LANDSCAPE LOGIC

LINKING LAND AND WATER MANAGEMENT TO RESOURCE CONDITION TARGETS

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Selecting catchments for the retrospective study of land-use and water quality

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LANDSCAPE LOGIC is a research hub under the Commonwealth Environmental Research Facilities scheme, managed by the Department of Environment, Water Heritage and the Arts. It is a partnership between:

- **six regional organisations** – the North Central, North East & Goulburn–Broken Catchment Management Authorities in Victoria and the North, South and Cradle Coast Natural Resource Management organisations in Tasmania;
- **five research institutions** – University of Tasmania, Australian National University, RMIT University, Charles Sturt University and CSIRO; and
- **state land management agencies in Tasmania and Victoria** – the Tasmanian Department of Primary Industries & Water, Forestry Tasmania and the Victorian Department of Sustainability & Environment.

The purpose of Landscape Logic is to work in partnership with regional natural resource managers to develop decision-making approaches that improve the effectiveness of environmental management.

Landscape Logic aims to:

1. Develop better ways to organise existing knowledge and assumptions about links between land and water management and environmental outcomes.
2. Improve our understanding of the links between land management and environmental outcomes through historical studies of private and public investment into water quality and native vegetation condition.

Selecting catchments for the retrospective study of land-use and water quality

By Dr Bill Cotching and Prof Ted Lefroy, UTAS

Summary

This report describes the criteria and process use to select Tasmanian catchments in a study of the relationships between land use, land management and water quality. This research was part of the Landscape Logic Tasmanian Retrospective Project (Project 4). To reach consensus on the water quality parameters required across the sub-projects within Project 4 (Land use, Riverine, Estuarine, Riparian), a meeting was convened on 7 September 2007 at the University of Tasmania (Hobart Campus) with nine participants representing participating research groups (TAFI, TIAR, CSE, Freshwater Systems P/L and UTAS). This followed an initial selection process to identify a suitable catchment for high frequency water quality monitoring in Project 5 (Catchment Nutrient and Sediment Processes) on 18 May 2007.

The exclusion criteria used were associated with regulation of river systems and industrial development, and the near pristine rivers of the west coast, namely: hydroelectric development, major dams and reservoirs at the head of catchments, industrial development and mining, little or no agricultural development. The inclusion criteria were: water quality and flow data available, hydrologically discrete catchment boundary, not prone to extensive flooding, connected to an estuary, easily accessible, data available from previous research studies.

This process produced a list of 11 priority catchments for study: Ansons Bay, Black, Carlton/Pitt Water, Coal/Pitt Water, Duck, George, Little Swanport, Meredith, Montagu, Pipers and Rubicon/Port Sorrell. It was decided that additional studies would be undertaken in several other catchments and sub-catchments to examine smaller scale relationships between land use and river health, and between riparian intervention, water quality and river health. These include: Arthur sub-catchments, Black, Brid, Brumbys, Cam (Pet), Esperance, Great Forester, Huon (Forsters rivulet), Jordan, Inglis/Flowerdale, Lake, Leven, Lower Derwent, Macquarie, Meredith, Mersey (Don, Dasher, Minnow), Musselroe/Ansons, Nelson Bay, North Esk, Prosser, Quamby, Scamander–Douglas, South Esk and Swan–Apsley.

Acronyms

CFEV	Conservation of Freshwater Ecosystems Values
CSE	CSIRO Sustainable Ecosystems
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DPIW	Department of Primary Industries and Water (Tasmania)
TAFI	Tasmanian Aquaculture and Fisheries Institute
TIAR	Tasmanian Institute for Agricultural Research

Introduction

The Tasmanian Retrospective Study is investigating how water quality responds to changes in land use and land management, and how water quality in turn affects riverine and estuarine health and function. The links established in this study will assist future environmental management decision making.

The study aims to:

1. Identify the relative impact of land use, land management and previous landscape interventions on water quality.
2. Provide new knowledge and improved assumptions about the responsiveness of river health to water quality as a result of historic changes in land resource parameters.
3. Provide new knowledge and improved assumptions about responsiveness of estuarine health to water quality as a result of historic changes in land resource parameters.

