Derwent Catchment Review

PART 1 Introduction and Background

Prepared for Derwent Catchment Review Steering Committee June, 2011

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♦♦♦ Technical Advice on Water ♦♦♦

Aquatic Science

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1 Introduction

1.1 Project Scope and Need

The Derwent Catchment Technical Review project has been initiated by organisations and agencies with a significant interest in the management of water quality and quantity in the greater Derwent catchment: NRM South, Derwent Estuary Program, Southern Water, Hydro Tasmania, DPIPWE and Derwent Catchment NRM. There have been several major reviews of water quality issues in parts of the Derwent catchment undertaken by major stakeholders (Coughanowr, 2001; Hobart Water, 2006; Hydro Tasmania, 2001; Andrew 2002) however there is an identified need to integrate this information with contemporary datasets, and to include data from the entire catchment.

This report aims to synthesise water quality and stream-flow data, and information about the greater Derwent catchment upstream of New Norfolk (Figure 1) over the past 15 or so years. The focus is on the present condition of the catchment, and resultant surface water quality in the River Derwent. Although it is acknowledged that groundwater and surface water are critically linked, the paucity of available information regarding ground water in the Derwent catchment makes detailed investigation of this resource impossible in this study.

The project involved reviewing existing water quality and stream-flow datasets, with a focus on quality, long-term ambient datasets from strategic locations within the catchment. Analysis of identified key water quality datasets was used to develop a series of conceptual models for the catchment, with the aim of identifying major stressors, data and information gaps, and requirements for additional monitoring to better assess the health of the broader catchment. Conceptual models were developed for waterways impacted by regulation (hydroelectric power generation, irrigation) and waterways with no significant modification to flow regime.

The major outcomes of the review are to provide an assessment of the adequacy of existing monitoring, to identify any emergent water quality issues within the Derwent catchment, and to provide recommendations for an integrated monitoring program that can be implemented by stakeholders.

2 Physical setting

Several comprehensive documents relating to the Derwent provide detailed descriptions of the river and its catchments (Coughanowr, 2001; Hydro Tasmania, 2001; Hobart Water 2006). More recently NRM South conducted a series of expert workshops to prepare catchment summaries for the Southern Region (NRM South, 2011 a;b;c;d). Information important to the assessment of water quality and stream flow in this report are described here, however for more detail the original reports should be consulted.

2.1 Catchment description

The greater Derwent River catchment (also referred to here as “the Derwent catchment”) covers approximately 8900 km^2 of south-eastern and central Tasmania (Figure 1), and is one of the largest river basins in the State (Hobart Water 2006). The catchment area of the freshwater portion of the Derwent is estimated to be 7400 km^2, and lies predominantly (80%) within the Central Highland Municipality, with the remainder in the Derwent Valley municipality (Andrew, 2002). The river originates within Tasmanian Wilderness World Heritage Area (Cradle Mountain-Lake St Clair National Park) at Lake St Clair, at an elevation of 735 m, and flows in a south-easterly direction through a series of dams, power stations and reservoirs until it joins the Derwent Estuary at New Norfolk 190 km downstream. A minor fraction of the Derwent catchment lies within the Walls of Jerusalem National Park.

Figure 1 Greater Derwent catchments, note the Jordan catchment is not included in this study (Base data by the LIST, © State of Tasmania).

The major tributaries, water bodies and population centres in the Derwent are shown in Figure 2. Catchments in the Derwent catchment include the Upper Derwent, the Ouse and Clyde, and the Lower Derwent (Figure 1). The Jordan catchment drains into the estuary, and is not included in this study.

The Upper Derwent catchment occupies about half of the overall catchment area, and includes the Upper Derwent, Dee, Nive and Florentine Rivers (Table 1). The catchment extends from the Walls of Jerusalem National Park in the northwest to the Meadowbank Dam and Power Station (Figure 2). Much of the upper reaches lie within the Tasmanian Wilderness World Heritage Area, with all runoff in the catchment captured by storages used for hydroelectric power.

The Lower Derwent catchment extends from Meadowbank Dam to New Norfolk, and includes the Tyenna, Styx and Plenty Rivers which originate in State Forest or National Park, draining the wetter part of the western catchment. The eastern side of the catchment is significantly drier, with only small intermittent creeks, often experiencing variable water quality. The rivers in this region are unregulated.

The Ouse catchment extends from the junction of the Ouse River with the Derwent at Lake Meadowbank to the top of the Central Plateau, above Lake Augusta. The catchment above Lake Augusta lies within the Tasmanian Wilderness World Heritage Area. The hydrology of the catchment is highly modified due to flow regulation, water diversions and abstractions. Flows in both the Ouse and the Shannon Rivers are regulated by hydroelectric power schemes, with water in the upper reaches diverted into the South Esk catchment via the Poatina power station. The Lagoon of Islands was created as an impoundment by Hydro Tasmania to provide water for riparian demand in the Shannon and lower Ouse rivers (DPIW, 2009a). Shannon Lagoon can provide water to both the Great Lake during wet periods, and be used to supply irrigation water to the Shannon and Ouse catchments during the irrigation season (Hydro, 2001).

The Clyde River catchment lies within the driest region in Tasmania, and extends from Lake Crescent to Lake Meadowbank, on the eastern side of the Derwent. The upper catchment contains two significant natural lakes, Lakes Crescent and Sorell. Water level in both lakes is regulated, and flows for irrigation and domestic town water supply are managed at the Lake Crescent outlet. Flows in the Clyde River are strongly influenced by the releases from Lakes Sorell and Crescent, particularly in summer (DPIW, 2009b). Agricultural activities and abstractions have altered the magnitude and seasonal pattern of base-flows since the mid-1800’s (Davies et al, 2005).

Sub-catchment	**Area (km^2)**	**Mean annual rainfall (mm)**
Upper Derwent	3,561	1,375
Lower Derwent	1,517	956
Ouse	1,478	922
Clyde	1,131	607
Jordan[1]	1,243	565

Table 1 Summary of catchments within the greater Derwent catchment (LIST), area and mean annual rainfall. The Jordan catchment is included in Table but excluded from this investigation (and maps) as it enters the Derwent downstream of New Norfolk.

[1] Jordan catchment is outside the project area of this study.

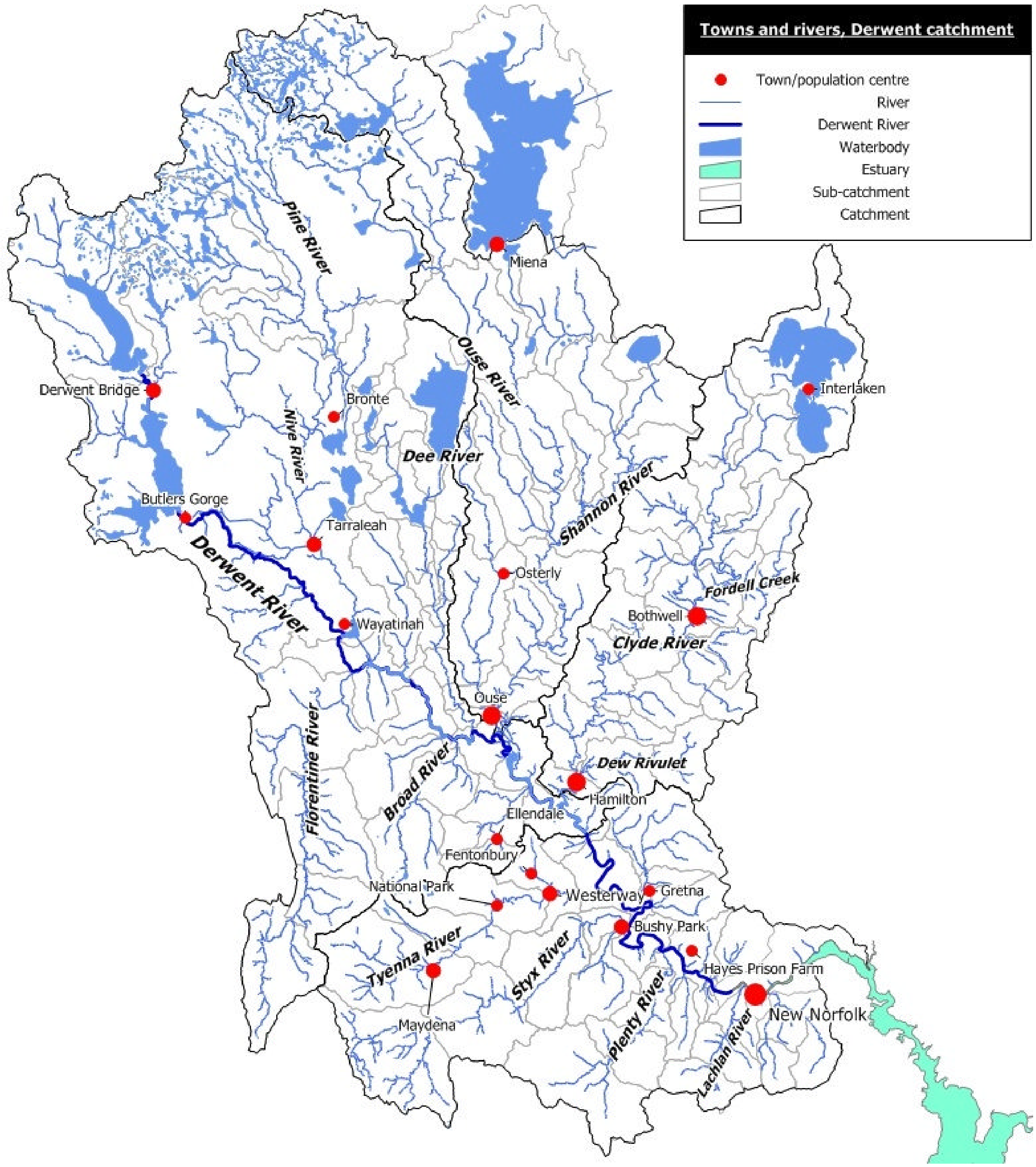


Figure 2 Map of the study areas showing major waterbodies, towns and rivers within the greater Derwent catchment. Great Lake (shown outside catchment boundary) is no longer part of Derwent catchment. Base layer by CFEV, the LIST © State of Tasmania.

2.2 Geology and Geomorphology

The geology of the Derwent catchment was broadly described by Coughanowr (2001) as post-Carboniferous sediments (e.g. Triassic sandstone and Permian mud and siltstones) intruded by Jurassic igneous dolerites and Tertiary basalts. The igneous rocky substrates are relatively resistant to erosion, while the alluvial deposits are more erosion prone. The Junee-Florentine karst is one the most important in Australia, with the limestone in this area attributed to the Gordon Group (DPIWE, 2003). The majority of the Derwent catchment is classified as Parmeener and dolerite by Seymour et al (2006,Figure 3).

