Land Resource Assessment of Fernvale, Esk and Avoca Vale, Brisbane River Catchment

South East Queensland

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Summary

The soils and landscapes of the Fernvale, Esk and Avoca Vale regions were identified as a critical data gap in the foundational land resource data sets for South East Queensland (SEQ). The data collected in this project (known as the SEQE project) can be used to inform and support land degradation studies, natural resource and catchment management planning as well as local government and regional planning decisions.

Soil and landscape attributes were assigned to unique mapping areas (UMAs) based on information collected from 462 sites, air photo and satellite imagery interpretation. The information collected in this project was supplemented by knowledge gained from surrounding land resource assessment projects. Conceptual soil profile descriptions, known as Soil Profile Classes (SPCs) and landscape concepts were devised to describe the geomorphic relationship between the soils, lithology and associated landforms.

The project builds on and releases published and unpublished soils and landscape information that was collected between 1976 and 2016 from a variety of projects. All sites are located within the upper and mid Brisbane River catchment. The Avoca Vale and Esk landscapes form part of the Wivenhoe Dam catchment while the Fernvale study area is downstream of the dam wall.

Soil and landscape attributes were used to assess the limitations of each UMA allowing the assessment of their suitability for a range of agricultural crops. Agricultural land classes (ALC) were assigned for each UMA by re-interpretation of the land suitability data.

Within this project area, there are known areas of Class A, B and C1 agricultural land. Agriculture has a significant presence in the local economy and there are competing land use pressures for both agricultural and urban expansion. The accurate mapping of the land resources and their agricultural suitability will support sustainable management of the state's land and water resources.

Land degradation is a significant issue for the catchment. Sheet, rill, gully and streambank erosion are evident in the Fernvale, Esk and Avoca Vale landscapes, particularly on sodic texture-contrast soils where groundcover is reduced and grazing is the dominant land use. Water quality is affected by sedimentation and nutrient delivery to water bodies arising from erosion, and secondary salinity expressions are prevalent in the alluvial valleys, particularly in the stream channels of the Esk and Fernvale landscapes. An erosion model to predict potential erosion risk areas at a catchment scale has been trialled using moderate and high resolution digital elevation models (DEMs) to identify landscape features associated with erosion. Opportunities are available to further trial and validate these models where rill and gully erosion are prevalent.

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Acknowledgements

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List of Acronyms Used in this Report

ALC	Agricultural Land Class
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DEM	Digital Elevation Model
DNRM	Department of Natural Resources and Mines
DSITI	Department of Science, Information Technology and Innovation
EC	Electrical conductivity
GIS	Geographic Information System
LiDAR	Light Detection and Ranging
MrVBF	Multi-Resolution Valley Bottom Flatness
NLWRA	National Land and Water Resource Audit
PAWC	Plant Available Water Capacity
QLUMP	Queensland Land Use Mapping Program
REDD	Regional Ecosystem Description Database
RUSLE	Revised Universal Soil Loss Equation
SALI	Soil and Land Information Data Base
SEDG	South East Data Gaps
SEQ	South East Queensland
SIR	Spatial Information Repository
SPC	Soil Profile Class
SRTM DEM	One arc-second hydrological enforced Shuttle Radar Topography Mission Digital Elevation Model
STI	Sediment Transport Index
TERN	Terrestrial Ecosystem Research Network
TPI	Topographic Position Index
TWI	Topographic Wetness Index
UMA	Unique Mapping Area

1. Introduction

Soils and landscapes of the upper Brisbane River were studied in the *Land Resource Assessment of the Brisbane Valley, Queensland* (Harms and Pointon 1999), (referred to as the Brisbane Valley report). This publication is a supplement to the Brisbane Valley report, due to its common borders, geology, hydrology and landforms. Discussions of common themes have not been duplicated in this document, and the reader should consult the Brisbane Valley report for more information when directed. Other relevant land resource survey projects include:

- *Landscape and salinity assessment of the Black Snake Creek Catchment South East Queensland* (Ellis and Bigwood 2006)
- *Soils and irrigated land suitability of the Lockyer Valley alluvial plains, South-East Queensland* (Powell et al. 2002)
- *Soils and land suitability of the Kilcoy-Woodford Area, South East Queensland* (Loi and Malcolm 1998)
- *Understanding and managing soils in the Moreton Region* (Noble 1996 ed.)
- *The soils on three major rock types in the Upper Brisbane Valley, South Eastern Queensland* (Murtha 1977) and
- *Moreton Region non-urban land suitability study* (DPI 1974).

A variety of other land resource projects have been completed in SEQ over the past 40 years. The relevant projects that are mapped at 1:100 000 or broader are displayed in Figure 1.

The land resources of Fernvale, Esk and Avoca Vale have been investigated in this project to satisfy the following objectives:

- to compile a soil and land resource foundational dataset
- to assist government, the community and stakeholders with management and planning decisions relating to land resources
- to evaluate agricultural potential
- to identify land that is degraded and/or prone to land degradation, including erosion and salinity and understand the connection with downstream water quality
- to trial predictive models for soil loss risk using moderate and high resolution DEMs
- to monitor soil health
- to collate spatial data and produce a series of maps, and
- to demonstrate applications of the data and communicate these to potential users.

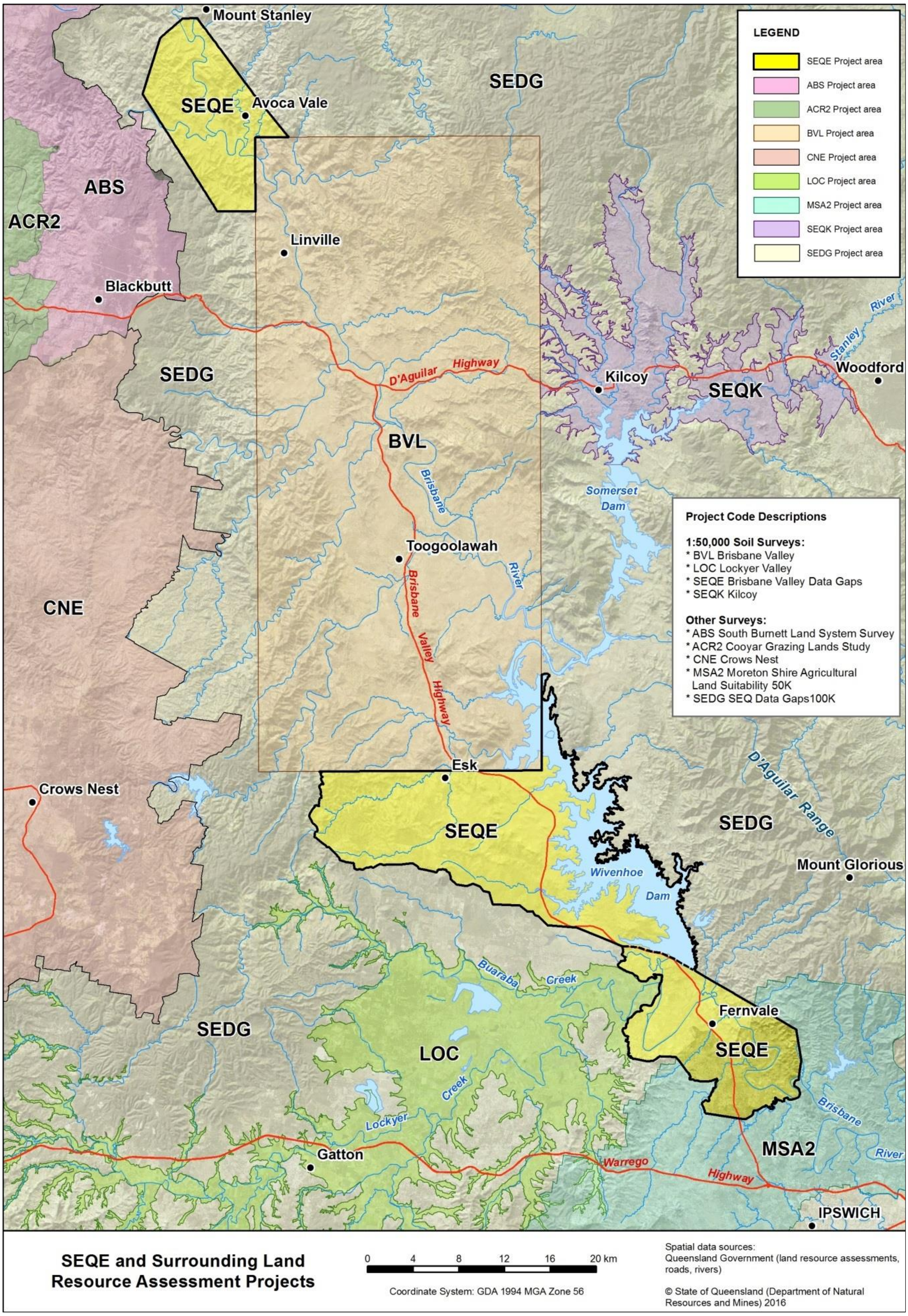


Figure 1 SEQE project area and surrounding land resource assessment projects

This project addresses a critical gap in the Queensland Government foundational data set of soils and land resources. The data has been analysed at a variety of scales, due to the dispersed nature of the study areas and the differing pressures in those parts of the catchment. Land suitability classification has been assessed and ALC has been allocated for all of the UMAs, based on the SEQE land suitability framework (Appendix 4). The soil profile class information, landscape concepts, and erosion modelling that was trialled can be used to extrapolate gully erosion and predict water quality and land degradation issues for the catchment.

The results of this project will be used to inform and support a range of planning and natural resource management decisions through the application of knowledge in landscape processes, geologic landscapes, soil forming processes, and land use/land management interactions. Catchment processes, degradation hazards (salinity, waterlogging and erosion), soil/land attributes and ALC have been documented. Mapping has used existing broad scale geology and landform data in association with site-specific, soil landscape field data collected during the course of the study, and reinterpretation of existing site data. The data outputs from this project will support:

- local farmers through access to better information to make informed land and water management decisions affecting property planning, agricultural productivity and land degradation
- improved decision making by SEQ Water in relation to the management and operation of Wivenhoe Dam and its surrounding lands
- Somerset Regional Council land use decision making
- natural resource planning and allocation decisions
- further trialling of erosion modelling using moderate and high resolution DEMs, and
- the Queensland Government's Open Data Policy and the accurate and timely supply of property and spatial information resources.

The soils data collected in this project and stored in the SALI database including site data, agricultural land suitability and ALC is available digitally via web based services.

2. Study Areas

For the SEQE project, data was collected in three study areas, which adjoin the Brisbane Valley and Lockyer Valley projects. The three study areas of Fernvale (13 111 ha), Esk (33 035 ha) and Avoca Vale (11 252 ha) are displayed in Figure 2.

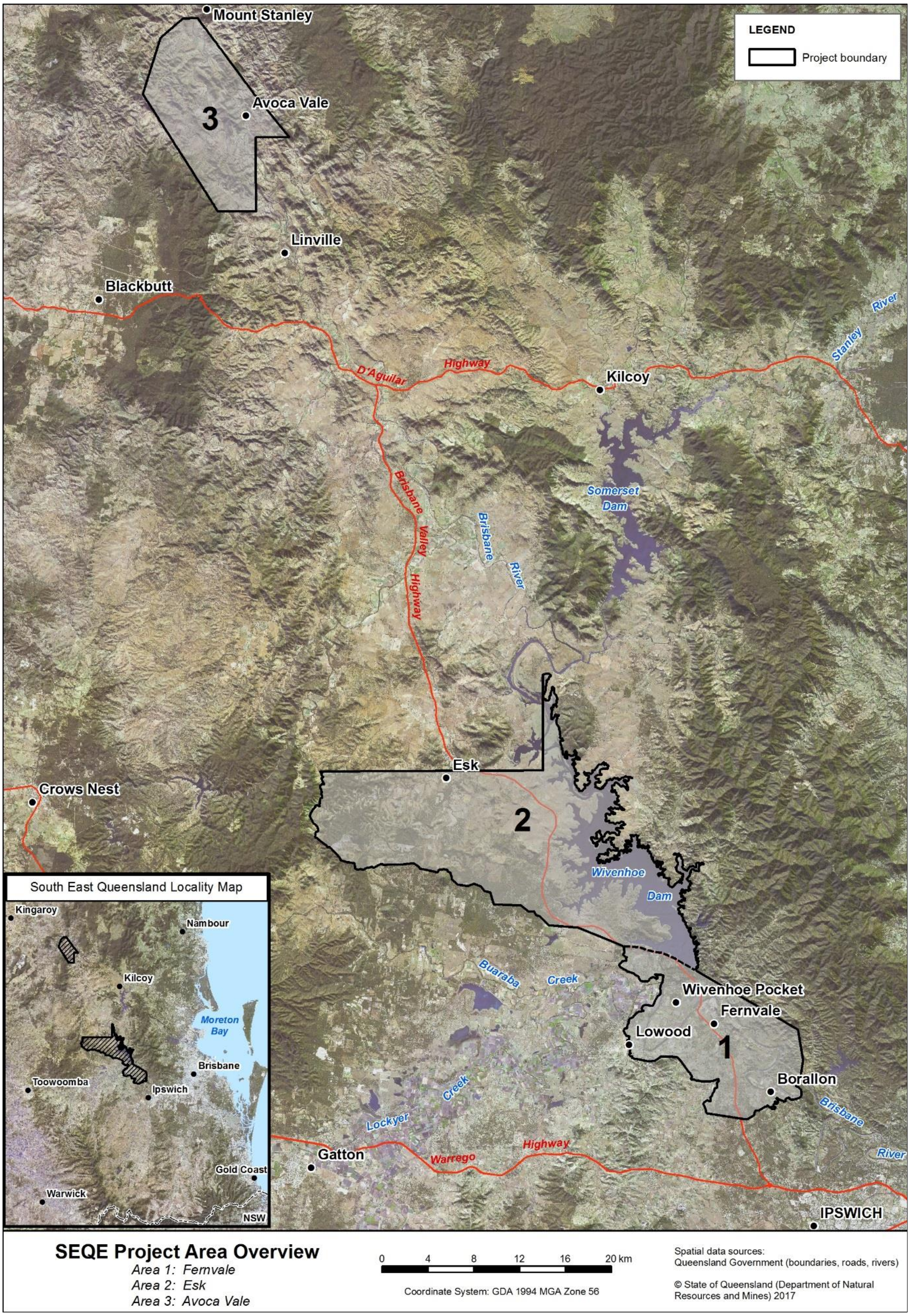


Figure 2 Three study areas—Fernvale (1), Esk (2) and Avoca Vale (3)

Study Area 1—Fernvale (Borallon to Wivenhoe Pocket)

Study area 1 includes areas downstream of the Wivenhoe Dam wall, following the alluvium of the Brisbane River towards Borallon, and abuts the Lockyer Valley project at the junction of Lockyer Creek and Brisbane River (Figure 3). The soils in this study area are influenced by sediment discharged from Lockyer Creek, Black Snake Creek and Sandy Creek. Land management issues within the area include flooding, salinity, erosion, nutrient and sediment delivery to Brisbane River and Moreton Bay and pressure from competing land uses.

Figure 3 Agricultural production at Wivenhoe Pocket, study area 1

Study Area 2—Esk (Wivenhoe to Esk)

Study area 2 includes areas west of Wivenhoe Dam and south of the town of Esk (Figure 4), adjoining the southern boundary of the Brisbane Valley project. The southwestern project boundary follows the Brisbane River catchment, including the sub-catchments of Spring Creek, Logan Creek, Paddy Gully, Sandy Creek, and Redbank Creek. Land management issues within the area include salinity, erosion, nutrient and sediment delivery to Wivenhoe Dam and pressure from competing land uses.

Figure 4　　Cultivation at Esk, study area 2

Study Area 3—Avoca Vale

Study area 3 follows the Brisbane River north of Linville towards Mount Stanley, and abuts the north western boundary of the Brisbane Valley project (Figure 5). This area is dominated by the alluvium associated with the streams at the confluence of the eastern and western Branches of the Brisbane River and then the confluence of the Brisbane River and Cooyar Creek. The catchments of Avoca Creek and Muddy Creek are included in the study area. Land management issues within the area include flooding, erosion, and the transport of nutrient and sediment to Brisbane River and Wivenhoe Dam.

Figure 5　　Agricultural production at Avoca Vale, study area

3. Climate

The climate within the project area is sub-tropical with higher rainfall between October and March, resulting in warm wet summers and mild dry winters. Seasonal and annual rainfall is variable with incidences of flooding usually associated with cyclonic weather patterns in the summer months (Figures 6 and 8). The major climatic variability across the study area relates to the frequency and severity of frosts. Frosts become more regular and more extreme in the upper catchment area of Avoca Vale. The Brisbane Valley report provides more information on climate of the Brisbane Valley.

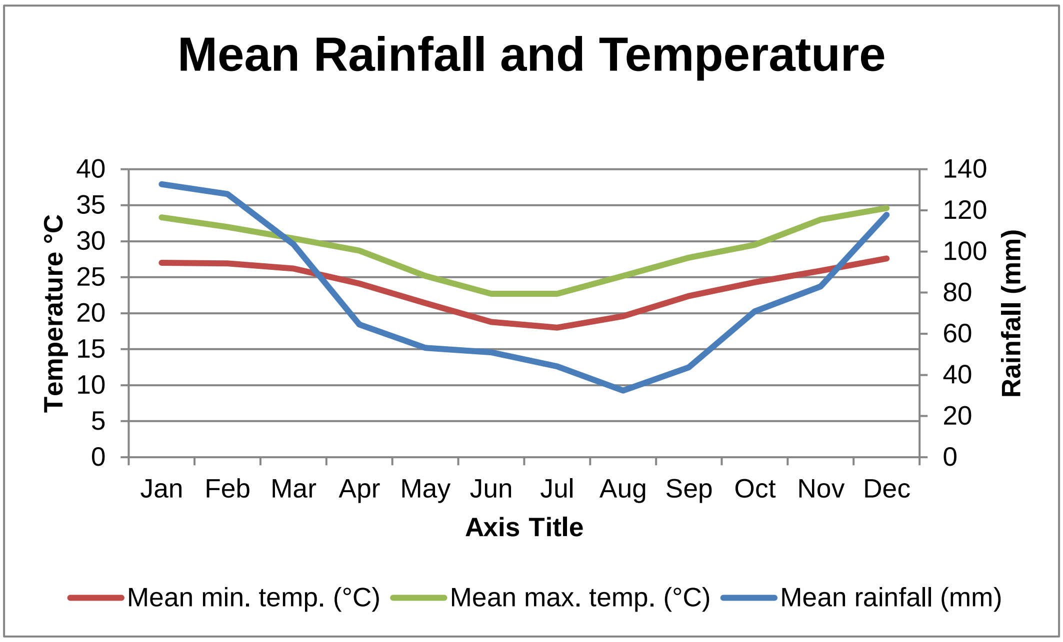


Figure 6 **Mean rainfall and temperature—Esk**

4. Hydrology

The study areas follow the valley of the Brisbane River and tributary streams including Cooyar Creek, Avoca Creek, Muddy Creek and Redbank Creek. Wivenhoe Dam, in the middle of the project area, supplies drinking water, is used for flood mitigation of Brisbane city and also acts as a sediment trap. Downstream from Wivenhoe Dam, Lockyer Creek, Black Snake Creek and Spring Creek also discharge into the river system. Streamflow variability in the Brisbane River is linked to climatic factors described above. Streamflow is summarised in Figure 7. Refer to the Brisbane Valley report and Lockyer Valley reports for more information on the hydrology of the Brisbane River catchment.

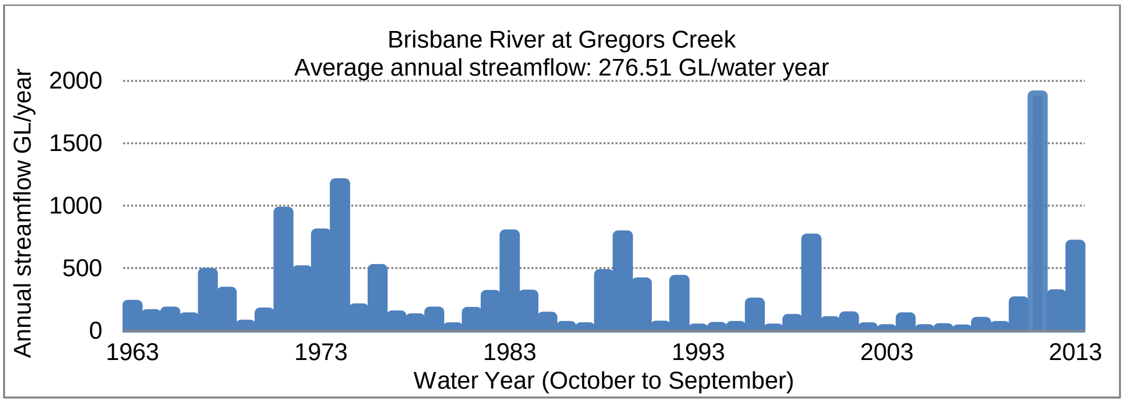


Figure 7 **Brisbane River streamflow**

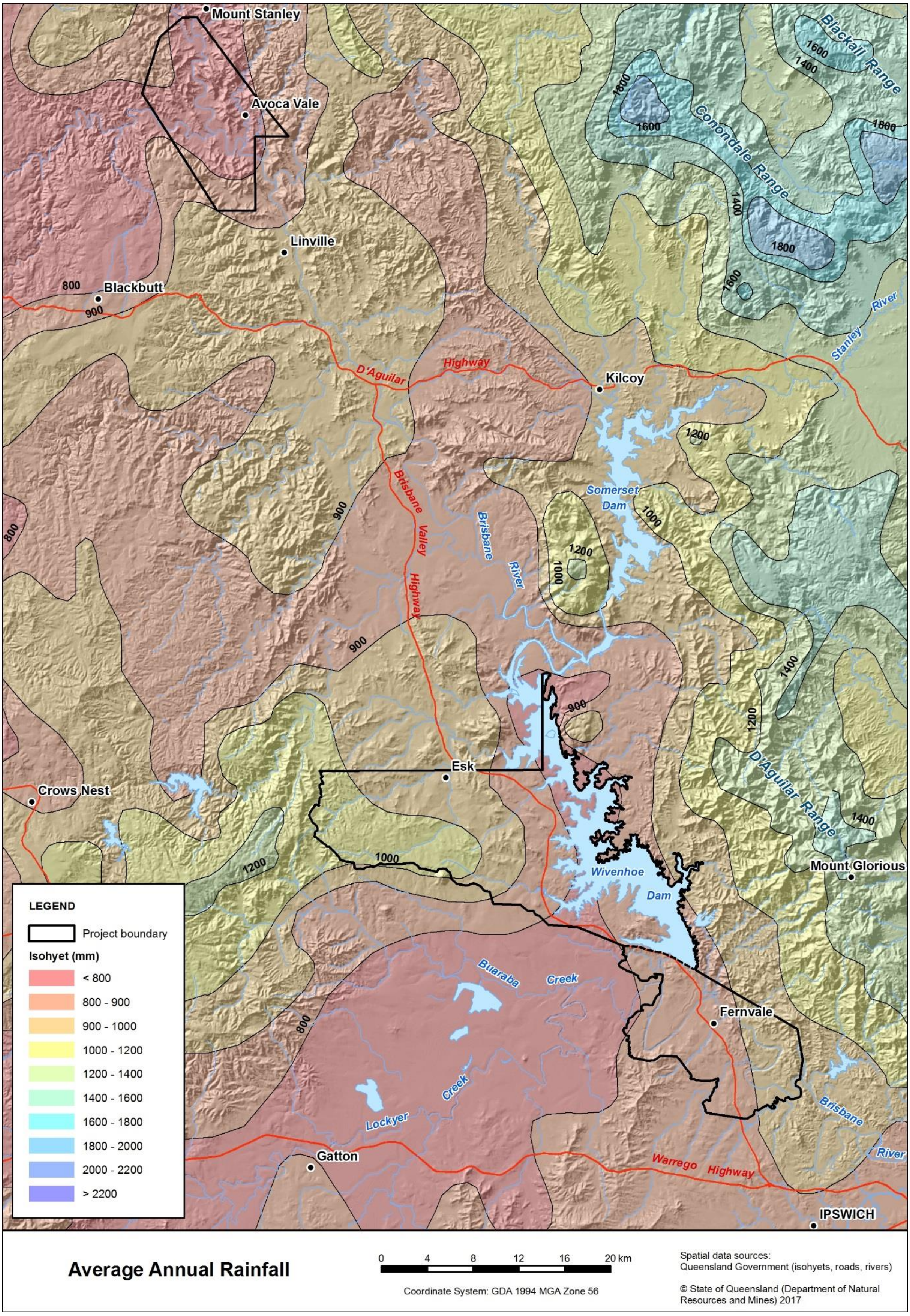


Figure 8 Average annual rainfall

5. Land Use

After settlement of the Brisbane Valley during the early 1840’s, beef cattle production became the dominant rural industry in terms of production area. The region also supported a timber industry, with mills continuing to operate at Esk and Linville. Irrigated cropping and pasture production occur on the more fertile soils of the floodplain. Improved pasture production and occasional dryland cropping occur on the adjacent slopes. Grazing of native pastures is the primary land use on the steeper slopes above the more undulating landscapes. There are increasing pressures from competing land uses (predominantly agricultural, urban and rural residential) near the towns of Fernvale, Lowood and Esk. These pressures tend to decrease further upstream in the catchment. The Brisbane Valley report contains additional information on land use. The primary land uses in the study areas for 2012–2013 according to the Queensland Land Use Mapping Project (QLUMP) are summarised in Table 1 and Figure 9.

Table 1 Land use statistics (QLUMP 2012–13)

Land Use	Fernvale (ha)	Esk (ha)	Avoca Vale (ha)
Cropping/horticulture	1 213	637	135
Grazing improved pastures	0	282	140
Grazing native pastures	8 177	18 732	10 148
Forestry	11	1 816	33
Conservation	388	1 514	700
Rural residential	2 288	776	0
Urban	471	258	2
Water	432	8 583	94
Other minimal use	76	12	0
Total Area	13 111	33 035	11 252

Note: Land uses smaller than 0.5% of the total area are not displayed

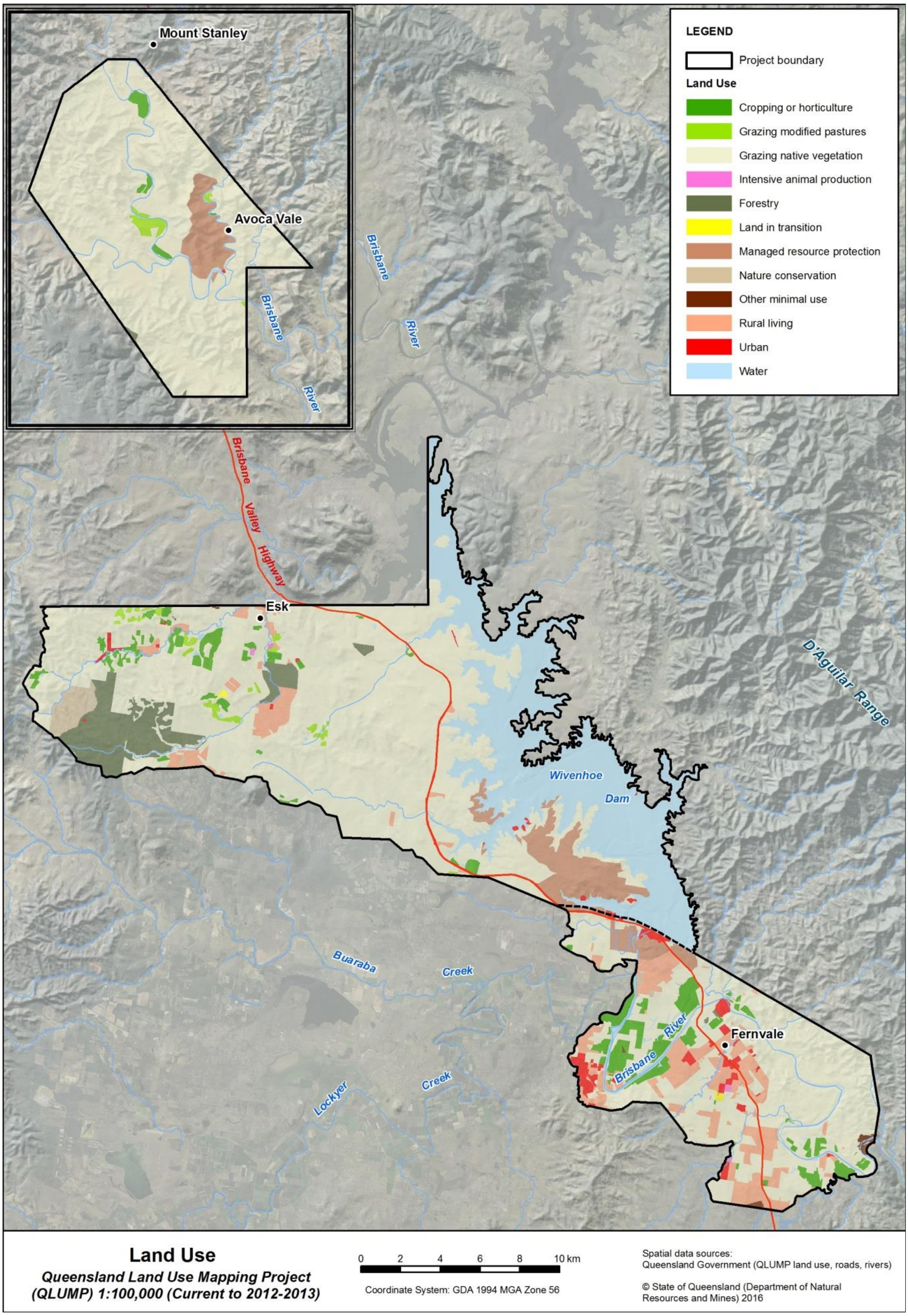


Figure 9 Land use—Fernvale, Esk and Avoca Vale

6. Geology, Lithology and Landform

The landscapes throughout the project area are predominantly undulating to rolling low hills and hills with adjacent areas of level to gently undulating plains and alluvial flood plains. There are also some steep inaccessible areas of rugged terrain. The elevation ranges from approximately 30 m to 450 m ASL/AHD (Figure 10).

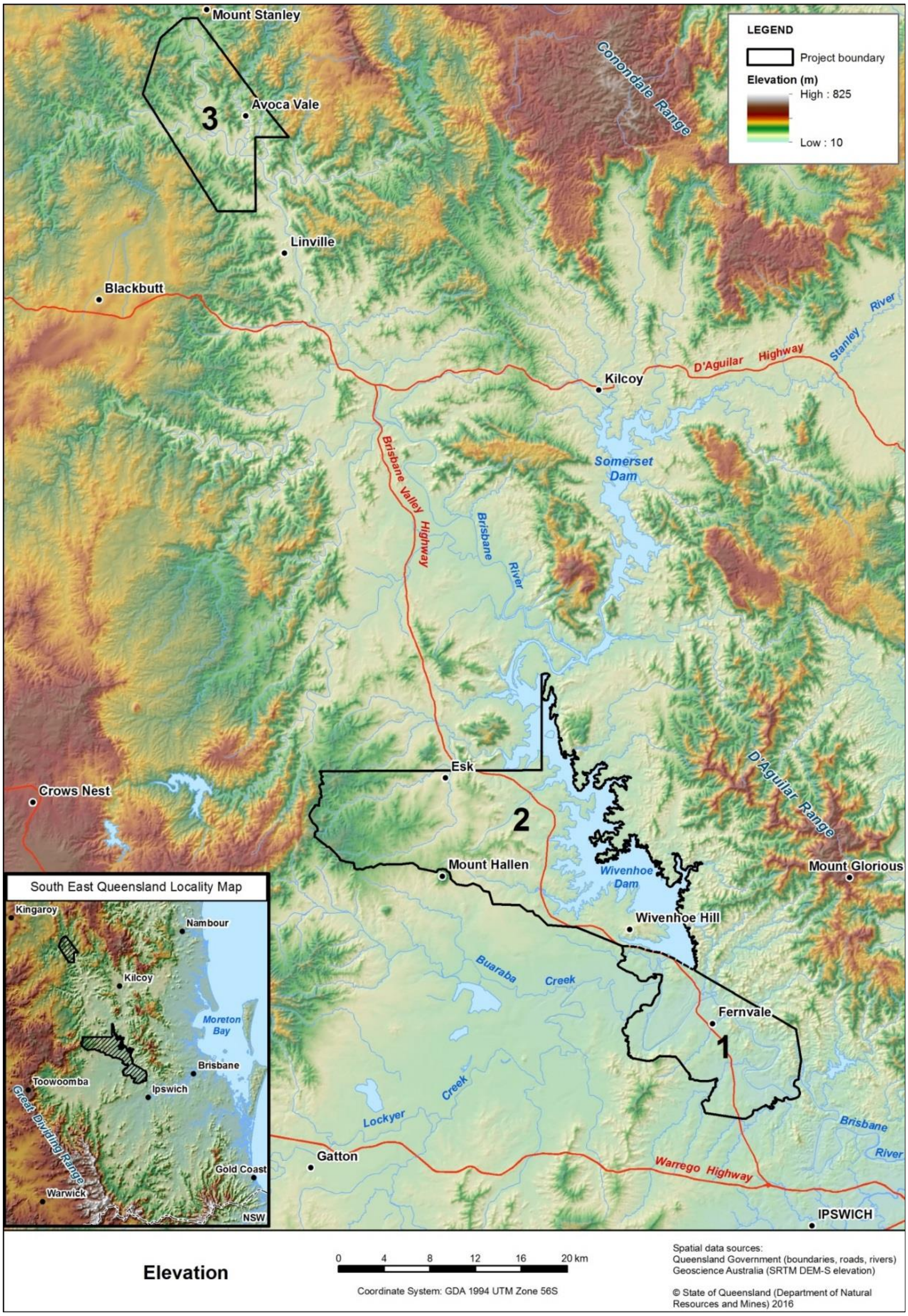


Figure 10 Elevation—Fernvale, Esk and Avoca Vale

Geology and Lithology

The geology of the project area has been mapped at 1:100 000 scale in the Esk, Nanango, Caboolture and Ipswich map sheets, and the Gympie Special sheet at 1:250 000 (Cranfield et. al., 2001) (Figure 11). Further description of the geology of the project areas and surrounds is available in Wilmott (2005) and the Brisbane Valley report.

Across the three study areas, there are six dominant geomorphic units. These geomorphic units have been used to organise the soils into landform and lithology groups that have then been arranged as landscape concepts and soil profile classes (see Section 10 and Appendix 1). The geological units, lithology and landform are summarised in Table 2, and are described in the following section.

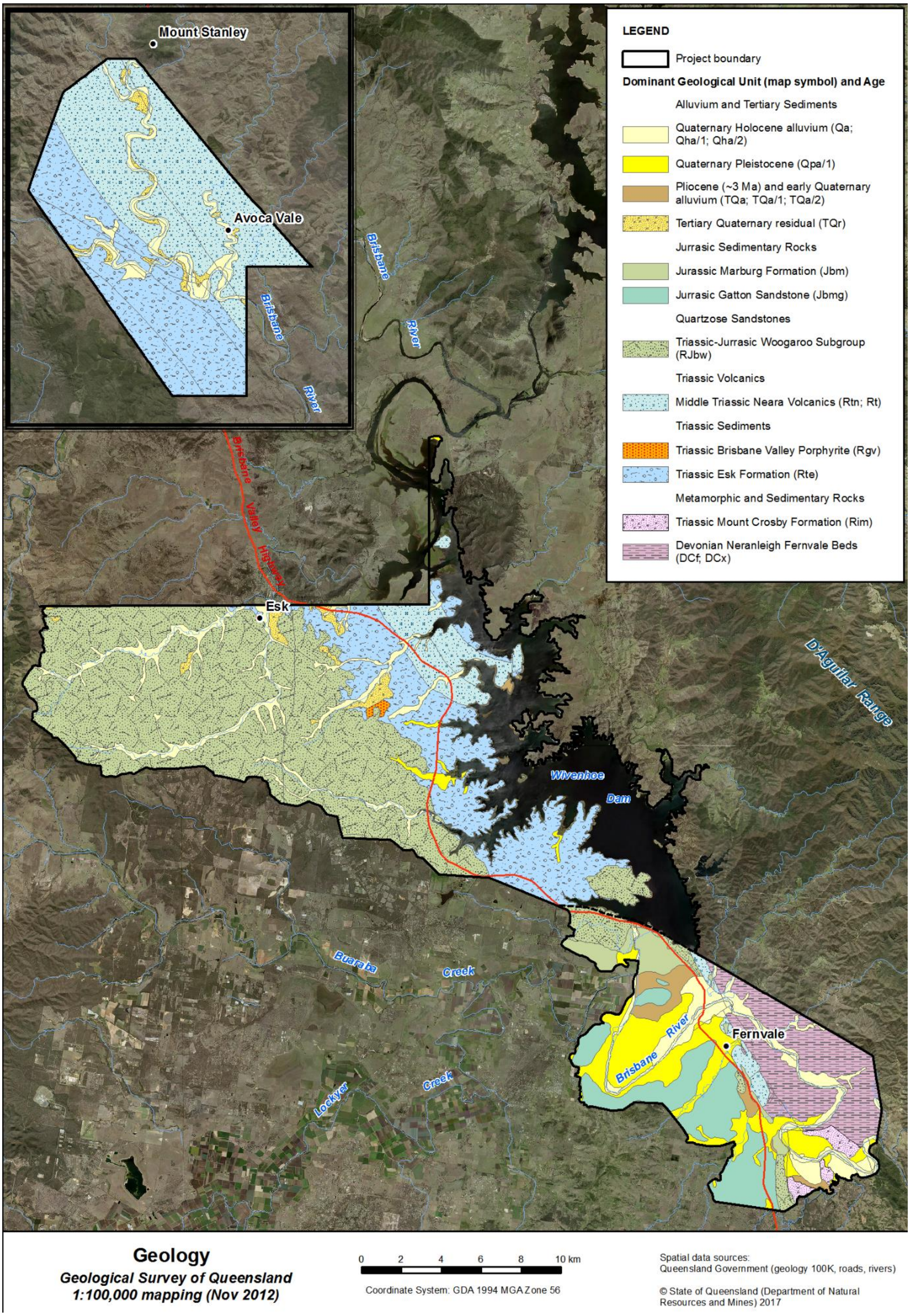


Figure 11 Geological units—Fernvale, Esk and Avoca Vale

Table 2 Geological units, lithology and landform

Geological unit (map symbol) and Age (Period/Epoch)	Lithology	Study area and landform
Quaternary/Tertiary alluvium and Tertiary sediments of the floodplain		**Fernvale, Esk, Avoca Vale**
Quaternary alluvium (Qa)	Gravel, sand, silt and clay	Channel benches, terrace flats/plains, drainage depressions, back plains and swamps on floodplains and terraced lands
Quaternary Holocene (Qha/2, Qha/1)	Gravel, sand, silt and clay	
Quaternary Pleistocene (Qpa/1)	Gravel, sand, silt and clay	Plains, drainage depressions, backplains and swamps on stagnant alluvial plains
Tertiary[1] Quaternary residual (TQr)	Pediment slope wash, clay, scree and soil	Plains and footslopes on plains and rises
Pliocene ~3 million yrs. and early Quaternary alluvium (TQa)	Poorly consolidated sand, silt, clay, minor gravel. High level alluvial deposits	Drainage depressions and swamps on stagnant alluvial plains
Sandstones and siltstones of the Marburg Subgroup		**Fernvale**
Jurassic Marburg Formation (Jbm)	Lithofeldspathic labile/sub-labile sandstone, siltstone, shale, minor coal, ferruginous oolite marker	Undulating/rolling rises and low hills
Jurassic Koukandowie Formation (Jbmk)	Lithofeldspathic labile and sub-labile to quartzose sandstone, siltstone, shale, minor coal, ferruginous oolite marker	
Jurassic Gatton Sandstone (Jbmg)	Lithic labile and feldspathic labile sandstone	
Quartzose sandstones of the Woogaroo Subgroup		**Esk, Fernvale**
Triassic-Jurassic Woogaroo Subgroup (RJbw)	Quartzose sandstone, siltstone, conglomerate and shale	Undulating/rolling rises, low hills and hills
Andesites and volcanoclastic conglomerates of Neara Volcanics		**Esk, Avoca Vale**
Middle Triassic Neara Volcanics (Rtn)	Andesite, andesitic boulders and volcanoclastic conglomerate with interbedded layers of siltstone, mudstone and conglomerate	Undulating/steep rises, low hills and hills
Brisbane Valley Porphyrite (Rgv)#	Porphyritic hornblende diorite and microdiorite	Rolling low hills
Sandstones, shales and conglomerates of Esk Formation		**Esk, Avoca Vale, Fernvale**
Esk Formation (Rte)##	Polymictic pebble to boulder conglomerate, feldspathic sandstone, shale and minor acid tuff	Undulating/steep rises, low hills and hills
Mount Crosby Formation (Rim) ##	Poorly sorted conglomerate with interbedded sandstone, siltstone, shale and rhyolitic tuff	Undulating/rolling rises and low hills
Mudstones, shales, cherts and conglomerates of the Neranleigh-Fernvale Formation		**Fernvale**
Devonian/Carboniferous Neranleigh-Fernvale beds (DCf)	Mudstone, shale arenite, chert, jasper, basic metavolcanics, pillow lava and conglomerate	Rolling/steep low hills and hills

Rgv units have limited distribution in the Esk study area

##Rte units are restricted to Esk and Avoca Vale, and Rim units are restricted to Fernvale

[1] Due to the age of the geological mapping used in this project, the reference to Tertiary Period has been retained, rather than the use of Paleogene/Neogene Periods.

Landscapes on Quaternary/Tertiary Alluvium and Tertiary Sediments

Quaternary alluvium (Qa) and Quaternary Holocene alluvium (Qha/1, Qha/2) occur as channel benches, plains, terrace flats and terrace plains of gravel, sand, silt and clay on floodplains and terraced lands of Wivenhoe Pocket, Brisbane River, Cooyar Creek, Avoca Creek, Muddy Creek, Redbank Creek and Blacksnake Creek and minor valley flats that discharge directly into the Brisbane River, Cooyar Creek and Wivenhoe Dam (Figure 12). The source of the sediments and floodplain hydrology has influenced the resulting soils. Finer sediments are deposited on the plains and backplains away from the channel during flood events, with the coarse textured sediments deposited on levees closer to the river channel. Faster flowing stream bends tend to be more scoured, with more stream bank erosion than the slower flowing meanders.

Figure 12 Quaternary alluvium (Qa) at Borallon (left) and Wivenhoe Pocket (right)

Quaternary alluvial soils derived from Jurassic sediments include Black/Brown Dermosols and Vertosols. Tenosols and Kandosols with loamy surfaces occupy (Qha/1) levees and terrace flats. Sediment from Lockyer Creek, derived from basalt, shales, mudstones, siltstones and sandstones which enters the Brisbane River in this landscape, have an influence on the nature of soils, particularly the prevalence of Vertosols. Gravel is found at various depths, depending on landscape position.

Alluvial soils of Redbank Creek, derived from the Woogaroo Subgroup, include Kandosols and Tenosols that are moderately to highly permeable and moderately to well drained.

Alluvial soils derived from the Neara Volcanics are moderately permeable, moderately well drained Kandosols and Dermosols with clay loam to light clay surfaces. Gravel occurs at various depths, depending on landscape position. Where drainage is impeded, slowly permeable sodic Dermosols and Sodosols dominate.

Alluvial soils derived from the Esk Formation are moderately to slowly permeable and imperfectly to moderately well drained Dermosols and Chromosols with sandy clay loam surfaces. Slightly saline Sodosols dominate the swamps and backplains.

Soils developed on the older (TQa/1) river terraces are very slowly to slowly permeable, imperfectly drained Sodosols. Drainage depressions, backplains and swamps of the stagnant alluvial plains of (Qpa/1) are dominated by alkaline sodic Vertosols and Sodosols (Figure 13).

Tertiary Quaternary residuals (TQr) occur as pediment slope wash, clay, scree and soil. The TQr in this landscape often includes the lower slopes of low hills and hills adjoining the Neara Volcanics, the Esk Formation and the Woogaroo Subgroup. These soils are influenced by the parent material upslope.

Figure 13 Qpa/1 (left) and TQa/1 (right) landscapes at Borallon

Landscapes on Sandstones and Siltstones of the Marburg Subgroup

The Marburg Subgroup (Jbm), Gatton Sandstone (Jbmg) and Koukandowie Formation (Jbmk) are Jurassic sediments of quartzose to litho-feldspathic labile and sub-labile sandstone, siltstone, shale, minor coal, ferruginous oolite marker, and minor cobble to pebble polymictic conglomerate. These sedimentary rocks formed in a meandering stream environment, deposited in bars and channels, braided floodplains of large, active high energy rivers and streams, and are exposed following dissection and erosion of the weathered sandstone surface (Willmott 2005).

The Marburg landscapes in this study comprise gently inclined slopes on rises and low hills (Figure 14), and weather to produce imperfectly drained, slowly to very slowly permeable Sodosols or Kurosols.

Figure 14 Gatton Sandstone landscapes—Wivenhoe Pocket

Landscapes on Quartzose Sandstones of the Woogaroo Subgroup

The Woogaroo Subgroup (RJbw) is composed of Triassic, quartzose sandstone, siltstone, conglomerate and shale. These are found as thick sediments that formed after sand, gravel and lesser volumes of silt were deposited in bars and channels of a braided floodplain of large, active high energy rivers and streams. These sedimentary rocks were exposed following dissection and down wearing of the weathered sandstone surface. Lithology ranges from resistant, coarse grained quartzose sandstone to moderately weathered, pale brown sub-labile sandstone. Rocks are iron rich but have undergone only moderate alteration as rock fabric and matrix structures are easily recognisable. Weathering features appear restricted to coarse mottling and iron staining. These rocks outcrop throughout Esk and to a smaller degree at Fernvale.

The Woogaroo Subgroup landscape comprises gently to moderately inclined slopes on rises, low hills and hills (Figure 15). These rocks weather to produce moderately well drained and moderately to highly permeable, earthy, porous soils. Well drained Red Kandosols that grade into Red Chromosols dominate this landscape. Where drainage is impeded, the soils grade towards Yellow/Brown Kandosols and Chromosols. Grey Sodosols are common on lower slopes and drainage depressions.

Figure 15 Rises and low hills of the Woogaroo Subgroup—Esk

Landscapes on Andesites and Volcanoclastic Conglomerates of the Neara Volcanics

Neara Volcanics (Rtn) are Mesozoic, middle Triassic, folded, intermediate to basic volcanics and volcanoclastic sediments with interbedded layers of siltstone, mudstone and conglomerate. The Neara Volcanics in this landscape include andesite, andesitic boulders and volcanoclastic conglomerate. These rocks outcrop in the eastern section of the Esk and Avoca Vale study areas. The Neara Volcanics are thought to have been deposited as lava streams that filled valley floors, in a partly aqueous environment (Murphy et al. 1976).

The Neara Volcanics landscape comprise rises, low hills and hills that are dissected by the Brisbane River, Avoca Creek and Paddy Gully (Figure 16). These rocks weather to produce soils with moderate clay content and segregations of manganiferous oxides in zones of intermittent waterlogging. The soils are weathering in situ over the underlying parent material. In moderately inclined upper and mid-slopes, natural erosion limits the depth of soil. Moderately to well drained Dermosols and Tenosols dominate the upper and mid slopes. Sodosols and Chromosols are more dominant where drainage is impeded or there is lateral seepage.

Figure 16 Andesite low hills and hills—Avoca Vale

Landscapes on Sandstones, Shales and Conglomerates of Esk and Mount Crosby Formation

The Esk Formation (Rte) is characterised by Triassic, polymictic pebble to boulder conglomerate, feldspathic sandstone, shale and minor acid tuff. The Esk Formation was deposited in a fluvial landscape. These rocks outcrop to the east of Esk and the western section of Avoca Vale. At Avoca Vale, the Brisbane River meanders through the boundary between the Esk Formation and Neara Volcanics, and generally favours a path through the softer Esk Formation sediments over the harder Neara Volcanics.

This landscape comprise rises, low hills and hills (Figure 17). The Esk Formation weathers to produce Chromosols and Sodosols, with segregations of manganiferous oxides in zones of intermittent waterlogging. In moderately inclined upper and mid-slopes, natural erosion limits the depth of soil. The surface horizons are often strongly leached with conspicuously bleached A2 horizons, and the subsoils commonly retain carbonates and are often sodic and slightly saline.

Figure 17 Esk Formation at Cooyar Creek (left) and at Esk (right)

The Mount Crosby Formation (Rim) is poorly sorted conglomerate with interbedded sandstone, siltstone, shale and rhyolitic tuff. This unit outcrops either side of the Brisbane River, and exists as undulating to rolling low hills and hills adjacent to the Neranleigh-Fernvale beds at Fernvale (Figure 18).

The Mount Crosby Formation weathers to sandy clay soils, with segregations of manganiferous oxides in zones of intermittent waterlogging. In moderately inclined upper and mid-slopes, natural erosion limits the depth of soil. The surface horizons are often strongly leached with sporadically bleached A2 horizons, and the subsoils commonly retain carbonates and are often sodic and slightly saline.

Figure 18 Mount Crosby Formation at Borallon (left) and Fernvale (right)

Landscapes on Mudstones, Cherts and Conglomerates of the Neranleigh-Fernvale Formation

The Neranleigh-Fernvale Beds (DCf) are heavily metamorphosed and folded sedimentary rocks that formed in a deep marine environment before being structurally distorted due to tectonic forces associated with a subduction zone active during the Carboniferous period (Donchak et al. 2013). They comprise mudstone, shale, arenite, chert, jasper, basic metavolcanics, pillow lava and conglomerate. At Fernvale they are predominantly to the east of the Brisbane River, with a smaller outcrop west of the Brisbane River, towards Borallon.

The Neranleigh-Fernvale Beds in the study area are steeply inclined hills and low hils (Figure 19). These rocks weather to produce Red/Brown Dermosols and Chromosols with sodic subsoils on upper and mid slopes. Sodosols and Kurosols are common on lower slopes.

Figure 19 Neranleigh-Fernvale low hills and hills

7. Vegetation

Since the commencement of European settlement of the upper Brisbane River Valley in the 1840's, the vegetation of the region has undergone extensive modification. Vegetation clearing for grazing and agriculture, timber harvesting and the cessation of Indigenous burning have all contributed to the state of the current vegetation communities (Young 1990). Pre-clearing vegetation communities are presented in Figure 22.

Methodology

Dominant vegetation species, where apparent, were recorded at all soil description sites. Site vegetation observations were checked for alignment with the Regional Ecosystem Description Database (REDD) of the Queensland Herbarium (2015). Regional ecosystems (RE) are defined as vegetation communities in a bioregion that are consistently associated with a particular combination of geology, landform and soil (Sattler and Williams 1999). The REDD builds on the descriptors from 1999 to include additional regional ecosystems and vegetation communities.

The REDD is a hierarchical classification system utilising a three part code for each regional ecosystem. The numeric codes classify regional ecosystems by bioregion, then land zone and then vegetation (Wilson and Taylor 2012). The study areas lie within the South East Queensland bioregion which is allocated the code of 12.

The second number in the three part code indicates the land zone category which relates to a simplified geology/substrate-landform classification for Queensland. The short descriptions for the predominant land zones in the project area are:

Land zone 3 – Recent Quaternary alluvial systems

Land zone 9 – Fine grained sedimentary rocks

Land zone 10 – Coarse grained sedimentary rocks (Sandstone ranges)

Land zone 11 – Hills and lowlands on metamorphic rocks

Land zone 12 – Mesozoic to Proterozoic igneous rocks

The third number in the REDD system code represents the vegetation type. In non-rainforest plant communities the vegetation type is described by the predominant plant species determined by relative biomass. The database can be accessed for full descriptions of associated plant species found within a regional ecosystem and other information including biodiversity status and fire management guidelines.

An example of an REDD code common to this project is 12.3.3. This indicates that this regional ecosystem is found in South East Queensland (Bioregion 12), on recent Quaternary alluvial systems (land zone 3) which is usually vegetated with *Eucalyptus tereticornis* (Queensland Blue Gum) woodland. This is the third regional ecosystem to be described within the bioregion 12 land zone 3 combination.

The regional ecosystems of the study areas broadly mirror the pattern of geology, landform and soil types. The floodplains have distinct plant communities, the composition of which is often dictated by landscape hydrology. The vegetation on the elevated plains and rises adjacent to the floodplain is characterised by several distinct types of eucalyptus woodlands. Common species found in these woodlands include *E. tereticornis, Corymbia intermedia* (Red Bloodwood), *Eucalyptus crebra* (Narrow Leaved Ironbark), *Eucalyptus moluccana* (Gum-topped Box), *Eucalyptus melanophloia* (Silver-leaved Ironbark) and *Corymbia citriodora subsp. variegata* (Spotted Gum). The different eucalyptus woodlands are defined by the dominant species occurring.

Vegetation on Quaternary/Tertiary Alluvium and Tertiary Sediments

Remnants of regional ecosystem (12.3.3), *E. tereticornis* woodland, were found throughout the three study areas on the streambanks, drainage depressions and floodplains bordering the Brisbane River and its tributaries of Cooyar Creek, Avoca Creek and Redbank Creek.

The *E. tereticornis* woodlands have been extensively cleared for cropping and grazing and are classified as an endangered regional ecosystem. Introduced grasses, legumes and fodder crops are common on the lower terrace flats and channel benches. In addition to *E. tereticornis, Corymbia tesselaris* (Moreton Bay Ash) and *Angophora subvelutina* (Broad-leaved Apple) are conspicuous large trees in places. *E. crebra* and *E. moluc*cana are also found, usually on edges of terrace plains and terrace flats on alluvial floodplains where inundation is not a regular occurrence.

Figure 20 Fringing riverine wetland (12.3.7)—Brisbane River Wivenhoe Pocket

Less widespread than the *E. tereticornis* woodland and occurring on fringing levees, riverbanks and in stream channels, is the *E. tereticornis, Casuarina cunninghamiana subsp. cunninghamiana +/- Melaleuca* spp narrow fringing woodland (12.3.7) (Figure 20). This vegetation occurs in narrow belts and was observed in patches on the Brisbane River, the upper reaches of smaller streams and along the deeply incised channel of Redbank Creek.

Scattered in the Quaternary and Tertiary floodplains and stagnant alluvial plains, pockets of four distinct wetland vegetation communities occur which have been classified under the 12.3.7 descriptor as follows:

- Riverine wetland or fringing riverine wetland occurring in drainage depressions (12.3.7a). These wetlands are dominated by *Melaleuca bracteata* open forest +/- emergent *E. tereticornis.*
- Riverine wetland or fringing riverine wetland occurring in the bed of active or intermittent river channels (12.3.7b). Naturally occurring instream waterholes and lagoons, both permanent and intermittent including exposed stream beds and bars.

- Palustrine wetland (vegetated swamp) (12.3.7c). Billabongs and ox-bow lakes containing either permanent or periodic water bodies. Old river beds now cut off from regular flow (drainage depressions and swamps) (Figure 21).
- Palustrine wetland (vegetated swamp) (12.3.7d). Aquatic vegetation usually fringed with *E. tereticornis*. Closed depressions on alluvial plains (drainage depressions, backplains and swamps).

An additional type of palustrine wetland plant community is also found on the floodplains, although due to their small areas they are not mapped by the REDD at the 1:100 000 scale. Known as swamps with *Cyperus* spp., *Schoenoplectus* spp. and *Eleocharis* spp (12.3.8) these wetlands contain a range of waterlilies, sedges and other aquatic plants and may also have emergent *Melaleuca* spp

Larger areas of the above group of wetlands occur on the broad floodplains south of the Wivenhoe Dam, but are relatively small in size and are difficult to map at the scale of this project. However, these wetlands provide important habitat for a range of plant and animal species. Expressions of secondary salinity are currently presenting in similar wetlands at Lowood and Blacksnake Creek.

Figure 21 Palustrine wetland (12.3.7c)—Wivenhoe Pocket

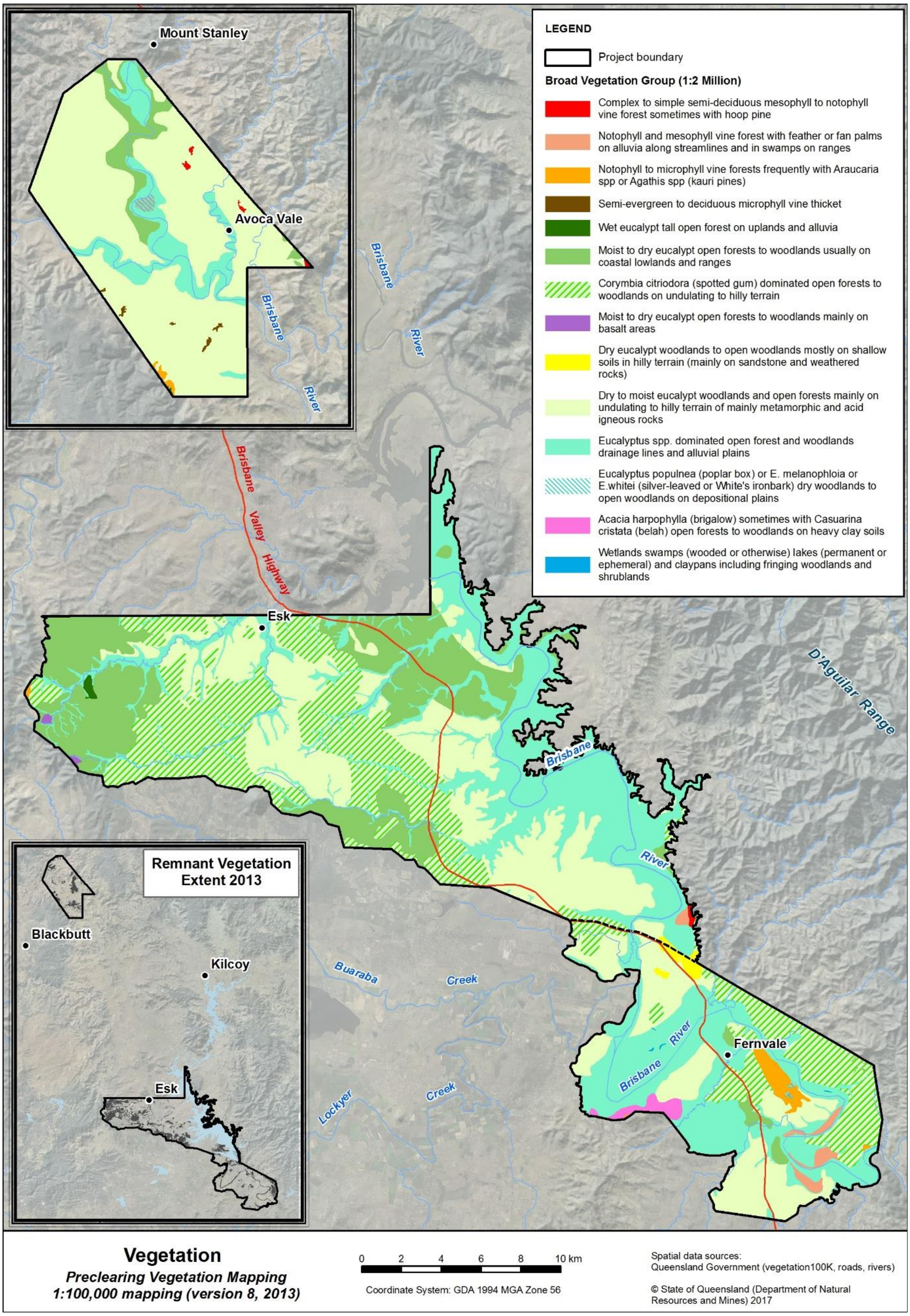


Figure 22 Pre-clearing vegetation—Fernvale, Esk and Avoca Vale

Vegetation on Sandstones and Siltstones of the Marburg Subgroup

In the Fernvale study area, remnant vegetation has been retained in scattered patches on slopes and crests of rises and low hills of the sandstones and siltstones of the Marburg Subgroup. In the REDD system these areas have been classified as land zone 9-10; a combination of fine grained sedimentary rocks and coarse grained sedimentary rocks, associated with the Marburg Subgroup (Jbm) and Gatton Sandstones (Jbmg).

The vegetation on the Marburg Subgroup is predominately a combination of the *E. crebra +/- E. tereticornis, C. tesselaris, Angophora spp., E. melanophloia* woodland (12.9-10.7) and *C. citriodora* and *E. crebra* open forest on sedimentary rocks (12.9-10.2) (Figure 23) and also the 12.9-10.7 community combined with the *E. moluccana +/- C. citriodora subsp. variegata* open forest (12.9-10.3.).

Figure 23 ***C. citriodora*** **and** ***E. crebra*** **open forest (12.9-10.2)—Wivenhoe Pocket**

Vegetation on Quartzose Sandstones of the Woogaroo Subgroup

The patchy remnant vegetation on the lower slopes of rises and low hills of the Woogaroo landscape at Esk includes a combination of *C. citriodora* and *E. crebra* open forest on sedimentary rocks (12.9-10.2) (Figure 24) and the *E. crebra +/- E. tereticornis, C. tesselaris, Angophora spp., E. melanophloia* woodland (12.9-10.7).

The small areas of this geological unit at Fernvale have been extensively cleared; however remnants of the 12.9-10.2 vegetation community were evident either side of the Brisbane Valley Highway adjacent to Lake Wivenhoe.

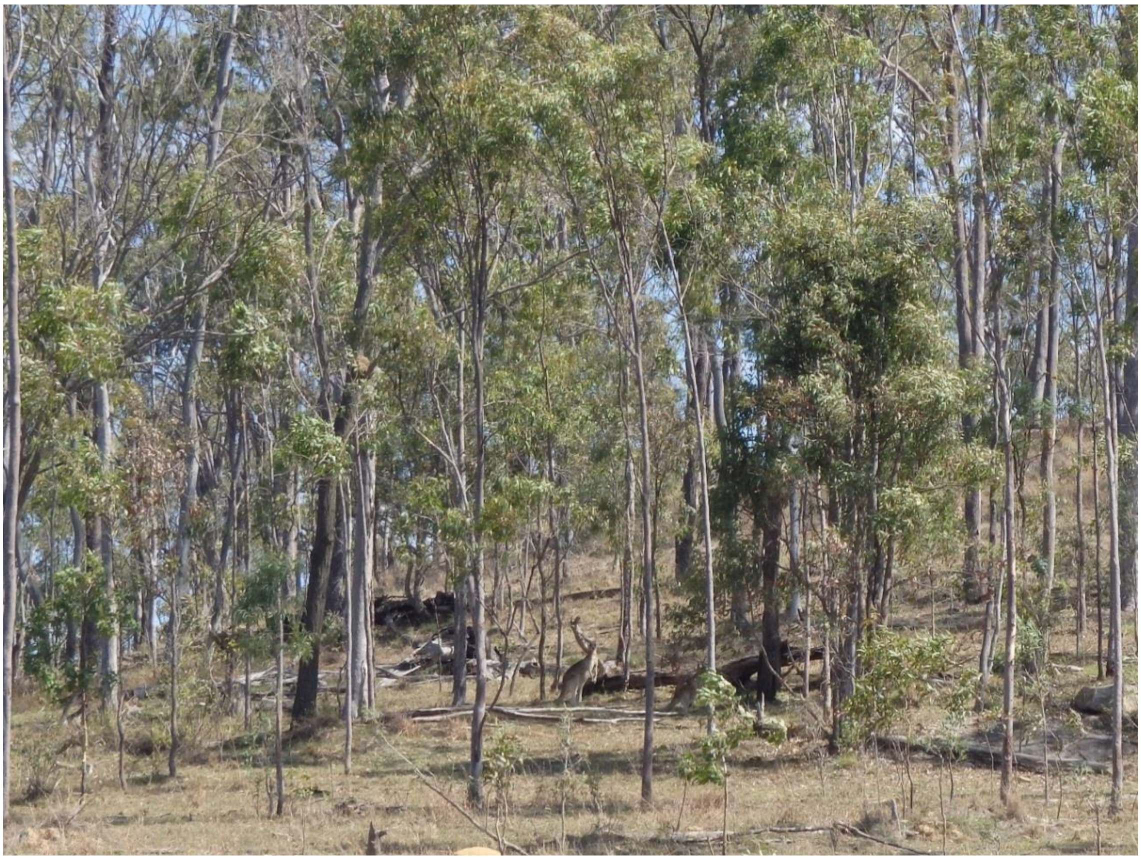


Figure 24 Woogaroo Subgroup, *C. citriodora* and *E. crebra* open forest (12.9-10.2)—Esk

Vegetation on Sandstones, Shales and Conglomerates of Esk and Mount Crosby Formation

Areas to the west of the Brisbane River at Avoca Vale, are characterised by the more rounded hills of the Esk Formation which have been extensively cleared for pasture. The dominant vegetation type occurring on the sedimentary rock formation is a combination of *E. crebra +/- E. tereticornis, C. tessellaris, Angophora spp., E. melanophloia* woodland (12.9-10.7) listed as 'of concern' and the 'endangered' *E. melanophloia, E. crebra* grassy woodland (12.9-10.8) (Figure 25).

At Esk, where the underlying geology changes to the Esk Formation in the east, the areas of remnant vegetation are smaller and are predominately *C. citriodora* & *E. crebra* open forest (12.9-10.2) and *E. crebra +/- E. tereticornis, C. tessellaris, Angophora spp., E. melanophloia* woodland (12.9-10.7)

Three small areas of the Mount Crosby Formation (Rim) are found in the south-east corner of the Fernvale study area. This landscape is characterised by rounded hills which have been extensively cleared for pasture. The dominant vegetation type occurring on the sedimentary rock formation is a combination of *C. citriodora* & *E. crebra +/- Eucalyptus siderophloia, Lophostemon confertus, C. intermedia* open forest (12.11.6/12.11.5e/12.11.3a).

Figure 25 ***E. melanophloia*** **and** ***E. tereticornis*****, (12.9-10.8)—Avoca Vale**

Vegetation on Andesites and Volcanoclastic Conglomerates of Neara Volcanics

Areas that are generally positioned east of the Brisbane River at Avoca Vale are characterised by the low hills and hills of the Neara Volcanics. This landscape has been extensively cleared for grazing but remnant vegetation indicates a combination of *E. crebra* grassy woodland (12.12.7) and *E. tereticornis, C. intermedia, E. crebra* open forest to woodland (12.12.12). A significant area of remnant vegetation has been retained at Rathburnie Environmental Estate (Figure 26 and 27).

Smaller remnants of the latter vegetation community were also observed on the hillslopes of the Neara Volcanics at Moombra in the vicinity of Paddy Gulley at Esk. This landscape is generally bereft of remnant vegetation excepting scattered small areas of *E. tereticornis, C. intermedia and E. crebra +/- Lophostemon suaveolens* woodland (12.12.12).

