Land Resource Assessment – Land Resources of the Lake Cootharaba Catchment

South East Queensland

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Summary

The land resource assessment of the Lake Cootharaba catchment was produced to inform and support strategic planning decisions. It presents soil physical and chemical attributes and land resource limitations to assist planning for competing land uses, specifically involving land suited to agricultural production.

Soil and landscape attributes were assigned to unique mapping areas based on information sourced from a total of 311 sites. The 266 project sites were supplemented with information from an additional 45 sites described in previous studies which overlapped the current study area, including sites from South East Queensland acid sulfate soils projects and South East Queensland pasture trial projects. Conceptual soil descriptions known as soil profile classes were then used to describe the associations between soils and the landforms on which they occur.

The complex of 24 soil profile classes and 574 unique mapping areas identified within the survey area reflects the diverse range of geologies and landforms found in the catchment.

Soil and landscape attributes were used to assess the limitations of each unique mapping area and therefore their suitability for a wide range of agricultural and horticultural uses. Using the process herein, it was determined that 19% (4 855 ha) of the catchment is class A1 cropping land, 36% (9 445 ha) is class A2 horticultural land, 2% (546 ha) is class B limited crop land while the remainder is grazing land or non-agricultural land (class C or D). Therefore, a total of 57% (14 846 ha) of the catchment is considered potential cropping land, much of which exists along Kin Kin Creek, its tributaries and on surrounding gentle slopes.

This land resource assessment identified soil types in the Lake Cootharaba catchment and the location and quality of land suited to agricultural and horticultural production. This information will inform future local and regional planning decisions made by land holders, industry groups, community groups, state and local government departments and other land managers.

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Introduction

The Lake Cootharaba catchment encompasses many land uses including agriculture, horticulture, recreation and residential. Maintaining a balance between diverse land uses requires informed land use planning. This land resource assessment provides information to support such planning.

Planning instruments to which this information applies include the single State Planning Policy (sSPP) and the South East Queensland Regional Plan (SEQ Regional Plan, Queensland Government 2009) which aim to guide regional growth. Additionally it will inform and support the Noosa Council Planning Scheme which supports development in a sustainable and integrated way to protect the community's environmental, economic and social values.

The Lake Cootharaba catchment land resource assessment aims to:

- identify, describe and map soils and landscape processes
- assess soil quality and land suitability for a range of existing and potential uses
- provide information to inform resource management
- allow clients and stakeholders access to land resource information to better inform land use planning, sustainable management programs and best management practices (BMP)
- provide information regarding the risk of land degradation
- provide a range of spatial/digital information products to form a GIS information base which can be used to make catchment, local and property planning decisions and be incorporated into:
  - state, local and regional planning schemes
  - regional plans e.g. SEQ Regional Plan
  - development assessment decision making
  - decision making and decision support tools e.g. interactive mapping tools.

The SEQ Regional Plan (Queensland Government 2009) describes the Lake Cootharaba catchment as being dominated by regional landscapes and rural production areas. The exception is a relatively small area of urban footprint surrounding the villages of Boreen Point and Kin Kin.

Although the study area is dominated by rural production, there are pressures from urban and rural residential development. Maintaining the balance between competing land uses in the study area was previously constrained by:

- limited availability of land resource information
- limited soil attribute knowledge and knowledge of their impacts on land suitability.

The project was undertaken using enhanced resource assessment (ERA) techniques. ERA uses technology and modelling techniques, in conjunction with traditional soil survey methodology to achieve a practical, efficient and accurate land resource assessment outcome.

Previous resource assessments which overlap or adjoin the Lake Cootharaba study area include:

- 1980 study of the Cooloola-Noosa River area which includes the area east and north to north-west of Lake Cootharaba
- 2003 South East Queensland acid sulfate soil mapping (Queensland Government 2003) covering the area immediately surrounding Lake Cootharaba and Boreen Point
- 2008 survey of the Cooloola region (Ellis & Wilson 2009) covering an area of 127 000 ha to the north and west of this study area.

The land resource information created by this study is available in electronic format via the Queensland Globe, the Queensland Government web sites (www.qld.gov.au and www.information.qld.gov.au) and in this

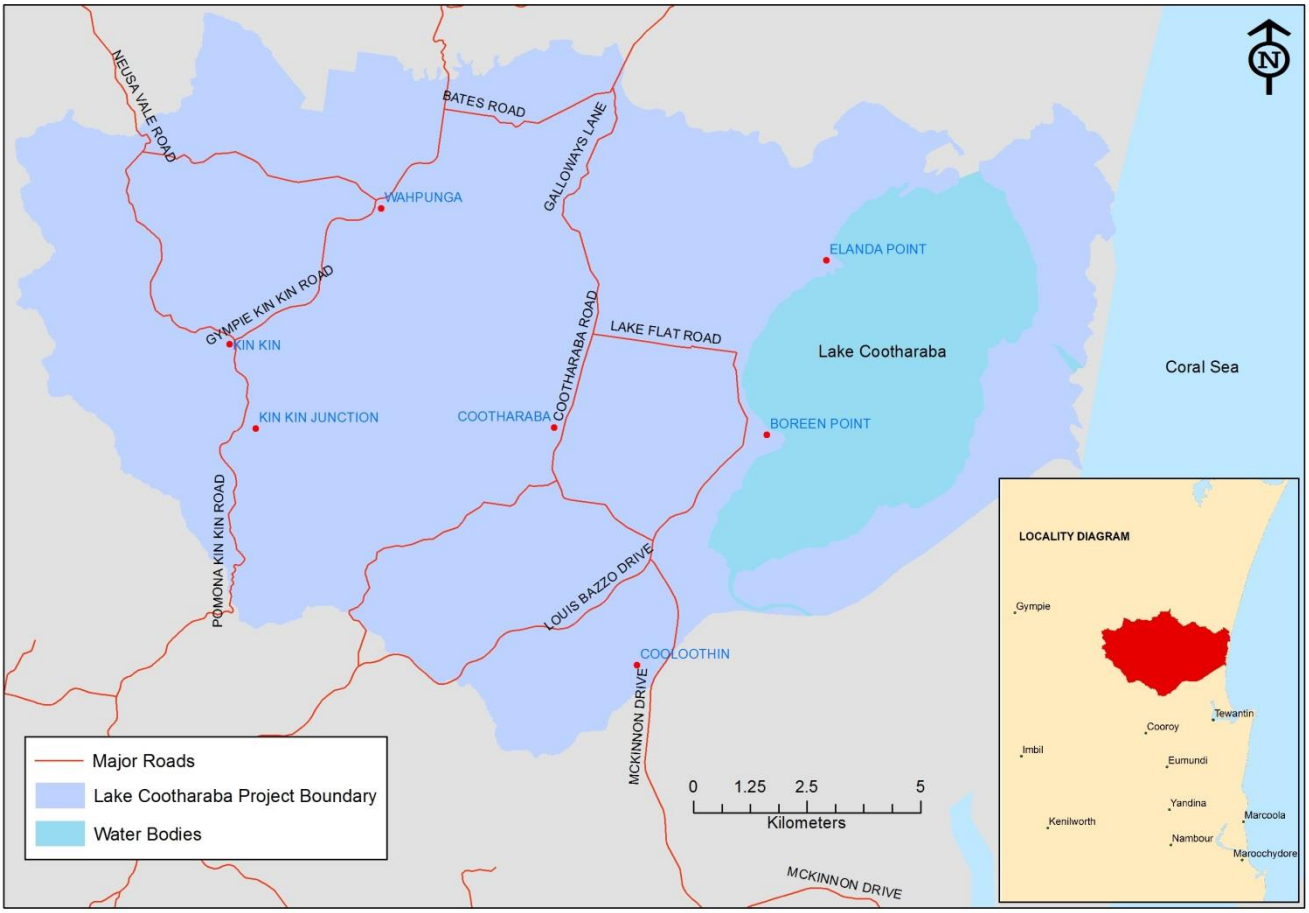
report (www.publications.qld.gov.au). Data for this area is also available from DNRM. All mapping and spatial products have been produced at a scale of 1:50 000.

Study area

The Lake Cootharaba catchment covers an area of approximately 27 110 ha and is located north-west of Noosa and south-east of Gympie in South East Queensland (SEQ). The study area lies within the catchment and is approximately 25 944 ha (Figure 1).

The area covered by this report includes the localities of Kin Kin, Boreen Point, Cootharaba and Teewah which are administered by Noosa Shire Council. Major industries of the catchment are rural production, forestry, tourism and recreation.

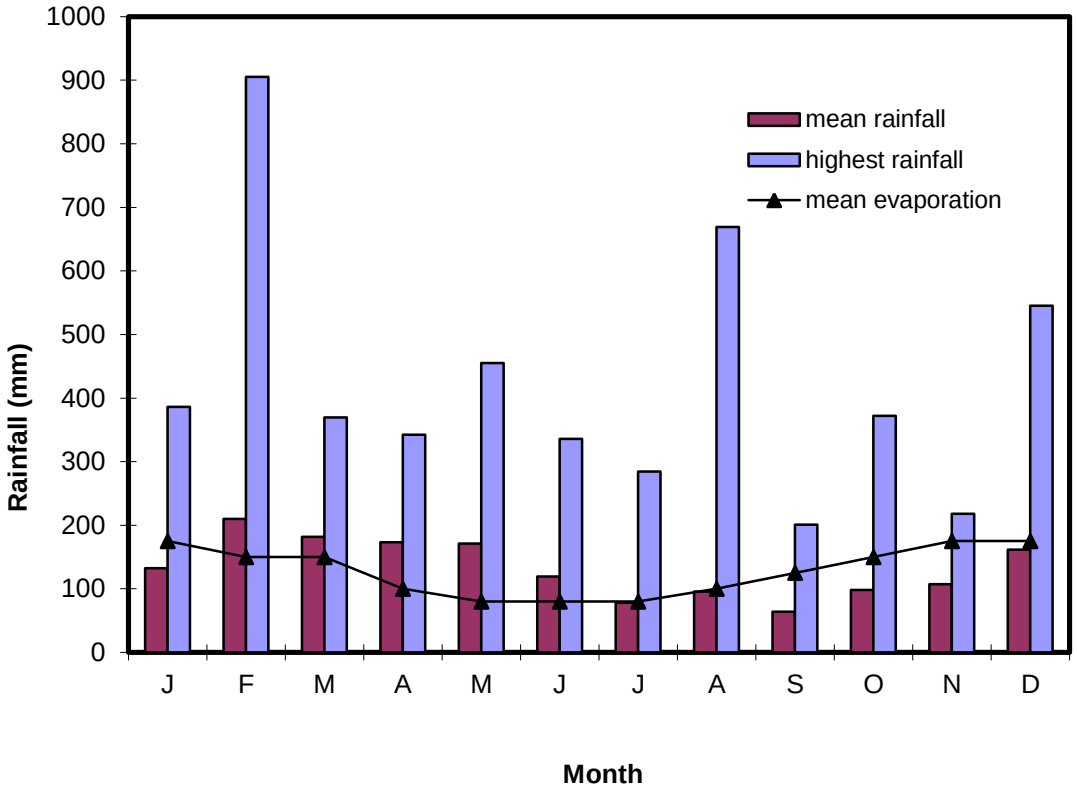
Figure 1 – Location of the Lake Cootharaba catchment study area



Climate

The Lake Cootharaba catchment has a subtropical climate and receives most of its annual rainfall during the warmer months of summer and autumn (Figure 2).

Figure 2 – Monthly mean rainfall, highest monthly rainfall and monthly mean evaporation[1]



Highest recorded monthly rainfall figures are three to four times greater than the mean monthly figures demonstrating the variability in rainfall intensity. The number of days per month where rainfall of greater than 1 mm was recorded follows the expected pattern of summer dominant rainfall, with 5.8 to 10.5 rainfall days per month between May and October and 7.9 to 14.3 days per month rainfall between November and April.

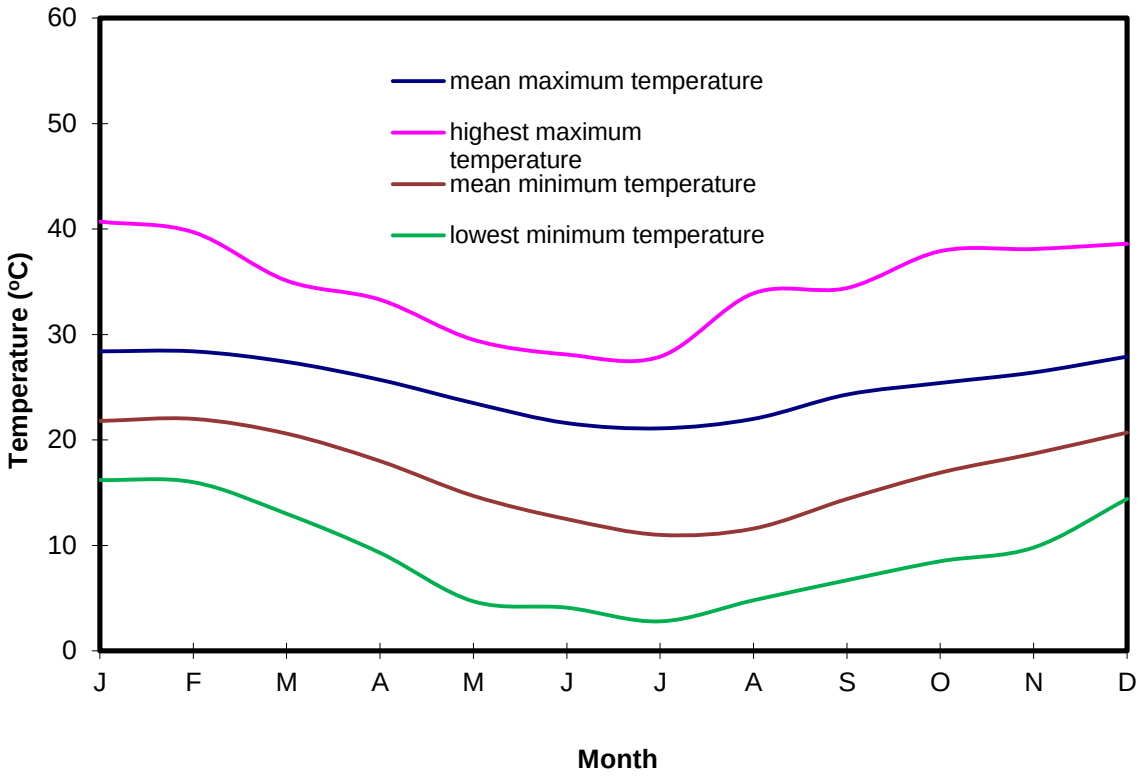
Effective rainfall (rainfall received minus evaporation) remains positive throughout the period February to June with a deficit persisting for the balance of the year.

More than half of the mean annual rainfall of 1 590 mm is received between November and April when maximum daytime temperatures range between 25.2 and 28.4 °C and minimums range from 18.0 to 22.0 °C. The highest recorded daytime summer temperatures range between 33.3 °C (April 2006) and 40.7 °C (January 2002) (Figure 3).

Lowest mean monthly rainfall totals occur between June and October, with September totals being the lowest. Maximum daytime temperatures range between 21.1 and 25.4 °C between May and October, with minimums of 11.0 to 16.9 °C over the same period. Lowest recorded minimum temperatures range between 2.8 °C (July 2007) and 8.5 °C (October 2010). Frosts are uncommon and confined to the most sheltered valleys and flats.

[1] Source: Bureau of Meteorology 2012 – Tewantin RSL weather station rainfall between 1996 and 2011. Mean evaporation data taken from Average Pan Evaporation maps for the Australian continent.

Figure 3 – Mean monthly minimum and maximum temperatures and lowest and highest recorded temperatures[2]



[2] Source: Bureau of Meteorology 2012 – Tewantin RSL weather station between 1996 and 2011

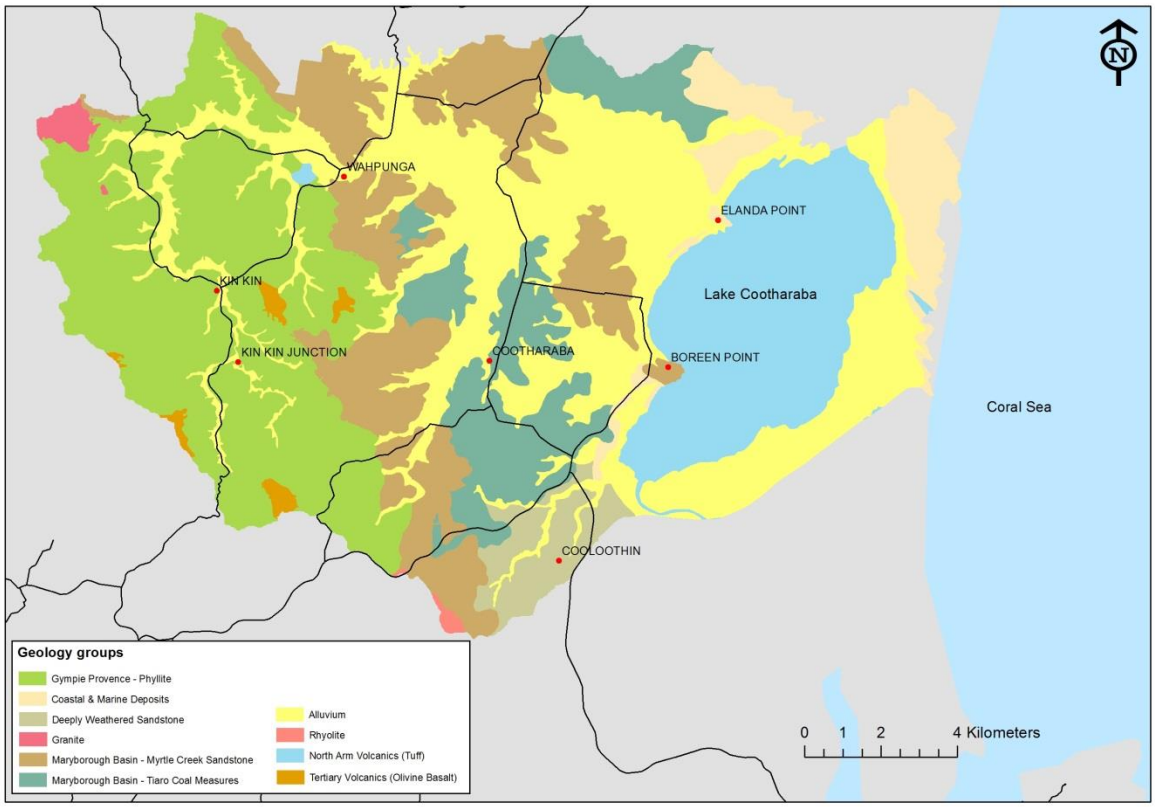
Geology

The geology of Lake Cootharaba includes the major units—Gympie province, Maryborough basin, alluvium and coastal sands; and the minor units—tertiary (Neogene) rocks, South East Queensland volcanic and plutonic province (Intrusive Subprovince) (Cranfield 1999).

The study area can be divided into four significant geological elements—along an almost north-south alignment—which generally follow the lines of past subduction zones (Figure 4). The western quarter of the catchment is dominated by the Gympie province (Kin Kin subprovince) with elements of the Maryborough basin and Quaternary alluvium occupying the quarter to its east. Coastal sands along the eastern coast and Lake Cootharaba make up the remaining parts of the study area. Small, isolated areas of late Triassic intrusives (Woondum granite), Triassic volcanics (rhyolitic tuff) and Neogene (Miocene) volcanics (olivine basalt) are also present within the Kin Kin subprovince area.

The Triassic Kin Kin subprovince occupies the undulating to steep low hills and hills in the western portion of the study area and includes the Wahpunga Range and the southern extent of the Beenham and Wolvi Ranges surrounding the Kin Kin township. The Kin Kin Beds are the dominant geology unit within the subprovince in this area and consist of phyllite, argillite and arenite, with phyllite being the most common. Minor areas of further metamorphosed phyllite occur around areas of intrusive late Triassic Woondum Granite in the north-west.

Figure 4 – Geology of the Lake Cootharaba catchment



Plains, gently undulating and rolling rises grading to low hills and steeper high hills of the central portion of the study area are dominated by the Duckinwilla Group of the Maryborough basin formation. These late Triassic to Jurassic formations fall into two broad groups: the Tiaro Coal Measures, confined to plains, gently rolling and rolling rises (lithofeldspathic labile and sublabile to quartzose sandstone, siltstone, shale and

minor coal) and the Myrtle Creek Sandstones (quartzose sandstone, orthoquartzite, sublabile to labile sandstone, siltstone and shale) found on plains to steep hills.

Quaternary alluvial deposition (freshwater and marine) has occurred throughout the lowest elevations of the study area, forming low and gently undulating alluvial plains and flood plains. The largest concentrations occur within the central portion along the many drainage lines, flats and small creeks that meet to form Kin Kin Creek and flow into Lake Cootharaba. Soil properties (e.g. texture, gravel content, pH, drainage) are determined by the geology of the contributing alluvia.

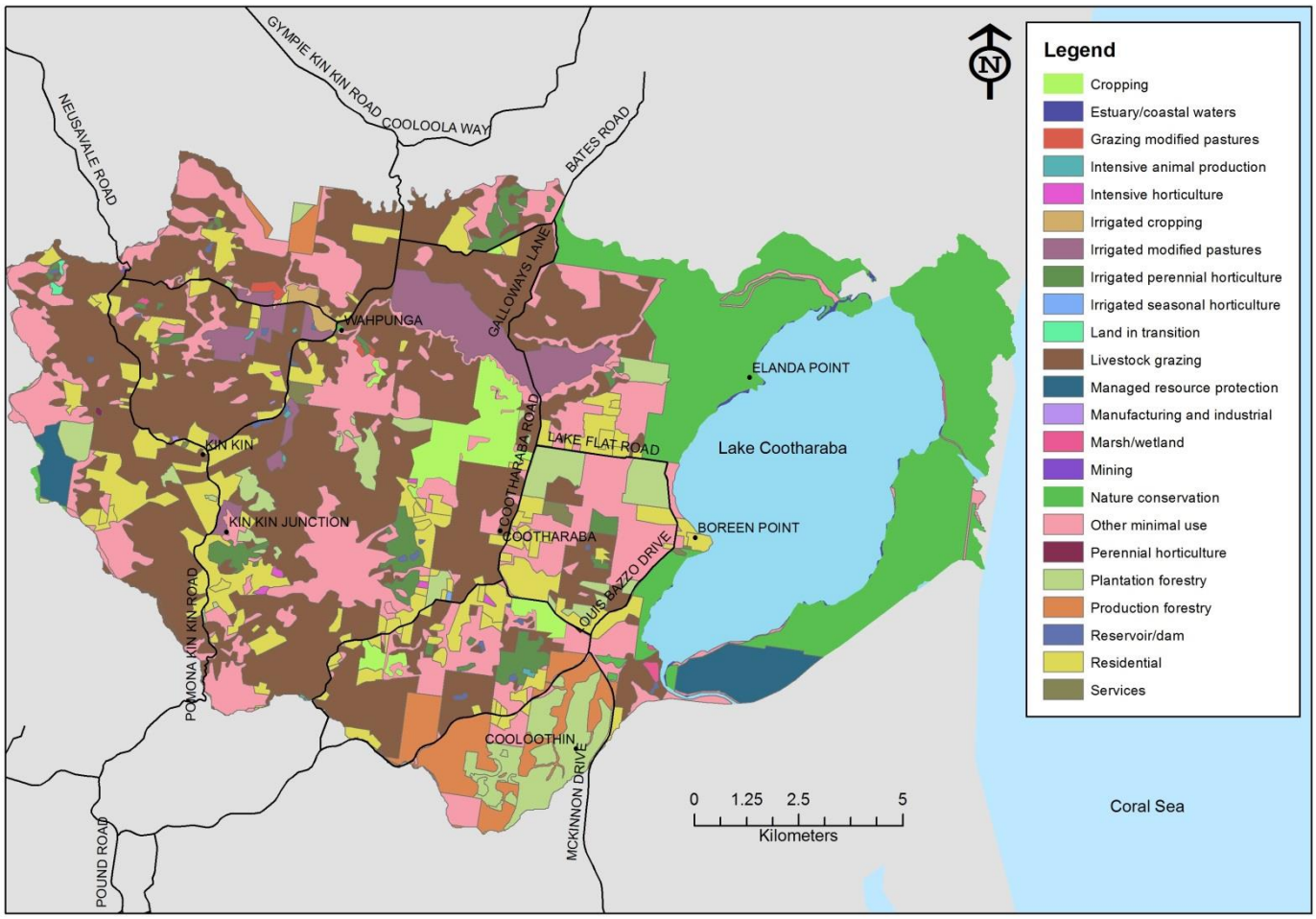
The final significant geological element of the catchment is the complex band of Quaternary (Pleistocene and Holocene) sandy beach ridges, dunes and swales along the eastern extremity of the study area. Pleistocene dunes are oriented generally in a south-west to north-east direction and were shaped by wind during periods of low sea level during the last ice age. Holocene dunes have a more north-south orientation as a result of recent ocean and wind formation and re-working influences. These dune systems grade into lake alluvium on their western side and down through active frontal dune systems to the Coral Sea in the east (Thompson & Moore 1984).

Land use

The dominant land use within the Lake Cootharaba catchment is the grazing of cattle on irrigated and rainfed pastures (QLUMP 2006). Other significant agricultural uses include perennial horticulture such as macadamia plantations and limited cropping on alluvial soils (Figure 5).

Significant non-agricultural land uses include nature conservation, residential (including rural residential) development, forestry and recreation (Lake Cootharaba). Urban development in the study area has resulted in minor losses of potentially productive agricultural land.

Figure 5 – Land use mapping in the Lake Cootharaba catchment area (QLUMP 2006)



Methodology

The approach taken in this survey was dictated by the complexity of the catchment. In order to derive an adequate representation of the land resources, a hybrid methodology (also known as enhanced resource assessment) combining aerial photograph interpretation (API), free soil survey and digital soil mapping was applied.

During the free survey phase, data was collected from 266 sites (34 of which were validation sites). This was supplemented with information from an additional 45 sites described as part of previous studies including SEQ acid sulfate soils (ASS) (Queensland Government 2003) and SEQ pasture trials (Queensland Government unpublished) which overlapped the study area. Therefore, a total of 311 sites were used to form the basis of this assessment.

Combining colour aerial photography and stereoscope equipment, areas of alluvium were delineated using API. Areas of pediment and other definitive landforms, such as alluvial fans, were also delineated using API as no suitable modelling technique was found to identify these. Hand drawn API line work was then digitised by scanning the images, importing them into ArcGIS®, rectifying them and tracing to form polygons.

Following API identification of the above zones, other known areas of geology/lithology were delineated based on site data, airborne gamma-ray spectrometry (radiometrics) interpretation (Wilford 2012) and existing lithology/geology mapping (where it was deemed suitably accurate). These additional boundaries were then digitised as described above.

Due to the complex nature of geologies and the soil formation processes within the study area, digital soil modelling of the area, as a whole, yielded unsatisfactory results. Modelling within each of the discrete areas outlined above (described below) yielded the most favourable result. The discrete areas were then recombined at the conclusion of this process to form a continuous spatial representation of the study area soils and land attributes.

Formation of soil-landscape associations

Based on the delineation of areas with common lithology/geology, 16 broad lithology groups were formed. Within each of these groups (see 'Soils and soil-landscape units') a number of soil-landscape concepts were developed based on analysis of site data and its association with landscape position, lithology and slope (Table 4). These were further developed and refined to identify 574 unique mapping areas (UMAs) across the catchment.

Having formed concepts of where differences in soils existed in the landscape, their boundaries were defined using the combination of site data and available digital information.

In determining the UMAs within each lithology group, the derived one arc second hydrological enforced Shuttle Radar Topography Mission (SRTM) Digital Elevation Model (DEM), equivalent to a 30 m grid, was used to provide elevation and derivatives such as slope and curvature for upper and lower slope UMAs. Further, the DEM derived Topographic Position Index (TPI) was used to develop the Slope Position Classification as used by Tagil and Jenness (2008), to determine the extent of the crest UMAs and other topographic positions.

TPI is the difference between a cell elevation value and the average elevation of the cells surrounding it. A positive value indicates the cell is higher than its surroundings and a negative value means it is lower. Slope Position Classification combines TPI and slope to develop landform classes such as crests, upper and mid slopes. Importance was placed on the TPI radius, which is the number of cells in a circular pattern

surrounding or neighbouring cells used in the calculation of TPI. A TPI radius of 90 m (3 cell radius) indicated more local relief changes compared to that of 300 m (10 cell) or 900 m (30 cell) radius.

Determination of land suitability attributes

The *Guidelines for agricultural land evaluation in Queensland* (DSITIA & DNRM 2015), state that land evaluation involves estimating the potential of land for alternative forms of land use. Resource related land evaluation takes into account the link between land use requirements and land resource attributes. The application of consistent collected attribute data sets allows a thorough evaluation process and ensures that an appropriate land use is recommended.

Attributes that were used to define soil suitability across the study area are set out in Table 1. These are taken from the standard coastal SEQ land suitability framework. The framework and its components are outlined in Appendix 3.

Table 1 – Land suitability attributes

Land suitability attributes
Climate – frost and precipitation (long term data from Bureau of Meteorology)#
Actual acid drainage water hazard (from existing Queensland ASS mapping)
Potential acid drainage water hazard (from existing Queensland ASS mapping)
Water erosion risk
Flooding
Water availability (measured by plant available water capacity or PAWC)
Nutrient deficiency (derived from laboratory analyses)
Element toxicity (pH)
Soil depth
Soil surface condition (based on site data)
Rockiness (maximum profile coarse fragments)
Soil salinity* (based on site data)
Microrelief* (based on site data)
Topography (slope)
Profile wetness (drainage and permeability)
Landscape complexity (based on UMA area and location)

Attributes in bold were predicted using the environmental correlation (modelling) approach, remaining attributes were derived by other means.
* Salinity and microrelief had no bearing on land classification results in this study area as neither was identified in anything other than minor areas or areas where more dominant concerns reduced land suitability.
# Incidence of frost across the catchment was determined to be <3 days per year and not influencing land suitability. Bureau of Meteorology rainfall mapping indicated the entire catchment received an average rainfall of >1 500 mm which does not limit land suitability for the suite of crops chosen.

Calculation of plant available water capacity

Plant available water capacity (PAWC) was used to estimate the water availability attribute. PAWC was determined using a look-up table in *Protecting Queensland's strategic cropping land: Guidelines for applying the proposed strategic cropping land criteria* (Table 9, Department of Environment and Resource Management 2011) (see Table 2) on the basis that the procedure for estimating soil water storage (SWS) can be used as an approximation of PAWC. This is a soil field texture based process rather than a laboratory

determination which would require particle size analysis. The soil textures referred to are field texture grades, derived by evaluating the behaviour of a moist soil bolus as per the *Australian soil and land survey field handbook* (National Committee on Soil and Terrain 2009).

Field texture was determined for each horizon of a soil profile. Total PAWC was calculated by summing the SWS, measured in millimetres of water, for each 100 mm increment of soil depth. If a soil horizon was not an exact multiple of 100 mm, the PAWC value was proportioned accordingly, e.g. a 350 mm thick soil horizon will have its appropriate PAWC value per 100 mm increment multiplied by 3.5 (i.e. 350/100).

Table 2 – SWS for various soil textures

Estimated SWS (mm) per 100 mm depth of soil	Field texture grade
4	Sand, clayey sand, loamy sand
5	Sandy loam
6	Loam, silty loam, sandy clay loam
8	Clay loam, clay loam – sandy, silty clay loam
10	Light clay, light medium clay
12	Medium clay, medium heavy clay, heavy clay

The total soil depth used for this calculation was either 1 000 mm or the effective rooting depth (i.e. depth to decomposing rock, rock, pan, high salts or impermeable layer).

Soils with >10 per cent coarse fragments (gravel) in the soil profile required an adjustment to their SWS values.

Attribute modelling

The process used to compile landscape conceptual models was based on the relationship between observed soil attributes, spatial relationships and derived ancillary covariates. It is known as Digital Soil Mapping (DSM) and has been described in detail by McBratney et al. (2000, 2003).

An increase in the development of tools used in DSM, together with accurately derived ancillary covariates such as digital elevation models has contributed to a greater use of quantitative approaches in soil mapping surveys.

Producing a continuous attribute surface which is based on soil forming factors creates an enhanced soil map. Digital soil mapping techniques can be used to capture the spatial structure of soil variation and can be used successfully in soil surveys.

In order to achieve an accurate depiction of the soil attributes for the Lake Cootharaba catchment a DSM approach was used. This consisted of developing a quantitative predictive model based on sampling the accessible areas and combining with readily available ancillary spatial data representing soil forming factors (covariates). It was based on the principles of ‘scorpan’ modelling (McBratney et al. 2000). Pedometric modelling approaches were used to build a separate quantitative model for the predicted soil properties based on environmental covariates that included local spatial correlation. The local spatial correlation relied on regression kriging which combines a regression of the dependent variable on ancillary variables (such as land surface parameters, remote sensing imagery and thematic maps) with simple kriging of the regression residuals (Hengl, Heuvelink & Rossiter 2007).

Attributes in bold from Table 1 were calculated on the standard derived one arc second hydrological enforced SRTM DEM (30 m grid). Spatially correlated secondary information together with regression kriging was utilised to improve the accuracy of soil property prediction.

Covariates or ancillary information used to spatially predict the soil limitations (Table 2) included: elevation, slope (Figure 6), airborne (400 m runs) gamma-ray spectrometry, K (potassium), Th (thorium), U (uranium), TPI, topographic wetness index (TWI) (Figure 7), SAGA (System for Automated Geoscientific Analyses) wetness, plan curvature, multi-resolution index of valley bottom flatness (MRVBF) (Figure 8), multi-resolution index of the ridge top flatness (MRRTF), solar radiation, magnetics, gravity variation, aspect and solar radiation.

Figure 6 – Example of percentage slope data used

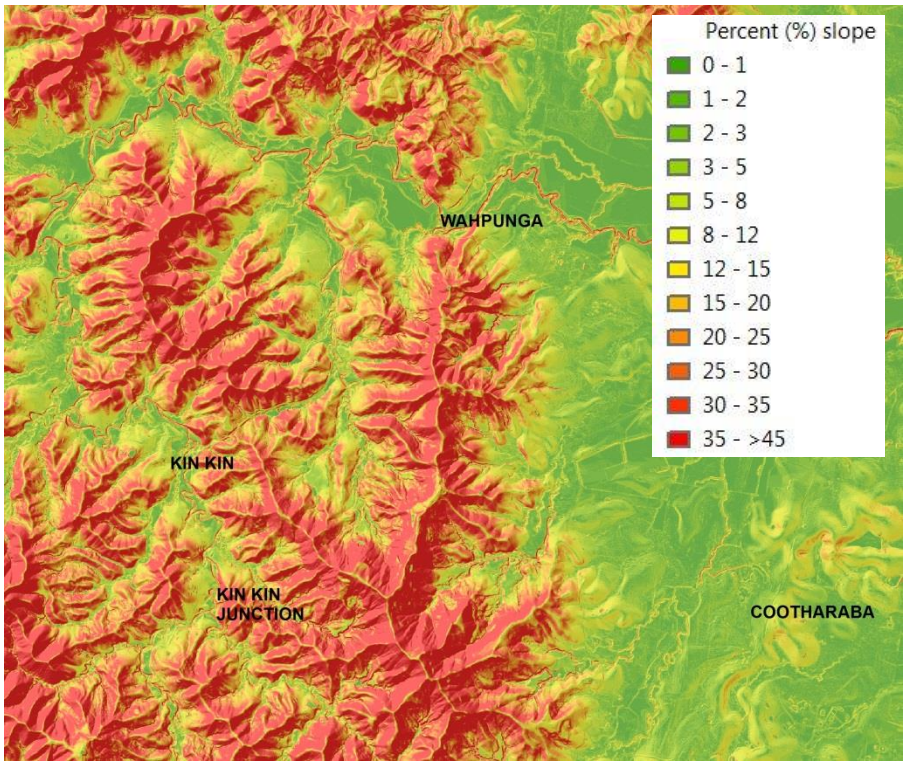
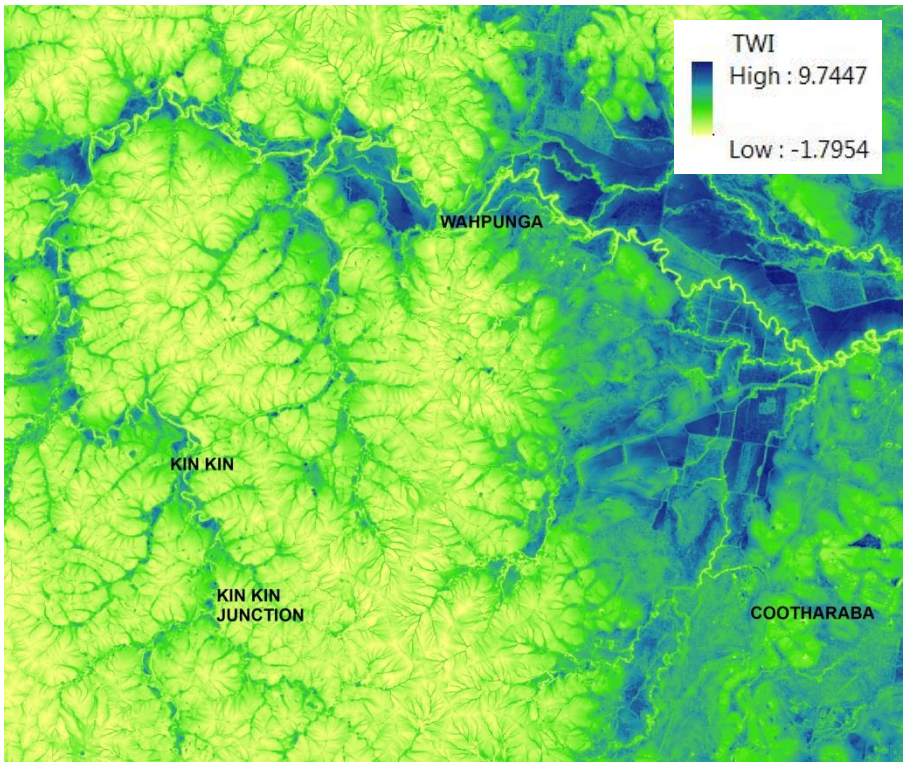
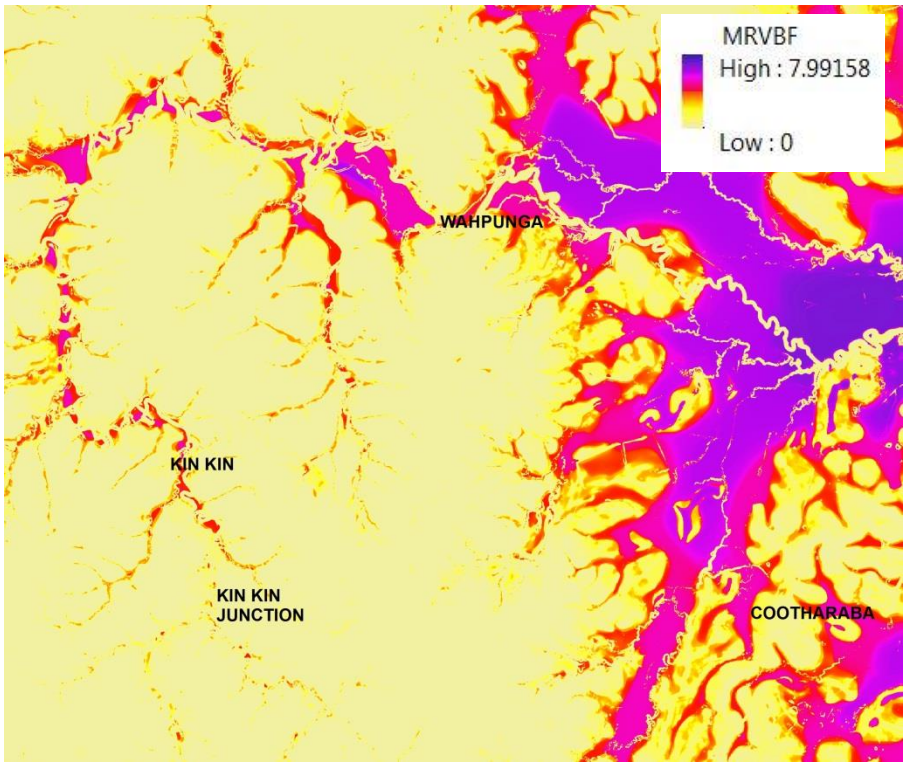


Figure 7 – Example of TWI



To determine the spatial distribution of wetness conditions a TWI and SAGA wetness index was used. TWI relates upslope area as a measure of water flowing towards a certain point, to the local slope, which is a measure of subsurface lateral transmissivity (Grabs et al. 2009). SAGA wetness is similar to TWI but differs in the catchment area calculation in that the flow is not assumed to be a very thin film. This results in valley floors showing higher potential soil moisture which is a more realistic depiction of catchment moisture flows.

Figure 8 – Example of MRVBF index



Airborne gamma-ray spectrometry measures the natural gamma-ray flux emitted from soils and bedrock to a depth of approximately 400 mm (Wilford 2012). It relates largely to the mineralogy and geochemistry of the bedrock and weathered materials and provides a further information source for soil/regolith properties.

MRVBF analysis combines multiple algorithms into a single index using a slope classification that is constrained to convergent areas. The classification algorithm is applied at multiple scales by progressive generalisation of the DEM combined with progressive reduction of the slope class threshold (Gallant & Dowling 2003).

The above covariates were extracted to a 30 m grid for the catchment to produce GIS layers used in the pre-modelling statistical analysis.

Modelling of the soil limitations was carried out using JMP 10 (SAS 2012) and JMP 11 (SAS 2013) using multiple covariate predictors and step-wise regression. This process was applied across the entire catchment, to derive a continuous attribute surface across all lithology groups. The covariates used for each attribute in the modelling process are presented in Table 2. Data transformation was performed on some covariates to produce a normal statistical distribution to aid the modelling process.

Regression kriging was used to develop the catchment wide 30 m grid maps for the soil attributes in Table 3. It is defined as the sum of the regression value of the covariates, or exhaustive variables and the kriging value of the residuals of the regression (Sun, Minasny & McBratney 2012). Application of regression kriging across broad environmental scales also allows robust determination of relationships between soil properties and important ancillary variables (Watt & Palmer 2012).This method has been used in a number of recent studies (Bishop & McBratney 2001; Baxter & Oliver 2005; Minasny & McBratney 2007) and has demonstrated that it can be both a flexible method for modelling and a robust technique for practical application.

Typical distributions of the modelled attributes are illustrated in Figures 9–16.

