Soil and land capability assessment for horticulture in Perth Hills

Phase 2 of 'Provision of rural property level soil, land and water assessment in the Perth Hills of Kalamunda and Armadale'

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Main findings of the study

Soil descriptions and land capability assessment

The current DPIRD broadscale soil landform mapping and unit descriptions can be improved upon by the use of remote sensing techniques and conducting a higher density of soil profile descriptions. This information can be used to modify the existing DPIRD capability ratings for horticultural crops.

Soil

There are estimated to be at least 3000 hectares of soils that have a high or very high capability for fruit production in the study area. The well drained loams on the valley floors, the duplex soils on the lower slopes and the gravelly soils on the mid to upper slopes are all good horticultural soils. The area of suitable land is much greater than the estimated 644 hectares that is currently under orchard.

Water

Limited volumes of irrigation water are available in the Perth Hills. Irrigation water is obtained from shallow bores, seepages and farm dams. It is estimated that about 6500 megalitres per year is currently being used for irrigation within the study area.

Water availability and not soil type is the major physical limitation to the expansion of horticulture in the study area. Significantly greater volumes of irrigation water are available in other fruit growing areas such as Gingin and Donnybrook.

Area of horticulture in the study area

The estimated total area of horticulture in the study area decreased from 1148 ha in 1981 to 644 ha in 2019.

Growers cite the poor return on investment from fruit production as the main reason for the decline in horticulture. Prospective larger scale horticultural developers would be unlikely to choose the Perth Hills as a location for a new property. The reasons for not choosing this area include:

- The cost of land is high compared to other horticultural areas
- The block size is too small to be profitable for many types of horticulture
- Water resources are limited on many properties

Competition for land from people wanting rural lifestyle blocks has contributed to the decline in the area of orchards within the study area.

Contents

Background

The Western Australian State Government established a working group to develop a 'Sustainability and Tourism Strategy for Pickering Brook and Surrounds'. The Sustainability and Tourism Strategy will support rural planning in the Cities of Kalamunda and Armadale. An assessment of priority agricultural land and a report which documents outcomes and recommendations will be produced by the working group.

In December 2019, the Department of Primary Industries and Regional Development (DPIRD) contracted Western Horticultural Consulting (WHC) to assess the land, soil and water resources in the rural areas of the Cities of Kalamunda and Armadale and to assess the suitability of these areas for horticulture. This information is to be used by DPIRD to help them provide input into the Sustainability and Tourism Strategy.

There were two phases to the consultancy. Phase 1 was a detailed soil survey and land capability assessment for the ninety hectare 'Planning Investigation Area' near the Pickering Brook townsite. Phase 1 is presented in a separate report. Phase 2 investigated a broader study area of about 4986 hectares of privately owned land in the Perth Hills within the Kalamunda and Armadale local government areas. This report details the work conducted in Phase 2. Figure 1 shows the location of the Phase 2 study area.

The objectives of the Phase 2 consultancy were to:

1. To investigate whether available imagery and the urban monitor datasets are a useful tool to improve the DPIRD broadscale soil landscape mapping of the area.
2. Where possible modify the broadscale mapping to provide more accurate and useful maps for use in regional land use planning.
3. Describe the soils and their percentage occurrence in the map units.
4. Provide information on the water resources that are available in the study area.
5. Conduct mapping of current and past areas of horticulture to determine the change in land use over last 40 years.
6. Provide comment on the soil requirements of the range of horticultural crops that are grown in the study area.

DPIRD land capability mapping, which is available on NRInfo, has been used by land use planners for regional planning purposes, however for property scale assessments more detailed scale mapping is often required.

The City of Kalamunda have received feedback, that in some cases, the regional mapping does not accurately represent what occurs on the ground. This is most likely due to the broadscale nature of the regional mapping, however DPIRD wish to determine if the regional mapping can be improved upon. Describing a greater number of soil profiles in the area will provide more certainty on the soil types and their percentage occurrence within the map units.

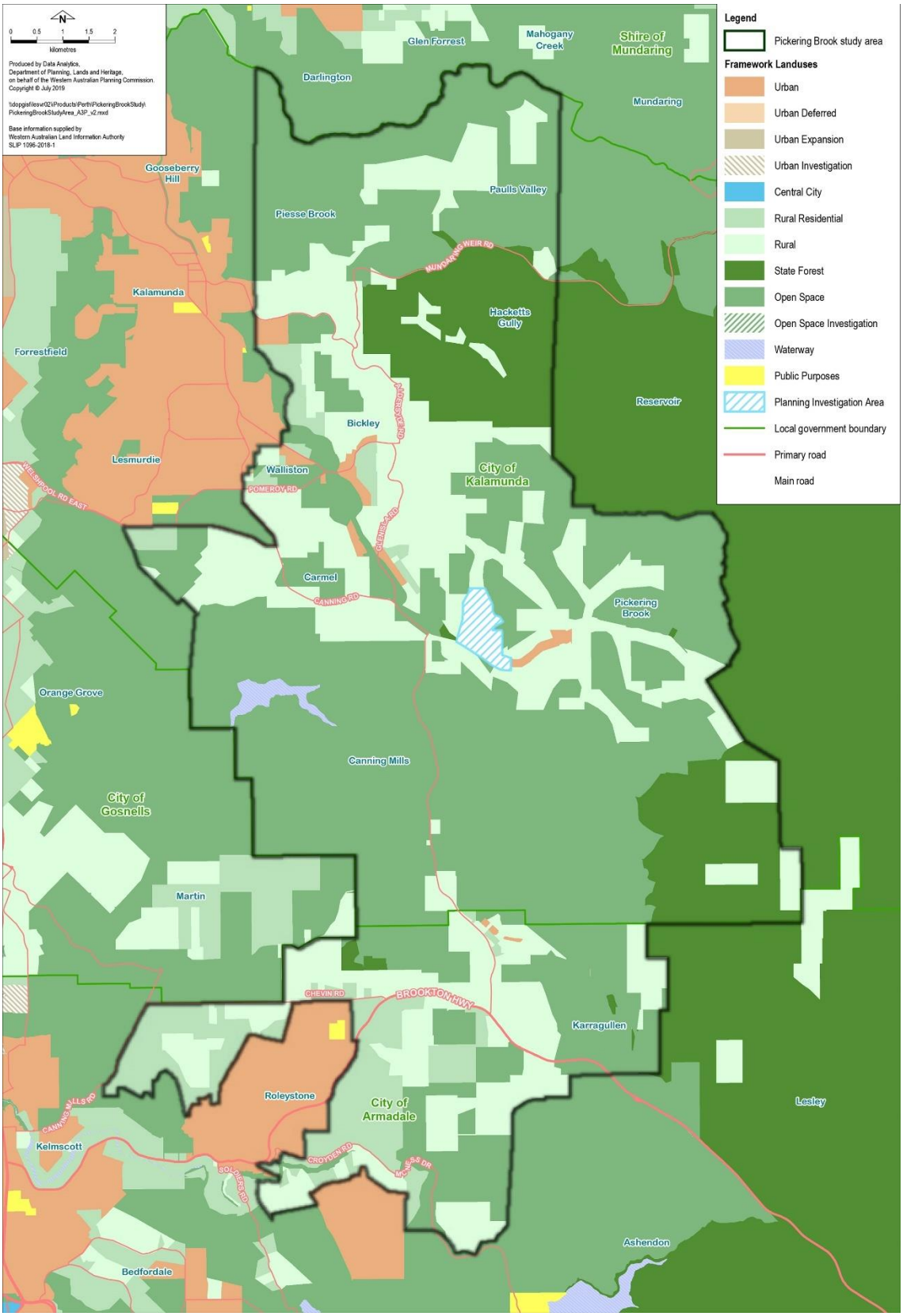

Figure 1. Pickering Brook and Surrounds Sustainability and Tourism Strategy – Study area

Methodology

Soil landscape mapping

WHC was asked to investigate if the areas that were not suitable for horticulture could be better mapped at a regional scale over the study area. In particular, WHC was asked to map the areas of shallow rock and waterlogged areas.

DPIRD provided WHC with maps of the study area that contained aerial photography and the map unit boundaries of the existing broadscale mapping. The DPIRD mapping was completed in 1990 using stereo interpretation of aerial photographs and subsequent ground truthing. Advances in remote sensing technology, such as accurate slope mapping, have become available since that time. This technology can be used to assist with better defining soil landscape units.

Karen Holmes, senior research scientist from DPIRD, was approached and asked to provide remote sensing data that might be able to be used to help delineate areas of shallow rock and waterlogged areas.

It was thought that high resolution gamma radiometric data, which had proven useful in mapping gravelly soils in the Western Australian Wheatbelt may be able to assist with identifying the *Shallow gravel*/lateritic outcrop complex. However no high-resolution data was available for the study area, and even if it was, it would be unlikely that these areas would be able to be distinguished from the surrounding areas of *Deep sandy gravel*s and *Duplex sandy gravels* because of their high ironstone gravel content. It was not possible to identify these shallow soils and rocky areas by using aerial photography.

The Urban Monitor data provided by CSIRO was used to run a terrain analysis over the study area to produce 'Multi resolution valley bottom flatness' maps. Multi-resolution valley bottom flatness is an index created using a digital elevation model. It takes the elevation and slope (derived from elevation in a local analysis window) to classify flat, low areas as valley bottoms. This is accomplished through a series of calculations at progressively coarser spatial resolutions with the goal of identifying both small and large valleys.

