Characteristics of Tasmanian Estuaries and Catchments: Physical Attributes, Population, and Land Use

by

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Statement

This thesis contains no material that has been accepted for the award of any other degree or diploma in any university, and to the best of the author's knowledge and belief it contains no copy or paraphrase of material previously published or written by other persons except where due reference is made in the text.

Dave Graddon

25 March 1997

Abstract

Estuaries are the interface between the sea and drainage from the land. They can be severely affected by human activities within the catchment. Little is known of the conservation status of Tasmania's estuarine environments. This research is part of an Ocean Rescue 2000 (OR2000) funded project titled 'Regional classification of Tasmanian coastal waters - stage 2, estuaries'. The aim of this research was to augment available data on Tasmanian estuaries by deriving data on the physical attributes and human land use of the catchments of Tasmanian estuaries, and to rank catchments according to their conservation status and degree of human impact. The data derived complements the concurrent survey of estuarine biota and habitats being done as the major part of the OR2000 project.

The thesis mapped the catchments of 122 estuaries identified around the coastline of mainland Tasmania and the Bass Strait islands. These catchments were classified into five groups based on the physical attributes derived for each catchment. The division largely reflected the unique hydrological characteristics of the Tasmanian environment. Catchments in the west and south are characterised by high annual rainfall and high runoff. Catchments in the north-west and south-east have moderate rainfall and runoff, while catchments in the east, north and on the Bass Strait islands are relatively dry.

Land clearance and broad categories of land use were determined for 60 catchments using available data derived from satellite images. Tasmanian catchments are highly conserved in comparison with most mainland states of Australia. Eleven out of these 60 catchments can be considered to be pristine with little human impact on the catchment or estuarine conservation values. More than 50% of all catchments are relatively uninhabited, particularly those catchments in the south and west of the state. However a small number of catchments are severely impacted by large scale land clearance and many others are threatened by human impacts. The degree of land clearance and human developments was found to increase greatly with proximity to estuaries. The highest levels of land clearance, population and urban development were detected in catchments along the south-east, east and north coasts of Tasmania.

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For Jo-Anne and Zenani (born 4/02/97)

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List of Abbreviations and Acronyms

AAT	arc attribute table
ABS	Australian Bureau of Statistics (Commonwealth Government)
AIMI	Arc/Info MapInfo translation software
AMG	Australian Map Grid
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CSL	Central Science Laboratory (University of Tasmania)
DELM	Department of Environment and Land Management (Tasmanian Government)
DEM	digital elevation model
DPIF	Department of Primary Industry and Fisheries (Tasmanian Government)
EBZ	estuary buffer zone
ECA	estuary catchment area
EDA	estuary drainage area
EIF	environmental impact factor
ESRI	Environmental Systems Research Institute, Inc., USA
FDA	fluvial drainage area
FUSE	polythetic agglomerative fusion module
GIS	geographic information system
HEC	Hydro-Electric Corporation (Commission), Tasmania
Landsat TM	Landsat Thematic Mapper
LIB	Land Information Bureau, DELM (Tasmanian Government)
MEPA	marine and estuarine protected area
NOAA	National Oceanic and Atmospheric Association, USA
PAT	polygon attribute table
PCC	principle axis correlation
RWH	Division of Resources, Wildlife and Heritage, DELM (Tasmanian Government)
RWSC	Rivers and Water Supply Commission, DPIF (Tasmanian Government)
SCS	United States Soil Conservation Service
SER	State of the Environment Report (Tasmania)
SSH	semi strong hybrid
TCM	total catchment management
UPGMA	unweighted pair group arithmetic averaging
VAT	value attribute table
ybp	years before present

Chapter 1

Introduction

1.1 Context of the Thesis

Worldwide, estuaries have been major focal points for human development. The productivity and fertility of estuaries and their surrounds have contributed to the success of human settlements. Rivers and their associated fertile, alluvial plains have provided dependable supplies of freshwater and agricultural land, while the productive estuarine waters have been a source of bountiful supplies of fish and shellfish. Estuaries offered sheltered ports for the development of sea travel and trade, while rivers made possible access to hinterland areas. Expanding world trade and the development of heavy industries, which rely on transport of raw materials and produce, have promoted the growth of ports and urban and industrial developments around estuaries.

In Australia, estuaries have been the principal sites of European settlement (Hodgkin, 1994). Over 75% of the population of New South Wales (NSW) live in towns and cities located adjacent to estuaries. Population and urban development continues to grow along Australia's coastline (Adam *et al.*, 1992). In Tasmania ocean trade has been critical to the economic development of the state and the major urban centres have developed around the ports of Hobart, Launceston, Devonport and Burnie.

Estuaries support highly productive natural ecosystems with large populations of birds, fish and invertebrates. They provide important nursery areas for commercial fish and crustacean species. Estuaries are popular fishing grounds and are significant to both commercial and recreational fisheries (Saenger, 1995). Estuaries are also popular sites for tourism and recreational activities adding to pressures for new developments.

Human activities compromise estuarine ecosystems and in many cases have led to large scale alterations of the natural communities in estuaries. Estuaries have been used as conduits for industrial and urban wastes while reclamation of wetlands, dredging of shipping channels and construction of port facilities, has caused large scale habitat destruction.

Deforestation within estuarine catchments for agriculture, forestry and urban development has increased runoff and peak flow rates while erosion of exposed soils has increased sediment loads of rivers. The intensive development of estuaries and their catchments since European settlement has resulted in the deterioration of water quality, increased siltation, reduction and degradation of important habitats such as seagrass, mangroves and saltmarsh, disruption of estuarine ecosystems and declining fish populations (Dyer, 1973; Adam *et al.*, 1992, Saenger, 1995).

In Australia there is a strong public awareness of the importance of the conservation of estuaries and their associated wetlands (Saenger, 1995). However, human population growth, and urban and industrial development, continue to threaten estuarine ecosystems. Appropriate management of estuarine environments is essential to ensure the protection of natural resources and ecosystems, as well as maintaining the quality of human habitation near estuaries. Estuaries are not independent ecosystems. They are inextricably linked to processes within their catchments and the adjacent marine environment. Management strategies therefore require an understanding of all factors that affect the estuarine environment (Day and Grindley, 1981).

Bucher and Saenger (1989, 1991) recognised the need for a broad overview of the status of Australian estuaries. Their inventory of Australian estuaries included habitats, the value of estuarine fisheries, conservation values, water quality, catchment clearance and landuse. The inventory summarised the current status of knowledge for over 700 Australian estuaries. In Tasmania, 63 estuaries were identified that met the criteria used in the study. However there was a paucity of information available for the majority of these estuaries. Bucher and Saenger (1989) identified significant areas requiring additional information in Tasmania including: catchment clearance and landuse; water quality; saltmarsh and seagrass distribution; and the value of commercial and recreational estuarine fisheries. Other information recorded in the inventory, such as rainfall and runoff values for estuarine catchments, was based on only minimal data.

Edgar *et al.* (1994) report that virtually all estuaries along the east and north coasts of mainland Tasmania are badly degraded by pollution, siltation, nutrification and onshore development. They conclude that estuarine ecosystems are under greater threat from human impacts than any marine community in Tasmania. Small areas of estuarine habitat are contained within existing reserves (Kriwoken & Haward, 1991). However, no component of the estuarine biota is fully protected and there are only minimal restrictions on fishing in these sensitive areas.

Edgar *et al.* (1994) recommended urgent survey work to identify appropriate estuarine areas for protection. This was the impetus for a project to describe and classify the biota and physical attributes of Tasmanian estuaries. This project is part of a broader Commonwealth government initiative to identify representative areas around Australia for inclusion in a comprehensive system of marine and estuarine protected areas (MEPAs) (Zann, 1995). The first stage of this project was a regional classification of rocky reef habitats around Tasmania (Edgar *et al.*, 1994). This thesis, which is a study of the physical attributes and extent of human impact on estuarine catchments, is part of the second stage, a regional classification of estuaries, that includes an ongoing survey of biota in Tasmanian estuaries (G. Edgar, pers. comm., 1996). Stage 3 of the program is the mapping of marine habitats. This is currently being done using available aerial photography and satellite images (H. Kirkman, pers. comm., 1996).

1.2 Aims and Objectives

The aim of this thesis was to augment the inventory of Tasmanian estuaries and their catchments (Bucher & Saenger, 1989) as an aid to defining the conservation values of estuarine environments and identifying those estuaries that have high conservation value and those that are threatened by extensive human development within the catchment.

The main objectives were:

- to define the boundaries of the catchments of Tasmanian estuaries and their major river catchments;
- to derive physical attributes for each catchment and estuary including: catchment area; water surface area; catchment rainfall; and catchment runoff; and to classify catchments into groups with similar physical characteristics;

- to obtain statistics on human population, degree of catchment clearance and broad categories of landuse within each catchment; and
- to rank catchments according to the degree of anthropogenic impact.

1.3 Methodology

The approach used in this study was to develop a computer based Geographic Information System (GIS) covering Tasmanian catchments and analyse available digital data on rainfall, population and landtypes. GIS was the method of choice because of the broad, regional nature of the study, the availability of digital data sets, and to enable integration of the data with related projects that also use GIS. After determining that no suitable digital coverage of Tasmania's estuarine catchments was available, catchment boundaries for estuaries, major rivers and major dams were derived empirically from published topographic maps and converted to digital format. Digital data for annual average rainfall and population census statistics were available and readily analysed using the GIS. The most up to date data on landtypes for Tasmania, derived from satellite images, was being produced for the State of the Environment Report. This data was scheduled for completion in March 1996 which would have allowed adequate time for inclusion in this thesis. Unfortunately, the completion of this landtype data-set has been delayed by technical difficulties and staff shortages. The data set that was available in time for inclusion in this thesis (late September 1996) covered little more than 50% of Tasmania's land surface. Now that the analytical methods have been developed using this data-set, it is hoped that once the complete landtype data-set becomes available the analysis can be quickly completed in time for publication of the stage 2 project report.

1.4 Thesis Structure

The first part of this thesis identified the importance of estuaries in human development. It outlined the use, abuse and degradation of these environments, and provided a justification for this study and how it relates to concurrent studies of Tasmania's marine environment.

The following chapters demonstrate the importance of processes within the catchment for the health of estuarine environments and describe the data-sets and methods used, the analyses of the results obtained, and the conclusions reached, in order to satisfy the aims and objectives of this thesis.

Chapter 2 provides an overview of estuarine processes and ecosystems. The impacts on estuaries of human activities within the catchment and the estuary are reviewed, and the importance of catchment management for maintaining estuarine water quality and ecosystems is demonstrated

Chapter 3 describes the methods and data-sets used to define catchment boundaries and to derive statistics of physical attributes, population and landtypes for each catchment. Methods of statistical and geographic analyses of the data are described.

Chapter 4 provides a summary of the catchment statistics that are appended to the thesis and discusses the results of statistical and geographic analyses of the data.

Chapter 5 concludes with an assessment of the present status of Tasmania's estuarine catchments and identifies catchments with high conservation status and those that are heavily impacted by human activities. Estuaries are identified where potential MEPAs would be least affected by activities within the catchment, and broad recommendations are made for further research.

Chapter 2

Understanding Estuarine Processes

Before analysing the attributes of Tasmanian estuaries and their catchments, it is instructive to gain some understanding of the complexity and variability inherent in estuarine environments. This chapter defines what is meant by an estuary in both conceptual and practical terms. It provides an overview of how estuaries have formed, the physical and biological processes that occur within estuaries, and the impacts on estuaries of human activities within the catchment and the estuary itself. The present state of Tasmania's marine environment and the level of conservation of marine ecosystems in representative MEPAs is reviewed.

2.1 Defining an Estuary

Estuaries are the interface for terrestrial and marine processes. They are also the focus of much human development. Some suggest that they are the most likely environments where life made its first steps from sea to land (Dyer, 1973). No two estuaries are alike in all aspects. They are dynamic environments, each with varied and individual characteristics that make generalisations, categorisations and comparisons difficult. Estuaries have been defined by their geographical location, their geological formation and the physical, chemical and biological processes that occur within them.

In broad terms estuaries are 'the part of the earth's coastal zone where there is interaction of ocean water, fresh water, land and atmosphere' (Day *et al.*, 1989). This definition indicates the complexity of estuarine environments, however in its broadest sense it could be taken to include any coastal waters.

Most people associate the term estuary with the mouth of a river, where it meets the sea. The new shorter Oxford Dictionary defines an estuary as 'the tidal mouth of a large river, where the tide meets the stream' (Brown, 1993).

However, neither of these definitions considers important physical and biological features of estuaries. There is broad agreement that variability in salinity is an essential feature of all estuaries (Day, 1981). A widely quoted definition is that of Pritchard (1967 as quoted in Dyer, 1973) - 'An estuary is a semi-enclosed body of water which has a free connection with the open sea and within which sea water is measurably diluted with fresh water derived from land drainage.' This definition excludes many saline lakes and marine inlets without fresh water inflow. It also excludes tidal reaches of rivers that are beyond the limit of saline incursion. Day (1981) suggests that this may be a useful characteristic as it marks the change from brackish to freshwater and related changes in flora and fauna. McComb & Lukatelitch (1986) argue that this could exclude whole rivers where high flow levels prevent any saltwater incursion while some marine embayments not associated with fluvial drainage show detectable variation in salinity through input of groundwater seepage. For this reason their definition focuses on the importance of fluvial drainage - 'that part of a river system in which the level or salinity of water may be affected by that of the sea' (McComb & Lukatelitch, 1986).

However Bayly (1980) also includes other coastal water bodies that have salinity levels 'that are outside the range encountered in oceanic waters'. This incorporates many hypersaline coastal lakes common in arid zones, such as parts of Australia where evaporation often exceeds fresh water inflow. Day (1981) also includes these hypersaline lakes and other temporarily closed or 'blind' estuaries in his variation of Pritchard's definition: 'An estuary is a partially enclosed coastal body of water which is either permanently or periodically open to the sea and within which there is a measurable variation of salinity due to the mixture of sea water with fresh water derived from land drainage.'

Ketchum (1983) also focuses on variable salinity as the major factor for defining estuarine waters. He attempts to define the inner boundaries of an estuary as the point where there is no net movement of water upstream during a flood tide. Essentially this is the landward extent of saline incursion and the definition excludes the 'tidal river' above this point. He notes that the boundary is a dynamic one, varying with river flow levels.

Focussing on salinity as the determinant of estuarine boundaries ignores other physical factors acting within the estuarine environment. Variations in tide and river flows have marked effects on patterns of water circulation and movement of sediments, in all areas under tidal influence. Further, defining the seaward boundary of an estuary using salinity is problematic. Large rivers and smaller rivers in flood discharge plumes of fresh and brackish water for large distances offshore. Plumes have been termed offshore estuarine zones (Ketchum, 1983). They have a biota that is distinct from the surrounding marine environment (Kingsford & Suthers, 1994).

There is obviously great difficulty in arriving at a general definition of an estuary that satisfies all researchers and all situations. This is further complicated when administrative or geographical boundaries are imposed on naturally variable systems. However, the important features of estuaries are that they are unique and highly variable environments that represent the major interface between land based processes within the catchment and the marine environment. A useful general definition of an estuary needs to recognise the importance of the interaction between drainage from the land and marine waters, and the unique environments created by the combination of the physical and chemical characteristics of both. At the same time, for practical and administrative purposes, there needs to be some indication of the geographical limits of an estuary.

For the purposes of this thesis an estuary is defined as: a semi-enclosed or periodically closed coastal body of water in which the aquatic environment is affected by the physical and chemical characteristics of both fluvial drainage and marine systems. This definition will include coastal lakes, lagoons and rivers upstream to the limit of tidal influence. It recognises the importance of external inputs from both marine and terrestrial environments and it implies a seaward geographical limit at the opening to the sea. This definition does not include consideration of freshwater plumes and offshore estuarine zones.

2.1.1 Defining Geographical Boundaries of Estuaries

A generalised definition of an estuary emphasises the processes occurring within the estuarine environment and recognises the variable and fluctuating nature of these processes. However, for analytical and administrative purposes it is necessary to define precise geographical boundaries for an estuary.

2.1.1.1 Upstream Limits

Ketchum (1983) suggests that the upstream limit of an estuary is the point where there is no net movement of water upstream on the flood tide. This may exclude long sections of river affected by changes in tidal levels. It may correspond to the upstream limit of saline incursion. Either of these limits are variable in geographic location and can be difficult to measure. The limit of tidal influence is probably less variable (Adam *et al.*, 1992) but can be difficult to determine by simple observation. Bucher & Sanger (1989) use the point where the sides of the estuary that are represented by separate lines on a 1:100,000 topographic map change to a single line as the point where the river runs into an estuary. This is an easily definable limit and may have some physical validity as an indication that the topography prevents further upstream incursion of the tide. At smaller scales (1:25,000 and lower), it may be valid to use the point where the first contour (5 or 10 m) intersects the river bank.

2.1.1.2 Downstream Limits

Seaward limits of estuaries cannot be precisely defined by salinity distribution. Freshwater plumes from large rivers can extend large distances offshore and most coastal waters are diluted by freshwater runoff from land (Ketchum, 1983). Ketchum (1983) suggests that the seaward boundary can be geographically defined by a 'line between the land masses on each side of the entrance to an estuary'. This is usually a convenient definition and meets the requirement of the general definition that estuaries are semi-enclosed.

The New South Wales (NSW) Estuary Management Manual (Adam *et al.*, 1992) suggests that there is an hydraulic boundary where topography ceases to affect tidal behaviour within an estuary. This boundary may not be evident or distinct in broad-mouthed estuaries of drowned river valleys where there has been little sill or barrier development.

2.1.1.3 Lateral Boundaries

Adam *et al.*, (1992) define ecological boundaries for estuaries to include all wetlands affected by extremes in tidal or riverine flood events that occur within upstream and downstream boundaries. Other publications do not specifically define lateral estuarine boundaries but generally include in discussion of estuarine ecosystems all associated wetlands, intertidal mud and sand flats, beaches and foreshore environments. The simplest determination of estuarine limits is obtained from the representation of permanent water shown on 1:100,000 or smaller scale maps. Unfortunately these may not include extensive ares of associated wetlands.

2.1.1.4 Estuarine Catchment Areas

The definition of physical and geographical boundaries of estuaries is not intended to suggest their isolation from other inputs. Indeed the dominant factor that makes estuarine environments distinct from the rest of the marine environment is the influence of the volume and quality of freshwater runoff from the land. The catchment is the area of land that drains into the estuary or into stream and river channels that flow into the estuary. The National Oceanic and Atmospheric Administration (NOAA) of the United States Department of Commerce divide estuarine catchment areas (ECAs) into estuarine and fluvial drainage areas (NOAA, 1990).

An Estuarine Drainage Area (EDA) is the land area that drains directly into estuarine waters, while a Fluvial Drainage Area (FDA) drains into rivers or streams upstream of the EDA. NOAA (1990) make the assumption that natural processes and human activities close to an estuary will usually have the greatest effect on estuarine waters. However, where FDAs comprise a large fraction of the catchment, the influence of drainage from the EDA may not be significant (NOAA, 1990).

2.2 Formation of Estuaries

On a geological time scale, present day estuaries can be considered to be ephemeral features of the landscape. Periodic changes in sea level associated with cycles of glaciation result in a cycle of erosion of river channels at low sea levels, and flooding of these eroded channels as sea levels rise. Sea level rise is associated with deposition of marine and fluvial sediments in flooded river channels. Sediments may build up to form barriers across the mouths of river channels and shallow embayments, thus creating tidal lakes. Sometimes these lakes are almost totally infilled leaving a meandering, shifting river channel. Deep, narrow river channels are not totally blocked and remain as drowned river valleys, often with relatively shallow sills at the entrance (Hodgkin, 1978; Adam *et al.*, 1992; Morrisey, 1995).

The process of sediment accumulation, stabilisation of sediments by vegetation with a subsequent synergistic increase in sedimentation rates is occurring at different rates in all estuarine environments. With the passage of time natural processes within estuaries are likely to produce low lying marshland, sealed off from the ocean between coastal barriers until falling sea levels again cause rivers to scour old and new channels in their endless rampage to the sea (Carne, c1991; Adam *et al.*, 1992).

The last period of extensive glaciation (ice age) on earth ended between 15,000 and 20,000 years before present (ybp). Sea levels during this glaciation were up to 150 m below present day levels. The coastline extended out to the edge of the continental shelf in some places. Some of the deep river channels eroded across this coastal plane are still evident as submarine trenches that dissect the continental shelf. As the large, glacial ice sheets receded with global warming, sea levels rose at a relatively rapid rate, (approximately 1 m per century), until they reached present levels some 5,000 to 7,000 ybp. Sea level changes due to melting of polar ice sheets is termed eustatic change (Davies, 1974; Hodgkin, 1994; Harris, 1995)

Changes in sea level since then can largely be attributed to uplifting or sinking of land masses (isostatic change). These tend to be relatively localised events resulting from tectonic movements (Yonekura *et al.*, 1984) or land subsidence (Belperio, 1992) related to movement of continental plates or localised subsidence respectively. Once sea levels stabilise, large volumes of marine and fluvial sediments accumulate on depositional coastlines, creating beaches, sandbars and estuarine barriers. Depositional processes are governed by the water circulation patterns of oceans, tide and wind induced currents, riverine flow rates and land erosion.

2.3 Categorisation of Estuaries

Each estuary has a unique and dynamic environment that varies with shape, size, aspect, topography of the estuary and surrounding land, degree of tidal variation and incursion, and land based processes within the catchment. Catchment factors that effect estuaries include rainfall and runoff, rock and soil type, erosion, vegetation cover and anthropogenic effects.

Attempts to classify estuaries are generally based on their geomorphology, the characteristics of salinity distribution and their characteristic water circulation patterns. These characteristics are largely interdependent as geomorphology, tidal range and river flows are the main determinants of salinity distribution, which in turn affects circulation patterns. Ocean circulation patterns driven by tide and wind currents, as well as river flows, can influence the geomorphology of estuaries and surrounding coastlines. Classifications of estuaries using these characteristics are presented by Ketchum (1983), Dyer (1973), Morrisey (1995) and Adam *et al.* (1992).

2.3.1 Classification by Geomorphology

Geomorphological types of estuaries identified in Australia, as shown in Figure 2.1, are:

a) Drowned River Valleys, recognised by wide river mouths with rocky headlands, such as the Derwent and Tamar estuaries;

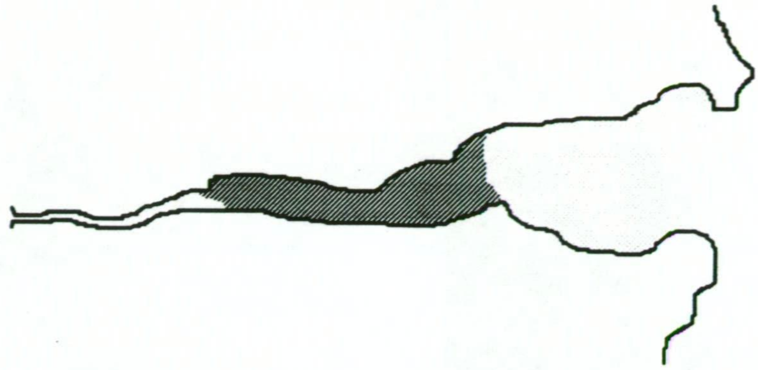
b) Barrier or Bar-built estuaries, with characteristic sandbars across their mouths. These are generally associated with depositional coastlines and relatively high fluvial sediment loads. (e.g. Moulting Lagoon and Ansons Bay estuaries); and

c) Saline Coastal Lakes and Lagoons, that are only intermittently open to the sea. Incursion by seawater generally only occurs after high runoff events or extreme tides breach the sand barrier sealing the opening. There are a number of coastal lakes and lagoons on Tasmania's east coast and Bass Strait Islands.

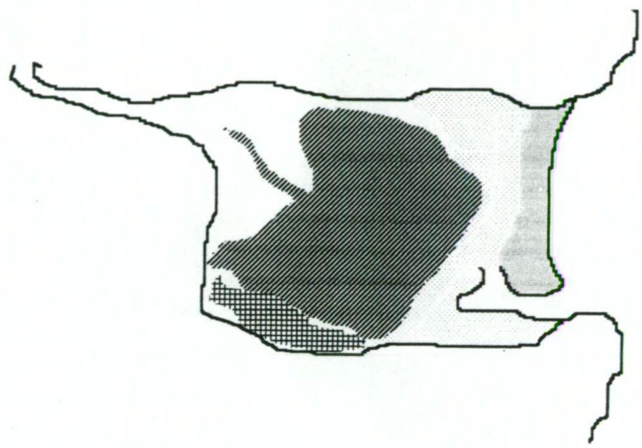
There are many transitional stages between these three forms. Estuarine morphology is continually changing with ongoing depositional factors being counteracted by periodic climatic events such as storm seas and tides and riverine flooding.

Figure 2.1 Geomorphology of Estuaries

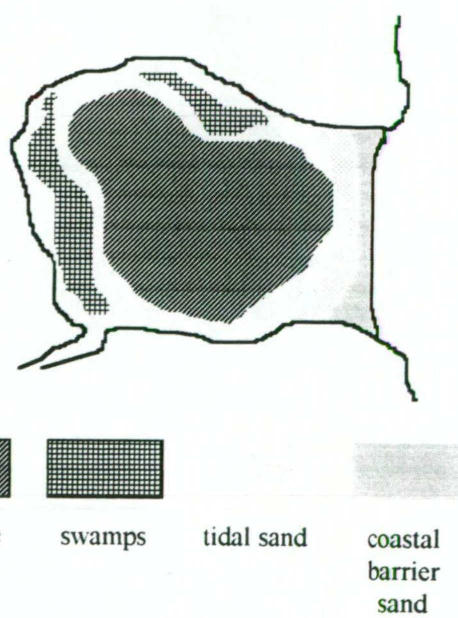
a) Drowned River Valleys



b) Barrier Estuaries



c) Saline Coastal Lakes and Lagoons



Source: Morrisey, 1995

2.3.2 Classification by Salinity Regime

Salinity distribution within estuaries is determined by the amount of mixing between freshwater from river flows and saline marine water. The rate of mixing is affected by tidal range, river flows and the shape and depth profile of the estuary, particularly at the mouth of the estuary.

Seawater contains a solution of different salts. The worldwide average salinity of seawater is taken as 35 kg/m^3 or 35 parts per thousand (expressed as 35‰). The density of saline water is greater than that of fresh water. This difference has significant effects on estuarine water circulation. Freshwater tends to float on top of seawater. Mixing only occurs by slow diffusion unless turbulence generated by shear stress causes vertical mixing (Adam *et al.*, 1992).

Three stages of estuarine mixing (Figure 2.2) are recognised (Dyer, 1973; Adam *et al.*, 1992; Morrisey, 1995). These are:

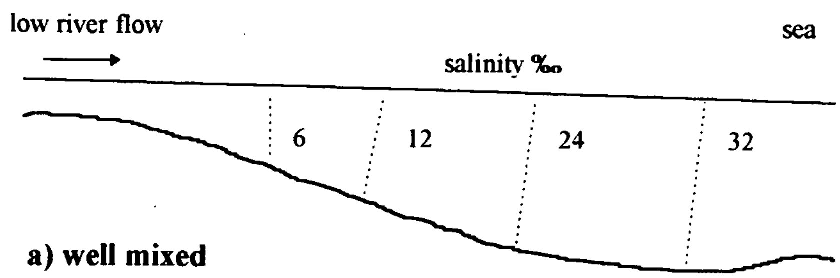
a) well mixed, salinity varies little with depth;

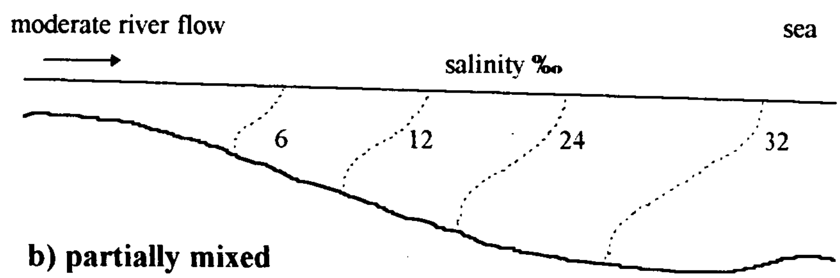
b) partially mixed, salinity varies continuously with depth, with no evident interface between the upper and lower layers and;

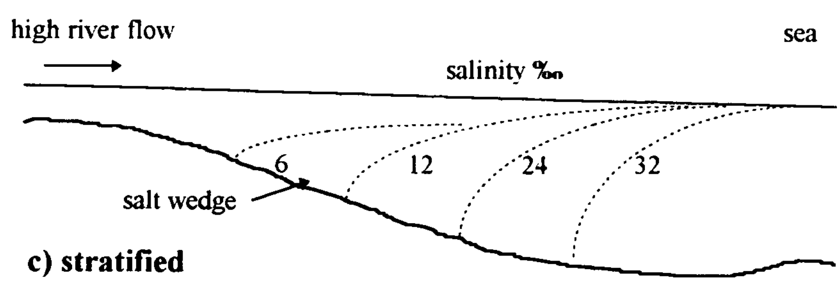
c) stratified, there is an abrupt increase in salinity at the depth of the interface between fresh water (top) and saltwater (bottom) layers.

The degree of mixing within an estuary varies with the amount of freshwater inflow and variations in tidal flows. Stratified conditions result from low tidal current velocities or high river flows. The underlying 'salt wedge' can penetrate many kilometres into the estuary. For example saline water reaches 60 to 80 km up the Hawkesbury river in NSW (Adam *et al.*, 1992) and as far as New Norfolk on the Derwent River in Tasmania (Coughanowr, 1995). The freshwater flowing over the salt wedge gradually entrains saltwater as it flows seaward, becoming increasingly brackish. During low river flows following extended dry periods, estuaries will be well mixed. Wet weather results in partially mixed conditions, while flood flows can result in stratified conditions down to the estuary mouth and sometimes out to sea. High tidal current velocities, usually

Figure 2.2 Salinity Regimes in Estuaries







associated with large tidal ranges or narrow channels, promote vertical mixing of estuarine waters (Dyer, 1973, Adam *et al.*, 1992).

In Tasmania, estuaries with low tidal ranges along south-east, south and west coasts, are likely to be stratified during winter when river flows are high and partially mixed during lower flow periods over summer. East coast estuaries and lagoons with lower river flows are likely to be mixed to a greater extent, while estuaries along the Bass Strait coastline, where tidal ranges reach up to 3m, are likely to be well mixed during periods of average river flow.

2.4 Water Flow in Estuaries

Water movement in an estuary is predominantly affected by freshwater inflows from rivers and cyclical movement of seawater into, (flood tide), and out off, (ebb tide), the estuary. Wind, temperature and salinity gradients also generate secondary currents important in mixing and sediment transport.

Freshwater inflows can fluctuate widely following a general seasonal trend (higher flows in the winter wet season, lower flows in summer) with occasional unpredictable flood flows. Freshwater flow from rivers results in a net seaward flow of water over each tidal cycle.

Tidal flows vary in velocity and direction with the rise and fall of the tide and with the monthly tidal cycle (i.e. spring tides with the greatest tidal range cause the strongest tidal currents) (Dyer, 1973, Adam *et al.*, 1992).

2.4.1 The Behaviour of Tides in Estuaries

Tides are a regular and predictable feature of the marine environment. They are driven by the gravitational effects of the moon, sun and the planets. Tides around the Tasmanian coastline are semi-diurnal (high and low water occur twice daily), with a pronounced diurnal inequality in most areas. The tidal range varies markedly between the Bass Strait coastline (> 2m between Stanley and Cape Portland), and the rest of the Tasmanian coastline (<1.3m) (Dept. of Defence, 1995). Within estuaries, the movement of tides is affected by the shape and depth of the estuary.

Drowned river valleys that typically have channels which become wider and deeper to seawards provide little or no restriction to tidal incursion. Narrowing of the channel as the tide moves inland can result in an amplification of the tidal range. This is seen in the Tamar estuary where the tidal range at the Port of Launceston is over 25% greater than the tidal range 55 km downstream at Georgetown, near the entrance to the estuary. Attenuation occurs as the estuary becomes shallow in broad reaches or at the entrance of rivers.

Narrow drowned river valleys and barrier estuaries have narrow entrances and sand bars that restrict tidal incursion. Tidal range is attenuated in these estuaries. When the estuary extends as a narrow, relatively shallow channel, the tidal range again becomes amplified until the tidal wave is damped completely by the shallow river bed at the head of the estuary. Saline lakes and barrier estuaries, with broad shallow water bodies behind relatively narrow inlet channels, show strong attenuation of the tidal range which diminishes rapidly with distance from the ocean inlet (Dyer, 1973, Adam *et al.*, 1992).

2.4.2 Gravitational Circulation

The movement of dense saline waters into the seaward end of an estuary is counteracted by flow of freshwater into the head of an estuary. This results in a longitudinal density gradient with the highest density to seaward. Gravity forces denser saline water upstream along the bottom of the estuary, causing a downstream flow of less dense freshwater at the surface. This gravitational circulation enhances flood tide currents near the bottom of the estuary and ebb tide currents near the surface (Adam *et al.*, 1992).

2.4.3 Estuary Flushing

Tidal flows are complicated by the length and shape of an estuary such that high and low tides can be experienced at the same time in different parts of an estuary and tidal ranges can be amplified or attenuated. The tidal wave propagates from the ocean to the head of the estuary and back each tidal cycle. This can be a distance of several hundred kilometers in some instances. However the movement of a particular parcel of water with each tidal cycle is much less. Assuming a net inflow of freshwater from rivers, the net flow of an estuary is seaward. A parcel of water oscillates up and down the estuary with net seaward movement, eventually 'flushing' out to sea. The amount of seaward flushing is dependent on the net seaward flow caused by river discharge, the rate of mixing between freshwater and seawater masses, and the longitudinal dispersion of tidal flows. The greater the river discharge and tidal velocities, the better flushed the estuary. Low river flows and tidal velocities limit the amount of flushing of an estuary (Adam *et al.*, 1992).

2.4.4 Tidal Prism

The total volume of water moving into and out of an estuary with each tidal cycle is termed the tidal prism. This volume is dependent on the dimensions of the estuary and the tidal range, although the calculation of the volume is complicated by factors such as tidal amplification and attenuation, the lag phase and tidal resonance of the tidal wave moving up the estuary (Ketchum, 1983). A simple but crude estimation of the tidal prism is obtained from the product of estuary water surface area at mean sea level and the tidal range.

The ratio of river flow (per tidal cycle) to the tidal prism may provide a rough indication of the degree of mixing within estuarine waters. Dyer (1973), citing Simmons (1955), suggests that flow ratios of 1.0 or greater are consistent with highly stratified conditions; a ratio of about 0.25 suggests partial mixing and with a ratio of less than 0.1, the estuary is likely to be well mixed. The degree of mixing in estuarine waters is greatest when lateral and vertical movement of waters is greatest. This is promoted by fast tidal flows and narrow channels meandering through shallows, bays, shoals and other obstructions that cause redirection of the main current and generation of eddies.

2.5 Sediment Transport in Estuaries

Detailed discussion of sediment transport in estuaries is beyond the scope of this thesis. However some general principles of sediment transport are relevant to the consideration of impacts of catchment activities on estuarine processes.

Sediments consisting of sand, salt, clay and organic matter enter estuaries from a number of sources. These include erosion of soils and rock within the catchment, bank erosion, drift of littoral (ocean) sediments, wind erosion, human effluent and solid wastes, and detritus from marine and river organisms. Sediments are transported within an estuary by river and tidal currents. Sediments settle at times or locations of low current velocity. They are eroded and transported as current velocities increase. Sediment deposits build up where high current velocities are least frequent (Morrisey, 1995).

The difference between peak flood tide and peak ebb tide velocities, and the effects of gravitational circulation result in a net upstream transport of marine sands. Freshwater flow rates generally slow rapidly as sloping river beds run into the estuary and as the estuary broadens. Suspended sediments settle as the flow rate decreases thus adding to the sediment build up in the estuary. During large flood tides however, river flow is often greater than peak tidal flow. Floodwaters can erode large amounts of estuarine sediments and transport then downstream to be deposited on the seaward side of the estuary entrance bar (Ketchum, 1983).

2.6 Estuarine Ecosystems

2.6.1 Estuarine Habitats

Estuaries include a wide range of habitats such as rocky foreshores and rocky reefs with associated macroalgal communities, deep river and tidal channels, shallow sand and mud flats, seagrass beds and fringing wetlands vegetation such as saltmarshes and mangroves. These support many rich and varied, though interdependent, aquatic, intertidal, and terrestrial ecosystems. Estuaries provide important feeding and breeding areas for fish, birds and other animals.

Estuarine ecosystems are highly productive yet precise measurements of productivity and comparison of the results obtained by different researchers are difficult to make. The productivity of estuaries can be equivalent to that of intensively cropped farmland (~3000 $g/m^2/y$) and an order of magnitude greater than the productivity of the open ocean (~125 $g/m^2/y$) and the continental shelf zone (~300 $g/m^2/y$) including upwelling zones (550 $g/m^2/y$) (Day, 1981; Morrisey, 1995). High productivity results from the relatively high level of nutrients usually present in estuarine environments. Nutrients are imported in freshwater inflow and 'trapped' by estuarine circulation and ecosystems with only slow leakage to the open sea.

As on land, primary production in estuaries relies on photosynthesis by plants which convert dissolved and atmospheric carbon dioxide into plant tissue. Three main groups of plants occur in estuaries: aquatic macrophytes, microscopic phytoplankton and microphytobenthos. The extent of macrophytes is limited by the availability of suitable habitat such as shallow depositional environments for saltmarsh, mangroves and seagrasses; or hard rock or shell substrata for macroalgae (seaweeds) (Hodgkin, 1994; Morrisey, 1995).

Aquatic macrophytes may be further divided into two groups :

- submerged plants, such as seagrasses and macroalgae, that extend from intertidal areas to depths where light becomes limiting (1-30 m); and
- fringing plants such as mangroves and saltmarsh species that require exposure to the atmosphere to obtain oxygen and carbon dioxide.

Mangroves provide an important habitat in estuaries in mainland Australia. However they do not occur in Tasmania. The southernmost limit of their range is near Wilson's Promontory in southern Victoria. Mangrove species richness increases from southern to northern Australia. Conversely, the species diversity of saltmarshes increases from north to south, and these plant communities largely replace mangroves in southern Australia (Carne, c1991; McComb & Lukatelich, 1986).

Fringing marshes become established in sheltered, shallow flats and act to increase the rate of sediment deposition. Bucher and Saenger (1989) recorded saltmarshes in over 60% of Tasmanian estuaries included in their study. Where their presence has been mapped they occupy from 0.5% to 60% of the area of the estuary.

Seagrasses and macroalgae are essentially marine species although some seagrass species such as *Ruppia* spp. are predominantly estuarine. Macroalgae are generally only found growing on solid substrata near the mouths of estuaries, however seagrasses can cover extensive areas of sediments in shallow bays and estuaries (Hodgkin, 1994).

Macrophytes provide important habitat for invertebrates, fish and bird life. Where present in significant amounts their biomass may also represent a major store of nutrients and an important fraction of total estuarine production (McComb & Lukatelich, 1986).

Microscopic plants grow in the water column (phytoplankton), epiphytically on macrophytes and in the upper layer of benthic substrates. The most important groups of microscopic plants are the diatoms, dinoflagellates and cyanobacteria. The standing biomass of these plants is small when compared with macrophytes, however their annual productivity is similar. Because they occupy most of the estuarine water column and much of the benthos, microscopic plants make a major contribution to total estuarine productivity. They grow rapidly in response to favourable environmental conditions, depending on available light and nutrients and suitable temperatures (Hodgkin, 1994). Phytoplankton are rapidly consumed by invertebrate grazers and filter feeders, or die and decompose. Growth cycles of phytoplankton are closely linked to seasonal cycles and circulation patterns within the water column. These cycles are briefly outlined under section 2.9.

Unvegetated bed sediments make up a large proportion of most estuaries. They vary in sediment size (mud to sand), depth of water, salinity and distance from the estuary mouth. The sediments provide a relatively uniform habitat that supports benthic algae, bacteria and meiofauna. These microorganisms in turn are consumed by the worms, molluscs and crustaceans that burrow into or live on the surface of the sediment (Morrisey, 1995). While seagrasses and macrophytes are recognised as habitat for schools of juvenile fish, such schools are also commonly found over unvegetated sediments. (Humphries *et al.*, 1992)

2.6.2 Estuarine Food Webs

Primary production by estuarine plants provides the basis for estuarine food webs. Plant material may be consumed directly or become part of the detrital food web. Microscopic plants, phytoplankton and benthic microalgae, provide a direct source of food for grazing animals and filter feeders, which in turn become food for predatory invertebrates, fish, birds and mammals. Few animals feed directly on macrophyte plants. Most of the production of these plants is deposited as dead tissue that provides the basis for the detrital food web (Hodgkin, 1978; Bayly, 1980).

Detritus is comprised of all non living organic matter. It includes the dead tissue of microscopic plants and macrophytes, and the waste products and carcasses of animals. Detritus is broken down by bacteria which are able to utilise the available nutrients. As they grow and die, bacteria release soluble nutrients into the water column where they are reused by plants. Bacteria also improve the food quality of the detritus and become a food source for detritivores (Adam *et al.*, 1992; Hodgkin, 1994).

These two major pathways provide a continuous cycling of nutrients through the estuarine environment. Nutrients are largely conserved within these estuarine ecosystems and are redistributed by estuarine circulation. Nutrients are lost from estuaries through deposition and binding to sediments (e.g. phosphorus), diffusion of gasses to the atmosphere (e.g. nitrogen), in migrating fauna, and as dissolved nutrients and attached to sediments contained in outflowing waters. High river flows may carry large amounts of detritus, sediments and soluble nutrients out to sea, enriching surrounding coastal waters (Adam *et al.*, 1992).

2.6.3 Ecological Classification of Estuarine Biota

Numerous environmental variables affect estuarine waters. However the variation in salinity from freshwater to seawater is considered to be the dominant factor influencing the distribution and abundance of aquatic species.

Though abundance and productivity of estuarine species is high, the diversity of species found in estuarine waters is low. This is because most marine species can only survive salinities in a narrow range at about the salinity of seawater (35‰), and few freshwater organisms can survive at salinity levels greater then 5‰. Estuarine water has been defined as possessing salinity below 33.5‰ (McHugh 1967 as cited by Ketchum 1983).

Species found in estuaries can be divided into five groups:

- freshwater species - restricted to low salinity waters associated with river flows;

- stenohaline marine species - organisms adapted to a narrow salinity range that are found at the saline mouth of an estuary;
- euryhaline marine species - organisms adapted to a wide range of salinity and which extend from the sea to areas of moderate salinity (~25 ‰);
- true estuarine species - a small group restricted to estuarine waters; and
- migratory species - organisms that pass into or through estuaries from either marine or freshwater environments, often for spawning. (Day 1981);

The lowest numbers of marine and freshwater species are generally found to occur in brackish water at 5-8‰ (Remane, 1934, as cited by Hodgkin, 1994).

Salinity varies with time and distance along an estuary as river and tidal flows fluctuate. While mobile organisms may be able to migrate to areas of favourable salinity, sessile or sedentary organisms must be able to survive or tolerate sudden changes and short and long term periods in an unfavourable environment. The salinity range in parts of an estuary may vary little except in extreme flood flows. In contrast, organisms on rocky shores and intertidal areas must often endure variations across the whole range of salinities from freshwater to marine, and even hypersaline conditions when evaporation results in increased salt concentration (Hodgkin, 1994).

2.7 Factors Affecting Estuarine Ecosystems

While salinity is considered to be the main determinant of species distribution, a number of other physical parameters have considerable effects on the growth, survival and life cycles of organisms living within estuaries. These factors include light, temperature, dissolved oxygen, nutrients, turbidity and substratum.

2.7.1 Light

Light is critical for photosynthesis of plants. Net production only occurs if photosynthesis is greater than respiration on a daily basis. At high latitudes such as Tasmania, low sun angle and short day lengths over winter months limit light penetration and plant growth in coastal waters. Strong winds and cool seawater temperatures (commonly dropping below 10°C in Tasmanian winters) enhance vertical mixing, breaking down salinity and density gradients and mixing nutrient rich bottom waters with surface waters. However, deep vertical mixing also removes phytoplankton populations from the photic zone for long periods, limiting plant production (Furnas, 1995).

Estuarine waters are often turbid due to sediment laden river flows or resuspension of fine estuarine sediments during storms. Turbidity rapidly reduces light penetration so that only surface layers receive adequate light for plant growth. Limitation of light by the high turbidity of water in the Derwent River Estuary in Tasmania is considered the major factor preventing algal blooms (Coughanowr, 1995). Rapid growth of phytoplankton in suitable conditions can also limit light penetration to deeper waters. In Tasmania, estuarine water may also be highly opaque due to high tannin levels in many Tasmanian rivers. These factors can limit the distribution of benthic plants such as seagrass, macroalgae and benthic microalgae. For instance, seagrasses that can grow to depths of 45 m in clear tropical waters, and 20-30 m in Tasmanian oceanic waters, may be limited to depths of less than 2 m in estuarine environments (McComb & Lukatelich, 1986; Rees, 1994).

2.7.2 Dissolved Oxygen

Dissolved oxygen is essential for most aquatic organisms. Dissolved oxygen enters the water as a result of diffusion from the atmosphere. This is aided by aeration in turbulent river waters and wave action, and by photosynthetic activity of aquatic plants. Oxygen is utilised during respiration of aquatic organisms.

Solubility of oxygen changes significantly with water temperature and salinity. Increasing temperature or salinity reduces the solubility of oxygen. Saturation levels of oxygen vary from 9.8 mg/l in freshwater to around 6.5 mg/l in seawater at 25°C (Adam *et al.*, 1992).

Aquatic plants are net producers of oxygen while photosynthesis occurs during daylight hours, and net consumers at night. This results in a diurnal fluctuation in dissolved oxygen in surrounding waters. Rapid growth of phytoplankton can reduce oxygen levels significantly, causing stress and even death to other animals.

Organic detritus on the estuarine floor provides food for large numbers of bacteria and detritivores. Respiration by these organisms consumes large amounts of dissolved oxygen. Poor circulation of water resulting from stratification during high river flows can result in deoxygenation of this low level water. If dissolved oxygen levels fall below 5% saturation (0.2-0.4 mg/l) anaerobic bacteria become active. These bacteria obtain metabolic energy by reducing nitrates (NO_3^{-}) (denitrification) and sulphates (SO_4^{2-}). Under these conditions hydrogen sulphide (H_2S), methane (CH_4), gaseous nitrogen (N_2) and phosphates (PO_4^{3-}) are released into the water column (Adam *et al.*, 1992).

2.7.3 Nutrients

While available light and deep vertical mixing of coastal waters limit plant growth in the Tasmanian winter, these are not limiting factors at other times. Plant growth requires an adequate supply of many different nutrients. In aquatic environments, nitrogen (N) and phosphorus (P) are usually the only nutrients present at levels that limit plant growth. The following discussion is therefore limited to consideration of the supply and utilisation of N and P in estuaries.

2.7.3.1 Nitrogen

Nitrogen enters estuaries via river flow, tidal transport and diffusion from the atmosphere. It is present as dissolved gaseous nitrogen (N_2), ions of inorganic salts (nitrate-NO_3^{-}, nitrite-NO_2^{-}, dissolved ammonia-NH_3 and ammonium ions-NH_4^{+}), and in organic compounds (e.g. proteins, urea, plant growth products). Only some bacteria and blue-green algae are able to utilise N_2, converting it to NH_4^{+} and incorporating it into organic compounds. They also utilise organic and inorganic forms of N. Plants utilise NO_3^{2-} and NH_4^{+} to synthesise proteins and other complex organic molecules. Animals obtain N from food and excrete it as ammonia, urea and organic N. Under anoxic conditions, denitrifying bacteria utilise NO_2^{-} and NO_3^{-} and release N_2 (Adam *et al.*, 1992; McComb & Lukatelich, 1986).

2.7.3.2 Phosphorus

The main source of P in estuaries is derived from erosion and weathering of soils and rock within the catchment. The amount and type of P carried within river flows will depend on soil types, weathering processes, runoff volume and human activity (Adam *et al.*, 1992; McComb and Lukatelich, 1986). Nutrients in river flows are often attached to sediments or fine clay particles that persist in colloidal suspension. It is uncertain whether these nutrients become available to organisms on mixing with saline water (McComb and Lukatelich, 1986). Some rivers carry large proportions of P as free inorganic PO_4^{3-}. Some of the P, and other nutrients, will be flushed from the estuary during high river flows. Phosphorus that is trapped in the estuary will eventually be bound up in the sediments as insoluble compounds. In the water column, available P is rapidly consumed by living organisms. Phytoplankton and macroalgae absorb dissolved P from the water column, while macrophytes (marsh plants and seagrasses) are also able to take up P from the sediments through their roots. Animals obtain P from their food. Phosphorus released from decomposing detritus is recycled rapidly through the food web. Release of soluble P from the sediments can occur when anoxic conditions and low pH develop in organic sediment layers. This P is rapidly immobilised in oxygenated sediment layers. However stratification of estuarine waters with resulting deoxygenation in lower layers can result in the release of significant amounts of soluble P. Some sediments release phosphorus more readily than others. This may depend on the proportion of calcium salts of P (apatite) compared to other (non-apatite) salts. Apatite P has been found at high levels in some marine sediments and is not readily available for algal growth (McComb & Lukatelich, 1986; Hatcher, 1994; Furnas, 1995).

2.8 Human Impacts on Estuarine Values

Human activities can have significant impacts on estuarine environments and their ecosystems. These are conveniently divided into activities that take place within the catchment and those that take place within the boundaries of the estuary.

2.8.1 Catchment Activities

Land clearance for agriculture, forestry and urban development results in significant increases in catchment runoff, and in sediment and nutrient loads carried by catchment runoff (Williams, 1980; Campbell & Doeg, 1989; Brodie, 1995). Radiocarbon dating and pollen analysis of sediment layers in a New Zealand estuarine environment has shown an increase in sediment accumulation rates since commencement of clearing and European farming practises (3 mm/y), compared with pre-settlement rates (1 mm/y) (Hume & McGlone 1986). Sediment loads and concentrations of N and P from clearfelled forest coups were 10-30 times greater than from uncleared forest. However, these losses are significantly reduced with carefully planned roading, use of strip harvesting and maintenance of streamside reserves. Despite these measures, losses were still twice that of uncleared forest (Sopper, 1975). Sediment losses are greatly exacerbated by storm flows (Beasley *et al.*, 1986; Campbell & Doeg, 1989).

Cultivation of agricultural land results in a large increase of soil loss through runoff. In a study of a small catchment in NSW, more than 90% of the sediment in a stream draining the catchment came from cultivated vineyard soils that made up only 10% of the catchment. The majority (79%) of the sediment loss occurred in three major runoff events. The remaining sediment was derived from forest and grasslands (Loughran *et al.*, 1986).

In Tasmania, the rate of clearance of natural vegetation from 1972 to 1994, as determined from satellite images, has varied between 6,000 ha/y to 15,000 ha/y (average 10,000 ha/y). Some of the losses have resulted from inundation for hydroelectricity production, some from forestry harvesting and forest plantation establishment, and a large proportion (greater than 50%) for agricultural land uses (Kirkpatrick & Dickinson, 1982; Kirkpatrick 1991; Kirkpatrick & Jenkin 1996).

Human activities within the catchment are the major cause of increased organic matter and nutrient supply to coastal waters. This enrichment can result in the eutrophication of estuarine ecosystems (Brodie, 1995). Burning, cropping and grazing all result in increased nutrient level in runoff. A number of studies have shown that N and P levels increase according to the proportion of agricultural land within a catchment. Kronvang *et al.*, (1995) averaged nutrient losses from 270 catchments in Denmark. The ratios of N and P from agricultural and undisturbed catchments were 14:1 and 4:1 respectively. Gabric & Bell (1993) and Cooper & Thomsen (1988) found that N and P concentrations were an order of magnitude (~10 times) higher in agricultural versus pristine catchments, while Pailles *et al.* (1993) found PO_4^{3-} was 3 times higher in suspended sediments from streams draining agricultural catchments. The use of P in agricultural fertilisers in

Australia has increased fourfold between 1950 and 1990, while use of N fertilisers has escalated since the 1960s (Brodie, 1995).

Major urban areas in Australia are often located close to estuaries, and most of the urban sewage effluent is discharged into estuarine coastal waters. Nutrient levels, especially phosphorus, may exceed inputs from all other sources. An estimated 10,000 tonnes/y phosphorus and 100,000 tonnes/year nitrogen is discharged through sewage in Australia annually (Brodie, 1995). Sewage discharged each year to the Derwent Estuary is estimated to contain over 100 tonnes/y phosphorus and 400 tonnes/y nitrogen, contributing 78% and 69% respectively of total nutrient inputs to the estuary. (Coughanowr, 1995).

In urban areas developments, such as roadworks and subdivisions, result in land clearance and exposure of soils to erosion. Large areas of impermeable surfaces, such as roads and roofs, and channelisation of surface drainage cause high peak storm flows. Runoff from urban areas is characterised by high sediment loads and high nutrient levels (Williams, 1980; Hogg & Norris 1991). While sewage discharges are the major source of nutrients, stormwater runoff can contribute up to 10% or more of the nutrients from urban catchment (Kingston *et al.*, 1990; Brodie, 1995; Coughanowr, 1995).

Runoff from urban areas, agriculture and forestry operations also contain pollutants such as oil, fuels, plastics, heavy metals and toxic organic compounds such as pesticide and herbicide residues. Pesticide levels in urban runoff can be equivalent to residues in agricultural runoff (Kimbrough and Litke, 1994; Lenat & Crawford, 1994).

Mining and associated industries add high levels of sediments to runoff waters. Heavy metal contamination is also common, especially where the exposure of sulphide ores results in oxidisation, producing acids and releasing metals into solution. Mining activities in and around estuaries (e.g. sand mining) can cause locally heavy sediment loads and changes to estuarine circulation patterns (Adam *et al.*, 1992).

Estuarine environments are also affected by dams and other flow controls in the catchment. Sediments and nutrients can be trapped in dams. This can help to slow sedimentation in the estuary, but can also result in coastal erosion. Dams change the hydrology of the catchment. Freshwater flow is reduced or eliminated except in flood flows. The frequency and size of flood flows is reduced (Adam *et al.*, 1992).

A large proportion of Tasmanian river systems are dammed for hydroelectricity generation. These are largely flow-through systems, however seasonal and diurnal flow patterns are changed and flood levels are reduced. High flood levels can be important for flushing the estuary (Davies & Kalish 1992). Freshwater flows are a major stimulus for estuarine and marine productivity, and can be a signal for breeding or migrational behaviour in marine and estuarine species. Dams and weirs can also prevent the migration of fish along the river for breeding (Adam *et al.*, 1992).

The quality of water released from large dams can be detrimental to downstream organisms. Water from deep levels is often cold and deoxygenated, possibly containing toxic compounds such as hydrogen sulphide (Adam *et al.*, 1992). A large fish kill on the Pieman River was the result of the entrapment of air in water passing through turbines in the power station. Expanding air bubbles in the supersaturated water caused embolisms in fish present in shallow waters below the dam (O'Donnell and Livingston, 1992).

Little information exists on the effects of dams on estuarine ecosystems in Australia. However, overseas experience suggests that dams and water diversions can result in the decline of some coastal fisheries and an overall effect on biota associated with reduced freshwater flows (Adam *et al.*, 1992).

2.8.2 Activities within the Estuary

The sheltered waters and coastlines of estuaries are the site for many human activities. Estuaries act as ports for shipping, and provide waters for fishing, marine farms, boating and other recreations. Port facilities such as wharves and container terminals can have adverse effects on estuaries. These include the destruction of habitat, pollution from oil spills, fauna disturbance, and the introduction of exotic aquatic organisms via ballast water. Shipping operations are estimated to account for about 30 % of marine pollution (Bateman, 1996). Circumstantial evidence suggests that the Northern Pacific seastar, *Asterias amurensis* (Morrice, 1995), the Japanese seaweed, *Undaria pinnatifida* (Sanderson & Barrett, 1989) and dinoflagellates which cause paralytic shellfish poisoning such as *Gymnodinium catenatum* (Hallegraeff, 1995), were introduced to south-eastern Tasmania via ballast water. The problems for Australian shipping are exacerbated by the high level of bulk cargo vessels used to export relatively low value commodities such as raw materials and agricultural produce, compared with imports of high value commodities such as manufactured goods and oil. This means that large numbers of bulk carriers must travel to Australia with ballast water, while the economic viability of the trade is likely to be heavily impacted by enforcing environmental regulations (Bateman, 1996).

Dredging and training walls are often necessary in estuaries with port facilities in order to maintain shipping channels. Dredging can result in localised sediment loads that can smother flora and fauna, while training walls, commonly used to stabilise an estuary entrance, result in changes to habitat and alteration of estuarine water circulation patterns (Adam *et al.*, 1992).

Marine farms are becoming more common as a means of producing seafood products. Oyster farming has been common in estuaries for many years. Their major impacts are a loss of amenity for other users and a reduction in habitat for particular local species. The pacific oyster, *Crassostrea gigas*, was introduced to Tasmania in the 1950s (Rees, 1995).

The introduction of live oysters from New Zealand late last century is thought to have been accompanied by the introduction of a number of other organisms that are now well established in Tasmania. Included among these species are gastropods (*Maoricolpus roseus*), echinoderms (*Patiriella regularis*), chitons (*Amaurochiton glaucus*) and crabs (*Cancer novaezelandae*) (G. Edgar, pers.comm., 1996)

Fish farming is a rapidly growing enterprise in Tasmanian marine waters. It is associated with intense organic loading as waste products accumulate below the cages. At present, the impact of this organic pollution is considered to be localised, and affected sediments are thought to slowly recover once cages are removed (Woodward *et al.*, 1992).

Waterfront estates, canal developments and marinas can degrade habitat and change water circulation patterns, sometimes resulting in poorly flushed areas that may become anoxic. Boating can cause pollution through spills, exhausts, untreated wastes, and anti-fouling chemicals. Wash from power boats can cause bank erosion whilst moorings and anchors can damage sensitive habitats (Adam *et al.*, 1992).

2.9 Effects of Eutrophication on Estuarine Environments

The effects of human populations and their activities on local and global environments are often difficult to assess because of the inherent variability in natural systems (e.g. climate, hydrological cycles and biological populations). Impacts of human populations are often insidious. Windom (1992, as cited in Brodie, 1995) estimates that the input of nutrients to oceans from human sources is equal to or greater than inputs from natural sources. Nutrients from agricultural runoff and urban and industrial wastes are trapped in the coastal zone, especially in estuaries where water circulation patterns and plant growth rapidly incorporate nutrients into estuarine ecosystems.

The trophic or nutrient status of aquatic ecosystems is determined by the supply of nutrients available for primary production. In depositional environments such as lakes and estuaries, the natural trend is for a gradual increase in the productivity and biomass of plants as nutrients are trapped. This process is termed eutrophication. Nutrient enrichment rapidly increases the rate of eutrophication and excessive growth of aquatic plants, which can result in the rapid depletion of levels of dissolved oxygen (McComb & Lukatelich, 1986; Adam *et al.*, 1992).

Increased levels of nutrients that limit growth (particularly N and P) result in an increase in primary production. In the early stages of nutrient enrichment, increased primary production may be considered beneficial with increases in food and habitat. However, eutrophication is associated with serious imbalances in affected ecosystems.

Several stages of eutrophication are recognised:

a) an initial increase in phytoplankton and macrophyte growth followed by;

b) prolific growth of algae (phytoplankton and macroalgae) which become the dominant species;

c) changes in species composition;

d) massive blooms of nuisance and toxic phytoplankton; and

e) development of anoxic conditions.

The latter stages of eutrophication can be marked by massive fish kills resulting from oxygen depletion and toxic algae, and death of agricultural stocks from ingesting toxic algae (McComb & Lukatelich, 1986; Brodie, 1995; Cloern, 1996)

Phytoplankton blooms relate to episodic, rapid population increases in microscopic, planktonic algae. Blooms are natural, recurrent events in oceans and waterways. They occur in response to particular combinations of climatic events, seasonal changes and nutrient availability. Blooms can recur as annual events (Hallegraeff & Jeffrey, 1993) or spontaneously in response to favourable conditions (Blackburn & Cresswell, 1993). The common cycle in temperate seas is marked by a large bloom in the late winter or spring, dominated by diatoms; smaller summer blooms of dinoflagellates and diatoms, and moderate autumn blooms dominated by dinoflagellates. Spring blooms occur as increasing light and warmth help to maintain the standing crop of phytoplankton within the photic zone (surface layers that have adequate light for photosynthesis). Populations of zooplankton grazers are initially too small to limit the bloom, although benthic grazers and filter feeders have been shown to suppress blooms in shallower waters. In summer, blooms are periodically stimulated by nutrients contained in high river flows or storm events that overturn stratified waters, bringing nutrients to the surface (Cloern, 1996).

