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Technical Report **38/98**, October 1998

Land & Water Resources Research & Development Corporation

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Characterisation of six soil profiles at the MLA SGSKP site at Vasey, Victoria

by

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Technical Report 38/98

October 1998

Summary

The table below is an integration of the soil profile morphology, soil chemistry, soil physics and inferred degree of soil saturation discussed in detail in this report.

I Soil Pit Number and slope position	II Soil Classification	III Soil Description	IV Wetness Ranking	V Soil Physics/ Saturation
1. Tableland	Yellow Sodosol (Lateritic podzolic)	• Sodic, non saline; • Clay loam at 25 cm won't impede infiltration[1] (see Column V) but clay at 90 cm might	Low	• 50-60% gravel from 50–180 cm; • Relatively high water storage capacity; • Relatively dense layer at 25 cm could impede infiltration[2]
2. Mid-slope	Grey Chromosol (Lateritic podzolic)	• Non sodic, non saline; • Loam at 30 cm won't impede infiltration (see Column V) but clay at 60 cm might	Moderate	• <30% gravel; • Relatively moderate water storage capacity; • Relatively dense layer at 25–30 cm could impede infiltration
3. Mid-slope	Brown Chromosol (Lateritic podzolic)	• Non sodic, non saline; • Clay at 20 cm may impede infiltration	Low	• 41% gravel from 12–20 cm; • Relatively moderate water storage capacity; • Sudden increase in density at 20 cm could slightly impede infiltration (however, density not high)
4. Lower slope	Hydrosol (Gleyed podzolic)	• Sodic, saline; • Clay at 40 cm may impede infiltration (see Column V)	High	• 52-73% gravel from 20–85 cm; • Lowest water storage capacity; • Dense layers at 40 cm and 65 cm could impede infiltration • Soil probably remains saturated below about 1 m all year (due to groundwater)
5. Tableland	Brown Sodosol (Lateritic podzolic)	• Sodic, non saline; • Clay at 40 cm may impede infiltration	Moderate	• 36–44% gravel from 40–180 cm; • Relatively low water storage capacity; • Clay (40–180 cm) has invariably low density
6. Lower slope	Aquic Vertosol (grey clay)	• Sodic, non saline; • Clay loam over clay at 20 cm. Clay may impede infiltration	High	• 73% gravel from 35–45 cm; • Highest water storage capacity; • Clay (20–200 cm) has invariably low density

[1] This interpretation is based only on the absence/presence of redoximorphic features and may be different to interpretation[2] which is based only on soil texture.

Introduction

This is the second report on the soils at the Vasey site which has been selected as one of Meat and Livestock Australia's (MLA's) national research sites under the Sustainable Grazing Systems Key Program (SGSKP). The first report (Cox *et al*. 1997) described two soils (Pits 1 and 2) which have been included in this report with additional information.

The Vasey site is located 45 km NNW of Hamilton on the Dundas Tablelands. This report presents soil descriptions, classifications and bulk densities of six profiles. Locations of the soil pits are shown in Fig. 1.

Methods

Six pits were excavated (Soil Pits 1 to 6, Figure 1) to about 2 m and soils described using McDonald *et al.* 1990. Pit 6 was located below the high water mark of a dam, which was installed in the late 1970s or early 1980s. At the time of inspection, the water level was at least 1 m below the top of the pit. Soils were classified according to the Australain Soil Classification System (Isbell, 1996), the US Classification System (Soil Survey Staff, 1996) and by the Australian Great Soil Groups (Stace *et al*., 1968).

Samples were collected from each soil horizon on 2 March and 3 April 1997. These were analysed in the laboratory (CSIRO Land and Water Analytical Laboratories, Adelaide) for pH (in H_2O and $CaCl_2$), $EC_{1:5}$, exchangeable cations and cation exchange capacities (CECs), C, P, S, Al and Mn. Additional samples were collected in mid April 1997 and analysed at the State Chemistry Laboratory of Victoria (SCL) at Werribee for acid neutralising capacity (Michael *et al.,* 1989), mechanical composition, nitrate and ammonium N, phosphate sorption index, total P and S, and available sulfur (Anderson *et al*., 1994).

Samples were collected from each soil horizon on 2 March and 3 April 1997. These were analysed in the laboratory (CSIRO Land and Water Analytical Laboratories, Adelaide) for pH (in H_2O and $CaCl_2$), $EC_{1:5}$, exchangeable cations and cation exchange capacities (CECs), C, P, S, Al and Mn. Additional samples were collected in mid April, 1997 and analysed at the State Chemistry Laboratory of Victoria (SCL) at Werribee for acid neutralising capacity (Michael *et al.,* 1989), particle size, NO_3-N, NH_4-N, phosphate absorption, total P and S, and available sulfur (Anderson *et al*., 1994).

Bulk density and soil moisture were determined from samples taken in duplicate from each horizon with 98.2 cm^3 soil cores.

Water seeping into Pit 4 was analysed for EC, pH, turbidity, Cl, NO_3-N, total dissolved carbon, dissolved inorganic carbon, dissolved organic carbon, Al, B, Ca, Cu, Fe, K, Mg, Mn, Na, P, S and Zn.

Results and discussion

Soil descriptions, classification and chemistry

General soil profile descriptions are in Tables 1 to 6. Detailed soil profile descriptions are in Appendix 1. For reference Soil Pit 3 is located at 5860877 N 581146E (37°24' S, 141°55' E, 261 m elevation, map reference 7223-S Nareen-Dundas WD809607).

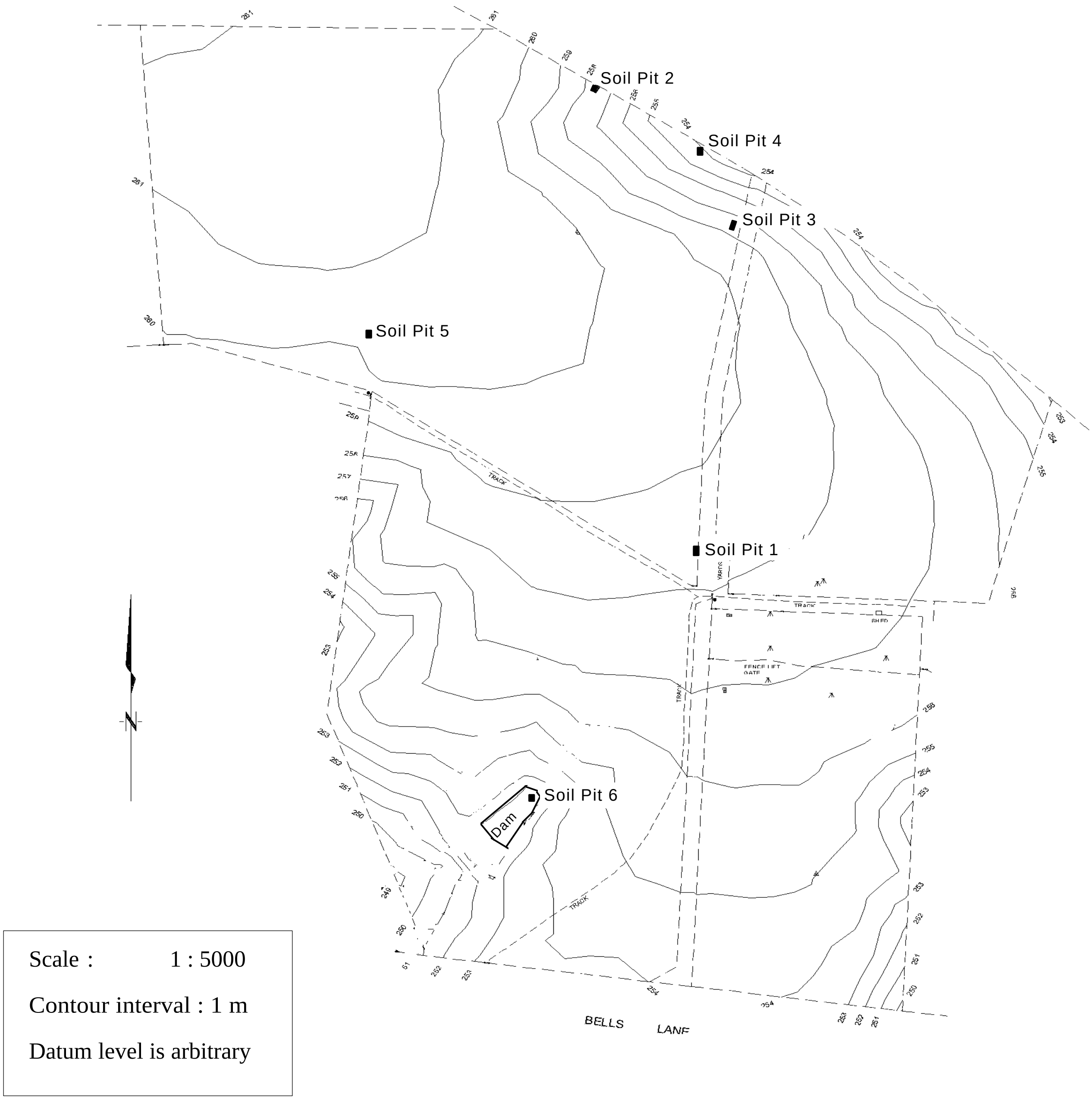


Figure 1. Locations of soil pits (1 to 6) on the Vasey site.

