SECTION SEVEN

Soil Management

Contents

This chapter addresses two key aspects of soil management on NSW golf courses: soil erosion and acid sulfate soils. Other elements of soil management are covered elsewhere in this manual, including fertiliser practices and water management. The full range of potential soil management issues for golf courses should also be considered, including soil fertility and nutrient management, soil structure, waterlogging and drainage, acidification, irrigation and dryland salinity, soil contaminants and healthy soil fauna/ microbial activity**.**

SECTION 7:
Soil Management

KEY CONCEPTS

Soils and soil structure provide the foundation for high-quality turf.

Poor management of soils can result in:

- loss of valuable topsoil;
- erosion;
- exposure of acid sulfate soils;
- loss of organic matter;
- siltation of water bodies;
- excessive compaction, dispersion or waterlogging;
- long-term maintenance problems; and
- poor or uneven turf growth

Site evaluations are critical in the planning of any new works that involve soil disturbance.

7.1 INTRODUCTION

Golf courses are constructed on a wide variety of soil types, ranging from sands to marine clays. Consequently, each site will have conditions peculiar to the site, which will impose special management requirements.

Identifying the soils on the site is the first step in developing an appropriate management plan. Many golf courses are disturbed sites where soils have been moved around to shape and contour fairways. If particular care has not been taken in the construction of the course and placement of these soils, the results can be:

- erosion;
- run-off of sediments to water ways and consequent siltation;
- impacts on aquatic life can lead to fish kills;
- severely compacted soils;
- topsoils lacking in organic matter;
- shallow topsoil layers;
- high salinity; and/or
- variable pH.

The construction stage is the ideal time to undertake any remediation required to improve the structure, water-holding capacity or drainage of the soils. This is done through:

- addition of gypsum to soils with high clay content or high exchangable sodium percentage;

- addition of organic matter to sandy soils;
- careful stockpiling of topsoils for later replacement;
- shaping profiles to assist in surface drainage; and/or
- installation of supplementary pipe drainage.

Where there is development of new sites and construction activities on existing sites in coastal areas, care needs to be taken with respect to the disturbance of acid sulfate soils (ASS). The disturbance of acid sulfate soils causes the release of sulfuric acid that acidifies water bodies, causes the death of aquatic life and corrodes concrete structures.

Compaction is a major concern on any construction site due to machinery operation and soil disturbance. Compacted layers have low infiltration rates; this will result in water runoff during irrigation, in turn resulting in wasted water and stressed areas of turf. Well-aerated soils encourage strong, vigorous root systems and healthier turfgrasses that require less water and fertilisers and are more resistant to pest attack.

On sandy soils, nutrient and moisture retention is very low; management strategies should include the addition of organic matter to improve both water and nutrient retention. This results in improved water conservation and lower fertiliser applications.

7.2 SOIL EROSION

Well-established golf courses have a dense vegetation cover that is highly resistant to erosion. However, during the construction phase, golf courses will often have large areas of land that are devoid of vegetation cover and are highly susceptible to erosion.
The extent of erosion can be minimised by careful management and the use of protective materials. It is important to consider methods of controlling erosion at the time of planning a project for the following reasons:

- erosion is harder to eradicate once it starts;
- erosion can lead to heavy sediment flow that contaminates waterways; and
- the soil that is lost may be valuable topsoil, which is costly to replace.

The environmental considerations of soil erosion are extremely important and major projects will require appropriate controls such as the development of Erosion and Sediment Control Plans. Erosion management should adopt the principles and management practices published in the NSW Department of Housing (1998) (The ‘Bluebook’) *Managing Urban Stormwater - Soils and Construction.* The NSW Department of Planning have prepared a brochure on preparing Erosion and Sediment Control Plans.

Another factor to consider is the long-term management of sites where valuable topsoil has been lost due to erosion. Topsoil takes hundreds of years to develop and contains the ‘living’ fraction of the soil that makes growing and maintaining turfgrasses so much easier. Topsoil contains organic matter, microbes and essential nutrients that are impossible to replicate with ‘artificial’ additions.

