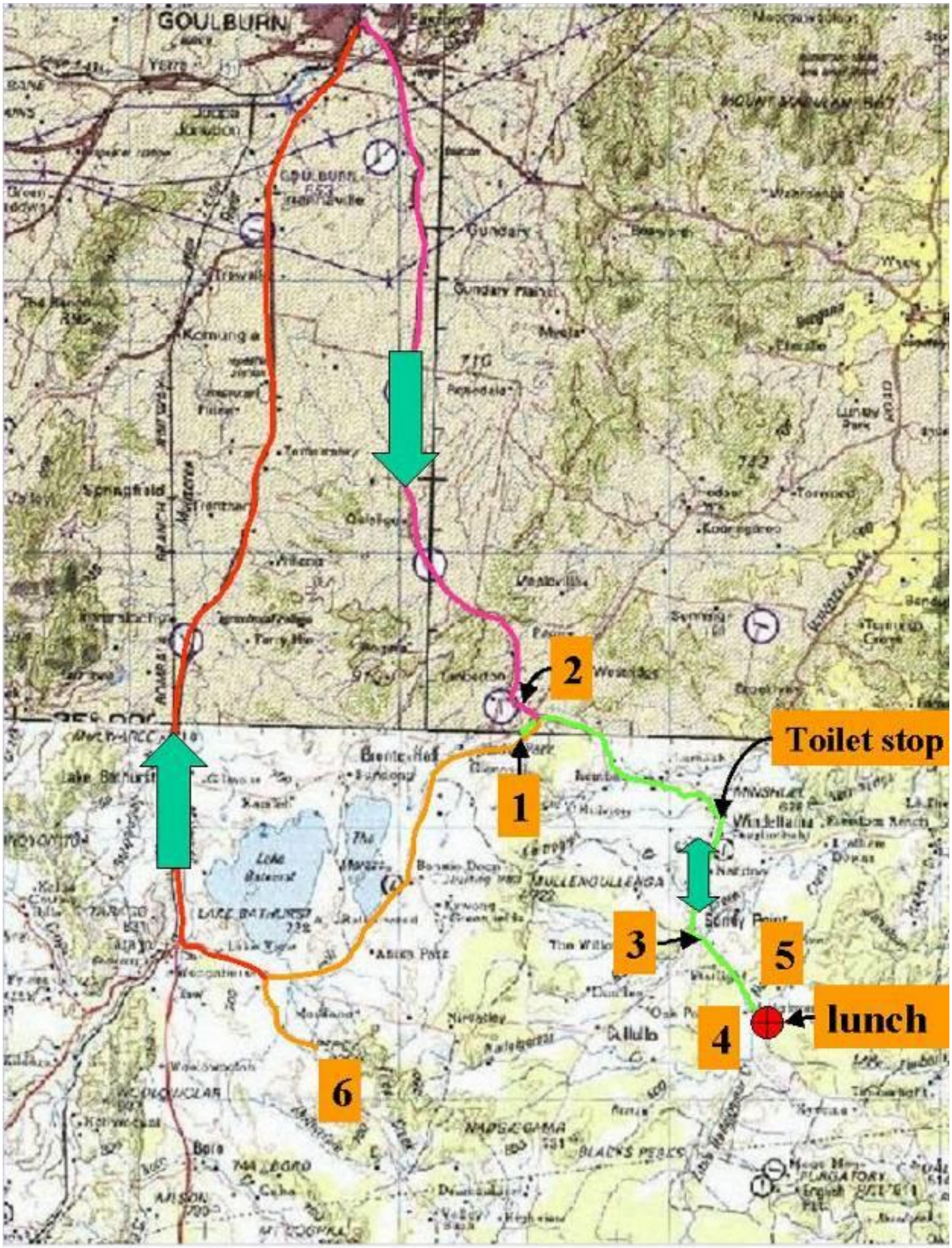
AUSTRALIAN SOCIETY OF SOIL SCIENCE INCORPORATED

Field Guide

THE CENTRAL SHOALHAVEN PLAIN



GEOLOGY, LANDSCAPE AND SOILS

Introduction

The field trip traverses an undulating high plain region of southern New South Wales about 20-40 km west of the Great Escarpment. The main river in the area is the Shoalhaven which rises about 40 km from the coast southeast of Canberra and flows north for about 170km across the high plain (at about 600 m) before turning sharply east. From there it descends the escarpment, incised in places up to 500 m. To the west of the Plain is a higher range bounded by a series of fault scarps (Mulwaree and Shoalhaven Faults). The eastern boundary of the plain is formed by erosional scarps along the edge of the nearly flat-lying Permian sediments of the Sydney Basin. Much of the area retains deep (20-30 m) weathering profiles with considerable development of clays within these profiles. Relict land surfaces and associated duricrusts are common.

Geology

Palaeozoic. The bedrocks underlying much of the Shoalhaven Plain are folded Ordovician sandstones and shales, intruded by Silurian granites, with Silurian volcanics along the western edge.

Tertiary. There is ample evidence across the central Shoalhaven Plain of widespread alluviation prior to the late Eocene. These, now scattered remnants of fluvial and lacustrine sediments, vary from conglomerates to shales, some with organic-rich layers from which floral remains and pollen have indicated an early- to mid-Eocene age.

Following alluviation, late Eocene basalt flows covered substantial parts of the plain. These are now left as small remnants capping hills except on the northeast margin of the plain along the Endrick River where over 100 m of basalt fills an early Eocene precursor of the present valley. The pre-basalt relief of the plain was about 50 m.

While there is no evidence of pre-basaltic weathering profiles, there are many examples of deep weathering and of duricrusts on both the basalts and the Palaeozoic rocks throughout the plain. Palaeomagnetic results from bauxites and lateritic duricrusts indicate mid-Miocene fixation of the magnetic character.

Duricrusts (Fig. 1).