Table 3 – Ancillary covariates used to predict modelled limitations

Soil attribute	Ancillary covariates
Drainage	Th, elevation, slope, TWI, magnetics
Flooding	MRVBF, TWI
Maximum profile coarse fragments (rockiness)	Th, slope, K, plan curvature, MRRTF, SAGA Wetness, TPI, aspect, magnetics
Maximum soil depth	Th, elevation, slope, U, MRVBF, TPI
PAWC	K, TPI, Th, TWI, magnetics, MRRTF, SAGA wetness
Permeability	Th, elevation, K, U, Th, SAGA wetness, gravity variation
pH (A horizon)	K, elevation, U, K, Th, MRVBF, SAGA wetness, solar radiation
pH (B horizon)	elevation, K, Th, U, SAGA wetness
Slope	DEM

Figure 9 – Predicted drainage in areas surrounding Kin Kin

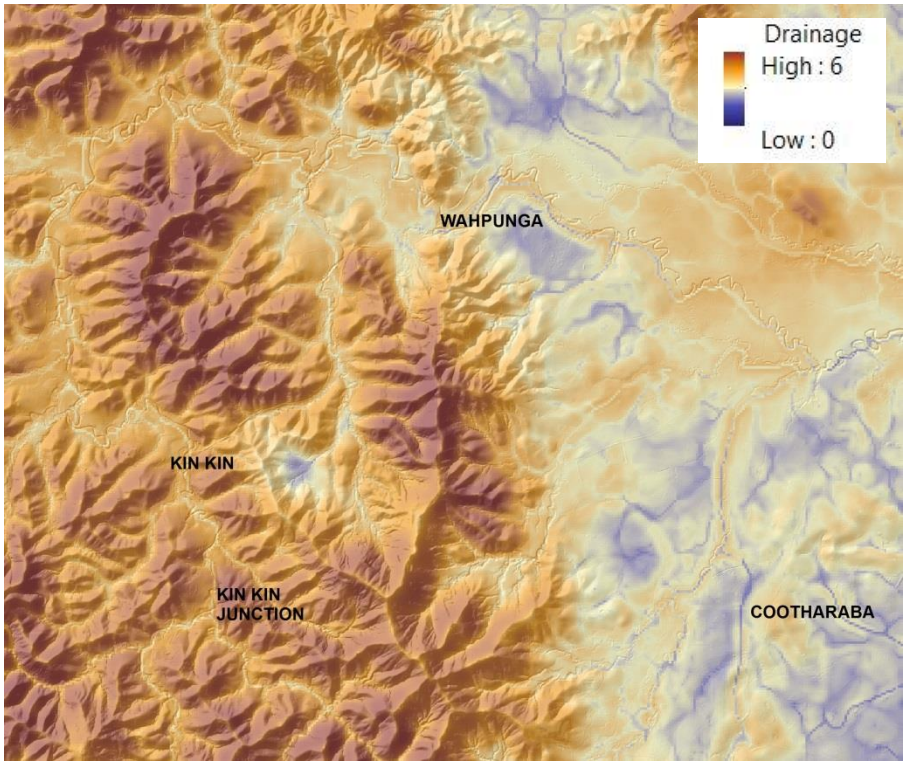


Figure 10 – Predicted permeability in areas surrounding Kin Kin

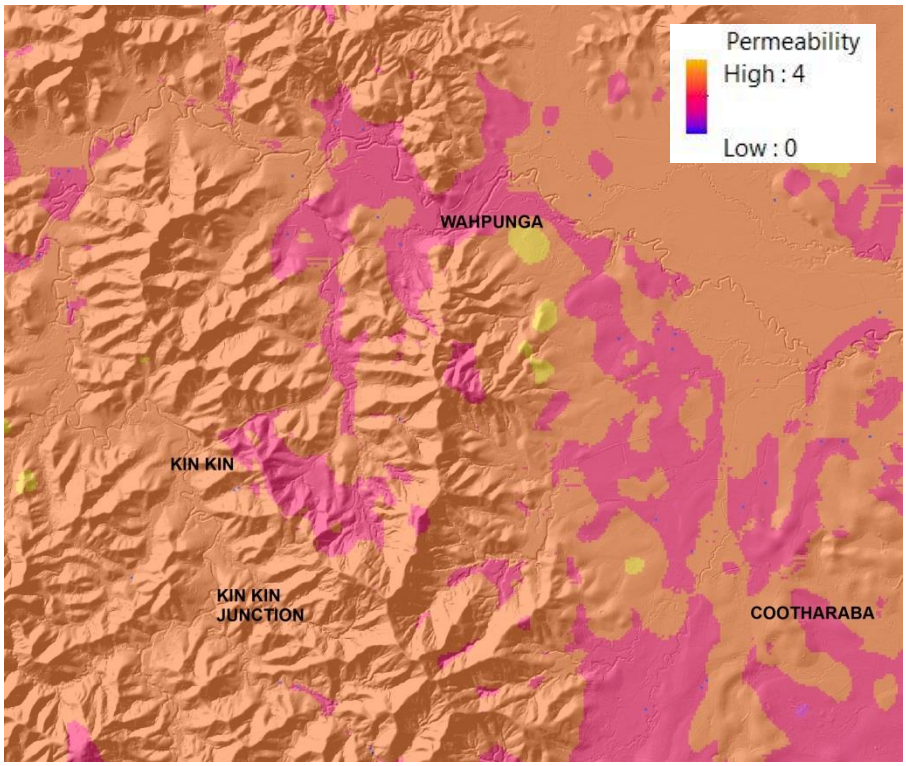


Figure 11 – Predicted maximum soil depth (m) in areas surrounding Kin Kin

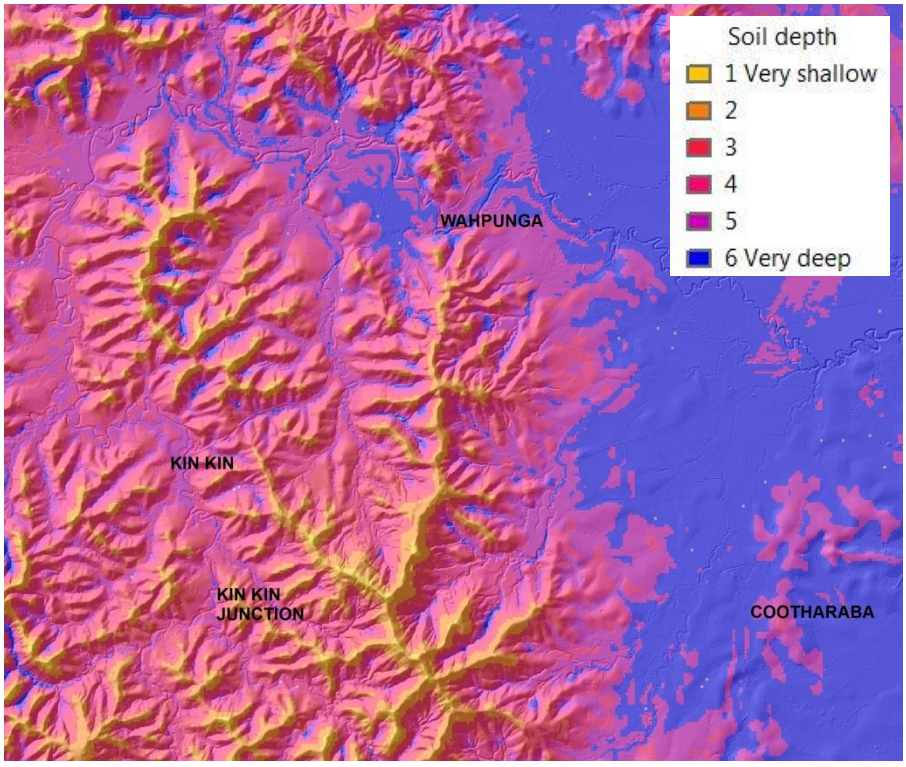


Figure 12 – Predicted A horizon pH in areas surrounding Kin Kin

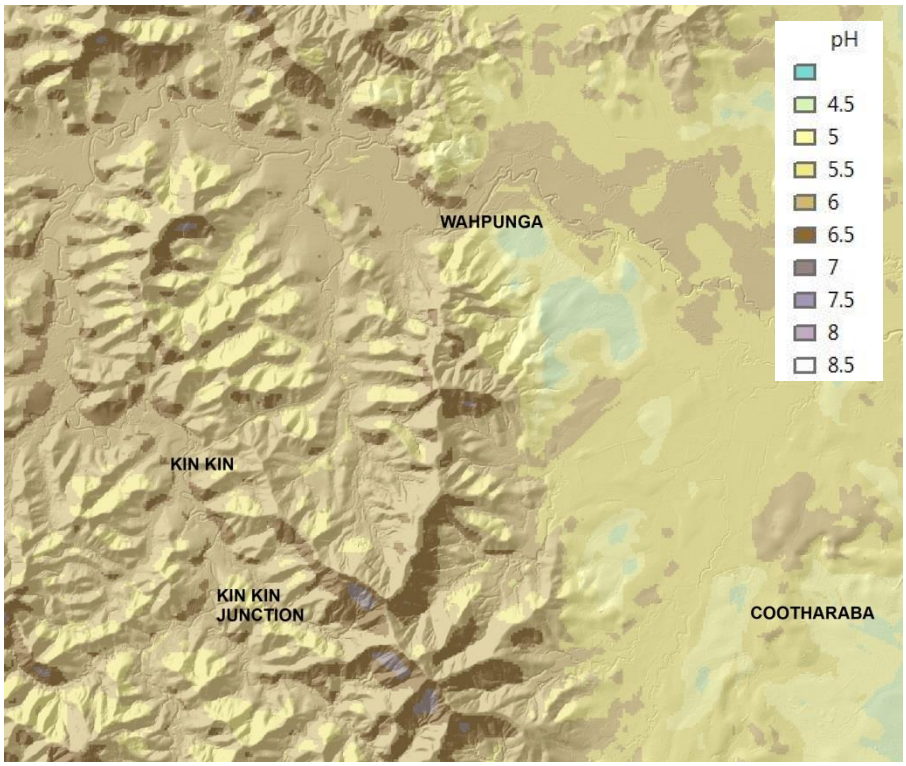


Figure 13 – Predicted B horizon pH in areas surrounding Kin Kin

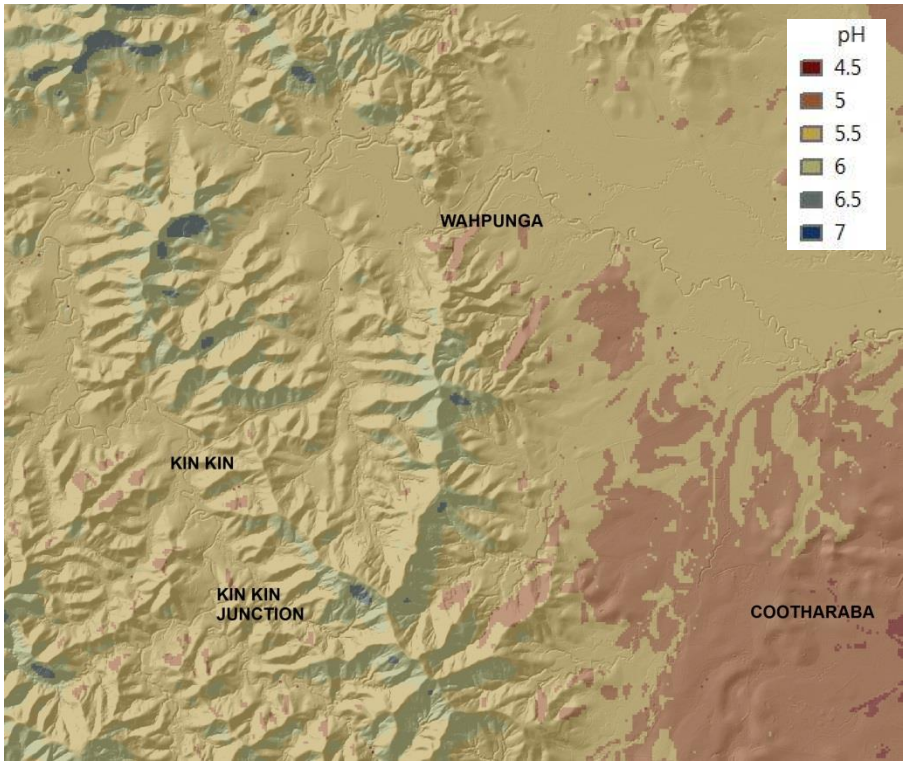


Figure 14 – Predicted maximum rockiness (%) in areas surrounding Kin Kin

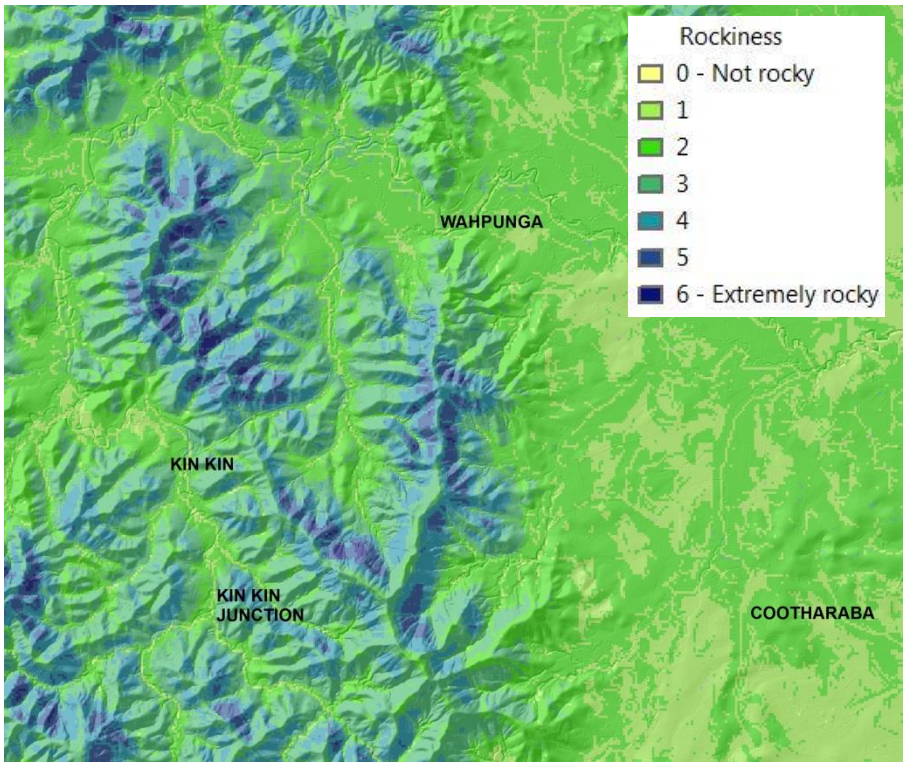


Figure 15 – Predicted PAWC (mm) in areas surrounding Kin Kin

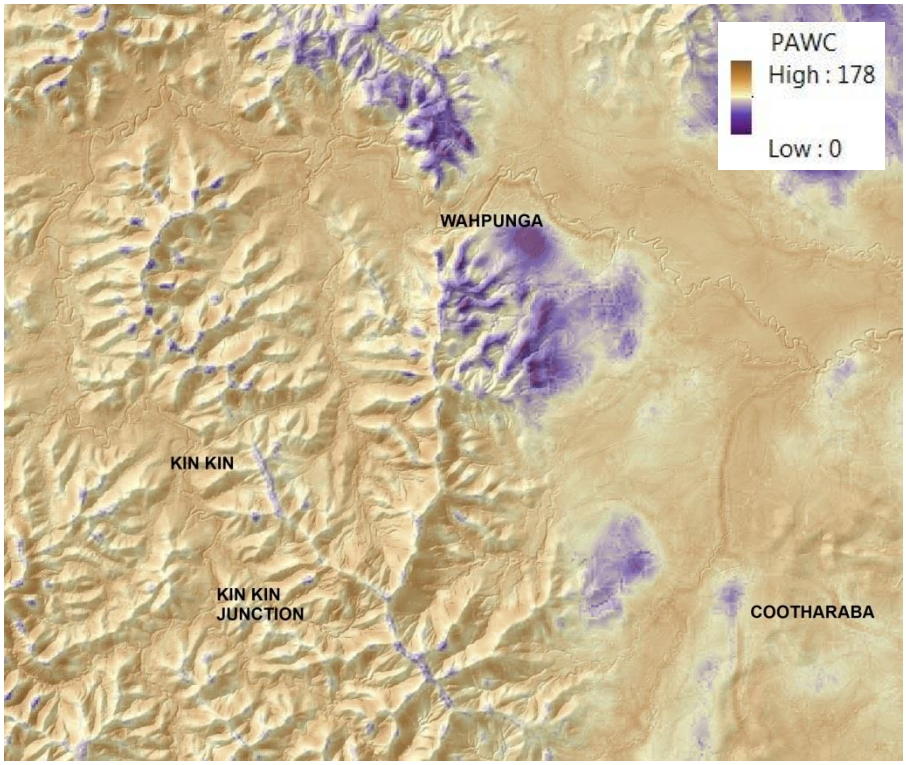
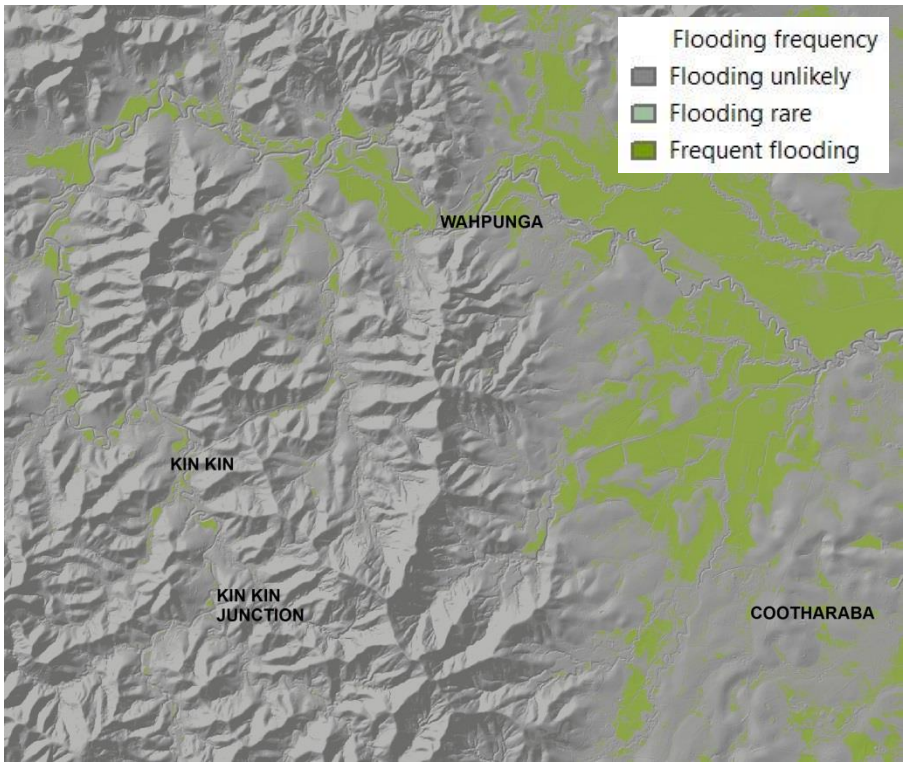


Figure 16 – Predicted flooding frequency in areas surrounding Kin Kin



Verification of results

Thirty-four randomly selected sites from across the study area were described and their measured and modelled attribute values compared to test the accuracy of the modelled data. The key areas of verification were:

- selected sites were located within the correct UMA as mapped
- measured soil and landscape attributes correlated with those predicted.

The results of the verification exercise are presented in Table 4.

Table 4 – Per cent (%) correlation between measured and modelled attribute values

Attributes	Kin Kin bed geology	Alluvium	Others (combined)	Overall
UMA/SPC	90	60	65	74
pH (A horizon)[#]	89	100	75	82
pH (B horizon)[#]	89	80	75	79
Permeability[#]	89	40	18	41
Drainage[#]	33	60	65	56
Slope[#]	55	80	60	62
Soil depth[#]	56	60	75	68
PAWC[#]	44	60	40	44

Attributes	Kin Kin bed geology	Alluvium	Others (combined)	Overall
Maximum rockiness	78	80	55	65
Average	**87**	**68**	**59**	**63**

Tolerances – PAWC within 10 mm, pH within 0.5, slope within 5%, soil depth within 0.25 m. No tolerance allowed for permeability or drainage.

Most attributes were predicted to a satisfactory level by the modelling process and predictions were comparable to, or better than, values obtained in other modelled or traditional land resource studies.

The lowest correlation between predicted and actual values occurred for permeability and PAWC. The PAWC result can be explained by comparing the PAWC values for the validation sites to those of the sites used by the model. Many of the validation PAWC values far exceeded those of the previous sites and thus the model under predicted the values at the validation sites.

Soils and soil-landscape units

The study area was divided into dominant lithology groups for modelling. Lithology describes the rock or parent material type found in association with a particular soil type or types. Lithology was used in preference to geology grouping as it is more specific. A geology unit may contain many different lithology types some of which have no influence on the soil observed, or alternatively a lithology unit may exist across more than one geology type. For example, sandstone derived soils with similar characteristics derived from the labile sandstone lithology group could be from either the Tiaro Coal Measures or Myrtle Creek Sandstone geology types.

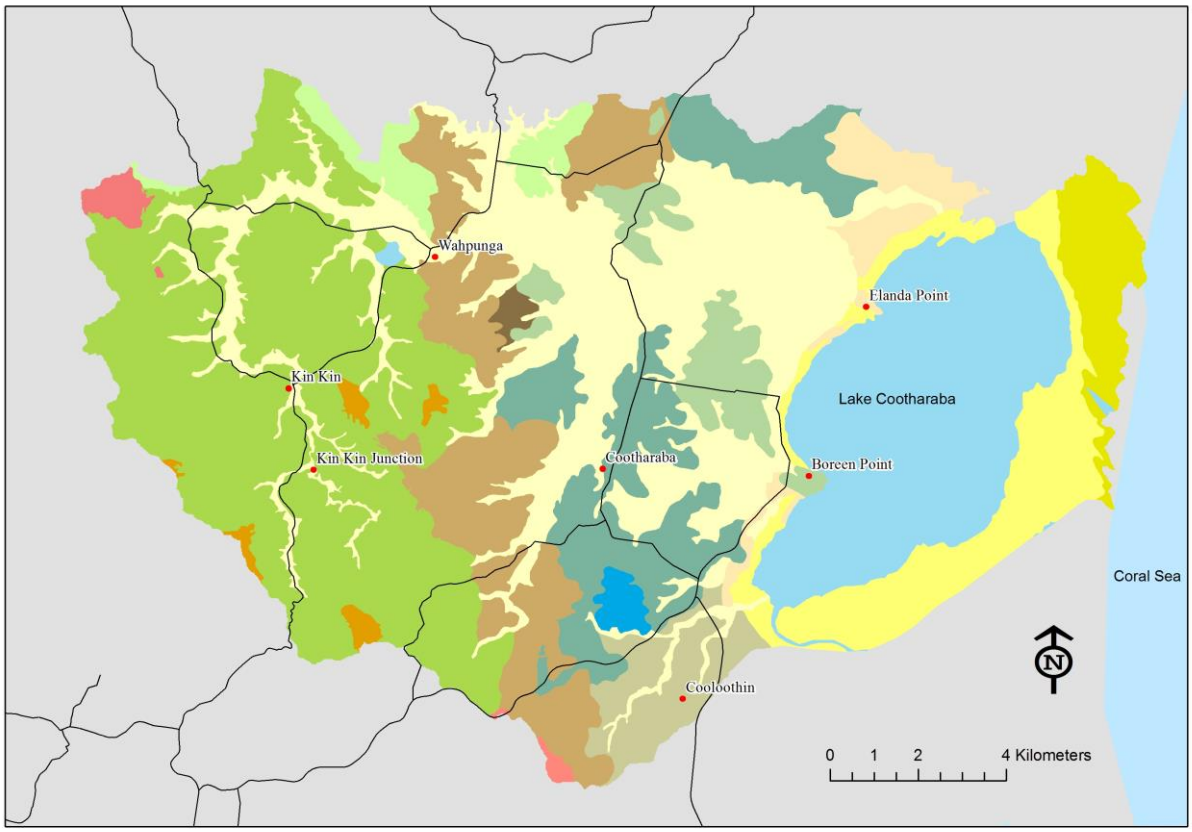
Each lithology group contains a number of soil units based on specific field assessment derived soil characteristics and is linked by common parent materials and soil forming processes (weathering, leaching, translocation, accumulation of clays, waterlogging). These lithology groups directed the modelling within each lithology and are described in Table 5 and shown spatially in Figure 17.

Table 5 – Lithology groups and their corresponding geologies (Cranfield 1999)

Lithology group	Lithology	Geology unit code
Coastal dunes and associated swales	Sand	Qhd, Qpb-SEQ, Qpd
Beach ridges	Sand, silt, clay	Qhd, Qpb-SEQ, Qpd
Quaternary alluvium – stream alluvia	Clay, silt, sand and gravel	Qa
Quaternary alluvium – active and extratidal lake alluvia	Mud, sand, peat	Qc, Qhl/c, Qa, Qlc, Ql/s, minor Qcw
Myrtle Creek Sandstone – northern and eastern facing slopes	Quartzose sandstone, orthoquartzite	RJdm
Myrtle Creek Sandstone – southern and western facing slopes	Quartzose sandstone, orthoquartzite	RJdm
Myrtle Creek Sandstone on rises	Quartzose sandstone, orthoquartzite, sublabile to labile sandstone, siltstone, shale	RJdm
Tiaro Coal Measures	Lithofeldspathic labile and sublabile sandstone, siltstone, shale, minor coal	Jdt, Jdt(w)
Deeply Weathered Myrtle Creek Sandstones and Tiaro Coal Measures	Weathered sandstone, siltstone, shale, mudstone	RJdm(w), Jdt(w), Qr-SEQ>Jdt
Phyllites	Arenite, argillite, phyllite	Rk
Granites	Granite, granodiorite	Rgw/g
Rhyolitic tuff	Tuff	Rv
Rhyolites	Rhyolite	Ti
Neogene basalts	Olivine basalt, minor tuff and andesite	Tb-SEQ

Descriptions of the soil-landscape models, the units within each of the broader lithology groups and their suitability limitations are shown in Figures 18–37. Soil profile classes (SPCs) are defined in Appendix 6, while limitations and their codes are defined in Appendix 3. Limited soil samples were collected for chemical analysis to assist with soil classification, the results of these analyses are presented in Appendix 4.

Figure 17 – Distribution of lithology groups within the Lake Cootharaba catchment



Lithology groups

- Coastal Dunes
- Beach Ridges
- Deeply Weathered Sandstone
- Granite
- Myrtle Creek Sandstone - Northern & Eastern Slopes
- Myrtle Creek Sandstone - Southern and Western Slopes
- Stream Alluvia
- Lake/Marine Alluvia
- Tertiary Rhyolite
- Rhyolitic Tuff
- Myrtle Creek Sandstone - Rises
- Phyllite
- Tertiary Basalt
- Tiaro Coal Measures - Mudstone
- Tiaro Coal Measures - Fine Sandstone
- Tiaro Coal Measures - Sand

Coastal dunes and associated swales (Qhd, Qpb-SEQ, Qpd)

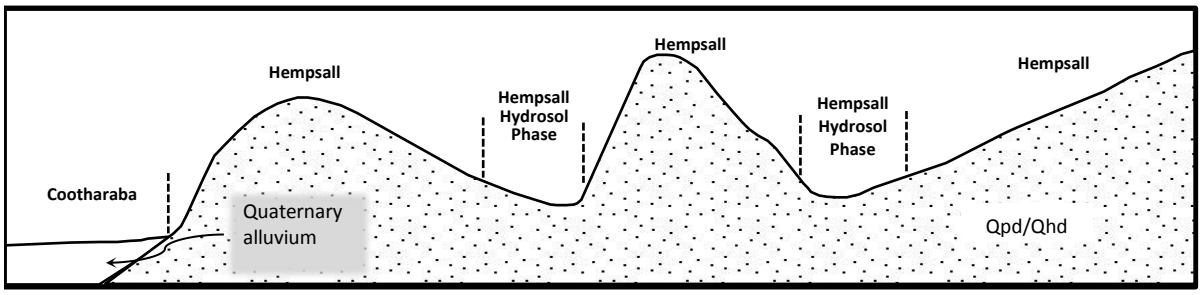
Coastal Pleistocene and Holocene dune fields comprise sands deposited during previous sea level rises and reworked into large beach ridges (dunes). This group excludes lake alluvia and coastal marine deposits.

Linear Pleistocene ridges are located further from the coast and generally oriented in a north-west to south-east direction. Additionally, these ridges are characterised by a succession of cemented sand layers and coffee rock at various depths tracing the fluctuations in groundwater mineral deposition over time. This formation results in the ‘coloured sand’ patterns on exposed profiles.

Holocene ridges are also linear but located closer and more parallel to the current coastline. Many areas of Holocene beach ridges are actively eroding and/or aggrading. Whilst they show less profile development than Pleistocene age sands they share many defining soil characteristics and have, therefore, been included in the same SPC

Soils are deep to very deep, sandy, highly permeable, poorly to rapidly drained (depending upon landscape position and degree of cementation) Podosols.

Figure 18 – Soil-landscape units of the coastal dunes and associated swales



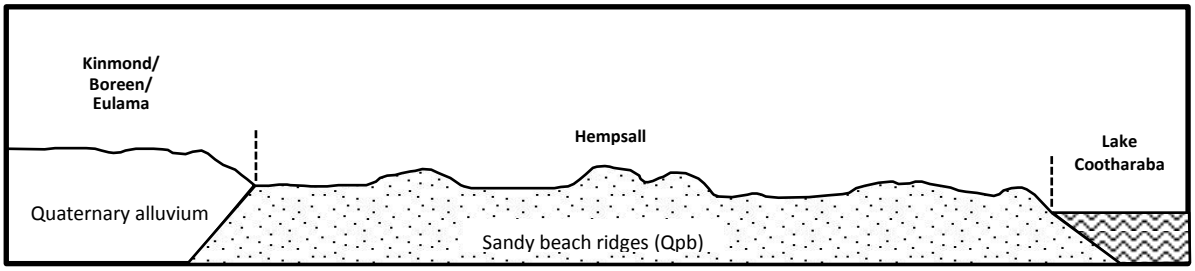
Soil	Area (ha)	Soil descriptions	Landform	Limitations
Hempsall (Semi-aquic or Aquic Podosol)	644	Deep to very deep, uniform soils subject to short to long-term saturation. Black or grey sand to sandy clay loam overlying organic grey, brown and black sand to clayey sands dominated by the accumulation of organic-aluminium/iron compounds.	Crests and slopes of rolling low hills and gently undulating rises on Pleistocene and Holocene dune fields.	**Dp3** – PASS[#] between 2 and 3 m deep **F1** – Flooding <1 in 10 years **M6** – <50 mm PAWC **Nd4** – Phosphorus (P) <5 ppm **W1** – Imperfectly drained, highly permeable at 1 m **W3** – Poorly drained, highly permeable at 1.5 m
Hempsall Hydrosol Phase (Oxyaquic Hydrosol)	107	Deep to very deep, uniform soils subject to short to long-term saturation. Black or grey sand overlying organic grey sand with seasonal or permanent water table.	Wet or swampy, narrow to wide linear swales in low-lying, relict areas between undulating dunes. Largely within Pleistocene dune fields.	**Dp3** – PASS between 2 and 3 m deep **F1** – Flooding <1 in 10 years **M6** – <50 mm PAWC **Nd4** – P <5 ppm **W1** – Imperfectly drained, highly permeable at 1 m **W3** – Poorly drained, highly permeable at 1.5 m

PASS – potential acid sulfate soil

Beach ridges (Qhd, Qpb-SEQ, Qpd)

Relict (and often truncated) Pleistocene beach ridges west and north-west of Lake Cootharaba and areas west and south of Boreen Point, formed by past lake wave action and modified by wind into long, narrow, low ridges perpendicular to the wind direction. In this instance they are oriented from south-west to north-east and slightly curved with a convex toward the north-west following the current outline of Lake Cootharaba.

Figure 19 – Soil-landscape units of the low beach ridges

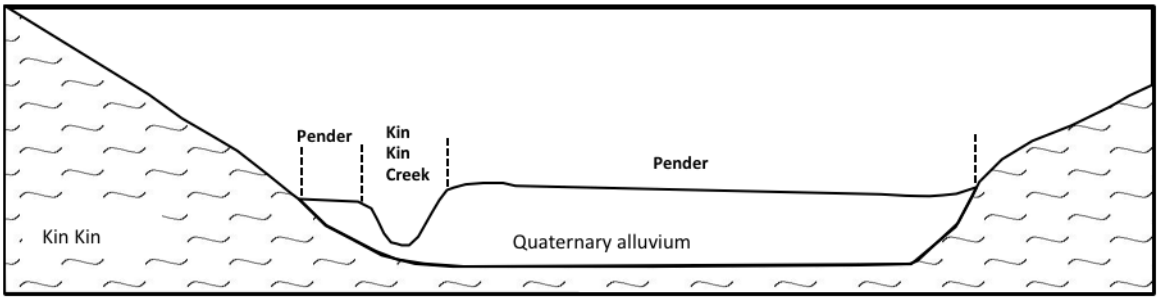


Soil	Area (ha)	Soil descriptions	Landform	Limitations
Hempsall (Semi-aquic or Aquic Podosol)	622	Deep to very deep, uniform soils subject to short to long-term saturation. Black or grey sand to sandy clay loam overlying organic grey, brown and black sand to clayey sands dominated by the accumulation of organic-aluminium/iron compounds.	Long, low beach ridges and adjacent level plains with relief generally less than 2 m. Slopes are level to very gently inclined (0–3%).	**Dp3** – PASS between 2 and 3 m deep **F1** – Flooding <1 in 10 years **M6** – <50 mm PAWC **Nd4** – P <5 ppm **W1** – Imperfectly drained, highly permeable at 1 m **W3** – Poorly drained, highly permeable at 1.5 m

Quaternary alluvium – stream alluvia (Qa)

Alluvial plains, flood plains and minor terraces and levees surrounding Kin Kin Creek and its tributaries. Red and Brown (rarely grey or yellow) Dermosols on phyllite derived alluvial plains, flood plains terraces and levees surrounding Pender Creek, Wahpunga Creek, Yellow Creek, the western extents of Kin Kin Creek and related small tributaries. Slope 0–5%.

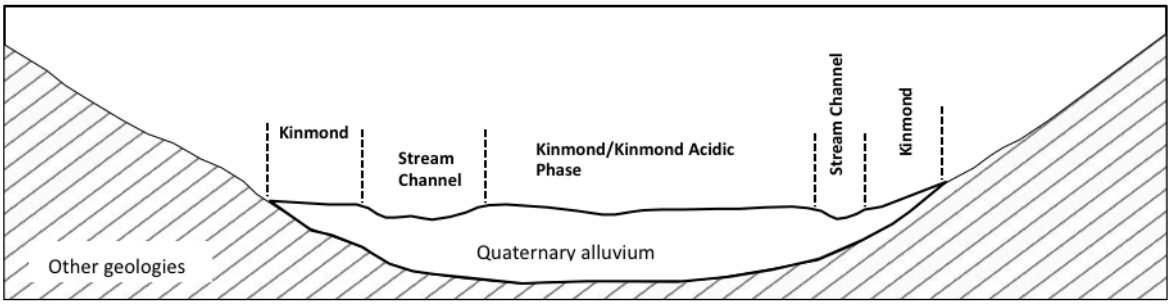
Figure 20 – Soil-landscape units of the phyllite derived alluvium



Soil	Area (ha)	Soil descriptions	Landform	Limitations
Pender (Brown or Red Dermosol; rarely Grey and Yellow Dermosol)	518	Phyllite derived, deep to very deep, brown, gradational soils. Brown and grey clay loams to light medium clays (often silty) overlying frequently mottled, red, brown or yellow light to medium heavy clays.	Alluvial plains, flood plains and terraces. Slope 0–5%.	**F2** – Flooding occurs approximately 1 in 5 years **W3** – Imperfectly drained, moderately permeable

Sandstone (RJdm and Jdt) derived alluvial plains overlying a range of other geologies. Flood plains and minor terraces associated with Kinmond Creek, Scrubby Creek, Sandy Creek, Banyan Creek, sections of Eulama Creek and the low lying areas north of Kin Kin Creek along the Gympie to Kin Kin Road, extending to the base of the surrounding ranges. Includes many unnamed small tributaries originating from the hills surrounding these areas and low lying areas west of Lake Cootharaba. Brown and Grey Dermosols with areas of Grey Sodosols and Hydrosols Slope 0–1.5%.

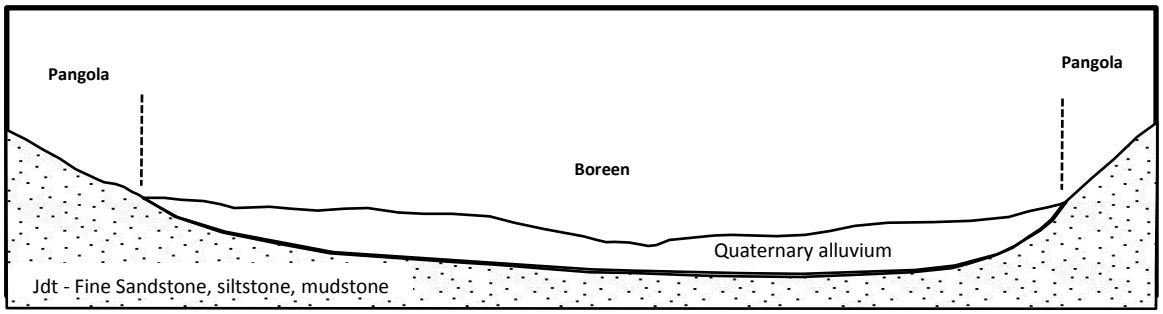
Figure 21 – Soil-landscape units of the sandstone derived alluvium



Soil	Area (ha)	Soil descriptions	Landform	Limitations
Kinmond (Grey or Brown Dermosol; Grey Sodosol; Redoxic Hydrosol)	2 040	Sandstone derived deep to very deep, grey (rarely brown) soils often with buried horizons at depth. Black, brown and grey loamy sand to light clays overlying brown or grey sandy clay loam to medium heavy clay.	Alluvial plains, flood plains and terraces, valley flats and lower slopes of gently undulating rises. Slope 0–1.5%.	**F2** – Flooding occurs approximately 1 in 5 years **W1** – Imperfectly drained, moderately permeable **W3** – Imperfectly drained, moderately permeable
Kinmond Acidic Phase (Grey Dermosol; Grey or Black Vertosol; Oxyaquic Hydrosol)	253	Acidic deep to very deep, grey and black, gradational (or rarely texture contrast soils) often with buried horizons at depth. Black or grey loamy sand to light medium clays (often silty or sandy) overlying grey or black light to medium heavy clay (frequently mottled or sandy). Includes many acid sulfate soils.	Alluvial plains, flood plains and swamps. Slope 0–1.5%.	**Dp3** – PASS between 2 and 3 m deep **F2** – Flooding occurs approximately 1 in 5 years **W1** – Imperfectly drained, moderately permeable **W3** – Imperfectly drained, moderately permeable **Nt4** – Soil pH at 0.6 m <5.0

Acidic Vertosols and Hydrosols on alluvial plains, flood plains and swamps in low lying areas west of Lake Cootharaba and the Boreen Township. Slope 0–1.5%.

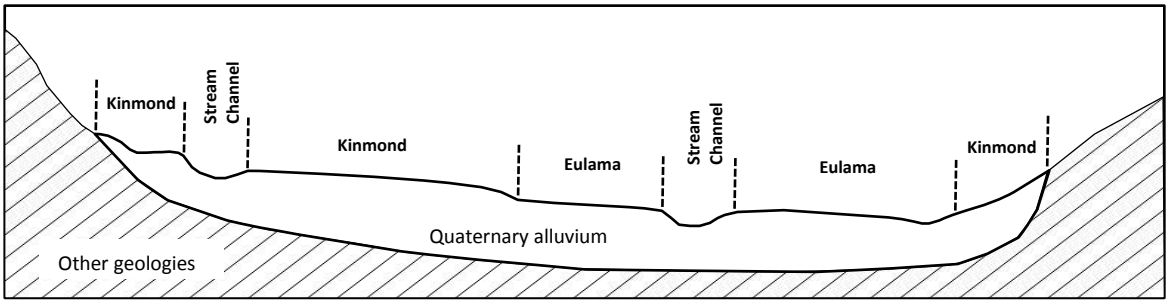
Figure 22 – Soil-landscape units of the acidic flood plains west of Boreen Point



Soil	Area (ha)	Soil descriptions	Landform	Limitations
Boreen (Grey or Aquic Vertosol; Redoxic Hydrosol)	506	Strongly acidic deep to very deep, grey, gradational or texture contrast soils frequently with at least one buried horizon at depth. Grey or black clay loam to light medium clay overlying grey light to medium clay. Includes many acid sulfate soils.	Alluvial plains, flood plains and swamps. Slope 0–1.5%.	**Dp3** – PASS between 2 and 3 m deep **F2** – Flooding occurs approximately 1 in 5 years **W1** – Poorly drained, moderately permeable **W2** – Poorly drained, moderately permeable **W3** – Poorly drained, moderately permeable **Nd4** – P <5 ppm **Nt4** – Soil pH at 0.6 m <5.0

Brown, Yellow and Grey Dermosols on alluvial plains, flood plains and minor terraces derived from a mixture of parent materials including phyllite and sandstones. Found in areas associated with Wahpunga Creek, Yellow Creek, sections of Eulama Creek and the lower reaches of Kinmond Creek and Sandy Creek. This unit extends to include large areas surrounding Kin Kin Creek north-west of Lake Cootharaba. Slope 0–3%.

Figure 23 – Soil-landscape units of the mixed parentage flood plains



Soil	Area (ha)	Soil descriptions	Landform	Limitations
Eulama (Grey, Brown or Yellow Dermosol; Redoxic Hydrosol)	1 842	Acidic to neutral alluvial soils. Deep to very deep, brown, yellow and grey gradational (non-cracking) soils. Black, brown or grey sandy clay loam to light clay (often silty) overlying grey, brown or yellow light to medium heavy clay.	Alluvial plains, flood plains and minor drainage depression and terraces. Slope 0–3%.	**F2** – Flooding occurs approximately 1 in 5 years **W1** – Imperfectly drained, moderately permeable **W3** – Imperfectly drained, moderately permeable
Eulama Buried Variant (Brown or Yellow Dermosol; Brown Kurosol)	204	Acidic to neutral alluvial soils. Deep to very deep, brown and yellow gradational or texture contrast soils. Brown or grey sandy loam to light clay (often silty or sandy) overlying buried horizons of brown or yellow light to medium clay.	Alluvial plains, flood plains and minor terraces. Slope 0–2%.	**F2** – Flooding occurs approximately 1 in 5 years **W1** – Imperfectly drained, moderately permeable **W3** – Imperfectly drained, moderately permeable

Quaternary alluvium – active and extra-tidal lake alluvia (Qc, Qhl/c, Qa, Qlc, Ql/s, Qcw)

Organic, wet, acidic, very deep, grey gradational soils with a peaty surface horizon.

Figure 24 – Soil-landscape units of the alluviums east of Lake Cootharaba

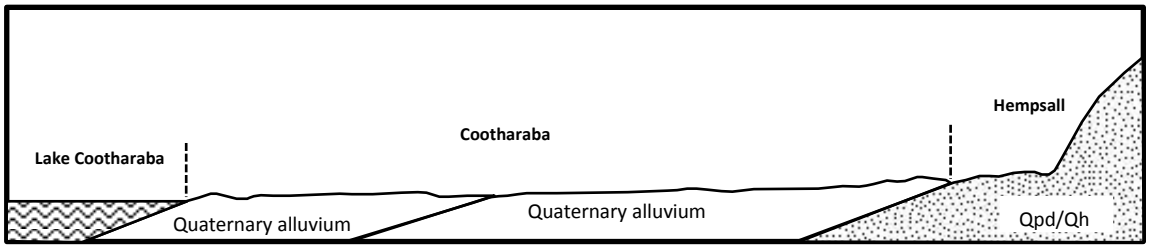
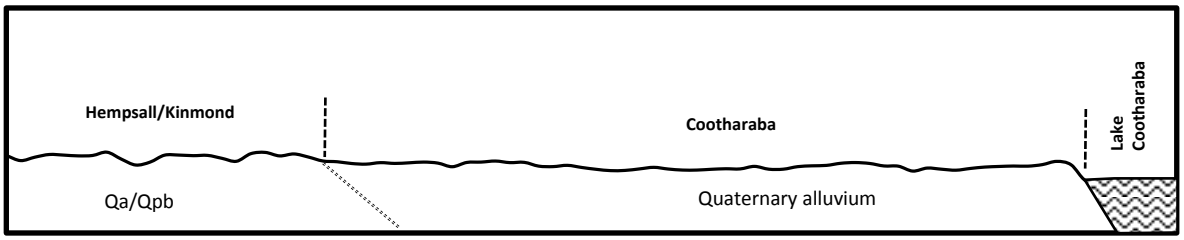


Figure 25 – Soil-landscape units of the alluviums west of Lake Cootharaba



Soil	Area (ha)	Soil descriptions	Landform	Limitations
Cootharaba (Oxyaquic or Redoxic Hydrosol; Extra-tidal Hydrosol)	1 810	Organic, wet, acidic, deep to very deep, black or grey sandy uniform or gradational soils subject to seasonal or permanent inundation. Frequently with underlying buried horizons.	Very low lying, level, tidal and non-tidal plains, open depressions, swamps and relict beach ridges surrounding Lake Cootharaba. Slope <1.5%.	**Dp3** – PASS between 2 and 3 m deep **F2–3** – Flooding between 1 in 2 years to 1 in 5 years **M6** – <50mm PAWC **Nd4** – P <5 ppm **W1** – Very poorly drained **W2** – Very poorly drained **W3** – Very poorly drained **X3** – Practical production area 2.5–5 ha

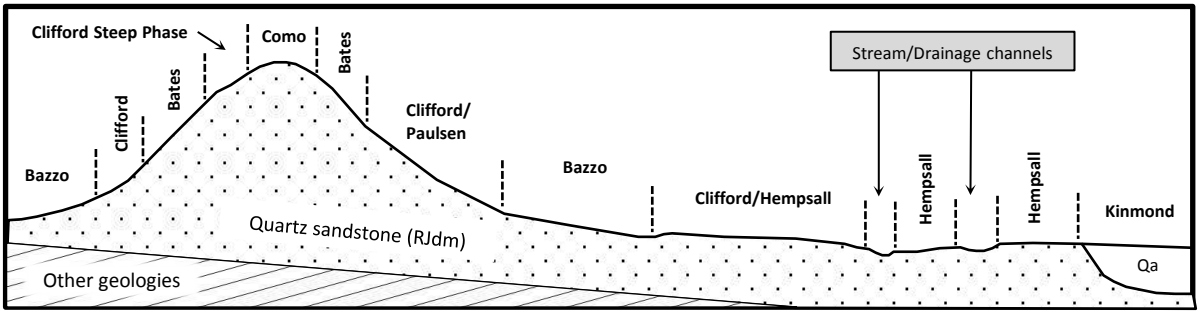
Myrtle Creek Sandstones (RJdm)

Hills, rises, fans, plains and drainage depressions on Myrtle Creek Sandstone (RJdm) giving rise to a wide variety of soils throughout the central catchment and along the northern and southern catchment boundaries. A range of soils are present, generally characterised by sandy A horizons overlying sandy loam to sandy clay subsoils. Soil characteristics are dependent upon degree of weathering as determined by aspect, landform and landscape position.