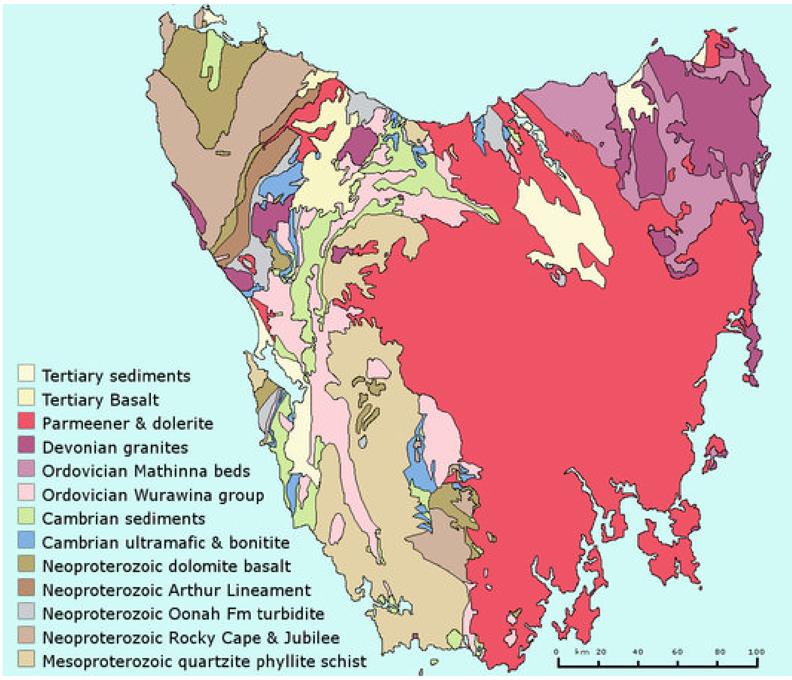


Figure 3 Broad geological features of mainland Tasmania, based on Seymour et al, 2006

Edgar et al (1999) summarized the area of major geological classes of the Derwent catchment, presented in Table 2.

Basalt (km^2)	Cambrian Ore Deposits (km^2)	Carbonaceous (km^2)	Dolerite (km^2)	Dolomite (km^2)	Lake (km^2)	Limestone (km^2)	Sediment-ary (km^2)	Total (km^2)
572	9	106	4456	24	296	142	3750	9249

Table 2 Summary of the major geological classes in the Derwent catchment (includes estuarine catchment areas) from Edgar et al (1999).

River landscapes can be described by the form and character of individual sections of river, with groupings possible based on the environmental controls of river development. CFEV (DPIW, 2008a) derived geomorphic river typologies for Tasmania based on the underlying geomorphic mosaics as described by Jerie *et al.,* 2003. The river typologies group together rivers which have similar geomorphic characteristics in a downstream direction, resulting in 44 fluvial geomorphic river types. The Derwent catchment contains a range of river types as summarized in Table 3. The headwaters of the Derwent arise on the Central Plateau, an area affected by glacial processes. The western tributaries originate on the flanks of the steep dolerite plateau, and both river types grade to lower slope rolling hills. In Tasmania, boundaries for the river types generally coincide with catchment boundaries, however in some catchments, more than one river type can occur. Examples include the Ouse catchment, which is split between east and west along the western boundary of the Shannon and Ouse River sub-catchments, and the Derwent River itself split along the main stem of the river (DPIW, 2008a ;b; Figure 4).

River type (code)	**Catchments**	**Characteristics**
Great Lake (G20)	Great Lake	
Upper Derwent (G21)	Upper Derwent River Nive Dee Western Ouse	Strongly glaciated plateau in headwater. Glacial till & outwash plains. Inland slopes in lower catchments.
Southern Midlands (G22)	Eastern Ouse (Shannon R) Clyde Jordan	Dolerite plateau in headwaters of western rivers. Predominantly dolerite, rounded interfluves & broad alluvial valleys. Dry hills increase in East. Ouse split along Shannon River catchment
Florentine (G23)	Florentine R	South east karst basin
Western Derwent (G24)	Broad Tyenna Plenty	Steep dolerite dissected escarpment & scree slopes. Broad rolling hills in lower catchment. Karst in upper Tyenna.
South east karstic (G25)	Styx	Dolerite scree slopes and high relief karst in headwaters. Dissected escarpment in lower catchment.
Derwent Main stem (G26)	Derwent River from estuary to confluence with Ouse R	Low gradient, broad valley.
South-east Derwent (G29)		High altitude dolerite in headwaters. Dissected eastern escarpment.

Table 3. Summary of river typologies in Derwent River catchment as described by CFEV (DPIW, 2008). Limited to study area.

The presence of karst around the Florentine and upper Tyenna exerts a strong influence on the geomorphology of these sub-catchments, with the karst having both low and high relief in the region (Figure 5). The remaining western tributaries are characterised by steeper terrains associated with the eastern escarpment and dolerite plateau. The headwaters of the Ouse and Clyde Rivers flow from unglaciated dolerite plateau through the rolling hills and gentle valleys of the midlands. The mainstem of the Derwent is also characterised by gently rolling hills and valleys.

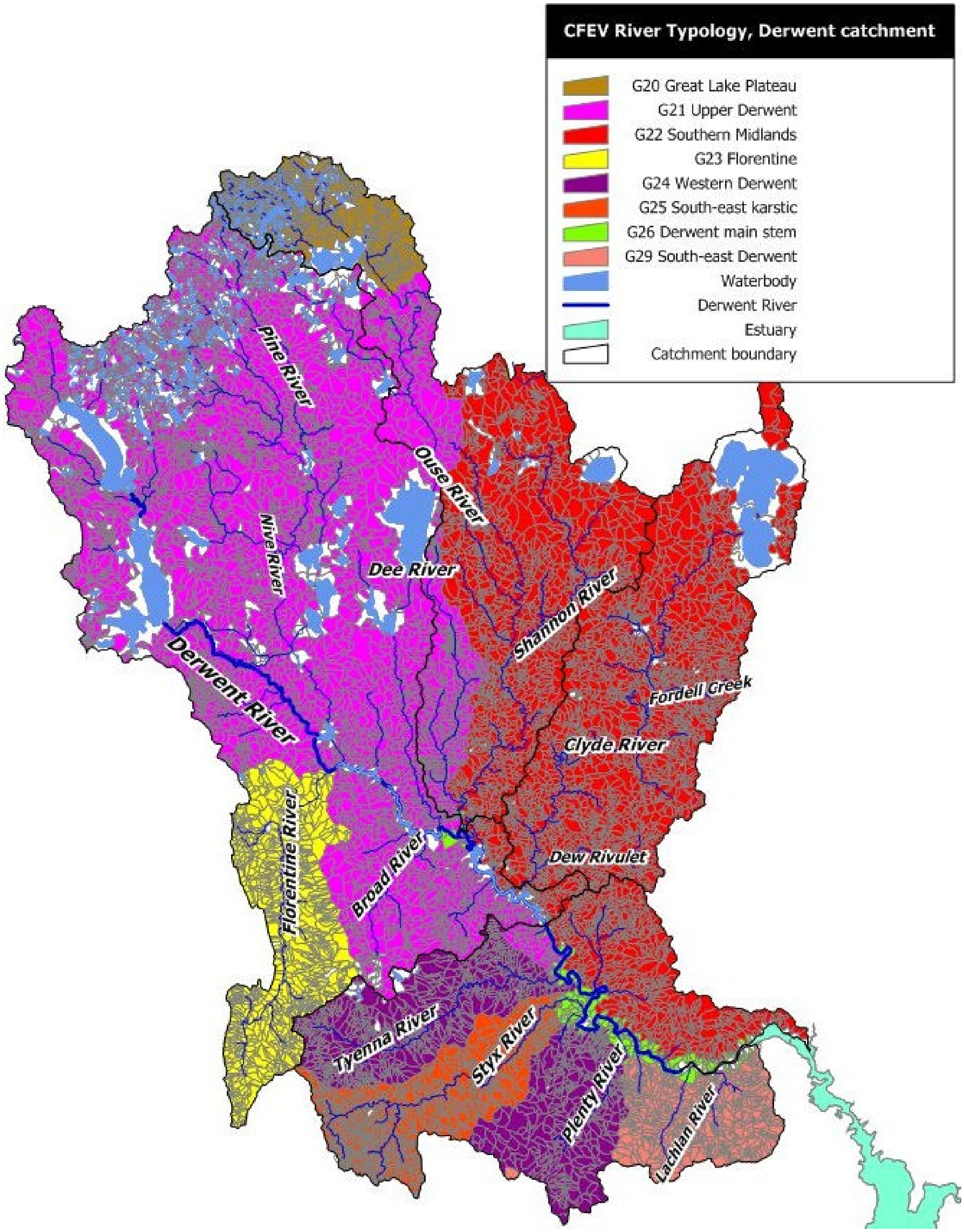


Figure 4 Geomorphic river types of the greater Derwent catchment (Base data by CFEV, WIST © State of Tasmania).

