BURNIE-TABLE CAPE
SOIL REPORT

Reconnaissance Soil Map Series of Tasmania

A Revised Edition
By Stacey Spanswick & Darren Kidd
Department of Primary Industries, Water and Environment
Tasmania
2000

Soils and Land Use Series No 26 Burnie-Table Cape
By J. Loveday & R.N Farquhar
C.S.I.R.O Division of Soils, Adelaide, 1958

Burnie-Table Cape Report
and accompanying 1:100 000 Burnie-Table Cape
Soil Reconnaissance map

DEPARTMENT *of* PRIMARY INDUSTRIES, WATER *and* ENVIRONMENT
Tasmania

Natural Heritage Trust
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ACKNOWLEDGEMENTS

This report and accompanying map are revised versions of original work by CSIRO (Loveady & Farquhar, 1958). We gratefully acknowledge the original work of Loveday and Farquhar and the CSIRO Division of Soils, Adelaide for supporting this project.

We would like to acknowledge the contribution of the following groups and individuals who have assisted with the reprinting and updating of this report and accompanying map.

We would like to especially thank Dr J Loveday and Mr R N Farquhar for editing the draft map sheet and report.

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PREFACE

The Reconnaissance Series

Over a 27 year period (1940 - 1967), the CSIRO Division of Soils, Adelaide undertook a series of reconnaissance (small scale) soil surveys and some more detailed (large scale) soil surveys of the agricultural land in Tasmania. However, most of these reports are out of print and of limited availability, the terminology is dated and inconsistencies in map units exist across map sheets. In 1997, the Department of Primary Industries, Water and Environment (DPIWE) and the Natural Heritage Trust, put together a project to correlate and reprint the maps and reports and to extend this information and its value as a tool for sustainable land management, to a variety of potential users.

This report is part of the "Reconnaissance Soil Map of Tasmania" series which were published at a scale of 1 inch to 1 mile (1:63 360). The reconnaissance series has been expanded to include the soil maps that were not part of the original "Reconnaissance Soil Map of Tasmania" series but mapped at scales of 1 inch to 1 mile and 1 inch to 2 miles (1:126 000). These maps have been reformatted and reprinted by the DPIWE at a scale of 1:100 000 to be consistent with more recent soil mapping scales (eg South Esk 1:100 000 soil map (southern half), Doyle, 1993), the land capability mapping series and the current Tasmanian Land Tenure map series.

It is not the aim of this project to remap the areas covered by the Reconnaissance series or to change the intensity of mapping, but to correlate, standardise and enhance existing information and provide the public and DPIWE staff with more consistent, reliable and accessible soil resource information.

Correlation of the Burnie-Table Cape Reconnaissance Soil Map

The Burnie Reconnaissance report (Loveday, 1955) was superseded in 1958 by the Soils of the Burnie-Table Cape districts (1958). The Burnie Reconnaissance survey was done as a very broad overview of the Burnie area in preperation for the more comprehensive Burnie-Table Cape survey. The Burnie-Table Cape map extends further north then the Burnie Reconnaissance map to include the Table Cape area. Only the map unit boundaries of the basalt soils were significantly modified in the later publication with much more detailed information about the properties of the soils and their management added to the report. Correlation has been based on the more up to date Burnie-Table Cape Survey. This survey has been included in the Reconnaissance series and has been renamed the Burnie-Table Cape Reconnaissance Soil Map. Accompanying the original Burnie-Table Cape report was a detailed survey of the area south of Doctors Rock. This detailed map is refererred to as Map 2 throughout the report.

Edits to the Burnie-Table Cape Map

As the 1:100 000 South Esk soil map (southern half), (Doyle, 1993), has only recently been published and is in circulation, it has been our aim to correlate the Burnie-Table Cape map as much as possible to the South Esk soil map.

Due to resource constraints only a limited amount of time could be spent investigating map unit boundaries and soils of the less well defined soil associations. Map unit boundary changes have been done using aerial photos and field work and have been recorded in the Appendix of this report and in the Spatial Information System (SIS).

There are two maps for this report in circulation. The map that accompanies this report has polygons coloured according to the different map units identified. The second map, which is intended solely as a DPIWE in-house publication, has map units coloured according to the Australian Soil Classification for the dominant SPC within each unit. No colour is assigned to a map unit if a SPC has not been identified. This approach can lead to soil of different agricultural potential having a similar map colour, therefore the second map is not suitable for general use.

Legend
Where possible the dominant soil of each map unit has been classified to soil order using the Australian Soil Classification (Isbell, 1996). Soils have also been classified according to Great Soil Group (Stace *et al.*, 1968).

Edits to the Burnie-Table Cape Report

The Burnie report has been reformatted to provide a more consistent structure across all reports. The soil terminology used within the Burnie-Table Cape report has been updated to be consistent with the Australian Soil and Land Survey Field Handbook (McDonald *et al.*, 1990), old imperial measurements have been converted to the metric system and sentence structure has been changed where it did not read with clarity. All the changes made to the report are shown in italics.

The map unit names used by the original surveyor have been preserved and underlined in the report, with the correlated map unit name and code appearing above. Map unit names have been changed were possible to be consistent with naming conventions outlined by Gunn *et a.,l* (1988).

Soil Taxonomic Units
The soil taxonomic units used by Loveday and Farquhar in this survey are soil series and great soil groups. These have been replaced by Soil Profile Class (SPC) as this will standardise taxonomic units across the Burnie-Table Cape map and be consistent with taxonomic units used within the more recent South Esk soil map and by other states. A SPC is a group or class of soil profiles within a map unit which have similar morphological characteristics, and may have similar chemical properties (Gunn *et al*., 1988). The SPCs were constructed through the use of existing reports, historical soils data in the DPIWE soil database (Talbot *et al*, 1998) and additional field work. A key to soil horizon designations used within the SPCs is provided in Appendix 2. The lines separating horizons within the SPC reports are shown by broken or solid lines. The broken lines show a diffuse or gradual change to the next horizon whereas the filled lines show a clear or abrupt transition. Soil Profile Classes were not compiled for soil types where no, or insufficient data was available, or where descriptions were too variable or not spatially representative.

Laboratory Data

CSIRO laboratory data is available for some of the dominant soils identified on this map. Readers should be aware that some of the laboratory methods used by CSIRO in the 1950's and 1960's differ to the methods used in more recent DPIWE laboratory analysis. All CSIRO sites have the character "H" at the beginning of the profile number eg H68. An outline of the different methods used is presented in Appendix 1.

Soil Associations

Outlined below are the map units within the Burnie-Table Cape report which have been edited or identified as lacking the data needed to produce SPCs.

Soils of the Basaltic Soil Associations

We were able to define SPCs for all the dominant Basalt soils. The basaltic soils are morphologically similar in texture and structure, but vary in colour, depth and stoniness. They form a catena of associations from the coast to well inland (Eldridge 2000). Transitional soils exist between these soil types, and this, along with the similarity of the soil types, has made Soil Profile Class definition difficult.

Soils of the Less well defined Associations

Due to insufficient data and variability of the soils we were unable to define SPCs for the dominant soils of the Natone, Riana, Hellyer and Inglis Associations. More work is required within these units.

Accuracy of Maps

Base data on the original Burnie-Table Cape Reconnaissance Soil Map was compiled at the Tasmanian Regional laboratory CSIRO from aerial photographs by the slotted template method. Ground control supplied by the Forestry Commission, Tasmania and the Department of Lands and Surveys, Tasmania in 1952. The original map used the Transverse Mercator Projection with co-ordinates displayed in yards. Soil boundaries were delineated by stereoscopic interpretation of aerial photographs. The old paper soil maps were transferred to electronic form in the early 1990s with the Co-ordinate system converted to the Australian Map Grid, however no projection was recorded. Accuracy checks of the Burnie-Table Cape digital map have revealed a range of spatial errors. The coastline was incorrect and rivers and estuaries have changed position over time. However the major source of spatial error on all the Reconnaissance Soil Maps has been caused by the absence of rectification of the aerial photographs during delineation of line work. Hence, Ground Control Points (GCP) in some areas on the map sheet, eg hilltops, do not match current true ground positions.

We have not had the resources or time to address all the inaccuracies within this map sheet. Corrections have been made to the coastline only and users need to be aware that in some areas the boundaries of map units may be out by considerable distances.

Appendices

A series of appendices have been attached providing additional information relevant to this report and the accompanying soil map. Much of this information was either unavailable or not recorded with the original report by CSIRO (Loveady & Farquhar, 1958).

The Soils and Some Aspects of Land Use in the Burnie, Table Cape, and Surrounding Districts, North-West Tasmania

By J. Loveday and R. N. Farquhar

Soils and Land Use Series No 26

Division of Soils
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Mr A. M. Graley and Mrs E. Emms of the Chemistry Section of the Division of Soils, Hobart, carried out the soil analyses, while Mr A. Skoda, also of the Division of Soils, Hobart, constructed the base map from aerial photographs and redrafted the soil map for publication.

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The Soils and Some Aspects of Land Use in the Burnie, Table Cape, and Surrounding Districts, North-West Tasmania

By J. Loveday[1] and R. N. Farquhar[2]

(*Manuscript received August 12, 1957)*

Summary

A survey of the soils and land use of 1250 square kilometres in the Burnie-Table Cape area is presented, and problems of land use, particularly those relating to soil fertility and erosion, are discussed.

The area is of considerable and increasing importance both for agriculture and forestry. The climate is humid cool temperate, with a marked winter incidence of rainfall and mild summers. With altitude increasing from the coast to *580m* inland, the average annual rainfall increases from *1000mm* to *1900mm* and the average temperature decreases from *12°C* to *9°C*. The numerous streams flowing in a northerly direction into Bass Strait have produced a sharply dissected landscape. Agriculture has been most readily developed on the undulating ridge tops where the predominant soils are basaltic "red loams" or krasnozems *(ferrosols).* Forest regrowth occurs on many steep valley slopes, mainly on soils showing podzolic features and developed from a variety of rocks. Some areas of very acid, infertile podzolic soils support stunted eucalypts and heath vegetation.

Fourteen soil associations have been mapped and described. Five and part of a sixth are of soils formed from basalt and together comprise 53 percent of the total area. Representative areas, totalling 44 square kilometres, of the basaltic soils, mainly krasnozems, have been surveyed in detail. The krasnozems are deeply weathered clay soils with strong granular structure and friable consistence. They show a range of colour, acidity, and content of organic matter corresponding to climatic changes with distance inland. The remaining associations include a wide variety of soils, the majority of which show podzolic features.

Of the land use problems those of soil fertility are of major significance because both the krasnozems and the soils with podzolic features have been subjected to considerable leaching and loss of essential plant nutrients. Sheet erosion of the surface soil, with the consequent loss of the plant nutrients concentrated therein, is widespread on the krasnozems. In addition, the latter have a high content of hydrated oxides of iron and aluminium responsible for fixing phosphorus, and probably also molybdenum, in forms of low availability to plants.

There is a widespread use of superphosphate on crops and pastures. Application of lime has been replaced to a large extent by the use of molybdenum, though in some heavily cropped and eroded areas molybdenum cannot entirely replace it. Potassium fertiliser has been used for some years on potato crops and more recently responses have been obtained on pastures. In animals, a more or less severe cobalt deficiency occurs in certain areas and in more restricted areas there is a copper deficiency. These problems of animal and plant nutrition are discussed in relation to soil features.

The conflicting and complementary demands of forestry and agriculture present an interesting land use problem in this area.

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INTRODUCTION

Throughout Tasmania there are widely scattered occurrences of basaltic soils, varying from black clays to "red loams", which have been extensively developed for agriculture. The Burnie - Table Cape area has been selected as well suited to the study of the "red loams" or krasnozems.[3] A knowledge of the soils of this area should serve as a starting point for later extension of mapping. Moreover, despite the popular belief that the krasnozems are highly fertile, an increasing variety of fertility problems is becoming apparent on these soils. Widespread pasture and crop responses to superphosphate and responses to lime application, particularly in the higher rainfall zone, have been recognised for many years. Fricke (1945) showed that clear-cut responses to molybdenum occurred on a number of soils from north-west Tasmania, and since that time molybdenum applications have largely replaced those of lime (Paton 1956a, 1956b). Potash fertiliser has for some years been used on potato crops, and recent findings of Paton (personal communication) indicate responses also on pasture. Thain, since his initial discovery of cobalt deficient animals at Rocky Cape (1955), considers now that a more or less severe cobalt deficiency in animals is widespread in the Wynyard district (personal communication). He has also observed and successfully treated copper-deficient animals, but from more restricted areas than those showing cobalt deficiency. Thus problems of plant and animal nutrition arising from one or more deficiencies of phosphorus, potassium, calcium, molybdenum, cobalt, and copper are known in various parts of the Burnie – Table Cape area. Definition of the soils and their extent is fundamental to an assessment of the magnitude of these problems and to their successful solution.

The 1250 square kilometres surveyed comprises the military index sheets of Burnie and Table Cape bounded on the north by Bass Strait and on the other sides by lines of latitude and longitude. All of an earlier semi-detailed soil survey by Stephens (1937) and a reconnaissance survey by Hubble (1944) are embraced by this survey (Fig 1). With a reliable rainfall of greater than *1000mm* the area is of considerable and increasing importance agriculturally. Dairy products, potatoes, meat, timber and paper are major exports from this and surrounding districts.

The survey was conducted in three stages. Initially a reconnaissance was carried out by traversing the close network of roads and tracks and inspecting the soils at 1 mile intervals at some 530 sites. The reconnaissance soil map arising from this has been included in a separate report (Loveday 1955). As a result of this survey two areas, one of *26 square kilometres* and another of *1.6 square kilometres*, were selected for detailed study of the krasnozems, these being the most extensive and important soils agriculturally. This second stage involved inspection of the soil at intervals of about *300m* along traverses some *200-300m* apart. During the third stage of the survey the whole area was re-inspected in the light of knowledge gained from the detailed surveys. The maps produced, a soil association map of 1250 square kilometres and soil type maps of 44 square kilometres (Map 2 and Fig. 8) accompany this report.

The discussion of land use problems in Section 6 is not intended to be exhaustive. Rather it is aimed to discuss those of the more outstanding problems which are particularly related to the soils, and in this area of relatively high rainfall and usually free drainage these specially concern soil fertility and erosion. Although irrigation offers possibilities for increased production on individual farms, more major problems associated with it can be envisaged as far as purely soil factors are concerned. Forestry for the production of both milling and pulp timber is gradually passing from the purely exploitative stage and is beginning to be placed on a sounder basis. Some aspects of this form of land use and its relationships to agricultural usage are discussed.

[3] Krasnozem is the technical term for the deep red soil known commonly as "red loam", "red basaltic", or "red volcanic" soil and will be used throughout this report instead of these other terms. Currently classified as ferrosols (Isbell 1996).

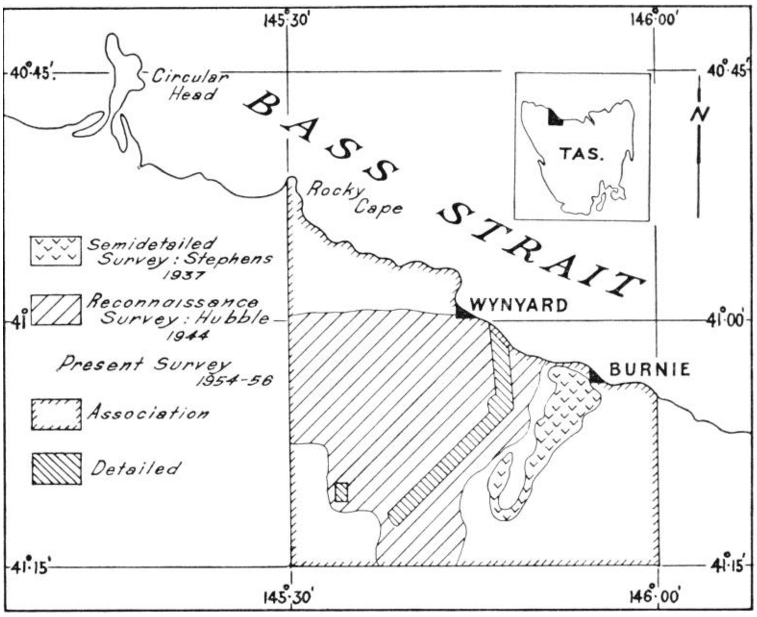


Figure 1: Locality plan showing present survey and earlier surveys.

HISTORY OF SETTLEMENT AND PRESENT PATTERN OF LAND USE

The production of wool is now relatively unimportant in the Burnie – Table Cape area, but it was responsible for the initial settlement.

By 1820, 17 years after settlement of the colony, "Van Diemen's Land" was carrying two-thirds of a million sheep and exporting more wool than New South Wales. This excited much interest in England and in 1825 the Van Diemen's Land Company was formed with the primary object of producing improved-quality wool. The concessions it was granted included the heavily timbered Emu Bay block and the Hampshire Hills and Surrey Hills blocks further south containing some open plain-like country. Sheep were introduced to these high, cold plains but, although several breeds were tried including Merinos, Cotswolds and Cheviots, large losses were sustained, owing to the unsuitable coarse native pasture, cold winters, foot rot, caterpillars and depredations of the aborigines and the marsupial wolf (*Thylacinus cynocephalus)*. In 1834 sheep were removed from the area and replaced by cattle.

Attention was then turned to the heavily forested coastal region, which, following initial success with potato and wheat crops, was soon recognised to be of great potential for arable agriculture. With the primitive methods available for clearing and crop cultivation progress was very slow, but the Van Diemen's Land Company during the 1840's encouraged settlement by supplying ships and guaranteed prices for produce. Settlement gradually extended westward along the coast to Table Cape and beyond, with the embryo town of Burnie on Emu Bay as the outlet port. The mainland gold discoveries in the 1850's caused an acute labour shortage which seriously handicapped the VDL Company. However, the high prices for potatoes, wheat, oats and barley encouraged the ordinary settler.

Table 1 Livestock Numbers and Areas of Principal Crops: Municipalities of Burnie and Wynyard*

(a) Livestock Number, 1914/15 to 1954/55

Livestock	1914/15	1924/25	1934/35	1944/45	1954/55
Cattle	20141	19722	21242	16432	30653
Sheep	18057	9755	19690	22105	37002
Pigs	4146	4978	4188	4683	5883
Total	42344	34455	45120	43220	73538

(b) Areas (hectares) of Principal Crops, 1914/15 to 1954/55

Crop	1914/15	1924/25	1934/35	1944/45	1954/55
Potatoes	2330	3461	4240	8670	3348
Blue peas	496	380	683	494	40
Wheat for grain	140	207	206	4	6
Oats for grain	1018	741	464	123	34
Total	3957	4789	5593	9291	3428

** The municipalities of Burnie and Wynyard, respectively east and west of the River Cam, together include most of the area of the soil survey. The large increase in cattle and sheep in the last decade has taken place mostly in the Wynyard Municipality. This is consistent with the continued growth of the largely rural population of the Wynyard Municipality and the decrease in the rural but sharp increase in urban population in the Burnie Municipality.*

The growth of Waratah, following the discovery of tin in 1871, opened an inland market for all farm produce and gave local agriculture more stability than it had previously enjoyed. The use of bullock teams speeded up land clearing. Oats for hay and feed grain became a more important crop particularly in the Table Cape district. Butter factories were established, with depot "creameries" to which whole milk was carted. With the later introduction of the cream separator and refrigerated shipping dairying steadily expanded.

The beginning of the present century saw the last of the true pioneering which took place mainly in inland districts from West Takone in the south-west to Upper Natone in the south-east. Trees were either "face-felled" and burnt or ring-barked and left standing. "Bush-burn" mixtures, basically cocksfoot (*Dactylis glomerata*) and white clover (*Trifolium repens*), were sown "on the ash" and proved very productive. Potatoes were used as a pioneering crop for arable areas. Sawmilling, commenced in the 1890's, became a major interstate exporting industry. Roads were improved and railways opened markets in the cities of Hobart and Launceston.

The advent of World War I brought an end to this period of expansion. Data extracted from Commonwealth statistical records and presented in Table 1(a) show that during the 30 years 1915 – 1945 there were no significant increases in stock numbers in the municipalities of Burnie and Wynyard. The area sown to potatoes, the principal cash crop, gradually increased up to 1935 and then doubled in the 10 years to 1945 (Table 1 (b)). Average yields per acre, however, fluctuated about a low level. This static position in stock numbers and crop yields per acre, despite more intensive land use, rapid strides in farm mechanisation, and the introduction of the use of lime and superphosphate, was due to a number of causes. Initial high levels of soil fertility were wasted by excessive cropping and in many places by soil erosion. Superphosphate was used mainly on potatoes and even then in inadequate quantities. Few farmers realised the value of superphosphate and lime in producing improved clover and grass pastures to maintain and improve soil fertility. An increasing rabbit population took a severe toll of pastures and crops, while bracken fern encroached upon the grazing areas. The economic depression of the 1930's reduced many people to peasant-type farming and forced others to abandon their partially developed holdings.

By 1937 urban industrialisation was beginning to affect land use, particularly in the Burnie Municipality. Since 1933 rural population in this municipality has steadily decreased while urban population has rapidly increased. This effect is even more significant when it is realised that a considerable proportion of those who live in rural areas work in Burnie. The Wynyard Municipality was not so affected and by the late 1930's a more stable form of agriculture was evident.

World War II brought new problems. Labour, fuel and machinery were in short supply and there was increased demand, particularly for potatoes and other vegetables, pulse crops, and flax fibre. Pastures suffered from lack of fertilisers, causing reduction in stock numbers, while potato acreages reached an all time high (Table 1(a) and (b)). The end of World War II ushered in the present phase in land use for this area. Farmers, partly because of wartime rationing, have become increasingly conscious of the value of mechanisation and fertiliser application. Since Fricke's (1945) discovery of a molybdenum deficiency in a number of soils from north-west Tasmania, this trace element has largely replaced the widespread use of lime, which has meant a very considerable reduction in costs. In those areas of basalt soils, particularly in the zone of rainfall greater than 45 in. per annum, with a history of light or no phosphate dressing it is becoming recognised that heavier applications than the "standard" annual dressing of 187 lb (1 bag) of 22 percent superphosphate give an economic response at least for a year or two – providing, of course, that requirements of molybdenum, or lime, or both are also met. Improved pastures with adequate provision of pasture hay and silage has become the aim of progressive farmers throughout the area, with potato growing a less important sideline. The success of this is shown in the rapid increase in livestock numbers over the last decade.

On backward farms, which are still common in most inland districts, potato growing is usually the main source of income. Those farms devoted almost solely to this form of land use frequently have low potato yields per acre, are badly eroded, have a high rabbit population, and are infested with weeds, particularly bracken and onion twitch (*Arrhenatherum elatius* var. *bulbosum*).

Yields of potatoes throughout the area as a whole have risen slightly in recent years owing to such factors as improved supply of disease-free "seed" potatoes, increased use of fertiliser, and wider rotations including longer periods under pasture.

Following work by Wade (1950), which confirmed "fire blight" in this area, as in other countries, to be a potassium deficiency disease of potatoes, potassium fertilisers have become commonly used on this crop.

Spray irrigation of both pastures and potatoes is attracting increasing attention from farmers. In the coastal belt of *1000mm-1100mm* annual rainfall, it has been shown that application of sufficient water (*4-5cm* every 10 days) by irrigation to supplement the natural rainfall from mid December until March, plus adequate fertiliser application, doubled production for normal years.

An important aspect of the present pattern of land use is the increasing emphasis being placed on forestry through the State Forestry Commission and the Associated Pulp and Paper Mills Ltd. of Burnie. These bodies have recognised the urgent necessity for re-afforestation and rational utilisation of forest areas so that regrowth is encouraged and conserved.

The Forestry Commission, pursuing a policy of purchasing land of lesser agriculture value – steep and often stony river valley areas – has acquired *5120 ha* in the Oldina area for a State Forest. Since 1945 the Commission has implemented a comprehensive plan for conservation of the natural eucalypt regrowth forests and has planted on a commercial basis *757 hectares* to *Pinus radiata*. It is planned to plant a possible further *600 ha* in the near future. Several experimental areas of *Pinus radiata* have also been established at scattered sites to cover a range of soils and climate.