Northern and eastern facing slopes

Soil types range from Kurosols, Tenosols and Red and Brown Dermosols at higher elevations through midslopes with Brown and Yellow Dermosols and Kandosols and Kurosols. Lower slopes are characterised by Yellow and Grey Kurosols grading into Podosols at lower elevations, with Hydrosols in drainage lines.

Figure 26 – Soil-landscape units of the northern and eastern facing Myrtle Creek Sandstone slopes



Soil	Area (ha)	Soil descriptions	Landform	Limitations
Como (Brown or Grey Kurosol; Brown Sodosol)	255	Moderately deep to very deep, mottled, brown and grey, texture contrast soils. Black, brown and grey loamy sands to light clays overlying frequently mottled, acidic brown or grey sandy light clay to medium heavy clays on	Crests and ridges of steep, rolling and undulating hills, low hills and rises. Slope <1–8%.	**E(B3)** – Unstable soils 3–5% slope **RG2** – 2–10% coarse gravel **W1** – Imperfectly drained, moderately permeable **W3** – Imperfectly drained, slowly

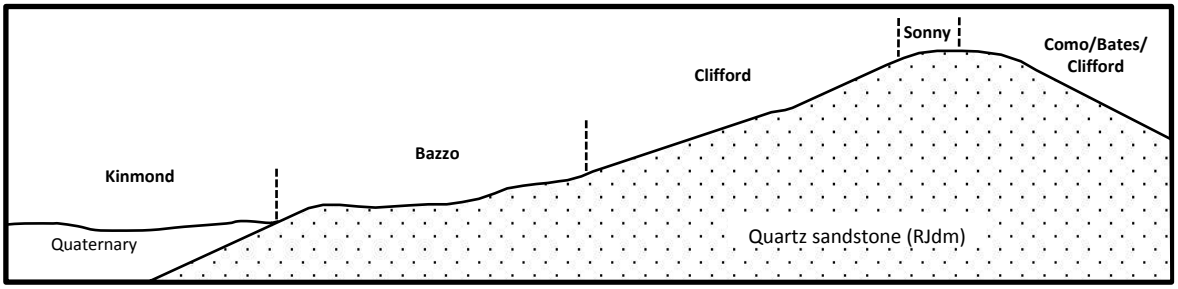
Soil	Area (ha)	Soil descriptions	Landform	Limitations
		sandstone.		permeable **X4** – Practical production area 1.5–2.5 ha
Bates (Leptic Tenosol; Red or Brown Dermosol; Red Kurosol)	135	Very shallow to shallow red and brown, texture contrast and gradational soils on steep slopes of Myrtle Creek sandstone.	Upper and mid slopes of steep and rolling hills. Slope 20–50%.	**E(A7)** – Stable soils, slope >20% **M5** – 50–75 mm PAWC **Pd3** – soil depth 0.3–0.5 m **RM4** – 20–50% medium gravel **Ts6** – Slope >30% **X5** – Practical production area <1.5 ha
Clifford (Red or Brown Kandosol; Brown Dermosol)	853	Deep to very deep, red or brown gradational soils. Red, black, brown and grey sandy loam to sandy clay loam overlying occasionally mottled red or brown sandy loam to light medium clay on Myrtle Creek sandstone. Lower and foot slopes may overlie unconsolidated sediments.	Mid and lower slopes of rolling hills and low hills and undulating and gently undulating rises. Slope 5–25%. Includes pediments and minor fans on mid and lower slopes of steep, rolling and undulating hills, low hills, rises and plains. Slope 2–15%.	**E(A5)** – Stable soils, slope 12–15% **Ts5** – Slope 20–30% **X5** – Practical production area <1.5 ha
Clifford Steep Phase (Brown Dermosol)	16	Moderately deep to deep, brown gradational soils. Brown or grey clay loam to light medium clay overlying occasionally mottled brown light to medium heavy clay on slopes of Myrtle Creek sandstone.	Mid and upper slopes of steep and rolling hills. Slope >20%.	**E(A7)** – Stable soils, slope >20% **M5** – 50–75 mm PAWC **Pd3** – Soil depth 0.3–0.5 m **RM4** – 20–50% medium gravel **Ts6** – Slope >30% **X5** – Practical production area <1.5 ha
Paulsen (Brown Kurosol)	67	Moderately deep to very deep, brown, acidic texture contrast soils. Black, brown and grey sand to sandy clay loam surface overlying frequently mottled brown sandy light clay to medium clay on Myrtle Creek sandstone.	Mid slopes of rolling hills and low hills and undulating and gently undulating rises. Slope 8–25%.	**E(A5)** – Stable soils, slope 12–15% **Ts5** – Slope 20–30% **X5** – Practical production area <1.5 ha
Bazzo	906	Moderately deep to very deep, yellow or grey	Mid and lower slopes of rolling	**E(A3)** – Stable soils, slope 5–8%

Soil	Area (ha)	Soil descriptions	Landform	Limitations
(Grey or Yellow Kurosol; Grey Dermosol; Redoxic Hydrosol)		texture contrast (rarely gradational) soils. Black, brown or grey sand to clay loam overlying mottled (sometimes sodic) grey or yellow light to medium heavy clay over Myrtle Creek Sandstone. Lower and foot slopes may overlie unconsolidated sediments.	hills and low hills, undulating and gently undulating rises. Slope 1–10% (some areas up to 20%).	
Hempsall (Semi-aquic or Aquic Podosol)	347	Deep to very deep, uniform soils subject to short to long-term saturation. Black or grey sand to sandy clay loam overlying organic grey, brown and black sand to clayey sands dominated by the accumulation of organic-aluminium/iron compounds.	Flats and lower slopes (rarely broad flat crests) of level plains to rolling rises and undulating hills. Slope <5%. Includes fans on lower slopes steep hills and flats.	**F1** – Flooding <1 in 10 years **M6** – <50 mm PAWC **Nd4** – P <5 ppm **W1** – Imperfectly drained, highly permeable **W3** – Poorly drained, highly permeable

Southern and western facing slopes

Soils of the southern and western facing slopes range from Red and Brown Dermosols on gentle crests of low hills and rises with Red and Brown Dermosols and Kandosols found on midslopes. Lower slopes are occupied by Yellow and Grey Kurosols, Grey Sodosols and occasionally Hydrosols. Lower and foot slopes terminate at the boundary with deep Brown and Grey Dermosols of alluvial origin.

Figure 27 – Soil-landscape units of the southern and western facing Myrtle Creek Sandstone slopes



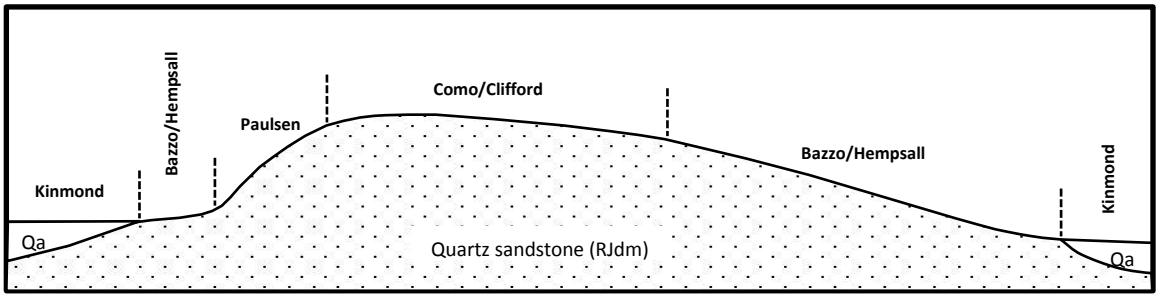
Soil	Area (ha)	Soil descriptions	Landform	Limitations
Sonny (Red or Brown Dermosol)	310	Deep to very deep non-cracking, red and brown gradational soils. Brown light to light medium clays overlying rarely mottled red light medium to medium heavy clays on weathered mudstone or siltstone	Crests and slopes of rolling and undulating low hills and rises. Slope 1–10%.	**E(A3)** – Stable soils, slope 5–8% **W3** – Moderately well drained, moderately permeable **X3** – Practical production area 2.5–5 ha

Soil	Area (ha)	Soil descriptions	Landform	Limitations
Clifford (Red or Brown Kandosol; Brown Dermosol)	96	Deep to very deep, red or brown gradational soils. Red, black, brown and grey sandy loam to sandy clay loam overlying occasionally mottled red or brown sandy loam to light medium clay on Myrtle Creek sandstone. Lower and foot slopes may overlie loose sediments.	Mid and lower slopes of rolling hills and low hills. Slope 5–25%. Includes pediments and minor fans on mid and lower slopes of steep, rolling and undulating hills and low hills. Slope 2–15%.	**E(A5)** – Stable soils, slope 12–15% **Ts4** – Slope 15–20%
Bazzo (Grey or Yellow Kurosol; Grey Dermosol; Redoxic Hydrosol)	108	Deep or very deep, brown texture contrast soils. Black and grey silty or sandy loam overlying acidic, mottled brown and grey light to medium heavy clay over weathered Myrtle Creek sandstone.	Mid and lower slopes of rolling and low hills. Slopes <20%.	**E(A3)** – Stable soils, slope 5–8% **W1** – Imperfectly drained, moderately permeable **W2** – Imperfectly drained, moderately permeable **W3** – Imperfectly drained, slowly permeable

Myrtle Creek Sandstones on low rises

Red and Brown Kandosols and Kurosols dominate the crests and upper slopes of these low rises with lesser areas of Brown Dermosols and Sodosols. Brown Kurosols occupy steep midslopes while Grey and Yellow Kurosols and Dermosols are found on gentler midslopes and lower slopes with occasional Hydrosols and Podosols in areas of very low slope and on flats. Lower slopes and foot slopes terminate at the boundary with deep brown and grey soils of alluvial origin.

Figure 28 – Soil-landscape units of Myrtle Creek Sandstones on low rises



Soil	Area (ha)	Soil descriptions	Landform	Limitations
Como (Brown or Grey Kurosol; Brown Sodosol)	154	Moderately deep to deep, non-sodic, brown (sometimes grey) non-gravely to moderately gravelly texture contrast soils. Loamy sand to sandy clay loam A	Crests, ridges and upper slopes of undulating and gently undulating rises. Slopes <1–8%.	**E(B3)** – Unstable soils 3–5% slope **RG2** – 2–10% coarse gravel **W1** – Imperfectly drained, moderately permeable

Soil	Area (ha)	Soil descriptions	Landform	Limitations
		horizons overlying sandy light medium to medium heavy clays underlain by weathering Myrtle Creek Sandstone.		**W2** – Imperfectly drained, moderately permeable **W3** – Imperfectly drained, slowly permeable
Clifford (Red or Brown Kandosol; Brown Dermosol)	48	Deep to very deep, red or brown gradational soils. Red, black, brown and grey sandy loam to sandy clay loam overlying occasionally mottled red or brown sandy loam to light medium clay on Myrtle Creek sandstone. Lower and foot slopes may overlie unconsolidated sediments.	Crests, ridges and upper slopes of undulating and gently undulating rises. Slopes <1–8%.	**E(B3)** – Unstable soils 3–5% slope **RG2** – 2–10% coarse gravel **W1** – Imperfectly drained, moderately permeable **W2** – Imperfectly drained, moderately permeable **W3** – Imperfectly drained, slowly permeable
Paulsen (Brown Kurosol)	31	Deep to very deep, non-sodic, brown (occasionally red) non-gravely to gravelly gradational and texture contrast soils. Sand to sandy clay loam A horizons overlying sandy loam to sandy medium heavy clay B horizons underlain by weathering Myrtle Creek Sandstone.	Mid and lower slopes of rolling, undulating and gently undulating rises. Slopes 6–20%.	**E(B6)** – Unstable soils >12% **M5** – 50–75 mm PAWC **Ts4** – Slope 15–20% **W1** – Imperfectly drained, moderately permeable **W2** – Moderately well drained, moderately permeable **W3** – Imperfectly drained, moderately permeable **X4** – Practical production area 1.5–2.5 ha
Bazzo (Grey or Yellow Kurosol; Grey Dermosol; Redoxic Hydrosol)	509	Deep or very deep, brown texture contrast soils. Black and grey silty or sandy loam overlying acidic, mottled brown and grey light to medium heavy clay over weathered Myrtle Creek sandstone.	Mid and lower slopes of rises. Slopes <20%.	**E(A3)** – Stable soils, slope 5–8% **W1** – Imperfectly drained, moderately permeable **W2** – Imperfectly drained, moderately permeable **W3** – Imperfectly drained, slowly permeable
Hempsall (Semi-aquic or Aquic Podosol)	124	Deep to very deep, uniform soils subject to short to long-term saturation. Black or grey sand to sandy clay loam overlying organic grey,	Flats and lower slopes (rarely broad flat crests) of level plains to rolling rises. Slope <5%.	**F1** – Flooding <1 in 10 years **M6** – <50 mm PAWC **Nd4** – P <5 ppm **W1** – Imperfectly

Soil	Area (ha)	Soil descriptions	Landform	Limitations
		brown and black sand to clayey sands dominated by the accumulation of organic-aluminium/iron compounds.	May include fans on lower slopes.	drained, highly permeable **W3** – Poorly drained, highly permeable

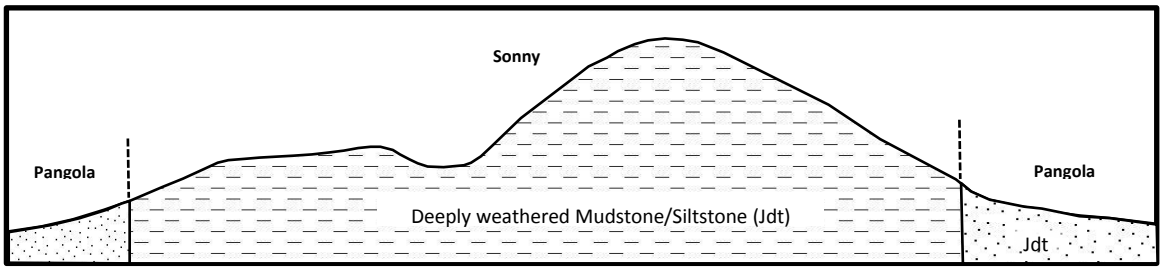
Tiaro Coal Measures (Jdt)

Low hills, rises, fans, plains and drainage depressions of Tiaro Coal Measures (Jdt) in the central and southern catchment east of the Wahpunga Range and west of the Boreen Township and Lake Cootharaba.

Mudstone - Soils on deeply weathered mudstone/siltstone

Isolated area of deep Red and Brown Dermosols south west of Boreen Point formed on crests and slopes of weathered mudstone and sandstone low hills and rises.

Figure 29 – Soil-landscape units on deeply weathered mudstones and siltstones

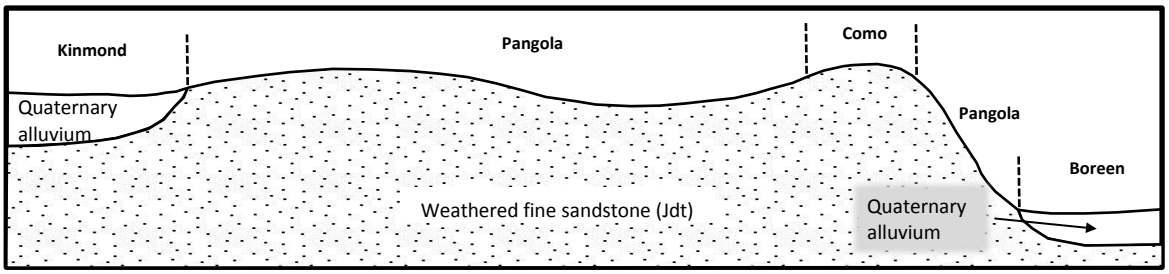


Soil	Area (ha)	Soil descriptions	Landform	Limitations
Sonny (Red or Brown Dermosol)	136	Deep to very deep, red and brown gradational soils. Brown light to light medium clays overlying rarely mottled red light medium to medium heavy clays on weathered mudstone or siltstone.	Crests and slopes of rolling and undulating low hills and rises. Slope 1–15%.	**E(A2)–A4** – Stable soils, slope 2–12%

Fine Sandstone - Soils derived from fine sandstones

Brown and Grey Dermosols and Kurosols found across crests, ridges, slopes and plains of undulating rises on weathered, fine sandstone. Occasional Sodosols and Hydrosols in lower landscape positions e.g. some lower slopes and drainage depressions.

Figure 30 – Soil-landscape units on weathered fine sandstone

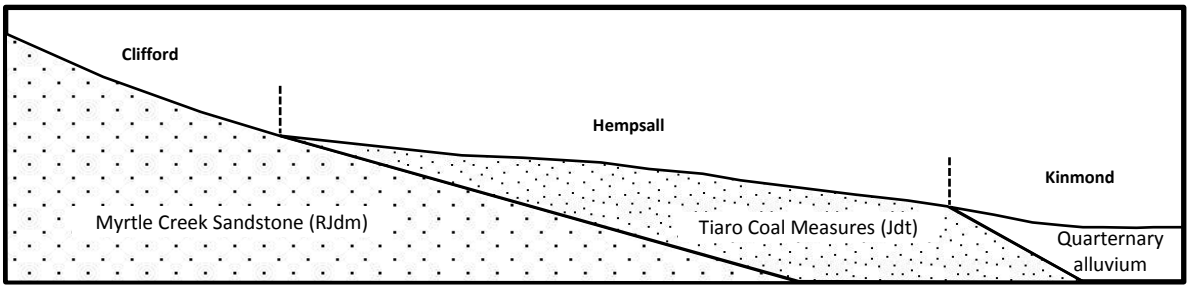


Soil	Area (ha)	Soil descriptions	Landform	Limitations
Pangola (Brown or Grey Kurosol; Brown Dermosol; Redoxic Hydrosol)	1 988	Deep to very deep, brown and grey, texture contrast and gradational soils. Black and grey sandy loams to light clays overlying frequently mottled brown or grey sandy clay loam to medium heavy clays.	Slopes, flats and drainage depressions of very gently inclined gently undulating to rolling rises. Slope 1–20%.	**E(B4)** – Unstable soils, slope 5–8% **F1** – Flooding <1 in 10 years **Nd4** – P <5 ppm **Nt4** – Soil pH at 0.6 m <5.0 **Ts1–4** – Slope <8–20% **W1** – Imperfectly drained, moderately permeable **W3** – Imperfectly drained, slowly permeable
Como (Brown or Grey Kurosol; Brown Sodosol)	207	Moderately deep to very deep, mottled, brown and grey, texture contrast soils. Black, brown and grey loamy sands to light clays overlying frequently mottled, acidic brown or grey sandy light clay to medium heavy clays on sandstone.	Crests and ridges of rolling and undulating rises. Slope <1–8%.	**E(B3)** – Unstable soils, slope 3–5% **RG2** – 2–10% coarse gravel **W1** – Imperfectly drained, moderately permeable **X2–3** – Practical production area 2.5–10 ha

Sand - Uniform sandy soils forming on Tiaro Coal Measures or colluvium derived from Myrtle Creek Sandstone

These soils are deep Podosols, Hydrosols and Tenosols, consisting of poorly structured fine to medium sands, on plains and lower slopes on the eastern extremes of Myrtle Creek Sandstone rises and hills.

Figure 31 – Soil-landscape units exhibiting uniform sandy soils

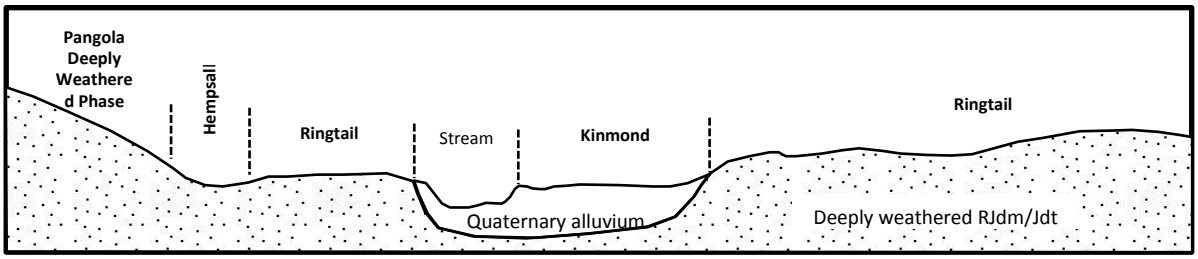


Soil	Area (ha)	Soil descriptions	Landform	Attribute levels
Hempsall (Semi-aquic or Aquic Podosol)	75	Deep to very deep, uniform soils subject to short to long-term saturation. Black or grey sand to sandy clay loam overlying organic grey, brown and black sand to clayey sands dominated by the accumulation of organic-aluminium/iron compounds.	Lower slopes of rolling rises and undulating low hills and hills. Slope <5%.	**E(B3)** – Unstable soils 3–5% slope **F2** – Flooding occurs approximately 1 in 5 years **W1** – Poorly drained, moderately permeable **W3** – Poorly drained, moderately permeable

Deeply weathered Myrtle Creek Sandstones and deeply weathered Tiaro Coal Measures (RJdm(w), Jdt(w), Qr-SEQ>Jdt)

Gently undulating plains and rises to undulating rises of deeply weathered sandstones of Myrtle Creek and Tiaro Coal Measures origin, located in the south of the catchment. Brown and Yellow Dermosols are found on rises while gentler rises and plains give rise to Grey and Brown Kurosols, Sodosols and Hydrosols. Relief ranges between <9 m and <30 m, slopes range from level to 3% with small areas up to 5%. Lithology includes deeply weathered fine sandstone and mudstone.

Figure 32 – Soil-landscape units of the deeply weathered Myrtle Creek Sandstones and deeply weathered Tiaro Coal Measures



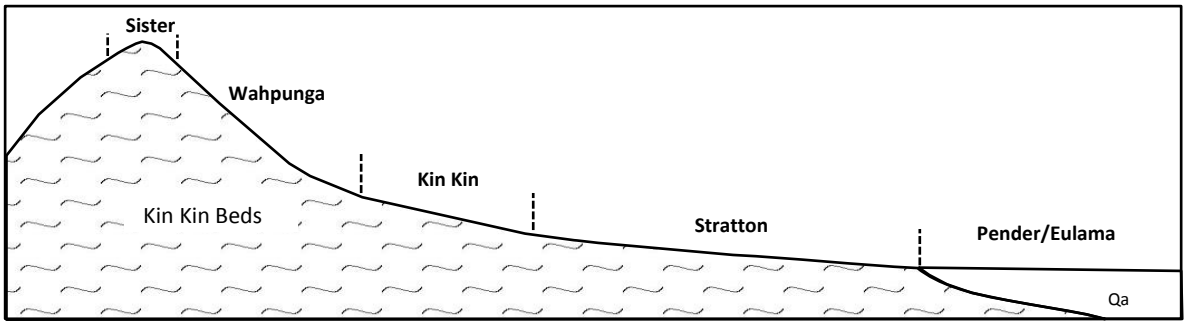
Soil	Area (ha)	Soil descriptions	Landform	Limitations
Pangola Deeply Weathered Phase (Brown or Yellow Dermosol)	136	Strongly acidic, deep to very deep, brown and yellow, gradational soils. Black clay loams to light clays overlying mottled brown or yellow light to medium heavy clays over deeper red and grey clays on deeply weathered sandstone or mudstone.	Crests and slopes of level to gently inclined undulating rises. Slope 1–5%.	**W1** – Imperfectly drained, moderately permeable at 1 m **W3** – Imperfectly drained, slowly permeable at 1.5 m
Ringtail (Grey or Brown Kurosol; Grey Sodosol; Redoxic Hydrosol)	542	Deep, sodic, brown or grey, texture contrast soils. Black or grey sandy loam to clay loam surface overlying frequently mottled brown and grey sandy clay loams to heavy clays on deeply weathered fine sandstone	Crests and slopes of gently undulating rises and plains. Slope 0–3%.	**F1** – Flooding <1 in 10 years **Nd4** – P <5 ppm **W1** – Poorly drained, slowly permeable at 1 m **W2** – Imperfectly drained, slowly permeable at 0.5 m

		and mudstone.		**W3** – Poorly drained, slowly permeable at 1.5 m
Hempsall (Semi-aquic or Aquic Podosol)	61	Deep to very deep, uniform soils subject to short to long-term saturation. Black or grey sand to sandy clay loam overlying organic grey, brown and black sand to clayey sands dominated by the accumulation of organic-aluminium/iron compounds.	Level to very gently inclined plains and slopes (0–3%).	**Dp3** – PASS between 2 and 3 m deep **F1** – Flooding <1 in 10 years **M6** – <50 mm PAWC **Nd4** – P <5 ppm **W1** – Imperfectly drained, highly permeable at 1 m **W3** – Poorly drained, highly permeable at 1.5 m

Phyllites (Rk)

The phyllites are found within the Triassic Kin Kin Beds dominating the western section of the catchment, surrounding the Kin Kin township. Landforms consist of undulating and rolling rises, undulating to steep low hills and undulating to steep hills. Lithology is predominately phyllite with smaller representations of argillite (weakly metamorphosed mudstone/shale). Alluvial soils formed on phyllite materials have not been included in this group. Soil types follow a clearly identifiable pattern of shallow, well drained, gravelly, Red and Brown Dermosol and Tenosol soils on hill crests and upper slopes, grading to Brown Dermosols on mid slopes and less well drained Yellow Dermosols on lower slopes. Deeper (but generally still gravelly) Red and Brown Dermosols exist on the numerous, gentler sloped pediments often found between mid-slopes and adjacent alluvial plains.

Figure 33 – Soil-landscape units of the Kin Kin Beds



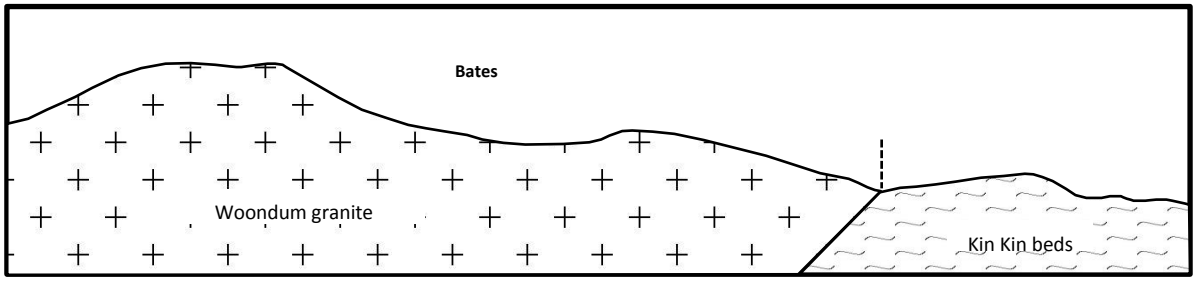
Soil	Area (ha)	Soil descriptions	Landform	Limitations
Sister (Brown or Red Dermosol; rarely Leptic Tenosol)	1 201	Shallow to moderately deep, brown and red, gradational soils. Brown, black and grey silty clay loams, clay loams and light clays overlying light to medium clays (occasionally mottled) on weathered and non-	Crests and ridges of steep and rolling hills and low hills. Slope 0–20%.	**E(A5)** – Stable soils slope 12–15% **Pd3** – Soil depth 0.3–0.5 m **RM3** – 10–20% medium gravel **Ts4** – Slope 15–20% **X3** – Practical production area

Soil	Area (ha)	Soil descriptions	Landform	Limitations
		weathered phyllite.		2.5–5 ha
Wahpunga (Red Dermosol)	3 131	Moderately deep to deep, red, gradational soils. Brown or red clay loams to light medium clays overlying red and brown light to medium clays with an acidic trend over phyllite	Hillslopes of steep and rolling hills and low hills. Slope ≥25%.	**E(A7)** – Stable soils, slope >20% **RM3** – 10–20% medium gravel **Ts6** – Slope >30%
Kin Kin (Brown or Red Dermosol)	1 782	Moderately deep to deep, brown and red, gradational soils. Brown and grey clay loams, light clays and light medium clays overlying frequently mottled light to medium clays on weathered and non-weathered phyllite	Hillslopes of rolling rises, steep and rolling low hills and steep and rolling hills. Slope ≤25%.	**EA5** – Stable soils, slope 12–15% **RM3** – 10–20% medium gravel **Ts4** – Slope 15–20%
Stratton (Red Dermosol)	181	Deep to very deep, red, gradational soils. Brown clay loams to light medium clays (sometimes sandy) overlying frequently mottled red and brown light to medium clays on weathered and non-weathered phyllite	Pediments and fans on steep low hills, rolling hills and low hills, undulating hills and undulating plains.	**E(A4)** – Stable soils, slope 8–12%

Granites (Rgw/g)

Granites are a minor lithology group occurring as steep and rolling hills of Triassic Woondum Granites north-west of Kin Kin township. Steep upper slopes and crests have shallow, permeable and well drained Red Dermosols grading into deeper less well drained Brown Dermosols on gentler slopes. As granites occur only as an outcrop they are not represented in lower slopes. Lower slope positions are occupied by phyllite derived soils typical of the surrounding areas.

Figure 34 – Soil-landscape units of the granites



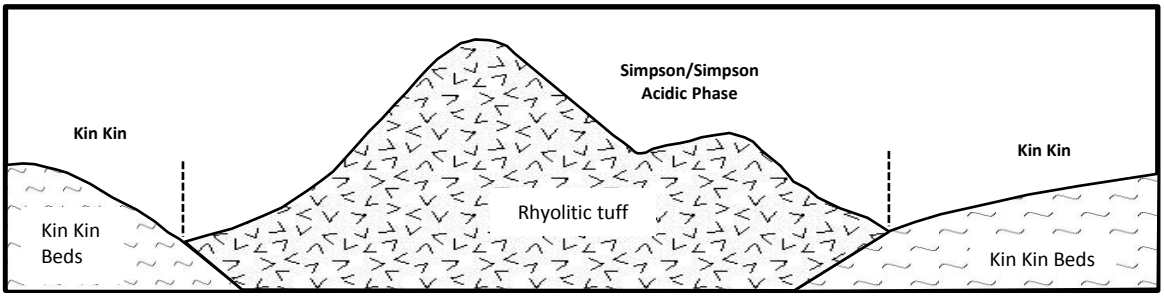
Soil	Area (ha)	Soil descriptions	Landform	Limitations
Bates (Leptic	135	Very shallow to shallow red and brown, texture contrast and gradational	Upper and mid slopes of steep and	**E(A7)** – Stable soils, slope >20% **M5** – 50–75 mm

Soil	Area (ha)	Soil descriptions	Landform	Limitations
Tenosol; Red or Brown Dermosol; Red Kurosol)		soils on steep slopes of Woondum granites. Black, brown or grey sandy loam to light clay overlying (where present) red or brown light to medium clays over granite.	rolling hills. Slope 20–50%.	PAWC **Pd3** – soil depth 0.3–0.5 m **RM4** – 20–50% medium gravel **Ts6** – Slope >30%

Rhyolitic tuff (Rv)

Grey Dermosols found on isolated, rolling low hills of Neogene rhyolitic tuff.

Figure 35 – Soil-landscape units on rhyolitic tuff

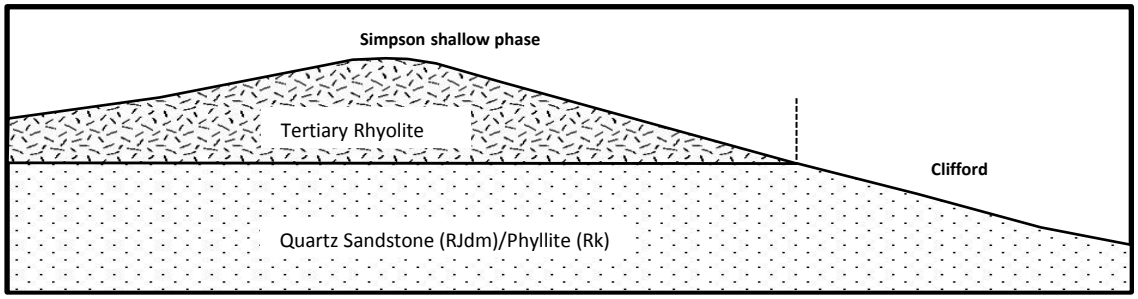


Soil	Area (ha)	Soil descriptions	Landform	Limitations
Simpson Acidic Phase (Grey Dermosol)	24	Moderately deep to very deep, grey, gradational soils. Black fine sandy clay loams to sandy clay loams (rarely light clays) overlying acidic, frequently mottled, grey sandy clay loams and sandy light clays to medium clays on weathered parent material at depth.	Crests and hillslopes of rolling low hills. Slope 5–20%.	**E(A4)** – Stable soils, slope 8–12% **Nt4** – Soil pH at 0.6m <5.0 **Ts3** – Slope 12–15% **W1 –** Imperfectly drained, slowly permeable **W2** – Imperfectly drained, moderately permeable **W3** – Imperfectly drained, slowly permeable

Rhyolites (Ti)

Shallow Leptic Tenosols on crests and upper slopes of Neogene Rhyolite intrusive hills, located along the southern catchment boundary.

Figure 36 – Soil-landscape units on Neogene Rhyolite

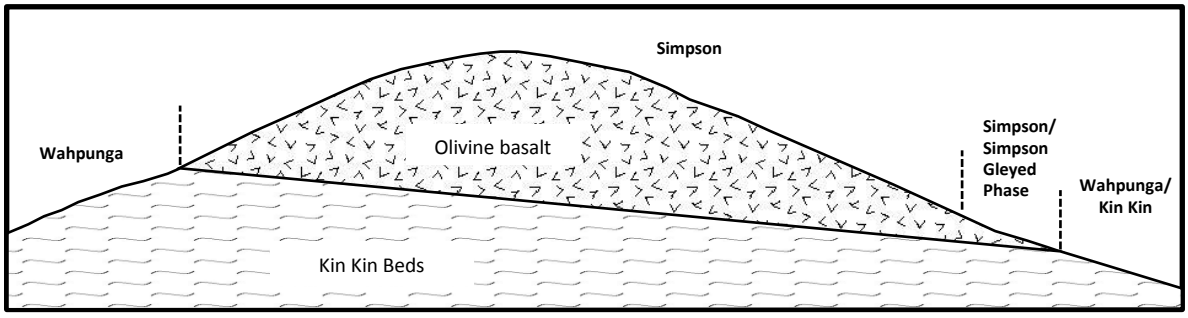


Soil	Area (ha)	Soil descriptions	Landform	Limitations
Simpson Shallow Phase (Leptic Tenosol)	41	Shallow soils. Grey clay loam overlying rhyolite rock.	Crests, ridges and slopes of steep rolling hills and low hills. Slope up to 40%	**E(A6)** – Stable soils, slope 15–20% **M5** – 50–75 mm PAWC **Pd3** – Soil depth 0.3–0.5 m **RG3** – 10–20% coarse gravel **Ts5** – Slope 20–30% **W1** – Moderately well drained, slowly permeable **W2** – Moderately well drained, slowly permeable **W3** – Imperfectly drained, moderately permeable

Neogene basalts (Tb-SEQ)

Small isolated outcrops of Neogene basalt within steep and rolling hills on the western and southern catchment boundary and steep and rolling hills and low hills of the central catchment range, giving rise to deep Black, Brown and Grey Dermosols. Outcrops occur within and above surrounding Kin Kin Bed (Rk) geology.

Figure 37 – Soil-landscape units on Neogene basalt



Soil	Area (ha)	Soil descriptions	Landform	Limitations
Simpson (Black, Brown or Grey Dermosol)	153	Moderately deep to very deep, black, brown and grey gradational soils on weathered and non-weathered basalt (rarely andesite, tuff or rhyolite). Black and grey light to medium clay overlying grey, brown and black medium heavy to heavy clays.	Crests and upper slopes of steep and rolling hills and low hills. Slope 3–37%.	**E(A6)** – Stable soils, slope 15–20% **RG3** – 10–20% coarse gravel **Ts5** – Slope 20–30% **X3** – Practical production area 2.5–5 ha
Simpson Gleyed Phase (Redoxic Hydrosol)	18	Moderately deep to deep, brown and grey gradational soils on tuff. Brown and grey light clay overlying grey and brown light medium to medium clays.	Lower slopes of rolling low hills. Slope 3–5%.	**RG3** – 10–20% coarse gravel **W1** – Very poorly drained

Attribute codes are defined in Appendix 3.

Areas represented by each of the above SPCs within the study area are summarised below in Table 6. The study area is dominated by Brown and Red Dermosols on Kin Kin Bed geology and its alluvial derivatives, followed by sandstone parented soils and their associated alluviums. Neogene basalts and rhyolites occupy the least amount of the study area.

Table 6 – Percentage of the study are occupied by each dominant SPC

SPC	Area (ha)	Percentage (%) of study area
Bates (Ba)	270	1.21
Bazzo (Bz)	1 523	6.82
Boreen (Br)	506	2.27
Clifford (Cf)	997	4.47
Clifford Steep Phase (CfSp)	16	0.07
Como (Cm)	616	2.76
Cootharaba (Ct)	1 810	8.11
Eulama (El)	1 842	8.25
Eulama Buried Variant (ElBv)	204	0.91
Hempsall (Hs)	1 873	8.39
Hempsall Hydrosol Phase	107	0.48
Kin Kin (Kk)	1 782	7.99
Kinmond (Km)	2 040	9.14
Kinmond Acidic Phase (KmAp)	253	1.13
Pangola (Pg)	1 988	8.91
Pangola Deeply Weathered Phase (PgDp)	136	0.61

SPC	Area (ha)	Percentage (%) of study area
Paulsen (Ps)	98	0.44
Pender (Pd)	518	2.32
Ringtail (Rt)	542	2.43
Simpson (Ss)	236	1.06
Sister (Si)	1 201	5.38
Sonny (So)	446	2.00
Stratton (St)	181	0.81
Wapungah (Wp)	3 131	14.03

Land evaluation

Land suitability

Land resource information collected during the course of this land resource assessment was used to determine the suitability of the land within the Lake Cootharaba catchment for a range of 44 land uses (Table 7).

Significant land use limitations were assessed and rated across all 574 unique mapping areas (UMAs) in the catchment according to the *Guidelines for agricultural land evaluation in Queensland* (DSITIA & DNRM 2015). The overall land use suitability for a UMA is, in most cases, determined by its most severe limitation. The severity of each limitation was assigned on a scale of 1 (least limiting) to 5 (most limiting) as follows:

- Class 1 Suitable land with negligible limitations
- Class 2 Suitable land with minor limitations
- Class 3 Suitable land with moderate limitations
- Class 4 Unsuitable land with severe limitations
- Class 5 Unsuitable land with extreme limitations.

A full definition of each of the suitability classes is provided in Appendix 1.

Table 7 – Land suitability by crop

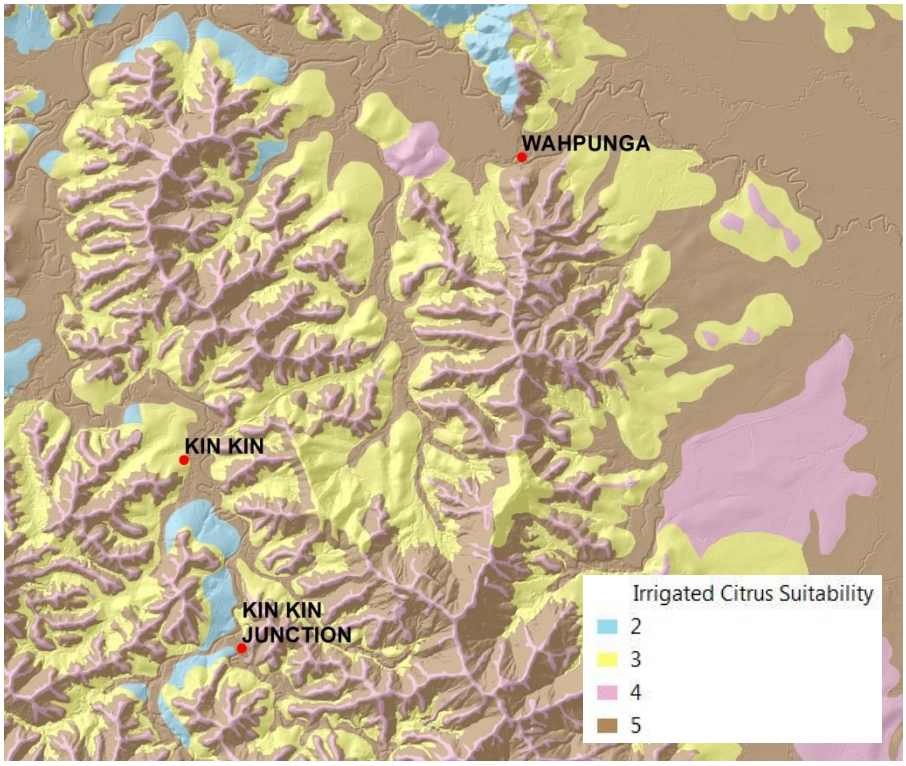
Land use[#]	**Land suitability rating**				
	Suitable land (ha)			**Unsuitable land (ha)**	**Unsuitable land (ha)**
	Class 1	**Class 2**	**Class 3**	**Class 4**	**Class 5**
Avocado	—	—	663	2 227	19 362
Bamboo	—	6 779	6 197	5 746	3 531
Banana	—	2 997	9 899	1 685	7 671
Banana – irrigated		7 139	7 478	1 716	5 920
Blackbutt (plantation forestry)	—	6 236	5 205	8 059	2 753
Capsicum (summer) – irrigated	—	—	6 578	3 892	11 782
Capsicum (winter) – irrigated	—	2 046	5 641	2 783	11 782
Caribbean pine (plantation forestry)	—	1 318	11 762	2 561	6 611
Choko – irrigated	—	—	446	6 281	15 525
Citrus – irrigated	—	626	6 344	3 451	11 832
Cucurbits (summer) – irrigated	—	—	6 578	3 892	11 782
Cucurbits (winter) – irrigated	—	3 951	3 736	2 783	11 782
Custard apple – irrigated	—	—	2 897	6 305	13 050
Dunn’s White Gum (plantation forestry)	—	—	11 872	7 592	2 789

Land use[#]	Land suitability rating				
	Suitable land (ha)			Unsuitable land (ha)	Unsuitable land (ha)
	Class 1	Class 2	Class 3	Class 4	Class 5
Flooded Gum (plantation forestry)	—	6 236	5 205	8 059	2 753
Ginger (summer) – irrigated	—	—	2 906	9 137	10 209
Ginger (winter) – irrigated	—	—	2 906	9 137	10 209
Gympie messmate (plantation forestry)	—	6 236	5 205	8 059	2 753
Hemp	—	—	—	6 968	15 284
Improved pasture	—	5 095	7 881	5 746	3 531
Lychee – irrigated	—	331	6 238	2 656	13 027
Macadamia	—	—	2 671	4 779	14 802
Macadamia – irrigated	—	—	2 671	6 531	13 050
Maize (summer forage)	—	—	1 277	6 763	14 213
Mango – irrigated	—	2 271	6 923	37	13 021
Millet (summer forage)	—	—	1 277	6 763	14 213
Passionfruit – irrigated	—	—	4 624	5 810	11 819
Pawpaw – irrigated	—	—	3 204	7 194	11 855
Persimmon – irrigated	—	343	6 542	3 536	11 832
Pineapple	—	—	1 161	4 463	16 629
Sorghum (summer forage)	—	—	5 361	2 759	14 132
Soya bean	—	—	5 361	2 291	14 600
Spotted Gum (plantation forestry)	—	6 236	6 925	6 338	2 753
Stone fruit – irrigated	—	—	2 813	7 584	11 855
Strawberry – irrigated	—	—	7 702	4 945	9 606
Sugarcane	—	2 564	6 174	2 323	11 192
Sugarcane – irrigated	—	4 469	4 269	2 323	11 192
Sweet corn (summer) – irrigated	—	—	2 997	6 789	12 466
Sweet corn (winter) – irrigated	—	—	7 084	2 783	12 386
Sweet potato (summer) – irrigated	—	—	7 012	3 663	11 578
Sweet potato (winter)	—	2 046	7 720	908	11 578

Land use[#]	Land suitability rating				
	Suitable land (ha)			Unsuitable land (ha)	Unsuitable land (ha)
	Class 1	Class 2	Class 3	Class 4	Class 5
– irrigated					
Tomato (summer) – irrigated	—	—	6 578	3 892	11 782
Tomato (winter) – irrigated	—	2 046	5 641	2 783	11 782
Turf – irrigated	—	2 046	7 796	2 323	10 087

Unless specified as irrigated, crops are considered dryland/rainfed.