The project is made up of four inter-linked sub-projects:

- P 4.1 Links between land use, land management and water quality,
- P4.2 Links between river health and water quality parameters,
- P4.3 Links between estuarine health and changes in land use and management, and
- P4.4 Riparian water quality buffering.

1. Data requirements and availability

It was agreed that each of the sub-projects require daily time series, modelled or historical water quality data (specific data requirements are shown in Appendix 1). This data is required as medians, upper and lower percentiles, maximum and minimum for preceding three months, year and long term.

A coordinated approach to requests for data and modelled outputs from the Department of Primary Industries and Water (DPIW) was agreed, with Dr Bill Cotching (Project Leader) to be responsible for sourcing data through DPIW on behalf of the Tasmanian Retrospective Study team, with sub-project data requests made through Dr Shane Broad. To achieve a consistent approach in comparing catchments, the sub-projects agreed to use modelled data.

The flow data required in Project 4 is listed in Appendix 4. This data can be generated using a standard software package, and towards this end the following information has been supplied by the Department of Primary Industries and Water (DPIW):

- Metadata for dated and referenced sites with continuous and discrete data parameters has been supplied.
- Original Excel files for the Water Information System for Tasmania (WIST) database as it applies to State of Rivers (SoR) Reports, and Riverworks database.

The following data was also required from DPIW:

- The referenced location of hydrologic nodes within the data map for the Conservation of Freshwater Ecosystems Values (CFEV) sub-catchments and model. It was noted that CFEV sub-catchment nodes don't necessarily align with mapped nodes.
- To ensure data availability to all project team members, it was agreed that a data library should be established to include SoR Reports, data bases and data map layers.

Sub-project data requirements

Sub-project 2: links between river health and water quality parameters

- Daily time series data and aggregated data, including medians, percentiles, and box plots,
- A breakdown of all CFEV catchments and sub-catchments by percentage area of all land uses, and
- A GIS layer (shape file) for the above, i.e. a CFEV catchment layer with all land-uses as attributes (data as percentage area) and the same for a CFEV sub-catchment layer.

Peter Davies advised the group that he is able to provide data extraction software when the study catchments are determined. The software is capable of aggregating data over time series, and characterising flow regime using SOR data.

Sub-project 3: links between estuarine health and changes in land use and management

15 minute flow and daily flow data, 30–40 years of real flow data for catchment characterisation, and top-of-estuary data for each study catchment. If sub-project 3 adopts a palaeo approach to assessing links between estuarine health and changes in land use and management, historical data as far back in time as possible will be required.

2. Catchment selection

Background

The Tasmanian retrospective study of Landscape Logic (Project 4) is to have a common focus between its component sub-projects. This will be achieved by drawing on data from a range of catchment settings across Tasmania and Australia in order to determine

the range of water quality responses associated with simple landscape/land use associations.

Integrated studies within the same set of a small number of yet to be selected Tasmanian catchments, selected on the basis of availability of water quality, river health, land use and land management data, will test these simple responses in catchments with more complex mosaics of land use and land management/intervention data.

The intention is to investigate the links in the overall relationship between land management, water quality and aquatic ecosystem health, and for the river health and estuarine sub-project to relate water quality and flow data to key environmental functions for both riverine and estuarine systems, taking into account the differences between estuary and river types.

This integrated catchment research gives a mountains-to-the-sea type understanding of the mobilisation, transport, downstream attenuation and impacts of nutrients and sediment. One of the key enablers of achieving strong research integration is having teams working in, and building collective understanding of the same catchments. A prerequisite is the selection of catchments that are suitable for the different types of research and acceptable (e.g. travel distances) to the relevant research teams.

Methodology

The catchment selection process was consensus-based involving the different research teams. On 18 May 2007, researchers from Projects 4 and 5 met to select catchments suitable to undertake Landscape Logic research.

The catchment selection process had the objective of selecting a single catchment to be the main focus for Project 5. A total of 48 catchments were put forward (see Appendix 2) along with a set of criteria for catchment selection. Following an exclusion process, 3 catchments were selected as potentially suitable sites for Project 5 field work.

