DEPARTMENT OF
PRIMARY INDUSTRIES

acid sulfate soil hazard maps

guidelines for coastal Victoria

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Acid sulfate soil hazard maps guidelines for coastal Victoria

Paul Rampant, Austin Brown and George Croatto

1 Summary and recommendations

The disturbance of acid sulfate soils in coastal areas of New South Wales and Queensland has resulted in degradation of lowland environments and estuarine water quality. Recorded disturbance of acid sulfate soils in Victoria has been quite low. This may be due to the relatively low occurrence of acid sulfate soils within the state (Figure 1). A number of incidents may have been caused by the disturbance of such soils, but in most cases there was no investigation of the presence or effects of acid sulfate soils.

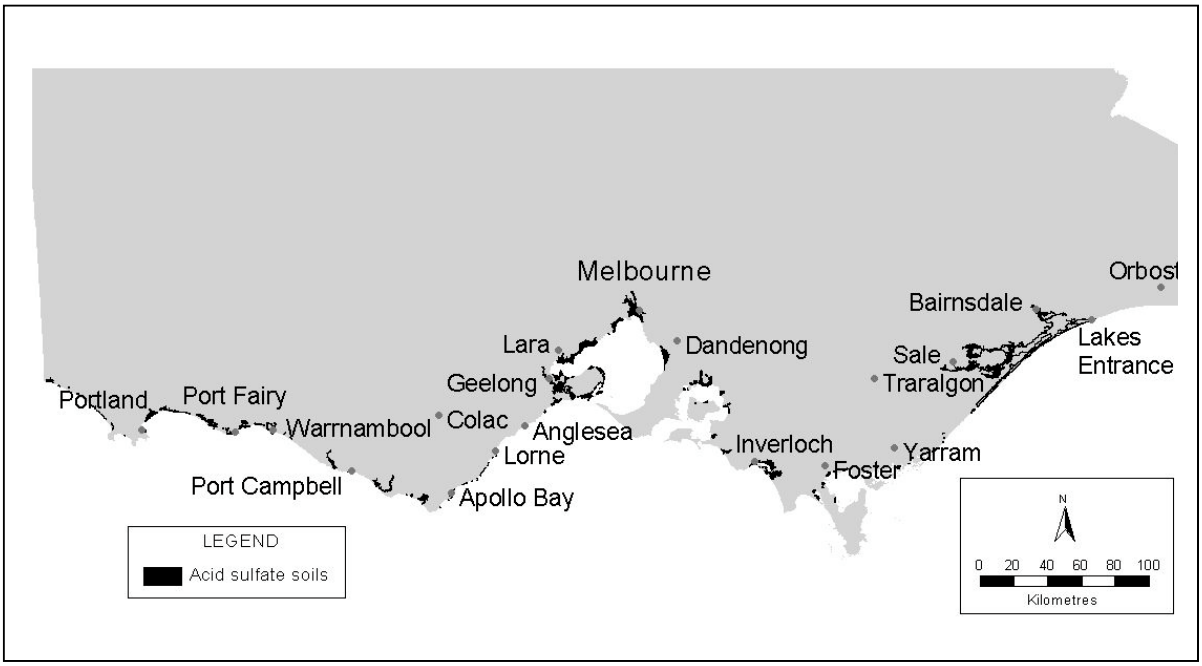

Figure 1. Indicative ASS distribution in Victoria

Assessment of geological records, analysis of digital elevation models, aerial photo interpretation, extensive field work and laboratory analyses of soil samples were used to produce acid sulfate soil risk maps. A set of 1:100 000 scale maps of coastal acid sulfate soils is presented for the purposes of land management and environmental planning in landscapes in coastal Victoria. The maps show two land classes, indicating either low to high, or nil to very low probability of occurrence of acid sulfate soils. Boundaries for public land, local government and catchment management authorities are also shown.

The mapping has been designed to provide information on acid sulfate soil distribution and indicate to land managers where caution is needed or where further investigation and analysis is required before any land disturbance. Due to the scale limitations of mapping, areas adjacent to those assessed as having a probable hazard should also be investigated.

1.1 Management of acid sulfate soils

The best management technique for ASS is to avoid the disturbance of the ASS layers.

The greatest risk of disturbance of ASS in Victoria is urban and rural development. As further pressure for housing development occurs in the coastal zone, the likelihood of disturbance of ASS increases due to increased engineering works such as bridges, tunnels and pipes. Being aware of the existence of ASS is the first step. The second step is the knowledge of the likelihood of ASS occurring in the area of interest and avoiding it. This was the main purpose of this mapping project.

If disturbance is unavoidable then refer to the Environment Protection Authority (EPA) *Industrial Waste Management Policy (Waste Acid Sulfate Soils)* (EPA 1999).

1.2 Interpreting the acid sulfate soil hazard maps

Intended use of the acid sulfate soil hazard maps

The acid sulfate soil hazard maps predict the distribution of ASS based on an assessment of the geomorphic environment. Included in the mapping are the public land boundaries as well as boundaries for local government and catchment management authorities (CMAs).

Use of the map key

The acid sulfate soil hazard maps display two types of information.

Map class description

This is the estimated distribution of acid sulfate soils.

The maps have two primary classes:

- Low to high probability of occurrence of ASS (solid green on maps)
- Nil or very low probability of occurrence of ASS (all other areas of maps)

The coastal ASS hazard maps for Victoria were produced at a scale of 1:100 000. Due to this scale, the areas mapped as low, medium or high probability may include areas that have no ASS. Similarly, the areas outside the mapped region may also include some small areas of ASS.

Site information

The site information included on the maps is exclusively based on survey work (field and laboratory) conducted at the time of mapping.

This information includes three levels of data (with priority in the following order):

1. ASS detected within 1 m from the soil surface (red dot on maps).
2. ASS detected deeper than 1 m from the surface (yellow dot on maps).
3. No ASS detected at the site (red cross on maps).

If ASS was detected, the value on the map was given a symbol of a size relating to the concentration of ASS (low, medium or high).

The body of this report presents a more detailed description of the nature of ASS, the methodologies used in this project and a discussion related to the results that were obtained.

2 Introduction

Acid sulfate soils (ASS) present a serious economic threat and there is an urgent need to recognise their occurrence and distribution. Victoria is a signatory to the *National Strategy for the Management of Coastal Acid Sulfate Soils* (National Working Party on Acid Sulfate Soils 1999). Other strategies in place are the *Victorian Coastal Strategy* (Victorian Coastal Council 2002) which includes the management strategies for coastal ASS, and the statewide *Industrial Waste Management Policy (Waste acid sulfate soils)* (EPA 1999).

Relevant state agencies in New South Wales and Queensland have determined the extent and severity of ASS along the majority of their coastlines. In the Northern Territory some mapping close to Darwin has been completed, while in South Australia the process of mapping the extent of ASS in the coastal zones has recently commenced. In Victoria, a scoping study of the distribution of ASS in the coastal zone was conducted in 2001 by the Department of Natural Resources and Environment's (NRE) Centre for Land Protection Research (CLPR) and State Chemistry Laboratory (SCL). Funding was provided by NRE and the project included input from the Victorian Coastal Council (VCC) and the Environment Protection Authority (EPA).

2.1 Objectives

Study objectives were to:

- obtain an understanding of the extent and severity of ASS within the Victorian coastal region
- assess the risk of acid sulfate soils if disturbed through coastal development
- inform the review of the local government planning and regional catchment strategies
- inform the review and development of coastal action plans.

2.2 Background

Definition

Soils that contain significant amounts of iron sulfides are referred to as ASS. Most of the coastal ASS in Victoria were formed since the sea level was last at its highest, approximately 10 000 years ago during the Holocene epoch. The formation of ASS requires seawater infiltration into an existing freshwater environment. In this estuarine condition, sulfate in seawater mixes with the organic and iron-rich sediments of the freshwater. A suite of biological and chemical processes lead to formation of iron sulfides in sediments and soil; the most common being pyrite. In Victoria, these iron sulfide layers commonly occur well below the soil surface and within a saturated zone (local watertable).

Problem

Whilst the iron sulfide layers remain under anaerobic (without oxygen) conditions under water, they usually have a near neutral pH and are therefore not problematic. Under these conditions, the soils are known as potential acid sulfate soils (PASS) as they have the potential to form sulfuric acid. When these iron sulfides are oxidised, they can produce large volumes of acid and the pH is often below a value of 4. When this occurs, these soils are called actual acid sulfate soils (AASS). AASS will normally only occur in Victoria if the soils are disturbed, for example, in the event of urban or industrial development.

In Queensland and New South Wales, agricultural development has been known to expose or drain these acid-producing soils. There are many possible negative impacts when these soils are exposed to air. If distributed across the surface, the acid may have long-term detrimental effects on plant growth. Leached acid from these soils may corrode concrete and steel infrastructure. It may also mobilise toxic levels of iron, aluminium and manganese, which are harmful to aquatic organisms.