Figure 38 – Example of predicted land suitability for citrus



Agricultural land classification

Agricultural land classification in Queensland follows a simple hierarchical scheme that is applicable across the state. It allows the presentation of interpreted land evaluation data to indicate the location and extent of agricultural land that can be used sustainably for a range of land uses with minimal land degradation. Three broad classes of agricultural land and one non-agricultural land class are identified:

- Class A Crop land
- Class B Limited crop land
- Class C Pasture land
- Class D Non-agricultural land.

The classes imply a decreasing range of land use choice and an increase in the severity of land use limitations and/or an increasing land degradation hazard. The classification is hierarchical, with class A land

having the greatest potential for the production of the widest array of crops and class D land being unsuitable for any agricultural land use.

Class A (crop land) has been subdivided into two subclasses: A1 - land suitable for a wide range of broadacre crops and A2 - land suitable for horticultural crops (A2) only. Class C (pasture land) is subdivided into three subclasses. The four classes, including subgroups, are summarised in Appendix 2.

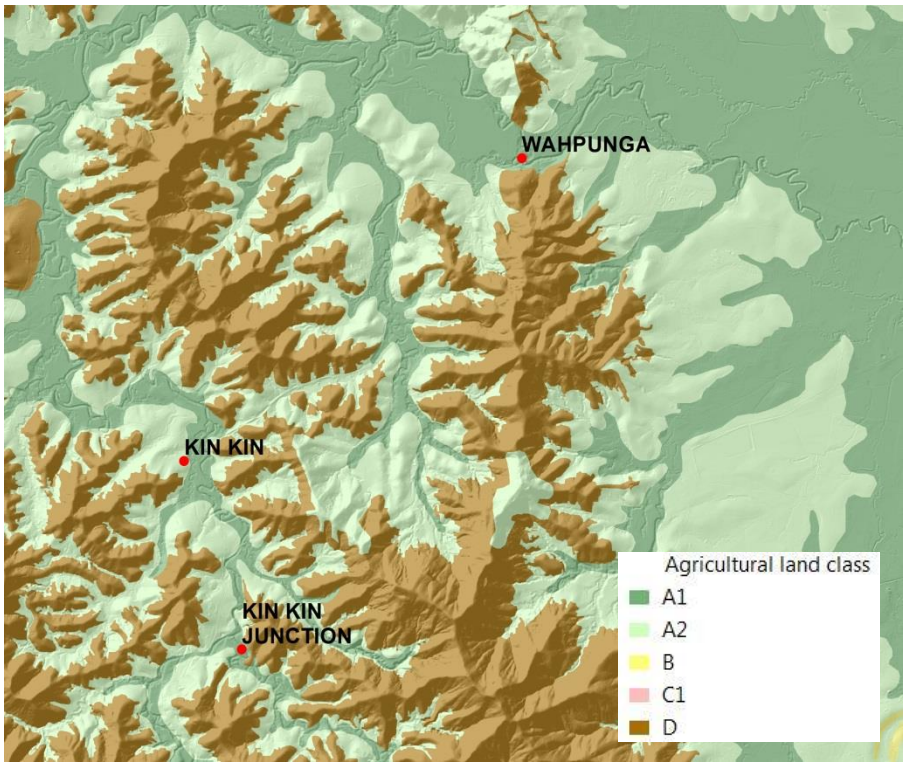
Table 8 – Area of each agricultural land class in the Lake Cootharaba catchment

Agricultural land class	Area (ha)	Percentage of total area
A1 Crop land	4 855	19
A2 Horticultural crop land	9 445	36
B Limited crop land	546	2
C1 Pasture land	36	<1
D Non-agricultural land	7 370	28

From Table 8, 57% (14 876 ha) of the Lake Cootharaba catchment is suitable agricultural land (sum of classes A1, A2 and B).

The majority of the A1 class lands exist along the flats and lower slopes of Kin Kin Creek and its tributaries, while the bulk of the horticultural lands (class A2) are located throughout the central portion of the catchment and on the gentler slopes of the valleys in the west. An extensive area of A2 class land was identified in the catchment and this is due to the wide range of horticultural crops in the classification scheme and the undulating nature of the catchment topography. Major limitations to the expansion of class A1 lands are the regularity of flooding and poor soil profile drainage. An example of the spatial distribution of agricultural land classifications is provided in Figure 39.

Figure 39 – Example of predicted agricultural land class



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Appendices

Appendix 1 – Land suitability classes

Appendix 2 – Agricultural land classifications

Appendix 3 – Land suitability classification scheme

Appendix 4 – Morphological and analytical data

Appendix 5 – Key to the soils of the Lake Cootharaba catchment

Appendix 6 – Soil profile classes

Appendix 1 – Land suitability classes

Five land suitability classes have been defined for use in Queensland, with land suitability decreasing progressively from class 1 to class 5 (DNRM & DSITIA 2015). These classes are used to describe an area of land in terms of its suitability for a **particular land use** which allows optimum, sustainable production using current technology while minimising degradation to the land resource in the short, medium or long term.

Land is considered less suitable as the severity of limitations for a specified land use increase, reflecting:

- reduced potential for production
- increased inputs required to achieve an acceptable level of production
- increased inputs required to prepare the land for successful production
- increased inputs required to prevent land degradation.

The five land suitability classes are explained below.

Table A1.1 Land suitability classes

Class	Suitability	Limitations	Description
1	Suitable	Negligible	Highly productive land requiring only simple management practices to maintain economic production.
2	Suitable	Minor	Limitations that either constrain production, or require more than the simple management practices of Class 1 land to maintain economic production.
3	Suitable	Moderate	Limitations that either further constrain production, or require more than those management practices of Class 2 land to maintain economic production.
4	Unsuitable	Severe	Currently unsuitable land. The limitations are so severe that the sustainable use of the land in the proposed manner is precluded. In some circumstances, the limitations may be surmountable with changes to knowledge, economics or technology.
5	Unsuitable	Extreme	Land with extreme limitations that preclude any possibility of successful sustained use of the land in the proposed manner.

The first three classes of land (classes 1 to 3) are considered **suitable** for the specified land use, as the benefits obtained from that land use in the long-term should outweigh the inputs required to initiate and maintain production. Class 3 land may be as productive as class 1 or 2 land; however increased inputs (e.g. fertiliser, land preparation and maintenance operations) would generally be required. It is not uncommon to find in a land resource survey that there is no land assessed as suitability class 1 for a particular land use.

Class 4 land is considered **currently unsuitable** for the specified land use, due to the severity of one or a number of limiting factors. It is implied that the inputs required to achieve and maintain production outweigh the benefits of production in the long-term. This land may be upgraded to a suitable class if future agronomic, edaphic or engineering studies show it to be economically viable and environmentally sustainable. Changes

in climate, economic conditions, or technology may alter the level of management inputs required to achieve satisfactory long-term productivity.

Class 5 land is considered **unsuitable** for the specified land use, as it has limitations that singly or in aggregate are so severe that the benefits would not justify the inputs required to initiate and maintain sustainable production in the long term. Such land is unlikely to ever be suitable for the specified land use.

Appendix 2 – Agricultural land classes[3]

Code	Description
A	**Crop land** **Land that is suitable for a wide range[1] of current and potential crops with nil to moderate limitations to production.**
A1	Suitable for a wide range of current and potential broadacre and horticultural[2] crops.
A2	Suitable for a wide range of current and potential horticultural crops only.
B	**Limited crop land** **Land that is suitable for a narrow range[3] of crops. The land is suitable for sown pastures and may be suitable for a wider range of crops with changes to knowledge, economics or technology.**
C	**Pasture land** **Land that is suitable only for improved or native pastures due to limitations that preclude continuous cultivation for crop production. Some areas may tolerate a short period of ground disturbance for pasture establishment.**
C1	Suitable for grazing sown pastures requiring ground disturbance for establishment; or native pastures on higher fertility soils.
C2	Suitable for grazing native pastures, with or without the introduction of pasture species, and with lower fertility soils than C1.
C3	Suitable for light grazing of native pastures in accessible areas, and includes steep land more suited to forestry or catchment protection.
D	**Non-agricultural land[4]** **Land not suitable for agricultural use, including land alienated from agricultural use.**
A/C A/D B/C C/D	Land that is a complex of class A, B, C or D land where it is not possible to delineate the land class at the map scale. The dominant class is the first code in the sequence and is assumed to be >50% of the area, but <70%[5].

[1] A wide range of crops is four or more crop types of local commercial significance.
[2] Horticulture includes intensively grown small crops (e.g. vegetables) as well as tree crops (e.g. grown for nuts, seeds or fruit). Silviculture (plantation forestry) is not included.
[3] A narrow range of crops is three or fewer crop types (broadacre or horticulture) of local commercial significance. Silviculture (plantation forestry) may be included. Crops with similar agronomic requirements e.g. maize and grain sorghum, peaches and nectarines are not generally regarded as different crop types. Different management regimes (including irrigation strategies) for the same crop do not increase the number of crops.
[4] Non-agricultural land includes land that cannot be placed in any of the other land classes and includes land such as urban areas and stream channels.
[5] In cases where two or more land classes are equally dominant and none are greater than 50%, judgement is used to identify the most appropriate agricultural land class/es for the unit.

[3] *Guidelines for agricultural land evaluation in Queensland*— (2nd edn) (DSITI & DNRM 2015)

Appendix 3 – Land suitability classification scheme

Suitability framework for the coastal South East Queensland area

The following 17 limitations were used to assess land suitability in the coastal South East Queensland region.

Land use requirements	Limitations	Soil and land use attributes used to assess each limitation
Frost-free	**Frost (Cf)**	Frequency of damaging frosts, landform, landscape position
Adequate rainfall (non-irrigated crops only)	**Precipitation (Cp)**	Amount and distribution of rainfall, evaporation, crop modelling
Avoid environmental harm from acid drainage water from actual acidity	**Acid drainage water hazard actual (Da)**	Depth to actual existing acidity (pH <4.0), soil texture
Avoid environmental harm from acid drainage water from potential acidity	**Acid drainage water hazard potential (Dp)**	Depth to potential acidity, depth to oxidisable sulfur (S) above %S threshold, soil texture
Minimise soil loss from erosion	**Water erosion (E)**	Soil susceptibility to erosion, slope, soil stability group, erodibility factor (K factor)
Absence of damaging floods	**Flooding (F)**	Frequency of flooding (average recurrence interval, ARI)
Adequate water supply	**Soil water availability (M)**	PAWC
Adequate nutrients	**Nutrient deficiency (Nd)**	Level of P in top 0.3 m of soils
Low levels of toxic elements	**Element toxicity (Nt)**	pH at the soil surface (<0.3 m) and pH at 0.6 m depth
Adequate soil depth for physical support	**Soil depth (Pd)**	Depth to C horizon, hard rock or other impermeable layer
Ease of seedbed preparation and plant establishment	**Soil surface condition (Ps)**	Surface (<0.3 m) physical condition, texture, structure
Rock-free	**Rockiness (R)**	Size and content (%) of coarse fragments, % rock outcrop
Favourable levels of soluble salts	**Soil salinity (Sa)**	Saturated extract conductivity (dS/m ECse) of the top 0–0.1 m of soil
Level land surface	**Microrelief (Tm)**	Height of microrelief vertical interval
Land surface of acceptable slope	**Topography (Ts)**	Slope (%)
Adequate soil aeration	**Wetness (W)**	Soil drainage and permeability, height of underground water table
Adequate land area available for efficient production	**Landscape complexity (X)**	Minimum area of contiguous suitable soil available for crop production

The following land management options (44 in total) were considered in the compilation of the coastal South East Queensland land suitability framework:

Avocado	Maize (summer forage) – dryland/rainfed
Bamboo – dryland/rainfed	Mango – irrigated
Banana – irrigated and dryland/rainfed	Millet (summer forage) – dryland/rainfed
Blackbutt (plantation forestry) – dryland/rainfed	Passionfruit – irrigated
Capsicum (summer and winter) – irrigated	Pawpaw – irrigated
Caribbean pine (plantation forestry) – dryland/rainfed	Persimmon – irrigated
Choko – irrigated	Pineapple – dryland/rainfed
Citrus – irrigated	Sorghum (summer forage) – dryland/rainfed
Cucurbits (summer and winter) – irrigated	Soybean – dryland/rainfed
Custard apple – irrigated	Spotted gum (plantation forestry) – dryland/rainfed
Dunn's white gum (plantation forestry) – dryland/rainfed	Stone fruit – irrigated
Flooded gum (plantation forestry) – dryland/rainfed	Strawberry – irrigated
Ginger (summer and winter) – irrigated	Sugarcane – irrigated and dryland/rainfed
Gympie messmate (plantation forestry) – dryland/rainfed	Sweet corn (summer and winter) – irrigated
Hemp – dryland/rainfed	Sweet potato (summer and winter) – irrigated
Improved pasture – dryland/rainfed	Tomato (summer and winter) – irrigated
Lychee – irrigated	Turf – irrigated
Macadamia – irrigated and dryland/rainfed	

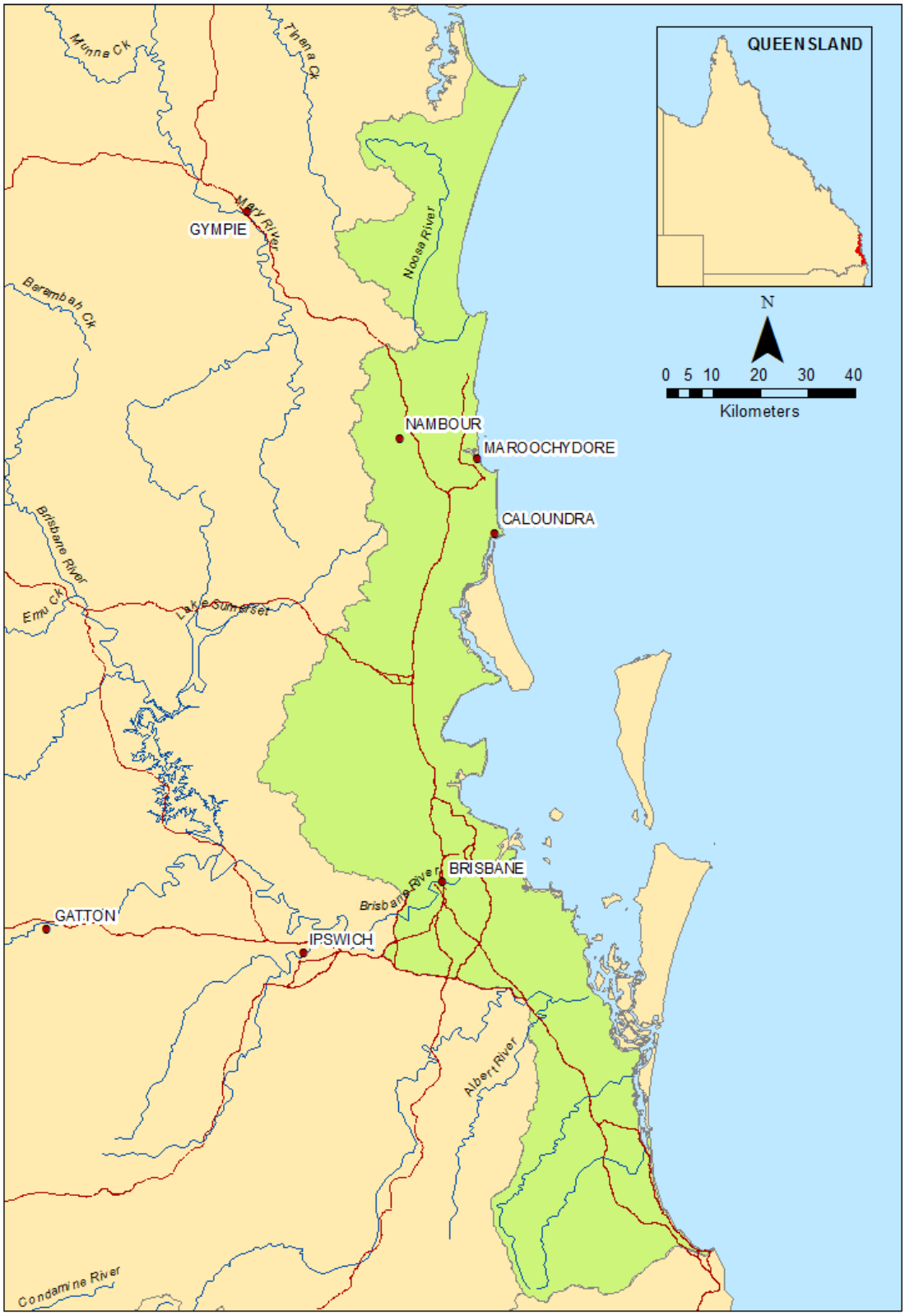


Figure A3.1. Area covered by the coastal South East Queensland suitability framework

Frost (Cf)

Frosts may kill plants, suppress growth and reduce yield.

Limitation class determination

Crop tolerance and local experience were used to determine the impact of frosts.

Additional notes:

- Strawberries can tolerate regular moderate frosts but require night watering to avoid frost damage to flowers. This can lead to problems with excess wetness and a decline in fruit quality.
- Cucurbits, capsicums and tomatoes are highly susceptible to frost and careful management is required in frost prone areas to avoid all but occasional, very light frosts.

Cf – Climate – frost

Limitation value	Description	Suitability subclasses for various land management options							
		Group A	Group B	Group C	Group D	Group E	Group F	Group G	Group H
1	Frost free or occasional light frost >–1 °C (<3 events per year)	1	1	1	1	1	1	1	1
2	Regular light frosts >–1 °C (= or >3 events per year)	1	1	1	2	2	3	4	5
3	Regular moderate frosts –1 to –4 °C (= or >3 events per year)	1	2	2	3	4	4	5	5
4	Regular severe frosts <–4 °C (= or >3 events per year)	2	3	4	4	5	5	5	5

Group A	Group B	Group C	Group D	Group E	Group F	Group G	Group H
Dunn's white gum	Persimmon-irrigated-trickle	Turf-irrigated-spray	Sugarcane-dryland/rainfed	Citrus-irrigated-trickle	Caribbean pine	Avocado-irrigated-trickle	Banana-dryland/rainfed
Improved pasture-dryland/rainfed	Rose gum/flooded gum		Sugarcane-irrigated-spray		Choko-irrigated-spray	Blackbutt	Banana-irrigated-trickle
					Ginger-winter-spray	Capsicum-winter-spray	Cucurbit-winter-spray
					Gympie messmate	Custard apple-irrigated-trickle	Pawpaw-irrigated-trickle
					Strawberry-irrigated-spray	Lemon-scented gum/spotted gum	Tomato-winter-spray
					Sweet corn-winter-spray	Lychee-irrigated-trickle	
						Macadamia-dryland/rainfed	
						Macadamia-irrigated-trickle	
						Mango-irrigated-trickle	
						Passionfruit-irrigated-trickle	
						Pineapple-dryland/rainfed	
						Stone fruit-irrigated-trickle	
						Sweet potato-winter-spray	

Precipitation (Cp)

Rainfall amount and distribution largely control cropping and grazing productivity, and particularly cropping success in rainfed (dryland) situations.

Limitation class determination

Local experience and industry recommendations were used to determine crop yields and the success of achieving a harvestable product under rainfed conditions.

Additional notes:

- The Cp limitation only applies to crops that can be grown on a regular basis without supplementary irrigation. These include sugarcane, soybean, maize, sorghum and commercial plantation forestry (blackbutt, Dunn's white gum, flooded gum, Gympie messmate and spotted gum).
- Where annual rainfall has not been sufficient, sugarcane can be held over for a second year if required (i.e. two year crop) to achieve a tonnage that is economic to harvest.
- Pineapple can be grown in low rainfall areas but the need for timely rainfall at crucial stages in the crop cycle means that low rainfall areas are high risk.
- Yield of Dunn's white gum decreases in summer dominant high rainfall areas (particularly where high temperatures are associated with high rainfall) due to disease problems.
- Cp limitation does not apply to irrigated crops.

Cp – Rainfall

Limitation		Suitability subclasses for various land management options								
value	Description	Group A	Group B	Group C	Group D	Group E	Group F	Group G	Group H	Group I
1	Mean annual rainfall >1500 mm	1	1	1	1	1	1	1	3	3
2	Mean annual rainfall >1200 to 1500 mm	1	1	1	2	2	3	3	2	2
3	Mean annual rainfall >1000 to 1200 mm	1	1	1	3	4	4	5	2	2
4	Mean annual rainfall >850 to 1000 mm	2	2	3	4	5	5	5	2	3
5	Mean annual rainfall <850 mm	2	3	4	5	5	5	5	2	4

Group A	Group B	Group C	Group D	Group E	Group F	Group G	Group H	Group I
Bamboo-dryland/rainfed	Lemon-scented gum/spotted gum	Soybean-dryland/rainfed	Caribbean pine	Banana-dryland/rainfed	Sugarcane-dryland/rainfed	Blackbutt	Hemp-dryland/rainfed	Dunn's white gum
	Maize-summer		Gympie messmate	Macadamia-dryland/rainfed		Rose/flooded gum		
	Millet-summer		Pineapple-dryland/rainfed					
	Sorghum-summer							
	Improved pasture-dryland/rainfed							

Acid drainage water hazard (Da and Dp)

Toxic quantities of acid, aluminium, iron and heavy metals may contaminate land and adjacent waterways when acid sulfate soils (ASS) are disturbed or drained which can reduce crop yields.

Limitation class determination

The potential for acid drainage water hazard was determined by:

- PASS (soil material with pH >4 and oxidisable sulfur levels above the action criteria)

or

- AASS (soil material with pH <4 and/or jarosite present)

and

- the depth to which drainage is required for a particular land use.

Crops requiring a soil depth of 1.5 m to AASS/PASS are restricted to:

Avocadoes

Crops requiring a soil depth of 1.0 m to AASS/PASS include:

Sweet corn, maize, sorghum, choko, citrus, custard apple, macadamia, pawpaw, stone fruit, mango, lychee, passionfruit, persimmon, Gympie messmate, blackbutt, spotted gum, flooded gum, Dunn's white gum and Caribbean pine

Crops requiring a soil depth of 0.5 m to AASS/PASS include:

Capsicum, cucurbit, sweet potato, tomato, turf, strawberry and improved pasture

Da – Drainage water hazard, acid sulfate

Limitation value	Description	Suitability subclasses for various land management options				
		Group A	Group B	Group C	Group D	Group E
1	AASS (pH < or = 4) not present or present at depths >3.0 m	1	1	1	1	1
2	AASS present at depths between 2.0 and 3.0 m	1	1	1	1	1
3	AASS present at depths between 1.0 and 2.0 m	1	1	1	3	4
4	AASS present at depths between 0.5 and 1.0 m	1	3	3	4	5
5	AASS present at depths <0.5 m	3	4	5	5	5

Group A	Group B	Group C	Group D	Group E
Bamboo-dryland/rainfed	Turf-irrigated-spray	Banana-irrigated-trickle	Citrus-irrigated-trickle	Avocado-irrigated-trickle
	Banana-dryland/rainfed		Stone fruit-irrigated-trickle	
	Capsicum-summer-spray		Blackbutt	
	Capsicum-winter-spray		Caribbean pine	
	Cucurbit-winter-spray		Choko-irrigated-spray	
	Cucurbit-summer-spray		Custard apple-irrigated-trickle	
	Ginger-summer-spray		Dunn's white gum	
	Ginger-winter-spray		Gympie messmate	
	Pineapple-dryland/rainfed		Hemp-dryland/rainfed	
	Soybean-dryland/rainfed		Lemon-scented gum/spotted gum	
	Strawberry-irrigated-spray		Lychee-irrigated-trickle	
	Sugarcane-dryland/rainfed		Macadamia-dryland/rainfed	
	Sugarcane-irrigated-spray		Macadamia-irrigated-trickle	
	Sweet potato-summer-spray		Maize-summer	
	Sweet potato-winter-spray		Mango-irrigated-trickle	
	Improved pasture-dryland/rainfed		Millet-summer	
	Tomato-summer-spray		Pawpaw-irrigated-trickle	
	Tomato-winter-spray		Passionfruit-irrigated-trickle	
			Persimmon-irrigated-trickle	
			Rose gum/flooded gum	
			Sorghum-summer	
			Sweet corn-summer-spray	
			Sweet corn-winter-spray	

Dp – Acid drainage hazard, potential

Limitation		Suitability subclasses for various land management options			
value	Description	Group A	Group B	Group C	Group D
1	PASS (%S > action threshold) not present or present at depths >3.0 m	1	1	1	1
2	PASS present at depths between 2.0 and 3.0 m	1	1	1	1
3	PASS present at depths between 1.0 and 2.0 m	1	1	3	4
4	PASS present at depths between 0.5 and 1.0 m	1	3	4	5
5	PASS present at depths <0.5 m	3	5	5	5

Group A	Group B	Group C	Group D
Bamboo-dryland/rainfed	Turf-irrigated-spray	Citrus-irrigated-trickle	Avocado-irrigated-trickle
	Banana-dryland/rainfed	Stone fruit-irrigated-trickle	
	Banana-irrigated-trickle	Blackbutt	
	Capsicum-summer-spray	Caribbean pine	
	Capsicum-winter-spray	Choko-irrigated-spray	
	Cucurbit-winter-spray	Custard apple-irrigated-trickle	
	Cucurbit-summer-spray	Dunn's white gum	
	Ginger-summer-spray	Gympie messmate	
	Ginger-winter-spray	Hemp-dryland/rainfed	
	Pineapple-dryland/rainfed	Lemon-scented gum/spotted gum	
	Soybean-dryland/rainfed	Lychee-irrigated-trickle	
	Strawberry-irrigated-spray	Macadamia-dryland/rainfed	
	Sugarcane-dryland/rainfed	Macadamia-irrigated-trickle	
	Sugarcane-irrigated-spray	Maize-summer	
	Sweet potato-summer-spray	Mango-irrigated-trickle	
	Sweet potato-winter-spray	Millet-summer	
	Improved pasture-dryland/rainfed	Pawpaw-irrigated-trickle	
	Tomato-summer-spray	Passionfruit-irrigated-trickle	
	Tomato-winter-spray	Persimmon-irrigated-trickle	
		Rose gum/flooded gum	
		Sorghum-summer	
		Sweet corn-summer-spray	
		Sweet corn-winter-spray	

Water erosion (E)

Land degradation and long-term productivity decline will occur on unprotected arable land due to excessive soil erosion.

Qualitative features have been linked to K factor ranges generated by USLE. Four soil stability categories from very stable to very unstable were recognised.

Very stable soils: K factor
Strongly structured surface soils high in free iron (e.g. Ferrosols). Profiles are highly permeable throughout.

Stable soils: K factor <0.04
Friable surface soils with moderate to strong surface structure (granular or blocky); or surface soils with a soft, firm or weakly hard setting, medium to coarse sandy surface (sands, sandy loam, sandy clay loam); or surface soils very high in organic matter. Profiles are moderately to highly permeable throughout.

Unstable soils: K factor 0.04–0.06
Hard setting surface soils with weak (granular, blocky) to massive surface structure and fine sandy textures (fine sandy clay loam to fine sandy light clay). Surface horizons are moderately to slowly permeable. Slowly permeable, sodic subsoils are often developed within 1.0 m of the surface in lower landscape positions.

Very unstable soils: K factor >0.06
Hard setting surface soils with weak (granular, blocky) to massive surface structure and silty textures (silty loam to silty light clay). Surface horizons are low in organic matter, slowly permeable and typically overlie slowly to very slowly permeable, sodic subsoils within 0.5 m of the surface.

Limitation class determination
Soil stability classes combined with appropriate slope classes were used to derive the limitation categories for water erosion.

Additional notes:

- Perennial tree and vine orchards typically practice grass/cover crop sward management and represent relatively stable land uses (i.e. suitable on slopes between >5–20% depending on soil type).
- Pawpaws and bananas, which are replanted every 6–7 years, were not included with the perennial tree and vine crops. Typically, they require irregular cultivation, are planted in spring and are normally mounded on the contour. They were grouped with macadamia and choko because of the predominance of bare surface soil when compared with sward based systems, even in a mature orchard.
- Crops with extended crop cycles, such as sugarcane and pineapples are only cultivated every 2–4 years, and once established, have good levels of crop cover and produce significant crop residues. While the potential for erosion is greater with these land uses than for tree and vine crops, it was considered less critical than for annual field and horticultural small crops. Although pineapples are only planted every 3 years, soils may be prone to significant erosion due to strict weed control practices that expose bare surface soil. Where pineapples are mounded on the contour with run-off control structures in place, erosion risk is reduced.

- Turf is regularly stripped back to a completely bare surface but with a significant root mass and without regular tillage. Rilling and deposition following erosion events is a potential problem because uneven surface contours can present problems with harvesting. Standard management practices such as topdressing and levelling would largely overcome such erosion effects.
- Most field crops/horticultural crops require seedbed preparation on an annual basis. Tillage during late summer to prepare for the winter cropping period leaves paddocks exposed and subject to potentially erosive rainfall events through the autumn months. Tillage is usually aggressive, surface soils very loose and paddocks laid out in straight rows. Land uses in this category were considered most at risk from erosion and slope limits are therefore more robust.
- Slope limits described for forestry situations assumed land is already cleared and pastured and broadscale clearing is not required. These limits assumed minimal soil disturbance is practised during land preparation for planting. Lower limits would apply were significant soil disturbance involved.

E – Water erosion

Limitation value	Description	Suitability subclasses for various land management options										
		Group A	Group B	Group C	Group D	Group E	Group F	Group G	Group H	Group I	Group J	Group K
E0	Very stable soils with 0% slope	1	1	1	1	1	1	1	1	1	1	1
E1	Very stable soils with 0–2% slope	1	1	1	1	1	1	1	1	1	1	1
E2	Very stable soils with 2–5% slope	1	1	1	1	1	1	2	2	2	2	2
E3	Very stable soils with 5–8% slope	1	1	1	1	2	2	2	2	3	3	3
E4	Very stable soils with 8–12% slope	1	1	1	2	3	3	3	4	4	4	4
E5	Very stable soils with 12–15% slope	1	1	2	3	3	4	4	5	5	5	5
E6	Very stable soils with 15–20% slope	2	2	3	3	4	4	5	5	5	5	5
E7	Very stable soils with 20–30% slope	3	4	4	4	5	5	5	5	5	5	5
E8	Very stable soils with >30% slope	5	5	5	5	5	5	5	5	5	5	5
A0	Stable soils (K < or = 0.04) with 0% slope	1	1	1	1	1	1	1	1	1	1	1
A1	Stable soils (K < or = 0.04) with 0–2% slope	1	1	1	1	1	1	1	2	2	2	2
A2	Stable soils (K < or = 0.04) with 2–5% slope	1	1	1	1	2	2	2	3	2	3	3
A3	Stable soils (K < or = 0.04) with 5–8% slope	1	1	1	2	3	3	3	4	3	3	4
A4	Stable soils (K < or = 0.04) with 8–12% slope	1	1	2	3	4	4	4	5	4	4	5
A5	Stable soils (K < or = 0.04) with 12–15% slope	2	2	3	3	5	5	5	5	5	5	5
A6	Stable soils (K < or = 0.04) with 15–20% slope	3	3	3	4	5	5	5	5	5	5	5
A7	Stable soils (K < or = 0.04) with >20% slope	4	4	4	5	5	5	5	5	5	5	5
B0	Unstable soils (K >0.04 and K < or = 0.06) with 0% slope	1	1	1	1	1	1	1	1	1	1	1
B1	Unstable soils (K >0.04 and K < or = 0.06) with 0–1% slope	1	1	1	1	1	1	1	2	2	2	2
B2	Unstable soils (K >0.04 and K < or = 0.06) with 1–3% slope	1	1	1	1	2	2	2	3	3	3	3
B3	Unstable soils (K >0.04 and K < or = 0.06) with 3–5% slope	1	1	1	2	3	3	3	4	4	4	4
B4	Unstable soils (K >0.04 and K < or = 0.06) with 5–8% slope	1	1	2	3	4	4	4	5	5	5	5
B5	Unstable soils (K >0.04 and K < or = 0.06) with 8–12% slope	2	2	3	3	5	5	5	5	5	5	5
B6	Unstable soils (K >0.04 and K < or = 0.06) with >12% slope	4	4	4	4	5	5	5	5	5	5	5
V0	Very unstable soils (K >0.06) with 0% slope	1	1	1	1	1	1	1	2	2	2	2
V1	Very unstable soils (K >0.06) with 0–1% slope	1	1	1	1	2	2	2	3	3	3	3
V2	Very unstable soils (K >0.06) with 1–3% slope	1	1	1	2	3	3	3	4	4	4	4
V3	Very unstable soils (K >0.06) with 3–5% slope	1	1	2	3	4	4	4	5	5	5	5
V4	Very unstable soils (K >0.06) with 5–8% slope	2	2	3	4	5	5	5	5	5	5	5
V5	Very unstable soils (K >0.06) with 8–12% slope	3	3	4	5	5	5	5	5	5	5	5
V6	Very unstable soils (K >0.06) with >12% slope	4	4	5	5	5	5	5	5	5	5	5

Group A	Group B	Group C	Group D	Group E	Group F	Group G	Group H	Group I	Group J	Group K
Blackbutt	Bamboo-dryland/rainfed	Citrus-irrigated-trickle	Banana-dryland/rainfed	Sugarcane-dryland/rainfed	Ginger-summer-spray	Turf-irrigated-spray	Hemp-dryland/rainfed	Sweet potato-winter-spray	Sweet potato-summer-spray	Capsicum-winter-spray
Dunn's white gum		Stone fruit-irrigated-trickle	Banana-irrigated-trickle	Sugarcane-irrigated-spray	Ginger-winter-spray	Choko-irrigated-spray				Capsicum-summer-spray
Gympie messmate		Avocado-irrigated-trickle	Macadamia-irrigated-trickle			Pineapple-dryland/rainfed				Cucurbit-winter-spray
Lemon-scented gum/spotted gum		Caribbean pine	Macadamia-dryland/rainfed			Strawberry-irrigated-spray				Cucurbit-summer-spray
Rose gum/flooded gum		Custard apple-irrigated-trickle	Pawpaw-irrigated-trickle							Maize-summer
		Lychee-irrigated-trickle								Millet-summer
		Mango-irrigated-trickle								Sorghum-summer
		Passionfruit-irrigated-trickle								Soybean-dryland/rainfed
		Persimmon-irrigated-trickle								Sweet corn-summer-spray
		Improved pasture-dryland/rainfed								Sweet corn-winter-spray
										Tomato-summer-spray
										Tomato-winter-spray

Flooding (F)

Flood events typically involve inundation from overbank stream flows. Effects of flooding include yield reduction or plant death. Other effects include physical removal of or damage to the crop by flowing water, floodplain erosion and damage to infrastructure such as irrigation equipment.

Limitation class determination

- Consultation with local authorities, state agencies, community groups and local landholders
- Published flood maps and flood modelling outputs

Additional notes:

- Sugarcane and many other crops are commonly grown on low-lying areas, despite regular flooding. In such cases, some degree of crop tolerance means the effects of flooding do not detract from the intrinsic value of the land.
- Flooding was not considered a limitation for winter grown horticultural small crops because the growing season is relatively short and can be timed to avoid most seasonal flooding.
- Some tree crops (e.g. citrus, lychee and mango) tolerate inundation for periods of about 1 day. This assumes low velocity floodwaters, relatively low silt loads, reasonable water temperatures and rapid internal soil drainage once floodwaters recede.
- While loss of trees due to flooding represents a severe financial loss, most orchard enterprises work towards a return on their investment after about 10 years. Floods less frequent than 1 in 10 years (i.e. 1:20 to 1:50 years or less frequent) are statistically beyond the productive life of the trees and areas subject to such floods were classed as marginal for production rather than unsuitable.
- Pineapples are very sensitive to flooding and suffer significant fruit damage resulting in financial loss following an event. However, losses in pineapples are less significant than those suffered through tree losses in orchards because planting occurs every few years and land can be brought back into production relatively quickly. As such, flood events less frequent than 1 in 10 years were considered borderline class 3/4 for pineapples.

F – Flooding

Limitation value	Description	Suitability subclasses for various land management options									
		Group A	Group B	Group C	Group D	Group E	Group F	Group G	Group H	Group I	Group J
0	No flooding	1	1	1	1	1	1	1	1	1	1
1	Flooding <1 in 10 years (about 1 in 30 to 1 in 50 years)	1	1	1	1	1	1	2	3	4	5
2	Flooding occurs 1 in 2 to 1 in 10 years (about 1 in 5 years)	1	1	1	2	2	3	4	5	5	5
3	Annual flooding (about 1 in 1 to 1 in 2 years)	1	2	3	3	4	5	5	5	5	5

Group A	Group B	Group C	Group D	Group E	Group F	Group G	Group H	Group I	Group J
Bamboo-dryland/rainfed	Capsicum-winter-spray	Turf-irrigated-spray	Maize-summer	Banana-dryland/rainfed	Capsicum-summer-spray	Ginger-summer-spray	Citrus-irrigated-trickle	Stone fruit-irrigated-trickle	Avocado-irrigated-trickle
	Cucurbit-winter-spray		Millet-summer	Banana-irrigated-trickle	Caribbean pine	Ginger-winter-spray	Choko-irrigated-spray	Custard apple-irrigated-trickle	
	Sweet corn-winter-spray		Sorghum-summer	Blackbutt	Cucurbit-summer-spray	Hemp-dryland/rainfed	Lychee-irrigated-trickle	Macadamia-dryland/rainfed	
	Sweet potato-winter-spray		Sugarcane-dryland/rainfed	Dunn's white gum	Strawberry-irrigated-spray		Mango-irrigated-trickle	Macadamia-irrigated-trickle	
	Improved pasture-dryland/rainfed		Sugarcane-irrigated-spray	Gympie messmate	Sweet corn-summer-spray		Pawpaw-irrigated-trickle		
	Tomato-winter-spray			Lemon-scented gum/spotted gum	Sweet potato-summer-spray		Passionfruit-irrigated-trickle		
				Rose gum/flooded gum	Tomato-summer-spray		Persimmon-irrigated-trickle		
				Soybean-dryland/rainfed			Pineapple-dryland/rainfed		

Soil water availability (M)

Plant yield can be severely affected by periods of water stress, particularly during critical growth periods.

Limitation class determination

PAWC was used to determine soil water availability. PAWC is less critical for irrigated crops than for rainfed crops and in irrigated situations is used largely to estimate the required irrigation frequency.

Additional notes:

- All crops were considered irrigated except where indicated as rainfed. Forestry species and improved/sown pastures are rainfed.
- In areas receiving >1200 mm of annual rainfall, macadamias and bananas may be grown without supplementary irrigation but only on soils with a high PAWC (see Cp limitation).
- PAWC was predicted to the effective rooting depth (ERD). This is the depth to any impenetrable or impermeable layers (as defined for the Pd limitation). Native hardwood eucalypt species however have the ability to penetrate weathered/fractured rock and many impermeable layers and the PAWC boundary between suitable and marginal/unsuitable classes has been relaxed accordingly (when compared with cropping).

M – Soil water availability

Limitation		Suitability subclasses for various land management options										
value	Description	Group A	Group B	Group C	Group D	Group E	Group F	Group G	Group H	Group I	Group J	Group K
1	>150 mm PAWC	1	1	1	1	1	1	1	1	1	1	1
2	125–150 mm PAWC	1	1	1	1	1	1	1	1	1	2	2
3	100–125 mm PAWC	1	1	1	1	2	2	2	2	2	2	2
4	75–100 mm PAWC	1	1	2	2	2	2	3	3	3	2	2
5	50–75 mm PAWC	1	2	3	3	3	5	3	4	5	2	3
6	<50 mm PAWC	2	3	4	5	5	5	3	5	5	3	4

Group A	Group B	Group C	Group D	Group E	Group F	Group G	Group H	Group I	Group J	Group K
Banana-irrigated-trickle	Caribbean pine	Blackbutt	Pineapple-dryland/rainfed	Bamboo-dryland/ rainfed	Hemp-dryland/ rainfed	Avocado-irrigated-trickle	Maize-summer	Banana-dryland/ rainfed	Choko-irrigated-spray	Turf-irrigated-spray
Capsicum-summer-spray	Lemon-scented gum/spotted gum	Dunn's white gum	Sugarcane-irrigated-spray				Millet-summer	Macadamia-dryland/ rainfed	Ginger-summer-spray	
Capsicum-winter-spray		Gympie messmate	Improved pasture-dryland/rainfed					Soybean-dryland/ rainfed	Sweet corn-summer-spray	
Citrus-irrigated-trickle		Rose gum /flooded gum						Sugarcane-dryland/ rainfed	Sweet potato-summer-spray	
Cucurbit-winter-spray		Sorghum-summer								
Cucurbit-summer-spray										
Custard apple-irrigated-trickle										
Ginger-winter-spray										
Lychee-irrigated-trickle										
Macadamia-irrigated-trickle										
Mango-irrigated-trickle										
Pawpaw-irrigated-trickle										
Passionfruit-irrigated-trickle										
Persimmon-irrigated-trickle										
Strawberry-irrigated-spray										

Group A	Group B	Group C	Group D	Group E	Group F	Group G	Group H	Group I	Group J	Group K
Stone fruit-irrigated-trickle										
Sweet corn-winter-spray										
Sweet potato-winter-spray										
Tomato-summer-spray										
Tomato-winter-spray										

Soil nutrient deficiency (Nd)

Reduced crop growth may be associated with nutrient deficiencies in many soils. Livestock production may also be affected as a result of reduced pasture yield and/or pasture quality and/or lowered nutrient intake in animals.

For coastal SEQ it was determined that P is the only limiting nutrient that cannot easily be added in sufficient quantities to meet crop demands, therefore, Nd assessment was based on the level of P within the surface soil (0 to 0.3 m).

Limitation class determination

Nutrient deficient soils require additional P applications over and above standard management practices.

Additional notes:

- Because fertiliser use is considered a standard management practice associated with intensive cropping systems, nutrient deficiency is only recognised as a minor limitation.

Nd – Nutrient deficiency

Limitation		Suitability subclasses for various land management options		
value	Description	Group A	Group B	Group C
1	P >20 ppm	1	1	1
2	P 10–20 ppm	2	2	2
3	P 5–10 ppm	2	2	3
4	P <5 ppm	2	3	4

Group A	Group A cont.	Group B	Group C
Citrus-irrigated-trickle	Maize-summer	Blackbutt	Bamboo-dryland/rainfed
Stone fruit-irrigated-trickle	Mango-irrigated-trickle	Caribbean pine	Improved pasture-dryland/rainfed
Turf-irrigated-spray	Millet-summer	Dunn's white gum	
Avocado-irrigated-trickle	Pawpaw-irrigated-trickle	Ginger-summer-spray	
Banana-dryland/rainfed	Passionfruit-irrigated-trickle	Gympie messmate	
Banana-irrigated-trickle	Persimmon-irrigated-trickle	Lemon-scented gum/spotted gum	
Capsicum-summer-spray	Pineapple-dryland/rainfed	Rose gum/flooded gum	
Capsicum-winter-spray	Sorghum-summer	Sugarcane-dryland/rainfed	
Choko-irrigated-spray	Soybean-dryland/rainfed	Sugarcane-irrigated-spray	
Cucurbit-winter-spray	Strawberry-irrigated-spray		
Cucurbit-summer-spray	Sweet corn-summer-spray		
Custard apple-irrigated-trickle	Sweet corn-winter-spray		
Ginger-winter-spray	Sweet potato-summer-spray		
Hemp-dryland/rainfed	Sweet potato-winter-spray		
Lychee-irrigated-trickle	Tomato-summer-spray		
Macadamia-dryland/rainfed	Tomato-winter-spray		
Macadamia-irrigated-trickle			

Element toxicity (Nt)

Reduced crop growth may be associated with the oversupply or toxicity (i.e. excessive levels) of some mineral nutrients, particularly where soil pH is very low. Livestock production may be also be affected under such conditions as a result of reduced pasture yield and/or pasture quality.

Limitation class determination

Field or laboratory pH data were assessed against published research relating low pH to crop tolerance and element toxicity.

Additional Notes:

- While high pH values (greater than 8.5) are not common in inland SEQ nutrient availability may be reduced where they exist
- Forestry crops are commonly grown in soils with a surface pH of 5.5, with subsoil pH values of 4.5 to 5.

