CIRCULAR HEAD REPORT

Land Capability Survey of Tasmania

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Department of Primary Industries, Water and Environment
Prospect Offices
2000

Circular Head Report
and accompanying 1:100 000 scale map

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

Natural Heritage Trust
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Contents

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SUMMARY

This report and map describes and classifies the privately owned and leased Crown land resources occurring within the limits of the 1:100 000 scale Circular Head map (Sheet No. 7916). This region is referred to throughout this report as the Circular Head area. It is located in north west Tasmania and includes the population centres of Smithton, Stanley, Rocky Cape, Mawbanna and Forest together with smaller rural settlements such as Montumana, Irishtown, Lileah and Mengha. The area is well known for its dairy industry, sea fisheries, fresh vegetable production, fine scenery and for its industrial and agricultural input to the State's economy.

The survey area extends from the coast inland for approximately 20km. A large flat coastal plain dominates the topography along the coast. In the west a large Quaternary drainage basin occurs bordered by hills and ridges of Cambrian age. To the east Precambrian hills and mountains occur. In the central north and north east, basaltic lava flows of Tertiary age have resulted in gently to moderately sloping plateaux and hills.

This wide variety of landscapes and rock types has resulted in a wide range of soils. The better agricultural soils are confined to the Tertiary and Cambrian volcanic materials where both red and brown Ferrosol soils have formed. On coastal lowlands and plains a series of wet soils, with both sandy and clay textures, are utilised for intensive grazing purposes. The poorest soils occur on material of Precambrian age where erosion risk, poor drainage or stone content severely restricts agricultural land capability.

Land use in the area is dominated by intensive cropping and dairying enterprises. Other land uses such as beef farms, market gardening, hobby farming and plantation forestry also occur.

Despite receiving moderate to high average annual rainfall (900-1400mm/annum) most of the rains occur in winter and necessitate the use of irrigation of both crops and pastures during the summer period to achieve optimum yields. The majority of this irrigation water is supplied from on-farm storage or taken directly from rivers or creek systems. Where irrigation water is unavailable or dam creation impossible, such as on some plateau tops, agricultural uses are significantly constrained.

The total survey area extends over 84 000ha of which approximately 28 600ha (33%) is considered exclusion and has not been mapped.

The land has been classified according to the land capability classification system for Tasmania as described by Noble 1992a and Grose (in prep) and boundaries have been determined by a combination of field investigation, aerial photo interpretation and computer modelling.

Land capability is based on the ability of the land to produce sustainable agricultural goods without impairing the long-term, sustainable productive potential of the land. The system categorises land into seven capability classes with increasing degree of limitation for agricultural production or decreasing agricultural versatility as the system progresses from Class 1 to Class 7. Classes 1 to 4 are considered suitable for all agricultural activities especially cropping activities, Classes 5 and 6 suitable for pastoral activities only and Class 7 is considered unsuitable for agricultural use.

Complex units have been mapped where two land classes have been identified but cannot be usefully separated at the scale of mapping. Within each complex the first land class identified is dominant and occupies 50-60% of the unit, while the second class occupies 40-50%.

The best agricultural areas, (Class 1, 2 and 3 land), occur where deep soils have formed from basaltic and sedimentary rocks of Tertiary and Cambrian age and erosion risk is low (slopes less than 18%). A wide variety of crops are produced in these locations including potatoes, carrots, onions, peas, beans, buckwheat, an assortment of brassicas, poppies and cut flowers. This land is found south of Smithton, Forest, Montumana, Circular Head Peninsula and Lileah. It represents the most intensively used agricultural land within the Circular Head area. This "Prime Agricultural Land" represents 14.3% of this map sheet.

Where less well drained land, shallow soils and topographic constraints occur, a transition towards intensive grazing and occasional cropping land use occurs. Most of this land is identified as Class 4 land. This land requires much higher levels of management to prevent degradation. Major limitations on this land include erosion risk and soil drainage.

The largest land capability class on the map is Class 5 making up just under 30% of the total map area. This land is mostly found on the poorer drained sandy alluvial sediments that are very wet for most of the year (too wet for cropping activities apart from fodder crops). Intensive drainage keeps these areas producing high quality pastures especially where hump and hollow drainage has been implemented. Other areas include the steep and rocky slopes of the coastal escarpment as well as the poorly drained areas on clay soils in Mowbray Swamp and where shallow Cambrian mudstone soils occur at Christmas Hills and Barcoo Road.

A small proportion of the Circular Head area is comprised of Class 6 land. This land is predominantly found on or surrounding the coastal escarpments, low coastal plains or steep hillslopes of the Dip Range, Circular Head and the Sisters Hills. Shallow soils, poor drainage, rock outcrop and highly erodible soil types generally limit this land restricting agricultural use to rough or seasonal grazing.

Land unable to sustain agricultural use (Class 7) is found mainly on the highly erodible frontal dunes and coastal swamps and mudflats where highly fragile landforms occur. Agricultural use of these areas can lead to unsustainable levels of degradation and potential reactivation of currently stabilised dune systems. Other areas of Class 7 occur in combination with Class 6 land on hill slopes with extremely high erosion risk and shallow soils. Examples can be found at most coastal locations such as Anthony, Black River, Peggs and Forward Beaches. Small areas are also found at Sisters Hills and Beacom Hill (locally known as White Hills).

Overall the major limitations to agriculture in the Circular Head area are:

- **Soil drainage** - poorly drained soils, high groundwater levels
- **Erosion risk** - rill, sheet, wind and landslip
- **Poor soil condition** - stoniness, poor soil structure, shallow topsoil depth.

Other minor but locally significant limitations found include:

- **Topographic complexity** - irregular and fragmented microrelief
- **Climate –** frost risk and exposure to strong winds, salt spray and high evaporation rates. This impacts on the range of crops that can be grown but its significance is generally confined to the basalt soils as other limitations are usually of greater significance elsewhere.

Table 1 shows the amount of each land capability class and each complex identified within the Circular Head area together with its proportion of the total map area.

Capability Class	Area(ha)	% of Circular Head Map
1	1283	1.51
2	4056	4.78
2+1	132	0.16
2+3	988	1.16
3	2904	3.42
3+2	738	0.87
3+4	1726	2.04
4	8139	9.60
4+3	2445	2.88
4+5	1638	1.93
5	21018	24.78
5+4	1943	2.29
5+6	3686	4.35
6	3722	4.39
6+5	197	0.23
6+7	81	0.10
7	1500	1.77
E	28611	33.74
TOTAL	84806	100.00

Table 1. Extent of land classes and land class complexes on Circular Head map.

1. INTRODUCTION

1.1 Background

This report continues a series of land capability reports published by the Department of Primary Industries, Water and Environment as part of a 1:100 000 scale land capability survey of Tasmania's agricultural land which began in 1989. The report and accompanying map describes the land capability classes found within the agricultural land of the Circular Head area (Figure 1). It evaluates the land capability of private freehold and leased Crown land only. Other areas are considered non-agricultural and are mapped as exclusion areas.

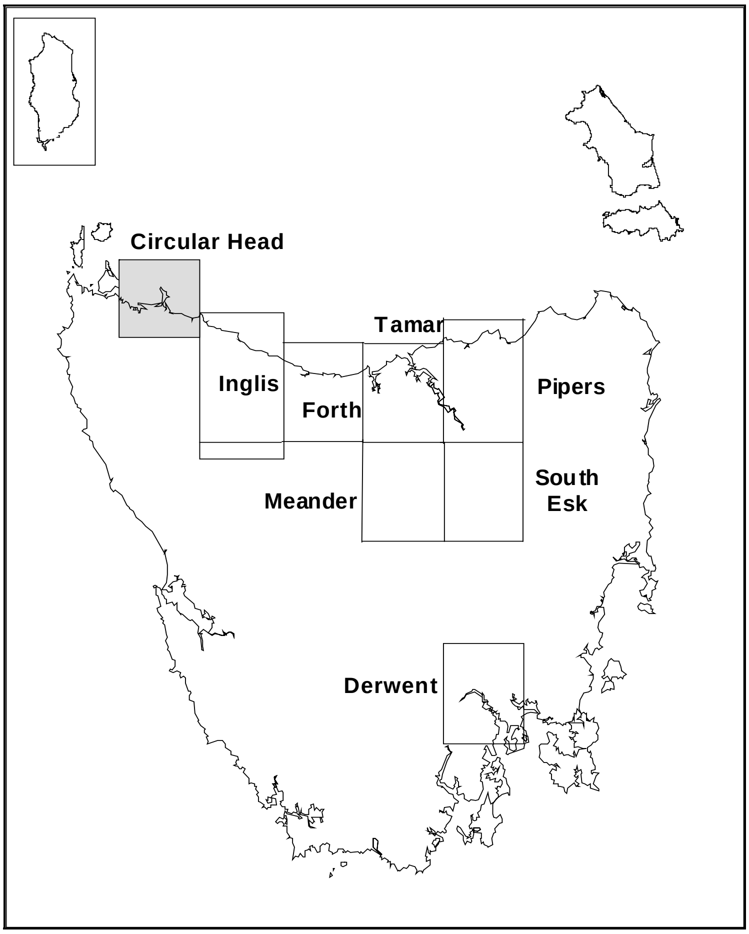


Figure 1. Circular Head survey location and previous land capability surveys in Tasmania.

The land capability project aims to: a) identify and map the extent of different classes of agricultural land in order to provide an effective base for land use planning decisions; and b) ensure that the long-term productivity of the land is maintained at a sustainable level, through the promotion of compatible land uses and management practices. It undertakes to achieve these aims through a program of mapping activities and associated extension and awareness programs such as the Farmwi$e program. It also supports the State Policy on the Protection of Agricultural Land (2000) by identifying areas of Prime Agricultural Land (Classes 1, 2 and 3).

The land capability classification system for Tasmania comprises a seven class classification and is based on the capability of the land to support a range of agricultural uses on a long-term sustainable basis.

The evaluation system takes into account only the land's capability to support sustained agricultural production and does not consider suitability for individual crops, forestry, orchards, vineyards or other non-agricultural uses.

Much of Tasmania's agricultural land has limitations that restrict its agricultural versatility. The land capability classification system recognises these limitations and uses the physical characteristics of the land and the local climatic characteristics to evaluate the area and classify it accordingly.

The information printed here and in the accompanying map is intended for use at a regional planning level and has limited use at the farm scale. The system can however, be applied at any level (see Section 3).

Surveys undertaken to date indicate that the State of Tasmania has only a small percentage of high quality, ‘Prime’ agricultural land (Class 3 or better) in proportion to the total area of agricultural land (Table 2).

Land Capability Map	**Class 1** **(ha)**	**Class 2** **(ha)**	**Class 3** **(ha)**	**Total Prime Land on map** **(ha)**	**Agricultural Land on map** **(ha)**	**Prime Land as a % of Agric. land mapped.**
Pipers	0	898	3459	4357	150930	2.89
Tamar	42	629	8958	9629	135626	7.10
Meander	0	127	12859	12986	106698	12.17
South Esk	0	0	8661	8661	216487	4.00
Forth	880	7149	16861	24890	113173	21.99
Inglis	748	3868	17533	22149	188051	11.78
Derwent	0	0	144	144	173564	0.08
Circular Head	1336	5023	5756	12115	56196	21.56
Total (to date)	3006	17694	74231	94931	1140725	8.32

Table 2. Prime agricultural land statistics for land capability maps produced to date. (based on current GIS measurements)

With ever increasing demands placed on our agricultural land to produce greater yields per unit area and the continuing uptake of good agricultural land for urban development and subdivision, the incidence of degradation and the loss of Tasmania's prime agricultural resource has been escalating. The acknowledgment of this has come in the form of legislation (State Policy on the Protection of Agricultural Land, 2000) which sets out to protect prime land and regionally significant agricultural areas, in order to prevent their loss to non-agricultural uses.

By determining the location and extent of Tasmania’s better quality agricultural land we are better able to protect it from loss to non-agricultural use or degradation through inappropriate land management practices.

2. HOW TO USE THIS MAP AND REPORT

This publication comprises a report and map. It is important that the land capability map be used in conjunction with the accompanying report. By referring to the map, and locating the area of interest, the land capability class assigned to that area can be determined. This is indicated on the map by a class number (1 to 7) and an associated colour shade.

Definitions of the land capability classes are given on the side legend of the map and in Section 3 of the report. Further detail about each of the land capability classes occurring within the Circular Head area is given in Section 6.

2.1 Limitations of Scale

Special attention needs to be paid to the limitations imposed by the scale of mapping.

It is important that the map is used at the scale at which it is published (1:100 000). **The map should not be reproduced at a larger scale (eg 1:25 000)**. The land capability boundaries found on this map are accurate only at the published scale of 1:100 000. Errors in interpretation will occur if the map is enlarged. If more detail is required, the area of interest should be remapped at a more suitable scale for the end use, rather than enlarging this map.

Gunn *et al* (1988) indicate that, at a scale of 1:100 000, the standard minimum area for a map unit which can be adequately depicted on the map is approximately 64ha. Landon (1991) suggests a wide range of "minimum areas" are currently in use. For the purposes of this work however, unit areas of less than 25ha have been mapped only where they are identifiable on the basis of clearly visible boundaries (usually topographic) or where they link with larger areas on adjacent map sheets or within exclusion areas. Impurities in map units will occur where land class changes are a result of less obvious changes in land characteristics or qualities.

In any mapping exercise there are always areas which are physically too small to delineate accurately at a given map scale and in such cases these areas are absorbed into surrounding units. The map units shown on this map will therefore often contain more than the one land capability class or subclass. The map units are assigned the dominant land capability class within them but it should be recognised that some map units may contain up to 40% of another class.

Complex map units (eg 4+5) have been identified in a number of areas where, due to the complexity of the soil pattern and particularly the variation in the topography, two land classes are identified. Each occupies between 40% and 60% of the total unit area, but cannot be adequately distinguished at the scale of mapping. Such areas are shown as striped units on the map. The first digit of a complex map unit label represents the dominant land capability class and is represented by the slightly wider of the two coloured stripes on the map. Further discussion of complexes and the method of labelling map units is found in Sections 3 and 4.

The accuracy of the land capability class boundaries depends on a number of factors including the complexity of the terrain, soils and geology. Where topography or other visible features change abruptly, the class boundaries may be well defined. Alternatively, changes may be gradual and more difficult to assess such as with a change in soil depth, some soil types, slope, or extent of rockiness. In these cases the boundary is transitional and therefore can be less precisely plotted on the map.

The majority of the exclusion boundaries for this survey have been supplied in digital format by Forestry Tasmania and are deemed to be accurate to 1998. Some areas less than 25ha have been removed to improve legibility of the map and absorbed into the adjacent land capability units.

2.2 Interpretation of the Land Capability Information

The scope and range of applications of the land capability information depends on the scale at which the surveys are carried out. This map has been produced at 1:100 000 scale and is targeted for use at the district or regional planning level.

Larger scale maps such as those at 1:5 000 or 1:10 000 are more suitable for whole farm planning purposes, to plan farm layouts and identify appropriate land uses, soil conservation and land management practices. A scale of 1:25 000 is more appropriate for catchment planning, although this is a guide only for the scale used will often be determined by the size of the catchment to be surveyed and the amount of time that is allocated for mapping it.

Best use can be made of this map and report by local government, regional and State land use planning authorities. The information at this scale is **not** intended to be used to make planning decisions at farm level, although the information collected does provide a useful base for more detailed studies. The methodology does however apply to all scales of mapping and can be utilised equally well by local landowners, local, regional or State planning authorities.

Examples of other potential uses of land capability information at 1:100 000 scale are:

- Identifying broad areas of prime agricultural land (Classes 1 to 3) for retention for agricultural use.
- Rational planning of urban and rural subdivisions.
- Identifying areas for new crops, enterprises or major developments.
- Identifying areas for expansion of particular land uses.
- Planning of new routes for highways, railways, transmission lines, etc.
- Identifying areas of land degradation, flooding or areas that may require special conservation treatment.
- Identifying areas of potential erosion hazard.
- Resolving major land use conflicts.
- Integrated catchment management (depending on catchment size).

Combining land capability information, with other resource data using a GIS (Geographic Information System), can greatly enhance its use, accessibility and interpretation.

While intended for use by regional and State planning authorities, the information supplied by this map and report can still be used at the farm level to give a general indication of the land quality at a particular location. For example, a newcomer to an area wishing to purchase good quality land for cropping could look to the map to find where Class 1, 2 and 3 has been identified.

The land capability maps and reports do not purport to have legal standing as documents in their own right, nor should they attempt to stand alone in planning decisions without being supported by other relevant land resource, economic, social or conservation considerations. The information is intended as a guide to planning development and, where more detailed planning is required, for farm planning or route alignment for example, further fieldwork at a more appropriate scale needs to be undertaken.

Section 3 of this report provides more information about land capability classification and definitions for the individual land capability classes, while Section 4 discusses the survey methodology used. A general description of the survey area, including climate, geology, topography, soils, vegetation and land use appears in Section 5, while a detailed account of land capability classes found is presented in Section 6.

2.3 Copyright

The maps, reports and digital information stored on the DPIWE databases are copyright, and the data is solely owned by the Department of Primary Industries, Water and Environment, Tasmania. Every encouragement is given to individuals and organisations who wish to use the information contained in this report and accompanying map to assist with property management or regional planning activities. However, commercial organisations or individuals wishing to reproduce any of this information, by any means, for purposes other than private use, should first seek the permission of the Secretary, Department of Primary Industries, Water and Environment.

2.4 Availability of Land Capability Publications in this Series

An Index of the land capability maps (based on the TASMAP 1:100 000 Series) is shown on the rear cover of this report. The locations of maps available to date are indicated in Figure 2. and the prices (including GST) of the land capability publications are listed below.

Pipers Report and Map	$16.50
Tamar Report and Map	$16.50
Meander Report and Map	$22
South Esk Report and Map	$33
Forth Report and Map	$33
Inglis Report and Map	$33
Derwent Report and Map	$33
Circular Head Report and Map	$33
Land Capability Handbook	$11
Land Capability Classification in Tasmania, Information Leaflet	No Charge

All listed items may be viewed and ordered at DPIWE reception desks or telephone 1300 368 550 State wide or Service Tasmania on 1300 366 173.

DPIWE land resource assessment staff welcome constructive comment and criticism of all reports and accompanying maps and, in the event that significant errors in classification are identified (at a scale appropriate to the level of mapping), they can be reported to DPIWE staff and documented appropriately.

3. LAND CAPABILITY CLASSIFICATION

Land capability classification is an internationally recognised means of land evaluation used to determine the capability of land to support a range of land uses on a long-term, sustainable basis.

For the Tasmanian classification system, agricultural land uses only are considered, and are defined as broad scale grazing and cropping uses. Land capability ratings for specific land uses are not evaluated, nor is the capability of land for forestry use incorporated into the classification system.

Land capability may be defined as a rating of the ability of land to sustain a range of land uses without degradation of the land resource. It is an interpretive and somewhat subjective assessment based on the physical limitations and hazards of the land, potential cropping and pastoral productivity, and the versatility of the land to produce a range of agricultural goods (Figure 2).

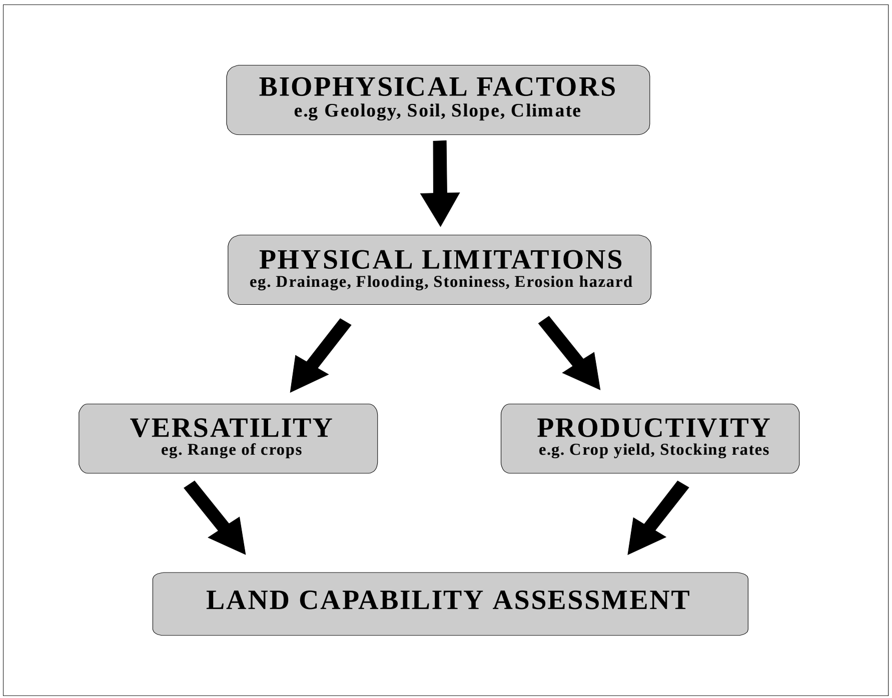


Figure 2. Factors in land capability assessment.

Land capability assessment takes into account the physical nature of the land (eg geology, soils, slope) plus other factors (eg climate, erosion hazard, land management practices) which determine how that land can be used without destroying its long-term potential for sustainable agricultural production. It also takes into account limitations that might affect agricultural use, eg stoniness, drainage, salinity or flooding. Land capability assessment is therefore based on the permanent biophysical features of the land (including climate), and does not take into account the economics of agricultural production, distance from markets, or social or political factors.

Land capability assessment should not be confused with land suitability assessment which, in addition to the biophysical features, may take into account economic, social and/or political factors in evaluating the 'best' use of a particular type of land.

Land capability classification gives a grading of land for broad scale agricultural uses, whereas land suitability is applied to more specific, clearly defined land uses, such as land 'suitable' for growing carrots, and usually defines specific management systems. The basic principle of land capability brings together both land conservation and protection of land as well as its potential for broad scale agricultural production, in other words, the balance between use of the land and the risk of degradation of the land resource.

3.1 Features of the Tasmanian Land Capability Classification System

The Tasmanian system of land capability classifies land into seven classes according to the land's capability to produce agricultural goods. The system is modelled on the USDA (United States Department of Agriculture) approach to land capability (Klingbiel and Montgomery, 1961) and is described in full by Noble (1992) and Grose (in prep). A summary of the system is presented here to assist with the interpretation of the report and accompanying map. The classification does not attempt to portray specific land uses, or rank the value of any particular agricultural land use above another. Neither does it attempt to give an indication of land values.

The Tasmanian land capability classification system is based on agricultural production (cropping and pastoral productivity). It is based on cultivation of the land for cropping purposes and not other land use systems which can sustain 'crops' on steeper land with longer rotations and less risk of erosion (eg perennial horticulture, silviculture).

The classification relates primarily to the three permanent biophysical features of the landscape - soil, slope and climate. These three factors have a major influence in determining the capability of the land to produce agricultural goods. Other factors which must be taken into account include rock type, erosion hazard, range of crops that can be grown, management practices, soil conservation treatment, risk of flooding and past land use history.

A valid criticism of the land capability classification process is that it is a very subjective system. In order to improve this aspect of the system a revised set of guidelines has been produced by Grose (in prep). This handbook will supersede that of Noble and sets out more quantitative guidelines for assessing some land attributes. While the guidelines will improve the consistency between different surveyors, a certain amount of subjectivity still remains in the determination of cut-offs for each land class.