Figure 26 ***E. crebra*** **woodland with** ***Xanthorrhoea johnsonii*** **(12.12.7)—Avoca Vale**

Figure 27 **Neara Volcanics,** ***E. crebra*** **woodland (12.12.7)—Avoca Vale**

Vegetation on the Mudstones, Cherts and Conglomerates of the Neranleigh-Fernvale Formation

The steeply to gently inclined hills of the Neranleigh-Fernvale Beds occur on the eastern side of the Fernvale study area. The vegetation has been extensively cleared on the lower slopes, with areas of remnant vegetation observed on the steeper slopes and hills. The open forest is dominated by *C. citriodora* and includes, *E. crebra* woodland (12.11.6) and C. *citriodora subsp. variegata* woodland usually including *E. siderophloia* or *E. crebra* (12.11.5e).

Figure 28 Neranleigh-Fernvale Formation (12.11.6/12.11.5e/12.11.3a)—Fernvale

8. Methodology Used for Land Resource Assessment

The soils of the project area were mapped at either 1:50 000, or 1:100 000 map scale (Figure 29) and were evaluated for agricultural suitability. A combination of transects, free survey and digital soil mapping techniques were used, together with air photograph interpretation following the standards specified in McKenzie et al. (2008). Accessibility was a factor in site selection. Effort was focused on characterising the alluvial floodplains and lower-mid slopes at the larger scale of 1:50 000 using traditional soil survey techniques. Digital terrain modelling was used to assist with the assessment of steep terrain and to refine the bounds of the drainage depressions. Rugged and inaccessible areas of the three study areas were mapped at 1:100 000 scale.

Field work involved a reconnaissance trip of the three project areas, an assessment of the reliability of the existing site data, a short reference making phase, and a mapping phase. A vehicle mounted rig with a hydraulic push tube was used to extract the relatively undisturbed soil core from each site. A soil reference was prepared, correlating the soils with those identified in the Brisbane Valley Report, Lockyer Valley and Kilcoy-Woodford Land resource survey projects. A field key was prepared and then refined for the identification of SPCs for soils with similar soil properties in the field. The SPCs (Appendix 1) and the field key (Appendix 2) are attached.

Soil morphology to a depth of up to 1.8 m (field texture, colour, mottles, structure, segregations of pedogenic origin, permeability, drainage etc.), field pH, location, slope, landform element, landform pattern, surface condition, erosion and vegetation were described for the 302 new sites using terminology and codes of the *Australian Soil and Land Survey Field Handbook* (NCST 2009). Soil profiles were then classified using the *Australian Soil Classification* (Isbell 2002; Isbell and NCST 2016). The data was then entered into SALI, the Queensland Government's soil and land information database (Biggs et al. 2000). Each site was assigned to an SPC and where appropriate, soil phases and soil variants were also described. A similar process was followed for the 160 sites that were described in previous projects. The SPCs are illustrated in conceptual diagrams, detailing landform, geology, vegetation, permeability, drainage, surface features and soil profile morphology. A series of soil-landscape concepts that detail the association of the SPC with landform, landscape position, lithology and slope are illustrated in a series of cross-sections. The soil-landscape concepts are detailed in section 10.

Site and soil chemical analysis data, air photo interpretation, recent colour high resolution digital satellite imagery and a LiDAR derived Digital Elevation Model (DEM) were used to map the area into UMAs. The derived one arc-second hydrological enforced Shuttle Radar Topography Mission (SRTM) DEM was used where LiDAR was not available. This SRTM DEM was also used to derive elevation and other digital terrain derivatives such as slope, Topographic Position Index (TPI), Multi-Resolution Valley Bottom Flatness (MrVBF), and Topographic Wetness Index (TWI). Covariates that are relevant to soil forming factors can be used as surrogates for detecting spatial patterns in soil properties (Gallant and Austin 2015). TPI, MrVBF and TWI were sourced through CSIROs Data Access Portal and the TERN Data Discovery Portal. Refer to Smith and Crawford (2015) and McBratney et al. (2000, 2003) for further information on DEM derivatives that are of use in land resource assessment. SPCs were then allocated to each UMA.

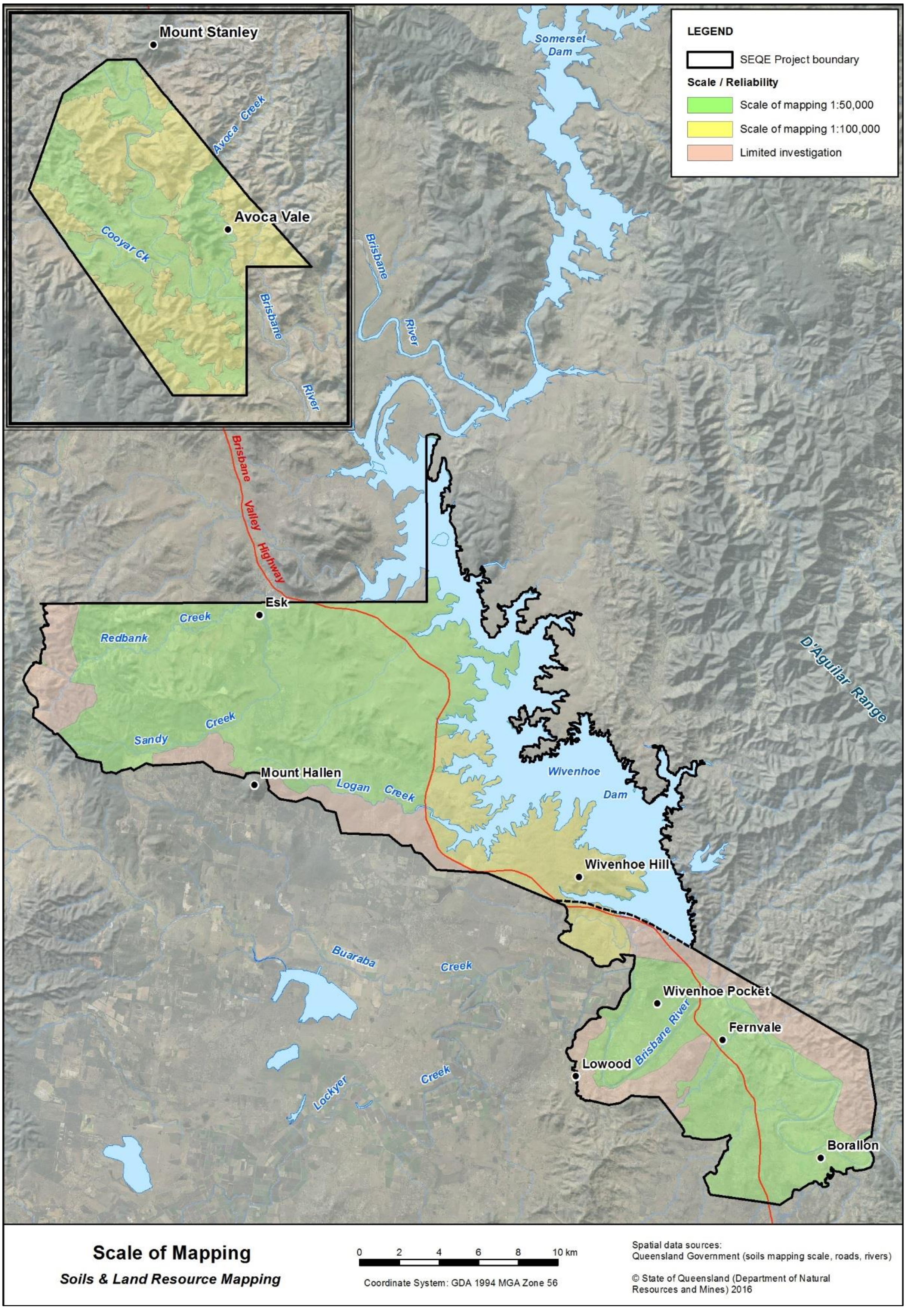


Figure 29 Scale—Fernvale, Esk and Avoca Vale

Predicting Terrain Ruggedness

ArcGIS software was used to process vector and raster format data, spatial imagery and the SRTM DEM to predict and map terrain ruggedness using the standard deviation of elevation. This produced a raster dataset that identified areas of topographic heterogeneity, i.e. a measure of the difference between the elevation at a location as compared with the average surrounding elevation. A selective number of transects were sampled to verify the effectiveness of the predicted terrain ruggedness and to refine the polygon boundaries. While there are additional factors that are used to determine agricultural suitability (e.g. soil depth, rockiness and rocky outcrops, among others), this method proved to be an efficient means of generating polygons in inaccessible areas, and in areas where further investment in detailed soil survey was not warranted. The smaller polygons were then merged and smoothed after field validation of the process. Terrain Ruggedness has been used to map agricultural land class in SEQ in areas lacking reliable land resource data, and forms part of the South East Data Gaps project (SEDG). Further detail on the Terrain Ruggedness Index is available from soilenquiry@dnrm.qld.gov.au.

9. Soils

This section describes the occurrence, distribution and properties of the soils within the three study areas. Table 3 describes the SPCs according to their distinguishing features and geomorphic units as described in section 6. The significant soils are described in more detail. Cross sections of the landscape concepts that illustrate the topographic position and relationship of each soil are also included. These schematic landscape cross sections depict only a generalised snapshot of the landscape. Detailed descriptions of representative soil profiles and results of laboratory analysis are included in Appendix 1 and 3.

Soil morphology is described using the *Australian Soil and Land Survey Field Handbook* (NCST 2009). The soils were then classified using the *Australian Soil Classification* (Isbell 2002).

Table 3 Summary of SPCs, distinguishing features and geomorphic units

Geomorphic unit	Shallow soils (<0.5 m) sandy to loamy soils, often rocky	Deep/very deep sandy to loamy soils	Structured cracking/non-cracking clay soils	Massive or weak structure, gradational/ texture contrast	Texture contrast, sodic upper subsoil – strong acid reaction	Texture contrast/ gradational, sodic upper subsoil – neutral, alkaline reaction	Texture contrast/ gradational non-sodic upper subsoil
Quaternary alluvium on floodplains		Cressbrook Cressbrook rocky Honey Honey rocky	Cooeeimbardi Gira Gira Gira Gira rocky Monsildale	Honey Gallanani			Gallanani
Quaternary/Tertiary alluvium – drainage depressions, swamps and backplains			Basel Glamorgan Tuckerimba Spencer		Glencairn		Gunyah
Tertiary sediments on plains			Avoca			Beppo Moore	Dunwich Watt
Sandstones/siltstones – Marburg Subgroup on rises and low hills	Ferny				Lowood	Lowood Koukandowie Burnage	Burnage
Quartzose sandstones of Woogaroo Subgroup	Hallen	Hibiscus light Yellowbank light		Hibiscus Hibiscus nodular Hibiscus shallow Yellowbank Yellowbank nodular	Quinine	Quinine[2]	
Andesites/volcanoclastic conglomerates of Neara volcanics	D'Aguilar Neara shallow[3]		Avoca Jimna Neara			Moore	Avoca Dunwich Linville
Sandstones, shales and conglomerates of Esk Formation and Mount Crosby Formation	Grienke		Beer			Beppo Moombra	Kipper Lakeview Watt
Mudstones, shales, cherts and conglomerates of Neranleigh-Fernvales	Ferny		Neranleigh		Fernvale	Fernvale	

[2] Quinine has acid or neutral soil reaction, never alkaline

[3] Neara shallow has clay loam surface

Summary of the Significant Soils

Soils that are significant in terms of agricultural productivity or are prone to land degradation are summarised in this section. The remainder are detailed in Appendix 1. To avoid duplication, where an SPC falls within more than one category of Table 3, the SPC has been described once in the text below.

Soils on Quaternary alluvium on floodplains and terraced lands

These soils include: Cressbrook, Honey, Monsildale, Gira Gira, Cooeeimbardi and Gallanani.

Very deep sandy to loamy soils

Cressbrook (Stratic Rudosols) are brown sandy soils with massive or weak structure and a neutral soil reaction trend on recent alluvium on the levees, channel benches and plains of floodplains. These soils have been deposited in faster moving water, closer to the stream channels and show little pedological development, other than organic matter accumulation. Cressbrook soils are highly permeable and rapidly drained, and set hard due to the high fine sand and silt content of the surface horizons. These soils flood frequently as they occupy the areas closest to the river. Soil fertility is high and plant available water capacity (PAWC[4]) is low. These soils are suited to winter grown vegetable crops where irrigation is available and flooding is not an annual occurrence (Figure 30).

Figure 30 Cressbrook SPC and landscape

Honey (Brown Kandosols, Brown/Black-Orthic Tenosols, and occasional Stratic Rudosols) are very deep brown or black loamy gradational soils, with massive or weak structure, and a neutral soil reaction trend. These soils have been deposited as recent alluvium on levees adjacent to the stream channels of the floodplain. Honey soils are moderately permeable and well drained. These soils often set hard due to the high fine sand and silt content. These soils flood frequently. Soil fertility is high and PAWC is low to moderate. These soils are suited to winter and summer grown vegetable crops and irrigated pastures where flooding is not an annual occurrence (Figure 31). Honey soils adjacent to the river can be prone to mass slumping if there is a loss of cohesion after extended periods of saturation (Figure 32).

[4] Plant available water capacity is the amount of soil water stored in the soil profile, and is the difference between the upper wetted limit (field capacity) and the lower extraction limit of a crop (wilting point) to the depth of the active root zone, expressed in mm (Salcon 1997). PAWC was calculated to the effective rooting depth.

Figure 31 Honey SPC and landscape

Figure 32 Honey SPC, slumping at Borallon (left) and Honey Rocky Phase (right)

Structured cracking and non-cracking clays

Monsildale (Black/Brown Dermosols) are very deep neutral gradational soils with clay loam surfaces, found on terrace plains. The surfaces set hard due to the high fine sand and silt content, which can impede seedling emergence. Soil fertility and PAWC are high. These soils are prone to compaction. These soils are moderately permeable and moderately well drained, although occasionally they are sodic at depth. Some of these soils recorded salt bulges at depth[5], which is likely to affect the effective rooting depth. Management practice techniques including stubble retention, minimum tillage and controlled traffic will be beneficial for these soils to enhance retention of organic matter in the soil, reduce soil erosion, increase water infiltration rates and reduce runoff. These soils are suited to winter grown vegetable crops, summer vegetables, irrigated pastures and citrus depending on the frequency of flooding and frost (Figure 33).

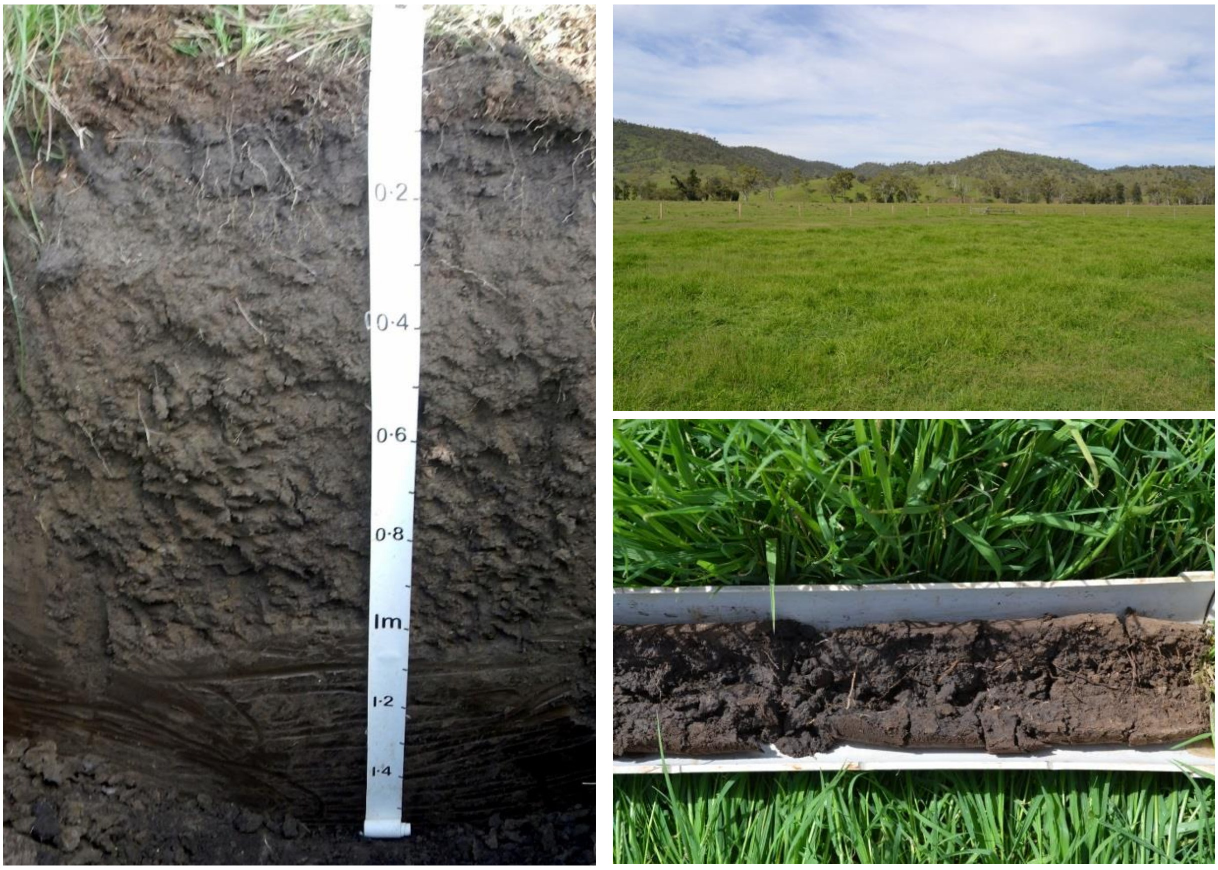


Figure 33 Monsildale SPC and landscape

Gira Gira (Black Dermosols) are very deep, strongly structured, non-cracking clay soils with a neutral soil reaction trend found on channel benches, plains and terrace plains of the alluvial floodplains. Gira Gira soils have been deposited in slower flowing waters, have a restricted occurrence, however, are distributed from Avoca Vale to Borallon. Gira Gira soils frequently set hard, depending on the fine sand and silt content. Soil fertility and PAWC are high, although on occasion the deep subsoils are sodic. Some of the soils recorded a salt bulge at depth, which is likely to affect the effective rooting depth. Management practice techniques including stubble retention, minimum tillage and controlled traffic will be beneficial for these soils to enhance retention of organic matter in the soil, reduce soil erosion, increase water infiltration rates and reduce runoff. Gira Gira soils are suited to winter grown vegetables, summer crops, irrigated pastures, broad-acre cropping and tree crops depending on the frequency of flooding and frost (Figure 34).

[5] A salt bulge shows a sudden and significant increase in subsoil salinity at a particular depth below which water levels stay constant or may decrease (Burgess, 2003).

Figure 34 Gira Gira SPC and landscape

Cooeeimbardi (Black Vertosols) are very deep strongly structured, cracking clay soils with heavy clay textures and an alkaline soil reaction trend on older alluvium. The surfaces are self-mulching and form small aggregates after shrinking and swelling due to the smectite content of the clay. The subsoils contain prominent slickensides (slip planes), retain calcium carbonate segregations and are frequently slightly sodic at depth. Some of the soils recorded a salt bulge at depth, which is likely to affect the effective rooting depth. Gilgai are a common feature. Soil fertility and PAWC are high. Internal drainage is restricted when the soils are moist due to swelling of the clays, and at times the profile may become waterlogged. Cracking can cause damage to the plant roots, and poor contact between the roots and the soil occurs when cracks open. Cooeeimbardi soils can tolerate a degree of cultivation with limited impact on soil structure, providing the soil is not cultivated when too moist. Management practice techniques including stubble retention, minimum tillage and controlled traffic will be beneficial for these soils to enhance retention of organic matter in the soil, reduce soil erosion, increase water infiltration rates and reduce runoff. Cooeeimbardi soils are suited to winter grown vegetables, summer crops, irrigated pastures, broad-acre cropping and citrus depending on the frequency of flooding and frosts (Figure 35).

Figure 35 Cooeeimbardi SPC and landscape

Massive/weak structure, gradational or texture contrast
Gallanani (Brown Chromosol/Dermosols) are very deep gradational or texture contrast soils, with a neutral soil reaction and sandy clay loam surfaces on terrace plains and relict levees of terraced lands. These surfaces set hard due to high fine sand and/or silt content, which can impact seedling emergence. Gallanani soils are moderately permeable and moderately well drained. Soil fertility is high and PAWC is moderate. The surface horizons rely on organic matter to promote good soil structure. Soil structure can decline if the organic matter is broken down after excessive cultivation, particularly when the soils are moist. Crop management incorporating perennials into the crop rotation can assist the maintenance of organic matter in the surface horizons. The subsoils are occasionally sodic at depth. Management practice techniques including stubble retention, minimum tillage and controlled traffic will be beneficial for these soils to enhance retention of organic matter in the soil, reduce soil erosion, increase water infiltration rates and reduce runoff. Gallanani soils are suited to winter grown vegetable crops, summer vegetables, irrigated pastures and citrus depending on the frequency of flooding and frosts (Figure 36).

Figure 36 Gallanani SPC and landscape

Soils on Quaternary/Tertiary alluvium, drainage depressions, backplains and swamps

These soils are on older alluvium and include: Basel, Glamorgan, Tuckerimba, Spencer, Glencairn and Gunyah

Cracking or non-cracking clays/sodic upper subsoil, neutral or alkaline
Basel (Grey Vertosols) are very deep cracking clay or non-cracking clay soils (with vertic properties) with an alkaline soil reaction trend found in drainage depressions, swamps and backplains of floodplains and stagnant alluvial plains. The surfaces when dry can be weakly self-mulching and form small aggregates after shrinking and swelling due to the smectite clay content. Other surfaces set hard, which can impact seedling emergence. Cracking can cause damage to the plant roots, and poor contact between the roots and the soil occurs when cracks open. Soil fertility is moderate. Gilgai are common. These soils are predominantly slowly permeable and imperfectly drained. Internal drainage is often restricted from 0.3 m, and the soil profile may be waterlogged at depth. The grey subsoils retain calcium carbonate segregations, are sodic and often saline. PAWC is moderate as it is limited where high sodicity and salt levels exist. Basel soils are prone to compaction. The subsoil horizons readily disperse and slake, and are susceptible to erosion when groundcover is removed or soil surfaces are disturbed. These soils are suited to a narrow range of broad-acre crops and irrigated pastures, depending on the frequency of flooding, salinity and wetness of the subsoil (Figure 37).

Figure 37 Basel SPC and landscape

Glamorgan (Black/Brown Vertosols or Dermosols) are very deep cracking or non-cracking clay soils (with vertic properties) with an alkaline soil reaction trend on swamps and backplains of floodplains and stagnant alluvial plains (Figure 38). The surfaces when dry are generally weakly self-mulching and form small aggregates after shrinking and swelling due to smectite clay content. Other surfaces set hard, which can impact seedling emergence. Cracking can cause damage to plant roots, and poor contact between the roots and the soil occurs when cracks open. Soil fertility is high. Gilgai are common. These soils are slowly permeable and imperfectly drained. Internal drainage is often restricted from 0.65 m, and the profile may be waterlogged at depth. The grey subsoils retain calcium carbonate segregations, are frequently sodic and saline. PAWC is moderate as it is limited where the high sodicity and salt levels exist (Figure 39). Glamorgan soils are prone to compaction. The subsoil horizons readily disperse and slake, and are susceptible to erosion when groundcover is removed or soil surfaces are disturbed. These soils are suited to a narrow range of broad-acre crops and irrigated pastures, depending on the frequency of flooding, salinity and wetness of the subsoil).

Figure 38 Glamorgan SPC—surface horizons (left) and grey subsoil (right)

Tuckerimba (Grey Vertosols or Dermosols) are very deep cracking or non-cracking clay soils (with vertic properties) with brown subsoils, and an alkaline soil reaction trend, on swamps and backplains of floodplains and stagnant alluvial plains. Soil fertility is moderate. The surfaces are generally weakly self-mulching and form small aggregates after shrinking and swelling due to the smectite clay content.

Other surfaces set hard, which can impact seedling emergence. Cracking can cause damage to plant roots, and poor contact between the roots and the soil occurs when cracks open. These soils are slowly permeable and imperfectly drained. Internal drainage can be restricted from 0.3 m and the soil profile may be waterlogged. The subsoils retain calcium carbonate segregations, are sodic and often saline. PAWC is moderate as it is limited where high sodicity and salt levels exist (Figure 39). Tuckerimba soils are prone to compaction. The subsoil horizons readily disperse and slake, and are susceptible to erosion when groundcover is removed or soil surfaces are disturbed. These soils are suited to a narrow range of broad-acre crops and irrigated pastures, depending on the frequency of flooding, salinity and wetness of the subsoil.

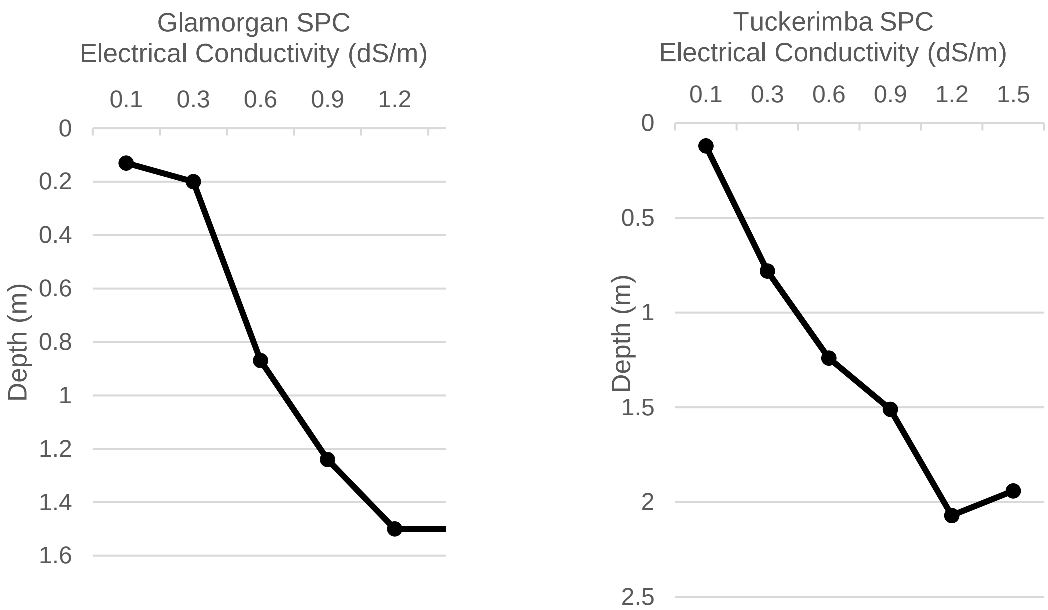


Figure 39 EC profiles for Glamorgan and Tuckerimba SPCs

Spencer (Brown/Grey Sodosols) are very deep sodic texture contrast soils with an alkaline soil reaction trend. This soil occupies drainage depressions, backplains and swamps of terraced land, stagnant alluvial plains and alluvial plains. The surface horizons can be up to 0.5 m thick, and set hard due to the high fine sand and silt content. This can impact on seedling emergence. Soil fertility is low to moderate. The surface horizons have a low clay content, and rely on organic matter to promote good soil structure. Soil structure can decline if the organic matter is broken down after excessive cultivation, particularly when the soils are moist. Crop management incorporating perennials into the crop rotation may assist the maintenance of organic matter in the surface horizons. Spencer soils are slowly permeable and imperfectly drained. Internal drainage can be restricted from 0.3 m and the subsoil may be waterlogged at depth. PAWC is low to moderate as it is limited by light surface textures, and where high sodicity and salt levels exist. The upper subsoil horizons readily disperse and slake, and are susceptible to erosion when groundcover is removed, or surface soil horizons are disturbed, resulting in deeply incised drainage depressions. These soils are suitable for a narrow range of broad-acre crops and irrigated pastures depending on the frequency of flooding and wetness of the subsoil (Figure 40).

Figure 40 Spencer SPC, soil profile, landscape and mottling

Texture contrast, sodic upper subsoil; strong acid soil reaction

Glencairn (Grey/Brown Kurosols or Sodosols, occasional Grey Dermosols) are very deep, grey sodic texture contrast sodic soils with mottled, neutral to strongly acidic subsoils. These soils occur on back plains and swamps of stagnant alluvial plains. The subsoils are occasionally saline, and soil fertility is low. The surface horizons have low clay content, and rely on organic matter to promote good soil structure. Soil structure can decline if the organic matter is broken down or lost after sheet erosion or cultivation. Glencairn soils are slowly permeable and imperfectly drained. Internal drainage can be restricted from 0.25 m. PAWC is limited by the light surface textures. The subsoils are sodic and dispersive, and are prone to slaking and erosion if exposed or disturbed, however, the exchangeable aluminium in the strongly acidic subsoils assists with structural stability, making them less prone to erosion. These soils are likely to have deficiencies in phosphorus, nitrogen and calcium, and potential toxicities of aluminium and manganese below 0.25 m. These soils are suitable for grazing native and improved pastures depending on frequency of flooding, wetness and subsoil acidity (Figure 41).

Figure 41 Glencairn SPC and landscape

Texture contrast, or gradational soils, non-sodic upper subsoil

Gunyah (Brown Chromosols/Dermosols) are very deep texture contrast or gradational soils, with a neutral to slightly alkaline soil reaction and sodic lower subsoils. Gunyah soils occupy drainage depressions, backplains and swamps on floodplains and stagnant alluvial plains. The surface horizons set hard due to the high fine sand and silt content, which can impact on seedling emergence. Soil fertility is low to moderate. The surface horizons have low clay content, and rely on organic matter to promote good soil structure. Soil structure can decline if the organic matter is broken down after excessive cultivation, particularly when the soils are moist. Crop management incorporating perennials into the crop rotation can assist the maintenance of organic matter in the surface horizons. These soils are slowly permeable, and imperfectly drained at depth, and experience short periods of waterlogging. PAWC is low to moderate as it is limited by the light surface textures, and high sodicity and salt levels when present. The surface horizons can be shallow, and at risk of erosion if groundcover is removed or the soil surface is disturbed. Salinity levels are occasionally moderate in the subsoil. These soils are suitable for a narrow range of broad-acre crops and irrigated pastures depending on the frequency of flooding, frosts and wetness of the subsoil (Figure 42).


Figure 42 Gunyah SPC and landscape

Soils on sandstones and siltstones of the Marburg Subgroup

The significant soils include Lowood and Koukandowie.

Texture contrast soils, sodic upper subsoil, strong acid soil reaction

Lowood (Grey/Brown Kurosols, Sodosols or occasional Dermosols) are very deep, grey or brown mottled sodic texture contrast soils with a neutral to strongly acidic soil reaction trend. These soils occur on mid and lower slopes of rises on Jurassic sandstones. The subsoils are often saline. Soil fertility is low. The surface horizons have low clay content, and rely on organic matter to promote good soil structure. Soil structure can decline if the organic matter is broken down or lost after sheet erosion. Lowood soils are slowly permeable and imperfectly drained. Internal drainage can be restricted from 0.3 m and the soil profile may be periodically waterlogged at depth. PAWC is low as it is limited by the light texture, low pH values, and high sodicity and/or salinity levels. The subsoils are prone to slaking and erosion if exposed. However, the higher levels of exchangeable aluminium in the strongly acidic subsoils of the Kurosols assist with structural stability, making them less prone to erosion. The Lowood soils are likely to have deficiencies in phosphorus, nitrogen and calcium, and potential toxicities of aluminium and manganese below 0.3 m (Figure 43). These soils are suited to grazing native pastures.

Figure 43 Lowood SPC and landscape

Sodic upper subsoil, alkaline soil reaction

Koukandowie (Brown/Black/Yellow Sodosols) are deep sodic texture contrast soils with an alkaline soil reaction. They occur on lower and mid slopes of rises, low hills and hills of Jurassic sandstones and siltstones. The surface horizons set hard due to the high fine sand and silt content. This can impact on seedling emergence. Soil fertility is low. The surface horizons have low clay content, and rely on organic matter to promote good soil structure. Soil structure can decline if the organic matter is broken down or lost. These soils are slowly to very slowly permeable, and imperfectly drained. Internal drainage can be restricted from 0.4 m. The subsoils retain calcium carbonate segregations and are often slightly to moderately saline. PAWC is low to moderate, and is limited by the light surface textures and the high sodicity levels. The surface horizons can be shallow, and are at risk of erosion if groundcover is removed or disturbed. The subsoil horizons readily disperse and slake, and are prone to rill and gully erosion if exposed. These soils are suited to grazing native pastures (Figure 44).

Figure 44 Koukandowie SPC and landscape

Soils on quartzose sandstones of Woogaroo Subgroup

The significant soils include Hibiscus, (including Hibiscus Light Phase, Hibiscus Nodular Variant), Yellowbank (including Yellowbank Light phase, Yellowbank Nodular variant, Yellowbank Discontinuous variant) and Quinine.

Massive/weak structure, gradational or texture contrast soil

Hibiscus (Red Kandosols, occasional Red Chromosols) are very deep red earthy soils with massive or weak structure. These soils occur on hillslopes of rises and low hills of Triassic-Jurassic quartzose sandstones. The surface horizons set hard due to the high fine sand content. This can impact on seedling emergence. Soil fertility is low to moderate. The soil is moderately permeable and well drained. The surface horizons have low clay content, and rely on organic matter to promote good soil structure and moisture holding capacity. Soil structure can decline if the organic matter is broken down after cultivation when the soil is moist, or lost after sheet erosion. PAWC is low to moderate and is limited by the light soil textures (Figure 45).

Hibiscus Nodular Variant is moderately well drained and contains many 2–20 mm ferromanganiferous nodules. **Hibiscus Light Phase** is dominated by loamy textures throughout, and a reduced PAWC. The light phase is thought to be of colluvial origin, and often occupies broad concave depressions high in the landscape. The depth of Hibiscus and Hibiscus Light Phase ranges from 1 m to approximately 5 m (Murtha 1977). Hibiscus soils are suited to winter grown vegetables, summer crops and tree crops. Slope is a limitation, and contour banks have been routinely constructed on these soils for slopes of 5–12%.

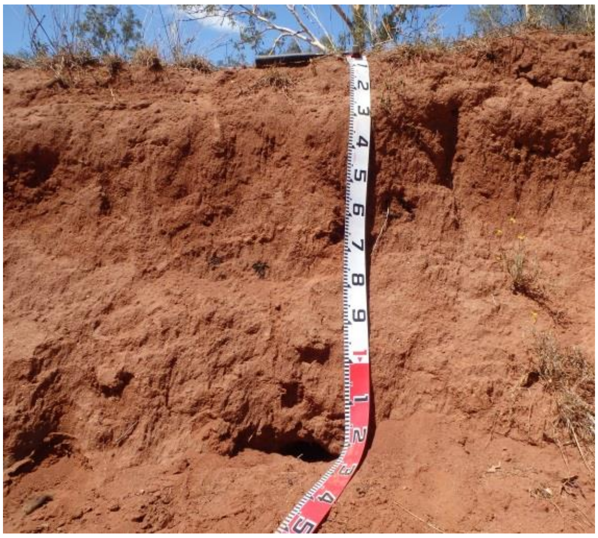



Figure 45 Hibiscus SPC and landscape

Yellowbank (Yellow/Brown Chromosols or Kandosols) are deep yellow/brown texture contrast or gradational soils with massive or weak structure occurring on lower and mid slopes of rises and low hills of Triassic-Jurassic quartzose sandstones. The surface horizons set hard due to the high fine sand content. This can impact on seedling emergence. Soil fertility is low. The surface horizons have low clay content, and rely on organic matter to promote good soil structure and moisture holding capacity. Soil structure can decline if the organic matter is broken down after cultivation when the soil is moist, or lost after sheet erosion. Yellowbank soils are moderately permeable and moderately well drained, and grade to soils that are slowly permeable and/or imperfectly drained, and sodic at depth. Deeper subsoils are often highly mottled. PAWC is low to moderate and is limited by the light textures and reduced soil depth. The Yellowbank Chromosols tend to occupy the lower slopes, and Yellowbank Kandosols are more dominant on upper and mid slope positions. Chromosols with sodic subsoils that grade to Sodosols are prone to erosion and slaking if subsoils are exposed (Figure 46).

Yellowbank Nodular Variant is moderately deep and imperfectly drained. As formation of these soils occurred in an environment of deep weathering and fluctuating water tables, they contain many 2–20 mm ferromanganiferous nodules in the subsurface (A2 horizon) and subsoil horizons, and occasionally iron-cemented sandstone. **Yellowbank Light Phase** is dominated by loamy textures throughout. **Yellowbank Discontinuous Variant** has a red subsoil, where the red sandy clay continues unchanged to 4 m deep. These soils have a limited distribution and are found in drainage depressions high in the landscape. Murtha (1977) suggested that the differences in the Yellowbank soils reflected a lithological difference within the Woogaroo Subgroup.

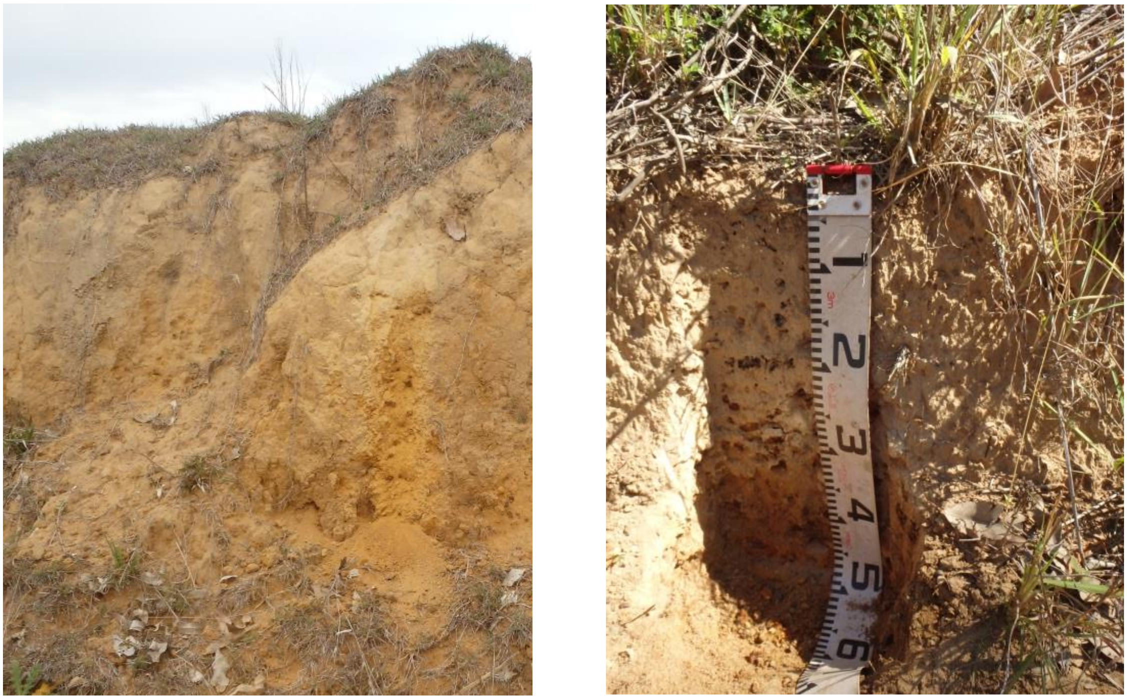


Figure 46 Yellowbank SPC (left) and Yellowbank Nodular Variant SPC (right)

Landscape hydrology has had an impact on the range of soils formed on the Woogaroo Subgroup. The Hibiscus soils are deep (often more than 4 m to parent material), freely draining soils. Lateral drainage from these deeper soils is retained for longer periods in the shallower soils such as Yellowbank (where there is less than 2 m to parent material). The Yellow Kandosols are saturated for a longer period than the deeper Red Kandosols, and the longer period of seasonal saturation was suggested to have promoted the development of the yellow colour, the subsoil mottling and ferromanganiferous segregation formation (Murtha 1977). Hibiscus soils with segregations are likely to have more seasonal saturation than the Hibiscus soils with no segregations (Figure 47).

Figure 47 Yellowbank grading to Hibiscus (left) and Hibiscus Light Phase (right)

Sodic upper subsoil, neutral soil reaction

Quinine (Yellow/Grey Sodosols or Chromosols, occasional Brown Kurosols) are deep sodic texture contrast soils with a neutral or slightly (occasionally strongly) acidic soil reaction trend, found on concave floors of drainage depressions and lower slopes of rises, low hills and hills of Triassic-Jurassic quartzose sandstones. The surface horizons set hard due to the high fine sand content. This can impact on seedling emergence. Surface fertility is low. The surface horizons have low clay content, and rely on organic matter to promote good soil structure. Soil structure can decline if the organic matter is broken down after excessive cultivation or lost due to erosion. These soils are slowly permeable, and imperfectly drained. The subsurface (A2 horizon) is conspicuously bleached and internal drainage is restricted from 0.4 m. The subsoils may be waterlogged. PAWC is low and is limited by the light soil textures, sodicity and reduced soil depth. These soils are thought to have formed largely from colluvial materials (Murtha 1977). The surface horizons are up 0.4 m deep, and are at risk of erosion if groundcover is removed or if the soil surface horizons are disturbed. The subsoils readily disperse and slaking and gully erosion is a common feature. The depth of the gully is generally determined by the depth to the underlying parent material. These soils are suitable for native pastures and forestry (Figure 48).

Figure 48 Quinine SPC (left), Erosion of drainage line in Quinine soil (right)

Soils on andesites and volcanoclastic conglomerates of the Neara Volcanics

The significant soils include Avoca, Dunwich, Jimna and Moore.

Structured cracking and non-cracking clays

Avoca (Brown Chromosols or Dermosols) are deep texture contrast or gradational soils, with a loamy surface and a neutral soil reaction. Avoca occurs on plains, foot slopes and lower slopes of plains and rises of Triassic andesites and Tertiary-Quaternary colluvium. Avoca soils have vertic properties and often have a sodic lower subsoil. Soil fertility is high. The surface horizons have low clay content, and rely on organic matter to promote good soil structure and water holding capacity. Soil structure can decline if the organic matter is broken down after cultivation when the soil is moist, or is lost during sheet erosion. Management practice techniques including stubble retention, minimum tillage and controlled traffic will be beneficial for these soils to enhance retention of organic matter in the soil, reduce soil erosion, increase water infiltration rates and reduce runoff. These soils are moderately permeable and moderately well drained. PAWC is high. These soils are prone to compaction. Avoca soils are suited to winter grown vegetables, summer crops, irrigated pastures, broad-acre cropping and tree crops depending on the frequency of frosts, the wetness of the subsoil, and soil depth (Figure 49).

Figure 49 Avoca SPC and landscape

Jimna (Black/Brown Vertosols) are deep strongly structured cracking clay soils, with an alkaline soil reaction trend on lower slopes and footslopes of rises and low hills of Triassic andesites or volcanoclastic conglomerates. The surfaces when dry are weakly self-mulching and form small aggregates after shrinking and swelling due to the smectite clay content. The subsoils contain slickensides (slip planes), retain calcium carbonate segregations and are frequently sodic. Cracking can cause damage to the roots, and poor contact between the roots and the soil occurs when cracks open. Surface fertility and PAWC are high. Jimna soils are prone to compaction. Jimna soils are suited to winter grown vegetables, summer crops, irrigated pastures and broad-acre cropping depending on the frequency of frosts, the wetness of the subsoil, and soil depth.

Figure 50 Jimna SPC Slickensides and landscape

Texture contrast or gradational soil, sodic upper subsoil

Moore (Grey/Black Sodosols or Dermosols) are deep sodic texture contrast or gradational soils, with a conspicuously bleached A2 horizon and an alkaline soil reaction trend. Moore soils occur on mid and lower hillslopes and footslopes of rises, low hills and hills of Triassic andesites, volcanoclastic conglomerates or late Tertiary-Quaternary colluvium. The surface horizons set hard due to the high fine sand content. This can impact on seedling emergence. Surface fertility is low to moderate. The surface horizons have a low clay content, and rely on organic matter to promote good soil structure. Soil structure can decline if the organic matter is broken down after excessive cultivation or lost due to erosion. These soils are slowly permeable, and imperfectly drained. The subsoils retain calcium carbonate segregations and are often slightly to moderately saline at depth. PAWC is low to moderate, due to the light surface textures, depth of surface horizons and the sodicity levels. The surface horizons range in depth, but are commonly 0.3 m deep, and are at risk of erosion if groundcover is removed. The subsoils are dispersive, slake, and are susceptible to gully erosion if exposed. Contour banks have been constructed on these soils to reduce erosion for slopes of 5–12% at Esk. Erosion and limited effective rooting depth are the major limitations for these soils. Moore soils have impeded drainage at depth or are the recipient of lateral drainage, where they occur on slopes. They are suited to a narrow range of broad-acre, horticultural crops and irrigated pastures. These soils are often associated with the Dunwich soils (Figure 51).

Figure 51 Moore SPC and landscape

Figure 52 Moore SPC—showing conspicuous bleach (left), soil erosion (right)

Texture contrast, non-sodic upper subsoil

Dunwich (Brown/Black Chromosols) are deep texture contrast soils, with a neutral soil reaction trend and a sporadic bleach on mid and lower hillslopes and foot slopes of rises, low hills and hills of Triassic andesites, volcanoclastic conglomerates or late Tertiary-Quaternary colluvium. Lower subsoils are often sodic and vertic at depth. The surface horizons set hard due to the high fine sand content. This can impact on seedling emergence. Surface fertility is low. The surface horizons have a low clay content, and rely on organic matter to promote good soil structure and water holding capacity. Soil structure can decline if the organic matter is broken down or lost during sheet erosion. These soils are moderately permeable and moderately to imperfectly drained. PAWC is low to moderate and is limited by the light surface textures and soil depth. The surface horizons are at risk of erosion if groundcover is removed or soil surface horizons are disturbed. The subsoils are often dispersive, slake at depth, and are susceptible to rill and gully erosion if exposed. Dunwich soils have impeded drainage at depth or are the recipient of lateral drainage, where they occur on slopes. Erosion is a limitation, and contour banks have been constructed on these soils for slopes of 5–12% at Esk. Dunwich soils are associated with the Moore soils, and are suited for a narrow range of broad-acre and horticultural crops and irrigated pastures (Figure 53).

Figure 53 Dunwich SPC and landscape

Soils on sandstones, shales and conglomerates of Esk and Mount Crosby Formation

The significant soils include Beer, Beppo, Moombra and Watt.

Structured cracking and non-cracking clays

Beer (Black/Brown/Grey Vertosols or Dermosols) are moderately deep, strongly structured, cracking or non-cracking clay soils with vertic properties, and an alkaline soil reaction trend. Beer occurs on lower slopes and foot slopes of rises, low hills and hills of Triassic sandstones, shales or conglomerates. The surfaces when dry are weakly self-mulching and form small aggregates after shrinking and swelling due to the smectite clay content. The subsoils contain prominent slickensides (or slip-plains), calcium carbonate segregations and are frequently sodic. Cracking can cause damage to plant roots, and poor contact between the roots and the soil occurs when cracks open. Soil fertility is high. Beer soils are slowly permeable. The brown/black soils are moderately well drained, and grey Beer soils are imperfectly drained. PAWC is high, but is reduced in the grey soils where higher sodicity and salinity levels exist. Internal drainage can be restricted from 0.5 m. The surface horizons are at risk of erosion if groundcover is removed or soil surface horizons are disturbed. The subsoils are dispersive, slake and are susceptible to rill and gully erosion if exposed. Contour banks have been constructed on these soils for slopes of 5–12% at Esk. Maintenance of channel outlets on contour banks is an important consideration for these soils, as poorly maintained contour banks and their adjoining constructed waterways erode in this landscape. The depth of the gully is determined by the depth to the underlying parent material. Beer soils are prone to compaction. Erosion and limited effective rooting depth are major limitations for these soils. Beer soils are suited to winter grown vegetables, summer crops, irrigated pastures and tree crops depending on the slope, erosion, wetness, and soil depth (Figure 54).

Figure 54 Beer SPC and landscape

Moombra (Brown/Black Dermosols) are neutral moderately deep, non-cracking clay soils on mid and upper slopes of low hills of Triassic sandstones, shales or conglomerates. The surface horizons set hard due to the high fine sand and silt content. This can impact on seedling emergence. Surface fertility is moderate. These soils are slowly or moderately permeable, and moderately well drained. PAWC is moderate, and is limited due to the reduced soil depth. The surface horizons are at risk of erosion if groundcover is removed or soil surface horizons are disturbed. The subsoils are slightly sodic and dispersive, and are prone to slaking and erosion if exposed. Moombra soils are suited to winter grown vegetables, summer crops and irrigated pastures, depending on slope, wetness, and soil depth.

Figure 55 Moombra SPC and landscape

Texture contrast, sodic upper subsoil

Beppo (Brown Sodosols) are very deep sodic texture contrast soils with an alkaline soil reaction and conspicuously bleached A2 horizon, on lower and mid hillslopes and footslopes of rises, low hills and hills of Triassic sandstones, shales, conglomerates or Tertiary-Quaternary colluvium (Figure 56). The surface horizons set hard due to the high fine sand and silt content. This can impact on seedling emergence. Surface fertility is low to moderate. Beppo soils are slowly to very slowly permeable, and imperfectly drained. The subsoils contain calcium carbonate segregations and are often slightly to moderately saline. There is evidence of salinisation in the landscapes around Esk. PAWC is low to moderate, and is limited due to the light surface textures and high sodicity and/or salinity levels. The surface horizons are shallow, and are at risk of erosion if groundcover is removed. The subsoils disperse and slake and are prone to rill and gully erosion if exposed. Contour banks have been constructed on these soils for slopes of 5–12% at Esk. Maintenance of channel outlets on contour banks is an important consideration for these soils, as poorly maintained contour banks and their adjoining constructed waterways erode in this landscape. Gully erosion is the dominant feature of Beppo Eroded Phase (Figure 57). The depth of the gully is often determined by the depth to the underlying parent material. Erosion and limited effective rooting depth are the major limitations for these soils. These soils are often associated with the Watt soils. Beppo soils are suited to a narrow range of broad-acre crops and irrigated pastures, depending on slope, erosion, wetness and soil depth.

Figure 56 Beppo SPC—conspicuous bleach and landscape

Figure 57 Beppo Eroded Phase SPC at Esk

Texture contrast or gradational soil, non-sodic upper subsoil

Watt (Brown Chromosols) are moderately deep texture contrast soils, with a neutral soil reaction that is frequently sodic in the lower subsoil on lower slopes and foot slopes of rises and low hills of Triassic sandstones, conglomerates or Tertiary-Quaternary colluvium. The surface horizons set hard due to the high fine sand and silt content. This can impact on seedling emergence. Surface fertility is low. These soils are moderately to slowly permeable and moderately well drained. PAWC is low to moderate and is limited due to the light surface soil textures and reduced soil depth. The surface horizons are at risk of erosion if groundcover is removed or soil surfaces are disturbed. The subsoils are often dispersive, slake at depth and are susceptible to rill and gully erosion if exposed. Watt soils have impeded drainage at depth or are the recipient of lateral drainage, where they occur on slopes. Watt soils are occasionally moderately saline at depth, and there is evidence of salinisation in the landscapes around Esk. Watt soils are often associated with the Beppo soils, and are suitable for winter grown vegetables, broad-acre crops, citrus and irrigated pastures, depending on slope, erosion, wetness and soil depth (Figure 58).

Figure 58 Watt SPC and landscape

Soils on mudstones, shales, cherts and conglomerates of the Neranleigh-Fernvale Formation

The significant soils are Fernvale.

Texture contrast, sodic upper subsoil, strong acid soil reaction
Fernvale (Brown Kurosols/Sodosols) are very deep, brown texture contrast sodic soils with mottled, strongly or slightly acidic subsoils on lower slopes of rises and low hills on Devonian-Carboniferous colluvium, mudstones, shales, chert, arenite, conglomerate or sandstone. The subsoils are often saline. Surface fertility is low. PAWC is low and is limited due to the high sodicity, salinity and acidity. The shallow surface horizons are at risk of erosion if groundcover is removed or soil surfaces are disturbed. The subsoils disperse and are susceptible to erosion if exposed. However, the higher levels of exchangeable aluminium in the strongly acidic subsoils of the Kurosols assist with structural stability, making them less prone to gully and rill erosion. The Kurosols are likely to have deficiencies in phosphorus, nitrogen and calcium, and potential toxicities of aluminium and manganese. Fernvale soils are likely to have such deficiencies below 0.2 m. These soils are suited to improved and native pastures (Figure 59).

Figure 59 Fernvale SPC

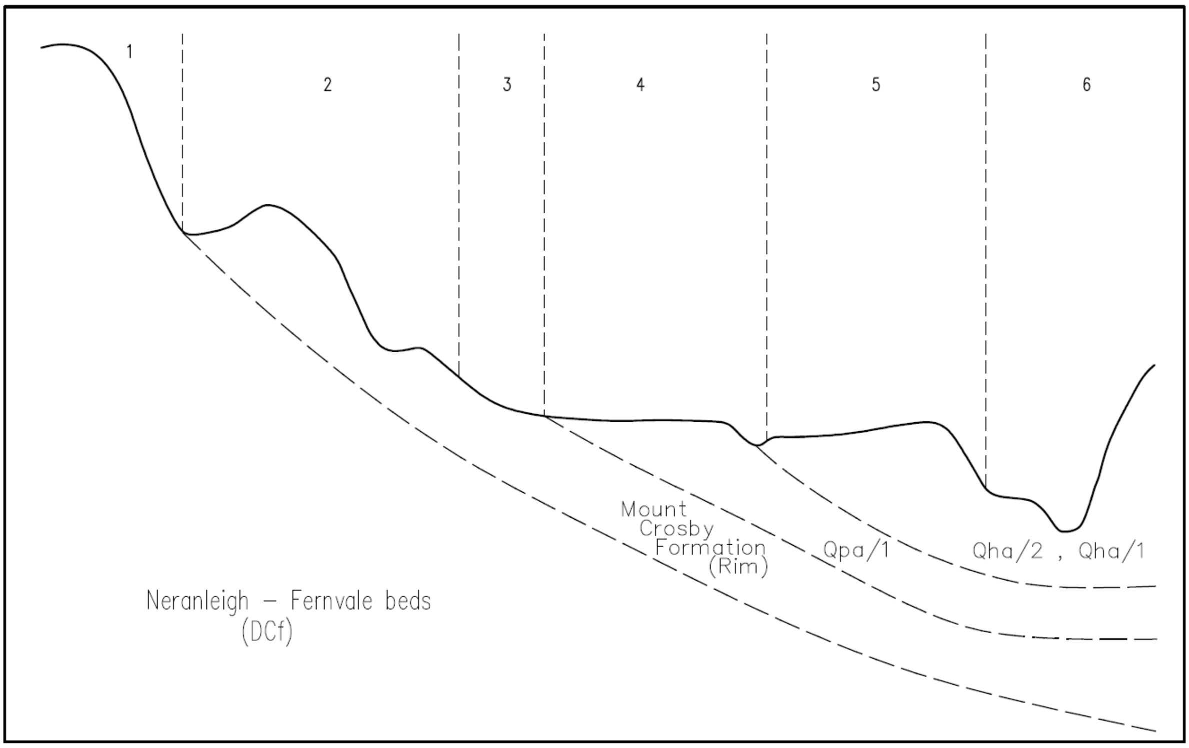
10. Landscape Concepts

A series of diagrammatic cross-sections showing idealised relationships between geological unit, landform, SPCs and vegetation have been developed. These have been displayed as conceptual drawings in this section.

Steep hills and hills with adjacent alluvium, Fernvale

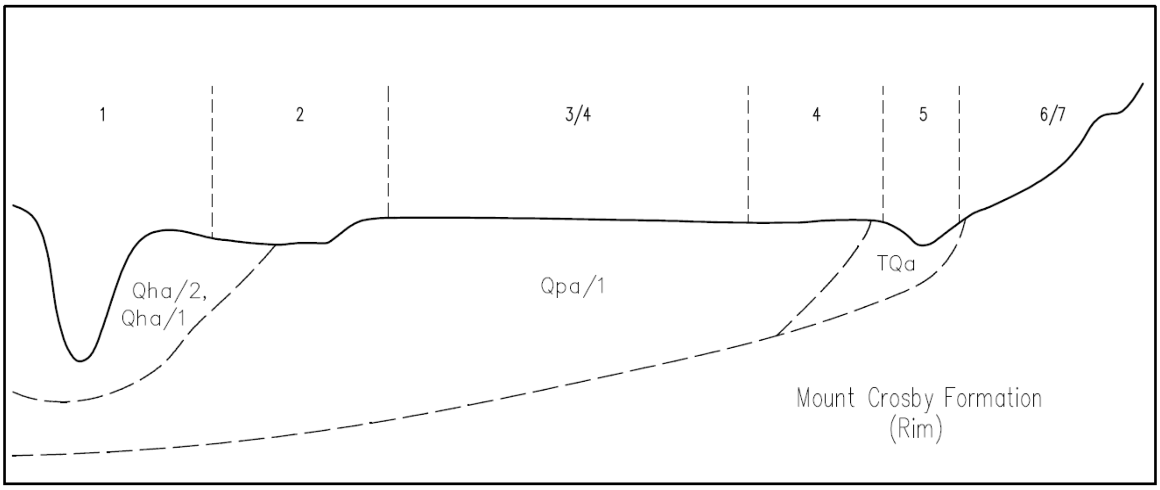
Distributed from Borallon to Wivenhoe-Pocket, following the alluvium of the Brisbane River, the landscape was formed from the weathering, dissection and erosion of exposed rocks of the Neranleigh-Fernvale Beds, Mount Crosby Formation and the Woogaroo Subgroup. It comprises undulating or rolling rises and low hills on the Jurassic and Triassic sedimentary units and rolling or steep low hills and hills on the Devonian-Carboniferous sediments. The Brisbane River meanders through the unit with a prevalence of narrow terrace flats where the river reaches are constricted by the hard rock geology, with broader floodplains developing on the softer, more gently inclined sedimentary units. Drainage depressions, swamps, backplains and terrace plains dominate the stagnant alluvial plains and terraced lands on the older more elevated landscapes, while younger active channel benches and plains that are inundated more regularly, have formed closer to the river, as recent alluvium. Smaller drainage networks such as Black Snake Creek and Sandy Creek enter the Brisbane River in this landscape. There has been an increase in stream bank erosion and slumping in this landscape, associated with multi-peak flood events after extended inundation. Landscape processes occurring in this area have resulted in poor water quality entering the Brisbane River and Moreton Bay. Primarily this has been caused by the development of salinity expressions in and adjacent to stream lines, erosion (resulting in sediment and nutrient delivery) and sedimentation.

