

## Soil Management

### Fact Sheet by Michael O'Brien posted 15 Jul 2008

Soil and its management is a fundamental part of any development project. Soil type, structure, and chemistry all need to be given due consideration ? at the design stage, during development works, and following completion, in order to ensure that environmental values are not compromised, that contaminated or particularly reactive soils are not disturbed in such a way as to harm the environment, and that development features including landscaping, buildings, dwellings and structures are not compromised by changes to soil characteristics, such as moisture content, or soil chemistry.

#### •Categorised under:

- Feasibility, Planning,
- Site Ecology, Estate Design,

## Introduction

This section deals with a number of areas related to management of soils during development activities, including:

- Identification of soil types and potential impacts on development (reactive soils)
- Management of acid sulfate soils (in coastal locations)
- Management and remediation of contaminated soils
- Salinity and pH “ impacts on development works
- Engineering considerations “ cut and fill
- Avoidance of impacts from erosion and sedimentation, including impacts to waterways and wetlands
- Topsoil management - retention and reuse to avoid loss of endemic seedstock, reduce loss of material (through windblown or water borne erosion), reduce importation or topsoil from offsite.

This section will also deal with the management of soils at various stages of development works, and the relevant impacts and benefits. The topic areas covered (relevant to soil management) include:

**Feasibility and Planning:** site investigation, soil mapping, contamination, topography, environmental features, waterways and drainage;

**Design:** Engineering, cut/fill balance, dealing with acid sulfate soils and/or contaminated soils through appropriate management or avoidance;

**Construction:** Site establishment, including site access and vehicle washdown facilities, stockpile locations and soil and erosion control, management of particular soil types, stormwater management, topsoil management, landscaping and site restoration;

**Lot Creation:** Site establishment, stormwater management, construction management, materials management - stockpiling and storage, and site stabilisation/landscaping.

## Overview

Techniques for the appropriate management of soils during development works are largely dependant on the types of soil encountered, and factors such as site location, topography and drainage, previous land uses, the type of development project, for example greenfield vs brownfield, or low density vs high density, and the extent of works being undertaken, including installation of trunk infrastructure.

Appropriate site assessment and identification of potentially "complex" soils (requiring extensive management if bed) will assist in avoiding the risk of environmental issues (including regulatory action for environmental incidents) and/or additional remediation costs (to both the site and structures). Soil classification is a key element in determining the level of risk and appropriate management approaches " a number of excellent online resources exist which provide information relating to classification of Australian soil types.

These include:

- The Australian Soil Club
- The Australian Collaborative Land Evaluation Program
- The Australian Soil Resource Information System
- Wikipedia: Soil Classification

## Soils characteristics

### Acid sulfate soils (ASS)

ASS are usually found in low-lying coastal locations associated with mangroves, saltmarshes and swamps. They contain high quantities of sulfides which, when exposed to air due to drainage or disturbance, readily oxidise to produce sulfuric acid, also often releasing toxic quantities of iron, aluminium and other heavy metals to the environment. Any development activities in proximity to marine/estuarine environments may have the potential to expose ASS. These include waterway and canal estates, drainage of coastal lowlands, construction of bridges, drains, water/sewage pipes and bridge abutments, and clearing of coastal vegetation.

The resulting acidity when these soils are exposed (and not properly remediated and managed) results in damage to coastal marine environments, damage to marine ecosystems and water quality in affected local waterways, and may also have significant impacts on constructed features, particularly concrete and/or steel structures.

The impacts of ASS exposure are often long term, and difficult to reverse, as once ASS is exposed and

oxidisation begins, the chemical reaction is largely self perpetuating, due to the increased oxygen produced effectively catalysing further oxidisation in the soil.

As a guide, the Queensland Department of Natural Resources and Water, identifies potential aspects and impacts from the exposure and/or inappropriate management of acid sulfate soils (see <http://www.nrw.qld.gov.au/land/ass/index.html>).

