

# Soil survey of the Pickering Brook Planning Investigation Area

## Phase 1

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## Summary

The vast majority of the Pickering Brook Planning Investigation Area (PIA) has a high or very high capability for perennial horticulture (orchards). Fruit trees have been successfully grown in this area for many years, so it is not surprising that most of the soils are well suited to fruit production.

Forty nine soil profile sites were excavated and described across the PIA. Five units were mapped within the PIA. The range of soils in each map unit was described. The capability of the five map units was rated for perennial horticulture.

- The loamy soils on the mid and lower slopes (Map Unit 1) have a very high capability for perennial horticulture.
- The deep sandy gravels on the upper slopes and plateau surface (Map Unit 2) have a high capability for perennial horticulture.
- The soils on the valley floor (Map Unit 3) are sufficiently well drained to not present waterlogging issues for deciduous fruit trees. In fact, these soils are some of the most productive in the PIA.
- An area at head of the valley (Map Unit 4) contains soils that were historically poorly drained. Subsurface drainage has been installed to help overcome drainage issues. These soils have a moderate capability for perennial horticultural crops.
- Map Unit 5 contains a complex of lateritic outcrop ('cap rock'), shallow gravelly soils over ironstone boulders and deep sandy gravels. These areas generally have a low capability for perennial horticulture.

It was not possible to obtain accurate information on amount of water that is available on each property. Some landowners were not willing to share this information, others did not know the sustainable yield of their bores, and others had not explored all water supply options on their properties.

If the area of orchard on each property is known, then this can be multiplied by an estimate of the water requirement of each crop to calculate an estimate of the water that is currently being used on each property. Higher yielding bores are more commonly found lower in the landscape.

Water availability, and not soil type, is the major physical limitation to the expansion of horticulture in the PIA.

## Introduction

Western Horticultural Consulting was contracted by the Department of Primary Industries and Regional Development (DPIRD) to provide a rural property level soil, land and water assessment in the Perth Hills. Phase 1 of the work involved undertaking a property scale survey across 90 hectares in the Pickering Brook Planning Investigation Area (PIA). The PIA is immediately west of the Pickering Brook townsite. Figure 1 shows the location of the PIA.

The information from this study is required to assist DPIRD identify high quality agricultural land for the Pickering Brook and Surrounds Sustainability and Tourism Strategy and to make recommendations about Priority Agricultural Land to the cities of Kalamunda and Armadale.

## Background

The soils and land capability in the PIA were mapped by the Department of Agriculture as part of the Darling Range rural land capability study (King and Wells 1990). This assessment was done to assist local government plan for rural-residential and agricultural land uses. The mapping was conducted at a scale of 1:50 000 which is considered suitable for strategic land use planning. The King and Wells maps were incorporated into DPIRD's digital soil and land capability mapping. In 2016 and 2017, DPIRD updated the previous mapping and land capability assessments.

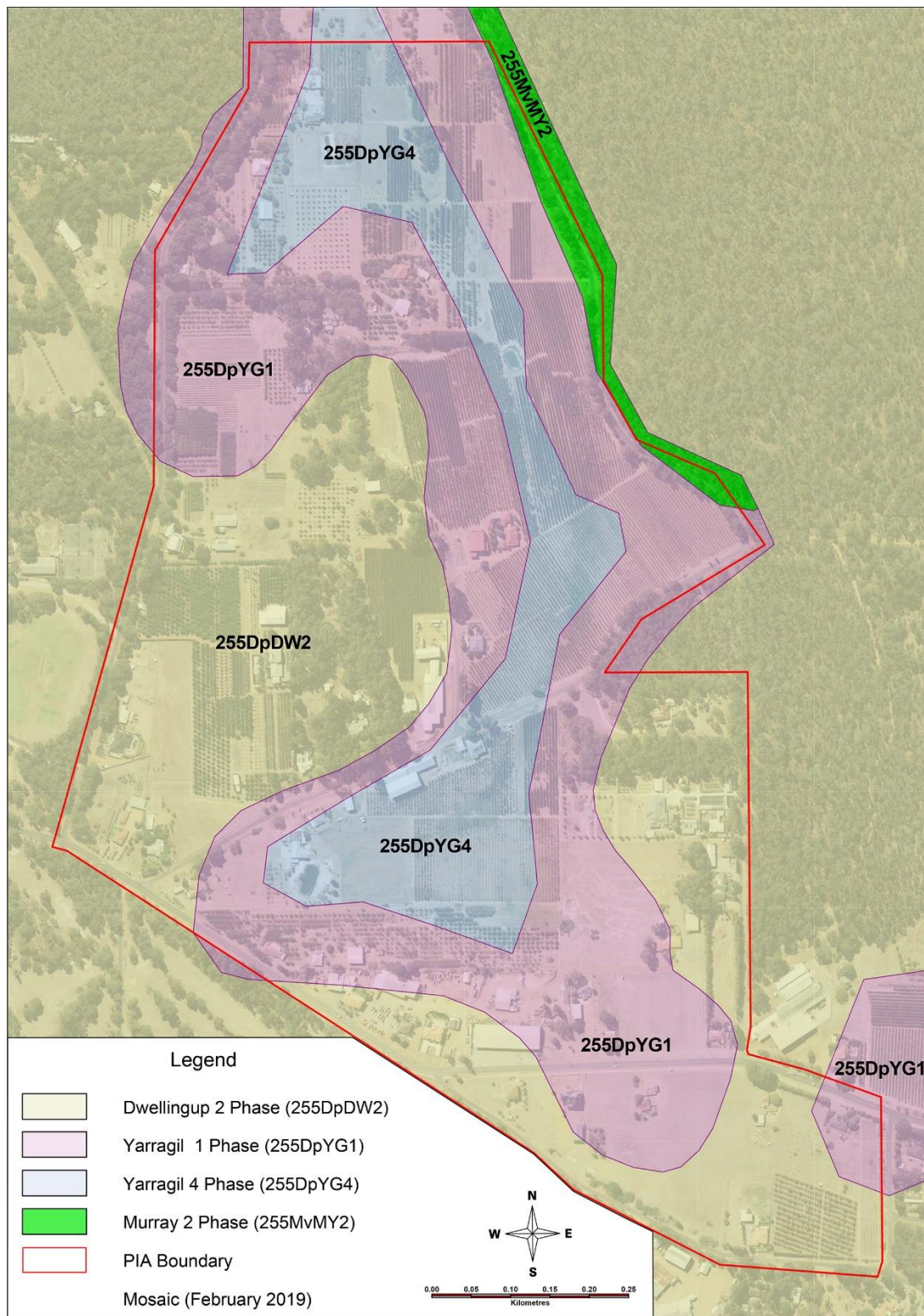
The DPIRD mapping identifies four soil-landscape units that occur within the Pickering Brook PIA (see Figure 1). Table 1 describes each of these soil-landscape units and gives information on their land capability.