GENERAL STRATEGIES FOR EROSION CONTROL

- Minimise bare or disturbed areas.
- Where practical, break down the project into stages to keep earthworks areas as small as possible.
- Schedule works to ensure that erodible areas are stabilised as quickly as possible.
- Installing proper erosion and sediment control devices (sediment fences etc.)
- Limit damage via water flow by planning earthworks for the drier part of the year.
- Make sure that overland flows are diverted away from bare areas.
- Where water flow over bare areas is anticipated it should be slowed as much as possible by:
  - reducing the steepness of slopes;
  - diverting water off bare steep slopes (e.g. unsealed roads) into vegetated areas;
  - installing contour drains to intercept overland flows; and
  - leaving some vegetation strips.
- Avoid changing any natural watercourses during construction as this will speed up the flow of water and encourage erosion.

7.3 ACID SULFATE SOILS

Acid sulfate soils (ASS) are generally found in low-lying areas along the coastline, estuaries and estuarine floodplains throughout New South Wales, particularly in wetland areas. 600,000 hectares of ASS have been identified in NSW, including extensive deposits in the Tweed, Richmond, Clarence, Macleay, Hunter, Hawkesbury - Nepean and Shoalhaven catchments, Newcastle Harbour, and Tuggerah Lakes.

It is not practical to determine where all ASS deposits occur within the complex coastal soils. However, for planning purposes, areas of high risk have been identified and the NSW Department of Land and Water Conservation (DLWC) (now the Department of Water and Energy) has mapped ASS risk at 1:25,000 scale as part of the Resource and Conservation Assessment Council (RACAC) resource inventory program.

An Acid Sulfate Soils Management Advisory Committee has also been established to:

- advise government on the management of acid sulfate soils.
- coordinate research and management initiatives of government agencies.
- develop generic guidelines and principles for effective management at a local level.

Detailed information on ASS management is available in the *NSW Acid Sulfate Soil Manual* (by Stone, Ahern and Blunden, 1998) which superintendents should use to manage a landscape that has a high probability of ASS problems. Contact numbers for further information and/or to obtain copies of the manual are provided in the References and Further Reading Section and ASSMAC contacts.

The ASS Manual enables a proper assessment of the acid sulfate soil status of the site, the likely impact of the development on these soils and the options for managing these impacts. It also helps councils and others in assessing development applications on sites potentially affected by acid sulfate soils.

The following information on acid sulfate soils was adapted from Larsen and Graham (2000) and Stone, Ahern and Blunden (1998).