2.3 Acid sulfate soils – characteristics and formation

Formation of potential acid sulfate soils (PASS)

The focus of this study was on the ASS formed since the last major sea level rise within the last 10 000 years, or the Holocene epoch. Due to the sea level change, areas in Victoria that are prone to the formation of ASS are commonly within 2.5 m of current sea level. In Victoria, areas that have been built-up by urban development (e.g. Melbourne Docklands) and areas where there has been potential for accumulation of large quantities of alluvium, the depth to ASS may exceed 2 m. Generally ASS are found within 1.5 m of the soil surface.

There are two main coastal environments in which pyrite sediments form. The first and most dominant is a saline and brackish lowland including tidal flats, salt marshes and mangrove swamps (Pons & van Breeman 1982). The other is a lower sedimentary environment of saline and brackish estuaries, rivers, lakes and creeks.

In these anaerobic environments certain types of bacteria can reduce sulfates in seawater and break down the organic matter (often transported by streams and rivers) to eventually form pyrites. These pyritic sediments are called potential acid sulfate soil (PASS). Pyrite is still being formed in present-day mangrove and salt marshes (Naylor *et al.* 1998). In other areas, ASS are covered with either a wind or water borne sediment which effectively caps the pyritic layer and, with the associated water level, prevents oxidation and the associated acid production (Figure 2).

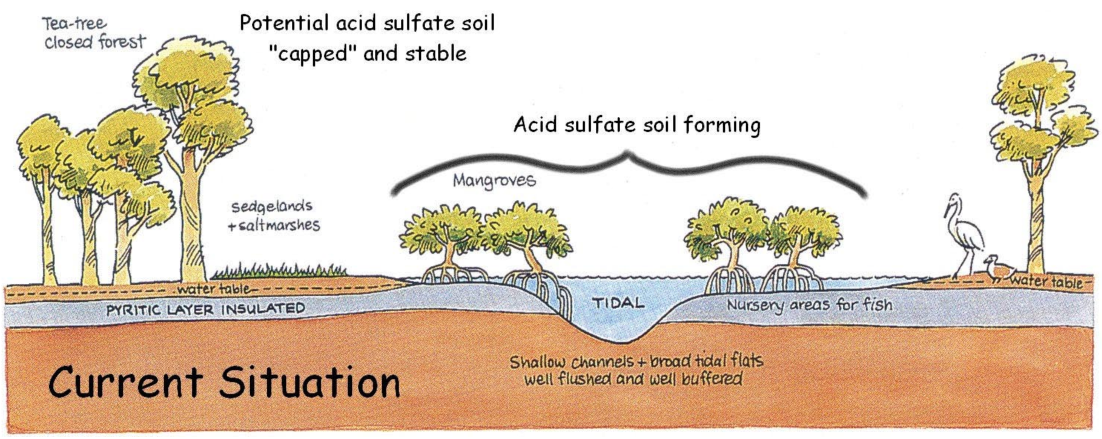

Figure 2. Diagram of formation of ASS *(modified from Sammut and Lines-Kelly 1995)*

Development of actual acid sulfate soil (AASS) layers

Actual acid sulfate soils (AASS) are formed when pyrites and other oxidisable sulfides (in PASS) are exposed to air. The principal end product of this oxidation process is sulfuric acid. Exposure of PASS layers to form AASS layers is usually the result of drainage or excavation. The acid produced by the oxidation process can affect the soil and water. Acidification can cause the mobilisation of iron and manganese from the soil (Sammut *et al.* 1993). These soils form an extremely hostile environment for plant growth and, if at the surface, will often result in areas denuded of all vegetation. Any water crossing or originating from this acidic area transfers the acid and dissolved metals to watercourses and waterbodies. A concentration of these acid products has devastating effects on aquatic flora and fauna.

In New South Wales and Queensland there have been large areas of AASS formed when floodplains were drained (predominantly for agricultural purposes). Due to the relatively small extent of coastal floodplains, this type of activity is not a major contribution to the formation of AASS in Victoria.

Self-neutralising acid sulfate soils

Potential acid sulfate soils (PASS) are often neutral to slightly acidic (pH 6-7) and may be found in conjunction with layers of shell and other carbonates. This naturally occurring lime has the potential to neutralise the acid formed from oxidised pyrite. However, the shell layers vary in thickness and may be quite discontinuous. Also, large shell fragments may acquire a relatively insoluble iron coating under some acidic conditions.

2.4 Potential impacts of acid sulfate soils

Oxidation of pyritic material can generate large amounts of sulfuric acid and have an immediate, and often long-term, effect on plant growth on the affected land. The acidic runoff from these soils leaches iron and aluminium from the soil and water.

The resultant runoff and leachate has a severe detrimental terrestrial and aquatic impact. Massive fish kills may occur when this acid is washed into waterways. Aquaculture industries such as oyster farms that utilise natural watercourses are particularly vulnerable to acidification.

The acid has a corrosive effect on infrastructure such as bridges, tunnels and pipes, to the extent where structures may fail prematurely.

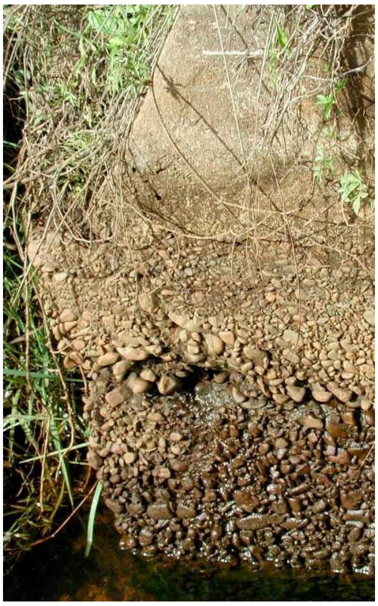

Figure 3. Corrosion of concrete from sulfuric acid originating from ASS

3 Methods

The following methods were used to predict the occurrence of ASS and assist with the delineation of the extent and severity of ASS.

- A digital elevation model (DEM) was utilised to determine the approximate height above sea level.
- Geological studies were utilised to indicate the formations that occurred over the Holocene epoch.
- Where soil-landform mapping existed it was utilised to indicate the presence of pyritic material.
- Targeted fieldwork to ground-truth the mapping.
- Laboratory analysis of soil samples collected during the fieldwork was used to confirm field observations and determine the concentrations of pyritic material in the sediments along the Victorian coast.

Areas excluded from mapping

- This survey focussed on the occurrence of ASS in close proximity to the coast. The areas higher than 10 m above sea level were excluded except in locations where ASS were already known to exist and had been disturbed due to building programs (e.g. Melbourne Docklands).
- The risk of PASS in the saltmarsh intratidal area is known to be high especially in mangrove communities. Mangrove areas were not included in this study because they are protected under the Wetlands Conservation Program and are therefore not likely to be disturbed or developed.
- Pyrite can exists in a range of sedimentary and metamorphic rocks. Activities such as mining and road construction can expose deposits of rock containing pyrite to oxidation and creation of acid sulfate conditions (Naylor *et al.* 1998). These sources of acidification were not considered in this mapping program.

3.1 Digital elevation model

The sea level in southern Australia has dropped by up to 2.5 m since the major deposition of the pyritic sediments (Graham & Larson 2000). Therefore the search for coastal ASS was limited to land below 2.5 m above AHD. This includes surfaces that are now greater than 2.5 m above AHD but have been built up over the last 7000–10 000 years by natural or man-made causes. This characteristic of the ASS formation process made the digital elevation model (DEM) one of the primary datasets for the determination of the extent of probable ASS. The DEM used in this case was created with the software package ANUDEM using statewide 1:25 000 topographic data, as well as stream information and spot height information.

3.2 Geological information

Geological mapping (1:250 000 scale) was used at a statewide level to indicate the formations developed over the last 10 000 years. In the area around Melbourne, 1:63 000 geology mapping was used. The sediments that formed in the Holocene epoch have the majority of pyritic material in Australia. Geological bore log data was studied for reference to pyritic sediments. Where there was reference to shell material in the logs, further investigation was also warranted, as layers of shell are evidence of marine sediments that are often associated with pyritic layers.

3.3 Soil-landform mapping

West of Western Port, unpublished soils mapping by Sargeant and Imhof at a scale of 100 000 and better was also used. The map unit labelled as 'Marine Sediments' had a very strong relationship with occurrence of ASS.

3.4 Field observation and analysis

A field description was recorded for each profile in accordance with the *Australian Soil and Land Survey Field Handbook* (McDonald *et al.* 2000). An example of one of these profile descriptions is given in Appendix 3.

Field peroxide test

A simple peroxide field test described in detail by Hey *et al.* (2000) was carried out as a preliminary assessment of the likelihood of ASS. Hydrogen peroxide was used to oxidise the soil and both the immediate visual reaction and the change in pH from another sample of the same soil (measured in water) were recorded. Visible reaction was described according to the scale in Table 1.

Table 1. Soil reaction rating scale from the peroxide test (Hey *et al.* 2000)

Reaction scale	Rate of reaction
X	Slight effervescence
XX	Moderate reaction
XXX	Vigorous reaction
XXXX or V	Volcanic : very vigorous reaction, gas evolution and heat generation commonly >80°C

The peroxide oxidation is an artificial and much accelerated version of what would occur when the pyrite contacts air. The pH measured at the conclusion of the peroxide reaction (pH_{FOX}) is then assessed against the initial pH_{WATER} to check for a drop in pH. The combination of the reaction, the drop in pH and the final pH (pH_{FOX}) can give a good indication of the presence of PASS.