Purchases by the Associated Pulp and Paper Mills Ltd., within the surveyed area, have totalled *8498 hectares*. A proportion of this land carries regrowth of the natural forest; other areas although denuded of forest are suited to forestry but not agriculture because of steepness, or stoniness, or both, while a further proportion is arable land abandoned or only partially used for agriculture. A program aimed at conservation and regeneration of natural hardwood forest species has been commenced, as has also a program of softwood (*P. radiata*) establishment. It is estimated that approximately *4050 hectares* of *P. radiata* will be necessary to make the industry independent of imports of softwood pulp. The whole of this could come from scattered individual farm plantations, efficiently using local patches of steep or stony land without risk of heavy losses through fire. However, very few such plantations exist as yet. This point is discussed more fully in Section 6.1.

GENERAL CHARACTERISTICS OF THE AREA

Geology, Landscape Features and Drainage

Geology – The rocks, from which the soil develops by weathering processes, will be discussed in order of age.

(1) Precambrian quartzites and schists are the oldest rocks in the area. Often they are extensively folded. The Sisters Hills are predominantly quartzites with some schists, while along the lower valley tracts of the Blythe, Emu, Cam, Guide and Flowerdale rivers schists with some quartzites are exposed.

As soil parent materials the highly siliceous quartzites are particularly infertile, but the schists, some of which are micaceous, are considerably better.

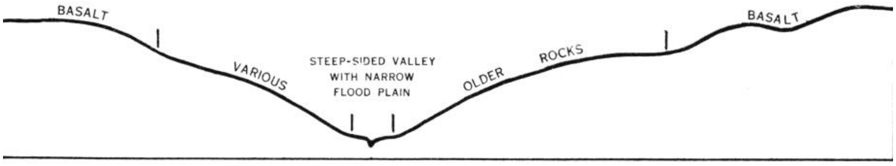


Figure 2 – An ideal cross section showing the deep dissection through the basalt sheet into the underlying rocks.

(2) Devonian granites occurring in the south-east of the surveyed area are next oldest. They outcrop as large boulders and produce soils distinctive by their grittiness. These soils, however, vary considerably in other properties as will be described in Section 5.3.

(3) A variety of sediments of Permian age are exposed along valleys south of Wynyard. The most extensive are tillites of considerable thickness formed by glacial action early in the Permian Period. Associated with the tillites are varved shales and stratigraphically above these are sandstones and mudstones with several coal seams in the Preolenna locality. The soils tend to inherit the textural characters of the rocks from which they are formed so that they vary from sands to clay loams and clays.

(4) During the Jurassic Period the igneous rock dolerite intruded Permian sediments throughout much of Tasmania. Several small areas of dolerite are now exposed in the south west of the surveyed area. This rock is chemically similar to basalt and gives rise here, as does basalt, to krasnozemic soils. However, these are considerably more stony than the majority of krasnozems from basalt.

(5) The Tertiary Period was marked by both deposition of sediments and extrusion of basalts. Of the sediments, the beds of water-worn quartz gravels and sands are most striking and occur on the slopes immediately south of the Wynyard plain and on the valley sides of the Inglis and Flowerdale rivers further south. They overlie Permian and Precambrian rocks. There are also deposits of clays and limestone, the latter being exposed best at Fossil Bluff, Wynyard. Only the gravels and sands are exposed in sufficient amounts to be significant as soil parent materials, and even these are not very extensive. However, the Tertiary basalts are the most extensive rocks in the area.

The basalts occur as ridge cappings throughout. There were at least two periods of volcanic activity separated by a considerable time interval. The beds of limestone with basalt both above and below exposed in the steep slopes behind Doctor's Rocks bear witness to this. As a result of the lava outpourings the whole countryside (with the exception of the Sisters Hills in the west and perhaps Round Hill near Burnie) was covered by a sheet of basalt. Subsequent erosion by the numerous streams has dissected this sheet and exposed areas of all the rock types mentioned above. Weathering of the basalt has produced a variety of krasnozemic soils with only minor amounts of other types.

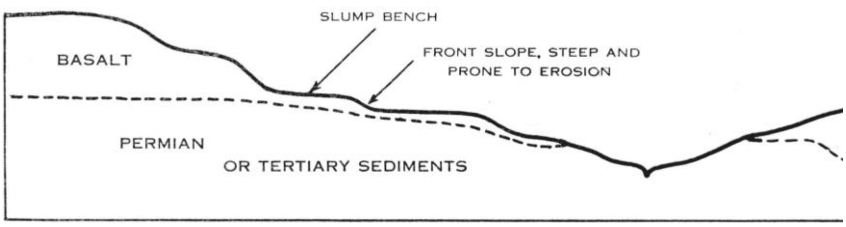


Figure 3 – An ideal cross section showing the effect of slumping on topography

(6) Quaternary sediments of both marine and freshwater origin are confined almost exclusively to the narrow coastal plains. The gravels, sand and clays represented provide a varied assortment of soil parent materials.

Landscape Features – From the coast forming the northern boundary of the surveyed area, the country at first rises sharply to about *90m* and then more gradually to reach a general height of *580m* in the south-west and *450m* in the south-east. The steep slopes which give the initial *90m* rise from the narrow coastal plains represent abandoned sea cliffs.

Numerous actively eroding streams flow in a general south to north direction, the major ones being the rivers Blythe, Emu, Guide, Cam, Calder, Inglis, Flowerdale and Hellyer. These have sharply dissected the landscape to produce steep-sided ridges and valleys, which are illustrated diagrammatically in the section of Figure 4. Many of the steep valley sides are broken by slumping of soil and weathering basalt, forming small benches and hollows with short, steep slopes above and below as shown in Figure 4. The slumping is particularly prominent in the central and south-west regions where the basalt overlies Permian and Tertiary sediments. These sediments apparently provide an unstable foundation, in contrast to the stability of almost all slopes where basalt rests on granite, quartzites, or schists.

As a consequence of the steep dissection, apart from the narrow coastal plains, areas of level country are few and of relatively small extent, as residuals of a former extensive basalt plateau. However, the more or less extensive ridge tops between valleys are undulating and it is here that agriculture has been most easily developed. Of the narrow and discontinuous plains along the coast, the Wynyard plain is by far the largest with an area of about *4 square kilometres*. It has a general altitude of *9m*. Increasing areas of these plains are being urbanised.

Other landscape features of note are the Sisters Hills, which lie along the western boundary of the surveyed area, and the Dial Range just outside the eastern boundary. The flat-topped residuals mentioned above are most prominent in the Oldina, West Takone, and Highclere districts. A dominating feature of the coastline is Table Cape, *180m* high, the remains of an ancient volcanic neck.

Drainage – As already noted, the area is drained by numerous streams, swiftly flowing and without flood plains except for the lower reaches of the Flowerdale and Inglis rivers and small sections along the upper Inglis and Calder rivers. This and the hilly nature of the topography makes for very free and rapid external drainage. Exceptions to this, of course, are the narrow coastal plains, where drainage problems exist because of flatness and of the excessive amounts of water received from nearby hill slopes. A further case of restricted external drainage results from the slumping of parts of the basalt sheet. The slumping, which appears to have occurred mainly during a past age, produces numerous back-sloping benches, usually not larger than a square chain in extent and without drainage outlets. Subsequent dissection eventually drains the benches, but they are to be found in all stages of maturity from those with ponded water and swamp vegetation to the eventual freely draining types.

The slumping is partly a result of internal drainage conditions. The krasnozems have unrestricted internal drainage, so much so in fact that plants may wilt after only a few weeks of dry weather. This free internal drainage aids the saturation of lower, less permeable layers so that a slope may become unstable, causing slumping to take place.

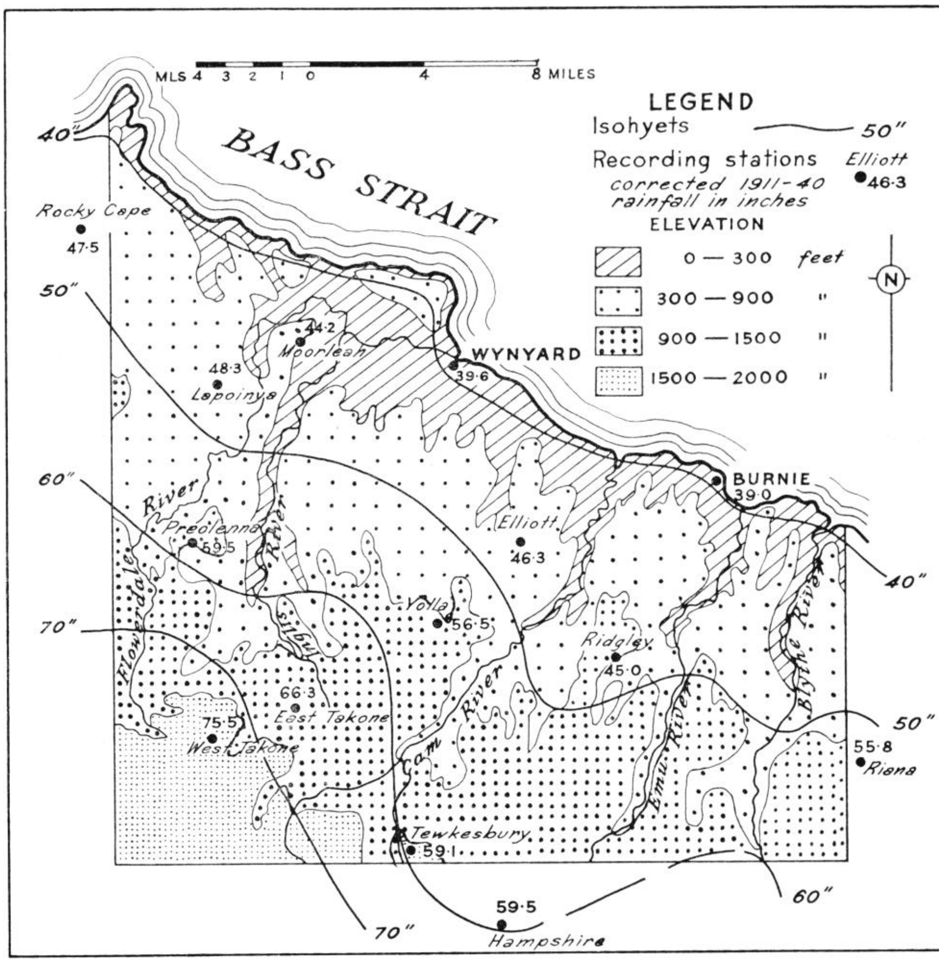


Figure 4 – Rainfall map of Burnie – Table Cape area, Tasmania

Common features of the basalt slopes are small streams arising at springs. These are frequently used as farm water supplies, but for the limited irrigation practised larger streams are tapped.

Climate

The climate of the area has been described by Davidson (1936) as humid cool temperate with a marked winter incidence of rainfall and mild summers. The following data regarding rainfall, temperature, humidity, and wind and the rainfall isohyet map have been extracted from an unpublished report on the climate of the area made available by the Commonwealth Meteorological Bureau, Hobart.

Rainfall – The area is one of heavy rainfall, increasing from *1000mm* at the coast to *1900mm* at West Takone. The map (Figure 4) shows the average annual rainfall at 14 stations, and the rainfall isohyets, which are approximately parallel to the coast. As one goes inland, the rainfall increases at a rate between 1 and 2 in. per mile.

On the average about two-thirds of the annual rainfall comes in the winter months, April – October. The seasonal distribution for the area as a whole is exemplified by data for Burnie and Tewkesbury in Table 2.

The area rarely experiences a prolonged dry period which could be called a drought. On the other hand, heavy falls of rain may occur, which can be a hazard particularly from the point of view of soil erosion of cultivated land. For instance, the greatest rainfall in 24 hours recorded at Burnie was *145.3mm* in April 1929, and from the same storm *281.43mm* fell in 24 hours at Riana.

Temperature and Frost – Mean monthly temperatures for Burnie on the coast (7 *m* above mean sea-level) and Tewkesbury some *24 km* inland (*500m*) are set out in Table 3.

Air temperatures on the coast above 30^oC or below -1^oC are rare, but inland at altitudes near *600m* temperatures up to 35^oC and as low as -8^oC occur occasionally.

A frost normally occurs when the air temperature at *1 m* above ground is 2^oC or less. Along the coast the average frost-free period is in the order of 300 – 340 days. Those frosts which do occur are light and generally come in July and August. Inland the average frost-free period is much shorter, e.g. at Tewkesbury it is only 70 days during December, January and February. Light snow falls several times each year on the country above *450 m* but does not remain on the ground for long.

Length of Growing Season - The important factors determining the length of the growing season are the period of effective rainfall and the temperature.

Local experience indicates that there is sufficient rainfall for continuous plant growth throughout the greater part of the year but that during the summer in coastal districts there may not be sufficient for optimum plant growth. Considerable growth increases can be obtained by the judicious use of spray irrigation during the latter part of December and throughout January and February.

The criterion for the period of effective rainfall developed by Prescott, Collins and Shirpurkar (1952) is the index $P/s.d.^{0.75}>4$ (*P* = rainfall, *s.d.* = saturation deficit). On this criterion both Burnie and Tewkesbury have a full 12 months of effective rainfall (see Table 4). However, this estimate is based on the minimum water requirement for continuous plant growth and is for monthly periods taking no account of distribution of rain within the month. In an area such as this, where most of the agriculture is on soils which drain extremely rapidly and hold large amounts of water so tenaciously as to be unavailable to plants, the distribution of rainfall from week to week can be of a major importance. Although rainfall in each summer month is quite considerable, it generally comes in a few heavy falls unevenly distributed, and in the interval between any particular fall and the next there may be time for soils to dry out and plants to wilt. It is in such short dry periods that spray irrigation is proving invaluable in maintaining optimum growth.

Table 2 Average monthly rainfall (mm) at Burnie and Tewkesbury for 30 years (1911 – 1940) and the number of wet days per month at Burnie

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
Burnie	38.6	43.9	47.7	82.1	89.7	115.6	125	124	99.8	92.7	66.5	67.3	992.9
Tewkesbury	73.6	65.5	77	126.2	133.3	170.7	198.1	185.4	146.8	129.8	94.5	99.8	1500.7
No of wet days at Burnie*	10	8	11	12	14	17	20	19	18	16	13	12	170

* Days on which 0.25 mm or more has been recorded

Table 3 Mean monthly temperatures (^{o}C) at Burnie and Tewkesbury

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
Burnie	15.2	15.7	14.7	12.7	11	9.2	8.7	8.7	9.7	11	12.9	14.6	12
Tewkesbury	13.1	13.2	11.8	10	8.4	6.4	5.8	5.9	7.2	8.4	10	12	9.3

Table 4 Climatic Indices for Burnie and Tewkesbury

Quantity	Location	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
Relative humidity at 9 am (%)	Burnie	68	74	77	77	85	82	85	78	75	73	75	66	76
	Tewkesbury	71	75	78	83	86	88	89	87	83	80	77	74	81
Saturation deficit, *s.d.* (in. Hg)	Burnie	0.16	0.14	0.12	0.10	0.06	0.06	0.05	0.07	0.08	0.11	0.11	0.16	
	Tewkesbury	0.14	0.12	0.09	0.06	0.04	0.04	0.03	0.04	0.05	0.06	0.09	0.11	
$P/s.d.^{0.75*}$	Burnie	6.1	7.5	9.4	18.0	29.4	37.9	44.7	34.9	25.5	19.2	13.8	10.6	
	Tewkesbury	12.6	12.9	18.9	41.4	58.3	74.7	111	81.1	52.5	42.6	23.3	20.7	
Evapotranspiration (in) Rainforest ($Etr = 16\ s.d.^{0.75}$)	Burnie	4.00	3.68	3.2	2.88	1.92	1.92	1.76	2.24	2.4	3.04	3.04	4.00	34.08
	Tewkesbury	3.68	3.2	2.56	1.92	1.44	1.44	1.12	1.44	1.76	1.92	2.56	3.04	26.08
Pasture ($Etr = 12\ s.d.^{0.75}$)	Burnie	3.00	2.76	2.4	2.16	1.44	1.44	1.32	1.68	1.8	2.28	2.28	3.00	25.56
	Tewkesbury	2.76	2.4	1.92	1.44	1.08	1.08	0.84	1.08	1.32	1.44	1.92	2.28	19.56

**P = rainfall (in.)*

When mean monthly temperatures fall below *10°C* plant growth is substantially reduced. At Burnie this occurs during the four months June – September and at Tewkesbury during 6 months, May – October (Table 3). Thus, although the growing season is not limited by rainfall, except for perhaps a month, January or February, in occasional dry years in coastal areas, it is limited by temperature during 4 winter months at Burnie and six months at Tewkesbury.

Because pasture has a lower rate of transpiration than rainforest, now that the country has been largely denuded of forest there is a greater surplus of water than before available for run-off and transfer through the soil to ground water. This adds to both surface erosion and slumping hazards. An estimate can be made of the increased water surplus by use of the formulae of Prescott, Collins, and Shirparkar (1952), as in the second half of Table 4. At Burnie under forest conditions there is an annual surplus of *120mm* of rain available for run-off and transfer to the ground water, but under pasture this is increased to *330mm*. Similarly at Tewkesbury there is a surplus of *860mm* under forest and *990mm* under pasture.

Wind – Observations on wind directions have been recorded only at coastal stations for any length of time. These indicate that at 9 a.m. the wind blows most frequently towards the sea from a southerly direction. However, at 3 p.m. the majority of winds come from the sector from north-east through north to west. Only in winter months does a significant proportion of winds blow from the sector between south and west. During this season the high plateau areas are particularly exposed, adding to the restriction of growth already imposed by low temperatures and to the necessity for shelter belts for stock.

Vegetation

The natural vegetation has now either been completely removed or considerably altered over the greater part of the surveyed area. Forests in the south western part in the valleys of the Hellyer and Arthur Rivers have been least exploited. Regrowth forests in varying stages of maturity occur along most of the river and larger creek valleys.

From early records it is obvious that dense forests covered all but small areas of the landscape. In coastal districts stringybark (*Eucalyptus obliqua*)[4] was the dominant tree species. White gum (*E. viminalis*) and mountain ash (*E. regnans*) occurred less frequently. There was a dense undergrowth of various shrubs and ferns. Southwards with rainfall increasing above *1300mm*, myrtle (*Nothofagus cunninghamii*) with sassafras (*Atherosperma moschatum*) and blackwood (*Acacia melanoxylon*) formed rainforest, but in some areas white-topped stringybark (*E. delegatensis*) was the dominant tree species. Regrowth areas of all these forest trees occur, particularly along valley sides too steep for agriculture.

Those areas not covered by forest originally, include the Sisters Hills carrying a heath vegetation and in some places a woodland vegetation dominated by black peppermint (*E. amygdalina*). Other small areas of the black peppermint woodland occur where quartzites outcrop elsewhere in conjunction with the schists, as at Round Hill near Burnie, and also on the deposits of Tertiary gravels south of Wynyard. Tea tree thickets (particularly the paper-bark, *Melaleuca ericifolia*) and areas of swamp vegetation (various rushes and sedges) occur on the poorly drained coastal plains. In the vicinity of Hampshire on the southern boundary of the area there were, according to early reports of the land survey (Hellyer, quoted by Bischoff 1832), plain-like areas carrying tussock grass (*Poa caespitosa*). The most reasonable explanation for the existence of these open areas in an otherwise forested landscape seems to be that the aborigines opened them and kept them open by annual firing in order to promote grass and herb growth, thereby increasing the carrying capacity for native game.

[4] Common and botanical names follow Curtis (1956)

SOIL CHARACTERISTICS

General Features

The great majority of soils in this area may be placed in one or other of two broad groups, viz.: krasnozems and soils showing podzolic features. Both groups of soils are characteristic of climates of moderate to strong leaching potential and the present instance is no exception. Recognition of this point allows an understanding of many of the characteristics, both morphological and chemical, of these soils.

(i) The *krasnozems* are deep, red or brown soils. They have a strongly developed granular structure and are of a friable consistency over a wide range of moisture conditions, properties which make for ease of working during most seasons. The field texture of the surface soil is frequently clay loam while the subsoil is clay. In the coastal areas these soils are relatively free from stones, but in the inland higher areas stoniness is more common and some soils are relatively shallow. In the natural state the organic matter content of the surface horizons is high, much higher in fact than indicated by the colour of the soil. A considerable proportion of the available nutrients of krasnozems is held in this organic matter in the surface few inches; should these be lost by erosion an important part of the nutrient supply is lost.

Two processes are particularly important in determining the chemical properties of krasnozems. The first is leaching by percolating rainwater. The weathering of a rock such as basalt to depths commonly of the order of *15m* or more indicates that strong leaching of the soil horizons has taken place over a long time interval. Substances essential to plant growth which are particularly liable to loss by leaching include calcium, potassium, sulphur and magnesium. The second process, which works against this loss, is the progressive accumulation of nutrients in organic matter in the surface soil, nutrients which have been withdrawn from deeper soil layers by plant roots. From the agricultural viewpoint this is a very important difference between the surface few inches of a krasnozemic soil and the layers beneath, despite the very similar appearance of the surface and the underlying layers.

A further property of krasnozems should be mentioned in respect of plant nutrient supply. As is evident by their red colour these soils have a high content of free hydrated iron oxides; they also contain considerable amounts of hydrated aluminium oxides. These substances are responsible for the fixing of phosphorus and in the more acid soils possibly also the trace element molybdenum (Davies 1956) in highly insoluble forms which are neither available to plants nor appreciably lost by leaching. Thus, despite the fact that the soils may contain considerable total amounts of these elements, there is still a very great need for their application as mineral fertilisers in an available form.

(ii) The *podzol and podzolic* soil groups include a wide variety of soils which, however, have several features in common. The surface horizon is darkened to a greater or less extent by organic matter, usually of a fairly coarse nature. The texture of the surface is frequently a sandy or silty loam but not invariably so. Beneath the surface is a bleached horizon varying from less than an inch to many inches in thickness, with a texture similar to that of the surface. The subsoil may be one of two general types. Either it is a clay horizon, in which case it is usually weakly mottled with yellow colours predominating, or it is a hardpan which may be black and organic or light grey and siliceous. The depth of these soils is not nearly so great as that of the krasnozems. Some are stony and many are developed on steep slopes.

Because of the wide variety of soils included in this group only very general statements can be made about their chemical properties. Those soils showing features such as a well-developed bleached subsurface horizon with or without hardpan formation in the subsoil may be regarded as the most strongly leached and therefore the most poorly supplied with essential plant nutrients. Some of these, such as the podzols developed on Precambrian quartzites and on Tertiary gravels and sands, are very low in fertility indeed. Their inherent infertility has been accentuated by the strongly leaching climate. Those soils which have only a weakly or moderately developed bleached subsurface horizon and have a clay subsoil, such as many of the soils developed on granite, schists, and Permian sediments, are in most cases better supplied with plant nutrients than those mentioned above. However, in comparison with many agricultural soils their reserves of plant nutrients are low, and response would be expected to a variety of fertilisers.

Table 5 The relationship between the groups of Stephens (1937) and the soil types of the present survey

Stephens (1937)	**Present Survey**
Black Soil Chocolate soil Red-brown soil Dark brown soil Very dark brown soil Brownish black soil	Hicks clay loam Burnie clay loam Lapoinya clay loam Yolla clay loam Takone clay loam Oonah clay loam Unnamed Type 1

The Soil Maps and Mapping Units

The maps accompanying this report show the distribution of the soils of the area. Map 2 and Figure 5, depicting the *soil types* which regularly occur together in a distinctive landscape is called a *soil association*, and this is the unit of mapping which has been used to produce Map 1[5] covering the *1250 square kilometres* surveyed.

5 The base map for the area was constructed from air photographs at the Tasmanian Regional Laboratory, CSIRO. In the field, photographs, at a scale of 1:23 760 and 1:15 840 for the association and soil type mapping respectively, were used for plotting boundaries.

Figure 5 – Soil map of a small area (2.6 sq. kilometres) near West Takone, illustrating the pattern of soils on a gently dissected plateau residual.

The following descriptions of the soil associations list and describe the soil types included in each association, noting particularly the dominant ones and pointing out relationships between neighbouring soil types and landscape features. It should be noted that a soil type name is a combination of a locality name and the texture of the surface soil, e.g. Burnie Clay Loam - a soil occurring in the Burnie locality (and elsewhere) with a clay loam surface texture. Stephens (1937) in his survey of the Burnie-Ridgley districts did not use this way of naming the soils he described, but gave them names descriptive of their colour. Table 5 shows the relationships between his groups and present soil type names.

Each soil association is normally given the name of the dominant soil type occurring in it. However, where the constituent soil types have not been named, because of lack of specific definition, the associations have nevertheless been given names of localities in which they occur.

The Soil Associations

Of the 14 soil associations mapped in the surveyed area five and part of a sixth are of soils formed on basalt and comprise together 53 percent of the total area. The other associations are of soils formed from a variety of parent rocks. Table 6 summarises the main characteristics of the soil associations.

