DLWC ACID SULPHATE SOIL RISK MAPPING

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ABSTRACT

In response to encouragement from the first National Conference on Acid Sulphate Soils and to assist with the management and environmental planning of coastal lands in NSW, DLWC has prepared a series of 120 Acid Sulfate Soil Risk maps covering the entire NSW coastline. They predict the distribution of ASS based on an assessment of their geomorphic environment. Three primary map classes; high probability, low probability and no known occurrence were mapped with codes indicating landform and depth class. Six thousand hectares of ASS were mapped. The distribution of ASS is strongly related to Holocene estuarine sediments and they do not occur at elevations above 1 m AHD. These maps can be the basis for future detailed surveys and for land use policy development.

Key Words: ASS Risk mapping, NSW, soil survey,

1. INTRODUCTION

Acid sulfate soils (ASS) were first identified in Australia in 1960 in the Macleay River floodplain (Walker,1963) and warnings were issued about the potential dangers of misusing these soils in 1972 (Walker, 1972). Despite this, land use in the coastal zone of NSW has been carried out without the appropriate knowledge or regard for the potential problems of exposing the environment to pyrite oxidation. By the time of the first National Conference on Acid Sulfate Soils in 1993 the environmental impact of the ASS problem was beginning to be widely recognised but still little was known of their distribution. As DLWC was responsible for soil survey in NSW, the delegates to that conference encouraged the Department to undertake ASS risk mapping along the NSW coast in a manner similar to that described in a paper by Atkinson (1993).

This paper is a report back to the 2nd National Conference on the outcomes of that mapping. It describes the strategies and methods used and some of the outcomes achieved. Because of the large area to be mapped, and a 15 month time frame, it was essential for a mapping technique to be developed which was efficient and which would provide the key elements for future management and land use planning. It also needed to provide information on the distribution of ASS to a broad cross section of the community.

2. MAPPING STRATEGY

Pyritic sediments in coastal landforms of NSW are generally associated with Holocene estuarine environments because estuarine environments provide the key elements for the formation of pyrite in sediments (Pons and van Breeman, 1982). Therefore to map the distribution of ASS it was essential to understand the processes and modes of formation of NSW estuaries and to map their present and past extent. Although pyrite has been found in Pleistocene sediments elsewhere in the world (Dent, 1986), it has been assumed locally that pyrite, which may have previously existed in these sediments, has long since been completely oxidised during periods of low sea level. (This is not entirely valid and certainly some exampled do exist, but often well below sea level. (see Drury and Roman, 1982). The existence of these deposits however, is largely unexplored and it is highly unlikely that there are widespread occurrences of pyrite in Pleistocene sediments in NSW.

Estuaries in NSW have been classified by Roy, (1984) into: 1) Drowned River Valley Estuaries - occur mainly in central NSW and have steep sided narrow valley systems formed by the deep incision of prior bedrock; 2) Barrier Estuaries - are the most common type of estuary in NSW particularly on the North Coast and are the most likely to produce ASS conditions; and 3) Saline Coastal Lakes - are the least common of the three estuary types, and are found with greater frequency on the south coast of NSW. With an understanding of the relationship between the formation of ASS and these estuarine environments it was possible to design a mapping strategy based on the morphology of those environments that allowed good prediction of the distribution of ASS conditions.

Landform relief patterns in many NSW coastal floodplains consist of three identifiable zones including levee, levee toe and backswamps (Walker, 1963). The pattern of land use relates largely to the hydrologic conditions which occur from levee to backswamp. Each zone or landform element has variable potential for agriculture. For example, the backswamps of the floodplains are prone to waterlogging and flooding. In addition, the presence of pyritic sediments becomes increasingly more important for agricultural and environmental management in the backswamps where the cover of alluvium is thinnest. The relationship between, landforms land use and ASS management practices is also an important factor. Therefore a mapping technique of delineating coastal landform elements (eg. levee, backswamp, lagoon) and indicating the likelihood and depth of the occurrence of ASS materials in each element was adopted.

