Soils of the Riverina



Australian Government
Grape and Wine Research and Development Corporation

1. Introduction

A. Background

The Grape and Wine Research and Development Corporation (GWRDC) is currently developing regional profiles for winegrape growing regions throughout Australia. The purpose of these regional profiles is to provide background information on resources and current practices and to assist in identifying areas suitable for viticultural development.

Cropsol Soil & Irrigation Management has undertaken the soils investigation component of the regional profile development for the Riverina.

B. Brief

The aim of the investigation was to identify: the predominant soil types present within the Riverina that have been developed for viticulture; any potential soil constraints that would restrict viticultural development; and cultural practices that are specific to the varying soil types.

2.0 Executive Summary

This is a summary report, commissioned by the GWRDC, of a reconnaissance investigation into the soils within the Riverina catchment. Importantly it investigates and discusses the various soil types, their suitability for viticultural development and general cultural practices that would be best suited to those soil types.

The investigation depicted variation in all of the soil parameters tested and highlighted various soil characteristics that should be considered prior to the development of a winegrape production property.

The general soil characteristics that should be considered come under the headings of:

- Physical barriers
- Salinity and sodicity
- Waterlogging
- Chemical barriers
- Shallow water tables
- Fertility

Physical barriers to root development and water movement are considered to be the main risks associated with irrigation development within the Riverina. This soil characteristic is most prevalent in the sub-plastic soils of the lower hill slopes and the plastic soils of the plains.

Whatever the cause, a physical barrier to root development can also be closely linked with reduced permeability, reduced drainage rates and an elevated soil salinity level.

Elevated soil salinity levels are also detrimental to vine health. They can be attributed to inappropriate irrigation practices, insufficient leaching rainfall, rising water tables, impermeable subsoils and the salinity level of the irrigation water used (Murrumbidgee Irrigation, 2004).

3.0 Assessing The Potential and Risks For Irrigated Crops

The economic viability of any winegrape growing region is influenced by available resources, which include a range of soil types. It is for this reason that it is vitally important to identify areas that have soil conditions that are ideally suited for viticultural development, and conversely soil types that should be avoided.

When assessing the potential of a soil type, there are three main points that should be considered. These are:

1. Hydraulic properties (infiltration rates, drainage gradients, water holding ability, permeability, readily available water levels and presence of water tables).

2. Chemical properties (inherent fertility, pH levels, presence of toxic elements, soil salinity and soil sodicity)

3. Physical properties (soil texture, soil structure, pedality type and topography)

The preferred method of assessing soil properties is through the use of soil trenches dug to a depth of approximately one point five (1.5) metres. Observation and sample collection is achieved effectively on the excavated face of the soil trench.

It is important that soil properties are assessed individually as well as collectively as the interaction between parameters can create an adverse environment. An example of this is where fine soil carbonate is densely packed into a well drained light clay layer.

The methodology used for soil trench investigation in this report is discussed in Appendix One.

a.Waterlogging

Grapevines prefer soils that are well drained. Waterlogged conditions provide the ideal environment for root rotting organisms to attack the already stressed root system. They reduce the potential of the vine to uptake both nutrients and soil moisture, consequently affecting the potential yield.

There are two kinds of waterlogging events that affect vines within the Riverina namely surface and subsurface waterlogging.

Surface waterlogging

The two main causes of surface waterlogging are slowly permeable topsoil layers or densely-packed B1 horizons that have low permeability. These characteristics can generally be adjusted through the regular incorporation of both gypsum and organic matter.

Subsurface waterlogging

Subsurface waterlogging events generally occur in the plastic soils of the plains, which are found in the low lying regions of the Riverina Plain. It is the clay nature of the subsoil that restricts the movement of water throughout the profile, and as consequence waterlogging occurs within the subsoil.

Amelioration to prevent subsurface waterlogging could include deep ripping, incorporation of gypsum, subsurface drainage and mounding prior to establishment.

b. Salinity and sodicity

Elevated soil salinity levels can create a 'drought affect' within the soil, reducing the vines osmotic potential and consequently imposing a negative affect on crop yields. When soil salinity levels are elevated, it is common for the deleterious effects of soil sodicity and sodium toxicity to be observed.

The main causes of elevated soil salinity levels are rising saline groundwater levels, insufficient salt leaching rainfall events and inappropriate irrigation management practices.

Subsurface drainage systems, revegetation of perennial plant species, and efficiency improvements to the on farm application of this irrigation water should reduce the potential for elevated soil salinity levels.

Commonly linked with soil salinity is both soil sodicity and soil dispersion. It is an imbalance of the cation exchange complex, particularly calcium and sodium that causes soil particles to repel against each other thus reducing the structural stability of each soil aggregate and degradation in overall soil structure.

The incorporation of a calcium-based product, for example gypsum, should adjust the exchange complex, which improves the structural stability of the soil.

c. Shallow water tables

Restrictions on water movement both vertically and horizontally, can create a perched watertable, particularly if the quantity of irrigation water applied exceeds vine requirements.

Saline water tables should be avoided, as it is possible for the salty water to rise through capillary action into the rootzone, raising the salt loading. Non-saline water tables are also considered to be detrimental in viticulture, as this water source can be utilised by the vine at anytime, thus potentially creating excess vigour.

d. Chemical Barriers

Chemical barriers exist in many Riverina soils. These barriers include:

1. Sodium toxicity - caused by a high exchangeable sodium percentage (ESP).

2. Boron – commonly found in soils that contain high carbonate levels.

3. Alkalinity – high concentrations of active carbonate elevate the soil pH into the strongly alkaline range.

4. Chloride – generally is prevalent when sodium levels are elevated.

Chemical Barrier	Low risk	Medium risk	High risk
Alkalinity (H20)	< 8.5	8.5 – 9.2	> 9.2
Acidity (CaCl2)	> 5.0	4.2 – 5.0	< 4.2
Sodium Toxicity (ESP)	<13	13- 25	> 25
Boron (mg/kg)	< 1	1 - 3	> 3
Chloride (mg/kg)	< 350	350 - 1060	> 1060

Amelioration of these chemical barriers is difficult, with the only solution involving rootstock selection, or mounding the soil prior to establishment to avoid the RAW rootzone being in the affected soil horizon

e. Physical barriers

Physical barriers to both root and water movement within the profile are found in several of the region's soil types but are most evident in the plastic soils of the plains.

It is the clay nature of the subsoil that creates an initial barrier, but it is when this is coupled with soil sodicity and elevated dispersion levels that this physical barrier has a substantial affect on the potential root-zone area and consequently crop yields.

f. Fertility

The inherent fertility rating of a soil type is based on the clay content and the organic matter level of the soil. Generally, if the soil has a high clay content, it has a greater ability to retain nutrients that will be later made available to the vines.

The presence of soil carbonate has the potential for nutrient tie-up, for example, high soil pH levels can impact on phosphorus uptake, whereas low soil pH levels have a bearing on manganese, zinc and iron availability.

4.0 Soil Profile Summaries

Soil 1 – Deep Sand (Cudgel Sand)

Landscape

Aeolian material, typically found in close proximity to the Murrumbidgee River.

Profile

Consisting of grey-brown sand, the topsoil is classed as non-structured and exists to an average depth of thirty (30) centimetres. The subsoil consists of a very permeable sand to a depth of one hundred (100) centimetres, followed by a clay sand to light clay layer. The depth to the clay sand/light clay layer will vary according to its exact location on the sand dune. Soil carbonate is not present within the sand layers.

Drainage

The sand layers within this soil type are extremely well drained. The clay sand/light clay layers found at depth have a lower drainage rate and consequently can create a perched water table.

Salinity and sodicity

Generally, the soil salinity level is low within the readily available water (RAW) rootzone.

Potential rootzone (RAW) 79 cm in sampling pit

Barriers to root growth

Chemical barriers: There are no chemical barriers that would restrict root growth

Physical barriers: The sandy clay/light clay layer would be a barrier to root exploration and water movement on the lower slopes of the sand dunes..

Waterholding capacity

Total available water 49 mm/m
Readily available water 29 mm/m

Fertility

The inherent fertility of the soil is low due to the low level of organic matter in the topsoil and the low clay content of the profile. As a result the soil has a reduced ability to retain nutrients.

Because of the high drainage rate of this soil, nutrients may be readily leached beyond the vines rootzone if not managed correctly.

Erosion potential

There is moderate potential for soil erosion if the mid-row area is kept bare, and the application rate of the irrigation system is too high.

Vine performance

Vine performance on this soil type will be moderate to high, due to the deep potential rootzone area. Plant vigour will need to be closely monitored.

Irrigation practices

Because of the high drainage rate of the soil, irrigation shifts will need to be relatively short and frequent to minimise water moving beyond the plants rootzone and to maintain soil moisture levels within the plants RAW rootzone.

Leaching of salts from the RAW rootzone should be easily achieved on the upper and mid slopes of the sand dunes, however the clay sand/light clay layer may restrict salt leaching on the lower lying areas. Soil moisture monitoring devices are suggested to manage irrigations successfully.

Nutrition and soil amendments

Regular applications of both macro and micro-nutrients will be required as nutrients may be easily leached through irrigation and rainfall events. Regular monitoring of both plant and soil nutrient status is essential.

To improve overall soil structure, waterholding capacity and to minimise the potential for soil erosion, organic matter levels should be increased through the incorporation of a bulk organic material prior to planting.

Vineyard floor management and accessibility

To improve organic matter levels and overall soil structure, a cover crop should be grown in the inter-row area, and regularly slashed under the vine. An annual plant species such as ryegrass or oats is suggested as it will assist in removing excess soil moisture in spring, provide a bulk source of organic matter, but not compete with the vines during the critical summer months.

Cultivation practices should be limited to maintain soil structure and to minimise the potential for soil erosion on the upper hill slopes.

Soil 1 – Deep Sand (Cudgel Sand)

Depth (cm)	0-29	29-64	64-110	110-150
Horizon Name	A1	B1	B2	B3
Texture	S	S	S	SC
Soil Colour	Brown - Grey	Red -Brown	Red - Brown	Red
Soil Mottle	-	-	-	-
Fragment Lithology	-	-	-	-
Fragment Percentage (%)	-	-	-	-
Carbonate Class	-	-	-	-
Carbonate Reaction	-	-	-	-
Pedality Grade	NS	NS	NS	W
Pedality Type	-	-	-	SB
Root Density	3	2	2	0
Soil pH	6.7	6.7	6.4	7.4
Soil ECe	0.6	0.8	0.6	0.34
Slaking Index	4	4	4	4
Dispersion Index	1	1	0	0
Nitrate NO3-N (mg/kg)	13	5	3	3
Phosphorus BSES (mg/kg)	62	16	9	20
Phosphorus Colwell (mg/kg)	36	4	8	7
Potassium (meq/100gm)	0.12	0.08	0.12	0.14
Calcium (meq/100gm)	2.56	1.38	1.75	2.96
Magnesium (meq/100gm)	0.80	0.89	0.63	1.24
Sodium (meq/100gm)	0.09	0.07	0.09	0.26
SAR	0.81	0.82	0.97	2.17
Ca/Mg ratio	5.33	2.57	4.65	3.96
Sulphate – S (ppm)	1.0	2.0	4.0	2
Zinc (ppm)	1.9	0.4	0.1	0.1
Copper (ppm)	1.2	0.5	0.4	0.2
Manganese (ppm)	0.16	0.14	0.13	0.16
Iron (ppm)	4.4	9.2	9.2	4.7
Boron (ppm)	0.01	0.01	0.01	0.01
Organic Carbon (%)	0.45	0.15	0.17	0.22
Organic Matter (%)	0.77	0.25	0.29	0.37
Chloride ppm	11.0	23.0	11.0	11.0
Carbonate CO3 (%)	0.00	0.00	0.00	0.00




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Soil 2 – Sandy Clay Loam over Light Clay and Clay Loam (Merungle Loam)

Landscape

Mid to lower slopes of the Merungle and Corbie Hill regions. Sub-plastic soil of the lower hill slopes and plains.

Waterholding capacity

Total available water 106 mm/m
Readily available water 45 mm/m

Profile

Consisting of a red-brown sandy clay loam, the topsoil is generally well structured, and exists to an average depth of twenty-eight (28) centimetres. The subsoil consists of a semi-permeable, moderately well structured light clay band in the B1 horizon, followed by clay loam and clay sand. Soil carbonates are present at an average depth of fifty centimetres (50), and moderate reactions to one (1) Mole Hydrochloric acid (HCl) can be observed.

Fertility

The inherent fertility of the soil is moderate to high, due to the high level of organic matter in the topsoil and the elevated clay content of the subsoil. These two factors give the soil the potential to retain a high percentage of nutrients within the RAW rootzone.

Because of the reactive limestone within the soil profile, the availability of micro-nutrients will need to be closely monitored.

Drainage

There is a moderately well drained profile, provided the clay band in the B1 horizon has minimal dispersive characteristics. Some surface water ponding may occur after substantial rainfall events.

Erosion potential

There is low potential for soil erosion on the lower hill slopes. On the upper and mid hill slopes there is moderate potential for soil erosion, if the irrigation system's application rate exceeds the infiltration rate of the surface soil.

Salinity and sodicity

Generally, the soil salinity level is low to moderate within the readily available water (RAW) rootzone. Soil salinity can become elevated deep within the profile if irrigation events do not provide adequate leaching.

Sodicity and soil dispersion levels are commonly in the low to moderate range. Regular maintenance applications of a calcium-based soil ameliorant, would generally inhibit the deleterious effects of soil sodicity, but would be more effective if applied and incorporated prior to planting.

Vine performance

Vine performance on this soil type will be moderate. The semi-permeable light clay layer combined with the presence of reactive limestone within the subsoil reduces the potential rootzone depth and consequently the RAW value.

Irrigation practices

While vine performance is classed as moderate, it is important that irrigation quantities are limited for vigorous varieties and rootstocks, particularly between the phenological growth phases of fruit set and veraison. Due to the hot climate within the Riverina, irrigation quantities should not be limited at any stage of growth for young vines or during the canopy development stage of growth in mature vines.

In general, irrigation shifts should be long and infrequent for optimum vine balance and root distribution.

Leaching of salts from the RAW rootzone is vital, and can generally be achieved through extended irrigation events. Soil moisture monitoring devices are suggested to manage irrigations successfully.

Potential rootzone (RAW) 76 cm in sampling pit

Barriers to root growth

Chemical barriers: The presence of reactive carbonate at a depth of sixty (60) centimetres will be restrictive to root development in sensitive rootstocks. High levels of sodium and boron exist in the subsoil.

Physical barriers: The light clay layer located at a depth of twenty-eight centimetres (28) would be a barrier to root exploration.

Soil 2 – Sandy Clay Loam over Light Clay and Clay Loam (Merungle Loam)

Nutrition and soil amendments

This soil profile has a high fertility rating and because of the potential ability of the soil to retain nutrients, periodic applications of macro-nutrients will generally be sufficient. The presence of reactive limestone and the effect this has on soil pH may affect the availability of some micro-nutrients.

This soil benefits from regular maintenance applications of a calcium-based soil ameliorant to minimise soil dispersion.

Vineyard floor management and accessibility

To improve organic matter levels and overall soil structure, a cover crop should be grown in the inter-row area, and regularly slashed under the vine. An annual plant species such as ryegrass or oats is suggested as it will assist in removing excess soil moisture in spring, but will not compete with the vines during the critical summer months. Legume-based cover crops are not suggested for this soil type because nitrogen fixation could exacerbate a vine vigour problem.

Cultivation practices should be limited to maintain soil structure and to minimise the potential for soil erosion on the upper hill slopes.

