W, solid green line), peroxide pH (pH_{OX}, solid red line) and incubation pH ($pH_{INCUBATION}$ after 19 weeks, solid purple line). Dashed lines show the critical values for pH_W/$pH_{INCUBATION}$ and pH_{OX}. Right Plot: TAA (red bar), S_{CR} (pink bar), ANC (blue bar) and Net Acidity (green line).

Lake William (sites KER 21-22)



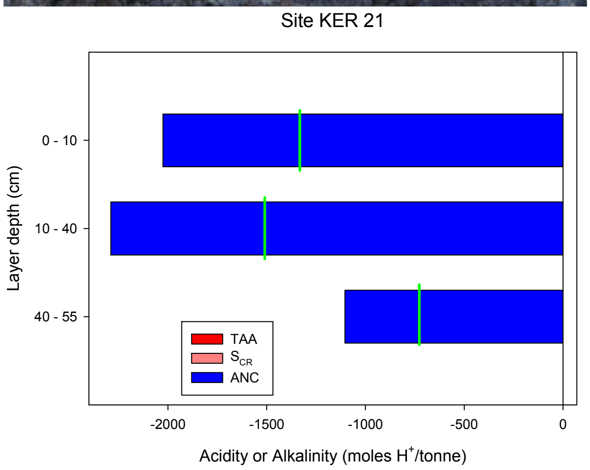
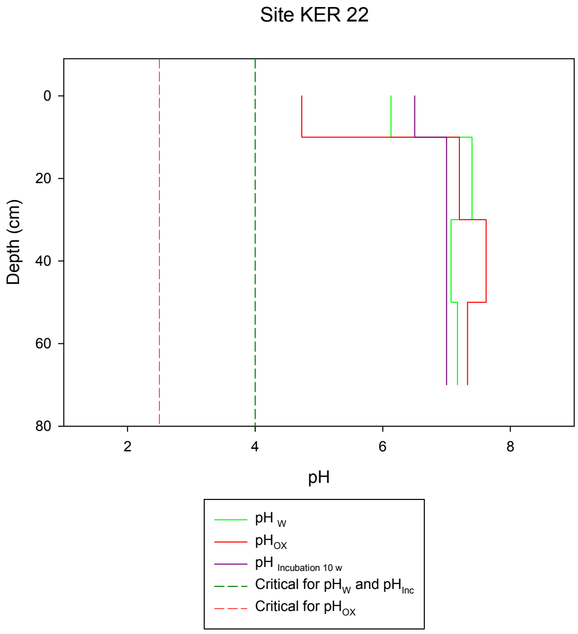


Figure 7-21 Site KER 21. Soil pH (pH_W, solid green line), peroxide pH (pH_{OX}, solid red line) and incubation pH ($pH_{INCUBATION}$ after 19 weeks, solid purple line). Dashed lines show the critical values for pH_W/$pH_{INCUBATION}$ and pH_{OX}. Right Plot: TAA (red bar), S_{CR} (pink bar), ANC (blue bar) and Net Acidity (green line).



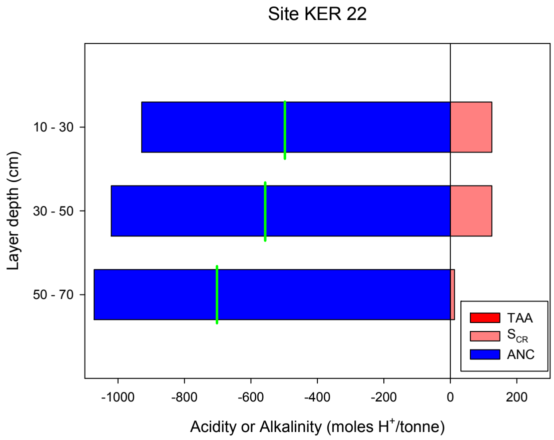


Figure 7-22 Site KER 22. Soil pH (pH_W, solid green line), peroxide pH (pH_{OX}, solid red line) and incubation pH ($pH_{INCUBATION}$ after 19 weeks, solid purple line). Dashed lines show the critical values for $pH_W/pH_{INCUBATION}$ and pH_{OX}. Right Plot: TAA (red bar), S_{CR} (pink bar), ANC (blue bar) and Net Acidity (green line).