3.5 Laboratory techniques and results

The analytical methods adopted by the State Chemistry Laboratory (SCL) were current with those used by the Queensland Department of Natural Resources and Mines (DNRM).

Soil collection and sample handling

The soil samples were collected with powered or hand augers depending on conditions.

Where access was good, a Gemco diesel-powered flighted auger was used (Figure 4). This unit drove the auger into the soil while rotating slowly. The auger was then extracted without rotation and soil was sampled from the flights (Figure 5). Depth measurement in this method is reliable to ∂ 10–15 cm.

Figure 5. Soil peeled off Gemco auger flights

Figure 4. Gemco drilling rig sampling ASS

The second method of sampling was to use a combination of a Jarret hand auger and a Number 4 Dormer sand auger (Figure 6), depending on the soil texture and ease of extraction.

The collection, handling and storage of the soil samples for analysis were conducted as per the procedures documented in detail by DNRM Queensland (Ahern *et al.* 1998).


Figure 6. Dormer hand auger in use

The soils were described in the field and the preliminary field tests performed as described above. The soils were then sampled by layers, and placed in snap-lock plastic bags, evacuating as much air as possible. The samples were immediately placed into a portable freezer and transported and stored in a frozen state until time of analysis at SCL.

Total oxidisable sulfur (TOS)

Analysis of total oxidisable sulfur (TOS) was used primarily as a screening tool to predict the potential acidity of an unoxidised ASS. However, the method is subject to interferences from organic sulfur found in soils with high organic matter content. For soils low in oxidisable sulfur and soils with high levels of organic matter, the chromium reducible sulfur test, which is unaffected by organic sulfur, is preferred.

The TOS method involved two separate assays; a total sulfur analysis using a LECO Sulfur analyser and a hydrochloric acid (4M HCl) extraction of the sample to determine the sulfates or non-pyritic sulfur (Ahern *et al.* 2000a). Total oxidisable sulfur was determined as the difference between total sulfur and HCl extractable sulfur.

Total sulfur

Soil samples were combusted in a high temperature induction furnace (LECOTM CNS 2000) in an oxygen atmosphere. The sulfur dioxide produced was quantitatively sampled by the instrument and measured with an infrared detector. Results were calculated as percentage sulfur in the soil.

HCl extractable sulfur

HCl extractable sulfur was determined by shaking samples end over end in 1:40 (soil:4M HCl) suspensions for 16 hours. Filtered aliquots were used for determination of calcium, magnesium, sodium and sulfur by ICP-AES. Measurement of calcium and magnesium in the hydrochloric acid extracts enabled estimation of the neutralising capacity of the soil.

Modified Peroxide Oxidation – Combined Acidity & Sulfate (POCASm) method

This method measures both the sulfur trail and the acidity trail as well as the pH before and after oxidation. The POCASm method allows comparison between the acid and sulfur trails and provides a check on the consistency of the amount of neutralising material reacted in the digestion by measuring acid reacted calcium and magnesium. Organic matter is variable in composition and its effects on both the sulfur and acid trail are difficult to quantify and predict. This method can overestimate the acid producing potential of acid sulfate soils with high organic matter contents, so again, the chromium reducible sulfur method is recommended for soils low in oxidisable sulfur and/or high in organic matter. Analysis was carried out according to the methods of Ahern *et al.* (2000b).

Titratable acidity and soluble sulfate were determined on separate samples before and after reaction with 30% hydrogen peroxide. Total sulfidic acidity (TSA) was calculated by measuring the difference between the total potential acidity (TPA) after oxidation and total actual acidity (TAA) without oxidation. Peroxide oxidisable sulfur (S_{pos} %) was calculated by measuring the difference between sulfur determined after peroxide oxidation and potassium chloride (KCl) extractable sulfur without oxidation.

Total actual acidity (TAA)

Acidity in the soil before oxidation with peroxide was measured by extracting samples for four hours in 1M KCl solution (1:20 soil solution ratio) and allowed to stand overnight. The samples were then shaken for a further 30 minutes. An aliquot of the extract was titrated against a standard sodium hydroxide solution to determine acidity. A second aliquot was analysed by ICP-AES for calcium, magnesium, sodium and sulfur.

Total potential acidity (TPA)

ASS, when exposed to water and oxygen release (due to oxidation of sulfidic material) sulfuric acid into the environment. This method accelerates this oxidation with the use of 30% hydrogen peroxide. Soils samples were heated to approximately 80^{o}C in the presence of repeated additions of 30% hydrogen peroxide. On completion of oxidation, an aliquot of the extract was then analysed (by titration against a standard sodium hydroxide solution) for acidity. A second aliquot was analysed by ICP-AES for calcium, magnesium, sodium and sulfur.

Chromium reducible sulfur

Chromium reducible sulfur is not subject to interference by organic sulfur and sulfates as are other methods for determining pyritic sulfur in soils. Results from this analysis take precedence when two sulfur trail measurements are in conflict. This analysis is particularly useful for soils with high amounts of organic matter. It is also a sensitive method and can be used on soils where the percentage sulfur is very low (e.g. 0.05% or so). The method was carried out according to Sullivan *et al.* (2000). Soil samples were mixed with an acidic solution of chromium chloride and heated, causing reduction of inorganic sulfur to hydrogen sulfide gas, which was trapped in a solution of zinc acetate as zinc sulfide. The zinc sulfide was then quantified by titration with standard iodine solution and expressed as percentage of sulfur in the soil.

PASS risk

Rating of PASS risk (based on the POCASm sulfur trail or TOS) followed the Queensland Department of Natural Resources and Mines Laboratory methodology where nil or minimal risk = < 25 mol H^+/tonne, low risk = 25-200 mol H^+/tonne, medium risk = 200-400 mol H^+/tonne and high risk = > 400 mol H^+/tonne production.

4 Results

4.1 Extent of acid sulfate soils in Victoria

ASS occurred in a range of soil textures, from loamy sands to light clays and heavier. This survey focussed on the occurrence of ASS in close proximity to the Victorian coast (Figure 1), with some exclusions (mangroves). The area of ASS above the high water line was estimated to be approximately 55 000 ha. In comparison with New South Wales and Queensland, this is a relatively small area of land.

4.2 Distribution of acid sulfate soils in Victoria

The estimated areas with ASS for each catchment management authority (CMA) region and shire are shown in Tables 2 and 3 respectively. The West Gippsland CMA region has the highest area, followed by Corangamite CMA and then Port Phillip CMA regions (Table 2). About one-quarter of this area is on public land. Shires with the highest areas of ASS are Wellington and Greater Geelong City, each with 3-4 times the area of ASS of the shires of South Gippsland, Moyne, Wyndham, East Gippsland and Glenelg (Table 3).

Table 2. Extent of ASS within each CMA region

CMA region	Private land (ha)	Public land (ha)	Total land area (ha)
Corangamite	9 614	4 231	13 845
East Gippsland	1 723	928	2 651
Glenelg	5 850	1 256	7 106
Port Phillip	10 277	1 351	11 628
West Gippsland	14 305	5 361	19 666

Table 3. Extent of ASS within local government areas (shires)

Shire	Private land (ha)	Public land (ha)	Total land area (ha)
Bass Coast	1 335	599	1 934
Bayside City	Nil	Nil	Nil
Cardinia City	975	58	1 033
Casey City	1 685	214	1 899
Colac Otway	815	516	1 331
Corangamite	858	523	1 381
East Gippsland	1 505	1 110	2 615
Frankston City	324	Nil	324
Glenelg	1 938	602	2 540
Greater Dandenong City	119	Nil	119
Greater Geelong City	8 305	3 440	11 745
Hobson Bay City	764	260	1 024
Kingston City	1 726	Nil	1 726
Mornington Peninsula	22	25	47
Moyne	3 889	572	4 461
Queenscliffe Borough	109	36	145
South Gippsland	3 946	636	4 582
Surf Coast	426	56	482
Warrnambool City	391	199	590
Wellington	9 697	4 257	13 954
Wyndham City	2 937	24	2 961

4.3 Severity of acid sulfate soils in Victoria

Of the 44 sites examined in the field and/or laboratory, only three (Tooradin and Venus Bay in West Gippsland and Kings Way, South Melbourne) had actual acid sulfate soil (AASS) while 28 indicated the presence of potential acid sulfate soil (PASS) (Appendix 1). Of the sites with PASS, 10 had at least one soil layer with a high risk rating and a further seven had a layer with medium risk. The depth to an ASS layer ranged from 0.3 to 2.65 m and thickness of the ASS layer ranged from 0.1 to more than 2.9 m. At least 16 of the 28 sites with ASS were potentially self-neutralising due to the presence of shell fragments or fine lime. The concentrations of the pyrite and thickness of the pyritic layer at the sampled sites were in most cases quite low compared to those found in the northern regions of Australia. In field tests, strong effervescence coincided with large pH change for many sites. For example, pH depressions of 5-6 units were observed in samples from Bass Landing (2.0 to 2.6 m), Patterson Lakes (0.9 to 1.6 m), Maribyrnong (1.75 to 2.4 m) and Warrnambool (2.1 to 2.2 m).

