Mapping Melbourne for land capability:

Assessing the agricultural capability of Melbourne's peri-urban area

A preliminary evaluation

Report prepared for VicHealth
by the Victorian Eco-Innovation Lab
University of Melbourne
September 2013

www.vichealth.vic.gov.au

VicHealth

Table of contents

Executive Summary

This study and the maps and data generated are intended to improve understanding of land capability for agriculture, and initiate a system for consistent and public access to, and use of, this information. It is intended to guide stakeholders and decision-makers who value protecting high quality agricultural land for food production, even in the face of competing land use pressures.

This report outlines the results and methods used to map and classify land within the peri-urban areas of:

- Nillumbik Shire
- City of Casey
- Mornington Peninsula Shire
- parts of the Cardinia and Yarra Ranges Shires (where data was available).

The methodology used was developed through a number of preparatory phases of work and included the following steps:

- interpretation and classification of land systems into four classes of agricultural land capability
- re-mapping and conversion of maps to Geographic Information Systems (GIS)
- ground-truthing and verification using aerial photographs
- GIS-based spatial analysis.

Approximately 379,500 hectares of land were surveyed across six Local Government Shires to the north-east, east and south-east of Melbourne. Of this approximately 20% was classified as Class 1 (suitable for intensive cropping), 15% as Class 2 (cropping or grazing) and just over 50% as Class 3 (considered suitable for grazing only).

Within the Urban Growth Boundary (UGB), there are approximately 2400 hectares of Class 1 and 3900 hectares of Class 2 land potentially still available (i.e. not yet developed).

This study has demonstrated that it is feasible to map arable land and that this would provide a valuable tool for planning. The researchers have identified that further work would improve the quality of the results and increase the mapping coverage to the north and west of Melbourne.

Introduction

Promoting healthy eating by providing environmental resources

Healthy eating is essential for good physical and mental health, which is why VicHealth invests in programs and research to increase the accessibility, affordability and sustainability of healthy food and to create a culture that supports the consumption of healthy foods.

There is a growing understanding in Victorian communities of the benefits of healthier eating, and the health impacts of poor nutrition. However, all too often the healthy food choice is not the easiest choice, and while most Australians have enough to eat and recognise the importance of a good diet for health, the ready availability of fresh and nutritious supplies of food is a critical factor in ensuring the health opportunities of the population. Poor nutrition accounts for around one-sixth of the total burden of disease and costs Victoria between $1.25 and $4.15 billion every year. The environment in which we live influences our diet, from the availability of fresh fruit and vegetables, the choice to drink water instead of other less healthy options, to time pressures and cultural norms.

The VicHealth Action Agenda for Health Promotion outlines our commitments to promote healthy eating. VicHealth's investment in nutrition and food systems has included innovative partnerships with Local Government aimed at promoting healthy eating and improving access to healthy foods at the individual and local community level. This study represents an investment by VicHealth in building knowledge about the uses of land in Victoria, and to establish a baseline for studying the impacts of urban growth on the availability of land needed for ensuring local fresh food supply. VicHealth will work with governments and stakeholders to address this important health issue by advocating and investing to ensure that eating healthy food and drinking more water becomes the easier choice for most Victorians.

The Victorian Government's blueprint for the future of Melbourne's development, Plan Melbourne (2013), has highlighted the need to identify and protect land and areas that are important to food production; to provide fresh food to local consumers and for positioning Victoria to take advantage of niche agricultural export markets. The Government's short term strategies outlined in Plan Melbourne:

- Investigate a high-value agricultural food overlay for particular use in protecting high-value agricultural and in peri-urban areas.
- Prepare and implement planning provisions to better identify and protect strategically significant agricultural land.
- Ensure localised planning in acknowledge areas that are important for food production.

As Plan Melbourne has acknowledged, many Melbournians now want to source food that is grown locally, as enjoyed by many people living in regional Victoria through easier access to the farm gate and community farmers markets.

This project was undertaken for VicHealth by the Victorian Eco-Innovation Lab (VEIL) of the University of Melbourne's, Faculty of Architecture, Building and Planning to:

- identify and map the extent and capability of 'prime agricultural' land in peri- urban Melbourne
- assess where prime agricultural land is at greatest risk of being lost.

This research report will help planners and policy makers to assess the agricultural capability of Victorian lands in proximity to Melbourne.

About this study

In discussions about the long-term security of food systems in Australia, researchers, environmentalists, planners and other stakeholders have frequently raised concerns about the loss of some of Victoria's most productive land due to urban expansion. The loss of highly productive areas suitable for horticulture (fruit and vegetable growing) has been of particular concern.

Fruit and vegetables are critical to a healthy diet. Maintaining the production systems and supply chains that affect their availability and affordability is therefore important, particularly in light of growing stress factors such as climate change and rising resource costs.

This study explores the extent to which fruit and vegetable production around Melbourne is at risk from changing stress factors. Potential advantages of maintaining fresh produce supplies close to the city include proximity to markets and reduced transport cost and the potential integration of economic development, health and sustainability outcomes.

Currently, there are gaps in the availability of data needed to evaluate the potential loss of high quality agricultural land. The difficulty in accessing and interpreting relevant data is an issue identified by the researchers in undertaking this study. Because information on land agricultural capability is not easily available, to date, there has not been a single region-wide assessment to identify and compare which lands have the greatest agricultural potential. While data exists for some local areas, existing assessments of soil and landform region do not have contiguous coverage, nor are they easily comparable. Not only have assessment and classification methods changed a number of times, meaning the same areas are sometimes classified in different ways, some studies were conducted for engineering purposes and not with the intention of assessing agricultural potential.

This study goes some of the way towards addressing the gaps in the knowledge, and will shed some light on where future efforts should be directed.

Value of this report

This study and the maps and data generated are intended to improve understanding of land capability for agriculture, and build on existing systems of land use mapping available for public access to and use of this information. The resulting preliminary maps developed for this report are intended to provide land use planners, decision-makers and other stakeholders who value protecting high quality agricultural land for food production, with some preliminary tools for assessing agricultural capability of Melbourne's surrounding landscape.

This report outlines the results and methods used to map and classify land within the peri-urban areas of:

- Nillumbik Shire
- City of Casey
- Mornington Peninsula Shire
- parts of the Cardinia and Yarra Ranges Shires (where data was available).

These areas were chosen as the focus of this study because of significance of the south-east of Melbourne's horticultural production, the existence of slightly better surveying than other peri-urban areas to the north and west of Melbourne, and the willingness of the City of Casey and Mornington Peninsula Shire to contribute to the work. These areas have been used as a starting point to build up a uniform and contiguous assessment process that can be applied across the rest of the peri-urban area.

Methodology

Producing the agricultural land capability maps developed in this study involved five key steps. These are described as follows.

1. Data collection

A range of published maps, including historical soil surveys, land-form, topographical and land use descriptions, were collected from the Victorian Resources Online website, University of Melbourne map collections, the Victorian State Library and private collections.

2. Interpretation and classification of land systems

Maps and surveys were analysed by a soil and land capability specialist who collated or generated land systems and classified these by agricultural land capability into Land Classes. Land systems were hand drawn onto base maps at a 1:100,000 scale. Surveys did not consider areas zoned as having conservation status (e.g. national parks) or urban development.[1] However, where possible, surveys covered 'undeveloped' land within the Urban Growth Boundary (UGB). These areas were zoned for 'special use' or urban growth prior to the recent changes in the Victorian planning provisions.

In this study agricultural land capability was defined following a method of assessing areas (or mapping units) of land comprising multiple similar attributes – 'land systems'. Each land system comprises a single area containing similar geology, recurring soils, landforms, vegetation types and drainage patterns. Due to the variety of attributes involved, very different land systems may share the same Agricultural Land Class.

A land system is a complex mapping unit comprising areas of similar geology and recurring soils, landforms, vegetation types and drainage patterns. While not as detailed as land component maps (which would often be used to differentiate land for specific types of agricultural production), land system maps contain a high degree of predictive value for broad-scale land use planning at a 1:100,000 scale. For a description and summary of the land systems classified in the study, including relevant soils, geology, refer to Appendix 2. Appendix 3 summarises the landform classifications used.

Land systems were then classified into four different land classes of agricultural capability which rate the ability of each land system to support on-going agricultural production and the type of production. The method and classification scheme used follows work by Van de Graaf and Howe (1976). Some relevant factors such as water availability were not factored. According to this method, each land class is described as follows.

- **Class 1. Land suitable for intensive cropping.**
  This land is most suitable for maintaining intensive horticultural production. Land characteristics permit cultivation on short rotations or annually. Safe management practices are required to minimise environmental deterioration.
- **Class 2. Land suitable for cropping and/or grazing.**
  This land is suitable for a diversity of horticultural purposes but is more prone to land degradation than Class 1. One or more land characteristics are not compatible with intensive cropping, however longer

[1] Urban development is defined here as areas currently built on, used for urban infrastructure, public services or industrial activities. It does not include land within urban areas currently used for agriculture.

rotations between crop and pasture, combined with normal safe management, will generally minimise environmental deterioration.

- **Class 3. Land suitable for grazing only.**
  One or more land characteristics are not compatible with cultivation. Moderate degree of hazard can be largely overcome by normal safe management practices with emphasis on the maintenance of vegetative ground cover. Flexible control of grazing pressure will further reduce risk of environmental deterioration.
- **Class 4. Land not suitable for cropping or grazing**
  This land has no sustainable agricultural potential and is not compatible with cultivation due to the high degree of hazard imposed by the land characteristics.

This classification scheme was deemed appropriate for the purpose of the study and at the scale required. Due to the complexity of factors built into classifying each land system, some generalisation was required and actual agricultural capability may vary within a single mapping unit. This is no different to any other method for classifying and mapping land capability. For more information see Van de Graaf and Howe (1976). Note: this study only considers the agricultural land capability – interpreted from the soil type, topography and other land system features. It does not consider whether water is available or the influence of other factors, including climate change.

3. Re-mapping and conversion of maps to GIS

Hand-drawn land system maps were scanned, georectified and digitised using ESRI ArcMap software. Conversion to digital form was done at 1:60,000 to retain the original 1:100,000 scale accuracy.

4. Ground-truthing

In areas where existing published data was not sufficient, land systems and land classes were verified by field surveys. Ten centimetre aerial photos taken in December 2011 were used to assess land use within the UGB.

5. GIS-based spatial analysis

Resulting digital land system maps were analysed together with aerial photos and planning overlays to identify where land of different agricultural capability exists and how these areas are currently zoned. Analysis of land inside the UGB was based on planning overlays used before and after recent provision changes. Analysis was conducted using simple spatial queries and geographical calculation tools in ArcMap.

Analysis sought to identify:

- **Agricultural capability of land zoned for agricultural use.** This is defined by land outside the UGB gazetted as Rural Living Zone (RLZ), Rural Conservation Zone (RCZ), Farming Zone (FZ), Rural Activity Zone (RAZ) or Green Wedge Zone (GWZ). Under the new planning provisions, agriculture is allowed within these zones though some forms are prohibited and permits may be required.
- **Land of high and medium agricultural capability within the UGB.** Based on analysis of aerial photos and previous planning overlays, this land was identified as falling within Special Use Zone (SUZ) or Urban Growth Zone (UGZ). Because of planning and land use changes since 2011 (when the aerial photos were taken), these figures should be seen as indicative only. In some cases land parcels identified had been partially developed or irreparably changed (e.g. due to mining).

Approximately 1.5% of the surveyed area could not be classified. These areas are labelled ‘not classified’. In most cases, failure to classify areas was due to conflicting data suggesting different land classes should be applied. These issues could be solved with further analysis.