Subsequently, Project 4 researchers met on 7 September 2007 to review the initial catchment selection process and to identify suitable catchments for research in Project 4. The process introduced new criteria for assessment (see Appendix 3) as the requirements for each sub-project as well as the integrated studies needed to be considered. This report details the process and result of the Project 4 catchment selection.

Those attending the workshop were: Shane Broad (TIAR), Bill Cotching (TIAR), Christine Crawford (TAFI), Peter Davies (Freshwater Systems), John Gibson (TAFI), Shaun Lisson (CSIRO), Steve Read (Forestry Tasmania), Jeff Ross (TAFI) and Philip Smethurst (CSIRO), with spatial data input from James Shaddick (TIAR).

Step one – excluding unsuitable catchments

The first step in the process of identifying suitable catchments in which to undertake Project 4 research was to exclude those catchments that were obviously unsuitable.

Ten exclusion factors were identified that might preclude a catchment from the study. These are listed below, and the affected catchments detailed in Appendix 2.

1. Industrial development: Many of the catchments contain some industrial development, but in many cases these are in the estuarine zone, such as towns, and have little effect on the rivers above the estuary. Those catchments considered to be adversely affected by industrial development are identified in Appendix 2.
2. Hydroelectric development
3. Major dams and reservoirs at the head of catchments
4. Significant mining, both current and historic
5. Channel diversions
6. Catchment not hydrologically discrete
7. Groundwater system not understood
8. Major land use changes not likely in the short term/documented previously.
9. Catchment prone to extensive flooding
10. Access difficult

On the basis of these exclusion criteria, 25 of the 48 catchments were identified as potential research catchments for Project 4. These are: Anson's Bay (Musselroe–Anson's), Arthur, Black–Detention, Brumbys–Lake, Cam, Carlton, Derwent Estuary, Duck, George, Jordon, Little Swanport, Lower Derwent, Nelson Bay, Macquarie, Meredith, Mersey, Montagu, North Esk, Pipers, Pitt Water–Coal, Port Sorrell (Rubicon), Scamander–Douglas, South Esk, Swan–Apsley and Welcome.

Step two – identifying catchments suited to integrated land-use–freshwater–estuarine study

The second step in the selection process considered a body of information related to the following factors which would facilitate integrated studies across all sub-projects:

- Continuous surface water quality data available from DPIW
- State of Rivers reports
- Land-use
- Estuaries with previous studies and available data.

Some of the information considered is detailed below.

Edgar *et al.* (1999) identified and studied 111 estuaries around the Tasmanian coastline. Of these,

five were on King Island and 16 in the Furneaux group, leaving 90 on the coastline of mainland Tasmania. The estuaries could be separated on physical grounds into eight major groups, which are split across three Natural Resource Management areas: South, North and Cradle Coast, two of which contained single examples (the Tamar and the Derwent estuaries). One of the factors considered in choosing the catchment–estuary pairs to be studied from the 90 Tasmanian mainland estuaries was the existence of a DPIW monitoring program for both river flow through constantly gauged stations and at least a regular (monthly) record of nutrient concentrations (N, P), electrical conductivity (EC), dissolved oxygen (DO) and turbidity from at least one station within the catchment. The availability of quasi-continuous EC, DO and turbidity within some catchments was considered an advantage. Applying this test resulted in the selection of a list of 26 estuary–river pairs:

Table 1: The 26 estuary–river pairs selected in step 2.

Anson's Bay (Musselroe–Anson's)	Little Swanport
Black	Meredith
Booballa (Ringarooma)	Mersey
Brid	Montagu
Carlton	Moulting Lagoon (Apsley)
Douglas	Moulting Lagoon (Swan)
Dover	Nelson Bay
Duck	Pipers
George	Pitt Water– Coal
Great Forester	Port Sorrell (Rubicon)
Huon	Prosser
Inglis	Scamander
Leven	Welcome

Land-use related nutrient impacts are evident and of significance (e.g. aquaculture industries, Ramsar wetlands, high conservation value estuaries). Edgar *et al.* (1999) provided a 'Naturalness Index' for catchments that can be used to asses the river–estuary pairs.

One of the rivers, the Nelson Bay, was considered near pristine, and, considering the extremely limited agriculture in the basin is not considered further here. Of the remainder, the five least natural catchments were the Duck, Montagu, Piper's, Rubicon and Little Swanport.