### **Contaminated soils/contaminated land**

Contaminated soils generally contain man-made chemical residues or substances left as a result of previous land activity. Typical contaminants include hydrocarbons (oil and fuel residues typically from fuel storage, vehicle maintenance or industrial activity), pesticide residues (rural activities e.g. cattle dips), leachate and residual material from landfill/waste dumping, heavy metal residues, and in some areas, unexploded ordinance.

From a development perspective, these contaminants pose a potential health risk, both from exposure during development works and as chemical residues which may result in residual exposure or otherwise affect residents after development completion.

Identification of contaminated soil sites and the resulting cleanup are both time consuming and costly. In some states, known contaminated sites are recorded on a land register (such as the Queensland EPA Contaminated Land Register). These sites are generally identified as potentially contaminated as a result of known land uses (e.g. brownfield development). However, developers of rural (greenfield) sites may be unaware of potential contamination, which may only be identified once development (earthworks) have commenced. Contaminated soils, once identified, are required to be either disposed of to an appropriate (licensed) facility, or suitably remediated to the satisfaction of environmental and planning authorities, in order for development to be undertaken. Once remediation is undertaken, the site's level of potential contamination hazard may be downgraded, or the site may be removed from any contaminated land register altogether.

The various State environmental agencies across Australia will have different specific requirements for management of contaminated land – seek the advice of the relevant agency in your State or territory.

Subsequently the identification and remediation of contaminated soils necessitates the assistance of professionals skilled in fields such as mapping and geographic information systems (GIS), geology, hydrology, environmental management, waste disposal, engineering, soil science, chemistry and computer modelling (for additional information see also [http://en.wikipedia.org/wiki/Soil\\_contamination](http://en.wikipedia.org/wiki/Soil_contamination)).

### **Reactive soils**

Clay soils are generally also found to be reactive soils (easily reactive to changes in moisture content), but this soil type may also include the 'black earth' or 'black soils' found in parts of Queensland, western New South Wales and South Australia.

Reactive soil types may readily swell and retain moisture when saturated, and shrink and collapse when water is removed from them by excessive evaporation, physical drainage, or through the action of trees and/or other landscape vegetation. In contrast, non-reactive soils include such soils as rock, gravel, shale, phyllite or sand. Their volume does not increase or decrease depending on the moisture content.

These "plastic" soils represent a challenge both during development, and following completion, leading to damage

ldings, structures and infrastructure. Swelling and shrinkage in the soil has the potential to result in a range of structural impacts such as deformation, cracking and structural failure, particularly in modern houses/structures with concrete slab floors, brick construction, and reduced structural "flexibility".

The management of reactive soils is best achieved through techniques to manage moisture content (landscaping, regular wetting etc) or through removal and use of clean suitable fill where appropriate. (see also [http://www.greenweb.com.au/archicentre/html/diy\\_cracking\\_checklist.html](http://www.greenweb.com.au/archicentre/html/diy_cracking_checklist.html))

## Salinity

Sodic soils are a natural part of the Australian landscape. Salinity occurs when salts found naturally in soil or groundwater are mobilised, and the resulting capillary rise and evaporation of ground moisture concentrate the mobilised salts at the ground's surface. Urban salinity is a complex problem, difficult to predict and model. Significant changes to surface and subsurface hydrology that result from urban development also mean that accurately mapping the potential occurrence and impact of urban salinity is also difficult. There are time lags between cause and effect, and the extent of evidence/impacts from salinity may change substantially over time. Hence, it is difficult to accurately predict where salinity will occur, and the likely extent of impacts on both natural systems and built features.

Urban development impacts on and may encourage salinity through causing changes in the natural water cycle. Urban structures such as building pads and foundations, underground infrastructure and other urban resources which come into contact with mobilised or otherwise disturbed salt in soil or groundwater may be adversely impacted. Excavation of soils during engineering works may expose affected soils, and resulting erosion during rainfall may further expose and/or mobilise affected soils, as well as introducing increased moisture levels which encourage percolation of salinity during subsequent evaporation of stormwater.

In urban areas the likelihood of mobilisation and surface percolation of salinity is magnified by the increased volume of water added to the natural system from sources such as

- irrigation of landscaping, parks and open space
- leaking underground pipes and pools, and
- increased concentration and volume of stormwater.