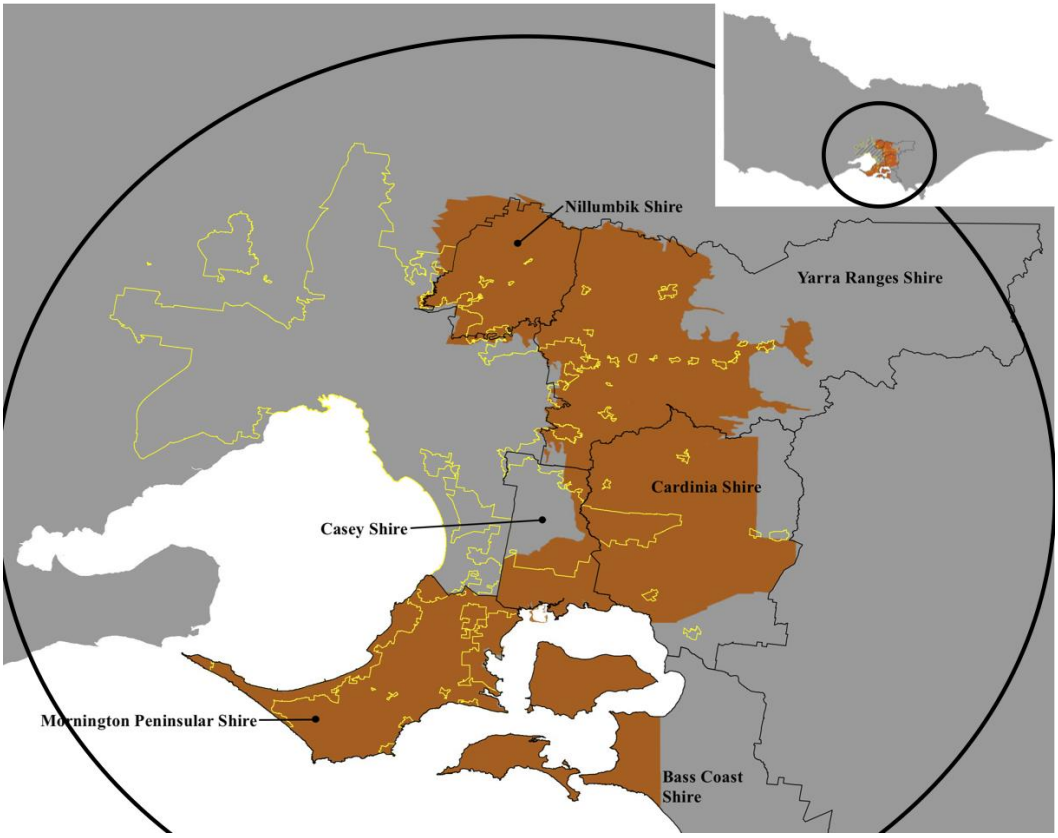
Results

The following section provides a breakdown of key statistics identifying the quantity and location of land systems classified by agricultural capability. An overview of the total survey area is followed by a summary of the five Local Government Areas in focus.

Overview

Approximately 379,546 hectares of land was surveyed across six Local Government Shires to the north-east, east and south-east of Melbourne (Map 1). The study area was chosen due to the higher quality and availability of soil and land form data and also because the eastern peri-urban areas of Melbourne have a current and historical record of contributing to Melbourne's fruit and vegetable supplies.

Map 1: Melbourne peri-urban study area (surveyed areas in brown)



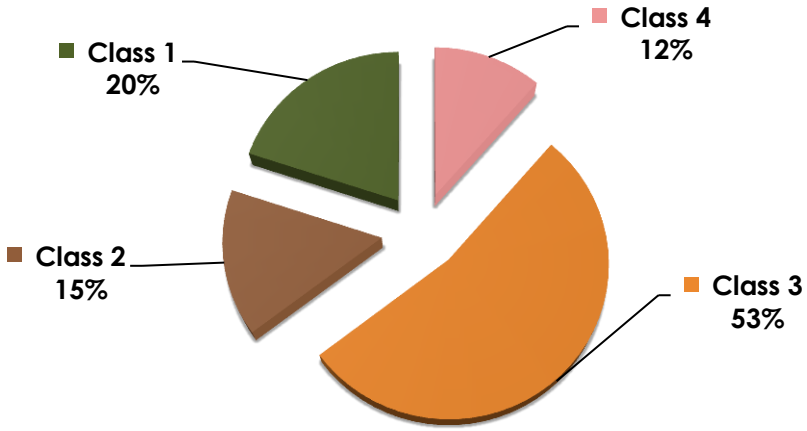
Of the total survey area classified:

- around 20% was rated as suitable for intensive cropping (Class 1)
- 15% for cropping or grazing (Class 2)
- just over half (53%) was considered to be suitable for grazing only (Class 3).

Due to discrepancies in data records, 1.5% of the total area could not be classified and requires further analysis.

Figure 1 illustrates these proportions, and Appendix 3 provides a detailed map of results across the whole area surveyed.

Figure 1: Contribution of Agricultural Land classes across survey area (by percentage)



Outside the Urban Growth Boundary (UGB), planning zones compatible with some form of agricultural use comprise approximately 229,000 hectares (60% of the survey area) (see Figure 2). Of this:

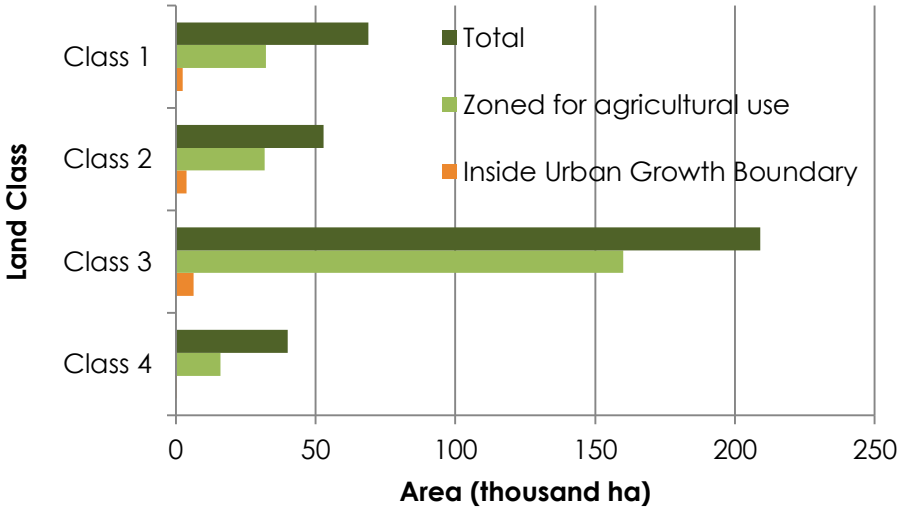
- Class 1 and Class 2 each comprise 13% of the land available (or approximately 32,000 hectares each)
- Class 3 (approximately 67% or 160,000 hectares).

Within the UGB, approximately 12,500 hectares were identified as potentially suitable for agricultural use (see Figure 2 and sections 2 and 3 on pages 10 and 11). Of this:

- 2,400 hectares (19%) is Class 1
- 3,900 hectares (30%) of Class 2
- 6,500 hectares (51%) is designated as Class 3.

Figure 2: Area of agricultural land classes across the total survey

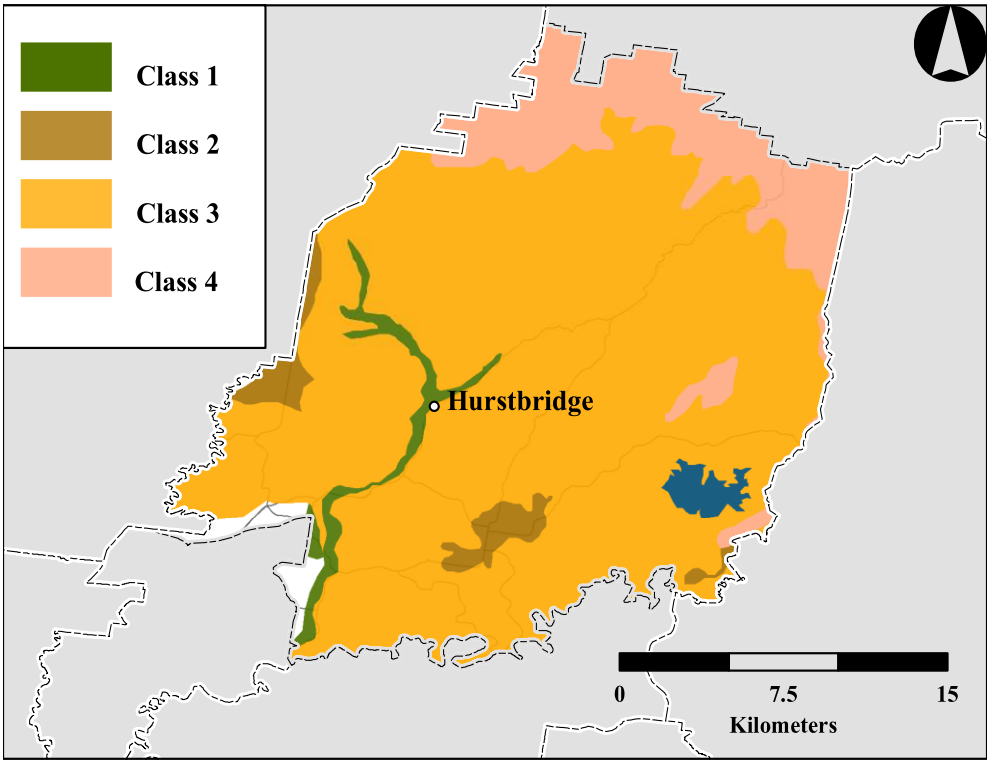
NB. The areas already developed for urban and commercial uses are part of the total land area, but not shown on these graphs.



1. Nillumbik Shire

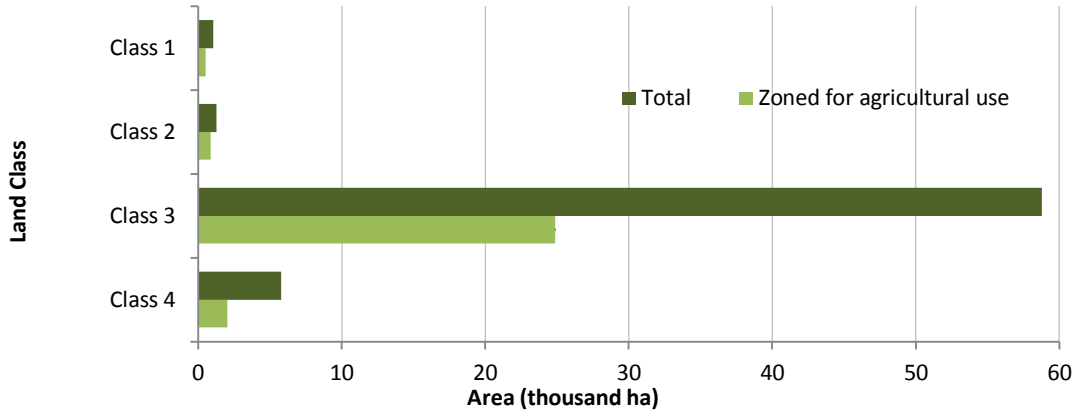
Nillumbik Shire forms part of Melbourne's furthest extent to the north-east and has a total area of 43325 hectares – see Map 2. For a full detailed map of Nillumbik Shire refer to Appendix 4 a/b.

Map 2: Map of survey coverage in Nillumbik Shire



Nillumbik Shire is dominated by land suitable only for grazing – approximately 59,000 hectares is Class 3. Some 5,800 hectares is unsuitable for any agriculture, the largest area of the five LGAs surveyed. Class 1 and Class 2 land cover only 1000 hectares and 1200 hectares respectively.

Figure 3: Area of agricultural land classes in Nillumbik Shire

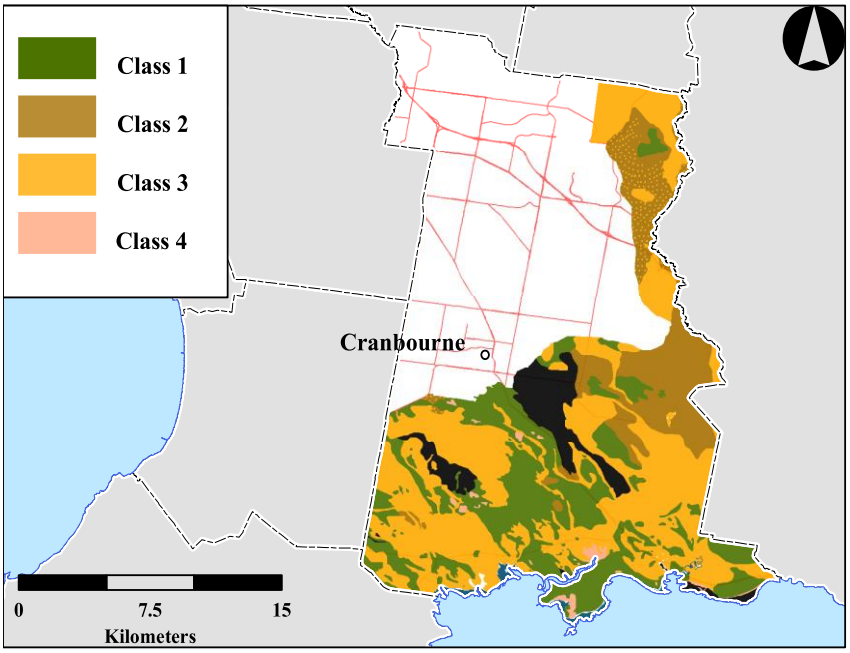


As shown in Appendix 4 a/b, Class 1 soils exist only along the alluvial flats of the Diamond and Arthurs Creeks (north and south of Hurstbridge) while the main areas of Class 2 lie around Kangaroo Ground and along the western Shire border near Yarrambat.

