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South Australian Inventory of Acid Sulfate Soil Risk (Atlas)

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Natural Heritage Trust
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A Commonwealth Government Initiative

Department for environment and heritage

Government of South Australia

Final Report, February 2003

Important Disclaimer

Cover

From CSIRO Land and Water

Description: Brett Thomas and Rob Fitzpatrick sampling mangrove soils from a SA Coast and Marine transect, Davenport Ck, west of Ceduna, SA. This site represents the western extremity of the range of *Avicennia marina* in South Australia.

ASS Risk Map of the coast to the north of Adelaide showing the only known significant area of actual ASS in South Australia.

Contents

FINAL REPORT

Coastal Acid Sulfate Soils Program (CASSP)

1. Project title: *South Australian Inventory of Acid Sulfate Soil Risk (Atlas)*

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3. Plain English Summary

The risk to the South Australian coastal environment from disturbance of actual acid sulfate soils (AASS) and potential acid sulfate soils (PASS) was not known prior to the completion of this project. Nor were there any specific guidelines for their management should they be disturbed from their natural state, which is generally benign. There are many potential causes of disturbance, such as the construction of coastal infrastructure such as: boat ramps, dredging, road building, freshwater or sewage outfall, and including increasing pressures to build marinas and for public access to existing natural areas.

The project was established to be consistent with the recommendations of the National Strategy for the Management of Coastal ASS (CASS). It aimed to provide the following information to local government and state agencies, natural resource managers and others at scales appropriate to their decision-making requirements:

- an inventory of ASS risk in the form of maps covering the entire SA coastline,
- a world wide web accessible database and map, and
- a set of ASS planning policies at state and local government level for SA.

To achieve this, an assessment of likely distribution was based on the detailed landform and vegetation mapping of 65 saltmarsh habitats carried out by the South Australian Coast and Marine Branch (viewable as part of the web-based South Australia Atlas: http://www.atlas.sa.gov.au/). Field inspections and sampling was undertaken at 70 sites from Fowlers By on western Eyre Peninsula to Hindmarsh Island near the mouth of the Murray River to understand better the range the probable ASS materials present. These soils and sites were recorded with digital images, briefly described, and the following properties were measured: total carbon, equivalent calcium carbonate content, organic carbon and total sulfur, with dry bulk density and sulfide sulfur on selected samples. The profiles were also classified using a “user-friendly” system, the Australian Soil Classification, US Soil Taxonomy and the FAO World Reference Base.

A simplified set of ASS risk classes was developed from the vegetation mapping of saltmarsh habitats, field inspection and laboratory analyses from the 70 sites. This information was used to construct a web-based map, with attached soil database, indicating the risk of acid sulfate soil development should the soil profiles be disturbed. The risk classes were associated with treatment categories, based on recent management guidelines developed in Queensland.

To establish a sound basis for the development of planning policy and management of ASS, the following reports were produced and endorsed by the SA Coast Protection Board (CPB), which has jurisdiction over most coastal areas:

- Review of Australian State ASS Planning Approaches,
- Strategy for Implementing CPB Policies on Coastal Acid Sulfate Soils in South Australia,
- Development Guidelines and Risk Assessment Criteria for Coastal Acid Sulfate Soils, South Australia, and
- Checklist for Development in Coastal Acid Sulfate Soils, South Australia.

This information is being used as a basis by Planning SA to consider a whole of government policy approach.

During the project, several opportunities arose to communicate the many aspects of risk associated with AASS and PASS in the South Australian coastal environment and to increase the level of awareness among state agencies, local government and consultants.

In addition to the CPB reports, a 12-page colour bulletin (January edition of Coastline: No 33), titled “A strategy for Implementing CPB Policies on Coastal Acid Sulfate Soils in South Australia”, has been published. This bulletin summarises contemporary knowledge on the processes of AASS and PASS formation, and also outlines management issues and proposed implementation polices in SA. At least 1500 copies have been printed for distribution to the relevant authorities and development proponents. The bulletin will also be available through the Department for Environment and Heritage website (www.environment.sa.gov.au).

A file containing 36 images of ASS and associated landscapes, with captions, has been produced.

4. Project Performance

The project objectives from the original proposal were as follows:

Project Objectives

1. Consistent with the recommendations of the National Strategy for the Management of coastal ASS, produce a South Australian state map of ASS. This will be achieved through the application of consistent state and regional estimates of ASS in terms of damage, risk and hazard to estuarine and coastal questions on ASS. This will result in a map relevant at state and regional scale and include a web site showing distribution using, for example, the NLWRA world wide web site.

2. Ranking of regions and localities by importance of ASS hotspots to the triple bottom line:

Risk x land use pressure x economic impact x ecological impact x social impact

3. Build an information base to support a national economic, social and health analysis of ASS, allowing for example development of management options to reduce the export of acid to estuarine and coastal waters.

4. Develop the foundation for evidence based and strategic extension of the on-ground experience gained from CASSP demonstration sites throughout Australia.

5. Introduce a State Planning policy on acid sulfate soils.

6. Provide guidance for the development of new industries such as aquaculture and tourism as well as provision of infrastructure.

7. Provide the ASS information necessary for the management and protection of Ramsar wetlands and World Heritage Areas.

Note: A brief Glossary of Terms is included towards the end of this report to provide more technical definitions of some of the terms used.

Project Objective 1)

Consistent with the recommendations of the National Strategy for the Management of coastal ASS, produce a South Australian state map of ASS. This will be achieved through the application of consistent state and regional estimates of ASS in terms of damage, risk and hazard to estuarine and coastal questions on ASS. This will result in a map relevant at state and regional scale and include a web site showing distribution using, for example, the NLWRA world wide web site.

Methodology

As part of the CAMRIS project, CSIRO re-interpreted Galloway's data (Galloway et al., 1984[1]), assigning morphostratigraphic units to each point in Galloway's coastal sections and producing a "Australian Coastal Soils/Geomorphology Inventory and Management" data set. Initially, it was expected that this inventory could be used as a basis for a state map of ASS in SA, though some biases, geo-referencing and scale problems had been noted that would make its use less satisfactory. Some time was spent trying to locate the base photography and other associated data. Photographs and associated material was located in CSIRO archives for the complete Australian coastline *except* for South Australia and the Northern Territory. These limitations and the availability of more suitable data meant that we chose not to use the CAMRIS/ Galloway data.

The possible use of remote sensing was discussed at the workshop and project meeting in November 2001. Coast and Marine (C&M) Branch (South Australian Department for Environment and Heritage) had previous experience with airborne remote sensing but was not successful in gaining a usable product. They then decided to develop their habitat maps from conventional colour aerial photography and this forms the basis of mapping used for this project.

Satellite, remotely-sensed ASTER imagery for the SA coastline were obtained from NASA's Earth Observing System Data Gateway. Preliminary evaluation of the imagery suggests the potential to discriminate C&M Branch's vegetation habitats and possibly relate these to ASS risk class. This may provide a means to extend mapping beyond the study areas in SA. It may also be very important as a basis for provision of national risk maps. Development of this approach further than this preliminary appraisal was not considered for the SA project, but the possibilities should be noted.

Coastal landform and vegetation mapping, part based on PIRSA mapping of upper Spencer Gulf, has been completed by Coast and Marine Branch more recently than the CAMRIS work. Evaluation of the C&M Branch landform and vegetation mapping, based on 1:40,000 scale or better aerial photography and already in digital form, indicated that it should form an ideal base for the development of the South Australian ASS risk map. This map base is viewable as intertidal/marine maps of the SA Atlas at the following URL:

http://www.atlas.sa.gov.au/

[1] RW Galloway, R Story, R Cooper and GA Yapp (1984) Coastal Lands of Australia. CSIRO Division of Water and Land Resources. Natural Resource Series No. 1. 53 pp.

For practical purposes, the mapped coastal acid sulfate soils risk information is being presented as a coverage in the digital atlas. In addition to the mapping, C&M Branch have surveyed detailed transects for which much detail of landform and vegetation is available, but with no soil data.

This base was used to establish preliminary rules for mapping units. The C&M Branch marine and intertidal mapping, with 63 landform/vegetation mapping units, is at much greater detail than required for development of the ASS risk maps. Previous experience and field trips suggested an initial simplification to about 9 risk classes, but this was developed without detailed knowledge of the ASS/PASS condition or spatial variability. The C&M maps were re-classified based on expected relationships between habitats and soils and the number of classes reduced from 63 to 9.

Field work clearly indicated that some re-allocation of C&M classes was needed within the preliminary risk classes. This re-allocation (as shown in Table 1) is in part due to misjudgement of the amount of PASS in some landform units and to the need to evaluate the amount of whole and comminuted shelly material, and fine carbonate contained in the soils, and their potential to neutralise acid that may be generated.

Site selection for field soil sampling was based on the need to:

- Use any previous knowledge of existing ASS mapped areas in SA (i.e. Gillman and St. Kilda areas),
- be representative of C&M's SA Atlas mapping classes,
- be representative of the simplified preliminary risk map classes,
- key into detailed survey transect lines of C&M,
- be represented in as many areas of the state as possible,
- include at least 30 sites for soil analysis,
- include sites at risk due to actual or proposed development,
- be accessible by vehicle or walking,
- have prior approval for access, if possible.

Thirteen sites were selected or inspected because of a potential environmental threat, planned excavation for marinas, aquaculture, pipelines or other works.

