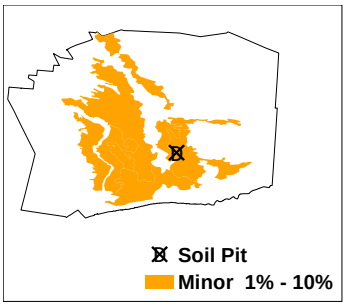
Soil 2 Thick sand over sandy clay loam



Landscape Very gently undulating dune field superimposed on a former flood plain of the Bremer River. Site is on a dune slope. Surface is soft and stone free.

Profile Very thick red loamy sand over a red sandy clay loam grading to coarse grained alluvium below 100 cm.

Depth (cm)	*Description*
0-15	Dark reddish brown soft single grain loamy sand. Diffuse to:
15-40	Yellowish red soft single grain loamy sand. Diffuse to:
40-65	Red soft single grain loamy sand. Abrupt to:
65-108	Dark reddish brown firm fine sandy clay loam with weak subangular blocky structure. Abrupt to:
108-120	Red soft single grain sand (windblown deposit). Abrupt to:
120-140	Reddish brown friable massive sandy loam (alluvial deposit). Clear to:
140-180	Strong brown soft single grain loamy sand (alluvial deposit).

Key properties

Drainage — Rapidly drained. The soil never remains wet for more than an hour or so following heavy or prolonged rainfall. Deep drainage is good.

Potential root zone — Good root growth to 65 cm, with a few roots extending to the base of the sampling pit (180 cm).

Barriers to root growth

Physical: There are no significant physical barriers.

Chemical: Low nutrient availability is the only likely chemical barrier.

Water holding capacity : Estimated for the depth of the potential root zone of grapevines

Total available: 150 mm
Readily available: 85 mm

Fertility — Inherent fertility is low, as indicated by the exchangeable cation data and low clay content. At sampling site, concentrations of sulphur and copper are low.

Erosion potential — Moderate potential for wind erosion, low potential for water erosion.

Laboratory data

Depth Cm	pH H_2O	pH $CaCl_2$	CO_3 %	ECe dS/m	Cl mg/kg	S mg/kg	B mg/kg	Ext P mg/kg	Ext K mg/kg	Org C %	Exchangeable cations - cmol(+)/kg					#ESP
											Ca	Mg	Na	K	#CEC	
Target →	< 9.2	>5.0	na	< 2.0	< 350	10	< 3	80	200	> 1.0	% of (Ca+Mg+Na+K)				> 5	< 6
											65-75	10-15	< 6	3-8		
0-15	7.9	7.6	0	0.38	9	2.9	0.7	54	240	0.64	5.76	2.00	0.08	0.65	7.1	1.1
15-40	7.7	7.1	0	0.28	5	1.6	0.5	8	164	0.28	2.58	0.80	0.07	0.46	3.9	1.8
40-65	7.7	7.1	0	0.25	3	1.2	0.4	2	158	0.23	1.83	0.77	0.09	0.42	3.1	2.9
65-108	8.0	7.1	0	1.84	98	47.5	1.9	2	259	0.32	5.3	7.81	1.59	0.73	15.4	10.3
108-120	8.0	7.1	0	1.23	73	19.1	0.5	2	113	0.10	1.51	1.05	0.57	0.28	3.4	16.7
120-140	7.7	7.1	0	1.32	74	25.2	1.1	2	193	0.19	2.93	5.91	1.06	0.49	10.4	10.2
140-180	8.6	7.8	0	4.15	164	94.8	0.9	2	180	0.14	3.74	5.53	1.34	0.47	11.1	12.1

CEC estimated from sum (Ca+Mg+Na+K). # ESP is estimated by = Na / (Ca+Mg+Na+K)

Explanation of highlighted data

Exchangeable sodium less than 6% of total of all four cations is desirable.
Sulphur concentration is low (although ample reserves in subsoil).

Notes:

Management of Soil 2
Thick sand over sandy clay loam
by John Rasic

Problems
The abrupt boundary between sand and sandy clay loam imposes a mild constraint to root growth and water movement, but at 65 cm depth, it is relatively easy to tackle.

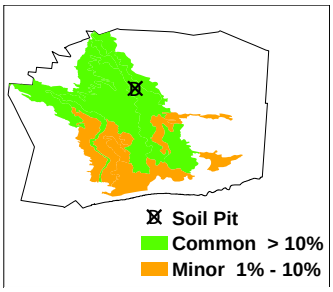
Pre-planting action that can be used to tackle the problems
Eliminate the abrupt boundary between the sand and the sandy clay loam and prevent its re-occurrence by ripping to below 100cm using a parabolic-curve sub-soiler with wings at a high lift angle selected between 30 and 50 degrees.

Soil management after planting
Establish a drought resistant mid-row cover crop to hold the soil particles together and to prevent wind erosion.

Apply fertiliser to achieve quicker and better growth of the cover crop. The cover crop can provide the much needed increase in soil organic matter. Organic matter helps to prevent slaking, capping and pan formation and it reduces compaction because it causes compressed soil to spring back (the rebound effect).

To minimise compaction and to allow the cover crop to establish, minimise vehicle traffic and the grazing of animals.

Soil 3 Deep silty loam



Landscape — Alluvial flats and levees. Surface soil is firm and stone free.

Profile — Very thick brown loamy sand to silty loam, often showing depositional layering, grading to soft brown fine sand overlying older alluvial sediments. These are young alluvial soils, often still being laid down.

Depth (cm)	*Description*
0-10	Dark brown massive light silty loam. Clear to:
10-50	Dark brown massive fine sandy loam. Gradual to:
50-85	Very dark brown massive fine sandy loam. Clear to:
85-150	Light brown with brown mottles massive soft loamy sand. Clear to:
150-200	Very dark grey and dark yellowish brown mottled medium heavy clay with strong blocky structure (older alluvium).

