ADELAIDE HILLS WINE REGION PROFILE

prepared by

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A division of Kirklinton Pty Ltd as trustee for Davidson Viticultural Consulting Trust

DECEMBER 2004

Davidson Viticultural Consulting

Adelaide Hills Wine Region Australia

Australian Government
Grape and Wine Research and Development Corporation

ADELAIDE HILLS WINE REGION PROFILE

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COMMONLY USED ABBREVIATIONS

AHWR	Adelaide Hills Wine Region
AWBC	Australian Wine & Brandy Corporation
P&GIB	Phylloxera & Grape Industry Board
BEDD	Biologically Effective Day Degrees
BOM	Bureau of Meteorology
DVCS	Davidson Viticultural Consulting Services
GWRDC	Grape and Wine Research and Development Corporation

ADELAIDE HILLS WINE REGION PROFILE

LIST OF APPENDICES

1 Sources of information for Adelaide Hills Wine Region Profile

2 Location of plantings, by variety, in the Adelaide Hills Wine Region

3 Detailed description of soil types in the Adelaide Hills Wine Region

4 Adelaide Hills Wine Region – sub-catchment maps

EXECUTIVE SUMMARY

The Adelaide Hills Wine Region Profile has been compiled from a wide range of information sources and from the experience of many wine grape producers and wine makers in the Region. It provides the following information:

- a description of existing vineyard plantings
- a discussion of climatic issues
- a discussion of soil types
- comments on water resources
- sub-catchment features
- an overview of viticultural challenges in the Region.

The information collated in the report provides a framework of information and knowledge which is useful in identifying the current status of the viticultural industry, the inherent viticultural risks in the Region and the viticultural challenges. The report also highlights where information is lacking and areas for further research.

The AHWR includes two registered sub-regions, Lenswood and Piccadilly Valley, and eight other loosely identified "sub-regions" – Paracombe, Birdwood, Charleston, Echunga, Hahndorf, Macclesfield, Mt Barker and Kuitpo. The Profile considers features of all of these "sub-regions".

Climatic Issues

The diversity and extremes of macro and meso climates throughout the Region are challenging for viticultural management. Further, on each site there are micro-climate effects which influence the viability of viticulture both positively and negatively. Clearly there are many sites where the micro climate allows the production of high quality fruit, even though an overview of the macro climate would suggest that wine grapes could not be successfully grown or ripened. It is clear that climatic impacts can be very site specific.

Undoubtedly the climatic issue of greatest concern throughout the Region is poor weather (rain and wind) during spring, which adversely affects flowering and floral initiation for the following season, and creates management problems. In Section 4.4, this link between spring temperatures and yields, from 2000 – 2004, is shown.

The climatic data available for analysis is very limited and has been used with caution . There are only seven (7) Bureau of Meteorology sites in the AHWR, and not all have reliable data. We have also consulted two stations just outside the AHWR, and where possible the Profile draws inferences from the data, and calculates indices which are likely to be useful in planning for future developments or in replanting decisions.

For seven sub-regions we have calculated the likelihood of ripening white and red varieties. This information is detailed in Section 4.3. In summary, it is clear that whilst white varieties should be able to be ripened in each year in each "sub-region", there is a significant risk of not being able to ripen all red varieties, especially Cabernet Sauvignon in all regions in all years. The red ripening risks appear to be highest in the Mt Crawford and Piccadilly "sub-regions", however the data is not robust and there is anecdotal evidence of difficulties from throughout the Region.

In summary the climatic data available is of only limited usefulness. For more meaningful analyses to be carried out, weather stations should be established throughout the Region.

The Soils

The soils in each sub-region are classified and described in the Profile, with more detailed descriptions of profiles in Appendix 3. Appendix 4 provides detailed maps of rainfall, relief, land use and erosion potential for most of the sub-catchments within the AHWR.

The soils of the AHWR are highly variable, both in their chemical and structural properties reflecting the geological bases from which they have been formed. They range from sandy loams to clay loams over light to heavy clay subsoils, some with significant amounts of shale and rock.

Many of the soils are of moderate depth with an available rooting zone of 600mm or more, are well drained and of moderate fertility. However the soils on the top of ridges and hills are typically shallower than those on lower slopes and this does create some issues in many vineyards where vines are planted up and down the slope across a range of soil types. However, there is only anecdotal, and scarce, data available.

Experiences indicate that higher vigour varieties such as Sauvignon Blanc, Shiraz and Nebbiolo perform better when planted on low potential soils; similarly Pinot Noir may benefit from a lower potential site in order to limit excessive vine vigour.

Water Resources

The water resources of the Adelaide Hills are fragile. Water is drawn from surface catchment, bores and rivers, but the recent (2004) prescription of water use in the Eastern Mount Lofty Ranges and the likely early 2005 prescription in the Western Mount Lofty Ranges reflects the concerns of Government regarding water usage and quality in the watershed. The outcome of these limitations on further water use for the next two years may not be detrimental to most existing vineyard plantings, but may reduce land owners' opportunities for further vineyard development. The findings of Rural Solutions' "Mt Lofty Irrigation Evaluation Study" (2004, and extended for 2 further years) will provide useful information for the determination of permissible water use on individual vineyards and properties.

Viticultural Challenges and Concerns

The major viticultural issues of concern to participants and wine grape producers in the Region are:

- The ability to ripen late maturing varieties, particularly red varieties.
- Related to the above is the identification of an appropriate cropload to allow consistent production of consistent quality fruit from year to year.
- Vine balance is difficult to manage in naturally fertile soils, particularly when wet springs make it difficult to use irrigation as a canopy management tool.
- Related to the above point, the difficulty in growing naturally balanced vines in many parts of the Region has a major impact upon consistency of fruit quality and causes fluctuating economic returns due to fluctuations in operating costs and revenue.
- Encroaching urbanisation – there are situations where this is promoting unease between residents and growers.
- That there is less cohesion than desirable for the Region because many vineyard owners are not the operators, and may have a primary business interest outside the industry or the Region.
- A lack of processing facilities in the Region is causing increased pressure on the Hills infrastructure, particularly in relation to roads and transport issues.

In summary, the Profile records much known data and information with relation to the AHWR. It highlights however the **lack of information** relating to:

- weather / climate
- actual size and location of individual varietal plantings
- phenological data
- performance of specific rootstock / variety combinations
- performance of varieties on different soil types.

More detailed examination of the performance of varieties, in a range of locations and on a range of soil types is recommended in order to assist in implementing the most appropriate management practices for desired wine styles. The overriding, and virtually uncontrollable, effect of spring weather conditions (wind and rain) on the viticultural and economic performance of vineyards in any one season demands that very careful and strategic site selection be implemented for any new plantings and replantings. In order to achieve consistency of quality fruit and wine production throughout the AHWR it may be that some poorly performing and high risk vineyards should be removed or replanted to more suitable varieties.

1.0 INTRODUCTION

This report has been prepared by Davidson Viticultural Consulting Services (DVCS) for the Adelaide Hills Wine Region Inc (AHWR). The AHWR requested a profile of the Region and a preliminary study of issues influencing the wine grape production industry in the Adelaide Hills. The Region is geographically one of the larger, and arguably the most diverse, wine grape producing Regions in Australia, in terms of climate, soil and topography.

This Project has been funded by the AHWR and the Grape and Wine Research and Development Corporation (GWRDC). DVCS was requested to construct a regional profile including reference to

- a description of existing vineyard plantings
- climatic issues
- soil types
- water resources
- sub catchment features
- an overview of viticultural challenges in the Region.

In order to fulfil the requirements of the Project, DVCS met regularly with the AHWR Viticulture Committee in the early stages of the Project, and presented a Progress Report to an AHWR seminar in June 2004. DVCS also consulted a wide range of participants in the AHWR, and relevant government sources. A listing of all parties consulted is given in Appendix 1.

The information collated in the report provides a framework of information and knowledge which describes the current status of the viticultural industry, the inherent viticultural risks in the Region and the viticultural challenges. The report also highlights where information is lacking and areas for further research.

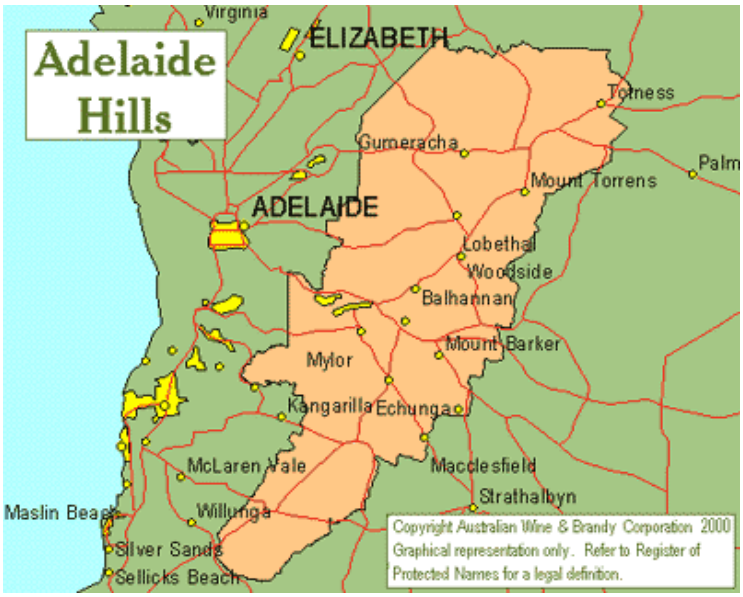
2.0 SCOPE OF THE ADELAIDE HILLS REGIONAL PROFILE STUDY

The aim of this preliminary study is to construct a regional profile for the Adelaide Hills Wine Region which describes the climatic and soil characteristics of the region and assesses the variability that exists between the "subregions" of the Region, in order to provide an information base for future site and varietal selection. It can be used to assist in future planning and redevelopment of vineyards within the AHWR.

The Australian Wine & Brandy Corporation (AWBC) has defined the Adelaide Hills as one of the largest geographical wine Regions in Australia, and amongst the most diverse in terms of climate, soil and topography. Due to the Region's large size, variability and extremes of macro, meso and microclimates, viticulture is challenging and highly variable. Some parts of the region are very marginal for viticulture. A map of the AHWR, as defined by the AWBC in 2000, is shown in Figure 1. The region includes two registered sub-regions, Lenswood and Piccadilly Valley. According to the variability seen within the region, the AHWR Inc has loosely identified a further eight "subregions". Hence, for the purposes of this report10 "subregions" will be identified:

Piccadilly	Lenswood
Paracombe	Birdwood
Charleston	Hahndorf
Echunga	Macclesfield
Mount Barker	Kuitpo

Figure 1: Adelaide Hills Wine Region (Australian Wine & Brandy Corporation 2000)



This report is not designed to be a set of prescriptive guidelines for viticulture in the Adelaide Hills; rather, it attempts to explain those important indices determining viticultural potential of, and indirectly causing the variability experienced in, the Region.

3.0 DESCRIPTION OF WINE GRAPE PLANTINGS

The cool climate characteristics of the Region, such as a cool growing period, cool spring and dry summer lend the Region towards sparkling production as identified by Brian Croser in the 1970s. The Region has a minimum elevation of 400 metres above sea level, despite the floor of the Onkaparinga Valley being only 300m at Hahndorf rising to 500 – 600m at Lenswood and Piccadilly. Rainfall in the AHWR averages above 1000mm and can reach 1400mm and more in wet years. The majority of this rainfall falls within the winter months of June – August.

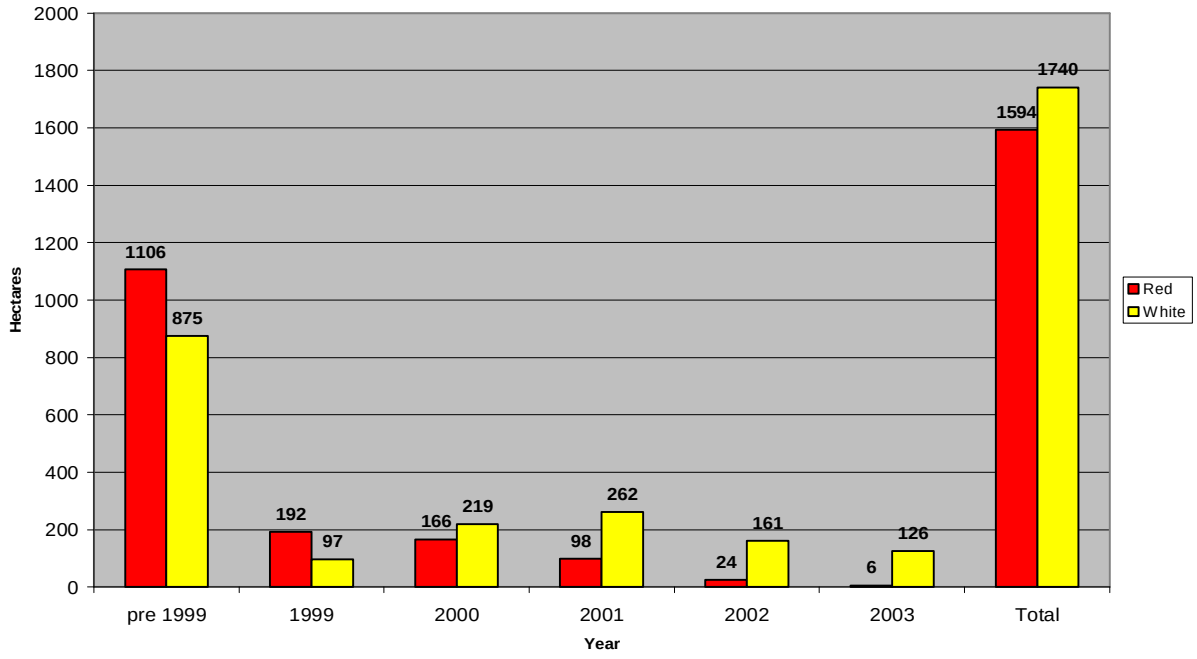
3.1 Location and Approximate Age

Grape plantings in the AHWR stretch from Birdwood in the north to Mount Compass in the south. Major concentrations of planting exist around Lobethal, Lenswood Piccadilly, Hahndorf, Macclesfield and Kuitpo (Figure 3).

The age of vineyards varies throughout the region with Halliday (1991) reporting that vines were planted in the Adelaide Hills as early as the 1830s near Mt Barker, and then closer to Hahndorf and Lobethal. There were very few vineyards in the Hills throughout most of the 20th Century, due to economic issues. In the mid 1980s, plantings began, mostly in the Piccadilly Valley and continued throughout the 1990s with a "peak" in 1998 (P&GIB 2000 Utilisation Survey) Planting has slowed with 2003 plantings representing only 4% of the total vineyard area in the AHWR (P&GIB, 2004). Of the current planting of 3,333ha, 59% are recorded as being planted before 1999. Some small plantings are planned for 2004.

Figure 2 shows that planting during the late 1990s saw a shift from a predominance of red varieties, to a slight increase in hectares of white varieties planted. Red varieties (including those such as Pinot Noir used for sparkling wine) currently comprise 48% of the total area. White varieties comprise 52%.

Figure 2: Hectares of Red and White varieties planted in the Adelaide Hills Wine Region



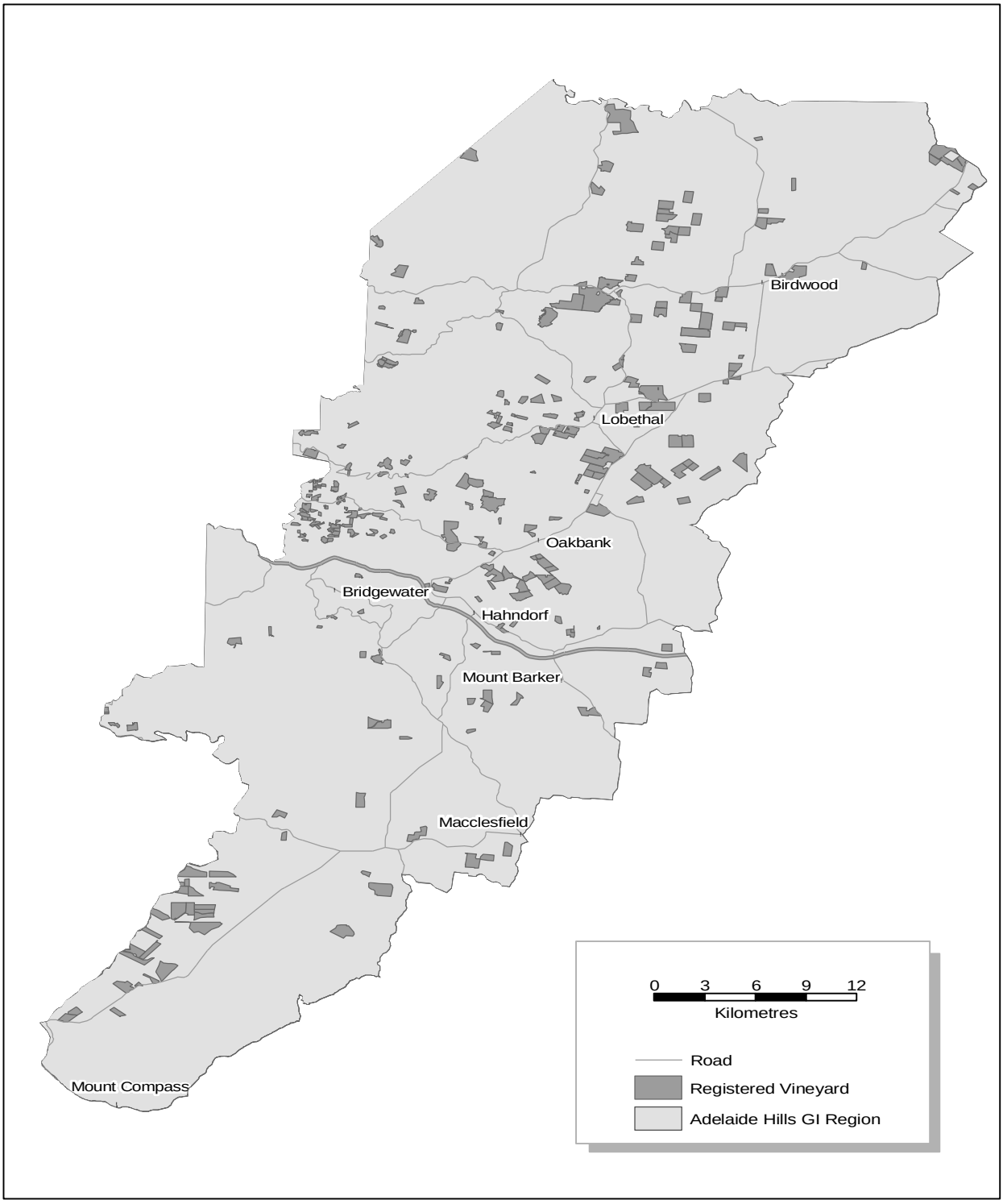
The geographical spread of wine grape plantings, as recorded by P&GIB (2004) is shown in Figure 3. Maps of plantings for all major varieties within the AHWR are provided in Appendix 2.

Figure 3 does not give an accurate description of the size of individual plantings. It does however, show the spread of vineyards throughout the Region and where concentrations of plantings exist.

The maps in Appendix 2 show the location of varieties in greater detail. However due to Privacy Act restrictions the maps are unable to identify actual areas of each variety planted. Hence the study is unable to identify the specific location and size of varietal plantings in the AHWR. The colour key refers only to the size of the property on which a particular variety is planted and not to the area of the individual variety itself.

Despite the inability to identify precise varieties by location in the AHWR, our on-the-ground field work suggests that all varieties are planted in all parts of the Region, with the exception of the absence of later ripening red varieties in the Piccadilly Valley. This continues to reinforce the variability of the AHWR, ie. if the correct microclimate is found, Cabernet Sauvignon can be adequately ripened in areas of the AHWR which do not theoretically support this.

Figure 3: Location of wine grape plantings in the Adelaide Hills Wine Region (Source P&GIB 2004)



3.2 Varieties

White varieties comprise 52% of total plantings. The most commonly planted white varieties in the AHWR are Chardonnay (24%) and Sauvignon Blanc (16%). Red varieties comprise 48% of the total plantings. The main red varieties are Pinot Noir (15%), Merlot (10%), Cabernet Sauvignon (10%) and Shiraz (9%) (Phylloxera & Grape Industry Board of South Australia, 2004).

Table 1 Varietal planting summary (hectares) (P&GIB, 2004).

Variety	Pre-1999	1999	2000	2001	2002	2003	Total
RED WINE GRAPES							
Barbera	0	0	0	0	1	0	**1**
Cabernet Franc	10	1	2	0	0	0	**13**
Cabernet Sauvignon	272	20	23	16	3	1	**335**
Grenache	2	2	0	0	0	0	**4**
Malbec	1	1	2	0	0	0	**4**
Mataro	0	0	0	1	0	0	**1**
Merlot	235	44	42	15	0	1	**337**
Nebbiolo	3	0	2	1	0	0	**6**
Petit Verdot	0	2	0	1	1	1	**5**
Pinot Noir	345	82	49	38	16	1	**531**
Ruby Cabernet	0	0	0	0	0	0	**0**
Sangiovese	5	1	4	0	0	0	**10**
Shiraz	199	38	37	21	2	2	**299**
Tempranillo	2	2	5	5	0	0	**14**
Other Red	33	0	0	0	1	0	**34**
TOTAL RED VARIETIES	**110**	**7193**	**166**	**98**	**24**	**6**	**1594**
WHITE WINE GRAPES							
Chardonnay	431	35	83	131	77	57	**814**
Chenin Blanc	0	0	0	0	0	0	**0**
Riesling	24	5	17	27	32	0	**105**
Sauvignon Blanc	277	28	72	84	34	26	**520**
Semillon	80	7	8	1	0	0	**96**
Traminer	1	0	0	5	15	0	**21**
Verdelho	25	3	0	0	0	0	**28**
Viognier	19	9	20	12	3	2	**65**
Other white	17	11	19	2	0	40	**89**
TOTAL WHITE VARIETIES	**874**	**98**	**219**	**262**	**161**	**125**	**1739**
Rootstock block	1	1	0	1	0	0	3
TOTAL ALL VARIETIES	**1981**	**291**	**385**	**360**	**185**	**131**	**3333**

3.3 Clones

This information has been gathered from the grower / winemaker / viticulturists survey and the P&GIB. Respondents included wine grape growers, Grower Liaison Officers, viticulturalists, wine makers from large and smaller wineries and vineyard contractors. Views were sought from persons working in different areas of the Region, so as to gain some geographical spread.

Range in vineyard size (ha)	3 – 138 ha
Age of plantings	One – 24 years old Small 2005 plantings planned
Locations	Kersbrook, Gumeracha, Mt Torrens, Lobethal, Lenswood, Summertown, Piccadilly, Balhannah, Hahndorf, Meadows, Kuitpo.
White Varieties	Chardonnay, Sauvignon Blanc, Riesling, Semillon, Viognier, Pinot Gris.
Red Varieties	Pinot Noir, Merlot, Cabernet Sauvignon, Shiraz, Cabernet Franc, Sangiovese, Grenache, Nebbiolo, Petit Verdot, Barbera, Mataro,

Table 2 summarises the comments about clonal characteristics expressed in vineyards in the AHWR. It is fair to say that, generally, little consideration had been given to clone selection until the late 1990s, primarily due to lack of experience in the Region, but also to lack of availability of planting material. Even so, some growers are carrying out significant clone investigation, and the Adelaide Hills Vine Improvement Committee is an active Group within the AHWR.

Table 2: Clone Characteristics

Variety	Clone	Comments
PINOT NOIR	**General Comments**	• The major clones of interest are D5V12, MV6, Martini, 114, 115 (114 and 115 known also as Bernard clones), 777 • Clones in which wine makers are interested for flavour characteristics are: 114, 115, MV6, 777 • The newer plantings (primarily Bernard) are immature, therefore full characteristics are not evident. • Replanting of newer clones is occurring as older clones are too vigorous and bunches too big. • Small parcels of MV6, 114, 115 are used for table wines. • In terms of wine quality, the clonal difference is less important than the actual management practices used, vine balance & aspect (northerly preferred).
	D5V12	• Tends to overcrop and needs to be vigorously thinned. • The 'D' clones (D5V12, D2V6, D2V5) are preferred by wine makers for sparkling wines • Being kept in small areas for their gamey herby characters as background notes. • Higher cropping than other clones. • Widely planted throughout the Region
	MV6	• Has smaller berries with a pinker colour. • Preferred clone for table wines, but one wine maker "not particularly keen". • Has lighter fruits which add aromatics and "ethereal" elements.
	114 & 115 (Bernard Clones)	• Growers are still assessing these clones as they are only new plantings, but seem better than D5V12 in showing characteristics desired by wine makers. • Therefore these clones are currently considered to be more desirable for table wines. • Several (most) growers have no experience of this clone
	Other clones	• Mariafield – bigger berries, thicker skins and good colour. • D4V2 – lower cropping than D5V12. • 777 – still young plantings, but seem quite good

Table 2: Clone Characteristics (cont'd)

CHARDONNAY	**General Comments**	• Bernard clones 76 and 95, and Antav 84 and 85 are being used for replacement and replanting. • Major issue is not the suitability of the clone for winemaking, but vine balance and a tendency to over cropping by clones other than Bernard and Antav.
	I10V1	• Main clone grown in the Region. • Great "workhorse" • Seems to vary greatly in fruit set with location. • General perception that this clone is a good consistent performer, however in cold damp sites the set is variable, resulting in hen & chicken in most seasons. Generally there seems to be poor set problems in cooler areas. • This clone is being replaced by Bernard clones & Antav (84 & 85).
SAUVIGNON BLANC	**F4V6**	• Bigger and heavier bunches compared with Morialta clone. • Has intense flavour.
	F14V9	• Is the most common clone planted, but growing interest in F4V6 due to wine makers' preference for wine styles. • Has tighter bunches than F4V6 and is therefore more prone to disease
	5385	• Seems to have smaller bunches than F4V6. • Flavours acceptable.
SHIRAZ	**BVRC30**	• This is the highest yielding clone planted in the AHWR, followed by BVRC12
	PT23	• Has suspected leaf roll virus.
	1654 & 1127	• These clones are the most widely planted. • Have better peppery characters but more uneven budburst and bunch size resulting in more variable yields. These clones seem to respond better to cane pruning.
CABERNET SAUVIGNON	**CW44** **G9V3**	• This clone has preferred characteristics and yields are higher than Reynella clone. • The yields are more variable and cyclic.
RIESLING	**239**	• Prone to over cropping, needs heavy thinning. There are differences in set between 239 and 198.