2 proposed marinas (Wallaroo and Ceduna)

1 abandoned prawn farm (Pt Broughton)

2 gypsum mines (Lake McDonnell and Clare Pt)

1 abandoned salt evaporation pan (Pt Davenport)

1 pipeline through fore dunes (Barcoo Inlet, Adelaide)

1 potential urban expansion (Fowlers Bay)

1 intertidal/offshore mineral exploration (Bird Island)

1 land drainage producing actual ASS (Gillman, Adelaide)

3 effects of causeways built for roads (Cowell, Weeroona Is, Yorkey's Crossing)

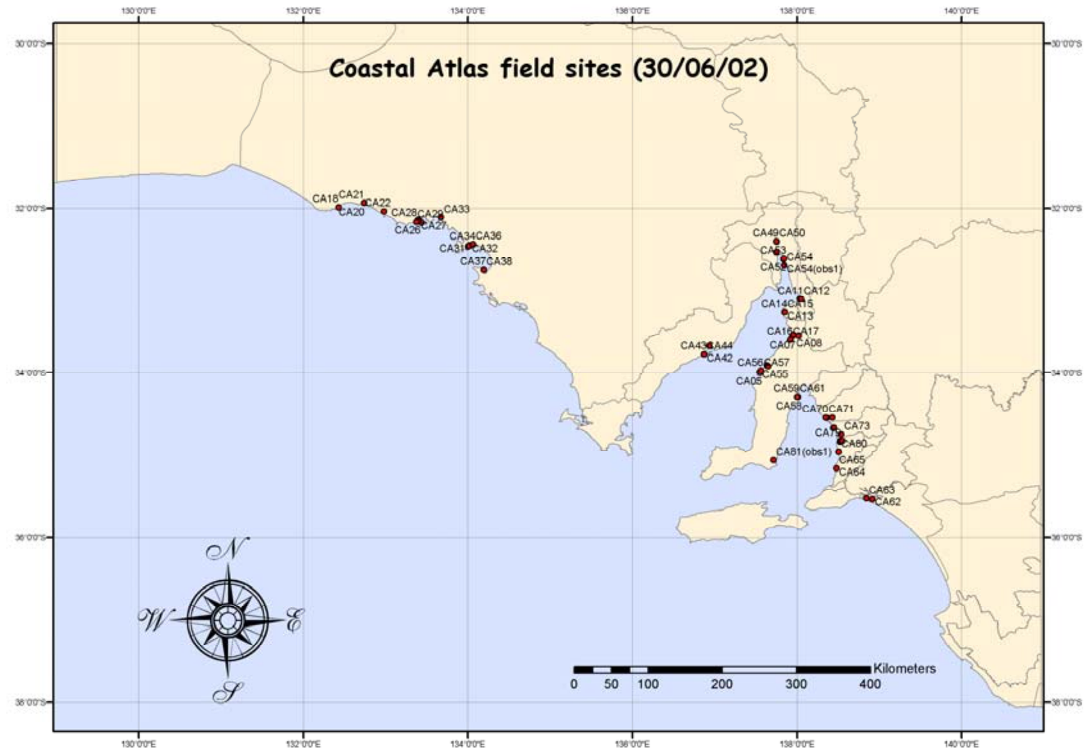
Field verification entailed the following two approaches.

a) "Verification" sites were regarded as locations or areas where the reliability of the SA Coast and Marine Branch landform/coastal vegetation mapping was checked. The mapping was found to be highly accurate spatially.

b) Soil profile inspection in the field without sampling. Excavation or augering was used at 35 sites, but few or no soil samples taken. Profile details were briefly recorded to help assess field variability or confirm that expected materials were present.

Soil profile sampling took place at 47 sites, with mostly continuous sampling by screw or gouge auger to depths up to 2.5m. In excess of 300 soil samples were obtained for analysis. An Excel spreadsheet was constructed to summarise site information, location and soil data. An extensive digital photo collection was obtained (a selection of digital photographs are presented in Appendix 2).

Figure 1. Map showing soil sampling and verification sites. Note that because of the scale, sites that are close together may not be clearly discriminated.



The spatial distribution of sampling and observation points is shown in Figure 1. This distribution is representative, in a geographic sense, of the known distribution of potential coastal acid sulfate soils (PASS) and actual acid sulfate soils (ASS). The SA Coast and Marine Branch landform and vegetation mapping has proved to be an ideal database on which to base sampling because of its consistency and spatial resolution.

We have investigated more than 80 sites in various degrees of detail and visually assessed (by driving or walking) many kilometres of coastal land, however southern Eyre and Yorke Peninsulas have not been as fully covered. Within the scope of this project, this should be considered a reconnaissance inspection and sampling for verification of the 80,000 ha of mapped coastal soils environments. There is a particular landform unit, high coastal sand hills, that has probably not been adequately investigated in this project because (often) of remoteness and the expense of sampling through high sand hills. Early published reports (1940s) indicate the presence of buried mangrove soils (PASS) under (at present) mainly urban areas along the Adelaide coastline. These materials were exposed recently in the excavation of the Barcoo Inlet. The large coastal dune fields of the West Coast of South Australia are likely to overlie PASS materials of unknown spatial distribution, but similar to adjoining land not covered with sand.

Table 1: Acid Sulfate Soil Map Classes for South Australia

	Map Legend	Class Description
1	(a) Actual ASS (disturbed)	**Actual acid sulfate soils** (existing AASS). Very high risk. Only found in this mapping unit in the Port Adelaide – Gillman, Barker Inlet area and in the adjacent "Other Soils" mapping unit.
	(b) Potential ASS (disturbed)	**PASS in subsoil below 20 cm (up to 1 metre thick) with surface monosulfidic black ooze (MBO), intertidal** (mainly in samphire). Moderate risk because carbonate layers usually occur above and below.
2	Potential ASS (mangrove)	**Thick PASS - mangrove soil** (potential acid sulfate soils). Mainly in mangroves with high risk.
3	Potential ASS (tidal stream)	**PASS of tidal streams** (PASS underlying tidal streams, not extensive laterally). Moderate risk.
4	Potential ASS (intertidal)	**PASS in subsoil below 20 cm (up to 1 metre thick) with surface monosulfidic black ooze (MBO), intertidal** (mainly in samphire). Moderate risk because carbonate layers usually occur above and below.
5	Potential ASS (supratidal)	**PASS in subsoil below 50 cm (up to 1 metre thick) with some surface MBO – supratidal** (mainly in samphire, salt bush, blue bush, or saltpan associated with hyper saline soils where there is less frequent tidal inundation). Moderate to low risk.
6	Sand	**Soils of sand dunes, ridges** (no PASS and ASS within 1 metre of surface). Low risk of PASS below watertable.
7	Calcarenite	**Calcareous soils and hardpans** (no PASS, high neutralising). No or very low risk.
8	Marine Soils	**Marine soils – subtidal and intertidal marine** (PASS may be present; ASS neutralised by tides and carbonates). No or very low risk.
9	Other Soils	**Soils associated with other land uses within coastal landforms**. Risk requires individual investigation; guided by adjacent mapped units.
10	Soils Not Classified	**Soils outside area of mapped coastal landforms**.

The soil profiles (point data) should be adequate to cover the range of expected profile types and materials but, as stated above, cannot be expected to be fully comprehensive. The rationale for selecting sampling points was based on:

- an adequate representation of mapped landform/vegetation units,
- the need for geographic coverage, and,

➢ where possible, keyed into transects surveyed by SA Coast and Marine (landform, vegetation, topography).

Within the constraints of this project, we have sampled a range of types of profile. Full evaluation is not possible until all chemical and physical characterisation is complete. It is expected that this may impact on the guidelines to be developed for site investigation.

Examples of maps using these ASS risk classes for four areas are shown in Figures 2 -5. Map classes are as in Table 1, C&M surveyed transects are red lines and ASS sampling sites from this project are red stars.

Figure 2. Map showing distribution of coastal ASS, Tourville Bay and Davenport Creek, western South Australia.

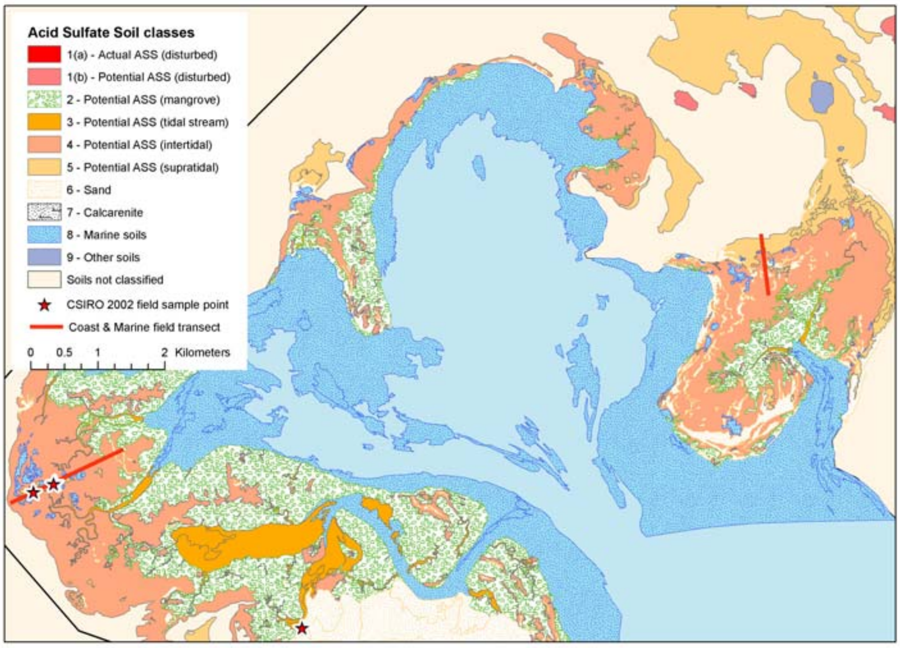


Figure 3. Map showing distribution of coastal ASS, Cowell, eastern Eyre Peninsula, South Australia.

