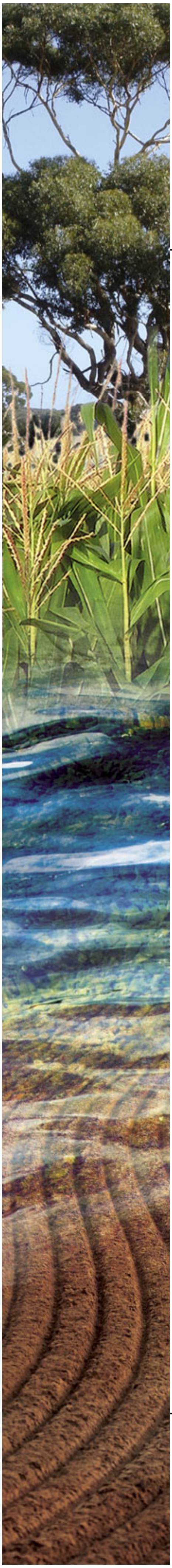

Sydney Environmental & Soil Laboratory

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Making Soils on a Large Scale - Remediated and Constructed Soils of Sydney Olympic Park

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Making Soils on a Large Scale –

Remediated and Constructed Soils of Sydney Olympic Park

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The Sydney Olympic Park and Millennium Parklands development was the largest urban reconstruction yet carried out in Australia. The site encompasses the original State Sports Centre, the "Urban Core" of the Olympic site, the Olympic Village, and the Millennium Parklands including the Haslam's creek corridor, Newington Forest, Waste reburial mounds, the "Millennium Markers", and the old state brick works as well as large areas of saltmarsh and mangrove. Each of these precincts presented unique problems and required innovative solutions. Solutions ranged from stripping and reusing topsoil on the Olympics Village, to the complete reconstruction of a "podsolic profile form" using waste fill materials on the waste reburial mounds and Millennium Markers. Engineered structural soils provided solutions to tree rootzone limitations in the highly urbanised core of the Olympic park.

Native soils of the site are supposed to be "Blacktown" landscape Red and Yellow Podsolic soils with heavy clay B horizons (Chapman and Murphy 1989) but much of the area was highly disturbed by industrial activity and topsoils were usually absent. What topsoils were present were mixed with clays and kept in large stockpiles called "B grade fill". The "B grade Fill" stockpiles were used for finishing landscape sections early on but the heavy clay texture combined with various degrees of sodicity, salinity and very poor water infiltration gave very poor initial results when used to cap "Kronos Hill" (a waste reburial mound). Growth rates of grasses and trees was slow. Many areas of the original State Sports Centre and Golfing range showed heavy compaction, poor grass growth, and poor growth or death of trees. Native grasses (Themeda australis) cover on the Aquatic Centre berm grew patchily due to the presence of salinity or very poor physical conditions.

Large areas of the site remained to be topsoiled in the next stage of Olympic Park and Millennium Park development. No site topsoil was available. The only area where topsoil did occur was the Royal Armament Depot site (future Olympic Village) where a large (around 150ha) site contained perfectly intact native topsoils. Over the rest of the site including all of Haslam's creek, the Archery Centre, Australia Avenue, Brick Pit and residual areas topsoil was not present and subgrades were unsuitable heavy clays.

Over large areas along the Haslam's creek corridor Waste Services NSW had to strip, relocate, and encapsulate hundreds of thousands of tonnes of waste, some of it toxic. This waste was placed in the old fashioned manner: a swampy and salt marsh area was used as landfill and waste placed over a 1-1.5m deep sheet on top of swamp land and roughly buried with clean fill. The method used to rebury this material was an encapsulation technique where an impermeable base is constructed and waste is placed in a naturalistic landform on top of this to be capped by specially chosen impermeable clay cap. The Kronos Hill and North Newington hills are waste

reburials developed in this manner. Silty clay materials to line and cap the landfill were abundant on the site but no clean topsoil was available.
Apart from some complex acid sulphate soil issues while removing the waste from the old mangrove swamp soils it was anticipated than none of the excavated materials could be used as topsoil. It became obvious from previous work that the "B grade" clay fill used for capping the reburials was not a suitable topsoil medium and that a shortfall of nearly 250,000 tonnes of topsoil was going to occur.

