The Soil Landscapes of Brisbane and South-eastern Environs

G. G. Beckmann, G. D. Hubble and C. H. Thompson

SOILS AND LAND USE SERIES No. 60

COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANISATION, AUSTRALIA 1987

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Commonwealth Scientific and Industrial
Research Organisation, Australia
1987

National Library of Australia Cataloguing-in-Publication Entry

Beckmann, G G (Geoffrey George)

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Bibliography
ISBN 0 643 04251 2

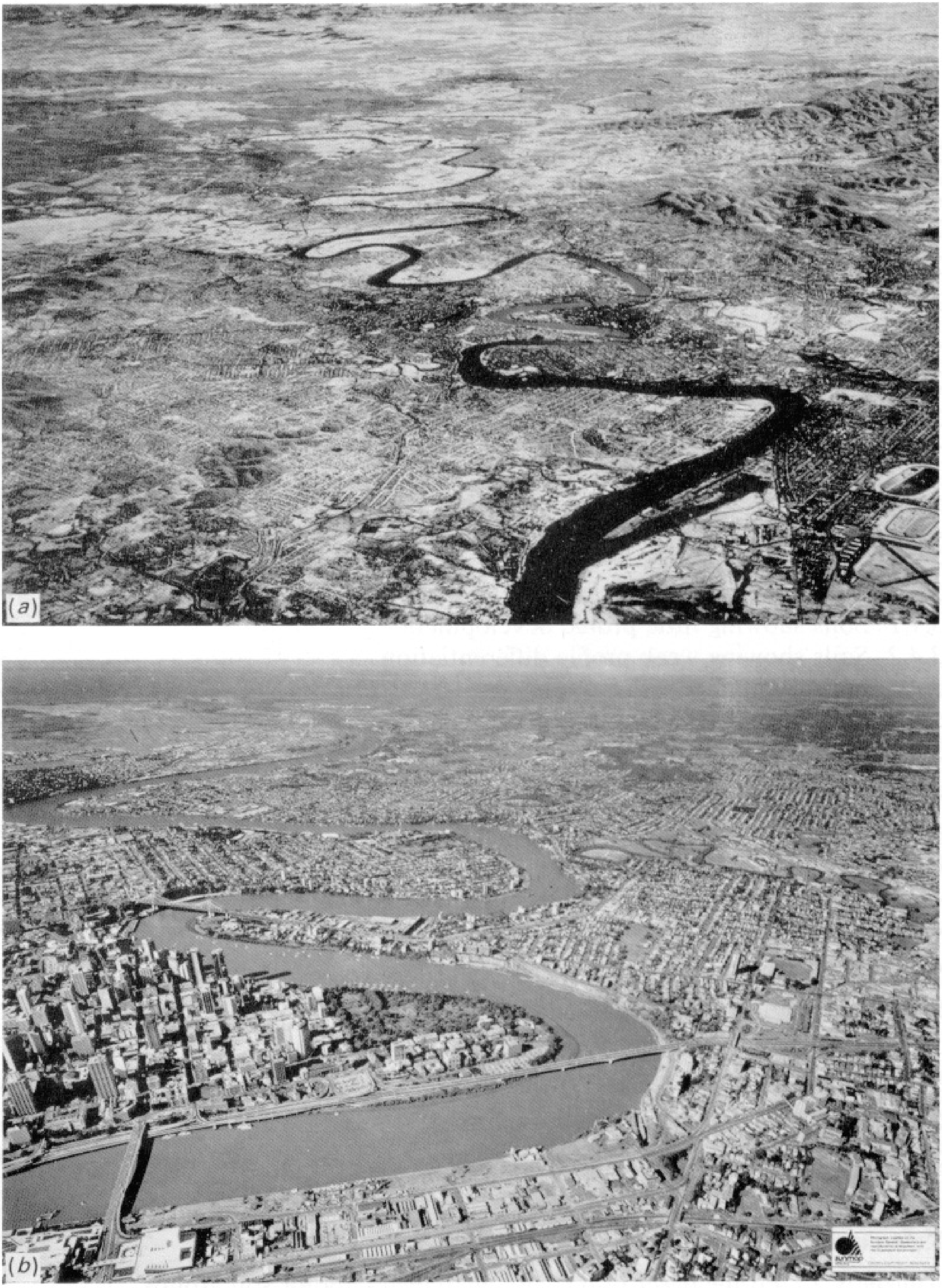
1 Soils—Queensland—Brisbane Region 2 Landforms—Queensland—Brisbane Region I Hubble, G D II Thompson, C H (Clifford Harry), 1926– III Commonwealth Scientific and Industrial Research Organisation (Australia) IV Title (Series Soils and land use series, no 60)

631 4'7'9431

 Printed by CSIRO, Melbourne

87 104–2640

Contents



Aerial photographs over Brisbane:

(*a*) infrared photograph of city and valleys and hills to the west, *c.* 1957 [from the *Courier Mail*, Brisbane];

(*b*) downstream over the city area showing the landscape of low hills and alluvial plains [courtesy of the Surveyor-General, Brisbane].

CSIRO Aust Soils and Land Use Ser No 60, 1–79 (1987)

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Abstract

The soils of 1240 km^2 of the Greater Brisbane City area and contiguous areas to the south-east have been placed into 44 soil landscape units (a soil landscape is an area with characteristic assemblages of soils associated with a constant pattern of landforms on a particular parent material) The soils include *lithosols*, several *podzolic soils* (*red*, *yellow*, *lateritic* and *gleyed*), *red earths* and *krasnozems*, cracking clay soils, *podzols* and well-drained and poorly drained soils on transported materials The parent rocks include sedimentary and metamorphosed sedimentary rocks, some igneous rocks (particularly basalt and granite) and unconsolidated materials ranging in texture from sands to clays The area is made up of low hills, plateaus and ridges (to 90 m) surmounted by isolated hills and mountain ranges (to 300 m) The low hills are separated by valleys with alluvial floors and are fringed to the north-east by a moderately wide (up to 8 km) alluvial plain

Chemical and physical properties of soils may restrict plant growth through limits on inherent nutrients and/or poor drainage at many sites Site, as well as soil properties, determines the suitability of areas for urban development Two elements of landscape history, namely the past climates, with their influence on the weathering trends, and the past sea-level changes, with their influence on the modern landforms, have modified the general patterns of soil development which are primarily controlled by parent materials and topography, as well as by present climate

1. Introduction

This report and the accompanying map have been produced in response to the many inquiries received each year by soil scientists in Brisbane about the kinds of soils found in the suburban and fringing areas there Most of these inquiries have come from keen gardeners and weekend farmers wanting to know how to treat their soils to improve plant performance, and from students seeking information for study projects, and latterly also from engineers and others with a technical interest in soils Although much is known about the general nature and distribution of the soils, such information has accumulated from opportunist observations as pedologists have moved about the area rather than from a specific study. No soil map of medium or larger scale has hitherto been produced, nor have the necessary observations for such a map been undertaken The city and suburbs are now so densely developed that large-scale soil mapping would be virtually impossible and probably not warranted. Of the small-scale soil maps, the most detailed is Sheet 4 of the 'Atlas of Australian Soils' (at 1:2 000 000 scale, Isbell *et al* 1967) which shows only two to three map units covering the area.

The map accompanying this report is an attempt to meet the need for soil information, as far as is possible, in a medium-scale map using available data with no more additional field work than necessary to achieve a reasonably uniform generalisation for the whole area. That part of the Brisbane–Beenleigh soil map

(Beckmann 1967) covering the south-eastern environs down to Redland Bay has been included to provide, in the one map, cover for the fringing area where greatest urban development is occurring. The total area covered by the map is about 1240 km^2

2. The Area and Physical Environment

2.1 Location and Extent

The City of Brisbane (lat 27° 30′S , long 153°E , in south-eastern Queensland) lies across the Brisbane River, extending 35 km westward from the coast to the crest of the D'Aguilar Range (Fig 1) It is the second largest city area in the world (officially 974 7 km^2) but its population is relatively small (estimated 1 000 000 in 1983), and considerable land toward the city limits is unoccupied or undeveloped Much of the information on physical environment, soils and land use of the Brisbane–Beenleigh area (Beckmann 1967) is applicable to Brisbane, and that report should be consulted for additional information

2.2 Topography and Geology

Three topographic units characterise the mapped area. These with their associated rock types (Tucker and Houston 1967, Cranfield *et al* 1976, Willmott *et al* 1978) are

(*a*) Coastal plain (less than 10 m above sea level) extending from the Pine River in the north to just south of the Brisbane River and merging inland with the valley plains of the Brisbane River and its tributaries, and those of several minor streams (e.g Cabbage Tree Creek) which drain directly to Moreton Bay The surface is flat to very gently undulating and toward its seaward margin there are salt pans, swampy areas, occasional sandy beach ridges, and mud flats and mangrove flats bordering creeks The coastal plain consists of mixed marine foreland, estuarine and alluvial deposits; the valley alluvia range from sands to sandy clays but tend to medium texture

(*b*) Undulating to low hilly lands, typifying the greater part of the city area, of less than 80 m elevation, but rising to about 120 m, with a few isolated higher hills, Mt Gravatt (255 m) being the highest The unit also includes, as very low-level plateaus (e g the Sunnybank area), small remnants of an old surface which had gentle slopes toward the coast. The low hilly areas usually have gentle to moderate slopes, whereas the middle to upper slopes of the higher ridges, particularly in the western suburbs, and of isolated prominent hills, are moderately to steeply sloping A variety of rock types are found in this unit, the more important are.

(1) Phyllites of the Bunya Formation in the western suburbs extend from Oxford Park to Indooroopilly and to Upper Kedron.

(2) Metamorphosed sediments (greywacke, siltstone and shale), with some basic volcanic rocks and chert and jasper, of the Paleozoic Neranleigh–Fernvale Group extend south-easterly in a belt from West Chermside to the Holland Park–Mt Gravatt and Belmont–Mt Petrie areas, and are exposed again further south towards Mt Cotton

(3) Carbonaceous shales and lithic sandstones of the Tingalpa Formation have main exposures lying east of the city centre between Aspley and upper Tingalpa and extend to the coast in the Wynnum–Manly area. A

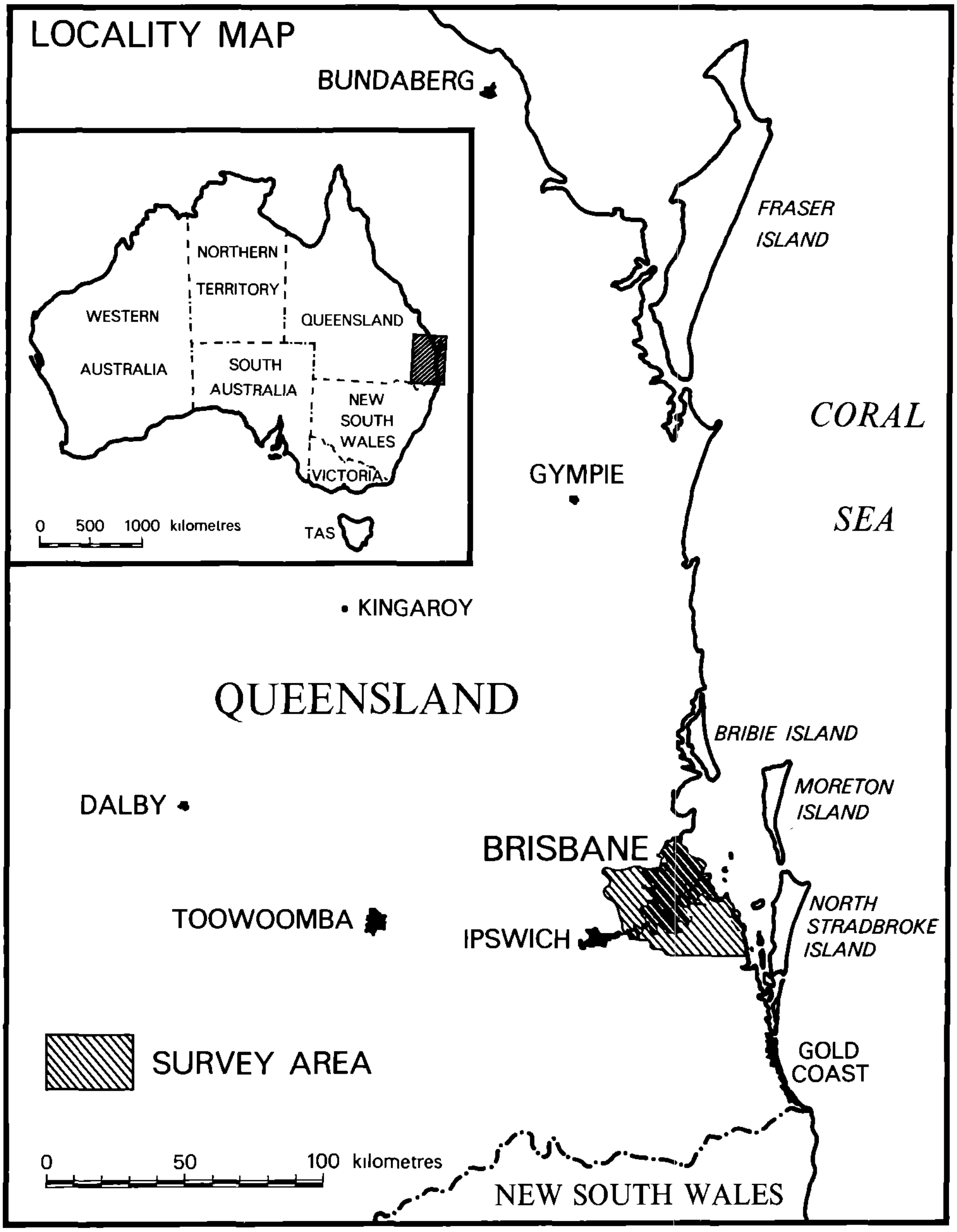


Fig. 1. Locality plan.

rhyolitic tuff (ignimbrite) extends in a narrow, roughly north–south, band to the east of the city.

(4) Mudstones, siltstones, sandstones and minor basalt of the Tertiary Petrie Formation are exposed in the Bald Hills–Boondall–Nudgee area.

(5) Tertiary basalt of the Corinda Formation and associated sediments are exposed in the Wynnum–Manly, Capalaba, Eight Mile Plains, Kuraby and Runcorn areas.

(6) Quartzose sandstones and siliceous conglomerate of the Triassic Moorooka Formation and lithic and feldspathic sandstones of the Triassic Ipswich Coal Measures, along with a variety of other sandy, gravelly and clayey sedimentary rocks extend across the southern suburbs between Moggill and Rochedale.

(*c*) Steep hilly and mountainous lands above about 120 m in elevation extend westward from the suburban fringe to the city limits on the crest of the D'Aguilar Range, and reach a maximum elevation of 550 m at Jolly's Lookout, at the north-western extremity of the city area. The dominant rocks comprising the western two-thirds of this unit are the greywackes, siltstones, shales etc. of the Neranleigh–Fernvale Group. These lands also embrace the Taylor Range (made up of Bunya Phyllite in The Pinnacles–Mt Coot-tha area) and the Enoggera Granite, lying northwards from The Summit to Grovely.

2.3 Climate

Features of the climate have been discussed by Beckmann (1967), and the following is based in part on that statement which should be consulted for further detail.

The climate is sub-tropical and maritime. It is characterised by hot, dominantly humid, rainy summer seasons and by short, mild and relatively dry winters; there may be a minor rainfall peak about June–July. On average, two-thirds of the yearly rain falls in the 6 months November–April.

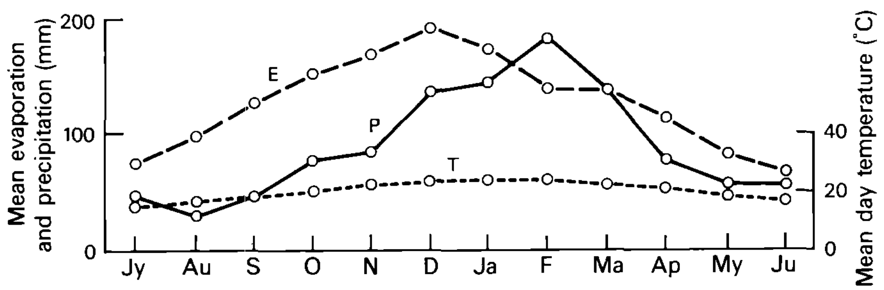


Fig. 2. Selected climatic data for Brisbane: P, precipitation (Bureau of Meteorology 1966, and Monthly Weather Review, Queensland, July 1981 to June 1983); E, evaporation (Bureau of Meteorology, Class 'A' Pan Evaporation 1967–85 varying 17–20 year record for individual months); T, temperature (Bureau of Meteorology 1975).

Fig. 2 shows monthly mean values for precipitation (P), measured evaporation (E) and temperature (T) at Brisbane. The city has a mean annual rainfall of 1146 mm, mean annual maximum and minimum temperatures of 25° and 19°C respectively, and a mean annual evaporation (Hounan 1961) of 1630 mm (1550 mm by Class A pan). A few frosts may be experienced between early June and late August (Foley 1945), usually confined to low-lying areas away from the coast. On the coastal plain, there have been occasional frosts severe enough to damage sensitive crops including tomatoes and bananas. Apart from the mountainous north-western sector, which has the highest rainfall (1788 mm at Mt Glorious, 640 m in elevation), there is a pronounced decreasing trend in rainfall inland from the coast; annual means decrease from about 1200 mm (1346 mm at Ormiston: Redlands Horticultural Research Station) to 927 mm at Goodna. The annual and monthly totals vary greatly, the 10 and 90 percentiles for annual rainfall at Brisbane being 411 and 1632 mm respectively (Bureau of Meteorology 1968).

The main plant-growing season lies between mid December and late April, i.e. in the period within which monthly mean rainfalls exceed evaporation (calculated from atmospheric saturation deficit) and day length is longest. Lower temperatures and shorter day length after April restrict the growth of summer-growing and tropical plants in most years, even when soil water is available. Though there is no well-defined dry season, periods of 'drought days' (in which there is no plant-available water in the soil down to 60 cm depth) commonly occur during October, November and December, or in all 3 months (Stirk 1963). In most years there is a pronounced drought period of this type of about 6 weeks duration, usually within the September–late January period.

Important in their effects on soil formation and properties are the coincidences of available soil water and high temperatures in summer; these promote rapid weathering, and often provide a large excess of water (rainfall greater than evapotranspiration) for leaching and runoff. Fig. 3 shows monthly means and individual values for 1981–2 and 1982–3 for the climatic index $P/E^{0\cdot75}$ (Prescott and Thomas 1949), where P (mm) is rainfall and E (mm) is evaporation (Hounan 1961). Prescott (1948) considered this to be the most important single-value index for the leaching factor in soil formation, values in the range of 1·1–1·5 corresponding to the point where rainfall balances transpiration from vegetation and evaporation from the soil. With the higher of these values accepted as the threshold for this area, a surplus of rainfall for leaching and/or runoff is likely for all months except August and September, with a substantial surplus in January, February and March. The general leached character of the soils, their moderate acidity and low to moderate base saturation are in keeping with this assessment. Some of the soils, however, are relicts formed under past climates that were possibly very different from the current one.

The monthly climatic indices for 1981–2 and 1982–3 in Fig. 3 show the great variation that can occur within and between years. The effectiveness of monthly rains in weathering, leaching and soil formation is affected very much by

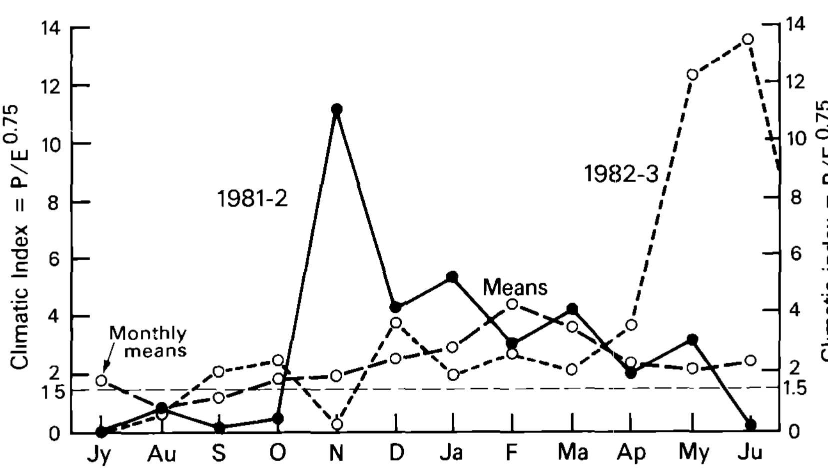


Fig. 3. Climatic index $P/E^{0\cdot75}$ for Brisbane, showing monthly values for 1981–2 and 1982–3 and also monthly means from evaporation data and standard-period normal rainfalls.

antecedent soil water status, the intensity of individual falls and the distribution of falls within the month A high proportion of heavy storms and extended less-intense rains is lost in runoff Although the climatic indices for December to April 1982–3 ranged between 3 7 and 1 9, the high December value followed a November drought, and the April rains came right at the end of the month. The soil was, in fact, relatively dry throughout this period and no leaching was likely The infrequent very wet years or seasons (say above the 90 percentile) are likely to set the upper limit to the intensity of weathering and leaching, and data for these are likely to correlate better with soil character than would climatic means.

2.4 Drainage

Surface drainage within the area is effectively controlled by topography with a minor influence only from soil and plant cover It ranges from rapid with excessive runoff in the mountainous north-west, where the soils are dominantly thin and stony, to sluggish with short-term flooding on the valley floors and low-lying coastal plain, where the soils are deep and have higher water storage capacities

The Brisbane River running through the area from south-west to north-east provides the outfall for drainage from the western and south-western sections A central southern section drains southward to the Logan River through Scrubby and Slacks Creeks. The remaining area, mostly lying close to the coast, drains directly to the coast except that along the northern margin which is drained by Kedron Brook–Serpentine Creek and by Downfall and Cabbage Tree Creeks. The estuarine and marine forelands drain through a network of tidal channels.

Major flooding by the Brisbane River inundates its flood plain, lower terraces and the lower parts of its tributary valleys within the area When river floods coincide with high tides and heavy local runoff, as in the 1974 floods, water backs up these valleys for some distance leading to extensive flooding and water logging of the soils

Most of the upland soils are freely drained except on the lower slope sites that receive seepage from higher areas. Some of the soils with strong texture-contrast perch water on their clay subsoils for short periods following prolonged rains and on near-level sites show clear evidence of poorly drained subsoils On valley floors and low-lying plains, especially near the coast, internal drainage is imperfect to poor and in many situations is impeded by fluctuating water tables within the solum.

2.5 Vegetation

The native vegetation over most of the area has been destroyed during urban and rural development and the remainder has suffered varying modification. The least disturbed remnants are on steep lands (especially west of the city), on areas of poorer soils generally and on wet and saline lands of the lower plains and littoral. From these it is evident that several major vegetation formations were present (Herbert 1951, Dowling and McDonald 1976, Elsol and Dowling 1978). Their distribution, and that of the component communities, was closely related to soil differences, determined mainly by parent rocks, by soil nutrient contents, by soil water regimes and by salinity. The main vegetation types are.

(*a*) *Eucalyptus* open forests and open woodlands: These formations, dominated by varying assemblages of *Eucalyptus* species, are the commonest and most widespread and probably covered most of the uplands. Elsol and Dowling (1978) regarded the large continuous forests (and woodlands) of *Eucalyptus* vegetation as mosaics of many species, and they grouped the majority of the communities to form the Nerang–Beenleigh open-forest alliance and woodland alliance. These occur mainly on the widespread rocks of the Neranleigh–Fernvale Formation, Bundamba sedimentary group, Bunya phyllites and Ipswich Coal Measures. *Eucalyptus signata* (scribbly gum) and *E. intermedia* (bloodwood) are prominent on the coarser-textured *podzolic soils* overlying sandstones and some Neranleigh–Fernvale rocks, e.g. near Tingalpa, *E. maculata* (spotted gum) and *E. crebra* (narrowleaf ironbark) are prominent on the finer-textured *podzolic soils* and *lithosols* formed from Bunya phyllites. Many other species of *Eucalyptus* and other genera, e.g. *Lophostemon confertus* (Brisbane box) and *Angophora* sp., occur in these communities. Some of the woodlands are the result of selective thinning of open forests. It is also likely that there were occurrences of *Eucalyptus* closed forest on parts of the uplands.

(*b*) *Melaleuca* open forests and woodlands: *Melaleuca quinquenerva* (paper-bark teatree) is dominant in some communities on the poorly drained parts of the coastal plain and adjoining valley bottoms. *Eucalyptus tereticornis* (blue gum) and *Lophostemon suaveolens* (swamp box) are co-dominants in one community, an associated community is *Casuarina glauca* (swamp sheoak) dominant. The soils are mainly *gleyed podzolic soils* and *humic gleys*.

(*c*) Closed forest with emergent *Araucaria cunninghamii* (hoop pine). This vegetation (rainforest. Herbert 1951) is recorded as occurring along streams, in sheltered valleys and on southern slopes; its presence appears to be determined by local favourable conditions of water supply, soil or shelter. Patches occurred along the Brisbane River on *alluvial* and weakly developed *prairie soils*, on small areas of *krasnozems* and *euchrozems* on basic volcanic rocks (e.g. in the Brookfield area), and on *red podzolic soils* and associated soils on colluvium and fine-textured rocks.

(*d*) Littoral vegetation: Two vegetation types characterise the littoral.

(1) Mangrove communities ranging from open forest to low open shrublands (Dowling and McDonald 1976) occur on muddy sediments within the zone of tidal influence. The soils are *saline muds*.

(2) Saltmarsh vegetation including patches of *Sporobolus virginicus* (salt-water couch) closed grassland and other salt-tolerant plants, along with some bare mudflats, occur in areas with occasional flooding but with a fluctuating saline water table at shallow depth. The associated soils are saline gleys, peaty gleys and *solonchaks*.

3. The Soil Map

3.1 Compilation

The soils of Queensland are strongly determined by the nature of their parent materials, which are in turn closely dependent on the rocks from which they have been weathered. For this reason, the 1:31680 scale reconnaissance geological map of the City of Brisbane (Tucker and Houston 1967) was a suitable base for the soil map. By stereoscopic examination and interpretation of air-photographic cover, the geological units were subdivided, mainly on the basis of topography and drainage net, into more uniform landscape units. Finally, using existing soil information supplemented by limited observations along road traverses, these landscape units were characterised in terms of their dominant or more important component soils.

3.2 *Soil Landscape Units*

Each unit shown on the map is referred to as a 'soil landscape', a natural area of land in which the soils bear a constant relationship to each other, being formed on a limited range of landforms and from a single rock type or complex of parent rocks Each soil landscape thus has a characteristic drainage pattern (expressed as the 'drainage net') throughout (Thompson and Moore 1984). The soils were classified according to the Australian great soil group scheme (Stace *et al* 1968), 'Great Soil Group association' (cf. Beckmann 1967) is therefore equally applicable and acceptable as a general name for the map units.