**Table 1: DPIRD's Soil-landscape map units within the PIA**

Map unit	Description	Land capability
Dwellingup 2 (25DpDW2)	Very gently to gently undulating terrain (<10%) with well drained, shallow to moderately deep gravelly brownish sands, pale brown sands and earthy sands overlying lateritic duricrust.	50-70% of the land has high to very high capability for perennial horticulture.
Murray 2 (255MvMY2)	Gentle 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 gradational soils.	>70% of the land has moderate to very high capability for perennial horticulture.
Yarragil 1 (255DpYG1)	Very gentle to moderately inclined concave side slopes. Moderately well drained yellow duplex soils and yellow and brown massive earths and gravels.	>70% of the land has high to very high capability for perennial horticulture
Yarragil 4 (255DpYG4)	Valley floors with some poorly drained mottled yellow duplex soils and gentle lower slopes with moderately well to well drained loamy and sandy earths, gravels and duplex soils.	50-70% of the land has high to very high capability for perennial horticulture.



**Figure 1: DPIRD's soil-landscape map units within the Pickering Brook Planning Investigation Area**



## Method

The landowners in the PIA were contacted by telephone or by farm visit and asked whether they would participate in the study. Six of the properties in the PIA are small (< 1 ha) and do not contain farmland. The owners of these properties were not contacted. It was not possible to get approval to go onto each property in the PIA. Some landowners did not want to be involved and others did not respond to phone calls.

Forty nine soil profiles were described within the PIA. The locations of these sites were selected to cover the range of land units and soil types that were present. The auger holes were dug to a depth of one metre or to where clay was encountered, or to where gravels prevented further digging. In some cases, soil descriptions were made using road site cuttings.

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)
- 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. The soils were classified using 'Soil Groups of Western Australia' (Schoknecht and Pathan, 2013) methodology.

It was planned to excavate five soil pits in the five major soil groups found in the PIA and take soil samples for laboratory analysis. However, at this stage COVID19 prevented access to properties. The soils at five roadside cuttings were described and soil samples from the different soil horizons were sent to a soil laboratory for physical and chemical analysis. Note that some of these cuttings were located outside of the PIA, but that the samples are representative of the soil groups in the PIA. The GPS coordinates of these sites are available in the DPIRD soils database.

A map was produced showing the five map units that were identified.

The soil groups that occurred in each map unit were identified and the capability of each map unit for perennial horticulture was rated using the DPIRD five class capability rating system. Land capability maps for perennial horticulture were produced using the DPIRD proportional mapping approach.

This capability assessment does not take into account the availability of irrigation water.

Discussions were held with landowners on water availability.



## Results

### Map units and soil description sites in the PIA

Figure 2 shows the location of the five map units that were identified in this study. The locations of the soil description sites are also shown. Details of the soil profile descriptions and their GPS coordinates can be found in the DPIRD soils data base.

**Figure 2: The location of the map units and soil description sites that were identified within the PIA.**

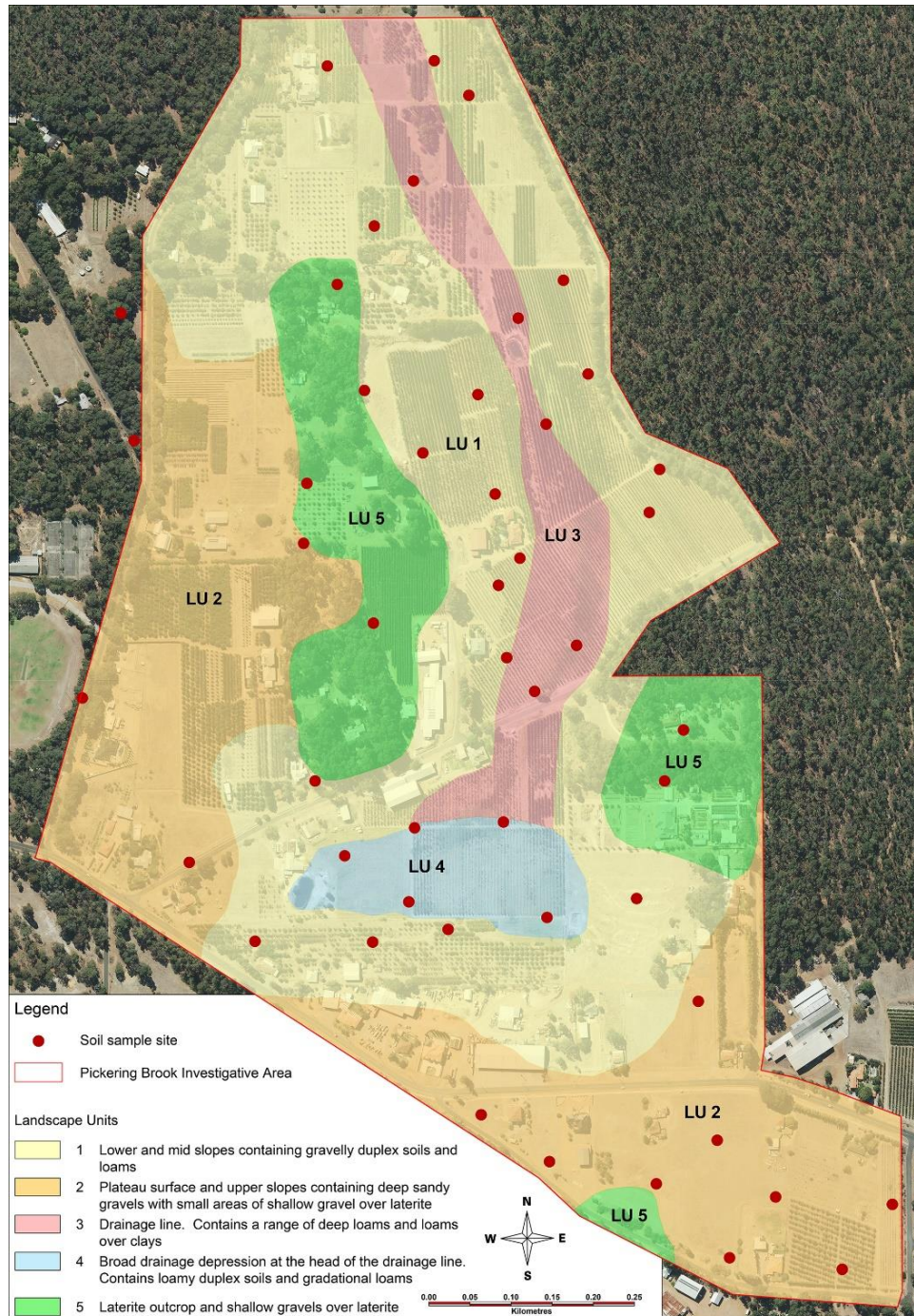


Table 2 shows the position in the landscape of each map unit and the percentage occurrence of the main soil groups that occur in the unit.