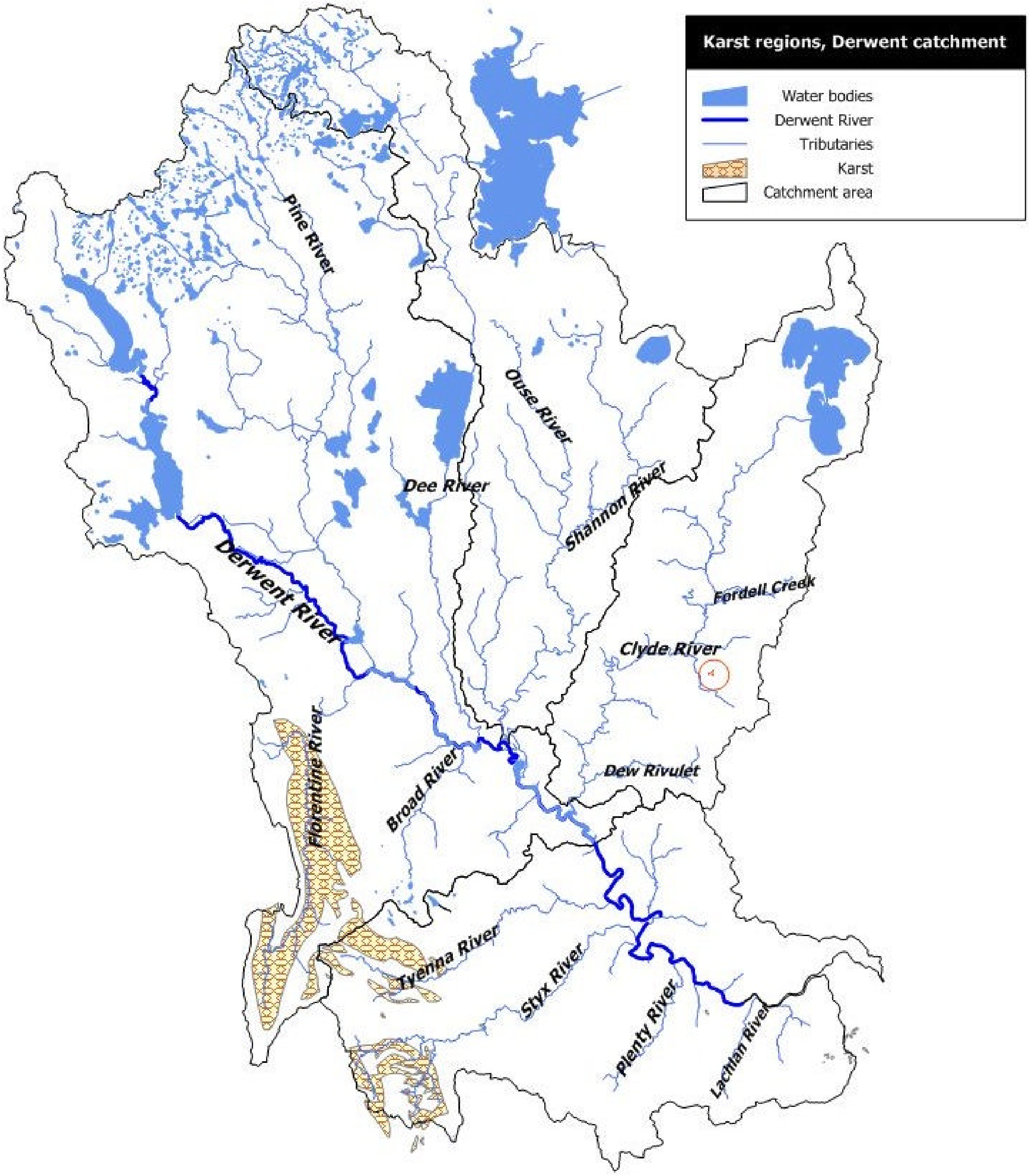


Figure 5 Location of karst systems within the greater Derwent catchment. Note Clyde region within circle (Base data by CFEV, LIST © State of Tasmania).

2.3 Rainfall and climate

2.3.1 Current climate

The average annual rainfall across the greater Derwent catchment is variable, ranging from around 1200 mm in the mountains of the upper catchment to 500mm in the east of the catchment (Australian Natural Resources Atlas; Table 1, Figure 6). The mountainous western and northern part of the catchment has high rainfall and snow in winter months (Andrew, 2002). Further south, the area is less mountainous and has significantly lower rainfall. Rainfall also decreases from west to east within the catchment (CSIRO, 2009). Highest rainfall typically occurs in winter during July and August, with January and February the driest months; however the catchment experiences less seasonality than other catchments in Tasmania (CSIRO, 2009).

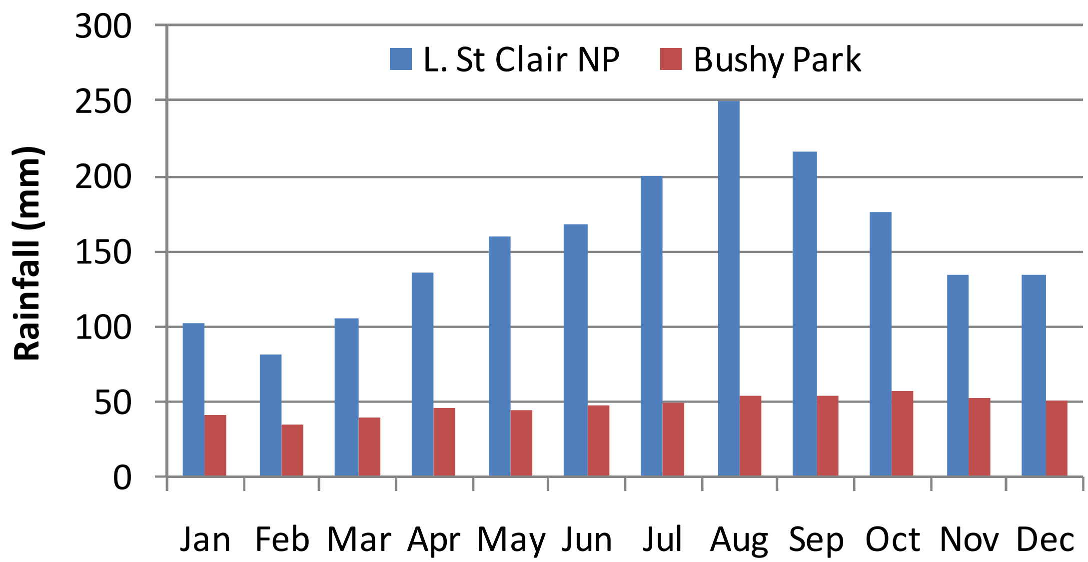


Figure 6 Rainfall at Lake St Clair National Park, and at Bushy Park showing variability within catchment. Lake St Clair based on 1989 – 2011 rainfall, Bushy Park based on 1874 – 2011 rainfall. Data from BoM.

Average rainfall and evaporation in the Derwent are compared to other major river basins in Tasmania in Figure 7. CSIRO (2009) compared recent climate patterns (1997 to 2007) in the Derwent-South East region with historical climate (1924 to 2007). In general, recent climate was found to be drier than the previous 84 years, and warmer with temperatures rising steadily by 0.1 ^{o}C per year. Rainfall and runoff have declined since the 1970's, however reductions in the Derwent-South East region were lower than for any other region in the State. The Eastern part of the region experienced the greatest change, most pronounced in autumn and linked to shifts in large-scale climate pattern such as El Nino events (Grose et al 2010).

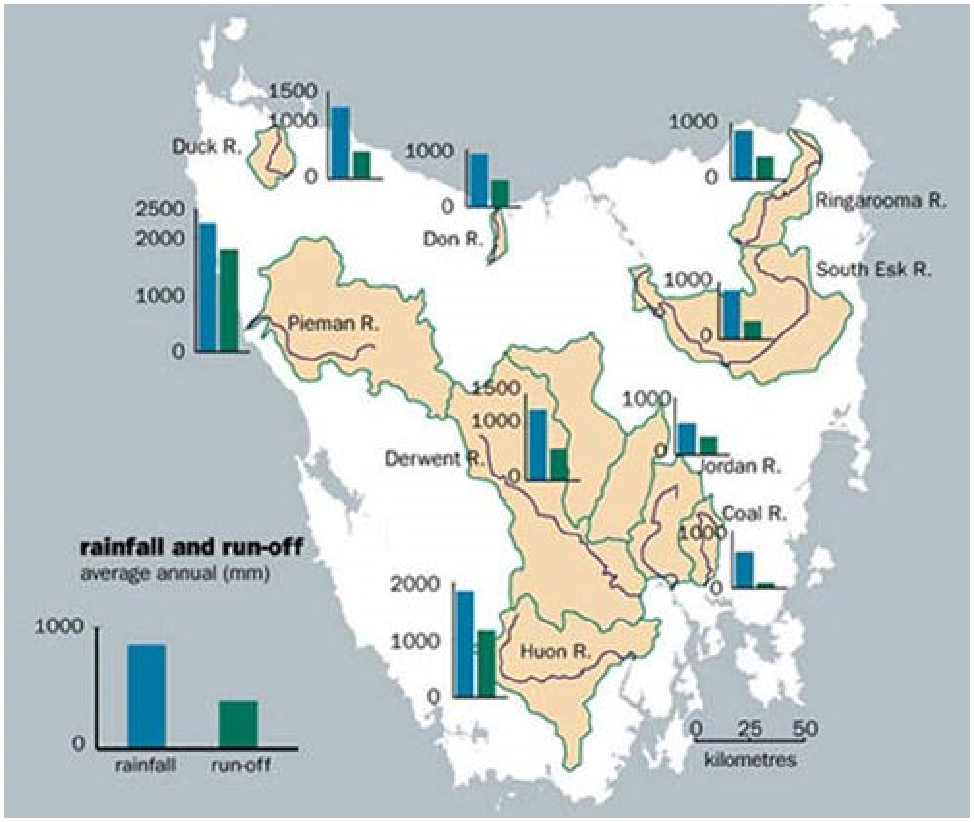


Figure 7 Average rainfall & runoff (mm) for the River Derwent, compared to major rivers in Tasmania (DPIWE).

2.3.2 Future climate

Extensive climate change modelling as part of the Climate Futures for Tasmania Project has been undertaken recently to allow a better understanding of the impacts of climate change in Tasmania, and to enable planning around expected changes in temperature, rainfall, run-off and evaporation at a catchment scale (ACE CRC, 2010). A combination of regional climate and hydrological models were used to project and analyse changes to runoff and river flow in Tasmania, with the runoff models developed by CSIRO for the Sustainable Yields project (see later). Future climate impacts predicted for Tasmania include an increase in temperature over the 21st century of between 1.6 and 2.9 ^{o}C, lower than the Australian or global average change, attributed to the capacity of the Southern Ocean to store heat.

The Climate Futures for Tasmania projections used the scenario of higher emissions and stronger climate response (scenario A2 from the Intergovernmental Panel on Climate Change) which best matches recent rates of greenhouse gas emissions (ACE CRC, 2010). Projected rainfall variation for the Derwent study area under scenario A2 is presented in Figure 8. The spatial and seasonal patterns of rainfall in Tasmania are predicted to change, with reduced rainfall over central Tasmania in all seasons, but increased rainfall over eastern coastal regions in summer and autumn (Grose et al, 2010).

Modelling predicted that resulting changes in stream flow would overall have very little impact on water allocations for extractions in most catchments, however large irrigation storages fed from runoff from the Central Highlands such as Lakes Crescent and Sorell are likely to have reduced inflows by 2100. Declines in inflows to these storages could affect the reliability of supply to water users downstream who rely on releases from these storages (ACE CRC, 2010). Run-off is likely to increase in agricultural regions of the Derwent Valley and Midlands, including the lower Clyde. Demand for irrigation water for pastures (and probably other crops) is predicted to remain unchanged on a per hectare basis.