Prior to the development of a multi-disciplinary approach to coordinating the Millennium Parkland's design our company had worked since the late 80's on the State Sports Centre, the Olympics Park itself, the Olympic Village Site, and for Waste Services during their rehabilitation work along Haslams creek. Pivotal to shaping our future thinking was an important soil survey we performed on the Armaments Depot site, the future Olympic Village, commissioned by the Olympic Coordination Authority (Leake and Todd 1996).

This soil survey, conducted in GIS format showed some important results-
1. The Blacktown soil landscape was not present on top of hills where a sandy yellow podsolic named by us "Newington Lateritic" was present.
2. All topsoils were uniformly deep and mostly undisturbed and uncontamainted.
3. A net surplus of about 100,000 tonnes of good quality topsoil was available if the Olympic Village site was stripped properly. This would be mostly sandy native soil identical to that on which the Newington Forest has formed.

Soil recommendations were made as a result of this survey for the Mirvac/Lend Lease/OCA client. Important recommendations included-
1. Stripping all topsoil rather than trying to achieve net neutral cut and fill. This would give a useful topsoil for export to the Millennium Parklands. Net Neutral cut and fill is the usual mantra of development and the Olympic Village was viewed in isolation as regards development. It took some effort to convince all parties that it was not appropriate to fill topsoil when a site exists next door (the Olympics site) which has a dire shortfall of available topsoil.
2. That by stripping Blacktown landscape topsoil separate from the "Newington lateritic" a range of topsoils could be manufactured from recovered materials to suit all urban uses. The only exception was for full sand table construction in highly trafficked areas where some sand had to be imported. Otherwise, by offering a range of soil mix and fertiliser formulations soils could be made to suit general planting, on slab, native plant, grasses and turf, and large tree planting purposes. The only items imported were green waste compost and appropriate fertilisers, lime and gypsum.

Eventually about 100,000 tonnes of Newington lateritic topsoil was exported to the newly forming North Newington Reburial and Auburn Landfill.

The design team for the "Millennium Parklands Concept Design" put together by Hassell under Tony McCormick had many issues on its plate (Hassell 1997). One of the pivotal issues was what to do about soil problems which is why Tony invited us on to his team, knowing that we were very familiar with the site.

The concept design team held many meetings with various stakeholders. The brief was basically to develop an environmentaly responsible low maintenance landscape concept where nature could continue to heal itself. At some of the early meetings we expounded the view that the primary determinant of vegetation distribution is the soil type, together with the influence of rainfall and runoff. This is especially important when planning low maintenance landscapes as a plant type imposed on a soil and microenvironment unsuited to it will be a recipe for failure or high maintenance costs. Our considerations started with a list of the vegetation types known to occur on the Millennium Parklands site as shown in Table 1.

Table 1. Natural Vegetation/Soil Associations of the Homebush Area.

Vegetation Type	Soil Type
1. Tall open Ironbark/Turpentine woodland	Deep Red and Yellow podsolics on shale
2. Tall scribbly gum/grey gum forest	Deep Lateritic yellow podsolics on sandstone weathering remnants
3. Hydromorphic /Casuarina tall form	Low lying grey and hydromorphic podsolics on shale, some of the deeper but poorly drained low lying reconstructed soils.
4. Hydromorphic Melaleuca Tea tree heath, short form some of the shorter Casuarinas	A heath of M. stypheliodes/nodosa occurred on dryland but poorly drained plateaux and slopes. Shallow soils.
5. Dryland xerophytic heath	Kunzea, shrubby Melaleuca and Leptospermum, Dodonea and Bursaria on shallow Red Podsolics.
6. Riparian Melaleuca/Casuarina	Gleyed Humisols and solonchaks on the edges of water bodies, creeks and swamps both fresh and salt water.
6. Riparian rainforest remnants like Glochidion, F. rubiginosa, Eleocarpus, Callitris (Port Jackson cyprus).	Low lying spots just uphill from the riparian zone on deep yellow podsolics and colluviums. Sometimes only a few metres wide before giving way to ironbark woodland
7. Salt Marsh	Minimal solonchaks and gley clay
8. Mangroves	Unconsolidated gleyed clay and ooze
9. Freshwater swamps	Undifferentiated sediment, fill or alluvium substrate virtually unimportant.
10. Sedges and hydromorphic vegetation	Humose hydrosols in valleys and elevated hanging swamps.
11. Urban Vegetation	Wide variety of substrate both natural and reconstructed
12. Native Grassland	Variety of shallow topsoils.