2. City of Casey

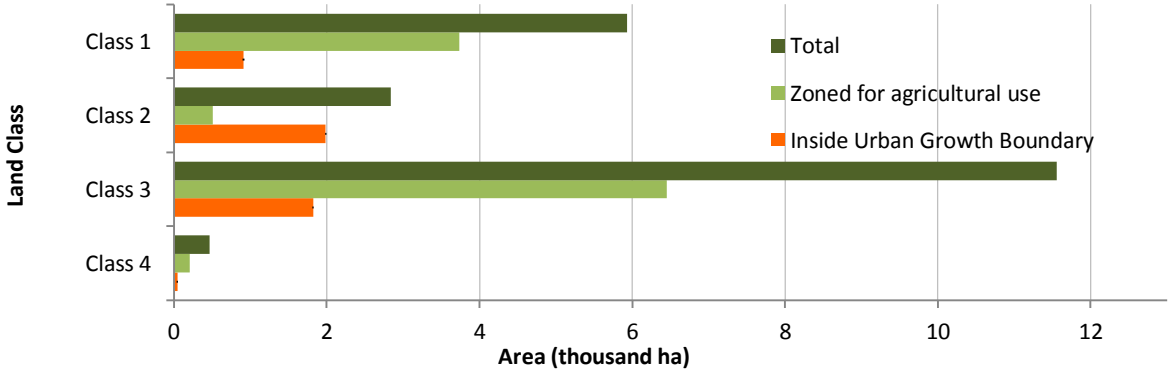
The City of Casey covers 40,556 hectares, straddling the UGB to the east of Melbourne. 22,678 hectares (56 % of the total) was surveyed, much of this within the UGB. Some 1500 hectares could not be successfully classified and requires additional fieldwork (see Map 3). For a full detailed map of City of Casey refer to Appendices 5a and 5b.

Map 3: Map of survey coverage in the City of Casey



Of the area surveyed, land systems of Class 3 and Class 1 are most common, comprising approximately 11,500 hectares (50%) and 5,900 hectares (26%) respectively. Areas given Class 2 cover 2800 hectares (12%) (see Figure 4). As shown in Appendices 5a and 5b, a substantial component of Class 1 (900 hectares – 15%) and Class 2 (2000 hectares – 90%) land lies within the UGB and zoned for 'special use' or urban growth. Due to 1500 hectares not successfully classified, the proportion of Class 1-3 land both within and outside the UGB is likely to be higher in reality.

Figure 4: Area of agricultural land classes in the City of Casey

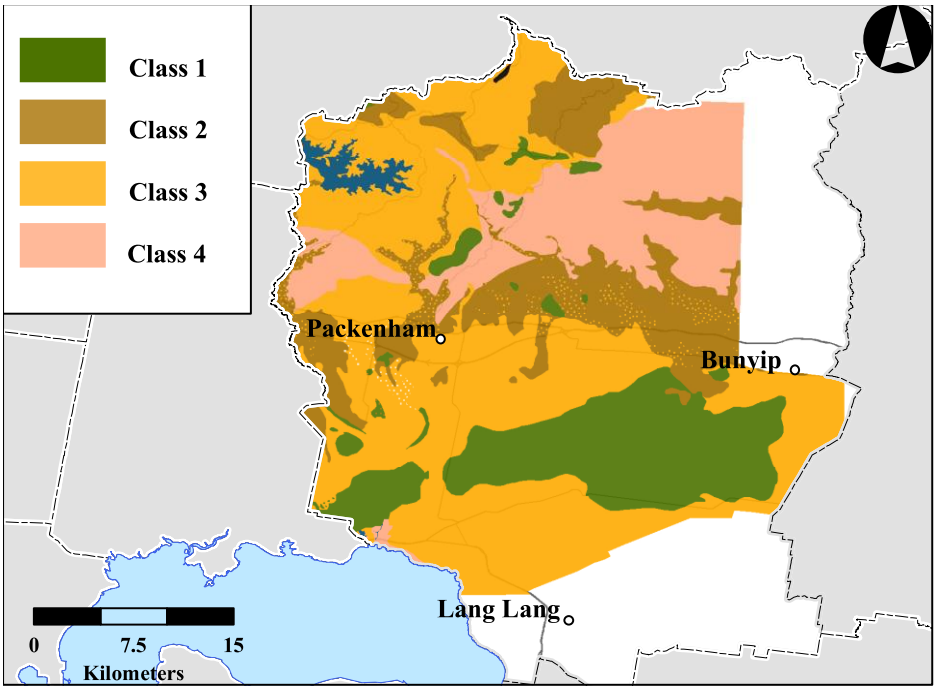


As shown in Appendices 5a and 5b, Class 1 soils are scattered throughout the survey area but with the largest contiguous area lying south of Cranbourne and immediately west of the South Gippsland Highway. Class 2 soils primarily lie along the eastern City of Casey boundary, and mostly within the UGB.

3. Cardinia Shire

Cardinia Shire covers 128,421 hectares immediately east of City of Casey. Of this, 75% was surveyed (see Map 4).

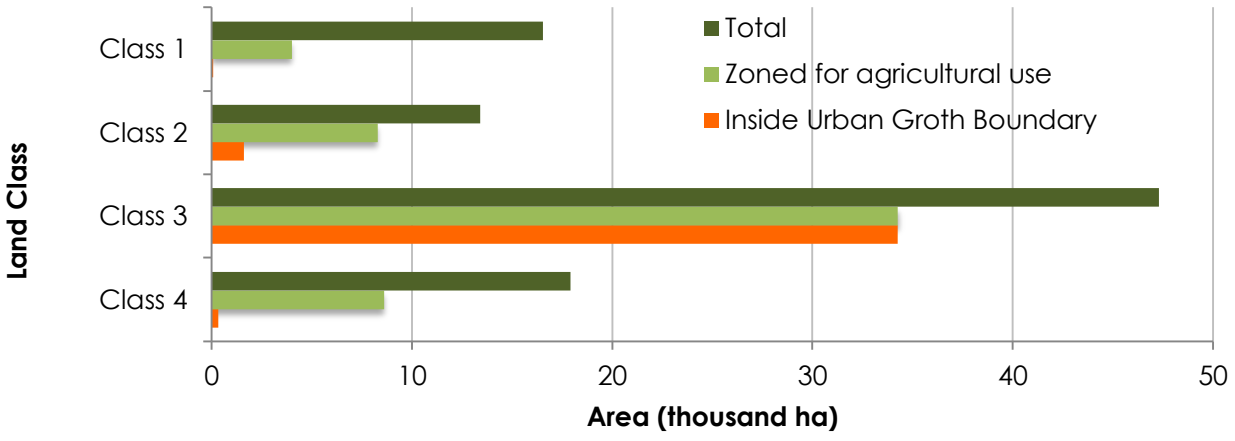
Map 4: Map of survey coverage in Cardinia Shire



As shown in Figure 5, Class 3 land systems make up the largest proportion (47,000 hectares or 49%) of the surveyed area. In decreasing size, Class 4 (18,000 hectares or 19%), Class 1 (16,500 hectares or 17%) and Class 2 (13,500 hectares or 14%) make up the remainder.

Most of the high value (Class 1 and 2) land lies outside the UGB with almost all Class 1 land systems extending roughly south-west from Bunyip. The largest contiguous area of Class 2 land lies immediately north of Princes Highway between Pakenham and Bunyip. For a full detailed map of land classes in Cardinia Shire refer to Appendices 6a and 6b.

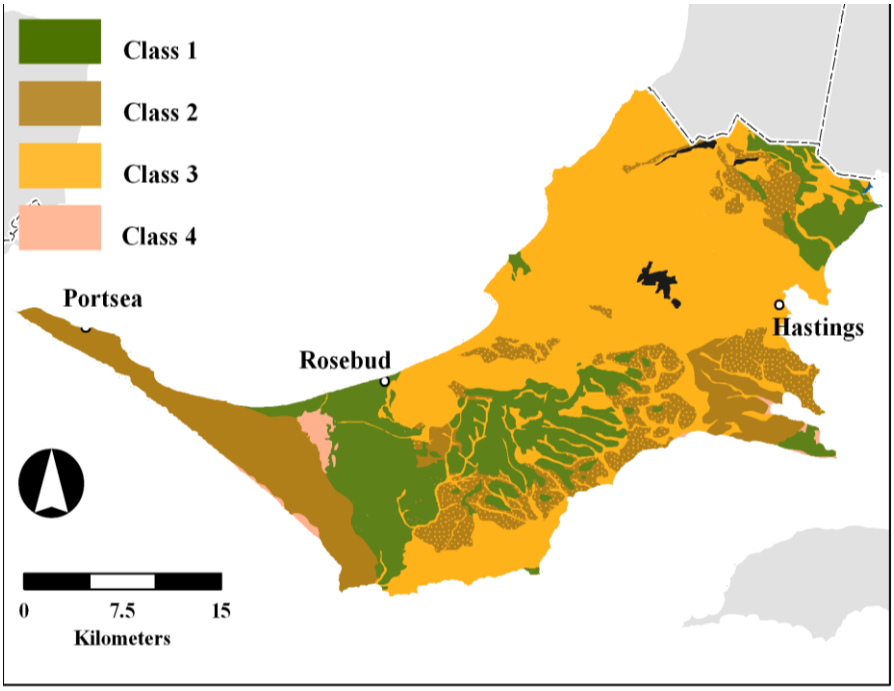
Figure 5: Area of agricultural land classes in Cardinia Shire



4. Mornington Peninsula Shire

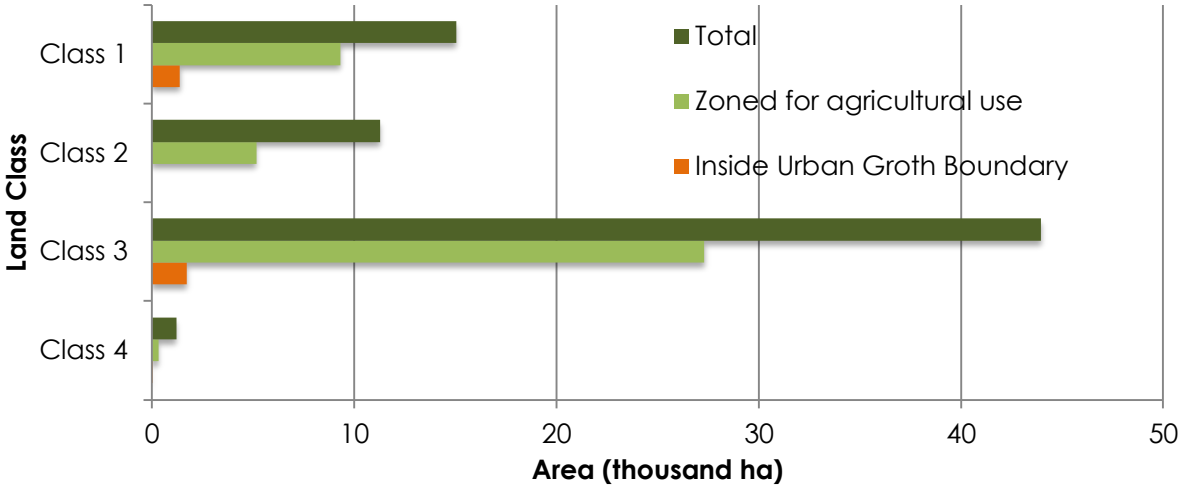
Mornington Peninsula Shire covers 72,841 hectares, of which 99% was successfully surveyed (see Map 5).

Map 5: Map of survey coverage in Mornington Peninsula Shire



Class 3 land systems make up the 61% of Mornington Peninsula or approximately 44,000 hectares (see Figure 6). Class 1 is the next most widespread (15,000 hectares or 21%) followed land systems rated Class 2 covering 11,000 hectares (16%) and Class 4 covering 1000 hectares (2%).