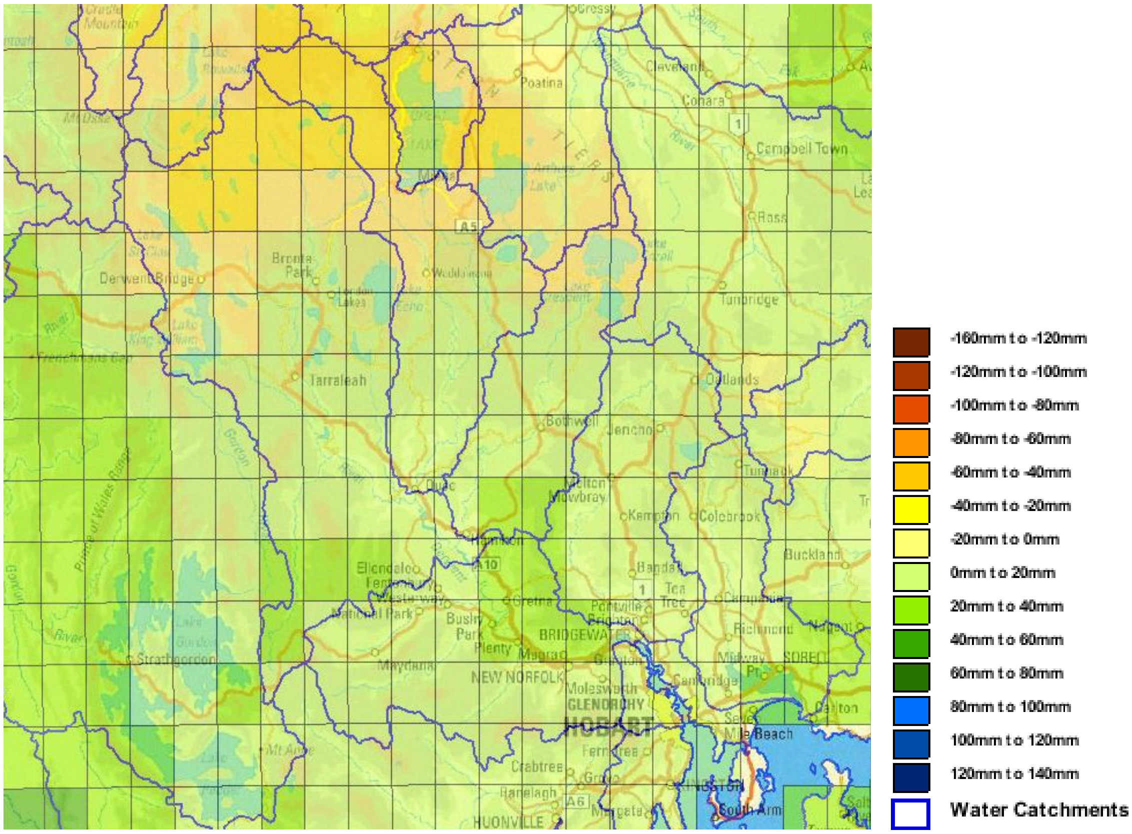


Figure 8 Projected rainfall variation for near future (2010 – 2030) under scenario A2 high emissions (Grose et al, 2010) in the study are. Image generated in the LIST, © State of Tasmania.

On a catchment scale, changes in the seasonality and intensity of rainfall are expected to have a greater impact on water quality than climate-change induced increases in temperature rise or evaporation, due to the strong linkage between nutrient transport and river flow. On a local scale, temperature rise and increased evaporation may result in increased stress to aquatic fauna, and/or shifts in community composition in the longer term.

Future climate and future development in the Derwent- South East region were also modelled as part of an assessment of sustainable yields[2] for surface and groundwater systems in Tasmania (CSIRO, 2009). The basin scale assessment of the anticipated effects of climate change, catchment development and surface and groundwater extractions was primarily designed to assess water availability and the use of water resources. Future climate scenarios included three estimates of temperature change representing a wet extreme, median and dry extreme future climate (relative to

[2] Maximum volume of water that can be made available after taking into account estimates of in-stream environmental water requirements. Not necessarily divertible yield that can be used due to physical inability to take the water.

historical climate) to develop a spectrum of possible 2030 climates. Table 4 summarises the modelled change in rainfall, runoff and water quantity for each scenario (extracted and non-extracted) for the *entire* South-East region, which includes the Derwent catchment.

Under future development scenarios, changes in land use such as increased area under forest plantation lead to a small decrease in run-off, less than 1% in the Derwent-South East region (CSIRO, 2009). The reduction in runoff is predicted to have virtually no impact on inflows to rivers. Using the long-term historical climate patterns (1924 to 2007) current levels of catchment development are predicted to impact less than 1% of the sub catchments of the South-East region. Using only recent climate (1997-2007), CSIRO found approximately 20% of the sub-catchments in the South-East region are potentially impacted by changes in flow regime due to recent climate. Future changes in development of the groundwater resource in the region were not modelled.

Future climate scenario ~ 2030	% change in rainfall	% change in runoff	% change in volume of non-extracted water (GL)	% change in volume of extracted water (GL)	Change in volume of water released for hydro (GL)
Wet extreme	+3	+5	+3 (280)	+0.5 (1)	42
Median	-1	-3	-3 (252)	<1 (1)	23
Dry extreme	-6	-8	-8 (682)	-1 (3)	63

Table 4 Summary of predicted changes in rainfall, surface runoff and volume of extracted and non-extracted water, and water released for hydro power generation under future 2030 climate scenarios, Note data is for the whole Derwent-South East region (CSIRO, 2009).

2.4 Vegetation patterns

Vegetation within the Derwent catchment reflects the rainfall distribution and underlying geology and geomorphology, with the wetter western area dominated by wet eucalypt forest and rainforest. The northern catchment (Central Plateau) is characterised by alpine heathland and wet forest on the southern slopes, while further south, where there is considerably less rainfall, remnant native grasslands and open grassy woodlands occur with most of the area now devoid of trees (Andrew, 2002). Most of the land within 5 km of the western side of the Derwent Riverhas been cleared for agriculture (Andrew, 2002). Additional information about land use is discussed in later sections.

2.5 River hydrology

2.5.1 Overview

The major tributaries and lakes of the Derwent River between Lake St Clair and New Norfolk are shown in Figure 2. The Derwent has a mean annual flow of approximately 90 cumecs (at Meadowbank, 1985-2011 data), but the hydrology is highly complex due to alterations of flows through the development of hydroelectric power schemes and irrigation schemes within the sub-catchments (Davies, 2001; Hobart Water 2006). River alterations associated with power developments commenced in 1916 with the damming of Great Lake, and continued until 1968 with the construction of the Repulse Dam and the formation of Lake Repulse. A brief summary of flow alterations associated with the hydroelectric and irrigation schemes is presented here. For more detailed information, Hydro Tasmania (2001) should be consulted.

Figure 9 and Figure 10 show schematics of the hydro-electric schemes developed in the Derwent. The high rainfall headwaters of the Derwent, Nive, Dee and Ouse Rivers have been modified through damming and flow diversions, creating a number of water storages. These headwater storages feed the Echo and Butlers Gorge Power Stations in the upper reaches of the catchment, before being harnessed by the Tarraleah and Tungatinah power stations. The outflow from these two power stations is augmented by the remaining flow of the Nive River to feed the Lower Derwent Power scheme which consists of a series of six storages and power stations (Liapootah to Meadowbank). Lake Meadowbank, the most downstream storage and power station, is located 46 km upstream of New Norfolk.

A summary of the storages and power stations associated with the hydroelectric schemes is presented in Table 5 and Table 6, respectively. The main storages in the headwaters, Lake King William and Lake Echo are managed on time-frames of months to years to ensure stability of energy supply within the overall Hydro-electric system. Generally, once water is released from these storages the system is operated as a 'run-of-river' scheme, with water flowing through the downstream power stations and lakes without being stored for long-periods in any intermediate storage. Collectively, these power stations represented about 24% of Tasmania's total installed hydro generating capacity in 2006 (ABS, 2008).

Power scheme	Storage (River)	Reservoir volume ($x\ 10^6\ m^3$)
Upper Derwent	Lake St Clair (Derwent)	2000
	Lake King William (Derwent, Navarre)	540
	Tarraleah No 2 Pond	0.9
Nive-Dee	Pine Tier Lagoon (Nive, Pine)	7.4
	Laughing Jack Lagoon	25
	Bronte Lagoon	19
	Little Pine Lagoon (Nive)	2.9
	Lake Echo (Dee)	725
	Dee Lagoon (Dee)	40
	Bradys Lake (Nive)	46
	Lake Binney (Nive)	26
	Tungatinah Lagoon	5
Lower Derwent	Lake Liapootah (Nive)	1.9
	Wayatinah Lagoon (Derwent)	8.9
	Lake Catagunya (Derwent)	26.0
	Lake Repulse (Derwent)	15.9
	Cluny Lagoon (Derwent)	4.9
Ouse-Shannon	Shannon Lagoon	1.7
	Penstock Lagoon[3]	-
	Lagoon of Islands	37.5

Table 5 Storages within the Derwent catchment, and reservoir volume (Hydro Tasmania, 2001).

Hydro-electric development has also resulted in the diversion of flows into and out of the Derwent catchment. The headwaters of the Ouse River are diverted into Great Lake via Liawenee canal. This is a major inflow to the Great Lake, with the water exiting the Derwent catchment via the Poatina

[3] Operated in conjunction with IFS as recreational trout fishery.

Power Station into the South Esk River catchment. Flows diverted into the Derwent catchment include water from the upper Franklin catchment, via diversion of three headwater streams (Rufus Creek via the Rufus Canal, Beehive Creek via the Beehive Canal, and Burns Creek). In the past, Hydro also diverted water from part of the Lake River catchment into the Lagoon of Islands (Ouse River catchment) to provide irrigation flows for downstream users in the Shannon River.

Figure 9 Schematic representation of power developments in the Derwent Catchment (Hydro Tasmania, 2001).

The low rainfall in the Clyde River sub-catchment lead to the creation of Lakes Sorell and Crescent in the 1800s. The lakes are managed with the aim of providing irrigation and town water supply through the dry months of the year.

The only unregulated major tributaries in the Derwent catchment occur on the western side of the Derwent catchment, with the Florentine and Broad Rivers in the upper catchment, and the Tyenna, Styx and Plenty in the lower catchment. Compared to the overall catchment, the combined catchment area of the unregulated rivers is relatively small compared to the regulated rivers. Smaller tributaries and creeks, not included in Table 7, include Black Bobs Rivulet (75 km^2), Repulse River (90 km ^{2}), Jones River (75 km^2), and the Lachlan River (98 km^2). The combined area of these and other smaller watercourses contributes less than 5% of the total catchment.