A summary of all the field and laboratory data for each site in terms of depth to ASS, depth (or thickness) of ASS, presence of AASS, risk of PASS and potential neutralising value is presented in Appendix 1.

5 Discussion

The coastal acid sulfate soil hazard maps are a set of preliminary maps presented at a scale of 1:100 000 for the purposes of land management and environmental planning in landscapes of coastal Victoria. The mapped extent of probable ASS is based on a combination of knowledge and data, including formation processes, height above current sea level, geological mapping, soil mapping and site assessment. Due to the state of flux of the environment in which ASS form, and due to the processes that have occurred since their formation, the actual distribution of ASS is difficult to accurately predict. What is mapped is the most likely occurrence of the formation of ASS. At some sites, the laboratory results have indicated the potential for self-neutralisation but due to the extreme spatial variability, this was not included in the mapping.

Observations of shell or lime, field textures, and effervescence and pH change due to oxidation for various layers of each soil profile can be found in Appendix 2. In 25 sites, vigorous or volcanic effervescence was observed in at least one soil layer, but did not always coincide with a large pH change or a very acid soil after oxidation. This could be partly due to the variable nature of the ASS sediments, whereby a small subsample drawn from a layer for effervescence testing may vary from another drawn for pH testing. Where organic matter levels were high (e.g. near surface layers or buried peat layers), excessive frothing during peroxide treatment could mask effervescence. On the other hand, effervescence and pH change could have been inhibited where conditions were cold and the peroxide reaction was slow to take effect. This latter condition was compensated to some degree by using a warm water bath in which to conduct the tests.

Although the laboratory pH data generally agreed with the field pH data they did not always match. The pH after oxidation sometimes varied from that found in the field because of the longer and more complete reaction time provided in the laboratory testing (e.g. more acid produced or alternately, self neutralised from fine lime). Change in pH also varied between field and laboratory, not only due to the difference and completeness of reaction times and subsample variability, but also because the original pre-peroxide pH is measured in a different extract (water in the field, potassium chloride solution in the laboratory).

Total oxidisable sulfur (TOS) testing was performed on most samples from most sites. Selected samples representing soil layers of interest (i.e. often with indications of ASS through field testing) were also analysed by a modification of the Peroxide Oxidation – Combined Acidity & Sulfate (POCAS) method, where both a calculation of acid production (mol H^+/tonne) via an acidity trail and a sulfur trail were made. Comparison of the TOS and POCAS results provide confirmation of the presence or absence of ASS or suggest that other factors play a role in the chemistry of the soil (e.g. the POCAS acidity trail often shows no acid production when self neutralisation due to lime occurs).

Total carbon testing was performed for all samples and, where high, organic sulfur was expected to be giving a misleading high acid production rate. In theses cases chromium reducible sulfur testing was carried out as a confirmatory method (data not shown in this report). Apart from surface soils where organic matter interference was expected, this situation happened occasionally where buried layers of peat occurred (e.g. Dalmore – site 2, Tooradin – site 6).

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Appendix 1. Risk of coastal acid sulfate soils summary

Site	Depth to ASS (cm)	Depth of ASS (cm)	Presence of AASS	Risk of PASS	Drop in lab pH	Final lab pH	PSN	Comments
1 – Tooradin: recreational reserve	nil ?	na	no	no data				Á field observations indicate PASS risk unlikely
2 – Dalmore: Pound Road	100	20	no	nil	0	5.1	na	Á peat layer at 100-120 cm (S is mainly organic)
3 – Bass: Bass Landing	200	100+	no	medium-low	4.4-2.6	2.3-6.0	yes	Á PSN for 260-300 cm only
4 – Tooradin: airport	nil ?	na	no	no data				Á field observations indicate PASS risk unlikely (perhaps low for 180-200 cm)
5 – Patterson Lakes: Patterson River	45	255+	no	low-medium	5.2-5.5	2.4-5.6	no	
6 – Tooradin: riverside reserve	110	20	yes	low	+0.3-1.1	4.3-5.0	no data	Á peat layer 110-130 cm (some non-organic S) Á AASS (based on field pH) at 130-220 cm
7 – Dalyston: Powlett River mouth	80	290+	no	low-high	0.9-3.0	2.2-7.4	yes	Á PSN partial for 120-180 cm, then complete to 300 cm
8 – Pound Creek: Pound Creek	140	160+	no	low-high	0.9-1.1	6.9-7.6	yes	
9 – Venus Bay: Anderson Inlet	45	255+	yes	low-high	0.7-3.2	1.9-6.9	yes	Á PSN from 130 cm (data to 180 cm only) Á AASS (based on field pH) at 65-75 cm

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Appendix 1. continued

Site	Depth to ASS (cm)	Depth of ASS (cm)	Presence of AASS	Risk of PASS	Drop in lab pH	Final lab pH	PSN	Comments
10 – Sandy Point: Shallow Inlet	90	230+	no	low	0-1.1	7.4-7.9	yes	Á no field pH for 200+ cm
11 – Yanakie: Black Swamp	75	175+	no	medium-high	2.1-4.5	2.3-2.6	no	
12 – Darriman: Jack Smith Lake	nil	na	no	nil	+0.6	6.5	na	
13 – Port Albert: new subdivision	65	235+	no	low	1.1-3.9	3.3-6.4	yes	Á high organic layer at 20-25 cm: low PASS Á PSN for 115-140 cm, then partial to 165 cm
14 – Foster: Old Hat Road	120	95+	no	low-medium	+0.1-0.4	7.4-7.6	yes	
15 – Sale: La Trobe River	160	145	no	low	0.6	5.9	yes	
16 – Clydebank: telephone exchange	nil ?	na	no	no data				Á field observations indicate PASS risk unlikely
17 – Clydebank: Clydebank Morass	nil ?	na	no	no data				Á field observations indicate PASS risk unlikely
18 – Seacombe: Lake Wellington	95	215+	no	low	no data			
19 – Seacombe: McLennans Strait	80	95	no	medium-low	+0.5-5.8	2.5-8.3	yes	Á PSN partial for 125-150 cm, then complete
20 – Loch Sport: Gippsland Lakes Coastal Park	nil	na	no	nil	+2.8-+0.8	5.8-6.6	na	

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Appendix 1. continued

Site	Depth to ASS (cm)	Depth of ASS (cm)	Presence of AASS	Risk of PASS	Drop in lab pH	Final lab pH	PSN	Comments
21 – Bairnsdale: McLeod Morass	265	65	no	medium	no data			Á a low PASS risk rating applies for 25-70 cm but is partly due to organic S
22 – Bairnsdale: Mitchell River	nil	na	no	nil	no data		na	
23 – Bairnsdale: Point Bolodun	100	30	no	medium	no data			
24 – Lakes Entrance: coastal reserve	nil	na	no	nil	no data		na	
25 – Sunny Banks: Tambo River	205	95+	no	low	no data			
26 – Bruthen: Tambo River	nil ?	na	no	no data				Á field observations indicate PASS risk unlikely
27 – Paynesville: McMillan Strait	nil	na	no	nil	0.6-1.9	4.1-5.7	na	
28 – Tabbara: Lake Curlipp	210	50+	no	low	no data			Á a low PASS risk rating applies to 20-75 cm but is due to organic S
29 – Orbost: Snowy River	200	40+	no	low	no data			
30 – Maribyrnong: Coulson Gardens	175	125+	no	high	1.6-3.0	2.0-2.1	no	
31 – Footscray: Dynon Road	nil	na	no	nil	no data			

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Appendix 1. continued

Site	Depth to ASS (cm)	Depth of ASS (cm)	Presence of AASS	Risk of PASS	Drop in lab pH	Final lab pH	PSN	Comments
32 – North Melbourne: Vaughan Terrace Reserve	210	20	no	low	no data			
33 – South Melbourne: Kings Way/Sturt Street	250	275+	yes	low-high	0.7-5.2	1.9-6.1	no	Á AASS (based on field pH) at 310-380 cm
34 – Point Cook: Cheetam Wetlands	110	25+	no	low	0.1-0.5	8.0-8.5	yes	
35 – Point Wilson: wildlife reserve	90	170+	no	low-high	+0.1-2.0	7.4-8.8	yes	
36 – Connewarre: Lake Connewarre	nil	na	no	nil	no data			Á no field pH
37 – Swan Bay: foreshore	10	10	no	high	0.1	8.1	yes	Á peat layer at 10-20 cm: partly organic S only Á no field pH
38 – Barwon Heads: Salt Swamp	nil	na	no	nil	0.0-0.5	8.8-9.0	na	
39 – Breamlea: flora reserve	160	10	no	high	1.2	6.3	part	
40 – Peterborough: Curdies Inlet	95	55+	no	low-medium	0-1.4	8.0-8.3	yes	

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Appendix 1. continued

Site	Depth to ASS (cm)	Depth of ASS (cm)	Presence of AASS	Risk of PASS	Drop in lab pH	Final lab pH	PSN	Comments
41 – Mepunga West: **Killeens Road**	150	70	no	low	0.1-1	7.1-8.1	part	Á a low PASS risk rating applies to 30-90 cm but is partly due to organic S
42 – Warrnambool: Kelly Swamp	100	110+	no	low-high	0.7-1.1	7.3-8.3	yes	
43 – Yambuk: Eumeralla River	nil	na	no	nil	+0.1-0.6	6.9-7.6	na	
44 – Princetown: Gellibrand River	30	15	no	nil	no data			Á organic S layer at 30-45 cm

Depth: + indicates bottom of examined profile; Risk of PASS: based on POCAS (or TOS) acid production via sulphur trail where nil = <25, low = 25-200, medium = 201-400, high = >400 mol H^+/tonne (note: In most situations <25 mol H^+/tonne production for a nil risk more or less matched the action criteria used by DNR Queensland and was used here. Risk for PASS in surface samples (except for metropolitan soils) is regarded as nil, on the assumption that, despite acid production indicated by TOS or POCAS, these soils are aerated, generally high in organic matter and the acid is likely to derive from calculations of S as sulfate. Where PASS is nil, PSN is treated as not applicable. Potential Self Neutralising (PSN) [based on POCAS sulphidic S minus Ca and Mg analyses where such are assumed to be in carbonate form]: PSN can only be determined where POCAS has been done); Comments relate to ASS layers.

