DEPARTMENT OF
PRIMARY INDUSTRIES

Ararat Rural City Land Capability Pilot Project

Volume 2: Methodology

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Summary

Local government is responsible for making planning decisions that influence the use and management of land. If planning decisions are made without a sound technical basis, it could lead to detrimental impacts upon the land and natural resource base. The end result is often far more costly to rectify than the time and resources required to gather the technical information in the first place. The provision of sound, detailed information about the natural resource base is therefore a necessity to better inform planning decisions at the local government level.

The Glenelg Hopkins Catchment Management Authority (GHCMA) recently acquired 1:100 000 scale soil-landform information for the GHCMA region (Baxter & Robinson 2001) to assist their planning and decision making processes, however, the scale of this information is best suited to broader state and regional planning needs. Therefore, the GHCMA recognised the need to acquire land hazard and land capability information at a scale of 1:25 000 to support local government and subcatchment planning activities.

The Ararat Rural City and the GHCMA have formed a partnership in this project to develop a modified methodology of land resource assessment. The adoption of new technologies and alternative approaches to traditional land resource survey enables the refinement of existing regional scale information to a level of detail appropriate for local government decision making.

The advent of digital elevation models, remote sensing techniques and GIS based extrapolation enables a more targeted approach to field survey and refinement of the data. This will serve to make future surveys for local government more focussed and efficient.

This pilot project was also required to deliver a range of report and map based outputs for use by the GHCMA, Ararat Rural City and landholder groups. Four reports have been prepared as follows:

Ararat Rural City Land Capability Pilot Project, Volume 1: Soil-landform units, land capability analyses and lands hazards

Ararat Rural City Land Capability Pilot Project Volume 2: Methodology

Ararat Rural City Land Capability Pilot Project Volume 3: Soil profile descriptions

Ararat Rural City Land Capability Pilot Project Volume 4: Salinity hazard overlay report for two urban development zones within the Ararat Rural City

In addition the following mapping products have been produced describing the landform elements, land capability, land hazards, salinity hazards and soil properties of the study area:

- Land capability maps at 1:25 000 for agricultural versatility and rural subdivision.
- Land hazard maps for sheet and rill erosion, gully and tunnel erosion, mass movement, and wind erosion.
- Soil property maps for topsoil depth, pH and soil sodicity.
- Salinity hazard maps.

The mapping products and associated report information will assist the Rural City of Ararat in their strategic planning needs, the application of appropriate zones and overlay provisions, and also will aid in the identification of areas that will require on-site detailed inspection prior to any proposed developments or changing land use.

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Ararat Rural City Land Capability Pilot Project: Volume 2 - Methodology

Bluml, MR, Reynard, KA.

Keywords: land capability assessment, land evaluation, soils, landform, land degradation

1 Introduction

The Glenelg Hopkins Catchment Management Authority (GHCMA) recently acquired 1:100 000 scale soil-landform information for the GHCMA region (Baxter & Robinson 2001); however, the scale of the information is best suited to state and regional planning needs. The GHCMA has recognised the need to acquire land capability information to support local government and subcatchment planning. Although suitable methods of land capability assessment exist, a modified method is being sought to meet limited funding opportunities and take advantage of new technologies.