Table 6 Chief characteristics of the soil associations

Soil Association	Area (sq. kilometres)	Dominant Soils	Topography	Parent Rock
Burnie	91	Burnie clay loam with slump complex Hicks clay loam	Generally moderate to gentle slopes, but sometimes steep	Basalt
Lapoinya	249	Lapoinya clay loam with slump complex	Generally moderate to gentle slopes, but sometimes steep	Basalt
Yolla	171	Yolla clay loam, normal and stony phases with slump complex	Gentle, moderate, and steep slopes	Basalt
Oonah	117	Oonah clay loam Yolla clay loam Takone clay loam	Undulating plateau and ridge tops, some short steep slopes	Basalt
West Ridgley	31	Type 1 Yolla clay loam Oonah clay loam	Gentle, moderate and steep slopes	Basalt
Calder	26	Types 2 and 3 (stony krasnozems)	Gentle, moderate and steep slopes	Dolerite
Natone	60	Natone sandy clay loam Unnamed podzolic soil	Gentle, moderate and steep slopes	Granite
Riana	13	Miscellaneous soils of mixed parent material	Gentle and moderate slopes	Basalt and Granite
Sisters Hills	73	Sisters Hills sand (podzol)	Mostly moderate and steep slopes	Quartzites
Cam	135	Unnamed yellow podzolic soils	Mostly steep-sided narrow ridges	Schists
Hellyer	205	Unnamed yellow podzolic soils	Variable but much steeply sloping	Tillites and shales
Inglis	28	Type 6 (gravelly podzol) Unnamed sandy podzol	Gentle and moderate slopes	Quartz gravel and sand
Wynyard	18	type 5 (ground water podzol)	Flat or very gently sloping	Sandy marine and/or estuarine deposits
Flowerdale	36	Flowerdale series Type 4	Flat or very gently undulating	Alluvium (mainly fine textured)

The boundaries of some associations are well defined by sharp breaks in parent material, or topography, or both, and these have been shown on Map 1 as full lines. In other cases, particularly between the basalt soil associations, no distinct boundary exists but rather a broad transition from one association to the next. This is represented on the map as a dotted line. In several instances one soil type is a member of two or more soil associations, e.g. Yolla clay loam occurs in the Yolla, Oonah and West Ridgley associations. When this occurs the location of an association boundary is often arbitrary, since it may have to be placed with the same soil type on either side of it. A third type of boundary includes those which owing to difficulties of terrain were not observed in the field and have been interpreted from aerial photographs. These boundaries are shown on the map as broken lines.

Several of the basalt soil types have a general similarity of appearance and at first may only be separated with difficulty. To aid this separation their distinguishing characters are set out in Table 7.

Table 7 The distinguished characters of the soil types formed on basalt.

Soil Type	Surface Colour	Subsoil Colour	Surface Structure	Other Characters
Burnie clay loam	Dark reddish brown (2.5-5YR 3/3-4)*	Bright red-brown (2.5YR 3/6, 4/6-7-8)	Strongly developed granular	Deep profile, few stones
Lapoinya clay loam	Reddish brown (5YR 3/3-4, 4/3-4)	Bright red-brown (5YR 4/6-8, 5/6-7)	Moderately developed granular, “snuffy” when overworked	Deep profile, few stones
Yolla clay loam	Brown to dark brown (7.5YR 3/3-4, 10YR 4/3-3/3)	Bright brown or reddish brown (7.5YR 4/4-6, 5/6)	Moderately developed granular	Deep profile, stones more frequent
Takone clay loam	Dull or dark brown (10YR 4/3-4, 3/3-4)	Yellowish or yellow brown (10YR 5/6-7)	Moderately developed granular	Subsoil slightly plastic
Oonah clay loam	Brown to dark brown (7.5YR 3/3-4, 10YR 4/3-3.3)	Brown or reddish brown (7.5-5YR 4/4-6)	Fine crumb breaking to “snuffy” material	Shallow profile, very stony. Texture sometimes loam
Hicks clay loam	Very dark grey-brown (10YR 3/1-2, 4/1)	Yellow-grey with rusty brown mottles	Granular	Subsoil hard when dry, sticky when wet
Type 1	Dark grey-brown to black (10YR 3/2-2/2	Yellowish grey or yellowish brown (10YR-2.5Y 4/4-3)	Fine granular	Subsoil usually friable

** Colour notations refer to the standard Munsell system, but colour names do not conform to any generally accepted standard.*

SOIL MAP UNITS AND SPCS

Soils on Basalt

Burnie Association (*90 sq. kilometres*)

Dominant soil type	Burnie Clay Loam and slump complex (*Burnie SPC*)
Subdominant soil type	Hicks clay loam
Minor soil types	Unnamed creek soils and dark soils of steep coastal slopes

Wherever basalt occurs in the belt of country extending from the coast inland a distance of approximately *5 km*, soils of the Burnie association are found. The occurrences comprise the northern portions of basalt ridges from sea-level up to about *180m* and the more extensive basalt area in the vicinity of Table Cape and Boat Harbour. The ridge tops are more or less extensive and are gently or moderately sloping. However, the ridge sides and ends are usually steep and in places show typical slump topography with small benches or hollows and short, steep slopes above and below them (see Fig. 3 in Section 3.1). In this association slumping is confined particularly to areas behind Somerset and near Mt. Hicks.

The distribution of the Burnie association is correlated with climate, for it occurs only in areas with average rainfall less than *1150mm* and mean annual temperature near *12°C*.

The pattern of the soil types within the association is illustrated by reference to Map 2 representing the soils of the strip of country extending inland from Doctor's Rocks. This area may not be thoroughly typical of the association as a whole because it contains a greater than usual proportion of Hicks clay loam and slump complex soils. However, the dominant soils here as elsewhere is the Burnie clay loam occurring on gentle and moderate, rounded slopes of the ridges and on some steep side slopes. The surface is a dark red-brown clay loam, very friable over a wide moisture range and with a strong granular structure. At about *20cm* the texture changes to clay, still very friable but with a slightly coarser structure. With depth the subsoil colour brightens to red-brown or bright red-brown. Below *90cm* soft fragments of weathering basalt with some black staining may be present although depth to the horizon of mealy decomposing basalt may be as much as *2m* or more. Relatively unweathered rock is rarely seen except as isolated boulders or floaters through the profile. In very occasional patches, stony phases, the floaters are more numerous, especially in the surface soil. Rainfall penetrates easily into the Burnie clay loam so that it is well leached to considerable depths. Sheet erosion, although not so obvious as on soils further south, has in places removed part of the surface soil, reducing the depth to the clay to a few inches.

The soils of the slump complex show a gradation from the typical Burnie clay loam in the upper slope areas to duller soils towards the bottom of the slope, particularly on benches or in hollows. Here the surface colour may be a greyish brown or even dark grey-brown, while the subsoil may be mottled brown, yellow-brown, and red-brown.

The steep slopes at the front of the benches are particularly liable to erosion, as is evidenced by the patchiness of growth in many paddocks.

Hicks clay loam is a dark soil found in association with the Burnie clay loam but showing a clear-cut topographical relation to it. It occurs on both gently sloping ridg areas and steep ridge side slopes. Generally there are scattered paper-barks (*Melaleuca ericifolia*) growing on areas of this soil, indicative of the poor internal drainage conditions. The surface is a very dark grey-brown clay loam or light clay sometimes with slight rusty brown stains along root channels. The subsoil at about *20cm* is a dark yellow-grey to dark grey-brown clay with rusty brown flecks, hard and tough when dry but sticky when wet. Below *45cm* the colour becomes yellow-grey with yellow-brown mottling. Fragments of basalt become increasingly prominent, passing at about *75cm* to weathering basalt.

The unnamed creek soils occupy narrow strips along the creeks and gullies, and are a miscellaneous group varying considerably in character. Some in the better drained situations are dark-coloured clay soils, while others more permanently wet might be described as “mucks”.

The dark soils of steep coastal slopes are a very minor constituent of this association. They vary in character, depending on their parent rock, which may be limestone, basalt colluvium, or a mixture of both, and sometimes other Tertiary sediments.

Correlation

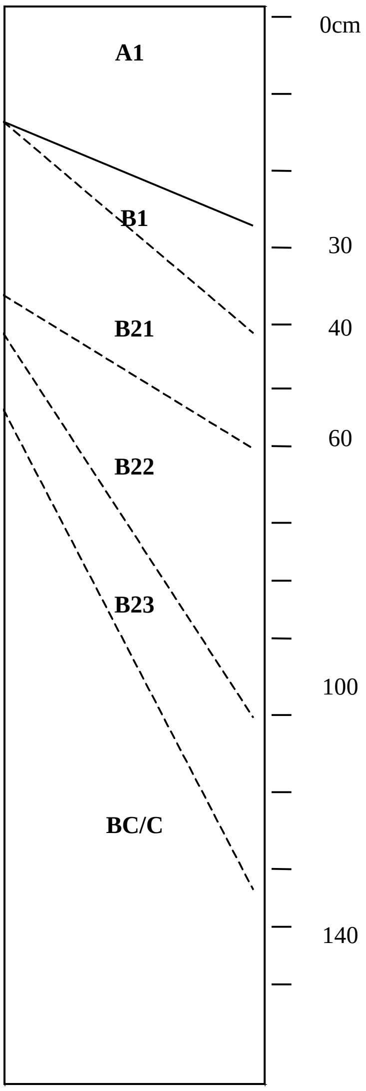
The Burnie Soil Profile Class is typically well drained, with deep red subsoils (usually deeper than 1.5m) and very few stones. Many CSIRO site descriptions include heavy clay subsoils, with diffuse boundary changes. Recent DPIWE field work indicates these subsoils range between light and medium clay. These discrepancies could be due to CSIRO textures taken from particle size analysis, or changes in soil terminology and definitions. Recent detailed work on the basalt soils by Elderidge (2000) found the Burnie Soil Profile Class up to elevations of 200m.

These profiles can vary in depth, with a moderately deep phase identified. Drainage can also be impeded, with the identification of a moderately well drained phase. A sandy variant has also been identified, with sandy clay subsoils where tertiary sediments and basalt occur (Eldridge 2000).

Burnie Soil Profile Class

Concept **Deep, well drained friable red clayey soils developed on Tertiary Basalt.**

Aust. Soil Classification Haplic to Acidic, Eutrophic to Mesotrophic Red Ferrosol
Great Soil Group Kraznozem
Principal Profile Form Gn
Mapping Units Burnie Association (Bu)
Parent Material Tertiary Basalt
Landform Level to gently inclined crests of plateau residuals, and gently to moderately inclined low hills adjacent to the coastline to elevations of 200m.
Vegetation Pasture and annual crops
Surface Conditions Firm
Permeability Moderately permeable
Drainage Well drained



A1: Dark reddish brown (2.5YR 2/3, 2/4, 3/2, 3/4, 5YR 3/3, 3/4); clay loam to heavy clay loam; moderate to strong 2-5mm subangular blocky or granular, plus <2mm granular structure; very weak to weak (moist) consistence; none to very few, <2mm manganiferous nodules; 0-2% basalt fine gravels; pH 5.6 - 6.8; clear change to

B1: Dark reddish brown (2.5YR 2/4, 3/3, 3/4, 5YR 3/3); heavy clay loam to light medium clay; strong 2-5mm subangular blocky or polyhedral structure; weak (moist) consistence; none to few <2mm manganiferous concretions; 0-2% basalt fine gravels; pH 4.9 – 6.0; clear to gradual change to

B21: Dark red to dark reddish brown (2.5YR 2/4, 2/5, 3/3, 3/4, 3/5, 3/6); light to medium clay; strong 5-10mm subangular blocky or polyhedral, plus 2-5mm subangular blocky or granular structure; very weak to weak (moist) consistence; none to very few <2mm manganiferous concretions; 0-2% basalt fine to coarse ravels; pH 5.6 - 6.4; clear to gradual change to

B22: Dark red to dark reddish brown (2.5YR 3/4, 3/5, 3/6, 4/6); light to medium clay; moderate to strong 5-10mm polyhedral or subangular blocky, plus 2-5mm angular blocky structure; very weak to weak (moist) consistence; none to very few <2mm manganiferous soft segregations or concretions; 0-2% weak, basalt fine gravels; pH 5.1 – 6.4; gradual change to

B23: Red to dark reddish brown (2.5YR 3/4, 3/5, 3/6, 4/6); light to medium clay; weak 5-10mm subangular blocky, plus weak <2mm subangular blocky or granular structure; very weak to weak (moist) consistence; 0-10% <2mm manganiferous concretions; 0-2% basalt fine gravels; pH 6.0 – 6.5 ; gradual change to

BC/C: Weathered basalt

Phases: **Burnie moderately deep phase** (Eldridge 2000).

Variants: **Burnie Coarse Sandy Variant** (Eldridge 2000)**, Burnie slump complex**

Morphological Sites: CSIRO H94, H121, H122, H136, H142, BURNIE 1039, 1049, 1107, 1110, 1121, 1127, 1141, 1198, 1201, 1206, 1209
Analysed Sites: CSIRO H94, H136, H122, H142
Related soil names: Burnie Clay Loam, Red-brown & dark red-brown krasnozems on basalt, chocolate soils
Previously described by: Stephens (1937), Hubble (1944), Loveday (1955), Loveday & Farquhar (1958), Eldridge (2000)

Soil Profile Class Grid Reference	**Profile Number**	**Horizon**	**Sample Depth (cm)**	**pH water (1:5)**	**EC (d/sm)**	**Total P (mg/kg)**	**Avail P (mg/kg)**	**Avail K (mg/kg)**	**Org. Carb. (%)**	**Total N (%)**	**C/N Ratio**	**Ca meq**	**Mg meq**	**Na meq**	**K meq**
Burnie SPC	H136	A11	0-8	5.9		0.123			6.4	0.638	10	17.6	2.5	0.31	0.76
410638 E		A11	8-15	5.9		0.111			5.4	0.657	8	16.6	2.7	0.26	0.71
5451126 N		B21	18-29	6.1					2.7	0.25	11				
		B21	29-38	6.4		0.07			1.8	0.179	10	8.1	1.6	0.23	0.67
		B22	38-53	6.3					1.4						
		B22	53-69	6.3		0.062						6.0	1.65	0.23	0.44
		B23	69-84	6.0											
		B24	91-109	5.6											
		B3	124-145	4.8											
		C	193-203	4.7											
		R	203-213	2.0											

Soil Profile Class Grid Reference	**Profile Number**	**Horizon**	**Sample Depth (cm)**	**Total Bases**	**ECEC meq**	**BASE SAT (%)**	**ESP (%)**	**Ca/Mg Ratio**	**Gravel (of total) >2000 (um) (%)**	**Sand Coarse >200 (um) (%)**	**Sand Fine <200 (um) (%)**	**Silt (%)**	**Clay (%)**
Burnie SPC	H136	A11	0-8	21.17	54.67	39	0.6	7.04		2	14	41	24
410638 E		A11	8-15	20.27	53.27	38	0.5	6.15		1	13	41	27
5451126 N		B21	18-29										
		B21	29-38	10.60	28.30	37	0.8	5.06		1	13	29	56
		B22	38-53										
		B22	53-69	8.32	23.82	35	1.0	3.64		1	9	23	69
		B23	69-84										
		B24	91-109										
		B3	124-145										
		C	193-203										
		R	203-213										

Table 8 Analytical data for the Burnie SPC

Lapoinya Association *(250 sq kilometres*)

Dominant soil type	Lapoinya Clay Loam and slump complex *(Lapoinya SPC)*
Minor soil types	Unnamed creek soils Oonah Clay Loam (*Oonah SPC)*

This is the largest association, comprising 20 per cent. of the surveyed area. It occurs on basalt ridges in a belt of country at an elevation between approximately *150m* and *270m,* parallel to the coast and immediately south of the Burnie association, i.e. its northern boundary is approximately *5km* inland. Its southern boundary, however, varies from *11km* inland in central areas to *19km* in the south-east. As has already been mentioned, the boundaries in the north with the Burnie association and in the south with the Yolla association are broad transitions. In the zone of transition from Burnie association to Lapoinya association Burnie clay loam tends to occupy ridge top positions while the Lapoinya clay laom occurs on the slopes below – see Map 2. Slopes throughout the Lapoinya association vary considerably. The ridge of the valley sides is extensive in the central areas where the basalt overlies sedimentary rocks. In the eastern and western parts it is an inconspicuous feature of the landscape.

Once again there is an obvious correlation between the distribution of this association and the interrelated factors of elevation, rainfall and temperature. The northern boundary corresponds approximately with the *1150mm* isohyet and the southern boundary with the *1400mm* isohyet. The mean annual temperature is near *11^{o}C.*

Reference to Map 2 shows a relatively simple pattern of soils within this association. The Lapoinya clay loam occupies a large percentage of the total area, occurring for the most part on gentle and moderate slopes but sometimes on steep slopes. The surface soil is a reddish brown friable clay loam of moderately well-developed granular structure. In some areas the soil crumbles under light pressure to powdery or snuffy material and it seems probable that the initial structure has been destroyed by over-cultivation. Sheet erosion of the surface soil is a common feature so that depth to the subsoil clay horizon may be as little as *10cm* but where erosion has not occurred it is near *22cm*. The subsoil horizon is of similar colour to the surface but brightens to red-brown or bright red-brown below *45cm*. It is friable throughout over a wide moisture range and in the upper parts has a granular structure. Below about *90cm* the amount of weathering basalt increases, soon passing to a mottled red, yellow-brown, white, or black mealy weathering horizon which continues to considerable depths. Floaters of relatively unweathered rock occur infrequently in the surface soil. There are scattered patches more stony than usual but these are of no great extent. Except where the surface soil has been powdered and the subsoil compacted by over-cultivation, rainfall penetrates easily, leaching the profile strongly.

Wherever slumping has occurred a complex of soils is found. On the freely drained but not too steeply sloping parts of the slump the soil is very similar to the Lapoinya clay loam but the surface is slightly duller. On steeply sloping banks an eroded phase occurs where the surface soil is only *10cm* or less in depth and of a powdery or snuffy character when dry. On the benches and in hollows the type of soil depends on the degree of development of internal drainage. A range of soils from those similar to the Lapoinya clay loam in the free-drainage sites to those with a grey-brown or dark grey-brown surface overlying a mottled subsoil in the poorly drained sites, is encountered.
The minor constituents of this association are the miscellaneous group of *creek soils* occupying narrow strips along the streams and small areas of the Oonah clay loam in the Milabeena, Upper Natone and South Riana districts. This soil is described under the Oonah association. It is stony and relatively shallow, occurring on gently undulating plateau residuals.

Correlation
The Lapoinya Soil profile Class is typically well drained, with reddish-brown subsoils. They are slightly more acidic, slightly stonier and shallower than the Burnie Soil profile Class. Many CSIRO site descriptions include heavy clay subsoils, with diffuse boundary changes. Recent DPIWE field work indicates these subsoils range between light and medium clay. These discrepancies could be due to CSIRO textures taken from particle size analysis, or changes in soil terminology and definitions.

Recent detailed work on the basalt soils by Elderidge (2000) found that the Lapoinya Soil Profile Class occurred at elevations between 160 and 300m.

In addition to the eroded phase, several other phases have been identified. These include profiles with greater than 20% stones and cobbles, occurring on upper slopes, crests and plateau residuals, (Lapoinya Stony Phase).

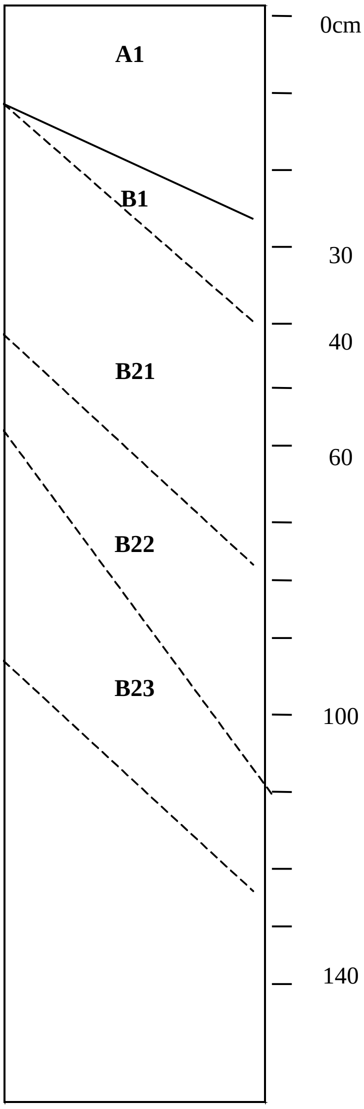
Drainage is also variable, with a moderately well drained phase identified in drainage depressions and footslopes, and an imperfectly drained variant where outflow is restricted from these areas.

Surface horizons may differ, with a snuffy phase identified. This comprises a weakly developed structure, with a high organic mater content in areas of old pasture. A darker loamy phase also exists on crests and low hills to a minor extent in the Ridgely area, which may be due to a slightly different basalt composition.

A manganiferous phase has been identified on intensively irrigated areas, where 20-50% manganiferous segregations, concretions and nodules are thought to have been formed from substantial water addition (Eldridge 2000).

Lapoinya Soil Profile Class

Concept	**Well drained, friable red-brown clayey soils developed on Tertiary Basalt.**
Aust. Soil Classification	Acidic to Haplic, Mesotrophic to Dystrophic Red Ferrosol
Great Soil Group	Krasnozem
Principal Profile Form	Gn
Mapping Units	Lapoinya Association (Lp)
Parent Material	Tertiary Basalt
Landform	Gently to moderately inclined hill-slopes of plateau residuals, and gently to moderately inclined crests and hill-slopes of low hills and hills between elevations of 160 and 300m.
Vegetation	Pasture & annual crops
Surface Conditions	Firm
Permeability	Moderately permeable
Drainage	Well drained



A1: Dark reddish brown to dark brown (5YR 3/3, 3/4, 7.5YR 3/3); clay loam to heavy clay loam; moderate 2-5mm subangular, plus <2mm granular structure; very weak to weak (moist) consistence; 0-2% basalt fine gravels; pH 5.0 – 6.3; clear change to

B1: Dark reddish brown (2.5YR 3/4, 5YR 3/3, 3/4); light clay; moderate to strong 5-10mm subangular blocky or polyhedral, plus 2-5m subangular blocky or granular structure; very weak to weak (moist) consistence; pH 4.9 – 6.1; clear to gradual change to

B21: Dark reddish brown to reddish brown (5YR 3/3, 3/4, 3/5, 4/3, 4/4); light to medium clay; strong 5-10mm subangular blocky or polyhedral, parting to 2-5mm subangular blocky structure; very weak to weak (moist) consistence; 0-2% <2mm ferromanganiferous concretions; pH 4.9 – 6.0; clear to gradual change to

B22: Dark reddish brown to yellowish red (2.5YR 3/4, 4/4, 5YR 3/4, 3/5, 3/6, 4/5, 4/6); light to medium clay; strong 5-10mm subangular or polyhedral, plus 2-5m subangular blocky structure; very weak to weak (moist) consistence; 0-2% <2mm ferromanganiferous or manganiferous concretions; 0-10% basalt fine to coarse gravels; pH 4.8 – 6.9; clear to gradual change to

B23: Dark red to reddish brown (2.5YR 3/5, 3/6, 4/6, 5YR 3/4, 3/5, 4/4, 4/5); light medium to medium clay; moderate to strong 5-20mm subangular or angular blocky, parting to 2-5mm subangular or angular blocky structure; weak to very weak (moist) consistence; 0-10% <2mm manganiferous concretions; none to varying amounts of basalt fine to coarse gravels; pH 4.7 – 5.7

Phases: **Lapoinya: stony clay loam phase, moderately well drained phase, moderately deep phase, snuffy clay loam phase, shallow phase, loamy phase, manganiferous phase, ironstone phase, bouldery phase** (Eldridge 2000)

Variants: **Lapoinya: imperfectly drained variant, bouldery clay loam variant, fine sandy variant, transitional variant, gritty variant Lapoinya slump complex** (Eldridge 2000)

Morphological Sites: CSIRO H116, H120, H137, H138, H143, H10, H92, BURNIE 1104, 1106, 1114, 1152, 1089, 1086, 1070, 1064, 1094, 1103
Analysed Sites: CSIRO H116, H120, H137, H138, H143, H10, H92
Related soil names: Red brown soils, Lapoinya Clay Loam
Previously described by: Stephens (1937), Hubble (1944), Loveday (1955), Loveday & Farquhar (1958), Eldridge (2000)

Soil Profile Class Grid Reference	**Profile Number**	**Horizon**	**Sample Depth (cm)**	**pH water (1:5)**	**EC (d/sm)**	**Total P (mg/kg)**	**Avail P (mg/kg)**	**Avail K (mg/kg)**	**Org. Carb. (%)**	**Total N (%)**	**C/N Ratio**	**Ca meq**	**Mg meq**	**Na meq**	**K meq**
Lapoinya	H10	A1	3-10	6.6		0.088			5.80	0.558	10	13.6	9.7	0.41	2.4
406225 E		A1	3-10												
5449526 N		B1	10-25	6.1					3.77	0.35	11				
		B21	25-46	5.8					2.48						
		B22	46-61	5.8		0.169			2.14			1.2	1.5	0.3	0.15
		B23	61-91	5.6		0.108			1.18	0.09	13				
		B24	137-152	5.3					0.5			0.61	1.5	0.56	0.19
		B24	137-152												
		B3	213-259	5.2					0.23						

Soil Profile Class Grid Reference	**Profile Number**	**Horizon**	**Sample Depth (cm)**	**Total Bases**	**ECEC meq**	**BASE SAT (%)**	**ESP (%)**	**Ca/Mg Ratio**	**Gravel (of total) >2000 (um) (%)**	**Sand Coarse >200 (um) (%)**	**Sand Fine <200 (um) (%)**	**Silt (%)**	**Clay (%)**
Lapoinya	H10	A1	3-10	26.11	62.81	42	0.7	1.40	0	2	10	19	53
406225 E		A1	3-10										
5449526 N		B1	10-25										
		B21	25-46										
		B22	46-61	38.55	38.55	8	0.8	0.80	3	3	8	15	70
		B23	61-91										
		B24	137-152	30.46	30.46	9	1.8	0.41	10	5	19	18	52
		B24	137-152										
		B3	213-259										

Table 9 Analytical data for the Lapoinya SPC

Yolla Association (*170 sq. kilometers*)

Dominant soil type	Yolla Clay Loam and slump complex *(Yolla SPC)*
Subdominant soil type	Yolla Clay Loam stony phase
Minor soil types	Unnamed soils of creeks and hollows
	Oonah clay loam *(Oonah SPC)*
	Takone clay loam (*Takone SPC)*

The Lapoinya association grades southwards into the Yolla association some *11-19 kilometres* from the coast. The general elevation of this region is of the order of *270m* and increases towards the south. Although the Yolla association comprises on the whole moderately dissected country with gentle, moderate and steep slopes, some almost flat plateau residuals occur. Slumping, particularly on the steeper slopes, is common throughout most areas of this association.