Table 2: Clone Characteristics (cont'd)

MERLOT	**D3V14**	• Most commonly planted clone.
	8R & 6R	• Better bunch structure and more reliable set (when used with Teleki 5C, Merlot tends to over crop).
VIOGNIER	**68 MONTPELLIER**	• Very large bunches. Has struggled in the first 7 years, then "goes mad", ie high vigour.
	HTK & 642	• Both grow vigorously in the early years, cropping in Year 2. Once the vine settles it appears to be less sensitive to the virus load than 68 Montpellier.

3.4 Rootstocks

3.4.1 Current Plantings

The majority of plantings in the AHWR comprise *Vitis vinifera,* the predominant species used in grape production throughout the world. Rootstocks (other *Vitis* species) may be used for a variety of purposes including:

- Resistance to Phylloxera
- Resistance to nematodes
- Salt tolerance
- Soil acidity tolerance
- Lime tolerance
- Drought tolerance or increased water use efficiency
- Decreased sensitivity to waterlogging
- Increase or decrease in scion vigour
- Improving fruit set
- Advancing fruit maturity.

However, of the 3253ha of vines planted in the Adelaide Hills only 135ha (4.2%) are planted on rootstocks (P&GIB 2004). There is little information available regarding purpose and location of rootstock planting. The P&GIB advises (pers.comm.) that, from the limited research it has conducted, Chardonnay on rootstocks is of greatest concentration in the Piccadilly, Summertown and Uraidla area. This type of rootstock mapping has not been completed for any other varieties within the Adelaide Hills Wine Region, and so no data regarding varietal performance on different rootstocks is available.

Table 3: Rootstock plantings in the Adelaide Hills Wine Region, September 2004.

Rootstock	Area (ha)
101-14	9.75
110 Richter	4.84
1103 Paulsen	1.19
140 Ruggeri	3.58
420A	0.14
5A Teleki	1.6
5BB Kober	2.65
5C Teleki	18.31
99 Richter	2.4
K51-40	1.15
Ramsey	6.13
Schwarzmann	36.84
SO4	2.42
Total rootstock (ha)	**135.69**
Total plantings (ha)	**3295.98**
% Rootstock	**4.20**

Source Mr Nick Dry, P&GIB, 2004

The most commonly planted rootstocks planted in the AHWR are Schwarzmann (36.84ha), 5C Teleki (18.31ha) and 101-14 (9.75 ha). The following explanations for use or non-use of rootstocks in the AHWR have been given during consultation and discussion with wine grape growers, viticulturists, Grower Liaison Officers and winemakers from the Region.

3.4.2 Reasons given for use of rootstocks

- To control vigour and limit vegetative growth (eg. Teleki 5C, 101 – 14)
- To improve fruit set in Merlot.
- To improve vigour on leaner, older blocks (eg. Schwarzmann) in replant situations.
- Tolerance of acid soils.
- Tolerance of water logged soils.

3.4.3 Reasons given for not using rootstocks

- The major concern with growers regarding rootstock is the lack of regional knowledge and experience of typicity and fruit/wine quality. Most respondents indicated a need for trial work to assess the characteristics of rootstock/variety combinations in the AHWR.
- Cost and availability.
- There do not appear to be any 'viticultural' problems which necessitate the use of rootstocks, *eg* soil/water salinity, root rot, nematodes.
- Historically, the perceived risk of Phylloxera infestation has been (is) low.
- Some wine makers have a concern that rootstocks may reduce fruit/wine quality.

3.4.4 Future use

- Most respondents answered that they would consider rootstocks in future plantings or replanting for Phylloxera protection, especially if characteristics of variety/rootstock combinations were better documented

The following descriptions of the three most commonly used rootstocks in the AHWR may be useful in identifying their usefulness in future plantings (P&GIB 2003).

Schwarzmann

- Moderate in vigour
- Improves fruit set in scion (when planted in the correct environment)
- Moderate to low yielding in cool and warm climates **but** moderate to high yielding in hot areas
- Low to moderate yielding on acidic soils
- Good nematode resistance
- Performs best on deep sandy soils with adequate soil moisture.
- Does not tolerate high levels of lime

5C Teleki

- Moderate in vigour
- Improves fruit set in scion (especially Merlot)
- Early maturation
- Good nematode resistance
- Well suited to well drained fertile clay or clay loam soils
- Tolerance to calcareous soils
- Performs less well on acid soils

101-14

- Low vigour (which may encourage fruit quality) and has active resistance to lime (Galet 1998)
- Low yielding in cooler climates similar to *Vitis vinifera*
- Short vegetative and small open canopies which may advance maturity
- Can tolerate active lime but is not suited to acid soils
- May be susceptible to waterlogging
- Low / moderate resistance to root knot nematode
- Good tolerance to salt

Table 4: Variety & Rootstock combinations in use in the Adelaide Hills Wine Region

	Total Plantings (Ha)			
Rootstock	**Chardonnay**	**Pinot Noir**	**Merlot**	**Sauvignon Blanc**
101-14	3.86	4.09	0.27	1.39
140 Ruggeri	2.14	0.2	0.5	
1103 Paulsen			1.05	
5A Teleki		0.3	1.3	
5BB Kober	1.74		0.34	
5C Teleki	5.9	4.91	6.1	
Ramsey	4.35	1.33	0.45	
Schwarzmann	17.85	3.21	11.18	1.4
Yes	3.25	5.41	11.24	
Own Roots	765.02	494.46	298.83	507.36
Total rootstock plantings (ha)	**39.09**	**19.18**	**32.43**	**2.79**
Total plantings (ha)	**804.11**	**513.64**	**331.26**	**510.15**
Total rootstock as % of variety area	**4.86**	**3.73**	**9.79**	**0.55**

Source: Mr Nick Dry, P&GIB 2004

The use of rootstocks with Merlot appears to be higher than for the rest of the varieties. According to P&GIB this trend is common throughout all regions and is most probably related to:

- Certain rootstocks' propensity to improve fruit set, *eg* 5C Teleki
- Using rootstocks in an attempt to increase the vigour of the inherently lower vigour Merlot

The percentage of Sauvignon Blanc on rootstock is particularly low. This is probably related to existing vigour management concerns with Sauvignon Blanc and an uncertainty as to how this inherently high vigour scion will perform on rootstocks.

3.5 Yields

This Regional Profile was not intended to gather detailed yield data, however for the sake of completeness some general comments are provided here. Our survey of wine makers and viticulturalists indicates that the following yields are appropriate for high quality wine product:

Sparkling Base

Chardonnay	10 – 15t/ha
Pinot Noir	10 – 15t/ha

White Table Wine

Chardonnay	8 – 10t/ha
Sauvignon Blanc	up to 15t/ha

Red Table Wine

Highest quality maximum 7 – 8t/ha

Actual production figures show significant variation around these yields. Some reds perform best at 4 – 6t/ha, whilst red yields above 8t/ha are known but quality is generally poor to average, mainly due to poor ripening. White varietal yields can be higher, as indicated without jeopardising ripening, but varietal flavour seems to drop off after about 10t/ha.

Annual yields in the AHWR are significantly influenced by climate which can adversely affect both fruit set in any one season, and fruit initiation for the following season.

For this reason many wine grape producers prune to higher bud numbers than they may desire for fruit quality, so as to allow for poor set, and lower than anticipated yields.

Different wine styles require fruit of differing character, and it is clear that the AHWR does provide a range of environments for a range of fruit styles.

4.0 CLIMATIC PROFILE

Despite the climatic diversity seen within the AHWR, the climate is described as one of high rainfall, especially in comparison with the rest of South Australia. Annual rainfall ranges from around 680 mm at Kersbrook to over 1200 mm at Stirling. Despite this wide range of rainfall, the pattern in which it falls is very similar for all sites, and is strongly representative of a Mediterranean climate.

Summers are warm and dry in comparison with winter, but summer temperatures are significantly lower than in areas outside the AHWR. In general, the AHWR does not suffer from the summer temperature extremes experienced in other parts of South Australia. On average, there are less than 11 days of the year which reach more than 35^{o}C, even in the warmest areas (Bureau of Meteorology 2004). Most rainfall is received during the winter months and summers are considered to be dry. A moisture deficit generally occurs in all parts of the Adelaide Hills between February to May (ie, evaporation exceeds rainfall). Therefore, availability of supplementary water during these months is an important consideration for all vineyards, although it may not be required in all seasons.

4.1 Weather Station Data

Weather station data can be a useful tool not only for selecting sites and varieties, but also for the management of existing vineyards. A total of 11 official Bureau of Meteorology (BOM) sites have been collecting temperature data (minimum and maximum) and Relative Humidity within the Adelaide Hills for varying periods since observations started in South Australia. In addition, several other sites, including Belair and Strathalbyn, which fall just outside the AHWR, have been collecting data which may be useful to this Profile despite being located outside the official region.

Of the 11 sites within the Adelaide Hills Wine Region, only 6 are still currently active, but only 4 stations are relevant to viticulture because Mt Crawford Fire Tower is on an exposed peak and Mt Lofty collects only rainfall information. Although many are no longer collecting data, 6 stations have 20 or more years of data which is relevant to this Profile for long term trends. Rainfall data is much more extensive, with many additional sites collecting data.

Table 5: Location of BOM sites.

Site Name	Opened	Closed	Years of data	Comment
Mt Barker	1863	Still Open	**143**	Sheltered site
Mt Crawford Forest Headquarters	1967	Still Open	**37**	
Mt Crawford Fire Tower	1996	Still Open	**7**	On exposed peak
Stirling Post Office	1964	1985	**21**	
Stirling	1884	1964	**80**	
Lenswood Research Centre	1967	Still Open	**37**	
Kuipto Forest HQ	1971	1998	**27**	
Kuipto Forest Reserve	1998	Still Open	**6**	
Kersbrook Forest Reserve	1973	1983	**6**	
Piccadilly	1994	1996	**2**	
Mt Lofty	1993	Still Open	**11**	Only collects rainfall
Belair	1900	1996	**70**	

The obvious gaps in the data base decrease the ability to accurately predict climatic events or to attribute certain vine physiological responses to climatic events. This is further discussed in section 4.4. There is a small number of Private Automated Weather Stations (PAWS) now operational in the AHWR. These PAWS can record various parameters such as temperature, rainfall, relative humidity, soil temperature, leaf wetness, day light hours and degree days. PAWS can provide much more detailed and specific weather data than current BOM stations as they are usually placed in areas of viticultural interest.

The inconsistency of the parameters measured from BOM stations highlights the need for an increased number of PAWS in the Adelaide Hills Wine Region, and for this data to be networked, collated and distributed by a central organization, such as the Bureau of Meteorology. This would allow the AHWR to access and use a more complete and informative data base for day to day management as well as project planning.

Climatic data from the BOM sites in the AHWR has been summarised in Table 6. This table allows for general comparisons of climatic indices for 9 sites listed in the AHWR. The calculations are based on averages over the life of the recording station and are in accordance with standard industry methods of calculations.

A description of the tabulated indices follows Table 6.

Table 6: Climate Summary

	Stirling	Stirling PO	Lenswood	Mt Crawford	Mt Barker	Kersbrook	Kuitpo Forest	Belair	Strathalbyn
Elevation (m)	496	496	480	395	360	340	300	305	70
DD (standard)	1172	1263	1422	1318	1416	1583	1402	1711	1713
DD (19/10)	1172	1260	1395	1304	1397	1479	1395	1580	1622
DD (BEDD)	1150	1248	1392	1198	1332	1436	1351	1577	1597
% Years Ripen Cabernet[1]	11%	33%	81%	8%	53%	#	60%	100%	100%
Mean January Temperature - MJT	18.2	18.7	19.2	19.2	19.5	20.4	18.9	20.7	20.5
Mean Ripening Month Temperature (March)	16.7	16.6	17.6	17.0	17.5	18.2	16.9	19.2	18.8
Mean Ripening Month Temperature (April)	13.3	13.8	14.7	13.8	14.3	14.6	14.3	16.2	15.9
Continentality Factor	10.6	11.2	11.1	11.7	10.8	12.4	10.9	11.4	10.2
Ave 9am RH (Oct-Apr)	51.6	55.4	67.4	64.1	61.7	65.6	67	61.9	60.3
Sunshine Hours (Oct –Apr)	n/a	n/a	8.4	n/a	n/a	n/a	n/a	n/a	n/a
Spring Frost Index	10.1	10.5	12.7	10.9	12.9	13.3	12.0	12.3	14.5
Mean Frost Incidence (Sept-Nov)	3.7	1.7	0.4	7.9	4.7	1.1	1.6	0	1.2
Mean no days > 35C	5.7	4.5	5.3	10.2	10.9	11.8	9.9	7.9	16.4
Mean no days < 2.2C (Oct-Apr)	1.1	0.7	0.2	13.3	4.3	1.7	3.4	0	0.6
Mean no foggy days (Oct-Apr)	n/a	8.3	3.2	2.1	3.9	n/a	2.5	1.3	n/a
Annual Rainfall (mm)	1189	1118	1028	755	766	734	835	723	492
Oct-Apr Rainfall (mm)	422	426	351	267	284	287	301	271	203
Ripening Month Rainfall (April)	95.8	96.7	74.7	53.3	58.9	62	64.5	58.2	38.4
No of rain days (Oct-Apr)	63	68	66	56	58	59	60	45	51

1. Percentage of years with accumulated BEDD greater than 1300.
Insufficient data available due to missing data records.

4.2 Some indices used for climate descriptions

4.2.1 Elevation

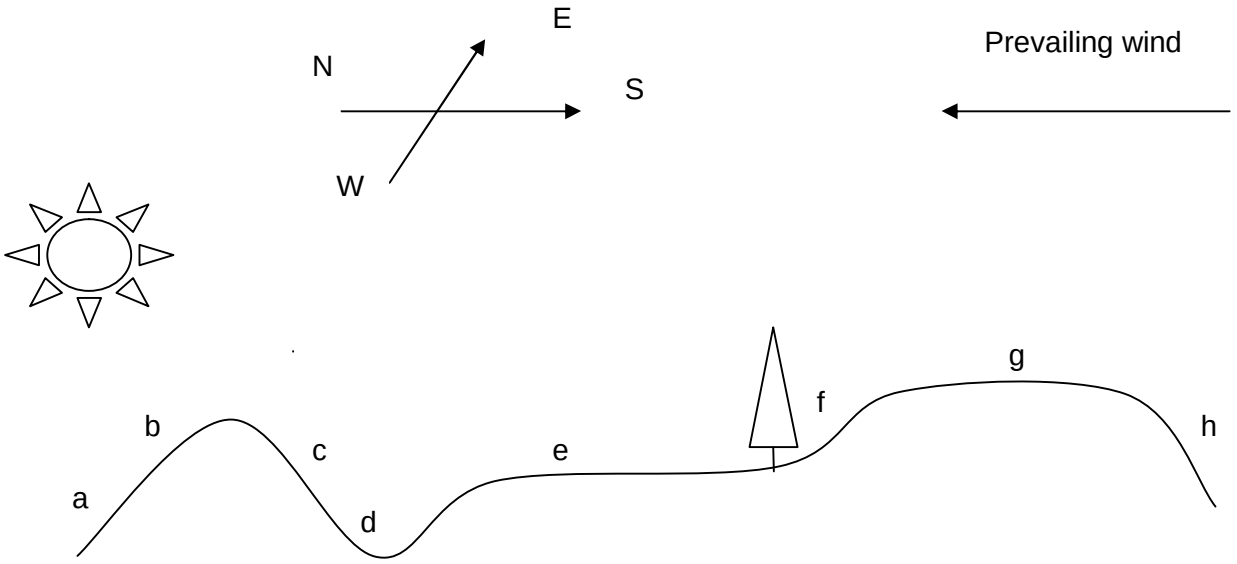
The AHWR has a nominal elevation of around 400m (Henschke, 1993), although points as low as 300m do exist, such as the floor of the valley around Hahndorf and in a number of the outlying areas such as Kuitpo. Many vineyards of the Piccadilly Valley and Lenswood are much higher than this, situated at between 500m and 600m (Wine Industry Journal 1995). The impact of elevation on mesoclimates and the ability to ripen grapes is due to several factors. Gladstones (1992) suggests that for every 100m increase in altitude there is a corresponding drop in mean temperature of 0.6^{o}C. This has a direct impact on the ripening ability of any given grape variety, which can be predicted by heat summation models, as demonstrated by Gladstones.

4.2.2 Aspect

As the AHWR is located within a relatively narrow mountain range, a wide variety of slopes and aspects exist. This makes each individual vineyard within the region unique; and hence subregion classification difficult. Aspect determines the amount of exposure a vineyard has to the sun and therefore its relative warmth in relation to the local climate. The warmest aspects are those facing north, north-easterly and easterly, while westerly aspects, which are cool in the morning but receive the harsh afternoon sun, are the next warmest aspects (Wine Industry Journal 1988). Southerly aspects are the coolest.

Slope, along with aspect, also has an important impact on the mesoclimates in the Adelaide Hills. A steep slope, particularly when combined with a warm aspect (i.e. northerly or easterly) may greatly increase the opportunity for a given variety to ripen fruit fully.

Figure 4. Effect of aspect, slope and elevation upon vineyard mesoclimates (source Jackson and Spurling (1988)).



(a) This warm site will intercept more sunlight due to the lie of the land and will miss late spring and early autumn frosts as the cold air can drain to lower lying areas.
(b) This site has counteracted the advantages seen in (a) due to its increase in altitude, decreasing temperatures.
(c) This site is cold and will accumulate less heat in summer due to its elevation, exposure to prevailing wind and poor exposure to the sun. It may however miss spring and autumn frosts.
(d) This site is very cold and susceptible to frosts as cold air will drain to this point from the surrounding region.
(e) This site is frost prone but less than (d). Prevailing winds should be decreased by the hill and dense tree plantation.
(f) The dense tree planting at the base of the hill prevents cold air from draining away from this site, and hence a frost- free site has been lost.
(g) This site is warmer than (e) but the prevailing wind and increase in altitude may hinder the accumulation of heat in summer.
(h) Cold, like (c) above.

4.2.3 Temperature and Degree Days (DD)

Degree Days refers to the summation of the mean monthly temperature above 10ºC. Degree Days is a temperature-time integration of growing season conditions (Smart 1979). Temperature related indices are commonly used for two reasons; temperature has a significant impact on plant growth, and it is one of the cheapest and easiest climatic indices to measure.

Indices have been devised from heat summation factors to predict the suitability of districts for grape production. The heat summations for climatic regions are listed by Winkler et al (1974)

Table 7: Climatic Regions

Region	Heat summation ºF	Heat summation ºC	Examples of Regions
I	less than 2500 DD	(less than 1371DD)	Coonawarra & Blenheim, NZ
II	2501 **à** 3000 DD	(1372 **à** 1649 DD)	Barossa Valley and Auckland, NZ
III	3001 **à** 3500 DD	(1650 **à** 1927 DD)	Clare Valley & Montpellier, France
IV	3501 **à** 4000 DD	(1928 **à** 2204 DD)	McLaren Vale and Cape Town, South Africa
V	4001 DD or more	(2205 DD or more)	Hunter Valley and Fresno, USA

The AHWR is generally classed as a Region I, having approximately 1200 DD above 10ºC, however there are sites which fall into Region II.

There are three methods of calculating Degree Days: “Standard Base 10°”, “19/10” and “Biologically Effective Day Degrees (BEDD)”.

4.2.3.1 Standard Base 10 Calculation

Base 10 is calculated by the summation of the mean monthly temperature minus 10 and multiplied by the number of days in the month. 10ºC is used as the base temperature on the assumption that little or no growth occurs below 10ºC. This index is calculated for the fixed period of October to April. This has been identified as the standard HDD summation. Within the AHWR Kersbrook has the highest Day Degree Summation (Base 10) of 1583°, followed by Kuipto (1402°), Mt Barker (1416°) and Lenswood (1422°). Stirling has the lowest day degree summation of all the “subregions” in the AHWR.

4.2.3.2 19/10 Calculation

Gladstones (1992) developed a different method, whereby any month with a mean temperature greater than 19°C or higher is truncated at 19°C; ie. a maximum day degree summation of 279° is the highest summation possible for any month. Thus the 19/10 DD is the mean temperature (truncated at 19°C) minus 10°C, multiplied by the number of days in that month, and summed over the growing season.

The “subregions” which have the highest day degree summation (19/10) are Kersbrook (1479°), Mt Barker (1397°) and Kuipto (1395°). Stirling (1172°) and Mt Crawford (1304°) show some of the lowest accumulation of day degrees in the region.

4.2.3.3 Biologically Effective Day Degrees Calculation

Biologically Effective Day Degrees (BEDD) is a climatic index that has been derived from the HDD summation. It limits summation to between 10°C and 19°C and also adjusts for latitude and daily temperature range. This climatic index is the most common and comprehensive temperature-time measure used in the Australian viticultural industry, and hence will be the main Day Degree summation referred to in this report.

Different varieties require different heat summations in order to ripen fruit fully. Examples given by Gladstones (1992) are:

Pinot Gris	1100º BEDD
Pinot Noir	1150º BEDD
Chardonnay	1150° BEDD
Sauvignon Blanc	1150° BEDD
Shiraz	1250° BEDD
Merlot	1250° BEDD
Cabernet Sauvignon	1300° BEDD

Stirling	1150º BEDD
Mt Crawford	1198º BEDD
Mt Barker	1332º BEDD
Kuitpo	1351º BEDD
Kersbrook	1436º BEDD

Stirling (1150°) and Mt Crawford (1198°) in most cases will not ripen red varieties such as Cabernet Sauvignon, Shiraz and Merlot and may be marginal for ripening white varieties such as Chardonnay and Sauvignon Blanc in certain mesoclimates.

4.2.4 Mean January Temperature (MJT)

MJT is a simple calculation of how warm a specific site or region is, and is the average of the monthly maximum and minimum temperatures.

Throughout the AHWR there is a 2.2°C difference in MJT for the 7 “subregions” assessed for climate in this report. As would be expected from the rankings of day degree summation, Stirling has the lowest MJT (18.2°C) and Kersbrook has the highest MJT (20.4ºC).

4.2.5 Mean Daily Range (MDR)

Mean Daily Range (MDR) is the difference between daily maximum and minimum curves which indicates the constancy of temperature (Smart & Dry 1979). In best conditions the maximum and minimum values for the ripening period should be parallel. Due to the lack of daily weather station data available there are no comparisons of this index for the AHWR "subregions".

4.2.6 Mean Ripening Month Temperature

Mean ripening month temperature is the mean temperature of the 30 days prior to the expected harvest date for any variety. Gladstones (1992) suggests that there is a broad association between mean temperature of the ripening month and the styles of wine which can be produced.

Sites with ripening month average mean temperatures below 15°C may or may not allow full sugar ripeness. Ripening month average mean temperatures of between 15°C and 21°C will generally allow for well balanced wines for dry table wines. Comments from the survey of wine makers confirm that wines which are made from grapes grown closer to 15°C tend to be lighter bodied, more fresh and delicate, whilst wines produced from grapes with mean ripening month temperature closer to 21°C are likely to be more full bodied.

4.2.7 Continentality or Mean Annual Range (MAR)

Continentality is an index which measures the difference between the mean temperature of the warmest and coolest months. It is commonly overlooked when comparing climatic conditions of sites. It is often used as a measure of the moderating influence of large water bodies.

A comparison of the continentality of various sites in the Adelaide Hills shows that there are only marginal differences and these do not seem to be correlated with distance from Gulf St Vincent or Lake Alexandrina . The distance to Gulf St Vincent ranges from about 12km near the Willunga Range & Kuitpo to over 50km at Mt Pleasant.