Figure 6: Area of agricultural land classes in Mornington Peninsula Shire

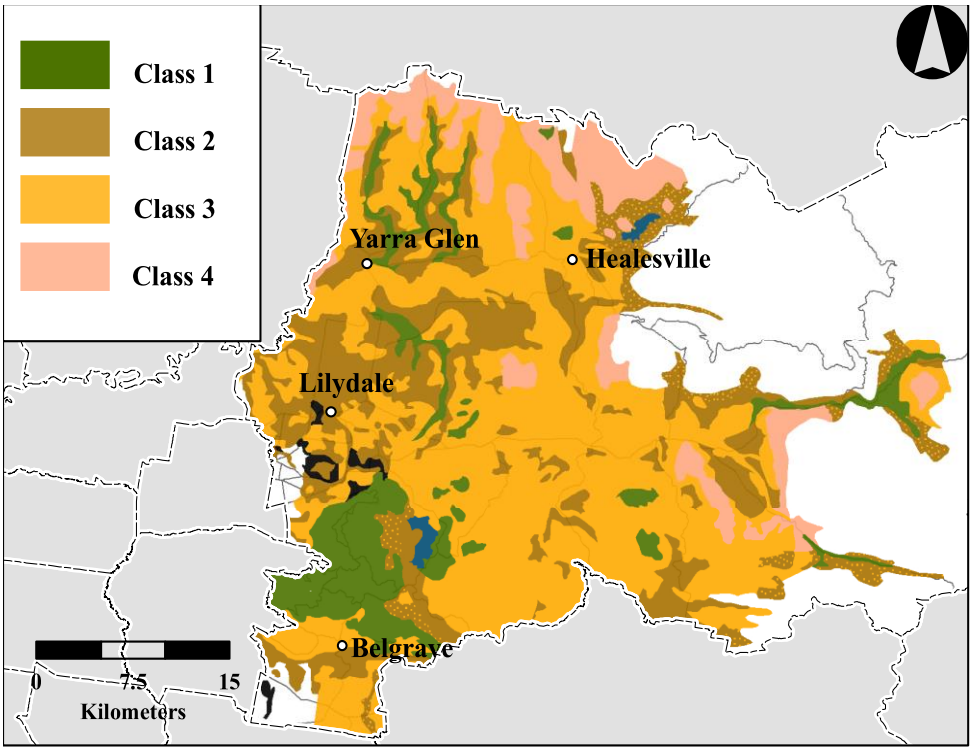


As shown in Appendices 7a and 7b, Class 1 and 2 lands lie across much of the southern and central areas of the Shire, including approximately 1300 hectares within the UGB near Hastings that has not been intensely developed for urban use.

5. Yarra Ranges Shire

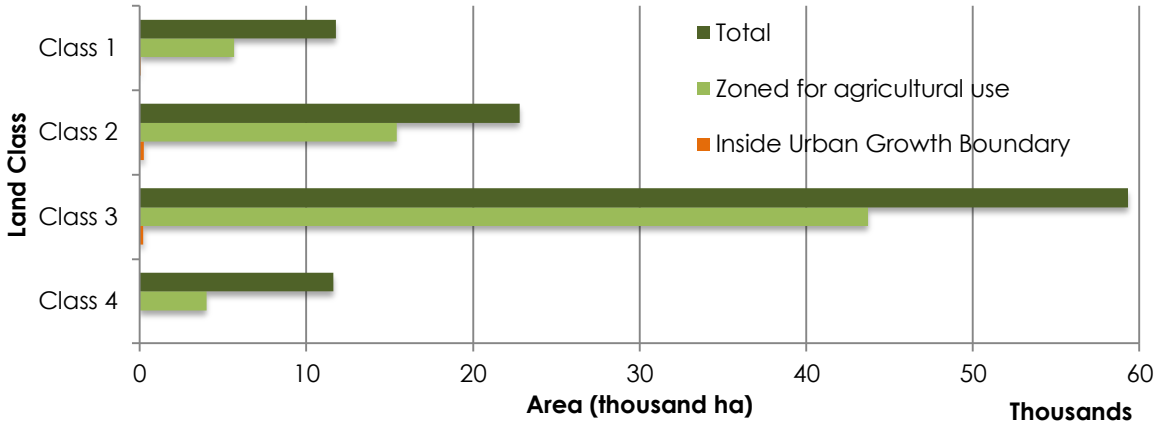
Yarra Ranges Shire covers 186,352 hectares, of which 57% was surveyed (see Map 5). Most of the areas not surveyed were protected areas and/or too steep to cultivate.

Map 6: Map of survey coverage in Yarra Ranges Shire



As shown in Figure 7, the majority (approx. 59,000 hectares or 56%) of the survey area falls under Class 3 and considered not suitable for cropping. Class 2 land (suitable for grazing or carefully managed cropping) covers 22,800 hectares or 21%. 11,700 hectares (11%) is considered Class 1 (suitable for intensive cropping) with the remainder (11,600 hectares or 11%) considered Class 4, or not suitable for agriculture. The total area within the UGB is negligible, accounting for less than 500 hectares of Class 1, 2 and 3 combined.

Figure 7: Area of agricultural land classes in Yarra Ranges Peninsular Shire



As shown in Appendices 8a and 8b, the largest contiguous area of Class 1 land lies directly between parts of the UGB extending around Belgrave and Lillydale. Other areas of Class 1 exist primarily along the main valleys and river flats (for example, near Yarra Glen). Class 2 lands are scattered throughout the shire but particularly between Lillydale, Healesville and Yarra Glen and adjacent to the Class 1 soils just described.

Notes about this report

The classification of land systems is a valuable way of grouping land to aid planning and other decisions that affect or change its use. This report and the data generated demonstrate that the development of mapping tools to assess the agricultural capability of complex land systems would be very useful. This preliminary exploration has charted the direction where future work would add value; however, the report and data cannot be used as predictive at the parcel level and are not suitable as a definitive planning tool.

For example, some areas within the maps given Class 3 (suitable only for grazing) currently support healthy viticulture industries. This reality reflects a number of factors:

1. There is a level of generalisation required to define any single land system due to the diversity of conditions that may be present.
2. Some factors are not considered in this current research (such as capacity to create or access groundwater or dams).
3. The actions of land managers to work with their land and apply innovative methods and/or sacrifice long-term capability for short-term productivity from land classified under the mapping system used, as less than suitable for agriculture.

However, with this caveat in mind, the authors are confident of the accuracy of the maps at 1:100,000 for determining where the most agriculturally capable land exists within the area surveyed.

Discussion

Land with the greatest agricultural capability is rare. The vast proportion of land zoned for agriculture land within the peri-urban areas surveyed is not suitable for any long-term intensive cropping (e.g. vegetable production), primarily due to soil characteristics. Ensuring the capacity to produce a variety of quality fruit and vegetables in proximity to Melbourne depends on Class 1 (and to a lesser degree Class 2) land being protected, highlighting the importance of knowing where these areas are.

The largest areas of remaining Class 1 land in the surveyed area lies in the west of Yarra Ranges Shire, the City of Casey, Cardinia Shire and Mornington Peninsula Shire. These areas are frequently adjacent to, or overlapping, the UGB (except for Cardinia). They are therefore at risk from urban development within the UGB and from any further boundary expansion.

As a total proportion of Class 1 land surveyed, approximately 5600 hectares (8%) lie inside the Urban Growth Boundary. Of this, some 2400 hectares were not developed in December 2011, when the reference aerial photographs were taken. These areas are scheduled to be lost (or may have already been) as a result of urban expansion. City of Casey and Mornington Peninsula Shire have the largest areas of Class 1 land within the UGB (a combined area of 4800 hectares). Roughly half (2200 hectares) was not developed. Much of this area is currently under cultivation.

This scoping study has shown that considerable work is required to identify and classify agricultural land capability in the peri-urban area. In some cases previous soil and land surveys could be easily accessed and directly interpreted for the study's purpose. More often, finding and accessing relevant, trusted data was difficult and time consuming. Even where good quality data exists, specialist knowledge is required to

interpret and re-classify it in a way consistent with the simple four-class system used. Research done prior to the mapping process discussed in this report showed how many of the specialists with the relevant knowledge and skills are retired or unwilling to conduct such assessments without substantial funding. This study was only possible due to considerable goodwill and commitment from a retired soil scientist with a particular passion for protection of high quality soils in the surveyed area.

The mapping process used here was successful in converting highly complicated land and soil data into a format that is very accessible to the non-specialist. While it has limitations in the way land capability is generalised, and results still require some interpretation, the work offers the community of stakeholders, concerned about loss of productive land near Melbourne, a basis to engage with policy and planning decisions affecting fruit and vegetable growing areas. Without this capacity to engage, the knowledge of where our most agriculturally capable land will exist only within a small and generally retiring generation of land owners who are often themselves under pressure to sell-off land for non-agricultural purposes.

This study has focused primarily on where agricultural land exists in proximity to urban development. However, urban sprawl is not the only risk to agricultural production in peri-urban areas. The data generated in this study offers the potential to do further analysis of existing and future risks to Class 1 and Class 2 land posed by factors such as climate change, mining and coal seam gas extraction.

Conclusion and recommendations

This project was undertaken as a feasibility study and has demonstrated the value of mapping land to improve general knowledge about the value and location of land suitable for agriculture. Results show how difficult the process is of mapping land suitable for intensive cropping, how little of that land exists in the peri-urban area, and that valuable portions of this land are at risk from urban development.

The variable quality of data that exists suggests further research could draw on specialist and local knowledge where possible, to improve the value of the results and increase the mapping coverage to the north and west of Melbourne. Where local governments have expressed interest in the study, these should be further engaged. Allowing the data generated in this study to be accessed and added to by interested community members would also be of great value. Ideally, the data should be offered as an online data source that can be verified and added to akin to any open source knowledge bank.

References

Jeffrey, P 1981, *A Study of the Land in the Catchments to the North of Melbourne*, report, Soil Conservation Authority, Victoria.

National Committee on Soil and Terrain 2009, *Australian Soil and Land Survey Field Handbook*, 3rd edn, CSIRO Publishing, Victoria.

Plan Melbourne 2013, viewed 8 November 2013, www.planmelbourne.vic.gov.au.

Soil Conservation Authority 2013, viewed 8 November 2013, http://vro.dpi.vic.gov.au/dpi/vro/vrosite.nsf/pages/landform_studies_hscals.

Van de Graaf, R and Howe, D 1976, *Upper Yarra and Dandenong Ranges Land Management and Stream Environments Study*, Kinnaird Hill deRohan and Young, Victoria.

Victorian Resources Online, viewed 6 November 2013, www.dpi.vic.gov.au/vro.

Appendix 1 – Description of land systems

Description of land systems' agricultural capability

This evaluation is based on the suitability of the land for the types of use defined on page 6. It does not take into account climate or water availability.

The area of each land system, including the percentages of the various land classes are derived from multiple reports, in particular by the Soil Conservation Authority and Jeffrey (1981). However, in the latter case, percentages were not provided and were estimated using a similar rationale as that used by Soil Conservation Authority.

The percentages given are approximate and should not be taken as the precise percentage within each agricultural class.

Chateau Yering (Class 1: 0%, Class 2: 88%, Class 3: 12%, Class 4: 0%)
Mostly cleared for agriculture and most (88%) is quite suitable for cropping with normal safe management to minimize soil and environmental deterioration. Normally there is a low risk of sheet erosion. The other 12% is either in a drainage line or on steeper slopes.

Chirnside Park (Class 1: 0%, Class 2: 60%, Class 3: 40%, Class 4: 0%)
This land is mostly cleared for agriculture and sub-division. There is no reason why horticulture (row cropping) and orchards can't take place as these soils are mostly friable and easily cultivated. Areas classed as Class 3 land are steeper and thus more prone to sheet erosion.

***Doreen** (Dor)* (Class 1: 0%, Class 2: 40%, Class 3: 60%, Class 4: 0%)
None of this land is suited to intensive cropping. The main concern with the sodic duplex soils is their dispersive properties which make the soils prone to gully, tunnel and sheet erosion. The remaining soils are generally stony gradational soils, not suited for anything other than grazing.

***Mernda** (Mer)* (Class 1: 0%, Class 2: 98%, Class 3: 2%, Class 4: 0%)
This land is marginal for intensive cropping. The main concern with the sodic duplex soils is their dispersive properties which make the soils prone to gully, tunnel and sheet erosion. Slopes on this land system are more gentle that for Doreen.

***Paul Range** (Pau)* (Class 1: 0%, Class 2: 0%, Class 3: 49%, Class 4: 51%)
Mostly of this land system is under native forest. The land is either too steep or 'rocky' for any form of intensive agriculture.

***Schoolhouse Ridge** (Scr)* (Class 1: 0%, Class 2: 0%, Class 3: 100%, Class 4: 0%)
This land system is mostly cleared for grazing, with only a few scattered trees remaining. Subdivision for urban and rural subdivision purposes has occurred. The soil is too shallow and the land is too steep for Intensive agriculture.

***Toolangi** (Too)* (Class 1: 70%, Class 2: 30%, Class 3: 0%, Class 4: 0%)
Most of this land system is cleared for cropping. Some is classed as Class 2 because of steeper slopes and safety issues associated with cultivation.