Considerations of the system

The system assesses the versatility of the land to produce a range of agricultural goods that are considered typical for Tasmania, and not just those that are specific or suited to localised areas. For example, small scale intensive activities like soft fruit orchards and floriculture are not considered when evaluating the versatility of an area. Opportunities for silviculture are another activity that the system does not consider. The main agricultural land uses that are considered when evaluating land include cereals, poppies, broad acre vegetable production (potatoes, peas, beans, onions etc), pyrethrum and essential oils, dairy, beef, lamb and wool production.

The system considers degradation of the soil resource and does not take into account the possible effects of agricultural land use on water quality, aesthetics, wildlife, etc except where it might impact on the quality of the agricultural resource.

The classification, in particular at the unit level, takes into account the management strategies and soil conservation requirements the land may need in order to maintain a level of production without long-term degradation.

For 1:100 000 scale surveys the issue of irrigation and its impact on land capability classification has created much discussion. While it is recognised that some areas of the State have the potential to attain an improved land capability ranking through the application of irrigation water, the extent of beneficial effects from irrigation on land capability will vary considerably depending upon such factors as water quality, economics and the skill of the property manager. These factors all require assessment on an individual property basis, a procedure inappropriate at this level of mapping. As well, it is beyond the scope of this survey to identify areas where irrigation water might be available. Land capability is therefore assessed on the ability of the land to support rain fed agriculture except where irrigated agriculture is considered normal practice and water is readily available from on farm water storage.

Assumptions

As with most land classification systems certain assumptions are necessary. These include:

(a) A moderately high level of management is being applied to the land.

(b) Appropriate soil and land conservation measures have been applied.

(c) Where it is reasonable and feasible for an individual farmer to remove or modify physical limitations (eg surface and subsurface drainage, stoniness, low fertility) the land is assessed assuming the improvements have been made.

(d) Assessments are based on the capability of the land for sustained agricultural productivity, since use of the land beyond its capability can lead to land degradation and permanent damage.

(e) For the purpose of this work "*agriculture*" does not include forestry operations.

Main features of the system

- The land capability classification is an interpretive classification based on the permanent biophysical characteristics of the land.
- Land capability assessments of an area can be changed by major schemes that permanently change the nature and extent of the limitations (eg drainage or flood control schemes).
- The land capability classification is not a productivity rating for specific crops, although the ratio of inputs to outputs may help to determine the land capability class.

- Land capability does not take into account economic, social or political factors and is not influenced by such factors as location, distance from markets, land ownership, or skill of individual farmers.
- Present and past uses of the land (or similar land elsewhere) are guides to potential, in that they can indicate the limits of the capability of the land. Present land use and vegetation cover are not always good indicators of land capability class. The system of land capability is aimed at assessing the potential sustainable productivity of land rather than current productivity.
- The feasibility of irrigated landuse is not considered when evaluating land capability. However, in areas where irrigation is standard agricultural practice the capability of the land is assessed assuming irrigation is used.
- The system is consistent across the State.

It is important to remember that the land capability of an area can change as a result of improved farming practices, changes in crop variety, technical innovations or just a better understanding of the relationships between soils, farming and the natural environment. The information in this report has a limited lifespan and care should be given to its interpretation in future years. Farming practices that today are only available for the advanced or innovative farmer may become common practice in the future.

3.2 The Classification Hierarchy

Three levels are defined within the Tasmanian land capability classification:

- ***Class*** - which gives an indication of the general degree of limitation to use;
- ***Subclass*** - which identifies the dominant kind of limitation, and
- ***Unit*** - which differentiates between land with similar management and conservation requirements, productivity characteristics, etc.

The levels are also shown in Figure 3.

The land capability system can be used and applied at various scales by mapping to the class, subclass and unit levels. The level at which the mapping is undertaken and presented depends on the purpose and scale of the survey.

Class

The classification system comprises seven classes ranked in order of increasing degree of limitation, and in decreasing order of versatility, for agricultural use. The system is hierarchical. Class 1 land is identified as the best land and can produce a wider variety of crops and pastures at higher levels of production with lower costs, or with less risk of damage to the land, than any of the other classes of land. Class 2 land is similarly superior to Classes 3 to 7, and so on.

A range of land may occur in any one capability class. Thus it is often possible, for example, to identify good and poor quality Class 4 land. While the intensity of mapping required to achieve this is not feasible when mapping land classes at 1:100 000 scale, it would be possible to map such differences at the unit level.

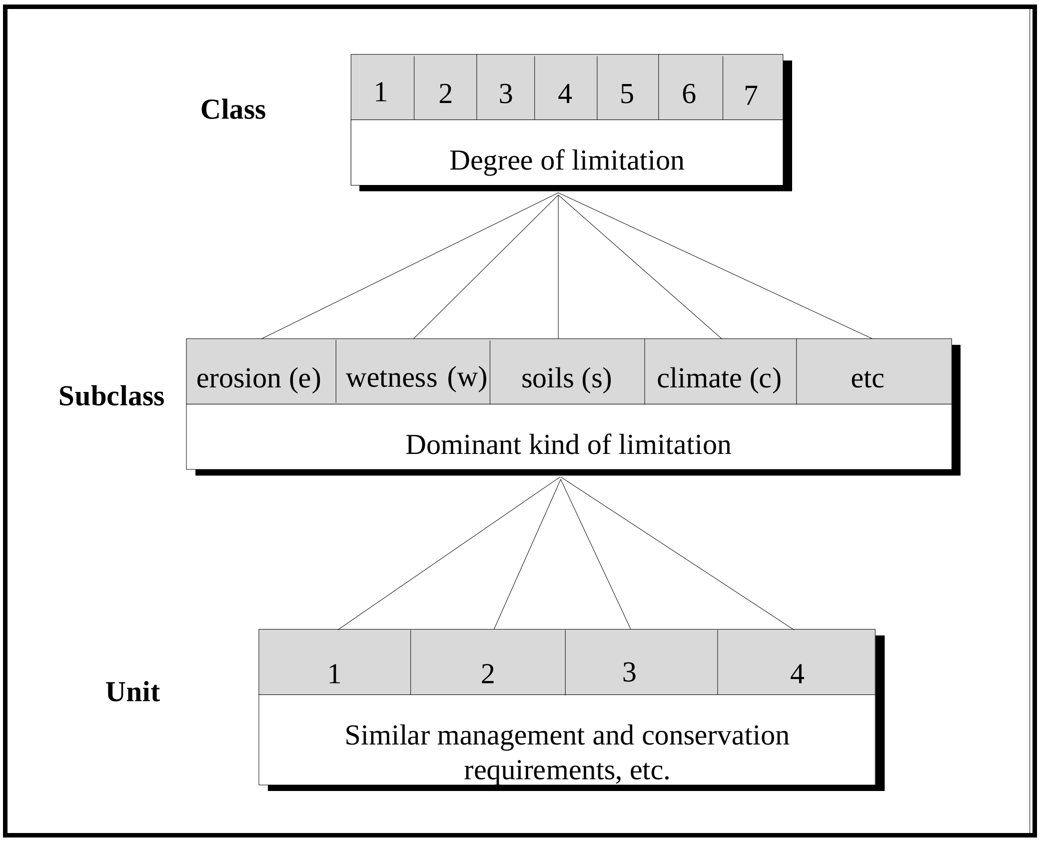


Figure 3. Levels of the land capability classification system.
(Adapted from: National Water and Soil Conservation Organisation, 1979, Our Land Resources. (NWASCO), Wellington, New Zealand.)

Classes 1-4 only are considered capable of supporting cropping activities on a sustainable basis; Classes 5 and 6 are more suited to grazing activities only although occasional fodder cropping and pasture improvement may be possible on Class 5 land, while grazing of native pastures only is appropriate for Class 6 land. Class 7 land is unable to support any form of sustainable agricultural activity.

Definitions

CLASS 1

Land well suited to a wide range of intensive cropping and grazing activities. It occurs on flat land with deep, well drained soils, and in a climate that favours a wide variety of crops. While there are virtually no limitations to agricultural usage, reasonable management inputs need to be maintained to prevent degradation of the resource. Such inputs might include very minor soil conservation treatments, fertiliser inputs or occasional pasture phases.

Class 1 land is highly productive and capable of being cropped eight to nine years out of ten in a rotation with pasture or equivalent without risk of damage to the soil resource or loss of production.

CLASS 2

Land suitable for a wide range of intensive cropping and grazing activities. Limitations to use are slight and these can be readily overcome by management and minor conservation practices. However the level of inputs is greater, and the variety and/or number of crops that can be grown is marginally more restricted than for Class 1 land. This land is highly productive but there is an increased risk of damage to the soil resource or of yield loss. The land can be cropped five to eight years out of ten in a rotation with pasture or equivalent during 'normal' years, if reasonable management inputs are maintained.

CLASS 3

Land suitable for cropping and intensive grazing. Moderate levels of limitation restrict the choice of crops or reduce productivity in relation to Class 1 or Class 2 land. Soil conservation practices and sound management are needed to overcome the moderate limitations to cropping use.

Land is moderately productive, requiring a higher level of inputs than Classes 1 and 2. Limitations either restrict the range of crops that can be grown or the risk of damage to the soil resource is such that cropping should be confined to three to five years out of ten in a rotation with pasture.

CLASS 4

Land well suited to grazing but which is limited to occasional cropping or to a very restricted range of crops. The length of cropping phase and/or range of crops are constrained by severe limitations of erosion, wetness, soils or climate. Major conservation treatments and/or careful management are required to minimise degradation.

Cropping rotations should be restricted to one to two years out of ten in a rotation with pasture or equivalent to avoid damage to the soil resource. In some areas longer cropping phases may be possible but the versatility of the land is very limited.

CLASS 5

This land is unsuitable for cropping, although some areas on easier slopes may be cultivated for pasture establishment or renewal and occasional fodder crops may be grown. The land may have slight to moderate limitations for pastoral use. The effects of limitations on the grazing potential may be reduced by applying appropriate soil conservation measures and land management practices.

CLASS 6

Land marginally suitable for grazing because of severe limitations. This land has low productivity, high risk of erosion, low natural fertility or other limitations that severely restrict agricultural use.

CLASS 7

Land with very severe to extreme limitations which make it unsuitable for agricultural use.

E - Exclusion Areas

Land with tenure other than private freehold or leased crown land according to 1998 Forestry Tasmania data. Exclusion areas include urban centres and other obvious non-agricultural areas such as National Parks, State Forests, Reserved land and large water bodies within the map area.

Notes on the Class Definitions

The length of cropping phase given for Classes 1-4 is intended as a general guide only. Past experience has shown that there is some confusion and concern regarding the figures given. While some land will just not support production beyond the intensity recommended (due to the risk of erosion or soil structure decline), other areas are limited by the risk of loss occasioned by such factors as adverse climatic conditions or flooding.

For example, some parts of the survey area are subject to a significant flood risk. Due to rainfall patterns in recent years it has been possible to cultivate these areas more frequently than might 'normally' be achieved. By cultivating these areas farmers are accepting a high risk of failure or damage to crops from flooding, and whether or not a crop is planted in any particular year is dependent, in part, on just how much risk an individual farmer is prepared to accept. In other areas the soils are such that significant periods of cultivation without a break can lead to severe structure decline, hindering germination, water infiltration, and soil aeration and increasing the likelihood of erosion.

Also, the classification system takes into account the *variety* of crops that can be grown. Thus Class 4 land might incorporate areas where a relatively wide range of crops could be grown but the risk of damage to the resource is such that cropping should **only** be undertaken one or two years out of ten. Conversely, other areas may support a more limited range of crops but production may be sustainable over a longer period.

It should be noted that capability classes have not been defined on the basis of productivity. This is partly due to problems in comparing the relative value of different agricultural practices and partly due to the lack of data regarding just what is sustainable for each land class. As well, within any particular land class, there is likely to exist a range of land and, at a more detailed level of mapping, it may be possible to distinguish, for example, between good Class 4 land and poor Class 4 land.

Figure 4 summarises the main features of the land capability classes.

Subclass

Within each class it may be possible to identify a number of limitations that restrict agricultural use. Limitations may be defined as physical factors or constraints that affect the versatility of the land and determine its capability for long-term sustainable agricultural production. Where limitations are found a class may also be allocated a subclass code indicating the nature of the dominant limitation or hazard that exists. Subclass codes are a single letter that is added directly after the Class. For example an area identified as Class 4 that is limited by water erosion risk is coded 4h. A range of subclass codes exists. The four basic subclass codes are (c)-Climate, (s)-Soil, (e)-Erosion and (w)-Wetness. This list of four codes has in recent times been subdivided and added to by Grose (in prep), in an attempt to make each subclass code more informative (see Table 3).

In practice it may be possible to identify more than one limitation that restricts the use of an area of land. When mapping, every attempt should be made to record the dominant limitation although it may occasionally be necessary to record a maximum of two subclass codes. If more than two limitations are evident they should be grouped according to the broad limitation code under which they fall (e, w, s, or c).

CLASS		LIMITATIONS	CHOICE OF CROPS	CONSERVATION PRACTICES
1	Under cultivation	Very minor	any	Very minor
2		Slight	Slightly reduced	Minor
3		Medium	Reduced	Major
4		Severe	Restricted	Major + careful management
5	Under pastoral use	Slight to moderate	Grazing	
6		Severe	Grazing	
7		Very severe to extreme	No, or very minor agricultural value	

Figure 4. Features of land capability classes

Unit

Unit codes may be added to the *Class* and *Subclass* classification when conducting a detailed land capability study at the farm scale. Unit codes help to distinguish between similar areas that have different management or conservation requirements. They may also be used to separate areas that have slightly different productivity characteristics which may not be significant in a broader scale study. For example, an area identified as 5h may be further divided into land requiring conservation practices appropriate for gully erosion 5h1 and land requiring conservation practices appropriate for sheet erosion 5h2. Unit codes are not considered in a 1:100 000 scale study.

• **e** (erosion) Unspecified erosion limitation (both current and potential). – **a** (aeolian) Erosion caused by the effects of strong wind. Usually affects sandy or poorly aggregated soils and can occur on slopes of very low gradient. – **h** (water) Erosion resulting from the effects of rainfall, either directly through raindrop impact or through secondary effects of overland flow and surface run off (including stream bank erosion). – **m** (mass movement) Landslip, slumping, soil creep and other forms of mass movement. • **w** (wetness) Unspecified wetness limitation. – **f** (flooding) Limitations created through the surface accumulation of water either from overbank flow from rivers and streams, run-on from upslope areas or because the area lies in a topographic depression. – **d** (drainage) Limitations resulting from the occurrence of a ground watertable, or restricted or impeded permeability within the soil profile, leading to the development of anaerobic conditions. • **x** (complex topography) Limitations caused by irregular, uneven or dissected topography which limit ease of management or divide land into parcels difficult to manage individually at the paddock scale.	• **s** (soils) Unspecified soil limitations. – **g** (coarse fragments) Limitations caused by excess amounts of coarse fragments (particles of rock 2 - 600mm in size), including gravel, pebbles and stones, which impact on machinery, damage crops or limit growth. Coarse fragments may occur on the soil surface or throughout the profile. – **r** (rockiness) Limitations caused by boulders or outcrops of bedrock material greater than 600mm in size (cf coarse fragments, above). – **k** (conductivity) Land at risk from salinity (as indicated by high electrical conductivity readings of a 1:5 ratio soil:water paste). – **l** (limiting layer) Rooting depth or depth to some limiting layer. • **c** (climate) Unspecified climatic limitations. – **p** (precipitation) Limitations resulting from insufficient, excess or uneven distribution of rainfall. – **t** (temperature) Limitations caused by frost risk or by reduced length of growing season due to low temperatures. • More than one subclass may be recorded by listing the dominant subclass first eg Class 5 (a,c,f).

Table 3. Subclass codes and their definitions

4. SURVEY METHODOLOGY

The land capability map is produced through a combination of fieldwork and aerial photo interpretation (API). Fieldwork commenced in late July 1999 and concluded in early November 1999. A review of relevant land resource information was also undertaken to provide a background for field investigation.

Resource Information used

Resource information that has been utilised by this study has been referenced within the relevant sections of this report. Other information data sets have been used to determine relationships between landform, geology, soil and the associated land capability and are listed below.

Computer generated slope maps developed by the DPIWE GIS section from 1:25 000 scale contour information (10m contour intervals) and spot heights, interpret slope from a digital elevation model. These maps have a resolution of 50m. This information has proved invaluable in locating class boundaries where access has been difficult or in areas that are extensively covered by forest. While these slope class maps have assisted in boundary placement some underestimation of slope angle was occasionally found. This is attributed to the scale or resolution used to create the digital elevation model.

Black and white aerial photos at a scale of 1:42 000 taken during March 1992 have been utilised to determine boundaries where access has been difficult or where topography and landform have been the major determinant of the boundary (eg ridge or steep valley top). The location of detailed soil profile description sites has also been recorded on these photos.

Most of the survey area only has reconnaissance and regional scale, land resource information available. The Mowbray Swamp is the one area that has very detailed land resource information. This information takes the form of a soil map and accompanying explanatory report (Hubble and Bastick 1991) at a scale of 3 inches to 1 mile (1:21 120) this information has greatly assisted placement of land capability boundaries within this area.

The Mapping Process

Fieldwork proceeded along public roads and private property when needed, to assess land capability on-site and to check soil types, geological boundaries etc. Soil investigations have been made by hand auger and spade, as well as examination of soil exposures in ditches or road cuttings to determine depth of soil horizons and other important soil properties (Photo 1).

A combination of aerial photo interpretation and field assessment was used to determine land capability boundaries. These boundaries were then recorded onto 1:50 000 scale field maps before being transferred to base maps for digitising.

In line with standard mapping practice not all map units have been visited, rather informed assumptions have been made about some map units based on the knowledge of similar areas and the information extrapolated from these sites. Interpretations of existing land information and aerial photographs have also been used to predict land capability. This approach is necessary to reduce the time required to produce an end product and is appropriate where a good understanding of the relationships between soil, geology, landform etc and land capability exists. This is consistent with 1:100 000 scale mapping methodology.

In assessing land capability, consideration has been given to a wide range of land factors, together with information supplied by local farmers, land managers and agricultural advisers within DPIWE.

Storage of the data

All map information has been captured and stored in the Arc Info GIS at the government's Prospect Offices in Launceston. This information was digitised from 1:50 000 scale base maps and also includes subclass label information for some of the map units.

Site descriptions recorded in the field have been entered into the Department's Soil and Land Capability Database for reference and quality control purposes. This database includes a range of site information relevant to evaluating land capability and holds both land capability class and subclass information. Site information from other studies has also been used as reference sites for this survey giving a total of 203 reference sites.

Photo 1. The description and characterisation of soil types forms an important part of land capability fieldwork. Here soil depth and stone/rock abundance severely limits agricultural capability. (GR E 370600, N 5462900)

Reliability of the Data

Figure 5 provides an indication of the distribution of the observation sites and those used for reference purposes. Each site observation recorded during the survey is only accurate for the locality specified by its corresponding grid reference.

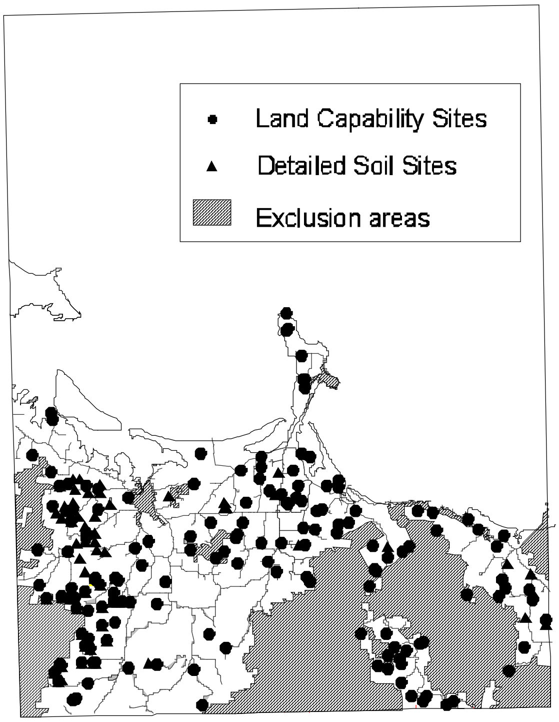


Figure 5. Distribution of land capability observation and soil reference sites for the Circular Head study area.

To facilitate mapping some areas under dense vegetation or with difficult or no access have been mapped using a combination of aerial photo interpretation, referral to other land resource information data (eg Land systems), and extrapolation of data from similar sites. Areas mapped using this technique include Perkins Island, parts of Robbins Island and both Mawbanna and Brickmakers Plains.

Complex Map Units

In some parts of the survey area the complexity of topography or soils make it impossible to separate pure land capability classes at the scale of mapping. In such instances ‘complex’ map units have been identified.

Considerable effort is made to map areas of a single land class but inevitably some complex units are unavoidable.

The complex areas identified within the Circular Head area could be separated into their relevant land classes at a more detailed level of mapping.

Use of Subclass Codes

Although the published map does not display any subclass codes, an attempt has been made to identify the dominant limitations (subclass) to agriculture within each map unit during the course of this survey. No attempt has been made to determine the boundaries between each of the subclasses however. As mentioned above the subclass information is stored by DPIWE. This information can be requested by contacting the resource assessment staff at Prospect Offices in Launceston.

In the Circular Head area it is common for large map units to occur that contain several limitations which change frequently over a very short distance. In such cases multiple subclass codes are recorded in order of dominance within that area (eg 4es).

5. THE CIRCULAR HEAD SURVEY AREA

5.1 Introduction

The study area lies on the north west coast of Tasmania (see Figure 2). It includes the coastal centres of Stanley and Smithton and a few small rural settlements such as Forest, Edith Creek and Lileah. The total area is some 84 806ha of which just over 33% is identified as exclusion areas which comprise State Forest, Forest Reserves, National Park and urban areas.

The area has a range of landforms, micro climates and associated land uses which are discussed in the sections below.

5.2 Climate

The climate of the Circular Head area is considered temperate maritime with cool, drier summers and mild, wet winters.

A small range of climatic conditions is experienced within the Circular Head area which can be directly related to distance from the coast, proximity to mountain ranges, elevation, topography and aspect.

Climate has influenced distribution and type of land use. Both intensive vegetable production and urban settlements have located near to the coast where warmer conditions occur. These conditions allow longer growing seasons, greater growth rates and increased crop varieties. At inland locations cropping enterprises often give way to beef grazing or dairy farming, as well as plantation forestry.

Two main areas have the harshest climatic conditions. One of these is at the coast in topographically exposed areas. Here strong wind and salt sprays influence the type and growth of the vegetation found. Another area is in the higher south eastern part of the survey area where cold, wetter conditions occur. Here conditions are less favourable for agriculture, due to short growing seasons, frost, more overcast conditions and high frequency of rainfall.

5.2.1 Precipitation

The amount of rainfall received in the Circular Head area increases from north to south. The northern coastal locations of Stanley and Port Latta are the driest regions recording just over 900mm each year. The southern margins of the map area are the wettest, with up to 1500mm each year. Figure 6 shows a simplified rainfall isohyet diagram for the survey area. This information has been created using ESOCLIM climatic modelling software, and the results closely reflect previous work by HEC (1986) which was used during the field work stage of this study.