Appendix 2. Coastal acid sulfate soils summary results

Site	Depth	Texture	TC	Shell & Lime	Soft CO_3	Field Eff	Field pH H_2O	Field pH H_2O_2	Field pH change	Lab pH oxidised	Lab pH change	POCAS acid trail	POCAS S trail & PSN	TOS
	Cm		**%**						**(drop)**		**(drop)**	**acid prod., mol H^+/tonne**		
1 – Tooradin:	0-60	cl				x	5.2	4.6	0.5			no data		
recreational reserve	60-120	sl				x	5.3	3.7	1.5			no data		
	120-200	cl				x	5.1	3.5	1.5			no data		
	200-350	sl				x	5.3	4.0	1.5			no data		
	350+	sl				x	5.5	4.2	1			no data		
2 – Dalmore:	0-100	cl-mc	6.9-4.1			n-x	6.0-6.4	2.9	3.5			no data		19-37
Pound Road	100-120	peaty lc	12.6			xx	6.1	3.4	2.5	5.1	0	53	95	105
	120-300	mc-mhc	1.3-0.4			xx	5.8-6.4	3.5-4.0	2-3.5	5.4-5.9	+0.5	0-6	2-7	0-12
3 – Bass:	0-30	l	8.4			n	5.9	2.8	3			no data		28
Bass Landing	30-200	mc-lys	2.2-0.3			n	5.9-6.4	3.7-4.6	1-3	4.8	0	15	2	0-28
	200-260	lys	0.5-0.7	1,1		v	8.3-8.9	1.9-(6.2)	6	2.3	4	223-242	312-319	250-408
	260-300	lys	0.7			n	8.6	4.8	4	6.0	2	0	59-62**	53-58
4 – Tooradin:	100-180	lc				n	5.4-5.8	3.7-3.8	1.5-2			no data		
airport	180-200	lc				xx	6.3	3.0	3			no data		
	200-230	mc				xx	5.9	3.9	2			no data		
	230-250	mc-mhc				xx	6.9-5.8	4.5-4.8	1-2.5			no data		

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Appendix 2. continued

Site	Depth	Texture	TC	Shell & Lime	Soft CO_3	Field Eff	Field pH H_2O	Field pH H_2O_2	Field pH change	Lab pH oxidised	Lab pH change	POCAS acid trail	POCAS S trail & PSN	TOS
	Cm		%						(drop)		(drop)	acid prod., mol H^+/tonne		
5 – Patterson Lakes: Patterson River	0-30	l	14.7			x	6.5	3.8	2.5			no data		133
	30-45	cs-lc	1.0-2.1	5,1-2		x	6.9-7.3	5.5-6.3	1-1.5			no data		7-13
	45-90	s	0.8	2,2-3		xx	7.6	6.2	1.5			no data		111
	90-160	s	0.7-0.4	1-2,1-3		v	6.8-7.7	1.6-1.8	5.5-6	2.5	5.5	152-155	269-271	262-481
	160-200	s	0.3			v	7.5-8.0	1.8-(5.7)	6	2.4	5	232-246	278-297	317-358
	200-300	s	0.2	2,2-3		n-x	7.4-7.7	4.8-6.0	2-3			no data		19-29
6 – Tooradin: riverside reserve	0-25	l	11.3			x	6.5	4.0	1.5			no data		51
	25-110	mhc-lc	1.9-1.2			n-x	5.1-7.1	3.1-4.5	2-2.5			no data		6-11
	110-130	peat	20.7			x	4.5	2.4	2			no data		400
	130-220	sc	0.8-0.4			x-xx	3.7-3.8	2.0-2.5	2	4.3-5.0	+0.5	2-18	13-19	12-30
	220-300	mc	0.2			v	6.4	4.4	2	4.9	1.5	17	6	19
7 – Dalyston: Powlett River mouth	0-20	l-sc	5.5-3.6			x	7.3-7.4	5.1-5.6	2-2.5			no data		27-45
	20-60	lc-sc	1.3-0.3			x	7.1-7.2	4.8-4.9	2			no data		10-18
	60-80	scl	0.4			xx	6.9	1.6	5.5			no data		11
	80-120	cs	0.9			v	7.6	1.4	6.0			no data		143
	120-180	cs	1.3			v	7.1	1.8	5	2.2	3	529-575	567-608*	974
	180-300	s-sc	1.3-3.5	5, 1-2		x	8.4-8.5	6.0-6.5	2-2.5	7.4	2	0	323-1160**	280-1065
	300-350	s	1.0			x	9.0	6.3	2.5			no data		183

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Appendix 2. continued

Site	Depth	Texture	TC	Shell & Lime	Soft CO_3	Field Eff	Field pH H_2O	Field pH H_2O_2	Field pH change	Lab pH oxidised	Lab pH change	POCAS acid trail	POCAS S trail & PSN	TOS
	Cm		%						(drop)		(drop)	acid prod., mol H^+/tonne		
8 – Pound Creek: Pound Creek	0-15	cl	8.2			x	6.0	3.6	2.5			no data		37
	15-40	mc	1.1			x	6.4	4.7	2			no data		11
	40-140	sl	3.4-4.0	2-3, 2-3		n	8.4-8.5	6.4-6.5	2	7.6-7.8	0.5-1	0	3-8	7-8
	140-170	scl	3.3			xx	8.3	5.6	3	7.6	1	0	144**	133-144
	170-200	lc	1.9			v	8.3	2.8	5.5	6.9	2	0	618**	653
	200-225	lc-lmc	0.9			xx	8.4	5.4	3			no data		479
	225-300	lmc	0.5-0.4			xx	8.7-8.8	5.5-6.7	2-3			no data		90-137
9 – Venus Bay: Anderson Inlet	0-15	lc	12.7			x	5.5	5.4	0			no data		82
	15-45	lmc	1.9			x	6.5	5.0	1.5			no data		9
	45-75	lmc	1.2-2.4			x	3.9-4.2	2.8-2.9	1-1.5			no data		0-33
	75-130	lc	3.1-1.3			xx	4.1	3.0	1	1.9-2.2	2-3	673-1590	683-1597	935-2098
	130-155	s	1.1			xx	6.9	5.7	1	6.9	2	0	343**	307
	155-300	s	1.4-1.9			n-xx	7.4-8.8	6.2-6.4	1-2	6.8	1	0	177-179**	102-190
10 – Sandy Point: Shallow Inlet	0-10	mat-scl	29.5-9.8			xx	7.8-8.2	4.4-4.7	3.5			no data		78-156
	10-25	lmc	1.9			n	7.7	5.1	2.5			no data		28
	25-85	sl	0.4-0.7	2, 1-2		x-xx	6.7-7.6	4.9-5.3	2-2.5			no data		0-2
	85-90	sl		2, 1-2		xxx	7.0	1.9	1			no data		
	90-100	sl	2.0	2, 1-2		x	8.3	6.3	2	7.5	0	0	124**	121
	100-320	ksl-ks	2.5-1.2	2, 1-2		x-xx	8.4-8.6	6.3-6.6	2	7.4-7.9	0-1	0	50-116**	44-177