***Yarra Flood Plain** (Yaf)* (Class 1: 0%, Class 2: 2%, Class 3: 93%, Class 4: 5%)
Mostly cleared for grazing. Not suitable for intensive agriculture due to flooding. Some intensive crops may be grown on the levees but these are of small areal extent.

***Yarra Glen** (Yag)* (Class 1: 0%, Class 2: 78%, Class 3: 22%, Class 4: 0%)
This land system is wholly cleared for grazing or some intensive cropping. There are also urban and rural subdivision areas. Some of the Class 3 land is subject to periodic water-logging and the remainder steeper slopes. All Class 2 land is quite suitable for cropping with normal safe management to minimize soil and environmental deterioration.

***Whittlesea** (Whi)* (Class 1: 0%, Class 2: 78%, Class 3: 22%, Class 4: 0%)
The terraces have gentle slopes, mainly less than 3%. They are mostly classified as Class 2 soils due to their lack of friability and their need for careful management. Low permeability, weak surface structure, hard setting surfaces, high water table are the main problems associated with these soils.

***Wollert** (Woo)* (Class 1: 0%, Class 2: 0%, Class 3: 100%, Class 4: 0%)
The stony basaltic rises are the distinctive feature of this land system. On the crests, these rises have shallow stony red-brown gradational soils which grade into grey calcareous clay where the soil is deep enough. Black clay soils occur on the apron of the rises and yellow-brown calcareous sodic duplex soils on the plains. The gradational soils are fertile but, being too shallow and stony for cultivation, are mostly left timbered. The flatter areas may be cultivated but water-logging reduces their usefulness.

Soil descriptions used

The dominant soils only are given. These are subdivided into texture contrast, gradational and uniform texture as well as their subsoil colour. A generalized description of these classes is given below.

Duplex soils: Light textured topsoil overlying clayey subsoil (e.g. loam overlaying clay).
Sodic duplex soils: As above, but the subsoil clay contains more that 6% of the exchangeable cation sites occupied by sodium. These subsoils are generally dispersive, making the soils prone to tunnel and gully erosion.
Gradational soils: Gradual increase in clay content with depth.
Uniform soils: Similar soil textures down the soil profile.
Friable: Easily crumbled into smaller sized soil peds.

Table 1: Summary of land system characteristics

Name	Symbol	Class 1%	Class 2%	Slope Class 2	Soil depth Class 2 m	Class 3%	Slope Class 3	Soil depth Class 3 m	Class 4%
Chateau Yering	Chy	0	88	<3%	0.8-2.0+	12	0% (half) 8% (half)	0.8-2.0+	0
Chirnside Park	Chi	0	60	<12% Av 7%	1-2.0+	40	10-20% Av 14%	0.8-1.5	0
Doreen	Dor	0	40	Av 7%	1-2.0	60	Av 14%	Average 0.5	0
Mernda	Mer	0	98	Av 5%	Average 2.0	2	<1	Average 1.0	0
Paul Range	Pau	0	0	----------	----------	49	30-80%	0.8-2.0	51
Schoolhouse Ridge	Scr	0	0	----------	----------	100	15-35%	0.5-1.2	0
Settlement	Set	75	13	<3%	>2.0	0	----------	----------	8
Seville	Sev	0	13	generally <12%	0.8-2.0+	77	<20% Av 12%	0.8-2.0	10
Toolangi	Too	70	30	generally <12%	>2.0	0	----------	----------.	0
Yarra Flood Plain	Yaf	0	2	<3%	>2.0	93	<5	>2.0	5
Yarra Glen	Yag	0	78	generally <5%	0.8-2.0+	2	<15% Av 10%	Mostly <1.0	0
Whittlesea	Whi	0	90	<3%	<2.0	10	<3	<2	0
Wollert	Woo	0	0	----------	----------	100	<9% hummocky	Average 0.3-0.5	0

Table 2: Geology, land form, dominant soils, elevation range and rainfall of the various land systems

Name	Symbol	Geology	Landform	Dominant soils	Elevation (m)	Rainfall (mm)
Chateau Yering	Chy	Paleozoic sediments	Gently undulating rise	Grey and yellow-brown mottled duplex soils	60-200	750-1200
Chirnside Park	Chi	Tertiary basalt	Undulating to rolling low hills	Friable uniform grey clay soils	100-180	800-900
Doreen	Dor	Paleozoic sediments	Rolling low hills	50% stony red duplex soils, 40% yellow sodic duplex soils	100-300	620-750
Mernda	Mer	Paleozoic sediments	Rolling low hills	98% mottled yellow & brown sodic duplex soils	150-230	620-750
Paul Range	Pau	Paleozoic sediments	Rolling hills	Yellowish to reddish brown gradational with some duplex soils	200-600	800-1200
Schoolhouse Ridge	Scr	Paleozoic sediments	Rolling hills	Yellow & brown gradational soils some yellow duplex soils, generally stony	120-250	800-1200
Settlement	Set	Quaternary alluvium	Flood plain	Uniform medium and coarse textured soils	80-100	750-1200
Seville	Sev	Paleozoic sediments	Undulating to rolling low hills	Yellow duplex soils some yellow gradational soils	80-300	750-1200
Toolangi	Too	Paleozoic sediments	Undulating low hills	Friable red gradational soils	400-500	1000-1250
Yarra Flood Plain	Yaf	Quaternary alluvium	Flood plain	Mostly uniform grey clay soils	60-80	750-1000
Yarra Glen	Yag	Paleozoic sediments	Undulating rises	Yellow and grey duplex soils	100-300	750-1250
Whittlesea	Whi	Quaternary alluvium	Terraced land	Mostly yellow-brown duplex soils, some sodic, various uniform soils	60-80	680-740
Wollert	Woo	Pleistocene basalt	Undulating rises (stony)	40% dark grey uniform clay soils, 50% shallow stony red gradational soils	120-180	630-710

Appendix 2 – Description of land forms

The landform definitions given in table X accord with those used in Australian Soil and Land Survey Field Handbook(2009).

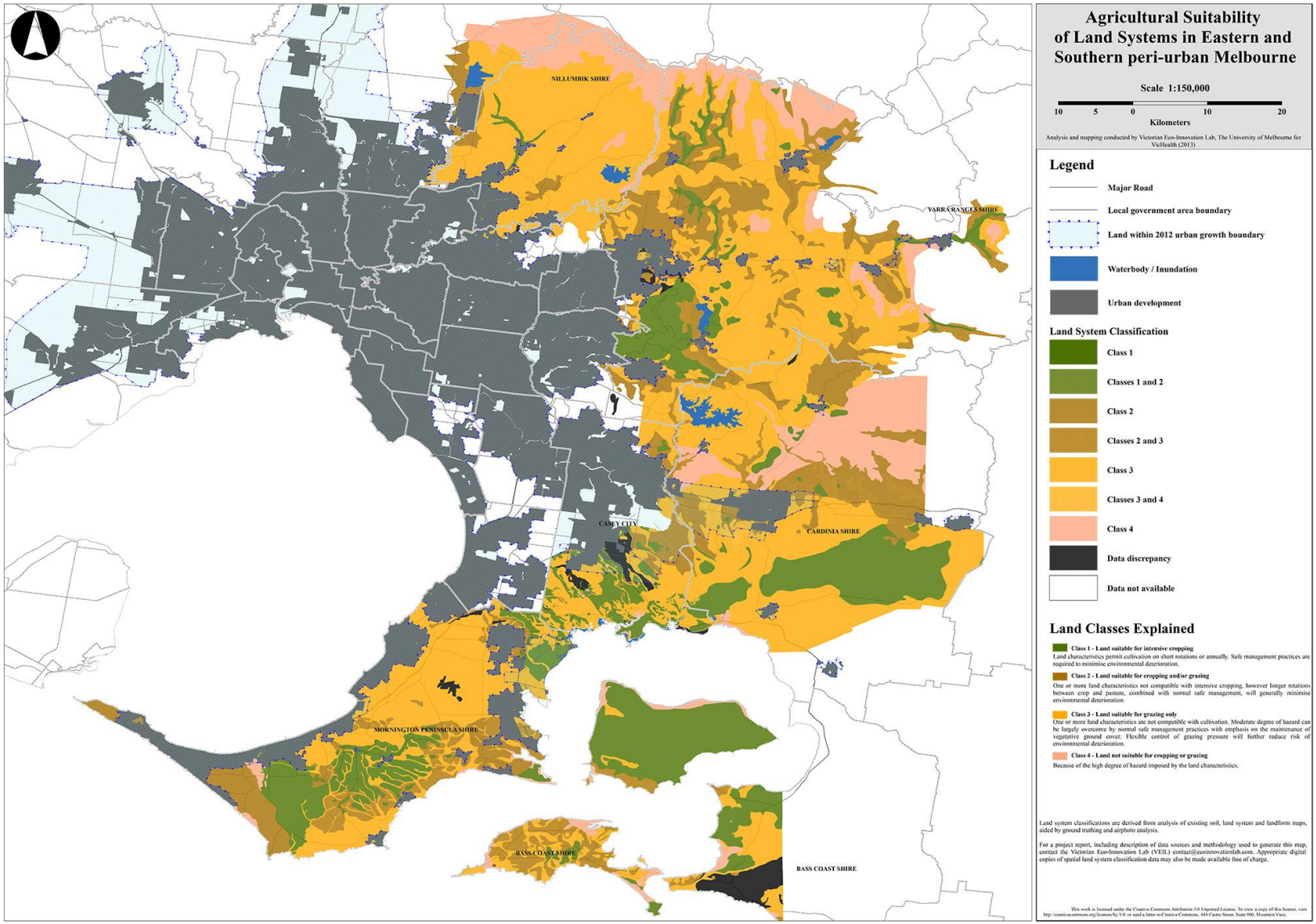
Table 3: Definitions of land forms referred to in this report.

Relief	Modal terrain slope						
	Level <1% (About 1:300)	Very gently inclined 1%-3% (About 2%)	Gently inclined 3%-10% (About 6%)	Moderately inclined 10%-32% (About 20%)	Steep 32%-56% (About 40%)	Very steep 56%-100% About 70%	Precipitous >100% (About 150%)
Very high >300 m (about 500 m)	----------	----------	----------	Rolling mountains	Steep mountains	Very steep mountains	Precipitous mountains
High 90-300 m (About 150 m)	----------	----------	Undulating hills	Rolling hills	Steep hills	Very steep hills	Precipitous hills
Low 30-90 m (About 50 m)	----------	----------	Undulating low hills	Rolling low hills	Steep low hills	Very steep low hills	Badlands
Very low 9-30 m (About 15 m)	----------	Gently undulating rises	Undulating rises	Rolling rises	Steep rises	Badlands	Badlands
Extremely low <9 m (About 5 m)	Level plain	Gently undulating plain	Undulating plain	Rolling plain	Badlands	Badlands	Badlands