Depth (cm)	0-26	26-58	58-150
Horizon Name	A_1	B_1	B_2
Texture	SCL	LC	SC
Soil Colour	Red-Brown	Red	Red
Soil Mottle	-	Black, Yellow	Black, Yellow
Fragment Lithology	-	-	Limestone
Fragment Percentage (%)	-	-	20
Carbonate Class	-	-	IIIAL
Carbonate Reaction	-	-	M
Pedality Grade	W	M	S
Pedality Type	SB	SB	SB
Root Density	3	2	1
Soil pH	6.5	7.5	7.8
Soil ECe	1.20	1.29	5.25
Slaking Index	3	3	3
Dispersion Index	2	2	1
Nitrate NO_3-N (mg/kg)	23	36	118
Phosphorus BSES (mg/kg)	88	7	4
Phosphorus Colwell (mg/kg)	90	10	7
Potassium (meq/100gm)	1.47	0.75	0.65
Calcium (meq/100gm)	8.73	7.29	17.23
Magnesium (meq/100gm)	2.51	5.54	5.65
Sodium (meq/100gm)	0.14	0.82	2.49
SAR	0.71	4.10	8.91
Ca/Mg ratio	5.80	2.19	5.08
Sulphate – S (ppm)	6	33	170
Zinc (ppm)	11.9	0.3	0.2
Copper (ppm)	0.9	0.2	0.1
Manganese (ppm)	0.11	0.24	0.07
Iron (ppm)	8.8	0.8	0.8
Boron (ppm)	0.35	2.03	4.3
Organic Carbon (%)	2.2	0.33	0.11
Organic Matter (%)	3.78	0.56	0.19
Chloride ppm	14	25	107
Carbonate CO_3 (%)	1.00	1.00	10.5




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Soil 3 – Sand over clay (Wamoon Sand)

Landscape

Sandy rises found to the west of Leeton (Aeolian deposits)

Waterholding capacity

Total available water 45 mm/m
Readily available water 27 mm/m

Profile

Consisting of grey-brown sand, the topsoil is classed as non-structured and exists to an average depth of twenty-five (25) centimetres. The subsoil consists of a very permeable sand to a depth of one hundred and ten (110) centimetres, followed by a clay sand to light clay layer which generally has a very mottled colour.

Fertility

The inherent fertility of the soil is low, due to the low level of organic matter in the topsoil and the low clay content of the profile. Because of the high drainage rate of this soil, nutrients may be readily leached beyond the vine rootzone.

Drainage

The sand layers within this soil type are extremely well drained. The clay sand/light clay layers found at depth have a lower drainage rate and consequently can create a perched water table if irrigation events exceed the storage capacity of the sand layers.

Erosion potential

There is moderate potential for soil erosion if the mid-row area is kept bare, and the application rate of the irrigation system is too high.

Salinity and sodicity

Generally, the soil salinity level is moderate to high within the readily available water (RAW) rootzone. The clay sand/light clay layer will restrict salt leaching and consequently salinity may increase above the restrictive layer.

Sodicity and soil dispersion levels are commonly low within the RAW rootzone, however slaking levels are moderate to high due to the non-structured characteristic of the sands.

Vine performance

Vine performance on this soil type will be moderate to high, due to the potential rootzone area. Plant vigour will need to be closely monitored.

Irrigation practices

Because of the high drainage rate of the soil, irrigation shifts will need to be relatively short and frequent to minimise water moving beyond the vine rootzone and to maintain soil moisture levels within the RAW rootzone.

Leaching of salts from the RAW rootzone can be achieved on the upper and mid slopes of the sand dunes, however the clay sand/light clay layer does restrict salt leaching on the lower lying areas. Soil moisture monitoring devices are suggested to manage irrigations successfully.

Potential rootzone (RAW) 73 cm in sampling pit

Barriers to root growth

Chemical barriers: There are no chemical barriers to root growth. Monitoring of soil salinity levels is essential.

Physical barriers: The sandy clay/light clay layer would be a barrier to root exploration and water movement on the lower slopes of the sand dunes.

Nutrition and soil amendments

Regular applications of both macro and micro-nutrients will be required, as nutrients will be easily leached through irrigation and rainfall events. Regular monitoring of both plant and soil nutrient status is essential.

To improve overall soil structure, waterholding capacity and to minimise the potential for soil erosion, organic matter levels should be increased through the incorporation of a bulk organic material prior to planting.

Vineyard floor management and accessibility

To improve organic matter levels and overall soil structure, a cover crop should be grown in the inter-row area, and regularly slashed under the vine. An annual plant species such as ryegrass or oats is suggested as it will assist in removing excess soil moisture in spring but will not compete with the vines during the critical summer months. Establishment of a cover crop on this soil type will depend on autumn rainfall events.

Cultivation practices should be limited to maintain soil structure and to minimise the potential for soil erosion on the upper hill slopes.

Soil 3 – Sand over clay (Wamoon Sand)

Depth (cm)	0-23	23-110	110-150
Horizon Name	A1	B1	B2
Texture	S	S	SC
Soil Colour	Brown - Grey	Brown – Grey	Red - Brown
Soil Mottle	-	-	Re Ye Gr
Fragment Lithology	-	-	-
Fragment Percentage (%)	-	-	-
Carbonate Class	-	-	-
Carbonate Reaction	-	-	-
Pedality Grade	NS	NS	S
Pedality Type	-	-	SB
Root Density	1	0	0
Soil pH	6.8	6.4	6.9
Soil ECe	4.02	0.40	0.26
Slaking Index	2	4	2
Dispersion Index	0	3	2
Nitrate NO3-N (mg/kg)	54	7	6
Phosphorus BSES (mg/kg)	158	36	12
Phosphorus Colwell (mg/kg)	89	23	4
Potassium (meq/100gm)	0.27	0.09	0.34
Calcium (meq/100gm)	4.23	1.31	2.77
Magnesium (meq/100gm)	0.94	0.19	1.52
Sodium (meq/100gm)	0.27	0.05	0.07
SAR	1.97	0.65	0.63
Ca/Mg Ratio	7.49	11.35	3.04
Sulphate – S (ppm)	22	1.0	1.0
Zinc (ppm)	9.3	1.0	0.3
Copper (ppm)	2.1	0.5	0.4
Manganese (ppm)	0.18	0.1	0.08
Iron (ppm)	12.4	9.3	31.8
Boron (ppm)	0.08	0.01	0.04
Organic Carbon (%)	0.62	0.14	0.17
Organic Matter (%)	1.06	0.24	0.29
Chloride ppm	70	7.0	6.0
Carbonate CO3 (%)	0.00	0.00	0.00





Soil 4 – Hard Setting Clay Soil (Whitton Clay)

Landscape

Plastic soils of the plains. Flood plains of the Riverina.

Waterholding capacity

Total available water 86 mm/m
Readily available water 33 mm/m

Profile

Consisting of a grey-brown light clay, the topsoil is generally poorly structured and hard setting. The subsoil consists of non-permeable medium to heavy clay. Soil carbonate is present at an average depth of sixty (60) centimetres, and moderate reactions to one (1) Mole Hydrochloric acid (HCl) can be observed.

Fertility

The inherent fertility of the soil is considered moderate. While this soil has a high potential to retain nutrients, the uptake of these nutrients by the vine's root system will be restricted by the heavy, hard-setting nature of the clay profile.

Because of the reactive limestone within the soil profile, the availability of micro-nutrients will need to be closely monitored.

Drainage

Infiltration and drainage rates are commonly very low. Surface water ponding may occur in heavy rainfall events.

Erosion potential

There is low potential for soil erosion.

Salinity and sodicity

Generally, the soil salinity level is moderate within the readily available water (RAW) rootzone. Below the RAW rootzone soil salinity levels tend to increase due to the low drainage capacity of the soil.

Sodicity and soil dispersion levels are commonly in the moderate to high range, influenced in part by the high clay content of the profile. Regular maintenance applications of a calcium-based soil ameliorant would generally inhibit the deleterious effects of soil sodicity.

Vine performance

Vine performance on this soil type will be low to moderate. The dense clay subsoil will restrict both root and water exploration. The poorly drained and sodic subsoil may restrict plant growth and development in spring.

Irrigation practices

Irrigation shifts should be relatively long and infrequent for optimum vine balance, water penetration and root distribution. It is important to allow adequate time for the vines to utilize the available water prior to the next irrigation. This practice will help minimise waterlogging events and the potential for water tables to develop.

Leaching of salts from the RAW rootzone is vital and can generally be achieved through extended irrigation events. Soil moisture monitoring devices are suggested to manage irrigations successfully.

Potential rootzone (RAW) 58 cm in sampling pit

Barriers to root growth

Chemical barriers: The presence of reactive carbonate at a depth of sixty (60) centimetres will be restrictive to root development in sensitive rootstocks. Boron is at a level which could be considered dangerous in the B3 horizon. Exchangeable sodium levels are above the threshold level of six (6) per cent in the lower subsoil area.

Physical barriers: The B1 layer which consists of heavy clay, densely formed into a massive pedal structure, would be a barrier to root exploration and water penetration.

Nutrition and soil amendments

This soil profile has a high fertility rating and because of the potential ability of the soil to retain nutrients periodic applications of macro-nutrients will generally be sufficient. The presence of reactive limestone and the effect this has on soil pH may affect the availability of some micronutrients, particularly zinc and molybdenum.

This soil would benefit from a bulk application of a calcium-based soil ameliorant, such as gypsum, prior to planting. Ideally this gypsum should be incorporated to a depth of at least fifty (50) centimetres. Regular maintenance applications of gypsum should be employed to minimise soil dispersion.

Vineyard floor management and accessibility

To improve organic matter levels and overall soil structure a cover crop should be grown in the inter-row area. An annual plant species such as faba beans is suggested, as it will assist in removing excess soil moisture in spring, provide an organic source of nitrogen early in the season and the thick tap root should help break up the densely packed subsoil.

Prior to establishment of the vineyard a bulk application of organic matter in the form of composted manure would be beneficial in improving soil structure.

Deep ripping of the soil will be required prior to planting to improve water and root exploration. Once plant establishment has been achieved cultivation should be minimised to maintain and improve soil structure.

Soil 4 – Hard Setting Clay Soil (Whitton Clay)

Depth (cm)	0-28	28-62	62-103	105-150
Horizon Name	A1	B1	B2	B3
Texture	LC	HC	MC	MC
Soil Colour	Grey-Brown	Grey-Brown	Grey	Grey-Yellow
Soil Mottle	-	Black	Bl Ye Re	Bl Ye Re
Fragment Lithology	-	-	Limestone	Limstone
Fragment Percentage (%)	-	-	35	25
Carbonate Class	-	-	IIIAL	IIIAL
Carbonate Reaction	-	-	M	M
Pedality Grade	M	V	S	M
Pedality Type	SB	-	SB	SB
Root Density	2	0	0	0
Soil pH	6.0	7.0	8.3	9.1
Soil ECe	1.29	0.48	1.40	2.17
Slaking Index	3	2	4	4
Dispersion Index	1	2	2	4
Nitrate NO3-N (mg/kg)	43	15	62	76
Phosphorus BSES (mg/kg)	70	13	16	17
Phosphorus Colwell (mg/kg)	99	14	3	9
Potassium (meq/100gm)	0.95	0.36	0.05	0.10
Calcium (meq/100gm)	5.00	6.65	16.89	15.28
Magnesium (meq/100gm)	3.60	5.15	5.43	5.62
Sodium (meq/100gm)	0.27	0.42	0.93	2.99
SAR	1.67	2.20	3.39	11.27
Ca/Mg Ratio	2.31	2.15	5.19	4.53
Sulphate – S (ppm)	11	3	10	18
Zinc (ppm)	1.4	0.2	0.3	0.3
Copper (ppm)	0.4	0.2	0.1	0.1
Manganese (ppm)	0.14	0.26	0.07	0.38
Iron (ppm)	14.5	1.7	0.9	1.2
Boron (ppm)	0.19	0.23	1.35	5.8
Organic Carbon (%)	1.21	0.62	0.33	0.14
Organic Matter (%)	2.08	1.06	0.56	0.24
Chloride ppm	42	23	12	15
Carbonate CO3 (%)	0.00	0.50	3.50	3.00





Soil 5 – Self Mulching Clay Soil (Willbriggie Clay)

Landscape

Flood plains of the Riverina. Plastic soils of the plains.

Waterholding capacity

Total available water 78 mm/m
Readily available water 30 mm/m

Profile

Consisting of a grey-brown light medium clay, the topsoil has self mulching properties, but is generally poorly structured. The subsoil consists of a non-permeable heavy clay. Soil carbonates are present at an average depth of twenty (20) centimetres, and slight reactions to one (1) Mole Hydrochloric acid (HCl) can be observed.

Fertility

The inherent fertility of the soil is moderate to high due to the elevated clay content of the profile and the moderate levels of organic matter in the topsoil. Because of the reactive limestone within the soil profile, the availability of micro-nutrients will need to be closely monitored.

Drainage

Infiltration and drainage rates are commonly very low.

Erosion potential

There is low potential for soil erosion.

Salinity and sodicity

Generally the soil salinity level is moderate within the readily available water (RAW) rootzone and is considered restrictive to plant growth. Below the RAW rootzone soil salinity levels tend to increase due to the low drainage capacity of the soil.

Sodicity and soil dispersion levels are commonly in the moderate range, due in part to the relatively high clay content of the profile. Regular maintenance applications of a calcium-based soil ameliorant would generally inhibit the deleterious effects of soil sodicity.

Vine performance

Vine performance on this soil type will be low to moderate. The dense clay subsoil will restrict both root and water exploration. The poorly drained and sodic subsoil would restrict plant growth and root development in spring.

Irrigation practices

Irrigation shifts should be long and infrequent for optimum vine balance, water penetration and root distribution. It is important to allow adequate time for the vines to utilise the available water prior to the next irrigation. This practice will help minimise waterlogging events and the potential for water tables to develop.

Leaching of salts from the RAW rootzone is vital and can generally be achieved through extended irrigation events. Soil moisture monitoring devices will enable successful irrigation management.

Potential rootzone (RAW) 53 cm in sampling pit

Barriers to root growth

Chemical barriers: The presence of reactive carbonate at a depth of twenty-eight (28) centimetres will sometimes be restrictive to root development in sensitive rootstocks. Sodium and Boron levels are elevated to a level that is considered toxic in the B1 and B2 horizons of this profile.

Physical barriers: The B1 layer which consists of heavy clay, may be a barrier to root exploration and water penetration.

Nutrition and soil amendments

This soil profile has a high fertility rating, and because of the potential ability of the soil to retain nutrients, periodic applications of macro-nutrients will generally be sufficient. The presence of reactive limestone and the effect this has on soil pH may affect the availability of some micro-nutrients, particularly zinc, copper and manganese.

This soil would benefit from a bulk application of a calcium-based soil ameliorant, such as gypsum, and a well composted organic matter prior to planting. Ideally the gypsum and organic matter would be incorporated to a depth of approximately thirty (30) centimetres. Regular maintenance applications of gypsum should be employed to minimise soil dispersion.

Vineyard floor management and accessibility

To improve organic matter levels and overall soil structure, a cover crop should be grown in the inter-row area and regularly slashed under the vine. An annual plant species such as faba beans is suggested as it will assist in removing excess soil moisture in spring, provide an organic source of nitrogen early in the season and the thick tap root should help break up the densely packed subsoil.

Once plant establishment has been achieved cultivation practices should be minimised to maintain and improve soil structure.

Soil 5 – Self Mulching Clay Soil (Willbriggie Clay)

Depth (cm)	0-28	28-62	62-103
Horizon Name	A1	B1	B2
Texture	LMC	HC	HC
Soil Colour	Grey-Brown	Grey	Grey
Soil Mottle	-	-	BI
Fragment Lithology	-	Limestone	Limestone
Fragment Percentage (%)	-	3	5
Carbonate Class	-	I	I
Carbonate Reaction	-	SI	SI
Pedality Grade	W	M	S
Pedality Type	SB	SB	SB
Root Density	3	1	0
Soil pH	7.3	7.9	8.6
Soil ECe	0.96	2.52	2.76
Slaking Index	2	2	2
Dispersion Index	1	0	4
Nitrate NO3-N (mg/kg)	20	64	79
Phosphorus BSES (mg/kg)	141	13	16
Phosphorus Colwell (mg/kg)	129	2	2
Potassium (meq/100gm)	0.66	0.18	0.14
Calcium (meq/100gm)	9.65	8.00	7.95
Magnesium (meq/100gm)	5.46	6.20	5.93
Sodium (meq/100gm)	0.67	2.86	4.29
SAR	3.01	13.59	20.58
Ca/Mg Ratio	2.95	2.15	2.23
Sulphate – S (ppm)	5.0	120	79
Zinc (ppm)	0.3	0.3	0.1
Copper (ppm)	0.2	0.1	0.1
Manganese (ppm)	0.24	0.07	0.20
Iron (ppm)	1.0	0.8	0.9
Boron (ppm)	0.31	6.20	11.10
Organic Carbon (%)	0.93	0.33	0.31
Organic Matter (%)	1.59	0.56	0.53
Chloride ppm	52	102	137
Carbonate CO3 (%)	2.00	2.50	2.00





Soil 6 – Sandy clay loam over light sandy clay loam (Mallee Soil)

Landscape

Aeolian deposit on the north-west side of Griffith

Waterholding capacity

Total available water 92 mm/m
Readily available water 48 mm/m

Profile

Consisting of a red-brown sandy clay loam, the topsoil is generally very well structured, and exists to an average depth of sixteen (16) centimetres. The subsoil consists of a permeable well-structured light sandy clay loam to sandy clay loam. Soil carbonates are present to an average depth of ninety (90) centimetres, and moderate reactions to one (1) Mole Hydrochloric acid (HCl) can be observed.