As nutrient levels increase, species composition of blooms changes. Increases in the proportion of levels of N and P relative to silicon (Si) selectively promotes non-diatom blooms. Larger blooms of dinoflagellates and blue-green algae then tend to become more common. Many of these species are unpalatable to zooplankton grazers, disrupting the normal food web. In some situations dinoflagellates produce toxins which cause mortalities at higher trophic levels (Cloern, 1996; Hallegraeff, 1995).

Lavery *et al.* (1991) documented changes in macroalgal species with changing nutrient levels in Peel Inlet in WA. Large populations of the filamentous macroalgae *Cladophora* sp. disappeared as a result of storm events and shading by nutrient induced blooms of the blue-green alga *Nodularia spumigena*. *Cladophora* sp. has been replaced by shallow growing macroalgae *Chaetomorpha* sp., *Ulva* sp. and *Enteromorpha* sp. Populations of these species fluctuate in response to the level of nutrient inputs from river flows. Blooms of *Nodularia spumigena* in Peel Inlet appear to be related to phosphorus from agricultural fertilisers and sewage in winter river flows that drain agricultural and urban developments in the catchment (Hillman *et al.*, 1990, as cited in Hallegraeff, 1995).

Eutrophication of coastal waters is recognised as a worldwide problem. It is most evident in enclosed and semi-enclosed waters, with high nutrient inputs and long water residence times (low flushing). Problems related to rapid eutrophication resulting from anthropogenic nutrient enrichment are documented in numerous estuaries, including the Baltic and Black Seas in Europe, Chesapeake and San Francisco Bays in the USA and various water bodies around Japan, Hong Kong, Australia and New Zealand (Table 1 in Cloern, 1996).

The Australian coastline is affected by increasing eutrophication in areas affected by urban and agricultural runoff. In the south-western regions of Western Australia, eutrophication of estuaries and coastal embayments, with accompanying nuisance and toxic algal blooms, has been recognised as a problem since the 1970s. Leaching of nutrients from heavily fertilised, sandy soils in local agricultural districts is blamed (Hodgkin & Hamilton, 1993). Other examples include the Gippsland lakes, many NSW coastal lakes and major ports such as Gulf St. Vincent (South Australia), Western Port (Victoria), Botany Bay (NSW), and Moreton Bay (Queensland) (Brodie, 1995). In Tasmania, a toxic bloom of *Nodularia spumigena* has occurred at Orielton Lagoon as a result of high nutrient inputs and the restriction of tidal flows from the adjacent estuary (Jones *et al.*, 1994).

2.9.1 Seagrass Decline

Seagrasses often form extensive, dense meadows in shallow coastal waters and estuaries. They are highly productive and provide important habitat and food resources for flora and fauna. Low levels of nutrient enrichment can increase productivity and growth of seagrass beds (Bulthuis *et al.*, 1992), however decline in seagrass beds commonly follows eutrophication in Australia's coastal environment (Brodie, 1995).

Walker & McComb (1992) summarise losses of seagrass from eleven locations around Australia. The main reasons given for seagrasses decline are nutrient enrichment and smothering by sediment. Nutrient enrichment enhances growth of phytoplankton and algae that grow epiphytically on seagrass stems and leaves. Increased algal growth results in shading of seagrass beds, reducing photosynthesis and seagrass density. Increased levels of suspended sediments and settlement of fine sediments on leaf blades also reduce light penetration and photosynthesis. Using aerial photographs and satellite images from the 1990s, Rees (1994) mapped an area of over 22,000 ha of seagrass in coastal waters around Tasmania and the Bass Strait Islands. By comparison with archive photographs, he documented losses of over 5,500 ha since the 1950s (although unable to compare all areas). In many areas showing decline, remaining seagrasses were covered by elevated levels of epiphytic algae and sediments. Rees argues that most of the losses have occurred in areas likely to be affected by nutrient enrichment from sewage, agricultural runoff, coastal shack developments and mariculture activities. Losses are most evident in the south-east of the state.

2.10 The Tasmanian Marine Environment

Tasmania is considered to be the core of a small, but distinct marine, biogeographic province. The marine environment is influenced by three main ocean currents. The Antarctic circumpolar current brings cold, nutrient rich waters to the south and west coasts. Warmer waters from the Great Australian Bight extend into the Bass Strait during the cooler months, and the East Australian Current brings warm waters to Tasmania's north east coast at the end of summer. Water temperatures vary from a mean of 12°C in late winter, to a mean of 18°C in late summer, with locally greater fluctuations (Edgar *et al.*, 1994). Floral and faunal assemblages have many similarities in regions around Tasmania, including Bass Strait and the southern and south-eastern mainland coastline between Kangaroo Island (SA) and Bermagui (southern NSW). This zone has been termed the Maugean Province (Edgar, 1981).

In a study of Tasmanian ichthyofauna (fish), Edgar (1981) supported the existence of the Maugean Province as a distinct biogeographic province. However along Tasmania's north coast and around the Bass strait islands there is a significant overlap with the fish fauna of the Flindersian Province (the warm temperate waters of southern Western Australia and South Australia). On Tasmania's north east coast there is a lesser degree of overlap with fish fauna of the Peronian Province (NSW warm temperate waters). Fish species common to the NSW coast probably extend southwards with the East Australian Current. Edgar *et al.* (1994) subdivide the Maugean Province into Bassian and Tasmanian Provinces due to the well defined distinction between the Bass Strait waters and the rest of Tasmanian coastal waters. They further divide the Tasmanian marine environment into eight distinct biogeographic regions, four in the Bass Strait region and four more around the west, south and east coasts of Tasmania. These divisions are based on analysis of data obtained for the distribution of reef fish, invertebrates and marine plants. This work was done with the aim of refining the regionalisation of Tasmanian reef habitats and identifying areas that should be included in a future expansion of the marine reserve system.

There have been few studies of estuarine biota in Tasmania. Last (1983) surveyed fishes of soft bottom habitats around Tasmania, Taw & Ritz (1978 &1979) described the distribution of zooplankton in the Derwent Estuary and Edgar (1991) studied the variation in epifauna grown on artificial habitats with depth and distance along the estuary in Bathurst Harbour. However there has been no standardised, regional survey of estuarine biota in Tasmania (Edgar *et al.*, 1994).

2.10.1 The Status of Tasmania's Marine Environment

Including all of the islands administered by the Tasmanian Government, the state has over 5000 km of coastline (Bosworth, 1995). Most development, major industries and population centres are located on or near the coast. Most of the Tasmanian marine environment has been impacted by people to some extent. The problem of assessing the current state of Tasmania's marine environment stems from a lack of baseline data. However the major sources of impacts can be identified and include activities on land and sea (Barrett, 1995).

Coastal waters around Tasmania have long been the focus of extensive traditional, recreational and commercial fishing activities, shipping and more recently, increasing development of aquaculture. These are all activities that contribute significantly to the economy of the state. Marine waters are also affected by waste disposal and runoff from mining, heavy industry, agriculture, forestry and urban developments (Barrett, 1995; Rees, 1995)

Fisheries have direct effects on targeted species and indirect effects on the marine environment as a consequence of declining numbers of ecologically important species, habitat destruction and high levels of undesired by-catch (non-targeted species). Fishing methods such as dredging, demersal trawling and gill-netting have been identified as damaging and indiscriminatory (Barrett, 1995).

Many of Australia's commercial fisheries are considered to be over-exploited or fully exploited (Zann, 1995). In Tasmania, the scallop fishery has been greatly restricted since 1987 due to over-exploitation and damaging fishing methods. Catch rates of rock lobster are declining and present yields are considered unsustainable. Populations of school and gummy shark have declined leading to severe restrictions on fishing and increased protection of nursery areas. Commercial harvesting of clams and cockles has been restricted because of damage done to large areas of critical habitat on tidal flats (Rees, 1995). The commercial fishery for whitebait declined rapidly from its height in the 1940s until the fishery was closed in 1973 (Fulton, 1991). Rocky reef communities are heavily targeted by both commercial and recreational fishers, with the widespread use of gillnetts causing considerable impact and concern for fisheries management (Barrett, 1995).

International shipping and trade in marine livestock have been the vectors for the introduction of a number of potentially damaging exotic marine organisms. The economic impact of toxic dinoflagellates (*Gymnodinium catenatum*) can be measured in terms of lost trade for the Tasmanian shellfish industry (Hallegraeff, 1995). However the impacts of introduced species on other commercial fisheries and the native marine biota are difficult to determine. The North Pacific seastar (*Asterias amurensis*) has been found in a number of estuaries in the east and south east of Tasmania between Spring Bay and Port Esperance (Morrice, 1995) while extensive beds of the Japanese seaweed, *Undaria pinnatifida* have become established near Spring Bay and throughout the Mercury

Passage, as far south as Blackman Bay (Barrett, 1995 and C. Sanderson, pers. comm., 1996). *Undaria pinnatifida* has also recently been found in the south east of Tasmania, within the marine reserve at Tinderbox Bay in the D'Entrecasteaux Channel (C. Sanderson, pers. comm., 1997).

Aquaculture is a growth industry in Tasmania but it also has environmental impacts. Fish farms are associated with high levels of localised organic pollution resulting from waste and unused food dropping to the ocean floor. Regular fallowing of the affected sea bed, by moving the fish cages to new areas, appears to alleviate the problem (Woodward *et al.*, 1992). However the effects of elevated nutrient levels in the surrounding water column are yet to be determined. While shellfish farms appear to have little ecological impact, they along with other aquaculture ventures are associated with visual pollution, noise pollution, and loss of public access for recreation purposes (Barrett, 1995). Environmental issues may also arise from associated onshore developments and processing plants.

Some of the most obvious degradation of the marine environment results from the impact of land based activities in river catchments and the coastal zone. The damming of most of the large river systems in Tasmania for hydroelectricity production, irrigation and water supply has modified their hydrology and seasonal flow levels. Nutrients and sediments from agriculture, forestry operations, urban runoff and 45 sewage treatment plants around the state also impact on many of Tasmania's bays and estuaries. Effluent from mining and heavy industries have resulted in significant pollutant levels in the Derwent, Tamar and Pieman estuaries, the King River which flows into Macquarie Harbour, and the north-west coast near Burnie (Rees, 1995). There is little documentation of the effects of these impacts on the marine environment although Rees (1994) showed that seagrasses around Tasmania have declined significantly in areas near to urban developments. Major biological impacts of effluent from Tioxide, Burnie have been documented and heavy metal contamination of fish and shellfish has been detected in Macquarie Harbour, Pieman River and Derwent River estuaries. Anecdotal accounts suggest that the Derwent River estuary has been significantly degraded with extensive sandy beaches of 50-100 years ago now replaced by eutrophic, nutrient rich muds (Barrett, 1995).

2.10.2 Marine and Estuarine Protected Areas in Tasmania

In 1981 the World Conservation Strategy (WCS) was launched by the International Union for Conservation of Nature (IUCN), the World Wide Fund for Nature (WWF) and the United Nations Environment Program (UNEP). The WCS promotes the protection of threatened species, habitats and ecosystems and representative samples of ecosystem types in order to safeguard all critical habitats (feeding, breeding, nursery and resting areas). Important aspects of the strategy for marine conservation are the conservation of ocean species and ecosystems through the establishment of marine sanctuaries, improved controls over marine pollution and sustainable use of marine living resources. In Australia, support for the principles of the WCS is promoted through the National Conservation Strategy of Australia (NCSA) and the intergovernmental Council of Nature Conservation Ministers (CONCOM) (CONCOM is now called the Australia New Zealand Environment Conservation Council, ANZECC). The Australian National Parks and Wildlife Service (ANPWS) and CONCOM defined MEPAs using IUCN objectives as:

> any area of intertidal or subtidal terrain, together with its superjacent waters and associated flora and fauna, which has been reserved by legislation to protect part or all of the enclosed environment for conservational, scientific, educational and or recreational purposes (Kriwoken, 1989).

Up until 1991, Tasmania was the only Australian state without marine reserves dedicated for the preservation of representative habitats or marine ecosystems. There were 15 limited MEPAs that were mostly marine extensions of terrestrial national parks or conservation areas. These areas have no management plans or regulatory controls relating to marine conservation. A reserve at Crayfish Pt., Taroona was established in 1971. The reserve is protected under *The Fisheries Act* (1959) as a site for crayfish research (Kriwoken, 1989; Bosworth, 1995).

A further ten wetland sites around Tasmania are listed under the *Convention on Wetlands of International Importance Especially as Waterfowl Habitat* (Ramsar Convention, 1971). Nine of these sites are estuarine or coastal wetlands. However these sites have limited conservation value as the Convention is restricted to wetlands and has no legal support for the prohibition of ecologically damaging activities (Kriwoken &

Haward, 1991). Some of these sites are seriously degraded. They are often adjacent to or include private property carrying livestock, some are infested by introduced species and most are used for uncontrolled recreational activities including hunting. Despite being under the jurisdiction of the Parks and Wildlife Service, and in several cases containing refuges of rare and threatened species, few of these areas are actively managed (Kriwoken & Haward, 1991; Australian Nature Conservation Agency, 1996).

In 1991, four marine reserves were declared. All are located on the east and south-east coasts of Tasmania. There are three small reserves of scientific and recreational interest: Governor Island near Bicheno (60 ha); Ninepin Point (60 ha) and Tinderbox (45 ha) in the D'Entrecasteaux Channel; and one larger reserve on the north-west coast of Maria Island (1,500 ha). Unfortunately, public pressure resulted in the exclusion of important representative habitats from the Maria Island reserve (Edgar *et al.*, 1994; Bosworth, 1995). These reserves represent only a small part of Tasmania's marine ecosystems (less than 0.5%) on a restricted area of the coastline. Recommended areas for protection with high conservation values in the Bass Strait (Edgar, 1981 & 1984) and the west and south coasts (Edgar *et al.*, 1994) remain unprotected. Habitat types other than rocky reefs and their associated soft bottom habitats are not protected. No consideration has yet been given to protection of estuarine areas that are most subjected to land based impacts, although Edgar *et al.* (1994) recommended that the protection of Bathurst Harbour in the South West National Park should be extended to cover marine flora and fauna. This proposal has tripartisan support from the present Tasmanian Parliament and a proposal for a marine protected area in Bathurst Harbour is being developed (C.Bell & N.Barrett, pers. comm., 1996). Three of the areas proposed by Rees (1994) for the protection of seagrass habitat occur in estuaries covered in this study (Southport Lagoon, Recherche Bay and Robbins Passage).

Marine reserves are a vital part of any strategy to conserve our marine ecosystems. However, they cannot succeed in isolation. The next important step in policy development must be the integration of management of catchments and the coastal and marine zones. This applies not only to protected areas, but also to the widespread application of land use planning, pollution control and marine resources management.

2.11 Catchment Management

Critical to the management of estuaries is the recognition of the impacts of activities within the catchment. 'Upstream catchment activities are the single most important factor in determining the present day nutrient balance and water quality of estuaries' (Adam *et al.*, 1992). In NSW, the Catchment Management Act, 1989 formalises the procedures for implementation of catchment management (Adam *et al.*, 1992). The concept of catchment management has not been legislated in Tasmania, however, it has become a policy of the main land and water management agencies, the Department of Primary Industry and Fisheries, the Hydro-Electric Commission and the Forestry Commission. These agencies and other community groups are involved in a number of pilot projects such as Meander River and Huon River Catchment projects. Total catchment management (TCM) requires that all issues of resource allocation and environmental effects within a catchment are considered during planning for developments (O'Donnell & Livingston, 1992). The objectives of TCM as outlined in the NSW Catchment Management Act, 1989 are to ensure the sustainable use of natural resources, rectifying degradation of natural resources and to provide stable and productive soils, high quality water and a protective, productive vegetation cover. Fundamental to the success of TCM is active community involvement in resource management, with the development of a heightened awareness of the need for conservation of land, water and other natural resources (Adam et al., 1992).

The importance of the management of land clearance and landuse within catchments for the maintenance of estuarine water quality and ecosystems has been demonstrated in this chapter. Effective catchment management requires knowledge of the many and complex processes occurring within the catchment. Bucher & Saenger (1989, 1991) identified the lack of information on land clearance and land use within Tasmanian catchments. The remainder of this thesis aims to augment this data and to provide an overview of human impacts in Tasmanian estuarine catchments. The next chapter describes the data-sets and methods used to define boundaries of catchments of estuaries and major rivers in Tasmania, derive statistics for population, land clearance and landuse within these catchments, and classify catchments by their physical attributes and degree of anthropogenic impact.

Chapter 3

Data Sets and Analysis

To acquaint the reader with some of the methods and terminology used in this section, this chapter firstly gives a brief outline of the use of remote sensing and geographic information systems. The second part of this chapter describes the source and derivation of the data sets used in this thesis. Subsequent sections describe the methods of analysis used to obtain statistics for physical attributes, population and landtypes, and the methods used to analyse these statistics to classify catchments by their physical attributes, examine trends in the data, and rank catchments according to the degree of anthropogenic impact.

3.1 Remote Sensing and Geographic Information Systems

3.1.1 Remote Sensing

Remote sensing is a term applied to techniques of obtaining information about objects with a sensor that is physically remote from the object. Sensors detect energy emitted or reflected from the object as electromagnetic radiation, gravity, magnetism or sound waves. Sensors are mounted on platforms such as towers, aircraft or spacecraft (Harrison and Jupp, 1989).

Landuse and vegetation mapping generally uses images produced from reflected light in the visible and infra red range. These images are obtained from aircraft or spacecraft. Aircraft allow greatest flexibility in terms of timing of flights to coincide with clear weather conditions and optimal sun angles, choice of scanning device, flight path and height, and production of high resolution images. The disadvantages of aircraft are that they are a less stable platform than spacecraft; images are more restrictive in coverage and more expensive for coverage of large areas; edge-matching between adjacent flight lines is difficult; and images contain significant geometric distortions that require rectification (Harrison and Jupp, 1989).

Images produced by sensors mounted on spacecraft such as the Landsat series of satellites are competitive with aerial photography. They cover a greater area at a single time and they are updated on a regular basis (every 16 days for Landsat). Frequent overpasses allow selection of suitable cloud free scenes and multi-temporal images allow examination of temporal variations in previously mapped areas. The main benefit of satellite imagery is the provision of a regional overview, allowing spatial analysis on a scale not feasible with other methods (Evans, 1995; Ritman, 1995).

The interpretation of spectral data produced by satellite mounted sensors must be supported by knowledge based classification based on ground truthing, aerial photographs, existing map data and expert knowledge. The current resolution of satellite images (Landsat TM pixel size is 30 m) is significantly coarser than images produced from aerial photography. Satellite imagery is unlikely to replace aerial photography for detailed, localised vegetation mapping (Johnston and Barson, 1993) and it is important that the scale of landuse units classified does not exceed the resolution of the images.

3.1.2 Geographic Information Systems

The term Geographic Information System (GIS) can be used to describe any set of geographically referenced information. Increasingly it is used in reference to computer based geographical databases. Data relevant to particular geographical features is stored as attributes of digitally encoded maps that use vectors or grid cells (rasters) to represent natural (vegetation, rivers, topography), human-made (buildings, roads) and conceptual (land tenure, administrative boundaries) features of the landscape (ESRI, 1994). Maps representing different attributes of a particular geographical location can be overlayed to allow analysis of any number of spatial parameters useful for the development of planning, management and experimental strategies. In combination with digital data from remote sensing and results of measurements of land or water based parameters, spatial analysis using GIS provides an ideal tool for monitoring and modelling of the environment on both regional and local scales (Jupp *et al.*, 1994).

3.1.2.1 Arc/Info™

The GIS software used in this study was Arc/Info version 7.0.4, (1996) written by Environmental Systems Research Institute, Inc. (ESRI) and Doric Computer Systems

International Ltd. Arc/Info was chosen because of its ability to store and analyse large data-sets. Arc/Info is a powerful GIS toolbox that can work on a number of data types including vector based maps (coverages), raster or cell based maps (grids), tables, TINs (triangulated irregular networks) and images (ESRI, 1994).

Coverages are used to represent points, lines or arcs, enclosed areas or polygons and regions. Once coverages are 'built', Arc/Info uses polygon or arc topology to determine the geographical location of each point or arc, the direction of each arc, which arcs make up a polygon and which side of each arc a polygon is located. Regions can be made up of a number of polygons. Attributes can be linked to points, arcs, polygons or regions. Attributes for each coverage are contained in arc attribute or polygon attribute tables (AATs or PATs respectively). PATs automatically contain the area and perimeter for each polygon as well as internal and user-defined identification numbers. Any number of polygon attributes can be added to the PAT.

Grids are used to store data about specific locations on the earth's surface such as vegetation type, soil type or elevation. They can represent continuous surfaces or discrete groups or classes. Each location is represented as a cell. The cell matrix, or grid, is organised into rows and columns. Cell values are numbers that represent nominal data such as land types or actual or relative measurements such as elevation, rainfall or reflectance values. For grids containing categorical data, Arc/Info creates a value attribute table (VAT) that contains cell values (value) and the number of cells (count) in the grid for each particular value. Additional attributes that can be related to particular cell values can be added to the VAT. Grids containing a wide range of actual measurements or floating point values do not have a VAT.

Tables are used to store data for all features of the geographic files. Data can be added or analysed, and tables can be linked to tables from other data-sets to create a fully relational geographic database.

Tins are used to provide high precision representation of surfaces. This data type was not used in this study so it is not considered any further.

Images can include scanned photographs or satellite images. They can be included as descriptive attributes for cell or vector based coverage units. Alternatively they can be used to produce grids or coverages by registering the image using known geographic reference points.

Arc/Info facilitates the conversion of map data between coverages and grids. Coverages can be produced by vectorisation of grid images. Grids can be produced from coverage polygons using any numeric attribute as the cell value. Some accuracy is lost with each conversion so it is important to limit the number of times that data is converted from one data type to another.

Spatial analysis is most readily done using raster or cell based analysis tools. The Arc/Info module GRID provides tools for simple and complex grid-cell analysis. GRID allows transparent processing of grids at different resolutions. It does this by automatically resampling input grids to the coarsest resolution using nearest neighbour resampling. Arc/Info also provides modules for interactive editing and digitising of individual coverages and grids, and displaying and querying multiple layers of coverages and grids (ESRI, 1994).

3.2 Data Sets

3.2.1 Available Digital Data Sets

A number of digital map coverages of the state of Tasmania were made available by the Department of Geology, University of Tasmania. These included coverages for coastline, drainage (rivers and lakes) and contours (100 m); derived from 1:250,000 map sheets by the Land Information Bureau (LIB), Department of Environment & Land Management (DELM). A digital coverage of the Tasmanian coastline derived from 1:25,000 map sheets by the LIB was provided by the Division of Resources, Wildlife and Heritage (RWH), DELM.

3.2.2 Catchment Boundaries

GIS software such as Arc/Info can be used to derive catchment boundaries from digital elevation models (DEMs) where these exist. However the accuracy of boundaries is dependent on the resolution of available DEMs. This was attempted in this study using an available DEM derived from the 1:250,000 contour coverage (100 m contours). The resulting catchment boundaries were nonsensical in areas of shallow topography. This method was rejected in favour of hand drawn catchment boundaries. Catchment boundaries derived from DEMs are typically assessed by comparison with hand drawn boundaries suggesting that the latter produces optimal boundaries (Civco, 1995). Future availabilty of high resolution DEMs for Tasmania may allow more precise catchment boundaries to be determined by digital analysis. This will be useful where catchments need to be determined for large numbers of small subcatchments or multiple pour points within a catchment. For the purposes of this study, digitised hand drawn boundaries provided the most precise determination of catchment boundaries. These boundaries will provide a useful reference for any future determination of catchment boundaries using digital techniques.

3.2.2.1 Criteria for Selecting Estuaries

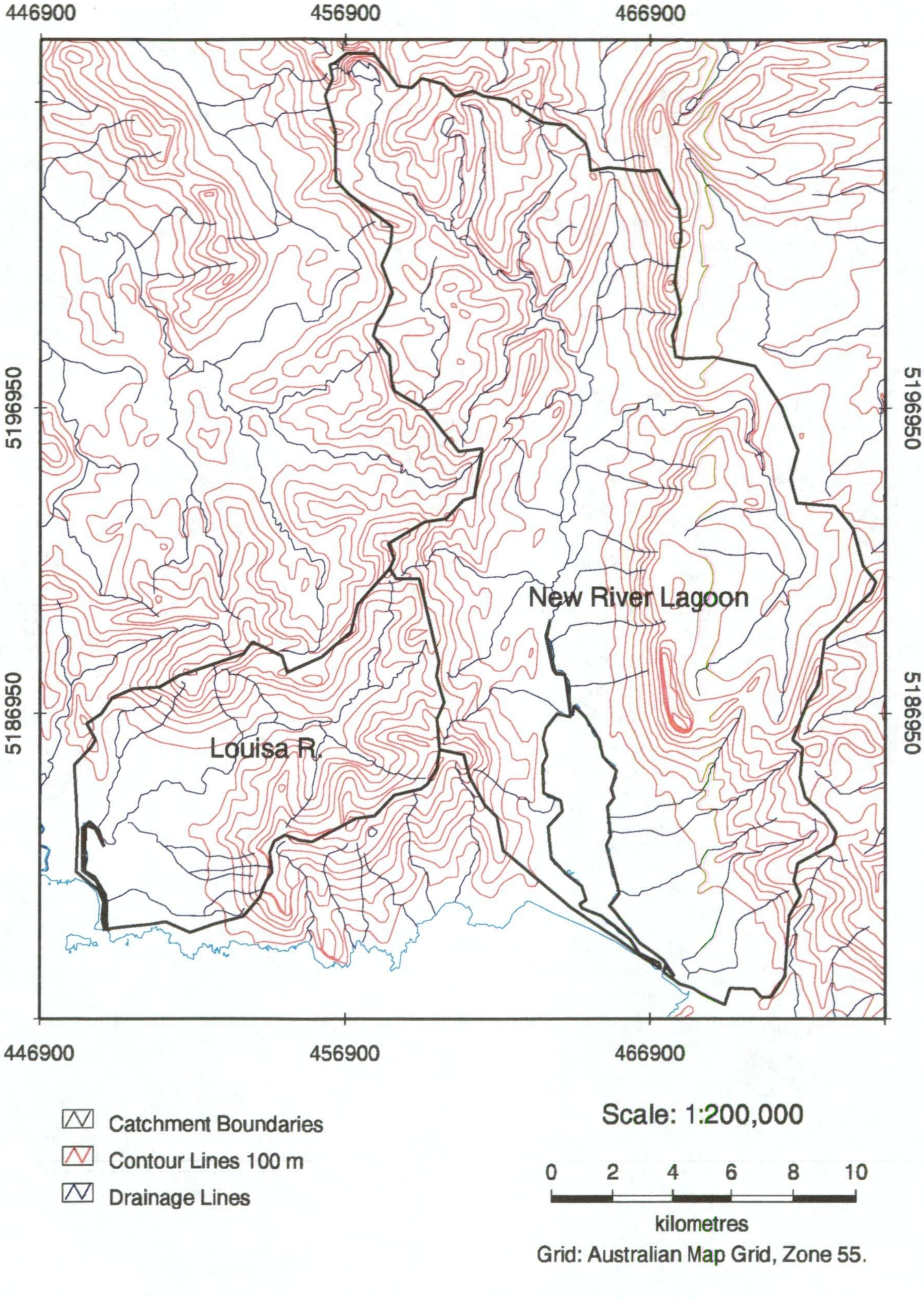
Catchment boundaries were determined for Tasmanian estuaries, coastal lagoons and embayments that have banks represented by separate lines on 1:100,000 topographic map sheets. Major river catchments within each estuarine catchment were also outlined.

3.2.2.2 Determination of Catchment Boundaries

Catchment boundaries were determined from contour lines and drainage courses shown on 1:100,000 topographic map sheets. The boundary or catchment divide is predicted by assuming that all surface flow occurs in the direction of the land slope, in a direction perpendicular to the contours. The boundary only intersects contour lines when it runs along a ridge (Figure 3.1). Catchment boundaries were traced from the most recent editions of LIB 1:100,000 topographic maps onto polyester drafting film (Rapidraw 0.003") using a 0.4 mm drafting pen. All reference (or Tic) points used Australian Map Grid (AMG), Zone 55 coordinates.

Traced images were scanned, at a resolution of 300 dots per inch (dpi), on a flat bed scanner at the LIB, DELM. In order to import these images into Arc/Info, the images were inverted (to white lines on a black background) using the image processor package XV (Bradley, 1993). Inverted images were then imported into Arc/Info, then registered and rectified to AMG Zone 55 using the marked Tic points. Rectified grid based images were then vectorised using the Arc command Gridline. The command option settings

Figure 3.1 Defining Catchment Boundaries Using Contours and Drainage



used were thinning, filter, round, line thickness of 50 map units, minimum dangle length 200 map units and weed tolerance 2 map units. Map units were set in meters.

Vectorised coverages were cleaned to remove intersecting arcs and sliver polygons using a minimum dangle length of 100 m and a fuzzy tolerance of 5 m. Cleaned coverages were edge matched to neighbouring coverages then all individual map sheet coverages were appended to a single coverage of all catchment boundaries.

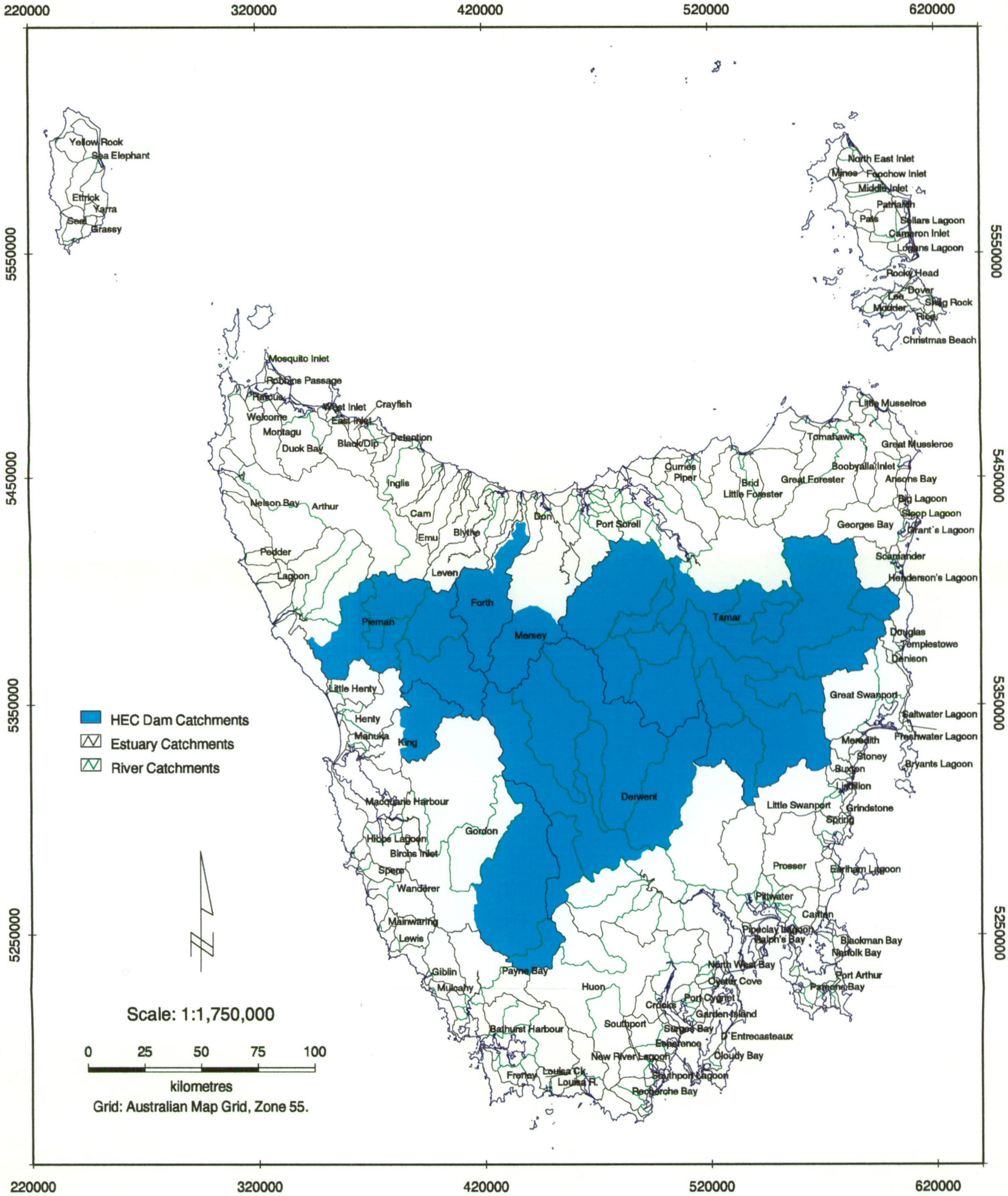
The catchment coverage was then appended to the 1:25,000 coastline coverage. Estuarine catchment boundaries were joined to the coastline in order to close the polygon for each catchment. Errors in catchment boundaries were identified by overlaying the catchment coverage on the available 1:250,000 drainage and contour coverages.

Corrections were made where boundaries intersected with rivers represented on the drainage coverage. Changes to catchment boundaries were made interactively where corrections of less then 100 m (as determined on the image display) were required. For larger errors and serious anomalies in boundaries, the original map-sheets and line work were referred to. Resulting corrections were manually digitised into the coverage.

Three coverages were created from the original coverage. These covered catchment boundaries for whole catchments (estcatch) which include all land draining into the estuaries, major river catchments with each estuarine catchment (rivcatch) and catchments of major dams built for hydroelectricity production, irrigation projects or water supply (damcatch). Each coverage was made by deleting non-relevant areas from the original coverage. Polygon topography was then built for each coverage and each catchment was attributed with a unique code number and the name of the catchment. Map 1 shows all catchment coverages combined.

3.2.2.3 Sources of Error

The catchment boundaries derived are subject to error resulting from errors in the original map sheets, errors in defining catchment boundaries and errors in transcription of linework to digital coverage. The stated error in horizontal position on LIB 1:000,000 topographic map sheets is +/- 25 m. Errors in determining catchment boundaries are difficult to assess. In areas of steep topography (close contours), errors are likely to be of



Map 1 Catchment Boundaries of Tasmanian Estuaries, Rivers & Dams

the same order as the error in the map-sheet. However in areas of shallow topography and indeterminate drainage representation, errors in catchment boundaries are likely to be high (up to 500 m). Other difficulties in determining catchment boundaries arise with numerous human made diversions of water flow within and between catchments for hydro-electricity generation and irrigation purposes. The main examples of this are: the diversion of Great Lake waters from the Derwent Estuary (Ouse River) catchment to the Tamar Estuary (Macquarie River) catchment; diversion of Lake Pedder from the Huon River catchment to the Gordon River Catchment; and diversions between the Nive, Dee and Ouse river catchments. The latter are difficult to interpret from map-sheets, but are all subcatchments of the Derwent Estuary Catchment. Where diversions could be determined, their catchments have been included in the catchments to which they were diverted. Great Lake and Lake Pedder Catchments are mapped separately in the coverage of river catchment boundaries.

3.2.2.4 Transcription Errors

Small errors are introduced at all stages in transcribing catchment boundaries to digital coverages. A line width of 0.4 mm corresponds to 40 m at 1:100,000 scale. Scanning of this line at 300 dpi gives a line approximately 5 cells wide (cell size is ~ 8.5 by 8.5 m). It is necessary to have a line several cells wide so that it will be recognised as a line during vectorisation, rather than a series of disconnected points. Errors occur in marking Tic points and in geographical registration of images using these points. Four Tic points were marked on each map sheet, as close to the corners of the map sheets as practical. For 42 map sheets, the average error recorded during rectification was 10.6 m, equivalent to a RMS error of 0.004 (Maximum error was 26.5 m, RMS 0.01).

Vectorisation produces a line of zero thickness from the grid/cell image. The error at any point in this line will be equivalent to the line thickness of the image, that is +/- 40 m. Summing errors from determining catchment boundaries (+/- 50 m) and transcription (+/- 50 m) gives an approximate error of +/- 100 m. As noted above, this error may be considerably greater in areas of shallow topography. The nominal scale for coverage of catchment boundaries is the same as the source maps, 1:100,000.

3.2.3 Estuary Boundaries

A digital coverage of estuaries was created using the LIB 1:25,000 coastline coverage. As discussed in Chapter 2.1.1, in the absence of data on salinity, tidal limits and bathymetry, the definition of estuarine boundaries is necessarily arbitrary.

Upstream boundaries were determined as the point where the separate lines representing estuary banks on 1:100,000 map sheets became single lines. This rule was used in most cases, except where separate lines continued many kilometers inland. In these cases the head of the estuary was taken as either the point of intersection of the last major tributary, the point where 20 m contour lines intersected river banks, or where significant features, such as gorges or rapids, were considered to represent a probable obstruction to tidal incursion. For example: the head of Pieman River estuary was taken as the intersection with the Donaldson River; the head of the Gordon River estuary was taken at the 'first gorge'; the Arthur River at the intersection with the Frankland River, and the Derwent River at the intersection with the Lachlan River.

Downstream limits were marked as a line between the headlands on either side of the entrance to the estuary. Lateral boundaries used were lines on a topographic map that represented the coastline (Australian height datum).

Where estuaries and coastal lagoons were missing from the LIB coverage, or showed significant variation to those shown on 1:100,000 map sheets, the coverage was edited by digitising estuary boundaries from either 1:100,000 or 1:25,000 topographic map sheets. Downstream boundaries were drawn by adding a straight line joining the points where estuarine catchment boundaries intersected the coastline. Polygon topology was built and each estuary was attributed with the code number and name of the related estuarine catchment.

3.2.3.1 Categorisation of Estuaries

Each estuary was classified according to the geomorphology represented on 1:25,000 map sheets. Estuaries were classified into 4 types: 1 drowned river valleys; 2 barrier estuaries; 3 coastal lagoons; and 4 embayments. Types 1 to 3 are as shown in figure 2.1. Type 4, embayments covers four partially enclosed bodies of water (Robbins Passage, Norfolk Bay, Ralphs Bay and Recherche Bay). These embayments are characterised by narrow entrance channels (<2km between headlands), however they are likely to have a strong marine influence with only periodic dilution by freshwater from river flows. They are included in this study largely because of their inclusion in the inventory of Australian estuaries (Bucher and Saenger, 1989).

3.2.4 Estuary Buffer Zone

The Buffer command in Arc/Info was used to produce a coverage of polygons representing a 1 km buffer around all estuary polygons. These areas were termed estuarine buffer zones (EBZs).

3.2.5 Rainfall Data

Rainfall data was extracted by RWH from the Bioclimate Prediction System (BIOCLIM) and imported into Arc/Info. The data represents annual rainfall values for one km square grid cells that are derived from 504 Tasmanian rainfall stations with a minimum of 5 years of records. The estimated error in predicted values is less than 10% (Busby, 1986). Rainfall data was stored as a grid with a cell size of 1000 m x 1000 m.

3.2.5.1 Mean Annual Runoff

Figures for mean annual runoff from selected river catchments were derived from annual discharge values published by the Rivers and Water Supply Commission (RWSC), Department of Primary Industry and Fisheries (RWSC, 1983). Mean annual runoff was calculated by dividing mean annual discharge by catchment area.

3.2.6 Population Statistics

Data for population, dwelling and occupancy statistics for Tasmania were taken from Australian Bureau of Statistics (ABS) census data, 1991 (Cdata91) (ABS, 1993). A digital map of the census districts used for Census 1991 was translated from the MapInfo version of Cdata91 (owned by the Department of Geography and Environmental Studies), to an Arc/Info vector coverage. The translation was done with the help of Landfile Consultancy Pty. Ltd. using version 2.70c of AIMI (Arc/Info MapInfo) translation software. The AIMI translation was imported into Arc/Info and projected using AMG Zone 55 coordinates (the original file in MapInfo used geographic coordinates, latitude and longitude).

There are a number of problems with transferring vector coverages between MapInfo and Arc/Info. MapInfo represents areas with complete polygons so that adjacent polygons do not share arcs at their adjoining edges. In Arc/Info, the polygon topology allows arcs to be shared by adjacent polygons. When translating from MapInfo to Arc/Info, this results in double arcs where two polygons meet. The resulting areas contain multiple intersection points which are illegal or invalid in Arc/Info polygon coverages. Intersections are removed by using 'clean'. The fuzzy tolerance must be set at a level that prevents formation of sliver polygons without removing smaller map areas.

A major problem with versions of AIMI prior to 2.70c is that polygon attributes become randomised. Version 2.70c has largely eliminated this problem although twenty 'island' polygons lost their attributed census district and were labelled with the attributes of the surrounding polygon.

The imported coverage of census districts was cleaned and polygon topology built. Island polygons were attributed with the correct census codes obtained by using MapInfo to refer to the original coverage. Each polygon was also attributed with values for population density (population/ha - popdens), dwelling density (dwellings/ha - dweldens) and occupation density (occupied dwellings/ha - occdens). These values were determined by dividing census values for each census district by the total area for each district as derived from the Arc/Info coverage.

Tasmania has been divided into 953 census districts. ABS attempts to create districts with an equivalent number of dwellings and population. The average population and number of dwellings for Tasmanian census districts are 475 and 165 respectively. There is a wide variation in the size of census districts between densely populated urban areas and sparsely populated rural and remote areas. The area of census districts ranges from 3.125 ha to 497,205.5 ha with a median of 101 ha and a mean of 7,195 ha.

3.2.7 State of Environment Report - Satellite Derived Landtype Data

Digital raster images showing major landtypes for eastern Tasmania were provided under licence by the State of Environment Report (SER) unit of DELM through Mr. Ross Lincolne at the Central Scientific Laboratories (CSL). These images were derived from composite Landsat TM images selected from available images for early summer of 1988 and 1994. Landtype classification was based on digital analysis of spectral data from Landsat TM bands 1,2,3,4 and 5 using ERDAS Imagine software. Land was classified into 9 main landtypes representing water, woody vegetation, non-woody vegetation, agricultural land, urban land and bare land or rock. Additional classifications were made by re-classifying alpine landtypes using an alpine contour mask. Cleared woody vegetation was also identified by analysing temporal changes from or to woody vegetation classes over the 6 years separating image sets. Landtype classifications were validated by comparison with aerial photographs of representative areas, comparison with existing vegetation maps and expert knowledge. Landtype categories identified are shown in Table 3.1.

Table 3.1: Landtype categories used in Landsat TM classification

No.	*Landtype Category*
1	water
2	rainforest
3	forest
4	woodlands
5	scrub
6	agriculture
7	heath or buttongrass
8	cleared forest
9	bare land or rock
10	urban
11	alpine scrub
12	alpine heath
13	alpine bare land or rock

The images were produced with a resolution of 25 m (i.e. minimum pixel or cell size is 25 m by 25 m). The landtype data was supplied as ERDAS Imagine images. Arc/Info supports the conversion of ERDAS images to grids. All landtype data was imported into Arc/Info and stored as grids with a cell size of 25 m x 25 m.

3.2.7.1 Preparation of Landtype Data for Use in Analysis

Four images were received from the SER Unit. These were categorisations derived from 1988 and 1994 Landsat TM images for the south-east (SE88, & SE94) and north-east (NE88 & NE94) of the Tasmanian mainland and Maria Island. Classification of the south-east images was complete, however, the north-east images were only preliminary classifications of the satellite images.

All grids contained varying amounts of unclassified cells resulting form cloud cover or shadowing caused by low sun angle. As the categorisation for the whole of Tasmania was not completed, a single grid was produced from the available data sets that represented eastern Tasmania. This grid was based primarily on the 1994 images.

For the south-east images, problems with cloud and shading affected only areas in the south and south-western portions of the image. These areas are mostly contained within the South-West World Heritage Area. As such they are unlikely to be subject to significant changes. The two south-east grids were merged so that where SE94 had non-zero data this data was used, but where cells had null or no data, data from SE88 was used.

The combination of NE grids was more involved. In agricultural areas digital classification had differentiated ploughed paddocks from vegetated paddocks into bare and agricultural categories respectively. In order to approximate the full extent of agricultural land, this class was selected from each grid and combined to give a single agricultural class. That is, cells were classed as agricultural land if they were classified as agricultural in either grid. Cells classed as bare land in both grids remained as bare land. The combined agricultural grid was then merged with NE94. The resulting grid reduced the area of urban land around population centres such as Launceston and Georgetown. To overcome this problem, cells classed as urban in the original NE94 grid were selected and merged with the new NE94 grid. Significant areas of the southern parts of both NE88 and NE94 had cloud cover. However, these areas were almost completely covered by the northern extent of SE88 and SE94. A small area of cloud cover in the South-west of NE94 was replaced with cell values form NE88. This area was north of Great Lake at the head of the Meander Catchment and unlikely to be subject to significant change in land cover.

The two adjusted 1994 grids, SE94 and NE94, were then merged to produce the final working image of eastern Tasmania, called TE94. Where there were non-zero values for SE94 these were used, otherwise values for NE94 were used.

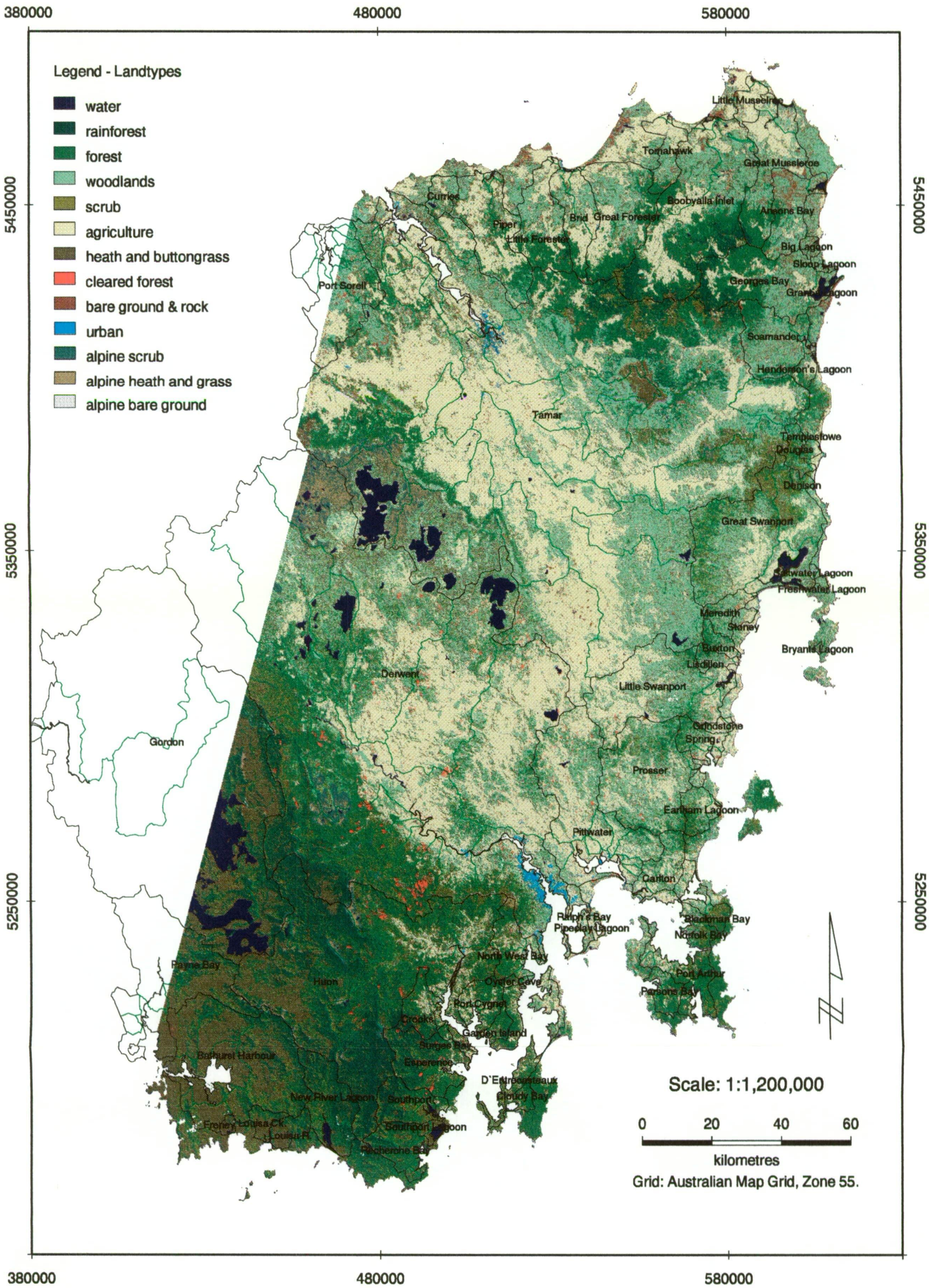
The main remaining anomalies in this grid were: alpine regions north of Great Lake, including the Ben Lomond Plateau, were not identified as alpine class; the analysis of change from or to woody class, to give the 'cleared' class was not done for areas north of Great Lake. These classifications required an alpine mask and reference to spectral properties in the original Landsat images respectively. Neither of these were available for this study. Map 2 shows the landtype coverage TE94 overlayed with estuary catchment boundaries.

3.2.7.2 Limitations of Satellite Derived Landtype Classification

In a broad sense, the classification of landtypes across Tasmania from satellite data provides a reasonably accurate representation of the major vegetation classes. The accuracy of the data has not been assessed by ground based mapping (this would be prohibitively expensive on this scale). However, truthing using aerial photography of representative areas and comparison with existing vegetation maps is an accepted method of verifying digital classifications of satellite data (Ritman, 1995).

In this study, the landtypes used have been equated with landuse. Agricultural, urban and cleared forest landtypes are associated with those anthropogenic activities, while other landtypes are considered to be natural features. Classification of agricultural land did not differentiate natural grasslands or wetlands. There is no attempt to differentiate between different agricultural operations such as pasture production, cropping, horticulture or grazing. Significant areas of scrub, heathlands and open woodlands are likely to be used for grazing. The level of impact of grazing on these vegetation types is dependent on the intensity of grazing pressure. It can be severe.

No attempt has been made to differentiate land uses of cleared forest. This may represent areas of natural or plantation wood harvesting, or land clearance for development of agricultural or urban land. The differentiation of heath and buttongrass was complex and these vegetation classes were amalgamated into one landtype category. For the purpose of this study this is not significant. The bareground category includes rock, sand and bare earth. Roads and areas of land cleared for urban development, or ploughed paddocks could be included in this category. However, the



Map 2 Land Type Categories in Eastern Tasmanian Catchments

majority of these areas are likely to be classified in their relevant categories by post processing procedures. Some small areas of highly reflective sand dunes and claypans have been classified as urban land. This has resulted in some small errors in the subsequent analysis, most evident as areas of urban land in otherwise pristine catchments such as Saltwater and Freshwater Lagoons in the Freycinet National Park.

Overall. the data provided a reasonable representation of landtypes and land clearance for anthropogenic purposes on the regional scale used in this study.

3.3 Analysis of Data

3.3.1 Cell Based Analysis with Arc/Info Grid Module

All analyses of data sets were done using the cell based analysis tools in the Arc/Info module, Grid. Vector coverages were converted to grids using the Arc command Polygrid.

Catchment coverages (estcatch, rivcatch, and damcatch) and the EBZ coverage were converted to grids with a cell size of 25 m by 25 m. This cell size was chosen to match the resolution of the landtype data. Cell values were obtained from the value item in the relevant coverage PAT for catchment code (i.e. est-code, riv-code, and dam-code). That is, the value of each cell within a catchment was equal to the code number for that catchment. Cell values for EBZs were 100 for buffer zones and nodata outside of buffer zones.

Three grids were created from the ABS census district coverage representing population density, dwelling density and density of occupied dwellings. Cell values for each census district were obtained from the polygon attributes popdens, dweldens and occdens respectively. Due to the limited available disc space at the time these grids were created, they were created with a cell size of 100 m by 100 m (1 ha). This resolution was considered adequate to accurately represent population values for each census district as the minimum census district area was greater than 3 ha.

Rainfall data (1000 m by 1000 m cell grid) and landtype data (25 m by 25 m cell grid) did not require further processing.

3.3.2 Determination of Physical Attributes of Estuaries and Catchments

Estuary catchment areas (ECAs) and estuary water surface area (ESA) were obtained from PATs of vector coverages. The fluvial drainage area, (FDA) for each estuary was derived by summing all of the river catchments within the ECA. The estuarine drainage area (EDA) was calculated as the difference between ECA and FDA for each estuary. For coastal lagoons, no river catchments were outlined so that EDA was equal to ECA for these catchments.

Appendix 1 lists values for ECA, FDA, EDA, ESA and the nearest tide gauge and tidal values. Appendix 1 also includes physical parameters that were estimated using this data and rainfall data included in Appendix 2. These parameters were: estimated tidal prism (TP); estimated runoff per tidal cycle or diurnal runoff (DRO); flow ratio (FR); estimated mixing status for each estuary; and estuary type. These values were derived as shown below.

Average tidal range was calculates as:

$$TR = 0.5*(MHWS - MLWS)+(MHWN-MLWN).$$

Estimated tidal prism was calculated as:

$$TP = TR*ESA \text{ (in } m^2).$$

Runoff per tidal cycle was calculated as;

$$DRO = TAR / (365*2) * ROC.$$

TAR (total annual rainfall) and ROC (runoff coefficient) are taken from Appendix 2. Calculation of these parameters is described in section 3.3.2.

Flow ratio is calculated as:

$$FR = DRO / TP$$

The estimated mixing status for each estuary was determined from the estimated flow ratio as suggested by Simmons (1955 as cited in Dyer, 1973). Flow ratios > 1.0 indicate highly stratified conditions, values between 0.1 and 1.0 indicate partial mixing, and values less than 0.1 indicate well mixed conditions.

Estuary type was determined as described in section 3.2.3.1.

3.3.2 Rainfall Statistics

Rainfall statistics were determined for each catchment area using the zonalstatistics function of the Grid module. This function calculates the minimum, maximum, range, median, mean and sum of all cell values of the value grid (Rainfall data) for each cell value in the input (catchment) grid. The sum of values equals the Total Annual Rainfall (TAR) for the catchment. The mean is the average annual rainfall (Rav) across the catchment and also equals the quotient of TAR and catchment area. Minimum (Rmn) and maximum (Rmx) are the lowest and highest cell values for annual rainfall within the catchment. (These values should not be interpreted as minimum and maximum rainfall events, nor as minimum and maximum annual records.) Range (Rrn) and median (Rmd) values give an indication of the variation in annual rainfall levels across a catchment. The proportion of each catchment that is dammed was determined by combining estcatch and damcatch grids.

Appendix 2 lists rainfall statistics by estuarine and river catchments, and the area and proportion of each catchment that is dammed. Data derived from river gauging stations (RWSC, 1983) are included in this appendix. These data include the catchment area upstream of the gauge, the mean annual runoff (MAR) and the coefficient of runoff (ROC), presence of upstream regulation of stream flow, and the number of years records have been kept for each gauge.

MAR was estimated for each catchment from stream-flow records as follows. For records where the catchment area above the gauge is greater than 50% of total catchment area as determined in this study, MAR was plotted against Rav obtained in this study. The line of best fit was calculated using Microsoft Excel™ regression analysis (Figure 3.2). A binomial equation gave a correlation coefficient equal to 0.92. When the value for the Huon River catchment was removed, the correlation coefficient for the regression line increased to 0.95. The value for the runoff from the Huon River was anomalous with MAR equal to 99% of annual rainfall for the catchment. This is partly due to underestimation of Rav as a result of the diversion of part the catchment into the Gordon River catchment via Lake Pedder. Stream gauge records were collected prior to the diversion. However this only accounts for about 10% of incident rainfall.

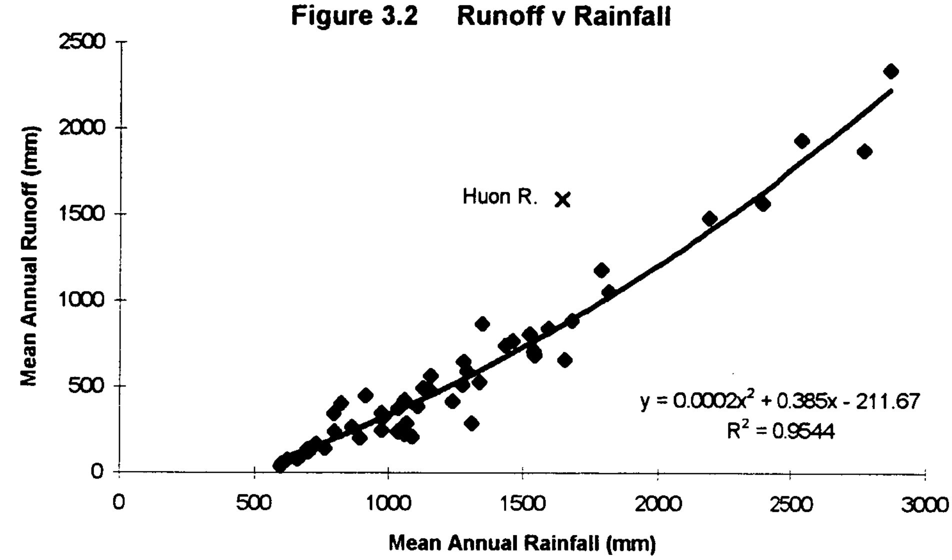
The regression equation was used as an estimate for MAR for all catchments using the equation:

$$MAR = 0.0002*(Rav)^2 + 0.385*Rav - 211.67$$

The runoff coefficient for each catchment was calculated as the ratio of estimated MAR to Mean Annual Rainfall:

$$ROC = MAR/Rav$$

Figure 3.2 Runoff v Rainfall



3.4 Classification of Tasmanian Estuaries and Catchments

Tasmanian estuaries were classified into groups with similar physical and hydrological attributes using multivariate analysis techniques to analyse attributes for the presence of consistent patterns and clusters. Thirteen attributes were used in the analysis of 122 estuaries. The attributes used included physical and hydrological attributes derived for both the estuaries and their catchments. These were: estuary catchment area (ECA); estuarine water surface area (ESA); tidal range (TR); estimated tidal prism (TP); estimated diurnal runoff (DRO); flow ratio (FR); total annual runoff (TAR); minimum annual rainfall value for the catchment (Rmn); maximum annual rainfall value for the catchment (Rmx); range of annual rainfall values for the catchment (Rrn); mean of annual rainfall values for the catchment (Rav); estimated mean annual runoff (MAR) and coefficient of runoff for the catchment (ROC).

Analyses were done using the Commonwealth Scientific and Industrial Research Organisation (CSIRO) pattern analysis package, PATN (Belbin, 1995). Variables with large variations, ECA, ESA, TP, DRO and TAR, were transformed using Log10(X+1) before they were entered into PATN data files. All variables were then standardised using the PATN module TRND (data transformation). Data were standardised by subtracting the minimum value for each variable and dividing by the range of values for that variable. This places all values within each variable on a scale of zero to one. This is the recommended standardisation procedure to provide equal weighting for all variables in subsequent analyses (Belbin, 1995).

Multivariate analyses used default settings at all times. The association matrices were generated using the default Bray & Curtis dissimilarity measure (Belbin, 1995). Hierarchical cluster analysis was done using the flexible unweighted pair group arithmetic averaging (UPGMA) option of the polythetic agglomerative fusion (FUSE) module. Results are printed as dendrograms created with PATN module DEND. This shows the order of clustering with the value of association along the 'x-axis'.

Ordination analysis was done using the semi-strong-hybrid (SSH) multi-dimensional scaling module of PATN. The analyses was done using three dimensions to achieve a stress value of 0.0993. The Principal axis correlation (PCC) module was used to determine the direction of best fit and the correlation coefficient for each attribute used in the ordination. Results are presented as a plot of the first two dimensions of the ordination with vectors showing the direction of best fit for each attribute. The correlation coefficient for each attribute is also shown.