Lake Tutchewop (sites KER 23-24)

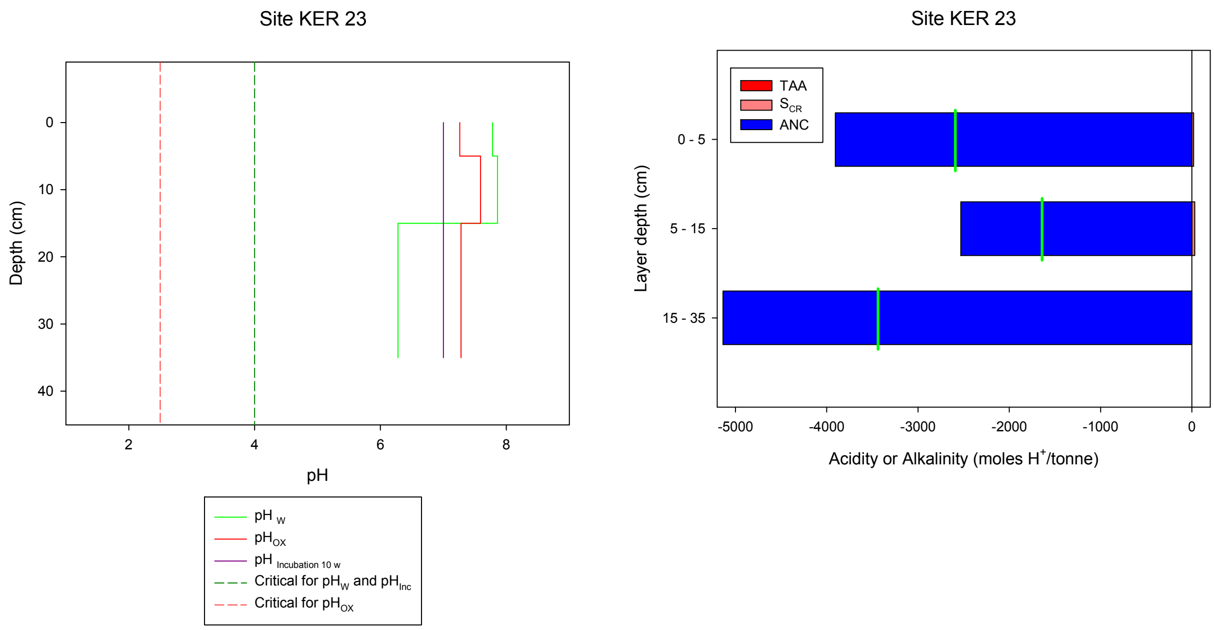


Figure 7-23 Site KER 23. Soil pH (pH_W, solid green line), peroxide pH (pH_{OX}, solid red line) and incubation pH ($pH_{INCUBATION}$ after 19 weeks, solid purple line). Dashed lines show the critical values for $pH_W/pH_{INCUBATION}$ and pH_{OX}. Right Plot: TAA (red bar), S_{CR} (pink bar), ANC (blue bar) and Net Acidity (green line).