An example is the Toowong (soil) landscape which occupies low hills of Bunya phyllite in the Toowong-Indooroopilly area In this landscape *red podzolic soils* are the dominant soils over most of the slopes, with *lithosols* and shallow *podzolic soils* on hillcrests and with minor *red–yellow podzolic soils* on lower slopes.

3.3 *Soil Groups*

3 3 1 Classification

Most soils of the Brisbane region can be placed in one of 19 great soil groups of the Australian classification (Stace *et al* 1968) However, a high proportion of the soils with podzolic form are essentially intergrades between the *red podzolic* and *yellow podzolic* great soil groups and are identified as *red–yellow podzolic soils* in the text and map legend In addition, for this area only, some less important but distinctive soils have been named as separate units representing subdivisions or near relatives of the great groups These are 'peaty gleys', being a subgroup of *humic gleys*; 'dark acid clays', closely related to *black earths* but differing mainly in having a strongly acid profile and some attendant characteristics; and the 'gilgaied acid clays', a subgroup of the *grey, brown* and *red clay* groups but with some features of gleys

Other soil classification systems are also applied to Australian soils, and units of these may be encountered in the literature 'A Factual Key for the Recognition of Australian Soils' (Northcote 1979) was developed as a basis for the 'Atlas of Australian Soils' and has since been widely used in this country The U S D A System, 'Soil Taxonomy' (Soil Survey Staff 1975) and the legend for the FAO–UNESCO (1974) 'Soil Map of the World' are now in common use in many countries and also frequently used in Australia. The great soil groups and local units used for the Brisbane soil map are listed in Table 1 with their approximate equivalents in two of these other classification systems

3 3 2 The Soils

The distinguishing features and more important properties of the soil groups of the area are outlined under subheadings emphasising differences in the degree of profile development and horizon differentiation A fuller general characterisation of the great groups is provided by Stace *et al* (1968) and more details for the soils of this area by Beckmann and Reeve (1972). Descriptions and laboratory data for available representative profiles are given in Appendix 1, and example profile descriptions of the other groups are given in Appendix 2

Table 1. Approximate correlations between soil groups and units of other classification systems

Soil Group[A]	Factual Key [B]	Principal Profile Form or Class	Soil Taxonomy[C]
Solonchaks	Um 5 4	dense loams	Salorthid
	Uf 6 62	non-cracking plastic clays	
Alluvial soils	Uc 1 21, 22	quartzose sands (over layered alluvium)	Ustifluvent
	Um 6 2	shallow friable loams with rough ped fabric	
Siliceous sands	Uc 1 21	quartzose sands	Quartzipsamment
Lithosols	Um 2 12	shallow bleached loams	Ustorthent and Ustochrept
	Um 4 11–13	pale loams	
	Um 4 21, 23	pale loams with colour B horizon	
Prairie soils			
Minimal	Uc 1 44	firm quartzose sands	Ustochrept
	Um 6 23	shallow friable loams with rough ped fabric	Ustifluvent
	Gn 2 42	brown or mottled-red massive earths	Haplustoll
	Uc 5 21	earthy sands	Ustifluvent
Maximal	Db 3 13	friable brown duplex soil	Argiustoll
	Dg 5 12	friable pedal mottled yellow duplex soil	
	Gn 3 42	black smooth-ped earth	Haplustoll
	Gn 3 92	grey smooth-ped earth	
'Dark acid clay'	Ug 5 14	black self-mulching cracking clay	Chromustert/Pellustert
Black earth	Ug 5 12	black self-mulching cracking clay	Haplustoll
	Gn 3 93	grey smooth-ped earth	
'Gilgaied acid clays'	Dy 3 11	hard pedal mottled-yellow duplex soil	Chromustert
	Gn 3 91	grey smooth-ped earth	
Wiesenboden	Ug 5 28	grey self-mulching cracking clay	Chromustert
Red earths	Gn 2 11–14	red massive earths	Paleustalf
	Dr 4 21	friable red duplex soils	
Krasnozems	Gn 3 11–14	red smooth-ped earths	Paleustalf
Red podzolic soils	Dr 2 21–41	hard pedal red duplex soils	Paleustalf, Haplustalf, Rhodustult Haplustult
	Dr 3 21–41	hard pedal mottled-red duplex soils	
	Dr 4 21–41	friable red duplex soils	
	Gn 3 50	mottled brown and red smooth-ped earths	
Yellow podzolic soils	Dy 3 41	hard pedal mottled-yellow duplex soils	Paleustalf–Haplustult
	Dy 5 41	sandy pedal mottled-yellow duplex soils	
Lateritic podzolic soils	Dy 5 41	sandy pedal mottled-yellow duplex soils	Paleustult
	Dy 5 61–81	sandy apedal mottled-yellow duplex soils	

[Continued on p 10]

Soil Group[A]	Factual Key [B]	Principal Profile Form or Class	Soil Taxonomy[C]
Gleyed podzolic soils	Dy 2 81	hard apedal gley duplex soils	Albaquult–Ochraquult–Albaqualf
	Dy 5 31–41	sandy pedal mottled-yellow duplex soils	
	Gn 2 94	hard apedal mottled-yellow duplex soils	
Podzols	Uc 2 36	bleached sands with pan	Haplorthod
Humus podzols	Uc 2 20	bleached sands with colour B horizons	Haplohumod
	Uc 2 33	bleached sands with pan	
Soloths	Dy 3 41	hard pedal mottled-yellow duplex soil	Paleustalf, Natrustalf
Solodic soils	Dy 3 42–43	hard pedal mottled-yellow duplex soil	Natrustalf, Paleustalf
Humic gleys	Gn 3 51	mottled brown and red smooth-ped earths	Argiudoll
	Dy 5 11	friable pedal mottled-yellow duplex soil	Paleaquult
Humic gleys (saline)	Dy 5 11	friable pedal mottled-yellow duplex soil	Salorthid, Halaquept
	Dd 4 11	(no class name)	Umbraquult–Umbraqualf

[A] Stace *et al* (1968), where there is no provision the local name is given in quotation marks
[B] Northcote *et al* (1975), Northcote (1979)
[C] Soil Survey Staff, U S Department of Agriculture (1975)

For convenience, soils have been assembled into five broad groupings.

(*a*) Soils with little profile development soils mainly of weathered mineral material, little altered from its original state, any horizon differentiation is limited to darkening of the surface layer;

(*b*) Soils with weak profile differentiation. mainly dark clay soils derived from basalt or from alluvium, although they show little *texture* difference they show considerable structure and/or colour development below the dark surface layer,

(*c*) Soils with profiles dominated by sesquioxides: commonly deep, red, well-structured soils, including both sandy and clayey profiles, which usually become more clayey with depth,

(*d*) Soils with markedly differentiated profiles. soils having distinct contrasts in texture, structure and colour between surface and subsoil;

(*e*) Soils showing the influence of poor drainage both soils with contrasting texture profiles and those with uniform profiles are included, but all soils show signs of permanent or intermittent saturation of all or parts of their profiles

These groupings are described in more detail below.

(*a*) *Soils with little profile development*

Horizon differentiation is limited mainly to the surface soil (A1 horizon), darkened by some organic matter, overlying a varying depth of weathered mineral material that shows little structure or other pedological development. In this grouping are the following

(1) *Solonchaks* (Appendix 1.1)—strongly saline soils, typically of loamy or clayey texture, and often with bare patches of salt-encrusted or puffy surface. They occur along the seaward margin of the coastal plain, have saline ground water at shallow depths, and may have a patchy cover of salt-tolerant plants, especially *Salicornia* spp. The subsoil immediately above the water table is characteristically mottled grey, red and ochre. These soils develop from saline mud flats when flooding by sea or estuarine waters becomes infrequent and the ground water table is lowered They are infertile, due to high salt contents in the soil solution.

(2) *Alluvial soils* (Appendix 2 1)—a darker surface soil overlies more-or-less distinctly layered alluvium, each layer differing in colour, texture, gravel content or thickness These are mainly sandy or loamy soils in which sedimentary laminae, current bedding and/or minor coarse sand and gravel lenses are usually evident. They occupy the lower parts of landscapes bordering streams, and are freely drained but may be occasionally inundated by floods. They are neutral to mildly acid soils in which available water storage capacity (AWC) and fertility vary with texture, but both are commonly moderate

(3) *Siliceous sands* (Appendix 2 2)—sands or loamy sands with fairly uniform colour and profile texture or with slightly increasing clay content with depth, little or no gravel or stone and of moderate or greater depth They are very permeable, drain rapidly after wetting and have low AWC. Soil reaction is mildly to moderately acid, and nutrient status and fertility are low Occurrences are limited to highly quartzose parent materials ranging from littoral sands and alluvium (on older terraces and levees) to sandstones and granite in the uplands.

(4) *Lithosols* (Appendix 2.3)—stony and gravelly soils of sandy, loamy or clayey texture usually overlying fragmented and weathering rock at shallow depth (40–60 cm) They occur mainly on ridge crests or steep to moderate upper slopes, where continual removal of fine earth by erosion limits profile development. Where these soils have A horizon characteristics of *podzolic soils*, e.g. well-developed pale or bleached A2, but have no clay B horizon, the intergrade qualification 'podzolic' may be added Nutrient status varies with the composition of the parent rock, but AWC is commonly low and the soils are non-arable due to stone and gravel

(*b*) *Soils with weak profile differentiation*

These soils have considerable pedological development below the darker surface soil, but horizon differentiation is generally subdued.

(1) *Prairie soils* (Appendixes 1.2, 2 4, 2.5)—dark friable loamy surface soil of moderate thickness and organic content with a gradual or clear change to brownish–yellowish clayey subsoils, usually of blocky structure (Fig 4*a*). They are characteristically acid to mildly alkaline, moderately deep, and have moderate to high AWC.

(2) 'Dark acid clays' (Appendix 1.3)—moderately deep, dark grey-brown to grey heavy clays with granular structure at the surface, grading below a few centimetres depth into moderate medium blocky clays The deep subsoil below 60–90 cm has well-developed lenticular structure and is usually mottled yellowish-brown and grey. These are acid soils, tending to become more so with increasing depth, and are formed from basaltic parent materials AWC is moderate to high.

(3) *Black earths* (Appendix 1.4)—very dark brownish grey heavy clays, similar to the dark acid clays but having neutral to alkaline reaction and, in this area, shallow profiles up to 80 cm deep to weathered basalt rock. In some locations, they grade downslope into deeper typical *black earths* with low gilgai microrelief, some lime segregations and nodules in the deep subsoil, and lime nodules in the granular surface soil on the mounds of the gilgai. AWC varies with soil depth from moderate to high and the soil is sticky and difficult or impossible to till when wet.

(4) 'Gilgaied acid clays' (Appendixes 1.5, 1.6)—dull brownish grey, deep, heavy clays with a few centimetres of clay loam to light clay at the surface and olive to yellow-brown, grey and reddish mottled subsoils with blocky structure grading into lenticular structure in the deep subsoil. The gilgai microrelief is subdued with small shallow depressions and low mounds of granular clay differing in level by about 10 cm or less. The clays are mixed montmorillonite and kaolin, strongly acid and low in base saturation throughout. Magnesium is the dominant exchangeable metal cation and the exchangeable calcium content is very low. The deep subsoil has significant salt and exchangeable sodium contents; the AWC is only moderate and soil fertility is low.

(5) *Wiesenboden* (Appendix 1.7)—poorly drained dark-grey clays, similar in the upper part to the *black earths* with which they are associated but grading at shallow depth into grey heavy clay subsoils mottled with yellow-grey, yellow-brown and reddish patches. The mottling is the result of poor subsoil drainage and the material is called 'gley'. Generally they are deep soils, slightly acid at the surface but alkaline in the deep subsoil which may have lime segregations. Some fine black manganiferous nodules occur throughout the solum and there may be slight gilgai development. AWC and fertility are moderate.

(c) Soils with profiles dominated by sesquioxides

These are red, deep soils with fair to strong pedological organisation but weak horizon differentiation, friable consistence and gradually increasing amounts of clay with increasing depth.

(1) *Red earths* (Appendix 1.8)—red soils which are deep, porous and friable but generally massive or with weakly developed structure. The sandy to loamy A1 horizon may have weak to moderate structure. The clay content increases gradually with depth to sandy clay, or heavier, deep subsoils which are massive or with coarse medium blocky structure (Fig. 4*b*). Mottles of light grey and yellowish colours are common at greater depth. The surface soil is mildly acid and both fertility and AWC are low. Lateritic *red earth* is a variant containing appreciable amounts of ironstone nodules. In this area, *red earths* are relict soils associated with the modified remnants of old land surfaces now forming low, bevelled plateaus, as at Sunnybank.

(2) *Krasnozems* (Appendixes 1.9, 1.10)—strongly structured, clay-textured, red acid soils (Fig. 4*c*). Horizon differentiation is weak except for the dark A1 horizon with strong crumb structure and a zone of strongly mottled red and grey clay in deep subsoils below about 1.5 m. The clay content (dominantly kaolin) is characteristically more than 50% throughout the profile but the surface soil behaves like a loam, owing to its humus and sesquioxide content. The subsoil is moderately to strongly acid, and base saturation is low (less than 50%). AWC per unit depth is low but to some extent the depth of solum compensates for this, for deep-rooting

plants. The fertility of virgin soils is moderate to high but declines fairly rapidly under intensive use unless fertilisers are applied. There is a lateritic variant containing much ironstone gravel. The *krasnozems* of this area are relict soils occurring on modified old land surfaces but they have formed in materials rich in clay or in parent rocks that weather to produce much clay, such as basalt.

(3) *Euchrozems*—red, strongly structured clay soils with a somewhat lower clay content in the surface horizon than in the subsoil, weak differentiation below the darker surface soil, and essentially neutral reaction. They differ from the closely related *krasnozems* mainly in their weakly acid to weakly alkaline reaction profile, mild base unsaturation, rather compact firm to friable subsoils and moderate depth.

(4) *Xanthozems*—predominantly yellow-brown friable clay soils with weak horizonation below the darker surface soil but strongly structured throughout. They are essentially yellow counterparts of *krasnozems* (Stace *et al* 1968), and are acid, deep soils with some red mottling and/or black ferro-manganiferous segregations or nodules in the deeper subsoil.

(d) Soils with markedly differentiated profiles

The common features of these soils are distinct to prominent horizon contrasts in colour, texture, structure and related properties, mainly between the surface (A) and subsoil (B) horizons.

(1) *Red podzolic soils* (Appendixes 1.11, 1.12, 1.13, 2.6) and *yellow podzolic soils* (Appendix 1.14)—probably the commonest soils of the Brisbane area and therefore those that best characterise it. They have pronounced texture contrast and a clear to gradual boundary between weakly structured sandy to loamy A horizons (pale in the A2) and red or yellow-brown clay B horizons of moderate blocky or polyhedral structure and firm to friable consistence (Fig. 4*d*). In this area, intermediate forms that are prominently mottled in red and yellow-brown are more common. The pale or bleached A2 horizon is massive but porous and is very gravelly when formed from rocks such as phyllite, e.g. in the *red podzolic soils* of the Toowong unit.

These podzolic soils are moderately to strongly acid soils, particularly in the subsoils which consist mainly of mica, kaolin and interstratified clay minerals (cf. Koppi 1981) and are commonly rather dense and strongly base unsaturated. Soil depth ranges from less than 0.5 m to more than 1 m. Both nutrient status and AWC per unit of depth are low. Most of these soils have very low phosphorus levels, and deficiencies are common.

(2) *Lateritic podzolic soils* (Appendixes 1.15, 1.16)—similar to the mottled intergrade form of *red* and *yellow podzolic soils* but with large amounts of ironstone nodules in the lower part of the thick sandy A2 horizon and mottled upper B horizon. They are usually of greater depth (more than 2 m) than the *red* and *yellow podzolic soils*, and have prominent red and light grey coarse mottling toward the base of the solum (Fig. 4*e*). The upper B horizons are usually strongly fine blocky to polyhedral and friable to firm when moist but structure becomes coarser and consistence may be very firm in the deep subsoil.

These podzolic soils are moderately to strongly acid, the clays are dominantly kaolin, and exchange capacity and base saturation are low. Their AWC is also low, and nutrient status is very low with common deficiencies of molybdenum, copper and zinc in addition to gross deficiencies of phosphorus and nitrogen and significant deficiencies of potassium and calcium.

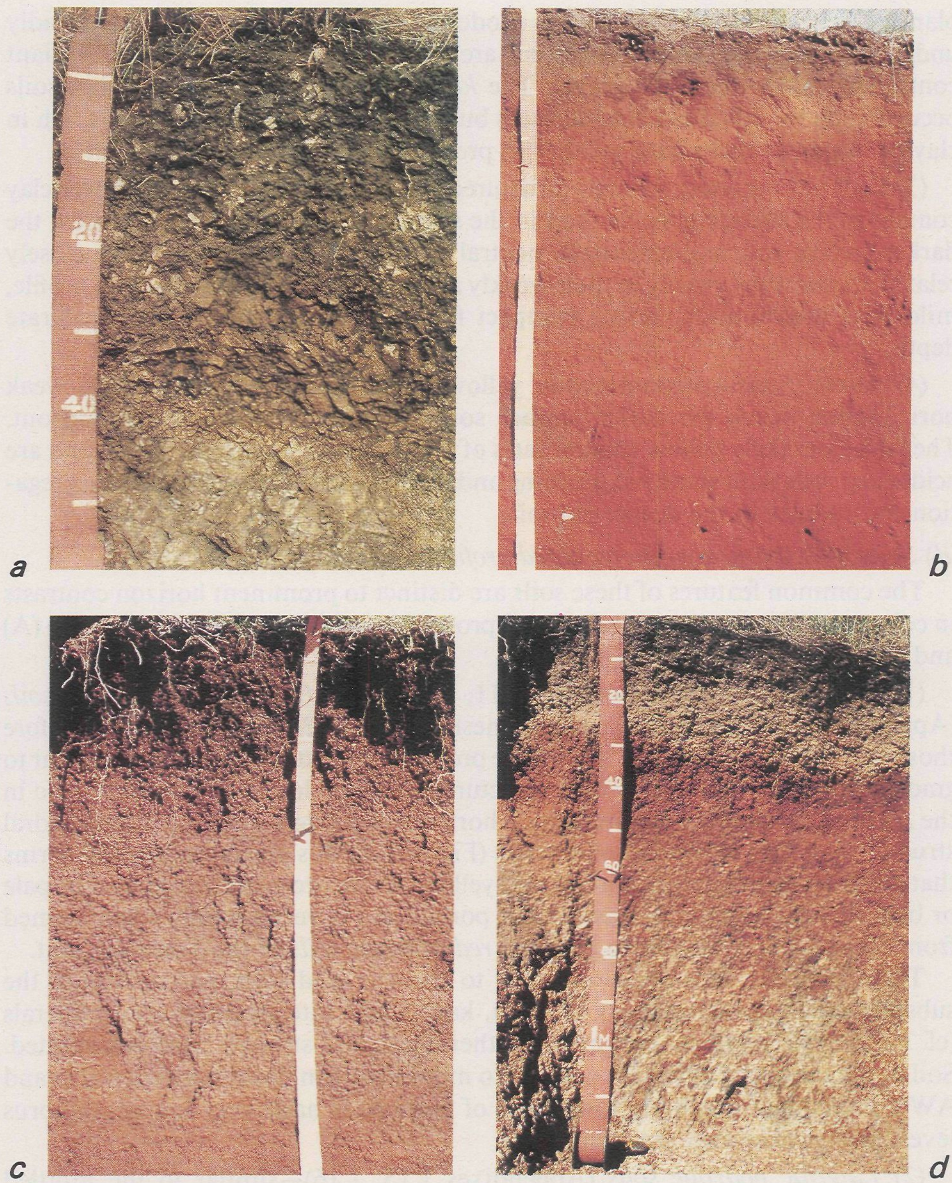


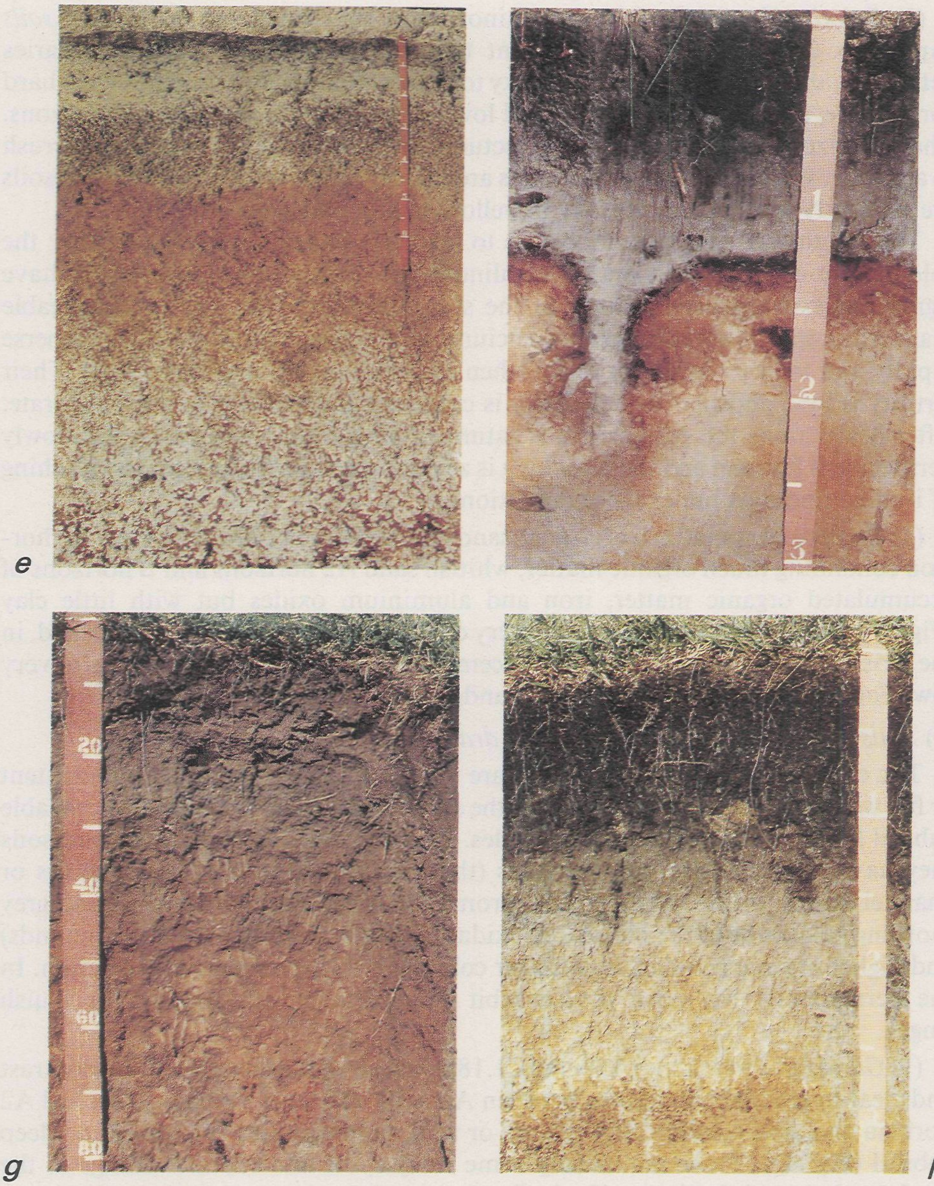
Fig. 4. Selected soil profiles:

(*a*) *prairie soil*—shallow dark clay soil on spilite on a hill slope in the Brookfield area (Brookfield soil landscape);

(*b*) *red earth*—sandy loam grading into massive sandy clay subsoil on sandstone near Beerburrum (Sunnybank soil landscape);

(*c*) *krasnozem*—red strongly structured deep clay soil on basalt near Mapleton (Redlands soil landscape);

(*d*) *red podzolic soil*—texture-contrast soil of loam abruptly overlying red structured clay on Bunya phyllite at Long Pocket (Toowong soil landscape);



(*e*) *lateritic podzolic soil*—sandy A horizons with ironstone nodules over thick yellow–red and mottled clay near Beerburrum (Park Ridge soil landscape);

(*f*) *podzol*—organic sandy soil with humus and iron-enriched B horizon on sandy alluvium in the Blunder area (Blunder soil landscape);

(*g*) *gleyed podzolic soil*—texture-contrast soil, poorly drained internally, on transported material in the Samford district (Eprapah, Willawong and Moggill Creek soil landscapes);

(*h*) *humic gley*—poorly drained organic soil with ochrous mottled clay subsoil on alluvial plains near Beerwah (Woongoolba and Lota soil landscapes).

Profiles *b, c, e, g* and *h* from north of Brisbane are typical of the soils within the landscapes of the Brisbane area.

(3) *Soloths* (Appendix 2.7) and minor areas of closely related *solodic soils* (Appendix 2.8)—both have prominent texture contrast and sharp boundaries between A and B horizons, coarse blocky to weak columnar structure, tough to hard consistence, and high bulk density and low permeability in the upper B horizons. The A horizons are loamy, weakly structured or massive, very compact and crush to a powder when dry. The A2 horizons are strongly bleached and the clay subsoils are variously mottled, commonly in yellow-brown and grey.

The soloths are acid with moderate to low base saturation in the subsoils, the solodics are mildly to moderately alkaline in the deeper subsoil. Both soils have significant exchangeable sodium in the subsoils, along with high exchangeable magnesium and low exchangeable calcium, as a consequence, the clays disperse rapidly and tend to erode seriously when exposed to rain and water flow. Their fertility is low, phosphorus deficiency is common and AWC is low to moderate. After heavy rains the A2 horizon is saturated with water perched on the slowly permeable B horizon and the bleaching is a consequence of reduction and leaching of iron compounds under these conditions.

(4) *Podzols* (Appendix 1.17)—acid sandy soils characterised by a grey A1 horizon containing much organic matter, whitish sand A2 horizons and B horizons of accumulated organic matter, iron and aluminium oxides but with little clay (Fig. 4*f*). The B horizons are streaky, very dark brown and yellowish brown and, in the Brisbane area, may be somewhat cemented. Inherent nutrient status is very low. For more details see Thompson and Hubble (1980).

(*e*) *Soils showing the influence of poor drainage*

The common features of these soils are the consequence of partial, intermittent or full water-saturation of some part of the solum associated with slowly permeable subsoil horizons, seepage or water tables. In comparison with well-drained soils they have characteristic 'gley' features (that is, rusty spots and root tracings or channel linings in the upper profile, prominent ochrous, rust-coloured and grey mottling below due to the reduction, oxidation and hydration of iron compounds) and higher organic contents and darker colours in the upper part of the solum. In the permanently wet zone they exhibit grey colours with greenish or bluish tinges.