4. METHODS AND MATERIALS

4.1 Initial Mapping. Initial maps were prepared by stereoscopic interpretation of 1:25 000 aerial photographs to identify landform elements in coastal environments with an elevation up to approximately 10 metres AHD (Australian Height Datum is approximately mean tide). Landform elements were mapped onto 1:25 000 topographic maps; the same scale at which the maps were to be published. Where possible, numerous sets of air photos of the same area were used to allow for seasonal effects to be taken into account. Each map unit was allocated a landform process class, a landform element class and an elevation class.

Table 1. Landform Codes used on the Acid Sulphate Soil Risk Maps

Landform Process Class	Landform Element		Elevation
W.........Aeolian	b.........Backplain	t..........Levee Toe	0........0-1 m
A..........Alluvial	k.........Backswamp	o.........Ox-bow	1........1-2 m
B..........Beach	m........Bottom Sediments	p.........Plain	2........2-4 m
E..........Estuarine	n.........Channel	a.........Sandplain	4.........>4 m
L..........Lacustrine	d.........Dune	s.........Swamp	**Additional Descriptive Codes**
S..........Swamp	r..........Interbarrier Swamp	y.........Splay	(p)........Pleistocene
X.........Disturbed Terrain	i..........Intertidal Flat	u.........Supratidal Flat	(s)........Acidic Scald
	g.........Lagoon	w........Swale	
	l..........Levee	c.........Tidal Creek	

Elevation data were taken form 1:4000 scale orthophotomaps where they were available and by extrapolation from known elevation points. Areas which had been mined, filled or subjected to major soil disturbance were mapped as Disturbed Terrain. The elevation code was used to indicate the elevation of the present-day ground surface. Water bodies, such as rivers, lakes, creeks and estuaries were mapped because of the likely occurrence of iron monosulphides within the bottom sediments. No elevation code was allocated to these areas.

4.2 Soil Data Collection Soil profiles were examined and described in detail at over 840 sites and inspected at countless more along the NSW coast by the team of seven soil surveyors each working in separate areas. Field work commenced in March 1994 and was completed by April 1995. In some areas existing Soil Landscape Maps provided additional data. Initially, representative soil profile sites were chosen during the aerial photograph interpretation phase to establish field relationships between landform type, elevation and the occurrence and depth of acid sulphate soil materials. Further profile site selection was primarily aimed at understanding the geomorphology and stratigraphic sequences in various landforms comprising each catchment. This process enabled the distribution and occurrence of pyritic sediments to be better understood and predicted. At each soil profile site, soil morphological data, pH and site information were recorded on NSW Soil Data Cards.

Soil sampling equipment included extendable stainless steel Jarret hand augers, 110cm stainless steel gouge augers and in some areas a backhoe which was used for excavation of soil pits for soil profile description. The depth of inspection varied between sites depending on the requirements and soil conditions of each site. All equipment was capable of sampling to 3 m.

During the early stages of the survey it was found that the level of the pyritic/fluvial sediment interface occurred at less than 1 metre AHD. This information allowed estimation of the depth of occurrence of the pyritic sediment based on elevation of the ground surface. It also resulted in no soil inspections on landforms higher than 4 metres AHD as soil sampling equipment did not penetrate to the anticipated level of the pyritic sediment layer. These areas were assessed primarily on geomorphic principles in combination with soil data from surrounding landforms or soil data from other sources.

In the field, site inspection was often difficult due to poor accessibility of some areas by vehicle. Dense vegetation, flooding, waterlogged soils and restricted access onto private property. Soil profile descriptions were supplemented by many thousands of observations of ASS indicators, including: ferric iron oxide staining on drain sides; jarosite in spoil from excavations and drain construction; unusually clear water and iron flocs in drain waters; and low pH in surface water and drain water.

4.3 Soil Sample Testing At selected sites, between 1 and 4 soil samples of 300 - 500 grams were collected for laboratory analysis from horizons suspected or considered to be ASS or PASS material. Over 1600 samples were collected for laboratory analysis. All samples were sealed and tagged within 2 plastic bags to minimise contact with oxygen during time of transport and chilled to minimise oxidation of any pyritic material. Within 24 hours of collection, samples were either frozen for dispatch at a later date or chilled and transported to the DLWC's Wellington Laboratory for immediate oven drying. The samples were tested in the laboratory for electrical conductivity, pH (1:5 soil water), pH (1:20) in H^2O^2, total actual acidity (TAA) and total potential acidity (TPA).