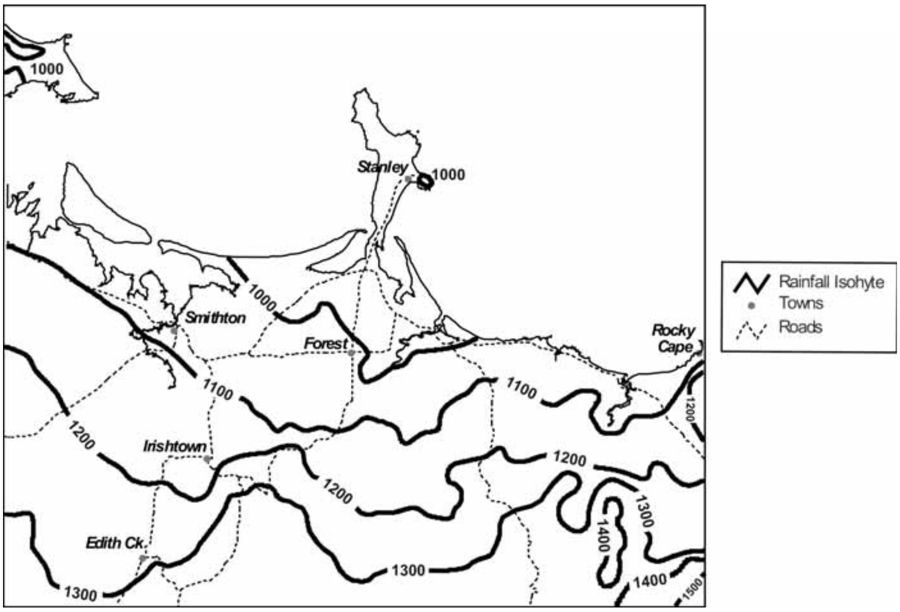


Figure 6. Simplified rainfall isohyet diagram (mm/year)
for the Circular Head area. (ESOCLIM)

A selection of rainfall stations have been chosen throughout the survey area to show average monthly rainfall and the variation between coastal and inland locations (Figure 7). Precipitation is winter dominant at all stations with over two thirds falling between the start of April and end of October. The driest period of the year is January through to March.

Within the intensive agricultural areas, and even within some of the intensive grazing areas (especially dairy), irrigation is essential to achieve economic and reliable productivity during the summer months. The need to irrigate is also a reflection of the seasonal distribution of precipitation in this region. An interesting feature of the rainfall data in Figure 7, is the three distinct winter peaks separated by troughs for May, July and September at the higher altitude location of Lileah.

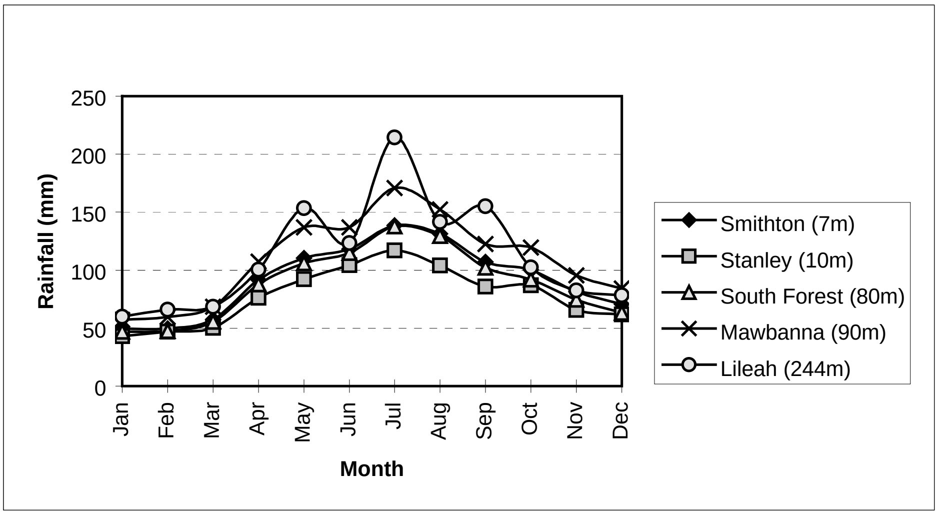


Figure 7. Average monthly rainfall for selected stations
(Source: Bureau of Meteorology, unpublished data, 1999)

At mainly inland areas of the south east snowfalls, sleet and hailstorms can occur, mainly between April and October. When south to south westerly weather systems prevail, snow may even settle on the mountain ranges in the south east for short periods of time. Occasionally snow may fall within 12km of the coast, but rarely settles for any great length of time.

5.2.2 Evaporation

No stations record evaporation data within the Circular Head survey area. Evaporation information has therefore been modelled using the ESOCLIM climate modelling to create an evaporation surface for the Circular Head area. By combining data from this surface with actual rainfall data, it is possible to see the period of the year most likely to experience a moisture deficit (Table 4). Stanley and South Forest have the longest period of moisture deficit from October to the end of March. The model indicates that evaporation can exceed rainfall for five to six months of the year. Figure 8 shows the relative distribution of these "dry" periods.

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Smithton	Evap	162.0	139.0	106.0	66.0	45.0	33.0	37.0	48.0	64.0	94.0	121.0	142.0	1057.0
	Rain	49.6	49.6	57.4	91.6	110.4	118.0	138.5	131.3	107.0	100.1	81.5	70.6	1105.6
Stanley	Evap	163.5	140.0	107.5	67.0	45.0	33.5	37.0	48.0	65.0	96.0	123.5	144.5	1070.3
	Rain	43.0	46.9	50.1	76.1	92.1	104.4	117.1	103.9	85.9	86.8	65.8	61.9	934.0
South Forest	Evap	159.5	137.0	104.5	65.0	44.0	32.0	36.0	46.5	63.0	93.0	119.5	140.5	1040.5
	Rain	46.9	47.4	55.4	87.8	106.0	114.8	137.7	129.3	102.1	92.0	74.6	63.3	1057.3
Mawbanna	Evap	159.0	136.0	104.0	65.0	43.0	32.0	35.0	46.0	63.0	93.3	120.3	141.0	1037.5
	Rain	57.1	59.6	68.4	107.3	136.8	136.8	170.9	152.4	122.6	119.6	95.6	84.2	1311.3
Lileah	Evap	153.9	132.0	99.0	62.0	41.7	30.0	33.0	43.7	59.0	88.0	114.0	135.0	990.9
	Rain	60.0	65.9	68.3	100.4	153.3	123.4	214.5	141.6	155.1	102.3	82.6	78.5	1345.9

Table 4. Average monthly evaporation (modelled) and recorded annual rainfall figures for selected stations. Shaded areas indicate months where a moisture deficit occurs ie where evaporation exceeds rainfall.

Both this map and the table above imply that evaporation significantly impacts upon soil water availability in the Circular Head area.

Calculations of effective rainfall using the modelled monthly evaporation figures and the formula developed by Prescott and Thomas (1949) indicate that some locations will experience acute shortages of moisture during the growing season. Average monthly rainfall falls short of the amount of rainfall required for germination and to maintain plant growth during the months October through to May (eight months) at Stanley.

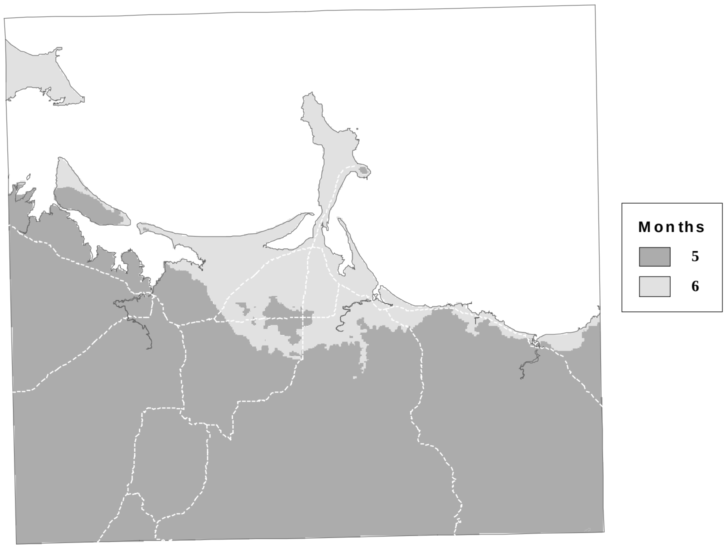


Figure 8. Number of months that evaporation exceeds rainfall in the Circular Head survey area (ESOCLIM).

Similar trends occur at Smithton, South Forest and Lileah where the period is October through to April (seven months). This moisture stress period is significantly shortened at the higher altitude and inland location of Mawbanna where only five months each year (November through to March) are dry.

Without supplementary applications of water during these months, the risk of crop failure or yield loss is considered very high. Consequently irrigation is a common practice in the intensive cropping areas and considered essential to maintain the high levels of production currently demanded by growers to ensure their economic viability. Irrigation of pastures to sustain dairy herds is also common practice throughout the region.

Some of the low lying areas that suffer from high water tables or poor drainage during most of the year are less impacted by the high evaporation rates and low rainfall during the early summer period. These areas access ground water for their moisture requirements. Some areas with clay soils are also able to hold soil moisture for longer at the beginning of summer.

5.2.3 Temperature

Only two temperature stations exist within the survey area. These stations are Smithton and Stanley and their mean monthly maximum and minimum temperatures are displayed in Figure 9.

January and February are the warmest months in both locations with June through to August being the coldest. Elevation and proximity to the coast have a significant effect on these mean daily maximum and minimum temperatures.

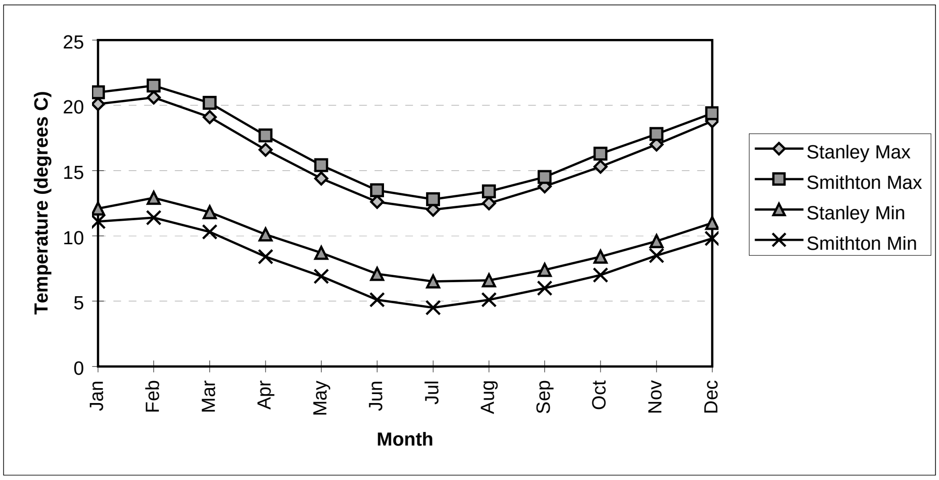


Figure 9. Mean monthly maximum and minimum temperatures for Stanley and Smithton. (Source: Bureau of Meteorology, unpublished data, 1999)

It can therefore be expected that cooler temperatures will be experienced in locations with high elevations or those that are found further inland.

Smithton experiences lower minimum temperatures probably due to cold air drainage into the Duck River Valley from the surrounding hill country.

Although no collected temperature data is available to confirm it, low temperatures have been reported by some landholders to impact upon both pasture and crop growth at Mawbanna and Lileah. The occurrence of low temperatures is confirmed by modelled temperature data presented in Figure 10 which displays the number of months per year average monthly minimum temperatures are below six degrees Celsius (the minimum temperature at which pasture growth occurs).

This figure shows that the north western, lowland, coastal areas experience fewer months each year where minimum temperatures fall below six degrees. In more elevated areas away from the moderating effect of the ocean, up to six and seven months of the year experience temperatures less than six degrees Celsius. This figure can also give a rough guide as to the areas most likely to receive frosts.

Table 5 shows the actual frequency of frost days per month each year for Smithton and Stanley. This ranges from 11 days per year at Stanley to 23 per year at Smithton with the greatest risk generally occurring between May and September.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Stanley	0	0	0	1	1	2	3	3	1	0	0	0	11
Smithton	0	0	0	1	2	5	6	4	3	1	1	0	23

Table 5. Mean number of days per month with frost (Source: Bureau of Meteorology, unpublished data, 1999)

Figure 10. The number of months per year that average monthly minimum temperature falls below six degrees Celsius.

Frost risk is a significant consideration when assessing the versatility of the land. Due to the close relationship between temperatures and altitude, elevation has been used to separate land capability classes on the basis of frost risk. The elevation limits for each land capability class have been determined (see Table 6) through observation and discussion with land managers and crop experts. These limits have been used as a **general guide** during fieldwork to determine areas limited by colder temperature. It is recognised that cold air drainage, aspect and topography will also affect the frequency and severity of frost at the local level. This is apparent in the differences between the frost occurrences per month at Smithton and Stanley (Both locations are below 180m but Smithton experiences significantly more frost).

Altitude Range	Potential Activities	Capability Class
<180m	Full range of crops and livestock, Long season and low frost risk.	1
180-260m	Full range but higher risk for frost sensitive crops.	2
260-380m	Not sweet-corn or other frost sensitive crops.	3
380-500m	Very restricted range of crops, eg cereals, seed potatoes, dairy.	4
500-700m	Grazing, some improved pasture, occasional fodder crops.	5
700-900m* (*Upper limit is only tentative)	Low intensity grazing, often on native pastures only.	6
No limits set	No agricultural activities possible.	7

Table 6. Altitude limits set for land capability assessment. (Table modified from Grose in prep.)

5.2.4 Growing Season

A synthesis of the previous climatic information in order to describe their impact on growing season follows. However, due to a lack of reliable and detailed additional information on this subject in this area, only general comments can be made.

Moisture availability and temperature are determining factors for the length of growing season in the Circular Head survey area. As discussed earlier, the natural growing season can be significantly extended with the application of irrigation and this has become standard practice in many parts of the survey area where better soil types make greater levels of inputs more financially viable.

In coastal areas other than exposed locations, such as on windward sides of headlands etc, warmer temperature conditions and ample precipitation occur for most of the year. These areas therefore potentially have the longest growing season. Moisture deficit periods which occur at these locations during the spring and summer are being overcome to some degree by the storage of rainfall and run-off water in farm dams and irrigation during the cropping/growth period.

Little cropping is undertaken in the area without supplementary irrigation. It seems generally accepted that some crops could be grown without extra water but yields would be significantly reduced or perhaps not viable. Irrigation extends the length of the growing season well into the summer months and allows the growing of more than one crop per season in some areas. Irrigation is also practised in intensive dairying areas sustaining pasture growth further into summer.

In the regions that experience a 6 month moisture deficit, farmers, especially cropping farmers closer to the coast on well draining soils, will need to use more irrigation water than those further inland. More importantly though, at these locations they can plant crops earlier and harvest later, due to more favourable (drier) soil moisture conditions. These farmers thereby enjoy a longer growing season. In some locations this extra month of drier conditions allows an extra crop to be grown each year.

At locations where a shorter (five month) deficit period occurs, areas either receive more rainfall or have colder temperatures or a combination of both. These characteristics result in longer periods, especially in early spring or at harvest time, when wet soils prevent use of machinery. Damage to the soil from pugging and treading by stock during this time is also greater in these areas.

On the lowland plains the lack of drainage outfall, the extent of low permeability soils and high winter rainfall result in shorter growing seasons. The wet conditions impact upon the growth and development of pastures and crops and also prevent timely access to perform planting and harvesting activities. For the areas with clay soils an increased risk of soil degradation exists also. Growing seasons and working windows are significantly shortened at these locations in spring and autumn.

Higher elevation regions further from the moderating effect of the ocean have the coldest climatic conditions, highest frost risk, highest rainfall and lowest evaporation rates. These areas stay wetter for longer at the beginning and end of summer impacting upon the ability to plant and harvest crops. The choice and variety of crops that may be grown is also impacted upon. These areas have the shortest growing period within the Circular Head area.

Local topographic effects, aspect, frost hollows and local airflow patterns are likely to have significant effects on growing season but the identification of these falls outside the scope and level of detail of this work.

5.3 Geology

The geology of the survey area is covered by the Geological Survey of Tasmania Sheet 7916s SMITHTON (1982). This geological information has in Figure 11, been grouped and draped over a digital terrain model in an attempt to show the relationship between the geology types and the topography across the Circular Head survey area.

From this figure it is possible to visualise the area and the wide diversity of rock types covering a substantial geological time-span. Rock ages range from the Precambrian (older than 570 million years) to very recent dune and alluvial deposits of the Quaternary period (less than 2 million years).

Figure 11 also clearly shows the group of low lying Quaternary sediments that represent the extent of inundation by the sea during periods of higher sea levels. Volcanic lavas can be seen capping older sedimentary rock types and the faulted and folded Precambrian sedimentary strata in the south eastern section are also easily seen.

Only a summary of the major rock types and their main form are presented in the next few pages and readers are directed to the Geological Survey Explanatory Report Sheet 21 compiled by Brown (1989) that accompanies the Smithton geological map for more detailed information. Rock types are described in order of their age beginning with the oldest rocks within the survey area. Readers are directed to Appendix A for the relative ages of the following rock types.

Precambrian Rocks

Precambrian rock types occupy most of the area within the Circular Head map. They include finely laminated siltstones, very fine sandstone, mudstone, quartzite, orthoquartzite, conglomerates, chert and dolomite. These materials are some of the oldest found within Tasmania and most have been faulted and folded during an early period of mountain building (the Penguin Orogeny). A product of this mountain forming period was a number of geanticlines that have revealed some of the oldest basal bed sequences. These have been heavily eroded, dissected or covered by more recent materials such as Quaternary sands and lavas of various ages such as at Mawbanna Plains or at the settlement of Rocky Cape.

The oldest of the Precambrian rock types is a suite of highly siliceous sediments ranging to 5000m thick in places and collectively termed the Rocky Cape Group. This group has been described by Gee in the Geological Atlas 1:63 360 Series study of the Table Cape, area (1971). He subdivides this suite of rocks into four subgroups, three of which occur within the Circular Head survey area. These include the Cowrie Siltstone at the base, Detention Quartzite and Irby Siltstone as the most recent material in the sequence.

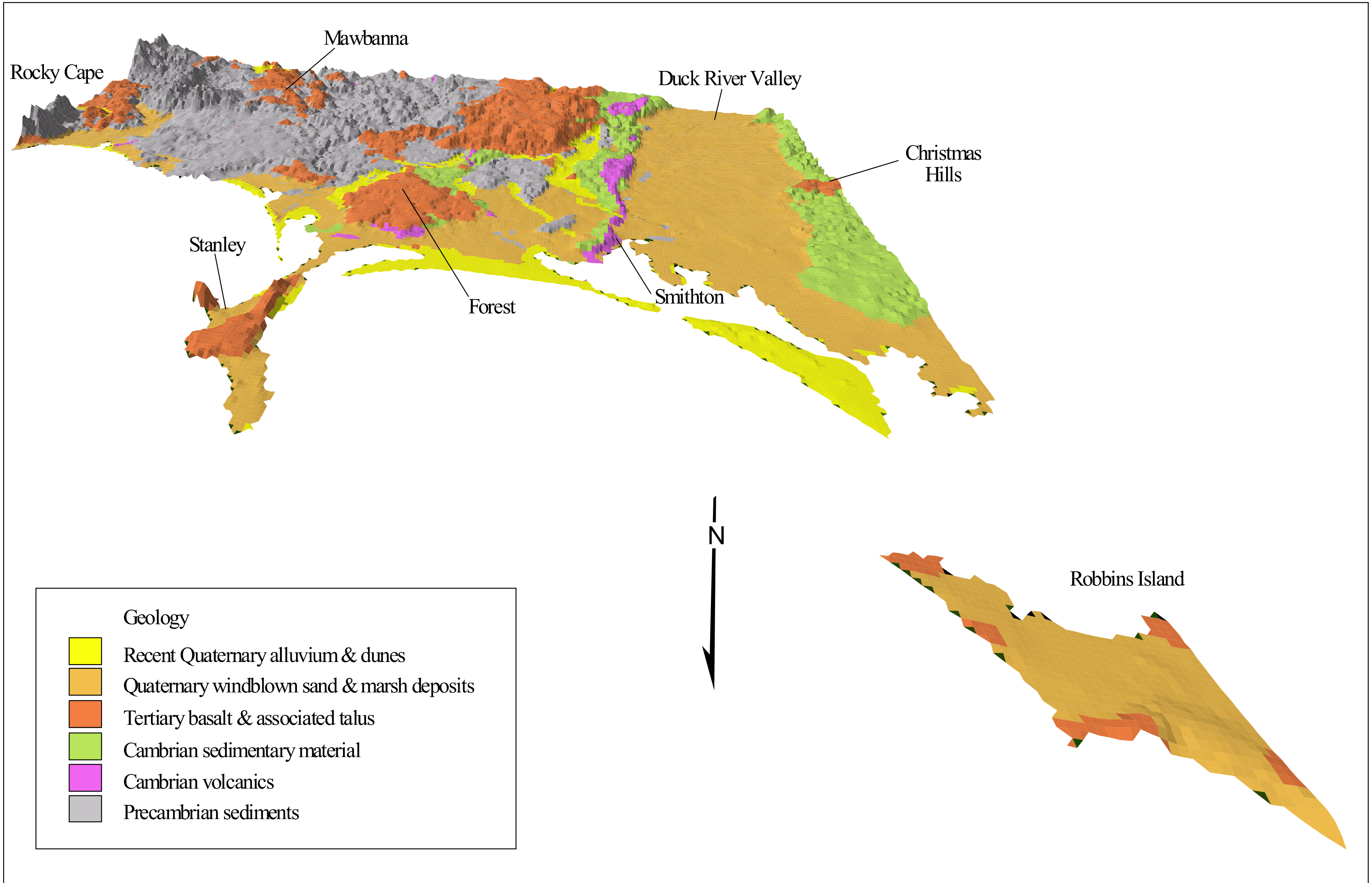


Figure 11. Simplified geology information draped over an elevation model of the Circular Head survey area.

The Irby Siltstone and Detention Quartzite, with their faulted and folded nature, form the steeper country adjacent to the Shakespeare Hills, Alarm River and Rocky Cape National Park, while the Cowrie Siltstone, which is the most ubquitous of the Rocky Cape sediments, occurs in the central and northern areas. This sub group has a less rugged landform and generally occurs below 200m elevation. In places Quaternary sand and peaty deposits have sporadically overlain the Cowrie Siltstone, such as at Mawbanna Plain.

Overlying the Rocky Cape Group occur younger Precambrian sediments such as the Forest Conglomerate and Quartzite and Smithton Dolomite. The Forest Conglomerate is found only in small, often linear formations that comprise ridges or small escarpments in the Black River, Mengha, Beacom Hills and Lake Mikany areas. This relatively thin geological unit consists of a siliceous boulder conglomerate comprised of angular quartzite fragments within a sandy matrix. These fragments range in size from 20-100mm near the surface to 600mm at depth. There are several quarries that extract this material for construction purposes within the Circular Head area.

Although they compose the uppermost Precambrian units, the Smithton and Black River Dolomites are rarely observed in large exposures other than quarries. They underlie most of the Duck River drainage basin and are the source of the magnesium carbonate deposits associated with the artesian spring mounds, or “blows” as they are locally called, in the Mella and Mowbray Swamp areas.