**Table 2: Position in the landscape of each map unit and the main soil groups that occur in the unit**

Map unit	Position in landscape	Main soil groups (estimate of % occurrence)
1	Lower and mid slopes	Duplex sandy gravel (60%) Deep sandy gravel (10%) Yellow/brown deep sandy duplex (5%) Brown deep loamy duplex (5%) Brown loamy earth (5%)
2	Plateau surface and upper slopes	Deep sandy gravel (70%) Shallow gravel (15%) Duplex sandy gravel (5%)
3	Narrow valley floor	Friable red/brown loamy earth (30%) Brown loamy earth (20%) Brown deep loamy duplex (20%) Yellow loamy earth (10%)
4	Broad drainage depression at the head of the drainage line	Semi wet soils (20%) Brown loamy earth (20%) Brown sandy earth (20%) Brown deep loamy duplex (20%)
5	Rocky areas on plateau surface and upper slopes	Shallow gravel (70%) Deep sandy gravel (25%) Laterite outcrop (5%)

These soil groups are described in more detail in Appendix 1 with their descriptions taken from <https://researchlibrary.agric.wa.gov.au/rmtr/348/>



### Land capability assessment for perennial horticulture for the PIA

DPIRD uses a five class system to define land capability. The capability classes are shown in Table 3.

**Table 3. Land capability class for given land use types (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.

Neil Lantzke from Western Horticultural Consulting has over 30 years experience in horticulture, soil survey and land capability assessment. He used his 'expert opinion' to determine the capability of the map units for horticulture.

The majority of the soils on the lower slopes (Map Unit 1) have a very high capability for perennial horticulture.

The deep sandy gravels on the upper slopes and plateau surface (Map Unit 2) have a high capability for perennial horticulture. These soils have a lower water holding capacity than the loamy soils that are found lower in the landscape. This is due to the sandy textures and high percentage of ironstone gravel within the soil. This lower water holding capacity is not a major constraint to fruit production as irrigation is applied to meet the crop needs. Water may need to be applied at a greater frequency on these soils than on the loamy soils.

There are small areas of shallow soils over ironstone boulders and cap rock in Map Unit 2. Roadside cuttings showed that the rock generally consists as boulders within a gravelly sand matrix and that there are areas of deeper soils immediately adjacent. Fruit trees are not greatly impacted by the presence of some lateritic boulders in the subsoil.

The soils on the narrow valley floor (Map Unit 3) are sufficiently well drained to not present waterlogging issues for deciduous fruit trees. These soils are some of the most productive in the PIA.

An area at the head of the valley (Map Unit 4) contained soils that experience transient waterlogging in winter. Subsurface drainage has been installed in this area to help overcome drainage issues. In this map unit, deciduous fruit crops that are more tolerant of waterlogging, such as pears and apples, are more suited than stone fruit. Avocados require well drained soils and are not suited to areas that experience waterlogging.

Map Unit 5 contains a complex of shallow gravelly soils over ironstone boulders, lateritic outcrop ('cap rock') and deep sandy gravels. This map unit generally has a low capability for perennial horticulture. The restricted rooting volume and high gravel percentage limits the amount of soil water that is available to fruit trees. If these areas are to be developed for orchards then ripping, rock breaking and removal of the laterite boulders is generally required. There are areas of deep sandy gravel within this map unit that have a greater soil depth.

#### Land capability maps of the PIA

The map units shown in Figure 2 are comprised of a range of soil groups (see Table 2). These soil groups have different capabilities for perennial horticulture.

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 (van Gool *et al*, 2005. The approach is outlined in Figure 3.

**Figure 3. Land capability classes used by DPIRD for proportional mapping**




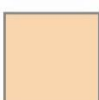


A1		>70% of the area is Class 1 or 2
A2		50-70% of the area is Class 1 or 2
B1		>70% of the area is Class 1 or 2 or 3
B2		50-70% of the area is Class 1 or 2 or 3
C1		50-70% of the area is Class 4 or 5
C2		>70% of the area is Class 4 or 5

Table 4 shows the capability category of each map unit in the PIA for perennial horticulture when using this approach. It does not take into account water availability.

**Table 4: Land capability category for perennial horticulture for each map unit**

Map unit	Position in landscape	Land capability category for perennial horticulture
1	Lower and mid slopes	<b>A1</b> >70% of the area is Class 1 or 2
2	Plateau surface and upper slopes	<b>A1</b> >70% of the area is Class 1 or 2
3	Narrow valley floor	<b>A1</b> >70% of the area is Class 1 or 2
4	Broad drainage depression at the head of the valley	<b>B1</b> >70% of the area is Class 1, 2 or 3
5	Rocky area on plateau surface and upper slopes	<b>C1</b> 50 – 70% of the area is Class 4 or 5

Figure 4 shows a map of the capability categories of land in the PIA for perennial horticulture that was produced when using the standard DPIRD proportional mapping approach.

This approach fails to distinguish between the very high quality loam and duplex soils that are found on the lower slopes and valley floors (in map units 1 and 3) and the deep gravelly soils that are found on the plateau surface and upper slopes (in map unit 2).

