CFPA	SAAPPA / SASPA / SAT	DFTS	Winetech
Canning Fruit Producers' Assoc. Submit to: Wiehahn Victor Tel: +27 (0)21 872 1501 inmaak@mweb.co.za	Fruitgro Science Submit to: Louise Liebenberg Tel: +27 (0)21 882 8470/1 louise@fruitgro.co.za	Dried Fruit Technical Services Submit to: Dappie Smit Tel: +27 (0)21 870 2900 dappies@dtd.co.za	Submit to: Jan Booysen Tel: +27 (0)21 807 3324 booysenj@winetech.co.za

			X

Indicate (X) client(s) to whom this final report is submitted.
Replace any of these with other relevant clients if required.

FINAL REPORT
FOR 2012

PROGRAMME & PROJECT LEADER INFORMATION

	Programme leader	Project leader
Title, initials, surname		Dr VA Carey
Present position		Extra-ordinary Senior Lecturer
Address		584 Mt Moberly Place Coldstream, B.C. V1B 3Y1 Canada
Tel. / Cell no.		+1 250 558 5422
E-mail		vcarey18@telus.net

PROJECT INFORMATION

Project number	DVO-VAC02
Project title	**The use of local knowledge relating to vineyard performance to identify terroirs for Chardonnay and Shiraz in a sub-region of the Robertson Valley**
Project Keywords	Local knowledge; natural terroir units, Shiraz, Chardonnay, Soil, Robertson

Industry programme	**CFPA**	
	Deciduous	
	DFTS	
	Winetech	Cultivation, Terroir
	Other	

Fruit kind(s)	Wine Grapes
Start date (dd/mm/yyyy)	01/01/2006
End date (dd/mm/yyyy)	31/12/2009

FINAL REPORT

(Completion of points 1-5 is compulsory)

1. Executive summary

Give an executive summary of the *total* project in no more than 250 words

This project aimed to delimit terroirs for Chardonnay and Shiraz in the Robertson Wine of Origin District using a survey of the vineyard managers to generate the viticultural and oenological data.

The land use/cover layer was combined with the slope aspect and soil landscape to provide a three-component NTU description. One hundred and seventy NTU were identified, of which fifty five units exist for agriculture. These NTU can be used for site selection of agricultural produce and effective planning and management of land use. Climate was not included in the delimitation of NTU because of the coarse resolution of climatic data.

Data measured in 20 vineyards each of Chardonnay and Shiraz in 2007/2008 was compared to the survey data. The growth-vigour score on the surveys can be considered validated for both cultivars.

A survey was performed amongst grape producers/buyers for Chardonnay and Shiraz in the Robertson Wine District. 96 Shiraz and 199 Chardonnay vineyards were surveyed and their data captured in a database. The vineyard positions were digitised. Many of the surveys had missing data and variables with more than 20% missing values had to be excluded from statistical analyses. Univariate analyses were used to test for relationships between data. The variables “wine category” and “growth vigour” were compared with other variables in the survey database for each of Shiraz and Chardonnay. For both cultivars, although management practices play a strong role in determining wine quality category or are adapted for a production of a grapes for specific wine category, environmental variables do play a role in the determination of wine quality category and thus terroirs for production of a specific wine category can be identified. For Shiraz soil type and aspect are important identifiers and for Chardonnay, soil type, day temperature prior to ripening and night temperature prior to ripening are important identifiers.

A study of four plots each of Chardonnay/101.14 Mgt and Shiraz/101.14 Mgt was carried out in eight commercial vineyards in the Robertson region in order to investigate the relationship between soil and root morphology, and the influence thereof on canopy development and berry growth. These plots had different soil types. Important soil properties are reported to limit root growth, individually or as a combination of restrictions. It was found that the size of the root system of 101.14 Mgt is defined by soil physical and chemical properties. The roots of 101.14 Mgt under irrigation can grow to a depth of 100 cm or beyond if the soil physical and chemical properties allow it. The balance between canopy growth before véraison and the ability of the root-soil system to maintain that canopy size during the ripening process is crucial in an area with a high evaporative demand. In this regard, not all the soil properties-root system combinations showed satisfactory performance in maintaining the canopy functioning, which affected the berry sugar loading and the berry volume.

In another study, forty soil profiles were characterised in the Robertson valley. The root systems were first classified according to rooting depth – into shallow and deep root systems. The deep root systems were then subdivided, creating two subgroups of high root density and low root density. The two extreme groups (i.e. shallow roots, and deep roots with high root density) are particularly associated with different soil properties. The soil characteristics found in these extremes are represented up to certain point by families of the South African soil taxonomy, mainly due to the restrictive function of the B horizon. This restrictive function is related to soil properties that are taken into consideration in the South

African soil classification and that are important for grapevine root growth, as well as the thickness of the described horizons and the physical and chemical differences between the horizons.

Based on the results obtained from surveys and field studies, criteria for optimal performance of Chardonnay and Shiraz were determined and natural terroir units representing these criteria were identified. Thirty NTU that have the potential for agriculture (agriculture, bare surfaces or natural vegetation land use) were identified for Shiraz (25 438 ha) and nine (6 819 ha) for Chardonnay.

In this study, it did not appear that a survey of local knowledge was a suitable methodology for determining terroirs for Chardonnay and Shiraz. a more focussed survey or round table discussion amongst expert viticulturists and soil scientists may be better for the Robertson Wine of Origin District. This research has provided a good overview of the current situation in Robertson Wine of origin District and could provide information that is useful for marketing purposes if compiled as a popular document.

2. Problem identification and objectives

State the problem being addressed and the ultimate aim of the project.

Terroir studies in South Africa have thus far been focussed on the Stellenbosch District and on Cabernet Sauvignon and Sauvignon blanc in order to determine suitable methodology for delimitation of terroirs. This preliminary study has been completed and it is necessary to test the methodology in a different region.