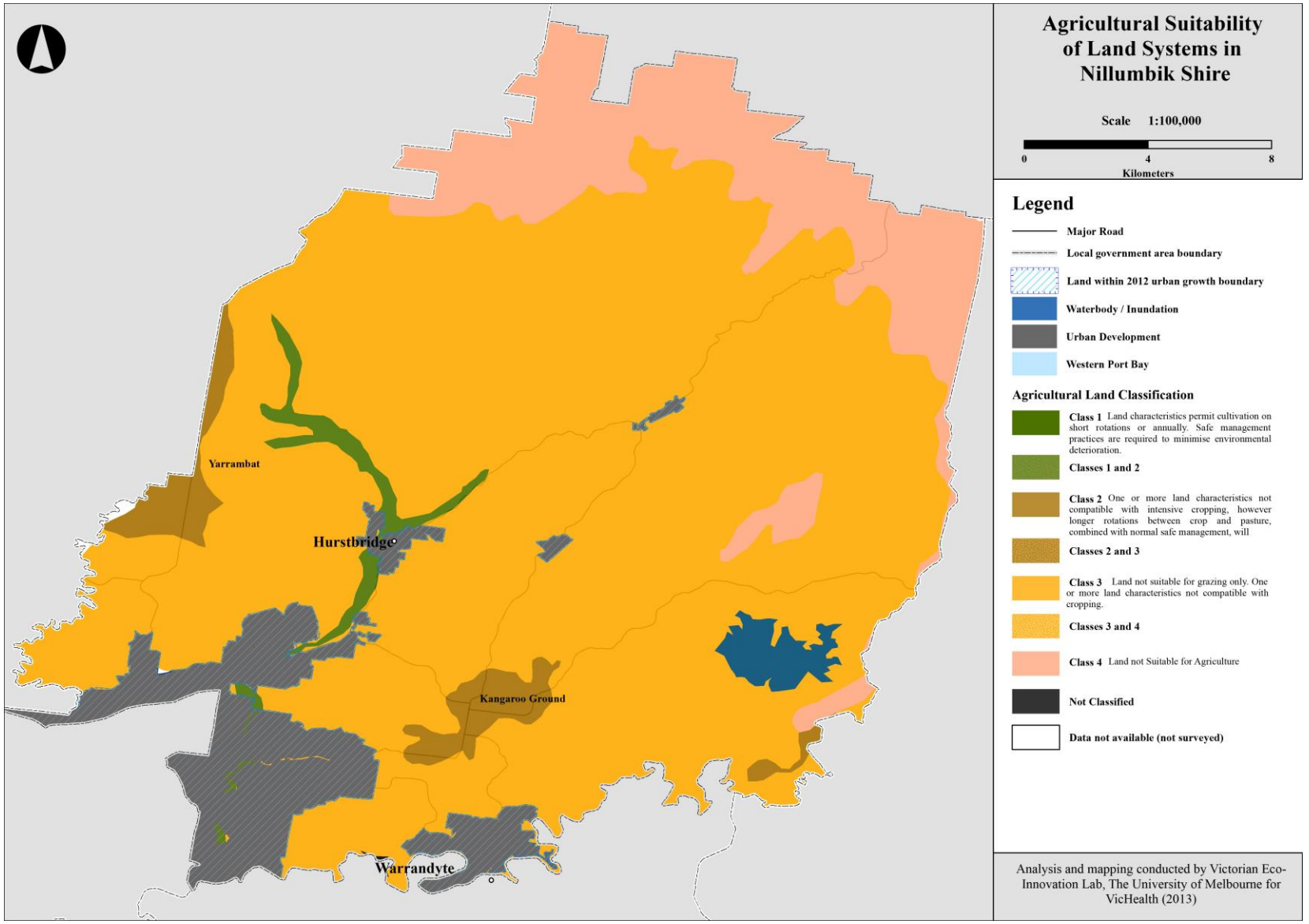
Other land forms referred to in this report

Flood plain: Alluvial plain characterised by frequently active erosion and aggradation (i.e. deposition) by channelled or overbank stream flow. Frequently active means that the flow has an Average Recurrence Interval of 50 years or less. Common elements are levee, back-plain, swamp, ox-bow and scroll.
Terraced land (alluvial): Land form pattern including one or more terraces and often a flood plain. Relief is low or very low (<9 to 30 m). Terrace plains or terrace flats occur at stated heights above the top of the stream bank. Typical elements are terrace plain, terrace flats, scarps, scroll plain, stream channel.

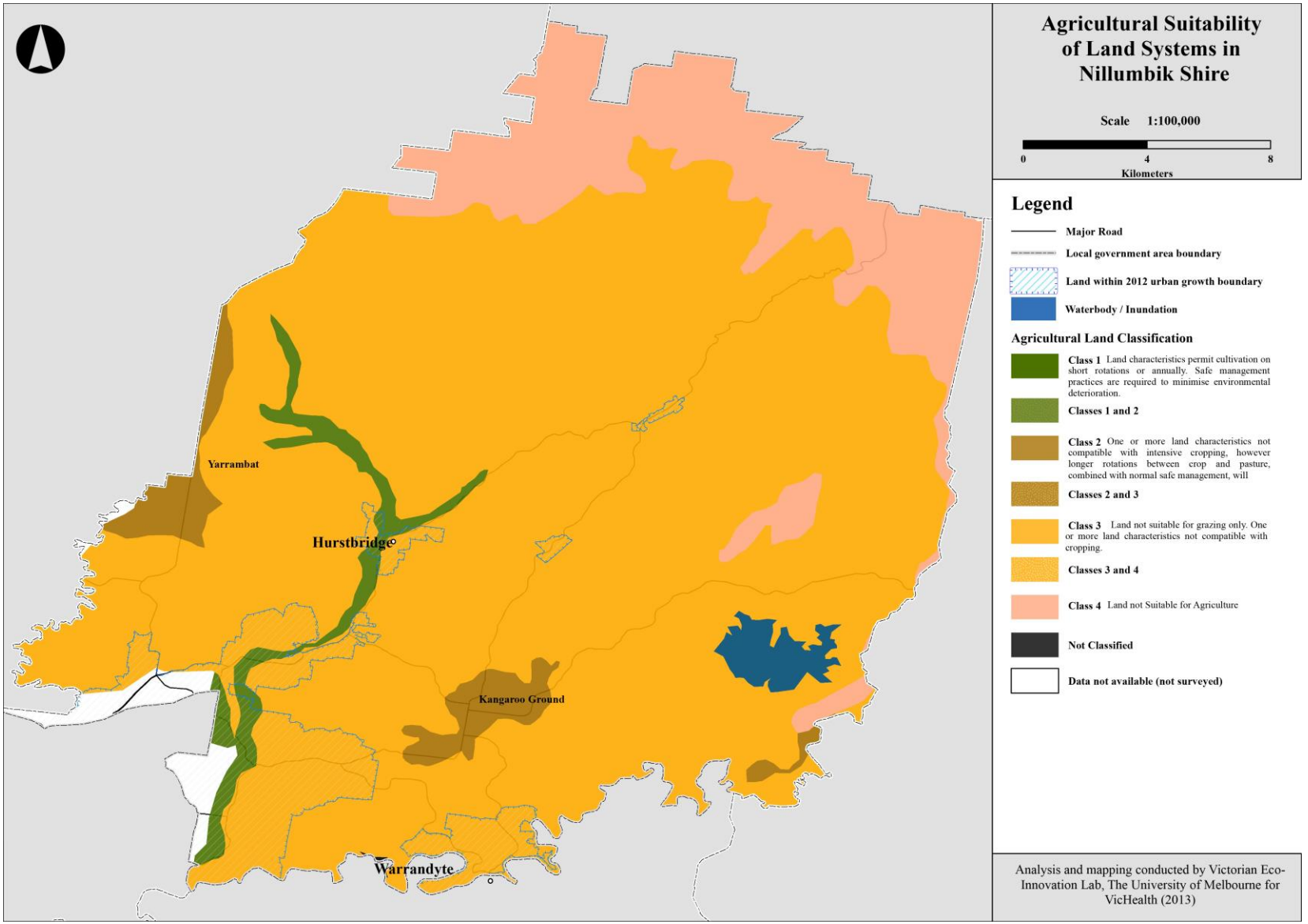
Appendix 3 – Survey region



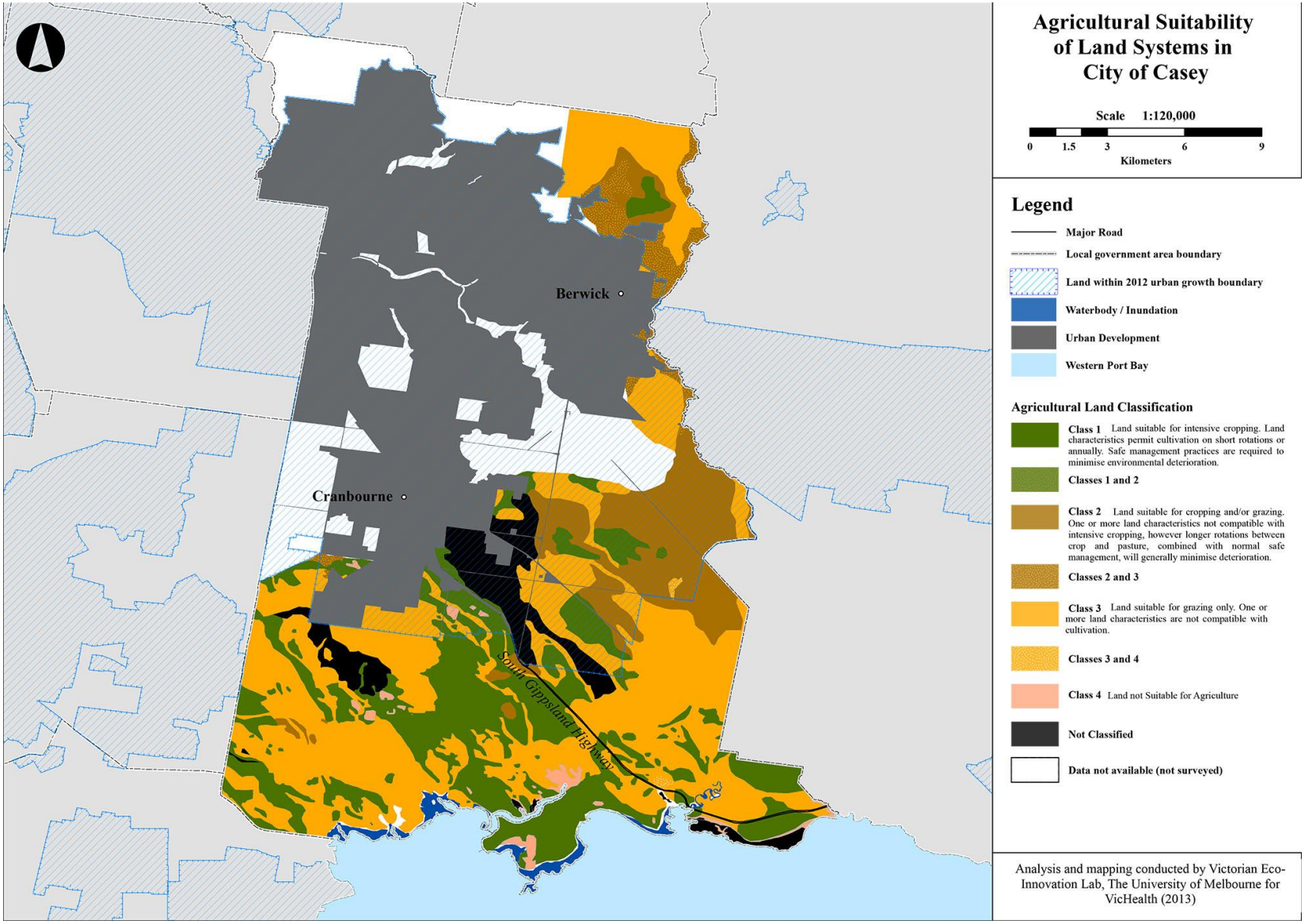
Appendix 4a – Nillumbik Shire (with urban development shown)



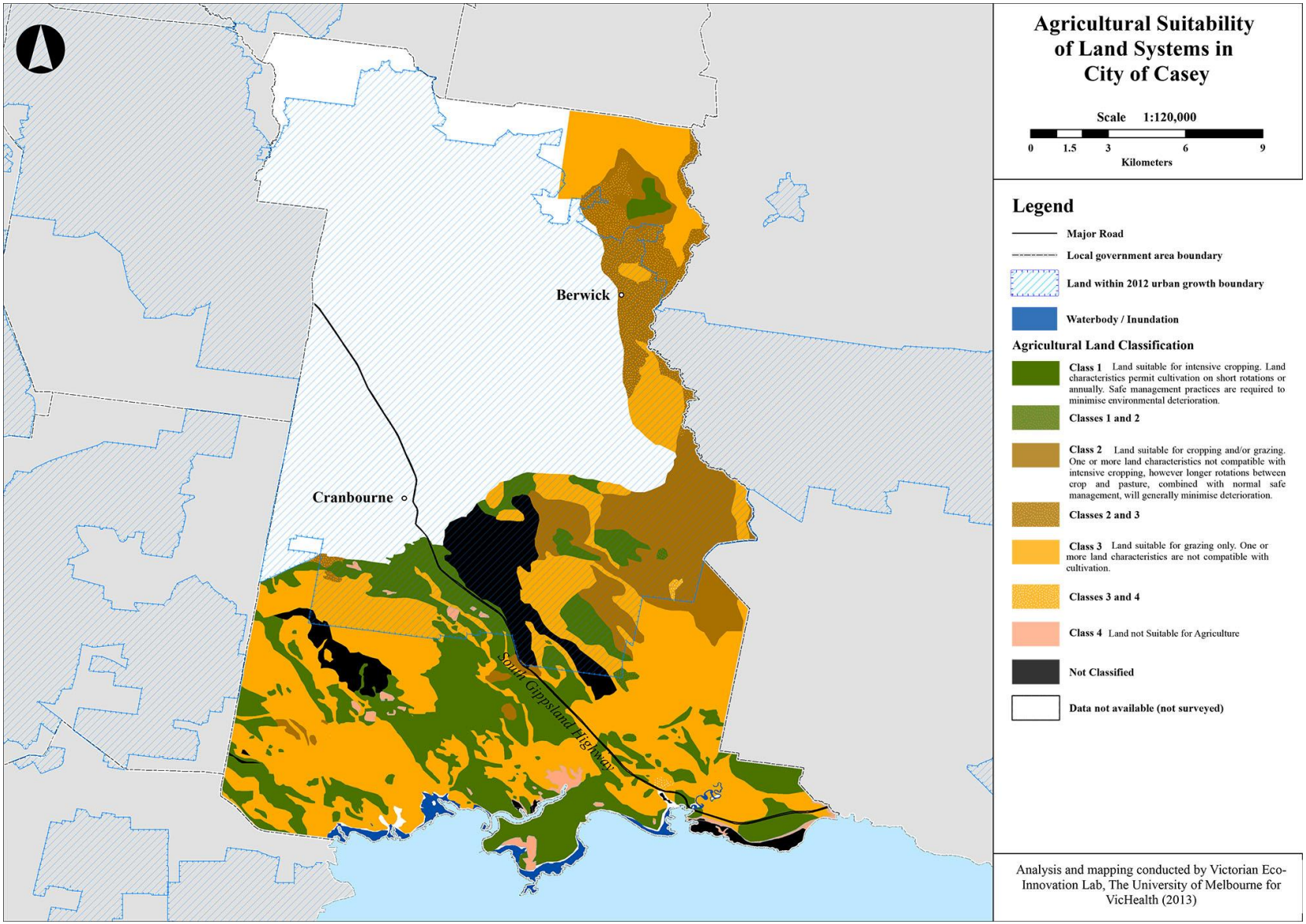
Appendix 4b – Nillumbik Shire (without urban development shown)