Hubble and Bastick (1991) suggest that the water that supplies these spring mounds originates from rainfall higher in the catchment. As it passes through the fissures and joints in the dolomite rock, magnesium carbonate moves into solution. In lower catchment areas these heavily mineralised waters become pressurised and are forced to the surface depositing much of the carbonates and forming the characteristic mound shape.

A number of small outcrops of dolomite can be observed in the valley between Scantlebury Hill and Smokers Bank, as well as at Briant Hill and South Forest. The largest area appears east of Lake Mikany adjacent to a large down thrusting faultline. Dolomite is quarried, predominantly for agricultural fertiliser, west of Smithton and south of the study area at Roger River. It has also been used as a road construction material from sources at Edith Creek and the Duck River valley (Bacon C.A. cited by Brown 1989).

Cambrian Rocks

Cambrian rock types are found on both sides of the Duck River drainage basin and in the South Forest region. A range of lithologies are found and can be divided into two main groups – igneous and sedimentary rock types.

Igneous rocks include the breccias, spilites and pillow lavas. These occur in a ridgeline with a north south alignment on the eastern side of the Duck River basin as well as at a few isolated occurrences on the western margins of the Forest Plateau and again east of Lake Mikany. On gently sloping land such as the plateau tops the materials have weathered to produce red ferrosol soils that are highly regarded for intensive agricultural use. On steep slopes rock outcrop occurs, and soils are shallow and susceptible to mass movement and water erosion.

The sedimentary rocks of Cambrian age consist of finely textured mudstone, siltstone and greywacke of varying colours ranging from purple, red brown through to yellows and greys. They are often laminated and sometimes fossiliferous. Christmas Hills and the hills extending from Tier Hill east of Smithton, through to Coopers Hill in the south, are formed from these rock types. They are also found at Forest, in the upper reaches of Ghost, Kings and Myrtle Creeks where erosion has removed the overlying Tertiary basalt.

Tertiary Volcanic Rocks and Sediments

Tertiary basalts occur in several regions throughout the Circular Head area. The main extent occurs in the central portion of the map. Basaltic plateaux extend from Green Hills at Stanley through the townships of Forest, South Forest, Alcomie, and Lileah to Sunny Hills in the south. Other areas include those at Mawbanna, Rocky Cape, Black River and Christmas Hills. The most notable basaltic feature is "The Nut" at Stanley. Research by Gill and Banks (1956) first recognised its pyroclastic features and it has since been confirmed to be the remains of a volcanic feeder.

The mineralogy of the Tertiary basalts is such that they weather to form the best agricultural soils in the area. The lava flows often cap other older sediments and have been logged to 160m thick at The Nut at Stanley but are generally up to 15m thick on the lava flows at Forest. Below and between the basalt flows near Montumana and Irishtown are other materials of Tertiary age including quartz gravel conglomerates, sandstone and claystone.

Basalt hill slopes are commonly sites for springs and water seepage to occur. Water percolates through the fractures in the bedrock and may flow laterally along the contact zone with underlying less permeable sediments or through very permeable sediment lenses sandwiched by the lava, to then exit at mid-slope or lower slope positions. The risk of landslip and erosion at these sites is high.

Quaternary Sediments

Quaternary alluvium within the Circular Head Map occurs mainly on the relict coastal platform, river valleys, flood plains, swamps and marshes. This alluvium includes beach cobbles and boulders, through to clays, freshwater limestone and fine windblown sands. Original deposition of these sediments is the result of higher sea levels during interglacial periods as well as material transported by the major rivers.

The dominant material is sand of windblown origin. It has collected in the low lying coastal plains and swale country to the south of Smithton in the Duck River drainage basin, Smokers Bank, Tatlows Folly and Fords Plains. It also occurs adjacent to Wilsons Creek and at the foot of the coastal escarpments at Forest, Black River, Hellyer and Crayfish Creek. Underlying the windblown sands at some locations are in-situ sands of marine and also freshwater origin. Within area of Quaternary sediments a great variation and complexity of landforms exists including barchan lunettes, terraces and marshes.

Close to the coast, in the bays and inlets behind Anthonys Beach and Black River Beach tidal marshes occur. These areas support a range of salt and water tolerant vegetation species and are often inundated during spring tide events. Other extremely wet areas include peat swamps found at Jones Plain and in the south western part of the Duck River drainage depression. Here extremely acid shallow peats have formed above highly leached white sand.

Contemporary and remnant dune systems occur in many coastal locations. Extensive areas can be found at Anthony, Black River, Peggs, Hellyer and Forwards Beaches. The older stabilised dunes occur on Perkins Island and inland on the coastal plains with examples clearly seen south east of Smithton aerodrome and adjacent to both Montagu and Back Line Road.

A small deposit of fresh water limestone occurs at Pulbeena south east of Smithton. A small quarry was once worked on this shallow exposure. Windblown sands and other sandy alluvium have mantled most of this material.

Quaternary talus and strandline conglomerates occur at the base of some of the large hills and escarpments. An area of quartz talus has formed a fan like feature at the base of the Precambrian Rocky Cape bedrock in the north east. Other areas of talus occur below The Nut and at the eastern and southern sides of Green Hills at Stanley but, unlike the Rocky Cape area, these are derived from Tertiary Basalts. Here boulders and cobbles occur within a matrix of soil. These areas correlate to areas of past slumping and landslip. On the western plains, at the northern end of the Stanley Peninsula, an area of conglomerate occurs. This deposit occurs to approximately 20m above current sea level and is believed to correlate to an old beach strandline as indicated by the well-rounded clasts of basalt that occur within it and other fluvial characteristics.

The Circular Head area is noted for its variety of fossils. Many plant and animal fossils have been recovered from the Quaternary sediments, particularly in the Mowbray Swamp area where skeletons of the giant herbivorous marsupial *Nototherium tasmanicum* have been discovered.

5.4 Topography and Geomorphology

The land within the Circular Head area has a number of distinct topographic regions and related geomorphology and these are briefly discussed below. The area generally is characterised by a large frontal coastal plain that extends inland in the west into the Duck River drainage basin. These lowland areas mostly occur below 10m above sea level (asl) but rarely exceed 20m asl. They receive sediment and drainage waters from the catchments areas above. In the central areas of Forest, Mengha and Mawbanna, rolling hills, escarpments and plateaux rise above the coastal plains to an altitude of 200m asl. These features are, in places, heavily eroded and dissected where river and creek systems have cut their course. In the south west, the mountain peaks of the Dip Range are the highest features attaining an altitude of 420m asl.

The topographic units identified within the study area are discussed in the following paragraphs. Figure 11 also provides a simplified overview of landform as well as geological relationships. For more detailed information readers may wish to refer to studies by Edwards (1941), Gill and Banks (1956) and Davies (1961) and van de Geer (1981).

Coastal Dunes and Sand Plains

A series of dune systems occur almost parallel to the coast. These have been formed by prevailing westerly winds and are still mobile in some locations due to removal of vegetation. Behind the dune fields, swales occur. These swales form a barrier to drainage outflow and also impact upon the drainage status of the plains further inland resulting in marshes and swamps. The plains themselves are composed of windblown alluvium of both marine and freshwater origin and grade very gently towards the sea resulting in very slow run off rates for surface water. These plains are part of an emergent shore platform that extends for much of the north coast of Tasmania (Edwards 1941) and are the result of eustatic sea level changes during glacial and post glacial periods. It is likely that Perkins Island and parts of Robbins Island emerged during these periods.

Coastal Escarpments, Headlands and Plateaux

As sea levels have dropped, the sea cliffs have been left behind and currently form a steep escarpment with a height of approximately 20m parallel to the coast, together with headlands such as Circular Head which is joined to the mainland by a narrow isthmus. The plateau like landforms formed behind the escarpments and cliffs are formed from more resistant rock types such as the Tertiary basalts and Precambrian sediments and are now safe from the erosive forces of the sea that once shaped them. Elsewhere and where erosion rates have been higher, a more dissected environment occurs forming gently to steeply sloping hill country.

Hills and Steep Mountain Ranges

In the rolling to steep hill country within the area adjacent to the Duck River valley, Cambrian sediments grade steeply to form two north south trending ridges on either side of the valley. The creek systems that feed the valley with sediments have been responsible for the dissection and erosion of the ridges and have formed steep sided hills and gullies. Other areas of hill country are found inland south of Forest at Lileah, Alcomie, Mawbanna and Montumana. Again high rainfall, creeks and river systems have shaped basaltic lava flows in these areas, deeply incising both the capping materials and the basement rock at some locations.

The steeper hills that occur within the survey area include The Nut and Green Hills, Sunny Hills, Mount Lileah, Spion Kop Lookout and Doughboy Hill. All are basaltic structures that are either more resistant or have escaped the erosive forces exerted on the surrounding countryside. On the south western slopes of Sisters Hills, at Rocky Cape and parts of the Dip Range, very steep hills and peaks are found. Other higher elevation areas with steep hills are also found but are located within the exclusion areas of the map.

Major Rivers and Hydrology

The major river systems in the area include the Duck, Black, Dip, Detention and Alarm Rivers. All trend in a northward direction and except for the Dip and Alarm Rivers, which are tributaries of the Black and Detention Rivers respectively, outflow to the sea. Some of these rivers, such as Black River, are tidal for some distance upstream.

Many feeder creeks occur which either flow into the major rivers or find their own course to the sea. In the Duck River drainage basin the major creeks are Geales, Scopus, Copper and Edith Creeks. Further east Deep, Sedgy, Waterwheel and Wilsons Creeks are all important drainage systems for their respective localities.

This complex and mainly dendritic pattern of river and creek systems, together with high winter rainfall and low rates of run off, concentrates water onto the very flat lowland areas. This has required the implementation of an intensive drainage network to overcome near surface seasonal groundwater tables and provide an outflow to the sea. The creation of a drainage trust has also seen areas south west of Smithton brought into higher levels of agricultural production than were once possible before drainage was implemented.

Draining the lowland areas has lead to a number of environmental issues in the area, and although they are not the focus of this report, management of the surrounding agricultural areas can affect their severity. High leaching rates in most of the soils that occur in these areas result in high nutrient loads within the network of drainage channels and waterways at certain times of the year. These levels have been reported to have had impacts upon wetland areas near the coast and also contribute to higher nutrient loads in the more sheltered water body of Duck Bay. Fertilisers and animal wastes are the largest source of these contaminants. Land managers are therefore encouraged to tailor their nutrient application to minimising the leaching of nutrients into the drainage system. Where practical, smaller amounts applied at more regular intervals during the drier periods of the year (especially for the more soluble nutrients such as nitrogen) are more advisable. This, while more environmentally friendly, may also prove to be more cost effective.

Recent discoveries of very acid water (pH 2) in drainage lines near Mella are suspected to be caused from water draining from the highly acidic Loira peat areas higher in the catchment or from leachate from acid sulfate soils or a combination of these two processes. Appropriate monitoring and water management practices are required in this area especially if these waters are used for stock watering purposes.

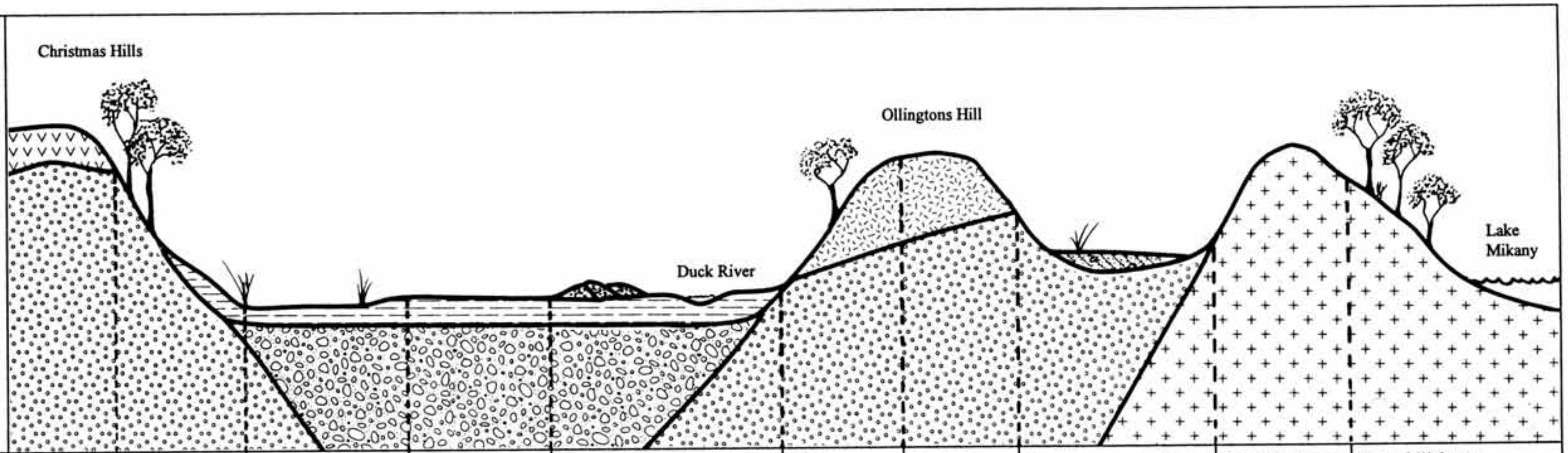
For descriptions of other notable geomorphic and topographic features such as the artesian springs mounds near Mella and the structure of The Nut at Stanley readers are referred to the geology section of this report.

Stylised cross sections have been created for parts of the survey area and presented in Figures 12, 13 and 14. These transects represent the dominant landforms present within the Circular Head survey area and aim to display the interrelationships between landform, geology, soil and land capability.

5.5 Soils

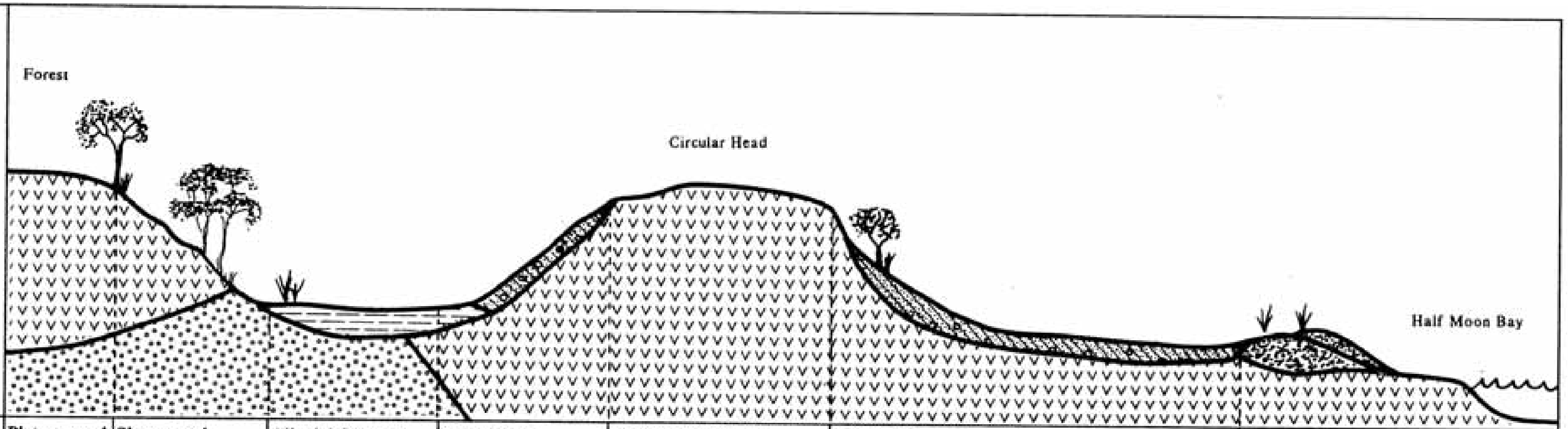
5.5.1 Background and Previous Studies

The agricultural potential of the north west coast of Tasmania has attracted primary producers to the area since the early days of settlement. The Van Diemens Land Company, with its pioneering interests in this part of the State, was one of the early investors who recognised the combination of favourable climatic conditions and good grazing and cropping lands. Agricultural development and expansion followed as the



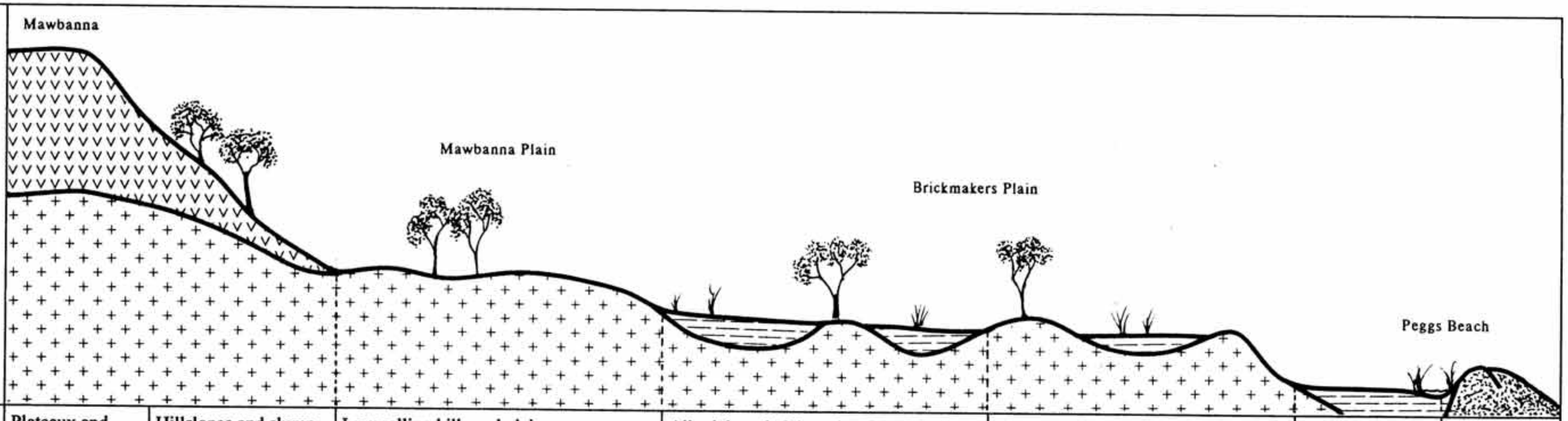
Typical Landform	Plateaux and hills.	Hillslopes and fans.	Plains and drainage depressions.	Plains.	Dunes and river valley, Alluvial sand plains.	Hillslopes.	Moderate slopes and Plateaux.	Footslopes and valley flats.	Steep hillslopes and crests.	Steep hillslopes.
Geology	Tertiary basalt.	Cambrian siltstone, mudstone and derived alluvium.	Quaternary windblown sands.	Quaternary windblown sands.	Quaternary windblown sands.	Cambrian siltstone, mudstone.	Cambrian volcanics.	Cambrian siltstone, mudstone, greywacke.	Siltstone and quartzite.	Precambrian siltstone and quartzite.
Soil Type	Red Ferrosols (Lapoinya Assoc).	Yellow/ Brown Dermosols (Castra Assoc). Chromosols (Kana clay loam).	Kandosols, Dermosols, and Hydrosols (Scopus clay, Kana clay loam) Organosols (Mella peat, Loira peat).	Aquic Podosols and Hydrosols (Woolnorth sands).	Hydrosols, Podosols (Lupari sands, Mowbray sandy loam and sandy clay).	Brown Dermosols.	Red Ferrosols (Minnow Assoc).	Brown Chromosols and Dermosols.	Kurosols, Kandosols.	Kurosols, Dermosols.
Slope Range	0-12%	12-28%	0-3%	0-3%	0-5%	18-45%	0-18%	0-28%	>56%	18-56%
Drainage Status	Moderately well-well drained.	Moderately well-poorly drained.	Poorly drained.	Imperfectly drained.	Poorly-well drained.	Moderately well-well drained.	Well drained.	Moderately well-imperfectly drained.	Well drained.	Well drained.
Permeability	Moderate.	Moderate.	Rapid-Slow.	Rapid-Slow.	Rapid-Slow.	Moderate.	Moderate.	Moderate-Slow	High.	High.
Erosion Risk	Low.	High.	Low.	Low.	Low.	Very high.	Moderate.	High	Very high.	High.
Main Limitations	Erosion (e).	Erosion (e) Drainage (d).	Drainage (d).	Drainage (d).	Wind erosion (a), Water erosion (h), Drainage (d).	Erosion (e).	Erosion (e).	Drainage (d), Soil depth (l).	Erosion (e), Soil depth (l).	Erosion (e), Soil depth (l).
Land Capability Classes	2, 3	5	5	4	5, 4	5, 6	2, 3	4	6	5, 4

Figure 12. Stylised cross-section from Christmas Hills eastward to Lake Mikany



Typical Landform	Plateaux and hills.	Slumps and footslopes.	Alluvial flats and drainage depressions.	Slumps and footslopes.	Plateaux and gently undulating hills.	Colluvial fan and sand plain.	Dune and shore platform.
Geology	Basalt.	Basalt, Cambrian siltstone, Mudstone.	Quaternary windblown sands.	Basalt and Talus.	Basalt.	Conglomerate and Basalt talus.	Stabilised dunes. Younger beach dunes.
Soil Type	Red Ferrosol.	Red and Brown Ferrosols.	Aquic Podosols and Hydrosols.	Red Ferrosols.	Red Ferrosols.	Ferrosols, Podosols.	Tenosols, Rudosols.
Slope Range	0-12%	12-18%	0-3%	12-28%	0-18%	18-45%	0-12%
Drainage Status	Well drained.	Moderately well-Well drained.	Poorly drained.	Moderately well-Well drained.	Well drained.	Well to poorly drained.	Rapidly drained.
Permeability	Mod-High.	Moderate.	Rapid-Slow.	Moderate.	Moderate-High.	Moderate-Slow.	High.
Erosion Risk	Low.	Moderate-High.	Low-Moderate.	Moderate-High.	Low.	Moderate-Low.	High-Very High.
Main Limitations	Erosion (e).	Erosion (e), Soil limitation (s).	Drainage (d), Wind erosion (a).	Erosion (e), Coarse fragments (g).	Erosion (e), Coarse fragments (g).	Coarse fragments (g).	Wind erosion (a), Water erosion (h).
Land Capability Classes	1, 2	3, 4	5	4, 5	2, 3	4, 5	6, 7

Figure 13. Stylised cross-section from Forest northward to Half Moon Bay, north of Stanley.



Typical Landform	Plateaux and hills.	Hillslopes and slump complexes.	Low rolling hills and plains.	Alluvial sand plains, clay ridges and rises.	Alluvial sand plains and clay ridges.	Alluvial sand plain and drainage depressions.	Dunes and beach ridges.
Geology	Tertiary basalt.	Tertiary basalt.	Precambrian Cowrie siltstone and Detention quartzite.	Predominantly Quaternary windblown sand plain with Precambrian siltstone and quartzite.	Predominantly Precambrian siltstone and quartzite with smaller area of Quaternary windblown sand plain.	Quaternary windblown sands.	Quaternary windblown sands.
Soil Type	Red and Brown Ferrosols.	Red and Brown Ferrosols.	Grey Kurosols, Podosols.	Podosols, Organosols.	Podosols.	Hydrosols, Organosols.	Podosols, Rudosols.
Slope Range	0-12%	12-28%	5-12%	0-5%	0-5% and exceeding 28% on escarpments.	0-3%	5-18%
Drainage Status	Moderately well-well drained.	Moderately well-well drained.	Moderately well-poorly drained.	Poorly drained.	Poorly drained.	Poorly drained.	Rapidly drained.
Permeability	Moderate.	Moderate.	Slow.	Moderate-high.	Moderate-high.	Low-moderate.	High.
Erosion Risk	Low-moderate.	Moderate-high.	Moderate.	Low-moderate.	Low-moderate.	Low.	High.
Main Limitations	Erosion (e), Climate (c).	Gully and Sheet erosion (e), Landslip (m).	Drainage (d), Erosion (e), Soil depth (l).	Drainage (d), Soil depth (l).	Drainage (d), Soil depth (l).	Drainage (d), Soil fertility (s).	Wind erosion (a).
Land Capability Classes	2, 3	4	5, 6	5	6	5	7

Figure 14. Stylised cross-section from Mawbanna north west to Peggs Beach.

red friable soils were targeted for cropping and mixed grazing, while the plains were cleared and a number of drainage trusts established to drain the swamps and marsh lands.