The ultimate aims of this project were

1. to delimit natural terroir units in a selected sub-region of the Robertson valley
2. to determine the viticultural and oenological performance of Chardonnay and Shiraz in the Robertson valley
3. to delimit terroirs for Chardonnay and Shiraz in the Robertson valley.

The more detailed objectives for the project are:

Aim 1. Identify natural terroir units in the selected sub-region of the Robertson valley

Milestone 1. Gather all available soil, geological, topographical and climatic data and digitise data where necessary

Milestone 2. Perform a GIS analysis to identify natural terroir units

Aim 2. Determine the viticultural and oenological performance of Chardonnay and Shiraz in the selected sub-region of the Robertson valley

Milestone 1. Compile survey based on consultation with viticulturists and wine makers in the region

Milestone 2. Perform a guided survey of as many existing Chardonnay and Shiraz vineyards in the region as possible and create a spatial data-base of the results.

Milestone 3. Compile a data-base of viticultural and oenological measurements of ca. 20 vineyards each of Chardonnay and Shiraz

Milestone 4. Investigate the relationship between soil type, rooting profile, viticulture performance and wine style for Chardonnay and Shiraz.

Aim 3. Delimit terroirs for production of Chardonnay and Shiraz in the selected sub-region of the Robertson valley

Milestone 1. Statistical analysis of survey data base

Milestone 2. Spatial interpolation of statistical rules to identify terroirs for the 2 cultivars.

3. Workplan (materials & methods)

List trial sites, treatments, experimental layout and statistical detail, sampling detail, cold storage and examination stages and parameters.

Aim 1. Identify natural terroir units in the selected sub-region of the Robertson valley
GIS data and methodology

For the purposes of this research, the study area followed the municipal boundary of the Robertson Local Municipality (LM) as determined by the Municipal Demarcation Board of South Africa. This boundary differs from the Robertson Wine of Origin District (WD) as demarcated by the Wine and Spirit Board. It excludes the Bonnievale ward, east of Robertson and encompasses a total area of 158 897 ha. This area was selected as it represented the Robertson district and was included on single images. The study area used is shown in Figure 1.1.

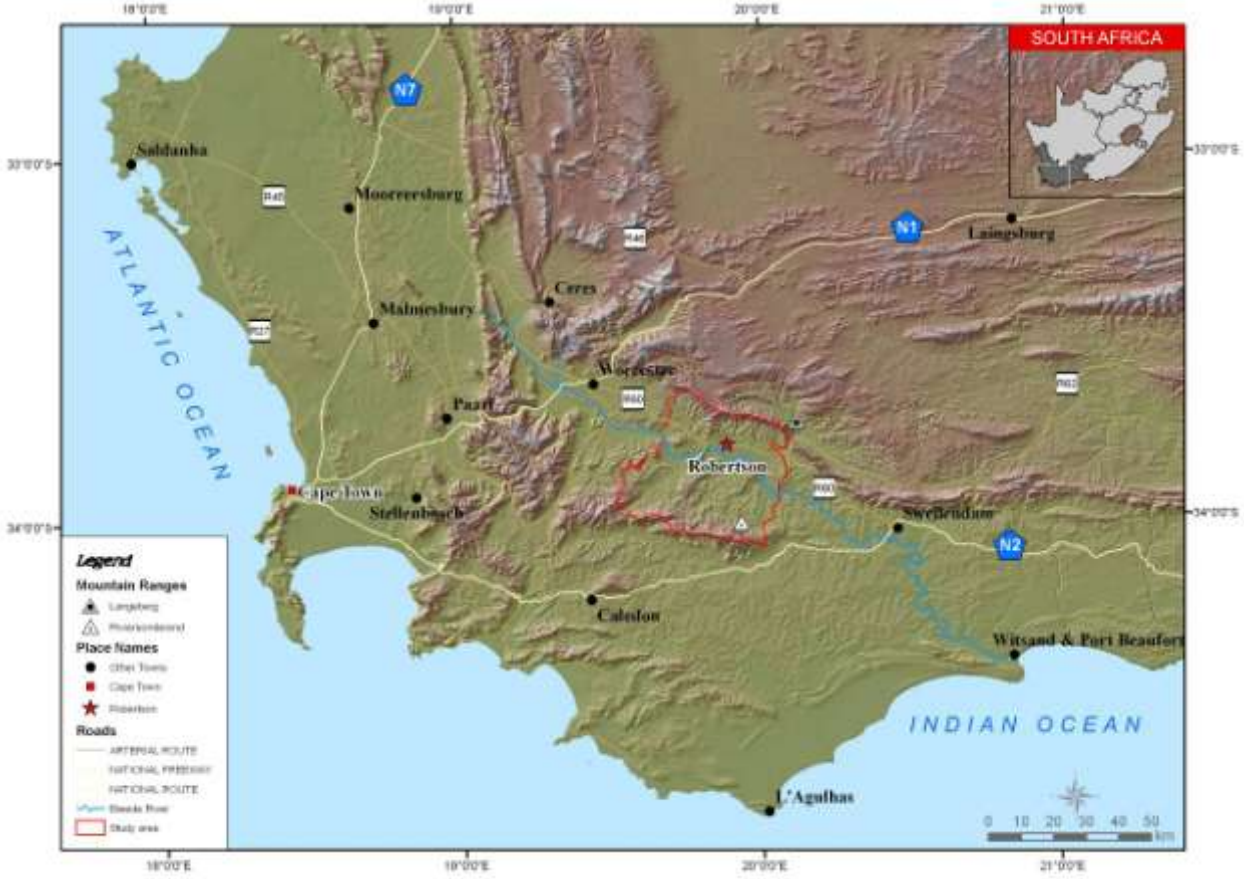

Figure 1.1. Robertson study area for GIS analyses

He acquired the following spatial data for use in the identification of soil landscapes and natural terroir units in the study area:

Satellite Imagery (acquired from CSIR Satellite applications centre and USGS)
SPOT 4 multispectral summer image (20m resolution) (11 December 2005)
SPOT 4 panchromatic summer image (10m resolution) (11 December 2005)
SPOT 4 multispectral winter image (20m resolution) (6 April 2005)
SPOT 4 multispectral winter image (10m resolution) (6 April 2005)
SPOT 5 multispectral (10m resolution) summer image (23 October 2006)
SPOT 5 panchromatic (2.5m resolution) summer image (23 October 2006)
ASTER visible (15m) winter image (26 August 2006)
ASTER shortwave infrared (30m) winter image (26 August 2006)
ASTER thermal infrared (60m) winter image (26 August 2006)

Aerial Imagery (acquired from Department of Forestry/ DWAF)

This imagery required Geometric correction. Radiometric Correction was unnecessary. The Geometric correction was performed using Erdas Imagine 8.7 software and all datasets were georeferenced to UTM zone 34. The WGS 84 datum and ellipsoid were used. Twenty-five evenly spread ground control points (GCPs) were collected over the study area. A 2.5m

resolution mosaic of orthorectified aerial photographs of the study area was used as a reference image to locate X- and Y coordinates on the SPOT 5 panchromatic image. The DEM was used to extract elevation (Z-value). A total root mean square error (RMSE) of less than 1m was maintained for the entire panchromatic image. The SPOT 5 multi-spectral image and the ASTER images were georeferenced to the orthorectified SPOT 5 panchromatic image. The RMSE was kept below 3m for the SPOT 5 multi-spectral image and below 5m for the ASTER image.

The following additional data was obtained:
Rasters and Rasterized vector data
Digital Elevation Model (20m) (University of Stellenbosch Department of Geography and Environmental Sciences)
Soil (1:25 000) (Department of Agriculture-Elsenburg)
Geology (1:250 000) (Council for GeoScience)
Topographic map (1:50 000) (CDSM)
Landtype (1:50 000) (Department of Agriculture-Elsenburg)

All topographic parameters (local relief, slope and aspect) in this section were computed by means of a 20m DEM in the ArcGIS 9.1 software. This DEM was resampled to 20m from a 50m DEM that was produced by the Chief Directorate Surveys and Mapping (CDSM).
The soil groups as documented in the GIS database of Department of Agriculture in Elsenburg were used in this study as the Catena booklet had not yet been finalized.
Fig 1.2 illustrates the methodology followed in this research. This includes, acquiring the necessary data, preprocessing, image segmentation, object-based image analysis (OBIA), classification of soil landscapes and, finally, the identification of natural terroir units. Image analysis was performed by using the Definiens Developer 7.0.3 software.
Rule-based classification methodology was followed for image classification. Initially eight basic land cover classes were identified for the classification process. These are water, built-up areas, agricultural land, natural vegetation, bare rock or soil, roads, recreational areas and mining and industry.