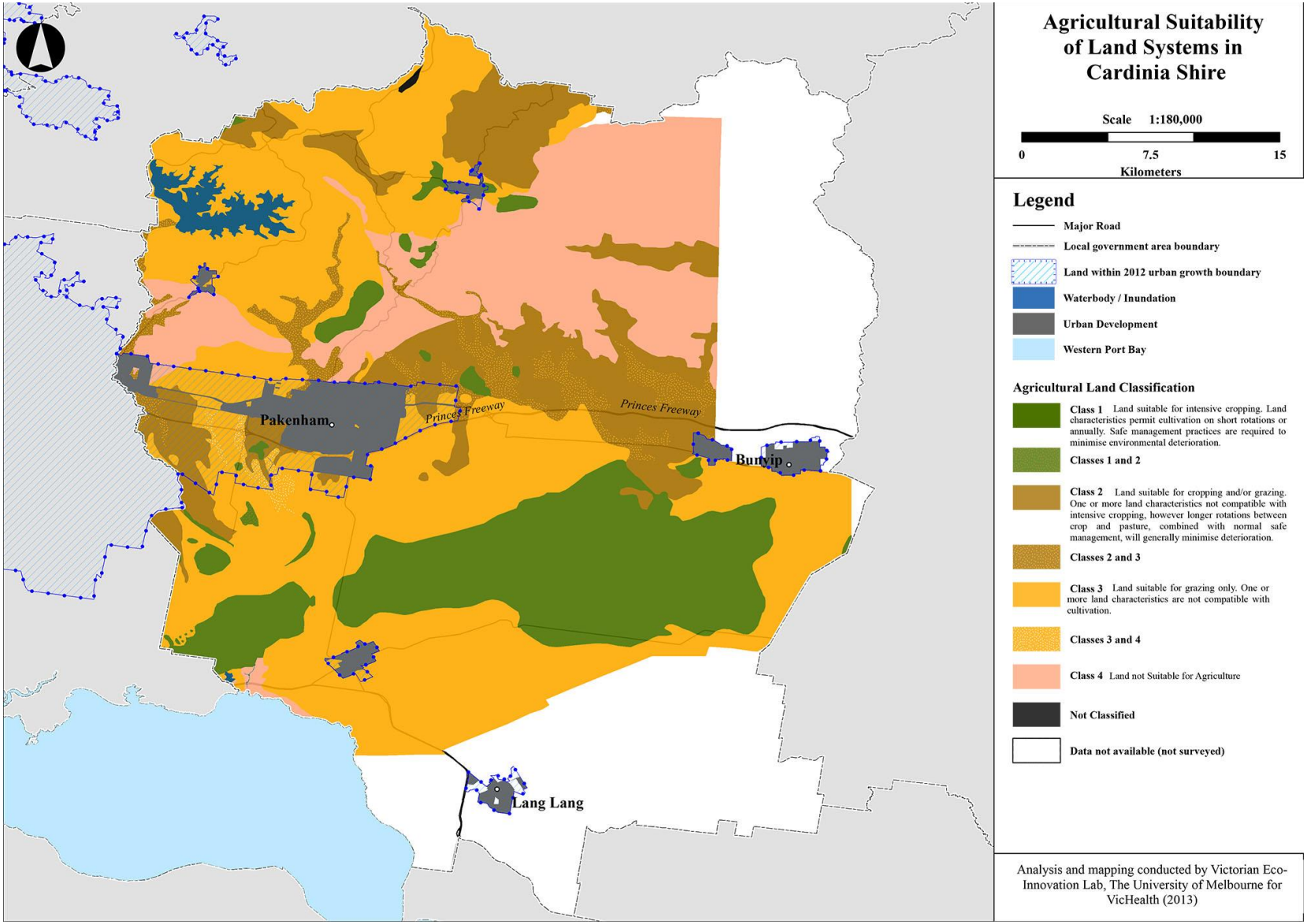
Appendix 5a – City of Casey (with urban development shown)



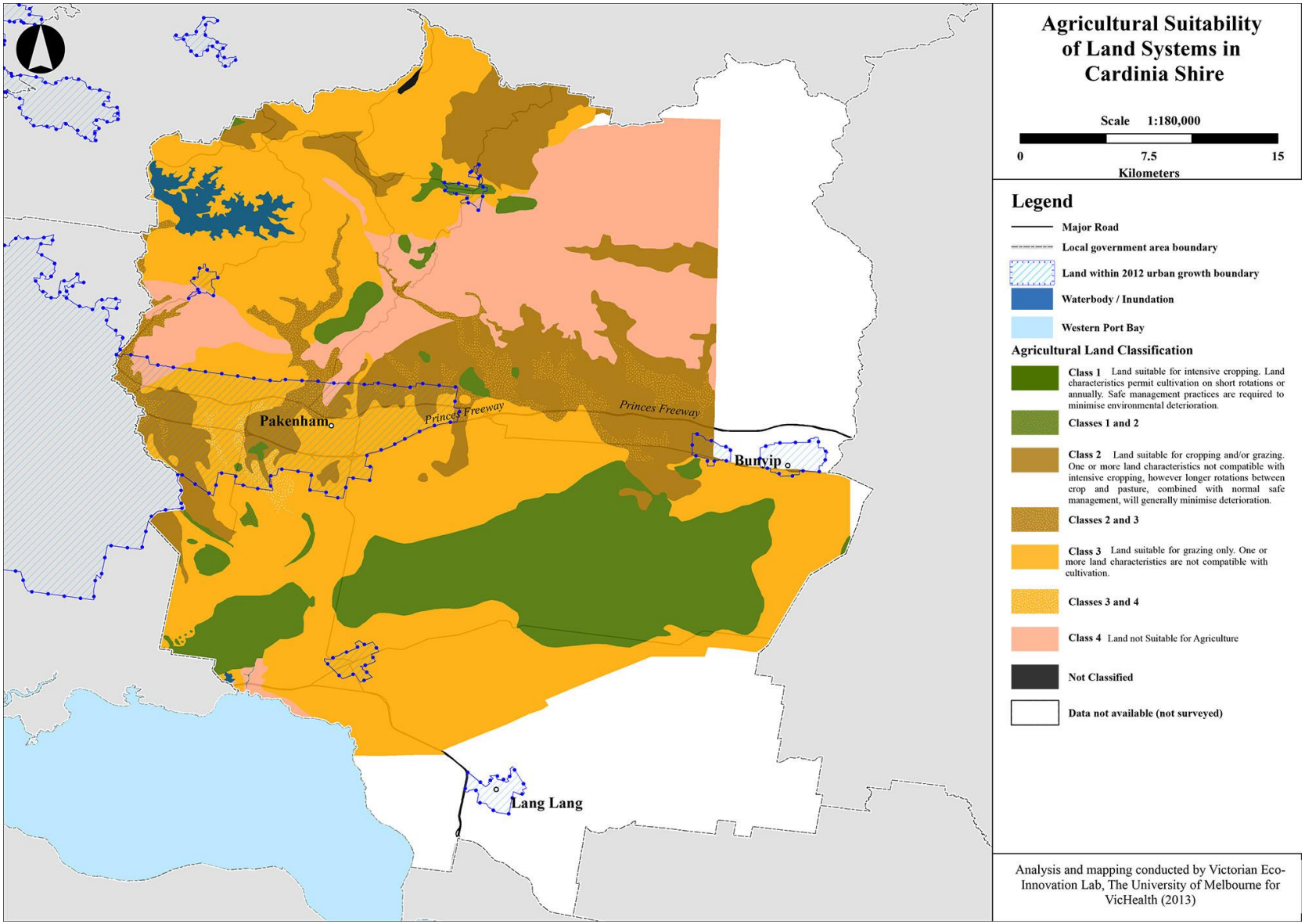
Appendix 5b – City of Casey (without urban development shown)



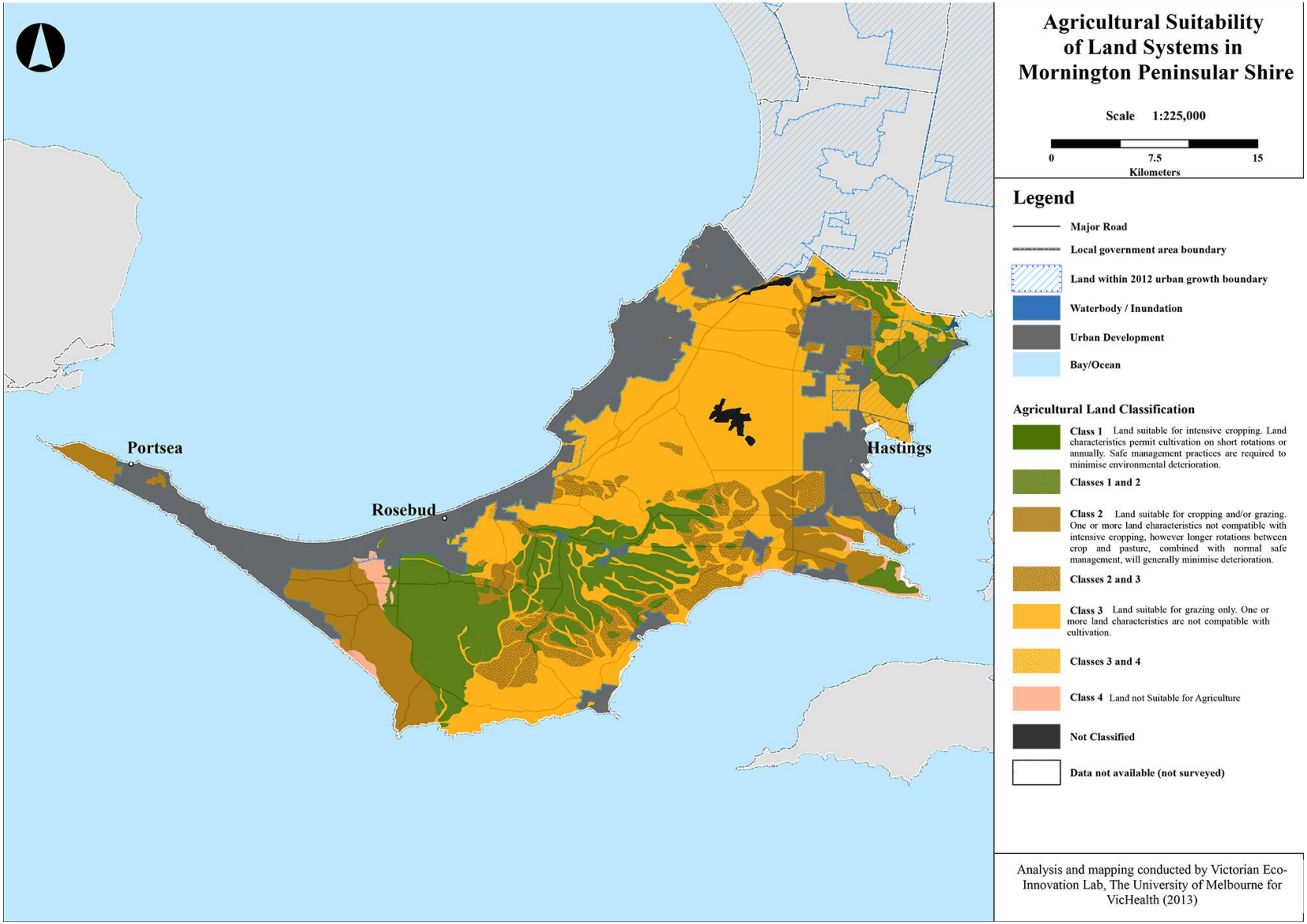
Appendix 6a – Cardinia Shire (with urban development shown)