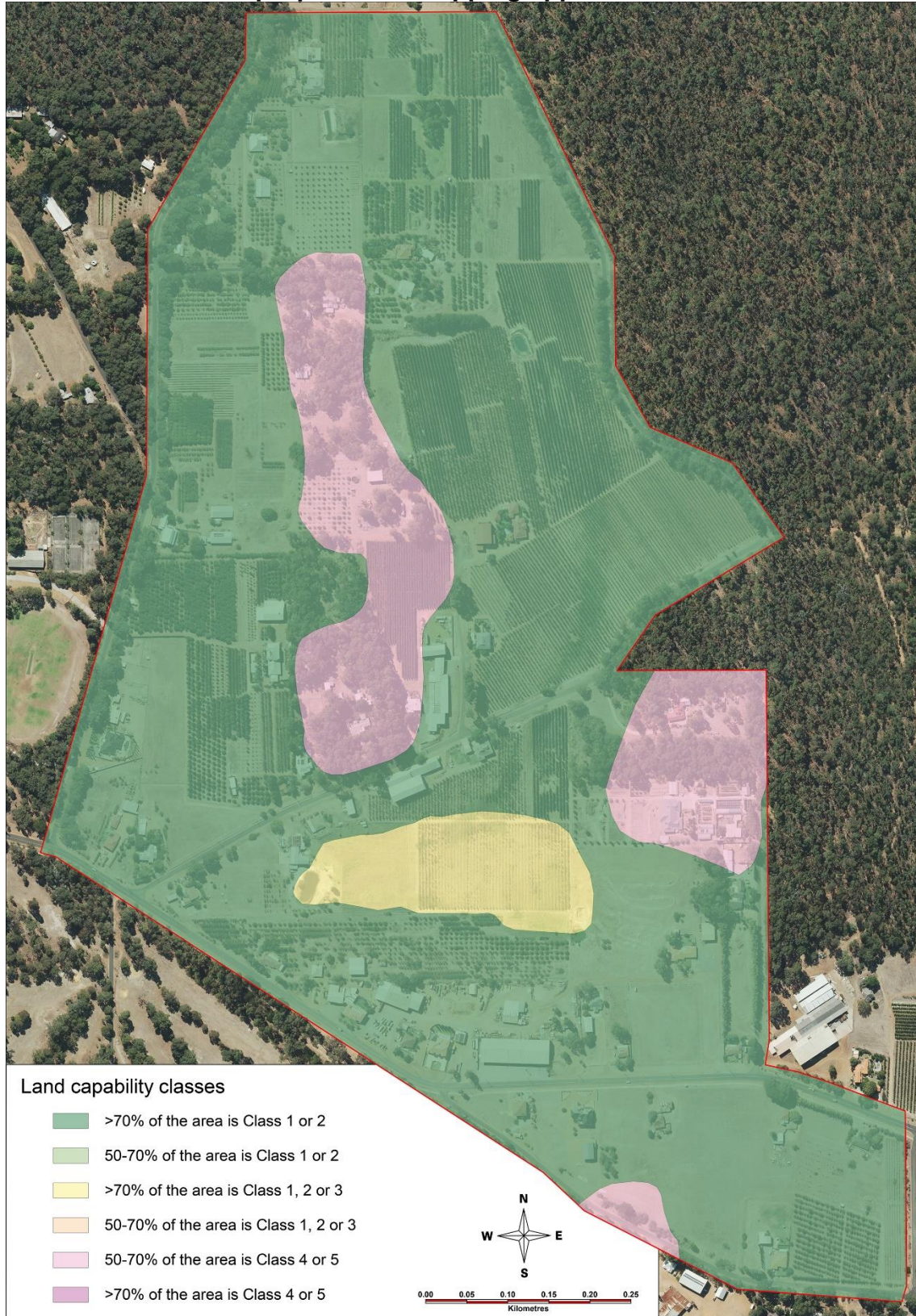
Modifications were made to the standard DPIRD proportional approach to produce an additional land capability map for perennial horticulture (Figure 5). Table 5 shows the land capability categories that were used to produce this map. This approach gives a better representation of the capability of the PIA for perennial horticulture.

**Table 5: Modified land capability category for perennial horticulture for each unit**

Unit	Position in landscape	Land capability category for perennial horticulture
1	Lower and mid slopes	>70% of the area is Class 1
2	Plateau surface and upper slopes	>70% of the area is Class 2
3	Narrow valley floor	>70% of the area is Class 1
4	Broad drainage depression at the head of the drainage line	>70% of the area is Class 3
5	Rocky area on plateau surface and upper slopes	>70% of the area is Class 4 or 5