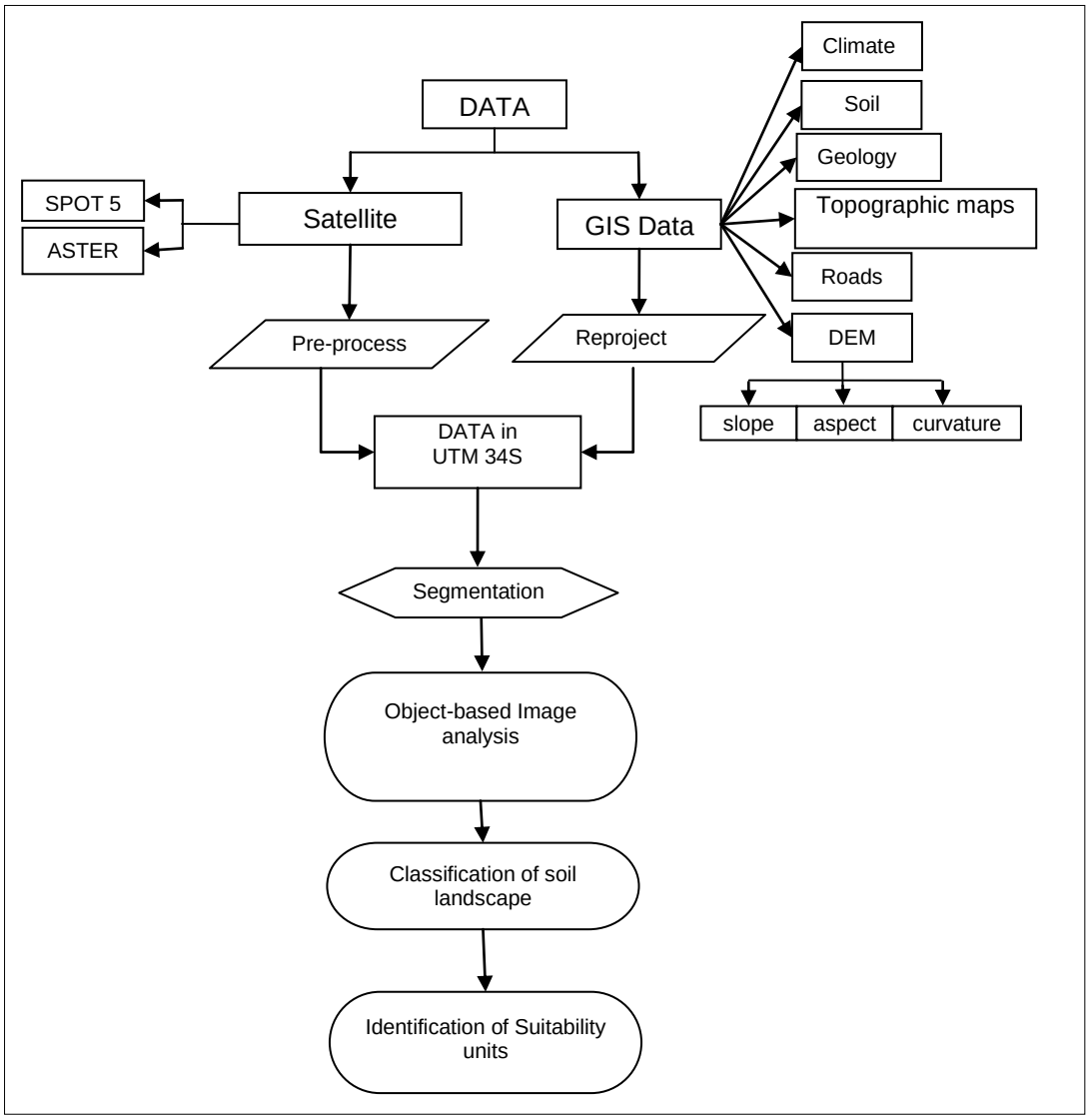

Figure 1.2. Flow chart representing research methodology.

Further details are provided in the MSc thesis of Hadley Remas, entitled “The identification of natural terroir units in the Robertson Wine District using GIS and Remote sensing.”, 2012.

Aim 2. Determine the viticultural and oenological performance of Chardonnay and Shiraz in the selected sub-region of the Robertson valley

Survey of the viticultural and oenological performance of Chardonnay and Shiraz in the selected sub-region of the Robertson valley

The final surveys were compiled in consultation with Willem Botha, Briaan Stipp and Anton Laas and comments from the Cultivation committee were addressed. These questionnaires included questions with unstructured line scale, multiple choice and free choice answers. The categories included general viticultural information, management practices, vegetative, productive and berry characteristics and general environmental characteristics. The surveys from private own estates were completed at the estates with the help of the viticulturist and/or the winemaker and the surveys from grape producers were completed with the help of viticulturists from the grape-buying cooperative cellars. The assistance of Briaan Stipp, Robertson Cellar, is gratefully acknowledged.

Table 2.1. Details of the wine estates and the grape producers approached for surveys

Farm name	Contact	Telephone	CY Survey	SH Survey
Appelsdrift	Wouter de Wet	0832312236	x	x
Appelsdrift	A Viljoen	0846261838		x
Arabella	S De Wet	0823772677	x	x
Arendsig	Frikkie van der Westhuizen	0829402836	x	x
Bella Vista	J & W Bruwer	0827702279	x	x
Boesmansrivier	Van Zyl Rossouw	0823487727	x	x
Bruwer Poort	HB Kloppers	0829606876	x	
Buffelskloof	M Tolmay	0825774257	x	
Buitenverwacht	AW Malherbe	0828926328	x	
Cloverfield	K Marais	0823358065	x	
De Erf	PF Malan	0828511041	x	
De Heuwel	GJ Joubert	0236162706	x	
De Wilgen	D De Wet	0823354877	x	x
Die dam	JS du Toit	0825708141	x	
Die Hoek	J Cloete	0828202238	x	
Dwarswater	J Oosthuizen	0824740711	x	
Eilandia	Michau Viljoen	0828988470	x	x
Excelsior	Peter de Wet	0236151980	x	x
Gideonsrus	Brink/-*G.V.Z.*Mnr	0828283404	x	
Glen	J Smit	0845869424	x	
Goeiehoop	H Bruwer	0825623421	x	x
Goree	Pierre Bruwer	0827702288	x	x
Goudmyn	FJ du Toit		x	
Goudmyn	SG Malherbe	0827702488	x	
Goudmyn	DJ Zeeman	0842470767	x	x
Graham Beck	Marco Ventrella	0828888820	x	x
Greenlands	Jaco Joubert	0845158339	x	x
Groenland	R Beatie	0826060747	x	x
Grootrivier	C. Brink	0827812804		x
Hoek-Hoek	David Rossouw	0834147651	x	x
Jakkelsleegte	HP van der Merwe	0823224264	x	x
Kleinbegin Boerdery	C Baard	0827888712	x	x
Klipbos	EJ Conradie	0846228685	x	x
Klipboslaagte	Anton Smuts	0236262103	x	x
Klipdrift	Briaan Stipp	0834555196	x	x
Koningsriver	Francois Naude	0236251940	x	
Koningsriver	Koningsrivier Boerdery	0825881262	x	x
Koningsriver	R de Clerq	0738666975	x	x
Koningsrivier	P Kriel	0827722230	x	
Kranskop	Nakkie Smit	0823389371	x	x
La Chasseur	M Viljoen	0828988470	x	x
La Colline	Swiegers Broers	0828070255	x	x
La Chasseur	HN de Villiers	0236264707	x	x
La Chasseur	PR de Villiers	0824985220	x	
La Chasseur	Onder Platberg Boerdery			x
Lucerne	Anton Smuts	0236262098	x	x