(1) *Gleyed podzolic soils* (Appendix 1.18)—usually pronounced texture contrast and clear to gradual boundaries between A and B horizons, a pale or bleached A2 horizon and acid reaction throughout, or acid and becoming neutral in the deep subsoil (Fig. 4*g*). There are usually some rusty spots and channel linings in the sandy to loamy A horizons. Typically the clay B horizons are coarse blocky to prismatic, grey on the faces and in the outer portion of the peds and mottled with ochrous colours within. Where the deeper subsoil is permanently saturated it is grey, with ochrous markings only along old root channels in the upper part. The clay subsoils are firm when moist to wet and often less acid than those of other podzolic soils, but like them are kaolin-dominant with low base saturation.

In the natural state the *gleyed podzolic soils* have marked deficiencies of major plant nutrients but their water regimes ensure available water for plant growth for longer periods than occur in adjacent freely drained podzolic soils. This is the result of capilliary movement above the water table, where this is present, and/or some downslope seepage following heavy rains. These soils respond well to surface drainage and correction of nutrient deficiencies.

(2) *Humus podzols*—acid sandy soils similar to *podzols* but differing in the character of the B horizon and in subsoil drainage (see Farmer *et al* 1983) The A1 horizons are usually sands to sandy loams containing much organic matter, there is a gradual change to bleached sand A2 horizons, and a clear change to very dark brown or black B horizons of translocated organic matter The B horizons are commonly cemented, overlie permanent water tables and seasonally perch water above them. Inherent fertility is very low

(3) *Humic gleys* (Appendix 2.9)—soils with a dark, humic surface horizon that is commonly much thicker than the A horizon of well-drained soils, prominently mottled ochrous and grey subsoils and grey deep subsoils (Fig. 4*h*). Textures range from sand to clay and the texture profiles vary from uniform to strongly contrasted, with clay subsoils. The humic surface soil is usually loamy, has moderate fine blocky to crumb structure and shows some rusty markings. The subsoil in the zone of fluctuation of the water table is grey with rusty mottling, and is essentially massive in sandy soils but is coarsely prismatic with grey faces and ochrous mottling in clays The permanently saturated deep subsoil is grey with some greenish or bluish patches. *Humic gleys* occur on low-lying sites, usually on the coastal plain where there is a permanent water table at shallow depth

Humic gleys are moderately acid soils and their inherent nutrient status is low, but they can be highly productive when adequately drained and fertilised Drainage is more important than AWC· when the capillary zone above the water table is within reach of plant roots, a continuous water supply is assured Where *humic gleys* are used for horticulture the soil is usually formed into raised beds to improve the drainage of the upper part of the solum.

(4) 'Peaty gleys' (Appendix 2 10)—*humic gleys* with a peaty surface horizon have been recognised as 'peaty gleys' in this area. Under natural conditions the water table is always close to the surface, rising to it for extended periods and thus limiting the oxidation and decomposition of plant remains which accumulate to form the peaty soil In this area, 'peaty gleys' occupy shallow depressions; the peaty horizon and the solum are generally thin and, near the coast, both the ground water and soil are somewhat saline They are infertile soils of little importance because of their small area, and effective drainage for pastures or crops is generally impracticable owing to their low topographic position.

3.4 Description of Soil Landscapes (Table 2)

Soil landscapes have also been grouped according to the profile form of the major profiles, the major soils being named as great soil groups (Stace *et al.* 1968) or Principal Profile Forms (PPF, Northcote 1979). Soil landscapes dominated by *soils showing little profile development* include some on lowlands, mainly alluvial plains and tidal mudflats, these are usually of deep soils Those on high hills and on steep slopes are of soils which are shallow and stony and which are derived from a variety of parent rocks, the properties of the soils reflecting some of the characteristics of the parent rocks.

The soil landscapes of *soils showing weak profile differentiation* usually occupy low hills of basic igneous rocks, the dominant soils being shallow dark clays, or alluvial plains and terraces, with dark medium to fine textured soils. The landscapes with *soils dominated by sesquioxides* occupy low plateaus and low hills,

Table 2. Summary of soil landscapes of Brisbane and south-eastern environs

Soil landscape	Map symbol	Area (ha) City of Brisbane	Area (ha) South-eastern environs	Portion of mapped area (%)	Dominant Soil Groups	Landscape and parent rock
				Soils Showing Little Profile Development		
(*a*) *Lowlands*						
Mud flats	MF	2640	700	2 7	Saline mud	Muds of the tidal zone
Salt marsh	SM		88	<0 1	*Solonchak*	Low coastal plains of estuarine sediments
Logan	L	2240	220	2 0	*Alluvial soils*, with some *humic gleys*	Low terraces and flood plain of river sediments
(*b*) *High hills and steeply sloping areas*						
Chermside	Cm	1750		1 4	*Lithosols* with shallow *podzolic soils*	Low hills, some with steep slopes, of rhyolitic tuff
Enoggera	En	1320		1 1	Shallow stony *lithosols* and gritty *yellow podzolic soils*	Steep hills of granite
Mt Coot-tha	MCo	3620		3 0	Gravelly *lithosols* with shallow gravelly *podzolic soils*	Steep high hills of phyllite and hornfels
Mt Cotton	MC	810	430	1 0	*Lithosols*, with some red clays	Isolated high hills of quartzite
Priestdale	P		140	0 1	Sandy *lithosols*	Steep slopes of coarse sandstone
Pullenvale	Pu	7770	1340	7 5	*Lithosols*, with thin *red–yellow podzolic soils*	Crests and slopes on greywackes, shales, phyllites
				Soils Showing Weak Profile Differentiation		
Archerfield	A	910		0 7	Shallow *black earths* and *wiesenboden*	Low hills of basalt and plains of clay alluvium
Brisbane River	Be	2480		2 0	*Prairie soils*, with some sandy *alluvial soils*	Low undulating plain and terrace remnants along Brisbane River
Brookfield	Br	1100		0 9	*Prairie soils*, with some reddish *prairie* and *lithosols*	Hills of basic volcanic rock
Runcorn	Ru	1050	140	1 0	*Prairie soils*, 'dark acid clays' and shallow *black earths*	Low hills of highly weathered basalt
Waterford	Wa		360	0 3	'Gilgaied acid clays'	Terraces of clay alluvium

				Soils Dominated by Sesquioxides		
Aspley	As	1170		1 0	*Red earths* and *krasnozems* with *gleyed podzolic soils*	Hills of clays and sandy clays
Birkdale	Bk	300	570	0 7	*Krasnozems* and *prairie soils*	Low hills of weathered basalt
Bracken Ridge	BR	400		0 3	Sandy *red earths*, with minor *podzolic soils*	Low hills of ferruginous sandstone
Clayfield	Cl	450		0 4	*Red earths*, with some mottled *yellow podzolic soils*	Low undulating surface on gravelly clays and sands
Corinda	Co	550		0 8	*Red earths* and *krasnozems* with dark clay soils	Low hills and undulating surfaces of sandstones and clays
Elphinstone	El	760		0 6	Stony *krasnozems* and *lithosols*	Steep hills of basic volcanic rocks
Manly	M	1200		1 0	*Red earths* and *krasnozems*	Gently undulating plateau surface and low hills
Moggill	Mo	88		<0 1	*Krasnozems* with *red earths* and minor *red podzolic soils*	Plateau remnants of deeply weathered sandstone, clays and gravel beds
Redlands	R	550	2100	2 2	*Krasnozems*	Low hills of deeply weathered (lateritised) basalt and clay
Sunnybank	S	1810	48	1 5	Lateritic *red earths*, with some *lateritic podzolic soils*	Undulating plateau surfaces and adjoining slopes in Tertiary sediments
				Soils with Markedly Differentiated Profiles		
Beenleigh	B	7430	8550	13 1	*Red–yellow podzolic soils*, with *lithosols* and some *gleyed podzolic soils*	Low hills of greywacke, phyllite, shale etc
Boombana	Bo	64		0 1	*Red podzolic soils* and *lithosols*	Steep hills of granodiorite
Carbrook	Ck	1060	260	1 1	*Yellow podzolic soils*, *alluvial soils* and gleys	Low terraces and flood plains of alluvium
Coopers Plains	CP	3270	610	3 2	*Red–yellow podzolic soils* and *lateritic podzolic soils*	Slopes below plateau surfaces on sandy clays and sandstones
Darra	Da	750		0 6	Mottled *podzolic soils* and *soloths*	Undulating surface on mudstone, siltstone and sandstone
Jamboree	Je	2870		2 4	Gravelly *podzolic soils* and *lithosols*	Low hills of deeply weathered sandstone and conglomerate

Table 2 (*Continued*)

Soil landscape	Map symbol	Area (ha) City of Brisbane	Area (ha) South-eastern environs	Portion of mapped area (%)	Dominant Soil Groups	Landscape and parent rock
Kenmore	Ke	3520	220	3.1	Gravelly *red podzolic soils* and podzolic *lithosols*, with minor *yellow podzolic soils*	Hills of greywackes, siltstones and shales
Nundah	Nu	2350		1.9	*Red–yellow podzolic soils* with *red earths*	Low hills of sandstones, shales and clay
Park Ridge	PR	8040	1450	7.8	*Lateritic podzolic soils* and sandy *red–yellow podzolic soils*	Low hills and undulating surface of sandstone with shale and conglomerate
Samford	Sa	780		0.6	*Soloths* and *yellow podzolic soils*	Low hills of granodiorite
Toowong	T	5500		4.5	*Red podzolic soils* with *lithosols*	Low hills of phyllite
Witty	Wy	180		0.1	Gravelly *red podzolic soils*, with minor *red earths*	Hills of gravel beds, clays and decomposed sandstone
Woodridge	W	11210	9320	16.9	*Red–yellow podzolic soils*, with *lithosols*, *gleyed podzolic soils* and *lateritic podzolic soils*	Low hills of sandstones, and shales
					Soils Showing Influence of Poor Drainage	
Blunder	Bl	1660		1.4	*Gleyed podzolic soils*, with minor sandy gleys and *alluvial soils*	Flood plains of sandy alluvium
Eprapah	E	2190	870	2.5	*Gleyed podzolic soils* with *alluvial soils* and *humic gleys*	Low terraces of silty alluvium and flood plains of coastal streams
Lota	Lt	12	420	0.4	*Humic gleys* and *siliceous sands*	Low plains and beach ridges
Moggill Creek	MCk	590		0.5	*Gleyed podzolic soils*, with minor *prairie* and *alluvial soils*	Creek flats of sandy and clayey alluvium
Swamp	Sw	56		<0.1	Peaty gleys and *humic gleys*	Depressions on low coastal plains of alluvium
Willawong	Wg	700		0.6	*Gleyed podzolic soils* with *solodic soils*, *podzolic soils* and gleys	Low-lying undulating plain and low terraces with sandy and clayey alluvium
Woongoolba	Wo	8400	100	6.8	*Humic gleys*, 'peaty gleys' and *solonchaks*	Low (coastal) plains of alluvium and narrow depressions

and most are composed of deep red clayey or sandy soils, either uniform or with a progressive texture increase down the profile.

The landscapes with *soils with markedly differentiated profiles*, the podzolic soils, occupy low hills of sedimentary and altered sedimentary rocks and of granite, the characteristic colour and textures of the subsoils being determined by parent rock and topographic position. The landscapes with *soils showing the influence of poor drainage* are associated with low-lying sites on flood plains and coastal plains, the soils commonly have 'gley' features, dull-coloured surface horizons and mottled subsoils.

3.4 1 Soils Showing Little Profile Development

(*a*) *Lowlands*

In these soils, young alluvial materials on modern flood plains, on the coastal plain and on tidal mudflats preserve many of the features of the original sediments from which they have been derived *Alluvial soils* (Uc1 21, Um6 2) exhibit the texture banding which reflects the conditions of deposition. Saline muds and tidal *solonchaks* (Um5 4) show little development of soil features down the profile, except mottling which is the result of poor drainage.

Mudflat landscapes (MF—saline muds) This unit embraces the gently sloping estuarine–marine forelands of sandy muds mainly adjacent to and northward from the mouth of the Brisbane River and other occurrences associated with minor estuaries to the south The flats are regularly flooded by tidal waters and are bare or carry mangroves. The only soil features are those of gleys—prominent grey, ochrous and red mottling almost from the surface, grading at shallow depth into grey or bluish grey permanently saturated sediments.

Salt marsh landscape (SM—*solonchaks*). Salt marshes occur along the seaward edges of coastal plains and penetrate a short distance up drainage depressions. They consist of low, flat alluvial plains, less than 50 cm above high tide level, and are composed of deltaic material laid down by streams and sediment carried by currents. Drainage is very slow The dominant soils are *solonchaks*, showing evidence of salinity and of poor drainage.

Logan landscape (L—*alluvial soils*). This landscape includes the lower alluvial plains of most of the streams of the district (Slacks Creek, Breakfast Creek, Enoggera Creek, Kedron Brook, Downfall Creek etc.) and the South Pine River It is made up of sets of low, unmatched and discontinuous terraces and the modern flood plain of depressions and levee banks All of the terraces may be covered in modern floods, when they still receive small amounts of sediment. *Alluvial soils* (Uc1.21, Um6 2) and *prairie soils* (Um6.23) occupy the stream banks, with gleyed clays and *humic gleys* (Dy5 11) on lower parts of plains. 'Peaty gleys' are minor soils in swampy areas of flood plains, gleyed clays are commoner soils on flood plains higher upstream, and *humic gleys* occur in the floors of depressions between numerous low banks nearer the mouth.

(*b*) *High hills and steeply sloping areas*

The soils of these sites are commonly shallow (50 cm or less) and stony, and have properties determined by the type of parent rock *Lithosols* (Um2.12) derived from medium to fine textured sedimentary parent materials, such as greywackes, phyllites and mudstones, have sandy loam to loam textures and are commonly finely aggregated and loose *Lithosols* are generally light-coloured, but often reflect the colour of the parent rock

Chermside landscape (Cm—*lithosols*) This landscape occupies hills and high ridges of Brisbane tuff, extending from Chermside south through Lutwyche and New Farm to Ekibin, with some occurrences around St Lucia, Belmont and Seven Hills Within the unit there are some hills of metamorphosed sedimentary rocks and some areas of colluvium with alluvium along minor valleys. The dominant soil is a *lithosol* which occupies the higher crests and upper slopes while thin podzolic soils are associated with more rounded and lower hills *Alluvial soils* and gleyed soils are found on the small valley floors

Enoggera landscape (En—*lithosols*) This unit comprises the steep hilly terrain with relatively shallow gritty soils associated with the Enoggera granites Gritty *lithosols* (Uc4 1) on steep slopes and knolls are probably dominant Associated soils are rudimentary *podzols* (Uc2 21) and *earthy sands* (Uc5 23–Uc4 24) on gentle slopes and saddles Soil data are limited

Mt Coot-tha landscape (MCo—gravelly *lithosols*) This extensive unit comprises the steep hilly to mountainous land of Taylors Range running north-westward from Mt Coot-tha and formed of slightly metamorphosed Bunya Phyllites with some associated hornfels rocks. *Lithosols* (Um4 11), 20–40 cm thick, are dominant and occupy the crests and upper slopes Gravelly *red podzolic soils* (Dr2 21, Dr3 41), generally less than 50 cm thick, are associated soils, mainly on mid to lower slopes On the footslopes, where thicker bodies of parent material including colluvium have accumulated, deeper *red* (Dr3 41) and *yellow podzolic soils* (Dy3 41) predominate

Mt Cotton landscape (MC—*lithosols*, some red clays) This landscape includes the steep slopes and crests of moderately high hills of quartzite (60–230 m) at Mt Cotton, Pine Mountain, Mt Gravatt and Belmont Schists and small areas of igneous rocks occur with the quartzite and there are areas of colluvium on the lower hillslopes. *Podzolic lithosols* (Um2.12) with loamy textures and containing large pieces of quartzite are the dominant soils on the steep upper slopes Red clay soils, some of which are associated with igneous rocks, also occur on the slopes, along with gravelly *red podzolic soils* (Dr3 31) Red clay soils similar to *red earths* occur on colluvium.

South of Mt Gravatt there are *red earths* (Gn2 11) on the colluvial lower slopes, there are gravelly *red podzolic soils* on higher slopes at Mt Petrie and red clay soils derived from igneous rock on upper slopes of Mt Cotton

Priestdale landscape (P—sandy *lithosols*) The Priestdale landscape has a very restricted occurrence, on a narrow ridge crest north-east of Slacks Creek and on the steep upper slopes fringing it Sandy *lithosols* derived from coarse sandstones and grits occupy most of the unit but there are also minor areas of thin *podzolic soils.* Coarse sandstone boulders and outcrops of sandstone occur on both crests and steep slopes.

Pullenvale landscape (Pu—*lithosols* and *red-yellow podzolic soils*) Hilly to mountainous terrain, cut in the weakly metamorphosed Palaeozoic rocks of the Neranleigh–Fernvale Group, forms this unit *Podzolic lithosols* (Um2.12) and shallow *red podzolic soils* (Dr2 31, 2.41) are dominant, interspersed with much outcropping rock on crests and steeper slopes The *lithosols* are generally loamy and less than 40 cm deep with varying stone and gravel, the *red podzolic soils* range up to more than 1 m in thickness and the red, structured clay subsoils are thicker and more plastic on the lower slopes, where they are often associated with similar mottled *yellow podzolic soils* The surface soils are characteristically dark brownish, crumbly loams *Prairie soils* (Gn3 12, Db3 12, Dy4.12) formed from volcanic rocks and basic dykes occur as a minor component.

3 4 2 Soils Showing Weak Profile Differentiation

Mildly leached dark soils are associated with basic igneous rocks exposed on many slopes in the city and adjoining areas. On freely drained sites on crests and on old land surfaces these rocks have been strongly weathered to give red clay soils, but on slopes and on low rises the characteristic soil is a shallow (80 cm) dark clay. There are three main groups·

(1) *Prairie soils* which have medium-textured surface horizons with crumb structure overlying dark brown or dark grey-brown, blocky structured subsoils.

(2) 'Dark acid clay soils' which have cracking surface layers and blocky structure just below the surface

(3) *Shallow black earths* which are neutral to slightly alkaline cracking clay soils with a self-mulching surface

Prairie soils (Uc1 44) of generally lighter texture occur also on low river terraces in sites where the layering characteristic of alluvial soils has been masked by cumulative incorporation of biological materials

Archerfield landscape (A—shallow *black earths*) This is one of the less extensive landscapes, mainly on the low basalt hills of the Archerfield area and as a minor occurrence at Corinda. The hills have broadly convex crests with concavo-convex side slopes (8–10°) and relatively small foot slopes The dominant soils over the crests and much of the slopes are shallow *black earths* (Ug5.12) derived from moderately weathered basalt Dark clay soils with gley features occur in drainage lines, and a gleyed clay soil, of considerable depth and with gilgai micro-relief, occupies several hectares of the flood plain of Stable Swamp Creek

Brisbane River landscape (Be—*prairie soils*) The gently undulating alluvial lands bordering the Brisbane River form this unit which embraces the flood plain and remnants of possibly two terraces (Fig. 5) The dominant soils are probably *prairie soils* (Um6 23)—weakly developed sandy to loamy forms—occupying the lower terrace which is above the level of all but high floods, such as that of 1974 On the flood plain, subject to irregular flooding and sediment deposition, sandy *alluvial soils* (Uc1.21) are dominant with small areas of gleys on the floors of depressions and channels. Strongly differentiated *solodic soils and solodized solonetz* (variously Dy2, Dy3, Db3 23 or 3 43) and minor occurrences of strongly developed *prairie soils* (Gn3 92) on rounded remnants of the higher terrace, as at Moggill Pocket (Smith *et al.* 1983), make up a relatively small part of the unit.

Brookfield landscape (Br—*prairie soils*) The low hilly lands of this unit are cut in basaltic rock (spilite, an altered sodic basalt). The main soils are gravelly *prairie soils* (Gn3.92), generally less than 40 cm thick, on crests and upper slopes Associated on some slopes are reddish *prairie soils* (Gn3.12) about 50 cm deep to yellow-brown, friable weathered spilite. There are minor occurrences of *lithosols*

Fig. 5. Oblique aerial photograph looking westward over (1) the low hilly to undulating Corinda landscape of red earths with some *krasnozems*, (2) the undulating alluvial lands of the Brisbane River landscape at Mandalay, and (3) the timbered low hills of the Woodridge landscape to the south.

(Um6.41) on crests and of *humic gleys* (Gn3.02) and alluvial soils (Um5.22) on drainage line floors.

Runcorn landscape (Ru—*prairie soils*). This unit is associated with low hills of Early Tertiary basalt in the east of the city, mainly in the Runcorn to Eight Mile Plains area but also at Thornlands, from Lota to Fort Lytton, and at Capalaba and Bald Hills. The hills have convex crests and concave lower slopes and are separated by broad drainage depressions; local relief is up to 30 m. Maximum slope gradient is about 7°.

Prairie soils (Dy4.12) are the major soils of the association, but shallow *black earths* (Ug5.12) occupy almost all of some low hills. 'Dark acid clays' (Ug5.14) are most common on mid to lower positions on slopes, and gleyed clay soils occur in small drainage lines. There are some minor areas of red clay soils on hill crests, both *krasnozems* (Gn3.11) and shallow stony red clays.

Waterford landscape (Wa—'gilgaied acid clays'). This unit comprises flat to slightly uneven plains of clay alluvium with a cover almost entirely of 'gilgaied acid clay soils' (Db4.11 and Gn3.91). The sediments form an extensive high terrace along the Logan and Albert Rivers (Fig. 6) but only a small portion lies within the map limits. Surface drainage is slow and internal drainage very slow, resulting in dominantly grey subsoil colours with some ochrous mottling. These soils are also moderately saline, and deep (more than 1·5 m) grading below into several metres of similar clay coarsely mottled with red and yellow-brown. Small mounds of self-mulching granular clay and larger shallow depressions set in an almost level surface form a crab-hole type gilgai with vertical interval seldom exceeding 10 cm. The soils of the shelf and depression commonly have a paler, hard-setting surface of clay loam or light clay that is a few centimetres thick.

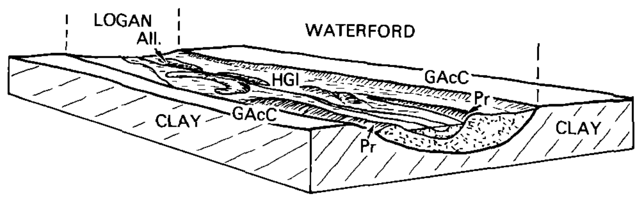


Fig. 6. Block diagram of the Waterford and Logan landscapes, showing the terrace of 'gilgaied acid clay' (GAcC) at Waterford, and the low terraces of *prairie soils* (Pr) and flood plains of *alluvial soils* (All.) and *humic gleys* (HGl) making up the Logan landscape.

3.4.3 Soils Dominated by Sesquioxides

These soils are dominantly red beneath a darker surface layer. Those which are sand to sandy clay throughout, including soils with some texture contrast, are classed as *red earths*; those which have dominantly clay profiles, with surface textures as light as clay loam or loam, are classed as *krasnozems*. Both of these groups may have accumulations of ferruginous nodules below about 1 m and both may have deep subsoils of strongly mottled red and grey clay.

Aspley landscape (As—*red earths* and *krasnozems*). This is a unit of restricted extent. It occurs only in the Aspley–Bald Hills area on broadly rounded hills, up to 45 m high, but includes some alluvial plains extending to Bracken Ridge. The soils are derived from sediments of the Tertiary Petrie Formation (mudstones, siltstones, and clays), many of which have been deeply weathered. *Krasnozems* (Gn3.11) on clays are the dominant soils and occupy crests and upper slopes. With these are associated *red earths* (Gn2.11) on coarser materials and some *red podzolic soils* (Dr3.21, 3.41). *Gleyed podzolic soils* (Dy2.81) occur on the lower slopes and alluvial plains, where they are usually dominant.

Birkdale landscape (Bk—*krasnozems* and *prairie soils*). This landscape occupies low hills of basalt in the Thorneside–Birkdale area and at Eight Mile Plains. The local relief is about 30 m and the hills have small convex crests and long concave slopes to the narrow drainage lines. The dominant soils in the Thorneside–Birkdale area are *krasnozems* (Gn3.11), *prairie soils* (Dy4.12) and 'dark acid clays' (Ug5.14) derived from basalt. *Krasnozems* occur mainly on crests and upper to middle slopes, whereas *prairie soils* and 'dark acid clays' occupy the greater part of the lower slopes. There are small areas of *xanthozems* (Gn3.71) in intermediate positions and minor areas of gleyed clays along drainage lines.

Krasnozems (Gn3.11) occupy the greater proportion of occurrences in the Eight Mile Plains area, extending down to the middle slope position, but are of lesser extent near the coast.

Bracken Ridge landscape (BR—sandy *red earths*). This unit is of limited occurrence, being restricted to low hills of dominantly ferruginous sandstone (9–45 m high) in the Bracken Ridge area. These hills have smooth rounded crests and relatively straight side slopes and are separated by narrow valley floors. *Red earths* (Gn2.11) occur on sandstone on the crests and over much of the slopes although there may be some areas of earthy *krasnozems* (Gn4.11) on shales and clays. There are minor areas of gleys and of *gleyed podzolic soils* (Dy5.31) on the lower slopes and in drainage lines.

Clayfield landscape (Cl—*red earths*) This unit occupies low to moderately high hills from Eagle Junction to Ascot, it includes some low rounded spurs (10–20 m above sea level), between the hills as well as the adjoining alluvial plains. The valleys crossing it are broad and shallow. The soils are derived from Mesozoic sandstone (possibly Tingalpa Formation), and gravelly clays of uncertain age (possibly Tertiary or younger colluvium) All of the parent materials are deeply weathered. The most common soils are deep *red earths* (Dr4 21) with distinct duplex profiles and mottled deep subsoils, shallower sandy *red earths* occur on low sandstone spurs and gravelly *krasnozems* (Gn3 11) in gravelly clays

Corinda landscape (Co—*red earths*). This unit extends from Oxley through Corinda to Graceville and occupies low hills (about 60 m above sea level) with rounded crests and gentle side slopes; some low convex hills are included also The soils are derived from deeply weathered Tertiary sediments, a small area of basalt, and from local colluvium and alluvium *Red earths* (Gn2.11) are the major soils on the highest slopes of these hills with some areas of *krasnozems* (Gn3 11) on the mid slopes and possibly on the lower hills. *Gleyed podzolic soils* (Dy2 81) occur along drainage lines

Elphinstone landscape (El—stony *krasnozems*) These are steep hilly lands on spilite *Krasnozems* (Gn3.11), often stony to bouldery and probably shallower than 1 m, are the main soils on slopes and crests, these latter may be remnants of an old land surface. *Lithosols* (Um6) are associated soils on the steeper ridges and slopes *Euchrozems* (Gn3 12) occur in some areas, and *red podzolic soils* (Gn3 14) on colluvium are of minor importance.