Power scheme	Power station (River)	Diversions from[4]	Catchment area km^2 (dams, diversions)[5]	Generating Capacity (MW)
Upper Derwent	Butlers Gorge (Derwent)	Upper Franklin	582 (9)	12.7
	Tarraleah (Derwent)	Franklin, Wentworth	582 (118)	93.6
Nive -Dee	Lake Echo (Dee)	Little Pine, Ouse	139 (530)	33.5
	Tungatinah (Nive)	Ouse, Clarence, Dee	50 (1350)	130.5
Lower Derwent	Liapootah (Nive)	Ouse, Dee	1449 (363)	87.3
	Wayatinah (Derwent)	Ouse, Dee	2390 (363)	45.9
	Catagunya (Derwent)	Ouse, Dee	2993 (363)	50
	Repulse (Derwent)	Dee, Ouse	3106 (363)	29.1
	Cluny (Derwent)	Ouse, Dee	3251 (363)	18.6
	Meadowbank (Derwent)	Great Lake	6545 (628)	41.8

Table 6 Power stations in the Derwent catchment (Hydro Tasmania, 2001).

Tributary	Flow regime	Catchment area km^2	Average flows	Comments
Nive	Modified	1277	4.6[5]	Receives flows from adjacent catchments, 3 power stations along river course. Joins Derwent at Wayatinah Lagoon.
Ouse	Modified	1735	3.8[6]	Largest sub-catchment, irrigation scheme, contributes to hydroelectric storages
Dee	Modified	355		Enters Derwent below Cluny Dam, flows diverted to Nive system via Dee tunnel.
Clyde	Modified	1109	0.8[6]	Contributes to hydroelectric storages, irrigation scheme
Florentine	Natural	436	10.5[6]	Contributes 10% of Derwent mean flow, meets Derwent at Lake Catagunya
Broad	Natural	140	4.2[7]	Contribute to hydroelectric storages (Cluny), originates in Mt Field National Park
Tyenna	Natural	284	6[7]	Joins Derwent above Glenora
Styx	Natural	347	8[6]	Joins Derwent below Glenora
Plenty	Natural	204	2.1[7]	Last significant tributary prior to Bryn Estyn intake, joins Derwent at Plenty

Table 7 Major tributaries of the Derwent River, catchment area and average flows (Andrew, 2002).

[4] Taken from Edgar et al (1999)

[5] 2005 data from Water Resources department, HEC cited in Hobart Water 2006.

[6] Source Coughanowr (2001).

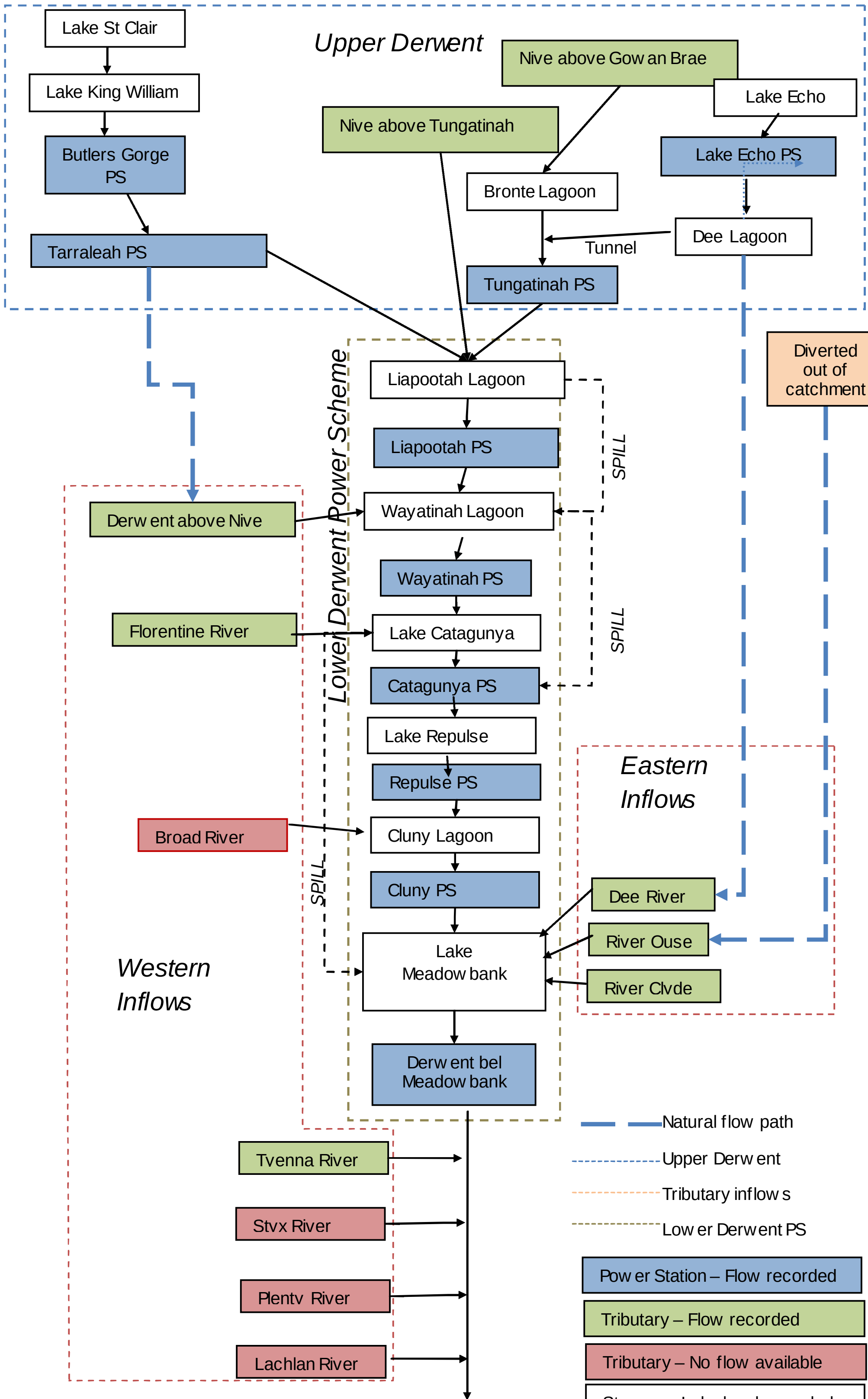


Figure 10 Schematic of Derwent catchment showing main flow paths and water storages in Hydro system. Colours indicate availability of flow records.

2.5.2 Long-term flow patterns in the Derwent

Annual flow patterns in the Derwent are highly modified due to the extensive regulation of the tributaries and main stem Derwent River. Figure 11 shows monthly flow variability for many sites (see Figure 10), in the catchment based on average daily flows. The period of record used varied somewhat due to varying lengths of available flow records. The 'box' in each plot encompasses the 25th to 75th percentile flow range for the month, whilst the 'whiskers' show minimum and maximum values. The line within the box indicates the median flow value for the period.

The box and whisker plots are arranged such that the unregulated tributaries and unregulated spills from lakes are shaded green and are on the left side, with the regulated flows and power stations shaded blue and on the right side of the graphic. It is evident from the graphs that the unregulated inflows and power station spills have much higher flow variability as compared to the power stations, with the inflows showing a strong seasonal pattern of higher winter flows.

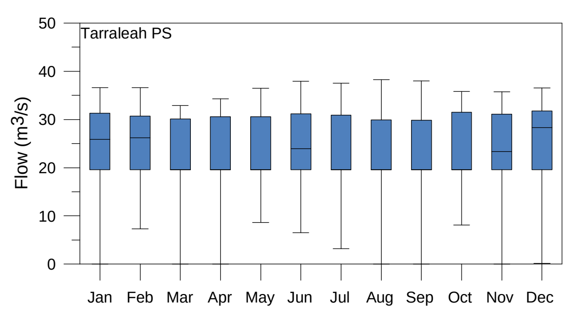
Flows through the Tarraleah Power station (A), sourced from Lake King William, are fairly uniform through the year. In the western head waters, unregulated flow from the Nive River at Gowan Brae (B) combined with the discharge from the Echo Lake and Power Station via Dee Lagoon (C) and outflow from Bronte Lagoon (no graph presented) feed the Tungatinah Power Station (D). The higher winter inflows from unregulated the Nive River (B) are reflected in the increased flow-through at Tungatinah (D), accompanied by a reduction in flows derived from Dee Lagoon (C).

The outflow from Tarraleah (A) and Tungatinah (D) is combined and augmented by additional inflows from the Nive River above the Derwent (E), and is directed to the Liapootah Power Station (F), the first station in the Lower Derwent scheme. At this point in the system, mean flows range from about 50 cumecs in summer to about 70 cumecs in winter. From Liapootah, water flows through the series of Lower Derwent Power Stations (Wayatinah (I), Catagunya (L), Repulse, Cluny, and Meadowbank (P)), being augmented with inflows from the unregulated tributaries on the west, and the regulated tributaries from the east.

Figure 11. Monthly flow analysis for select waterways in the Derwent catchment based on average daily flow data. Graphs presented in roughly geographic order down the catchment, with inflows and unregulated rivers on the left side and Hydro power stations and regulated flows on right. Period of record indicated under each graph, data courtesy Hydro Tasmania and DPIPWE.

Tributaries / PS Spills

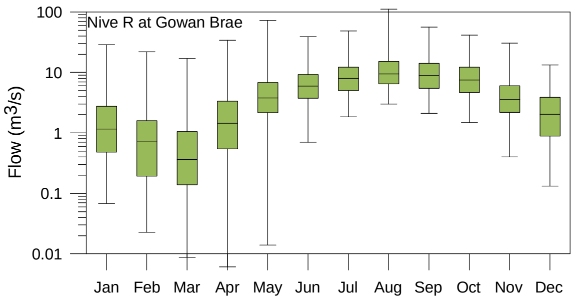
Power Stations/Regulated flows



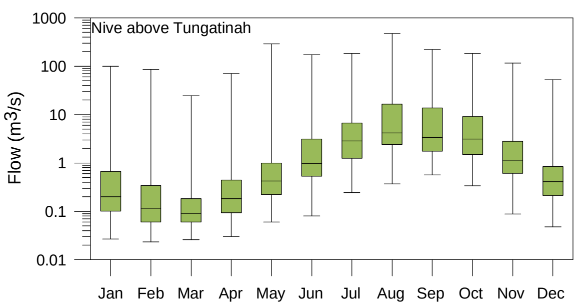
A. Tarraleah Power Station 6/1996-12/2010

Figure 11 cont.