Increased salinity may also be caused by disturbance/impedance of sub-surface water flows by construction of major infrastructure such as roads, trunk infrastructure such as water/sewage pipes or structures, or through poor drainage conditions. Urban salinity has the potential to adversely impact on landscaping and gardens, lawns, and playing fields and may also adversely affect remnant natural features including bushland, wetlands, and waterways.

The chemical and physical impacts of urban salinity may also be noticeable in built infrastructure, through the corrosive effect of salt on concrete, bricks and metal. Salt moves into the pores of bricks and concrete when these materials are exposed to damp, salt-laden soils, and becomes concentrated as the water evaporates from the material.

The potential impacts of salinity in urban structures includes corrosion and damage to buildings and structures,

recognisable through evidence such as crumbling, cracking or flaking of concrete and mortar. Consequently, underground service pipes, such as those used for water supply or sewerage, may also be damaged, with the affecting salinity exacerbated through the increased flow of water from leaking pipes. Urban salinity also has the potential to impact significantly on roads and pavements. Impacts include physical and chemical degradation of the road base resulting in increased susceptibility to cracking, pot-holing and eventual failure. (see also Planning Guide - Salinity)

## **Topsoil**

Although not likely to result in environmental harm in the same way as complex or reactive soils, topsoil, the top layer of soil rich in micro-organisms, nutrients, and locally endemic seed stock, is equally important to be appropriately managed due to its biological value onsite, and significance in landscape restoration/remediation post earthworks. Topsoil removed to facilitate earthworks should be stockpiled and kept onsite, ideally covered to reduce loss through wind or water borne erosion (See also erosion and sediment control). Alternatively, topsoil may be removed and stockpiled/stored at a local plant nursery or similar. Either way, a key process for a local plant group is to collect locally endemic seed stock (if present) for propagation and use in landscaping in the development. The reuse of topsoil minimises the need for costly importation of this resource from other sites, or the use of commercial chemical based fertilisers and/or seed stock in landscape/restoration post earthworks.

## **Techniques for managing/reducing impacts**

The techniques for managing complex soils types and the impacts resulting from their disturbance during development works in order of simplicity essentially fall in to the following areas:

- avoidance
- minimisation
- management.

### **Avoidance**

A thorough investigation of potential site issues during the feasibility and/or planning stages of development should provide for appropriate identification of potentially complex soils which may impact on development. The most simplistic method of managing those soils is to avoid their disturbance either through selection of alternative sites or the inclusion of affected areas into areas which will not be disturbed during development works.

### **Minimisation**

It is acknowledged that total avoidance of complex soils may not be possible, although it may be possible to design the development in order to minimise the extent of soil disturbed, or to minimise the types of development features in those areas which will result in extensive disturbance (e.g. significant excavation for construction/placement of infrastructure).

### **Management**

A number of specific soil management techniques are an essential part of the development process. Their application will depend on the types of soils identified, and the potential for onsite and offsite impacts resulting from their disturbance. The most common soil management options are as follows:

●**Erosion and sediment control** - Minimisation and control of soil erosion (during both development construction works and during lot creation - building/landscaping) helps to prevent the loss of soil material from site (both as wind blown dust and during rainfall events), as well as helping to protect water quality in streams and rivers from sediment which would otherwise be washed into drains. Furthermore, appropriate management and minimisation of erosion and soil loss may also assist in the management of impacts from the disturbance to acid sulfate and sodic soils, resulting in mobilisation of acids, salts, and/or other soil contaminants.

As well as a key onsite environmental management technique for protecting water quality and avoiding offsite dispersal of soil borne contaminants, erosion and sediment control is generally recognised as a key element of water sensitive urban design (WSUD).