Compiled From: Benson and Howell. (1990)

All of these vegetation types were found on the Olympics site. Some, like the Melaleuca styphelioides occurring only on a few remnant square metres. A major theme of the rehabilitated landscape was to include indigenous vegetation types.

A consideration of this list and the soils on site lead to some guiding statements-

• Water and hence topographic position define the vegetation type.

• As one proceeds up a hill the status of the vegetation declines as does the soil depth. Deeper soils and taller status forest occurs in the lower slope position.

• Where there is no slope the soil will be hydromorphic even at the top of a hill.

• Vegetation on the Blacktown soils is adapted to periodic poor drainage.

It was obvious from these considerations that a variety of soil treatments, some of which could be constructed very cheaply, was acceptable and even preferable to one conventional approach to soil reconstruction. This lead to the concept that scarce "good" quality topsoil resources could be prioritised both in location and depth of topsoil used, so as to conserve available topsoil. Three fundamental concepts emerged-

1. Topsoil was not even needed in some areas such as the reconstructed riverine corridor as wetland plants are quite used to growing in clayey mud.
2. If a naturalistic treatment was used topsoil could be shallower at the top of hills and deeper towards the bottom. This would allow a natural order of things with a shorter form vegetation, or even grassland, on top of hills, and a taller forest form at the bottom of hills with deeper topsoils to provide adequate rooting depth.
3. Podsolic profile forms are not only natural to the area but would function better in the landscape treatments and climate.

During one particular session with Waste Services, who had performed all the remedial work on the waste reburials, I explained the findings of our survey of the Olympic Village site. I explained the functioning of a podsolic profile form in its natural environment and gave details of the unique profile form we had dubbed the "Newington Laterite".

The podsolic profile form has a sandier A horizon overlying a usually clayey B horizon subsoil. It is in equilibrium with a climate where long dry periods can be followed by intense rain. The sandy A horizon admits water rapidly reducing erosion and runoff hazards, is more compaction resistant than the clayey B horizon and provides better pore space for root growth than the subsoil below. Tree roots grow almost exclusively in the topsoil layer that is adapted to periods of waterlogging indicated by the presence of iron/manganese nodules (hence the name "lateritic"). The sandier topsoil dries out more quickly than clay after heavy rain and hence the permanent waterlogging that we had seen when planting in the clay layer does not occur.

We could easily reconstruct this soil profile using the lateritic topsoil that had been recovered off the Olympic Village site but what about the total shortfall of around 250,000 tonnes?

Waste Service's John Pym had been thinking about this issue too and during discussions on available soil resources he questioned whether crushed sandstone from the many building excavations around Sydney would be suitable. These materials are usually quite sandy and very cheaply obtained. The possibility of reconstructing a soil profile which would function in the same way as the indigenous Blacktown and Newington podsolic profiles of the area became immediately obvious and Waste Services were encouraged to develop the concept.

Initial samples sent to our laboratory showed a variety of pH conditions and clay contents. Some of the crushed sandstones were quite high in clay (like brickies loam) and considered unsuitable. It was found that the ideal clay content was 8-12% but that levels as high as 15% clay rendered the material highly compactable and impermeable. All the products were very infertile chemically and a few had high pH's due to lime content. Some were acidic but none were saline.