Table 1. Soil Profile 1: Ferric, Mottled-subnatric, Yellow Sodosol (Lateritic podzolic)

Soil horizon and summary description	Inferred waterlogging duration*
0–5 cm (Ap) uniform coloured very dark grey sandy loam	Soils is infrequently saturated
5–25 cm (Ec) dark reddish grey loam with 15% brownish yellow mottles	Soil becomes saturated periodically in winter
25–50 cm (Btc1) brownish yellow fine sandy clay loam with 7% strong brown mottles	Soil becomes saturated periodically in winter
50–90 cm (Btv2) dark yellowish brown clay loam with 35% light brownish grey and 15% brownish yellow mottles	Soil becomes saturated periodically in winter
90–140 cm (Btv3) dark red light medium clay with 35% light grey and 15% strong brown mottles	Soil becomes saturated periodically in winter and drains slowly during spring
140–180 cm (Btv4) red medium to heavy clay with 35% light brownish grey and 7% yellowish brown mottles; common distinct clay skins	Soil becomes saturated periodically in winter and drains slowly during spring; preferential vertical flow
180–200 cm (Btv5) red heavy clay with 35% light brownish grey and 7% yellowish brown mottles; common distinct clay skins	Soil becomes saturated periodically in winter and drains slowly during spring; preferential vertical flow

* based on Cox *et al*. 1996

Table 2. Soil Profile 2: Ferric-sodic, Eutrophic, Grey Chromosol (Lateritic podzolic)

Soil horizon and summary description	Inferred waterlogging duration*
0–5 cm (Apc) uniform coloured dark grey sandy loam	Soil is infrequently saturated
5–30 cm (Ec) dark greyish brown loam with 15% brownish yellow mottles	Soil is periodically saturated by a perched watertable developing in winter at 60 cm
30–60 cm (Btc1) yellowish brown clay loam with prismatic structure and 35% greyish brown and 15% dark red mottles	Soil is periodically saturated by perched watertable and possibly groundwater in winter
60–130 cm (Btc2) yellowish brown light to medium clay with prismatic structure and 35% greyish brown and 15% dark red mottles; common prominent clay skins	Soil is periodically saturated and probably influenced by groundwater in winter
130–180 cm (Btcg3) light grey heavy clay with prismatic structure and 15% dusky red and 7% strong brown mottles; common prominent clay skins	Soil is periodically saturated and probably influenced by groundwater in winter
180–200 cm (Btg4) light grey heavy clay with prismatic structure and 15% dusky red and 7% strong brown mottles; common prominent clay skins	Soil is periodically saturated and probably influenced by groundwater in winter

Table 3. Soil Profile 3: Ferric-sodic, Eutrophic, Brown Chromosol (Lateritic podzolic)

Soil horizon and summary description	Inferred waterlogging duration
0–5 cm (Apc) uniform coloured very dark greyish brown sandy loam with massive apedal structure	Soil is infrequently saturated
5–12 cm (Ec1) uniform coloured dark greyish brown clay loam with massive apedal structure	Soil is infrequently saturated in winter
12–20 cm (Ec2) uniform coloured dark greyish brown clay loam with massive apedal structure	Soil is infrequently saturated in winter
20–50 cm (Btc1) brown medium clay with strong pedal structure and 7% dark red primary mottles	Soil is periodically saturated in winter and drains slowly during spring
50–85 cm (Btv2) strong brown loamy clay with plinthitic platy structure and 35% dark red primary mottles	Soil is periodically saturated in winter and drains slowly during spring
85–100 cm (Btv3) brownish yellow medium clay with 35% dusky red primary mottles	Soil is periodically saturated in winter and drains slowly during spring
110–180 cm (Btv4) very pale brown medium clay with prismatic structure and very pale brown primary mottles	Soil is periodically saturated in winter and drains very slowly over spring and summer, probably influenced by groundwater in winter

Table 4. Soil Profile 4: Petroferric, Salic, Hydrosol (Gleyed podzolic)

Soil horizon and summary description	Inferred waterlogging duration
0–5 cm (Apc) uniform coloured greyish brown sandy loam with massive structure	Soil is frequently saturated (in winter)
5–20 cm (Ec1) uniform coloured light grey clayey sand with massive structure	Soil is frequently saturated (in winter)
20–40 cm (Ec2) uniform coloured light grey clayey sand with >70% ironstone gravel	Soil is frequently waterlogged (perched watertable)
40–85 cm (Btc1) yellowish brown loamy clay with 15% primary mottles, large fragments of hard ferricrete and > 50% ironstone gravel	Soil is frequently waterlogged (perched watertable)
85–100 cm (Btv2) yellowish brown heavy clay with prismatic structure and 30% weak red primary mottles	Soil is frequently saturated throughout the year and remains so due to groundwater
100–150 cm (Btn3) dusky red heavy clay with prismatic structure and 30% grey primary mottles	Soil is frequently saturated throughout the year and remains so due to groundwater
150–200 cm (Btg4) light grey loamy clay with prismatic structure and 5% yellowish brown primary mottles	Soil is frequently saturated throughout the year and remains so due to groundwater
200–250 cm (Ctg) light grey clay with massive apedal structure and 20% yellowish brown primary mottles	Soil is frequently saturated by groundwater
>250 cm (R)	

Table 5. Soil Profile 5: Ferric, Mottled-subnatric, Brown Sodosol (Lateritic podzolic)

Soil horizon and summary description	Inferred waterlogging duration
0–5 cm (Apc) uniform coloured dark brown sandy loam	Soil is infrequently saturated in winter
5–20 m (Ec1) uniform coloured dark brown sandy clay loam	Soil is infrequently waterlogged in winter
20–40 cm (Btc1) yellowish brown clay loam with polyhedral structure and 10% yellowish red primary mottles	Soil is waterlogged in winter
40–95 cm (Btv2) yellowish brown loamy clay with plinthitic platy structure and 30% weak red primary mottles	Soil is periodically saturated in winter and drains slowly during spring
95–180 cm (Btv3) dark greyish brown medium clay with plinthitic platy structure and 20% strong brown primary mottles	Soil is periodically saturated in winter and drains slowly during spring
>180 cm (Btg4) light grey medium to heavy clay with prismatic structure	Soil is frequently saturated and remains so due to groundwater

Table 6. Soil Profile 6: Bleached, Epipedal, Aquic Vertosol (Grey clay)

Soil horizon and summary description	Inferred waterlogging duration
0–5 cm (Ap) very dark greyish brown clay loam with polyhedral structure and 10% strong brown primary mottles	Soil is frequently saturated in winter
5–20 cm (E1) very dark greyish brown clay loam with prismatic structure and 10% strong brown primary mottles	Soil is frequently saturated in winter, evidence of some saturation due to groundwater
20–35 cm (2Btg1) light brownish grey medium clay with prismatic structure and 2% strong brown primary mottles	Soil is frequently saturated in winter, evidence of some saturation due to groundwater
35–45 cm (2Btg2) light brownish grey medium clay with massive apedal structure and <2% strong brown primary mottles	Soil is frequently saturated in winter and drains slowly over summer
45–62 cm (3Btgss1) dark greyish brown medium clay with prismatic structure and 30% dusky red primary mottles	Soil is frequently saturated by groundwater
62–110 cm (3Btgss2) olive yellow medium clay with prismatic structure and 25% dark red primary mottles	Soil is frequently saturated by groundwater
110–200 cm (3Btg) white medium clay with prismatic structure and 10% yellow primary mottles	Soil is frequently saturated by groundwater
>200 cm (3Ctg) white loamy clay with massive structure and 10% dark yellowish brown primary mottles	Soil is frequently saturated by groundwater

Selected chemical properties of the soils are presented in Tables 7 and 8. Available S increased substantially with depth in all profiles. Exchangeable sodium percentage (ESP) generally increased with depth (Table 7) in all soil profiles. The soil at Pits 2 and 3 were non sodic (ESP < 6%) over the depth sampled (about 2 m). The Hydrosol at Pit 4 was the most sodic (maximum ESP was 21.1%) of the soils. This soil was sodic within 5 cm of the soil surface and would be very prone to dispersion if drained.

Table 7a. Selected soil chemical properties of horizons from Soil Pits 1 to 6

Pit	Depth		EC (1:5 soil:water)	pH (1:5 soil:water)	pH (0.01 M $CaCl_2$)	Cl	Total C (Leco)	Total S (Leco)	KCl Ext Al	KCl Ext Mn	HCO_3^- ext. P	S (CPC)
	cm		dS/m			mg/kg	%	%	mg/kg	mg/kg	mg/kg	mg/kg
1	0–5	Ap	0.12	5.5	5.1	62.3	7.78	0.08			31	9
	5–25	E	0.05	5.5	4.8	40.1	1.87	0.02			5	15
	25–50	Bt1	0.08	6.1	5.8	72.0	0.17	0.01			<4	120
	50–90	Bt2	0.14	5.7	5.6	206	0.15	0.01			<4	89
	90–140	Bt3	0.20	5.4	5.2	295	0.15	0.02			<4	150
	140–180	Bt4	0.37	4.4	4.2	566	0.07	0.04	130		<4	>200
	180–200	Bt5	0.59	4.1	4.0	882	0.11	0.06	370		<4	>200
2	0–5	Ap	0.04	5.4	4.7	19.3	2.42	0.01			21	47
	5–30	E	0.01	5.7	4.5	8.9	0.80	<0.01			<4	12
	30–60	Bt1	0.03	6.5	6.0	10.7	0.17	0.01			<4	46
	60–130	Bt2	0.04	6.4	6.0	23.0	0.12	0.01			<4	52
	130–180	Bt3	0.12	4.9	4.3	80.9	0.10	0.01			<4	120
	180–200	Btss4	0.34	4.1	3.9	505	0.06	0.02	190		<4	110
3	0–5	Ap	0.19	5.5	4.80		5.4	0.04				9
	5–12	E1	0.05	5.4	4.74		1.9		34.6	7.5		4
	12–20	E2	0.02	6.0	4.98		1.0					4
	20–50	Bt1	0.02	6.4	6.21							47
	50–85	Bt2	0.04	6.4	5.67		0.14					60
	85–110	Bt3	0.04	6.5	6.04							74
	110–180	Bt4	0.04	5.7	4.32			0.02	120			73
4	0–5	Ap	0.19	6.2	5.45		3.6	0.04				17
	5–20	E1	0.11	6.4	5.64		0.45					5
	20–40	E2	0.17	6.9	5.7		0.78	0.01				17
	40–85	Bt1	0.30	5.9	5.8							64
	85–100	Bt2	0.95	5.8	5.23		0.2	0.02				140
	100–150	Bt3	1.14	4.7	4.19			0.04	63.2	0.2		>200
	150–200	Bt4	0.98	4.5	3.75				53.1	0.1		180
	200–250	Ctg	0.61	5.1	4				43.7	0.1		93
5	0–5	Ap	0.28	5.4	5.06		6.1	0.05				43
	5–20	E1	0.04	5.5	4.74		2.4		41.2	8.8		12
	20–40	Bt1	0.05	6.2	5.8		0.29					9
	40–95	Bt2	0.05	6.6	5.92			0.01				88
	95–180	Bt3	0.10	5.7	4.73							133
	180–200	Bt4	0.52	4.2	3.54			0.04	283	0.2		100
6	0–5	Ap	0.19	5.8	4.95		4.55	0.02	5.3	10		17
	5–20	E1	0.07	5.5	4.72		3.12	0.01	27	8.7		11
	20–35	E2	0.03	6.5	5.01				3.3	4.7		77
	35–45	E3	0.03	6.6	5.24		1.03	<0.01				62
	45–62	Bt1ss	0.06	6.2	5.22				1.6	1.2		75
	62–100	Bt2ss	0.07	5.9	5.6							130
	110–200	Btg	0.11	6.1	4.62		0.17	0.01	19	0.2		142
	200–	Cg	0.12	5.5	4.52			<0.01	8.3	0.2		180