With the increasing altitude rainfall is higher and temperatures lower than for the Lapoinya association. The average rainfall ranges from *1400mm to 1800mm*, while the mean annual temperature is *9 – 10^{o}C.* The natural forests of the Yolla association are reputed to have been largely myrtle (*Nothofagus cunninghamii*), sassafras (*Atherosperma moschatum*), and blackwood (*Acacia melanoxylon*), in contrast to the stringybark (*E. obliqua*) forests of the Burnie and Lapoinya associations.

The Yolla clay loam with its slump complex and stony phase is by far the most extensive soil. It occurs on slopes varying from gentle to steep. The surface soil is brown to dark brown friable clay loam, with a moderately well-developed granular structure. Under dry conditions in some areas, but less frequently than in the Lapoinya association, the surface soil crumbles easily to a powder. Depth to the brown or bright brown subsoil clay horizon varies between *10cm* and *22cm*, largely because of surface sheet erosion. The subsoil is very friable and of a coarse granular structure. With depth the colour brightens and often there is black staining of aggregate faces and decomposing basalt fragments. Below about *75cm* the amount of weathering basalt increases and passes gradually to a mottled horizon of mealy, highly weathered basalt. As with other krasnozems, this soil is easily penetrated by rainfall and is well leached. Occasional floaters of unweathered basalt are normal in the surface horizons. However, significant areas are considerably stony and these have been designated the stony phase of this soil type.

In this association the slump complex has in the freely drained sites typical of the Yolla clay loam. Short, steep banks frequently show severe erosion of the surface, while on benches and in hollows a soil with a dark-coloured surface and weakly mottled subsoil may be developed. Some slumped areas are rather stony.

On the almost flat plateau residuals scattered throughout the Yolla association, the shallow and stony soil, Oonah clay loam, is found. Further south in the Oonah association where the basalt residuals are less dissected it occurs more extensively.

A variety of unnamed soils occurs along creek lines and in drainage hollows. Their total extent is small and they vary considerably in profile characteristics. In the vicinity of these drainage hollows on low slopes are small areas of Takone clay loam described more fully under the Oonah association.

Correlation

These soils are typically well drained, with yellowish brown subsoil. They display darker topsoil, and are relatively shallower, stonier and less well structured than the Lapoinya or Burnie soils. Many CSIRO site descriptions include heavy clay subsoils, with diffuse boundary changes. Recent DPIWE field work indicate these subsoils range between light and medium clay. These discrepancies could be due to CSIRO textures taken from particle size analysis, or changes in soil terminology and definitions.

Recent detailed work on the basalt soils by Elderidge (2000) found the Yolla Soil Profile Class at elevations above 300m.

Drainage can become moderately well drained in depressions and lower slopes, (Yolla moderately well drained phase), where ferruginous and manganiferous nodules are identified below 50cm. An *imperfectly drained variant exists where surface outflow is restricted, with darker colours, and common to many manganese and ironstone concretions found in the subsoils.*

These soils can also vary in depth on crests and lower slopes, with a shallow phase of less than 50cm and a moderately deep phase between 50 and 100cm, over weathered basalt.

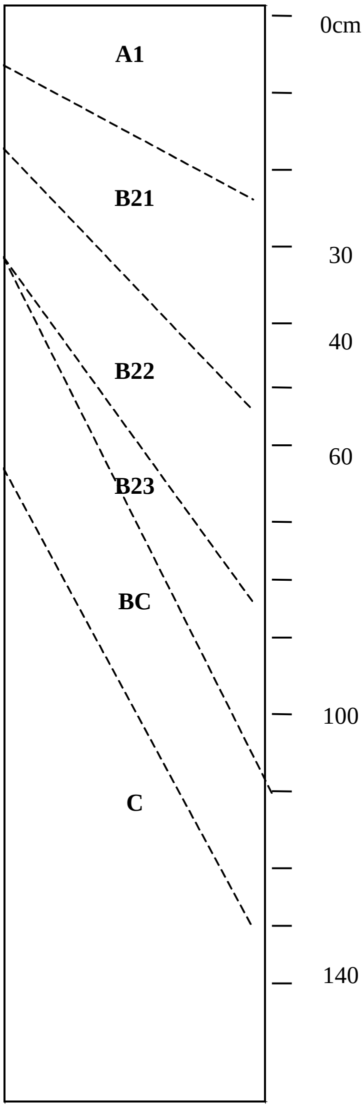
The Yolla stony phase usually contains more than 20% cobbles and stones, and is found on upper slopes and hill crests (Eldridge 2000).

Yolla Soil Profile Class

Concept — **Well drained, friable brown clayey soils developed on rolling to steep hills of Tertiary Basalt.**

Aust. Soil Classification Acidic, Mesotrophic to Dystrophic Brown Ferrosol
Great Soil Group Krasnozem
Principal Profile Form Gn
Mapping Units Yolla Association (Yo), West Ridgely Association (Wr), Oonah Association (On)
Parent Material Tertiary Basalt
Landform Rolling to steep hills, elevations higher than 300m

Vegetation Mostly cleared
Surface Conditions Firm
Permeability Moderately permeable
Drainage Well drained



A1: Very dark brown to brown (7.5YR 2/2, 2/4, 3/3, 3/4, 10YR 3/2, 3/3, 3/4, 4/3); loam to heavy clay loam; moderate to strong 2-5mm subangular blocky, plus <2mm granular structure; very weak (moist or dry) to firm (dry) consistence; 0-10% basalt fine to coarse gravels; pH 4.9 – 6.0; clear to gradual change to

B21: Dark to strong brown (7.5YR 3/4, 4/4, 4/6, 5/6, 10YR 3/3); light to medium clay; strong 5-10mm subangular blocky or polyhedral, plus 2-5mm subangular blocky or polyhedral structure; very weak to weak (moist) consistence; 0-2% basalt medium gravels; pH 4.7 – 5.6; clear to gradual change to

B22: Dark reddish brown to dark brown (5YR 3/4, 7.5YR 4/4, 4/5, 4/6, 10YR 3/3); light to medium clay; moderate to strong 5-10mm subangular blocky or polyhedral, plus 2-5mm subangular blocky structure; very weak to weak (moist) consistence; 0-10% basalt coarse gravels and boulders; pH 4.5 – 5.4; clear to gradual change to

B23: Yellowish red to dark yellowish brown (5YR 4/5, 4/6, 7.5YR 4/4, 4/6, 5/6, 10YR 3/3, 3/4); light to medium clay; weak to moderate 5-10mm subangular blocky, plus 2-5mm angular blocky or granular structure; very weak to weak (moist) consistence; 0-20% basalt gravels and cobbles; pH 4.5 – 5.4; gradual to diffuse change to

B3/BC: Brown to yellowish brown (7.5YR 4/4, 4/6, 10YR 4/4, 4/6, 5/4); clay loam to medium clay; massive structure; very weak to weak (moist) consistence; 0-20% weak basalt fine to coarse gravels; pH 4.5 – 4.7; diffuse change to

C: Weathered basalt

Phases: **Yolla moderately well drained phase, Yolla shallow phase, Yolla moderately deep phase, Yolla stony phase,** (Eldridge 2000), **Yolla Steepland phase** (Grose & Cotching 1996)

Variants: **Yolla imperfectly drained variant,** (Eldridge 2000), **Yolla slump complex.**

Morphological Sites: CSIRO H135, H96, H132, H133, H117, H119, H145, BURNIE 1019, 1030, 1151, 1154, 1160, 1180, 1216, 1219,
Analysed Sites: CSIRO H135, H96, H132, H133, H117, H119, H145
Related soil names: Yolla Clay Loam, Yolla SPC
Previously described by: Stephens (1937), Hubble (1944), Nicolls (1955), Loveday (1955), Loveday & Farquhar (1958), Hill et al (1995), Eldridge (2000)

Soil Profile Class Grid Reference	**Profile Number**	**Horizon**	**Sample Depth (cm)**	**pH water (1:5)**	**EC (d/sm)**	**Total P (mg/kg)**	**Avail P (mg/kg)**	**Avail K (mg/kg)**	**Org. Carb. (%)**	**Total N (%)**	**C/N Ratio**	**Ca meq**	**Mg meq**	**Na meq**	**K meq**
Yolla SPC	H135	A11	0-8	4.9		0.19			7.3	0.424	17	3.2	1.0	0.20	0.35
390838 E		A11	0-8												
5433122 N		A12	8-15	4.7		0.181			7.0	0.408	17				
		B21	17-28	4.7		0.134			4.7	0.288	16	2.8	1.0	0.10	0.36
		B22	28-43	4.5					3.3						
		B23	46-61	4.7											
		B24	61-74	4.6											
		BC	81-94	4.7											
		C1	104-122	4.8											
		R	277-287	4.6											

Soil Profile Class Grid Reference	**Profile Number**	**Horizon**	**Sample Depth (cm)**	**Total Bases**	**ECEC meq**	**BASE SAT (%)**	**ESP (%)**	**Ca/Mg Ratio**	**Gravel (of total) >2000 (um) (%)**	**Sand Coarse >200 (um) (%)**	**Sand Fine <200 (um) (%)**	**Silt (%)**	**Clay (%)**
Yolla SPC	H135	A11	0-8	4.75	32.05	15	0.6	3.20		2	7	15	66
390838 E		A11	0-8										
5433122 N		A12	8-15										
		B21	17-28	4.26	27.26	9	0.2	2.80		1	5	12	75
		B22	28-43										
		B23	46-61										
		B24	61-74										
		BC	81-94										
		C1	104-122										
		R	277-287										

Table 10 Analytical data for the Yolla SPC

Oonah Association *(117 sq. kilometres)*

Dominant soil type	Oonah Clay Loam *(Oonah SPC)*
Subdominant soil type	Yolla clay loam, (normal and stony phase) *(Yolla SPC)*
	Takone Clay Loam *(Takone SPC)*
Minor soil types	Unnamed soils of creeks

The most southerly and the most elevated of the basalt country, i.e. land between *400m* and *580m*, constitutes this association. It includes, largely, gently undulating ridges and almost flat plateau residuals which have steep and in places almost precipitous sides. There are some areas of more moderate slopes where local dissection is proceeding and some slumping has occurred. The average rainfall is high – greater than *1500mm* – and temperatures are low – mean annual temperature is near *9°C*. Each year occasional falls of snow are experienced. In contrast with the Burnie, Lapoinya and Yolla associations which are practically all cleared of standing and fallen timber, considerable areas of the Oonah association have not yet been cleared of fallen logs, and small areas still carry myrtle forest.

Under forest which has not been burnt recently there is a significant accumulation of decomposing organic matter on the surface of the soil. The deepest layer of this observed was of the order of *30cm*. Clearing, burning and cultivation destroys this organic accumulation as such, but some may be incorporated in the surface soil. Those areas where the trees have been felled but clearing carried no further have a dense mat of various grasses, herbs, and mosses which form a peaty turf layer up to *5cm* thick. Again, cultivation destroys this accumulation.

The most extensive soil is the Oonah clay loam found on flat or very gently undulating residuals and ridges. It is a relatively shallow stony soil, which depending on whether it is cultivated or not, may or may not show a surface accumulation of organic matter. The surface soil is a brown to dark brown loam or clay loam with a fine crumb structure powdering under light pressure to snuffy material. At *15cm* there is a gradual change to brown or reddish brown light clay. Relatively unweathered basalt stone and gravel occur from the surface and increase in amount with depth. Below *45cm*, there may be a narrow horizon of yellow decomposing basalt with black staining, before passing to massive basalt between *60cm* and *90cm*. Although the external drainage may in some instances be restricted by flatness, water penetrates easily into this soil.

It is considered that the stoniness and relatively shallow nature of the Oonah clay loam may in a large part be due to the physical nature of the basalt parent rock. The flat plateau residuals owe their existence to protection from dissection by a harder and denser than usual layer of flow basalt, which is frequently seen to outcrop at their edges. Such dense basalt offers considerable resistance to the weathering processes of soil formation and adds to the chance of a stony soil resulting. Further, it is not unlikely that this soil is younger than the deeper soils of the more mature landscape nearer the coast.

Subdominant soils are the Yolla clay loam, particularly the stony phase, which occurs on gentle, moderate and steep slopes where local dissection has occurred, and the Takone clay loam which occurs on low slopes in the vicinity of sluggish drainage lines crossing the plateaux and ridges. The pattern of these soils is indicated in Figure 5. The surface of the Takone clay loam, like that of the Oonah clay loam, may or may not have an accumulation of organic matter. The top soil horizon is a dull brown or dark brown clay loam which changes at about *15cm* to a dull yellowish brown or yellow-brown friable clay. Below *45cm* the colour brightens and the clay may be plastic when worked. At about *75cm* a mottled mealy much weathered basalt with black staining is encountered, and there is sometimes a temporary water-table in this material.

The unnamed soils of the creeks and hollows are minor constituents of this association.

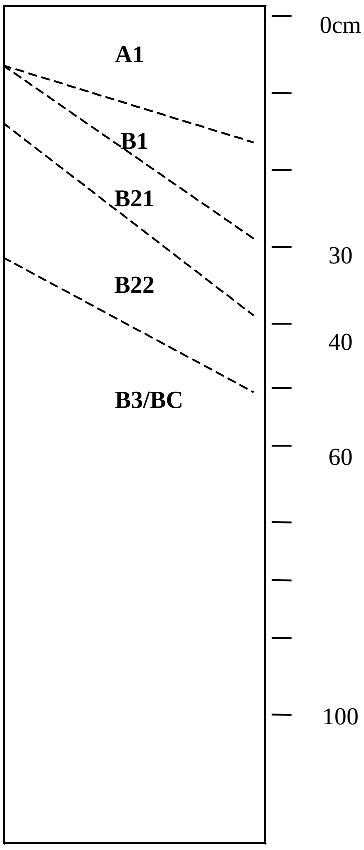
Correlation
These soils are typically dark brown, and are shallower and stonier than the basalt soils to the north (Burnie, Lapoinya and Yolla) due to lower temperatures and higher rainfall. Profile depth can vary, with a deep phase identified. Stone content is also variable, with the stony phase comprising up to 50% cobbles (Eldridge 2000).

Oonah Soil Profile Class

Concept **Shallow, well drained, friable red-brown to very dark brown clayey soils. Developed on undulating residual Tertiary Basalt plateaus at elevations above 400m.**

Aust. Soil Classification Homose-acidic to Acidic, Dystrophic to Mesotrophic Brown or red Ferrosols
Great Soil Group Krasnozem
Principal Profile Form Gn
Mapping Units Oonah Association (On)
Parent Material Tertiary Basalt
Landform Undulating plateau residuals predominantly at elevations above 400m.

Vegetation Mostly cleared
Surface Conditions Firm
Permeability Moderately permeable
Drainage Well drained



A1: Very dark brown to dark brown (7.5YR 2/2, 3/2, 3/3, 3/4); loam to clay loam; moderate to strong 2-5mm subangular blocky, plus <2mm subangular blocky or granular structure; weak (moist) consistence; 0-10% basalt coarse gravels; pH 5.2 – 5.5; clear to gradual change to

B1: Dark reddish brown to brown (5YR 3/4, 7.5YR 3/4, 4/4); clay loam to light clay strong 2-5mm subangular blocky, plus <2mm subangular blocky structure; weak (moist) consistence; 0-20% basalt coarse gravels; pH 5.0 – 5.4; gradual to diffuse change to

B21: Dark reddish brown to brown (5YR 3/4, 4/4, 7.5YR 3/4, 4/4); light to medium clay; strong 5-10mm subangular blocky, plus <2mm subangular blocky structure; weak (moist) consistence; 0-20% basalt coarse gravels; pH 5.0 – 5.4; clear to gradual change to

B22: Dark reddish brown to brown (5YR 3/4, 4/4, 7.5YR 4/4); light to medium clay; moderate to strong 5-10mm subangular blocky, parting to <2mm subangular blocky structure; weak to firm (moist) consistence; 20-90% basalt coarse gravels and cobbles; pH 5.0 – 5.5; gradual to diffuse change to

B3/BC: Reddish brown to strong brown (5YR 4/4, 4/6, 7.5YR 4/6); light to medium clay; massive to moderate 5-10mm subangular blocky structure; weak (moist) consistence; 50-90% basalt coarse gravels and cobbles; pH 4.5 – 5.1

Phases: **Oonah deep phase, Oonah bouldery phase** (Eldridge 2000), **Oonah steepland soils** (Grose & Cotching 1996)

Morphological Sites: CSIRO H118, H134, H146, BURNIE 1273, CARDS C1281, C0353
Analysed Sites: CSIRO H118, H134, H146
Related soil names: Dark-brown and very dark brown soils, Oonah Clay Loam, Oonah SPC
Previously described by: Stephens (1937), Hubble (1944), Loveday (1955), Nicolls (1955), Loveday & Farquhar (1958), Kershaw (1975), Eldridge (2000), Hill *et al* (1995)

Soil Profile Class Grid Reference	Profile Number	Horizon	Sample Depth (cm)	pH water (1:5)	EC (d/sm)	Total P (mg/kg)	Avail P (mg/kg)	Avail K (mg/kg)	Org. Carb. (%)	Total N (%)	C/N Ratio	Ca meq	Mg meq	Na meq	K meq
Oonah SPC	H118	A1	0-8	5.3		0.128			10.6	0.714	15				
393475 E		B1	8-15	5.2		0.112			7.8	0.491	16	2.1	1.45	0.31	0.48
5444265 N		B1	8-15												
		B21	15-30	5.0					6.1	0.408	15				
		B22	30-38	5.2		1.09			5.0	0.334	15	0.72	0.78	0.28	0.27
		B3	43-56	5.1											

Soil Profile Class Grid Reference	Profile Number	Horizon	Sample Depth (cm)	Total Bases	ECEC meq	BASE SAT (%)	ESP (%)	Ca/Mg Ratio	Gravel (of total) >2000 (um) (%)	Sand Coarse >200 (um) (%)	Sand Fine <200 (um) (%)	Silt (%)	Clay (%)
Oonah SPC	H118	A1	0-8										
393475 E		B1	8-15	4.34	58.34	7	0.5	1.45	3	7	8	15	57
5444265 N		B1	8-15										
		B21	15-30										
		B22	30-38	2.05	50.85	4	0.6	0.92	14	7	11	16	56
		B3	43-56										

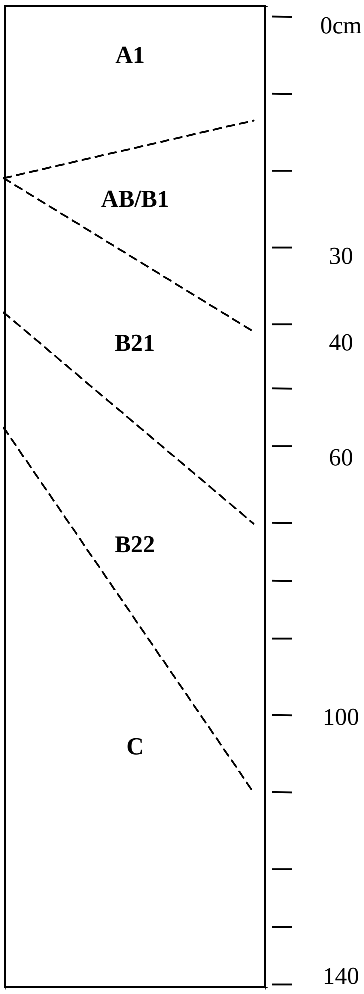
Table 11 Analytical data for the Oonah SPC

Takone Soil Profile Class

Concept — **Brown, well structured, imperfectly drained clayey soils developed on Tertiary Basalt in drainage depressions.**

Aust. Soil Classification Brown Ferrosol
Great Soil Group Krasnozem
Principal Profile Form Gn
Mapping Units Oonah Association (On)
Parent Material Tertiary Basalt
Landform Level to gently undulating plateau residuals in drainage depressions with impeded outflow, and lower slopes adjacent to creek-lines, landslip and slump areas.

Vegetation Mainly cleared, with small areas of Myrtle forest.
Surface Conditions Firm to soft
Permeability Moderately permeable
Drainage Imperfectly drained



A1: Dark brown to very dark greyish brown (5YR 3/3, 3/4, 10YR 4/3, 3/3, 3/2); clay loam to light clay; moderate to strong 5-20mm subangular blocky structure; weak to firm (moist) consistence; 0-10% 2-6mm manganiferous concretions or soft segregations; 0-2% basalt fine gravels; pH 5.1 – 7.0; clear to gradual change to

AB/B1: Brown to dark yellowish brown (7.5YR 4/4, 10YR 3/4, 4/4); light to medium clay; weak to strong 5-10mm subangular blocky or polyhedral structure; weak to firm (moist) consistence; 0-10% 2-6mm manganiferous concretions; pH 5.4 – 5.7; clear to gradual change to

B21: Brown to dark yellowish brown (7.5YR 4/4, 4/6, 10YR 4/4, 4/3) with occasional reddish brown to orange mottles; light to medium clay, moderate to strong 5-10mm subangular blocky or polyhedral structure; weak to firm (moist) consistence; 2-20% 2-20mm manganiferous concretions; pH 5.2 – 6.9; clear to gradual change to

B22: Strong brown to dark yellowish brown (10YR 4/3, 4/4, 4/6, 7.5YR 5/8) with orange, red and yellowish brown mottles; light to medium clay; moderate 5-20mm subangular blocky structure; weak to firm (moist) consistence; 2-20% 6-20mm manganiferous concretions; pH 5.1 – 6.3; clear change to

C: Dark yellowish brown to yellowish brown (10YR 4/4, 5/8) with brown, yellowish brown and red mottles; loam to light clay; massive structure

Phases: **Takone moderately well drained phase, Takone poorly drained phase** (Eldridge 2000)

Morphological Sites: CARDS C0366, NWBEC G43, BURNIE 1168, 1076, 1010, 1102
Analysed Sites: BURNIE 1010 (Part analysis)
Related soil names: Takone Clay Loam
Previously described by: Stephens (1937), Hubble (1944), Loveday (1955), Loveday & Farquhar (1958), Grose & Cotching (1996), Eldridge (2000)

Soil Profile Class Grid Reference	**Profile Number**	**Horizon**	**Sample Depth (cm)**	**pH water (1:5)**	**EC (d/sm)**	**Total P (mg/kg)**	**Avail P (mg/kg)**	**Avail K (mg/kg)**	**Org. Carb. (%)**	**Total N (%)**	**C/N Ratio**	**Ca meq**	**Mg meq**	**Na meq**	**K meq**
Takone SPC 401300 E 5443700 N	BURNIE 1010	AB	16-34									8.5	11	1.58	1.47

Soil Profile Class Grid Reference	**Profile Number**	**Horizon**	**Sample Depth (cm)**	**Total Bases**	**CEC meq**	**BASE SAT (%)**	**ESP (%)**	**Ca/Mg Ratio**	**Gravel (of total) >2000 (um) (%)**	**Sand Coarse >200 (um) (%)**	**Sand Fine <200 (um) (%)**	**Silt (%)**	**Clay (%)**
Takone SPC 401300 E 5443700 N	BURNIE 1010	AB	16-34	22.55	23	98	6.9	0.77					

Table 12 Analytical data for the Takone SPC

West Ridgley Association (*31 sq. kilometres*)

Dominant soil types	Type 1 *(West Ridgely SPC)* Yolla clay loam *(Yolla SPC)* and slump complex
Subdominant soil type	Oonah clay loam (*Oonah SPC)*
Minor soil types	Unnamed dark soil with plastic subsoil Unnamed creek soils

Two areas, each of about *15 sq. kilometres*, in the West Ridgley and Tewkesbury districts comprise this association. It is distinguished from the surrounding Yolla and Oonah associations by the occurrence within it of certain very dark soils which do not occur in these other two associations. As the West Ridgley association also contains significant areas of both the soil types, the Yolla clay loam, and the Oonah clay loam, the boundary with the surrounding associations is in many places arbitrarily placed.