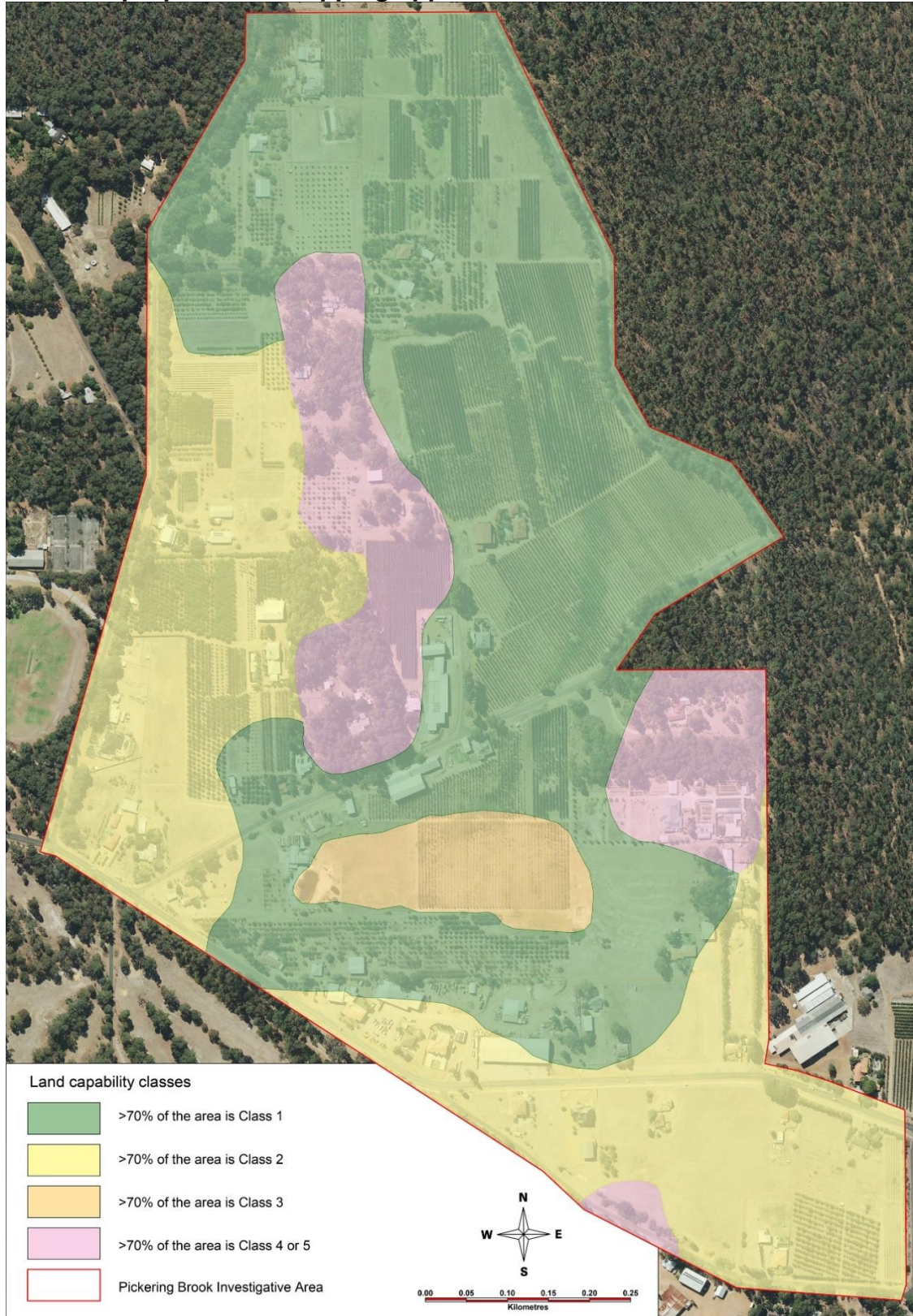


**Figure 4: Map of the capability of land in the PIA for perennial horticulture using the standard DPIRD proportional mapping approach**





**Figure 5: Map of the capability of land in the PIA for perennial horticulture using a modified proportional mapping approach**



### Comments on the capability for vegetable and wine grape production

The soil requirements for annual horticulture (vegetable production) and perennial horticulture 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 pasture species in the mid row, protect the soil surface.

The land capability map for perennial horticulture (Figure 5) can be used for annual horticulture, with the exception being the thin strip of steeper land along the west side of Repatriation Road in the north of the PIA. This area has a low capability for annual horticulture.

Wine grape growers often prefer gravelly soils over deep loamy soils such as those found on the valley floor in the Pickering Brook area. The reduced water holding capacity of these gravelly soils allows greater control of excess vegetative growth, which can improve wine quality.

Areas of the map unit 5 (Figure 2) are suited for the production of wine grapes, though in areas where the lateritic cap rock is at or close to the surface vine growth will be poor.

### Water availability

It was not possible to obtain accurate information on the amount of water that is available on each property. Some landowners were not willing to share this information, others did not know the sustainable yield of their bores, and others had not explored all water supply options on their properties.

However, generally properties with orchards have sufficient water to irrigate the area of crop that is present. An exception would be if the grower is obtaining water from another property and pumping it to their property.

By knowing the area of orchard on each property and by knowing the water requirements of each crop, calculations can be made to estimate the water that is currently being used on each property.

A mature stone fruit, apple or citrus orchard in the Perth Hills typically requires about 7 to 9 ML/ha/year. A mature avocado orchard in the Perth Hills typically requires about 15 ML/ha/year.

There are 35 hectares of orchard in the PIA. Assuming an average irrigation requirement of 10 ML/ha, then it can be deduced that the PIA can supply at least 350 ML per year.

The area of orchard in the Perth Hills is less now than what it was 40 years ago. This indicates that there is water available that is not currently being accessed. However,



the drying climate may have affected the amount of recharge and volume of groundwater that is available.

**Figure 6: Photograph showing a dam which is used for irrigation**



**Summary of water supplies in the Perth Hills:**

- Large volumes of irrigation water are not 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 located lower in the landscape (Map units 1, 3 and 4) are generally higher yielding. However, bores that are installed higher in the landscape (Map unit 2) can, in some cases, supply sufficient quantities for irrigation purposes.
- Additional irrigation water can be obtained on many properties, although a costly drilling program may be required, as many bore holes may not deliver a sufficiently high flow rate to warrant equipping the bore.
- Farm dams can also receive seepage from upslope and from the deep drainage that has been installed in the valleys.
- Some dams receive surface runoff. However, runoff is generally limited to the June to September period. The dams in the Perth Hills are generally small so the amount of water from this source is less important than that from groundwater.
- Significantly greater volumes of irrigation water are available in other fruit growing areas such as Gingin and Donnybrook.

**Water availability and not soil type is the major physical limitation to the expansion of horticulture in the Perth Hills.**

## References

King, PD and Wells, MR, 1990, "Darling Range rural land capability study", Land Resources Series Number 3, Department of Agriculture and Food, Western Australia

Macdonald *et al*, 1990, *Australian Soil and Land Survey Field Handbook*, Inkata Press, Melbourne and Sydney

Schoknecht, NR and Pathan, S, 2013, *Soil groups of Western Australia: a simple guide to the main soil groups of Western Australia*, Report 380, 4<sup>th</sup> edition, Department of Agriculture and Food, Western Australia

van Gool, D, Tille, PJ, and Moore, GA, 2005, *Land evaluation standards for land resource mapping: assessing land qualities and determining land capability in south-western Australia*, Report 298, Department of Agriculture and Food, Western Australia, Perth



## Appendix 1: Soil groups found in the PIA

### Deep sandy gravel

Ironstone gravel soil, with a predominantly sandy matrix, usually over clay, cemented gravels (ferricrete) or reticulite at >80 cm

#### Characteristics

- Yellow, brown and grey colours common
- Neutral to acid pH
- High gravel content (>20%, often much higher) throughout
- Usually over sandy loam to sandy clay loam (reticulite), sandy clay loam to clay, or cemented gravels (ferricrete) at >80 cm

### Shallow gravel

Ironstone gravel soil over cemented gravels (ferricrete), rock or other hard or permanently cemented layers at <80 cm

#### Characteristics

- Yellow, brown, grey or sometimes red in top 30 cm
- Neutral to acid pH
- High gravel content (>20%, often much higher) throughout
- Sandy, or less commonly loamy, matrix
- Overlies cemented gravels (ferricrete), rock or other hard or permanently cemented layers at <80 cm

### Duplex sandy gravel

Ironstone gravel soil, with a predominantly sandy matrix, over a permeability contrast layer at 30-80 cm. The permeability contrast layer may be either a texture contrast or reticulite (mottled sandy loam to sandy clay loam)

#### Characteristics

- Yellow, brown or grey in top 30 cm
- Neutral to acid pH
- Over clay loam to clay or reticulite (mottled sandy loam to sandy clay loam) at 30-80 cm
- High gravel content (>20%, but often much higher) above the texture or contrast layer

### Yellow/brown deep sandy duplex

Yellow/brown sand over sandy clay loam to clay at 30-80 cm

#### Characteristics

- Surface layers mainly yellow or brown
- May have a paler subsurface and various colours in subsoil
- Neutral subsoil pH common, but may be acid to alkaline