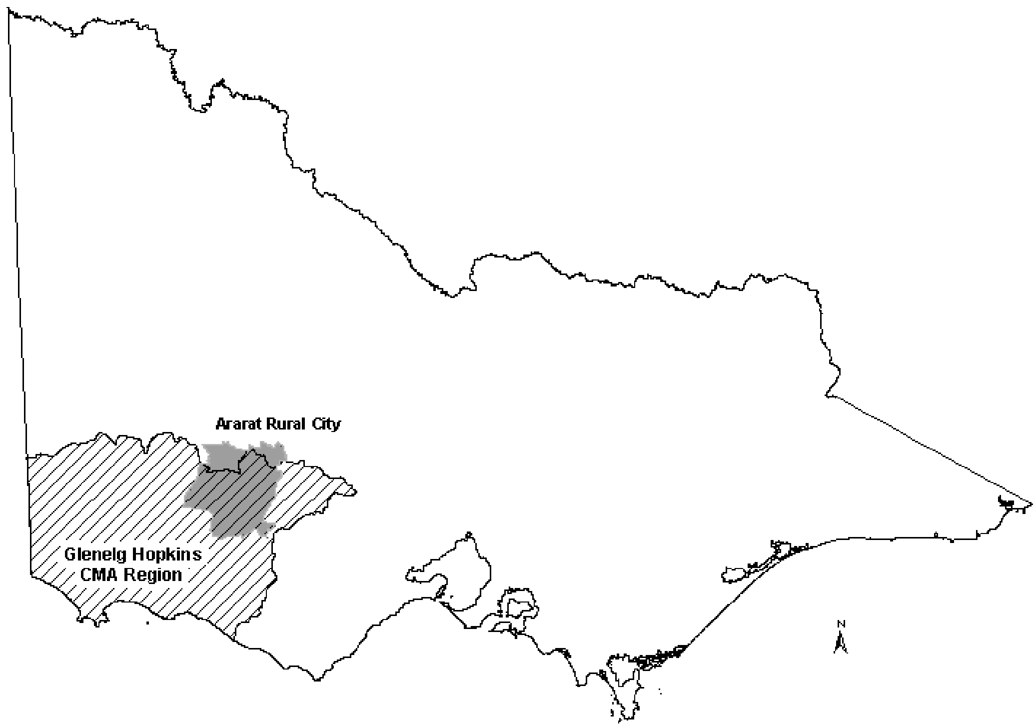
This report focuses on the development and evaluation of a modified method for 1:25 000 scale land resource survey and assessment. The GHCMA has selected an area of 4208 km^2 covering the Ararat Rural City for the implementation and evaluation of this method (refer to Map 1). Primary Industries Research Victoria (PIRVic) has been contracted to develop the method and deliver a range of map and report based products. PIRVic has designed the method to meet the following guidelines:

- That the method developed be scientifically rigorous and robust.
- That the method developed be transportable across the GHCMA and other CMA regions.
- That the method developed be cost-effective.
- That the method continues to build on existing soil-landform datasets developed by the recent 1:100,000 soil-landform mapping project.
- That the method deliver a range of map and report based outputs at 1:25 000 scale.

In addition to the development of a modified method for land capability assessment, the project has also delivered the following:

- A summary report (*Ararat Rural City Land capability Pilot Project Volume 1, Technical report no.55)* describing soil-landform units, land capability, land hazards and soil properties in the study area.
- A technical report (*Ararat Rural City Land Capability Pilot Project Volume 2 - Methodology, Technical report no.56*) that includes a clear description and evaluation of the modified method employed for the project.
- Development of land capability maps at 1:25 000 scale for agricultural versatility and rural subdivision.
- Development and delivery of land hazard maps at 1:25 000 scale for sheet and rill erosion, gully and tunnel erosion, mass movement and wind erosion.
- Development and delivery of soil property maps at 1:25 000 scale for pH, topsoil depth and soil sodicity.

Ararat Rural City Land capability Pilot Project Volume 2: Methodology, Technical report no.56 forms part of a CD based report and mapping package for the Pilot Project. Each of the associated land capability, land hazard and soil property maps can be viewed on the CD using Adobe Acrobat Reader.



Map 1 Study area

2 Methods

The establishment of a reliable and cost-effective method has been achieved through the adoption of new technologies and alternative approaches to traditional land resource survey and assessment (these traditional approaches are described by Gunn et al. 1988; Rowe, Howe & Alley 1981). The replacement of traditional land survey techniques with digital elevation models, remote sensing and GIS based extrapolation have reduced the reliance upon field based survey. Field based survey has become more targeted, allowing significant savings to be made.

Stratification of the study area

Soil-landform surveys exist at a range of scales (1:25 000 to 1:250 000) for much of the Ararat Rural City; however, there was insufficient coverage of soil-landform information to ensure that modelling outputs would obtain the required level of confidence across the entire study area. Consequently, field survey was carefully targeted to ensure that greater map confidence could be obtained in critical areas.

Three pilot areas were selected with stakeholder input to identify those areas with the highest pressure for land use change or development (refer to Map 2). These critical areas were intensively surveyed to ensure high confidence levels could be obtained from soil-landform modelling.