Nine of the estuaries have an aquaculture industry that could be affected by catchment processes; and four (Boobyalla, Pitt Water, Moulting Lagoon (Apsley) and Moulting Lagoon (Swan) have Ramsar-listed wetlands surrounding or close to the estuaries. Edgar *et al.* (1999) also provided an assessment of the conservation significance of each Tasmanian estuary. Of the estuaries listed above, only the Black was considered of critical conservation significance, while Boobyalla and Moulting Lagoon were of high conservation value.

The next level of significance (moderate) included Welcome, Montagu, Piper, Anson's Bay and Douglas.

For integrated catchment study, the estuary must have been the subject of previous research as a source of environmental data. Some information is available for each of the estuaries. Appendix 5 summarises the studies that have been undertaken. The work of Edgar *et al.* (1999) and Murphy *et al.* (2005) involved Tasmania-wide surveys of estuarine characteristics, while the other studies listed were in general more limited in their scope. This table indicates that some catchments are relatively well-studied (Georges, Pitt Water, Little Swanport), while there are a few catchments with no information: Scamander, Dover, Great Forester and Brid.

Consideration was also given to catchments selected by Project 5 for their research, to either work within the same catchment or select a parallel catchment. Using the information detailed above, as well as the expert opinion of those attending the workshop, eleven catchments were selected for integrated research across Project 4. Catchments were selected in each of the North, Cradle Coast and Southern NRM Regions of Tasmania (Table 2 and Figure 1) with the reasons for exclusion of other catchments presented in Appendix 2.

Table 2: Catchments selected for integrated studies in the Tasmanian Retrospective Project.

Catchment	Region
Ansons Bay	North
Black	Cradle Coast
Carlton	South
Coal/Pitt Water	South
Duck	Cradle Coast
George	North
Little Swanport	South
Meredith	South
Montagu	Cradle Coast
Pipers	North
Rubicon/Port Sorrell	Cradle Coast

Step three – sub-catchment selection for river health and riparian studies)

Researchers in the separate sub-projects of Project 4 identified that some studies would need to be undertaken at sites other than those well suited to integrated studies. This is because research across a range of environments will build a more complete picture when there is a paucity of catchments with

data reflecting changes over time, i.e. studies that substitute space for time.

Sub-catchments with water quality monitoring data available for the River Health sub-project were identified. The catchments and sub-catchments listed in Table 3 were identified as potential study areas for the separate sub-projects within Project 4 (river health, estuarine health, and land-use/management) because of the availability of water quality monitoring data or record of land-use change. Some of the virtues of these catchments as potential study sites have been discussed previously. Rivers with State of Rivers reports have water quality data collected at multiple points, which is important for the land-use management study.

Riparian intervention

Catchments with significant riparian intervention history were identified as potential study catchments for both the land use/land management sub-projects and for integrated studies with Project 2, Social research. These catchments, along with water quality data availability, are listed in Table 4.