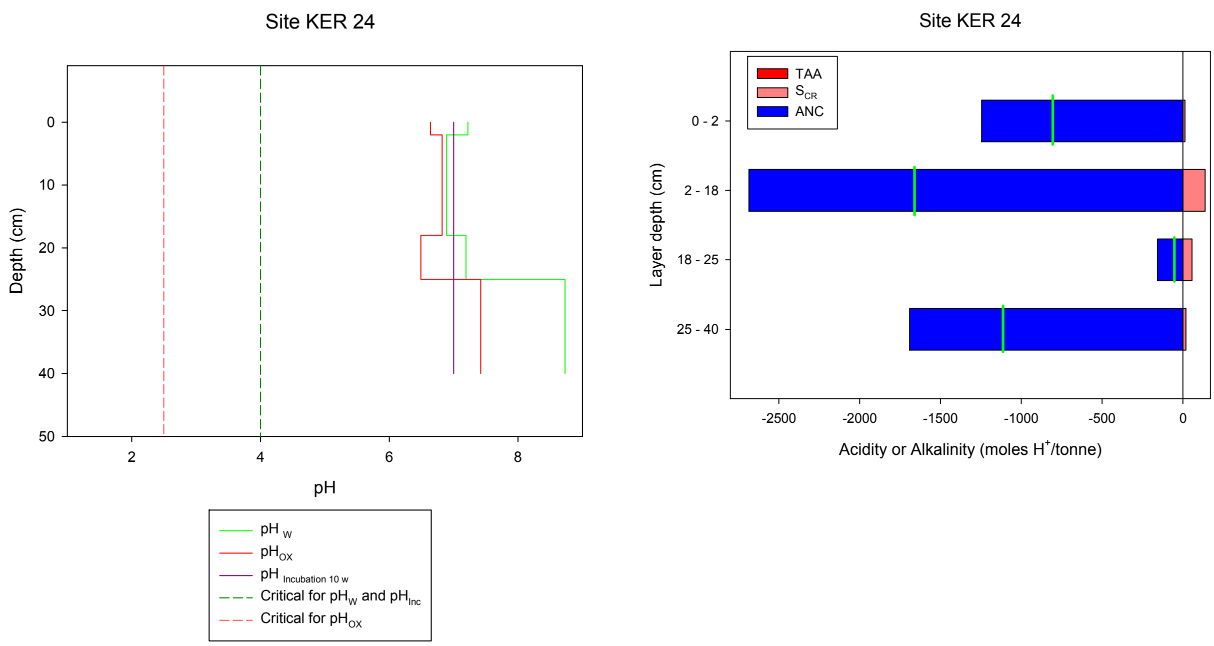
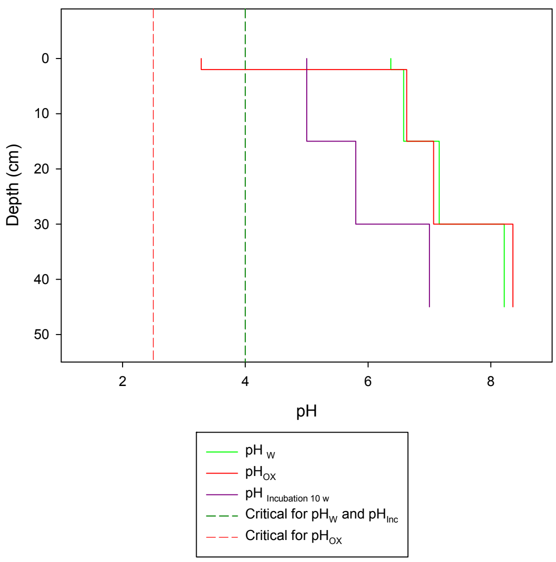


Figure 7-24 Site KER 24. Soil pH (pH_W, solid green line), peroxide pH (pH_{OX}, solid red line) and incubation pH ($pH_{INCUBATION}$ after 19 weeks, solid purple line). Dashed lines show the critical values for $pH_W/pH_{INCUBATION}$ and pH_{OX}. Right Plot: TAA (red bar), S_{CR} (pink bar), ANC (blue bar) and Net Acidity (green line).