Manly landscape (M—*red earths* and *krasnozems*) This unit occurs only in the Manly-Wynnum-Lota area on a gently undulating surface (15–45 m above sea level) and the associated lower slopes. The parent materials of the soils are Mesozoic and Tertiary sandstones or Tertiary basalt and exercise strong control over soil distribution *Red earths* (Gn2 11) derived from the sandstones generally occur at higher levels than the *krasnozems* (Gn3 11) on basalts, e g. west of Manly, but near Wynnum they are at approximately the same level Small areas of *red* and *yellow podzolic soils* (Dr3 41 and Dy3 41) occur on slopes leading to the drainage lines and there are *gleyed podzolic soils* (Dy2 81) on the broad flat alluvial plains.

Moggill landscape (Mo—*krasnozems*) This unit occupies a small plateau (60 m above sea level) at the south-western limit of the mapped area It is apparently the remnant of an extensive surface overlying semi-consolidated and deeply weathered Cainozoic sediments Deep *krasnozems* (Gn3 11, 3 14) formed in clays are dominant on the gently convex surface Associated are deep *red earths* (Gn2.11) formed from sandier parent materials and moderately deep, gravelly *red podzolic soils* (Dr2.44) overlying clayey conglomerates on marginal areas where slopes are generally more than 4° (Smith *et al* 1983)

Redlands landscape (R—*krasnozems*) Deep *krasnozems* (Gn3 11) on broadly convex and elongated hills (30–45 m above sea level) along the coast, south of Wellington Point, make up the Redlands landscape (Fig 7). These hills have straight or concave lower slopes and have formed during the dissection of a thick

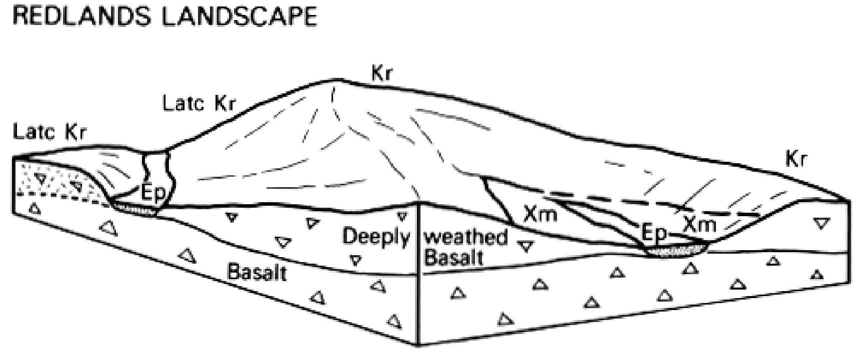


Fig. 7. Block diagram of the Redlands landscape, showing the distribution of *krasnozems* (Kr), lateritic *krasnozems* (Latc Kr) and *xanthozems* (Xm) and of weathered and fresh basalt (Ep, Eprapah landscape).

mass of lateritised clay derived from basalt. Sections fronting the coast have been cut back by wave attack to almost vertical cliffs.

The *krasnozems* (Gn3.11) and related lateritic *krasnozems* occur on almost all parts of the landscape (see also Powell 1982). Most overlie mottled clays although some grade directly into weathered basalt. There are minor areas of *red earths* (Gn2.11) on sediments associated with the basalts, and of *xanthozems* (Gn3.71) and *prairie soils* (Gn3.92) on lower hillslopes. The southern occurrences along the coast are represented by the preceding description. The Boondall and Nudgee areas are also dominantly *krasnozems*, but the profiles are sandier.

Sunnybank landscape (S—lateritic *red earths*). Remnants of low plateaus (30–90 m above sea level) which were traversed by minor drainage lines occur south of the city, in the Sunnybank–Rochedale area (Fig. 8). These plateaus are dominated by red soils derived from Tertiary sandstones and from sandy and gravelly alluvium. The plateau edges may be defined by relatively steep scarps or

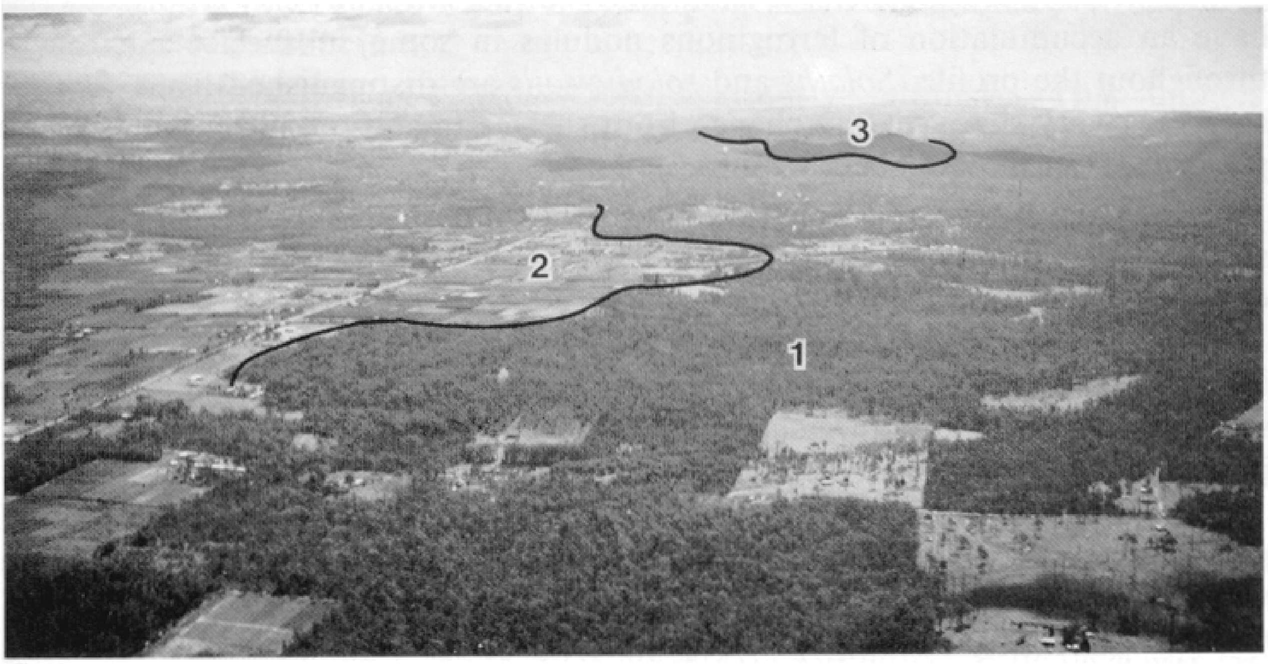


Fig. 8. Oblique aerial photograph looking north-west towards Rochedale over (1) the timbered hills of *red-yellow podzolic soils* of the Woodridge landscape, to (2) the undulating plateau of *red earths* of the Sunnybank landscape and (3) the high hills of *lithosols* of the Mount Cotton landscape.

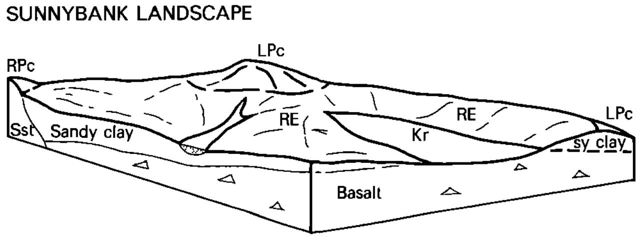


Fig. 9. Block diagram of the Sunnybank landscape, showing the relationships of *red earths* (RE), *lateritic podzolic soils* (LPc), and minor red–yellow *podzolic soils* (RPc) and *krasnozems* (Kr); Sst is sandstone.

may grade into a high-level gently undulating surface. The dominant soils are *red earths* with either gradational (Gn2.11) or duplex (Dr4.21) textural profiles. Many of these have layers of nodules and they commonly overlie mottled deep subsoils. *Lateritic podzolic soils* (Dy5.41) occur in close association with the *red earths*, at higher levels, intermingled with them or just above the scarps (Fig. 9). Minor soils include *krasnozems* (Gn3.11) and some *red* and *yellow podzolic soils* (Dr3.41, Dy3.41) on plateau surfaces, and gleyed soils and *humus podzols* (Uc2.33) along drainage lines.

3.4.4 Soils with Markedly Differentiated Profiles

The commoner soils of the city are those with 'duplex' profiles (Northcote 1979), i.e. soils with coarse textured sand–sandy loam surface horizons fairly sharply separated from sandy clay or clay B horizons. These have the common connotation 'podzolic' soils, from the lighter colour of the immediate subsurface, just above the clay; and are subdivided according to other properties of the profile. *Red*, red–yellow, or *yellow podzolic soils* have these colours in the generally blocky-structured clay subsoils. *Lateritic podzolic soils* have sandy profiles with a gradual or sharp texture increase from sandy surfaces to sandy clay B horizons and have an accumulation of ferruginous nodules in some subsurface horizon or throughout the profile. *Soloths* and *solodic soils* are distinguished from *podzolic soils* by a very sharp texture change from surface to subsoil and a tougher, less permeable but more dispersive subsoil.

Beenleigh landscape (B—red–yellow *podzolic soils*). The Beenleigh soil landscape is one of the more extensive units, particularly in the south-east of the area. It occupies low hills and spurs up to 120 m elevation and with a local relief of 15–30 m. These hills have narrow convex crests, straight side slopes and narrow foot slopes; the included alluvial plains are also narrow. The parent materials of the soils are metamorphosed Paleozoic sedimentary rocks, particularly greywackes, phyllites and quartzites, with minor areas of a basic igneous rock.

Red–yellow *podzolic soils* (Dr3.21, 3.41, Dy3.41, 5.41) are dominant, red profiles being more common on hill crests and on some upper slopes, and the mottled or yellow profiles on lower slopes (Fig. 10). *Lithosols* (Um2.12) with loam textures are common on many hill crests and on some of the steeper slopes. Most of these soils have hard-setting surfaces. There are minor areas of *krasnozems* (Gn3.11) associated with a basic igneous rock and small areas of *gleyed podzolic soils* (Dy2.81) on the alluvial plains.

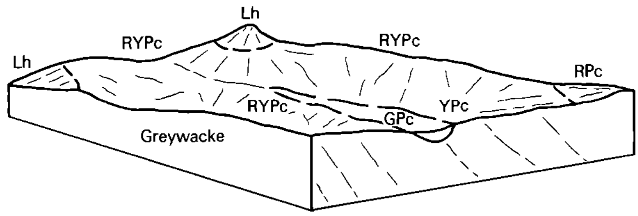


Fig. 10. Block diagram of the Beenleigh landscape, showing the relationships of *lithosols* (Lh) and *red* (RPc), red-yellow (RYPc), *yellow* (YPc) and *gleyed* (GPc) *podzolic soils.*

Boombana landscape (Bo—*red podzolic soils*). A small area of steep hilly scarpland, cut in granodiorite and small inclusions of andesitic rocks, form this unit. *Red podzolic soils* (Dr2.61) under wet sclerophyll forest appear to be dominant, with *lithosols* under dry sclerophyll forest as associates. Minor areas of stony *solodic soils* (Dy3.42) occur on the andesite outcrops as at Jolly's Lookout.

Coopers Plains landscape (CP—red-yellow *podzolic soils*). This unit occupies the slopes below the surface of the red earth plateaus in the Coopers Plains-Springwood area and similar slopes of other hills at about the same height. The soils are derived from coarse sandstones of the Moorooka and Sunnybank Formations, and from small areas of basalt similar to those associated with the Runcorn and Birkdale soil landscapes. Red-yellow *podzolic soils* (Dr3.41, Dy3.41) with sandy surface horizons and *lateritic podzolic soils* (Dy5.41) are dominant. Associated are some *soloths* (Dy3.41) and *solodic soils* (Dy3.42, 3.43) with sharp boundaries to clay subsoils of coarse, blocky structure and firm to tough consistence. Minor soils include a number of shallow dark clay soils on basalt and *gleyed podzolic soils* (Dy2.81, 3.81) on alluvium.

Darra landscape (Da—*podzolic soils,* variously mottled). This unit is characterised by rolling to undulating topography and *podzolic soils* (Dy3.41) with subsoils variously mottled but dominantly grey-brown and yellow-brown with some red. The forms with denser subsoils tend towards *soloths* (Dy3.41). The soil parent materials are derived from sandstones, mudstones and siltstones of the Darra Formation and generally have strongly clayey subsoils. Local relief is only 15-20 m and slopes are dominantly gentle to moderate. Surface drainage is usually free but internal drainage is strongly impeded by the rather dense medium to heavy clay subsoils at relatively shallow depth.

Jamboree landscape (Je—gravelly *yellow* and *red podzolic soils*). Gravelly *yellow* (Dy3.31, 3.41) and *red podzolic soils* (Dr3.31, 3.41) with mottled clay subsoils dominate this low hilly unit. They are formed in parent materials weathered from the Ipswich Coal Measures, i.e. lithic and feldspathic sandstones, shales and conglomerates. Associated are gravelly *lithosols* with bleached A2 horizons (Um2.12) and minor areas of shallow *gleyed podzolic soils* (Dy2.81). Elevations range from 15 to 60 m and slopes are gentle to moderate, rising to rounded crests. Most of the soils have free surface drainage.

Kenmore landscape (Ke—gravelly *red podzolic soils*). This is hilly terrain with moderate slopes cut in the Neranleigh–Fernvale Formation of weakly metamorphosed sedimentary rocks. Differences in the parent rocks are reflected in the features of the soil profiles. The dominant *red podzolic soils* (Dr2.21, 2.41, Dr3.41) are formed in weathered shale and phyllite on hillslopes and benches. Associate soils are podzolic *lithosols* (Um2.12) on hill crests over a range of parent materials and *yellow podzolic soils* (Dy3.41) on greywacke. There are minor occurrences of *solodic soils* (Dy3.43) formed in freshly weathered shale or in alluvium on some lower slopes, and *gleyed podzolic soils* (Gn2.94), *humic gleys* (Gn3.01, 3.02) and *alluvial soils* (Um5.22) along creek flats.

Nundah landscape (Nu—red-yellow *podzolic soils*). This is a unit of low hills (up to 40 m above sea level) mantled by soils with texture-contrast profiles formed in materials derived from lithic sandstones, shales and clays. Broad rounded crests grade into straight to slightly concave slopes; drainage is free except on the floors of the drainage depressions. The dominant Dy3.41 and Dr3.41 soils, mainly occupying middle to lower slopes but extending onto some upper slopes, are probably intergrades between red-yellow *podzolic soils* and *soloths*. Minor soils include somewhat clayey *red earths* (Gn2.14) on hill crests, and *gleyed podzolic soils* (Dy2.81) on valley floors.

Park Ridge landscape (PR—*lateritic podzolic soils*). The Park Ridge soil landscape occupies low hills (75–90 m above sea level) which form a gently undulating surface to the south and south-east of the city; slopes to drainage lines are gentle to moderate (Fig. 11). The parent materials of the soils are weathered grits and coarse sandstones of the Triassic Moorooka Formation and coarse colluvial materials derived from them.

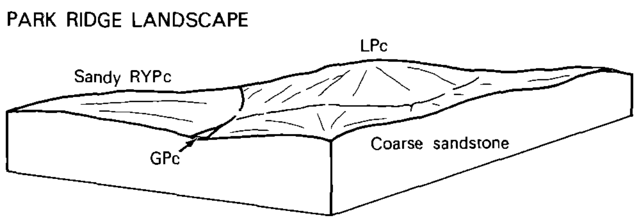


Fig. 11. Block diagram of the Park Ridge landscape, showing the relationships of *lateritic* (LPc), sandy red-yellow (RYPc) and *gleyed* (GPc) *podzolic soils*.

The dominant soils are *lateritic podzolic soils* (Dy5.41, 5.61, 5.81) on higher areas and *red-yellow podzolic soils* (Dr3.41, Dy3.41) with thick surface horizons of sand. Profiles intermediate between these two groups are common. Associated with these major soils are red-yellow *podzolic soils* with thinner surfaces and sandy *lithosols* (Uc1.21), the principal control of soil type being parent material. *Gleyed podzolic soils* (Dy2.81) are minor soils along the floors of drainage lines.

Samford landscape (Sa—*soloths*). This is a unit of low hilly lands on granodiorite. The soil data are largely inferred from observations beyond the Brisbane area, mainly near Samford (Thompson and Murtha 1960). Sandy *soloths* (Dy3.41) are likely to be the dominant soils. Smaller areas of *yellow podzolic soils* (Dy3.41), with weaker texture-contrast and more permeable subsoils than those of the

Fig. 12. Oblique aerial photograph of (1) the Toowong landscape (middle distance and foreground) bordered by (2) the Brisbane River landscape at St Lucia, with (3) the Moggill Creek landscape along Sandy Creek at the Indooroopilly golf course, and (4) a small area of the Chermside landscape at the University.

soloths, and minor areas of *lithosols* (Uc4.1) on some crests and *red podzolic soils* (Dr2.41) on gently sloping well-drained sites also occur.

Toowong landscape (T—*red podzolic soils*). Low hilly lands cut in the Bunya phyllites, e.g. the Toowong–Indooroopilly area, make up this unit (Fig. 12). Elevation ranges from 8 to 75 m and slopes from moderate to gentle; many of the steeper upper slopes and narrow crests show irregular outcropping rocks. *Red podzolic soils* (Dr4.21, 4.41) are dominant and are shallow to moderately deep, with much fine angular quartz and phyllite gravel in their A horizons and with structured or moderately dense red heavy clay B horizons (Figs 4*d*, 13). Thin gravelly *lithosols* (Um4.11–Um3.11) with a pale pinkish subsurface horizon are intermingled with shallow *red podzolic soils* (Dr2.21) in the higher parts of the landscape (cf. Koppi 1981). The moister footslope sites are occupied by deep, mottled red–yellow *podzolic soils* (Dr5.41, Dy5.41) with a coarsely mottled yellow-brown and light-grey stiff plastic to friable clay horizon in the deep subsoil. Where alluvium has accumulated on the drainage floors, there are minor areas of *gleyed podzolic soils* (Dy2.81) and *humic gleys* (Dy5.11).

Witty landscape (Wy—gravelly *red podzolic soils*). The low hilly terrain flanking the Moggill landscape makes up this unit which is formed in unconsolidated gravel beds, clays and weakly consolidated sandstones of Quaternary age. Elevation ranges from 30 to 60 m and slopes are generally moderate, rising to steeper gradients along the plateau margin. The dominant *red podzolic soils*

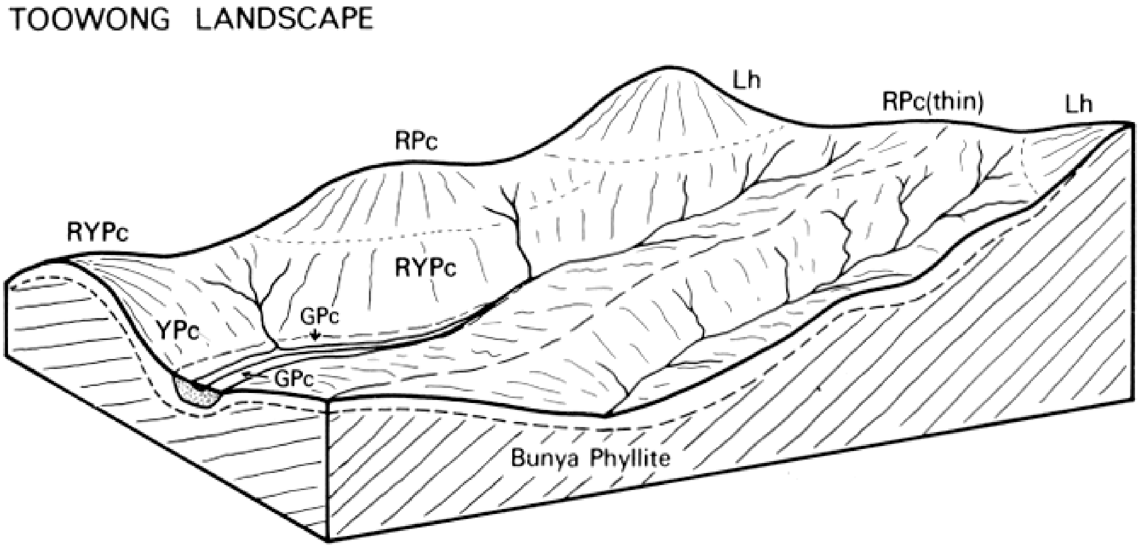


Fig. 13. Block diagram of the Toowong landscape, showing the relationships of *lithosols* (Lh), and *red* (RPc), red-yellow (RYPc), *yellow* (YPc) and *gleyed* (GPc) *podzolic soils* over Bunya phyllite.

(Dr2.21) occupying upper and middle slope sites have much water-worn gravel accumulated in their A horizons. Associated, on the lower slopes, are mottled *yellow podzolic soils* (Dy3.21). There are minor areas of *krasnozem–red earth* intergrade soils (Gn3.14–Gn2.14), on isolated rounded crests which are eroded remnants of the plateau surface.

Woodridge landscape (W—red-yellow *podzolic soils*). This soil landscape occurs on low convex hills and ridges south of the Brisbane River, and on a gently undulating surface (up to 60 m above sea level) which has narrow alluvial plains (Figs 14, 15). The soils are derived from sedimentary rocks of the Triassic Tingalpa Formation—clayey sandstones, sandy mudstones, clays, shales and some coarse sandstones. *Red-yellow podzolic soils* (Dr3.41, Dy3.41) with moderately thick (30 cm or more) surface horizons are dominant and occur in all positions on slopes

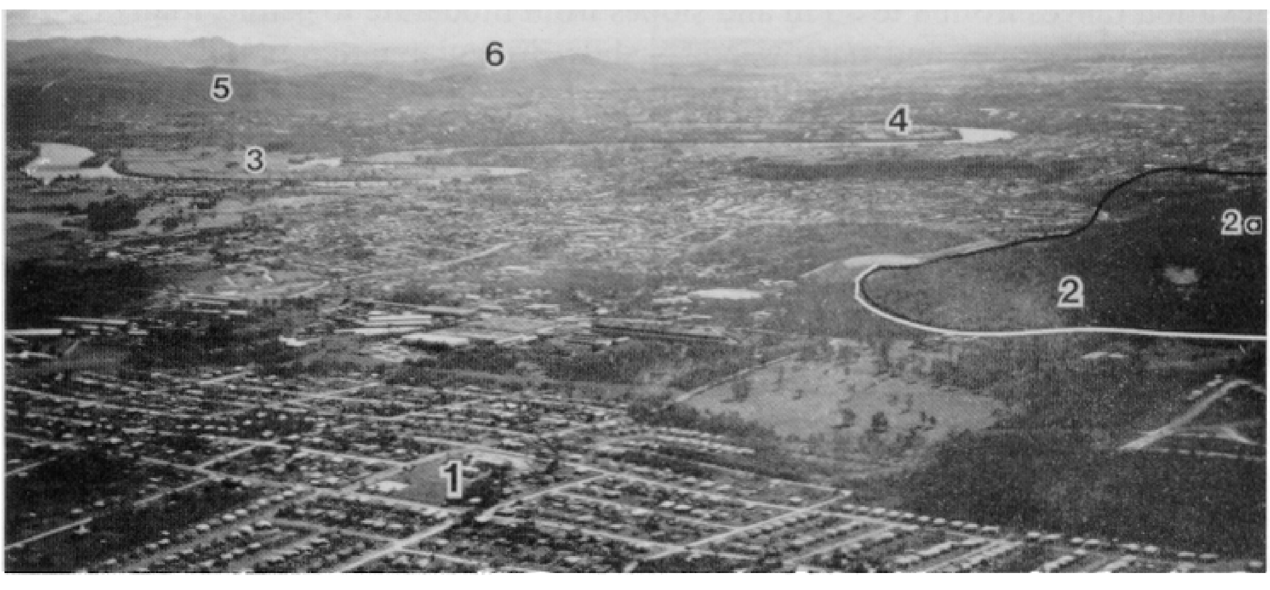


Fig. 14. Oblique aerial photograph looking north-west from Salisbury over (1) the Woodridge landscape and (2) the Pullenvale landscape at (2a) Toohey Mountain, with (3) Long Pocket and (4) St Lucia in the middle distance to (5) Taylor's Range and (6) The Gap.

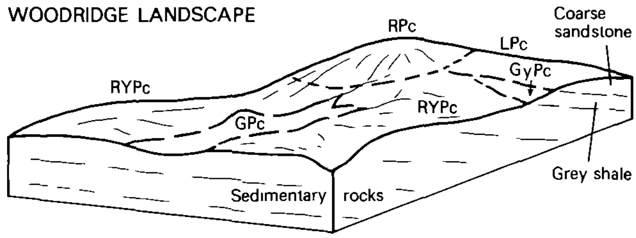


Fig. 15. Block diagram of the Woodridge landscape, showing the relationships of *red* (RPc), *lateritic* (LPc), red-yellow (RYPc), *grey* (GyPc) and *gleyed* (GPc) *podzolic soils* on sedimentary rocks.

(Fig. 15). *Lateritic podzolic soils* (Dy5.41) and *gleyed podzolic soils* (Dy2.81) are minor components, the *gleyed podzolic soils* occurring on the upper parts of minor drainage lines. The distribution of these is related to particular parent materials and/or topographic position. *Humic gleys* (Dy5.11) and 'peaty gleys' occur at lower sites in the drainage lines.

3.4.5 Soils Showing the Influence of Poor Drainage

Soils in low-lying sites on modern or former flood plains and on low coastal plains show gley features which are the result of intermittent or permanent poor drainage. Gley features include dull colours in surface horizons and coarse mottles of yellow and grey in the subsoil. The *humic gleys* have dark highly organic surface horizons to 30 cm over coarsely mottled subsoils; the *gleyed podzolic soils* have weakly differentiated profiles with grey surface layers and grey and yellow clay subsoils.

Blunder landscape (Bl—*gleyed podzolic soils* and *siliceous sands*). A mixed assemblage of weakly developed soils formed in dominantly sandy alluvium in the shallow valleys of Oxley and Blunder Creeks comprise this unit. Drainage is generally imperfect to poor. Knowledge of the soils is limited but sandy *gleyed podzolic soils* (Dg3.81-4.81) and *siliceous sands* (Uc1.4) are common with lesser occurrences of sandy *alluvial soils, humic gleys, humus podzols* (Uc2.33) and *podzols* (Uc2.36). Small areas of *soloth* (Dy3.41) or *solodized solonetz* (Dy3.42) are associated with a low terrace and bordering areas of colluvium.