Farm name	Contact	Telephone	CY Survey	SH Survey
Moreson	Willem Viljoen	0823757890	x	
Morgenstond	H van der Merwe	0723095499	x	
Paynesdale	C Mouton	0845898988	x	
Prevoyance	P vd Merwe	0833213113		x
Prospect	J & W Bruwer	0827702279	x	x
Retreat A	J de Wet	0823903022	x	
Retreat B	JK de Wet	0823397230	x	
Rhebokskraal	B Auret		x	
Rhebokskraal	J Malherbe	0828202260	x	
Rietvlei	PB Viljoen	0829272814	x	
Rietvlei	A Conradie	0828941349	x	
Rietvlei	Jakkie Oosthuizen	0823783987	x	
Riverton	DJ Barry	0823358951	x	x
Robertson Proefplaas	N.I.W.W.	0836295918	x	x
Roodehoogte	GJ Colyn	0236264059	x	
Rouxvale	C. Brink	0827812804		x
Rouxvale	JM Brink		x	
Secunda	D Conradie	0236151954	x	
Springfield	A Bruwer	0846046655	x	
Steenboksvlakte	Albert Cloete	0721048690	x	x
Steenboksvlakte	C Viviers	0721337573	x	
Steenboksvlakte	P Kriel	0827722230		x
Stockwell Boerdery	S Malherbe	0822254577	x	
Takkap Trust	Takkap	0827722230	x	
Uitnood	JJ van Zyl	0825603161	x	x
Uitnood Restant	Phantoprops	0824769054	x	x
Uitvlugt	F Swanepoel	0828724014	x	
Voorspoed	E Botha	0824434154	x	x
Vooruitzicht	HH vd Merwe	0842958010	x	x
Vruchtbaar	AB Bruwer	0846264081	x	
Wakkerstroom	Dr P vd Westhuizen	0827892726	x	
Wakkerstroom	GB Viljoen	0725174378	x	
Wakkerstroom	JJ de Wet	0829784393	x	x
Wakkerstroom	FS Breytenbach	0823974351	x	x
Wansbeck	Hannes Erasmus	0828938049	x	
Wansbeck	D Erasmus	0828309787	x	x
Wel van Pas	Wouter de Wet	0832312236	x	x
Weltevrede RS	Philip Jonker	0845886540	x	x
Wildepaardehoek	LA Van Zyl	0236151829	x	
Wildepaardhoek	Stefan Botes	0236151831		x
Willemnelsrivier	JS Bruwer	0836972270	x	
Willemnelsrivier	AB Bruwer	0846264081	x	
Windkraal	Pieter Joubert	0236162221	x	
Wolfkloof	Heil-Viljoen Boerdery	0236264948		
Zandvliet	PJ De Wet	0832560221	x	

The locations of 20 vineyards each of Chardonnay and Shiraz (Table 2.2) were chosen with help from the viticulturists from the region to ensure that the different environmental conditions (potential terroirs) are covered. Three reference plots were laid out diagonally across vineyards to ensure a good representation of the vineyard block. These vineyards were monitored in terms of viticultural and oenological performance in 2007/2008. Vineyard scoring was performed using the standard score sheet. Point quadrat measurements were also performed. Primary and secondary shoot length, leaf number, leaf area and number of bunches per shoot were determined just prior to ripening. At harvest, bunch and berry mass and volume and number of berries per bunch were determined. At pruning, pruning mass, cane length and internode diameter were measured. For Chardonnay, grapes of the three mini-plots were combined before microvinification, while for Shiraz, separate wines were made from each of the three mini-plots. Must analyses were performed for °B, TTA, pH, malic and tartaric acids, and for Shiraz only, total colour and total phenols. Carbon isotope ratio was determined on the must samples. Wines were analysed sensorially using trained panels. Soil and root profiles were performed during September 2008 for one reference plot per vineyard for the full network in order to ground-truth the survey responses.

Table 2.2 Shiraz and Chardonnay reference vineyards in Robertson

Farm	Shiraz	Chardonnay
Arendsig	x	x
Excelsior	x	x
Kleinbegin	x	x
Wandsbek	x	x
Klipdrift (BEE)	x	x
Kranskop	x	x
Rooiberg	x	x
Eilandia Plase	x	x
Graham Beck	x	x
Lucerne	x	x
Goree	x	x
Weltevrede	x	x
Weltevrede	x	x
Greenlands	x	
Windkraal		x
Wildepaarde Kloof	x	
Wildepaarde Kloof		x
De Wilgen	x	
Wel Van Pas		x
Steenboksvlakte	x	x
Boesmansrivier	x	x
Koningsrivier	x	x
Welville	x	x

A more detailed investigation into the relationship between soil type, rooting profile and viticultural performance for Chardonnay and Shiraz.
Four experimental vineyards for each of Chardonnay and Shiraz were selected for the 2009 season from amongst the existing network of commercial vineyards that were monitored in 2008. The criteria for selection were the following: same rootstock type, similar age (was considered a mature vine if 7 years old or older) same trellis system and similar planting density and certainty that the soils were different. The information about scion clones was unknown in most of the cases. Details of each vineyard are provided in Table 2.3. Three mini plots were laid out within each vineyard with the aim to cover homogenous portions. Aerial images available for two different dates were used to map the vigour response in each vineyard block, in order to avoid extreme differences in vigour, and thus possible extreme differences in soil profile or water retention.

Six shoots per vineyard were sampled one week post-veraison and primary and secondary shoot length, leaf number, leaf area and number of bunches per shoot were determined. Plant water status was measured post-veraison using pre-dawn LWP and stem LWP as indicators. Composite berry samples, consisting of 200 berries, were analysed from veraison onwards, including: Total Soluble Solids (°B), Total Titratable acidity, pH, berry weight and volume. The sugar loading curves were calculated as well as the daily dynamic of sugar loading into the berry. For Chardonnay, the berry tint angle was also determined with Dysotem®. Soil and root profiles were performed during 2009 for the three reference plots per vineyard. Soils were described by an experienced soil scientist and chemical and physical soil analyses were performed for samples from each profile by an independent laboratory.