Kow Swamp (sites KER 25-26)

Site KER 25



Site KER 25

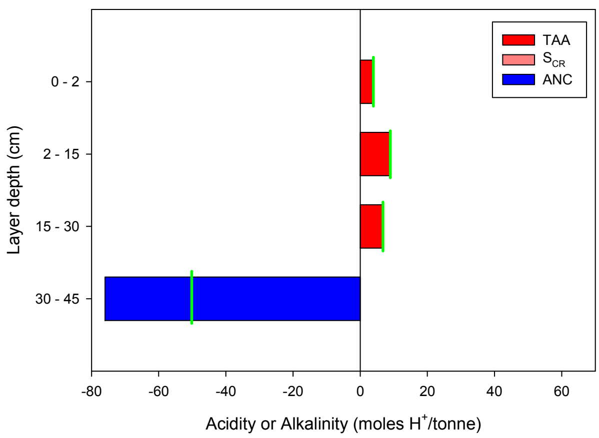
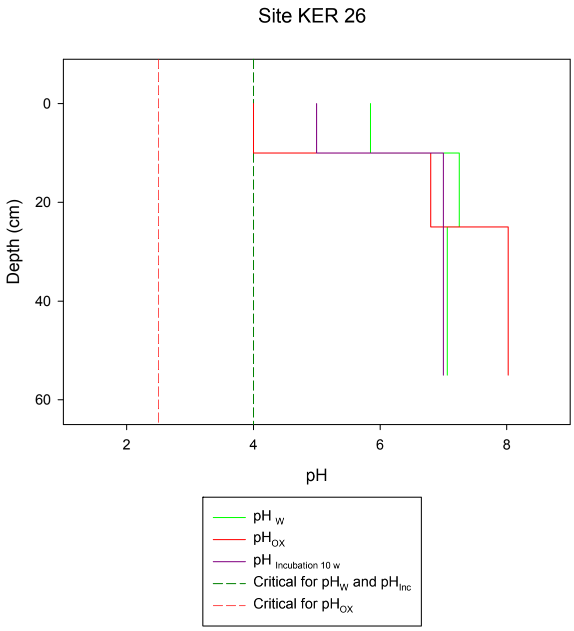


Figure 7-25 Site KER 25. Soil pH (pH_W, solid green line), peroxide pH (pH_{OX}, solid red line) and incubation pH ($pH_{INCUBATION}$ after 19 weeks, solid purple line). Dashed lines show the critical values for $pH_W/pH_{INCUBATION}$ and pH_{OX}. Right Plot: TAA (red bar), S_{CR} (pink bar), ANC (blue bar) and Net Acidity (green line).



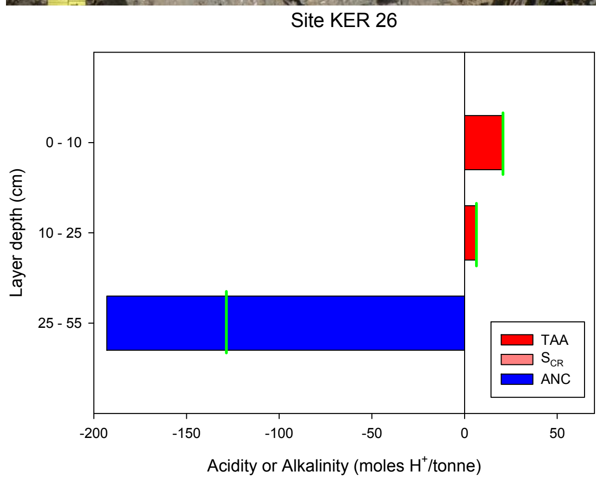
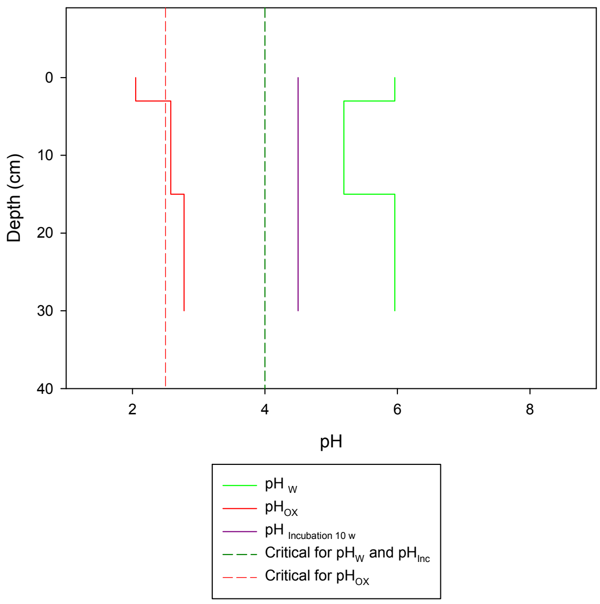