Tributaries / PS Spills

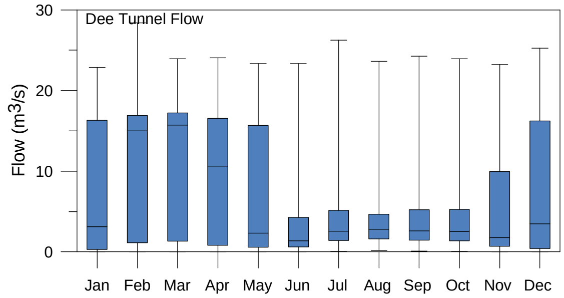


B. Nive at Gowan Brae 1/1985 – 12/2010 (note log scale)

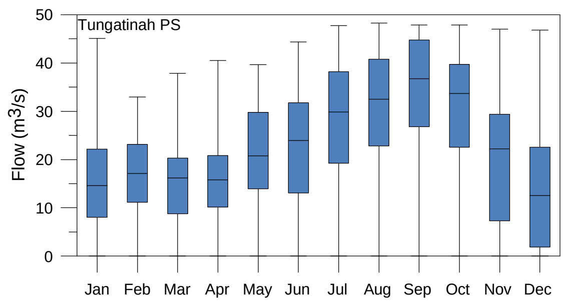


E. Nive above Tungatinah 1/1985-12/2010 (note log scale)

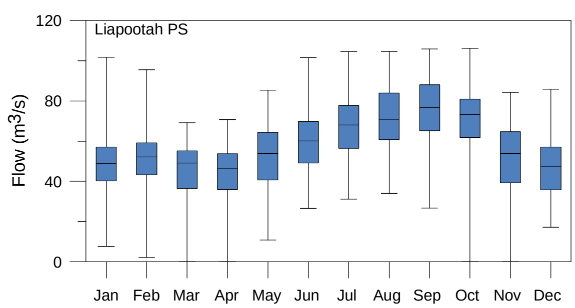
Power Stations/Regulated flows



C. Dee Tunnel Flow 1985 - 2010



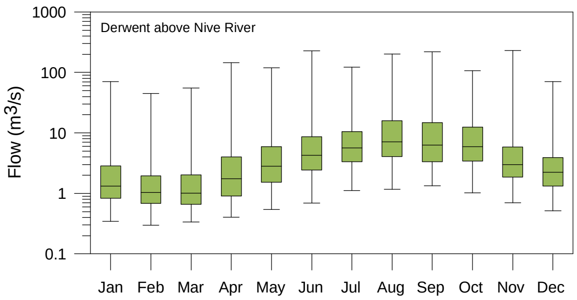
D. Tungatinah Power Station 1/1985-12/2010



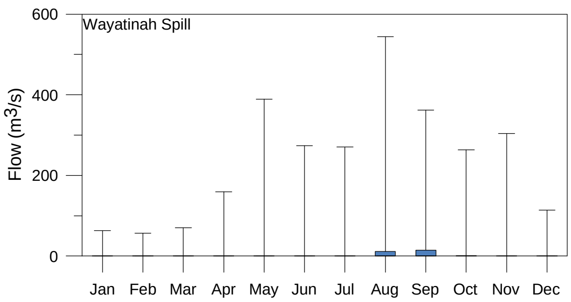
F. Liapootah PS 1/1997 – 12/2010

Figure 11 Cont.

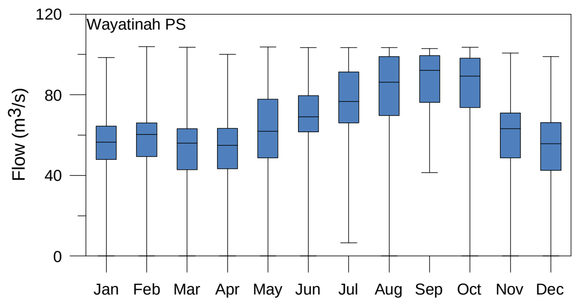
Tributaries / PS Spills **Power Stations/Regulated flows**



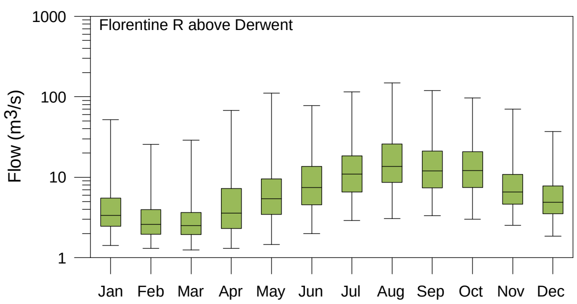
G. Derwent above Nive River 1/1985-12/2010 (note log scale)



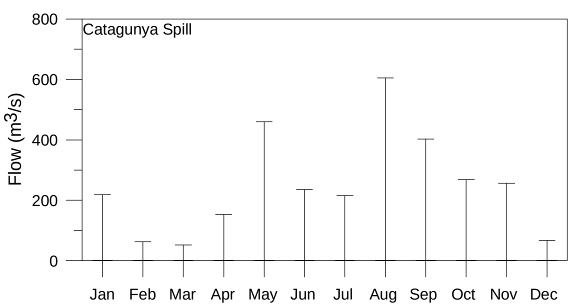
H. Wayatinah Spill 1/1990 – 12/12010



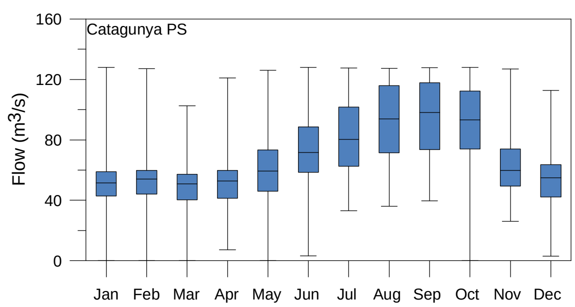
I. Wayatinah 1/1996-12/2010



J. Florentine R above Derwent 1/1985 – 12/2010 (note log scale)



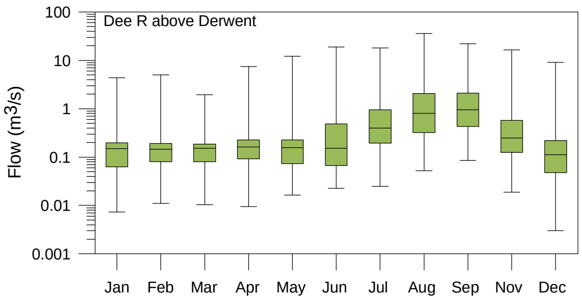
K. Catagunya Spill 1/1985 12/2010



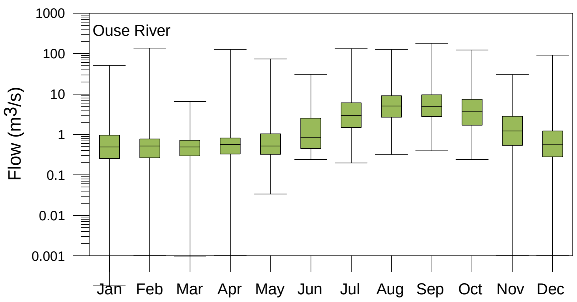
L. Catagunya PS 6/1996 12/2010

Figure 11 cont.

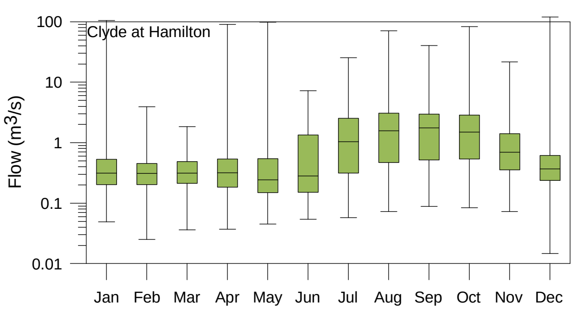
Tributaries / PS Spills **Power Stations/Regulated flows**



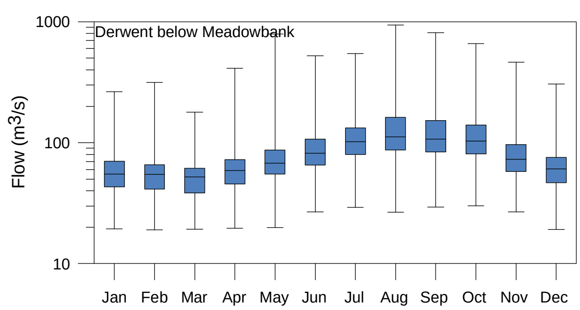
M. Dee River above Derwent 3/1994-12/2010 (note log scale)



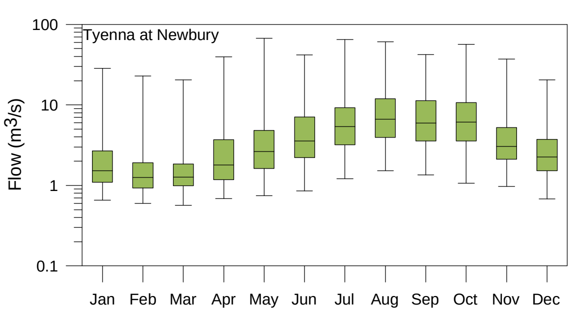
N. Ouse River above #B Weir 1/1985 – 12/10 (note log scale)



O. Clyde River at Hamilton 1/1985 – 2/2006 (note log scale)



P. Derwent below Meadowbank 1/1985-12/2010



Q. Tyenna at Newbury 1/85 – 12/10

Inflows from all sources to the lower Derwent can be estimated by comparing median flows at the Liapootah Power Station at the top of the scheme and at the Derwent below Lake Meadowbank site (Figure 12). Inflows from the lower catchment are low during the summer months, with flow very similar between the two sites. During the winter, however, flow downstream of Meadowbank is considerably higher as compared to Liapootah, reflecting tributary inflows of up to 40 cumecs. The comparison also shows that the upper Derwent power schemes, which feed Liapootah, are managed to provide a relatively constant flow year round, with summer and winter median flows varying by only 30 cumecs.

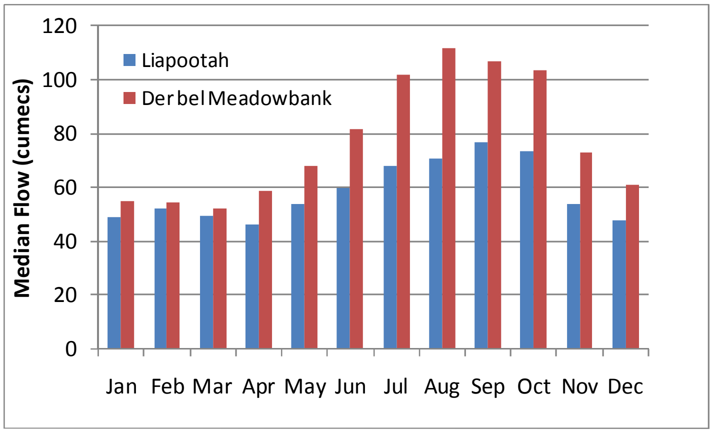


Figure 12 Comparison of median flows at Liapootah power station and at the Derwent below Meadowbank monitoring site.