Table 2.3 Shiraz and Chardonnay reference vineyards in Robertson for more detailed studies

Farm	Cultivar	Year planted	Planting distance	Trellis system	Soil type
KD	CY	1995	1.5 x 2.2	4 wire ext. P	Oakleaf
SBV	CY	1996	1.5 x 2.5	5 wire ext. P	Sepane
WPK	CY	1995	1.5 x 2	4 strand Hedge	Westleigh
WB	CY	1996	1.4 x 2.5	4 wire ext. P	Glenrosa
EX	SH	2000	2.5x1.5x1.25	5 wire ext. P	Coega
WTBR	SH	2000	1.2x2.4	5 wire ext. P	Glenrosa
WTRS	SH	1999	1.2x2.5	5 wire ext. P	Etosha
WV	SH	1998	1x2.4	4 wire ext. P	Glenrosa

Statistical analysis
In the investigation into root profiles, Principal component analyses were performed separately on the data from the Chardonnay and Shiraz plots using Unscrambler® software. In each case the variables of root density to a depth of 60 cm and to the profile depth of 100 cm, the total rooting depth, the vineyard age, the total number of root contacts in the profile and the number of contacts for roots that had a diameter less than or greater than 2 mm were included. A one-way ANOVA was performed on the groups identified using the PCA. Statistica® software was used.

For the survey data, Continuous/ordinal variables were analysed using Spearman correlations. Categorical variables were analysed using one-way ANOVA and the corresponding non-parametric techniques (Kruskal-Wallis or Mann-Whitney U test). To compare surveyed and measured data, Spearman correlations were used.

4. Results and discussion

State results obtained and list any benefits to the industry. Include a short discussion if applicable to your results.
This final discussion must cover ALL accumulated results from the start of the project, but please limit it to *essential* information.

Aim 1. Identify natural terroir units in the selected sub-region of the Robertson valley

Milestone	Achievement
1. Gather all available soil, geological, topographical and climatic data and digitise data where necessary	A MSc Geography student, Mr Remas Hadley, was appointed to investigate "The identification of natural terroir units in the Robertson Wine District using GIS and remote sensing". He was predominantly funded under the NRF Thuthuka grant "Soil landscapes for viticultural zoning", but his work was of direct application to this project and assisted in the achievement of Aim 1 of this project. This achievement of this milestone is described in greater detail in the MSc report of Mr Hadley Remas and in section 2.2 of the full project report. Mr Hadley Remas acquired the following spatial data for use in the identification of soil landscapes and natural terroir units in the study area: *Satellite Imagery* (acquired from CSIR Satellite applications centre and USGS) SPOT 4 multispectral summer image (20m resolution) (11 December 2005) SPOT 4 panchromatic summer image (10m resolution) (11 December 2005) SPOT 4 multispctral winter image (20m resolution) (6 April 2005) SPOT 4 multispctral winter image (10m resolution) (6 April 2005) SPOT 5 multispectral (10m resolution) summer image (23 October 2006) SPOT 5 panchromatic (2.5m resolution) summer image (23 October 2006) ASTER visible (15m) winter image (26 August 2006) ASTER shortwave infrared (30m) winter image (26 August 2006) ASTER thermal infrared (60m) winter image (26 August 2006) *Aerial Imagery* (acquired from Department of Forestry/ DWAF) This imagery required Geometric correction. Radiometric Correction was unnecessary. The Geometric correction was performed using Erdas Imagine 8.7 software and all datasets were georeferenced to UTM zone

	34. The WGS 84 datum and ellipsoid were used. Twenty-five evenly spread ground control points (GCPs) were collected over the study area. A 2.5m resolution mosaic of orthorectified aerial photographs of the study area was used as a reference image to locate X- and Y coordinates on the SPOT 5 panchromatic image. The DEM was used to extract elevation (Z-value). A total root mean square error (RMSE) of less than 1m was maintained for the entire panchromatic image. The SPOT 5 multi-spectral image and the ASTER images were georeferenced to the orthorectified SPOT 5 panchromatic image. The RMSE was kept below 3m for the SPOT 5 multi-spectral image and below 5m for the ASTER image. The following additional data was obtained: *Rasters and Rasterized vector data* Digital Elevation Model (20m) (University of Stellenbosch Department of Geography and Environmental Sciences) Soil (1:25 000) (Department of Agriculture-Elsenburg) Geology (1:250 000) (Council for GeoScience) Topographic map (1:50 000) (CDSM) Landtype (1:50 000) (Department of Agriculture-Elsenburg) All topographic parameters (local relief, slope and aspect) were computed by means of a 20 m DEM in the ArcGIS 9.1 software. This DEM was resampled to 20 m from a 50 m DEM that was produced by the Chief Directorate Surveys and Mapping (CDSM). The local relief was determined by creating a summit map and a base level map as described by Kühni and Pfiffner (2001). The base level map was then subtracted from the summit map to calculate the local relief. The soil groups as documented in the GIS database of Department of Agriculture in Elsenburg were used in this study as the Catena booklet had not yet been finalized.
2. Perform a GIS analysis to identify natural terroir units	This is described in greater detail in the MSc report of Mr Hadley Remas and in section 2.3 of the full project report. The result of the object based image classification gave an overall accuracy of 81.3%, with a κ (kappa) coefficient of 0.76. Many samples that were

	selected as 'agriculture' were incorrectly classified as 'bare rock / soil' because none of the indices could separate bare soils from cultivated land. Natural terroir units (NTUs) are defined as the grouping of land surfaces with homogeneous patterns in topography, climate, geology and soil (Carey 2005). The combination of these natural factors together with the current land cover as a single GIS layer requires that each of these natural factors has to be multiplied with every other natural factor in order to define a single unit of the land surface. Theoretically this is possible, but the representation thereof on a single GIS layer is challenging – as has already been shown for Stellenbosch. The soil map was combined with the landscape elements to create a soil landscape map. Terrain elements such as slope gradient, elevation and curvature were combined to define landscape elements. Next, the segmentation was refined according to the position of the objects on the hillslope. This position was determined by five terrain morphological units. Of the 170 NTU identified, 55 NTU were described for agriculture and 54 each for natural vegetation and bare surfaces. Of the 55 agricultural NTU, 35 units have areas of more than 100 ha. The NTU describing Agriculture practiced on soils with red B-horizons that occur on flood plains, has the largest area (2315 ha), followed by areas with southerly slope aspects and soils with red B-horizons on the foot slopes of the terrain (1550 ha). Carey VA 2005. The use of viticultural terroir units for demarcation of geographical indications for wine production in Stellenbosch and surrounds. Doctoral dissertation. Stellenbosch: University of Stellenbosch, Department of viticulture and Oenology.