Fertility

The inherent fertility of the soil is moderate to high, due to the moderate level of organic matter in the topsoil and the ability of this organic matter to retain nutrients. As there are limited barriers to root growth and water movement, the potential soil mass available for water and nutrient uptake is substantial.

Drainage

Generally, the soil profile is well drained and infiltration rates allow for high application rates. Frequent cultivations can cause the soil structure to break down and form layers that have reduced capacity for water movement

Erosion potential

There is low potential for soil erosion on the lower hill slopes. On the upper hill slopes there is moderate potential for soil erosion if the irrigation system's application rate exceeds the infiltration rate of the surface soil or if surface soil has been degraded.

Salinity and sodicity

Normally the soil salinity level is low to moderate within the readily available water (RAW) rootzone.

Sodicity and soil dispersion levels are commonly in the low to moderate range, whereas the slaking index is very high in the subsoil. Regular maintenance applications of a calcium-based soil ameliorant would generally inhibit the deleterious effects of soil sodicity.

Vine performance

Vine performance on this soil type will be moderate to high due to the potential rootzone area and readily available water (RAW) holding capacity of the soil.

Irrigation practices

Because potential vine vigour is classed as moderate to high it is important that irrigation quantities are limited for vigorous varieties and rootstocks between the phenological growth phases of fruit set and veraison. Due to the hot climate within the Riverina irrigation quantities should not be limited at any stage of growth for young vines or during the canopy development stage of growth in mature vines.

In general irrigation shifts should be relatively long and infrequent for optimum vine balance and root distribution.

Leaching of salts from the RAW rootzone is vital and can generally be achieved through extended irrigation events. Soil moisture monitoring devices are suggested to manage irrigations successfully.

Potential rootzone (RAW) 66 cm in sampling pit

Barriers to root growth

Chemical barriers: The sodium percentage is greater than six (6) in the B1 and B2 horizon, which could lead to sodium toxicity and soil structural problems.

Physical barriers: There are no physical barriers to root growth for this soil pit.

Nutrition and soil amendments

Because the fertility rating of this soil is moderate to high due to the ability of the soil to retain nutrients, periodic applications of macro-nutrients will generally be sufficient. Regular monitoring of the plant nutrient status is suggested to determine the availability of the micro-nutrients stored within the profile.

This soil benefits from regular maintenance applications of a calcium-based soil ameliorant to minimise soil dispersion.

A bulk application of composted organic matter should be applied and incorporated into the soil profile to reduce the soil's propensity to slake and improve overall soil structure and fertility

Vineyard floor management and accessibility

To improve organic matter levels and overall soil structure, a cover crop should be grown in the inter-row area, and regularly slashed under the vine. An annual plant species such as ryegrass or oats is suggested as it will assist in removing excess soil moisture in spring, but will not compete with the vines during the critical summer months. Legume based cover crops are not suggested for this soil type as nitrogen fixation could exacerbate a vine vigour problem.

Cultivation practices should be limited to maintain soil structure and to minimise the potential for soil erosion on the upper hill slopes.

Soil 6 – Sandy clay loam over light sandy clay loam (Mallee Soil)

Depth (cm)	0-16	16-52	52-97	97-150
Horizon Name	A1	B1	B2	B3
Texture	SCL	LSCL	SCL	SCL
Soil Colour	Red-Brown	Red	Red	Brown-Red
Soil Mottle	-	-	Bl	Bl Gr
Fragment Lithology	-	-	-	Limestone
Fragment Percentage (%)	-	-	-	50
Carbonate Class	-	-	-	IIR
Carbonate Reaction	-	-	-	M
Pedality Grade	W	W	M	M
Pedality Type	SB	SB	SB	SB
Root Density	2	2	1	1
Soil pH	6.6	6.8	7.1	8.2
Soil ECe	1.68	1.01	1.80	1.80
Slaking Index	1	4	4	4
Dispersion Index	0	2	1	1
Nitrate NO3-N (mg/kg)	20	5	8	64
Phosphorus BSES (mg/kg)	111	7	5	7
Phosphorus Colwell (mg/kg)	70	8	7	9
Potassium (meq/100gm)	0.83	0.26	0.50	0.26
Calcium (meq/100gm)	6.02	3.27	6.94	21.14
Magnesium (meq/100gm)	2.07	1.80	4.05	3.03
Sodium (meq/100gm)	0.43	0.52	0.70	0.51
SAR	2.63	4.04	3.72	1.74
Ca/Mg ratio	4.85	3.02	2.85	11.61
Sulphate – S (ppm)	21	15	25	13
Zinc (ppm)	4.2	0.3	0.3	0.5
Copper (ppm)	0.5	0.3	0.3	0.1
Manganese (ppm)	0.11	0.11	0.12	0.13
Iron (ppm)	2.1	3.0	0.8	0.6
Boron (ppm)	0.2	0.05	0.37	0.49
Organic Carbon (%)	0.91	0.19	0.22	0.22
Organic Matter (%)	1.56	0.32	0.37	0.37
Chloride ppm	54	39	76	33
Carbonate CO3 (%)	0.50	0.00	0.50	11.00




10
20
30
40
50
60
70
80
90
100

Soil 7 – Sandy clay loam over light to medium clay (Mallee Soil)

Landscape

Aeolian deposit on the north side of Griffith.

Waterholding capacity

Total available water 111 mm/m
Readily available water 47 mm/m

Profile

Consisting of a red sandy clay loam, the topsoil is generally very well structured and exists to an average depth of thirty (30) centimetres. The subsoil consists of a semi-permeable, well structured light to light-medium clay. Soil carbonates are present to an average depth of one hundred and seven (107) centimetres, and moderate reactions to one (1) Mole Hydrochloric acid (HCl) can be observed. The soil contains some rock fragments, particularly on the upper hill slopes.

Fertility

The inherent fertility of the soil is moderate to high due to the moderate level of organic matter in the topsoil and the high clay content of the subsoil. Some areas contain high percentages of rock fragment in the RAW rootzone which will limit the fertility of the site.

Drainage

Generally, the soil profile is moderately well drained and infiltration rates allow for moderate to high irrigation application rates. Frequent cultivations can cause the soil structure within the topsoil to break down and reduce capacity for water movement and storage.

Erosion potential

There is low potential for soil erosion on the lower hill slopes. On the upper hill slopes there is moderate to high potential for soil erosion if the irrigation system's application rate exceeds the infiltration rate of the surface soil or if surface soil has been degraded.

Salinity and sodicity

Normally the soil salinity level is low within the readily available water (RAW) rootzone. Prior to irrigation development, this soil can be affected by dryland salinity.

Sodicity and soil dispersion levels are commonly in the low to moderate range, whereas the slaking index is in the moderate to high range throughout the soil profile.

Vine performance

Vine performance on this soil type will be moderate to high due to the potential rootzone area, the readily available water (RAW) holding capacity of the soil, and the high fertility of the soil.

Irrigation practices

While vine performance is classed as moderate to high, it is important that irrigation quantities are limited for vigorous varieties and rootstocks, particularly between the phenological growth phases of fruit set and veraison. Due to the hot climate within the Riverina irrigation quantities should not be limited at any stage of growth for young vines or during the canopy development stage of growth in mature vines.

In general, irrigation shifts should be relatively long and infrequent for optimum vine balance and root distribution.

Leaching of salts from the RAW rootzone is vital and can generally be achieved through extended irrigation events. Soil moisture monitoring devices are suggested to manage irrigations successfully.

Potential rootzone (RAW) 82 cm in sampling pit

Barriers to root growth

Chemical barriers: The salt loading in the topsoil is a chemical barrier to plant establishment. Irrigation events that follow on from the initial planting should leach salts through the profile. Within the subsoil sodium levels exceed the six (6) per cent threshold and may become toxic to the root system. Boron is elevated at a depth of one hundred and ten (110) centimetres, and is thus considered less of a constraint than if it were higher in the profile.

Physical barriers: The light clay layer located at a depth of thirty-two (32) centimetres would be a barrier to root exploration.

Nutrition and soil amendments

With fertility of this soil profile rated as moderate to high and the potential ability of the soil to retain nutrients, periodic applications of macro-nutrients will generally be sufficient. Regular monitoring of the plant nutrient status is suggested to determine the availability of the micro-nutrients stored within the profile.

This soil would benefit from a bulk application of a calcium-based soil ameliorant, such as gypsum and a well composted organic matter prior to planting. Ideally the gypsum and organic matter would be incorporated to a depth of approximately fifty (50) centimetres. Regular maintenance applications of gypsum should be employed to minimise soil dispersion.

Vineyard floor management and accessibility

To improve organic matter levels, overall soil structure, and to minimise the potential for wind erosion, a cover crop should be grown in the inter-row area, and regularly slashed under the vine. An annual plant species such as ryegrass or oats is suggested as it will assist in removing excess soil moisture in spring but will not compete with the vines during the critical summer months.

Cultivation practices should be limited to maintain soil structure and to minimise the potential for soil erosion on the upper hill slopes.

Soil 7 – Sandy clay loam over light to medium clay (Mallee Soil)

Depth (cm)	0-32	32-69	69-107	107-150
Horizon Name	A1	B1	B2	B3
Texture	SCL	LC	LC	LMC
Soil Colour	Red	Red	Red	Red
Soil Mottle	-	-	Bl	Bl Gr Ye
Fragment Lithology Granite	-	-	Limestone	
Fragment Percentage (%)	20	-	-	20
Carbonate Class	-	-	-	IIIAL
Carbonate Reaction	-	-	-	M
Pedality Grade	W	M	S	S
Pedality Type	SB	SB	SB	SB
Root Density	2	2	0	0
Soil pH	5.7	6.5	6.7	7.7
Soil ECe	5.16	0.26	0.43	0.96
Slaking Index	2	3	4	4
Dispersion Index	1	1	2	3
Nitrate NO3-N (mg/kg)	18	6	5	12
Phosphorus BSES (mg/kg)	15	3	3	3
Phosphorus Colwell (mg/kg)	8	11	10	2
Potassium (meq/100gm)	0.84	0.34	0.54	0.78
Calcium (meq/100gm)	6.75	3.13	3.96	5.30
Magnesium (meq/100gm)	2.41	3.10	4.59	6.05
Sodium (meq/100gm)	0.17	0.49	0.98	1.55
SAR	0.96	3.55	6.14	8.43
Ca/Mg ratio	4.67	1.68	1.44	1.46
Sulphate – S (ppm)	300	1	1	13
Zinc (ppm)	0.5	0.3	0.2	0.2
Copper (ppm)	0.3	0.3	0.2	0.1
Manganese (ppm)	1.57	0.12	0.18	0.26
Iron (ppm)	2.0	1.2	0.7	0.9
Boron (ppm)	0.09	0.09	0.17	3.20
Organic Carbon (%)	18	0.37	0.25	0.12
Organic Matter (%)	0.91	0.63	0.43	0.20
Chloride ppm	1.56	11	28	42
Carbonate CO3 (%)	0.00	0.05	1.00	1.00





Soil 8 – Sandy clay loam over sandy loam to sandy clay (Mallee Soil)

Landscape

Aeolian deposit on the north side of Griffith.

Waterholding capacity

Total available water 72 mm/m
Readily available water 38 mm/m

Profile

Consisting of a red sandy clay loam, the topsoil is very well structured, and exists to an average depth of ten (10) centimetres. The subsoil consists of a permeable, well structured sandy loam to sandy clay. Soil carbonates are present at an average depth of seventy (70) centimetres, and slight reactions to one (1) Mole Hydrochloric acid (HCl) can be observed.

Fertility

The inherent fertility of the soil is moderate, due to the low to moderate level of organic matter in the topsoil and the moderate clay content of the subsoil. This fertility rating would increase with an elevation in organic matter levels.

Drainage

Generally the soil profile is well drained and infiltration rates allow for high application rates of water. Frequent cultivations can cause the soil structure to degrade and reduce the soils capacity for water movement and storage.

Erosion potential

Due to the low organic matter levels in the topsoil, the potential for wind erosion is high, on both the upper and lower hill slopes.

Salinity and sodicity

Normally the soil salinity level is low within the readily available water (RAW) rootzone. Prior to irrigation development, this soil could be affected by dryland salinity.

Sodicity and soil dispersion levels are commonly in the moderate to high to range, and the slaking index is high within the subsoil. Regular maintenance applications of a calcium-based soil ameliorant would generally inhibit the deleterious effects of soil sodicity.

Vine performance

Vine performance on this soil type will be moderate. The shallow topsoil has reduced the theoretical RAW rootzone area and the RAW holding capacity of the soil.

It is suggested to increase the topsoil depth through mounding the soil in the planting rows. This will improve the RAW value for the topsoil and consequently increase the potential vine performance.

Potential rootzone (RAW) 60 cm in sampling pit

Barriers to root growth

Chemical barriers: The presence of a reactive carbonate layer at a depth of sixty-eight (68) centimetres may pose a minor impendence to root growth. Within the same horizon, the level of exchangeable sodium is greater than six (6) per cent threshold for wine grapes.

Physical barriers: The strong pedality structure in the B1 and B2 horizon will restrict root movement in its current state. Deep cultivation of this profile prior to vine establishment should remove this physical barrier.

Irrigation practices

While vine performance is classed as moderate it is important that irrigation quantities are limited for vigorous varieties and rootstocks, particularly between the phenological growth phases of fruit set and veraison. Due to the hot climate within the Riverina irrigation quantities should not be limited at any stage of growth for young vines or during the canopy development stage of growth in mature vines.

In general, irrigation shifts should be relatively long and infrequent for optimum vine balance and root distribution.

Leaching of salts from the RAW rootzone is vital and can generally be achieved through extended irrigation events. Soil moisture monitoring devices are suggested to manage irrigations successfully.

Nutrition and soil amendments

This soil profile has inherently low levels of nitrogen, phosphorus, potassium and calcium. Regular applications of these elements are required to maintain vine performance. Regular monitoring of the plant nutrient status is suggested to determine the availability of the micro-nutrients stored within the profile.

This soil would benefit from a bulk application of a calcium-based soil ameliorant, such as gypsum, and a well composted organic matter prior to planting. Ideally the gypsum and organic matter would be incorporated to a depth of approximately fifty (50) centimetres. Regular maintenance applications of gypsum should be employed to minimise soil dispersion.

Vineyard floor management and accessibility

To improve organic matter levels, overall soil structure, and to minimise the potential for wind erosion, a cover crop should be grown in the inter-row area, and regularly slashed under the vine. An annual plant species such as ryegrass or oats is suggested as it will assist in removing excess soil moisture in spring, but will not compete with the vines during the critical summer months.

Cultivation practices should be limited to maintain soil structure and to minimise the potential for soil erosion on the upper hill slopes.