The soil is micaceous throughout.

Key properties

Drainage — The soil is well drained. It is never wet for more than a day or so, unless a perched water table forms above the clay layer at 150 cm.

Potential root zone — Most root growth occurs above the clay layer at 150 cm (in sampling pit).

Barriers to root growth

Physical: There are no apparent physical barriers, apart from a minor restriction due to the clay layer at depth.

Chemical: There are no apparent physical barriers above the deep clay layer.

Water holding capacity : Estimated for the depth of the potential root zone of grapevines

Total available:	160 mm
Readily available:	75 mm

Fertility — The soil has a moderate to low level of natural fertility due to its low clay content, but adequate nutrient levels can be readily maintained.

Erosion potential — Low.

Laboratory data

Depth cm	pH H_2O	pH $CaCl_2$	CO_3 %	ECe dS/m	Cl mg/kg	S mg/kg	B mg/kg	Ext P mg/kg	Ext K mg/kg	Org C %	Exchangeable cations - cmol(+)/kg					ESP
											Ca	Mg	Na	K	CEC	
Target →	< 9.2	>5.0	na	< 2.0	< 350	10	< 3	80	200	> 1.0	% of (Ca+Mg+Na+K)				> 5	< 6
											65-75	10-15	< 6	3-8		
0-10	7.0	6.7	0	1.07	-	-	2.1	48	483	2.0	10.7	3.48	0.72	0.86	11.5	6.3
10-50	7.1	6.6	0	1.08	-	-	0.9	8	350	0.5	3.83	2.16	0.47	0.50	5.7	8.2
50-85	7.1	6.5	0	0.78	-	-	1.2	4	432	0.6	6.58	3.99	0.70	0.70	10.6	6.6
85-150	7.4	6.7	<0.1	0.42	-	-	0.3	<4	165	0.1	0.80	0.70	0.26	0.16	2.1	n.a.
150-200	7.8	6.9	<0.1	0.66	-	-	3.0	18	651	1.1	15.1	8.93	2.39	1.49	28.1	8.5

Explanation of highlighted data

Slight elevation of ECe (salinity) and exchangeable sodium (sodicity) levels at the surface are probably due to evaporation concentrating salts at the surface. Slight sodicity in the 150-200 cm layer is too deep to be a problem

Notes:

Management of Soil 3
Deep silty loam
by John Rasic

Problems
Saturated silt is unstable. It can collapse (slake), become a slurry and flow down through the profile. This slurry can block pores and then, when it dries, the slurry can become an impenetrable pan or cap (capping).

Silt has a low capacity to support any weight (e.g. machinery, animals or the soil above), it is slippery and, if worked when wet, it can smear and compact.

Smearing can be caused by implements or by spinning tractor wheels. Smearing seals the network of connecting soil pores. This seal prevents drainage and it can cause the soil above the seal to become saturated, to collapse and then dry to form a hard pan that can seriously restrict the penetration of roots and of water.

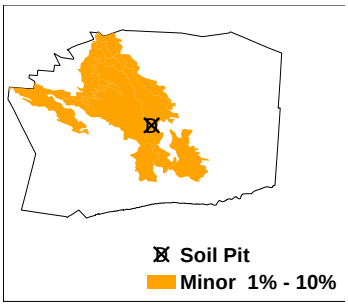
Pre-planting action that can be used to tackle the problems
Mechanical mixing of soil layers is not needed because this soil has no physical limitation to the penetration of roots and of water.

Soil management after planting
Establish a deep rooting cover crop to provide some protection against compaction and slaking.

The cover crop is needed because silt, like sand, does not shrink and swell so that, if it is compacted, silt does not self-repair. Also, silt particles do not carry electric charges so the addition of lime or gypsum will not hold the particles together and prevent slaking.

When this soil is wet, avoid cultivation and exclude vehicle traffic and grazing animals.

Soil 4 Clay loam over loamy sand on red clay



Landscape Bremer River flood plain formed on silty alluvium. Original surface is covered by variable thickness of recent flood-deposited sediment. Surface is firm and stone free.

Profile Surface wash burying a thick reddish loamy sand over a red and brown light clay, calcareous with depth grading to medium textured micaceous alluvium.

Depth (cm)	*Description*
0-25	Dark brown firm fine sandy clay loam with weak subangular blocky structure (recent wash). Clear to:
25-40	Dark reddish brown soft single grain loamy sand. Gradual to:
40-85	Yellowish red soft single grain loamy sand. Abrupt to:
85-110	Yellowish red and strong brown firm fine sandy light clay with weak coarse prismatic structure. Gradual to:
110-160	Reddish brown firm slightly calcareous light clay with moderate subangular blocky structure, 10-20% soft and 2-10% hard carbonate segregations. Gradual to:
160-190	Reddish brown and dark yellowish brown mottled friable massive light silty clay loam.

Key properties

Drainage — Well drained. The profile rarely remains wet for more than a day or so. Deep drainage is satisfactory.

Potential root zone — Root growth is strong to 40 cm, diminishes with depth, and picks up again from 160 cm, possibly due to deep subsoil moisture reserves.

Barriers to root growth

Physical: There are no significant physical barriers.

Chemical: There are no significant chemical barriers.

Water holding capacity : Estimated for the depth of the potential root zone of grapevines

Total available: 230 mm
Readily available: 125 mm

Fertility — Inherent fertility of the original soil is low due to the low clay content of its surface. However, the finer textured alluvium overlying the modern soil has significantly higher nutrient status and retention capacity. Test results indicate low phosphorus levels, but concentrations of all other elements are satisfactory.

Erosion potential — Low potential for both water and wind erosion.