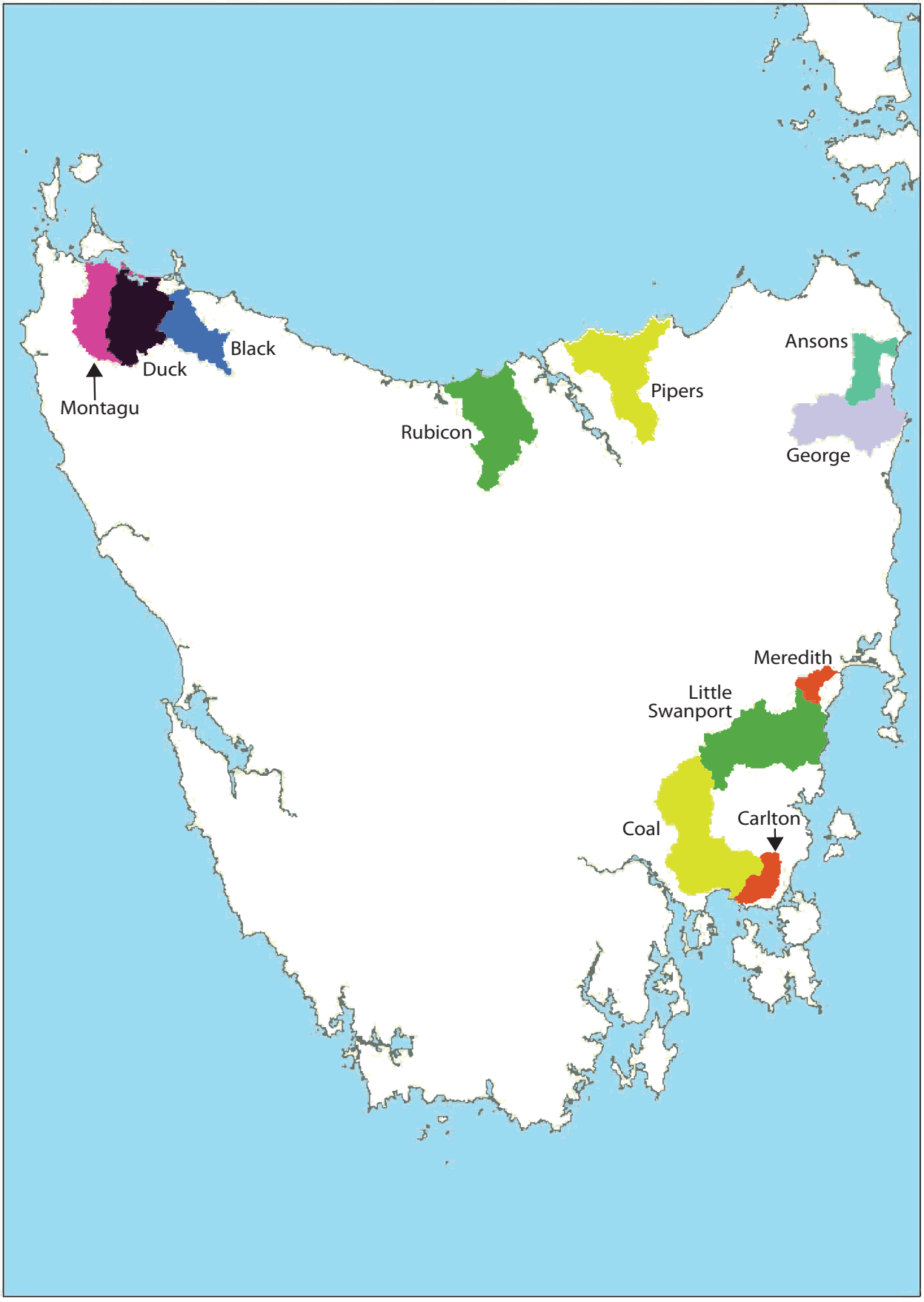
Table 3: Tasmanian catchments and sub-catchments suitable for river health studies.

Catchment	Sub-Catchments or Tributaries
Arthur	
Huon	Forsters Rivulet
Mersey	Don, Dasher and Minnow
Derwent Estuary – Bruny	Browns Rivulet
Boobyalla	Ringarooma
Cam	Pet and Guide Rivers
Forth–Wilmot	Upper Forth
Great Forester – Brid	Brid
Inglis	Flowerdale
Rubicon	Port Sorrell
Scamander–Douglas	Meredith
Lower Derwent	Styx, Tyenna and Plenty
Musselroe–Anson's	Ansons
South Esk	Upper South Esk, Break O'Day and St Paul's
Tasman	Carlton

Table 4: Potential catchments for riparian zone intervention study sites.

	State of rivers report (years)	Discrete water quality data		Continuous water-quality data
		Baseline start date	Hydrometric start date	Start date
George		8/11/2004	26/05/2004	16/09/2004
Prosser		16/10/2003	16/10/2003	8/12/2004
Coal	99/01	6/11/2003	2/07/1974	24/03/1995
		23/09/2003	25/01/1995	
Jordan	99/01	6/11/2003	2/07/1974	29/10/2004
Lake				
Macquarie		9/02/2005	11/07/1979	26/07/2004
		19/09/2003	26/07/2004	
Meander		20/10/2003	7/03/1986	23/03/1995
Quamby Brook				
Dasher (Mersey)				
Inglis	99/02			11/02/99–12/04/02
				Flowerdale 21/03/1995
Pet (Cam)				

Figure 1:
Catchments selected for integrated studies in the Tasmanian Retrospective Project.