Soil 8 – Sandy clay loam over sandy loam to sandy clay (Mallee Soil)

Depth (cm)	0-10	10-64	64-68	68-150
Horizon Name	A1	B1	B2	B3
Texture	SCL	SL	SC	SC
Soil Colour	Red	Red - Brown	Red – Brown	Red
Soil Mottle	-	-	Bl Gr	Gr Ye
Fragment Lithology	-	-	-	Limestone
Fragment Percentage (%)	-	-	-	3
Carbonate Class	-	-	-	IIIAS
Carbonate Reaction	-	-	-	Sl
Pedality Grade	W	S	S	V
Pedality Type	SB	SB	SB	-
Root Density	1	0	0	0
Soil pH	6.7	6.8	7.7	7.6
Soil ECe	0.34	0.24	0.52	1.03
Slaking Index	0	4	4	4
Dispersion Index	0	1	4	4
Nitrate NO3-N (mg/kg)	15	5	8	8
Phosphorus BSES (mg/kg)	29	4	2	2
Phosphorus Colwell (mg/kg)	11	5	5	4
Potassium (meq/100gm)	0.48	0.19	0.35	0.56
Calcium (meq/100gm)	2.17	1.47	1.69	2.22
Magnesium (meq/100gm)	0.98	1.33	2.59	3.96
Sodium (meq/100gm)	0.14	0.06	0.63	1.84
SAR	1.36	0.66	5.7	13.96
Ca/Mg ratio	3.7	1.84	1.08	0.93
Sulphate – S (ppm)	2.0	1.0	1.0	3.0
Zinc (ppm)	0.6	0.2	0.2	0.1
Copper (ppm)	0.5	0.3	0.2	0.2
Manganese (ppm)	0.21	0.12	0.29	0.28
Iron (ppm)	4.3	4.1	8.6	3.4
Boron (ppm)	0.06	0.10	0.33	0.12
Organic Carbon (%)	0.50	0.15	0.11	0.08
Organic Matter (%)	0.86	0.25	0.19	0.13
Chloride ppm	13	11	29	80
Carbonate CO3 (%)	0.00	0.00	0.00	0.00





Soil 9 – Light sandy clay loam over clay loam (Wyangan Loam)

Landscape

Sub-plastic soil of the upper hill slopes. Found on the hill slopes of the McPherson Ranges in the Lake Wyangan region.

Waterholding capacity

Total available water 88 mm/m
Readily available water 43 mm/m

Profile

Consisting of a red-brown light sandy clay loam, the topsoil is very well structured and exists to an average depth of thirteen (13) centimetres. The subsoil consists of a permeable well-structured sandy clay loam to clay loam. Soil carbonates are present at an average depth of ninety-five centimetres, and slight reactions to one (1) Mole Hydrochloric acid (HCl) can be observed.

Fertility

The inherent fertility of the soil is moderate to high due to the moderate level of organic matter in the topsoil and the low to moderate clay content of the subsoil. As there are limited barriers to root growth and water movement, the potential soil mass available for water and nutrient uptake is relatively high.

Drainage

Generally, the soil profile is well drained and infiltration rates allow for high application rates.

Erosion potential

There is low potential for soil erosion on the lower hill slopes. On the upper hill slopes there is moderate potential for soil erosion if the irrigation system's application rate exceeds the infiltration rate of the surface soil.

Salinity and sodicity

Soil salinity levels range from moderate to high within the readily available water (RAW) rootzone.

Sodicity and soil dispersion levels are commonly in the low to moderate range. Regular maintenance applications of a calcium-based soil ameliorant should assist to reduce the deleterious effects of soil sodicity.

Vine performance

Vine performance on this soil type will be high due to the deep potential rootzone area, the high readily available water (RAW) holding capacity of the soil and the high fertility rating of the soil.

Irrigation practices

As vine performance is classed as high, it is important that irrigation quantities are limited for vigorous varieties and rootstocks between the phenological growth phases of fruit set and veraison. Due to the hot climate within the Riverina irrigation quantities should not be limited at any stage of growth for young vines or during the canopy development stage of growth in mature vines.

Irrigation shifts should be relatively long and infrequent for optimum vine balance and root distribution.

Leaching of salts from the RAW rootzone is vital and can generally be achieved through extended irrigation events. Soil moisture monitoring devices are suggested to manage irrigations successfully.

Potential rootzone (RAW) 63 cm in sampling pit

Barriers to root growth

Chemical barriers: Elevated soil salinity levels within the RAW rootzone of the vine may pose a restriction on the quantity of both nutrients and water that the rootzone can uptake.

Physical barriers: There are no physical barriers to root growth for this soil pit.

Nutrition and soil amendments

This soil profile has a high fertility rating, and because of the potential ability of the soil to retain nutrients, periodic applications of macro-nutrients will generally be sufficient.

Vineyard floor management and accessibility

To improve organic matter levels and overall soil structure, a cover crop should be grown in the inter-row area, and regularly slashed under the vine. An annual plant species such as ryegrass or oats is suggested as it will assist in removing excess soil moisture in spring, but will not compete with the vines during the critical summer months.

Cultivation practices should be limited to maintain soil structure and to minimise the potential for soil erosion, particularly on the upper hill slopes.

Soil 9 – Light sandy clay loam over clay loam (Wyangan Loam)

Depth (cm)	0-16	16-52	52-97	97-150
Horizon Name	A1	B1	B2	B3
Texture	LSCL	SCL	CL	CL
Soil Colour	Red-Brown	Red- Brown	Red	Red
Soil Mottle	-	-	-	BI
Fragment Lithology Granite	-	-	Limestone	
Fragment Percentage (%)	10	-	-	15
Carbonate Class	-	-	-	IIIAS
Carbonate Reaction	-	-	-	SL
Pedality Grade	W	W	W	W
Pedality Type	SB	SB	SB	SB
Root Density	2	0	0	0
Soil pH	6.3	6.1	6.4	7.3
Soil ECe	3.04	0.36	0.29	1.18
Slaking Index	1	2	4	4
Dispersion Index	0	3	3	1
Nitrate NO3-N (mg/kg)	73	6	6	21
Phosphorus BSES (mg/kg)	317	46	5	3
Phosphorus Colwell (mg/kg)	198	43	5	6
Potassium (meq/100gm)	0.59	0.10	0.54	0.72
Calcium (meq/100gm)	9.30	4.12	5.93	7.43
Magnesium (meq/100gm)	2.23	1.34	4.47	5.68
Sodium (meq/100gm)	0.24	0.14	0.33	0.32
SAR	1.19	1.02	1.86	1.59
Ca/Mg ratio	6.97	5.12	2.21	2.18
Sulphate – S (ppm)	39	5.0	4.0	5.0
Zinc (ppm)	6.2	0.2	0.1	0.1
Copper (ppm)	0.7	0.3	0.2	0.2
Manganese (ppm)	0.03	0.08	0.12	0.07
Iron (ppm)	1.7	2.7	0.6	0.2
Boron (ppm)	0.08	0.04	0.32	1.50
Organic Carbon (%)	1.24	0.41	0.14	0.06
Organic Matter (%)	2.13	0.71	0.24	0.10
Chloride ppm	56	7.0	9.0	9.0
Carbonate CO3 (%)	1.00	0.00	1.50	2.00





Soil 10 – Sandy clay loam over clay loam (Tharbogang)

Landscape

Sub-plastic soils of the upper hill slopes. Found on the hill slopes of the McPherson Ranges in the Tharbogang region.

Waterholding capacity

Total available water 85 mm/m
Readily available water 46 mm/m

Profile

Consisting of a red-brown sandy clay loam, the topsoil is very well structured and exists to an average depth of thirty (30) centimetres. The subsoil consists of a semi-permeable, imperfectly structured clay loam, with strong to massive pedal structures. Soil carbonates are present at an average depth of thirty-three centimetres, and strong reactions to one (1) Mole Hydrochloric acid (HCl) can be observed.

Fertility

The inherent fertility of the soil is low to moderate due to the low level of organic matter in the topsoil and the relatively low clay content of the subsoil. The fertility rating of this soil could be lifted considerably through the incorporation of organic matter and gypsum in the soil profile.

Drainage

Generally, the soil profile is moderately well drained and infiltration rates allow for moderate to high application rates. The drainage of this site is restricted by the strong and massive pedal structures in the B1 and B2 horizon.
Although deep ripping this site should assist in reducing the effect of the hard pan located in the subsoil the potential for lifting the reactive carbonate into the topsoil layer is high, so care must be taken not to disturb this underlying layer.

Erosion potential

There is moderate potential for soil erosion on the hill slopes due to the low levels of soil organic matter and the subsequent lack of soil structure.

Vine performance

Vine performance on this soil type will be moderate due to the limited potential rootzone area, the relatively low readily available water (RAW) holding capacity of the soil, and the moderate fertility rating. The potential for winegrape development on these soils would be greatly improved through soil structure amelioration.

Salinity and sodicity

Soil salinity levels range from moderate to high within the readily available water (RAW) rootzone. It should be noted that at the time of analysis, these areas had not received a leaching rainfall or irrigation for a considerable period and salt accumulation may have occurred because of this.

Sodicity and soil dispersion levels are commonly in the moderate to high range. This soil would benefit from a bulk application of a calcium-based soil ameliorant, such as gypsum, prior to planting. Ideally this gypsum should be incorporated to a depth of at least thirty (30) centimetres. Regular maintenance applications of gypsum should be employed to minimise soil dispersion.

Irrigation practices

The irrigation shifts need to be tailored to prevent waterlogging in the subsoil region. These waterlogging events could be caused by strong and massive pedal structures and could reduce the drainage potential of the soil. Irrigation runtimes should be moderate in length and applied frequently.

The deep drainage characteristics of this soil profile need to be improved for effective salt leaching to occur. Soil moisture monitoring devices are suggested to successfully manage irrigations, and to observe salt leaching practices.

Potential rootzone (RAW) 83 cm in sampling pit

Barriers to root growth

Chemical barriers: The presence of reactive carbonate at a depth of thirty-three (33) centimetres will be restrictive to root development in sensitive rootstocks. Exchangeable sodium levels in the subsoil are at a dangerously high level, which may be both toxic to the vines and cause soil structural issues.

Physical barriers: The strong and massive pedality structures in the B1 and B2 horizon are considerable barriers to root growth.

Nutrition and soil amendments

As the fertility rating of this soil profile is considered moderate, and because of the potential ability of the soil to retain nutrients, periodic applications of macro-nutrients will generally be sufficient. Regular monitoring of the plant nutrient status is suggested to determine the availability of the micro nutrients stored within the profile.

This soil would benefit from a bulk application of a calcium-based soil ameliorant, such as gypsum, and a well composted organic matter prior to planting. Ideally the gypsum and organic matter would be incorporated to a depth of approximately fifty (50) centimetres. Regular maintenance applications of gypsum should be employed to minimise soil dispersion, and also to improve soil structure.

Vineyard floor management and accessibility

To improve organic matter levels and overall soil structure, a cover crop should be grown in the inter-row area, and regularly slashed under the vine. An annual plant species such as ryegrass or oats is suggested as it will assist in removing excess soil moisture in spring, but will not compete with the vines during the critical summer months.

Soil 10 – Sandy clay loam over clay loam (Tharbogang)

Depth (cm)	0-33	33-75	75-150
Horizon Name	A1	B1	B2
Texture	SCL	CS	CS
Soil Colour	Red-Brown	Red- Brown	Red-Brown
Soil Mottle	-	-	Bl Gr Ye
Fragment Lithology	-	Limestone	Limestone
Fragment Percentage (%)	-	25	30
Carbonate Class	-	IIIAS	IIIAS
Carbonate Reaction	-	ST	ST
Pedality Grade	W	W	W
Pedality Type	SB	SB	SB
Root Density	2	0	0
Soil pH	6.4	8.3	8.9
Soil ECe	0.84	6.27	6.84
Slaking Index	1	2	4
Dispersion Index	0	3	3
Nitrate NO3-N (mg/l)	14	96	149
Phosphorus BSES (mg/l)	7	6	7
Phosphorus Colwell (mg/l)	3	1	1
Potassium (% cations)	0.53	0.30	0.36
Calcium (% cations)	16.12	12.32	14.88
Magnesium (% cations)	2.39	5.08	5.38
Sodium (% cations)	0.42	3.05	3.30
SAR	1.62	12.67	12.59
Ca/Mg ratio	11.23	4.04	4.61
Sulphate – S (ppm)	6.0	19	28
Zinc (ppm)	0.2	0.1	0.1
Copper (ppm)	0.3	0.1	0.1
Manganese (ppm)	0.03	0.05	0.09
Iron (ppm)	1.5	0.7	0.6
Boron (ppm)	0.09	1.20	1.50
Organic Carbon (%)	0.61	0.28	0.03
Organic Matter (gm/kg)	1.05	0.48	0.05
Chloride ppm	34	106	136
Carbonate CO3 (%)	0.00	2.00	3.50





Soil 11 – Sandy Clay Loam over Light to Medium Clay (Beelbangera Clay Loam)

Landscape

Sub-plastic soils of the plains.

Waterholding capacity

Total available water 110 mm/m
Readily available water 47 mm/m

Profile

Consisting of a red-brown sandy clay loam, the topsoil is well structured and exists to an average depth of twenty-nine (29) centimetres. The subsoil consists of a semi-permeable, imperfectly structured light to medium clay. Soil carbonates are present at an average depth of fifty centimetres (50), and slight to moderate reactions to one (1) Mole Hydrochloric acid (HCl) can be observed.

Fertility

The inherent fertility of the soil is moderate to high, mainly because of the high level of organic matter in the topsoil, as well as the elevated clay content of the subsoil. These two factors give the soil the potential to retain a high percentage of nutrients within the RAW rootzone.

Because of the reactive limestone within the soil profile, the availability of micro-nutrients will need to be closely monitored.

Drainage

This soil has moderately well drained profiles where the clay bands in the subsoil have minimal dispersive characteristics. Some surface water ponding may occur after substantial rainfall events.

Erosion potential

There is low potential for soil erosion on these soils.

Salinity and sodicity

Generally, the soil salinity level is moderate within the readily available water (RAW) rootzone. Soil salinity can become elevated deep within the profile if irrigation events do not provide adequate leaching.

Sodicity and soil dispersion levels are commonly in the low to moderate range. Regular maintenance applications of a calcium-based soil ameliorant would generally reduce the deleterious effects of soil sodicity.

Vine performance

Vine performance on this soil type will be moderate. The semi-permeable light clay layer, combined with the presence of reactive limestone within the subsoil reduces the potential rootzone depth and consequently the RAW value.

Irrigation practices

While vine performance is classed as moderate, it is important that irrigation quantities are limited for vigorous varieties and rootstocks, particularly between the phenological growth phases of fruit set and veraison. Due to the hot climate within the Riverina irrigation quantities should not be limited at any stage of growth for young vines or during the canopy development stage of growth in mature vines.

Leaching of salts from the RAW rootzone is vital, and can generally be achieved through extended irrigation events. Soil moisture monitoring devices are suggested to successfully manage irrigations.

Potential rootzone (RAW) 78 cm in sampling pit

Barriers to root growth

Chemical barriers: The presence of reactive carbonate at a depth of forty-eight (48) centimetres will be restrictive to root development in sensitive rootstocks. Both sodium and boron have elevated levels in the subsoil, which would create an environment that inhibits root development

Physical barriers: The clay nature of the subsoil, coupled with the strong pedal grade in the B2 and B3 horizon, is considered restrictive to root growth.

Nutrition and soil amendments

The presence of reactive limestone and the effect this has on soil pH may affect the availability of some micro-nutrients, particularly zinc and iron.

This soil benefits from regular maintenance applications of a calcium-based soil ameliorant to minimise soil dispersion and to adjust the cation exchange complex within the subsoil.

Vineyard floor management and accessibility

To maintain organic matter levels and overall soil structure, a cover crop should be grown in the inter-row area, and regularly slashed under the vine. An annual plant species such as faba beans is suggested as it will assist in removing excess soil moisture in spring, provide an organic source of nitrogen early in the season, and the thick tap root should help break-up the densely packed subsoil

Cultivation practices should be limited to maintain soil structure.