Bauxite. Bauxites cap many small flat-topped hills at around 650 m in the Windellama region (Stops 1 & 2). They have formed by the weathering of the Tertiary basalt and in places, such as at Hedley Homestead, they cap a thick (15m) weathering profile passing up from fresh basalt through a zone of kaolinized purplish basalt, into a mottled or vermicular zone of kaolinite and ferric oxyhydroxides, then into massive bauxite which grades into yellow pisolitic bauxite or a red-brown pisolitic ironstone. At some sites this zone is brecciated, probably due to compaction. The presence of rounded quartz sand and pebbles in some bauxites indicates a colluvial or alluvial veneer having been deposited on the top of the bauxite profile.

In some places the bauxite profiles directly overlie weathered Paleozoic sediments, interpreted as indicating the complete loss of prior basalt. There is insufficient data to assess the possibility that some bauxites formed directly from the Palaeozoic rocks.

Not all the pisolitic alumina-rich duricrusts can be labelled bauxite, as some have Fe>Al and are more correctly termed pisolitic ferricretes. The alumina content ranges from 15%-55%, with Fe_2O_3 showing an antipathetic range from 5% to 60%. Silica ranges from 5% to 40%.

Manganocrete. Manganocretes containing up to 20% MnO_2 occur as cobalt-rich manganese oxide cemented slope and alluvial deposits flanking the higher bauxite ridges, or as isolated outcrops close to and topographically below bauxite.

Silcrete. Silcretes occur throughout the Shoalhaven Plain between elevations of 580 and 640 m. They show microcrystalline quartz and/or quartz overgrowth cementation of quartzose alluvium; polymictic pebble silcretes occur on low terraces 5-9 m above the valley floors. Silcretes occur downslope from bauxites and manganocretes as rims to alluvium-covered ridges and hills (e.g. along Nadgigomar Ck), as semicontinuous drapes from hilltops to valley floors (in one case over 30 m vertically), and in intra-and sub-basaltic leads (e.g. Mt Tomboye and Hedley Homestead).

At many localities the silcretes have formed along seepages or percolines in fills, around the margins of alluvial caps, and locally where permeable sediments directly overlie impermeable bedrock or weathering profiles. Where quartzose alluvium filled earlier valleys, silicification may have taken place at the impermeable bedrock boundaries, producing the silcrete drapes such as those near Windellama. At some localities, such as Charleyong, reworked silcrete pebbles are recemented by silica, suggesting polygenesis of some duricrusts.

Ferricrete and deep weathering. Ferricretes cap both the alluvial deposits and weathering profiles on Palaeozoic rocks. They occur at all positions in the landscape, and vary from massive, thick (3-5 m) ferricretes such as at Mogo and Nadgigomar Trig to thin ferruginous cappings on alluvium topped hills.

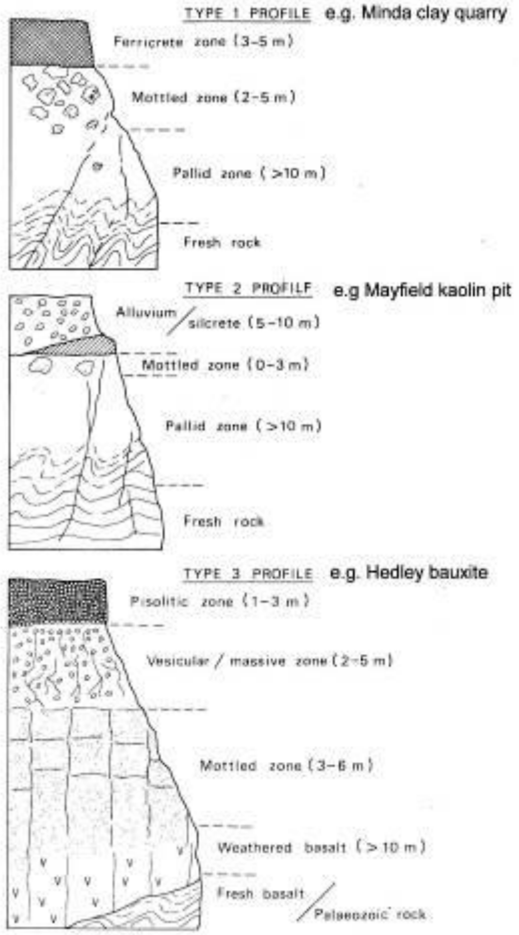


Figure 1. Schematic sketches of the three types of lateritic/bauxitic profiles of the Middle Shoal-haven Plain. Scale not shown as the profile depths vary considerably. (Taylor and Ruxton 1987)

Below the ferricretes is typically a thin mottled zone of a deep weathering profile, below which is a plasmic (pallid) zone of illite, kaolinite and quartz. This passes down into weathered Paleozoic rocks. Although the ferricretes are by no means continuous, kaolinized bedrock occurs extensively throughout the Plain, including in many areas that do not appear to have been covered by basalt. This zone of the weathering profile has been extensively quarried for brick clay.

Soils of the Canberra – Windellama Area

Soils of the Canberra – Windellama area tend to be inherently acid, sodic, have hard setting bleached A2 horizons, shallow topsoils, are organic matter deficient and are generally infertile. They are characteristically texture contrast with a sharp to clear boundary between the lighter textured topsoils and the clay subsoils.

Geological time, parent material and climate have combined to shape these soils. They are relatively old and have long been subjected to a climate that encourages ‘leaching’ – the removal of soluble material, such as nutrients and other minerals, from the soil by water percolating through it.

The leaching process tends to acidify soils. The soils of the Canberra – Windellama area have inherently acid topsoils ie. they are acidic even without the addition of fertilisers.

Many of the drainage lines in the region are gullied. Human activities are obviously a factor but the soils themselves are susceptible to the gully erosion process. Leaching once again is a culprit as it has helped formed ‘sodic’ subsoils, as highly leached soils end up with relatively high levels of exchangeable sodium. Sodic soils are defined as having an exchangeable sodium percentage (ESP) ≥ 6 (Isbell, 1996), and are unstable and highly erodible. Exchangeable sodium is a dispersive agent which forces clay particles apart and into suspension when wet. The region’s most highly sodic subsoils are found in the drainage lines further compounding the gully erosion hazard.