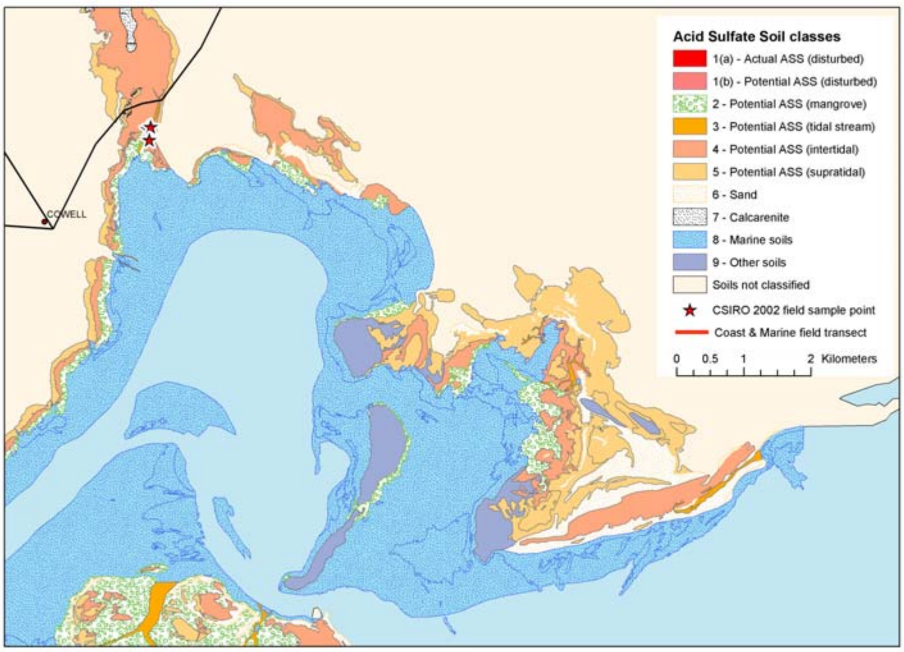


Figure 4. Map showing distribution of coastal ASS, Weeroona Island and Port Pirie, Spencer Gulf, South Australia.

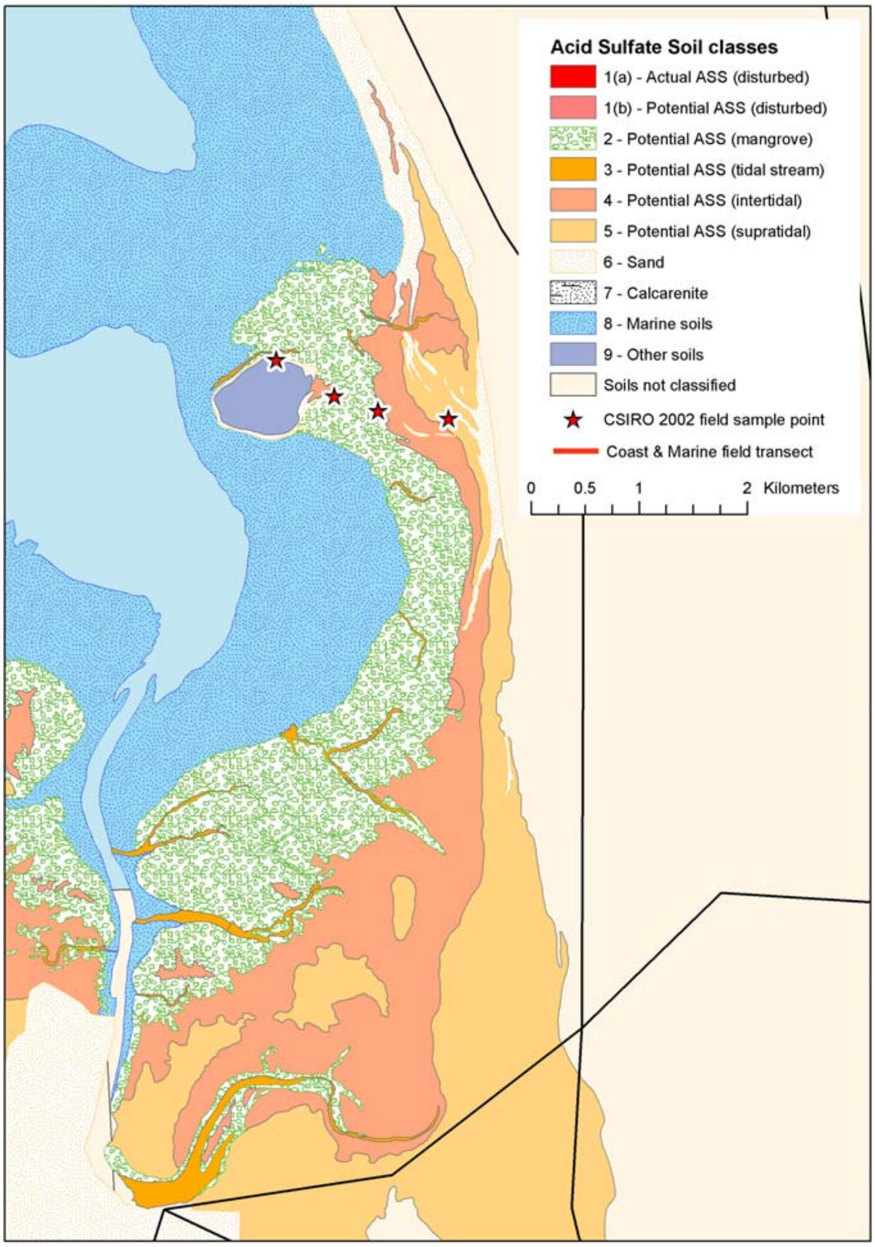
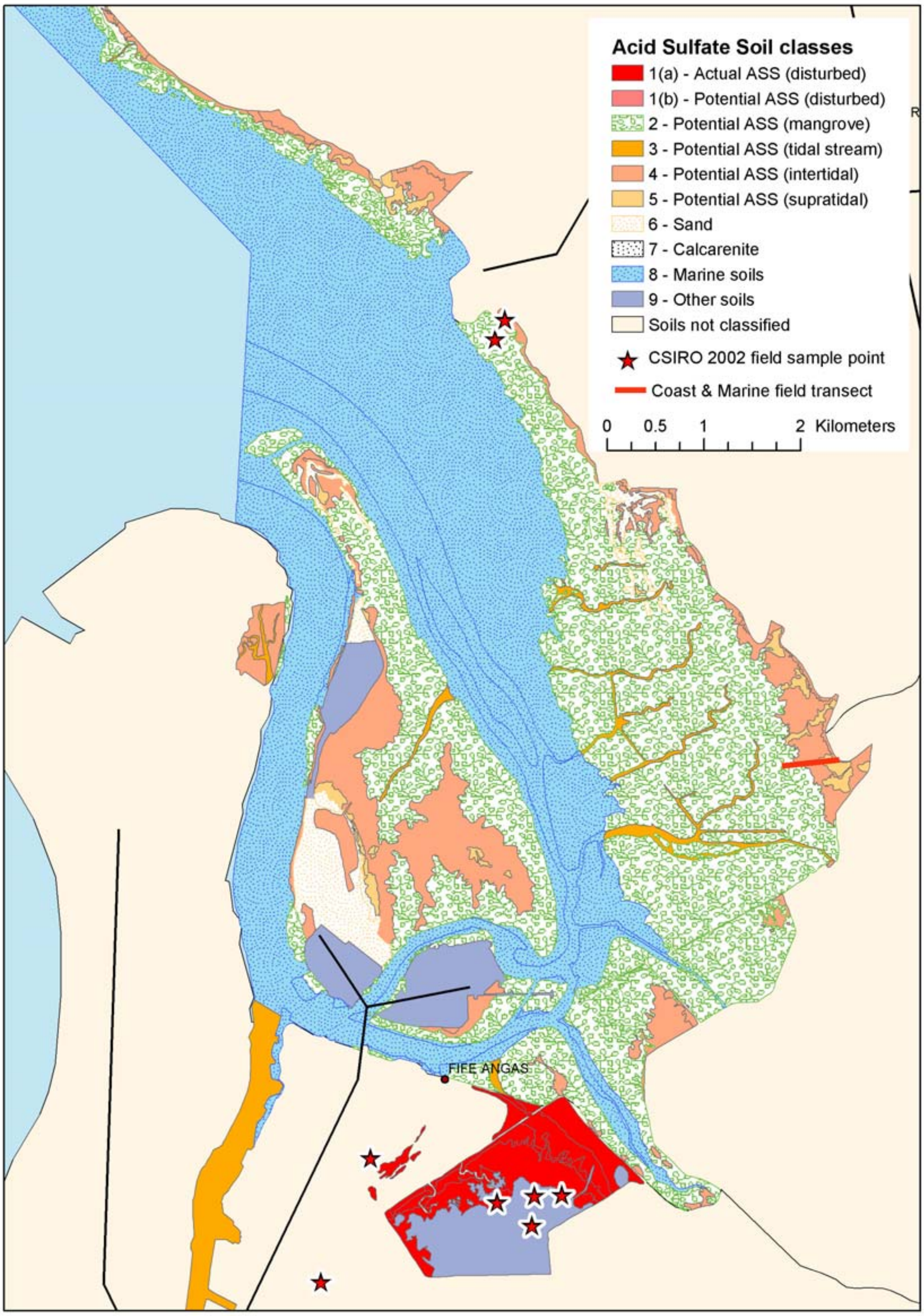


Figure 5. Map showing distribution of coastal ASS, including *actual* ASS in the Gillman-Barker Inlet area, Adelaide, South Australia.



In summary:

Most of the ASS risk material encountered was PASS. Some locations have significant content of gypsum in the soil profile. Raised sea water levels will result in altered oxidation state (reduction) of these materials. In the FAO system of classification of these soils, these gypseous materials can also be PASS, depending on the amount of calcium carbonate present.