Eprapah landscape (E—*gleyed podzolic soils*). Low terraces and the flood plains of small streams from Redland Bay to Capalaba and from Northgate East to Zillmere form the Eprapah landscape. The terrace surface is almost flat and about 3-5 m above the stream (Fig. 16). The flood plains are small and uneven, including some low banks representing old levee banks. *Gleyed podzolic soils* (Dg2.81) with silty textures are the dominant soils on the high terrace; on the flood plains, *humic gleys* (Dy5.11) and *alluvial soils* (Uc1.21) are the most extensive, with *prairie soils* (Um6.23) on the banks.

Lota landscape (Lt—*humic gleys* and *siliceous sands*). Small alluvial plains between low spurs along the coast are included in the Lota soil landscape. They differ from Woongoolba (see below) in that broad depressions are absent and sand ridges or sets of sand ridges, generally less than 4 m above sea level, are more extensive. *Siliceous sands* (Uc1.21) are the dominant soils on almost all of the sand

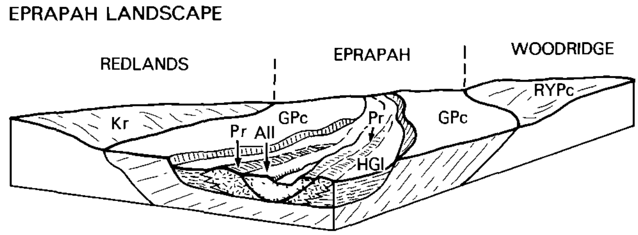


Fig. 16. Block diagram of the Eprapah landscape, showing its *gleyed podzolic soil* (GPc) on a terrace, *prairie soils* (Pr) on low terraces and *alluvial soils* (All.) and *humic gleys* (HGl) on flood plains, the relationship to the adjoining *krasnozem* (Kr) and red-yellow *podzolic soils* (RYPc) of the Redlands and Woodridge landscapes respectively is also shown.

ridges. Gravelly sands, consisting of ferruginous sands cemented in places into pebbles or blocks, occur in the Cleveland–Redland Bay area. *Humic gleys* (Dy5.11) with minor areas of 'peaty gleys' are dominant on the plains. Sands containing shell fragments occur south of Cleveland Point, whereas the occurrences near Birkdale are dominantly gleys.

Moggill Creek landscape (MCk—*gleyed podzolic soils*). The narrow alluvial plains of Moggill Creek and other minor drainage lines joining the Brisbane River from the steep hilly lands in the south-western part of the area form this unit. Poor drainage is a feature of the soils and there is occasional flooding during the wet season. The dominant soils are *gleyed podzolic soils* (Dg3.41) with sandy to loamy surface horizons and mottled grey and yellow-brown sandy clay or heavier subsoils. Small occurrences of *alluvial soils* (Uc1.21, Um6.2) and weakly developed *prairie soils* (Um6.23) and (where the tributaries drain areas of volcanic rocks) small areas of *humic gleys* occur.

Swamp (Sw—*humic gleys*). Several small areas of dominantly swampland have been mapped near the coast and there are minor inclusions within other soil landscapes of the coastal plain. Most are closed depressions or remnants of former shallow drainageways. The soils are *humic gleys* (Dy5.11) and variants with much more-organic (peaty) surface horizons 10–20 cm thick. They have formed mainly in clayey alluvium but also in sandy sediments under a water regime determined by a permanent water table close to the surface and with intermittent flooding.

Willawong landscape (Wg—*gleyed podzolic soils*). This is a unit of low-lying, near-level plains (5–16 m above sea level) made up of fine-to-medium grained, sandy alluvium with some clay lenses, low sand banks and contributions from shallow-lying sandstone and siltstone. Soil information is limited but sandy *gleyed podzolic soils* (Dy2.81) appear to be dominant. Associated are *podzolic soils* with thick sandy A horizons (Dy3.41), *soloths* with thin loamy ones (Dy3.41), both of which have mottled clay subsoils, and some *solodic soils* (Dy2/3.42). There are smaller occurrences of *humus podzols* (Uc2.20), *podzols* (Uc2.21) and *siliceous sands* (Uc1). The underlying sandy sediments are commonly saturated at various depths.

Woongoolba landscape (Wo—*humic gleys*). The flat to gently undulating plain, which is less than 3 m above sea level, extending along the coast from north

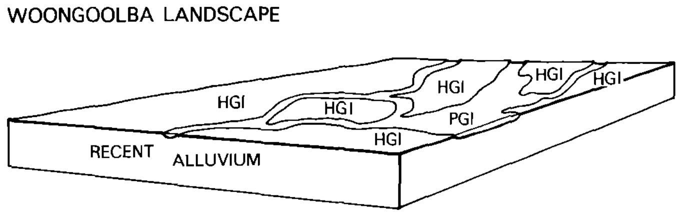


Fig. 17. Block diagram of the Woongoolba landscape, showing the relationships, on Recent alluvium, of *humic gleys* (HGl) on plains and 'peaty gleys' (PGl) in swamps.

of the Brisbane River to Sandgate makes up most of the area of Woongoolba landscape (Fig. 17; see also Powell 1974). There are also small areas along the floors of some stream valleys. *Humic gleys* (Dy5.11) with sandy or clayey profiles are the dominant soils in this unit and occur on the higher flat surface. 'Peaty gleys' occupy the swampy depressions and there are minor areas of *solonchaks* (Um5.4) on small saltmarshes. Low sand banks with *siliceous sands* (Uc1.21) occur in a few places.

4. Soil–Use Relationships

4.1 Introduction

Interest in the soils of Brisbane and its south-eastern environs centres mainly on the way in which their properties affect their suitability for:

(1) foundations of buildings, roads and other structures;

(2) gardening and intensive horticulture, such as tropical fruits, vegetables and cut flowers;

(3) grazing in fringe areas, involving some improvement of pastures, and small areas of fodder crops.

Suburban development combines all three of these uses, lawns substituting for pastures. Discussion of the soils in relation to their use then condenses to questions of their suitability as media for plant growth and as foundations for structures.

The soil cover has no importance in the inner city area and on any sites developed for high rise or heavy commercial buildings. For these uses, load-bearing capacity of the underlying materials and depth to rock or other firm foundations are the important considerations. Except in some parks, most of the soils have long since been stripped or mixed with the underlying weathered materials during site preparation for buildings and roads.

In the suburbs, soils are of varying importance for the uses listed above. Also, in non-sewered areas, soils are used for disposal of septic tank effluents and domestic drainage. The kind of soil is of greatest interest on level areas, where it is normally deep, and of less importance on moderate to steep upper slopes and narrow ridge crests, which characteristically have a thin and patchy soil cover from which water is shed down-slope. For gardening and lawns in this zone, unfavourable soils are either partially replaced with better, imported soil materials used in deep mixing of the natural soil or after removal of the surface layer, or they are greatly modified and improved by addition of a variety of fertilisers, compost etc.

The character of Brisbane soils has greatest significance in the dominantly rural land extending south-easterly from the suburban margin to the bay-side Initially, the soil type largely determined land use in this area. the *krasnozems* and *red earths* of the lands bordering the bay and in the Sunnybank–Rochedale area were developed for tropical fruits and vegetable production because of their suitable physical properties, the better-watered but poorer *podzolic soils* of the plains and gently undulating lowlands were cleared for pastures, and the poorest soils of hilly lands (*lithosols* and *shallow podzolics*) were left under native forest, providing some timber and sparse grazing. In recent years, the pressure of urban expansion has resulted in continuing displacement of horticulture by houses on the favoured red soil lands, leading to some spreading of these activities to the sandy *podzolic soils*, e.g. grape-growing in the Richlands area At the same time, there has been increasing subdivision and development of the grazing areas on poor soils, as small farms and farmlets or acreage blocks (4–10 hectares), accompanied by some further pasture improvement

4.2 Soils and Plant Growth

The main soil properties influencing plant growth are the surface soil structure, the moisture characteristic and the soil water regime (physical properties), and the soil reaction, the content and availability of plant nutrients, and the concentration of toxic materials, principally soluble salts Few laboratory data are available for representative sites sampled within the area covered by the map, and many of those recorded in Appendix 1 have been reported previously (Beckmann and Reeve 1972). The following general discussion is based on these and the known properties of other representatives of the same soil groups It also summarises observations and experience of their behaviour in use.

4 2 1 Soil Physical Properties and Limitations

Overall, the range in physical properties of the soils is very wide, from those of the porous structureless sands to those of the strongly structured cracking clays and *krasnozems*. However, over the greater part of the mapped area three physical limitations for plant growth are common.

(a) Surface soil structure

Most of the soils either have little or no structure in the surface horizon, and therefore tend to compact and set hard or crust on drying; where there is moderate structure in the virgin condition, this deteriorates rapidly under intensive use In both cases, the tilth of cultivated soils tends to collapse under heavy rains or prolonged wetting, aeration is reduced, and soil–water relations are impaired, increasing run-off and erosion.

The *podzolic soils* and *lithosols* are generally the most affected, including some with sandy surface horizons. Generally, these have low organic contents, very little structure, and loamy textures resulting in low porosity when they slake Some, like the loamy *red podzolic soils* of the Toowong unit, develop moderate crumb–granular structure under a full cover of plant litter or couch grass sward but lose this very rapidly when used in gardens. Heavy composting is necessary to maintain a moderate tilth in these and similar soils. Even some of the permeable *krasnozems* (and to a lesser extent *red earths*) which have higher organic contents and moderate crumb structure (generally considered rather durable) have suffered serious deterioration under the intensive cultivation used in commercial vegetable growing. Heavy additions of organic matter, through green manuring or poultry manure, are then necessary to maintain reasonable surface conditions.

The dark soils formed from basalt (*prairie soils*, 'dark acid clays' and *black earths*) also have moderate to strong crumb–granular surface structure and, despite relatively low organic contents, tend to hold it fairly well under average cultivation. The 'gilgaied acid clays' of the same general type are poorer in these respects and have less-durable surface structure

Some of the *humic* and 'peaty gleys' (such as those of the Woongoolba unit with moderate clay and high organic contents) have the strongest development and most stable surface soil structure in the area but drainage problems, due to their low-lying situations and high water tables, have restricted their use under cultivation. Where they have been used for horticulture, e g. near Brisbane Airport, raised beds have been used to reduce drainage problems

(b) Available water storage capacity and soil water regimes

Most of the freely drained upland soils have rather low 'available water' storage capacity (AWC) within the main rooting depth (50–75 cm) for all but the deeper-rooting tree crops. This aggravates drought problems during the hot rainless periods that are a feature of the late spring–summer growing season in the majority of years. Thus, the 45 mm of available water stored in the top 60 cm of a *krasnozem* at Redland Bay after thorough wetting by rain (A. S. Black, personal communication) would be exhausted and plants would wilt after 10 average rainless days in November, December or January. Plant growth, however, would be severely reduced in a much shorter period. The mean potential evapo-transpiration during mid summer is estimated at about 125 mm depth of water per month or 4 mm per day For very hot days, the potential evapotranspiration may be 7 mm or more per day (G B. Stirk, personal communication).

The low AWC–drought problem is greatest on the shallow sandy and loamy *lithosols* on ridge crests and upper slopes. These soils lose water by rapid runoff from heavy rains and mostly drain excessively. In some, water may be perched temporarily in the subsoil overlying slowly permeable rock, thus providing some additional water for plant growth. Low AWC is also a problem in deep sands, in the *lateritic podzolic soils* and *podzols* and in other soils with thick sandy upper horizons. It is quite important, too, in the deep permeable *krasnozems* and *red earths* used for vegetables and other shallow rooted crops in these cases, the deeper soil cannot compensate for low storage in the main rooting zone and supplementary irrigation is necessary for successful cropping where uninterrupted plant growth is required. Water stored below 60–70 cm depth can be used more effectively by tree crops and pastures.

The moderately deep, freely drained *podzolic soils* on slopes are also rather drought-prone, despite the higher water storage capacity of their clay subsoils. The *red podzolic soils* formed on phyllite in the Toowong landscape afford a good example: as much as 50% of the relatively thick A horizons consist of fine quartz and phyllite gravels which have essentially no AWC, and their freely drained, red kaolinitic clay subsoils have only moderate water-holding capacity. After saturation of these soils by heavy rains in mid summer months, pastures and lawns on middle slope sites will exhaust the stored available water and show signs of stress after about two rainless weeks. The deeper *podzolic soils*, including some gleyed soils on lower slopes, can provide available water for longer periods because of their thicker and more organic A1 horizons, and thicker more-clayey B horizons. Extra available water is also held in the saturated A2 and upper B horizons following heavy rains, and may be received from higher sites by surface flow and by downslope drainage within the solum and occasionally through the C horizons. Pastures often continue growing on these soils and sites when those on midslopes have burnt off through drought, but where no artificial drainage is provided, periods of saturation of the A horizons also reduce plant growth.

Some of the highly organic and strongly structured clayey *humic gleys* have the highest AWC values in the upper part of the profile For these, as for the *gleyed podzolic soils* of the drainage depressions and other sites having shallow water tables, water from this source greatly extends the period of water availability during drought However, seasonal flooding and poor drainage of these soils pose problems for pasture (Ebersohn *et al* 1973) and crop production, and some artificial drainage is usually necessary On the small areas still used for horticulture and vegetables, crops are normally grown on raised beds to increase the depth of drained soil above average water tables and to reduce the effects of minor flooding associated with heavy rains

Moderate AWC values are characteristic of the dark soils containing swelling clays (*black earths*, 'dark acid clays' and *prairie soils* on basalt and the 'gilgaied acid clays'), and *prairie soils* of the Brookfield and Brisbane River units. A clayey *prairie soil* at Samford, similar in character to those of the Brookfield unit has an AWC of 86 mm depth of water for its 60 cm solum depth Brookfield *prairie soils* that are much shallower than 60 cm would have much lower AWC except where underlain by clayey weathered rock which behaves more like soil. Apart from infrequent shallow river flooding, the minimal *prairie soils* of the Brisbane River unit probably have the best water regimes of all of the well-drained soils, combining good AWC with free infiltration of rain and good internal drainage

(*c*) *Drainage*

Owing to the heavy rains and prolonged rainy periods that are common in the spring–summer growing season in most years, good soil drainage is particularly important for agricultural use and especially for intensive horticulture Many of the district soils have drainage problems of varying severity affecting use, management practices and productivity Apart from the low-lying lands of the coastal fringe which are subject to occasional tidal flooding, the more important drainage problems in order of decreasing severity are.

(1) Permanent water tables at depths of <1 m during the growing period The main affected soils are the *humic gleys*, 'peaty gleys' and some *gleyed podzolic soils* of low-lying near-level areas, particularly the Woongoolba unit and alluvial flats along creeks. These soils owe their distinctive features to the influence of water tables; they also have some surface drainage problems because of slow runoff after heavy rains, short-term flooding of confined creek flats, and water tables rising to the surface during these periods

(2) Temporary perched water tables resulting from impedance of internal drainage by clay subsoils underlying more permeable surface horizons

Gleyed and other *podzolic soils* with dense clay subsoils and *soloths* are the main soils affected, especially where they occur on lower slopes receiving water from higher sites by surface flow and seepage. Even some *lithosols* that are underlain by *platy rock* on gently sloping sites may be saturated in a subsurface horizon for short periods after heavy rain

(3) Slow internal drainage of the swelling clay soils due to their very fine pores and low hydraulic conductivity These soils (*black earths*, 'dark acid clays' and *prairie soils* on basalt and 'gilgaied acid clays') are very sticky when wet and puddle if worked in this state, still further slowing their drainage For agricultural or urban use, good surface drainage is essential to remove water in excess of infiltration capacity.

(4) Impeded drainage resulting from deterioration of soil structure and porosity in the upper profile of *krasnozems* due to continued heavy cultivation In these normally freely drained soils, this decline has been sufficient to affect shallow-rooting vegetable and other crops during very wet periods.

4 2 2 Chemical Properties and Limitations

(a) Soil reaction

Most of the soils are acid, and many, particularly the various *podzolic groups* (e.g. Appendix 1 13), *podzols* or *humus podzols* (e.g Appendix 1 17), *lithosols* and gleys are strongly acid with pH values of 5 5–5 0 in both surface and subsoil. The main exceptions are the *black earths* (e.g Appendix 1 4) and the *prairie soils* (e.g. Appendix 1.2) formed from basalt, which tend to have slightly acid surface soils but alkaline subsoils. The *prairie soils* on Brisbane River alluvium are also generally mildly acid to neutral at the surface but alkaline in the strongly developed forms on terrace remnants The *krasnozems* and *red earths* (respectively Appendixes 1.10 and 1 8) commonly have mildly acid surfaces, moderately acid subsoils and strongly acid deep subsoils

Generally mildly acid to neutral reactions (pH 6–7) are favourable to a wide range of plants and to the overall availability of nutrient elements, striking a balance between reduced availability of some under more acid conditions and of others under alkaline conditions. For suburban gardening, some liming of moderately to strongly acid surface soils to reduce their acidity is desirable, except for such plants as azaleas which do better under acid conditions Some *krasnozems* of the Redlands area, which have been heavily fertilised with ammonium sulfate in intensive vegetable production, have become more acid, with values down to pH 5, and have developed 'acid soil problems' which are not yet fully understood Similar problems have been encountered on some naturally strongly acid *podzolic soils*

(b) Soil nutrient status

Major elements Available chemical data (Appendix 1; Beckmann 1967; Beckmann and Reeve 1972) are all for virgin soils and show generally very low contents of the major plant nutrients phosphorus (P), potassium (K), nitrogen (N) and calcium (Ca). The few soils with higher contents have fair but adequate levels of Ca and K only. These better soils are:

for Ca, the *black earths* (e.g Appendix 1.4), the *prairie soils* (Appendix 1 2) and surface horizons of the *krasnozems* on basalt (Appendixes 1 9, 1.10), for K, surface horizons of the *krasnozems*, several *podzolic soils* (e.g. Appendixes 1.12, 1.13, 1.14), the *prairie soil* on basalt (Appendix 1.2), the 'dark acid clay' (Appendix 1.3) and the *humic gley*.

The *prairie soils* on Brisbane River alluvium probably have adequate levels of available Ca and K but no data are available. Gross deficiencies of P, N and Ca can be predicted for most of the virgin, strongly acid soils, particularly the various *podzolic soils* and *lithosols*, *podzols*, gleys, *red earths* and *soloths*.

Liberal applications of fertilisers, including phosphate, nitrogen and potassium, are necessary for good performance of garden and horticultural crops and lawns on all of the soils. This would also hold for sown pastures, except that potassium should not be required on soils with contents equivalent to those of the soils listed above as having fair or higher levels. The soils of many suburban gardens and lawns have been considerably modified from their original state, the surface soil having been built up by additions of fertilisers and organic matter or replaced by soil materials from elsewhere. In other cases, the materials of the original soil have been mixed or removed to varying extent by cut and fill during site development.

Moderate to heavy application of mixed fertilisers is common practice in both suburban gardens and intensive plantation horticulture, and the low inherent nutrient status of these soils has therefore not been a significant factor in restricting their use. More recently, the increasing cost of heavy fertiliser additions has become important in high-cost commercial agriculture. Most gardens and plantations with a history of heavy fertiliser application now probably have moderate contents of major nutrients and are unable to hold more, the excess being lost in drainage. This applies particularly to the *krasnozems* and *red earths* of the Redland Bay, Rochedale and Sunnybank areas which have received cumulatively very large dressings of NPK fertilisers.

Trace elements. No published trace-element analyses are available for the soils of the Brisbane area. Predictions of likely deficiencies must therefore be based on limited experience of known deficiencies for particular soil groups both within and beyond the district. For the dominant soil groups the likely deficiencies of both trace and major elements are tabulated by Beckmann (1967, p. 44) as a summary of such experience.

Information is best for the red soils of the three areas used for horticulture in which deficiencies of molybdenum, boron, zinc and copper have occurred with particular crops and might be expected over a wider area of these soils. These deficiencies are also likely on the *podzols* and gleys. Molybdenum, zinc, and copper deficiencies have been recorded also for sown pastures on *podzolic soils* and can be predicted as likely for sensitive plant species on the range of *podzolic soils* and *lithosols* in this area. Beckmann (1967) lists, as possible deficiencies, sulfur and molybdenum on the shallow *black earths* and 'gilgaied acid clays', and copper, zinc and molybdenum on the *humic gleys* of the Woongoolba and Lota units. The trace-element status of the other groups is unknown, the relatively fertile *prairie soils* of the Brisbane River unit are, however, the least likely to have trace-element deficiencies.

(c) Salinity and toxicity

The moderate rainfall of the district has strongly leached most of the upland soils and they have negligible to low salt contents. The main soils with significant salt concentrations are those influenced by shallow saline ground waters and tidal flooding, now or in the past These occur on the estuarine plains and bordering low-lying alluvium, tidal marshes and mud flats Apart from the tidal marshes, mud flats and swamps, salt contents sufficient to affect plant growth are largely confined to the lower parts of the Woongoolba and Eprapah units, and to the Waterford unit. The deep gilgaied clays of the last unit probably were salted under estuarine or brackish ground water influences as the sediments were deposited. Their low permeability and lack of through-drainage have prevented subsequent leaching.

Many special and localised salt problems have occurred at some sites on natural and modified soils of golf courses (Indooroopilly, Virginia and Oxley) and playing fields. These are due mostly to unfavourable soil water regimes arising from poor watering practice (sometimes with poor quality water) or inadequate drainage resulting in temporary saturation close to the soil surface. In these circumstances, salt concentrations high enough to kill turf grasses occur in patches. In most cases, the salts are sodium-chloride-dominant and the high concentration resulting from evaporation at the soil surface is confined to the top 2–3 cm of soil. Provision of adequate subsurface drainage usually overcomes the problem.

Apart from salt problems, the toxicities most likely to be encountered are those due to excess availability of aluminium and manganese. These are usually associated with strongly acid soils (pH less than 5 5–5 0), manganese toxicity being more likely in soils formed from rocks with a high content of ferro-magnesian minerals, e.g. *krasnozems* on basalt pH values for the example *krasnozems* from this area are above this critical level and no problems have been recorded However, data for other soil groups indicate that many soils of the district are acid enough to be suspect for aluminium toxicity The larger areas of the more-acid soils have not been developed for agriculture and horticulture and no aluminium problems have been identified where they are used If these problems are encountered, liming to raise the surface soil reaction a little above the critical level should overcome them while avoiding other nutritional problems, such as reduced availability of copper and zinc Poor root development and low nutrient uptake from the more acid subsoils (particularly in some *red podzolic soils*) by sensitive crops may still be problems

4.3 Soil Use for Urban Structures

Soils separated at series or type level have a wide potential application as basic units for all information relevant to foundation behaviour (Aitcheson 1953). The soils of Brisbane have not yet been classified and characterised at this level, nevertheless some general information based on observation, experience and extrapolation from other areas can be related to the soil groups and landscapes. The main restraints affecting use of the soils of the Brisbane area for urban structures, especially dwellings, are susceptibility to flooding, poor soil drainage, and the instability of swelling clay soils.

(*a*) *Flooding*

Large areas within and beyond the city boundary are subject to flooding and therefore have reduced value or are unsuitable for building sites These are the alluvial plains and low terraces of the Brisbane River and tributaries, the floors of smaller drainage depressions and some poorly drained higher terraces that receive run-on water Flash flooding by local runoff is fairly common; some areas in and bordering depressions are flooded with each heavy storm or cyclonic rain.

Major flooding from the Brisbane River is rare, but 14 floods have been recorded since 1841. The flood map of Brisbane and suburbs (Survey Office Staff 1974) shows the areas likely to be covered by backwater from the river at flood heights of 10, 15, 20, 26 and 30 ft (approximately 3, 4, 6, 7 and 9 m respectively) on the Port Office gauge It also shows the limits of the disastrous 21 75 ft (6 63 m) flood of January 1974 which damaged a large number of houses and destroyed some. It is likely that seven recorded floods since 1841 (with the two peaks of February 1893 taken as one flood) have exceeded the critical 15 ft (4 m) gauge level below which no serious damage need be anticipated (Survey Office Staff 1974), although a 10 ft (3 m) gauge level flood will cover considerable areas of low-lying land away from the river. In the earlier development of Brisbane, a small amount of building on flood-prone or poorly drained land was mainly for houses, of which most were on timber or concrete piers which raised the structure above damage level. With urban expansion over the last several decades, both houses and commercial buildings have been built on lower-lying areas, most of them at ground level, the severity of the 1974 flood damage to buildings was related to this. At the same time, much low-lying land, mainly in the floors of drainage depressions, has been raised by refuse filling. These, along with other flood-prone areas, have been developed for recreation for which they are best suited Some of this development has affected the extensive flooding (not shown in the map) from local storms

(*b*) *Poor soil drainage*

Poorly drained soils occur in many of the Brisbane landscapes and dominate those of low-lying plains, e.g the Woongoolba unit. Many of these soils have permanent water tables at relatively shallow depth, others, mostly on the lower slopes of hilly lands, are affected by water tables or seepage above or below the clay subsoil during prolonged wet periods or following very heavy rains These drainage conditions restrict urban use by (1) reducing soil load-bearing capacity, and (2) preventing use of septic systems and the disposal of domestic drainage (both requiring effective soakage trenches) where integrated systems are not provided

The bearing-capacity problem can be reduced or overcome by drainage (where this is feasible) and by special foundation structures, but both add to costs. This is probably most significant for commercial buildings and heavy-duty roads In some situations effective drainage is impossible An example of special and costly foundation treatments is the driving of a set of concrete piles 5–7 m deep through gleyed clays to underlying rock to support the University Printery, built over the alluvium of an old drainage depression at St Lucia.

Road development on poorly drained soils requires stronger (thicker) subgrades as well as improved drainage. The latter is often achieved by excavating roadside channels and forming up the roadbed or filling well above the adjoining land surface Much of the pot-holing and failure of Brisbane suburban and extra-urban roads, even those of some high sloping sites that would normally be well drained, are due to a combination of short-term saturation below the roadbed and inadequate subgrade and foundation. Often the excess water is seepage from upslope sites, in many cases the structure itself or others, such as retaining walls and water-disposal channels on adjoining land, cause water to accumulate where it would not otherwise have built up. The disposal of domestic drainage from suburban sites and over-watering of gardens also contribute to the problem in some situations

(*c*) *Instability of swelling clay soils*

All clay soils tend to swell and shrink to some degree with extreme changes in water content, but under normal climatic conditions only those with high contents of expansive clay minerals (e.g montmorillonites) move significantly The *black earths*, 'dark acid clays', *prairie soils* and 'gilgaied acid clays' of the Archerfield, Runcorn and Waterford units are in this class. The presence of gilgai (small mounds and hollows) on the deeper clay soils of these units is evidence of their inherent instability which is a problem in their use as sites for buildings and roads. Such structures initiate changes in soil water distribution beneath and around them which can cause heaving and settling of sufficient magnitude to crack brick and masonry buildings or road pavements, unless special design and construction measures are adopted The shallow sedentary *black earths* and 'dark acid clays' of the Archerfield and Runcorn units respectively present least problems, the deeper clay soils of these units (generally >1 m deep) and the very deep clays of the Waterford unit (all showing some gilgai) are most likely to give trouble

The wide variety of design and construction measures used to minimise instability problems aim at either limiting movement of the structures by isolating them from the upper zones of the soil (as for buildings on piers) or providing a sufficiently flexible construction to accommodate the anticipated movements (Yeates 1973).