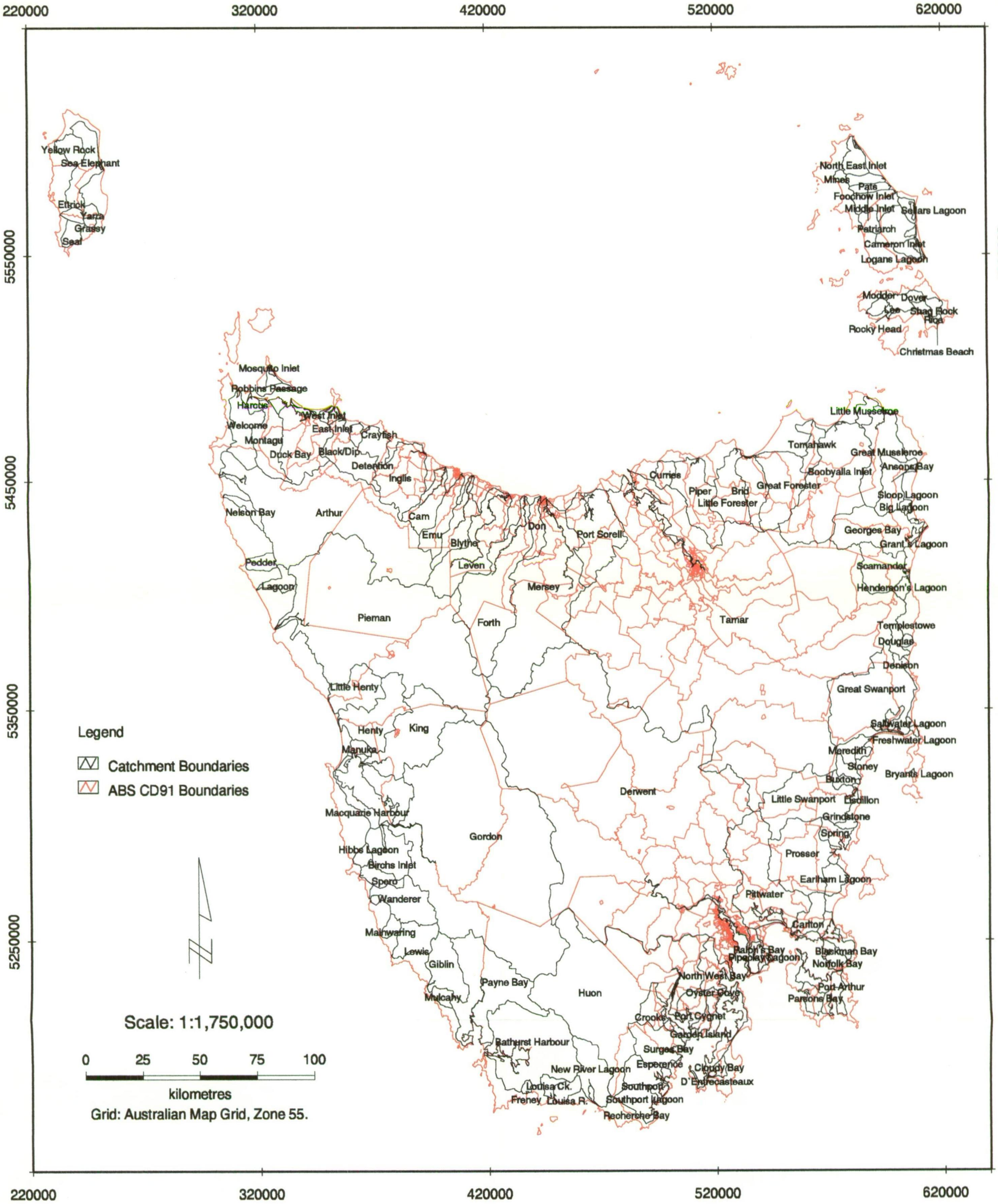
3.5 Population and Dwelling Statistics

Total population, number of dwellings and number of occupied dwellings were determined for each catchment area using the zonalstatistics function of Grid. The sum of values of cells from the grids popdens, dweldens, and occdens for each catchment gave total population, total dwellings and total occupied dwellings. Statistics for FDAs were calculated by subtracting values for EDAs from values for ECAs. Population and dwelling densities were calculated by dividing total population and dwellings by catchment area. Appendix 3 lists population statistics for all catchment areas.

As can be seen in the map of census districts overlaid on estuary catchments (Map 3), ABS collection district boundaries do not often match up well with catchment boundaries. This brings into question the validity of the results obtained by this method. However, closer observation shows that areas of high density population (represented by large numbers of small collection districts) are concentrated around estuaries, and therefore contained within catchment boundaries, often within estuarine drainage areas and within 1 km of the estuary. Estimates of population and number of dwellings are valid where small census collection districts, with high population/dwelling densities lie wholly within a catchment area. Erroneous results are obtained where large, low density census collection districts overlap large proportions of adjacent catchments. These errors are most significant in statistics derived for remote, unpopulated, or sparsely populated, catchments. Where such errors are evident or suspected, the number of dwellings was determined by reference to 1:25,000 scale topographic map sheets (where available) of the areas identified. The number of buildings mapped is recorded in brackets under dwellings in Appendix 3. No attempt was made to extrapolate the population values from the number of mapped buildings. In remote areas occupancy rates are likely to be lower than urban areas and are probably subject to seasonal fluctuations.

3.6 Landtype Areas and Proportions within Catchments

The area of each landtype category used in the SER landtype data within eastern Tasmanian catchments was determined by combining catchments grids with the SER landtype grid, TE94. The value attribute table of the resulting grid contained a unique value for each combination of cell values from the catchment grid and landtype grid. This data was compiled using the pivot table facility of Microsoft Excel to list the total area for each landtype within each catchment. Statistics for FDAs were calculated by subtracting values for EDAs from values for ECAs. The area of each landtype is listed by catchment area in Appendix 4. The proportion of each landtype within each catchment area was determined by dividing the landtype area by the total area for each catchment. These values are shown as a percentage of catchment area in Appendix 5.



Map 3 Census Districts and Catchment Boundaries of Tasmanian Estuaries

The SER landtype data set used (TE94), represented land in 63 estuarine catchments (Map 2). Three of these catchments are not considered in further analysis because landtype data only covered a portion of the catchment (Port Sorrell 56%, Payne Bay 41% and Gordon 24%). The landtype data covered only 86% of the Derwent Estuary Catchment, Tasmania's second largest catchment. The area of this catchment not covered by the landtype data is mostly within the World Heritage Conservation area. As such, the missing area will be mostly water, bareground and natural vegetation landtypes. The landtype data covered greater than 99% of all other catchment areas listed in appendices 4 and 5.

3.6.1 Distribution of Landtypes by Mean Annual Rainfall

To assess the relationship between annual rainfall and the distribution of landtypes, the rainfall grid was resampled to a cell size of 25 m by 25 m and combined with the landtype grid, TE94. The percentage of each landtype was plotted as a frequency histogram for average rainfall values up to 500 m, then every 100 mm up to 2,800 mm.

3.6.2 Evaluation of Changes in Population Density and Landtype Proportions with Proximity to Estuaries

Human activities that occur in areas closest to estuaries are likely to have a greater and more direct impact on the estuary than activities that occur in areas within the catchment that are remote from the estuary. Data derived for population density and proportion of landtypes was divided into Fluvial drainage Areas (FDAs), Estuarine Drainage Areas (EDAs) and Estuarine Buffer Zones (EBZs) for a majority of catchments identified in this study. These represent areas with increasing proximity to the estuary.

For each catchment, the change in population density and proportions of representative landtypes was determined by subtracting values for FDAs from values for EDAs and EBZs and the values for EDAs from the values for EBZs. Where the catchment was not divided into FDA and EDA, the values for the ECA were substituted for the missing values.

A negative result indicates a decrease in the population density or landtype proportion; zero indicates no change; and a positive result indicates an increase in the population density or landtype proportion with increasing proximity to the estuary. The change was statistically significant if greater than the least significant difference (L.S.D.) of the means of the two sets of data being compared. L.S.D. was calculated as:

$$L.S.D._{(0.05)} = \sqrt{EMS} * \sqrt{2} * t_{1/2} / \sqrt{n}$$

Where:

EMS = the error mean square of the two way analysis of variance of the two sets of data being compared.

n = number of catchments

$t_{1/2}$ = the t value at p= 0.05 for a two sided test of significance of the two means with n degrees of freedom

3.7 Evaluation of Catchment Naturalness and Anthropogenic Impact

Two methods were used to group catchments according to naturalness or conversely anthropogenic impacts. The basic assumptions underlying all methods were that woody vegetation, non-woody vegetation, water, bareground and alpine landtypes represent natural landtypes. Agricultural, urban and cleared forest landtypes represent anthropogenic impact.

3.7.1 Method 1 : Calculating a Naturalness Index

For each catchment the proportion of each landtype was multiplied by an environmental impact factor (EIF) (Table 3.2). The results were summed for the whole catchment to give the naturalness index (NI):

$$NI = \Sigma(EIF * \text{Landtype Area} / \text{Catchment Area})$$

The EIF for each landtype was determined as follows. Natural landtypes were considered to have a neutral impact (EIF = 1). Agricultural and cleared forest landtypes were given an EIF = 5. This value was derived as a conservative estimate of the likely increase in nutrient and sediment loads contained in runoff from these landtypes, compared to natural landtypes. Examples quoted in section 2.8.1 suggest that nutrient levels from agricultural land and cleared forest are from 2 to 30 times higher than from the same area of natural vegetation while the volume of sediment can be considerably greater from cultivated land. Urban land was given an EIF = 100. This is again a conservative estimate of the increase in nutrient and sediment loads from urban sewage, industry effluent and runoff from urban developments compared with natural landtypes. Coughanowr (1995) reported that sewage discharges contributed around 70% of nutrient input into the Derwent Estuary. Urban land makes up less than 1% of this catchment (Appendix 5) which translates to over 200 times higher nutrient load per unit of area from urban sources than all other sources.

Table 3.2: Environmental Impact Factors used for Calculating Naturalness Index

No.	*Landtype Category*	*EIF*
1	water	1
2	rainforest	1
3	forest	1
4	woodlands	1
5	scrub	1
6	agriculture	5
7	heath or buttongrass	1
8	cleared forest	5
9	bare land or rock	1
10	urban	100
11	alpine scrub	1
12	alpine heath	1
13	alpine bare land or rock	1

Catchments were grouped into naturalness classes according to NI as shown in Table 3.3. Class 1 contains only natural landtypes and represents catchments that are largely untouched by human activities. The upper value of 1.01 was chosen to account for small errors in landtype classifications described in section 2.3.7.2. Class 2 includes catchments that have less than 25% agricultural or cleared land, class 3 has less than 50% agricultural or cleared land, class 4 has up to 75% agricultural or cleared land, class 5 has the equivalent of up to 76% agricultural or cleared land plus 4% urban land, and class 6 has the equivalent of greater than 76% agricultural or cleared land plus 4% urban land. Naturalness groups were determined for ECAs, EDAs and EBZs.

Table 3.3: Groupings by Naturalness Index

Class	*NI*	*Naturalness*
1	0-1.01	pristine
2	1.01-2	natural
3	2-3	low impact
4	3-4	moderate impact
5	4-8	high impact
6	>8	severe impact

3.7.2 Method 2: GIS Modelling of Runoff and Anthropogenic Impacts.

Method 1 described above, does not take into account the variation in runoff with rainfall intensity and different landtypes. GIS was used to incorporate these factors in a simple model relating runoff to rainfall and landtype. The aim of this model was to derive a simple, visual representation of the relative degree of naturalness of catchments or conversely the relative degree of anthropogenic impact on catchments in relation to the estuaries to which the catchments drain. The available geographic database is inadequate for complex modelling such as determining mass balance of nutrients and sediments and their movements within estuaries and their catchments.

The assumptions used in the procedure are: 1) that runoff varies with landtype, generally increasing with the change from natural to agricultural and urban landtypes; 2) the coefficient of runoff from each landtype increases with increasing annual rainfall; and 3) that the environmental impact of landtypes is neutral for natural landtypes and increases with clearing of vegetation, agricultural and urban landtypes. The environmental impact factor used is the same as that used for method 1. The derivation of runoff values for each landtype is set out below.

3.7.2.1 Derivations of Runoff Coefficients for Each Landtype

The model used values for runoff coefficients derived from United States Soil Conservation Service (SCS) curve number procedure as presented by Ward (1995). The SCS curve number is a variable that depends on infiltration rate of water into soils, land use and soil water content at the start of a rainfall event. They are derived for use in single rainfall events, not for derivation of annual runoff values using annual rainfall data.

Using the SCS runoff equation, runoff calculated for all curve numbers approaches 100% as the value used for rainfall increases (see Box 1).

Box 1: SCS Runoff Equation

Volume of surface runoff (in inches) is given by the equation:

$$Q = (P - 0.2S)^2 / (P + 0.8S)$$

Where: Q = Runoff, P = Precipitation (in inches),
S = (1000/CN) - 10. CN is known as the curve number

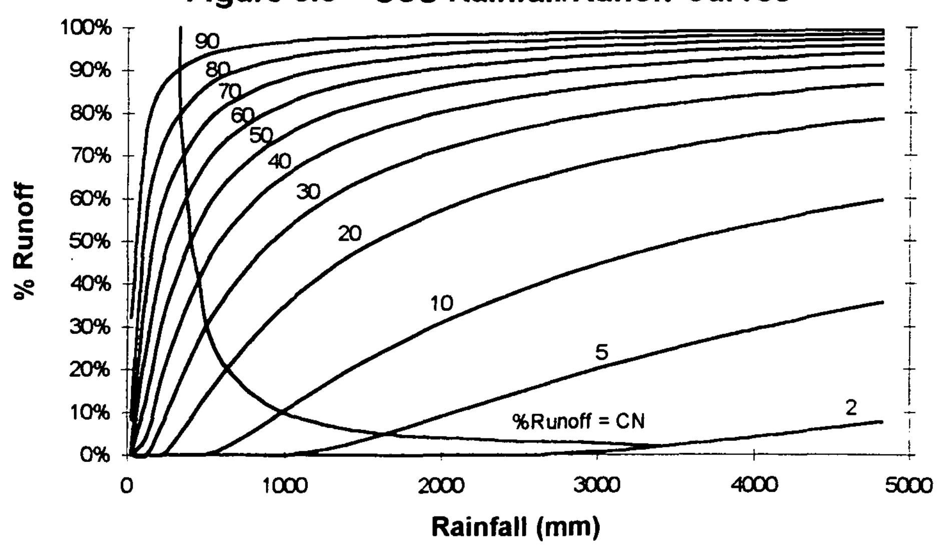
as $P \rightarrow \infty$

$$Q = P^2 / P$$

i.e. Runoff = Precipitation

This method is therefore invalid for use with annual rainfall data. However, analyses of variation in runoff with precipitation showed that runoff as a percentage of precipitation approached the value of the curve number for rainfall values equivalent to the most severe rainfall events (300-400 mm) (Figure 3.3).

Figure 3.3 SCS Rainfall/Runoff Curves



As Tasmania has relatively high rainfall levels over much of the state, and soil moisture levels are likely to be maintained at high levels for much of the year, it was considered valid to use the SCS curve numbers derived for soils with low potential runoff (high infiltration rate) to estimate runoff coefficients for different landtypes.

Further, adjustments in curve number for antecedent moisture content (AMC) were used to allow for an increase in estimated runoff in high rainfall areas. AMC1 was used for annual rainfall values of less than 750 mm; AMC2 was used for annual rainfall values between 750 and 1500 mm; and AMC3 was used for annual rainfall values greater than 1500 mm.

Table 3.4 lists SCS curve numbers for specific land uses and the runoff coefficients derived from SCS curve numbers for each SER landtype category.

Table 3.4: SCS curve numbers and Calculated Runoff Coefficients for SER Landtypes

US SCS Curve Numbers (Ward, 1995)				Calculated Runoff Coefficients for SER Landtypes			
Land Use	AMC 1	AMC 2	AMC 3	Landtype	SCS 1	SCS 2	SCS 3
				water	100	100	100
forest	12	25	44	rainforest	12	25	44
				forest	12	25	44
woodlands	26	45	65	woodlands	26	45	65
meadow	15	30	50	heath/buttongrass[1]	19	35	54
pasture, good	21	39	59	scrub[2]	26	45	65
pasture, poor	50	68	83	agriculture[3]	36	53	70
fallow, poor	62	77	89	bare ground or rock	57	74	87
cultivated	55	72	86	cleared forest[4]	55	72	86
houses	66	80	91	urban[5]	83	90	96
pavement	99	100	100	alpine[6] heath	19	35	54
				alpine scrub	26	45	65
bare	57	74	87	alpine bare	57	74	87

1. heath/buttongrass = 0.5 (forest + woodlands); 2. scrub = woodlands; 3. agriculture = 0.25 (pasture poor + pasture good + meadow) + 0.125 (fallow poor + cultivated); 4. cleared forest = cultivated; 5. urban = 0.5 (pavement + houses); 6. alpine types equal to equivalent non alpine type

The analysis of landtype and rainfall data was done using Arc/Info Grid module to classify each catchment area according to naturalness or anthropogenic impact.

The runoff coefficients for each landtype at three different moisture levels were added to the value attribute table for the SER landtype grid, TE94. The environmental impact factor for each landtype was also added. The ARC/Info terminology for each of these attributes was TE94.SCS1, TE94.SCS2, TE94.SCS3 and TE94.EIF respectively.

A grid combining runoff and environmental impact factors (ROXEIF) was created using the following logic :

while rainfall is less than 750 mm,

ROXEIF = TE94.SCS1 * TE94.EIF;

while rainfall is between 750 mm and 1500 mm,

ROXEIF = TE94.SCS2 * TE94.EIF;

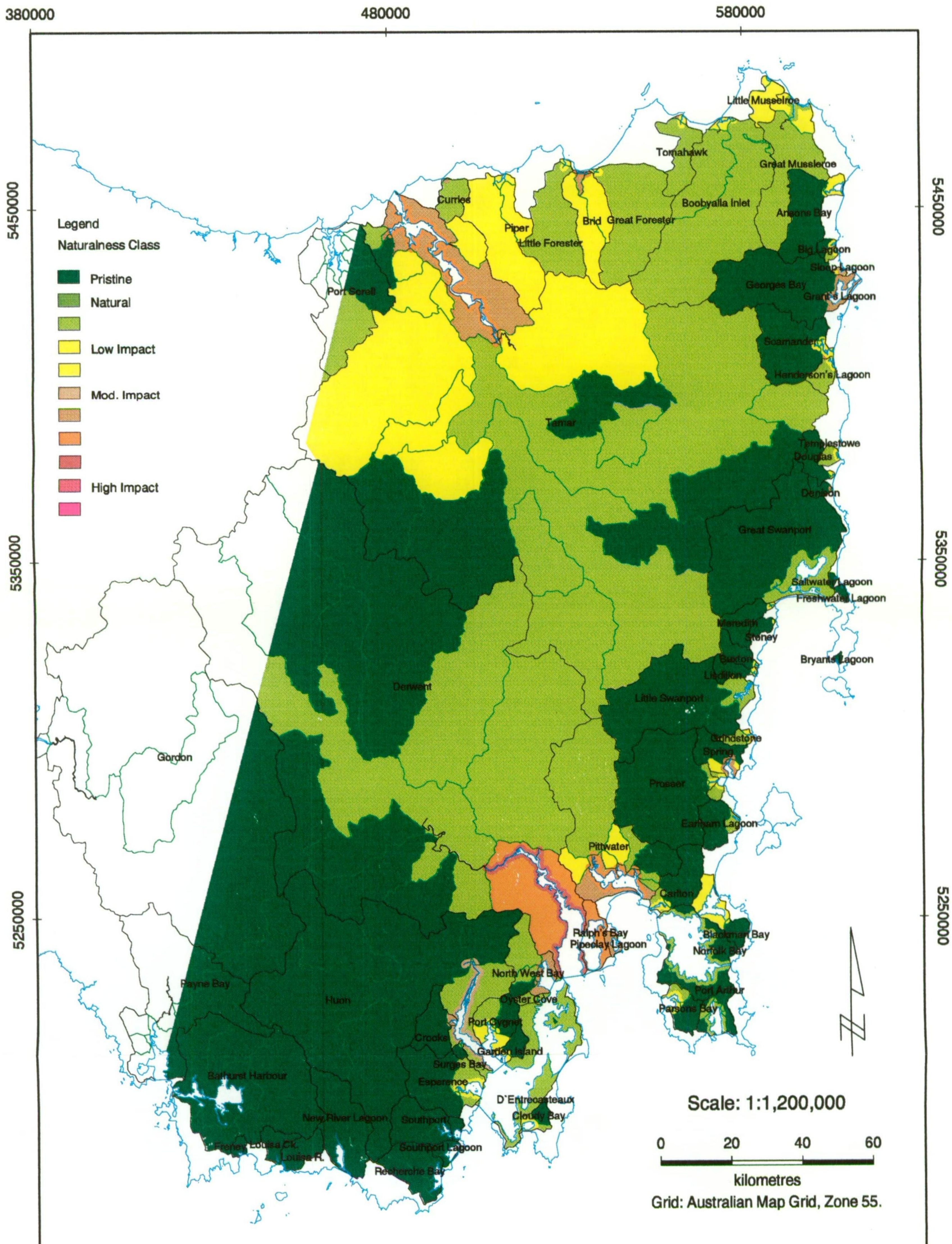
while rainfall is greater than 1500 mm,

ROXEIF = TE94.SCS3 * TE94.EIF.

The zonalmean function was then used to produce a grid with cell values equal to the average of cell values for ROXEIF within each catchment area, including EBZs, EDAs and river catchments. These cell values were then reclassed using the groupings in Table 3.5. The resulting grid map shows the relative naturalness for each catchment area, providing easy identification of highly conserved to severely impacted catchment areas for eastern Tasmania (Map 4).

Table 3.5: Reclassification Table for Average ROXEIF Values

Average ROXEIF Value	Class	Naturalness
0-100	1	pristine
100-150	2	natural
150-200	3	natural
200-250	4	low impact
250-300	5	low impact
300-350	6	moderate impact
350-400	7	moderate impact
400-500	8	high impact
500-700	9	high impact
700-1000	10	severe impact
>1000	11	severe impact



Map 4 Naturalness Classes for Eastern Tasmanian Catchments

This chapter has described the mapping of the catchments of Tasmania's estuaries and the methods used to determine the physical attributes, population and landuse within these catchments. The statistics for each catchment are appended. The results of the analyses of catchment statistics and the classification of catchments by their physical attributes and the degree of human impact are discussed and summarised in chapter 4.

Chapter 4

Results and Discussion

This chapter presents a summary of the data derived for Tasmanian estuaries and catchment areas and a discussion of the trends in different attributes for catchment areas. Groups of catchments with similar physical attributes are identified and catchment areas are ranked according to the degree of anthropogenic impact on the catchment. Specific data derived for each catchment area can be found in Appendices 1 - 6.

4.1 Tasmanian Estuaries - A Summary of Physical Attributes

Bucher & Saenger (1989) identified 63 Tasmanian estuaries in the inventory of Australian estuaries. This study identifies 122 estuaries, lagoons and embayments which are subject to fluvial drainage around Tasmania. These included the 63 estuaries previously identified, and an additional 22 estuaries identified on the Bass Strait Islands (King Island 6, and the Furneaux Group 16); 13 estuaries that are sub-estuaries of some previously defined; and 24 estuaries on mainland Tasmania that were not identified previously. The latter include 9 east coast lagoons and 15 small estuaries distributed around the coastline that were not included in the inventory of Bucher & Saenger (1989).

Table 4.1 summarises Tasmanian estuaries by type, water surface area, catchment size and estimated estuarine mixing type. These data show a relationship between estuary type and physical attributes. Average estuary water surface area and catchment area increase from lagoons to barrier estuaries and again to drowned river estuaries. Embayments have the greatest average water surface area because they include significant areas of marine waters. They may also include a number of sub-estuaries and their catchments (for example, Robbins Passage and Recherche Bay). Drowned river estuaries are more likely to have stratified conditions than barrier estuaries, lagoons and embayments. These trends are largely a reflection of catchment size and runoff. Larger catchments will generally have greater volumes of freshwater runoff, which in turn will erode deeper and wider valleys, hence producing larger estuaries. High flow volumes will help to maintain channels and reduce sediment accumulation that results in the formation of barrier and lagoon estuaries.

Table 4.1: Tasmanian Estuaries: Summary of Types and Physical Attributes

		Water surface area (km^2)			*Catchment area (km^2)*			*Estimated. Mixing Status (%)**		
Estuary type	*No*	min.	max.	mean	min.	max.	mean	mixed	partially mixed	stratified
drowned river	22	0.04	466	59.9	51	11,588	2,389	11 (50)	2 (9)	9 (41)
barrier	80	0.01	46	3.9	13	1,178	232	38 (47)	33 (41)	9 (11)
lagoon	16	0.02	12	2.1	6	78	30	14 (87)	2 (13)	
embayment	4	10.6	183	79	57	447	227	4 (100)		
totals	**122**	**0.01**	**466**	**16.8**	**5.8**	**11,588**	**577**	**67 (55)**	**37 (30)**	**18 (15)**

* figures in brackets are a % of the number of estuaries of each type.

The mixing status of estuaries is also related to the volume of runoff from the catchment as well as the degree of marine influence in the estuary or embayment. The mixing status recorded for each estuary in this study (Appendix 1) is only a rough estimate of the probable average conditions within each estuary. It is meant only as a guide to the relative proportion of catchment runoff to tidal influence in the absence of actual measurements of salinity gradients. This is relevant for consideration of factors affecting estuarine ecosystems and the distribution of estuarine biota. The actual mixing status of estuarine waters is subject to great variation, depending on unpredictable variations in river flows and more predictable tidal variations.

Of the estuaries identified as stratified, 14 out of 18 (nearly 80%) are located on the west coast of Tasmania between Payne Bay in the south and Arthur River in the north. These are narrow, drowned river estuaries that are subject to regular high river flow. They are likely to be strongly stratified for much of the time.

Stratified conditions are likely to be more common in other estuaries than estimates of mixing status suggest because the values for tidal prisms in barrier and lagoon estuaries are probably overestimated. In barrier estuaries, tidal incursion will be restricted by barrier development at the mouths of the estuaries that creates narrow openings to the open ocean. This will result in attenuation of the tidal range in the estuary and a reduced tidal exchange. Storm river flows and in some cases normal river flows will result in stratified conditions in many of these estuaries.

Many lagoons on the east coast and Bass Strait Islands are only intermittently open to the sea. Tidal incursion is obviously very restricted in these environments. However, most of these lagoons receive only low volumes of runoff. The degree of mixing in these water bodies is likely to vary as a result of thermal stratification caused by solar radiation and wind driven mixing.

The mixing of estuaries will also vary at different locations along the estuary. For example, the upper estuary of the Derwent River is highly stratified at most river flow levels while the broad lower estuary is generally well mixed except during flood flows (Coughanowr, 1995).

The tidal range around the east, south and west coasts of Tasmania is generally low (around 1 m). On the north coast between Stanley and Cape Portland the tidal range can be greater than 2.5 m on spring tides. Higher tidal ranges provide greater tidal flows and greater mixing of estuarine waters.

4.1.2 Rainfall and Runoff

Tasmania has a distinctive hydrological region within Australia. It has a cool temperate climate with rugged mountain ranges rising to about 1500 m in the west, south-east, central and north-eastern parts of the island. Heavy rainfall, in excess of 3000 mm per annum, occurs in the western highlands, reducing to 1500 mm per annum in the north-west, south-east and north-eastern highland areas. In the shadow of the mountain ranges, rainfall in central, eastern and south-eastern districts decreases to as low as 500 mm per annum. Potential evaporation in Tasmania is the lowest in Australia. Evaporation is less than 600 mm per annum in the Western Highlands but is generally higher in other inland areas and increases around the coast (AWRC, 1976; Hughes 1987).

Hughes (1987) used available hydrological data from 77 Tasmanian rivers to derive a hydrological classification of Tasmanian rivers. Rivers were divided into four distinct hydrological groups. Rivers in the south-east lowlands and coastal areas were characterised by low runoff levels and greatest variability of flow. Rivers in the west and south have high annual runoff levels with low variation in flow levels. The other two groups of rivers have characteristics intermediate to these. Rivers in the north west having higher, more predictable flows than rivers in the central north and north east of Tasmania.

The runoff values used by Hughes (1987) were derived from records of river gauging stations (RWSC, 1983). These values and mean annual rainfall values derived using GIS analysis of rainfall data, were used to extrapolate estimates of mean annual runoff for each of the catchments included in this study.

The mean of average annual rainfall and the estimated mean annual runoff for each ECA is shown in Figure 4.1. Error bars indicate the range of annual average rainfall values for each catchment. Catchment numbers refer to those listed in Appendix 1. Approximate geographical groupings of estuaries are shown. Very high rainfall values are evident for west coast and some north west catchments, whilst the rainshadow effect is evident as low rainfall values for east coast catchments. The rainfall range for each catchment is indicative of geographical location, size of the catchment and topographical relief of the catchment. Rainfall estimates for south west Tasmania are based on records from a small number of long term stations situated at low altitude. Nuñez *et al.* (1995) suggest that these estimates significantly underestimate rainfall in this region. They derived average annual rainfall values for the region using satellite images. The predicted precipitation data correlated well with variation in alpine flora. Unfortunately this data could not be accessed for this study.

4.1.3 Classification of Tasmanian Estuaries and their Catchments

The association dendrogram resulting from UPGMA analysis is shown in Figure 4.2. Five groups of estuaries were identified using an association value of around 0.5 as the cutoff level. As would be expected from analysis of essentially continuous variables, ordination analysis did not derive immediately apparent groupings. However, when coordinates for each estuary are labelled with group numbers derived by cluster analysis, these groupings were repeated in ordination analysis as seen in the plot of ordination values in Figure 4.3.

Principal axis correlation showed a strong correlation of most variables with the association matrix used for ordination analysis. The effect of each variable on the ordination of samples is shown by the vectors on the ordination plot. Correlation

Figure 4.1 Range of Annual Average Rainfall and Runoff in Catchments of Estuaries

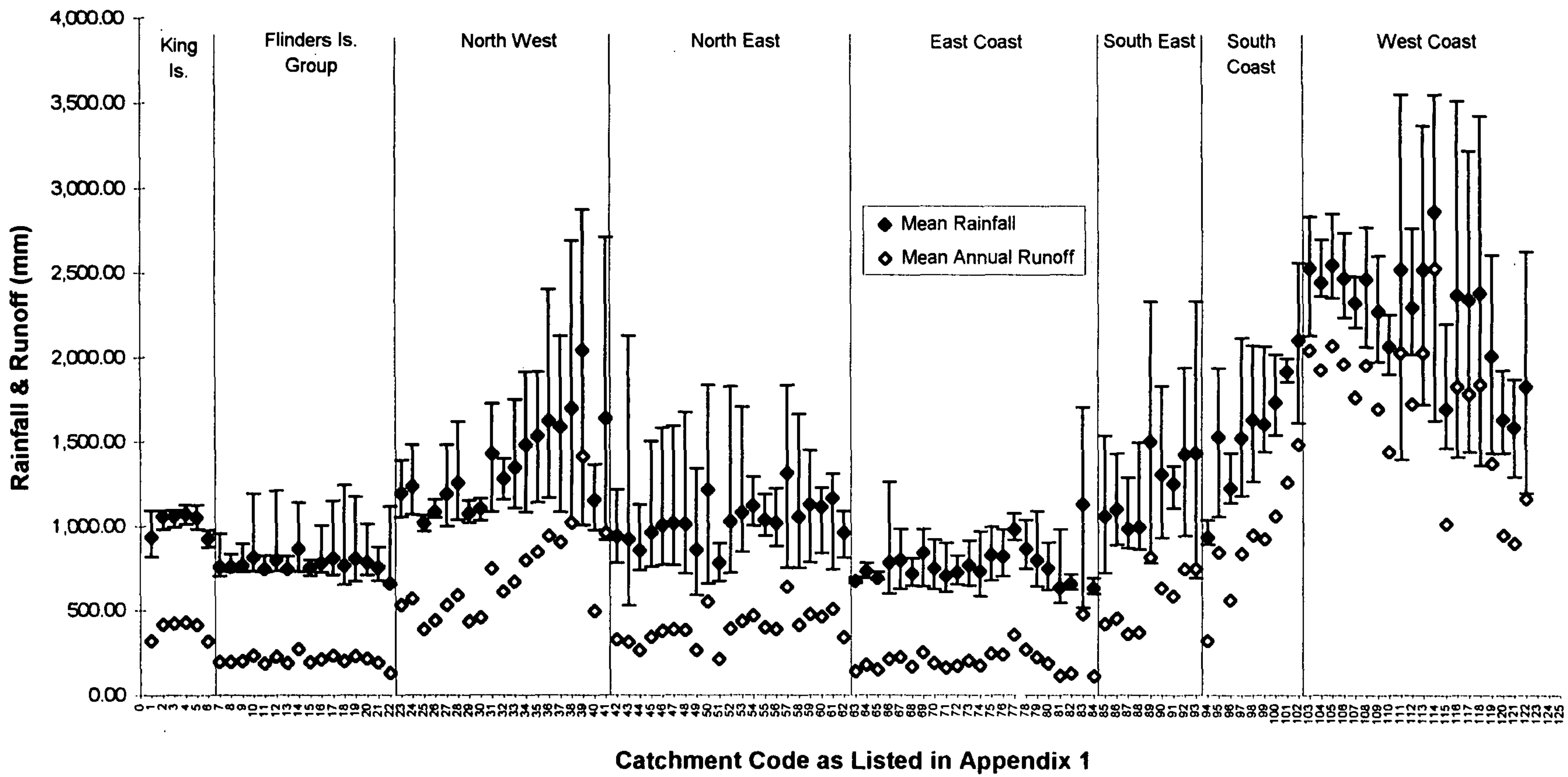


Figure 4.2 Dendrogram of Association Values Obtained by UPGMA Analysis of Physical Parameters for all Estuaries

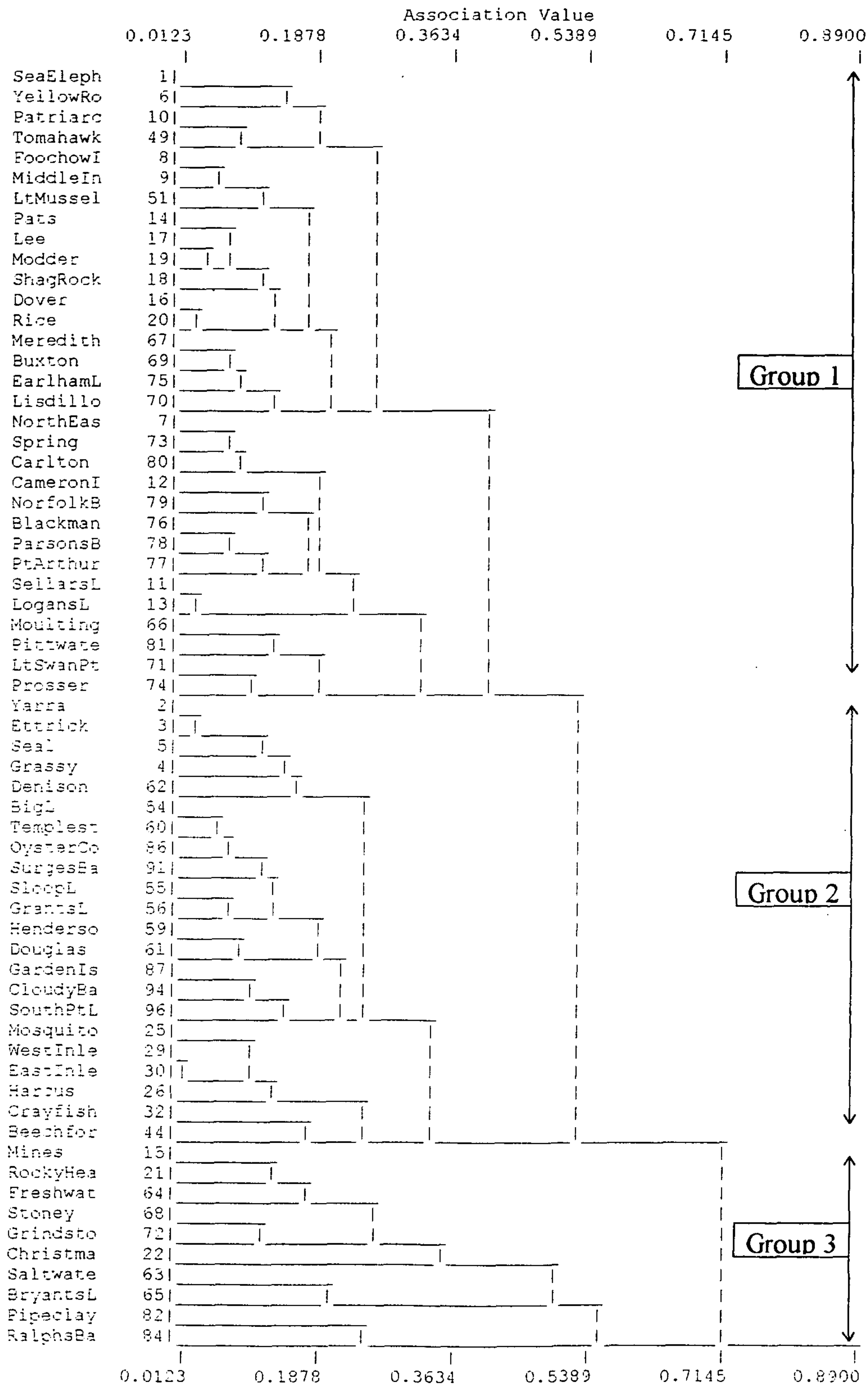


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Figure 4.2 (cont.) Dendrogram of Association Values Obtained by UPGMA Analysis of Physical Parameters for all Estuaries

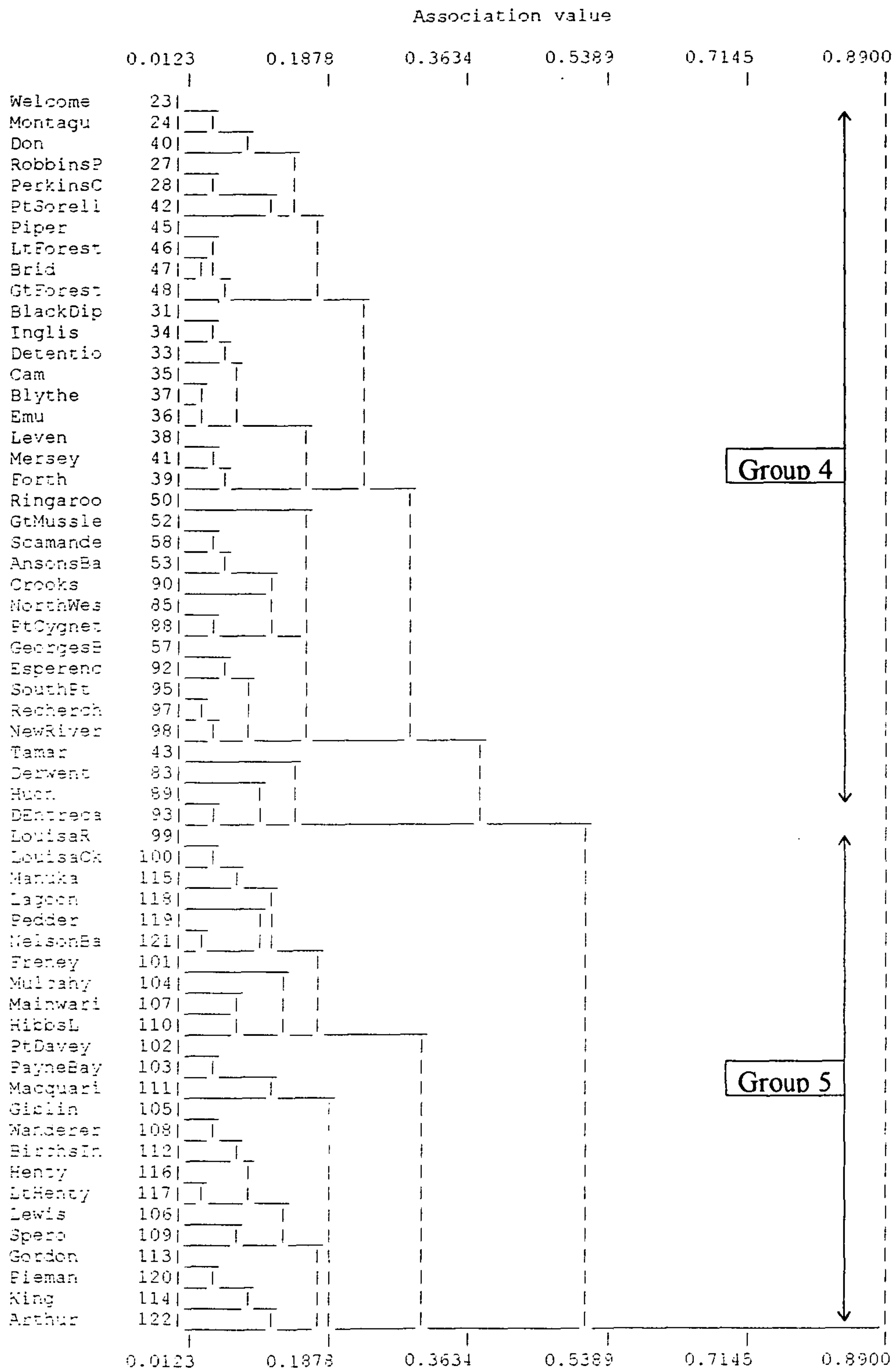
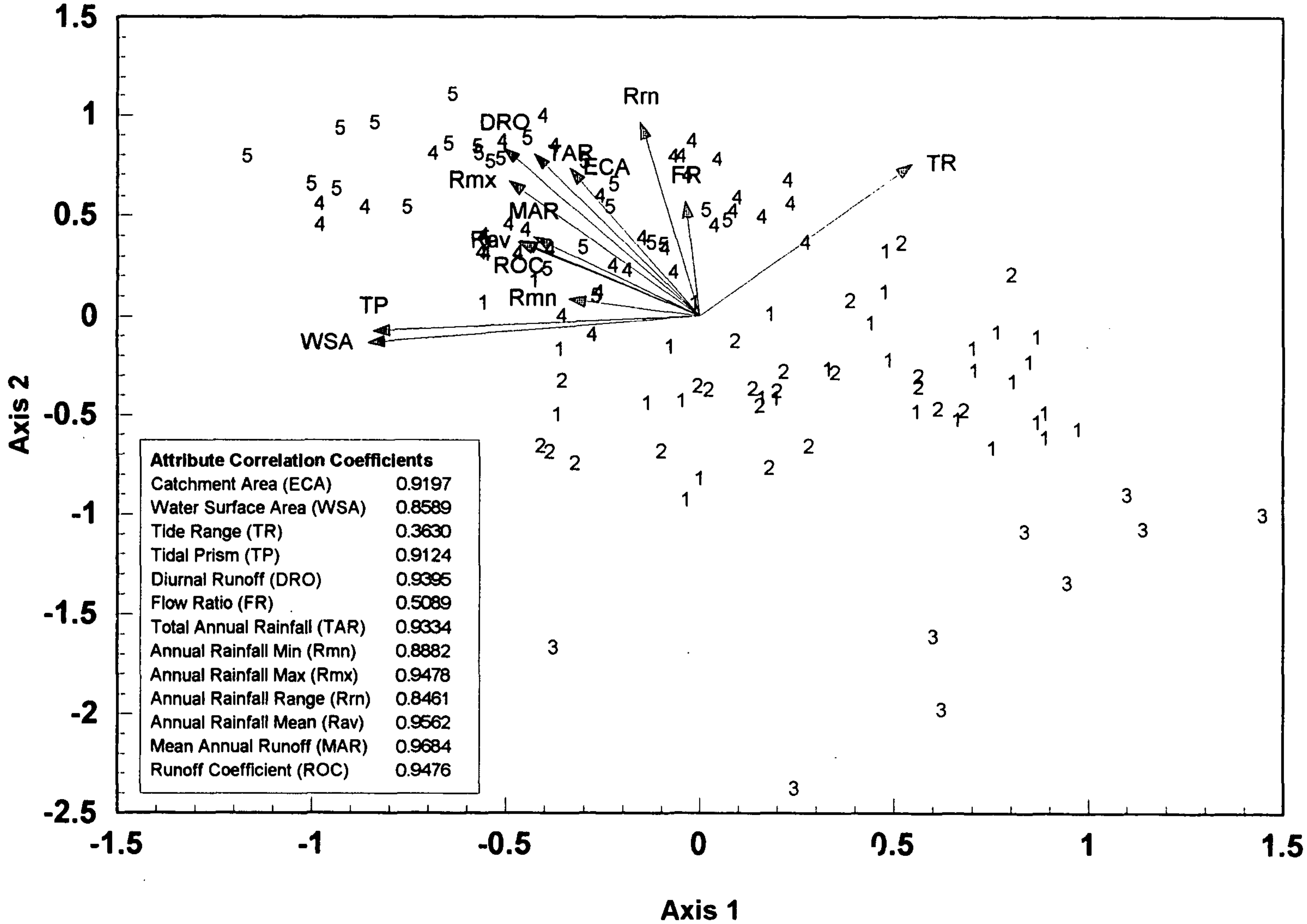


Figure 4.3 Ordination (SSH) and Principal Axis Correlation (PCC) of Physical Attributes of Estuaries and Catchments



coefficients for each attribute are also shown. Group numbers obtained for each estuary were plotted on the estuary catchment map of Tasmania (Figure 4.4). This shows a definitive distribution for each group. Groups 1, 2 and 3 represent drier catchments on the east coast and Bass Strait Islands. Groups 2 and 3 represent the smaller catchments with group 2 having higher rainfall and runoff values than group 3. Groups 4 and 5 represent higher rainfall catchments along the north, central and north west coast (group 4) and the west coast (group 5).

These groupings are very similar to those obtained for Tasmania river catchments by Hughes (1987). This is indicative of the dominance of hydrological characteristics used in the analysis and the highly distinctive hydrological regimes of the Tasmanian environment.

The groups obtained by this analysis provide a useful indication of hydrological conditions likely to be found in each estuary.

4.1.4 Regulation of Water Flow in Tasmanian Catchments

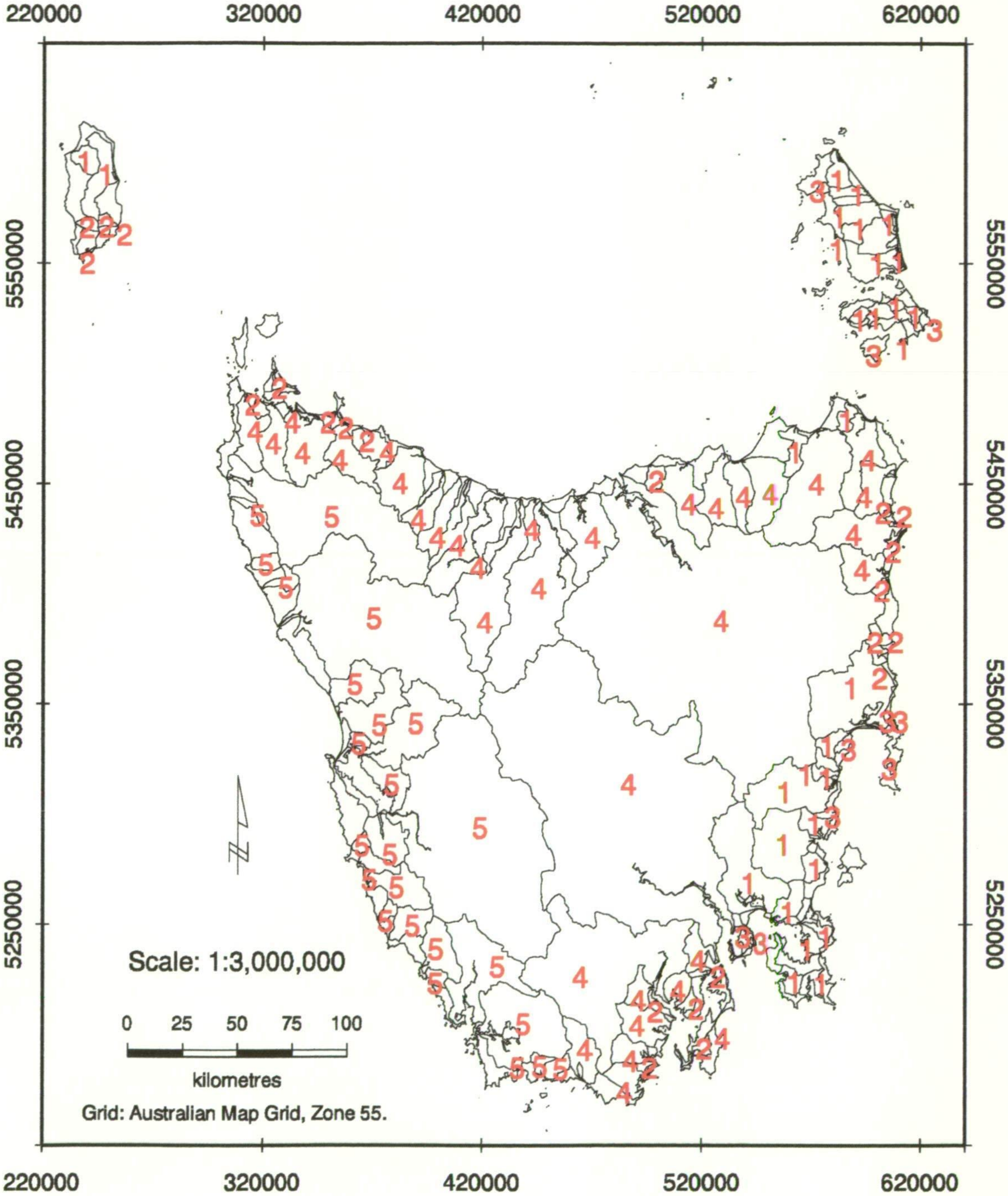
Much of Tasmania's surface water resources have been regulated for generation of hydro-electric power. This has also involved extensive water diversions between river basins. Table 4.2 lists dams used for power generation, their river catchment and diversions from other catchments, contributing catchment areas and required riparian release volumes (Frost, 1983). Hydro Electric developments have affected catchment areas of eight ECAs (including 39 major river basins) identified in this study (Appendix 2). The total catchment area contributing to hydro electric developments was calculated as 22,548 km^2, around 33% of the total land area of Tasmania.

There are a number of other large water storage dams in Tasmanian catchments that are used for irrigation and domestic water supply purposes.

The catalogue of dams in this study is incomplete as significant water storages were not all readily identified from 1:100,000 map sheets. Only 22 hydro electric dam catchments and 2 other dam catchments were defined, although this did represent all of the catchment areas contributing to hydro electric power.

Figure 4.4 Classification of Tasmanian Catchments

Groups Obtained by Heirarchical Cluster Analysis (UPGMA)



The effects of dams on estuarine processes in Tasmania has not been extensively studied. Davies & Kalish (1989) suggest that changed flow regimes in the Derwent River have prevented adequate flushing of the upper estuary. Reduced flood flows in conjunction with increased organic loading from paper mill effluent have resulted in the development of anoxic conditions in sections of the upper estuary.

Table 4.2: Statistics for Dams and Water Diversions for Production of Hydro-Electricity in Tasmania

Dam	Capacity (MW)	River	Diversions	Catchment Area dam (diversions) km^2	Riparian Release m^3/s
Tarraleah	90	Derwent	Franklin/Wentworth	582 (118)	
Waddamana B	48	Ouse	Great Lake	(Penstock lagoon 5) (Shannon lagoon 22)	
Butlers Gorge	12.2	Derwent	Upper Franklin	582 (9)	
Tungatinah	125	Nive	Ouse/Clarence/Dee	50 (1350)	0
Trevallyn	80	South Esk	Great Lake	8986 (628)	0.42
Lake Echo	32.4	Dee	Little Pine/Ouse	139 (530)	0
Wayatinah	38.25	Derwent	Ouse/Dee	2390 (363)	
Liapootah	83.7	Nive	Ouse/Dee	1449 (363)	
Catagunya	48	Derwent	Ouse/Dee	2993 (363)	
Poatina	300	Shannon	Ouse/Liffey/Brumby Ck.	408 (262)	0.57
Tod's Corner	1.6	Lake River	Westons Rt.	263	0
Meadow Bank	40	Derwent	Great Lake	6545 (628)	17.0
Repulse	28	Derwent	Dee/Ouse	3106 (363)	0
Rowallan	10.5	Mersey		338	0
Lemonthyme	51	Forth	Mersey	(696)	0.03
Devils Gate	60	Forth	Mersey/Wilmot	723 (829)	0
Wilmot	30.6	Wilmot		133	0.56
Cethana	85	Forth	Mersey/Wilmot	594 (829)	0
Cluny	17	Derwent	Ouse/Dee	3251 (363)	11.33
Paloona	28	Forth	Mersey/Wilmot	759 (829)	0.7
Fisher	43.2	Fisher		75	
Gordon Stage 1	288	Gordon	Lake Pedder/Huon	1280 (734)	2.83
Mackintosh	80	Pieman	Murchison	512 (750)	0
Bastyan	80	Pieman		1397	0
Pieman	224	Pieman		2653	8
Anthony Henty	82	Anthony	Henty	37.2 (90.6)	0
King	130	King		561	

Source: Frost, 1983

In the Gordon River, high summer flows maintained by operation of the power station has reduced the upstream penetration of saline waters. This has disturbed the equilibrium of a number or meromictic lakes that rely on annual replenishment of saline waters during low summer flows (King & Tyler, 1982, 1983).

The quality of water released from the large hydro electric dams has recently come under scrutiny. A large fish kill in the Pieman River below the power station outlet was caused by expanding air bubbles that resulted from air entrainment during power station operation. A study of water quality and potential impacts of land uses in the Pieman catchment was instigated. Early results suggest that there is an accumulation of heavy metal pollution in dam waters (O'Donnell & Livingston, 1992). The study has not yet been completed.

Low dissolved oxygen concentration and elevated levels of organic matter were detected in the lower King River and Macquarie Harbour after the operation of the John Butters power station commenced in April 1992. Water for operation of the power station is drawn from the deep deoxygenated waters of Lake Burbury. The problem has been largely resolved by the entrainment of air in the turbine operation. However, monitoring for dangerous levels of hydrogen sulphide and supersaturation of released waters is a continuing requirement. Methods to destratify lake waters are being considered as a long term solution (Sanger, 1993).

Lake Burbury is also being monitored for heavy metal contamination from old mine workings. However the solution to this problem has been to divert polluted waters into the already heavily polluted Queen River, which flows into the King River and Macquarie Harbour (O'Donnell & Livingston, 1992).

4.2 Population and Dwellings in Tasmanian Catchments

The 1991 census of Tasmanian population (ABS, 1993) recorded a total population of 452,851. Population statistics were collected from 953 collection districts (CDs), with an average population of 475 (mode 426). The census counted 156,686 dwellings of which 138,929 (around 88%) were occupied on census night (Table 4.3).

Table 4.3: Summary of Census Data for Tasmania 1991

	Total	mean	mode
No. of CDs	953	-	-
population	452851	475	426
dwellings	156686	164	133
occupied dwellings	138929	146	140
% occupied	88.7	89	-

GIS analysis of population and dwelling densities gave estimates of population and dwellings for each catchment area (Appendix 3). These results are summarised for ECAs, FDAs, EDAs and EBZs in Table 4.4. Errors in these estimates result from mismatching of catchment boundaries and CD boundaries (as discussed in section 3.5), loss of resolution in transforming data from a vector coverage to a grid, and using a 1 ha grid cell size for analysis. The total population for Tasmania derived by GIS analysis is 447,096. This underestimates the population by around 1.3%.

Table 4.4: Total Population and Dwellings in Tasmanian Catchments

	population		dwellings		occupied	
	no.	% of total	no.	% of total	no.	%
ECAs	394527	88.2	158995	87.0	141849	89.2
FDAs	145406	32.5	59543	32.6	51457	86.4
EDAs	249074	55.6	99432	54.5	90376	90.9
EBZs	159334	35.6	64218	35.2	57545	89.6
outside catchments	52569	11.8	23564	12.9	19219	81.6
Tasmania	447096	100	182560	100	161067	88.2

80% of Tasmania's population lives within ECAs, with nearly 56% living in areas that drain directly to estuaries (EDAs), and 36% living within 1 km of an estuary (EBZs). Thirty-two % live in inland river catchments, while around 12% live outside ECAs (Table 4.4). The area outside catchments mostly consists of land in the coastal zone that drains directly to the ocean or to small streams that run into the ocean and are not identified as estuaries in this study. Adding the population outside of catchments to the population in estuarine drainage areas gives an estimation of the population inhabiting the coastal zone of Tasmania. By this calculation, approximately two thirds (67%) of the population lives in the coastal zone.

4.2.1 Change in Population Density with Proximity to Estuaries

The population and density of population has a significant bearing on the degree of anthropogenic impact on a catchment. Development and industry are generally associated with higher population densities as requirements for labour increase. Sewage loads increase with increasing population. Where population centres in Australia are located near estuaries or the coastline, sewage and industrial effluent have been traditionally disposed of in adjacent estuarine or coastal waters (Brodie, 1995). This is also true of Tasmania. Around the state there are 45 sewage treatment plants that discharge directly to coastal or estuarine waters (Rees, 1995).

The frequency of catchment areas with different ranges of population level is shown in Table 4.5, while Table 4.6 shows the range of population densities in catchment areas. There are only two ECAs with populations greater than 100,000. These are the Derwent Estuary catchment (pop. 171,000) and the Tamar Estuary catchment (pop. 110,000). Another three catchments (Mersey pop. 20,000; Huon, pop. 11,000; and D'Entrecasteaux, pop. 21,000) have populations greater than 10,000. Twenty-three ECAs have populations less than 10 while a further 41 catchments have populations less than 100. Over 50% of all catchment areas have an average population density of less than 1 person/km^2.

Table 4.5: Frequency of Different Population Levels in Tasmanian Catchments

	population level*					
catchment	0-10	10-100	100 - 1,000	1,000 - 10000	10,000 - 100,000	>100,000
ECAs	23(19)	41(34)	29(24)	24(20)	3(2)	2(2)
FDAs	38(19)	65(33)	27(14)	2(1)	0	
EDAs	59(48)	30(25)	17(14)	12(10)	3(2)	1(1)
EBZs	73(60)	16(13)	19(16)	12(10)	2(2)	0

* figures in brackets are a % of the total number of catchments

Table 4.6: Population Densities in Tasmanian Catchments

	population density (pop/km^2)*				
catchment	0-1	1-2	2-20	20-200	>200
ECAs	62(51)	19(16)	37(30)	4(3)	0
FDAs	106(54)	28(14)	59(30)	4(2)	0
EDAs	67(55)	14(11)	21(17)	16(13)	4(3)
EBZs	69(57)	10(8)	16(13)	20(17)	6(5)

* figures in brackets are a % of the total number of catchments

Analysis of the difference in population densities of ECAs, EDAs and EBZs shows that population density increases with proximity to the estuary (Table 4.7). The increase in population density is statistically significant in 23 (19%) of EDAs (least significant difference - l.s.d. = 9.6/km^2) and 24 (20%) of EBZs (l.s.d. = 14/km^2). Twenty-one (17%) of EBZs have significantly higher population density than the surrounding EDA (l.s.d. = 6.5/km^2). One EBZ has a significantly lower population density than the ECA. In the Ralph's Bay catchment the major population centre, Rokeby, is more than 1 km from the bay. The EDAs of the Don, North West Bay and Emu estuaries have significantly greater population densities than their EBZs. The highest population densities of Devonport, Margate and Burnie respectively, are more than 1 km from these estuaries. However, their population densities within both the EDAs and the EBZs of these estuaries are significantly greater than for their whole ECA or FDAs.