There are significant layers of PASS buried at some depth below other coastal materials.

PASS materials, particularly in locations on the eastern sides of Eyre Peninsula and Yorke Peninsula, but also in a few other locations, may frequently be overlaid by up to 50 or 60 cm of fine (terrestrial) clay. Mixing of this material with the underlying sulfidic materials and exposure to air has a greater potential to release significant (toxic) aluminium than other materials encountered. These materials also have low dry bulk densities and may collapse when de-watered under load, such as occurs in road building.

Indicators of oxidation (usually iron precipitation) are apparent more consistently where there has been (human) disturbance of the sediments, but are also evident in other locations, often appearing on sandy beaches near the water/air interface and where seagrass accumulation (reducing environments) has occurred. The latter situations are likely to experience tidal inundation and regular acid neutralisation.

Most of the materials sampled contained or were overlaid by materials containing calcium carbonate of varying amounts and particle sizes, from coarse shelly material to very fine reactive particles. The amounts of calcium/ magnesium/sodium carbonates (able to neutralise acidity produced on oxidation) relative to sulfide will be important for assessing the likelihood of difficulty in managing sulfidic materials exposed in developments.

Indicator shells (*Anadara*) confirm that at least some of the buried mangrove sediments are older than 120,000 years.

The data associated with this project exist as spatially attributed (GIS) and textually attributed (spreadsheet) sets that facilitate project needs. These are readily converted to a database or www format compatible with the final project outputs. Chemical and other physicochemical data will be linked of GIS data and developed to optimum formats for web presentation.

Project Objective 2)

Ranking of regions and localities by importance of ASS hotspots to the triple bottom line:

> ***Risk x land use pressure x economic impact x ecological impact x social impact***

The ranking of regions and localities by importance of potential ASS hotspots (resulting from site disturbance) in relation to the triple bottom line is implicit in the legend of the risk map (Table 1 and Table 2). Each category has an associated risk indicated that is based on a judgement of observed soil properties. Field investigations were targeted to the mapped landforms that suggested hotspots may be present and sites of known disturbance and the final legend and map corrected accordingly.

The highest risk areas (about 158 km^2) are clearly those associated with past or existing mangrove soils and those disturbed areas that formerly supported mangroves. These soils usually have insufficient neutralising capacity (carbonate, exchangeable basic cations or clay minerals) such that the introduction of oxygen during excavation or exposure would potentially result in the net sulfuric acid generation. Actual ASS (ASS class 1a) with associated environmental problems, have been specifically identified only in the Gillman area (1.6 km^2) and fall into the treatment categories High to Extra High (Table 2).

Table 2. ASS Risk Class and Treatment categories

ASS Class No	**ASS Class Legend**	**AREA km^2**	**Risk Class**	**Treatment category[1]**
1a	AASS (disturbed)	1.6	Very High	H - XH
1b	PASS (disturbed)	104.7	Moderate	H - XH
2	PASS (mangrove)	156.0	High	H - XH
3	PASS (tidal stream)	21.2	Moderate	M-H
4	PASS (intertidal)	244.7	Moderate	M-H
5	PASS (supratidal)	355.2	Moderate to Low	L-M
6	Sand	361.9	Low	L
7	Calcarenite	7.4	None or Low	L
8	Marine	1366.9	None or Low	L
9	Other	188.9	Requires individual investigation	
	Total	**2809.4**		

[1]Low level treatment = L, Medium level treatment = M, High level treatment = H, Very high level treatment = VH, and Extra High level treatment - XH)

From: Dear SE, Moore NG, Dobos SK, Watling KM, and Ahern CR (2002) Soil Management Guidelines: In *Queensland Acid Sulfate Soil Technical Manual*: (version 3.8) Department of Natural Resources and Mines, Indooroopilly, Queensland, Australia.

The other intertidal and supratidal areas (about 726 km^2) present moderate risk because of the almost universal presence of finely divided or shelly carbonate materials with excess potential to neutralise acid that may be formed from any reduced form of sulfur that may be present. Consequently, these areas fall into the treatment categories Moderate to Low (Table 2).

As explained above, there is evidence of buried mangrove soils below sand dunes at least in the Adelaide area (eg, Cotton, 1950[2]), but these are likely to be maintained below the water table, as was the case of Barcoo Inlet excavations. Excavation through sand dunes is expected to be uncommon. It is not uncommon to see iron oxide materials staining beaches. We have observed oxidation of iron sulfides leaving iron oxide staining on beaches, however neutralising capacity is available through tidal flushing and carbonate minerals. Consequently, this area (sand) falls into the treatment category Low (Table 2).

Land use pressure (and social and economic impacts, which are expected to be similar) is not ranked, but is related closely to proximity to urban areas where demand for infrastructure development and amenity is highest. Demand for infrastructure development and recreation is increasing, especially within a few hundred kilometres of urban Adelaide. Ecological effects will depend on the specific impact on, for example, fish or bird life in each location. An estimated 20% of the area mapped is protected as conservation area or national park, however, this does not preclude such activity as boat launching and fishing.

It is expected that the guidelines produced during this project, along with increased awareness, should have a large impact on future management of land use and infrastructure development.

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[2] Cotton, BC (1950) An old mangrove mud-flat exposed by wave scouring at Glenelg, South Australia. Trans. Roy. Soc. 73, 59-61.

Project Objective 3)

Build an information base to support a national economic, social and health analysis of ASS, allowing for example development of management options to reduce the export of acid to estuarine and coastal waters.

Since no information of this kind describing properties of these soils has previously been available in SA, we have provided knowledge that will underpin future management of ASS areas. This information (mapping and soil data) has been used as in integral part of development of strategy and draft development guidelines. The value of these areas to the economy (for example, through fisheries, biodiversity management or tourism and recreation) has not been evaluated.

Apart from the Gillman area, where actual ASS occur, the overall impression of the areas visited and sampled, is one of a relatively healthy environment with potential ASS being largely in a benign (reduced) state. The soils probably differ most from the eastern states ASS areas in the presence of (typically) large quantities of carbonate mineral. It is felt that increasing pressure for infrastructure, etc, will test this situation.

Georeferenced soil description and analysis information is to be linked to the SA Digital Atlas. Specific information has been gathered on more than 70 field sites and several hundred individual soil samples, and many kilometres have been inspected. We should emphasise that this coverage of soil is still minimal, but should be adequate for the purposes of this project. The soil information exists at present as computer file. Our aim is to assemble these as a web report that is appropriate to the medium and acceptable to the SA Department of Environment and Heritage, who manage the SA Digital Atlas web site. We have developed the following plan for the presentation of material on the web, but at the time of writing this report are unsure of its final appearance and content:

Introduction
Reasons for risk maps and soil characterisation
Brief definition of PASS and AASS
Hot links to strategy and guidelines documents
Web atlas map with legend (part of SA Digital Atlas)
Explanation of legend, risk classes
Site information
Site identifier
Site information
Georeference
Landform and geomorphology
Vegetation
Images appropriate to site, eg landscape, soil materials, developments
Brief description of soil
Soil classification (user friendly, Australian, US Soil Taxonomy, World Soil Reference Base – as appropriate)
Soil analytical data
Notes appropriate to site relating to ASS.

Examples of site information sheets are included below.

Field and laboratory methods

Field soil samples were prepared and archived in several ways. Each significant soil sample was subsampled in the following ways:

a) Approximately 200 g retained and frozen

b) Approximately 50 g placed profile horizon order in plastic percussion sample trays and frozen

c) A 100 ml sample of wet soil placed in a plastic phial and freeze dried

d) A bulk sample of up to 500 g air dried in a forced draught oven at 40^{o}C, lightly ground to pass a 2mm sieve and stored. The proportion of material greater than 2 mm material was determined, inspected and characterised as shell, calcium carbonate, gypsum or organic matter.

Selected samples were also retained for specialised analysis for salt and iron mineral identification (XRD). All samples have been stored for future reference. Subsample c) was retained for determination of water content and calculation of dry bulk density (see Progress Report 2) and selected samples used to confirm the presence of inorganic sulfides (Cr reducible sulfide). The < 2 mm material of subsample d) was used for laboratory determination of:

- Total carbon (by LECO furnace)
- Total sulfur (by LECO furnace)
- Carbonate carbon (by modified CO_2 gas pressure calcimeter).

Soil organic carbon can be estimated by subtraction of carbonate carbon values from total carbon.

Planned laboratory characterisation and analysis is essentially complete, although it is normally expected that a few confirmatory analyses will be required. Although we expect that with storage there has been oxidation of sulfide forms in the freeze dried samples, selected samples were analysed for Cr reducible S to confirm its presence. Field measurements with platinum electrodes were also used at some locations to confirm that the sulfur present must be in a reduced form.

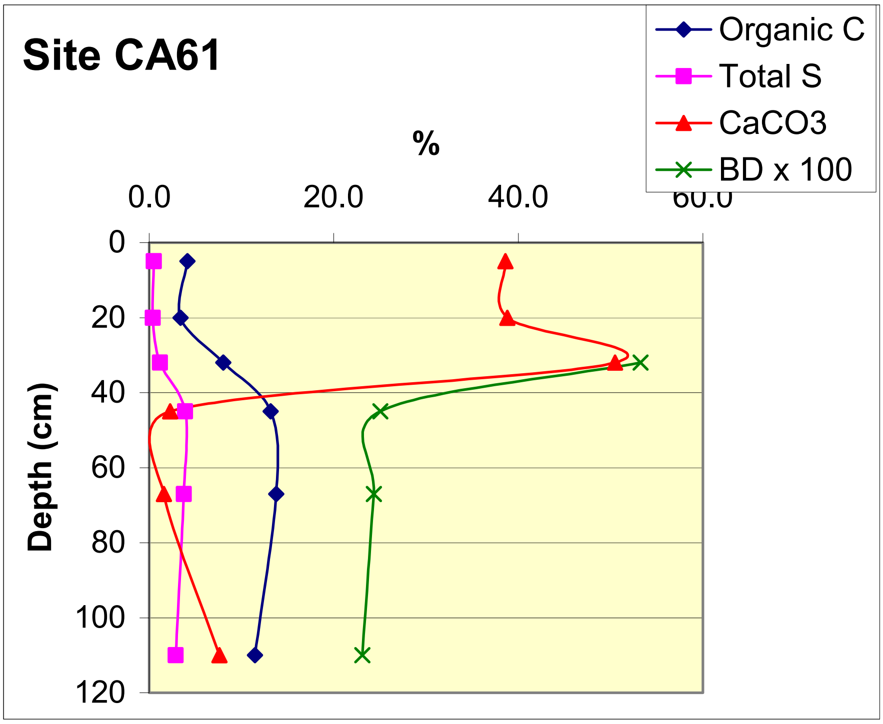
Representative Case Study Sites

Data from four field profiles, which are representative, are presented here with brief explanation, and followed by site description sheets.