If a cell is blank, its value was not determined; CPC S determinations were made at the State Chemistry Laboratory of Victoria; all other analyses were conducted by CSIRO Land and Water Analytical Services

Table 7b. Selected soil chemical properties of horizons from Soil Pits 1 to 6

			I--------------- Exch. Cations pH 7.0 --------I					C.E.C.	ESP
Pit	Depth		Ca	Mg	Na	K	Total	(NH_4)	
	cm		I--------------------------- cmol(+)/kg					-------------------I	%
1	0–5	Ap	13.91	2.34	0.27	0.50	17.0	20.4	1.3
	5–25	E	4.05	1.17	0.20	0.09	5.5	8.7	2.3
	25–50	Bt1	3.94	5.01	0.69	0.11	9.7	11.4	6.0
	50–90	Bt2	3.16	5.85	1.01	0.08	10.1	12.0	8.4
	90–140	Bt3	2.32	6.17	1.10	0.06	9.6	11.8	9.3
	140–180	Bt4	0.75	5.09	1.17	0.03	7.0	8.9	13.1
	180–200	Bt5	0.22	4.43	1.47	0.04	6.2	10.0	14.6
2	0–5	Ap	3.13	0.87	0.16	0.23	4.4	6.4	2.5
	5–30	E	1.70	1.12	0.18	0.08	3.1	5.2	3.4
	30–60	Bt1	3.96	4.38	0.39	0.11	8.8	10.6	3.7
	60–130	Bt2	4.50	5.68	0.66	0.07	10.9	12.8	5.1
	130–180	Bt3	2.12	4.45	0.53	0.06	7.2	8.6	6.2
	180–200	Btss4	0.97	3.43	0.61	0.04	5.0	8.5	7.2
3	0–5	Ap	5.68	1.63	0.25	0.61	8.2	12.1	2.0
	5–12	E1	3.21	1.41	0.19	0.07	4.9	8.5	2.2
	12–20	E2	2.76	1.70	0.21	0.08	4.7	7.0	3.0
	20–50	Bt1	2.99	3.08	0.29	0.07	6.4	10.3	2.8
	50–85	Bt2	4.55	5.76	0.52	0.10	10.9	12.4	4.2
	85–110	Bt3	3.03	4.57	0.45	0.05	8.1	9.1	4.9
	110–180	Bt4	0.94	3.06	0.44	0.03	4.5	6.3	7.0
4	0–5	Ap	4.94	3.44	0.80	0.17	9.3	10.9	7.3
	5–20	E1	1.41	1.30	0.41	0.03	3.1	3.2	12.5
	20–40	E2	2.18	2.41	0.64	0.06	5.3	5.8	11.0
	40–85	Bt1	1.05	2.46	0.90	0.05	4.5	4.6	19.4
	85–100	Bt2	2.53	7.56	2.71	0.13	12.9	14.8	18.3
	100–150	Bt3	2.14	7.36	3.05	0.09	12.6	14.8	20.6
	150–200	Bt4	1.90	7.61	2.92	0.05	12.5	16.1	18.1
	200–250	Ctg	1.67	6.64	2.54	0.03	10.9	12.0	21.1
5	0–5	Ap	8.87	1.50	0.19	0.78	11.3	14.1	1.4
	5–20	E1	3.47	1.77	0.24	0.17	5.6	9.3	2.6
	20–40	Bt1	3.56	4.59	0.51	0.12	8.8	11.2	4.6
	40–95	Bt2	4.32	5.22	0.75	0.07	10.4	12.4	6.1
	95–180	Bt3	2.15	5.17	0.80	0.11	8.2	10.4	7.7
	180–200	Bt4	0.38	3.49	1.13	0.02	5.0	7.8	14.4
6	0–5	Ap	8.3	2.7	0.34	0.35	12	15	2.2
	5–20	E1	5.6	2.8	0.26	0.21	9	13	2.0
	20–35	E2	3.9	2.7	0.29	0.09	7	9	3.1
	35–45	E3	3.0	2.0	0.24	0.08	5	7	3.5
	45–62	Bt1ss	4.2	4.8	0.49	0.13	10	11	4.5
	62–100	Bt2ss	3.2	4.9	0.49	0.12	9	12	4.1
	110–200	Btg	2.3	5.1	0.68	0.04	8	9	8.0
	200–	Cg	1.4	3.7	0.78	0.04	6	6	12.6

Table 8. Selected soil chemical properties of horizons from Soil Pits 1,2 and 4, and one horizon of Soil Pit 6 (from Victorian State Chemistry Laboratory)

Pit	Depth (cm)		Acid neutral capacity*	Coarse sand (%)	Fine sand (%)	Silt (%)	Clay (%)	>2 mm fraction** (vol %)	NO_3-N (mg/kg)	NH_4-N (mg/kg)	Phosphate sorption index (%)	Total P (mg/kg)	S (CPC) [mg/kg]	Total S (mg/kg)
1	0–5	Ap	2.2	14.3	46.7	14.3	20.0	3	4.4	<8	34	220	9	360
	5–25	E	1.4	20.6	37.4	14.4	27.7	8	1.3	<8	44	110	15	170
	25–50	Bt1	1.3	8.8	22.0	11.9	58.5	12	0.58	<8	100	130	120	250
	50–70	Bt2	1.4	9.4	20.0	10.4	59.4	40	0.48	<8	100	100	80	210
	70–90	Bt2	1.2	9.7	19.8	12.1	59.5	40	<0.4	<8	100	70	98	250
	90–115	Bt3		9.9	18.6	12.6	59.4	40	<0.4	<8	100	70	120	310
	115–140	Bt3		8.5	18.9	11.5	60.9	40	<0.4	<8	100	60	180	450
	140–160	Bt4		8.5	16.5	12.7	62.3	33	0.61	<8	94	<50	>200	740
	160–180	Bt4		7.4	16.8	12.2	63.8	33	<0.4	<8	83	50	>200	750
	180–200	Bt5		14.1	14.4	11.0	58.0	10	0.44	14	82	<50	>200	790
2	0–5	Ap	1.8	25.6	41.3	15.4	13.9	3	3.0	8	20	150	47	240
	5–30	E	1.2	19.9	47.4	15.7	16.2	15	0.42	<8	25	60	12	100
	30–45	Bt1	1.2	9.2	25.5	9.7	54.0	17	<0.4	<8	100	80	32	150
	45–60	Bt1	1.2	8.3	25.9	10.3	56.0	17	<0.4	<8	100	100	60	150
	60–80	Bt2	0.97	12.1	31.0	11.3	46.3	10	<0.4	<8	100	60	46	130
	80–100	Bt2		15.0	33.2	11.7	41.5	10	<0.4	10	100	60	46	120
	100–130	Bt2		9.4	24.8	13.1	53.3	10	<0.4	8	100	<50	64	170
	130–155	Bt3		9.1	24.3	11.9	52.5	5	<0.4	<8	72	<50	140	260
	155–180	Bt3		10.9	34.4	16.4	39.2	5	<0.4	<8	47	<50	100	190
	180–200	Btss4		12.0	39.0	16.3	32.7	3	<0.4	8	37	<50	110	230
4	0–5	Ap	2.4	35.0	33.1	12.4	11.9		1.1	16	18	240	17	490
	5–20	E1	0.54	43.8	31.2	13.2	10.1		0.69	15	6	60	5	100
	20–40	E2	0.82	19.8	39.6	17.3	22.9		<0.4	<8	65	70	73	210
	40–60	Bt1	0.72	18.1	34.6	15.8	32.6		1.9	12	53	90	55	170
	60–85	Bt1		5.7	13.1	6.2	73.8		<0.4	<8	100	70	140	340
	85–100	Bt2		13.7	15.2	8.0	62.8		<0.4	<8	95	70	>200	530
	100–125	Bt3		8.7	11.4	5.2	71.8		<0.4	<8	70	<50	>200	560
	125–150	Bt3		10.0	11.1	5.1	70.8		0.43	<8	62	<50	>200	430
	150–170	Bt4		11.3	10.6	9.9	61.6		0.51	<8	42	<50	140	300
	170–200	Bt4		36.4	14.6	10.8	28.5		1.6	10	30	<50	93	200
6	170–200	Btg		10.3	9.9	7.0	61.0		<0.4	<8	68	<50	180	510

* cmol H^+/kg.pH unit; ** from > 2 mm wt % whole soil (Appendix 1) and estimated specific gravity (2.0 for A and E horizons and 1.5 for Bt horizons)

All soils show evidence of subsoil acidification generated by acid sulphate conditions at depth. The groundwater (as sampled in the bottom of Pit 4) had a relatively high sulfur concentration (69 mg/L). Acidification would severely limit root growth between about 1 and 2 m depth. The acidity that is generated from the oxidation of sulfur (just above the groundwater table) is probably removing easily weatherable minerals. This process could be the cause of coarsening of soil textures in the deep soil layers of profile 4, which was the lowest in the landscape. In most of the profiles, acidification is also evident close to the soil surface suggesting that a continuing liming program is needed. In some subsoils, the pH_w and pH_{Ca} values were similar indicating an increase in positive charge (EC is low). If the positive charge is large (this needs confirming) then a significant effect on anion retention can be expected.