Table 4.7: Analysis of Change in Population Density with Proximity to Estuaries

	Change in population density/km^2										
	negative				zero	positive					
Catchments compared	15-100	10-15	6-10	0-6	0	0-6	6-10	10-15	15-100	>100	l.s.d. (p=0.05)
EBZ-FDA	1*	0	1	35	14	41	2	3	16*	6*	14.5
EBZ-EDA	3*	0	0	49	12	35	7*	2*	10*	4*	6.5
EDA-FDA	0	0	1	34	12	49	3	5*	11*	8*	10

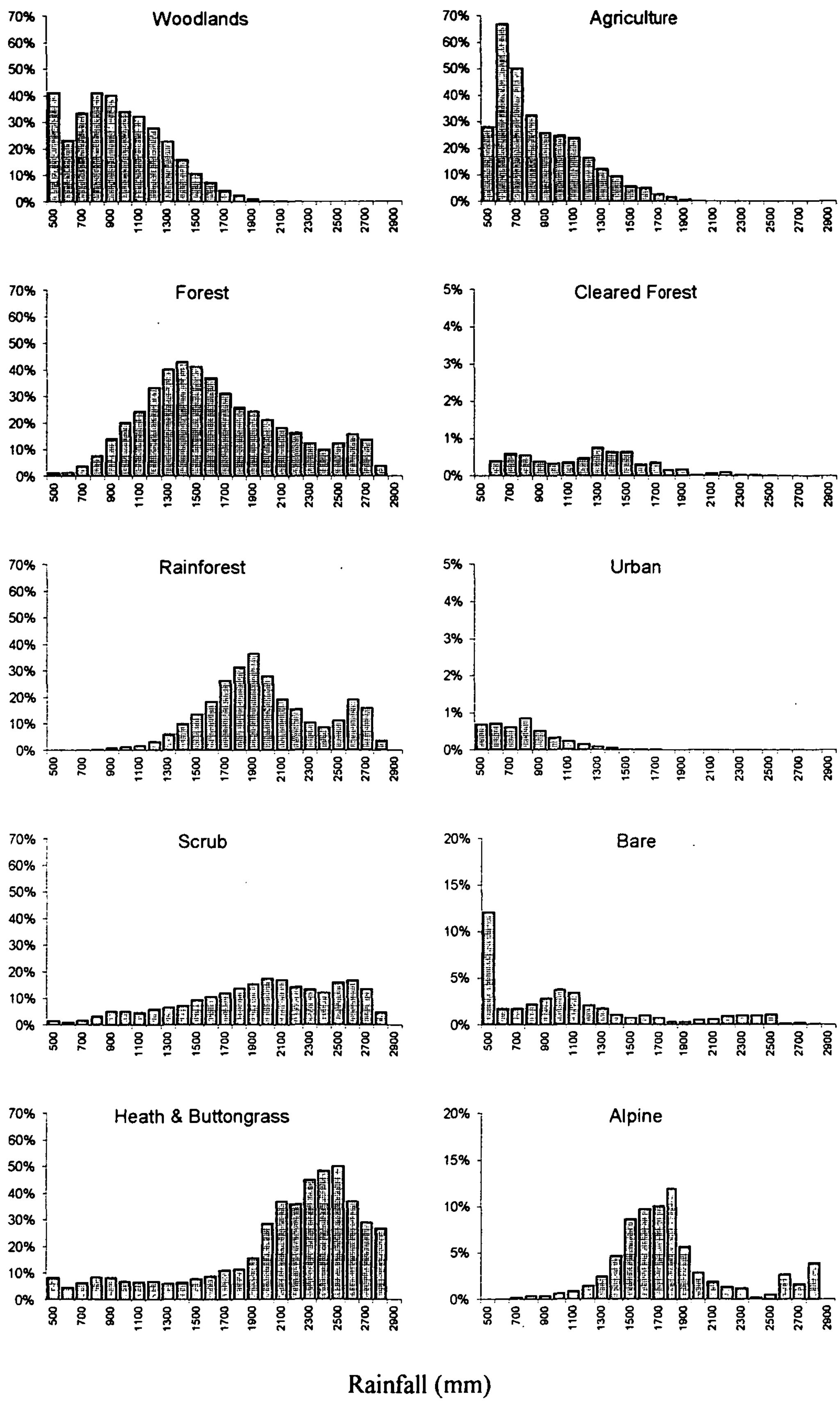
*change in population density > l.s.d. of two means at p = 0.05

4.3 Analysis of landtypes in Tasmanian Catchments

4.3.1 Distribution of Landtypes with Annual Average Rainfall

The proportion of landtypes varies with annual average rainfall (Rav). The proportion of each landtype within successive 100 mm rainfall ranges is shown in Figure 4.5. Rainfall appears to affect the distribution of vegetation types and anthropogenic activities. However, variation in rainfall is likely to reflect variation in a number of other factors such as altitude, topography and soil types. The proportion of agricultural land is highest where rainfall is less than 600 mm per year and decreases to zero at annual rainfall values of 2000 mm per year and above. This reflects the large areas of dry land pasture and grazing holdings in the midlands and east coast regions of the state and the use of river flats and valleys for more intensive agricultural production. The low lying topography of

Figure 4.5 Variation in Proportion of Landtype with Average Annual Rainfall



these areas makes land clearance and farming operations easier than in the high rainfall zones where topography and impenetrable vegetation growth would make these activities difficult or impossible.

Most urban development has occurred in low rainfall areas (<1000 mm) with little settlement in areas with annual rainfall greater than 1700 mm. Most urban development has occurred within the vicinity of estuaries and rivers in the south-east and north of the state where ports and estuaries have acted as centres for trade, industry and commercial fisheries.

The distribution of natural vegetation type appears to be most dependent on rainfall distribution. Woody vegetation types show distinct changes in distribution with rainfall. The woodlands category represents dry schlerophyll forests. This is the dominant forest type at annual rainfall values less than 1200 mm. The forest category probably represents mixed forests of wet and dry schlerophyll that are predominant between 1200 mm and 1700 mm. Rainforests are largely restricted to areas with annual rainfall of greater than 1500 mm. Areas of rainforest identified at lower rainfall levels are probably located in moist, sheltered gullies where rainfall is locally higher than averages suggest but not recorded at the resolution of the rainfall data used. The proportion of heath and buttongrass category increases markedly at rainfall values greater than 2000 mm. This may reflect the ability of vegetation in this category to withstand high soil moisture levels.

In addition to a peak in the proportion of bare ground at low rainfall levels (< 500 mm), there is a another peak between rainfall levels of 1000 mm and 1200 mm. The first peak probably corresponds to beaches and coastal sand dunes in low rainfall coastal areas while the second peak corresponds to rainfall values on the escarpments and steep rocky slopes of the Ben Lomond Plateau, The Western Tiers, The Mount Wellington Range and other southern ranges. The distribution of alpine land types corresponds to annual rainfall levels of 1500 mm to 2800 mm.

4.3.2 Land use in Eastern Tasmanian Catchments

The digital land classification data set made available for this study covered land in the south, east and north east of mainland Tasmania, east of a line joining Payne Bay in the south, to West Head at the mouth of the Tamar River in the north. It covers an area of around 39,000 square kilometers, representing approximately 58% of Tasmania's land surface. This area covered 59 whole ECAs, 86% of the Derwent estuary catchment and a proportion of the Port Sorell (56%), Payne Bay (41%) and Gordon (24%) estuary catchments. The coverage includes 108 river catchments. The catchments covered include representative catchments from all groups identified by the classification of estuaries using physical attributes (section 4.1.3). They include catchments in the remote, almost pristine south of the state with high rainfall and runoff, the most heavily populated and developed catchments in Tasmania with moderate rainfall in the south-east and north-east of the state, and catchments in the low rainfall area of the east coast - from the small untouched lagoon catchments found in Freycinet National Park, to larger catchments with varying degrees of development and clearance for agricultural production. The data set did not cover any of the Bass Strait Islands or catchments of estuaries on the west, north-west or north-central coastal areas of Tasmania.

More than 50% of the land is classified as one of the woody vegetation types, and around 16% is classified as scrub, heath or buttongrass, 2% is classified as alpine landtypes and 2% as natural or man-made water storages. Less than 0.5% is classified as urban land or cleared forest, while 25% is classified as agricultural land.

Bucher and Saenger (1989) identified the need for more information on landuse and catchment clearance in their inventory of Tasmanian estuaries. Of the 63 estuaries identified in their study they classified 17 catchments as sparsely developed (<25% of the catchment cleared of native vegetation for agricultural or urban development), and another 46 catchments as insufficient information. The 17 catchments classified are remote, largely untouched catchments on the south-west coasts from New River to Mosquito Inlet. This classification is justified for most of these catchments, however some of them are significantly impacted by the effects of mining and agriculture. Unfortunately the landuse of most of these catchments could not be reviewed in this study because the data-set did not extend to cover them.

There have been comprehensive studies on land systems (Richley *et al.*, 1978-1989), land clearance (Kirkpatrick & Jenkin, 1996), land degradation (Grice, 1995) and land capability (Noble, 1992) in Tasmania, but none of these has focussed on catchments as a unit of study.

4.3.3 Change in Proportion of Landtypes with Proximity to Estuaries

The area and proportions of each landtype in the catchments covered by the landtype data are given in Appendices 4 and 5 respectively. The results are summarised for 60 ECAs, FDAs, EDAs and EBZs in Table 4.8. Catchment areas are ranked according to the proportion of each of the following landtype groups: cleared land (agricultural, urban and cleared forest); woody vegetation (rainforest, forest and woodlands); and herbaceous vegetation (heath, buttongrass and scrub). A high proportion (nearly 60%) of the 60 ECAs are only sparsely cleared for human uses, with a small proportion having greater than 40% of natural vegetation cleared.

Table 4.8: Frequency of Catchment Areas with Different Proportions of Landtype Groups

		Proportion of Catchment				
Landtype Group	Catchment	*0-20%*	*20-40%*	*40-60%*	*60-80%*	*80-100%*
Cleared (agriculture, urban, cleared)	ECA	35(58)	17(28)	5(8)	3(5)	0
	FDA	37(62)	15(17)	5(8)	3(5)	0
	EDA	25(42)	13(22)	8(13)	13(22)	1(2)
	EBZ	23(38)	11(18)	8(13)	15(17)	3(5)
Woody Vegetation (rainforest, forest, woodlands)	ECA	3(5)	5(8)	15(17)	36(60)	1(2)
	FDA	3(5)	3(5)	13(22)	38(63)	3(5)
	EDA	12(20)	10(17)	19(32)	19(32)	0
	EBZ	16(27)	16(27)	17(28)	11(18)	0
Heath & Scrub (heath & scrub)	ECA	43(72)	12(20)	1(2)	2(3)	1(2)
	FDA	43(72)	12(20)	3(5)	1(2)	1(2)
	EDA	41(68)	13(22)	1(2)	0	5(8)
	EBZ	41(68)	11(18)	3(5)	0	5(8)

* figures in brackets are a % of the total number of catchments.

There is an apparent increase in the proportion of land cleared for human uses with increasing proximity to estuaries and a concomitant decrease in proportion of woody vegetation. Twenty-two EDAs and 26 EBZs have greater than 40% of cleared land with more than 80% of land cleared in one EDA and 3 EBZs. The proportion of both agricultural land and urban land increases in EDAs and EBZs (Tables 4.9 & 4.10).

Table 4.9: Proportion of Agricultural Land in Catchments

	0-20%	*20-40%*	*40-60%*	*60-80%*	*80-100%*
ECA	36(60)	16(27)	5(8)	3(5)	0
FDA	39(65)	13(22)	6(10)	2(3)	0
EDA	27(45)	13(22)	9(15)	10(17)	1(2)
EBZ	23(38)	15(17)	4(7)	15(17)	3(5)

* figures in brackets are a % of the total number of catchments

Table 4.10: Proportion of Urban Area Within Catchments

	0-0.5%	*0.5-1%*	*1-2%*	*2-4%*	*4-8%*	*>8%*
ECA	51(85)	5(8)	2(3)	1(2)	1(2)	0
FDA	56(93)	1(2)	1(2)	2(3)	0	0
EDA	27(45)	16(27)	5(8)	9(15)	3(5)	0
EBZ	22(37)	10(17)	15(17)	6(10)	6(10)	1(2)

* figures in brackets are a % of the total number of catchments

Conversely, the proportion of woody vegetation is reduced in EDAs and EBZs (Table 4.8). The proportion of heath and scrub remains fairly consistent across catchments except for 5 remote, high rainfall catchments in the south of the state where extensive buttongrass plains and coastal heath cover coastal lowlands surrounding the estuaries and river channels (Table 4.8).

These trends are confirmed by the analysis of the change in the proportion of woody, agricultural and urban landtypes between FDAs, EDAs and EBZs. This analysis shows that catchment clearance and development increases with proximity to the estuary in the majority of catchments where there has been any land clearance. Using the least significant difference between the means of the data sets being compared (as described in section 3.6.2), the proportion of agricultural land in the EDAs and EBZs is significantly greater than the proportion in FDAs in more than 50% of the catchments studied. It is significantly less in 5% of catchments. Fifty per cent of EBZs have a significantly greater proportion of agricultural land than the corresponding EDAs while 12% have less (Table 4.11). The proportion of urban land is also greater in around 50% of EDAs and EBZs. One-third of these EBZs are more urbanised than their EDAs whilst EBZs are less urbanised than the EDAs in 4 catchments (8%) (Table 4.12).

Table 4.11: Change in Proportion of Agricultural Land with Proximity to Estuaries

	Change in Proportion of Agricultural Land (%)											
	negative				zero	positive						
Catchments Compared	10-20	5-10	2.5-5	0-2.5	0	0.2.5	2.5-5	5-10	10-20	20-50	>50	l.s.d. (0.05)
EBZ-FDA	1*	2*	2	2	7	7	4	4*	9*	15*	7*	5.43
EBZ-EDA	4*	1*	3*	3	7	10	6*	15*	8*	3*		2.41
EDA-FDA	1*	0	3	3	18	2	3	6*	10*	19*	4*	4.9

*change in proportion of agricultural land > l.s.d. of two means at p = 0.05

Table 4.12: Change in Proportion of Urban Land with Proximity to Estuaries

	Change in Proportion of Urban Land (%)										
	negative				zero	positive					
Catchments Compared	1-5	0.6-1	0.3-0.6	0-0.3	0	0-0.3	0.3-0.6	0.6-1	1-5	>5	l.s.d. (0.05)
EBZ-FDA	0	0	0	1	7	10	12	7*	22*	1*	0.66
EBZ-EDA	1*	1*	2*	8	7	20	4*	9*	7*	1*	0.44
EDA-FDA	0	0	0	0	17	12	118	7*	12*	1*	0.31

*change in proportion of urban land > l.s.d. of two means at p = 0.05

Conversely, the proportion of woody vegetation decreases significantly with increasing proximity to estuaries in over 60% of catchments (Table 4.13). The decrease in the proportion of woody vegetation is closely correlated ($r^2 = 0.68$) with the increase in the proportion of anthropogenic landtypes in nearly all catchments. In catchments where there is little or no human impact, decrease in woody vegetation is correlated with an increase in herbaceous vegetation ($r^2 = 0.99$). When changes in the proportion of human landtypes are summed with changes in herbaceous landtypes, there is a very strong inverse correlation with woody landtypes for all catchments ($r^2 = 0.97$). The decrease in woody vegetation with increasing proximity to estuaries is completely explained by a combination of clearance for human land use and displacement by herbaceous vegetation types.

Table 4.13: Change in Proportion of Woody Vegetation with Proximity to Estuaries

	Change in Proportion of Woody Vegetation (%)											
	negative						zero	positive				
Catchments Compared	>50	20-50	10-20	4-10	2-4	0-2	0	0-2	2-4	4-10	10-20	l.s.d (0.05)
EBZ-FDA	7*	25*	13*	5*	3	4	0	1	1	1*	0	4.5
EBZ-EDA	0	2*	16*	17*	8*	4	0	3	4*	5*	1*	2.36
EDA-FDA	4*	20*	11*	6*	2	2	13	1	2	0	0	4.54

*change in proportion of woody vegetation > l.s.d. of two means at p = 0.05

4.4 Catchment Naturalness Index

Appendix 6 lists the naturalness index (NI) and naturalness group for each of the catchment areas covered by the available landtype data. They are listed in descending order of NI for EBZs. The results are summarised for EBZs, EDAs and ECAs in Table 4.14.

Table 4.14: Summary of Naturalness Groups of Catchment Areas

	Catchment Area		
Class	EBZ	EDA	ECA
(1) Pristine	7	6	7
(2) Natural	5	10	26
(3) Low Impact	9	16	20
(4) Moderate Impact	16	5	4
(5) High Impact	19	22	3
(6) Severe Impact	4	1	0
Totals	60	60	60

Three ECAs are rated highly impacted (Ralph's Bay, Pipeclay Lagoon and Little Musselroe Bay); the Derwent Estuary EDA is rated severely impacted and a further 22 EDAs are rated highly impacted; four EBZs are rated as severely impacted (Derwent, Ralph's Bay, Pittwater and Tamar estuaries); and a further 19 EBZs are rated highly impacted.

It is difficult to compare these results to studies of estuaries in Australia or other parts of the world. Significant water quality problems have been documented in both the Derwent

Estuary (Davies & Kalish, 1994; Bloom & Ayling, 1977) and the Pittwater Estuary (Armstrong & Guidici, 1995; Jones *et al.*, 1994). Bucher & Saenger (1989, 1991) identified 15 Australian estuaries with 'poor' water quality and 18 with 'fair' water quality. Of Tasmanian estuaries, water quality in the Derwent was classed as 'poor' and in Pittwater as 'fair'. They identified 36 ECAs around Australia with greater than 75% clearance of natural vegetation. No Tasmanian catchments are cleared to this degree although there are 3 catchments with greater than 60% of natural vegetation cleared - Little Mussleroe Bay (74%), Pipeclay Lagoon (72%) and Grindstone Bay (64%) catchments.

Seven catchments in this study were identified as pristine. Five of these catchments are located within the Tasmanian Wilderness World Heritage Area (Louisa Creek, Louisa River, Freney Lagoon, Port Davey and New River Lagoon). Southport Lagoon and its catchment are protected as a wildlife reserve and no clearing has occurred in the catchment. Recherche Bay ECA and EBZ are rated as pristine although there are some areas of forestry operations within these catchment areas. There are 30 ha of cleared forest identified in this catchment. The majority of this landtype occurs within the EDA (21 ha) but outside the EBZ.

A further 5 estuaries have EBZs , EDAs and ECAs classified as natural. These are Saltwater, Freshwater and Bryants Lagoons, which are contained within the Freycinet National Park, and Southport and Port Arthur. The latter two estuaries have only 2, 5 and 5 %, and 7,9 and 11 % of land cleared for human use in their ECAs, EDAs and EBZs respectively. A further 21 ECAs are rated as natural. However, of these, 7 have lightly impacted EBZs, 7 have moderately impacted EBZs and 7 have highly impacted EBZs.

The proportion of landtypes in each catchment are shown in Figures 4.6a (FDAs), 4.6b (EDAs) and 4.6c (EBZs). Catchments have been ranked by NI which is shown on the right hand axis of each graph. Naturalness classes are indicated along the x-axis.

Figure 4.6a Percentage of Landtypes in FDAs - Ranked by Naturalness Index.

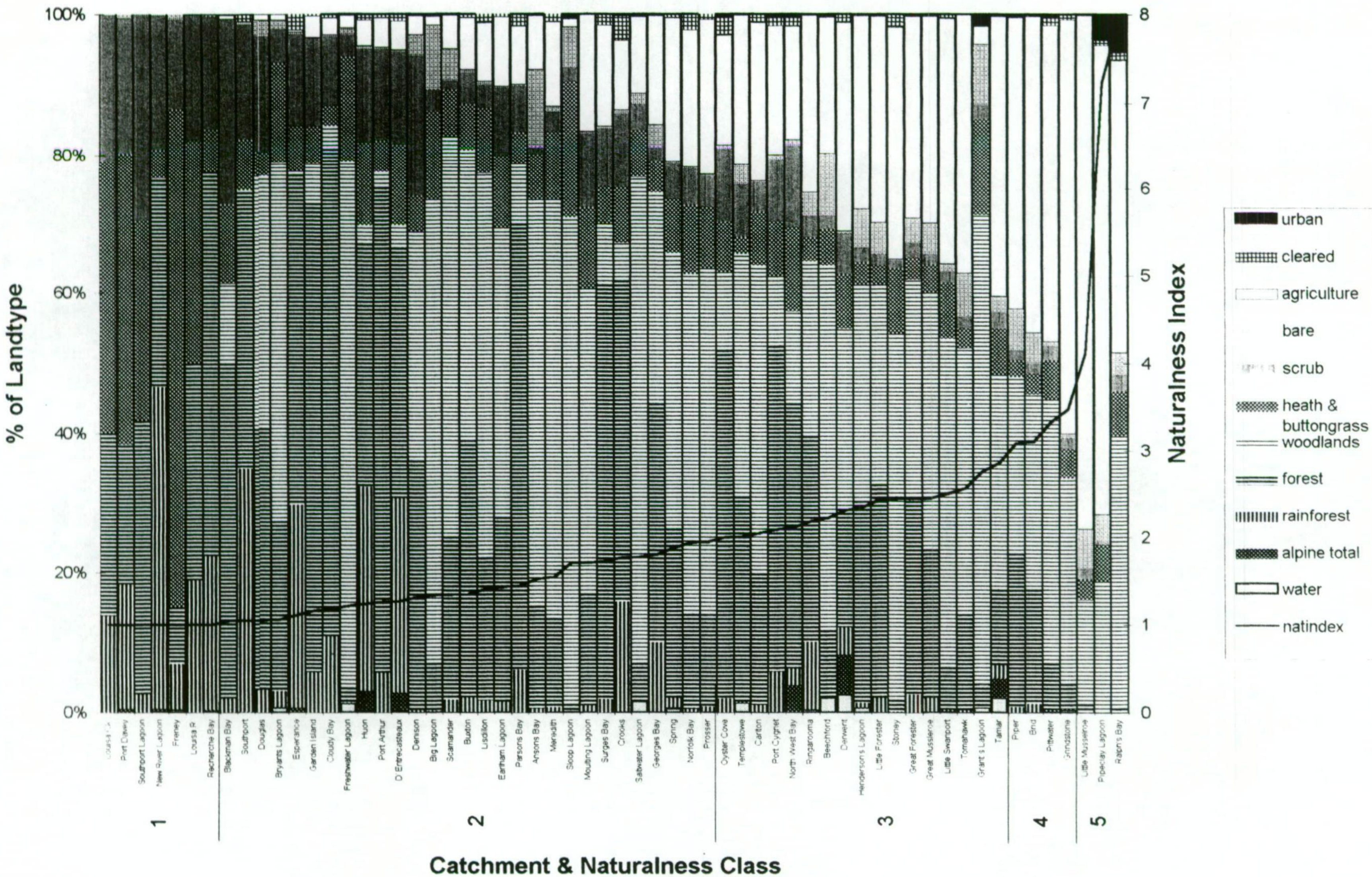


Figure 4.6b Percentage of Landtypes in EDAs - Ranked by Naturalness Index.

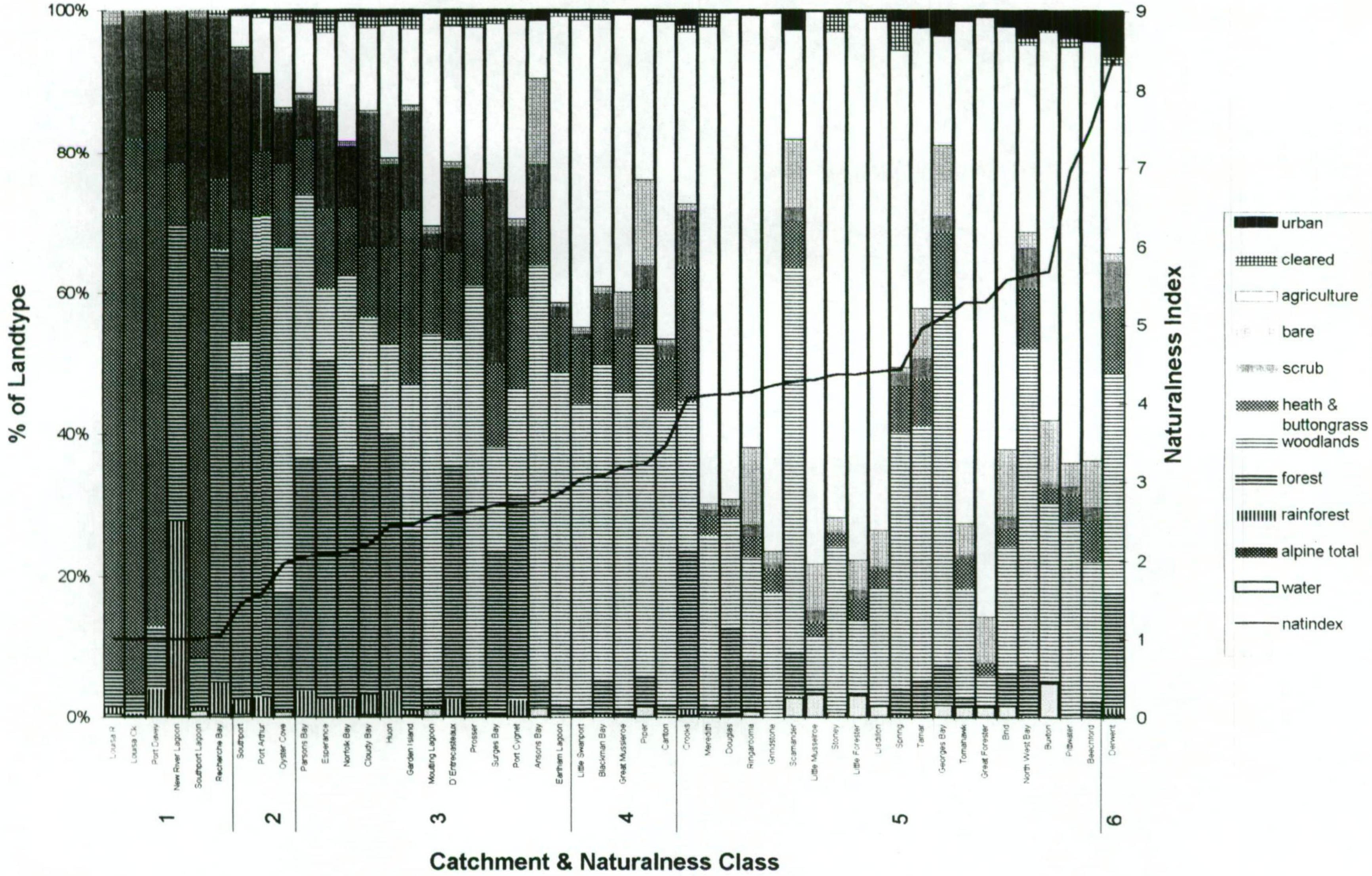
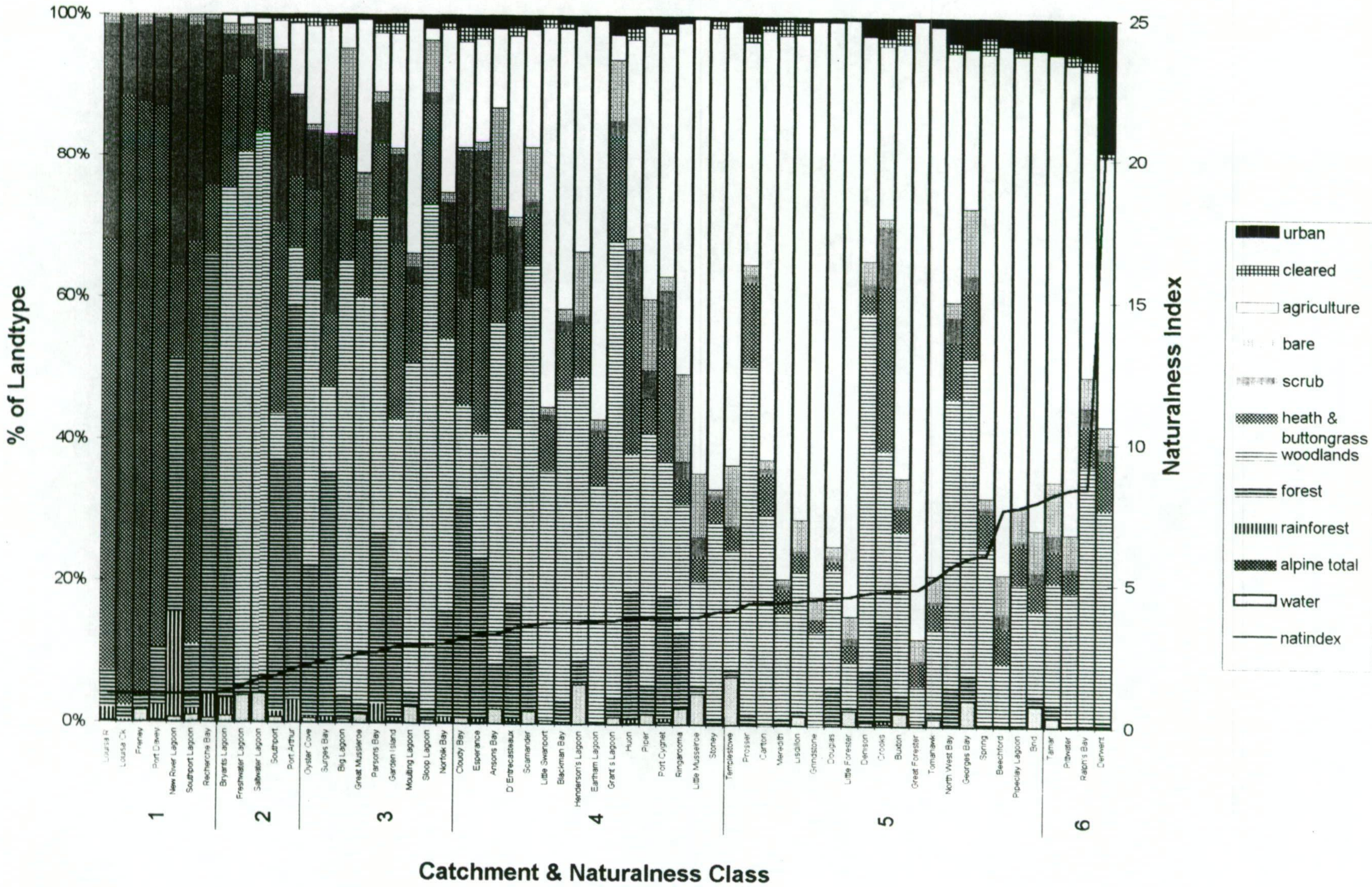


Figure 4.6c Percentage of Landtypes in EBZs - Ranked by Naturalness Index.



4.5 Visual representation of Catchment Naturalness Using GIS Modelling

Map 4 (page 71) shows the average value of the product of runoff coefficient and environmental impact factor, reclassified into 11 classes, for river catchments, EDAs and EBZs of estuary catchments in eastern Tasmania. Increasing human impact is indicated by colour change from dark green and green for pristine and natural catchment areas, to yellow, brown and orange for low to moderate impact, then red to purple for high to severe impact.

The most severely impacted catchment areas identified by this method are the EDA and EBZ of the Derwent River Estuary. Other catchments with a severe level of impact are the EBZs of the Tamar, Pittwater and Brid River estuaries, plus Ralphs Bay which adjoins the Derwent Estuary. Catchments that are highly impacted by human activities include Pipeclay Lagoon, North West Bay, Georges Bay and Curries River Estuary.

Catchments that are threatened by moderate human impacts are EBZs of Grants Lagoon, Denison Rivulet, Spring Bay and Hospital Bay, and EDAs of Scamander River, Great Forester River and Tomahawk River.

Sixty-seven out of 109 river catchments are identified as pristine. These catchments occur in 38 estuary catchments. However, only 11 whole estuary catchments are identified as pristine. These are the catchments of Bathurst Harbour, Freney Lagoon, Louisa Creek, Louisa River, New River Lagoon, Recherche Bay, Southport Lagoon, Southport, Bryants Lagoon, Freshwater Lagoon and Saltwater Lagoon.

A further 18 estuary catchments are identified as natural, however six of these have greater than 20% of agricultural land [Boobyalla Inlet (26%), Great Musselroe (31%), Stoney River (34%), Little Swanport (36%), Grindstone Bay (63%) and Carlton River (26%)]. The remaining 12 estuary catchments ranked in order of increasing proportion of agricultural land are Esperance (2.7%), Garden Island Creek (4.3%), Port Arthur (6.1%), Cloudy Bay Lagoon (6.3%), Parsons Bay (8.8%), Lisdillon Lagoon (12.3%), Meredith River (12.8%), Earlham Lagoon (14.6%), Surges Bay (15%), Oyster Cove (15.6%), Norfolk Bay (17%) and Great Swanport (18.34%).

The results obtained using the catchment naturalness index and GIS modelling methods are very similar. The most striking difference is the low impact score for Little Musselroe obtained by modelling compared to the high impact score obtained using the catchment naturalness index. This catchment has a high level of clearance for agricultural land (74%). However, there is little urban development in the catchment (0.14 km^2, or 0.17%). Because rainfall (Rav = 781 mm/yr) and runoff (ROC = 0.14) in this catchment are relatively low, the influence of the large area of agricultural land is diminished when using the runoff model. This effect is also evident for Grindstone Bay and Pipers River catchments.

The results obtained from the analysis of digital data described in chapter 3 have been summarised and discussed in this chapter. This has enabled the identification of catchments with high conservation value and catchments that are affected by human development. Conclusions and recommendations relating to the conservation status of estuary catchments and the identification of potential sites for MEPAs are presented in chapter 5, along with suggestions for further research in the areas of catchment management and estuarine conservation.

Chapter 5

Conclusion

In the preceding chapters, a review of literature demonstrated the importance of managing the effects of human activities on land and sea for the maintenance of estuarine water quality and ecosystems, and data were derived that provides a broad overview of the variation in the physical attributes and the degree of human impact on the catchments of Tasmania's estuaries. This chapter concludes with the identification of catchments with high conservation status and those that are threatened by the impact of human development. Some potential sites for MEPAs are suggested on the basis the conservation status of the catchment. Areas for further research are identified in the concluding remarks.

5.1 Summary of Data Derived in the Thesis

The main aim of this thesis was to augment information on the catchments of Tasmanian estuaries as an aid to determining areas of high conservation status. The first objective was to define and map estuary catchments. Digital coverages covering 121 estuary catchments, 200 major river catchments and 24 major dam catchments were produced as separate Arc/Info vector coverages. The nominal scale for these coverages is 1:100,000.

The second objective was to derive physical attributes for each catchment and classify catchments into groups with similar characteristics. Catchment areas, estuary water surface area, and annual rainfall statistics were determined using GIS analysis techniques. Other attributes were estimated from these figures including catchment runoff statistics and water exchange in estuaries. Estuary catchments were classified into five groups with similar physical attributes. Hydrological characteristics were the dominant factors in the classification due to the distinctive hydrological regimes of the Tasmanian environment. The classification provides a useful indication of hydrological conditions likely to exist in each estuary.

Objective three was to obtain statistics on human impacts on catchments including population, land clearance and broad categories of land use. More than 50% of Tasmania's population lives in areas that drain directly to estuaries with 36 % living within 1 km of an estuary. Two thirds of the state's population lives within the coastal zone. The majority of the population lives within 4 catchments while nearly 20 % (19) of catchments have populations of less than 10. Eight catchments contain dams for hydro-electricity production with 33 % of Tasmania's total land area contributing to dam catchments. Landtype data was available for only 60 of the estuary catchments identified. Of these, 3 catchments had more than 60 % of land cleared for agricultural, forestry and urban land uses, another 5 had greater than 40 % of land cleared, while 35 had less than 20 % of land cleared for human activities. The level of land clearance for human activities increased significantly with proximity to the estuary in more than 50 % of catchments.

The final objective was to rank catchments according to the degree of anthropogenic impact. Of the 60 catchments where landtype data was available, 11 were classified as pristine, 18 were classified as relatively natural with only minimal disturbance by human activities while 31 catchments were classified with low to high levels of human impacts.

5.1.1 Availability of Data Produced in the Thesis

Copies of the digital data sets produced during the course of this thesis (i.e. vector coverages of catchment boundaries described in Chapter 3.1.1) will be held at the Department of Geography and Environmental Studies, University of Tasmania and at the GIS section of the Division of Resources, Wildlife and Heritage, DELM. The data is presently held as an Arc/Info vector coverage. This data is freely available for research done within the Department of Geography and Environmental Studies. Researchers from outside this department should negotiate the use of the data with the Division of Resources, Wildlife and Heritage.

5.2 Conclusions Drawn From This Study

This is the first study to provide an overview of landuse in catchments across Tasmania with a focus on estuaries. Tasmania has a large number of estuaries with a diverse range of physical and environmental attributes. The hydrological regime within each catchment is likely to be the dominant physical attribute affecting estuarine environments. There is a wide variation in rainfall across the state, from the very wet catchments of the west and south coasts to the very dry catchments of the east coast and Bass Strait islands.

Land clearance and landuse in Tasmanian catchments was determined using available satellite derived landtype data for 60 out of 122 estuary catchments identified in this study. Over 50% of these catchments are relatively untouched by human activities with 11 catchments considered to be pristine (Bathurst Harbour, Freney Lagoon, Louisa Creek., Louisa River, New River Lagoon, Recherche Bay, Southport Lagoon, Southport, Bryants Lagoon, Freshwater Lagoon and Saltwater Lagoon). Tasmanian catchments are highly conserved compared with most mainland states (Bucher & Saenger, 1989), however, a number of catchment areas are severely impacted and many others are threatened by human activities and clearance of natural vegetation. These estuaries are located in the south-east, east coast and north-east of Tasmania. Estuaries with the most severely impacted catchments are the Derwent River Estuary, Ralphs Bay, Pittwater, and Pipeclay Lagoon in the south-east, and the Tamar River Estuary in the north-east. Estuaries threatened by catchment clearance and development include North West Bay and Hospital Bay in the south-east, Curries River, Brid River, Great Forester, Tomahawk and Little Musselroe Bay in the north-east, and Grants Lagoon, Georges Bay, Scamander and Spring Bay on the east coast.

Although the landtype data did not cover the whole of Tasmania, population statistics provide an indication of the level of human impact in other catchments.

More than 50% of all catchments are relatively uninhabited, particularly in the south and west. Nineteen catchments between Southport Lagoon in the south east and Nelson Bay in the North West are virtually uninhabited. This is largely as a result of the inhospitable environment, with high rainfall, dense vegetation and rugged terrain. Major population centres in this area are associated with mining or hydroelectricity operations. Mining (King River and Pieman River) and hydroelectricity production (Gordon River, King River and Pieman River catchments) can have severe impacts on water quality and river flow regimes.

There are a number of catchments with significant population centres along the north coast (Duck, Inglis, Cam, Emu, Blythe, Leven, Forth, Don, Mersey, Port Sorell, Tamar, Brid, Great Forester and Boobyalla estuaries) and in the south east (Pittwater, Derwent, Ralphs Bay, Port Cygnet, Huon, Hospital Bay and D'Entrecasteaux estuaries). Most of these settlements are concentrated around the estuary and have had significant effects on the estuarine environment including increased sedimentation, nutrification, pollution and habitat destruction caused by training walls and land reclamation.

Catchments on the Bass Strait Islands have low population levels, however many catchments on these islands are extensively impacted by agricultural activities.

5.2.1 Identification of Estuaries for Potential MEPAs

This study aimed to provide information to aid in the identification of estuaries with high conservation values. Concurrent studies of estuarine biota and marine habitat will aim to identify areas of significant conservation value such as fish nursery areas, representative assemblages of flora and fauna and specific habitats. Knowledge of the potential impacts on catchment water quality will be important for the management of any proposed estuarine protected areas. Where catchments are known to be pristine and proposed MEPAs are associated with protected areas on adjacent land, management will be less complex. For catchments that are impacted by human activities, management of proposed MEPAs will need to take account of processes occurring upstream in the catchment and potential conflicts between land users, private and public ownership and administration. Important issues will include catchment activities that affect water quality of catchment runoff such as dams, mining, forestry, agriculture and urban developments, and factors within the estuary such as conflicts with the development of marine farms and the presence, spread and control of introduced marine pests.

Catchments that obviously have high conservation values are those that are contained within national parks and the Tasmanian Wilderness World Heritage Area including Bathurst Harbour, Freney Lagoon, Louisa Creek, Louisa River and New River Lagoon in the South West National Park, and Bryants Lagoon, Freshwater Lagoon and Saltwater Lagoon in Freycinet National Park in the east. Other estuaries with low impact include Recherche Bay, Southport Lagoon, Southport, Esperance, Cloudy Bay Lagoon and Port Arthur in the south, and Lisdillon Lagoon, Earlham Lagoon and Great Swanport on the east coast. No catchments on the north coast have been identified as having high conservation value. This is likely to pose the most difficulty for the selection of a representative MEPA due to the extensive agricultural, urban and industrial developments and potential conflicts of conservation with both commercial and recreational users of land and water resources.

5.3 Recommendations for Further Study

The future of the marine and estuarine environments depends on gaining a greater understanding of how they are affected by human activities, and the development of management strategies that are able to encompass all of the conflicting interests for resources on land and sea without compromising these environments.

The resolution of the data used in this study is adequate to provide an overview only of catchment landuse. The methods used could be useful for monitoring large scale and long term changes in catchment land clearance and land use. These data could be readily included in regular monitoring programs such as the State of the Environment Report. Further baseline studies that would complement this overview are: monitoring of the water quality of catchment runoff into estuaries with reference to specific land uses; studies of the social, economic and environmental values of commercial and recreational fisheries and marine farming; inventories of aquatic and wetland habitats associated with estuaries; and detailed inventories of upstream land uses for specific areas that are identified for potential MEPAs.

While ongoing baseline studies of the environment are critical to monitoring human impacts on the marine environment, management issues are likely to be the most important factors in the success of MEPAs. This is especially so where catchment or aquatic activities have significant potential to affect the ecosystems that are being protected, as management will require the involvement of many agencies, that often have conflicting objectives. The development of policies and effective procedures to resolve conflicts over the use of land and water resources will be a crucial adjunct to scientific research and environmental monitoring

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Appendix 1 Characteristics of Tasmanian Estuaries: Estuarine Water Body

Appendix 1: Characteristics of Tasmanian Estuaries - Estuarine Water Body

		GIS Derived Catchment Areas (km^2)				Tide Data - Australian Tide Tables							Calculated Parameters				
Code	ESTUARY	Catchment area (km^2)	FDA area (km^2)	EDA area (km^2)	Water area (km^2)	Tide Guage	mhws	mhwn	msl	mlwn	mlws	Tidal Range[a] (m)	Tidal Prism[b] (ML)	Runoff/ cycle[c] (ML)	Flow Ratio[d]	Estimated Mixing Status	Estuary Type
1	Sea Elephant	294.72	280.22	14.51	0.90	Grassy	1.5	0.9	0.8	0.8	0.1	0.75	672.4	131.2	0.20	Partially Mixed	2
2	Yarra	38.15	0.00	37.65	0.03	Grassy	1.5	0.9	0.8	0.8	0.1	0.75	24.1	22.1	0.92	Partially Mixed	2
3	Ettrick	45.41	45.22	0.19	0.03	Surprise Bay	1.5	0.9	0.8	0.7	0.1	0.80	25.8	25.9	1.00	Stratified	2
4	Grassy	21.05	0.00	21.07		Grassy	1.5	0.9	0.8	0.8	0.1	0.75	ND	12.9	ND	ND	3
5	Big Lake (Seal R.)	77.50	70.85	6.65	0.68	Grassy	1.5	0.9	0.8	0.8	0.1	0.75	509.5	43.1	0.08	Mixed	3
6	Yellow Rock	119.20	117.68	1.52	0.09	Grassy	1.5	0.9	0.8	0.8	0.1	0.75	67.1	51.7	0.77	Partially Mixed	2
7	North East Inlet	125.22	103.36	21.87	4.01	Lady Barron Hr.	1.6	1.4	0.9	0.5	0.3	1.10	4,412.5	32.3	0.01	Mixed	2
8	Foochow Inlet	67.33	64.53	2.80	0.21	Lady Barron Hr.	1.6	1.4	0.9	0.5	0.3	1.10	235.3	18.3	0.08	Mixed	2
9	Middle Inlet	61.12	59.58	1.54	0.08	Lady Barron Hr.	1.6	1.4	0.9	0.5	0.3	1.10	89.9	16.6	0.18	Partially Mixed	3
10	Patriarch	177.92	173.40	4.52	0.36	Lady Barron Hr.	1.6	1.4	0.9	0.5	0.3	1.10	392.1	57.0	0.15	Partially Mixed	2
11	Sellars Lagoon	44.19	0.00	44.14	11.84	Lady Barron Hr.	1.6	1.4	0.9	0.5	0.3	1.10	13,023.8	12.8	0.00	Mixed	3
12	Cameron Inlet	192.87	149.46	43.41	13.46	Lady Barron Hr.	1.6	1.4	0.9	0.5	0.3	1.10	14,804.9	59.9	0.00	Mixed	2
13	Logans Lagoon	69.69	0.00	69.67	9.75	Lady Barron Hr.	1.6	1.4	0.9	0.5	0.3	1.10	10,720.1	17.3	0.00	Mixed	3
14	Pats	69.62	68.35	1.27	0.05	Lady Barron Hr.	1.6	1.4	0.9	0.5	0.3	1.10	53.1	26.5	0.50	Partially Mixed	2
15	Mines	21.11	20.84	0.26	0.04	Lady Barron Hr.	1.6	1.4	0.9	0.5	0.3	1.10	47.3	5.0	0.11	Partially Mixed	2
16	Dover	32.19	29.83	2.35	0.03	Lady Barron Hr.	1.6	1.4	0.9	0.5	0.3	1.10	27.9	9.6	0.34	Partially Mixed	2
17	Lee	61.55	61.02	0.53	0.09	Lady Barron Hr.	1.6	1.4	0.9	0.5	0.3	1.10	97.1	20.2	0.21	Partially Mixed	2
18	Shag Rock	39.24	35.64	3.59	0.24	Lady Barron Hr.	1.6	1.4	0.9	0.5	0.3	1.10	259.9	10.9	0.04	Mixed	2
19	Modder	45.20	42.97	2.23	0.07	Lady Barron Hr.	1.6	1.4	0.9	0.5	0.3	1.10	72.5	14.0	0.19	Partially Mixed	2
20	Rice	29.86	28.16	1.70	0.06	Lady Barron Hr.	1.6	1.4	0.9	0.5	0.3	1.10	62.9	8.8	0.14	Partially Mixed	2
21	Rocky Head	15.53	14.44	1.09	0.20	Lady Barron Hr.	1.6	1.4	0.9	0.5	0.3	1.10	216.4	3.7	0.02	Mixed	2
22	Christmas Beach	12.85	10.57	2.28	0.03	Lady Barron Hr.	1.6	1.4	0.9	0.5	0.3	1.10	38.2	2.3	0.06	Mixed	2
23	Mosquito Inlet	28.62	0.00	28.62	6.56	Stack Is.	2.0	1.8	1.0	0.3	0.1	1.70	11,150.0	14.8	0.00	Mixed	2
24	Welcome	304.21	291.82	12.39	2.72	Stack Is.	2.0	1.8	1.0	0.3	0.1	1.70	4,629.7	217.8	0.05	Mixed	2
25	Montagu	327.54	317.42	10.13	0.64	Stack Is.	2.0	1.8	1.0	0.3	0.1	1.70	1,079.8	258.0	0.24	Partially Mixed	2
26	Harcus	39.69	35.72	3.97	0.38	Stack Is.	2.0	1.8	1.0	0.3	0.1	1.70	654.2	23.5	0.04	Mixed	2
27	Robbins Passage	447.24	353.16	94.08	70.00	Stack Is.	2.0	1.8	1.0	0.3	0.1	1.70	119,001.0	326.2	0.00	Mixed	4
28	Duck Bay	549.21	470.97	78.24	22.30	Stack Is.	2.0	1.8	1.0	0.3	0.1	1.70	37,915.8	438.5	0.01	Mixed	2
29	West Inlet	22.55	19.06	3.49	4.07	Stanley	3.3	3.0	2.0	1.0	0.7	2.30	9,366.3	12.4	0.00	Mixed	2

		GIS Derived Catchment Areas (km^2)				Tide Data - Australian Tide Tables							Calculated Parameters				
Code	ESTUARY	Catchment area (km^2)	FDA area (km^2)	EDA area (km^2)	Water area (km^2)	Tide Guage	mhws	mhwn	msl	mlwn	mlws	Tidal Range[a] (m)	Tidal Prism[b] (ML)	Runoff/ cycle[c] (ML)	Flow Ratio[d]	Estimated Mixing Status	Estuary Type
30	East Inlet	21.28	16.68	4.60	4.76	Stanley	3.3	3.0	2.0	1.0	0.7	2.30	10,938.6	13.1	0.00	Mixed	2
31	Black	345.10	335.35	9.75	0.56	Stanley	3.3	3.0	2.0	1.0	0.7	2.30	1,282.9	352.0	0.27	Partially Mixed	2
32	Crayfish	44.27	43.82	0.45	0.04	Stanley	3.3	3.0	2.0	1.0	0.7	2.30	81.1	38.3	0.47	Partially Mixed	2
33	Detention	151.97	146.33	5.63	0.49	Stanley	3.3	3.0	2.0	1.0	0.7	2.30	1,121.7	139.0	0.12	Partially Mixed	2
34	Inglis	504.72	498.43	6.29	0.30	Burnie	3.2	2.9	1.9	0.9	0.6	2.30	692.1	552.1	0.80	Partially Mixed	2
35	Cam	248.45	238.68	9.77	0.09	Burnie	3.2	2.9	1.9	0.9	0.6	2.30	197.2	285.0	1.44	Stratified	2
36	Emu	243.20	241.96	1.24	0.07	Burnie	3.2	2.9	1.9	0.9	0.6	2.30	163.3	311.8	1.91	Stratified	2
37	Blythe	276.35	271.22	5.13	0.21	Burnie	3.2	2.9	1.9	0.9	0.6	2.30	472.2	347.8	0.74	Partially Mixed	2
38	Leven	695.56	647.04	48.52	2.27	Devonport	3.2	2.9	2.0	1.0	0.8	2.15	4,870.1	961.4	0.20	Partially Mixed	2
39	Forth	1,123.33	1,108.02	15.31	0.98	Devonport	3.2	2.9	2.0	1.0	0.8	2.15	2,099.6	2,165.7	1.03	Stratified	2
40	Don	135.59	129.70	5.90	0.45	Devonport	3.2	2.9	2.0	1.0	0.8	2.15	962.3	89.5	0.09	Mixed	2
41	Mersey	1,751.84	1,707.57	44.28	4.83	Devonport	3.2	2.9	2.0	1.0	0.8	2.15	10,384.6	2,292.7	0.22	Partially Mixed	1
42	Port Sorell	643.13	562.96	80.17	17.25	Devonport	3.2	2.9	2.0	1.0	0.8	2.15	37,077.9	281.4	0.01	Mixed	2
43	Tamar	11,588.49	11,030.14	558.35	97.91	Georgetown	3.1	2.9	1.9	0.9	0.7	2.20	215,405.5	4,950.2	0.02	Mixed	1
44	Curries R.	83.77	82.00	1.77	0.04	Georgetown	3.1	2.9	1.9	0.9	0.7	2.20	98.9	31.3	0.32	Partially Mixed	2
45	Pipers R.	464.46	450.05	14.41	1.20	Georgetown	3.1	2.9	1.9	0.9	0.7	2.20	2,641.8	220.8	0.08	Mixed	2
46	Little Forester	347.20	342.68	4.52	0.24	Georgetown	3.1	2.9	1.9	0.9	0.7	2.20	524.2	176.7	0.34	Partially Mixed	2
47	Brid	256.67	243.29	13.38	0.73	Georgetown	3.1	2.9	1.9	0.9	0.7	2.20	1,603.6	135.7	0.08	Mixed	2
48	Great Forester	519.67	517.66	2.01	0.12	Georgetown	3.1	2.9	1.9	0.9	0.7	2.20	270.2	270.1	1.00	Partially Mixed	2
49	Tomahawk	144.54	138.78	5.77	0.32	Swan Is.	1.4	1.3	0.8	0.7	0.2	0.90	283.6	52.1	0.18	Partially Mixed	2
50	Boobyalla Inlet	1,178.39	1,162.34	16.05	1.09	Swan Is.	1.4	1.3	0.8	0.7	0.2	0.90	979.3	890.5	0.91	Partially Mixed	2
51	Little Musselroe	79.30	72.83	6.48	0.48	Swan Is.	1.4	1.3	0.8	0.7	0.2	0.90	435.9	23.1	0.05	Mixed	2
52	Great Mussleroe	439.94	368.73	71.21	3.39	Swan Is.	1.4	1.3	0.8	0.7	0.2	0.90	3,050.3	231.5	0.08	Mixed	2
53	Ansons Bay	258.94	237.18	21.75	4.93	Eddystone Pt.	1.3	0.8	0.6	0.5	0.0	0.80	3,945.6	154.5	0.04	Mixed	2
54	Big Lagoon	17.25	0.00	17.19	0.51	Eddystone Pt.	1.3	0.8	0.6	0.5	0.0	0.80	404.4	10.2	0.03	Mixed	3
55	Sloop Lagoon	10.82	0.00	10.81	0.30	Eddystone Pt.	1.3	0.8	0.6	0.5	0.0	0.80	242.8	6.5	0.03	Mixed	3
56	Grant's Lagoon	6.79	0.02	6.77	0.47	Eddystone Pt.	1.3	0.8	0.6	0.5	0.0	0.80	380.0	3.7	0.01	Mixed	3
57	Georges Bay	556.71	522.58	34.14	21.15	Eddystone Pt.	1.3	0.8	0.6	0.5	0.0	0.80	16,917.7	486.6	0.03	Mixed	1
58	Scamander	340.67	326.94	13.73	1.60	Eddystone Pt.	1.3	0.8	0.6	0.5	0.0	0.80	1,277.6	188.6	0.15	Partially Mixed	2
59	Henderson's Lagoon	50.49	0.00	50.39	0.96	Eddystone Pt.	1.3	0.8	0.6	0.5	0.0	0.80	767.4	31.7	0.04	Mixed	3
60	Templestowe Lagoon	25.23	0.00	25.13	0.57	Eddystone Pt.	1.3	0.8	0.6	0.5	0.0	0.80	452.8	15.8	0.03	Mixed	3

		GIS Derived Catchment Areas (km^2)				Tide Data - Australian Tide Tables							Calculated Parameters				
Code	ESTUARY	Catchment area (km^2)	FDA area (km^2)	EDA area (km^2)	Water area (km^2)	Tide Guage	mhws	mhwn	msl	mlwn	mlws	Tidal Range[a] (m)	Tidal Prism[b] (ML)	Runoff/ cycle[c] (ML)	Flow Ratio[d]	Estimated Mixing Status	Estuary Type
61	Douglas	73.53	70.37	3.15	0.07	Eddystone Pt.	1.3	0.8	0.6	0.5	0.0	0.80	53.3	53.1	1.00	Partially Mixed	2
62	Denison	26.83	0.00	26.42	0.02	Eddystone Pt.	1.3	0.8	0.6	0.5	0.0	0.80	18.2	13.0	0.71	Partially Mixed	3
63	Saltwater Lagoon	8.58	0.00	8.59	0.22	Eddystone Pt.	1.3	0.8	0.6	0.5	0.0	0.80	178.3	1.9	0.01	Mixed	3
64	Freshwater Lagoon	11.86	0.01	11.86	0.27	Eddystone Pt.	1.3	0.8	0.6	0.5	0.0	0.80	216.4	2.9	0.01	Mixed	3
65	Bryants Lagoon	5.81	0.00	5.82	0.32	Spring Bay	1.3	0.8	0.7	0.7	0.2	0.60	193.6	1.6	0.01	Mixed	3
66	Great Swanport	1,031.10	890.63	140.47	40.71	Spring Bay	1.3	0.8	0.7	0.7	0.2	0.60	24,427.9	298.3	0.01	Mixed	2
67	Meredith	98.23	96.66	1.57	0.09	Spring Bay	1.3	0.8	0.7	0.7	0.2	0.60	51.1	28.8	0.56	Partially Mixed	2
68	Stoney	26.71	26.34	0.36	0.01	Spring Bay	1.3	0.8	0.7	0.7	0.2	0.60	7.8	5.9	0.76	Partially Mixed	2
69	Buxton	60.66	59.56	1.10	0.15	Spring Bay	1.3	0.8	0.7	0.7	0.2	0.60	92.7	20.7	0.22	Partially Mixed	2
70	Lisdillon	51.17	47.91	3.26	0.23	Spring Bay	1.3	0.8	0.7	0.7	0.2	0.60	136.4	13.0	0.10	Mixed	2
71	Little Swanport	733.42	677.69	55.73	4.82	Spring Bay	1.3	0.8	0.7	0.7	0.2	0.60	2,891.5	158.3	0.05	Mixed	2
72	Grindstone	30.62	23.84	6.78	0.20	Spring Bay	1.3	0.8	0.7	0.7	0.2	0.60	117.1	6.8	0.06	Mixed	2
73	Spring	115.97	90.22	25.75	5.44	Spring Bay	1.3	0.8	0.7	0.7	0.2	0.60	3,266.9	30.8	0.01	Mixed	1
74	Prosser	722.39	686.98	35.42	0.37	Spring Bay	1.3	0.8	0.7	0.7	0.2	0.60	220.4	173.6	0.79	Partially Mixed	2
75	Earlham Lagoon	109.68	92.63	17.06	0.77	Spring Bay	1.3	0.8	0.7	0.7	0.2	0.60	462.5	35.7	0.08	Mixed	2
76	Blackman Bay	102.35	41.49	60.86	26.72	Spring Bay	1.3	0.8	0.7	0.7	0.2	0.60	16,032.4	32.0	0.00	Mixed	2
77	Port Arthur	78.06	36.85	41.21	21.37	Pirates Bay	1.1	0.5	0.5	0.5	0.0	0.55	11,752.3	38.8	0.00	Mixed	1
78	Parsons Bay	88.77	58.24	30.53	10.82	Parsons Bay	1.2	0.8	0.6	0.5	0.0	0.75	8,115.2	31.7	0.00	Mixed	1
79	Norfolk Bay	225.89	13.09	212.80	182.82	Impression Bay	1.3	0.8	0.6	0.5	0.0	0.80	146,258.8	67.1	0.00	Mixed	4
80	Carlton	164.70	141.40	23.30	1.72	Impression Bay	1.3	0.8	0.6	0.5	0.0	0.80	1,380.0	42.8	0.03	Mixed	2
81	Pittwater	922.98	813.70	109.28	46.41	Impression Bay	1.3	0.8	0.6	0.5	0.0	0.80	37,130.4	137.8	0.00	Mixed	2
82	Pipeclay Lagoon	16.52	0.00	16.52	5.27	Impression Bay	1.3	0.8	0.6	0.5	0.0	0.80	4,214.6	2.9	0.00	Mixed	3
83	Derwent	9,393.76	8,613.35	780.41	189.50	Hobart	1.5	1.0	0.8	0.7	0.2	0.80	151,600.4	6,105.8	0.04	Mixed	1
84	Ralph's Bay	57.53	0.00	57.53	51.70	Hobart	1.5	1.0	0.8	0.7	0.2	0.80	41,362.8	8.1	0.00	Mixed	4
85	North West Bay	176.74	141.65	35.10	19.42	Hobart	1.5	1.0	0.8	0.7	0.2	0.80	15,539.1	101.2	0.01	Mixed	2
86	Oyster Cove	20.06	15.59	4.47	1.22	Hobart	1.5	1.0	0.8	0.7	0.2	0.80	978.6	12.9	0.01	Mixed	2
87	Garden Island	48.04	39.88	8.15	3.81	Hobart	1.5	1.0	0.8	0.7	0.2	0.80	3,049.6	23.8	0.01	Mixed	2
88	Port Cygnet	140.68	104.33	36.35	14.56	Hobart	1.5	1.0	0.8	0.7	0.2	0.80	11,650.7	70.9	0.01	Mixed	1
89	Huon	3,043.73	2,742.91	300.83	76.35	Hobart	1.5	1.0	0.8	0.7	0.2	0.80	61,077.7	3,390.2	0.06	Mixed	1
90	Hospital Bay	139.50	132.60	6.90	1.21	Hobart	1.5	1.0	0.8	0.7	0.2	0.80	966.4	121.5	0.13	Partially Mixed	2
91	Surges Bay	13.08	11.71	1.37	0.22	Hobart	1.5	1.0	0.8	0.7	0.2	0.80	178.8	9.5	0.05	Mixed	2

		GIS Derived Catchment Areas (km^2)				Tide Data - Australian Tide Tables							Calculated Parameters				
Code	ESTUARY	Catchment area (km^2)	FDA area (km^2)	EDA area (km^2)	Water area (km^2)	Tide Guage	mhws	mhwn	msl	mlwn	mlws	Tidal Range[a] (m)	Tidal Prism[b] (ML)	Runoff/ cycle[c] (ML)	Flow Ratio[d]	Estimated Mixing Status	Estuary Type
92	Esperance	306.62	236.14	70.48	15.13	Hobart	1.5	1.0	0.8	0.7	0.2	0.80	12,107.6	310.9	0.03	Mixed	2
93	D'Entrecasteaux	3,810.16	3,128.22	681.95	466.15	Hobart	1.5	1.0	0.8	0.7	0.2	0.80	372,916.8	3,891.5	0.01	Mixed	1
94	Cloudy Bay	42.69	24.46	18.24	6.10	Maatsuyker Is.	1.2	0.7	0.6	0.5	0.0	0.70	4,270.1	17.9	0.00	Mixed	2
95	Southport	189.20	142.66	46.55	4.15	Maatsuyker Is.	1.2	0.7	0.6	0.5	0.0	0.70	2,903.2	215.9	0.07	Mixed	2
96	Southport Lagoon	27.21	13.50	13.70	10.51	Maatsuyker Is.	1.2	0.7	0.6	0.5	0.0	0.70	7,356.6	20.6	0.00	Mixed	2
97	Recherche Bay	179.44	151.13	28.31	10.59	Maatsuyker Is.	1.2	0.7	0.6	0.5	0.0	0.70	7,416.1	207.6	0.03	Mixed	4
98	New River Lagoon	298.08	222.97	75.11	12.01	Maatsuyker Is.	1.2	0.7	0.6	0.5	0.0	0.70	8,404.5	376.2	0.04	Mixed	2
99	Louisa R.	83.20	79.21	3.99	0.34	Maatsuyker Is.	1.2	0.7	0.6	0.5	0.0	0.70	237.0	100.5	0.42	Partially Mixed	2
100	Louisa Ck.	56.72	54.31	2.41	0.18	Maatsuyker Is.	1.2	0.7	0.6	0.5	0.0	0.70	124.7	88.0	0.71	Partially Mixed	2
101	Freney	19.61	0.00	19.52	0.71	Maatsuyker Is.	1.2	0.7	0.6	0.5	0.0	0.70	495.1	36.1	0.07	Mixed	3
102	Bathurst Harbour	1,067.28	854.03	213.25	65.76	Bramble Cove	0.8	0.7	0.5	0.3	0.2	0.50	32,879.9	2,160.4	0.07	Mixed	1
103	Payne Bay	924.69	793.99	130.71	44.17	Bramble Cove	0.8	0.7	0.5	0.3	0.2	0.50	22,085.4	2,573.5	0.12	Partially Mixed	1
104	Mulcahy	58.07	54.83	3.25	1.96	Cape Sorell	1.0	0.8	0.6	0.3	0.1	0.70	1,374.8	147.3	0.11	Partially Mixed	2
105	Giblin	323.30	309.44	13.86	0.44	Cape Sorell	1.0	0.8	0.6	0.3	0.1	0.70	304.8	925.3	3.04	Stratified	2
106	Lewis	213.14	194.26	18.88	0.07	Cape Sorell	1.0	0.8	0.6	0.3	0.1	0.70	48.7	570.0	11.71	Stratified	1
107	Mainwaring Inlet	51.00	48.01	2.99	0.08	Cape Sorell	1.0	0.8	0.6	0.3	0.1	0.70	56.1	125.3	2.24	Stratified	1
108	Wanderer	353.73	283.38	70.34	0.99	Cape Sorell	1.0	0.8	0.6	0.3	0.1	0.70	690.7	942.4	1.36	Stratified	1
109	Spero	115.78	112.77	3.01	0.06	Cape Sorell	1.0	0.8	0.6	0.3	0.1	0.70	44.8	273.7	6.11	Stratified	1
110	Hibbs Lagoon	52.18	47.24	4.94	0.56	Cape Sorell	1.0	0.8	0.6	0.3	0.1	0.70	393.9	98.2	0.25	Partially Mixed	2
111	Macquarie Harbour	6,790.28	6,281.94	508.34	291.69	Cape Sorell	1.0	0.8	0.6	0.3	0.1	0.70	204,185.7	18,816.9	0.09	Mixed	1
112	Birchs Inlet	312.84	236.95	75.89	10.56	Cape Sorell	1.0	0.8	0.6	0.3	0.1	0.70	7,395.0	728.7	0.10	Mixed	2
113	Gordon	5,217.43	5,184.16	33.27	2.54	Cape Sorell	1.0	0.8	0.6	0.3	0.1	0.70	1,776.6	14,441.8	8.13	Stratified	1
114	King	816.07	812.19	3.88	0.39	Cape Sorell	1.0	0.8	0.6	0.3	0.1	0.70	274.1	2,829.5	10.32	Stratified	1
115	Manuka	55.70	48.42	7.28	2.96	Cape Sorell	1.0	0.8	0.6	0.3	0.1	0.70	2,074.7	74.7	0.04	Mixed	2
116	Henty	502.52	488.91	13.60	0.81	Cape Sorell	1.0	0.8	0.6	0.3	0.1	0.70	565.9	1,253.4	2.21	Stratified	2
117	Little Henty	329.58	281.15	48.42	0.89	Cape Sorell	1.0	0.8	0.6	0.3	0.1	0.70	624.5	809.6	1.30	Stratified	2
118	Pieman	3,866.08	3,830.88	35.20	2.29	Pieman	1.1	0.8	0.6	0.4	0.2	0.65	1,490.0	9,697.7	6.51	Stratified	1
119	Lagoon	86.44	85.62	0.82	0.08	Pieman	1.1	0.8	0.6	0.4	0.2	0.65	49.8	163.0	3.27	Stratified	2
120	Pedder	82.54	80.86	1.68	0.04	Pieman	1.1	0.8	0.6	0.4	0.2	0.65	23.0	109.8	4.78	Stratified	2
121	Nelson Bay	70.57	67.88	2.69	0.04	Pieman	1.1	0.8	0.6	0.4	0.2	0.65	23.1	84.4	3.65	Stratified	1
122	Arthur	2,494.62	2,398.97	95.65	1.20	Pieman	1.1	0.8	0.6	0.4	0.2	0.65	777.6	3,942.2	5.07	Stratified	1

		GIS Derived Catchment Areas (km^2)				Tide Data - Australian Tide Tables							Calculated Parameters				
Code	ESTUARY	Catchment area (km^2)	FDA area (km^2)	EDA area (km^2)	Water area (km^2)	Tide Guage	mhws	mhwn	msl	mlwn	mlws	Tidal Range[a] (m)	Tidal Prism[b] (ML)	Runoff/ cycle[c] (ML)	Flow Ratio[d]	Estimated Mixing Status	Estuary Type
	Totals	61,755.17	56,465.69	5,288.15	1,776.36												T1 = 22
	Minimum	5.81	0.00	0.19	0.01		0.8	0.5	0.5	0.3	0.0	0.50	7.8	1.6	0.00	mixed = 67	T2 = 80
	Maximum	11,588.49	11,030.14	780.41	466.15		3.3	3.0	2.0	1.0	0.8	2.30	372,916.8	18,816.9	11.71	part.mixed = 37	T3 = 16
	Mean	577.15	527.72	49.42	16.76		1.7	1.3	0.9	0.6	0.2	1.09	15,344.4	675.4	0.69	stratified = 18	T4 = 4

a - Tidal Range = (mhws - mlws + mhwn - mlwn)/2

c - Runoff per Tidal cycle is estimated by multiplying the Estimated Runoff Coefficent by Total Annual Runoff, divided by approximate tidal cycles per year (ROC x TAR/(365*2)).

d - Flow Ratio is Runoff/Tidal Cycle / Tidal Prism.

e - When flow ratio > 1.0 the estuary is likely to be highly stratified.