4.2.8 Sunshine Hours

The amount of sunshine at the time of flowering has a direct impact on fruit set through enhanced photosynthesis. Sunshine hours can be considered at specific times during the growing season, or over the seven month growing season period as a general indication.

A figure of 1250 sunshine hours from October to April is a generalised requirement for viticulture according to Gladstones (1992) and Becker (1997). This equates to approximately 5.9 hours per day. The AHWR exceeds this requirement with an average of 1750 sunshine hours observed (Gladstones 1992). In the AHWR, sunshine hours are only available for the Lenswood site, which receives 8.4hours/day of sunlight on average during the growing season. Dry & Smart (1988) have calculated sunshine hours for each MJT category in Australia. Lenswood with 8.4 hours/day exceeds every other region with an MJT below 20.9ºC, ie, Yarra Valley, Launceston, Coonawarra and Mt Barker, W.A Sunshine hours are available on a large scale by interpretation and extrapolation from a climatic atlas and thus will not be discussed for each "subregion" identified in the report.

4.2.9 Relative Humidity (%RH)

Relative humidity is an important climatic index for determining disease risk, irrigation requirements and potential for heat damage due to persistence of hot dry winds. The 9am %RH of Jan is used as an index of relative humidity for the season (Gladstones 1992). For the purposes of this climatic summary the average over the growing season has been used as the index as it accounts for more humid conditions experienced during flowering and harvest. There is little variation in humidity records between the sites, with 51.6% at Stirling to 67% at Kersbrook.

According to Dry and Smart (1988) **a moderate to high incidence of bunch rot** is expected when the following conditions occur in the ripening month

Rainfall exceeds 60mm
Rain days exceed 8
9am RH exceeds 60%

These conditions are most likely to occur at Kuitpo, Stirling, Kersbrook and Lenswood in April.

Dry & Smart (1988) also suggest that **a moderate to high incidence of downy mildew can be expected** when the following conditions occur throughout the season:

Rainfall (Oct – Mar) exceeds 200mm
Rainfall (Nov) exceeds 40mm
Raindays (Oct-Mar) exceed 40
9am RH (Nov) exceeds 60%

These conditions are most likely to occur at Kuitpo, Stirling, Lenswood and Mt Barker

4.2.10 Spring Frost Index

Gladstones (2000) has established an index known as Spring Frost Incidence. The SFI is calculated as the spring months' average mean temperature minus its average lowest minimum temperature, usually recorded between the months of October and November. Stirling and Mount Crawford have the lowest chance of frost, whilst Mount Barker has the highest (Gladstones 2000).

When comparing this with data collected by Gladstones (1992), frost risk in the AHWR is similar to that experienced in Coonawarra, Clare, Reims (France), Fresno (California) and Blenheim (NZ)

4.2.11 Rainfall

Rainfall is an important factor to consider in the climatic evaluation of a viticultural region because of its impact on irrigation requirements and the potential disease risk associated with ripening month rainfall

4.2.11.1 Annual Rainfall

The highest annual rainfall recorded by selected BOM weather stations in the AHWR is 1189 mm at Stirling (excluding sites which are irrelevant to viticulture eg. Mt Lofty Fire Tower). Kersbrook and Mt Crawford are the driest "subregions" within the Region, receiving 734mm and 755mm respectively.

4.2.11.2 Growing Season Rainfall

Growing season rainfall is measured as the total rainfall for October to April, and is useful for the aridity index (irrigation requirements) and disease risk assessment. The distribution of annual rainfall and growing season rainfall are similar.

4.2.11.3 Ripening Month Rainfall

The Ripening month rainfall index is used mainly to predict the disease risk associated unfavourable ripening month conditions, such as downy mildew more importantly Botrytis. It is the summation of rainfall (mm) for the 30 days preceding the expected harvest date.

4.2.11.4 Number of Rain days (October - April)

This index is used as a predictor of disease pressure during the growing season. There is little variation in the number of rain days in the AHWR between "subregions".

4.3 Ripening Issues – Biologically Effective Day Degrees (BEDD)

BEDD is an index which indicates ripening potential based on heat accumulation of the growing period. The basis of this index is that growth of vines only occurs above 10°C and that further increases in temperature above 19°C have no further influence on heat summation. Summation relates to the amount of heat experienced above the baseline of 10°C for the entire growing season (Gladstones 1992) – see Section 4.2.3.3.

Indices which relate to phenological development and site suitability such as Mean January Temperature (MJT), Sunshine hours and Degree Days (DD) have been researched by many; with the main index used being more recently is Biologically Effective Day Degrees (BEDD). The difference between DD and BEDD is that DD sums the mean monthly temperature at base 10°C. BEDD also uses a base value of 10°C but values are truncated at above 19°C, and also incorporates factors for latitude and mean daily range (MDR).

In the following section of this Profile, a summary of each BOM site attempts to validate the data and make it applicable to vineyard sites in each area. A table has been produced for each BOM site which gives the BEDD for the actual site as well as some example site adjustments for effects of elevation, aspect and cold air drainage. Details of adjustments and categories are given at the end of this section. Below is the key for the tables for each site.

Reliable		> Required BEDD +5%
Marginal		Between Required BEDD -5% and required BEDD +5%
Unreliable		< Required BEDD -5%

The Kersbrook site listed above was only operational for a relatively short period and has a large amount of missing data. Therefore, some calculations are not available due to insufficient data. Care should be taken when making comparisons with Kersbrook due to the poor quality of the database.

Explanation of BEDD tables

BEDD figures are calculated according to Gladstones model (1992), as explained in Section 4.2.3.3. Maturity groupings and required BEDD are also from Gladstones (1992). It is important to note that maturity groupings are based on ripening to table wine specifications. Therefore, for sparkling wine production, Pinot Noir and Chardonnay may shift down a group. Unreliable, marginal and reliable categories are based on a variation of +/- 5% each side of the required BEDD as follows:

Reliable:	Greater than required BEDD + 5%
Marginal:	Between required BEDD + 5% and required BEDD – 5%
Unreliable:	Less than required BEDD – 5%.

These figures have been chosen arbitrarily, but do approximately reflect the standard deviation of annual BEDD, calculated for longer term sites. Ground-truthing may indicate that this figure should be adjusted.

Vineyard Site Adjustments

Elevation

- An adjustment of +0.6^{o}C is made to both mean maximum and minimum temperatures for every 100m decrease in altitude.
- An adjustment of -0.6^{o}C is made to both mean maximum and minimum temperatures for every 100m increase in altitude.

These adjustments are based on recommendations by Gladstones (1992).

Aspect

- The aspect of the recording site is assessed as either sunny or not sunny.
- If the recording site has a sunny aspect, sites without a sunny aspect have mean maximum temperatures adjusted down 0.25^{o}C and mean minimum temperatures adjusted down 0.75^{O}C.
- If the recording site does not have a sunny aspect, sites with a sunny aspect have mean maximum temperatures adjusted up 0.25^{o}C and mean minimum temperatures adjusted up 0.75^{O}C.

These adjustments are based on recommendations by Gladstones (1992).

Cold air drainage

- If the vineyard site is considered to be a cold air drainage sump, the mean minimum temperature is adjusted down 0.7^{o}C. The mean maximum temperature is unchanged.

This adjustment is based on observations made comparing the two Stirling sites, due to a lack of data regarding this adjustment.

4.3.1 Lenswood

The BOM officially recorded a full range of climate data at Lenswood from 1967 to 1999. Today, only rainfall is officially recorded by the BOM. However, Lenswood Research Station has an automatic weather station still in operation on the same site and is able to provide an almost complete data set from 1999 to present.

The Lenswood recording site is situated on top of a range behind the Lenswood Research Station. The site is flat and relatively exposed.

Although this site is at the higher end of elevation for Lenswood (480m), its full exposure to the sun during the day and its distance from cold air drainage points would have a significant impact upon temperatures. Therefore, despite its elevation, it is likely to be a significantly warmer site in comparison to sites on the valley floor. This is supported by local experience, where it was observed over a number of years that temperatures at a site adjacent to the main office of the Lenswood Research Centre (on a relatively low site) was consistently approximately 1^{o}C cooler when compared to the BOM site (D. Traeger, pers. comm.).

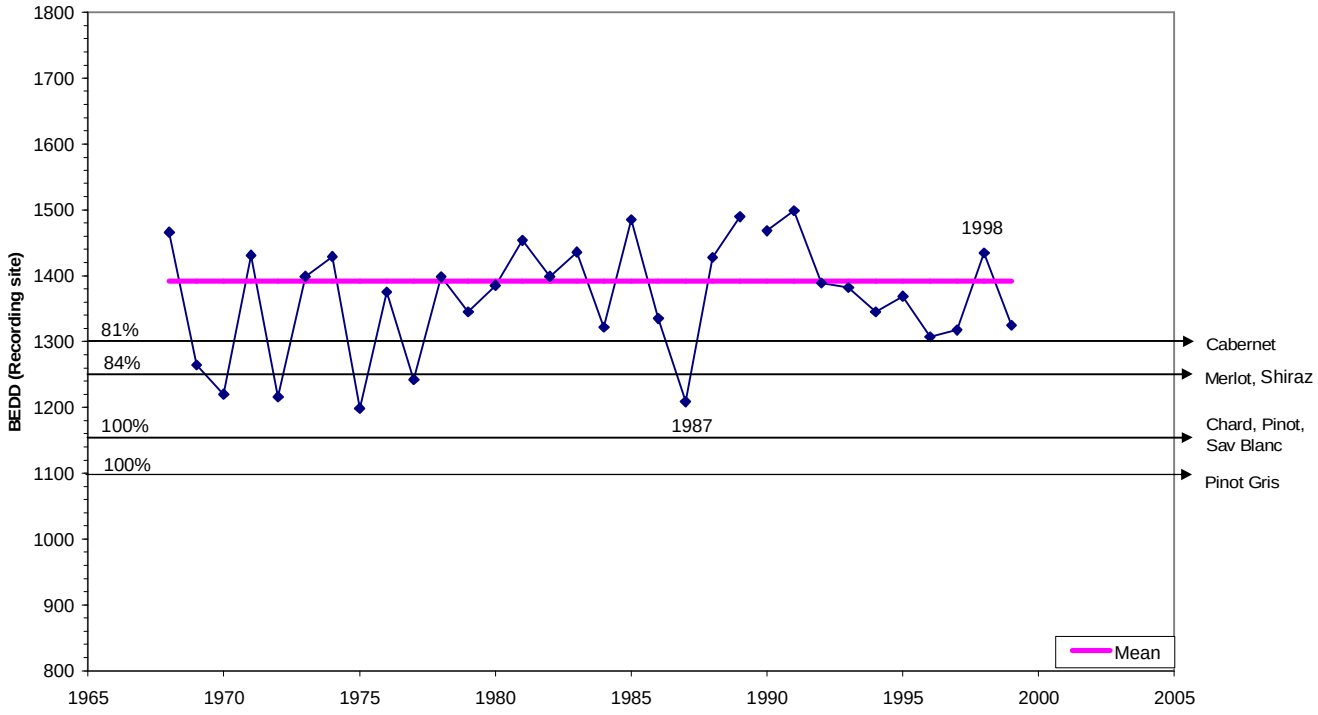
As a result of this site information, it is important to consider that the Lenswood BOM site is likely to be representative of a cooler site within the Lenswood region. The table below gives some examples of the effect of precise vineyard site on the ripening ability of varieties based on Gladstones' degree day model (1992).

			Group 6	Group 5	Group 3	Group 2
			Cab Sauv	Merlot & Shiraz	Pinot Noir, Chardonnay, Sauv Blanc	Pinot Gris
Vineyard Site	Elevation (m)	BEDD	> 1300	> 1250	> 1150	> 1100
Lenswood BOM Site*	480	1392				
Higher elevation	520	1349				
Lower elevation	420	1452				
Same elevation, cold air drainage	480	1317				
Same elevation, cool aspect	480	1294				
Same elevation, cold air drainage, cool aspect	480	1205				

* Sunny, flat, away from cold air drainage points.

Reliable		> Required BEDD +5%
Marginal		Between Required BEDD -5% and required BEDD +5%
Unreliable		< Required BEDD -5%

Figure 5: Annual BEDD comparison at Lenswood



This indicates that from the data available, all white varieties and Pinot Gris can be ripened at Lenswood in all years, but red varieties are only likely to ripen in 81 – 84% of years.

4.3.2 Mt Barker

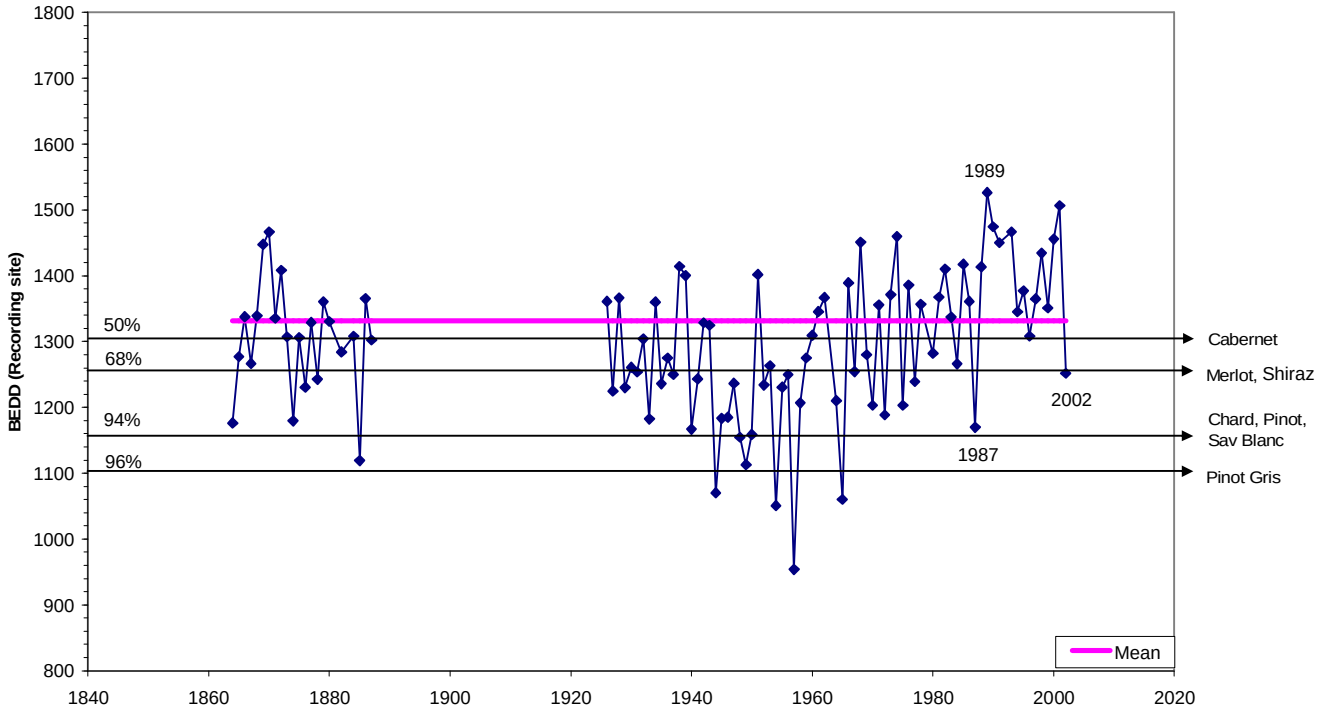
Mt Barker has the most extensive records of any BOM site; however, the location of the recording station has changed on several occasions throughout the recording period. The station which has taken the most recent recordings is located within a yard behind the Post Office and is therefore not representative of a viticultural climate.

			Group 6	Group 5	Group 3	Group 2
			Cab Sav	Merlot & Shiraz	Pinot Noir, Chardonnay & Sauv Blanc	Pinot Gris
	Elevation (m)	BEDD	>1300	>1250	>1150	>1100
Mt Barker BOM site*	360	1332				
Higher elevation	450	1219				
Lower elevation	300	1407				
Same elevation, cold air drainage point	360	1232				
Same elevation, cool aspect	360	1209				
Same elevation, cold air drainage, cool aspect	360	1105				

* Sunny aspect, away from cold air drainage, flat

Reliable	> Required BEDD +5%
Marginal	Between Required BEDD -5% and required BEDD +5%
Unreliable	< Required BEDD -5%

Figure 6: Annual BEDD comparison at Mt Barker



This indicates that from the data available white varieties and Pinot Gris can be ripened in 94 – 96% of years. Red varieties can be ripened in 50 – 68% of years.

4.3.3 Stirling

The exact location of the Stirling BOM site is located slightly south of, but quite close to the Stirling Post Office site (BOM, pers. comm.). Despite the close proximity to Stirling PO, average temperatures are significantly lower than at the Stirling PO. While mean maximum temperatures are similar, it is the significantly lower minimum temperatures which impact upon the mean temperature and therefore the heat summations. The reason for this difference in minimum temperature is due to more pooling of cold air at the Stirling site in comparison to the Stirling PO site.

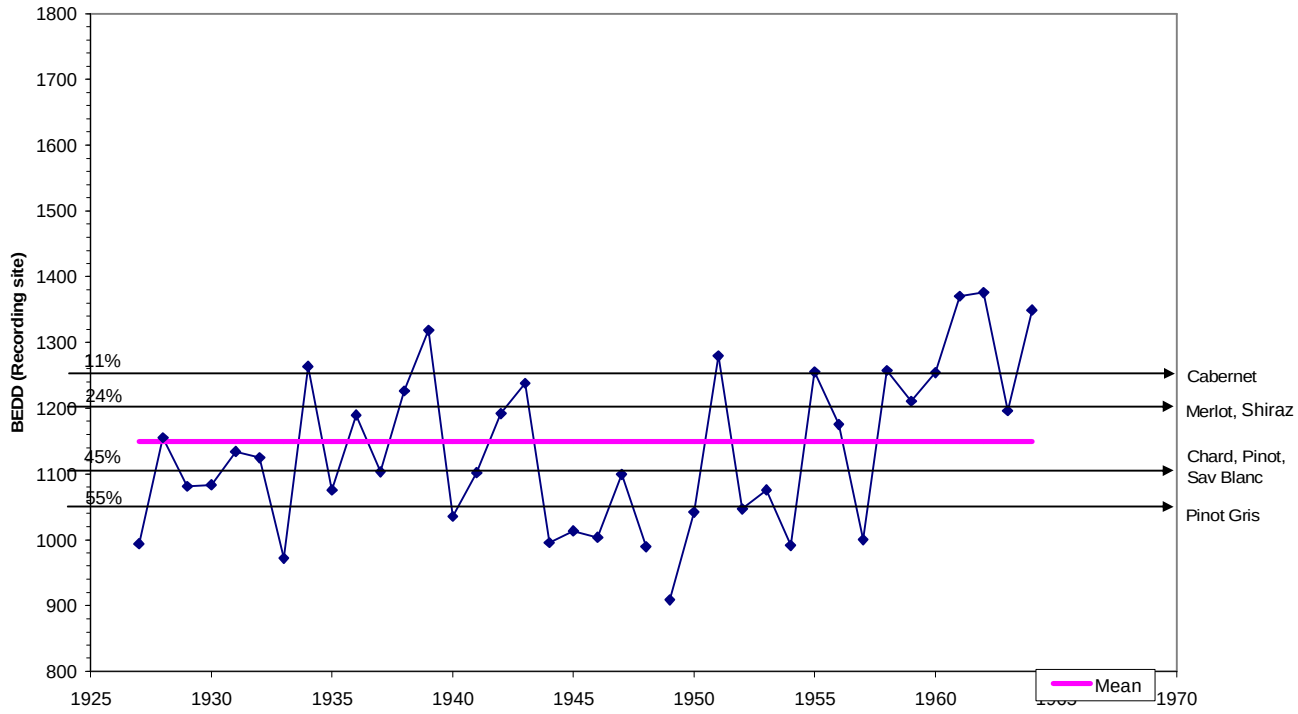
Therefore, Stirling could be considered to represent the coolest extreme of sites in the Stirling area and in particular, those that are located at pooling points for the drainage of cold air eg. bottom of valley etc.

			Group 6	Group 5	Group 3	Group 2
			Cab Sav	Merlot & Shiraz	Pinot Noir, Chardonnay & Sauv Blanc	Pinot Gris
	Elevation (m)	BEDD	>1300	>1250	>1150	>1100
Stirling BOM site*	496	1150				
Higher elevation	550	1083				
Lower elevation	420	1245				
Same elevation, away from cold air drainage	496	1237				
Same elevation, cool aspect	496	1036				

* Cold air drainage point, flat, sunny aspect

Reliable	> Required BEDD +5%
Marginal	Between Required BEDD -5% and required BEDD +5%
Unreliable	< Required BEDD -5%

Figure 7: Annual BEDD comparison at Stirling



This indicates that from the data available, white varieties and Pinot Gris can be ripened in 45 – 55% of years. Red varieties can only be ripened in 11 – 24% of years.

4.3.4 Stirling Post Office

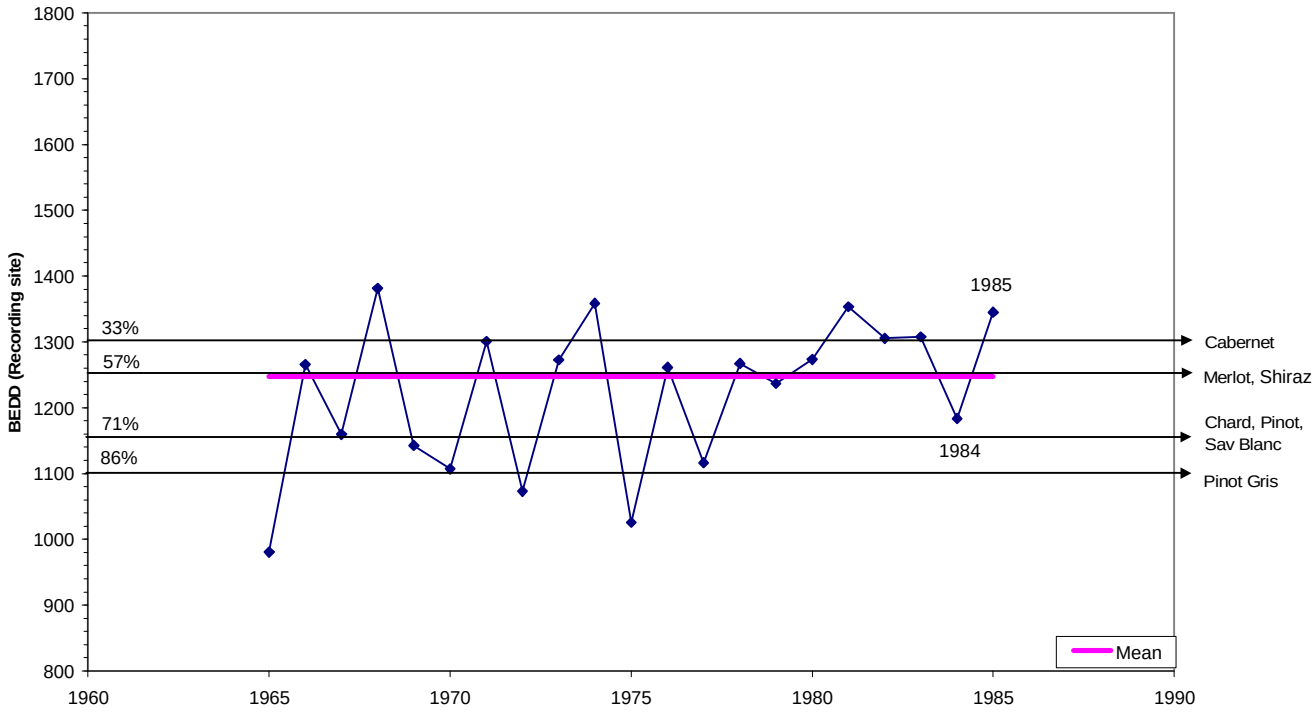
The Stirling PO site operated between 1964 and 1985. It was located approximately 200m from the Stirling PO behind the Stirling council chambers at a site which now is a car park. The site is between a creek valley and the built-up area of Stirling, which may have some impact on temperatures. Many of the present buildings would not have been there during the period of data collection, so it is likely that the site was more exposed then than it is now. The site is relatively flat and effectively exposed to the sun for most of the day. Therefore, it is likely to be indicative of the warmer sites of the Piccadilly Valley. Sites at lower elevation, but away from cold air drainage points are likely to be significantly warmer. Sites with less exposure are likely to be significantly cooler.

			Group 6	Group 5	Group 3	Group 2
			Cab Sav	Merlot & Shiraz	Pinot Noir, Chardonnay & Sauv Blanc	Pinot Gris
	Elevation (m)	BEDD	>1300	>1250	>1150	>1100
Stirling PO BOM site*	496	1248				
Higher elevation	550	1180				
Lower elevation	420	1333				
Same elevation, cold air drainage point	496	1164				
Same elevation, cool aspect	496	1138				
Same elevation, cold air drainage, cool aspect	496	1049				

* Away from cold air drainage, flat, sunny aspect

Reliable	> Required BEDD +5%
Marginal	Between Required BEDD -5% and required BEDD +5%
Unreliable	< Required BEDD -5%

Figure 8: Annual BEDD comparison at Stirling Post Office



This indicates that from the data available, white varieties and Pinot Gris can be ripened in 71 - 86% of years. Red varieties can only be ripened in 33 - 57% of years.