A number of early studies have been undertaken aimed at understanding soil distribution, bedrock geology, soil formation, soil nutrient status, pasture production and drainage. Despite this earlier work a detailed soil map does not exist for the whole of the Circular Head area. Hubble undertook reconnaissance mapping of the coastal heathland and the accompanying report (Hubble 1951) provides comprehensive soil descriptions of the common soil types found. While these descriptions have been extremely useful, the accompanying map provides only a very rough indication of the actual position of the soil boundaries. This is caused by poor correlation between the original base map used and modern day base information.

Another study originally undertaken by CSIRO Division of Soils in 1946 and later published by Hubble and Bastick (1991), is the Soils and Landuse of the Mowbray Swamp Area. This area was mapped at a scale of 3 inches to 1 mile (1:21 120) with a view to describing and assessing agricultural potential of "undeveloped land" in the Smithton district. It has provided valuable soil chemistry data, and information on specific restrictions to agricultural production in the area and has assisted identification of similar soils in other areas of the Duck River drainage basin.

For many of the upland areas the only soil information available is that contained within the land systems report by Richley (1978).

These studies have all been used to better understand the soil and landscape processes and assist with land capability boundary placement especially where land capability boundaries reflect change in soil properties.

Other studies in neighbouring areas

Soil descriptions collected during coupe planning by Forestry Tasmania at Mawbanna, in areas adjacent to the mapping area, have been used to indicate likely soil properties in areas with difficult access or those with little or no soils information. The text, Forest Soils of Tasmania by Grant *et al* (1995) has also aided in the identification of the soil types especially those formed from Precambrian and Cambrian parent materials.

One of the earliest studies in neighbouring areas was the report by Stephens (1937) on the basaltic soils of northern Tasmania. Soil descriptions by Loveday and Farquhar (1958) in areas further to the east also give good comparative references to the red basaltic soils found on the Tertiary basalt flows in the Circular Head area.

The following sections refer to the major soil types by their local name or their classification according to the Australian Classification (Isbell 1996). In some cases the classification terminology developed by Stace *et al* (1968) is also used.

5.5.2 Soils of the Circular Head Area

Soils of the Coastal Dunes

These soils occur within the Peggs Beach land system, as described by Richley (1978). The majority of the dune soils in the Circular Head area seem to be moderately or highly leached as well as non-calcareous. Few positive reactions to field HCl tests occurred. Hubble, however, notes that calcium carbonate leached from higher in the profile may concentrate at approximately 60cm and shelly fragments occur at greater depths at some locations.

The soils range from Rudosols on active frontal dune areas to Tenosols in more stable areas. The Rudosols typically have a poorly developed A1 horizon overlying uniformly coloured white sand. The Tenosols have a dark organic sandy A1 horizon up to 30cm in depth containing many roots over leached light grey sand in the areas that support native woody vegetation. Organic and iron staining in the upper A2 horizon is also often seen. An obvious fibrous root mat occurs in the A1 horizon as plant roots tap into the most fertile part of the soil profile.

Older dune soils occur on dunes with lower slope gradients at inland positions such as at Backline Road and Mella Road. These soils are similar to those found on the back of the dune systems closer to the coast with deep, organic, sandy A1 horizons over a much more uniformly coloured light grey or white A2 horizon. Although often sown down to pastures these soils share the same risk of wind and stock induced erosion as their coastal counterparts.

Soils of the Coastal Heathland

The soils of this group correlate to the Stony Heath and Sandy Heath soils described by Hubble (1951) and by Hubble and Bastick (1991). They include a range of Aquic Podosols and Hydrosols, Organosols and other "Marsh" or “Meadow” soils which classify as Dermosols.

The dominant soil type within this landform is the Woolnorth Sand or Peaty Sand. It usually has a dark grey to black sandy A1 horizon to 20cm over a bleached, grey, fine sandy A2 horizon which is often but not always underlain by a dense organic horizon at depth. The origin of this horizon is still unclear. Hubble describes this soil as a groundwater podsol and suggests that the organic horizon be attributed to leaching and concentration of organic material from higher in the profile. However similar materials have been observed in near coast sediments and in these locations this layer appears to represent a buried surface. This compact horizon appears to impede vertical drainage and is often underlain by lighter coloured white, grey or brown sand at depth.

Acid peat soils (Organosols) occur in the closed depressions within the heathland. Typically fibrous in nature these peat soils sharply overlie bleached raw sand.

Shallow, sandy and often skeletal soils are found along the northern coast where Precambrian parent material is close to the surface or where they have been covered by windblown sand. These soils are highly erodible especially where subsoils have developed thixotropic characteristics in the A2 horizon. These areas are characterised by stunted vegetation due to shallow soil depth with cutting grass and heath the most common understorey species (Photo 2)

Another sandy profile identified in the Duck River area is the Lupari Sand. This soil is often found in linear sand ridges. It can be distinguished from the Woolnorth Sand by the presence of a very thick A2 horizon of highly leached white sand.

Peat Soils

Fen peat soils have formed in the Mowbray Swamp area near Mella. These soils classify as Organosols (Isbell 1996) and have been drained and utilised by the farmers in the district for a variety of agricultural uses. This peat has a more favourable topsoil pH compared to the peat underlying the coastal heathland. This has been suggested by

Photo 2. Precambrian soils in coastal areas can have highly erosion prone, thixotropic A2 horizons. (GR E 364500, N 5475300).

Hubble and Bastick (1991) to be caused by the moderating effect of, and proximity to, alkaline springs that rise from the Precambrian dolomite basement of the Duck River valley. The dominant peat soil (Mella Granular Peat) has a deep, fibrous profile in excess of 105cm with an alkaline to acid pH trend. A number of variants and transitional soils are also associated with it. Shallower profiles occur at the fringe of the swamp. Some peat soils overlie sand while others overlie clay subsoils; still others have thin clay topsoils overlying peat implying a buried profile.

Some peat soils in this area have been found to contain pyritic materials high in iron sulphides. Drainage of these soils, particularly near Mella, exposed these sulphides and has lead to oxidation and the development of acid sulphate soils. The highly acidic leachate from these soils can severely impact upon water quality for downstream users. The extent of the sulphidic materials is currently unknown and therefore detailed investigation is required prior to any future drainage development in this area.

Clay Soils

Alluvial clay soils owe their origin to sediments transported from the surrounding mudstone and siltstone hills to the plains below. They occur in the central southern part of the Duck River drainage basin adjacent to the major creek lines and near the base of the surrounding hills.

The Scopus Clay is a Dermosol typical of these areas. It comprises a fine textured light-medium clay with a grey brown topsoil, grading to yellow brown in the subsoil. Strong mottling occurs in this subsoil indicating prolonged seasonal wetness. Variants of this soil type include profiles with loamier surface soils found nearer to the surrounding sandy soils and others with heavier medium clay surface textures closer to the drainage lines and depressions.

Other fine grained alluvial soils include the Kana Clay Loam and Kana Clay soils (Kandosols and Dermosols respectively), found near Geales Creek. The Kana Clay soils have gradational clay profiles but are not as heavy or poorly drained as the Scopus Clay. Its close relative, the

Kana Clay loam, has less clay throughout the solum and is shallower to the underlying saturated sand (Hubble and Bastick 1991). The humic variant of the Kana Clay loam is shallower still and has higher humus content due to its proximity to the peat margins.

At Edith Creek, along the north eastern edge of the Duck River drainage basin and in the valley north of Scantlebury Hill, another clay soil with very similar properties to the Scopus Clay occurs. This soil is also very mottled in the subsoil and has shallow topsoils.

Sandy Soils

Sandy soils found within the marshes, swamps, alluvial terrace systems and sand plains occur adjacent to the major river systems within the Circular Head area. These areas include most of the Duck River drainage basin, Yanns Flats adjacent to the Detention River and at areas adjacent to the Black River near Mawbanna.

These soils can be separated into those which are more fertile but have drainage problems due to their relative position in the landscape, those which are acidic and poorly drained and those which are better drained but are less fertile, more acidic and prone to erosion. Depth to an underlying organic horizon also has an influence upon the drainage status of the soils within the Duck River drainage basin.

The sandy soils with higher fertility occur in the Mowbray Swamp area where the alkaline effect of the local spring waters is more conducive to plant growth. Unfortunately all these soils have high seasonal ground water tables and are saturated for the majority of the winter season. In their natural state these soils are classified as Hydrosols. Where intensive drainage has been implemented such as in the Mowbray Swamp area, these soils are classified as Kandosols and Tenosols and have been named the Mowbray Sand, Sandy Loam and Sandy Clay Loam depending upon topsoil texture. These soils have humic topsoils up to 25cm in depth underlain by brown, yellow or greyish leached sand to depths sometimes over 1m. Below this, brighter mottled clayey fine sand occurs which in turn overlies, more often than not, a dark humus stained organic pan-like layer at depths of 120 and 150cm. Where this layer has been identified as an illuvial accumulation of organic material (Bh horizon) the soils are classified as Podosols.

A variant of the Mowbray Sandy Loam occurs on the fringe of the Mella Peat. This soil has a greater amount of organic matter in the sandy loam topsoil and is moderately acid in nature. Similar soils occur near the Detention and Black Rivers. These soils are also less influenced by alkaline spring waters and are consequently more acidic.

Podosol profiles occur within the Mowbray Swamp and Edith Creek areas. These soils are highly leached and acid in nature and have a deep fine sandy profile. The Sabur Sand is the best drained of these soils occurring on the higher sand ridges and levees. It has a pronounced bleached A2 horizon of considerable depth capped by a dark grey to light grey, fine sandy topsoil ranging to approximately 30cm. The A2 horizon is underlain by the dark coloured Bh horizon, at approximately 100cm, characteristic of Podosols.

Flanking these sand ridges are the Carua Sand and Sandy Loam soils. While similar to the Sabur Sand in texture the Carua soils have a deeper more organic A1 horizon and occur in more poorly drained locations with high ground water tables. The Carua Sandy Loam has a shallower A2 horizon depth before the Bh horizon is encountered.

Photo 3. A typical sandy heathland soil (ruler graduations are 10cm)
Note the likely buried topsoil at approx 30cm.
(GR E 336050, N 5469450).

Soils of the Tertiary Basalt Hills and Plateaux

Relatively deep, well structured and well drained soils have formed upon the Tertiary basalt hills and plateaux. They include soils formed *in situ*, intergrade soils or soils formed from basaltic talus material. Most of these soils correlate well with those profiles previously described by Loveday and Farquhar (1958) and Stephens (1937) in areas east of the Circular Head area. These descriptions have been used in identifying similar soils found within the survey area.

Most of the Tertiary basalt soils found fit the description of either the Burnie Clay Loam or the Lapoinya Clay Loam Soil Associations. Red and Brown Ferrosol soils dominate these soil associations. Even without irrigation these soil types are considered to comprise some of the best cropping land in the state.

Soils on the better drained sites at lower altitudes, such as those in the Forest, Rocky Cape and Montumana districts, have redder colours throughout the soil profile while those in the poorer drained sites, higher altitude or higher rainfall areas have browner colours approaching colours similar to the to the Yolla Clay Loam described near Ridgley by Loveday and Farquhar (1958). Soils in the poorly drained areas may also sometimes display mottling or manganiferous nodules in the subsoil.

The Burnie Clay Loam soil occurs on land with near level gradients close to the coast. This deep, dark red soil has a well structured topsoil overlying a bright red brown, moderate to well structured medium clay subsoil. It is relatively stone free, well drained and highly valued for agricultural use due to its robust nature and ease of cultivation. This soil correlates with the Chocolate and Red Brown soils described by Stephens (1937).

On higher (>160m), often steeper, country the Lapoinya Clay Loam becomes the dominant soil. While similar to the Burnie Clay Loam, the Lapoinya Clay Loam has more stone within the profile and occurs in a wider variety of landscape positions. A typical soil profile of the Lapoinya Clay Loam comprises a well structured reddish brown topsoil, overlying a moderate to well structured, brighter red brown, medium clay subsoil. Coarse fragments range in size from 20-250mm in the upper B horizon and are often brought to the surface by deep cultivation. This soil corresponds to the Red Brown soil described by Stephens (1937) and shares similar characteristics with the Wilmot and Lebrina Soil Profile Class described by Hill *et al* (1995).

Lapoinya Clay Loams generally are less intensively used for cropping purposes due to the changeable nature of the topography, climate and increased stone content. At the fringe of the basalt plateaux a zone of mass movement and slumping often occurs resulting in highly unstable soils on the steeper slopes.

Basaltic soils in the Circular Head area also often intergrade with the surrounding sediments down slope. This occurs south of Forest where basalt flow margins combine with Cambrian mudstone and siltstone soils creating a complex soil pattern. These soils are duller red to brown in colour and appear to be structurally inferior to the true basaltic profiles.

Soils of the Cambrian Hills

A variety of Cambrian soils occur in the Circular Head area, reflecting the range of parent material that occurs. They can be divided into two main groups: soils formed from volcanics and those formed from sedimentary material including siltstone, mudstone and greywacke.

Volcanic Soils

The soils formed from Cambrian volcanic rocks such as spillites, breccias and pillow lavas share many soil properties with the deep, gradational Tertiary volcanic soil types. They are gradational, well drained soils with good structure. Their depth to clay subsoil however is more variable and tends to be shallower than the Tertiary volcanic soils. These soils classify as Red Ferrosols and are very similar to the Minnow Soil and Gawler Profile classes described by Hill *et al* (1995).

Found on the plateau on which the Scotchtown Road is situated, these soils typically occur where less steep, more gently sloping land occurs. On the steeper hill slopes stone content increases, profile depths decrease and erosion risk becomes high.

Sedimentary Soils

Much of the land with soils formed from siltstone, mudstone and greywacke tends to occur higher in the landscape either on hill crests or plateaux. The soils are generally stony, have shallow topsoils or extremely compact subsoils. The soils correspond well with the Farnham and Fagan Soil Profile classes described in neighbouring forested areas by Grant *et al* (1995) and are described as podsolised clay soils by Hubble (1991).

Elsewhere on toe slopes and fans, deeper, less stony, moderately structured soils occur. These are the best Cambrian soils formed from sedimentary rocks. They classify as Brown Dermosols and can intergrade quite intricately with surrounding soils of different parent material. These soils are similar to the Castra soil association described by Hill *et al* (1995). Despite their good natural structure (under virgin native vegetation), this structure soon degrades under agriculture.

Photo 4. Brown Dermosols formed from Cambrian sediments can intergrade intricately with surrounding soils of different parent material. (GR E 349550, N 5473350).

Soils of the Precambrian plains, hills and mountain ranges

Very poor soil depth and fertility are typical of soils formed on Precambrian age parent materials. A variety of soil types occur, with a wide diversity of topsoil depths and profile textures. Soils include Organosols, Podosols, Kandosols and Dermosols and soil properties closely reflect changes in Precambrian parent materials.

The best soils formed from Precambrian sediments occur on the plains and lower slopes of the mountain ranges and steep hills. Here the formation of deeper soils has occurred from sediments transported from hilltop positions. Organosols mainly occur here and have formed a sandy peat layer over sand or gravel substrates. Podosols occur in the better drained sites. These two soils are common in the Sisters Hills and the Dip Range areas and are described by Loveday and Farquhar (1958).

In the Mawbanna area clay soils have developed primarily from Cowrie Siltstone. These soils have fine silty clay topsoils overlying a yellow brown clay subsoil. Quaternary sand of considerable depth sometimes caps these siltstone areas. In places, water erosion has removed the sandy topsoils exposing a compact and impermeable clay subsoil. Other poor soils are found in drainage depressions where poor drainage and reducing condition within the profile produces a mottled and gleyed subsoil.

Very shallow soils formed from Cowrie Siltstone occur next to the coast on relict sea cliffs and escarpments. Other shallow soils have also formed from the Detention quartzite and Irby siltstone parent materials on the high hills and mountains. Commonly these soils display thin topsoils and either thixotropic A2 horizons (those formed from Cowrie siltstone) and sporadic bedrock out crop, rocky soils and gravel layers. These soils occur surrounding Lake Mikany, Beacom Hills, Shakespeare Hills and at Briant Hill.

5.6 Vegetation

Much of the vegetation information below has been prepared from observations and identifications made during the fieldwork. Texts by the Launceston Field Naturalists Club (1992) as well as Kirkpatrick and Backhouse (1997) have assisted in field identification. Some general facts and climatic relationships have been noted from personal communications with local landholders and from Richley (1978).

The coastal dunes were once vegetated by a scrub regime of White Gum (*Eucalyptus viminalis*), *Banksia spp*. and *Melaleuca spp*. However since settlement much of the original vegetation has been cleared or burned, coastal wattle (*Acacia sophorae*) and marram grass (*Ammophila arenaria*) now dominates this environment.

The shallow, fast draining, gravelly topsoil of Precambrian quartzite, slate and mudstone near the coast at Rocky Cape supports heath and scrub comprised of Black peppermint (*Eucalyptus amygdalina*) and Smithton peppermint (*Eucalyptus nitida*) interspersed with *Leptospermum spp*., *Banksia spp*., *Melaleuca spp*. and blackboys *(Xanthorrea australis*).

Inland in higher rainfall areas where soil profiles have a deeper organic topsoil, such as around Shakespeare Hills, Beacom Hills and Kellys Knob, vegetation includes stringybark (*Eucalyptus obliqua*), Smithton peppermint, leatherwood (*Eucryphia lucida*), *Melaleuca spp*., cutting grass (*Gahnia grandis*) and button grass (*Gymnoschoenus sphaerocephalus*).

The flat to gently rolling slopes north of Mawbanna, known as Mawbanna Plains, situated on grey to light brown gravelly duplex soils contain areas of button grass, *Bauera spp.*, *Melaleuca squarrosa* and heaths with a more open canopy of stringybark and Smithton peppermint. This area is being improved for agriculture and sown to pasture.

Areas around Smithton and between Irishtown and Nabageena have forests of stringybark, blackwood (*Acacia melanoxylon*), dogwood *(Pomaderris apetala*) and paperbark (*Melaleuca ericifolia*) growing on Cambrian sediments. Evidence of erosion after vegetation removal was also apparent at these locations.

Further inland at greater elevation and increased rainfall, remnant forest including stringybark, white gum, blackwoods and swamp gum (*Eucalyptus ovata)* occurs. These forest communities are mainly concentrated along steep valley sides and natural drainage lines at Lileah, South Forest, Mawbanna and south of the Bass Highway at Rocky Cape.

The flat Quaternary sand plains around Mella and south to Edith Creek, support heath and sedgeland of *Melaleuca spp, Leptospermum spp, Leptocarpus tenax*, and *Juncus spp*. Remnant stands of giant *Melaleuca* forest, which once covered most of these plains, also occur. These wetter, poorly drained areas are interspersed with stands of Smithton peppermint, swamp gum and white gum on higher better drained rises, terraces and remnant dunes. Similar vegetation is also found on Robbins and Perkins Islands in lower areas of the landscape.

Photo 5. Remnant giant *Melaleuca* forest at Waratah Plain (GR E 335050, N 5463500)

5.7 Land Use and Major Industries

This part of the north west coast has attracted farmers, saw millers, timber harvesters and miners since the early 1800s and current land use continues to follow these traditional activities. Land use throughout the area is also determined by a number of physical factors such as soil type, geology and topography.

Dairying and forestry still remain the region's largest industries and also occupy the largest extent of land. The main dairy areas are found in the Duck River Valley and much of the coastal lowlands. Dairy farms from these districts supply milk to factories at Wynyard, Cooee, Burnie and Spreyton as well a local industry based at Edith Creek.

Most of the forestry activity occurs within state forest surrounding the Mawbanna region as well as at Christmas Hills. These areas supply saw logs to the large mills at Smithton as well as smaller local mills.

Plantation forestry is becoming a popular option on private land, as attractive returns exist for plantation timber and commodity prices continue to remain low in other agricultural sectors. Most of the plantations to date are located on lower capability (Class 4 and 5) agricultural land or state forest located higher in the catchments. Recent trends are showing an expansion of forest plantation onto former dairy farms and cropping land and there is currently some concern about the potential social and economic impacts of this trend.

Cropping is another important land use to the region with a large vegetable processing company located at Smithton. A range of crops is grown, predominantely on the red basaltic soils. These include peas, beans carrots, brassicas, sweet corn, potatoes and onions. In recent times poppy crops have been grown with mixed results due to the wet climate which affects alkaloid yield.

As elevation increases and proximity to mountains and high hills occurs, subtle climatic influences result in a shortened growing season and a land use change away from cropping and dairying. Plantation forestry and a variety of other grazing enterprises become increasingly dominant. Beef and lamb production are often, but not exclusively, found at these locations and supply local abattoir and export markets. A number of successful beef studs exist which are important in providing top quality breeding stock for the district as well as other areas of the State.

Quarrying is also an important industry and takes place at a number of locations scattered throughout the area. A wide range of materials is targeted for construction purposes, including siltstone, basalt, quartzite, sand and gravel. Dolomite outcrops at a number of locations and is quarried for both construction and agricultural purposes. A large quarry west of Smithton produces agricultural grade dolomite that is utilised for soil amelioration purposes in many cropping and grazing areas to achieve optimum pH values. Another large industry is the iron ore pelletizing plant at Port Latta. Here iron ore slurry, piped from Savage River, is reconstituted and exported to market by ship.

Tourism is also a large industry in this area with a number of scenic drawcards such as "The Nut" at Stanley, historic properties and long, white beaches. Recreation activities such as fishing, camping and bushwalking also attract many holiday makers to the area each year.

6. LAND CAPABILITY CLASSES - CIRCULAR HEAD

The following sections of this report describe the different classes of land that have been identified during the course of the survey. General information on the nature of the land, soil type and geology are given together with an indication of the major limiting factors and any other information that is considered relevant. Each class is described according to broad geological groups found within it.

For each class of land a simple diagram is presented indicating the distribution of that land class across the map together with a table listing the total hectares that each occupies. These diagrams and tables include all complexes that occur in combination with that class.

The following graph shows the spread of land capability classes recorded within the Circular Head area together with their proportion of total map area. Apart from the large extent of Exclusion areas (E), Class 5 land is the most abundant making up 28.1% of the Circular Head area. Class 1 represents the smallest class with only 1.6%.

In calculating the class percentages for Figure 16, complex areas where two capability classes are identified have been split 60:40 and the relative proportion of each combined with the appropriate class. For example, the total area of Class 2 land equals "the total area of Class 2 + (60% of the area of Class 2+1 and Class 2+3) + (40% of the area of Class 3+2)".