Figure 7-26 Site KER 26. Soil pH (pH_W, solid green line), peroxide pH (pH_{OX}, solid red line) and incubation pH ($pH_{INCUBATION}$ after 19 weeks, solid purple line). Dashed lines show the critical values for pH_W/$pH_{INCUBATION}$ and pH_{OX}. Right Plot: TAA (red bar), S_{CR} (pink bar), ANC (blue bar) and Net Acidity (green line).

Kow Swamp (sites KER 27-28)

Site KER 27

Site KER 27



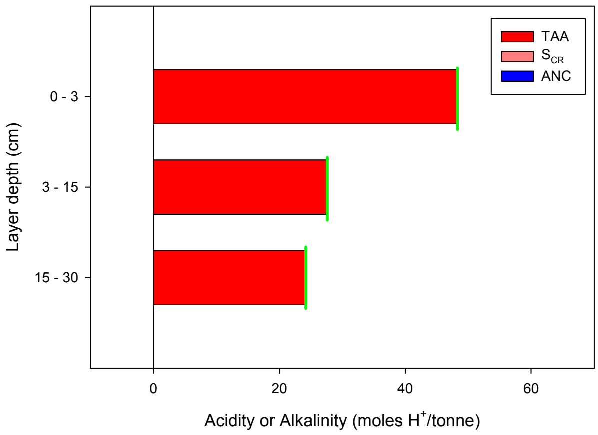
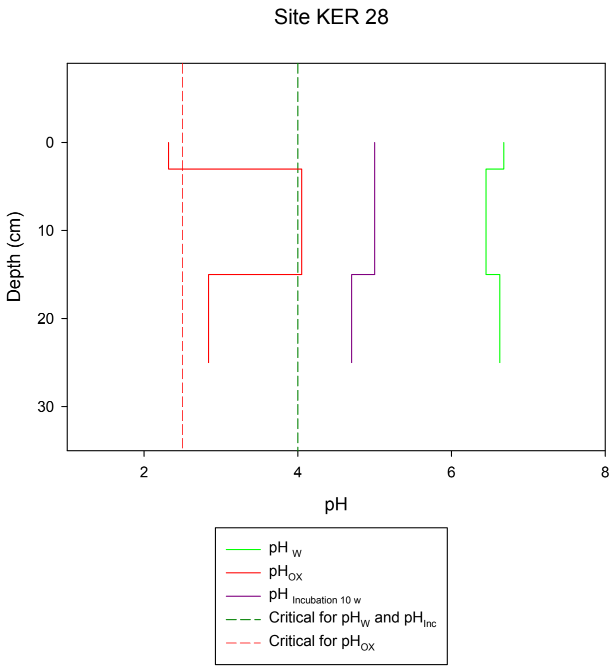


Figure 7-27 Site KER 27. Soil pH (pH_W, solid green line), peroxide pH (pH_{OX}, solid red line) and incubation pH ($pH_{INCUBATION}$ after 19 weeks, solid purple line). Dashed lines show the critical values for pH_W/$pH_{INCUBATION}$ and pH_{OX}. Right Plot: TAA (red bar), S_{CR} (pink bar), ANC (blue bar) and Net Acidity (green line).