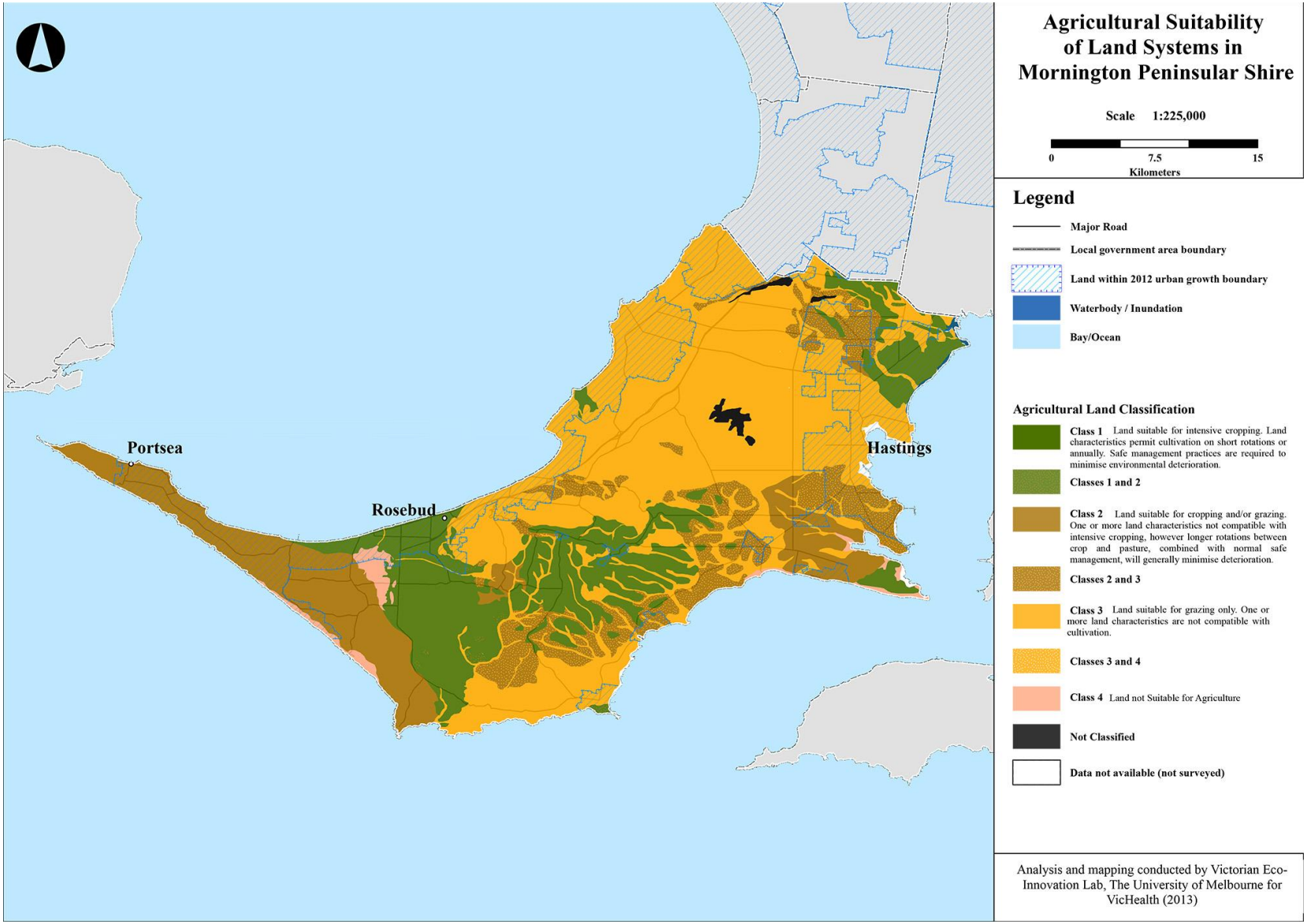
Appendix 6b – Cardinia Shire (without urban development shown)



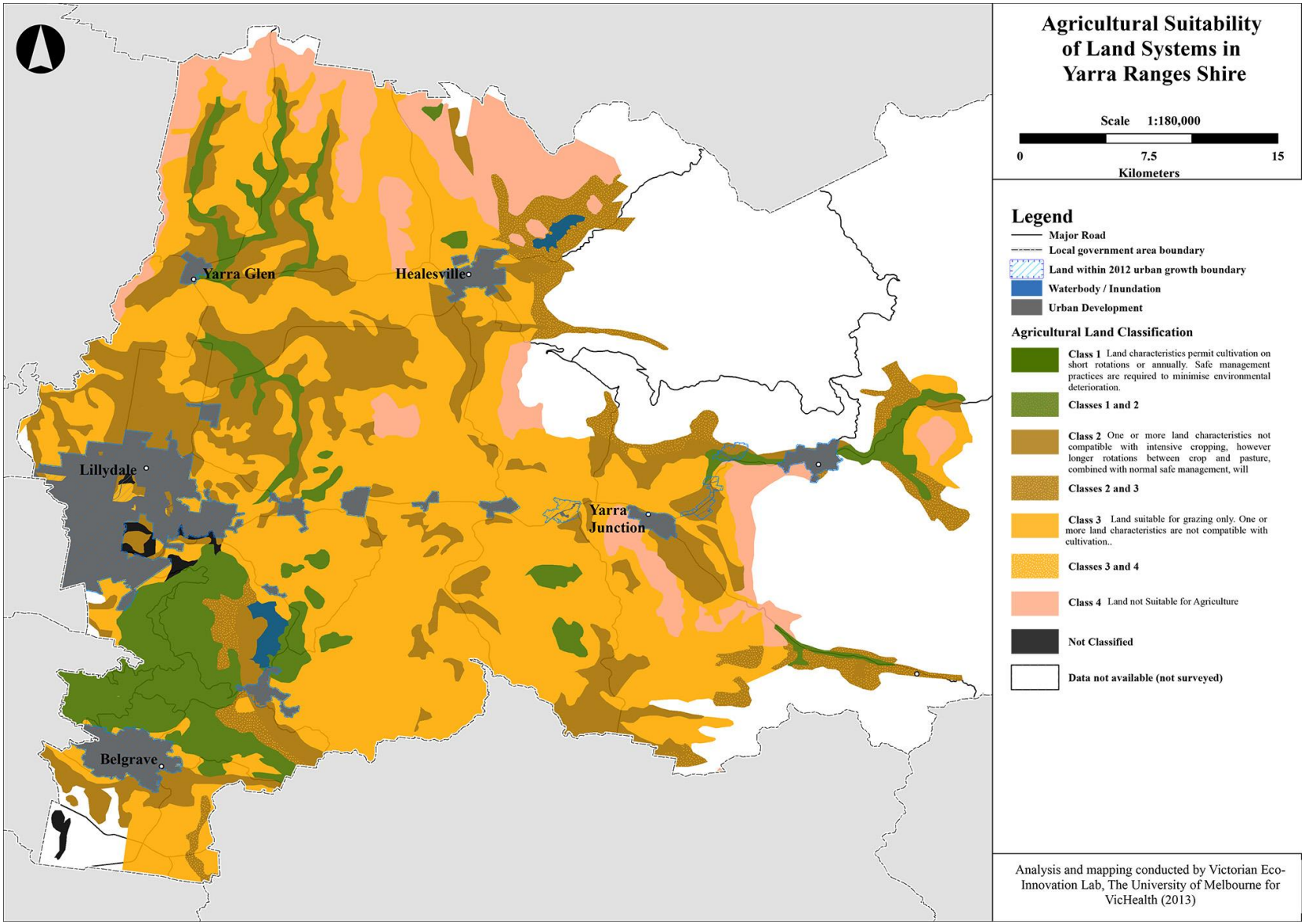
Appendix 7a – Mornington Peninsula Shire (with urban development shown)



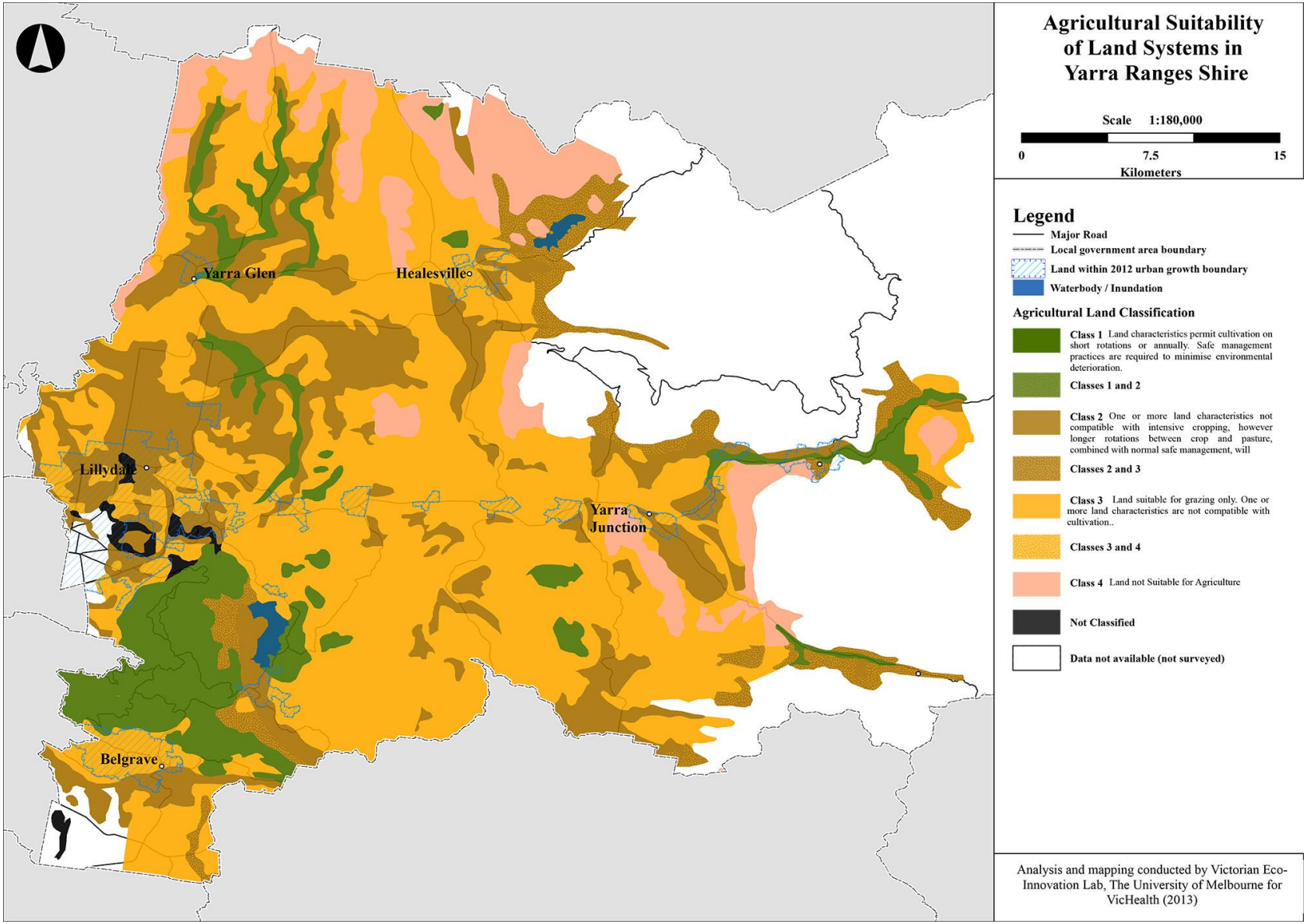
Appendix 7b – Mornington Peninsula Shire (without urban development shown)



Appendix 8a – Yarra Ranges Shire (with urban development shown)



Appendix 8b – Yarra Ranges Shire (without urban development shown)



Victorian Health Promotion Foundation
PO Box 154 Carlton South, VIC 3053, Australia
T: +61 3 9667 1333 F. +61 3 9667 1375
vichealth@vichealth.vic.gov.au
www.vichealth.vic.gov.au
November 2013
Publication number: P-123-HE

VicHealth acknowledges the support
of the Victorian Government.