Leaching has removed nutrients and smaller particles such as clay from the topsoil. The regions soils often exhibit a marked change in texture down the profile. Brown loamy topsoils

(A Horizons) typically overlie coloured (red and yellow) clay subsoils (B Horizons).

The area's A_1 horizons are generally shallow and fragile. An A_2 horizon is commonly present immediately below the A_1 horizon. It is characterised by its paler colouring relative to the A_1 horizon. In some instances a bleached A_2 horizon may have developed in which case the layer has a white appearance. These layers mostly set hard when dry, providing a barrier to root development, and are often indicative of drainage problems. In the southern tablelands bleached A_2 horizons are evident in many of the drainage lines and adjacent lower slopes. Subsoils (B horizons) of the Canberra – Windellama area are generally light to medium clays.

Soil Types demonstrates a characteristic and repeatable pattern related to the position in the landscape. A typical suite of soils in the Windellama area would be Leptic Rudosols on crests, Red to Yellow Chromosols and Kurosols on hill slopes and Sodic to Natric Kurosols and Bleached-Mottled Sodosols in drainage lines. In many cases this is true regardless of the lithology – shales, sandstones, bauxities, volcanics and granitiods.

In the Widellama area basalts buck the trend outlined above. Basaltic soils in this area are heavier, better structured, typically gradational and dark coloured. This is most notable in drainage lines where dark Vertosols may be found in preference to the Sodic Kurosols and Sodosols.

ROUTE

We will travel south from Goulburn to Hawkes Lane via the Windellama Road, then retrace our steps to the Windellama Road where we continue south east to Oallen Ford for lunch. A number of interesting sites will be examined along the Windellama Road prior to heading east to Tarago and then returning to Goulburn via the Braidwood Road.

0 km	Goulburn Park opposite the Town Hall. Head towards the rail line and turn **right** onto Sloane Street passing the Goulburn railway station on your left.
1.1 km	**Left** onto Braidwood Road over the railway line
1.3 km	**Left** onto the Windellama Road. we pass through a ………….. country
20.5 km	We pass through the first in a series of clearly visible cuttings of steeply deeping and kaolinised sediments. We will not stop here as we will visit a similar site latter in the day STOP 3.
29.0 km	Pass the soils pits (STOP 2). Do not stop here yet as the bachoe will still be feverishly uncovering the soil pits.
30.2 km	**Right** onto Hawkes Lane
32.0 km	Stop at the Crest of the hill. **STOP 1: Hedley bauxite**
35.0 km	**Retrace** your steps to the Soil Pits take the gate on the right. There is a black earth dam and a tree crowned hill to the east. **STOP 2: Bronte property soil pits**

Stop 1 Hedley bauxite (Braidwood 1:100,000 sheet, GR 535 244 – near Hedley homestead)

This is a Type 3 profile of Taylor and Ruxton (1987). Here, a deeply weathered remnant of Eocene basalt is exposed, and we will look at pisolitic ferricrete/bauxite on a hill top and a small exposure of mottled regolith at the road-side. The profile is described in Table 1 (after Taylor and Ruxton 1987, chemical data from McCormack 1985).

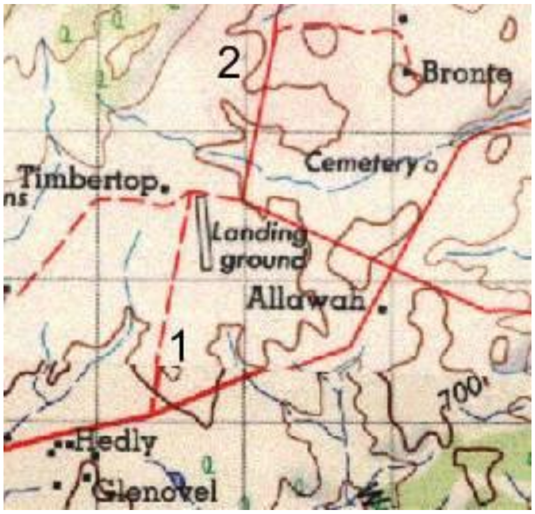


Table 1. Hedley bauxite profile.

		SiO_2	TiO_2	Al_2O_3	Fe_2O_3
1-3 m	**Pisolitic zone** (ferricrete) Pisoliths up to 30 mm in a plasma of gibbsite with silt- and sand-sized quartz. Ferrans and gibbsans line some voids, and there are ferruginous mottles in the plasma. Commonly poorly- to well-bedded	6.7	4.3	28.2	40.2
2-5 m	**Vesicular/massive zone** Red pisoliths in a yellow, vesicular plasma. The concentration of pisoliths decreases downward. The zone is dominated by gibbsite with minor hematite, maghemite, goethite and anatase pellets with silt-and sand-sized quartz.				
3-6 m	**Mottled zone** Red clay-sized material disrupted by white clay-and silt-sized material. The *red material* is hematite dispersed evenly through gibbsite, with goethite pseudomorphs after pyroxene and lithoclasts of weathered basalt. It contains striotubules and patches of bimasepic fabrics. The *white material* is gibbsite with quartz silt and sand. It shows very little fabric, although some crude ferruginous segregations and striotubules occur.	7.8	6.3	55.9	3.5
~10-15 m	Weathered basalt. Mauve, clayey basalt saprolite. Olive and pyroxene are pseudomorphed by goethite and/or hematite, the feldspars by gibbsite and the glass by gibbsite and anatase. Minor kaolinite occurs.				
>5m	Fresh basalt	51	2.0	12.0	7.0

Leslie and Tilley (1998) examined 162 pisoliths and nodules from a similar bauxite near Windellama. Representative mineral compositions are presented in Table 2. Almost all the samples showed appreciable quantities of poorly diffracting material (PDM). The characteristics of PDM-rich nodules and pisoliths are:

- brown to black colour;
- subvitreous to vitreous lustre;
- hardness 6-7; and,
- density from 2.7-3.5.