Laboratory data

Depth Cm	pH H_2O	pH $CaCl_2$	CO_3 %	ECe dS/m	Cl mg/kg	S mg/kg	B mg/kg	Ext P mg/kg	Ext K mg/kg	Org C %	Exchangeable cations - cmol(+)/kg					#ESP
											Ca	Mg	Na	K	#CEC	
Target →	< 9.2	>5.0	na	< 2.0	< 350	10	< 3	80	200	> 1.0	% of (Ca+Mg+Na+K)				> 5	< 6
											65-75	10-15	< 6	3-8		
0-25	7.8	7.1	0	0.60	27	8.5	1.1	11	329	1.22	9.37	6.58	0.77	0.84	17.6	4.4
25-40	7.8	6.9	0	0.48	20	4.8	0.4	2	132	0.27	2.72	1.46	0.38	0.33	4.9	7.8
40-85	7.1	6.7	0	0.76	48	8.6	0.3	2	81	0.13	1.33	0.83	0.31	0.23	2.7	na
85-110	7.7	6.8	0	0.60	35	9.7	0.9	2	244	0.22	5.49	8.33	1.11	0.7	15.6	7.1
110-160	8.5	7.7	2.4	1.01	59	25.4	1.0	2	256	0.22	10.6	7.68	1.28	0.72	20.3	6.3
160-190	8.5	7.7	0.7	0.84	43	11.8	0.7	2	234	0.24	7.52	6.3	0.99	0.61	15.4	6.4

CEC estimated from sum (Ca+Mg+Na+K). # ESP is estimated by = Na / (Ca+Mg+Na+K)

Explanation of highlighted data

Target phosphate level is 30-40 mg/kg.
Apply gypsum to increase the low ratio of Ca to Mg.

Notes:

Management of Soil 4
Clay loam over loamy sand on red clay

by John Rasic

Problems

There are no apparent physical or chemical soil limitations but the sparse growth of roots through the bleached sandy layer indicates low fertility between the soil depths of 25 and 85 cm.

Pre-planting action that can be used to tackle the problems

Increase the water holding capacity of the highly permeable and low water holding sand. Aim to mix two volumes of loam or clay with one volume of sand. Improve soil fertility by incorporating slow-release granular fertilisers, compost or organic fertilisers.

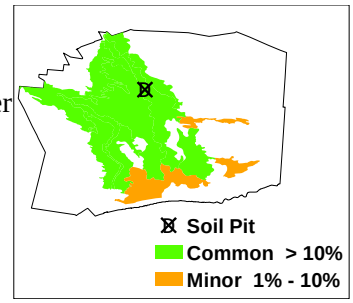
Maximise the volume of soil that is wetted by installing an irrigation system with closely spaced emitters to avoid any soil remaining dry between the drippers. Install injection equipment to apply fertiliser into all of the wetted soil.

Soil management after planting

Manage the irrigation system to achieve slow wetting and to apply precise dosages of liquid fertilisers.

Establish and maintain an inter-row cover crop. Grasses are best for loam and clay. Raising the level of organic matter in the soil increases its capacity to retain water and fertiliser. A higher level of soil organic matter also reduces slaking and capping and it increases structural recovery from compaction.

Soil 5 Gradational red sandy loam



Landscape Very gently undulating alluvial flats of the Angas - Bremer flood plains formed on sandy to silty, occasionally clayey alluvium. Surface soil is hard setting and stone free.

Profile Thick loamy sand to sandy loam overlying a massive red brown light sandy clay loam to sandy clay with minor carbonate nodules, grading to silty or sandy alluvium.

Depth (cm)	*Description*
0-12	Dark reddish brown fine sandy loam with moderate granular structure. Clear to:
12-35	Dark reddish brown fine sandy loam with weak coarse blocky structure. Diffuse to:
35-100	Dark reddish brown fine sandy clay loam with weak coarse blocky structure. Clear to:
---------- buried soil ----------	
100-140	Red massive loamy sand. Clear to:
140-175	Yellowish red massive fine sandy clay loam. Clear to:
175-200	Yellowish red soft massive loamy sand.

Key properties

Drainage Well drained. Soil is never wet for more than a day or so.

Potential root zone More than 200 cm in sampling pit.

Barriers to root growth

Physical: There are no apparent physical barriers to root growth. The soil is not excessively hard.

Chemical: There are no apparent chemical barriers to root growth.

Water holding capacity : Estimated for the depth of the potential root zone of grapevines

Total available: 200 mm
Readily available: 110 mm

Fertility Nutrient retention capacity is moderate. Maintaining adequate levels of nutrition in these soils is straightforward. There are no pH extremes or free carbonates to reduce nutrient availability.

Erosion potential Low potential for water erosion, moderately low potential for wind erosion.

Laboratory data

Depth Cm	pH H_2O	pH $CaCl_2$	CO_3 %	ECe dS/m	Cl mg/kg	S mg/kg	B mg/kg	Ext P mg/kg	Ext K mg/kg	Org C %	Exchangeable cations - cmol(+)/kg					ESP
											Ca	Mg	Na	K	CEC	
Target →	< 9.2	>5.0	na	< 2.0	< 350	10	< 3	80	200	> 1.0	% of (Ca+Mg+Na+K)				> 5	< 6
											65-75	10-15	< 6	3-8		
0-12	7.7	7.4	0.5	0.91	-	-	2.9	84	615	2.7	9.68	2.65	0.42	1.40	11.9	3.5
12-35	8.4	7.9	0.1	1.46	-	-	1.8	18	398	0.6	4.35	1.68	0.82	0.73	6.6	18.9
35-100	8.7	8.1	<0.1	2.02	-	-	1.2	11	341	0.4	3.53	1.61	1.21	0.69	6.2	19.5
100-140	8.7	7.6	<0.1	0.86	-	-	0.7	6	167	0.1	1.36	0.95	0.63	0.27	3.3	19.1
140-175	8.8	7.7	<0.1	0.76	-	-	1.2	7	298	0.1	2.72	2.49	1.47	0.61	6.5	22.6
175-200	9.0	8.0	<0.1	0.87	-	-	0.6	<4	210	<0.1	1.35	0.97	0.98	0.33	3.6	27.2

Explanation of highlighted data

Exchangeable sodium less than 6% of total of all four cations is desirable.
Apply gypsum to increase the low ratio of Ca to Mg.