The 'Multi resolution valley bottom flatness' maps, recent aerial photography and extensive field checking were used to make minor modifications to DPIRD's regional soil landscape mapping. This updated mapping, which was digitised by DPIRD Research Scientist Greg Doncon, can be incorporated into DPIRD's digital soil mapping or it can be kept separate and be used for any more detailed capability assessments within the study area.

Modified soil landscape descriptions

Descriptions of the modified DPIRD soil landscape units, including the percentage occurrence of each soil group by qualifier and landscape position are given in this report. These percentages can be used to calculate land capability ratings for each soil landscape unit.

WHC made an independent assessment of land capability for annual horticulture, perennial horticulture and vineyards based on its own 'expert opinion.' These ratings may differ from the DPIRD ratings.

Soil descriptions

Two hundred soil observation sites were described across the study area to gain a good understanding of the soil groups within each soil landscape unit. Auger holes were dug to a depth of one metre or to where clay was encountered. In many cases, road-side cuttings were used to make the soil descriptions.

The locations of the soil description sites were chosen to:

- Give a spread of sites across the study area.
- Fully explore the soils that are farmed.
- Concentrate of soil landscape units that have a higher variability of soils rather than units where the range of soils is small and well understood.

Soil parameters that were described at each site included; the depth of each soil horizon, soil texture (hand assessment), soil structure, colour, percentage of coarse fragments including gravel (field sieving) and field pH. The soil profiles were described using the terminology of McDonald et al (1990). Soil colours were described according to standard Munsell colour chart notation.

These soil observation sites were classified using the WA Soil Groups methodology (Schoknecht and Pathan, 2013) and the site descriptions have been added to the DPIRD Soil Profile Database.

The soil observations from this study were combined with the smaller number of soil observations from the existing DPIRD soils data base and the existing soil landscape descriptions were updated. This higher density of site descriptions provides more accurate information on the range of soils and their percentage occurrence within the soil landscape units.

Land use mapping

DPIRD Research Scientist Greg Doncon used aerial photography to produce land use maps of the study area for the years of 1981 and 2019.

In the 2019 mapping the following horticultural land uses were identified:

- Stone and pome fruit
- Citrus
- Avocados
- Wine grapes
- Nurseries
- Flower and bulb production

The accuracy of the 2019 land use map was checked by field observations. There were some areas of horticulture that could not be seen from the roadside so these areas could not be checked. The areas of stone and pome fruit (apples and pears) could not be separated on the aerial photographs as they have similar tree spacings and canopy shapes.

The 1981 land use map is less accurate as no field checking could be conducted to confirm the air photo interpretation. For this date, all fruit tree crops were mapped together.

Water resources

WHC was asked to provide information on the volume of groundwater available for irrigation within the study area.

It is difficult to obtain information on the amount of groundwater that is available in the Perth Hills. On many properties the extent of the water resources has not been fully explored. Some irrigators are not willing to make public how much water they are abstracting. Information on water abstraction is not available from the Department of Water and Environmental Regulation as the area is not a proclaimed groundwater supply area and irrigators do not require a licence.

An estimate of the water that is currently being used for irrigation was made by multiplying the area of the different types of horticulture (from land use mapping) by an estimate of the irrigation requirements of each crop.

Fruit production in the Perth Hills and soil considerations

The soil requirements of different horticultural crops were discussed in this report, in particular in relation to the soils present within the study area. Information is presented for apples and pears, stone fruit, citrus, avocados, wine grapes and vegetables. Some management considerations that relate to crop production on the different soils are outlined.

Results

Remote sensing to assist in defining soil landscape units

Figure 2 shows an example of a multi-resolution valley bottom flatness index map. Ground truthing of this mapping showed a good correlation between the dark blue areas on the map that occurred in lower parts of the landscape and the valley floors. The dark blue colour indicates level to very gently inclined land (<3%). The valley floors can be seen as long thin areas of dark blue. Some of the broad patches of dark and light blue on the map are areas of lateritic plateau that occur at the top of the landscape.

The multi resolution valley bottom flatness maps were used to subdivide the Yarragil 4 (YG4) unit into two map units or phases:

- The flat valley floors that contain areas of alluvial soils (deep loams and poorly drained duplex soils). A new map unit Yarragil 6 (YG6) was created for these areas.
- The lower slopes that generally contain gravelly duplex soils and well drained duplex soils. A new map unit Yarragil 7 (YG7) was created for these areas.

Aerial photography that was flown in summer was also used to help distinguish the YG6 unit from the YG7 unit. The areas of green grass on the aerial photographs were used in combination with the dark blue areas on the multi resolution valley bottom flatness maps to identify the YG6 unit.

Where the valley floor was very narrow (less than about 30 m wide) the areas of the YG4 were not subdivided into the YG6 and YG7 units.

The existing DPIRD mapping was found to be accurate, at a scale of 1:50000, in almost all cases. However, in a small number of areas the unit boundaries did not line up with what was observed on the ground (see Figure 3 for an example). This may have been due to errors in the mapping, due to distortion errors in the aerial photographs or due to errors in digitising the linework from the stereo pairs.

This updated mapping produced in this study can be incorporated into DPIRD's digital soil and land capability mapping or it can be kept separate and be used for any more detailed capability assessments within the study area.

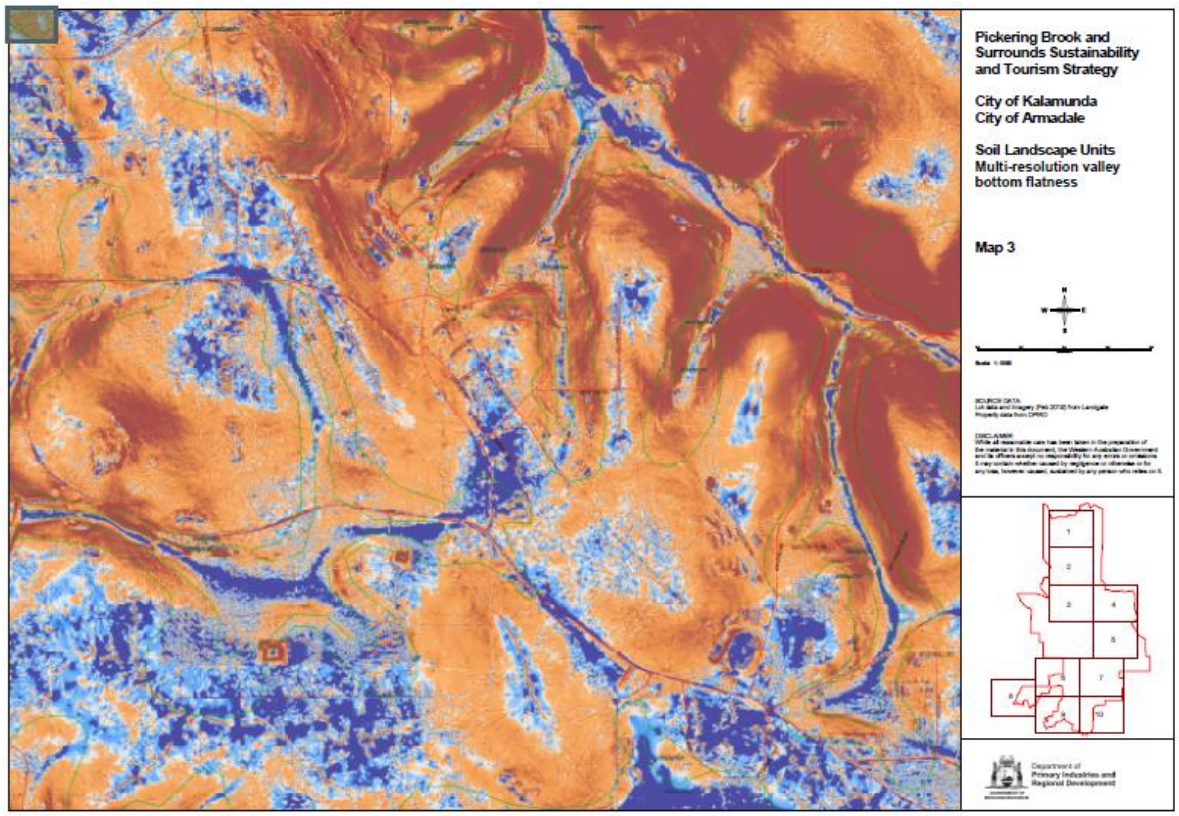

Figure 2. A multi resolution valley bottom flatness map with the DPIRD soil landscape units superimposed. The dark blue colour indicates level to very gently inclined land (<3%). The valley floors can be seen as long thin areas of dark blue. Some of the broad patches of dark and light blue are areas of lateritic plateau that occur at the top of the landscape.

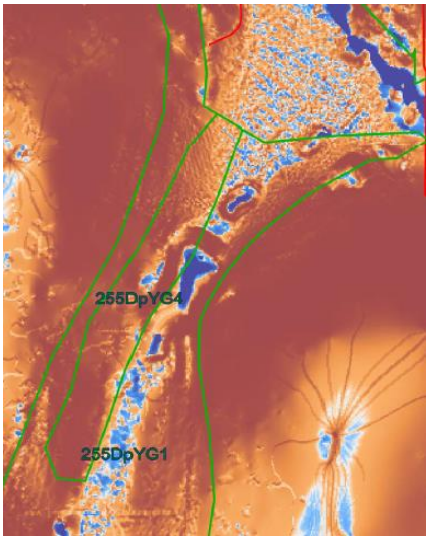

Figure 3. A 'multi resolution valley bottom flatness' map showing an area where the DPIRD YG4 soil landscape unit (green lines) does line up with the valley floor (dark blue area). The unit boundary was subsequently modified.