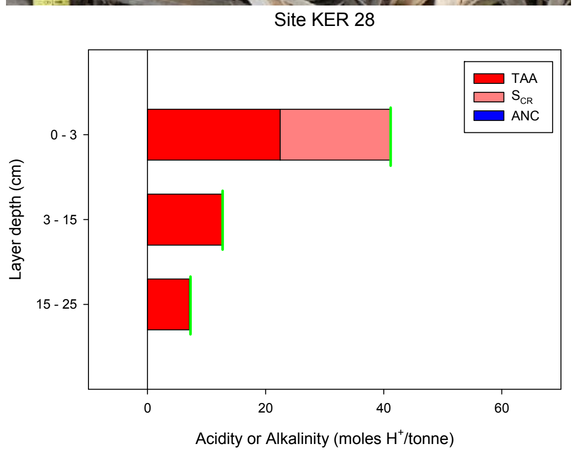


Figure 7-28 Site KER 28. Soil pH (pH_W, solid green line), peroxide pH (pH_{OX}, solid red line) and incubation pH ($pH_{INCUBATION}$ after 19 weeks, solid purple line). Dashed lines show the critical values for $pH_W/pH_{INCUBATION}$ and pH_{OX}. Right Plot: TAA (red bar), S_{CR} (pink bar), ANC (blue bar) and Net Acidity (green line).

Reedy Lake (sites KER 29-30)

Site KER 29

Site KER 29

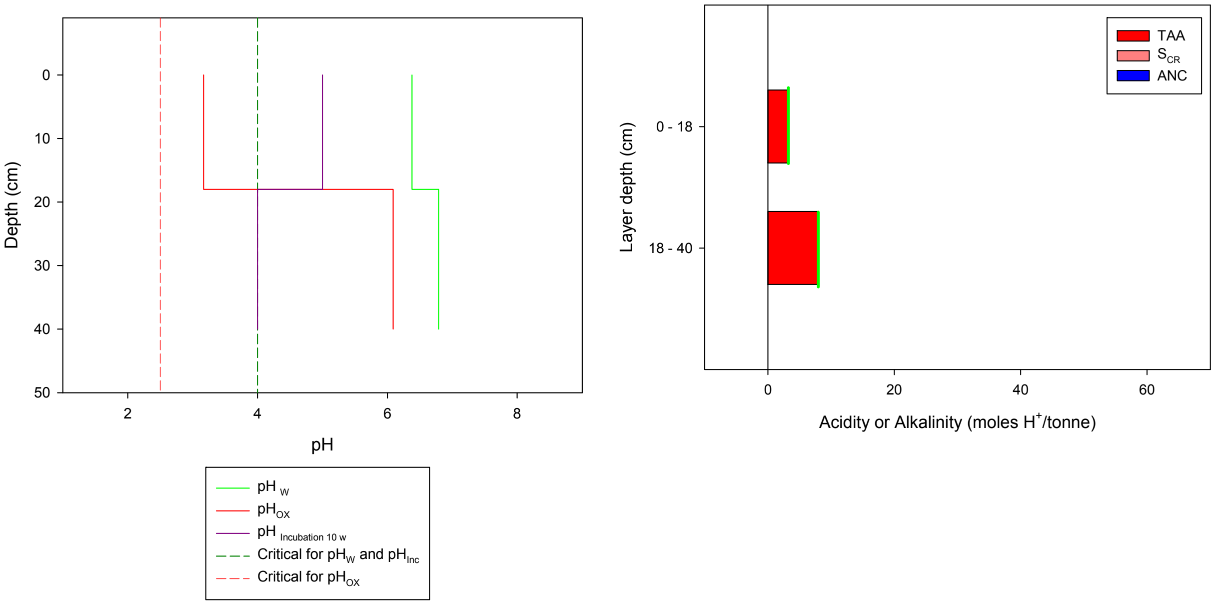
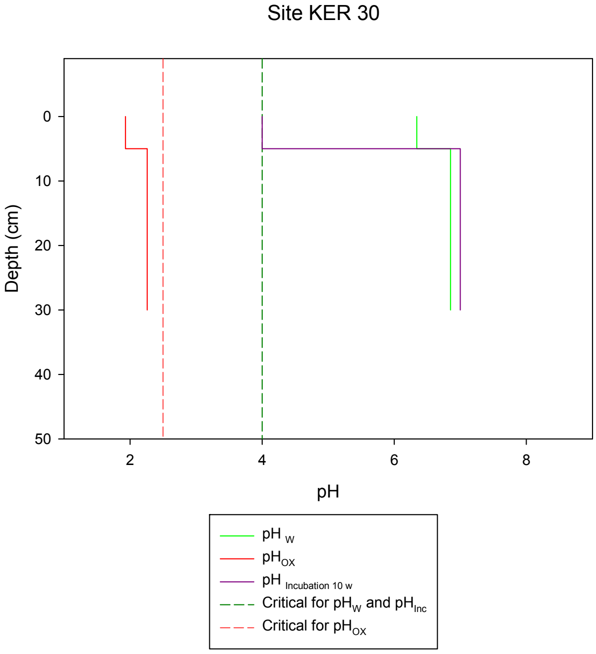