The dark soils vary from those with rather friable surface and subsoils (Type 1) to those with plastic and mottled subsoils. Occurring as they do on gentle, moderate, and steep slopes no obvious relation with topography or drainage could be observed. In this general area there are several exposures of volcanic breccia indicating explosive volcanic activity in the vicinity. It is therefore suggested that a possible explanation for the existence of these dark soils is a difference in the parent basalt.

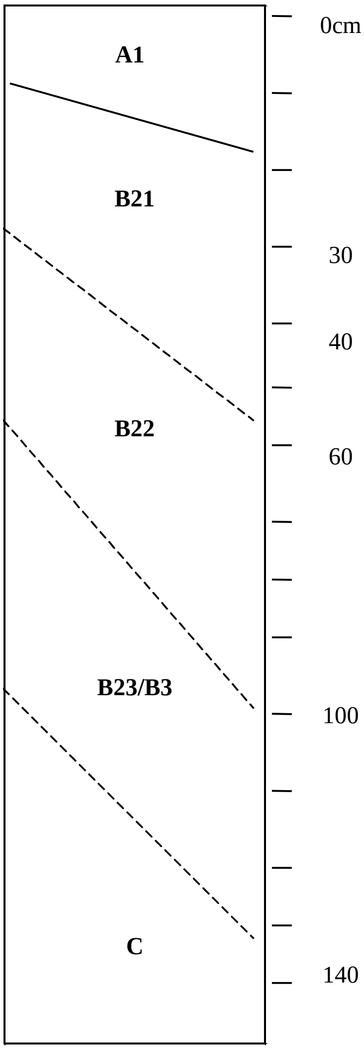
Type 1 has a dark grey-brown or black friable clay loam surface. This overlies at about *20cm* a dark yellowish or dark brownish grey friable clay with a well-developed granular structure. The colour becomes lighter with depth and between *60cm* and *100cm* there is a gradual change to a mottled, mealy, and much-weathered basalt horizon. This soil occupies considerable areas, but the unnamed dark soil with a mottled and plastic subsoil is of minor extent only. The latter is similar in many respects to Hicks clay loam of the Burnie association.

Correlation
These soils include a moderately well drained phase, with more strongly developed structure, and mottles below 50cm. A heavy clay variant is also found, which is poorly drained and have weakly developed or massive structured heavier clay subsoils (Eldridge 2000).

West Ridgely Soil Profile Class

Concept	**Moderately deep, imperfectly to moderately well drained, dark grey clayey soils developed on Tertiary Basalt around West Ridgely.**

Aust. Soil Classification	Brown or grey Ferrosol
Great Soil Group	Krasnozem
Principal Profile Form	Gn to Uf
Mapping Units	West Ridgely Association (Wr)
Parent Material	Tertiary Basalt
Landform	Mid and lower slopes, and upper landslip areas of rolling hills, localised to small area at West Ridgely
Vegetation	Mostly cleared
Surface Conditions	Firm
Permeability	Moderately to slowly permeable
Drainage	Imperfectly to moderately well drained



A1:	Very dark brown to very dark greyish brown (7.5YR 2/3, 10YR 2/3, 3/2); heavy clay loam to light clay; moderate 2-5mm subangular blocky, plus moderate to strong <2mm subangular blocky structure; weak (moist) consistence; 0-10% basalt coarse gravels to cobbles; pH 5.8 – 6.8; abrupt to clear change to
B21:	Dark brown to dark grey (10YR 3/3, 3/2, 2.5Y 3/2) with yellow or brown mottles sometimes present; light medium to medium heavy clay; moderate to strong 10-50mm polyhedral or subangular blocky, parting to 5-10mm subangular blocky structure; weak to firm (moist) consistence; 0-2% quartz fine gravels; pH 5.3 – 6.2; clear to gradual change to
B22:	Dark grey to olive brown (10YR 4/1, 4/3, 3/6, 2.5Y 4/3) with prominent yellow, brown or reddish brown mottles; light medium to medium heavy clay; weak to moderate 10-20mm subangular blocky or polyhedral, plus 5-10mm subangular blocky structure; weak to firm (moist) consistence; 0-20% manganiferous soft segregations; 0-10% basalt fine gravels; pH 4.8 – 6.2; gradual to diffuse change to
B23/B3:	Dark yellowish brown to olive brown (10YR 4/4, 2.5Y 4/3) with red mottles; light to medium clay; weak to moderate 5-10mm angular or subangular blocky structure; weak (moist) consistence; 0-20% soft segregations; 0-50% weak basalt medium gravels; pH 4.7 – 5.0; diffuse change to
C:	Mealy, decomposed basalt
Phases:	**Moderately well drained phase, Poorly drained phase** (Eldridge 2000).

Morphological Sites: CSIRO H144, BURNIE 1022, 1020, 1265
Analysed Sites: CSIRO H144
Related soil names: West Ridgely Clay, Type 1
Previously described by: Stephens (1937), Hubble (1944), Loveday (1955), Loveday & Farquhar (1958), Eldridge (2000)

Soil Profile Class Grid Reference	**Profile Number**	**Horizon**	**Sample Depth (cm)**	**pH water (1:5)**	**EC (d/sm)**	**Total P (mg/kg)**	**Avail P (mg/kg)**	**Avail K (mg/kg)**	**Org. Carb. (%)**	**Total N (%)**	**C/N Ratio**	**Ca meq**	**Mg meq**	**Na meq**	**K meq**
West Ridgely SPC	H144	A11	0-8	5.8		0.08			3.4	0.314	11	10.8	4.0	0.18	1.3
397210 E		A11	0-8												
5443852 N		A12	8-18	5.6		0.62			2.7	0.228	12				
		B21	22-33	5.3		0.24			1.3	0.124	10	5.05	4.8	0.15	0.82
		B22	33-46	5.0											
		B23	46-61	4.8					0.6						
		B24	61-81	4.7											
		B25	81-99	4.9		0.016						2.6	4.9	0.16	0.10
		C1	104-124	4.8											
		C2	168-183	4.7											

Soil Profile Class Grid Reference	**Profile Number**	**Horizon**	**Sample Depth (cm)**	**Total Bases Sum meq**	**ECEC meq**	**BASE SAT (%)**	**ESP (%)**	**Ca/Mg Ratio**	**Gravel (of total) >2000 (um) (%)**	**Sand Coarse >200 (um) (%)**	**Sand Fine <200 (um) (%)**	**Silt (%)**	**Clay (%)**
West Ridgely SPC	H144	A11	0-8	16.28	39.48	41	0.5	2.70		2	16	3`	37
397210 E		A11	0-8										
5443852 N		A12	8-18										
		B21	22-33	10.82	30.42	36	0.5	1.05		1	11	32	48
		B22	33-46										
		B23	46-61										
		B24	61-81										
		B25	81-99	7.76	28.76	27	0.6	0.53		5	11	25	58
		C1	104-124										
		C2	168-183										

Table 13 Analytical data for the West Ridgely SPC

Soils on Dolerite

Calder Association (*25 sq. kilometres*)

Dominant soil types	Types 2 *(Calder SPC)* and Type 3
Subdominant soil types	Intergrades between Types 2 and 3

Krasnozemic soils formed on several ridges and hills of dolerite, mainly in the vicinity of Henrietta, make up the Calder association. Slopes vary from gentle to steep. Although generally the dolerite is weathered to considerable depths the soil surface is strewn with relatively unweathered dolerite boulders and stones. This feature, probably more than any other, has prevented these soils being developed for agriculture. The natural forest was of stringybark with myrtle in the wettest situations. This has been largely cut over and regrowth forest is now establishing.

There is variation in the soils present from those of reddish colour throughout the profile (*Calder SPC*) to those of yellowish colour (Type 3). All grades between these types exist. Though no clear-cut relation with topography was observed, it is probably that the Type 3 soils occur in the less well-drained situations. Under forest there is a surface layer of fallen leaves and twigs over a layer of rotting organic matter and charcoal with earthworms, living roots and white fungal hyphae. This layer may be absent, owing presumably to repeated burning.

The *Calder SPC* has the following description. The surface is brown or reddish brown friable clay loam of granular structure and with some dolerite gravel and stone. At about *15cm* there is a gradual change to a red-brown friable clay usually with considerable decomposing dolerite, yellow-brown in colour. Below *60cm* there is a gradual transition to yellow-brown mealy highly weathered dolerite with red-brown clay down cracks and pockets and streaks stained with black. This weathered material continues to depths greater than *1.5m*.

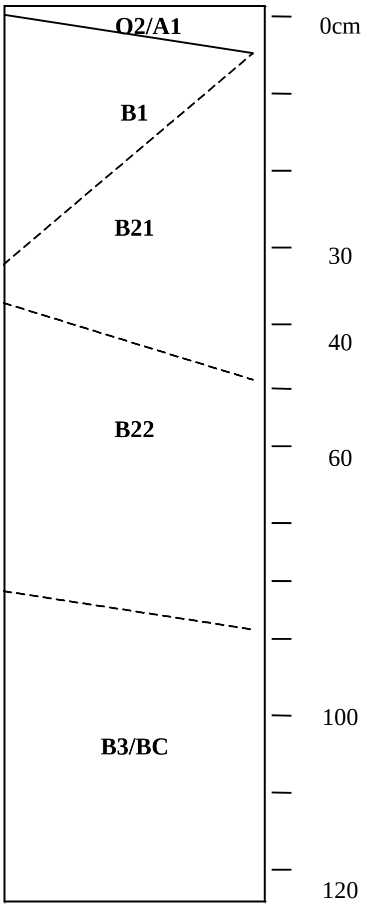
Type 3 is similar except that the surface colour is brown or yellowish brown and the subsoil yellow brown.

Correlation
This is a relatively small unit. The Calder Soil Profile Class (Type 2) appeared in greater extent, and seemed to be present at higher elevations, than the Type 3 soils. This could imply a colour influence from the more elevated basalt soils, although small random areas of yellow-brown subsoils were observed

The browner Type 3 soils were mainly found in lower elevations in the southern areas of the unit. No intact profiles could be obtained due to disturbance caused by forestry clearing and re-planting.

Calder Soil Profile Class

Concept	**Well drained, friable red clayey soils developed on dolerite.**
Aust. Soil Classification	Red Ferrosol
Great Soil Group	Krasnozem
Principal Profile Form	Gn
Mapping Units	Calder Association (Cl)
Parent Material	Jurassic dolerite
Landform	Gentle to steep hills and ridges.
Vegetation	*E. obliqua*, Myrtle, mostly cleared with forestry regrowth
Surface Conditions	Loose
Permeability	Moderately permeable
Drainage	Well drained



O2: Decomposing organic accumulation; or

A1: Black (5YR 2/1); clay loam; massive structure; very weak (moist) consistence; 10-20% dolerite fine gravels; abundant 1-2mm fine roots; pH 6.2; sharp change to

B1: Reddish brown (5YR 4/4); clay loam; moderate 5-10mm granular structure; very weak (moist) consistence; many <1mm live roots; 5-10% dolerite fine gravels; pH 5.8; gradual change to

B21: Reddish brown to yellowish red (5YR 4/4, 4/8); light to medium clay; moderate 5-10mm granular structure; very weak to weak (moist) consistence; many 1-2mm live roots; 2-20% dolerite coarse gravels; pH 5.6 – 5.8; gradual change to

B22: Dark reddish brown to yellowish red (2.5YR 3/4, 5YR 4/8) with occasional faint red mottles; medium clay; moderate 5-10mm granular or polyhedral structure; very weak to weak (moist) consistence; few to common 1-2mm live roots; 2-10% dolerite cobbles; pH 5.1 – 5.2; gradual change to

B3/BC: Dark reddish brown to red (2.5YR 3/4, 4/5) with occasional faint yellowish red mottles; light medium to medium clay; massive structure; very weak to weak (moist) consistence; occasional manganiferous segregations; 10-20% decomposing dolerite fine gravels and cobbles; pH 5.1 – 5.3

Morphological Sites: CSIRO H165, SOILCO 101
Analysed Sites: CSIRO H165
Related soil names: Type 2
Previously described by: G. Dimmock (1957), J. Loveday & R. Farquhar, (1958)

Soil Profile Class Grid Reference	**Profile Number**	**Horizon**	**Sample Depth (cm)**	**pH water (1:5)**	**EC (d/sm)**	**Total P (mg/kg)**	**Avail P (mg/kg)**	**Avail K (mg/kg)**	**Org. Carb. (%)**	**Total N (%)**	**C/N Ratio**	**Ca meq**	**Mg meq**	**Na meq**	**K meq**
Calder SPC	H165	A1	0-3	6.2	0.063	0.06			6.9	0.328	21	13.4	5.2	0.18	0.83
386564 E		B21	3-10	5.8	0.045	0.031			3.8	0.146	26	5.5	2.6	0.15	0.42
5438455 N		B21	10-18	5.6	0.042				2.8	0.105	27				
		B21	18-38	5.4	0.042				2.2	0.091	24	2.2	2.7	0.27	0.42
		B22	38-61	5.2	0.030				1.95	0.07	28				
		B22	61-89	5.3	0.027	0.02			0.80	0.04	20	1	0.8	0.26	0.35
		B22	89-102	5.2	0.039					0.026					
		B3	102-119	5.1	0.039				0.47	0.021	22	0.94	1.2	0.20	0.22
		B3	119-135	5.1	0.054										
		BC	137-152	5.3	0.042	0.048				0.01		0.53	0.42	0.39	0.19

Soil Profile Class Grid Reference	**Profile Number**	**Horizon**	**Sample Depth (cm)**	**Total Bases meq**	**ECEC meq**	**BASE SAT (%)**	**ESP (%)**	**Ca/Mg Ratio**	**Gravel (of total) >2000 (um) (%)**	**Sand Coarse >200 (um) (%)**	**Sand Fine <200 (um) (%)**	**Silt (%)**	**Clay (%)**
Calder SPC	H165	A1	0-3	19.61	53.81	36	0.3	2.58	8	8	13	22	45
386564 E		B21	3-10	8.67	35.87	24	0.4	2.12	8	5	9	15	62
5438455 N		B21	18-38	5.59	30.09	19	0.9	0.81	13	4	10	29	51
		B22	38-61						0	3	10	10	75
		B22	61-89	2.41	22.81	11	1.1	1.25	0	2	11	13	72
		B22	61-89										
		B22	89-102										
		B3	102-119	2.56	23.86	11	0.8	0.78	0	1	8	34	52
		B3	119-135										
		BC	137-152	1.53	21.93	7	1.8	1.26	0	6	36	23	19

Table 14 Analytical data for the Calder SPC

Soils on Granite

Natone Association (*60 sq. kilometres*)

Dominant soil type	Natone sandy clay loam
Subdominant soil type	Unnamed soils with bleached subsurface
Minor soil types	Unnamed soils with hard pans
	Soils of mixed granite and basalt parentage

In the south-east part of the surveyed area dissection of the basalt sheet has exposed underlying granites, which have in turn been dissected to produce a hilly landscape with slopes varying from gentle to steep. Large granite outcrops or tors occur, particularly on the steeper slopes. The vegetation is largely regrowth eucalypt forest, both the normal stringybark (*E. obliqua*) and white-topped stringybark (*E. delegatensis*) occurring. There are some areas of rather sparsely growing black peppermint (*E. amygdalina*).

The soils of these granite areas have been mapped as the Natone association. They are all gritty to a greater or less degree, but show considerable variation in other characters. They may be arranged in sequence in order of increasing profile maturity: (1) Natone sandy clay loam, a soil with a bleached horizon; (2) unnamed soils with a loamy sand surface and a bleached subsurface horizon; (3) unnamed soils with a grit surface, a bleached subsurface horizon, and a hardpan. Gradations between these three soils were observed.

Of the three, Natone sandy clay loam is the most extensive. It occurs on the steeper slopes in association with granite outcrops. The surface may have a shallow leaf litter and decomposing organic matter layer over the grey-brown friable sandy clay loam topsoil. This contains much angular quartz grit. There is a gradual change through a brown friable gritty sandy clay loam to a brown, reddish, or yellowish brown gritty sandy clay subsoil. At depth yellow colours are more general and mica flakes and feldspar grains from the weathering granite becomes prominent. Below *75cm* there is a gradual change to light yellow weathering granite.

The *unnamed soils with a bleached subsurface horizon* occur on gentle or moderate slopes. A shallow surface accumulation of organic matter overlies a grey-brown to dark grey loamy sand or sandy loam with quartz grit. The subsurface is a light grey-brown gritty sandy which passes gradually to the subsoil at *30cm.* This is a brown, reddish brown, or yellow-brown gritty sandy clay becoming brighter in colour with depth. Below *50cm* weathering granite appears.

The third group, *soils with a hardpan horizon*, is of restricted occurrence in gently undulating areas. A dark grey or black grit with coarse organic matter overlies a light grey sandy grit loose in the upper part but becoming compacted and then indurated to an impenetrable hardpan at depths between *30cm* and *90cm.*

The soils with a bleached subsurface horizon and those with a hardpan are closely paralleled by soils of the Emita association and the Boyes series respectively of Flinders Island described by Dimmock (1957).

Included with this association are some small areas where dissection of the basalt has barely exposed the granite, so that a variety of soils of mixed parentage are formed.

Correlation
Insufficient data and a high variability of these soils prevented the compilation of the Natone soil profile class. Several sites were found on the DPIWE soils database, but descriptions were too different to enable typical features to be identified.

Soils on Granite and Basalt

Riana Association `(*13 sq. kilometres*)

Soil types present	Miscellaneous soils of mixed parentage (basalt and granite)
	Lapoinya clay loam (*Lapoinya SPC)*
	Natone sandy clay loam
	Dark, poorly drained soils of a flat area

This, the smallest of the associations, comprises an area of country in the south-east of the survey, where basalt and granite are intimately associated, and consequently many of the soils are of mixed parentage. The landscape is undulating with gentle and moderate slopes and granite outcrops scattered here and there.

Many of the soils are similar to Lapoinya clay loam but contain some angular quartz grit through the profile. Other soils fit the description of Natone sandy clay loam, while some show intermediate characters depending on the relative contribution of basalt and granite to the parent material.

In the north-west corner of the association there is an unusually flat and poorly drained piece of country approximately half a square mile in extent. The soils, which are developed on basalt, are dark coloured with mottled and sticky subsoils.

Correlation

There was insufficient data available for this small, highly variable association.

Soils on Quartzite

Sisters Hills Association (*72 sq. kilometres*)

Dominant soil type	Sisters Hills sand *(Sisters Hills SPC)*
Minor soil types	Peaty podzols
	Yellow podzolics of Cam association
	Sandy soils on sandstone

The country of the Sisters Hills and its outliers forms a distinct unit with soil, vegetation, topography and parent rock sharply differentiated from the surrounding Lapoinya and Burnie associations. This country has been mapped as the Sisters Hills association. The dominant rock is a dense white quartzite, but some schists, conglomerate and sandstone also occur. The slopes of the Sisters Hills are generally moderate or steep and rock outcrops are common. The vegetation is largely heath with sparse stunted eucalypts (*E. simmondsii* and *E. amygdalina*). In some gullies and on areas of schist and sandstone, patches of stringybark (*E. obliqua*) forest have developed.

The most widespread soil in the moderate and steep slopes is the *Sisters Hills sand*. It has a dark grey or black organic sand surface, usually coherent and with angular quartz grit and gravel. This overlies a light grey or very light grey subsurface of loose or slightly compacted sand with angular quartz gravel. Between *25cm* and *75cm* there is a change to an almost white strongly indurated sand and gravel hardpan, which in quarries and roadcuts was seen to pass directly to the parent quartzite or quartzitic colluvium.

In limited areas where slopes are more gentle a shallow sandy peat develops over a podzol profile. One such profile consisted of *22cm* of sandy black fibrous peat over a grey-brown compact loamy sand with angular quartz gravel. At *45cm* this passed to a very light grey compact sand with much gravel and dark grey-brown organic staining, particularly in the upper part. The bleached compact sand horizon continued beyond *120cm*. The heath vegetation of such sites includes scattered plants of button grass (*Gymnoschoenus sphaerocephalus*).

Other minor constituents are yellow podzolic soils of the Cam association and sandy soils developed on sandstone which vary from shallow and stony profiles to deep sands darkened by organic matter in the surface and bleached below.

Correlation

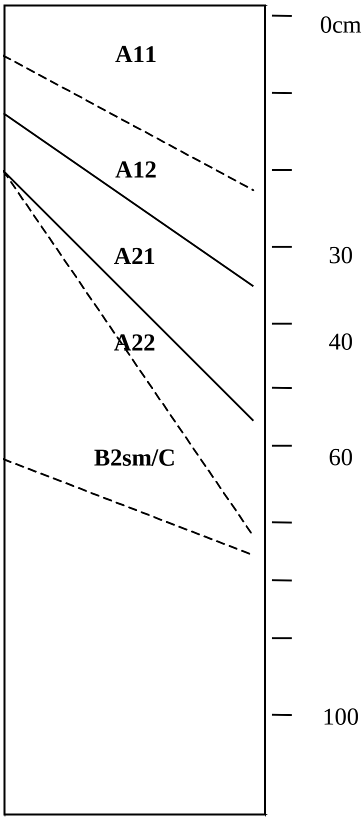
The Sisters Hills soil profile class is based on descriptions correlating to the dominant soil described by the original author. These soils were found to have a white cemented hard pan, which can display traces of an organic-humus-iron complex lining pores and cracks. When present, this Bsm horizon identifies these profiles as Podosols, or Rudisols when absent.

Sisters Hills Soil Profile Class

Concept **Poorly structured, shallow, stony sandy soils.**

Aust. Soil Classification Aeric Podosols or Rudosols
Great Soil Group Podzol
Principal Profile Form Uc
Mapping Units Sisters Hills Association (Sh)
Parent Material Precambrian quartzite
Landform Moderate to steep hills, with common rock outcrops.