Notes:

Management of Soil 5
Gradational red sandy loam
by John Rasic

Problems
The exchangeable sodium percentage (ESP) that increases down this profile, the coarse particle sizes and the low level of organic matter will make this soil unstable when it becomes wet.

Before development this soil may not display any physical limitation but, if saturated under irrigation, sand can collapse to become a slurry that can flow down through the profile and seal the network of connecting soil pores. This seal prevents drainage and can cause the saturation and collapse (slaking) of the overlying soil. On drying, where the texture changes at 40cm, the collapsed soil can form a hard sandy cap (capping) that restricts root growth and water penetration.

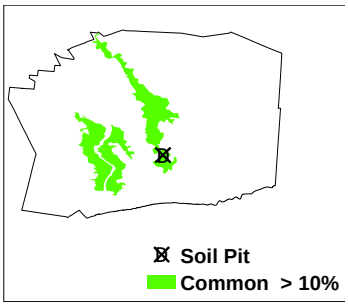
Pre-planting action that can be used to tackle the problems
Incorporate gypsum down to 20cm to reduce the high ESP.
Mechanical mixing of the soil layers is not required because there are no major limitations.

Soil management after planting
Manage the low chemical fertility by frequent, precise applications of liquid fertilisers.

Establish a drought-resistant mid-row cover crop to hold the soil particles together and to provide the much needed increase in soil organic matter. The organic matter helps reduce compaction because it causes compressed soil to spring back (the rebound effect). The organic matter also helps to prevent slaking and capping.

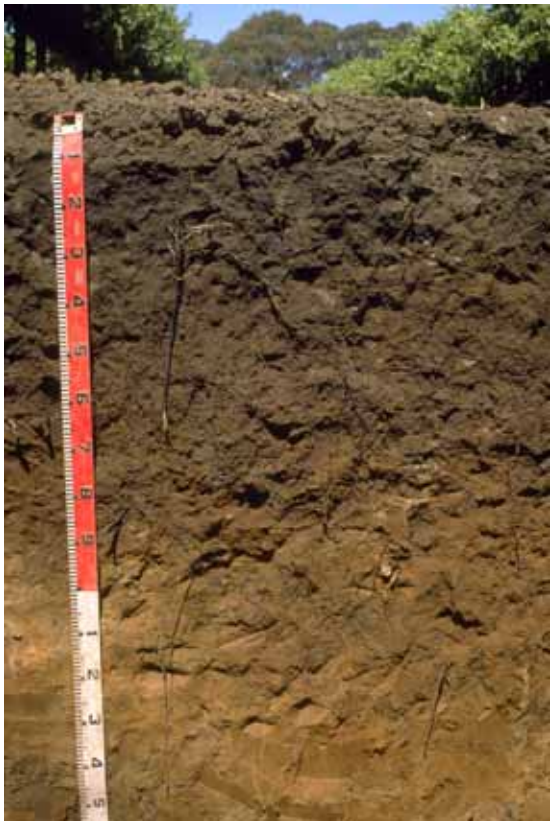
Reduce compaction and allow the cover crop to establish by minimising vehicle traffic and excluding grazing animals.

Soil 6 Gradational clay loam



Landscape — Alluvial flats of the lower reaches of the Bremer River. Surface soil is firm and stone free.

Profile — Thick dark brown clay loam grading to a brown or red well structured clay, becoming yellower or greyer and sometimes weakly calcareous with depth.



Depth (cm)	*Description*
0-25	Black clay loam with strong granular structure. Clear to:
25-40	Very dark grey massive silty clay loam. Clear to:
40-60	Yellowish red and dark brown light medium clay with moderate coarse angular blocky structure. Gradual to:
60-85	Yellowish red and brown fine sandy light clay with weak coarse blocky structure. Gradual to:
85-180	Brown and yellowish red soft interbedded river sediments ranging from clayey fine sand to fine sandy loam.

Key properties

Drainage — The soil is moderately well drained and is unlikely to remain wet for more than a week or so. Deep drainage is satisfactory due to the sandy substrate.

Potential root zone — 180 cm in sampling pit.

Barriers to root growth

Physical: There are no apparent physical barriers.

Chemical: There are no chemical barriers to root growth, but further sodium build up under irrigation may occur over time.

Water holding capacity : Estimated for the depth of the potential root zone of grapevines

Total available: 225 mm
Readily available: 120 mm

Fertility — Inherent fertility of the soil is moderately high, as indicated by the exchangeable cation data. Maintenance of adequate nutrient levels on this soil is straight-forward.

Erosion potential — Low potential for both water and wind erosion.