Appendix 1:
Water quality data required by Project 4

Outputs from Land use/land management sub-project 4.1	Units	Availability	River health requirements	Estuary health requirements
Daily flows	ML/Day	All sites		Daily flows
Nitrite as N	mg/L	All sites	Nitrite as N	Nitrite as N
Nitrate as N	mg/L	All sites	Nitrate as N	Nitrate as N
Ammonia as N	mg/L	All sites		Ammonia as N
Total Nitrogen as N	mg/L	All sites	TN	TN
Phosphorus – Dissolved Reactive P	mg/L	All sites	DRP	DRP
Total Phosphorus	mg/L	All sites	TP	TP
Turbidity	NTUs	All sites	Turbidity	Turbidity
Total suspended solids	mg/L	Not at all sampling sites		TSS
Water Temperature	degC	All sites	Temp	
Field Cond @ TRef 25		All sites	Conductivity	
pH field – sensor TC		All sites	pH	alkalinity/DIC
Dissolved Oxygen		All sites	DO	
Apparent Colour	Hazen Units	Not at all sampling sites	Colour	
Suspended Solids	mg/L	Not at all sampling sites		
Calcium (Total) as Ca	mg/L	Not at all sampling sites		
Chloride as Cl	mg/L	Not at all sampling sites		
Fluoride as F	mg/L	Not at all sampling sites		
Iron (Total) as Fe	mg/L	Not at all sampling sites		
Magnesium (Total) as Mg	mg/L	Not at all sampling sites		
Manganese (Total) as Mn	mg/L	Not at all sampling sites		
Potassium (Total) as K	mg/L	Not at all sampling sites		
Silica as SiO_2	mg/L	Not at all sampling sites	Silica as SiO_2	Silica as SiO_2
Sodium (Total) as Na	mg/L	Not at all sampling sites		
Sulphate (Total) as SO_4	mg/L	Not at all sampling sites		
Alkalinity (Total)	mg/L	Not at all sampling sites		
Total Hardness ($CaCO_3$)	mg/L	Not at all sampling sites		
Total Dissolved Sol	mg/L	Not at all sampling sites		
Aluminium (Total) as Al	mg/L	Not at all sampling sites		
Arsenic as As	mg/L	Not at all sampling sites		
Cadmium (Total) as Cd	mg/L	Not at all sampling sites		
Copper (Total) as Cu	mg/L	Not at all sampling sites		
Lead (Total) as Pb	mg/L	Not at all sampling sites		
Zinc (Total) as Zn	mg/L	Not at all sampling sites		

Appendix 2: Tasmania's 48 water management catchments showing criteria for exclusion from and inclusion in Project 4 studies

Catchment	Criteria for exclusion	Criteria for inclusion
Arthur	Modified due to mining impacts Some flow regulation in the Hellyer	River health study interest in sub-catchments
Black	Observed stream nutrient concentrations too low for Project 5	Estuarine health study interest Continuous data collected by DPIW Homogeneous geology
Blythe	No estuarine data available	
Boobyalla–Tomahawk (Ringarooma)	Two major influents into the estuary Ringarooma is complicated by mining disturbance and related point source pollution Difficult to distinguish an estuary in Tomahawk Dams on the Ringarooma for irrigation schemes Mining activity (Tin) on the Ringarooma Drainage and channel alteration on the Ringarooma	Estuarine health study interest in Ringarooma River health study interest Continuous data collected by DPIW
Brumbys–Lake	Catchment doesn't have an estuary	Land-use management and river health study interest in the mid to lower sections Riparian intervention
Cam (Pet and Guide)	Difficult to distinguish an estuary and no estuary data available	Land-use management study interest in Pet sub-catchment River health study interest Riparian intervention
Clyde	Catchment doesn't have an estuary Potentially compromised by the current water management system which yields it unsuitable for a retrospective study	
Derwent Estuary–Bruny	Water quality dominated by multiple industrial point sources	Estuarine health study interest in Browns Rivulet
Duck	Significant town on shores Mining activities (dolomite) Alternation of drainage channels in lower reaches Possible groundwater concerns	Estuarine health study interest Continuous data collected by DPIW State of Rivers reports
Emu	No estuarine data Likely to be dominated by point-source pollution	
Forth–Wilmot	Modified flow regime for hydro-electric power generation	River health study interest in upper Forth
Furneaux	Islands present unsuitable topography and difficult (expensive) to access	
George	Mining activity (gold)	Estuarine health study interest Continuous data collected by DPIW Discrete water quality data Riparian intervention
Gordon–Franklin	Modified for hydro-electric power generation No land-use management history	
Great Forester–Brid	Major channel alteration in the Great Forester and Brid Rivers Small town development on Brid Possible groundwater concerns	Estuarine health study interest in Great Forester and Brid River health study interest in Brid Continuous data collected by DPIW in Brid and Great Forester
Great Lake	Is a lake rather than a catchment and estuary	
Huon (Forsters Rivulet)	Minor mining Small town development Potential major flood risk	Estuarine health study interest Continuous data collected by DPIW River health study interest in sub-catchments; Forsters Rivulet Ensis working in Forsters Rivulet