Modified soil landscape descriptions

Dwellingup 2 soil-landscape unit (DW2)

Brief description: Very gently to gently undulating terrain (<10%) with well drained, shallow to deep, gravelly, yellowish sands overlying lateritic duricrust.
Soil: Shallow to deep, gravelly, yellowish sands overlying lateritic duricrust. Lateritic rocks often occur in the soil profile.
Landform: Well drained very gently to gently undulating terrain (<10%).
Geology: Remnant lateritic profile.
Vegetation: *Eucalyptus marginata, Corymbia calophylla* and *Banksia sessilis*.
Landform pattern: Hills
Relief/modal slope class(s): Undulating plains and rolling plains
Morphological type(s): Mid-slope and upper slope

In this study 34 soil profile sites were described within the DW2 unit. The percentage occurrence of Soil Groups outlined in the table below was determined by using the site descriptions from this study and from field observations and roadside cuttings. King and Wells (1990) did not describe any soils on the DW2 unit within the study area.

WA Soil Groups by qualifier and landscape position - percent of Map Unit

WASG Name	Qualifier	Landscape	%
Shallow gravel	Sandy matrix	Crests and slopes <3%	15
Shallow gravel	Sandy matrix	Slopes 3- 5%	15
Shallow gravel	Sandy matrix	Slopes 5 – 10%	10
Shallow gravel	Very shallow rock substrate	Crests and slopes <3%	5
Shallow gravel	Very shallow rock substrate	Slopes 3- 5%	5
Deep sandy gravel	Good sand, deep rock substrate	Crests and slopes <3%	15
Deep sandy gravel	Good sand, deep rock substrate	Slopes 3- 5%	15
Deep sandy gravel	Good sand, deep rock substrate	Slopes 5 – 10%	10
Duplex sandy gravel	Deep rock substrate	Crests and slopes <3%	3
Duplex sandy gravel	Deep rock substrate	Slopes 3- 5%	3
Duplex sandy gravel	Deep rock substrate	Slopes 5 – 10%	4

Deeper versions of the *Shallow gravel* have a high capability for horticulture. Versions of the *Shallow gravel* that have large amounts of ironstone rock in the top 30 cm restrict cultivation which makes the soil unsuitable for annual horticulture. Small areas of surface rock in a paddock may make it impractical to cultivate the remainder of the paddock.

Land capability assessment (Class %, code and description)

Land Use	pc1_2	pc3	pc4_5	Code	Cap Rating desc
Annual horticulture	45	30	25	B1	>70% of the area is Class 1, 2 or 3
Dry Cropping					
Grazing					
Perennial horticulture	70	5	25	A2	50-70% of the area is Class 1 or 2
Vineyards	70	5	25	A2	50-70% of the area is Class 1 or 2

Figure 4. An area of the DW2 soil landscape unit. The unit occurs on the upper slopes and plateau surface and predominantly contains the *Deep sandy gravel* and *Shallow gravel* soil groups.

Figure 5. The DW2 unit was generally not cleared for horticulture as it was considered to have a lower capability than the units in the valleys. However, deeper soils in this unit are suited for horticulture, though in some places ironstone rocks and boulders limit cultivation. This unit occurs higher in the landscape in areas where groundwater is less available.

Yarragil 1 soil-landscape unit (YG1)

Brief description: Very gently to moderately inclined concave side slopes. Moderately well drained gravelly yellow duplex soils and loams with areas of well drained sandy gravels. Woodland of *Eucalyptus marginata and Corymbia calophylla.*
Soil: Gravelly yellow duplex soils and loams with areas of deep and shallow sandy gravels.
Landform: Moderately well drained very gently to moderately inclined (<15%) concave valley side slopes.
Geology: Soils derived from the dissected lateritic profile.
Vegetation: Woodland of *Eucalyptus marginata* and *Corymbia calophylla*
Landform pattern: Hills
Relief/modal slope class(s): Undulating hills and rolling plains
Morphological type(s): Mid-slope and lower slope

In this study 79 soil profile sites were described within the YG1 unit. The percentage occurrence of different Soil Groups outlined in the table below was determined by using the site descriptions from this study, site descriptions from King and Wells (1990) and from field observations of the soil surface and roadside cuttings.

WA Soil Groups by qualifier and landscape position - percent of Map Unit

WASG Name	Qualifier	Landscape	%
Deep sandy gravel	Good sand deep rock substrate	Slopes 3- 5%	10
Deep sandy gravel	Good sand deep rock substrate	Slopes 5 – 10%	15
Deep sandy gravel	Good sand deep rock substrate	Slopes 10 – 15%	10
Duplex sandy gravel	Neutral subsoil	Slopes 3- 5%	10
Duplex sandy gravel	Neutral subsoil	Slopes 5 – 10%	10
Duplex sandy gravel	Neutral subsoil	Slopes 10 – 15%	5
Shallow gravel	Sandy matrix	Slopes 3- 5%	5
Shallow gravel	Sandy matrix	Slopes 5 – 10%	5
Shallow gravel	Sandy matrix	Slopes 10 – 15%	10
Loamy gravel	Neutral subsoil	Slopes 3- 5%	5
Loamy gravel	Neutral subsoil	Slopes 5 – 10%	5
Loamy gravel	Neutral subsoil	Slopes 10 – 15%	5
Yellow brown deep sandy duplex	Good neutral subsoil	Slopes 3- 5%	2
Yellow brown shallow loamy duplex	Good neutral subsoil	Slopes 3- 5%	1
Brown loamy earth	Good neutral subsoil	Foot slopes <3%	1
Yellow brown shallow sand	Good sand rock substrate	Foot slopes <3%	1

The soils that occur on the mid and lower slopes of this unit generally have more loamy textures and contain less gravel (*Duplex sandy gravel*s, *Loamy gravel*s, other duplex soils and loamy earths). The *Deep sandy gravel*s and *Shallow gravel*s are more commonly found on the upper slopes of this unit. The depth to the lateritic duricrust in the *Shallow gravel* is generally deeper in this unit than in the Dwellingup 2 unit.

Land capability assessment (Class %, code and description)

Land Use	pc1_2	pc3	pc4_5	Code	Cap Rating desc
Annual horticulture	30	35	35	B2	50-70% of the area is Class 1, 2 or 3
Dry Cropping					
Grazing					
Perennial horticulture	90	5	5	A1	>70% of the area is Class 1 or 2
Vineyards	95	2	3	A1	>70% of the area is Class 1 or 2

Figure 6. A view across a Yarragil valley. The side slopes show the YG1 unit with the YG4 unit occurring on the valley floor and lower slopes in the centre of the photograph.

Figure 7. The *Duplex sandy gravels*, *Loamy gravels*, other duplex soils and loamy earths that occur on the YG1 unit are well suited to fruit production.

Yarragil 4 soil-landscape unit (YG4)

Brief description: Valley floors with moderately well drained to well drained loams and areas of poorly drained mottled duplex soils, and gentle lower slopes with moderately well drained to well drained duplex soils, loamy and sandy earths and gravels. Woodland of *Corymbia calophylla with some Eucalyptus patens,* paperbark *(Melaleuca sp.) and Eucalyptus rudis* on the valley floors.
Soil: Loams and areas of mottled duplex soils on the valley floors. Duplex soils, loamy and sandy earths and gravels on the gentle lower slopes.
Landform: Well drained lower slopes (<10%) and well drained to poorly drained valley floors (<3%).
Geology: Soils derived from the dissected lateritic profile.
Vegetation: On the lower slopes and better drained valley floors *Corymbia calophylla* is the dominant species with *Eucalyptus patens* in some areas. On the more poorly drained valley floors paperbark *(Melaleuca sp) and E. rudis* occur.
Landform pattern: Hills
Relief/modal slope class(s): Undulating low hills and gently undulating plains
Morphological type(s): Lower slope and open depression (vale)

The percentage occurrence of different Soil Groups outlined in the table below was determined by using the site descriptions from this study, site descriptions from King and Wells (1990) and from field observations of the soil surface and roadside cuttings.

WA Soil Groups by qualifier and landscape position - percent of Map Unit

WASG Name	Qualifier	Landscape	%
Friable red/brown loamy earth	Good neutral subsoil	Slopes <3%	15
Yellow/brown shallow loamy duplex	Good neutral subsoil	Slopes 3- 5%	15
Yellow/brown shallow sandy duplex	Good neutral subsoil	Slopes 3- 5%	15
Duplex sandy gravel	Neutral subsoil	Slopes 3- 5%	10
Loamy gravel	Neutral subsoil	Slopes 3- 5%	10
Yellow brown deep sandy duplex	Good neutral subsoil	Slopes 3- 5%	8
Brown loamy earth	Good neutral subsoil	Slopes 3- 5%	5
Semi wet soil	Loamy duplex	Slopes <3%	5
Brown deep loamy duplex	Good neutral subsoil	Slopes 3- 5%	5
Grey deep sandy duplex	Fair sand very deep	Slopes <3%	5
Brown sandy earth	Good neutral subsoil	Slopes 3- 5%	5
Brown deep sand	Fair sand very deep	Slopes 3- 5%	1
Yellow loamy earth	Good neutral subsoil	Slopes 3- 5%	1

Land capability assessment (Class %, code and description)

Land Use	pc1_2	pc3	pc4_5	Code	Cap Rating desc
Annual horticulture	70	20	10	A2	50-70% of the area is Class 1 or 2
Dry Cropping					
Grazing					
Perennial horticulture	80	20	0	A1	>70% of the area is Class 1 or 2
Vineyards	80	20	0	A1	>70% of the area is Class 1 or 2

Figure 8. This photograph shows the YG4 unit. The YG4 unit includes the valley floor and lower slopes of the concave valleys that occur higher in the landscape. The soils that occur on the narrow valley floor are predominantly alluvial loams and *Semi wet soil*s and they often remain moist into summer (indicated by the green grass in the photograph). The soils on the lower slopes are moderately drained to well drained duplex soils and gravels. At the site shown in the photograph the valley floor was too narrow (<30 m wide) so it was not mapped as the YG6 unit.