4.3.5 Belair (Kalyra)

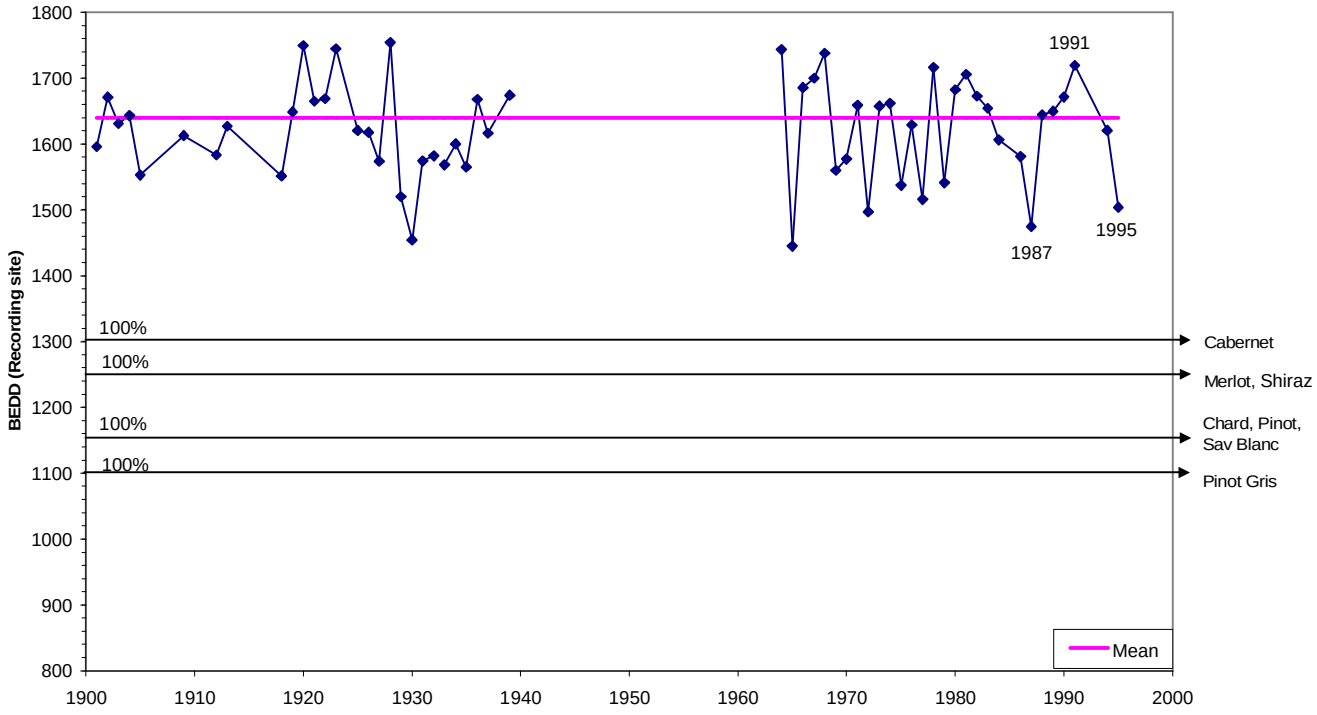
This site is located at 300m above sea level and therefore is moderated significantly by its altitude, despite its proximity to Adelaide. The site is fully exposed to the West and affords a view across the city of Adelaide. This makes it quite different to much of the Adelaide Hills, which are protected to the West and are less affected by sea breezes or the afternoon heat. Its proximity keeps minimum temperatures significantly above those of other Adelaide Hills sites and therefore increases the BEDD for the site. For the same reason, incidence and risk of frosts are very low. Despite Belair being just outside the GI for the AHWR it is an indicator of viticultural conditions at Cherry Gardens.

			Group 6	Group 5	Group 3	Group 2
			Cab Sav	Merlot & Shiraz	Pinot Noir, Chardonnay & Sauv Blanc	Pinot Gris
	Elevation (m)	BEDD	>1300	>1250	>1150	>1100
Belair (Kalyra) BOM site*	305	1640				
Higher elevation	400	1557				
Lower elevation	250	1678				
Same elevation, cold air drainage point	305	1581				
Same elevation, cool aspect	305	1560				
Same elevation, cold air drainage, cool aspect	305	1502				

* Away from cold air drainage, flat, sunny aspect

Reliable		> Required BEDD +5%
Marginal		Between Required BEDD -5% and required BEDD +5%
Unreliable		< Required BEDD -5%

Figure 9: Annual BEDD comparison at Belair



This indicates that from the data available, all varieties will ripen in all years.

4.3.6 Kuitpo Forest

The Kuitpo Forest BOM site is located in the Kuitpo Forest, 7.9km south west of Meadows. The station is located in a semi-exposed part of the forest in a 60m clearing. It sits on a sough facing slope and is 365m above sea level.

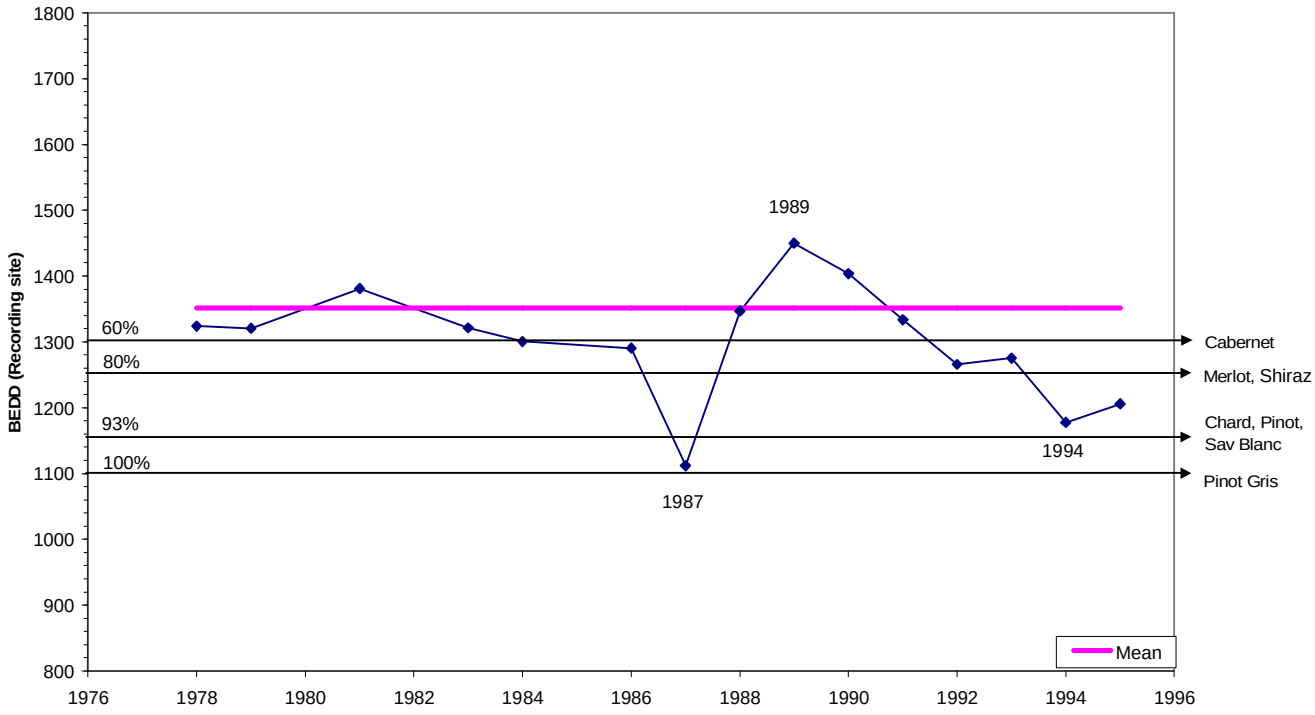
It is difficult to know how this site compares with a viticultural site due to the dense forest which surrounds it. No direct inferences for viticulture, however the data has been used in the absence of any more useful data.

			Group 6	Group 5	Group 3	Group 2
			Cab Sav	Merlot & Shiraz	Pinot Noir, Chardonnay & Sauv Blanc	Pinot Gris
	Elevation (m)	BEDD	>1300	>1250	>1150	>1100
Kuitpo Forest BOM site*	300	1351				
Higher elevation	400	1226				
Lower elevation	250	1413				
Same elevation, cold air drainage point	300	1251				
Same elevation, cool aspect	300	1228				
Same elevation, cold air drainage, cool aspect	300	1124				

* Away from cold air drainage, flat, sunny aspect

Reliable	> Required BEDD +5%
Marginal	Between Required BEDD -5% and required BEDD +5%
Unreliable	< Required BEDD -5%

Figure 10: Annual BEDD comparison at Kuitpo



This indicates that from the data available, white varieties and Pinot Gris can be ripened in 93 - 100% of years. Red varieties can only be ripened in 60 - 80% of years.

4.3.7 Mt Crawford

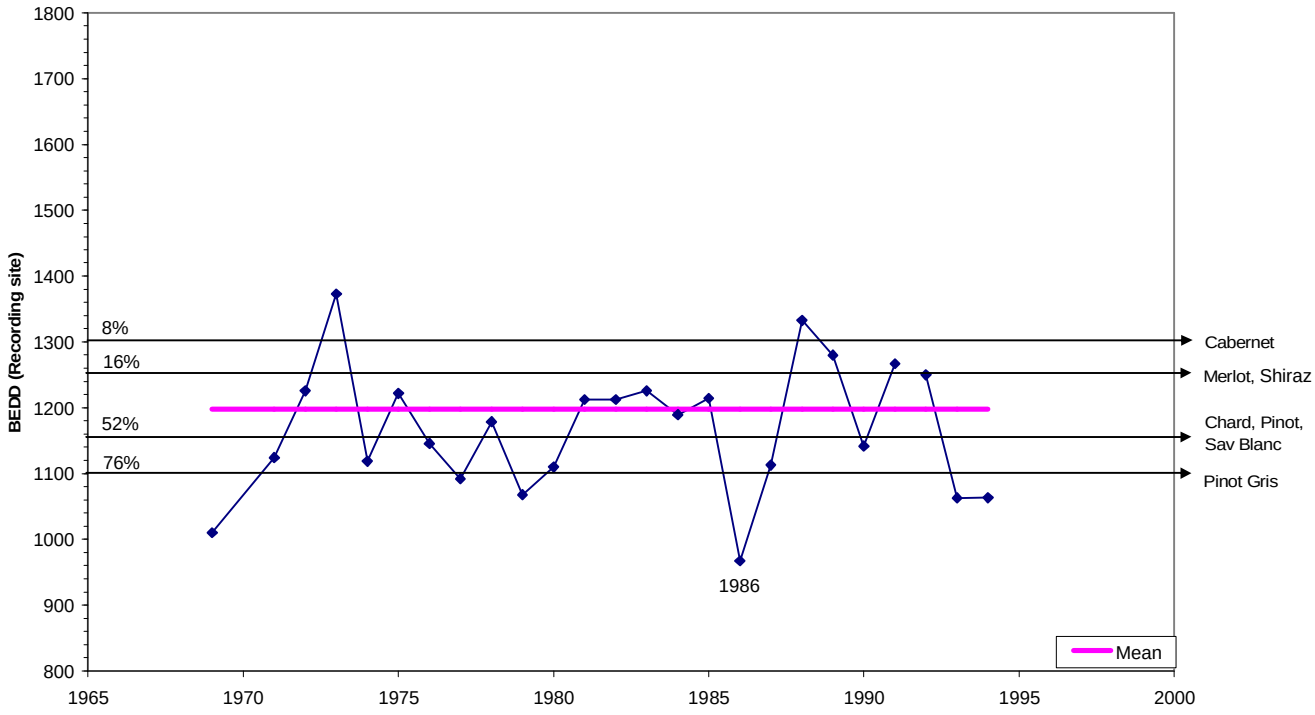
The Mount Crawford weather station was situated near the Mt Crawford Forest HQ, but it has been moved to a higher exposed site, which is quite different from the type of data collected previously and most likely not relevant to viticulture. Metadata from the BOM is available for this site, but has not yet been provided. It has been assumed that this site is affected by pooling from cold air drainage and has a sunny aspect.

			Group 6	Group 5	Group 3	Group 2
			Cab Sav	Merlot & Shiraz	Pinot Noir, Chardonnay & Sauv Blanc	Pinot Gris
	Elevation (m)	BEDD	>1300	>1250	>1150	>1100
Mt Crawford BOM site*	395	1198				
Higher elevation	450	1129				
Lower elevation	350	1254				
Same elevation, away from cold air drainage	395	1301				
Same elevation, cool aspect	395	1067				

* Cold air drainage point, flat, sunny aspect

Reliable	> Required BEDD +5%
Marginal	Between Required BEDD -5% and required BEDD +5%
Unreliable	< Required BEDD -5%

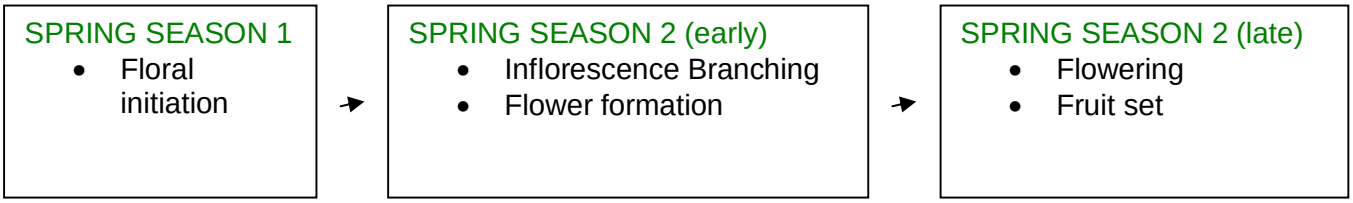
Figure 11: Annual BEDD comparison at Mt Crawford Forest



This indicates that from the data available, white varieties and Pinot Gris can be ripened in 52 - 76% of years. Red varieties can only be ripened in 8 - 16% of years.

4.4 Flowering and Fruit Set Issues Due to Climate

Poor yields as a result of unfavourable conditions during the spring flowering period appear to be one of the greatest concerns of viticulture in the AHWR. Below is a schematic diagram representing the timing of individual reproductive events. This diagram is important when attempting to analyse climatic events which may affect flowering and fruit set in grapevines.



4.4.1 Phenological Data

Phenology is the study of the natural growth of plants which recurs periodically, and the relationships of the growth to climate (Coombe 1988). Phenological data has the ability to describe the causes of variation in timing of growth by assessing the correlation between particular growth stages and climatic indices. Phenological data can help to predict how a grapevine will react to certain climatic conditions. This data plays an important role in decision making throughout phases of viticultural production such as:

- Site selection
- Vineyard layout
- Labour requirements
- Pest and Disease control
- Irrigation management

Existing information from AHWR Inc members has been collected in an attempt to asses site variation measured by phenological development (Table 8). However, this data is of little value as it is collected using differing parameters. In order to compare phenological data it must be recorded in a uniform manner.

Table 8 Phenological Data collected from AHWR growers

Variety	Location	2001/2002				2002/2003				2003/2004			
		Budburst	50% Flowering	Bunch Closure	Harvest	Budburst	50% Flowering	Bunch Closure	Harvest	Budburst	50% Flowering	Bunch Closure	Harvest
CHA	HAH						15-Dec	15-Jan	19-Mar		8-Dec	12-Jan	14-Apr
PIN	HAH						1-Dec	1-Feb	10-Mar		8-Dec	10-Jan	
SAB	HAH						20-Dec	20-Jan	13-Mar		12-Dec	5-Jan	8-Mar
CHA	LEN	20-Sep	12-Dec		24-Apr	5-Oct	26-Nov		1-Apr	10-Oct	29-Nov		2-Apr
SAB	LEN	29-Sep	15-Dec		23-Apr	15-Oct	28-Nov		26-Mar	12-Oct	8-Dec		8-Apr
RIE	LEN	28-Sep	15-Dec			17-Oct	28-Nov		7-Apr	14-Oct	6-Dec		16-Apr
PIN (T)	LEN	22-Sep	12-Dec		16-Apr	5-Oct	26-Nov		12-Apr	14-Oct	1-Dec		16-Apr
CAB	LEN	19-Oct	18-Dec		13-May	29-Oct	4-Dec		29-Apr				
MER	LEN	28-Sep	16-Dec										
CHA	LOB									15-Sep	8-Dec		13-Apr
PIN (S)	LOB									15-Sep	8-Dec		3-Apr
SAB	LOB									22-Sep	15-Dec		16-Apr
SAB	KUI	10-Oct	2-Jan			24-Oct	30-Dec			1-Oct	30-Dec		
CHA	KUI	2-Oct	18-Dec			25-Nov	2-Dec			10-Nov	15-Dec		

Key:

HAH	Hahndorf	KUI	Kuitpo
LEN	Lenswood	CHR	Charleston
LOB	Lobethal	MEA	Meadows

Table 8 Phenological Data collected from AHWR growers (cont'd)

Variety	Location	2001/2002				2002/2003				2003/2004			
		Budburst	50% Flowering	Bunch Closure	Harvest	Budburst	50% Flowering	Bunch Closure	Harvest	Budburst	50% Flowering	Bunch Closure	Harvest
CHA	CHR	13-Aug	16-Nov	4-Feb	30-Apr	1-Oct	27-Nov	22-Oct	28-Apr	26-Sep	8-Dec	13-Jan	23-Apr
CAB	CHR	25-Sep	30-Nov		3-May					8-Oct	9-Dec		11-May
MAL	CHR	5-Sep	26-Nov		23-Apr					26-Sep	9-Dec		19-Apr
SAB	CHR	25-Sep	27-Nov		9-Apr					8-Oct	18-Dec		4-Apr
PIN	CHR	13-Sep	19-Nov		6-Apr					29-Sep	9-Dec		7-Apr
RIE	CHR	28-Sep								29-Sep	9-Dec		27-Apr
MER	CHR	25-Sep	1-Dec		5-May					29-Sep	9-Dec		19-Apr
SEM	CHR	25-Sep								29-Sep	9-Dec		19-Apr
CAB	MEA	19-Sep	10-Dec			27-Sep	6-Dec	12-Feb	1-May	22-Sep	8-Dec	6-Feb	
SHI	MEA	16-Sep	12-Dec			20-Sep	2-Dec	10-Feb	22-Apr	22-Sep	8-Dec	6-Feb	
MER	MEA	19-Sep	7-Dec			20-Sep	28-Dec	5-Dec	10-Apr	22-Sep	8-Dec	20-Jan	
CHA	MEA	3-Sep	14-Dec			20-Sep				15-Sep	8-Dec	5-Jan	1-Apr
SAB	MEA	19-Sep	12-Dec			3-Oct	12-Dec	1-Dec	15-Mar	29-Sep	15-Dec	20-Jan	29-Mar
VIO	MEA	10-Sep	16-Dec			20-Sep				22-Sep	8-Dec	5-Jan	30-Apr

Key:
HAH Hahndorf
LEN Lenswood
LOB Lobethal
KUI Kuitpo
CHR Charleston
MEA Meadows

4.4.2 Floral Initiation

Flowers are formed at the time of budburst and temperature at this time affects the number of flowers formed. Pouget (1981), states that lower temperatures from before and until after budburst favours inflorescence growth and formation by disadvantaging shoot growth at that time. Thus cold temperatures around budburst time may result in significantly more flowers and longer inflorescences.

4.4.3 Flowering

There are few comprehensive published reports of either temperature conditions or phenology dates from Australian research. Hence there are no solid guidelines on which to base conclusions when discussing temperature at flowering and its effect on yield. The French journal *Le Vigneron Champenois* publishes annually the records for the month of flowering, comprising maxima, minima and mean temperatures, rainfall, the number of rain days and the sunshine hours for the whole month (May 2004). This data allows averages for 10-day periods to be compared with long term averages and used in determining climatic conditions at flowering.

4.4.4 Fruit Set

It is known that low temperatures may detrimentally affect fruit set, but May (2004) also reports that high temperatures during the flowering and fruit set period are damaging. However, just how low, or high, the temperatures need to be to have an impact on flowering and fruit set is unknown in Australia, as May's information was collected from vineyards overseas with different climates to Australia.

Reproductive growth of vines occurs over a relatively long period and varies from season to season, so it is almost impossible to predict the effects that particular climatic conditions will have upon the final yield of a grapevine. By simplifying the interactions and vine physiology Figure 12 attempts to explain the variation seen in the AHWR 1998 - 2003 by comparing maximum, minimum temperatures, and rainfall during the months of November and December. In order to better assess and predict the effects of climatic events upon reproductive growth, more accurate phenological and climatic data should be collected and collated.

4.4.5 Comparison of climatic conditions during the flowering period

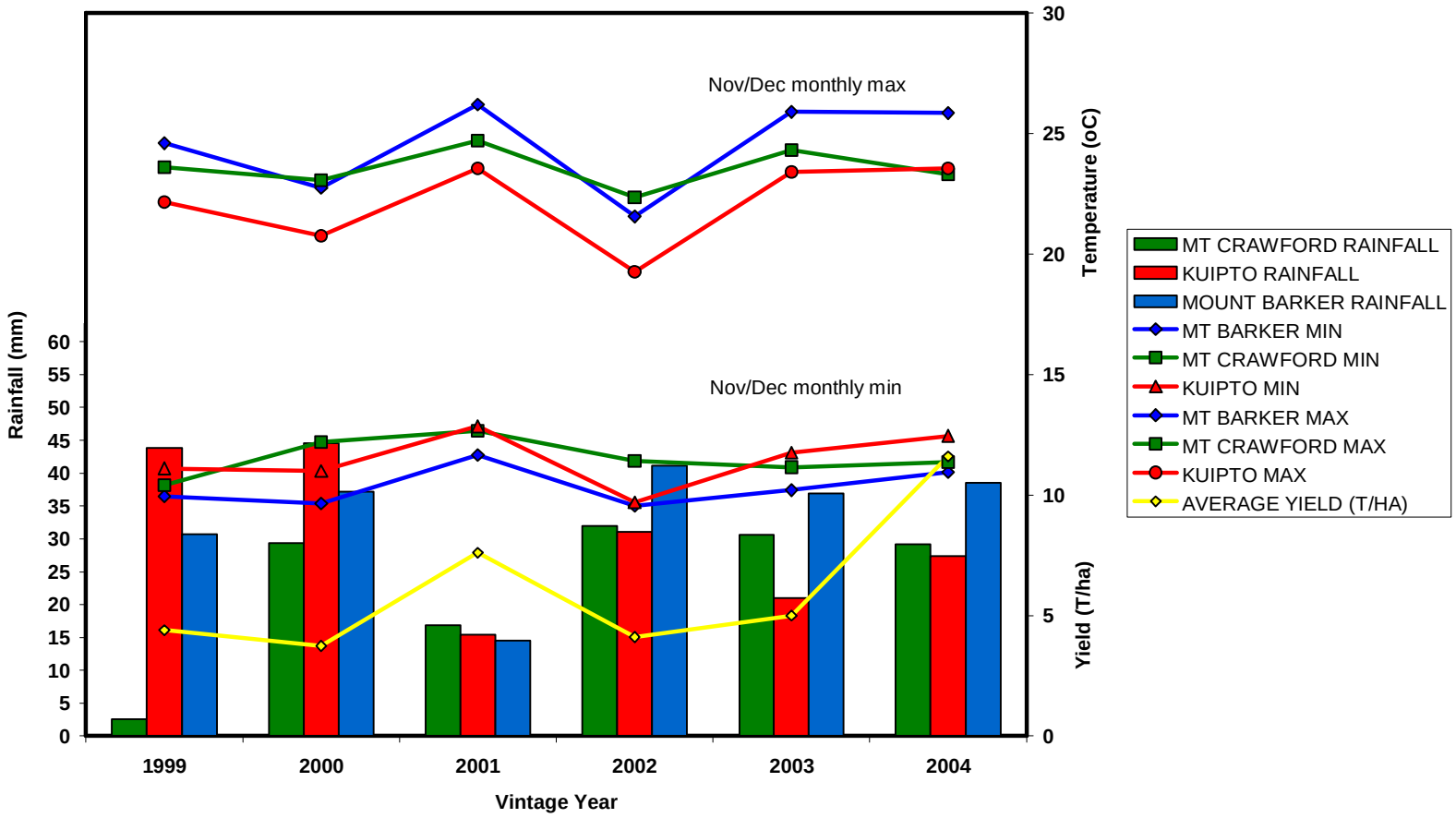
Figure 12 represents a comparison of important data to assess the effect of flowering conditions on yield. This graph should be considered with some caution due to the general nature of the yield data used and lack of reliable phenology. It does however indicate the potential power of analysis of weather data in association with phenological events.

This graph depicts the effect that November/December mean monthly temperature has on the yield for that vintage year, and potentially the next season's crop. Where the November/December mean monthly maximum temperature is lower than average there is a decrease in yields, as can be seen in the 2002 vintage year.