Site CA61 was sampled from intertidal samphire at Price on upper Gulf St Vincent (Risk Class 4, Treatment Category: M-H, Tables 1 and 2; Figure 6). About 40 cm of calcareous clays (probably with a significant terrestrial input) overlies about 100 cm of relict peaty mangrove soil and underlain at 140 cm by coarse shelly material (not sampled). The watertable at sampling was at about 15 cm. The peaty material was characterised by high organic carbon and total sulfur content, with a strong H_2S smell. The dry bulk density of the peaty layer was about 0.25 g/cc. Although the top 40 cm was significantly calcareous, the reduced peaty layer contained insufficient acid-neutralising carbonates to neutralise the acid potentially produced should the material be exposed to the air.

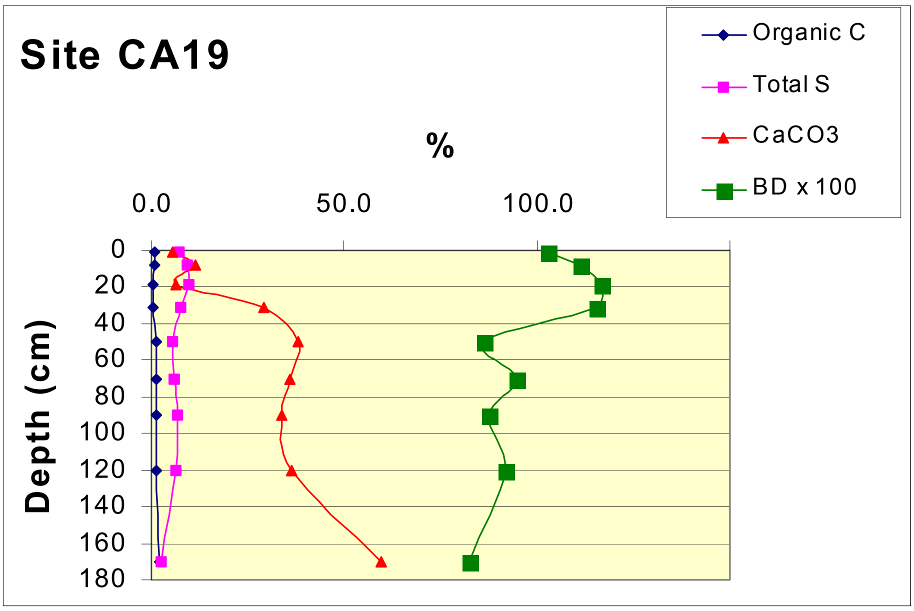
The presence of the peaty layer about 100 cm thick also presents a high risk if de-watering under load with consequent consolidation.

Figure 6: Analytical data for soil profile CA61.



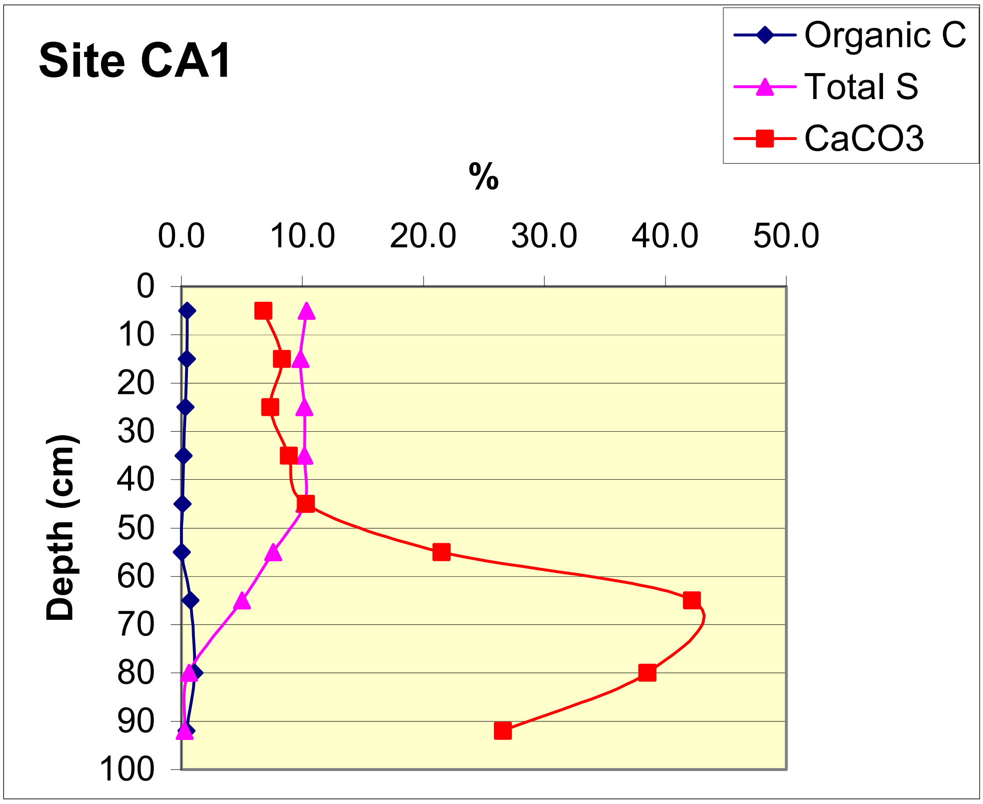
Site CA19 (Risk Class 5; Treatment Category: L-M; Figure 7, below) was sampled from a salt pan near Clare Bay, western Eyre peninsula. In this region, soils have a high sulfur content, often as gypsum, and large gypsum deposits are mined nearby. In this profile, sulfur is present in the oxidised form at the surface and gypsum was also noted below about 20 cm, but with some black sulfidic material. We believe that periodic oxidation of sulfides has produced acid, which may have resulted in removal of calcium carbonate from the upper 20 cm of the profile. Nearby at the outflow of the salt pan, there was clear evidence of thinning of calcrete and significant formation of ferricrete (iron oxides), presumably from a long period of pyrite oxidation.

Figure 7: Analytical data for soil profile CA19



Site CA1 (Risk Class 5; Treatment Category L-M; Figure 8, below) was sampled at Wallaroo, upper Yorke Peninsula (western side). This site is proposed for development as a marina/residential complex. This site also contains sulfur as gypsum in the top 80 cm. Below about 50 cm there is significant calcium carbonate, with shell beds at about 100 cm. As it exists, this profile presents few risks. However, should the upper soil layers be relocated or buried below a water table, it is likely that reduction will convert the gypsum to pyrite and produce a possible future risk from acid sulfate conditions.

Figure 8: Analytical data for soil profile CA1



Site CA78 (also MFP96/Site1, and similar to site BG14; Risk Class 1a; Treatment Category H-XH): This profile is representative of the actual ASS soils found in the Gillman area, north-west of Adelaide city. Here an area of 1.6 km^2 has acidified very strongly following the construction of bund walls that have excluded tides and lowered the saline groundwater table. The sands of the old dune systems in this area have limited acid neutralising capacity and soil pH values as low as about 2 have been recorded. Significant environmental problems have been reported in the area, which is also the site of CASSP-funded remediation experiments. This area is the only significant actual ASS site that we know of in South Australia and

Description Sheet for Site CA01

Site No: CA 01	**Locality**: Wallaroo, proposed marina site, N of existing marina			
Datum: WGS84 UTM (m)	**Zone: 53**	**Easting**: 743609	**Northing**: 6244971	
ASS Risk Class	**5**: Potential ASS (supratidal)			**Photo file**:
Coast &Marine Mapping Unit [1]	[Supratidal Bare]			CA01_01, 02, 03
Soil Classification	[2] Gypsic Hypersalic Hydrosol	[3] Gypsic Haploxerept	[4] Protothionic Fluvisol (Gypsic and Calcic)	
Vegetation	Nil, salt pan; samphire nearby			
Site observations made and sampled by: CSIRO L&W			**Date**: 20-Feb-02	
Site description: Salt pan, just inland from coastal dune with holiday houses. Not vegetated.				