The chemical poverty could be overcome with judicious amounts of composted green waste materials and appropriate fertiliser levels. We specified that the clay plus silt content should not be higher than 10%. The concept was immediately embraced by all parties. The advantages were-

- development of a "facsimile" podsolic soil profile similar to the natural soil
- use of low cost recycled waste materials (Green Games)
- development of any fertility level required given a "clean slate" of low nutrient sandstone
- high permeability and compaction resistance
- better erosion resistance than clay
- installation of varying topsoil depths appropriate to the planting.

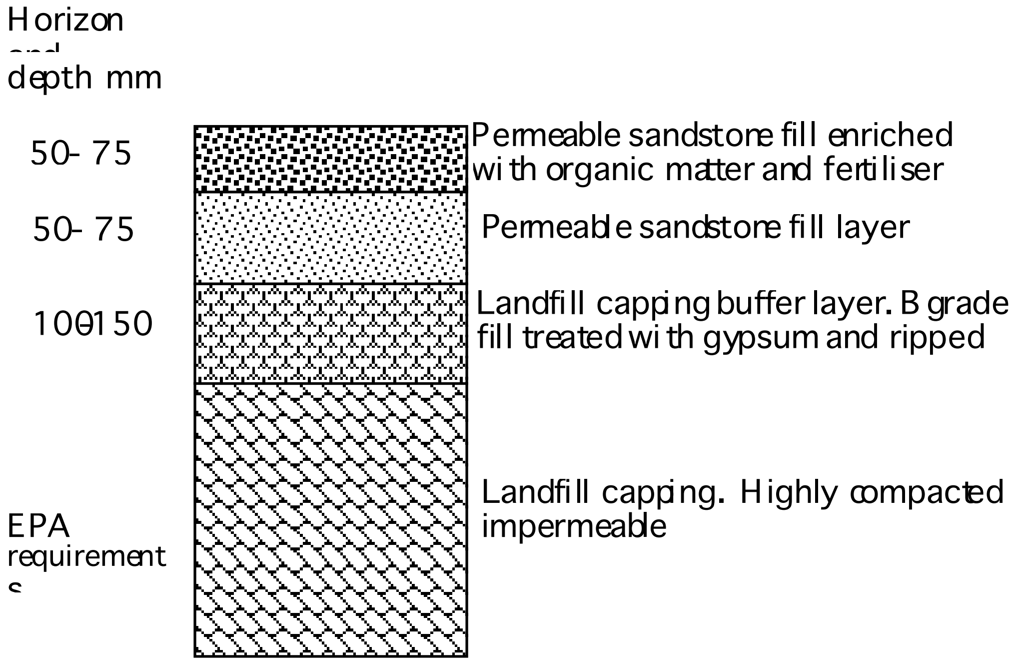
Figure 1 shows the profile concept developed during these discussions (Leake 1997). It was an essentially "modular" system whereby the topsoil could simply be deepened for taller forest components and fertilisers altered to suit specific plantings (eg low P fertilisers for P sensitive plantings). Areas where topsoil was needed included-

- Waste reburial mounds, eg North Newington
- Haslam's creek corridor
- Millennium Markers
- Auburn landfill and playing fields
- Many residual areas around the site.

A variety of contractors supplied samples of various sandstones from around the city. Some generators of waste sandstone were also contractors on site. Our lab had to work fast in such a QA/QC program with answers returnable sometimes the same day. We developed a fast hand texture method that proved useful in distinguishing even minor variations in the clay contents very quickly.

Figure 1. Reconstructed Soil Profile: Facsimile Podsolic

(Source: Millennium Parklands Concept Design Plan. Leake 1999



The soil construction occurred on site and the basic method was-
1. Pass ripped rock through a primary breaker followed by 20mm screening
2. Pass screenings oversize through a jaw crusher for finer crushing
3. Recombine and stockpile crushed sandstone fines
4. Treat subgrade clay with gypsum and roughen and work in using chisel ploughs
5. Place Crushed sandstone to the required depth
4. Apply 30-50mm of composted green waste with any fertiliser requirement
5. Work compost and fertiliser into the surface
6. Plant and mulch with composted woody mulch.