Bulk densities

The bulk densities of selected soil horizons at Soil Pits 1 to 6 are shown in Figures 2 to 7, respectively.

Figure 2. Bulk densities with depth at Soil Pit 1

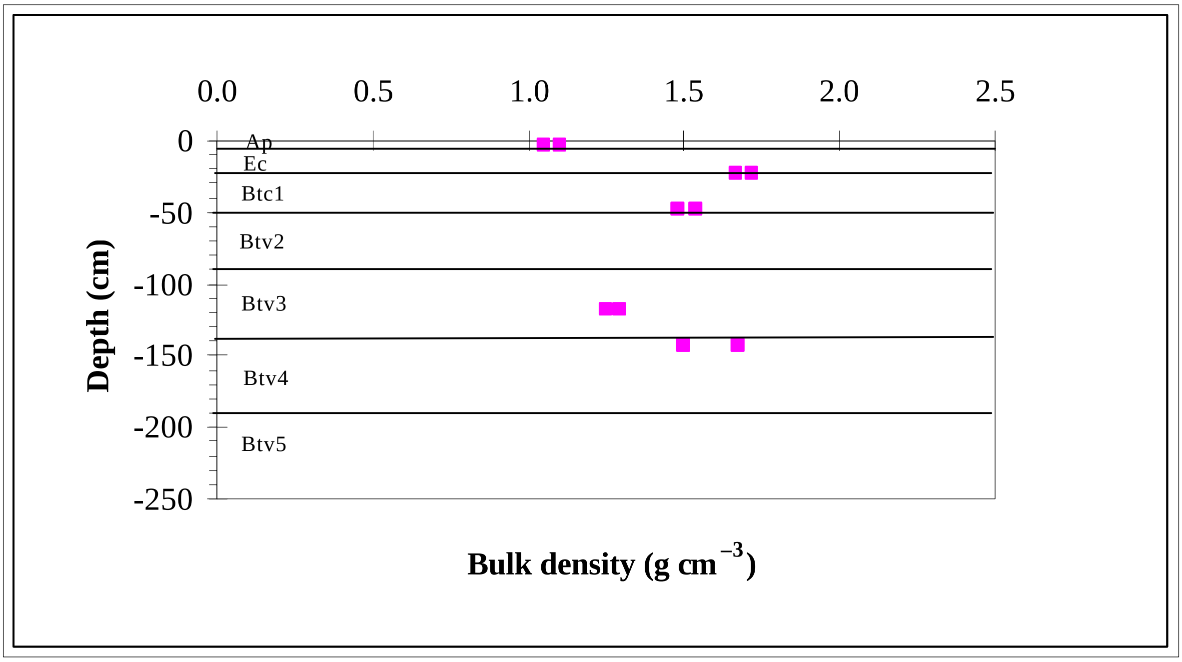


Figure 3. Bulk densities with depth at Soil Pit 2

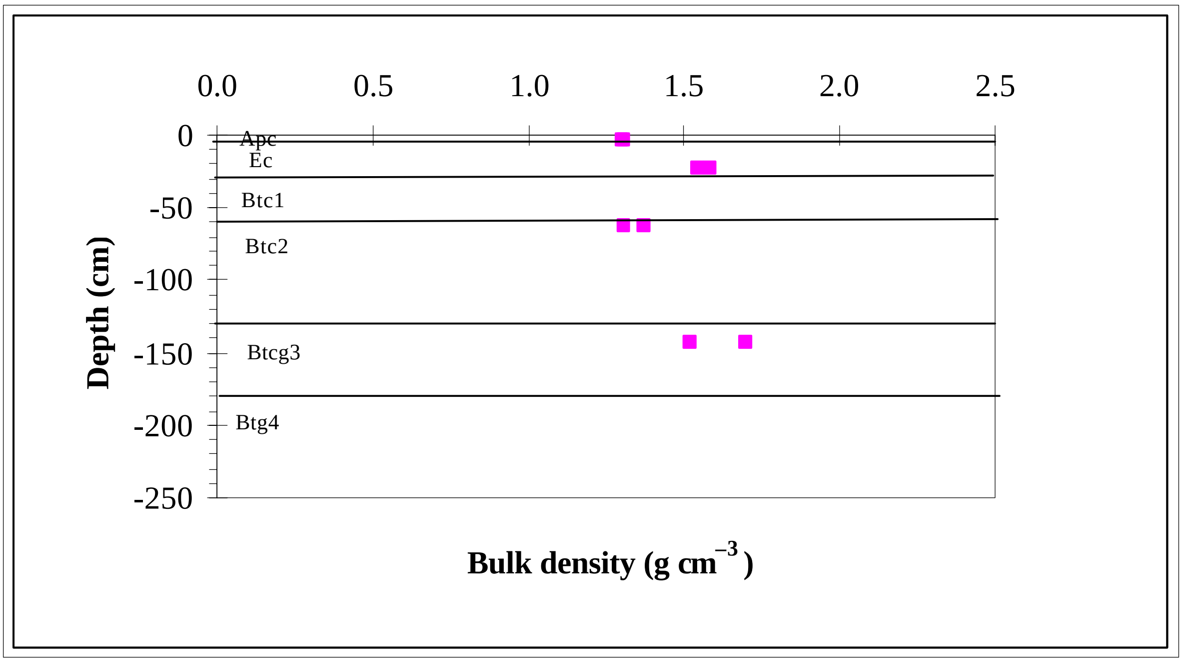


Figure 4. Bulk densities with depth at Soil Pit 3

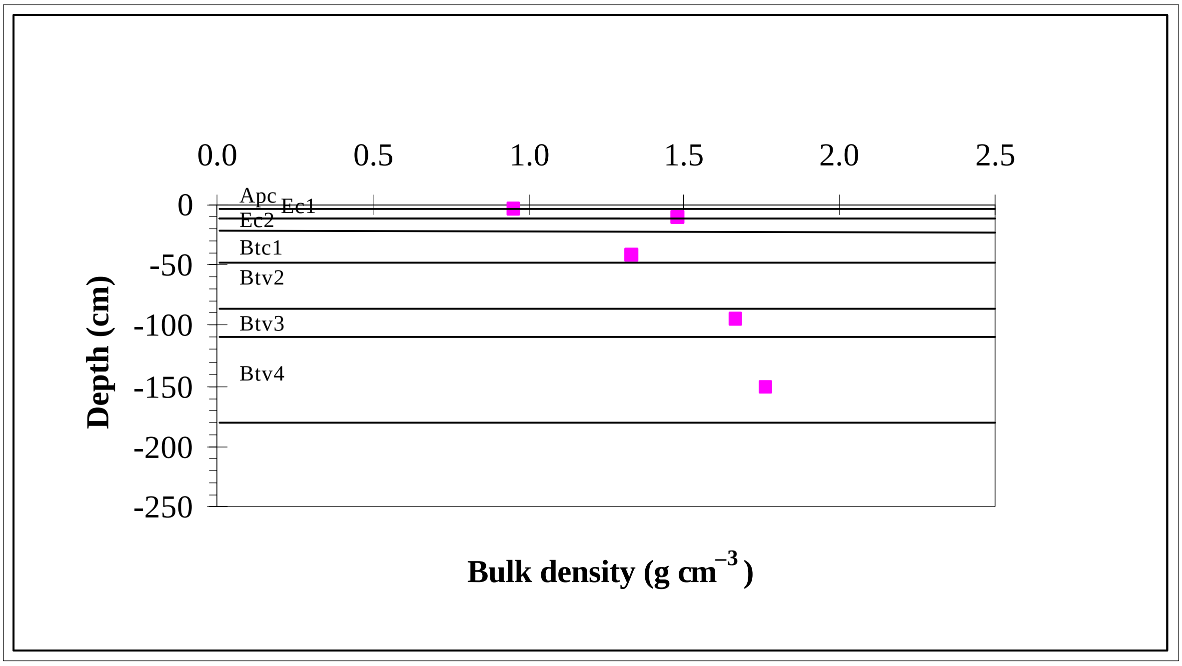