Figure 9. At the headwaters of the YG4 soil landscape unit the valley floors often become broader and the side slopes become flatter. In these areas sandy duplex soils are more common (see Figure 34) and alluvial loams are less common.

Yarragil 6 Soil- landscape unit (YG6)

Brief description: Valley floors with moderately well drained to well drained loams and areas of poorly drained mottled duplex soils. Woodland of *Corymbia calophylla with some Eucalyptus patens,* paperbark *(Melaleuca sp.) and E. rudis*.
Soil: Moderately well drained to well drained alluvial loams and imperfectly drained mottled duplex soils.
Landform: Narrow valley floors with slopes of less than 3 %. This unit is typically 30 to 100 metres wide, but it may become wider at the heads of the valleys.
Geology: Alluvium.
Vegetation: On the better drained valley floors *Corymbia calophylla* is the dominant species. On more poorly drained valley floors *Eucalyptus patens,* paperbark *(Melaleuca sp) and E. rudis* also occur.
Landform pattern: Hills
Relief/modal slope class(s): Undulating low hills and gently undulating plains
Morphological type(s): Open depression (vale)

In this study 24 soil profile sites were described within the YG6 unit. The percentage occurrence of Soil Groups listed in the table below was determined by using the site descriptions from this study and from observations of the soil surface and roadside cuttings.

WA Soil Groups by qualifier and landscape position - percent of Map Unit

WASG Name	Qualifier	Landscape	%
Friable red/brown loamy earth	Good neutral subsoil	Slopes <3%	40
Brown loamy earth	Good neutral subsoil	Slopes <3%	10
Semi wet soil	Loamy duplex	Slopes <3%	10
Brown deep loamy duplex	Good neutral subsoil	Slopes <3%	10
Yellow/brown shallow loamy duplex	Good neutral subsoil	Slopes <3%	10
Yellow brown deep sandy duplex	Good neutral subsoil	Slopes <3%	7
Grey deep sandy duplex	Fair sand very deep	Slopes <3%	5
Brown sandy earth	Good neutral subsoil	Slopes <3%	5
Yellow loamy earth	Good neutral subsoil	Slopes <3%	2
Brown deep sand	Fair sand very deep	Slopes <3%	1

The dominant soil found on this unit is the *Friable red/brown loamy earth* (see Figure 32). There are areas of *Brown loamy earth* (Figure 33) and *Semi wet soils.* At the heads of the valleys this unit often contains a higher percentage of *Grey deep sandy duplex* soils which are imperfectly drained (Figure 34).

Land capability assessment (Class %, code and description)

Land Use	pc1_2	pc3	pc4_5	Code	Cap Rating desc
Annual horticulture	75	20	10	A2	>70% of the area is Class 1 or 2
Dry Cropping					
Grazing					
Perennial horticulture	75	25	0	A1	>70% of the area is Class 1 or 2
Vineyards	75	25	0	A1	>70% of the area is Class 1 or 2

Figure 10. The YG6 valley floor unit often receives seepage water from upslope and is characterised by green pasture into summer.

Figure 11. The photograph shows the YG6 valley floor unit. The concrete structure is a manhole for the main sub surface drain that has been installed down the centre of this valley. Slotted drain coil runs perpendicular to this main drain to remove excess water from the YG6 unit. The soil at this site was a *Brown deep loamy duplex*. Apples and pears are more suited than stone fruit to these winter damp soils.

Yarragil 7 Soil-landscape unit (YG7)

Brief description: Gentle lower slopes with moderately well drained to well drained duplex soils, loamy and sandy earths and gravels. Woodland of *Corymbia calophylla* with some areas of *E. marginata*.
Soil: Duplex soils, loamy and sandy earths and gravels.
Landform: Well drained lower slopes (<10 %)
Geology: Soils derived from the dissected lateritic profile.
Vegetation: Woodland of *Corymbia calophylla* with some areas of *E.marginata*.
Landform pattern: Hills
Relief/modal slope class(s): Undulating low hills and gently undulating plains
Morphological type(s): Lower slope and open depression (vale)

The percentage occurrence of different Soil Groups outlined in the table below was determined by using the site descriptions from this study, site descriptions from King and Wells (1990) and from field observations of the soil surface and roadside cuttings.

WA Soil Groups by qualifier and landscape position - percent of Map Unit

WASG Name	Qualifier	Landscape	%
Yellow/brown shallow loamy duplex	Good neutral subsoil	Slopes 3- 5%	15
Yellow/brown shallow sandy duplex	Good neutral subsoil	Slopes 3- 5%	15
Yellow brown deep sandy duplex	Good neutral subsoil	Slopes 3- 5%	15
Duplex sandy gravel	Neutral subsoil	Slopes 3- 5%	15
Loamy gravel	Neutral subsoil	Slopes 3- 5%	15
Deep sandy gravel	Good sand deep rock substrate	Slopes 3- 5%	10
Friable red/brown loamy earth	Good neutral subsoil	Slopes <3%	5
Brown loamy earth	Good neutral subsoil	Slopes 3- 5%	5
Brown deep loamy duplex	Good neutral subsoil	Slopes 3- 5%	5

Land capability assessment (Class %, code and description)

Land Use	pc1_2	pc3	pc4_5	Code	Cap Rating desc
Annual horticulture	70	20	10	A2	50-70% of the area is Class 1 or 2
Dry Cropping					
Grazing					
Perennial horticulture	80	20	0	A1	>70% of the area is Class 1 or 2
Vineyards	80	20	0	A1	>70% of the area is Class 1 or 2

Figure 12. The YG7 unit includes the lower slopes, but not the valley floors of the concave valleys that occur higher in the landscape. The soils in this unit are predominantly loamy duplex soils and ironstone gravel soils

Murray 2 Soil-landscape unit (MY2)

Brief description: Gently to moderately inclined side slopes (3-25%) and narrow valley floors with few areas of rock outcrop. Variable moderately well to well drained duplex and ironstone gravel soils.
Soil: Variable duplex and gradational soils. Ironstone gravel soils occur higher in the landscape.
Landform: Gently to moderately inclined side slopes (3-25%) and narrow valley floors with few areas of rock outcrop.
Geology: Soils formed from the dissected lateritic profile are more common on the upper slopes and soils developed from igneous rock are more common lower in the landscape.
Vegetation: *Corymbia calophylla* is the dominant species. *Eucalyptus marginata* occurs on gravels.
Landform pattern: Hills
Relief/modal slope class(s): Undulating hills and rolling hills
Morphological type(s): Mid-slope and lower slope

In this study 20 soil profile sites were described within the MY2 unit. The percentage occurrence of different Soil Groups outlined in the table below was determined by using the site descriptions from this study, site descriptions from King and Wells (1990) and from field observations of the soil surface and roadside cuttings.

WA Soil Groups by qualifier and landscape position - percent of Map Unit

WASG Name	Qualifier	Landscape	%
Yellow brown deep sandy duplex	Good neutral subsoil	Slopes 5 – 10%	10
Yellow brown deep sandy duplex	Good neutral subsoil	Slopes 10 – 15%	15
Yellow brown deep sandy duplex	Good neutral subsoil	Slopes 15 – 30%	10
Brown deep loamy duplex	Good neutral subsoil	Slopes 10 – 15%	10
Brown deep loamy duplex	Good neutral subsoil	Slopes 15 – 30%	5
Yellow brown shallow sandy duplex	Good neutral subsoil	Slopes 10 – 15%	5
Yellow brown shallow sandy duplex	Good neutral subsoil	Slopes 15 – 30%	5
Shallow gravel	Sandy matrix	Slopes 15 – 30%	10
Loamy gravel	Neutral subsoil	Slopes 10 – 15%	4
Deep sandy gravel	Good sand deep rock substrate	Slopes 10 – 15%	4
Red deep loamy duplex	Good neutral subsoil	Slopes 10 – 15%	4
Grey deep sandy duplex	Good sand topsoil good neutral subsoil	Slopes 5 – 10%	4
Brown loamy earth	Good neutral subsoil	Slopes 10 – 15%	4
Brown deep sand	Fair sand rock substrate	Slopes 10 – 15%	4
Brown sandy earth	Rock substrate	Slopes 10 – 15%	3
Yellow brown shallow loamy duplex	Good neutral subsoil	Slopes 10 – 15%	3

Steeper areas of this unit are susceptible to water erosion when cultivated. Annual crops should not be grown on steep areas. The risk of water erosion is much less on orchards as the ground is only cultivated when the trees are planted, and pasture species grow in the mid row.

Land capability assessment (Class %, code and description)

Land Use	pc1_2	pc3	pc4_5	Code	Cap Rating desc
Annual horticulture	10	20	70	C1	50-70% of the area is Class 4 or 5
Dry Cropping					
Grazing					
Perennial horticulture	30	50	30	B1	>70% of the area is Class 1, 2 or 3
Vineyards	30	50	30	B1	>70% of the area is Class 1, 2 or 3

Figure 13. A photograph showing the MY2 soil landscape unit on the side slopes and the MY3 soil landscape unit on the lower slopes and valley floors.