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Appendix 2. continued

Site	Depth	Texture	TC	Shell & Lime	Soft CO_3	Field Eff	Field pH H_2O	Field pH H_2O_2	Field pH change	Lab pH oxidised	Lab pH change	POCAS acid trail	POCAS S trail & PSN	TOS
	Cm		%						(drop)		(drop)	acid prod., mol H^+/tonne		
11 – Yanakie:	5-15	cl	7.3			x	5.0	3.0	2			no data		49
Black Swamp	15-30	lmc	1.5			x	5.1	3.3	2			no data		10
	30-75	lc	0.7-0.9	1, 2		x	5.4-5.6	3.7-5.1	0.5-1.5	5.0-5.2	1.5-+0.5	0-10	0-12	0-7
	75-225	lc	0.9-2.3	1, 2		xx-v	6.1-7.1	1.4-2.1	5	2.3-2.6	2-4	221-417	270-577	222-940
	225-250	lc	0.8			x	7.3	5.9	1.5			no data		279
12 – Darriman:	0-20	cl-mhc	4.6-2.2			xx	6.8-7.2	3.7-4.4	3			no data		22-42
Jack Smith Lake	20-300	lc-mhc	0.9-0.2			x-xx	7.1-7.9	5.1-6.4	1.5	6.5	1.5	0	0	0-9
13 – Port Albert:	5-20	scl	3.1			x	5.8	4.1	1.5			no data		33
new subdivision	20-25	l	16.5			x	5.4	4.1	1			no data		166
	25-65	lc	0.8			x	5.4	4.2	1			no data		6
	65-115	ls	0.6-0.3	1, 1		xx-xxx	6.6-6.8	1.4-2.2	4-4.5	2.9-3.3	3-3.5	64-89	80-94	80-98
	115-140	ls	0.5	1, 1		xxx	6.8	1.4	5	4.5-6.5	1-3	0	138-146**	132
	140-165	ls	0.6	1, 1		v	7.8	1.9	6			0	153*	171
	165-265	ls	0.3-0.6			xx-xxx	7.1-7.3	1.5-1.9	6			12-33	76-79	85-97
	265-300	ls	0.2-0.5			x	6.8	2.7	4			no data		56-65
14 – Foster:	0-10	l	23.8			xx	4.6	3.9	0.5	5.9	+0.5	0	190-191	196
Old Hat Road	10-95	mc-lmc	1.9-0.3			x-xx	5.5-5.9	3.6-3.7	2			no data		0-24
	95-120	sl	0.3			xx	6.2	(1.5)?	4.5			no data		5
	120-190	sl	0.6-0.7	1-2, 1-2		x-xx	8.3-8.8	6.1-6.2	2.5	7.4-7.5	0	0	120-129**	68-120
	190-315	scl	0.9-1.0			xx-xxx	8.2-8.6	6.2-6.1	2.5	7.5-7.6	0	0	163-211**	133-198

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Appendix 2. continued

Site	Depth	Texture	TC	Shell & Lime	Soft CO_3	Field Eff	Field pH H_2O	Field pH H_2O_2	Field pH change	Lab pH oxidised	Lab pH change	POCAS acid trail	POCAS S trail & PSN	TOS
	Cm		%						(drop)		(drop)	acid prod., mol H^+/tonne		
15 – Sale:	0-65	cl	16.8-5.1			x-xx	4.3-5.3	3.5-3.8	1-1.5			no data		76-145
La Trobe River	65-140	cl-lc	2.1-0.5			n-x	4.9-5.1	2.6-3.5	1.5-2.5			no data		0-14
	140-160	lc	0.5			v	6.1	7.0	+1	5.9	0.5	0-2	18-21**	12
	160-200	lc	0.4			v	5.9	2.8	3			no data		57
	200-305	lc	0.6-0.9			xxx	5.7-6.3	2.5-3.9	2-4			no data		13-36
	305-320	lc	0.5			n	6.4	5.2	1			no data		6
16 – Clydebank:	0-10	cl				xxx	6.5	4.4	2			no data		
telephone exchange	10-190	scl-lc				xxx	5.9-6.4	5.2-5.7	0.5-1			no data		
	190-330	mc-sl				n-x	7.0-7.1	5.4-5.5	1.5			no data		
17 – Clydebank:	0-15	cl				xx	5.4	3.1	1.5			no data		
Clydebank Morass	15-60	lc-sc				xx	5.0-5.4	3.4-3.9	1.5			no data		
	60-320	lc-mc				x-xx	5.9-6.7	4.6-5.6	1			no data		
18 – Seacombe:	0-45	sl	5.5-4.4			xx	5.6-5.8	3.0-4.0	1.5			no data		14-15
Lake Wellington	45-55	s	0.2			xx	5.8	4.1	1.5			no data		2
	55-95	s	0.7			v	4.6	1.8	2.5			no data		4
	95-180	s	0.1-0.2			xxx	5.3	1.3-1.4	4			no data		33-38
	180-265	s	0.1			xx	4.0-5.3	1.8-2.2	2-3			no data		20-25
	265-310	s	0.1			x	5.4	4.7	1			no data		22

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Site	Depth	Texture	TC	Shell & Lime	Soft CO_3	Field Eff	Field pH H_2O	Field pH H_2O_2	Field pH change	Lab pH oxidised	Lab pH change	POCAS acid trail	POCAS S trail & PSN	TOS
	Cm		%						(drop)		(drop)	acid prod., mol H^+/tonne		
19 – Seacombe: **McLennans Strait**	0-35	cl	6.0			xx	5.7	2.7	3			no data		40
	35-100	s-sc	0.2			x-xx	6.0-6.5	5.0-5.3	1			no data		3-35
	100-125	lc	0.2		s	v	7.6	2.4	5	2.5	6	180	272	318
	125-150	lc	0.3		s	xx	7.9	6.1	2	3.5	5	27	128*	218
	150-200	lc	0.3-0.6		s	xxx-xf	8.1-8.2	6.4-8.5	0-1.5	8.2-8.3	0.5-+0.5	0	17-59**	16-33
	200-315	ls-lc	0.3-1.4	1-4, 1-3	s	x	8.3-8.5	6.0-6.4	2-2.5	8.0-8.6	1	0	0-34**	0-27
20 – Loch Sport: **Gippsland Lakes** **Coastal Park**	0-40	ls	2.4			x	5.5	4.6	1	6.6	+3	0	4	0
	40-110	s	0.3			n	6.0	5.1	1	5.8	+1	5	0	0
	110-120	ls	1.7			x	5.7	2.9	2.5			no data		5
	120-245	ls-s	0.4-0.2			x	4.9-6.3	3.8-4.9	1.5-2			no data		1-5
	245-320	s	0.2-0.1			xx	4.9-5.0	2.6-3.7	1.5-2.5			no data		5-10
21 – Bairnsdale: **McLeod Morass**	0-25	cl	6.7			xx	5.0	2.3	2.5			no data		41
	25-70	cl	3.2			xx	4.2	1.9	2			no data		36
	70-265	lmc-ls	1.5-0.3			x-xx	4.0-4.5	1.6-2.9	1.5-2.5	4.9	+0.5	0	12-19	1-24
	265-330	sl	0.3-0.5			v	4.0-4.2	1.8-1.9	2			no data		318-343
22 – Bairnsdale: **Mitchell River**	0-20	cl	5.5			xx	5.6	2.6	3			no data		68
	20-300	cl-mc	2.1-0.8	3, 2	m	x-xx	5.7-6.3	2.8-3.6	2.5-3			no data		18-31
23 – Bairnsdale: **Point Bolodun**	0-55	cl-scl	5.2-3.0			xx	4.8-5.4	2.7-3.1	1.5-2.5			no data		0-11
	55-100	mc-lc	0.6-0.9			x-xx	4.4-5.0	3.0-3.3	1.5-2			no data		0
	100-130	lc	0.3			xx	4.7	3.3	1.5			no data		308
	130-160	lc	0.2			xx	5.0	3.5	1.5	5.1	+1.5	0	0	1
	160-225	lc	0.3			xx	5.0-5.3	2.8-3.5	1.5-2.5	5.7-6.0	0	0	1-2	1
	225-300	scl	0.3			xxx	5.6-5.8	4.0-4.1	1.5	5.6-5.9	0	0	0-5	0

Continued next page…

Appendix 2. continued

Site	Depth	Texture	TC	Shell & Lime	Soft CO_3	Field Eff	Field pH H_2O	Field pH H_2O_2	Field pH change	Lab pH oxidised	Lab pH change	POCAS acid trail	POCAS S trail & PSN	TOS
	Cm		%						(drop)		(drop)	acid prod., mol H^+/tonne		
24 – Lakes Entrance: coastal reserve	0-5	s	6.9			xx	6.8	5.2	1.5			no data		22
	5-25	s	0.8-0.4			xx	6.9-7.0	5.0-5.4	1.5-2			no data		5-6
	25-100	s				n-xx	6.3-6.4	4.3-5.0	1.5-2			no data		
	100-300	s				n-x	7.5-8.6	5.7-5.8	2-3			no data		
25 – Sunny Banks: Tambo River	0-70	sl-scl	3.3-1.0			x-xx	5.4-5.6	3.5-3.7	1.5-2			no data		7-14
	70-180	lc	0.5-0.2			n-x	5.8-6.1	3.7-4.8	1.5-2			no data		0-5
	180-205	sc	0.3			xx	6.2	2.7	3.5			no data		0
	205-300	cs-lc	0.3			xx-v	6.0-6.5	1.6-2.1	4			no data		75-134
26 – Bruthen: Tambo River	0-300	s-scl				x-xxx	6.1-6.6	4.0-5.0	1-1.5			no data		
27 – Paynesville: McMillan Strait	0-40	scl	2.9			n	6.4	4.7	2			no data		19
	40-75	mc-hc	1.0			n	5.2	2.5	2.5			no data		18
	75-160	mc-hc	0.3-0.2			n	4.5-4.7	2.8-3.5	1-1.5			no data		0-6
	160-180	mc-hc	0.2			n	6.1	6.8	+0.5	4.1	2	9	20	37
	180-280	mc-hc	0.2-0.1			v	6.6-7.3	7.3-7.5	0-+0.5	5.3-5.7	0.5	0-7	1-19	0-32
28 – Tabbara: Lake Curlipp	0-20	lc	4.6			xx	6.1	3.7	2.5			no data		54
	20-75	cl-scl	2.8-1.2			xx-xxx	6.1-6.2	3.3-3.6	2.5			no data		18-37
	75-125	lc	0.9-1.0			xx-xxx	5.0-5.2	3.3-4.1	1-1.5			no data		19-24
	125-210	mc-sc	0.8-2.1			x-xx	4.0-4.4	1.9-3.3	1-2			no data		18-45
	210-260	s	0.5			v	4.6	1.3	3			no data		94
29 – Orbost: Snowy River	0-40	cl	2.0			vf	6.9	3.9	3			no data		38
	40-175	cl-lc	1.4-0.6			xx-vf	7.2-7.6	5.3-6.2	1-2			no data		20-28
	175-200	zcl	1.0			xx	7.1	3.0	4			no data		29
	200-240	zcl-cs	1.8-1.4			xx-xxx	6.9-7.2	3.7-4.5	2.5			no data		72-94