Depth (cm)	**Brief soil description**:	**Material > 2mm, %**	**Total C %**	**Org C %**	**$CaCO_3$ %**	**Total S %**	**S_{CR} %**	**Bulk Density**[4]
0 - 1	Salt crust, some soil (?)	7.2 (clay?)[5]	5.8	0.7	41.9	1.0	n/a	n/a
1 -10	Mainly sand sized, loose, mainly gypsum; pale grey	7.4 (gypsum)	1.3	0.5	6.8	10.4	n/a	n/a
10 - 20	Mainly sand sized, loose, mainly gypsum; pale grey	9.5 (gypsum)	1.4	0.4	8.3	9.8	n/a	n/a
20 - 30	Mainly sand sized, loose, mainly gypsum; pale grey	4.5 (gypsum)	1.2	0.3	7.4	10.2	n/a	n/a
30 - 40	Mainly sand sized, loose, mainly gypsum; pale grey	2.7 (gypsum)	1.2	0.2	8.9	10.2	n/a	n/a
40 - 50	Mainly sand sized, loose, mainly gypsum; pale grey	3.5 (gypsum)	1.3	0.1	10.3	10.2	n/a	n/a
50 - 60	As above, increasingly calcareous with depth	1.4 (gypsum l)	2.6	0.0	21.5	7.6	n/a	n/a
60 - 70	As above, increasingly calcareous with depth	2.7 (gypsum)	5.8	0.7	42.2	5.0	n/a	n/a
78 - 85	As above, increasingly calcareous with depth	1.7(gypsum)	5.7	1.1	38.5	0.6	n/a	n/a
85 - 100	Grey matrix, mainly calcium carbonate, some coarse shell; saturated rounded quartz gravel	17.4 (quartz)	3.6	0.4	26.6	0.3	n/a	1.39
> 100	Coarse shelly layer, not penetrated						n/a	n/a

Comments:
Site will possibly be developed as part of a marina. Soil highly gypseous in top metre. Possibly becomes reduced at about 130 cm at shelly layer

[1] SA Department of Environment and Heritage, Coast and Marine Branch [2] Australian Soil Classification, Isbell (1996) [3] US Soil Taxonomy (1999) [4] World Reference Base for Soil resources, FAO (2000) [5] Estimated for saturated soils from % dry weight [6] Composition of coarse material

Description Sheet for Site CA19

Site No: CA 19	**Locality**: Inland from Clare Bay, east of Fowlers Bay, SA			
Datum: WGS84 UTM (m)	**Zone**: 53	**Easting**: 286398	**Northing**: 6464552	
ASS Risk Class	**5**: Potential ASS (supratidal)			**Photo file**:
Coast &Marine Mapping Unit [1]	[Supratidal Bare]			CA19_01, 02, 03, 04, 05
Soil Classification	[2] Sulfidic Hypersalic Hydrosols	[3] Halaquept?	[4] Protothionic Fluvisols (Calcic)	
Vegetation	Nil, saltpan.			
Site observations made and sampled by: CSIRO L&W			**Date**: 26-Feb-02	

Site description:
Salt pan, well inland from high coastal dunes. Not vegetated. Surrounded by rolling hills with calcrete soils. Outlet of saltpan shows thinning and removal of calcrete from soil and accumulation of extensive iron oxide.

Depth (cm)	**Brief soil description:**	**Material > 2mm, %**	**Total C %**	**Org C %**	**$CaCO_3$ %**	**Total S %**	**S_{CR} %**	**Bulk Density[4]**
0 - 1	Salt crust; sampled for mineralogy	n/a	n/a	n/a	n/a	n/a	n/a	1.83
1 - 2	Pinkish (algal) layer)	8.3	1.4	0.8	5.7	7.1	n/a	1.25
2 - 15	Dark grey to black; sandy clay; sulfidic smell, saturated	2.2	2.0	0.6	11.2	9.3	n/a	1.44
15 - 23	Brownish with pale grey and black patches; weakly sulfidic smell	1.2	1.3	0.6	6.5	9.7	n/a	1.59
23 - 40	Pale grey sand and clay with gypsum crystals; 10% brown mottles; some fibrous organic material; sulfidic smell	0.4	3.8	0.3	29.0	7.5	n/a	1.55
40 - 60	Pale grey clay with gypsum; weaker sulfidic smell?	1.7	5.7	1.2	38.1	5.5	n/a	0.94
60 - 80	Pale grey clay with gypsum; weaker sulfidic smell?	2.0	5.7	1.4	35.8	6.0	n/a	1.09
80 - 100	Grey, gleyed clay, orange-brown mottling; sulfidic smell	7.0	5.4	1.3	33.9	6.7	n/a	0.96
100 - 140	As above	1. 6	5.5	1.1	36.4	6.2	n/a	1.03
140 - 200	Pale grey clay; weak sulfidic smell	1.0	9.1	1.9	59.5	2.5	n/a	0.88

Comments:
Site within a conservation park. Note on US Soil Taxonomy class – this soil has a gypsic horizon, and therefore is an Inceptisol, but the classification does not allow for wet soils or soils with sulfidic materials

[1] SA Department of Environment and Heritage, Coast and Marine Branch [2] Australian Soil Classification, Isbell (1996) [3] US Soil Taxonomy (1999) [4] World Reference Base for Soil resources, FAO (2000) [5] Estimated for saturated soils from % dry weight [6] Composition of coarse material

Description Sheet for Site CA61

Site No: CA 61	**Locality**: Price, upper eastern Yorke Peninsula; Gulf St Vincent.							
Datum: WGS84 UTM(m)	**Zone:** 54	**Easting**: 224015	**Northing**: 6201792					
ASS Risk Class	**4**: Potential ASS (intertidal)					**Photo file**:		
Coast &Marine Mapping Unit [1]	Intertidal Terrestrial – Samphire Intact							
Soil Classification	[2] Histic-Sulfidic Intertidal Hydrosols	[3] Terric Sulfisaprists	[4] Protothionic Histosols (Sapric and Calcaric)					
Vegetation	Samphire of several kinds, both shrub and prostrate forms							
Site observations made and sampled by: CSIRO L&W			**Date**: 18-Apr-02					
Site description: Tidal streams and pools nearby; about 25 m south of causeway.								

Depth (cm)	**Brief soil description**:	**Material > 2mm, %**	**Total C %**	**Org C %**	**$CaCO_3$ %**	**Total S %**	**S_{CR} %**	**Bulk Density**[4]
0 - 10	Grey clayey matrix (probably terrestrial) with brown-orange mottles; very fine roots; some grey sapric material	41.5 (clay)[5]	8.8	4.2	38.6	0.5	n/a	n/a
10 - 30	As above, more clayey and mottled, some shell	31.8 (clay)	8.1	3.4	38.8	0.4	n/a	n/a
30 - 35	Thin shelly layer over saturated grey clay with black sulfidic material; old mangrove roots	17.6 (shell, org)	14.1	8.0	50.5	1.2	n/a	0.50
35 - 55	Black, sulfidic and organic; low bulk density; buried mangrove and seagrass	16.5 (org)	13.4	13.2	2.3	3.9	n/a	0.24
55 - 80	Black, sulfidic, very decomposed mangrove roots and seagrass (sapric)	26.4 (org)	13.9	13.7	1.6	3.8	n/a	0.23
80 - 140	Black sulfidic material with shell towards base	7.4 (shell)	12.4	11.5	7.6	2.9	n/a	0.22
> 140	Strong shelly layer; not recovered	shell	n/a	n/a	n/a	n/a	n/a	n/a

Comments:
Sapric horizon from at least 35 yo 80 cm.

[1] SA Department of Environment and Heritage, Coast and Marine Branch [2] Australian Soil Classification, Isbell (1996) [3] US Soil Taxonomy (1999) [4] World Reference Base for Soil resources, FAO (2000) [5] Estimated for saturated soils from % dry weight [6] Composition of coarse material

Description Sheet for Site CA78 (MFP96 Site 1; BG14)

Site No: CA78 [Mfp96/Site 1]	**Locality**: Gillman, Barker Inlet area, Adelaide								
Datum: WGS84 UTM(m)	**Zone:** 54	**Easting**: 275465	**Northing**: 6143180						
ASS Risk Class	**1a:** Actual ASS (disturbed)						**Photo file**:		
C&M Mapping Unit [1]	Land Outside Saltmarsh; outside C&M Branch mapped area; reclaimed drained land						BG14 (B Thomas)		
Soil Classification	[2] Sulfuric Redoxic Hydrosols	[3] Hydraquentic Sulfaquept	[4] Orthithionic Fluvisols						
Vegetation	Annual grasses								
Site observations made and sampled by: CSIRO L&W				**Date**: 1996/2002					
Site description: Eastern end of MFP transect and close to site BG11, east of Gillman rifle butts: flat, relict dune; shallow water table.									
Depth (cm)	**Brief soil description**:	**Material > 2mm, %**	**Total C %**	**Org C %**	**pH** 0.01M $CaCl_2$	**EC DS/m, 1:5**	**Bulk Density**[4]		
0 - 20	A1: dark grey-brown; sandy clay loam; mottled; sub angular blocky, firm; many fine roots	n/a	n/a	n/a	7.1	0.79	n/a		
20 - 38	E: pale brown; loamy sand; mottled; massive; few roots; very weak; sharp wavy boundary	n/a	n/a	n/a	7.3	1.47	n/a		
38 - 58	Btg1: dark grey; light clay; mottled; massive; very weak; sharp boundary	n/a	n/a	n/a	5.4	1.95	n/a		
58 - 90	Bgj2: greyish brown;; clayey sand; yellow jarosite mottles; massive; very weak; sharp/ smooth boundary	n/a	n/a	n/a	5.1	1.00	n/a		
90 - 130	Bgj3: greyish brown; sand; yellow jarosite mottles; massive; very weak; diffuse boundary	n/a	n/a	n/a	3.5	2.08	n/a		
130 - 160	Bg4: greyish brown; sand; yellow jarosite mottles; massive, very weak; diffuse boundary	n/a	n/a	n/a	4.3	3.94	n/a		
160 - 200	Bg5: olive grey; sand; massive	n/a	n/a	n/a	7.1	0.79	n/a		
Comments: This profile is an actual ASS that has significantly acidified the soil materials.									
[1] SA Department of Environment and Heritage, Coast and Marine Branch [2] Australian Soil Classification, Isbell (1996) [3] US Soil Taxonomy (1999) [4] World Reference Base for Soil resources, FAO (2000) [5] Estimated for saturated soils from % dry weight [6] Composition of coarse material									

In summary, apart from the already recognised actual ASS area at Gilman, Adelaide, and some samples from near the Murray River mouth, the PASS materials encountered so far are predominantly in a natural state containing gypsum or reduced (sulfidic) form of sulfur that is tidally inundated at regular intervals. Of the latter, about 70 of 270 samples did not also contain sufficient calcium carbonate to fully counteract potential acidity (assuming all sulfur is in a reduced state). However, about 50 of these 70 samples contain sulfur as the oxidised form (sulfate) and under the current undisturbed and aerobic conditions are not considered a risk.