Figure 14. A photograph showing MY2 soil landscape unit that occurs on the side slopes of the major valleys.

Murray 3 Soil-landscape unit (MY3)

Brief description: Valley floors, gently inclined lower slopes and small areas of moderately inclined side slopes. Very few areas of rock outcrop. Variable moderately well to well drained duplex and gradational soils.
Soil: Variable duplex and gradational soils.
Landform: Very gentle inclined (1- 3 %) valley floors, gently inclined (3 - 10 %) lower slopes with some areas of moderately inclined side slopes (10 - 32 %). Very few areas of rock outcrop.
Geology: Igneous rock.
Vegetation: On the lower slopes and better drained valley floors *Corymbia calophylla* is the dominant species with *Eucalyptus patens* in some areas.
Landform pattern: Hills
Relief/modal slope class(s): Undulating hills and rolling hills
Morphological type(s): Lower slope and valley floors

In this study 13 soil profile sites were described within the MY3 unit. The percentage occurrence of different Soil Groups outlined in the table below was determined by using the site descriptions from this study, site descriptions from King and Wells (1990) and from field observations of the soil surface and roadside cuttings.

WA Soil Groups by qualifier and landscape position - percent of Map Unit

WASG Name	Qualifier	Landscape	%
Friable red/brown loamy earth	Good neutral subsoil	Slopes <3%	15
Yellow/brown deep sandy duplex	Good neutral subsoil	Slopes 3-10%	15
Yellow/brown shallow loamy duplex	Good neutral subsoil	Slopes 3-10%	15
Yellow/brown shallow sandy duplex	Good neutral subsoil	Slopes 3-10%	10
Duplex sandy gravel	Neutral subsoil	Slopes 10-30%	10
Loamy gravel	Neutral subsoil	Slopes 10-30%	10
Deep sandy gravel	Good sand deep rock substrate	Slopes 10-30%	5
Red deep loamy duplex	Good neutral subsoil	Slopes 3-10%	5
Brown loamy earth	Good neutral subsoil	Slopes <3%	5
Semi wet soil	Loamy duplex	Slopes <3%	5
Brown deep loamy duplex	Good neutral subsoil	Slopes 3-10%	5

The valley floors contain *Friable red/brown loamy earths, Brown loamy earths* and *Semi wet soils*. The lower slopes contain Yellow/brown, brown and red duplex soils. They are some areas of ironstone gravel soils on the side slopes.

Land capability assessment (Class %, code and description)

Land Use	pc1_2	pc3	pc4_5	Code	Cap Rating desc
Annual horticulture	20	50	30	B1	>70% of the area is Class 1, 2 or 3
Dry Cropping					
Grazing					
Perennial horticulture	70	15	15	A1	>70% of the area is Class 1 or 2
Vineyards	70	15	15	A1	>70% of the area is Class 1 or 2

Figure 15. A photograph showing the lower slopes and valley floor of the MY3 soil landscape unit. These areas have a high capability for horticulture.

Figure 16. A photograph showing the valley floor of the MY3 soil landscape unit which contains the *Friable red/brown loamy earth* soil group.

Helena 1 Soil- landscape unit (HE1)

Brief description: Moderate to steep side slopes (10-35%) and narrow drainage floors with areas of rock outcrop. Variable mostly well drained duplex and gradational soils. *Corymbia calophylla* woodland, *E.marginata* on gravels, Acacia and Casuarina on rocky soils
Soil: Variable duplex and gradational soils.
Landform: Moderate to steep side slopes (10-35%) and very narrow drainage floors with areas of rock outcrop.
Geology: Igneous rock
Vegetation: *Corymbia calophylla,* and *E.marginata* on the ironstone gravel soils. Acacia and Casuarina spp. on shallow rocky soils.
Landform pattern: Hills
Relief/modal slope class(s): Rolling plains
Morphological type(s): Upper slope and mid-slope

In this study nine soil profile sites were described within the HE1 unit.

WA Soil Groups by qualifier and landscape position - percent of Map Unit

WASG Name	Qualifier	Landscape	%
Bare rock	differentiation not required	slopes 15-30%	10
Stony soil	sandy matrix	slopes 15-30%	10
Yellow/brown deep sandy duplex	good neutral subsoil	slopes 15-30%	10
Yellow/brown shallow sandy duplex	good neutral subsoil	slopes 15-30%	10
Yellow/brown deep loamy duplex	good neutral subsoil	slopes 15-30%	10
Yellow/brown shallow loamy duplex	good neutral subsoil	slopes 15-30%	10
Red deep loamy duplex	good acid subsoil	slopes 15-30%	10
Red shallow loamy duplex	good acid subsoil	slopes 15-30%	10
Shallow gravel	loamy matrix	slopes 15-30%	10
Loamy gravel	acid subsoil	slopes 15-30%	10

Land capability assessment (Class %, code and description)

Land Use	pc1_2	pc3	pc4_5	Code	Cap Rating desc
Annual horticulture	0	15	85	C2	>70% of the area is Class 4 or 5
Dry Cropping					
Grazing					
Perennial horticulture	0	25	75	C2	>70% of the area is Class 4 or 5
Vineyards	0	25	75	C2	>70% of the area is Class 4 or 5

Figure 17. The HE1 soil landscape unit. Much of this steep and rocky unit is under native vegetation.

Figure 18. Steep rocky soils on the HE1 unit

Helena 2 Soil-landscape unit (HE2)

Brief description: Gentle to moderately inclined side slopes and lower slopes (3-25%) with areas of rock outcrop. Variable mostly well drained duplex and gradational soils. *Corymbia calophylla, E.marginata* on gravels, Acacia and Casuarina on rocky areas.
Soil: Variable duplex and gradational soils.
Landform: Moderately well to well drained gentle to moderately inclined side slopes and lower slopes (3-25%) with few areas of rock outcrop.
Geology: Igneous rock
Vegetation: *Corymbia calophylla,* and *E.marginata* on the ironstone gravel soils. Acacia and *Casuarina spp*. on shallow rocky soils
Landform pattern: Hills
Relief/modal slope class(s): Rolling plains
Morphological type(s): Mid slope and lower slopes with a narrow valley floor.

In this study eight soil profile sites were described within the HE2 unit.

WA Soil Groups by qualifier and landscape position - percent of Map Unit

WASG Name	Qualifier	Landscape	%
Yellow/brown deep sandy duplex	good acid subsoil	slopes 10-15%	20
Yellow/brown shallow sandy duplex	good neutral subsoil	slopes 10-15%	20
Yellow/brown shallow loamy duplex	good neutral subsoil	slopes 10-15%	20
Red shallow loamy duplex	good neutral subsoil	slopes 10-15%	15
Yellow/brown deep loamy duplex	good neutral subsoil	slopes 10-15%	10
Stony soil	sandy matrix	slopes 10-15%	5
Red deep loamy duplex	good acid subsoil	slopes 10-15%	5
Bare rock	differentiation not required	slopes 10-15%	2
Friable red/brown loamy earth	good neutral subsoil	slopes 5-10%	2
Grey shallow sandy duplex	good neutral subsoil	slopes 10-15%	1

Land capability assessment (Class %, code and description)

Land Use	pc1_2	pc3	pc4_5	Code	Cap Rating desc
Annual horticulture	0	30	70	C1	>70% of the area is Class 4 or 5
Perennial horticulture	30	40	30	B2	50-70% of the area is Class 1, 2 or 3
Vineyards	30	40	30	B2	50-70% of the area is Class 1, 2 or 3

Figure 19. A photograph of the HE2 unit in the lower Piesse Brook area showing the narrow valley floor and moderately inclined side slopes.

Figure 20. There are areas of rock outcrop in the Helena soil landscape units.

The area of land that is suitable for perennial horticulture within the study area

Table 1 shows the area of the soil landscape units in the study area that are typically used for perennial horticulture. The area of land that has a very high (Class 1) or high (Class 2) capability for perennial horticulture is estimated to be 3000 hectares. In addition, there are areas of the DW2 unit which have been cleared that are suitable for horticulture. The area of suitable land in the study area is much greater than the estimated 644 ha that is currently under orchard.

Table 1. Area of soil landscape units and the estimated area of land that has a very high (Class 1) or high (Class 2) capability for perennial horticulture within the study area

Map unit	Area of the soil landscape unit in the study area (Hectares)	Percentage of high or very high capability land for perennial horticulture in the map unit	Estimated area of high or very high capability land for perennial horticulture in the map unit (Hectares)
YG1	2206	90%	1985
YG4	261	80%	209
YG6	203	75%	152
YG7	279	80%	223
MY2	575	75%	431
Total	**3524**		**3000**

Soil descriptions

Two hundred soil profile sites were described within the study area, with each site being classified according to the WA Soil Groups methodology (Schoknecht and Pathan, 2013). The soil descriptions and GPS coordinates of the sites can be found in the DPIRD soils database.

The following soil supergroups are the most common in the study area:

- Ironstone gravelly soils
- Rocky or stony soils
- Sandy and loamy duplexes
- Loamy earths

The *Semi wet soil* group may have been more common on the valley floors than is indicated in the soil landscape unit descriptions. Perched water tables were not encountered in summer and early autumn when the survey was conducted. It was difficult to determine whether some soil profiles were waterlogged at a depth of 30 to 80 cm for a major part of the year.

The following pages show photographs of the most common soil groups in the study area.