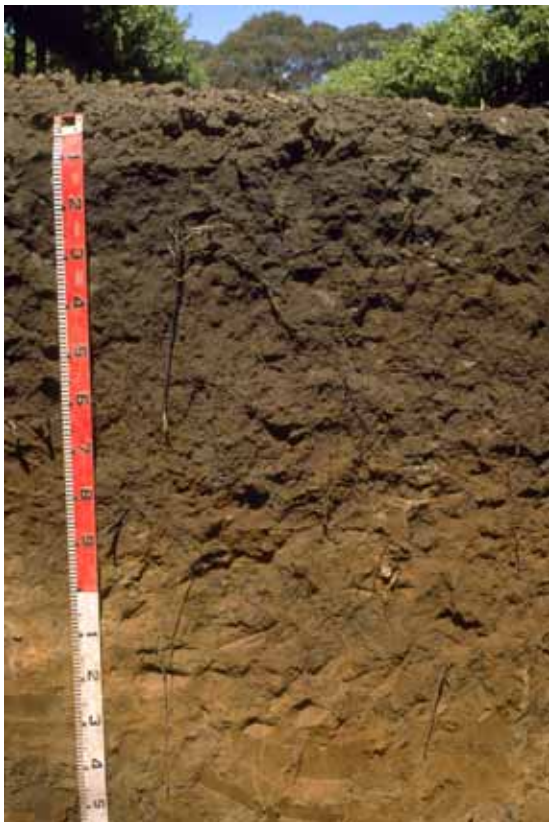
Laboratory data

Depth Cm	pH H_2O	pH $CaCl_2$	CO_3 %	ECe dS/m	Cl mg/kg	S mg/kg	B mg/kg	Ext P mg/kg	Ext K mg/kg	Org C %	Exchangeable cations - cmol(+)/kg					ESP
											Ca	Mg	Na	K	CEC	
Target →	< 9.2	>5.0	na	< 2.0	< 350	10	< 3	80	200	> 1.0	% of (Ca+Mg+Na+K)				> 5	< 6
											65-75	10-15	< 6	3-8		
0-25	7.2	6.6	0	1.07	-	-	2.2	18	490	1.9	14.1	6.39	1.65	1.17	20.4	8.1
25-40	7.3	6.5	0	0.86	-	-	1.4	6	299	0.7	5.21	3.18	1.15	0.60	10.3	11.2
40-60	7.3	6.5	0	0.82	-	-	1.7	<4	306	0.4	5.59	3.89	1.27	0.70	11.7	10.9
60-85	7.3	6.5	0	0.74	-	-	1.5	<4	273	0.2	4.27	3.44	1.00	0.56	9.5	10.5
85-180	7.1	6.4	0	0.75	-	-	0.9	<4	218	0.1	2.23	2.46	0.65	0.39	5.1	12.7

Explanation of highlighted data

Exchangeable sodium less than 6% of CEC is desirable.
Apply gypsum to increase the low ratio of Ca to Mg.

Notes:



Management of
Soil 6 Gradational clay loam

by John Rasic

Problems

With mechanised grape growing, wheels move along both sides of the plants. This causes compaction, smearing and puddling when the wheels sink and spin on soft soils.

Under tractor wheels, the silty layer between 25 and 40cm is susceptible to compaction. Spinning wheels cause smearing and sealing of the network of connecting soil pores. Water, salts and toxins will accumulate above the sealed layer. This silty layer is sandwiched below the layer of clay loam, that prevents drying, and above the light to medium clay that holds moisture.

Pre-planting action that can be used to tackle the problems

Incorporate surface broadcast gypsum, using light cultivation to 20cm, then shallow rip to 40cm using a winged ripper to mix the surface layers with the deeper, more stable clay layer.

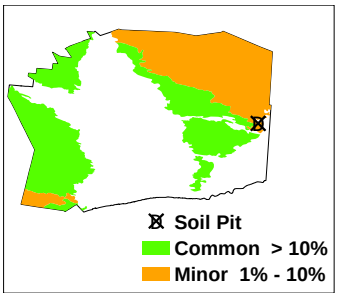
Soil management after planting

Shallow rip (depth less than 50cm) along the mid-row and establish a fast growing cover crop to reduce any soil degradation that was caused by heavy machinery during the establishment of the vineyard.

Reduce compaction and allow the cover crop to establish by minimising vehicle traffic and excluding grazing animals.

To avoid saturating this soil use the information from continuous soil moisture monitoring equipment to determine the date and the length of each irrigation.

Soil 7 Thick sand over sandy clay loam



Landscape Gently undulating rises of the “mallee” component of the Langhorne Creek Region, formed on highly calcareous windblown deposits. Surface soil is loose and stone free.

Profile Medium to thick (variable) red brown sand over a red sandy clay loam, highly calcareous with depth.

Depth (cm)	*Description*
0-10	Reddish brown loose sand (drift). Clear to:
10-35	Light reddish brown loose sand (drift). Abrupt to:
---------- original soil surface ----------	
35-88	Dark reddish brown soft light loamy sand. Sharp to:
88-95	Yellowish red firm massive sandy clay loam with 2-10% calcrete fragments. Abrupt to:
95-140	Reddish yellow very highly calcareous light sandy clay loam with more than 50% fine carbonate and minor nodules. Diffuse to:
140-180	Red, brown and yellow mottled hard massive clayey sand with 10-20% fine carbonate.

Key properties

Drainage — Well drained. The soil rarely remains wet for more than a day or so. Deep drainage is adequate.

Potential root zone — 160 cm in sampling pit, but few roots below 140 cm.

Barriers to root growth

Physical: The hard clayey sand substrate is a moderate restriction on root penetration.

Chemical: High pH and marginally high sodicity and boron concentrations restrict root growth below 95 cm.

Water holding capacity : Estimated for the depth of the potential root zone of grapevines

Total available: 110 mm
Readily available: 65 mm

Fertility — Inherent fertility is low due to low clay content. There is virtually no contribution to nutrient retention capacity from the subsoil either.

Erosion potential — Potential for wind erosion is moderate due to the sandy surface and high position in the landscape. Low potential for water erosion.