Landscape 1: Neranleigh-Fernvale, Mount Crosby Formation and alluvium



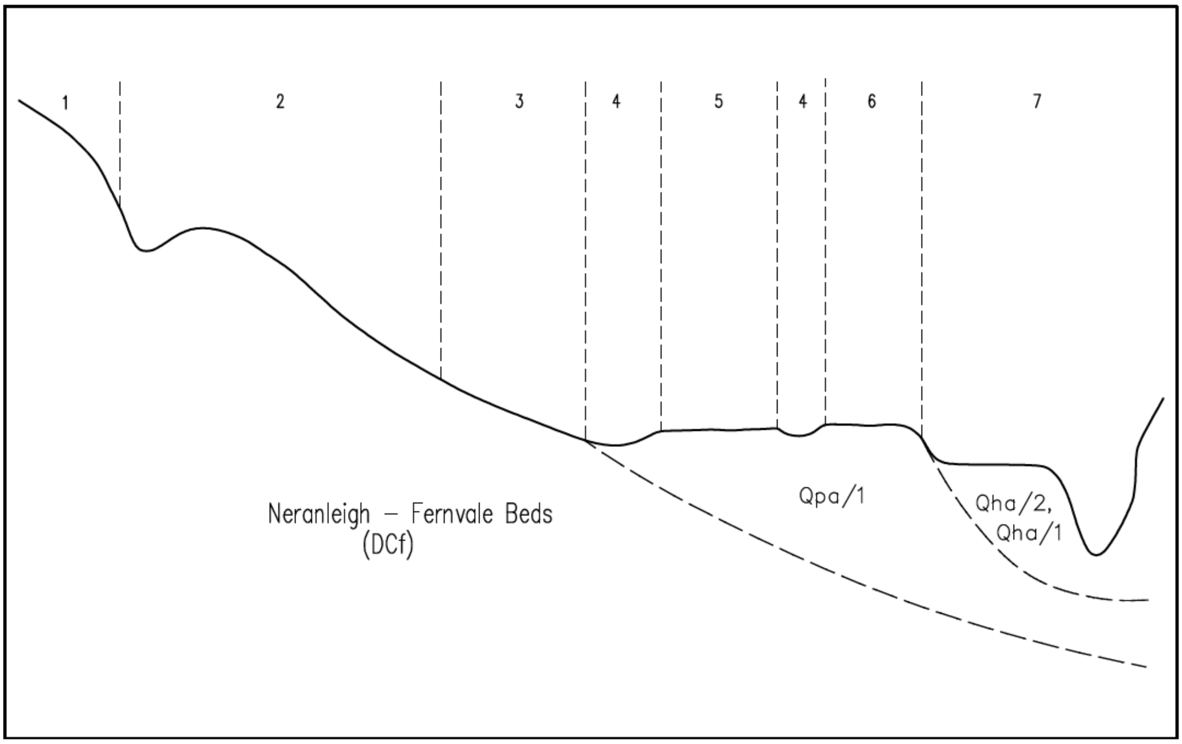
Unit	Landform	Soil Description	Soil Profile Class
1	Lower, mid and upper slopes of hills and low hills. Slopes 5–25%.	Moderately deep neutral, red or brown gradational sodic soils on chert, arenite, conglomerate or sandstone. Moderately well drained.	**Neranleigh** (Brown Dermosol)
2	Hillcrests, upper and mid slopes of hills and low hills. Slopes 5–35%.	Moderately deep, neutral brown texture contrast or gradational soils on sandstone. Loamy surface. Moderately well drained.	**Lakeview** (Brown Dermosol/ Chromosol)
3	Mid and lower slopes of rises and low hills. Slopes 5–20%.	Moderately deep, brown texture contrast or gradational soils on sandstone, shale or conglomerate. Frequent pale or sporadically bleached A2 horizon. Often sodic and vertic in lower subsoil. Moderately to imperfectly drained.	**Watt** (Brown Chromosol/ Dermosol)
4	Drainage depressions and backplains. Slopes 0–3%.	Very deep, alkaline, grey/brown, sodic texture contrast soils on older alluvium. Imperfectly drained.	**Spencer** (Brown/Grey Sodosol)
5	Terrace flats and levees. Slopes 1–3%.	Very deep neutral brown loamy soils over buried horizons on recent alluvium. Well drained.	**Honey** (Brown/Black Kandosol, Brown-orthic Tenosol)
6	Channel benches on floodplains. Slopes 0.5–2%.	Very deep, sandy textured soils over buried horizons and gravel on recent alluvium. Rapidly drained.	**Cressbrook** (Stratic Rudosol) **Cressbrook Rocky Phase** (Stratic Rudosol)

Landscape 2: Mount Crosby Formation with Brisbane River alluvium



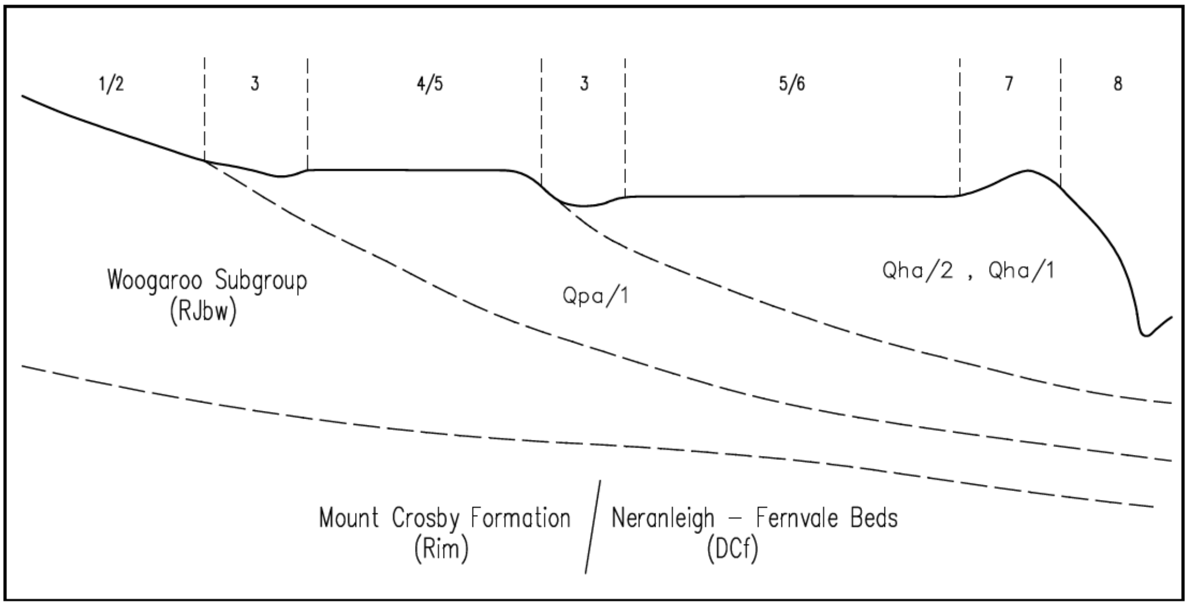
Unit	Landform	Concept	Soil
1	Channel benches and levees. Slopes 1–3%.	Very deep neutral brown loamy soils over buried horizons on recent alluvium. Well drained.	**Honey** (Brown/Black Kandosol, Brown-orthic Tenosol)
2	Terrace plains and relict levees. Slopes 0.5–2%.	Very deep, neutral brown texture contrast or gradational soils on alluvium. Subsoils are moderately structured sandy clays, over buried horizons. Occasionally sodic at depth. Moderately well drained.	**Gallanani** (Brown Chromosol/ Dermosol)
3	Terrace plains. Slopes 1–3%.	Very deep, alkaline self-mulching black cracking clay soils with slightly sodic subsoils on older alluvium. Occasional slight to moderate salinity at depth. Moderately well or, occasionally imperfectly drained.	**Cooeeimbardi** (Black Vertosol)
4	Terrace plains. Slopes 0.5–2%.	Very deep neutral, strongly structured black non-cracking clay soils on older alluvium. Moderately well drained.	**Gira Gira** (Black Dermosol)
5	Drainage depressions. Slopes 0–3%.	Very deep, alkaline/neutral grey/brown, sodic texture contrast or gradational soils on older alluvium. Imperfectly drained.	**Spencer** (Brown/Grey Sodosol) **Gunyah** Brown Chromosol/ Dermosol
6	Mid and lower slopes of rises and low hills. Slopes 5–20%.	Moderately deep, brown texture contrast or gradational soils on sandstone, shale or conglomerate. Frequent pale or sporadically bleached A2 horizon. Often sodic and vertic in lower subsoil. Moderately to imperfectly drained.	**Watt** (Brown Chromosol/ Dermosol)
7	Crests, upper and mid slopes of steep or rolling hills and low hills. Slopes 5–35%.	Moderately deep, neutral brown texture contrast or gradational soils on sandstone. Loamy surface. Moderately well drained.	**Lakeview** (Brown Dermosol/ Chromosol)

Landscape 3: Neranleigh-Fernvale Beds and adjacent Brisbane River alluvium



Unit	Landform	Soil Description	Soil Profile Class
1	Hillslopes and crests of low hills and hills. Slopes 5–15%.	Shallow, neutral loamy soils, weathering in situ on chert, mudstone or conglomerate. Moderately to well drained.	**Ferny** (Bleached-Leptic Tenosol, Leptic Rudosol)
2	Lower, mid and upper slopes of hills and low hills. Slopes 5–25%.	Moderately deep, neutral, red or brown sodic gradational soils on chert, arenite, conglomerate or sandstone. Moderately well drained.	**Neranleigh** (Brown Dermosol)
3	Lower slopes of low hills and rises. Slopes 3–15%.	Very deep, sodic brown texture contrast soils with a mottled and acidic subsoil on colluvium, mudstone, shale, chert, arenite, conglomerate or sandstone. Imperfectly drained.	**Fernvale** (Brown Kurosol/ Sodosol)
4	Drainage depressions and backplains. Slopes 0.5–2%.	Very deep, neutral brown texture contrast or gradational soils on alluvium. Subsoils are frequently mottled and/or sodic at depth. Imperfectly drained or occasionally moderately well drained.	**Gunyah** (Brown Chromosol/ Dermosol)
5	Back plains and swamps. Slopes 0.5–2%.	Very deep, alkaline, calcic black and brown cracking clay and non-cracking clay soils (with vertic properties) on alluvium. Subsoils are grey, moderately saline and sodic. Imperfectly drained.	**Glamorgan** (Black/Brown Vertosol/ Dermosol)
6	Terrace flats and terrace plains. Slopes 0.5–2 %.	Very deep neutral, strongly structured black non-cracking clay soils on alluvium. Moderately well drained.	**Gira Gira** (Black/Brown Dermosol)
7	Terrace flats, levees and channel benches. Slopes 1–3%.	Very deep neutral brown loamy soils over buried horizons on recent alluvium. Well drained. Very deep, sandy textured soils over buried layers on recent alluvium. Rapidly drained.	**Honey** (Brown/Black Kandosol, Brown-orthic Tenosol) **Cressbrook** (Brown Orthic Tenosol, Stratic Rudosol)

Landscape 4: Woogaroo Subgroup with adjacent Brisbane River alluvium

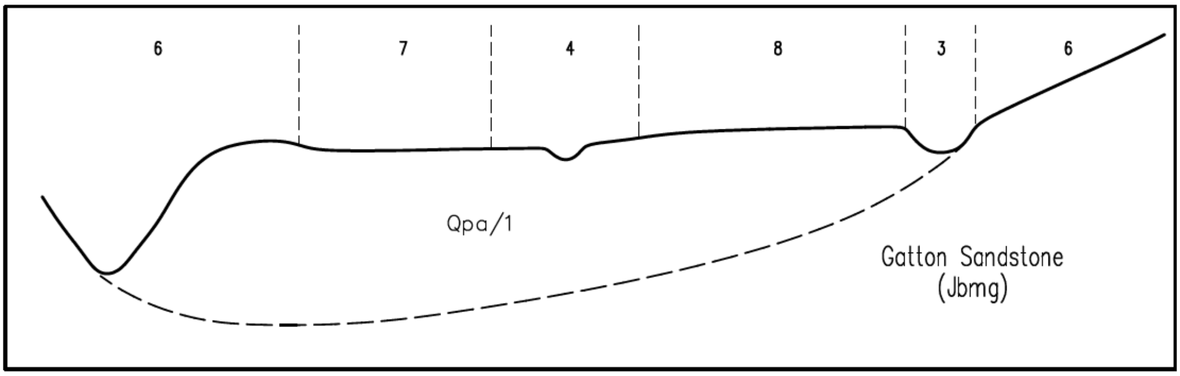


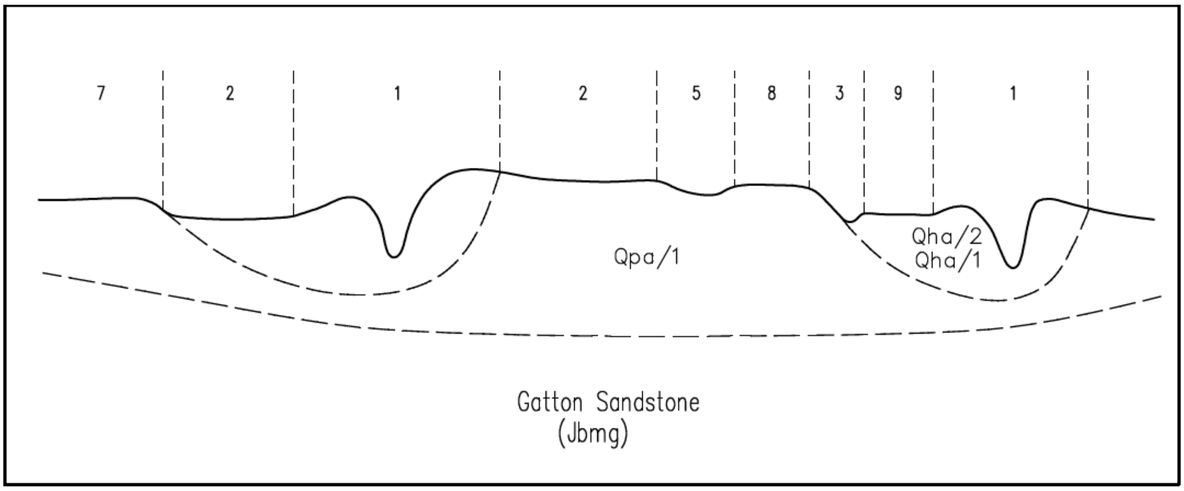
Unit	Landform	Soil Description	Soil Profile Class
1	Mid and lower slopes on rises. Slopes 5–15%.	Deep and very deep gradational red earthy soils on quartzose sandstone. Well drained.	**Hibiscus** (Red Kandosol)
2	Lower slopes on undulating rises. Slopes 2–10%.	Deep yellow/brown earthy texture contrast or gradational soils on quartzose sandstone. Moderately to imperfectly drained.	**Yellowbank** (Yellow/Brown Kandosol/Chromosol)
3	Drainage depressions. Slopes 0–3%.	Very deep, alkaline/neutral, grey/brown, sodic texture contrast or gradational soils on alluvium. Imperfectly drained.	**Spencer** (Brown/Grey Sodosol) **Gunyah** Brown Chromosol/ Dermosol
4	Backplains and swamps. Slopes 0.5–2%.	Very deep, alkaline, calcic black and brown cracking clay and non-cracking clay soils (with vertic properties) on alluvium. Subsoils are grey, moderately saline and sodic. Imperfectly drained.	**Glamorgan** (Black/Brown Vertosol/ Dermosol)
5	Terrace plains. Slopes 0.5–2%.	Very deep, alkaline self-mulching black cracking clay soils with slightly sodic subsoils on older alluvium. Occasional slight to moderate salinity at depth. Moderately well or, occasionally imperfectly drained.	**Gira Gira** (Black/Brown Dermosol) **Cooeeimbardi** (Black Vertosol)
6	Terrace plains and relict levees. Slopes 0.5–2%.	Very deep, neutral brown texture contrast or gradational soils on alluvium. Subsoils are moderately structured sandy clays, over buried horizons. Occasionally sodic at depth. Moderately well drained.	**Gallanani** (Brown Chromosol/ Dermosol)
7	Levees. Slopes 1–3%.	Very deep neutral brown loamy soils over buried horizons on recent alluvium. Well drained.	**Honey** (Brown/Black Kandosol, Brown-orthic Tenosol)
8	Channel benches. Slopes 0.5–2%.	Very deep, sandy textured soils on alluvium over buried horizons and gravel on recent alluvium. Rapidly drained.	**Cressbrook** (Stratic Rudosol) **Cressbrook Rocky Phase** (Stratic Rudosol)

Rises on Marburg Formation and adjacent alluvium, Fernvale

Distributed from the confluence of the Brisbane River and Lockyer Creek at Wivenhoe Pocket to Fernvale, following the alluvium of the Brisbane River, this landscape was formed by the weathering, dissection and erosion of exposed rocks of the undulating rises of Gatton Sandstone, Koukandowie Formation and Marburg Formation. Brisbane River in-flows at the confluence of the two drainage systems are constricted during flood events. This has created an extensive alluvial floodplain of elevated terrace plains, drainage depressions, backplains and swamps at Wivenhoe Pocket, Lowood and Fernvale. The construction of Wivenhoe Dam has disrupted these flow events, reducing the current supply of sediment from up river. Sediment in this landscape is now sourced predominantly from the Lockyer Valley. Agricultural production and turf farming are dominant land uses in these areas, and there is significant land use pressure for residential development. Erosion, salinity and water quality issues associated with sediment and nutrient delivery to the Brisbane River and Moreton Bay are significant land degradation issues for these landscapes.

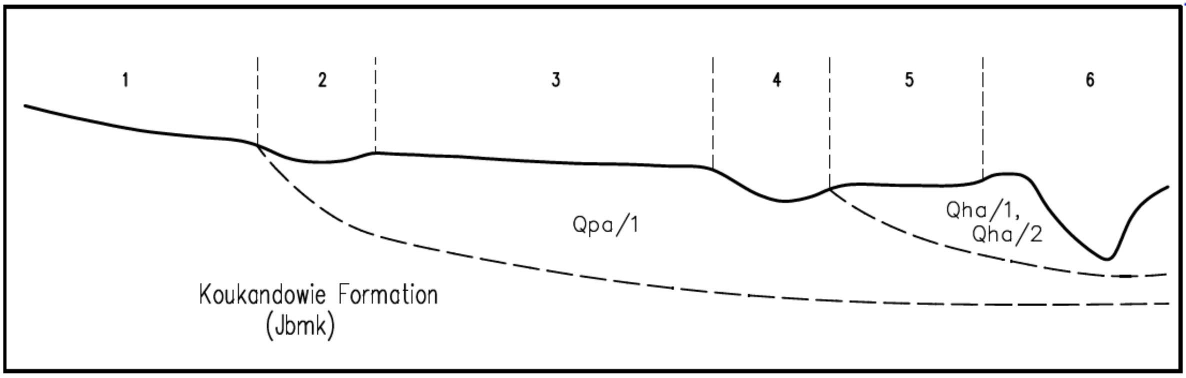
Landscape 1: Gatton Sandstone with Brisbane River alluvium, Wivenhoe Pocket

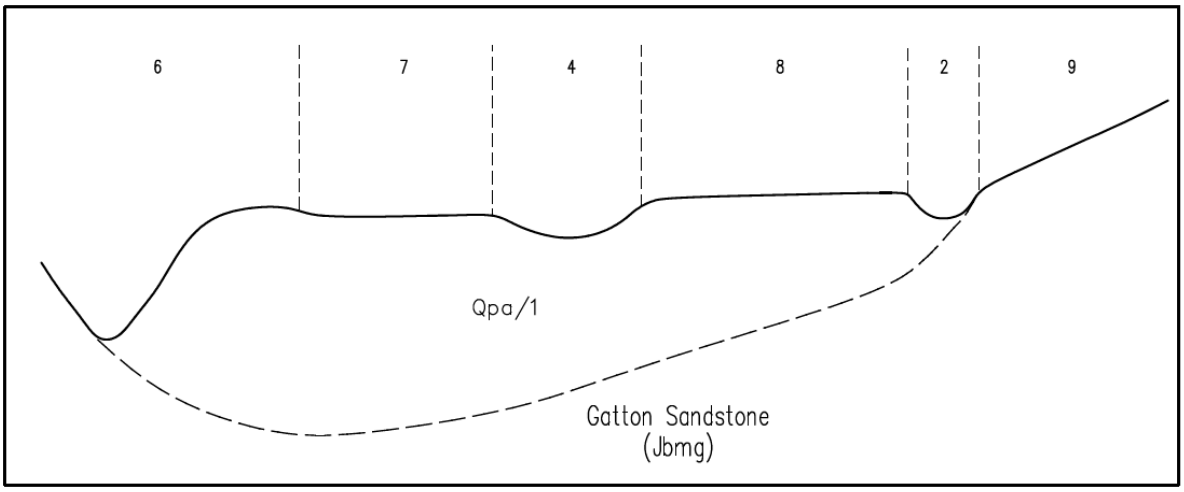




Unit	Landform	Soil Description	Soil Profile Class
1	Levees, terrace flats and channel benches. Slopes 1–3%.	Very deep, neutral brown loamy soils over buried horizons on recent alluvium. Well drained. Very deep, sandy textured soils on alluvium over buried horizons on recent alluvium. Rapidly drained.	**Honey** (Brown/Black Kandosol, Brown-orthic Tenosol) **Cressbrook** (Stratic Rudosol)
2	Channel benches and terrace plains. Slopes 0.5–2%.	Very deep, neutral brown texture contrast or gradational soils on alluvium. Subsoils are moderately structured sandy clays, over buried horizons. Occasionally sodic at depth. Moderately well drained.	**Gallanani** (Brown Chromosol/ Dermosol)
3	Drainage depressions. Slopes 0–2%.	Very deep, neutral brown texture contrast or gradational soils on alluvium. Subsoils are frequently mottled and/or sodic at depth. Imperfectly drained or occasionally moderately well drained.	**Gunyah** (Brown Chromosol/ Dermosol)
4	Drainage depressions, backplains and swamps. Slopes 0–2%.	Very deep, alkaline/neutral grey/brown, sodic texture contrast or gradational soils on alluvium. Imperfectly drained.	**Spencer** (Brown/Grey Sodosol) **Gunyah** Brown Chromosol/ Dermosol
5	Drainage depressions. Slopes 0–3%.	Very deep, alkaline grey cracking clay soils on alluvium. Moderately saline at depth. Imperfectly drained.	**Basel** (Grey Vertosol)
6	Mid and lower slopes of rises. Slopes 1–15%.	Deep, mottled neutral to acidic grey and brown soils with sodic subsoil on sandstone. Often slightly to moderately saline at depth. Imperfectly drained.	**Lowood** (Brown/Grey Sodosol/ Kurosol)
7	Terrace plains and plains. Slopes 1–3%.	Very deep, alkaline, self-mulching black cracking clay soils with slightly sodic subsoils on older alluvium. Occasional slight to moderate salinity at depth. Moderately well or, occasionally imperfectly drained.	**Cooeeimbardi** (Black Vertosol)
8	Terrace flats and plains. Slopes 0.5–2%.	Very deep, neutral, strongly structured black non-cracking clay soils on alluvium. Moderately well drained.	**Gira Gira** (Black/Brown Dermosol)

Landscape 2: Gatton Sandstone, Koukandowie Formation and Brisbane River, Lockyer Creek alluvium





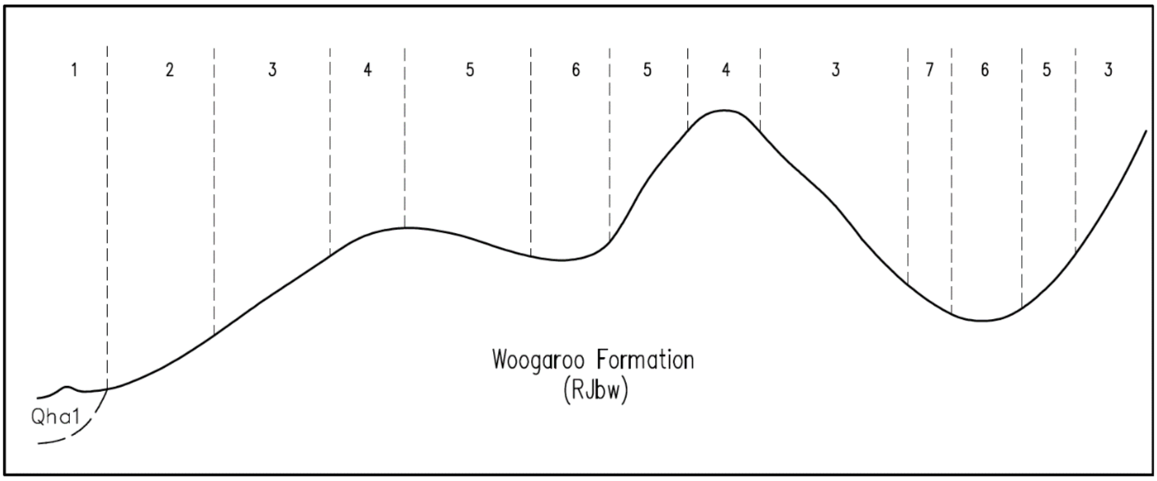
Unit	Landform	Concept	Soil
1	Lower and mid slopes of rises, low hills and hills. Slopes 1–10%.	Deep, alkaline brown, black or occasionally yellow sodic texture contrast soils with mottled calcic subsoil on siltstone or sandstone. Often slightly to moderately saline. Imperfectly drained.	**Koukandowie** (Black/Brown/Yellow Sodosol)
2	Drainage depressions. Slopes 0–3%.	Very deep alkaline grey cracking or non-cracking clay soils on alluvium. Moderately saline at depth. Imperfectly drained. Very deep alkaline, sodic grey/brown texture contrast soils on alluvium. Imperfectly drained.	**Basel** (Grey Vertosol/ Dermosol) **Spencer** (Brown/Grey Sodosol)
3	Backplains and swamps. Slopes 0–2%.	Very deep, alkaline, calcic black, brown and grey cracking clay and non-cracking clay soils (with vertic properties) on alluvium. Subsoils are grey, or transition to brown moderately saline and sodic. Imperfectly drained.	**Glamorgan** (Black/Brown Vertosol/ Dermosol) **Tuckerimba** (Grey Vertosol)
4	Drainage depressions. Slopes 0–3%.	Very deep, alkaline/neutral, grey/brown, sodic texture contrast or gradational soils on older alluvium. Imperfectly drained.	**Spencer** (Brown/Grey Sodosol) **Gunyah** Brown Chromosol/ Dermosol
5	Terrace plains. Slopes 0–3%.	Very deep, neutral black/brown gradational soils with clay loam surface on alluvium. Subsoils are moderately structured clay soils over buried horizons. Occasionally sodic at depth. Moderately well drained.	**Monsildale** (Brown/Black Dermosol)

6	Levees, terrace flats and channel benches. Slopes 1–4%.	Very deep neutral brown sandy or loamy soils over buried horizons on recent alluvium. Well to rapidly drained.	**Honey** (Brown Kandosol, Brown-orthic Tenosol) **Cressbrook** (Brown Orthic Tenosol, Stratic Rudosol)
7	Terrace plains. Slopes 0–3%.	Very deep neutral brown texture contrast or gradational soils. Sandy clay loam surfaces over moderately structured clay loam or light clays, over buried horizons. Occasionally sodic at depth. Moderately well drained.	**Gallanani** (Brown Chromosol/ Dermosol)
8	Backplains and swamps on floodplains. Slopes 0–2%.	Very deep neutral to acidic, grey or brown mottled texture contrast soils on alluvium. Imperfectly drained.	**Glencairn** (Grey/Brown Kurosol/ Sodosol)
9	Mid and lower slopes of rises Slopes 1–10%.	Deep, neutral to acidic grey or brown sodic texture contrast soils on sandstone. Subsoils are mottled and often slightly to moderately saline at depth. Imperfectly drained.	**Lowood** (Brown/Grey Sodosol/ Kurosol)

Rises and low hills on Woogaroo Subgroup, Esk Formation and Neara Volcanics, Esk

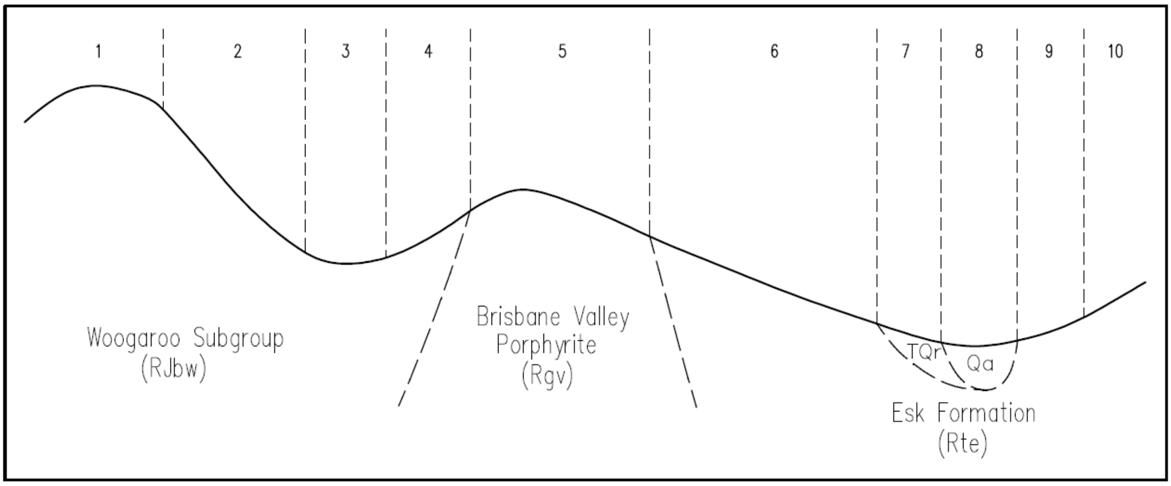
Distributed from west of Esk, south to Mount Hallen, and east to Wivenhoe Dam, this landscape is formed by the weathering, dissection and erosion of exposed rocks of the Woogaroo subgroup, Esk Formation and Neara Volcanics. It comprises undulating or rolling rises, low hills and rolling hills. Redbank creek meanders through the unit, as do many smaller drainage systems that discharge into Wivenhoe Dam. Agricultural production is the dominant land use on the Red, Brown and Yellow Kandosols and Chromosols south of Esk. The soils closer to Wivenhoe Dam are prone to erosion if exposed and there are expressions of salinity in many drainage lines. This has implications for water quality due to sedimentation and resultant nutrient delivery to Wivenhoe Dam.

Landscape 1: Woogaroo Subgroup on rises and low hills



Unit	Landform	Soil Description	Soil Profile Class
1	Terrace flats and levees. Slopes 0.5–2%.	Very deep, sandy soils on recent alluvium over buried horizons. Small pockets of red earthy clay loam soils are included. Well to rapidly drained.	**Cressbrook** (Red/Brown Orthic Tenosol, Red Kandosol, Stratic Rudosol)
2	Lower slopes on rises, low hills and hills. Slopes 1–10%.	Very deep red earthy sandy soils on quartzose sandstone. Dominated by loamy sand to sandy clay loam textures. Well to rapidly drained.	**Hibiscus Light Phase** Red Kandosol, Red-orthic Tenosol
3	Upper, mid and lower slopes on rises, low hills and hills. Slopes 2–20%.	Deep and very deep red earthy gradational soils on quartzose sandstone. Well drained.	**Hibiscus** (Red Kandosol, occasional Red Chromosol)
4	Hillcrests and upper slopes of rises, low hills and hills. Slopes 1–10%.	Shallow, earthy soils on quartzose sandstone weathering in situ from 0.1 m. Well to rapidly drained.	**Hallen** (Red/Brown Orthic Tenosol, Red/Brown Kandosol)
5	Mid and lower slopes (occasionally upper slopes) on rises, low hills and hills. Slopes 1–15%.	Deep yellow or brown earthy texture contrast or gradational soils on quartzose sandstone. Moderately well to imperfectly drained.	**Yellowbank** (Yellow/Brown Kandosol/Chromosol)
6	Lower slopes and drainage depressions where drainage is impeded. Slopes 2–15%.	Moderately deep to deep, neutral/acidic grey or yellow sodic texture contrast soils with massive subsoils and bleached A2 horizon on quartzose sandstone. Imperfectly drained.	**Quinine** (Grey/Yellow Sodosol/Kurosol)
7	Lower and mid slopes on rises, low hills and hills. Slopes 1–10%.	Moderately deep yellow or brown earthy soils on quartzose sandstone. Dominated by loamy sand to sandy clay loam textures. Moderately well drained.	**Yellowbank Light Phase** (Yellow/Brown-orthic Tenosol, Yellow/ Brown Kandosol)

Landscape 2: Woogaroos, Brisbane Valley Porphyrite and Esk Formation



Unit	Landform	Soil Description	Soil Profile Class
1	Hillcrests and upper slopes of rises, low hills and hills. Slopes 1–10%.	Shallow, earthy soils with massive structure, on quartzose sandstone weathering in situ from 0.1 m. Rapidly to well drained.	**Hallen** (Red/Brown Orthic Tenosol, Red/Brown Kandosol)
2	Upper, mid and lower slopes on rises, low hills and hills. Slopes 3–20%.	Deep to very deep red, yellow and brown earthy texture contrast or gradational soils on quartzose sandstone. Moderately to well drained.	**Hibiscus** (Red Kandosol/ Red Chromosol) **Yellowbank** (Yellow/ Brown Kandosol/ Chromosol)
3	Lower slopes and drainage depressions. Slopes 1–15%.	Moderately deep to deep, neutral/acidic grey or yellow sodic texture contrast soils with massive subsoils and bleached A2 horizon on quartzose sandstone. Imperfectly drained.	**Quinine**[6] (Grey/Yellow Sodosol/Kurosol)
4	Mid and lower slopes on undulating or rolling rises and low hills. Slopes 3–15%.	Deep to very deep red, yellow or brown earthy texture contrast or gradational soils on quartzose sandstone. Many nodular ferromanganiferous segregations from 0.3 m. Moderately well to imperfectly drained.	**Hibiscus, nodular variant** (Red Kandosol) **Yellowbank, nodular variant**[7] Yellow/ Brown Kandosol/ Chromosol)
5	Upper and mid slopes of low hills. Slopes 10–20%.	Shallow to moderately deep, neutral, texture contrast soils with sandy clay loam surface over black or grey moderately structured light clay on diorite. Imperfectly drained.	**Linville**[8] (Grey/Black Chromosol)
6	Mid slopes of rises and low hills. Slopes 2–15%.	Moderately deep to deep, black, brown or grey cracking or non-cracking clay soils on sandstone, shale or conglomerate. Subsoils are calcic, sodic, vertic and moderately saline at depth. Moderately well to imperfectly drained.	**Beer** (Black/Brown/Grey Vertosol/ Dermosol)
7	Lower slopes of rises and low hills. Slopes 1–10%.	Very deep, alkaline sodic, brown texture contrast soils on sandstone, conglomerate or colluvium. Subsoils are calcic, vertic and mottled. Imperfectly drained, often eroded.	**Beppo/Beppo eroded phase** (Brown/Grey Sodosol)
		Very deep, brown or grey cracking clay soils on sandstone, shale, conglomerate or colluvium. Subsoils are calcic, sodic, vertic and moderately saline at depth. Imperfectly drained, often eroded.	**Beer/Beer eroded Phase** (Brown/Grey Vertosol/Dermosol)

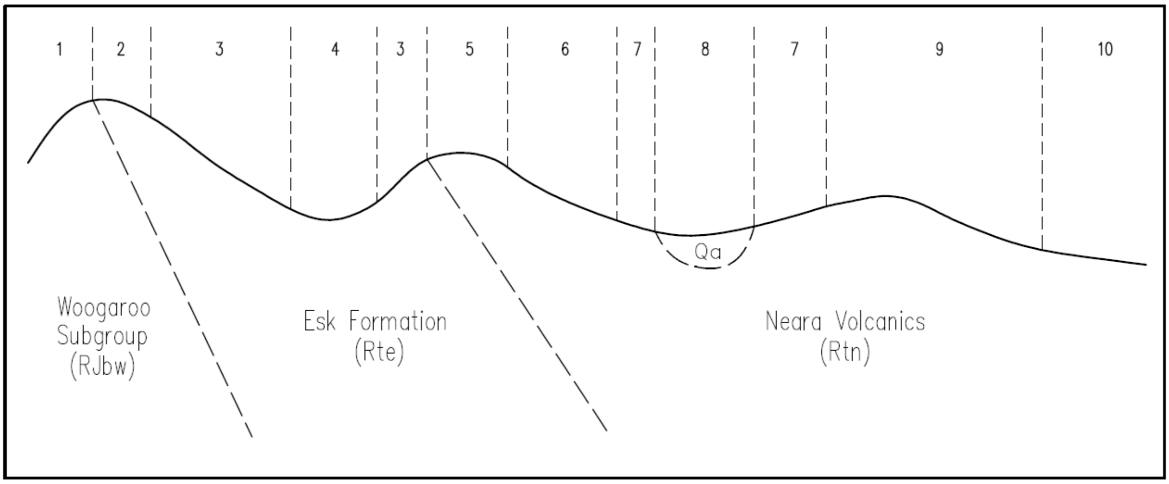
[6] Quinine also occurs on plains and drainage depressions on gently undulating plains where drainage is impeded.

[7] Yellowbank nodular variant also occurs on plains on gently undulating plains where drainage is impeded.

[8] Linville is shallow in an upper slope position.

8	Drainage depressions. Slopes 0.5–2%.	Very deep alkaline grey, calcic, cracking clay and non-cracking clay soils with vertic properties on local alluvium. Moderately saline at depth. Imperfectly drained.	**Basel** (Grey Dermosol/ Grey Vertosol)
9	Lower slopes of rises and low hills. Slopes 1–10%.	Moderately deep, brown texture contrast or gradational soils on sandstone or conglomerate. Frequent pale or sporadically bleached A2 horizon. Often sodic and vertic in lower subsoil. Moderately well to imperfectly drained.	**Watt** (Brown Chromosol/ Dermosol)
		Very deep, alkaline sodic, brown texture contrast soils on sandstone or conglomerate. Subsoils are calcic, vertic and mottled. Imperfectly drained.	**Beppo** (Brown/Grey Sodosol)
10	Mid and upper hill-slopes of rises and low hills. Slopes 2–15%.	Moderately deep, neutral black or brown non-cracking clay soils on sandstone or shale. Moderately well drained.	**Moombra** (Black/Brown Dermosol)

Landscape 3: Woogaroos, Esk Formation and Neara Volcanics, Esk

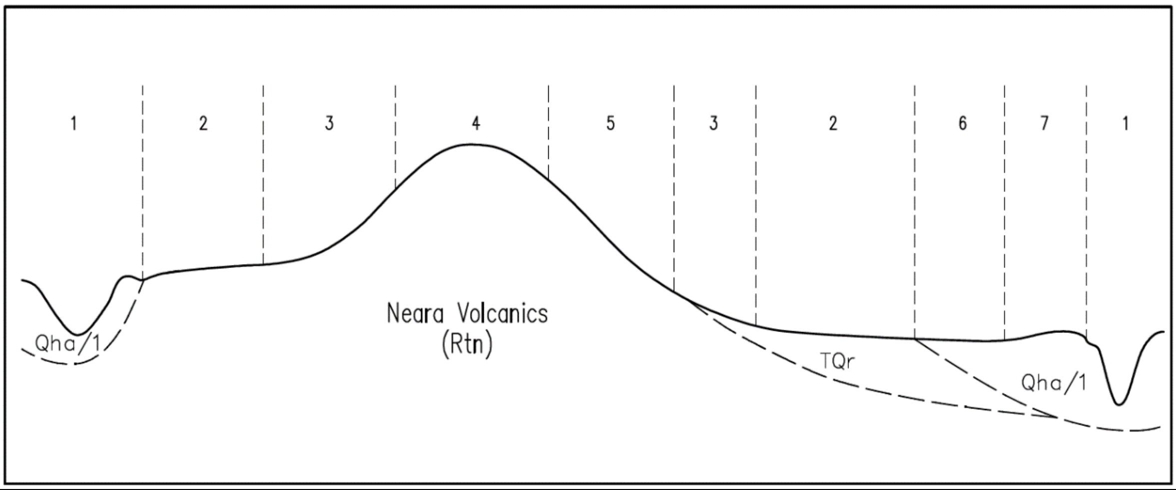


Unit	Landform	Soil Description	Soil Profile Class
1	Crests and upper slopes of hills. Slopes 2–15%.	Shallow, earthy soils on quartzose sandstone weathering in situ from 0.1 m. Rapidly drained.	**Hallen** (Red/Brown Orthic Tenosol, Red/Brown Kandosol)
2	Crests and upper slopes of rises, hills and low hills. Slopes 5–40%.	Very shallow, neutral loamy soils on quartzose sandstone weathering in situ from 0.1 m. Well to rapidly drained.	**Grienke** (Leptic Tenosol)
3	Mid and lower hillslopes of rises and low hills. Slopes 2–15%.	Moderately deep to deep, black, brown or grey cracking or non-cracking clay soils on sandstone, shale or conglomerate. Subsoils are calcic, sodic, vertic and moderately saline at depth. Moderately well to imperfectly drained.	**Beer** (Black/Brown/Grey Vertosol/ Dermosol)
4	Mid, lower and foot slopes of rises and low hills. Slopes 2–15%.	Very deep, alkaline sodic, brown or grey texture contrast soils on sandstone or conglomerate. Subsoils are calcic, vertic and mottled. Imperfectly drained.	**Beppo** (Brown/Grey Sodosol)
5	Crests and upper slopes of rolling rises and low hills. Slopes 1–25%	Shallow or very shallow, neutral brown loamy soil on andesite or volcanoclastic conglomerate. Moderately well to well drained.	**D'Aguilar** (Leptic Tenosol)
6	Upper and mid slopes of rises and low hills. Slopes 5–15%.	Shallow to moderately deep gradational soils on andesite or volcanoclastic conglomerate. Clay loam to light clay surface. Moderately well drained.	**Neara** (Brown Dermosol) **Neara Shallow Phase** (Brown Dermosol)
7	Mid and lower slopes of rises and low hills. Slopes 1–10%.	Deep, black or brown sodic and non-sodic texture contrast or gradational soils on andesite or volcanoclastic conglomerate. Bleached sub-surface. Moderately well to imperfectly drained.	**Dunwich** (Brown/Black Chromosol) **Moore** (Grey/Black Sodosol/ Dermosol)
8	Drainage depressions and terrace flats. Slopes 0.5–2%.	Very deep alkaline grey, calcic, cracking clay and non-cracking clay soils with vertic properties on local alluvium. Moderately saline at depth. Imperfectly drained.	**Basel** (Grey Vertosol/ Dermosol)
9	Upper and mid slopes of rises and low hills. Slopes 10–20%.	Shallow to moderately deep texture contrast or gradational soils on andesite or volcanoclastic conglomerate. Sandy clay loam surface. Moderately well drained.	**Linville** (Brown Chromosol/ Dermosol)
10	Flats, footslopes and lower slopes of rises and plains. Slopes 1–3%.	Very deep non-sodic texture contrast or gradational soils. Loamy surface over structured brown sandy clay on andesite or volcanoclastic conglomerate, often vertic at depth. Moderately well drained.	**Avoca** (Brown Chromosol/ Dermosol)

Hills and Low Hills of Neara Volcanics with Alluvium, Avoca Vale

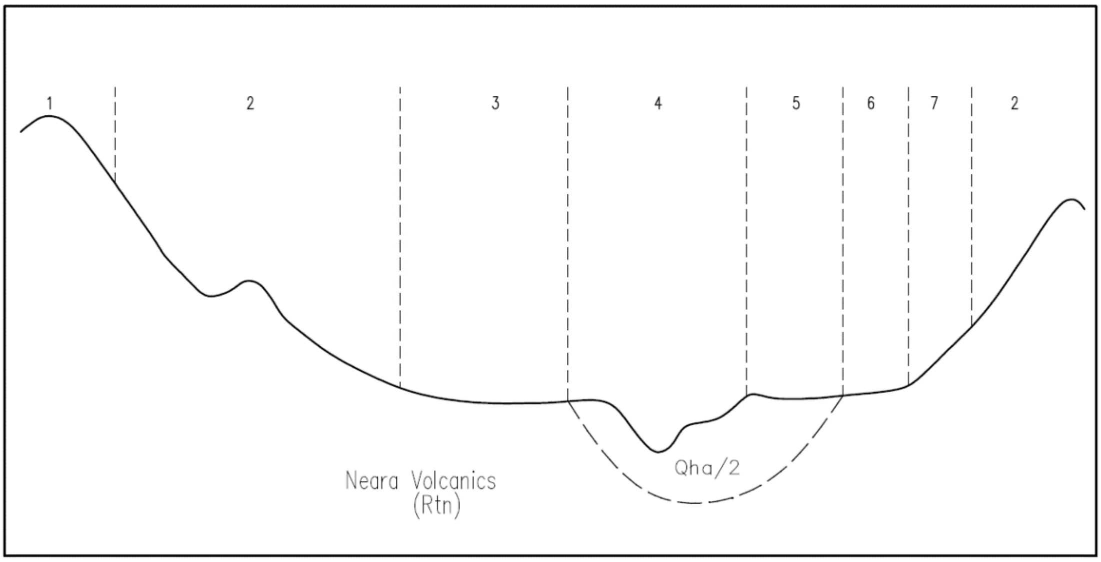
Distributed south from Mount Stanley to the intersection of Avoca Creek with the Brisbane River, this landscape was formed from the weathering, dissection and erosion of exposed rocks of the Neara Volcanics. It comprises undulating or rolling rises, low hills and hills. The east and west branches of the Brisbane River and Avoca Creek meander through the unit. Alluvial soils occupy the backplains, swamps and drainage depressions, terrace plains and terrace flats of the alluvial floodplain. Terrace plains are broader at the confluence of drainage systems, where streams are constricted during peak flows, and narrow where the river reaches are constricted by hard rock geology. Valley flats of minor drainage systems discharge directly into the Brisbane River during major rainfall events.

Landscape 1: Neara Volcanics and alluvium



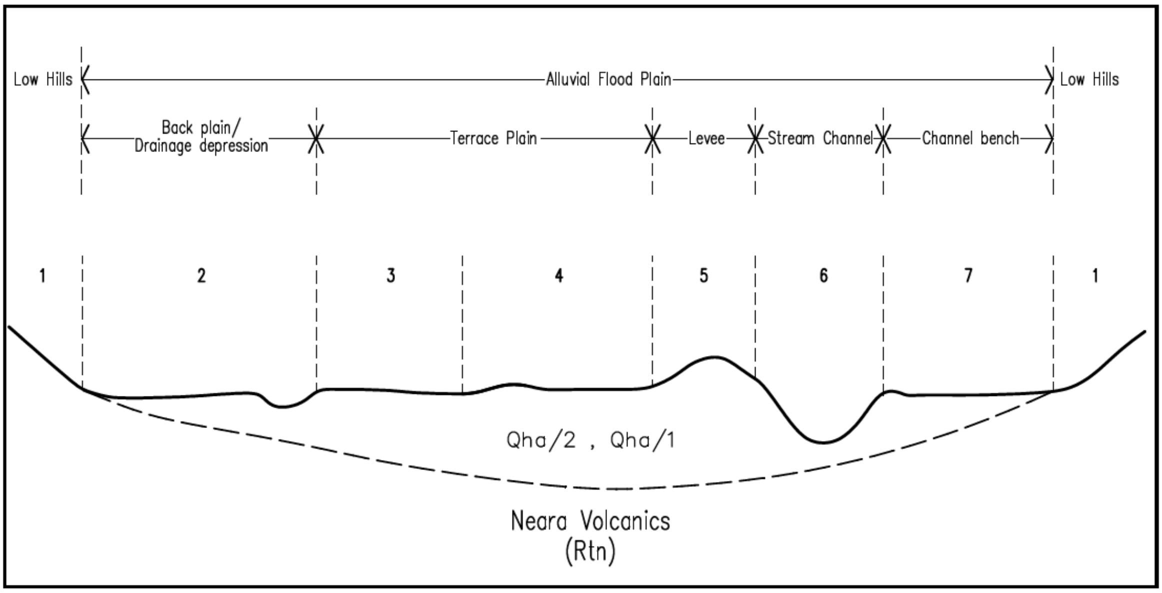
Unit	Landform	Soil Description	Soil Profile Class
1	Channel benches and levees on floodplains. Slopes 0.5–2%.	Very deep, sandy textured soils over buried horizons and gravel on recent alluvium. Rapidly drained.	**Cressbrook, Cressbrook Rocky Phase** (Stratic Rudosol)
2	Flats, footslopes and lower slopes of plains and rises. Slopes 1–3%.	Very deep texture contrast or gradational soils on andesites, volcanoclastic conglomerates or associated colluvium. Loamy surface over moderately structured neutral brown sandy. Moderately well drained.	**Avoca** (Brown Chromosol/ Dermosol)
3	Mid, lower slopes and footslopes of low hills and rises. Slopes 1–10%.	Deep, black, brown or grey sodic and non-sodic texture contrast or gradational soils on andesites, volcanoclastic conglomerates or associated colluvium. Bleached A2 horizon. Imperfectly or moderately well drained.	**Dunwich** (Brown/Black Chromosol) **Moore** (Grey/Black Sodosol/ Dermosol)
4	Crests and upper slopes of low hills. Slopes 3–10%.	Shallow to moderately deep non-sodic texture contrast or gradational soils on andesite or volcanoclastic conglomerate. Sandy clay loam surface. Moderately well drained.	**Linville** (Brown Chromosol/ Dermosol)
5	Upper and mid slopes of low hills and rises. Slopes 10–20%.	Moderately deep gradational soils on andesite or volcanoclastic conglomerate. Clay loam to light clay surfaces. Moderately well drained.	**Neara** (Brown Dermosol)
6	Terrace plain. Slopes 0.5–2%.	Very deep, neutral brown texture contrast or gradational soils on alluvium. Subsoils are moderately structured sandy clays, over buried horizons. Occasionally sodic at depth. Moderately well drained.	**Gallanani** (Brown Chromosol/ Dermosol)
7	Levees and terrace flats. Slopes 1–3%.	Very deep neutral brown loamy soils over buried horizons on alluvium. Well drained.	**Honey** (Brown Kandosol, Brown-orthic Tenosol)

Landscape 2: Hillslopes and valley flats of the Neara Volcanics



Unit	Landform	Soil Description	Soil Profile Class
1	Crests and upper slopes of hills and low hills. Slopes 1–25%.	Shallow or very shallow, neutral brown loamy soils on andesite or volcanoclastic conglomerate. Moderately well to well drained.	**D'Aguilar** (Leptic Tenosol)
2	Crests, upper and mid slopes of hills and low hills. Slopes 1–20%.	Shallow to moderately deep gradational soils on andesite or volcanoclastic conglomerate. Clay loam to light clay surfaces. Moderately well drained.	**Neara** (Brown Dermosol) **Neara Shallow Phase** (Brown Dermosol)
3	Lower slopes and footslopes of hills and low hills. Slopes 1–3%.	Very deep, alkaline black or brown cracking clay soils on andesites. Often sodic at depth. Moderately well drained.	**Jimna** (Black/Brown Vertosol)
4	Drainage depressions. Slopes 0–2%.	Very deep, alkaline, grey or brown, sodic texture contrast soils, with conspicuously bleached A2 horizon. Subsoils are calcic and mottled. Imperfectly drained.	**Spencer** (Grey/Brown Sodosol)
5	Levees, terrace flats and flats. Slopes 0–2%.	Very deep neutral brown loamy soils over buried horizons on alluvium. Well drained.	**Honey** (Brown/Black Kandosol, Brown-orthic Tenosol)
6	Flats, footslopes and lower slopes of hills and low hills. Slopes 1–3%.	Very deep texture contrast or gradational soils on andesite or volcanoclastic conglomerate. Loamy surface over moderately structured neutral brown sandy. Moderately well drained.	**Avoca** (Brown Chromosol/ Dermosol)
7	Mid, lower and footslopes of hills and low hills. Slopes 1–10%.	Deep, black, brown or grey sodic and non-sodic texture contrast or gradational soils on andesite or volcanoclastic conglomerate. Bleached A2 horizon. Imperfectly or moderately well drained.	**Dunwich** (Brown/Black Chromosol) **Moore** (Grey/Black Sodosol/ Dermosol)

Landscape 3: Brisbane River and Avoca Creek alluvium with Neara Volcanics

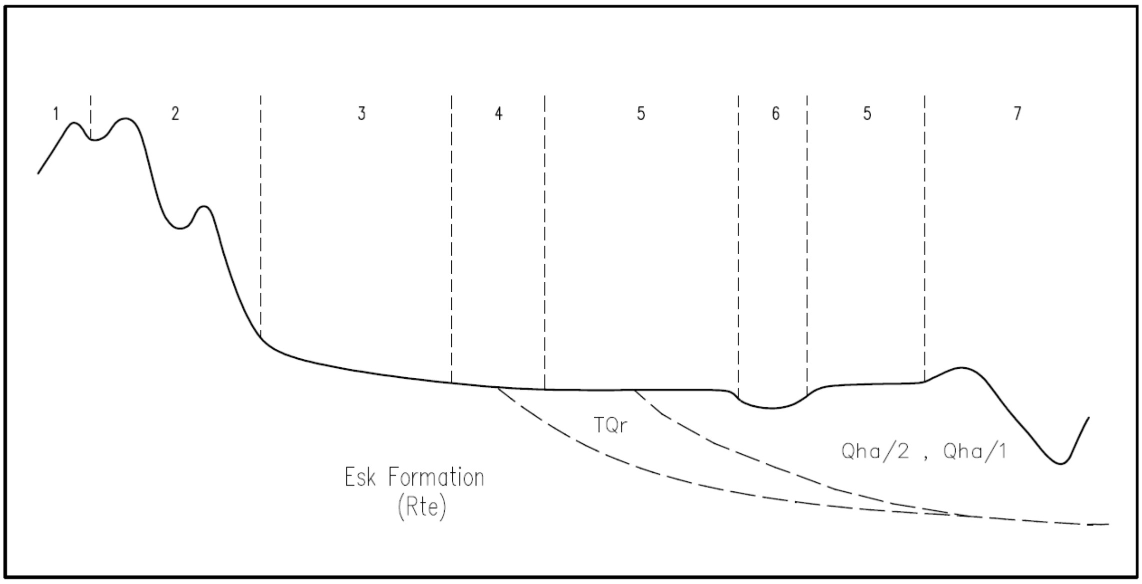


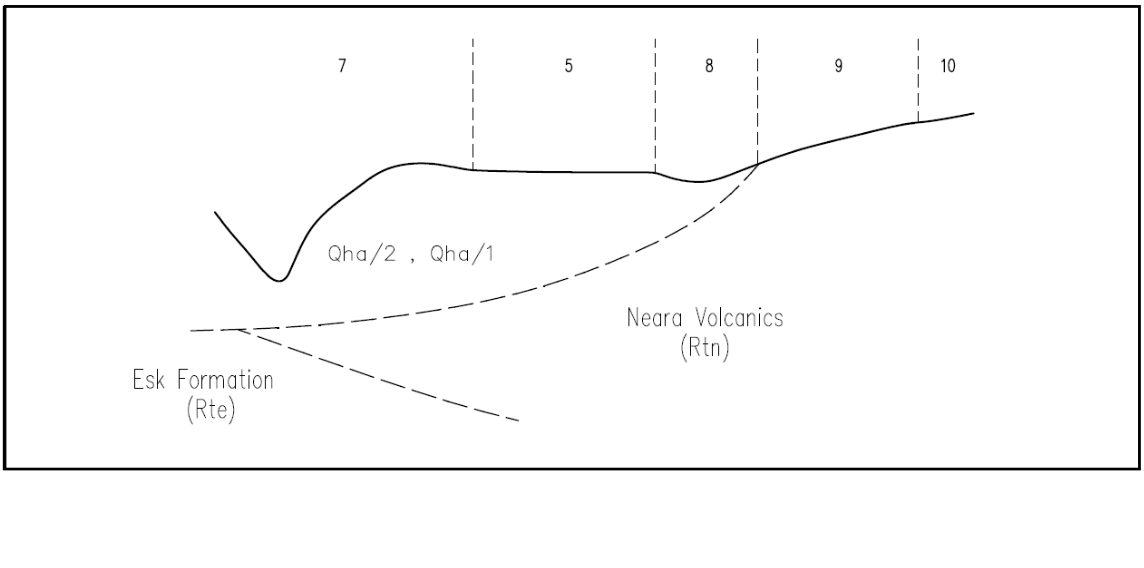
Unit	Landform	Soil Description	Soil Profile Class
1	Lower and footslopes of low hills and hills. Slopes 1– 10%.	Deep to very deep, black, brown or grey sodic and non-sodic texture contrast or gradational soils on andesite or volcanoclastic conglomerate. Bleached A2 horizon. Imperfectly or moderately well drained.	**Dunwich** (Brown/Black Chromosol) **Moore** (Grey/Black Sodosol/ Dermosol)
2	Drainage depressions and backplains. Slopes 0–2%.	Very deep alkaline, grey or brown, sodic texture contrast soils, with a conspicuously bleached A2 horizon. Subsoils are calcic and mottled. Imperfectly drained.	**Spencer** (Brown/Grey Sodosol)
3	Terrace plains. Slopes 0.5–2%.	Very deep, neutral black/brown gradational soils with clay loam surfaces on alluvium. Subsoils are moderately structured clay soils over buried horizons. Occasionally sodic at depth. Moderately well drained.	**Monsildale** (Brown/Black Dermosol)
4	Terrace plains and relic levees. Slopes 0.5–2%.	Very deep, neutral brown texture contrast or gradational soils on alluvium. Subsoils are moderately structured sandy clays, over buried horizons. Occasionally sodic at depth. Moderately well drained.	**Gallanani** (Brown Chromosol/ Dermosol)
5	Levees. Slopes 1–3%.	Very deep neutral brown loamy soils over buried horizons on alluvium. Well drained.	**Honey** (Brown/Black Kandosol, Brown-orthic Tenosol)
6	Channel benches, stream channel and levees. Slopes 0.5–2%.	Very deep neutral brown sandy and loamy soils over buried horizons on recent alluvium. Many large cobbles and pebbles within buried horizons. Well to rapidly drained.	**Honey Rocky Phase** (Brown-orthic Tenosol, Stratic Rudosol) **Cressbrook** (Stratic Rudosol
7	Plains and channel benches. Slopes 0.5–2%.	Very deep neutral, strongly structured black non-cracking clay soils over buried horizons on recent alluvium. Frequently with many large cobbles and pebbles in buried horizons. Moderately well drained.	**Gira Gira** (Black/Brown Dermosol) **Gira Gira Rocky Phase** (Black/Brown Dermosol)

Hills and Low hills of the Esk Formation and Neara Volcanics with Alluvium, Avoca Vale

Distributed from Cooyar Creek to Muddy Creek, this landscape is formed from the weathering, dissection and erosion of exposed rocks of the Esk Formation and Neara Volcanics. It comprises undulating or rolling rises, low hills and hills. Cooyar and Muddy Creek meander through the unit. The Brisbane River often forms the boundary between the softer Esk Formation and the more resistant Neara Volcanics. Valley flats of minor drainage systems discharge directly into Cooyar Creek, Muddy Creek and the Brisbane River during major rainfall events. Terrace plains are broader at the confluence of major drainage systems where flows are constricted during peak events and narrow where the river reaches are confined by the underlying hard rock geology.

Landscape 1: Esk Formation and Neara Volcanics with alluvium





Unit	Landform	Soil Description	Soil Profile Class
1	Crests and upper slopes of hills and low hills. Slopes 5–35%.	Very shallow, neutral gradational loamy soils on sandstone or conglomerate weathering in situ from 0.1 m. Rapidly drained.	**Grienke** (Leptic Tenosol)
2	Crests, upper and mid slopes of hills, low hills and rises. Slopes 10–40%.	Moderately deep, neutral red or brown texture contrast or gradational soils on sandstone or conglomerate. Frequent sporadic bleach. Moderately well drained or well drained.	**Kipper** (Red Chromosol/ Dermosol) **Lakeview** (Brown Chromosol/ Dermosol)
3	Mid, lower and footslopes of rolling rises and low hills. Slopes 5–25%.	Moderately deep, brown texture contrast or gradational soils on sandstone or conglomerate. Frequent pale or sporadically bleached A2 horizon. Often sodic and vertic in lower subsoil.	**Watt** (Brown Chromosol/ Dermosol)
4	Mid, lower slopes and foot slopes of rises and low hills. Slopes 2–10%.	Very deep, alkaline sodic, brown texture contrast soils on sandstone or conglomerate. Subsoils are calcic, vertic and mottled. Imperfectly drained. Very deep, black or brown cracking and non-cracking clay on sandstone or conglomerate. Subsoils are slightly sodic and vertic. Moderately well drained to imperfectly drained	**Beppo** (Grey/Brown Sodosol) **Beer** (Black/Brown Vertosol/Dermosol)
5	Terrace plains. Slopes 0.5–2%.	Very deep, neutral brown texture contrast or gradational soils on alluvium. Subsoils are moderately structured sandy clays, over buried horizons. Occasionally sodic at depth. Moderately well drained.	**Gallanani** (Brown Chromosol/ Dermosol)
6	Drainage depressions. Slopes 0–2%.	Alkaline, grey or brown, sodic texture contrast soils, with a conspicuously bleached A2 horizon. Subsoils are calcic and mottled. Imperfectly drained.	**Spencer** (Brown/Grey Sodosol)
7	Channel benches and levees. Slopes 0.5–3%.	Very deep neutral brown sandy or loamy soil over buried horizons and/or many large cobbles and pebbles on recent alluvium. Rapidly to well drained.	**Honey** (Brown Kandosol, Brown-orthic Tenosol) **Honey Rocky Phase** (Brown-orthic Tenosol, Stratic Rudosol) **Cressbrook** (Brown Orthic Tenosol, Stratic Rudosol)
8	Drainage depressions and backplains. Slopes 0.5–2%.	Very deep, neutral brown texture contrast or gradational soils on alluvium. Subsoils are frequently mottled and/or sodic at depth. Imperfectly drained or occasionally moderately well drained.	**Gunyah** (Brown Chromosol/ Dermosol)
9	Mid, lower and footslopes of hills and low hills. Slopes 1–10%.	Deep to very deep, black, brown or grey sodic and non-sodic texture contrast or gradational soils on andesite or volcanoclastic conglomerate. Bleached A2 horizon. Imperfectly or moderately well drained.	**Dunwich** (Brown/Black Chromosol) **Moore** (Grey/Black Sodosol/ Dermosol)
10	Mid slopes of low hills and rises. Slopes 3–20%.	Shallow to moderately deep texture contrast or gradational soils on andesite or volcanoclastic conglomerate. Sandy clay loam to light clay surface. Moderately well drained.	**Neara** (Brown Dermosol) **Linville** (Brown Chromosol/ Dermosol)

11. Agricultural Land Suitability

The *Guidelines for agricultural land evaluation in Queensland—2nd Edition* (DSITI and DNRM 2015) provide the framework and procedures for the determination of agricultural land suitability in Queensland. A land suitability assessment considers a series of alternative agricultural uses and identifies land management requirements for sustainable use. The land suitability information produced in this project does not give preference to a particular agricultural use of the land. However, it can be used to determine if the land is generally suitable for sustainable agricultural production.

The *Regional Land Suitability Frameworks for Queensland* (DNRM and DSITIA 2013) provide the detail for assessing which crops are suitable for individual areas of land. These frameworks have been tailored for individual regional areas. This project falls within the Inland SEQ framework area. The Inland SEQ framework has been slightly modified and updated for this project to tailor the suitability to the characteristics of the Brisbane River catchment area.

Using the SEQE Suitability Framework, the soil and land attributes have been evaluated based on a series of specified land use requirements, using current technology and management practices. Socio-economic factors were considered in general terms only, and water is considered to be available, unless otherwise specified in the land use considered. Irrigation is based on spray or drip irrigation only. Land suitability classes do not equate to actual crop yields or costs. Refer to the *Guidelines for agricultural land evaluation in Queensland—2nd Edition* for further explanation. The SEQE Suitability Framework and its components are included in Appendix 4.

Land Evaluation

Land resource information collected during the project was used to determine crop suitability for the 38 land uses listed in the land suitability framework. The 14 land use limitations (Table 4) were applied across the 367 UMAs in the project area according to the *Guidelines for agricultural land evaluation in Queensland*. 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 5. Land suitability maps for Lucerne (Figure 60) and Cucurbits (Figure 61) are attached. Additional land suitability maps are included in Appendix 6.

Table 4 Land use limitations

Climate – frost and precipitation (using long term data from Bureau of Meteorology)
Water erosion risk
Flooding
Water availability (plant available water capacity - soil water storage)
Nutrient deficiency (derived from laboratory analysis)
Element toxicity (pH)
Soil depth
Soil surface condition (based on site data)
Rockiness (maximum profile coarse fragments)
Soil salinity (based on site data)
Micro-relief (based on site data)
Slope (based on safe use of machinery)
Profile wetness (drainage and permeability)
Landscape complexity (based on UMA area and location)

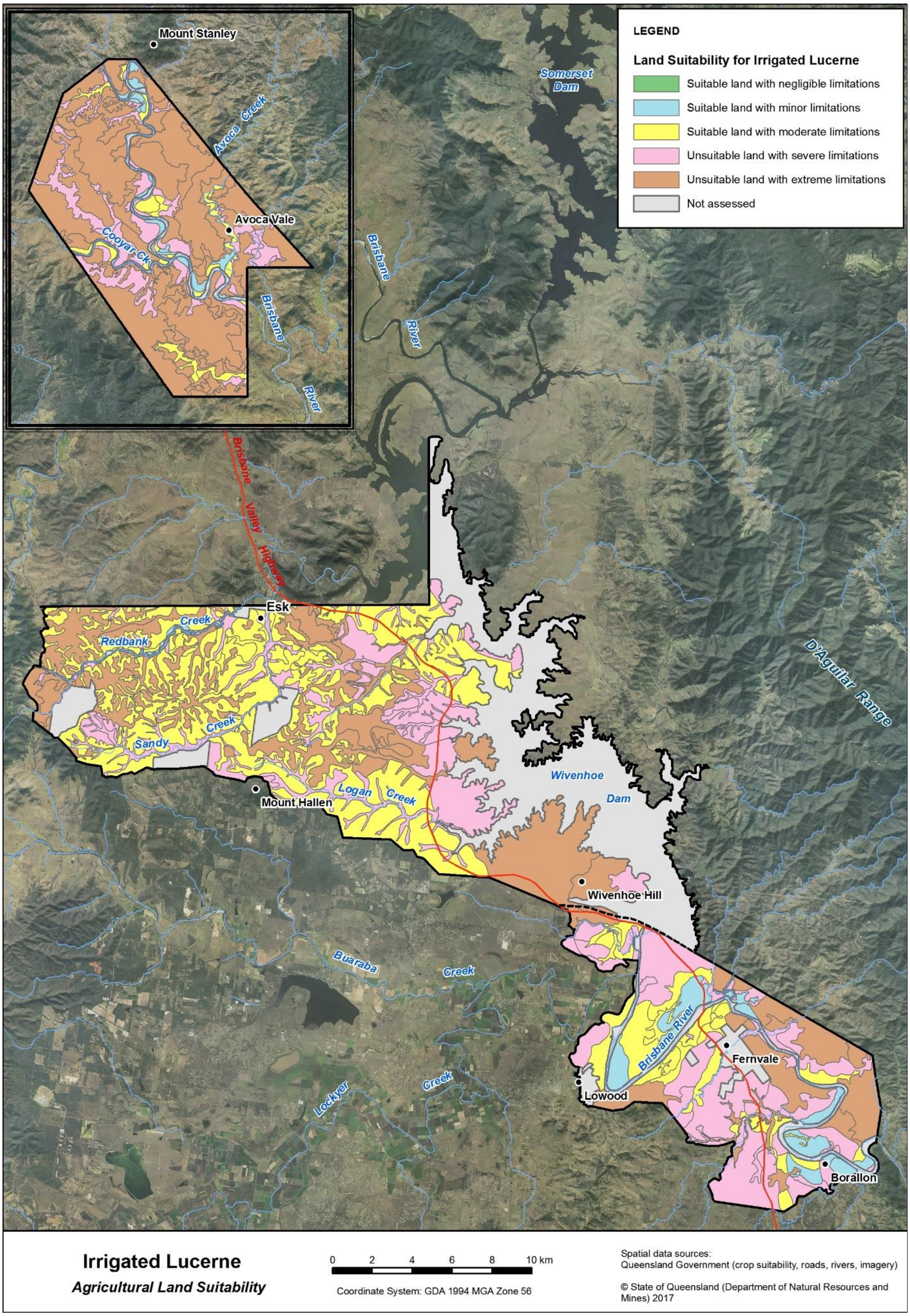


Figure 60 Land suitability for irrigated Lucerne

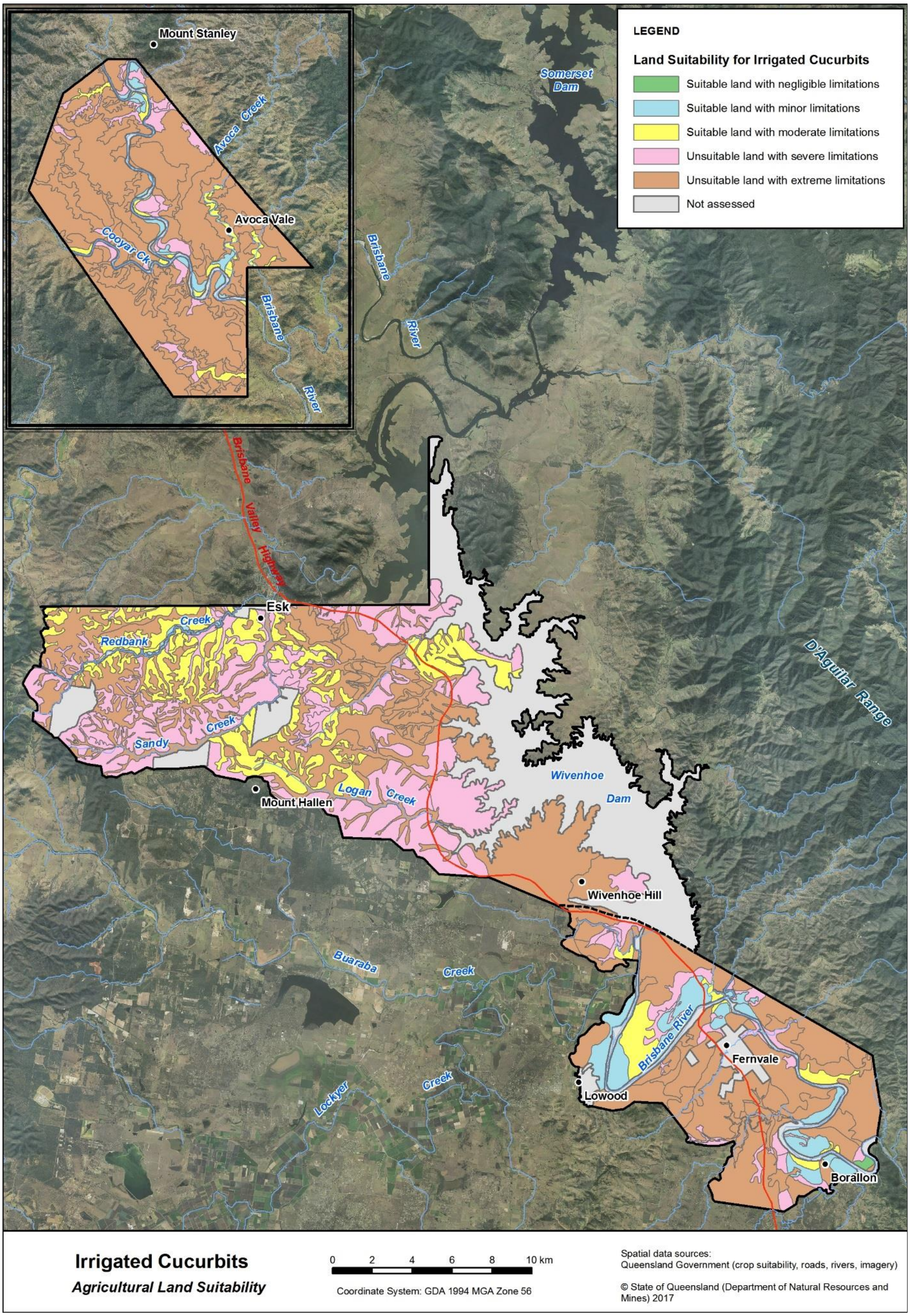


Figure 61 Land suitability for irrigated cucurbits

12. Agricultural Land Classification

Agricultural land classification follows a hierarchical scheme that indicates the location and extent of agricultural land that can be used sustainably for a range of land uses with minimal land degradation. The classes imply a decreasing range of land use choice and an increase in the severity of limitations and/or land degradation hazard. Class A land has the greatest potential for producing the widest range of crops, and has been subdivided into subclasses of A1, land suitable for a wide range of broad acre crops and A2, land suitable for horticultural crops only. Class B land is limited crop land. Class C (pasture land) is subdivided into three subclasses. Class D land is unsuitable for agricultural use. The four classes, including subclasses, are summarised in Appendix 7.

Table 5 Area of agricultural land class—Fernvale, Esk and Avoca Vale

Agricultural land class	Fernvale (ha)	Esk (ha)	Avoca Vale (ha)
A1 Crop land	2511	4578	635
A2 Horticultural crop land	72	22	103
B Limited crop land	1411	5790	368
C1 Pasture land	180	1356	944
C2 Native pasture land	5698	8084	1973
C3 Light grazing	1769	1453	3528
D Non-agricultural land	1467	11700	3702

From Table 5, 17 970 ha of the project area 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 adjacent to the Brisbane River and its tributaries, and on the undulating rises of the Woogaroo sandstones. More extensive areas of Class B land are situated in the southern section of the Esk study area. Limitations restricting the distribution of class A1 lands include frequency of flooding, subsoil wetness, moisture, water erosion and slope. The spatial distribution of agricultural land class is provided in Figures 62, 63, 64 and 65.