Ironstone gravelly soils

Figure 21. *Deep sandy gravel* (left). This soil group is commonly found on the plateau surface (DW2 unit) and on the upper and mid slopes of the YG1 unit. The soil has a fair to high capability for perennial horticulture. Irrigation water is less available higher in the landscape where these soils are most commonly found.

Figure 22. *Loamy gravel* (right). This soil group is commonly found on the mid and lower slopes of the Yarragil and Murray units. These soils have a high to very high capability for perennial horticulture.

Figure 23. *Duplex sandy gravel* (left). At this site a gravelly clay loam layer was encountered at a depth of 80 cm. The soil profile in this photograph is more typical of this soil group when it is found on the YG1 unit. This soil group has a high to very high capability for perennial horticulture.

Figures 24. *Duplex sandy gravel* (right). At this site a clay layer was encountered at 70 cm and a gritty white clay occurred below 90 cm. The soil profile is this photograph is more typical of this soil group when it is found on the MY3 unit. Dissection of the landscape is greater in the MY3 unit than the YG1 unit and the sub soil clay layer may overlay decomposing bedrock.

Figure 25. *Shallow gravel*. This soil group is common on the DW2 and YG1 units. In locations were the lateritic duricrust is shallow it limits the rooting depth and hence the amount of water available to plants. In addition, some of these soils contain large amounts of lateritic rock within topsoil which prevents cultivation. Shallow versions of this soil group have a low or very low capability for perennial horticulture. Deeper versions of this soil group which contain no rock within the topsoil have a fair to high capability for perennial horticulture.

Figure 26. Outcrop of ironstone caprock (duricrust). Small areas of these shallow soils occur on the DW2 unit.

Rocky or stony soils

Figure 27. Bare rock. Areas of bare rock are common in the HE1 soil landscape unit

Figure 28. *Stoney soils*. This soil group is found on the HE1, HE2 and MY2 units. These soils have a low capability for perennial horticulture.

Duplex soils

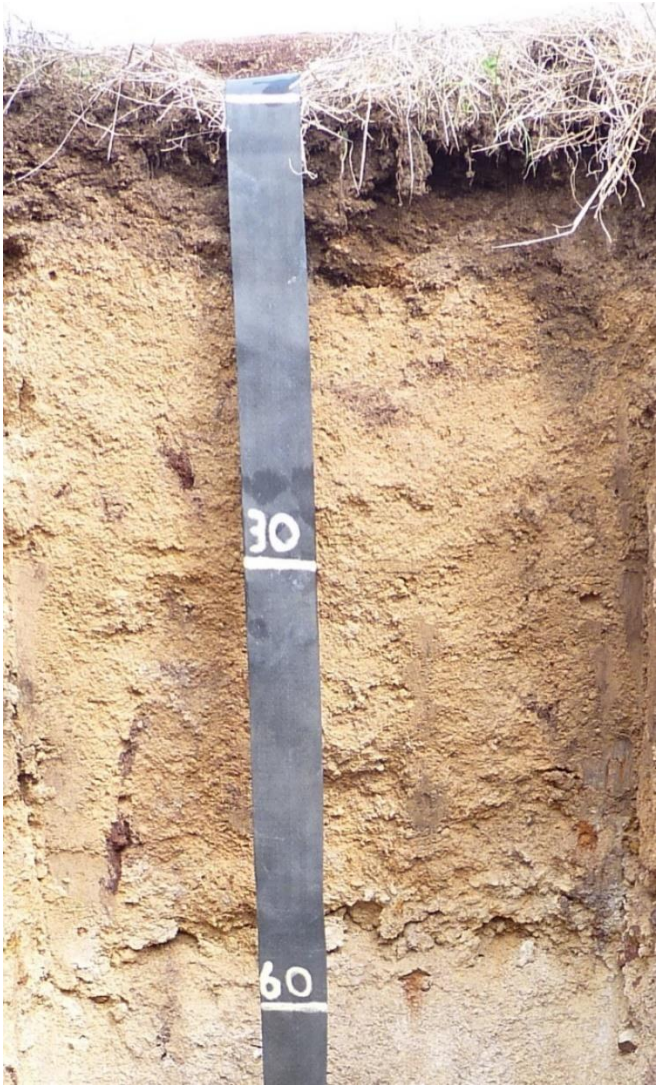

Figure 29. *Yellow/brown shallow loamy duplex* (left). This soil group is commonly found on the Murray and Helena units. The soil has a high capability for perennial horticulture provided the land is not too steep. Some areas of this soil on the lower slopes are prone to waterlogging.

Figure 30. *Yellow/brown deep sandy duplex* (right). This soil group is found on the Yarragil, Murray and Helena units. The soil has a high capability for perennial horticulture provided the land is not too steep.

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Figure 31. *Red deep loamy duplex*. This soil group occurs on the Helena and Murray units. It has a high capability for perennial horticulture provided the land is not too steep and rocky.

Loamy earths and valley floor soils

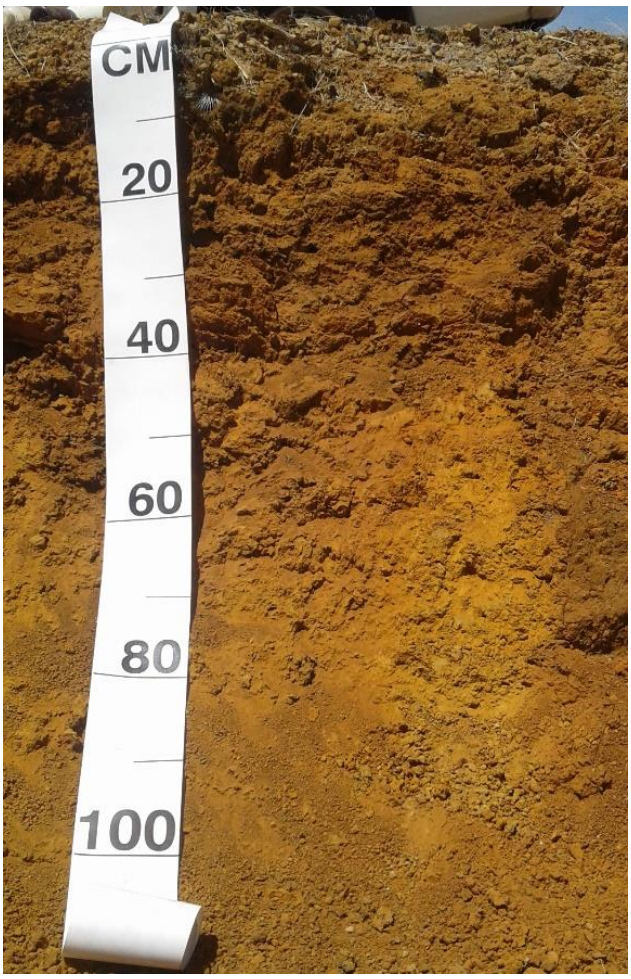

Figure 32. *Friable red/brown loamy earth*. These well drained, loamy alluvial soils are common on the YG4, YG6 and MY3 units. They have a very high capability for perennial and annual horticulture.

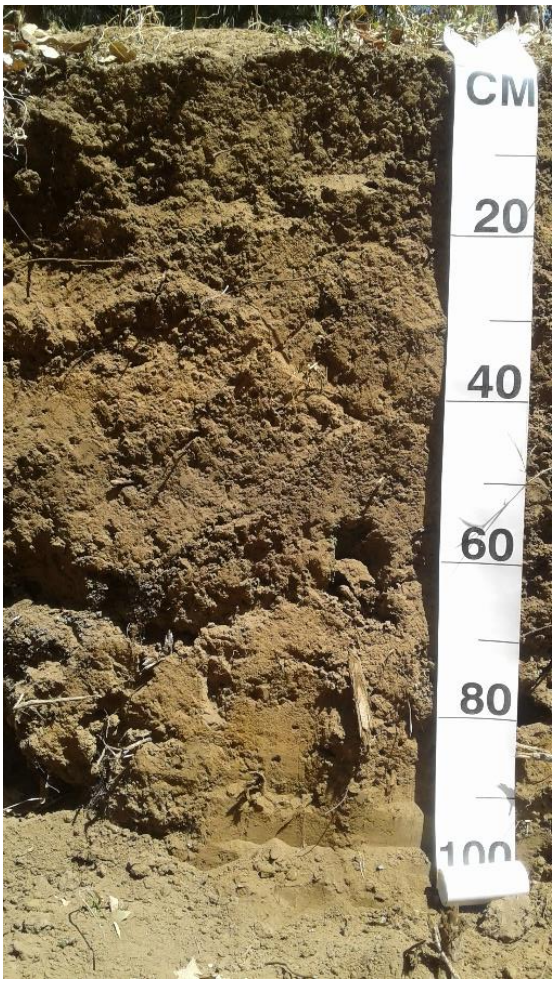

Figure 33. *Brown loamy earth* (left). These deep loamy alluvial soils are less well drained than the *Friable red/brown loamy earth*s. They are found on the YG4, YG6 and MY3 units.

Figure 34. The *Grey deep sandy duplex* soil group (right) is commonly found in the depressions at the heads of the valleys (YG6 and YG4 units). A yellow mottled clay layer can be seen in the photograph at about 60 cm. The rock at the bottom of the photograph is a moderately cemented iron- organic pan which is locally referred to as 'coffee rock'. These soils are imperfectly drained and have only a fair capability for perennial horticulture.

Land use mapping

The land use maps that were produced by identifying horticultural areas on past aerial photographs (years of 1981 and 2019) are available from Greg Doncon at DPIRD.