Aim 2. Determine the viticultural and oenological performance of Chardonnay and Shiraz in the selected sub-region of the Robertson valley

Milestone	**Achievement**
1. Compile survey based on consultation	The final surveys included questions with

with viticulturists and wine makers in the region	unstructured line scale, multiple choice and free choice answers. The categories included general viticultural information, management practices, vegetative, productive and berry characteristics and general environmental characteristics. Limits for berry size and block variability were confirmed in conjunction with viticulturists. Limits were also established for diseases that occur most regularly with the help of pathologists.
2. Perform a guided survey of as many existing Chardonnay and Shiraz vineyards in the region as possible and create a spatial data-base of the results	The surveys from private own estates were completed at the estates and the surveys from grape producers were completed with the help of viticulturists from the grape-buying cooperative cellars. A MSc Agric (Viticulture) student, Stefan Lourens, was tasked with performing a guided survey of the vineyards. The survey was sent out to as many producers as possible which include 227 Chardonnay and 169 Shiraz questionnaires. All surveys were supposed to be followed up with the producers and collected by Stefan Lourens to ensure that as many as possible were returned. In the end, 96 Shiraz and 199 Chardonnay vineyards were surveyed and their data captured in a database. The vineyard positions were digitised. Unfortunately many of the resulting surveys were incomplete, which made statistical analysis of the data difficult. The survey results were compiled in an Excel database. Variables with more than 20% missing values had to be excluded from statistical analyses on the advice of Prof Martin Kidd. Due to their importance, the variables of Aspect and Soil were, none-the-less, included. These questionnaires covered a total of 678.73 ha for Chardonnay and 302.13 ha for Shiraz.
3. Compile a data-base of viticultural and oenological measurements of ca. 20 vineyards each of Chardonnay and Shiraz	Data was gathered from 20 vineyards each of Chardonnay and Shiraz during the 2007/2008 season. This data is presented and discussed in detail in sections 3.4.1.2 and 3.4.1.3.
4. Investigate the relationship between soil type, rooting profile, viticulture performance and wine style for Chardonnay and Shiraz.	The size of the root system plays a key role in arid areas. Firstly, the size of the root system determines the size of the canopy to a certain extent, and thus the transpiration surface. Secondly, the size of the root system determines the buffer capacity during seasonal and diurnal events with high

	evaporative demands. It was shown in sections 3.4.1.1 and 3.4.2.1 that the size of the root system for grapevines in Robertson is strongly influenced by soil properties. The morphology of the root system in a two-dimensional plane (i.e. the root-wall method) was studied for 101.14 Mgt in four different soil types, each with Chardonnay or Shiraz as scion (described in detail in section 3.4.2.1). The rooting depth was related to the effective soil depth. The restriction factors determining soil depth were of a physical (i.e. hard pan carbonate, high consistency layers and freshly weathered rock) and/or chemical nature (i.e. salinity, sodicity and pH). Depending on the soil volume available for growth, the size of the root system in Robertson appeared to play a fundamental role in the canopy development before véraison, and in sustaining the canopy after véraison. It is suggested that irrigation (which represents an extremely important management tool under these conditions) should be used with this in mind. It was shown (discussed in section 3.4.2.2) that a small root system could promote the same canopy size as others with the same water applied before véraison, but that the small root system struggled to supply enough water when the evaporative demand of the troposphere increased after véraison, resulting in a stress situation. The plant water status is responsible for the plant functioning and, importantly, influences transpiration and photosynthetic activity. The shortage of water was therefore related to the sugar loading into the berries. The results were thus interpreted using the berry sugar loading as reference for a constraint/stress plant situation. In this study it was also observed that 23.5% loss of berry mass took place in four weeks in the Shiraz plot with the largest canopy area, probably due to berry dehydration. As a consequence of these conditions it was found that a root system with fewer roots but growing with some depth into clayey layers could maintain a better functioning canopy than one with higher numbers of roots but shallower growth, which depleted the soil water content much faster. The function of these deep occasional roots deserves more study, as do the management techniques of soil preparation that can create favourable conditions for them to develop.

	Forty plots of two scions cultivars (Shiraz and Chardonnay) on various rootstocks were studied (detailed in section 3.4.1.1). The root systems were grouped by depth into two groups: shallow rooting (SR) and deep rooting (DR). The latter group was divided further into DR high root density (DRH) and DR low root density (DRL). In the two extreme groups (i.e. SR and DRH), it was found that each group shared similar soil properties, and that these properties differed when comparing the groups to each other. The root system grouped as DRL combined characteristics of the two extreme groups. It is probable that the influence of cultural practices is more strongly manifested in this last mentioned group, alleviating or increasing determined restrictive properties under particular conditions. The presence and combination of these soil physical and chemical properties determine the restrictive rooting potential of the soil. The different characteristics that separate the extreme groups were associated with determined diagnostic horizons described in the South African Soil Classification, which determined that certain soil families corresponded to one group and others to another group. Extremely important were: the parent material, the properties that classify the B diagnostic horizons, and the thickness of this B horizon. The homogeneity in depth and the nature of the transition between horizons also play an important role in determining the soil volume available and the easiness of root growth. Soil families associated with the shallow root system were Glenrosa, Valsrivier and Gamoep. Soil families associated with the deep and high-density root system were Oakleaf, Augrabies and Brandvlei. The diagnostic horizons of the South African soil taxonomy can represent important soil characteristics that determine the root morphology despite the influence of many other properties and the differences in rootstock and irrigation system. The soil properties must be assessed in every single case to determine the thickness of the horizons and the presence of any limiting factors in the horizons.