In vintage year 2003, yields were low due to the below average mean monthly maximum temperature in November/December 2001. However, despite the higher mean monthly maximum temperature in November/December 2002, the 2003 yields were mostly due to poor floral initiation in November/December 2001 when lower temperatures occurred.

In vintage year 2004 the very high yields were a result of better than average conditions for floral initiation in November/December 2002, in addition to the stable conditions for the flowering and fruit set period in November/December 2003.

Figure 12: Mean minimum and maximum temperatures and rainfall during flowering period at Mt Barker, Mt Crawford and Kuitpo



4.5 Climatic Risks

4.5.1 Climate Change

Significant changes to the world's atmosphere have occurred in the past 200 years due to the impact of human activities. Increased greenhouse gas levels lead to an increase in the warming of the earth's surface, and as long as greenhouse gasses continue to increase, global warming will continue to be a problem (CSIRO 2001).

Predicting the likely impacts of climate change are difficult and complicated as changes to climatic factors can interact differently in various environments. Overall it can be suggested that increasing levels of CO_2 will increase plant growth and water use efficiency, but the projected increases in temperature and frequency of extreme events is likely to cause a loss in production (Australian Greenhouse Office 2002)

Ugalde and Jones (2003) have summarized the effects of climate change for viticulture as follows;

- Reduced chilling days for fruiting requirements.
- Overall increases in temperature of 0.4 to 2.0°C by 2030 relative to 1990.
- Changes in pest, disease and plant interaction.
- Increased water requirements when water availability is reduced.
- Possible increased risk of hail, wind and heavy rain damage but reduced risk frost damage.
- Impacts on viticultural industries are complex and little is known about the effects that climate change will have.

The general impact of climate change will see warmer climates provide higher ripening temperatures, allowing even shorter optimal harvesting window. Intermediate climates will have earlier phenological development, thus ripening in warmer months may reduce quality. Cool climates may benefit the most from climate change, as they will have the ability to ripen marginal varieties more fully (Australian Greenhouse Office 2002). This may have direct influence on the AHWR. Sellars (2000) reports that Snow Barlow from the University of Melbourne has indicated that regions such as Coonawarra (similar to the AHWR) could be more like McLaren Vale by 2050.

The Australian Greenhouse Office (2002) predicts that the effect of global warming on the cost of Light Brown Apple Moth damage will decrease by $500,000 - $1.9million with an increase in overall temperature of 1°C and 2°C respectively. This is a result of the pests being displaced from warmer climates into cooler climates. Areas that currently receive low rainfall during summer months will be likely to have increased frequency of summer rainfall thus increasing the risk of damage caused by Botrytis and other pathogens.

Regional analysis of the effect of climate change upon viticultural productivity is important and modifications to suitable varieties for the region and common cultural practices may need to be revised.

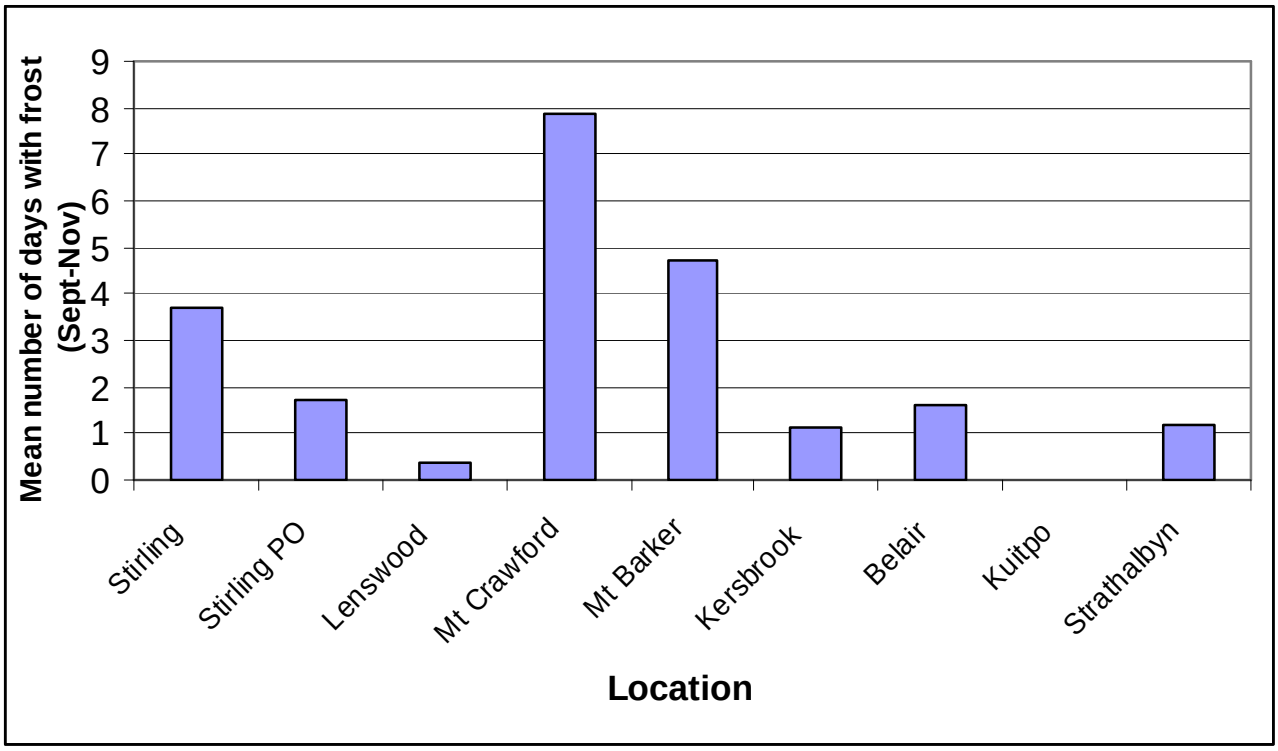
4.5.2 Frost Risk

In cool regions such as the AHWR damage caused by spring frosts is a factor limiting potential returns for many vineyards. Appropriate site selection includes gently sloping land with sheltered slopes allowing cool air to drain away from the vineyard.

The nature of the diverse and widely spread mesoclimates of the AHWR make it difficult to define specific areas of significant risk to frost. In general, frost is a risk throughout the AHWR but careful site selection and appropriate vineyard management practices will reduce the risk.

Table 6 and Figure 13 highlight the incidence of frosts between September and November, suggesting Mt Crawford has the highest number of frosts. It is noteworthy that there are few vineyards located around the Mt Crawford sub region.

Figure 13: Spring Frost incidence from September to November



5.0 SOILS

5.1 Vine Response to Soil Type

The soils of the AHWR are highly variable both in their chemical properties and the geological base from which they have been formed. While the soils of the AHWR are diverse, they can be described as loam to clay loams over clay subsoils of varying structure. Acidity is common throughout the Region as is shale and stony outcrops. The high water holding capacity of these clay soils can present issues of excessive vigour. Soils are generally of low fertility which is significant during vine development, but can be easily managed when vines reach maturity. Permanent grass swards which assist in improving soil fertility are common in the Region; they also minimise erosion of soil on steeper vineyards.

Grape vine growth and development is highly dependent upon the nature of the soil. Vine capacity and vigour generally is higher on soil types which permit more extensive root development due to their well drained deep profiles with relatively high water holding capacities, eg. sands over loam clays and clay containing rock/shale. Such soils are described as being high potential.

Many of the soils in the AHWR fit this description and experience indicates that higher vigour varieties such as Nebbiolo, Sauvignon Blanc and Shiraz should not be planted on high potential soils, as there are significant issues with vine balance and crop and canopy management. Similarly Pinot Noir may benefit from a lower potential site as it seems to have significant management requirements during the growing season to limit excessive shoot number and bunch number for the production of fruit for high quality wine.

Many AHWR soils are of moderate depth with an available rooting zone of 600mm or more, they are well drained and of moderate fertility (some former market gardening soils are of very high fertility).

Potential root depth depends upon both physical and chemical barriers, and in the AHWR the major physical barrier is heavy soil texture (clay). Poorly structured subsoil clays are relatively common and these not only reduce root development, but do require appropriate amelioration before planting to prevent localised water logging. Water logging during the growing season will stop root growth, weaken the roots and reduce nutrient uptake and subsequent shoot growth. Therefore the careful selection of vineyard sites in these sorts of situations is critical.

The soils on the top of ridges and hills in the AHWR are typically shallower than those on lower slopes, and this does create some issues in most vineyards where vines are planted up and down the slope. Management must take account of the variation in soil type and develop strategies for appropriate irrigation and fertilisation to obtain uniform vine development throughout individual plantings.

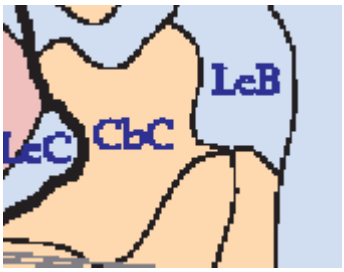
The high variability of AHWR soils is described in detail in the following section.

5.2 Detailed Description of Soil Types

The following summaries of the main land systems of each "subregion" have been taken from the Department of Water, Land and Biodiversity Conservation CD "*Central Districts Land Resource Information"*, with the aim of identifying the main features of the predominant land systems for the 10 nominated "sub-regions".

Each "subregion" is discussed in much detail with the format being an introduction of the land system in which the "subregion" exists, rainfall, area of the land system and general topographical features. The Soil Landscape Units (SLUs) are areas within a land system of similar soil characteristics. For example, the Birdwood "subregion" has 15 SLUs within the Mount Torrens land system, and each of these SLUs has a number of major soil types which have been explained in detail. To further supplement the written information on the soil types, a two page soil type characteristic summary will be attached as an appendix for each soil type within an SLU (see appendix 3). These soil type characteristic summaries contain information gained from an extensive number soil pits throughout the region.

Below is a legend for the maps provided in this section. Further and more detailed information may be obtained from the *"Central Districts Land Resource Information"* CD. Due to the format of the CD it was impossible to accurately represent all areas of the AHWR; and hence this report will provide information for the majority of grape growing areas, but cannot provide information for all regions. For a complete and continuous map reference should be made to the above mentioned CD.

	This large font refers to the land system (i.e. Mount Torrens or Paechtown) and not to the subregion or town.
	This bold black type simply refers to the name the town on the map.
	The SLU is given in a three letter code which can be found on the corresponding map in blue. SLUs which have very similar soil geology will appear in the same colour (e.g. LeC and LeB); where as different SLUs will appear as different colours (e.g. Cbc and LeB above). The thicker black line represents the boundary of the land system, the thinner black line represents the boundaries of the SLUs and the grey lines on the maps represent roads.

5.2.1 Birdwood

The Birdwood "subregion" lies within the Mount Torrens land system, which has an area of 66.5km^2 and receives an annual rainfall of 725 – 875mm. Linear ridges dominate this system, although less than 5% of the total area comprises steep and very rocky crests. Moderately steep non-arable ridges occupy about 45% of total area, and about 40% is undulating to gently rolling hills. Soils are characteristically moderately deep to deep sandy loams with brown mottled clayey subsoils. Many are waterlogged during winter. Most have low inherent fertility and all are prone to acidification. Erosion is a potential problem on cultivated or overgrazed land due to the high erodibility of the soils, and moderate slopes. About 10% of the land area is drainage depressions and fans. Soils are similar to those of the rising ground, but waterlogging is a greater threat and salinity is more likely to be a problem, albeit minor.

Most soils are formed in freshly or deeply weathered basement rock. Most have sandy loam su abruptly overlie clayey subsoils, or merge with them indistinctly. On steeper and/or rocky slopes, and stony directly overlying hard rock. On lower or gentle slopes, soils are deeper, usually with surfaces over thick brown clayey subsoils. On creek flats, sandy texture contrast and deep loa combination with the loamy texture contrast types. All soils are acidic, at least in their surface layers.

15 Soil Landscape Units (SLU's) are mapped in the Mount Torrens Land System with most vineyards planted on the CbC and CbD units, which comprise 30.0% of the land system. The CbC unit is described as undulating rises with relief to 40m and slopes of 3 - 8%. The CbD unit is described as gently rolling low hills with relief to 60m and slopes of 8 - 18%.

The majority of these units are soils of sandy to loamy surfaces overlying brown or red clay subsoils forming in fresh, or more commonly deeply weathered, basement rock. Deeper texture contrast soils on alluvium are common on lower slopes. Main soils are:

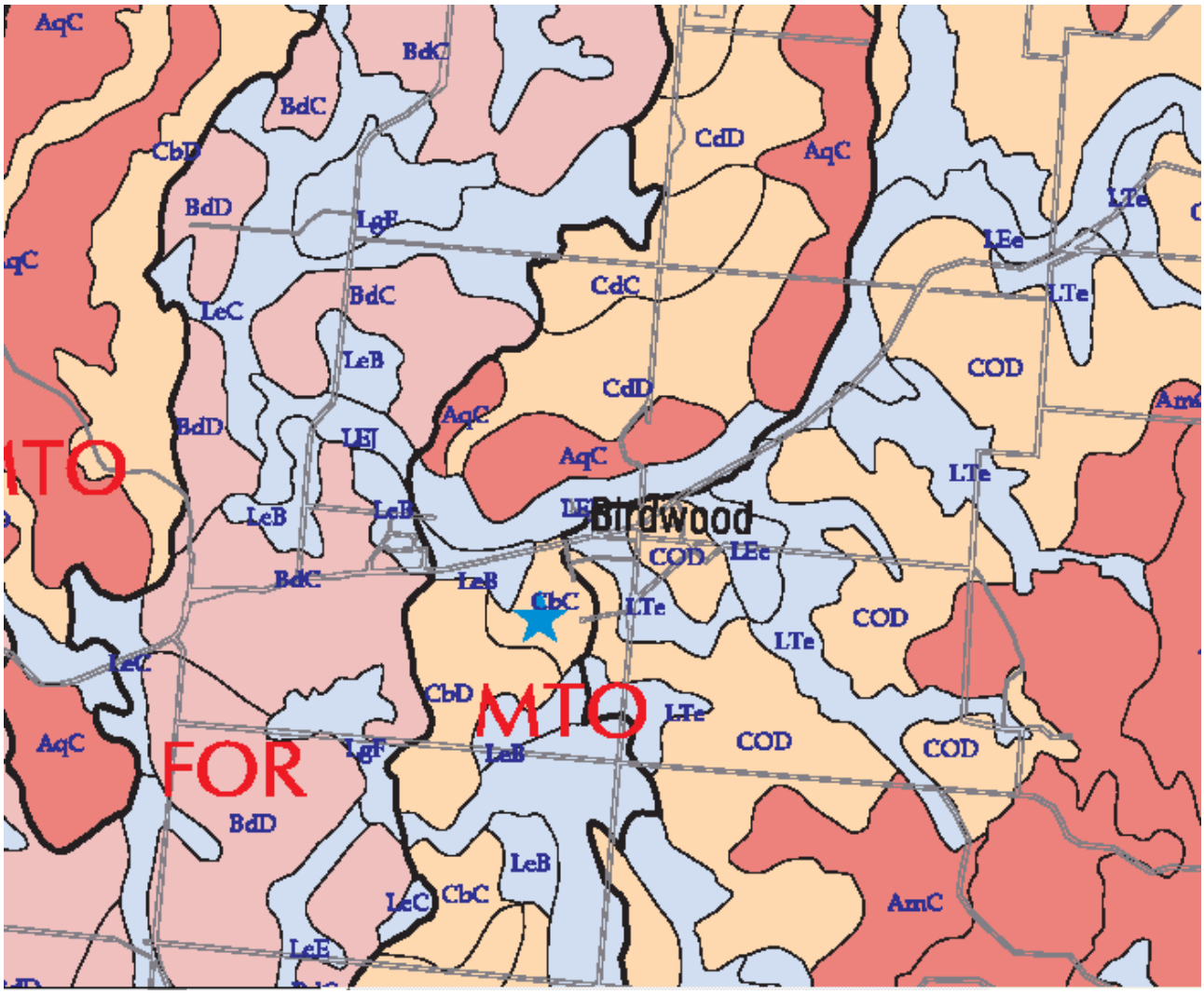
> **Acidic sandy loam over poorly structured brown cla**y (Bleached-Mottled, Eutrophic, Brown Kurosol) (See Appendix 3, pages 1 & 2)
>
> Medium thickness sandy loam to loam, with a pale and gravely A2 horizon, overlying a yellow and brown sandy clay loam grading to clay loam or light clay subsoil formed in soft weathering sandstone.
>
> **Acidic sandy loam over red clay** (Bleached, Eutrophic, Red Kursol) (See Appendix 3, pages 3 & 4)
>
> Thick, brown loamy sand to sandy loam with a gravely and bleached A2 horizon, overlyi structured clay, stony and browner with depth, grading to weathering metasandstone by
>
> **Thick sandy loam over brown clay on deeply weathered rock** (Bleached-Mottled, Mesotrophic, Brown Kurosol) (See Appendix 3, pages 5 & 6)
>
> Thick grey loamy sand with a gravely and bleached A2 horizon, overlying a brown, yell red coarsely prismatic sandy clay to clay subsoil, becoming siltier and greyer with depth metasandstone occurs from about 150cm.

Sandy loam over brown clay on alluvium (Bleached-Mottled, Hypocalcic, Brown Chromosol) (See Appendix 3, pages 7 & 8)

Thick loamy sand to sandy clay loam surface soil with a strongly bleached A2 horizon, sl yellowish brown, grey and red mottled clay subsoil grading to fine grained alluvium.

Most soils are deep, but drainage is commonly imperfect due to perching of water on clayey subsoils, and natural fertility is low. All soils are prone to acidification. The soils are highly erodible, so CbD in particular is at high risk of erosion if protective vegetative cover is removed.

Figure 14: Main soil landscape units of the Birdwood "sub-region"



5.2.2 Charleston

The Charleston "subregion" is mostly part of the 47.9km^2 Onkaparinga land system, which receives and annual rainfall of 800 - 900mm, however some viticultural land in the Charleston "subregion" exists in the Mount Torrens land system. The Onkaparinga land system has extensive alluvial flats and gently sloping outwash fans grading to undulating rolling low hills. The alluvial landscapes occupy about 40% of the system. They have deep soils that are typically loamy with clayey subsoils in narrow valleys, and sandier with variable subsoils near the major watercourses. They are moderately fertile and have ample water holding capacity, but many are imperfectly drained. The soils on the rising ground are loamy with clayey subsoils. They are generally moderately deep to deep, moderately well drained and inherently fertile. Except for some minor and moderately steep slopes, all the land is at least semi arable, although all slopes are susceptible to erosion. There is significant potential for horticulture and other more intensive uses throughout.

The soils on the basement rock rises are almost all loamy texture contrast types, moderately deep to deep over rock. Related but deeper texture contrast soils characterize lower slopes. On valley flats there are a range of texture contrast and uniform to gradational coarse textured soils.

9 Soil Landscape Units (SLU's) are mapped in the Onkaparinga land system with most vineyards planted on BdC and BdD units, which comprise 54.7% of the land system. The BdC unit is described as undulating low hills and gentle slopes with relief to 50m and slopes of 4 - 10%. The BdD unit is described as moderately inclined upper slopes with relief to 20m and slopes of 10 - 18%.

Soils are mostly moderately deep, overlying fine grained metamorphic rocks. They have loamy surfaces and variably coloured and structured subsoil clays. Deeper texture contrast soils occur on lower slopes and minor flats. Less well developed medium to fine grained soils on deeply weathered rock occur on upper slopes. Main soils are:

Acidic loam over brown clay (Eutrophic, Brown Kurosol) (See Appendix 3, pages 9 & 10)

Thick loam with paler coloured gravely A2 horizon, overlying a dark brown, yellowisl mottled, coarsely structured clay subsoils, grading to weathering metasiltstone or phy 100cm.

Acidic loam over red clay (Eutrophic, Red Kurosol) (See Appendix 3, pages 11 & 12)

Medium thickness reddish loam to clay loam with gravely and paler coloured A2 horizon very well structured clay, grading to weathering schist or phyllite from about 100cm.

Acidic sandy loam over red clay (Bleached, Eutrophic, Red Kursol) (See Appendix 3, pages 3 & 4)

Medium thickness sandy loam with a paler or bleached A2 horizon, overlying a dark red and brown mottled prismatic structured clay, grading to weathering schist or phyllite by 100cm.

Loam over brown clay (Eutrophic, Brown Kurosol) (See Appendix 3, pages 13 14)

Thick, dark brown sandy loam to clay loam with a bleached A2 horizon, overlying a brown and red, coarsely blocky clay subsoil grading to grey and brown coarsely prismat weathering schist or phyllite, deeper than 200cm.

Loam to Sandy loam over brown clay or coarse grained rock (Bleached-Mottled, Mesotrophic, Brown Kurosol) (See Appendix 3, pages 15 16)

Thick loamy sand to loam with gravely and bleached A2 horizon, overlying a brown, yell red coarsely prismatic sandy clay subsoil, becoming siltier and greyer with depth. metasandstone occurs from about 150cm.

Acidic gradational loam (Mesotrophic, Red Dermosol) (See Appendix 3, pages 17 & 18)

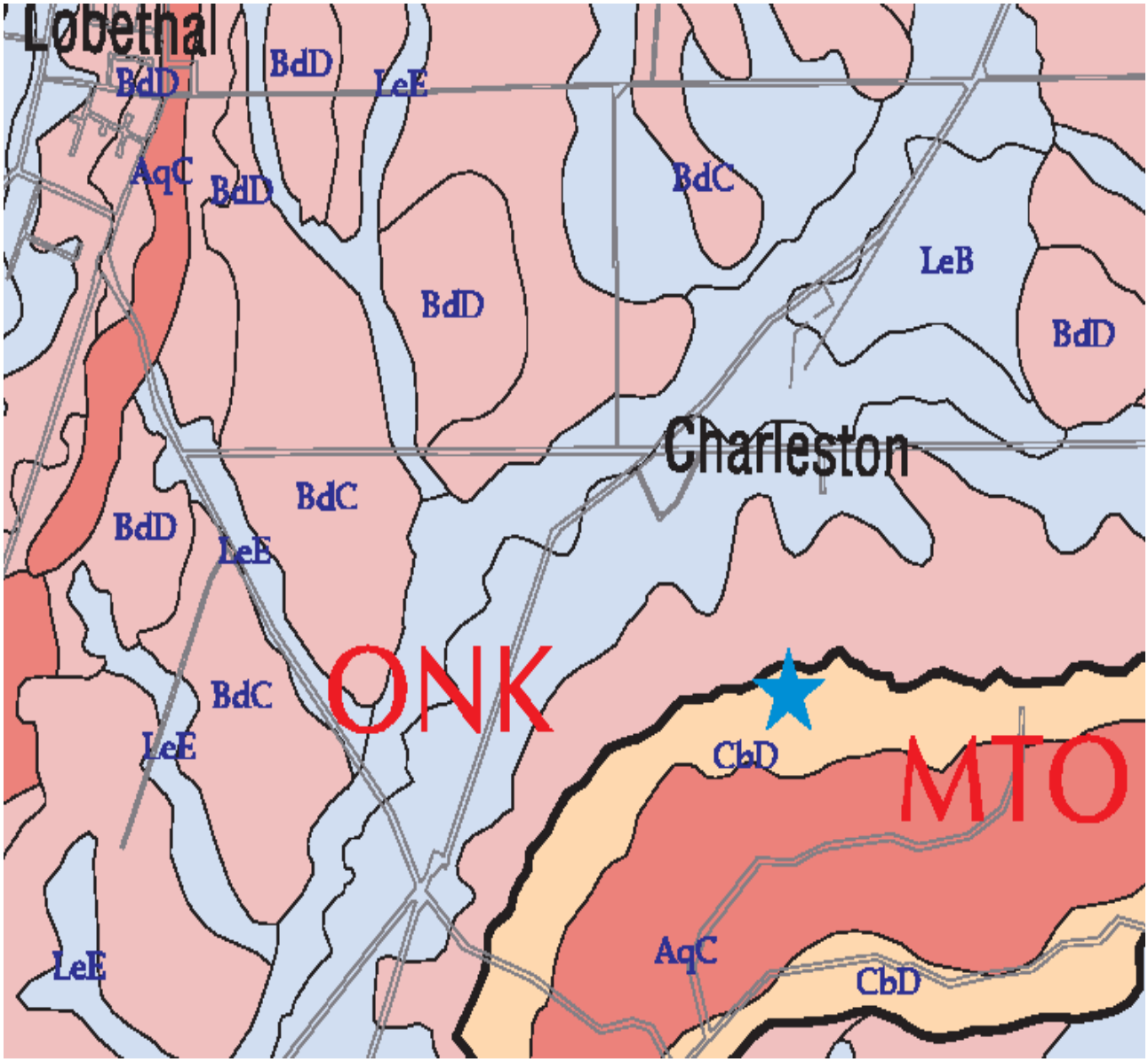
Thick fine sandy loam with minor ironstone grading to a brownish or reddish coarsely blo clayey subsoil, siltier with depth, grading to kaolinized phyllite or siltstone, continuing to or more.

Sandy loam to loam over brown clay (Bleached-Mottled, Eutrophic / Hypocalcic, Brown Chromosol) (See Appendix 3, pages 7 & 8)

Thick loamy sand to clay loam surface soil with a strongly bleached A2 horizon, sh yellowish brown, grey and mottled clay subsoil grading to fine grained alluvium.