Road failures show as the development of an uneven or undulating surface due to differential heaving, to loss of soil strength in the subgrade because of an increase in water content beneath the pavement, and to longitudinal cracking at the edge of pavements which leads to subgrade failures when water penetrates. Measures taken to minimise failures include:

(1) construction of deep pavements to control heave and subgrade failures,
(2) close control in compacting subgrade or fill to limit subsequent changes in water content,
(3) widening and partial sealing of shoulders to prevent edge cracking,
(4) adequate verge drainage.

Yeates (1973) also outlines the problems for buildings, the design and construction measures taken to overcome them, and estimates of the additional foundation costs involved The principal building foundation problems are associated with heave movements rather than load capacity of foundations, these are expressed as: (i) cracking of walls and architectural finishes; (ii) disruption of services to and from buildings, (iii) distortion of internal and external structures. Among the measures taken to minimise domestic building problems are

(1) provision of an impermeable moisture barrier around the building (usually the most economical),
(2) partial excavation and replacement of the expansive clay (economics depend on the availability of suitable fill material),

(3) rigid raft (slab) construction;

(4) deep pier foundations supporting slab or beams (this is the most expensive type of construction and is normally used only for multistorey structures or on highly expansive soils).

5. Soil Formation and Landscape History

5.1 Factors Controlling Soil Formation

Soils are the products of the weathering and leaching of rocks and of the addition and mixing of organic matter These two 'processes' are controlled by the soil-forming factors. climate, parent material, organisms and topography (together comprising the environment) and time (Jenny 1941) In the Brisbane area, as elsewhere in Australia, the most important single factor determining the kind of soil formed is the parent material. it determines the soil texture (sand, silt and clay content) which can develop and it provides the mineral assemblages that largely determine soil physical and chemical properties. Next in importance as a differentiating factor is topography which controls drainage of the landscape and the kinetic energy of water moving over the soil surface and through the soil.

Climate, acting within the limits set by the parent rock, determines the general character of the soils of a region (see Section 2.3 above) and is commonly considered to be the dominant factor in determining the weathering trend The amount and temporal distribution of rainfall, interacting with temperature, control the rate of weathering and leaching, the kind and rate of growth of vegetation and associated micro-organisms, and indirectly the rate of addition, decomposition and incorporation of organic matter.

Time is important in an indirect way. With stable conditions and long duration of weathering and soil formation, profiles can attain their maximum degree of development. However, conditions are seldom stable and, over the several million years during which the landscape of Brisbane has been developing, there have been several substantial changes. While denudation of steeper slopes may have been going on steadily, there have been intermittent falls of sea level, causing rejuvenation of valley cutting and widening, or rises of sea level, causing partial infilling of valleys Climate has changed also, particularly during the Quaternary There have been several changes in the environment that would have affected the rates of weathering and would have changed some of the trends of soil development on some parent materials in the area The soil pattern of Brisbane is complex, but an appreciation of the relationship of the soil-forming factors shows that order in the pattern can be found. The processes which are important in producing the soils here are.

(1) mineral breakdown, especially of primary minerals in the parent rocks, and clay transformations in the course of weathering and soil development,

(2) mobilisation and transport of clay and of iron and aluminium oxides,

(3) leaching of soluble materials, such as salts, and the breakdown and movement of organic materials;

(4) transport of solid materials, suspensions and dissolved materials over the surface,

(5) gleying, i.e. the development of features reflecting poor internal and/or external drainage at the site;

(6) formation of nodules, particularly of iron, manganese and aluminium compounds, at different levels in profiles.

The action of these processes, either singly or together, on different parent materials and soils, and over varying time spans, is discussed in the following sections.

5.2 Parent Materials

The parent materials of the soils of the Brisbane area fall into several distinct classes and it is these which have exerted the primary control on the way the soils have developed. Brewer (1954) pointed out that there are five major aspects of parent materials which are significant in their effect on soil development.

(i) the proportion of clay which can be formed by weathering of the rock in place,

(ii) the amount of iron, both ferrous and ferric, which can be released;

(iii) the amount of alkali and alkaline earth cations which can be released during weathering,

(iv) the ease by which these elements, or ions, are released,

(v) the permeability of the rock, i.e. how easily leaching will remove such weathered products

Brewer classified parent materials at a series of levels based on each of these in turn (i) amount of kaolinite which could be produced; (ii) the equivalents of ferrous and ferric irons in 100 g; (iii) the equivalents of calcium, magnesium, sodium and potassium; (iv) rock types and mode of formation; (v) degree of fracturing or jointing, i.e. whether massive, fractured or shattered. All of these sets of features need to be considered when assessing the type of soil material which may be produced

The major parent material groups, and their characteristics as soil-forming materials, in Brisbane are:

(1) Basalt, which yields high amounts of clay, moderate to high amounts of iron, calcium and magnesium, low sodium and potassium, and is a rock which is little fractured. Together these indicate that a stable heavy clay soil will develop with little likelihood of texture differentiation in the profile.

(2) Metamorphosed sedimentary rocks: greywackes and phyllites. Greywackes are fractured rocks, which yield moderate amounts of clay, low amounts of iron, and low amounts of calcium, magnesium, sodium and potassium. Phyllites are similar but slightly higher in iron and lower in calcium The soils they will weather to will thus have moderate amounts of fine sand, silt and clay and probably some rock fragments through the profile. With this range of particle sizes, soils with texture contrasts are likely to be produced

(3) Sedimentary rocks, particularly Mesozoic and Tertiary sandstones and shales. Most sandstones have very low clay-forming potential and yield low amounts of iron, low to moderate amounts of calcium and magnesium and low amounts of sodium and potassium. Soils from such rocks are mostly coarse- to medium-textured depending on the composition of the grains and clasts, and may

have coarse uniform, gradational or duplex profiles. On the other hand, shales, being composed of clay particles, have a higher clay-forming potential, and may have low to moderate amounts of iron, calcium and magnesium and also of sodium and potassium Soils from shales are usually medium- or fine-textured and may have uniform, gradational or duplex profiles.

Notwithstanding the controls exerted by the texture and mineralogy of the parent rocks, the type of soil which ultimately develops is affected by the weathering history of the area Long continued weathering on a stable surface under conditions which were, continuously or intermittently, warmer and wetter than the present environment could transform a wide variety of rocks to a very similar end product The textural variations will usually persist but chemically the rocks could have been thoroughly leached to produce kaolinitic and oxidic clays with low reserves of nutrients. Such highly altered material could then become the parent material of younger soils following dissection of the former surface and, under the different drainage conditions prevailing on the slopes, different soils would develop from those on the older higher surface. It is possible, too, that the degree and form of original weathering might have varied with depth, so that a range of variously weathered rocks would be exposed during dissection, allowing soils with quite varied characteristics to develop

After some loss of clay in run-off, the sediments eroded from the hills may be deposited on the valley floors and exposed there to further weathering and soil formation processes. A range of soils may then be produced depending on the characteristics of the parent material, which in turn is influenced by topographic position, e g. levee bank as opposed to flood plain, and by drainage conditions at the site.

All of these situations exist in the Brisbane area and have produced the highly complex soil pattern of the present. To explain the soil at any site thus demands an understanding of the parent materials, the processes, and the geomorphic (or landscape) history of the area The interactions of these are discussed in the following sections.

5.3 Weathering and Landscape Development

The second most important single factor determining the kind of soil in the Brisbane area is topography, because it controls the drainage conditions at any site and thus influences the way in which the parent rocks weather and form soils as well as the erosion and deposition of surface materials. In this area, however, the effects of past climate on weathering and the way in which landscapes have been dissected are both important

The pattern of hills and valleys has resulted from backwearing away from major and tributary streams, following lowering of sea level and incision of valleys below the initial stream courses. The shapes of the valleys and thus the pattern of soils in them has been controlled by rock type and structure, both of which determine the weathered product and its permeability.

Some remnants of an old land surface still persist and weathering has continued along the same lines as previously but on highly weathered material. This highly weathered material extended to such depths that, when now exposed on slopes, it can yield only soils similar to those on the crest. Where less-weathered rocks are exposed on slopes, they will, however, have different weathering trends under the changed environment. This is especially evident on basalt but less so on altered sedimentary and metamorphosed sedimentary rocks.

These features may be illustrated by some examples in four different situations each typical of several areas around Brisbane; between them they represent conditions over a large proportion of the low hilly and valley areas.

(*a*) *Lateritic podzolic–red earth–podzolic–gley soils*

Following the initial incision of an old surface mantled by *red earths* and *lateritic podzolic soils* the valleys were widened, exposing highly weathered Mesozoic sedimentary materials to subaerial weathering on the slopes. In time as the scarps retreated, those facing relatively widely spaced neighbouring streams met and the old surface disappeared (Fig. 18). At such points, low knolls were all that remained to indicate the presence of a former surface, and these surmounted long concave slopes cut through the relatively soft, and variably weathered, early Tertiary sediments. The whole surface was progressively lowered, either continuously or in stages, and *red* and/or *yellow podzolic soils* developed on the exposed sediments, the actual soil depending on the drainage conditions at that site. *Gleyed podzolic soils* and *humic gleys* formed in colluvium and alluvium in poorly drained environments on footslopes and along drainage lines. Where the plateau surfaces have survived but have been only slightly denuded, *red earths* and some *lateritic podzolic soils* have persisted.

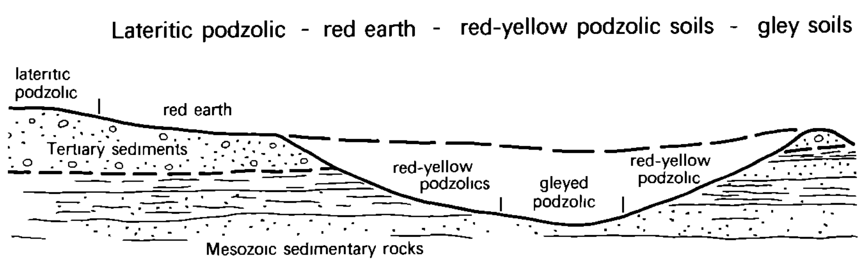


Fig. 18. Development of *lateritic podzolic soils* and *red earths* on old plateau surfaces, and red–yellow and *gleyed podzolic soils* on younger surfaces cut below these.

(*b*) *Krasnozem–prairie soils–black earths*

Krasnozems appear to have formed initially on an old surface equivalent to, and in some cases adjoining, that of the *red earths.* Severe weathering extended some tens of metres into the underlying basalts and some interbedded clays, transforming them into kaolinites and iron oxides (Fig. 19). Only small areas of the plateaus with *krasnozems* have persisted following dissection; most areas of *krasnozems* now occupy low rounded hills.

Two situations have pertained since dissection, largely related to the depth to which the deep weathering extended. Where it continued to possibly more than 30 m (Fig. 19), and rock fabric was almost completely destroyed, kaolinitic clays were exposed to weathering on the younger surface and were transformed to soils very similar to the *krasnozems* of the original plateau surface. Slopes in these areas, e.g. from Cleveland south to Redland Bay, are concavo–convex on both high and low hills with only the lowest parts having *xanthozem* or gley soils on locally derived colluvium.

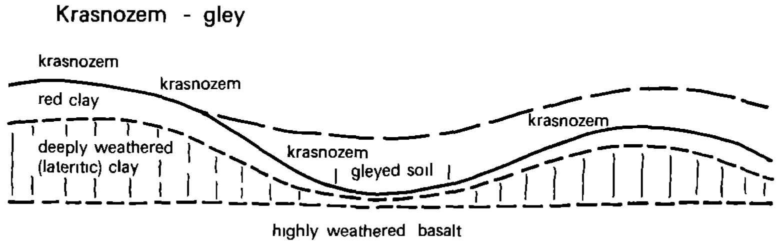


Fig. 19. Development of *krasnozem* soils following dissection of deeply weathered (lateritic) clay over basalt, with gleyed soils in poorly drained depressions

In the second situation (Fig. 20), the intense weathering was much shallower, possibly 10 m or less, and rock fabric has been preserved in less-weathered material The landscape shape and the environment of later weathering differed from the original Under lower relief as the valleys were widened, the upper slopes particularly were dominantly convex and the altered basalt exposed in a high run-off environment developed into 'dark acid clay' soils or *prairie soils*. These soils were also produced on low knolls formed when the *krasnozem* crests disappeared Where denudation stripped all of the highly weathered material, shallow *black earths* developed on the much less weathered basalt below Areas with this pattern occur from Runcorn to Kuraby and at Manly West.

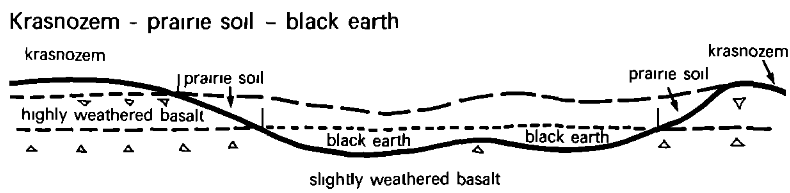


Fig. 20. Development of *prairie soils* and *black earths* on slightly weathered basalt following the dissection of a landscape of *krasnozems* over highly weathered basalt

(*c*) *Lithosol–red podzolic–yellow podzolic–gleyed podzolic soils*

Areas where this toposequence occurs have a different form from those already discussed There are few, if any, remnants of an old plateau surface, even on hills of about the same height as those with *red earth* or *krasnozem* remnants Instead there are broad rounded crests, some with low knolls, surmounting concavo–convex slopes leading to the drainage lines (Fig. 21).

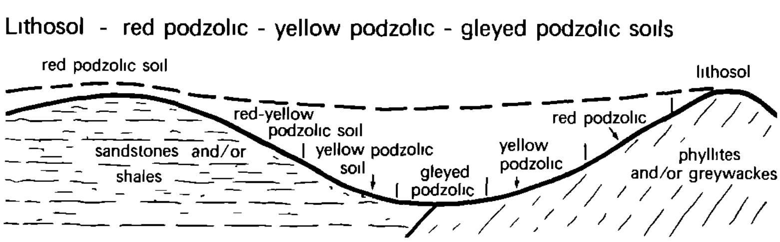


Fig. 21. Dissection of sandstones and shales or phyllites and/or greywackes to give sequences of *lithosols*, *red podzolic*, red–yellow *podzolic*, *yellow podzolic* and *gleyed podzolic soils*

The sedimentary and metamorphosed sedimentary rocks, which have a moderate clay-forming potential, show the effects of earlier deep weathering in the coarse reticulate mottling prevalent in many of them. This weathering has not affected their tendency to form medium-textured, texture-contrast soils, and various *podzolic soils* are dominant in most slope positions *Lithosols* occur, especially on quartzites on higher crests, but, on the low broad rises which have appeared as dissection proceeded and on upper slopes, *red podzolic soils* are the most common Red–yellow and *yellow podzolic soils* are common on middle to lower slopes, the local drainage situation controlling the state of hydration of the iron oxides in the system and hence the colour of the subsoil.

The coarser-textured A horizons may be the result of pedological processes but, on lower slopes, at least part of the A horizon has probably come from surface transport downslope. The finer-textured B horizon acts as a barrier to water movement vertically through the profile and tends to deflect water downslope This contributes to the development of gley features in the *gleyed podzolic soils* on colluvium on footslopes and on valley floors, where their development is also favoured by the low energy available for leaching

(d) 'Gilgaied acid clay' or gleyed podzolic soil–prairie soil–alluvial soil, humic gley

In the alluvial system, parent materials vary sufficiently and there are enough variations in local topography for differences in internal drainage to affect leaching and the course of soil development. Erosion following changes in sea levels has caused partial removal of earlier alluvial bodies and some infilling of younger sediments between the eroded remnants, soil-forming processes operating over varying times have caused distinctive ranges of soils to develop. These are illustrated in Fig. 22

The highest terraces, which represent the floors of infilled valleys cut during earlier falls of sea level, are dominated by 'gilgaied acid clay' soils or *gleyed* or *yellow podzolic soils* depending on the texture and properties of the parent alluvium They are relatively old and have persisted during later changes of sea level, but the high clay content (~70%) of the alluvium of acid clays has inhibited much profile development. Where the parent material was significantly silty, *gleyed podzolic soils* have appeared, with improved drainage and on sandy clay

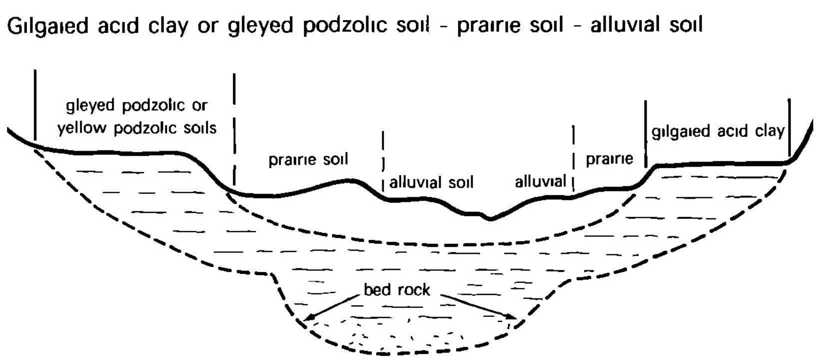


Fig. 22. Succession of soils on terrace sequences associated with eustatic sea-level changes, showing *gleyed podzolic soils* or 'gilgaied acid clays' on matched terraces, with *prairie soils* and *alluvial soils* on infills in valleys cut below these

either *gleyed podzolic* or *yellow podzolic soils* or in some cases *solodic soils* have developed

Younger alluvium deposited within the earlier valleys excavated in the older high-level alluvium has varying textures which can be related to its position on former flood plains. Older levee banks have deeper *prairie soils* whereas younger levees, where there has not been sufficient time for homogenisation of the materials, have *alluvial soils* Flood plains have gleyed soils, sometimes *humic gleys* which become more common on the upper levels of the coastal plain into which the flood plains merge. In these sites the poor internal drainage largely overrides any influence of parent material, and alluvia of all textures have similar profile forms.

5.4 Landscape History and Soil Formation

The modern soil landscapes of Brisbane have resulted from a complex series of geological, geomorphological and pedological changes over many millions of years. The summary presented here is based on the report by Beckmann and Stevens (1978).

By the end of the Triassic Period The Triassic–Paleozoic basement extended through the entire city area, and Paleozoic sedimentary (metamorphosed) rocks and granites occupied what are now mountainous areas of the D'Aguilar Range and also those of the isolated mountains to the south-east of the city These project above other areas of Paleozoic rocks which now occupy low hills up to 100 m above present sea level. Triassic sediments, which also occupy hills up to about 100 m above present sea level, filled basins between the major blocks of Paleozoic rocks, they are roughly associated with the current trends of the Brisbane River and its major tributaries From the end of the Triassic to the beginning of the Tertiary, the area appears to have been entirely land

Paleocene–Oligocene. During this period, the topography was hilly with valleys filled with river deposits and interbedded basalts that make up the Silkstone and Corinda Formations The highest (and therefore the youngest) sediments of the basins are sands and river gravels of the Sunnybank Formation The basins near Brisbane had an approximate east–west orientation, a different alignment from the modern trend of the river Clays with some gravels of the Petrie Formation occupy areas along the Pine Rivers and the coast to the south of their mouth Basalts and associated sediments of this age occur along the coast south of the Brisbane River, particularly in the Redlands district.

Late Miocene–Early Pliocene A denudation surface, the Woodford Surface, developed along the coast and up the major river valleys, and both it and the streams draining it may have extended further seaward at this time During this period the Brisbane River was diverted to a course separate from that when the Tertiary basins were filled. Its trend, apparently structurally controlled as it follows the line of the Buranda Fault, became approximately that of the present stream. The large meanders which developed during this period may indicate high discharges at that time from heavy rains falling over the entire catchment, which would have had about the same limits as at present

Late Pliocene–Early Pleistocene Following a minor amount of uplift, the Woodford Surface was destroyed over wide areas and replaced by the Brisbane Surface, which becomes lower seaward. This surface may have extended well beyond the present coastline, as equivalents are found on many of the islands within Moreton Bay. The Brisbane Surface was deeply weathered (lateritised), especially on favourable, i e permeable, parent materials, such as sands and sandy clays. Tertiary and Mesozoic sediments and basalts (Sunnybank, Manly and Redlands landscapes) were most affected The less permeable Paleozoic metamorphosed sediments were only superficially altered

Pleistocene This was the time of development of the form of the detailed topography of Brisbane. There was deep incision within the meander belt of the Brisbane River, with down-cutting to about 45 m below present sea level This entrenchment was probably controlled by sea-level fall during the major glacial stages of the Pleistocene and appears to have been in at least two stages, as indicated by buried valley floors at 20–30 m and at 45 m All of the tributaries of the larger streams were affected also but to a lesser degree, as their courses were shorter and they had steeper gradients

Backwearing from the network of streams removed much of the Brisbane Surface, leaving plateau remnants on the more-permeable sandy Tertiary sediments and rounded hills on Mesozoic and early Tertiary clays and on basalts. These surfaces now have soil landscapes such as Coopers Plains and Manly of *red earths* and/or *lateritic podzolic soils*, and Birkdale and Aspley of *krasnozems* The Paleozoic metamorphics which had been only slightly affected by deep weathering formed steepsided ridges with *lithosols* (Beenleigh and Mt Cotton, Mt Coot-tha landscapes)

The pattern of the Brisbane Ridges was formed at this time as the tributaries to the north-west and to the south of the river cut down through a variety of sedimentary rocks Those to the north-west, e g. Kedron Brook and Enoggera Creek were flowing across the dominant strike, so that smaller tributaries flowing into them were draining and cutting into rocks of varying resistance to erosion Where the streams crossed quartzite ridges, as Kedron Brook does at Sparkes Hill, the valley at that point is narrow, while upstream and downstream, the valley has widened giving a series of distinct basins, e g those of Toowong landscape.

On the south side of the river the tributaries such as Norman Creek and Oxley Creek are flowing either along the dominant strike of the metamorphic rocks or through the Mesozoic sedimentary rocks Their valleys are more even than those to the north and widen progressively downstream. In the course of the dissection, lower concavo-convex ridges developed, particularly close to the streams, and less-weathered rocks were exposed to soil formation, a range of soils developed on hill slopes which have persisted to the present. Most of the duplex soils on sedimentary rocks commenced to form during this period, e g those of Woodridge, Beenleigh and Park Ridge landscapes, as did the dark clay soils on basalt, e.g Runcorn landscape.

Coastal areas were cut back by wave action during high sea levels as well as by backwearing from the streams when the sea level was lowered. The low islands became separated from the mainland and the original Brisbane River became detached from its original downstream tributaries, e.g Kedron Brook and Tingalpa Creek

Late Pleistocene The deeply incised valleys were infilled by fluvial and estuarine sediments during times of relatively high sea level within the later Pleistocene. The highest distinctive matched terraces, the Strathpine, Kalinga and

Waterford Terraces, are found along the major streams, namely the Pine Rivers, Kedron Brook, the Brisbane River and the Logan River They appear to be related to a sea level about 6 m above the present, probably during the last interglacial about 120 000 years ago, and the type of alluvium and hence the type of soil depends on the source material from which the alluvium was derived Duplex soils (mainly *gleyed* and *yellow podzolic soils* formed on mixed alluvia) make up Eprapah and Carbrook landscapes (cf. Mew 1978), and 'gilgaied acid clays' (Waterford landscape) formed from clayey alluvium

There are suites of terraces on each of the major streams on materials infilled below the matched terraces and developed as the stream readjusted to the changing sea level The lower are poorly matched across the valley and are composed of materials which vary in texture from sands on levee banks to clays in small flood plains The soils on them are minimal *prairie soils* and *alluvial soils*, with minor areas of *humic gleys*, and these make up the Logan landscape. The lowest of the terraces merge with the modern flood plain and the coastal plain

Small marine benches occur in places along the coast, and these represent remnants of more extensive platforms which were dismembered by erosion at times of low sea level and by marine attack when the sea rose

Recent In Recent times the streams have continued to deposit sediment over their flood plains and the Brisbane River has formed its present delta The amount of discharge and the amount and type of sediment have been affected by the development in the area, both urban and rural. All of the terraces up to the level of the Strathpine Terrace are covered by high floods, but sediment seems to be deposited only when flood waters are receding, and then mainly in places where the flow has slackened

A low coastal plain has built up in conjunction with the flood plains, and low beach ridges occur within this and fringing the modern beaches. This plain is less than 5 m above sea level, and is traversed by sinuous swampy depressions (Woongoolba landscape).

Acknowledgments

The authors would like to thank several colleagues for their assistance in the preparation of this paper K. J Smith for assistance in the field and for the initial drafting of the map, the Soil Chemistry Section of the Division of Soils, CSIRO, Brisbane, under the supervision of R. Reeve and J O Skjemstad, for chemical analyses, the Agricultural Chemist, Queensland Department of Primary Industries, for permission to reproduce some chemical analyses; the staff of the Drawing Office, Division of Soils, CSIRO, Adelaide, for preparation of the final map and for drafting the figures.

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Appendix 1. Profile Descriptions and Analytical Data for Soil Groups Sampled

Notation in Tables

Descriptive terms and soil horizon notation used in the following tables essentially follow those proposed by the Soil Survey Staff, U S Department of Agriculture (1951, 1975). Abbreviations used are.

d,	dry colour,
m,	moist colour,
w,	wet colour,
TSS,	total soluble salts by conductivity of 1.5 suspension,
NaCl,	chloride calculated as sodium chloride,
$CaCO_3$,	carbonate calculated as calcium carbonate,
Org. C,	organic carbon by dry combustion or by Walkley–Black method, the latter shown by an asterisk;
N,	total nitrogen by Kjeldahl digestion,
C/N,	carbon to nitrogen ratio,
P,	phosphorus. 'A (ppm)', 'available phosphorus' by modified 0 01 N H_2SO_4 Truog extraction method, 'Total (%)', total phosphorus;
CS,	coarse sand,
FS,	fine sand;
Si,	silt,
C,	clay,
H_2O,	air-dry moisture, OD H_2O, oven-dried moisture,
CEC,	cation exchange capacity (exchangeable cations: Ca, calcium, Mg, magnesium, K, potassium, Na, sodium)

Laboratory Methods

pH was determined on a 1·5 soil–water suspension using a glass electrode with a silver–silver chloride electrode in 0 1 N potassium chloride as reference half cell. Sodium chloride and total soluble salts were determined on the same suspension, the latter conductimetrically

Carbonate was determined by a modified Passon method described by Martin and Reeve (1955).