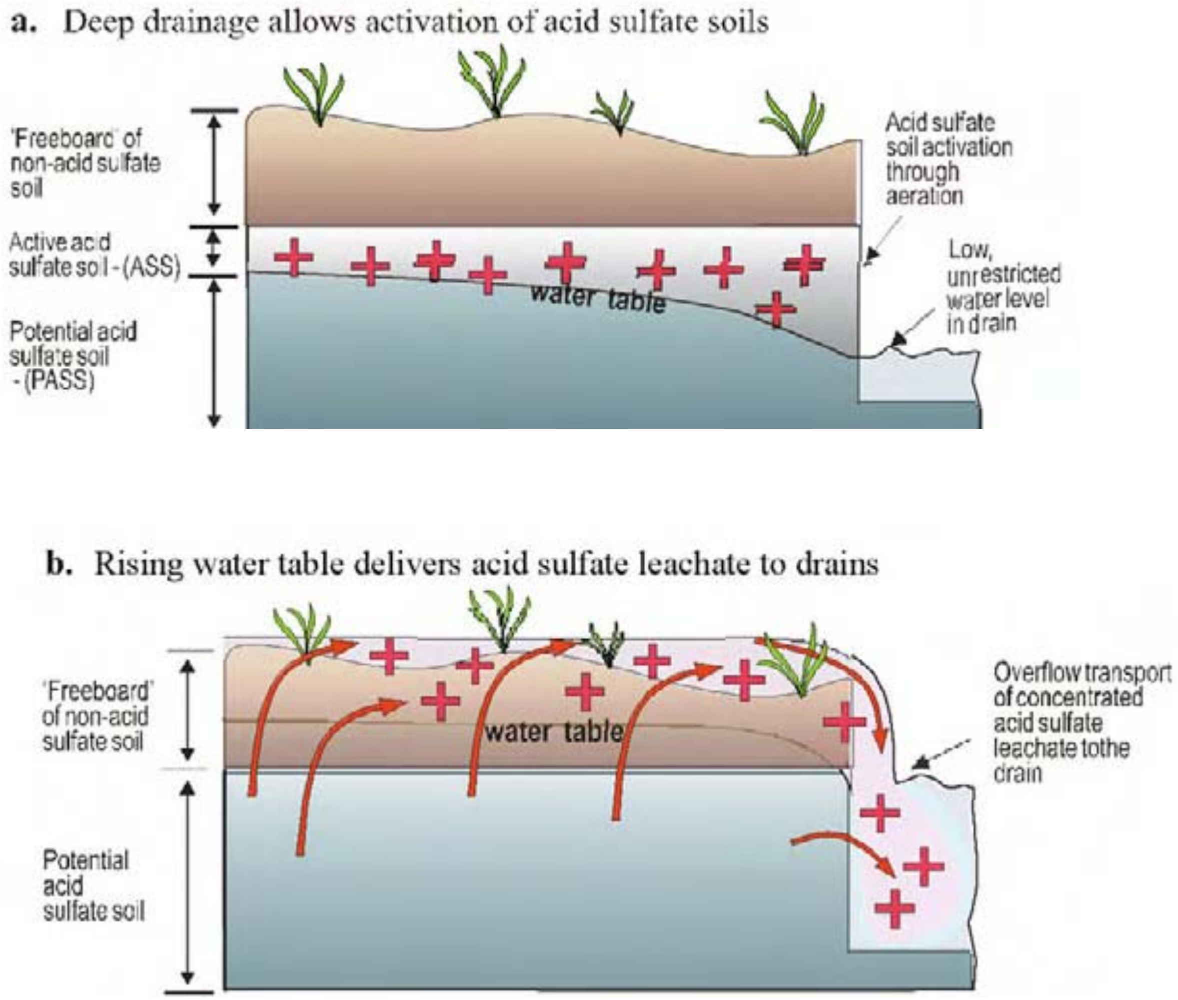
7.3.1 Disturbance of acid sulfate soils

Acid sulfate soils (ASS) occur naturally in low-lying coastal areas. These sediments were formed during the last major phase of coastal deposition between ~9000 and 2000 years ago, coinciding with the completion of the last great sea level rise. They commonly occur in areas with elevations of less than 5 metres above mean sea level and are often blanketed by a 1–2 metre surface cover of alluvial soil or dune sand. This surface cover generally has little or no acid sulfate potential and is commonly referred to as the ‘freeboard’.

Natural biological and chemical processes during deposition of these sediments result in there being rich in iron sulfides, particularly pyrite (FeS_2). Acid sulfate activation occurs when they are exposed to air, either directly by excavation or indirectly by drainage lowering local watertables (Fig. 7.1). When exposed to air the sulfides oxidise, producing sulfuric acid with pH levels commonly less than 1 (equivalent to car battery acid), iron flocs and often solubilised aluminium. These products build up in the soil and are released in high, often toxic concentrations to nearby waterways after rain, causing the death of fish and other aquatic organisms, as well as corrosion of concrete structures. Soil structure, soil arability and plant growth can also be impacted by acid runoff.

If the surface ‘freeboard’ layer is thin, ASS products may rise to the surface and cause surface scalds — patches of stunted and/or dead vegetation.

Figure 7.1: Formation of acid sulphate soils (adapted from Larsen and Graham (2000) and Stone, Ahern and Blunden ,1998).



7.3.2 Acid sulfate indicators

A number of indicators suggest that disturbance of acid sulfate soils is possible or has already occurred. Indicators that may be used in a preliminary assessment include those listed in Table 7.1.