- Ironstone gravel sometimes present, especially on top of Clay

### **Brown deep loamy duplex**

Brown loam over clay at 30-80 cm

#### **Characteristics**

- Brown the dominant colour of the surface layer/s
- Surface may be grey or black
- Neutral pH
- Firm to hard setting surface
- Non-alkaline clay subsoil
- Non-sodic subsoil more common than sodic

### **Brown loamy earth**

Brown loam (may be clayey at depth)

#### **Characteristics**

- Brown or grey topsoil
- Loam throughout, or grading to clay with depth
- Neutral to acid pH, may be calcareous at depth
- Gravels may be present in subsoil
- Phases with a grey topsoil are often mottled
- Often formed in recent alluvium

### **Friable red/brown loamy earth**

Red/brown loam, may grade to clay, very friable and porous

#### **Characteristics**

- Red or brown within top 30 cm
- Neutral to acid pH
- Friable topsoil
- Porous throughout
- Gravel (ironstone and non-ironstone) may be present

### **Brown deep loamy duplex**

Brown loam over clay at 30-80 cm

#### **Characteristics**

- Brown the dominant colour of the surface layer/s
- Surface may be grey or black
- Neutral pH
- Firm to hard setting surface
- Non-alkaline clay subsoil

### **Semi-wet soil**

Non-saline soils waterlogged to 30-80 cm for a major part of the year

#### **Characteristics**

- Lower part of profile (30-80 cm) saturated for the major part of the year
- Often with dark grey, brown or black topsoil
- Sands, loams and clays
- Acid to neutral pH
- Variable subsoil, may contain bog iron
- Common in plains with elevated fresh water tables

## **Appendix 2: Laboratory analysis**

Soil samples from each horizon were taken from five commonly occurring soil groups and submitted for laboratory analysis. The five soil groups sampled were:

1. Duplex sandy gravel
2. Brown loamy earth
3. Deep sandy gravel
4. Shallow gravel
5. Friable red/brown loamy earth

The following analysis was conducted on the samples:

- Phosphorus (Colwell)
- Potassium (Colwell)
- Sulphur (KCl 40)
- Organic Carbon (Walkley-Black)
- Nitrate Nitrogen and Ammonium Nitrogen
- Electrical Conductivity
- pH (water) and pH (CaCl<sub>2</sub>)
- Boron
- Trace Elements (DTPA) - Copper, Zinc, Manganese, Iron
- Exchangeable Cations - Calcium, Magnesium, Sodium, Potassium, Aluminium
- Phosphorus Buffering Index (PBI)
- Phosphate Retention Index (PRI)

The results from the laboratory analysis are in Table A3.1.

Photographs of the five soil pits are shown on the subsequent pages.

**Table A3.1: Soil chemistry data from the laboratory analysis conducted by CSBP**

	Lab number	IWS2 0011	IWS2 0012	IWS2 0013	IWS2 0014	IWS2 0015	IWS2 0016	IWS2 0017	IWS2 0018	IWS2 0019	IWS2 0020	IWS2 0021	IWS2 0022	IWS2 0023	IWS2 0024
	Name	Pit 1	Pit 1	Pit 1	Pit 2	Pit 2	Pit 2	Pit 3	Pit 3	Pit 3	Pit 4	Pit 4	Pit 5	Pit 5	Pit 5
	Code	A1	B1	B2	A1	B1	B2	A1	A3	B2	A1	B1	A1	B1	B2
	Sample depth (cm)			75-120	0-20	20-70	70-100	0-15	15-40	40-140	0-15	15-75	0-10	10-50	50-100
Gravel	%	5-10	55-60	5-10	0	0	0	5-10	55-60	75-80	75-80	25-30	0	0	0
Texture		1.5	1.0	3.0	2.0	2.0	2.5	1.5	1.0	1.0	1.0	2.5	3.0	3.0	3.5
Ammonium nitrogen	mg/kg	7	<1	<1	2	2	1	2	2	2	6	7	32	4	1
Nitrate nitrogen	mg/kg	<1	<1	<1	4	1	<1	<1	<1	<1	<1	<1	73	6	5
Phosphorus (Colwell)	mg/kg	5	<2	<2	5	5	5	<2	<2	<2	4	<2	165	7	<2
Potassium (Colwell)	mg/kg	112	50	102	148	140	106	47	22	20	108	62	889	255	170
Sulphur	mg/kg	5.8	2.0	11.9	7.2	9.9	8.5	6.9	8.8	22.8	6.9	8.9	21.6	35.1	96.7
Organic carbon	%	4.79	0.38	0.45	1.89	2.59	1.64	1.58	0.64	0.16	4.76	0.71	2.94	0.70	0.48
Conductivity	dS/m	0.051	0.014	0.032	0.044	0.062	0.072	0.023	0.015	0.017	0.050	0.028	0.234	0.032	0.060
pH level (CaCl <sub>2</sub> )		5.2	6.0	6.1	5.8	6.0	6.1	5.7	5.9	6.0	5.4	6.0	5.4	4.9	5.7
pH level (H <sub>2</sub> O)		6.1	6.6	6.7	6.7	6.9	7.2	6.5	6.6	6.5	6.2	6.5	6.2	5.7	6.1
DTPA Copper	mg/kg	0.49	0.26	0.35	2.09	1.39	1.65	0.51	0.27	0.44	0.28	0.19	9.97	0.24	0.15
DTPA Iron	mg/kg	52.10	9.60	10.70	47.00	42.00	43.00	14.30	10.40	7.30	31.10	11.70	40.50	23.30	34.70
DTPA Manganese	mg/kg	8.35	0.14	0.39	2.60	2.82	1.91	2.38	1.71	0.41	11.31	0.33	29.94	3.44	0.84
DTPA Zinc	mg/kg	0.49	0.03	0.02	1.42	1.46	1.16	0.03	0.06	0.11	0.59	0.02	5.25	0.04	0.04
Exc. Aluminium	meq/100g	0.210	0.070	0.070	0.050	0.040	0.050	0.110	0.060	0.050	0.300	0.050	0.040	0.170	0.070
Exc. Calcium	meq/100g	10.73	0.52	0.63	5.70	8.72	6.86	1.10	0.71	0.24	6.83	0.98	6.75	1.27	2.14
Exc. Magnesium	meq/100g	2.79	0.37	0.51	2.38	3.38	3.14	0.35	0.24	0.17	1.46	0.66	2.01	1.07	1.05
Exc. Potassium	meq/100g	0.24	0.11	0.24	0.32	0.29	0.24	0.11	0.05	0.04	0.25	0.16	2.03	0.61	0.39
Exc. Sodium	meq/100g	0.22	0.03	0.10	0.25	0.55	0.63	0.08	0.04	0.04	0.22	0.08	0.22	0.11	0.16