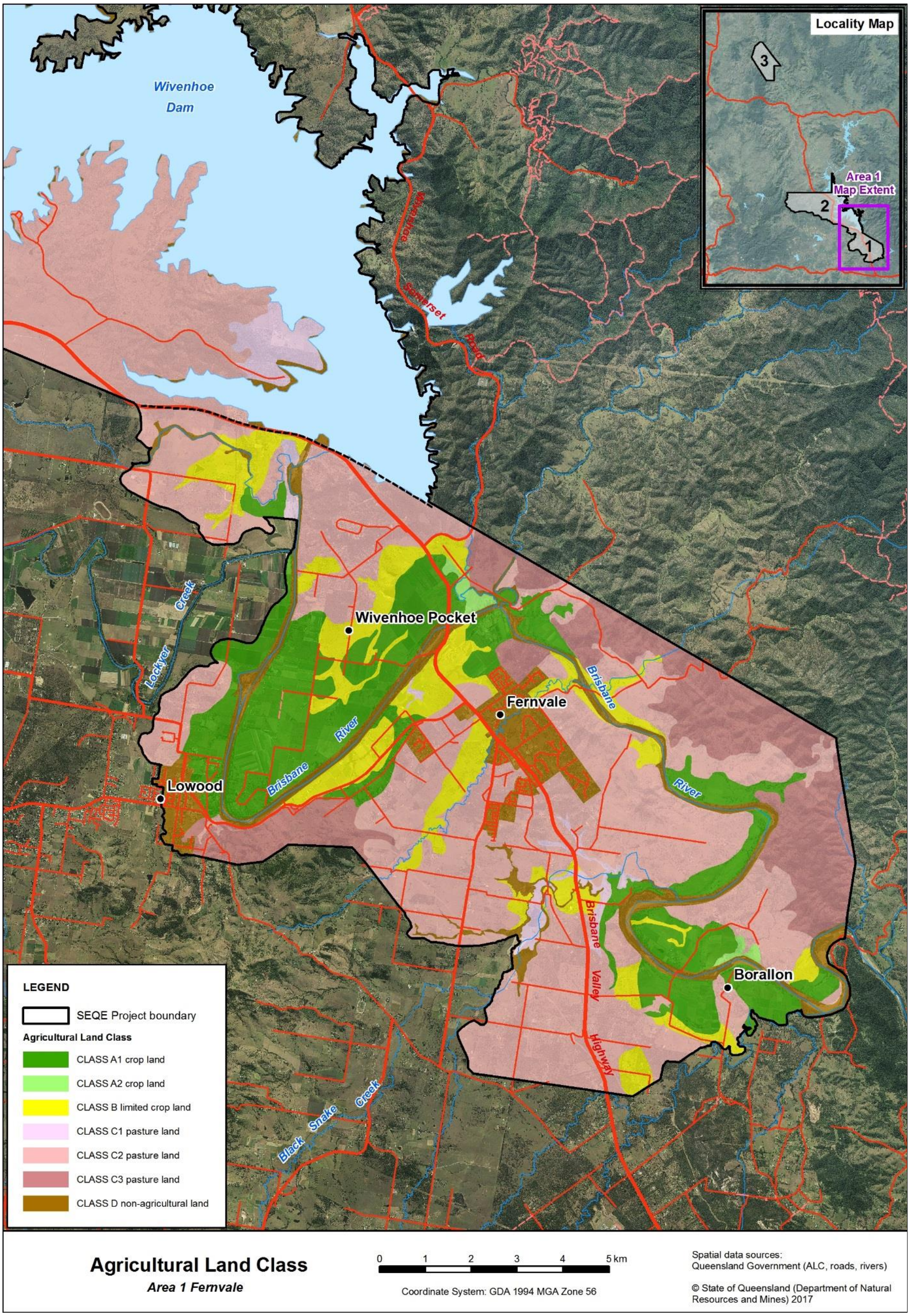


Figure 62 Agricultural land classes—Fernvale

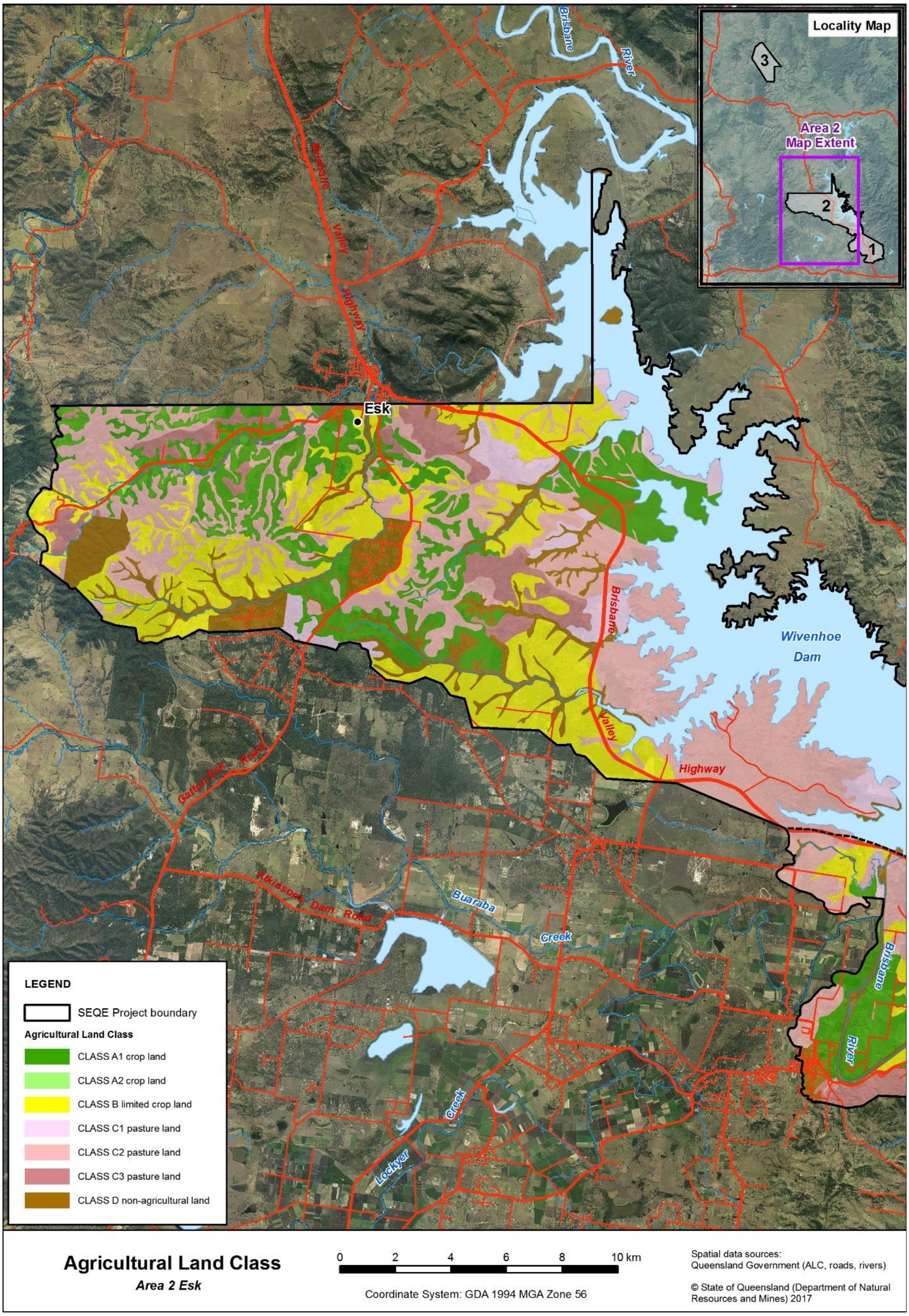


Figure 63 Agricultural land classes—Esk

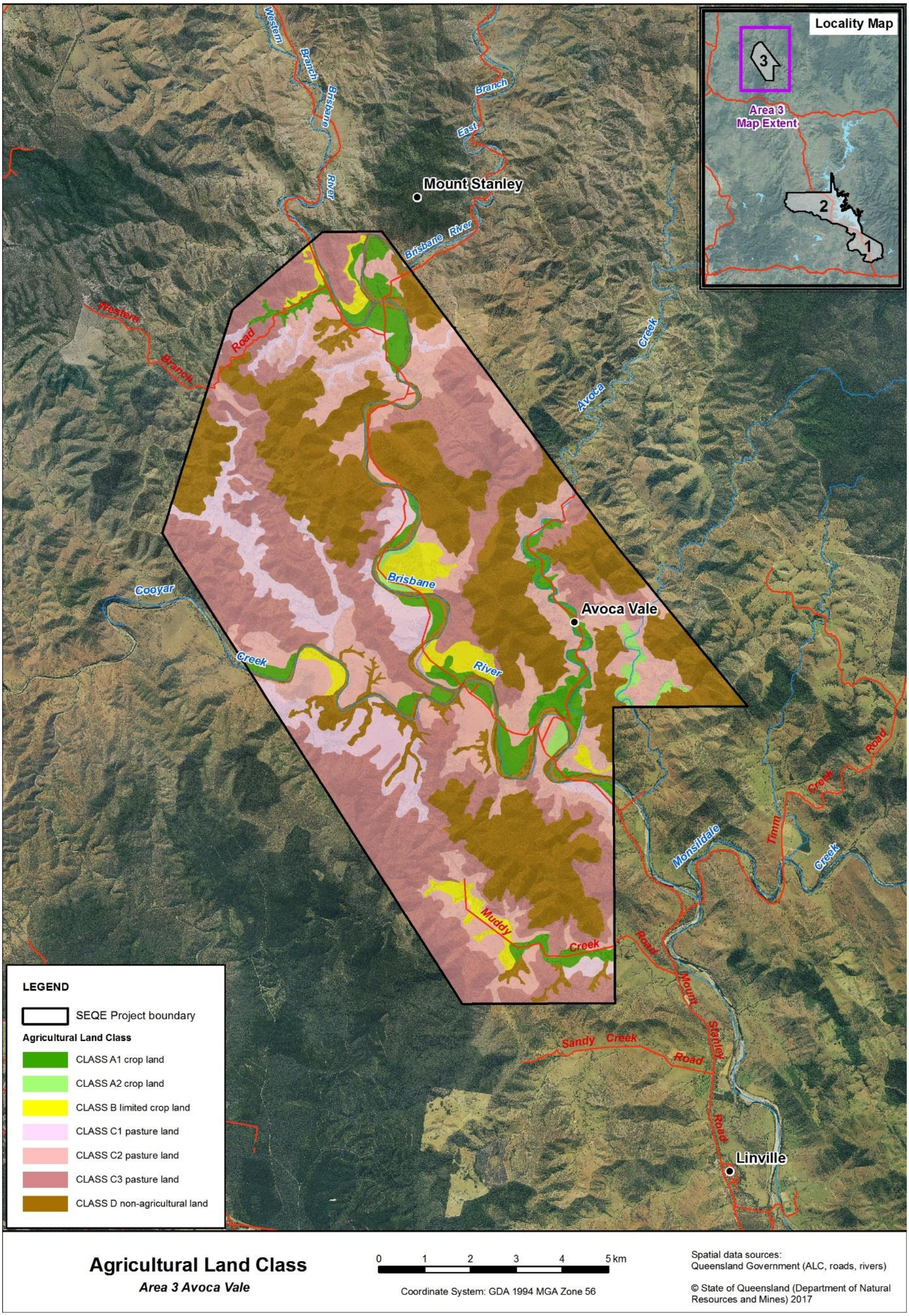


Figure 64 Agricultural land classes—Avoca Vale

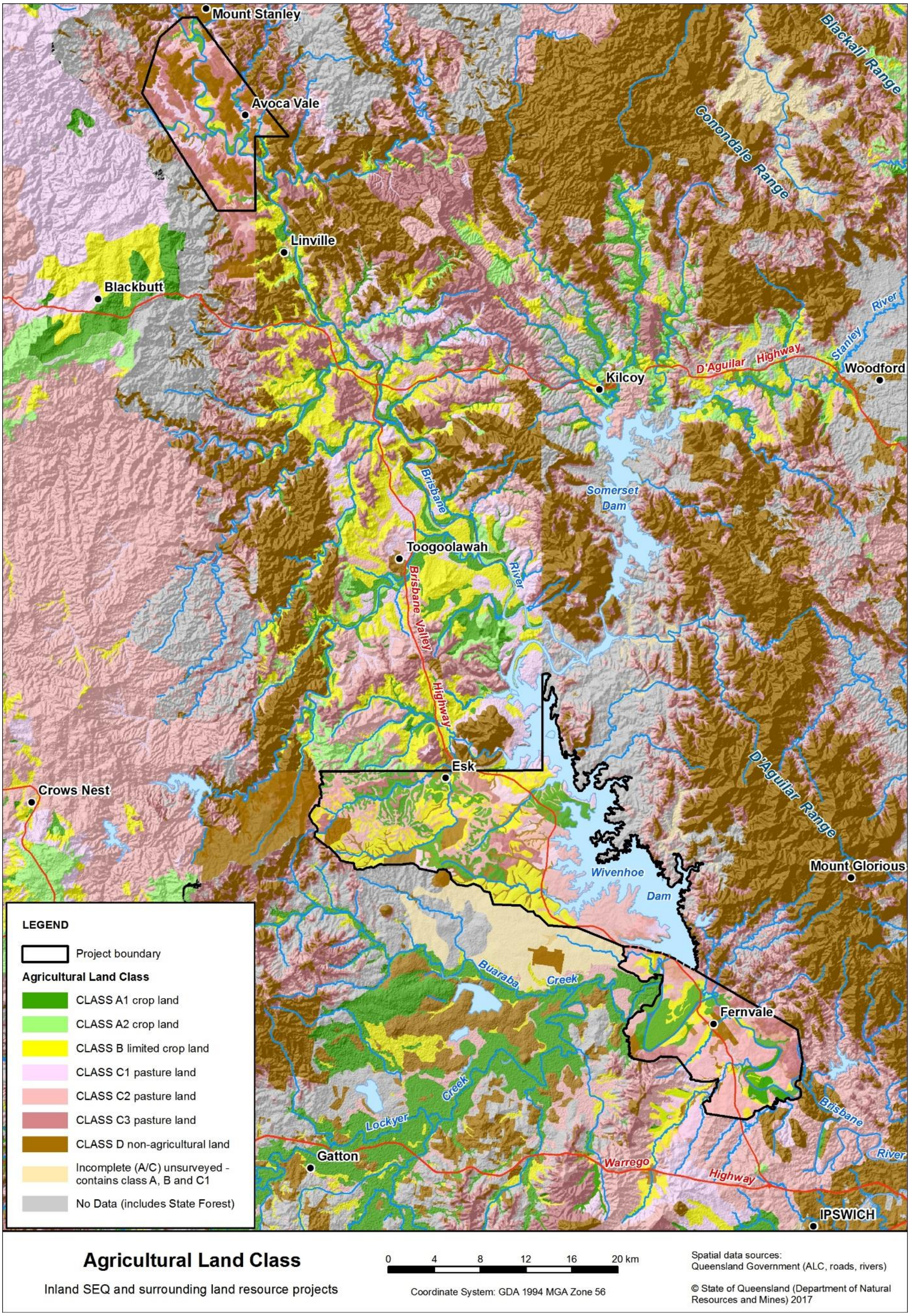


Figure 65 Agricultural land classes—Inland SEQ and surrounds

13. Land Degradation and Water Quality Issues

Land degradation is a significant issue in the Brisbane River catchment as evident by soil erosion, sedimentation, compaction, nutrient runoff, waterlogging and salinity. These processes, to varying extents, have been shown to adversely influence water quality in Wivenhoe Dam, Brisbane River and Moreton Bay.

Soil Erosion, Nutrients and Sedimentation

During the 2011 and 2013 floods, an estimated 20 million tonnes of sediment was delivered into the waterways of SEQ. This resulted in increased turbidity, high pollutant loads (e.g. pesticides, nitrogen and phosphorus), the smothering of aquatic plants and seagrass beds of Moreton Bay and additional costs for water treatment at the Mount Crosby treatment plant (Healthy Waterways 2017). In 2016, the upper Brisbane River received an overall grade of D from the Healthy Waterways environmental monitoring program, while the mid Brisbane River was assessed at a D+ for overall condition. *'D = Poor: Conditions meet few of the guidelines in most of the reporting area. Many key processes are not functional and most critical habitats are impacted'* (Healthy Waterways 2017).

Consequences associated with increased rates of soil erosion range from a decline in soil depth, soil structure, water and nutrient holding capacity of the soil, agricultural productivity and soil health to the destabilisation of infrastructure, reduced water quality and degradation of habitat. There can be significant losses of agricultural land after streambank mass movement. Silted up waterways with reduced capacity to transmit water flows often have more frequent overbank flooding with eroded soil deposited in road culverts, reservoirs, creeks, rivers and marine environments (Carey et al. 2015, DERM 2011).

Severe gully and sheet erosion in arable cropping lands, and moderate gully erosion in the grazing lands of the upper Brisbane river catchment has long been recognised, with 1400 ha of severe gully erosion and 41 000 ha of severe sheet erosion documented in 1974 (DPI 1974). In 1999, 7457 ha of the BVL project area was estimated to be affected by minor gully erosion, and 1289 ha affected by moderate gully erosion (Harms and Pointon 1999). In 2017, 4573 ha was affected by moderate to severe rill and gully erosion in the SEQE project area. Sheet erosion was recorded in most UMAs, but was more severe in cleared, grazed hillslope landscapes with reduced groundcover. Rill and gully erosion was more prevalent on sodic and texture contrast soils on the Esk formation (Beppo, Watt and Beer SPCs), Neara Volcanics (Moore and Dunwich SPCs), Woogaroo subgroup (Quinine SPC), Mount Crosby Formation (Lakeview and Watt SPCs), Neranleigh-Fernvale beds (Neranleigh SPC) and alluvium (Spencer SPC), and was frequently associated with drainage networks. The subsoils of these soils readily disperse when exposed to rainfall, runoff or seepage, particularly when groundcover is limited.

The Esk Formation has been identified as the major sediment source for Wivenhoe Dam, comprising 10% of the catchment area, but contributing 50% of the sediment and 33% of the total phosphorus inputs to the dam; the Neara Volcanics contribute 26% of the sediment load to the dam, 37% of the total phosphorus, but comprise 14% of the catchment area; and soils derived from the Woogaroo Subgroup deliver sediment into the lower dam catchment (Douglas et al. 2007). Incised, steep sided gullies, 10 m to 15 m deep occur in the Beppo Eroded Phase and Beer Eroded Phase SPCs of the Esk Formation, and slightly shallower gullies occur in the Moore Eroded Phase of the Neara Volcanics. In the project area, 304 ha of land affected by actively eroding gullies have been mapped. These gullies were present at a scale able to be mapped as UMAs, ranging between 6–36 ha in size.

Figure 66 Gully erosion of Esk Formation

Severe streambank retreat or mass movement of the Honey SPC soils in the channel benches adjacent to the Brisbane River at Fernvale occurred after the multi-peaked flood event of 2011. Gravitational failures and wet earth flows after fluvial undercutting, following extended periods of inundation and rapid recession of stream water levels resulted in mass failures of the banks, significant sediment delivery downstream to the water treatment facility, and losses of agricultural land. This is a common occurrence when groundwater levels in the stream bank do not drain quickly, and remain at a higher level than the water in the stream. Similar observations of streambank mass movement, wet earth flows and bank seepage are documented in the literature (Olley *et al*., 2012; Abernethy 2011 and Sands 2008). Further research is required to better understand the causal factors, including, inundation and drainage processes, and identifying management options for affected streambanks.

Figure 67 Gully erosion—associated with contour bank waterways on Esk Formation

Grazing was the dominant land use associated with the sheet, rill and gully erosion, and cropping was the more dominant land use observed to be associated with stream bank mass movement. Failed contour banks and constructed waterways that are now grazed on the Beppo and Beer SPCs at Esk have resulted in a series of 10–15 m deep gullies (Figure 67). A lack of groundcover at Esk and Avoca Vale accounted for the extensive sheet erosion on the soils of the Esk Formation and Neara Volcanics. Vehicle and cattle tracks accelerate rill, gully and occasionally tunnel erosion, and this was more prevalent on all of the sodic and texture contrast soils, however rill erosion was also identified on the more stable Red Kandosol Hibiscus SPCs of the Woogaroo subgroup in lower landscape positions (Figures 68 and 69).


Figure 68 Erosion—vehicular and cattle tracks on Woogaroo Subgroup


Figure 69 Erosion on soils of the Woogaroo Subgroup at Esk

Nutrients from applied fertilisers, particularly nitrogen and phosphorus, and pesticides that are adsorbed onto eroded clay and silt colloids are readily transported into waterways. Wivenhoe Dam acts as a sediment trap, capturing nutrients, pesticides and sediments from the erosion of the upstream soils. This has implications for algal bloom outbreaks in the dam. Downstream of Wivenhoe Dam, nutrients and sediments from Lockyer Creek pose the biggest threat to the mid Brisbane River water quality (Healthy Waterways 2017).

The maintenance of groundcover and stocking to an appropriate grazing pressure will help limit erosion in grazing areas (Burton et al., 2014, DERM 2011) and is therefore critical to the reduction of all erosion types. A variety of treatments can assist in reducing gully formation and sedimentation including a combination of engineering works, earthworks and revegetation. There is however a high risk of failure of remediation works (Carey et al. 2015), and consequently any gully remediation works require careful planning, management and long term maintenance. Lands affected by rill, gully and streambank erosion can be managed by measures such as preventing stock access, fencing off rills and gullies, revegetation and management of upstream runoff to allow rehabilitation. Expert advice should be sought prior to any erosion control works. Managing grazing pressure, ensuring good ground cover, and soil structure will help ensure landscapes prone to sheet and rill erosion will remain stable and reduce the initiation of new gullies. Management of the near vertical river banks post slumping and wet earth flows is costly, and requires further investigations from a geotechnical, surface and groundwater hydrology perspective to better understand the causal factors, including the nature of inundation and drainage processes. Appropriate management options for amelioration will then be better informed.

Erosion Risk Modelling

Given the significance of soil erosion in the project area, a pilot erosion risk model was completed for the Fernvale study area (Figure 70), trialling moderate and high resolution digital elevation models (DEMs) as a means of more accurately predicting erosion prone areas.

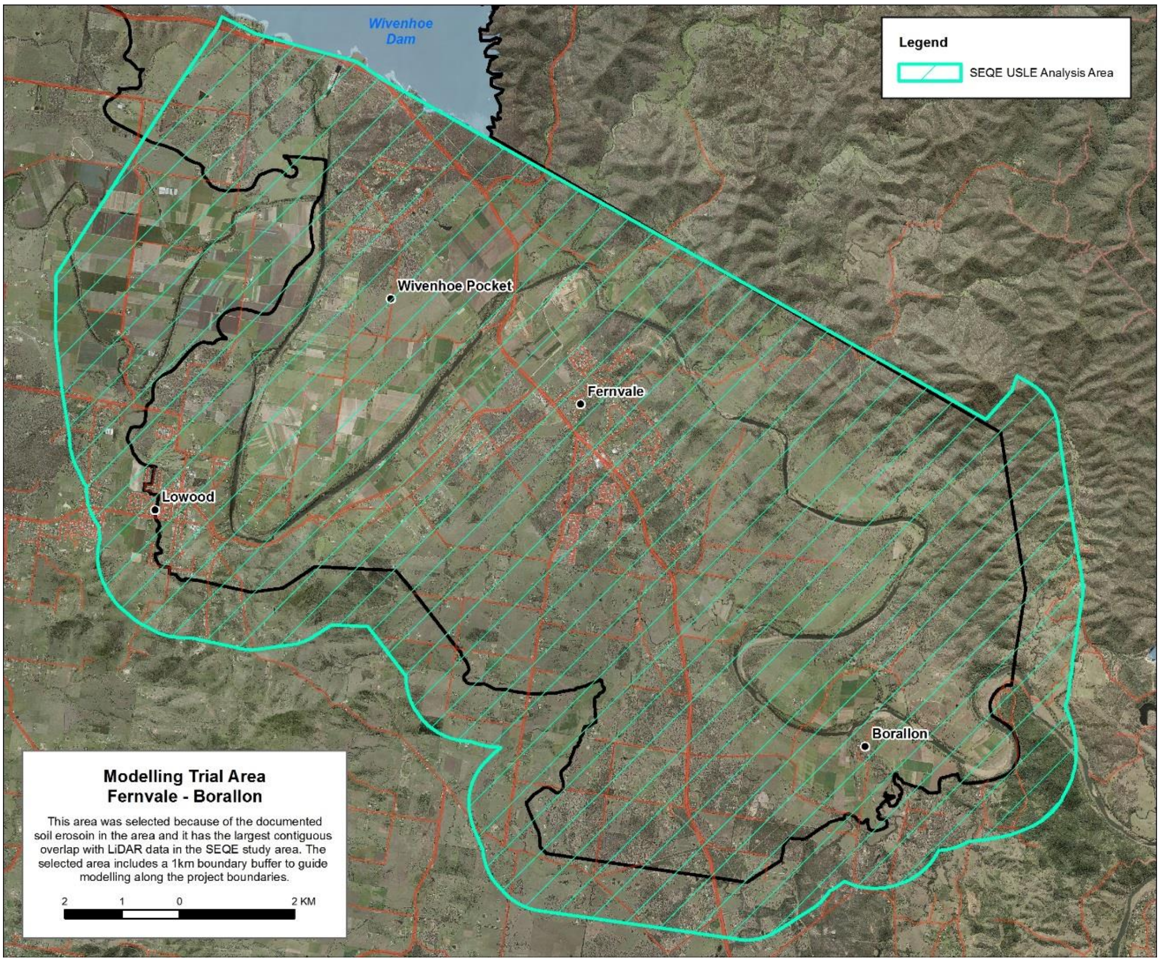


Figure 70 **Fernvale study area selected for potential erosion risk modelling trial**

Potential average annual soil loss risk, at a catchment scale, caused by rainfall and associated overland flow was estimated using a modified version of the United States Department of Agriculture's Revised Universal Soil Loss Equation (RUSLE) (USDA 1996). The RUSLE equation is: A = R*K*LS*C*P where,

A = predicted soil loss (tonnes per hectare per year)
R = rainfall erosivity factor
K = soil erodibility factor
LS = slope factor (slope length and gradient)
C = ground cover factor
P = land practice management factor

The RUSLE equation was modified by substituting the sediment transport index (STI) (GITTA 2006) for the LS factor to adapt for catchment scale use by improving the representation of three-dimensional flow by taking into account the upslope contributing area. Variations in the resolution of data were tested with the use of moderate and high resolution DEMs. Use of a hypothetical bare ground factor (C-Factor) provided an indication of maximum inherent erosion risk and allowed the comparison of different models. Fernvale was chosen for this study due to the documented soil erosion of Sodosols on the Fernvale SPCs on mid and lower slopes of the Mount Crosby Formation, and the availability of high resolution LiDAR DEM data.

Method

ArcGIS ModelBuilder (v. 10.2.1) (ESRI 2011) was used to implement the modified RUSLE model using raster data. The rainfall erosivity factor was sourced from CSIRO and the soil erodibility factor was sourced from DNRM's Spatial Information Repository (SIR). The STI raster was generated using TauDEM software 2009 with the D-Infinity option for flow direction enabled. A bare ground factor (0.45) (Silburn 2011; Institute Water Research 2002) was used to represent the ground cover factor. The Land management practice (P-factor) was excluded due to lack of available data. All raster data used in the modelling was resampled to the minimum input cell size available to optimise the value of the detail available in the DEM data. The high frequency noise that is often an issue with LiDAR data was effectively managed by resampling the 1 m DEM to a 2 m cell size.

Once the input data was compiled, three variations were trialled:

1. 2D RUSLE, using LS factor based on the lower resolution three arc-second (3") SRTM-DEM (~90 m cell size)
2. 3D RUSLE, modified using STI factor based on the moderate resolution one arc-second (1") SRTM-DEM (~30 m cell size)
3. 3D RUSLE, modified using STI factor based on resampled high resolution the 2m LiDAR DEM (2 m cell size)

Results and discussion

Table 6 Estimated potential erosion risk, for a hypothetical bare-ground scenario

Model	DEM source	Estimated erosion risk (t/ha/yr)				Notes
		Min	Max	Mean	Standard Deviation	
2D RUSLE (LS-factor)	Three arc-second SRTM-DEM (~90m)	1.0	3,365	131	241	High values (>300) over 13.8% of area and principally located over hill slope areas
3D RUSLE (STI)	One arc-second SRTM-DEM (~30m)	0.2	2,665	60	98	High values (>300) negligible area
3D RUSLE (STI)	2m LiDAR DEM	1.0	4,915	35	53	High values (>300) over 0.5% of area and principally located along drainage lines

The high resolution LiDAR DEM improved accuracy in the representation of landscape features, particularly long narrow linear features such as narrow stream banks, terraces and small valleys (Figures 71–73). Overall the 3D RUSLE variations had lower and more realistic average predicted erosion risk values than the 2D RUSLE. Although the high resolution (2 m cell size) 3D RUSLE predicted the highest maximum erosion risk rate the total area of high erosion risk values was much smaller than the 2D RUSLE values indicating a better overall model fit. The higher values in the high resolution (2 m cell size) 3D RUSLE may be due to greater inclusion of flow accumulation and the more detailed representation of landscapes and slope gradients, as these tend to be smoothed out when using lower resolution DEM data. This finding was also identified by Panagos (2015) and Wilson (2000) who found that slope decreases as cell size increases.

Conclusions and recommendations

As RUSLE was developed for the paddock-scale estimation of sheet and rill erosion, this extension of use is only intended to provide an indication of relative erosion risk across the landscape. Despite this limitation, the mapping of individual risk factors allows the assessment of the key drivers of erosion that, when used in conjunction with local knowledge, can support the evaluation of the prioritisation of amelioration works. In particular, the sharing of information through the intuitive visual assessment of mapping can support an improved understanding of causal and risk factors by all stakeholders. Findings from this pilot work demonstrated that when compared to known erosion extent (Figure 71–73) the 3D RUSLE using high resolution LiDAR data (2 m cell size) provided the best fit as it includes the detail required to identify the landscape features associated with erosion (e.g. small rills and gullies).

Given the extent of erodible soils in the study area, further trialling of the 3D RUSLE using high resolution LiDAR data in other areas of the catchment is recommended to assess its applicability for identifying land at risk of gully and rill erosion, and to assess change over time, based on cover. This in conjunction with improving the soil erosivity (K-Factor) raster is required due to the low spatial accuracy of this dataset. Inclusion of the actual ground cover (C-Factor) and land management practice (P-Factor, if data is available) would be a logical extension of the work. Soil erodibility is currently being investigated by DSITI in the Upper Brisbane River catchment as part of a complementary digital soil mapping project. Products will include K-Factor and a soil erodibility classification of topsoil, subsoil and the soil profile. These will be modelled at the 1 arc second (30 m) pixel size and is a modification of the soil erodibility model of Zund and Payne (2014) (J Walton 2017, pers. comm., 23 June). Management practices which target the sources of fine sediment delivery to Wivenhoe Dam and the Brisbane River, including the gullies identified in this project could be developed collaboratively with key stakeholders.

For more information on the RUSLE modelling used in this project, contact soilenquiry@dnrm.qld.gov.au.

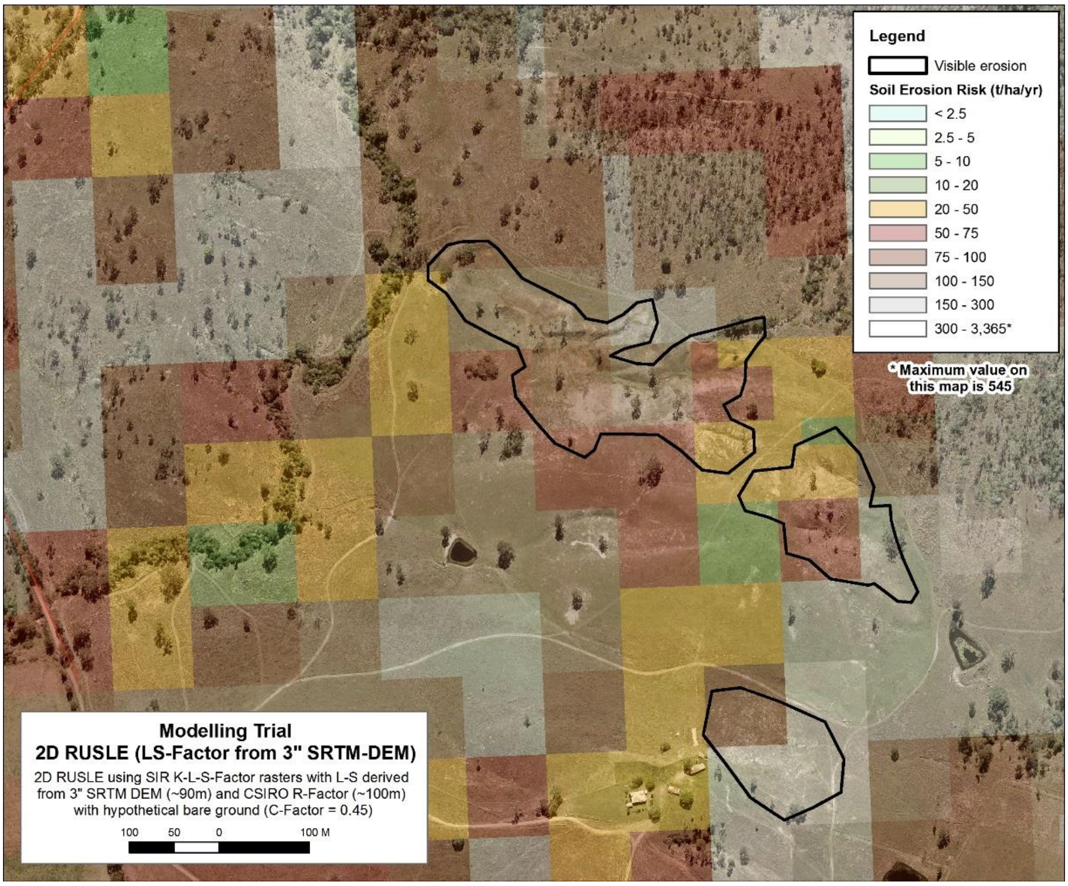


Figure 71 Example standard 2D RUSLE (LS-factor)—visible erosion outlined

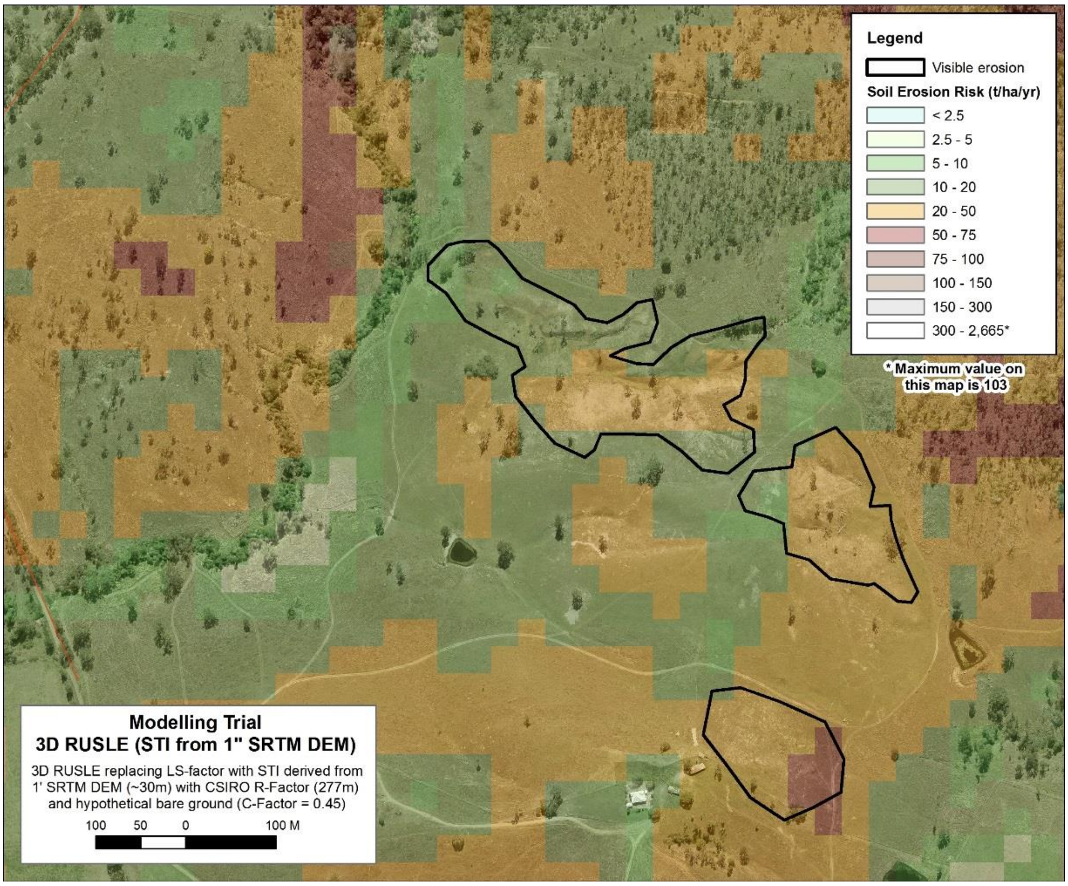


Figure 72 Example modified 3D RUSLE (STI) (~30m)—visible erosion outlined

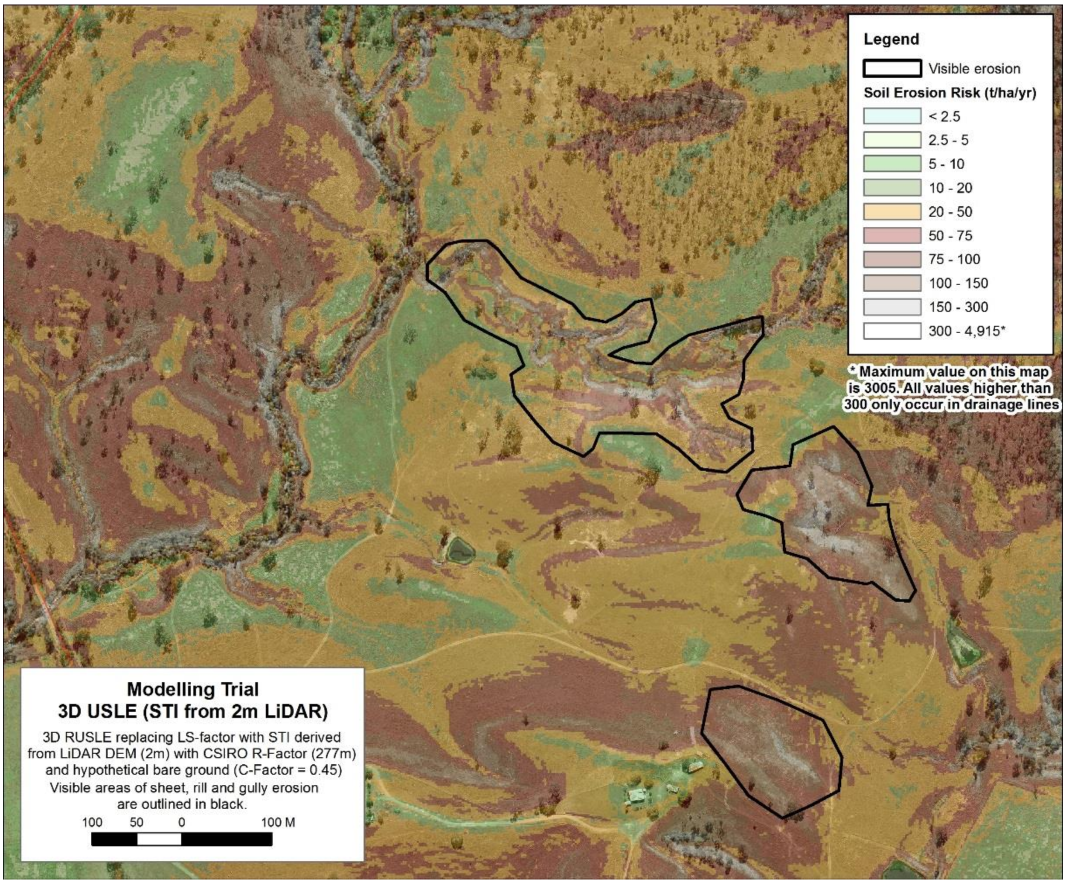


Figure 73 Example modified 3D RUSLE (STI) (2m)—visible erosion outlined

Secondary Salinity

Secondary salinity refers to salting (i.e. the process and result of soluble salts accumulating in soils or waters) that results from human activities, often associated with land development and agriculture (SalCon 1997). Salinity is responsible for an estimated $3.5 billion worth of lost agricultural production, damage to infrastructure, and impacts on ecosystem health of streams within Australia each year (DNRW, 2006).

Salinity in the project area has the potential to impact on water quality in Wivenhoe Dam, and the Brisbane River. Southeast Queensland (SEQ) contains the largest recorded areas of salt affected land in Queensland, and in general, secondary salinity in the region is associated with land clearing for agriculture, changes in catchment hydrology and subsequent rises in groundwater levels (Kirjan et al. 2008). In the mid and upper Brisbane River catchment, 664 ha of salt affected land has been identified with 112 ha identified as 'severe salt affected' in the project area, predominantly at Black Snake Creek (DNRM 2017). Major outbreaks have formed on soils derived from Quaternary alluvium and fine-grained sedimentary deposits such as Gatton Sandstone.

The alluvial valley model described by SalCon (1997) has been identified as the main process causing salt outbreaks in SEQ. Smaller areas of salinity which follow the stratigraphic model and catchment restriction model are also represented (Appendix 8).

The salinity expressions that are prevalent in the Black Snake Creek catchment (Ellis and Bigwood 2006) of the Fernvale study area, included scalded areas occurring on the alluvial plains where saline watertables are close to the surface. A series of natural subsurface flow constrictions exist throughout the catchment and salt outbreaks are extensive upstream of these constrictions. Soil salinity in the impermeable subsoils on the lower slopes of the Koukandowie Formation and Gatton Sandstone has been recorded up to 1.97 dS/m (Ellis and Bigwood 2006). This was consistent with field EC results measured during the field work component of this project.

Salinity has been observed in the town of Lowood (Figure 74), and secondary salinity is prevalent in the stream lines of the Esk and Fernvale landscapes and in alluvium at Fernvale. Within the Esk study area, saline seepages were expected to be associated with discharge areas at the break-of-slope positions in the Esk Formation. There was no discharge recorded during the study period due to long term dry conditions. However, erosional scalding, which is often a secondary effect of salting, was observed. Field EC measurements collected during 2014–2016 recorded up to 1.2d S/m in subsoils.

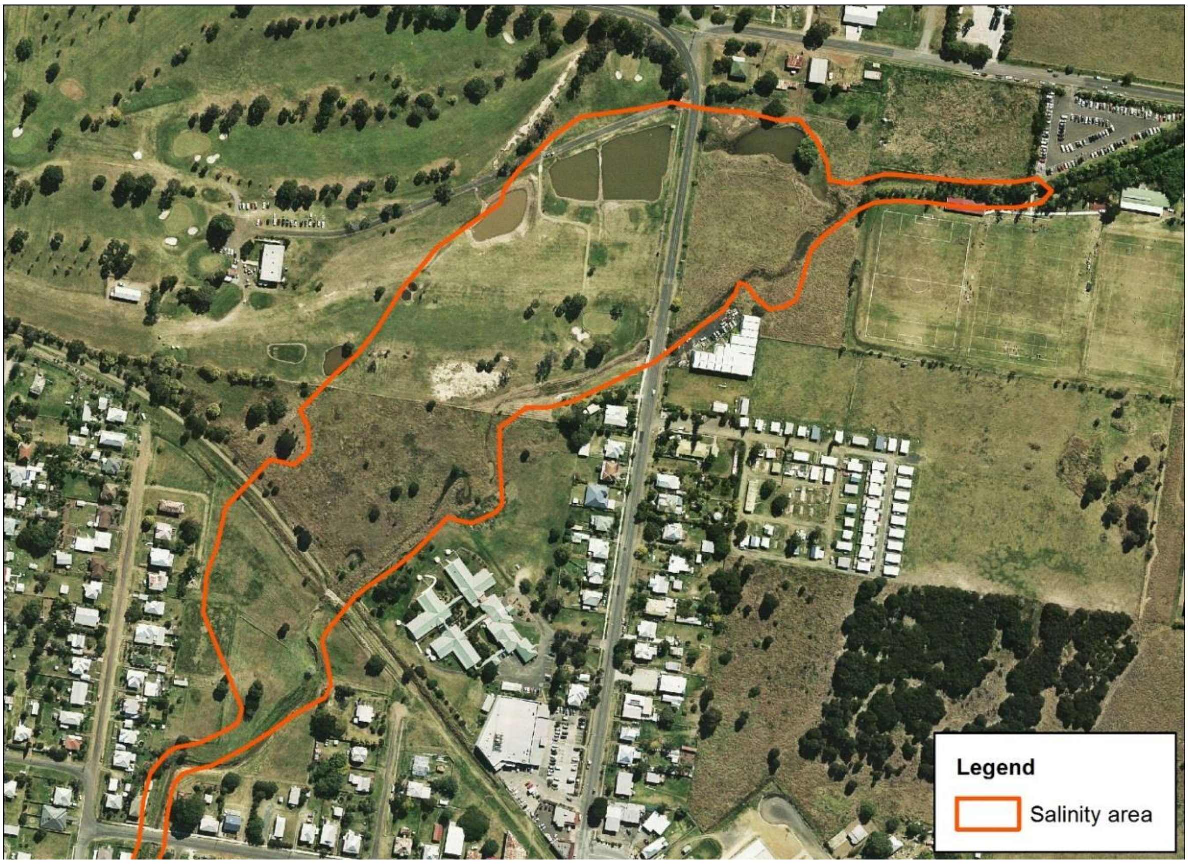


Figure 74 Dams in lower parts of the landscape, with saline waterbodies—Lowood

The location, size and intensity of salt affected areas should ideally be monitored every 5 to 10 years to more accurately determine changes over time (NLWRA 2008) and to evaluate the driver of these changes. Known recharge and erosion prone areas should be targeted, and it is recommended that modelling approaches be trialled to identify at risk landscapes, to inform prioritisation of investment in management practices and to identify outbreaks.

14. References

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SPOT satellite imagery data: © Astrium Services 2016.

Terrestrial Ecosystem Research Network (TERN) Data sets from CSIRO Data Access Portal including TWI, MrVBF and TPI. Undated data available at http://portal.tern.org.au/#/61e77273

Appendices

Appendix 1: Soil Profile Classes

Conventions used in the descriptions of the morphology, landscape and SPCs

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. Yellowbank Nodular Variant (YbNv).

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. Cressbrook Rocky Phase (CrRp).

Australian Classification as described by Isbell (Revised Edition 2002 and 2016) is listed in order of frequency of occurrence. If more than one classification applies to an SPC, the dominant soils are displayed as bold.

Geology as defined on the Esk, Nanango, Caboolture and Ipswich maps sheets, 1:100,000, and the Gympie Special Sheet 1:250 000.

Surface characteristics as in the *Australian Soil and Land Survey Field Handbook* or '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 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). Only the dominant Munsell colours have been listed in the descriptions. There will be some slight deviations from the range specified.

Representative site(s) for SPCs are shown in bold.

BSC are sites described in the Black Snake Creek project (Ellis and Bigwood 1996).

MFM are sites described in the Moreton Land Management Field Manual (Noble 1996).

SEQ are sites described in the SEQ project.

MISSE are sites described in the miscellaneous SEQ project.

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SEQE soil profile classes

Avoca (Av)
Basel (Bs)
Beppo (Bp)
Beer (Br)
Burnage (Bn)
Cooeeimbardi (Cb)
Cressbrook (Cr)
D'Aguilar (Dg)
Dunwich (Dw)
Fernvale (Fv)
Ferny (Fy)
Gallanani (Gl)
Gira Gira (Gg)
Glamorgan (Gm)
Glencairn (Gc)
Grienke (Gk)
Gunyah (Gh)
Hallen (Hl)
Hibiscus (Hb); Hibiscus light Phase (HbLp)
Honey (Hy)
Jimna (Jm)
Kipper (Kp)
Koukandowie (Kk)
Lakeview (Lv)
Linville (Le)
Lowood (Lw)
Monsildale (Md)
Moombra (Mb)
Moore (Mo)
Neara (Na)
Neranleigh (Nr)
Quinine (Qn)
Spencer (Sp)
Tuckerimba (Tk)
Watt (Wt)
Yellowbank (Yb); Yellowbank light Phase (YbLp)

AVOCA (Av)

Concept: Very deep brown texture contrast or gradational soils on andesite or volcanoclastic conglomerate. Loamy surface over neutral, moderately structured sandy clay.

Soil Classification: **Brown Chromosol**, occasional Brown Dermosol.

Landform: Lower slopes, footslopes and plains of rises and plains. Slopes generally <5%.

Geology: Andesites or volcanoclastic conglomerates of Neara volcanics (Rtn) and late Tertiary-Quaternary Residual Colluvium (TQr).

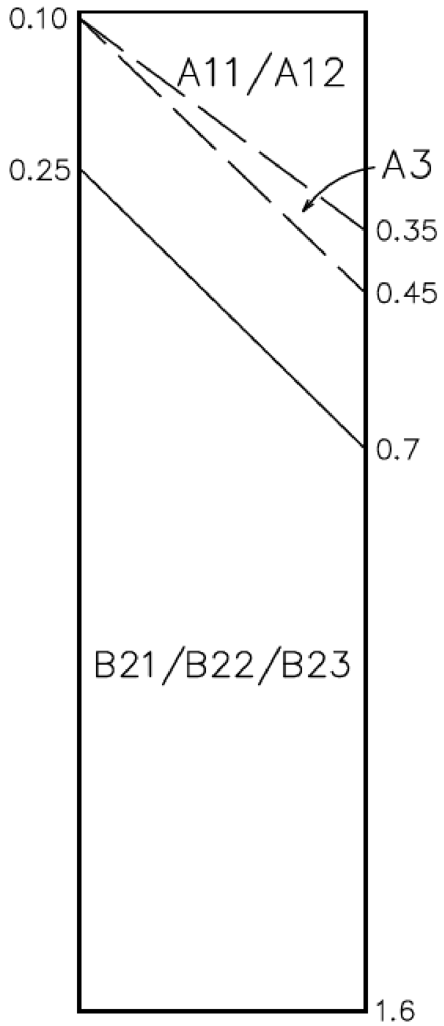
Vegetation: *E. tereticornis* woodland. Other species present include *Angophora subvelutina* and *E. melanophloia* (12.3.3).

Permeability: Moderately permeable.

Drainage: Moderately well drained.

Surface features: Firm, no microrelief.

Depth (m)



A11/ A12 Black or dark brown (10YR 3/2–3 moist) sandy loam to clay loam; weak to moderate granular or subangular blocky structure; field pH 6.0 to 7.0, clear change to

A3 Where present, brown (10YR 3/3 moist) fine sandy loam; weak to moderate subangular blocky structure; field pH 6.0 to 7.0, clear change to

B21/ B22/ B23 Brown (10YR 3/4–5, 4/4 moist) sandy light clay to medium clay; moderate to strong angular/subangular blocky with coarse prismatic structure; rarely <10% faint brown mottles and/or <10% 2–6 mm manganiferous segregations; field pH 6.0 to 7.0

Sites SEQE 5, 6, **12**, 13, 24, 28, 54

Distribution: Restricted occurrence in the north portion of Avoca Vale and eastern portion of Esk.

BASEL (Bs)

Concept: Very deep grey cracking clay soils on alluvium. Subsoils are alkaline, sodic, calcic and moderately saline at depth.

Soil Classification: **Grey Vertosol**, Grey Dermosol.

Landform: Drainage depressions, swamps and backplains of floodplains and stagnant alluvial plains. Slopes generally 0–3%.

Geology: Quaternary and Tertiary alluvium (Qha/2, Qpa/1, TQa) derived from andesites, sandstones, shales, siltstones or conglomerates.

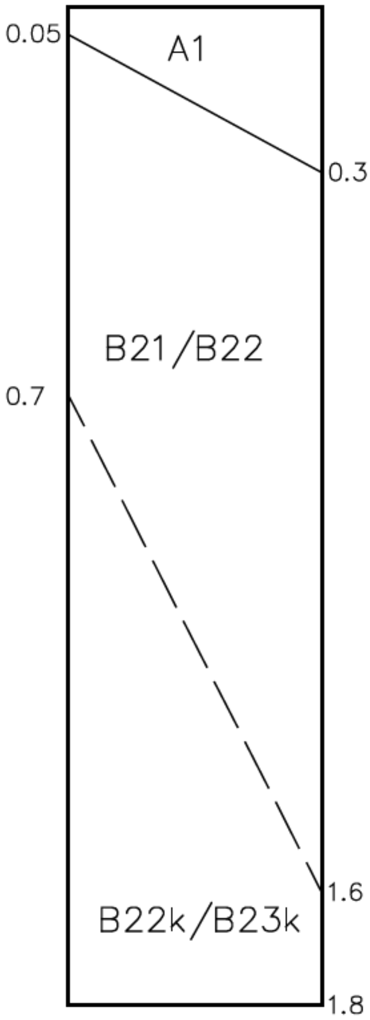
Vegetation: *E. tereticornis* woodland. *E. melanophloia* and *Corymbia tessellaris* also present (12.3.3).

Permeability: **Slowly** to very slowly permeable.

Drainage: **Imperfectly** to poorly drained.

Surface features: Weakly self-mulching, firm or hard setting, gilgai common.

Depth (m)



A1 Black or grey (10YR 3/1–2, 4/1–2 moist) fine sandy light medium clay to medium clay; moderate angular/subangular blocky structure; field pH 5.5 to 6.5, clear or gradual change to

B21/ B22 Grey (2.5Y 4/1–2, 10YR 4/1–2, 10YR 5–6/2 moist) light medium to medium clay; moderate to strong angular/subangular blocky or lenticular structure with prominent slickensides; frequently 2–20% 2–6 mm manganiferous segregations; occasionally 2–10% pebbles and 2–10% mottles; field pH 6.0 to 8.5, clear change to

B22k/ B23k Where present, grey (2.5Y 6/2, 10YR 4–5/2 moist) light medium clay; moderate to strong lenticular structure with prominent slickensides; 2–20% 2–6 mm calcareous nodules and manganiferous concretions; occasionally 2–10% faint mottles; field pH 6.0 to 8.5.

Sites: SEQE **172**, 179, 259;
SEQ 1395, 1399, 1400, 1405, 1406, 1407, 1408, 1409, 1410, 1420, 1426, 1431, 1433, 1435, 1440, 1468, 1470, 1480
BSC 36, 37, 40, 50

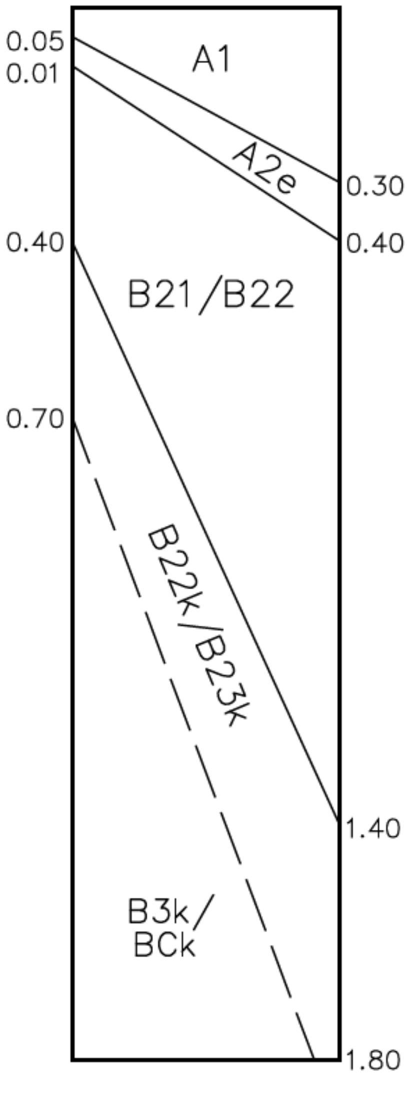
The sites at Black Snake Creek are often very slowly permeable, poorly drained and saline, and grade to Aquic Vertosols

Distribution: Widespread throughout Esk and Fernvale.

BEPPO (Bp)

Concept:	Very deep, sodic, brown texture contrast soils with conspicuous bleach on sandstone or conglomerate. Subsoils are alkaline, mottled, calcic and have vertic properties.
Soil Classification:	**Brown Sodosol**, Grey Sodosol.
Landform:	Mid, lower and footslopes of rises, low hills and hills. Slopes generally 1–15%.
Geology:	Sandstones or conglomerates of the Esk Formation (Rte) and late Tertiary-Quaternary residual colluvium (TQr).
Vegetation:	*E. crebra* +/- *E. tereticornis, Corymbia tessellaris, Angophora* spp., *E. melanophloia* woodland (12.9-10.7).
Permeability:	**Slowly** to very slowly permeable.
Drainage:	Imperfectly drained.
Surface condition:	Hard setting, no microrelief.

Depth (m)



A1	Black or brown (10YR 2–3/2, 3–4/3 moist) sandy clay loam to clay loam; weak angular/subangular blocky structure; field pH 6.0 to 6.5, clear or abrupt change to
A2e	Grey (10YR 4/1–2, 6/2–3 moist, 10YR 7–8/2 dry) conspicuously bleached loam to clay loam; massive to weak subangular blocky structure; field pH 6.0 to 6.5, clear or abrupt change to
B21/ B22	Brown or grey (10YR 4–5/4; 10YR 4–5/1 moist) coarse sandy light medium to medium clay; weak to moderate angular blocky or lenticular structure with prominent slickensides; 2–20% distinct mottles; 2–10% 2–6 mm manganiferous segregations; field pH 6.5 to 8.5, clear or gradual change to
B22k/ B23k	Brown or grey (10YR 4–5/4; 10YR 4–5/1 moist) sandy light medium to medium heavy clay; moderate to strong lenticular structure; 2–20% mottles; 2–10% <2–20 mm calcareous and manganiferous segregations; frequently 2–10% 2–6 mm sandstone pebbles; field pH 8.5 to 9.0, gradual change to
B3k	Where present, brown or grey (10YR 4–5/4; 10YR4–5/1) coarse sandy light to medium clay; weak subangular blocky structure; 2–10% distinct mottles and frequently 10–20% <2–6 mm calcareous and manganiferous segregations; field pH 8.5 to 9.0
BCk	Parent material weathering insitu; frequently 10–50% >2–6 mm calcareous and manganiferous segregations; field pH 8.5 to 9.0
Sites	SEQE 65, 84, 93, 96, 100, 101, **132**, 134, 135, 137,141, 199, 201, 219, 250, 260 Eroded Phase SEQE 225

Distribution: Western portion of Avoca Vale, eastern portion of Esk.

BEER (Br)

Concept: Moderately deep to very deep, brown, black or grey clay cracking clay or non-cracking clay soils with vertic properties on sandstone or conglomerate. Subsoils are alkaline, calcic, sodic and often moderately saline at depth.

Soil Classification: **Brown**/Black **Vertosol**, Black/Brown/Grey Dermosol.

Landform: Mid and lower slopes of undulating rises and low hills. Slopes generally 2–15%.

Geology: Feldspathic sandstones, shales and conglomerates of the Esk Formation (Rte) and late Tertiary-Quaternary residual colluvium (TQr).

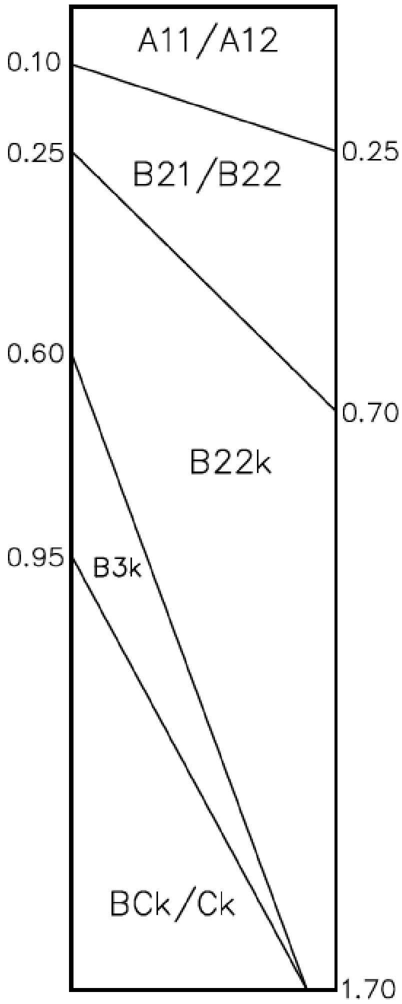
Vegetation: *E. crebra +/- E. tereticornis, Corymbia tessellaris, Angophora* spp., *E. melanophloia* woodland /*C. citriodora* subsp. variegata +/- *E. crebra* open forest (12.9-10.7/12.9-10.2).

Permeability: **Slowly** to moderately permeable.

Drainage: **Moderately well drained** to imperfectly drained.

Surface features: Hard setting, cracking.

Depth (m)



A11/ A12 Black (10YR 2–3/2 moist) light to light medium clay; weak to moderate subangular/angular blocky structure; field pH 6.0 to 6.5, clear change to

B21/ B22 Black, brown or grey (10YR 2–3/2, 10YR 3/3–4, 10YR 4–5/2 moist) medium to medium heavy clay; weak to moderate subangular blocky or lenticular structure with prominent slickensides; occasionally 2–10% faint mottles; 2–10% 2–6 mm ferromanganiferous segregations; 2–10% 2–6 mm quartz or sandstone pebbles; field pH 7 to 8.5, clear or gradual change to

B22k Black, brown or grey (10YR 2–3/2, 10YR 3/3–4, 10YR 4–5/2 moist) medium to medium heavy clay; weak to moderate lenticular or occasionally polyhedral structure; occasionally 2–10% faint mottles; 2–20% 2–6 mm calcareous and ferromanganiferous nodules; <2–10% 2–6 mm quartz or sandstone pebbles; field pH 8.5 to 9.0, clear or gradual change to

B3k Brown or grey (10YR 3/3–4, 10YR 5–6/3 moist) light medium to medium heavy clay; 2–20% 2–20 mm calcareous and ferromanganiferous segregations and 2–20% 2–20 mm sandstone pebbles weathering in situ; field pH 8.5. to 9; clear or gradual change to

BCk/ Ck Parent material weathering in situ; 10–20% 2–20 mm ferromanganiferous and calcareous segregations; field pH 8.5 to 9.0

Sites SEQE 139, 200, 202, 220, 223, 227, 228, 229, 232, 233, **276** MFM 385
Shallow versions occasionally on upper slopes.
The grey version of Beer is imperfectly drained, has weaker structure and often has a sporadic bleach: SEQE 159, 246, 247, 251, 252, 261
Distribution: Minor distribution in western Avoca Vale, more extensive distribution in eastern portion of Esk.

BURNAGE (Bn)

Concept: Moderately deep to very deep, red texture contrast or gradational soils on microdiorite. Subsoils are neutral.

Soil Classification: **Red Chromosol**, Red Dermosol.

Landform: Upper slopes and crests of rises. Slopes generally 2–15%.

Geology: Late Jurassic to early Cretaceous intrusive microdiorites (JKib).

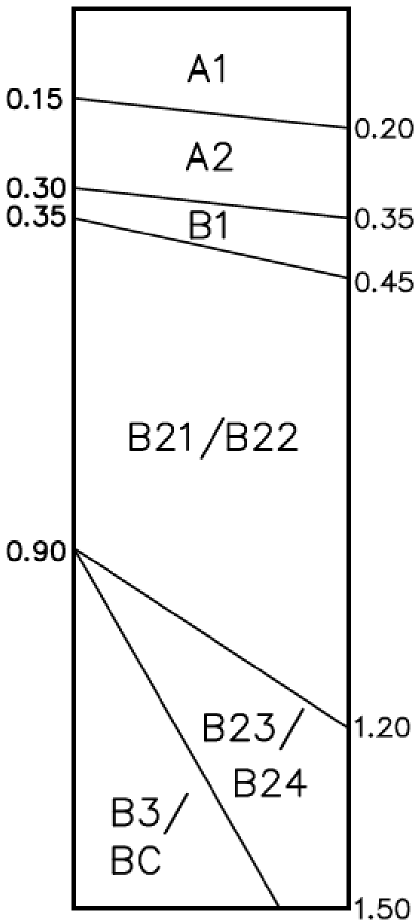
Vegetation: *E. tereticornis, Corymbia intermedia, E. crebra +/- Lophostemon suaveolens* woodland (12.12.12).

Permeability: Slowly to **moderately permeable**.

Drainage: **Moderately** to well drained.

Surface features: Hard setting.

Depth (m)



A1 Brown (7.5YR 3/3 moist) sandy loam to clay loam; moderate granular structure; field pH 6.0 to 7.0, gradual change to

A2 Red (5YR 4/3–4 moist) sandy loam to clay loam; weak or moderate granular structure; 2–10% 2–20 mm pebbles; field pH 6.0 to 7.0, clear change to

B1 Red (2.5YR 4/4 moist) light to medium clay; moderate or strong polyhedral structure; 2–10% 2–20 mm pebbles; field pH 6.5 to 7, clear change to

B21/ B22 Red (2.5YR 4/3–4; moist) light medium to medium clay; moderate or strong polyhedral or blocky structure; few 2–20 mm manganiferous segregations; 10–20% mottles; 2–20% pebbles; field pH 6.5. to 7.5; gradual or diffuse change to

B23/ B24 Red or brown (2.5YR 4/3–4; 7.5 YR 4/3–4 moist) light medium to medium clay; few 2–20 mm manganiferous segregations; 10–20% mottles; 2–20% pebbles; field pH 6.5. to 7.5; gradual or diffuse change to

B3/ BC Parent material weathering in situ; field pH 6.5 to 7.

Sites BSC **30**, 31

Distribution: Minor distribution in the Black Snake Creek catchment of Fernvale.

This SPC requires further development to confirm characteristics.

COOEEIMBARDI (Cb)

Concept: Very deep self-mulching black cracking clay soils on alluvium. Subsoils are alkaline, calcic and slightly sodic with slight to moderate salinity at depth.

Soil Classification: Black Vertosol.

Landform: Plains and terrace plains on terraced lands, floodplains and stagnant alluvial plains.

Geology: Quaternary Pleistocene alluvium (Qpa/1).

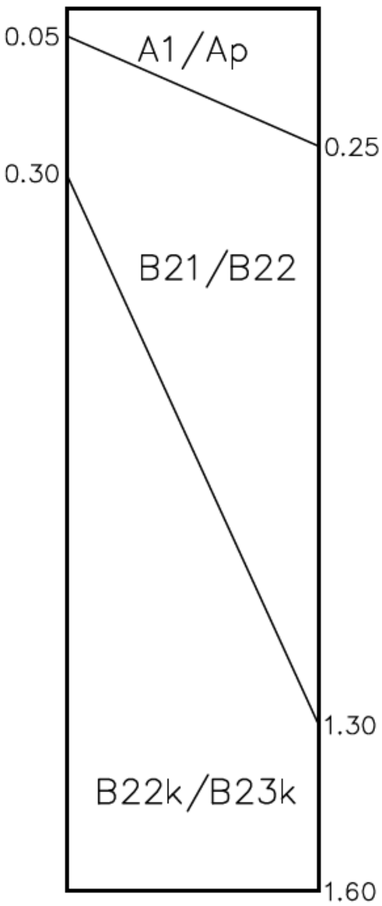
Vegetation: *E. tereticornis* woodland. *Corymbia tessellaris*, *Angophora subvelutina*, *E. melanophloia* and *Casuarina cunninghamiana* also present (12.3.3).