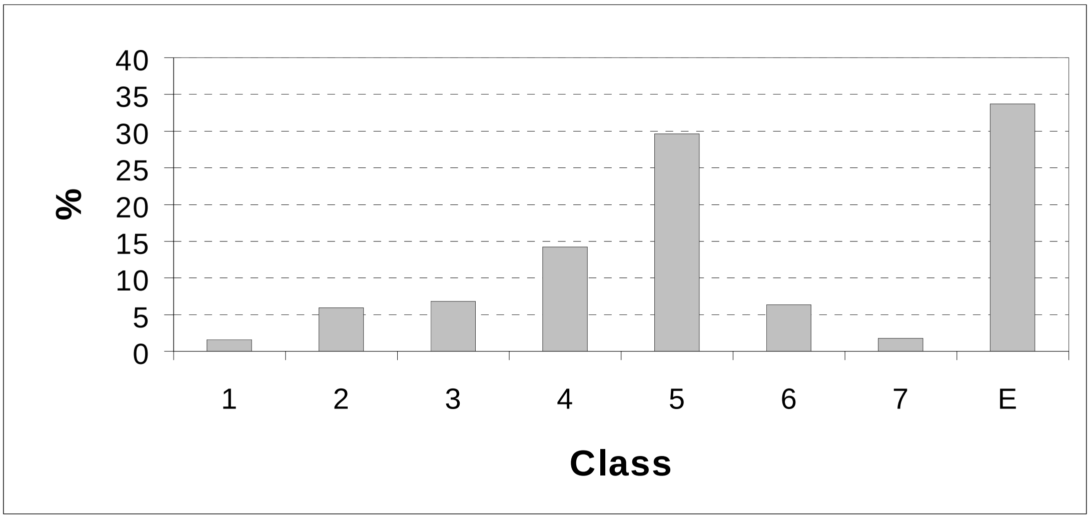
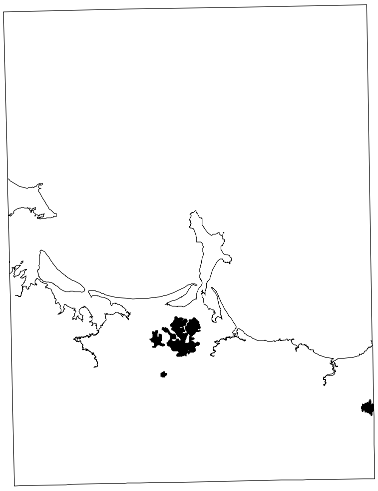


Figure 16. Proportion of land capability classes in the Circular Head area.

CLASS 1 LAND

Class 1	1 283 ha
Class 2+1	132 ha



Class 1 land in the Circular Head area is found only on Tertiary basalt parent material where the soils are freely draining and stone free. This land is often level or very gently sloping and experiences a climate conducive to growing a wide range of crops over a long growing season. Despite being the best agricultural land the State possesses, care is required to prevent structural decline and erosion in these areas. Class 1 land has the capacity to support all agricultural uses but particularly lends itself to intensive cropping, due to its favourable soil, climate and landform characteristics.

Class 1 Land on Tertiary Basalt

A number of areas of Class 1 land have been mapped where soils derived from Tertiary basalt occur. They are found within a few kilometres of the coast and below an elevation of 180m. The main areas occur on flat or gently undulating plateaux (<5%) at Forest with small extents also found west of Wilsons Creek at Rocky Cape and north of Bellingers Road at South Forest.

These areas are characterised by the iron-rich Red Ferrosol soil, similar to the Burnie Clay Loam described by Loveday and Farquhar (1958). At all Class 1 locations this soil type has good depth for cultivation (typically exceeding 1m to impenetrable layer), is well structured and freely draining. The soil's relatively stone free nature, robust structure and low risk of natural erosion allows for easy planting, harvesting and paddock layout (Photo 6).

Despite these favourable soil and land qualities for intensive cropping, management that maximises organic matter retention and minimises sheet erosion is necessary to keep this land in good condition. Due to intensive use and cultivation, this land is at risk of degradation through sheet and rill erosion (h) during those periods when the ground has little vegetation cover. Loss of organic matter and soil structure is also a risk if conservation measures are neglected.

Rainfall during winter months is heavier, longer in duration and more frequent in the Class 1 areas of Circular Head than in the Class 1 land mapped elsewhere in the State. This, combined with slightly lower temperatures and evaporation rates, requires land managers to use careful judgement and timing when preparing paddocks for planting in the early spring. Tillage occurring when soil moisture is high will result in compaction, reduced rates of drainage and the reduced ability of the soil to hold nutrients.

While rainfall is low and evaporation rates are high during summer months, moisture deficits are usually overcome by irrigation using water predominantly from farm dams and watercourses.

Class 1 land is capable of supporting two or even three crops a year and is well suited to all agricultural uses.

Areas of Class 1 land on the map include some smaller areas of steep land, areas of lateritic or heavier clay soil, farm water storages and dissected creek lines especially in the Forest area. These impurities are too small to have a major bearing upon land capability classification at this scale of mapping but do affect the way the land is managed at the farm scale.

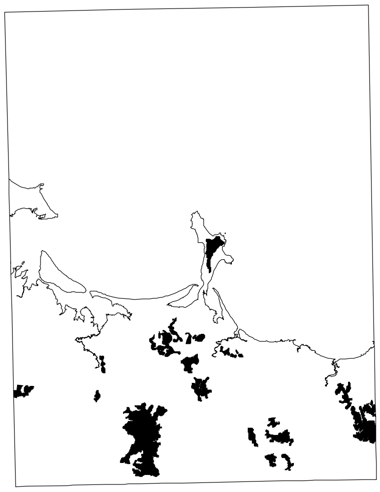
Complex Classes

No complex classes occur where Class 1 is dominant.

Photo 6. Paddock preparation - Class 1 land at Montumana.
(GR E 373600, N 5465000)

6.2 CLASS 2 LAND

Class 2	4 056 ha
Class 2+1	132 ha
Class 2+3	988 ha
Class 3+2	738 ha



Class 2 land is found in areas below 270m altitude and where the terrain is gently sloping (<12%). Soils in these areas are deep and freely draining. The long growing season is suitable for a wide range of crops. The main limitations for this land are sheet and rill erosion risk (h) and a climatic limitation (c) relating to exposed topographic position.

Class 2 Land on Tertiary Basalt

Areas of Class 2 land on Tertiary basalt occur on gently sloping land (<5%) at Rocky Cape adjacent to Yanns and Montumana Roads, Mawbanna, Forest, north west of Stanley on Circular Head itself and extensive areas surrounding Lileah and Alcomie. Smaller areas of Class 2 land also occur north west of Black River

This land is characterised by the occurrence of Red Ferrosol soils similar to the Class 1 areas but they are either shallower (65-90 cm deep), less well drained or stonier in nature. Burnie and Lapoinya Clay Loam soils are dominant.

In areas of steeper slope (5-12%) Class 2 areas have a higher erosion risk (h) compared with Class 1 land. These areas require implementation of soil conservation measures to prevent sheet and rill erosion under intensive cropping regimes. Use of contour drains, cut off drains and grassed irrigator runs are necessary to prevent degradation of this land. Areas of Class 2 surround and incorporate water courses, dams and small areas of steeper gradient which are unable to be identified separately.

Climatic limitations for Class 2 land occur between 180-270m and on some coastal bluffs and headlands. Increased frost risk, reduced growing season and exposure to strong prevailing winds are the main limitations.

Areas above 180m, such as at Mawbanna, Lileah and Alcomie, are more susceptible to out of season frost and have a greater frost occurrence than those areas closer to the coast or at lower elevations. Lower daily temperatures and lower evaporation rates result in later paddock preparation in the spring due to unfavourable soil moisture conditions for tillage.

Class 2 areas on the Circular Head plateau near Stanley also have been identified as having a climatic limitation associated with their physiographic position. The high exposure to salt spray, strong winds and high evaporation during the summer period and lower annual temperatures all combine to restrict the types of crops which may be grown. For example, tall crops such as sweet corn or those susceptible to salt burn, may not be viable at these locations. The dry conditions experienced during summer are compounded by poor availability for irrigation with the result that only a small proportion of the land resource can be utilised for cropping each year. While this poor availability of irrigation water does not affect land capability classification, increased storage of water from winter rainfall could maximise the use of the land in this area. Also the implementation of shelterbelts would lessen the effects of salt spray, reduce exposure to wind and lower the high evaporation rates leading to improved growing conditions.

In some areas, such as south east of Lileah and also where laterite occurs within the basalt at Forest, Class 2 land has been identified that is limited by stony or gravelly soils. In these areas moisture and nutrient availability are reduced, and ease of tillage is also affected.

Other Class 2 Land

Areas of gently sloping land on Cambrian Volcanics have been identified as Class 2. These areas have deep Red Ferrosol soil types and occur south of Scotchtown and Ollingtons Hill. These areas have similar landform and soil characteristics as the Class 2 land on Tertiary basalt and are similarly susceptible to minor rill and sheet erosion. Some areas tend to have gravels throughout the profile but these coarse fragments are sporadic and pose no problem to cultivation or plant growth.

Photo 7. Gently sloping Class 2 land on Cambrian Volcanics at Pokes Hill. (GR E 342500 N 5473800)

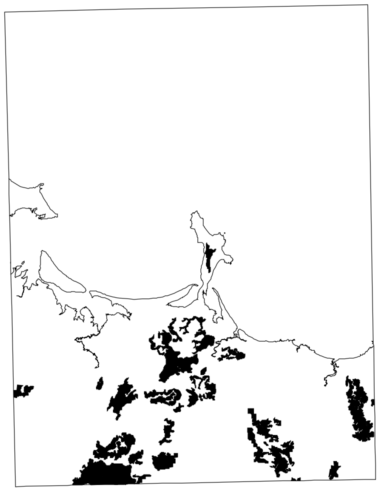
Complex Classes 2+1 & 2+3

Class 2+1 land is found east of Montumana Road where level Class 1 land combines with more undulating Class 2 land. Management of surface water during irrigation and rainfall events is necessary to prevent sheet and rill erosion.

Class 2+3 occurs west of Stanley and Black River, and at Mawbanna where gently to moderately sloping hills combine to produce a rolling landform. Red Ferrosol soil types exist and provide good growth media for a wide range of crops. Erosion risk, stone abundance and exposure to the climatic elements associated with such an elevated and exposed position restrict this land to Class 2. The steeper and/or stonier areas that occur in an intricate fashion within this class are identified as the Class 3 component.

6.3 CLASS 3 LAND

Class 3	2 904 ha
Class 3+2	738 ha
Class 2+3	988 ha
Class 3+4	1 726 ha
Class 4+3	2445 ha



This Class is the last category which is capable of supporting regular intensive cropping uses. Class 3 land has been identified on Tertiary and Cambrian basalts and where deep Ferrosol soils have formed overlying Cambrian mudstone. Landforms tend to be gentle to moderately steep with slopes ranging up to 18%. The dominant limitations to agriculture in these areas are erosion risk (h), stoniness (g) and slow internal soil drainage (d).

Class 3 Land on Tertiary Basalt

Class 3 land on Tertiary basalt occurs at a number of locations throughout the Circular Head area particularly at Montumana, Mawbanna, Lileah, Alcomie and adjacent to South Road in the centre of the map area. These areas are often found close to areas of Class 1 or 2 as they share the same parent material. The Class 3 areas however tend to be stonier, steeper or have a complex, changeable landform which restricts agricultural use. Soil types range from Brown Ferrosols in depressions or foot slope positions through to Red Ferrosols on the freely draining hill slopes. The areas that have suffered from erosion in the past often display shallower topsoil depths than those that occur in colluvial footslope positions.

Most Class 3 land on Basalt is limited by risk of sheet and rill erosion. It typically occurs on slopes between 12 and 18% and requires strict management to control soil erosion when cultivated for crops. The use of soil conservation techniques while the ground is bare, especially if a fine tilth has been created, will protect this land from damaging rainfall events and erosion resulting from the application of irrigation water during the cropping period. Compared with Classes 1 and 2, Class 3 land on basalt is often more dissected by creek lines and watercourses, which makes management more difficult.

Basaltic soils in the Circular Head area often intergrade with the surrounding sediments down slope. This occurs south of Forest and results in a less robust, imperfectly drained soil containing fragments of mudstone (see below).

Photo 8. Undulating Class 3 land on Tertiary basalt with Class 2 land in foreground (GR E 5465000, N 373600)

Class 3 Land on Cambrian Parent Material

This land is found to the south of Smithton at Ollingtons Hill and south west of Forest between Boys and Cyathea Roads. At Ollingtons Hill volcanic material of Cambrian age makes up the ridge which Scotchtown Road follows. On the upper slopes of this ridge the gradients range between 12 and 18%. This land is capable of growing a range of crops where deep but sometimes stony Ferrosol soils have formed. Soil types are similar to the Minnow Soil Profile Class described by Hill *et al* (1995).

Other areas of Class 3 land occur on Cambrian sedimentary rock down slope from the basalt capped hills south of the Forest plateau and adjacent to Boys Road. The depth of the Tertiary basalt material on the Forest plateau, as determined by local bore holes, is relatively shallow (approximately 15 metres). Where this capping has been eroded away in lower hillslope positions exposing the underlying material, weathering has resulted in the creation of well structured red soil. With a strong basalt influence this soil classifies as either a Brown or Red Ferrosol. These soils are deeper and better structured closer to the basalt hills than the profiles found further away and down slope. Yellower, less well drained clay profiles occur at these later landscape positions.

This higher clay content, compared with the soils formed from Tertiary basalt, results in a short working window with paddocks remaining wetter into spring and more susceptible to damage during wet harvests. The poorer soil structure makes these areas less capable of sustaining intensive cultivation. To achieve the required tilth for crop establishment many of these areas needed multiple passes by cultivation machinery in order to break up cloddy and compacted soils.

Localised ponding of surface water for a number of days can occur in small closed depressions on these areas. Fragments of mudstone are often dispersed throughout the soil profile as a reminder of the geological origin of these soils.

To be managed within its capability, this land needs more regular "resting" or fallow phases incorporated into the rotation, as well as green manuring to help retain structure and organic carbon levels in the soil.

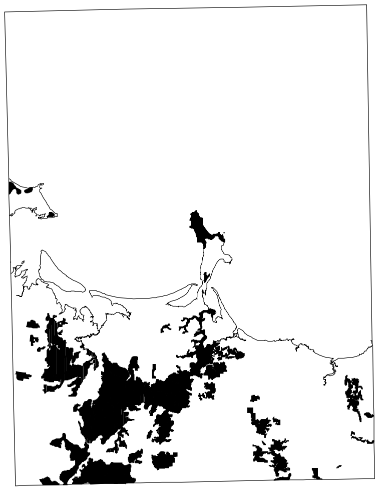
Complex Classes (3+2 & 3+4)

Areas of Class 3+2 land occur on basaltic soil types north east of Sedgy Creek near Forest, adjacent to Montumana Road and immediately west of Mawbanna. In these areas gently sloping Class 2(e) land on Tertiary basalt intermingles with the steeper Class 3(e) with basaltic soils and 3(es) land (south of Forest) where both basaltic and Cambrian mudstone soils have formed. The Class 3 areas are limited by rill and sheet erosion risk on the steeper slopes as well as a weaker soil structure where they occur on the basalt/mudstone intergrade areas. In the Mawbanna area Class 2 land limited by topographic complexity (x) and lower growing season temperatures (c) combines with Class 3 land on Tertiary basalt which again is limited by rill and sheet erosion risk.

While all of these complex areas have slopes below 18%, many land managers often neglect the implementation of surface water management techniques during the cropping period and therefore have a high risk and incidence of soil loss.

6.4 CLASS 4 LAND

Class 4	8 139 ha
Class 4+3	2 445 ha
Class 3+4	1 726 ha
Class 4+5	1 638 ha
Class 5+4	1943 ha



Large areas of Class 4 land occur on a range of geology types and landforms with slopes ranging up to 28%. This class represents land in which cultivation and cropping can be tolerated only on an infrequent or opportunistic basis, so as to prevent damage to the land resource (approx 2 years out of 10). Class 4 land has a much more restricted range of crops than Classes 1, 2 and 3. On some Class 4 land more regular cropping can occur but is restricted to only a very limited range of crops. The most common limitations to agriculture within the Class 4 land are erosion risk (e), rockiness (r), soil stoniness (g), soil drainage (d) and general soils limitations (s).

Class 4 Land on Tertiary Basalt

Class 4 land on Tertiary basalt occurs mainly in the central area of the map between Forest in the north and Sunny Hills in the south. Other areas occur near Mawbanna and Montumana. These areas are characterised by landforms that are dissected by creeks and spring lines and vegetation is dominated by blackwood, dogwood, tea tree and brambles.

In these areas Red Ferrosol soils occur. The soil types are similar to Yolla and Lapoinya soil associations described by Loveday and Farquhar (1957) for the Burnie and Wynyard areas. While generally well structured and well to imperfectly drained, these soils tend to be naturally acid. They do however show excellent response to applications of lime.

Slope gradient and position in the landscape determine the agricultural limitations to this land. These include high erosion risk (including landslip) on the higher slope gradients, stony soils, often with rock outcrop occurring on the escarpments or hillcrests and those areas with imperfect soil drainage on the lower or flatter terrain.

Where slope gradients occur between 18 and 28% Class 4(e) has been identified. This land has a high risk of rill, gully and sheet erosion. High intensity rainfall events can occur at any time of the year and lead to unsustainable soil losses should bare ground be exposed regularly through intensive cropping practices. This risk is acknowledged by most landholders and the steeper terrain is retained for predominantly grazing purposes and tree farming. In some areas steep land has been used to grow potatoes with little use of soil and water management techniques resulting in severe erosion events. Land managers are reminded and encouraged to use erosion control measures should they contemplate even occasional cropping on this steeper land. Advice on such techniques is available through DPIWE regional land management officers and publications.

Class 4(e) land on Tertiary basalt occurs south west of Mawbanna Siding, east of Wilsons Creek near Rocky Cape, Sunny Hills in the southern central area and much of the escarpment south east of Irishtown.

Land limited by stony soils and/or rock outcrop also occurs on these steeper slopes. Here it is the abundance and distribution of stone within the soil that limits agriculture. Stony ground is often encountered at the break in slope and at the apex of hills as well as in toe slope positions where colluvial processes lead to the deposition of material transported from up slope. Where land has been cleared, paddocks cultivated, or where outcrop is clearly visible this limitation becomes easier to assess in terms of abundance and distribution of stone. It is therefore acknowledged that some underestimation of the rockiness/stoniness limitation may occur in some areas. Areas that have been classified Class 4(r) are found south of Alcomie; many other areas occur within the Class 4+5 complex units (see below).

Class 4 Land on Quaternary Alluvium

Class 4 on alluvium occurs on gently undulating to flat sand plains and river valleys throughout the central portion of the Circular Head area. These areas are characterised by imperfectly drained soils with topsoil textures ranging from loamy sands through to peat and medium clays. The main areas include parts of Mowbray Swamp south west of Smithton, east of Hopeless Plain near Edith Creek, in the valley to the east of Irishtown Road and small areas east of Forest and Nabageena.

Class 4 land on alluvium may be divided into those areas dominated by clay soils and those dominated by sandy soils.

The clay soils are always found down slope from Cambrian mudstone, siltstone and greywacke and to a smaller extent the Tertiary basalt. The soils types here often correlate with the Kana Clay Loam, Scopus Clay and Alluvial soils identified by Hubble (1991). The soils are typically deep gradational soils with characteristic mottling in the subsoils indicating imperfect soil drainage. Even though the soils are moderately fertile, slow surface water run-off rates, low permeability and slowly draining subsoils restrict agricultural production. Being immediately down slope from the hill country and having low slope gradients, these areas collect large amounts of run-on water resulting in lengthy wet periods that severely restrict the window of operation for cultivation and harvest. Yield losses and sometimes crop failure have occurred due to wetness in these areas. The growing season is short and the choice of suitable crops restricted. Operating machinery on this land when soil moisture is too high leads to compaction and poor aeration and reduced internal soil drainage for subsequent crops.

These management problems result in most of this land being used for grazing purposes but some opportunistic cropping of potatoes, beans, poppies, peas and a range of fodder crops takes place. Underground and hump and hollow drainage have been used with success in the western parts of the Mowbray Swamp area on the Scopus medium clay and the Kana clay loam soil. Although these structures assist with the removal of surface water and increase internal soil drainage, a high risk of degradation still exists if the soil is worked or grazed when wet. Careful management during the wet months is needed to prevent pugging, smearing and compaction which may negate the benefits of costly earthworks and underground drainage.

Class 4 land on sandy Quaternary alluvium occurs mainly in the Mowbray Swamp area, part of Hopeless Plain and north of Pulbeena. The boundary between these and the clay soils can often be difficult to identify due to the patchy nature of alluvial deposition in these localities.

Photo 9. Dairying - Class 4 land on Quaternary alluvium
Greenacres (GR E 337700, N 5474300).

Typically, Class 4 land on sandy alluvium includes soils described by Hubble as Mowbray Sand, Loamy Sand and Sandy Clay Loam. These soil types, although not as naturally fertile as the clay soils, respond well to applications of lime and fertiliser. However these soils are highly permeable and dry off quickly during the summer months while suffering from high water tables during the winter. This results in a short growing season and a restricted range of crops that can be grown. Surface drainage, including hump and hollow has improved productivity of this land. Intensive grazing as well as limited cropping of this land occurs. Fodder cropping is common with brassicas and oats the most commonly grown crops.

Class 4 Land on Cambrian Volcanics, Siltstone, Mudstone and Greywacke

Class 4 on Cambrian materials has been identified in the hills to the west and east of the Duck River valley and associated alluvial plain. Small areas of this land are also found south east of Lake Mikany and on the footslopes of Sunny Hills in the south.

Class 4 land with soils formed from Cambrian Volcanics occurs west of Scotchtown Road south of Smithton. Here well structured Red Ferrosols intermingle with those poorer structured gradational soils formed from Cambrian sedimentary rocks. The resulting intergrade soils are often red brown in colour with a medium clay texture. They are sometimes difficult to distinguish from the Tertiary basalt soils at first glance, but these small areas are significantly different for they are not as structurally robust as their younger basalt cousins. Cloddy compacted profiles often demonstrate plough pans as a result of regular cropping. Heavy stocking or grazing in wet conditions on these areas also leads to degradation of soil structure. Long periods under pastures and incorporation of organic matter see structure return to these soils as seen in areas that have been rested for a number of years.

The above soil limitations (s) and the erosion risk (e) on slopes that exceed 18% are the dominant limitations to agriculture for land on Cambrian volcanics. Occasional cropping and grazing is the main land use. In some areas shallow soil depth (l) and high stone content (g) can make tillage and harvesting difficult.

In areas where soils have formed from Cambrian siltstone, mudstone and greywacke and where brown to yellow/brown Dermosols with moderate structured clay to clay loam textures occur, Class 4 (s, e) land has been identified. Where slope gradients are gentle (ie <18%) these areas support occasional cropping of crops such as potatoes, poppies and an assortment of fodder crops. While these areas produce good yields, this land is limited by soil drainage (d). High soil moisture levels impact upon paddock preparation and harvesting. Land managers need to wait for this land to dry out before working the soil type found on this land. Wet years have prevented some areas from being cropped and reports of crop failure due to the land being too wet to harvest have also been reported. This "late" country is at least half to one month behind the cropping areas on the more freely draining Tertiary basalt soils near Forest.