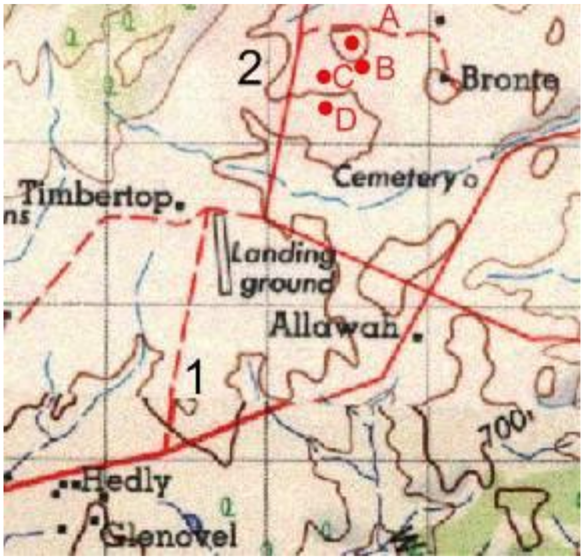
The most PDM rich parts (generally the cores) of pisoliths and nodules, were shown by differential to be χ-alumina. Though the chemical composition of the PDM-rich parts varies quite widely, high alumina is a common factor (ranging from 45% to 90% with an average of about 60%). Highly magnetic PDM from Hawk's Lane appears to be an intimate mixture of minute (5 nm) crystals of maghemite in a matrix of PDM (Eggleton, 1987). The cell dimension of the maghemite from Windellama is approximately 8.13 Å (Leslie & Tilley, 1998), which corresponds, on the basis of Vegard's Law, to approximately 70 mol% Al, far beyond the known substitution of Al in Maghemite (~20%). This material needs further study.

Table 2. Mineralogical composition of selected nodules and pisoliths from Windellama, NSW (Leslie and Tilley, 1998)

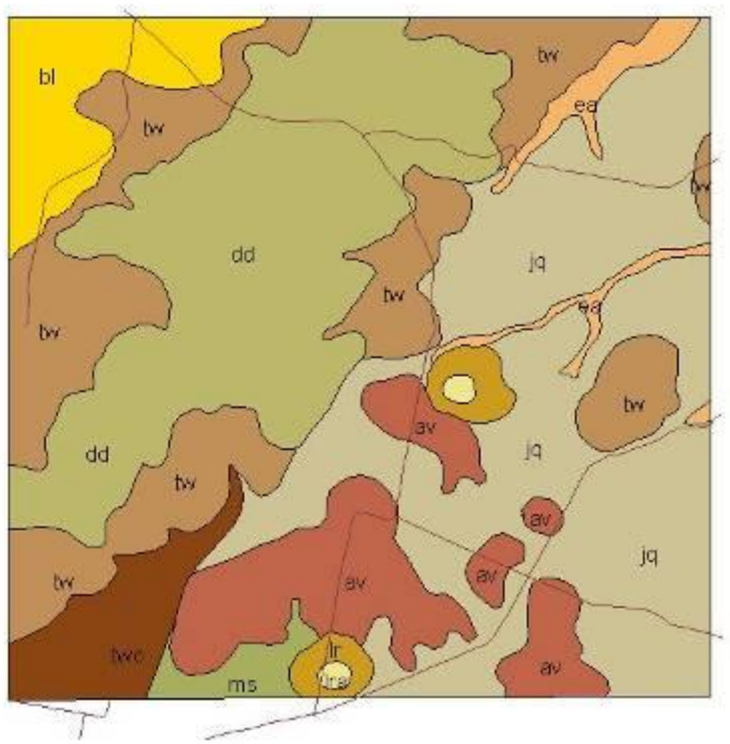
Pisolith #	Appearance	Mineralogy						Density	Magnetism
		Gb	At	Qz	Hm	Mh	PDM		
W3	brown black	1	1	1	1	3	94	3.52	y
B82	black core	9	1	7	0	5	78	2.40	y
L51	red-brown	15	1	0	7	0	77	2.77	n
W4	brown	20	2	1	14	16	48	2.85	y
L4	brown	22	5	3	32	23	16	3.49	y
L53	brown	42	3	0	40	0	15	2.95	n
B65	cream-brown	79	5	14	0	0	2	1.88	n

Figure 2. Soil pits at Stop 2:

● A - Orthic Tenosol (Lithosol)
● B – Red Chromosol (Red Podzolic Soil)
● C – Grey Vertosol (Cracking Clay)
● D – Brown Ferrosol (Chocolate Soil)



Soils map of the Hawks Lane-Bronte area (Davey 2002).



av - Avoca Soil Landscape. Residual tertiary basalt flows and associated footslopes. Typical flat-topped basalt hills and adjacent valley fill materials. Tenosols (Lithosols), Brown Ferrosols (Chocolate Soils), Grey/Black mottled Vertosols (Weisenbodens).

bl - Bullamalito Soil Landscape. Undulating low hills and rises on the Towrang Beds. Local relief < 50 m between 650 and 800 m elevation. Slopes < 10 %. Paralithic Bleached Leptic Tenosols, Red Kurosols, Brown Kurosols, Brown Sodosols.

dd - Durran Durra Soil Landscape. Rolling hills on Ordovician meta-sediments. Infertile stony soil landscape often left under timber. Often 50 % or greater surface cobbles and stones. Tenosols (Lithosols), Kandosols (Yellow Earths, Earthy Sands), Yellow/Brown Kurosols, Solodic

ea - Eastfields creek soil landscape. Long thin (< 100m wide) valley flats and small alluvial flats. Often incised deeply incised with gullies. Poor drainage and waterlogging common. Alluvial Soils, Solodic Soils, Kurosols. Hardsetting bleached A2's common with low wet bearing strengths.

jq - Jaqua Soil Landscape. Extremely erosive undulating rises and low hills on undifferentiated meta-sediments. High to extreme gully erosion risk. Localised salinity and high water tables. Natric and non-natric Kurosols, Sodosols.

lr - Larkin Soil Landscape. Inverted landscape of low hills formed on resistant ferricrete. Tenosols (lithosols), Red Kurosols, Red Ferrosols.

lra - Larkin variant. Steeper areas with > 20 % ferricrete outcrop, shallow soils and poor land capability.

ms - Morass Soil Landscape.

tw - Tarawarra Soil Landscape. Undulating low hills and rises on Ordovician meta-sediments. Red Kurosols, Brown Kurosols, Solodic Soils, Earthy sands (on siliceous p.m.). High sheet and gully erosion hazard.

twc - Tarrawarra variant. Gentle waning lower slopes with highly dispersible soils, saline seepage and severe gully erosion hazard.