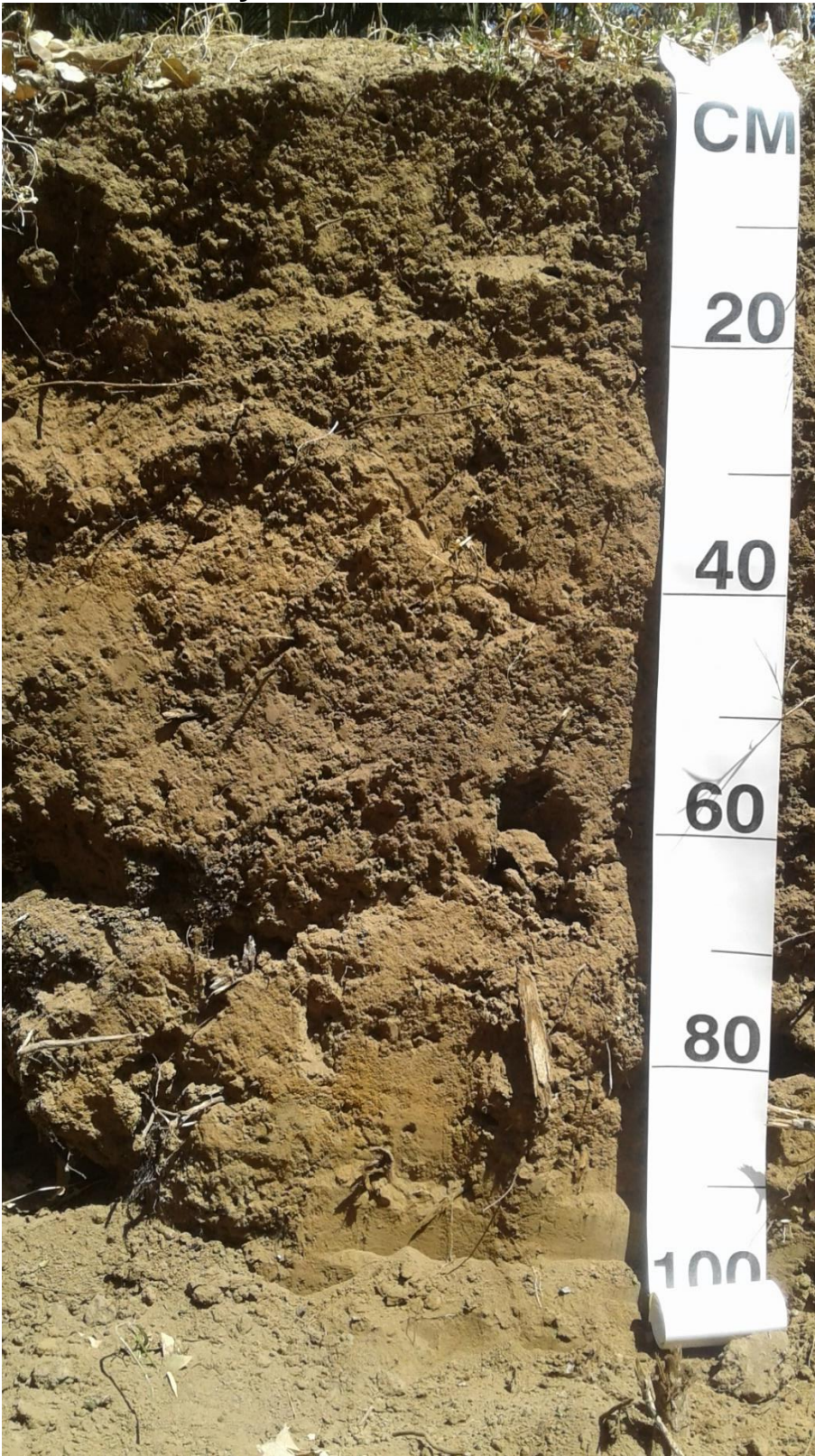
	Lab number	IWS2 0011	IWS2 0012	IWS2 0013	IWS2 0014	IWS2 0015	IWS2 0016	IWS2 0017	IWS2 0018	IWS2 0019	IWS2 0020	IWS2 0021	IWS2 0022	IWS2 0023	IWS2 0024
	Name	Pit 1	Pit 1	Pit 1	Pit 2	Pit 2	Pit 2	Pit 3	Pit 3	Pit 3	Pit 4	Pit 4	Pit 5	Pit 5	Pit 5
	Code	A1	B1	B2	A1	B1	B2	A1	A3	B2	A1	B1	A1	B1	B2
	Sample depth (cm)	0-15	15-75	75- 120	0-20	20-70	70- 100	0-15	15-40	40- 140	0-15	15-75	0-10	10-50	50- 100
Boron (Hot CaCl <sub>2</sub> )	mg/kg	0.56	0.17	0.46	0.45	0.60	0.47	0.26	0.17	0.17	0.44	0.33	1.00	0.59	0.46
Phosphorus retention index		184.9	15.1	406.5	415.4	577.1	434.6	67.5	82.5	389.8	244.6	209.7	152.4	> 1000	> 1000
PBI		163.1	42.9	180.1	220.9	276.9	295.2	105.8	102.6	151.5	156.2	133.4	235.1	607.8	667.6