Figure 5. Bulk densities with depth at Soil Pit 4

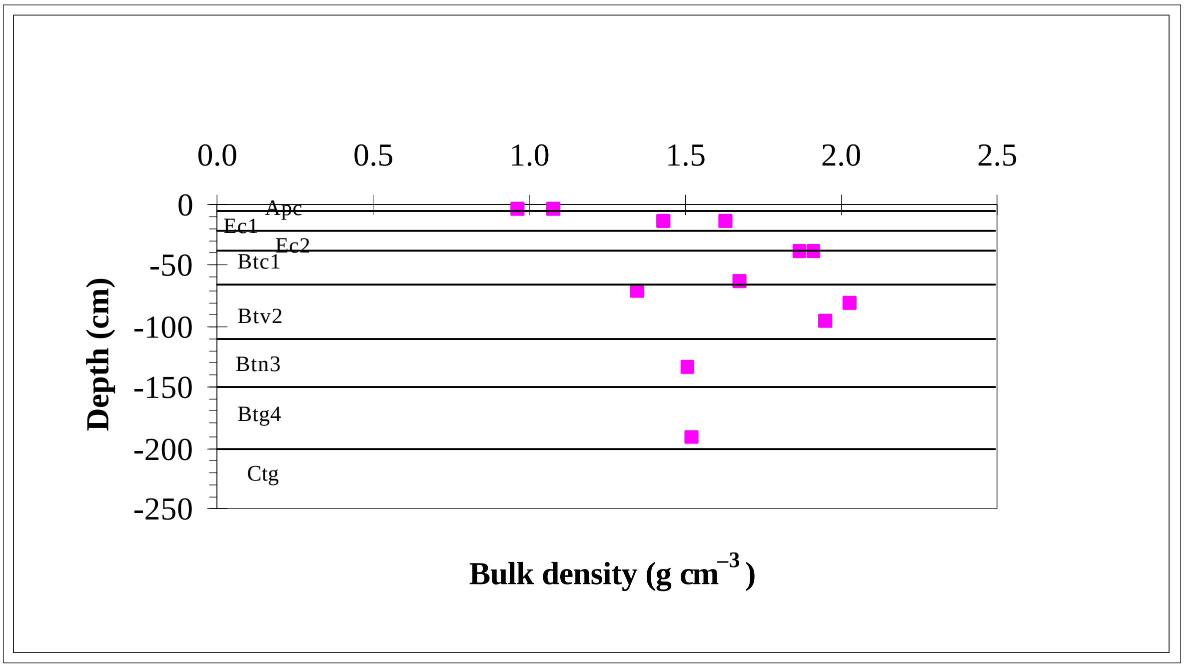


Figure 6. Bulk densities with depth at Soil Pit 5

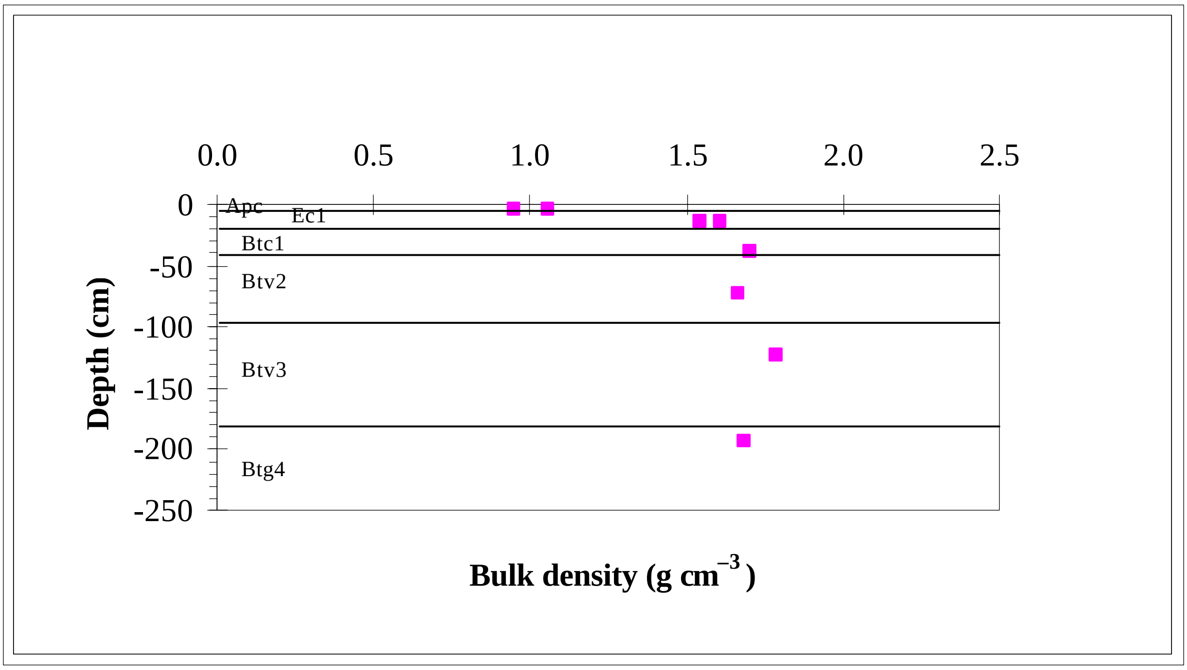


Figure 7. Bulk densities with depth at Soil Pit 6

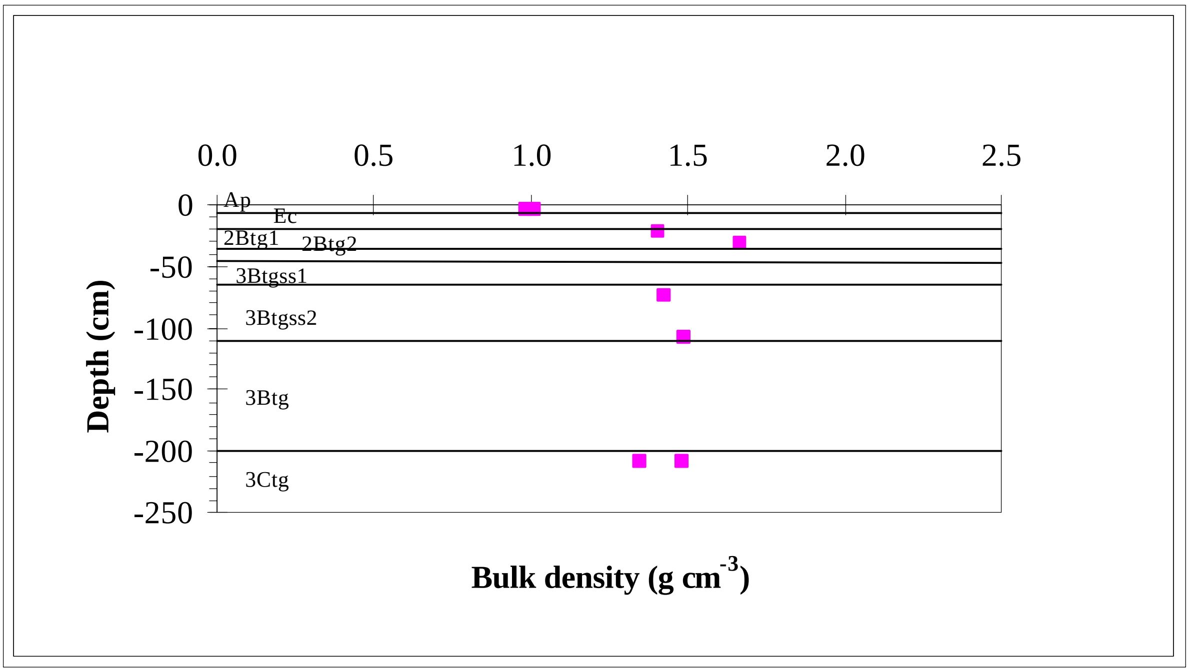
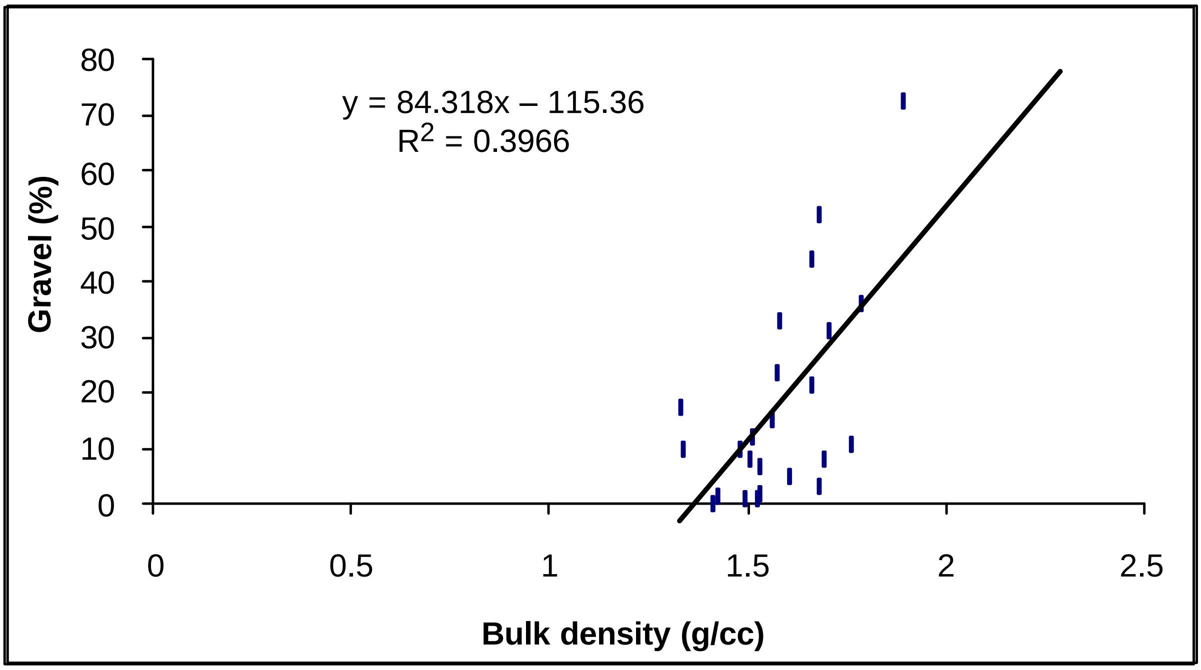


Figure 8. Relationship between bulk density and gravel content for soil layers below 10 cm.