Where slopes increase to over 18% and where watercourses and gullies dissect the landform, erosion risk (e) takes over from soil drainage as the dominant limitation. The susceptibility of this land to erosion is demonstrated at Coventry Creek, on Connells Cross Road, where eroded gullies and creek lines occur. This land class includes small areas of Class 5 land limited by erosion where gradients exceed 28%. Maintaining vegetation cover along creek banks, restricting stock access from erosion prone areas and the diversion of surface run off safely into watercourses are all practices necessary to keep this land in good condition and prevent degradation through erosion.

Class 4 Land on Precambrian Siltstone, Quartzite, Dolomite and Chert

Class 4 land on Precambrian material is mainly concentrated in the gently sloping areas of this geological group or where intergrade soils have formed with the Cambrian mudstone and Tertiary basalt. The main occurrences are south east of South Forest, south of Black River and in the Mengha area. Here soils have formed on relatively gently sloping landforms and are highly variable in their topsoil textures, depths,

Photo 10. Class 4 land on Cambrian mudstone and siltstone.
Preparation for potatoes. (GR E 341400, N 5466100).

colours and stone content. Cultivated paddocks will reflect this variability with a patchwork soil pattern displayed after cultivation.

General soil limitations (s) relating to the variable nature of the soil type restrict use of this land to occasional cropping and intensive grazing and is the principal limitation found on this land.

Less common limitations found on this land are water erosion risk (e), which occurs on land with finer textured soil types, and restricted drainage (d) limitations caused by slowly permeable subsoils. Increasing pressure from cropping is occurring at some of these locations. This land requires careful management under cropping practices in order to prevent degradation and would best suit shallow rooting crops that require minimal tillage and trafficking.

Other Class 4 Land

Small areas of Class 4 land with imperfectly drained soil types (d) occur on Tertiary Sediments. These areas are found near Black River where colluvial and alluvial soils combine to form a heavy dark brown soil on the river terraces and also at the base of small escarpments where run-off waters accumulate during the wetter periods of the year. Other areas are found adjacent to Allen Creek south of Irishtown where imperfect soil drainage, erosion risk and general soils limitations combine to limit agricultural use to grazing and opportunistic cropping only.

Within Mowbray Swamp, areas of Class 4 land have also been identified in areas of peat. These soils share many of the same limitations as the land with sandy soils. The peats are highly fertile but due to intensive drainage and regular cultivation, irreversible drying has degraded them. The peaty horizons range in depth to over 105cm, sometimes overlying sand or clay. These comparatively deep soils have supported a wide range of crops post World War II, using hand harvest techniques. It appears that they could do so again using minimum tillage and restricted traffic techniques. The risk of crop failure however is very high due to high groundwater tables excluding traffic by early April through to late October/November in many areas. Only a very small window of opportunity for cropping use exists.

More class 4 land is identified where a variant of the Mowbray Sandy Loam soil type occurs on the fringe of the Mella Peats. This organic soil is moderately acid in nature and, with appropriate drainage and applications of lime and fertiliser is successfully and intensively grazed for milk production.

Complex Classes (4+3 & 4+5)

Much of the Class 4 land is found in combination with classes 3 and 5 and these complex units comprise a significant area of the Circular Head region.

Class 4+3 land is identified at Rocky Cape, Spion Kop Lookout and the land adjacent to Ghost and Myrtle Creeks where there is a complex landform with slopes ranging from 12-28%. Here the land with slope gradients up to 18% is limited by erosion risk and is identified as Class 3(h). Those areas with slopes ranging from 18-28% are also limited by erosion risk but identified as Class 4. The slope complexity in these areas is such that these classes are unable to be individually mapped.

Much of these complexes occurs on Tertiary basalt or on associated colluvium and the more gently sloping lower slopes or flatter hilltops that are used for cropping. The small size of the Class 3 areas within these complexes makes paddock layout challenging but good yields can reward the extra inputs required for paddock planning and implementation of erosion control structures. The creation of cut-off drains to divert run-on water is also necessary to protect soil and crops situated on lower slopes. Small areas of outcrop exist in places but are often excluded from the productive areas.

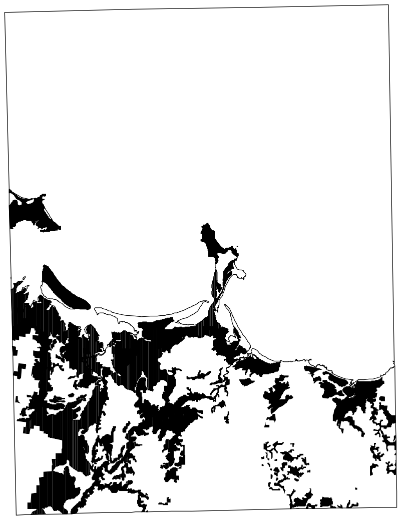
Other areas of Class 4+3 land occur at Nabageena and Irishtown where Tertiary basaltic, Cambrian and alluvial soils combine in a complex pattern. Land on the gently sloping hills with soils formed from Cambrian materials and areas located in low lying landscape positions are both limited by imperfectly drained soil profiles and have been mapped as Class 4(d). The better drained areas within this complex with deep, well structured soil profiles that allow intensive cultivation have been identified as Class 3. Structural degradation and erosion risk is the dominant limitation found on this land. If utilised for cropping, these areas require both strict wet soil management and organic matter retention to keep them in top condition.

The majority of the Class 4 areas that complex with Class 5 land occur surrounding and to the north of the Tertiary basalt plateau on which Lileah and Alcomie are situated. The dominant limitations that are found in these areas are erosion risk and rocky soils. Here Class 5 land on the steep sides of the escarpment is at risk from landslip, is dissected by watercourses, and often has rock outcrop. The lower hill slopes are predominantly Class 4. Soil depths are often deeper here and erosion risks lower than in the Class 5 areas. Red-brown soils, which correlate with the Lapoinya and Yolla clay loams, provide areas where cultivation may be conducted and limited cropping undertaken.

Other small areas of rocky Class 4+5 land are found south of Forest, near Mawbanna and adjacent to Munatrick Road where Cambrian rocks outcrop within the coastal sandy soils. The distribution and quantity of rock found within the soil profile impedes management of these areas. The stone content ranges from gravel through to outcrop and, where it has been possible to do so, stone picking has occurred to allow occasional cropping.

6.5 CLASS 5 LAND

Class 5	21 018 ha
Class 5+4	1 943 ha
Class 4+5	1638 ha
Class 5+6	3 686 ha
Class 6+5	197 ha



Class 5 is the most common land capability class on the Circular Head map, accounting for just over 28% of the map area. The majority of this land occurs on the flat coastal plains and river valleys in the north and on the hill country in the central and western areas. Class 5 land represents land that is unable to withstand cropping even on an irregular basis. Fodder crops and improved pastures can be grown but require high levels of management inputs. Quaternary sediments of the coastal plains and river valley terraces are the dominant parent material for this land but areas of Cambrian and Precambrian materials as well as Tertiary basalt also occur. Much of this land has been developed for dairying and is intensively grazed year round. Soil drainage, erosion risk and stony soils are the main limitations to agriculture.

Class 5 Land on Quaternary Alluvium

This is the largest land capability unit on a single geology type. It totals approximately 65% of the Class 5 land and 20% of the total map area.

This land occurs on flat or very gently sloping sand plains and river terraces along most of the northern coast at Fords Plain, Wiltshire, Smokers Bank and north of the Montagu Road. Much of the Hopeless, Waratah and Jones Plains located in the Duck River drainage basin together with parts of the Mowbray Swamp are also included.

Poorly drained quartz sands identified by Hubble (1951) as groundwater Podzols dominate this land class. Areas with soil types formed from peat, clay and gravels also exist. Seasonally high groundwater levels and high annual rainfall are the main reasons for poor drainage.

The relationship between poor soil drainage and the close proximity of bedrock or other slowly permeable layer is strong. High groundwater tables occur in these areas and impede the use of this land, they rise rapidly and remaining at or near the surface for at least seven months of the year during the wetter part of the year. In areas that also have less permeable clay soil textures, surface water ponding during winter also restricts the use of the land. Much of this land remains too wet for timely paddock preparation, and guarantee of harvest. It has a very high risk of yield loss and therefore been classified Class 5d.

Where drainage systems have been implemented, especially hump and hollow earth works, tremendous improvements in pasture and feed crops productivity have been achieved, particularly during the wetter months. Excellent responses to lime and fertiliser, together with mild temperatures and ample rainfall during spring, result in increased pasture growth rates. The use of additional drainage structures, such as underground drainage, on the clay soils west of Scopus Creek has also led to increases in pasture productivity. Fodder cropping is undertaken on this land with good results.

The resulting drier conditions caused by hump and hollowing increases the wind erosion risk and results in a longer "droughty" period in summer especially for the lighter textured (sandy) soils.

Other Class 5 land limited by stony, gravelly and shallow soils occurs on the northern footslopes of the Forest plateau and where the alluvial sediments overlie Cambrian material on the western side of the Duck River drainage basin.

Isolated areas of Class 6 land too small to be mapped individually and characterised by peat marshes and button grass plains have been included within the Class 5 land on Quaternary alluvium. These areas have very poorly drained, acidic, peaty soils resembling the Loira peat described by Hubble (1991) and occur within the Jones Plain area. These areas lie wet for most of the year and require extensive improvements to drainage and pH in order to produce pasture.

Wet soil management and soil drainage are the major considerations for land managers on Class 5 land on alluvium in the Circular Head area. Land managers needing assistance or advise on how to best manage this wet country are referred to local drainage experts and DPIWE regional staff/publications.

Feeding out stock on the sandy rises and remnant dunes on this land is a common practice during the winter to keep stock off the wettest areas and prevent compaction and pugging damage of the best paddocks. However, when summer arrives and drier conditions prevail, wind and water erosion risks threaten these areas if inadequate pasture cover is left on the sandy banks. Removal of stock as early as possible in late spring helps to regenerate pastures prior to the arrival of dry, windy summer conditions and thereby minimises degradation. Examples of land with this erosion risk occur south of Backline Road, Wiltshire and the Bass Highway near Hellyer.

Photo 11. Hump and hollow drainage improves production on Class 5 land with Scopus Clay soils. (GR E 334200, N 5475400).

Class 5 Land on Cambrian and Precambrian Materials

This land is found on a variety of landforms west of the Duck River drainage basin, east of Smithton, Mawbanna and small areas near Rocky Cape, Forest and south east of Tierneys Road. Here the land is limited either by soil drainage on flatter land where a thin capping of sand overlies a slowly permeable material, or erosion risk on steeper land where shallow and/or finely textured soils occur.

Class 5 Land on Cambrian sediments is found on the hills west of the Duck River drainage basin south of Scopus and near Christmas Hills. The soils here have formed from Cambrian mudstone and siltstone and have shallow silty loam topsoils overlying compact and sometimes shaly clay subsoil. Soil depth is such that deep tillage is not achievable in most areas, although where slope gradients and erosion risk are low, enough cultivation for pasture renewal and/or shallow rooted fodder crops can occur. At some locations plantation forestry has been established on this land. The main concern for the land manager on these Class 5 areas is the management of surface water and the prevention of sheet and rill erosion on these highly erodible shallow soils. A high risk of soil compaction also exists.

At the base of these steep Cambrian and Precambrian hillslopes narrow strips of poorly drained land covered by sandy material are found. These areas receive large amounts of surface run off and lateral drainage from the hills. This high volume of water and the poor permeability of the materials underlying the soils on the footslopes restrict agricultural use. Grazing and fodder cropping can occur when these soils dry out. Similar limitations occur in the Mawbanna Plain and Speedwell Road on flatter terrain areas where sands overlie slowly permeable Precambrian siltstone.

East of Smithton township and north of the Forest Plateau volcanic parent material of Cambrian age forms steep rocky hill slopes that have high erosion risk and severe gradient limitations. Pasture is difficult to establish on these slopes and vegetation has been left on most of the steeper slopes to stabilise areas at risk from slumping and landslip.

Other Class 5 Land

Areas of Class 5 land on Tertiary basalt have been identified along the plateaux and river valley margins at Forest, Rocky Cape, Mawbanna, south of Black River and near Doughboy Hill and on Robbins Island. Often steep, subject to erosion, stony or poorly drained, these areas are capable of supporting grazing activities with some of the flatter areas allowing pasture improvement or establishment of fodder crops.

A small area of land on siliceous Tertiary gravels and coarse sandy deposits is found south of Black River. Some parts have been mined for gravel but areas cleared of vegetation and otherwise undisturbed can support good pastures. Shallow soil depth and stone content limit this land to Class 5. Shallow working and limited tillage for pasture establishment is advisable on this land to avoid bringing gravels to the surface.

Complex Classes (Class 5+4 & Class 5+6)

Class 5+4 land is identified at four main locations, the northern end of Circular Head, South Forest, south west of Lake Mikany and east of the Trowutta Road near Eurebia. Here Class 5 and Class 4 land occurs in such a pattern that each class cannot be separated at this scale of mapping.

The area on Circular Head includes steep sections of the basalt escarpment where slope gradients vary considerably in a complex pattern. The less steep or less stony areas are suitable for occasional cropping while other areas are not. The lower ground to the north however is severely limited by stone within the profile (g limitation). Even though paddocks have been heavily stone picked in the past, indicated by many stone heaps and walls, stones and boulders still exceed approx 35% of the profile in most areas and prevent cultivation other than for pasture establishment and renewal purposes. As well as being limited by stoniness, the lowland areas (<10m asl.) can lie very wet for parts of the year further impacting upon agricultural activities.

An area at South Forest sweeps westward and encompasses the area surrounding Lake Mikany and the adjacent timber reserve. Much of this area is steep and overlies Precambrian and Cambrian rock types that weather to form shallow, finely textured soils that are subject to erosion. These locations have better areas of Class 4 within them where land with deeper soils formed from Cambrian and Quaternary clay sediments occur. Occasional cropping (especially poppies) in these areas was noted during fieldwork but potential areas are small and topographic variation made paddock layout and harvesting challenging at some locations.

A smaller area of Class 5+4 land occurs between Sharmans Hill and O'Hallorans Hill north east of Eurebia. This area represents the upper western hill slopes of a drainage basin that extends to Smokers Bank to the north. Here underlying Precambrian and Cambrian rock types form steep hill slopes that are dissected by minor drainage channels including Copper Creek. These dissected areas are prone to erosion and have been mapped as Class 5 together with the areas of shallow soil and small areas on the valley floor that are poorly drained. Class 4 land occurs on the Cambrian and Quaternary intergrade soils that are well structured and have adequate depth and drainage for occasional cropping uses. These areas are inhibited by soil wetness and drainage well into spring and may delay planting in wetter years. Structural decline is a concern on these areas and wet soil management procedures need to be applied to prevent degradation.

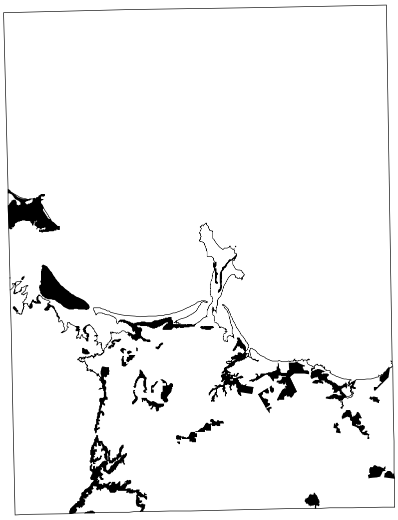
Class 5+6 land occurs on similar geological material as Class 5+4 land but also includes areas on Cambrian volcanics. It also shares many of the same limitations within its Class 5 components.

Land with steep and rocky landforms is found along the valley sides, escarpments and drainage lines. The main limitations of the Class 6 component are erosion risk and very shallow soil depths. The Class 5 land here allows for pasture establishment but remains stony and has a sheet and rill erosion risk. Examples of this land occur south of Smithton along the steep valley side of the Duck River drainage basin and the dissected land adjacent to Edith Creek.

Other Class 5+6 land occurs on Quaternary alluvium on Robbins and Perkins Islands. These areas include very poorly drained areas scattered throughout Class 5 land limited also by poor drainage. Much of this land remains under native heathland and swamp vegetation. Linear areas of steep sided and highly erodible dunes occur in the northern portion of Perkins Island and contribute to the Class 6 component of this complex.

6.6 CLASS 6 LAND

Class 6	3 722 ha
Class 5+6	3686 ha
Class 6+5	197 ha
Class 6+7	81 ha



Class 6 land in the Circular Head survey area identifies all the land considered marginal for sustainable agricultural production. Agricultural use of these areas is severely constrained by a range of limitations including poor soil drainage, shallow soil depth, erosion risk (both wind and water) and rock outcrop. Rough grazing with low stocking rates is the dominant agricultural practice in these areas. The majority of the Class 6 land occurs in the northern region of the map, and is located on Precambrian and Quaternary sediments. Some of this land is complexed with Classes 5 and 7. In the more remote areas, such as Perkins Island and parts of Brickmakers Plains, identification of Class 6 Land has relied heavily upon aerial photo interpretation, existing geological and land systems information.

Class 6 Land on Precambrian and Cambrian Sediments and Cambrian Volcanics

Class 6 land on Precambrian and Cambrian Sediments and Cambrian Volcanics makes up the majority of the Class 6 land identified in the Circular Head area. The major limitations are soil depth, stoniness, limiting layers within the soil profile, very poor drainage and finely textured topsoil horizons that are susceptible to high rates of erosion.

Those areas that are limited by poor soil depth, stoniness and limiting layers within the soil profile are found mainly on the Precambrian parent materials. Areas include Brickmakers Plain and Black River in the north together with a few scattered areas where outcrop occurs along the coastline and in the far south along Newhaven Road.

A range of shallow soils occur but the dominant soil is a shallow, light grey, silty loam overlying a yellow brown clay subsoil which has many bright orange mottles. This subsoil is extremely compact and lacks good soil structure. Root development is restricted to the topsoil. In the areas that have been cleared of timber, topsoils have all but been removed, eroded by sheet erosion. Re-establishing pasture on these subsoil materials is exceedingly difficult.

Other areas of very rocky land are found at Boyden Road at Black River where conglomerate ridges occur, as well as south of the Bass Highway at Cowrie Point, Port Latta and Edgecumbe Beach. Outcrops of siltstone are also visible at these locations along the coastal escarpments. Shallow, erosion prone soils with thixotropic A2 horizons were found to overlie the siltstone at most locations. It is recommended that disturbance of these areas be kept to a minimum, with only light forage grazing in order to retain vegetative cover and minimise soil degradation risk.

Other Class 6 land on Cambrian and Precambrian sediments occurs at Peppermint Hill and East Creek south of Mengha as well as parts of Mawbanna and Brickmakers Plain. Here the land is limited either by erosion risk or by very poor drainage.

Class 6 Land on Quaternary Sediments

Class 6 land on Quaternary alluvium can be divided into three main groups according to their main agricultural limitation – those areas limited by poor drainage, erosion risk and shallow or gravelly soils.

Land limited by poor drainage is found in scattered areas along the northern coastal sand plain where the land is extremely low lying and subject to long periods of wetness due to high groundwater levels and inundation. Tidal inundation from major storm events and spring tides occurs from time to time and combines with sea spray to result in highly saline conditions. When cleared of native vegetation some areas have been sown down to pasture, but these rarely thrive and commonly become dominated by sedges, rushes and other salt tolerant plant species. Due to prolonged high groundwater levels limited grazing during the drier months is the only sustainable landuse on these poor pastures. These areas are found behind the dune barriers south of Anthony and Black River Beaches and at locations adjacent to the many inlets and bays along the coast.

In the exposed coastal location of Perkins Island Class 6 land has been mapped where wind and water erosion become major risks to the sandy soil resource should this land be disturbed for pasture production. The prevailing strong westerly winds and the potential for damage from grazing animals combine to result in areas which can only sustain light stocking rates and require careful management to preserve the shallow organic topsoils and prevent sand blows.

Class 6 land with gravelly, stony and shallow soils or poor rooting conditions within the soil has been mapped in many scattered locations throughout the survey area. The main areas include land immediately west of Rocky Cape National Park where colluvium from the Precambrian rock types which form the headland have been deposited in a fan with gravelly soils and shallow topsoil depths. Another area occurs south of Newhaven Creek in the south of the survey area where extremely gravelly subsoils and A2 horizons overlain by acidic topsoils restrict agricultural use to limited grazing. This area has been utilised for gravel extraction and a large quarry exposure gives a good indication of the poor soil types found. Other areas occur at Black River along the rocky ridges and riverbanks, encircling Briant Hill near Smithton and south of Port Latta along the coastal escarpment.

Photo 12. Class 6 land on Quaternary alluvium with poorly drained soils.
Newhaven Road (GR E 364100, N 5460900).

Class 6 land on Quaternary alluvium also includes small areas of mudflats, estuarine fringes that are highly saline and rock platforms. These areas would normally be classified as Class 7 but are too small to be mapped separately at this scale of mapping.

Other Class 6 land

Other Class 6 land is found in small areas at the fringe of Tertiary basalt landforms where colluvium and Quaternary alluvium have resulted in the formation of very poorly drained soils or where steep slopes have a high risk of landslip or slumping. Areas at West Inlet and those areas on the side slopes of Green Hill near Stanley show these characteristics.

Each of these areas pose serious management problems for land managers. At West Inlet very poorly drained land restricts trafficking by stock to only the drier months of the year and the erosion risk on the steep and the unstable soils of Green Hills reduces the versatility of the land to light grazing only.

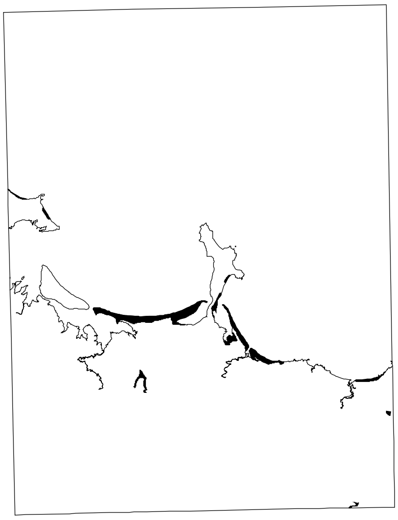
Complex Classes (6+5 & 6+7)

One area of Class 6+5 and Class 6+7 land occur in the Circular Head area. The Class 6+5 area is found inland from Anthony Beach and composes much of the coastal swales of Thousand Island Plain. Here small areas of Class 5 land that are better drained or less prone to erosion combine with Class 6 land that is found in less well drained depressions and on the highly erodible remnant dunes.

The 6+7 land occurs on the extremely steep slopes of Beacom Hills south east of Smithton (see background of Photo 6). This range of hills is composed of Precambrian conglomerate dominated by white quartz rock. Soil profiles range from shallow organic topsoils that sustain sufficient vegetation and pasture species for rough grazing, to profiles with little to no topsoil at all. Quarrying for construction and roading materials is the dominant land use at this location.

6.7 CLASS 7 LAND

Class 7	1 500 ha
Class 6+7	81 ha



Class 7 land in the Circular Head area represents land that is unable to support agricultural activities on a sustainable basis. The dominant limitation is erosion risk and in the Circular Head area this is determined by landform gradient, degree of exposure to the prevailing winds and soil type. Class 7 land has also been mapped in areas with not only extremely steep gradients but also very shallow soil depths. The majority of Class 7 land is identified on the coast, in estuarine areas adjacent to the mouths of rivers and bays. Dunes, sea cliffs and highly erodible landforms occur at these locations and prevent sustainable agricultural practices occurring.