## 1. Duplex sandy gravel



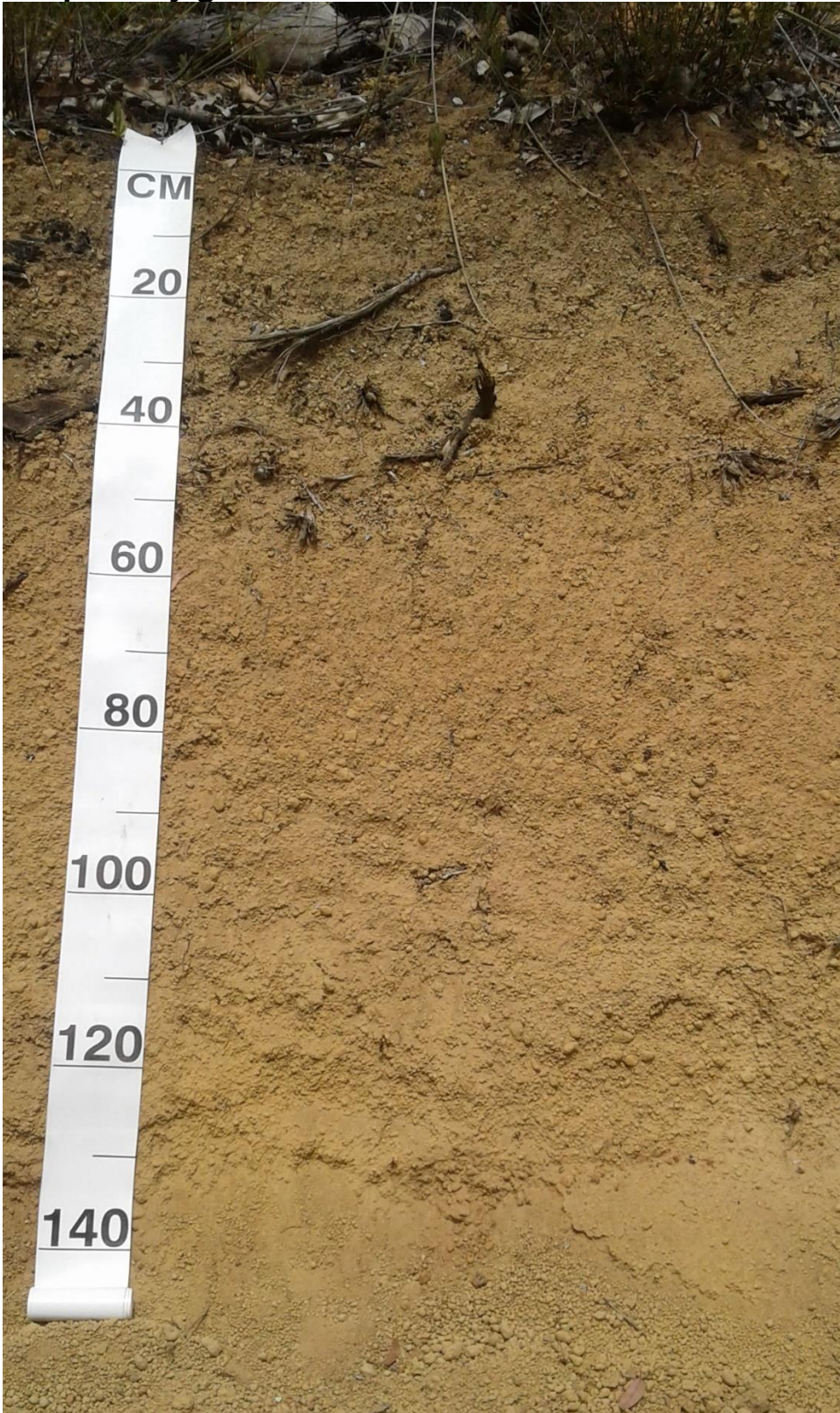


## 2. Brown loamy earth



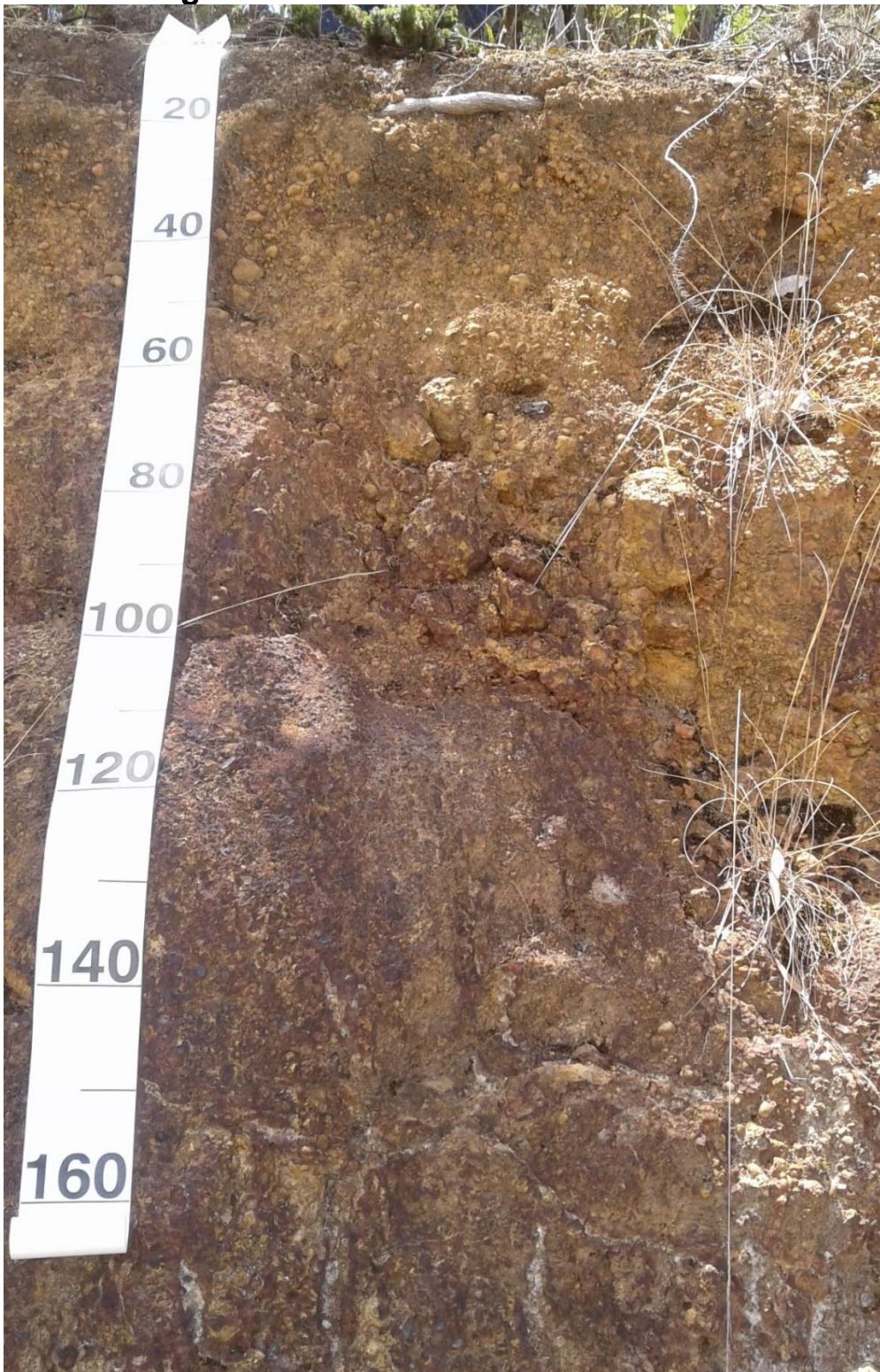


### 3. Deep sandy gravel





#### 4. Shallow gravel





**5. Friable red/brown loamy earth**