This information was used to help verify the map units (ASS classes) and develop treatment categories as developed by Dear *et al*. (2002) (Table 2).

Project Objective 4)

Develop the foundation for evidence based and strategic extension of the on-ground experience gained from CASSP demonstration sites throughout Australia.

We have also transferred the knowledge gained in this project to the scientific community through a number of publications at conferences and in journals (in press). This process will continue as the papers make their way through the scientific refereeing and publishing process. As there has been no previous extensive work on the distribution and properties of coastal ASS in South Australia, this project has resulted in a rapid increase in local awareness that will be reinforced by the adoption of planning procedures. There has been a strong reliance on information and management approaches from established CASSP sites in NSW and Queensland.

Although no specific demonstration sites have been established in this project, detailed work in the St Kilda area and broader investigations in this study have indicated several aspects where South Australian ASS differ from those observed in the north-eastern states:

- presence of large quantities of calcite ($CaCO_3$) in most soils,
- presence of large quantities of gypsum ($CaSO_4$) in several soils,
- evidence that C cycling and turnover may differ in mangrove soils because of the high concentatrion of sapric material in these soils, which is more finely divided and reactive than the coarser, “fibric” materials observed in tropical areas, where organic carbon decomposition rates are much faster. It is thought that the "sapric" materials in these South Australian soils form from the detritus of seagrass and mangroves in the Gulf St Vincent. Also, the intense reducing conditions (i.e. low redox potential or Eh values to -600 mv) occurring in potential ASS where mangrove dieback is present in the St Kilda area may be the result of increased nutrient loads (eutrophic conditions). These soil processes and materials must be better understood if effective approaches to management are to be developed.
- the presence of eutrophied mangrove soils that result in mangrove decline.

The process of developing planning policy (Objective 5) has relied heavily on the application of interstate experience to management of proposed development of ASS sites in South Australia. The “Coastline” bulletin and the interim reports that have been accepted by the Coast Protection Board will provide vehicles for extension of good management of ASS through greater awareness and the rigorous planning and analytical requirements targeting ASS.

Project Objective 5)

Introduce a State Planning policy on acid sulfate soils

Prior to this project, no legislative mechanism existed within South Australia to assess proposed developments in coastal acid sulfate soil (CASS) risk areas. As a result of the project, the Coast Projection Board (CPB), which has jurisdiction over most coastal areas, has now included development and hazard policies within its draft Policy Document relating specifically to coastal acid sulfate soils:

1. Development

Policy 1.3. The Coast Protection Board will identify specific areas of the coast that require particular management actions.
[In doing so, it will have regard to coastal flooding and erosion, acid sulfate soils, areas of conservation significance and landscape amenity values.]
The Guidelines relating to Flooding and Erosion and Acid Sulfate Soils are contained in Appendix 1 and 2, respectively of the Policy Document.

2. Hazards

Policy 2.1. The Board will formulate hazard standards for the state of South Australia with reference to:

- Risk management approaches to hazard management using the intergovernmental Panel on Climate Change's recommendations to policy makers, and
- Commonwealth recommended approach to management of Coastal Acid Sulfate Soils.

Policy 2.2. The Board will facilitate:

(a) the use of strategic and legally enforceable agreements to manage the risk of damage from coastal hazards on development.
(b) a program of vulnerability assessment to ensure that sufficient coastal buffer zones are provided for predicted physical processes and to accommodate public infrastructure, use and access.

[In so doing the Board will have regard to the identification of Coastal Acid Sulfate Soil areas.]

Policy 2.3. The Board will advise on development proposals within coastal areas.
[The standards to be applied to Flooding and Erosion and Acid Sulfate Soils are contained in Appendix 1 and 2, respectively of the Policy Document].

For Development in areas identified as being at risk from CASS, the Board will seek the following information before providing advice to the relevant planning authority;

- Specific site and watertable levels, relative to Australian Height Datum (AHD),
- soil and water sampling and analyses to determine presence of coastal acid sulfate soils contamination, and
- where CASS are confirmed seek additional information on remedial strategies to minimise surface water and groundwater contamination, and a management plan for ongoing monitoring and best-practice management of the area.

Details of the policies are contained within three interim CASS reports that constitute Appendix 2 of the Board's Policy Document:

- Interim Strategy for Implementing CPB Policies on Coastal Acid Sulfate Soils in South Australia,
- Interim Development Guidelines and Risk Assessment Criteria for Coastal Acid Sulfate Soils, South Australia, and
- Interim Checklist for Development in Coastal Acid Sulfate Soils, South Australia.

An overall summary of the strategy has been produced as a CPB Coastline Bulletin (No. 33: January 2003) – A Strategy for Implementing CPB policies on Coastal Acid Sulfate Soils in South Australia (see Appendix 1, final report).

Proposed development in coastal areas[3] must now be referred to the CPB for advice before a decision about approval is made by the Development Assessment Commission (DAC). Moreover, the reports and CPB Policy Document have been submitted to Planning SA for consideration of a whole of government approach to CASS, either through a State Planning Strategy (SPS) or local councils' Plan Amendment Reports (PAR).

During the course of the project, a review of Coast Protection Board policies was conducted. The new CPB Development Policy 1.3 deals with acid sulfate soils in that 'the CPB will identify specific areas of the coast that require particular management actions. In doing so, it will have regard to coastal flooding and erosion, acid sulfate soils, areas of conservation significance and landscape amenity values'. The new CPB Hazards Policies 2.1 to 2.3 also deal with coastal acid sulfate soils. The CASS strategy, associated development guidelines and checklist prepared in this project relate to these policies and provide an action plan for the assessment of proposed developments in coastal-zoned acid sulfate soil risk areas.

Summary of process used to develop policy:

Both the NSW and Queensland acid sulfate soils approaches to policy were reviewed and utilised in the strategy and development guidelines. However, South Australia has more temperate acid sulfate soils compared to these states and the risk assessment criteria reflect this difference.

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[3] Other than a declared major development or project that undergoes a state Environmental Impact Statement process.

Project Objective 6)

Provide guidance for the development of new industries such as aquaculture and tourism as well as provision of infrastructure.

Coastal ASS guidelines are applied to off-shore and coastal development proposals presented to the Coast Protection Board. In addition, discussions are underway with Planning SA to broaden the application of the guidelines using a whole of government approach to all developments along the coast including aquaculture and tourism ventures.

The project has provided information and guidance through the preparation of coastal ASS maps, a number of reports and publications, as well as oral presentations to several state and local government agencies and community groups that potentially deal with ASS management. We also expect the Coastline Bulletin to greatly facilitate awareness among those undertaking new development in aquaculture, tourism and infrastructure.

Risk assessment and management of disturbance

A checklist was prepared that gives guidance and management procedures for disturbance of ASS during the process of development. This is summarised below.

Projects involving the possible disturbance of ASS must first assess the risk associated with disturbance through the consideration of both on- and off-site impacts. A thorough ASS investigation is an essential component of risk assessment. Such an investigation is needed to provide information on the environmental setting, location of and depth to ASS, existing and potential acidity present in the soil, and soil characteristics.

Successful management of ASS depends on the results of the investigation—and results from the investigation determine the most appropriate management strategy for a site. The following staged approaches to assessment of large disturbances/developments is suggested:

Establish whether acid sulfate soils are present on the site

A 'desk top' study is the first step in any preliminary assessment. A desktop study should be followed by field assessments, including preliminary field tests such as field pH, the field peroxide test and the field sulfate test. Detailed soil and water sampling and laboratory analysis may be required at the detailed assessment stage to validate the likely environmental risks of undertaking the proposal.

Step 1: Check AHD and size of excavation

Check whether the proposed site development is located <5 m AHD, where the natural groundcover is <20 AHD, and involve excavation of >100 m3 or fill >500 m3 over 0.5 m average depth. However, if yes proceed to Step 2. If no it can be assumed that coastal ASS are not present.

Step 2: Check ASS risk maps

Step 2: Check whether the site is located in an area mapped as having either a high or low risk of ASS on the ASS risk maps. Reference to coastal ASS maps should be the first step in any investigation. For example, if the works are not located within Classes 1a-3 (high risk category) or within 500 m of Classes 4-6 (medium risk category), it can be assumed that costal ASS are not present. However, if the works are located within Classes 1-7, or within 500 m of Classes 1-7 further investigation is then required to determine if ASS are actually present and whether they are present in such concentrations as to pose a risk to the environment.

Action following Step 2

If the works are in an area identified on maps as suggesting a risk to the environment, and if the works are likely to disturb these soils proceed to Step 3. If the works are not in or will not affect a mapped area, proceed without further consideration of acid sulfate soils.

Step 3: Examine field soil and water indicators

Step 3: Examine whether any of the soil or field indicators listed in the glossary are present. The investigation should include a field inspection to consider soil and surface and subsurface water characteristics and if necessary, limited ground water analysis. Because many of the indicators for actual and potential ASS are quite different, field inspection should investigate for the presence of both soil materials (see glossary – for indicators).

Treatment Categories (Table 2) should then be used to develop the best approach to managing ASS materials.

Project Objective 7)

Provide the ASS information necessary for the management and protection of Ramsar wetlands and World Heritage Areas.