The combustion method of Piper (1942) was used to determine organic carbon in most surface soils, but for subsoils the method of Walkley and Black (1934) was used, as indicated in the tables by an asterisk after the value

'Available' phosphorus was that extracted by shaking for 16 h with 0 01 N sulfuric acid, as described by Kerr and von Stieglitz (1938), while 'total' phosphorus was determined on a boiling hydrochloric acid extraction of pre-ignited soil using the vanadate method described by Beckwith and Little (1963).

Nitrogen was determined by Kjeldahl digestion.

Normal ammonium chloride, adjusted to pH 8 4 with ammonium hydroxide, was used as leachate for exchangeable cations. Sodium and potassium were determined with an E.E.L. flame photometer while calcium and magnesium were determined by EDTA titration. The value for sodium was corrected by subtracting an amount equivalent to the soluble chloride, and the calcium by deducting an amount equivalent to the soluble sulfate present Sulfate was determined turbidimetrically for this purpose All soils with pH in excess of 7 8 were leached with alcoholic ammonium chloride, as described by Tucker (1954). Total exchange capacity was determined directly by estimating the ammonium and chloride subsequently removed by normal sodium nitrate, and taking the differences as being equivalent to the exchange capacity at pH 8 4, allowance being made for the higher than equivalent NH_4 to Cl ratio in the normal ammonium chloride.

The Plummet method of Hutton (1955) was used for particle size analysis.

More complete analyses have been done on the major horizons, and values of adjoining or intermediate horizons can be estimated or interpolated. Where very low values for available phosphorus were obtained for the upper layers, no further determinations were made in the lower layers, although total phosphorus was determined for several depths.

Appendix 1 1

Great Soil Group	Solonchak (tidal mudflats)	Parent material estuarine mud	Location Beenleigh
Principal Profile Form	Um 5 42		1 100000 305447
Soil Taxonomy	Salorthid (?)	Land use none	Site estuarine mudflats

Sample No	Horizon	Depth (cm)	Morphological description		
B880 1	A11g	0–10	Dark brown (7 5 YR 3/2 m) with some rusty mottling (5 YR 4/4 m) bordering mangrove pneumatophores,	clay loam to light clay,	weak medium subangular blocky, plastic
2	A12g	10–20	Dark brownish grey (10 YR 3/1 w) with red-brown (5 YR 4/4 w) bordering roots,	as above,	massive with dense fibrous root network
3	II A11g	20–30	Dark brownish grey with few rusty red-brown spots, abrupt boundary (sedimentary discontinuity),	as above,	as above, but fibrous roots decreasing to few
4	II A12g	30–60			
5a	II ACg	60–70			
5b	D1	70–90	Brownish grey (10 YR 4/1 w),	gravelly clay loam,	massive, much reddish ironstone gravel (nodules) 3–35 mm size
6	D2	90–120	Dark grey (5 Y 3/1 w),	clay,	massive, few live mangrove roots and many dead decaying ones
			Continuing below to 150 cm depth		

No	pH Field[A]	pH Lab[A]	TSS (%)	NaCl (%)	H_2O (%)	Org C (%)	N (%)	C/N ratio	P A (ppm)	Particle size (%) CS	FS	Si	C	CEC (m e /100 g)	Exchangeable cations (m e /100 g) Ca	Mg
1	6 5	6 4	6 2	4 2	7 3	5 70	0 289	20	39	1	21	13	54			
2	6 5	5 6	6 4	4 5	8 2	4 83	0 260	19	114					33 0	8 3	20 7
3	6 5	5 1	8 1	5 5	8 8	7 40	0 252	29	101	19	15	11	34			
4	6 5	4 9	5 2	3 4	5 5	4 15	0 150	28	73	32	17	10	27	23 1	0 9	10 9
5a	6 7	5 0	5 6	3 7		3 05	0 147	21	93	23	18	12	34			
5b	8 2	5 7	2 3	1 5	2 0	1 68	0 034	49		44	16	11	24			
6		5 2	4 7	3 1		3 26	0 089	37		5	26	14	38	29 4	1 5	10 6

[A] Field pH from colorimetric determination on wet mud, oxidation on drying gives a reduced laboratory pH

Appendix 1 2

Great Soil Group	Prairie soil	Parent material weathered basalt	Location Brisbane
Principal Profile Form	Dy 4 12		1 100 000 151608
Soil Taxonomy	Argiustoll	Land use pasture	Site gentle lower slope

Sample No	Horizon	Depth (cm)	Morphological description		
B340 1	A11	0–10	Dark grey-brown (10 YR 3 5/1 m), clear boundary,	clay loam,	strong medium granular, firm to friable, few fine black (ferro-manganiferous) nodules
2	A12	10–16	Dark grey-brown (10 YR 3 5/1 5 m) with many faint rusty-brown flecks, clear boundary,	as above,	as above with low to moderate 10–20 mm black nodules
3	B21	18–33	Dark grey-brown (10 YR 4/2 m) grading into faintly mottled yellowish brown,	heavy clay,	moderate medium prismatic breaking irregular blocky, plastic, few black nodules
4	B22	35–61	Dull yellowish brown (2 5 Y 4/4 m) passing into light yellowish grey,	as above,	strong medium to coarse lenticular, plastic
5	C	61–69	Dull grey (2 5 Y 4/2 m) and yellowish grey (5 Y 4/2 m) with yellow-brown speckling,	clay loam to light clay,	massive, friable, passing into soft weathered rock

No	pH	TSS (%)	NaCl (%)	H_2O (%)	$CaCO_3$ (%)	Org C (%)	N (%)	P A (ppm)	P Total (%)	Particle size (%) CS	FS	Si	C	CEC (m e /100 g)	Exchangeable cations (m e /100 g) Ca	Mg	K	Na
1	5 8	0 02	<0 01	5 2		3 83	0 27	4	0 023	15	25	26	26	27 3	5 9	6 1	0 44	0 94
2	6 3	0 02	<0 01	5 4		1 91*				21	24	25	26					
3	6 7	0 03	0 01	8 5		1 40*				12	16	18	52					
4	8 0	0 07	0 03	9 9	0 07	0 74*				4	25	29	39	52 7	11 9	30 0	0 04	3 3
5	8 7	0 04	0 02	7 4	0 05				0 012	22	48	18	13					

Appendix 1 3

Great Soil Group	'Dark acid clay'	Parent material highly weathered basalt	Location Beenleigh
Principal Profile Form	Ug 5 14		1 100 000 071482
Soil Taxonomy	Chromustert	Land use suburban development and horticulture	Site gentle slope of low spur

Sample No	Horizon	Depth (cm)	Morphological description		
B364 1	A11	0–10	Very dark grey-brown (10 YR 2 5/1 5 d) with few fine rusty flecks,	medium clay,	strong fine crumb to granular grading below 25 mm to strong medium angular blocky, very hard, friable when moist
2	A12	10–38	Dark grey-brown (10 YR 3/2 m) with browner patches (10 YR 3/3 m),	heavy clay,	strong coarse and medium angular blocky, firm, traces of soft weathered basalt
3	A13	38–52	Dark grey-brown with patches of yellow-brown and light grey,	as above,	weak to moderate coarse lenticular, firm to plastic, weathered basalt increasing
4	A14	52–65	Dark grey-brown (10 YR 3/2 m) and dark brown,	as above,	moderate coarse lenticular structure, firm, some soft weathered basalt
5	A–C	65–90	Faintly mottled grey-brown (10 YR 4/2 m) and brown (7 5 YR 4/4 m),	medium clay,	weak medium blocky, firm to friable, much weathered basalt

No	pH	TSS (%)	NaCl (%)	H_2O (%)	Org C (%)	N (%)	P A (ppm)	P Total (%)	Particle size (%) CS	FS	Si	C	CEC (m e /100 g)	Exchangeable cations (m e /100 g) Ca	Mg	K	Na
1	5 4	0 03	0 01	11 1	5 71	0 40	4	0 031	5	14	20	50	66 7	4 8	25 7	0 88	1 8
2	5 3	0 02	0 01	11 3	1 10*			0 013	2	9	14	74	76 7	2 1	33 9	0 16	2 7
3	5 1	0 03	0 01	10 8	0 53*												
4	4 9	0 05	0 02	12 5					6	18	19	58	80 7	0 17	39 3	0 05	4 2
5	4 7	0 09	0 04	10 7				0 005									

Appendix 1 4

Great Soil Group Black earth (shallow) Parent material weathered basalt Location Beenleigh
Principal Profile Form Ug 5 12 1 100 000 013493
Soil Taxonomy Haplustoll Land use suburban residential Site gentle slope of convex spur

Sample No	Horizon	Depth (cm)	Morphological description		
B354 1	A11	0–8	Very dark brownish grey (10 YR 2/1 m),	medium to heavy clay,	strong fine granular to angular blocky, friable to firm when moist, sticky when wet
2	A12	8–15	Very dark brownish grey,	heavy clay,	strong medium angular blocky, hard when dry, firm when moist, few pieces of gravel–basalt to 25 mm
3	A13	15–22	Very dark grey-brown (10 YR 2/2 m),	as above,	strong medium to coarse angular blocky, firm to plastic, common gravel
4	A–C	22–40	Very dark grey-brown with yellowish tinge,	as above,	soft weathered and fresh basalt
5	C	40–45	Olive brown (2 5 Y 4/4 m) and dark grey-brown (2 5 Y 3/2 m),	weathered basalt with some clay,	massive, friable

No	pH	TSS (%)	NaCl (%)	H_2O (%)	Org C (%)	N (%)	P A (ppm)	P Total (%)	Particle size (%) CS	FS	Si	C	CEC (m e /100 g)	Exchangeable cations (m e /100 g) Ca	Mg	K	Na
1	6 4	0 03	<0 01	6 5	3 84	0 27	2	0 031	4	27	24	38					
2	6 4	0 02	<0 01	7 2	2 91				5	28	23	39	45 8	23 9	9 2	0 10	0 40
3	6 7	0 02	<0 01	8 4													
4	7 3	0 02	<0 01	9 7					4	27	18	49	61 3	36 3	14 5	0 04	0 92
5	7 3	0 02	<0 01	8 6				0 034									

Appendix 1 5

Great Soil Group	'Gilgaied acid clay'—mound	Parent material alluvial clay	Location Beenleigh
Principal Profile Form	Gn 3 91		1 100000 138399
Soil Taxonomy	Chromustert	Land use grazing on native pasture	Site low gilgai mound on plain

Sample No	Horizon	Depth (cm)	Morphological description		
B352 1	A1	0–5	Light grey (5 Y 5/2 m) with dull yellowish grey and yellowish brown streaks, abrupt irregular boundary,	light clay,	moderate medium granular to fine sub-angular blocky, firm, sticky when wet
2	B21	5–30	Yellowish grey (2 5 Y 4 5/2 m) with dull brown staining in the upper 10 cm and rusty patches below,	heavy clay,	moderate fine to medium angular blocky, firm, few 2–3 mm black (manganiferous) nodules
3	B22	30–45	Dull yellowish grey (2 5 Y 4/2 m) and grey with some light red mottles,	as above,	weak coarse angular blocky with glazed faces, plastic to sticky, few black nodules and soft ferruginous segregations
4	B23	45–90	Brownish grey (10→7 5 YR 5/2 m) with yellowish grey and yellow streaks,	as above,	as above
5	B24	90–120	Brownish grey with many yellowish grey, yellow and red mottles,	as above,	massive, plastic to sticky
6	BC	130–183	Light grey (2 5 Y 7/2 m) mottled with yellow and red,	as above,	as above

No	pH	TSS (%)	NaCl (%)	H_2O (%)	Org C (%)	N (%)	P A (ppm)	P Total (%)	Particle size (%) CS	FS	Si	C	CEC (m e /100 g)	Exchangeable cations (m e /100 g) Ca	Mg	K	Na
1	4 4	0 03	0 01	5 8	3 47*		6		5	7	39	41					
2	5 6	<0 02	<0 01	6 5	1 62	0 10	<1		2	4	31	61	28 0	1 3	6 2	0 07	1 3
3	5 2	0 03	0 01	7 7				0 01									
4	4 7	0 09	0 04	9 1	0 28*				1	5	21	76	40 9	0 05	13 2	0 15	3 7
5	4 4	0 18	0 08	9 0				0 01									
6	4 7	0 19	0 08	10 1													

Appendix 1 6

Great Soil Group	'Gilgaied acid clay'—depression	Parent material alluvial clay	Location Beenleigh
Principal Profile Form	Dy 3 11		1 100000 138399
Soil Taxonomy	Chromustert	Land use grazing on native pasture	Site shallow gilgai depression on plain

Sample No	Horizon	Depth (cm)	Morphological description		
B351 1	A1	0–5	Grey (10 Y 4/1 m) with some yellow-brown markings, abrupt change,	clay loam,	weak fine angular blocky, slightly hard dry-friable moist
2	B1	5–15	Grey, faintly mottled with dull brown (10 YR 4/2 m) and olive (2 5 Y 4/4 m),	medium clay,	moderate medium blocky, friable to firm, few fine black (manganiferous) nodules
3	B21	15–35	As above,	heavy clay,	moderate to strong medium blocky, firm, few 2–5 mm black nodules
4	B22	35–45	Faintly mottled dull grey, olive (2 5 Y 5/3) and yellow-brown (10 YR 5/8 m),	as above,	moderate medium blocky, plastic, few black nodules
5	B23	45–75	Light brownish grey (10 YR 5 5/1 m) with prominent olive and yellow (10 YR 5/6 m) mottling,	as above,	massive, plastic, few black nodules
6	B24	75–95	Grey with olive to yellow mottles,	as above,	massive, very plastic, few nodules
7	B2–C	95–135	Brownish grey (10 YR 5/1 m) with light yellowish grey and yellow to yellow-brown mottles,	as above,	as above

No	pH	TSS (%)	NaCl (%)	H_2O (%)	Org C (%)	N (%)	P A (ppm)	P Total (%)	Particle size (%) CS	FS	Si	C	CEC (m e /100 g)	Exchangeable cations (m e /100 g) Ca	Mg	K	Na
1	5 3	<0 02	<0 01	4 5	5 43		8		2	4	45	40					
2	5 5	<0 02	<0 01	3 5	2 04	0 13	4	0 017	1	4	50	41	23 5	0 90	3 0	0 18	0 65
3	5 4	<0 02	<0 01	3 9	0 70*				2	4	46	51	23 4	0 36	4 7	0 06	1 1
4	5 5	<0 02	<0 01	3 8				0 009									
5	5 4	0 02	<0 01	4 5					2	3	42	54	24 0	0 05	4 7	0 04	1 6
6	4 9	0 06	0 03	7 8													
7	4 6	0 14	0 07	9 2					1	3	22	76	45 9	0 05	14 1	0 24	5 8

Appendix 1 7

Great Soil Group	Wiesenboden	Parent material colluvial/alluvial clay derived from basalt	Location Beenleigh
Principal Profile Form	Ug 5 28		1 100 000 003508
Soil Taxonomy	Pellustert	Land use part of aerodrome reserve	Site depression on plain

Sample No	Horizon	Depth (cm)	Morphological description		
B307 1	A11	0–15	Dark brownish grey (10 YR 3/1 m) with some yellowish grey-brown patches — gradual change,	medium clay,	moderate medium granular to 1 cm depth, weak medium blocky below, few 1–3 mm black manganiferous nodules
2	A12g	15–23	Grey (2 5 Y 4/1 m) and dark grey with rusty red-brown (5 YR 4/8 m) patches and root tracings,	as above,	weak medium blocky, firm, few fine nodules
3	A13g	25–46	Grey with rusty red-brown (7 5 and 5 YR 4/4–8 m) spotting and root tracings,	heavy clay,	weak medium to coarse angular blocky, firm, few fine soft black nodules
4	ACg	48–81	Yellow-grey to olive-brown (2 5 Y 5/3 m) with grey (2 5 Y 5/1 m) aggregate faces,	as above,	moderate to strong coarse lenticular, plastic, few fine soft nodules
5	Cg	84–122	Mottled yellow-grey to olive-brown, grey, and light brownish yellow (2 5 Y 7/6 m),	as above,	strong coarse lenticular, plastic, few fine carbonate nodules and patches, few fine black patches
6	Cg	122–183	As above,	as above,	strong coarse lenticular, plastic to sticky, few fine lime nodules, 10–50 mm

No	pH	TSS (%)	NaCl (%)	H_2O (%)	Org C (%)	N (%)	C/N ratio	P A (ppm)	Particle size[A] (%) CS	FS	Si	C	CEC[A] (m e /100 g)	Exchangeable cations[A] (m e /100 g) Ca	Mg	K	Na
1	5 9	0 06	0 04	7 6	1 98	0 14	14	14	5	14	32	41	24	8 9	10 8	0 18	0 42
2	5 9	0 13	0 08	4 5	1 71	0 12	14	14	3	14	36	49	35	8 4	15 1	0 15	0 79
3	5 9	0 23	0 16	5 9				13	5	7	27	63	42	8 2	19 1	0 06	3 0
4	7 9	0 18	0 10	7 4				11	2	5	21	71	48	8 5	30 8	0 06	9 6
5	8 5	0 20	0 08	6 9				9	1	4	16	78	49	7 2	31 9	0 06	10 8

[A] Analyses by Division of Soils, CSIRO, St Lucia, Queensland, other data are from the Agricultural Chemistry Branch, Queensland Department of Primary Industries

Appendix 1 8

Great Soil Group	Red earth	Parent material weathered sandstone	Location Beenleigh
Principal Profile Form	Dr 4 21		1 100 000 061514
Soil Taxonomy	Paleustalf	Land use suburban	Site crest on gently undulating surface

Sample No	Horizon	Depth (cm)	Morphological description		
B346 1	A1	0–10	Dark grey-brown (10 YR 4/2 m),	loamy sand,	moderate fine irregular blocky breaking to crumb, friable
2	A2	10–30	Faintly mottled brownish grey and dull yellow-brown (10 YR 5/4–6 m) to strong brown (7 5 YR 5/6 m),	as above,	massive breaking to single grain, friable
3	A2	30–65	Yellow-brown to orange brown (5 YR 5/8 m) with some brownish grey along roots, uneven boundary over 2–5 cm,	loamy sand to sandy loam,	massive, friable
4	B21	71–94	Dull red (10 R 4/6 m) with few faint yellow mottles,	sandy medium clay,	weak to moderate medium angular blocky, firm
5	B22	94–135	Red (10 R 4/8 m),	medium to heavy clay,	weak blocky to massive, firm, few ferruginous nodules, increasing with depth
6	B23	135–150	Dull red (10 R 4/6 m)	as above,	weak medium angular blocky, firm, large amounts (58%) of red ferruginous nodules 10–25 mm size

No	pH	TSS (%)	NaCl (%)	H_2O (%)	Org C (%)	N (%)	P A (ppm)	P Total (%)	Particle size (%) CS	FS	Si	C	CEC (m e /100 g)	Exchangeable cations (m e /100 g) Ca	Mg	K	Na
1	6 1	<0 02	<0 01	1 0	1 55	0 06	4	0 006	32	48	10	8	6 2	0 81	0 28	0 06	0 04
2	5 9	<0 02	<0 01	0 7		0 03											
3	5 6	<0 02	<0 01	0 7	0 19*	0 01			29	52	8	10					
4	6 0	<0 02	<0 01	2 1		0 02			19	32	7	44	8 5	1 1	2 9	0 02	0 18
5	6 0	<0 02	<0 01	3 1				0 005	18	30	7	46					
6	5 8	<0 02	<0 01	3 0					20	28	9	46	8 0	0 59	3 6	0 01	0 18

Appendix 1.9

Great Soil Group	Krasnozem	Parent material weathered basalt	Location Beenleigh
Principal Profile Form	Gn 3 11		1 100 000 231567
Soil Taxonomy	Paleustalf	Land use intensive horticulture/suburban	Site convex low hill crest

Sample No	Horizon	Depth (cm)	Morphological description		
B341 1	A1	0–15	Dark reddish brown (5 YR 3/3 m), gradual change,	light clay,	strong fine to medium crumb, friable, a few fine ferro-manganiferous nodules
2	A3	15–28	Dark reddish brown passing into red-brown (5 YR 3 5/3 m), gradual change,	as above,	crumb grading to moderate fine angular blocky, friable to firm, few nodules
3	B2	29–50	Brownish red (2 5 YR 3/6 m) passing into red,	medium clay,	moderate irregular fine to medium blocky, friable to firm, few nodules
4	B2	50–75	Red (1 5 YR 3/6 m),	as above,	as above
5	B2	75–120	As above,	as above,	as above
6	B2	120–150	Faintly mottled red and light brownish yellow-grey (2 5 Y 6/4 m),	medium to heavy clay,	moderate to strong, medium angular blocky, firm to plastic, many ferro-manganiferous nodules to 25 mm size
7	B3	150–225	Mottled brownish red, light yellowish grey and light grey,	as above,	as above

No	pH	TSS (%)	NaCl (%)	H_2O (%)	Org C (%)	N (%)	P A (ppm)	P Total (%)	Particle size (%) CS	FS	Si	C	CEC (m e /100 g)	Exchangeable cations (m e /100 g) Ca	Mg	K	Na
1	6 2	0 02	<0 01	5 0	5 08	0 28	9	0 026	8	23	26	34	27 0	6 6	4 9	1 7	0 31
2	6 3	<0 02	<0 01	4 7													
3	6 3	<0 02	<0 01	5 5	0 73*				5	16	21	59	14 1	2 3	3 5	0 58	0 25
4	6 3	<0 02	<0 01	6 9				0 017									
5	6 0	<0 02	<0 01	6 3	0 21*				3	10	16	74	9 2	1 6	3 7	0 02	0 13
6	6 0	<0 02	<0 01	6 0													
7	5 9	<0 02	<0 01	4 4					5	10	15	74					

Appendix 1 10

Great Soil Group	Krasnozem	Parent material weathered volcanic rocks—agglomerate and basalt	Location Beenleigh
Principal Profile Form	Gn 3 11		1 100 000 085493
Soil Taxonomy	Paleustalf	Land use suburban development	Site near crest of low ridge, 1-2° slope

Sample No	Horizon	Depth (cm)	Morphological description		
B360 1	A1	0–13	Dark reddish brown (5 YR 3/3, 4/3 m), clear boundary,	clay loam,	strong fine sub-angular blocky, friable, many pores and channels
2	A3	13–20	Dark reddish brown and red-brown (2 5 YR 3/2 m), clear boundary,	light clay to medium clay,	as above
3	B21	20–41	Brownish red (2 5 YR 3/8 m),	medium clay,	moderate fine angular blocky, friable
4	B22	41–76	Red (10 R 4/8 m),	medium to heavy clay,	as above, with few 3–6 mm black ferro-maganiferous nodules
5	B22	76–127	Red (10 R 4/8 m),	as above,	as above
6	B23	127–168	Mottled red and yellow-brown (10 YR 6/8 m),	heavy clay,	moderate fine blocky, firm with few to common 6–12 mm nodules
7	B23	168–218	Mottled red and yellow-brown (7 5 YR 6/6 m),	as above,	as above

No	pH	TSS (%)	NaCl (%)	H_2O (%)	Org C (%)	N (%)	P A (ppm)	P Total (%)	Particle size (%) CS	FS	Si	C	CEC (m e /100 g)	Exchangeable cations (m e /100 g) Ca	Mg	K	Na
1	6 2	<0 02	<0 01	4 0	2 76*	0 17	2	0 014	16	23	22	34	21 8	5 7	3 0	0 15	0 07
2	6 0	<0 02	<0 01	4 1	1 53*				13	20	18	46					
3	6 0	<0 02	<0 01	4 7	0 38*												
4	6 1	<0 02	<0 01	3 7				0 005	7	12	12	70	12 7	1 6	3 4	0 02	0 26
5	6 0	<0 02	<0 01	5 1													
6	5 7	<0 02	<0 01	5 4													
7	5 6	<0 02	<0 01	4 5													

Appendix 1 11

Great Soil Group	Red podzolic (atypical)	Parent material weathered greywacke	Location Ipswich 1 50 000
Principal Profile Form	Gn 3 50		1 100 000 922553
Soil Taxonomy	Paleustalf	Land use improved pasture	Site broad rounded crest in hilly land

Sample No	Horizon	Depth (cm)	Morphological description		
B278 1	A1	0–9	Very dark grey-brown (10 YR 3/1 5 m), clear boundary,	clay loam,	strong fine blocky, friable, very low gravel content, quartz and greywacke, 3–25 mm
2	A3	10–19	Mottled grey-brown, brownish grey and red-brown, gradual change,	light clay,	weak to moderate medium blocky, friable to firm, low 3–12 mm gravel mainly quartz fragments
3	B21	22–50	Brownish red (2 5 YR 3/6 m) finely mottled with yellow-brown and light yellowish grey,	heavy clay,	moderate medium blocky, plastic, very low gravel content as above
4	B22	50–84	Yellowish brown (7 5 YR 5/6 m) mottled with light grey and reddish brown,	medium clay,	as above but low gravel content of rock fragments, increasing with depth
5	B3	84–117	Mottled yellow-brown, brownish yellow and light grey,	light to medium clay,	weak medium blocky, friable, moderate gravel of rock fragments to 25 mm
	C	117–137	As above,	weathered rock with some clay	

No	pH	TSS (%)	NaCl (%)	H_2O (%)	Org C (%)	N (%)	P Total (%)	Particle size (%) CS	FS	Si	C	CEC (m e /100 g)	Exchangeable cations (m e /100 g) Ca	Mg	K	Na
1	7 2	0 03	0 02	8 4	3 67*	0 34	0 097	14	15	41	24	29 2	18 2	4 2	0 61	0 00
2	6 3	0 02	0 01	4 9	0 95*	0 08		14	15	41	31					
3	5 7	0 03	0 02	7 9	0 52*	0 04	0 037	8	10	33	52	44 2	7 4	13 7	0 15	1 6
4	5 5	0 13	0 08	9 4	0 24*			6	14	49	34					
5	5 1	0 34	0 21	7 8	0 10*		0 108	13	16	48	26					

Appendix 1 12

Great Soil Group	Red podzolic soil	Parent material weathered meta-sediments—mudstone or phyllite	Location Beenleigh
Principal Profile Form	Dr 3 41		1 100 000 240458
Soil Taxonomy	Haplustult	Land use modified native forest	Site rounded hill crest