Nt – Nutrient toxicity

Limitation		Suitability subclasses for various land management options
value	Description	Group A
1	Surface soil (0–0.3 m) pH >5.0	1
2	Soil pH at 0.6 m >5.0	1
3	Surface soil (0–0.3 m) pH <5.0	3
4	Soil pH at 0.6 m <5.0	3

Group A		
Citrus-irrigated-trickle	Dunn's white gum	Pineapple-dryland/rainfed
Stone fruit-irrigated-trickle	Ginger-summer-spray	Rose gum/flooded gum
Turf-irrigated-spray	Ginger-winter-spray	Sorghum-summer
Avocado-irrigated-trickle	Gympie messmate	Soybean-dryland/rainfed
Bamboo-dryland/rainfed	Hemp-dryland/rainfed	Strawberry-irrigated-spray
Banana-dryland/rainfed	Lemon-scented gum/spotted gum	Sugarcane-dryland/rainfed
Banana-irrigated-trickle	Lychee-irrigated-trickle	Sugarcane-irrigated-spray
Blackbutt	Macadamia-dryland/rainfed	Sweet corn-summer-spray
Capsicum-summer-spray	Macadamia-irrigated-trickle	Sweet corn-winter-spray
Capsicum-winter-spray	Maize-summer	Sweet potato-summer-spray
Caribbean pine	Mango-irrigated-trickle	Sweet potato-winter-spray
Choko-irrigated-spray	Millet-summer	Improved pasture-dryland/rainfed
Cucurbit-winter-spray	Pawpaw-irrigated-trickle	Tomato-summer-spray
Cucurbit-summer-spray	Passionfruit-irrigated-trickle	Tomato-winter-spray
Custard apple-irrigated-trickle	Persimmon-irrigated-trickle	

Soil depth (Pd)

Shallow soils limit root proliferation and anchorage. Plants in shallow soils may lodge or become uprooted during strong winds.

Limitation class determination

Consultation with agronomic extension staff and local landholder experience.

Additional notes:

- Native hardwood eucalypt species have a rooting depth requirement >0.6 m, but have the ability to penetrate weathered/fractured rock and many impermeable layers. Therefore, the 'suitable' soil depth limit to impermeable layers was decreased from 0.6 m to 0.4 m.
- Vine crops (e.g. choko, passionfruit) and some horticultural crops (e.g. tomatoes) are normally trellised and lodging due to shallow soil depth is not considered an issue. As such, these crops have been treated in the same way as shallow rooted crops of low height.
- Depth to acidic subsoil material, as a result of acid sulfate soil, is dealt with in other limitations (i.e. Da, Dp).

Pd – Soil depth

Limitation		Suitability subclasses for various land management options					
value	Description	Group A	Group B	Group C	Group D	Group E	Group F
1	Effective soil depth >1.0 m	1	1	1	1	1	1
2	Effective soil depth 0.5–1.0 m	1	1	1	2	2	2
3	Effective soil depth 0.3–0.5 m	1	1	2	3	4	5
4	Effective soil depth <0.3 m	3	4	5	4	5	5

Group A	Group B	Group C	Group D	Group E	Group F
Improved pasture-dryland/rainfed	Turf-irrigated-spray	Hemp-dryland/rainfed	Blackbutt	Banana-dryland/rainfed	Avocado-irrigated-trickle
	Capsicum-summer-spray	Maize-summer	Caribbean pine	Banana-irrigated-trickle	Custard apple-irrigated-trickle
	Capsicum-winter-spray	Millet-summer	Gympie messmate	Citrus-irrigated-trickle	Lychee-irrigated-trickle
	Choko-irrigated-spray	Sorghum-summer	Lemon-scented gum/spotted gum	Dunn's white gum	Macadamia-dryland/rainfed
	Cucurbit-winter-spray	Sugarcane-dryland/rainfed	Rose gum/flooded gum	Pawpaw-irrigated-trickle	Macadamia-irrigated-trickle
	Cucurbit-summer-spray	Sugarcane-irrigated-spray		Persimmon-irrigated-trickle	Mango-irrigated-trickle
	Ginger-summer-spray	Sweet corn-summer-spray		Stone fruit-irrigated-trickle	
	Ginger-winter-spray	Sweet corn-winter-spray			
	Passionfruit-irrigated-trickle				
	Pineapple-dryland/rainfed				
	Soybean-dryland/rainfed				
	Strawberry-irrigated-spray				
	Sweet potato-summer-spray				
	Sweet potato-winter-spray				
	Tomato-summer-spray				
	Tomato-winter-spray				

Soil surface condition (Ps)

Problems with germination and seedling development during crop establishment are typically associated with adverse physical conditions in the surface soil, such as hard setting behaviour, coarse aggregates and crusting.

Limitation class determination

Plant tolerance limits and requirements in relation to germination were matched with soil properties and supported by agronomic experience.

Additional notes:

- Crops planted from seed (particularly small seeded grasses or pasture species) are most affected by this limitation.
- Horticultural crops such as tomatoes, capsicum and cucurbits, which are planted as seedlings, are less affected.
- Tree and vine crops, which are planted as large tree seedlings, and also crops planted using vegetative material (e.g. ginger, pineapple, sugarcane) are least affected.

Ps – Surface condition

Limitation value	Description	Suitability subclasses for various land management options					
		Group A	Group B	Group C	Group D	Group E	Group F
0	No restrictions	1	1	1	1	1	1
1	Hard setting soils with SL to CL surface textures and dry firm consistency	1	1	1	2	2	2
2	Hard setting massive soils with FSL to CLFS surface textures and dry firm consistency	1	2	2	3	3	3
3	Surface crusts present	1	2	3	3	3	4
4	Large soil aggregate size on surface (>20 mm)	4	2	3	4	5	4

Group A	Group B	Group C	Group D	Group E	Group F
Stone fruit-irrigated-trickle	Ginger-summer-spray	Turf-irrigated-spray	Soybean-dryland/rainfed	Millet-summer	Hemp-dryland/rainfed
	Ginger-winter-spray	Capsicum-summer-spray		Sorghum-summer	
	Pineapple-dryland/rainfed	Capsicum-winter-spray		Improved pasture-dryland/rainfed	
	Sugarcane-dryland/rainfed	Cucurbit-winter-spray			
	Sugarcane-irrigated-spray	Cucurbit-summer-spray			
	Sweet potato-summer-Spray	Maize-summer			
	Sweet potato-winter-spray	Strawberry-irrigated-spray			
		Sweet corn-summer-spray			
		Sweet corn-winter-spray			
		Tomato-summer-spray			
		Tomato-winter-spray			

Rockiness (R)

Coarse fragments (e.g. pebbles, gravel, cobbles, stones and boulders) and rock in the plough zone can damage and/or interfere with the efficient use of agricultural machinery. Surface gravel, stone and rock are particularly important and can interfere significantly with planting, cultivation and harvesting machinery used for root crops, macadamias, small crops, annual forage crops and sugarcane.

Limitation class determination

Consultation with landholders and machinery operators were used to establish accepted tolerances to rockiness.

Additional notes:

- Coarse fragments are particles greater than 2 mm that are not continuous with the underlying bedrock. Rock is defined as being continuous with the bedrock.
- Gravel and rock create serious problems for subsurface crops (ginger, sweet potato). These crops are subject to significant soil disturbance during harvest and face serious post-harvest issues if gravel and rock need to be separated from the crop. Severe problems also apply to turf, particularly the effect gravel or rock may have on subsurface cutting equipment. Gravel sized coarse fragments <60 mm also create significant issues for macadamia crops during harvest. Problems arise because of the similarity in size between surface gravels and nuts on the ground following shaking. Larger stones and rock also make the ground surface uneven for harvesting equipment and for routine activities such as slashing. As such, the presence of significant surface coarse fragments in macadamias represents a similar limitation to that experienced by most root crops.
- Strawberries and other horticultural small crops have low harvest heights and require numerous machinery passes (e.g. green manure, seedbed preparation, fumigation, bedding up, plastic application, picking etc.). While they are severely affected by significant stone or rock, it is less critical than for root crops or macadamias.
- Pineapples require intensive but infrequent (only every 3 years) bed preparation prior to planting. Significant stone or rock can severely restrict this and cause excessive damage to machinery. However, fruit is handpicked.
- Ground preparation for sugarcane is less intensive than for pineapples and crop cycles are normally 4 years. Significant stone or rock can severely impede low harvest height however.
- Bananas require extensive land preparation for a medium term crop (every 6–7 years) and stone or rock can represent a significant limitation during cultivation and planting. As such, bananas are more sensitive to the presence of stone or rock than most tree crops, but less sensitive than sugarcane or pineapples.

R – Rockiness

Limitation		Suitability subclasses for various land management options								
value	Description	Group A	Group B	Group C	Group D	Group E	Group F	Group G	Group H	Group I
R0	No rock	1	1	1	1	1	1	1	1	1
RF2	2–6 mm (fine gravel) 2–10%	1	1	1	1	1	1	1	1	3
RF3	2–6 mm (fine gravel) 10–20%	1	1	1	1	1	2	2	2	4
RF4	2–6 mm (fine gravel) 20–50%	1	1	1	2	2	3	3	3	5
RF5	2–6 mm (fine gravel) >50%	1	2	2	3	3	3	4	4	5
RM2	6–20 mm (medium gravel) 2–10%	1	1	1	1	1	1	1	3	3
RM3	6–20 mm (medium gravel) 10–20%	1	1	1	1	1	1	2	3	4
RM4	6–20 mm (medium gravel) 20–50%	1	1	1	2	2	2	3	4	5
RM5	6–20 mm (medium gravel) >50%	1	1	2	3	3	3	4	5	5
RG1	20–60 mm (coarse gravel) <2%	1	1	1	1	1	2	1	2	4
RG2	20–60 mm (coarse gravel) 2–10%	1	1	1	1	1	3	2	3	5
RG3	20–60 mm (coarse gravel) 10–20%	1	1	1	2	2	4	3	4	5
RG4	20–60 mm (coarse gravel) 20–50%	1	2	2	3	3	5	4	5	5
RG5	20–60 mm (coarse gravel) >50%	2	3	3	4	4	5	5	5	5
RC1	60–200 mm (cobbles) <2%	1	1	1	2	2	2	3	4	5
RC2	60–200 mm (cobbles) 2–10%	1	2	2	3	3	2	4	5	5
RC3	60–200 mm (cobbles) 10–20%	1	3	3	4	4	3	5	5	5
RC4	60–200 mm (cobbles) 20–50%	2	4	4	5	5	4	5	5	5
RC5	60–200 mm (cobbles) >50%	3	5	5	5	5	5	5	5	5
RS1	200–600 mm (stones) <2%	1	2	2	3	3	2	4	5	5
RS2	200–600 mm (stones) 2–10%	2	3	3	4	4	3	5	5	5
RS3	200–600 mm (stones) 10–20%	3	4	4	5	5	4	5	5	5
RS4	200–600 mm (stones) 20–50%	4	5	5	5	5	5	5	5	5
RS5	200–600 mm (stones) >50%	5	5	5	5	5	5	5	5	5
RO1	>600 mm or rock outcrop (boulders) <2%	2	3	3	1	4	3	5	5	5
RO2	>600 mm or rock outcrop (boulders) 2–10%	3	4	4	5	5	4	5	5	5
RO3	>600 mm or rock outcrop (boulders) 10–20%	4	5	5	5	5	5	5	5	5
RO4	>600 mm or rock outcrop (boulders) 20–50%	5	5	5	5	5	5	5	5	5
RO5	>600 mm or rock outcrop (boulders) >50%	5	5	5	5	5	5	5	5	5

Group A	Group B	Group C	Group D	Group E	Group F	Group G	Group H	Group I
Bamboo-dryland/rainfed	Caribbean pine	Banana-dryland/rainfed	Sugarcane-dryland/rainfed	Maize-summer	Macadamia-dryland/rainfed	Cucurbit-winter-spray	Capsicum-summer-spray	Turf-irrigated-spray
Citrus-irrigated-trickle		Banana-irrigated-trickle		Millet-summer	Macadamia-irrigated-trickle	Cucurbit-summer-spray	Capsicum-winter-spray	
Stone fruit-irrigated-trickle		Choko-irrigated-spray		Sorghum-summer		Ginger-summer-spray	Strawberry-irrigated-spray	
Avocado-irrigated-trickle		Pawpaw-irrigated-trickle		Sugarcane-irrigated-spray		Ginger-winter-spray	Sweet potato-summer-spray	
Blackbutt		Pineapple-dryland/rainfed		Sweet corn-summer-spray		Hemp-dryland/rainfed	Sweet potato-winter-spray	
Custard apple-irrigated-trickle				Sweet corn-winter-spray		Soybean-dryland/rainfed	Tomato-summer-spray	
Dunn's white gum							Tomato-winter-spray	
Gympie messmate								
Lemon-scented gum/spotted gum								
Lychee-irrigated-trickle								
Mango-irrigated-trickle								
Passionfruit-irrigated-trickle								
Persimmon-irrigated-trickle								
Rose gum/flooded gum								
Improved pasture-dryland/rainfed								

Salinity (Sa)

High soluble salts within the root zone can limit water uptake, result in toxicity effects and restrict root development.

Limitation class determination

Subclass determination was based on surface (0–0.1 m) salinity (ECse dS/m) combined with the productivity decrease guides in Table 46 of the *Salinity management handbook* (SalCon 1997). This assumes that surface salinity indicates root zone salinity. Subclasses were assigned based on predicted yield reduction:

Limitation subclass	Predicted yield reduction as a result of root zone salinity
Class 1	0 to 10% yield reduction
Class 2	10 to 20% yield reduction
Class 3	20 to 35% yield reduction
Class 4	35 to 50% yield reduction
Class 5	>50% yield reduction

Spatial representation of surface salinity data for SEQ is available from the Queensland Department of Natural Resources and Mines or from http://www.qld.gov.au/environment/land/soil/salinity/

Sa – Salinity

Limitation		Suitability subclasses for various land management options											
value	Description	Group A	Group B	Group C	Group D	Group E	Group F	Group G	Group H	Group I	Group J	Group K	Group L
1	No salinity or salinity <2 dS/m ECse	1	1	1	1	1	1	1	1	1	1	2	2
2	Dominantly slightly saline (2–4 dS/m ECse)	1	1	2	2	2	2	3	3	3	4	3	4
3	Dominantly moderately saline (4–8 dS/m ECse)	2	3	3	3	4	5	4	4	5	5	5	5
4	Dominantly severely saline (>8 dS/m ECse)	4	4	4	5	5	5	4	5	5	5	5	5

Group A	Group B	Group C	Group D	Group E	Group F	Group G	Group H	Group I	Group J	Group K	Group L
Sorghum-summer	Soybean-dryland/rainfed	Custard apple-irrigated-trickle	Sugarcane-dryland/rainfed	Stone fruit-irrigated-trickle	Sweet corn-summer-spray	Bamboo-dryland/rainfed	Caribbean pine	Choko-irrigated-spray	Banana-dryland/rainfed	Citrus-irrigated-trickle	Avocado-irrigated-trickle
		Macadamia-dryland/rainfed	Sugarcane-irrigated-spray	Turf-irrigated-spray	Sweet corn-winter-spray		Dunn's white gum	Ginger-summer-spray	Banana-irrigated-trickle	Capsicum-summer-spray	Blackbutt
		Macadamia-irrigated-trickle		Cucurbit-winter-spray	Tomato-summer-spray		Maize-summer	Ginger-winter-spray	Lychee-irrigated-trickle	Capsicum-winter-spray	Gympie messmate
		Millet-summer		Cucurbit-summer-spray	Tomato-winter-spray		Sweet potato-summer-spray		Pawpaw-irrigated-trickle		Hemp-dryland/rainfed
		Rose gum/flooded gum		Mango-irrigated-trickle			Sweet potato-winter-spray		Passionfruit-irrigated-trickle		Lemon-scented gum/spotted gum
		Improved pasture-dryland/rainfed		Persimmon-irrigated-trickle					Pineapple-dryland/rainfed		
									Strawberry-irrigated-spray		

Microrelief (Tm)

Microrelief such as melon holes, swamp hummock, rills and small gullies cause irregular and reduced crop productivity. This is mainly as a result of uneven water distribution (e.g. water ponding in depressions), irregular cultivation and impeded trafficability. Effects associated with the presence of microrelief such as temporary waterlogging and poor surface condition are covered in the wetness (W) and soil physical (Ps) limitations respectively.

The vertical interval (VI) of the microrelief typically dictates the amount of levelling required and/or the potential for reduced productivity. Therefore VI was used to determine the severity of the limitation.

Limitation class determination
Land resource surveys, consultation with agronomic extension staff and local landholder experience.

Tm – Microrelief

Limitation		Suitability subclasses for various land management options		
value	Description	Group A	Group B	Group C
0	No microrelief	1	1	1
1	Microrelief with a vertical interval <0.3 m	1	2	3
2	Microrelief with a vertical interval 0.3–0.5 m	2	3	4
3	Microrelief with a vertical interval >0.5 m	3	4	5

Group A	Group B	Group C	Group C cont.
Blackbutt	Turf-irrigated-spray	Citrus-irrigated-trickle	Macadamia-dryland/rainfed
Caribbean pine	Maize-summer	Stone fruit-irrigated-trickle	Macadamia-irrigated-trickle
Dunn's white gum	Millet-summer	Avocado-irrigated-trickle	Mango-irrigated-trickle
Gympie messmate	Sorghum-summer	Bamboo-dryland/rainfed	Pawpaw-irrigated-trickle
Lemon-scented gum/spotted gum	Sugarcane-dryland/rainfed	Banana-dryland/rainfed	Passionfruit-irrigated-trickle
Rose gum/flooded gum	Sugarcane-irrigated-spray	Banana-irrigated-trickle	Persimmon-irrigated-trickle
Improved pasture-dryland/rainfed		Capsicum-summer-spray	Pineapple-dryland/rainfed
		Capsicum-winter-spray	Soybean-dryland/rainfed
		Choko-irrigated-spray	Strawberry-irrigated-spray
		Cucurbit-winter-spray	Sweet corn-summer-spray
		Cucurbit-summer-spray	Sweet corn-winter-spray
		Custard apple-irrigated-trickle	Sweet potato-summer-spray
		Ginger-summer-spray	Sweet potato-winter-spray
		Ginger-winter-spray	Tomato-summer-spray
		Hemp-dryland/rainfed	Tomato-winter-spray
		Lychee-irrigated-trickle	

Topography (Ts)

The safety and/or efficiency of farm vehicle/machinery operation are affected by:

- steep gradients, specifically rolling and side-slip hazards
- erosion control layouts on land with significant variability in the degree and direction of slopes (e.g. complex slopes). It is particularly important with row crops where final layouts on such lands would necessitate impractical short rows and sharp curves.

Limitation class determination

Consultation with workplace, health and safety guidelines and landholder experience were used to determine the upper slope limit for safe machinery operation over a range of land uses. Farmer tolerance to short row length and the inability of trailing implements to effectively negotiate curves with less than 30 m radius were also considered.

Additional notes:

- Where tillage forms part of normal management within the crop cycle, a slope limit of 15% was recognised as the upper limit for general machinery use.
- However, where contour based or cross slope sward management is practised in horticultural situations (e.g. tree and vine orchards) slopes of 20% were considered manageable.
- In commercial hardwood timber production, where specialised techniques (e.g. hand planting and cable logging) are used in planting and harvesting operations, steeper slope limits up to 35–40% are considered workable.
- Where spraying and harvesting operations in horticultural tree and vine crops can be carried out directly up and down slopes, a maximum slope limit of 25% was considered manageable for safe machinery operation.
- The exception to this limit was macadamias, where mechanised ground harvesting equipment needs to be able to turn safely on side slopes. This reduces the safe working slope limit to 20% for these crops.

Ts – Slope

Limitation value	Description	Suitability subclasses for various land management options						
		Group A	Group B	Group C	Group D	Group E	Group F	Group G
1	Slope <8%	1	1	1	1	1	1	1
2	Slope 8–12%	1	1	1	1	1	2	3
3	Slope 12–15%	1	1	1	1	2	3	4
4	Slope 15–20%	1	1	1	2	3	4	5
5	Slope 20–30%	1	2	2	3	4	5	5
6	Slope >30%	4	3	4	5	5	5	5

Group A	Group B	Group C	Group D	Group E	Group F	Group G
Bamboo-dryland/rainfed	Blackbutt	Improved pasture-dryland/rainfed	Citrus-irrigated-trickle	Banana-dryland/rainfed	Turf-irrigated-spray	Soybean-dryland/rainfed
	Dunn's white gum		Stone fruit-irrigated-trickle	Banana-irrigated-trickle	Capsicum-summer-spray	
	Gympie messmate		Avocado-irrigated-trickle	Choko-irrigated-spray	Capsicum-winter-spray	
	Lemon-scented gum/spotted gum		Caribbean pine	Lychee-irrigated-trickle	Cucurbit-summer-spray	
	Rose gum/flooded gum		Custard apple-irrigated-trickle	Macadamia-dryland/rainfed	Cucurbit-winter-spray	
			Mango-irrigated-trickle	Macadamia-irrigated-trickle	Ginger-summer-spray	
			Passionfruit-irrigated-trickle	Pawpaw-irrigated-trickle	Ginger-winter-spray	
			Persimmon-irrigated-trickle		Hemp-dryland/rainfed	
					Maize-summer	
					Millet-summer	
					Pineapple-dryland/rainfed	
					Sorghum-summer	
					Strawberry-irrigated-spray	
					Sugarcane-dryland/rainfed	
					Sugarcane-irrigated-spray	
					Sweet corn-summer-spray	
					Sweet corn-winter-spray	
					Sweet potato-summer-spray	
					Sweet potato-winter-spray	
					Tomato-summer-spray	

Group A	Group B	Group C	Group D	Group E	Group F	Group G
					Tomato-winter-spray	

Wetness (W1, W2 and W3)

Waterlogged soils reduce plant growth and delay effective machinery operations.

Crops requiring a minimum drained soil depth of 1.5 m are restricted to:
Avocadoes

Crops requiring a minimum drained soil depth of 1.0 m include:
Sweet corn (summer and winter), maize, sorghum, choko, citrus, custard apple, macadamia, pawpaw, stone fruit, mango, lychee, passionfruit, persimmon, Gympie messmate, blackbutt, spotted gum, flooded gum, Dunn's white gum and Caribbean pine

Crops requiring a minimum drained soil depth of 0.5 m include:
Ginger, capsicum (summer and winter), cucurbits (summer and winter), pineapple, sweet potato (summer and winter), tomato (summer and winter), turf, strawberry, sugar cane, sown pasture and banana

Limitation class determination
Crop tolerance information, consultation with agronomic extension staff and local landholder experience was used in determining the severity of this limitation. The effects of delayed machinery operations were also considered.

Additional notes:

- Wetness subclasses for bananas are similar to sugarcane except soil wetness has a greater effect on machinery usage.
- For sown pastures, a wide range of species is available to cater for pasture production across a range of soil wetness conditions (with the exception of very poorly drained sites where there is no recognised non-invasive species).
- Imperfectly drained soils significantly affect plant growth for many crops and are usually the soils where mounding is important. Mounding is a common management practice for tree crops.
- Wetness subclasses for winter horticultural crops (capsicum, cucurbits, sweet potato, tomato) are less stringent than for equivalent summer crops because winter period conditions are drier and temporary watertables may disappear or drop significantly allowing the allocation of a higher (better) drainage class.

W1 – Wetness to 1 m

Limitation		Suitability subclasses for various land management options			
value	Description	Group A	Group B	Group C	Group D
W60	Rapidly drained	1	1	1	1
W54	Well drained (5) & highly permeable (4)	1	1	1	1
W53	Well drained (5) & moderately permeable (3)	1	1	1	2
W44	Moderately well drained (4) & highly permeable (4)	1	1	1	2
W43	Moderately well drained (4) & moderately permeable (3)	1	2	2	3
W42	Moderately well drained (4) & slowly permeable (2)	2	3	3	4
W41	Moderately well drained (4) & very slowly permeable (1)	2	3	3	4
W34	Imperfectly drained (3) & highly permeable (3)	2	1	3	4
W33	Imperfectly drained (3) & moderately permeable (3)	3	4	4	4
W32	Imperfectly drained (3) & slowly permeable (2)	3	4	4	5
W31	Imperfectly drained (3) & very slowly permeable	4	4	4	5
W24	Poorly drained (2) & highly permeable (4)	4	5	5	5
W23	Poorly drained (2) & moderately permeable (3)	4	5	5	5
W22	Poorly drained (2) & slowly permeable (2)	5	5	5	5
W21	Poorly drained (2) & very slowly permeable (1)	5	5	5	5
W10	Very poorly drained (1)	5	5	5	5

Group A	Group B	Group C	Group D
Caribbean pine	Maize-summer	Citrus-irrigated-trickle	Stone fruit-irrigated-trickle
Mango-irrigated-trickle		Lychee-irrigated-trickle	Choko-irrigated-spray
Sorghum-summer		Millet-summer	Custard apple-irrigated-trickle
Sweet corn-winter-spray		Persimmon-irrigated-trickle	Hemp-dryland/rainfed
		Sweet corn-summer-spray	Macadamia-dryland/rainfed
			Macadamia-irrigated-trickle
			Pawpaw-irrigated-trickle
			Passionfruit-irrigated-trickle

W2 – Wetness to 0.5 m

Limitation		Suitability subclasses for various land management options								
value	Description	Group A	Group B	Group C	Group D	Group E	Group F	Group G	Group H	Group I
W60	Rapidly drained (6)	1	1	1	1	1	1	1	1	1
W54	Well drained (5) & highly permeable (4)	1	1	1	1	1	1	1	1	2
W53	Well drained (5) & moderately permeable (3)	1	1	1	1	1	1	1	1	2
W44	Moderately well drained (4) & highly permeable (4)	1	1	1	1	1	1	1	1	2
W43	Moderately well drained (4) & moderately permeable (3)	1	1	1	1	1	2	2	2	3
W42	Moderately well drained (4) & slowly permeable (2)	1	1	2	2	2	3	3	3	4
W41	Moderately well drained (4) & very slowly permeable (1)	1	1	2	2	2	3	3	3	4
W34	Imperfectly drained (3) & highly permeable (4)	1	2	2	2	2	2	2	3	4
W33	Imperfectly drained (3) & moderately permeable (3)	1	2	2	2	2	3	4	4	4
W32	Imperfectly drained (3) & slowly permeable (2)	2	2	3	3	3	4	4	4	5
W31	Imperfectly drained (3) & very slowly permeable (1)	2	2	3	3	3	4	4	4	5
W24	Poorly drained (2) & highly permeable (4)	3	4	3	3	4	5	5	5	5
W23	Poorly drained (2) & moderately permeable (3)	3	4	3	3	4	5	5	5	5
W22	Poorly drained (2) & slowly permeable (2)	4	4	4	4	5	5	5	5	5
W21	Poorly drained (2) & very slowly permeable (1)	4	4	4	4	5	5	5	5	5
W10	Very poorly drained (1)	5	4	4	5	5	5	5	5	5

Group A	Group B	Group C	Group D	Group E	Group F	Group G	Group H	Group I
Improved pasture-dryland/rainfed	Bamboo-dryland/rainfed	Sugarcane-dryland/rainfed	Turf-irrigated-spray	Banana-dryland/rainfed	Soybean-dryland/rainfed	Strawberry-irrigated-spray	Capsicum-summer-spray	Ginger-summer-spray
		Sugarcane-irrigated-spray		Banana-irrigated-trickle	Blackbutt		Cucurbit-summer-spray	Ginger-winter-spray
				Capsicum-winter-spray	Gympie messmate		Pineapple-dryland/rainfed	
				Cucurbit-winter-spray	Lemon-scented gum/spotted gum		Sweet potato-summer-spray	
				Dunn's white gum	Rose gum/flooded gum		Tomato-summer-spray	
				Sweet potato-winter-spray				
				Tomato-winter-spray				

W3 – Wetness to 1.5 m

Limitation		Suitability subclasses for various land management options
value	Description	Group A
W64	Rapidly drained (6) & highly permeable (4)	1
W63	Rapidly drained (6) & moderately permeable (3)	2
W54	Well drained (5) & highly permeable (4)	2
W53	Well drained (5) & moderately permeable (3)	3
W44	Moderately well drained (4) & highly permeable (4)	3
W43	Moderately well drained (4) & moderately permeable (3)	4
W42	Moderately well drained (4) & slowly permeable (2)	5
W41	Moderately well drained (4) & very slowly permeable (1)	5
W34	Imperfectly drained (3) & highly permeable (4)	4
W33	Imperfectly drained (3) & moderately permeable (3)	5
W32	Imperfectly drained (3) & slowly permeable (2)	5
W31	Imperfectly drained (3) & very slowly permeable (1)	5
W24	Poorly drained (2) & highly permeable (4)	5
W23	Poorly drained (2) & moderately permeable (3)	5
W22	Poorly drained (2) & slowly permeable (2)	5
W21	Poorly drained (2) & very slowly permeable (1)	5
W10	Very poorly drained (1)	5

Group A
Avocado-irrigated-trickle

Landscape complexity (X)

This limitation assessed the effect soil complexity and/or topographic dissection may have on the size or shape of an area of suitable land. A ‘minimum production area’ is defined as the minimum area of land that is practicable to utilise for a particular land use.

Limitation class determination

The minimum production area for each land use was determined by consultation with agronomic extension staff and landholders. The suitability may be modified according to the proximity and extent of surrounding non-contiguous suitable land.

Additional notes:

- Landscape complexity has most effect on broadacre crops that require large paddock sizes for efficiency (e.g. sugarcane, forage crops, commercial timber). Surveyed lot size is not considered.

X – Landscape complexity

Limitation value	Description	Suitability subclasses for various land management options						
		Group A	Group B	Group C	Group D	Group E	Group F	Group G
1	Minimum practical production area >10 ha	1	1	1	1	1	1	1
2	Minimum practical production area 5–10 ha	1	1	1	1	1	3	3
3	Minimum practical production area 2.5–5 ha	1	1	1	1	3	4	5
4	Minimum practical production area 1.5–2.5 ha	1	1	2	3	4	4	5
5	Minimum practical production area <1.5 ha	2	4	3	4	5	5	5

Group A	Group B	Group C	Group D	Group E	Group F	Group G
Turf-irrigated-spray	Capsicum-summer-spray	Citrus-irrigated-trickle	Stone fruit-irrigated-trickle	Maize-summer	Blackbutt	Hemp-dryland/rainfed
Choko-irrigated-spray	Capsicum-winter-spray	Avocado-irrigated-trickle	Lychee-irrigated-trickle	Millet-summer	Caribbean pine	Soybean-dryland/rainfed
	Cucurbit-winter-spray	Banana-dryland/rainfed	Macadamia-dryland/rainfed	Sorghum-summer	Dunn's white gum	
	Cucurbit-summer-spray	Banana-irrigated-trickle	Macadamia-irrigated-trickle		Gympie messmate	
	Pineapple-dryland/rainfed	Custard apple-irrigated-trickle	Persimmon-irrigated-trickle		Lemon-scented gum/spotted gum	
	Sweet corn-summer-spray	Ginger-summer-spray			Rose gum/flooded gum	
	Sweet corn-winter-spray	Ginger-winter-spray				
	Sweet potato-summer-spray	Mango-irrigated-trickle				
	Sweet potato-winter-spray	Pawpaw-irrigated-trickle				
	Tomato-summer-spray	Passionfruit-irrigated-trickle				
	Tomato-winter-spray	Strawberry-irrigated-spray				
		Sugarcane-dryland/rainfed				
		Sugarcane-irrigated-spray				

Appendix 4 – Morphological and analytical data

Soil type: Bazzo (Bz)

Site No.: 264
Location: Zone 56, 491718E, 7100197N
ASC: Sodic, Magnesic, Grey Dermosol

Slope: 15%
Landform element: Hillslope
Landform pattern: Low hills
Geology: Myrtle Creek Sandstone (RJdm)

Microrelief: None
Surface condition: Soft
Surface coarse fragments: Nil
Vegetation: Pasture grasses

Profile morphology:

Horizon	Depth (m)	Description
A1	0.0 to 0.17	Brown (10YR 4/3); clay loam sandy; moderate 5–10 mm subangular blocky structure; moderately moist; <2% weathered subrounded sandstone 2–6 mm; clear change to
B21	0.17 to 0.25	Grey (10YR 6/1); many (20–50%) fine (<5 mm) distinct orange substrate inclusion mottles; sandy light clay; moderate 5–10 mm subangular blocky structure; moist; <2% weathered subrounded sandstone 2–6 mm; abrupt change to
B22	0.25 to 0.40	Grey (10YR 6/2); many (20–50%) fine (<5 mm) distinct orange substrate inclusion mottles; sandy light clay; moderate 5–10 mm subangular blocky structure; moist; 20–50% weathered subangular platy sandstone 6–20 mm; abrupt change to
B23	0.40 to 0.60	Grey (10YR 7/2);); few (2–10%) fine (<5 mm) prominent orange substrate inclusion mottles; sandy medium clay; moderate 5–10 mm subangular blocky structure; moist; clear change to
C	0.60 to 0.65	Weathered sandstone rock.

Analysis results

	1:5 aqueous		Citrate soluble										Extractable cations (ICP)				
Depth	pH	EC	Fe	Al	Al Sat	ESP	ADMC	NO_3N	Cl	ECEC	Exch Al	Exch Acid	Ca	Mg	Na	Exch. Na	K
(m)		(dS/M)	%		%			mg/kg		meq/100g			cmol_c/kg				
0.40–0.60	5.3	0.05	–	–	42.2	6.16	—	1	<20	23.3	9.83	12.1	0.231	9.2	1.43	1.43	0.301

Soil type: Eulama (El)

Site No.: 18
Location: Zone 56, 489419E, 7098014N
ASC: Acidic-Sodic, Magnesic, Brown Dermosol

Slope: <1%
Landform element: Plain
Landform pattern: Alluvial plain
Geology: Quaternary Alluvium (Qa)

Microrelief: None
Surface condition: Soft
Surface coarse fragments: Nil
Vegetation: *Eucalyptus grandis*, pasture grasses

Profile morphology:

Horizon	Depth (m)	Description
A12	0.0 to 0.09	Grey (10YR 4/2); light clay; moderate 5–10 mm angular blocky structure; moist; 2–10% manganiferous concretions <2 mm; gradual change to
A12	0.09 to 0.25	Brown (2.5Y 4/3) light clay; moderate 5–10 mm angular blocky structure; moderately moist; 10–20% manganiferous concretions <2 mm; gradual change to
B21	0.25 to 0.75	Brown (10YR 5/6); medium clay; moderate 10–20 mm angular blocky structure; moderately moist; 10–20% manganiferous segregations <2 mm; diffuse change to
B22	0.75 to 1.15	Brown (10YR 4/6); common (10–20%) medium (5–15 mm) distinct brown mottles; medium clay; moderate 10–20 mm prismatic structure; moderately moist; 2–10% soft manganiferous segregations <2 mm; gradual change to
B23	1.15 to 1.35	Brown (10YR 4/6); common (10–20%) medium (5–15 mm) distinct brown mottles; medium clay; moderate 10–20 mm angular blocky structure; moderately moist; 20–50% soft manganiferous segregations <2 mm.

Analysis results

	1:5 aqueous		Citrate soluble										Extractable cations (ICP)				
Depth	pH	EC	Fe	Al	Al Sat	ESP	ADMC	NO_3N	Cl	ECEC	Exch Al	Exch Acid	Ca	Mg	Na	Exch. Na	K
(m)		(dS/M)	%		%			mg/kg		meq/100g			cmol_c/kg				
1.00–1.10	5.4	0.14	–	–	4.7	15	–	2	115	11.6	0.54	1.02	0.191	8.51	2.06	1.74	0.116

Soil type: Eulama (El)

Site No.: 20
Location: Zone 56, 489310E, 7098008N
ASC: Acidic, Demosolic, Redoxic Hydrosol

Slope: <1%
Landform element: Drainage depression
Landform pattern: Alluvial plain
Geology: Quaternary Alluvium (Qa)

Microrelief: None
Surface condition: Soft
Surface coarse fragments: Nil
Vegetation: Pasture grasses

Profile morphology:

Horizon	Depth (m)	Description
A1	0.0 to 0.07	Dark grey (2.5YR 4/1); light clay; moderate 5–10 mm subangular blocky structure; moist; clear change to
A2	0.07 to 0.15	Grey (2.5Y 5/1); few (2–10%) fine (<5 mm) distinct brown mottles; light clay; moderate 10–20 mm subangular blocky structure; moist; <2% soft manganiferous segregations <2 mm; clear change to
B21	0.15 to 0.65	Grey (5Y 7/1); many (20–50%) medium (5–15 mm) distinct brown mottles; medium clay; moderate 20–50 mm prismatic structure; moist; gradual change to
B22	0.65 to 1.25	Grey (5Y 7/1); many (20–50%) coarse (15–30 mm) prominent brown mottles; medium clay; weak 20–50 mm subangular blocky structure; moist; 2–10% soft manganiferous segregations 2–6 mm; gradual change to
B23	1.25 to 1.45	Grey (5Y 7/1); common (10–20%) medium (5–15 mm) prominent brown mottles; fine sandy medium clay; weak 20–50 mm subangular blocky structure; wet.

Analysis results

	1:5 aqueous		Citrate soluble										Extractable cations (ICP)				
Depth	pH	EC	Fe	Al	Al Sat	ESP	ADMC	NO_3N	Cl	ECEC	Exch Al	Exch Acid	Ca	Mg	Na	Exch. Na	K
(m)		(dS/M)	%		%			mg/kg		meq/100g			cmol_c/kg				
0.90–1.00	5.1	0.03	–	–	35.2	4.98	–	1	<20	9.85	3.47	4.52	0.351	4.37	0.491	0.491	0.122

Soil type: Eulama (El)

Site No.: 266
Location: Zone 56, 490791E, 7098026N
ASC: Acidic-mottled, Mesotrophic, Yellow Dermosol

Slope: 0%
Landform element: Plain
Landform pattern: Alluvial Plain
Geology: Quaternary Alluvium (Qa)

Microrelief: None
Surface condition: Firm
Surface coarse fragments: Nil
Vegetation: Pasture species (grasses)

Profile morphology:

Horizon	Depth (m)	Description
Ap	0.0 to 0.06	Grey (10YR 4/2); sandy clay loam; moderate 2–5 mm subangular blocky structure; moderately moist; abrupt change to
B1	0.06 to 0.10	Brown (10YR 5/3); few (2–10%) fine (<5 mm) distinct orange mottles; light clay; moderate 10–20 mm subangular blocky structure; dry; <2% angular quartz coarse fragments 6–20 mm; abrupt change to
B21	0.10 to 0.23	Brown (10YR 5/3); light medium clay; moderate 2–5 mm subangular blocky structure; dry; <2% manganiferous nodules <2 mm; abrupt change to
B22	0.23 to 0.90	Yellow (2.5Y 6/4); common (10–20%) fine (<5 mm) distinct orange mottles; light medium clay; moderate 10–20 mm subangular blocky structure; dry; 2–10% manganiferous nodules 2–6 mm; diffuse change to
B23	0.90 to 1.80	Yellow (2.5Y 6/4); common (10–20%) fine (<5 mm) distinct orange mottles; light medium clay; moderate 2–5 mm subangular blocky structure; dry; 2–10% manganiferous nodules 2–6 mm.

Analysis results

	1:5 aqueous		Citrate soluble										Extractable cations (ICP)					Particle size				Disp.	15	Total element (XRF)		
Depth	pH	EC	Fe	Al	Al Sat	ESP	ADMC	NO_3N	Cl	ECEC	Exch Al	Exch Acid	Ca	Mg	Na	Exch. Na	K	CS	FS	Si	Cl	Ratio	BAR	K	P	S
(m)		(dS/M)	%					mg/kg		meq/100g			cmol_c/kg					%				R1	%	%		
0.00–0.05	5.7	0.35	–	–	—	—	5	101	92	—	—	—	19.9	9.13	0.257	<0.080	1.34	21.1	26.8	32	24.9	0.45	22.4	1.35	0.086	0.072
0.23–0.30	5.4	0.09	–	–	1.9	1.66	2.4	23	<20	9.33	0.18	0.2	4.96	3.43	0.155	0.155	0.588	1.8	21.3	43.3	37.8	0.46	20.1	1.45	0.064	0.027
0.50–0.60	5.1	0.03	–	–	27	3.45	2.2	4	<20	6.77	1.83	2.13	1.75	2.53	0.234	0.234	0.138	7.2	14.3	38	46.2	0.54	19.2	1.52	0.045	0.018
0.80–0.90	5	0.04	3.1	0.3	34.6	4.36	2.3	2	<20	7.34	2.54	2.92	0.98	3.03	0.32	0.32	0.087	3.1	15.9	39.7	46.3	0.52	19.3	1.51	0.037	0.02
1.10–1.20	5.2	0.03	3.5	0.3	33	5.03	2.1	2	<20	7.16	2.36	2.7	0.526	3.49	0.361	0.361	0.082	5.6	12.7	39.6	47.9	0.49	19.5	1.5	0.037	0.014
1.40–1.50	5.1	0.03	–	–	30.8	4.11	2	2	27	7.2	2.22	2.53	0.371	3.92	0.371	0.296	0.081	6	10.8	41.3	46.1	0.5	19.8	1.53	0.037	0.012

Soil type: Pangola (Pg)

Site No.: 256
Location: Zone 56, 494606E, 7091142N
ASC: Mottled, Mesotrophic, Grey Kurosol

Slope: 7%
Landform element: Hillslope
Landform pattern: Rises
Geology: Tiaro Coal Measures (Jdt)

Microrelief: None
Surface condition: Soft
Surface coarse fragments: Nil
Vegetation: Pasture grasses

Profile morphology:

Horizon	Depth (m)	Description
A1	0.0 to 0.12	Black (7.5YR 3/2); very few (<2%) fine (<5 mm) faint brown mottles; clay loam sandy; moderate 2–5 mm subangular blocky structure; moist; clear change to
B21	0.12 to 0.28	Grey (2.5Y 5/2); common (10–20%) fine (<5 mm) distinct orange and distinct red mottles; medium clay; moderate 2–5 mm subangular blocky structure; moist; <2% rounded mudstone and quartz coarse fragments; diffuse change to
B22	0.28 to 0.56	Grey (2.5Y 6/2); many (20–50%) fine (<5 mm) distinct orange and distinct red mottles; medium clay; moderate 10–20 mm subangular blocky structure; moist; diffuse change to
B31	0.56 to 0.84	Grey (2.5Y 7/2); few (2–10%) medium (5–15 mm) distinct orange and distinct red substrate inclusion mottles; sandy light clay; massive; moist; gradual change to
B32	0.84 to 0.93	White (5Y 8/1); very few (<2%) fine to medium (<5–15 mm) distinct orange and distinct red substrate inclusion mottles; light medium clay; massive; moist; clear change to
BC	0.93 to 0.98	Brown (10YR 6/8); few (2–10%) medium (5–15 mm) distinct orange substrate inclusion mottles; sandy clay loam; massive; moist.

Analysis results

	1:5 aqueous		Citrate soluble										Extractable cations (ICP)				
Depth	pH	EC	Fe	Al	Al Sat	ESP	ADMC	NO_3N	Cl	ECEC	Exch Al	Exch Acid	Ca	Mg	Na	Exch. Na	K
(m)		(dS/M)	%		%			mg/kg		meq/100g			cmol_c/kg				
0.15–0.28	4.6	0.03	–	–	75.8	0.98	—	1	<20	17.3	13.1	15.4	0.57	0.961	0.169	0.169	0.193

Soil type: Pangola (Pg)

Site No.: 258
Location: Zone 56, 497013E, 7092550N
ASC: Acidic-mottled, Mesotrophic, Brown Dermosol

Slope: 2.5%
Landform element: Riseslope
Landform pattern: Rises
Geology: Tiaro Coal Measures (Jdt)

Microrelief: None
Surface condition: Firm
Surface coarse fragments: Nil
Vegetation: *Eucalyptus moluccana*, grasses

Profile morphology:

Horizon	Depth (m)	Description
A1	0.0 to 0.11	Brown (10YR 4/3); clay loam; moderate 2–5 mm subangular blocky structure; moist; 2–10% subangular quartz coarse fragments 6–20 mm; 10–20% ferruginous nodules 2–6 mm; gradual change to
B1	0.11 to 0.45	Brown (10YR 4/6); few (2–10%) fine (<5 mm) faint brown mottles; light clay; moderate 5–10 mm subangular blocky structure; moderately moist; 2–10% subangular mudstone coarse fragments 2–60 mm; 2–10% ferruginous nodules 2–20 mm; gradual change to
B21	0.45 to 0.65	Brown (7.5YR 5/6); common (10–20%) medium (5–15 mm) distinct red mottles; light clay; moderate 5–10 mm subangular blocky structure; moderately moist; <2% subangular mudstone coarse fragments 2–6 mm; 2–10% ferruginous nodules <2 mm; gradual change to
B22	0.65 to 0.92	Brown (7.5YR 5/6); many (20–50%) medium (5–15 mm) distinct brown mottles; light medium clay; moderate 2–5 mm subangular blocky structure; moderately moist; 2–10% subrounded mudstone coarse fragments 20–60 mm; <2% ferruginous nodules 2–6 mm; gradual change to
B23	0.92 to 1.18	Red (5YR 4/6); many (20–50%) medium (5–15 mm) distinct red mottles; medium clay; moderate 2–5 mm subangular blocky or lenticular structure; moderately moist; <2% ferruginous nodules 2–20 mm; gradual change to
B24	1.18 to 1.32	Brown (10YR 5/6); common (10–20%) fine (<5 mm) faint orange mottles; medium clay; moderate 2–5 mm subangular blocky structure; moderately moist; <2% subangular quartz coarse fragments 2–6 mm; gradual change to
B25	1.32 to 1.60	Grey (10YR 7/1); common (10–20%) fine (<5 mm) distinct red and brown mottles; medium clay; moderate 2–5 mm subangular blocky structure; moderately moist; <2% ferruginous nodules 2–6 mm; gradual change to
B26	1.60 to 1.85	Grey (10YR 7/1); many (20–50%) fine (<5 mm) distinct red and brown mottles; medium heavy clay; moderate 2–5 mm subangular blocky structure; moist.