At flow ratios < 1.0 mixing is likely to occur, with complete mixing likely at flow ratios < 0.25.

Appendix 2 Characteristics of Tasmanian Estuaries: Rainfall and Runoff Statistics for all Catchments

Appendix 2: Characteristics of Tasmanian Estuaries - Rainfall and Runoff Statistics for all Catchments															
		GIS Derived Data			GIS Derived, RWH Rainfall Data					RWSC Data - River Discharge Data				Calculated	
Catchment		Catchment	Dam Area	Dammed	TAR	Min	Max	Median	Mean	Catchment	MAR	Upstream	Records	Est.	Runoff
Estuary	Sub-Catchment	area (km^2)	(km^2)	%	(ML)	(mm)	(mm)	(mm)	(mm)	area (km^2)	(mm)	Regulation*	(yrs)	MAR	Coefficient
Outside Catchments	Total	6,184.24			7,185,737	445	2,525	1,051	1,075					296	0.28
Sea Elephant	EDA	14.51			11,529	823	922	889	887					173	0.19
	SaltmarshCk.	117.77	0	0%	102,188	816	942	860	866					160	0.18
	Sea Elephant	162.31	0	0%	164,178	871	1,087	980	983					235	0.24
Sea Elephant	Total	294.72	0	0%	277,895	816	1,087	910	933					202	0.22
Yarra	Total	38.15	0	0%	41,021	976	1,089	1,053	1,052					280	0.27
Ettrick	EDA	0.19													
	Ettrick	45.19	0	0%	47,633	990	1,092	1,065	1,059	44.6	225.0	nil	5	285	0.27
Ettrick	Total	45.41	0	0%	47,633	990	1,092	1,065	1,059					285	0.27
Grassy	Total	21.07	0	0%	23,527	1,007	1,124	1,064	1,069					292	0.27
Big Lake (Seal R.)	EDA	6.65			4,101	1,014	1,039	1,016	1,025					263	0.26
	Seal	70.80	0	0%	75,767	981	1,123	1,056	1,052					281	0.27
Big Lake (Seal R.)	Total	77.49	0	0%	79,868	981	1,123	1,036	1,051					280	0.27
Yellow Rock	EDA	1.52			1,805	889	916	889	903					183	0.20
	Yellow Rock	117.65	0	0%	108,538	874	975	924	928					199	0.21
Yellow Rock	Total	119.20	0	0%	110,343	874	975	907	927					199	0.21
North East Inlet	EDA	21.87			14,959	702	833	735	748					87	0.12
	North East	29.38	0	0%	22,010	711	954	745	759					93	0.12
	Arthurs	73.98	0	0%	55,217	711	914	741	756					92	0.12
North East Inlet	Total	125.23	0	0%	92,186	702	954	740	756					91	0.12
Foochow Inlet	EDA	2.80			2,187	728	730	729	729					75	0.10
	Foochow	64.40	0	0%	49,972	728	832	750	757					92	0.12
Foochow Inlet	Total	67.33	0	0%	52,159	728	832	740	756					91	0.12
Middle Inlet	EDA	1.54			1,464	731	733	731	732					77	0.11
	Middle Inlet	59.41	0	0%	44,594	730	896	758	769					99	0.13
Middle Inlet	Total	61.11	0	0%	46,058	730	896	745	768					99	0.13
Patriarch	EDA	4.52			3,721	732	779	736	744					84	0.11
	Drains (Patriarch)	32.79	0	0%	26,169	734	874	760	770					100	0.13
	Patriarch	140.39	0	0%	114,384	739	1,190	790	829					136	0.16
Patriarch	Total	177.92	0	0%	144,274	732	1,190	762	815					128	0.16

		GIS Derived Data			GIS Derived, RWH Rainfall Data					RWSC Data - River Discharge Data				Calculated	
Catchment Estuary	Sub-Catchment	Catchment area (km^2)	Dam Area (km^2)	Dammed %	TAR (ML)	Min (mm)	Max (mm)	Median (mm)	Mean (mm)	Catchment area (km^2)	MAR (mm)	Upstream Regulation*	Records (yrs)	Est. MAR	Runoff Coefficient
Sellars Lagoon	Total	44.18	0	0%	37,313	730	827	737	746					86	0.11
Cameron Inlet	EDA	43.41			32,576	731	759	739	740					82	0.11
	Nelsons Drain	118.98	0	0%	95,967	742	1,210	775	813					127	0.16
	Chew Tobacco Ck.	30.27	0	0%	27,384	750	946	822	830					137	0.17
Cameron Inlet	Total	192.88	0	0%	155,927	731	1,210	779	800					118	0.15
Logans Lagoon	Total	69.69	0	0%	50,563	728	817	738	744					84	0.11
Pats	EDA	1.27			1,465	729	736	729	733					77	0.11
	Pats	68.26	0	0%	60,596	742	1,137	842	866	20.6	225.2	nil	14	159	0.18
Pats	Total	69.62	0	0%	62,061	729	1,137	786	862					157	0.18
Mines	EDA	0.26			707	707	707	707	707					62	0.09
	Mines	20.84	0	0%	13,626	705	798	760	757					92	0.12
Mines	Total	21.10	0	0%	14,333	705	798	734	754					91	0.12
Dover	EDA	2.35			2,244	732	768	744	748					87	0.12
	Dover	29.82	0	0%	23,551	726	1,002	763	785					109	0.14
Dover	Total	32.18	0	0%	25,795	726	1,002	754	782					107	0.14
Lee	EDA	0.53			710	710	710	710	710					64	0.09
	Rooks	6.63	0	0%	5,271	739	1,148	797	879					168	0.19
	Lee	54.35	0	0%	45,736	707	1,059	780	802					120	0.15
Lee	Total	61.56	0	0%	51,717	707	1,148	762	808					124	0.15
Shag Rock	EDA	3.59			2,180	722	734	724	727					74	0.10
	Shag Rock	35.57	0	0%	28,340	700	1,239	782	766					98	0.13
Shag Rock	Total	39.24	0	0%	30,520	700	1,239	753	763					96	0.13
Modder	EDA	2.23			669	669	669	669	669					39	0.06
	Modder	42.96	0	0%	36,272	669	1,172	755	806					122	0.15
Modder	Total	45.20	0	0%	36,218	669	1,172	728	805					122	0.15
Rice	EDA	1.70			707	707	707	707	707					62	0.09
	Rice	28.06	0	0%	22,808	724	1,009	768	786					110	0.14
Rice	Total	29.85	0	0%	23,515	707	1,009	738	784					109	0.14
Rocky Head	EDA	1.09			673	673	673	673	673					42	0.06
	Rocky Head	14.36	0	0%	9,867	682	875	735	759					93	0.12
Rocky Head	Total	15.54	0	0%	10,540	673	875	704	753					90	0.12
Christmas Beach	EDA	2.28			2,012	700	950	949	671					40	0.06
	Christmas Beach	10.53	0	0%	6,532	700	1,111	791	653					30	0.05

		GIS Derived Data			GIS Derived, RWH Rainfall Data					RWSC Data - River Discharge Data				Calculated	
Catchment		Catchment	Dam Area	Dammed	TAR	Min	Max	Median	Mean	Catchment	MAR	Upstream	Records	Est.	Runoff
Estuary	Sub-Catchment	area (km^2)	(km^2)	%	(ML)	(mm)	(mm)	(mm)	(mm)	area (km^2)	(mm)	Regulation*	(yrs)	MAR	Coefficient
Christmas Beach	Total	12.85	0	0%	8,544	700	1,111	870	657					32	0.05
Mosquito Inlet	Total	28.62	0	0%	28,457	968	1,061	1,015	1,016					257	0.25
Welcome	EDA	12.39			13,084	1,048	1,152	1,077	1,090					306	0.28
	Welcome	291.77	0	0%	346,458	1,061	1,384	1,203	1,195					378	0.32
Welcome	Total	304.23	0	0%	357,102	1,048	1,384	1,123	1,190					375	0.31
Montagu	EDA	10.13			10,825	1,063	1,105	1,079	1,083					301	0.28
	Montagu	317.05	0	0%	398,716	1,092	1,478	1,221	1,238	323.0	415.0	nil	18	408	0.33
Montagu	Total	327.53	0	0%	409,470	1,063	1,478	1,150	1,233					405	0.33
Harcus	EDA	3.97			3,162	1,051	1,059	1,052	1,054					282	0.27
	Harcus	35.70	0	0%	39,066	1,047	1,152	1,084	1,085					303	0.28
Harcus	Total	39.69	0	0%	42,228	1,047	1,152	1,068	1,083					301	0.28
Robbins Passage	EDA	94.08	0		98,664	995	1,127	1,052	1,049					278	0.27
Robbins Passage	Total	447.22	0	0%	536,375	995	1,478	1,068	1,199					381	0.32
Duck Bay	EDA	78.24			84,716	1,034	1,193	1,104	1,115					323	0.29
	Deep Ck.	78.24	0	0%	98,935	1,068	1,468	1,191	1,221					396	0.32
	Duck	392.37	0	0%	500,232	1,076	1,617	1,264	1,289	339.0	587.9	nil	17	445	0.34
Duck Bay	Total	549.22	0	0%	685,091	1,034	1,617	1,192	1,255					420	0.33
West Inlet	EDA	3.49			2,050	1,017	1,033	1,017	1,025					263	0.26
	Grays Ck.	19.04	0	0%	20,465	1,033	1,147	1,075	1,077					297	0.28
West Inlet	Total	22.54	0	0%	22,515	1,017	1,147	1,046	1,072					294	0.27
East Inlet	EDA	4.60			4,306	1,028	1,146	1,052	1,077					297	0.28
	Ghost Ck.	16.63	0	0%	18,860	1,043	1,160	1,117	1,109					319	0.29
East Inlet	Total	21.29	0	0%	23,166	1,028	1,160	1,085	1,103					315	0.29
Black	EDA	9.75			11,235	1,080	1,187	1,117	1,124					329	0.29
	Black/Dip	334.94	0	0%	479,543	1,143	1,723	1,455	1,436	324.0	738.0	nil	14	552	0.38
Black	Total	345.10	0	0%	492,267	1,080	1,723	1,354	1,427					545	0.38
	Crayfish Ck.	43.79	0	0%	58,824	1,152	1,395	1,271	1,279					437	0.34
Crayfish	Total	44.27	0	0%	58,824	1,152	1,395	1,271	1,279					437	0.34
Detention	EDA	5.63			6,885	1,104	1,177	1,140	1,148					345	0.30
	Wilson Ck.	38.37	0	0%	48,303	1,103	1,408	1,202	1,208					387	0.32
	Detention	107.77	0	0%	149,196	1,169	1,744	1,411	1,408					531	0.38
Detention	Total	151.96	0	0%	204,384	1,103	1,744	1,251	1,345					484	0.36
Inglis	EDA	6.29			7,946	1,079	1,325	1,096	1,135					337	0.30

		GIS Derived Data			GIS Derived, RWH Rainfall Data					RWSC Data - River Discharge Data				Calculated	
Catchment		Catchment	Dam Area	Dammed	TAR	Min	Max	Median	Mean	Catchment	MAR	Upstream	Records	Est.	Runoff
Estuary	Sub-Catchment	area (km^2)	(km^2)	%	(ML)	(mm)	(mm)	(mm)	(mm)	area (km^2)	(mm)	Regulation*	(yrs)	MAR	Coefficient
	Flowerdale	172.65	0	0%	258,997	1,111	1,911	1,562	1,524	152.0	806.0	nil	17	618	0.41
	Inglis	325.53	0	0%	483,410	1,080	1,888	1,461	1,460	172.0	765.0	nil	16	570	0.39
Inglis	Total	504.76	0	0%	750,353	1,079	1,911	1,373	1,477					582	0.39
Cam	EDA	9.77			11,078	1,139	1,567	1,197	1,231					403	0.33
	Cam	238.48	0	0%	368,227	1,135	1,910	1,475	1,541	221.0	684.0	nil	15	631	0.41
Cam	Total	248.50	0	0%	376,422	1,135	1,910	1,369	1,530					623	0.41
Emu	EDA	1.24			1,163	1,163	1,163	1,163	1,163					356	0.31
	Emu	241.56	0	0%	391,402	1,167	2,400	1,515	1,624	92.7	1,172.0	yes	28	695	0.43
Emu	Total	243.20	0	0%	392,889	1,163	2,400	1,505	1,624					695	0.43
Blythe	EDA	5.13			5,630	1,078	1,168	1,150	1,126					330	0.29
	Blythe	270.81	0	0%	442,454	1,112	2,126	1,427	1,592	285.0	838.0	nil	6	670	0.42
Blythe	Total	276.35	0	0%	446,800	1,078	2,126	1,383	1,584					664	0.42
Leven	EDA	48.52			53,000	1,015	1,279	1,098	1,104					316	0.29
	Leven	559.73	0	0%	1,008,918	1,094	2,687	2,038	1,815	500.0	1,053.0	nil	20	848	0.47
	Gawler	86.67	0	0%	109,490	1,098	1,601	1,248	1,273	85.9	513.0	yes	18	433	0.34
Leven	Total	695.53	0	0%	1,170,594	1,015	2,687	1,402	1,697					752	0.44
Forth	EDA	15.31			15,788	1,003	1,149	1,044	1,053					281	0.27
	Forth	1,107.21	936	85%	2,276,531	1,046	2,872	1,830	2,055	311.0	1,480.0	nil*	17	1,051	0.51
Forth	Total	1,123.33	936	83%	2,292,555	1,003	2,872	1,868	2,041					1,039	0.51
Don	EDA	5.90			3,946	974	997	980	987					237	0.24
	Don	129.44	0	0%	149,027	981	1,362	1,205	1,155	128.0	562.0	nil	16	350	0.30
Don	Total	135.59	0	0%	151,717	974	1,362	1,067	1,149					346	0.30
Mersey	EDA	44.28			43,131	942	1,113	998	1,003					248	0.25
	Mersey	1,706.41	713	42%	2,825,887	915	2,709	1,638	1,654	1,618.0	658.0	yes hec	21	718	0.43
Mersey	Total	1,751.84	713	41%	2,868,576	915	2,709	1,648	1,638					706	0.43
Port Sorell	EDA	80.17			64,093	777	917	831	832					139	0.17
	Sheepwash	15.86	0	0%	13,976	789	883	846	822					132	0.16
	Brown Ck.	25.16	0	0%	20,517	795	949	845	855					153	0.18
	Panatana	68.79	0	0%	59,948	842	968	894	895					178	0.20
	Branchs	30.11	0	0%	27,154	813	969	862	876					166	0.19
	Franklin Rt.	132.43	0	0%	127,553	855	1,136	971	974	132.0	244.8	nil	8	229	0.23
	Green Ck.	28.00	0	0%	25,360	882	978	946	939					206	0.22
	Rubicon	262.31	0	0%	256,758	881	1,211	983	980	259.0	326.0	nil	16	233	0.24

		GIS Derived Data			GIS Derived, RWH Rainfall Data					RWSC Data - River Discharge Data				Calculated	
Catchment Estuary	Sub-Catchment	Catchment area (km^2)	Dam Area (km^2)	Dammed %	TAR (ML)	Min (mm)	Max (mm)	Median (mm)	Mean (mm)	Catchment area (km^2)	MAR (mm)	Upstream Regulation*	Records (yrs)	Est. MAR	Runoff Coefficient
Port Sorell	Total	643.12	0	0%	593,486	777	1,211	892	936					204	0.22
Tamar	EDA	558.35			481,881	687	1,114	862	870					162	0.19
	Fourteen Mile Ck.	97.69	0	0%	89,097	832	1,107	908	928					199	0.21
	Masseys Rt.	33.55	0	0%	29,252	840	1,120	929	944					209	0.22
	Andersons	49.50	0	0%	56,138	925	1,256	1,041	1,059	49.5	423.0	nil	19	285	0.27
	Johnston Ck.	61.43	0	0%	60,954	916	1,195	993	1,016					256	0.25
	Supply	134.86	0	0%	138,521	914	1,278	1,015	1,034	134.0	373.3	nil	19	268	0.26
	North Esk	1,064.69	0	0%	1,234,807	638	1,676	1,202	1,158	373.0	466.0	nil	60	353	0.30
	Stony Bk.	42.33	0	0%	41,363	894	1,121	932	962					221	0.23
	South Esk	9,543.34	9,524	100%	8,526,469	524	2,126	886	893	8,997.0	200.3	yes hec	82	177	0.20
	Meander	1,333.57	1,334	100%	1,505,540	763	2,126	1,033	1,128	1,269.0	492.0			332	0.29
	Liffey	234.44	234	100%	269,785	756	1,803	1,071	1,129	224.0		yes	3	332	0.29
	Nile	323.21	323	100%	316,707	632	1,662	912	984	226.0		nil	1	235	0.24
	Break`O`Day	229.90	230	100%	220,329	612	1,434	928	958	111.0	800.0	nil		219	0.23
	Macquarie	1,557.37	1,558	100%	1,004,091	532	982	623	646	365.0	201.7	yes	4	26	0.04
	Ben Lomond Rt.	199.85	200	100%	166,422	601	1,283	786	816					128	0.16
	St. Pauls	520.93	521	100%	435,684	557	1,384	776	836					141	0.17
	Brumby	308.49	308	100%	334,610	676	1,701	993	1,090					306	0.28
	Lake	812.90	813	100%	745,531	650	1,531	1,044	914	421.0	446.0	yes	26	190	0.21
	Great Lake	396.22	396	100%	529,254	847	1,828	1,361	1,343					484	0.36
	Isis	337.01	337	100%	236,664	542	1,163	630	698					57	0.08
	Elizabeth	399.01	399	100%	286,596	538	1,030	740	718	69.7	330.9	yes	7	69	0.10
	Blackman	557.50	558	100%	339,951	524	929	580	617					9	0.01
Tamar	Total	11,588.46	9,522	82%	10,660,469	524	2,126	925	920					194	0.21
Curries R.	EDA	1.77			737	737	737	737	737					80	0.11
	Curries	82.00	0	0%	73,499	746	1,122	840	855	16.5	296.0	nil	4	153	0.18
Curries R.	Total	83.78	0	0%	74,236	737	1,122	789	853					152	0.18
Pipers R.	EDA	14.41			11,810	756	826	780	787					111	0.14
	Pipers R.	375.47	0	0%	371,857	784	1,499	940	973	298.0	347.0	nil	11	229	0.23
	Pipers Bk.	74.35	0	0%	68,476	769	1,070	934	925					197	0.21
Pipers R.	Total	464.46	0	0%	452,143	756	1,499	885	960					220	0.23
Little Forester	EDA	4.52			3,923	767	797	789	785					109	0.14
	Little Forester	342.51	0	0%	340,769	773	1,578	970	1,005					249	0.25

		GIS Derived Data			GIS Derived, RWH Rainfall Data					RWSC Data - River Discharge Data				Calculated	
Catchment		Catchment	Dam Area	Dammed	TAR	Min	Max	Median	Mean	Catchment	MAR	Upstream	Records	Est.	Runoff
Estuary	Sub-Catchment	area (km^2)	(km^2)	%	(ML)	(mm)	(mm)	(mm)	(mm)	area (km^2)	(mm)	Regulation*	(yrs)	MAR	Coefficient
Little Forester	Total	347.21	0	0%	344,692	767	1,578	880	1,002					247	0.25
Brid	EDA	13.38			11,259	764	837	802	804					121	0.15
	Brid	148.88	0	0%	165,149	776	1,588	1,007	1,108	140.0	386.0	nil	18	318	0.29
	Hurst Ck.	94.12	0	0%	86,133	779	1,102	971	897					179	0.20
Brid	Total	256.67	0	0%	261,482	764	1,588	897	1,013					255	0.25
Great Forester	EDA	2.01			521,725	715	1,672	993	1,009					252	0.25
	Great Forester	517.34	0	0%	523,303	715	1,672	1,286	1,010	193.0	465.0	nil	13	253	0.25
Great Forester	Total	519.69	0	0%	522,784	715	1,672	1,026	1,009					252	0.25
Tomahawk	EDA	5.77			2,396	586	607	599	599					0	0.00
	Tomahawk	138.69	0	0%	120,791	588	1,337	885	863	115.0	265.0	nil	15	158	0.18
Tomahawk	Total	144.53	0	0%	123,187	586	1,337	742	855					153	0.18
Boobyalla Inlet	EDA	16.05			12,518	657	800	677	695					55	0.08
	Ringarooma	912.01	0	0%	1,170,707	682	1,832	1,283	1,278	482.0	644.0	nil	6	437	0.34
	Boobyalla	249.57	0	0%	251,756	705	1,610	998	1,003	116.0		yes		248	0.25
Boobyalla Inlet	Total	1,178.41	0	0%	1,436,559	657	1,832	1,134	1,211					389	0.32
Little Musselroe	EDA	6.48			6,311	671	766	694	701					58	0.08
	Little Musselroe	72.81	0	0%	56,869	683	895	756	790					112	0.14
Little Musselroe	Total	79.30	0	0%	62,450	671	895	738	781					107	0.14
Great Mussleroe	EDA	71.21			51,648	720	872	779	783					108	0.14
	Great Musselroe	368.15	0	0%	392,400	749	1,819	1,307	1,066	352.0	286.3	nil	14	290	0.27
Great Mussleroe	Total	439.94	0	0%	442,344	720	1,819	844	1,022					260	0.25
Ansons Bay	EDA	21.75			20,206	843	991	923	918					193	0.21
	Ansons	236.82	0	0%	259,997	861	1,703	1,060	1,088	228.0	209.4	nil	14	305	0.28
Ansons Bay	Total	258.94	0	0%	280,203	843	1,703	992	1,074					295	0.27
Big Lagoon	Total	17.24	0	0%	17,824	997	1,287	1,080	1,114					322	0.29
Sloop Lagoon	Total	10.82	0	0%	12,376	941	1,186	1,006	1,031					267	0.26
Grant's Lagoon	Total	6.78	0	0%	7,107	878	1,218	988	1,015					256	0.25
Georges Bay	EDA	34.14			28,772	748	1,128	853	872					163	0.19
	Georges	522.06	0	0%	701,538	793	1,829	1,323	1,336	405.0	525.0	nil	8	478	0.36
Georges Bay	Total	556.70	0	0%	732,014	748	1,829	1,293	1,310					459	0.35
Scamander	EDA	13.73			10,242	752	871	770	788					111	0.14
	Scamander	301.23	0	0%	316,049	747	1,659	1,005	1,061					286	0.27
	Arm Ck.	25.31	0	0%	24,194	782	1,309	985	1,008					251	0.25

		GIS Derived Data			GIS Derived, RWH Rainfall Data					RWSC Data - River Discharge Data				Calculated	
Catchment Estuary	Sub-Catchment	Catchment area (km²)	Dam Area (km²)	Dammed %	TAR (ML)	Min (mm)	Max (mm)	Median (mm)	Mean (mm)	Catchment area (km²)	MAR (mm)	Upstream Regulation*	Records (yrs)	Est. MAR	Runoff Coefficient
Scamander	Total	340.65	0	0%	351,430	747	1,659	926	1,046					276	0.26
Henderson's Lagoon	Total	50.51	0	0%	54,972	782	1,444	1,141	1,122					328	0.29
Templestowe Lagoon	Total	25.23	0	0%	27,686	835	1,224	1,148	1,107					318	0.29
Douglas	EDA	3.15			3,413	739	1,017	744	853					152	0.18
	Douglas	70.17	0	0%	85,836	863	1,305	1,191	1,176					365	0.31
Douglas	Total	73.53	0	0%	89,249	739	1,305	968	1,159					353	0.30
Denison	Total	26.83	0	0%	26,773	808	1,081	973	956					217	0.23
Saltwater Lagoon	Total	8.59	0	0%	6,718	655	690	674	672					41	0.06
Freshwater Lagoon	Total	11.86	0	0%	8,742	686	777	720	729					75	0.10
Bryants Lagoon	Total	5.82	0	0%	5,506	676	726	680	688					51	0.07
Great Swanport	EDA	140.47			94,565	601	751	648	648					27	0.04
	Apsley	230.85	0	0%	190,366	647	1,257	799	824	155.0	402.0	nil	15	133	0.16
	Swan	659.05	0	0%	522,500	595	1,214	788	794	448.0	343.0	nil	19	115	0.14
Great Swanport	Total	1,031.13	0	0%	807,431	595	1,257	745	780					106	0.14
Meredith	EDA	1.57			662	662	662	662	662					35	0.05
	Meredith	96.42	0	0%	74,894	621	978	797	797	86.4	239.0	nil	13	117	0.15
Meredith	Total	98.24	0	0%	75,556	621	978	730	795					116	0.15
Stoney	EDA	0.36													
	Stony	26.25	0	0%	18,554	642	804	710	714					66	0.09
Stoney	Total	26.71	0	0%	18,554	642	804	710	714					66	0.09
Buxton	EDA	1.10			638	638	638	638	638					21	0.03
	Buxton	59.38	0	0%	49,698	655	976	863	842					145	0.17
Buxton	Total	60.65	0	0%	50,336	638	976	751	839					143	0.17
Lisdillon	EDA	3.26			1,893	621	641	631	631					17	0.03
	Lisdillon	47.73	0	0%	36,073	632	914	757	752					89	0.12
Lisdillon	Total	51.16	0	0%	37,966	621	914	694	744					85	0.11
Little Swanport	EDA	55.73			36,674	605	821	665	679					45	0.07
	Swanport	605.38	0	0%	421,868	605	896	687	698	597.0	121.0	nil	22	57	0.08
	Ravensdale Rt.	71.63	0	0%	56,597	634	854	760	755					91	0.12
Little Swanport	Total	733.43	0	0%	515,139	605	896	704	703					59	0.08
Grindstone	EDA	6.78			3,979	651	674	663	663					36	0.05
	Eighty Acre Ck.	23.75	0	0%	16,976	658	819	738	738					81	0.11
Grindstone	Total	30.61	0	0%	20,955	651	819	701	723					71	0.10

		GIS Derived Data			GIS Derived, RWH Rainfall Data					RWSC Data - River Discharge Data				Calculated	
Catchment Estuary	Sub-Catchment	Catchment area (km^2)	Dam Area (km^2)	Dammed %	TAR (ML)	Min (mm)	Max (mm)	Median (mm)	Mean (mm)	Catchment area (km^2)	MAR (mm)	Upstream Regulation*	Records (yrs)	Est. MAR	Runoff Coefficient
Spring	EDA	25.75			18,389	644	836	742	736					79	0.11
	Spring	90.03	0	0%	67,900	641	910	776	772					101	0.13
Spring	Total	115.98	0	0%	86,289	641	910	759	764					96	0.13
Prosser	EDA	35.42			27,068	650	838	730	732					77	0.10
	Prosser	686.42	687	100%	502,340	580	963	718	727	684.0	167.0	n?	19	74	0.10
Prosser	Total	722.38	686	95%	529,408	580	963	724	727					74	0.10
Earlham Lagoon	EDA	17.06			12,162	697	823	745	760					94	0.12
	GriffithsRt.	92.48	0	0%	76,841	673	992	840	835					140	0.17
Earlham Lagoon	Total	109.68	0	0%	89,003	673	992	793	824					133	0.16
Blackman Bay	EDA	60.86			47,223	699	927	786	787					111	0.14
	Blackman Rt.	41.38	0	0%	34,128	767	973	850	853					152	0.18
Blackman Bay	Total	102.36	0	0%	81,351	699	973	818	814					127	0.16
Port Arthur	EDA	41.21			41,403	925	1,066	986	986					237	0.24
	Simmons Ck.	8.91	0	0%	8,653	932	993	962	961					221	0.23
	Long Bay Ck.	8.05	0	0%	8,474	913	981	942	942					208	0.22
	Alberry Ck	6.57	0	0%	5,591	915	947	931	932					202	0.22
	Denmans Ck.	13.23	0	0%	13,876	977	1,012	990	991					240	0.24
Port Arthur	Total	78.06	0	0%	77,997	913	1,066	962	975					230	0.24
Parsons Bay	EDA	30.53			23,845	744	885	787	795					115	0.15
	Parsons Bay	41.52	0	0%	37,762	806	1,031	908	899					181	0.20
	Cripps Ck.	16.71	0	0%	13,091	797	960	873	873					164	0.19
Parsons Bay	Total	88.77	0	0%	74,698	744	1,031	856	859					155	0.18
Norfolk Bay	EDA	212.80			164,449	640	1,081	786	794					115	0.14
	SaltwaterCk.	12.99	0	0%	11,500	753	923	814	821					132	0.16
Norfolk Bay	Total	225.88	0	0%	175,949	640	1,081	800	796					116	0.15
Carlton	EDA	23.30			15,585	620	708	640	649					28	0.04
	Carlton	141.17	0	0%	109,554	654	899	758	761	141.0	143.0	nil	14	94	0.12
Carlton	Total	164.72	0	0%	125,139	620	899	699	745					85	0.11
Pittwater	EDA	109.28			64,814	547	706	609	617					9	0.01
	Coal	541.22	246	45%	339,557	539	975	611	623	303.0	75.0	yes	23	12	0.02
	Orielton	49.68	0	0%	30,132	546	667	601	603	48.2	53.0	nil	11	1	0.00
	Sorell Rt.	40.78	0	0%	24,558	573	731	619	630					16	0.03
	Iron Ck.	93.85	0	0%	64,931	592	839	691	698	94.8	139.0	nil	21	57	0.08

		GIS Derived Data			GIS Derived, RWH Rainfall Data					RWSC Data - River Discharge Data				Calculated	
Catchment Estuary	Sub-Catchment	Catchment area (km²)	Dam Area (km²)	Dammed %	TAR (ML)	Min (mm)	Max (mm)	Median (mm)	Mean (mm)	Catchment area (km²)	MAR (mm)	Upstream Regulation*	Records (yrs)	Est. MAR	Runoff Coefficient
	Duckhole	46.37	0	0%	29,122	553	773	635	633					18	0.03
	Frogmore	16.59	0	0%	9,305	544	673	560	582					0	0.00
	Forcett Rt.	13.54	0	0%	9,216	590	640	610	614					7	0.01
	Gilling Bk.	10.97	0	0%	6,225	595	676	615	623					12	0.02
Pittwater	Total	922.97	246	27%	577,860	539	975	616	629					16	0.03
Pipeclay Lagoon	EDA	16.52			11,086	619	708	648	652					29	0.05
Pipeclay Lagoon	Total	16.52	0	0%	11,086	619	708	648	652					29	0.05
Derwent	EDA	780.41	0		652,339	536	1,456	705	836					141	0.17
	Ouse	1,649.21	1,650	100%	1,732,134	517	2,227	849	1,052					281	0.27
	Nive	1,089.29	1,089	100%	1,691,468	937	2,368	1,417	1,542	186.0	1,058.0	nil	19	632	0.41
	Derwent	7,366.85	6,145	83%	9,166,460	515	2,710	1,417	1,243	7,060.0	486.0	yes hec	24	412	0.33
	Clyde	1,117.24	1,118	100%	738,814	515	982	649	661	1,012.0	79.0	yes hec	20	35	0.05
	Dee	361.87	362	100%	354,420	760	1,170	978	979					232	0.24
	Jordan	1,243.83	0	0%	746,900	512	1,180	576	598	742.0	36.0	nil	23	0	0.00
	Florentine	442.59	443	100%	752,792	1,365	2,035	1,689	1,680	436.0	883.0			740	0.44
	Tyenna	336.44	0	0%	453,555	667	1,821	1,419	1,346	205.0	865.0	nil	18	485	0.36
	Styx	342.08	0	0%	497,773	649	1,793	1,499	1,443					557	0.39
	Plenty	223.58	0	0%	271,253	658	1,559	1,245	1,211					389	0.32
Derwent	Total	9,393.70	6,147	65%	10,572,092	512	2,710	2,052	1,720					771	0.45
Ralph's Bay	Total	57.53	0	0%	33,996	593	686	631	630					16	0.03
North West Bay	EDA	35.10			30,808	717	1,232	873	880					169	0.19
	North WestBay	95.57	0	0%	100,136	833	1,423	979	1,032	88.2	238.0	yes	18	267	0.26
	Margate	22.49	0	0%	24,410	911	1,405	1,137	1,162					355	0.31
	Snug	23.40	0	0%	31,405	1,038	1,531	1,329	1,309	17.1	286.0	nil	19	458	0.35
North West Bay	Total	176.75	0	0%	186,759	717	1,531	1,080	1,055					283	0.27
Oyster Cove	EDA	4.47			5,853	885	1,041	953	976					230	0.24
	Oyster Cove	15.53	0	0%	17,084	1,003	1,423	1,102	1,139					339	0.30
Oyster Cove	Total	20.07	0	0%	22,937	885	1,423	1,028	1,092					308	0.28
Garden Island	EDA	8.15			7,016	869	885	876	877					167	0.19
	Garden Island Ck.	39.81	0	0%	40,850	862	1,282	985	996					244	0.24
Garden Island	Total	48.03	0	0%	47,866	862	1,282	931	977					231	0.24
Port Cygnet	EDA	36.35			33,685	861	1,197	890	936					204	0.22
	Nicholls Rt.	47.24	0	0%	51,023	859	1,489	1,040	1,063					288	0.27

		GIS Derived Data			GIS Derived, RWH Rainfall Data					RWSC Data - River Discharge Data				Calculated	
Catchment		Catchment	Dam Area	Dammed	TAR	Min	Max	Median	Mean	Catchment	MAR	Upstream	Records	Est.	Runoff
Estuary	Sub-Catchment	area (km^2)	(km^2)	%	(ML)	(mm)	(mm)	(mm)	(mm)	area (km^2)	(mm)	Regulation*	(yrs)	MAR	Coefficient
	Agnes Rt.	43.18	0	0%	42,631	857	1,116	961	969					226	0.23
	Gardners Ck.	13.90	0	0%	13,052	856	1,058	906	932					202	0.22
Port Cygnet	Total	140.67	0	0%	140,391	856	1,489	949	989					239	0.24
Huon	EDA	300.83	0		305,380	784	1,473	917	1,015					256	0.25
	Weld	420.05	0	0%	715,649	1,015	2,069	1,774	1,720					771	0.45
	Huon	2,266.11	0	0%	3,722,832	807	2,327	1,689	1,641	1,829.0	1,588.0	yes hec	35	708	0.43
	Mountain River	186.89	0	0%	194,055	778	1,422	959	1,021	40.0	690.0	nil	15	260	0.25
	Picton	484.26	0	0%	818,746	1,137	2,049	1,689	1,685					743	0.44
Huon	Total	3,043.73	0	0%	4,562,654	778	2,327	1,111	1,499					599	0.40
Hospital Bay	EDA	6.90			7,711	925	1,040	944	964					222	0.23
	Crooks Rt.	132.33	0	0%	177,353	958	1,825	1,340	1,324					469	0.35
Hospital Bay	Total	139.49	0	0%	183,661	925	1,825	1,111	1,303					454	0.35
Surges Bay	EDA	1.37													
	Surges	11.70	0	0%	16,271	1,100	1,349	1,286	1,252					418	0.33
Surges Bay	Total	13.07	0	0%	14,955	1,100	1,349	1,256	1,246					414	0.33
Esperance	EDA	70.48			80,242	937	1,419	1,152	1,163					356	0.31
	Esperance	173.14	0	0%	266,377	1,068	1,908	1,559	1,540	175.0	705.0	nil	18	630	0.41
	Creekton Rt.	62.68	0	0%	87,871	1,095	1,932	1,320	1,373					505	0.37
Esperance	Total	306.62	0	0%	436,218	937	1,932	1,416	1,421					540	0.38
D`Entrecasteaux	EDA	410.87	0		422,283	3,323	5,165	3,895	1,028					264	0.26
D`Entrecasteaux	Total	3,547.17	0		5,208,568	717	2,327	1,095	1,468					576	0.39
Cloudy Bay	EDA	18.24			15,483	888	971	907	911					188	0.21
	Cloudy	24.46	0	0%	22,596	905	1,028	931	942					208	0.22
Cloudy Bay	Total	42.70	0	0%	38,079	888	1,028	919	929					200	0.21
Southport	EDA	46.55			54,536	1,050	1,598	1,133	1,186					371	0.31
	Lune	131.78	0	0%	219,239	1,132	1,930	1,707	1,661					724	0.44
	SouthportRt.	10.60	0	0%	11,173	1,126	1,361	1,236	1,241					411	0.33
Southport	Total	189.22	0	0%	286,291	1,050	1,930	1,355	1,523					617	0.41
Southport Lagoon	EDA	13.70			15,220	1,130	1,238	1,174	1,171					361	0.31
	Donnelys	13.48	0	0%	17,745	1,177	1,427	1,220	1,268					429	0.34
Southport Lagoon	Total	27.21	0	0%	32,965	1,130	1,427	1,197	1,221					396	0.32
Recherche Bay	EDA	28.31			41,341	1,172	1,517	1,231	1,253					419	0.33
	D`entrecasteaux	73.38	0	0%	115,211	1,183	2,019	1,627	1,623					694	0.43

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Catchment		Catchment	Dam Area	Dammed	TAR	Min	Max	Median	Mean	Catchment	MAR	Upstream	Records	Est.	Runoff
Estuary	Sub-Catchment	area (km^2)	(km^2)	%	(ML)	(mm)	(mm)	(mm)	(mm)	area (km^2)	(mm)	Regulation*	(yrs)	MAR	Coefficient
	Catamaran	66.66	0	0%	107,247	1,204	2,112	1,556	1,577					659	0.42
	Cockle	10.88	0	0%	12,330	1,181	1,323	1,222	1,233					405	0.33
Recherche Bay	Total	179.43	0	0%	276,129	1,172	2,112	1,409	1,517					613	0.40
New River Lagoon	EDA	75.11			107,182	1,259	2,065	1,333	1,448					561	0.39
	New	222.68	0	0%	366,871	1,325	2,031	1,713	1,683					742	0.44
New River Lagoon	Total	298.09	0	0%	474,053	1,259	2,065	1,523	1,623					695	0.43
Louisa R.	EDA	3.99			3,128	1,514	1,614	1,514	1,564					649	0.41
	Louisa R.	79.01	0	0%	124,936	1,432	2,062	1,540	1,602					678	0.42
Louisa R.	Total	83.19	0	0%	128,064	1,432	2,062	1,527	1,601					677	0.42
Louisa Ck.	EDA	2.41			6,398	1,535	1,680	1,579	1,600					676	0.42
	Louisa Ck.	54.18	0	0%	99,138	1,602	2,015	1,694	1,739					787	0.45
Louisa Ck.	Total	56.72	0	0%	105,536	1,535	2,015	1,637	1,730					779	0.45
Freney	Total	19.61	0	0%	40,142	1,847	1,991	1,907	1,912					928	0.49
Bathurst Harbour	EDA	213.25			468,149	1,934	2,457	2,159	2,167					1,150	0.53
	Spring	150.33	0	0%	354,805	2,239	2,557	2,413	2,414					1,375	0.57
	North	137.74	0	0%	311,660	2,087	2,476	2,294	2,275					1,247	0.55
	Old	428.34	0	0%	815,188	1,605	2,277	1,896	1,909					926	0.49
	Horseshoe	16.82	0	0%	40,341	2,180	2,294	2,247	2,241					1,216	0.54
	Ray	53.06	0	0%	103,637	1,845	2,182	1,988	1,993					998	0.50
	Melaleuca	67.36	0	0%	146,244	1,900	2,336	2,073	2,089					1,081	0.52
Bathurst Harbour	Total	1,067.26	0	0%	2,240,024	1,605	2,557	2,153	2,099					1,090	0.52
Payne Bay	EDA	130.71			318,094	2,310	2,718	2,413	2,428					1,389	0.57
	Davey	723.53	0	0%	1,837,283	2,124	2,830	2,436	2,538	686.0	1,933.0	nil	19	1,493	0.59
	Crossing	238.97	0	0%	580,785	2,124	2,615	2,354	2,410					1,372	0.57
	Dewitt	46.18	0	0%	120,443	2,448	2,760	2,601	2,618					1,572	0.60
	BlackwaterCk.	23.54	0	0%	55,655	2,405	2,711	2,507	2,530					1,486	0.59
Payne Bay	Total	924.67	0	0%	2,329,354	2,124	2,830	2,524	2,526					1,483	0.59
Mulcahy	EDA	3.25			9,484	2,360	2,378	2,371	2,371					1,335	0.56
	Mulcahy	54.77	0	0%	129,807	2,362	2,696	2,508	2,449					1,409	0.58
Mulcahy	Total	58.07	0	0%	136,694	2,360	2,696	2,395	2,441					1,401	0.57
Giblin	EDA	13.86			35,488	2,350	2,420	2,363	2,366					1,331	0.56
	Giblin	309.21	0	0%	797,229	2,386	2,848	2,533	2,555					1,510	0.59
Giblin	Total	323.31	0	0%	832,717	2,350	2,848	2,448	2,547					1,502	0.59

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Catchment		Catchment	Dam Area	Dammed	TAR	Min	Max	Median	Mean	Catchment	MAR	Upstream	Records	Est.	Runoff
Estuary	Sub-Catchment	area (km^2)	(km^2)	%	(ML)	(mm)	(mm)	(mm)	(mm)	area (km^2)	(mm)	Regulation*	(yrs)	MAR	Coefficient
Lewis	EDA	18.88			42,917	2,230	2,326	2,247	2,259					1,232	0.55
	Lewis	194.03	0	0%	482,278	2,282	2,731	2,491	2,486					1,444	0.58
Lewis	Total	213.14	0	0%	525,195	2,230	2,731	2,369	2,466					1,425	0.58
Mainwaring Inlet	EDA	2.99			6,534	2,171	2,183	2,180	2,178					1,159	0.53
	Mainwairing	47.97	0	0%	114,158	2,175	2,478	2,346	2,330					1,297	0.56
Mainwaring Inlet	Total	51.00	0	0%	120,692	2,171	2,478	2,263	2,321					1,289	0.56
Wanderer	EDA	70.34			163,845	2,058	2,549	2,293	2,276					1,247	0.55
	Wanderer	283.06	0	0%	705,360	2,183	2,766	2,520	2,510					1,467	0.58
Wanderer	Total	353.73	0	0%	869,205	2,058	2,766	2,407	2,462					1,421	0.58
Spero	EDA	3.01			5,931	1,969	1,987	1,975	1,977					984	0.50
	McCarthy	27.41	0	0%	57,605	1,974	2,280	2,134	2,134					1,120	0.52
	Spero	112.60	0	0%	261,941	1,974	2,598	2,239	2,278					1,249	0.55
Spero	Total	115.80	0	0%	267,872	1,969	2,598	2,151	2,270					1,242	0.55
Hibbs Lagoon	EDA	4.94			9,501	1,893	1,912	1,897	1,900					919	0.48
	Hibbs	47.23	0	0%	93,627	1,909	2,250	2,077	2,081					1,073	0.52
Hibbs Lagoon	Total	52.18	0	0%	103,128	1,893	2,250	1,987	2,063					1,058	0.51
Macquarie Harbour	EDA	508.34	0		1,089,544	1,388	3,380	2,040	2,143					1,128	0.53
Macquarie Harbour	Total	6,790.31	2,570		17,075,077	1,388	3,546	2,336	2,515					1,471	0.59
Birchs Inlet	EDA	75.89			169,134	2,013	2,761	2,233	2,255					1,229	0.54
	Sorell	236.79	0	0%	536,665	2,035	2,611	2,297	2,303					1,273	0.55
Birchs Inlet	Total	312.82	0	0%	708,276	2,013	2,761	2,336	2,292					1,263	0.55
Gordon	EDA	33.27			74,948	1,996	2,610	2,169	2,204					1,183	0.54
	Franklin	1,655.97	0	0%	4,571,799	2,183	3,365	2,573	2,769	1,590.0	1,872.0	nil	22	1,722	0.62
	Denison	663.29	0	0%	1,667,463	2,060	2,942	2,508	2,500					1,457	0.58
	Gordon	5,182.90	2,013	39%	13,029,802	1,717	3,365	2,487	2,519	458.0	1,550.0			1,475	0.59
	Lake Pedder	262.09	263	100%	561,132	1,851	2,548	2,081	2,134					1,120	0.52
Gordon	Total	5,217.49	2,013	39%	13,107,993	1,717	3,365	2,505	2,517					1,473	0.59
King	EDA	3.88			6,576	1,621	1,663	1,636	1,644					711	0.43
	King	811.50	557	69%	2,330,448	1,650	3,546	2,753	2,866	449.0	2,339.0	nil	55	1,822	0.64
King	Total	816.08	557	68%	2,339,346	1,621	3,546	2,477	2,860					1,815	0.63
Manuka	EDA	7.28			10,640	1,453	1,570	1,532	1,520					615	0.40
	Manuka	38.08	0	0%	65,932	1,470	2,192	1,633	1,735					783	0.45
	BotanicalCk.	10.30	0	0%	14,644	1,554	1,735	1,606	1,627					698	0.43

		GIS Derived Data			GIS Derived, RWH Rainfall Data					RWSC Data - River Discharge Data				Calculated	
Catchment Estuary	Sub-Catchment	Catchment area (km^2)	Dam Area (km^2)	Dammed %	TAR (ML)	Min (mm)	Max (mm)	Median (mm)	Mean (mm)	Catchment area (km^2)	MAR (mm)	Upstream Regulation*	Records (yrs)	Est. MAR	Runoff Coefficient
Manuka	Total	55.70	0	0%	91,216	1,453	2,192	1,590	1,689					747	0.44
Henty	EDA	13.60			19,858	1,402	1,469	1,415	1,418					539	0.38
	Henty	375.25	0	0%	958,031	1,429	3,509	2,530	2,555	116.0	271.0	nil	18	1,510	0.59
	Badger	45.20	0	0%	81,453	1,423	2,351	1,719	1,771					812	0.46
	Tully	68.01	0	0%	133,476	1,421	2,584	2,177	1,934					948	0.49
Henty	Total	502.53	0	0%	1,190,190	1,402	3,509	1,995	2,366					1,331	0.56
Little Henty	EDA	48.42			76,834	1,434	2,387	1,495	1,601					677	0.42
	Little Henty	280.85	0	0%	699,011	1,571	3,215	2,515	2,461					1,420	0.58
Little Henty	Total	329.55	0	0%	775,845	1,434	3,215	2,005	2,337					1,304	0.56
Pieman	EDA	35.20			56,455	1,353	2,013	1,808	1,764					807	0.46
	Donaldson	332.04	0	0%	714,441	1,578	2,600	2,173	2,172					1,154	0.53
	Savage	302.93	0	0%	647,865	1,632	2,432	2,160	2,124					1,112	0.52
	Whyte	386.52	0	0%	845,083	1,695	2,832	2,184	2,189	325.0	1,480.0	nil	23	1,169	0.53
	Huskisson	508.95	509	100%	1,149,577	1,917	2,779	2,291	2,272					1,244	0.55
	Pieman	3,829.54	2,661	69%	9,120,725	1,505	3,422	2,203	2,384	2,541.0	1,566.0	yes hec	28	1,347	0.57
	Mackintosh	534.14	534	100%	1,247,647	1,780	3,031	2,203	2,323					1,291	0.56
	Murchisson	793.77	794	100%	2,165,243	2,088	3,422	2,756	2,727					1,680	0.62
Pieman	Total	3,866.14	2,660	69%	9,173,683	1,353	3,422	2,328	2,378					1,342	0.56
Lagoon	EDA	0.82			1,428	1,428	1,428	1,428	1,428					546	0.38
	Lagoon	85.53	0	0%	173,268	1,435	2,603	2,018	2,015					1,016	0.50
Lagoon	Total	86.42	0	0%	174,696	1,428	2,603	1,723	2,008					1,010	0.50
Pedder	EDA	1.68			2,854	1,427	1,427	1,427	1,427					545	0.38
	Pedder	80.86	0	0%	135,350	1,426	1,917	1,627	1,631					700	0.43
Pedder	Total	82.54	0	0%	138,204	1,426	1,917	1,527	1,626					697	0.43
Nelson Bay	EDA	2.69			3,862	1,284	1,292	1,286	1,287					443	0.34
	Nelson Bay	67.87	0	0%	104,945	1,294	1,863	1,610	1,590					669	0.42
Nelson Bay	Total	70.57	0	0%	108,807	1,284	1,863	1,448	1,577					659	0.42
Arthur	EDA	95.65			120,389	1,189	1,357	1,282	1,281					438	0.34
	Arthur	1,828.62	0	0%	3,338,888	1,263	2,622	1,951	1,822	1,535.0	1,179.0	nil	28	854	0.47
	Frankland	569.18	0	0%	1,091,815	1,360	2,433	1,923	1,912					929	0.49
	Hellyer	326.66	0	0%	648,888	1,592	2,622	1,987	1,984	102.0	1,343.0	nil	26	990	0.50
Arthur	Total	2,494.61	0	0%	4,545,189	1,189	2,622	1,737	1,741					788	0.45

		GIS Derived Data			GIS Derived, RWH Rainfall Data					RWSC Data - River Discharge Data				Calculated	
Catchment		Catchment	Dam Area	Dammed	TAR	Min	Max	Median	Mean	Catchment	MAR	Upstream	Records	Est.	Runoff
Estuary	Sub-Catchment	area (km²)	(km²)	%	(ML)	(mm)	(mm)	(mm)	(mm)	area (km²)	(mm)	Regulation*	(yrs)	MAR	Coefficient
Grand Total		67,934.00	23,480	35%	97,418,804	512	3,546	1,305	1,314						
	Statistics all catchments														
	mean	279.99	192	11%	552,219	1,036	1,545	1,225	1,228	623.0	634.0		19	442	0.29
	std. dev.	842.64	1,065	29%	1,745,121	474	727	562	550	1,403.9	518.4		13	428	0.16
	min.	0.19	0	0%	638	512	607	560	582	16.5	36.0		1	0	0.00
	max.	11,588.46	9,522	100%	17,075,077	3,323	5,165	3,895	2,866	8,997.0	2,339.0		82	1,822	0.64
	median	67.36	0	0%	81,351	874	1,292	1,026	1,045	228.0	465.5		18	280	0.27

Appendix 3 Characteristics of Tasmanian Estuaries: Population and Dwellings

Appendix 3: Characteristics of Tasmanian Estuaries
Population and Dwellings

Catchment Estuary	Sub-Catchment	Catchment Area (km²)	ABS CData91 - Population and Dwellings Population	Pop./(km²)	Dwellings	(Count)	Occupied	% Occupied
outside catchments		6,184.2	52569	8.501	23564		19219	82%
Sea Elephant	EBZ	10.6	10	0.920	5	(0)	3	76%
	EDA	14.5	15	1.059	7	(0)	5	76%
	FDA	280.2	240	0.856	103		84	82%
	SaltmarshCk.	117.8	55	0.467	23		18	80%
	Sea Elephant	162.3	185	1.139	80		66	83%
Sea Elephant	ECA (Total)	294.7	255	0.866	110	(58)	90	82%
Yarra	EBZ	1.2	1	0.894	1		0	75%
	EDA	37.6	41	1.077	19		15	75%
	FDA	0.5	0	0.000	0		0	75%
Yarra	ECA (Total)	38.1	41	1.073	20		15	75%
Ettrick	EBZ	0.9	0	0.000	0	(0)	0	83%
	EDA	0.2	0	0.000	0	(0)	0	86%
	FDA	45.2	46	1.010	20		17	84%
	Ettrick	45.2	46	1.011	20		17	84%
Ettrick	ECA (Total)	45.4	46	1.009	20	(17)	17	84%
Grassy	EBZ		0					
	EDA	21.1	33	1.576	125		14	11%
Grassy	ECA (Total)	21.1	33	1.577	125		14	11%
Big Lake (Seal R.)	EBZ	5.9	4	0.609	2	(0)	1	75%
	EDA	6.6	4	0.611	2	(0)	2	75%
	FDA	70.9	43	0.607	22		16	75%
	Seal	70.8	43	0.608	22		16	75%
Big Lake (Seal R.)	ECA (Total)	77.5	47	0.608	24	(0)	18	75%
Yellow Rock	EBZ	2.8	1	0.460	1	(1)	0	80%
	EDA	1.5	0	0.000	0	(1)	0	80%
	FDA	117.7	55	0.466	23		18	80%
	Yellow Rock	117.7	55	0.466	23		18	80%
Yellow Rock	ECA (Total)	119.2	56	0.466	23	(33)	18	80%
North East Inlet	EBZ	12.3	3	0.271	3	(3)	1	46%
	EDA	21.9	6	0.273	5	(3)	2	46%
	FDA	103.4	28	0.273	25		12	46%
	North East	29.4	8	0.273	7		3	46%
	Arthurs	74.0	20	0.273	18		8	46%
North East Inlet	ECA (Total)	125.2	34	0.273	31		14	46%
Foochow Inlet	EBZ	3.9	1	0.275	1	(0)	0	46%
	EDA	2.8	0	0.000	1	(0)	0	46%
	FDA	64.5	18	0.272	16		7	46%
	Foochow	64.4	18	0.272	16		7	46%
Foochow Inlet	ECA (Total)	67.3	18	0.272	16		7	46%
Middle Inlet	EBZ	2.6	0	0.000	1	(0)	0	46%
	EDA	1.5	0	0.000	0	(0)	0	46%
	FDA	59.6	16	0.272	14		7	46%
	Middle Inlet	59.4	16	0.273	14		7	46%
Middle Inlet	ECA (Total)	61.1	17	0.272	15		7	46%
Patriarch	EBZ	5.3	2	0.428	1	(0)	1	62%
	EDA	4.5	2	0.380	1	(0)	1	58%
	FDA	173.4	66	0.380	45		26	59%
	Drains (Patriarch)	32.8	9	0.273	8		4	46%
	Patriarch	140.4	57	0.405	37		23	62%

Catchment		Catchment	ABS CData91 - Population and Dwellings					
Estuary	Sub-Catchment	Area (km²)	Population	Pop./(km²)	Dwellings	(Count)	Occupied	% Occupied
Patriarch	ECA (Total)	177.9	68	0.380	46	(13)	27	59%
Sellars Lagoon	EBZ	17.7	10	0.591	5	(0)	4	75%
	EDA	44.1	26	0.590	13	(0)	10	75%
	FDA	0.0	0	0.000	0		0	
Sellars Lagoon	ECA (Total)	44.2	26	0.590	13	(0)	10	75%
Cameron Inlet	EBZ	16.2	10	0.587	5	(0)	4	75%
	EDA	43.4	25	0.587	13	(0)	10	75%
	FDA	149.5	83	0.552	43		32	75%
	Nelsons Drain	119.0	69	0.580	36		27	75%
	Chew Tobacco Ck.	30.3	14	0.446	7		5	74%
Cameron Inlet	ECA (Total)	192.9	108	0.560	56	(23)	42	75%
Logans Lagoon	EBZ	19.2	11	0.590	6	(0)	4	75%
	EDA	69.7	41	0.591	21	(0)	16	75%
	FDA	0.0	0	0.000	0		0	
Logans Lagoon	ECA (Total)	69.7	41	0.590	21	(5)	16	75%
Pats	EBZ	2.3	0	0.000	1		0	48%
	EDA	1.3	0	0.000	0	(0)	0	48%
	FDA	68.4	20	0.298	14		8	62%
	Pats	68.3	20	0.298	14		8	62%
Pats	ECA (Total)	69.6	21	0.297	14	(17)	9	61%
Mines	EBZ	2.2	0	0.000	1	(0)	0	46%
	EDA	0.3	0	0.000	0	(0)	0	46%
	FDA	20.8	6	0.273	5		2	46%
	Mines	20.8	6	0.273	5		2	46%
Mines	ECA (Total)	21.1	6	0.273	5		2	46%
Dover	EBZ	2.5	0	0.000	0	(0)	0	72%
	EDA	2.4	0	0.000	0	(0)	0	72%
	FDA	29.8	9	0.311	5		4	72%
	Dover	29.8	9	0.311	5		4	72%
Dover	ECA (Total)	32.2	10	0.311	6	(0)	4	72%
Lee	EBZ	3.1	0	0.000	1	(0)	0	72%
	EDA	0.5	0	0.000	0	(0)	0	72%
	FDA	61.0	19	0.310	11		8	72%
	Rooks	6.6	2	0.310	1		1	72%
	Lee	54.4	17	0.311	10		7	72%
Lee	ECA (Total)	61.5	19	0.310	11	(0)	8	72%
Shag Rock	EBZ	3.2	1	0.315	1	(0)	0	72%
	EDA	3.6	1	0.317	1	(0)	0	72%
	FDA	35.6	11	0.310	6		5	72%
	Shag Rock	35.6	11	0.311	6		5	72%
Shag Rock	ECA (Total)	39.2	12	0.311	7	(0)	5	72%
Modder	EBZ	2.5	0	0.000	0	(0)	0	72%
	EDA	2.2	0	0.000	0	(0)	0	72%
	FDA	43.0	13	0.311	8		6	72%
	Modder	43.0	13	0.311	8		6	72%
Modder	ECA (Total)	45.2	14	0.311	8	(0)	6	72%
Rice	EBZ	3.5	1	0.310	1	(0)	0	72%
	EDA	1.7	0	0.000	0	(0)	0	72%
	FDA	28.2	9	0.309	5		4	72%
	Rice	28.1	9	0.311	5		4	72%
Rice	ECA (Total)	29.9	9	0.309	5	(0)	4	72%
Rocky Head	EBZ	1.5	0	0.000	0	(0)	0	72%
	EDA	1.1	0	0.000	0	(0)	0	72%