Sample No	Horizon	Depth (cm)	Morphological description		
B344 1	A1	0–2	Very dark grey (10 YR 3/1 m) slightly mottled with light yellowish grey,	loam (sandy),	massive breaking to single grain, friable when moist, some fine gravel
2	A21	2–8	Light yellowish grey (2 5 Y 7/4 m),	loam,	massive, slightly hard, moderate amounts (40%) of fine gravel-quartz and platy rock fragments
3	A22	8–16	Light yellowish grey with some pale brown (10 YR 7/6 m) mottles,	loam,	as above
4	B1	16–21	Light red-brown (2 5 YR 4/6 m), slightly mottled with light yellowish grey,	light clay,	weak to moderate medium angular blocky, firm, low content (6%) of gravel-quartz and shale fragments
5	B21	22–35	Red (2 5 YR 4/8 m) slightly mottled with yellow-grey,	heavy clay,	moderate medium angular blocky, firm, low content of gravel
6	B22	36–56	Mottled red and yellowish grey,	heavy clay,	as above but gravel content increasing with depth
7	B3	56–74	Mottled grey, yellowish grey and red,	heavy clay,	as above, 15% gravel content, mainly shale fragments

No	pH	TSS (%)	NaCl (%)	H_2O (%)	Org C (%)	N (%)	P A (ppm)	P Total (%)	Particle size (%) CS	FS	Si	C	CEC (m e /100 g)	Exchangeable cations (m e /100 g) Ca	Mg	K	Na
1	5 4	0 02	<0 01	3 9			15	0 024									
2	5 4	0 02	<0 01	1 4	2 13	0 08	2	0 009	2	19	66	13	4 5	0 51	0 31	0 28	0 09
3	5 5	<0 02	<0 01	1 0	0 61*				16	28	44	12					
4	5 4	<0 02	<0 01	2 0					10	20	40	32					
5	5 3	0 02	<0 01	3 3				0 013	6	12	27	56	16 5	0 10	2 9	0 12	0 23
6	5 1	0 02	<0 01	3 8					4	9	27	63	20 4	0 02	3 0	0 06	0 25
7	5 0	0 03	<0 01	4 9				0 011									

Appendix 1 13

Great Soil Group	Red podzolic soil	Parent material shale/siltstone of Neranleigh–Fernvale Group	Location Beenleigh
Principal Profile Form	Dr 3 41		1 100 000 109583
Soil Taxonomy	Rhodustult	Land use grazing of unimproved pasture	Site upper slope off broad convex crest

Sample No	Horizon	Depth (cm)	Morphological description		
B501 1	A11	0–10	Grey-brown (10 YR 2 5/2 m), gradual change to next horizon,	gravelly sandy loam,	weak medium blocky, slightly hard, 50% angular gravel to 25 mm size, mainly siliceous
2	A12	10–20	Light grey-brown (10 YR 3/2 m), clear boundary,	as above,	as above with more (50%) gravel
3	A2	20–33	Pale grading to very pale brown (10 YR 5/4–6/5 m), abrupt boundary to B21,	as above,	structureless, slightly hard, 50% gravel as above
4	B21	33–61	Dark red (2 5 YR 3/4 m) with fine mottles of yellow-brown (10 YR 5/4 m),	medium clay,	moderate fine blocky, slightly hard, 20% siliceous gravel
5	B22	61–76	Red (10 R 3/6 m) with prominent fine mottles of yellow-brown (10 YR 5/4 m),	as above,	moderate to strong fine blocky, hard, 8% of fine siliceous gravel
6	B3	76–109	Grey (10 YR 6/2 m) mottled with red and slight yellow-brown,	as above,	moderate medium blocky, slightly hard, 6% of decomposing rock gravel
7	C	109–127	Mottled white (10 YR 9/2 m), grey (10 YR 6/2 m), red and yellow-brown,	silty clay,	weak blocky to structureless, friable, 4% of decomposing rock gravel to 6 mm

No	pH	TSS (%)	NaCl (%)	Org C (%)	N (%)	P A (ppm)	P Total (%)	Particle size (%) CS	FS	Si	C	CEC (m e /100 g)	Exchangeable cations (m e /100 g) Ca	Mg	K	Na
1	5 1	0 02	<0 01	2 97	0 18	8	0 017	21	42	22	10	20	0 92	0 69	0 33	0 10
2	5 2	<0 02	<0 01	1 65				24	38	22	13					
3	5 4	<0 02	<0 01	0 87				23	37	24	16	12	0 13	0 78	0 06	0 06
4	5 5	<0 02	<0 01	0 27				12	12	20	58	26	0 14	3 8	0 06	0 42
5	5 2	0 02	<0 01					10	13	20	60					
6	5 3	<0 02	<0 01					12	17	26	45	29	0 02	3 0	0 10	0 43
7	5 4	<0 02	<0 01					10	25	36	30					

Appendix 1 14

Great Soil Group	Yellow podzolic soil	Parent material phyllite or schist	Location Beenleigh
Principal Profile Form	Dy 5 41		1 100000 203423
Soil Taxonomy	Paleustalf	Land use native eucalypt forest—modified	Site gentle slope of low hills

Sample No	Horizon	Depth (cm)	Morphological description		
B345 1	A11	0–8	Dark brownish grey (10 YR 3/1 m) with grey-brown (10 YR 4/2 m) patches,	coarse sandy loam,	massive breaking to single grain, friable
2	A12	8–15	Grey with grey-brown and light yellowish grey patches,	as above,	massive, friable, low amounts of fine siliceous gravel and ferro-manganiferous nodules, 2–5 mm
3	A2	15–25	Pale yellowish brown (2 5 Y 7/4 m) with some light yellowish grey (5 Y 6/2 m) and dark grey-brown mottling,	clayey coarse sand,	massive, friable, low to moderate amounts of gravel, rounded pieces of parent rock
4	A3	25–30	Pale yellowish grey (5 Y 6 5/3 m) with some yellow-grey and yellow-brown, sharp change,	clayey coarse sand with pockets of clay,	as above
5	B2	30–44	Yellow-brown (10 YR 6 5/8 m) with some light yellowish grey mottling,	clay,	weak medium blocky, plastic, few pieces of rock gravel to 25 mm
6	C	44–55	Mottled light grey and yellow-brown,	clayey weathered rock,	massive, friable

No	pH	TSS (%)	NaCl (%)	H_2O (%)	Org C (%)	N (%)	P A (ppm)	P Total (%)	Particle size (%) CS	FS	Si	C	CEC (m e /100 g)	Exchangeable cations (m e /100 g) Ca	Mg	K	Na
1	5 6	<0 02	<0 01	2 0	3 75	0 15	2	0 013	37	38	12	8	18 8	0 26	0 84	0 21	0 16
2	5 5	<0 02	<0 01	1 2	1 19*		4	0 009	36	41	11	9					
3	5 5	<0 02	<0 01	0 7	0 46*				35	43	12	8					
4	5 8	<0 02	<0 01	0 5					36	41	14	8					
5	5 9	0 02	<0 01	2 9				0 017	21	25	18	35	13 3	0 05	3 8	0 10	0 64
6	6 0	0 02	<0 01	2 0													

Appendix 1 15

Great Soil Group	Lateritic podzolic soil	Parent material weathered siliceous sandstone	Location Ipswich 1 50 000
Principal Profile Form	Dy 5 81		Sheet 9442-I 958468
Soil Taxonomy	Paleustult	Land use modified native forest	Site on low convex crest

Sample No	Horizon	Depth (cm)	Morphological description		
B306 1	A11	0–11	Brownish grey (10 YR 5/1 5 d),	loamy sand,	weak medium angular blocky, weakly coherent, very friable
2	A12	11–28	Light grey-brown to brownish grey (10 YR 6 5/2 5 d) with few light grey mottles,	sand,	massive, weakly coherent, a few pieces of fine quartz gravel, some 3–5 mm ferruginous nodules below 28 cm depth
3	A21	28–62	Very pale yellow-brown (10 YR 7/5 d),	as above,	as above
4	A22	62–90	Very pale yellowish brown (10 YR 8/4 d) with few light grey-brown patches,	as above,	massive, weakly coherent and very porous, low amounts of round ferruginous nodules (11%), increasing to moderate (48%) below 90 cm
5	A3	90–128	Pale yellow-brown (10 YR 6/4 m) with some light grey-brown,	as above,	as above, nodules increasing to moderate
6	B1	128–162	Light yellowish brown (7 5 YR 6/6 m) slightly mottled with red-brown,	clayey sand to sandy clay,	massive, friable, moderate ferruginous nodules and some quartz gravel
7	B2	162–226	Pale olive (5 Y 6/4 m) mottled with red (10 R 3/6 m) and yellow-grey,	gritty clay,	weak fine angular blocky, friable, 40% grit and fine quartz gravel

No	pH	TSS (%)	NaCl (%)	H_2O (%)	Org C (%)	N (%)	P A (ppm)	P Total (%)	Particle size (%) CS	FS	Si	C
1	6 4	<0 02	<0 01	0 6	1 46	—	6	—	63	28	8	1
2	6 1			0 4	0 39*				65	28	8	1
3	5 9			0 5	0 15*				58	32	8	2
4	6 0			0 4					61	32	7	2
5	6 3			1 3					60	31	9	2
6	6 3			4 8					49	25	13	16
7	5 8			8 7					48	15	11	27

Appendix 1.16

Great Soil Group	Lateritic podzolic soil	Parent material clayey quartzose sandstone	Location Beenleigh
Principal Profile Form	Dy 5 41		1 100 000 023406
Soil Taxonomy	Paleustult	Land use suburban subdivision	Site upper slope off broad convex crest

Sample No	Horizon	Depth (cm)	Morphological description		
B349 1	A1	0–12	Faintly mottled grey-brown and dark grey,	coarse sand,	structureless–single grain, loose to friable
2	A21	12–32	Dull yellowish grey (2 5 Y 4/4 m) with dark grey and passing into dull yellow to brownish grey at 25 cm,	as above,	structureless, friable to loose
3	A22	32–55	Dull light brownish grey (2 5 Y 6 5/4 m) with trace of light brown,	as above,	structureless, weakly coherent
4	A3	55–62	Light brownish to very light brown,	clayey sand to sandy loam,	structureless, friable, few red soft nodules
5	B1	62–70	Yellow-grey to yellow-brown (5 Y 6/5 m) with reddish brown,	sandy clay,	weak fine to medium blocky, firm, moderate amounts of red nodules
6	B2	70–98	Yellow-brown with red-brown staining near nodules,	light increasing to medium clay,	weak to moderate medium blocky, firm, large amounts (47%) of red ferruginous nodules
7	B2	98–135	Distinctly mottled light yellowish grey (10 YR 6/8 m), red, yellow-brown and traces of light grey from 120 cm,	heavy clay,	weak to moderate blocky, firm to plastic, moderate amounts of ferruginous nodules

No	pH	TSS (%)	NaCl (%)	H_2O (%)	Org C (%)	N (%)	P A (ppm)	P Total (%)	Particle size (%) CS	FS	Si	C	CEC (m e /100 g)	Exchangeable cations (m e /100 g) Ca	Mg	K	Na
1	5 7	<0 02	<0 01	0 6	1 29	0 06	4	0 003	49	37	6	6	6 3	0 60	0 23	0 06	0 01
2	5 5	<0 02	<0 01	0 5													
3	5 8	<0 02	<0 01	0 3	0 13*				46	40	7	5	4 6	0 07	0 13	0 02	0 02
4	5 9	<0 02	<0 01	0 5													
5	5 9	<0 02	<0 01	1 1													
6	5 6	<0 02	<0 01	2 2				0 009	30	27	6	36	11 8	0 01	3 3	0 02	0 16
7	5 6	<0 02	<0 01	2 8													

Appendix 1.17

Great Soil Group	Podzol	Parent material siliceous, sandy alluvium	Location Beenleigh
Principal Profile Form	Uc 2 36		1 100 000 002480
Soil Taxonomy	Haplorthod	Land use suburban subdivision	Site level, poorly drained plain

Sample No	Horizon	Depth (cm)	Morphological description		
675	A11	0–23	Very dark grey (10 YR 3/1 m) speckled with white sand grains,	loamy sand,	weak medium crumb, friable, light fibrous roots
676	A12	23–33	Dark grey (10 YR 4/1 m) with light grey (10 YR 7/2 m) patches, clear boundary,	as above,	as above with fewer roots
	A2	33–41	Light grey (10 YR 7/2 m) grading to white (10 YR 8 5/2 m), abrupt change,	sand,	structureless, weakly coherent
677	B2 hir	41–46	Very dark brown (7 5 YR 2/2 m),	sandy loam,	humus–sesquioxide-cemented pan, very hard
	B2 ir	46–58	Mottled reddish brown (5 YR 4/4 m), yellow-brown (7 5 YR 5/6 m) and yellowish brown (10 YR 6/6 m),	loamy sand,	structureless, weakly cemented pan
678	B2 ir	58–109	Patchy strong brown (7 5 YR 5/6 m), light brownish grey (10 YR 6 5/2 m) and yellowish brown,	as above,	structureless, slightly hard
679	D	109–168	Mottled light brownish grey and yellow brown,	sandy loam to sandy clay loam,	structureless, firm

No [A]	pH	Org C (%)	N (%)	C/N ratio	P A (ppm)	Particle size (%) CS + FS	Si	C	OD H_2O (%)	Exchangeable cations (m e /100 g) Ca	Mg	K	Na
675	4 1	2 7	0 21	13	5	88	8	4	2 6	0 40	0 36	0 24	0 06
676	4 6	0 5	0 02	25	4	88	8	4	0 2	0 25	0 05	0 05	0 06
677	5 1	1 4	0 09	16	2	90	6	4	6 4	0 15	0 19	0 05	0 05
678	5 8	0 3	0 02	15	3	87	9	4	1 5	0 20	0 22	0 09	0 06
679	5 7	0 0	0 02	15	6	73	8	19	5 4	0 35	0 19	0 09	0 04

[A] Laboratory data for all samples from the Agricultural Chemistry Branch, Queensland Department of Primary Industries

Appendix 1 18

Great Soil Group Gleyed podzolic soil | Parent material clayey alluvium or estuarine sediment | Location Beenleigh
Principal Profile Form Gn 2 94 | | 1 100 000 283492
Soil Taxonomy Ochraquult | Land use suburban farmlets | Site low terrace of creek

Sample No	Horizon	Depth (cm)	Morphological description		
B342 1	A1	0–14	Dark grey (10 YR 4 5/1 m) beneath 25 mm of very dark grey,	silt loam,	massive with few large vesicular pores, hard, friable when moist
2	A2	14–25	Grey grading to light yellowish grey (N 6/0 m) faintly mottled with yellow-brown, clear boundary,	as above,	massive with some vesicular pores, brittle to weakly friable, a few ferro-manganiferous nodules 2–5 mm
3	B1	25–50	Yellow grey (2 5 Y 7/4 m) faintly mottled with light grey and yellow-brown,	silty clay,	massive, few vesicles, breaks to irregular lumps, plastic when moist
4	B21	50–70	Dull yellowish grey (5 Y 7/4–6 m) distinctly mottled with light grey and yellow-brown,	as above,	massive, stiff and sticky
5	B22	75–112	Light grey (5 YR 7/1 m) distinctly mottled with yellow-brown (2 5 Y 5/8 m) and light red segregations (2 5 YR 4/6 m),	as above,	massive, plastic to firm, red segregations are brittle
6	B23	112–150	Light grey faintly mottled with yellow-brown and red,	as above,	massive, firm

No	pH	TSS (%)	NaCl (%)	H_2O (%)	Org C (%)	N (%)	P A (ppm)	P Total (%)	Particle size (%) CS	FS	Si	C	CEC (m e /100 g)	Exchangeable cations (m e /100 g) Ca	Mg	K	Na
1	5 1	0 07	0 04	1 3	1 94	0 09	4	0 006	1	18	66	11	8 9	0 71	1 1	0 06	0 02
2	5 1	0 05	0 02	1 2	0 44*				2	18	67	14					
3	5 2	0 04	0 02	1 3	0 23*				1	14	65	18	5 9	0 10	1 7	0 06	0 25
4	5 0	0 03	0 02	1 4	0 18*				1	13	64	21					
5	4 6	0 06	0 04	1 5				0 003	1	10	64	22	5 8	0 07	0 92	0 01	0 15
6	4 6	0 08	0 05	2 3													

Appendix 2. Descriptions of Example Profiles for Soil Groups Not Sampled

2 1 *Alluvial Soil* Brisbane River landscape, on layered alluvium

Factual key Uc 1 1
Soil Taxonomy Ustifluvent

Horizon	Depth (cm)	Description
AC	0–15	Brown (10 YR 4/2 5 m) sand, single grain, weakly coherent, some fine water-worn gravel, pH (field)[B] 6, abrupt boundary
IIAC[A]	15–40	Brown (10 YR 4/3 m) clay loam, weakly platy, firm, low fine water-worn gravel, pH 6 5, clear boundary
IIIC	40–80	Brown (7 5 YR 4/3 m) sand, single grain, loose, pH 6, clear boundary
IVAC	80–100	Yellowish brown (10 YR 3 5/4 m) clay loam to light clay, weak medium blocky, slightly friable to firm, pH 7, continuing below

[A] Layered alluvium
[B] All pH values throughout Appendix 2 are field pH

2 2 *Siliceous Sand* Willawong landscape; on a low bank of alluvial sand

Factual key Uc 1 21
Soil Taxonomy Quartzipsamment

Horizon	Depth (cm)	Description
A1	0–10	Brownish grey (10 YR 5/2 m) sand, weak crumb to single grain, coherent, friable, clear boundary
C1	10–60	Light yellowish grey (10 YR 6/3 m) sand, single grain, weakly coherent, gradual boundary
C2	60–100	Pale yellow-brown (10 YR 6 5/4 m) sand, single grain, weakly coherent, continuing below

2 3 *Podzolic Lithosol* Toowong landscape, hill-crest site on phyllite

Factual key Um 2 12
Soil Taxonomy Ustorthent

Horizon	Depth (cm)	Description
A1	0–10/20	Very dark brownish grey (10 YR 3/1 5 m) gravelly loam, weak fine blocky, friable, moderate angular gravel, mainly quartz, clear uneven boundary
A2	10/20–30/60	Pale brown (10 YR 6/3 m) to light brownish grey (10 YR 6/2 m) gravelly loam, massive, porous and friable, much angular quartz and phyllite gravel increasing with depth, gradual boundary with some patches of yellow-brown, more clayey material
C	30/60→	Weathered phyllite with some loamy soil, grading into hard rock *in situ*

2 4 *Prairie Soil.* Brisbane River landscape; bank on low terrace of sandy alluvium

Factual key Gn 2 42
Soil Taxonomy Haplustoll

Horizon	Depth (cm)	Description
A1	0–20	Dark brown (7 5 YR 3/2 m) loam, slightly sandy, moderate fine blocky, friable, very porous, pH 6, gradual boundary
A3	20–70	Dark brown sandy loam to sandy clay loam, weak fine blocky, friable, very porous, gradual change
B1	70–80	Dark brown (6 6 YR 3/3 m) sandy clay loam, massive, friable, pH 6, gradual change
B2	80–90	Dark reddish brown (6 YR 3/3 m) sandy clay loam increasing to sandy clay, massive, firm
B3	90–100	Dark reddish brown sandy loam, massive, friable, pH 7, continuing below

2.5 *Prairie Soil (red-brown earth intergrade).* Brisbane River landscape; undulating high terrace remnant on alluvium

Factual key Db 3 13
Soil Taxonomy Argiustoll

Horizon	Depth (cm)	Description
A1	0–25	Dark brown (7 5 YR 2/2 m) loam, slightly sandy, moderate medium crumb, friable, pH 6, clear boundary
B21	25–55	Brown (10 YR 4/3 m) faintly mottled with dark brown and ochrous spots, medium clay, moderate coarse blocky, firm to plastic, some fine black (manganiferous) segregations, pH 6 5, gradual boundary
B22	55–80	Dark yellowish brown (10 YR 4/4 m) heavy clay, moderate coarse blocky, firm, low fine black segregation 1–2 mm, pH 8, gradual boundary
B2 ca	80–90	As above with scattered soft lime (calcium carbonate segregation)
	90–100	Dark brown (10 YR 4/3 m) heavy clay, weak to moderate blocky, few lime segregations, pH 8, continuing below

2.6 Red Podzolic Soil Toowong landscape, on phyllite

Factual key Dr 2 41
Soil Taxonomy Rhodustult

The most striking example of the *red podzolic soils* is that which dominates the Toowong landscape and is prominent in St Lucia, Toowong, Taringa and Indooroopilly Characteristically it occurs from upper to lower slope sites in toposequence with *lithosols*, *podzolic soils* with mottled clay subsoils, and *gleyed podzolic soils* Part of this toposequence has been described and studied by Koppi (1981) who presents laboratory data for four profiles from the sequence The profile below is for a mid-slope site

Horizon	Depth (cm)	Description
A11	0–20	Dark reddish brown (5 YR 3/2 m, 7 5 YR 4 5/2 d) loam, moderate medium crumb to fine blocky, friable, low angular gravel 3–25 mm size, mainly quartz, clear boundary
A12	20–35	Gradually paler and with increasing amounts of gravel
A2	35–45	Light reddish brown (5 YR 6/4 m, 7 5 YR 7/4 d) gravelly sandy loam, weak fine blocky to apedal, friable, high angular gravel, clear to abrupt boundary
B2	45–75	Red (10 R 3/6 m, 5/6 d) heavy clay, moderate fine to medium blocky with glossy ped faces, firm, very low gravel content, gradual change
B3	75–95	Red with increasing fine greyish brown mottles (10 YR 6/3 m) heavy clay, as above but low gravel content, gradual change
C	95–110	Mottled light grey (5 Y 6/1 m, 7/1 d), brownish yellow (10 YR 6/5–7/6 m), yellow-brown (10 YR 5/6 m) and red gravelly clay, weak medium blocky, firm, low increasing to moderate–high gravel of weathered phyllite
R	110→	Weathered rock

On higher slopes and broad rounded crests both the solum and the individual horizons are thinner, and the surface soil paler and lighter textured, for example

A11	0–8	Dark brownish grey (10 YR 3/1 m) loam to sandy loam
A12	8–15	Grey brown (10 YR 4/2 m) gravelly sandy loam
A2	15–20	Light greyish to yellowish brown (10 YR 5/4 m) gravelly loamy sand
B2	20–55	Red (2 5 YR 3/6 m) with few fine mottles, heavy clay
B3	55–84	As for the mid-slope site described above
C	84–100	

The bright colour of the A2 horizon and uniformly red upper B horizon bear witness to good drainage, probably mainly lateral through the more permeable A2 Even after heavy rains, any partial saturation at these depths must be very short-lived The position is quite different at the base of the solum, free water is still moving downslope through the mottled C horizon for several weeks following heavy or prolonged rain and the bluish grey mottling of the C and B3 horizons is evidence of longer-term partial saturation On the footslopes, prolonged partial saturation of the whole of the B (and C) horizon is reflected in prominent grey mottling but the A horizons are still fairly well drained On the adjacent drainage-line floors, even the A horizons of the gleyed podzolic soils are wet long enough to develop some rusty and ochrous spotting, while the deeper subsoils are mottled yellow-brown and grey

2 7 *Soloth* Coopers Plains landscape, lower slope of a spur on shale

Factual key Dy 3 41
Soil Taxonomy Natrustalf or Paleustalf

Horizon	Depth (cm)	Description
A1	0–8	Dark brownish grey (10 YR 4/2 m, 6/2 d) loamy sand, weak fine blocky to massive, friable, slightly hard when dry, pH 5, clear boundary
A2	8–20	Very pale brown (10 YR 8/3 d) and light brownish grey (10 YR 6/2 m) loamy sand, massive, very friable, slightly hard and pulverulent when dry, pH 5, abrupt boundary
B21	20–40	Mottled yellowish brown (10 YR 5/4 m) and grey (10 YR 5/1 m) heavy clay, moderate coarse prismatic breaking to medium blocky, very firm, pH 5, gradual boundary
B22	40–120	Very pale brown (10 YR 6/3 m) medium clay, weak medium blocky, some pockets of light yellowish brown sand
C	120→	Weathering shale

2 8 *Solodic Soil* Willawong landscape, level low terrace of Oxley Creek alluvium

Factual key Dy 3 43
Soil Taxonomy Natrustalf or Paleustalf

Horizon	Depth (cm)	Description
A1	0–12	Greyish brown (10 YR 5/2–3 m) loam, massive, friable, hard and pulverulent when dry, moderate ferro-manganiferous nodules to 6 mm size, pH 6, clear boundary
A2	12–24	Light grey-brown to very light grey (10 YR 7/2 d) loam to sandy loam, massive, weakly vesicular, slightly hard, moderate to high amounts of ferro-manganiferous nodules, pH 6 5, very abrupt boundary
B21	24–45	Greyish brown with fine dull red mottles, and some black ferro-manganiferous segregations, medium to heavy clay, moderate medium blocky, hard, low nodules, pH 6 5–7, gradual boundary
B22	45–60	Brown and yellowish brown medium clay, moderate medium blocky, very firm
B23	60–90	Yellowish brown becoming mottled with light grey medium clay, as above, pH 8+, continuing below

2 9 *Humic Gley (saline)* Woongoolba landscape; low terrace of Bulimba Creek on estuarine alluvium

Factual key Dd 4 11
Soil Taxonomy Umbraquult or Umbraqualf

Horizon	Depth (cm)	Description
A1	0–10/20	Very dark grey-brown (5 YR 2/2 m) organic loam, medium fine angular blocky, friable, dense mat of salt-water couch roots in upper 2–3 cm [laboratory data 0–10 cm pH, 4 6, TSS, 1 7%, NaCl, 1 42%, available P, 240 ppm], clear uneven boundary
B21 g	10/20–60	Greyish black (10 YR 2/1 m) finely mottled with grey (10 YR 4–6/1 m) and brownish yellow (10 YR 6/6 m) heavy clay, moderate medium to coarse prismatic, plastic, many fibrous roots, gradually becoming mottled grey, brownish-yellow and red with increasing depth [laboratory data 20–30 cm pH, 4 4, TSS, 1 2%, available P, 5 ppm]
B22 g	60–75	Mottled dark grey (10 YR 4/1 w), light grey (10 YR 6/1 w) and brownish yellow (10 YR 6/8 w) heavy clay, massive, stiff and sticky, some vertical channels [laboratory data 60–70 cm pH, 4 3, TSS, 1%, available P, 3 ppm]
	75→	Passes into bluish grey saturated clay below water table at 80 cm

2 10 *'Peaty Gley'* Woongoolba landscape, swamp on flood plain of Bulimba Creek, on clayey alluvium

Factual key Gn 2 01
Soil Taxonomy Hydraquent

Horizon	Depth (cm)	Description
O	0–8/13	Very dark brown (10 YR 2/2 m) fibrous peat, clear uneven boundary
A11 g	8/13–30/40	Very dark grey (10 YR 3/1 w) organic clay loam, massive, water-saturated and extremely sticky to fluid, gradual boundary
A12 g	30/40–90/105	Very dark grey (10 YR 2/1 w) organic light clay, massive, water-saturated, extremely sticky, clear boundary
C	90/105→	Brownish white (10 YR 8/1 w) sand, massive, water-saturated, slightly coherent