Permeability: Slowly to **moderately permeable**.

Drainage: **Moderately well drained**, occasionally imperfectly drained.

Surface condition: Cracking, self-mulching and gilgai common.

Depth (m)



A1/ Ap Black (10YR 2–3/2 moist) light clay to light medium clay; moderate to strong angular/subangular blocky structure; field pH 6.0 to 7.0, clear or gradual change to

B21/ B22 Black (10YR 2–3/1–2, 2.5Y 3/2 moist) light medium clay to medium clay; moderate to strong angular blocky grading to lenticular structure; few to 2–20% 2–6 mm manganiferous segregations; occasionally with 2–10% distinct mottles; field pH 6 to 8.5, clear or gradual change to

B22k/ B23k Black or brown (10YR 2–3/1–3, 2.5Y 4–5/3 moist) medium clay; strong lenticular structure; 2–20% 2–20 mm calcareous and manganiferous nodules; occasional distinct mottles; field pH 8.5 to 9.0.

Sites: SEQE **37**, 111, 209, 281, 282, 290
SEQ **1430**, 1444
BSC 16, 23, 35

Distribution: Fernvale.

CRESSBROOK (Cr)

Concept: Very deep, neutral sandy textured soils on alluvium over buried horizons or gravel.

Soil Classification: **Stratic Rudosol**, Brown-Orthic Tenosol.

Landform: Channel benches, plains and terrace flats on floodplains and terraces.

Geology: Quaternary Holocene alluvium (Qha/1, Qha/2).

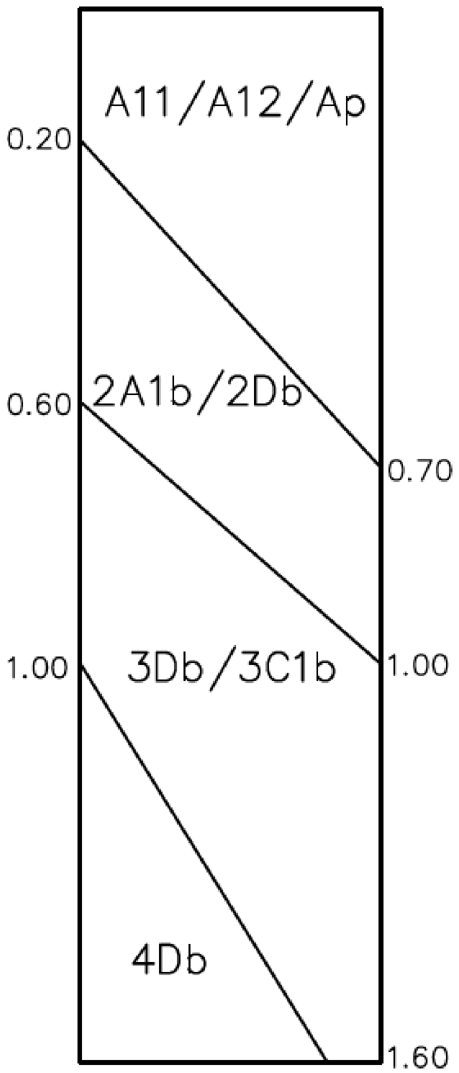
Vegetation: *E. tereticornis* woodland including, *Casuarina cunninghamiana* and *Angophora subvelutina* (12.3.3).

Permeability: Highly permeable.

Drainage: Rapidly to well drained.

Surface features: Hard setting or firm, no microrelief.

Depth (m)



A11/ A12/ Ap Black or dark brown (10YR 2–3/2 moist); loamy sand to sandy clay loam; massive or weak angular/subangular blocky structure; field pH 6.0 to 7.0, abrupt, clear or gradual change to

2A1b Where present, black or brown (10YR 2–3/2 moist); loamy sand to sandy loam; massive or weak subangular blocky structure; field pH 6.0 to 7.5, clear change to

2Db/ 3Db/ 4Db Brown (10YR 3–4/4 moist); sandy loam to sandy clay loam; massive or weak subangular blocky structure; field pH 6.0 to 7.0, clear change to

3C1b Where present, brown (10YR 3–4/5, 7.5YR4/6 moist) loamy sand to clayey sand; massive structure; frequently 2–10% sub-rounded 2–20 mm pebbles; field pH 6.0 to 7.5.

Sites: SEQE **17**, 30, 46, 59, 92, 108, 226, 265
SEQ 1446

Cressbrook Rocky Phase (CrRp): As above, but with >50% pebbles and cobbles in one or two horizons. SEQE 9, 95, 128

Distribution: Extensive throughout Avoca Vale, Esk and Fernvale.

D’AGUILAR (Dg)

Concept: Shallow or very shallow, neutral brown loamy soils on andesite or volcanoclastic conglomerate. Sandy loam to sandy clay loam surfaces.

Soil Classification: **Leptic Tenosol**, Brown-Orthic Tenosol.

Landform: Crests and upper slopes of hills and low hills. Slopes generally <20%.

Geology: Andesites or volcanoclastic conglomerates of the Neara volcanics (Rtn).

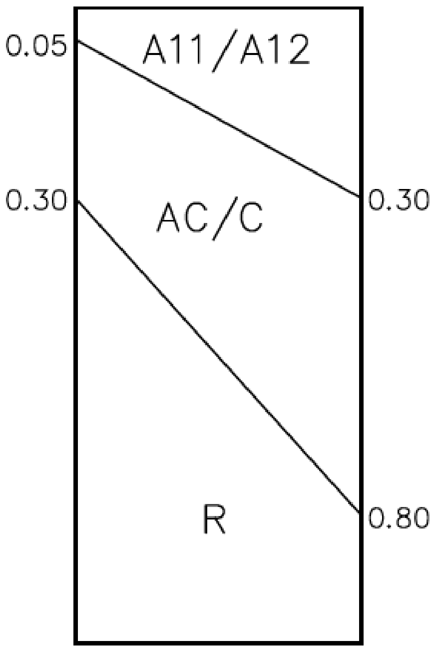
Vegetation: *E. crebra* grassy woodland. *E. tereticornis*, *Corymbia tessellaris* present. /*E. tereticornis*, *C. intermedia*, *E. crebra* open forest to woodland (12.12.7/12.12.12).

Permeability: **Highly** to moderately permeable.

Drainage: Moderately well to **well drained**.

Surface condition: Firm or hard setting, no microrelief, frequent 2–200 mm andesite or volcanoclastic conglomerate pebbles and cobbles; frequent rock outcrop.

Depth (m)



A11/ A12 Black (10YR 2–3/2, 7.5YR 3/1 moist) sandy loam to sandy clay loam; weak or moderate subangular blocky structure; few 2–60 mm cobbles/pebbles; field pH 6.0 to 6.5, clear or gradual change to

AC Black or brown sandy loam; weak or massive structure and common 20–200 mm subangular andesitic and conglomerate pebbles; field pH 6.0 to 6.5, clear change to

C Andesitic pebbles and conglomerate, weathering in situ; field pH 6.0 to 6.5.

R Andesite or volcanoclastic conglomerate.

Sites: SEQE 41, 48, 49, 89, **242**

Distribution: Esk, Avoca Vale.

DUNWICH (Dw)

Concept: Deep, neutral brown or black texture contrast soils with sporadic bleach on andesite or volcanoclastic conglomerate. Subsoils are frequently sodic and have vertic properties at depth.

Soil Classification: **Brown Chromosol,** Black Chromosol.

Landform: Mid and lower slopes and footslopes of hills, low hills and rises. Slopes generally <15%.

Geology: Andesites or volcanoclastic conglomerates on Neara Volcanics (Rtn) or late Tertiary-Quaternary Residual Colluvium (TQr).

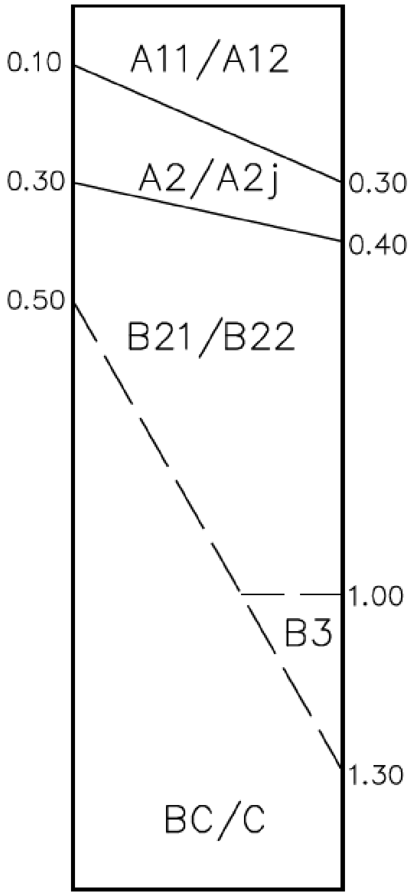
Vegetation: *E. crebra* grassy woodland/*E. melanophloia* woodland (12.12.7/12.12.8).

Permeability: Moderately permeable.

Drainage: **Moderately well** to imperfectly drained.

Surface features: Firm to hard setting, no microrelief, occasionally 2–10% 2-200 mm andesite or volcanoclastic pebbles.

Depth (m)



A11/ A12 Black or dark brown (10YR 2–3/2, 10YR 3/3 moist) loam to clay loam; weak or moderate granular or angular/subangular blocky structure; field pH 5.5 to 6.0, clear or abrupt change to

A2/ A2j Grey or brown (10YR 4–5/2 moist, 10YR 6–7/2 dry) pale or sporadically bleached loam to clay loam; weak or moderate subangular blocky structure; 2–20% 2–6 mm manganiferous segregations; occasionally 2–10% small pebbles; field pH 6.0 to 7.0, clear or abrupt change to

B21/ B22 Brown or black (10YR 4/3–6, 10YR 3/1–2 moist); medium to medium heavy clay; moderate to strong angular blocky, grading to lenticular structure with distinct slickensides; 2–20% manganiferous segregations; occasionally 2–10% faint mottles; frequently 2–10% 2–20 mm sub-rounded pebbles; field pH 6.0 to 7.0, gradual change to

B3 Where present, brown (10YR 4/3–6 moist) light medium to medium clay; few substrate influenced mottles; occasionally 2–20% 2–20 mm manganiferous segregations and 2-20% 2–20 mm pebbles; field pH 7 to 7.5.

BC/C Brown (10YR 4/3–6 moist) light clay; 2–10% substrate influenced mottles; occasionally 2–20% 2–20 mm manganiferous segregations and 20–50% 2–20 mm pebbles weathering in situ; field pH 7 to 7.5.

Sites: SEQE 7, 32, **56**, 68, 80, 107, 176, 277
MFM 356 SEQ 1563
SEQE 14, 69 as above, but pH at depth reaches 8.

Distribution: North and eastern portion of Avoca Vale and eastern portion of Esk.

FERNVALE (Fv)

Concept: Very deep, brown texture contrast soils on colluvium, mudstone, shale, chert, arenite, conglomerate and sandstone. Subsoils are acidic, mottled and sodic.

Soil Classification: **Brown Kurosol,** Brown Sodosol.

Landform: Lower slopes of hills, low hills and rises. Slopes generally 3–15%.

Geology: Mudstones, shales, cherts, arenites or conglomerates of Neranleigh-Fernvale beds (DCf) and Toogoolawah group (Rt).

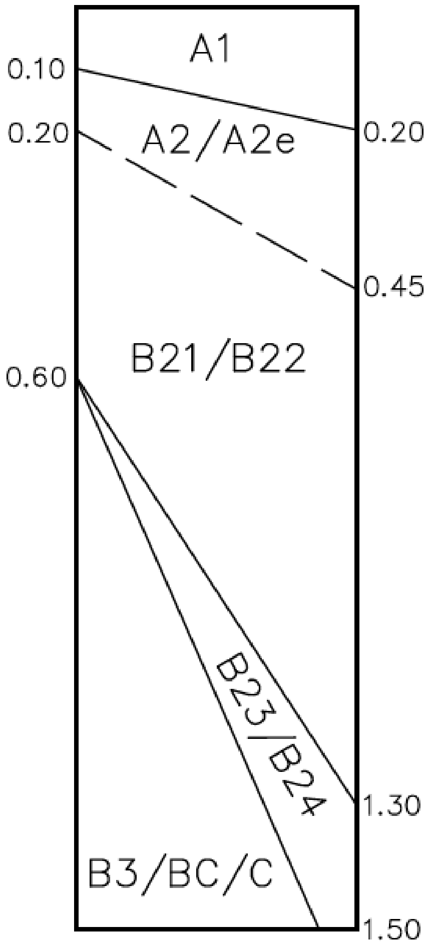
Vegetation: *E. crebra*, *E. tereticornis*, *Corymbia intermedia* grassy woodland (12.11.14).

Permeability: **Slowly** to very slowly permeable.

Drainage: Imperfectly drained.

Surface features: Firm, no microrelief.

Depth (m)



A1 Black or brown (10YR 2–3/2, 7.5YR 3/2 moist) sandy loam to clay loam fine sandy; moderate granular structure (occasionally massive); <2–20% 2–20 mm subrounded pebbles; field pH 5.5 to 6.5, clear or abrupt change to

A2/ A2e Grey, brown or black (10YR 5/2–3, 7.5YR 5/2–3, 10YR 3/2–4 moist, 10YR 7/2 dry) pale or conspicuously bleached sandy loam to clay loam sandy; weak to moderate subangular blocky or granular structure; frequently 2–20% <2–20 mm ferromanganiferous segregations; <2–20% 2–20 mm subrounded or angular pebbles; field pH 5.5 to 6.5, clear or abrupt change to

B21/ B22/ B23/ B24 Brown (7.5 YR 4–5/3, 10YR 5/3-4, 10YR 4-5/6, moist) light medium clay to heavy clay; weak to moderate subangular blocky, often grading to lenticular structure with occasional slickensides; 10-20% distinct or prominent mottles; occasionally 2–6 mm ferromanganiferous segregations; <2–20% 2–200 mm angular pebbles; field pH 4.5 to 5.5, clear or abrupt change to

B3/ Where present, grey or brown (10YR 4–6/2, 7.5YR 4–5/3 moist) light clay to light medium clay; massive or weak structure; substrate influenced mottles; 10–20% subangular/angular 60–200 mm pebbles/cobbles; field pH 4.5 to 5.5.

BC/C Parent material weathering insitu.

Sites: MISSE 640, 641, 642
SEQ **1454**
BSC 33, 34, 73, 80

Distribution: Central Fernvale.

FERNY (Fy)

Concept: Shallow, neutral loamy soils on chert, mudstone or conglomerate.

Soil Classification: **Bleached-Leptic Tenosol,** Leptic Rudosol.

Landform: Hillslopes and hillcrests of hills and low hills. Slopes generally <15%.

Geology: Chert, mudstones or conglomerates of the Neranleigh Fernvale beds (DCf).

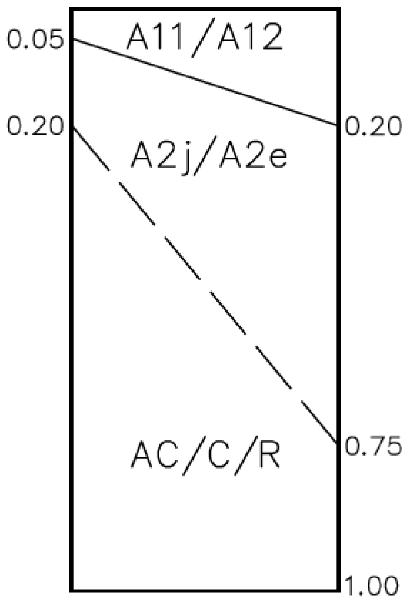
Vegetation: Open forest to woodland of *Corymbia citriodora subsp. variegata* generally with *E. crebra, E. tereticornis* and *C. tessellaris* present (12.11.6).

Permeability: Slowly to **moderately permeable**.

Drainage: **Moderately well** to well drained.

Surface condition: Firm to hard setting, no microrelief, frequent 2–200 mm chert and conglomerate pebbles and cobbles; frequent rock outcrops.

Depth (m)



A11/ A12 Black (10YR 3/2, 7.5YR 3/1–2 moist) sandy loam to clay loam; weak to moderate granular structure; field pH 5.5 to 6.0, clear or gradual change to

A2j/ A2e Where present grey or black (10YR 5/2, 7.5YR 3–4/2 moist, 10YR 7/1, 7.5YR 7/2 dry) conspicuously or sporadically bleached, sandy loam to clay loam; massive or weak subangular blocky structure; occasionally <2% manganiferous segregations; frequently 2–20% 2–6 mm angular pebbles; field pH 5.5 to 6.0, clear or abrupt change to

AC Brown sandy loam to clay loam; weak structure; 10–20% 6–200 mm subangular pebbles/cobbles weathering in situ; field pH 5.5 to 6.0.

C Chert, mudstone or conglomerate, weathering in situ; field pH 5.5 to 6.0.

R Chert, mudstone or conglomerate.

Sites: BSC **72**, 75, 77, 78, 79

Distribution: Fernvale in the Black Snake Creek catchment.

GALLANANI (Gl)

Concept: Very deep, neutral texture contrast or gradational soils on alluvium. Subsoils are moderately structured brown sandy clays, over buried horizons. Occasionally sodic at depth.

Soil Classification: **Brown**/Black **Chromosol**, Brown/Black Dermosol.

Landform: Terraces flats, terrace plains and plains on terraced lands and flood plains. Slopes generally <2%.

Geology: Quaternary alluvium (Qha/1, Qha/2).

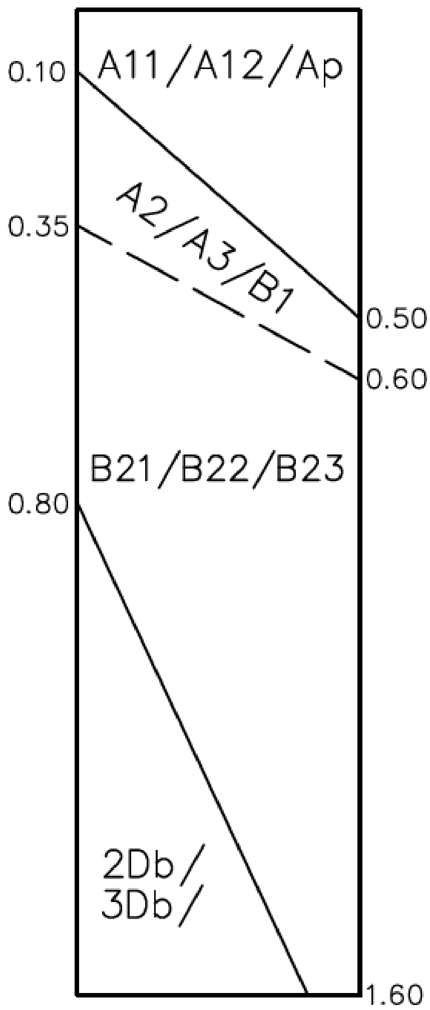
Vegetation: *E. tereticornis* woodland. /*E. tereticornis*, *Casuarina cunninghamiana* +/- *Melaleuca* spp. fringing woodland (12.3.3/12.3.7).

Permeability: Moderately permeable.

Drainage: Moderately well drained.

Surface features: Firm or hard setting, no microrelief, occasional 20-600 mm subangular cobbles.

Depth (m)



A11/ A12/ Ap Black or brown (10YR 2–3/2, 7.5YR 3/3 moist); sandy/silty loam to sandy clay loam; weak or moderate subangular blocky structure; field pH 6.0 to 7.5; clear change to

A2 Where present, brown or grey (10YR 3–4/3, 10YR 4/4-6, 10YR 4–5/2 moist, 10YR 4–6/3–4 dry); sandy loam to clay loam sandy; massive or weak subangular blocky structure; field pH 6.0 to 6.5; clear or abrupt change

A3/ B1 Brown (10YR 3–4/4, 7.5YR 4–5/4 moist) sandy loam to clay loam sandy; massive or weak subangular blocky structure; field pH 6.0 to 6.5, clear change

B21/ B22/ B23 Black or brown (10YR 2–3/2, 10YR 3/3–6, 7.5YR 4–5/4 moist) clay loam sandy to sandy light medium clay; moderate prismatic/angular blocky structure; occasionally 2–10% faint mottles, 2–10% 2–6 mm manganiferous segregations and/or 2–10% rounded 2-6 mm pebbles; field pH 6.5 to 7.5, clear change to

2Db/ 3Db Black or brown (10YR 2–3/2, 10YR 3/3–6, 7.5YR 4–5/4 moist) sandy clay loam to medium clay; moderate prismatic/angular blocky structure; occasionally distinct mottles; occasionally <2–10% rounded 2–6 mm pebbles; field pH 6.0 to 7.5; clear or abrupt change to

Sites: SEQE 15, 16, **19**, 20, 52, 61, 63, 94, 98, 102, 104, **109, 110**, 113, 120, 125, 140, 150, 166, 174, 264, 291 SEQ 1465, 1473, 1484, 1487, 1488, 1491, 1502, 1504, 1506,1514, 1517, 1521, 1522 MFM 427

Distribution: Avoca Vale, Esk and Fernvale.

GIRA GIRA (Gg)

Concept: Very deep, neutral strongly structured black non-cracking clay soils on alluvium.

Soil Classification: Black Dermosol.

Landform: Channel benches, plains and terrace flats on terraced lands and flood plains. Slopes generally <2%.

Geology: Quaternary alluvium (Qha/1, Qha/2, Qpa/1).

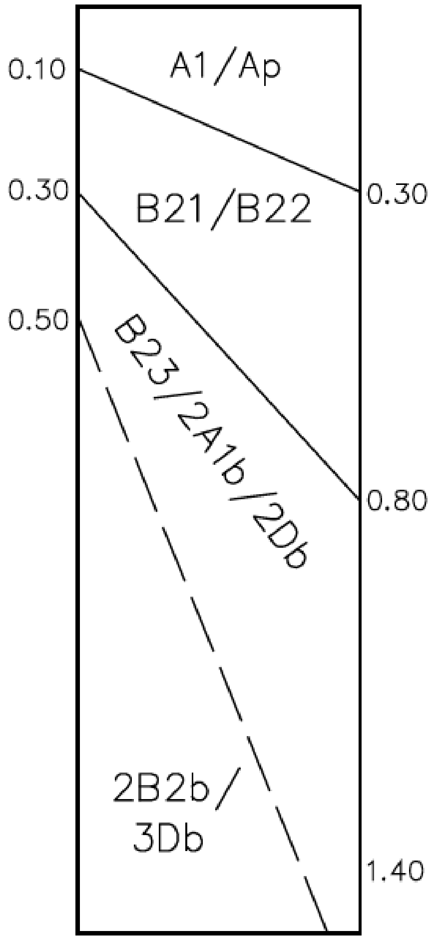
Vegetation: *E. tereticornis* woodland. /*E. tereticornis*, *Casuarina cunninghamiana* +/-*Melaleuca* spp. fringing woodland (12.3.3/12.3.7).

Permeability: Moderately permeable.

Drainage: Moderately well drained.

Surface condition: Firm, no microrelief.

Depth (m)



A1/ Ap Black (10YR 2–3/1–2 moist) silty clay loam to light clay; moderate granular, subangular blocky or polyhedral structure; field pH 6.0 to 7.0, clear change to

B21/ B22/ B23 Black or brown (10YR 2–3/2 moist) light clay to silty light medium clay; strong subangular blocky or polyhedral structure; occasionally 2–10% faint mottles; field pH 6.0 to 7.0, clear or gradual change to

2A1b/ 2Db/ Where present, black or brown (10YR 2–3/1–3 moist) silty/sandy light clay to medium clay; strong polyhedral or subangular blocky structure; field pH 6.0 to 7.0

2B2b/ 3Db Where present, black or brown (10YR 3/2–3, 7.5YR 3/2 moist) silty/sandy light medium clay to medium heavy clay; moderate to strong prismatic or blocky structure; field pH 6.0 to 7.0.

Sites: SEQE **31**, 64, 115, 126, 257, 293, 295
SEQ 1445, 1447, 1448, 1449, 1451, 1452, 1474, 1475, 1477, 1478, 1479, 1481, 1485
BSC 128

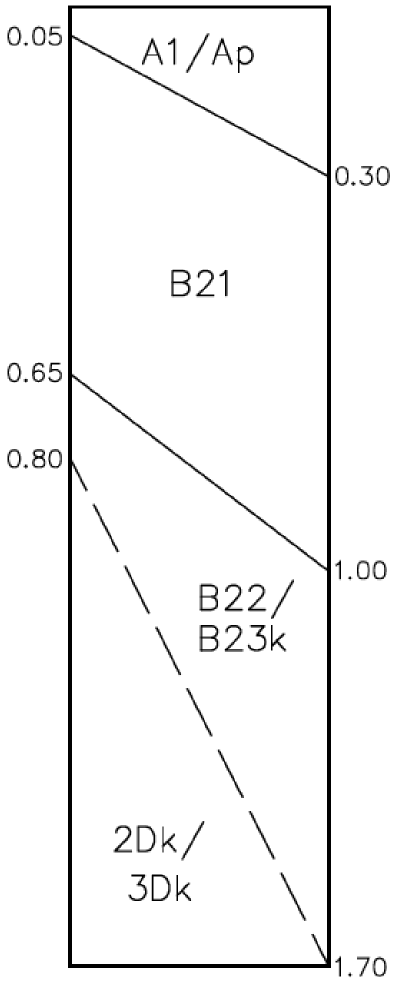
Gira Gira Rocky Phase (GgRp), as above but with 20-50% pebbles/cobbles in one or more of the buried horizons. SEQE 116

Distribution: Central Avoca Vale and Fernvale.

GLAMORGAN (Gm)

Concept:	Very deep, brown or black cracking clay or non-cracking clay soils with vertic properties, on alluvium. Subsoils are alkaline, calcic, grey, moderately saline and sodic.
Soil Classification:	**Brown/**Black **Vertosol**, Black/Brown Dermosol.
Landform:	Swamps and backplains of floodplains and stagnant alluvial plains.
Geology	Quaternary Pleistocene alluvium (Qpa/1).
Vegetation:	*E. tereticornis* woodland. / *Acacia harpophylla* open forest +/- *Casuarina cristata.* (12.3.3/12.9-10.6).
Permeability:	**Slowly** to very slowly permeable.
Drainage:	Imperfectly drained.
Surface condition:	Firm or hard setting, crusting, cracking.

Depth (m)



A1/ Ap	Black (10YR 3/1–3 moist) silty light clay to light medium clay; moderate angular/subangular blocky structure; field pH 6.0 to 7.0, clear change to
B21	Black or brown (10YR 3/1–2, 2.5Y 3/1–2, 7.5 YR 3/2, 10YR 4–5/4, 2.5Y 5/3 moist) silty light medium clay to medium clay; moderate to strong angular blocky structure; occasionally 20–50% 2–20 mm manganiferous segregations; occasionally 2–10% distinct mottles; field pH 6.0 to 8.0; clear or gradual change to
B22/ B23	Grey (10YR 4–5/2, 2.5Y 4–6/1 moist) silty light medium clay to medium clay; moderate to strong angular blocky grading to lenticular structure; 20–50% 2–20 mm manganiferous segregations; occasionally 2–10% or many distinct mottles; field pH 6.0 to 8.5; clear or gradual change to
B22k/ B23k	Grey or brown (10YR 3–6/1, 2.5YR 4–6/4 moist) silty medium to medium heavy clay; moderate to strong lenticular structure; 20-50% 2–20 mm manganiferous and calcareous segregations; occasionally 2–20% distinct mottles; field pH 8.5 to 9.0.
2Dk/ 3Dk/	Where present, grey (10YR 4/1 moist) medium clay; massive structure; 2–10% calcareous segregations; 2–10% distinct mottles; field pH 8.0 to 9.0.
Sites:	SEQE 127, 193, 271, **274** SEQ 1396, 1397, 1398, 1401, 1403, 1404, 1413, 1418, 1427,1432, 1434, 1438, 1441, 1456, 1457, 1458, 1459, 1461, 1464, 1518, 1570, 1571 BSC 1, 38, 41, 70, 87, 92, 102, 103, 109, 110

Distribution: Fernvale.

GLENCAIRN (Gc)

Concept: Very deep acidic, grey sodic texture contrast soils on alluvium. Subsoils are mottled.

Soil Classification: **Grey**/Brown **Kurosol,** Grey/Brown Sodosol, occasional Grey Dermosol.

Landform: Swamps and backplains of stagnant alluvial plains.

Geology: Quaternary Pleistocene alluvium (Qpa/1).

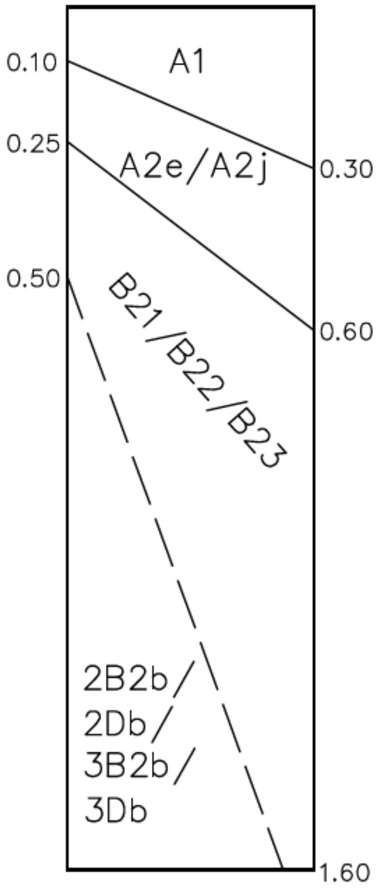
Vegetation: *Acacia harpophylla* open forest +/- *Casuarina cristata*. /*E. tereticornis* woodland. *E. crebra* and *E. moluccana* are sometimes present (12.9-10.6/12.3.3).

Permeability: **Slowly** or very slowly permeable.

Drainage: Imperfectly drained.

Surface features: Firm or hard setting, no microrelief.

Depth (m)



A1 Black, dark brown or grey (10 YR 3/1–3, 7.5YR 3–5/2–3 moist) loamy sand to clay loam; weak or moderate angular blocky structure (occasionally massive); field pH 5.0 to 6.0, clear or gradual change to

A2e/ A2j Grey or brown (10YR 4/1-2, 3–4/3, 7.5 YR 4–6/2, 4/3 moist 10YR 7/1–2 dry) loamy sand to clay loam, with conspicuous or sporadic bleach; weak or moderate angular blocky structure (occasionally massive); field pH 5.0 to 6.0, clear or abrupt change to

B21/ B22/ B23 Grey or brown (10YR 4–6/2, 2.5Y 6/1–2, 7.5YR 4–5/3 moist) sandy light clay to medium clay; moderate or strong prismatic, angular/subangular blocky or grading to lenticular structure; frequently 2–20% faint or distinct mottles; field pH 4.5 to 6, clear or gradual change to

2B2b/ 3B2b/ 2Db/ 3Db Where present, brown or grey (7.5YR4/3, 10YR 5/4, 2.5Y 6/1 moist) light medium clay to medium clay; moderate or strong subangular blocky structure; occasionally 2–10% faint or distinct mottles; <2–20% 6–20 mm angular sandstone pebbles; field pH 4.0 to 6.0.

Sites: SEQE 3, **50**
SEQ 1411, 1414, 1423, 1428, 1439, 1442, 1443, 1493, 1497, 1498, 1507, 1520

BSC 28, 62,

Distribution: Fernvale, limited occurrence Avoca Vale.

GRIENKE (Gk)

Concept: Very shallow to shallow, neutral, dark loamy soils with many small pebbles on sandstone or conglomerate weathering in situ from 0.1.

Soil Classification: **Leptic Tenosol**/Rudosol, occasional Brown Dermosol.

Landform: Crests and upper slopes of low hills, hills and mountains. Slopes generally <30%.

Geology: Sandstones or conglomerates of the Esk Formation (Rte).

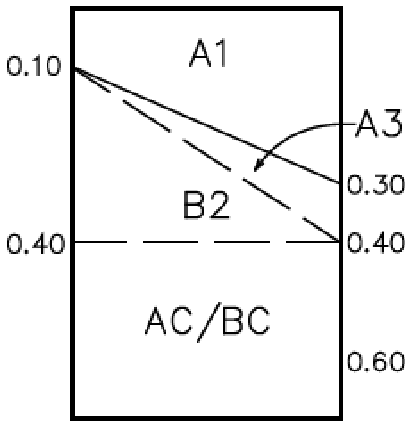
Vegetation: *E. tereticornis*, *Corymbia intermedia*, *E. crebra +/- Lophostemon suaveolens* woodland./ *E. crebra +/- E. tereticornis*, *C. tessellaris*, *Angophora leiocarpa*, *E. melanophloia* woodland./ *C. citriodora subsp. variegata +/- E. crebra* open forest (12.12.12/12.9-10.7/12.9-10.2).

Permeability: **Moderately** to highly permeable.

Drainage: Well drained.

Surface features: Hard setting, frequent <2–10% of 2–200 mm sandstone or conglomerate pebbles and cobbles, occasional rock outcrops.

Depth (m)



A1 Black (10YR 2–3/2, 7.5YR 3/2 moist) loam to clay loam; weak or moderate granular or subangular blocky structure; 2–20% 2–6 mm pebbles; field pH 6.0 to 6.5, clear change to

A3 Where present, black or brown (10YR 2–3/2, 7.5YR 3/3 moist) sandy clay loam; weak or moderate subangular blocky structure; 10–20% 2–60 mm pebbles; field pH 6.0 to 6.5, clear change to

B2 Occasionally present, dark brown (10YR 3/3 moist) coarse sandy light clay; weak or moderate subangular blocky structure; 10–20% 2–60 mm pebbles; field pH 6.0 to 6.5, abrupt change to

AC/BC Where present, light clay with parent material weathering in situ; field pH 6.0 to 7.0.

Sites: SEQE 22, 35, **70**, 87, 216, 249, 299

Distribution: Eastern Esk, Avoca Vale.

GUNYAH (Gh)

Concept: Very deep, neutral brown texture contrast or gradational soils on alluvium. Subsoils are frequently mottled and/or sodic at depth.

Soil Classification: **Brown Chromosol**, Brown Dermosol.

Landform: Drainage depressions, swamps, backplains and terrace plains on floodplains, stagnant alluvial plains and terraces.

Geology: Quaternary alluvium (Qha/1, Qha/2, Qpa/1).

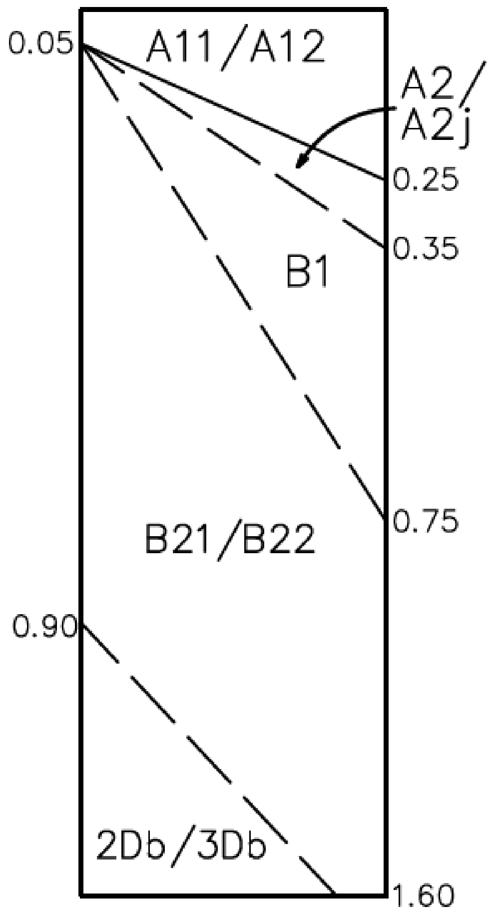
Vegetation: *E. tereticornis* woodland. /*E. tereticornis*, *Casuarina cunninghamiana* +/- *Melaleuca* spp. fringing woodland. (12.3.3/12.3.7) *E. tereticornis*, *Corymbia intermedia*, *E. crebra* open forest to woodland (12.12.12) north of Avoca Vale.

Permeability: Slowly permeable.

Drainage: **Imperfectly drained**, occasionally moderately well drained.

Surface features: Firm, no microrelief.

Depth (m)



A11/ A12 Black, brown or grey (10YR 2–3/2, 3/3, 4/1–2) moist, silty loam to silty clay loam; weak to moderate granular or subangular blocky structure; field pH 6.0 to 6.5, clear or abrupt change to

A2/ A2j Grey or brown (10YR 4–6/1–2, 4/4–6 moist, 10YR 6–7/1–3 dry) frequently sporadically bleached loam to clay loam; weak to moderate subangular blocky structure; occasionally 2–10% 2–6 mm ferromanganiferous segregations; field pH 6.0 to 6.5, clear or abrupt change to

B1 Where present, brown (10YR 4–5/4) moist, sandy clay loam to light clay; moderate subangular/angular blocky structure; occasionally distinct mottles; field pH 6.0 to 7.0, clear or abrupt change to

B21/ B22 Brown, black or grey (10YR 3/3–4, 2.5Y 5–6/3, 10YR 2–3/2, 10YR 5–6/2, 7.5 YR 4–6/2 moist), light to medium heavy clay; moderate angular/ subangular blocky or lenticular structure (occasionally weak), occasionally 2–10% 2–6 mm manganiferous segregations and/or 2–20 mm pebbles; 2–20% faint or distinct mottles; field pH 7.0 to 7.5, clear or gradual change to

2Db/ 3Db Where present, black or brown 7.5YR 3–4/3–4, 10YR 2–3/2 moist, light medium clay; moderate blocky or lenticular structure; 2–10% 2–6 mm manganiferous segregations and distinct mottles; field pH 7.0 to 7.5.

Sites: SEQE **45**, 73, 77, 130
SEQ 1455, 1489, 1516, 1524, 1534

Distribution: Avoca Vale, Esk and Fernvale.

HALLEN (Hl)

Concept: Shallow, red or brown earthy soils on quartzose sandstone weathering in situ from 0.1 m. Massive structure throughout and neutral soil reaction.

Soil Classification: **Red/Brown-Orthic Tenosol**, Red/Brown Kandosol.

Landform: Hillcrests and upper slopes of rises, low hills and hills. Slopes generally <15%.

Geology Quartzose sandstones of the Woogaroo Subgroup (RJbw).

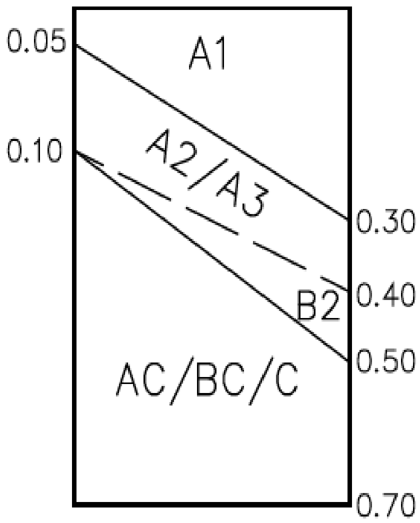
Vegetation: *Corymbia citriodora* subsp. variegata +/- *E. crebra* open forest. /*E. crebra* +/- *E. tereticornis*, *C. tessellaris, Angophora* spp., *E. melanophloia* woodland (12.9-10.2/12.9-10.7).

Permeability: Highly permeable.

Drainage: Well drained to **rapidly drained**.

Surface features: Hard setting, frequent <2-10% of 2–600 mm sandstone and conglomerate pebbles and cobbles and rock outcrops.

Depth (m)
****



A1	Black, brown or red (10YR 2–4/3, 7.5 YR 2.5–4/3, 5YR 3/3 moist) clayey sand to clay loam sandy; weak angular blocky or massive structure; 2–10% 2–20 mm ferrruginised sandstone pebbles; field pH 6.0 to 7.0, clear change to
A2	Where present, brown (10YR 3–5/4 moist 10YR 6/3, 7.5YR 6/4 dry) clayey sand to sandy loam; massive structure; 2–10% 2–20 mm pebbles; field pH 6.0 to 7.0, clear change to
A3	Where present, brown or red (7.5YR 3/3–4, 5YR 3–4/4 moist) loamy sand to clay loam fine sandy; massive structure; 2–20% sandstone 2–60 mm pebbles and cobbles; field pH 6.0 to 7.0, clear change to
B2	Where present red (2.5 YR 4/4, 5YR 4/4–6 moist) sandy loam to coarse sandy light clay; massive structure; 2–20% 2–60 mm sandstone pebbles and cobbles; field pH 6.0 to 7.0, clear change to
AC/ BC	Brown or red (7.5 YR 4/3–4, 2.5YR 4-5/4, 5YR 4/2–6 moist) loamy sand to sandy light clay; massive structure; 20–50% ferruginised sandstone fragments weathering in situ; field pH 6.0 to 7.0.
C	Parent material weathering insitu.
Sites:	143, 153, 191, 211, 231, 235, 236, **238**, 241, 253, 256

Distribution: Western portion of Esk.

HIBISCUS (Hb)

Concept: Deep to very deep red earthy gradational soils on quartzose sandstone. Occasionally texture contrast.

Soil Classification: **Red Kandosol,** Red Chromosol.

Landform: Hillslopes of rises, low hills and hills. Slopes generally <20%.

Geology: Moderately weathered quartzose sandstones and sandy colluvial deposits of Woogaroo Subgroup (RJbw).

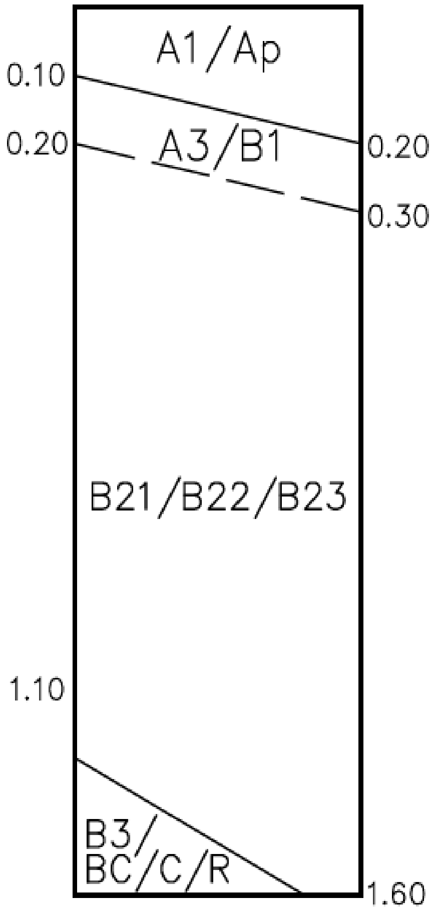
Vegetation: *Corymbia citriodora* subsp. *variegata* +/- *E. crebra* open forest /*E. crebra* +/- *E. tereticornis*, *C. tessellaris, Angophora spp*., *E. melanophloia* woodland (12.9-10.2/12.9-10.7).

Permeability: **Moderately** to highly permeable.

Drainage: Well drained to **rapidly well drained**.

Surface features: Hard setting.

Depth (m)



A1/ Ap Brown, black or red (7.5YR 3/2–4, 2.5YR 3/2–3, 5YR 3/1–6 moist) massive or weak blocky structure; clayey sand to sandy clay loam; occasionally 2% ferromanganiferous segregations; field pH 5.0 to 6.0, clear or gradual change to

A3/ B1 Where present, red or brown (7.5YR 3/3–6, 5YR 3–4/3–6, 2.5YR 3/3–6 moist) sandy loam to sandy light clay; massive or weak blocky structure; occasionally 2–10% <2–6 mm ferromanganiferous segregations and 2–10% 2–6 mm pebbles; field pH 5.0 to 6.0, gradual change to

B21/ B22/ B23 Red (5YR 5/3–8, 2.5YR 4/3–8 moist) clay loam, sandy to sandy light medium clay; massive or weak blocky structure; frequently 2–10% <2–6 mm ferromanganiferous segregations and 2–10% 2–6 mm pebbles; field pH 5.0 to 6.5, gradual change to

B3 Red (5YR 5/6–8, 2.5YR 4/4–6 moist) sandy light medium clay; massive structure; frequently 10–20% 2–6 mm quartz and ferruginised sandstone pebbles; occasionally 2–10% <2–6 mm ferromanganiferous segregations; occasional substrate influenced mottles; field pH 5.0 to 7.0, gradual change to

BC/ C Where present, red (2.5YR 5/4 moist) clay loam coarse sandy; massive structure; many sandstone pebbles weathering in situ and occasionally 2–10% <2–6 mm Ferromanganiferous segregations; field pH 5.0 to 7.0

R Sandstone rock.

Sites SEQE 112, 146, **148**, 151, 155, 158, 162, 163, 170, 171, 192, 195, 224, 255 MFM 348, **349**, 350, 387, 428
Hibiscus Nodular Variant (HbNv) with 20–50% ferromanganiferous segregations in A2 and/or B2 horizons. In lower landscape positions: SEQE 154, 156, 165, 168, 212, 230, 239, 263
Hibiscus Shallow Phase (HbSp) in upper slopes: SEQE 258

Distribution: Western Esk and southern Fernvale.

HIBISCUS LIGHT PHASE (HbLp)

Concept: Deep to very deep red earthy gradational soils on quartzose sandstone. Dominated by loamy sand to sandy clay loam textures throughout.

Soil Classification: **Red Kandosol,** Red-Orthic Tenosol.

Landform: Lower slopes on rises and low hills. Slopes generally <10%.

Geology: Moderately weathered quartzose sandstones and sandy colluvial deposits of Woogaroo Subgroup (RJbw).

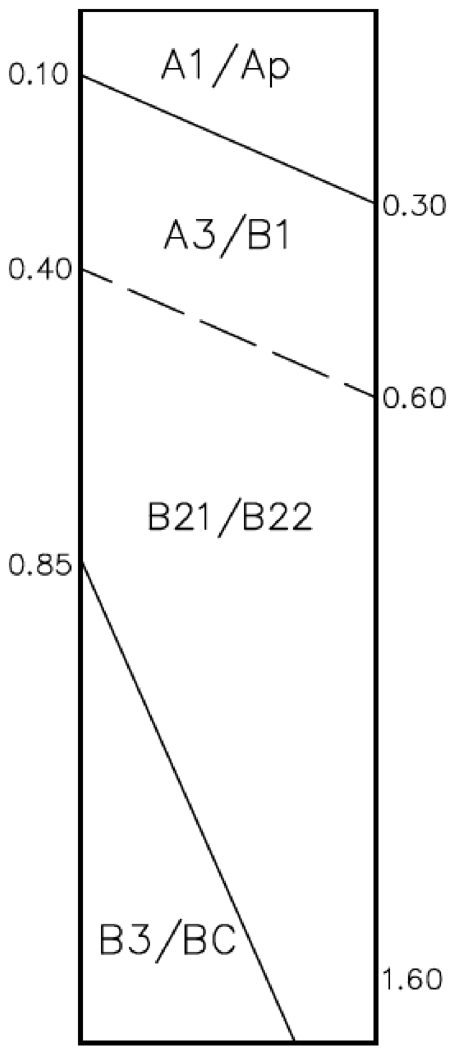
Vegetation: *Corymbia citriodora* subsp. *variegata* +/- *E. crebra* open forest./*E. crebra* +/- *E. tereticornis, C. tessellaris, Angophora* spp., *E. melanophloia* woodland (12.9-10.2/12.9-10.7).

Permeability: Highly permeable.

Drainage: Rapidly well drained.

Surface features: Hard setting.

Depth (m)



A1/ Ap Brown, black or red (10YR 3/3, 7.5YR 3–4/3, 2.5YR 3/2–3, 5YR 3/1–4 moist) massive or weak angular blocky structure; loamy sand to clayey sand; field pH 5.0 to 6.0, clear to gradual change to

A3/ B1 Where present, brown or red (7.5YR 3–4/3–6, 5YR 3–4/3–6, 2.5YR 2–5/3–8 moist) loamy sand to sandy clay loam; massive or weak blocky structure; 2–10% 2–6 mm pebbles; field pH 5.0 to 6.0, gradual change to

B21/ B22 Red (5YR 3–5/3–8, 2.5YR 2.5–4/3–8 moist) loamy sand to clay loam sandy; massive or weak angular blocky structure; occasionally 2–10% <2–20 mm ferromanganiferous segregations and/or 2–10% 2–6 mm pebbles; field pH 5.0 to 6.5, gradual change to

B3 Red or brown (5YR4–5/6–8, 2.5YR 2.5–4/4–6 7.5YR 5/6 moist) loamy sand to clay loam sandy; massive structure; frequently 10–20% 2–6 mm quartz and ferruginised sandstone pebbles; occasionally 2–10% <2–6 mm ferromanganiferous segregations; field pH 5.0 to 7.0, gradual change to

BC Where present, red (2.5YR 5/4 moist) sandy clay loam to sandy light clay; massive structure; 10–20% sandstone pebbles weathering in situ and occasionally 2–10% <2–6 mm Ferromanganiferous segregations; field pH 5.0 to 7.0.

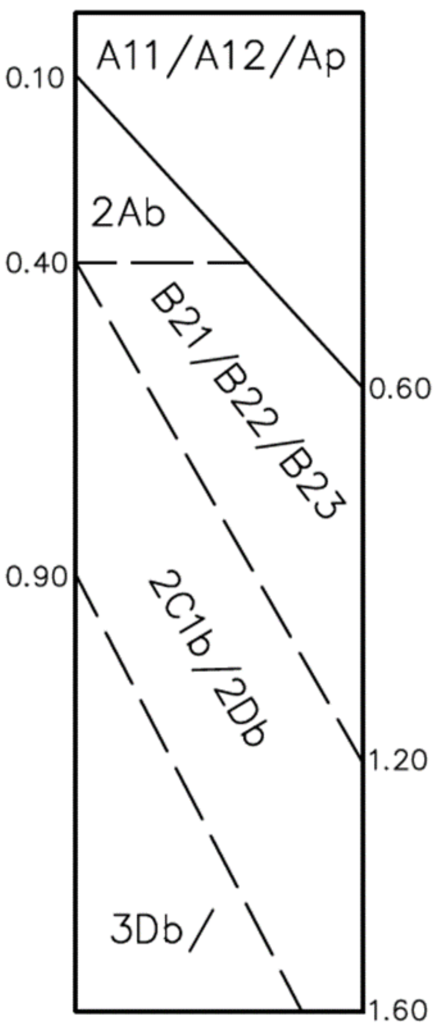
Sites: SEQE 147, **169**, 182, 183, 197, 203, 207, 234
MFM 353

Distribution: Central portion of Esk.

HONEY (Hy)

Concept:	Very deep, neutral brown (occasionally black) loamy soils with buried horizons on alluvium.
Soil Classification:	**Brown Kandosol**, Brown/Black-Orthic Tenosol, occasional Stratic Rudosol.
Landform:	Terrace flats, levees and channel benches on terraced land and floodplains.
Geology:	Quaternary alluvium (Qha/1, Qha/2, Qa).
Vegetation:	*E. tereticornis* woodland. / *E. tereticornis*, *Casuarina cunninghamiana* subsp. *cunninghamiana* +/- Melaleuca spp. fringing woodland (12.3.3/12.3.70).
Permeability:	Moderately to highly permeable.
Drainage:	Moderately to well drained.
Surface features:	Hard setting or firm.

Depth (m)



A11/ A12/ Ap	Black or brown (10YR 3/2–3 moist) sandy loam to sandy clay loam; weak to moderate subangular blocky structure; field pH 6.0 to 7.0, abrupt or clear change to
B21/ B22/ B23	Where present, black or brown (10YR 3/2–4 moist) sandy loam to clay loam sandy; massive to weak angular/subangular blocky structure; field pH 6.0 to 7.0, clear change to
2Ab/ 2Db	Where present, black or brown (10YR 3/1–4 moist) sandy loam to sandy clay loam; massive or weak angular/subangular blocky structure; field pH 6.0 to 7.0; clear change to
2C1b	Where present, brown (10YR 3/3–4 moist) loamy sand to sandy loam; massive structure; field pH 6.0 to 7.0, clear or abrupt change to
3Db	Where present, brown (10YR 3/3–5 moist) sandy loam to sandy light clay; massive to weak angular/ subangular blocky structure; occasionally 2–10% 2–6 mm pebbles; field pH 6.0 to 7.0.
Sites:	SEQE 18, 23, 53, 62, **103**, 112, 288, 292, 296
	SEQ 1450, 1453, 1466, 1503, 1513, 1515, 1519
	Honey Rocky Phase (HyRp): As above, but with 20–50% pebbles and cobbles in one or two horizons. SEQE 76

Distribution: Avoca Vale, Fernvale.

JIMNA (Jm)

Concept: Deep to very deep, black or brown cracking clay soils on andesite or volcanoclastic conglomerate. Subsoils are alkaline and often sodic at depth.

Soil Classification: **Black Vertosol**, Brown Vertosol.

Landform: Lower slopes and footslopes of rises and low hills. Slopes generally <5%.

Geology: Andesites or volcanoclastic conglomerates of the Neara Volcanics (Rtn).

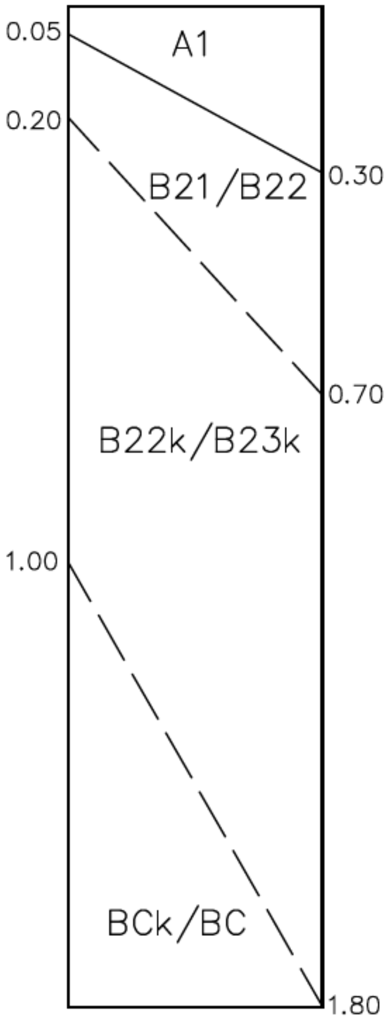
Vegetation: *E. tereticornis* woodland including *E. melanophloia*, *E. crebra*, *Corymbia tessellaris* and *Angophora subvelutina* (12.3.3).

Permeability: Slowly permeable.

Drainage: Moderately well drained.

Surface features: Weakly self-mulching, cracking.

Depth (m)



A1 Black (10YR 2–3/2 moist) light clay; moderate subangular blocky structure; field pH 6.0 to 6.5, clear or abrupt change to

B21/ B22 Black or brown (10YR 3/1–2, 10YR 3/3–4 moist) sandy light medium clay to medium heavy clay, moderate subangular blocky grading to lenticular structure with prominent slickensides; few <2–6 mm manganiferous segregations; 2–10% 2–6 mm andesitic pebbles; field pH 6.0 to 8.5, clear or gradual change to

B22k/ B23k Where present, black (10YR 3/1–2 moist) fine sandy light medium clay; strong lenticular structure; 2–10% 2–6 mm calcareous segregations and <2–6 mm manganiferous segregations; 2–10% 2–6 mm andesitic pebbles; field pH 8.5–9.0.

BCk/ BC Parent material weathering insitu.

Sites: SEQE 10, **29**

Distribution: Limited occurrence in northern portion of Avoca Vale, but described in BVL project.

KIPPER (Kp)

Concept: Moderately deep, neutral to slightly acid red or brown texture contrast gradational soils on sandstone. Sub-surface is frequently pale or has sporadic bleach.

Soil Classification: **Red Dermosol**, Red Chromosol.

Landform: Mid and upper hillslopes of rises and low hills. Slopes generally 10–40%.

Geology: Feldspathic sandstones of the Esk Formation (Rte).

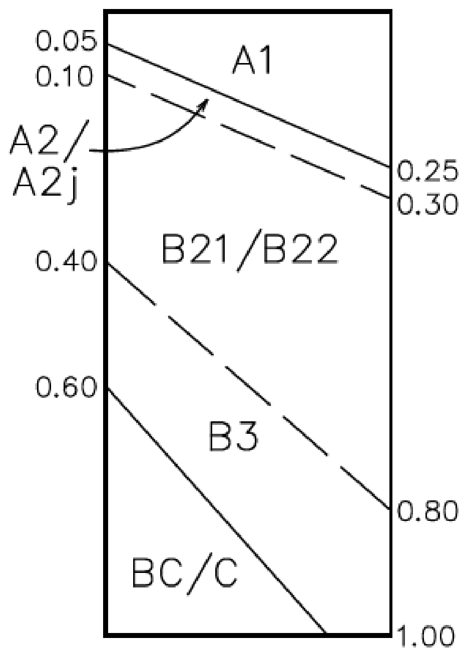
Vegetation: *E. crebra* +/- *E. tereticornis*, *Corymbia tessellaris*, *Angophora leiocarpa*, *E. melanophloia* woodland./ *Eucalyptus moluccana* +/- *C citriodora* open forest (12.9-10.7/12.9-10.3).

Permeability: Moderately permeable.

Drainage: Moderately well drained.

Surface features: Firm, frequent 2–10% 2–20 mm quartz and sandstone pebbles.

Depth (m)



A1 Black (10YR 2–3/2 moist) sandy clay loam to clay loam; moderate granular or cast structure; field pH 6.0 to 6.5, clear or abrupt change to

A2/ A2j Where present, brown (10YR 3–4/3–4 moist 10YR 6–7/2–3 dry) sandy clay loam to sandy light clay; massive or moderate subangular blocky structure; occasionally <2% <2 mm manganiferous segregations; field pH 6.0 to 7.0, clear or abrupt change to

B21 Red (5YR 4–6/4–6 moist) medium clay; moderate subangular blocky or polyhedral structure; occasionally 2–10% faint mottles; occasionally 2–10% <2 mm manganiferous segregations; field pH 6.0 to 7.0, clear change to

B22 Red or brown (5YR 4–6/4–6, 7.5 YR 4–5/4–8 moist) medium clay; moderate subangular blocky or polyhedral structure; occasionally 2–10% faint mottles; occasionally 2–10% <2 mm manganiferous segregations; field pH 6.0 to 7.0, clear change to

B3 Where present, red (5YR 5/4–6 moist), sandy light medium clay; moderate subangular blocky or polyhedral structure; occasionally 2–10% sandstone pebbles; field pH 6.0 to 7.0 clear to gradual change to

BC/C Red (5YR 5/4–6 moist) sandy light to light medium clay, with 10–20% sandstone pebbles weathering in situ; 2–10% 2–6 mm manganiferous segregations; field pH 6.0 to 7.0.

Sites: SEQE 1, **44**, 117, 121, 177

Distribution: Western portion of Avoca Vale.

KOUKANDOWIE (Kk)

Concept: Deep, alkaline brown, black or occasionally yellow sodic texture contrast soils on siltstone or sandstone. Subsoils are calcic and mottled. Often slight to moderately saline.

Soil Classification: **Brown**/Black/Yellow **Sodosol**.

Landform: Hillslopes on rises, hills and low hills. Slopes generally <10%.

Geology Siltstones or sandstones of Koukandowie formation (Jbmk) and Gatton sandstones (Jbmg).

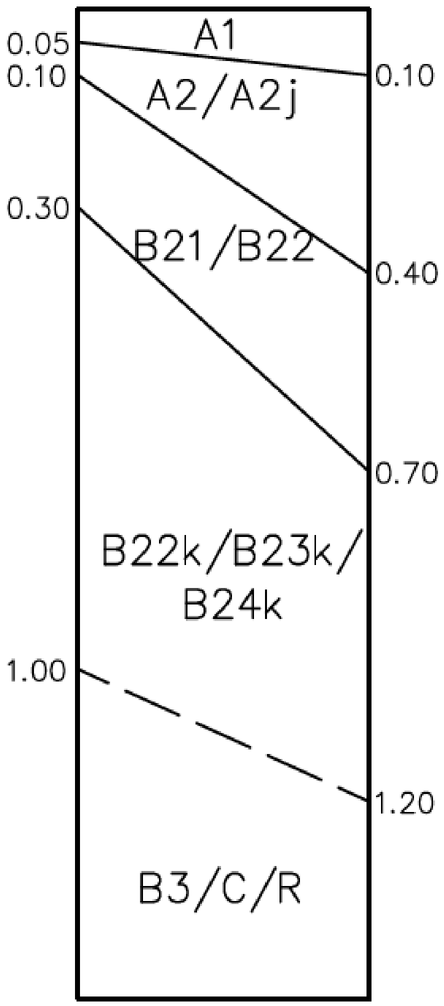
Vegetation: *E. crebra* +/- *E. tereticornis*, *Corymbia tessellaris*, *Angophora* spp., *E. melanophloia* woodland /*E. tereticornis* woodland/*Acacia harpophylla* open forest (12.9-10.7/12.3.3/12.9-10.6).

Permeability: Slowly to very slowly permeable.

Drainage: Imperfectly drained.

Surface condition: Hard setting, <2–10% of 20–200 mm angular sandstone and basalt, no microrelief.

Depth (m)



A1 Black or brown (7.5 YR 3/2, 10YR 3/3–4 moist) sandy clay loam to clay loam; weak or moderate granular or angular blocky structure; occasional 2–6 mm sandstone pebbles; field pH 6.0 to 7.0, clear change to

A2/ A2j Dark brown or grey (10YR 3/3–4, 7.5 YR 4/2 moist 10YR 5–7/2, 7.5 YR 7/3 dry) sandy clay loam to clay loam; massive or moderate angular/subangular blocky structure; occasional faint mottles; field pH 6.5 to 7.0, clear or abrupt change to

B21/ B22 Brown, black or yellow (10YR 5/3–4, 7.5YR 4–6/3, 10YR 3/2, 10YR 6/4, 2.5 YR 6/4–6 moist) fine sandy light medium clay to medium heavy clay; strong prismatic, angular/subangular blocky or lenticular structure; frequently 2–50% distinct mottles; occasionally <2% 6–20 mm sandstone or shale pebbles; field pH 7.0 to 8.5; clear or gradual change to

B22k/ B23k/ B24k Grey or yellow (2.5Y 6/2, 2.5Y 6–7/6, 10YR 6/6 moist) fine sandy light medium clay to medium heavy clay; moderate prismatic, angular/subangular blocky structure; frequently 2–20% distinct mottles; few calcareous segregations; field pH 8.5 to 9.0, clear or gradual change to

B3 Where present, grey light medium clay; 10–20% distinct mottles and substrate influenced mottles; 10-20% 6–20 mm siltstone or sandstone pebbles weathering in situ; field pH 8.0 to 8.5.

C/R Parent material and rock.

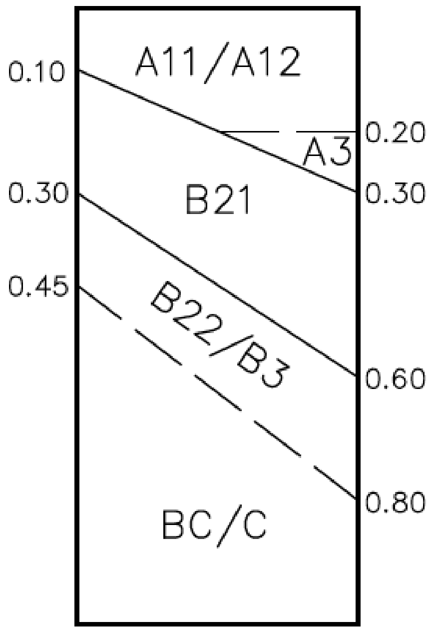
Sites: SEQE **196**
BSC 20, 64**,** 94

Distribution: Fernvale and Blacksnake Creek catchment.

LAKEVIEW (Lv)

Concept:	Moderately deep, neutral brown texture contrast or gradational soils on sandstone or conglomerate.
Soil Classification:	**Brown Dermosol,** Brown Chromosol.
Landform:	Mid slopes, upper slopes and hillcrests of low hills, hills and mountains. Slopes generally <35%.
Geology:	Sandstones and conglomerates of the Esk Formation (Rte) and Mount Crosby Formation (Rim).
Vegetation:	Eucalyptus woodland dominated by *Corymbia citriodora* subsp. *variegata*, *E. crebra*, *E. tereticornis* and *E. moluccana* (12.11.6/12.9-10.7/12.9-10.3).
Permeability:	Moderately permeable.
Drainage:	Moderately well drained.
Surface features:	Firm to hard setting, no microrelief, frequently <2–10% of 2–200 mm sandstone and conglomerate pebbles and cobbles, occasional rock outcrops.

Depth (m)



A11/ A12	Black or brown (10YR 2–3/2–3 moist) sandy clay loam to clay loam; weak to moderate subangular or granular structure; field pH 6.0 to 7.0, clear or gradual change to
A3	Where present, brown (10YR 3/2 moist) sandy light clay; moderate subangular blocky structure, 2–10% 2–6 mm pebbles; field pH 6.0 to 6.5; clear change to
B21/ B22	Brown (10YR 3/3–4, 4–5/6 moist) fine sandy light clay to medium clay; weak to moderate subangular blocky or polyhedral structure; occasionally substrate influenced mottles; frequently 2–10% 2–6mm pebbles; occasionally <2% manganiferous segregations; field pH 6.0 to 7.0, clear or gradual change to
B3	Where present, brown (10YR 4/3 moist) sandy light medium clay; moderate to weak subangular blocky structure; 10–20% 2–20 pebbles, frequently weathering insitu; field pH 6.0 to 7.0.
BC/C	Parent material weathering insitu.

Sites **47**, 66, 78, 97, 218, 284, 285, 289

Distribution: Western Avoca Vale, eastern portion of Esk, southern portion of Fernvale.

LINVILLE (Le)

Concept: Shallow to moderately deep, brown, texture contrast or gradational soils on andesite or volcanoclastic conglomerate. Sandy clay loam surfaces, with occasionally bleached sub-surface.

Soil Classification: **Brown Chromosol**, Brown Dermosol.

Landform: Upper and midslopes of rises and low hills. Slopes generally <15%.

Geology: Andesites or volcanoclastic conglomerates of the Neara volcanics (Rtn) and diorites of the Brisbane Valley Porphyrite (Rgv).