In the remaining study area, where less pressure exists for land use change and development, no additional field survey was undertaken. In these less critical areas, modelled outputs relied upon the extrapolation of soil-landform information from pre-existing studies and pilot areas.

Where considered appropriate, specific landform elements have also been excluded from intensive field survey. These exclusions were based upon land tenure classifications that prohibit the development of the land (e.g. public land reserves).

2.1 Delineation of landform elements

In Victoria, a spatial hierarchy exists for the characterisation and mapping of recurring landforms. This spatial hierarchy is consistent with the approach adopted at a national level by the Australian

Collaborative Land Evaluation Program (ACLEP), with the exception that different terms are used to describe the various tiers in the hierarchy (refer to Table 1). The Victorian hierarchy has been used to define the spatial mapping unit and survey scale for this project.

Table 1 A spatial hierarchy for the characterisation of Victorian landscapes

Victorian hierarchy	National hierarchy	Mapping scale	Defining attributes	Recommended use
Geomorphic unit	Land district	1:250 000	Geomorphic process, climate, landscape evolution	Statewide planning and policy development
Soil-landform unit	Land system	1:100 000	Geology, climate, relief, soil profile	Regional planning and policy development
Landform element	Land facet	1:25 000	Geology, climate, slope, aspect, soil profile	Local and subcatchment planning

(modified from Gunn et al. 1988)

As described in Table 1 above, a landform element represents the most appropriate spatial unit for 1:25 000 scale land resource assessment. The delineation of landform elements has several purposes including:

- the spatial identification of recurring map units, providing a basis for land use planning at local government and subcatchment level
- the extrapolation of point observations (e.g soil and landform properties) across recurring landform elements
- the identification of land hazard and land performance (capability) across recurring landform elements.

For this project, preliminary landform elements were generated through the use of digital elevation modelling and pre-existing geological and regolith mapping (Cayley & Taylor 1997, 2000; Stuart-Smith & Black 1999; Williams 2003). The landform elements were then refined using pre-existing soil-landform mapping, gamma ray spectrometry (radiometrics) and limited ground truthing.

2.2 Attribution of landform elements

To enable land hazard, land capability and soil property mapping to be undertaken, a suite of soil, landform and climatic attributes were collected for each landform element. Most of the required attributes were collected during intensive field survey (e.g. soil depth); however, certain landform attributes were assigned using the digital elevation model (e.g. slope %). Each of the soil and landform attributes have been described using national standards set out in Isbell RF (1998) and McDonald et al. (1990). Climate information was gathered from existing Bureau of Meteorology weather stations within the study area.