Soil 11 – Sandy Clay Loam over Light to medium Clay (Beelbangera ClayLoam)

Depth (cm)	0-29	29-48	48-81	81-150
Horizon Name	A1	B1	B2	B3
Texture	SCL	MC	LC	MC
Soil Colour	Red - Brown	Red	Grey - Brown	Grey – Brown
Soil Mottle	-	-	Bl Ye Gr	Bl Ye Gr
Fragment Lithology	-	-	Limestone	Limestone
Fragment Percentage (%)	-	-	10	5
Carbonate Class	-	-	IIIAL	I
Carbonate Reaction	-	-	M	SL
Pedality Grade	W	M	S	S
Pedality Type	SB	SB	SB	SB
Root Density	2	2	1	0
Soil pH	6.5	7.8	8.6	8.8
Soil ECe	2.52	0.64	1.98	1.75
Slaking Index	2	2	4	4
Dispersion Index	0	1	1	1
Nitrate NO3-N (mg/kg)	42	23	143	137
Phosphorus BSES (mg/kg)	144	10	7	6
Phosphorus Colwell (mg/kg)	116	1	4	2
Potassium (meq/100gm)	1.35	0.54	0.45	0.67
Calcium (meq/100gm)	8.00	6.41	6.07	3.53
Magnesium (meq/100gm)	3.13	5.39	5.96	6.48
Sodium (meq/100gm)	0.54	3.51	4.38	5.56
SAR	2.81	18.37	22.96	33.18
Ca/Mg ratio	4.26	1.98	1.70	0.91
Sulphate – S (ppm)	22.0	25	94	125
Zinc (ppm)	1.3	0.1	0.1	0.1
Copper (ppm)	1.0	0.2	0.1	0.1
Manganese (ppm)	0.15	0.1	0.08	0.15
Iron (ppm)	2.1	0.6	0.4	0.4
Boron (ppm)	0.25	1.10	5.00	6.70
Organic Carbon (%)	1.37	0.49	0.13	0.02
Organic Matter (%)	2.36	0.84	0.22	0.03
Chloride ppm	48	35	61	64
Carbonate CO3 (%)	1.50	2.00	2.00	1.00





Soil 12 – Sandy Clay Loam over Light to Heavy Clay (Griffith Clay Loam)

Landscape

Sub-plastic soils of the plains.

Waterholding capacity

Total available water 98 mm/m
Readily available water 41 mm/m

Profile

Consisting of a red-brown sandy clay loam, the topsoil is well structured and exists to an average depth of twenty-two (22) centimetres. The subsoil consists of an impermeable, imperfectly structured light to heavy clay. Soil carbonates are present at an average depth of fifty-nine centimetres (59), and strong reactions to one (1) Mole Hydrochloric acid (HCl) can be observed.

Fertility

The inherent fertility of the soil is moderate to high, due to the moderate to high level of organic matter in the topsoil and the elevated clay content of the subsoil. These two factors give the soil the potential to retain a high percentage of nutrients within the RAW rootzone.

Because of the reactive limestone within the soil profile, the availability of micro-nutrients will need to be closely monitored.

Drainage

This soil profile is poorly drained. The sodic saline subsoil restricts water movement and as a consequence leaching irrigation events are inhibited. Surface ponding and water run-off occur when the topsoil is at field capacity, as the water will not readily infiltrate into the B1 horizon.

Erosion potential

There is low potential for soil erosion on these soils.

Salinity and sodicity

Generally, the soil salinity level is moderate to high within the readily available water (RAW) rootzone. The reduced ability to leach salts from the profile can cause an accumulation of salts.

Sodicity and soil dispersion levels are commonly in the moderate to high range. Prior to the establishment of a vineyard on this soil, bulk quantities of high grade gypsum and composted manure should be incorporated into the soil to a depth of approximately fifty (50) centimetres. Once the vineyard is established, regular maintenance applications of gypsum should be applied to maintain adequate levels of calcium and low levels of sodium within the soil.

Vine performance

Vine performance on this soil type will be moderate. The impermeable clay subsoil combined with the presence of reactive limestone reduces the potential rootzone depth and consequently the RAW value.

Irrigation practices

Vine vigour is classed as moderate. The irrigation shifts need to be tailored to prevent waterlogging in the subsoil region, caused by the sodic saline subsoil which tends to reduce the drainage potential of the soil. Irrigation run times should be moderate in length and applied relatively frequently.

The deep drainage characteristics of this soil profile needs to be improved for effective salt leaching to occur. Soil moisture monitoring devices are suggested to successfully manage irrigations.

Potential rootzone (RAW) 72 cm in sampling pit

Barriers to root growth

Chemical barriers: The presence of reactive carbonate at a depth of fifty-nine (59) centimetres will be restrictive to root development in sensitive rootstocks. Both sodium and boron have elevated levels in the subsoil, creating an environment that inhibits root development.

Physical barriers: The heavy clay nature, combined with the sodic and dispersive properties of the subsoil, is considered restrictive to root growth.

Nutrition and soil amendments

There is a relatively high fertility rating due to an elevated capacity to retain nutrients. This means periodic applications of macro-nutrients should be adequate to supply macro-nutrients to the vines. The presence of reactive limestone and the effect this has on soil pH may restrict availability of some micro-nutrients.

This soil would benefit from a bulk application of a calcium-based soil ameliorant, such as gypsum, prior to planting. Ideally this gypsum should be incorporated to a depth of at least fifty (50) centimetres. Regular maintenance applications of gypsum should be employed to minimise soil dispersion.

Vineyard floor management and accessibility

To maintain organic matter levels and overall soil structure a cover crop should be grown in the inter-row area and regularly slashed under the vine. An annual plant species such as faba beans is suggested as it will assist in removing excess soil moisture in spring, provide an organic source of nitrogen early in the season, and the thick tap root should help break up the densely packed subsoil.

Soil 12 – Sandy Clay Loam over Light to Heavy Clay (Griffith Clay Loam)

Depth (cm)	0-22	22-59	59-102	102-150
Horizon Name	A1	B1	B2	B3
Texture	SCL	LC	MC	HC
Soil Colour	Red - Brown	Grey - Brown	Grey - Brown	Grey
Soil Mottle	-	Bl Re	Bl Ye Re	Bl Ye Re
Fragment Lithology	-	-	Limestone	Limestone
Fragment Percentage (%)	-	-	40	15
Carbonate Class	-	-	IIIB	IIIAL
Carbonate Reaction	-	-	ST	ST
Pedality Grade	W	M	M	S
Pedality Type	SB	SB	SB	SB
Root Density	3	3	1	0
Soil pH	7.3	8.1	9.2	9.3
Soil ECe	2.28	1.98	3.36	4.20
Slaking Index	4	3	3	4
Dispersion Index	1	2	3	4
Nitrate NO3-N (mg/kg)	45	37	60	89
Phosphorus BSES (mg/kg)	159	6	2	8
Phosphorus Colwell (mg/kg)	118	5	1	16
Potassium (meq/100gm)	1.42	0.63	0.42	0.45
Calcium (meq/100gm)	11.15	9.61	14.10	10.73
Magnesium (meq/100gm)	2.91	5.38	5.63	5.45
Sodium (meq/100gm)	0.16	1.88	4.63	7.43
SAR	0.71	8.54	18.01	32.28
Ca/Mg ratio	6.39	2.98	4.18	3.28
Sulphate – S (ppm)	42	12	74	101
Zinc (ppm)	2.4	0.1	0.1	0.1
Copper (ppm)	0.5	0.1	0.1	0.1
Manganese (ppm)	0.06	0.04	0.31	0.33
Iron (ppm)	0.9	0.1	0.1	0.1
Boron (ppm)	0.14	0.94	7.8	25.50
Organic Carbon (%)	1.48	0.28	0.13	0.05
Organic Matter (%)	2.55	0.48	0.22	0.09
Chloride ppm	23	17	35	56
Carbonate CO3 (%)	1.50	2.50	8.50	4.5




60
70
90

Soil 13 – Clay Loam over Clay Sand to Light Clay (Griffith Loam)

Landscape

Sub-plastic soils of the plains.

Waterholding capacity

Total available water 103 mm/m
Readily available water 49 mm/m

Profile

Consisting of a red-brown clay loam, the topsoil is well structured and exists to an average depth of thirty-one (31) centimetres. The subsoil consists of a semi-permeable, imperfectly structured clay sand to light clay. Soil carbonate is present at an average depth of sixty (60) centimetres, and slight reactions to one (1) Mole Hydrochloric acid (HCl) can be observed.

Fertility

The inherent fertility of the soil is moderate due to a low level of organic matter in the topsoil combined with the relatively high clay content of the subsoil. Trace element levels are inherently low in this soil profile, and consequently frequent monitoring of the plant nutrient status is advised.

Drainage

Moderately well drained profile, provided the clay bands in the subsoil have minimal dispersive characteristics. Some surface water ponding may occur after substantial rainfall events.

Erosion potential

There is low potential for soil erosion on these soils.

Salinity and sodicity

Generally, the soil salinity level is moderate to high within the readily available water (RAW) rootzone, and can accumulate deep within the profile if irrigation events do not provide adequate leaching.

Sodicity and soil dispersion levels are commonly in the moderate range. Regular applications of a calcium-based soil ameliorant can assist in maintaining the balance of the cation exchange complex.

Vine performance

Vine performance on this soil type will be low to moderate. The elevated soil salinity levels, coupled with the toxic nature of the sodium and boron concentrations will reduce the vine rootzone area and also the osmotic potential of the root system.

Irrigation practices

Irrigation shifts should be relatively long and infrequent for optimum vine balance, root distribution and salt leaching. Soil moisture monitoring devices are suggested to manage irrigations successfully.

Potential rootzone (RAW) 81 cm in sampling pit

Barriers to root growth

Chemical barriers: Both sodium and boron have elevated levels in the subsoil, creating an environment that inhibits root development. Soil salinity levels within the B1 and B2 horizon are very high, and may reduce yields by as much as fifty (50) per cent.

Physical barriers: There are no physical barriers to root growth.

Nutrition and soil amendments

This soil profile has a moderate fertility rating, requiring relatively regular applications of both macro and micro-nutrients. Monitoring of nutrient uptake by the vine is suggested, as the elevated levels of sodium, boron and soil salinity will impact on the vines ability to access nutrients contained in the soil.

Vineyard floor management and accessibility

To improve organic matter levels and overall soil structure, a cover crop should be grown in the inter-row area, and regularly slashed under the vine. An annual plant species such as ryegrass or oats is suggested as it will assist in removing excess soil moisture in spring but will not compete with the vines during the critical summer months.

Cultivation practices should be limited to maintain soil structure.

Soil 13 – Clay Loam over Clay
Sand to Light Clay (Griffith Loam)

Depth (cm)	0-31	31-64	64-120
Horizon Name	A1	B1	B2
Texture	CL	CS	LC
Soil Colour	Red - Brown	Grey - Brown	Grey
Soil Mottle	-	Bl Re	Re Ye Gr
Fragment Lithology	-	-	Limestone
Fragment Percentage (%)	-	-	5
Carbonate Class	-	-	I
Carbonate Reaction	-	-	SL
Pedality Grade	W	W	M
Pedality Type	SB	SB	SB
Root Density	2	2	1
Soil pH	6.7	8.0	8.9
Soil ECe	0.98	8.55	4.47
Slaking Index	4	3	3
Dispersion Index	1	1	4
Nitrate NO3-N (mg/kg)	4	14	43
Phosphorus BSES (mg/kg)	168	4	2
Phosphorus Colwell (mg/kg)	187	4	1
Potassium (meq/100gm)	0.38	0.34	0.28
Calcium (meq/100gm)	8.20	6.90	13.18
Magnesium (meq/100gm)	2.48	5.48	4.31
Sodium (meq/100gm)	0.19	3.71	4.20
SAR	0.98	18.92	17.20
Ca/Mg ratio	5.52	2.10	5.10
Sulphate – S (ppm)	44	176	97
Zinc (ppm)	0.3	0.1	0.1
Copper (ppm)	0.3	0.2	0.1
Manganese (ppm)	0.05	0.05	0.14
Iron (ppm)	3.3	0.2	0.1
Boron (ppm)	0.18	2.30	4.20
Organic Carbon (%)	0.50	0.20	0.06
Organic Matter (%)	0.86	0.34	0.10
Chloride ppm	7	79	120
Carbonate CO3 (%)	2.00	2.00	2.50




30
70
90

Soil 14 – Sandy Clay Loam over Light to Medium Clay (Jondaryan Clay Loam)

Landscape

Sub-plastic soils of the plains.

Waterholding capacity

Total available water 121 mm/m
Readily available water 50 mm/m

Profile

Consisting of a red-brown sandy clay loam, the topsoil is well structured and exists to an average depth of twenty-three (23) centimetres. The subsoil consists of an imperfectly structured, light to medium clay that has a low permeability rating. Soil carbonates are present at an average depth of sixty-four (64) centimetres, and slight to moderate reactions to one (1) Mole Hydrochloric acid (HCl) can be observed.

Fertility

The inherent fertility of the soil is moderate to high due to a high level of organic matter in the topsoil and elevated clay content of the subsoil. These two factors give the soil the potential to retain a high percentage of nutrients within the RAW rootzone.

Drainage

Moderately well drained profile provided the clay based subsoil has minimal dispersive characteristics. Surface water ponding may occur after substantial rainfall.

Erosion potential

There is low potential for soil erosion on these soils.

Salinity and sodicity

The soil salinity level is generally low to moderate within the readily available water (RAW) rootzone. Soil salinity can become elevated deep within the profile if irrigation events do not provide adequate leaching.

Sodicity and soil dispersion levels are commonly in the low to moderate range. Regular maintenance applications of a calcium-based soil ameliorant would generally inhibit the deleterious effects of soil sodicity.

Vine performance

Vine performance on this soil type is classed as moderate to high, due to the deep potential rootzone area, the relatively high readily available water (RAW) holding capacity of the soil and the high fertility rating of the soil.

Irrigation practices

As vine performance is classed as moderate to high, it is important that irrigation quantities are limited for vigorous varieties and rootstocks, particularly between the phenological growth phases of fruit set and veraison. Due to the hot climate within the Riverina irrigation quantities should not be limited at any stage of growth for young vines or during the canopy development stage of growth in mature vines.

Irrigation shifts should be relatively long and infrequent for optimum vine balance and root distribution.

Leaching of salts from the RAW rootzone is vital and can generally be achieved through extended irrigation events. Soil moisture monitoring devices are suggested to manage irrigations successfully.

Potential rootzone (RAW) 83 cm in sampling pit

Barriers to root growth

Chemical barriers: At a depth of sixty-four (64) centimetres the reactive limestone layer poses only a minor barrier to root development.

Physical barriers: The clay nature of the subsoil, coupled with the strong pedality grade in the B2 horizon are considered restrictive to root growth.

Nutrition and soil amendments

A high fertility rating and potential ability of the soil to retain nutrients mean periodic applications of macro-nutrients will generally be sufficient. The presence of reactive limestone and the effect this has on soil pH may affect the availability of some micro-nutrients, particularly zinc, iron and manganese.

This soil benefits from regular maintenance applications of a calcium-based soil ameliorant to minimise soil dispersion.

Vineyard floor management and accessibility

To maintain organic matter levels and overall soil structure a cover crop should be grown in the inter-row area and regularly slashed under the vine. An annual plant species such as ryegrass or oats is suggested as it will assist in removing excess soil moisture in spring but will not compete with the vines during the critical summer months.

Cultivation practices should be limited to maintain soil structure.