Continued next page…

Appendix 2. continued

Site	Depth	Texture	TC	Shell & Lime	Soft CO_3	Field Eff	Field pH H_2O	Field pH H_2O_2	Field pH change	Lab pH oxidised	Lab pH change	POCAS acid trail	POCAS S trail & PSN	TOS
	Cm		%						(drop)		(drop)	acid prod., mol H^+/tonne		
30 – Maribyrnong: **Coulson Gardens**	0-115	cl-lmc	3.5-1.3			xx	6.3-6.6	3.4-4.2	2.5			no data		0-13
	115-175	lmc-lc	2.2-0.9			xx-vf	8.1-8.4	5.5-6.6	2.5	5.9-6.0	1	0	0-16	33-37
	175-240	lc	5.4			v	7.8	2.4	5	2.0	3	859	1312	1769
	240-300	lc	5.3-3.1			v	7.5-8.0	2.4	5-5.5	2.0-2.1	2-2.5	729-925	1045-1374	1480-1869
31 – Footscray: **Dynon Road**	0-50	cl		2, 2		xx	6.3-6.9	5.2-5.8	1			no data		
	50-80	scl				x	5.2	3.9	1.5			no data		
	80-140	scl-lc	0.5-1.4			x-xx	5.1-5.3	3.6-4.8	0.5-1.5			no data		0
	140-220	scl-lc	0.4-3.1			xx	5.5-5.7	2.5-2.8	3			no data		0-11
	220-260	lmc	1.9-1.1			x-xx	6.0-6.1	4.0-4.7	1.5-2			no data		0
32 – North **Melbourne:** **Vaughan Terrace Reserve**	155-180	lc-mc	0.6-0.9			v	7.8-7.9	5.5-6.5	1.5-2.5			no data		23-41
	180-210	zcl	1.3-0.3			xx	8.0-8.7	5.4-6.1	2.5			no data		0-14
	210-230	zcl	0.2			xx	9.1	5.6	3.5			no data		106
	230-240	zcl	0.2			xx	9.3	5.9	3.5			no data		11
	240-290	cl	0.2	2, 2		xx	8.2-8.7	5.8-6.3	2.5	5.8	1	0	0-4	12
	290-300	lc	0.7			xx	8.0	6.2	2	7.8	0.5	0	0	14
	300-410	lc-sc	0.2			xx	7.7-8.3	5.8-7.3	1-1.5	5.9	0.5	0	2	8-12
	410-500	lmc-lc	0.2			x-v	7.8-8.4	5.7-7.6	0-2.5			no data		13-17
33 – South **Melbourne:** **Kings Way/Sturt St**	200-250	lc-fscl	2.1-0.7			xx	3.8-4.0	1.9-2.2	2			no data		0
	250-330	fscl-lc	0.7-2.1			x-xx	3.5-3.8	1.5-1.8	2			no data		18-51
	330-350	lc	3.4			x	3.5	1.2	2			no data		652
	350-380	lc	2.8			x	3.4	2.2	1			no data		2037
	380-500	scl-mc	2.3-1.5	2, 1		v	4.1-6.4	2.0-2.3	2-4	1.9-2.1	5	732-924	1123-1194	1710-2149
	500-525	mc	0.5			v	7.9-8.0	3.2-6.0	2-5	6.1	0.5	0	81	134

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Appendix 2. continued

Site	Depth	Texture	TC	Shell & Lime	Soft CO_3	Field Eff	Field pH H_2O	Field pH H_2O_2	Field pH change	Lab pH oxidised	Lab pH change	POCAS acid trail	POCAS S trail & PSN	TOS
	Cm		%						(drop)		(drop)	acid prod., mol H^+/tonne		
34 – Point Cook:	0-50	cl-lmc		0-6, 1-2	n-v	n	7.4-8.2	6.3-7.7	0.5-1			no data		
Cheetam Wetlands	50-100	lmc	0.9	4, 1	s	n	7.8-7.9	6.5-8.5	+0.5-1.5			no data		9
	100-110	shell	7.3	5, 2-3	v	n	7.8	8.3	0.5	8.5	0.5	0	2	40
	110-120	lmc	0.3		s	n	8.0	2.5	5.5	8.0	0.5	0	67**	62
	120-135	mc	0.2			n	8.1	6.9	2	5.6	0	0	31**	32
35 – Point Wilson:	0-70	sl		2-6, 1-2	v	n-xx	8.7-9.1	6.4-6.6	2-2.5			no data		
wildlife reserve	70-90	ksl		6, 1-2	v	n	8.2	8.3	0			no data		
	90-180	ksl	7.1	6, 1-2	v	xx	9.0	6.8	2	7.5	2	0	99**	126
	180-190	lc	1.2			v	9.1	8.4	0.5	7.8	0.5	0	126**	126
	190-200	lc	0.9			v	9.2	8.7	0.5	7.4	1	0	417*	509
	200-260	lc-lmc	4.5-2.5		m-h	v	9.2-9.3	8.2-10.0	1-+1	8.6-8.8	0	0	28-51**	55-204
36 – Connewarre:	0-70	lmc-fscl										no data		
Lake Connewarre	70-340	lc-lmc	0.7-0.2			n						no data		0-7
37 – Swan Bay:	10-20	peat-scl	9.7	2, 2	m					8.1	0	0	562**	658
foreshore	20-35	ks	7.1	6, 2-3						8.9	0.5	0	11	22
	35-60	sl	1.4	6, 2-3						9.3	0.5	0	3	2
38 – Barwon Heads:	0-15	scl	2.8		n	xx	7.5	5.7	2			no data		7
Salt Swamp	15-75	scl-lc	0.5-0.4		m	xx	8.3-8.4	6.1-6.6	2			no data		0-1
	75-100	sc	4.7		h	v	8.8	10.1-10.3	+1.5	8.8	0	0	6	8
	100-150	sc	4.3		h	xxx	8.6-8.7	8.3-9.0	0	8.8	0	0	7	12
	150-230	s	5.9		v	x	8.3-8.4	6.3-6.7	1.5-2	9.0	0.5	0	20-21	40

Continued next page…

Appendix 2. continued

Site	Depth	Texture	TC	Shell & Lime	Soft CO_3	Field Eff	Field pH H_2O	Field pH H_2O_2	Field pH change	Lab pH oxidised	Lab pH change	POCAS acid trail	POCAS S trail & PSN	TOS
	Cm		%						(drop)		(drop)	acid prod., mol H^+/tonne		
39 – Breamlea:	0-15	lc-peat	5.6-9.6			x	5.9-6.5	3.4-3.6	2.5-3			no data		11
flora reserve	15-160	sc	0.3-0.6	1-3, 1-2	s-m	n	7.0-8.2	5.4-6.4	2-2.5	8.4-8.5	0.5	0	0-19	0
	160-170	sc	1.2	2, 2		v	7.8	3.0	5	6.1	1	0	388*	491
	170-200	sc	0.2		n-s	x-xx	7.9	5.8-6.0	2	6.3-7.0	0.5	0	1-17	12-33
40 – Peterborough:	0-25	ls	11.6		v	x	8.9	5.8	3			no data		13
Curdies Inlet	25-95	s	10.3-9.7		m-h	n-x	8.3-8.7	6.1-6.4	2			no data		0-3
	95-100	sc	8.8		m	x	8.2	6.3	2	8.3	0	0	36**	66
	100-150	ls	9.4	1, 1		xx	8.6	5.9	2.5	8.0	1	0	205**	282
	150+	ls	9.5	1, 1		v	8.5	5.6	3	8.0	1.5	0	131**	189
41 – Mepunga	0-30	cl	25.8	2, 1	h	xx	7.2	5.8	1.5			no data		178
West: Killeens Road	30-90	zcl-scl	13.4-10.4	2-3, 1	h-v	x-xx	7.3-7.4	6.3-6.4	1			no data		23-45
	90-140	sl	0.9-0.5		s-m	xx	7.1-7.3	4.9-5.5	1.5-2			no data		0-2
	140-150	lmc			s	xx	7.5	3.3	4			no data		
	150-220	lmc-mc	0.7-0.4		m	xx-v	7.5-7.7	5.3-7.3	0-1.5	7.1-8.1	0-1	0	31-74*	37-78
	220-270	mc	0.2		s	v	7.9	6.2-7.7	1.0-1.5	7.4	0.5	0	2	10
	270-320	mc-mhc	0.2-0.3		s-m	x-xx	7.7-8.0	5.9-6.3	1.5	6.6-7.3	0-0.5	0	2	7-9
42 – Warrnambool:	0-5	s	15.2		v	x	7.2	5.9	1			no data		40
Kelly Swamp	5-100	ls-scl	10.5-10.4	0-2, 1	m-v	n-x	7.4-8.2	6.1-6.5	1.5-2	8.4	1	0	16	3-34
	100-210	kscl	10.1-10.6	1-2, 1	h	xxf	7.4-7.8	6.0-6.8	0.5-2	8.2-8.3	1	0	86-155**	129-209
	210-220	kscl	1.5	1, 1		v	7.8	2.9	5	7.3	0.5	0	636**	558
43 – Yambuk:	0-15	peaty lc	6.5-5.1			xx	7.1-7.5	4.8-5.9	2			no data		34-43
Eumeralla River	15-80	lc	2.2-1.0	3, 2		xx	7.6-8.1	5.6-6.4	1.5-2	6.9-7.1	0	0	6-10	10-22
	80-185	lc	1.0-0.4	1-2, 2		x-v	7.5-8.0	5.9-8.0	+0.5-2	7.2-7.6	0.5	0	1-6	11-17