Catchment		Catchment	ABS CData91 - Population and Dwellings					
Estuary	Sub-Catchment	Area (km²)	Population	Pop./(km²)	Dwellings	(Count)	Occupied	% Occupied
	FDA	14.4	4	0.308	3		2	72%
	Rocky Head	14.4	4	0.310	3		2	72%
Rocky Head	ECA (Total)	15.5	5	0.307	3	(0)	2	72%
Christmas Beach	EBZ	1.8	0	0.000	0	(0)	0	72%
	EDA	2.3	0	0.000	0	(0)	0	72%
	FDA	10.6	3	0.308	2		1	72%
	ChristmasBeach	10.5	3	0.310	2		1	72%
Christmas Beach	ECA (Total)	12.9	4	0.309	2	(0)	2	72%
Mosquito Inlet	EBZ	9.0	5	0.592	2		2	88%
	EDA	28.6	14	0.501	6		5	81%
	FDA	0.0	0	0.000	0		0	
Mosquito Inlet	ECA (Total)	28.6	14	0.501	6		5	81%
Welcome	EBZ	8.6	4	0.512	2	(3)	2	81%
	EDA	12.4	6	0.500	3		2	81%
	FDA	291.8	111	0.379	51		38	74%
	Welcome	291.8	111	0.380	51		38	74%
Welcome	ECA (Total)	304.2	117	0.384	54		40	75%
Montagu	EBZ	6.0	4	0.733	2		1	81%
	EDA	10.1	7	0.677	3	(15)	2	85%
	FDA	317.4	395	1.245	140		126	90%
	Montagu	317.0	395	1.246	139		126	90%
Montagu	ECA (Total)	327.5	402	1.227	142		128	90%
Harcus	EBZ	6.0	3	0.504	1		1	81%
	EDA	4.0	2	0.494	1		1	81%
	FDA	35.7	18	0.504	8		6	81%
	Harcus	35.7	18	0.504	8		6	81%
Harcus	ECA (Total)	39.7	20	0.503	8		7	81%
Robbins Passage	EBZ	51.5	47	0.906	18		16	88%
	EDA	94.1	96	1.022	36		32	89%
	FDA	353.2	413	1.170	147		132	90%
Robbins Passage	ECA (Total)	447.2	509	1.139	184		164	89%
Duck Bay	EBZ	36.7	2220	60.428	796		755	95%
	EDA	78.2	2006	25.638	730		691	95%
	FDA	471.0	3014	6.400	1048		989	94%
	Deep Ck.	78.2	348	4.454	114		107	93%
	Duck	392.4	2666	6.794	934		882	95%
Duck Bay	ECA (Total)	549.2	5020	9.141	1778		1680	94%
West Inlet	EBZ	6.9	32	4.661	11		10	90%
	EDA	3.5	16	4.522	5		5	90%
	FDA	19.1	91	4.789	30		27	90%
	Grays Ck.	19.0	91	4.794	30		27	90%
West Inlet	ECA (Total)	22.5	107	4.748	35		32	90%
East Inlet	EBZ	8.4	34	4.019	16		11	72%
	EDA	4.6	18	3.822	9		6	69%
	FDA	16.7	188	11.260	71		64	90%
	Ghost Ck.	16.6	188	11.297	71		64	90%
East Inlet	ECA (Total)	21.3	205	9.654	80		70	88%
Black	EBZ	6.9	23	3.338	16		9	57%
	EDA	9.7	34	3.445	22		13	59%
	FDA	335.4	570	1.700	263		189	72%
	Black/Dip	334.9	570	1.702	263		189	72%
Black	ECA (Total)	345.1	604	1.749	285		202	71%
Crayfish	EBZ	1.8	6	3.348	4		2	57%

Catchment		Catchment	ABS CData91 - Population and Dwellings					
Estuary	Sub-Catchment	Area (km^2)	Population	Pop./(km^2)	Dwellings	(Count)	Occupied	% Occupied
	EDA	0.5	2	3.668	1		1	57%
	FDA	43.8	94	2.148	60		36	59%
	Crayfish Ck.	43.8	94	2.150	60		36	59%
Crayfish	ECA (Total)	44.3	96	2.164	62		36	59%
Detention	EBZ	8.0	12	1.491	7		4	61%
	EDA	5.6	9	1.627	6		3	60%
	FDA	146.3	178	1.217	73		53	73%
	Wilson Ck.	38.4	34	0.886	15		10	70%
	Detention	107.8	144	1.337	58		43	74%
Detention	ECA (Total)	152.0	187	1.232	78		57	72%
Inglis	EBZ	6.3	2911	463.901	1158		1094	95%
	EDA	6.3	2251	357.942	916		864	94%
	FDA	498.4	4180	8.387	1514		1393	92%
	Flowerdale	172.6	716	4.145	249		221	89%
	Inglis	325.5	3465	10.643	1265		1171	93%
Inglis	ECA (Total)	504.7	6431	12.742	2431		2257	93%
Cam	EBZ	3.1	954	307.246	348		328	94%
	EDA	9.8	1299	132.986	462		443	96%
	FDA	238.7	1660	6.955	569		534	94%
	Cam	238.5	1660	6.961	569		534	94%
Cam	ECA (Total)	248.5	2959	11.910	1031		977	95%
Emu	EBZ	2.7	465	172.216	188		173	92%
	EDA	1.2	246	198.171	99		91	92%
	FDA	242.0	1366	5.646	488		460	94%
	Emu	241.6	1364	5.649	487		460	94%
Emu	ECA (Total)	243.2	1612	6.628	587		552	94%
Blythe	EBZ	5.6	245	43.437	96		91	95%
	EDA	5.1	233	45.516	92		87	95%
	FDA	271.2	868	3.199	296		278	94%
	Blythe	270.8	867	3.201	295		278	94%
Blythe	ECA (Total)	276.3	1101	3.984	388		365	94%
Leven	EBZ	19.7	5213	264.359	2069		1927	93%
	EDA	48.5	6387	131.637	2489		2317	93%
	FDA	647.0	1659	2.564	567		531	94%
	Leven	559.7	1016	1.816	345		320	93%
	Gawler	86.7	642	7.403	222		211	95%
Leven	ECA (Total)	695.6	8046	11.567	3056		2848	93%
Forth	EBZ	12.2	901	74.011	334		318	95%
	EDA	15.3	1030	67.288	384		365	95%
	FDA	1,108.0	1721	1.553	629		564	90%
	Forth	1,107.2	1721	1.554	629		564	90%
Forth	ECA (Total)	1,123.3	2751	2.449	1013		929	92%
Don	EBZ	6.4	1579	246.071	593		570	96%
	EDA	5.9	1641	278.456	612		587	96%
	FDA	129.7	1782	13.742	646		597	92%
	Don	129.4	1782	13.769	646		597	92%
Don	ECA (Total)	135.6	3424	25.251	1258		1184	94%
Mersey	EBZ	25.3	7908	312.718	3282		3005	92%
	EDA	44.3	12661	285.950	5102		4708	92%
	FDA	1,707.6	7498	4.391	2757		2543	92%
	Mersey	1,706.4	7497	4.394	2757		2543	92%
Mersey	ECA (Total)	1,751.8	20158	11.507	7859		7251	92%
Port Sorell	EBZ	53.5	1441	26.966	764		557	73%

Catchment		Catchment	ABS CData91 - Population and Dwellings					
Estuary	Sub-Catchment	Area (km²)	Population	Pop./(km²)	Dwellings	(Count)	Occupied	% Occupied
	EDA	80.2	1526	19.037	800		586	73%
	FDA	563.0	1625	2.887	638		546	86%
	Sheepwash	15.9	10	0.619	5		3	67%
	Brown Ck.	25.2	15	0.599	8		5	66%
	Panatana	68.8	690	10.027	262		231	88%
	Branchs	30.1	18	0.600	9		6	66%
	Franklin Rt.	132.4	236	1.779	85		74	86%
	Green Ck.	28.0	19	0.682	9		7	69%
	Rubicon	262.3	638	2.431	259		221	85%
Port Sorell	ECA (Total)	643.1	3151	4.900	1437		1132	79%
Tamar	EBZ	181.6	24250	133.516	9656		8726	90%
	EDA	558.3	38845	69.572	14727		13488	92%
	FDA	11,030.1	71209	6.456	29193		26267	90%
	Fourteen Mile Ck.	97.7	215	2.201	84		70	84%
	Masseys Rt.	33.5	38	1.120	15		11	72%
	Andersons	49.5	72	1.447	29		22	77%
	Johnston Ck.	61.4	483	7.862	171		158	92%
	Supply	134.9	1027	7.617	356		329	92%
	North Esk	1,064.7	34210	32.132	13947		12907	93%
	Stony Bk.	42.3	1033	24.400	387		362	94%
	South Esk	2,333.0	19900	8.530	7810		7251	93%
	Meander	1,333.6	7018	5.263	2801		2496	89%
	Liffey	234.4	1105	4.715	417		382	92%
	Nile	323.2	241	0.744	89		80	90%
	Break`O`Day	229.9	796	3.461	350		298	85%
	Macquarie	1,557.4	2288	1.469	999		868	87%
	Ben LomondRt.	199.9	104	0.520	42		35	82%
	St. Pauls	520.9	277	0.533	131		102	78%
	Brumby	308.5	743	2.408	310		259	84%
	Lake	812.9	212	0.261	263		81	31%
	Great Lake	396.2	176	0.443	374		61	16%
	Isis	337.0	57	0.170	43		22	52%
	Elizabeth	399.0	846	2.121	398		340	85%
	Blackman	557.5	367	0.659	177		133	75%
Tamar	ECA (Total)	11,588.5	110054	9.497	43920		39755	91%
Curries R.	EBZ	2.7	3	1.236	2	(55)	1	55%
	EDA	1.8	2	1.356	1	(55)	1	63%
	FDA	82.0	120	1.460	51		37	73%
	Curries	82.0	120	1.460	51		37	73%
Curries R.	ECA (Total)	83.8	122	1.458	53	(117)	38	72%
Pipers R.	EBZ	15.1	42	2.818	72		17	24%
	EDA	14.4	34	2.369	46		13	28%
	FDA	450.1	1621	3.602	738		546	74%
	Pipers R.	375.5	1480	3.943	674		499	74%
	Pipers Bk.	74.4	141	1.893	64		47	73%
Pipers R.	ECA (Total)	464.5	1655	3.564	784		559	71%
Little Forester	EBZ	8.0	21	2.679	9	(23)	8	82%
	EDA	4.5	13	2.860	10	(23)	5	56%
	FDA	342.7	797	2.324	326		271	83%
	Little Forester	342.5	797	2.325	326		271	83%
Little Forester	ECA (Total)	347.2	809	2.331	336		276	82%
Brid	EBZ	7.6	474	62.068	232		176	76%
	EDA	13.4	383	28.642	187		143	76%

Catchment		Catchment	ABS CData91 - Population and Dwellings					
Estuary	Sub-Catchment	Area (km^2)	Population	Pop./(km^2)	Dwellings	(Count)	Occupied	% Occupied
	FDA	243.3	1841	7.568	719		664	92%
	Brid	148.9	550	3.694	218		191	88%
	Hurst Ck.	94.1	1291	13.720	502		472	94%
Brid	ECA (Total)	256.7	2225	8.667	906		806	89%
Great Forester	EBZ	5.4	4	0.827	2	(0)	2	90%
	EDA	2.0	1	0.735	1	(0)	1	88%
	FDA	517.7	1451	2.803	566		522	92%
	Great Forester	517.3	1451	2.805	566		522	92%
Great Forester	ECA (Total)	519.7	1453	2.795	566		523	92%
Tomahawk	EBZ	7.9	2	0.237	1	(6)	1	52%
	EDA	5.8	1	0.234	1	(6)	0	50%
	FDA	138.8	53	0.385	29		18	62%
	Tomahawk	138.7	53	0.386	29		18	62%
Tomahawk	ECA (Total)	144.5	55	0.379	30		19	62%
Boobyalla Inlet	EBZ	13.9	3	0.218	3	(11)	1	37%
	EDA	16.1	3	0.215	3	(11)	1	37%
	FDA	1,162.3	1930	1.661	861		690	80%
	Ringarooma	912.0	1579	1.731	713		571	80%
	Boobyalla	249.6	351	1.407	148		119	80%
Boobyalla Inlet	ECA (Total)	1,178.4	1934	1.641	865		691	80%
Little Musselroe	EBZ	4.9	1	0.215	1	(3)	0	37%
	EDA	6.5	1	0.210	1	(3)	0	37%
	FDA	72.8	16	0.215	15		6	38%
	Little Musselroe	72.8	16	0.216	14		5	37%
Little Musselroe	ECA (Total)	79.3	17	0.214	16	(27)	6	38%
Great Mussleroe	EBZ	21.6	6	0.282	8	(56)	2	27%
	EDA	71.2	20	0.287	28	(56)	7	27%
	FDA	368.7	124	0.337	155		47	30%
	Great Musselroe	368.1	124	0.337	155		47	30%
Great Mussleroe	ECA (Total)	439.9	145	0.329	183		54	30%
Ansons Bay	EBZ	14.9	10	0.683	12	(141)	4	36%
	EDA	21.8	11	0.524	14	(141)	5	32%
	FDA	237.2	138	0.580	166		56	34%
	Ansons	236.8	137	0.580	166		56	34%
Ansons Bay	ECA (Total)	258.9	149	0.575	181		61	34%
Big Lagoon	EBZ	4.1	5	1.217	5	(2)	2	45%
	EDA	17.2	21	1.222	20	(2)	9	45%
	FDA	0.0	0		0		0	
Big Lagoon	ECA (Total)	17.2	21	1.218	20	(2)	9	45%
Sloop Lagoon	EBZ	4.3	5	1.212	5	(3)	2	45%
	EDA	10.8	13	1.214	13	(4)	6	45%
	FDA	0.0	0		0		0	
Sloop Lagoon	ECA (Total)	10.8	13	1.213	13	(4)	6	45%
Grant's Lagoon	EBZ	4.4	5	1.237	5	(43)	2	45%
	EDA	6.8	8	1.213	8	(43)	4	45%
	FDA	0.0	0		0		0	
Grant's Lagoon	ECA (Total)	6.8	8	1.210	8	(43)	4	45%
Georges Bay	EBZ	31.2	1248	40.037	733		495	68%
	EDA	34.1	1094	32.034	669		430	64%
	FDA	522.6	666	1.275	400		248	62%
	Georges	522.1	666	1.276	400		248	62%
Georges Bay	ECA (Total)	556.7	1760	3.161	1069		678	63%
Scamander	EBZ	21.0	276	13.116	192	(22)	117	61%

Catchment		Catchment	ABS CData91 - Population and Dwellings					
Estuary	Sub-Catchment	Area (km²)	Population	Pop./(km²)	Dwellings	(Count)	Occupied	% Occupied
	EDA	13.7	269	19.597	190		115	61%
	FDA	326.9	347	1.062	170		121	71%
	Scamander	301.2	287	0.951	141		101	72%
	Arm Ck.	25.3	61	2.392	29		20	70%
Scamander	ECA (Total)	340.7	616	1.809	360		236	66%
Henderson's Lagoon	EBZ	6.7	8	1.191	5	(19)	3	59%
	EDA	50.4	60	1.187	36	(22)	21	59%
	FDA	0.0	0		0		0	
Henderson's Lagoon	ECA (Total)	50.5	60	1.184	36	(39)	21	59%
Templestowe Lagoon	EBZ	5.3	6	1.204	4	(4)	2	59%
	EDA	25.1	30	1.195	18	(19)	11	59%
	FDA	0.0	0		0		0	59%
Templestowe Lagoon	ECA (Total)	25.2	30	1.192	18	(19)	11	59%
Douglas	EBZ	2.8	3	1.200	2	(26)	1	59%
	EDA	3.2	4	1.201	2	(4)	1	59%
	FDA	70.4	84	1.189	50		30	59%
	Douglas	70.2	84	1.193	50		30	59%
Douglas	ECA (Total)	73.5	87	1.190	52	(11)	31	59%
Denison	EBZ	2.0	2	1.026	1	(1)	1	54%
	EDA	26.4	28	1.067	18	(20)	10	56%
	FDA	0.0	0		0		0	49%
Denison	ECA (Total)	26.8	28	1.060	19	(26)	10	56%
Saltwater Lagoon	EBZ	3.3	2	0.536	2	(0)	1	37%
	EDA	8.6	5	0.533	5	(0)	2	37%
	FDA	0.0	0		0		0	
Saltwater Lagoon	ECA (Total)	8.6	1	0.116	5	(0)	2	37%
Freshwater Lagoon	EBZ	4.0	3	0.704	4	(65)	1	28%
	EDA	11.9	9	0.785	15	(1)	4	26%
	FDA	0.0	0		0		0	
Freshwater Lagoon	ECA (Total)	11.9	1	0.084	15	(2)	4	26%
Bryants Lagoon	EBZ	4.0	4	0.970	7	(18)	2	23%
	EDA	5.8	6	0.972	10	(0)	2	23%
	FDA	0.0	0		0		0	
Bryants Lagoon	ECA (Total)	5.8	1	0.172	10	(0)	2	23%
Great Swanport	EBZ	75.6	32	0.421	29	(9)	13	46%
	EDA	140.5	63	0.447	59	(65)	26	45%
	FDA	890.6	296	0.333	213		116	54%
	Apsley	230.8	162	0.701	136		62	46%
	Swan	659.0	134	0.204	77		53	70%
Great Swanport	ECA (Total)	1,031.1	359	0.348	272		142	52%
Meredith	EBZ	4.0	3	0.809	2	(18)	1	56%
	EDA	1.6	1	0.810	1	(18)	1	56%
	FDA	96.7	78	0.809	57		32	56%
	Meredith	96.4	78	0.811	57		32	56%
Meredith	ECA (Total)	98.2	79	0.809	58		32	56%
Stoney	EBZ	1.6	1	0.800	1	(17)	1	56%
	EDA	0.4	0	0.000		(9)		
	FDA	26.3	22	0.822	16		9	56%
	Stony	26.2	21	0.813	16		9	56%
Stoney	ECA (Total)	26.7	22	0.811	16	(9)	9	56%
Buxton	EBZ	2.9	2	0.807	2	(70)	1	56%
	EDA	1.1	0	0.000	1	(18)	0	56%
	FDA	59.6	48	0.808	35		20	56%

Catchment		Catchment	ABS CData91 - Population and Dwellings					
Estuary	Sub-Catchment	Area (km^2)	Population	Pop./(km^2)	Dwellings	(Count)	Occupied	% Occupied
	Buxton	59.4	48	0.810	35		20	56%
Buxton	ECA (Total)	60.7	49	0.807	36		20	56%
Lisdillon	EBZ	3.8	3	0.798	2	(0)	1	56%
	EDA	3.3	3	0.797	2	(17)	1	56%
	FDA	47.9	39	0.809	28		16	56%
	Lisdillon	47.7	39	0.812	28		16	56%
Lisdillon	ECA (Total)	51.2	41	0.808	30		17	56%
Little Swanport	EBZ	21.5	12	0.581	8		5	60%
	EDA	55.7	36	0.640	23	(70)	14	59%
	FDA	677.7	401	0.591	200		139	70%
	Swanport	605.4	367	0.606	183		128	70%
	RavensdaleRt.	71.6	34	0.471	17		11	66%
Little Swanport	ECA (Total)	733.4	436	0.595	223		153	68%
Grindstone	EBZ	4.8	2	0.468	1		1	66%
	EDA	6.8	3	0.468	2	(0)	1	66%
	FDA	23.8	11	0.468	6		4	66%
	Eighty Acre Ck.	23.7	11	0.470	6		4	66%
Grindstone	ECA (Total)	30.6	14	0.468	7		5	66%
Spring	EBZ	15.2	764	50.234	297		276	93%
	EDA	25.7	634	24.631	249		229	92%
	FDA	90.2	189	2.093	83		67	81%
	Spring	90.0	189	2.097	83		67	81%
Spring	ECA (Total)	116.0	823	7.097	332		295	89%
Prosser	EBZ	12.1	442	36.683	376	(62)	165	44%
	EDA	35.4	469	13.233	401		175	44%
	FDA	687.0	669	0.974	285		228	80%
	Prosser	686.4	669	0.975	285		228	80%
Prosser	ECA (Total)	722.4	1138	1.575	686		403	59%
Earlham Lagoon	EBZ	5.6	5	0.855	3	(7)	2	55%
	EDA	17.1	15	0.854	9	(7)	5	55%
	FDA	92.6	83	0.899	50		29	58%
	GriffithsRt.	92.5	83	0.900	50		29	58%
Earlham Lagoon	ECA (Total)	109.7	98	0.892	59	(10)	34	57%
Blackman Bay	EBZ	29.3	248	8.447	137		90	66%
	EDA	60.9	298	4.891	172		109	64%
	FDA	41.5	55	1.324	49		22	45%
	Blackman Rt.	41.4	55	1.327	49		22	45%
Blackman Bay	ECA (Total)	102.4	353	3.445	221		132	60%
Port Arthur	EBZ	26.8	131	4.866	122	(196)	50	41%
	EDA	41.2	184	4.469	164	(196)	70	43%
	FDA	36.9	60	1.623	42		24	56%
	Simmons Ck.	8.9	10	1.155	7		4	60%
	Long Bay Ck.	8.1	9	1.175	6		4	60%
	Alberry Ck	6.6	25	3.766	18		9	51%
	Denmans Ck.	13.2	15	1.159	10		6	60%
Port Arthur	ECA (Total)	78.1	244	3.125	206	(225)	94	45%
Parsons Bay	EBZ	16.0	282	17.643	181	(243)	111	61%
	EDA	30.5	321	10.526	228		128	56%
	FDA	58.2	201	3.444	196		79	40%
	Parsons Bay	41.5	131	3.144	107		50	47%
	Cripps Ck.	16.7	70	4.192	89		29	32%
Parsons Bay	ECA (Total)	88.8	522	5.879	424		206	49%
Norfolk Bay	EBZ	84.2	506	6.007	478		207	43%

Catchment		Catchment	ABS CData91 - Population and Dwellings					
Estuary	Sub-Catchment	Area (km²)	Population	Pop./(km²)	Dwellings	(Count)	Occupied	% Occupied
	EDA	212.8	747	3.512	669		302	45%
	FDA	13.1	32	2.479	28		13	47%
	SaltwaterCk.	13.0	32	2.498	28		13	47%
Norfolk Bay	ECA (Total)	225.9	780	3.452	697		315	45%
Carlton	EBZ	13.6	220	16.204	201		84	42%
	EDA	23.3	314	13.466	246		117	48%
	FDA	141.4	360	2.544	179		132	74%
	Carlton	141.2	360	2.548	179		132	74%
Carlton	ECA (Total)	164.7	673	4.089	425		249	59%
Pittwater	EBZ	66.2	4374	66.045	1786		1599	90%
	EDA	109.3	4794	43.867	1896		1705	90%
	FDA	813.7	3371	4.143	1292		1191	92%
	Coal	541.2	2088	3.859	819		749	91%
	Orielton	49.7	183	3.689	65		61	94%
	Sorell Rt.	40.8	366	8.965	141		134	95%
	Iron Ck.	93.8	271	2.891	101		93	92%
	Duckhole	46.4	248	5.352	87		82	94%
	Frogmore	16.6	69	4.149	24		23	94%
	Forcett Rt.	13.5	60	4.437	22		20	93%
	Gilling Bk.	11.0	84	7.638	32		28	89%
Pittwater	ECA (Total)	923.0	8165	8.846	3188		2896	91%
Pipeclay Lagoon	EBZ	10.3	537	52.128	253		194	77%
	EDA	16.5	710	43.015	315		252	80%
	FDA	0.0	0		0		0	
Pipeclay Lagoon	ECA (Total)	16.5	710	43.011	315		252	80%
Derwent	EBZ	160.8	81847	508.881	31783		29632	93%
	EDA	780.4	157897	202.326	61863		57910	94%
	FDA	8,613.3	12844	1.491	5422		4318	80%
	Ouse	1,649.2	433	0.263	617		161	26%
	Nive	1,089.3	467	0.429	226		135	60%
	Derwent	1,804.5	4467	2.475	1584		1433	90%
	Clyde	1,117.2	948	0.848	490		341	70%
	Dee	361.9	45	0.123	39		18	46%
	Jordan	1,243.8	5076	4.081	1931		1758	91%
	Florentine	442.6	85	0.192	37		30	82%
	Tyenna	336.4	617	1.835	228		201	88%
	Styx	342.1	359	1.050	138		124	90%
	Plenty	223.6	347	1.552	133		117	88%
Derwent	ECA (Total)	9,393.8	170741	18.176	67286		62228	92%
Ralph's Bay	EBZ	29.2	3706	127.114	1250		1157	93%
	EDA	57.5	8256	143.511	2661		2530	95%
	FDA	0.0	0		0		0	
Ralph's Bay	ECA (Total)	57.5	8256	143.509	2661		2530	95%
North West Bay	EBZ	23.6	2315	98.148	844		786	93%
	EDA	35.1	4435	126.361	1582		1480	94%
	FDA	141.6	2523	17.810	877		807	92%
	North West Bay	95.6	1499	15.684	504		477	95%
	Margate	22.5	692	30.751	230		212	92%
	Snug	23.4	332	14.190	142		118	83%
North West Bay	ECA (Total)	176.7	6958	39.365	2459		2287	93%
Oyster Cove	EBZ	4.5	58	12.731	25		21	83%
	EDA	4.5	57	12.719	25		20	82%
	FDA	15.6	198	12.715	85		70	82%

Catchment		Catchment	ABS CData91 - Population and Dwellings					
Estuary	Sub-Catchment	Area (km^2)	Population	Pop./(km^2)	Dwellings	(Count)	Occupied	% Occupied
	Oyster Cove	15.5	198	12.767	85		70	82%
Oyster Cove	ECA (Total)	20.1	255	12.716	110		91	82%
Garden Island	EBZ	7.6	70	9.310	66		27	41%
	EDA	8.2	79	9.712	72		30	42%
	FDA	39.9	341	8.548	265		124	47%
	Garden Island Ck.	39.8	341	8.564	265		124	47%
Garden Island	ECA (Total)	48.0	420	8.746	337		154	46%
Port Cygnet	EBZ	22.6	847	37.396	356		291	82%
	EDA	36.3	696	19.141	343		245	71%
	FDA	104.3	1388	13.305	518		474	91%
	Nicholls Rt.	47.2	334	7.064	127		116	92%
	Agnes Rt.	43.2	942	21.827	346		319	92%
	Gardners Ck.	13.9	112	8.059	46		39	85%
Port Cygnet	ECA (Total)	140.7	2084	14.813	862		719	83%
Huon	EBZ	119.9	3335	27.822	1334		1149	86%
	EDA	300.8	4601	15.295	1871		1586	85%
	FDA	2,742.9	6448	2.351	2532		2184	86%
	Weld	420.1	30	0.072	13		12	90%
	Huon	1,361.8	1237	0.909	438		397	91%
	Mountain River	186.9	2149	11.501	763		721	94%
	Picton	484.3	72	0.149	62		29	47%
Huon	ECA (Total)	3,043.7	11049	3.630	4403		3770	86%
Hospital Bay	EBZ	6.0	186	31.067	71		65	91%
	EDA	6.9	162	23.477	63		57	90%
	FDA	132.6	1147	8.648	431		395	92%
	Crooks Rt.	132.3	1147	8.665	431		395	92%
Hospital Bay	ECA (Total)	139.5	1309	9.382	494		452	92%
Surges Bay	EBZ	2.3	17	7.650	8	(16)	7	86%
	EDA	1.4	11	7.739	5	(16)	4	86%
	FDA	11.7	83	7.099	42		32	77%
	Surges	11.7	83	7.104	42		32	77%
Surges Bay	ECA (Total)	13.1	94	7.166	46		36	78%
Esperence	EBZ	23.4	530	22.674	245		187	77%
	EDA	70.5	682	9.679	342		242	71%
	FDA	236.1	217	0.920	125		77	62%
	Esperence	173.1	192	1.110	99		67	67%
	Creekton Rt.	62.7	25	0.400	26		10	39%
Esperence	ECA (Total)	306.6	899	2.933	466		319	68%
D`Entrecasteaux	EBZ	314.6	7292	23.176	3050		2536	83%
	EDA	681.9	11763	17.249	4910		4054	83%
	FDA	3,128.2	9213	2.945	3551		3077	87%
D`Entrecasteaux	ECA (Total)	3,810.2	20976	5.505	8460		7130	84%
Cloudy Bay	EBZ	9.1	9	1.033	10	(3)	4	39%
	EDA	18.2	32	1.743	36	(3)	15	41%
	FDA	24.5	32	1.309	44		16	37%
	Cloudy	24.5	32	1.308	44		16	37%
Cloudy Bay	ECA (Total)	42.7	64	1.494	80	(20)	31	39%
Southport	EBZ	24.4	18	0.720	19	(36)	8	42%
	EDA	46.5	18	0.393	19	(36)	7	39%
	FDA	142.7	57	0.398	59		23	39%
	Lune	131.8	53	0.399	55		21	39%
	SouthportRt.	10.6	4	0.401	4		2	39%
Southport	ECA (Total)	189.2	75	0.397	78	(122)	31	39%

Catchment		Catchment	ABS CData91 - Population and Dwellings					
Estuary	Sub-Catchment	Area (km^2)	Population	Pop./(km^2)	Dwellings	(Count)	Occupied	% Occupied
Southport Lagoon	EBZ	11.4	4	0.384	5	(0)	2	39%
	EDA	13.7	5	0.391	6	(0)	2	39%
	FDA	13.5	5	0.370	6		2	39%
	Donnelys	13.5	5	0.398	6	(0)	2	39%
Southport Lagoon	ECA (Total)	27.2	10	0.368	11	(0)	4	39%
Recherche Bay	EBZ	22.3	9	0.394	9	(15)	4	39%
	EDA	28.3	11	0.397	12	(58)	5	39%
	FDA	151.1	60	0.399	63		25	39%
	D`entrecasteaux	73.4	29	0.400	31	(0)	12	39%
	Catamaran	66.7	27	0.400	28	(0)	11	39%
	Cockle	10.9	4	0.399	5	(0)	2	39%
Recherche Bay	ECA (Total)	179.4	72	0.399	74	(58)	29	39%
New River Lagoon	EBZ	26.5	2	0.059	1	(0)	1	90%
	EDA	75.1	4	0.059	2	(0)	2	90%
	FDA	223.0	0	0.000	6		5	90%
	New	222.7	13	0.059	6	(0)	5	90%
New River Lagoon	ECA (Total)	298.1	1	0.003	8	(0)	7	90%
Louisa R.	EBZ	6.1	0	0.000	0	(0)	0	90%
	EDA	4.0	0	0.000	0	(0)	0	90%
	FDA	79.2	0	0.000	2		2	90%
	Louisa R.	79.0	5	0.059	2	(0)	2	90%
Louisa R.	ECA (Total)	83.2	1	0.012	2	(0)	2	90%
Louisa Ck.	EBZ	7.0	0	0.000	0	(0)	0	90%
	EDA	2.4	0	0.000	0	(0)	0	90%
	FDA	54.3	0	0.000	1		1	90%
	Louisa Ck.	54.2	3	0.059	1	(0)	1	90%
Louisa Ck.	ECA (Total)	56.7	1	0.018	1	(0)	1	90%
Freney	EBZ	4.4	0	0.000	0	(0)	0	90%
	EDA	19.5	1	0.059	1	(0)	0	90%
	FDA	0.0	0		0		0	
Freney	ECA (Total)	19.6	1	0.051	1	(0)	0	90%
Bathurst Harbour	EBZ	102.7	6	0.058	3	(5)	2	90%
	EDA	213.3	12	0.058	5	(5)	5	90%
	FDA	854.0	0	0.000	22		20	90%
	Spring	150.3	9	0.059	4	(0)	4	90%
	North	137.7	8	0.059	4	(0)	3	90%
	Old	428.3	25	0.059	11	(0)	10	90%
	Horseshoe	16.8	0	0.000	0	(0)	0	90%
	Ray	53.1	3	0.059	1	(0)	1	90%
	Melaleuca	67.4	4	0.059	2	(0)	2	90%
Bathurst Harbour	ECA (Total)	1,067.3	5	0.005	28	(5)	25	90%
Payne Bay	EBZ	56.6	1	0.025	1	(0)	1	90%
	EDA	130.7	5	0.036	2	(0)	2	90%
	FDA	794.0	0	0.000	11		10	90%
	Davey	484.6	12	0.025	5	(0)	5	90%
	Crossing	239.0	14	0.059	6	(0)	6	90%
	Dewitt	46.2	0	0.000	0	(0)	0	
	Blackwater Ck.	23.5	0	0.000	0	(0)	0	
Payne Bay	ECA (Total)	924.7	1	0.001	14	(0)	12	90%
Mulcahy	EBZ	5.2	0	0.000	0		0	
	EDA	3.2	0	0.000	0	(0)	0	
	FDA	54.8	0	0.000	0		0	
	Mulcahy	54.8	0	0.000	0	(0)	0	

Catchment		Catchment	ABS CData91 - Population and Dwellings					
Estuary	Sub-Catchment	Area (km²)	Population	Pop./(km²)	Dwellings	(Count)	Occupied	% Occupied
Mulcahy	ECA (Total)	58.1	1	0.017	0	(0)	0	
Giblin	EBZ	11.1	0	0.000	0		0	
	EDA	13.9	0	0.000	0	(0)	0	
	FDA	309.4	0	0.000	0		0	
	Giblin	309.2	0	0.000	0	(0)	0	
Giblin	ECA (Total)	323.3	1	0.003	0	(0)	0	
Lewis	EBZ	2.1	0	0.000	0		0	
	EDA	18.9	0	0.000	0	(0)	0	
	FDA	194.3	0	0.000	0		0	
	Lewis	194.0	0	0.000	0	(0)	0	
Lewis	ECA (Total)	213.1	1	0.005	0	(0)	0	
Mainwaring Inlet	EBZ	3.1	0	0.000	0		0	
	EDA	3.0	0	0.000	0	(0)	0	
	FDA	48.0	0	0.000	0		0	
	Mainwairing	48.0	0	0.000	0	(0)	0	
Mainwaring Inlet	ECA (Total)	51.0	1	0.020	0	(0)	0	
Wanderer	EBZ	14.9	0	0.000	0		0	
	EDA	70.3	0	0.000	0	(0)	0	
	FDA	283.4	0	0.000	0		0	
	Wanderer	283.1	0	0.000	0	(0)	0	
Wanderer	ECA (Total)	353.7	1	0.003	0	(0)	0	
Spero	EBZ	4.5	0	0.000	0		0	
	EDA	3.0	0	0.000	0	(0)	0	
	FDA	112.8	0	0.000	0		0	
	McCarthy	27.4	0	0.000	0	(0)	0	
	Spero	85.2	0	0.000	0	(0)	0	
Spero	ECA (Total)	115.8	1	0.009	0	(0)	0	
Hibbs Lagoon	EBZ	5.0	0	0.000	0		0	
	EDA	4.9	0	0.000	0	(0)	0	
	FDA	47.2	0	0.000	0		0	
	Hibbs	47.2	0	0.000	0	(0)	0	
Hibbs Lagoon	ECA (Total)	52.2	1	0.019	0	(0)	0	
Macquarie Harbour	EBZ	196.8	554	2.816	289		208	72%
	EDA	508.3	361	0.709	187		135	72%
	FDA	6,281.9	4049	0.645	1673		1443	86%
Macquarie Harbour	ECA (Total)	6,790.3	4409	0.649	1860		1578	85%
Birchs Inlet	EBZ	27.0	0	0.000	0		0	
	EDA	75.9	0	0.000	0		0	
	FDA	237.0	0	0.000	0		0	
	Sorell	236.8	0	0.000	0		0	
Birchs Inlet	ECA (Total)	312.8	1	0.003	0		0	
Gordon	EBZ	15.7	0	0.000	0	(0)	0	78%
	EDA	33.3	0	0.000	0	(0)	0	78%
	FDA	5,184.2	472	0.091	223		172	77%
	Franklin	1,656.0	57	0.035	35		21	59%
	Denison	663.3	62	0.094	28		22	79%
	Gordon	2,601.5	337	0.130	152		123	81%
	Lake Pedder	262.1	15	0.059	7		6	90%
Gordon	ECA (Total)	5,217.4	472	0.091	223		172	77%
King	EBZ	28.5	0	0.000	0	(5)	0	78%
	EDA	3.9	0	0.000	0	(5)	0	
	FDA	812.2	3344	4.117	1329		1184	89%
	King	811.5	3344	4.121	1329		1184	89%

Catchment		Catchment	ABS CData91 - Population and Dwellings					
Estuary	Sub-Catchment	Area (km²)	Population	Pop./(km²)	Dwellings	(Count)	Occupied	% Occupied
King	ECA (Total)	816.1	3344	4.098	1329		1184	89%
Manuka	EBZ	8.7	505	57.940	263		190	72%
	EDA	7.3	307	42.157	160		115	72%
	FDA	48.4	232	4.789	121		87	72%
	Manuka	38.1	169	4.429	88		63	72%
	BotanicalCk.	10.3	63	6.139	33		24	72%
Manuka	ECA (Total)	55.7	539	9.672	281		203	72%
Henty	EBZ	11.3	0	0.000	0	(3)	0	0%
	EDA	13.6	0	0.000	0	(3)	0	0%
	FDA	488.9	4	0.009	2		1	47%
	Henty	375.3	4	0.010	2		1	47%
	Badger	45.2	0	0.000	0		0	0%
	Tully	68.0	0	0.000	0		0	78%
Henty	ECA (Total)	502.5	4	0.009	2	(36)	1	46%
Little Henty	EBZ	9.9	0	0.000	0	(0)	0	19%
	EDA	48.4	0	0.000	1	(0)	0	20%
	FDA	281.2	1118	3.977	527		412	78%
	Little Henty	280.9	1118	3.981	527		412	78%
Little Henty	ECA (Total)	329.6	1119	3.394	528		412	78%
Pieman	EBZ	21.5	0	0.000	0	(17)	0	21%
	EDA	35.2	1	0.037	3	(17)	1	21%
	FDA	3,830.9	2966	0.774	1264		909	72%
	Donaldson	332.0	9	0.028	14		3	23%
	Savage	302.9	462	1.525	264		146	55%
	Whyte	386.5	75	0.194	43		23	54%
	Huskisson	509.0	9	0.018	11		3	27%
	Pieman	971.2	1659	1.708	694		548	79%
	Mackintosh	534.1	307	0.575	97		76	78%
	Murchisson	793.8	445	0.560	141		109	78%
Pieman	ECA (Total)	3,866.1	2968	0.768	1267		910	72%
Lagoon	EBZ	1.2	0	0.000	2	(0)	0	21%
	EDA	0.8	0	0.000	0	(0)	0	21%
	FDA	85.6	4	0.042	7		1	21%
	Lagoon	85.5	4	0.042	7		1	21%
Lagoon	ECA (Total)	86.4	4	0.042	7	(0)	1	21%
Pedder	EBZ	3.3	0	0.000	0	(0)	0	21%
	EDA	1.7	0	0.000	0	(0)	0	21%
	FDA	80.9	3	0.036	6		1	17%
	Pedder	80.9	3	0.042	6		1	21%
Pedder	ECA (Total)	82.5	3	0.036	6	(0)	1	17%
Nelson Bay	EBZ	2.0	0	0.000	0	(0)	0	21%
	EDA	2.7	0	0.000	0	(0)	0	21%
	FDA	67.9	3	0.042	5		1	21%
	Nelson Bay	67.9	3	0.042	5		1	21%
Nelson Bay	ECA (Total)	70.6	3	0.042	5	(0)	1	21%
Arthur	EBZ	24.9	1	0.042	2	(53)	0	21%
	EDA	95.7	4	0.042	7	(53)	2	21%
	FDA	2,399.0	766	0.319	390		256	66%
	Arthur	1,502.0	637	0.424	310		214	69%
	Frankland	569.2	24	0.042	43		9	21%
	Hellyer	326.7	105	0.320	37		33	89%
Arthur	ECA (Total)	2,494.6	770	0.309	398		257	65%

Catchment		Catchment	ABS CData91 - Population and Dwellings					
Estuary	Sub-Catchment	Area (km^2)	Population	Pop./(km^2)	Dwellings	(Count)	Occupied	% Occupied
Totals	Tasmania		447096		182560		161067	88%
	Outside Catchments		52569		23564		19219	82%
	Catchments		394527		158995		141849	89%
	FDAs		145406		59543		51457	86%
	EDAs		249074		99432		90376	91%
	1 km Buffer		159334		64218		57545	90%

Appendix 4 Characteristics of Tasmanian Estuaries: SER Data - Area of Landtype Categories by ECA, FDA, EDA & EBZ

Appendix 4: Characteristics of Tasmanian Estuaries - SER Data - Area of Landtype Categories By Estuarine Catchment Area (ECA), Fluvial Drainage Area (FDA), Estuarine Drainage Area (EDA), Estuarine Buffer Zone (EBZ) and River Catchments

ESTUARY	Sub-Catchment	Area (km^2) Assessed	% of Catchment	Landtype Categories - Area (km^2) water	rainforest	forest	woodlands	scrub	agriculture	heath & buttongrass	cleared forest	bare ground	urban	alpine scrub	alpine heath	alpine bare
Outside Catchments		5,877.74		35.59	123.33	1,102.57	1,681.14	415.95	1,364.92	803.64	34.24	216.59	95.60	1.15	2.91	0.13
Port Sorell	EDA	7.49	9%	0.01	0.00	3.61	3.67	0.00	0.02	0.15	0.00	0.03	0.00	0.00	0.00	0.00
	FDA	350.46	62%	0.35	0.30	72.66	147.84	3.56	92.25	12.79	0.00	20.35	0.35	0.00	0.00	0.00
	Sheepwash	8.48	53%	0.02	0.00	2.16	5.79	0.00	0.03	0.46	0.00	0.03	0.00	0.00	0.00	0.00
	Brown Ck.	15.03	60%	0.05	0.00	4.42	9.38	0.05	0.16	0.65	0.00	0.29	0.02	0.00	0.00	0.00
	Panatana	0.00	0%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Branchs	22.46	75%	0.10	0.02	6.59	12.07	0.24	1.18	0.93	0.00	1.26	0.07	0.00	0.00	0.00
	Franklin Rt.	125.98	95%	0.05	0.21	33.55	53.45	1.86	23.58	4.24	0.00	8.85	0.20	0.00	0.00	0.00
	Green Ck.	0.00	0%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Rubicon	179.03	68%	0.13	0.06	26.10	67.34	1.42	67.43	6.52	0.00	9.96	0.07	0.00	0.00	0.00
Port Sorell	ECA (Total)	357.95	56%	0.36	0.30	76.27	151.52	3.56	92.27	12.94	0.00	20.38	0.35	0.00	0.00	0.00
Tamar	EBZ	181.68	100%	2.55	0.00	3.51	30.65	4.38	110.17	8.31	0.00	13.35	8.77		0.00	
	EDA	558.35	100%	3.10	0.35	24.88	201.28	16.07	221.99	37.62	0.00	39.76	13.30	0.00	0.00	0.00
	FDA	10,988.36	100%	235.14	204.74	1,207.45	3,362.96	257.89	4,414.94	727.49	4.50	245.81	28.09	120.07	179.17	0.10
	Fourteen Mile Ck.	97.79	100%	0.04	0.05	12.32	29.79	1.97	44.21	2.77	0.00	6.47	0.16	0.00	0.00	0.00
	Masseys Rt.	33.56	100%	0.02	0.01	5.62	19.49	0.93	1.48	2.50	0.00	3.30	0.22	0.00	0.00	0.00
	Andersons	49.51	100%	0.00	0.08	11.55	20.46	1.81	8.68	1.50	0.00	5.35	0.08	0.00	0.00	0.00
	Johnston Ck.	61.43	100%	0.08	0.00	12.09	8.33	0.80	33.95	0.98	0.00	4.89	0.30	0.00	0.00	0.00
	Supply	134.88	100%	0.02	0.10	25.81	19.90	2.36	76.10	2.24	0.00	7.87	0.47	0.00	0.00	0.00
	North Esk	1,064.50	100%	0.66	71.82	274.30	285.60	35.56	304.21	56.79	0.00	25.78	9.80	0.00	0.00	0.00
	Stony Bk.	42.33	100%	0.00	0.00	2.84	11.63	1.38	21.78	1.38	0.00	3.05	0.27	0.00	0.00	0.00
	South Esk	9,504.94	10000%	234.32	132.56	862.81	2,968.28	213.22	3,924.47	659.57	4.50	189.09	16.80	120.06	179.16	0.10
	Meander	1,292.95	97%	2.08	12.63	226.35	234.57	30.47	638.23	40.64	0.00	62.27	2.87	23.40	19.44	0.00
	Liffey	234.42	100%	0.26	2.63	61.09	21.94	4.49	123.51	5.63	0.00	3.51	0.33	6.51	4.52	0.02
	Nile	323.08	100%	0.37	2.26	12.18	144.21	5.07	95.75	56.23	0.00	6.91	0.10	0.00	0.00	0.00
	Break'O'Day	230.08	100%	0.14	5.09	35.81	73.55	2.05	102.69	7.26	0.00	3.25	0.24	0.00	0.00	0.00
	Macquarie	1,557.99	100%	10.33	1.72	23.50	586.72	8.57	831.74	67.23	0.00	25.82	2.31	0.00	0.05	0.00
	Ben Lomond Rt.	199.74	100%	0.13	3.05	12.68	95.78	1.87	66.03	17.16	0.00	2.93	0.10	0.00	0.01	0.00

				Landtype Categories - Area (km^2)												
ESTUARY	Sub-Catchment	Area (km^2) Assessed	% of Catchment	water	rainforest	forest	woodlands	scrub	agriculture	heath & buttongrass	cleared forest	bare ground	urban	alpine scrub	alpine heath	alpine bare
	St. Pauls	521.47	100%	0.07	4.13	42.82	224.46	40.42	124.56	73.91	0.00	3.77	0.51	3.65	3.18	0.00
	Brumby	308.48	100%	0.47	0.46	40.91	52.24	5.52	169.48	11.83	0.00	2.43	0.47	10.21	14.44	0.01
	Lake	813.35	100%	65.76	1.93	53.94	298.63	19.75	181.10	100.85	0.10	3.52	0.41	23.75	63.59	0.00
	Great Lake	396.33	100%	143.74	0.16	3.33	64.69	3.61	21.81	39.13	0.00	2.33	0.06	48.56	68.90	0.02
	Isis	337.01	100%	0.95	0.29	17.62	114.34	6.73	173.71	15.61	0.00	6.70	0.64	0.22	0.22	0.00
	Elizabeth	399.15	100%	5.72	0.68	12.21	230.09	7.44	102.14	34.83	0.00	4.94	0.63	0.01	0.45	0.00
	Blackman	557.80	100%	0.34	0.66	12.60	132.48	8.48	367.25	19.68	4.39	10.91	0.58	0.00	0.43	0.00
Tamar	ECA (Total)	11,546.70	100%	238.24	205.09	1,232.33	3,564.24	273.96	4,636.93	765.11	4.50	285.57	41.40	120.07	179.17	0.10
Curries R.	EBZ	2.73	101%	0.00	0.00	0.01	0.23	0.05	2.05	0.14	0.00	0.15	0.10		0.00	
	EDA	1.77	100%	0.00	0.00	0.04	0.34	0.04	1.05	0.10	0.00	0.11	0.08	0.00	0.00	0.00
	FDA	82.00	100%	1.72	0.00	7.77	42.94	1.75	15.84	4.16	0.00	7.45	0.38	0.00	0.00	0.00
	Curries	82.23	100%	1.72	0.00	7.80	43.07	1.76	15.85	4.18	0.00	7.48	0.38	0.00	0.00	0.00
Curries R.	ECA (Total)	83.78	100%	1.72	0.00	7.81	43.28	1.78	16.89	4.27	0.00	7.57	0.45	0.00	0.00	0.00
Pipers R.	EBZ	15.06	100%	0.22	0.00	0.59	5.39	0.59	5.85	0.75	0.00	1.49	0.18		0.00	
	EDA	14.41	100%	0.22	0.00	0.65	6.72	0.48	3.27	1.13	0.00	1.75	0.19	0.00	0.00	0.00
	FDA	450.03	100%	0.12	3.38	98.01	114.68	7.02	188.57	10.61	0.00	25.77	1.88	0.00	0.00	0.00
	Pipers R.	375.73	100%	0.08	3.28	85.31	92.21	5.42	160.19	8.44	0.00	19.17	1.62	0.00	0.00	0.00
	Pipers Bk.	74.54	100%	0.03	0.10	12.74	22.52	1.60	28.51	2.17	0.00	6.61	0.26	0.00	0.00	0.00
Pipers R.	ECA (Total)	464.44	100%	0.34	3.38	98.66	121.39	7.50	191.84	11.75	0.00	27.52	2.07	0.00	0.00	0.00
Little Forester	EBZ	7.96	100%	0.18	0.00	0.03	0.52	0.09	6.72	0.18	0.00	0.23	0.01		0.00	
	EDA	4.52	100%	0.14	0.00	0.02	0.46	0.06	3.50	0.14	0.00	0.18	0.01	0.00	0.00	0.00
	FDA	342.61	100%	0.27	6.90	104.09	98.23	5.56	101.71	9.54	0.00	15.42	0.89	0.00	0.00	0.00
	Little Forester	342.93	100%	0.27	6.93	104.24	98.27	5.57	101.78	9.55	0.00	15.43	0.89	0.00	0.00	0.00
Little Forester	ECA (Total)	347.14	100%	0.42	6.90	104.11	98.69	5.63	105.21	9.68	0.00	15.60	0.90	0.00	0.00	0.00
Brid	EBZ	7.60	100%	0.24	0.00	0.10	0.90	0.11	5.18	0.31	0.00	0.44	0.32		0.00	
	EDA	13.38	100%	0.23	0.00	0.61	2.41	0.22	8.02	0.33	0.00	1.27	0.29	0.00	0.00	0.00
	FDA	243.26	100%	0.16	2.86	39.41	68.57	3.68	110.36	6.98	0.00	10.53	0.72	0.00	0.00	0.00
	Brid	149.05	100%	0.05	2.83	35.62	31.60	2.40	66.37	3.13	0.00	6.82	0.24	0.00	0.00	0.00
	Hurst Ck.	94.30	100%	0.10	0.03	3.80	36.95	1.27	44.09	3.86	0.00	3.70	0.49	0.00	0.00	0.00
Brid	ECA (Total)	256.65	100%	0.39	2.86	40.01	70.98	3.90	118.38	7.31	0.00	11.80	1.01	0.00	0.00	0.00
Great Forester	EBZ	5.45	101%	0.03	0.00	0.00	0.28	0.03	4.77	0.17	0.00	0.16	0.02		0.00	
	EDA	2.01	100%	0.03	0.00	0.01	0.08	0.01	1.70	0.03	0.00	0.13	0.02	0.00	0.00	0.00
	FDA	517.64	100%	0.17	12.92	147.63	159.63	11.09	150.34	16.10	0.00	18.25	1.51	0.00	0.00	0.00

				Landtype Categories - Area (km^2)												
ESTUARY	Sub-Catchment	Area (km^2) Assessed	% of Catchment	water	rainforest	forest	woodlands	scrub	agriculture	heath & buttongrass	cleared forest	bare ground	urban	alpine scrub	alpine heath	alpine bare
	Great Forester	517.87	100%	0.17	12.96	147.84	159.63	11.13	150.26	16.11	0.00	18.27	1.50	0.00	0.00	0.00
Great Forester	ECA (Total)	519.64	100%	0.20	12.92	147.64	159.71	11.10	152.04	16.14	0.00	18.38	1.53	0.00	0.00	0.00
Tomahawk	EBZ	7.81	99%	0.09	0.00	0.08	0.89	0.05	6.08	0.28	0.00	0.26	0.09		0.00	
	EDA	5.77	100%	0.09	0.00	0.09	0.87	0.04	4.10	0.24	0.00	0.25	0.08	0.00	0.00	0.00
	FDA	138.75	100%	0.06	0.42	18.67	53.10	2.47	51.50	3.94	0.00	8.47	0.11	0.00	0.00	0.00
	Tomahawk	139.04	100%	0.06	0.42	18.75	53.21	2.48	51.57	3.95	0.00	8.49	0.11	0.00	0.00	0.00
Tomahawk	ECA (Total)	144.52	100%	0.15	0.42	18.76	53.97	2.51	55.61	4.19	0.00	8.72	0.20	0.00	0.00	0.00
Boobyalla Inlet	EBZ	13.98	100%	0.33	0.00	1.53	2.48	0.36	6.96	0.49	0.00	1.72	0.11		0.00	
	EDA	16.05	100%	0.14	0.00	1.15	2.33	0.27	9.83	0.49	0.00	1.73	0.11	0.00	0.00	0.00
	FDA	1,162.27	100%	5.27	111.61	345.61	287.32	39.49	295.52	37.60	0.00	37.85	2.00	0.00	0.00	0.00
	Ringarooma	912.92	100%	4.78	110.87	297.77	189.51	33.51	222.13	28.70	0.00	24.11	1.55	0.00	0.00	0.00
	Boobyalla	249.60	100%	0.49	0.86	47.77	97.84	6.04	73.42	8.99	0.00	13.73	0.46	0.00	0.00	0.00
Boobyalla Inlet	ECA (Total)	1,178.32	100%	5.41	111.61	346.76	289.65	39.76	305.35	38.08	0.00	39.58	2.11	0.00	0.00	0.00
Little Musselroe	EBZ	4.82	99%	0.21	0.00	0.06	0.70	0.14	3.10	0.17	0.00	0.43	0.01		0.00	
	EDA	6.48	100%	0.21	0.00	0.04	0.49	0.12	5.06	0.13	0.00	0.42	0.01	0.00	0.00	0.00
	FDA	72.81	100%	0.01	0.00	1.03	10.60	1.21	53.62	2.18	0.00	4.04	0.13	0.00	0.00	0.00
	Little Musselroe	73.14	100%	0.01	0.00	1.03	10.68	1.21	53.81	2.20	0.00	4.08	0.13	0.00	0.00	0.00
Little Musselroe	ECA (Total)	79.28	100%	0.22	0.00	1.07	11.09	1.32	58.68	2.31	0.00	4.46	0.14	0.00	0.00	0.00
Great Mussleroe	EBZ	21.54	100%	0.28	0.00	0.37	12.25	0.37	4.72	2.04	0.00	1.40	0.13		0.00	
	EDA	71.21	100%	0.29	0.01	0.79	31.53	0.95	28.02	5.58	0.00	3.60	0.44	0.00	0.00	0.00
	FDA	368.72	100%	0.51	7.31	78.35	135.06	6.00	109.68	14.67	0.00	16.16	0.99	0.00	0.00	0.00
	Great Musselroe	368.71	100%	0.51	7.29	78.35	135.15	5.99	109.55	14.68	0.00	16.18	0.99	0.00	0.00	0.00
Great Mussleroe	ECA (Total)	439.93	100%	0.80	7.32	79.14	166.59	6.95	137.70	20.25	0.00	19.76	1.43	0.00	0.00	0.00
Ansons Bay	EBZ	14.82	99%	0.32	0.01	0.92	7.16	0.96	1.66	1.38	0.00	2.16	0.25		0.00	
	EDA	21.75	100%	0.28	0.00	0.80	12.81	1.37	1.77	1.77	0.00	2.64	0.31	0.00	0.00	0.00
	FDA	237.18	100%	0.05	1.32	35.19	137.67	2.89	17.89	15.44	0.00	26.19	0.54	0.00	0.00	0.00
	Ansons	237.12	100%	0.05	1.32	35.12	137.68	2.90	17.87	15.45	0.00	26.19	0.54	0.00	0.00	0.00
Ansons Bay	ECA (Total)	258.93	100%	0.33	1.33	35.99	150.48	4.26	19.66	17.22	0.00	28.83	0.85	0.00	0.00	0.00
Big Lagoon	EBZ	4.02	98%	0.02	0.00	0.14	2.46	0.14	0.14	0.58	0.00	0.48	0.05		0.00	
Big Lagoon	ECA (Total)	17.19	100%	0.03	0.02	1.15	11.41	0.53	0.23	2.23	0.00	1.55	0.05	0.00	0.00	0.00
Sloop Lagoon	EBZ	4.22	99%	0.03	0.00	0.06	3.00	0.07	0.07	0.61	0.00	0.30	0.07		0.00	
Sloop Lagoon	ECA (Total)	10.81	100%	0.03	0.00	0.12	7.51	0.22	0.12	2.14	0.00	0.60	0.07	0.00	0.00	0.00
Grant`s Lagoon	EBZ	4.39	99%	0.05	0.00	0.13	2.82	0.10	0.15	0.66	0.00	0.37	0.11		0.00	

				Landtype Categories - Area (km^2)												
ESTUARY	Sub-Catchment	Area (km^2) Assessed	% of Catchment	water	rainforest	forest	woodlands	scrub	agriculture	heath & buttongrass	cleared forest	bare ground	urban	alpine scrub	alpine heath	alpine bare
Grant's Lagoon	ECA (Total)	6.77	100%	0.05	0.00	0.22	4.55	0.15	0.17	0.95	0.00	0.57	0.11	0.00	0.00	0.00
Georges Bay	EBZ	30.94	99%	1.17	0.00	1.07	13.88	0.67	7.08	2.90	0.00	2.91	1.26		0.00	
	EDA	34.14	100%	0.61	0.02	1.88	17.69	0.80	5.19	3.30	0.00	3.45	1.20	0.00	0.00	0.00
	FDA	522.47	100%	0.86	51.39	178.56	157.75	11.67	80.53	23.53	0.00	17.17	1.01	0.00	0.00	0.00
	Georges	522.47	100%	0.86	51.36	178.63	157.81	11.66	80.48	23.49	0.00	17.18	1.01	0.00	0.00	0.00
Georges Bay	ECA (Total)	556.60	100%	1.46	51.40	180.44	175.43	12.47	85.73	26.84	0.00	20.62	2.22	0.00	0.00	0.00
Scamander	EBZ	20.87	99%	0.39	0.03	1.62	11.49	0.41	3.49	1.47	0.00	1.61	0.38		0.00	
	EDA	13.73	100%	0.38	0.02	0.90	7.42	0.27	2.10	0.92	0.00	1.34	0.37	0.00	0.00	0.00
	FDA	326.92	100%	0.20	5.69	75.80	188.37	4.75	15.39	21.79	0.00	14.41	0.51	0.00	0.00	0.00
	Scamander	301.51	100%	0.17	5.39	66.54	176.87	4.26	14.41	20.74	0.00	12.71	0.43	0.00	0.00	0.00
	Arm Ck.	25.38	100%	0.03	0.31	9.26	11.55	0.49	0.95	1.05	0.00	1.66	0.08	0.00	0.00	0.00
Scamander	ECA (Total)	340.65	100%	0.58	5.71	76.70	195.79	5.03	17.49	22.71	0.00	15.75	0.88	0.00	0.00	0.00
Henderson's Lagoon	EBZ	6.61	99%	0.38	0.00	0.21	2.65	0.09	2.12	0.49	0.00	0.59	0.09		0.00	
Henderson's Lagoon	ECA (Total)	50.50	100%	0.38	0.32	14.51	15.68	1.00	14.01	1.63	0.00	2.85	0.12	0.00	0.00	0.00
Templestowe Lagoon	EBZ	5.22	98%	0.36	0.00	0.06	0.88	0.03	3.28	0.15	0.00	0.45	0.03		0.00	
Templestowe Lagoon	ECA (Total)	25.17	100%	0.36	0.01	7.39	8.74	1.94	5.40	0.59	0.00	0.71	0.04	0.00	0.00	0.00
Douglas	EBZ	2.73	98%	0.01	0.00	0.14	0.45	0.02	2.03	0.03	0.00	0.04	0.01		0.00	
	EDA	3.15	100%	0.01	0.00	0.39	0.49	0.02	2.17	0.03	0.00	0.03	0.01	0.00	0.00	0.00
	FDA	70.25	100%	0.00	2.23	26.48	25.18	11.60	0.61	2.64	0.00	1.49	0.01	0.00	0.00	0.00
	Douglas	70.36	100%	0.00	2.23	26.54	25.22	11.62	0.61	2.63	0.00	1.50	0.01	0.00	0.00	0.00
Douglas	ECA (Total)	73.40	100%	0.01	2.23	26.87	25.67	11.62	2.78	2.67	0.00	1.52	0.03	0.00	0.00	0.00
Denison	EBZ	1.99	97%	0.01	0.00	0.14	1.00	0.03	0.64	0.05	0.00	0.07	0.05		0.00	
Denison	ECA (Total)	26.73	100%	0.01	0.07	9.57	8.72	5.45	0.73	1.38	0.00	0.75	0.06	0.00	0.00	0.00
Saltwater Lagoon	EBZ	3.26	98%	0.14	0.00	0.09	2.51	0.15	0.03	0.23	0.00	0.11	0.02		0.00	
Saltwater Lagoon	ECA (Total)	8.59	100%	0.14	0.00	0.48	5.95	0.33	0.93	0.60	0.00	0.12	0.03	0.00	0.00	0.00
Freshwater Lagoon	EBZ	3.99	99%	0.15	0.00	0.06	3.00	0.13	0.05	0.54	0.00	0.05	0.01		0.00	
Freshwater Lagoon	ECA (Total)	11.86	100%	0.15	0.01	0.25	8.95	0.37	0.22	1.78	0.00	0.11	0.02	0.00	0.00	0.00
Bryants Lagoon	EBZ	4.07	101%	0.04	0.10	0.98	1.96	0.23	0.05	0.65	0.00	0.06	0.00		0.00	
Bryants Lagoon	ECA (Total)	5.82	100%	0.04	0.13	1.40	3.01	0.28	0.05	0.83	0.00	0.07	0.00	0.00	0.00	0.00
Great Swanport	EBZ	75.58	100%	1.86	0.02	1.30	35.35	1.88	25.22	8.31	0.01	1.32	0.32		0.00	
	EDA	140.47	100%	1.84	0.12	3.85	70.14	3.15	42.28	16.98	0.11	1.50	0.48	0.00	0.01	0.00
	FDA	890.55	100%	0.11	7.72	144.57	386.22	97.72	146.76	103.60	0.27	2.15	0.44	0.00	0.97	0.00
	Apsley	231.06	100%	0.05	1.06	40.58	84.94	33.83	38.68	31.34	0.00	0.36	0.22	0.00	0.00	0.00