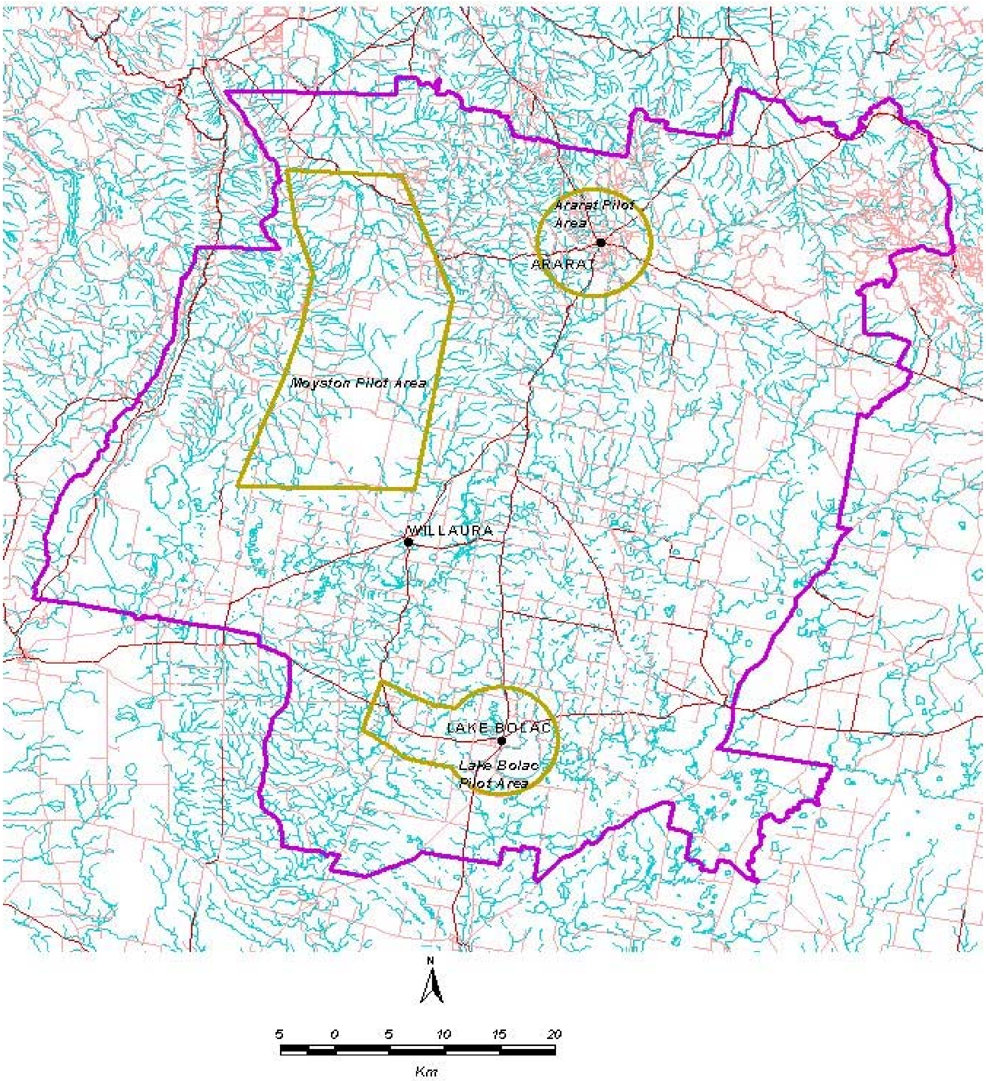
Where intensive field survey was not undertaken, pre-existing soil surveys were used to identify the relevant attributes for each landform element, these included White et al. (1985), White and Clift (1991), Badawy (1982a; 1982b; 1982c), Maher and Martin (1987), Bluml and Feuerherdt (1999), Baxter and Robinson (2001) and Robinson et al. (in press – Wimmera Land Resource Assessment project).

2.3 Assessment of agriculture versatility and rural subdivision

Land capability assessment provides a consistent and objective approach to predict the likely performance of the land (landform element) under a chosen land use. There are a number of scientifically credible methods including the Analytical Hierarchy Process (AHP) and Most Limiting Factor (MLF). MLF has been selected for this project as there is previous experience with the development of consolidated themes, and a less complex approach to assigning land capability classes to each landform element.

2.4 Land hazard assessment

Land hazard assessment is used to predict the susceptibility of a landform element to various forms of land degradation. Land hazard assessment utilises expert rule sets and arithmetic models to identify the specific soil, landform and climatic attributes that contribute to land hazards such as landslip, sheet or gully erosion. Each landform element can then be compared against these rule sets and arithmetic models to identify those landscapes that are susceptible to a particular land hazard.



Map 2 Pilot areas

In MLF, expert rule sets are developed to enable the capability of the land to be assessed for each desired land use. Rule sets allow us to compare the soil, landform and climatic attributes needed to sustain a particular land use with those that are present within each landform element. The rule sets are broken into a number of subclasses (very low to very high capability) in a land capability assessment table to reflect the degree of limitation associated with each attribute. With MLF, the single most severe limitation identified will determine the overall land capability class for the landform element.

Land capability information is commonly presented in map form for single land use themes (e.g. wheat production, dairy production, gravel roads, effluent disposal by septic tank); however, for this project a number of consolidated themes were developed for agricultural versatility and rural subdivision.

Agricultural versatility

This theme highlights the type of farming systems that can be supported by each landform element. Agricultural versatility ignores the gross value of production ($) from current agricultural enterprises, placing greater emphasis on the capacity of land to support more diverse and intensive land use options. It is assumed that these characteristics will allow the farming enterprise to change with fluctuating markets, deliver increased yields and remain in agricultural production.

In general terms, high agricultural versatility provides greater long-term security for agricultural production and development. High agricultural versatility is therefore considered the most appropriate measure of 'high quality agricultural land' for planning purposes.