Table 7.1: Deciding if acid sulfate soils are present based on soil or water field indicators

Soil type	Indicators
acid sulfate soils	**Landscape characteristics** • dominance of mangroves, reeds, rushes and other marine/estuarine or swamp-tolerant vegetation • low lying areas, back swamps or scalded/bare areas in coastal estuaries and floodplains • sulfurous smell after rain following a dry spell or when the soils are disturbed
actual acid sulfate soil	**Soil characteristics** • field pH < ≤4 in soils (see Appendix 1) • presence of shell • any jarositic horizons or substantial iron oxide mottling in auger holes, in surface encrustations or in any material dredged or excavated and left exposed. Jarosite is a characteristic pale yellow mineral deposits which can be precipitate as pore fillings and coatings on fissures. In the situation of a fluctuating watertable, jarosite may be found along cracks and root channels in the soil. However, jarosite is not always found in actual acid sulfate soils. **Water characteristics** • water of pH < 5.5 in adjacent streams, drains, groundwater or ponding on the surface • unusually clear or milky blue-green drain water flowing from or within the area (aluminium released by the acid sulfate soils acts as a flocculating agent.) • extensive iron stains on any drain or pond surfaces, or iron-stained water and ochre deposits **Landscape and other characteristics** • scalded or bare low lying areas • corrosion of concrete and/or steel structures.
potential acid sulfate soils	**Soil characteristics** • waterlogged soils-unripe muds (soft, buttery, blue grey or dark greenish grey) or estuarine silty sands or sands (mid to dark grey) or bottom sediments of estuaries or tidal lakes (dark grey to black) • presence of shell • soil pH usually neutral but may be acid-positive Peroxide Test **Water characteristics** • water pH usually neutral but may be acid

Source: Ahern et al *(1998a).*

7.3.3 Planning and management options

Management options vary according to the soil/sediment type and sulfide content (acid-forming potential), local hydrology and environmental sensitivity of the area. They may be broadly categorised under the headings, ‘New developments’, and ‘Existing acid-sulfate conditions’.

Land-use zoning and development control provisions in Local Environmental Plans (LEPs) are a key regulatory mechanism for ASS management. When proposing to undertake works which are likely to disturb acid sulfate soils or the associated watertable, a preliminary assessment should be undertaken and advice should be sought from the local council as to whether a development consent is required. Even if development consent is not required, an environmental assessment under Part 5 of the *Environmental Planning and Assessment (EP&A) Act 1979* may be required (Ahern et al 1998a).

Refer to the NSW ASS Manual for details of planning considerations. However, in most cases, or in any circumstances where no planning approval or consent is required, a good practice for superintendents overseeing works likely to disturb acid sulfate soils is to consult a person suitably qualified in ASS investigations (e.g. soil scientist) and conduct a preliminary assessment in accordance with the ASS Manual.

If the preliminary assessment confirms the presence of acid sulfate soils on the site, a sampling program should be designed to understand the extent and characteristics of the soils. If the soil sampling program establishes that a management plan is required to be prepared in accordance with the ASS Manual, additional soil surveying and sampling may be required to provide information to develop the management strategy. The level of investigation will depend on the characteristics of the site, particularly site variability, the type of disturbance proposed and the sensitivity of the surrounding environment (Ahern et al 1998a).

Where required, the selection of appropriate mitigation strategies will depend on the nature and scale of the works to be undertaken, the soil characteristics (e.g. concentration of sulfide, the variability of the material, the soil's physical characteristics and inherent neutralising capacity), the surface and sub-surface hydrology, the sensitivity of the surrounding environment and the past history of the site (Ahern et al 1998b).

The following outlines the most common mitigation approaches (Ahern et al 1998b):

- avoid disturbing acid sulfate soils by not undertaking works on land where they are located,
- if acid sulfate soils are present on the land, avoid disturbing them by not digging up the soil or lowering the watertable,
- if acid sulfate soils are to be disturbed, manage the acid generation potential, neutralise any acid produced, prevent any acid water leaving the site and use acid resistant construction materials,
- if acid sulfate soils have previously been disturbed, undertake works which will manage any acid already being produced, will minimise further production and will remediate any degradation in the long term,
- avoid using acid sulfate soils for land formation -if these soils are to be used, manage the acid generation potential before the material leaves the site where it originates,
- if material is very sandy, separate pyrite by sluicing,
- bury acid sulfate soils below the permanent water table.