As expected, the bulk densities of the Ap horizons of all Soil Pits are generally around 1.0 g/cm^3 due to cultivation and incorporation of organic matter. At Pits 1 to 4, bulk densities tended to be highest in the E horizon and also in the mid to lower B horizon (i.e. Bt3 or Bt4). A double peak in bulk densities in duplex soil profiles is common. Cox and McFarlane (1995) found that in some duplex soils in Western Australia high bulk densities of the E and upper Bt1 horizons were due to high gravel content and/or compaction from farm machinery. The highest bulk density was in Soil Pit 4 in the Btv2 horizon was due to the occurrence of plinthite (ferricrete). In general, soil layers with higher bulk densities tend to have higher gravel contents (Figure 8). This relationship was, however, not statistically significant. By solving the relationship for a gravel content of 100%, the bulk density of the gravel component can be estimated as 2.55 g/cm^3. For comparison the bulk density of pure quartz is 2.65 g/cm^3.

Soils with high bulk densities have correspondingly low porosities and therefore are more likely to become waterlogged. There was most pore space with depth in the soil profile at Pit 6 (a clay) and least at Pit 4 (a gleyed podzolic, Table 8).

Soil Moisture

Volumetric soil moisture increased with depth in all pits (Table 9). The wettest soil was below 0.95 m depth in Soil Pit 4 and this is consistent with its morphology and classification (Hydrosol). The data infers a water table is present within 1 m of the surface at Pit 4. By extrapolating this depth using the contour map of the site, the greatest depth to the water table elsewhere on the site would be 7 m below Pit 5 (the pit at the highest elevation). This is similar to the water heights recorded in a piezometer installed to a depth of 10 m by Schroder and Clifton (unpublished), located 150 m to the east of Pit 1. Between 1993 and 1997, late summer water levels were generally 6.5 m below the surface. However, during winter, water levels increased to within 80 cm of the surface. The high winter water tables confirm evidence from the soil morphology, which indicates the soils in all pits are sometimes influenced by saline, sulfidic groundwater (Tables 1–6).

Both the March and April samplings took place when the soil was extremely dry prior to the autumn break. Between 2nd March and 3rd April, 11.8 mm of rain fell at the site on 11 rain days (Clifton, pers. comm.). Nearly all this rain would have evaporated directly from the topsoil. Since little change in soil moisture would be expected deeper in the profile between the 2 samplings, they would both be close to the lower limit of plant-available water extractable by the phalaris/subclover pasture.

The pore space in each horizon was estimated from the bulk density assuming the matrix density was 2.65 g/cm^3, equivalent to that of quartz (Table 9). This enabled several other estimates to be made:

i) soil moisture as a percentage of pore space,

ii) cumulative pore space for the profile, expressed as mm of water equivalent, and

iii) the cumulative moisture storage capacity, assuming that all pore space not occupied by water at the March and April samplings can be filled by water.

Table 9. Soil moisture at time of sampling, and cumulative pore space with depth.

Pit		Horizon depth (cm)	Volumetric soil moisture [1] (%)	Soil moisture (% pore space)	Cumulative moisture (mm)	Pore fraction (mm)	Cumulative pore space	Cumulative water storage capacity[2] (mm)
1	Ap	0–5	10	17.1	5.1	0.594	29.7	25
1	Ec	5–25	16	44.3	37.1	0.362	102.2	65
1	Btc1	25–50	21	48.5	89.3	0.430	209.7	120
1	Btv2	50–90	24	45.5	184.1	0.521	418.0	234
1	Btv3	90–140	24	45.5	302.5	0.521	678.4	376
1	Btv4	140–180	24	59.3	397.9	0.402	839.2	441
2	Apc	0–5	10	20.0	5.1	0.508	25.4	20
2	Ec	5–30	7	18.2	23.8	0.411	128.2	104
2	Btc1	30–60	26	51.4	100.3	0.496	277.1	177
2	Btc2	60–130	26	51.4	278.9	0.496	624.4	346
2	Btcg3	100–180	24	59.9	468.0	0.394	939.9	472
3	Apc	0–5	12	18.7	6.0	0.642	32.1	26
3	Ec1	5–12	9	20.4	12.3	0.442	63.0	51
3	Ec2	12–20	17	36.2	25.9	0.470	100.6	75
3	Btc1	20–50	25	50.2	100.9	0.498	250.0	149
3	Btv2	50–85	27	61.9	195.4	0.436	402.5	207
3	Btv3	85–110	29	77.6	267.9	0.374	495.9	228
3	Btv4 2	110–180	26	77.4	449.9	0.336	731.0	281
4	Apc	0–5	10	15.4	4.8	0.615	30.8	26
4	Ec1	5–20	7	16.6	15.3	0.423	94.2	79
4	Ec2	20–40	9	31.2	33.3	0.289	151.9	119
4	Btc1 1	40–85	26	60.4	150.3	0.430	345.5	195
4	Btv2	85–100	3	11.4	154.8	0.264	385.1	230
4	Btn3	100–150	41	94.5	359.8	0.434	602.1	242
4	Btg4	150–>180	34	79.7	461.8	0.426	730.0	268
5	Apc	0–5	6	9.6	3.0	0.625	31.2	28
5	Ec1	5–20	10	24.5	18.0	0.408	92.4	74
5	Btc1	20–40	21	58.6	60.0	0.358	164.1	104
5	Btv2	40–95	22	58.9	181.0	0.374	369.5	189
5	Btv3	95–180	26	79.2	402.0	0.328	648.6	247
6	Ap	0–5	12	18.4	5.8	0.625	31.2	25
6	Ec	5–20	13	24.4	24.9	0.523	109.6	85
6	2Btg1	20–35	14	33.3	45.9	0.421	172.7	127
6	2Btgc2	35–45	32	72.3	77.4	0.436	216.3	139
6	3Btgss1	45–62	32	72.3	130.9	0.436	290.4	159
6	3Btgss2	62–110	35	77.6	298.9	0.451	506.9	208
6	3Btg	110–>180	35	76.3	543.9	0.458	827.8	284

[1] Pits 1 and 2 sampled 2 March 1997, pits 3 to 6 sampled 3 April 1997; [2] Difference between water storage capacity based on total porosity (fully saturated soil) and the soil water storage at the time of sampling (assumed to be the driest the soils will be during the year).

There was most pore space in the soil profile at Pit 2 and least at Pit 5 (Table 9). Soils with high bulk densities have correspondingly low porosities and therefore are more likely to become waterlogged.

Pore space, which could be filled by water in the top metre of the soil profile, ranged from 192 to 273 mm. This compares with a plant-available soil water content, estimated from the soil texture description from Pits 1 and 2, of about 75 mm over the top metre of the profile (Bond *et al.* 1997). This estimate was based on a water content at field capacity of 28% for both the A and B horizons, whereas the pore volume ranged between 26 and 64% (Table 9). There is clearly the capacity for the soil to store much more water if it remains saturated over a prolonged period, as could occur if there were high water tables.

Water quality

The water sample collected from the bottom of Pit 4, prior to soil sampling, must have been from below 95 cm, where the soil was saturated (Table 9). The water was very acidic (pH 4.7) and saline (EC 10 dS/m) with high concentrations of S (69 mg/L), Mg (272 mg/L) and Ca (107 mg/L). NO_3-N and K concentrations were relatively low for groundwater (Table 10). Total dissolved carbon in the groundwater was very high (7.4 mg/L) and most in the organic form. The P concentration (0.28 mg/L) is typical of groundwater below agricultural land.

Table 10. Chemistry of water in Pit 4 (sampled 3/4/97)

Field EC dS/m	Field pH	Turbidity	Cl (mg/L)	NO_3-N (mg/L)	Total dissolved carbon (mg/L)	Dissolved inorganic carbon (mg/L)	Dissolved organic carbon (mg/L)
10.2	4.7	130	3282.7	0.1	7.4	0.8	6.6

Total elemental analysis (mg/L)

Al	B	Ca	Cu	Fe	K	Mg	Mn	Na	P	S	Zn
28.1	0.082	107	0.03	16.5	3.09	272	0.62	1436	0.28	68.6	0.13

Further work

The formation of acid-sulphate like conditions with depth, which may restrict root growth and the leaching of anions, needs further research.

Acknowledgments

Michael Reynolds (CRC Soil and Land Management) drafted Figure 1. Ben Brown (University of Adelaide) sieved soil samples for Pits 1 and 2. Figure 1, the contour map of the site, was prepared by Brayley and Hayes Pty Ltd, consulting surveyors of Hamilton.