Vegetation Heath, with sparse stunted eucalypts (*E. simmondsii, E. amygdalina, E. obliqua*)
Surface Conditions Firm
Permeability Moderately to slowly permeable
Drainage Imperfectly drained



A11: Dark grey to very dark grey (10YR 3/1, 4/1); fibric sand or sand; single grain structure; loose (dry) to very firm (moist) consistence; some organic-humus coatings lining pores and cracks; 0-20% quartzite coarse gravels; pH 4.5 – 4.8; clear to gradual change to

A12: Grey to very dark greyish brown (10YR 6/1, 3/2); fibric sand or sand; single grain, plus weak subangular blocky structure; loose (dry) to very firm (moist) consistence; few organic-humus coatings lining pores and cracks; 2-20% quartzite fine to coarse gravels; pH 4.3 – 4.8; clear change to

A21: White to dark grey (10YR 8/1, 4/1); sand; single grain structure; loose (dry and moist) consistence; 10-90% quartz fine to coarse gravels; pH 4.2 – 5.5; clear change to

A22: Grey (10YR 5/1); sand; single grain structure; loose (moist) consistence; 50-90% quartz coarse gravels; pH 4.2; diffuse change to

B2sm/C: Light grey (10YR 7/1); sand; massive to single grain structure; occasional organic-humus coatings lining pores and cracks; 10-90% quartz fine to coarse gravels; discontinuous moderate cementation; pH 5.0

Morphological Sites: CSIRO H149, NWRBD 1
Analysed Sites: CSIRO H149
Related soil names: Sisters Hills Sands
Previously described by: Stephens (1937), Hubble (1944), Loveday (1955), Loveday & Farquhar (1958), Eldridge (2000)

Soil Profile Class Grid Reference	**Profile Number**	**Horizon**	**Sample Depth (cm)**	**pH water (1:5)**	**EC (d/sm)**	**Total P (mg/kg)**	**Avail P (mg/kg)**	**Avail K (mg/kg)**	**Org. Carb. (%)**	**Total N (%)**	**C/N Ratio**	**Ca meq**	**Mg meq**	**Na meq**	**K meq**
Sisters Hills SPC	H149	A11	0 – 6	4.5		0.006			10	0.374	27	7.1	3.4	0.26	0.24
381761E		A11	0 – 6								28				
5469062N		A12	6 – 15	4.3					4.4	0.156					
		A21	15 – 23	4.4						0.102					
		A22	35 - 46	4.2											

Soil Profile Class Grid Reference	**Profile Number**	**Horizon**	**Sample Depth (cm)**	**Total Bases Sum meq**	**ECEC Sum meq**	**BASE SAT (%)**	**ESP (%)**	**Ca/Mg Ratio**	**Gravel (of total) >2000 (um) (%)**	**Sand Coarse >200 (um) (%)**	**Sand Fine <200 (um) (%)**	**Silt (%)**	**Clay (%)**
Sisters Hills SPC	H149	A11	0 – 6	11	54	20	0.5	2.09	6	32	38	7	4
381761E		A11	0 – 6										
5469062N		A12	6 – 15						9				
		A21	15 – 23										
		A22	35 - 46										

Table 15 Analytical data for the Sister Hills SPC

Soils on Schists

Cam Association (*135 sq. kilometres*)

Dominant soil types	Various unnamed yellow podzolic soils *(Cam SPC)*
Minor soil types	Unnamed red podzolic soils Soils of the Sisters Hills association Soils of the Inglis association Soils of the Flowerdale association

Schists and some quartzites outcrop along the lower valley tracts of the Blythe, Emu, Cam, Guide, Inglis and Flowerdale rivers. Dissection, which has removed the basalt, has generally produced steep-sided sharp ridges in the underlying rocks, but in one area in particular, above the Flowerdale River, the country is more undulating. These areas together comprise the Cam association.

The vegetation of the majority of this association is regrowth stringybark (*E. obliqua*) forest in various stages of maturity. Small areas of the original forest west of Preolenna are still being exploited. Wherever the rock is mainly quartzitic a black peppermint (*E. amygdalina*) woodland replaces the stringybark forest. Under forests not recently fired shallow horizons of leaf litter and decomposing organic matter have accumulated. In one site under the original stringybark and myrtle forest the leaf and twig litter horizon was *2.5cm* deep and the decomposing organic matter, dark brown and fibrous, *30cm* deep. Where firing has destroyed these accumulations the soil surface is usually seen to be scattered with small fragments of angular quartz derived from the schists.

The dominant soils *(Cam SPC)* which occur on slopes ranging from gentle to steep are yellow podzolics. They show considerable variation. An organic matter accumulation may overlie the dark grey or dark grey-brown topsoil, which has a texture varying from loamy sand to sandy or silty loam, usually friable and containing angular quartz gravel. In most instances a bleached subsurface horizon, light grey and often weakly mottled with brownish and yellowish grey, is present. It may be finer textured than the topsoil, friable, slightly compact, or rarely indurated. The subsoil varies from yellowish brown to bright yellow-brown, sometimes mottled with light grey and with a grey-brown wash on aggregate faces in the upper part. Its texture varies from sandy clay loam to clay, which is usually friable in the moist state. At depth the colour generally brightens and below *60cm* there are increasing amounts of decomposing schist. Several profiles showed very light-coloured clay subsoils.

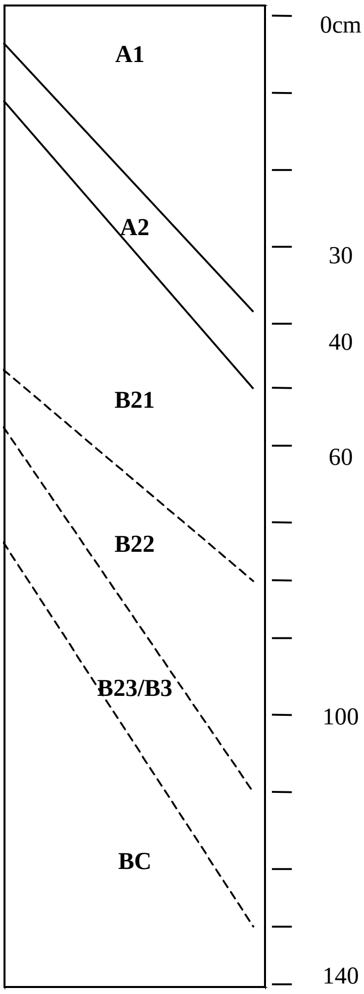
The minor constituents of this association are (i) unnamed red podzolic soils, usually stony and shallow and occurring particularly on steep sites, the surface of which is a dark silty loam or clay loam overlying a brown subsurface which gradually changes to a reddish or red-brown clay loam or clay subsoil, (ii) podzols developed on quartzites as described for the Sisters Hills association, (iii) podzols developed on gravels and sands-soils of the Inglis association and (iv) narrow strips of soils of the Flowerdale association along rivers and creeks.

Correlation

The extreme variability and low sample density of these soils results in a loosely defined soil profile class. This variability is due to different sediment types and the degree of metamorphism to which they have been subjected. These range from moderately well to poorly drained, and are usually moderately erodible on gentle slopes, to highly erodible on steeper slopes (Eldridge 2000).

Cam Soil Profile Class

Concept	**Shallow to moderately deep texture contrast soils, comprising bleached sandy sub-surface over a yellow mottled clay.**
Aust. Soil Classification	Brown Kandosol or Yellow Kurosol
Great Soil Group	Yellow Podzolic
Principal Profile Form	Gn, Dy
Mapping Units	Cam Association (Cc), Hellyer Association (Hl)
Parent Material	Precambrian quartzite, schists and slate
Landform	Steep slopes of river valleys, hill crests and outcrops
Vegetation	*E. obliqua, E. amygdalina*
Surface Conditions	Soft or self-mulching
Permeability	Slowly permeable
Drainage	Imperfectly to moderately well drained



A1: Dark brown, black to very dark grey (7.5YR 3/2, 10YR 2/2, 2/1, 3/1); silty or sandy loam; weak to moderate 2-10mm subangular blocky or polyhedral structure; weak (moist) to very weak (dry) consistence; 0-20% quartz fine to medium gravels; pH 3.8 – 4.5; clear change to

A2: Very dark greyish brown to grey (10YR 4/1, 3/2, 6/1); fine sandy to sandy loam; massive structure; weak (moist/ dry) to very weak (dry) consistence; 10-20% quartz fine gravels; pH 3.5 – 4.7; clear change to

B21: Dark yellowish brown to yellowish brown (10YR 4/6, 5/6, 5/7); light sandy clay loam to sandy light clay; weak to moderate 2-10mm subangular or polyhedral structure; weak (dry and moist) consistence; 2-50% quartz fine gravels; pH 4.1 – 4.5; gradual to diffuse change to

B22: Yellowish brown (10YR 5/6, 5/7), with occasional faint brown mottles; sandy light clay to fine sandy medium clay; massive to weak 2-5mm polyhedral structure; very weak to weak (moist) consistence; varying amounts (2-90%) of quartz or sandstone fine gravels; pH 4.1 – 4.6; gradual to diffuse change to;

B23/B3: Yellowish brown (10YR 5/6, 5/7); fine sandy to silty medium clay; massive structure; weak (moist) consistence; 10-20% fine quartz or sandstone gravels; pH 4.9

BC: Yellowish brown (10YR 5/7); heavy clay

Morphological Sites: CSIRO H141, BURNIE 1123, 1126
Analysed Sites: CSIRO H141
Related soil names: Grey Sandy Soil, Un-named yellow podzolic soil
Previously described by: Stephens (1937), Hubble (1944), Loveday (1955), Loveday & Farquhar (1958), Eldridge (2000)

Soil Profile Class Grid Reference	**Profile Number**	**Horizon**	**Sample Depth (cm)**	**pH water (1:5)**	**EC (d/sm)**	**Total P (mg/kg)**	**Avail P (mg/kg)**	**Avail K (mg/kg)**	**Org. Carb. (%)**	**Total N (%)**	**C/N Ratio**	**Ca**	**Mg**	**Na**	**K**
Cam SPC	H141	A1	5-10	4.0		0.02									
378640 E		A2	10-15	4.3		0.008			2.9	0.162	18	1.3	0.58	0.14	0.22
5452818 N		A2	10-15												
		B1	23-28	4.3					1.5	0.08	19				
		B21	30-46	4.5					0.8	0.051	16	0.1	0.65	0.11	0.09
		B22	46-61	4.6											
		B23	69-81	4.9											
		BC	81-94	4.6											
		C	94-112	5.0											
		R	112-117	5.0											

Soil Profile Class Grid Reference	**Profile Number**	**Horizon**	**Sample Depth (cm)**	**Total Bases Sum meq**	**ECEC meq**	**BASE SAT (%)**	**ESP (%)**	**Ca/Mg Ratio**	**Gravel (of total) >2000 (um) (%)**	**Sand Coarse >200 (um) (%)**	**Sand Fine <200 (um) (%)**	**Silt (%)**	**Clay (%)**
Cam SPC	H141	A1	5-10										
378640 E		A2	10-15	2.24	24.54	9	0.6	2.24	5	8	62	15	12
5452818 N		A2	10-15										
		B1	23-28										
		B21	30-46	0.95	9.25	9	0.9	0.15	6	10	61	16	15
		B22	46-61										
		B23	69-81										
		BC	81-94										
		C	94-112										
		R	112-117										

Table 16 Analytical data for the Cam SPC

Soils on Tillites and Shale

Hellyer Association (*205 sq. kilometres*)

Dominant soil types	Various unnamed yellow podzolic soils
Minor soil types	Unnamed red podzolic soils
	Deep sandy soils on sandstone
	Peats
	Soils of the Inglis association
	Soils of the Flowerdale association

This is the second largest of the associations and occurs in central and south-western parts of the surveyed area. The numerous rivers and creeks have dissected the basalt sheet to expose a variety of underlying sediments of Permian age. The dissection has generally produced steep-sided ridges and in places cliffs, but some of the ridge tops are gently sloping and more or less extensive. The most widespread of the sediments are tillites, while mudstones, shales and sandstone also occur.

Apart from some near-virgin forest of stringybark (both *E. obliqua* and *E. delegatensis*) with myrtle in the gullies in the south-west corner near the junction of the Hellyer and Arthur Rivers, the natural vegetation has been much altered. In many places regrowth eucalypt forests are flourishing, but in other areas land once cleared for farming is now carrying bracken fern and shrubs and some poor grasses.

The soils of a very large proportion of the association are yellow podzolics which show a considerable degree of variation. They may be broadly divided into two groups. The first group includes those soils which do not have a distinct bleached subsurface horizon. Where firing has not been recent there is a shallow accumulation of decomposing organic matter, over the grey-brown to dark grey-brown topsoil, which is more commonly a silty clay loam but may be a sandy or silty loam. This material is often compact when dry but friable in the moist state. There is a gradual change at depths between *10cm* and *30cm* to yellow-brown or light yellowish brown clay, sometimes silty or fine sandy. In the upper part there may be a grey-brown staining on aggregate faces. With depth the colour brightens and fragments of decomposing shale, mudstone or tillite become more prominent. Some water-worn quartz gravel may be present throughout the profile. The weathering rock is usually encountered at depths near *75cm* but the soil may occasionally be deeper.

The second group includes those soils which have a distinct bleached subsurface horizon. The topsoil is a brownish grey to dark grey fine sandy loam or less frequently a silty clay loam. Between *8cm* and *15cm* this passes to a very light grey or light grey-brown, sometimes weakly mottled with yellow-brown, fine sandy loam, or fine sandy or silty clay loam. The subsoil at *15-45cm* and other profile characteristics show a range similar to that described above for the first group. However several profiles were observed near Oonah where the subsoil rather than being yellow-brown was a very light grey or light yellowish grey.

A number of minor constituents have been recognised in this association. (i) Scattered small areas of unnamed *red-podzolic* soils occur in which the surface is a dark sandy or silty loam and the subsoil a brown or reddish brown clay. (ii) Sandstone, which outcrops over small areas and sometimes forms cliffs, weathers to form a deep sandy soil. (iii) In the vicinity of Oonah, on flat benches where drainage is restricted, a black peat layer up to *30cm* deep, fibrous in the upper part but structureless and greasy below, overlies a grey silty clay flecked with rusty brown. (iv) South of Wynyard some ridges retain a shallow capping of Tertiary gravels and sands which may be only a few hectares in extent. Although the soils are of the Inglis association such small occurrences have been mapped with the Hellyer association. (v) Along the numerous streams there are narrow strips of soils of the Flowerdale association.

Correlation

The extreme variability and low sample density of these soils has prevented the definition of a SPC for the dominant soil.

Tertiary quartz gravels and sands

Inglis Association (*28 sq. kilometres*)

Dominant soil type	Type 6
Subdominant soil type	Unnamed podzol on sand
Minor soil types	Miscellaneous soils of mixed parentage (basalt and Tertiary sediments)
	Soils of the Cam association
	Soils of the Hellyer association

Scattered patches of this association occur in an area extending from near Somerset westward almost to Moorleah and southward almost to Upper Calder and Upper Mt. Hicks. The Tertiary gravels and sands, from which the soils are formed, overlie rocks of Permian and Precambrian age but are themselves overlain by basalt. Dissection has proceeded to varying extents in different places. The basalt may be partially removed just exposing the gravels and sands so it may be completely removed exposing considerable areas. The gravels and sands in turn may be dissected so that they occur as ridge cappings over older rocks or may be completely removed from the ridges. The ideal section of Figure 6 illustrates the typical relation between the soil associations and the landscape form in the area south of Wynyard.

Slopes of the Inglis association are generally gentle or moderate, while the vegetation is frequently a black peppermint (*E. amygdalina*) woodland indicative of the low fertility status of the soils. Stringybark (*E. obliqua*) replaces black peppermint as the dominant tree in more favoured sites.

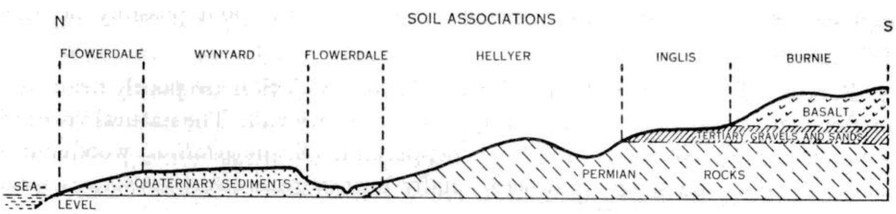


Figure 6 An ideal section showing the relation between the soil associations and the landscape form in the area south of Wynyard

The most widespread soils are podzols. Those developed on gravelly deposits have been designated Type 6, but the less extensive podzols of the sandy deposits are unnamed. Type 7 has a very dark grey organic sand surface containing water-worn quartz grit and gravel. At about *25cm* this passes to very light grey and often indurated material below. In the frequent quarries for road metal, for which this material is ideal, an undulating cemented horizon, brownish black for 2.5cm or so passing to rusty brown and yellow-brown for several centimetres, was observed at depths between *1m and 4.5m*. Below this there is a very light grey loose gravelly sand. In some instances the black and presumably organic layer of cementation was absent.

The unnamed podzols of the sandy deposits have a surface horizon similar to that for Type 6 but without the quartz gravel. The bleached horizon may be loose in the top few inches but indurated or cemented sand or fine sand below. A typical podzol B horizon was not observed but it is considered likely that such would be found at depth.

The minor constituents of this association include a miscellaneous group of soils to which both basalt and Tertiary sediments have contributed. They vary from reddish clays with occasional water-worn quartz gravel fragments, developed almost entirely from basalt to gravels and sands stained an orange colour, presumably by percolating ferruginous waters from the once overlying basalt. Other groups of small extent which have of necessity been included are soils of both the Cam and Hellyer associations where local dissection has penetrated through the gravels and sands to expose the older rocks beneath.

Correlation

Insufficient data for this association prevented the compilation of soil profile classes for the type 6 soils.

Quaternary sandy marine &/or estuarine deposits

Wynyard Association (*18 sq. kilometres*)

Dominant soil type	Type 5 *(Woolnorth SPC)*
Minor soil types	Unnamed sandy soils with sandy clay subsoils Unnamed gravelly soils Soils of the Flowerdale association

The main occurrence of this association is on the Wynyard plain, which at the Wynyard township is *9m* above mean sea-level. South of Wynyard those parts on the plain abutting the foothills are probably a little higher. There are also small areas of the association on coastal plains at Somerset and near the mouth of Sisters Creek.

The plains are dissected at intervals by crossing streams with their associated strips and fans of alluvium of the Flowerdale association (see Fig. 6). The sediments from which the plains have been built are largely sandy and probably of estuarine origin. They may date from the last interglacial period of the Pleistocene, some 100,000 years ago (Zeuner 1945). Around the margins of the plains, where finer textured sediments could be derived as wash from nearby hill slopes, sandy clay sediments were noted and also some gravel beds which could possibly be ancient raised beaches.

Because of the general flatness, areas of this association are poorly drained, and wherever slight depressions occur swampy conditions prevail. The natural vegetation, now much altered, consisted of a black peppermint (*E. amygdalina*) woodland with patches of rushes and sedges and occasionally button grass (*Gymnoschoenus sphaerocephalus*) in the swampy hollows.

The Woolnorth sand, a ground-water podzol, is the most extensive soil. It has a dark or very dark grey coherent loamy sand surface grading through grey to light grey very slightly coherent loose or occasionally compacted sand. Dark grey streaks along root channels may continue through this horizon. Between *38* and *75cm* there is a sharp but somewhat irregular boundary to a dark brown or black, sometimes with rusty brown mottles, compact organic sand. This hardpan continues to considerable depths with slight changes in degree of compactness and colour. Horizons between *90cm* and *180cm* of water-worn gravel and mottled sandy clay may be encountered.

Hubble’s (1951) description of Woolnorth sand, a soil of sandy heath country in the north-west corner of Tasmania, appears to be very similar to the description offered here for the *Woolnorth SPC.*

A soil of limited extent, found particularly around the margins of the plains, has a dark grey slightly coherent sand surface over a light grey sand sometimes with rusty brown fleckings. There is a fairly sharp change at depths between *45cm and 76cm*. to a mottled clayey sand to sandy clay which may have some dark grey-brown staining at the top. With depth the texture becomes finer. Occasional water-worn gravel may be present throughout the profile.

At several points abutting the foothills very gravelly soils occur on what might possibly be remnants of an ancient raised beach. The surface is a grey gravely sand over a bleached horizon containing large amounts of water-worn gravel. This in turn overlies a brown gravelly sandy clay horizon.
The other minor constituents of this association are narrow strips of soils on alluvium and some low sand dunes adjacent to the coastline, both of which occur also in the Flowerdale association and are described with it.

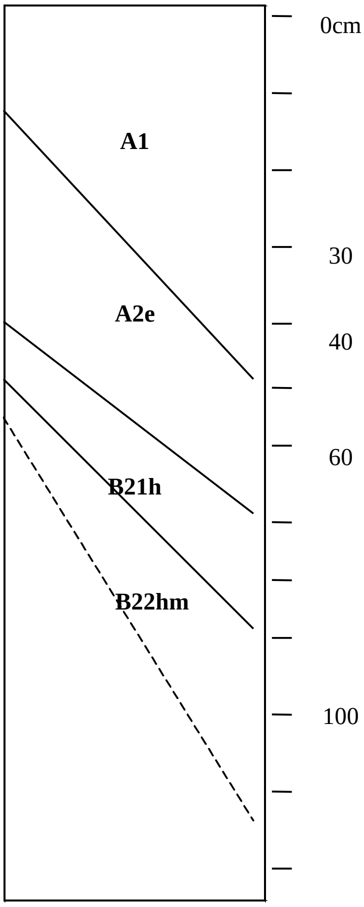
Correlation

The dominant soil of the area appears to be the same soil described by Hubble (1951), and has been called the Woolnorth Soil Profile Class. This has been verified by several DPIWE field staff, with the Podosols of the Wynyard area commonly referred to by this name.

Woolnorth Soil Profile Class

Concept **Poorly drained sandy soils formed on low lying plains of Quaternary estuarine sediments.**

Aust. Soil Classification	Aquic Podosol
Great Soil Group	Podzol
Principal Profile Form	Uc
Mapping Units	Wynyard Association (Wy)
Parent Material	Quaternary sediments
Landform	Flat, low lying alluvial plains
Vegetation	Mainly cleared, with patches of *E. amygdalina*, rushes, sedges and button grass
Surface Conditions	Firm
Permeability	Highly permeable
Drainage	Imperfectly to very poorly drained



A1: Very dark grey to black (10YR 3/1, 4/1, 2.5Y 2/1); fine sand to sandy loam; single grain or massive structure; weak to very weak (moist) consistence; pH 4.4 – 6.0; abrupt change to

A2e: Dark grey to light brownish grey (10YR 4/1, 6/2, 2.5Y 4/1); sand to fine sandy loam; massive or single grain structure; very weak (moist) consistence; pH 4.7 – 5.1; sharp, sometimes irregular change to

B21h: Very dark grey to black (7.5YR 3/1, 10YR 2/2, 3/1, 2.5Y 2/1); fibric sand to sandy loam; single grain or massive structure; very weak to firm (moist) consistence; sometimes moderately cemented massive continuous organic pan; pH 4.5 – 5.0; abrupt change to

B22hm: Very dark brown to brown (10YR 2/2, 4/3); sand to sandy loam; massive to single grain structure; very weak to firm (moist) consistence; sometimes strongly cemented massive continuous organic pan; pH 4.5 – 5.0

Morphological Sites: CSIRO H124, LCINGL 1005, 1015, 1019
Analysed Sites: CSIRO H124
Related soil names: Woolnorth Sand, Type 5
Previously described by: Hubble (1951), Loveday & Farquhar 1957

Soil Profile Class Grid Reference	**Profile Number**	**Horizon**	**Sample Depth (cm)**	**pH water (1:5)**	**EC (d/sm)**	**Total P (mg/kg)**	**Avail P (mg/kg)**	**Avail K (mg/kg)**	**Org. Carb. (%)**	**Total N (%)**	**C/N Ratio**	**Ca meq**	**Mg meq**	**Na meq**	**K meq**
Woolnorth SPC	H124	A11	0-8	4.4		0.009			6.6	0.466	14				
392064 E		A12	8-13	4.4		0.004			2.7	0.141	19	0.26	1.2	0.28	0.07
5460901 N		A21	18-38	4.7											
		A22	38-61	4.8					0.1	0.012	8	0.08	0.04	0.11	0.01
		B21hm	74-89	4.4					0.8	0.035	23				
		B22hm	89-114	4.5											
		B23hm	114-135	4.4											

Soil Profile Class Grid Reference	**Profile Number**	**Horizon**	**Sample Depth (cm)**	**Total Bases**	**ECEC meq**	**BASE SAT (%)**	**ESP (%)**	**Ca/Mg Ratio**	**Gravel (of total) >2000 (um) (%)**	**Sand Coarse >200 (um) (%)**	**Sand Fine <200 (um) (%)**	**Silt (%)**	**Clay (%)**
Woolnorth SPC	H124	A11	0-8										
392064 E		A12	8-13	1.81	13.11	14	2.1	0.22		11	78	4	3
5460901 N		A21	18-38										
		A22	38-61	0.24	0.84	29	13.1	2.00		11	87	3	0
		B21hm	74-89										
		B22hm	89-114										
		B23hm	114-135										

Table 17 Analytical data for the Woolnorth SPC

Soils formed from Quaternary Alluvium

Flowerdale Association(*36 sq. kilometres*)

Dominant soil types	Flowerdale fine sandy and silty loams Flowerdale fine sandy and silty clay loams *(Flowerdale SPC)*
Subdominant soil type	Type 4
Minor soil types	Unnamed soils of present-day flood plains Unnamed krasnozemic soils of terraces Unnamed soils of a variety of recent coastal features

Along the coast and several of the major streams, are a variety of erosional and depositional features of Quaternary age. With the exception of the mature groundwater podzols which have been placed in the Wynyard association, the soils of these features – terraces, flood plains, alluvial fans, wave-cut platforms, low coastal sand dunes, raised beaches, and isolated small hills of country rock – constitute the Flowerdale association.