2.5.3 Diversions out of the Derwent

The major water diversion out of the Derwent is associated with the channeling of the upper Ouse River into the Great Lake catchment via the Liawenee canal. This flow constitutes the major inflow into Great Lake, which feeds the Poatina Power Scheme. Because of the large storage volume of Great Lake, and inter-annual changes in lake level, the discharge from Poatina does not directly reflect inflows from the Ouse River on a daily or even seasonal basis, however, the long-term discharge from Poatina can be used as an indication of the volume of water diverted out of the Ouse catchment over the long-term. Because a small volume of water, up to 4 cumecs, also enters the Great Lake from the Lake River catchment via the Tods Corner Pumps, discharge from Poatina needs to be 'corrected' by this volume to estimate diversions out of the Ouse.

As shown in Figure 13, median discharge from Poatina ranges from about 35 cumecs in the summer months to <10 cumecs in the winter months. The station has a maximum discharge of about 50 cumecs throughout the year. This is in contrast to the power stations in the Derwent, which have higher discharges in the winter, as it is a run-of river system. The inflow from Tods Corner is a consistent 4 cumecs during the wet winter months, but alternates during the remainder of the year between 0 and 4 cumecs (i.e. on or off).

Based on the flow results, the annual median diversion of water out of the Derwent catchment is about 15 cumecs, which represents about a 10% reduction in flows for the river on an annual basis.

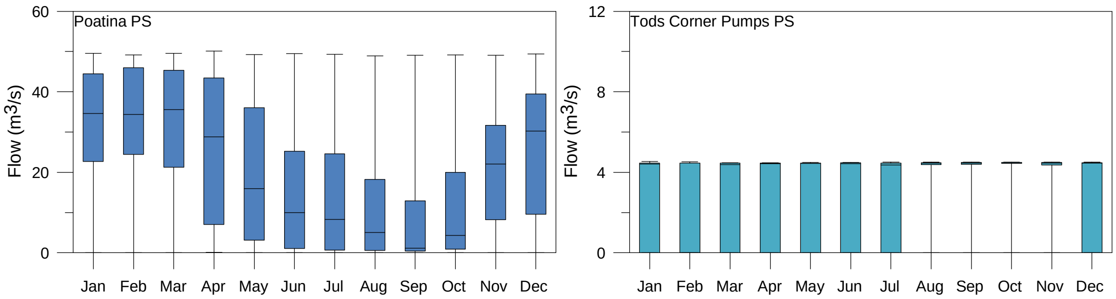


Figure 13 (left) Box and whisker plot of average daily discharge from the Poatina Power station (1997-2010) reflecting diversion of the upper Ouse River out of the Derwent catchment. Right: Box and whisker plot of average daily discharge from Tods Corner Pumps into Great Lake (1996 - 2010). Minimum, maximum, 25th, 50th and 75th percentile plotted.

2.5.4 Short-term flow variability in the Derwent

Daily (and hourly) flow within the Derwent is highly variable, and differs between regulated and unregulated tributaries. Unregulated rivers (Figure 14) are characterized by short-duration high flow events superimposed on seasonal flow patterns. Summer base-flow in these river is typically <5 cumecs, with winter high flow events of 10 to 100 cumecs. The similarity in flow patterns of these rivers reflects the similar weather patterns affecting the catchments, as these are all in the headwaters or western Derwent.

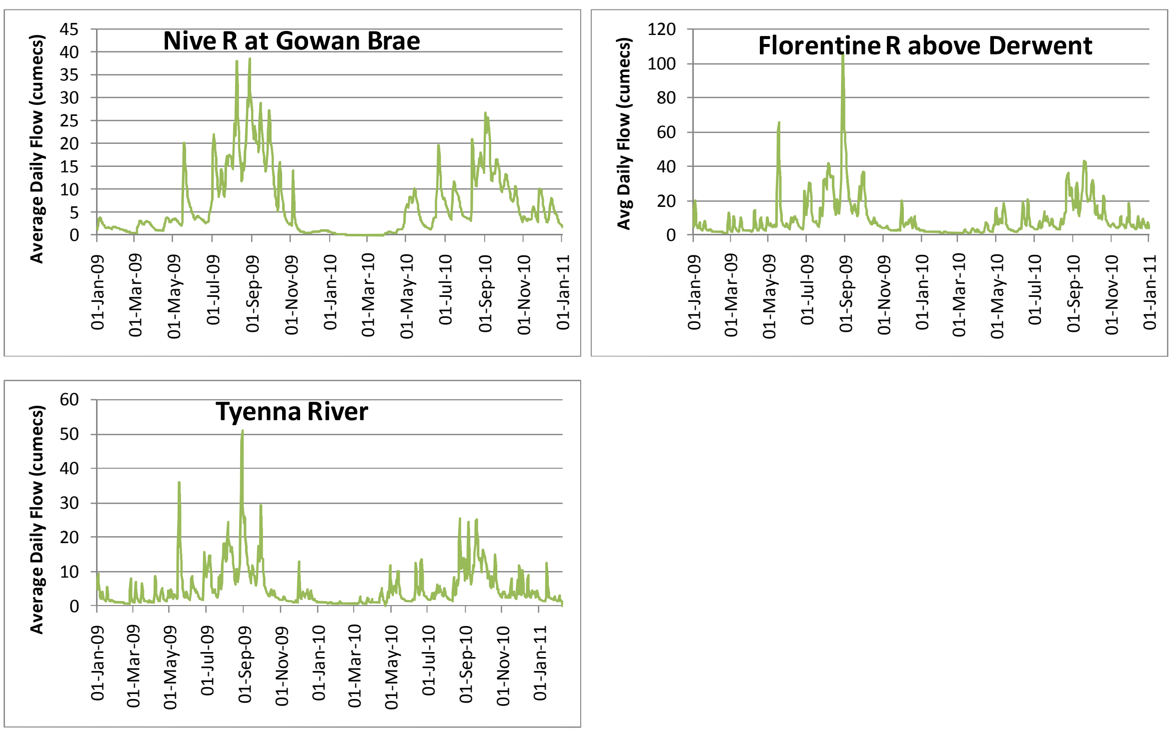


Figure 14 Average daily flow for unregulated rivers in Derwent catchment for 2009 - 2010. Data from Hydro Tasmania and DPIWE (WIST).

Examples of rivers regulated for power generation (Figure 15) show very different characteristics. Waterways which are controlled by power station discharges (Nive at Tungatinah, or Derwent at Wayatinah), show a high degree of flow variability associated with the on / off operation of the station. Maximum flows are limited by the maximum discharge capacity of the power station, leading to prolonged periods of maximum power station discharge. Summer 'base flows' are higher than in unregulated rivers, reflecting the use of the station during the summer months.

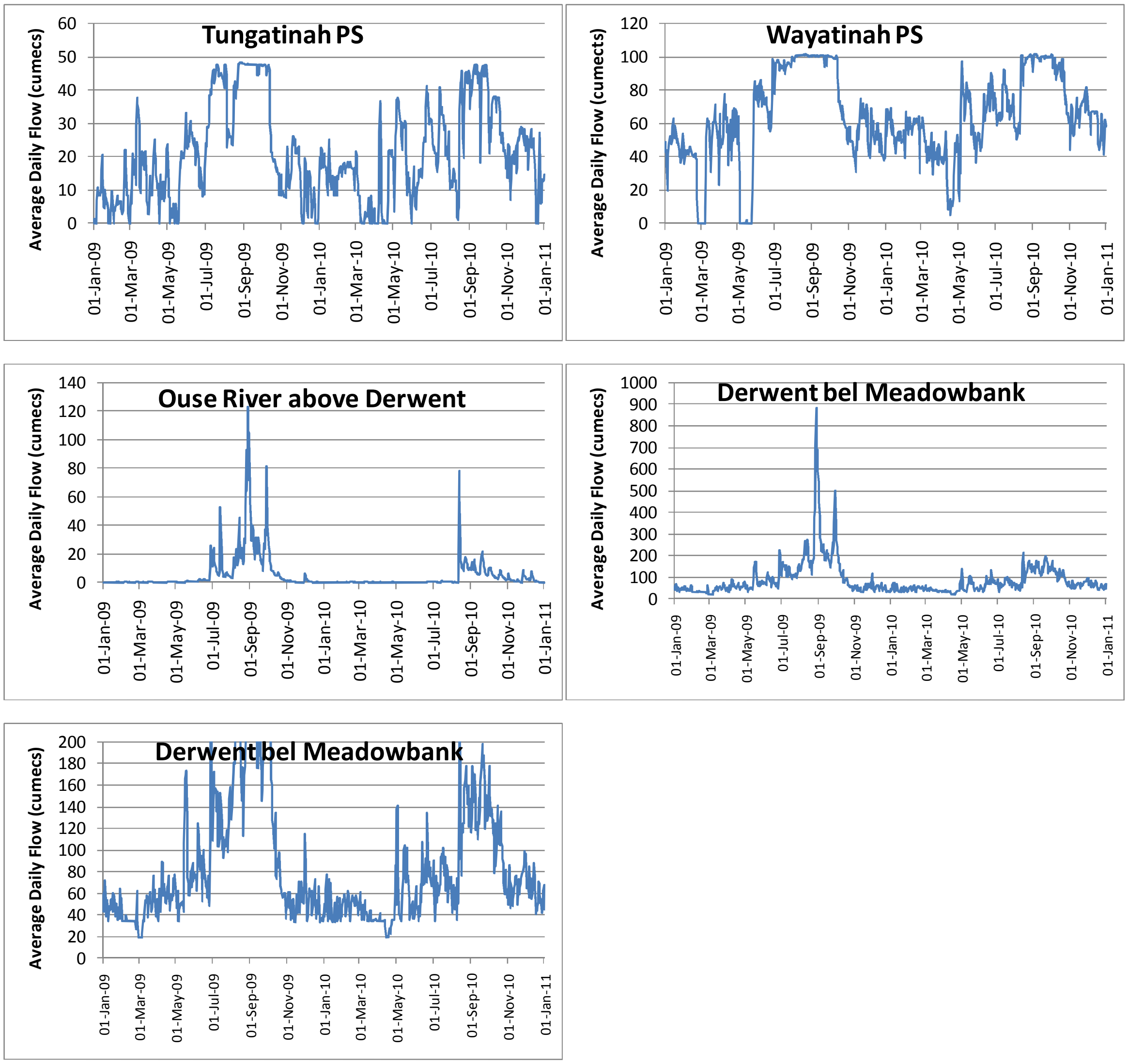


Figure 15 Examples of average daily flows for waterways regulated for hydro power.

The Ouse River, in which the headwaters have been diverted out of the catchment and into the Great Lake, shows virtually no flow except for high winter flow events. This reflects the episodic nature of rainfall in the catchment as well as the headwater diversions.

The Derwent below Meadowbank site (shown at two scales) reflects the combined flow characteristics of the catchment. Power station controlled flows of up to about 80 cumecs constitute the base flow year round, with winter high flow events superimposed. The inter-annual variability of the system is shown by a large flood event in 2009 with flows of almost 900 cumecs in the river compared to maximum winter flows in 2010 of about 200 cumecs.