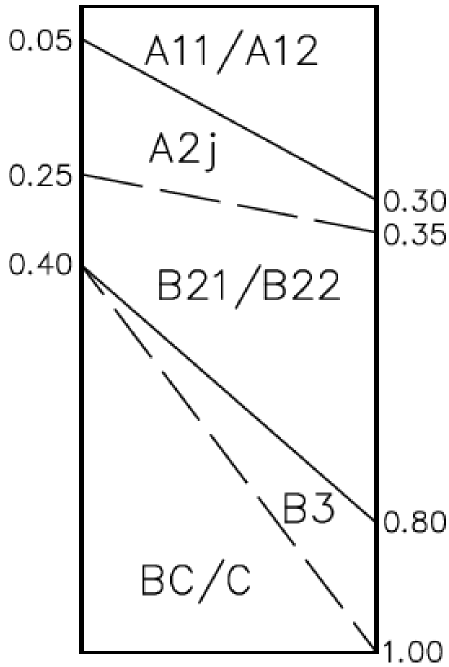
Vegetation: Eucalyptus woodland dominated by *E. melanophloia*, *E. crebra*, *E. tereticornis*, *Angophora subvelutina* and *Corymbia citriodora* subsp. *variegata* (12.12.12/12.12.7/12.12.5).

Permeability: **Slowly** to moderately permeable.

Drainage: **Moderately well drained**, occasionally imperfectly drained.

Surface features: Firm, 2–10% 2–20 mm pebbles.

Depth (m)



A11/ A12 Black brown (10YR 3/1–3 moist) sandy clay loam; moderate subangular blocky structure; field pH 6.0 to 6.5, clear change to

A2j Where present, brown (10YR 4–5/4 moist 10YR 6–7/2 dry) sandy clay loam; moderate subangular blocky structure; 10–20% <2–6 mm manganiferous segregations; field pH 6.0 to 7.0, clear change to

B21/ B22 Brown, occasionally black or grey (10YR 4–5/6, 3/1–3, 4/2 moist) light medium to medium clay; moderate subangular/angular blocky grading to lenticular structure; 2–10% faint mottles and substrate influenced mottles; 2–20% <2–6 mm manganiferous segregations; field pH 6.0 to 7.0, clear change to

B3 Brown or black (10YR 4–5/6, 3/2–3 moist), sandy light to medium clay; weak subangular blocky or lenticular structure; 2–10% faint mottles, or substrate influenced mottles; 2–20% <2–6 mm manganiferous segregations; occasionally 2–10% 2–20 mm andesitic pebbles; field pH 6.0 to 7.0, clear to gradual change to

BC/ C Where present, brown (10YR 3–5/4–6 moist) sandy light to light medium clay, 10-20% 2–20 mm andesitic pebbles; 2–20% <2–6 mm manganiferous segregations; field pH 6.0 to 7.0.

Sites: SEQE 8, 11, 88, **99**, 118, 119, 222
Note: SEQE 221 has calcareous segregations and is alkaline.

Distribution: Northern and eastern Avoca Vale and eastern portion of Esk.

LOWOOD (Lw)

Concept: Deep, neutral to acidic grey or brown sodic texture contrast soils with conspicuous/sporadic bleach on sandstone or siltstone. Subsoils are mottled and often slightly to moderately saline at depth.

Soil Classification: **Grey**/Brown **Sodosol**, Grey/Brown Kurosol, occasional Grey/Brown Dermosol

Landform: Mid and lower slopes of rises. Slopes generally <15%.

Geology: Sandstones or siltstones of Gatton sandstones (Jbmg) and Koukandowie Formation (Jbmk).

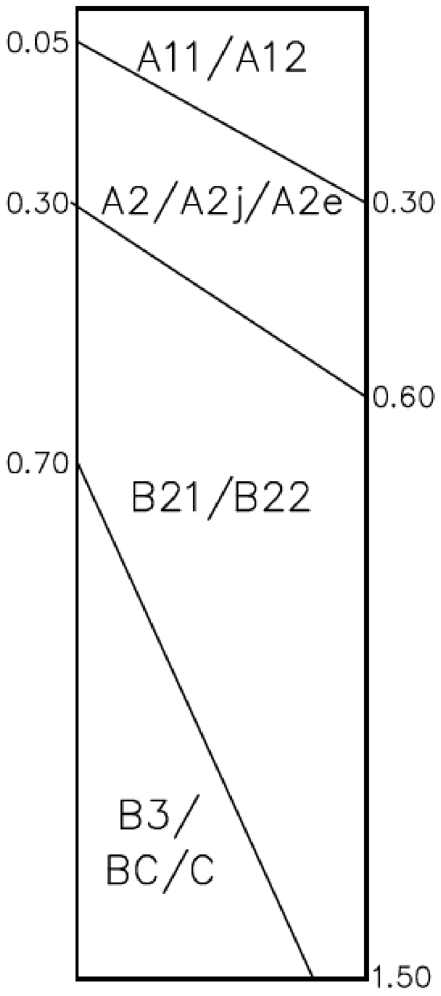
Vegetation: Eucalyptus woodlands with combinations of the following spp. *E. crebra*, *E. tereticornis*, *Corymbia tessellaris*, *Angophora* spp. *E. melanophloia*, *E. tereticornis*, and *E. moluccana* (12.9-10.7/12.9-10.6/12.9-10.3/12.3.3).

Permeability: Slowly to **very slowly permeable**.

Drainage: Imperfectly drained.

Surface condition: Hard setting, common active sheet erosion.

Depth (m)



A11/ A12 Black, brown or grey (10YR 2–3/2, 10YR 4-3/3, 7.5YR 3/1–2 moist) fine sandy loam to clay loam, sandy; weak or moderate granular or subangular blocky structure, occasionally massive; field pH 6.0 to 6.5, clear, abrupt or sharp change to

A2/ A2j/ A2e Brown or grey (10YR 5–6/3, 7.5 YR 4–5/3 moist 10YR 7–8/3, dry) frequently sporadically or conspicuously bleached loamy sand to clay loam; massive or moderate angular blocky structure; frequently 20–50% faint mottles; occasionally <2% manganiferous segregations; occasionally 10–20% 6–20 mm rounded pebbles; field pH 5.0 to 6.5, clear or abrupt change to

B21/ B22 Grey or brown (10YR 4–6/2, 2.5Y 5/2, 10YR 4/3, 7.5YR 4–5/3, moist) sandy light clay to medium heavy clay; weak or moderate angular/subangular blocky, grading to lenticular structure with slickensides; 2–50% faint or distinct mottles; occasionally 20–60 mm sandstone pebbles; field pH 4.5 to 6.0; clear or gradual change to

B3 Brown or grey (10YR 4–7/2–3, 10YR 5/3 moist) light medium to medium clay; moderate or weak structure; 20–50% distinct mottles and substrate influenced mottles; sandstone or siltstone coarse fragments weathering in situ; field pH 4.5 to 6.0.

BC/ C Sandstone or siltstone coarse fragments weathering in situ.

Sites: SEQE 269, 279, **280**
BSC 10, 11, 17, **24**, 29, 61, 65, 99, 100

BSC 66, 96 – as above, but gradational rather than texture contrast.

Distribution: Fernvale.

MONSILDALE (Md)

Concept: Very deep, neutral black or brown gradational soils on alluvium. Subsoils are neutral, moderately structured clays, with buried horizons. Occasionally sodic at depth.

Soil Classification: **Brown Dermosol**, Black Dermosol**.**

Landform: Terraces flats and terrace plains on terraced lands and flood plains. Slopes generally <2%.

Geology: Quaternary alluvium (Qha/1, Qha/2).

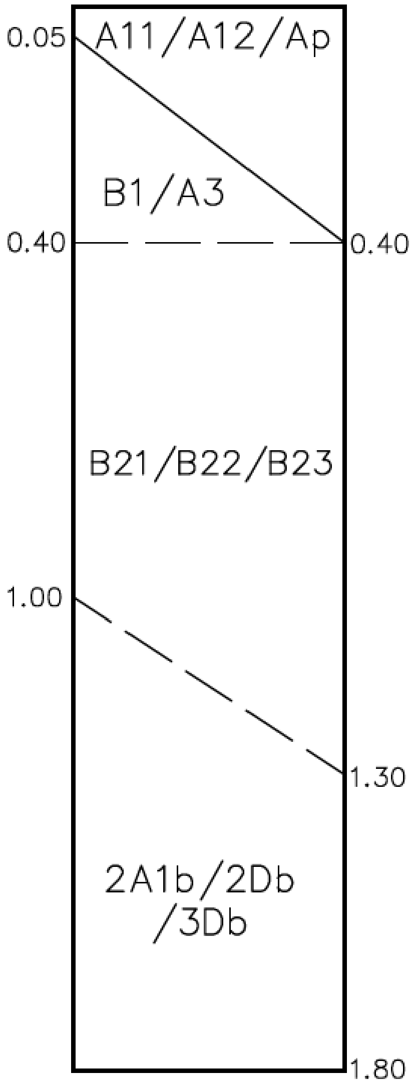
Vegetation: *E. tereticornis* woodland with *Angophora subvelutina*/, *E. tereticornis*, *Casuarina cunninghamiana* +/- *Melaleuca* spp. fringing woodland (12.3.3/12.3.7).

Permeability: **Moderately** to slowly permeable.

Drainage: Moderately well drained.

Surface features: Firm or hard setting.

Depth (m)



A11/ A12/ Ap Black or brown (10YR 2–3/1, 3/1–3 moist) clay loam to silty light clay; moderate subangular blocky structure, occasionally massive or weak; field pH 6.0 to 7.0, gradual change to

A3/ B1 Where present, black (10YR 3/2 moist) clay loam to silty light clay; moderate subangular blocky structure; <2% rounded 2–6 mm pebbles; field pH 6.0 to 7.0, gradual change to

B21/ B22/ B23 Black or brown (10YR 2–4/3–4, 7.5YR 4/3–4 moist) sandy light clay to medium heavy clay; moderate or strong subangular blocky and/or prismatic structure; occasionally 2–10% faint or prominent mottles; occasionally 2–10% <2–6 mm manganiferous segregations; field pH 6.0 to 7.0, diffuse to abrupt change to

2A1b/ 2Db/ 3Db Where present, black or brown (10YR 2–3/2, 3–4/3) fine sandy light clay, moderate or strong subangular/angular blocky, or prismatic structure; field pH 6.0 to 7.0.

Sites: SEQE 4, **21,** 36, 43, 272
SEQ 1460, 1467, 1472, 1473, 1500, 1501, 1502, 1509, 1510, 1511, 1525, 1528, 1530 MISSE 646

Distribution: Avoca Vale, Fernvale.

MOOMBRA (Mb)

Concept: Moderately deep brown or black non-cracking clay soils on sandstone or shale. Subsoils are neutral.

Soil Classification: **Brown Dermosol**, Black Dermosol.

Landform: Mid and upper hillslopes of low hills. Slopes generally <20%.

Geology: Feldspathic sandstones or shales of the Esk Formation (Rte).

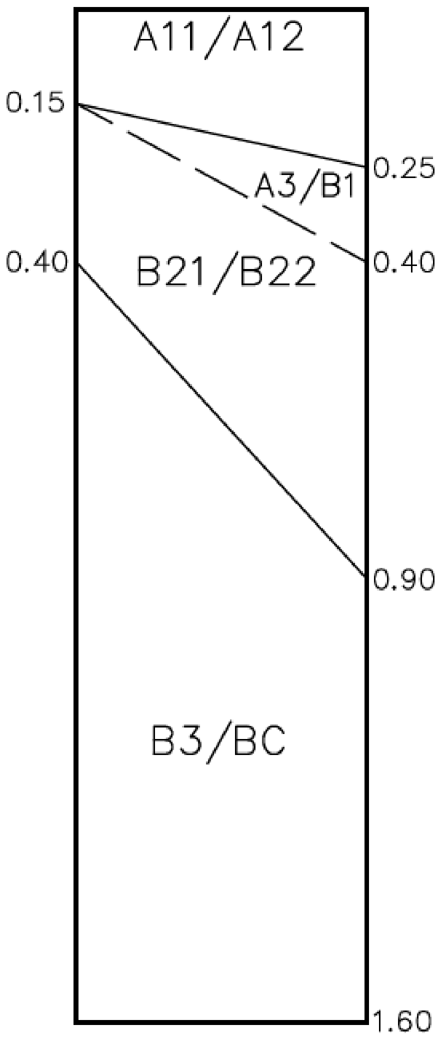
Vegetation: *E. tereticornis*, *Corymbia intermedia*, *E. crebra* open forest to woodland (12.12.12).

Permeability: **Slowly** or moderately permeable.

Drainage: Moderately well drained.

Surface features: Firm or hard setting, frequent few 2–200 mm sandstone pebbles and cobbles.

Depth (m)



A11/ A12 Black (10YR 2–3/1–2 moist) light to light medium clay; weak to moderate subangular/angular blocky structure; occasionally 2–10% 2–6 mm pebbles; field pH 5.5 to 6.5, clear or gradual change to

A3/ B1 Where present, brown (10YR 4/3–4 moist) light to light medium clay; weak subangular/angular blocky structure; 2-10% ferromanganiferous segregations; field pH 6.0 to 6.5, gradual change to

B21/ B22 Black or brown (10YR 3/1–2, 4/3–4 moist) light medium to medium clay; weak or moderate subangular/angular blocky structure; 2–10% <2-6 mm ferromanganiferous segregations; field pH 6.0 to 7.0, clear or gradual change to

B3 Where present, brown or grey (10YR 3/2–3, 4–5/2 moist) light to medium clay; weak structure; 2–50% <2-6 mm ferromanganiferous segregations; 2–20% sandstone pebbles weathering in situ; field pH 6.0 to 7.0.

BC Parent material weathering in situ.

Sites: SEQE 86, **142,** 215, 248

Distribution: Western Avoca Vale, eastern Esk.

MOORE (Mo)

Concept: Deep to very deep, sodic, grey, brown or black texture contrast or gradational soils with conspicuous bleach on andesite or volcanoclastic conglomerate. Subsoils are alkaline, mottled, calcic and have vertic properties.

Soil Classification: **Grey**/Brown/Black **Sodosol,** Grey Dermosol.

Landform: Mid and lower hillslopes and footslopes of rises, low hills and hills. Slopes generally <10%.

Geology: Andesites or volcanoclastic conglomerates of the Neara volcanics (Rtn) and Late Tertiary-Quaternary Residual Colluvium (TQr).

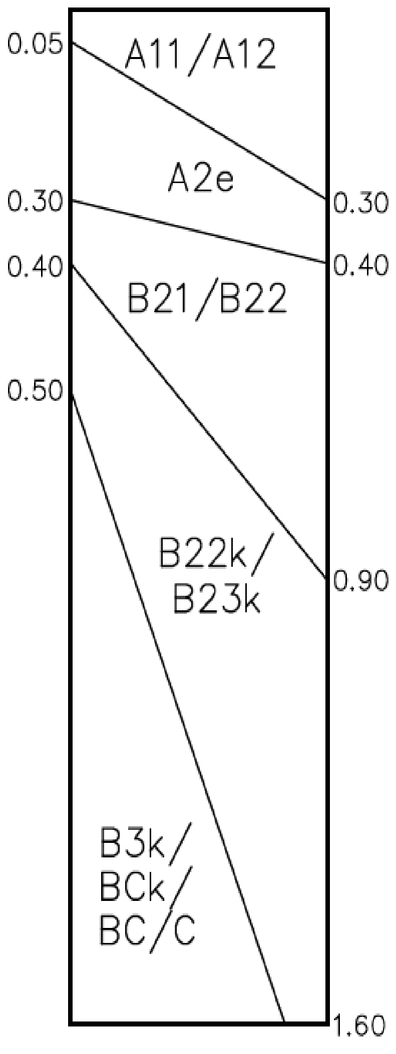
Vegetation: *E. tereticornis*, *Corymbia intermedia*, *E. crebra* open forest to woodland. *C. citriodora* subsp. *variegata* may also occur (12.12.12/12.12.7/12.12.5).

Permeability: Slowly permeable.

Drainage: Imperfectly drained.

Surface features: Hard setting.

Depth (m)



A11/ A12 Black or grey (10YR 2–3/2, 10YR 4/2 moist) sandy clay loam to clay loam; weak or moderate subangular blocky or granular structure; field pH 6.0 to 6.5, clear or abrupt change to

A2e Grey (10YR 4–5/2 moist 10YR 7–8/2 dry) conspicuously bleached sandy clay loam to clay loam; weak to moderate subangular blocky structure; frequently 2–20% <2–6 mm manganiferous segregations; field pH 6.0 to 7.0, clear or abrupt change to

B21/ B22/ Grey, brown or black (10YR 4–6/2, 10YR 3/3–4, 10YR 5/4–8, 10YR 3/1–2 moist); light medium to medium clay; weak to moderate subangular blocky grading to lenticular structure; 2–50% distinct to prominent mottles; 2–50% <2–6 mm ferromanganiferous segregations; occasionally 2–10% 2–6 mm andesitic pebbles; field pH 7.0 to 8.0, clear change to

B22k/ B23k Grey, brown or black (10YR 4–6/2, 10YR 5/4–8, 10YR 3/1–2 moist) medium to medium heavy clay; subangular blocky or lenticular structure, occasionally with prominent slickensides; 2–20% <2–6 mm calcareous and ferromanganiferous segregations; 2–10% 2–6 mm andesitic pebbles; field pH 8.5 to 9.0, gradual change to

B3k Where present, grey or brown (10YR 4–6/2, 10YR 4/4–8) light medium to medium heavy clay; 10–20% andesitic pebbles weathering in situ; 2–10% manganiferous and calcareous segregations; field pH 8.5 to 9.0.

BCk/ BC/C Andesitic parent material weathering in situ.

Sites: SEQE 25, 51, 55, 57, 58, **79**, 123, 213, 245
Eroded phase: SEQE 243

Distribution: Northern and eastern Avoca Vale, eastern Esk.

NEARA (Na)

Concept: Moderately deep, non-cracking clay or gradational soils on andesite or volcanoclastic conglomerate. Clay loam to light clay surfaces, and neutral soil reaction.

Soil Classification: Brown Dermosol.

Landform: Upper and mid slopes of rises, low hills and hills. Slopes generally 5–15%.

Geology: Andesites or volcanoclastic conglomerates of the Neara volcanics (Rtn).

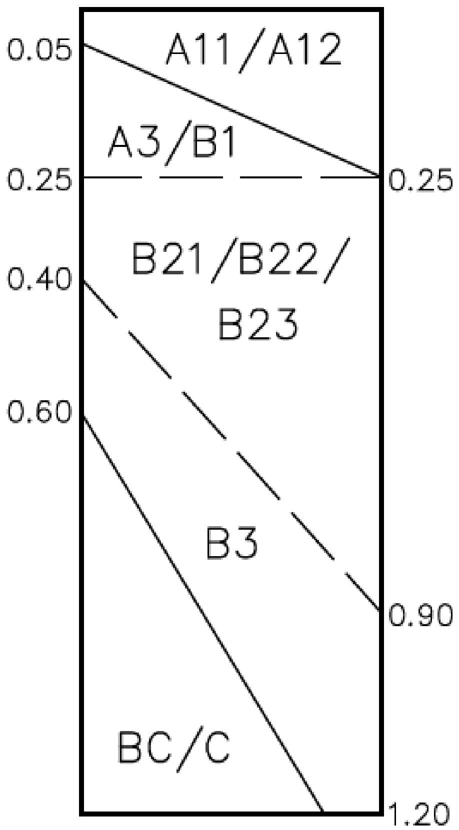
Vegetation: *E. tereticornis*, *Corymbia intermedia*, *E. crebra* open forest to woodland. *C. citriodora* subsp. *variegata* may also occur (12.12.12/12.12.7/12.12.5).

Permeability: Moderately permeable.

Drainage: Moderately well drained.

Surface features: Firm, no microrelief, occasionally <2–10% of 2–20 mm andesite pebbles and cobbles.

Depth (m)



A11/ A12 Black or dark brown (10YR 2–3/2–3, 7.5YR 3/1 moist); clay loam to light clay; weak to moderate subangular blocky structure; field pH 6.0 to 6.5, clear change to

A3/ B1 Where present, black or brown (10YR 3/2, 10YR 3/3-4 moist) clay loam to light clay; moderate subangular blocky structure; field pH 6.0 to 7.0, clear or gradual change to

B21/ B22/ B23 Brown (10YR 3–4/4, 7.5 YR 3/4 moist), light to medium clay; moderate subangular blocky grading to lenticular structure; occasionally 2–10% faint to distinct mottles, or substrate influenced mottles; occasionally manganiferous segregations present; occasionally 2–10% 2–6 mm andesitic pebbles; field pH 6.0 to 7.0 clear to gradual change to

B3 Where present, brown (10YR 4/3–6, 7.5 YR 4/3–4 moist) light medium to medium clay, frequently 10–20% 2-20 mm andesitic pebbles and 2–10% manganiferous segregations; field pH 6.0 to 7.0; gradual change to.

BC/C Brown or grey (10 YR 4/3–6, 10YR 4/2 moist) sandy light clay; 20–50% 2–20 mm andesitic pebbles weathering in situ.

Sites: SEQE **26**, 27, 34, 38, 40, 71, 72, 74, 75, 105, 106, 175
Red variant – SEQE 39
Shallow phase, solum less than 0.4 m – SEQE 33, 42, 81, 82, 83, 214, 217, 244, MFM 317

Distribution: North and eastern Avoca Vale, eastern Esk.

NERANLEIGH (Nr)

Concept: Moderately deep to deep neutral, red or brown gradational soils on chert, arenite, conglomerate or sandstone. Subsoils are frequently sodic.

Soil Classification: **Brown Dermosol**, Red Dermosol.

Landform: Hillslopes of low hills and hills. Slopes generally <25%.

Geology: Mudstones, shales, chert, arenites or conglomerates of Neranleigh-Fernvale beds (DCf) and Toogoolawah group (Rt).

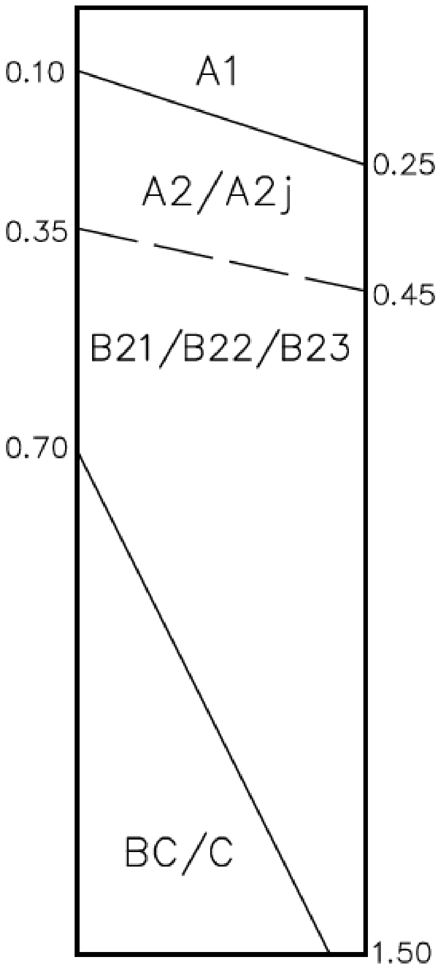
Vegetation: *Corymbia citriodora* subsp. *variegata*, *E. crebra* woodland. /*E. tereticornis* woodland (12.11.6/12.11.5/12.3.3).

Permeability: **Slowly** to moderately permeable.

Drainage: Moderately well drained.

Surface features: Firm, Hard setting, no microrelief.

Depth (m)



A1 Black or brown (10YR 2–3/2, 3/3 moist) clay loam to light clay; moderate to strong granular or subangular blocky structure; <2–20% 2–20 mm pebbles; field pH 5.5 to 6.5, clear change to

A2/ A2j Where present, red (5YR 5/3 moist, 5YR 6/2 dry) clay loam; massive structure; 2—20% 20–200 mm pebbles; field pH 5.5 to 6.5, clear change to

B21/ B22/ B23 Red or brown (5YR 4/3–6, 7.5 YR 4/4–6, 10YR 3/3–6 moist) light medium clay to medium clay; moderate subangular/angular blocky grading to lenticular structure (occasionally weak at depth); 10-20% distinct or prominent substrate influenced mottles; occasionally 2–10% 2–6 mm ferromanganiferous segregations; <2–20% 2–200 mm angular pebbles; field pH 6 to 8.5

BC/C Parent material weathering insitu.

Sites: SEQE **283**
BSC 74, 76, 81, 82, 83, 126

Distribution: Fernvale.

QUINE (Qn)

Concept: Moderately deep to deep neutral or acidic bleached grey or yellow sodic texture contrast soils with a massive subsoil on sandstone.

Soil Classification: **Grey**/Yellow **Sodosol**, occasional Brown Kurosol.

Landform: Lower slopes and drainage depressions of rises and low hills and occasionally on an upper slope where drainage is impeded. Slopes generally <15%.

Geology: Moderately weathered quartzose sandstones and sandy colluvial deposits of the Woogaroo Subgroup (RJbw).

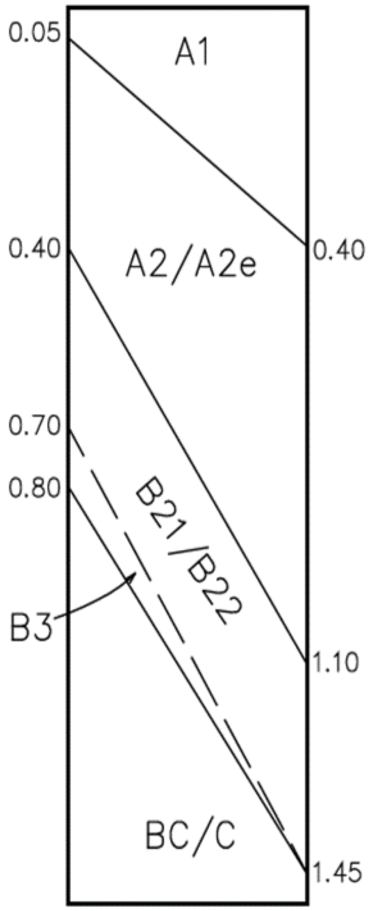
Vegetation: *Corymbia citriodora* subsp. *variegata* open forest or woodland usually with *E. crebra*. Other species such as *E. tereticornis*, *E. moluccana, E. acmenoides* and *E. siderophloia* may be present (12.9-10.2/12.3.7/12.3.3).

Permeability: **Slowly** to very slowly permeable.

Drainage: Imperfectly drained.

Surface features: Hard setting, no microrelief, occasionally 2–10% rounded quartz pebbles.

Depth (m)



A1 Grey or black (2.5Y 4/2, 10YR 4–6/2, 10YR 3/1–2 moist) loamy sand to sandy clay loam; massive structure; field pH 5.5 to 6.0, clear or abrupt change to

A2 A2e Grey, yellow or brown (7.5YR 4–5/2, 10YR 6/2–3, 10YR 5–6/4, 2.5Y 5/3, moist, 2.5Y 7/2, 10YR 6–8/2–3 dry) frequently conspicuously bleached loamy sand to sandy clay loam; massive structure; occasionally prominent mottles; field pH 5.5 to 6.0, clear or abrupt change to

B21/ B22 Grey or yellow (5Y 6/2, 10YR 5/1–2, 2.5Y 6/4, 10YR 5–7/6 moist) sandy light clay to sandy medium heavy clay; massive structure; 10–20% distinct mottles, occasionally influenced by substrate; frequently 2–50% ferruginised sandstone 2–20 mm pebbles; occasionally 2–10% <2-6 mm ferromanganiferous nodules; field pH 5.0 to 6.0, gradual change to

B3 Where present, grey, yellow or brown (5Y 7/1, 7.5YR 5–6/3, 10YR 5–6/1, 10YR 5–7/6 moist) coarse sandy light clay to sandy medium heavy clay; massive structure; frequently prominent red or orange mottles; frequently 6–60 mm ferruginised sandstone pebbles weathering in situ and <2–6 mm ferromanganiferous segregations; field pH 4.5 to 6.0, clear change to

BC/ C Coarse sandy light clay; massive structure; sandstone fragments 6–60 mm weathering in situ; field pH 5.0 to 6.0.

Sites: SEQE 114, 157, 160, 181, 185, 187, **189,** 210, 237, 266 MFM 311

Quinine Light Phase (QnLp): As above, but often with limited B2 development and grey coarse textured A/B horizons SEQE 184, 190, 254

Distribution: Western Esk.

SPENCER (Sp)

Concept: Very deep, alkaline, grey or brown, sodic texture contrast soils, with conspicuous bleach on alluvium. Subsoils are calcic and mottled, and occasionally moderately saline at depth.

Soil Classification: **Brown**/Grey **Sodosol,** Redoxic Hydrosol.

Landform: Drainage depressions, backplains, swamps and terrace flats of stagnant alluvial plains, terraced land and alluvial plains. Slopes generally <3%.

Geology: Quaternary alluvium (Qa, Qha/2, Qpa/1) or Tertiary-Quaternary alluvium (TQa)

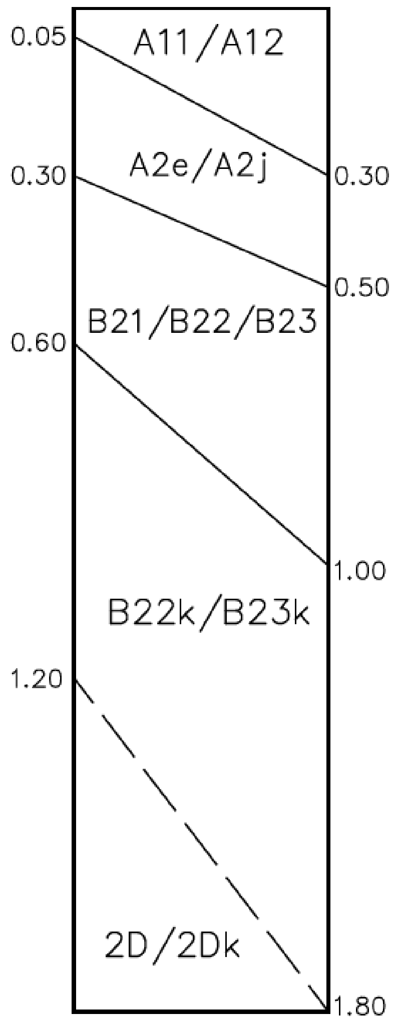
Vegetation: *E. tereticornis* woodland./ *E. tereticornis*, *Casuarina cunninghamiana* +/- *Melaleuca* spp. fringing woodland./ *E. crebra* +/- *E. tereticornis*, *Corymbia tessellaris*, *Angophora leiocarpa*, *E. melanophloia* woodland (12.3.3/12.3.7/12.9-10.7).

Permeability: **Slowly** or very slowly permeable.

Drainage: **Imperfectly** or poorly drained.

Surface features: Firm or hard setting, no microrelief, occasionally 6-20 mm pebbles.

Depth (m)



A11/ A12 Black or grey (10YR 3/1–2, 4/2) loam to clay loam sandy; weak or moderate granular or subangular blocky structure, occasionally massive; field pH 5.5 to 6.0, clear or abrupt change to

A2j/ A2e Grey or brown (10YR 4–6/2, 4/3–4 moist 10YR 6–8/2 dry) frequently sporadically bleached loam to clay loam; massive to moderate subangular blocky structure; occasionally 2–10% distinct mottles; occasionally <2% <2–6 mm ferromanganiferous segregations; field pH 6.0 to 7.0, abrupt change to

B21/ B22/ B23/ 2D Grey or brown (10YR 4–5/2, 2.5Y 4-5/2, 10YR 3–5/3, moist) sandy light clay to medium heavy clay; moderate or strong prismatic breaking to blocky, or grading to lenticular structure; 10–20% distinct mottles, frequently 2–20% <2–6 mm ferromanganiferous segregations; occasionally 2–10% 2–20 mm rounded pebbles; field pH 8.0 to 8.5, clear change to

B22k B23k/ 2Dk Grey or brown (10YR 4–5/2, 2.5Y 4–6/1, 10YR 4/3–4 moist) sandy light medium to medium clay; moderate lenticular or blocky structure; 2–20% <2–6 mm manganiferous and calcareous segregations; 2–20% rounded 2–20 mm pebbles; 2–10% faint to distinct mottles; field pH 8.5 to 9.0.

Sites: SEQE 2, **60,** 131, 144, 145, 262, 287, 297
SEQ 1463, 1476, 1482, 1483, 1486, 1490, 1492, 1494, 1495, 1496, 1505, 1508, 1523, 1526, 1527, 1529, 1531, 1532, 1533, 1535, 1536, 1569, 1572
MISSE 643, 644, 645

The Redoxic Hydrosols have limited distribution

Distribution: Avoca Vale, Esk and Fernvale.

TUCKERIMBA (Tk)

Concept: Very deep alkaline calcic, grey cracking clay or non-cracking soils with vertic properties, over brown subsoil on alluvium. Subsoils often slightly to moderately sodic and saline.

Soil Classification: **Grey Vertosol**, Grey Dermosol.

Landform: Swamps and backplains on floodplains and stagnant alluvial plains. Slopes generally <2%.

Geology: Quaternary Pleistocene alluvium (Qpa/1).

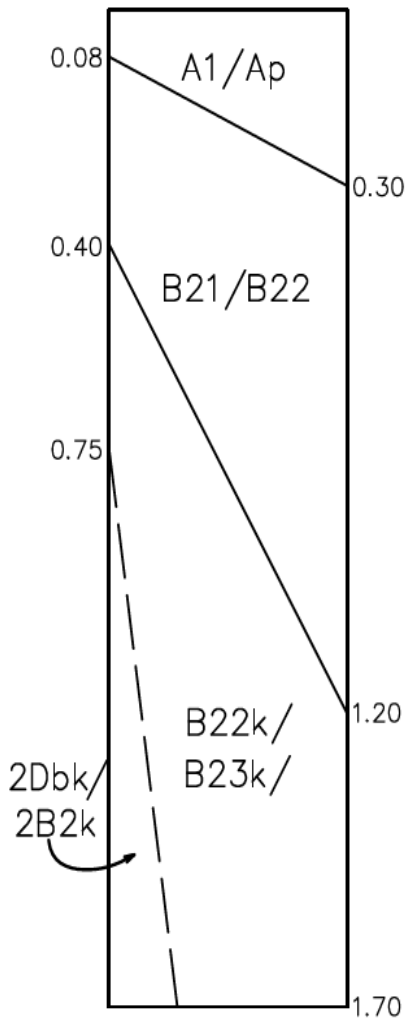
Vegetation: *E. tereticornis* woodland./ *Acacia harpophylla* open forest +/- *Casuarina cristata* and vine thicket species (12.3.3/12.9-10.6).

Permeability: Slowly permeable.

Drainage: Imperfectly drained.

Surface features: Weakly self-mulching, firm or hard setting, gilgai common.

Depth (m)



A1/ Ap Black, grey or brown (10YR 3/1–2, 10YR 4/1–3 moist) clay loam to light medium clay; strong or moderate angular/subangular blocky structure, occasionally massive; field pH 6.0 to 7.5, clear or gradual change to

B21/ B22 Grey (2.5Y 4–5/2, 10YR 4–5/2, 10YR 6/3 moist) light medium to medium clay; moderate to strong angular/subangular blocky grading to lenticular structure with prominent slickensides; occasionally 2–10% distinct mottles; occasional 2–20% 2–6 mm manganiferous segregations; occasionally 2–10% 2–6 mm pebbles; field pH 6.5 to 8.5, clear or gradual change to

B22k/ Brown or grey (2.5Y 4–6/2, 10YR 4–5/2, 10YR 4–3/4 moist) light medium clay to medium heavy clay; moderate to strong prismatic and lenticular structure with prominent slickensides; 2–20% 2–6 mm calcareous and manganiferous segregations; occasionally 2–10% faint or distinct mottles; field pH 8.5 to 9.0, clear change to

B23k Brown (2.5Y 5/3, 10YR 4–5/3–4 moist) light medium clay to medium heavy clay; moderate to strong prismatic and lenticular structure with prominent slickensides; 2–20% 2–6 mm calcareous and manganiferous segregations; occasionally 2–10% faint or distinct mottles; field pH 8.5 to 9.0, clear change to

2Dbk/ 2B2k Where present, brown or occasionally black (2.5 YR 4–5/3, 10YR 4–5/3, 10YR 4/2 moist) light medium to medium clay; moderate angular blocky structure; occasionally 2–10% rounded 2–20 mm pebbles; occasionally 2–6 mm calcareous and manganiferous segregations; occasionally 2–20% distinct mottles; field pH 8.5 to 9.0.

Sites: SEQ 1402, 1417, 1421, 1422, 1429, 1436, 1462, 1469, 1471, 1499
BSC 57, 58, 68, 104

Distribution: Fernvale.

WATT (Wt)

Concept: Moderately deep, neutral brown texture contrast soils with pale/sporadic bleach on sandstone, shale or conglomerate. Subsoils are frequently sodic and have vertic properties at depth.

Soil Classification: Brown Chromosol.

Landform: Mid and lower hillslopes of rises and low hills. Slopes generally <10%.

Geology: Sandstones, shales or conglomerates Esk Formation (Rte), Mount Crosby Formation (Rim) and late Tertiary-Quaternary Residual Colluvium (TQr).

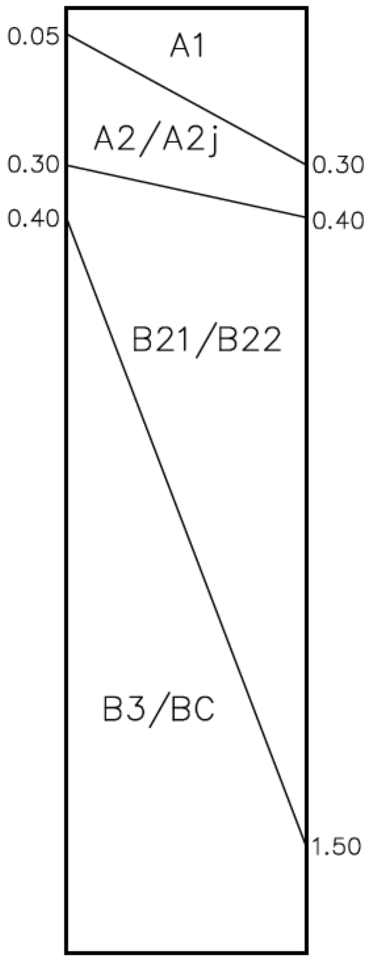
Vegetation: *E. crebra* +/- *E. tereticornis*, *Corymbia tessellaris*, *Angophora leiocarpa*, *E. melanophloia* woodland./ *C. citriodora* subsp. *variegata* +/- *E. crebra* open forest./ *E. tereticornis*, *C. intermedia*, *E. crebra* open forest (12.9-10.7/12.9-10.2/12.12.12).

Permeability: **Slowly** to moderately permeable.

Drainage: **Moderately well** to imperfectly drained.

Surface features: Firm or hard setting.

Depth (m)



A1 Black (10YR 2–3/1–2 moist) sandy clay loam to clay loam; weak to moderate subangular or angular blocky structure; field pH 6.0 to 6.5, abrupt change to

A2/ A2j Grey or brown (10YR 4–6/2, 4/3–6 moist, 10YR 7–8/1–2 dry) frequently sporadically bleached or pale loamy sand to clay loam; weak to moderate angular/ subangular blocky structure; 2–10% 2–6 mm pebbles; field pH 6.0 to 6.5, abrupt change to

B21/ B22 Brown (10YR 3–4/3–6 moist) coarse sandy light to medium heavy clay; moderately structured subangular blocky, occasioonally grading to lenticular structure with slickensides; frequently 2–20% <2–6 mm manganiferous segregations; 2–20% distinct or prominent mottles; 2-10% 2–20 mm sandstone or shale pebbles; field pH 6.5–7.5, clear, gradual or diffuse change to

B3 Brown (10YR 3–4/3–6 moist) coarse sandy light clay to light medium clay; weak structure; sandstone pebbles weathering in situ; few substrate influenced mottles; occasional <2 mm manganiferous segregations; field pH 6.5 to 7.5.

BC Parent material weathering insitu.

Sites: SEQE 67, 85**,** 90, 91, **122**, 124, 129, 133, 136, 178
MFM 386
SEQE 138: as above, but imperfectly drained and grey
SEQE 286, 294: As above, but no A2, and structure close to weak, rather than moderate, and saline at depth.

Distribution: Western portion of Avoca Vale, eastern portion of Esk.

YELLOWBANK (Yb)

Concept: Deep to very deep brown or yellow texture contrast or gradational earthy soils on quartzose sandstone.

Soil Classification: **Brown**/Yellow **Chromosol,** Brown/Yellow Kandosol.

Landform: Mid and lower slopes (occasionally upper slopes) on rises, low hills and hills. Slopes generally <15%.

Geology: Moderately weathered quartzose sandstones on mid to upper slopes; and sandy colluvial deposits of the Woogaroo Subgroup (RJbw).

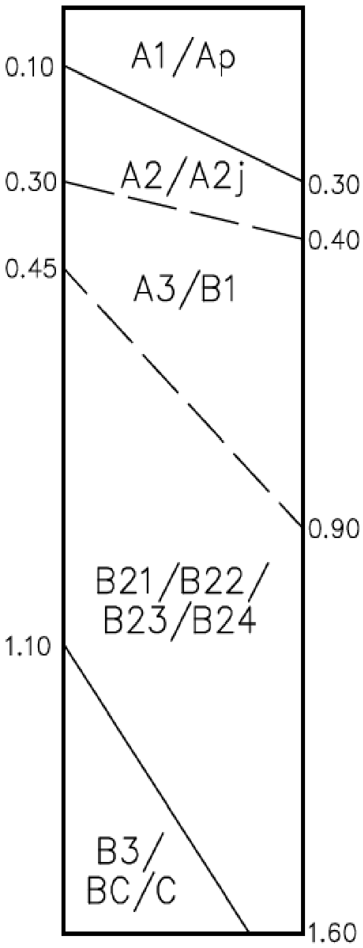
Vegetation: *Corymbia citriodora subsp. variegata* +/- *E. crebra* open forest/woodland complex./ *E. crebra* +/- *E. tereticornis*, C. tessellaris, *Angophora leiocarpa*, *E. melanophloia* woodland (12.9-10.2/12.9-10.5/12.9-10.7).

Permeability: Slowly to **moderately permeable**.

Drainage: **Moderately well drained** to imperfectly drained.

Surface features: Hard setting, occasionally 2–20 mm quartz pebbles, no microrelief.

Depth (m)



A1/ Ap Black, brown or grey (10YR 2–3/2, 7.5YR 3/3–4, 4/2 moist) loamy sand to clay loam sandy; massive to weak angular blocky or granular structure; occasional 2–6 mm pebbles; field pH 5.5 to 6.0, clear or gradual change to

A2/ A2j Where present, grey, brown or yellow (10YR 4–6/2, 7.5 YR 4/3–4 moist, 10YR 6/3, 8/1–3 dry) loamy sand to clayey sand; massive structure; occasionally <2–10% <2 mm ferromanganiferous segregations and 2-10% faint mottles; field pH 5.5 to 6.0; clear or abrupt to

A3/ B1 Where present brown (10YR 4/4–8, 7.5YR 5/6 moist); loamy sand to clay loam sandy; massive structure; occasionally <2–10% <2 mm ferromanganiferous segregations; 2–10% faint mottles; field pH 5.5 to 6.0, gradual change to

B21/ B22 Brown or yellow (10YR 5/4–6, 6/4–7, 7.5YR 5–6/7 moist) clay loam sandy to coarse sandy light clay; massive structure; frequently <2–10% 2–6 mm pebbles and <2–20 mm ferromanganiferous segregations; frequently faint or prominent mottles; field pH 5.0 to 6.0, clear change to

B23/ B24 Where present, brown, yellow or grey (10YR 5/3–6, 6/4–7, 5–6/2 moist) sandy light clay; massive structure; frequently <2–10% 2–6 mm pebbles and <2–6 mm ferromanganiferous segregations; frequently faint or prominent mottles; field pH 5.0 to 6.0, clear change to

B3/ BC/C Brown, yellow or grey (10YR 5/3–6, 6/4–7, 5–6/2 moist) sandy light to light medium clay; massive structure; 20–50% 6–20mm pebbles weathering in situ; common substrate influenced mottles; field pH 5.0 to 6.0. MISSE

Sites: SEQE **149**, 152, 173, **186,** 188, 204, 206, 240, 275, 278, 298, MFM 355, 388, **429**

Yellowbank Nodular Variant (YbNv) on lower landscape positions. As above, but 20–50% ferromanganiferous nodules and imperfectly drained: SEQE 161, 180, 198, 267 MFM 350, 352, 388

Discontinuous variant (YbDv). As above, but with red subsoil: SEQE 198, 205, 208

Distribution: Western Esk, southern Fernvale.

YELLOWBANK LIGHT PHASE (YbLp)

Concept: Deep to very deep brown or yellow earthy soils with massive structure on quartzose sandstone. Dominated by loamy sand to sandy clay loam textures throughout.

Soil Classification: **Brown-Orthic**/Yellow-Orthic **Tenosol**.

Landform: Mid and lower slopes (occasionally upper slopes) on rises, low hills and hills. Slopes generally <15%.

Geology: Moderately weathered quartzose sandstones on mid to upper slopes; and sandy colluvial deposits of the Woogaroo Subgroup (RJbw).

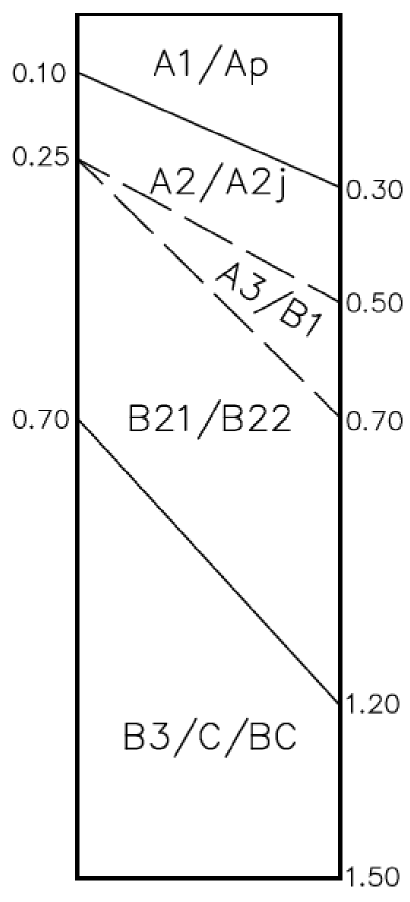
Vegetation: *Corymbia citriodora subsp. variegata +/- E. crebra* open forest./ woodland complex./ *E. crebra +/- E. tereticornis*, C. tessellaris, *Angophora leiocarpa*, *E. melanophloia* woodland (12.9-10.2/12.9-10.5/12.9-10.7).

Permeability: Slowly to **moderately permeable**.

Drainage: **Moderately well** to imperfectly drained.

Surface features: Hard setting, occasionally 2–20 mm quartz pebbles, no microrelief.

Depth (m)



A1/ Ap Black, brown or grey (10YR 2–3/2, 7.5YR 3/3–4, 4/2 moist) loamy sand to sandy loam; massive to weak angular blocky or granular structure; occasional 2–6 mm pebbles; field pH 5.5 to 6.0, clear or gradual change to

A2/ A2j Where present, grey, brown or yellow (10YR 4–6/2, 4–6/4 moist, 10YR 6–8/3 dry) loamy sand to sandy loam; massive structure; occasional <2 mm ferromanganiferous segregations and few faint mottles; field pH 5.5 to 6; clear or abrupt change to:

A3/ B1 Where present brown (10YR 3–5/4–8 moist); loamy sand to clay loam sandy; massive structure; occasional <2 mm ferromanganiferous segregations; 2–10% faint mottles; field pH 5.5 to 6.0, gradual change to

B21/ B22 Brown or yellow (10YR 4–5/3, 6/4–6 moist) loamy sand to sandy clay loam; massive structure; frequent sandstone 2–6 mm pebbles and <2–20 mm ferromanganiferous segregations; frequent faint or prominent mottles; field pH 5.0 to 6.0, clear change to

B3 Brown, yellow or grey (10YR 5–6/3–6 moist) sandy clay loam to clay loam sandy; massive structure; 10-20% 6–20mm pebbles weathering in situ; 10-20% substrate influenced mottles; field pH 5.0 to 6.0. clear change to

BC/C Parent material weathering insitu.

Sites: SEQE **164**, 167, 194, 268, MFM 351, 354, 394, 395

Distribution: Western Esk.

Appendix 2: Soil Key

Soils on Quaternary alluvium (Qha/1, Qha/2, Qa, Qpa/1, TQa)	Channel benches, levees and terrace flats on terraced lands and floodplains	Very deep to deep, sandy to loamy soils	Very deep, neutral sandy textured soils over buried horizons with >50% pebbles and cobbles in one or two horizons.	**Stratic Rudosol** Brown-orthic Tenosol	**Cressbrook Rocky Phase (CrRp)**
			Very deep, neutral sandy textured soils over buried horizons or gravel.	**Stratic Rudosol** Brown-orthic Tenosol	**Cressbrook (Cr)**
			Very deep, neutral brown loamy soils over buried horizons with 20–50% pebbles and cobbles in one or two horizons.	**Brown Kandosol** Brown-orthic Tenosol	**Honey Rocky Phase (Hy)**
			Very deep, neutral brown (occasionally black) loamy soils over buried horizons.	Brown Kandosol **Brown-orthic Tenosol** Black-orthic Tenosol	**Honey (Hy)**
	Plains, terrace plains and terrace flats on terraced lands, floodplains and stagnant alluvial plans	Structured cracking/non cracking clay soils	Very deep self-mulching black cracking clays. Subsoils are alkaline, calcic and slightly sodic with slight to moderate salinity at depth.	Black Vertosol	**Cooeeimbardi (Cb)**
			Very deep, neutral strongly structured black non-cracking clay.	Black Dermosol	**Gira Gira (Gg)**
			Very deep, neutral strongly structured black non-cracking clay with 20–50% pebbles/cobbles in one horizon.	Black Dermosol	**Gira Gira Rocky Phase (GgRp)**
			Very deep, neutral black or brown gradational soils. Subsoils are neutral, moderately structured clays, with buried horizons. Occasionally sodic at depth.	**Brown Dermosol** Black Dermosol	**Monsildale (Md)**
		Massive to weak structure, gradational or texture contrast	Very deep, neutral brown (occasionally black) loamy soils with buried horizons.	**Brown Kandosol**	**Honey (Hy)**
			Very deep, neutral texture contrast or gradational soils. Subsoils are moderately structured brown sandy clays, over buried horizons. Occasionally sodic at depth.	Brown/Black Dermosol **Brown/Black Chromosol**	**Gallanani (Gl)**
		Texture contrast, non-sodic upper subsoil, often sodic in lower subsoil	Very deep, neutral texture contrast or gradational soils. Subsoils are moderately structured brown sandy clays, over buried horizons. Occasionally sodic at depth.	**Brown**/Black Chromosol	**Gallanani (Gl)**
		Texture contrast, sodic upper subsoil, neutral/alkaline soil reaction	Very deep, alkaline, grey or brown, sodic texture contrast soils, with conspicuous bleach. Subsoil is calcic and mottled, and occasionally moderately saline at depth.	Grey Sodosol **Brown Sodosol**	**Gunyah (Gh)**
	Drainage depressions, swamps and backplains on floodplains and stagnant alluvial plains	Cracking/non cracking clay soils	Very deep grey cracking clay. Subsoils are alkaline, sodic, calcic and moderately saline at depth.	**Grey Vertosol** Grey Dermosol	**Basel (Bs)**
			Very deep alkaline calcic, grey cracking clay or non-cracking soils with vertic properties, over brown subsoil. Subsoils often slightly to moderately sodic and saline.	**Grey Vertosol** Grey Dermosol	**Tuckerimba (Tk)**
			Very deep, black or brown cracking clay or non-cracking clay soils with vertic properties. Subsoils are alkaline, calcic, grey, moderately saline and sodic.	Black/**Brown Vertosol** Black/Brown Dermosol	**Glamorgan (Gm)**
		Texture contrast, non-sodic upper subsoil, frequent sodic lower subsoil	Very deep, neutral brown texture contrast or gradational soils. Subsoils are frequently mottled and/or sodic at depth.	Brown Dermosol **Brown Chromosol**	**Gunyah (Gh)**
		Texture contrast, sodic upper subsoil, strong acid soil reaction	Very deep acidic, grey sodic texture contrast soils. Subsoils are mottled.	**Grey**/Brown **Kurosol** Grey/Brown Sodosol Occasional Grey Dermosol	**Glencairn (Gc)**
		Texture contrast, sodic upper subsoil, neutral/alkaline soil reaction	Very deep, alkaline, grey or brown, sodic texture contrast soils, with conspicuous bleach. Subsoils are calcic and mottled, and occasionally moderately saline at depth.	Grey Sodosol **Brown Sodosol**	**Spencer (Sp)**

Soils on Tertiary-Quaternary residual colluvium (TQr)	Plains and rises	Texture contrast, non-sodic upper subsoil, frequent sodic lower subsoil	Deep, neutral brown or black texture contrast soils with sporadic bleach. Subsoils are frequently sodic and have vertic properties at depth.	**Brown Chromosol** Black Chromosol	**Dunwich (Dw)**
			Moderately deep, neutral brown texture contrast soils with pale/sporadic bleach. Subsoils are frequently sodic and have vertic properties at depth.	Brown Chromosol	**Watt (Wt)**
		Texture contrast, sodic upper subsoil, neutral/alkaline soil reaction	Very deep, sodic, brown texture contrast soil with conspicuous bleach. Subsoils are alkaline, mottled, calcic and have vertic properties.	**Brown Sodosol** Grey Sodosol	**Beppo (Bp)**
			Deep to very deep, sodic, grey, brown or black texture contrast or gradational soils with conspicuous bleach. Subsoils are alkaline, mottled, calcic and have vertic properties.	**Grey**/Black **Sodosol** Grey/Black Dermosol	**Moore (Mo)**

Soils on intrusive microdiorites (Jkib)	Upper slopes and crests of rises	Texture contrast/gradational, non sodic upper subsoil	Moderately deep to very deep, red texture contrast or gradational soil. Subsoils are neutral.	**Red Chromosol** Red Dermosol	**Burnage (Bn)**
Soils on siltstones and fine grained Sandstones of Gatton sandstones (Jbmg) and Koukandowie Formation (Jbmk)	Crests, upper and mid slopes of rises, hills and low hills	Texture contrast, sodic upper subsoil, neutral/alkaline soil reaction	Deep, alkaline brown, black or occasionally yellow sodic texture contrast soil. Subsoils are calcic and mottled. Often slight to moderately saline.	**Brown**/Grey/Yellow Sodosol	**Koukandowie (Kk)**
	Mid and lower slopes of rises	Texture contrast/gradational sodic upper subsoil, strong acid soil reaction	Deep, neutral to acidic grey or brown sodic texture contrast soil with conspicuous/sporadic bleach. Subsoils are mottled and often slightly to moderately saline at depth.	Brown/**Grey Sodosol** Brown/Grey Kurosol	**Lowood (Lw)**
Soils on quartzose sandstones of the Woogaroo Subgroup (RJbw)	Crests and upper slopes of rises, low hills and hills	Shallow soils (<0.5 m) sandy to loamy, often rocky	Shallow, red or brown earthy soil weathering in situ from 0.1 m. Massive structure throughout and neutral soil reaction.	**Red/Brown-Orthic Tenosol** Red Kandosol Brown Kandosol	**Hallen (Hl)**
	Hillslopes of rises, low hills and hills	Deep–very deep sandy to loamy soils	Deep to very deep red earthy gradational soils. Dominated by loamy sand to sandy clay loam textures throughout.	**Red Kandosol** Red-orthic Tenosol	**Hibiscus Light Phase (HbLp)**
			Deep to very deep yellow or brown soils with massive structure. Dominated by loamy sand to sandy clay loam textures throughout.	Yellow-orthic Tenosol **Brown-orthic Tenosol**	**Yellowbank Light Phase (YbLp)**
			Moderately deep to deep neutral or acidic bleached grey or yellow sodic gradational soil. Massive subsoil, and limited B2 development.	Bleached-orthic Tenosol	**Quinine Light Phase (QnLp)**
		Massive/weak structure, gradational or texture contrast	Deep to very deep red earthy gradational soils. Occasionally texture contrast soil.	**Red Kandosol** Red Chromosol	**Hibiscus (Hb)**
			Deep to very deep yellow or brown texture contrast or gradational earthy soils.	Yellow/Brown Kandosol Yellow/**Brown Chromosol**	**Yellowbank (Yb)**
	Lower slopes and drainage depressions, or other slopes where drainage is impeded	Massive/weak structure, gradational or texture contrast	Moderately deep to deep neutral or acidic bleached grey or yellow sodic texture contrast soil with a massive subsoil.	**Grey**/Yellow **Sodosol** Brown Kurosol	**Quinine (Qn)**

Soils on andesite or volcanoclastic conglomerates of Neara volcanics (Rtn)	Crests and upper slopes of hills and low hills	Shallow soils (<0.5 m) sandy to loamy, often rocky	Shallow or very shallow, neutral brown loamy soils with sandy loam to sandy clay loam surfaces	**Leptic Tenosol** Brown-orthic Tenosol	**D'Aguilar (Dg)**
			Shallow soils with clay loam or light clay surface and brown subsoil	Brown Dermosol	**Neara shallow phase (NaSp)**
	Upper and mid slopes of rises, low hills and hills	Texture contrast/gradational, non-sodic upper subsoil	Shallow to moderately deep, brown, texture contrast or gradational soil. Sandy clay loam surfaces, with occasionally bleached sub-surface.	**Brown Chromosol** Brown Dermosol	**Linville (Le)**
			Moderately deep, non-cracking clay or gradational soil. Clay loam to light clay surfaces, and neutral soil reaction.	Brown Dermosol	**Neara (Na)**
	Mid and lower slopes and footslopes of rises, low hills and hills	Texture contrast, non-sodic upper subsoil, frequent sodic lower subsoil	Deep, neutral brown or black texture contrast soils with sporadic bleach. Subsoils are frequently sodic and vertic at depth.	**Brown Chromosol** Black Chromosol	**Dunwich (Dw)**
		Sodic upper subsoil, neutral/alkaline soil reaction	Deep to very deep, sodic, grey, brown or black texture contrast or gradational soil with conspicuous bleach. Subsoils are alkaline, mottled, calcic and have vertic properties.	**Grey/Black Sodosol** Grey/Black Dermosol	**Moore (Mo)**
			Deep, sodic, texture contrast soil or soils with gradual increasing clay content, with grey or black, motted and vertic subsoils. Conspicuously bleached A2 horizon. Active or partially stabilised gully erosion	**Grey/Black Sodosol** Grey/Black Dermosol	**Moore Eroded Phase (MoEp)**
	Lower slopes, footslopes and plains of rises and plains	Cracking/non cracking clay soils	Deep to very deep, black or brown cracking clay soil. Subsoils are alkaline and often sodic at depth.	**Black Vertosol** Brown Vertosol	**Jimna (Jm)**
			Very deep brown texture contrast or gradational soil. Loamy surface over neutral, moderately structured sandy clay.	**Brown Chromosol** Brown Dermosol	**Avoca (Av)**
Soils on sandstones, siltstones and conglomerates of Esk Formation (Rte)	Crests, upper and mid slopes of low hills, hills and mountains	Shallow soils (<0.5 m) sandy to loamy, often rocky	Very shallow to shallow, neutral, dark loamy soils with many small pebbles weathering in situ from 0.1.	**Leptic Tenosol** Leptic Rudosol Brown Dermosol	**Grienke (Gk)**
		texture contrast/gradational soil, non-sodic upper horizons	Moderately deep, neutral to slightly acid red or brown texture contrast gradational soil. Sub-surface is frequently pale or has sporadic bleach.	Red Chromosol **Red Dermosol**	**Kipper (Kp)**
			Moderately deep, neutral brown texture contrast or gradational soil.	**Brown Dermosol** Brown Chromosol	**Lakeview (Lv)**
	Upper and mid slopes of rises and low hills	Cracking/non cracking clay soils	Moderately deep brown or black non-cracking clay soil. Subsoils are neutral.	Black Dermosol **Brown Dermosol**	**Moombra (Mb)**
	Mid and lower slopes of rises and low hills	Cracking/non cracking clay soils	Moderately deep to very deep, brown, black or grey clay cracking clay or non-cracking clay with vertic properties. Subsoils are alkaline, calcic, sodic and often moderately saline at depth.	Black/**Brown Vertosol** Black/Brown Dermosol Grey Dermosol	**Beer (Br)**
		Sodic upper subsoil, neutral/alkaline soil reaction	Very deep, sodic, brown texture contrast soil with conspicuous bleach. Subsoils are alkaline, calcic, vertic and mottled.	**Brown Sodosol** Grey Sodosol	**Beppo (Bp)**
			Very deep, sodic, brown texture contrast soil with conspicuous bleach. Subsoils are alkaline, calcic, vertic and mottled. Active or partially stabilised gully erosion.	**Brown Sodosol** Grey Sodosol	**Beppo Eroded Phase (BpEp)**
		Texture contrast, non-sodic upper subsoil	Moderately deep, neutral brown texture contrast soils with pale/sporadic bleach. Subsoils are frequently sodic and have vertic properties at depth.	Brown Chromosol	**Watt (Wt)**
Soils of sandstones and conglomerates of Mount Crosby Formation (Rim)	Crests, upper and mid slopes of rises, low hills and hills	Texture contrast/gradational, non-sodic upper horizons	Moderately deep, neutral brown texture contrast or gradational soil.	**Brown Dermosol** Brown Chromosol	**Lakeview (Lv)**
	Mid and lower slopes of rises, hills and low hills	Texture contrast soil, non sodic upper horizons	Moderately deep, texture contrast soil with neutral brown subsoil that is often sodic and vertic at depth. Often with a pale or sporadically bleached A2 horizon.	Brown Chromosol	**Watt (Wt)**
Soils on Brisbane Valley Porphyrites (Rgv)	Hillslopes of low hills and rises	Texture contrast, gradational soil, non-sodic upper subsoil, frequent sodic lower subsoil	Shallow to moderately deep, brown, texture contrast or gradational soil. Sandy clay loam surfaces, with occasionally bleached sub-surface.	**Brown Chromosol** Brown Dermosol	**Linville (Le)**
Soils on mudstones, chert, arenties and conglomerates of Neranleigh-Fernvale beds (DCf)	Hillslopes of rises, low hills and hills	Shallow soils (<0.5 m) sandy to loamy, often rocky	Shallow, neutral loamy soils.	**Bleached-leptic Tenosol** Leptic Rudosol	**Ferny (Fy)**
		Non cracking clay soils	Moderately deep to deep neutral, red or brown gradational soil. Subsoils are frequently sodic.	**Brown Dermosol** Red Dermosol	**Neranleigh (Nr)**
		Texture contrast, sodic upper subsoil, neutral or acid soil reaction	Very deep, brown texture contrast soil. Subsoils are acidic, mottled and sodic.	**Brown Kurosol** Brown Sodosol	**Fernvale (Fv)**

Appendix 3: Soil Morphological and Analytical Data

Supplementary notes for the Analytical Results

Unless otherwise stated, all soils were analysed at Analytical Services, Ecosciences Precinct, Dutton Park, Brisbane. For an explanation of the laboratory methods, refer to Rayment and Lyons (2011).

Analytical results for sites within the project area that have not been published previously are included in this appendix. This includes sites within the SEQE and MISSE project codes. Refer to the Noble (1996) for additional laboratory data for site MFM 428 (Hibiscus SPC) and MFM 429 (Yellowbank SPC). The data from the MFM sites are available for viewing on the Qld Government open data portal. Analytical results from the CSIRO BV project (Murtha 1977) sites have been reproduced in the appendix. The data from these sites are not currently available for viewing on the Qld Government open data portal. The laboratory methods used for these sites are discussed in CSIRO BV report.

All analytical and morphological data is stored in the Sali database and can be viewed at the Qld Government open data portal: https://qldglobe.information.qld.gov.au/

Where full laboratory data is available, the Soil Classification confidence rating is 1. For the remainder, where analytical data is incomplete, but sufficient to classify the soil with a reasonable degree of confidence, the rating is 2. See Isbell and NCST (2016).

References

Murtha GG 1977, *The soils on three major rock types in the Upper Brisbane Valley*, *Southeastern Queensland,* CSIRO Divisional of Soils, Divisional Report No. 17, CSIRO Australia

Isbell R and National Committee on Soil and Terrain 2016, *The Australian soil classification, second edition,* CSIRO, Canberra.

Noble KE 1996 ed., *Understanding and managing soils in the Moreton Region*, Queensland Department of Primary Industries, Brisbane.

Rayment GE and Lyons DJ 2011, *Soil Chemical Methods - Australasia*, CSIRO Publishing Melbourne.

Soil Profile Class: Beppo (Bp)

Site No.: SEQE 96

Location: Zone 56, 419912E, 7041628N
ASC: Vertic, Mesonatric, Brown Sodosol
Erosion: Partly stabilised sheet erosion
Permeability: Very slow
Drainage: Imperfectly drained

Slope: 5%
Landform element: Hillslope
Landform pattern: Low hills
Microrelief: Zero

Surface condition: Hard setting
Surface coarse fragments: Nil
Vegetation: *Eucalyptus tereticornis, Eucalyptus crebra*
Geology: Sandstone on Esk Formation (Rte)

Profile morphology

Horizon	Depth (m)	Description
A1	0 to 0.22	Black (10YR 3/2 moist); clay loam; weak 2–5 mm angular blocky structure; dry weak; field pH 6; abrupt change to
A2e	0.22 to 0.32	Grey (10YR 4/1 moist, 10YR 7/1 dry); conspicuously bleached clay loam; massive; common 2–6 mm sub-rounded pebbles; dry weak; field pH 6.0; abrupt change to
B21k	0.32 to 0.80	Brown (10YR 4/3 moist); coarse sandy medium heavy clay; weak 2–5 mm lenticular structure; very few <2 mm calcareous segregations; dry strong; field pH 7.0; abrupt change to
B22k	0.80 to 1.2	Brown (10YR 5/6 moist) coarse sandy medium clay; moderate 2–5 mm lenticular structure; few 2–6 mm calcareous segregations; dry strong; field pH 8.5; clear change to
B23k	1.2 to 1.55	Brown (10YR 5/6 moist); coarse sandy light clay; moderate 2–5 mm subangular blocky structure; common >2 mm calcareous segregations, dry strong; field pH 8.5.