Inglis	Monitoring point does not capture characteristics of major inflow Significant town on shores	Estuarine health study interest (Flowerdale) River health study interest in tributaries Continuous data collected by DPIW State of Rivers report (99/02)
Jordon	Catchment doesn't have an estuary	River health study interest Continuous data collected by DPIW Discrete water quality data State of Rivers reports (99/01) Riparian intervention
King Island	Islands present unsuitable topography and difficult (expensive) to access	
King–Henty	Modified due to mining activity	
Leven	Very limited estuarine and other data Significant town on shores	Estuarine health study interest Continuous data collected by DPIW
Little Forester	No estuarine data	
Little Swanport	Potential access difficulties around Buckland Military area	Estuarine health study interest Continuous data collected by DPIW State of Rivers reports Homogeneous geology
Lower Derwent	Complex system with many point sources of nutrients/pollutants. Already being studied by the Derwent Estuary Program.	River health study interest in tributaries (Styx, Tyenna, Plenty)
Macquarie	Catchment doesn't have an estuary	Continuous data collected by DPIW Discrete water quality data Riparian intervention
Meander	Limited water quality data Catchment doesn't have an estuary	Quamby Brook riparian intervention Jackies Marsh and Upper Meander river health study interest Continuous data collected by DPIW Discrete water quality data
Mersey (Don)	Hydro-electric power development Only nutrient data available comes from Waterwatch; there are no water quality monitoring stations on the Mersey Flow data in the Don is modeled on the Mersey Point source pollution (pesticides) at the Old Bass Highway Karst geology in the upper Mersey Riparian intervention history unknown Mining activities (limestone) & industrial development (cement works) at Railton Significant town on shores (Devonport)	River health study interest in tributaries; Don, Dasher and Minnow Land-use management study interest in Don sub-catchment Dasher riparian intervention Continuous data collected by DPIW Some discrete water quality data
Montagu	Small irrigation scheme near headwaters Extensive drainage works Possible groundwater concerns	Estuarine health study interest Continuous data collected by DPIW State of Rivers reports
Musselroe–Ansons	Musselroe – lack of flow; lack of water quality monitoring data; potential mining influence Potential access difficulties around Anson's	Ansons – Estuarine health study interest and continuous data collected by DPIW (not EC and turbidity) Musselroe – River health study interest Homogeneous geology in Anson's
Nelson Bay	Multiple rivers Limited estuary. Difficult access in terms of distance from Hobart. No agriculture in catchment.	Estuarine health study interest (an unchanged estuary) Continuous data collected by DPIW
North Esk	Catchment not directly connected to an estuary	River health study and riparian intervention interest in sub-catchments