Figure 7-29 Site KER 29. Soil pH (pH_W, solid green line), peroxide pH (pH_{OX}, solid red line) and incubation pH ($pH_{INCUBATION}$ after 19 weeks, solid purple line). Dashed lines show the critical values for pH_W/$pH_{INCUBATION}$ and pH_{OX}. Right Plot: TAA (red bar), S_{CR} (pink bar), ANC (blue bar) and Net Acidity (green line).



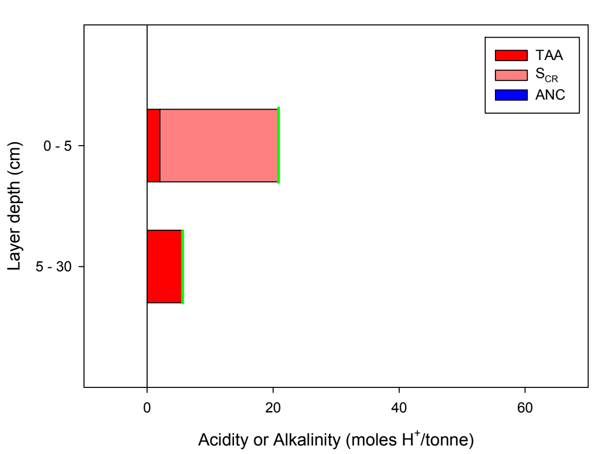
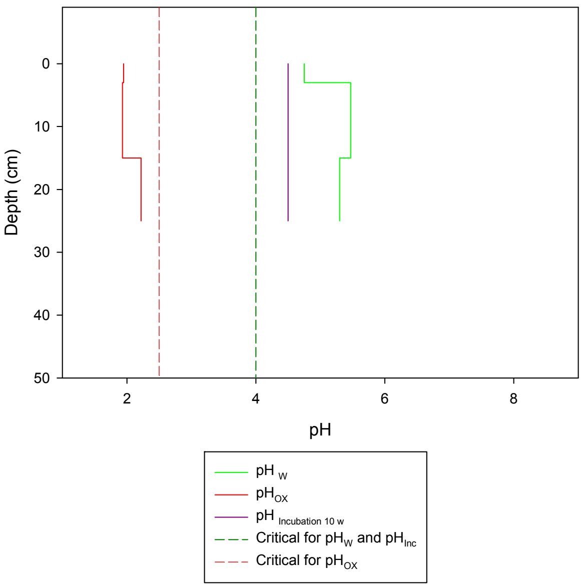


Figure 7-30 Site KER 30. Soil pH (pH_W, solid green line), peroxide pH (pH_{OX}, solid red line) and incubation pH ($pH_{INCUBATION}$ after 19 weeks, solid purple line). Dashed lines show the critical values for pH_W/$pH_{INCUBATION}$ and pH_{OX}. Right Plot: TAA (red bar), S_{CR} (pink bar), ANC (blue bar) and Net Acidity (green line).