5. RESULTS and CONCLUSIONS

5.1 Map Classes The final maps contained four main map classes based on differences in geomorphic

processes. The high and low probability classes were then subdivided into depth categories. For each of the resulting categories the environmental risk associated with land use activities was described and typical landforms identified (see Table 2). As an example of these classes Figure 1 shows a schematic cross section of a levee to backswamp landform within an area of high probability of occurrence of acid sulphate soils. Typical landform codes, the depths to acid sulphate soils and the land use activities with an environmental risk are shown on the figure.

Figure 1 - Schematic cross-section of a levee to backswamp landform indicating typical landform codes, depth to acid sulphate soil materials, and land use activities with an environmental risk.

5.2 Mapping Outputs 129, 1:25 000 scale Acid Sulfate Soil Risk Maps, 20, 1:100 000 scale catchment based maps and a set of guidelines for their use were published by DLWC covering the entire NSW coastline (Naylor *et al*., 1995).

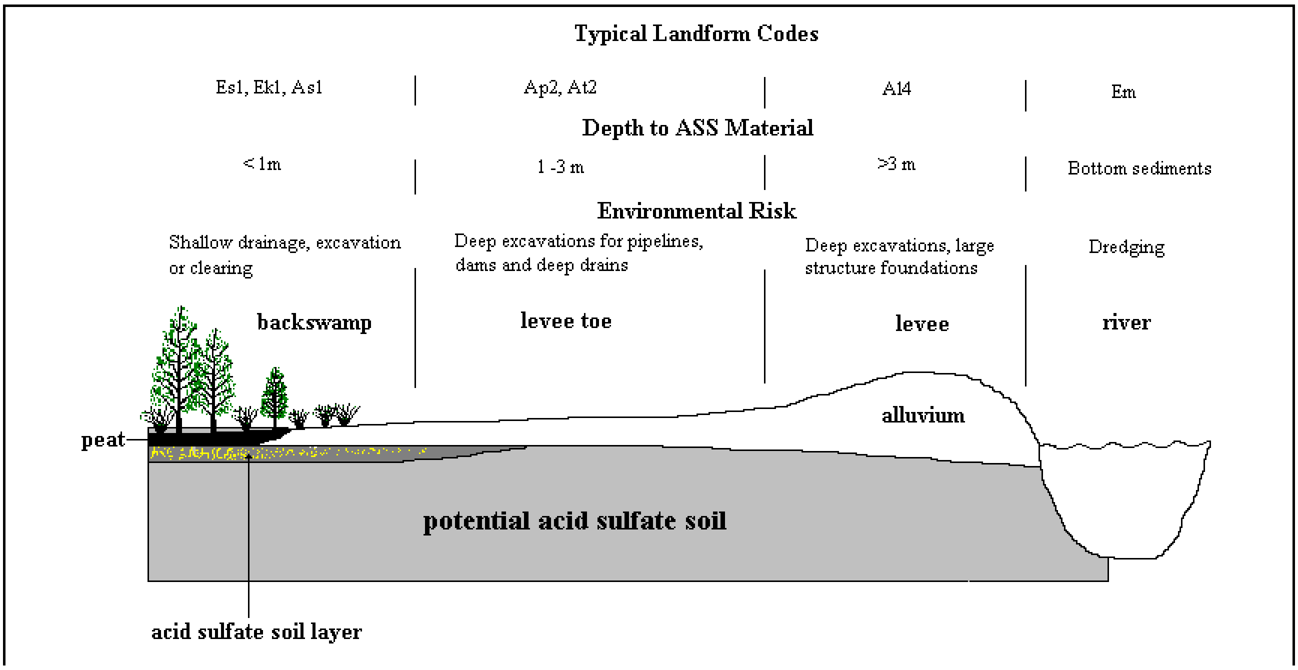

Table 3 Area of ASS risk classes in NSW

Process Class	High Risk (ha)	Low Risk (ha)	No Known (ha)	Disturbed (ha)
Alluvial	164 684	86 528	4 822	-
Estuarine	86 528	98 863	85	
Lacustrine	2 346	7 477	-	

Swamp	4 821	-	3 868	
Aeolian	7 862	3 234	23 953	
Beach	-	-	6 370	-
Disturbed	-	-	-	20 401
Total Land	265 341	207 030	39 100	20 401
Bottom Sediments	136 859	6 689	192	-
TOTAL AREA	403 349	213 719	39 292	20 401

5.3 Distribution of ASS Table 3 (above) lists the area of ASS risk classes by landform process type. The total area mapped was 676 760 ha of which 403 349 ha was high risk and 213 719 ha low risk, 39 292 ha no known occurrence and 20 401ha of disturbed terrain. Of this total 143 739 ha was bottom sediments which amounted to 21.0% of the total area.