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Appendix 1

Soil profile descriptions and classifications

Site No.: Vasey 1
Date described: 2/3/1997
Location: Vasey SGS
Aust Soil Class: Ferric, Mottled-subnatric, Yellow Sodosol [1], medium, slightly gravelly, loamy/clayey, very deep
Soil Taxonomy: Fine-loamy, kaolinitic, mesic, Natric Plinthoxeralf (Natric is a proposed new subgroup, otherwise Typic)
Handbook of Australian Soils (Stace *et al.* 1968): Lateritic podzolic

Depth/ thickness (cm)	Horizon (US Soil Tax C)	Matrix colour (moist) (d) = dry	Primary Mottles: (Secondary Mottles)				Tex-ture	Structure	Consis tence (dry)	Cutans	Voids	Segre-gations	Reac-tion HCl	Coarse frag-ments	Roots No. 100 mm^2	Boun-dary	> 2mm wt % whole soil
			Colour (moist)	%	Size	Contrast											
0–5	Ap	5YR3/1					SL	V	1	Z	1/2	2/F/N/2/2	N	N	3	C/W	5
5–25	Ec (A2)	10YR4/2	10YR6/6	15	1	D	L	V	3	Z	1/2	3/F/N/2/2			2	A/S	15
25–50	Btc1	10YR6/8	7.5YR5/6	7	2	D	FSCL	V	3	Z	1/2	4/F/N/3/2	N	N	1	A/W	30
50–90	Btv2	10YR4/6	10YR6/2 (10YR6/8)	15 35	3 3	P D	CL	Reticu-[2] late	5	C/1/D	1/2	5/F/N/3/2	N	N	1	C/W	60
90–140	Btv3	2.5YR3/6	10YR7/2 7.5YR5/6	35 15	3 3	P P	LMC	Reticu- late	6	C/2/D	1/2	5/F/N/3/2	N	N	1	G/W	60
140–180	Btv4	10YR4/6	10YR6/2 (10YR5/8)	35 7	3 2	P P	MHC	Reticu- late	6	C/2/D	1/2	5/F/N/3/2	N	N	0	C/W	50
180–200	Btv5	10YR4/6	10YR6/2 (10YR5/8)	35 7	3 2	P P	HC	Reticu- late	6	C/2/D	1/0	3/F/N/3/2	N	N	0	G/W	15

[1] This classification is based on knowledge of the particle size classes of the soil. If classified using the field description above, the soil is:
Ferric-sodic, Eutrophic, Yellow Dermosol; medium, slightly gravelly, loamy/clayey, very deep.
Note that field textures can be strongly influenced by the presence of fine iron oxides.

[2] The B horizons of this profile are predominantly plinthite (with strong reticulate structure).

Site No.: Vasey 2
Date described: 2/3/1997
Location: Vasey SGS
Aust Soil Class: Ferric-sodic, Eutrophic, Brown Chromosol, medium, slightly gravelly, loamy/clayey, very deep
Soil Taxonomy: Clayey, kaolinitic, mesic, Aquic Haploxeralf.
Handbook of Australian Soils (Stace *et al.* 1968): Lateritic podzolic

Depth/ thickness (cm)	Horizon (US Soil Tax C)	Matrix colour (moist) (d) = dry	Primary Mottles: (Secondary Mottles) Colour (moist)	%	Size	Contrast	Tex-ture	Structure	Consi stence (dry)	Cutans	Voids	Segre-gations	Reac-tion HCl	Coarse frag-ments	Roots No. 100 mm^2	Boun -dary	> 2mm wt % whole soil
0–5	Apc	10YR4/1					SL	V	1	Z	1/3	2/F/N/2/2	N	N	3	C/S	5
5–30	Ec (A2)	10YR4/2	10YR6/6	3	1	D	L	V	4	Z	1/2	3/F/N/2/2	N	N	2	A/T	30
30–60	Btc1	10YR5/6	10YR5/2 (2.5YR4/6)	35 15	2 3	D P	CL	PR/W/3	5	C/1/F	1/1	4/F/N/3/2	N	N	1	A/W	25
60–130	Btc2	10YR5/6	10YR5/2 (2.5YR4/8)	35 15	3 3	P P	LMC	PR/M/3	5	C/2/P	1/1	5/F/N/3/2	N	N	1	G/W	20
130–180	Btcg3	10YR7/1	2.5YR4/4 (7.5YR5/8)	15 7	3 2	P P	HC	PR/S/3	6	C/2/P	1/0	5/F/N/3/2	N	N	1	C/W	10
180–200	Btg4	10YR7/1	2.5YR4/4 (7.5YR5/8)	15 7	2 2	P P	HC	PR/S/4	6	C/2/P	1/0	3/F/N/3/2	N	N	0	G/W	5

Site No.: Vasey 3
Date described: 3/4/1997
Location: Vasey SGS
Aust Soil Class: Ferric-sodic, Eutrophic, Brown Chromosol; medium, slightly gravelly, loamy/clayey, very deep.
Soil Taxonomy: Fine-loamy, kaolinitic, mesic, Kandic Plinthoxeralf (Kandic is a proposed new sub-group, otherwise Typic).
Handbook of Australian Soils (Stace *et al.* 1968): Lateritic podzolic

Depth/ thickness (cm)	Horizon (US Soil Tax [C])	Matrix colour (moist) (d) = dry	Primary Mottles: (Secondary Mottles)				Tex-ture	Structure	Consis tence (dry)	Cutans	Voids	Segre-gations	Reac-tion HCl	Coarse frag-ments	Roots No. 100 mm^2	Boun -dary	> 2mm wt % whole soil
			Colour (moist)	%	Size	Contrast											
0–5	Apc	10YR3/2					SL	V	2-3		1/3	2/F/N/2/2	N		4	A/S	10
5–12	Ec1	10YR4/2					CL	V	4-5		1/3	3/F/N/2/2	N		3	A/S	10
12–20	Ec2	10YR4/2					CL	V	4		1/3	5/F/N/2/2	N		2	A/W	41
20–50	Btc1	10YR4/3	2.5YR4/6	7	2	D/D	MC	PO/S/2	6	C/2/D	3/1	4/F/N/3/2	N		2	C/W	17
50–85	Btv2	7.5YR5/6	2.5YR4/7	35	3	D/C	MC	PL/S/2	5	C/2/D	3/1	3/F/N/3/2	N		1	G/S	13
			(2.5YR7/2)	7	2	D/C											
85–110	Btv3	10YR6/6	2.5YR3/4	35	3	P/D	MC	PL/S/2[1]	5	C/2/D	3/1	3/F/N/3/2	N		1	C/I	21
			(10YR6/3)	15	2	D/C											
110–180	Btv4[2]	10YR8/2	10YR3/3	35	4	P/S	MC	PR/S/5	6	C/2/P	3/1	2/F/N/3/2	N		1		11

[1] Bt3 parts to AB/M/2.
[2] Bt4: common grey (organic) and yellow (Fe oxide) stain/cutan on whitish ped surfaces.
Note: "Pipestem" feature sampled (and photographed) for more research.

Site No.: Vasey 4
Date described: 3/4/1997
Location: Vasey SGS
Aust Soil Class: Petroferric, Salic, Hydrosol; thick, slightly gravelly, loamy/clayey, very deep
Soil Taxonomy: Clayey, kaolinitic, mesic Natric Plinthaqualf (Natric is a proposed new sub-group, otherwise Typic)
Handbook of Australian Soils (Stace *et al.* 1968): Gleyed podzolic

Depth/ thickness (cm)	Horizon (US Soil Tax [C])	Matrix colour (moist) (d) = dry	Primary Mottles: (Secondary Mottles) Colour (moist)	%	Size	Contrast	Tex-ture	Structure	Consi stence (dry)	Cutans	Voids	Segre-gations	Reac-tion HCl	Coarse frag-ments	Roots No. 100 mm^2	Boun -dary	> 2mm wt % whole soil
0–5	Apc	10YR3/2					SL	V	3		1/3	1/F/N/2/2	N	N	4	C/S	4
5–20	Ec1	10YR4/2 10YR7/2 (d)					CS	V	5		1/3| 3/3	2/F/N/2/2	N	N	2	A/W	7
20–40	Ec2	10YR4/2 10YR7/2 (d)					CS	V	4		2/3	5/F/N/3/2	N	N	2	A/T	73
40–85	Btc1[1]	10YR5/4	10YR4/1	15	2	D/D	LC	V	5		1/1	5/F/N/4/2	N	N	0	A/S	52
85–100	Btv2	10YR5/4	2.5YR4/6 (10YR4/1)	30 30	2 2	D/D D/D	HC	PR/S/2	5	C/2/P		4/F/N/4/2	N	N	1	G/D	21
100–150	Btn3	2.5YR4/5	10YR6/1 (10YR4/1)	30 20	3 3	D/S D/S	HC	PR/S/3	4	C/1/D	N	2/F/N/3/2	N	N	1	C/S	8
150–200	Btg4	2.5Y7/2	10YR5/8	5	2	D/D	LC	PR/S/4	5	C/1/D	N	2/F/N/3/2	N	N	1	A/W	1
200–250	Ctg	10YR7/1	10YR5/8	20	2	P/S	CKS[2]	V	5		N	4/F/N/3/2	N	N		A/W	29
>250	R							V			**N**		N	N			

[1] This horizon is essentially a fragmented petroferric horizon. Cemented material sampled.
[2] Coarse clayey sand.
Note: Below 150 cm there are increasing coarse grains of white (parent?) material in a greyer matrix.

Site No.: Vasey 5
Date described: 3/4/1997
Location: Vasey SGS
Aust Soil Class: Ferric, Mottled-subnatric, Brown Sodosol; medium, slightly gravelly, loamy/clayey, very deep.
Soil Taxonomy: Fine-loamy, kaolinitic, mesic Typic Plinthoxeralf.
Handbook of Australian Soils (Stace *et al.* 1968): Lateritic podzolic

Depth/ thickness (cm)	Horizon (US Soil Tax [C])	Matrix colour (moist) (d) = dry	Primary Mottles: (Secondary Mottles)				Tex-ture	Structure	Consistence (dry)	Cutans	Voids	Segre-gations	Reac-tion HCl	Coarse frag-ments	Roots No. 100 mm^2	Boun-dary	> 2mm wt % whole soil
			Colour (moist)	%	Size	Contrast											
0–5	Apc	10YR3/3					SL	GR/W/3	2		1/3		N	N	4	A/S	17
5–20	Ec1	10YR3/3					SCL	GR/W/3	3		1/2		N	N	3	C/S	23
20–40	Btc1	10YR5/6	5YR4/6	10	1	D/D	CL	PO/W/4	3	C/2/D	1/2		N	N	1	G/W	31
40–95	Btv2	10YR5/6	2.5YR6/3 (10R3/6) [1]	30 10	2 2	D/C D/C	LC	PL/M/3	4	C/2/D			N	N	1	G/W	44
95–180	Btv3	10YR4/2	7.5YR4/6 (2.5YR6/3)	20 10	2 2	D/D D/C	MC	PL/M/3	4	C/2/P			N	N	1	G/S	36
>180	Btg4	10YR7/2	10YR6/3 [2] 10R3/4 [2]				MHC	PR/M/7	5	C/3/P			N	N	1		3

[1] This "mottle" usually slightly to strongly cemented or strong consistence; could be iron segregation or plinthite.
[2] Strong organic or iron oxide stained cutans.