Analysis results

	1:5 aqueous		Citrate soluble										Extractable cations (ICP)					Particle size				Disp.	15	Total element (XRF)		
Depth	pH	EC	Fe	Al	Al Sat	ESP	ADMC	NO_3N	Cl	ECEC	Exch Al	Exch Acid	Ca	Mg	Na	Exch. Na	K	CS	FS	Si	Cl	Ratio	BAR	K	P	S
(m)		(dS/M)	%					mg/kg		meq/100g			cmol_c/kg					%				R1	%	%		
0.00–0.10	5.1	0.08	–	–	16.7	1.48	<1.5	17	36	5.39	0.9	1.05	2.19	1.6	0.172	<0.080	0.467	16.5	28	20.9	39.3	0.33	15.6	0.283	0.084	0.039
0.20–0.30	4.6	0.03	–	–	59.1	2.38	1.7	3	<20	3.37	1.99	2.28	0.458	0.486	<0.080	<0.080	0.065	10.7	25.5	17.5	51.2	FL	15.5	0.212	0.049	0.042
0.50–0.60	4.7	0.02	–	–	52.7	1.65	2.4	1	<20	4.83	2.55	2.9	1.11	0.68	<0.080	<0.080	0.06	8.6	19.3	12.4	63.5	FL	20.8	0.255	0.056	0.05
0.80–0.90	4.6	0.03	–	–	64.1	1.27	2.9	1	<20	6.28	4.02	4.51	0.67	0.954	<0.080	<0.080	0.063	10.9	11.3	10.9	72.3	FL	23.8	0.322	0.064	0.077
1.10–1.18	4.6	0.03	–	–	76.8	0.99	2.9	1	<20	8.67	6.66	7.58	0.149	0.792	0.086	0.086	0.064	3.5	14.1	12.5	72.3	FL	24	0.442	0.041	0.059
1.40–1.50	4.4	0.03	–	–	78.5	0.79	3	<1	<20	16.6	13	15.3	<0.140	0.851	0.131	0.131	0.147	1.3	6.8	17.6	75.8	FL	22.4	0.813	0.024	0.024

Soil type: Pangola (Pg)

Site No.: 260
Location: Zone 56, 495867E, 7089452N
ASC: Bleached-mottled, Mesotrophic, Brown Kurosol

Slope: 1%
Landform element: Hillslope
Landform pattern: Plain

Geology: Myrtle Creek Sandstone (RJdm)

Microrelief: None
Surface condition: Firm (previously disturbed)
Surface coarse fragments: <2% subangular quartz 6–20 mm
Vegetation: *Acacia spp. and* grass understory.

Profile morphology:

Horizon	Depth (m)	Description
A11	0.0 to 0.05	Grey (10YR 4/2); clay loam sandy; weak 5–10 mm angular blocky structure; moderately moist; gradual change to
A12	0.05 to 0.28	Grey (7.5YR 4/2); fine sandy clay loam; weak 2–5 mm subangular blocky structure; moderately moist; 2–10% subrounded quartz coarse fragments 2–6 mm; clear change to
A13	0.28 to 0.42	Grey (10YR 4/1); few (2–10%) fine (<5 mm) faint orange mottles; fine sandy clay loam; weak 5–10 mm angular blocky structure; dry; <2% subrounded quartz 2–6 mm; abrupt change to
A2	0.42 to 0.49	Brown (10YR 5/3); common (10–20%) fine (<5 mm) distinct orange mottles; sapric fine sandy clay loam; massive; dry; <2% subrounded quartz 2–6 mm; abrupt change to
2A1	0.49 to 0.80	Grey (10YR 4/1); few (2–10%) fine (<5 mm) distinct orange mottles; sandy loam; weak 2–5 mm angular blocky structure; dry; diffuse change to
2A2j	0.80 to 1.12	Grey (2.5Y 6/4); sporadically bleached; few (2–10%) fine (<5 mm) distinct orange and faint pale mottles; sandy clay loam; weak 5–10 mm angular blocky structure; dry; <2% subrounded quartz 2–6 mm; clear change to
2B21	1.12 to 1.45	Brown (10YR 5/5); few to common (2–20%) fine (<5 mm) distinct red and pale grey mottles; medium clay; moderate 2–5 mm subangular blocky structure; moderately moist; <2% angular quartz coarse fragments 2–6 mm; clear change to
2B22	1.45 to 1.50	White (10YR 5/5); many (20–50%) medium (5–15 mm) pale grey mottles; medium clay; moderate 2–5 mm subangular blocky structure; moderately moist; 2–20% subangular quartz coarse fragments 2–60 mm.

Analysis results

	1:5 aqueous		Citrate soluble										Extractable cations (ICP)				
Depth	pH	EC	Fe	Al	Al Sat	ESP	ADMC	NO_3N	Cl	ECEC	Exch Al	Exch Acid	Ca	Mg	Na	Exch. Na	K
(m)		(dS/M)	%		%			mg/kg		meq/100g			cmol_c/kg				
1.20–1.40	4.8	0.03	–	–	43.8	2.67	—	1	<20	4.79	2.1	3.01	0.62	1	0.128	0.128	0.031

Soil type: Paulsen (Ps)

Site No.: 146
Location: Zone 56, 494690E, 7101089N
ASC: Mottled, Mesotrophic, Brown Kurosol

Slope: 25%
Landform element: Hillslope
Landform pattern: Low hills
Geology: Myrtle Creek Sandstone (RJdm)

Microrelief: None
Surface condition: Firm
Surface coarse fragments: Nil
Vegetation: Macadamia plantation, grasses

Profile morphology:

Horizon	Depth (m)	Description
A1	0.0 to 0.1	Black (10YR 3/2); fine sandy clay loam; strong 2–5 mm subangular blocky structure; dry; <2% subangular sandstone coarse fragments 6–20 mm; clear change to
A2	0.1 to 0.2	Grey (10YR 4/2); fine sandy loam; moderate 5–10 mm subangular blocky structure; dry; <2% subangular sandstone coarse fragments 2–60 mm; abrupt change to
B21	0.2 to 0.4	Brown (10YR 4/6); many (20–50%) fine (<5 mm) distinct red substrate inclusion mottles; fine sandy light medium clay; moderate 10–20 mm subangular blocky structure; moist; clear change to
B3	0.4 to 0.7	Brown (7.5YR 4/6); many (20–50%) fine (<5 mm) prominent red and faint grey substrate inclusion mottles; fine sandy light medium clay; moderate 10–20 mm subangular blocky structure; moist; clear change to
C	0.7 to 0.8	Abundant (>50%) weathered, sub rounded sandstone boulders (>600 mm).

Analysis results

	1:5 aqueous		Citrate soluble										Extractable cations (ICP)					Particle size				Disp.	15	Total element (XRF)		
Depth	pH	EC	Fe	Al	Al Sat	ESP	ADMC	NO_3N	Cl	ECEC	Exch Al	Exch Acid	Ca	Mg	Na	Exch. Na	K	CS	FS	Si	Cl	Ratio	BAR	K	P	S
(m)		(dS/M)	%		%			mg/kg		meq/100g			cmol_c/kg					%				R1	%	%		
0.00–0.10	5.4	0.08	–	–	1.4	1.09	<1.5	7	32	7.31	0.1	0.16	4.87	1.78	0.108	<0.080	0.416	48.8	33.7	6.4	12.2	0.29	7.5	0.341	0.046	0.037
0.20–0.30	5.2	0.02	–	–	27.9	1.32	<1.5	1	<20	6.07	1.69	1.92	2.97	1.01	<0.080	<0.080	0.087	46.7	23.7	3.7	30.8	0.59	9.4	0.638	0.017	0.011
0.50–0.60	4.5	0.03	–	–	66.7	0.95	<1.5	1	<20	8.43	5.62	6.57	0.999	0.705	<0.080	<0.080	0.078	49	15	7.2	34.2	0.54	11.9	0.948	<0.015	0.013
0.70–0.80	4.3	0.03	–	–	72.9	0.92	<1.5	1	<20	8.67	6.32	7.37	0.566	0.582	<0.080	<0.080	0.076	51.6	14.9	5.7	30.8	FL	11.6	0.932	<0.015	0.017

Soil type: Ringtail (Rt)

Site No.: 261
Location: Zone 56, 495849E, 7089059N
ASC: Melacic-Magnesic, Demosolic, Hydrosol

Slope: 1%
Landform element: Hillslope
Landform pattern: Plain
Geology: Tiaro Coal Measures (Jdt)

Microrelief: None
Surface condition: Soft
Surface Coarse Fragments: <2% subangular quartz 2–6 mm
Vegetation: *Pinus spp., Melaleuca spp. and* grass understory

Profile morphology:

Horizon	Depth (m)	Description
A1	0.0 to 0.25	Black (10YR 3/1); very few (<2%) fine (<5 mm) distinct red and faint grey mottles; silty clay loam; moderate 2–5 mm subangular blocky structure; moist; clear change to
B21	0.25 to 0.53	Brown (10YR 5/4); few (2–10%) fine (<5 mm) distinct grey and faint orange mottles; light clay; moderate 2–5 mm subangular blocky structure; moist; <2% subrounded quartz 2–6 mm; gradual change to
B22	0.53 to 1.12	Grey (10YR 6/2); few to common (2–20%) fine (<5 mm) prominent brown mottles and prominent red substrate inclusion mottles; medium clay; moderate 5–10 mm subangular blocky structure; moist; diffuse change to
B23	1.12 to 1.63	Grey (10YR 7/1); very few (<2%) medium (5–15 mm) prominent orange mottles; medium heavy clay; strong 2–5 mm subangular blocky structure; moist.

Analysis results

	1:5 aqueous		Citrate soluble										Extractable cations (ICP)				
Depth	pH	EC	Fe	Al	Al Sat	ESP	ADMC	NO_3N	Cl	ECEC	Exch Al	Exch Acid	Ca	Mg	Na	Exch. Na	K
(m)		(dS/M)	%		%			mg/kg		meq/100g			cmol_c/kg				
0.60–0.80	4.2	0.53	–	–	50.8	18.1	—	2	451	17.6	8.96	11.6	0.19	2.53	4.46	3.19	0.085

Soil type: Sister (Si)

Site No.: 196
Location: Zone 56, 488851E, 7090076N
ASC: Acidic, Mesotrophic, Brown Dermosol

Slope: 1%
Landform element: Hillcrest
Landform pattern: Hills
Geology: Kin Kin Beds (Rk)

Microrelief: None
Surface condition: Soft
Surface coarse fragments: Nil
Vegetation: Pasture grasses

Profile morphology:

Horizon	Depth (m)	Description
A1	0.0 to 0.05	Brown (2.5Y 4/4); light clay; strong <2 mm subangular blocky structure; moist; <2% manganiferous nodules 2–6 mm; clear change to
A2	0.05 to 0.19	Brown (2.5Y 5/3) light clay; moderate <2 mm subangular blocky structure; moist; <2–10% angular quartz and angular platy phyllite coarse fragments 2–6 mm; gradual change to
B21	0.19 to 0.42	Brown (2.5Y 5/4); few (2–10%) fine (<5 mm) faint orange and faint pale substrate inclusion mottles; light clay; moderate 5–10 mm subangular blocky structure; moist; 10–20% angular platy phyllite coarse fragments 6–20 mm; gradual change to
B3	0.42 to 0.70	Brown (2.5Y 6/4); common (10–20%) fine (<5 mm) faint orange and faint pale substrate inclusion mottles; light medium clay; moderate 10–20 mm angular blocky structure; moist; 50–90% angular platy phyllite coarse fragments 6–20 mm; clear change to
C	0.70 to 0.98	Weathered phyllite rock.

Analysis results

	1:5 aqueous		Citrate soluble										Extractable cations (ICP)				
Depth	pH	EC	Fe	Al	Al Sat	ESP	ADMC	NO_3N	Cl	ECEC	Exch Al	Exch Acid	Ca	Mg	Na	Exch. Na	K
(m)		(dS/M)	%		%			mg/kg		meq/100g			cmol_c/kg				
0.20–0.40	4.5	0.05	–	–	56.8	2.68	—	17	<20	4.16	2.36	2.95	<0.14	0.861	0.111	0.111	0.095

Soil type: Sister (Si)

Site No.: 243
Location: Zone 56, 485999E, 7097234N
ASC: Acidic, Mesotrophic, Brown Dermosol

Slope: 14%
Landform element: Hillslope
Landform pattern: Low hills
Geology: Kin Kin Beds (Rk)

Microrelief: None
Surface condition: Firm
Surface coarse fragments: <2% subangular quartz 6–20 mm
Vegetation: Pasture grasses.

Profile morphology:

Horizon	Depth (m)	Description
A1	0.0 to 0.10	Brown (10YR 4/3); clay loam; moderate 2–5 mm subangular blocky structure; moderately moist; <2% subangular quartz coarse fragments 2–6 mm; <2% manganiferous nodules 2–6 mm; abrupt change to
A2	0.10 to 0.22	Brown (10YR 5/3) light clay; moderate 5–10 mm subangular blocky structure; moderately moist; 2–10% subangular quartz coarse fragments 2–20 mm; <2% manganiferous nodules 2–20 mm; clear change to
B21	0.22 to 0.52	Brown (7.5YR 5/8); light clay; moderate 10–20 mm subangular blocky structure; moderately moist; 2–10% subangular quartz coarse fragments 6–20 mm; <2% manganiferous nodules 6–20 mm; diffuse change to
B22	0.52 to 0.80	Brown (5YR 5/6); light medium clay; moderate 10–20 mm subangular blocky structure; moderately moist; <2% subangular quartz coarse fragments 2–6 mm; <2% manganiferous nodules 2–6 mm; gradual change to
B23	0.80 to 1.20	Red (2.5YR 5/8); medium clay; moderate 5–10 mm subangular blocky structure; moist; 2–10% subangular quartz coarse fragments 2–20 mm; <2% manganiferous nodules 2–6 mm; gradual change to
B24	1.20 to 1.45	Red (2.5YR 4/6); few (2–10%) fine (<5 mm) distinct yellow mottles; medium clay; moderate 5–10 mm subangular blocky structure; moist; <2% subangular quartz coarse fragments 2–6 mm; <2% manganiferous nodules 2–6 mm.

Analysis results

	1:5 aqueous		Citrate soluble										Extractable cations (ICP)				
Depth	pH	EC	Fe	Al	Al Sat	ESP	ADMC	NO_3N	Cl	ECEC	Exch Al	Exch Acid	Ca	Mg	Na	Exch. Na	K
(m)		(dS/M)	%		%			mg/kg		meq/100g			cmol_c/kg				
0.60–0.70	5.0	0.02	–	–	27	2.64	—	2	<20	3.03	0.82	1.07	0.942	0.652	<0.08	0.08	0.291

Soil type: Stratton (St)

Site No.: 265
Location: Zone 56, 487677E, 7094324N
ASC: Acidic, Dystrophic, Red Dermosol

Slope: 10%
Landform element: Pediment
Landform pattern: Hills
Geology: Kin Kin Beds (Rk)

Microrelief: None
Surface condition: Firm
Surface coarse fragments: <2% angular quartz 2–6 mm
Vegetation: Pasture species (grasses)

Profile morphology:

Horizon	Depth (m)	Description
A1	0.0 to 0.15	Brown (10YR 4/4); clay loam; moderate 2–5 mm polyhedral structure; moderately moist; <2% angular quartz coarse fragments 2–20 mm; abrupt change to
A2	0.15 to 0.26	Brown (7.5YR 4/6); very few (<2%) fine (<5 mm) faint pale mottles; light clay; strong 2–5 mm polyhedral structure; dry; <2% angular quartz coarse fragments 2–20 mm; <2% manganiferous nodules 2–6 mm; abrupt change to
B1	0.26 to 0.68	Red (5YR 5/8); very few (<2%) fine (<5 mm) faint pale mottles; light clay; moderate 10–20 mm subangular blocky parting to 2–5 mm polyhedral structure; dry; 2–10% angular quartz coarse fragments 2–20 mm; <2% manganiferous nodules 2–6 mm; gradual change to
B21	0.68 to 0.98	Red (2.5YR 4/8); few (2–10%) fine (<5 mm) distinct yellow mottles; light medium clay; moderate 10–20 mm subangular blocky parting to 2–5 mm polyhedral structure; dry; 2–10% angular mudstone coarse fragments 2–20 mm; gradual change to
B22	0.98 to 1.20	Red (10Y 4/8); few (2–10%) fine (<5 mm) distinct yellow mottles; light medium clay; moderate 10–20 mm subangular blocky parting to 2–5 mm polyhedral structure; dry; 2–10% angular mudstone coarse fragments 2–20 mm; 2–10% ferruginous nodules 2–20 mm; clear change to
B23	1.20 to 1.60	Red (10R 3/6); very few (<2%) fine (<5 mm) distinct yellow mottles; light medium clay; strong 10–20 mm subangular blocky parting to strong 2–5 mm polyhedral structure; dry; <2% angular quartz coarse fragments 6–20 mm; 10–20% ferruginous nodules 2–20 mm.

Analysis results

	1:5 aqueous		Citrate soluble										Extractable cations (ICP)					Particle size				Disp.	15	Total element (XRF)		
Depth	pH	EC	Fe	Al	Al Sat	ESP	ADMC	NO_3N	Cl	ECEC	Exch Al	Exch Acid	Ca	Mg	Na	Exch. Na	K	CS	FS	Si	Cl	Ratio	BAR	K	P	S
(m)		(dS/M)	%					mg/kg		meq/100g			cmol_c/kg					%				R1	%	%		
0.00–0.10	5.6	0.07	–	–	—	—	2.4	7	38	—	—	—	3.94	2.03	0.142	<0.080	0.839	18.8	15.5	31.3	37.8	0.47	15.4	0.875	0.064	0.041
0.26–0.36	5.5	0.03	–	–	4.5	2.12	2.1	3	29	3.77	0.17	0.2	2.01	0.999	<0.080	<0.080	0.477	11.1	12.2	29.5	51.4	0.36	17.8	0.967	0.034	0.022
0.50–0.60	4.9	0.02	–	–	37.2	2.63	2	1	<20	3.04	1.13	1.29	1.04	0.447	<0.080	<0.080	0.182	9.7	15.1	26.1	54.7	FL	18.4	1.02	0.032	0.026
0.80–0.90	4.6	0.03	–	–	56.2	1.94	2.1	1	<20	4.13	2.32	2.65	0.915	0.33	<0.080	<0.080	0.151	3.9	12.5	21	68.4	FL	21.4	1.31	0.031	0.04
1.10–1.20	4.5	0.03	–	–	65	1.54	3.3	<1	<20	5.2	3.38	3.85	0.842	0.316	<0.080	<0.080	0.109	1.7	10	17.6	76.1	FL	23.6	1.48	0.029	0.048
1.40–1.50	4.4	0.04	–	–	67.9	1.51	2.2	<1	<20	5.3	3.6	4.08	0.563	0.477	<0.080	<0.080	0.103	1.8	9.3	15.8	78.7	FL	24.6	1.52	0.027	0.053

Soil type: Wahpunga Deep Phase (WpDp)

Site No.: 11
Location: Zone 56, 488105E, 7098564N
ASC: Acidic, Magnesic, Red Ferrosol

Slope: 25%
Landform element: Hillslope
Landform pattern: Hills
Geology: Kin Kin Beds (Rk)

Microrelief: None
Surface condition: Firm
Surface coarse fragments: Nil.
Vegetation: *Corymbia intermedia, Corymbia citriodora*

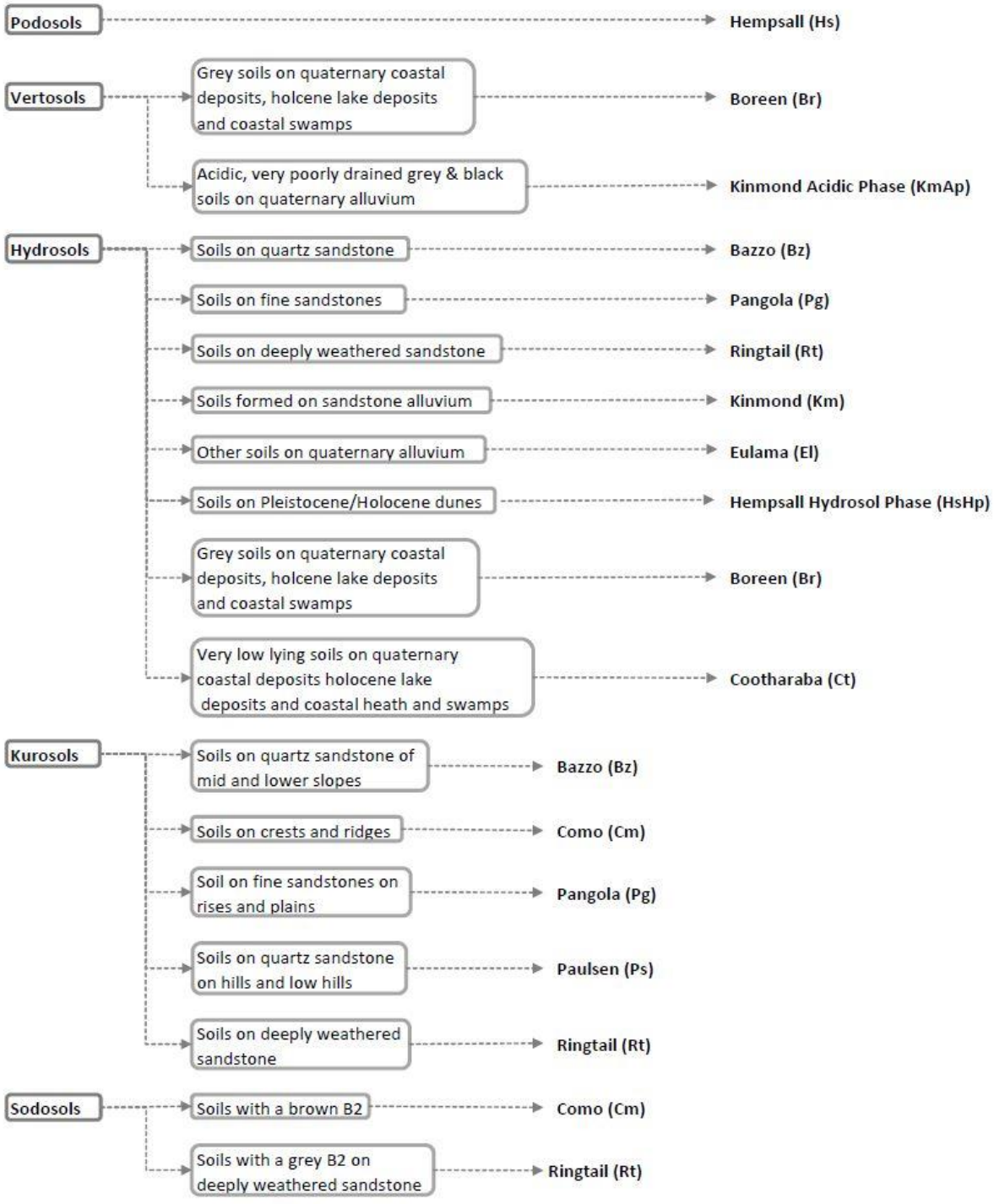
Profile morphology:

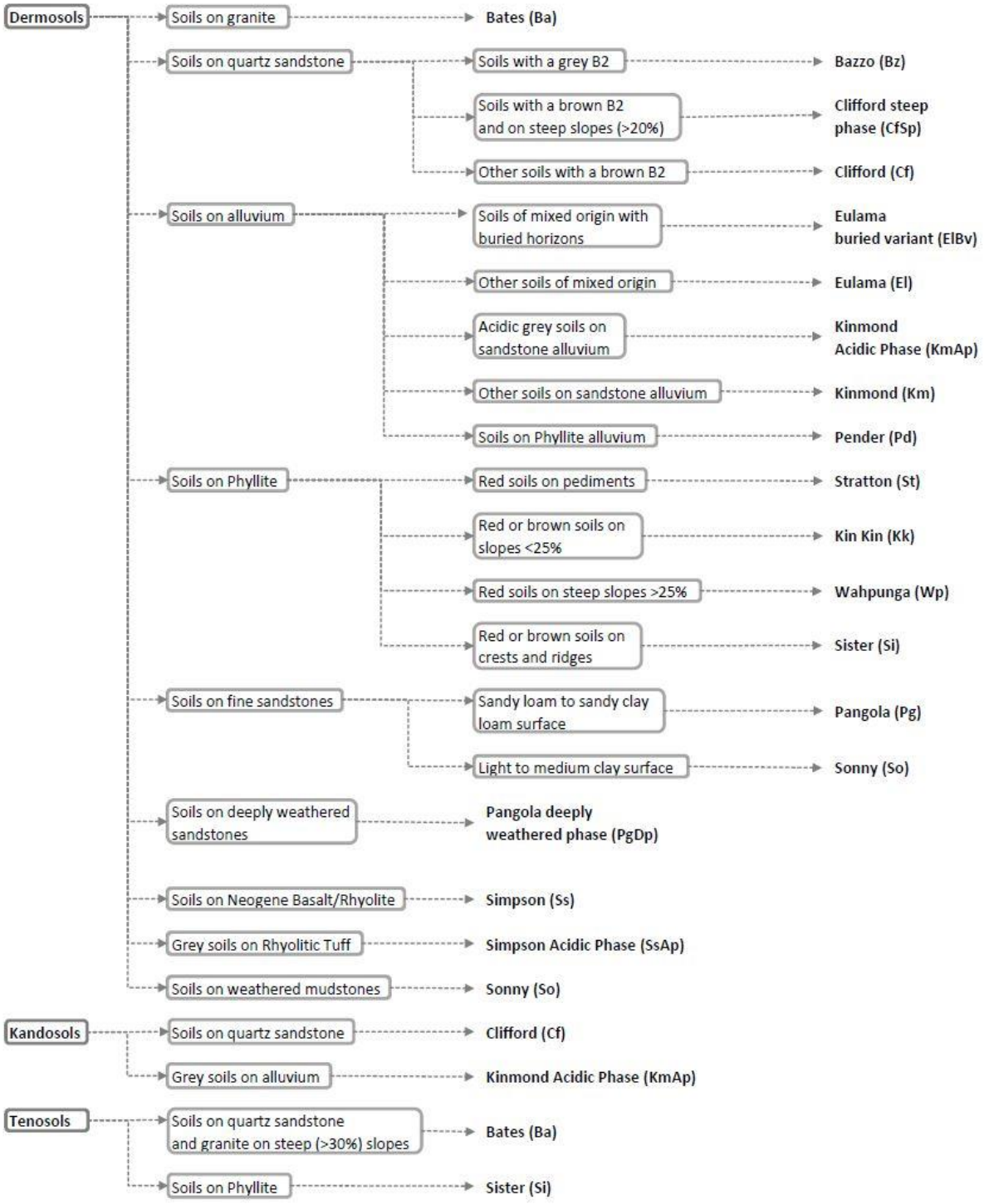
Horizon	Depth (m)	Description
A1	0.0 to 0.32	Brown (7.5YR 4/3); light clay; moderate 10–20 mm subangular blocky structure; dry; <2% angular quartz coarse fragments 2–6 mm; clear change to
B21	0.32 to 0.7	Red (2.5YR 4/6); light medium clay; strong 5–10 mm subangular blocky structure; dry; diffuse change to
B22	0.7 to 1.0	Red (2.5YR 4/6); light medium clay; strong 5–10 mm angular blocky structure; dry; diffuse change to
B23	1.0 to 1.4	Red (10R 4/6); light medium clay; strong 5–10 mm angular blocky structure; dry; diffuse change to
B3	1.4 to 1.7	Red (10R 4/6); light medium clay; strong 5–10 mm angular blocky structure; dry; 2–10% subangular platy phyllite coarse fragments 6–20 mm.

Analysis results

	1:5 aqueous		Citrate soluble										Extractable cations (ICP)				
Depth	pH	EC	Fe	Al	Al Sat	ESP	ADMC	NO_3N	Cl	ECEC	Exch Al	Exch Acid	Ca	Mg	Na	Exch. Na	K
(m)		(dS/M)	%		%			mg/kg		meq/100g			cmol_c/kg				
0.80–1.00	5.5	0.03	6.3	0.5	9.6	5.97	–	1	<20	4.69	0.45	0.74	<0.14	3.43	0.28	0.28	0.096

Appendix 5 – Key to the soils of the Lake Cootharaba catchment




Dermosols
Soils on granite
Bates (Ba)
Soils on quartz sandstone
Soils with a grey B2
Bazzo (Bz)
Soils with a brown B2 and on steep slopes (>20%)
Clifford steep phase (CfSp)
Other soils with a brown B2
Clifford (Cf)
Soils on alluvium
Soils of mixed origin with buried horizons
Eulama buried variant (ElBv)
Other soils of mixed origin
Eulama (El)
Acidic grey soils on sandstone alluvium
Kinmond Acidic Phase (KmAp)
Other soils on sandstone alluvium
Kinmond (Km)
Soils on Phyllite alluvium
Pender (Pd)
Soils on Phyllite
Red soils on pediments
Stratton (St)
Red or brown soils on slopes <25%
Kin Kin (Kk)
Red soils on steep slopes >25%
Wahpunga (Wp)
Red or brown soils on crests and ridges
Sister (Si)
Soils on fine sandstones
Sandy loam to sandy clay loam surface
Pangola (Pg)
Light to medium clay surface
Sonny (So)
Soils on deeply weathered sandstones
Pangola deeply weathered phase (PgDp)
Soils on Neogene Basalt/Rhyolite
Simpson (Ss)
Grey soils on Rhyolitic Tuff
Simpson Acidic Phase (SsAp)
Soils on weathered mudstones
Sonny (So)
Kandosols
Soils on quartz sandstone
Clifford (Cf)
Grey soils on alluvium
Kinmond Acidic Phase (KmAp)
Tenosols
Soils on quartz sandstone and granite on steep (>30%) slopes
Bates (Ba)
Soils on Phyllite
Sister (Si)

Appendix 6 – Soil profile classes

Conventions used in the descriptions of the morphology, landscape and vegetation of the soil profile classes

A **soil profile class** (SPC) is a three dimensional soil body or group or soil bodies, such that any profile within the body(s) has a similar number and arrangement of major horizons whose attributes primarily morphological, are within a defined range. All profiles within the units have similar parent materials. The soil profile class may be at varying levels of generalisation depending primarily on the scale of the survey and density of ground observations.

A **soil variant** is a soil with profile attributes clearly outside the range of defined soil types but not extensive enough to warrant defining a new type. e.g. Eulama – Buried Variant (ElBv).

A **soil phase** is a subdivision of a soil profile class based on attributes that have particular significance in the use of the soil, for example, rocky phase. e.g. Clifford – Steep Phase (CfSp).

Australian Classification as described by Isbell (Revised Edition 2002) is listed in order of frequency of occurrence

Geology as defined on the Gympie special sheet 9445, part 9545, Queensland 1:100,000

Surface characteristics as in the Yellow Book (2009)

Landform as in the *Australian Soil and Land Survey Field Handbook* or 'Yellow Book' (2009)

The **pH profiles** are based on field determination (Raupach test) for each horizon

Horizons as the Yellow Book (2009)

Textures are field textures as in the Yellow Book (2009)

Structure as in the Yellow Book (2009)

Segregation as in the Yellow Book (2009)

Boundary type as in the Yellow Book (2009)

Frequency of occurrence
Frequently = >30% of occasions
Occasionally = 10–30% of occasions
Rarely = <10% of occasions

Colour codes (moist) are those of Munsell soil colour charts (1994) while colour nomenclature is based on the colour class limits of Isbell (1996).

Representative site(s) for each SPC are shown in bold type.

References

Isbell, RF 2002, *The Australian Soil Classification – Revised edition*. CSIRO, Australia.

Munsell soil colour charts 2000, Munsell Colour, Grand Rapids, USA.

National Committee on Soil and Terrain 2009, *Australian Soil and Land Survey Field Handbook* ['Yellow Book'], CSIRO Publishing, Melbourne.

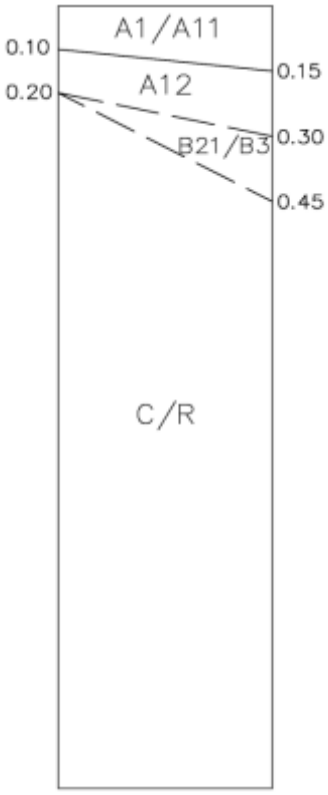
Lake Cootharaba Catchment soil profile classes

Bates (Ba)
Bates Deep Phase (BaDp)
Bazzo (Bz)
Boreen (Br)
Clifford (Cf)
Clifford – Steep Phase (CfSp)
Como (Cm)
Como Shallow Phase (CmSp)
Cootharaba (Ct)
Eulama (El)
Eulama – Buried Variant (ElBv)
Hempsall (Hs)
Hempsall Hydrosol Phase (HsHp)
Kin Kin (Kk)
Kin Kin Bleached Variant (KkBv)
Kin Kin Yellow Variant (KkYv)
Kinmond (Km)
Kinmond – Acidic Phase (KmAp)
Kinmond Discontinuous Variant (KmDv)
Pangola (Pg)
Pangola – Deeply Weathered Phase (PgDp)
Paulsen (Ps)
Pender (Pd)
Ringtail (Rt)
Simpson (Ss)
Simpson – Acidic Phase (SsAp)
Simpson Shallow Phase (SsSp)
Simpson Buried Variant (SsBv)
Simpson Gleyed Phase (SsGp)
Sister (Si)
Sister Deep Phase (SiDp)
Sonny (Sn)
Stratton (St)
Stratton Brown Variant (StBv)
Wahpunga (Wp)
Wahpunga Deep Phase (WpDp)

BATES (Ba)

Concept:	Very shallow to shallow red and brown, texture contrast and gradational soils on steep slopes of Myrtle Creek sandstone and Woondum granite.
Australian Soil Classification:	Leptic Tenosol; Red Dermosol, Brown Dermosol; Red Kurosol
Geology:	Myrtle Creek Sandstone (RJdm); Granite and Granodiorite of the Woondum Granites (Rgw/g).
Landform:	Upper and mid slopes of steep and rolling hills. Slope 20–50%.
Permeability:	Slowly to moderately permeable
Drainage:	Moderately well drained to well drained
Surface characteristics	
Surface condition:	Soft to firm
Coarse fragments:	Occasionally <2–90% subangular or subrounded sandstone 2–200 mm, and/or <2% subangular quartz 2–6 mm. Frequent sandstone cobbles on surface and at shallow depths.
Microrelief:	Nil
Vegetation:	*Corymbia spp., Eucalyptus tereticornus, Eucalyptus crebra*. Also *Angopohra spp.* and grass understorey. Many areas cleared and grassed.

Depth (m)



A1/A11	Black, brown or grey (10YR 3/1, 3/3, 4/1, 4/3, 7/3); sandy loam to light clay; massive or moderate to strong 5–10 mm cast or subangular blocky structure; <2–50% subangular sandstone or quartz coarse fragments 2–20 mm; field pH 6.0–7.5; clear to gradual change to
A12	Where present. Brown (10YR 3/3, 4/4); sandy loam to sandy clay loam; massive or moderate 5–10 mm cast structure; 2–20% subangular sandstone or quartz coarse fragments 2–6 mm; field pH 5.5–6.5; abrupt change to
B21	Not present in Leptic Tenosols. Red or brown (5YR 4/5; 10YR 5/3); occasionally mottled; light clay to sandy medium clay; massive to moderate 5–10 mm subangular blocky structure; 2–20% subrounded sandstone, granite, granodiorite and/or quartz 2–20 mm; field pH 5.0–6.5; abrupt change to
B3	Where present. Brown (7.5YR 4/3); sandy clay loam; massive; 50–90% subangular sandstone coarse fragments 20–60 mm; field pH 5.6.
C	Where present. Weathered rock.
R	Rock.
Sites:	62, **63**, 64, 84, **143**, 224

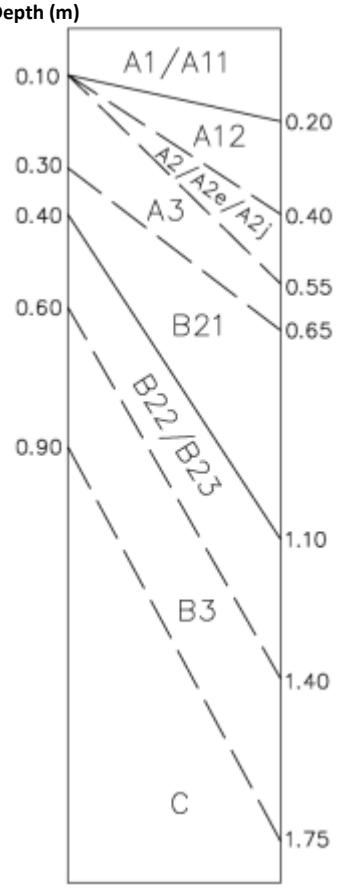
Bates Deep phase: Red Kandosol – A1 as above. Massive to weak brown or grey (7.5YR 4/3; 10YR 4/2) A2 and A3 overlying massive red (5YR 4/4, 4/5) B1/B21/B22 with pH 6.0 to 6.5. Underlain by buried phyllite profile.

Site **83**.

BAZZO (Bz)

Concept:	Moderately deep to very deep, yellow or grey texture contrast (rarely gradational) soils. Black, brown or grey sand to clay loam overlying mottled (sometimes sodic) grey or yellow light to medium heavy clay over Myrtle Creek Sandstone. Lower and foot slopes may overlie unconsolidated sediments.
Australian Soil Classification:	Grey Kurosol, Yellow Kurosol, Grey Dermosol, Redoxic Hydrosol
Geology:	Myrtle Creek Sandstone (RJdm)
Landform:	Mid and lower slopes of rolling hills and low hills, undulating and gently undulating rises. Slope 1–10% (some areas up to 20%).
Permeability:	Slowly to moderately permeable
Drainage:	Poorly to imperfectly drained
Surface characteristics	
Surface condition:	Soft to firm
Coarse fragments:	Nil
Microrelief:	Nil
Vegetation:	*Corymbia spp., Eucalyptus racemosa, Acacia spp., Melaleuca spp., Lomandra spp., Gahnia spp*., grasses.

Depth (m)



A1/A11	Black or grey (7.5YR 3/1; 10YR 3/2, 4/1; 2.5Y 3/1); sand to clay loam; weak to moderate 2–10 mm cast, angular blocky or subangular blocky structure; occasionally <2% subangular quartz coarse fragments 2–6 mm; field pH 5.5–6.0; abrupt to gradual change to
A12	Where present. Black (10YR 3/1); silty clay loam; moderate 5–10 mm subangular blocky structure; field pH 5.5–6.0; gradual change to
A2/A2e/A2j	Frequently present. Grey (10YR 4/2, 5/2; 2.5Y 6/3, 7/2); frequently sporadically or conspicuously bleached; sand to sandy clay loam; massive or weak 2–20 mm angular or subangular blocky structure; rarely <2% subangular quartz coarse fragments 2–6 mm; field pH 4.5–6.0; abrupt to clear change to
A3	Where present. Black (10YR 3/2); mottled; fine sandy clay loam; moderate 5–10 mm subangular blocky structure; field pH 5.5–6.0; gradual change to
B21	Yellow or grey (10YR 5/2; 2.5Y 6/2, 6/4; 5Y 7/1); mottled; light medium to medium heavy clay; moderate 2–50 mm angular or subangular blocky structure; frequently <2% angular quartz 2–6 mm; field pH 4.5–6.0; clear to gradual change to.
B22	Where present. Yellow or grey (10YR 6/1, 7/1; 2.5Y 6/6, 7/1; 5Y 7/1); mottled; medium to medium heavy clay; moderate 2–50 mm angular blocky, subangular blocky or prismatic structure; field pH 4.0–5.5; clear to gradual change to
B23	Where present. Yellow or grey (10YR 6/6; 2.5Y 7/1); mottled; light medium to medium clay; weak to moderate 2–50 mm subangular blocky structure; <2% subangular quartz coarse fragments; field pH 4.0–5.0
B3	Where present. Grey (10YR 7/1; 2.5Y 7/1); light to sandy light medium clay; massive to moderate 2–5 mm angular blocky structure; <2–10% subangular quartz coarse fragments 6–60 mm; field pH 4.0–4.5.
C	Where present. Weathered sandstone rock; grey; mottled; massive; <2% subrounded quartz coarse fragments 20–60 mm; field pH 4.0–4.5.
Sites:	54, 129, **139**, 182, 198, 226, **227**, 230, 233, **264**. *Analysed Site 264*.

BOREEN (Br)

Concept: Strongly acidic deep to very deep, grey, gradational or texture contrast soils. Frequently with at least one buried horizon at depth. Grey or black clay loam to light medium clay overlying grey light to medium clay. Includes many acid sulfate soils.

Australian Soil Classification: Grey Vertosol, Aquic Vertosol, Redoxic Hydrosol

Geology: Quaternary Alluvium (Qa) including areas of Quaternary coastal deposit (Qc), Holocene lake deposits (Qh1), coastal swamp and health (Qcw).

Landform: Marine and alluvial plains, flood plains and swamps (tidal and non-tidal). Slope 0–1.5%.

Permeability: Slowly to moderately permeable

Drainage: Imperfectly to moderately well drained

Surface characteristics

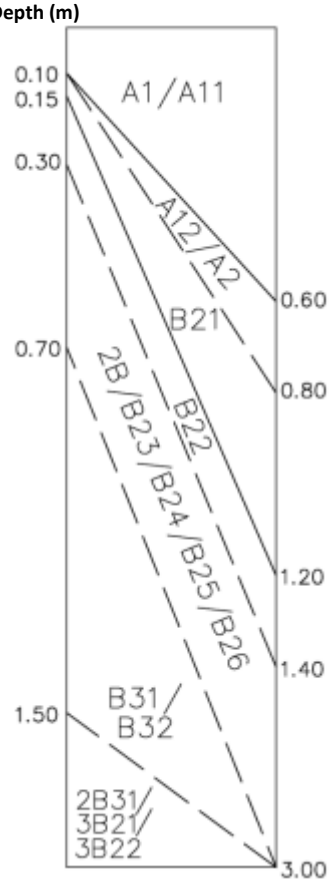
Surface condition: Soft to firm

Coarse fragments: Nil

Microrelief: Nil

Vegetation: *Melaleuca quinquenervia, Lophostemon suaveolens*, pastures.