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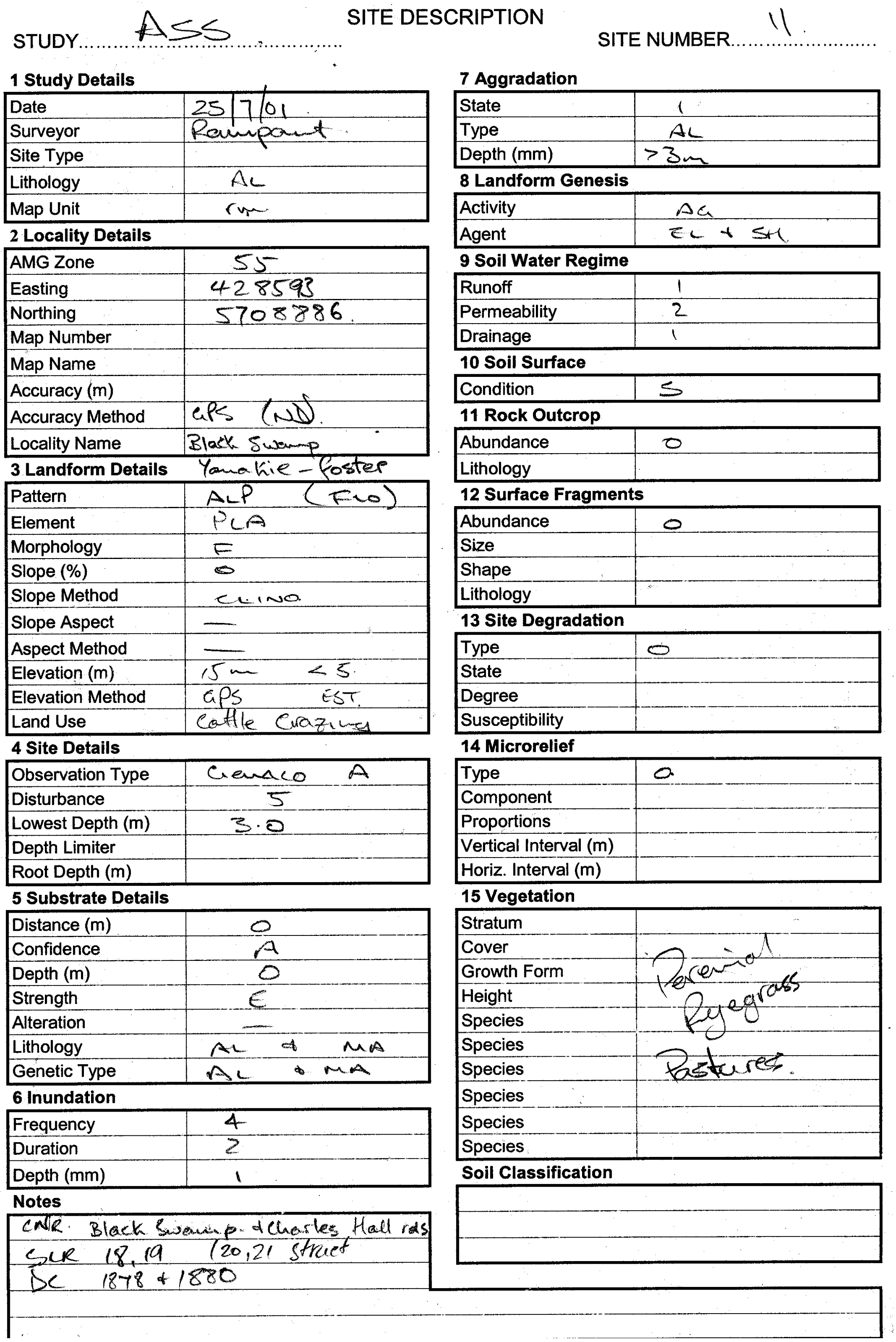
Appendix 2. continued

Site	Depth	Texture	TC	Shell & Lime	Soft CO_3	Field Eff	Field pH H_2O	Field pH H_2O_2	Field pH change	Lab pH oxidised	Lab pH change	POCAS acid trail	POCAS S trail & PSN	TOS
	Cm		%						(drop)		(drop)	acid prod., mol H^+/tonne		
44 – Princetown: Gellibrand River	0-30	lc	16.6			xx	7.3	4.6	3			no data		115
	30-45	lc	4.2		s	xx	8.2	5.7	2.5			no data		31
	45-80	lmc	2.4-1.4		s-m	v	8.1-8.2	6.6-7.6	0.5-1.5	7.7-7.9	0	0	4-16	11-20
	80-110	sc	4.6	2, 1	m	xx	8.1	6.4	1.5			no data		14

Texture, Shell & Limestone (aggregates: size and abundance) and Soft CO_3 (segregations): codes as per handbook; Field Eff: N = nil, X = slight, XX = moderate, XXX = vigorous, V = volcanic, f = froth; TC, %: Total Carbon (largely organic matter where shell and carbonates are undetected but will include the latter where present); Drop in pH has been rounded off to the nearest 0.5 of a pH unit;

Potential Self Neutralising (PSN) [based on POCAS Sulphidic S minus Ca and Mg analyses where such are assumed to be in carbonate form]: * partial neutralisation = at least 30% decrease in acid production (often from one PASS category to another), ** complete neutralisation = complete or near complete negation of acid production (note. data less than 20 mol H^+/tonne have not been assigned a PSN rating).

Appendix 3. Sample of field data collection sheet



SITE DESCRIPTION

STUDY ASS

SITE NUMBER 11

1 Study Details

Date	25/7/01
Surveyor	Rampant
Site Type	
Lithology	AL
Map Unit	cm

2 Locality Details

AMG Zone	55
Easting	428593
Northing	5708886
Map Number	
Map Name	
Accuracy (m)	
Accuracy Method	GPS (ND)
Locality Name	Black Swamp Yanakie - Foster

3 Landform Details

Pattern	ALP (FLO)
Element	PLA
Morphology	F
Slope (%)	0
Slope Method	CLINO
Slope Aspect	—
Aspect Method	—
Elevation (m)	15m <5
Elevation Method	GPS EST
Land Use	Cattle Grazing

4 Site Details

Observation Type	Gemco A
Disturbance	5
Lowest Depth (m)	3.0
Depth Limiter	
Root Depth (m)	

5 Substrate Details

Distance (m)	0
Confidence	A
Depth (m)	0
Strength	E
Alteration	—
Lithology	AL + MA
Genetic Type	AL + MA

6 Inundation

Frequency	4
Duration	2
Depth (mm)	1

7 Aggradation

State	1
Type	AL
Depth (mm)	>3m

8 Landform Genesis

Activity	AG
Agent	EL + SH

9 Soil Water Regime

Runoff	1
Permeability	2
Drainage	1

10 Soil Surface

Condition	S

11 Rock Outcrop

Abundance	0
Lithology	

12 Surface Fragments

Abundance	0
Size	
Shape	
Lithology	

13 Site Degradation

Type	0
State	
Degree	
Susceptibility	

14 Microrelief

Type	0
Component	
Proportions	
Vertical Interval (m)	
Horiz. Interval (m)	

15 Vegetation

Stratum	
Cover	
Growth Form	Perennial
Height	
Species	Ryegrass
Species	
Species	Pastures.
Species	
Species	
Species	

Soil Classification

Notes

CNR. Black Swamp + Charles Hall rds
SLR 18, 19 / 20, 21 Street
DC 1878 + 1880