Site No.: Vasey 6
Date described: 3/4/1997
Location: Vasey SGS
Aust Soil Class: Bleached, Epipedal, Aquic Vertosol; non-gravelly, fine/medium fine, very deep.
Soil Taxonomy: Clayey, mixed, mesic Xeric Epiaquert.
Handbook of Australian Soils (Stace *et al.* 1968): Grey Clay (overlying truncated lateritic profile)

Depth/ thickness (cm)	Horizon (US Soil Tax [C])	Matrix colour (moist) (d) = dry	Primary Mottles: (Secondary Mottles) Colour (moist)	%	Size	Contrast	Tex-ture	Structure	Consi stence (dry)	Cutans	Voids	Segre-gations	Reac-tion HCl	Coarse frag-ments	Roots No. 100 mm[2]	Boun -dary	> 2mm wt % whole soil
0–5	Ap	10YR3/2	7.5YR5/8[1]	10	see [1]	P/C	CL	PO/W/2	2		1/3	1/F/N/2/2	N		3	C	4
5–20	Ec	10YR3/2 5YR3/3 (d)	7.5YR5/8[1]	10	see [1]	P/C	CL	PR/W/2	4		1/3	1/F/N/2/2	N		3	C/S	2
20–35	2Btg1	10YR4/2 10YR6/2 (d)	7.5YR4/6	2	1	F/D	MC	PR/M/2	4		1/3	1/F/N/2/2	N		2	C/S	2
35–45	2Btgc2	(10YR4/2) 10YR6/2 (d)	7.5YR4/6[2]				MC	V	4?			5/F/N/3/2	N		2	A/W	73
45–62	3Btgss1	10YR4/2	10YR5/6 (2.5YR3/4)	30 10	2 1	D/D D/C	MC	PR/S/3	5	C/3/D	C1	1/F/N/2/2	N		2	S/W	8
62–110	3Btgss2	2.5Y6/6	10R3/6	25	2	D/D	MC	PR/S/4	4	C/3/P	C1	1/F/N/2/2	N		1	C/W	1
110–200	3Btg	10YR8/1	10YR7/6 (10R3/6 [3])	25 5	2 2	D/C D/C	MC	PR/S/8	5	C/3/P	C1	1/F/N/2/2			1	G/W	1
>200	3Ctg	10YR8/1	5R5/3 (10R3/6 [3])	20 10	4 1	P/S D/S	LC	V	4/5						0		0

[1] This bright orange colour (dry) is always associated with root channels (0–20 cm layers). [2] Mottling difficult to describe due to high gravel content.
[3] The 10R secondary mottles are usually small (<1 mm) hematitic flecks in a white matrix. **Note:** The large peds (>45 cm depth) frequently have orange/red core colours. Cutans (62–200cm) are dark grey (organic), pink, yellow (7.5YR 5/5) or deep red (10R 2.5/4 – hematite-rich).

Key to Soil Descriptions

Where: [A] Australian Soil and Land Survey: Field Handbook: McDonald *et al.* (1990), [B] Australian Soil Classification System (Isbell, 1996). [C] Soil Taxonomy (Soil Survey Staff, 1996) [D] Handbook of Australian Soils: Stace *et al*. (1968). Note: E horizons in Soil Taxonomy are equivalent to A2 horizons.

Horizon Designation Suffixes [C]

c	concretions or nodules	**m**	cementation or induration	**ss**	slickensides	**w**	development of colour or structure
g	strong gleying	**n**	accumulation of sodium	**t**	accumulation of silicate clay	**y**	accumulation of gypsum
k	accumulation of carbonates	**p**	tillage or other disturbance	**v**	plinthite	**z**	accumulation of salts more soluble than gypsum

Soil Profile Morphology [A]

Mottles: ABUNDANCE (%): 0=None; 1=Very few(<2)**; 2=Few**(2-10)**; 3=Common**(10-20)**; 4=Many**(20-50)**.**
SIZE (mm)**: 1=Fine**(<5)**; 2=Medium**(5-15)**; 3=Coarse**(15-30)**; 4=Very Coarse**(>30)**. CONTRAST: F**=Faint**, D**=Distinct**, P**=Prominent**. / S**=Sharp**, C**=Clear**, D**=Diffuse**.**

Texture: S=Sand, **LS**=Loamy Sand, **CS**=Clayey Sand, **SL**=Sandy Loam, **L**=Loam, **ZL**=Silty loam, **SCL**=Sandy Clay Loam, **LC**=Light Clay, **MC**=Medium Clay, **HC**=Heavy clay.

Structure: Apedal (**G**= Single grain; **V**=Massive)**; PL**=Platy**; PR=**Prismatic**; CO=**Columnar**; AB=**Angular blocky**; SB=**Subangular blocky**; PO=**Polyhedral**; LE=**Lenticular**; GR=**Granular**;**
A=Cast. Pedal (**W**=weak; **M**=moderate; **S**=strong). **Size (**mm**): 1**(<2)**; 2**(2-5)**; 3**(5-10)**; 4**(10-20)**; 5**(20-50)**; 6**(50-100)**; 7**(100-200)**; 8**(200-500)**; 9**(>500).

Consistency (dry/force/strength): 0=Loose; **1**=Very Weak; **2**=Weak; **3**=Firm; **4**=Very Firm; **5**=Strong; **6**=very strong; **7**=Rigid.

Cutans: TYPES: **Z**=Zero, **U=**Unspecified, **C**=Clay skins, **M**=Mangans, **S**=Stress cutans, **K**=Slikensides, **O**=Other cutans. **ABUNDANCE (%): 0=None, 1=few**(<10)**, 2=Common**(10-50)**,**
3=Many(>50). **DISTINCTNESS**: **F=**Faint**, D=**Distinct**, P=**Prominent**.**

Voids: CRACKS (mm): **1=Fine** (<5), **2=Medium** (5-10), **3=Coarse** (10-20), **4=Very Coarse** (20-50), **5=Extremely Coarse** (>50). / **MACROPORES** of DIAMETER (mm): **1= Very fine**(<1), **2=Fine**(1-2), **3=Medium**(2-5) & **4==Coarse**(>5) / ABUNDANCE (per 10x10mm) of Very fine (<1) & Fine (1-2) macropores: **0=None**, **1=Few**, (<1), **2=Common** (1-5),
3=Many(>5); *OR* ABUNDANCE (per 10x10cm) of Medium (2-5) & Coarse (>5) macropores **(<2/>2)**: **0=None, 1/4=Few** (<1), **2/5=Common**(1-5), **3/6=Many**(>5).

Segregations: ABUNDANCE (%): 0=None**, 1**=Very few **(**<2**), 2**=Few**(**2-10**), 3**=Common **(**10-20**), 4**=Many **(**20-50**), 5**=Very many **(**>50**). NATURE U**nidentified **K** Calcareous **Y** Gypseous, **M**anganous, **N** Ferro-mang, **F**erruginous, **A**luminous, **S**ulfurous, **Z** Saline, **H** organic, **G** Ferrug - organic, **L** Clayey, **E**arthy, **O**ther. **FORM C**oncretions, **N**odules, **F**ragments, **X**Crystals**, S**oft**, V**eins, **R**oot linings, **T**ubules, **L**aminae (see McDonald et al. 1990, p146 for full list**.)**
SIZE (mm**): 1=F**ine**(**<2**); 2=M**edium**(**2-6**); 3= C**oarse**(**6-20**); 4=V**ery **C**oarse**(**20-60**); 5=E**xtremely **C**oarse**(**>60**).**
STRENGTH: 1=Weak**, 2=S**trong**.**

Reaction or fizz to HCl/calcareous: N=Non-calcareous; **S=S**lightly; **M=M**oderately; **H=H**ighly; **V=V**ery highly.

Coarse Fragments: Type: **N**=None; **Q**=Quartz; **B**= Basalt; **E**=Ferricrete; **L**= Silcrete; **K**=Calcrete; **Sa**= Saprolite; **Sc**=Shells; **Cc**=Charcoal.
ABUNDANCE: (%): 0=None, 1=Very few(<2**), 2=Few(**2-10**), 3=Common(**10-20**), 4=Many(**20-50**), 5=Abundant(**50-90**), 6=Very Abundant (**>90**). SIZE (**mm**): 1=Fine gravelly (**2-6**), 2=Medium gr(**6-20**), 3= Coarse(**20-60**), 4=Cobbly(**60-200**), 5=Stony(**200-600**), 6=Bouldery(**600-2m**), 7=Large boulders(**>2m**). SHAPE: see p.99.**

Roots: SIZE 1 < 1mm, **2** 1-2mm, 3 2-5mm, 4 > 5mm. **ABUNDANCE**:100x100mm)**: 0**=No roots; **1**=Few (1-10); **2**=Common(10-25); **3**=Many(25-200); **4**=Abundant(>200).

Boundary: (mm)**: S**=Sharp (<5), **A**=abrupt(5-20), **C**=Clear (20-50), **G**=Gradual (50-100), **D**=Diffuse (>100). **/ S**=Smooth, **W**=Wavy, **I**=Irregular, **T**=Tongued, **B**=Broken