Stop 2. Bronte: basalt, bauxite, black soils and landscapes (Braidwood 1:100,000 sheet, GR 543 266 – near Bronte homestead).

Introduction

The aim of this stop is to examine the relationships between parent geology, its weathering into various soil-landscape associations, and consequences for land management. The general geology here is similar to that at Stop 1: bauxite developed over basalt.

Soils

At this stop, there are two low hills with an intervening valley flat containing a farm dam. Figure 2 shows the various soil-landscape associations in the Bronte area, and Table 3 describes the properties of these associations (Davy 2002). The southern low hill is formed on basalt and has weathered to form the Avoca Soil-Landscape Association (Figs. 2, 3). Basaltic soils are not typical of the region. On this hillsope we will examine a Brown Ferrosol (Chocolate Soil. This soil type is brown, moderately well drained, gradational, relatively fertile and lacks an A_2 horizon. In the valley flat a Black Vertosol (Black Earth, possibly a Wiesenboden) is evident. This soil is black to dark grey, highly structured, friable at the surface, relatively fertile and is clayey throughout. Figure 3 shows how these various soil materials are developed and related to each other, and Table 3 gives the properties of the soil layers. Soil pits have been opened on both the hillslope (D) and valley flat (C) to show these typical soil profiles.

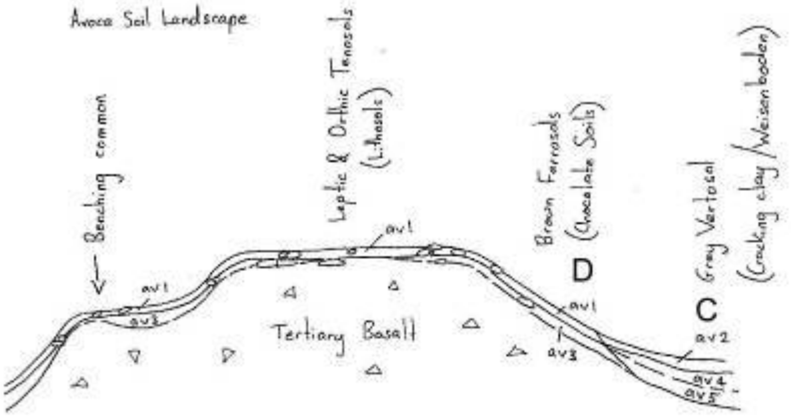


Figure: 3 Cross section of Avoca soil landscape association

Table 3 Properties of soil layers in Avoca soil landscape association

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av1 – Dark brown crumb clay loam (topsoil). Strong crumb structure, often containing 20 % or greater sub-rounded basalt stones.

av2 – Self mulching brownish black clay (topsoil). Strong crumb or polyhedral structure. Surface cracking common 5 – > 50 mm. Basalt and silcrete surface or near surface stones common.

av3 – Strong brown structured medium clay. Highly structured, stony.

av4 – Greyish black mottled sub-plastic clay. Strong smooth faced dense prismatic peds 10 – 50 mm, occasionally lenticular with slickenslides. Sub-plastic.

av5 – Mottled yellowish brown medium heavy clay. Strong pedality, peds lenticular, few (2 – 10%) calcareous soft segregations.

The northern low hill is formed on bauxite, and has weathered into the Larkin Soil Landscape Association. On the crest of the hill the bauxite and ferricrete are exposed, and near the crest soils are shallow and stony (Orthic tenesol, lithosol). The bauxite is sporadically pisolitic, paler and more pisolitic parts are up to 95% gibbsite. Anatase (2-5%) is ubiquitous in the profile; quartz < 3%. At the mid-slope (under the trees) is vermiform mottled regolith made up of approximately equal parts of gibbsite, hematite and goethite, and with about 10% kaolinite. (Figure 4) Here Red Kurosols and Chromosols (Red Podzolic Soils) are found where the soil material is deeper and less stony. This is a texture contrast soil with sandy loam topsoils and a red clay subsoil dominated by kaolin (50%) and hematite (33%) with minor goethite, gibbsite, anatase and quartz (all <5%. Figure 5 shows how the various soil materials are related, and Table 4 gives the properties of the various soil layers. A gravel pit has been opened up just down from the crest of the hill showing the bauxite and ferricrete (A, Fig 5), and another pit at the break of slope shows a Red Podzolic soil (B).

Consequences for management

Generally the soils formed from the weathering of the parent basaltic and bauxitic geologies are well suited to agriculture, particularly grazing, but also a limited amount of dryland fodder crops.

The Ferrosols and Vertosols formed from the basalts are excellent cropping soils in terms of soil structure, water holding capacity and fertility. The Red Chromosols (Red Podzolics) formed from the bauxites can be cropped provided rigorous adherence is made to methods of conservation tillage.

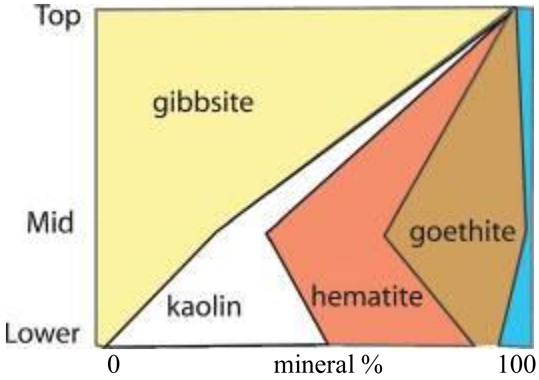

Figure 4. Mineralogy of the Brontebauxite catena.

Table 4 Properties of soil layers in the Larkin soil landscape association

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lr1 – Dark brown sandy loam/clay loam topsoil. Easily compacted and susceptible to structural decline. Grades from massive to moderate crumb structure depending upon management practices.

lr2 – Reddish brown clay loam/light clay. Weakly to moderately structured, often stony and shallow (tenic) on upper slopes.

lr3 – Red structured clay. Moderately to strongly structured sub-angular blocky medium clay.

lr4 – Pallid Zone.