Laboratory data

Depth cm	pH H_2O	pH $CaCl_2$	CO_3 %	ECe dS/m	Cl mg/kg	S mg/kg	B mg/kg	Ext P mg/kg	Ext K mg/kg	Org C %	Exchangeable cations - cmol(+)/kg					#ESP
											Ca	Mg	Na	K	#CEC	
Target →	< 9.2	>5.0	na	< 2.0	< 350	10	< 3	80	200	> 1.0	% of (Ca+Mg+Na+K)				> 5	< 6
											65-75	10-15	< 6	3-8		
0-10	6.2	5.8	0	4.09	90	133	0.7	49	214	0.69	4.06	1.19	0.33	0.50	6.1	5.4
10-35	7.3	6.7	0	1.75	33	45.2	0.5	22	163	0.38	3.43	0.65	0.16	0.43	4.7	3.4
35-88	7.9	7.3	0	2.01	41	47.9	0.8	5	314	0.33	4.67	1.15	0.28	0.80	6.9	4.1
88-95	9.1	8.3	1.2	1.52	41	15.1	4.3	4	377	0.29	6.64	3.67	1.08	1.00	12.4	8.7
95-140	9.4	8.5	24.6	2.27	87	28.8	10.5	4	296	0.23	8.62	4.69	2.60	0.80	16.7	15.6
140-180	9.5	8.5	3.6	3.95	175	67.3	10.4	2	287	0.07	5.81	4.25	3.96	0.75	14.8	26.8

CEC estimated from sum (Ca+Mg+Na+K). # ESP is estimated by = Na / (Ca+Mg+Na+K)

Explanation of highlighted data

Grape vines can suffer 10% yield loss when ECe exceeds 2.5 dS/m, or chloride exceeds 350 mg/kg. High surface reading here due to gypsum. This will leach away over time.
Exchangeable sodium less than 6% of total of all four cations is desirable.
Boron concentrations exceeding 3 mg/kg may be a problem for grape vines (American literature).
Root growth generally poor where pH in water exceeds 9.2.
High carbonate in a sandy clay loam matrix slightly decreases root growth.
Sum of exchangeable cations of less than 5 cmol(+)/kg is indicative of low inherent fertility (allow here for higher than natural calcium value due to gypsum application).
High surface sulphur and calcium indicative of gypsum application.

Notes:

Management of Soil 7
Thick sand over sandy clay loam
by John Rasic

Problems
This soil is susceptible to wind erosion and plants can become water-stressed due to the low water holding capacity of the upper, sandy layer. When sand is saturated, it is unstable and it can collapse (slake), become a slurry and flow down through the profile. This slurry can block pores and then, when it dries, the slurry can become a sandy, impenetrable cap (capping) likely in this soil at 88cm. If flood water ponds on this soil or if it is irrigated, this cap can develop quickly and it can severely restrict the penetration of roots and of water.

Before development, this soil may show little evidence of the waterlogging that can develop into a serious problem if it is irrigated.

The sharp change at 88cm from sand into carbonate-rich sandy clay loam is where porosity, the speed of water movement, drainage and chemistry all change sharply.

Pre-planting action that can be used to tackle the problems
Eliminate the sharp changes at 88 and 95cm by mechanically mixing the layers to achieve more uniform soil properties down to 100cm depth.

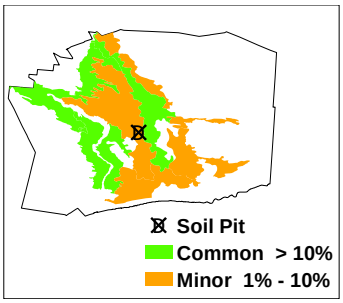
Into the mixed soil, keep below 10% the volume of soil from layers that contain problems like salinity, sodicity, high boron or high pH.

Soil management after planting
Establish a drought resistant mid-row cover crop to hold the soil particles together and prevent wind erosion.

Apply fertiliser to achieve quicker and better growth of the cover crop. The cover crop can provide the much needed increase in soil organic matter. Organic matter helps to prevent slaking, capping and pan formation and it reduces compaction because it causes compressed soil to spring back (the rebound effect).

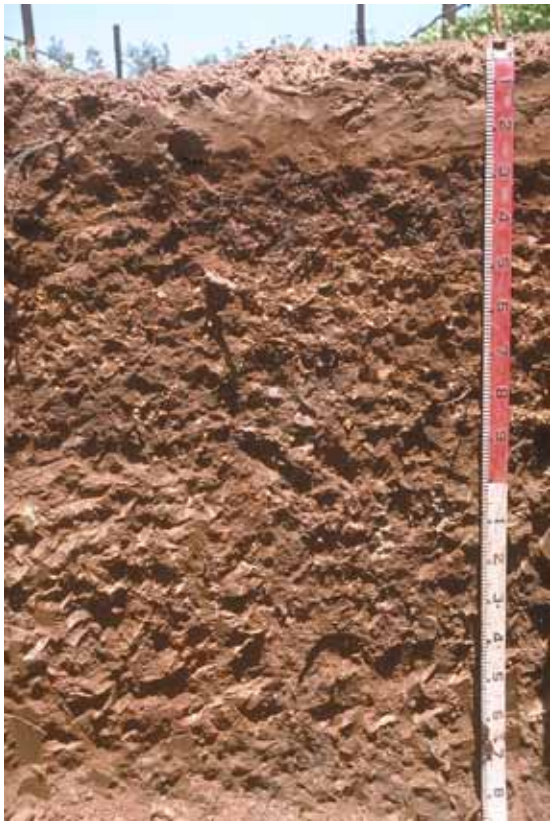
To minimise compaction and to allow the cover crop to establish, minimise vehicle traffic and the grazing of animals especially when the soil is wet. If the cover crop is growing vigorously, avoid the temptation to admit grazing animals.

Soil 8 Sandy loam over red clay



Landscape — Old alluvial flats of the Angas Bremer flood plains. Surface soil is hard setting and stone free.

Profile — Reddish brown hard setting loamy sand to clay loam overlying a dark reddish brown strongly structured clay, calcareous with depth.



Depth (cm)	*Description*
0-10	Reddish brown massive hard setting light sandy loam. Abrupt to:
10-20	Reddish brown massive hard sandy loam. Abrupt to:
20-30	Reddish brown massive hard light sandy loam. Sharp to:
30-50	Red and dark reddish brown firm medium clay with strong coarse prismatic structure. Clear to:
50-85	Dark reddish brown and orange light medium clay with polyhedral structure and 2-10% soft and nodular carbonate. Gradual to:
85-130	Dark reddish brown, yellowish red and brown light clay with blocky structure. Gradual to:
130-180	Yellowish brown, orange and pale brown soft massive clayey sand.