Laboratory analysis results

	1:5 aqueous				Exchangeable cations (ICP)					
Depth	**pH**	**EC**	**Cl**	**NO_3N**	**Ca**	**Mg**	**Na**	**K**	**CEC**	**ESP**
(m)		**(dS/M)**	**mg/kg**		**meq/100g**					**%**
0.32–0.42	6.4	0.23	282	<1	6.22	8.06	3.31	0.33	17.92	18.5

Soil Profile Class: Beppo (Bp)

Site No.: SEQE 100

Location: Zone 56, 419347E, 7043129N
ASC: Vertic, Subnatric, Brown Sodosol
Erosion: Partly stabilised sheet erosion
Permeability: Slow
Drainage: Imperfectly drained

Slope: 4%
Landform element: Hillslope
Landform pattern: Rises
Microrelief: Zero

Surface condition: Hard setting
Surface coarse fragments: Nil
Vegetation: *Eucalyptus tereticornis, Eucalyptus melanophloia*
Geology: Sandstone on Esk Formation (Rte)

Profile morphology

Horizon	Depth (m)	Description
A1	0.0 to 0.21	Brown (10YR 4/3 moist); clay loam; weak 2–5 mm angular blocky structure; dry firm; field pH 6.0; clear change to
A2e	0.21 to 0.4	Grey (10YR 6/3 moist, 10YR 7/2 dry); conspicuously bleached clay loam, fine sandy; weak angular blocky structure; common 2–6 mm ferromanganiferous segregations; dry firm; field pH 6.0; abrupt change to
B21	0.4 to 0.9	Brown (10YR 4/6 moist); medium heavy clay; few <5 mm faint red and yellow mottles; weak 2–5 mm lenticular structure, prominent slickensides; few 2–6 mm ferromanganiferous segregations; dry strong; field pH 7.0; diffuse change to
B22k	0.9 to 1.35	Brown (10YR 3/6 moist) coarse sandy light medium clay; few <5 mm faint red and yellow mottles; moderate 2–5 mm lenticular structure; few 6–10 mm calcareous segregations, few 2–6 mm ferromanganiferous segregations; dry strong; field pH 8.5; diffuse change to
B3k	1.35 to 1.8	Brown (10YR 4/6 moist); coarse sandy light medium clay; weak 2–5 mm lenticular structure; very few 6–10 mm calcareous segregations, common 2–6 mm ferromanganiferous segregations; dry strong; field pH 8.5.

Laboratory analysis results

	1:5 aqueous				Exchangeable cations (ICP)					
Depth	**pH**	**EC**	**Cl**	**NO_3N**	**Ca**	**Mg**	**Na**	**K**	**CEC**	**ESP**
(m)		**(dS/M)**	**mg/kg**		**meq/100g**					**%**
0.4–0.5	6.7	0.05	40	<1	3.78	13.9	1.89	0.21	19.8	9.6

Soil Profile Class: Beppo (Bp)

Site No.: SEQE 132

Location: Zone 56, 420460E, 7040518N
ASC: Vertic, Subnatric, Brown Sodosol
Permeability: Slow
Drainage: Imperfectly drained

Slope: 11%
Landform element: Hillslope
Landform pattern: Rises
Microrelief: Zero

Surface condition: Hard setting
Surface coarse fragments: None
Vegetation: *Eucalyptus siderophloia*
Geology: Sandstone of Esk Formation (Rte)

Profile morphology:

Horizon	Depth (m)	Description
A1	0.0 to 0.25	Brown (10YR 2/2 moist); loam; weak 2–5 mm subangular blocky structure; weak moderately moist; field pH 6.0; abrupt change to
A2e	0.25 to 0.3	Grey (10YR 6/3 moist, white 10YR 8/2 dry); loam; massive; very few <2 mm manganiferous nodules; weak dry; field pH 6.0; abrupt change to
B21	0.3 to 0.42	Grey (10YR 4/2 moist); coarse sandy medium heavy clay; weak 10–20 mm subangular blocky structure; few 5–15 mm distinct orange mottles; few 6–20 mm sub-rounded sandstone pebbles; few <2 mm manganiferous nodules; strong dry; field pH 6.0; abrupt change to
B22	0.42 to 1.1	Brown (10YR 5/4 moist); coarse sandy medium heavy clay; moderate 2–5 mm lenticular structure with few prominent slickensides; very few 5–15 mm faint orange mottles; few <2 mm manganiferous nodules; strong dry; field pH 7.5–8.5; clear change to
B23k	1.1 to 1.2	Brown (10YR 4/4 moist); coarse sandy light medium clay; strong 2–5 mm lenticular structure with few slickensides; few <2 mm manganiferous nodules; common 2–6 mm and few 6–20 mm calcareous nodules; strong dry; field pH 8.5; clear change to
B24k	1.2 to 1.8	Brown (10YR 5/6 moist); coarse sandy light medium clay; strong 2–5 mm lenticular structure with few slickensides; few <2 mm and very few 2–6mm manganiferous nodules; very few 2–6 mm calcareous nodules; strong dry; field pH 8.5.

Laboratory analysis results

	1:5 aqueous				Exchangeable cations (ICP)					
Depth	**pH**	**EC**	**Cl**	**NO_3N**	**Ca**	**Mg**	**Na**	**K**	**CEC**	**ESP**
(m)		**(dS/M)**	**mg/kg**		**meq/100g**					%
0.5–0.6	7.6	0.21	277	<1	5.16	15.0	4.33	0.25	24.70	14.8

Soil Profile Class: Cressbrook (Cb) **Site No.:** SEQE 17

Location: Zone 56, 420818E, 7043864N
ASC: Stratic Rudosol
Permeability: Highly Permeable
Drainage: Rapidly drained

Slope: 1%
Landform element: Plain
Landform pattern: Floodplain
Microrelief: Zero

Surface condition: Firm
Surface coarse fragments: Nil
Vegetation: *Eucalyptus tereticornis, Angophora subvelutina*
Geology: Quaternary Holocene alluvium (Qha/2)

Profile morphology

Horizon	Depth (m)	Description
A11	0.0 to 0.1	Black (10YR 3/2 moist); sandy loam; massive structure; dry strong; field pH 6.5; abrupt change to
A12	0.1 to 0.5	Black (10YR 3/2 moist); heavy sandy loam; weak 5–10 mm angular blocky structure; moderately moist weak; field pH 6.5; clear change to
2Db	0.5 to 0.88	Brown (10YR 3/3 moist); clayey sand; massive; moderately moist very weak; field pH 6.5; clear change to
3Db	0.88 to 1.0	Brown (10YR 3/3 moist); sandy loam; massive; moderately moist weak; field pH 6.5.

Laboratory analysis results

	1:5 aqueous				Exchangeable cations (ICP)							Particle size				Disp	15	Total Element (XRF)		
Depth	pH	EC	Cl	NO_3N	Ca	Mg	Na	K	CEC	ESP	ADMC	CS	FS	Si	Cl	Ratio	BAR	K	P	S
(m)		dS/M	mg/kg		meq/100g					%	%	%				R1	%	%		
0–0.1	7	0.04	<20	10	9.96	3.11	0.08	0.62	13.8	0.6	1.7	46	36	10	13	0.61	2.3	1.96	0.1	0.01

Soil Profile Class: Dunwich (Dw)

Site No.: SEQE 56

Location: Zone 56, 421195E, 7044200N
ASC: Melanic-Vertic, Eutrophic, Brown Chromosol
Erosion: Partly stabilised sheet erosion
Permeability: Moderate
Drainage: Moderately well drained

Slope: 20%
Landform element: Hillslope
Landform pattern: Rises
Microrelief: Zero

Surface coarse fragments: <2% 200–600 mm andesite cobbles
Surface condition: Hard setting
Vegetation: *Eucalyptus tereticornis, Eucalyptus melanophloia*
Geology: Volcanoclastic conglomerate of Neara Volcanics (Rtn)

Profile morphology:

Horizon	Depth (m)	Description
A1	0.0 to 0.22	Black (10YR 3/1 moist 10YR 5/2 dry); clay loam; moderate 2–5 mm subangular blocky structure; dry firm; field pH 6.0; clear change to
A21j	0.22 to 0.3	Grey (10YR 4/2 moist, 10YR 7/2 dry); sporadically bleached clay loam; moderate 2–5 mm subangular blocky structure; dry firm; field pH 6.0; abrupt change to
A22	0.3 to 0.35	Brown (10YR 4/3 moist); clay loam; very few 5–15 mm faint orange mottles; moderate 2–5 mm subangular blocky structure; dry firm; field pH 6.0; abrupt change to
B2	0.35 to 0.6	Brown (10YR 3/6 moist) medium clay; very few 5–15 mm faint orange mottles; moderate 2–5 mm lenticular structure, prominent slickensides; dry firm; field pH 6.5; clear change to
BC	0.6 to 0.7	Brown (10YR 5/4 moist); coarse sandy light medium clay; common substrate influenced faint orange mottles; common 6–60 mm angular andesite cobbles.

Laboratory analysis results

	1:5 aqueous				Exchangeable cations (ICP)						
Depth	**pH**	**EC**	**Cl**	**NO_3N**	**Ca**	**Mg**	**Na**	**Exch. Na**	**K**	**ECEC**	**ESP**
(m)		**(dS/M)**	**mg/kg**		**meq/100g**						%
0.4–0.5	6.8	0.02	<20	<1	13.3	9.01	0.44	0.44	0.37	23.2	2

Soil Profile Class: Dunwich (Dw)   **Site No.:** B444   **From CSIRO BV Project**

Location: Zone 56 451439E, 6 984110N
ASC: Black Chromosol
Permeability: Moderately permeable
Drainage: Imperfectly drained

PPF: Db3.13
GSG: Prairie Soil

Vegetation: *Heteropogon contortus*
Geology: Neara Volcanics **(**Rtn)

Profile morphology

Horizon	Depth (m)	Description
A11	0.0 to-0.06	Black (10YR 3/1 moist, 10YR 2/2 dry); clay loam; strong 3–6 mm angular blocky structure; friable; few gravels
A12	0.06 to 0.15	Black (10YR 3/1 moist, 10YR 2/2 dry); clay loam to light clay; strong 3–6 mm angular blocky structure; moderate gravel to 10 cm
B21	0.15 to 0.36	Black (10YR 3/1 moist); heavy clay; dark brown (7.5YR 3/1 moist) mottles; strong coarse prismatic breaking to coarse blocky structure; very firm; few 2.5 cm gravels
B22	0.36 to 0.58	Grey (10YR 4/2 moist) heavy clay; strong coarse blocky structure; very few 1.5 mm ferromanganese nodules, some decomposed parent material
BC	0.58 to 0.76	Yellow (10YR 7/5 moist); medium clay; grey (10YR 4/2 moist) mottles; strong coarse blocky structure; very few 1.5 mm ferromanganese nodules, some decomposed parent material
C	0.76 to 0.89	Brownish yellow; gritty clay loam; decomposed parent material.

Laboratory analysis results

							Exchangeable Cations							Particle size				Base Saturation	Phosphorus	
Horizon	pH	TSS	NaCl	H_2O	Org. C	N	Ca	Mg	Na	K	H	Total	ESP	CS	FS	Si	Cl		Avail. P	Total P
					%		meq/100g						%	%				%	ppm	%
1	6.3	0.02	0.01	6.1	3.41	.286	19.5	6.0	.2	1.0	7.7	34.4	0.6	9	23	26	32	78	52	.090
2	6.6	0.02	0.01	5.6	1.66	.145	17.7	5.7	.2	.4	2.6	26.6	0.8	12	26	27	32	90	-	-
3	7.3	0.02	0.01	8.6	0.88	.096	23.0	10.1	.7	.1	-	34	2.1	3	17	20	58	100	1	.047
4	8.6	0.07	0.02	10.9	0.77	.095	31.8	15.8	1.2	.1	-	48.9	2.5	2	14	16	64	100	-	-
5	8.0	0.07	0.02	7.7	0.27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6	8.7	0.07	0.02	6.8	0.17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.096

Soil Profile Class: Fernvale (Fv) **Site No.:** MISSE 640 **Reproduced from the MISSE PROJECT**

Location: Zone 56 468150E, 6964123N
ASC: Mottled-Sodic, Eutrophic, Brown Kurosol
Permeability: Slow
Drainage: Imperfectly drained

Slope: 6%
Landform element: Hillslope
Landform pattern: Low hills
Microrelief: Zero

Surface condition: Firm
Surface coarse fragments: Nil
Geology: Neranleigh-Fernvale beds (DCf)

Profile morphology

Horizon	Depth (m)	Description
A1	0 0 to 0.1	Black (7.5YR 3/2 moist); clay loam, fine sandy; moderate 5-10mm granular structure; very few 20–60 mm sub-rounded gravel pebbles; very weak moist; field pH 6.0; abrupt change to
A2	0.1 to 0.2	Grey (7.5YR 5/2 moist); clay loam, sandy; moderate 5–10mm granular structure; common 6–20 mm ferromanganiferous concretions; weak moist; field pH 6.5; clear wavy change to
B21t	0.2 to .5	Brown (7.5YR 5/3 moist); light medium clay; moderate 10-20 mm sub-angular blocky structure; common <5mm red and orange prominent mottles; firm moist; field pH 5.0; clear change to
B22t	0.5 to 1.3	Brown (7.5YR 5/3 moist); light medium clay; massive; very firm moist; field pH 4.5; gradual change to
B23t	1.3 to1.5	Brown (7.5YR 5/3 moist); light medium clay; few <5mm orange prominent mottles; many 60-200 mm sub-rounded quartz cobbles; massive; common slickensides; very firm moist; field pH 4.5.

Laboratory analysis results

	1:5 aqueous			Exchangeable cations (ICP)							Particle size				Disp	15	Total Element (XRF)		
Depth	**pH**	**EC**	**Cl**	**Ca**	**Mg**	**Na**	**K**	**CEC**	**ESP**	**ADMC**	**CS**	**FS**	**Si**	**Cl**	**Ratio**	**BAR**	**K**	**P**	**S**
(m)		**dS/M**	**mg/kg**	**meq/100g**					**%**	**%**	**%**				**R1**	**%**	**%**		
0–.1	6.1	0.1	36	3.18	2.12	0.14	1.29	6.73	2.0	3.0	34	28	19	26	0.71	12.3	-	-	-
.1–.2	6.1	0.04	23	3.11	3.50	0.2	0.72	7.53	2.6	2.5	37	24	14	31	0.61	12.7	0.341	0.056	0.018
.2–.3	6.2	0.03	20	2.08	2.15	0.15	0.42	4.80	3.2	<1.5	40	30	12	23	0.84	9.4	-	-	-
.3–.4	5.2	0.07	37	2.12	9.89	1.33	0.18	13.52	9.8	3.0	17	15	8	63	0.51	21.4	0.331	0.024	0.018
.5–.6	5.1	0.13	159	1.87	13.9	2.96	0.20	18.99	15.6	4.1	14	18	10	64	0.82	25.6	0.281	0.020	0.013
.8–.9	4.5	0.38	532	1.22	16.6	5.62	0.25	23.69	23.7	4.1	8	14	12	69	0.84	29.4	0.265	0.017	0.014
1.1–1.2	4.6	0.30	394	0.65	14.8	5.03	0.23	20.71	24.3	3.1	15	13	15	63	0.87	26.2	0.228	0.028	0.013
1.4–1.5	4.7	0.27	326	0.49	13.8	4.76	0.22	19.27	24.7	2.5	15.7	19.8	13.0	55.9	0.89	24.0	0.282	0.034	0.017

Fernvale SPC continued

Depth (m)	Exchangeable P mg/kg		Exchangeable K %	DTPA Exchangeable mg/kg			
	Acid	Bicarb		Fe	Mn	Cu	Zn
0–.1	54	67	1.1	242	130	1.8	4.3
.2–.3	-	11	-	-	-	-	-
.8–.9	-	3	-	-	-	-	-

Soil Profile Class: Gallanani (Gl) **Site No.:** SEQE 109

Location: Zone 56, 423601E, 7044786N
ASC: Haplic, Eutrophic, Brown Dermosol
Permeability: Moderate
Drainage: Well drained

Slope: 2%
Landform element: Plain
Landform pattern: Floodplain
Microrelief: Zero

Surface condition: Firm
Surface coarse fragments: Nil
Vegetation: *Eucalyptus tereticornis, Angophora subvelutina*
Geology: Quaternary Holocene alluvium (Qha/1)

Profile morphology

Horizon	Depth (m)	Description
A1	0.0 to 0.14	Brown (10YR 3/3 moist); heavy sandy loam; moderate 2–5 mm angular blocky structure; dry weak; field pH 6.0; clear change to
A12	0.14 to 0.27	Brown (10YR 3/3 moist); sandy clay loam; weak 5–10 mm angular blocky structure; dry weak; field pH 6.0; gradual change to
B1	0.27 to 0.4	Brown (10YR 3/4 moist); heavy sandy clay loam; moderate 5–10 mm angular blocky structure; dry firm; field pH 6.0; gradual change to
B21	0.4 to 0.58	Brown (10YR 3/6 moist);clay loam sandy; moderate 5–10 mm angular blocky structure; very few 2–6mm quartz sub-rounded pebbles; field pH 6.5; dry strong; clear change to
B22	0.58 to 0.8	Brown (10YR 3/6 moist); fine sandy light clay; weak 2–5 mm lenticular structure; very few 6–10 mm sub-rounded andesite pebbles; dry strong; field pH 6.0.

Laboratory analysis results

	1:5 aqueous				Exchangeable cations (ICP)							Particle size				Disp	15	Total Element (XRF)		
Depth	pH	EC	Cl	NO_3N	Ca	Mg	Na	K	CEC	ESP	ADMC	CS	FS	Si	Cl	Ratio	BAR	K	P	S
(m)		dS/M	mg/kg		meq/100g					%	%	%				R1	%	%		
0–0.1	5.6	0.05	<20	16	2.96	1.06	0.08	0.78	4.88	1.64	<1.5	29	42	15	16	0.73	7.2	1.8	0.06	0.01

Soil Profile Class: Gallanani (Gl)

Site No.: SEQE 110

Location: Zone 56, 424021E, 7043977N
ASC: Sodic, Eutrophic, Brown Dermosol
Permeability: Moderate
Drainage: Moderately well drained

Slope: 1%
Landform element: Terrace flat
Landform pattern: Terraced land
Microrelief: Zero

Surface condition: Firm
Surface coarse fragments: None
Vegetation: *Eucalyptus tereticornis*
Geology: Quaternary Holocene alluvium (Qha/1)

Profile morphology

Horizon	Depth (m)	Description
Ap	0.0 to 0.13	Brown (10YR 3/3 moist); sandy clay loam; weak 2–5 mm subangular blocky structure; weak dry; field pH 6.0, gradual change to
A3p	0.13 to 0.25	Brown (10YR 3/3 moist); heavy clay loam, sandy; weak 2–5 mm subangular blocky structure; weak dry; field pH 6.0; clear change to
B1	0.25 to 0.42	Brown (10YR 3/4 moist); fine sandy light clay; weak 5–10 mm subangular blocky structure; very few <2mm manganiferous nodules; very firm dry; field pH 6.5; gradual change to
B21	0.42 to 0.95	Brown (10YR 3/4 moist) moist; fine sandy light medium clay; very few <5 mm faint dark mottles; very few 6–20 mm subangular andesite pebbles; moderate 2-5 mm lenticular structure; very few <2 mm manganiferous nodules; strong dry; field pH 6.5; diffuse change to
B22	0.95 to 1.75	Brown (10YR 3/4 moist); fine sandy medium clay; moderate 10–20 mm prismatic structure, breaking to moderate 2–5 mm subangular blocky structure; very few <5 mm faint orange mottles; very few 20–60 mm subangular andesite pebbles; very few <2 mm manganiferous nodules; strong dry; field pH 6.5.

Laboratory analysis results

	1:5 aqueous				Exchangeable cations (ICP)							Particle size				Disp	15	Total Element (XRF)		
Depth	pH	EC	Cl	NO_3N	Ca	Mg	Na	K	CEC	ESP	ADMC	CS	FS	Si	Cl	Ratio	BAR	K	P	S
(m)		dS/M	mg/kg		meq/100g					%	%	%				R1	%	%		
0–0.1	5.7	0.19	<20	74	3.93	1.32	0.23	1.41	6.89	3.3	1.5	9	59	19	18	0.56	9.5	1.82	0.070	0.015

Soil Profile Class: Gira Gira (Gg)

Site No.: SEQE 64

Location: Zone 56, 421840E, 7041927N
ASC: Melanic, Eutrophic, Black Dermosol
Permeability: Moderate
Drainage: Moderately well drained

Slope: 1%
Landform element: Terrace flat
Landform pattern: Terraced land
Microrelief: Zero

Surface condition: Firm
Surface coarse fragments: Nil
Vegetation: *Eucalyptus tereticornis, Angophora subvelutina*
Geology: Quaternary Holocene alluvium (Qha/1)

Profile morphology

Horizon	Depth (m)	Description
Ap	0.0 to 0.2	Black (10YR 2/2 moist 10YR 4/3 dry); heavy silty clay loam; moderate 2–5 mm subangular blocky structure; dry firm; field pH 6.5; gradual change to
B21	0.2 to 1.1	Black (10YR 2/1 moist); silty light clay; strong 2–5 mm polyhedral structure; dry firm; field pH 6.5; clear change to
2B2b	1.1 to 1.5	Brown (10YR 3/3 moist); silty light medium clay; strong 2–5 mm polyhedral structure; few <5 mm faint orange mottles; dry firm; field pH 7.0; clear change to
3D	1.5 to 1.9	Black (10YR 3/2 moist); fine sandy light medium clay; strong 2–5 mm polyhedral structure; moderately moist weak; field pH 7.0.

Laboratory analysis results

	1:5 aqueous				Exchangeable cations (ICP)							Particle size				Disp	15	Total Element (XRF)		
Depth	pH	EC	Cl	NO_3N	Ca	Mg	Na	K	CEC	ESP	ADMC	CS	FS	Si	Cl	Ratio	BAR	K	P	S
(m)		dS/M	mg/kg		meq/100g					%	%	%				R1	%	%		
0–0.1	7.2	0.19	36	65	20.7	5.54	0.47	0.56	27.3	1.4	4.6	3	56	19	25	0.43	15.1	1.55	0.09	0.033

Soil Profile Class: Gira Gira (Gg)

Site No.: SEQE 115

Location: Zone 56, 424667E, 7040986N
ASC: Melanic, Eutrophic, Black Dermosol
Drainage: Moderately well drained
Permeability: Moderate

Slope: 2%
Landform element: Chanel Bench
Landform pattern: Flood plain
Microrelief: Zero

Surface condition: Hard setting
Surface coarse fragments: None
Vegetation: *Eucalyptus tereticornis*
Geology: Quaternary Holocene alluvium (Qha/1)

Profile morphology:

Horizon	Depth (m)	Description
A1	0.0 to 0.1	Black (10YR 3/2 moist, 10YR 4/3 dry); light silty clay loam; moderate 2–5 mm subangular blocky structure; strong dry; field pH 6.0; clear to
B21	0.1 to 0.8	Black (10YR 2/1 moist); silty light clay; strong 2–5 mm polyhedral structure; very few 2–6 mm sub-rounded andesite pebbles; strong dry; field pH 6.0; gradual to
2Db	0.8 to 1.5	Black (10YR 2/2 moist); silty light clay; moderate 2–5 mm polyhedral structure; very few 6–20 mm sub-rounded andesite pebbles; very firm dry; field pH 6.0; gradual to
3Db	1.5 to 1.8	Brown (10YR 3/3 moist); silty light clay; weak 2–5 mm polyhedral structure; very firm dry; field pH 6.

Laboratory analysis results

	1:5 aqueous				Exchangeable cations (ICP)							Particle size				Disp	15	Total Element (XRF)		
Depth	pH	EC	Cl	NO_3N	Ca	Mg	Na	K	CEC	ESP	ADMC	CS	FS	Si	Cl	Ratio	BAR	K	P	S
(m)		dS/M	mg/kg		meq/100g					%	%	%				R1	%	%		
0–0.1	6.7	0.17	30	51	19.1	5.36	0.12	1.59	26.16	0.3	5	1	49	35	20	0.55	18.5	1.71	0.10	0.041

Soil Profile Class: Hibiscus (Hb)

Site No.: SEQE 148

Location: Zone 56, 439488E, 6984484N
ASC: Haplic, Mesotrophic, Red, Kandosol
Permeability: Moderate
Drainage: Rapidly drained

Slope: 5%
Landform element: Hillslope
Landform pattern: Rises
Microrelief: Zero

Surface condition: Firm
Surface coarse fragments: Few 2–6 mm pebbles
Vegetation: Nil
Geology: Sandstone of Woogaroo Subgroup (RJbw)

Profile morphology

Horizon	Depth (m)	Description
Ap	0.0 to 0.45	Black (5YR 3/2 moist); sandy loam; few 2–6 mm subangular quartz small pebbles; massive; very weak moderately moist; field pH 6.0; clear change to
A3	0.45 to 0.60	Black (5YR3/2 moist); sandy clay loam; massive; very weak moderately moist; field pH 6.0; clear change to
B1	0.60 to 0.90	Red (5YR 3/3 moist); clay loam, sandy; massive; very few <2mm manganiferous nodules; weak moderately moist; field pH 6.5; clear change to
B21	0.90 to 1.40	Red (5YR 3/3 moist); coarse sandy light clay; massive; very few <2mm manganiferous nodules; weak moderately moist;; field pH 6.5; abrupt change to
B22	1.40 to 1.90	Red (5YR 3/3 moist); coarse sandy light medium clay; massive; very few <2mm manganiferous nodules; weak moderately moist; field pH 6.5.

Laboratory analysis results

	1:5 aqueous				Exchangeable cations (ICP)							Particle size				Disp	15	Total Element (XRF)		
Depth	**pH**	**EC**	**Cl**	**NO_3N**	**Ca**	**Mg**	**Na**	**K**	**CEC**	**ESP**	**ADMC**	**CS**	**FS**	**Si**	**Cl**	**Ratio**	**BAR**	**K**	**P**	**S**
(m)		**dS/M**	**mg/kg**		**meq/100g**					**%**	**%**	**%**				**R1**	**%**	**%**		
0–0.1	5.7	0.06	<20	22	1.24	0.45	<0.08	0.65	2.41	3.3	<1.5	81	9	2	11	0.96	3.6	0.284	0.037	<0.01
0.2–0.3	5.6	0.04	<20	15	1.20	0.42	<0.08	0.34	2.04	3.9	<1.5	79	11	3	11	0.91	3.6	0.241	0.035	<0.01
0.5–0.6	5.5	0.02	<20	5	2.21	0.54	<0.08	0.54	3.90	2.1	<1.5	56	16	9	23	0.60	7.2	0.331	0.036	<0.01
0.8–0.9	6.2	0.02	<20	<1	2.25	0.99	<0.08	0.60	3.91	2.1	2.1	51	14	7	31	0.39	9.6	0.389	0.021	<0.01
1.1–1.2	6.0	0.03	<20	<1	2.05	0.89	<0.08	0.60	3.62	2.2	1.6	52	13	3	33	0.13	10.5	0.407	0.021	<0.01
1.4–1.5	6.1	0.03	<20	<1	2.32	0.71	<0.08	0.50	3.61	2.2	<1.5	54	13	5	31	0.14	10.7	0.387	0.023	<0.01

Soil Profile Class: Honey (Hy)

Site No.: SEQE 103

Location: Zone 56, 420818E, 7043864N
ASC: Haplic, Eutrophic, Brown Kandosol
Permeability: High
Drainage: Rapidly drained

Slope: 0.5%
Landform element: Terrace flat
Landform pattern: Terraced land
Microrelief: Zero

Surface condition: Hard setting
Surface coarse fragments: Nil
Vegetation: Pasture grasses, *Eucalyptus tereticornis*
Geology: Quaternary Holocene alluvium (Qha/2)

Profile morphology:

Horizon	Depth (m)	Description
Ap	0.0 to 0.20	Black (10YR 3/2 moist); heavy sandy loam; weak 2–5 mm subangular blocky structure; dry firm; field pH 6.0; abrupt change to
B2	0.20 to 0.42	Brown (10YR 3/3 moist); heavy sandy loam; weak 5–10 mm subangular blocky structure; dry weak; field pH 6.5; abrupt change to
2Db	0.42 to 1.65	Brown (10YR 3/3 moist); sandy loam; weak 5–10 mm subangular blocky structure; dry weak; field pH 7.0; abrupt change to
3Db	1.65 to 1.80	Brown (10YR 3/5 moist); clayey sand; massive; dry loose; field pH 7.0.

Laboratory analysis results

	1:5 aqueous				Exchangeable cations (ICP)							Particle size				Disp	15	Total Element (XRF)		
Depth	pH	EC	Cl	NO_3 N	Ca	Mg	Na	K	CEC	ESP	ADMC	CS	FS	Si	Cl	Ratio	BAR	K	P	S
(m)		dS/M	mg/kg		meq/100g					%	%	%				R1	%	%		
0–0.1	6.6	0.11	<20	39	14.1	3.27	0.09	0.62	18.08	0.5	3.2	20	49	14	20	0.46	10.9	1.75	0.077	0.024
0.2–0.3	6.8	0.02	<20	5	9.93	2.65	<0.08	0.37	13.03	0.6	1.6	33	39	12	19	0.66	8.3	1.78	0.071	0.011
0.5–0.6	7.2	0.01	<20	2	10.2	3.11	0.11	0.22	13.64	0.8	1.5	30	44	12	19	0.69	8.2	1.78	0.068	<0.010
0.8–0.9	7.5	0.01	<20	<1	10.7	3.8	0.12	0.19	14.81	0.8	1.6	32	44	9	18	0.77	8.3	1.77	0.069	<0.010
1.1–1.2	7.7	0.02	<20	<1	10.7	3.72	0.15	0.22	14.80	1.0	2.0	34	41	9	18	0.77	8.3	1.76	0.069	<0.010
1.4-1.5	7.8	0.01	<20	<1	8.09	2.72	0.16	1.52	12.50	1.3	<1.5	54	33	3	9	0.80	5.4	1.87	0.065	<0.010

Soil Profile Class: Monsildale (Md)

Site No.: SEQE 21

Location: Zone 56, 420759E, 7049181N
ASC: Melanic, Eutrophic, Black Dermosol
Permeability Moderate
Drainage: Moderately well drained

Slope: 1%
Landform element: Terrace plain
Landform pattern: Terraced land
Microrelief: Zero

Surface condition: Hard setting
Surface coarse fragments: Nil
Vegetation: Pasture grasses, *Eucalyptus tereticornis*
Geology: Quaternary Holocene alluvium (Qha/2)

Profile morphology

Horizon	Depth (m)	Description
A11	0.0 to 0.09	Black (10YR 2/2 moist); heavy sandy clay loam; moderate 2–5 mm subangular blocky structure; dry firm; field pH 7.0; clear change to
A12	0.09 to 0.30	Black (10YR 2/1 moist); silty clay loam; moderate 2–5 mm subangular blocky structure; moderately moist firm; field pH 7.0; clear change to
B21	0.30 to 0.74	Black (10YR 2/1 moist); light clay; strong 2–5 mm subangular blocky structure; moderately moist weak; field pH 7.5; clear change to
B22	0.74 to 1.03	Brown (10YR 3/3 moist); fine sandy light medium clay; strong 5–10 mm prismatic structure breaking to strong 2–5 mm angular blocky structure; dry strong; field pH 7.5; abrupt change to
2Db	1.03 to 1.30	Brown (10YR 3/3 moist); fine sandy light clay; strong 10–20 mm prismatic structure breaking to strong 2–5 mm angular blocky structure; dry strong; field pH 7.5.

Laboratory analysis results

	1:5 aqueous				Exchangeable cations (ICP)							Particle size				Disp	15	Total Element (XRF)		
Depth	pH	EC	Cl	NO_3 N	Ca	Mg	Na	K	CEC	ESP	ADMC	CS	FS	Si	Cl	Ratio	BAR	K	P	S
(m)		dS/M	mg/kg		meq/100g					%	%	%				R1	%	%		
0–0.1	6.7	0.09	<20	24	19	5.05	0.08	1.25	25.38	0.3	3.1	3	50	22	28	0.4	16.8	1.72	0.11	0.03
0.2–0.3	6.6	0.05	<20	17	17.1	4.73	0.11	0.97	22.92	0.5	3.4	1	44	26	35	0.41	16	1.68	0.10	0.02
0.5–0.6	7.3	0.03	<20	2	20.3	5.6	0.21	0.39	26.5	0.8	3.4	1	41	29	37	0.4	16.3	1.55	0.09	0.02
0.8–0.9	7.6	0.02	<20	<1	20.7	5.92	0.25	0.40	27.27	0.9	3.4	3	37	24	42	0.36	16.2	1.54	0.09	0.01
1.1–1.2	7.7	0.02	<20	<1	20.2	6.02	0.29	0.28	26.80	1.1	3.4	5	45	16	39	0.42	15.5	1.55	0.09	0.01

Soil Profile Class: Monsildale (Md) **Site No.:** MISSE 646 **Reproduced from MISSE Project**

Location: Zone 56 468353E, 6964518N
ASC: Vertic, Eutrophic, Brown Dermosol
Permeability: Moderate
Drainage: Moderately well drained

Slope: 0%
Landform element: Valley flat
Landform pattern: Low hills
Microrelief: Zero

Surface condition: Firm
Surface coarse fragments: Nil
Vegetation: Nil
Geology: Quaternary alluvium (Qa)

Profile morphology

Horizon	Depth (m)	Description
O	0 to.05	Black (5YR 3/2 moist); heavy loam; strong 2–5 mm granular structure; moderately moist very weak; field pH 6.5; clear change to
A1p	.05 to 0.30	Black (7.5YR 3/2 moist); light clay; strong 50–100 mm angular blocky breaking to strong 5–10 mm angular blocky structure; moderately moist weak; field pH 6.0; gradual change to
B21	0.30 to 0.95	Brown (2.5Y 4/3 moist); medium heavy clay; moderate 50–100 mm angular blocky structure; moist very firm; field pH 8.0; diffuse change to
B22	0.95 to 1.50	Brown (2.5Y 3/3 moist); medium heavy clay; moderate lenticular structure; few slickensides; moist strong; field pH 8.5.

Laboratory analysis results

	1:5 aqueous			Exchangeable cations (ICP)							Particle size				Disp	15	Total Element (XRF)		
Depth	pH	EC	Cl	Ca	Mg	Na	K	CEC	ESP	ADMC	CS	FS	Si	Cl	Ratio	BAR	K	P	S
(m)		dS/M	mg/kg	meq/100g					%	%	%				R1	%	%		
0–.05	7.0	0.38	64	-	-	-	-	-	-	20.0	23	4	21	34		27.3	-	-	-
.1–.2	6.2	0.04	<20	9.19	7.16	0.16	0.75	17.26	0.9	4.7	9	24	30	44	0.65	14.1	-	-	-
.2–.3	6.3	0.04	<20	8.19	8.64	0.18	0.42	17.43	1.0	2.8	9	14	40	46	0.64	14.3	0.949	0.061	0.015
.5–.6	7.1	0.06	39	11.4	15.7	1.57	0.41	29.08	5.4	3.6	3	20	20	64	0.82	19.6	0.985	0.029	0.01
.8–.9	7.6	0.09	58	11.0	15.9	2.38	0.37	29.67	8.0	3.5	3	20	22	62	0.89	19.1	1.02	0.026	<0.01
1.1–1.2	8.1	0.21	254	11.4	16.6	3.35	0.36	31.31	10.6	3.3	3	15	30	53	0.91	17.9	1.05	0.028	<0.01
1.4–1.5	8.1	0.30	401	11.1	16.9	3.89	0.37	32.26	12.1	3.3	3	16	32	51	0.88	18.1	1.09	0.035	<0.01

Monsildale Continued

Depth (m)	Exchangeable P mg/kg		Exchangeable K meq%	DTPA Exchangeable (mg/kg)			
	Acid	Bicarb		Fe	Mn	Cu	Zn
0–.05	6.21	691	1.9	43.8	25.6	1.8	16.3
0.1–0.2	12	20	0.8	133	21.8	3.4	0.8
0.2–0.3	-	9	-	89.4	11.8	3.3	0.2
0.8–0.9	-	<2	-	-	-	-	-

Soil Profile Class: Moore (Mo)

Site No.: SEQE 245

Location: Zone 56, 451515E, 6981578N
ASC: Vertic, Subnatric, Black Sodosol
Erosion: Partly stabilised sheet erosion
Permeability: Slow
Drainage: Moderately well drained

Slope: 3.5%
Landform element: Hillslope
Landform pattern: Rises
Microrelief: Zero

Surface condition: Hard setting
Surface coarse fragments: Nil
Vegetation: Nil
Geology: Andesite of Neara Volcanics (Rtn)

Profile morphology

Horizon	Depth (m)	Description
A1	0.0 to 0.09	Black (10YR 3/2 moist); clay loam; moderate 2–5 mm angular blocky structure; moderately moist weak; field pH 6.0; clear change to
A2e	0.09 to 0.17	Black (10YR 3/2 moist, 10YR 7/2 dry); conspicuously bleached heavy clay loam; moderate 2–5 mm angular blocky structure; dry firm; field pH 6.5; clear change to
B2	0.17 to 0.55	Black (10YR 3/1 moist); medium heavy clay; moderate 2–5 mm lenticular structure; very few 2–6 mm calcareous segregations; dry strong; field pH 8.5; clear change to
BC	0.55 to 0.65	Many 2-20 mm andesite pebbles weathering insitu.

Laboratory analysis results

	1:5 aqueous				Exchangeable cations (ICP)						
Depth	**pH**	**EC**	**Cl**	**NO_3N**	**Ca**	**Mg**	**Na**	**Na**	**K**	**CEC**	**ESP**
(m)		**(dS/M)**	**mg/kg**		**meq/100g**						%
0.17–0.27	7.1	0.12	69	<1	11.6	17.3	3.2	3.20	0.20	32.3	9.9

Soil Profile Class: Moore (Mo)

Site No.: B445 **From CSIRO BV Project**

Location: Zone 56 451 274E, 6 984 233N
ASC: Eutrophic, Subnatric, Black Sodosol
Permeability: Slow

PPF: Dy3.43
GSG: Solodic
Drainage: Imperfectly drained

Geology: Neara Volcanics (Rtn)

Profile morphology

Horizon	Depth (m)	Description
A1/A2	0.0 to 0.13	Brownish grey (10YR 5/2 moist); loam; and light grey (10YR 7/1 dry) bleached loam; a pedal, few 2.4–5 cm gravel, thin bleached at base of A horizon
B21	0.13 to 0.28	Black (10YR 3/2 moist); heavy clay; moderate coarse angular blocky structure; few 1.5 mm ferromanganiferous nodules
B22	0.28 to 0.45	Black (10YR 3/2 moist); heavy clay; fine olive brown mottles; moderate coarse angular blocky structure; few 1.5 mm ferromanganiferous nodules
B3	0.45 to 0.60	Brown (2.5Y 5/4 moist); light clay; light greyish yellow mottles; strong coarse angular blocky structure
C1	0.60 to 1.52	Yellow (2.5Y 7/4 moist); fine sandy clay loam; soft weathered parent material
C2	1.52 to 1.83	Yellow (10YR 6/4 moist); sandy clay loam; soft weathered parent material.

Laboratory analysis results

							Exchangeable Cations							Particle size				Phosphorus		Base Sat.
Horizon	pH	TSS	NaCl	H_2O	Org. C	N	Ca	Mg	Na	K	H	Total	ESP	CS	FS	Si	Cl	Avail. Ppm	Total P %	%
					%				meq/100g				%		%					
1	5.5	0.02	0.01	3	2.0	.175	3.1	5.9	.4	.6	11.4	21.4	1.9	15	34	25	20	4	0.44	47
2	6.4	0.08	0.04	7.9	.9.6	-	-	-	-	-	-	-	-	12	14	14	59	-	0.44	-
3	7.6	0.19	0.1	8.9	0.6	-	9.3	30.2	3.9	.1	4.1	47.6	8.2	4	12	18	64	1	-	91
4	8.3	0.27	0.13	7.6	-	-	-	-	-	-	-	-	-	16	30	21	30	-	-	-
5	8.5	0.19	0.19	8.6	-	-	-	-	-	-	-	-	-	22	32	22	22	-	-	-
6	7.4	0.07	0.07	5.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.29	-

Soil Profile Class: Quinine (Qn)

Site No.: SEQE 114

Location: Zone 56, 435690E, 6985144N
ASC: Mesotrophic, Subnatric, Brown Sodosol
Permeability: Slow
Drainage: Imperfectly drained

Slope: 16%
Landform element: Hillslope
Landform pattern: Low hills
Microrelief: Zero

Surface condition: Surface crust
Surface coarse fragments: Few 2–6mm quartz pebbles
Vegetation: Pasture species
Geology: Sandstone of Woogaroo Subgroup (RJbw)

Profile morphology:

Horizon	Depth (m)	Description
A1	0.0 to 0.28	Grey (2.5Y 4/2 moist); sandy loam; weak 5–10 mm angular blocky structure; few subangular 2–6 mm quartz pebbles; very weak dry; field pH 6.0; clear to
A2e	0.28 to 0.58	Brown (2.5Y 5/3 moist, pale yellow 2.5Y 7/3 dry); clayey sand; massive; few 2–6 mm subangular quartz pebbles; few 6–20 mm subangular sandstone pebbles; very few 2–6 mm ferruginous modules; very weak moderately moist; field pH 6.0; clear to
B2	0.58 to 1.15	Brown (10YR 5/6 moist); light medium clay; weak 5–10 mm angular blocky structure; very few 5–15 mm distinct red substrate influenced mottles; few <5 mm distinct grey substrate influenced mottles; few 2–6 mm and very few 6–20 mm subangular quartz pebbles; very few 2–6 mm ferruginous nodules; weak moderately moist; field pH 5.7; clear to
BC	1.15 to 1.40	Grey (5YR 6/2 moist); medium clay; massive; common 5–15 mm distinct brown mottles, common 5–15 mm distinct red mottles, common 5–15 mm distinct red substrate influenced mottles; very abundant 60–200 mm sandstone cobbles; very firm moderately moist; field pH 5.3.

Laboratory analysis results

	1:5 aqueous				Exchangeable cations (ICP)							Particle size				Disp	15	Total Element (XRF)		
Depth	pH	EC	Cl	NO_3 N	Ca	Mg	Na	K	CEC	ESP	ADMC	CS	FS	Si	Cl	Ratio	BAR	K	P	S
(m)		dS/M	mg/kg		meq/100g					%	%	%				R1	%	%		
0–0.1	6.3	0.08	<20	71	8.00	3.23	0.12	.80	12.15	1.0	3.3	28	42	16	18	0.61	10.0	1.74	0.074	0.016

Soil Profile Class: Quinine (Qn)

Site No.: SEQE 266

Location: Zone 56, 438712E, 6983264N
ASC: Mesotrophic, Mottled-Subnatric Grey Sodosol
Erosion: Stream bank erosion close by
Permeability: Slow
Drainage: Imperfectly drained

Slope: 5%
Landform element: Drainage depression
Landform pattern: Low Hills
Microrelief: Zero

Surface condition: Hard setting
Surface coarse fragments: Nil
Vegetation: *Eucalyptus tereticornis, Eucalyptus siderophloia, Corymbia tesselaris*
Geology: Tertiary Quaternary Residual (TQr) derived from Woogaroo Subgroup (RJbw)

Profile morphology

Horizon	Depth (m)	Description
A1	0.0 to 0.25	Grey (10YR 5/1 moist); silty loam; massive; moderately moist weak; field pH 6.0; clear change to
A2e	0.25 to 0.45	Grey (10YR 7/1 moist, 10YR 7/1 dry); conspicuously bleached sandy loam; massive; very few <2 mm ferromanganiferous segregations; moderately moist weak; field pH 6.0; clear change to
B2	0.45 to 1.0	Grey (10YR 6/1 moist); coarse sandy medium clay; many >30 mm prominent orange mottles; massive; very few <2 mm ferromanganiferous segregations; moderately moist weak; field pH 6.5; clear change to
B3	1.0 to 1.5	Grey (2.5Y 7/1 moist) coarse sandy light medium clay; many substrate influenced >30 mm prominent orange mottles; massive; very few 2–6 mm ferromanganiferous segregations; moderately moist very firm; field pH 6.5; gradual change to
BC	1.5 to 1.7	Grey coarse sandy light medium clay; massive; field pH 6.5.

Laboratory analysis results

	1:5 aqueous				Exchangeable cations (ICP)					
Depth	**pH**	**EC**	**Cl**	**NO_3N**	**Ca**	**Mg**	**Na**	**K**	**CEC**	**ESP**
(m)		**dS/M**	**mg/kg**		**meq/100g**					%
0.5–0.6	6.2	0.02	<20	<1	0.81	3.93	0.54	0.40	5.7	9.5

Soil Profile Class: Quinine, Nodular Variant (QnNv) **Site No.:** B448 **From CSIRO BV Project**

Location: Zone 56, 435877E 6983916N
PPF: Dy3.42
Vegetation: *Heteropogon contortus*
ASC: Grey Sodosol
GSG: Gleyed Podzolic
Geology: Woogaroo Subgroup (RJbw) (Helidon Sandstone)
Permeability: Very slowly permeable
Drainage: Imperfectly drained

Profile morphology

Horizon	Depth (m)	Description
A1	0.0 to 0.13	Grey (10YR 6/2 dry) grading to light grey (10YR 7/1.5 dry) loamy fine sand; massive; very porous
A21	0.13 to 0.43	White (10YR 8/2 dry) loamy fine sand; massive; very porous
A22	0.43 to 0.58	White (10YR 8/2 dry) coarse sand; massive; high ferromanganese nodules to 10 mm size
B1	0.58 to 0.66	Yellow (10YR 6/4 dry) gritty sandy loam; white and brown mottles; coarse columnar structure; slight ferromanganese concretions
B2	0.66 to 0.84	Grey (2.5Y 6/2 dry) coarse sandy clay; yellow and brown mottles; coarse columnar structure; soft ferromanganese segregations
	0.84 to 1.17	Grey (10YR 6/1 dry) sandy clay; yellow and brown mottles; massive; slight soft ferromanganese segregations
	1.17 to 1.37	Grey (10YR 5/1 moist) sandy clay; yellowish brown mottles; massive; fine soft ferromanganese segregations
	1.37 to 2.08	Grey (10YR 5/1 moist) light medium clay; yellowish brown mottles; massive; slight soft ferromanganese segregations; a trace of water worn gravel.

Laboratory analysis results

							Exchangeable Cations							Particle size				Phosphorus		Base
Horizon	pH	TSS	NaCl	H_2O	Org. C	N	Ca	Mg	Na	K	H	Total	ESP	CS	FS	Si	Cl	Avail. ppm	Total P %	Sat.
					%		meq/100g						%	%						%
1	5.7	0.01	<0.01	.4	.64	.053	.7	.1	<.1	.1	.56	1.4	-	40	36	18	6	1	.012	60
2	5.9	0.01	<0.01	.2	.11	-	-	-	-	-	-	-	-	43	33	18	6	-	-	-
3	6.3	0.01	<0.01	.2	.04	.010	-	-	-	-	-	-	-	61	17	14	8	1	-	-
4	6.5	0.01	<0.01	.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5	6.5	0.01	<0.01	1.5	.01	.006	1.4	2.4	.8	.2	0.02	4.8	16.7	46	18	10	26	1	0.018	100
6	6.4	0.01	0.01	1.8	-	-	-	-	-	-	-	-	-	49	20	6	26	-	-	-
7	6.2	0.02	0.01	2.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	6.2	0.02	0.01	2.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Soil Profile Class: Spencer (Sp)

Site No.: SEQE 131

Location: Zone 56, 420703E, 7040845N
ASC: Vertic, Subnatric, Grey Sodosol
Erosion: Partly stabilised sheet erosion
Permeability: Slow
Drainage: Imperfectly drained

Slope: 2%
Landform element: Backplain
Landform pattern: Alluvial plain
Microrelief: Zero

Surface condition: Firm
Surface coarse fragments: Nil
Vegetation: Nil
Geology: Quaternary Holocene alluvium (Qha/2)

Profile morphology

Horizon	Depth (m)	Description
A1	0.0 to 0.15	Grey (10YR 4/1 moist); loam; moderate 2–5 mm subangular blocky structure; dry firm; field pH 6.0; sharp change to
A2j	0.15 to 0.17	Grey (10YR 4/1 moist, 10YR 7/2 dry); sporadically bleached loam; moderate 2–5 mm subangular blocky structure; dry firm; field pH 6.0; sharp change to
B21	0.17 to 0.27	Grey (10YR 4/2 moist); medium clay; moderate 2–5 mm subangular blocky structure; dry strong; field pH 6.5; clear change to
B22	0.27 to 0.8	Grey (10YR 4/2 moist) medium heavy clay; moderate 2–5 mm lenticular structure, with prominent slickensides; very few <2 mm ferromanganiferous segregations; dry strong; field pH 8.0; gradual change to
B23	0.8 to 1.15	Brown (10YR 3/3 moist); medium clay; very few <5 mm distinct orange mottles; strong 2–5 mm lenticular structure, prominent slickensides; few <2 mm ferromanganiferous segregations; dry strong; field pH 8.5; diffuse change to
B24k	1.15 to 1.50	Grey (10YR 5/1 moist); medium clay; few 5–15 mm distinct orange mottles strong 2–5 mm lenticular structure, prominent slickensides; common 2–6 mm calcareous segregations, few <2 mm ferromanganiferous segregations; dry strong; field pH 8.5.

Laboratory analysis results

	1:5 aqueous				Exchangeable cations (ICP)					
Depth	**pH**	**EC**	**Cl**	**NO_3N**	**Ca**	**Mg**	**Na**	**K**	**CEC**	**ESP**
(m)		**dS/M**	**mg/kg**		**meq/100g**					**%**
0.17–0.27	6.9	0.19	214	<1	6.72	15.3	2.91	0.29	25.22	11.5

Soil Profile Class: Spencer (Sp) **Site No.:** MISSE 644 **Reproduced from MISSE Project**

Location: 468107E, 6963875N
ASC: Hypocalcic, Subnatric Brown Sodosol
Permeability: Slow
Drainage: Imperfectly drained

Slope: 0%
Landform element: Terrace flat
Landform pattern: Terraced land
Microrelief: Zero

Surface condition: Firm
Surface coarse fragments: Nil
Vegetation: Nil
Geology: Quaternary Holocene alluvium/2 (Qha/2)

Profile morphology

Horizon	Depth (m)	Description
A11	0.0 to 0.05	Black (10YR 3/2 moist); fine sandy loam; weak 2–5mm granular structure; weak moderately moist; field pH 5.8 clear change to
A12	0.05 to 0.25	Black (10YR 3/1 moist); fine sandy loam; moderate 5–10 mm subangular blocky structure; common 5–15 mm faint brown mottles; weak moderately moist; field pH 6.0 ;abrupt change to
B1	0.25 to 0.40	Brown (10YR 4/3 moist); fine sandy light clay; moderate 10–20 mm subangular blocky structure; few <5 mm brown and 5–15mm distinct orange mottles; very few <2mm manganiferous soft segregations; weak moist; field pH 6; clear change to
B21	0.40 to 0.60	Brown (10YR 4/4 moist); medium heavy clay; weak 10–20 mm subangular blocky structure; few <5 mm distinct orange mottles; few <2mm manganiferous soft segregations; very firm moist; field pH 8.5; diffuse change to
B22k	0.60 to1.20	Brown (2.5Y 4/3 moist); medium heavy clay; weak lenticular structure with common slickensides; few < 5 mm distinct orange sharp mottles; few 6–20 mm subangular gravel pebbles; few 2–6 mm manganiferous soft segregations; very few 2–6mm calcareous nodules; strong moist; field pH 9.0; gradual change to
B23k	1.20 to 1.50	Brown (10YR 4/4 moist); medium heavy clay; weak lenticular structure with common slickensides; few <5mm distinct orange sharp mottles; very few <2 mm manganiferous nodules; few 2–6 mm calcareous nodules; strong moist; field pH 9.0.

Laboratory analysis results

	1:5 aqueous			Exchangeable cations (ICP)							Particle size				Disp	15	Total Element (XRF)		
Depth	pH	EC	Cl	Ca	Mg	Na	K	CEC	ESP	ADMC	CS	FS	Si	Cl	Ratio	BAR	K	P	S
(m)		dS/M	mg/kg	meq/100g				%		%	%				R1	%	%		
0–.05	5.8	0.04	24	3.78	2.47	0.15	0.52	6.92	2.2	2.4	24	47	16	18	0.55	10.1	-	-	-
.1–.2	6.1	0.02	<20	3.37	2.59	0.24	0.13	6.33	3.8	1.6	25	45	15	18	0.72	8.6	-	-	-
.3–.4	6.7	0.05	33	4.04	6.57	1.20	0.20	12.01	9.9	1.8	22	42	11	30	0.79	13.5	1.20	0.023	<0.010
.5–.6	7.4	0.11	108	5.17	9.05	2.34	0.19	16.75	13.9	2.2	15	43	15	34	0.82	15.3	1.17	0.020	<0.010
.8–.9	8.4	0.34	416	-	-	-	-	-	-	2.5	10	35	18	41	0.85	18.6	1.05	0.017	<0.010
1.1–1.2	8.6	0.41	505	-	-	-	-	-	-	3.2	10	33	14	48	0.97	21.5	0.958	0.021	<0.010
1.4–1.5	8.7	0.47	537	-	-	-	-	-	-	2.9	10	27	18	48	0.95	21.2	0.867	0.021	<0.010

Spencer continued

Depth (m)	Exchangeable P mg/kg		Exchangeable K meq%	DTPA Exchangeable mg/kg			
	Acid	Bicarb		Fe	Mn	Cu	Zn
0–.05	61	58	0.6	301	14.5	1.1	1.9
.1–.2	14	8	0.2	156	3.4	0.9	0.3
.8–.9	-	2	-	-	-	-	-

Soil Profile Class: Yellowbank (Yb) **Site No:** B443 **From CSIRO BV Project**

ASC: Mottled, Mesotrophic Brown Kandosol
Location: Zone 56 435932E 6984101N
Permeability: Moderate

PPF: Gn2.24
GSG: Yellow earth
Drainage: Moderately well drained

Vegetation: *Eucalyptus crebra, Eucalyptus punctate, Imperata cylindrica*
Geology: Woogaroo Subgroup (RJbw) (Helidon Sandstone)

Profile morphology

Horizon	Depth (m)	Description
A1	0 to 0.15	Black (10YR 3/2 moist) fine sandy loam; massive; very friable.
A2	0.15 to 0.34	Brown (10YR 4/3 moist) fine sandy loam; massive; friable; very few fine quartz gravel; 3 mm ferromanganese nodules
B1	0.34 to 0.48	Brown (7.5YR 5/6 moist) fine sandy clay loam; massive; friable; very few 6–25mm quartz gravel,
B21	0.48 to 0.66	Brown (7.5YR 5/8 moist) fine sandy clay with red (5YR 4/6 moist) distinct mottles; massive to very weak blocky structure; very friable; few 12 mm quartz gravel; ferromanganiferous nodules,
B22	0.66 to 0.84	Yellow (10YR 6/6 moist) fine sandy clay with red (5YR 5/6 moist) distinct mottles; massive to very weak blocky structure; very friable; very few12 mm quartz gravel; ferromanganiferous nodules,
B3	0.84 to 1.14	Yellow (10YR 6/6 moist) fine sandy clay loam with red (5YR 5/6 moist) distinct mottles; massive to very weak blocky structure; very friable; very few 12 mm quartz gravel; ferromanganiferous nodules,
C	1.14 to 1.30	Banded light grey; yellow-brown and red massive weathered parent material.

Laboratory analysis results

						Exchangeable Cations						Particle size				Phosphorus	
Horizon	**pH**	**TSS**	**H_2O**	**Org. C**	**N**	**Ca**	**Mg**	**Na**	**K**	**H**	**Total**	**CS**	**FS**	**Si**	**Cl**	**Avail.**	**Total P**
			%	%	%	meq/100g						%				ppm	%
1	6.2	0.01	.9	.90	.073	2.3	.9	<.1	.1	3.1	6.4	50	25	12	11	4	.036
2	6.2	0.01	.6	.30	.025	.9	.7	<.1	.1	2	3.7	49	22	14	12	-	-
3	6.4	0.01	.9	.22	.025	-	-	-	-	-	-	46	22	14	19	-	-
4	6.0	0.01	2.3	.28	.038	1.1	3.0	.2	.3	4.6	9.1	33	15	14	40	7	.044
5	5.9	0.01	1.9	.14	-	-	-	-	-	-	-	34	14	18	36	-	-
6	6.0	0.01	1.5	.08	-	.1	2.8	.1	.1	3.1	5.4	38	15	22	28	-	-
7	6.0	0.01	1.1	.90	-	-	-	-	-	-	-	45	15	27	15	-	.038

Appendix 4: SEQE Land Suitability Classification Scheme

The land suitability framework for the SEQE project was based on the Regional Land Suitability Frameworks for Queensland (DNRM and DSITIA 2013), for the Inland SEQ framework area. The framework was modified and updated to be consistent with the particularities of the Brisbane River catchment. Where possible, some of the Land Use Requirements and Limitations names were updated to be consistent with the Queensland Agricultural Land Evaluation Guidelines (DSITI and DNRM 2015).

Limitations and Land Management Options

The following 16 limitations were used to assess land suitability in the SEQE project.

Land use requirements	Limitations	Soil and land attributes used to assess each limitation
Frost-free	Frost (Cf)	Frequency, timing and severity of damaging frosts, landform and landscape position.
Minimise soil loss due to water erosion	Water erosion (E)	Slope/soil erodibility (USLE K factor), soil stability groups.
Minimise soil loss and land degradation from subsoil erosion	Subsoil erosion (Es)	Soil classification, depth to B horizon, B horizon dispersion, Exchangeable sodium percentage of B horizon, electrical conductivity, CEC and Ca/Mg ratio of B horizon.
Minimal impact of damaging floods	Flooding (F)	Frequency and depth of flooding based on position in landscape and historic flood levels.
Adequate water storage in the soil profile to maintain plant growth	Soil water availability (M)	PAWC and effective rooting depth.
Adequate nutrient supply	Nutrient deficiency (Nd)	Levels of Phosphorus (P) in top 0.3m.
Absence of of toxic levels of elements	Element toxicity (Nt)	Soil pH in the surface soil (<0.3 m) and at 0.6 m depth.
Ability to harvest underground crops	Soil adhesiveness (Pa)	Texture, structure, consistence and clay mineralogy of the surface soil (<0.3m).
Soil depth to a physical root barrier	Soil depth (Pd)	Depth to hard rock or other impermeable layer or chemical barrier.
Ease of seedbed preparation, no restriction to germination	Soil surface condition (Ps)	Surface condition, surface soil texture and structure (<0.3m), susceptibility to compaction.
Minimal impact from gravel, stone and rock at the soil surface	Rockiness (R)	Size and content (%) of coarse fragments, % rock outcrop.
Low levels of soluble salts in the soil profile	Soil salinity (Sa)	Saturated extract conductivity (dS/m ECse) of the top 0 -0.1m of soil.
Level land surface	Microrelief (Tm)	Vertical interval of microrelief.
Safe and efficient use of machinery	Slope (Ts)	Slope (%) variation in slope length and direction.
Adequate soil aeration	Wetness (W)	Soil drainage and permeability, depth to and degree of mottling, soil colour, ESP, native vegetation, redox, time period of water saturation, soil structure and texture.
Adequate size of uniform production areas and ability to access them	Landscape complexity (X)	Minimum area of contiguous suitable soil available for crop production, level of topographic dissection.

The following land management options were considered in the compilation of the SEQE land suitability framework:

Asian Vegetables (a, w, sp)	Green Panic	Potato (a, w, sp)
Avocado	Green bean (s)	Onion (w, sp, s)
Barley	Gympie messmate (*E. cloeziana*)	Rhodes Grass
Beetroot (a, w, sp)	Hoop Pine	Rye Grass
Blackbutt (*E. pilularis*)	Improved pasture legumes	Sorghum (forage)
Brassica (cabbage, Cauliflowers, etc.) (a, w, sp)	Kikuyu	Soybean
Broccoli	Lettuce (a, w, sp)	Soybean (irrigated)
Carrot (a, w, sp)	Leucaena	Spotted gum (C. citriodora)
Capsicum (s)	Lucerne (irrigated)	Sweet corn (s)
Chickpea	Mungbean	Tomato (s)
Citrus (lime, lemon)	Native pastures	Turf
Cucurbits (melons, pumpkins, Zucchini) (s)	Navy Bean	Wheat
Dunn's white gum (*E. dunnii*)	Oats	

Note: Summer (s), spring (sp), autumn (a) and winter (w) land uses have been identified to allow assessment for seasonal adaptation and variation in soil/land attributes such as frosts, temperature, flooding, wetness and soil water availability.

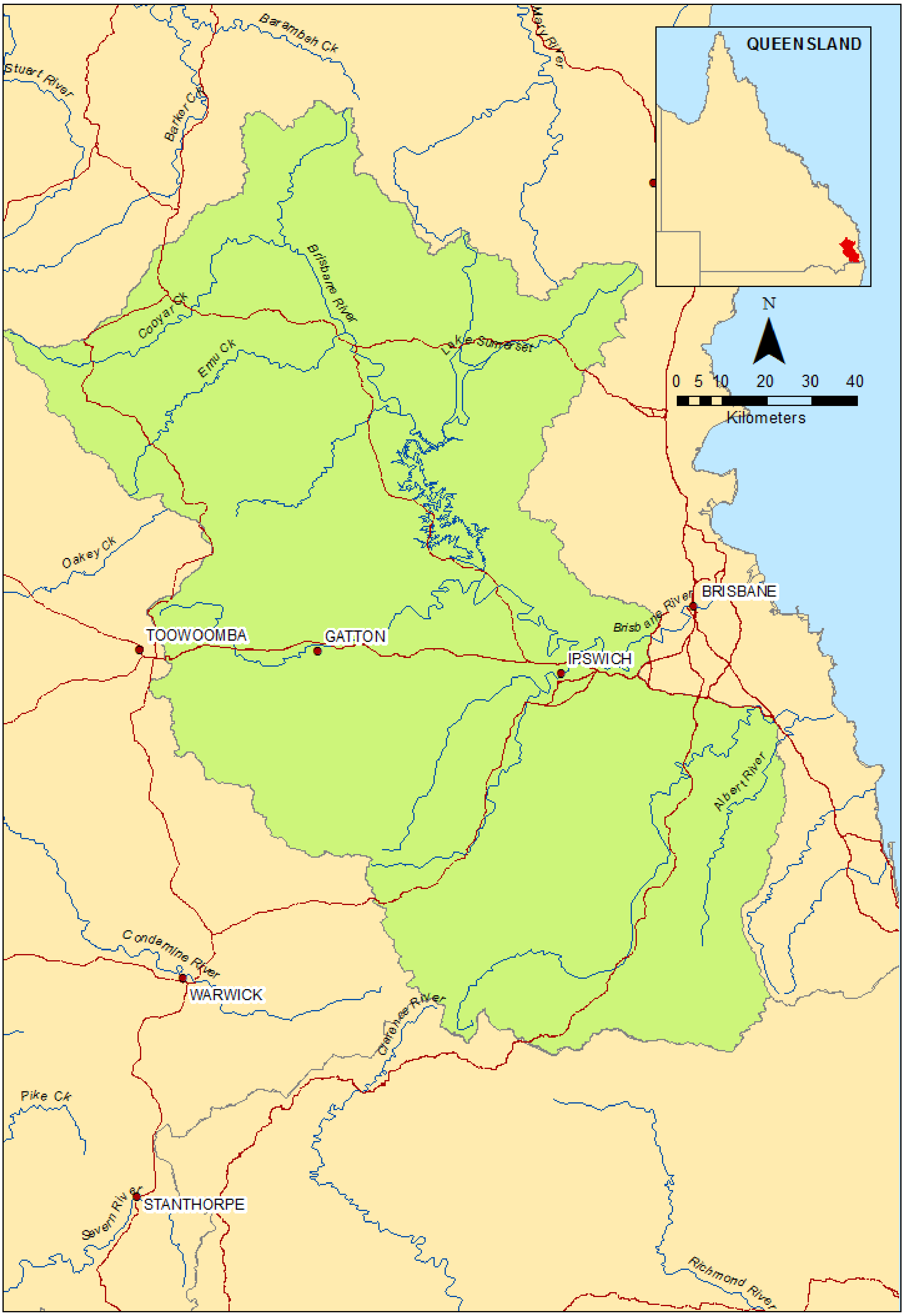


Figure 1 Area covered by the Inland SEQ suitability framework

Frost (Cf)

Frosts may kill plants, suppress growth and reduce yield, particularly if their occurrence coincides with frost sensitive periods in plant growth cycles.

Limitation category determination

Crop tolerance and local experience have been used to determine the incidence and severity of frosts.

Additional Notes:

- In general, the incidence and severity of frost is determined by the landscape position. Hill slopes and rises tend to experience fewer and less severe frosts, while lower lying areas may experience more regular frost. The frequency and severity of frost differs over the project area, and is more intense in the upper reaches of the Brisbane River catchment.
- All frost sensitive crops (including green beans, cucurbits, capsicums, tomatoes and Spotted Gum) are highly susceptible to frost and careful management is required in frost prone areas to avoid the effects of all but occasional, very light frosts.
- Horticultural cropping is carried out at times of the year which substantially avoids the effects of frosts. Irrigation strategies are used to mitigate frost risk (e.g. Potato).
- “Summer” vegetables (which are frost sensitive), are planted after the risks of frost are over in the late spring. Consecutive plantings are made over the summer, and the final harvests are made in the autumn before the risk of frosts affects quality. Consequently, frost is not considered a limitation for the summer vegetable crops. This includes green beans, cucurbits, capsicums, tomatoes and sweet corn.

Cf - Frost

Limitation 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
		Suitability subclasses for various land management options											
1	Frost free or occasional light frost >-1°C (<3 events per year)	1	1	1	1	1	1	1	1	1	1	1	1
2	Regular light frosts (>/= 3 events per year) over winter months only (>-1°C)	1	1	1	1	1	1	1	1	2	2	3	4
3	Regular light frosts over late autumn and early spring (>-1°C)	1	1	1	1	1	2	2	2	2	2	3	4
4	Regular moderate frosts (>/= 3 events per year) over winter months only (-1°C to -4°C)	1	1	2	2	3	2	3	5	2	3	4	5
5	Regular severe frosts (>/= 3 events per year) over winter months only (<-4°C)	1	2	2	3	4	3	4	5	4	4	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
Native Pasture	Dunn's White Gum-Dryland	Green Panic-Dryland	Forage Sorghum-Dryland	Turf-Irrigated	Brassicas-Irrigated	Broccoli-Irrigated	Potatoes - Irrigated	Beetroot-Irrigated	Barley-Dryland	Avocados-Irrigated	Asian Vegetable s-Irrigated
	Hoop Pine-Dryland	Kikuyu-Dryland	Leucaena-Dryland		Carrots-Irrigated				Chickpeas -Dryland	Gympie Messmate-Dryland	Blackbutt-Dryland
	Improved Pasture Legumes-Dryland	Lucerne-Irrigated	Maize-Dryland						Citrus-Irrigated		Spotted Gum-Dryland
		Rhodes Grass-Dryland	Onions-Irrigated						Oats-Dryland		Lettuce
		Rye Grass-Dryland	Sorghum-Dryland						Wheat-Dryland		
			Soybeans-Irrigated								
			Summer Pulses-Dryland								

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 <0.05
Strongly structured surface soils high in free iron (Ferrosols). Profiles are highly permeable throughout.