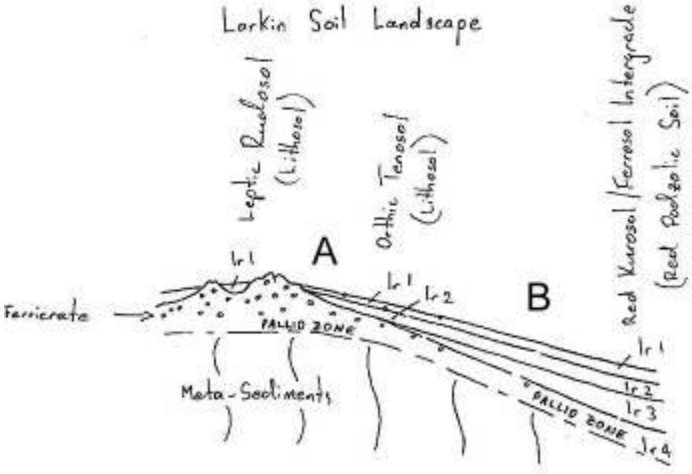

Figure: 5 Cross section of Larkin soil landscape association

46.9 km	**Turn south** on Windellama Road, passing Hawkes Lane, then east, cross Lumley Road and continue easterly on Windellama Road to Windellama Hall for an **amenities stop**
51.9 km	Continue south toward Nerriga on the Oallen-Nerriga Road. Stop 200 m south of the Sandy Creek Road turnoff **STOP 3: Sandy Creek - Windellama Road clays**
67.5 km	Continue travelling south and east to Oallen Ford, Stop on south side of ford **LUNCH STOP.**

Stop 3. **Sandy Creek - Windellama Road clays** (Braidwood 1:100,000 sheet, 5.0 km south of Windellama Hall, 200 m south of the Sandy Creek Road turnoff. Grid Ref 7 **61**201E 61 **15**866N.).

The Minda clay pit is in the pallid zone of a Type 1 profile of Taylor and Ruxton (1987). The bedrocks are Ordovician slates, shales and sandstones. The kaolinized zone, up to about 15 m thick, largely retains the fabric of the bedrock. Its composition is variable; analyses of two grab samples of saprolite (run of mine) are given in Table 5. The kaolinite is poorly ordered, however the presence of dominant mica prevents an accurate estimate of the degree of ordering on the basis of the XRD pattern.

Above the pallid zone is a thin (2-5 m) mottled zone, showing red ferruginous mottles, and iron oxyhydroxide boxworks toward the upper part of the zone. At the top of the profile is a 3-5 m ferricrete, becoming crudely nodular or pisolitic toward the top. Some parts are strongly magnetic (maghemite-bearing). Quartz sand and pebbles and poorly cemented limonitic sandstones are included particularly toward the base. The dominant iron mineral is goethite (Table 5). The Fe-stone sample analysed for Table 5 is from a small hill top about 100 m north east of the entrance gate.

Table 5. Mineralogy of the Minda clay pit.

	Minda		
	Sample 1	Sample 2	Fe-stone
Quartz	40.3	28.3	1.8
Kaolin	27.7	19.8	4.1
Illite	32.2	51.9	0.0
Hematite	0.0	0.0	17.5
Goethite	0.0	0.0	76.6

Table 6. Chemical analysis and brightness of Minda sample 2

	Sample 2
SiO_2	63.60
TiO_2	0.90
Al_2O_3	27.80
Fe_2O_3	1.08
MgO	1.00
CaO	0.03
Na2O	0.09
K2O	5.11
Cl	0.028
Brightness	48.5

Stops 4 & 5. Erosion gullies and associated land management.

Introduction

The aim of this stop is to provide a marked contrast to Stop 2. Whereas the soils at Stop 2 were derived from the weathering of basalts and bauxites, the soils and related issues of land degradation at Stops 3, 4 and 5 have developed on metasediments (Ordovician shales and sandstones).

Soils

The main soil feature at this stop is a gully containing a Natric Kurosol (Solodic Soil, Solodized Solonetz). This soil is highly erodible. It has virtually no A_1 horizon, a bleached hardsetting A_2 horizon and a highly dispersive B_2 horizon. It is infertile, acidic, prone to tunnel erosion and has very low agricultural potential. The properties of a typical soil profile in a gully are given in Table 7. Note the strong correlation between salt content (EC 1:5) and dispersion percentage. The headwall of the gully (0-250 cm), containing low levels of soluble salts, is highly dispersive, whereas the lower gully (below 300 cm) containing high levels of soluble salts is resistant to dispersion. These highly erodible soils are mainly formed on the Tarrawarra soil landscape association (Fig.6). The occurrence and relationships of the different soil types in the Tarrawarra formation are given in Table 6.

Rehabilitation of these gullies is difficult. At a minimum it requires fencing them out and replanting at the edges of the gully with mixtures of grasses to prevent further erosion. Treatment of active gully heads can require a range of engineering treatments depending on topography and soil characteristics (e.g. gully control structures, flumes, gabion rock structures). Recycled organic products (composted mulches) are often used on sites with little or no topsoil to aid revegetation.