Key properties

Drainage — Moderately well drained. Soil is unlikely to remain wet for more than a week. A perched water table on top of the clay subsoil may cause minor waterlogging. Deep drainage is satisfactory due to the sandy substrate.

Potential root zone — Few roots below 85 cm in sampling pit.

Barriers to root growth

Physical: The firm subsoil clay (sodic) may restrict the penetration of some roots

Chemical: There are no chemical barriers to root growth, but further sodium build up under irrigation can be expected over time.

Water holding capacity : Estimated for the depth of the potential root zone of grapevines

Total available: 105 mm
Readily available: 75 mm

Fertility — Inherent fertility of the soil is moderate, as indicated by the exchangeable cation data (high values in the clay subsoil, but low in the surface due to low clay and organic matter contents). Maintenance of adequate nutrient levels on this soil is straight-forward.

Erosion potential — Low potential for both water and wind erosion.

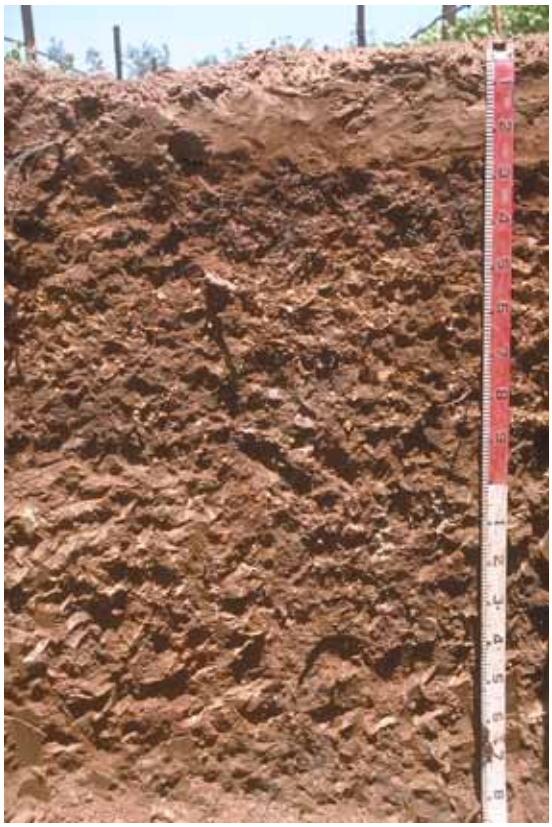
Laboratory data

Depth Cm	pH H_2O	pH $CaCl_2$	CO_3 %	ECe dS/m	Cl mg/kg	S mg/kg	B mg/kg	Ext P mg/kg	Ext K mg/kg	Org C %	Exchangeable cations - cmol(+)/kg					ESP
											Ca	Mg	Na	K	CEC	
Target →	< 9.2	>5.0	na	< 2.0	< 350	10	< 3	80	200	> 1.0	% of (Ca+Mg+Na+K)				> 5	< 6
											65-75	10-15	< 6	3-8		
0-10	6.6	6.2	0	0.42	-	-	1.4	11	353	0.9	4.23	1.78	0.45	0.64	6.4	7.0
10-20	6.9	6.4	0	0.71	-	-	1.2	5	357	0.7	3.81	1.72	0.48	0.63	5.1	9.4
20-30	7.2	6.8	0	0.65	-	-	1.0	<4	292	0.3	3.20	1.70	0.45	0.55	4.5	10.0
30-50	7.3	6.6	0	0.71	-	-	3.5	<4	472	0.5	8.19	5.68	1.37	1.42	18.7	7.3
50-85	8.5	8.1	4	0.75	-	-	2.5	<4	319	0.2	5.80	3.51	0.98	0.78	10.3	9.5
85-130	8.4	8.0	1	0.83	-	-	3.4	<4	546	0.4	8.13	5.84	1.55	1.27	14.7	10.5
130-180	8.1	7.3	0	0.31	-	-	1.0	<4	166	<0.1	1.87	1.36	0.39	0.31	3.2	12.2

Explanation of highlighted data

Exchangeable sodium less than 6% of CEC is desirable.
Boron concentrations exceeding 3 mg/kg may be a problem for grapevines (American literature).
Surface layers have relatively low nutrient retention capacity. These P levels are low, but P will vary for different soil pits.
Apply gypsum to increase the low ratio of Ca to Mg.

Notes:



Management of Soil 8
Sandy loam over red clay
by John Rasic

Problems
When this soil dries, the clay layer below 30cm shrinks and cracks into prism-shaped pieces. When wetted, this prismatic clay swells and the prisms fit back together precisely to form a seal. The sharp boundary between the porous surface layer and this prismatic clay at 30cm marks a sudden increase in density and a decrease in the ease of water movement and drainage.

Under irrigation, water, salts and toxins can accumulate above the sharp change at 30cm.

When saturated, the surface layer can collapse (slake) and become a slurry that can flow down through the profile and seal the network of connecting soil pores.

This seal prevents drainage, causing the saturation and collapse (slaking) of the overlying soil. On drying, the collapsed soil can form a hard sandy cap (capping) on top of the prismatic clay at 30cm. This cap will restrict root growth and water penetration.

Pre-planting action that can be used to tackle the problems
Eliminate the sharp boundary at 30cm between the sand and the prismatic clay and delay the re-forming of the boundary by incorporating sand between the clay prisms to stop them sealing when they close.

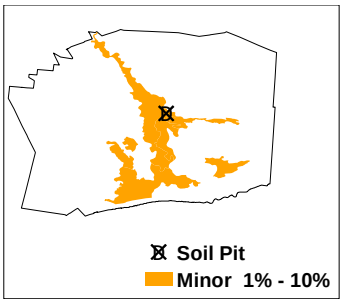
Deep ripping to 50cm (a depth that includes less clay than the depth of sand), incorporating gypsum and mixing can increase soil uniformity, increase the penetration of roots and of water and increase the shrinking and swelling of the (otherwise non-cracking) surface layers.