7.3.4 New developments (course construction/redevelopment)

A. Avoidance is often the best option.

No acidic products will be released if ASS are left undisturbed and under the watertable. The cost of ASS remediation can be substantial and high-quality initial investigation can provide substantial savings by avoiding 'hotspots' at the design stage. Where possible, works should be designed or redesigned to minimise disturbance of ASS, avoid any 'hotspots' and consider alternatives for groundwater use and management.

B. Treat excavated acid sulfate material.

Where disturbance of material is necessary three main options exist for treatment of excavated ASS:

i. Neutralisation—Sufficient neutralising material (including a safety factor of 1.5) must be mixed thoroughly with exposed ASS to neutralise all existing and potential acidity likely to be produced from oxidation of sulfides. Finely ground agricultural lime (pH ~8.2) is usually the safest, most economical material currently available for soils. Other types of lime that may be used include quicklime, mixed lime and dolomite, which are all less efficient. Other promising materials under trial include 'red mud', a waste product of bauxite mining.

ii. Rapid reburial—Excavated material from below the watertable that has not been exposed to air can be transferred immediately back below the watertable in a pre-existing or constructed hole/water body (or 'borrow pit'). As long as the material has not acidified and is buried below the permanent watertable, no neutralisation will be necessary.

iii. Separation of iron sulfides—Sluicing or hydrocloning of coarser sediment types, e.g. sands, can be used to partially or totally remove acid-producing sulfides.

Monitoring of all excavated soils and runoff waters must be carried out during and after the construction/development process.

C. Create/recreate a 'freeboard' and drainage control.

During design and implementation of new developments, planning should allow for the creation (or recreation) of a non-sulfidic 'freeboard'. This provides a zone within which the watertable can be regulated to avoid activation of potential ASS beneath. Drainage design should be planned to minimise deep drainage by laser-levelled falls and broad, shallow dish drains to limit the exposure of potential ASS by avoiding drawdown of the watertable.

'Clever' weirs that allow flow rates to be regulated should be installed in main drainage canals to maintain the watertable fluctuations within the 'freeboard'.

7.3.5 Existing ASS conditions

The options for management of areas where ASS has already been disturbed are:

- remediation;
- mitigation at the source; or
- mitigation of the discharge.

i. Remediation

Remediation is generally not an option within existing landscaped areas because of golf course downtime and expense, but neutralisation of near-surface ASS in ‘rough’ areas adjoining the course can substantially reduce environmental impacts.

ii. Mitigation at source—drainage control

This involves drainage redesign to replace deep drainage with shallow, broad drains with laser-levelled falls, and ‘clever’ weirs to regulate the watertable above potential ASS material. If the existing ‘freeboard’ layer is less than 0.7–1.0 m thick, consideration should be given to creation of such a layer by a combination of tillage and liming.

iii. Mitigation of acid discharge

This involves the installation and maintenance of a permanent automatic water-monitoring and lime-dosing facility in exit waterways. Generally, water pH must be controlled to between 6.5 and 8.5 although special conditions may apply to some sensitive waters. As a minimum, water pH must be at least 6.5; iron and aluminium levels should be brought to below ANZECC and ARMCANZ guidelines.

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Further reading and ASSMAC contacts

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- ASS inquiries may be directed to the Acid Sulfate Soil Information Officer, Wollongbar Agricultural Institute, Bruxner Highway, Wollongbar, NSW, 2477.
- ASS risk and adapted planning maps are available from regional offices of the Department of Water and Energy; each coastal council in NSW will also have copies.
- Copies of the NSW ASS Manual can be purchased from The Information Centre, Planning NSW, Telephone: 02 9762 8000 (switch) or 02 9762 8044 (enquiries) or see the website www.planning.nsw.gov.au.