Rural subdivision

This theme identifies land that can support rural subdivision where town water, surfaced roads and sewerage are absent. In rural situations, these services are commonly substituted with earthen dams (water supply), gravel roads (access) and effluent disposal by septic tanks. Consequently, the land must be assessed for its capability to support the above activities.

For rural subdivision the land capability has been assessed separately for earthen dam construction, effluent disposal and secondary (gravel) road construction. This allows any limitation to be identified back to a particular activity, and through the Working tables at Appendix A to Volume 1, limitations may be linked back to specific soil landform unit attributes. The results of each activity need to be considered in combination for an overall rural subdivision assessment.

It is important to note that this theme does not consider alternative water supply and effluent disposal options that may overcome existing soil-landform constraints and modify the overall capability class.

3 Discussion

The development of an accepted and repeatable method for land capability assessment has required that PIRVic balance survey quality, project outputs, budget and time constraints. Many decisions have been made that may impact upon the quality of survey information and hence the associated confidence in map based outputs. It is therefore important that some level of explanation is provided that allows the reader to understand the implications of these decisions.

3.1 Confidence levels

When providing land capability or hazard information, the reputed scale of mapping will not always indicate the level of confidence in the final map products, particularly in situations where numerous sources of information are combined to produce an underlying soil-landform cover, or where high soil and landform variability is encountered. As the modified method applied in this Pilot Project has not resulted in high confidence levels for the entire study area, confidence levels can be justified in terms of cost-effectiveness versus survey quality.

Confidence in map based outputs is normally gauged by comparing survey intensity with the presentation scale of the map. For example, figures in Table 2 indicate that traditional 1:25 000 scale survey requires 16 site observations in each 1 cm^2 of map; however, given the size of the study area (4208 km^2) this was never achievable given the budget or timeframe.

Table 2 Recommended site observations for soil-landform surveys

Type of survey	Nearest FAO equivalent nomenclature and final map scale	Aim and level	Site intensity and survey method
Exploratory	Exploratory to low intensity; <= 1:1 000 000 to 1:100 000	Resource inventory	Free survey of variable intensity usually much less than 1 per 100 Ha
Reconnaisance	Medium intensity; 1:100 000 to 1 :25 000	Prefeasibility Regional planning	Free survey of variable intensity usually less than 1 per 100 Ha
Semi-detailed	High intensity; 1:25 000 to 1:10 000	Feasibility Development planning	Flexible or rigid grid. Intensity 1 per 15 to 50 Ha
Detailed	Very high intensity; >= 1:10 000	Development Management Special purpose	Rigid grid. 1 per 1 to 25 Ha.

Source: Landon et al. (1984)

Consequently, an alternative approach was required to minimise the need for field based survey whilst maintaining an acceptable level of confidence in map based outputs. This resulted in a modified method where traditional survey processes were substituted with more cost and time efficient options. These options included:

identifying critical areas (pilot areas) for high intensity survey using stakeholder input.

excluding land with prohibitive soil-landform or land tenure constraints from intensive field survey.

replacing traditional soil-landform survey with remote sensing, computer modelling and extrapolation techniques outside the pilot areas.

limiting the collection and analysis of soil physical and chemical properties.

preparing simplified rather than comprehensive soil-landform reports.

producing all maps in digital form.

This approach delivered a soil-landform cover of variable confidence that was used to generate map based outputs and asses land performance. As this was expected to have some bearing on the accuracy of the results, confidence levels were attached to each landform element to allow the map user to exercise necessary caution.

In general, high confidence levels have been achieved within each pilot area, primarily because of the intensive field survey undertaken; however much of the remaining study area has not achieved the same level of confidence. Confidence outside of the pilot areas varies with the availability of previous survey information, the interpretation of gamma ray spectrometry (radiometrics) and the known variation in soil type. Much of the remaining study area has been given either a moderate or low confidence classification. These confidence levels are defined in Table 3.

Table 3 Confidence levels

Level of confidence	Description of analytical data
High	All necessary morphological, soil profile and analytical data are available for mapped landform elements.
Moderate	All morphological data available but limited soil profile and analytical data available. Generally coarser in scale but will support limited interpretation of soil properties and the extrapolation of data across landform elements.
Low	Only limited morphological and soil classification data available. Expert interpretation used to define soil properties and extrapolate data across landform elements.