5.4 Depth of ASS The assumption used in the mapping relating to the upper depth of ASS of 1metre AHD was found to be appropriate, as all actual ASS was found below this level and most potential ASS was found below 0.3 m AHD.

ACKNOWLEDGMENTS

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Table 2. Acid Sulphate Soil Risk Map Key

Map Class Description	Depth to Acid Sulphate Soil Materials	Environmental Risk	Typical Landform Types
High Probability High Probability of occurrence of acid sulphate soil materials within the soil profile. The environment of deposition has been suitable for the formation of acid sulphate soil materials. Acid sulphate soil materials are widespread or sporadic and may be buried by alluvium or windblow sediments.	Bottom Sediments	Severe environmental risk if bottom sediments are disturbed by activities such as dredging.	Bottom Sediments of lakes, lagoons, tidal creeks, rivers and estuaries
	At or near the ground surface	Severe environmental risk if acid sulphate soil materials are disturbed by activities such as shallow drainage, excavation or clearing.	Estuarine swamps, intertidal flats and supratidal flats.
	Within 1 metre of the ground surface	Severe environmental risk if acid sulphate soil materials are disturbed by activities such as shallow drainage, excavation or clearing.	Low alluvial plains, estuarine sandplains, estuarine swamps, backswamps and supratidal flats
	Between 1 and 3 metres below the ground surface	Environmental risk if acid sulphate soil materials are disturbed by activities such as deep excavation for pipelines, dams or deep drains.	Alluvial plains, alluvial swamps, alluvaial levees and sandplains

<table>
<tr><td></td><td>Greater than 3 metres below the ground surface</td><td>Environmental risk if acid sulphate soil materials are disturbed by activities such as deep excavations, - eg. large structure foundations or deep dans.</td><td>Elevated alluvial plains and levees dominated by fluvial sediments. Plains and dunes dominated by aeolain soils. Pleistocene plains. Lacustrine and alluvial bottom sediments.</td></tr>
<tr><td rowspan="4">Low Probability

Low probability of occurrence of acid sulphte soil materials within the soil profile.

The environment of deposition has generally not been suitable for the formation of acid sulphate soil materials. Soil materials ar e often pleistocene in age.

Acid sulphate soil materials, if present, are sporadic and may be buried by alluvium or windblown sediments.</td><td>Bottom Sediments</td><td rowspan="4">The majority of these landforms are not expected to contain acid sulphtae soil materials. Therefore, land management is generally not affected by acid sulphate soils.

However, highly localised occurrences may be found, especially near boundaries with environments with a high probability of occurrence. Disturbance of these soil materials will result in an environmental risk that will vary with elevation and depth of disturbance</td><td rowspan="4">Elevated alluvial plains and levees dominated by fluvial sediments. Plains and dumes dominated by aeolian soils. Pleistocene plains. Lacustrine and alluvial bottom sediments.</td></tr>
<tr><td>At or near the ground surface</td></tr>
<tr><td>Within 1 metre of the ground surface</td></tr>
<tr><td>Between 1 and 3 metres below the ground surface</td></tr>
</table>

	Greater than 3 metres below the ground surface		
No Known Occurrence Acid sulphate soils are not known or expected to occur in these environments.	No known occurrences of acid sulphte soil materials.	Land management activities not likely to be affected by acid sulphate soil materials.	Bedrock slopes, elevated Pleistocene and Holocene dunes, and elevated alluvial plains.
Disturbed Terrain	Disturbed terrain may include filled areas, which often occur during reclamation of low lying swamps for urban development. Other disturbed terrain includes areas which have been mined or dredged, or have undergone heavy ground disturbance through general urban development or construction of dams or levees. Soil investigations are required to assess these areas for acid sulphate potential.		