This land is arable with mostly deep, naturally fertile and moderately well drained soils. Slight limita by poorly structured hard setting surface soils and susceptibility to acidification and associated ma This is potentially some of the most productive land in the Mount Lofty Ranges, but more intens must be accompanied by appropriate erosion control.

Figure 15: Main land systems of the Charleston "sub-region"



5.2.3 Echunga

Areas in which vines are planted in the "subregion" of Echunga straddle both the Jupiter Creek land system and the Paechtown land system, however the soils are quite similar, and hence reference will be made to the Jupiter Creek system for this analysis. The Jupiter Creek land system is 47.4km^2 and receives and annual rainfall of 825 - 925mm. Four landscape features characterize the Jupiter Creek land system. Moderately steep non-arable slopes with shallow to moderately deep sandy loam soils occupy 10% of the area. Moderate slopes formed on basement rock account for 20% of the land. Soils are sandy to loamy, moderately deep, moderately well drained and acidic, with marginal fertility. They have good horticultural potential. Rises with broad flat to undulating crests occupy 40% of the land system. The characteristic ironstone soils are infertile and subject to waterlogging. They have limited potential for intensive development. Land use on the creek flats and broad valleys (30% of area) with deep sandy loam to clay loam soils, is principally limited b impeded drainage.

The soils fall into three main groups according to underlying geological materials. Shallow to moderately deep soils, with sandy loam surfaces over clayey subsoils forming in weathering rock are predominant on the slopes and low hills. Deep ironstone gravely soils characterize the highly weathered and lateralized slopes and plateaux. Deep texture contrast soils formed on alluvium are the main soils on flats and gentle lower slopes, associated with a range of deep uniform and gradational soils with sandy to clay loamy surface soils.

12 Soil Landscape Units (SLU's) have been mapped in the Jupiter Creek land system with vineyards generally planted on the BhD unit, which comprises only 9.5% of the land system. The BhD unit is described as gently rolling hills with relief of up to 40m and slopes of 10 - 18%.

Most soils have loamy to sandy surfaces with clayey subsoils grading to weathering rock at about 1m. Variations in surface texture, subsoil structure and colour are related to rock type. Main soils are:

Acidic loam over red mottled clay (Bleached-Mottled Eutrophic, Red Kurosol) (See Appendix 3, pages 19 & 20)

Thick sandy loam to loam surface soil with a bleached and gravely A2, horizon, overlyin brown and brown well structured clay grading to weathering siltstone or fine sandstone b

Acidic sandy loam over brown clay (Bleached, Mestotrophic, Brown Kurosol) (See Appendix 3, pages 21 & 22)

Medium to thick, gravely loamy sand to sandy surface soil, with a bleached and very gr overlying a yellowish brown, red and brown sandy clay to clay subsoil grading to weath fine sandstone by 100cm.

Acidic gradational brown loam over fresh weathering rock (Eutrophic, Brown Dermosol) (See Appendix 3, pages 23 & 24)

Medium thickness loamy surface soil, becoming clay loamy and gravely with depth, ov friable clay subsoil, grading to soft shale or siltstone.

Acidic gradational red loam over fresh weathering rock (Eutrophic, Red Dermosol) (See Appendix 3, pages 23 & 24)

Medium thickness dark brown loam with a paler coloured clay loamy A2 horizon con ferruginous rock fragments, overlying a red clay with polyhedral structure and increasin with depth, grading to soft weathering siltstone at about 100cm.

Sandy loam over thick brown clay on deeply weathered rock (Bleached-Mottled, Me Kurosol) (See Appendix 3, pages 15 & 16)

Thick grey loam sand to loam with a gravely and bleached A2 horizon, overlying a brown and red coarsely prismatic sand clay to clay, becoming siltier and greyer weathering metasandstone occurs from about 150cm.

Sandy loam to loam over thick brown clay on fine grained alluvium (Bleached-Mottled, Hypocalcic, Brown Chromosol) (See Appendix 3, pages 7 & 8)

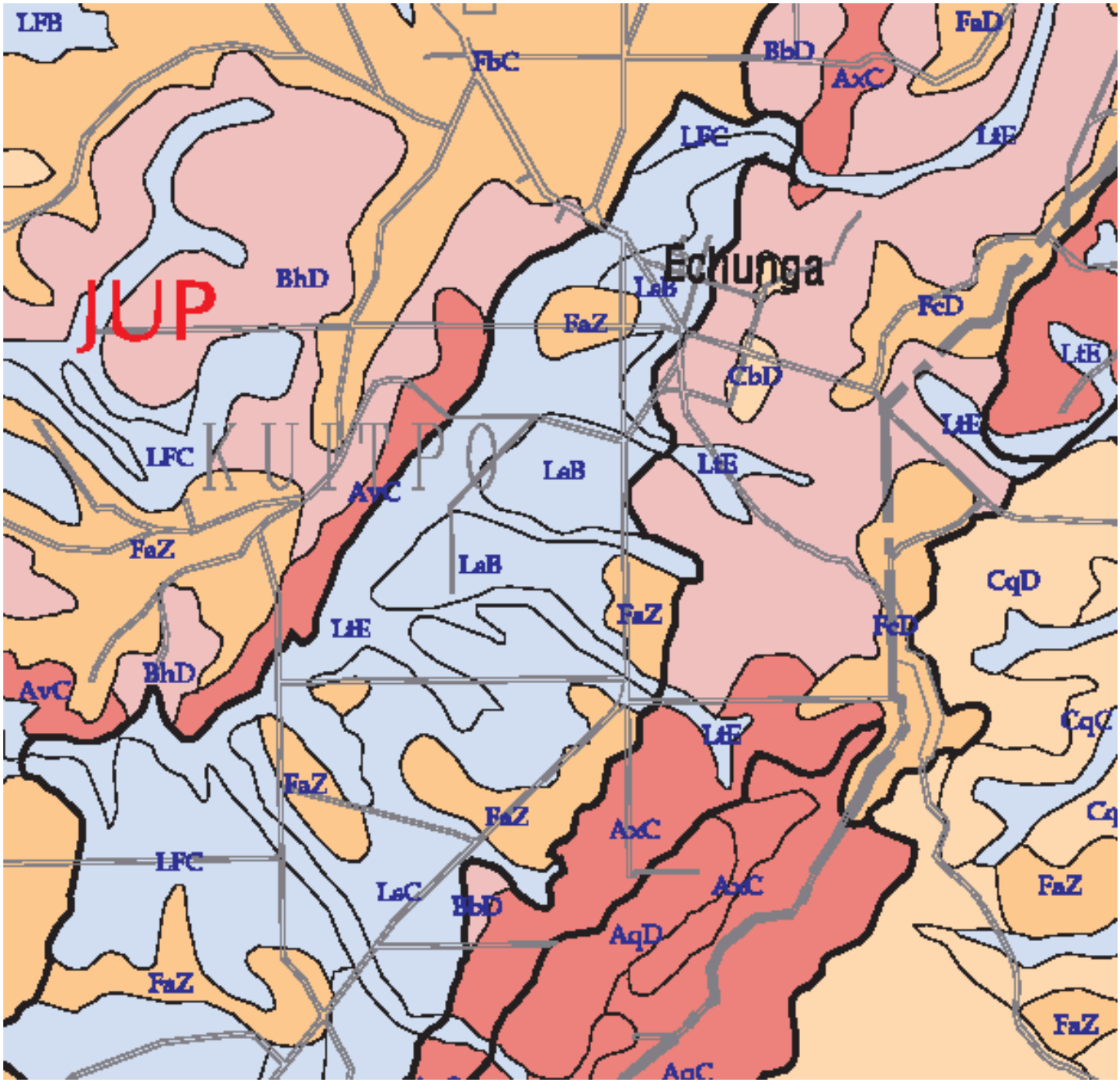
Thick loamy sand to sandy clay loam with a strong bleached A2 horizon, overlying a grey and red mottled clay grading to fine grained alluvium, weakly calcareous at base.

Deep acidic loam to ironstone soil (Ferric, Mesotrophic, Brown Kandosol) (See Appendix 3, pages 25 & 26)

Medium thickness loamy sand to sandy loam with abundant ironstone gravel, gradir yellow and red clay with ironstone fragments, over light grey and kaolinitic clay at about 1

These soils are moderately deep to deep with high water holding capacities. Natural fertility is low all are susceptible to acidification. Most of the land is well suited to more intensive development, should be monitored and erosion control measures are essential wherever soils are disturbed.

Figure 16: Main land systems of the Echunga "sub-region"



5.2.4 Hahndorf

The Hahndorf "subregion" lies predominantly in the Hahndorf land system, however the north eastern edges of the Hahndorf "subregion" fall into the Junction Creek land system, however the main soil types and underlying geology is similar in areas planted to vineyards. The land system is 34.9km^2 and is categorised as receiving 800 - 1025mm of annual rainfall. The Hahndorf land system is characterized by undulating to rolling hills with moderately deep loamy texture contrast soils. They are mostly moderately well drained and inherently infertile, although prone to acidification. Moderately steep, non-arable land is limited in area. There are extensive areas of gentle slopes and valley flats with deep soils formed on alluvium. Productive potential overall is high, although there is potential for severe erosion on moderately steep slopes, while the main limitation on the lower lying land is waterlogging.

The soils are moderately deep to shallow soils over weathering basement rock dominant in the rising ground. The most common types have acidic loamy surfaces with well structured clayey subsoils. Deep ironstone gravely soils forming on kaolinitic weathered rock are common on weakly dissected rising ground. On lower slopes and valley flats, loamy soils with thick clayey subsoils are most common, with deep coarse textured soils sub-dominant.

12 Soil Landscape Units (SLU's) have been identified in the Hahndorf land system with the major units of BGC and BGD being used for intensive horticultural production comprising 32.3% of the total area for the land system. The BGC unit is described as undulating rises and gentle slopes with relief to 20m and slopes of 4 - 10%. The BGD unit is described as gently rolling rises and low hills with relief to 30m and slopes of 10 - 18%.

The soils are predominantly loamy, usually with clayey subsoils. Main soils are:

Acidic loam over brown clay on weathering rock (Mottled, Eutrophic, Brown Chromosol) (See Appendix 3, pages 19 & 20)

Thick loam with a paler coloured gravely A2 horizon, overlying a dark brown, yellowish brown and red mottled, coarsely structured clay, grading to weathering metasiltstone or phyllite deeper than 100cm.

Acidic gradational loam on weathering basement rock (Acidic, Eutrophic, Brown / Red Dermosol) (See Appendix 3, pages 17 & 18)

Medium thickness dark brown loam with a paler coloured clay loamy A2 horizon containing abundant rock fragments, grading to a brown, orange or red clay with polyhedral structure and increasing rock fragments with depth, over to soft shale or siltstone at about 100cm.

Acidic sandy loam over red clay (Bleached–Mottled, Eutrophic, Red Chromosol) (See Appendix 3, pages 27 & 28)

Medium thickness hard loam with a paler or bleached A2 horizon, overlying a dark red and brown mottled prismatic structured clay, grading to weathering schist or phyllite by 100cm.

Acidic loam over red clay (Halphic, Eutrophic, Red Chromosol / Kurosol) (See Appendix 3, pages 11 & 12)

Medium thickness, reddish loam to clay loam with a gravely and paler coloured A2 horizon, overlying a red, very well structured clay subsoil grading to weathering phyllite from about 100cm.

Shallow acidic gradational loam on hard rock (Acidic, Eutrophic, Brown Kandosol) (See Appendix 3, pages 29 & 30)

Medium to thick loam with a pale coloured and gravely A2 horizon, grading to reddish yellow to brown massive clay loam, over a yellow light clay, with abundant rock fragments throughout. Highly weathered siltstone occurs between 50 and 100cm.

Sandy Loam to loam over brown clay on deeply weathered fine grained rock (Eutrophic, Brown Kurosol) (See Appendix 3, pages 13 & 14)

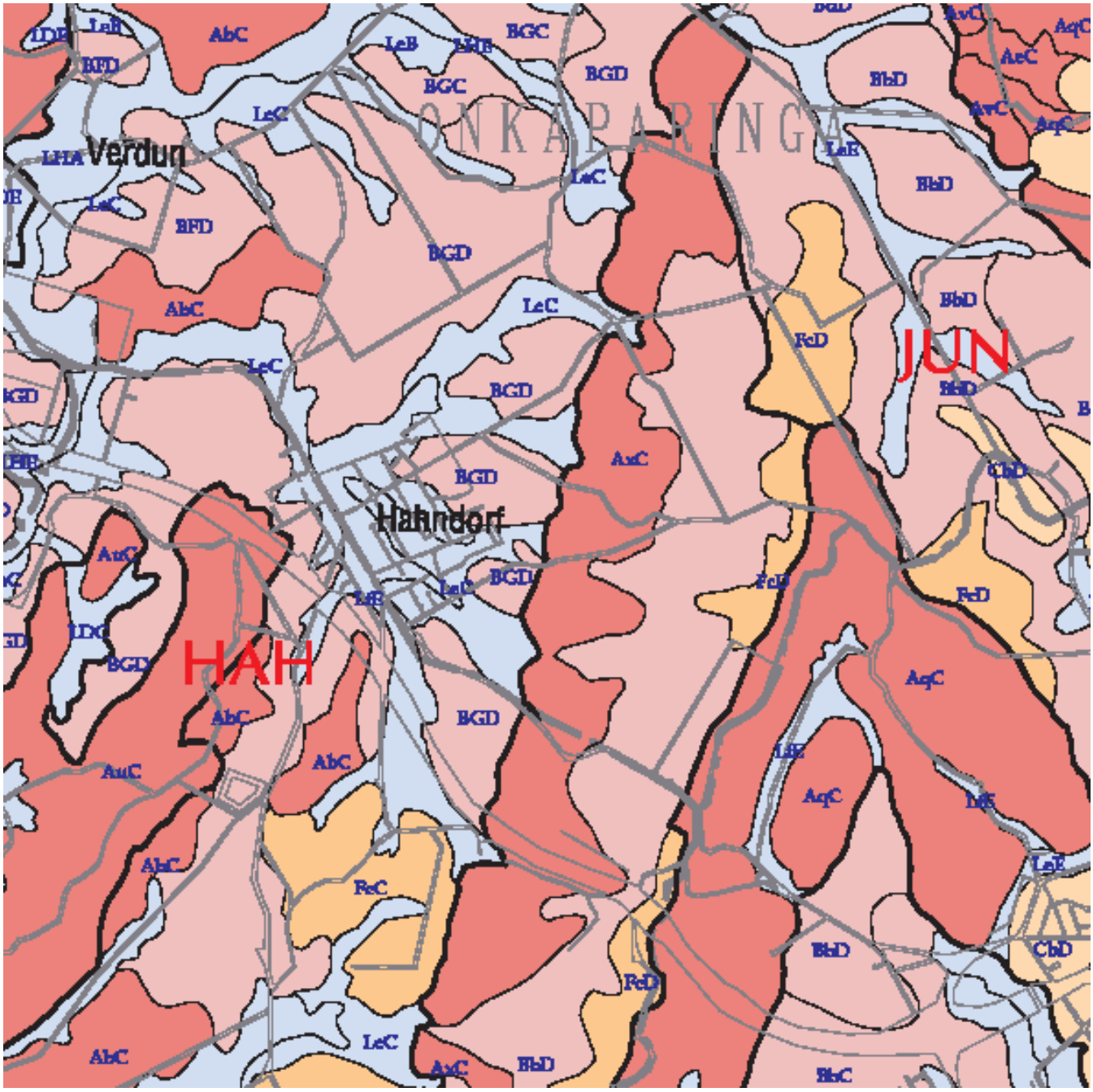
Thick, dark brown sandy loam to clay loam with a bleached A2 horizon, overlying a brown, yellowish brown and red, coarsely blocky clay subsoils grading to grey and brown coarsely prismatic clay forming in weathering schist or phyllite, deeper than 200cm.

Sandy loam to loam over brown clay on fine grained alluvium (Belached-Mottled, Hypocalcic, Brown Chromosol) (See Appendix 3, pages 7 & 8)

Thick loamy sand to sandy clay loam surface soil with a strongly bleached A2 horizon, sharply overlying a yellowish brown, grey and red mottled clay subsoil grading from fine grained alluvium.

Soils are moderately deep, adequately drained and inherently fertile, although prone to acidification. Productive potential is high, although moderate slopes are prone to erosion. The land is well suited to perennial horticulture or improved pastures.

Figure 17: Main land systems of the Hahndorf "sub-region"



5.2.5 Kuitpo

The Kuitpo "subregion" lies predominantly within the Montarra land system which is 74.5 km^2 and receives 725 – 875mm annual rainfall. The Montarra land system is dominated by broad undulating to gently rolling low hills and ironstone crests extending from Pages Flat through Hope forest to Kuipto. The soils are sand to loamy surfaced overlying thick clayey subsoils. These are moderately well drained with high water holding capacities. Inherent fertility is low to moderate and all soils are prone to acidification. The soils are erodible and all slopes are susceptible to erosion if soils are disturbed. Saline seepages (probably linked to the deep weathering profiles of the higher ground) occur sporadically. A smaller occurrence of the land system to the east is steeper and mostly non arable. Valleys with deep but imperfectly drained loamy texture contrast soils occupy less than 10% of the area.

The majority of soils are moderately deep to deep over weathering basement rock. They have sandy loam to loam surfaces over red or brown clayey subsoils; texture, colour and structure variations determined by differences in the rock. There are some shallow stony soils on deeper slopes. There are extensive ironstone soils on the lateritic remnants, and deep texture contrast or gradational soils on alluvium.

The Montarra land system has 14 Soil Landscape Units with the most common units for horticultural development being BhC, BhD, FaZ and AyC, which comprise 79% of the land system. The BhC unit is described as undulating rises and gentle slopes with relief to 30m and slopes of 4 - 10%. The BhD unit is described as gently rolling hills with relief from 40 - 60m and slopes of 10 - 18%. The FaZ unit is described as very undulating upper slopes and plateaus – remnant deeply weathered land surfaces. Underlying materials are kaolinized and lateralized sandstones and siltstones. The AvC unit is described as rolling low hills with relief to 80m and slopes of 16-30%.

These soils are generally moderately deep to deep with high water holding capacities. Natural fertility is low to moderate – some soils are quite sandy but others are heavy loams, and all are susceptible to acidification. Most of the land is well suited to more intensive development, although salinity should be monitored and erosion control measures are essential wherever soils are disturbed. The main soils are:

> **Acidic gradational loam on deeply weathered rock** (Mesotrophic, Red Dermosol) (See Appendix 3, pages 31 & 32)
>
> Thick fine sandy loam with minor ironstone grading to a brownish or reddish coarsely block clay loamy to clayey subsoil, siltier with depth, grading to kaolinized phyllite or siltstone, continuing to depths of 200cm or more.
>
> **Acidic gradational brown loam** (Eutrophic, Brown Dermosol) (See Appendix 3, pages 23 & 24)
>
> Medium thickness loamy surface soil, becoming clay loamy and gravely with depth, overlying an orange, friable clay subsoil, grading to soft shale or siltstone.

Acidic gradational red loam (Eutrophic, Red Dermosol) (See Appendix 3, pages 17 & 18)

Medium thickness dark brown loam with paler coloured clay loamy A2 horizon containing abundant ferruginous rock fragments, overlying a red clay with polyhedral structure and increasing rock fragment with depth, grading to soft weathering metasiltstone or phyllite deeper than 100cm.

Acidic loam over red mottled clay on rock (Bleached-Mottled, Eutrophic, Red Kursol) (See Appendix 3, pages 19 & 20)

Thick sandy loam surface soil with a bleached and gravely A2 horizon, overlying a red, yellowish brown and brown well structured clay grading to weathering siltstone or fine sandstone by 100cm.

Acidic sandy loam over brown clay (Bleached-Mesotrophic, Brown Kurosol) (See Appendix 3, pages 21 & 22)

Medium to thick, gravely loamy sand to sandy loam surface soil, with a bleached and very gravely A2 horizon, overlying a yellowish brown, red and brown sandy clay to clay subsoil grading to weathering medium to fine sandstone by 100cm.

Shallow sandy loam on rock (Acidic, Paralithic, Bleached-Leptic Tenosol) (See Appendix 3, pages 37 & 38)

Thick, very gravely loamy sand to sandy loam, overlying a brown gravely clayey sand grading to a weathering sandstone by 50cm.

Shallow loam on rock (Paralithic, Leptic Tenosol) (See Appendix 3, pages 37 & 38)

Thick, stony sandy loam to loam, forming in weathering schist or phyllite at 50cm or less.

Acidic sandy loam ironstone soil (Ferric, Mesotrophic, Brown Kandosol) (See Appendix 3, pages 57 & 58)

Medium thickness loamy sand to sandy loam with abundant ironstone gravel grading to a brownish yellow and red clay with ironstone fragments, over light grey and red kaolinitic clay at about 100cm.

Acidic loam ironstone soil (Ferric, Eutrophic, Red Chromosol) (See Appendix 3, pages 43 & 44)

Medium thickness dark brown loam with a pink A2 horizon containing abundant fragments of ferruginized siltstone, overlying a red and yellow brown clay with blocky structure, grading to grey mottled kaolinite silt clay. Hard siltstone is deeper than 200cm.

Sandy loam over brown mottled clay on weathered rock (Bleached-Mottled, Mesotrophic, Brown Kurosol) (See Appendix 3, pages 15 & 16)

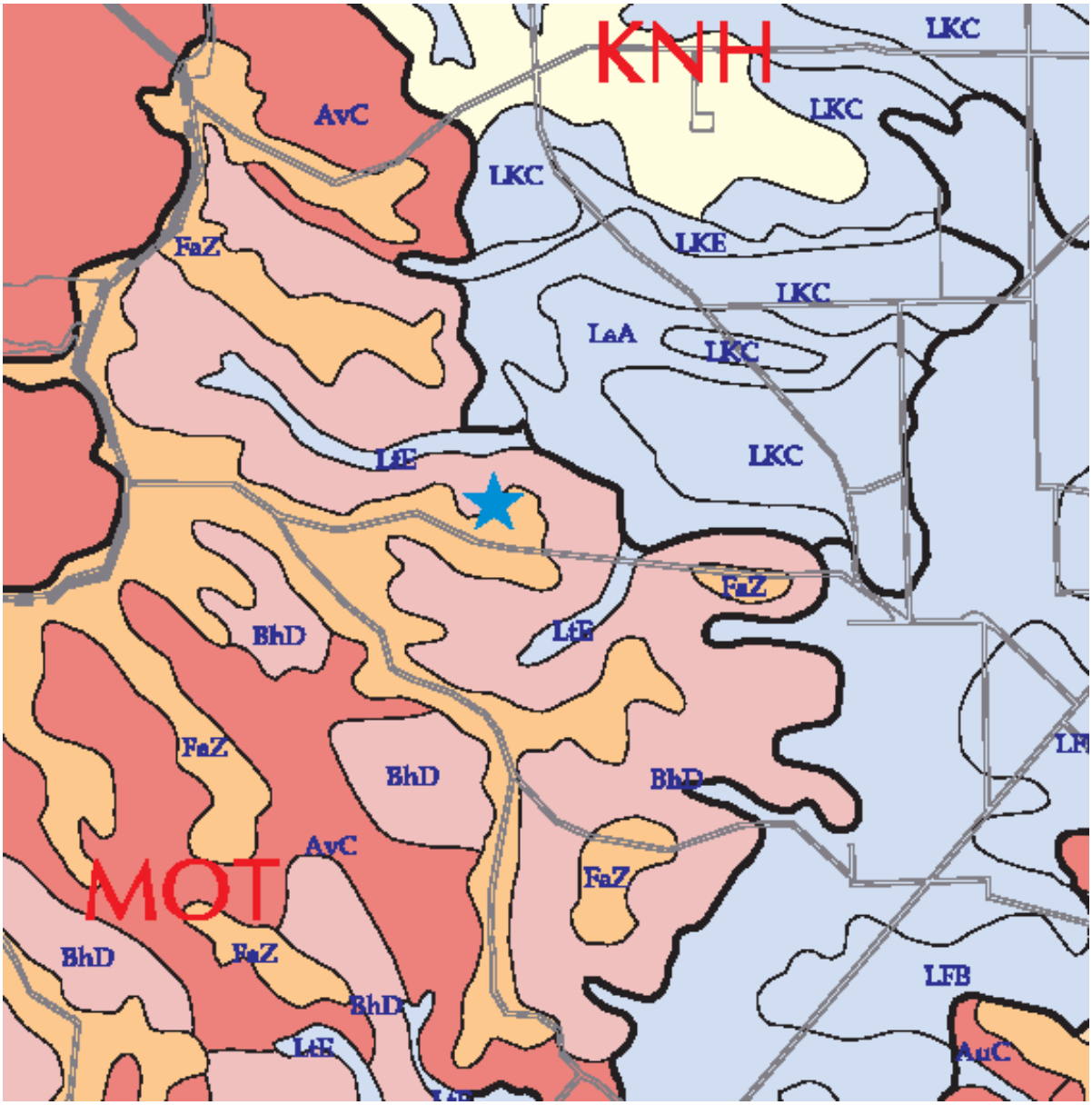
Thick grey loamy sand to sandy clay with a gravely and bleached A2 horizon, overlying a brown, yellowish brown and red coarsely prismatic sandy clay to clay, becoming siltier and greyer (Kaolinitic) with depth. Profile grades to soft weathering metasandstone kaolinitic and ironstone gravely clay below 100cm.