A number of basic, established and proven techniques for erosion and sediment control exist, including:

- sediment barriers/filter strips (placed down-slope from exposed soils or soil stockpiles, or upstream of drainage lines and waterways to capture mobilised sediment);
- diversion bunds/swales (placed up-slope of exposed soils/stockpiles to divert stormwater and prevent mobilisation);
- grassed/vegetated swales to channel stormwater, slow flow rates and capture sediments within the vegetated structure;
- physical covering of soil stockpiles with geotextile fabric or similar, appropriately weighted down to prevent it being blown off; and
- prompt revegetation/covering of exposed areas, particularly batters, with hydromulch or in combination with geotextile fabric to prevent mobilisation of soil and juvenile revegetation during heavier rainfall events.

●**Removal and disposal (of contaminated soils)** – Removal of contaminated or complex soil types (particularly ASS) and disposal offsite is a common management technique. The benefits are that it provides the opportunity for importation of clean soil material for use onsite, and alleviates the potential for leaching of soil contaminants, or dispersal of the contaminated soil onsite during construction, during rainfall events or as wind blown dust. However, it is necessary for soil being removed, particularly soil subject to contamination or severe risk ASS characteristics, to be transferred/disposed of to a facility which is appropriately licensed to accept such material (for either treatment or disposal). This is typically a landfill site for disposal, or an open, well drained, and minimally impacted site for treatment.

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●**Onsite remediation** - Some soils may be able to be successfully remediated onsite and returned to the subsoil profile, known as strategic reburial, provided they are appropriately capped by the upper soil layers such that they are effectively –entombed–™. It may be possible to do this with particular types of treated contaminated soils (eg certain hydrocarbons, etc), and with appropriately treated and remediated (low risk) acid sulfate soils such that future exposure and oxidisation is avoided.

## Case Study – Sydney Olympic Park Site Remediation

As part of the development of the Sydney Olympic Park site, the remediation of the site of a history of domestic,

commercial and industrial waste, including contaminated soil, was the largest project of its kind in Australia. The project represented a significant environmental achievement and legacy for the people of NSW.

Further, the remediated sites at Sydney Olympic Park continue to be maintained, monitored and managed so as to protect human health and the surrounding environment.

In undertaking redevelopment, approximately 160-hectares of the site was deemed to be contaminated, including approximately 90-hectares or approximately 19% of the parklands. Contaminated material requiring remediation included:

- material from the Parramatta River;
- power station ash;
- demolition rubble;
- asbestos;
- industrial hydrocarbons; and
- putrescent waste.

In addition, several areas of the parklands were found to contain naturally formed acid sulphate soils (mainly located in or adjacent to estuarine areas such as the Parramatta River and Haslams Creek). ASS presents the risk that once disturbed and exposed to air, oxidation occurs and sulphuric acid is ultimately produced which can drain into waterways and have severe detrimental environmental effects.

Site-specific remedial action plans were developed following extensive field investigations and preparation of soil and groundwater profiles. Remediation included the removal, consolidation and containment of approximately nine million cubic metres of waste. Acid sulphate soils were excavated and treated, consolidated in deep pits or used as landfill mounds and covered (known as strategic reburial) to ensure no resultant acid leachate discharge into local waterways.

*(Note: information sourced from*

*[http://www.sydneyolympicpark.com.au/education\\_and\\_learning/environment/remediation](http://www.sydneyolympicpark.com.au/education_and_learning/environment/remediation)).*

## Case Study – “Radius Industrial City, Larapinta, Brisbane

Radius Industrial City is a large scale master planned industrial development, located at 811 Paradise Road, Larapinta. The site is approximately 84.55 hectares in total area, with the proposed rehabilitation works of approximately 43.78 hectares. PLACE Design Group (environmental consultants) is overseeing the implementation of the vegetation management and rehabilitation plans and their associated vegetation rehabilitation works, as well as the implementation of the soil management plan.

The site is bound by Oxley Creek on its northern and western boundaries, with the Logan Motorway forming the southern boundary, and Paradise Road providing the eastern boundary and main access into the subject site. The majority of the Oxley Creek buffer conservation area (the rehabilitation area) is a former sand mining quarry and as such contains expansive areas with very little or no vegetation. Due to the historical sand mining and quarrying activities, the site lacks soil structure and topsoil as well as containing sodic (dissolving) soils (Landloch, 2006).