Only one Ramsar wetland site falls within the mapped ASS risk area. This is the Coorong and Lower Lakes Ramsar area. The Ramsar management officer based at Victor Harbor has been informed of the location of the risk area and provided with the necessary information to ensure appropriate management of the Ramsar area.

No World Heritage Areas are currently involved in South Australian CASS risk areas.

Glossary of Terms related to Acid Sulfate Soils

acid sulfate soils — saline soils or sediments containing pyrites, which once drained (as part of remedial land management measures, or as part of coastal development), become acidic releasing large amounts of acidity into the ecosystem with consequent adverse effects on plant growth, animal life, etc. These soils are widespread around coastal Australia (especially when associated with mangrove swamps) and occur to an unknown extent in inland areas.

potential acid sulfate soils (PASS) – in their pristine state, acid sulfate soils (also termed potential acid sulfate soils (PASS)), occur in saline wetland seeps or are buried beneath alluvium and:

(i) contain black sulfidic material (see below), are waterlogged and anaerobic;

(ii) contain pyrite (typically framboidal);

(iii) have high organic matter content;

(iv) have pH 6-8.

Other indicators: Waterlogged greyish or black sediments. Bottom sediments of estuaries or tidal lakes. Soils that react to the Peroxide Test.

actual acid sulfate soils (AASS) - when PASS are disturbed:

(i) contain a sulfuric horizon (see below) because pyrite is oxidised to sulfuric acid (pH <3.5-4);

(ii) iron sulfate-rich minerals form, commonly as pale and bright yellow or straw-coloured mottles containing jarosite, natrojarosite or sideronatrite. May occur in any material excavated and left exposed

Other indicators: Water characteristics: Water of pH < 4 in adjacent streams, drains, ground water, etc.; Unusually clear or milky blue-green drain water flowing from or within the area (due to aluminium released by the ASS); Iron stains on drain or pond surfaces, or iron-stained water Landscape and other characteristics; Sulfurous (H2S) smell after rain following a dry spell or when the soils are oxidised or disturbed; scalded or bare low lying areas. Corrosion of concrete and/or steel structures.

sulfidic material: — waterlogged material or organic material that has a pH >3.5 and contains sulfide-sulfur. If incubated as a layer 1 cm thick under moist conditions (field capacity) while maintaining contact with the air at room temperature shows a drop in pH of more than 0.5 or more units to a pH value of 4 or less (i.e. 1:1 by weight in water, or in a minimum of water to permit measurement) within 8 weeks (Soil Survey Staff 1999).

sulfuric horizon: — a horizon composed either of mineral or organic soil material that has both pH <3.5 (1:1 by weight in water, or in a minimum of water to permit measurement) and bright yellow jarosite mottles. A sulfuric horizon is defined as being 15 cm or more thick (Soil Survey Staff ,1999)

classification soil — the systematic arrangement of soils into groups or categories on the basis of their characteristics. Broad groupings are made on the basis of general characteristics and subdivisions on the basis of more detailed differences in specific properties. For complete definitions of taxa see Soil Survey Staff (1999).

Further Information:

Soil Science Society of America. 1997. Internet Glossary of Soil Science Terms [Online]. Available at http://www.soils.org/sssagloss/ (verified 3 May 2001).

Soil Survey Staff (1999). Soil Survey Staff 1999. Soil Taxonomy - a basic system of soil classification for making and interpreting soil surveys, Second Edition. United States Department of Agriculture, Natural Resources Conservation Service, USA Agriculture Handbook No. 436 pp 869.

Acknowledgements

During the conduct of this project, assistance and support was received from the following people. Their help is greatly appreciated.

Rebecca Dunn

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Sean Forrester

Additional Achievements and Data

Indicate important achievements you have made in addition to your project objectives. Again, please use the Performance Indicators as listed in Item K to support your statements.

Please include any other data that may have been collected during the life of the project that are consistent with the Performance Indicators as listed in Item K. For example, demonstration activities may not be a project objective but performance indicator data for demonstration may have been collected.

1. Implementing Regional, Catchment and Local Area and Land Management Planning

In what way has your project contributed to the development or implementation of a regional strategy or management plan?

This project has made considerable progress in identifying the distribution of ASS and their associated risks in SA. This task is a key action of the National Strategy for the Management of Coastal Acid Sulfate Soils. The development and endorsement of planning policy will for the first time provide a basis for land management planning in SA.

The whole SA coastline has been mapped and areas of high risk have now been identified, thereby ensuring proactive management and essential complementary planning measures can be implemented. This has allowed for potential problems to be prioritised (ASS Risk classes), minimised and mitigated in advance wherever possible.

This project has also advanced new concepts (properties of CASS in a Temperate/ Mediterranean climate) and practical information (ASS Risk, checklists, treatment categories) about coastal ASS in SA. This information has already been provided to policy makers and local stakeholders via websites (ASS maps), workshop and conference presentations, and as popular articles (e.g. Coastline – see Appendix 1) and fact sheets. This information will aid in avoiding excavation of Potential ASS and the tackling of solutions for remediation of Actual ASS in SA at regional and local government scales.

2. Use of Project Results

Has your project had any benefits for any other groups? If so, by whom and in what way?

Results and data (e.g. CASS Maps of SA) derived from this project have been used as follows:

- Incorporation of information and maps a new Manual developed by Transport South Australia entitled "Protecting Waterways". The manual is designed to give staff, consultants and the community guidance in procedures and measures to address water quality and protect aquatic ecosystems, and infrastructures. Rob Fitzpatrick gave a 45 minute presentation at the launch of the manual (including a training session) on 12th December 2002. Information about CASS in SA and digital photographs are included in the manual.

- In formation was provided to mining consultants regarding an environmental assessment of Weeroona Is where a causeway is planned to be constructed (part of a magnesium plant).
- Popular material has been provided to Mangrove Walk people for display.
- Uptake of results and conceptual biogeochemical models in scientific papers presented at the 5th International Acid Sulfate Soil Conference. Some of this information was presented in Invited key note address “Inland acid sulfate soils - a big growth area” presented at the 5th International Acid Sulfate Soils Conference, Tweed Heads, NSW, 25th to 30th August, 2002. Invited to publish a paper in the Australian Journal of Soil Science.
- The approaches and methodologies developed in the project to map and characterise coastal ASS in SA was used as a template to help staff in Western Australia develop a successful project to map coastal ASS in WA – at State and regional levels. This project was also used as a model for project development in Victoria.
- Similarly, the project was used to develop a new proposal to deliver a user-friendly national coverage of Australian coastal Acid Sulfate Soils to be depicted on the Audit’s or EA’s web atlas (www.nlwra.gov.au). At a national scale, these maps will identify the current extent and severity of the coastal ASS problem using a standardised approach (e.g. as developed in this project) for all jurisdictions and allow for risk assessment in terms of maintenance of existing development and of future development proposals.
- Landholder and Council meetings: several one-on-one discussions between the research team and local landholders have taken place and these prove to be a most effective communication mechanism. Researchers have learnt from Landholders and council staff, and local observation has been important to the design of our approach and verification of results.
- The project has provided context for one postgraduate research project involving mapping and remediation of ASS in SA.

3. Program Administration

Please provide comments on CASSP project administration. This information may be able to assist future funding programs.

We believe that this project benefited from having access to a good steering committee, interaction with NATCASS, and an effective technical committee of advisers (B Powell, Dr G Bowman, Dr D Dent and Mr D Maschmedt) whose input is gratefully acknowledged.

Establishment of the project also benefited from a very constructive strategic planning meeting (Project Reports 1 and 2) with field trip held in the early days of the project.

Have appreciated interaction with EA management their helpful feedback, especially from Trevor Costa during the establishment phase of the project.

4. Future Action

How is your group planning to maintain the project after funding has ceased?

The web-based products (map and databases) of this project will be maintained by the SA Department of Environment and Heritage and maintenance of policy will reside with the Coast and Marine Branch and Coast Protection Board. However, there are no guaranteed resources to ensure this in the long-term. The web-based products have not been fully finalised at the time of writing this report, because it is anticipated that changes will be needed to conform to the requirements of the SA Department of Environment and Heritage web site, which awaits full approval. Once obtained, the current project team will ensure that the data and maps are formatted appropriately and loaded to the web site.

We recommend that a South Australian Technical committee for ASS be formed to have oversight and to interact with local government and development zones. This committee should also be charged with identifying suitably qualified consultants and analytical laboratories to ensure that the guidelines, and soil and water analysis procedures, are followed.

The project will produce, in addition to web and other outputs already described, at least one scientific journal publication (Australian Journal of Soil Science) to be produced.

5. **Total Project Funding Details**

   Details of project funding are provided separately.

6. **Proponent declaration:**

   In order to maximise the benefits of the Natural Heritage Trust to others, information relating to all CASSP projects is regarded as in the public domain and is publicly available on request. Nevertheless, under Commonwealth privacy legislation, personal information cannot be divulged without the consent of those involved.

Do you consent to the inclusion of contact name and telephone details in response to public information requests concerning this project?	**Yes**	**Y**	**No**	

Signature			
Contact name (Please print)		Rob W Fitzpatrick	
Organisation		CSIRO Land and Water	
Position in organisation		Soil Scientist	
Date:	16/03/2003	Tel:	08 8303 8511

I declare that the information given on this form including data on project performance, is complete and correct, and expenditure of moneys paid under the financial agreement has been solely upon the project and in accordance with the terms of the Agreement and its conditions.

Signature			
Printed name		Rob W Fitzpatrick	
Organisation		CSIRO Land and Water	
Position in organisation		Soil Scientist	
Date:	16/03/2003	Tel:	08 8303 8511

Signature			
Printed name		M Staufacher	
Organisation		CSIRO Land and Water	
Position in organisation		Research Director	
Date:		Tel:	(02) 6246 5814