Class 7 Land on Quaternary Sediments

This land is composed of large unconsolidated and sparsely vegetated beach, sand dune or mudflat environments. These areas support fragile natural ecosystems that cannot tolerate disturbances that may occur from browsing stock or land clearance.

These areas are considered too sensitive for any form of agricultural use as even light grazing leads to vegetation decline, disturbance of loose sandy topsoils leaving them prone to wind erosion, sand blow and dune migration. Blow-outs and dune migration in the Circular Head area, as well as at other locations along the northern and western coastlines of Tasmania, reinforce the importance of maintaining native vegetative cover at these locations in order to prevent degradation occurring. Dune stabilisation is a costly, labour intensive and rarely successful activity once migration starts. Examples of this land may be found immediately south of Peggs, Black River, Forwards and Anthony Beaches. Smaller dune areas occur on Robbins Island and Tatlows Beach south of Stanley.

Photo 13. Class 7 dunes and beach ridges at Peggs Beach. (GR E 358000, N 5477500).

Some marsh and mud flat environments occur adjacent to the estuaries and river mouths along the coastline. These areas are subject to inundation cause by drains and water courses being impeded or "backed up" by spring tides. This land supports tussock and sedge vegetation which provide little or no feed value for stock. They are also very easily damaged if used for forage purposes. Areas of saline scalds also occur which limit vegetation to only salt tolerant species. Areas include “The Jam” north of Bolduans Road and south of East Inlet.

Class 7 Land on Precambrian Quartzite

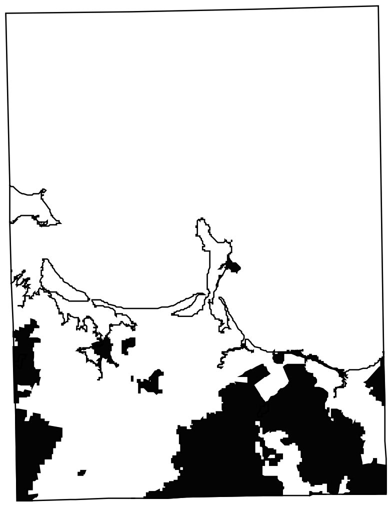
Small extremely steep and highly erodible areas occur within the Dip Range adjacent to Newhaven Road and on the southern slopes of Rocky Cape National Park. Shallow soil depth and high risk of erosion restrict any form of improvement for agricultural purposes. Disturbance of native vegetation in these areas can result in long term scarring and very slow vegetation regeneration, which in turn results in water erosion in these areas. On more gentle terrain button grass vegetation has established on the almost permanently wet, poorly drained and highly acidic soils. These areas are often underlain at shallow depths by quartz gravels and bedrock.

Complex Classes

No complex areas occur where Class 7 is the dominant land unit.

6.8 EXCLUSION AREAS

Exclusion areas 28 611 ha



The Circular Head area contains a large expanse of Exclusion area (approximately 34%) which is not included in the land capability survey.
Exclusion areas are all areas that are not private freehold or unallocated Crown Land as well as "Other Exclusion Areas".
Most exclusion areas can be grouped into one of the four categories below:

Land administered by the Forestry Commission

The majority of the Exclusion Area within the Circular Head land capability map is State Forest, Forestry Reserves or other forested areas which come under the jurisdiction of Forestry Tasmania. The areas include land south of Port Latta, Shakespeare Hills, Myhill Lookout, Kellys Knob and adjacent to the Black River. Other areas such as Christmas Hills and around Barcoo Road on the western boundary of the map also are excluded from the study.

Land administered under the National Parks & Wildlife Act

One National Park occurs within the limits of the survey area. Rocky Cape National Park is to be found in the north east corner of the map sheet and encompasses most of the Sisters Hills area. Other areas managed under the Act include The Nut, Highfield Historic Site and Bryant Hill State Recreation area.

Land administered under the Crown Lands Act

Many small areas are designated as reserves within the map area and can be divided into the following categories: quarries, schools, coastal reserves, river reserves and parks. Examples include Edith Creek School area and Hellyer and Forwards Beach north of the Bass Highway.

Other Exclusion Areas

Other Exclusion Areas include major urban areas. Such boundaries are not intended to represent the boundaries of individual land titles. The published exclusion boundaries in this report and accompanying map should be used with caution and do not purport to identify the exact cadastral location of said boundaries. Council administered areas, such as the banks of Lake Mikany and other major inland water bodies, are also excluded from this study.

Exclusion boundaries for this study have been obtained from Forestry Tasmania and are accurate to 1998. All exclusion areas appear white on the map and are identified with the letter E.

6.9 SUMMARY TABLES

A summary of the land capability classes, their land characteristics and the important land management issues for these classes is presented in Table 4. The Table is not intended as an exhaustive list of all the map units identified within the Circular Head area. It contains the most common groups within each class and aims to display the link between land capability, the associated land features and the range of limitations that may be expected.

The management practices necessary to keep the land within each land capability class in top condition as well as maximising productivity are indicated and a guide to the agricultural versatility of each land class is found in the last two columns of the table.

Land Capability Class	Land Characteristics						Land Management Issues		
	Geology	**Slope**	**Topography and Elevation**	**Erosion Type and Severity**	**Climatic Limitation**	**Important Soil Properties**	**Main Limitation to Agricultural Use**	**Main Land Management Requirements**	**Agricultural Versatility**
1	Tertiary basalt.	0-5%	Flat and very gently sloping land. <180m asl.	Very minor sheet and rill erosion risk.	Very minor frost risk.	Well drained. Stone free.	Erosion (e). (sheet and rill)	Very minor. Soil erosion control and soil conservation practices.	All annual crops and grazing.
2	Tertiary and Cambrian basalt.	0-5%	Gently inclined undulating rises. 180-270m asl.	Very minor sheet and rill erosion risk.	Minor out of season frost risk.	Well drained. Some stone.	Climate (c). (frost risk)	Very minor. Soil erosion control and soil conservation practices.	Annual crops which are frost tolerant. Grazing.
2	Tertiary and Cambrian basalt.	5-12%	Gently inclined undulating rises. <180m asl.	Minor sheet and rill erosion risk.	Nil	Well drained. Some stone.	Erosion (e). (sheet and rill)	Minor. Soil erosion control and soil conservation practices.	All annual crops and grazing.
2	Tertiary and Cambrian basalt.	0-5%	Gently inclined undulating rises <180m asl.	Very minor sheet and rill erosion risk.	Exposure to salt spray and strong prevailing winds, high evaporation rates, moisture deficit.	Well drained. Some stone.	Climate (c). (exposure to strong wind and associated moisture deficit)	Very minor. Soil conservation practices. Wind breaks.	Annual crops apart from salt sensitive and tall growing crops such as sweet corn. Grazing.
3	Tertiary basalt.	0-12%	Rolling hills and rises.	Slight sheet and gully erosion risk.	Nil	Well to moderately well drained. Stony.	Stony soil (g).	Moderate. Implementation of soil conservation practices. Stone picking.	Restricted range of crops. Grazing.
3	Tertiary and Cambrian basalt	12-18%	Moderately steep rolling hills and rises.	Moderate sheet and rill erosion. Slight gully erosion risk.	Nil	Well to moderately well drained.	Erosion (e). Undulating, broken terrain.	Moderate. Implementation of soil erosion control and soil conservation practices.	Restricted range of crops. Grazing.
3	Cambrian mudstone and Tertiary basalt intergrade.	0-12%	Moderately steep rises and footslopes.	Minor sheet and rill erosion.	Nil	Moderately well drained. Moderate soil structure.	Soil structure (s). Drainage (d).	Moderate. Implementation of soil drainage and soil conservation practices.	Restricted range of crops. Grazing.
4	Tertiary basalt.	18-28%	Moderately steep rolling rises and low hills.	High sheet, rill and gully erosion risks. Moderate mass movement.	Nil	Well structured. Well drained.	Erosion (e). Stony (g) and Rock outcrop (r). (all impact upon practicality of using planting and harvesting machinery)	Moderate. Implementation of soil erosion control and soil conservation practices, including surface water management.	Severely restricted range of crops. Grazing.

Table 4. Characteristics of the main land capability classes identified in the Circular Head survey area.
(NB. Not all map units are described. Some generalising of unit descriptions has been undertaken to avoid excessive repetition of data)

Land Capability Class	Land Characteristics						Land Management Issues		
	Geology	Slope	Topography and Elevation	Erosion Type and Severity	Climatic Limitation	Important Soil Properties	Main Limitation to Agricultural Use	Main Land Management Requirements	Agricultural Versatility
4	Quaternary alluvium.	0-5%	Very gently undulating hills to flat plains and river valleys.	Moderate sheet, rill and gully erosion risks.	Nil	Imperfect soil drainage and weak soil structure in clay soils. Sandy soils are highly permeable with high water tables.	Soil drainage (d). (narrow trafficking window at planting and harvest time due to high soil moisture)	Major. Soil drainage works and soil conservation practices including controlled trafficking and stocking during wetter months.	Severely restricted range of crops. Grazing.
4	Cambrian volcanics, siltstone, mudstone and greywacke.	0-12%	Gentle to moderately steep hills.	Minor sheet, rill and gully erosion risks.	Nil	Imperfectly drained soils. Soils subject to compaction.	Soil drainage (d). (narrow trafficking window at planting and harvest time due to high soil moisture)	Major. Careful management of wet soils. Implementation of soil conservation practices including organic matter retention and surface water management.	Severely restricted range of crops. Grazing.
4	Cambrian volcanics, siltstone, mudstone and greywacke.	12-28%	Moderately steep hills.	Severe sheet, rill and gully erosion risks.	Nil	Shallow erosion prone topsoils.	Erosion risk (e). Soil limitations (s).	Major. Implementation of soil erosion prevention and soil conservation practices including surface water management.	Severely restricted range of crops. Grazing.
4	Precambrian siltstone, quartzite, dolomite and chert.	0-12%	Gentle, undulating and rolling low hills.	Minor sheet, rill and gully erosion risks.	Nil	Variable topsoil texture. Stony soils. Imperfectly drained.	Shallow soil depth (s). Soil drainage (d).	Soil drainage. Careful management of wet soils. Soil structure maintenance including organic matter retention.	Severely restricted range of crops. Grazing.
5	Quaternary alluvium.	0-5%	Flat to very gently sloping plains.	Moderate risk of wind and water erosion.	Nil	Low natural nutrient levels due to rapid leaching.	Erosion (e). Drainage (d). Wetness (w).	Careful management of wet soils. Major drainage requirements.	Grazing. Occasional fodder crops.
5	Cambrian and Precambrian sediments.	12-18%	Moderate to rolling hillslopes.	High risk of rill and gully erosion.	Nil	Shallow, highly erodible soils on steeper slopes. Poorly structured, compact subsoils.	Drainage (d). Wetness (w). Erosion (e).	Surface water management. Major drainage requirements.	Grazing. Occasional fodder crops.

Table 4. Continued.
(NB. Not all map units are described. Some generalising of unit descriptions has been undertaken to avoid excessive repetition of data)

Land Capability Class	Land Characteristics						Land Management Issues		
	Geology	Slope	Topography and Elevation	Erosion Type and Severity	Climatic Limitation	Important Soil Properties	Main Limitation to Agricultural Use	Main Land Management Requirements	Agricultural Versatility
5	Tertiary basalt.	28-56%	Moderate to steep hillslopes.	High risk of sheet and rill erosion.	Nil	Often stony with shallow topsoils.	Stony (g). Erosion (e).	Moderate soil conservation methods.	Grazing. Occasional fodder crops.
6	Precambrian and Cambrian sediments, Cambrian volcanics.	0-18%	Moderate to rolling hills.	High rill and gully erosion risk.	Nil	Shallow erosion prone topsoils. Gravelly and poorly structured subsoils.	Erosion (e). Drainage (d). Soil depth (s). Stoniness (g).	Controlled stocking rates. Minimum tillage. Major soil erosion prevention and conservation practices.	Limited or seasonal grazing.
6	Quaternary alluvium and colluvium.	0-28%	Low to moderate hillslopes.	High wind and water erosion risk.	Nil	Shallow acidic topsoils. Gravelly soil.	Soil drainage (s). High groundwater tables (w). Erosion (e).	Controlled stocking rates. Minimum tillage. Major soil erosion and conservation practices.	Limited or seasonal grazing.
6	Quaternary alluvium.	0-28%	Gently to moderately sloping sand capped hills and coastal dunes.	Very high wind erosion risk on dunes. Gully and sheet erosion risk on hills.	Nil	Poor soil structure. Shallow stony topsoils. Low fertility.	Erosion (e). Drainage (d). Gravelly (g). Soil nutrients (s).	Controlled stocking rates. Major drainage requirements.	Limited or seasonal grazing.
7	Quaternary alluvium.	28-56%	Coastal sand dunes. <30m asl.	Very severe wind erosion risk.	Nil	Very low fertility.	Wind erosion (a). Soil nutrients (s).	Avoid agricultural use.	No sustainable agricultural use.
7	Quaternary alluvium.	Level	Alluvial and estuarine mud flats <2m asl.	Very low erosion risk.	Nil	High salinity levels.	Soil drainage (d). Salinity (k). Extremely high groundwater tables (w).	Avoid agricultural use.	No sustainable agricultural use.

Table 4. Continued.

(NB. Not all map units are described. Some generalising of unit descriptions has been undertaken to avoid excessive repetition of data)

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GLOSSARY

Alluvial sediment: Material transported by rivers.

Angular unconformity: An angular discordance between strata. The lower, older series of beds dip at a different angle to the younger, upper beds. This also includes the case where unfolded, younger strata rest upon folded, older, strata.

Barchan Lunette: Assymetrical crescent shaped dunes characterised by the points of the crescent extending downwind, and a convex windward slope of gentle gradient relative to that of the concave leeward face.

Breccias: Rocks comprised of angular fragments derived from a restricted source.

Clay: Soil particles <0.002 mm.

Coarse fragments: Particles >2 mm, but not segregations of pedogenic origin (formed in soil profile).

Colluvial deposits: Weathered material transported by gravity.

Complex: The term complex is used to refer to a map unit where two land capability classes are identified but cannot be separated at the scale of mapping. In a complex unit the proportion of the two land classes is at least 60-40.

Conglomerate: A group of sedimentary rocks with particles greater than 2 mm which are rounded and subrounded and cemented together by a finer matrix.

Dendritic: From the Greek word dendron (tree) used to describe a branching drainage pattern made by rivers and streams.

Degradation: This is the deterioration of a resource through inappropriate or uncontrolled management or use.

Dispersive Soils: Refers to those soils which contain a high proportion of sodium on the exchange sites of the clay minerals. The high sodium content causes soil aggregates to break down as they absorb water. Dispersive soils are inherently unstable and easily eroded.

Drainage: How water drains from the soil profile. Rapid drainage will cause water to move past the root zone in a short period limiting water uptake by the plant, while slow drainage will cause the soil profile to become saturated with water. A saturated profile will exclude most of the oxygen from the soil which leads to root cell death and greatly reduced uptake of moisture by the plant. Drainage depends on landscape position (which controls external drainage eg. run-off and run-on), permeability of soil (texture, structure and distribution of pore spaces) and impediments in the profile to water movement such as hardpan and rock.

Duplex Soils: These soils contain a strong texture contrast between the A and B horizons. Strong texture contrast is defined according to the *Australian Soil Classification* (Isbell, 1996).

Erosion risk: The potential for wind, sheet, rill or gully erosion to occur on a land surface. The land surface is most prone to erosion when cultivated and/or when little or no vegetative cover is present. Land management to suit site conditions can minimise the severity, and often prevent most occurrences of water erosion. Erosion hazard depends on soil erodibility (loose, weakly structured soils are most at risk from wind erosion), amount of ground cover, slope gradient, rainfall (intensity and amount), and the amount of run-on received.

Ferrosols: A soil order defined in the *Australian Soil Classification* (Isbell 1996) as having a free iron content in the B2 horizon greater than 5%.

Fine sand: Particles from 0.06 to 0.1 mm, just visible with the naked eye and which feel similar to coarse flour or table salt.

Horizons: Layers within a soil profile which have morphological properties different from those above and below (Northcote 1979).

Igneous rocks: Rocks formed through the solidification of magma, they include; hypabyssal, plutonic, pyroclastic and volcanic rocks.

Imperfectly drained: (soil) Water is removed only slowly in relation to supply.

Land Suitability: Identifies the suitability of an area for a defined land use. Land suitability usually considers the economic and cultural suitability of a land use in addition to the land requirements. A comparison of land suitability evaluations for a range of different uses can identify the most suitable use for a particular area.

Limitation: Refers to the physical factors or constraints which affect the versatility of the land and determine its capability for long term agricultural development.

Limiting Layer: A layer within the soil profile that severely impedes or restricts the development of plant roots, eg bedrock, groundwater, heavy massive subsoils, iron pans or other cemented layers.

Lithology: The general characteristics of rocks and sediments.

Moisture availability: This is a measure or rating of the amount of moisture held in the soil which is available to the plant. It is defined as the difference between the field capacity of the soil and the wilting point. Field capacity occurs when the soil's large pores (>30 microns) have drained but when all the small pores and capillary channels are still filled with water. Wilting point is when the soil is dry to the point where the plants can extract no more water. Soil texture has the greatest effect on availability of water to the plant.

Permeability: A rock or layer is permeable if water or other liquid tends to pass through to a lower surface.

pH: Soil pH is a measure of the acidity or alkalinity. A pH of 7 denotes a neutral soil with a log scale of increasing alkalinity of pH 7 to 14, and a log scale of increasing acidity of pH 7 to 1.

Pillow Lava: Lava extruded underwater which has cooled rapidly to form pillow-like globular masses typically exhibiting a vesicular interior, a concentric structure and a finely grained exterior.

Plastic limit: The water content of a soil corresponding to an arbitrary limit at which it passes from a plastic state to a more or less rigid solid state; the state where a plastic soil begins to crumble.

Plateau: Elevated flat land limited by abrupt slopes on one or more sides.

Podosols: A soil order defined in the *Australian Soil Classification* (Isbell 1996) as being soils that have B horizons dominated by the accumulation of compounds of organic matter and aluminium, with or without iron.

Prime Agricultural Land: Areas identified as land capability Class 1, 2 or 3.

Quartzite: Metamorphosed rocks of sedimentary origin rich in silica.

Sedimentary: Rocks formed from material derived from pre-existing rocks.

Soil Association: A related group of soils that contains a dominant soil and a number of sub-dominant and minor soils within it.

Soil compaction: The development of a traffic (compaction) pan below the soil surface, usually 10 to 30 cm deep. Pans restrict root growth and drainage into the sub-soil. Pan development can occur in most soils. Yield responses can be obtained on some soils by deep ripping to break the traffic pan.

Soil structure decline: The degradation of soil structure. Soil aggregates may be destroyed by excessive cultivation/harvesting or trampling by stock, leaving a compacted, massive or cloddy soil. Soils are particularly susceptible when wet.

Spilite: Basaltic rock type formed by volcanic lava flows that have flowed into or been extruded under the sea. Often found as pillow formations. Varies from other basalt by containing chlorite in lieu of augite and olivine and has albite as the plagioclase.

Strandline: Area in which material is deposited by wave action and subsequently stranded by receding sea levels.

Sustainable: The concept of sustainability in the agricultural context has given rise to considerable discussion. Very simply, *sustainable* land use implies a land use which can be continued in the long term without damage to the environment or the natural resource. It is generally agreed that agriculture inevitably results in some damage but for land use to be considered sustainable the damage has to be kept to an acceptable minimum and allow the continued long term use of that land.

Talus: Accumulation of rocks and boulders at the foot of a cliff or steep slope (also referred to as scree).

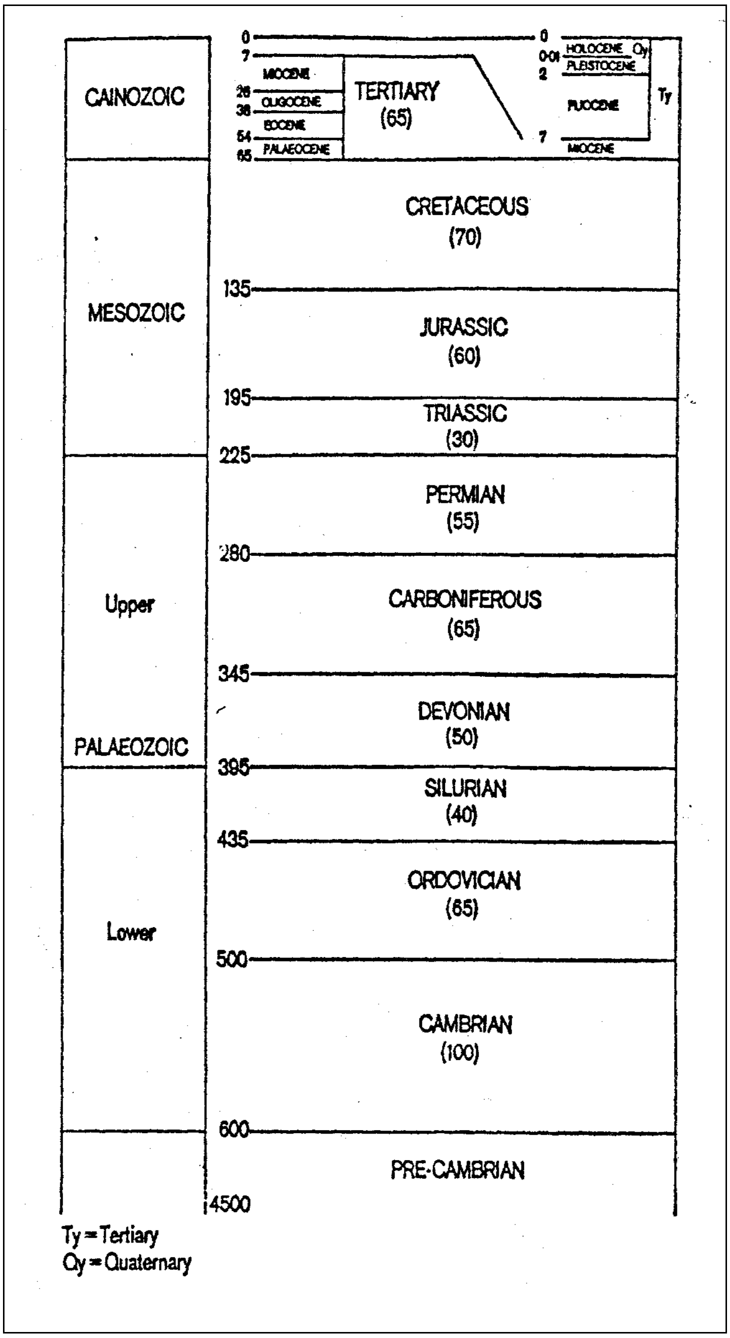
Thixotropic: Material which is solid when stationary but becomes mobile when affected by shearing stresses eg Quick clays

Tholeiitic, Tholeiite: Type of basalt consisting of basic plagioclase and pyroxene with interstitial glass or quartz-alkali feldspar intergrowths.

Transcurrent Fault: Also called a tear or wrench fault where movement is dominantly strike-slip (ie horizontal).

APPENDIX

Appendix A. Geological Timescale



*figures indicate millions (10^6) of years ago.