Ouse	Catchment doesn't have an estuary	
Pieman	Too remote	
Pipers	Limited alluvial gold mining	Estuarine health study interest Continuous data collected by DPIW (gauging stations) State of Rivers reports
Pitt Water–Coal	Minor mining around Pitt Water Small town development Dams for irrigation schemes	Estuarine health study interest Continuous data collected by DPIW Discrete water quality data State of Rivers reports (99/01) Riparian intervention (Coal)
Port Davey	Too remote	
Prosser	Dam downstream from monitoring point which will alter the quality of water reaching the estuary Small town development Potential access difficulties around Buckland Military area	Estuarine health study interest River health study interest Continuous data collected by DPIW Discrete water quality data Riparian intervention
Ringarooma	Mining sediments in river system Lack of estuarine data Wetland in lower reaches	
Rubicon (Port Sorrell)	Small town development	Estuarine health study interest at Port Sorrell Continuous data collected by DPIW
Scamander–Douglas (Meredith)	Split river structure in Scamander–Douglas Small town development on Meredith and Scamander	Estuarine health study interest in Meredith Continuous data collected by DPIW in Douglas, Scamander & Meredith Homogeneous geology
South Esk	Catchment doesn't have a distinct estuary (Tamar in a class of 1 in Edgar *et al*'s 1999classification of Tasmania's estuaries, limiting generalization,)	River health study interest in sub-catchments Land-use management study interest in Upper South Esk, Break-O-Day and St Paul's sub-catchment land use gradients
Swan–Apsley (Moulting Lagoon Apsley and Moulting Lagoon Swan)	Two major influents into the Moulting Lagoon estuaries	River health study interest in sub-catchments Moulting Lagoon (Apsley and Swan Rivers) estuarine health study interest Continuous data collected by DPIW
Tamar Estuary	Multiple catchments contribute; highly regulated	
Tasman (Carlton)		Carlton river and estuarine health study interest
Upper Derwent	Catchment doesn't have an estuary Karst geology	
Wanderer–Giblin	Too remote	
Welcome	Potential access difficulties Extensive drainage & channel works Possible ground water concerns	Estuarine health study interest River health study interest Continuous data collected by DPIW

Appendix 3: Catchment selection criteria for Project 4 research

Exclusion factors

- Industrial developments and point-source pollution, including significant towns on shores
- Hydroelectric developments
- Major dams
- Reservoirs at the top of catchments
- Significant mining, both current and historic
- Channel diversions
- Catchment needs to be hydrologically discrete
- Major land use changes not likely in the short term/documented previously.
- Catchment prone to extensive flooding
- Remote location or lack of accessibility
- Catchment does not have an estuary
- Multiple rivers entering an estuary

Inclusion factors

- Continuous data available from DPIW
- Riparian intervention or land-use history
- State of Rivers reports
- Estuarine data available
- Transferable methodology.

Appendix 4: Flow data required in Project 4

Flow regime characterisation
Mean Annual Q
Seasonal Amplitude
Seasonal period (shift)
Low flow frequency
High flow frequency
Low flow spells
High flow spells
Proportion of zero flow
Flow duration (curve comparison)
Variation Index (Monthly CVs)
Flow history
Preceding flow time series (< daily or daily at minimum) for 3 months
Flood exceedance curve (long term – preceding 20–30 years)
Flow duration curve (long term – preceding 10–20 years)

Appendix 5:
Tasmanian estuaries with research data

Estuary	Macroinvertebrates/fish	Chemistry	Other studies
	Edgar et al., 1999	Murphy et al., 2003	
Anson's Bay	Y	Y	
Black	Y	Y	Hirst et al., 2007; Crawford and White, 2006
Boobyalla	Y	Y	Ross (in progress)
Brid			
Douglas		Y	
Dover			
Duck		Y	Hirst et al., 2007
Georges	Y		Crawford and White, 2005; Crawford and Mitchell, 1999; Mount et al., 2005
Great Forester			
Huon	Y		Numerous
Inglis			Crawford and White, 2006
Leven	Y		Crawford and White, 2006
Little Swanport		Y	Crawford et al., 2005; Crawford and Mitchell, 1999; Ross (in progress)
Meredith		Y	
Mersey		Y	
Montagu			Hirst et al., 2007; Crawford and White, 2006
Moulting Lagoon	Y	Y	
Nelson Bay	Y	Y	
Pipers	Y		
Pitt Water	Y		Crawford and Mitchell, 1999
Port Sorrell	Y	Y	Crawford and White, 2006
Prosser	Y		
Scamander			
Welcome	Y		