Understanding the natural distribution of vegetation and soils on the site and the natural principles that lead to this inevitable distribution assisted designers in developing the “Rooms with Walls” concept for the Millennium Parklands. This elegant concept resolved the disparate nature of the site as well as employing the concepts of plant succession and the diverse natural soil/vegetation areas. It allows us to have “rooms” of different soils depending on what furnishing is required (shallower soil for turf, deeper for forest) but also allows the natural catenary relationship which occurs from the top to the bottom of a hill, to occur within a room. Thus the grassland hill “room” on shallow soils can be surrounded by forest “walls” in deeper soils just the way nature would have dictated.

The result is a low maintenance landscape built of recycled resources and prioritizing those scarce resources where they are most needed. Early results show outstanding growth rates on areas treated with this method. Growth rates are limited, in my view, only by our reluctance to use more fertiliser. The grassland landscape of the North Newington waste reburial was only a few months old on opening day but showed exactly the effect of waving grasses envisaged by the designers.

By explaining to the artists the limitations of site soil resources the scientists influenced design in a beneficial way. The result is a lost cost and low maintenance landscape able to function in its environment, look natural, and continue the natural processes of plant succession. I cannot praise the truly multi-disciplinary approach of the OCA and Hassell highly enough. The drive of John Pym, leadership of Tony McCormick and the facilitation skills of Peter Duncan should be especially recognised. From a soils point of view there is no doubt in my mind that this project is the finest achievement in Australia.

The urban core design team focussing, as the name suggests, on the highly urbanised core of the Olympic Park itself had their own problems.

The Hoop pine plantings along the Olympic boulevard used a two layered soil where a sandy material low in organic matter was used to bed the plants in and a more organic rich soil was used for topsoiling. Unfortunately some variation to this important specification (too much clay in the subsoil mix), combined with blocked drains resulting in the inevitable anoxic soil condition developing which affected some trees. Two or three actually died but remedial work to introduce oxygen and improve drainage worked well and the planting as a whole was highly successful.

The extensive hard surfaced areas around the railway station provided a particular problem. It was known that the subgrade was highly impermeable and that the limited root volume of a "vault" planting reduces tree growth greatly. We were requested by the OCA to advise on and design a "structural soil" which is a new solution to the problems of highly urbanised rootzones. The method had been developed and used in USA (Grabosky & Bassuk 1995) and in South Brisbane and although those plantings were not very old the initial results looked encouraging.

Technically a structural soil is a "gap graded bimodal support soil" . This means that a framework of large particle sizes (in this case railway ballast rocks 65mm in diameter) supports the weight of pavement and traffic, while the pore space between the rocks is filled with soil to provide water and nutrient holding. The concept is that no high cost suspended slabs or engineered solutions are needed, the soil itself supports the pavement, and roots can grow in the cracks without lifting pavements.

A soil mix along the line adopted by Grabosky and Bassuk 1995 was used with the following variations-

1. only 50% of the pore space between the rocks was filled with "filler soil"
2. The filler soil used was a high cation exchange capacity clayey soil not a sandy loam
3. additional combined air vent/irrigation/fertigation pipes were installed under each tree to ensure maximum aeration and admit water.

4. A special paver was developed by Rocla called “ecopave” which greatly increases the permeability of paving.

Initial growth rates are highly encouraging and no movement of pavers is evident despite intense pedestrian use. The large exposed areas around the railway and Boulevard need the shelter and protection offered by trees and the use of structural soils provided an innovative and neat solution to this age old problem of trees in cities. Since the OCA show-cased this technique at Sydney Olympic Park the method has been employed widely throughout Sydney, Melbourne and many other urban centres. This was one of the purposes and legacies of the Olympics development.

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Short Biography of Simon Leake:

Graduating with Ist Class honours in Agricultural science majoring in soil science in 1981 Simon established Sydney Environmental and Soil Laboratory (SESL) in 1983. Simon and SESL quickly established a reputation in the emerging field of urban soil science and his services came into demand at nearly all of the leading construction projects including Darling Harbour, Bond University and more lately the State Sports centre and Sydney Olympic Park. He was on the concept design team for the Millennium Parklands and consulted over 5 years to the OCA and all developers on the Olympic site. His laboratory also conduct agricultural and land rehabilitation analysis and advice.