Over the greater part of the association the surface is flat or very gently sloping so that external drainage is restricted. Internal drainage is also frequently restricted by the dense nature of the subsoil, a condition which is reflected in the vegetation of thickets of paper-bark (*Melaleuca ericifolia*) and patches of rushes.

The variety of geomorphic features in this unit means a wide range of parent materials and consequently of soils. The soil of greatest extent is the Flowerdale series of which the fine sandy loam, silty loam, fine sandy clay loam and silty clay loam types have been recognised. These occur mainly on terraces of the Flowerdale and Inglis Rivers west of Wynyard and on narrow terrace remnants upstream on the Calder and Inglis Rivers. The material of the terraces is very diverse, being derived from areas of basalt, dolerite, schists, quartzites, tillites and shales. The soils are greyish brown at the surface, friable when moist, and with a moderately well-developed granular structure. At about *20cm* there is a change to yellowish or greyish brown, usually friable clay, fine sandy or silty. The colour brightens below to yellow-brown and in some instances has a rusty brown mottling indicative of seasonal waterlogging. Occasional fragments of water-worn gravel may occur throughout the profile, and below *25cm* black stainings and inclusions are sometimes present.

A soil common on the alluvial fans, but not so widespread as the Flowerdale series, is Type 4, which has severely restricted internal drainage. The surface is a dark brownish grey or black clay loam or light clay with rusty brown stains along root channels. The structure is usually granular and the consistence firm or friable but when wet it is easily “pugged”. The subsoil at *15cm* is a dark yellowish grey clay, sometimes sandy, sticky when wet, and mottled with rusty brown. With depth the mottling is more prominent and water-worn pebbles are commonly present. At about *75cm* the colour is mottled grey or bluish grey and yellow-brown. Occasionally irregular ferruginous concretions are found in the upper part of the profile.

Of minor extent in the association are a variety of sandy, silty and clayey soils developing in the meander belts and on narrow flood plains of the streams. The meander belts are mostly in the lower reaches of the streams, but notable exceptions are those in the upper parts of the Calder and Inglis Rivers above an erosion resistant ridge of dolerite. On the valley sides above these meanders are small terrace remnants with dull brown krasnozemic soils.

The coastal features include narrow marine benches (less than 9*m* above mean sea-level) with variable soils, usually dark coloured and sandy at the surface, over a mottled sandy clay subsoil, usually with a considerable amount of water-worn gravel and grit. There are wave-cut platform remnants and small isolated hills of country rock both with shallow stony soils. The low and narrow (not more than *4.5m* high and *300m* wide) coastal sand dune systems, have been stabilised by vegetation and show a slight accumulation of organic matter in the surface, a weakly bleached subsurface, and light yellow subsoil. Some contain scattered shell fragments. Some very small areas of raised gravel beaches also contain shells. Behind the dunes at Seabrook one small patch of peat was observed. It is very dark brown and fibrous but powders easily to snuffy material, overlying at *30cm* a black silty clay.

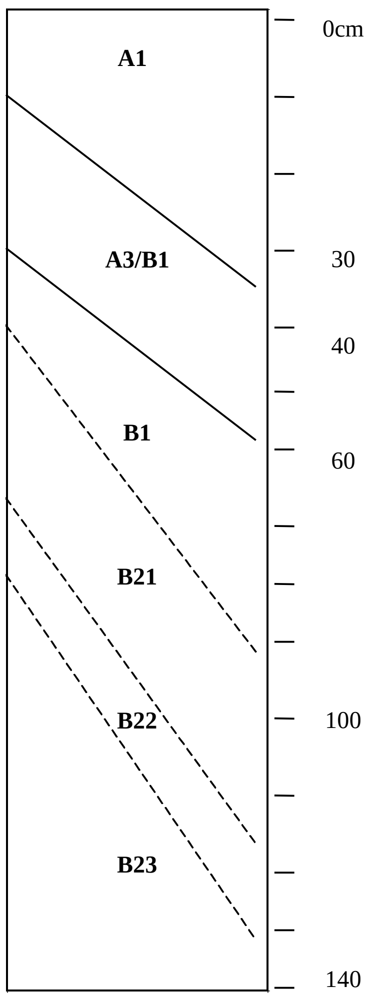
Correlation

The two dominant soils the Flowerdale fine sandy and silty loams and the Flowerdale fine sandy and silty clay loams originally described by the original authors have been grouped together to form the Flowerdale Soil Profile Class as they appear morphologically very similar, with variations only evident in surface textures.

Insufficient data prevented the compilation of a SPC for the poorly drained sub-dominant Flowerdale Type 4.

Flowerdale Soil Profile Class

Concept	**Well structured and friable clay loams developed on alluvial terraces of the Flowerdale and Inglis Rivers**
Aust. Soil Classification	Brown Dermosol
Great Soil Group	Prairie Soil
Principal Profile Form	Gn
Mapping Units	Flowerdale Association (Fl)
Parent Material	Quaternary Alluvium
Landform	Alluvial plain terraces
Vegetation	Mostly cleared
Surface Conditions	Soft (dry)
Permeability	Moderately permeable
Drainage	Imperfectly to moderately well drained



A1: Very dark greyish brown (10YR 3/2, 4/2); fine sandy or silty clay loam to clay loam; moderate 2-10mm subangular blocky structure; weak to firm (moist) consistence; pH 5.5 – 6.5; clear change to

A3/B1: Very dark greyish brown to dark yellowish brown (10YR 4/4, 3/2, 4/3); fine sandy clay loam to light clay; weak to strong variable sized (2 –50mm) subangular blocky structure; weak to firm (moist) consistence; 0-2% 2-6mm ferruginous soft segregations; pH 5.5 – 6.5; clear change to

B21: Dark brown to yellowish brown (7.5YR 3/3, 10YR 4/4, 5/4) with occasional reddish brown or red mottles; light to medium clay; moderate 20-50mm angular blocky, parting to strongly developed 2-5mm granular, subangular or polyhedral structure; weak to firm (moist) consistence; 2-10% manganiferous or ferruginous soft segregations or nodules; pH 5.0 – 6.0; diffuse change to

B22: Dark yellowish brown to light yellowish brown (10YR 4/4, 5/4, 2.5Y 6/4) with occasional red mottles; light to light medium clay; moderate to strong 2-5mm polyhedral or subangular blocky structure; firm to very firm (moist) consistence; 0-20% 2-6mm manganiferous soft segregations; pH 4.8; diffuse change to

B23: Dark yellowish brown to greyish brown (10YR 4/4, 2.5Y 5/2) with reddish brown mottles; light to medium clay; weak to strong 2-5mm subangular blocky or polyhedral structure; weak (moist) consistence; pH 5.0 – 6.0

Morphological Sites: CSIRO H148, LCINGL 9000, 1016, 1017, 1013,
Analysed Sites: CSIRO H148, LCINGL 9000
Related soil names: Flowerdale Fine Sandy and Silty Clay Loams, Flowerdale Fine Sandy and Silty Loams
Previously described by: Stephens (1937), Hubble (1944), Loveday (1955), Dimmock (1957), Loveday & Farquhar (1958), Eldridge (2000)

Soil Profile Class Grid Reference	**Profile Number**	**Horizon**	**Sample Depth (cm)**	**pH water (1:5)**	**EC (d/sm)**	**Total P (mg/kg)**	**Avail P (mg/kg)**	**Avail K (mg/kg)**	**Org. Carb. (%)**	**Total N (%)**	**C/N Ratio**	**Ca meq**	**Mg meq**	**Na meq**	**K meq**
Flowerdale SPC	H148	A11	0-9	5.9		0.66			3.6	0.337	11	7.4	2.3	0.33	0.28
388050 E		A11	0-9												
5463609 N		A12	9-17	5.3		0.052			2.5	0.215	12				
		B11	18-30	5.1		0.024			1.1	0.116	9				
		B12	30-41	5.1						0.088		2.3	0.69	0.06	0.05
		B21	41-56	4.8		0.02									
		B22	56-71	5.2											
		B23	71-91	5.2											
		BC	94-117	5.0											
		C	152-163	4.3											

Soil Profile Class Grid Reference	**Profile Number**	**Horizon**	**Sample Depth (cm)**	**Total Bases**	**ECEC meq**	**BASE SAT (%)**	**ESP (%)**	**Ca/Mg Ratio**	**Gravel (of total) >2000 (um) (%)**	**Sand Coarse >200 (um) (%)**	**Sand Fine <200 (um) (%)**	**Silt (%)**	**Clay (%)**
Flowerdale SPC	H148	A11	0-9	10.31	26.41	39	1.3	3.22		2	55	18	20
388050 E		A11	0-9										
5463609 N		A12	9-17										
		B11	18-30							1	56	17	23
		B12	30-41										
		B21	41-56	3.1	16.8	18	0.4	3.33		2	53	15	27
		B22	56-71										
		B23	71-91										
		BC	94-117										
		C	152-163										

Table 18 Analytical data for the Flowerdale SPC

SOME SOIL AND LAND USE PROBLEMS

Forestry and Agriculture

In some districts of the surveyed area there is a tendency for forestry and agriculture to become competitive rather than complementary forms of land use. Unlike agriculture, forestry is not limited to any extent by topography and stoniness. Because of this, land can be classified either as suitable only for forestry (very steep or stony areas or both) or suitable for both agriculture and forestry. Under ordinary circumstances where both types of land exist it seems preferable that large forestry plantations should not encroach upon agricultural areas. However, where potential agricultural land has been lying idle or only partially used for many years and the prospects of it being fully developed for agriculture in the near future are small, there is justification for such land being used for forestry.

Within the areas generally regarded as suitable for agriculture in this part of north-west Tasmania, there are at very frequent intervals small patches up to several acres in extent, which are too steep, or too stony, or both for agriculture, but are well suited to tree plantations. Several such patches occur on almost every farm, but only on a very few has any attempt been made to plant trees.

The advantages of planting such areas to useful tree species (e.g. *Pinus radiata*)[6] are manifold. (i) They provide much needed shelter for stock. The agricultural areas in this district are principally located on basalt ridges exposed to cold winter winds, and the wholesale destruction of the natural forests with only very sporadic replanting of exotics has left an unprotected landscape. The increased temperature of the local environment resulting from the plantations also means earlier and faster pasture and crop growth. (ii) Tree plantations can be regarded as long-term cash crops as there is a ready and highly profitable market for thinnings and mature trees at local saw, plywood and pump mills. (iii) They provide a source of farm timber. (iv) Weeds and vermin, difficult to control on such areas in their present state, are largely eliminated by a close growing stand of trees. (v) Finally, the appearance and value of farms with successful tree plantations are considerably enhanced.

Problems of Soil Fertility

It has already been pointed out that widespread responses have been obtained to a variety of fertilisers throughout the area of this survey, and from this it is inferred that there are more or less extensive deficiencies of a number of plant and animal nutrients. Because the availability of many mineral nutrients is influenced by the reaction (degree of acidity or alkalinity) of the soil, this will be discussed prior to individual discussion of the nutrient deficiencies.

[6] Wherever this species has been planted on basaltic soils throughout the area it has proved successful.

Table 19 - Surface Soil* Reaction of the Krasnozems

Soil Type	Number of Samples	pH†	
		Median Value ‡	Range
Burnie clay loam	20	5.8	5.3 to 6.6
Lapoinya clay loam	28	5.5	4.9 to 6.1
Yolla clay loam	26	5.3	4.9 to 6.2
Oonah clay loam	8	5.5	5.1 to 5.9

** Sampling depth 0-7.5cm (in several Oonah SPC samples a surface organic matter accumulation was first discarded).*

† pH values were determined on a 1 in 5 soil in water suspension.
‡ There are equal numbers of samples with pH values above and below this figure.

Soil Reaction – The degree of acidity or alkalinity of a soil, or soil reaction, is measured in units of pH.[7] Neutral or alkaline soils are usually well supplied with the basic plant nutrients calcium, potassium, and magnesium. On the other hand strongly, very strongly, or extremely acid soils have generally been well leached of these nutrients by percolating rain. In regard to the availability of trace elements, in general the higher the pH the more available is the molybdenum present in the soil, but the lower the pH the more available are the soil manganese, zinc, boron, cobalt, and copper. However, providing that the supply of all essential plant nutrients is adequate, a considerable range of plants, including many pasture and crop species, will grow satisfactorily on soils at least as acid as pH 5.

The krasnozems of the surveyed area are moderately acid near the coast but inland are strongly acid. This is illustrated by the data in Table 8, which agree with the findings of Stephens (1937).

The black soil, Hicks clay loam, associated with *Burnie SPC* in coastal areas, is slightly or moderately acid at the surface but rises to neutral values in the subsoil. Type 1, the black soil of the West Ridgley association, on the other hand, is moderately acid at the surface, becoming strongly acid in the subsoil.

Of the other soils, the small number of samples tested indicate that the podzols developed mainly on quartzitic parent rocks, i.e. soils of the Sisters Hills, Cam and Inglis associations, are the most strongly acid with surface pH values usually in the range from 4.0 to 4.5. Surface soils of the Calder, Hellyer, and Natone associations range between pH 4.0 and 5.5, while those of the Flowerdale association are generally between pH 5 and 6.

[7] The subdivision of the pH scale of soils accepted for discussion in this publication is: 4.0-4.5, extremely acid; 4.5-5.0, very strongly acid; 5.0-5.5, strongly acid; 5.5-6.0, moderately acid; 6.0-6.5, slightly acid; 6.5-7.5, neutral; 7.5-8.0, slightly alkaline; 8.0-8.5, moderately alkaline; 8.5-9.0, strongly alkaline; 9.0-9.5, very strongly alkaline.

Table 20 – Organic matter* and nitrogen† content of the surface‡ soils of the krasnozems

Soil Type	Average Distance from Coast (miles)	Average Organic Matter Content (%)	Average Nitrogen Content (%)
Burnie clay loam	0-3	13.0 (13)§	0.542 (7)§
Lapoinya clay loam	3-8	14.2 (16)	0.513 (7)
Yolla clay loam	8-12	16.2 (14)	0.513 (7)
Oonah clay loam	12-18	20.5 (8)	0.684 (4)

** Per cent. by weight of oven dry soil (2¼ times Walkley-Black value)*

† Kjeldahl N per cent. of oven dry soil.

‡ Sampling depth 0-3 in. (in several Oonah SPC samples a surface organic accumulation was first discarded)

§ Number of samples

Nitrogen – The nitrogen in a soil is largely held in the organic matter. The krasnozems, the important agricultural soils of this area, despite their appearance, contain high amounts of organic matter and nitrogen in the surface layers. As shown in Table 20 the amounts increase with distance from the coast, a feature probably largely due to slower decomposition inland arising from both lower temperatures and a shorter history of arable agriculture. In all the soils the levels of organic matter and nitrogen decrease fairly rapidly with depth.

Under the system of farming generally practised the maintenance of a high level of soil nitrogen is dependent on pasture management. Providing that well-balanced pastures of healthy clovers and grasses are established, the soil nitrogen is likely to be kept at a sufficiently high level. Generally, the experience has been on the krasnozemic soils that in the first two years of establishment pastures are clover dominant, after which the grass species tend to become co-dominant with the clovers. This suggests that despite, the high content of total nitrogen in these soils, there is insufficient nitrogen available for the grasses in the initial period.

Nitrogen deficiency symptoms have not been commonly observed, except in cereals and sometimes potatoes where excessive cropping is practised. The use of nitrogenous fertilisers, e.g. sulphate of ammonia, has proved economic only on cash crops, particularly potatoes. Paton (personal communication) has found only small responses by grass and weed species to nitrogenous fertilisers on well-balanced pastures containing vigorous clovers.

Phosphorus – The krasnozemic soils contain relatively high amounts of phosphorus (in the order of 0.1-0.2 per cent., hydrochloric acid soluble P in the surface layer). However, because of the high iron and aluminium content of the soils, the phosphorus is held in forms largely unavailable to plants, and applications are necessary on all soils without exception for satisfactory plant and animal growth.

Table 21 – The total molybdenum content of several soil and basalt samples

Sample	Depth (cm.)	Molybdenum Content* (p.p.m. of oven dry sample)
T873, Lapoinya clay laom	0 – 10	10
H92.1, Lapoinya clay loam	0 – 10	10
H92.5, Lapoinya clay loam	43 – 56	11
H96.2, Yolla clay loam	4 - 15	12
H117.1, Yolla clay loam	0 – 9	9
H119.1, Yolla clay loam	0 - 10	10
T872, Basalt from site of H92		9
T874, Basalt from site of T873		11

** Spectrographic analyses by R. M. McKenzie, Division of Soils, C.S.I.R.O.*

The "standard" annual dressing on pastures is between *190kg* and *250kg* of 22 percent, superphosphate per hectare, but economic responses are obtained to initial heavier dressings on most virgin soils and soils with a history of light superphosphate dressings. Likewise, economic responses are obtained to heavier dressings on cash crops, particularly potatoes.

There is some evidence on soils of the Burnie association (Paton, personal communication) that an available phosphorus reserve accumulates after total applications of superphosphate in the order of 1.5-2 tonnes. Local experience suggests that in the higher rainfall districts greater applications may be necessary to achieve this reserve.

Podzolic soils generally, wherever agricultural development has been attempted, appear to require even heavier dressings of superphosphate than the krasnozemic soils. Moreover, on podzolic soils in the Oldina State Forest, responses by *Pinus radiata* to phosphate applications have been reported (Cox, personal communication) and it has become standard practice to spread superphosphate in the plantations a year or two after planting.

Lime and Molybdenum – As molybdenum applications have in recent years largely replaced those of lime these are best discussed together.

During the 1930's the placing of lime in encouraging the growth of legumes was recognised in areas of krasnozemic soils where rainfall exceeded about 45 in. per annum, i.e. all areas except those of the Burnie association. However, it was later shown by Fricke (1945) on a number of soils from north-west Tasmania, that molybdenum applications gave as good a response as lime. Since that time the use of molybdenum as molybdate superphosphate has become general throughout the areas formerly found to respond to lime. Paton (1956a) in a series of trials has confirmed that on established clover pastures no significantly greater response can be obtained from the use of lime (at 2.5 tonne per hectare of ground limestone) than from the use of molybdenum (at 100g per hectare). In one trial at West Ridgley, Paton (personal communication) found that no significantly greater yield nor proportion of clover was obtained when lime was added together with molybdenum than when either was applied alone. Although at present there is no local information regarding the appropriate frequency of application of molybdenum, this aspect is being investigated. In the meantime it is recommended that molybdenum be applied not more often than once in 4 or 5 years to avoid possible animal health complications.

The average value for the total molybdenum content of soils commonly quoted is from 2 to 2.5 parts per million (Robinson and Alexander 1953; Swaine 1955). Values obtained for several samples of krasnozems collected from scattered sites in the area, and reported in Table 21, are high by comparison. It is evident that these considerable amounts of molybdenum are unavailable to plants, and it has previously been mentioned that this may be due to the high content of free hydrated iron and aluminium oxides (Davies 1956).

The effect of heavy lime applications is to render some of the unavailable molybdenum more available by raising the soil pH. The further possibility that the various types of lime used in this area may contain molybdenum as an impurity is discounted, for analyses have shown several samples of lime from locally available sources to contain negligible amounts of molybdenum.

Although molybdenum has replaced the use of lime on established clover pastures, lime has proved essential for clover establishment on some heavily cropped areas (Paton, personal communication). In these instances clover establishment is virtually a total failure without lime, and molybdenum cannot replace it. On some other cropped areas clover establishment, slow in the absence of lime, is much more rapid in its presence, even though molybdenum is also applied. In the virgin state clover establishment, at least on some of these areas, is reputed to have been satisfactory without lime.

Many such heavily cropped areas show signs of severe surface erosion, so that a possible explanation for the need for lime is to replace available calcium lost with the surface soil, for which the calcium of applied superphosphate alone is apparently inadequate. The krasnozemic soils, particularly those of the Lapoinya, Yolla and Oonah associations, are not well supplied with available calcium. That which is present is strongly concentrated in the surface soil, so that erosional losses could reduce the available calcium to a deficiency level.

Whether or not this is the case, many of these soils are more acid than pH 5.5, and the common effect of lime on such soils is to improve root nodulation of clover plants by increasing the survival of *Rhizobium*, the root nodule organism (Anderson and Moye 1952). Paton (personal communication) regards this effect on nodulation as the main function of lime in improving clover establishment on the heavily cropped soils. This is quite distinct from the effect of lime in increasing the uptake of molybdenum. The amount of lime required to counteract the harmful effects of soil acidity of *Rhizobium* is probably small, for Anderson and Moye consider that as little as 250kg/ha of lime per acre drilled with the seed is effective in inducing nodulation on the most acid soils of the Southern Tablelands of New South Wales. In fact, Lonergan *et al.* (1955) report an experiment which showed a favourable comparison between the use of lime, pelleted in inoculated subterranean clover seed, which at the rate of seeding used was equal to 5kg/ha, and drilling of lime with the seed at 250kg/ha. They consider that it should be possible to develop methods of pelleting seeds with lime which would

benefit many areas. It is, of course, essential when such small dressings of lime are used that molybdenum applications be also made.
The foregoing discussion has been concerned with the krasnozemic soils. Agricultural experience is limited on the podzolic soils generally, but it is expected that, since many of these soils are very strongly or extremely acid, there would be considerable responses to lime should they be developed for arable agriculture. It is probable also that considerable areas would be responsive to molybdenum applications.

Potassium – There is, as yet, no generally accepted method for estimating the amount of available potassium in the soil nor is there any well-established level above or below which there is considered to be a sufficiency or a deficiency respectively of potassium. Because of this, little comment can be made regarding the potassium determinations which have been carried out. They do show, however, that there is a wide variation in exchangeable potassium levels in all the krasnozemic soils, that no one soil series is generally better supplied with exchangeable potassium than the others, and that there is usually a strong concentration in the surface soils. This last fact is important from the point of view of surface soil erosion, for, as noted above for calcium, loss of the surface soil means loss of a large part of the available potassium. The one profile of Type 5, a ground water podzol of the Wynyard association, has a very low level of available potassium in the surface soil.

Potassium deficiency symptoms of potatoes, locally called “fire blight”, were recognised in north-west Tasmania by Wade (1950), and potassium fertilisers are now considered to be desirable for potatoes on all the krasnozemic soils. In clovers deficiency symptoms have been observed in a number of districts including those of Stowport, Natone, Upper Natone, Henrietta, Flowerdale and Boat Harbour and significant responses have been recorded to potash applications on trial areas at Upper Natone, Tewkesbury and Flowerdale (Paton 1956*b*). However, it is not yet known whether economic responses can be obtained to potassium applications on pastures generally in these areas.

Copper – Copper deficiency symptoms have not been observed in plants on any soils in the surveyed area, but growth responses to copper applications have been reported from several areas of podzols in the Inglis association. Considering the highly siliceous nature of these soils, this is to be expected.

However, in animals deficiency symptoms have been observed from more widespread areas. Thain (1955) has successfully treated copper deficient animals from farms, principally on areas of the Flowerdale and Wynyard associations. Although it is not unexpected that the groundwater podzols of the Wynyard association should be deficient in copper, it is difficult to conceive that soils with parent material of such diverse origin as those of the Flowerdale association should not have a reasonable total copper content. It is well known that organic soils are likely to show this deficiency but, except for several small areas of peat, the soils of the Flowerdale association are not unduly high in organic matter. This point appears to warrant further detailed investigation.

Apart from the soils of the two associations mentioned above, Thain (personal communication) has also successfully treated animals with copper deficiency symptoms, and in some cases concurrent cobalt deficiency, from farms on basaltic soils of both the Burnie and Lapoinya associations. In some instances at least, there have been more frequent applications of molybdenum than recommended, and it is suspected that this can lead to excessive uptake of molybdenum by plants and thus animals. If this be the case, and provided the sulphate uptake is also high, the appearance of copper deficiency symptoms may be due to disturbances in copper metabolism by the excessive molybdenum uptake (Dick 1954). However, despite the indication from several analyses (see Table 22) that the total copper content of the basalt soils is quite considerable, the possibility that some areas may be deficient cannot be overlooked.