3.2 Comparison with other surveys and methods

A direct comparison of this approach has been made with recent land resource assessment projects in Table 4. The comparison is presented to highlight the benefits and constraints of alternatives to traditional field survey. In particular, it is reasonable to compare the method applied to this Pilot project in comparison with that of the traditional approach applied to the Shire of Cardinia Land Capability Study (Macmillan, Smith & Baxter, 1997). Both have the same scale; however, there are considerable differences in method, outputs, cost and confidence.

In 1997, the Shire of Cardinia Land Capability Study was completed over a two year time period at a cost of $140 000. Intensive field survey was carried out over the entire study area of 1260 km^2, full physical and chemical analysis of soils was undertaken, and a comprehensive hardcopy report including maps was prepared. Confidence is considered high for all map based outputs.

In comparison, the 2004 Ararat Land Capability Pilot Project has been completed in less than 12 months at a cost of $150 000 for a study area of 4208 km^2. Intensive field survey has only been carried out in pilot areas with extrapolation of data across the remaining study area. Only partial physical and chemical analyses were completed and a basic digital report has replaced the numerous hardcopy reports. Confidence is considered to be high for approximately one-third of the study area and moderate to low for the remainder.

Although differences exist in report and map based outputs, key differences are to be found in the size of the study area mapped, the size of the project budgets and the confidence levels achieved. Given that the Pilot Project area is more than twice as large as that of the Cardinia area, it can be argued that the Pilot Project method is both cost-effective and time efficient, even though the confidence levels achieved in the Pilot Project are variable. However, there can be no claim that the approach adopted in the Pilot Project will produce more reliable and superior map based outputs.

A second comparison with the recent 1:100 000 scale Land Resource Assessment of the Glenelg Hopkins Region (Baxter & Robinson, 2001) is presented to define differences in scale and perceived effort. Although producing coarser scale soil-landform unit mapping costing $420 000 over two years, the GHCMA study area is approximately 25 000 km^2 and is therefore many times larger than the Pilot Project study area. Thirteen 1:100 000 scale map tiles were mapped as part this project. However; in order to complete 1:25 000 scale mapping for the same area, approximately 200 map tiles would need to be surveyed and mapped.

Table 4 Comparison of land resource surveys

Survey	A Land Capability Study for the Shire of Cardinia (Macmillan et al. 1997)	Ararat Rural City Land Capability Pilot Project (Bluml et al. 2004)	A Land Resource Assessment of the Glenelg Hopkins region (Baxter & Robinson, 2001)
Area (km^2)	1260	4208	25 000
Scale	1:25 000	1:25 000	1:100 000
Methodology	Public land excluded	Establish study area exclusions	Public land excluded
	Utilise existing geological mapping and air photo interpretation to define soil-landform units	Utilise existing geological mapping and digital elevation modelling to define soil-landform units	Utilise existing geological mapping, and air photo interpretation/digital elevation modelling to define soil-landform units
	High intensity survey targeted at landform elements across entire study area	High intensity survey targeted at landform elements in pilot areas, low intensity across remaining study area	Low intensity survey targeted at soil-landform units across entire study area
	Extrapolation of soils information to all landform elements	Extrapolation of soils information to all landform elements	Extrapolation of soils information to all soil-landform units
	Full physical and chemical analysis for each soil-landform unit in the study area	Partial physical and chemical analysis, primarily for soil-landform units within pilot areas	Partial physical and chemical analysis, primarily for dominant soil-landform units and soil types
Map and report based products	Archiving soil-landform information in Victorian soils database	Archiving soil-landform information in Victorian soils database	Archiving soil-landform information in Victorian soils database
	Multiple land capability themes	Limited land capability themes	Multiple land capability themes
	Not applicable	Multiple land hazard themes	Multiple land hazard themes
	Not applicable	Soil property themes	Not applicable
	Hardcopy report and GIS based mapping	Simplified digital report and GIS based mapping	Comprehensive digital report and GIS based mapping
	No confidence assessment	Confidence assessment	No confidence assessment
Budget ($)	140 000	150 000	420 000

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