The site has undergone three separate site soil analysis over three years. The soil analysis identified:

- all samples taken were very deficient in Phosphorous;
- all samples are sodic to greater or lesser degrees;
- the site recovered topsoil stockpiles are low in manganese (a trace element for plant growth);
- all samples are acidic to some degree; and
- Potassium (K) levels are low, though not extremely so.

A Soil Management Plan for the management of the site's soil during all construction and rehabilitation activities on site. In the initial stages of the project, site vegetation was cleared, mulched and re-laid back over the site to protect the newly exposed subgrade from erosion. Further rehabilitation will ensure stabilisation of areas more susceptible to erosion including all batters of 1:3 or steeper. The buffer area will also undergo weed management and be stabilised by native revegetation planting using a combination of direct seeding and infill tubestock planting. The newly stabilised areas will be subject to restricted access.

The management and stabilisation of site soils is paramount for the successful delivery of the revegetation works program, with the management of site soils working in unison with the Erosion and Sediment Control Plan methodology.

A Maintenance and Monitoring Program will allow for the continual assessment of the site soil condition as well as the erosion and sediment control measures until such time that the vegetative cover has been fully established and the industrial development works completed.

The proposed methodology for soil improvement is multi-staged, focussing on the amelioration and amendment of site (subgrade) soils and the topsoil stockpiles to ensure stabilisation and a favourable growing environment for the rehabilitation and revegetation works.

- Amendment to the site (subgrade) soils first prior to the application of topsoil, including application of lime, gypsum, organic carbon/ composts and controlled release fertilisers.
- Following amelioration of subgrade soil, topsoil will be applied at a depth of 150 mm. The topsoil will then be ameliorated in-situ in accordance with application rates and products proposed above.
- The topsoil combined with the subgrade is to be cultivated to a depth of 250mm to deliver a productive and healthy growing environment depth of 400mm.
- Throughout the course of the rehabilitation and revegetation works, periodic soil sampling and analysis will be undertaken to ensure soil condition is optimal for the works program and that any adverse soil condition can be remedied in a timely manner.

## Key Issues

### **Benefits**

Appropriate management of soil during development provides for a number of benefits. Aspects of soil management and its positive impacts include the following:

- Avoidance/minimisation of environmental harm, and the costs associated with remediation (excluding any fines potentially imposed by environmental regulatory agencies);
- Costs for strategic remediation and reuse/reburial of (suitable) complex or contaminated soil types may be less than the costs associated with offsite treatment/disposal and subsequent importation of soil material for use onsite;
- Retention and reuse of topsoil minimises costs for both importation of soil material and endemic seed stock for use in landscaping/remediation.

## **Risks**

The potential risks from inappropriate or mis-management of soils vary, depending on the soil characteristics that need to be managed, the nature and location of the development, the types of built structures proposed, and the ecological value of the surrounding environment. As indicated above, the likely risks from poor soil management include:

- environmental damage (and remediation costs) from mobilisation of soil offsite (impacts to adjoining landholdings) and from soil borne contaminants, including chemical contaminants, acids and salinity, and increased turbidity in local waterways (from sediment laden water runoff);
- costs associated with regulatory action resulting from the above;
- damage to buildings, built features and structures from the impacts of reactive, sodic, or acid sulfate soils;
- costs to repair/remediated damage caused by the above;
- increased costs (eg. holding costs) and/or loss of revenue as a result of additional time taken for corrective action as a result of poor/inappropriate soil management impacts;
- loss of revenue from poor sales, or from owners recouping costs associated with damage from the above.

## **Savings**

As with costs, savings from appropriate soil management during development activities may come in the form of financial and/or time savings. Savings will largely accrue through the avoidance of additional costs as a result of:

- thorough investigation and proper planning,
- appropriate management of soil according to results of feasibility investigations and development planning,
- application of appropriate environmental management methods and technologies (to minimise potential adverse impacts),
- avoidance of additional costs for remedial actions in the event of an environmental incident arising from soil mobilisation (including regulatory action),
- reduced potential for additional costs for remedial action, repairs, replacement of development features (landscaping, built structures, and other constructed elements) as a result of failure due to soil characteristics (ASS, sodic and reactive soils).