Sandy loam over brown mottled clay on fine grained alluvium (Bleached-Mottled, Hypocalcic, Brown Chromosol) (See Appendix 3, pages 7 & 8)

Thick loamy sand to sandy clay loam with a strongly bleached A2 horizon, overlying a yellowish brown, grey and red mottled clay grading to fine grained alluvium, weakly calcareous at base.

These soils are generally moderately deep to deep with high water holding capacities. Natural fertility is low to moderate – some soils are quite sandy, but others are heavy loams, and all are susceptible to acidification. Most of the land is well suited to more intensive developments, although salinity should be monitored and erosion control measures are essential wherever soils are disturbed.

Figure 18: Main land systems of the Kuitpo "sub-region"



5.2.6 Lenswood

The "subregion" of Lenswood lies within the land system of Lenswood, receiving an annual rainfall of 850 - 1025mm and consisting of 66.6km^2. The Lenswood system is characterized by moderately steep low hills separated by narrow creek flats. The soils of the hills are mainly loamy with clayey subsoils. They are inherently fertile although acidic, and well drained, and are consequently well suited to perennial horticulture. Significant areas of undulating to gently rolling slopes with similar soils are semi arable, and have some potential for annual crops, although the risk of erosion is high. Sandier soils are predominant on some slopes occupying 12% of the area. These are less fertile and more erodible, making them less attractive. The soils of the creek flats and lower slopes are deep and generally fertile, but are commonly susceptible to waterlogging, flooding and frost. However, being flat, they provide scope for more intensive uses.

The system is dominated by loamy soils, most of which have well structured clayey subsoils grading to weathering rock. Shallow soils on basement are common on steeper slopes, while sandy loam soils (with or without clayey subsoils) are typical of slopes formed on coarser grained rocks. Deep soils occur in valleys and on lower slopes. These have sandy, loamy or sometimes clayey surfaces with a variety of subsoils.

12 Soil Landscape Units are mapped for the Lenswood land system, with the AbC unit making up 50.0% of the total land area. The AbC unit is described as rolling low hills with relief to 80m and slopes of 18 - 30%.

The soils are predominantly loamy with brown to yellow subsoil clays forming in weathering rock. On steeper slopes, soils are shallow on rock, while on lower slopes, clay subsoils are thick with rock deeper than a metre. Main soils are:

Acidic gradational brown loam (Eutrophic, Brown Dermosol) (See Appendix 3, pages 23 & 24)

Medium thickness loamy surface soil, becoming clay and gravely with depth, overlying an orange, friable clay subsoil, grading to soft shale or siltstone.

Acidic loam over red clay (Eutrophic, Red Kurosol) (See Appendix 3, pages 33 & 34)
Medium thickness reddish loam to clay loam with a gravely and paler coloured A2 horizon, overlying a red, very well structured clay grading to weathering phyllite from about 100cm.

Acidic loam over red and brown clay (Mottled, Eutrophic, Red/Brown Kurosol) (See Appendix 3, pages 19 & 20)

Thick sandy loam to loam with a paler coloured and gravely A2 horizon, overlying a yellowish brown, brown and red, well structured clay grading to weathering siltstone or fine sandstone by

Shallow stony loam (Palic, Paralithic. Leptic Tenosol) (See Appendix 3, pages 37 & 38)

Thick stony sandy loam to loam, forming in weathering schist or phyllite at 50cm or less.

Acidic gradational red loam (Mesotrophic, Red Dermosol) (See Appendix 3, pages 17 & 18)

Thick fine sandy loam with minor ironstone grading to a brownish to reddish coarsely blocky clay loamy to clayey subsoil, siltier with depth, grading to kaolinized phyllite siltstone, continuing to depths of 200cm or more.

Loam over brown clay (Eutrophic, Brown Kurosol) (See Appendix 3, pages 13 & 14)

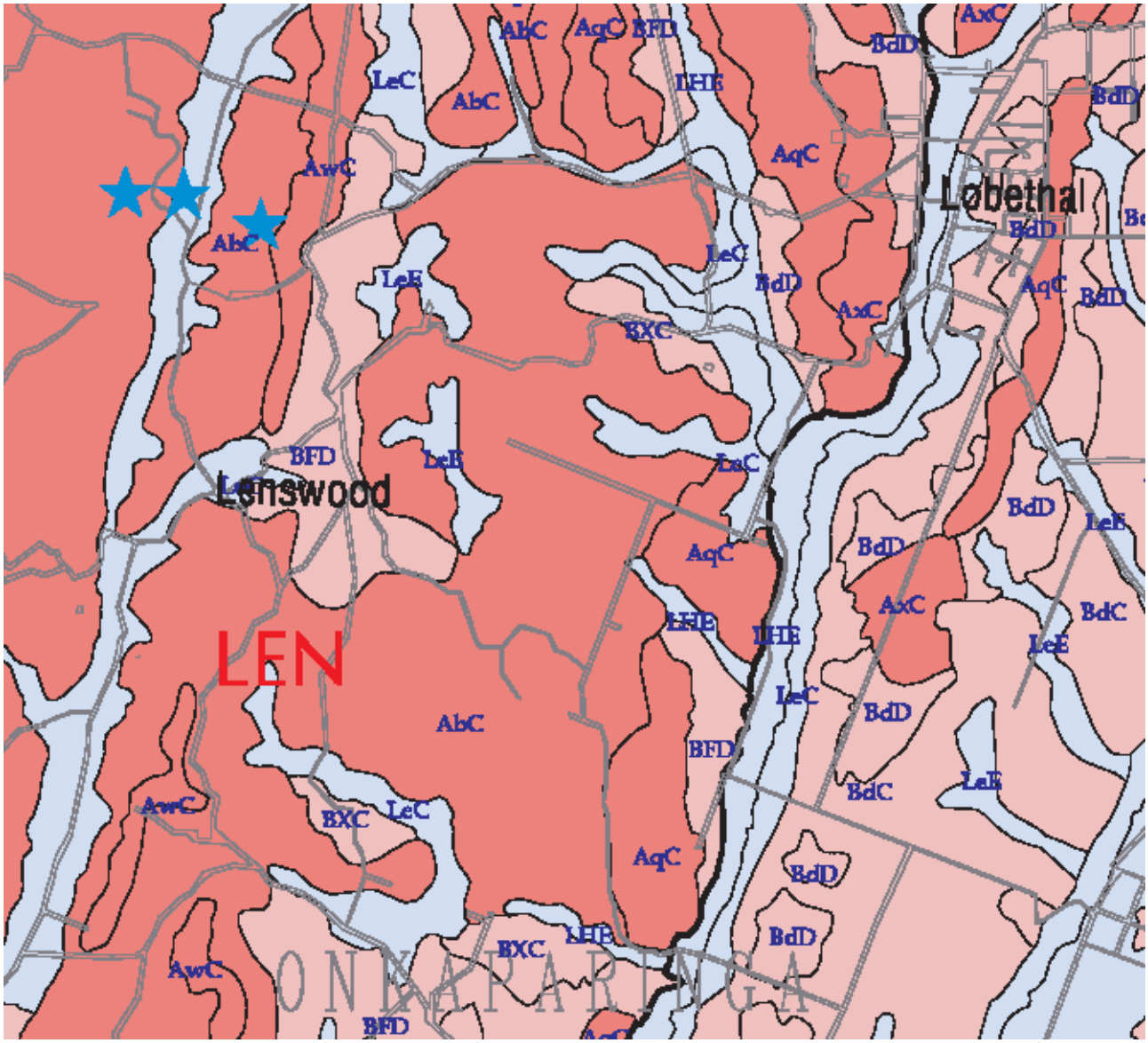
Thick, dark brown sandy loam to clay loam with a bleached A2 horizon, overlying a brown, yellowish brown and red, coarsely blocky clay subsoil grading to grey and brown, coarsely prismatic clay forming in weathering schist or phyllite, deeper than 150cm

Acidic loam over black clay (Eutrophic, Black Sodsol) (See Appendix 3, pages 35 & 36)

Medium to thick loam to clay loam over a coarsely structured black heavy clay with grey and yellow mottles, grading to carbonaceous shale from about 100cm.

This land is moderately steep and non arable, but is moderately deep, well drained and reasonably fertile soils are ideal for perennial horticulture. Main limitations are potential for erosion during establishment, and soil fertility.

Figure 19: Main land systems of the Lenswood "sub-region"



5.2.7 Macclesfield

Macclesfield "subregion" lies in the north east corner of the Strangways land system, which covers 273.8km^2, and receives 575 - 900mm annual rainfall. The Strangways land system is characteristically rolling to steep hill country. About 55% of the land area is too steep for cultivated agriculture. The soils on this land vary from shallow stony sandy loams on basement rock to deeper sandy loam to loam texture contrast typed with moderately low to moderate fertility and generally favourable conditions for plant growth. Variable soil depth causes uneven pasture growth, indicated by patchy haying off in springtime. All soils are susceptible to acidification and nutrition is a major management consideration. Similar soils occur on the 30% of land that is undulating to gently rolling and potentially arable. Shallow stony soils are less common on these gentler slopes; so productive potential is relatively high. Many of the soils, particularly the sandy loam over clay types, are highly erodible, so erosion control is paramount where soil is disturbed. Deep variable soils, usually with sandy to sandy loam surfaces, occur on lower slopes and flats. Impede drainage is a common problem in these areas, related to topographical position as much as to restrictive subsoil clay layers. Watercourse erosion is an issue in places.

Soils on hill slopes are moderately deep to shallow over basement rock, with sandy loam to loam surfaces and generally with clayey subsoils. Ironstone soils occur on some upper slopes and crests. Deep texture contrast soils dominate lower slopes and flats. Surfaces vary from sandy to loamy. Deep sands and sandy loams also occur.

54 Soil Landscape Units have been mapped with viticultural land existing mainly upon the AhC unit and CMD, whilst FeZ and LAC units are also planted with vines. The AhC unit is describes as rolling low hills with relief of up to 50 - 100m and slopes of 16 - 30%. The CMD unit is described as gently rolling hills with relief of 40m and slopes 18 - 16%. The FeZ unit is described as gently undulating plateaux with underlying rocks being schist of the Kanmantoo group. The LAC unit is described as sandy clay to clay sediments derived from Kanmantoo group rocks on lower slopes and fans with slopes of 3 - 8%. These four main soil landscape units comprise 31.7% of the total land area of the Strangways land system.

The main soils of the described unit are:

> **Acidic sandy loam over red clay on metagreywacke/sandstone** (Bleached-Sodic, Eutrophic, Red Chromosol) (See Appendix 3, pages 27 & 28)
>
> Medium thickness brown loamy sand to loam with a bleached and gravely A2 horizon, overlying a reddish brown and brown mottled, firm sandy to heavy clay grading to weathering metagreywacke by 100cm.
>
> **Acidic loam over red clay on schist** (Eutrophic, Red Chromosol / Kurosol) See Appendix 3, pages 11 & 12)
>
> Medium thickness hard setting reddish brown sandy loam to loam with a paler coloured and gravely A2 horizon, overlying a red strongly polyhedral structured clay grading to weathering schist or micaceous sandstone before 100cm.

Acidic gradational brown loam on silstone or phyllite (Eutrophic, Brown Dermosol) See Appendix 3, pages 29 & 30)

Medium thickness dark brown loam to clay with a paler brown gravely grey loam A2 horizon, overlying a brown clay with a strong polyhedral structure and increasing rock fragments with depth. Weathering siltstone or phyllite occurs at about 100cm.

Shallow loam (Palic-Acid, Lithic, Leptic Tenosol) (See Appendix 3, pages 37 & 38)

Thick dark brown loam with a paler brown clay loam A2 horizon containing up to 50% rock fragments, grading to metamorphosed siltstone or phyllite by 50cm.

Shallow sandy loam (Acidic, Lithic, Bleached-Leptic Tenosol) (See Appendix 3, pages 37 & 38)

Thick greyish very gravely loamy sand to sandy loam with a bleached A2 horizon, grading to hard metasandstone by 50cm.

Loam over brown clay (Sodic, Hypocalcic, Brown Chromosol) (See Appendix 3, pages 13 & 14)

Thick brown loam sand to clay loam with a bleached A2 horizon, overlying a dark brown, red and yellowish brown mottled firm heavy clay, grading to clayey alluvium or very highly weathered metagreywacke below 100cm

Sandy loam over brown clay (Bleached-Mottled, Hypocalcic, Brown Chromosol) (See Appendix 3, pages 39 & 40)

Thick loamy sand to sandy clay loam surface soil with a strongly bleached A2 horizon, sharply overlying a yellowish brown, grey and red mottled clay subsoil grading to medium grained alluvium.

Deep grey brown sandy loam (Bleached-Acidic, Mesotrophic, Brown Kandosol) (See Appendix 3, pages 41 & 42)

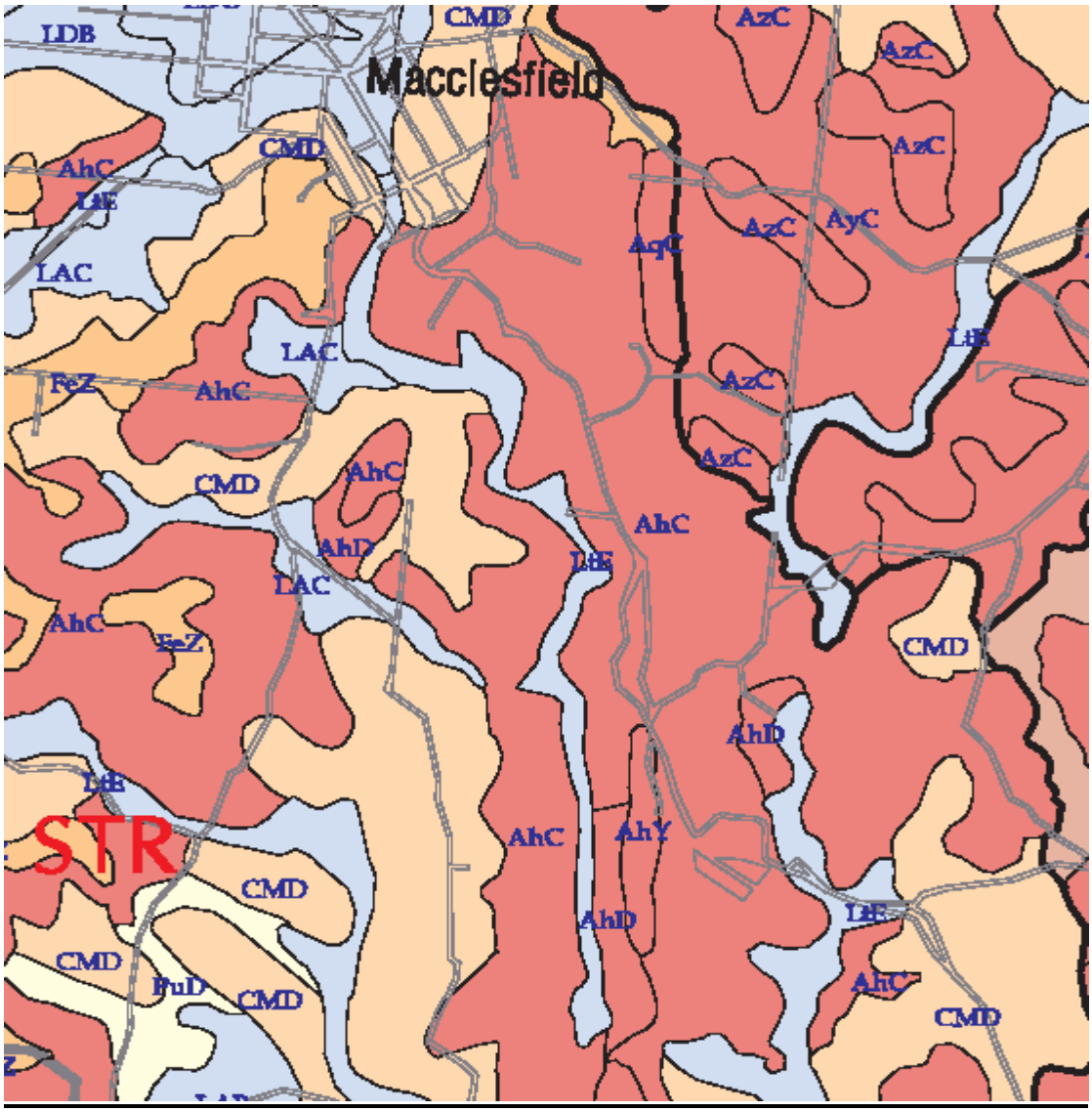
Very thick sandy loam, with a bleached A2 horizon, overlying a dark grey massive light sandy clay loam to sandy clay, grading to clayey sand alluvium.

Red ironstone soil (Ferric, Mesotrophic, Red Chromosol) (See Appendix 3, pages 43 & 44)

Medium thickness ironstone gravely sandy loam with a paler coloured A2 horizon, over a red or orange finely structured clay grading to kaolinized basement rock, with a soft and hard ironstone segregations from about 90cm, continuing below 150cm.

The variety of landscapes reflects the differences in the underlying geology and slope class and hence the variety of soil landscape units, however most soils are commonly moderately deep with loamy sand to loam surfaces (depending on parent rock type) and clayey subsoils. Water holding capacities vary with depth, but most soils are well to moderately well drained. Sandier surfaced soils have lower fertility than the loamier types. All soils are susceptible to acidification.

Figure 20: Main land systems of the Macclesfield "sub-region"



5.2.8 Mount Barker

The Mount Barker "subregion' has 2 distinct areas suitable for viticulture, the Nairne land system to the north east of Mount Barker and the Flaxley land system to the south. As most of the vineyards in this "subregion" are to the north east and main soil types are similar in the two areas, the information will be taken from the Nairne land system. The Nairne land system is 63.6km^2 and receives 675 - 850mm annual rainfall. The Nairne land system comprises predominantly rolling low hills with sandy loam surface texture contrast soils, mixed with shallow stony soils on upper slopes and deeper loamy texture contrast soils in drainage depressions. Almost 40% of the land is non arable due to moderately steep slopes, although nearly all the land is accessible to equipment for pasture management or for horticulture. The soils are generally deep but have moderately low inherent fertility due to the mainly low clay content of their surfaces, and most are prone to acidification and erosion. Drainage is impeded in many soils by clayey subsurface layers. Saline seepage is widespread although the total area is small. Nevertheless, its presence highlights the need for improved catchment management including better water use efficiency.

The soils are mainly shallow to moderately deep overlying basement rock. Sandy loam surface textures are characteristic. These generally overlie more clayey subsoils, but on steeper slopes, rock is at shallow depth and subsoils are absent. Deep sandy loam to clay loam soils occur in minor drainage depressions.

8 Soil Landscape Units (SLU's) are mapped in the Nairne land system with the major units being CoD and AyC. The AyC unit is described as rolling low hills up to 80m high and slopes of 10 - 18%. The CoD unit is described as gently rolling low hills with relief to 50m and slopes of 10 - 18%. Together both these units comprise 77.3% of the total land area for the Nairne land system.

The majority of the soils have sandy loam surfaces overlying reddish or brownish clay subsoils grading to weathering rock. Differences reflect variations in parent rock type, degree of weathering and position in the landscape. Main soils are:

Acidic sandy loam over red mottled clay (Bleached-Mottled, Eutrophic, Red Chromosol) (See Appendix 3, pages 3 & 4)

Medium thickness sandy loam with a paler or bleached A2 horizon, overlying a dark red and brown mottled prismatic structured clay, grading to weathering schist or phyllite by 100cm.

Acidic sandy loam over brown clay (Bleached-Mottled, Eutrophic, Brown Kurosol) (See Appendix 3, pages 45 & 46)

Thick, gravely loamy sand to loam with a bleached and gravely A2 horizon, overlying a yellowish brown, red and greyish brown, coarsely prismatic clay subsoil, grading to weathering metasandstone below 100cm.

Acidic gradational red loam (Eutrophic, Red Dermosol) (See Appendix 3, pages 47 & 48)

Thick gravely brown loam grading to a red and yellow micaceous, coarsely prismatic clay loamy to clayey subsoil, merging with weathering schist from about 100cm.

Acidic loam over red clay on rock (Eutrophic, Red Kurosol) (See Appendix 3, pages 49 & 50)

Medium thickness reddish brown loam to clay loam with a gravely and paler coloured A2 horizon, overlying a red, very well structured clay grading to weathering phyllite from about 100cm.

Thick stony sandy loam (Paralithic, Lepric Tenosol) (See Appendix 3, pages 37 & 38)

Thick, stony loamy sand to sandy loam, forming in weathering schist or phyllite at 50cm or less.

Acidic gradational loam (Mestotrophic, Red Dermosol) (See Appendix 3, pages 47 & 48)

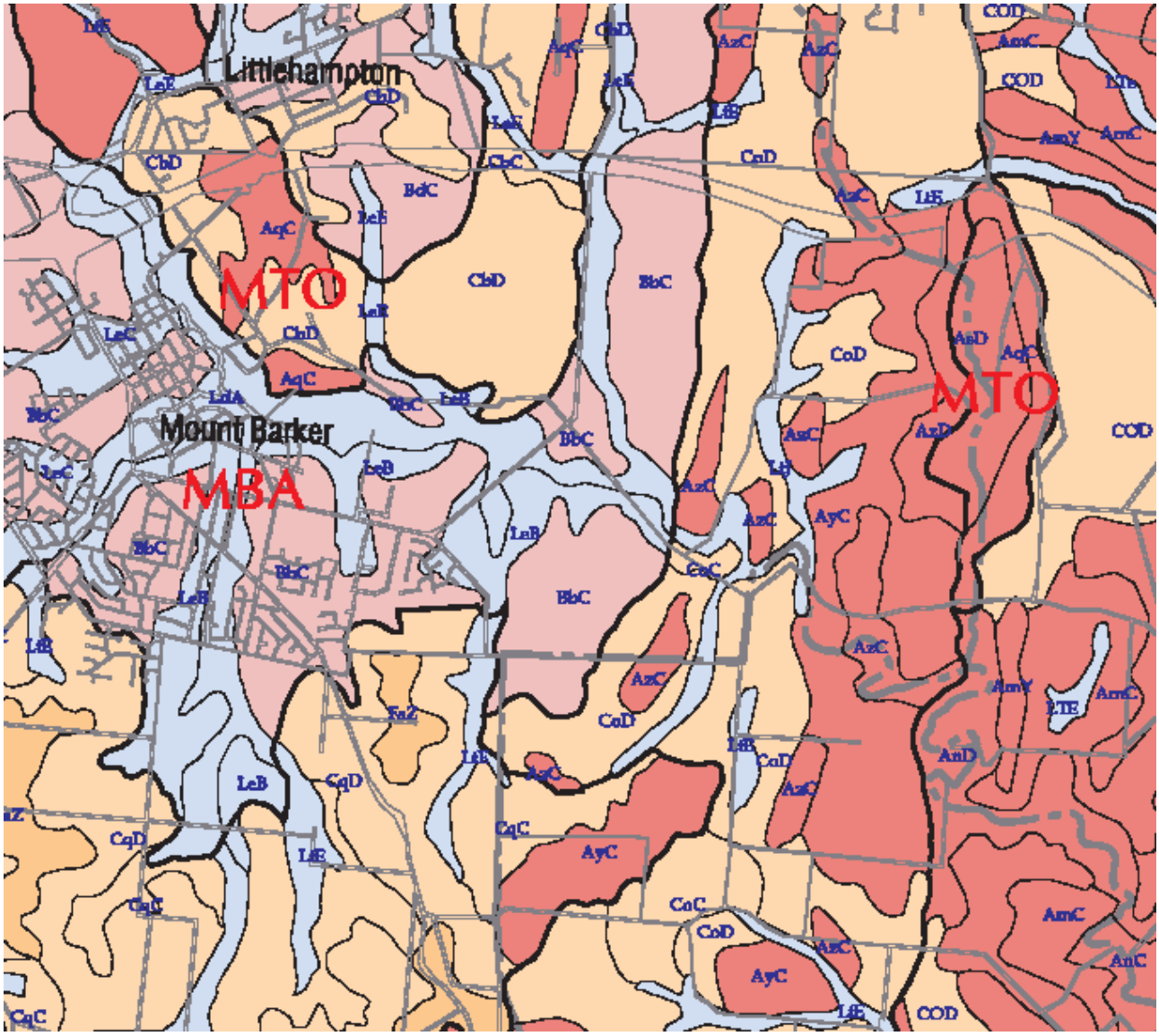
Thick fine sandy loam with minor ironstone grading to a brownish to reddish coarsely block clay loamy to clayey subsoil, siltier with depth, grading to kaolinized phyllite or siltstone, continuing below 200cm.