Aim 3. Delimit terroirs for production of Chardonnay and Shiraz in the selected sub-region of the Robertson valley.

Milestone	Achievement
1. Statistical analysis of survey data base	**Validation of survey database** Means were calculated for each of the variables that were measured for the 20 vineyards each of Chardonnay and Shiraz and compared to relevant survey variables. More details are provided in section 3.4.2.3. **Analysis of survey database** It was not possible to perform CART analyses on the survey database as Martin Kidd considered that the data sets were too small and the data was too sparse, i.e. for too many categories there were not enough cases. It was, however, possible to perform univariate analyses to test for relationships between data. The variables "wine category" and "growth vigour" were compared with other variables in the survey database for each of Shiraz and Chardonnay. These results are provided in section 3.4.2 of the report.
2. Spatial interpolation of statistical rules to identify terroirs for the 2 cultivars	Due to the poor responses and lack of validation of the survey results, it was not feasible to do interpolations to determine terroir units. However, it was possible to estimate the most suitable natural terroir units for each of the cultivars studied. Based on results from previous sections, Shiraz was described as performing well on soft, hard and shallow Karoo soils. Medium deep shale soils could also result in high performance, as long as the correct long-term decisions are made and the growth is managed judiciously. For the hard and shallow Karoo soils, soil preparation must be performed to break into the limiting layers. The soil landscapes that meet the criteria for optimal performance are soils with red B on foot slope, yellow-brown apedal on foot slope, soils with red B on mid slope, lime rich on foot slope and lime rich on mid slope. The most suitable slopes for Shiraz production would appear to have north and west slope aspects. Thirty NTU were identified that have the potential for agriculture (agriculture, bare surfaces or natural vegetation land use) that meet the criteria for the soil-landscape units and north or west slope aspects (25 438 ha).

	Similarly, based on information discussed in previous sections, Chardonnay was described as performing well on soft Karoo, hard Karoo and medium deep shale soils. For the last two mentioned soil colloquial groups, deep soil preparation is very important. These would equate to soils with red B horizons on foot slopes, yellow brown apedal soils on foot slopes, lime-rich soils on foot-slopes and lime rich soils on mid-slopes. Moderate to higher day and lower night temperatures are most likely to be found on foot slope positions on south-facing slopes. Nine NTU that have the potential for agriculture (agriculture, bare surfaces or natural vegetation land use) that meet the criteria for the soil-landscape units and south facing slope aspects were identified (6 819 ha). This would appear to be too limited an area to describe the situations where Chardonnay is planted and the limits would need to be revised.

5. Accumulated outputs

List ALL the outputs from the start of the project.
The year of each output must also be indicated.

Technology development, products and patents

Indicate the commercial potential of this project (intellectual property rights or a commercial product(s)).

Human resources development/training

Indicate the number and level (e.g. MSc, PhD, post doc) of students/support personnel that were trained as well as their cost to industry through this project. Add in more lines if necessary.

	Student level (BSc, MSc, PhD, Post doc)	Cost to project (R)
1.	Mr Hadley Remas (MSc Geography and Envionmental Sciences)	R0
2.	Mr Leonardo Erazo Lynch (MScAgric Viticulture) March 2011	
3.	Mr Stefan Lourens (MSc Agric Viticulture) Incomplete	
4.	Ms Zelmari Coetzee (Techincal assistant)	
5.	Ms Tinake van Zyl (Technical assistant)	

Publications (popular, press releases, semi-scientific, scientific)

Presentations/papers delivered

Carey, V.A. 2006. Introduction to terroir research in the Robertson Wine Valley. Winetech VinPro Information Day, Robertson. 3 October 2006.

Carey, V.A. 2006. Terroir en wyn kwaliteit. Worcester/Breedekloof VinPro winemakers study group, 19 June 2006.

Erazo-Lynch, L.E., V.A. Carey & A.J. Deloire. 2009. Berry sugar loading: an indicator of grapevine functioning? Fourth International Viticultural and Oenology Conference, Cape Town International Convention Centre, Cape Town, South Africa. (POSTER) (28 – 30 July)

Erazo-Lynch, L.E., V.A. Carey & B. Oberholzer. 2009. Grapevine root distribution in representative soil types in Robertson. Fourth International Viticultural and Oenology Conference, Cape Town International Convention Centre, Cape Town, South Africa. (POSTER) (28 – 30 July)

Erazo-Lynch, L.E. & V.A. Carey. 2010. The Chardonnay and Pinot Noir water use: are they near-pessimistic cultivars? First Wine Sciences Research Day. DVO-IWBT, Stellenbosch University (26 November).

Erazo-Lynch, L.E.; Deloire, A.; Carey, V. & Oberholzer, B. 2010. The effect of soil preparation of duplex soils on grapevine functioning and berry ripening. Thirty-second SASEV Congress, Somerset West, South Africa. (POSTER)

Erazo-Lynch, L. 2011. Diferencias en el uso del agua: Comparación entre syrah, garnacha, pinot noir y chardonnay [Differences in water use: Comparison between Syrah, Grenache, Pinot Noir and Chardonnay]. Thirteenth Latin-American Congress of Viticulture and Enology, Santiago, Chile (21-23 November).

Erazo-Lynch, L. 2011. Investigación de la relación entre tipo de suelo y morfologia del sistema radicular en Robertson, Sudáfrica [Investigation of the relationship between soil type and morphology of root systems in Robertson, South Africa]. Thirteenth Latin-American Congress of Viticulture and Enology, Santiago, Chile (21-23 November).

4. Total cost summary of project

	Year
Total cost in real terms for year 1	
Total cost in real terms for year 2	
Total cost in real terms for year 3	
Total cost in real terms for year 4	
Total cost in real terms for year 5	
TOTAL	

CFPA	Deciduous	DFTS	Winetech	THRIP	Other	TOTAL