The number of hectares of horticulture in the study area was calculated for 1981 and 2019. Over the 39 year period there was a significant reduction in the area of orchard. Table 2 shows that the total area of horticulture has decreased from 1148 ha in 1981 to 644 ha in 2019. In 1981, the major fruit crops grown in the Perth Hills were apples, pears and stone fruit (particularly plums) with smaller areas of citrus. Since 1981 there has been an increase in the area planted to avocado's and wine grapes. The small areas used for vegetable production have not been included in the table.

Table 2. The estimated area of horticulture in the study area in 1981 and 2019.

Crop type	**Approximate area in 1981 (Hectares)**	**Approximate area in 2019 (Hectares)**
Stone fruit and pome fruit	1145*	524
Citrus		31
Avocados		47
Wine grapes		32
Nurseries	2	5
Flowers and bulbs	1	5
Total	**1148**	**644**

*Includes citrus

The aerial photographs used for the land use mapping show that many areas that were under orchards in 1981 are now supporting non irrigated pasture. The ground truthing of the 2019 mapping showed that there are many abandoned orchards within the study area.

Figure 35. Abandoned citrus trees within the study area.

Horticulturalists in the study area indicated to WHC that the poor return on investment from fruit production is the main reason for the decline in horticulture. Prospective larger scale horticultural developers would be unlikely to choose the Perth Hills as a location for a new property. The reasons for not choosing this area include:

- The cost of land is high compared to other horticultural areas
- The block size is too small to be profitable for many types of horticulture
- Water resources are limited on many properties

Exceptions include businesses which may derive income from value adding or on-farm sales, and for a business that is intending to conduct high value types of horticulture such as protected cropping (greenhouses, shade houses etc).

In recent years people have been buying properties within the study area for rural lifestyle purposes. Some of these blocks were previously used for horticulture.

Water resources

The Perth Hills is not a proclaimed groundwater supply area and irrigators do not require a licence from the Department of Water and Environmental Regulation to take ground water.

Limited volumes of irrigation water are available in the Perth Hills. Irrigation water is obtained from shallow bores (generally 20 to 30 m deep, though they can be as deep as 100 m), seepages and farm dams. The shallow rock aquifers are low yielding, with a bore flow rate of 2 litres/second being considered good.

Bores that are located lower in the landscape are generally higher yielding. However, bores that are installed higher in the landscape (DW2 and upper parts of YG1 soil landscape units) can, in some cases, supply sufficient quantities for irrigation purposes.

Additional irrigation water can be obtained on many properties, however a costly drilling program may be required as many bore holes may not deliver a sufficiently high flow rate to warrant equipping the bore.

Significantly greater volumes of irrigation water are available in other fruit growing areas such as Gingin and Donnybrook.

It is difficult to obtain information on the amount of groundwater that is available in the Perth Hills. On many properties the extent of the water resources has not been fully explored. Some irrigators are not willing to make public how much water they are abstracting.

Properties with orchards generally have sufficient water to irrigate at least the area of crop that has been planted. An estimate of the water that is currently being used can be made by knowing the area of each orchard type (from land use mapping) and multiplying this area by the approximate water requirements (megalitres per hectare) of the crop type.

A mature stone fruit orchard in the Perth Hills typically requires about 7 to 9 ML/ha/year, while apples and citrus require about 10 to 12 ML/ha/year. A mature avocado orchard in the Perth Hills typically requires at least 15 ML/ha/year. Wine grapes in the Perth Hills typically require about 3 to 4 ML/ha/year. The amount of water required for each crop type will vary depending on the planting density, tree size, the moisture holding capacity of the soil and whether the site receives seepage water.

Table 3 shows the approximate area of each type of perennial horticulture in the study area, an estimate of the water requirement of each crop (ML/ha/year) and an estimate of the total amount of water currently used on each crop. It is estimated that about 6500 ML/year is currently being used for irrigation within the study area.

Table 3. The area of irrigated crops in the study area, estimated irrigation requirement of each crop type and the approximate volume of water being applied to these crops.

Crop type	**Estimated area (Hectares)**	**Estimated irrigation requirement (ML/ha/year)**	**Approximate current water use (ML/year)**
Stone fruit and pome fruit	524	10	5240
Citrus	31	11	341
Avocados	47	15	705
Wine grapes	32	4	128
Flowers, nurseries and greenhouses	10	10	100
Total	644		**6514**

There is considerably more water available in the study area than what is currently being used. An irrigation consultant in the Perth Hills, who has a good knowledge of the water supplies in the area, conducted a private study of water resources in the area and estimated that the water resource could potentially irrigate at least double the current area of crop.

Water use in the past, when there was a larger area of orchard in the Perth Hills, gives some indication of the water that is potentially currently available. The land use mapping shows that in 1981 the estimated area of orchard was 1148 hectares (Table 2). In 1981, the majority of the orchards in the study area contained pome fruit (apples and pears) and stone fruit. If it is assumed that 10 ML/ha of irrigation water is required for pome and stone fruit, then it can be calculated that 11480 ML of water was used for irrigation in 1981. This is about 75% more than is currently used.

The rainfall in the south west of Western Australia has decreased since the 1970s. Figure 36 shows the variation from the mean annual average rainfall for the south west of Western Australia from 1910 to 2013. The average annual rainfall has decreased by over 100 mm during this time frame (the sloping line in Figure 36 is the moving average over this period).

This decrease in rainfall would have resulted in a reduction in the amount of water recharging the shallow aquifers.

This decrease in ground water has caused a reduction in the irrigation water available for some orchardists, but reduced farm profitability and competition for land from people wanting rural lifestyle blocks are the main reasons for the decline in the area of orchard within the study area.

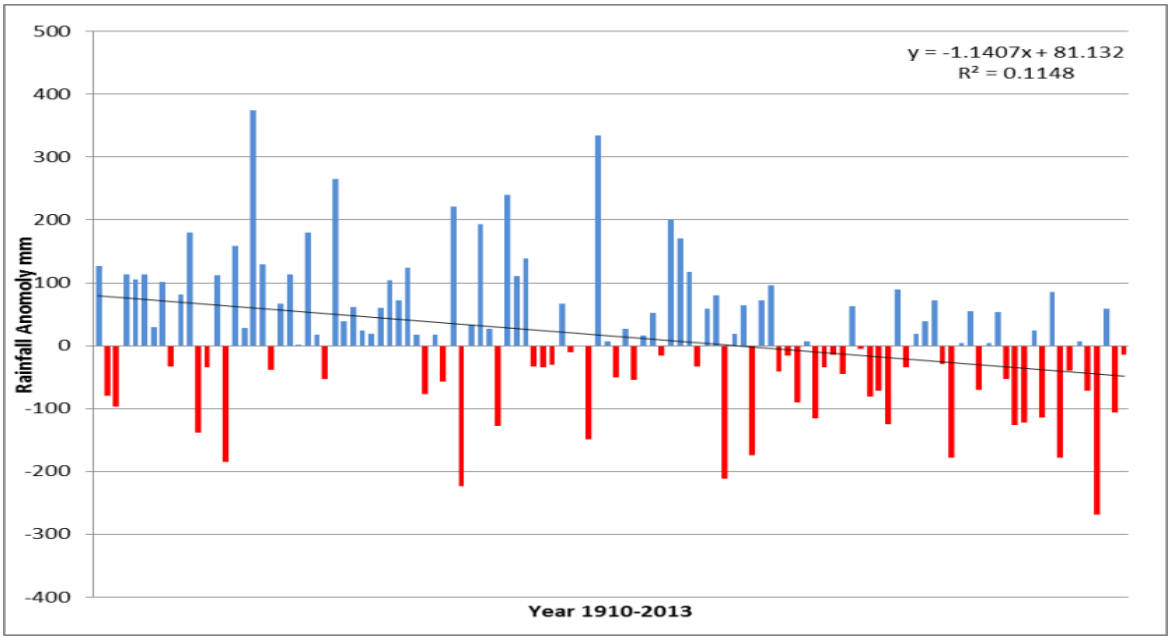

Figure 36. Variation from the mean annual average rainfall in the south west Australia 1910-2013 (BOM 2014)

Figure 37. A dam in the YG6 unit that is used for irrigation. Shallow bores are used to fill the dam and water is then pumped from the dam to the orchard to irrigate the trees.

Figure 38. The area of orchard in the Perth Hills has been decreasing for many years as growers leave the industry due to marginal profitability. This indicates that there is water available that is not currently being accessed. However, the drying climate has impacted on the amount of recharge and the volume of groundwater that is available.

Stocking rates for rural small holdings

This section was written by Heather Percy from DPIRD.

An increasing number of small properties in the study area are used for horses and other grazing animals. DPIRD's stocking rate guidelines for rural small holdings (van Gool, Angell and Stephens 2000) provides a method and information for determining the stocking rate most suited to particular soil landscape units.

Stocking rates refer to the number of stock that can be consistently kept on a piece of pasture year round, with minor additional feed provided, and without causing environmental degradation. Environmental degradation may include wind and water erosion, tree decline, increasing nutrients in groundwater and waterways, spread of weeds into adjoining bushland and soil compaction.

Dry Sheep Equivalent (DSE) is a standard measure of stocking rates. DSE is the number of non-breeding adult sheep, weighing 50kg, which can be grazed sustainably on a hectare of pasture throughout the year. On small rural holdings, the base stocking rate is the number of DSE that would apply with the lowest level of pasture management in an average year in order to:

- provide enough feed to maintain animals is good condition,
- avoid soil erosion by providing sufficient ground cover to protect the soil during the year

A light horse or a dry cow is equivalent to 10DSE. Table 4 lists the current published stocking rates for the map unit in the study area and updated values based on the results of this study. These can be used by the Cities of Kalamunda and Armadale when approving rural pursuits involving livestock.