Sandy loam over poorly structured brown clay (Eutrophic, Brown Sodsol or Bleached-Sodic, Eutrophic Brown Chromosol) (See Appendix 3, pages 59 & 60)

Thick, dark brown loamy sand to sandy clay loam with a bleached A2 horizon, overlying a brown, yellowish brown and red, coarsely blocky clay subsoil grading to grey and brown coarsely prismatic clay forming in weathering schist or phyllite, deeper than 150cm.

These soils are moderately deep but the predominant sandy loam surface soils are prone to nutrient deficiencies and acidification. The soils are imperfectly drained due to impeding clayey subsoils. Most of the land is arable, although erosion potential is moderate to high. There is a minor saline seepage on lower slopes

Figure 21: Main land systems of the Mount Barker "sub-region"



5.2.9 Paracombe

The Paracombe subregion lies within the Paracombe land system, which is 12.4 km^2 and has an annual rainfall of 700 – 800mm. The Paracombe land system is characterized by gentle to moderate slopes, making it an unusual feature in a region characterized by generally steep, strongly dissected landscapes. Three quarters of the land is arable, having mostly moderately deep t deep soils with sandy loam to loam surfaces and well structured clayey subsoils. They are moderately well drained and inherently fertile, making them well suited to horticulture. The steeper slopes in the northern areas less favourable, mainly because of a higher proportion of shallower soils and greater erosions potential.

The soils are typically loamy, with thick surfaces and well structured brown to red clayey subsoils. T stony soils on steeper slopes, ironstone soils on laterite remnants, and deep sandy loam texture creek flats.

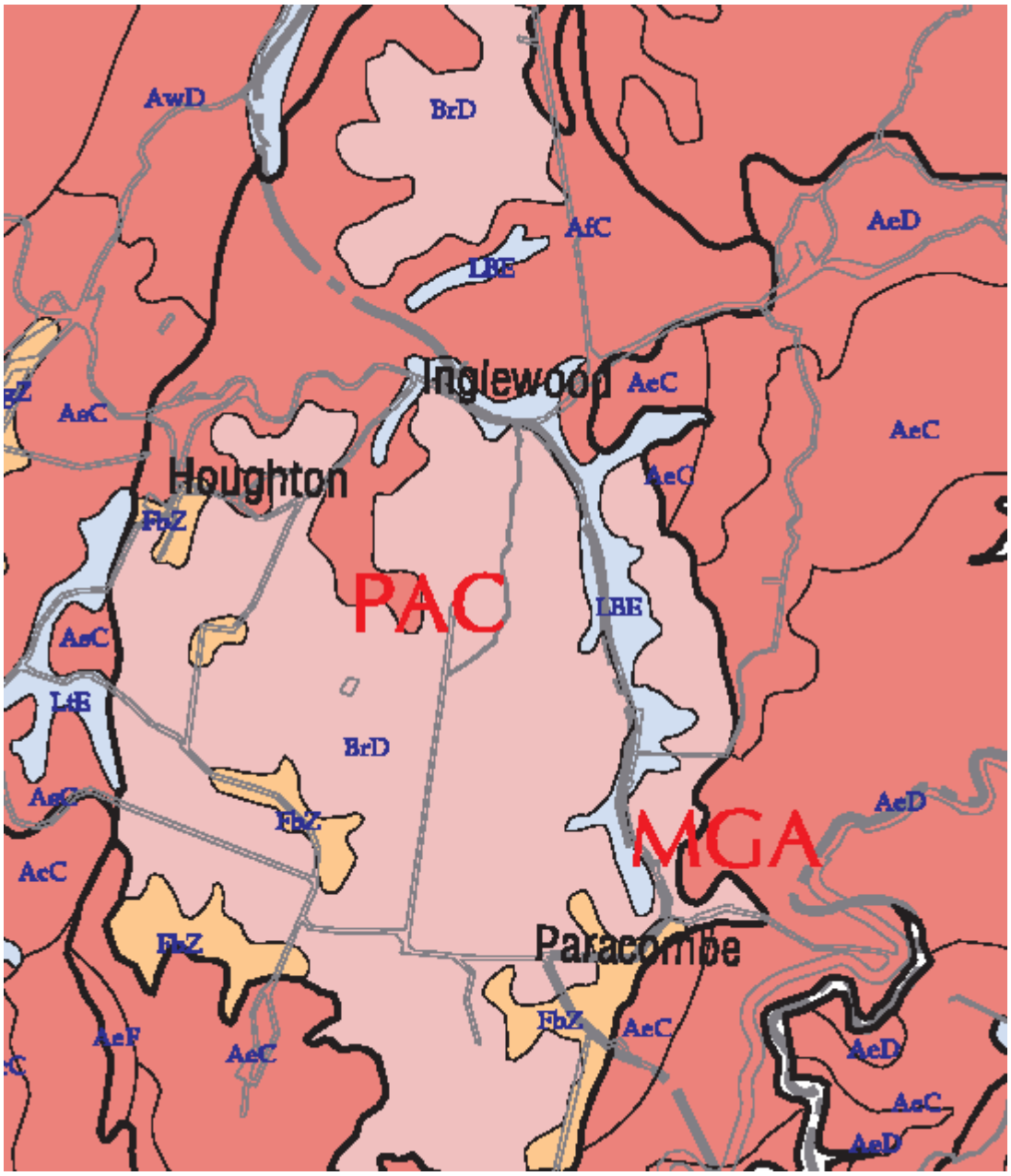
4 Soil Landscape Units have been mapped in the Paracombe land system of which BrD is the major land unit. The BrD unit comprises 60.9% of the total area of the land system and is described as undulating to gently rolling rises with gentle lower slopes, with relief up to 30m and slopes are 8 - 18%.

The soils typically have thick loamy surfaces and well structured high activity clay subsoils. The main soils are:

> **Acidic loam over red or brown clay** (Eutrophic, Brown / Red Chromosol) (See Appendix 3, pages 19 & 20)
>
> Thick dark loam, paler coloured at base, overlying a dark brown, yellowish red and greyish brown, well structured clay, grading to weathering gneiss before 150cm.
>
> **Acidic sandy loam over red sandy clay** (Eutrophic, Red Chromosol) (See Appendix 3, pages 51 & 52)
>
> Thick to very thick coarse sandy loam, with a paler coloured and gravely A2 layer, overlying a reddish brown well structured sandy clay, grading to weathering gneiss before 100cm.
>
> **Sandy loam over brown mottled clay** (Bleached-Mottled, Eutrophic, Brown Chromosol) (See Appendix 3, pages 7 & 8)
>
> Thick sandy loam to sandy clay loam, with a bleached and gravely A2 horizon, overlying a yellowish brown, brown and red mottled, firm, coarsely structured sandy to medium clay.

These soils are mainly moderately deep, inherently fertile and well drained, and generally well suited to perennial horticultural crops where water is available. Much of the land also has potential for annual crops, although water erosion is a potentially serious problem.

Figure 22: Main land systems of the Paracombe "sub-region"



is

5.2.10 Piccadilly

The subregion of Piccadilly lies within the Piccadilly land system, which is24.2km^2 and receives 1050 – 1150mm of annual rainfall. The Piccadilly land system is characterized by sandy loam to loam soils with well structured clayey subsoils on moderate slopes. Topographically, nearly all of the land is suitable for horticulture, but substantial areas in the south are urbanized. Historically the land has been extensively used for a variety of horticultural enterprises, and most of the land has high potential due to the combination of moderately deep and moderately well drained soils, cool climate and good quality groundwater. However, erosion and associated water pollution have caused problems in the past. Urban pressures are gradually forcing the traditional land uses elsewhere.

The soils are predominantly shallow to moderately deep over weathering rock. Most are texture contrast or gradational types with sandy loam to loam surfaces and well structured clayey subsoils. There are shallow stony soils on the minor rocky or steeper slopes. A range of texture contrast or deep course to medium textured soils occurs on the alluvium of creek flats and lower slopes.

Nine Soil Landscape Units have been mapped for the Piccadilly land system with the units of AvC and CsD comprising of 32.6% and 30.7% of the total land system area respectively. The AvC unit is described as rolling low hills formed on interbedded sandstones and siltstones with relief of up to 50m and slopes of 18 - 30%, and up to 40% on short slopes. The CsD unit is described as rolling rises and low hills formed on interbedded sandstones and siltstones with relief of 20 – 50m and slopes of 8 - 18%.

The majority of the soils are moderately deep over bedrock. Surface soils are generally sandy loams to loams with some sandier types on limited strata of course grained rocks. Subsoils are invariably friable yellow, brown or orange clays, but gravely and sandier subsoils occur on coarser grained rocks. Deep sandy to loamy soils with sandy clay loam to clay subsoils are predominant on lower slopes and in drainage depressions. Main soils are:

Acidic sandy loam over brown clay on gneiss (Bleached, Eutrophic, Brown Chromosol) (See Appendix 3, pages 53 & 54)

Thick sandy loam to loam with a paler coloured or bleached and gravely A2 horizon, overlying a brown or yellowish red, well structured clay grading to weathering gneiss by 100cm.

Acidic gradational brown loam (Eutrophic, Brown Dermosol) (See Appendix 3, pages 23 & 24)

Medium thickness loamy surface soil, becoming clay loamy and gravely with depth, overlying an orange, friable clay subsoil, grading to soft shale or siltstone.

Acidic clay loam over brown and red mottled clay (Eutrophic, Brown / Red Kurosol) (See Appendix 3, pages 19 & 20)

Medium thickness loam to clay loam with a bleached and gravely A2 layer, over a red and brown mottled well structured medium to heavy clay, grading to weathering siltstone from about 100cm.

Acidic gradational sandy loam (Bleached-Acidic, Mesotrophic, Yellow Kandosol) (See Appendix 3, pages 23 & 24)

Thick, gravely loamy coarse sand to coarse sandy loam surface soil with a bleached and very gritty and gravely A2 horizon, overlying a brown or yellow sandy clay loam to sandy clay subsoil with abundant rock fragments, grading to coarse grained sandstone.

Sandy loam over brown sandy clay loam over alluvium (Bleached-Mottled, Eutrophic, Brown Chromosol) (See Appendix 3, pages 55 & 56)

Thick dark brown loamy sandy clay loam to light clay with coarse prismatic structure, grading to a grey, brown and yellow mottled clayey sand.

Deep gradational sandy loam over alluvium (Bleached-Acidic, Mesotrophic, Grey Kandosol) (See Appendix 3, pages 41 & 42)

Very thick sandy loam surface soil, with a bleached A2 horizon, grading to a dark grey massive light sandy clay loam to sandy clay, overlying clayey sand alluvium.

Acidic sandy loam over brown clay on sandstone (Bleached, Mesotrophic, Brown Kurosol) (See Appendix 3, pages 21 & 22)

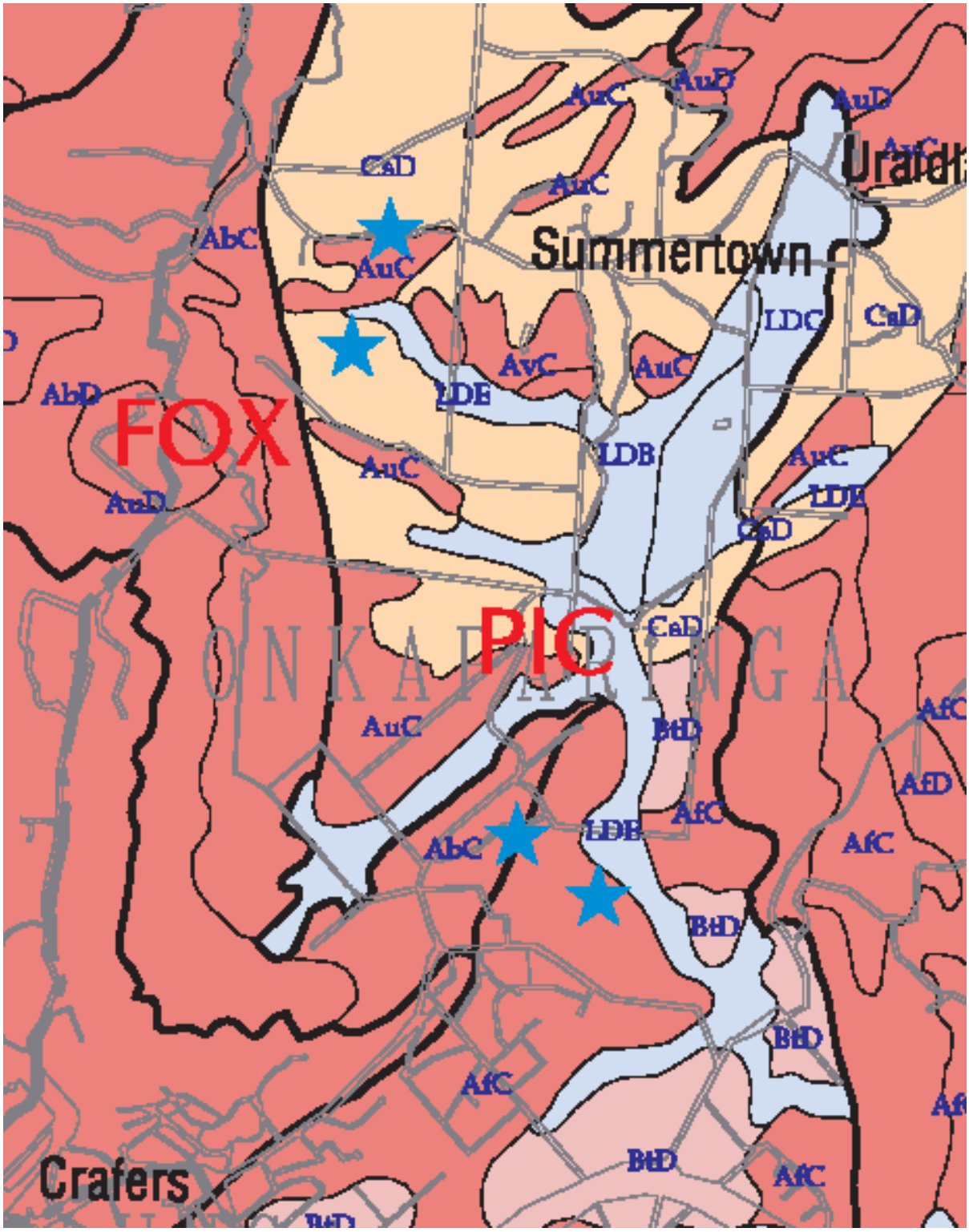
Medium to thick, gravely loamy sand to sandy loam surface soil, with a bleached and very gravely A2 horizon, overlying a yellowish brown, red and brown sandy clay to clay subsoil grading to a weathering sandstone by 100cm.

Shallow sandy loam (Acidic, Paralithic, Bleached-Leptic Tenosol) (See Appendix 3, pages 37 & 38)

Thick, very gravely loamy sand to sandy loam, overlying a brown gravely clayey sand, grading to weathering sandstone or gneiss by 50cm.

These soils are semi arable; the soils are moderately deep and usually well drained, although infertile and acidic. Erosion potential is high, and severe erosion has occurred in the past as a result of poor soil management. However, potential for perennial horticulture is generally good.

Figure 23: Main land systems of the Piccadilly "sub-region"



5.3 Detailed Description of Soil Types

Due to the varying topography and underlying geology of the region there are in excess of 30 different soil types which are present in viticultural areas of the AHWR. A detailed description of each of these soil types can be found in Appendix 3 – Adelaide Hills Wine Region Detailed Description of Soil Types. These profiles will give a general description of the soil type, substrates, vegetation and detailed soil pit descriptions. There is also a summary of drainage and fertility properties, pH, rooting depth, barriers to root growth, water holding capacity, erosion potential and a sample laboratory analysis.

This information has been sourced in conjunction with the soil landscape information, from the Department of Water, Land and Biodiversity Conservation, "Soil and Land information" CD, July 2003. It provides a good source of both written and pictorial information regarding specific soil types found within the AHWR.

6.0 WATER RESOURCES

Most vineyards in the AHWR are irrigated. The study was not able to identify any vineyards which do not use irrigation for grape production.

Water is mainly drawn from surface catchment (ie, dams), and underground aquifers (ie, bores). Water is also taken directly from river systems, such as the Onkaparinga or Torrens, S.A. Water pipelines ("mains water"). The study was unable to determine the relative proportion of each water source.

6.1 Water Usage

The average water use for the AHWR is thought to be 0.5 – 0.8ML/ha, however this varies depending upon soil type and with seasonal conditions. For example:

Sandy clay loam ≈ maximum 0.7ML/ha
Sandy loam, stony outcrops ≈ maximum 1.1ML/ha
Shale, well drained ≈ maximum 0.85ML/ha

6.2 Water Quality

It is generally accepted that in the eastern part of the Region, salinity of underground water is higher than the other areas of the AHWR. Water quality varies greatly with the rock sub stratum and depth to the aquifer.

6.3 Limitations on Water Usage

The State Government has created prescription programmes for both the Eastern Mt Lofty Ranges (EMLR) and the Western Mt Lofty Ranges (WMLR) in response to concerns regarding the water resources in these areas.

The WMLR has released a "Notice of Prohibition" October 14, 2004 which limits new water resource developments until 2006. This notice temporarily holds water use to current levels until detailed investigation of the water use is completed. The investigation is being carried out by the Dept. of Land, Water & Biodiversity Conservation in a "Land and Water Use Survey". This assessment of the level of water use over the past three years will be used in determining future allowable use if the area becomes prescribed.

The next stage after a "Notice of Prohibition" is for prescription, but before the resource is prescribed, a "Notice of Intent to Prescribe" must be issued. This period allows for comments from and consultation with the community, and will end on March 25, 2005.

Water usage in the EMLR is currently restricted under two Notices of Prohibition dated October 16, 2003. The first Notice restricts water use from underground sources, and the second Notice applies to taking water from a watercourse, or ground water. The use of water in the EMLR is controlled for 24 months; prescription is likely to be announced in early 2005.

A Mt Lofty Irrigation Evaluation Study has been carried out and a report released (April 2004). Rural Solutions SA is to continue this Study for two more seasons, 2004/05 and 2005/06. This information will be valuable in the determination of final water allocations for different locations throughout the AHWR.

7.0 SUB-CATCHMENTS OF THE AHWR

Management of individual sub-catchments is now a high priority throughout the Adelaide Hills and Mt Lofty Ranges. In 2002 the Department of Primary Industries and Resources, South Australia (PIRSA), Environmental Protection Agency (EPA) and the Mount Lofty Ranges Watershed Protection Office (MLRWPO) published "Land System Data Mapping for the Mount Lofty Ranges Watershed".

The objective of the Land Status Data Mapping Project was to make available a "cost effective, multi-layered classification system to map land cover and land use at a resolution suitable for sub-catchment analysis in the Mount Lofty Ranges".

A series of four basic maps has been created by PIRSA GIS Mapping Unit; these have been collated by DVCS in Appendix 3. The series of maps provides information for most sub-catchments in the AHWR, for land use, rainfall, topographical relief, and soil erosion potential.

7.1 Land Use

The land use maps define areas based upon similar land use types, such as

- Viticulture
- Broad scale grazing
- Water bodies
- Pome fruit
- Native vegetation

7.2 Rainfall

The rainfall maps categorise rainfall throughout the sub-catchments in 25mm increments. This data is based upon long term data held by PIRSA.

7.3 Topographical Relief

The relief maps show changes in elevation via a graded colour scale of purples through to browns. The gradation is in 20m increments.

7.4 Soil Erosion Potential

Soil erosion potential is calculated using data which relates to soil type and water erosion potential. This is a useful indicator for vineyard planning and development.

Table 9: Sub-catchments for which maps are included in Appendix 3.

Aldgate Creek	Angas Creek	Angas River	Angels Gully	Balhannah
Biggs Flat	Charleston	Cock Creek	Cox Creek	Cudlee Creek
Echunga Creek	Fifth Creek	Footes Creek	Forestry Headquarters	Gould Creek
Hahndorf	Hannaford	Inverbrackie Creek	Kenton Valley	Kersbrook Creek
Little Para River	Malcolm Creek	McCormick Creek	Millers Creek	Mitchell Creek
Mount Pleasant	Onkaparinga Main Channel	Portuguese Creek	Scott Creek	Sixth Creek
South Para	Torrens Main Channel	Tungali Creek	Upper Finniss	Upper Onkaparinga
Warren Reservoir	Western Branch			

8.0 KEY VITICULTURAL CHALLENGES

As mentioned in 3.3, a survey of the views of growers, viticulturalists, wine makers, Grower Liaison Officers and corporate technical offiers was carried out. Respondents were asked to identify the key viticultural challenges for the AHWR and their views are summarised below.

Most respondents agreed that the major challenges are coping with the climatic variability within sites and seasons, as well as managing vine vigour and cropload appropriately to achieve the quality which is expected from this Region.

8.1 Climatic Issues

- Poor weather conditions during spring (ie cool, wet, windy weather) adversely affects flowering and floral initiation for the following season.
- The climate limits the production of certain varieties to certain wine styles.
- Spring vigour in wetter years can make vegetative growth unmanageable with consequent increased management costs and possible yield and fruit quality problems.
- Due to the undulating nature of the Hills, there are areas on lower slopes and in valleys which are more prone to frosts – not always identifiable during initial site selection .
- Botrytis can be a major problem in years with persistent spring rain and/or late summer/autumn rains. Later ripening red varieties have a significant botrytis risk.

8.2 Vine Balance / Fruit Quality Issues

- The choice of late ripening varieties; in some years will struggle to get them sugar ripe. Flavour ripeness can also be a problem.
- Achieving the right cropload is critical in cool climates. In order to achieve appropriate ripeness and quality in some varieties, croploads need to be much lower than current production levels.
- Vine balance is difficult to manage in deep and/or fertile soils. This creates problems with canopy microclimate, especially shading.
- The inability of vines to be naturally balanced in some areas has a major impact on fruit quality and production costs.
- Crop regulation is difficult to manage in years of very good yields due mainly to a lack of site experience, and a slowness to recognise benefits of shoot thinning early in the season.
- Disease concerns such as Eutypa and Crown Gall are reasons behind some vineyards being replanted rather than grafted.
- Birds causing damage to crops create higher or increased production costs, and also increases the chance of disease.
- Evenness of ripening is important as the best crops tend to be those which ripen evenly and early in the season.

8.3 Water Resources

- The future of water resources, both quality and quantity is of major concern. The Prescription of water use in both the Western and Eastern Mt Lofty Ranges (as described in 6.3) has raised major concerns regarding the future economic viability of some plantings as well as concerns relating to opportunities for further development.

8.4 Industry Issues

- A lack of homogenous vineyard sites; this increases management costs and may detract from fruit quality.
- Encroaching urbanisation upon agricultural land is promoting unease between residents and growers, as there is little support, communication or knowledge transfer.
- There is a growing trend for owners of vineyards/wineries in the region to have their primary business interest outside the industry. This causes less cohesion than desirable for the Region.
- A lack of processing facilities in the Region is causing increased pressure on the Hills infrastructure, particularly in relation to roads and transport issues.

APPENDIX 1

APPENDIX 1: SOURCES OF INFORMATION FOR ADELAIDE HILLS WINE REGION PROFILE

1. Consulted Parties

Parties consulted in the preparation of this Report include:

- Private growers and wine makers
- Corporate Viticulturalists and Grower Liaison Officers (Hardys Wines, Orlando, Nepenthe)
- Vineyard contractors
- Participants in AHWR workshops/seminars in June, October 2004
- PIRSA
- Phylloxera & Grape Industry Board of South Australia
- Bureau of Meteorology

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APPENDIX 2

APPENDIX 2: LOCATION OF PLANTINGS BY VARIETY IN THE ADELAIDE HILLS WINE REGION

These maps have been produced by the Phylloxera & Grape Industry Board (P&GIB) from information collected with vineyard registrations and levy data.

This resource provides members of the AHWR with descriptions of plantings of the following varieties:.

Chardonnay
Sauvignon Blanc
Cabernet Sauvignon
Pinot Gris
Pinot Noir
Merlot
Shiraz

The varietal maps show the location of certain varieties in greater detail. However due to Privacy Act restrictions they are unable to define actual areas of each variety planted. Hence the study is unable to identify the specific location and size of varietal plantings in the AHWR. The colour key refers only to the size of the property on which that variety is planted and not to the size of the individual variety itself.

APPENDIX 3

APPENDIX 3: INTRODUCTION TO DETAILED DESCRIPTION OF SOIL TYPES

This resource provides members of the AHWR with detailed soil descriptions of the major soil types present in the AHWR. It has been collated by Davidson Viticultural Consulting Services (DVCS) for the Adelaide Hills Wine Region Inc (AHWR) for use with the Adelaide Hills Wine Region Profile, based on the CD "Central Districts – Land Resource Information" produced by the Department of Water, Land and Biodiversity Conservation (DWLBC) in 2003. The assistance of David Maschmedt of DWLBC is gratefully acknowledged.

Information included for each soil type includes:

- General description
- Land form
- Substrate
- Vegetation
- Soil description (including soil pit photograph)
- Classification of soil type
- Drainage properties
- Fertility properties
- pH
- Rooting depth
- Physical and chemical barriers to root growth
- Water holding capacity
- Seedling emergence properties
- Workability
- Erosion potential
- Sample soil laboratory data