Soil 14 – Sandy Clay Loam over Light to Medium Clay (Jondaryan Clay Loam)

Depth (cm)	0-23	23-64	64-115	115-150
Horizon Name	A1	B1	B2	B3
Texture	SCL	LMC	LC	MC
Soil Colour	Red - Brown	Red – Brown	Grey - Brown	Grey – Brown
Soil Mottle	-	-	Bl Gr	Bl Ye Gr
Fragment Lithology	-	-	Limestone	Limestone
Fragment Percentage (%)	-	-	5	15
Carbonate Class	-	-	I	IIIAL
Carbonate Reaction	-	-	M	SL
Pedality Grade	W	S	M	M
Pedality Type	SB	SB	SB	SB
Root Density	2	2	1	0
Soil pH	6.2	6.5	7.7	8.3
Soil ECe	2.52	0.64	1.98	1.75
Slaking Index	2	2	4	4
Dispersion Index	0	1	1	1
Nitrate NO3-N (mg/kg)	62	18	49	60
Phosphorus BSES (mg/kg)	410	56	11	3
Phosphorus Colwell (mg/kg)	270	50	6	1
Potassium (meq/100gm)	1.78	0.62	0.18	0.26
Calcium (meq/100gm)	10.49	8.17	16.67	18.48
Magnesium (meq/100gm)	2.78	3.64	4.60	5.01
Sodium (meq/100gm)	0.14	0.29	0.67	1.08
SAR	0.67	1.47	2.49	3.78
Ca/Mg ratio	6.28	3.74	6.04	6.15
Sulphate – S (ppm)	7	6	21	47
Zinc (ppm)	3.3	0.1	0.2	0.2
Copper (ppm)	1.8	0.2	0.2	0.2
Manganese (ppm)	0.18	0.09	0.05	0.06
Iron (ppm)	2.0	0.6	0.2	0.1
Boron (ppm)	0.46	0.06	0.60	2.00
Organic Carbon (%)	1.84	0.55	0.28	0.09
Organic Matter (%)	3.16	0.95	0.48	0.15
Chloride ppm	34	23	34	37
Carbonate CO3 (%)	1.50	1.00	2.50	1.00





Soil 15 – Sandy Clay Loam over Light to Heavy Clay (Mirool Loam)

Landscape

Sub-plastic soils of the plains.

Waterholding capacity

Total available water 96 mm/m
Readily available water 39 mm/m

Profile

Consisting of a red-brown sandy clay loam, the topsoil is well structured and exists to an average depth of seventeen (17) centimetres. The subsoil consists of an imperfectly structured light to heavy clay with low permeability. Soil carbonates are present at an average depth of sixty (60) centimetres, and moderate reactions to one (1) Mole Hydrochloric acid (HCl) can be observed.

Fertility

The inherent fertility of the soil is moderate to high due to the high level of organic matter in the topsoil and the elevated clay content of the subsoil. These two factors give the soil the potential to retain a high percentage of nutrients within the RAW rootzone.
Because of the reactive limestone within the soil profile the availability of micro-nutrients will need to be closely monitored.

Drainage

Moderately well drained profile, provided the clay bands in the subsoil have minimal dispersive characteristics. Some surface water ponding may occur after substantial rainfall.

Erosion potential

There is low potential for soil erosion on these soils.

Salinity and sodicity

Generally the soil salinity level is low to moderate within the readily available water (RAW) rootzone. Soil salinity can become elevated deep within the profile if irrigation events do not provide adequate leaching.

Soil dispersion levels are commonly in the low to moderate range, whereas slaking levels are moderate to high. While the calcium to magnesium ratio is greater than three (3.0) throughout the profile, sodium levels are very high in the B3 and B4 horizon, causing the sodium adsorption ratio (SAR) to range from thirteen (13) to twenty-two (22).

Vine performance

Vine performance on this soil type will be low to moderate. The impermeable clay subsoil combined with the presence of reactive limestone reduces the potential rootzone depth and consequently the RAW value.

The elevated soil salinity levels, coupled with the toxic nature of the sodium and boron concentrations within the subsoil, may reduce the vine rootzone area and the osmotic potential of the root system.

Potential rootzone (RAW) 67 cm in sampling pit

Barriers to root growth

Chemical barriers: At a depth of sixty-one (61) centimetres the reactive limestone layer poses only a minor barrier to root development. Both sodium and boron have elevated levels in the subsoil, creating an environment that is toxic to the root system of a vine.

Physical barriers: The clay nature of the sodic subsoil, coupled with the strong pedal grade in the B2 horizon, is considered restrictive to root growth.

Irrigation practices

While vine performance is classed as low to moderate, it is important that irrigation quantities are limited for vigorous varieties and rootstocks, particularly between the phenological growth phases of fruit set and veraison. Due to the hot climate within the Riverina, irrigation quantities should not be limited at any stage of growth for young vines or during the canopy development stage of growth in mature vines.

Irrigation shifts should be relatively long and infrequent for optimum vine balance and root distribution.

Leaching of salts from the RAW rootzone is vital, and can generally be achieved through extended irrigation events. Soil moisture monitoring devices are suggested to manage irrigations successfully.

Nutrition and soil amendments

A high fertility rating and potential of the soil to retain nutrients means periodic applications of macro-nutrients will generally be sufficient. The presence of reactive limestone and the effect this has on soil pH may affect the availability of some micro-nutrients.

This soil would benefit from a bulk application of a calcium-based soil ameliorant, such as gypsum, prior to planting. Ideally this gypsum

Vineyard floor management and accessibility

To maintain organic matter levels and overall soil structure a cover crop should be grown in the inter-row area.

The dense subsoil can be broken up by certain species such as faba beans, which have a thick tap root. At the same time these legume cover crops can remove excess soil moisture in spring following wet weather and supply organic nitrogen.

Soil 15 – Sandy Clay Loam over Light to Heavy Clay (Mirool Loam)

Depth (cm)	0-17	17-36	36-61	61-110	110-150
Horizon Name	A1	B1	B2	B3	B4
Texture	SCL	MC	LMC	HC	HC
Soil Colour	Red - Brown	Red - Brown	Red - Brown	Grey – Brown	Grey – Brown
Soil Mottle	-	-	Bl	Bl Re Ye	Bl Re Ye
Fragment Lithology	-	-	-	Limestone	Limestone
Fragment Percentage (%)	-	-	-	35	15
Carbonate Class	-	-	-	IIIB	IIIAL
Carbonate Reaction	-	-	-	M	M
Pedality Grade	M	M	S	M	M
Pedality Type	SB	SB	SB	SB	SB
Root Density	3	2	1	0	0
Soil pH	6.9	7.4	8.5	9.1	9.2
Soil ECe	1.08	0.42	1.76	3.18	4.44
Slaking Index	3	3	4	4	4
Dispersion Index	1	1	2	2	2
Nitrate NO3-N (mg/kg)	32	17	157	151	128
Phosphorus BSES (mg/kg)	246	12	4	2	2
Phosphorus Colwell (mg/kg)	115	11	7	10	6
Potassium (meq/100gm)	1.05	0.71	0.36	0.42	0.48
Calcium (meq/100gm)	11.28	9.73	18.31	15.59	13.70
Magnesium (meq/100gm)	4.02	5.07	5.25	6.17	5.98
Sodium (meq/100gm)	0.58	0.39	1.07	3.74	5.69
SAR	2.54	1.76	3.76	13.86	22.25
Ca/Mg ratio	4.68	3.20	5.81	4.21	3.81
Sulphate – S (ppm)	4	2	16	103	167
Zinc (ppm)	2.0	0.3	0.3	0.3	0.2
Copper (ppm)	0.5	0.1	0.1	0.1	0.1
Manganese (ppm)	0.12	0.14	0.05	0.04	0.07
Iron (ppm)	1.1	0.6	0.8	1.0	0.8
Boron (ppm)	0.11	0.23	1.88	24.10	30.80
Organic Carbon (%)	1.49	0.73	0.42	0.14	0.08
Organic Matter (%)	2.56	1.26	0.72	0.24	0.14
Chloride ppm	13	11	37	132	64
Carbonate CO3 (%)	1.00	1.50	14.50	13.50	6.00




30
70
90

Soil 16 – Sandy clay loam over clay loam and sandy clay (Hillston Sandy Loam)

Landscape

Sub-plastic soil of the Hillston plains, formed by alluvial deposits. Found in close proximity to the Lachlan River.

Profile

Consisting of a red-brown sandy clay loam, the topsoil is very well structured and exists to an average depth of twenty-three (23) centimetres. The subsoil consists of a permeable, well structured clay loam to sandy clay soil. Soil carbonates are present at an average depth of seventy (70) centimetres, and moderate reactions to one (1) Mole Hydrochloric acid (HCl) can be observed.

Drainage

Generally, the soil profile is well drained and infiltration rates allow for high application rates.

Salinity and sodicity

Soil salinity levels range from low to moderate within the readily available water (RAW) rootzone. Soil salinity can become elevated deep within the profile if irrigation events do not provide adequate leaching.

Sodicity and soil dispersion levels are commonly in the low to moderate range. Regular maintenance applications of a calcium-based soil ameliorant would reduce the deleterious effects of soil sodicity.

Potential rootzone (RAW) 73 cm in sampling pit

Barriers to root growth

Chemical barriers: Sodium levels exceed six (6) per cent in the B2 horizon, which is classed as slightly toxic to a wine-grapes root system.

Physical barriers: There are no physical barriers to root growth for this soil pit.

Waterholding capacity

Total available water 105 mm/m
Readily available water 49 mm/m

Fertility

The fertility of the soil is considered moderate, due to the moderate level of organic matter in the topsoil. As there are limited barriers to root growth and water movement, the potential soil mass available for water and nutrient uptake is relatively high.

Erosion potential

There is low potential for soil erosion on this site.

Vine performance

Vine performance on this soil type will be moderate to high, due to the potential rootzone area, the high readily available water (RAW) holding capacity of the soil, and the moderate fertility rating of the soil.

Irrigation practices

As vine performance is classed as moderate to high, it is vitally important that irrigation quantities are limited for vigorous varieties and rootstocks, particularly between the phenological growth phases of fruit set and veraison. Due to the hot climate within the Riverina irrigation quantities should not be limited at any stage of growth for young vines or during the canopy development stage of growth in mature vines. .

In general, irrigation shifts should be relatively long and infrequent for optimum vine balance and root distribution.

Leaching of salts from the RAW rootzone is vital, and can generally be achieved through extended irrigation events. Soil moisture monitoring devices are suggested to manage irrigations successfully.

Soil 16 – Sandy clay loam over clay loam and sandy clay (Hillston Sandy Loam)

Nutrition and soil amendments

This soil profile has a high fertility rating, and because of the potential ability of the soil to retain nutrients, periodic applications of macro-nutrients will generally be sufficient.

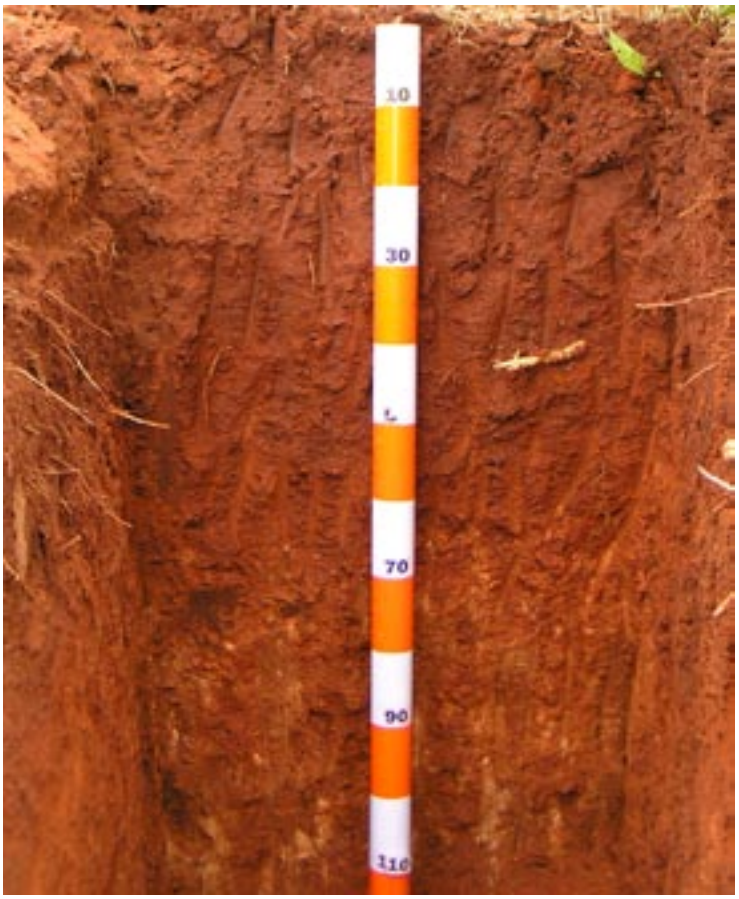
Vineyard floor management and accessibility

To maintain organic matter levels and overall soil structure, a cover crop should be grown in the inter-row area and regularly slashed under the vine. An annual plant species such as ryegrass or oats is suggested as it will assist in removing excess soil moisture in spring, but will not compete with the vines during the critical summer months.

Cultivation practices should be limited to maintain soil structure.

Depth (cm)	0-23	23-44	44-72	72-150
Horizon Name	A1	B1	B2	B3
Texture	SCL	CL	CL	SC
Soil Colour	Red-Brown	Red- Brown	Red- Brown	Grey- Brown
Soil Mottle	-	-	Bl	Bl Gr
Fragment Lithology	-	-	-	Limestone
Fragment Percentage (%)	-	-	-	40
Carbonate Class	-	-	-	IIIB
Carbonate Reaction	-	-	-	M
Pedality Grade	W	W	W	W
Pedality Type	SB	SB	SB	SB
Root Density	3	3	0	0
Soil pH	8.2	8.2	8.1	8.2
Soil ECe	1.20	1.61	3.42	1.98
Slaking Index	2	1	2	2
Dispersion Index	2	2	1	0
Nitrate NO3-N (mg/kg)	31	22	36	122
Phosphorus BSES (mg/kg)	43	12	13	9
Phosphorus Colwell (mg/kg)	19	2	3	2
Potassium (meq/100gm)	0.64	0.72	0.64	0.19
Calcium (meq/100gm)	6.58	6.01	8.23	18.40
Magnesium (meq/100gm)	3.92	3.61	5.11	5.27
Sodium (meq/100gm)	0.52	0.54	1.03	0.75
SAR	2.84	3.07	5.01	2.63
Ca/Mg ratio	2.80	2.77	2.69	5.82
Sulphate – S (ppm)	4	3	13	36
Zinc (ppm)	1.0	0.1	0.1	0.1
Copper (ppm)	0.3	0.2	0.2	0.2
Manganese (ppm)	0.27	0.21	0.17	0.05
Iron (ppm)	0.9	0.8	0.4	0.5
Boron (ppm)	0.25	0.24	0.52	1.10
Organic Carbon (%)	0.68	0.25	0.31	0.11
Organic Matter (%)	1.17	0.43	0.53	0.19
Chloride ppm	26	29	67	46
Carbonate CO3 (%)	1.00	0.50	2.50	22.50




10
30
70
90
110

Soil 17 – Light sandy clay loam over sandy clay loam (Hillston Sandy Clay

Landscape

Sub-plastic soil of the Hillston plains, formed by Aeolian deposits.

Waterholding capacity

Total available water 114 mm/m
Readily available water 58 mm/m

Profile

Consisting of a red-brown light sandy clay loam, the topsoil is very well structured and exists to an average depth of thirty-one (31) centimetres. The subsoil consists of a permeable, well structured sandy clay loam to sandy clay. Soil carbonates are present at an average depth of ninety-three (93) centimetres, and slight reactions to one (1) Mole Hydrochloric acid (HCl) can be observed.

Fertility

The inherent fertility of the soil is moderate. Organic matter levels need to be lifted for the fertility rating of this soil to be improved. As there are limited barriers to root growth and water movement, the potential soil mass available for water and nutrient uptake is relatively high.

Drainage

Generally, the soil profile is well drained and infiltration rates allow for high application rates of irrigation.

Erosion potential

There is moderate potential for soil erosion, due to the very low organic matter level of the topsoil.

Salinity and sodicity

Soil salinity levels range from moderate to high within the readily available water (RAW) rootzone. Soil salinity can become elevated deep within the profile if irrigation events do not provide adequate leaching.

Soil dispersion levels are commonly in the low range, whereas the sodicity indexes are elevated. Calcium levels are moderate and soil salinity levels inhibit dispersion. Sodium levels are elevated and require amelioration to prevent raising the dispersion levels over time. Regular applications of a calcium-based soil ameliorant would assist is displac-

Vine performance

Vine performance on this soil type will be moderate to high, due to the potential rootzone area, the high readily available water (RAW) holding capacity, and the moderate fertility rating of the soil.

Irrigation practices

As vine performance is classed as moderate to high, it is important that irrigation quantities are limited for vigorous varieties and rootstocks, particularly between the phenological growth phases of fruit set and veraison. Due to the hot climate within the Riverina irrigation quantities should not be limited at any stage of growth for young vines or during the canopy development stage of growth in mature vines.