Cobalt – This element is needed by ruminants and possibly all animals for healthy growth, but it has not as yet been shown necessary for plants. When it is present in insufficient amounts ruminant animals, particularly young stock, show symptoms of starvation brought about by loss of appetite. The onset of symptoms is seasonal and may be very sporadic. Thain (1955) has observed such symptoms throughout many areas in the Wynyard district and has had widespread success in treating them by administration of cobalt. On some properties, besides a history of unthriftiness, there has been considerable mortality prior to cobalt treatment. From Thain's records it appears that cobalt deficiency occurs mainly on basaltic soils, particularly of the Burnie and Lapoinya associations, although it is considered likely to occur also in areas of the Yolla, Oonah and West Ridgley associations. To the authors' knowledge this deficiency has not been reported from basaltic soils in the neighbouring districts but there seems no reason why it should be confined to the Wynyard district. It is confidently expected that its occurrence will be observed elsewhere in Tasmania on similar krasnozemic soils and possibly outside Tasmania.

The many references in the literature to the total cobalt content of soils (e.g. Russell 1944; Gilbert 1950; Swaine 1955) show that it varies considerably in a range between 1 and 40 p.p.m. with 10 p.p.m. about average. Soils with less than 2 p.p.m. are commonly deficient, but soils with higher values may also be deficient. The several analyses carried out on soil and basalt samples from scattered sites in the area are reported in Table 22.

There is a wide range, 3–18 p.pm., of cobalt in the soils, and further systematic analyses might prove that some areas are generally low, while others are generally much higher in cobalt. Thain (personal communication) has noted that some parts of some districts do not appear to be troubled by a cobalt deficiency. The fact that the content of cobalt of the soil samples H91.1, H92.5 and T873 is very much lower than that of the basalt samples collected from the same sites seems to indicate considerable losses of cobalt during soil formation.

The analyses presented are total values and no information is at hand regarding the availability of the cobalt present in the soils. Hill, Toth and Bear (1953) have elucidated some of the factors which control the cobalt status of plants growing on New Jersey soils. They found that both texture and drainage of the soil affected the cobalt uptake by plants – plants growing on poorly drained soils were higher in cobalt than those from well-drained soils – and that applications of liming materials reduced the availability of cobalt. They also suggest that the amount of available manganese or iron in the soil may influence the cobalt content of plants growing on it. It seems clear in the present instance that detailed investigational work combining soil, plant and animal studies is required, so that the nature and distribution of cobalt in the soils and the factors affecting its uptake by plants and animals may be understood.

Table 22 - The total cobalt and copper content of several soil and basalt samples*

Sample	Depth (cm.)	Content (p.p.m. of oven dry sample)	
		Cobalt	Copper
T873 Lapoinya clay loam	0 – 10	3	39
H92.1, Lapoinya clay loam	0 – 10	5	57
H92.5, Lapoinya clay loam	43 – 56	6	57
H96.2, Yolla clay loam	4 - 15	3	41
H117.1, Yolla clay loam	0 – 9	12	40
H119.1, Yolla clay loam	0 - 10	18	51
T872, Basalt from site of H92		40	43
T874, Basalt from site of T873		30	36

**Spectrographic analyses by R. M. McKenzie, Division of Soils, C.S.I.R.O.*

Soil Erosion

In contrast to the subsoil, the surface layer of the krasnozemic soils has a high organic matter content (in the order of 14 per cent.). The value of the surface soil in supplying available plant nutrients has already been stressed. It is of considerable importance, then, to prevent its loss by erosion.

Soil losses through erosion are usually not spectacular in krasnozemic soils. Nevertheless, they are particularly prone to insidious sheet erosion, the extent of which is not generally recognised because of the depth of the soil profile. Too frequent cultivation, where excessive cropping is practised, is the prime cause of accelerated sheet erosion, because it leads to a breakdown of surface soil aggregates to finer particles (“snuffy” condition) and a compacting of subsoil layers. The soil, while in this cultivated condition without the protection afforded by plant cover, is extremely vulnerable to water erosion. A further effect of cultivation can be the direct movement of soil downhill, as evidenced by large soil accumulations above fences across slopes. Sheet erosion losses are accentuated when new crops are planted down the slope rather than across it.

Of the krasnozems in the surveyed area, those of the Burnie association show least structural breakdown as a result of continued cultivation. Consequently, severe sheet erosion is not often apparent in areas of this association. However, accumulation along some lower slope fence lines is evidence of direct soil movement down slope during cultivation.

As one proceeds inland across the Lapoinya and Yolla associations to the Oonah association, the soils become increasingly liable to breakdown of the natural structure by cultivation. Generally speaking, the Lapoinya association soils have been subjected to longer periods of continued cultivation than those of the Yolla and Oonah associations, and it is in this association that “snuffy” surface soils and sheet erosion are most extensive (see Fig. 11). Individual paddocks within the Yolla and Oonah associations may show evidence of severe sheet erosion. In these three associations wherever slumped areas have been cultivated the particularly vulnerable steep banks are severely eroded, as is clearly shown by the patchiness of growth in such areas.

When soils other than the krasnozems are considered, only small patches of sloping land have been cleared for arable agriculture and, consequently, accelerated erosion is not yet a problem. However, should these soils of slopes, which are mostly podzolics with, in some cases, rather impervious clay subsoils, be developed for arable agriculture, precautions would be needed to prevent erosion.

The normal methods of conservation, including particularly long periods of pasture to maintain soil structure and contour furrowing, will control sheet erosion of both the krasnozemic and the podzolic soils. Some already severely eroded areas would seem best planted to trees, but others can be rehabilitated by establishing permanent pastures. To do this adequate fertiliser and often lime applications are necessary.

Conclusions

As a conclusion to the foregoing discussion it seems fitting to list the major problems which appear worthy of further investigation in considerable detail. These are:

(i) The availability of phosphate and residual effects of its application.
(ii) The effect of lime in rehabilitating heavily cropped areas. It seems possible that it may be overcoming a deficiency of calcium and/or through its effect on soil reaction influencing nitrogen fixation by root nodule organisms.
(iii) Pasture plant requirements of potassium and the economics of its application.
(iv) The availability of molybdenum and the residual effects of its application.
(v) The distribution and nature of copper and cobalt in the soils and the factors influencing their uptake by plants and animals.
(vi) The various factors involved in the use of the frequent small patches of steep and stony land within the agricultural areas for tree plantations.

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Appendix 1

List of Key Soil Horizon Designations Used in SPCs

Horizons (some of which may be subdivided eg, A11 and A12)

A1 Topsoil, zone of maximum biological activity, usually dark in colour.

A2 Grey, generally sandy, sometimes bleached, eluvial horizon (less clay, organic matter and sesquioxides than horizons above and below).

A3 Transitional horizon between A and B horizon and more similar to A than B horizon.

B1 Transitional horizon between A and B horizon and more similar to B than A horizon.

B2 Main subsoil horizon, either:-

1) illuvial clay, humus or sesquioxide accumulations or

2) maximum pedological development such as structure or colour.

B3 Transitional horizon between B2 and C horizon and having significant amount of clay to still be classed as part of the solum.

BC As above.

C Weathered parent material and partially weathered rock from which the soil has formed.

D Buried horizon which is unlike the pedological organisation of the overlying horizons.

R Bedrock.

P1 Primarily undecomposed organic matter (peat).

P2 Primarily decomposed organic matter (peat).

Horizon Suffixes Used

e conspicuously bleached horizon, for example A2e.

g gleyed horizon caused by very poor drainage.

h accumulation of humified, well decomposed organic matter.

j sporadically bleached horizon, for example, A2j.

k accumulation of carbonate.

m strongly cemented horizon

t accumulation of silicate clay (illuviation).

w weakly developed B horizon, ie, colour or structured B horizon, little or no illuviation.

For full horizon definitions refer to MacDonald *et al*. (1990). This figure has been modified from Doyle (1993), p 118.

Appendix 2

Analytical Methods for CSIRO sites

The following analytical methodology, taken from Graley (1961), is assumed to be similar for the sites analysed by CSIRO Division of Soils on this map.

The methods of analyses used were essentially those of Piper (1947) but with the following modifications:

pH was determined using a glass electrode and the system described by Raupach (1956).

Phosphorus is reported as "total" P dissolved by four hours boiling with concentrated hydrochloric acid. It was determined by a colorimetric method using butanol to extract the ammonium phosphomolybdate prior to its reduction with stannous chloride to the blue complex.

"Free" ferric oxide was determined using a modification by Haldane (1956) of Jeffries' method.

Particle size distribution was determined on a number of samples by the International pipette method and on others by the rapid plummet balance method (Marshall, 1956) after dispersion of the soil using "calgon" (Hutton, 1955). Use of the pipette method is indicated in the tabulated data by quoting the results of the silt and clay fractions to one decimal place and of the plummet method to the nearest whole number. Coarse and fine sands are quoted to the nearest whole number for both methods.

Exchangeable metal cations were extracted by leaching with normal ammonium chloride and the leachate examined by titration with E.D.T.A for calcium and magnesium (Bond and Tucker, 1954 and Hutton, 1954) and by the "Eel" flame photometer for potassium and sodium (Stace and Hutton, 1958).

Exchangeable hydrogen has been determined by both the paranitro phenol (to pH 7.0) and meta-nitrophenol (to pH 8.4) methods of Piper (1942) but the total exchangeable cations recorded are the sum of the metal ions and exchangeable hydrogen to pH 8.4.

Values are reported for fractionation of the coarse and fine sands from certain samples. These were determined by sieving through five inch sieves with hand shaking for twenty minutes.

Analytical methods for DPIWE sites

Soil pH and electrical conductivity were measured in a 1:5 soil:water ratio.

Clay mineralogy was determined by the Tasmanian Department of Mineral Resources using X-ray diffraction.

Exchangeable Aluminium and Acidity was measured using method 15G1 described by Rayment and Higginson (1992).

Organic Carbon was measured using the Walkley and Black method described in Rayment and Higginson (1992).

Available phosphorus was measured using method 9B2 described by Rayment and Higginson (1992) based on Murphy and Riley (1962).

Air-dry moisture content has been expressed as a percentage based on method 2A1 described by Rayment and Higginson (1992).

Total nitrogen was measured using an auto analyser following method 7A2 in Rayment and Higginson (1992).

Copper, Zinc, Manganese and Iron was measured using method 12A1 described in Rayment and Higginson (1992).

Exchangeable Calcium, Magnesium, Sodium and Potassium was measured by ammonium chloride at pH 7.0 using method 15B3 in Rayment and Higginson (1992).

Appendix 3

Rating table for analytical properties

General analytical properties

	Very low	Low	Medium	High	Very High
Organic Carbon (%)	<1	1-2	2-4	4-8	>8
Total Nitrogen (%)	<0.1	0.1-0.2	0.2-0.4	>0.4	
Total Phosphorus (mg/kg)	<100	100-200	200-500	500-1000	>1000
CEC (meq/100g soil)	<6	6-12	12-25	25-50	>50
Base Saturation (%)	<20	20-40	40-60	>60	

Note: Organic matter content can be estimated by multiplying organic carbon contents by 1.724.

Colwell Extractable Phosphorus and Potassium

Light soils (sandy loams)	Low	Medium	High
P (mg/kg)	<10	10-35	>35
K (mg/kg)	<100	100-200	>200
Heavy soils (clays)	Low	Medium	High
P (mg/kg)	<30	30-80	>80
K(mg/kg)	<150	150-300	>300

Salinity

	None	Slight	Moderate	High	Very High
(dSm-1)	<0.2	0.2-0.7	0.7-1.2	1.2-3.0	>3.0

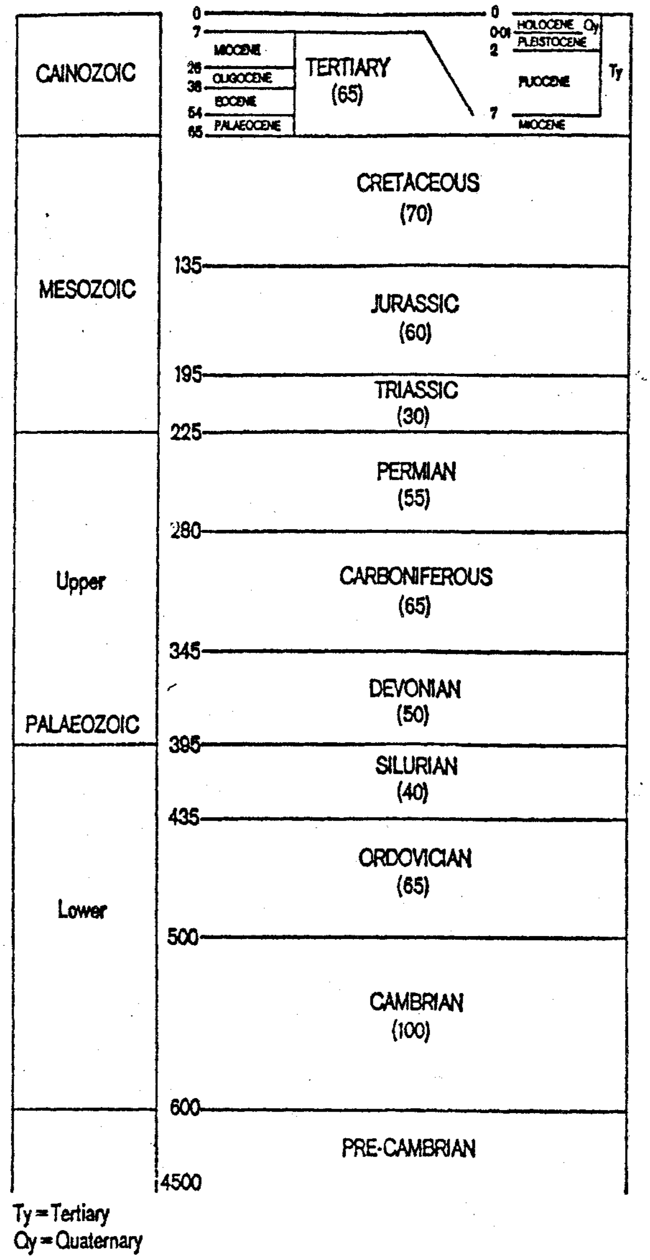
Soil Acidity

	Slightly	Moderately	Strongly	Extremely
pH range	6.5-6.0	5.9-5.3	5.2-4.5	<4.5

This table has been taken from Doyle (1993) p115

Appendix 4

Geological Timeline



Taken from Brooks J.R.V., and Whitten D.G.A., (1972) Dictionary of Geology . Published by Penguin, England.

Appendix 5

List of Reports in the Reconnaissance 1:100 000 Soil Map Series

Cowie, J.D. (1959), Reconnaissance soil map of Tasmania. Sheet 68, **Oatlands**. Div. Rep. Div Soils CSIRO Aust. 4/59**;** Scale 1:63 360

Doyle, R.B. (1993), Soils of the **South Esk** Sheet Tasmania (southern half) Reconnaissance Soil Map. DPIF Soil Survey Series of Tasmania No 1.
Scale 1:100 000

Dimmock, G.M. (1956), Reconnaissance soil map of Tasmania **Flinders Island**. Div. Rep. Div. Soils CSIRO Aust. 8/56**;** Scale 1: 63 360

Dimmock, G.M. (1960), Soil reconnaissance of the area between the **Tomahawk and Ringarooma Rivers**, N.E Tasmania. Tech memo. Div. Soils CSIRO Aust. 7/60**;** Scale 1:63 360

Dimmock, G.M. (1964), **Beaconsfield** Soil Survey. CSIRO (unpublished)**;**
Scale 1: 100 000

Hubble, G.D. (1951), Reconnaissance survey of the **Coastal Heath Country, N.W** Tasmania. Div. Rep. Div. Soils CSIRO Aust. 10/51 **;** Scale 1:126 720

Leamy, M.L. (1961), Reconnaissance soil map of Tasmania, Sheet 61. **Interlaken**. Div. Rep. Div. Soils CSIRO Aust. 6/61**;** Scale 1:63 360

Nicolls, K.D. (1955), Soils, geomorphology and climate of an area between the **Lagoon and Arthur Rivers**, West Coast of Tasmania Div. Rep. Div. Soils CSIRO Aust. 7/55**;** Scale 1:126 720

Nicolls, K.D. (1957), Reconnaissance of the soils around **Georgetown**, Tasmania. Tech. Memo Div Soils CSIRO Aust 3/57**;** Scale 1: 126 720

Spanswick S.B. and Kidd D. (2000d), Reconnaissance soil map of Tasmania **Ellendale** Department of Primary Industry Water and Environment, Tasmania. In press. Scale 1:100 000

Spanswick S.B. and Kidd D. (2000e), Reconnaissance soil map of Tasmania. - **Table Cape and Burnie**. Department of Primary Industry Water and Environment, Tasmania. In press. Scale 1:100 000.

Spanswick S.B. and Zund P. (1999a), Revised **Longford** Reconnaissance Soil Map of Tasmania. Department of Primary Industry Water and Environment, Tasmania. Scale 1:100 000.

Spanswick S.B. and Zund P. (1999b), Revised **Quamby** Reconnaissance Soil Map of Tasmania. Department of Primary Industry Water and Environment, Tasmania. Scale 1:100 000.

Spanswick S.B.. (2000), Revised **Sorell** Reconnaissance Soil Map of Tasmania. Department of Primary Industry Water and Environment, Tasmania. In press. Scale 1:100 000.

Spanswick S.B. and Kidd D.B. (2000a), Revised **Buckland** Reconnaissance Soil Map of Tasmania. Department of Primary Industry Water and Environment, Tasmania. In press. Scale 1:100 000.

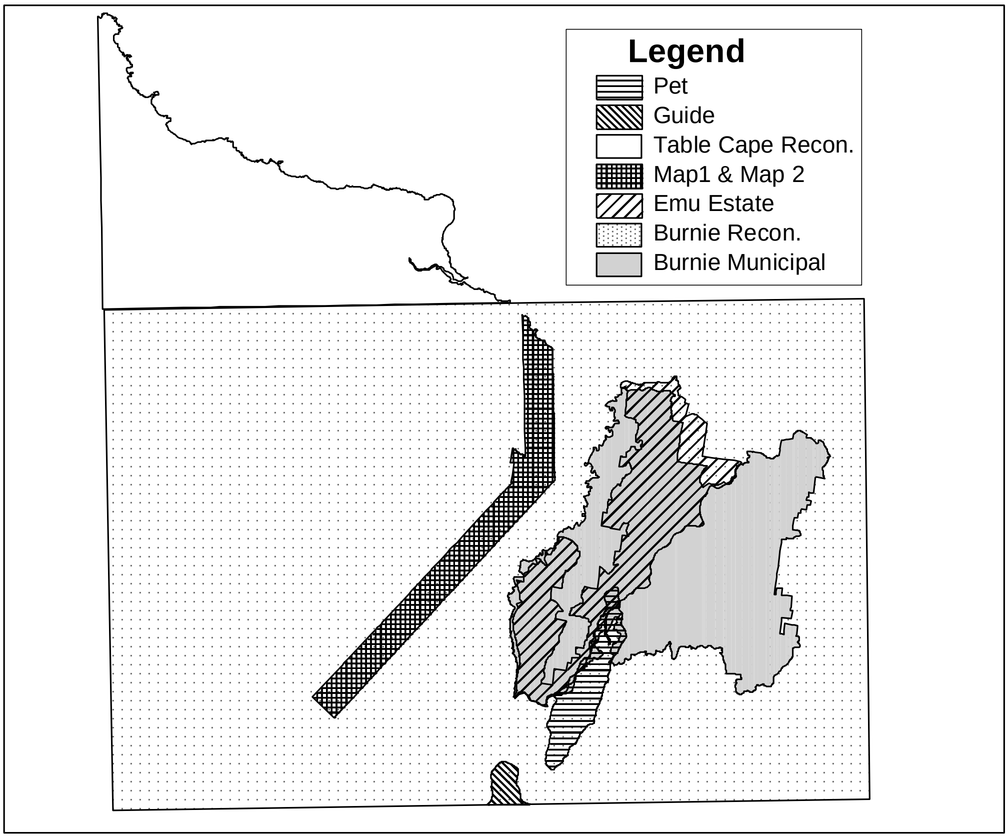
Spanswick S.B. and Kidd D.B. (2000b), Revised **Brighton** Reconnaissance Soil Map of Tasmania. Department of Primary Industry Water and Environment, Tasmania. In press. Scale 1:100 000.

Spanswick S.B. and Kidd D.B. (2000c), Revised **Hobart** Reconnaissance Soil Map of Tasmania. Department of Primary Industry Water and Environment, Tasmania. In press. Scale 1:100 000.

Stephens, C.G. and Hosking, J.S. (1932), A soil survey of **King Island**. Bull. No 70 CSIRO Aust**;** Scale 1:126 720.

Appendix 6

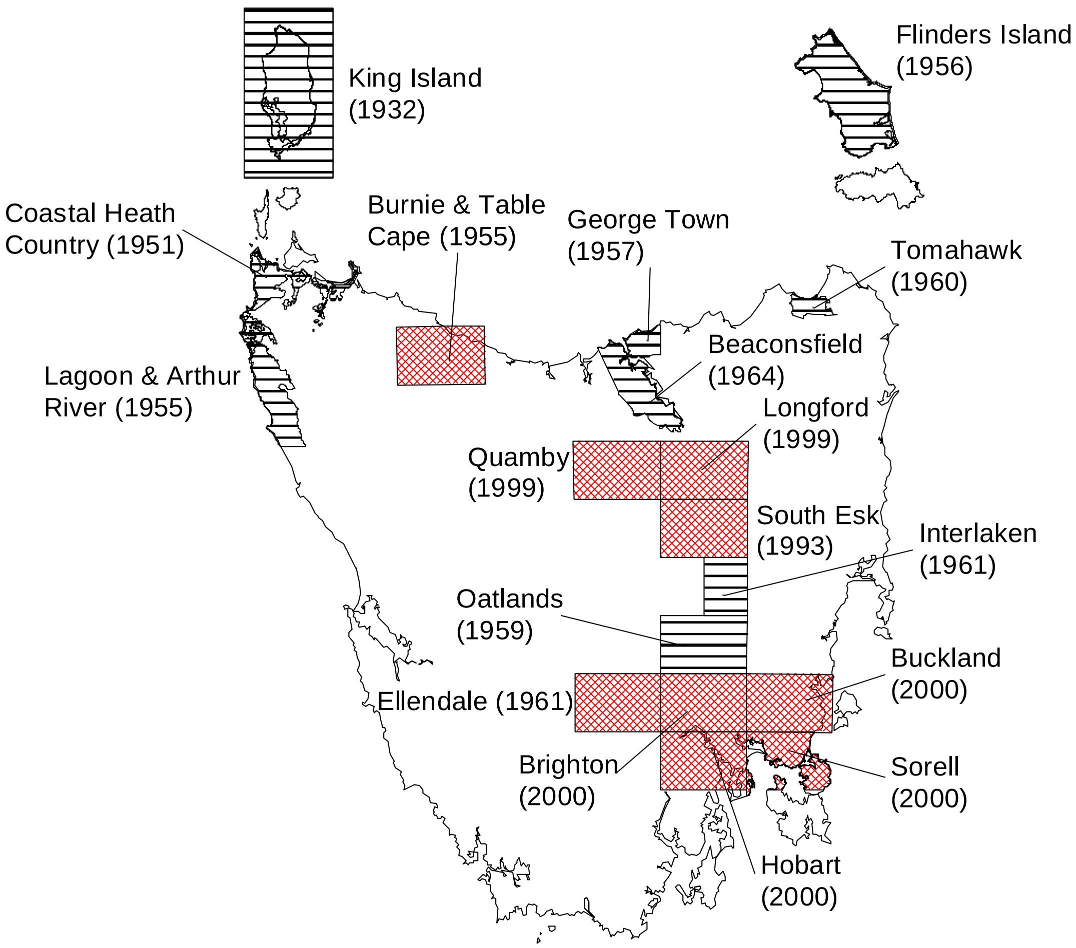
Index Map Showing Surveys occurring within the Burnie –Table Cape Reconnaissance Map



Appendix 7

Index Map of the 1:100 000 Reconnaissance Soil Surveys of Tasmania

(Maps now available shown iby cross hatching)



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