				Landtype Categories - Area (km^2)												
ESTUARY	Sub-Catchment	Area (km^2) Assessed	% of Catchment	water	rainforest	forest	woodlands	scrub	agriculture	heath & buttongrass	cleared forest	bare ground	urban	alpine scrub	alpine heath	alpine bare
	Swan	659.21	100%	0.06	6.66	104.02	301.18	63.78	108.12	72.13	0.27	1.79	0.22	0.00	0.97	0.00
Great Swanport	ECA (Total)	1,031.02	100%	1.95	7.84	148.42	456.36	100.87	189.05	120.59	0.39	3.65	0.92	0.00	0.98	0.00
Meredith	EBZ	3.90	99%	0.01	0.00	0.03	0.58	0.03	3.01	0.12	0.09	0.03	0.01		0.00	
	EDA	1.57	100%	0.01	0.00	0.01	0.38	0.01	1.06	0.04	0.03	0.01	0.01	0.00	0.00	0.00
	FDA	96.59	100%	0.01	0.58	12.12	57.95	2.70	11.53	9.76	1.04	0.75	0.02	0.00	0.13	0.00
	Meredith	96.67	100%	0.01	0.58	12.15	58.00	2.69	11.55	9.76	1.04	0.75	0.02	0.00	0.13	0.00
Meredith	ECA (Total)	98.16	100%	0.02	0.58	12.14	58.33	2.71	12.60	9.80	1.07	0.76	0.03	0.00	0.13	0.00
Stoney	EBZ	1.59	97%	0.00	0.00	0.02	0.43	0.01	1.04	0.05	0.02	0.01	0.01		0.00	
	EDA	0.36	100%	0.00	0.00	0.00	0.09	0.00	0.25	0.01	0.01	0.01	0.00	0.00	0.00	0.00
	FDA	26.35	100%	0.00	0.02	0.40	13.84	0.33	8.80	2.45	0.47	0.02	0.01	0.00	0.01	0.00
	Stony	26.36	100%	0.00	0.02	0.40	13.79	0.33	8.85	2.45	0.48	0.02	0.01	0.00	0.01	0.00
Stoney	ECA (Total)	26.71	100%	0.00	0.02	0.40	13.92	0.33	9.05	2.46	0.48	0.02	0.01	0.00	0.01	0.00
Buxton	EBZ	2.82	98%	0.05	0.00	0.08	0.64	0.02	1.74	0.09	0.06	0.11	0.04		0.00	
	EDA	1.10	100%	0.05	0.00	0.00	0.28	0.01	0.61	0.02	0.01	0.10	0.03	0.00	0.00	0.00
	FDA	59.52	100%	0.00	1.26	21.83	24.91	2.74	4.32	3.90	0.28	0.23	0.02	0.00	0.03	0.00
	Buxton	59.53	100%	0.00	1.26	21.81	24.92	2.73	4.34	3.90	0.28	0.23	0.02	0.00	0.03	0.00
Buxton	ECA (Total)	60.63	100%	0.06	1.26	21.84	25.19	2.74	4.92	3.92	0.28	0.33	0.05	0.00	0.03	0.00
Lisdillon	EBZ	3.70	99%	0.05	0.00	0.02	0.73	0.02	2.54	0.09	0.06	0.16	0.02		0.00	
	EDA	3.26	100%	0.05	0.00	0.00	0.54	0.02	2.35	0.08	0.03	0.16	0.02	0.00	0.00	0.00
	FDA	47.89	100%	0.00	0.78	9.75	26.33	1.62	3.94	4.63	0.56	0.22	0.02	0.00	0.04	0.00
	Lisdillon	47.89	100%	0.00	0.78	9.72	26.33	1.62	3.96	4.63	0.57	0.22	0.02	0.00	0.04	0.00
Lisdillon	ECA (Total)	51.14	100%	0.05	0.78	9.75	26.87	1.64	6.29	4.71	0.60	0.38	0.03	0.00	0.04	0.00
Little Swanport	EBZ	21.40	100%	0.12	0.00	0.04	7.47	0.19	11.51	1.56	0.25	0.19	0.08		0.00	
	EDA	55.73	100%	0.12	0.03	0.62	23.93	0.43	24.30	5.11	0.60	0.45	0.14	0.00	0.01	0.00
	FDA	674.90	100%	1.25	1.64	39.54	318.24	11.90	237.94	53.25	3.45	7.05	0.54	0.00	0.12	0.00
	Swanport	603.19	100%	1.25	1.22	33.21	283.53	9.95	217.54	47.02	1.96	6.94	0.48	0.00	0.09	0.00
	Ravensdale Rt.	71.58	100%	0.00	0.42	6.37	34.59	1.96	20.33	6.23	1.49	0.11	0.05	0.00	0.03	0.00
Little Swanport	ECA (Total)	730.63	100%	1.36	1.67	40.16	342.17	12.33	262.24	58.35	4.05	7.50	0.68	0.00	0.13	0.00
Grindstone	EBZ	4.72	99%	0.00	0.00	0.00	0.62	0.01	3.85	0.08	0.01	0.14	0.01		0.00	
	EDA	6.78	100%	0.00	0.00	0.00	1.19	0.05	5.16	0.23	0.02	0.12	0.01	0.00	0.00	0.00
	FDA	23.83	100%	0.11	0.02	0.83	7.02	0.38	14.13	1.00	0.16	0.15	0.02	0.00	0.00	0.00
	Eighty Acre Ck.	23.82	100%	0.11	0.02	0.84	7.01	0.37	14.14	1.00	0.16	0.15	0.02	0.00	0.00	0.00
Grindstone	ECA (Total)	30.60	100%	0.11	0.02	0.83	8.21	0.43	19.29	1.23	0.18	0.27	0.03	0.00	0.00	0.00

				Landtype Categories - Area (km^2)												
ESTUARY	Sub-Catchment	Area (km^2) Assessed	% of Catchment	water	rainforest	forest	woodlands	scrub	agriculture	heath & buttongrass	cleared forest	bare ground	urban	alpine scrub	alpine heath	alpine bare
Spring	EBZ	15.16	100%	0.02	0.00	0.09	3.72	0.10	9.55	0.72	0.36	0.23	0.37		0.00	
	EDA	25.71	100%	0.02	0.05	0.99	9.29	0.45	11.58	1.68	1.04	0.22	0.38	0.00	0.01	0.00
	FDA	89.69	99%	0.51	1.27	21.65	35.38	4.84	18.42	6.96	0.43	0.08	0.04	0.00	0.12	0.00
	Spring	89.65	100%	0.51	1.26	21.62	35.37	4.83	18.43	6.95	0.43	0.08	0.04	0.00	0.12	0.00
Spring	ECA (Total)	115.40	100%	0.53	1.32	22.64	44.67	5.29	29.99	8.64	1.47	0.31	0.42	0.00	0.13	0.00
Prosser	EBZ	11.71	97%	0.03	0.00	0.14	5.75	0.13	3.72	1.38	0.16	0.17	0.23		0.00	
	EDA	35.10	99%	0.03	0.09	1.23	20.01	0.66	7.57	4.44	0.58	0.20	0.25	0.00	0.04	0.00
	FDA	683.53	99%	0.25	4.87	88.90	339.78	30.69	152.36	59.91	4.90	1.14	0.20	0.00	0.53	0.00
	Prosser	683.54	100%	0.25	4.88	89.04	339.69	30.73	152.27	59.92	4.90	1.14	0.20	0.00	0.53	0.00
Prosser	ECA (Total)	718.62	99%	0.28	4.96	90.13	359.79	31.36	159.92	64.35	5.48	1.34	0.45	0.00	0.56	0.00
Earlham Lagoon	EBZ	5.53	98%	0.00	0.00	0.02	1.84	0.05	3.13	0.39	0.01	0.07	0.02		0.00	
	EDA	16.94	99%	0.00	0.00	0.32	7.94	0.25	6.87	1.31	0.11	0.09	0.04	0.00	0.00	0.00
	FDA	91.51	99%	0.00	1.22	24.53	37.50	9.00	9.01	9.78	0.28	0.07	0.03	0.00	0.11	0.00
	Griffiths Rt.	91.49	99%	0.00	1.22	24.53	37.49	8.99	9.01	9.77	0.28	0.07	0.03	0.00	0.11	0.00
Earlham Lagoon	ECA (Total)	108.45	99%	0.01	1.22	24.85	45.44	9.26	15.88	11.09	0.39	0.16	0.06	0.00	0.11	0.00
Blackman Bay	EBZ	29.16	99%	0.05	0.03	0.87	12.78	0.55	11.60	2.35	0.22	0.44	0.27		0.00	
	EDA	60.72	100%	0.05	0.11	3.13	26.98	1.33	22.95	4.79	0.48	0.58	0.32	0.00	0.00	0.00
	FDA	41.29	100%	0.00	0.82	19.82	4.63	11.04	0.23	4.67	0.06	0.00	0.01	0.00	0.00	0.00
	Blackman Rt.	41.30	100%	0.00	0.83	19.90	4.59	11.06	0.18	4.67	0.06	0.00	0.01	0.00	0.00	0.00
Blackman Bay	ECA (Total)	102.01	100%	0.05	0.93	22.95	31.61	12.37	23.18	9.47	0.54	0.58	0.33	0.00	0.01	0.00
Port Arthur	EBZ	26.11	97%	0.04	0.81	14.56	2.11	3.08	2.63	2.56	0.17	0.03	0.12		0.00	
	EDA	40.49	98%	0.04	1.09	25.17	2.46	4.40	3.14	3.74	0.31	0.03	0.10	0.00	0.00	0.00
	FDA	36.74	100%	0.00	2.08	25.53	0.79	4.85	1.54	1.76	0.15	0.01	0.03	0.00	0.00	0.00
	Simmons Ck.	8.96	101%	0.00	0.61	7.18	0.04	0.95	0.00	0.18	0.01	0.00	0.00	0.00	0.00	0.00
	Long Bay Ck.	8.00	99%	0.00	0.84	6.63	0.04	0.41	0.04	0.04	0.01	0.00	0.00	0.00	0.00	0.00
	Alberry Ck	6.53	99%	0.00	0.24	3.41	0.56	0.33	1.49	0.35	0.13	0.01	0.03	0.00	0.00	0.00
	Denmans Ck.	13.29	100%	0.00	0.39	8.34	0.16	3.18	0.00	1.22	0.01	0.00	0.00	0.00	0.00	0.00
Port Arthur	ECA (Total)	77.23	99%	0.04	3.17	50.69	3.25	9.25	4.68	5.51	0.46	0.04	0.13	0.00	0.00	0.00
Parsons Bay	EBZ	16.04	100%	0.02	0.39	3.88	7.12	0.97	1.34	1.71	0.21	0.21	0.18		0.02	
	EDA	30.41	100%	0.02	1.05	10.15	11.26	1.70	3.01	2.42	0.34	0.23	0.19	0.00	0.03	0.00
	FDA	58.02	100%	0.00	3.49	36.98	5.17	3.88	4.76	2.68	0.93	0.09	0.03	0.00	0.01	0.00
	Parsons Bay	41.44	100%	0.00	2.35	26.55	2.77	2.60	4.00	2.16	0.88	0.09	0.03	0.00	0.00	0.00
	Cripps Ck.	16.74	100%	0.00	1.14	10.55	2.40	1.28	0.77	0.53	0.06	0.00	0.00	0.00	0.00	0.00

				Landtype Categories - Area (km^2)												
ESTUARY	Sub-Catchment	Area (km^2) Assessed	% of Catchment	water	rainforest	forest	woodlands	scrub	agriculture	heath & buttongrass	cleared forest	bare ground	urban	alpine scrub	alpine heath	alpine bare
Parsons Bay	ECA (Total)	88.42	100%	0.02	4.54	47.13	16.43	5.59	7.77	5.10	1.27	0.32	0.22	0.00	0.04	0.00
Norfolk Bay	EBZ	83.99	100%	0.21	0.55	12.44	32.23	5.08	19.61	11.31	0.85	0.97	0.71		0.04	
	EDA	212.00	100%	0.21	4.99	70.81	56.56	18.66	35.62	20.78	2.36	1.12	0.84	0.00	0.05	0.00
	FDA	13.04	100%	0.00	0.06	1.76	6.34	0.71	2.58	1.29	0.28	0.02	0.01	0.00	0.01	0.00
	Saltwater Ck.	13.01	100%	0.00	0.06	1.77	6.33	0.71	2.56	1.29	0.28	0.02	0.01	0.00	0.01	0.00
Norfolk Bay	ECA (Total)	225.04	100%	0.21	5.05	72.57	62.89	19.37	38.20	22.07	2.63	1.14	0.85	0.00	0.06	0.00
Carlton	EBZ	13.58	100%	0.00	0.00	0.02	3.99	0.12	8.26	0.79	0.12	0.15	0.12		0.00	
	EDA	23.28	100%	0.00	0.02	0.43	9.64	0.44	10.49	1.73	0.22	0.17	0.15	0.00	0.00	0.00
	FDA	140.62	99%	0.08	1.38	26.56	61.80	6.03	32.14	10.76	1.51	0.20	0.13	0.00	0.04	0.00
	Carlton	140.67	100%	0.08	1.38	26.55	61.80	6.03	32.18	10.78	1.51	0.20	0.13	0.00	0.04	0.00
Carlton	ECA (Total)	163.90	100%	0.08	1.39	26.99	71.44	6.47	42.62	12.49	1.72	0.37	0.27	0.00	0.04	0.00
Pittwater	EBZ	66.14	100%	0.05	0.02	0.36	12.09	0.44	44.09	1.86	1.04	3.09	3.11		0.00	
	EDA	109.08	100%	0.05	0.03	0.79	29.46	1.27	64.37	4.10	1.60	3.53	3.88	0.00	0.00	0.00
	FDA	809.87	100%	1.61	1.84	52.77	307.07	16.87	367.78	45.12	8.66	4.20	3.90	0.00	0.07	0.00
	Coal	538.80	100%	1.58	0.69	30.53	202.14	11.98	249.16	30.19	7.58	2.58	2.35	0.00	0.03	0.00
	Orielton	49.49	100%	0.00	0.02	0.99	17.01	0.72	26.99	3.04	0.11	0.30	0.32	0.00	0.00	0.00
	Sorell Rt.	40.50	99%	0.01	0.34	4.89	16.96	0.72	14.75	2.36	0.05	0.09	0.32	0.00	0.01	0.00
	Iron Ck.	93.54	100%	0.00	0.74	15.06	43.52	2.56	25.24	5.79	0.42	0.13	0.06	0.00	0.02	0.00
	Duckhole	46.31	100%	0.02	0.00	0.14	15.98	0.36	26.08	1.92	0.33	0.87	0.61	0.00	0.00	0.00
	Frogmore	16.59	100%	0.00	0.00	0.00	1.89	0.08	14.03	0.32	0.01	0.10	0.15	0.00	0.00	0.00
	Forcett Rt.	13.56	100%	0.00	0.03	0.79	6.30	0.32	4.97	0.98	0.07	0.06	0.05	0.00	0.00	0.00
	Gilling Bk.	11.00	100%	0.00	0.03	0.33	3.41	0.13	6.37	0.53	0.09	0.08	0.03	0.00	0.00	0.00
Pittwater	ECA (Total)	918.95	100%	1.66	1.87	53.56	336.53	18.14	432.14	49.22	10.26	7.73	7.78	0.00	0.07	0.00
Pipeclay Lagoon	EBZ	10.21	99%	0.00	0.00	0.02	2.03	0.05	6.54	0.57	0.08	0.50	0.43		0.00	
Pipeclay Lagoon	ECA (Total)	16.52	100%	0.00	0.00	0.02	3.05	0.08	11.12	0.89	0.13	0.64	0.59	0.00	0.00	0.00
Derwent	EBZ	160.06	100%	0.24	0.00	1.43	47.26	2.96	60.71	11.57	1.47	4.53	29.89		0.00	
	EDA	776.54	100%	0.89	6.05	130.31	237.50	51.26	207.56	72.85	8.76	8.80	49.16	0.98	2.32	0.10
	FDA	7,268.19	84%	185.49	290.20	1,238.66	1,864.95	425.73	2,183.52	560.30	77.96	26.44	5.34	191.31	217.08	1.21
	Derwent	6,025.19	84%	174.71	287.93	1,174.78	1,523.25	400.69	1,475.12	488.79	68.53	19.14	3.23	191.35	216.45	1.21
	Ouse	1,494.83	91%	26.18	3.94	89.06	493.10	42.53	441.89	133.79	11.78	4.49	0.32	99.12	148.01	0.61
	Nive	548.83	50%	15.07	5.83	101.89	237.27	25.68	78.69	55.32	0.00	1.43	0.26	10.61	16.79	0.00
	Clyde	1,117.49	100%	71.51	1.50	44.25	340.88	26.46	523.42	84.86	13.28	2.56	0.35	0.00	8.41	0.00
	Dee	361.74	100%	48.47	4.94	70.49	132.58	24.88	43.92	29.35	0.25	1.21	0.06	0.71	4.90	0.00

				Landtype Categories - Area (km^2)												
ESTUARY	Sub-Catchment	Area (km^2) Assessed	% of Catchment	water	rainforest	forest	woodlands	scrub	agriculture	heath & buttongrass	cleared forest	bare ground	urban	alpine scrub	alpine heath	alpine bare
	Florentine	441.98	100%	0.43	117.39	174.49	16.55	63.93	4.28	41.91	2.54	1.59	0.12	10.03	8.47	0.26
	Tyenna	336.36	100%	1.03	34.05	159.59	26.07	33.06	31.37	17.16	6.77	0.99	0.23	16.12	9.77	0.16
	Styx	342.03	100%	0.02	81.82	127.29	12.52	52.98	13.42	36.88	3.36	0.87	0.23	8.69	3.79	0.16
	Plenty	223.50	100%	0.01	11.91	101.29	21.49	32.64	14.01	20.48	17.95	1.07	0.12	1.59	0.94	0.00
	Jordan	1,243.43	100%	10.78	2.23	63.93	341.75	24.99	708.77	71.44	9.43	7.30	2.11	0.00	0.69	0.00
Derwent	ECA (Total)	8,044.73	86%	186.38	296.25	1,368.97	2,102.46	476.99	2,391.08	633.15	86.72	35.24	54.50	192.29	219.39	1.31
Ralph's Bay	EBZ	29.34	101%	0.04	0.00	0.13	10.61	0.77	12.78	1.70	0.39	1.26	1.67		0.00	
Ralph's Bay	ECA (Total)	57.44	100%	0.04	0.00	0.29	22.48	1.44	24.21	3.57	0.62	1.75	3.04	0.00	0.00	0.00
North West Bay	EBZ	23.46	99%	0.05	0.02	1.19	9.57	0.85	8.32	1.89	0.34	0.47	0.76		0.00	
	EDA	35.10	100%	0.05	0.02	2.47	15.71	2.03	9.36	3.04	0.41	0.75	1.25	0.00	0.01	0.00
	FDA	141.53	100%	0.06	3.40	53.81	18.39	17.07	22.71	17.17	1.79	1.11	0.60	0.53	4.79	0.10
	North West Bay	95.64	100%	0.05	2.79	31.01	13.18	11.06	16.82	12.51	1.40	0.94	0.46	0.53	4.78	0.10
	Margate	22.49	100%	0.01	0.16	8.70	3.67	2.69	4.77	1.96	0.26	0.16	0.12	0.00	0.00	0.00
	Snug	23.38	100%	0.00	0.44	14.07	1.54	3.32	1.13	2.71	0.13	0.02	0.02	0.00	0.00	0.00
North West Bay	ECA (Total)	176.62	100%	0.11	3.43	56.28	34.10	19.10	32.07	20.21	2.20	1.86	1.85	0.53	4.80	0.10
Oyster Cove	EBZ	4.50	99%	0.03	0.01	0.95	1.81	0.40	0.63	0.58	0.05	0.03	0.02		0.00	
	EDA	4.47	100%	0.03	0.01	0.75	2.17	0.34	0.55	0.53	0.04	0.02	0.02	0.00	0.00	0.00
	FDA	15.52	100%	0.00	0.31	7.77	1.70	1.69	2.42	1.11	0.41	0.07	0.04	0.00	0.00	0.00
	Oyster Cove	15.58	100%	0.00	0.31	7.79	1.71	1.69	2.43	1.11	0.41	0.07	0.04	0.00	0.00	0.00
Oyster Cove	ECA (Total)	19.99	100%	0.04	0.32	8.52	3.88	2.02	2.97	1.64	0.45	0.10	0.06	0.00	0.00	0.00
Garden Island	EBZ	7.65	101%	0.03	0.02	1.51	1.71	0.98	1.24	1.89	0.12	0.07	0.08		0.00	
	EDA	8.15	100%	0.03	0.05	2.06	1.70	1.16	0.87	2.01	0.13	0.06	0.08	0.00	0.00	0.00
	FDA	39.80	100%	0.00	2.29	26.67	2.40	5.01	1.21	2.10	0.08	0.02	0.01	0.00	0.00	0.00
	Garden Island Ck.	39.93	100%	0.00	2.30	26.76	2.40	5.03	1.22	2.11	0.08	0.02	0.01	0.00	0.00	0.00
Garden Island	ECA (Total)	47.95	100%	0.03	2.35	28.73	4.10	6.17	2.08	4.12	0.21	0.08	0.09	0.00	0.00	0.00
Port Cygnet	EBZ	22.71	100%	0.12	0.09	3.97	4.27	1.83	7.86	3.63	0.20	0.44	0.31		0.00	
	EDA	36.34	100%	0.08	0.78	10.52	5.49	3.69	10.27	4.71	0.25	0.33	0.21	0.00	0.00	0.00
	FDA	104.10	100%	0.08	6.00	48.48	10.26	9.40	19.15	8.31	1.39	0.71	0.32	0.00	0.00	0.00
	Nicholls Rt.	47.26	100%	0.04	3.45	26.55	3.88	4.23	5.55	2.93	0.42	0.18	0.04	0.00	0.00	0.00
	Agnes Rt.	43.02	100%	0.03	1.96	15.93	4.45	3.96	11.16	3.98	0.82	0.49	0.24	0.00	0.00	0.00
	Gardners Ck.	13.95	100%	0.01	0.60	6.08	1.94	1.22	2.45	1.41	0.15	0.05	0.03	0.00	0.00	0.00
Port Cygnet	ECA (Total)	140.44	100%	0.16	6.79	59.01	15.75	13.09	29.43	13.03	1.64	1.04	0.52	0.00	0.00	0.00
Huon	EBZ	119.66	100%	0.30	0.56	21.92	22.80	12.02	33.95	22.53	1.96	1.79	1.84		0.00	

				Landtype Categories - Area (km²)												
ESTUARY	Sub-Catchment	Area (km²) Assessed	% of Catchment	water	rainforest	forest	woodlands	scrub	agriculture	heath & buttongrass	cleared forest	bare ground	urban	alpine scrub	alpine heath	alpine bare
	EDA	300.66	100%	0.33	10.56	109.14	38.85	35.20	56.15	41.45	4.52	2.49	1.94	0.01	0.02	0.00
	FDA	2,738.96	100%	5.95	799.43	951.32	74.86	367.19	100.52	333.93	19.85	7.32	1.68	40.27	35.43	1.21
	Huon	2,263.80	100%	5.63	757.14	729.57	35.33	314.02	40.49	288.92	12.59	5.48	0.47	39.61	33.38	1.17
	Weld	419.78	100%	0.47	204.95	113.22	0.05	52.22	0.00	29.17	0.90	0.42	0.00	10.69	7.50	0.18
	Picton	484.19	100%	1.42	264.95	122.51	0.00	56.54	0.00	22.32	2.43	0.99	0.00	8.42	4.39	0.21
	Mountain River	186.89	100%	0.06	13.05	78.75	18.71	23.28	24.94	23.22	1.11	0.57	0.55	0.62	1.99	0.03
Huon	ECA (Total)	3,039.62	100%	6.28	809.99	1,060.46	113.71	402.39	156.67	375.38	24.37	9.81	3.62	40.28	35.45	1.21
Hospital Bay	EBZ	5.87	98%	0.03	0.02	0.84	1.39	0.50	1.45	1.36	0.06	0.06	0.16		0.00	
	EDA	6.89	100%	0.03	0.05	1.56	1.43	0.57	1.68	1.32	0.06	0.06	0.14	0.00	0.00	0.00
	FDA	132.57	100%	0.16	20.74	60.91	7.18	14.46	13.04	10.70	4.54	0.52	0.32	0.00	0.00	0.00
	Crooks Rt.	132.58	100%	0.16	20.76	60.89	7.19	14.45	13.05	10.70	4.53	0.52	0.32	0.00	0.00	0.00
Hospital Bay	ECA (Total)	139.46	100%	0.19	20.78	62.47	8.61	15.03	14.72	12.02	4.60	0.58	0.47	0.00	0.00	0.00
Surges Bay	EBZ	2.23	99%	0.01	0.01	0.77	0.27	0.57	0.34	0.22	0.02	0.00	0.01		0.00	
	EDA	1.37	100%	0.01	0.00	0.32	0.19	0.36	0.30	0.16	0.02	0.00	0.01	0.00	0.00	0.00
	FDA	11.70	100%	0.00	0.22	6.97	0.98	1.01	1.68	0.63	0.16	0.03	0.01	0.00	0.00	0.00
	Surges	11.74	100%	0.00	0.22	6.98	0.99	1.01	1.69	0.64	0.17	0.03	0.01	0.00	0.00	0.00
Surges Bay	ECA (Total)	13.07	100%	0.01	0.22	7.29	1.17	1.37	1.98	0.79	0.18	0.03	0.02	0.00	0.00	0.00
Esperence	EBZ	23.16	99%	0.07	0.07	5.32	4.00	4.55	3.39	4.75	0.38	0.28	0.35		0.00	
	EDA	70.45	100%	0.08	1.71	33.70	7.14	9.88	7.31	8.05	1.78	0.39	0.40	0.00	0.00	0.00
	FDA	235.96	100%	0.03	68.73	110.88	1.60	30.81	0.87	16.05	5.11	0.36	0.03	0.55	0.91	0.03
	Esperence	173.10	100%	0.03	58.25	75.54	0.17	23.29	0.13	11.59	2.40	0.24	0.01	0.54	0.89	0.03
	Creekton Rt.	62.81	100%	0.00	10.41	35.39	1.44	7.52	0.74	4.43	2.72	0.12	0.02	0.00	0.01	0.00
Esperence	ECA (Total)	306.41	100%	0.11	70.44	144.58	8.74	40.69	8.18	24.10	6.90	0.75	0.43	0.55	0.91	0.03
D'Entrecasteaux	EBZ	314.25	100%	1.38	1.03	52.16	76.36	38.04	81.36	51.43	4.48	3.94	4.06		0.01	
	EDA	673.51	99%	1.43	15.60	221.05	121.07	80.60	129.70	83.72	9.66	5.48	5.15	0.01	0.05	0.00
	FDA	3,131.96	100%	6.04	871.87	1,123.77	96.55	416.76	126.52	368.25	27.17	8.86	2.35	41.35	41.13	1.34
D'Entrecasteaux	ECA (Total)	3,805.47	100%	7.47	887.46	1,344.82	217.62	497.36	256.22	451.98	36.83	14.34	7.50	41.35	41.18	1.34
Cloudy Bay	EBZ	9.19	101%	0.08	0.01	2.86	1.18	1.96	1.38	1.37	0.21	0.04	0.12		0.00	
	EDA	18.24	100%	0.08	0.51	7.99	1.71	3.49	2.12	1.85	0.31	0.04	0.12	0.00	0.00	0.00
	FDA	24.45	100%	0.00	2.67	17.17	0.76	2.43	0.58	0.70	0.11	0.02	0.02	0.00	0.00	0.00
	Cloudy	24.52	100%	0.00	2.69	17.22	0.76	2.43	0.58	0.70	0.11	0.02	0.02	0.00	0.00	0.00
Cloudy Bay	ECA (Total)	42.69	100%	0.08	3.18	25.16	2.46	5.92	2.70	2.55	0.43	0.06	0.14	0.00	0.00	0.00
Southport	EBZ	24.33	100%	0.21	0.17	8.65	1.58	5.92	1.02	6.49	0.07	0.10	0.11		0.00	

				Landtype Categories - Area (km^2)												
ESTUARY	Sub-Catchment	Area (km^2) Assessed	% of Catchment	water	rainforest	forest	woodlands	scrub	agriculture	heath & buttongrass	cleared forest	bare ground	urban	alpine scrub	alpine heath	alpine bare
	EDA	46.53	100%	0.22	0.92	21.45	2.21	10.59	2.04	8.64	0.23	0.11	0.12	0.00	0.00	0.00
	FDA	142.64	100%	0.00	49.72	55.98	0.71	23.30	0.17	10.83	1.41	0.39	0.01	0.01	0.09	0.01
	Lune	131.88	100%	0.00	49.37	47.82	0.55	22.53	0.15	10.50	0.61	0.23	0.00	0.01	0.09	0.01
	Southport Rt.	10.61	100%	0.00	0.31	8.12	0.16	0.73	0.02	0.30	0.79	0.16	0.01	0.00	0.00	0.00
Southport	ECA (Total)	189.17	100%	0.22	50.64	77.43	2.92	33.90	2.21	19.48	1.63	0.51	0.13	0.01	0.09	0.01
Southport Lagoon	EBZ	11.21	99%	0.12	0.09	1.00	0.00	3.47	0.00	6.36	0.01	0.15	0.00		0.00	
	EDA	13.70	100%	0.12	0.07	0.98	0.00	3.94	0.00	8.43	0.01	0.15	0.00	0.00	0.00	0.00
	FDA	13.48	100%	0.00	0.35	5.29	0.00	3.99	0.00	3.84	0.00	0.00	0.00	0.00	0.00	0.00
	Donnelys	13.50	100%	0.00	0.35	5.30	0.00	4.00	0.00	3.84	0.00	0.00	0.00	0.00	0.00	0.00
Southport Lagoon	ECA (Total)	27.19	100%	0.12	0.42	6.27	0.00	7.94	0.00	12.27	0.01	0.15	0.00	0.00	0.00	0.00
Recherche Bay	EBZ	22.11	99%	0.14	0.78	13.64	0.00	5.21	0.00	2.21	0.03	0.10	0.00		0.00	
	EDA	28.30	100%	0.14	1.26	17.30	0.00	6.43	0.00	2.84	0.21	0.12	0.00	0.00	0.00	0.00
	FDA	150.99	100%	0.18	33.33	83.01	0.00	24.27	0.00	9.41	0.08	0.34	0.00	0.05	0.14	0.17
	D`entrecasteaux	73.38	100%	0.00	15.12	37.56	0.00	14.11	0.00	6.14	0.07	0.19	0.00	0.04	0.07	0.08
	Catamaran	66.64	100%	0.18	17.66	38.35	0.00	7.77	0.00	2.37	0.01	0.14	0.00	0.01	0.07	0.09
	Cockle	10.93	100%	0.00	0.55	7.17	0.00	2.37	0.00	0.83	0.00	0.00	0.00	0.00	0.00	0.00
Recherche Bay	ECA (Total)	179.29	100%	0.32	34.59	100.32	0.00	30.70	0.00	12.25	0.30	0.46	0.00	0.05	0.14	0.17
New River Lagoon	EBZ	26.55	100%	0.20	3.94	9.53	0.00	9.30	0.00	3.41	0.00	0.17	0.00		0.00	
	EDA	73.55	98%	0.20	20.22	30.77	0.00	15.63	0.00	6.53	0.01	0.19	0.00	0.00	0.00	0.00
	FDA	222.25	100%	0.32	102.47	66.13	0.00	42.66	0.00	9.69	0.04	0.09	0.00	0.59	0.26	0.00
	New	222.22	100%	0.32	102.46	66.10	0.00	42.67	0.00	9.70	0.04	0.09	0.00	0.59	0.26	0.00
New River Lagoon	ECA (Total)	295.79	99%	0.52	122.69	96.89	0.00	58.30	0.00	16.23	0.04	0.27	0.00	0.59	0.26	0.00
Louisa R.	EBZ	6.21	102%	0.02	0.11	0.33	0.00	1.91	0.00	3.77	0.00	0.08	0.00		0.00	
	EDA	3.98	100%	0.02	0.03	0.21	0.00	1.08	0.00	2.56	0.00	0.08	0.00	0.00	0.00	0.00
	FDA	78.93	100%	0.01	14.93	24.46	0.00	14.08	0.00	25.42	0.03	0.01	0.00	0.00	0.00	0.00
	Louisa R.	78.96	100%	0.01	14.91	24.46	0.00	14.10	0.00	25.43	0.03	0.01	0.00	0.00	0.00	0.00
Louisa R.	ECA (Total)	82.91	100%	0.03	14.96	24.67	0.00	15.16	0.00	27.98	0.03	0.08	0.00	0.00	0.00	0.00
Louisa Ck.	EBZ	6.92	99%	0.01	0.02	0.14	0.00	0.78	0.00	5.97	0.00	0.02	0.00		0.00	
	EDA	2.41	100%	0.01	0.01	0.07	0.00	0.42	0.00	1.90	0.00	0.02	0.00	0.00	0.00	0.00
	FDA	54.23	100%	0.00	7.47	14.28	0.00	11.41	0.00	21.05	0.01	0.02	0.00	0.00	0.00	0.00
	Louisa Ck.	54.29	100%	0.00	7.46	14.28	0.00	11.41	0.00	21.11	0.01	0.02	0.00	0.00	0.00	0.00
Louisa Ck.	ECA (Total)	56.64	100%	0.01	7.48	14.35	0.00	11.82	0.00	22.95	0.01	0.03	0.00	0.00	0.00	0.00
Freney	EBZ	4.41	99%	0.08	0.01	0.08	0.00	0.47	0.00	3.71	0.00	0.07	0.00		0.00	

				Landtype Categories - Area (km²)												
ESTUARY	Sub-Catchment	Area (km²) Assessed	% of Catchment	water	rainforest	forest	woodlands	scrub	agriculture	heath & buttongrass	cleared forest	bare ground	urban	alpine scrub	alpine heath	alpine bare
Freney	ECA (Total)	19.44	99%	0.09	1.25	1.57	0.00	2.48	0.00	13.91	0.01	0.13	0.00	0.00	0.00	0.00
Bathurst Harbour	EBZ	102.10	99%	0.36	2.11	8.47	0.00	12.55	0.00	78.17	0.03	0.41	0.00		0.00	
	EDA	212.43	100%	0.37	8.03	18.89	0.00	22.75	0.00	161.33	0.04	1.03	0.00	0.00	0.00	0.00
	FDA	851.42	100%	0.11	152.17	171.41	0.00	163.79	0.00	355.23	0.09	4.58	0.00	2.90	1.11	0.04
	Spring	150.24	100%	0.01	17.39	23.12	0.00	23.23	0.00	83.87	0.00	2.63	0.00	0.00	0.00	0.00
	North	137.72	100%	0.00	17.78	17.98	0.00	20.09	0.00	81.21	0.02	0.64	0.00	0.00	0.00	0.00
	Old	427.95	100%	0.09	105.04	106.32	0.00	94.02	0.00	117.52	0.05	0.84	0.00	2.91	1.13	0.04
	Horseshoe	16.84	100%	0.00	2.06	3.34	0.00	3.36	0.00	8.06	0.00	0.02	0.00	0.00	0.00	0.00
	Ray	53.14	100%	0.00	7.84	15.27	0.00	12.75	0.00	17.08	0.02	0.18	0.00	0.00	0.00	0.00
	Melaleuca	65.90	98%	0.00	2.17	5.52	0.00	10.44	0.00	47.51	0.00	0.26	0.00	0.00	0.00	0.00
Bathurst Harbour	ECA (Total)	1,063.85	100%	0.47	160.20	190.30	0.00	186.54	0.00	516.56	0.12	5.61	0.00	2.90	1.11	0.04
Payne Bay	EDA	52.93	40%	0.05	0.11	3.75	0.00	1.90	0.00	46.04	0.00	1.08	0.00	0.00	0.00	0.00
	FDA	327.94	41%	0.71	73.23	62.78	0.00	60.16	0.00	121.38	0.03	0.19	0.00	4.81	4.60	0.07
	Davey	328.32	68%	0.71	73.31	62.81	0.00	60.21	0.00	121.56	0.03	0.19	0.00	4.82	4.62	0.07
	Crossing	235.97	99%	0.70	50.27	44.35	0.00	42.40	0.00	93.70	0.03	0.13	0.00	2.48	1.86	0.04
	Dewitt	0.00	0%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Blackwater Ck.	0.00	0%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Payne Bay	ECA (Total)	380.87	41%	0.76	73.34	66.53	0.00	62.05	0.00	167.41	0.03	1.27	0.00	4.81	4.60	0.07
Gordon	EDA	0.00	0%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	FDA	1,261.02	24%	300.34	251.35	156.71	4.78	163.95	0.00	359.64	0.79	9.58	0.00	5.50	8.02	0.36
	Gordon	1,261.93	76%	300.35	251.54	156.87	4.79	164.14	0.00	359.91	0.79	9.59	0.00	5.52	8.08	0.36
	Franklin	0.00	0%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Denison	0.00	0%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Lake Pedder	261.73	100%	65.49	60.38	30.66	0.00	32.23	0.00	67.08	0.04	1.19	0.00	2.71	1.90	0.05
Gordon	ECA (Total)	1,261.02	24%	300.34	251.35	156.71	4.78	163.95	0.00	359.64	0.79	9.58	0.00	5.50	8.02	0.36

				Landtype Categories - Area (km^2)												
ESTUARY	Sub-Catchment	Area (km^2) Assessed	% of Catchment	water	rainforest	forest	woodlands	scrub	agriculture	heath & buttongrass	cleared forest	bare ground	urban	alpine scrub	alpine heath	alpine bare
Totals		39,125.32	58%	777.98	2,413.57	7,106.01	10,292.71	2,352.29	10,399.33	3,883.02	169.89	754.61	147.96	367.76	456.77	3.43
Statistics For ECAs																
	Sum	36,823.8		755.1	2,352.5	6,626.7	9,589.4	2,192.9	9,939.5	3,619.8	162.8	626.6	131.2	367.6	456.3	3.4
	Mean	681.9	96%	14.0	43.6	122.7	177.6	40.6	184.1	67.0	3.0	11.6	2.4	6.8	8.5	0.1
	Std. Dev.	1,925.4	14%	56.8	133.4	299.2	555.3	101.6	700.4	162.8	12.7	39.2	9.2	30.9	38.4	0.3
	Min	5.8	24%	0.0	0.0	0.0	0.0	0.1	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0
	Max.	11,546.7	100%	300.3	887.5	1,369.0	3,564.2	497.4	4,636.9	765.1	86.7	285.6	54.5	192.3	219.4	1.3
	Median	111.9	100%	0.2	1.8	26.9	25.4	6.2	13.3	11.4	0.0	0.9	0.1	0.0	0.0	0.0
Statistics For EDAs																
	Sum	3,902.7		12.4	74.0	766.7	993.9	304.9	967.3	577.4	34.3	86.4	81.9	1.0	2.6	0.1
	Mean	76.5	95%	0.2	1.5	15.0	19.5	6.0	19.0	11.3	0.7	1.7	1.6	0.0	0.1	0.0
	Std. Dev.	162.5	20%	0.5	4.0	39.0	46.2	14.3	45.6	27.7	1.9	5.7	7.1	0.1	0.3	0.0
	Min	0.0	0%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Max.	776.5	100%	3.1	20.2	221.0	237.5	80.6	222.0	161.3	9.7	39.8	49.2	1.0	2.3	0.1
	Median	18.2	100%	0.1	0.0	1.0	2.3	0.7	3.1	1.9	0.0	0.2	0.1	0.0	0.0	0.0
Statistics For EBZs																
	Sum	1,693.0		13.2	11.0	180.7	419.8	126.9	550.1	269.5	13.5	50.7	57.5		0.1	
	Mean	28.2	99%	0.2	0.2	3.0	7.0	2.1	9.2	4.5	0.2	0.8	1.0		0.0	
	Std. Dev.	52.4	1%	0.4	0.6	7.8	13.2	5.4	19.6	12.1	0.7	1.9	4.0		0.0	
	Min	1.6	97%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	
	Max.	314.2	102%	2.5	3.9	52.2	76.4	38.0	110.2	78.2	4.5	13.3	29.9		0.0	
	Median	9.7	99%	0.1	0.0	0.3	2.1	0.4	3.1	1.4	0.0	0.2	0.1		0.0	
Statistics For River Catchments																
	Sum	34,471.4		744.1	2,302.6	6,204.8	8,825.5	1,958.4	9,662.9	3,117.3	135.5	598.6	55.2	390.0	473.3	3.3
	Mean	376.1	92%	9.7	25.5	62.3	98.0	20.6	106.3	33.9	1.6	5.6	0.5	5.3	6.8	0.0
	Std. Dev.	1,043.4	24%	40.5	83.2	149.2	309.6	52.0	392.6	85.2	6.7	18.4	1.8	22.7	29.4	0.2
	Min	0.0	0%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Max.	9,504.9	100%	300.4	757.1	1,174.8	2,968.3	400.7	3,924.5	659.6	68.5	189.1	16.8	191.4	216.4	1.2
	Median	96.2	100%	0.0	1.3	22.5	16.3	4.7	13.2	7.1	0.0	0.9	0.1	0.0	0.0	0.0

Appendix 5 Characteristics of Tasmanian Estuaries: SER Data - Percentage of Landtype Categories by ECA, FDA, EDA & EBZ

Appendix 5: Characteristics of Tasmanian Estuaries - SER Data - Proportion of Landtype Categories By Estuarine Catchment Area (ECA), Fluvial Drainage Area (FDA), Estuarine Drainage Area (EDA), Estuarine Buffer Zone (EBZ) and River Catchments

				Landtype Categories - % of Catchment Area												
ESTUARY	Subcatchment	Area (km^2) Assessed	% of Catchment	water	rainforest	forest	woodlands	scrub	agriculture	heath & buttongrass	cleared forest	bare ground	urban	alpine scrub	alpine heath &	alpine bare
Outside Catchments		5,877.74		0.61%	2.10%	18.76%	28.60%	7.08%	23.22%	13.67%	0.58%	3.68%	1.63%	0.02%	0.05%	0.00%
Port Sorell	EDA	7.49	9%	0.11%	0.00%	48.24%	49.07%	0.00%	0.22%	2.03%	0.00%	0.34%	0.00%	0.00%	0.00%	0.00%
	FDA	350.46	62%	0.10%	0.09%	20.73%	42.19%	1.02%	26.32%	3.65%	0.00%	5.81%	0.10%	0.00%	0.00%	0.00%
	Sheepwash	8.48	53%	0.19%	0.00%	25.41%	68.22%	0.00%	0.38%	5.40%	0.00%	0.41%	0.00%	0.00%	0.00%	0.00%
	Brown Ck.	15.03	60%	0.33%	0.03%	29.44%	62.44%	0.36%	1.04%	4.35%	0.00%	1.91%	0.11%	0.00%	0.00%	0.00%
	Panatana	0.00	0%													
	Branchs	22.46	75%	0.45%	0.09%	29.34%	53.75%	1.06%	5.26%	4.15%	0.00%	5.60%	0.31%	0.00%	0.00%	0.00%
	Franklin Rt.	125.98	95%	0.04%	0.17%	26.63%	42.43%	1.47%	18.71%	3.36%	0.00%	7.02%	0.16%	0.00%	0.00%	0.00%
	Green Ck.	0.00	0%													
	Rubicon	179.03	68%	0.07%	0.04%	14.58%	37.61%	0.79%	37.66%	3.64%	0.00%	5.56%	0.04%	0.00%	0.00%	0.00%
Port Sorell	ECA (Total)	357.95	56%	0.10%	0.08%	21.31%	42.33%	0.99%	25.78%	3.62%	0.00%	5.69%	0.10%	0.00%	0.00%	0.00%
Tamar	EBZ	181.68	100%	1.40%	0.00%	1.93%	16.87%	2.41%	60.64%	4.57%	0.00%	7.35%	4.83%	0.00%	0.00%	0.00%
	EDA	558.35	100%	0.55%	0.06%	4.46%	36.05%	2.88%	39.76%	6.74%	0.00%	7.12%	2.38%	0.00%	0.00%	0.00%
	FDA	10,988.36	100%	2.14%	1.86%	10.99%	30.60%	2.35%	40.18%	6.62%	0.04%	2.24%	0.26%	1.09%	1.63%	0.00%
	Fourteen Mile Ck.	97.79	100%	0.04%	0.05%	12.60%	30.47%	2.01%	45.21%	2.84%	0.00%	6.62%	0.16%	0.00%	0.00%	0.00%
	Masseys Rt.	33.56	100%	0.06%	0.02%	16.76%	58.07%	2.76%	4.41%	7.46%	0.00%	9.83%	0.64%	0.00%	0.00%	0.00%
	Andersons	49.51	100%	0.01%	0.15%	23.34%	41.33%	3.65%	17.52%	3.02%	0.00%	10.81%	0.17%	0.00%	0.00%	0.00%
	Johnston Ck.	61.43	100%	0.12%	0.01%	19.68%	13.56%	1.30%	55.27%	1.59%	0.00%	7.97%	0.49%	0.00%	0.00%	0.00%
	Supply	134.88	100%	0.02%	0.08%	19.14%	14.75%	1.75%	56.43%	1.66%	0.00%	5.83%	0.35%	0.00%	0.00%	0.00%
	North Esk	1,064.50	100%	0.06%	6.75%	25.77%	26.83%	3.34%	28.58%	5.33%	0.00%	2.42%	0.92%	0.00%	0.00%	0.00%
	Stony Bk.	42.33	100%	0.01%	0.01%	6.71%	27.47%	3.25%	51.45%	3.26%	0.00%	7.20%	0.64%	0.00%	0.00%	0.00%
	South Esk	9,504.94	407%	2.47%	1.39%	9.08%	31.23%	2.24%	41.29%	6.94%	0.05%	1.99%	0.18%	1.26%	1.88%	0.00%
	Meander	1,292.95	97%	0.16%	0.98%	17.51%	18.14%	2.36%	49.36%	3.14%	0.00%	4.82%	0.22%	1.81%	1.50%	0.00%
	Liffey	234.42	100%	0.11%	1.12%	26.06%	9.36%	1.92%	52.68%	2.40%	0.00%	1.50%	0.14%	2.78%	1.93%	0.01%
	Nile	323.08	100%	0.11%	0.70%	3.77%	44.64%	1.57%	29.64%	17.41%	0.00%	2.14%	0.03%	0.00%	0.00%	0.00%
	Break`O`Day	230.08	100%	0.06%	2.21%	15.56%	31.97%	0.89%	44.63%	3.16%	0.00%	1.41%	0.10%	0.00%	0.00%	0.00%
	Macquarie	1,557.99	100%	0.66%	0.11%	1.51%	37.66%	0.55%	53.39%	4.32%	0.00%	1.66%	0.15%	0.00%	0.00%	0.00%
	Ben Lomond Rt.	199.74	100%	0.07%	1.53%	6.35%	47.95%	0.94%	33.06%	8.59%	0.00%	1.46%	0.05%	0.00%	0.01%	0.00%

				Landtype Categories - % of Catchment Area												
ESTUARY	Subcatchment	Area (km^2) Assessed	% of Catchment	water	rainforest	forest	woodlands	scrub	agriculture	heath & buttongrass	cleared forest	bare ground	urban	alpine scrub	alpine heath &	alpine bare
	St. Pauls	521.47	100%	0.01%	0.79%	8.21%	43.04%	7.75%	23.89%	14.17%	0.00%	0.72%	0.10%	0.70%	0.61%	0.00%
	Brumby	308.48	100%	0.15%	0.15%	13.26%	16.94%	1.79%	54.94%	3.84%	0.00%	0.79%	0.15%	3.31%	4.68%	0.00%
	Lake	813.35	100%	8.09%	0.24%	6.63%	36.72%	2.43%	22.27%	12.40%	0.01%	0.43%	0.05%	2.92%	7.82%	0.00%
	Great Lake	396.33	100%	36.27%	0.04%	0.84%	16.32%	0.91%	5.50%	9.87%	0.00%	0.59%	0.02%	12.25%	17.38%	0.01%
	Isis	337.01	100%	0.28%	0.09%	5.23%	33.93%	2.00%	51.54%	4.63%	0.00%	1.99%	0.19%	0.07%	0.06%	0.00%
	Elizabeth	399.15	100%	1.43%	0.17%	3.06%	57.65%	1.86%	25.59%	8.73%	0.00%	1.24%	0.16%	0.00%	0.11%	0.00%
	Blackman	557.80	100%	0.06%	0.12%	2.26%	23.75%	1.52%	65.84%	3.53%	0.79%	1.96%	0.10%	0.00%	0.08%	0.00%
Tamar	ECA (Total)	11,546.70	100%	2.06%	1.78%	10.67%	30.87%	2.37%	40.16%	6.63%	0.04%	2.47%	0.36%	1.04%	1.55%	0.00%
Curries R.	EBZ	2.73	101%	0.16%	0.00%	0.21%	8.44%	1.97%	74.92%	5.01%	0.00%	5.61%	3.68%	0.00%	0.00%	0.00%
	EDA	1.77	100%	0.25%	0.00%	2.43%	19.36%	2.01%	59.45%	5.85%	0.00%	6.42%	4.23%	0.00%	0.00%	0.00%
	FDA	82.00	100%	2.09%	0.00%	9.48%	52.36%	2.13%	19.31%	5.08%	0.00%	9.09%	0.46%	0.00%	0.00%	0.00%
	Curries	82.23	100%	2.09%	0.00%	9.49%	52.38%	2.14%	19.27%	5.08%	0.00%	9.09%	0.46%	0.00%	0.00%	0.00%
Curries R.	ECA (Total)	83.78	100%	2.05%	0.00%	9.33%	51.66%	2.13%	20.16%	5.09%	0.00%	9.03%	0.54%	0.00%	0.00%	0.00%
Pipers R.	EBZ	15.06	100%	1.48%	0.00%	3.91%	35.77%	3.94%	38.83%	4.95%	0.00%	9.92%	1.22%	0.00%	0.00%	0.00%
	EDA	14.41	100%	1.53%	0.00%	4.54%	46.61%	3.34%	22.67%	7.87%	0.00%	12.13%	1.31%	0.00%	0.00%	0.00%
	FDA	450.03	100%	0.03%	0.75%	21.78%	25.48%	1.56%	41.90%	2.36%	0.00%	5.73%	0.42%	0.00%	0.00%	0.00%
	Pipers R.	375.73	100%	0.02%	0.87%	22.70%	24.54%	1.44%	42.63%	2.25%	0.00%	5.10%	0.43%	0.00%	0.00%	0.00%
	Pipers Bk.	74.54	100%	0.04%	0.13%	17.09%	30.22%	2.14%	38.24%	2.92%	0.00%	8.87%	0.34%	0.00%	0.00%	0.00%
Pipers R.	ECA (Total)	464.44	100%	0.07%	0.73%	21.24%	26.14%	1.61%	41.31%	2.53%	0.00%	5.92%	0.45%	0.00%	0.00%	0.00%
Little Forester	EBZ	7.96	100%	2.22%	0.00%	0.40%	6.48%	1.09%	84.41%	2.32%	0.00%	2.89%	0.18%	0.00%	0.00%	0.00%
	EDA	4.52	100%	3.18%	0.00%	0.46%	10.16%	1.40%	77.43%	3.03%	0.00%	4.08%	0.28%	0.00%	0.00%	0.00%
	FDA	342.61	100%	0.08%	2.01%	30.38%	28.67%	1.62%	29.69%	2.79%	0.00%	4.50%	0.26%	0.00%	0.00%	0.00%
	Little Forester	342.93	100%	0.08%	2.02%	30.40%	28.66%	1.62%	29.68%	2.78%	0.00%	4.50%	0.26%	0.00%	0.00%	0.00%
Little Forester	ECA (Total)	347.14	100%	0.12%	1.99%	29.99%	28.43%	1.62%	30.31%	2.79%	0.00%	4.49%	0.26%	0.00%	0.00%	0.00%
Brid	EBZ	7.60	100%	3.10%	0.00%	1.35%	11.80%	1.50%	68.06%	4.10%	0.00%	5.84%	4.25%	0.00%	0.00%	0.00%
	EDA	13.38	100%	1.74%	0.00%	4.52%	18.03%	1.66%	59.92%	2.46%	0.00%	9.48%	2.19%	0.00%	0.00%	0.00%
	FDA	243.26	100%	0.06%	1.18%	16.20%	28.19%	1.51%	45.37%	2.87%	0.00%	4.33%	0.30%	0.00%	0.00%	0.00%
	Brid	149.05	100%	0.03%	1.90%	23.90%	21.20%	1.61%	44.52%	2.10%	0.00%	4.57%	0.16%	0.00%	0.00%	0.00%
	Hurst Ck.	94.30	100%	0.11%	0.03%	4.03%	39.19%	1.35%	46.76%	4.09%	0.00%	3.93%	0.52%	0.00%	0.00%	0.00%
Brid	ECA (Total)	256.65	100%	0.15%	1.11%	15.59%	27.66%	1.52%	46.13%	2.85%	0.00%	4.60%	0.39%	0.00%	0.00%	0.00%
Great Forester	EBZ	5.45	101%	0.54%	0.00%	0.06%	5.13%	0.57%	87.46%	3.07%	0.00%	2.86%	0.32%	0.00%	0.00%	0.00%
	EDA	2.01	100%	1.50%	0.00%	0.50%	3.96%	0.28%	84.82%	1.56%	0.00%	6.48%	0.90%	0.00%	0.00%	0.00%
	FDA	517.64	100%	0.03%	2.50%	28.52%	30.84%	2.14%	29.04%	3.11%	0.00%	3.53%	0.29%	0.00%	0.00%	0.00%

				Landtype Categories - % of Catchment Area												
ESTUARY	Subcatchment	Area (km^2) Assessed	% of Catchment	water	rainforest	forest	woodlands	scrub	agriculture	heath & buttongrass	cleared forest	bare ground	urban	alpine scrub	alpine heath &	alpine bare
	Great Forester	517.87	100%	0.03%	2.50%	28.55%	30.82%	2.15%	29.01%	3.11%	0.00%	3.53%	0.29%	0.00%	0.00%	0.00%
Great Forester	ECA (Total)	519.64	100%	0.04%	2.49%	28.41%	30.73%	2.14%	29.26%	3.11%	0.00%	3.54%	0.29%	0.00%	0.00%	0.00%
Tomahawk	EBZ	7.81	99%	1.16%	0.00%	1.03%	11.34%	0.64%	77.79%	3.56%	0.00%	3.39%	1.09%	0.00%	0.00%	0.00%
	EDA	5.77	100%	1.57%	0.00%	1.48%	15.15%	0.74%	71.12%	4.24%	0.00%	4.25%	1.45%	0.00%	0.00%	0.00%
	FDA	138.75	100%	0.04%	0.30%	13.46%	38.27%	1.78%	37.12%	2.84%	0.00%	6.11%	0.08%	0.00%	0.00%	0.00%
	Tomahawk	139.04	100%	0.04%	0.30%	13.49%	38.27%	1.79%	37.09%	2.84%	0.00%	6.11%	0.08%	0.00%	0.00%	0.00%
Tomahawk	ECA (Total)	144.52	100%	0.10%	0.29%	12.98%	37.35%	1.74%	38.48%	2.90%	0.00%	6.03%	0.14%	0.00%	0.00%	0.00%
Boobyalla Inlet	EBZ	13.98	100%	2.34%	0.03%	10.94%	17.72%	2.61%	49.76%	3.47%	0.00%	12.33%	0.79%	0.00%	0.00%	0.00%
	EDA	16.05	100%	0.88%	0.02%	7.16%	14.53%	1.69%	61.22%	3.02%	0.00%	10.77%	0.69%	0.00%	0.00%	0.00%
	FDA	1,162.27	100%	0.45%	9.60%	29.74%	24.72%	3.40%	25.43%	3.23%	0.00%	3.26%	0.17%	0.00%	0.00%	0.00%
	Ringarooma	912.92	100%	0.52%	12.14%	32.62%	20.76%	3.67%	24.33%	3.14%	0.00%	2.64%	0.17%	0.00%	0.00%	0.00%
	Boobyalla	249.60	100%	0.20%	0.35%	19.14%	39.20%	2.42%	29.42%	3.60%	0.00%	5.50%	0.18%	0.00%	0.00%	0.00%
Boobyalla Inlet	ECA (Total)	1,178.32	100%	0.46%	9.47%	29.43%	24.58%	3.37%	25.91%	3.23%	0.00%	3.36%	0.18%	0.00%	0.00%	0.00%
Little Musselroe	EBZ	4.82	99%	4.45%	0.00%	1.23%	14.48%	2.93%	64.37%	3.51%	0.00%	8.81%	0.22%	0.00%	0.00%	0.00%
	EDA	6.48	100%	3.31%	0.00%	0.65%	7.51%	1.78%	78.12%	2.06%	0.00%	6.42%	0.17%	0.00%	0.00%	0.00%
	FDA	72.81	100%	0.01%	0.00%	1.41%	14.56%	1.66%	73.65%	3.00%	0.00%	5.55%	0.17%	0.00%	0.00%	0.00%
	Little Musselroe	73.14	100%	0.01%	0.00%	1.41%	14.60%	1.66%	73.57%	3.01%	0.00%	5.57%	0.17%	0.00%	0.00%	0.00%
Little Musselroe	ECA (Total)	79.28	100%	0.28%	0.00%	1.35%	13.98%	1.67%	74.01%	2.92%	0.00%	5.62%	0.17%	0.00%	0.00%	0.00%
Great Mussleroe	EBZ	21.54	100%	1.28%	0.00%	1.70%	56.88%	1.70%	21.90%	9.45%	0.00%	6.50%	0.59%	0.00%	0.00%	0.00%
	EDA	71.21	100%	0.41%	0.01%	1.11%	44.28%	1.33%	39.35%	7.83%	0.00%	5.06%	0.62%	0.00%	0.00%	0.00%
	FDA	368.72	100%	0.14%	1.98%	21.25%	36.63%	1.63%	29.75%	3.98%	0.00%	4.38%	0.27%	0.00%	0.00%	0.00%
	Great Musselroe	368.71	100%	0.14%	1.98%	21.25%	36.66%	1.63%	29.71%	3.98%	0.00%	4.39%	0.27%	0.00%	0.00%	0.00%
Great Mussleroe	ECA (Total)	439.93	100%	0.18%	1.66%	17.99%	37.87%	1.58%	31.30%	4.60%	0.00%	4.49%	0.33%	0.00%	0.00%	0.00%
Ansons Bay	EBZ	14.82	99%	2.16%	0.05%	6.19%	48.33%	6.49%	11.20%	9.31%	0.00%	14.58%	1.70%	0.00%	0.00%	0.00%
	EDA	21.75	100%	1.29%	0.01%	3.68%	58.90%	6.29%	8.13%	8.16%	0.00%	12.13%	1.41%	0.00%	0.00%	0.00%
	FDA	237.18	100%	0.02%	0.56%	14.83%	58.04%	1.22%	7.54%	6.51%	0.00%	11.04%	0.23%	0.00%	0.00%	0.00%
	Ansons	237.12	100%	0.02%	0.56%	14.81%	58.07%	1.22%	7.54%	6.51%	0.00%	11.05%	0.23%	0.00%	0.00%	0.00%
Ansons Bay	ECA (Total)	258.93	100%	0.13%	0.51%	13.90%	58.12%	1.65%	7.59%	6.65%	0.00%	11.13%	0.33%	0.00%	0.00%	0.00%
Big Lagoon	EBZ	4.02	98%	0.61%	0.00%	3.42%	61.22%	3.56%	3.56%	14.52%	0.00%	11.99%	1.13%	0.00%	0.00%	0.00%
Big Lagoon	ECA (Total)	17.19	100%	0.15%	0.09%	6.72%	66.40%	3.07%	1.33%	12.97%	0.00%	9.00%	0.29%	0.00%	0.00%	0.00%
Sloop Lagoon	EBZ	4.22	99%	0.59%	0.00%	1.50%	71.19%	1.66%	1.70%	14.49%	0.00%	7.16%	1.72%	0.00%	0.00%	0.00%
Sloop Lagoon	ECA (Total)	10.81	100%	0.23%	0.00%	1.12%	69.52%	2.07%	1.12%	19.75%	0.00%	5.52%	0.67%	0.00%	0.00%	0.00%
Grant's Lagoon	EBZ	4.39	99%	1.10%	0.00%	2.86%	64.12%	2.29%	3.46%	15.13%	0.00%	8.50%	2.53%	0.00%	0.00%	0.00%