Depth (m)



A1/A11	Grey or black (10YR 2/1, 3/1); clay loam to light medium clay (sometimes silty or sandy); massive to strong 2–5 mm granular structure; field pH 4.5 to 6.0.
A12/A2	Where present. Grey (10YR 4/1); clay loam to light clay; moderate 2–5 mm granular structure; field pH 4.5 to 6.0.
B21	Black or grey (10YR 3/1, 4/1, 4/2, 5/1, 6/1); rarely mottled; sandy clay loam to medium clay (occasionally silty); moderate to strong 2–10 mm subangular blocky or granular structure; field pH 2.0–6.0.
B22	Where present. Grey (10YR 4/1, 5/1; 2.5Y 4/1); frequently mottled; light medium to medium clay; moderate 2–20 mm subangular blocky or lenticular structure; field pH 3.2–5.5.
2B Or B23/B24/ B25/B26	Where present. Grey (10YR 4/1, 5/1, 5/2, 6/1; 2.5Y 4/1, 5/1, 6/1, 6/2); frequently mottled; medium to medium heavy clay; massive or moderate 2–20 mm subangular blocky or lenticular structure; rarely 2–10% ferruginous segregations 6–20 mm; field pH 3.0–5.5.
B31/B32	Where present. Grey (10YR 6/1, 7/1, 8/1; 2.5Y 6/1); frequently mottled; medium heavy clay (often silty or sandy); moderate subangular blocky or lenticular structure (sometimes prismatic); rarely 2–10% ferruginised sandstone coarse fragments 20–60 mm; field pH 3.5–6.0.
3B21/3B22	Where present. Grey (10YR 7/1; 2.5Y 6/1); medium to medium heavy clay (sandy or silty); massive or moderate 2–20 mm lenticular structure; field pH 3.5–5.0.
2B31	Where present. Grey (10YR 7/1); mottled; silty medium heavy clay; moderate 5–10 mm lenticular structure; 10–20% ferruginous segregations 6–20 mm; field pH 5.0–5.5.
Sites:	**259**. *Analysed Sites: SEA sites – 2513, 2514, 2515, 2517, 2518, 2521, 2522, 2527, 2528, 2530, 2531, 2532, 2533, 2534, 2535*.

CLIFFORD (Cf)

Concept: Deep to very deep, red or brown gradational soils. Red, black, brown and grey sandy loam to sandy clay loam overlying occasionally mottled red or brown sandy loam to light medium clay on Myrtle Creek sandstone. Lower and foot slopes may overlie unconsolidated sediments.

Australian Soil Classification: Red and Brown Kandosols, Brown Dermosol

Geology: Myrtle Creek Sandstone (RJdm)

Landform: Mid and lower slopes of rolling hills and low hills and undulating and gently undulating rises. Slope 5–25%. Includes pediments and minor fans on mid and lower slopes of steep, rolling and undulating hills, low hills, rises and plains. Slope 2–15%.

Permeability: Moderately to highly permeable

Drainage: Imperfectly to moderately well drained

Surface characteristics

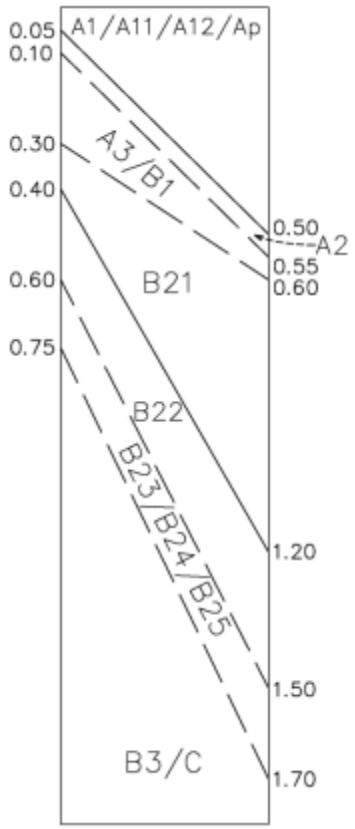
Surface condition: Soft to firm

Coarse fragments: Occasionally 2–50% subangular sandstone 60–200 mm, and/or <2% angular quartz 2–6 mm
Occasional sandstone outcropping

Microrelief: Nil

Vegetation: *Corymbia intermedia, Eucalyptus microcorys,* macadamia plantation, grass (pasture ssp.), *Eucalyptus grandis*, *Lophostemon confertus*, *Eucalyptus moluccana*, *Acacia spp.*

Depth (m)

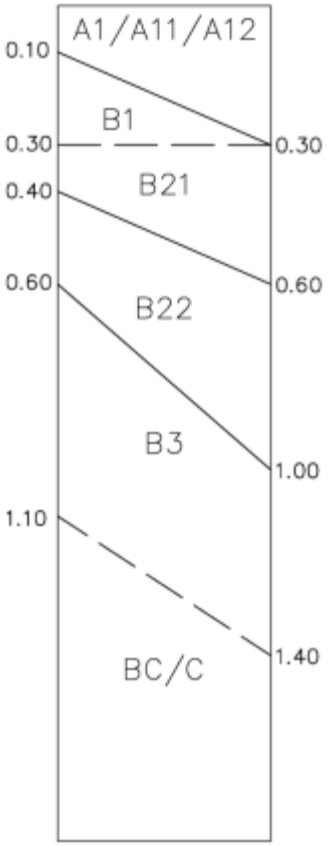


A1/A11/ Ap/A12	Red, black, brown or grey (5YR 4/4; 7.5YR 3/2, 5/5; 10YR 3/2, 3/3, 4/2, 4/3, 4/4); loamy sand to sandy clay loam; massive or weak to strong 2–20 mm cast, angular blocky or subangular blocky structure; <2–10% subangular, rounded or subrounded sandstone or quartz coarse fragments 2–20 mm; field pH 5.5–6.5; sharp to gradual change to
A2	Where present. Brown or grey (7.5YR 4/2, 5/3; 10YR 4/3, 5/4); loamy sand to sandy clay loam; massive or rarely moderate 2–5 mm subangular blocky structure; <2% subangular, rounded or subrounded sandstone or quartz coarse fragments 2–20 mm; field pH 5.0–7.0; abrupt to gradual change to
A3/B1	Where present. Red, brown or grey (5YR 5/6; 7.5YR 4/5, 5/4; 10YR 4/4, 4/6, 5/2, 5/4, 5/6); rarely mottled; loamy sand to clay loam sandy; massive or rarely moderate 5–10 mm subangular blocky structure; <2–10% subangular, rounded or subrounded sandstone or quartz coarse fragments 2–200 mm; field pH 5.0–7.0; abrupt to diffuse change to
B21	Red or brown (2.5YR 4/6; 5YR 4/6, 5/6; 7.5YR 5/6; 10YR 4/6, 5/4, 5/6); occasionally mottled; sandy loam to sandy light medium clay; massive or weak to moderate 5–50 mm angular blocky or subangular blocky structure; <2–20% subangular or subrounded sandstone and/or quartz 6–200 mm; frequently <2–10% manganiferous nodules <2–20 mm; field pH 4.5–6.0; clear to diffuse change to
B22	Where present. Red, brown or grey (2.5YR 5/6; 5YR 4/6; 10YR 5/4, 5/6, 6/4; 2.5Y 7/2); rarely mottled; sandy loam to light medium clay; massive or weak to moderate 5–20 mm angular blocky or subangular blocky structure; occasionally <2–20% subangular or subrounded sandstone coarse fragments 6–20 mm; frequently <2–50% manganiferous segregations <2–20 mm; field pH 4.5–6.5; clear to diffuse change to
B23/B24/ B25	Where present. Red, brown or grey (2.5YR 4/6; 7.5YR 4/4; 10YR 4/4, 5/6; 2.5Y 8/1); frequently mottled; sandy loam to sandy light clay; massive to weak 10–20 mm angular blocky structure; occasionally 2–10% subangular or rounded sandstone coarse fragments 2–6 mm; rarely 2–50% manganiferous or ferruginous nodules 6–20 mm; field pH 5.0–6.5; gradual change to
B3	Where present. Brown (7.5YR 4/6, 5/6); mottled; sandy light medium clay; moderate 10–20 mm subangular blocky structure; field pH 4.5–6.0.
C	Where present. Weathered sandstone rock; field pH 4.5–5.5.
Sites:	85, 87, **90**, 95, **96**, 144, 145, 147, 148, 151, 159, **184**, 194, 242, 246, 250, 506

CLIFFORD – Steep phase (CfSp)

Concept:	Moderately deep to deep, brown gradational soils. Brown or grey clay loam to light medium clay overlying occasionally mottled brown light to medium heavy clay on slopes of Myrtle Creek sandstone.
Australian Soil Classification:	Brown Dermosol.
Geology:	Coarse quartzose Myrtle Creek Sandstone (RJdm)
Landform:	Mid and upper slopes of steep and rolling hills. Slope >20%.
Permeability:	Moderately permeable
Drainage:	Moderately well drained
<u>Surface characteristics</u>	
Surface condition:	Firm
Coarse fragments:	Frequently 2–20% subangular sandstone 60–600 mm. Occasional sandstone outcrops.
Microrelief:	Nil.
Vegetation:	*Acacia spp.* and *Eucalyptus crebra* at higher elevations and on steeper slopes. Also *Corymbia spp., Eucalyptus microcorys.* Includes Macadamia plantations.

Depth (m)

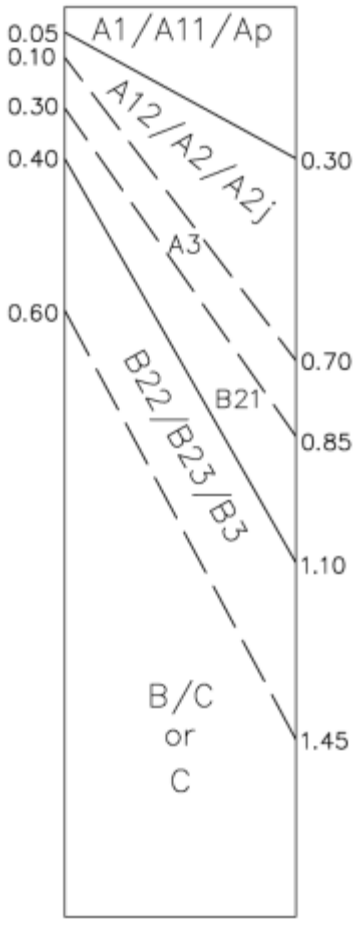


A1/A11/ A12	Grey (10YR 4/2, 5/1); clay loam to light medium clay; moderate to strong 2–20 mm cast or subangular blocky structure; <2–20% subangular or subrounded sandstone coarse fragments 2–60 mm; field pH 4.5–6.0; clear to gradual change to
B1	Where present. Brown (10YR 4/3); clay loam sandy; moderate 2–5 mm angular blocky structure; <2% subangular sandstone coarse fragments 2–20 mm; field pH 5.5–6.0; gradual change to
B21	Brown (10YR 4/3, 4/4); occasionally mottled; light clay to medium clay; moderate to strong 2–20 mm angular blocky or subangular blocky structure; <2% subangular sandstone 2–20 mm; frequently <2% manganiferous nodules 2–6 mm; field pH 5.5–6.0; clear to gradual change to
B22	Brown (7.5YR 4/4; 10YR 4/3); rarely mottled; light clay to medium heavy clay; moderate to strong 2–20 mm angular blocky or subangular blocky structure; occasionally <2–10% subangular sandstone coarse fragments 2–20 mm; frequently <2% manganiferous nodules 2–6 mm; field pH 4.5–6.0; clear to gradual change to
B3	Where present. Red or brown (5YR 4/4, 10YR 5/3); occasionally mottled; clay loam sandy to sandy light medium clay; moderate to strong 5–10 mm angular or subangular blocky structure; 2–20% subangular sandstone coarse fragments 2–20 mm; frequently <2% manganiferous nodules 2–6 mm; field pH 4.5–5.5.
BC/C	Where present. Weathered sandstone rock.
Sites:	162, **163**, **218**, 240

COMO (Cm)

Concept:	Moderately deep to very deep, mottled, brown and grey, texture contrast soils. Black, brown and grey loamy sands to light clays overlying frequently mottled, acidic brown or grey sandy light clay to medium heavy clays on sandstone.
Australian Soil Classification:	Brown Kurosol, Brown Sodosol, Grey Kurosol
Geology:	Myrtle Creek Sandstone (RJdm); Sandstones of Tiaro Coal Measures (Jdt).
Landform:	Crests and ridges of steep, rolling and undulating hills, low hills and rises. Slope <1–8%.
Permeability:	Slowly to moderately permeable
Drainage:	Imperfectly to moderately well drained
<u>Surface characteristics</u>	
Surface condition:	Firm to hard setting
Coarse fragments:	Occasionally <2–20% subangular sandstone 6–200 mm. Frequent sandstone outcrops on crests.
Microrelief:	Nil
Vegetation:	*Lophostemon confertus, Eucalyptus tereticornus*, *Casuarina spp.,* Macadamia plantation and grass understorey. Also *Corymbia spp*., *Melaleuca spp. Eucalyptus racemosa.*

Depth (m)



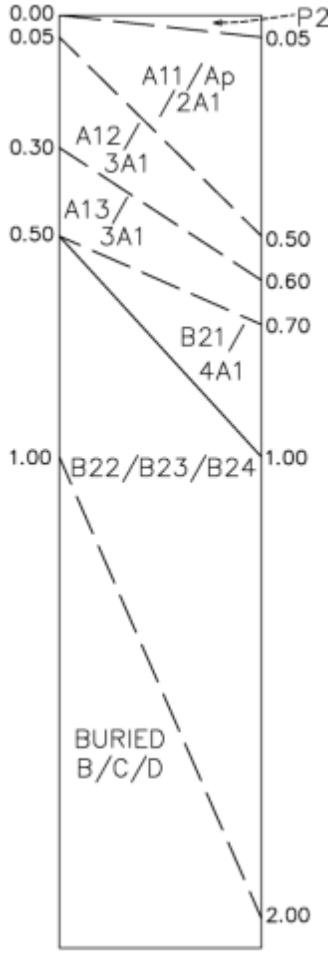
A1/A11/Ap	Black or grey (10YR 2/1, 2/2, 3/1, 3/2, 4/1, 6/1); loamy sand to light clay; massive or moderate to strong 2–20 mm cast or subangular blocky structure; occasionally <2–20% subangular sandstone or quartz coarse fragments 2–200 mm; field pH 5.0–6.5; clear to gradual change to
A12	Where present. Black or grey (10YR 3/2, 4/1); clayey sand to sandy loam; weak to moderate 5–10 mm cast or subangular blocky structure; field pH 5.5–6.0; abrupt to clear change to
A2/A2j	Where present. Brown or grey (7.5YR 4/1, 5/1; 10YR 4/3, 5/3, 5/4, 6/2, 6/3); occasionally bleached; sand to medium clay; massive or moderate to strong 5–20 mm angular or subangular blocky structure; occasionally 2–20% subangular sandstone coarse fragments 2–20 mm; field pH 5.5–6.0; abrupt to gradual change to
A3	Where present. Black, brown or grey (7.5YR 2.5/2, 5/1; 10YR 5/6); loamy sand to light medium clay; weak to strong 5–20 mm subangular blocky structure; occasionally <2–10% angular or subangular quartz coarse fragments 2–6 mm; field pH 5.5–6.0; abrupt to clear change to
B21	Brown or grey (7.5YR 4/4, 5/6; 10YR 5/6, 5/8, 6/1, 6/3); frequently mottled; sandy light clay to medium heavy clay; moderate to strong 2–50 mm angular or subangular blocky (rarely prismatic); occasionally <2–50% subangular sandstone or quartz 2–20 mm; field pH 4.5–6.0; abrupt to diffuse change to
B22/B23	Where present. Yellow or Grey (10YR 6/1, 6/2, 6/4, 7/1); mottled; light medium to medium heavy clay; weak to moderate 2–20 mm angular or subangular blocky or polyhedral structure; occasionally <2% subrounded quartz coarse fragments 2–6 mm; occasionally <2% ferruginous nodules 6–20 mm; field pH 4.5–5.5; clear to gradual change to
B3	Where present. Brown, grey or yellow (rarely red) (10R 4/6; 7.5YR 6/6; 10YR 5/6, 6/4, 7/1); frequently mottled with substrate inclusions; loamy sand to light medium clay; massive or weak to moderate 5–10 mm subangular blocky or platy structure; frequently <2–50% subangular sandstone or quartz coarse fragments 2–20 mm; field pH 5.0–6.0.
B/C	Where present. Brown (10YR 6/4); sandy clay loam; >50% subangular sandstone fragments 6–20 mm; field pH 5.0–5.5.
C	Where present. Grey (10YR 7/1); mottled; field pH 4.5–5.0. Weathered sandstone rock.
Sites:	**53**, 88, 97, 137, 140, 141, **142**, 152, 165, 166, 191, **215**, 251, 263, 502, 503

Como Shallow Phase (CmSp): Brown Kurosol – Shallow brown texture contrast soils. Crests and ridges of steep hills. As above with C horizon at 0.4–0.55m. Sites **223**, 229.

COOTHARABA (Ct)

Concept:	Organic, wet, acidic, deep to very deep, black or grey sandy uniform or gradational soils subject to seasonal or permanent inundation. Frequently with underlying buried horizons.
Australian Soil Classification:	Oxyaquic and Redoxic Hydrosols, minor Extra-tidal Hydrosols
Geology:	Quaternary coastal deposit (Qc), Holocene lake deposits (Qh1), coastal swamp and health (Qcw).
Landform:	Very low lying, level, tidal and non-tidal plains, open depressions, swamps and relict beach ridges surrounding Lake Cootharaba. Slope <1.5%.
Permeability:	Moderately permeable
Drainage:	Very poorly drained
Surface characteristics	
Surface condition:	Soft
Coarse fragments:	Nil
Microrelief:	Nil or swamp hummock (vertical interval 0.1–0.25 m, horizontal interval 0.5–1.5 m)
Vegetation:	*Melaleuca quinquenervia*, *Melaleuca viridiflora, Banksia robur, Banksia aemula, Xanthorrhoea spp.,* sedge spp.

Depth (m)



P2	Where present. Black (10YR 3/1); loam fine sandy; strong 2–5 mm granular structure; field pH 5.3.
A11/ Ap	Black or grey (7.5YR 3/1; 10YR 2/1, 3/1, 4/1; 2.5Y 4/1); sand to silty light clay; single grained, massive or moderate 2–5 mm granular structure; field pH 4.5–5.5, diffuse change to.
A12	Where present. Grey (7.5YR 4/1; 10YR 4/2; 2.5Y 5/1); sand to sandy loam (rarely light clay); single grained or massive; field pH 4.0–4.5; clear change to
A13	Where present. Grey (10YR 5/1); sandy light clay; massive; field pH 4.5–5.0, clear change to
B21	Grey (10YR 4/1, 6/2, 7/1; 2.5Y 4/1); sometimes mottled; sand or silty light clay to medium clay; single grained or massive to weak 2–5 mm subangular blocky structure; field pH 4.5–5.5; clear change to
B22/23/ B24	Where present. Grey (10YR 6/1); sandy or silty light to medium clay; massive to weak 2–5 mm subangular blocky structure; field pH 4.5–5.0; clear change to
2A1/3A1 /4A1	Where present. Grey (10YR 4/1, 4/2; 5Y 4/1, 5/1); sand, sandy loam or sandy light clay; single grained or massive; field pH 5.0–5.5.
Occasionally present	Buried B, C and D horizons. Grey (10YR 4/2, 5/1, 5/2, 6/1, 7/1, 8/1); rarely mottled; sand to medium heavy clay; single grained or massive.
Sites:	**169**, 170, 173, 174, 175. *Analysed Sites: SEA sites: 877, 2519, 2520, 2537, 2538, 2539, 2540*.

EULAMA (El)

Concept:	Acidic to neutral alluvial soils of mixed origin. Deep to very deep, brown, yellow and grey gradational soils. Black, brown or grey sandy clay loam to light clay (often silty) overlying grey, brown or yellow light to medium heavy clay.
Australian Soil Classification:	Grey, brown or yellow Dermosols, Redoxic Hydrosols
Geology:	Quaternary Alluvium (Qa)
Landform:	Alluvial plains, flood plains and minor drainage depression and terraces. Slope 0–3%.
Permeability:	Slowly to moderately permeable
Drainage:	Poorly to imperfectly drained
<u>Surface characteristics</u>	
Surface condition:	Soft to firm
Coarse fragments:	Nil
Microrelief:	Nil
Vegetation:	Large areas cleared for pasture/cropping. Also *Eucalyptus grandis*, *Eucalyptus tereticornis*, *Ficus spp.*, *Casuarina glauca*, *Melaleuca quinquenervia*, *Araucaria bidwillii*.

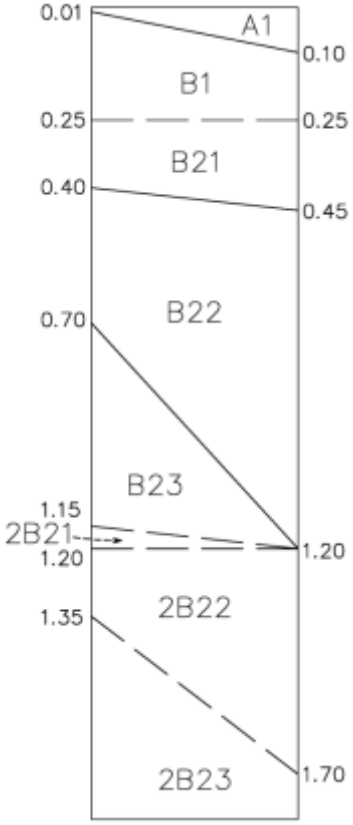
Depth (m)

Ap/A1 /A11	Black, brown or grey (10YR 3/1, 3/2, 3/3, 4/1, 4/2, 4/3, 5/2; 2.5Y 4/1); sandy clay loam to light medium clay (sometimes silty); weak to strong 2–20 mm cast, angular blocky or subangular blocky structure; occasionally <2–20% manganiferous or ferromanganiferous nodules <2–20 mm; field pH 5.5–6.5; abrupt to gradual change to
A12	Where present. Grey (10YR 4/2, 5/2, 6/1); light clay; moderate to strong 2–10 mm subangular blocky structure; rarely <2–20% manganiferous nodules 2–20 mm; field pH 5.5–6.5; clear change to
A2/A2e /A2j	Where present. Grey and rarely yellow (10YR 4/1, 4/2, 5/2, 6/1, 6/2, 7/1; 2.5Y 5/1, 7/3, 7/4); occasionally mottled; clay loam to light medium clay; moderate 2–20 mm angular blocky or subangular blocky structure; occasionally <2% rounded quartz or subrounded charcoal coarse fragments; frequently <2–20% manganiferous or ferruginous nodules <2–6 mm; field pH 5.5–6.5; clear to diffuse change to
B1	Where present. Brown or grey (10YR 4/1, 5/3, 6/1; 2.5Y 5/5); occasionally mottled; light medium to medium clay; weak angular blocky to moderate or strong subangular blocky structure; field pH 6.0–6.5; sharp to gradual change to
B21	Grey, brown or yellow (2.5YR 4/1; 10YR 4/6, 5/1, 5/2, 5/4, 5/6, 6/6; 2.5Y 5/1, 6/1, 6/4, 6/6; 5Y 7/1); light clay to medium clay; moderate to strong 2–50 mm angular blocky or subangular blocky (rarely lenticular or prismatic) structure; rarely <2–10% angular charcoal or subangular quartz coarse fragments 2–60 mm; frequently <2–20% manganiferous or ferruginous segregations <2–20 mm; field pH 5.0–7.0; clear to diffuse change to
B22	Grey or brown (rarely yellow) (2.5YR 5/3; 5YR 4/4; 10YR 4/6, 5/1, 5/2, 5/3, 5/8, 6/1, 6/2, 6/4, 7/1; 2.5Y 6/1, 6/3, 7/5; 5Y 6/1, 7/1); mottled; light to medium heavy clay; moderate 2–10 mm angular blocky, subangular blocky or polyhedral structure; occasionally <2–10% angular or subangular quartz coarse fragments; frequently <2–20% or manganiferous nodules 2–20 mm; field pH 5.0–6.0; clear to diffuse change to
B23/B23g /B24/B25	Where present. Grey, brown or yellow (7.5YR 6/4, 6/6; 10YR 4/6, 5/1, 5/6, 6/1, 6/4, 7/1; 2.5Y 6/1, 6/2, 7/1, 7/5; 5Y 6/1, 7/1); frequently mottled; light medium to medium heavy clay; weak to strong (B23g weak or massive) 2–20 mm angular blocky, subangular blocky or polyhedral structure; rarely <2% angular or subangular quartz coarse fragments; frequently <2–50% manganiferous or ferromanganiferous segregations <2–20 mm; field pH 4.5–6.0.
Sites:	17, **18**, 19, **20**, 26, 130, 132, 134, 135, 136, 178, 180, 183, 185, 186, 187, 188, 189, 192, 247, **266**, 505. *Analysed Sites 18, 20, 266.*

EULAMA – Buried Variant (ElBv)

Concept:	Acidic to neutral alluvial soils of mixed origin. Deep to very deep, brown and yellow gradational or texture contrast soils. Brown or grey sandy loam to light clay (often silty or sandy) overlying buried horizons of brown or yellow light to medium clay.
Australian Soil Classification:	Brown or yellow Dermosols, Brown Kurosols
Geology:	Quaternary Alluvium (Qa)
Landform:	Alluvial plains, flood plains and minor terraces. Slope 0–2%.
Permeability:	Slowly to moderately permeable
Drainage:	Poorly to moderately well drained
Surface characteristics	
Surface condition:	Soft to firm
Coarse fragments:	Nil
Microrelief:	Nil
Vegetation:	Large areas cleared for pasture (some with previous cropping). Also *Eucalyptus grandis*, *Eucalyptus tereticornis.*

Depth (m)

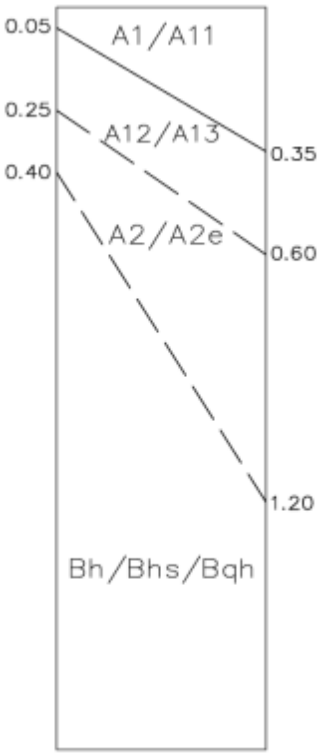


A1	Black, brown or grey (10YR 3/2, 4/2, 5/3, 5/4); sandy loam to light clay (often silty); weak to moderate 2–20 mm cast, polyhedral or subangular blocky structure; rarely <2–20% subangular coarse fragments 2–60 mm; field pH 5.0–6.0; abrupt to diffuse change to
B1	Where present. Brown (10YR 4/3); mottled; light clay; weak 10–20 mm angular blocky structure; field pH 6.0; clear change to
B21	Brown or yellow (2.5Y 5/5, 6/4); light medium clay to medium clay; moderate 2–10 mm angular blocky or subangular blocky structure; rarely <2–10% angular charcoal coarse fragments; frequently <2–10% ferromanganiferous nodules 2–20 mm; field pH 6.0; clear to gradual change to
B22	Yellow (10YR 6/6; 2.5Y 6/6); frequently mottled; light to light medium clay; moderate 2–10 mm angular blocky or subangular blocky structure; occasionally 2–10% angular charcoal coarse fragments 2–6 mm; frequently 2–10% ferromanganiferous nodules 2–6 mm; field pH 5.0–6.5; gradual to diffuse change to
B23	Where present. Brown (7.5YR 5/4); light clay; moderate 10–20 mm angular blocky structure; frequently 2–10% ferromanganiferous nodules 2–6 mm; field pH 6.5.
2B21	Where present. Brown (10YR5/4); sandy light clay; massive; field pH 5.5; clear change to
2B22	Where present. Yellow or grey (10YR5/1, 6/5); light to medium clay; moderate 2–5 mm subangular blocky or polyhedral structure; field pH 5.0–5.5.
2B23	Where present. Brown (7.5YR 5/4); fine sandy light clay; moderate 10–20 mm angular blocky structure; 2–10% ferromanganiferous soft segregations 2–6 mm; field pH 6.5.
Sites:	**47**, 177, 179

HEMPSALL (Hs)

Concept:	Deep to very deep, uniform soils subject to short to long-term saturation. Black or grey sand to sandy clay loam overlying organic grey, brown and black sand to clayey sands dominated by the accumulation of organic-aluminium/iron compounds
Australian Soil Classification:	Semiaquic Podosols, Aquic Podosols
Geology:	Pleistocene/Holocene dunes (Qpd/Qhd); Quaternary coastal swamp and heath (Qcw), Myrtle Creek Sandstone (RJdm), Neogene and Quaternary residuals associated with Tiaro Coal Measures (Qr>Jdt/Jdt).
Landform:	Flats and lower slopes (rarely broad flat crests) of level plains to rolling rises and undulating hills. Slope <5%. Also crests slopes and open depressions (swales) of dunes.
Permeability:	Moderately to highly permeable
Drainage:	Very poorly to imperfectly drained
Surface characteristics	
Surface condition:	Loose or soft
Coarse fragments:	Nil
Microrelief:	Nil
Vegetation:	*Eucalyptus resinifera, Lophostemon confertus, Eucalyptus Microcorys*, rainforest spp., *Acacia spp.*, *Gahnia spp*., *Melaleuca spp., Eucalyptus robusta*, *Syncarpia glomulifera, Pinus spp.,* bracken.

Depth (m)



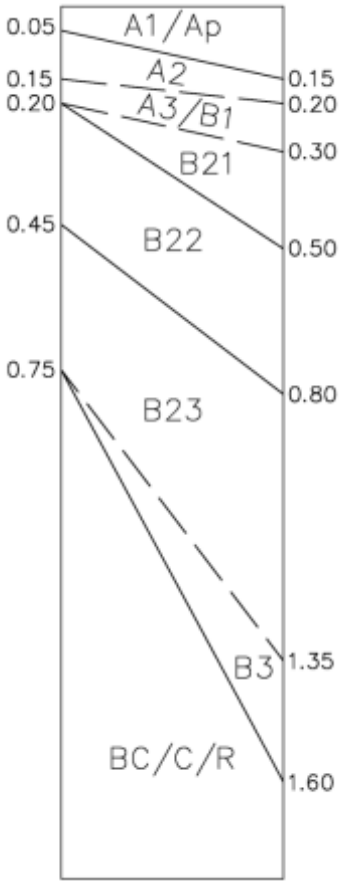
A1/A11	Black or grey (7.5YR 2.5/1, 3/1, 4/1; 10YR 2/1, 3/1, 3/2, 4/1); sand to sandy clay loam; single grained, massive or moderate 5–10 mm cast structure; field pH 4.0–5.5; sharp to gradual change to
A12/A13	Where present. Black or grey (10YR 2/1, 3/1, 3/2, 4/1, 5/2); sand to sandy loam; single grained or weak 5–10 mm subangular blocky structure; occasionally <2% subrounded quartz coarse fragments 6–20 mm; field pH 4.5–5.5; clear to diffuse change to
A2/A2e	Frequently present, often conspicuously bleached. Grey (7.5YR 4/1, 5/2; 10YR 2/1, 4/2, 5/1, 5/2, 7/1; 2.5Y 5/1, 6/2, 7/1); rarely mottled; sand to sandy loam; single grained or massive; rarely <2% ferruginous nodules 6–20 mm; field pH 4.0–6.5; abrupt to diffuse change to
Bh/Bhs/ Bqh	Black, brown, yellow and grey (7.5YR 3/2, 10YR 2/2, 3/1, 3/2, 4/1, 4/3, 5/3, 5/4, 5/5, 6/2/ 6/4, 7/2; 5Y 7/1); sand to clayey sand; single grained or massive; rarely <20% subrounded quartz coarse fragments 6–20 mm; field pH 4.0–6.5.
Sites:	133, **149**, 150, 171, 172, 176, 190, **210**, 214, **262**, 504

Hempsall Hydrosol phase (HsHp): Oxyaquic Hydrosols (Tenosolic) – As above with seasonal or permanent water table and no Bh/Bhs/Bqh horizon. Grey (10YR 8/1) B2/B21; Grey (10YR 8/1) B22; Grey (10YR 7/1) B23. Sites **82**, 216.

KIN KIN (Kk)

Concept:	Moderately deep to deep, brown and red, gradational soils. Brown and grey clay loams, light clays and light medium clays overlying frequently mottled light to medium clays on weathered and non-weathered phyllite.
Australian Soil Classification:	Brown Dermosol, Red Dermosol
Geology:	Phyllite and hornfels of the Kin Kin Beds (Rk)
Landform:	Hillslopes of rolling rises, steep and rolling low hills and steep and rolling hills. Slope ≤25%.
Permeability:	Slowly to moderately permeable
Drainage:	Moderately well drained to well drained
Surface characteristics	
Surface condition:	Soft to firm
Coarse fragments:	Frequent <2% to >20% angular and subangular quartz and phyllite. Nil outcrops.
Microrelief:	Nil
Vegetation:	Mostly cleared and grassed (pasture). Stringy bark, Grey gum, bloodwoods, *Casuarina spp.*

Depth (m)



A1/Ap	Black, brown or grey (7.5YR 4/3, 5/3, 5/4; 10YR 3/1, 4/2, 4/3, 4/4, 5/3, 5/4; 2.5Y 4/2); silty clay loam to light medium clay; moderate to strong <2–20 mm polyhedral, angular blocky and subangular blocky structure; <2% to >20% angular and subangular phyllite and/or quartz coarse fragments 2–60 mm; field pH 5.5 to 6.5; clear to gradual change to
A2	Where present (undisturbed soils). Brown (10YR 4/4, 5/3); silty clay loam to light clay; strong 2–10 mm subangular blocky structure; <2–10% angular phyllite and/or quartz coarse fragments 2–20 mm; field pH 6.0–6.5; clear to gradual change to
A3/B1	Where present. Brown (7.5YR 5/3; 10YR 3/2, 4/3, 5/5, 6/4); light clay (sometimes silty); moderate to strong polyhedral structure; 2–20% angular and/or subangular phyllite and/or quartz coarse fragments 2–60 mm; field pH 5.5–7.0; clear change to
B21/B22 /B23	Brown, red and rarely yellow (2.5YR 4/4, 5/6; 5YR 5/4, 5/6, 6/6; 7.5YR 5/6, 6/6; 10YR 5/3, 5/6, 5/8, 6/6); frequently mottled; light to medium clay (sometimes silty); moderate to strong 2–20 mm angular blocky, subangular blocky and polyhedral structure; <2–50% angular and subangular phyllite and/or quartz coarse fragments 2–60 mm; field pH 5.0–6.0; clear to diffuse change to
B3	Where present. Red, yellow and grey (2.5YR 4/6; 10YR 6/6, 7/6, 8/1; 2.5Y 7/3); frequently mottled; light medium clay to medium clay; weak to moderate 2–20 mm angular or subangular blocky structure; 2–90% angular phyllite (rarely quartz) coarse fragments 6–60 mm; field pH 4.0–6.0; clear to diffuse change to
BC	Where present. Yellow; light clay; weak subangular blocky and polyhedral structure; 20–50% angular phyllite coarse fragments 200–600 mm; field pH 4.5–5.5; clear change to
C	Where present. Yellow to white (2.5Y 8/2; 10YR 6/6, 7/6); weathered and unweathered phyllite; 20–>90% coarse phyllite fragments; field pH 5.0–5.5; clear change to
R	Where present. Phylite rock.
Sites:	3, **21**, **22**, 24, 31, 33, **34**, 39, 56, 67, 74, 100, 103, 193, **243**, 255. *Analysed Site: 243.*

Kin Kin Bleached Variant (KkBv): Brown Dermosol – As above with A2j Brown or grey (10YR 5/3, 5/4, 7/2, 7/3); silty light medium clay; moderate 2–5 mm subangular blocky structure; <2–10% subangular quartz coarse fragments 6–20 mm; field pH 5.5–6.0. Sites **48**, 49.
Kin Kin Yellow Variant (KkYv): Yellow Dermosol – As above with thin B21 and dominant yellow (7.5YR 6/6; 10YR 6/5, 6/6) B22. Also A2 horizon in undisturbed soils. Sites **38**, 40, 72, 93, 120, 254.

NB: B3 colouring dependent upon parent material inclusions.

KINMOND (Km)

Concept: Sandstone derived deep to very deep, grey (rarely brown) alluvial soils often with buried horizons at depth. Black, brown and grey loamy sand to light clays overlying brown or grey sandy clay loam to medium heavy clay.

Australian Soil Classification: Grey Dermosol, Brown Dermosol, Grey Sodosol, Redoxic Hydrosol

Geology: Sandstone derived Quaternary Alluvium (Qa)

Landform: Alluvial plains, flood plains and terraces, valley flats and lower slopes of gently undulating rises. Slope 0–1.5%.

Permeability: Slowly to moderately permeable

Drainage: Very poorly to imperfectly drained

Surface characteristics

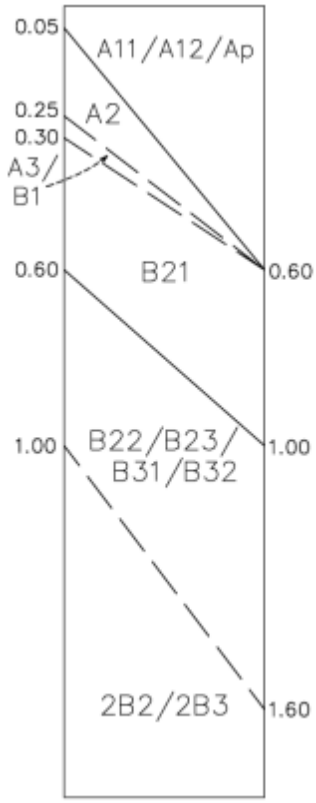
Surface condition: Soft to firm

Coarse fragments: Nil

Microrelief: Nil

Vegetation: Many areas cleared and grassed (pasture). *Melaleuca quinquenervia, Casuarina spp., Acacia spp.*, *Pinus spp.*, *Corymbia gummifera, Gahnia spp*.

Depth (m)



A11/A12/ Ap	Black, Brown or grey (7.5YR 2.5/1; 10YR 3/1, 3/2, 3/3, 4/1, 4/2; 2.5Y 4/1); rarely mottled; clay loam to light clay (frequently silty or sandy); moderate to strong 2–10 mm polyhedral or subangular blocky structure; rarely <2% rounded quartz coarse fragments 6–20 mm; rarely 2–10% manganiferous nodules 2–6 mm; field pH 4.0 to 6.0; abrupt to diffuse change to
A21/A22/ A2j/A2e	Where present. Frequently sporadically or conspicuously bleached. Grey (2.5Y 5/2, 6/1, 6/2); rarely mottled; sandy loam to clay loam sandy; massive; field pH 6.0–6.5; abrupt to gradual change to
A3/B1	Where present. Brown, yellow or grey (10YR 4/3; 2.5Y 5/2, 6/4); frequently mottled; light clay; moderate to strong 2–10 mm subangular blocky or polyhedral structure; frequently <2–10% manganiferous nodules <2–6 mm; field pH 5.5–6.0; abrupt to gradual change to
B21	Black, brown or grey (10YR 3/1, 4/4; 2.5Y 5/1, 6/1; 5Y 6/1); frequently mottled; sandy clay loam to medium heavy clay; weak to moderate 5–50 mm angular blocky, subangular blocky or rarely lenticular structure; rarely <2% rounded quartz coarse fragments 2–20 mm; rarely <2% soft manganiferous segregations <2 mm; field pH 4.5–6.5; abrupt to diffuse change to
B22/B23/ B31/B32	Where present. Brown or grey (10YR 5/1, 6/4, 7/1; 2.5Y 6/1, 7/1; 5Y 6/1, 7/1); frequently mottled; clay loam to medium heavy clay; moderate (rarely massive) 5–50 mm subangular blocky structure; rarely 2–10% subrounded quartz coarse fragments 2–6 mm; frequently <2–20% ferromanganiferous nodules 2–6 mm; field pH 4.0–8.0; abrupt to gradual change to
2B21/ 2B22/ 2B31/ 2B32	Where present. Grey or yellow (10YR 5/1, 6/1, 6/2, 6/8, 7/1, 7/2, 8/1; 2.5Y 5/1, 6/2, 7/2; 5Y 6/1); frequently mottled; loamy sand to medium heavy clay (often silty or sandy); single grained (sands), massive or weak to strong angular blocky, subangular blocky or lenticular structure; rarely <2–10% angular to rounded quartz coarse fragments 2–20 mm; rarely <2% manganiferous nodules 6–20 mm; field pH 5.0–6.0.
Sites:	**131**, 161, 164, **200**, 209, **217**, 220, 241

Kinmond discontinuous variant: Oxyaquic Hydrosol – As above with D horizons at depth. 2D1/2D2 – Grey (10YR 6/1, 7/1); sand to light clay; massive; 2–20% subangular quartz coarse fragments 2–6 mm; field pH 4.5–5.0. Site **98**.

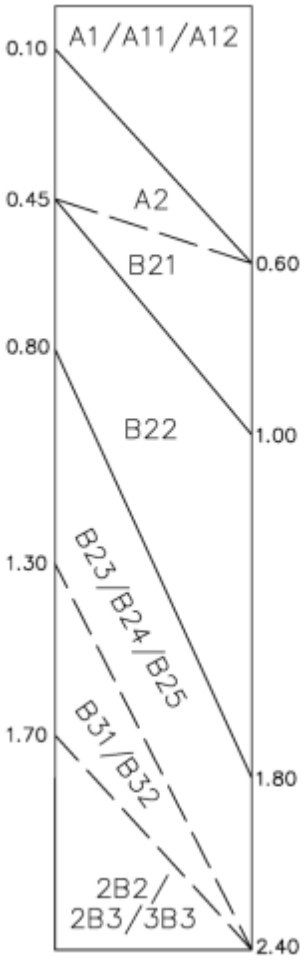
KINMOND – Acidic Phase (KmAp)

Concept: Strongly acidic, deep to very deep, grey and black, gradational or rarely texture contrast soils often with buried horizons at depth. Black or grey loamy sand to light medium clays (often silty or sandy) overlying grey or black light to medium heavy clay (frequently mottled or sandy). Includes many acid sulfate soils.

Australian Soil Classification: Grey Dermosol, Grey or Black Vertosol, Redoxic or Oxyaquic Hydrosol

Geology: Quaternary Alluvium (Qa); Organic deposits
Landform: Alluvial plains, flood plains and swamps. Slope 0–1.5%.
Permeability: Slowly to highly permeable
Drainage: Very poorly to imperfectly drained
Surface characteristics
Surface condition: Firm
Coarse fragments: Nil
Microrelief: Nil
Vegetation: *Melaleuca quinquenervia, Casuarina spp*.

Depth (m)



A1/A11/ A12	Black or grey (7.5YR 3/1; 10YR 2/1, 3/1, 4/1; 2.5Y 2.5/1); loamy sand to light medium clay (sometimes silty or sandy); massive or weak to strong 2–5 mm granular structure; field pH 1.7 to 5.5; clear change to
A2	Occasionally present. Grey or black (10YR 3/1, 4/1, 5/1); loamy sand to sandy loam; massive or weak 2–5 mm subangular blocky structure; field pH 4.0–4.5; abrupt to gradual change to
B21	Black or grey (7.5YR 4/1; 10YR 2/1, 4/1, 5/1, 6/1; 2.5Y 2.5/1); frequently mottled; sandy light clay to medium heavy clay; weak to moderate (rarely strong or massive) 2–20 mm angular blocky, subangular blocky or rarely prismatic structure; rarely 2–10% rounded quartz coarse fragments 6–20 mm; rarely <2% manganiferous segregations <2 mm; field pH 2.5–5.5; clear change to
B22	Black or grey (10YR 4/1, 4/2, 5/1; 5Y 2.5/1); frequently mottled; medium clay to medium heavy clay (often sandy); massive or weak to moderate 2–20 mm angular blocky, subangular blocky or lenticular structure; field pH 2.0–5.0; abrupt change to
B23/B24/ B25	Where present. Grey or yellow (10YR 5/1, 6/1, 7/2, 8/4); frequently mottled; medium clay to medium heavy clay (often sandy); massive or weak to moderate 2–50 mm angular blocky, subangular blocky or lenticular structure; field pH 3.0–6.0.
B31/B32	Where present. Grey (10YR 5/1, 7/1, 8/1); sandy clay loam to medium clay; massive; field pH 3.0–4.0.
2B2/2B3/ 3B2	Where present. Grey (10YR 5/1, 6/1, 7/1, 8/1; 2.5Y 4/1, 5/1); frequently mottled; sandy clay loam to medium heavy clay (often silty or sandy); massive or weak to strong angular blocky, subangular blocky or lenticular structure; rarely <2% rounded quartz coarse fragments 2–20 mm; field pH 3.0–5.5.
Sites:	*Analysed Sites: SEA sites – 876, 2506, 2508, 2509, 2510, 2511, 2516, 2525, 2526*.