Table 4. Base stocking rates for rural small holdings in the study area

Map unit code	**Map unit name**	**Base stocking rate (DSE/ha)** (van Gool et al 2000)	**Base stocking rate (DSE/ha) based on updated mapping**	**Minimum pasture area per horse**	**Minimum pasture area per horse**
				hectares	square metres
DW2	Dwellingup 2	6	6	1.7	17,000
HE1	Helena 1	Nil- Water erosion risk	4	2.5	25,000
HE2	Helena 2	10	8	1.25	12,500
MY2	Murray 2	6	7	1.4	14,000
MY3	Murray 3	10	8	1.25	12,500
YG1	Yarragil 1	10	10	1.0	10,000
YG4	Yarragil 4	6	9	1.1	11,110
YG6	Yarragil 6	NA	9	1.1	11,110
YG7	Yarragil 7	NA	9	1.1	11,110

Fruit production in the Perth Hills and soil considerations

Fruit trees have been successfully grown in the valleys in the Perth Hills for over 100 years, so it is not surprising that most of the soils are well suited to fruit production. The well drained loams on the valley floors, the duplex soils on the lower slopes and the gravelly soils on the mid to upper slopes are all good horticultural soils.

Fruit production in the Perth Hills is focused on the production of stone fruit (peaches, nectarines, plums and apricots) and pome fruit (apples and pears). These crops have a chilling requirement that generally cannot be met by the climate on the Swan Coastal Plain. Bickley, which is located in the Perth Hills, has on average about 1000 chill units per year, while Perth has an average of less than 250 chill units.

Smaller areas of avocados, citrus and wine grapes are also grown in the Perth Hills. There are nurseries in the Perth Hills that produce ornamental plants and there are very small areas of vegetable production.

Many orchardists in the Perth Hills grow a mixture of fruit crops. The diversity of crops reduces growing and marketing risks. It also spreads the harvest season over a longer period of time which allows family managed operations to harvest a larger area of crop.

When fruit production first commenced in the Perth Hills the orchards were not irrigated. The orchards were located on the loamy alluvial soils that received some seepage into the summer months. Yield and fruit size were compromised in many years due to moisture stress. The orchard soils were cultivated to control weeds so as to increase the amount of stored soil water to the trees. The introduction of irrigation increased yields and allowed planting to extend further up the valley side slopes.

The upper slopes and the gravelly plateau are generally not planted to orchard because:

- These areas contain a higher percentage of less suitable soils
- The greater distance from the water supplies, that are generally located on the valley floors, results in increased irrigation infrastructure and pumping costs
- Some of these areas contain steep slopes and rocky areas which makes vehicle access and farm activities more difficult
- The water erosion risk on the steep slopes is high

On the upper slopes (YG1 soil landscape unit) and plateau surface (DW2 soil landscape unit) there are areas of *Shallow gravel* soils. Where an extensive lateritic duricrust occurs within 50 cm of the soil surface these soils are not suitable for fruit production as the duricrust limits the rooting depth and water holding capacity of the soil. In versions of the *Shallow gravel* where the duricrust is deeper these soils can be used for fruit production. To develop this land orchardists can use machinery to remove any lateritic rocks and boulders. The resulting soil is similar to the *Deep sandy gravel*. The rocks can be sold to landscape companies to help cover costs.

The valley floor soils in the Perth Hills contain large areas of well drained alluvial loams (see Figure 32). These well drained loams, which are very good horticultural soils are currently not adequately identified in the NRInfo descriptions.

There are some poorly drained duplex soils on the valley floors that have a lower capability for fruit production, however lower rainfall in recent years has reduced the extent of waterlogging. Deep drainage has been installed on many orchards in the Perth Hills to remove excessive water from poorly drained soils (Figures 11 and 39). Major drains carry this water down the valleys and into the tributaries of Piesse Brook and other water courses. On some properties, surface drains have been installed to remove surface water and to direct runoff into dams (Figure 16).

Excessive vegetative growth of fruit trees can be an issue on some of the soils that occur on the valley floors. This is particularly so in seasons when rainfall occurs in the drier months. This results in unwanted shoot growth which increases pruning costs, and results in large trees which increase harvesting costs. Soils that are less fertile and which contain a higher percentage of gravel, which reduces the water stored in the soil profile, can for some fruit trees and for wine grapes result in a more balanced plant. The grower can implement a regulated deficit irrigation program that allows the same level of fruitfulness with less vegetative growth.

The risk of water erosion is considerably less on orchards and vineyards than on vegetable properties as annual cultivation is not required. On orchards, herbicides are used to keep a narrow strip under the trees free of weeds with the rest of the orchard floor being maintained as mowed pasture species. On steeper slopes it is important that ground cover is maintained when replanting of orchard trees occurs.

Apples and pears

The Perth Hills is an important area for the production of early to mid-season apples and pears. The main harvest season is from mid-February until May.

Apples and pears are generally planted on the valley floors and lower slopes. Waterlogged soils reduce oxygen supply to the roots of fruit trees and result in poor growth. Deciduous fruit trees, such as apples and pears, are marginally more tolerant of perched water tables that occur in the winter months than evergreen fruit species.

Stone fruit

The Perth Hills is an important area for the production of early to mid-season stone fruit. Stone fruit in the Perth Hills is harvested from November until March.

Peaches and nectarines are the most commonly planted types of stone fruit. The area of plums has decreased as a result of a decrease in the export market. There is a small area of apricots.

Stone fruit are planted on better drained areas of the valley floor and on the side slopes.

Citrus

The citrus industry in Western Australia is predominantly located in the Gingin to Moora district in the north and at Harvey in the south. There are only small areas of citrus planted in the Perth Hills. There is not the volume of water or areas of land in the Perth Hills to support large scale citrus production. Citrus is less tolerant of waterlogging than deciduous fruit trees with most of the plantings in the Perth Hills occurring on the mid and upper slopes.

Wine grapes

There are some small, wine grape properties in the Perth Hills, some of which have associated wineries, cellar door sales and restaurants.

The preferred soils for wine grapes are the gravels that occur on the mid and upper slopes (*Duplex sandy gravel*, *Deep sandy gravel*, deeper versions of the *Shallow gravel* and *Loamy gravel*s). The high gravel percentage limits the soils water holding capacity which allows the vineyard manager to manipulate the soil moisture, by regulated deficit irrigation, to control vine vigour. This produces better fruit quality than from vines that are grown on deep loamy soils.

Avocado

There are some avocado properties in the Perth Hills. Limited water availability in the Perth Hills prevents the development of significant sized avocado orchards.

Avocados are susceptible to frost damage and dieback (*Phytophthora cinnamomi*). Consequently, avocado plantings are best located on the mid and upper slopes where the risk of frost is lower and the soils are well drained. *Phytophthora cinnamomi* is a soil borne pathogen and dieback is more common in poorly drained soils. Avocado trees are generally planted on mounds to improve drainage and aeration in the root zone.

The hot temperatures that are experienced in the Perth Hills in the summer months result in fruit drop of avocados. This can be alleviated by pulsing irrigation with under tree sprinklers.

Vegetables

Small areas of vegetables are grown in the Perth Hills on the valley floors and lower slopes. Most vegetable production in the Perth Region occurs on the Swan Coastal Plain where large volumes of groundwater are available for irrigation.

The soil requirements for vegetable production and orchards are similar. The main exception is that steep land is not suitable for vegetable production because of the risk of water erosion. With vegetable crops the land needs to be cultivated prior to planting each crop. Cultivated soil is at much greater risk of water erosion than in an orchard where trees, and ground cover of pasture species, protect the soil surface.

Figure 39. Apple trees growing on an alluvial loam on the YG6 unit. These soils can receive seepage from upslope. The photograph on the left shows tall vigorous trees and the manhole to the deep drainage that runs the length of the valley.

Figure 40. Peaches being grown on the mid slopes (YG1 unit) on a *Duplex sandy gravel*.

Figure 41. Nectarines being grown on the YG1 unit. Note the area of laterite outcrop in the foreground. The presence of limited areas of laterite outcrop do not greatly impact on fruit tree growth.

Figure 42. Avocado orchards are suited to the better drained soils on the mid and upper slopes where the risk of frost is less (YG1 unit and DW2 unit)

Figure 43. An area of land being prepared for vegetable production on the lower slopes of the MY3 unit.

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Appendix 1. Land capability classes used by DPIRD

DPIRD uses a five class system to define land capability as outlined in Table A1.

Table A1. Land capability class for a given land use type (Van Gool *et al*, 2005**)**

Capability class	General description
1 Very high	Very few physical limitations present and easily overcome. Risk of land degradation is negligible.
2 High	Minor physical limitations affecting either productive land use and/or risk of degradation. Limitations overcome by careful planning.
3 Fair	Moderate physical limitations significantly affecting productive land use and/or risk of degradation. Careful planning and conservation measures required.
4 Low	High degree of physical limitation not easily overcome by standard development techniques and/or resulting in high risk of degradation. Extensive conservation measures and careful ongoing management required.
5 Very low	Severe limitations. Use is usually prohibitive in terms of development costs or the associated risk of degradation.

Land capability mapping

The soil landscape units are comprised of a range of soil groups. These soil groups have different capabilities for each land use. To account for this variation in capability within a map unit, DPIRD uses a proportional approach to display land capability ratings as capability categories on maps. The approach is outlined in the map legend below (van Gool *et al*, 2005).