Table 7 Properties of an erosion gully, Windellama region

Depth (cm)	Clay	Silt	F/Sand	C/Sand	Gravel	pH (1:5 soil/ water)	EC (1:5 soil/ water) (dS/m)	Disp(%)
100 (Headwall)	42	46	11	0	1	5.5	0.48	100
250 (Headwall)	41	42	15	1	1	4.8	0.82	71
300 (lower gully)	32	26	28	10	4	4.7	1.61	4
400 (lower gully)	21	11	48	19	1	4.5	2.44	8

XRD mineralogy of lower gully bulk sample: quartz 72%, smectite 5%, kaolin 9%, mica 13%, goethite 1%

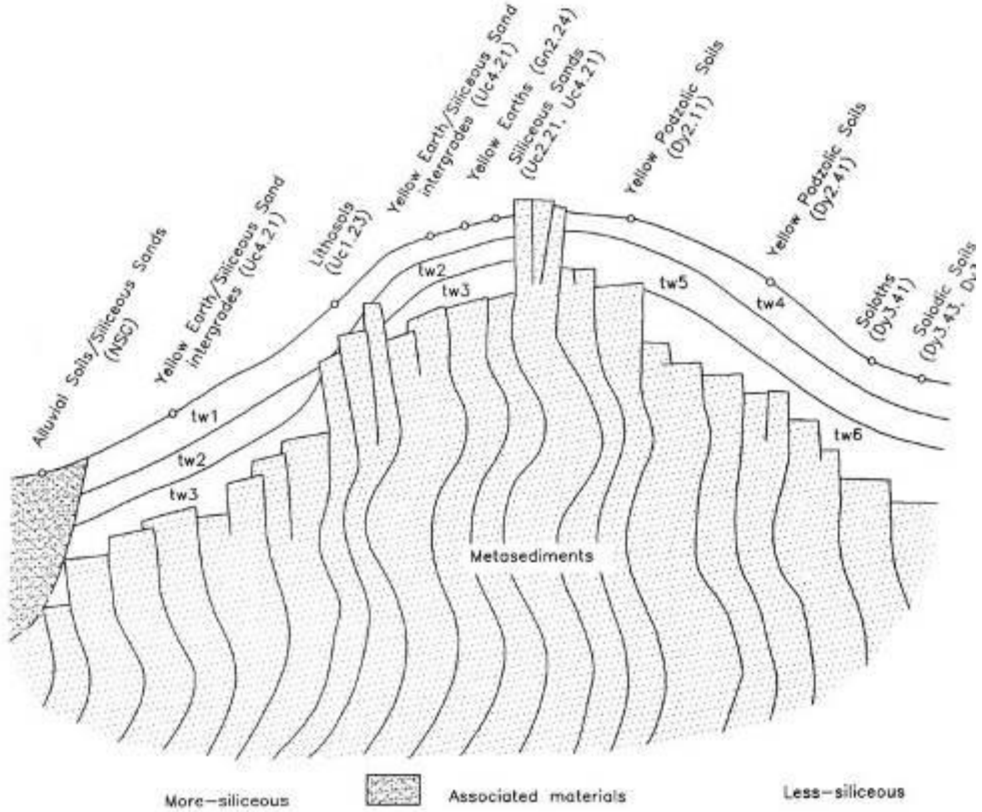

Figure 6. Schematic cross-section of the Tarrawarra soil landscape illustrating the occurrence and relationship of the dominant soil materials

Table 8 Occurrence and Relationships of soil types in Tarawarra soil landscape association

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Siliceous Parent Material

Crests. Up to 15 cm of yellowish brown sand **(tw1)** overlies <20 cm of dull yellow sand **(tw2)** which is underlain by <40 cm of orange clayey sand **(tw3).** Boundaries are clear to abrupt. [Well-drained Siliceous Sands (Uc2.21, Uc4.24, Uc4.21) and Yellow Earths (Gn2.24)]. Siliceous Sand/Yellow Earth intergrades are common. Total soil depth is <100 cm. **tw3** often grades into massive gravelly loamy C horizon.

Sideslopes. Up to 20 cm **tw1** directly overlies fractured bedrock. [Rapidly drained Lithosols (Uc1.23)].

Lower slopes. Up to 20 cm **tw1** overlies <30 cm **tw2** which is underlain by <60 cm **tw3.** Soil boundaries are clear. [Well-drained Siliceous Sand/Yellow Earth intergrades (Uc4.21)]. Total soil depth is <100 cm.

Less Siliceous Parent Material

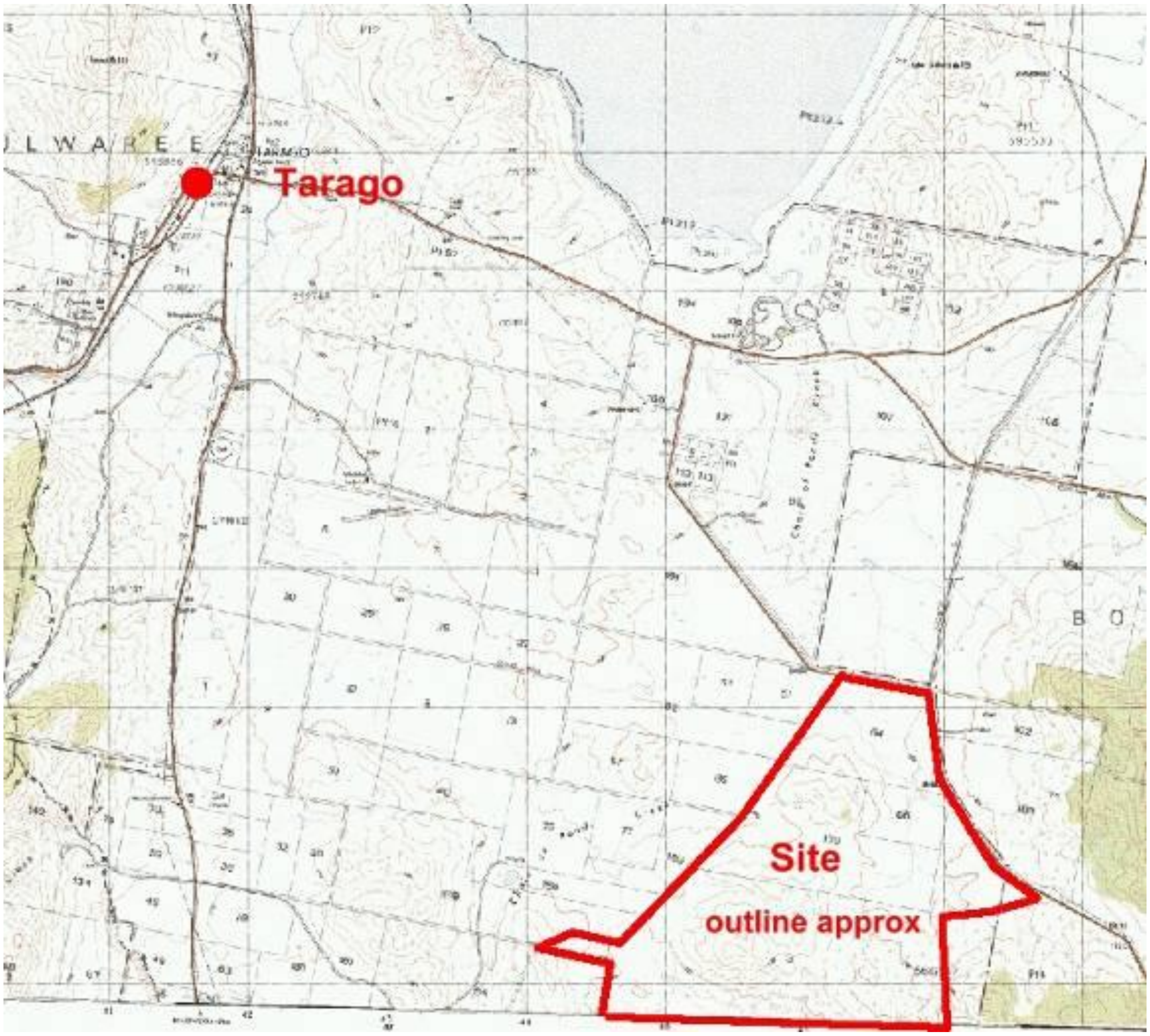
Crests and ridges. Up to 20 cm of brown loam **(tw4)** overlies <40 cm of bright yellowish brown medium clay **(tw5).** Boundaries are clear. [Moderately well-drained Yellow Podzolic Soils (Dy2.11)]. Total soil depth is <60 cm.