## **Costs**

The costs of soil management are essentially unavoidable, however the cost of planning for and undertaking appropriate soil management may be far outweighed by the potential costs of lost time, (mid project) changes to

development, and environmental management actions or remediation required post development as a result of poor planning and inadequate soil management.

Direct costs will be associated with the following aspects of soil management during the development process:

- Feasibility “ preliminary soil mapping/investigation, contaminated land searches, soil testing (borehole drilling and laboratory testing);
- Planning & design “ detailed soil investigation;
- Construction “ engineering costs, machinery operation costs, materials eg. agricultural lime (AgLime) for ASS treatment, geotextiles, plant stock, purchase and haulage of imported clean soils/fill/topsoil material, site management and operational costs (contractors and labour), haulage and disposal (soil disposal/remediation).

## **Barriers**

Given that soil management is simply an essential part of proper development practice, there should not be any significant barriers. It may be necessary to ensure that all site personnel and contractors are aware of their role and responsibility in ensuring proper environmental management procedures are followed at all times, including soil management. All site staff may need to have appropriate site induction and/or training in awareness and responsibility for appropriate action onsite.

## **Benchmarks**

Appropriate standards for soil management are regularly specified in relevant planning scheme supporting information (eg. Erosion & Sediment Control Guidelines, Planning Scheme Policies). Target levels for water quality in waterways in Australia vary from state to state “ being generally established by the relevant Government regulatory agency for environmental management matters.

## **Development phase actions**

### **Feasibility**

Feasibility and Planning “ relevant tasks:

- undertake site investigation
- obtain soil mapping
- investigation of likely soil contamination
- assessment of topography
- identification of environmental features, waterways and drainage.

### **Design**

- undertake engineering planning eg. cut/fill balance
- development design to maximise avoidance of complex soils (where possible)
- identification of appropriate management mechanisms/approaches to dealing with soil issues eg. dealing with acid sulfate soils and/or contaminated soils
- prepare site management, construction management, environmental management plans as required
- establish training/site awareness mechanisms/protocols to be applicable during construction stages.

## Construction

- undertake site establishment
- establish soil and erosion control (E&SC) mechanisms as part of site setup
- implement appropriate management of particular soil types
- implement and maintain stormwater management in conjunction with E&SC
- undertake topsoil management (for locally stripped or imported topsoil as applicable)
- undertake landscaping and site restoration.

## Lot Creation

- undertake site establishment for individual allotments
- provide appropriate site management, including E&SC, stockpile management, stormwater management, construction management, materials management - stockpiling and storage, and site stabilisation/landscaping.

## Completion

- Decommissioning of site management works.

### Links

- [The Australian Soil Club](#)
- [The Australian Collaborative Land Evaluation Program](#)
- [The Australian Soil Resource Information System](#)
- [Wikipedia: Soil Classification](#)
- [Queensland Department of Natural Resources and Mines ASS portal](#)
- [WSUD.org "Urban Salinity Fact Sheet"](#)
- [Australian ArchiCentre "Soil Cracking Factsheet"](#)
- [CSIRO, The Australian Collaborative Land Evaluation Program](#)
- [CSIRO, The Australian Soil Resource Information System](#)

### References

- [The Australian Soil Club](#)
- [CSIRO, The Australian Collaborative Land Evaluation Program](#)
- [CSIRO, The Australian Soil Resource Information System](#)

- Wikipedia:

- Queensland Department of Natural Resources and Mines. QASSIT (pers comm.) and Acid Sulfate Soils portal

- Water Sensitive Urban Design, WSUD.org ~~at~~ Urban Salinity Fact Sheet

- Australian ArchiCentre ~~at~~ Soil Cracking Factsheet

- Olympic Park Site Remediation

## Link to Content

- <http://yourdevelopment.org/factsheet/view/id/50>