Stable soils: K factor <0.05
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 0.05 – 0.07
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 1.0m of the surface in lower landscape positions.

Very Unstable soils: K factor >0.07
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 0.5m of the surface.

Limitation category determination

Slope limits are determined in consultation with soil conservation extension and research personnel, and extension and research agronomists.

Terrain covariates derived from the 1-arc second resolution DEM, available from the CSIRO's Data Access Portal and the TERN Data Discovery Portal, were used in conjunction with site data to model some of the limitations used in the suitability assessment. The slope component for the E limitation relied on the SRTM DEM.

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. Slopes limits have been reduced for more erodible soil types).
- 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/vegetable crops require seedbed preparation on an annual basis. Tillage during summer to prepare for the winter copping period leaves paddocks exposed and subject to potentially erosive rainfall events through the summer and autumn months. Tillage is usually aggressive, surface soils very loose and paddocks laid out in straight rows. Land uses in this category are considered most at risk from erosion and slope limits are therefore more robust.
- Soil loss on alluvial soils is exacerbated by channel deviation across cultivation resulting in loss and deposition processes.
- Slope limits described for forestry situations assume land is already cleared and pastured and broadscale clearing is not required. These limits assume minimal soil disturbance is practised during land preparation for planting. Lower limits would apply were significant soil disturbance involved.
- Appropriately designed and maintained contour banks and waterways can be used to reduce the risk of water erosion.
- Grazing management and resultant groundcover levels are the most critical factors affecting soil erosion in grazing landscapes.
- Irrigation is assuming spray or drip irrigation, and not furrow irrigation.

E - Water erosion

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
1A	Very stable soils; K factor <0.02 & slope range <2%	1	1	1	1	1	1	1	1	1	1
2A	Very stable soils; K factor <0.02 & slope range >2-5%	1	1	1	1	1	1	1	2	2	2
3A	Very stable soils; K factor <0.02 & slope range 5–8%	1	1	1	2	2	2	2	2	3	3
4A	Very stable soils; K factor <0.02 & slope range 8-10%	1	1	2	2	3	3	3	3	4	4
5A	Very stable soils; K factor <0.02 & slope range 10-15%	1	2	3	3	3	5	5	5	4	4
6A	Very stable soils; K factor <0.02 & slope range 15-20%	2	3	3	3	4	5	5	5	5	5
7A	Very stable soils; K factor <0.02 & slope range >20-25%	3	3	4	5	5	5	5	5	5	5
8A	Very stable soils; K factor <0.02 & slope range >25%	4	3	5	5	5	5	5	5	5	5
1B	Stable soils; K factor 0.02 – 0.05 & slope range <2%	1	1	1	1	1	1	1	1	1	1
2B	Stable soils; K factor 0.02 – 0.05 & slope range >2-5 %	1	1	1	1	1	2	2	2	2	2
3B	Stable soils; K factor 0.02 – 0.05 & slope range 5–8%	1	1	1	2	2	3	3	3	3	3
4B	Stable soils; K factor 0.02 – 0.05 & slope range 8-10%	1	2	2	3	3	3	3	4	4	4
5B	Stable soils; K factor 0.02 – 0.05 & slope range 10-15%slope	2	2	3	3	3	5	5	5	5	5
6B	Stable soils; K factor 0.02 – 0.05 & slope range 15-20%	3	3	3	4	4	5	5	5	5	5
7B	Stable soils; K factor 0.02 – 0.05 & slope range >20-25%	4	3	4	5	5	5	5	5	5	5
8B	Stable soils; K factor 0.02 – 0.05 & slope range >25%	4	3	5	5	5	5	5	5	5	5
1C	Unstable soils; K factor 0.05 – 0.07 & slope range <2%	1	1	1	1	1	2	2	1	1	1
2C	Unstable soils; K factor 0.05 – 0.07 & slope range >2-5%	1	1	1	2	1	3	3	3	3	3
3C	Unstable soils; K factor 0.05 – 0.07 & slope range 5–8%	1	2	2	2	2	3	3	4	4	4

4C	Unstable soils; K factor 0.05 – 0.07 & slope range 8-10%	2	3	3	3	3	4	4	5	5	5
5C	Unstable soils; K factor 0.05 – 0.07 & slope range 10-15%	3	3	3	4	3	5	5	5	5	5
6C	Unstable soils; K factor 0.05 – 0.07 & slope range 15-20%	4	3	4	4	4	5	5	5	5	5
7C	Unstable soils; K factor 0.05 – 0.07 & slope range 20-25%	5	3	5	5	5	5	5	5	5	5
8C	Unstable soils; K factor 0.05 – 0.07 & slope range >25%	5	4	5	5	5	5	5	5	5	5
1D	Very unstable soils; K factor > 0.07 & slope range <2%	1	1	1	1	1	2	2	2	2	2
2D	Very unstable soils; K factor > 0.07 & slope range >2-5%	2	2	2	2	2	3	3	3	3	3
3D	Very unstable soils; K factor > 0.07 & slope range 5-8%	2	3	3	3	3	4	4	4	4	4
4D	Very unstable soils; K factor > 0.07 & slope range 8-10%	3	3	4	3	4	5	5	5	5	5
5D	Very unstable soils; K factor > 0.07 & slope range 10-15%	4	3	4	4	4	5	5	5	5	5
6D	Very unstable soils; K factor > 0.07 & slope range 15-20%	5	3	5	5	5	5	5	5	5	5
7D	Very unstable soils; K factor > 0.07 & slope range 20-25%	5	4	5	5	5	5	5	5	5	5
8D	Very unstable soils; K factor > 0.07 & slope range >25%	5	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
Blackbutt-Dryland	Native Pasture	Kikuyu-Dryland	Avocados-Irrigated	Green Panic-Dryland	Summer Pulses-Dryland	Barley-Dryland	Turf-Irrigated	Asian Vegetables-Irrigated	Broccoli-Irrigated
			Citrus-Irrigated	Improved Pasture Legumes-Dryland		Chickpeas-Dryland		Beetroot-Irrigated	
			Dunn's White Gum-Dryland	Leucaena-Dryland		Forage Sorghum-Dryland		Brassicas-Irrigated	
			Gympie Messmate-Dryland	Rhodes Grass-Dryland		Lucerne-Irrigated		Capsicum-Irrigated	
			Hoop Pine-Dryland	Rye Grass-Dryland		Maize-Dryland		Carrots-Irrigated	

Suitability framework for the Inland South East Queensland area

	Spotted Gum-Dryland	Oats-Dryland Sorghum-Dryland Soybeans-Irrigated Wheat-Dryland	Cucurbits-Irrigated Green Beans-Irrigated Lettuce-Irrigated Onions-Irrigated Potatoes-Irrigated Sweet Corn-Irrigated Tomato-Irrigated

Subsoil erosion (Es)

Subsoil instability caused by high sodicity and/or a very low calcium/magnesium ratio can lead to reduced infiltration and drainage, increased erosion and loss of structural integrity. The proportion of sodium in relation to other cations is expressed as exchangeable sodium percentage (ESP).

Limitation category determination is via laboratory measured cations where available. Otherwise, ESP has been estimated on the basis of the DSITI/DNRM 'Standard Operating Procedure for field slaking and dispersion', based on the Emerson Aggregate Test (Emerson 1991).

Es - Subsoil erosion

Limitation		Suitability subclasses for various land management options				
Value	Description	Group A	Group B	Group C	Group D	Group E
0	No subsoil sodicity (ESP <6)	1	1	1	1	1
1	Subsoil sodic (ESP 6-15) and clay content >15%	1	1	2	2	3
2	Subsoil strongly sodic (ESP >15%) and clay content >15% and/or Ca/Mg <0.1	1	2	2	4	4

Group A	Group B	Group B cont.	Group C	Group D	Group E
Native Pasture	Avocados-Irrigated	Lucerne-Irrigated	Asian Vegetables-Irrigated	Turf-Irrigated	Potatoes-Irrigated
	Barley-Dryland	Maize-Dryland	Beetroot-Irrigated		
	Blackbutt-Dryland	Oats-Dryland	Brassicas-Irrigated		
	Chickpeas-Dryland	Rhodes Grass-Dryland	Broccoli-Irrigated		
	Citrus-Irrigated	Rye Grass-Dryland	Capsicum-Irrigated		
	Dunn's White Gum-Dryland	Sorghum-Dryland	Carrots-Irrigated		
	Forage Sorghum-Dryland	Soybeans-Irrigated	Cucurbits-Irrigated		
	Gympie Messmate-Dryland	Spotted Gum-Dryland	Green Beans-Irrigated		
	Hoop Pine-Dryland	Summer Pulses-Dryland	Green Panic-Dryland		
	Improved Pasture Legumes-Dryland	Sweet Corn-Irrigated	Lettuce-Irrigated		
	Kikuyu-Dryland	Wheat-Dryland	Onions-Irrigated		
	Leucaena-Dryland		Tomato-Irrigated		

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.
- Terrain covariates derived from the 1-arc second resolution DEM, available from the CSIRO's Data Access Portal and the TERN Data Discovery Portal, were used in conjunction with site data to model some of the limitations used in the suitability assessment. The flooding limitation was refined using an assessment of Multi Resolution Valley Bottom Flatness (MRVBF) and Topographic Wetness Index (TWI).

Additional Notes:

- Flooding is generally not considered a limitation for winter grown vegetable crops because the main growing season coincides with the dry season, allowing the majority of plantings to be timed to avoid most seasonal flooding. Notwithstanding flooding does irregularly occur in the months of April and May causing substantial damage.
- Some tree crops (e.g. citrus,) tolerate inundation for periods of about 1 day or so. 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 are classed as marginal for production rather than unsuitable.
- Avocados are highly sensitive to flooding and suffer significant fruit damage, root rot and financial loss following an event. Losses in avocados are more significant than other orchards.

F- Flooding

Limitation		Suitability subclasses for various land management options						
Value	Description	Group A	Group B	Group C	Group D	Group E	Group F	Group G
0	No flooding.	1	1	1	1	1	1	1
1	Flooding less frequent than 1 in 10 years	1	1	1	1	2	3	5
2	Flooding frequency between 1 in 2 and 1 in 10 years	2	2	3	3	3	5	5
3	Flooding frequency approaches annual occurrence	3	4	4	5	4	5	5

Group A	Group B	Group C	Group D	Group E	Group F	Group G
Green Panic-Dryland	Blackbutt-Dryland	Improved Pasture Legumes-Dryland	Asian Vegetables-Irrigated	Barley-Dryland	Citrus-Irrigated	Avocados-Irrigated
Kikuyu-Dryland	Dunn's White Gum-Dryland		Beetroot-Irrigated	Chickpeas-Dryland		
Leucaena-Dryland	Gympie Messmate-Dryland		Brassicas-Irrigated	Forage Sorghum-Dryland		
Native Pasture	Hoop Pine-Dryland		Broccoli-Irrigated	Lucerne-Irrigated		
Rhodes Grass-Dryland	Spotted Gum-Dryland		Capsicum-Irrigated	Maize-Dryland		
Rye Grass-Dryland			Carrots-Irrigated	Oats-Dryland		
Turf-Irrigated			Cucurbits-Irrigated	Sorghum-Dryland		
			Green Beans-Irrigated	Soybeans-Irrigated		
			Lettuce-Irrigated	Summer Pulses-Dryland		
			Onions-Irrigated	Wheat-Dryland		
			Potatoes-Irrigated			
			Sweet Corn-Irrigated			
			Tomato-Irrigated			

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. Soil water availability was based on a calculation of soil water storage, expressed as millimetres (mm) of water over a specified depth of soil or to the effective rooting depth (ERD). PAWC was then estimated for each SPC using the look-up table for soil water storage from the *Regional Planning Interests Act Guideline 08/14* (DILGP 2015) (Table 1). Field textures for each horizon, were correlated with Table 5.

Additional Notes

- PAWC is less critical for irrigated crops than for rain fed crops and in irrigated situations is used largely to estimate the required irrigation frequency.
- All crops were considered irrigated except where indicated as rain fed/dryland. Forestry species and sown pastures are rain fed.
- Soil drainage may modify PAWC for a particular soil. For example, a shallow watertable within the effective rooting depth for 2–3 months or longer (see W limitation) can provide water to plants for extended periods.
- All horticultural crops are irrigated, so soil water availability is not a significant limitation to production.
- Native hardwood eucalypt species 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).
- A maximum specified depth of 1.5 m was used for the strongly structured non-sodic soils on the floodplain. Elsewhere, the effective rooting depth was the depth to any physical root barrier, to impermeable or sodic layers should they exist, or to 1 m.
- Soils with greater than 10% coarse fragments required a reduction in their soil water storage values to reflect the reduction in soil material.

Table 1 Soil texture look up table to estimate plant available water capacity

Soil texture	Soil water storage
Sand; clayey sand; loamy sand	4 mm/100 mm
Sandy loam	5 mm/100 mm
Loam; silty loam; sandy clay loam	6 mm/100 mm
Clay loam; clay loam sandy; silty clay loam	8 mm/100 mm
Silty clays; clays with <45 % clay fraction	10 mm/100 mm
Clays with > 45 % clay fraction	12 mm/100 mm

M – Soil water availability

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	>150mm PAWC	1	1	1	1	1	1	1	1
2	125-150mm PAWC	1	1	1	1	1	2	2	2
3	100-125mm PAWC	1	1	1	2	2	2	2	3
4	75-100mm PAWC	1	1	2	2	3	3	3	3
5	50-75mm PAWC	1	2	3	4	3	3	4	4
6	<50mm PAWC	2	3	4	4	4	3	5	5

Group A	Group B	Group C	Group D	Group E	Group F	Group G	Group H
Asian Vegetables-Irrigated	Hoop Pine-Dryland	Blackbutt-Dryland	Lucerne-Irrigated	Avocados-Irrigated	Native Pasture	Green Panic-Dryland	Barley-Dryland
Beetroot-Irrigated	Spotted Gum-Dryland	Dunn's White Gum-Dryland	Soybeans-Irrigated	Citrus-Irrigated		Improved Pasture Legumes-Dryland	Chickpeas-Dryland
Brassicas-Irrigated		Gympie Messmate-Dryland				Kikuyu-Dryland	Forage Sorghum-Dryland
Broccoli-Irrigated						Leucaena-Dryland	Maize-Dryland
Capsicum-Irrigated						Rhodes Grass-Dryland	Oats-Dryland
Carrots-Irrigated						Rye Grass-Dryland	Sorghum-Dryland
Cucurbits-Irrigated							Summer Pulses-Dryland
Green Beans-Irrigated							Wheat-Dryland
Lettuce-Irrigated							
Onions-Irrigated							
Potatoes-Irrigated							
Tomato-Irrigated							
Turf-Irrigated							
Sweet Corn-Irrigated							

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 south-east Queensland it was determined that Phosphorus (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. This limitation is of more relevance to the pasture lands.

Nd – Nutrient deficiency

Limitation Value	Description	Suitability subclasses for various land management options Group A	Group B	Group C	Group D	Group E	Group F
1	Phosphorus (P) >20ppm	1	1	1	1	1	1
2	Phosphorus (P) 10-20ppm	1	1	2	2	2	2
3	Phosphorus (P) 5-10ppm	1	2	2	2	3	3
4	Phosphorus (P) <5ppm	2	3	2	3	3	4

Group A	Group B	Group C	Group D	Group E	Group F
Asian Vegetables-Irrigated	Barley-Dryland	Avocados-Irrigated	Blackbutt-Dryland	Improved Pasture Legumes-Dryland	Green Panic-Dryland
Beetroot-Irrigated	Leucaena-Dryland	Citrus-Irrigated	Dunn's White Gum-Dryland	Rhodes Grass-Dryland	Kikuyu-Dryland
Brassicas-Irrigated	Native Pasture		Forage Sorghum-Dryland	Rye Grass-Dryland	Oats-Dryland
Broccoli-Irrigated			Gympie Messmate-Dryland		Wheat-Dryland
Capsicum-Irrigated			Hoop Pine-Dryland		
Carrots-Irrigated			Lucerne-Irrigated		
Chickpeas-Dryland			Maize-Dryland		
Cucurbits-Irrigated			Sorghum-Dryland		
Green Beans-Irrigated			Soybeans-Irrigated		
Lettuce-Irrigated			Spotted Gum-Dryland		
Onions-Irrigated			Summer Pulses-Dryland		
Potatoes-Irrigated					
Sweet Corn-Irrigated					
Tomato-Irrigated					
Turf-Irrigated					

Nutrient 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, where they exist, nutrient availability may be reduced.
- 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	Group B	Group C
1	Surface soil (0-0.3m) pH >5.0.	1	1	1
2	Soil pH at 0.6m >5.0.	1	1	1
3	Surface soil (0-0.3m) pH <5.0.	2	2	3
4	Soil pH at 0.6m <5.0.	n/a	3	3

Group A	Group B	Group C
Asian Vegetables-Irrigated	Avocados-Irrigated	Barley-Dryland
Beetroot-Irrigated	Citrus-Irrigated	Chickpeas-Dryland
Brassicas-Irrigated		Forage Sorghum-Dryland
Broccoli-Irrigated		Green Panic-Dryland
Capsicum-Irrigated		Improved Pasture Legumes-Dryland
Carrots-Irrigated		Kikuyu-Dryland
Cucurbits-Irrigated		Leucaena-Dryland
Green Beans-Irrigated		Lucerne-Irrigated
Lettuce-Irrigated		Maize-Dryland
Onions-Irrigated		Native Pasture
Potatoes-Irrigated		Oats-Dryland
Sweet Corn-Irrigated		Rhodes Grass-Dryland
Tomato-Irrigated		Rye Grass-Dryland
Turf-Irrigated		Sorghum-Dryland
		Soybeans-Irrigated
		Summer Pulses-Dryland
		Wheat-Dryland
		Blackbutt-Dryland
		Dunn's White Gum-Dryland
		Gympie Messmate-Dryland
		Hoop Pine-Dryland
		Spotted Gum-Dryland

Soil adhesiveness (Pa)

Harvesting root crops can be difficult in soils that adhere to the harvested product or machinery, and can affect the quality and post-harvest treatment of harvest material. Adhesive soils are prone to significant levels of soil disturbance during harvest and may be subject to increased compaction and declining structural stability.

Soil adhesiveness categories		Inherent soil morphological properties affecting adhesiveness	
		structure and texture characteristics	surface condition
Pa0	No restrictions	Strongly structured (granular, polyhedral) surface soils high in free iron (Ferrosols)	soft or firm
		Sandy textured surface soils (<SL) low in organic matter	loose, soft or firm
		Humic surface soils very high in organic matter	soft or firm
Pa1	Slightly adhesive soils	Moderately to strongly structured (granular, blocky) surface soils (>SL) (friable Dermosols).	weakly hardsetting
Pa2	Moderately adhesive soils	Massive to weakly structured (granular, blocky), silty or fine sandy textured surface soils	moderately to strongly hard setting
Pa3	Strongly adhesive soils	Sticky and/or sodic clay within 0.3m of the surface (within the plough zone) (Dermosols, Vertosols, thin surfaced Sodosols)	firm to hard setting or self-mulching

Additional Notes:

- This limitation only applied to carrots, potatoes and beetroot. This issue is generally overcome by post-harvest washing.

Pa – Soil adhesiveness

Limitation		Suitability subclasses for various land management options
Value	Description	Group A
0	No restrictions	1
1	Slightly adhesive	1
2	Moderately adhesive	2
3	Strongly adhesive	2

Group A
Beetroot - Irrigated
Carrots-Irrigated
Potatoes-Irrigated

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 has been decreased from 0.6 m to 0.4 m.
- Some vegetable 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, vegetable crops of low height.

Pd – Soil depth

Limitation		Suitability subclasses for various land management options				
Value	Description	Group A	Group B	Group C	Group D	Group E
1	>1.0m	1	1	1	1	1
2	0.5-1.0m (minimum for tree crops)	1	1	2	2	4
3	0.3-0.5m	1	1	3	4	5
4	<0.3m	3	5	4	5	5

Group A	Group B	Group C	Group D	Group E
Green Panic-Dryland	Asian Vegetables-Irrigated	Blackbutt-Dryland	Barley-Dryland	Avocados-Irrigated
Improved Pasture Legumes-Dryland	Beetroot-Irrigated	Gympie Messmate-Dryland	Chickpeas-Dryland	
Kikuyu-Dryland	Brassicas-Irrigated	Hoop Pine-Dryland	Citrus-Irrigated	
Native Pasture	Broccoli-Irrigated	Leucaena-Dryland	Dunn's White Gum-Dryland	
Rhodes Grass-Dryland	Capsicum-Irrigated	Spotted Gum-Dryland	Forage Sorghum-Dryland	
Rye Grass-Dryland	Carrots-Irrigated		Lucerne-Irrigated	
	Cucurbits-Irrigated		Maize-Dryland	
	Green Beans-Irrigated		Oats-Dryland	
	Lettuce-Irrigated		Sorghum-Dryland	
	Onions-Irrigated		Wheat-Dryland	
	Potatoes-Irrigated			
	Soybeans-Irrigated			
	Summer Pulses-Dryland			
	Sweet Corn-Irrigated			
	Tomato-Irrigated			
	Turf-Irrigated			

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 vegetables, grasses or pasture species) are most affected by this limitation. Vegetable crops such as lettuce, brassicas, tomatoes, capsicum and cucurbits, which are in the main planted as seedlings, are less affected. Tree and vine crops, which are planted as large tree seedlings, and also crops planted using vegetative material are least affected.
- Irrigated crops are able to overcome limitations associated with crusting and hard setting soils.

Ps – Soil 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	2	2	3	3	3
2	Hard setting massive soils with FSL to CLFS surface textures and dry firm consistency.	2	2	2	3	3	3
3	Surface crusts present.	2	2	2	3	3	3
4	Large soil aggregate size on surface (>20mm)	2	2	3	3	4	5

Group A	Group B	Group C	Group D	Group E	Group F
Asian Vegetables-Irrigated	Beetroot-Irrigated	Soybeans-Irrigated	Chickpeas-Dryland	Barley-Dryland	Sorghum-Dryland
Brassicas-Irrigated	Carrots-Irrigated		Forage Sorghum-Dryland	Maize-Dryland	
Broccoli-Irrigated	Green Beans-Irrigated		Green Panic-Dryland	Oats-Dryland	
Capsicum-Irrigated	Lucerne-Irrigated		Improved Pasture Legumes-Dryland	Wheat-Dryland	
Cucurbits-Irrigated	Sweet Corn-Irrigated		Kikuyu-Dryland		
Lettuce-Irrigated			Leucaena-Dryland		
Onions-Irrigated			Native Pasture		
Potatoes-Irrigated			Rhodes Grass-Dryland		
Tomato-Irrigated			Rye Grass-Dryland		
Turf-Irrigated			Summer Pulses-Dryland		

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 sugar cane.

Limitation class determination

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

Additional Notes:

- Surface gravel, stone and rock are particularly important and can interfere significantly with planting, cultivation and harvesting machinery used for root crops, other vegetable crops, annual forage crops.
- Surface rock in particular interferes with harvester machinery for sub-surface and ground crops such as carrots and potatoes. The presence of rocks also affects plant available moisture (considered under the **M** limitation).

R - Rockiness

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	Group L	Group M	Group N
R0	No rock.	1	1	1	1	1	1	1	1	1	1	1	1	1	1
RF2	2-6mm (fine gravel) 2-10%.	1	1	1	1	1	1	1	1	1	1	1	2	2	1
RF3	2-6mm (fine gravel) 10-20%.	1	1	1	2	2	2	2	2	2	2	3	2	4	2
RF4	2-6mm (fine gravel) 20-50%.	1	1	1	3	3	3	3	3	3	3	3	3	5	3
RF5	2-6mm (fine gravel) >50%.	1	2	2	3	4	4	4	3	3	4	4	4	5	3
RM2	6-20mm (medium gravel) 2-10%.	1	1	1	2	1	2	2	2	2	3	3	1	5	3
RM3	6-20mm (medium gravel) 10-20%.	1	1	1	2	2	2	3	3	4	4	4	2	5	4
RM4	6-20mm (medium gravel) 20-50%.	1	1	2	3	3	3	4	4	5	5	5	3	5	5
RM5	6-20mm (medium gravel) >50%.	2	2	3	4	4	4	5	5	5	5	5	4	5	5
RG1	20-60mm (coarse gravel) <2%.	1	1	1	2	1	1	1	2	3	3	3	1	4	2
RG2	20-60mm (coarse gravel) 2-10%.	1	1	1	2	2	2	3	3	4	4	4	2	5	3
RG3	20-60mm (coarse gravel) 10-20%.	1	1	2	3	3	3	4	4	5	5	5	3	5	4
RG4	20-60mm (coarse gravel) 20-50%.	2	2	3	4	4	4	5	5	5	5	5	4	5	5
RG5	20-60mm (coarse gravel) >50%.	2	3	4	5	5	5	5	5	5	5	5	5	5	5
RC1	60-200mm (cobbles) <2%.	1	1	1	1	2	2	2	2	3	3	3	1	5	2
RC2	60-200mm (cobbles) 2-10%.	1	1	2	2	3	3	3	3	4	4	4	2	5	3
RC3	60-200mm (cobbles) 10-20%.	2	2	3	2	4	4	4	4	5	5	5	3	5	4
RC4	60-200mm (cobbles) 20-50%.	2	2	4	3	4	5	5	5	5	5	5	4	5	5
RC5	60-200mm (cobbles) >50%.	3	3	5	4	5	5	5	5	5	5	5	5	5	5
RS1	200-600mm (stones) <2%.	1	1	2	2	3	3	2	2	4	4	4	3	5	2
RS2	200-600mm (stones) 2-10%.	2	2	3	3	4	4	4	4	5	5	5	4	5	4
RS3	200-600mm (stones) 10-20%.	2	3	4	4	5	5	5	5	5	5	5	5	5	5
RS4	200-600mm (stones) 20-50%.	3	4	5	5	5	5	5	5	5	5	5	5	5	5
RS5	200-600mm (stones) >50%.	4	4	5	5	5	5	5	5	5	5	5	5	5	5
RO1	>600mm or rock outcrop (boulders) <2%.	1	2	2	2	3	3	2	2	3	3	3	3	5	2
RO2	>600mm or rock outcrop (boulders) 2-10%.	2	3	4	3	4	4	4	4	4	4	4	4	5	4
RO3	>600mm or rock outcrop (boulders) 10-20%.	3	4	4	4	5	5	5	5	5	5	5	5	5	5
RO4	>600mm or rock outcrop (boulders) 20-50%.	3	5	5	5	5	5	5	5	5	5	5	5	5	5
RO5	>600mm or rock outcrop (boulders) >50%.	4	5	5	5	5	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	Group L	Group M	Group N
Native Pasture	Blackbutt-Dryland	Green Panic-Dryland	Avocados-Irrigated	Barley-Dryland	Lucerne-Irrigated	Lettuce-Irrigated	Asian Vegetables-Irrigated	Beetroot-Irrigated	Carrots-Irrigated	Potatoes-Irrigated	Summer Pulses-Dryland	Turf-Irrigated	Onions-Irrigated
	Dunn's White Gum-Dryland	Improved Pasture Legumes-Dryland	Citrus-Irrigated	Chickpeas-Dryland			Brassicas-Irrigated						
	Gympie Messmate-Dryland	Kikuyu-Dryland		Forage Sorghum-Dryland			Broccoli-Irrigated						
	Hoop Pine-Dryland	Leucaena-Dryland		Maize-Dryland			Capsicum-Irrigated						
	Spotted Gum-Dryland	Rhodes Grass-Dryland		Oats-Dryland			Cucurbits-Irrigated						
		Rye Grass-Dryland		Sorghum-Dryland			Green Beans-Irrigated						
				Soybeans-Irrigated			Sweet Corn-Irrigated						
				Wheat-Dryland			Tomato-Irrigated						

Soil 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 (0-0.1m) 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. Sub-classes were assigned based on:

Limitation sub-class	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 south-east Queensland is available from the Queensland Department of Natural Resources and Mines and http://www.qld.gov.au/environment/land/soil/salinity/ .

Additional Notes:

- Salinity is a significant limitation for plantation timber species, particularly Blackbutt, Spotted Gum and Gympie Messmate.

Sa - Salinity

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

Grp A	Grp B	Grp C	Grp D	Grp E	Grp F	Grp G	Grp H	Grp I	Grp J	Grp K	Grp L	Grp M	Grp N	Grp O
Barley-Dryland	Rhodes Grass-Dryland	Leucaena-Dryland	Forage Sorghum-Dryland	Beetroot-Irrigated	Oats-Dryland	Kikuyu-Dryland	Green Panic-Dryland	Asian Vegetables-Irrigated	Turf-Irrigated	Carrots-Irrigated	Dunn's White Gum-Dryland	Capsicum-Irrigated	Improved Pasture Legumes-Dryland	Citrus-Irrigated
		Native Pasture	Sorghum-Dryland	Chickpeas-Dryland			Rye Grass-Dryland	Brassicas-Irrigated		Cucurbits-Irrigated	Hoop Pine-Dryland	Green Beans-Irrigated		
			Wheat-Dryland	Lucerne-Irrigated				Broccoli-Irrigated		Lettuce-Irrigated	Maize-Dryland			
				Soybeans-Irrigated						Onions-Irrigated				
				Summer Pulses-Dryland						Potatoes-Irrigated				
										Sweet Corn-Irrigated				
										Tomato-Irrigated				

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	Group D
0	No microrelief.	1	1	1	1
1	Microrelief with a vertical interval <0.3m.	2	1	1	3
2	Microrelief with a vertical interval 0.3-0.5m.	3	2	2	4
3	Microrelief with a vertical interval >0.5m.	4	2	3	5

Group A	Group B	Group C	Group D
Lettuce-Irrigated	Green Panic-Dryland	Blackbutt-Dryland	Asian Vegetables-Irrigated
Avocados-Irrigated	Improved Pasture Legumes-Dryland	Dunn's White Gum-Dryland	Beetroot-Irrigated
Chickpeas-Dryland	Kikuyu-Dryland	Gympie Messmate-Dryland	Brassicas-Irrigated
Citrus-Irrigated	Leucaena-Dryland	Hoop Pine-Dryland	Broccoli-Irrigated
Forage Sorghum-Dryland	Native Pasture	Spotted Gum-Dryland	Capsicum-Irrigated
Lucerne-Irrigated	Rhodes Grass-Dryland		Carrots-Irrigated
Maize-Dryland	Rye Grass-Dryland		Cucurbits-Irrigated
Oats-Dryland			Green Beans-Irrigated
Sorghum-Dryland			Onions-Irrigated
Soybeans-Irrigated			Potatoes-Irrigated
Summer Pulses-Dryland			Sweet Corn-Irrigated
Wheat-Dryland			Tomato-Irrigated
Barley			Turf-Irrigated

Slope (Ts)

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

- steep gradients, specifically rolling and side-slip hazards; and
- 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 30m radius were also considered.

Terrain covariates derived from the 1-arc second resolution DEM, available from the CSIRO's Data Access Portal and the TERN Data Discovery Portal, were used in conjunction with site data to model some of the limitations used in the suitability assessment. The Ts limitation relied on the SRTM DEM.

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 acceptable 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, most plantations are on slopes <25%. However, steeper slopes can be utilised with hand planting and specialised machinery for harvesting operations (e.g. cable logging) allowing steeper slope limits up to 35%.
- 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% is considered manageable for safe machinery operation.

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	Group H	Group I
1	Slope <5%	1	1	1	1	1	1	1	1	1
2	Slope 5-8%	1	1	1	1	1	1	2	3	3
3	Slope 8-12%	1	1	1	1	2	3	3	4	4
4	Slope 12-15%	1	2	2	2	3	4	4	4	5
5	Slope 15-20%	2	2	3	3	3	5	5	5	5
6	Slope 20-30%	3	3	4	5	4	5	5	5	5
7	Slope >30%	4	4	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
Native Pasture	Blackbutt-Dryland	Kikuyu-Dryland	Green Panic-Dryland	Avocados-Irrigated	Chickpeas-Dryland	Turf-Irrigated	Asian Vegetables-Irrigated	Sweet Corn-Irrigated
	Dunn's White Gum-Dryland		Improved Pasture Legumes-Dryland	Citrus-Irrigated	Forage Sorghum-Dryland		Beetroot-Irrigated	
	Gympie Messmate-Dryland		Leucaena-Dryland		Lucerne-Irrigated		Brassicas-Irrigated	
	Hoop Pine-Dryland		Rhodes Grass-Dryland		Maize-Dryland		Broccoli-Irrigated	
	Spotted Gum-Dryland		Rye Grass-Dryland		Oats-Dryland		Capsicum-Irrigated	
					Sorghum-Dryland		Carrots-Irrigated	
					Soybeans-Irrigated		Cucurbits-Irrigated	
					Summer Pulses-Dryland		Green Beans-Irrigated	
					Wheat-Dryland		Lettuce-Irrigated	
					Barley		Onions-Irrigated	
							Potatoes-Irrigated	
							Tomato-Irrigated	

Wetness (W)

Waterlogged soils reduce plant growth and delay effective machinery operations.

Limitation category determination

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

Additional Notes:

- Imperfectly drained soils (3H, 3M, 3S, 3V) 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.
- Crops requiring a minimum drained soil depth of **1.5m** are restricted to: Avocados.
- Crops requiring a minimum drained soil depth of **1.0m** are restricted to: Citrus.
- All remaining crops require a minimum drained soil depth of **0.5m**.

W1 wetness to 1.0m

Limitation		**Suitability subclasses for various land management options**
Value	Description	Group A
6	Rapidly drained	1
5	Well drained	1
4H	Moderately well drained and highly permeable	1
4M	Moderately well drained and moderately permeable	2
4S	Moderately well drained and slowly permeable	3
4V	Moderately well drained and very slowly permeable	3
3H	Imperfectly drained and highly permeable	3
3M	Imperfectly drained and moderately permeable	4
3S	Imperfectly drained and slowly permeable	4
3V	Imperfectly drained and very slowly permeable	4
0	Poorly to very poorly drained	5

Group A
Citrus-Irrigated

W2 wetness to 0.5m

Limitation Value	Description	Suitability subclasses for various land management options Grp A	Grp B	Grp C	Grp D	Grp E	Grp F	Grp G	Grp H	Grp I	Grp J	Grp K	Grp L	Grp M	Grp N
6	Rapidly drained	1	1	1	1	1	1	1	1	1	1	2	2	1	2
5	Well drained	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4H	Moderately well drained and highly permeable	1	1	1	1	1	2	2	2	2	2	1	1	3	2
4M	Moderately well drained and moderately permeable	1	1	1	2	2	2	2	2	2	3	2	2	3	3
4S	Moderately well drained and slowly permeable	1	1	2	2	3	2	2	2	3	3	2	2	3	3
4V	Moderately well drained and very slowly permeable	1	1	2	3	3	2	2	2	3	3	3	2	3	3
3H	Imperfectly drained and highly permeable	2	2	2	3	3	2	2	3	3	3	3	3	4	3
3M	Imperfectly drained and moderately permeable	2	2	3	3	3	3	3	3	3	4	3	3	4	4
3S	Imperfectly drained and slowly permeable	2	2	3	3	4	3	3	3	4	4	3	3	4	4
3V	Imperfectly drained and very slowly permeable	2	2	4	4	4	4	4	4	4	5	4	4	4	5
2H	Poorly drained and highly permeable	3	3	3	4	5	3	4	4	4	4	4	4	4	4
2M	Poorly drained and moderately permeable	3	3	3	4	5	4	4	4	5	5	4	4	4	5
2S	Poorly drained and slowly permeable	3	3	4	5	5	5	4	5	5	5	5	5	5	5
2V	Poorly drained and very slowly permeable	3	4	5	5	5	5	5	5	5	5	5	5	5	5
1H	Very poorly drained and highly permeable	4	3	4	5	5	5	4	5	5	5	5	5	5	5
1M	Very poorly drained and moderately permeable	4	3	4	5	5	5	5	5	5	5	5	5	5	5
1S	Very poorly drained and slowly permeable	4	4	5	5	5	5	5	5	5	5	5	5	5	5
1V	Very poorly drained and very slowly permeable	4	5	5	5	5	5	5	5	5	5	5	5	5	5

Grp A	Grp B	Grp C	Grp D	Grp E	Grp F	Grp G	Grp H	Grp I	Grp J	Grp K	Grp L	Grp M	Grp N
Leucaena-Dryland	Native Pasture	Rye Grass-Dryland	Forage Sorghum-Dryland	Asian Vegetables-Irrigated	Kikuyu-Dryland	Improved Pasture Legumes-Dryland	Green Panic-Dryland	Barley-Dryland	Chickpeas-Dryland	Summer Pulses-Dryland	Lucerne-Irrigated	Soybeans-Irrigated	Blackbutt-Dryland
		Dunn's White Gum-Dryland	Maize-Dryland	Beetroot-Irrigated	Rhodes Grass-Dryland			Oats-Dryland					Gympie Messmate-Dryland
			Sorghum-Dryland	Brassicas-Irrigated				Wheat-Dryland					Hoop Pine-Dryland
				Broccoli-Irrigated									Spotted Gum-Dryland
				Capsicum-Irrigated									
				Carrots-Irrigated									
				Cucurbits-Irrigated									
				Green Beans-Irrigated									
				Lettuce-Irrigated									
				Onions-Irrigated									
				Potatoes-Irrigated									
				Sweet Corn-Irrigated									
				Tomato-Irrigated									
				Turf-Irrigated									

W3 wetness to 1.5m

Limitation		Suitability subclasses for various land management options
Value	Description	Group A
6	Rapidly drained	1
5	Well drained	1
4H	Moderately well drained and highly permeable	2
4M	Moderately well drained and moderately permeable	2
4S	Moderately well drained and slowly permeable	3
4V	Moderately well drained and very slowly permeable	4
3H	Imperfectly drained and highly permeable	4
3M	Imperfectly drained and moderately permeable	4
3S	Imperfectly drained and slowly permeable	5
3V	Imperfectly drained and very slowly permeable	5
0	Poorly to very poorly drained	5

Group A
Avocados-Irrigated

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:

- The minimum practical area for forestry has been assessed for economic purposes, and not for amenity or environmental values (e.g. salinity, wind breaks, noise barriers).

Landscape complexity has most effect on broad acre crops that require large paddock sizes for efficiency (e.g. forage crops, commercial timber). Lot size is not considered.

X – Landscape complexity

Limitation		Suitability subclasses for various land management options										
Value	Description	Grp A	Grp B	Grp C	Grp D	Grp E	Grp F	Grp G	Grp H	Grp I	Grp J	Grp K
1	Minimal practical production area >10ha	1	1	1	1	1	1	1	1	1	1	1
2	Minimal practical production area 5-10ha	1	1	1	1	1	1	1	1	4	3	1
3	Minimal practical production area 2.5-5ha	1	1	1	1	2	2	4	1	5	4	1
4	Minimal practical production area 1.5-2.5ha	1	2	2	3	3	4	5	3	5	4	4
5	Minimal practical production area <1.5ha	1	4	3	4	4	5	5	5	5	5	4

Group A	Group B	Group C	Group D	Group E	Group F	Group G	Group H	Group I	Group J	Group K
Asian Vegetables-Irrigated	Green Panic-Dryland	Beetroot-Irrigated	Onions-Irrigated	Avocados-Irrigated	Green Beans-Irrigated	Lucerne-Irrigated	Potatoes-Irrigated	Barley-Dryland	Blackbutt-Dryland	Carrots-Irrigated
	Improved Pasture Legumes-Dryland	Brassicas-Irrigated		Citrus-Irrigated	Sweet Corn-Irrigated			Chickpeas-Dryland	Dunn's White Gum-Dryland	
	Kikuyu-Dryland	Broccoli-Irrigated						Forage Sorghum-Dryland	Gympie Messmate-Dryland	
	Leucaena-Dryland	Capsicum-Irrigated						Maize-Dryland	Hoop Pine-Dryland	
	Rhodes Grass-Dryland	Cucurbits-Irrigated						Oats-Dryland	Spotted Gum-Dryland	
	Rye Grass-Dryland	Lettuce-Irrigated						Sorghum-Dryland		
	Turf-Irrigated	Tomato-Irrigated						Soybeans-Irrigated		
		Native Pasture						Summer Pulses-Dryland		
								Wheat-Dryland		

Appendix 5: 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 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 6: Land Suitability Maps

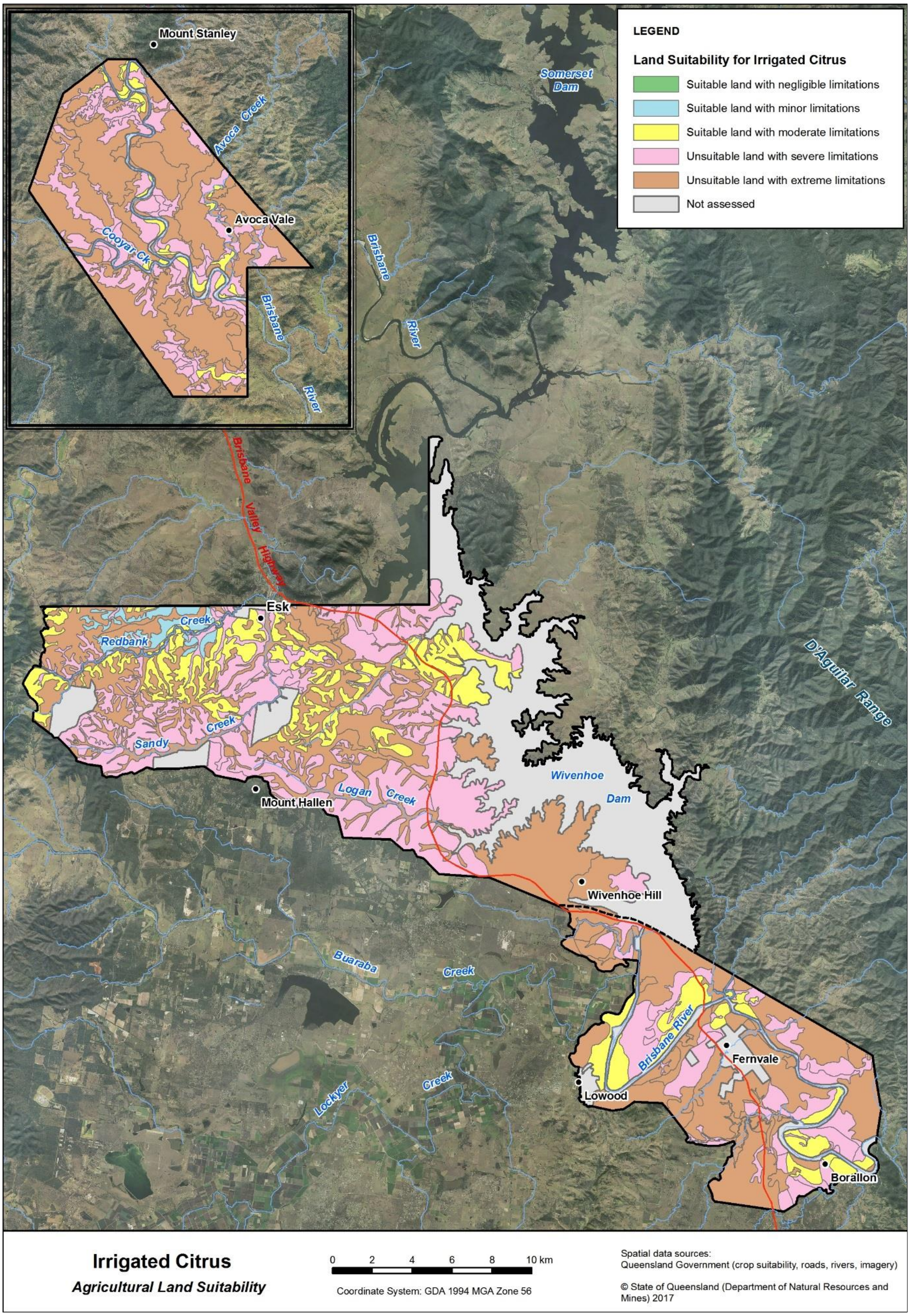


Figure A1 Agricultural suitability for irrigated citrus

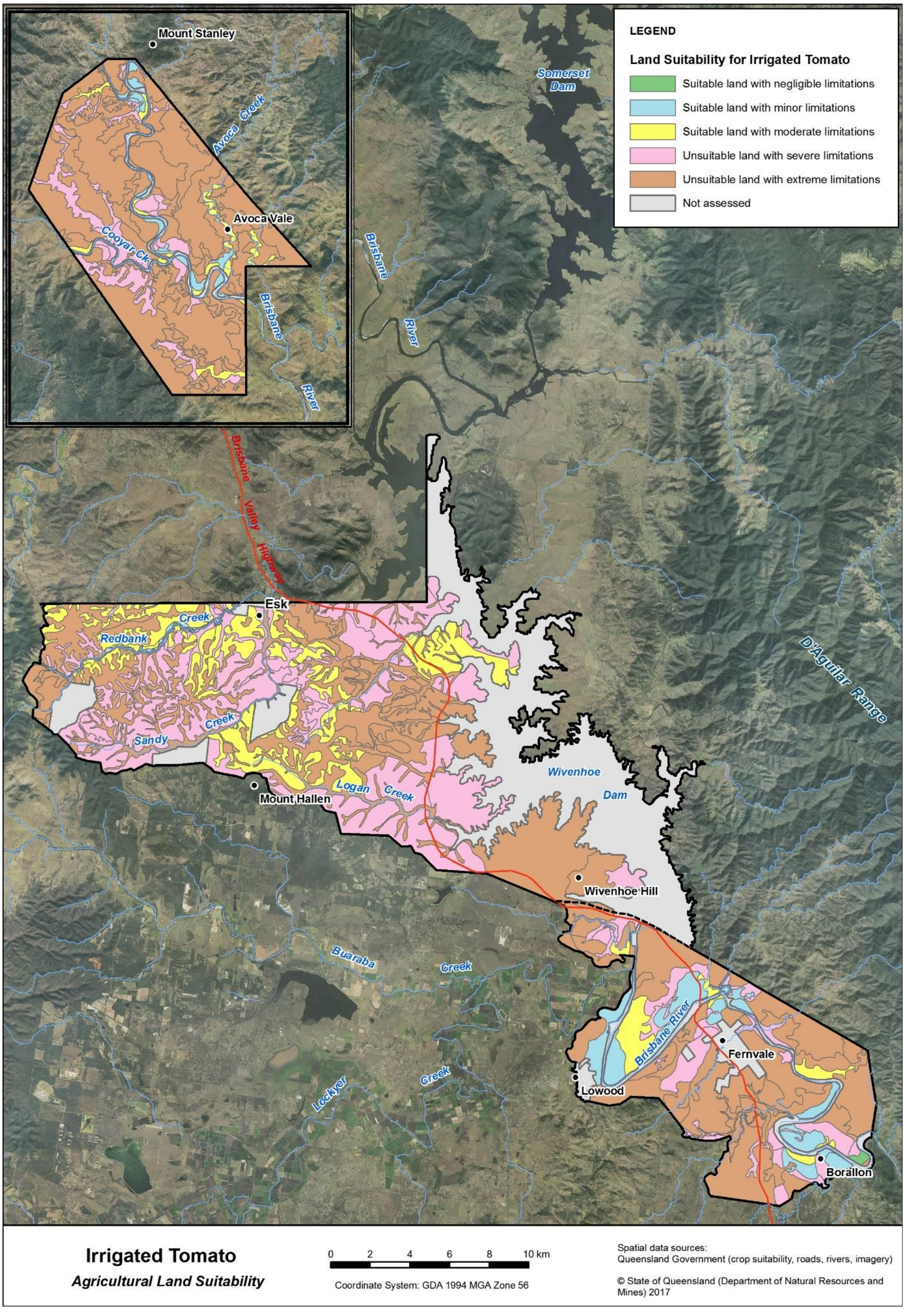


Figure A2 Agricultural suitability for irrigated tomato

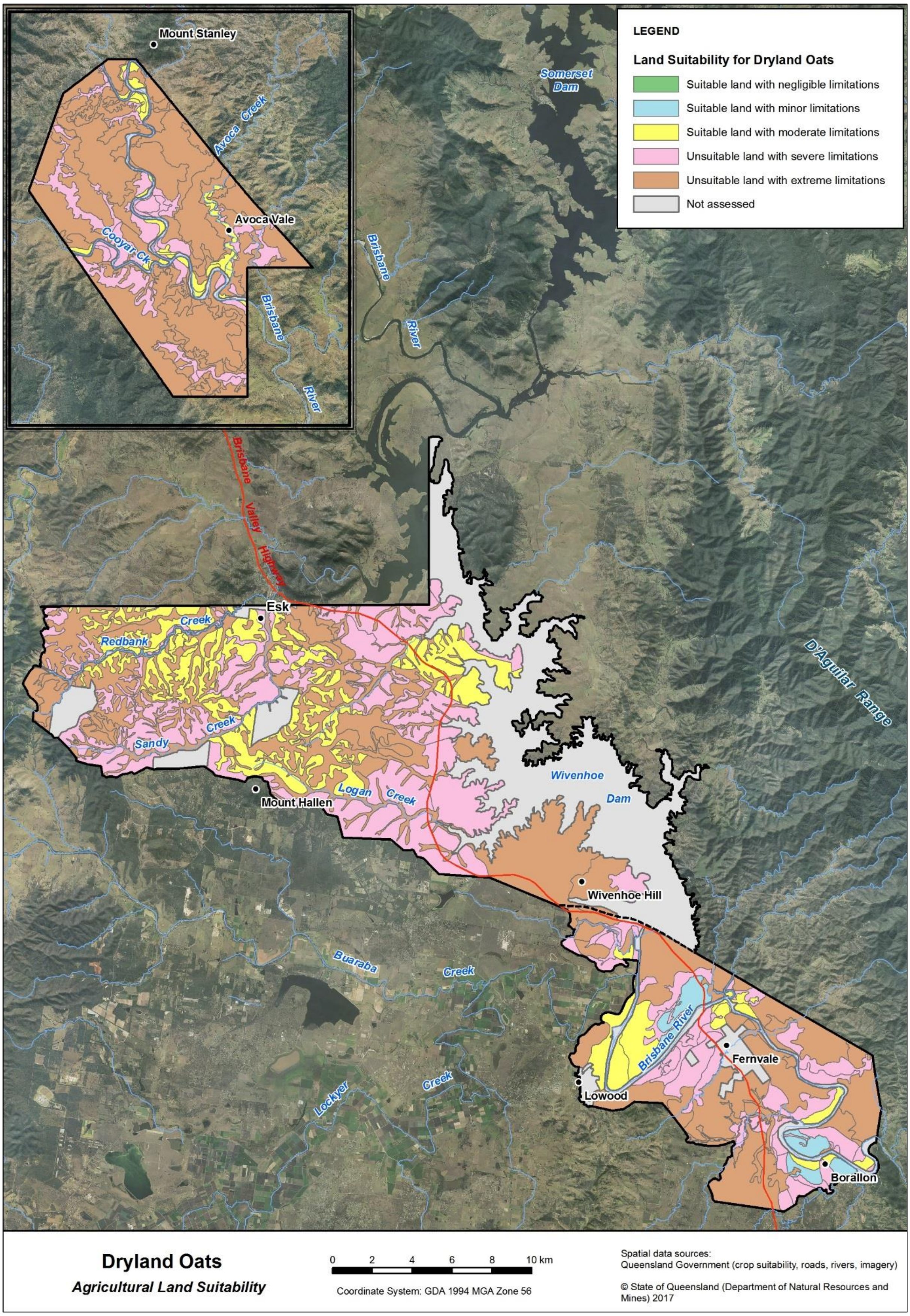


Figure A3 Agricultural suitability for dryland oats

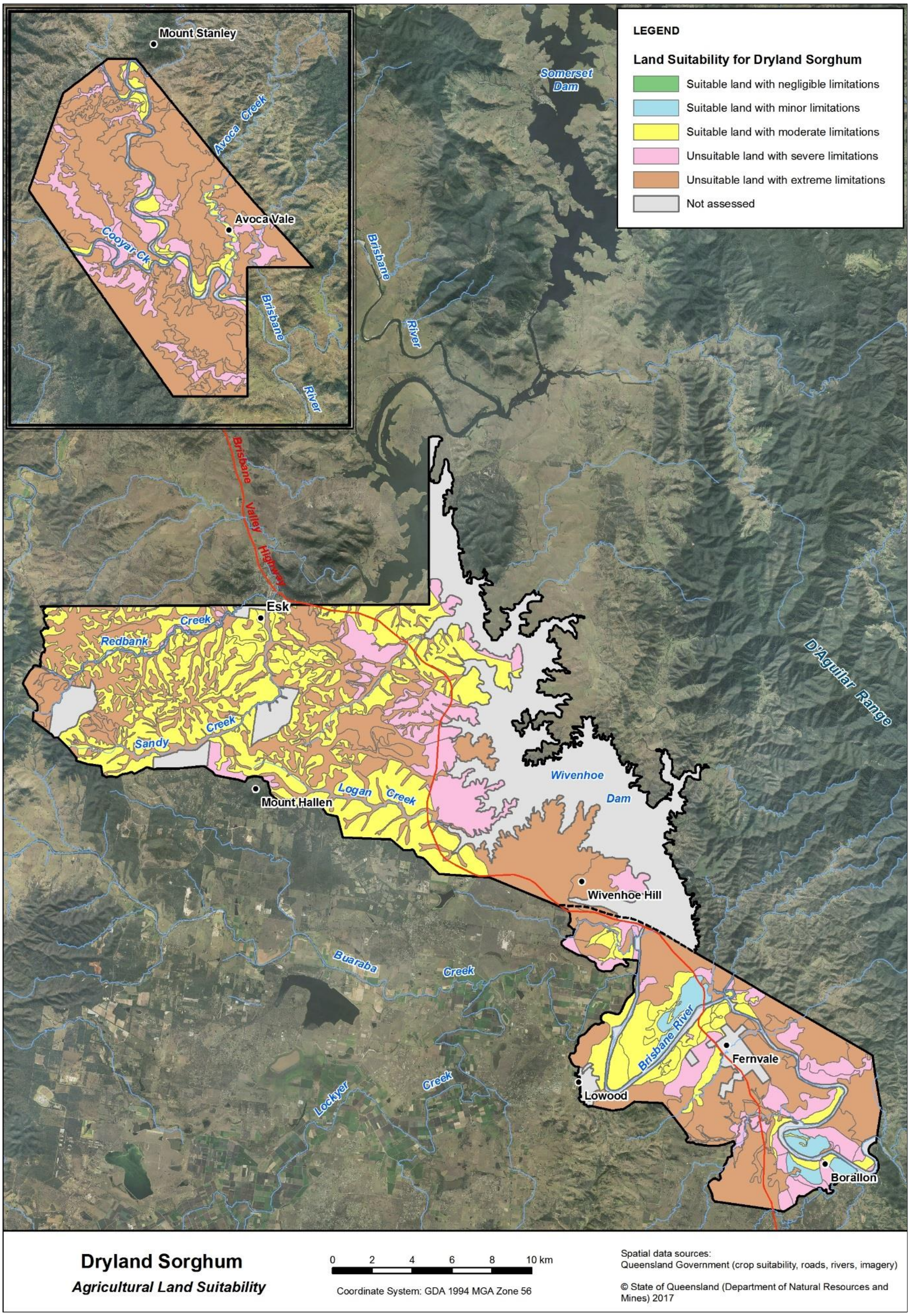


Figure A4 Agricultural suitability for dryland sorghum

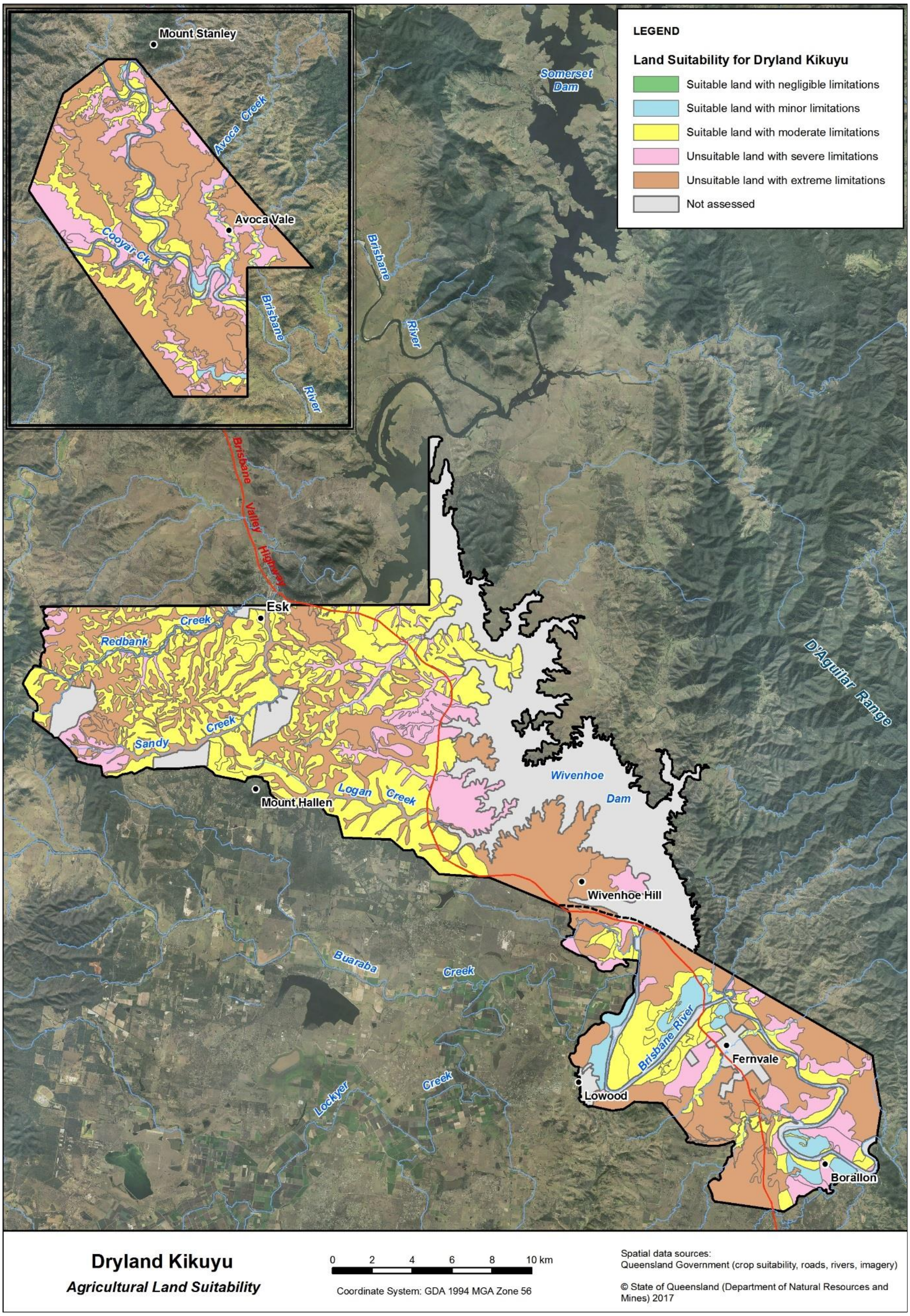


Figure A5 Agricultural suitability for dryland kikuyu

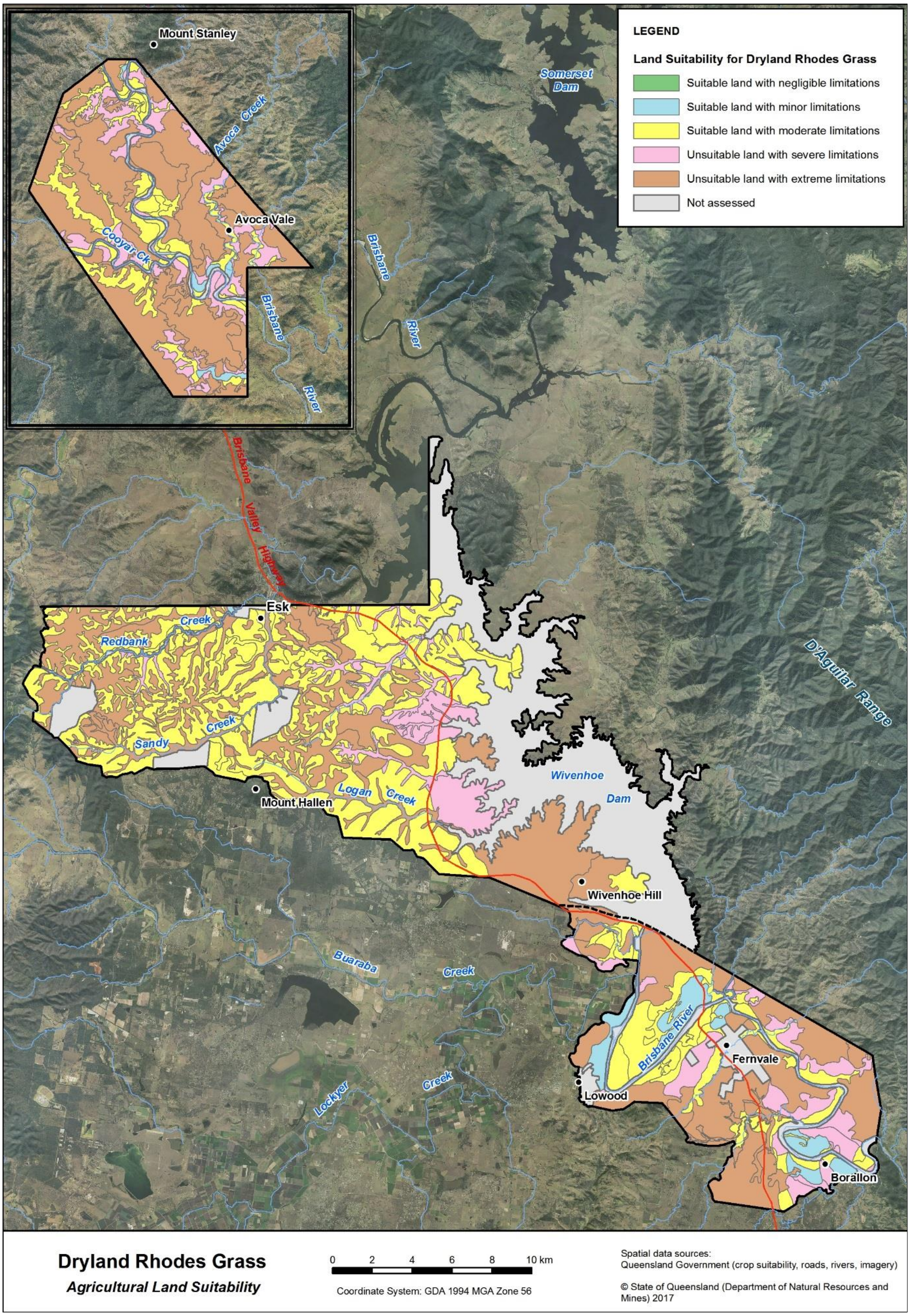


Figure A6 Agricultural suitability for dryland Rhodes grass

Appendix 7: Definition of Agricultural Land Classes

Agricultural Land Classes (from DSITI and DNRM 2015)

ALC	ALC Description
A	**Crop land** Land that is suitable for a wide range[9] 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[10] 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[11] 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[12]** 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%[13].

[9] A wide range of crops is four or more crop types of local commercial significance

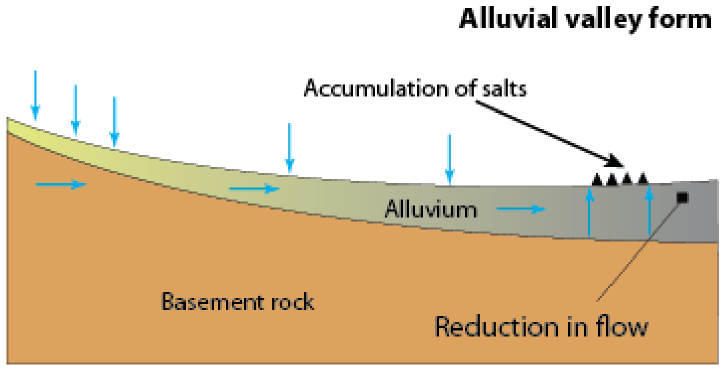
[10] Horticulture includes intensively grown small crops (e.g. vegetables) as well as tree crops (e.g. grown for nuts, seeds or fruit). Silviculture (plantation forestry) is not included.

[11] 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 corn, peaches and nectarines; are not generally regarded as different crop types. Different management regimes (including irrigation strategies) for the same crop does not increase the number of crops.

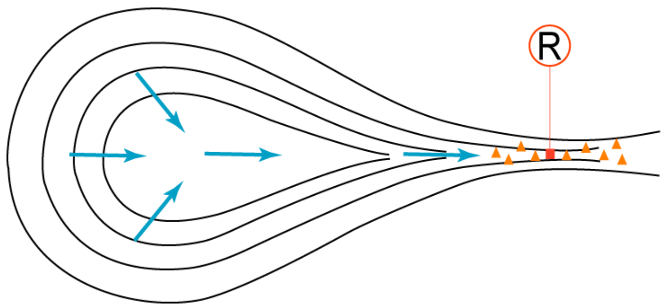
[12] Non-agricultural land includes land that cannot be placed in any of the other land classes and includes land such as urban areas and stream channels.

[13] In cases where two or more land classes are equally dominant and none are greater than 50%, judgement will be used to identify the most appropriate agricultural land class(es) for the unit.

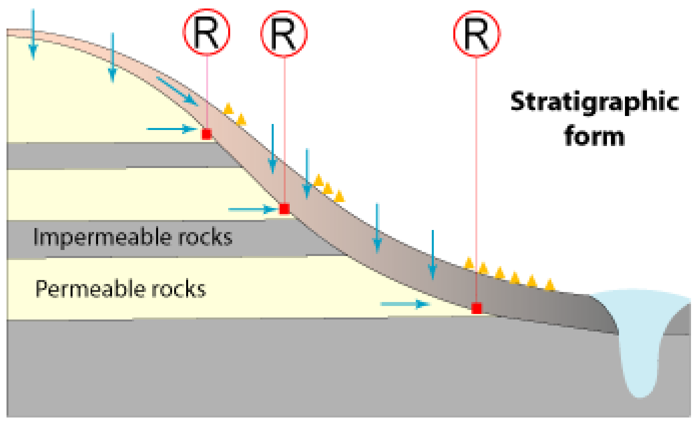
Appendix 8: Relevant Salinity Models (from SalCon 1997)



Alluvial valley model



Catchment constriction model



Stratigraphic model