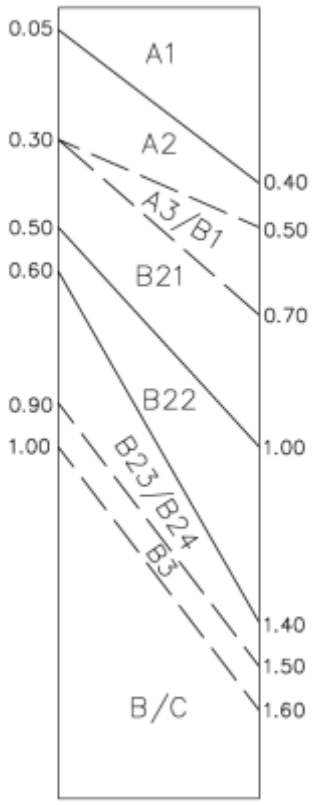
PANGOLA (Pg)

Concept:	Deep to very deep, brown and grey, texture contrast and gradational soils. Black and grey sandy loams to light clays overlying frequently mottled brown or grey sandy clay loam to medium heavy clays on Tiaro Coal Measures and Myrtle Creek sandstone.
Australian Soil Classification:	Brown Kurosol, Grey Kurosol, Brown Dermosol, Grey Dermosol, Redoxic Hydrosol
Geology:	Tiaro Coal Measures (Jdt) and Myrtle Creek Sandstone (RJdm)
Landform:	Slopes of very gently to moderately inclined gently undulating plains and gently undulating and undulating rises. Slope 1–10%.
Permeability:	Slowly to moderately permeable
Drainage:	Imperfectly drained (rarely poorly or moderately well drained)

<u>Surface characteristics</u>

Surface condition:	Soft to hard setting
Coarse fragments:	Nil
Microrelief:	Nil
Vegetation:	Mostly cleared for pastures. Some areas of *Pinus spp.* and other plantation timbers, Macadamia plantation, *Corymbia spp*.

Depth (m)



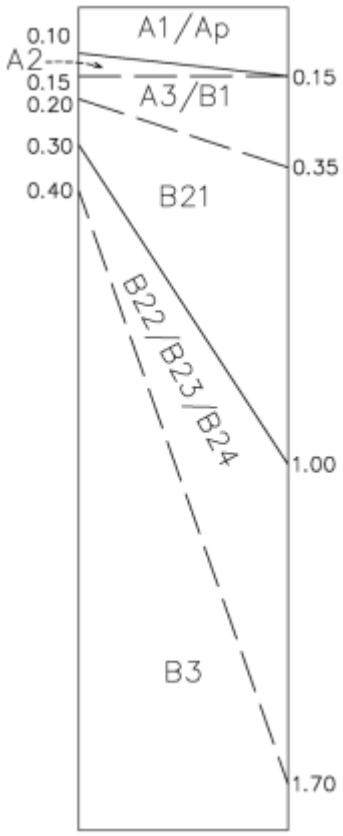
A1	Black or grey (10YR 2/1, 3/1, 3/2, 4/1, 4/3, 5/2); sandy loam to light clay (sometimes sandy or silty); massive or weak to strong 2–50 mm angular blocky or sub angular blocky structure; occasionally <2% rounded or subrounded quartz or sandstone coarse fragments 2–20 mm; field pH 4.5–6.0; abrupt to gradual change to
A2/A2e/ A2j	Where present. Occasionally bleached. Black or grey (10YR 3/2, 4/2, 5/2, 7/3; 2.5Y 5/1, 7/2); sandy loam to light clay; massive or weak to strong 5–10 mm angular blocky or subangular blocky structure; rarely 2–10% subrounded or rounded sandstone coarse fragments 6–20 mm; field pH 4.5–6.0; abrupt to clear change to
A3/B1	Where present. Black, brown or grey (10YR 3/2, 4/6, 5/6; 5Y 6/1, 7/2); sandy clay loam to light medium clay; massive or weak to moderate 5–10 mm subangular blocky structure; Occasionally <2% rounded or subrounded sandstone coarse fragments 2–20 mm; rarely <2–10% manganese segregations <2–6 mm; field pH 5.5–6.0; clear to gradual change to
B21	Brown or grey (10YR 4/1, 4/4, 5/2, 5/3, 5/6, 6/3; 5Y 7/1); mottled; sandy clay loam to medium clay; massive or weak to strong 2–20 mm angular blocky or subangular blocky structure; frequently <2–10% subrounded sandstone and or quartz 2–20 mm; occasionally <2% ferruginous nodules <2–6 mm; field pH 4.5–5.7; abrupt to diffuse change to
B22	Brown, yellow or grey (10YR 5/6, 6/1, 6/3, 6/8; 2.5Y 6/3, 6/6, 7/2, 8/1; 5Y 7/1); mottled; clay loam to medium heavy clay; weak to strong 2–50 mm angular blocky or subangular blocky structure; rarely <2–10% rounded or subrounded sandstone coarse fragments 2–6 mm; rarely <2–10% ferruginous nodules <2–6 mm; field pH 4.5–5.5; clear to diffuse change to
B23/B24	Where present. Red or grey (10R 4/6, 4/8; 7.5YR 5/1; 10YR 6/1; 2.5Y 6/2, 7/1); mottled; medium to medium heavy clay; massive or moderate to strong 2–50 mm subangular blocky structure; frequently 2–10% rounded sandstone coarse fragments 6–20 mm; rarely <2–10% ferruginous nodules <2–6 mm; field pH 4.5–6.0; clear to gradual change to
B3	Where present. Grey (10YR 7/1, 8/1; 2.5Y 6/1, 7/2); mottled; sandy light clay to medium heavy clay; weak to strong 2–10 mm subangular blocky structure; <2–20% subrounded sandstone coarse fragments 6–20 mm; rarely <2–10% ferruginous nodules <2–6 mm; field pH 4.5–5.0.
BC	Where present. Weathered sandstone. Yellow or grey (10YR 6/8; 2.5Y 8/1); mottled; sandy clay loam; massive to moderate subangular blocky structure 2–5 mm; field pH 4.5–5.0.

Sites: **80**, 81, 138, 153, 154, 155, 156, 157, 168, 167, 201, 202, 204, 248, 249, **256**, 257, **258**, **260**, 501. *Analysed Sites: 258, 260.*

PANGOLA – Deeply weathered phase (PgDp)

Concept:	Strongly acidic, deep to very deep, brown and yellow, gradational soils. Black clay loams to light clays overlying mottled brown or yellow light to medium heavy clays over deeper red and grey clays on deeply weathered sandstone or mudstone.
Australian Soil Classification:	Brown Dermosol, Yellow Dermosol
Geology:	Residual soil, colluvium; sand, soil, clay, minor rock debris over deeply weathered Tiaro Coal Measures (Qr>Jdt); Tiaro Coal Measures (Jdt).
Landform:	Crests and slopes of level to gently inclined undulating rises. Slope 1–5%.
Permeability:	Slowly to moderately permeable
Drainage:	Imperfectly drained
Surface characteristics	
Surface condition:	Soft
Coarse fragments:	Rarely 2–10% angular quartz. Nil outcrops.
Microrelief:	Nil
Vegetation:	Pinus radiata (plantation) dominant. Also *Lophostemon spp.*, bloodwoods, *Acacia spp., Livistonia spp.* Understorey of sedges and bracken.

Depth (m)

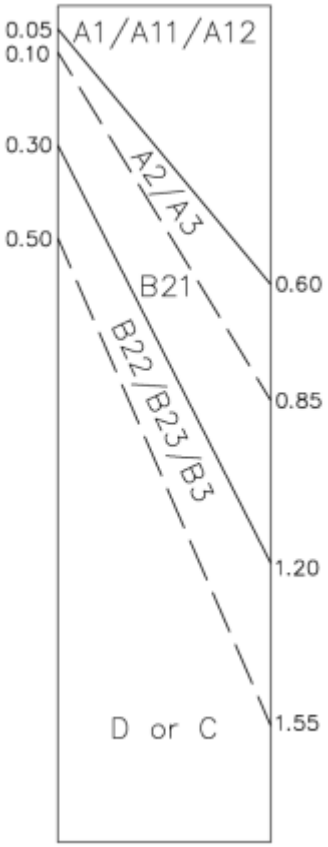


A1/Ap	Black (10YR 3/2); clay loam to light clay; moderate to strong 2–20 mm angular blocky or subangular blocky structure; field pH 5.0–6.0; clear to gradual change to
A2	Where present (undisturbed soils). Grey (10YR 4/2); mottled; light clay; moderate 2–5 mm subangular blocky structure; <2% ferruginous nodules 2–6 mm; field pH 5.5; clear change to
A3/B1	Where present. Brown (10YR 5/3, 5/4); light to light medium clay; 2–5 mm moderate polyhedral structure; frequently <2% ferruginous nodules 2–6 mm; field pH 5.0–5.5; clear to gradual change to
B21	Brown or yellow (10YR 5/4, 5/6, 6/4); mottled; light medium to medium heavy clay; moderate 2–20 mm subangular blocky or polyhedral structure; occasionally <2% ferruginous nodules 2–6 mm; field pH 4.5–5.0; gradual to diffuse change to
B22	Where present. Yellow or grey (10YR 6/2, 6/5, 7/2); mottled; medium to heavy clay; moderate to strong 2–10 mm subangular blocky or polyhedral structure (rarely prismatic); occasionally <2% ferruginous nodules 2–6 mm; field pH 4.5–5.0; clear to diffuse change to
B23/B24	Where present. Red or grey (2.5YR 4/6; 10YR 7/1); mottled; medium heavy clay; moderate prismatic to strong polyhedral structure; occasionally <2% ferruginous nodules 2–6 mm; field pH 4.5–5.0; gradual to diffuse change to
B3	Where present. Grey (10YR 6/3); mottled; medium heavy clay; strong 2–5 mm polyhedral structure; <2% ferruginous nodules 6–20 mm; field pH 4.0.
Sites:	**212**, 232, 235, 239

PAULSEN (Ps)

Concept:	Moderately deep to very deep, brown, acidic texture contrast soils. Black, brown and grey sand to sandy clay loam surface overlying frequently mottled brown sandy light clay to medium clay on Myrtle Creek sandstone.
Australian Soil Classification:	Brown Kurosol
Geology:	Myrtle Creek Sandstone (RJdm)
Landform:	Mid slopes of rolling hills and low hills and undulating and gently undulating rises, rarely pediments and fans. Slope 8–25%.
Permeability:	Slowly to moderately permeable
Drainage:	Imperfectly to moderately well drained
<u>Surface characteristics</u>	
Surface condition:	Soft to firm
Coarse fragments:	Rarely <2% angular quartz 2–6 mm
Microrelief:	Nil
Vegetation:	*Eucalyptus microcorys,* macadamia plantation, grass (pasture ssp.), *Corymbia spp.*

Depth (m)



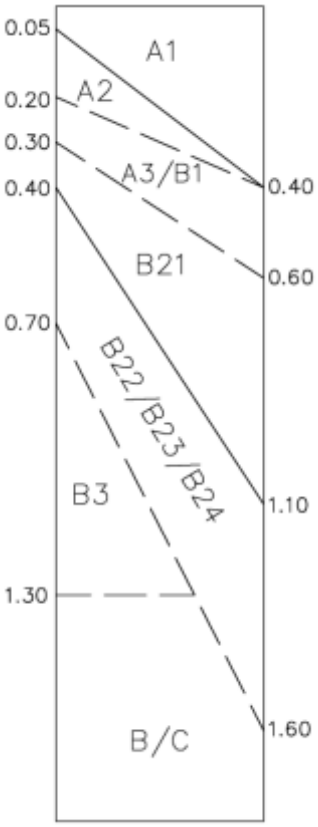
A1/A11/A12	Black or grey (10YR 2/1, 3/1, 3/2, 4/2, 4/3, 6/2); sand to sandy clay loam; massive or occasionally weak to moderate 2–10 mm cast, angular blocky or subangular blocky structure; <2% subangular or subrounded sandstone or quartz coarse fragments 2–20 mm; field pH 5.5–6.5; abrupt to clear change to
A2/A3	Where present. Red, brown or grey (5YR 5/4; 7.5YR 6/1; 10YR 3/4, 4/2, 5/2, 5/3, 6/3); loamy sand to sandy loam; single grained/massive rarely moderate 5–10 mm subangular blocky structure; <2–10% subangular or subrounded sandstone coarse fragments 2–60 mm; field pH 5.5–7.0; abrupt to clear change to
B21	Brown (10YR 4/3, 4/6, 5/6, 5/8); frequently mottled; sandy light clay to medium clay; massive or weak to moderate 5–20 mm angular blocky or subangular blocky structure; <2% subrounded sandstone and/or quartz 6–20 mm; rarely <2% ferromanganiferous nodules 2–20 mm; field pH 5.0–5.5; clear to gradual change to
B22/B23	Where present. Red, brown or grey (5YR 5/6; 10YR 5/1, 5/8, 7/1, 7/2); sandy medium clay to medium heavy clay; moderate 5–20 mm subangular blocky structure; occasionally <2% subangular or subrounded sandstone or quartz coarse fragments 2–20 mm; field pH 4.5–5.0; abrupt to gradual change to
B3	Where present. Brown or grey (7.5YR 4/6; 2.5Y 8/1); mottled; sandy light medium clay to medium clay; moderate 2–20 mm subangular blocky structure; frequently <2–10% angular or subangular sandstone coarse fragments 6–20 mm; field pH 4.0–5.5.
C	Where present. Weathered sandstone rock.
D	Where present. Buried horizons underlying pediments and fans.

Sites: 86, 89, 99, **146**, **160**, 225. *Analysed Site: 146.*

PENDER (Pd)

Concept:	Phyllite derived, deep to very deep, brown, non-cracking gradational soils. Brown and grey clay loams to light medium clays (often silty) overlying frequently mottled, red, brown or yellow light to medium heavy clays.
Australian Soil Classification:	Brown Dermosol, Red Dermosol, rarely Grey/Yellow Dermosol
Geology:	Phyllite dominated Quaternary Alluvium (Qa)
Landform:	Alluvial plains, flood plains and terraces. Slope 0–5%.
Permeability:	Slowly to highly permeable
Drainage:	Imperfectly to well drained
Surface characteristics	
Surface condition:	Soft to firm
Coarse fragments:	Rarely 2–10% angular quartz. Nil outcrops
Microrelief:	Nil
Vegetation:	Mostly cleared and grassed (pasture). Areas of rainforest species including *Archontophoenix cunninghamiana, Lephostemon confertus, Ficus spp., Elaeocarpus grandis, Araucaria bidwillii*.

Depth (m)



A1	Brown or grey (7.5YR 4/3, 4/6; 10YR 4/2, 4/3, 4/4, 5/2, 5/3, 5/4; 2.5Y 4/2, 4/4); clay loam to light medium clay (sometimes silty); weak to strong 2–20 mm polyhedral, granular, angular blocky or subangular blocky structure; frequently <2–10% angular or subangular quartz coarse fragments 2–20 mm; rarely <2% manganiferous nodules 2–6 mm; field pH 5.5 to 6.5; abrupt to diffuse change to
A2/A21/ A22/A2j	Where present. Rarely sporadically bleached. Brown or, red (5YR 4/3; 10YR 2/4, 5/3, 5/4, 6/3; 2.5Y 4/3); light to light medium clay (occasionally silty or sandy); weak to strong 2–20 mm subangular blocky or angular blocky structure; rarely 2–10% angular quartz coarse fragments 6–20 mm; frequently <2–10% manganiferous nodules <2–6 mm; field pH 5.5–6.5; clear to gradual change to
A3/B1	Where present. Brown or yellow (10YR 4/4, 5/4; 2.5Y 4/3, 6/4); rarely mottled; clay loam to light medium clay; moderate to strong 2–20 mm subangular blocky and angular blocky structure; rarely <2% angular quartz coarse fragments 2–60 mm; occasionally <2–10% manganiferous segregations <2–6 mm; field pH 5.0–6.5; clear to diffuse change to
B21	Brown (7.5YR 4/6, 5/6; 10YR 4/4, 4/6, 5/4, 5/6); occasionally mottled; clay loam to medium heavy clay; moderate to strong (rarely weak) 2–20 mm angular blocky, subangular blocky or polyhedral structure; frequently <2% phyllite or quartz coarse fragments 2–20 mm; frequently <2% manganiferous segregations <2–6 mm; field pH 5.0–6.5; abrupt to diffuse change to
B22/B23 /B24/B3	Where present. Brown, red and rarely yellow or grey (2.5YR 4/6; 7.5YR 4/6, 5/4; 10YR 4/2, 5/1, 5/4, 5/6, 5/8, 6/1, 6/5, 6/6, 7/8; 2.5Y 3/1, 4/1, 5/1); frequently mottled; light to medium heavy clay; weak to strong 2–20 mm angular blocky, subangular blocky or polyhedral (rarely lenticular) structure; <2–10% manganiferous segregations <2–6 mm; field pH 5.0–7.0; clear to diffuse change to
B/C	Where present. Brown (7.5YR 5/6); light medium clay; weak structure; 20–50% angular quartz coarse fragments 20–60 mm; field pH 5.5–6.0.
Sites:	1, **5**, 16, **35**, 36, **73**, 75, **94**, 104, 106, 113, 114, 119, 126, 128, 245

RINGTAIL (Rt)

Concept:	Deep, sodic, brown or grey, texture contrast soils. Black or grey sandy loams to clay loams overlying frequently mottled brown and grey sandy clay loams to heavy clays on deeply weathered fine sandstone and mudstone.
Australian Soil Classification:	Grey Kurosol, Brown Kurosol, Grey Sodosols, and Redoxic Hydrosols
Geology:	Deeply weathered mudstones and sandstones of Tiaro Coal Measures (Jdt) and minor Myrtle Creek Sandstones (RJdm)
Landform:	Crests and slopes of gently undulating rises and plains. Slope 0–3%.
Permeability:	Slowly permeable
Drainage:	Poorly to imperfectly drained
<u>Surface characteristics</u>	
Surface condition:	Soft
Coarse fragments:	Rarely <2% subangular quartz coarse fragments 2–6 mm
Microrelief:	Nil
Vegetation:	Pinus radiata (plantation) dominant. Also *Melaleuca quinquenervia*, *Banksia robur*, *Gahnia spp.*, *Casuarina spp.*, *Lophostemon spp.* Minor *Eucalyptus intermedia, Glochidion ferdinandi*. Understorey of sedges and bracken.

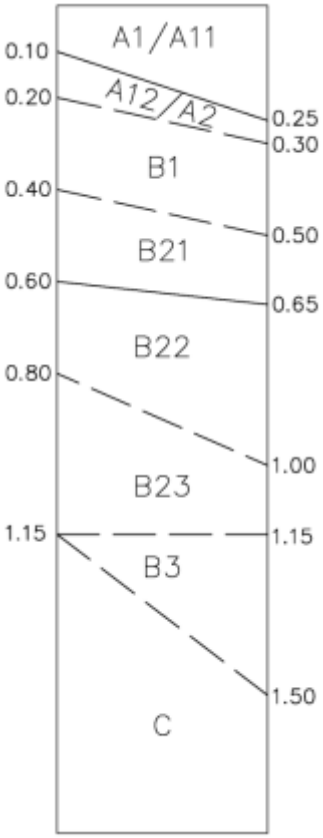
Depth (m)

A1/Ap	Black or grey (10YR 2/2, 3/1, 3/2, 4/2); sandy loam to clay loam; single grained or moderate to strong 2–10 mm cast or angular blocky structure; frequently <2% angular quartz coarse fragments 2–6 mm; field pH 4.5–6.0; abrupt to gradual change to
A2/A2e /A2j/A3	Frequently bleached (sporadically or conspicuously). Grey (10YR 4/1, 5/1, 5/2); frequently mottled; sandy loam to clay loam; single grained or massive to weak subangular blocky structure; field pH 5.0–6.0; sharp to clear change to
B21	Grey, rarely brown (10YR 4/1, 5/2, 5/7, 6/1, 6/5; 2.5Y 5/2); mottled; light clay to medium heavy clay, often sandy; massive or moderate to strong 2–50 mm angular or subangular blocky structure; rarely <2% angular quartz coarse fragments 2–6 mm; field pH 5.0–5.5; diffuse change to
B22	Grey (10YR 5/1, 6/1, 6/2); mottled; light clay to heavy clay; moderate 2–50 mm lenticular, angular blocky or prismatic structure; field pH 4.5–5.5; diffuse change to
B23	Where present. Grey (10YR 6/1; 5Y 6/1); mottled; light medium to medium heavy clay; moderate to strong 5–10 mm angular blocky structure; field pH 5.0–5.5; diffuse change to
B3	Where present. Grey (10YR 6/2; 5Y 7/1); mottled; medium clay to heavy clay; strong 5–10 mm lenticular or angular blocky structure; frequently <2% ferruginous nodules 20–60 mm; field pH 4.5–5.0.
Sites:	207, **208**, **211**, **213**, 231, 234, 236, 237, 238, **261**. *Analysed Site: 261.*

SIMPSON (Ss)

Concept:	Moderately deep to very deep, black, brown and grey gradational soils on weathered and non-weathered basalt (rarely andesite, tuff or rhyolite). Black and grey light to medium clay overlying grey, brown and black medium heavy to heavy clays.
Australian Soil Classification:	Black, Brown and Grey Dermosols
Geology:	Neogene basalt (Tb); rhyolitic tuff; Rhyolite (Rv)
Landform:	Crests, ridges and slopes of steep rolling hills and low hills. Slope up to 40%
Permeability:	Slowly to moderately permeable
Drainage:	Imperfectly to moderately well drained
Surface characteristics	
Surface condition:	Soft to firm
Coarse fragments:	<2 to 90% subrounded (rarely angular) basalt or andesite 60–600 mm. Occasional outcropping.
Microrelief:	Nil
Vegetation:	Mostly cleared and grassed (pasture). Some areas of lightly disturbed, weedy vegetation.

Depth (m)



A1/A11	Black and grey (10YR 2/2, 3/1, 3/2, 4/1); light to medium clay; weak to strong 2–20 mm cast, subangular blocky, polyhedral or granular structure; <2 to >50% angular or subrounded basalt or andesite (rarely quartz) coarse fragments 6–600 mm; field pH 5.5 to 6.0; clear to diffuse change to
A12/A2	Where present. Black and grey (7.5YR 4/1; 10YR 3/1; 2.5Y 4/1); light to medium clay; moderate 2–10 mm subangular blocky or polyhedral structure; <2% angular or subrounded basalt coarse fragments 6–20 mm; <2% manganese nodules 2–6 mm; field pH 5.5–6.0; clear change to
B1	Where present. Black and grey (7.5YR 4/1; 10YR 3/1, 4/2); rarely mottled; light to medium heavy clay; moderate to strong subangular blocky or polyhedral structure; <2–>50% angular or subrounded basalt or andesite coarse fragments 2–600 mm; field pH 5.5–6.0; clear to diffuse change to
B21	Black, brown and grey (7.5YR 5/1; 10YR 3/2, 4/2, 4/3, 5/2; 2.5Y 5/1); frequently mottled; medium heavy to heavy clay; moderate to strong 2–20 mm subangular blocky or lenticular (rarely prismatic) structure; frequently sodic; 2–20% angular basalt coarse fragments 6–600 mm or 20–50% subrounded andesite coarse fragments 60–200 mm; field pH 5.5–6.0; clear to diffuse change to
B22/B23 /B3	Where present. Brown, black or grey (10YR 3/2, 4/1, 4/2, 4/3, 4/4, 5/2, 5/4; 2.5Y 5/1, 7/2); frequently mottled; light to medium heavy clay; massive or moderate to strong 2–5 mm subangular blocky or lenticular structure; <2–20% angular or subrounded basalt coarse fragments 6–600 mm; field pH 5.0–7.5; clear to diffuse change to
C	Where present. 50–>90% coarse basalt fragments; field pH 5.5–6.0. Non-weathered and weathered basalt rock or tuff.
Sites:	**28**, 29, **77**, 91, **92**, 125, 195.

Simpson shallow phase: Leptic Tenosol – A11 – Black or grey (10YR 2/2, 6/3), field pH 6.0–6.5; A12 – Black or grey (10YR 2/2, 6/3), clay loam to light clay, massive, granular or angular blocky structure, field pH 5.5–6.5; R horizon at 0.10–0.40m. Sites **127**, 228.

Simpson buried variant: Red Dermosol – Black A1 overlying red B21/B22, overlying buried B2 horizons (2B21b/2B22b) of tuff geology, found on boundaries with surrounding Myrtle Creek geologies. Site **76**.

Simpson gleyed phase: Redoxic Hydrosol – Located on foot slope of Basalt landform on tuff lithology. Grey or brown (10YR 4/2, 4/3) light clay A11/A12 overlying regularly saturated, mottled brown (10YR 5/3) B21 and gleyed B22/B23. Site **78**.

SIMPSON – Acidic Phase (SsAp)

Concept:	Moderately deep to very deep, grey, gradational soils. Black fine sandy clay loams to sandy clay loams (rarely light clays) overlying acidic, frequently mottled, grey sandy clay loams and sandy light clays to medium clays on weathered parent material at depth.
Australian Soil Classification:	Grey Dermosol
Geology:	Rhyolitic tuff associated with late Triassic undivided volcanics-andesite flows, rhyolite to dacite volcanic breccia, rhyolitic ignimbrite (Rv)
Landform:	Crests and hillslopes of rolling low hills. Slope 5–20%.
Permeability:	Slowly permeable
Drainage:	Imperfectly drained
<u>Surface characteristics</u>	
Surface condition:	Soft to firm
Coarse fragments:	Nil
Microrelief:	Nil
Vegetation:	Mostly cleared and grassed (pasture)

Depth (m)

A1/A11	Black (7.5YR 3/2; 10YR 3/2); clay loam sandy; moderate to strong 2–10 mm subangular blocky or polyhedral structure; none to <2% subangular tuff coarse fragments 2–6 mm; field pH 6.0; sharp to diffuse change to
A12	Where present (undisturbed soils). Black (7.5YR 3/2); clay loam sandy; moderate 2–5 mm subangular blocky structure; no coarse fragments; field pH 6.0; clear change to
A3/B1	Where present. Grey or black (10YR 3/2, 4/2, 5/2); light clay (frequently sandy); moderate 2–10 mm subangular blocky structure; 0–10% subrounded tuff coarse fragments 2–6 mm; field pH 5.0–7.5; clear to gradual change to
B21	Grey (10YR 5/2, 6/2); frequently mottled; clay loam to medium clay (sometimes sandy); moderate 2–20 mm subangular blocky structure; 0–2% angular tuff coarse fragments 2–6 mm; field pH 5.0–6.5; clear to diffuse change to
B22	Where present. Grey (10YR 5/1, 6/2); frequently mottled; light to medium clay to medium clay; moderate 10–20 mm subangular blocky structure; 0–2% angular (sometimes subrounded) tuff coarse fragments 2–20 mm; field pH 4.5–5.5; clear to diffuse change to
B23/B3	Where present. grey (10YR 8/2); frequently mottled; medium to medium heavy clay; moderate subangular blocky structure; 0–20% angular (sometimes subrounded) tuff coarse fragments 2–20 mm; field pH 4.5–5.5; clear change to
C	Where present. 50–>90% coarse fragments; field pH 4.5–5.5.

Sites: 43, **44**, 45, **181**

SISTER (Si)

Concept: Shallow to moderately deep, brown and red, gradational soils. Brown, black and grey silty clay loams, clay loams and light clays overlying light to medium clays (occasionally mottled) on weathered and non-weathered phyllite.

Australian Soil Classification: Brown Dermosol, Red Dermosol, rare Leptic Tenosol

Geology: Phyllite and hornfels of the Kin Kin Beds (Rk)

Landform: Crests and ridges of steep and rolling hills and low hills. Slope 0–20%.

Permeability: Slowly to moderately permeable

Drainage: Moderately well drained to well drained

Surface characteristics

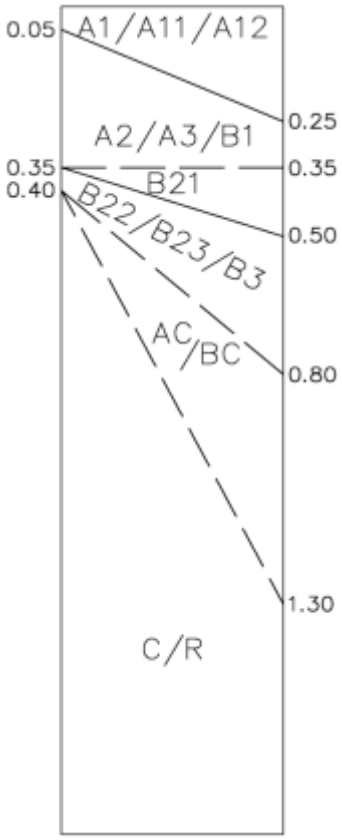
Surface condition: Soft to hard setting

Coarse fragments: Occasionally <2% to >20% angular and subangular quartz and phyllite. Nil outcrops.

Microrelief: Nil

Vegetation: Mostly cleared and grassed. Spotted gum, bloodwoods, iron bark and *Casuarina spp.*

Depth (m)



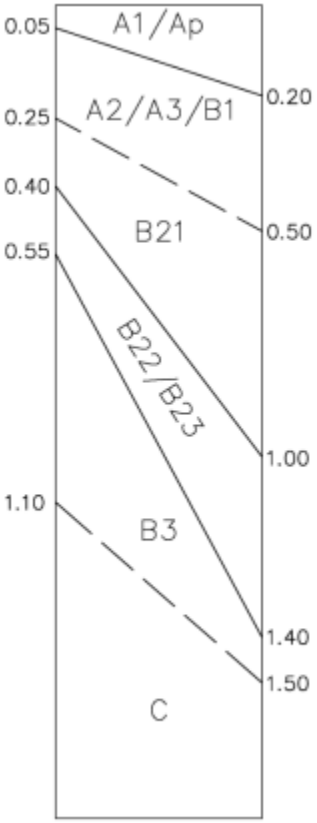
A1/A11 /A12	Brown, black or grey (7.5YR 4/2, 4/3, 5/4; 10YR 2/2, 3/2, 3/3, 4/2, 4/3, 5/3, 6/4); clay loam to light clay (sometimes silty); moderate to strong <2–10 mm polyhedral, granular or subangular blocky structure; <2% to >20% angular and subangular phyllite (rarely quartz) coarse fragments 2–60 mm; rare manganiferous nodules; field pH 4.5 to 7.5; abrupt to diffuse change to
A2	Where present (undisturbed soils) not bleached. Brown (7.5YR 5/4); light clay; moderate subangular blocky structure; 10–20% angular phyllite coarse fragments 6–20 mm; field pH 6.0; abrupt change to
A3/B1	Where present. Brown, red or black (5YR 4/4; 10YR 3/2, 4/4); light medium clay; moderate to strong subangular block or polyhedral structure; occasionally <2–10% subangular phyllite coarse fragments 2–6 mm; field pH 5.5–6.0; clear to diffuse change to
B21	Brown, red and rarely yellow (2.5YR 4/6; 5YR 4/6, 6/4; 7.5YR 3/3, 4/4, 5/4, 6/6; 10YR 4/3, 4/4, 5/3, 5/4, 6/6); rarely mottled; light to medium clay (sometimes silty); moderate to strong angular blocky, subangular blocky and polyhedral structure; <2%–50% phyllite (rarely quartz) coarse fragments 2–60 mm; field pH 5.0–6.5; abrupt to gradual change to
B22/B23	Where present. Brown, red and yellow (2.5YR4/6; 5YR 4/6, 6/6; 10YR 4/4, 5/3, 5/4, 6/6, 7/6); frequently mottled; light to medium clay (sometimes silty); moderate subangular blocky and polyhedral structure; <2–50% phyllite (rarely quartz) coarse fragments 2–200 mm; field pH 5.0–6.5; abrupt to gradual change to
B3	Where present. Red and brown (2.5YR 4/6; 7.5YR 6/4; 10YR 5/4); light to light medium clay; moderate subangular blocky structure; 2–90% angular phyllite coarse fragments 6–200 mm; field pH 5.0–6.0; clear change to
AC/BC	Where present. Brown (7.5YR 5/4, 6/4; 10YR 5/4); frequently mottled; clay loam to light medium clay; moderate angular blocky, subangular blocky and polyhedral structure; 10–90% angular and subangular phyllite coarse fragments 6–60 mm; field pH 5.0–6.0; abrupt to clear change to
C	Weathered and unweathered phyllite; clear change to
R	Phyllite rock.
Sites:	2, **6**, 12, 13, **27**, **30**, **32** 37, 50, 52, 66, 70, 79, 102, 109, 115, 121, **196**, 197, 199 *Analysed Site: 196.*

Sister deep phase: Red and Yellow Dermosols – Deep gradational soils with Red or Yellow B21/B22/B3; C/R horizons deeper than 1.80m. Found on gentler slopes 0–10%. Sites **55**, 101.

SONNY (So)

Concept:	Deep to very deep non-cracking, red and brown gradational soils. Brown light to light medium clays overlying rarely mottled red light medium to medium heavy clays on weathered mudstone or siltstone.
Australian Soil Classification:	Red Dermosol, Brown Dermosol
Geology:	Mudstones and sandstones of Tiaro Coal Measures (Jdt) and Myrtle Creek Sandstones (RJdm)
Landform:	Crests and slopes of rolling and undulating low hills and rises. Slope 1–10%.
Permeability:	Moderately permeable
Drainage:	Moderately well drained
Surface characteristics	
Surface condition:	Firm
Coarse fragments:	Rarely <2% angular quartz and/or subangular sandstone
Microrelief:	Nil
Vegetation:	Macadamia (*Macadamia integrifolia/Macadamia tetraphylla*) plantation with an understorey of grasses. Also *Eucalyptus spp.*, *Corymbia spp.*, *Acacia spp.*

Depth (m)



A1/Ap	Brown or grey (10YR 3/3, 3/4, 4/2, 4/3); clay loam to light medium clay; moderate to strong 2–10 mm subangular blocky or polyhedral structure; rarely <2% subrounded mudstone coarse fragments 6–20 mm; <2–10% manganiferous or ferruginous nodules <2–6 mm; field pH 5.5–6.5; abrupt to gradual change to
A2	Where present. Brown (10YR 3/4); light clay; moderate 2–10 mm subangular blocky or polyhedral structure; <2% subrounded mudstone 2–6 mm; <2% manganiferous or ferruginous nodules <2–20 mm; field pH 6.0; gradual change to
A3/B1	Where present. Brown, yellow or grey (7.5YR 4/4, 4/6; 10YR 4/4, 4/6, 5/2; 2.5Y 6/4); light to light medium clay; moderate to strong 2–10 mm subangular blocky or polyhedral structure; <2% ferromanganiferous nodules 2–6 mm; field pH 5.0–6.0; clear to gradual change to
B21	Red or brown (2.5YR 4/6, 6/4; 5YR 4/3, 4/6; 10YR 4/3, 5/4);frequently mottled; light to medium clay, moderate to strong 2–10 mm subangular blocky or polyhedral structure; rarely <2% subrounded mudstone or angular quartz coarse fragments 6–20 mm; <2–10% ferruginous nodules <2–6 mm; field pH 5.0–6.0; gradual to diffuse change to
B22/B23	Red or brown (10R 3/4; 2.5YR 4/6); frequently mottled; light to medium heavy clay; moderate to strong 2–10 mm subangular blocky or polyhedral structure; occasionally 2–10% subrounded mudstone or angular quartz coarse fragments; <2–10% ferruginous nodules 2–6 mm; field pH 4.5–6.0; diffuse change to
B3	Where present. Red, yellow or grey (2.5YR 4/6; 10YR 6/6; 2.5Y 7/1); mottled; light to heavy clay; moderate to strong 2–10 mm subangular blocky or polyhedral structure; <2% subrounded mudstone 6–20 mm; field pH 4.0–5.5.
C	Where present. Weathered sandstone.
Sites:	158, 203, **205**, **206**, 219, **252**, 253

STRATTON (St)

Concept: Deep to very deep, red, gradational soils. Brown clay loams to light medium clays (sometimes sandy) overlying frequently mottled red and brown light to medium clays on weathered and non-weathered phyllite.

Australian Soil Classification: Red Dermosol

Geology: Phyllite and hornfels of the Kin Kin Beds (Rk)

Landform: Pediments and fans on steep low hills, rolling hills and low hills, undulating hills and undulating plains

Permeability: Slowly to moderately permeable

Drainage: Moderately well drained to well drained

Surface characteristics

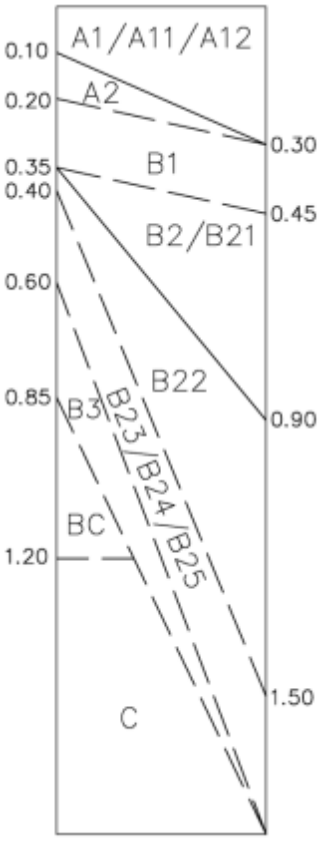
Surface condition: Soft to firm

Coarse fragments: Nil

Microrelief: Nil

Vegetation: Mostly cleared and grassed (pasture). Some bloodwoods.

Depth (m)



A1/A11/A12	Brown or black (7.5YR 4/3, 4/4, 4/6; 10YR 3/2, 4/3, 4/4, 5/3); light clay to light medium clay (rarely silty); moderate to strong <2–20 mm subangular blocky or polyhedral structure; <2% to 10% angular and subangular quartz and/or phyllite coarse fragments 2–60 mm; field pH 5.5 to 7.0; clear to gradual change to
A2	Where present (undisturbed soils) not bleached. Brown (7.5YR 5/3; 10YR 5/4); light clay (occasionally silty); moderate to strong 2–5 mm angular or subangular blocky structure; <2–20% angular quartz and/or subrounded phyllite coarse fragments 2–60 mm; field pH 6.0–6.5; clear to gradual change to
B1	Where present. Brown or yellow (7.5YR 6/6; 10YR 5/5, 5/6); light to light medium clay (occasionally silty); moderate <2–5 mm polyhedral structure; <2–10% angular and/or subangular quartz coarse fragments 2–20 mm; <2% manganiferous nodules 2–6 mm; field pH 5.5–6.0; clear change to
B2/B21	Red or brown (2.5YR 4/8, 5/6; 5YR 4/4, 5/6; 7.5YR 3/2, 4/6, 5/6; 10YR 4/6, 5/3, 5/6); frequently mottled; light to medium clay; moderate to strong 2–20 mm angular blocky, subangular blocky or polyhedral structure; <2–50% angular and subangular phyllite and/or quartz coarse fragments 2–60 mm; occasionally <2% manganiferous nodules 2–6 mm; field pH 5.5–6.0; clear to diffuse change to
B22	Where present. Red (rarely brown) (10R 4/6; 2.5YR 4/6, 5/6; 5YR 4/8; 2.5Y 5/3); occasionally mottled; light to medium clay; moderate to strong 2–20 mm angular blocky, subangular blocky or polyhedral structure (rarely prismatic); <2–20% angular or subrounded phyllite and/or quartz coarse fragments 2–60 mm; field pH 4.5–6.5; gradual to diffuse change to
B23/B24/B25	Where present. Red or brown (10R 4/6; 5YR 5/8; 7.5YR 4/6, 5/6; 10YR 5/6, 5/8); frequently mottled; light medium clay to medium clay; weak to moderate 2–20 mm angular blocky, polyhedral or prismatic (rarely lenticular) structure; none to >20% angular or subangular phyllite and/or quartz coarse fragments 2–60 mm; field pH 4.5–6.0; gradual to diffuse change to
B3	Where present. Red (rarely brown) (10R 4/6; 2.5YR 4/8, 5/6; 10YR 4/4); occasionally mottled; light medium to medium clay; moderate to strong 5–20 mm angular blocky or polyhedral structure; <2–90% angular or subangular phyllite and/or quartz coarse fragments 2–60 mm; <2–10% manganiferous nodules 2–6 mm; field pH 4.5–6.5.
BC	Where present. Red (5YR 4/6); light clay; weak 2–5 mm polyhedral structure; <2–10% angular or subangular phyllite and/or quartz coarse fragments 6–60 mm; <2% manganiferous nodules 2–6 mm; field pH 5.5.
C	Where present. Fine sandy clay loam; massive; 20–>90% coarse phyllite fragments; 10–20% manganiferous nodules 2–6 mm; field pH 6.0–6.5.
Sites:	9, **10**, 15, 25, **41**, 46, 51, 59, 61, 107, 118, 244, **265**. *Analysed Site: 265.*

Stratton brown variant (StBv): Brown Dermosol – Brown gradational soils on rolling low hills and undulating rises. As above with deeper brown B21, occasional lenticular structure at depth, increased manganiferous nodules (less well drained), rare yellow B3 horizons. Sites **4**, 8, 42.

WAHPUNGA (Wp)

Concept: Moderately deep, red, gradational soils. Brown or red clay loams to light medium clays overlying red and brown light to medium clays with an acidic trend over phyllite.

Australian Soil Classification: Red Dermosol

Geology: Phyllite and hornfels of the Kin Kin Beds (Rk)

Landform: Hillslopes of steep and rolling hills and low hills. Slope ≥25%.

Permeability: Moderately to highly permeable

Drainage: Moderately well drained to well drained

Surface characteristics

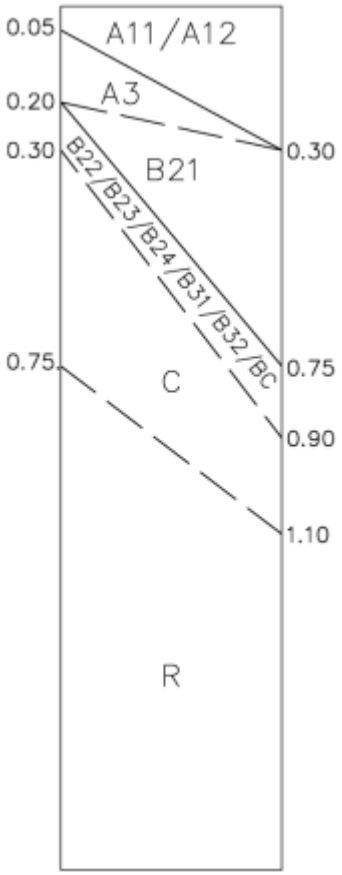
Surface condition: Soft to firm

Coarse fragments: 2% to >20% angular and subangular quartz and phyllite, 2–60 mm. Nil outcrops.

Microrelief: Nil.

Vegetation: Spotted gum, bloodwoods, iron bark and *Casuarina spp.* Some areas of rainforest and grasses.

Depth (m)



A11/A12	Black, brown or grey (5YR 5/4; 7.5YR 4/2, 4/3, 4/6; 10YR 2/2, 3/2, 4/2, 4/3, 4/4, 5/4, 5/6); clay loam to light medium clay; moderate to strong <2–10 mm polyhedral, granular or subangular blocky structure; <2% to >20% angular and subangular phyllite and/or quartz coarse fragments 2–60 mm; field pH 5.0 to 7.0; abrupt to gradual change to
A3	Where present. Brown (10YR 3/3); light clay; strong 2–5 mm polyhedral structure; frequently <2–20% subangular phyllite coarse fragments 6–60 mm; field pH 6.0–6.5; gradual change to
B21	Red or brown (2.5YR 5/6, 5/8; 5YR 4/4, 4/6, 5/6; 7.5YR 3/3, 4/6, 5/6; 10YR 3/4); light to medium clay; moderate to strong 2–20 mm angular blocky, subangular blocky or polyhedral structure; <2–20% angular and subangular phyllite (occasionally quartz) coarse fragments 2–60 mm; field pH 4.5–6.0; clear to diffuse change to
B22/B23 /B24	Where present. Red (2.5YR 4/6, 5/6; 5YR 4/4, 4/6, 5/6;); light to medium clay; moderate 5–20 mm subangular blocky or polyhedral structure; <2–50% angular and subangular phyllite coarse fragments 2–60 mm; field pH 5.0–6.0; clear to diffuse change to
B31/B32 /BC	Where present. Red (rarely brown) (2.5YR 4/6, 5/6; 5YR 4/4, 4/6, 6/6; 7.5YR 5/6); light to medium clay; massive to moderate 2–10 mm subangular blocky or polyhedral structure; 2–90% angular and subangular phyllite (rarely quartz) coarse fragments 2–60 mm; field pH 4.5–6.0; clear to gradual change to
C	Where present. Weathered and unweathered phyllite; field pH 4.4–5.5; clear change to
R	Where present. Phyllite rock.
Sites:	**7**, 23, 57, 60, 65, 68, 69, **71**, 105, 110, 112, 116, 117, **122**, 123, 124.

Wahpunga Deep Phase (WpDP): Red Ferrosol – As above with soil depth of >1.50m, BC/C/R not recorded (deeper than 1.8m). No surface coarse fragments. Sites **11**, 58. *Analysed Site: 11.*