Generally, irrigation shifts should be relatively long and infrequent for optimum vine balance and root distribution.

Leaching of salts from the RAW rootzone is vital, and can generally be achieved through extended irrigation events. Soil moisture monitoring devices will help achieve successful irrigation management.

Potential rootzone (RAW) 81 cm in sampling pit

Barriers to root growth

Chemical barriers: Sodium levels throughout the soil profile are elevated, and will inhibit root development.

Physical barriers: There are no physical barriers to root growth for this soil pit.

Nutrition and soil amendments

This soil profile has a moderate fertility rating, and because of the potential ability of the soil to retain nutrients, periodic applications of macro-nutrients will generally be sufficient.

This soil would benefit from a bulk application of a calcium-based soil ameliorant, such as gypsum, and a well composted organic matter prior to planting. Ideally this gypsum and organic matter should be incorporated to a depth of at least fifty (50) centimetres. Regular maintenance applications of gypsum should be employed to minimise soil dispersion.

Vineyard floor management and accessibility

To improve organic matter levels and overall soil structure, a cover crop should be grown in the inter-row area, and regularly slashed under the vine. An annual plant species such as ryegrass or oats is recommended as it will assist in removing excess soil moisture in spring, but will not compete with the vines during the critical summer months.

Cultivation practices should be limited to maintain soil structure and to minimise the potential for soil erosion.

Soil 17 – Light sandy clay loam over sandy clay loam (Hillston Sandy Clay Loam)

Depth (cm)	0-16	16-52	52-97	97-150
Horizon Name	A1	B1	B2	B3
Texture	LSCL	SCL	SCL	SC
Soil Colour	Red-Brown	Red- Brown	Red	Red
Soil Mottle	-	-	Bl	Bl Gr
Fragment Lithology	-	-	-	Limestone
Fragment Percentage (%)	-	-	-	20
Carbonate Class	-	-	-	IIIAL
Carbonate Reaction	-	-	-	SL
Pedality Grade	W	W	W	W
Pedality Type	SB	SB	SB	SB
Root Density	2	2	2	1
Soil pH	7.7	6.6	7.6	8.8
Soil ECe	2.35	1.68	2.88	3.01
Slaking Index	0	2	1	1
Dispersion Index	1	4	1	1
Nitrate NO3-N (mg/kg)	14	3	14	108
Phosphorus BSES (mg/kg)	26	9	9	8
Phosphorus Colwell (mg/kg)	18	7	7	14
Potassium (meq/100gm)	0.54	0.24	0.46	0.34
Calcium (meq/100gm)	5.02	2.56	3.91	14.76
Magnesium (meq/100gm)	3.57	3.50	6.27	5.73
Sodium (meq/100gm)	0.97	1.09	2.52	2.37
SAR	5.90	8.22	14.81	9.05
Ca/Mg ratio	2.34	1.22	1.04	4.30
Sulphate – S (ppm)	18	13	35	28
Zinc (ppm)	0.5	0.1	0.1	0.1
Copper (ppm)	0.3	0.3	0.2	0.2
Manganese (ppm)	0.12	0.15	0.08	0.14
Iron (ppm)	1.5	1.4	0.4	0.4
Boron (ppm)	0.14	0.22	1.20	3.90
Organic Carbon (%)	0.93	0.33	0.49	0.05
Organic Matter (%)	1.60	0.57	0.84	0.09
Chloride ppm	64	59	115	131
Carbonate CO3 (%)	1.00	1.00	2.00	5.00




10
70
90

Soil 18 – Sandy Clay Loam over Sandy Clay Loams to Light Clays (Hillston Clay Loam)

Landscape

Sub-plastic soils of the Hillston plains, formed by alluvial deposits. Found in close proximity to the Lachlan River.

Waterholding capacity

Total available water 123 mm/m
Readily available water 56 mm/m

Profile

Consisting of a red-brown sandy clay loam, the topsoil is well structured and exists to an average depth of thirty-six (36) centimetres. The subsoil consists of a semi-permeable, well structured light clay band in the B1 horizon, followed by sandy clay loam and light/medium clay in the B2 horizon. Soil carbonates are present at an average depth of seventy (70) centimetres , and nil to moderate reactions to one (1) Mole Hydrochloric acid (HCl) can be observed.

Fertility

The inherent fertility of the soil is moderate to high, due to the moderate level of organic matter in the topsoil and the elevated clay content of the subsoil. These two factors give the soil the potential to retain a high percentage of nutrients within the RAW rootzone.

Drainage

This soil profile has moderate drainage. The sodic saline subsoil restricts water movement and as a consequence leaching irrigation events are inhibited. Surface ponding and water run-off occur when the topsoil is at field capacity, as the water will not readily infiltrate into the B1 horizon.

Erosion potential

There is low potential for soil erosion.

Salinity and sodicity

Generally, the soil salinity level is moderate to high within the readily available water (RAW) rootzone. Soil salinity can become elevated deep within the profile if irrigation events do not provide adequate leaching.

Sodicity levels are commonly in the moderate to high range. Prior to the establishment of a vineyard on this soil, bulk quantities of high grade gypsum and composted manure should be incorporated into the soil to a depth of approximately fifty centimetres (50). Once the vineyard is established, regular maintenance applications of gypsum should be applied to reduce the effects of sodicity.

It is important to provide adequate leaching irrigation events to this soil type following an application of gypsum and/or organic matter, as a means of leaching the salts from the applied products and the soil profile.

Vine performance

Vine performance on this soil type will be moderate. The semi–permeable, light clay layer combined with the elevated salinity and sodium levels within the subsoil will reduce the osmotic potential of the vine, and consequently the yield potential.

Irrigation practices

While vine performance is classed as moderate, it is important that irrigation quantities are limited for vigorous varieties and rootstocks, between the phenological growth phases of fruit set and veraison. Due to the hot climate within the Riverina irrigation quantities should not be limited at any stage of growth for young vines or during the canopy development stage of growth in mature vines.

The irrigation shifts need to be tailored to prevent waterlogging in the subsoil region, caused by the sodic saline subsoil reducing the drainage potential of the soil. Irrigation run-times should be moderate in length, and applied frequently.

The deep drainage characteristics of this soil profile needs to be improved for effective salt leaching to occur. Soil moisture monitoring devices will help management of irrigations.

Potential rootzone (RAW) 86 cm in sampling pit

Barriers to root growth

Chemical barriers: The presence of reactive carbonate at a depth of sixty-seven (67) centimetres will be a minor restriction on root development. Levels of exchangeable sodium in the subsoil are classed as restrictive to root growth.

Physical barriers: The light clay layer located at a depth of thirty-six (36) centimetres would be a restriction on root exploration.

Soil 18 — Sandy Clay Loam over Sandy Clay Loams to Light Clays (Hillston Clay Loam)

Nutrition and soil amendments

This soil profile has a moderate to high fertility rating, generally only requiring periodic applications of macro-nutrients.

This soil would benefit from a bulk application of a calcium-based soil ameliorant, such as gypsum, and a well composted organic matter prior to planting. Ideally this gypsum and organic matter should be incorporated to a depth of at least fifty (50) centimetres. Regular maintenance applications of gypsum should be employed to minimise soil dispersion.

Vineyard floor management and accessibility

To improve organic matter levels and overall soil structure, a cover crop should be grown in the inter-row area, and regularly slashed under the vine. An annual plant species such as ryegrass or oats is suggested as it will assist in removing excess soil moisture in spring, but will not compete with the vines during the critical summer months.

Cultivation practices should be limited to maintain soil structure.

Depth (cm)	0-36	36-67	67-102	102-150
Horizon Name	A1	B1	B2	B3
Texture	SCL	LC	SCL	LMC
Soil Colour	Red-Brown	Red	Red- Brown	Red- Brown
Soil Mottle	-	-	Bl	Bl Ye Gr
Fragment Lithology	-	-	Limestone	Limestone
Fragment Percentage (%)	-	-	8	20
Carbonate Class	-	-	IIIAS	IIIAL
Carbonate Reaction	-	-	Nil	M
Pedality Grade	W	W	W	W
Pedality Type	SB	SB	SB	SB
Root Density	3	2	1	0
Soil pH	7.6	7.0	7.2	8.3
Soil ECe	3.12	3.53	7.56	4.08
Slaking Index	2	3	3	1
Dispersion Index	1	1	1	1
Nitrate NO3-N (mg/kg)	33	20	53	100
Phosphorus BSES (mg/kg)	101	11	9	10
Phosphorus Colwell (mg/kg)	61	14	11	2
Potassium (meq/100gm)	0.67	0.49	0.24	0.22
Calcium (meq/100gm)	8.18	5.53	10.52	15.96
Magnesium (meq/100gm)	3.95	5.07	5.44	5.58
Sodium (meq/100gm)	0.69	2.43	2.31	2.86
SAR	3.44	13.53	10.13	10.57
Ca/Mg ratio	3.45	1.82	3.22	4.76
Sulphate – S (ppm)	23	111	121	56
Zinc (ppm)	3.3	0.2	0.1	0.1
Copper (ppm)	0.7	0.3	0.1	0.1
Manganese (ppm)	0.16	0.12	0.05	0.06
Iron (ppm)	1.0	0.9	0.4	0.5
Boron (ppm)	0.06	0.26	0.90	1.90
Organic Carbon (%)	0.75	0.30	0.16	0.02
Organic Matter (%)	1.29	0.52	0.28	0.03
Chloride ppm	148	199	359	303
Carbonate CO3 (%)	1.00	1.00	2.00	3.50




30
70
90

Soil 19 – Deep Sand (Hillston Sand)

Landscape

Aeolian material found to the north-west of the Lachlan River.

Waterholding capacity

Total available water 43 mm/m
Readily available water 26 mm/m

Profile

Consisting of grey-brown sand, the topsoil is classed as non-structured, and exists to an average depth of nineteen (19) centimetres. The subsoil consists of a very permeable sand to a depth of greater then one hundred and fifty (150) centimetres. The depth to the clay sand/light clay layer will vary, dependent on its location on the sand dune. Soil carbonates are not present within the sand layers.

Fertility

The inherent fertility of the soil is low, due to the low level of organic matter in the topsoil, and the low clay content of the profile. As a result the soil has a reduced ability to retain nutrients.

Because of the high drainage rate of this soil, nutrients will be readily leached beyond the rootzone of vines.

Drainage

The sand layers within this soil type are extremely well drained. The clay sand/light clay layers found at depth have a lower drainage rate and consequently can create a perched water table.

Erosion potential

There is moderate potential for soil erosion if the mid-row area is kept bare.

Salinity and sodicity

Generally, the soil salinity level is low to moderate within the readily available water (RAW) rootzone. The clay sand/light clay layer found at depth will restrict salt leaching and consequently salinity may increase above the restrictive layer.

Sodicity levels are commonly in the moderate to high range, but due to the low percentage of clay fragments within the sand, dispersion levels are low. Slaking levels are generally high due to the non-structured characteristic of the sands.

Vine performance

Vine performance on this soil type will be moderate to high, due to the potential rootzone area. Plant vigour will need to be closely monitored.

Irrigation practices

Because of the high drainage rate of the soil, irrigation shifts will need to be relatively short and frequent to minimise water moving beyond the vine rootzone and to maintain soil moisture levels.

Leaching of salts from the RAW rootzone should be easily achieved on the upper and mid-slopes of the sand dunes. The clay sand/light clay layer however, may restrict salt leaching on the lower lying areas. Soil moisture monitoring devices are suggested to manage irrigations successfully.

Potential rootzone (RAW) 69 cm in sampling pit

Barriers to root growth

Chemical barriers: Elevated levels of exchangeable sodium within the B1 horizon would inhibit root development.

Physical barriers: There are no physical barriers that would restrict root growth.

Nutrition and soil amendments

Regular applications of both macro and micro-nutrients will be required, as nutrients will be easily leached through irrigation and rainfall events. Regular monitoring of both plant and soil nutrient status is essential.

To improve overall soil structure and waterholding capacity and to minimise the potential for soil erosion, organic matter levels should be increased through the incorporation of bulk organic material prior to planting.

Vineyard floor management and accessibility

To improve organic matter levels and overall soil structure, a cover crop should be grown in the inter-row area, and regularly slashed under the vine. An annual plant species such as ryegrass or oats is suggested as it will assist in removing excess soil moisture in spring, but will not compete with the vines during the critical summer months.

Depth (cm)	0-19	19-150
Horizon Name	A1	B1
Texture	S	S
Soil Colour	Brown - Grey	Red -Brown
Soil Mottle	-	-
Fragment Lithology	-	-
Fragment Percentage (%)	-	-
Carbonate Class	-	-
Carbonate Reaction	-	-
Pedality Grade	NS	NS
Pedality Type	-	-
Root Density	3	3
Soil pH	7.2	7.5
Soil ECe	1.41	3.82
Slaking Index	4	4
Dispersion Index	4	1
Nitrate NO3-N (mg/kg)	10	8
Phosphorus BSES (mg/kg)	71	9
Phosphorus Colwell (mg/kg)	58	9
Potassium (meq/100gm)	0.66	0.10
Calcium (meq/100gm)	2.57	3.21
Magnesium (meq/100gm)	1.56	1.90
Sodium (meq/100gm)	0.21	1.03
SAR	1.85	8.07
Ca/Mg ratio	2.75	2.82
Sulphate – S (ppm)	4	44
Zinc (ppm)	1.6	1.4
Copper (ppm)	2.0	0.3
Manganese (ppm)	0.23	0.13
Iron (ppm)	2.4	4.4
Boron (ppm)	0.13	0.13
Organic Carbon (%)	0.33	0.13
Organic Matter (%)	0.57	0.22
Chloride ppm	16	86
Carbonate CO3 (%)	0.50	0.50




0
10
1
70
90
110

Soil 20 – Self Mulching Clay Soil (Hillston Clay)

Landscape

Plastic soil of the Hillston plains, formed by alluvial deposits.

Waterholding capacity

Total available water 100 mm/m
Readily available water 38 mm/m

Profile

Consisting of grey light clay, present to a depth of twenty (20) centimetres the topsoil has self mulching properties, but is generally poorly structured. The subsoil consists of non-permeable medium to heavy clay. Soil carbonates are present at an average depth of fifty (50) centimetres, and slight reactions to One (1) Mole Hydrochloric acid (HCl) can be observed.

Fertility

The inherent fertility of the soil is moderate to high, due to the elevated clay content of the profile and the low to moderate levels of organic matter in the topsoil. Because of the reactive limestone within the soil profile, the availability of micro-nutrients will need to be closely monitored.

Drainage

Infiltration and drainage rates are commonly very low.

Erosion potential

There is low potential for soil erosion.

Salinity and sodicity

Generally, the soil salinity level is moderate within the readily available water (RAW) rootzone and is considered restrictive to plant growth. Below the RAW rootzone soil salinity levels tend to increase due to the low drainage capacity of the soil.

Sodicity and soil dispersion levels are commonly in the moderate range, due to the high clay content of the profile. Regular maintenance applications of a calcium-based soil ameliorant would generally inhibit the deleterious effects of soil sodicity.

Vine performance

Vine growth on this soil type will be low to moderate. The dense clay subsoil will restrict both root and water exploration. The poorly drained and sodic subsoil would restrict plant growth and development in spring.

Irrigation practices

Irrigation shifts should be relatively long and in-frequent for optimum vine balance, water penetration and root distribution. It is important to allow adequate time to allow the vines to utilize that available water prior to the next irrigation. This practice will help minimise waterlogging events and the potential for the water tables developing.

Leaching of salts from the RAW rootzone is vital, and can generally be achieved through extended irrigation events. Soil moisture monitoring devices will aid irrigation management.

Potential rootzone (RAW) 68 cm in sampling pit

Barriers to root growth

Chemical barriers: The presence of reactive carbonate at a depth of forty-nine (49) centimetres will be restrictive to root development in sensitive rootstocks. Sodium levels are elevated to a level that is considered toxic in the B2 and B3 horizons of this profile.

Physical barriers: The B2 layer consisting of sodic medium clay that has a strong pedality grade would be a barrier to root exploration and water penetration.