Sideslopes. Up to 15 cm **tw4** overlies <15 cm of yellowish brown loam **(tw5)** which is underlain by <50 cm **tw6.** Boundaries are clear to abrupt. [Moderately well-drained Yellow Podzolic Soils (Dy2.11)]. Total soil depth 60 - 80 cm.

Drainage lines. Up to 20 cm **tw4** overlies <30 cm **tw5** which is underlain by >60 cm **tw6.** [Poorly drained Solodic Soils (Dy3.43, Dy3.42) and Soloths (Dy3.41)]. Total soil depth is >80 cm.

70.1 km	**Retrace** your steps north along Windellama Road to Sodic Gullies **STOPS 4 & 5: Erosion gullies and associated land management**
98.8 km	**Retrace** our route south on the Oallen-Nerriga Road, Windellama Road to Hawkes Lane. **Left** onto Hawkes Lane

Stop 6. Morse McVey Salinity Site.



The aim of this stop is to investigate dryland salinity in the upper Shoalhaven catchment. The Sydney Catchment Authority are increasingly concerned about the water quality impacts of salinity, especially with increasing development pressure in the area. As such, water cycle management studies need to be prepared for all large developments, including subdivisions, to address both existing and potential issues.

Soils

The soils in this area are a mixture of residual, colluvial and transferal materials. The relatively low relief of the area contributes to long, waning footslopes overlying a variety of geologies. This site demonstrates that dryland salinity can develop over relatively small catchments if water tables are not effectively managed.

Soils are mainly Yellow Sodosols, with salts occurring in situ at around 1.0m depth and below. The origin of the salts is a combination of wind-blown and geological. Complex metamorphic sediments contribute to variable mineralogy and also to salts being concentrated at breaks in slope and around drainage depressions.

Management

The SCA now requires that developers (including those wishing to subdivide) submit a Water Cycle Management Study, detailing the potential impacts of the development on water quality. At sites such as these that are salt-affected, this requires extensive remediation to alleviate the existing issue, and a management regime enacted to minimize potential future impacts. At this site, this led to a number of measures being taken, including:

1. realigning the proposed road to avoid existing salt scalds and minimize the length it intercepted drainage depressions;
2. rearranging the lot layout according to sub-catchments;
3. use of salt-tolerant grass species and specific surface water management devices to rehabilitate scalded areas;
4. protection of existing Landcare works (some up to 20 years old);
5. extensive tree planting, especially along fencelines to minimize the risk of poor land management on one new lot impacting the water table on another;
6. implementation of measures for ongoing protection of trees;
7. specific requirements for onsite wastewater management;

One of the most significant issues was accessing accurate salt management information that is relevant to the Goulburn district. Much of the saltland management knowledge focuses on the WA wheatbelt or the Murray. Adaptation of research conducted around Yass was necessary, along with liaison with Greening Australia, particularly when recommending tree species. The endemic species for the area are not always easy to grow and establish and so other options need to be investigated.

The following photo is of some salt affected land on the Morass (**ms**) soil landscape (Jenkins 1995). The Morse McVey Salinity Site lies on this soil landscape and exhibits many of traits characteristic of the landscape. ie yellow, sodic and saline soils.

100.6 km 102.6 km 108.2 km	**Right** at Lumley Road. The Morass; a small lake formed by overflow from Lake Bathurst Lake Bathurst. This is a smaller analogue of Lake George; another fault-dammed lake. The road passes along the eastern shore of the lake on a lunette formed by deflation during the Quaternary. The road then skirts the southern margin of the Lake with Quaternary beach ridges on the left showing well-developed Red Chromosols.
108.3 km	**Left** onto Mayfield Road
112.4 km	Approximately 0.5 kms after the 90 degree right hand bend, there is a gate near a large shed on the right of the road. Turn in and park near the shed. Site is a short walk from there. A very attractive man named Andrew should be waiting to meet the bus. Look for a silver Mazda sedan, belonging to aforementioned very attractive man. (needless to say description provided by same said attractive man) **STOP 6 Morse McVey Salinity Site**
116.5 km 119.7 km	Retrace steps and turn left at T intersection and head towards Tarago. Right at Tarago onto the Goulburn-Braidwood Road.
157.6 km	Continue north along the Goulburn-Braidwood Road to Goulburn Park opposite the Town Hall and the trip completion **END**

Acknowledgements

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