Soil management after planting
Rip along the mid-row, incorporate gypsum and establish a fast growing cover crop to increase porosity and to help prevent slaking and capping. This will reverse the severe mid-row compaction that can occur during the establishment of a vineyard. Increasing the organic matter can provide insurance against compaction because it causes compressed soil to spring back (the rebound effect). Apply fertiliser for quicker and better establishment of the cover crop.

Reduce compaction and allow the cover crop to establish by minimising vehicle traffic and excluding grazing animals.

The roots can be encouraged to grow deeper into the soil (below 50cm) by applying larger quantities of irrigation water at longer time intervals. Continuous monitoring of soil moisture is the only accurate method for deciding how much irrigation water to apply and the date when the water should be applied

Soil 9 Clay loam over poorly structured red clay



Landscape — Alluvial plains formed on medium textured sediments. Surface soil is hard setting and stone free.

Profile — Hard clay loam over a coarsely structured red clay, calcareous with depth

Depth (cm)	*Description*
0-12	Very dark grey hard clay loam with moderate fine granular structure. Clear to:
12-25	Dark brown hard clay loam with weak fine granular structure. Abrupt to:
25-55	Dark reddish brown and dark brown very hard medium heavy clay with weak coarse prismatic structure. Clear to:
55-90	Dark brown very hard calcareous medium clay with weak coarse prismatic structure. Gradual to:
90-125	Yellowish brown, red and orange very hard calcareous sandy light clay with weak coarse prismatic structure. Gradual to:
125-160	Reddish yellow, dark brown and reddish brown hard weakly structured sandy clay loam.

Key properties

Drainage — Moderately well drained. Water perches on the clayey subsoil for up to a week following heavy or prolonged rainfall. Deep drainage is adequate.

Potential root zone — Vine roots to 160 cm in pit, but there are few below 25 cm.

Barriers to root growth

Physical: The tight clayey subsoil severely restricts root proliferation. Although there is some growth in the clay, it is confined to planes of weakness between aggregates.

Chemical: There are no apparent chemical barriers to root growth, although sodicity may build up over a long period under irrigation.

Water holding capacity : Estimated for the depth of the potential root zone of grapevines

Total available:	120 mm
Readily available:	55 mm

Fertility — Inherent fertility is moderately high. Maintaining adequate levels of nutrition in these soils is straightforward.

Erosion potential — Low potential for both water and wind erosion.

Laboratory data

Depth Cm	pH H_2O	pH $CaCl_2$	CO_3 %	ECe dS/m	Cl mg/kg	S mg/kg	B mg/kg	Ext P mg/kg	Ext K mg/kg	Org C %	Exchangeable cations - cmol(+)/kg					#ESP
											Ca	Mg	Na	K	#Sum	
Target →	< 9.2	>5.0	na	< 2.0	< 350	10	< 3	80	200	> 1.0	% of (Ca+Mg+Na+K)				> 5	< 6
											65-75	10-15	< 6	3-8		
0-12	8.2	7.6	0	*3.5	-	147	1.7	31	636	2.55	21.4	4.07	1.65	1.55	28.7	5.8
12-25	8.5	7.6	0	*1.3	-	21.9	1.2	9	437	1.92	16.9	3.40	1.04	1.06	22.4	4.6
25-55	8.2	7.4	0	*1.4	-	102	1.3	6	352	0.95	15.0	5.74	1.82	1.00	23.6	7.7
55-90	8.6	7.9	<10	*2.1	-	121	1.4	2	357	0.49	15.9	6.39	2.16	0.91	25.4	8.5
90-125	8.8	8.0	<10	*1.4	-	51.1	1.3	3	259	0.20	9.26	3.69	1.14	0.62	14.7	7.7
125-160	8.3	7.5	<10	*1.3	-	52.4	1.2	2	216	0.18	5.08	2.62	0.84	0.55	9.1	9.2

* ECe estimated from $EC_{1:5}$

CEC estimated from sum (Ca+Mg+Na+K). # ESP is estimated by = Na / (Ca+Mg+Na+K)

Explanation of highlighted data

Elevated surface electrical conductivity indicates evaporative concentration of salt.
Exchangeable sodium less than 6% of total of all four cations is desirable.
The high surface sulphur and calcium levels are either from salt in the irrigation water or from the remnants of a past gypsum application.

Notes:

Management of Soil 9
Clay loam over poorly structured red clay
by John Rasic

Problems
When this soil dries, the clay layer below 25cm shrinks and cracks into prism-shaped pieces. When wetted, this prismatic clay swells and the prisms fit back together precisely to form a seal. The abrupt boundary at 25cm between the porous surface layer and this prismatic clay marks a sudden increase in density and a decrease in the ease of water movement and drainage.

Under irrigation, the abrupt change causes waterlogging and an accumulation of salts and toxins above the clay layer.

The limitations of this soil are less severe than those of soils with sandier surfaces because, when it is wet, the surface clay loam of this soil does not collapse (slake) to the same extent.

Pre-planting action that can be used to tackle the problems
Incorporate gypsum to 20cm depth. Rip to 50cm and mix the top 25cm layer with the 25 to 55cm layer to increase the penetration of roots and of water down to 50cm. Unfortunately, over time the prismatic structure will re-appear.

Soil management after planting
The amount that this soil shrinks and cracks on drying then swells and closes on wetting depends upon how widely the water content varies. Minimise the variation in water content by using an irrigation system that wets the maximum volume of soil (low discharge drippers that are closely spaced) and irrigate frequently using small applications of water.

Increasing the organic matter will significantly improve the fertility of this soil.