				Landtype Categories - % of Catchment Area												
ESTUARY	Subcatchment	Area (km^2) Assessed	% of Catchment	water	rainforest	forest	woodlands	scrub	agriculture	heath & buttongrass	cleared forest	bare ground	urban	alpine scrub	alpine heath &	alpine bare
Grant`s Lagoon	ECA (Total)	6.77	100%	0.71%	0.00%	3.24%	67.23%	2.15%	2.55%	13.98%	0.00%	8.48%	1.67%	0.00%	0.00%	0.00%
Georges Bay	EBZ	30.94	99%	3.78%	0.01%	3.46%	44.87%	2.15%	22.89%	9.36%	0.00%	9.40%	4.07%	0.00%	0.00%	0.00%
	EDA	34.14	100%	1.77%	0.04%	5.51%	51.81%	2.34%	15.22%	9.67%	0.00%	10.11%	3.52%	0.00%	0.00%	0.00%
	FDA	522.47	100%	0.16%	9.84%	34.18%	30.19%	2.23%	15.41%	4.50%	0.00%	3.29%	0.19%	0.00%	0.00%	0.00%
	Georges	522.47	100%	0.16%	9.83%	34.19%	30.20%	2.23%	15.40%	4.50%	0.00%	3.29%	0.19%	0.00%	0.00%	0.00%
Georges Bay	ECA (Total)	556.60	100%	0.26%	9.23%	32.42%	31.52%	2.24%	15.40%	4.82%	0.00%	3.70%	0.40%	0.00%	0.00%	0.00%
Scamander	EBZ	20.87	99%	1.85%	0.16%	7.74%	55.04%	1.97%	16.71%	7.02%	0.00%	7.70%	1.81%	0.00%	0.00%	0.00%
	EDA	13.73	100%	2.80%	0.14%	6.57%	54.07%	1.98%	15.29%	6.70%	0.00%	9.75%	2.69%	0.00%	0.00%	0.00%
	FDA	326.92	100%	0.06%	1.74%	23.19%	57.62%	1.45%	4.71%	6.67%	0.00%	4.41%	0.16%	0.00%	0.00%	0.00%
	Scamander	301.51	100%	0.06%	1.79%	22.07%	58.66%	1.41%	4.78%	6.88%	0.00%	4.22%	0.14%	0.00%	0.00%	0.00%
	Arm Ck.	25.38	100%	0.12%	1.23%	36.46%	45.49%	1.92%	3.75%	4.15%	0.00%	6.56%	0.32%	0.00%	0.00%	0.00%
Scamander	ECA (Total)	340.65	100%	0.17%	1.68%	22.52%	57.48%	1.48%	5.13%	6.67%	0.00%	4.62%	0.26%	0.00%	0.00%	0.00%
Henderson's Lagoon	EBZ	6.61	99%	5.68%	0.03%	3.15%	40.11%	1.35%	32.06%	7.42%	0.00%	8.88%	1.32%	0.00%	0.00%	0.00%
Henderson's Lagoon	ECA (Total)	50.50	100%	0.75%	0.63%	28.73%	31.05%	1.98%	27.75%	3.23%	0.00%	5.63%	0.24%	0.00%	0.00%	0.00%
Templestowe Lagoon	EBZ	5.22	98%	6.80%	0.00%	1.13%	16.76%	0.55%	62.84%	2.84%	0.00%	8.58%	0.50%	0.00%	0.00%	0.00%
Templestowe Lagoon	ECA (Total)	25.17	100%	1.41%	0.04%	29.36%	34.72%	7.70%	21.44%	2.35%	0.00%	2.82%	0.15%	0.00%	0.00%	0.00%
Douglas	EBZ	2.73	98%	0.41%	0.00%	5.24%	16.28%	0.82%	74.27%	1.12%	0.00%	1.33%	0.53%	0.00%	0.00%	0.00%
	EDA	3.15	100%	0.36%	0.00%	12.41%	15.50%	0.56%	68.86%	1.03%	0.00%	0.93%	0.36%	0.00%	0.00%	0.00%
	FDA	70.25	100%	0.00%	3.17%	37.70%	35.84%	16.52%	0.87%	3.75%	0.00%	2.13%	0.02%	0.00%	0.00%	0.00%
	Douglas	70.36	100%	0.00%	3.16%	37.72%	35.84%	16.52%	0.87%	3.73%	0.00%	2.13%	0.02%	0.00%	0.00%	0.00%
Douglas	ECA (Total)	73.40	100%	0.02%	3.04%	36.61%	34.97%	15.83%	3.79%	3.64%	0.00%	2.08%	0.03%	0.00%	0.00%	0.00%
Denison	EBZ	1.99	97%	0.66%	0.00%	7.05%	50.44%	1.35%	32.06%	2.71%	0.00%	3.30%	2.42%	0.00%	0.00%	0.00%
Denison	ECA (Total)	26.73	100%	0.05%	0.25%	35.81%	32.61%	20.39%	2.73%	5.15%	0.00%	2.80%	0.21%	0.00%	0.00%	0.00%
Saltwater Lagoon	EBZ	3.26	98%	4.16%	0.02%	2.61%	76.88%	4.58%	0.79%	6.98%	0.00%	3.49%	0.50%	0.00%	0.00%	0.00%
Saltwater Lagoon	ECA (Total)	8.59	100%	1.58%	0.04%	5.55%	69.35%	3.89%	10.83%	6.97%	0.00%	1.43%	0.35%	0.00%	0.00%	0.00%
Freshwater Lagoon	EBZ	3.99	99%	3.84%	0.00%	1.41%	75.16%	3.37%	1.18%	13.46%	0.00%	1.33%	0.25%	0.00%	0.00%	0.00%
Freshwater Lagoon	ECA (Total)	11.86	100%	1.30%	0.06%	2.10%	75.51%	3.14%	1.82%	15.01%	0.00%	0.89%	0.15%	0.00%	0.02%	0.00%
Bryants Lagoon	EBZ	4.07	101%	0.98%	2.41%	23.98%	48.08%	5.66%	1.21%	16.04%	0.00%	1.57%	0.05%	0.00%	0.02%	0.00%
Bryants Lagoon	ECA (Total)	5.82	100%	0.75%	2.26%	24.14%	51.68%	4.83%	0.87%	14.27%	0.00%	1.13%	0.03%	0.00%	0.04%	0.00%
Great Swanport	EBZ	75.58	100%	2.46%	0.03%	1.72%	46.77%	2.49%	33.37%	11.00%	0.01%	1.74%	0.42%	0.00%	0.00%	0.00%
	EDA	140.47	100%	1.31%	0.09%	2.74%	49.93%	2.24%	30.10%	12.09%	0.08%	1.07%	0.34%	0.00%	0.01%	0.00%
	FDA	890.55	100%	0.01%	0.87%	16.23%	43.37%	10.97%	16.48%	11.63%	0.03%	0.24%	0.05%	0.00%	0.11%	0.00%
	Apsley	231.06	100%	0.02%	0.46%	17.56%	36.76%	14.64%	16.74%	13.56%	0.00%	0.16%	0.09%	0.00%	0.00%	0.00%

				Landtype Categories - % of Catchment Area												
ESTUARY	Subcatchment	Area (km^2) Assessed	% of Catchment	water	rainforest	forest	woodlands	scrub	agriculture	heath & buttongrass	cleared forest	bare ground	urban	alpine scrub	alpine heath &	alpine bare
	Swan	659.21	100%	0.01%	1.01%	15.78%	45.69%	9.68%	16.40%	10.94%	0.04%	0.27%	0.03%	0.00%	0.15%	0.00%
Great Swanport	ECA (Total)	1,031.02	100%	0.19%	0.76%	14.40%	44.26%	9.78%	18.34%	11.70%	0.04%	0.35%	0.09%	0.00%	0.09%	0.00%
Meredith	EBZ	3.90	99%	0.29%	0.10%	0.83%	14.79%	0.74%	77.04%	3.06%	2.24%	0.75%	0.16%	0.00%	0.00%	0.00%
	EDA	1.57	100%	0.48%	0.24%	0.87%	24.10%	0.83%	67.55%	2.78%	1.99%	0.83%	0.32%	0.00%	0.00%	0.00%
	FDA	96.59	100%	0.01%	0.60%	12.55%	60.00%	2.79%	11.94%	10.10%	1.08%	0.77%	0.03%	0.00%	0.14%	0.00%
	Meredith	96.67	100%	0.01%	0.60%	12.56%	59.99%	2.79%	11.95%	10.09%	1.07%	0.77%	0.03%	0.00%	0.14%	0.00%
Meredith	ECA (Total)	98.16	100%	0.02%	0.59%	12.36%	59.42%	2.76%	12.83%	9.98%	1.09%	0.77%	0.03%	0.00%	0.13%	0.00%
Stoney	EBZ	1.59	97%	0.16%	0.00%	1.10%	27.37%	0.75%	65.34%	2.99%	1.14%	0.83%	0.32%	0.00%	0.00%	0.00%
	EDA	0.36	100%	0.69%	0.00%	0.00%	23.58%	0.34%	68.85%	1.72%	2.41%	1.89%	0.52%	0.00%	0.00%	0.00%
	FDA	26.35	100%	0.00%	0.07%	1.52%	52.51%	1.25%	33.39%	9.31%	1.79%	0.07%	0.04%	0.00%	0.05%	0.00%
	Stony	26.36	100%	0.00%	0.07%	1.52%	52.33%	1.25%	33.56%	9.31%	1.81%	0.07%	0.04%	0.00%	0.05%	0.00%
Stoney	ECA (Total)	26.71	100%	0.01%	0.07%	1.50%	52.12%	1.24%	33.87%	9.21%	1.80%	0.09%	0.05%	0.00%	0.05%	0.00%
Buxton	EBZ	2.82	98%	1.91%	0.00%	2.66%	22.66%	0.60%	61.60%	3.35%	2.26%	3.73%	1.24%	0.00%	0.00%	0.00%
	EDA	1.10	100%	4.87%	0.00%	0.11%	25.47%	0.51%	55.01%	2.15%	0.45%	8.94%	2.49%	0.00%	0.00%	0.00%
	FDA	59.52	100%	0.01%	2.12%	36.68%	41.85%	4.60%	7.25%	6.55%	0.46%	0.39%	0.04%	0.00%	0.05%	0.00%
	Buxton	59.53	100%	0.01%	2.12%	36.64%	41.87%	4.59%	7.29%	6.55%	0.47%	0.39%	0.04%	0.00%	0.05%	0.00%
Buxton	ECA (Total)	60.63	100%	0.09%	2.08%	36.02%	41.55%	4.53%	8.12%	6.47%	0.46%	0.55%	0.08%	0.00%	0.05%	0.00%
Lisdillon	EBZ	3.70	99%	1.44%	0.00%	0.49%	19.78%	0.49%	68.74%	2.43%	1.71%	4.36%	0.57%	0.00%	0.00%	0.00%
	EDA	3.26	100%	1.63%	0.00%	0.02%	16.70%	0.56%	72.10%	2.59%	1.04%	4.89%	0.48%	0.00%	0.00%	0.00%
	FDA	47.89	100%	0.00%	1.63%	20.37%	54.98%	3.38%	8.23%	9.67%	1.18%	0.45%	0.03%	0.00%	0.08%	0.00%
	Lisdillon	47.89	100%	0.00%	1.63%	20.30%	55.00%	3.39%	8.27%	9.67%	1.18%	0.45%	0.03%	0.00%	0.09%	0.00%
Lisdillon	ECA (Total)	51.14	100%	0.11%	1.53%	19.07%	52.54%	3.20%	12.29%	9.22%	1.17%	0.74%	0.06%	0.00%	0.08%	0.00%
Little Swanport	EBZ	21.40	100%	0.54%	0.00%	0.21%	34.91%	0.87%	53.77%	7.31%	1.15%	0.90%	0.35%	0.00%	0.00%	0.00%
	EDA	55.73	100%	0.21%	0.06%	1.11%	42.93%	0.77%	43.60%	9.16%	1.08%	0.81%	0.25%	0.00%	0.02%	0.00%
	FDA	674.90	100%	0.18%	0.24%	5.86%	47.15%	1.76%	35.26%	7.89%	0.51%	1.04%	0.08%	0.00%	0.02%	0.00%
	Swanport	603.19	100%	0.21%	0.20%	5.51%	47.01%	1.65%	36.07%	7.79%	0.32%	1.15%	0.08%	0.00%	0.01%	0.00%
	Ravensdale Rt.	71.58	100%	0.00%	0.59%	8.90%	48.33%	2.73%	28.40%	8.70%	2.09%	0.15%	0.07%	0.00%	0.04%	0.00%
Little Swanport	ECA (Total)	730.63	100%	0.19%	0.23%	5.50%	46.83%	1.69%	35.89%	7.99%	0.55%	1.03%	0.09%	0.00%	0.02%	0.00%
Grindstone	EBZ	4.72	99%	0.00%	0.00%	0.00%	13.18%	0.21%	81.49%	1.76%	0.25%	2.93%	0.19%	0.00%	0.00%	0.00%
	EDA	6.78	100%	0.01%	0.00%	0.02%	17.56%	0.72%	76.08%	3.36%	0.28%	1.81%	0.17%	0.00%	0.00%	0.00%
	FDA	23.83	100%	0.46%	0.09%	3.49%	29.47%	1.59%	59.32%	4.20%	0.68%	0.61%	0.07%	0.00%	0.01%	0.00%
	Eighty Acre Ck.	23.82	100%	0.46%	0.09%	3.51%	29.44%	1.57%	59.35%	4.21%	0.68%	0.61%	0.07%	0.00%	0.01%	0.00%
Grindstone	ECA (Total)	30.60	100%	0.36%	0.07%	2.72%	26.83%	1.40%	63.03%	4.02%	0.59%	0.88%	0.09%	0.00%	0.01%	0.00%

				Landtype Categories - % of Catchment Area												
ESTUARY	Subcatchment	Area (km^2) Assessed	% of Catchment	water	rainforest	forest	woodlands	scrub	agriculture	heath & buttongrass	cleared forest	bare ground	urban	alpine scrub	alpine heath &	alpine bare
Spring	EBZ	15.16	100%	0.10%	0.00%	0.60%	24.55%	0.66%	62.98%	4.77%	2.35%	1.53%	2.46%	0.00%	0.00%	0.00%
	EDA	25.71	100%	0.06%	0.21%	3.84%	36.14%	1.75%	45.04%	6.55%	4.04%	0.87%	1.48%	0.00%	0.03%	0.00%
	FDA	89.69	99%	0.57%	1.41%	24.14%	39.45%	5.39%	20.53%	7.75%	0.48%	0.09%	0.05%	0.00%	0.14%	0.00%
	Spring	89.65	100%	0.57%	1.41%	24.11%	39.46%	5.39%	20.56%	7.75%	0.48%	0.09%	0.05%	0.00%	0.13%	0.00%
Spring	ECA (Total)	115.40	100%	0.46%	1.14%	19.61%	38.71%	4.58%	25.99%	7.49%	1.27%	0.26%	0.37%	0.00%	0.11%	0.00%
Prosser	EBZ	11.71	97%	0.26%	0.01%	1.19%	49.08%	1.11%	31.78%	11.81%	1.37%	1.41%	1.97%	0.00%	0.02%	0.00%
	EDA	35.10	99%	0.08%	0.27%	3.49%	57.01%	1.89%	21.56%	12.64%	1.66%	0.58%	0.71%	0.00%	0.11%	0.00%
	FDA	683.53	99%	0.04%	0.71%	13.01%	49.71%	4.49%	22.29%	8.76%	0.72%	0.17%	0.03%	0.00%	0.08%	0.00%
	Prosser	683.54	100%	0.04%	0.71%	13.03%	49.70%	4.50%	22.28%	8.77%	0.72%	0.17%	0.03%	0.00%	0.08%	0.00%
Prosser	ECA (Total)	718.62	99%	0.04%	0.69%	12.54%	50.07%	4.36%	22.25%	8.95%	0.76%	0.19%	0.06%	0.00%	0.08%	0.00%
Earlham Lagoon	EBZ	5.53	98%	0.07%	0.00%	0.36%	33.24%	0.86%	56.50%	7.12%	0.16%	1.34%	0.35%	0.00%	0.00%	0.00%
	EDA	16.94	99%	0.02%	0.02%	1.89%	46.85%	1.50%	40.56%	7.74%	0.66%	0.55%	0.21%	0.00%	0.01%	0.00%
	FDA	91.51	99%	0.00%	1.33%	26.80%	40.98%	9.84%	9.84%	10.68%	0.30%	0.07%	0.03%	0.00%	0.12%	0.00%
	Griffiths Rt.	91.49	99%	0.00%	1.33%	26.81%	40.98%	9.83%	9.85%	10.67%	0.31%	0.07%	0.03%	0.00%	0.12%	0.00%
Earlham Lagoon	ECA (Total)	108.45	99%	0.00%	1.12%	22.91%	41.90%	8.53%	14.64%	10.22%	0.36%	0.15%	0.06%	0.00%	0.10%	0.00%
Blackman Bay	EBZ	29.16	99%	0.16%	0.09%	2.99%	43.84%	1.87%	39.78%	8.05%	0.76%	1.52%	0.93%	0.00%	0.00%	0.00%
	EDA	60.72	100%	0.08%	0.17%	5.16%	44.43%	2.19%	37.81%	7.89%	0.79%	0.95%	0.53%	0.00%	0.01%	0.00%
	FDA	41.29	100%	0.00%	1.99%	48.01%	11.22%	26.74%	0.55%	11.32%	0.14%	0.01%	0.02%	0.00%	0.01%	0.00%
	Blackman Rt.	41.30	100%	0.00%	2.01%	48.19%	11.11%	26.77%	0.44%	11.30%	0.14%	0.01%	0.02%	0.00%	0.01%	0.00%
Blackman Bay	ECA (Total)	102.01	100%	0.05%	0.91%	22.50%	30.99%	12.13%	22.72%	9.28%	0.52%	0.57%	0.32%	0.00%	0.01%	0.00%
Port Arthur	EBZ	26.11	97%	0.15%	3.11%	55.78%	8.07%	11.78%	10.06%	9.79%	0.66%	0.13%	0.47%	0.00%	0.00%	0.00%
	EDA	40.49	98%	0.09%	2.70%	62.15%	6.08%	10.87%	7.76%	9.24%	0.76%	0.08%	0.25%	0.00%	0.00%	0.00%
	FDA	36.74	100%	0.00%	5.66%	69.49%	2.16%	13.19%	4.18%	4.80%	0.40%	0.03%	0.08%	0.00%	0.00%	0.00%
	Simmons Ck.	8.96	101%	0.00%	6.82%	80.10%	0.39%	10.63%	0.02%	1.95%	0.08%	0.00%	0.00%	0.00%	0.00%	0.00%
	Long Bay Ck.	8.00	99%	0.00%	10.52%	82.90%	0.46%	5.11%	0.47%	0.46%	0.07%	0.00%	0.01%	0.00%	0.00%	0.00%
	Alberry Ck	6.53	99%	0.00%	3.68%	52.13%	8.50%	5.03%	22.84%	5.33%	1.92%	0.14%	0.42%	0.00%	0.00%	0.00%
	Denmans Ck.	13.29	100%	0.00%	2.92%	62.71%	1.24%	23.89%	0.00%	9.18%	0.04%	0.00%	0.01%	0.00%	0.00%	0.00%
Port Arthur	ECA (Total)	77.23	99%	0.05%	4.11%	65.64%	4.21%	11.97%	6.06%	7.13%	0.59%	0.06%	0.17%	0.00%	0.00%	0.00%
Parsons Bay	EBZ	16.04	100%	0.13%	2.43%	24.16%	44.35%	6.05%	8.34%	10.63%	1.30%	1.33%	1.13%	0.00%	0.15%	0.00%
	EDA	30.41	100%	0.07%	3.46%	33.38%	37.05%	5.60%	9.89%	7.96%	1.11%	0.75%	0.62%	0.00%	0.11%	0.00%
	FDA	58.02	100%	0.00%	6.01%	63.74%	8.90%	6.69%	8.20%	4.62%	1.60%	0.15%	0.06%	0.00%	0.01%	0.00%
	Parsons Bay	41.44	100%	0.00%	5.67%	64.08%	6.69%	6.28%	9.66%	5.21%	2.12%	0.21%	0.08%	0.00%	0.01%	0.00%
	Cripps Ck.	16.74	100%	0.00%	6.83%	63.02%	14.34%	7.67%	4.57%	3.16%	0.34%	0.01%	0.01%	0.00%	0.03%	0.00%

				Landtype Categories - % of Catchment Area												
ESTUARY	Subcatchment	Area (km^2)	% of	water	rainforest	forest	woodlands	scrub	agriculture	heath &	cleared	bare	urban	alpine	alpine	alpine
		Assessed	Catchment							buttongrass	forest	ground		scrub	heath &	bare
Parsons Bay	ECA (Total)	88.42	100%	0.03%	5.13%	53.30%	18.58%	6.32%	8.78%	5.77%	1.43%	0.36%	0.25%	0.00%	0.05%	0.00%
Norfolk Bay	EBZ	83.99	100%	0.25%	0.65%	14.82%	38.38%	6.04%	23.35%	13.47%	1.01%	1.15%	0.85%	0.00%	0.05%	0.00%
	EDA	212.00	100%	0.10%	2.35%	33.40%	26.68%	8.80%	16.80%	9.80%	1.11%	0.53%	0.40%	0.00%	0.03%	0.00%
	FDA	13.04	100%	0.00%	0.44%	13.52%	48.59%	5.42%	19.76%	9.91%	2.12%	0.14%	0.06%	0.00%	0.04%	0.00%
	Saltwater Ck.	13.01	100%	0.00%	0.45%	13.59%	48.61%	5.45%	19.64%	9.88%	2.13%	0.14%	0.06%	0.00%	0.04%	0.00%
Norfolk Bay	ECA (Total)	225.04	100%	0.09%	2.24%	32.25%	27.95%	8.61%	16.97%	9.81%	1.17%	0.51%	0.38%	0.00%	0.03%	0.00%
Carlton	EBZ	13.58	100%	0.01%	0.01%	0.17%	29.40%	0.91%	60.84%	5.80%	0.91%	1.09%	0.87%	0.00%	0.00%	0.00%
	EDA	23.28	100%	0.01%	0.08%	1.83%	41.41%	1.90%	45.05%	7.43%	0.93%	0.73%	0.63%	0.00%	0.00%	0.00%
	FDA	140.62	99%	0.06%	0.98%	18.89%	43.95%	4.29%	22.85%	7.65%	1.07%	0.14%	0.09%	0.00%	0.03%	0.00%
	Carlton	140.67	100%	0.06%	0.98%	18.88%	43.93%	4.29%	22.87%	7.66%	1.07%	0.14%	0.09%	0.00%	0.03%	0.00%
Carlton	ECA (Total)	163.90	100%	0.05%	0.85%	16.47%	43.59%	3.95%	26.01%	7.62%	1.05%	0.22%	0.17%	0.00%	0.03%	0.00%
Pittwater	EBZ	66.14	100%	0.07%	0.03%	0.54%	18.28%	0.67%	66.66%	2.81%	1.56%	4.67%	4.70%	0.00%	0.00%	0.00%
	EDA	109.08	100%	0.05%	0.03%	0.72%	27.01%	1.16%	59.01%	3.76%	1.47%	3.24%	3.56%	0.00%	0.00%	0.00%
	FDA	809.87	100%	0.20%	0.23%	6.52%	37.92%	2.08%	45.41%	5.57%	1.07%	0.52%	0.48%	0.00%	0.01%	0.00%
	Coal	538.80	100%	0.29%	0.13%	5.67%	37.52%	2.22%	46.24%	5.60%	1.41%	0.48%	0.44%	0.00%	0.00%	0.00%
	Orielton	49.49	100%	0.00%	0.03%	2.01%	34.36%	1.45%	54.53%	6.14%	0.22%	0.60%	0.65%	0.00%	0.00%	0.00%
	Sorell Rt.	40.50	99%	0.01%	0.84%	12.07%	41.88%	1.77%	36.43%	5.83%	0.11%	0.23%	0.80%	0.00%	0.03%	0.00%
	Iron Ck.	93.54	100%	0.00%	0.79%	16.10%	46.53%	2.74%	26.98%	6.19%	0.45%	0.13%	0.06%	0.00%	0.03%	0.00%
	Duckhole	46.31	100%	0.04%	0.00%	0.30%	34.50%	0.78%	56.31%	4.15%	0.70%	1.88%	1.32%	0.00%	0.00%	0.00%
	Frogmore	16.59	100%	0.00%	0.00%	0.00%	11.41%	0.51%	84.60%	1.93%	0.08%	0.58%	0.89%	0.00%	0.00%	0.00%
	Forcett Rt.	13.56	100%	0.00%	0.19%	5.80%	46.43%	2.34%	36.64%	7.21%	0.54%	0.44%	0.40%	0.00%	0.00%	0.00%
	Gilling Bk.	11.00	100%	0.03%	0.26%	3.03%	31.02%	1.18%	57.88%	4.80%	0.80%	0.73%	0.28%	0.00%	0.00%	0.00%
Pittwater	ECA (Total)	918.95	100%	0.18%	0.20%	5.83%	36.62%	1.97%	47.03%	5.36%	1.12%	0.84%	0.85%	0.00%	0.01%	0.00%
Pipeclay Lagoon	EBZ	10.21	99%	0.04%	0.00%	0.16%	19.84%	0.45%	64.03%	5.59%	0.79%	4.90%	4.19%	0.00%	0.00%	0.00%
Pipeclay Lagoon	ECA (Total)	16.52	100%	0.03%	0.00%	0.12%	18.44%	0.48%	67.35%	5.39%	0.76%	3.88%	3.54%	0.00%	0.00%	0.00%
Derwent	EBZ	160.06	100%	0.15%	0.00%	0.89%	29.53%	1.85%	37.93%	7.23%	0.92%	2.83%	18.67%	0.00%	0.00%	0.00%
	EDA	776.54	100%	0.11%	0.78%	16.78%	30.58%	6.60%	26.73%	9.38%	1.13%	1.13%	6.33%	0.13%	0.30%	0.01%
	FDA	7,268.19	84%	2.55%	3.99%	17.04%	25.66%	5.86%	30.04%	7.71%	1.07%	0.36%	0.07%	2.63%	2.99%	0.02%
	Derwent	6,025.19	334%	2.90%	4.78%	19.50%	25.28%	6.65%	24.48%	8.11%	1.14%	0.32%	0.05%	3.18%	3.59%	0.02%
	Ouse	1,494.83	91%	1.75%	0.26%	5.96%	32.99%	2.85%	29.56%	8.95%	0.79%	0.30%	0.02%	6.63%	9.90%	0.04%
	Nive	548.83	50%	2.75%	1.06%	18.56%	43.23%	4.68%	14.34%	10.08%	0.00%	0.26%	0.05%	1.93%	3.06%	0.00%
	Clyde	1,117.49	100%	6.40%	0.13%	3.96%	30.50%	2.37%	46.84%	7.59%	1.19%	0.23%	0.03%	0.00%	0.75%	0.00%
	Dee	361.74	100%	13.40%	1.36%	19.49%	36.65%	6.88%	12.14%	8.11%	0.07%	0.33%	0.02%	0.20%	1.35%	0.00%

				Landtype Categories - % of Catchment Area												
ESTUARY	Subcatchment	Area (km^2) Assessed	% of Catchment	water	rainforest	forest	woodlands	scrub	agriculture	heath & buttongrass	cleared forest	bare ground	urban	alpine scrub	alpine heath &	alpine bare
	Florentine	441.98	100%	0.10%	26.56%	39.48%	3.74%	14.46%	0.97%	9.48%	0.57%	0.36%	0.03%	2.27%	1.92%	0.06%
	Tyenna	336.36	100%	0.31%	10.12%	47.45%	7.75%	9.83%	9.33%	5.10%	2.01%	0.30%	0.07%	4.79%	2.90%	0.05%
	Styx	342.03	100%	0.00%	23.92%	37.22%	3.66%	15.49%	3.92%	10.78%	0.98%	0.25%	0.07%	2.54%	1.11%	0.05%
	Plenty	223.50	100%	0.01%	5.33%	45.32%	9.61%	14.60%	6.27%	9.17%	8.03%	0.48%	0.05%	0.71%	0.42%	0.00%
	Jordan	1,243.43	100%	0.87%	0.18%	5.14%	27.48%	2.01%	57.00%	5.75%	0.76%	0.59%	0.17%	0.00%	0.06%	0.00%
Derwent	ECA (Total)	8,044.73	86%	2.32%	3.68%	17.02%	26.13%	5.93%	29.72%	7.87%	1.08%	0.44%	0.68%	2.39%	2.73%	0.02%
Ralph's Bay	EBZ	29.34	101%	0.14%	0.00%	0.46%	36.17%	2.62%	43.56%	5.78%	1.31%	4.28%	5.68%	0.00%	0.00%	0.00%
Ralph's Bay	ECA (Total)	57.44	100%	0.07%	0.00%	0.50%	39.14%	2.51%	42.15%	6.22%	1.08%	3.04%	5.29%	0.00%	0.00%	0.00%
North West Bay	EBZ	23.46	99%	0.20%	0.08%	5.07%	40.80%	3.62%	35.48%	8.07%	1.45%	2.01%	3.22%	0.00%	0.00%	0.00%
	EDA	35.10	100%	0.14%	0.06%	7.04%	44.76%	5.79%	26.66%	8.67%	1.16%	2.12%	3.55%	0.00%	0.04%	0.00%
	FDA	141.53	100%	0.04%	2.40%	38.02%	12.99%	12.06%	16.05%	12.13%	1.27%	0.79%	0.42%	0.38%	3.38%	0.07%
	North West Bay	95.64	100%	0.05%	2.92%	32.42%	13.78%	11.56%	17.59%	13.08%	1.47%	0.98%	0.48%	0.55%	5.00%	0.11%
	Margate	22.49	100%	0.05%	0.70%	38.68%	16.33%	11.94%	21.19%	8.73%	1.16%	0.70%	0.53%	0.00%	0.00%	0.00%
	Snug	23.38	100%	0.00%	1.90%	60.16%	6.59%	14.18%	4.85%	11.59%	0.57%	0.08%	0.09%	0.00%	0.00%	0.00%
North West Bay	ECA (Total)	176.62	100%	0.06%	1.94%	31.86%	19.31%	10.81%	18.16%	11.44%	1.25%	1.05%	1.05%	0.30%	2.72%	0.06%
Oyster Cove	EBZ	4.50	99%	0.75%	0.19%	21.14%	40.23%	8.81%	13.96%	12.82%	1.03%	0.61%	0.46%	0.00%	0.00%	0.00%
	EDA	4.47	100%	0.76%	0.24%	16.81%	48.61%	7.54%	12.29%	11.91%	0.89%	0.52%	0.43%	0.00%	0.00%	0.00%
	FDA	15.52	100%	0.02%	1.96%	50.05%	10.98%	10.87%	15.60%	7.12%	2.66%	0.47%	0.27%	0.00%	0.00%	0.00%
	Oyster Cove	15.58	100%	0.02%	1.96%	50.01%	10.98%	10.87%	15.62%	7.13%	2.66%	0.47%	0.27%	0.00%	0.00%	0.00%
Oyster Cove	ECA (Total)	19.99	100%	0.19%	1.58%	42.62%	19.39%	10.12%	14.86%	8.19%	2.26%	0.48%	0.31%	0.00%	0.00%	0.00%
Garden Island	EBZ	7.65	101%	0.34%	0.29%	19.73%	22.38%	12.86%	16.27%	24.74%	1.55%	0.85%	0.98%	0.00%	0.00%	0.00%
	EDA	8.15	100%	0.33%	0.64%	25.31%	20.85%	14.20%	10.66%	24.71%	1.59%	0.74%	0.97%	0.00%	0.00%	0.00%
	FDA	39.80	100%	0.00%	5.77%	67.01%	6.03%	12.59%	3.05%	5.28%	0.20%	0.04%	0.03%	0.00%	0.00%	0.00%
	Garden Island Ck.	39.93	100%	0.00%	5.77%	67.02%	6.02%	12.59%	3.05%	5.28%	0.20%	0.04%	0.03%	0.00%	0.00%	0.00%
Garden Island	ECA (Total)	47.95	100%	0.06%	4.89%	59.92%	8.55%	12.87%	4.35%	8.58%	0.44%	0.16%	0.19%	0.00%	0.00%	0.00%
Port Cygnet	EBZ	22.71	100%	0.51%	0.42%	17.49%	18.81%	8.05%	34.59%	15.98%	0.88%	1.92%	1.36%	0.00%	0.00%	0.00%
	EDA	36.34	100%	0.22%	2.16%	28.96%	15.11%	10.16%	28.27%	12.97%	0.69%	0.90%	0.56%	0.00%	0.00%	0.00%
	FDA	104.10	100%	0.08%	5.77%	46.57%	9.86%	9.03%	18.40%	7.99%	1.33%	0.68%	0.30%	0.00%	0.00%	0.00%
	Nicholls Rt.	47.26	100%	0.09%	7.29%	56.18%	8.20%	8.94%	11.75%	6.19%	0.89%	0.37%	0.08%	0.00%	0.00%	0.00%
	Agnes Rt.	43.02	100%	0.06%	4.54%	37.03%	10.34%	9.22%	25.94%	9.26%	1.90%	1.13%	0.56%	0.00%	0.00%	0.00%
	Gardners Ck.	13.95	100%	0.05%	4.33%	43.63%	13.93%	8.73%	17.58%	10.14%	1.04%	0.33%	0.24%	0.00%	0.00%	0.00%
Port Cygnet	ECA (Total)	140.44	100%	0.11%	4.83%	42.02%	11.22%	9.32%	20.95%	9.28%	1.17%	0.74%	0.37%	0.00%	0.00%	0.00%
Huon	EBZ	119.66	100%	0.25%	0.46%	18.32%	19.05%	10.05%	28.37%	18.83%	1.64%	1.49%	1.54%	0.00%	0.00%	0.00%

				Landtype Categories - % of Catchment Area												
ESTUARY	Subcatchment	Area (km^2) Assessed	% of Catchment	water	rainforest	forest	woodlands	scrub	agriculture	heath & buttongrass	cleared forest	bare ground	urban	alpine scrub	alpine heath &	alpine bare
	EDA	300.66	100%	0.11%	3.51%	36.30%	12.92%	11.71%	18.67%	13.79%	1.50%	0.83%	0.65%	0.00%	0.01%	0.00%
	FDA	2,738.96	100%	0.22%	29.19%	34.73%	2.73%	13.41%	3.67%	12.19%	0.72%	0.27%	0.06%	1.47%	1.29%	0.04%
	Huon	2,263.80	166%	0.25%	33.45%	32.23%	1.56%	13.87%	1.79%	12.76%	0.56%	0.24%	0.02%	1.75%	1.47%	0.05%
	Weld	419.78	100%	0.11%	48.82%	26.97%	0.01%	12.44%	0.00%	6.95%	0.21%	0.10%	0.00%	2.55%	1.79%	0.04%
	Picton	484.19	100%	0.29%	54.72%	25.30%	0.00%	11.68%	0.00%	4.61%	0.50%	0.21%	0.00%	1.74%	0.91%	0.04%
	Mountain River	186.89	100%	0.03%	6.98%	42.14%	10.01%	12.46%	13.35%	12.42%	0.59%	0.31%	0.29%	0.33%	1.07%	0.02%
Huon	ECA (Total)	3,039.62	100%	0.21%	26.65%	34.89%	3.74%	13.24%	5.15%	12.35%	0.80%	0.32%	0.12%	1.33%	1.17%	0.04%
Hospital Bay	EBZ	5.87	98%	0.45%	0.26%	14.32%	23.69%	8.50%	24.67%	23.25%	1.05%	1.09%	2.73%	0.00%	0.00%	0.00%
	EDA	6.89	100%	0.37%	0.71%	22.66%	20.73%	8.22%	24.36%	19.14%	0.93%	0.83%	2.06%	0.00%	0.00%	0.00%
	FDA	132.57	100%	0.12%	15.64%	45.94%	5.42%	10.91%	9.84%	8.07%	3.42%	0.39%	0.24%	0.00%	0.00%	0.00%
	Crooks Rt.	132.58	100%	0.12%	15.66%	45.93%	5.42%	10.90%	9.85%	8.07%	3.42%	0.39%	0.24%	0.00%	0.00%	0.00%
Hospital Bay	ECA (Total)	139.46	100%	0.14%	14.90%	44.79%	6.17%	10.78%	10.56%	8.62%	3.30%	0.41%	0.33%	0.00%	0.00%	0.00%
Surges Bay	EBZ	2.23	99%	0.25%	0.59%	34.69%	12.02%	25.55%	15.27%	10.06%	0.81%	0.17%	0.59%	0.00%	0.00%	0.00%
	EDA	1.37	100%	0.37%	0.05%	23.46%	14.19%	25.97%	22.14%	11.73%	1.10%	0.23%	0.78%	0.00%	0.00%	0.00%
	FDA	11.70	100%	0.01%	1.88%	59.59%	8.38%	8.64%	14.33%	5.40%	1.40%	0.26%	0.11%	0.00%	0.00%	0.00%
	Surges	11.74	100%	0.01%	1.89%	59.51%	8.40%	8.64%	14.36%	5.41%	1.42%	0.26%	0.11%	0.00%	0.00%	0.00%
Surges Bay	ECA (Total)	13.07	100%	0.05%	1.69%	55.81%	8.99%	10.46%	15.15%	6.07%	1.37%	0.25%	0.18%	0.00%	0.00%	0.00%
Esperence	EBZ	23.16	99%	0.32%	0.32%	22.95%	17.28%	19.63%	14.64%	20.50%	1.65%	1.21%	1.49%	0.00%	0.00%	0.00%
	EDA	70.45	100%	0.11%	2.43%	47.84%	10.13%	14.02%	10.38%	11.43%	2.53%	0.56%	0.57%	0.00%	0.00%	0.00%
	FDA	235.96	100%	0.01%	29.13%	46.99%	0.68%	13.06%	0.37%	6.80%	2.17%	0.15%	0.01%	0.23%	0.39%	0.01%
	Esperence	173.10	100%	0.02%	33.65%	43.64%	0.10%	13.45%	0.07%	6.69%	1.38%	0.14%	0.01%	0.31%	0.52%	0.02%
	Creekton Rt.	62.81	100%	0.00%	16.58%	56.34%	2.29%	11.98%	1.18%	7.06%	4.33%	0.19%	0.03%	0.00%	0.01%	0.00%
Esperence	ECA (Total)	306.41	100%	0.04%	22.99%	47.18%	2.85%	13.28%	2.67%	7.86%	2.25%	0.24%	0.14%	0.18%	0.30%	0.01%
D'Entrecasteaux	EBZ	314.25	100%	0.44%	0.33%	16.60%	24.30%	12.10%	25.89%	16.37%	1.43%	1.25%	1.29%	0.00%	0.00%	0.00%
	EDA	673.51	99%	0.21%	2.32%	32.82%	17.98%	11.97%	19.26%	12.43%	1.43%	0.81%	0.76%	0.00%	0.01%	0.00%
	FDA	3,131.96	100%	0.19%	27.84%	35.88%	3.08%	13.31%	4.04%	11.76%	0.87%	0.28%	0.08%	1.32%	1.31%	0.04%
D'Entrecasteaux	ECA (Total)	3,805.47	100%	0.20%	23.32%	35.34%	5.72%	13.07%	6.73%	11.88%	0.97%	0.38%	0.20%	1.09%	1.08%	0.04%
Cloudy Bay	EBZ	9.19	101%	0.90%	0.05%	31.07%	12.82%	21.28%	14.98%	14.89%	2.25%	0.43%	1.33%	0.00%	0.00%	0.00%
	EDA	18.24	100%	0.46%	2.80%	43.82%	9.37%	19.15%	11.65%	10.13%	1.72%	0.21%	0.68%	0.00%	0.00%	0.00%
	FDA	24.45	100%	0.00%	10.93%	70.21%	3.09%	9.93%	2.35%	2.87%	0.45%	0.10%	0.07%	0.00%	0.00%	0.00%
	Cloudy	24.52	100%	0.00%	10.95%	70.22%	3.08%	9.93%	2.35%	2.86%	0.45%	0.10%	0.07%	0.00%	0.00%	0.00%
Cloudy Bay	ECA (Total)	42.69	100%	0.20%	7.46%	58.93%	5.77%	13.87%	6.32%	5.97%	1.00%	0.15%	0.33%	0.00%	0.00%	0.00%
Southport	EBZ	24.33	100%	0.88%	0.71%	35.56%	6.48%	24.34%	4.20%	26.67%	0.29%	0.41%	0.47%	0.00%	0.00%	0.00%

				Landtype Categories - % of Catchment Area												
ESTUARY	Subcatchment	Area (km^2) Assessed	% of Catchment	water	rainforest	forest	woodlands	scrub	agriculture	heath & buttongrass	cleared forest	bare ground	urban	alpine scrub	alpine heath &	alpine bare
	EDA	46.53	100%	0.47%	1.98%	46.10%	4.74%	22.76%	4.38%	18.57%	0.49%	0.24%	0.26%	0.00%	0.00%	0.00%
	FDA	142.64	100%	0.00%	34.86%	39.24%	0.50%	16.34%	0.12%	7.60%	0.99%	0.28%	0.01%	0.01%	0.06%	0.01%
	Lune	131.88	100%	0.00%	37.44%	36.26%	0.42%	17.09%	0.11%	7.96%	0.46%	0.18%	0.00%	0.01%	0.07%	0.01%
	Southport Rt.	10.61	100%	0.00%	2.96%	76.56%	1.49%	6.89%	0.22%	2.84%	7.45%	1.54%	0.06%	0.00%	0.00%	0.00%
Southport	ECA (Total)	189.17	100%	0.12%	26.77%	40.93%	1.54%	17.92%	1.17%	10.30%	0.86%	0.27%	0.07%	0.01%	0.05%	0.01%
Southport Lagoon	EBZ	11.21	99%	1.11%	0.80%	8.95%	0.00%	30.95%	0.00%	56.76%	0.09%	1.33%	0.00%	0.00%	0.00%	0.00%
	EDA	13.70	100%	0.91%	0.48%	7.16%	0.00%	28.78%	0.00%	61.51%	0.08%	1.09%	0.00%	0.00%	0.00%	0.00%
	FDA	13.48	100%	0.00%	2.63%	39.26%	0.00%	29.61%	0.00%	28.49%	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%
	Donnelys	13.50	100%	0.00%	2.63%	39.29%	0.00%	29.60%	0.00%	28.47%	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%
Southport Lagoon	ECA (Total)	27.19	100%	0.46%	1.55%	23.08%	0.00%	29.19%	0.00%	45.13%	0.05%	0.55%	0.00%	0.00%	0.00%	0.00%
Recherche Bay	EBZ	22.11	99%	0.63%	3.52%	61.69%	0.00%	23.55%	0.00%	10.01%	0.14%	0.45%	0.00%	0.00%	0.00%	0.00%
	EDA	28.30	100%	0.49%	4.45%	61.14%	0.00%	22.72%	0.00%	10.02%	0.75%	0.42%	0.00%	0.00%	0.00%	0.00%
	FDA	150.99	100%	0.12%	22.07%	54.98%	0.00%	16.08%	0.00%	6.23%	0.06%	0.23%	0.00%	0.03%	0.09%	0.11%
	D`entrecasteaux	73.38	100%	0.00%	20.60%	51.18%	0.00%	19.22%	0.00%	8.37%	0.10%	0.26%	0.00%	0.06%	0.10%	0.11%
	Catamaran	66.64	100%	0.26%	26.50%	57.54%	0.00%	11.66%	0.00%	3.56%	0.02%	0.21%	0.00%	0.01%	0.10%	0.14%
	Cockle	10.93	100%	0.00%	5.07%	65.62%	0.00%	21.72%	0.00%	7.58%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Recherche Bay	ECA (Total)	179.29	100%	0.18%	19.29%	55.95%	0.00%	17.13%	0.00%	6.83%	0.17%	0.26%	0.00%	0.03%	0.08%	0.10%
New River Lagoon	EBZ	26.55	100%	0.75%	14.84%	35.90%	0.00%	35.01%	0.00%	12.84%	0.01%	0.64%	0.00%	0.00%	0.00%	0.00%
	EDA	73.55	98%	0.27%	27.49%	41.83%	0.00%	21.26%	0.00%	8.88%	0.01%	0.25%	0.00%	0.00%	0.00%	0.00%
	FDA	222.25	100%	0.14%	46.11%	29.76%	0.00%	19.20%	0.00%	4.36%	0.02%	0.04%	0.00%	0.26%	0.12%	0.00%
	New	222.22	100%	0.14%	46.11%	29.75%	0.00%	19.20%	0.00%	4.36%	0.02%	0.04%	0.00%	0.26%	0.12%	0.00%
New River Lagoon	ECA (Total)	295.79	99%	0.17%	41.48%	32.76%	0.00%	19.71%	0.00%	5.49%	0.01%	0.09%	0.00%	0.20%	0.09%	0.00%
Louisa R.	EBZ	6.21	102%	0.30%	1.71%	5.27%	0.00%	30.73%	0.00%	60.74%	0.00%	1.26%	0.00%	0.00%	0.00%	0.00%
	EDA	3.98	100%	0.47%	0.80%	5.35%	0.00%	27.10%	0.00%	64.32%	0.00%	1.96%	0.00%	0.00%	0.00%	0.00%
	FDA	78.93	100%	0.02%	18.91%	30.99%	0.00%	17.84%	0.00%	32.20%	0.04%	0.01%	0.00%	0.00%	0.00%	0.00%
	Louisa R.	78.96	100%	0.02%	18.89%	30.98%	0.00%	17.86%	0.00%	32.21%	0.04%	0.01%	0.00%	0.00%	0.00%	0.00%
Louisa R.	ECA (Total)	82.91	100%	0.04%	18.04%	29.76%	0.00%	18.28%	0.00%	33.74%	0.04%	0.10%	0.00%	0.00%	0.00%	0.00%
Louisa Ck.	EBZ	6.92	99%	0.09%	0.23%	1.98%	0.00%	11.21%	0.00%	86.25%	0.00%	0.24%	0.00%	0.00%	0.00%	0.00%
	EDA	2.41	100%	0.26%	0.21%	2.75%	0.00%	17.28%	0.00%	78.84%	0.00%	0.67%	0.00%	0.00%	0.00%	0.00%
	FDA	54.23	100%	0.01%	13.78%	26.33%	0.00%	21.03%	0.00%	38.81%	0.01%	0.03%	0.00%	0.00%	0.00%	0.00%
	Louisa Ck.	54.29	100%	0.01%	13.74%	26.30%	0.00%	21.02%	0.00%	38.89%	0.01%	0.03%	0.00%	0.00%	0.00%	0.00%
Louisa Ck.	ECA (Total)	56.64	100%	0.02%	13.20%	25.33%	0.00%	20.87%	0.00%	40.51%	0.01%	0.06%	0.00%	0.00%	0.00%	0.00%
Freney	EBZ	4.41	99%	1.82%	0.14%	1.72%	0.00%	10.68%	0.00%	84.14%	0.03%	1.47%	0.00%	0.00%	0.00%	0.00%

				Landtype Categories - % of Catchment Area												
ESTUARY	Subcatchment	Area (km^2) Assessed	% of Catchment	water	rainforest	forest	woodlands	scrub	agriculture	heath & buttongrass	cleared forest	bare ground	urban	alpine scrub	alpine heath &	alpine bare
Freney	ECA (Total)	19.44	99%	0.45%	6.45%	8.09%	0.00%	12.76%	0.00%	71.55%	0.04%	0.67%	0.00%	0.00%	0.00%	0.00%
Bathurst Harbour	EBZ	102.10	99%	0.35%	2.07%	8.30%	0.00%	12.29%	0.00%	76.56%	0.03%	0.40%	0.00%	0.00%	0.00%	0.00%
	EDA	212.43	100%	0.17%	3.78%	8.89%	0.00%	10.71%	0.00%	75.94%	0.02%	0.48%	0.00%	0.00%	0.00%	0.00%
	FDA	851.42	100%	0.01%	17.87%	20.13%	0.00%	19.24%	0.00%	41.72%	0.01%	0.54%	0.00%	0.34%	0.13%	0.00%
	Spring	150.24	100%	0.01%	11.57%	15.39%	0.00%	15.46%	0.00%	55.82%	0.00%	1.75%	0.00%	0.00%	0.00%	0.00%
	North	137.72	100%	0.00%	12.91%	13.06%	0.00%	14.59%	0.00%	58.97%	0.01%	0.47%	0.00%	0.00%	0.00%	0.00%
	Old	427.95	100%	0.02%	24.54%	24.84%	0.00%	21.97%	0.00%	27.46%	0.01%	0.20%	0.00%	0.68%	0.26%	0.01%
	Horseshoe	16.84	100%	0.00%	12.24%	19.81%	0.00%	19.96%	0.00%	47.86%	0.00%	0.13%	0.00%	0.00%	0.00%	0.00%
	Ray	53.14	100%	0.00%	14.75%	28.73%	0.00%	23.99%	0.00%	32.14%	0.04%	0.35%	0.00%	0.00%	0.00%	0.00%
	Melaleuca	65.90	98%	0.00%	3.30%	8.37%	0.00%	15.84%	0.00%	72.09%	0.00%	0.39%	0.00%	0.00%	0.00%	0.00%
Bathurst Harbour	ECA (Total)	1,063.85	100%	0.04%	15.06%	17.89%	0.00%	17.53%	0.00%	48.56%	0.01%	0.53%	0.00%	0.27%	0.10%	0.00%
Payne Bay	EDA	52.93	40%	0.09%	0.21%	7.09%	0.00%	3.58%	0.00%	86.97%	0.00%	2.05%	0.00%	0.00%	0.00%	0.00%
	FDA	327.94	41%	0.22%	22.33%	19.14%	0.00%	18.34%	0.00%	37.01%	0.01%	0.06%	0.00%	1.47%	1.40%	0.02%
	Davey	328.32	68%	0.22%	22.33%	19.13%	0.00%	18.34%	0.00%	37.02%	0.01%	0.06%	0.00%	1.47%	1.41%	0.02%
	Crossing	235.97	99%	0.30%	21.30%	18.80%	0.00%	17.97%	0.00%	39.71%	0.01%	0.06%	0.00%	1.05%	0.79%	0.02%
	Dewitt	0.00	0%													
	Blackwater Ck.	0.00	0%													
Payne Bay	ECA (Total)	380.87	41%	0.20%	19.26%	17.47%	0.00%	16.29%	0.00%	43.96%	0.01%	0.33%	0.00%	1.26%	1.21%	0.02%
Gordon	EDA	0.00	0%													
	FDA	1,261.02	24%	23.82%	19.93%	12.43%	0.38%	13.00%	0.00%	28.52%	0.06%	0.76%	0.00%	0.44%	0.64%	0.03%
	Gordon	1,261.93	76%	23.80%	19.93%	12.43%	0.38%	13.01%	0.00%	28.52%	0.06%	0.76%	0.00%	0.44%	0.64%	0.03%
	Franklin	0.00	0%													
	Denison	0.00	0%													
	Lake Pedder	261.73	100%	25.02%	23.07%	11.71%	0.00%	12.31%	0.00%	25.63%	0.02%	0.45%	0.00%	1.04%	0.73%	0.02%
Gordon	ECA (Total)	1,261.02	24%	23.82%	19.93%	12.43%	0.38%	13.00%	0.00%	28.52%	0.06%	0.76%	0.00%	0.44%	0.64%	0.03%

				Landtype Categories - % of Catchment Area												
ESTUARY	Subcatchment	Area (km^2) Assessed	% of Catchment	water	rainforest	forest	woodlands	scrub	agriculture	heath & buttongrass	cleared forest	bare ground	urban	alpine scrub	alpine heath &	alpine bare
Summary Statistics																
Totals		39,125.32	58%	2%	6%	18%	26%	6%	27%	10%	0%	2%	0%	1%	1%	0%
Statistics For ECAs																
	Sum	36,823.8		2%	6%	18%	26%	6%	27%	10%	0%	2%	0%	1%	1%	0%
	Mean	681.9	96%	1%	6%	24%	29%	8%	18%	11%	1%	2%	0%	0%	0%	0%
	Std. Dev.	1,925.4	14%	3%	9%	17%	22%	7%	18%	13%	1%	3%	1%	0%	1%	0%
	Min	5.8	24%	0%	0%	0%	0%	0%	0%	2%	0%	0%	0%	0%	0%	0%
	Max.	11,546.7	100%	24%	41%	66%	76%	29%	74%	72%	3%	11%	5%	2%	3%	0%
	Median	111.9	100%	0%	2%	23%	31%	5%	14%	8%	0%	1%	0%	0%	0%	0%
Statistics For EDAs																
	Sum	3,902.7		0%	2%	20%	25%	8%	25%	15%	1%	2%	2%	0%	0%	0%
	Mean	76.5	95%	1%	1%	15%	24%	7%	32%	15%	1%	3%	1%	0%	0%	0%
	Std. Dev.	162.5	20%	1%	4%	18%	18%	8%	26%	21%	1%	4%	1%	0%	0%	0%
	Min	0.0	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%
	Max.	776.5	100%	5%	27%	62%	59%	29%	85%	87%	4%	12%	6%	0%	0%	0%
	Median	18.2	100%	0%	0%	5%	20%	3%	26%	8%	1%	1%	1%	0%	0%	0%
Statistics For EBZs																
	Sum	1,693.0		1%	1%	11%	25%	7%	32%	16%	1%	3%	3%	0%	0%	0%
	Mean	28.2	99%	1%	1%	9%	27%	7%	34%	14%	1%	4%	2%	0%	0%	0%
	Std. Dev.	52.4	1%	1%	2%	14%	20%	9%	28%	19%	1%	4%	3%	0%	0%	0%
	Min	1.6	97%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%
	Max.	314.2	102%	7%	15%	62%	77%	35%	87%	86%	2%	15%	19%	0%	0%	0%
	Median	9.7	99%	1%	0%	3%	23%	3%	32%	9%	0%	2%	1%	0%	0%	0%
Statistics For River Catchments																
	Sum	34,471.4		2%	7%	18%	26%	6%	28%	9%	0%	2%	0%	1%	1%	0%
	Mean	376.1	92%	1%	7%	26%	24%	7%	21%	10%	1%	2%	0%	1%	1%	0%
	Std. Dev.	1,043.4	24%	5%	11%	20%	20%	7%	20%	12%	1%	3%	0%	2%	2%	0%
	Min	0.0	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Max.	9,504.9	100%	36%	55%	83%	68%	30%	85%	72%	8%	11%	1%	12%	17%	0%
	Median	96.2	100%	0%	2%	21%	25%	4%	17%	7%	0%	0%	0%	0%	0%	0%

Appendix 6 Characteristics of Tasmanian Estuaries: Naturalness Index and Naturalness Class

Appendix 6: Characteristics of Tasmanian Estuaries: Naturalness Index & Naturalness Class, Ranked by EBZ

	EBZ		EDA		FDA/ECA	
ESTUARY	natindex	natclass	natindex	natclass	natindex	natclass
Louisa R.	1.000	1	1.000	1	1.001	1
Louisa Ck.	1.000	1	1.000	1	1.000	1
Freney	1.001	1	1.001	1	1.001	1
Port Davey	1.001	1	1.001	1	1.000	1
New River Lagoon	1.003	1	1.001	1	1.001	1
Southport Lagoon	1.004	1	1.003	1	1.001	1
Recherche Bay	1.006	1	1.030	2	1.002	1
Bryants Lagoon	1.094	2	1.067	2	1.067	2
Freshwater Lagoon	1.295	2	1.219	2	1.219	2
Saltwater Lagoon	1.525	2	1.779	2	1.779	2
Southport	1.642	2	1.454	2	1.049	2
Port Arthur	1.891	2	1.592	2	1.264	2
Oyster Cove	2.054	3	1.957	2	2.001	3
Surges Bay	2.226	3	2.697	3	1.735	2
Big Lagoon	2.265	3	1.338	2	1.338	2
Great Mussleroe	2.462	3	3.186	4	2.456	3
Parsons Bay	2.504	3	2.050	3	1.449	2
Garden Island	2.684	3	2.447	3	1.164	2
Moulting Lagoon	2.749	3	2.544	3	1.710	2
Sloop Lagoon	2.769	3	1.709	2	1.709	2
Norfolk Bay	2.814	3	2.109	3	1.937	2
Cloudy Bay	3.002	4	2.210	3	1.181	2
Esperence	3.129	4	2.084	3	1.114	2
Ansons Bay	3.135	4	2.725	3	1.526	2
D'Entrecasteaux	3.371	4	2.585	3	1.271	2
Scamander	3.456	4	4.271	5	1.344	2
Little Swanport	3.547	4	3.037	4	2.509	3
Blackman Bay	3.547	4	3.070	4	1.047	2
Henderson's Lagoon	3.592	4	2.349	3	2.349	3
Earlham Lagoon	3.613	4	2.853	3	1.434	2
Grant's Lagoon	3.647	4	2.755	3	2.755	3
Huon	3.725	4	2.446	3	1.236	2
Piper	3.757	4	3.208	4	3.089	4
Port Cygnet	3.762	4	2.717	3	2.089	3
Ringarooma	3.774	4	4.135	5	2.188	3
Little Musselroe	3.793	4	4.297	5	4.116	5
Stoney	3.971	4	4.361	5	2.447	3
Templestowe	4.011	5	2.005	3	2.005	3
Prosser	4.276	5	2.634	3	1.949	2
Carlton	4.326	5	3.459	4	2.046	3
Meredith	4.330	5	4.097	5	1.546	2
Lisdillon	4.386	5	4.400	5	1.407	2
Grindstone	4.453	5	4.219	5	3.473	4
Douglas	4.492	5	4.108	5	1.055	2
Little Forester	4.555	5	4.371	5	2.445	3
Denison	4.681	5	1.318	2	1.318	2
Crooks	4.729	5	4.050	5	1.773	2
Buxton	4.784	5	5.684	5	1.348	2
Great Forester	4.816	5	5.288	5	2.451	3

	EBZ		EDA		FDA/ECA	
ESTUARY	natindex	natclass	natindex	natclass	natindex	natclass
Tomahawk	5.189	5	5.282	5	2.565	3
North West Bay	5.663	5	5.626	5	2.113	3
Georges Bay	5.949	5	5.096	5	1.809	2
Spring	6.045	5	4.426	5	1.887	2
Beechford	7.644	5	7.567	5	2.227	3
Pipeclay Lagoon	7.744	5	7.231	5	7.231	5
Brid	7.930	5	5.570	5	3.107	4
Tamar	8.204	6	4.949	5	2.862	3
Pittwater	8.383	6	6.945	5	3.336	4
Ralph's Bay	8.416	6	7.968	5	7.968	5
Derwent	21.039	6	8.382	6	2.317	3