Nutrition and soil amendments

This soil profile has a moderate to high fertility rating and because of the potential ability of the soil to retain nutrients periodic applications of macro-nutrients will generally be sufficient. The presence of reactive limestone and the effect this has on soil pH may restrict availability of some micro-nutrients, particularly zinc, copper and iron.

This soil would benefit from a bulk application of a calcium-based soil ameliorant, such as gypsum, and a well composted organic matter prior to planting. Ideally the gypsum and organic matter would be incorporated to a depth of approximately fifty (50) centimetres. Regular maintenance applications of gypsum should be employed to minimise soil dispersion.

Vineyard floor management and accessibility

To improve organic matter levels and overall soil structure, a cover crop should be grown in the inter-row area, and regularly slashed under the vine. An annual plant species such as faba beans is recommended, as it will assist in removing excess soil moisture in spring and provide an organic source of nitrogen early in the season. In addition, its thick tap root should help break up the densely packed subsoil.

Once plant establishment has been achieved cultivation should be minimised to maintain and improve soil structure.

Depth (cm)	0-18	18-49	49-99	99-150
Horizon Name	A1	B1	B2	B3
Texture	LC	LMC	MC	HC
Soil Colour	Grey	Grey	Grey	Grey
Soil Mottle	-	-	-	Ye
Fragment Lithology	-	-	Limestone	Limestone
Fragment Percentage (%)	-	-	3	5
Carbonate Class	-	-	I	I
Carbonate Reaction	-	SI	SI	SL
Pedality Grade	M	M	S	S
Pedality Type	SB	SB	SB	SB
Root Density	2	2	1	0
Soil pH	7.6	7.7	8.9	9.2
Soil ECe	2.49	3.44	3.15	2.82
Slaking Index	2	2	3	4
Dispersion Index	1	2	2	4
Nitrate NO3-N (mg/kg)	67	79	92	108
Phosphorus BSES (mg/kg)	71	11	15	17
Phosphorus Colwell (mg/kg)	57	8	5	6
Potassium (meq/100gm)	0.46	0.30	0.08	0.12
Calcium (meq/100gm)	16.83	10.65	11.25	9.93
Magnesium (meq/100gm)	3.15	4.41	3.92	4.22
Sodium (meq/100gm)	0.57	1.40	3.63	3.13
SAR	2.14	6.23	16.03	14.43
Ca/Mg Ratio	8.90	4.02	4.79	3.92
Sulphate – S (ppm)	99	151	57	18
Zinc (ppm)	0.2	0.1	0.1	0.1
Copper (ppm)	0.2	0.2	0.1	0.2
Manganese (ppm)	0.17	0.17	0.19	0.34
Iron (ppm)	0.3	0.3	0.4	0.3
Boron (ppm)	0.88	0.37	1.30	2.2
Organic Carbon (%)	0.63	0.36	0.20	0.17
Organic Matter (%)	1.08	0.62	0.34	0.29
Chloride ppm	46	115	175	208
Carbonate CO3 (%)	3.50	1.50	3.00	3.00




30
70
90

5.0 APPENDICES

A. Field Survey Testing

The reconnaissance soil investigation was based on the excavation of twenty (20) slot trenches, which were dug to a depth of approximately 1.5 metres. They were positioned across the Riverina Plain on a sparse grid using an aerial photograph map to depict key areas. These profiles were investigated for the following characteristics:

- Texture and carbonate activity
- Horizon and RAW root zone depths
- RAW holding calculations
- Amount and type of coarse fragments (gravel/rock) in each layer
- Munsell color description
- Elevated groundwater
- Soil pedality grade and type
- Geomorphic characteristics
- Other soil chemical properties, Nitrate nitrogen, Phosphorous (BSES & Colwell), Potassium, Calcium, Magnesium, Sodium, Sulphur, Zinc, Copper, Manganese, Iron, Boron, Chloride, Carbonate (CO3) and Organic carbon (%).

These characteristics were then summarised to obtain a RAW holding capacity. The RAW values of each layer were calculated by multiplying the thickness of each layer in centimetres and the assessed waterholding capacity of the texture grade, and then reducing this by a figure equivalent to the percentage of coarse fragments.

The rootzone RAW values of each pit were finally calculated by adding the RAW values of each layer within the potential rootzone. Depths of predicted rootzones were based on texture and structure of the clay B horizon. Where a slowly permeable columnar, lenticular or prismatic structure was present only twenty (20) centimetres of this layer was included in the rootzone calculation. Where a subangular blocky, angular blocky or weakly columnar, prismatic, granular or lenticular structure existed, fifty (50) centimetres was included in the rootzone calculation. Where massive ped structures existed, only thirty (30) centimetres were included in the rootzone calculation.

Where IIIAL carbonate layers were present in a horizon, only thirty (30) centimetres of the affected horizon were included. Where IIIB or IIIC carbonate layers are present in a horizon, all of this horizon may be included.

RAW values were calculated for winegrapes at all locations. The eight kilopascals (-8kPa) to sixty kilopascals (–60kPa) soil moisture deficit range was used for calculations, representing the approximate amount of water held within the soil between field capacity and where winegrapes would begin to suffer moderate stress.

B. Laboratory Analysis

Soil samples were collected from each layer at every site and were assessed for slaking and dispersion (index DI), soil EC(1:5), EC(e), soil pH (H20), macro and micro nutrients.

To evaluate the soils slaking and dispersion characteristics, the technique developed by Emerson (1991) was used. This methodology involved placing an air-dry soil aggregate into distilled water, then after one (1) hour the aggregate was visually observed and a slaking and dispersion index was given.

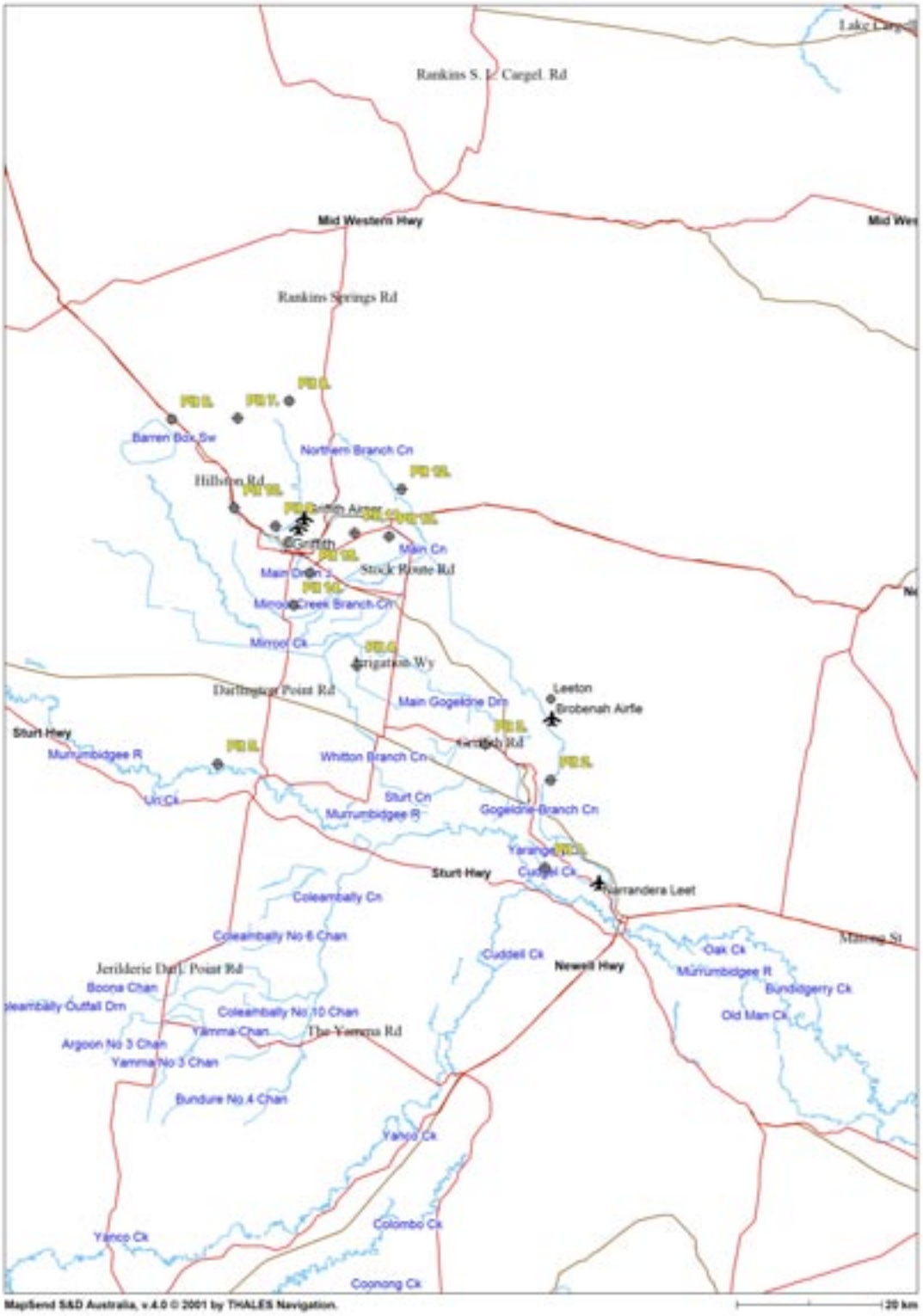
Using a 1:5 soil to extractant ratio, the soil pH in both water was measured using the standard laboratory technique detailed by Rayment & Higginson (1992).

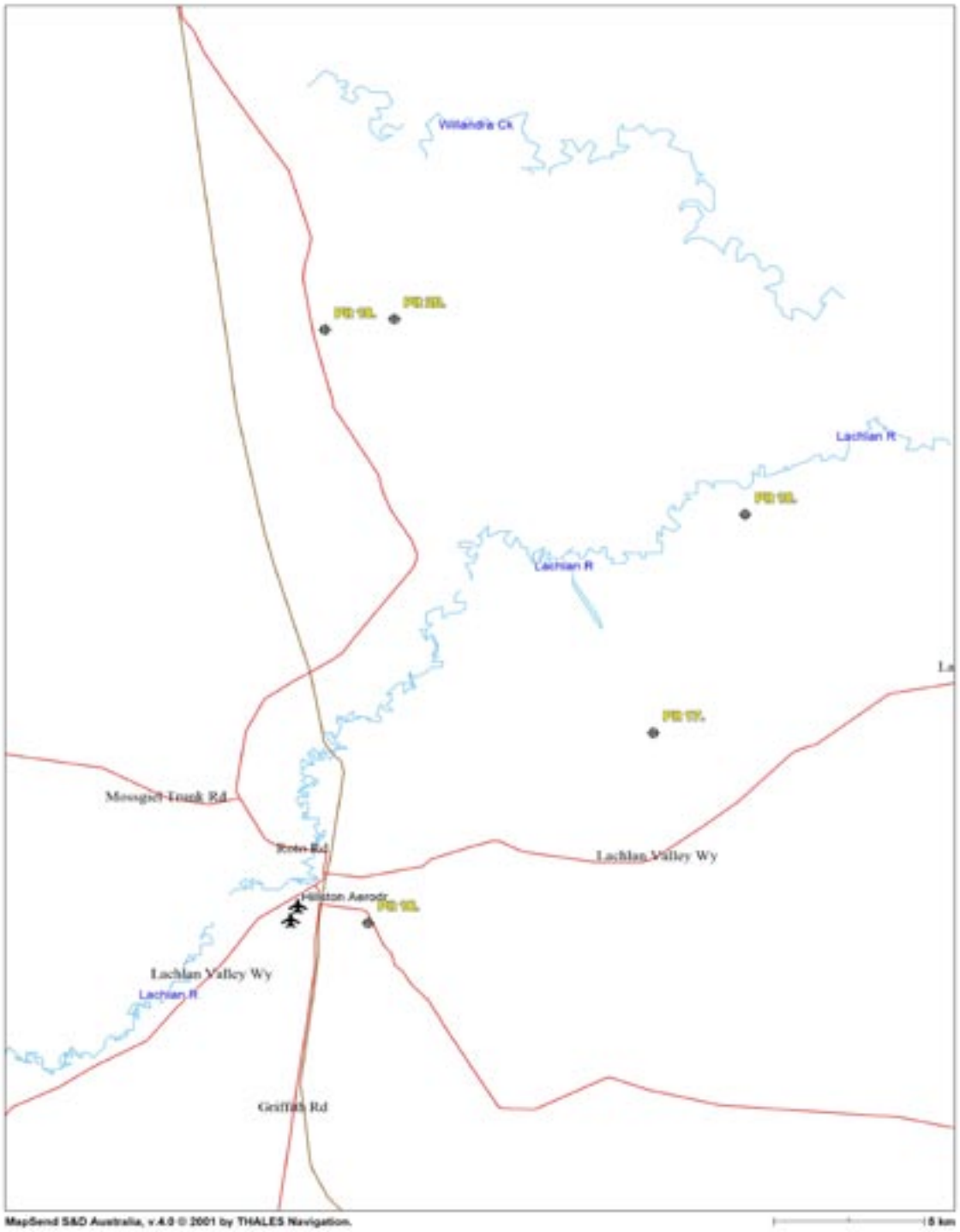
To measure soil EC the technique developed by Beatty and Loveday (1974) was followed. This involved a soil/water solution (1:5 ratio) being placed on a shaker for a period of one (1) hour, after which it was allowed to settle for half (½) an hour. It is in this state that the soil EC was measured.

The extraction method was used by CropTech Laboratories Pty Ltd to test the Nitrate nitrogen, Phosphorous (BSES & Colwell), Potassium, Calcium, Magnesium, Sodium, Sulphur, Zinc, Copper, Manganese, Iron, Boron, Chloride, Carbonate (CO3) and Organic carbon (%) of each soil horizon. The following table displays the extraction method used for each element.

Laboratory Testing Methods

Test	Extractant	Soil/Extractant Ratio	Analysis Equipment
PH	Water	1/5	
EC	Water	1/5	
NO3-N	Water	1/5	DIM
Phosphorus (BSES)	0.005M H_2SO_4	1/100	Photometric
Phosphorus (Colwell)	0.5M $NaHCO_3$	1/100	Photometric
Sulfur	0.01M $CaCl_2$	1/5	Photometric
Boron	0.01M $CaCl_2$	½	Photometric
Potassium	0.1M HCl	1/10	AAS
Calcium	0.1M HCl	1/10	AAS
Magnesium	0.1M HCl	1/10	AAS
Sodium	0.1M HCl	1/10	AAS
Iron	0.1M HCl	1/10	AAS
Copper	0.1M HCl	1/10	AAS
Manganese	0.1M HCl	1/10	AAS
Zinc	0.1M HCl	1/10	AAS
Organic Matter			Chromic acid oxidation
Bi-Carbonates	0.0005 H_2SO_4	1/100	Photometric


Rankins S. L. Cargel. Rd
Mid Western Hwy
Rankins Springs Rd
Barren Box Sw
Northern Branch Cn
Hillston Rd
Griffith Aerpt
Griffith
Main Cn
Main Drain 2
Stock Route Rd
Mirrool Creek Branch Cn
Mirrool Ck
Irrigation Wy
Darlington Point Rd
Main Gogeldrie Drn
Leeton
Brobenah Airfle
Sturt Hwy
Murrumbidgee R
Whitton Branch Cn
Um Ck
Sturt Cn
Murrumbidgee R
Gogeldrie Branch Cn
Sturt Hwy
Cuddell Ck
Narrandera Leet
Coleambally Cn
Coleambally No 6 Chan
Jerilderie Darl. Point Rd
Boona Chan
Coleambally Outfall Drn
Coleambally No 10 Chan
Yamma Chan
The Yamma Rd
Argoon No 3 Chan
Yamma No 3 Chan
Bundure No 4 Chan
Yanco Ck
Colombo Ck
Yanco Ck
Coonong Ck
Cuddell Ck
Newell Hwy
Oak Ck
Murrumbidgee R
Bundidgerry Ck
Old Man Ck
MapSend S&D Australia, v 4.0 © 2001 by THALES Navigation.
20 km


Willandra Ck
Lachlan R
Lachlan R
Lachlan Valley Wy
Lachlan Valley Wy
Lachlan R
Griffith Rd
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5 km

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7.0 DISCLAIMER:

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