Third Lake (sites KER 31-32)

Site KER 31

Site KER 31



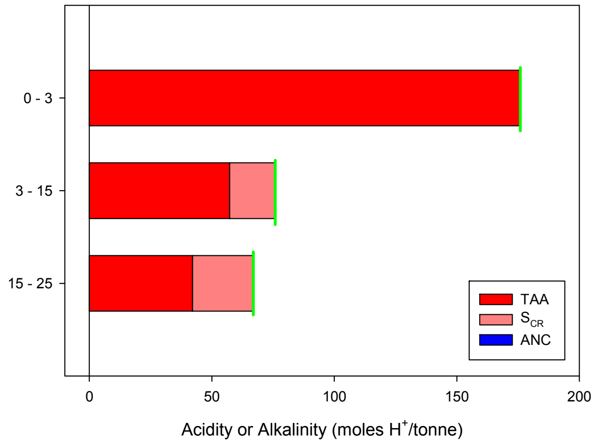
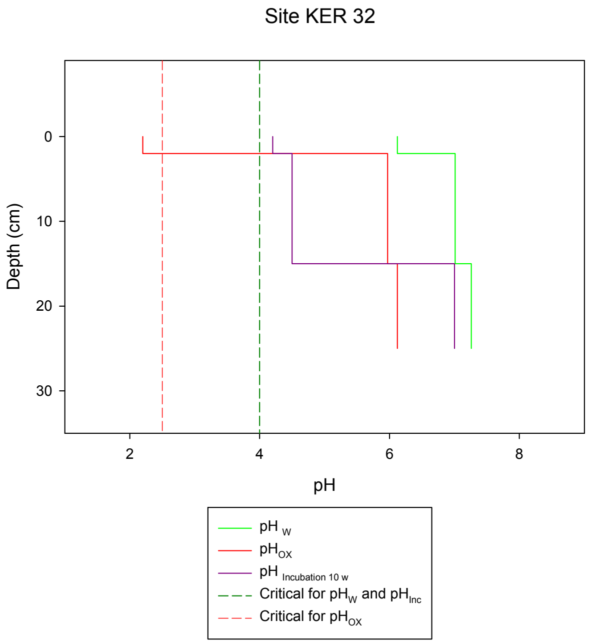


Figure 7-31 Site KER 31. Soil pH (pH_W, solid green line), peroxide pH (pH_{OX}, solid red line) and incubation pH ($pH_{INCUBATION}$ after 19 weeks, solid purple line). Dashed lines show the critical values for pH_W/$pH_{INCUBATION}$ and pH_{OX}. Right Plot: TAA (red bar), S_{CR} (pink bar), ANC (blue bar) and Net Acidity (green line).



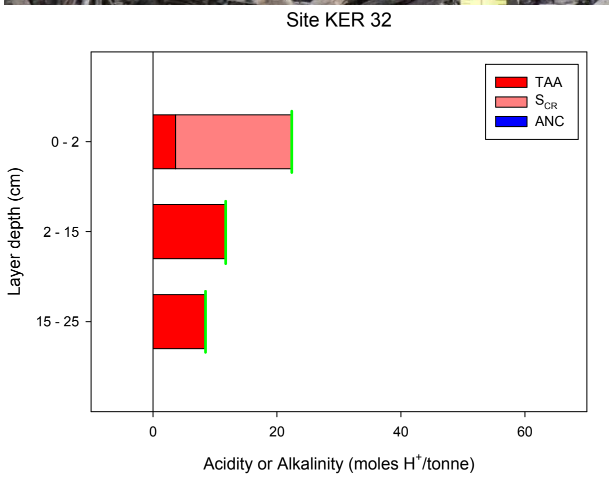


Figure 7-32 Site KER 32. Soil pH (pH_W, solid green line), peroxide pH (pH_{OX}, solid red line) and incubation pH ($pH_{INCUBATION}$ after 19 weeks, solid purple line). Dashed lines show the critical values for $pH_W/pH_{INCUBATION}$ and pH_{OX}. Right Plot: TAA (red bar), S_{CR} (pink bar), ANC (blue bar) and Net Acidity (green line).

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