Regulation for irrigation in the Clyde catchment (Figure 16) leads to different flow characteristics in the upper Clyde catchment. The discharge from Lake Crescent is minimised during the winter months, and increased over the summer period for downstream irrigation and town water supply needs. This leads to a flow regime which is a reverse of the natural regime. Note that the long-term flow results for the Clyde below Hamilton (Figure 11, O) shows very low summer flows, with higher winter flow events. This shows that pick-up in the catchment downstream of Lake Crescent accounts for the winter flow in the river (Figures 17-19).

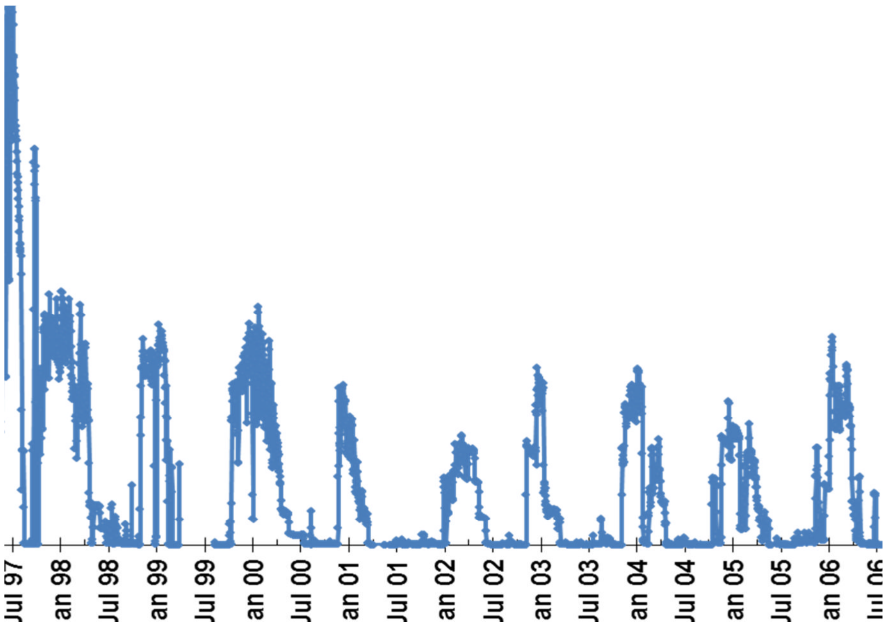


Figure 16 Average daily flows for the Clyde River downstream of Lake Crescent, regulated for irrigation (note box and whisker plots in Figure 10 are for Clyde River at Hamilton located just upstream of Lake Meadowbank). (Data from DPIPWE, via WIST).

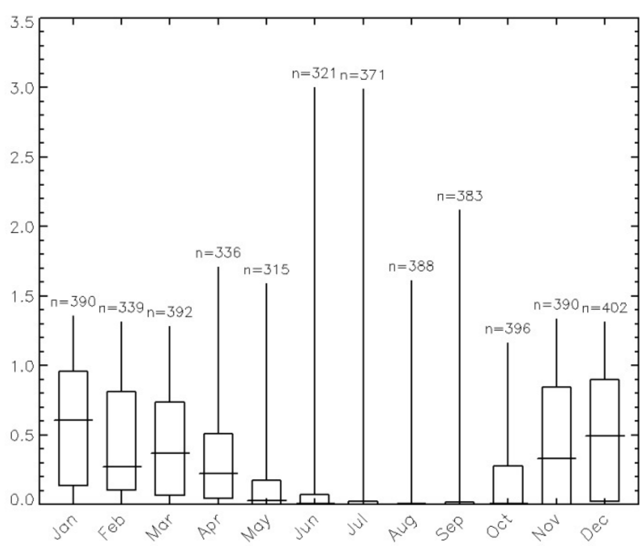


Figure 17 Average daily flow (cumecs) for the Clyde d/s of Lake Crescent,1997-2009. (Data from DPIPWE via WIST).

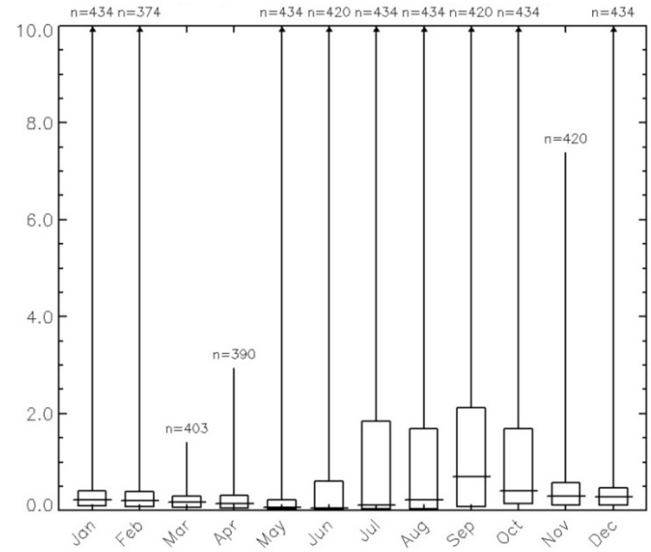


Figure 18 Average daily flow (cumecs) for the Clyde River at Bothwell, 1997-2009. (Data from DPIPWE via WIST).

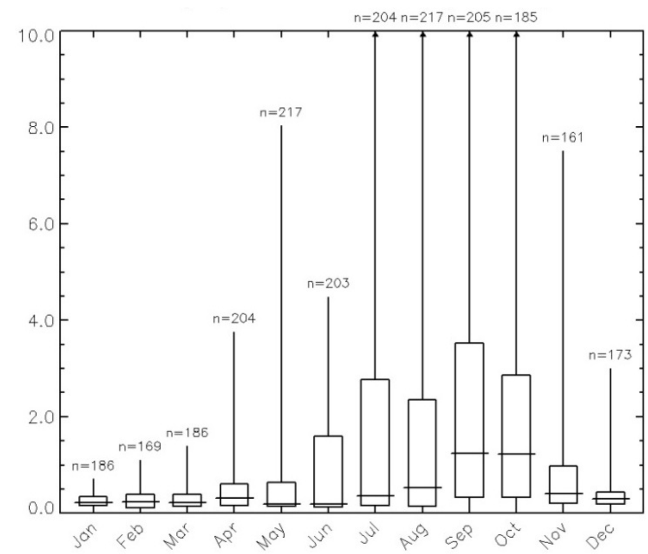


Figure 19 Average daily flow (cumecs) for the Clyde River at Hamilton, 1997-2006. (Data from DPIPWE via WIST).

Clyde River downstream of Lake Crescent

Clyde River at Bothwell weir

3 Water allocations and use

3.1 Water usage

Water usage within the catchment is primarily surface water, with groundwater extractions from the Derwent catchment being minor compared to surface water extractions (CSIRO, 2009). Use of surface water resources is mainly for town water supply, stock and domestic supply, irrigation, fish farms and power generation. A system for the licensing of groundwater use is being developed by DPIPWE and will be implemented progressively across the State in high priority areas and situations, through the appointment of Groundwater Areas (DPIPWE, 2011). Groundwater usage is currently not licensed within the Derwent Catchment.

Water used for town water, stock and domestic and fish farm operations mainly rely on taking water from permanent stream flows, where irrigation and power generation usage is broken up into river run and/or dam storage. Extractions (or abstractions) from natural waterways for the purposes of irrigation, hydro-electric power, aquaculture, town or industrial water supply may result in altered flow volumes and patterns, or seasonality as evident in the Clyde catchment, discussed in the previous section.

3.2 Water licenses, allocations and surety levels

Information shown in the tables and figures below has been assembled from the DPIPWE WIST database. *Data within these table and figures excludes duplicated, expired and cancelled allocations, and may differ from the DPIW 2008 Waterways Reports (DPIW 2009 a;b;c;d).* Licenses are not required for storages less than one ML, and are therefore not included in the summary tables.

Water allocations (direct takes and dams) for major uses in the greater Derwent catchment are shown in Table 8, and Figure 20. Water allocations define how much water can be taken from a stream, and conditions such as over what period water may be extracted. Water licenses and allocation details for each major catchment are described in more detail below.

Purpose	Number of Allocations	Annual Amount (ML)	Daily Rate (ML/day)	Allocation conditional?
Aquaculture	11	152,675	698.8	No, year round
Irrigation	294	119,381	682.2	Yes, defined take period
Town Water	8	81,905	331.7	No, year round
Commercial	11	41,551	762.6	No, year round
Stock & Domestic	49	254	0.06	No, year round
Recreation	2	33	-	No, year round
Aesthetic	1	5	-	No, year round
TOTAL	**376**	**395,805**	**2,475**	

Table 8 Summary of water allocations (excluding Hydro) in the greater Derwent catchment, by category and number of allocations. Data summarized from WIST Water Entitlements database. Aquaculture considered non-abstractive take.

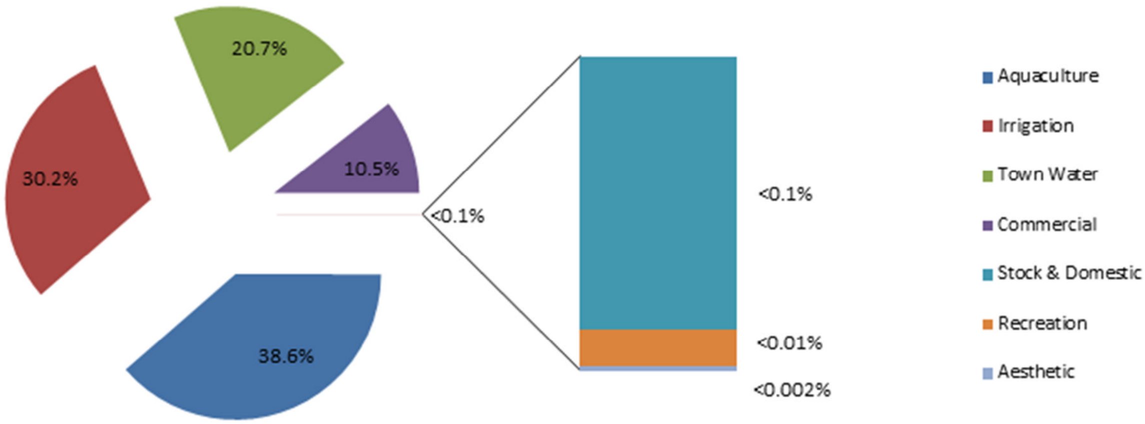


Figure 20 Summary of allocations by major use (excluding Hydro) as percentage of total allocations for whole catchment.

Surety levels (DPIPWE, 2011) indicate the surety with which a water allocation can be expected to be available for take, with Surety 1 the highest security of water supply. Where water restrictions are imposed, conditions generally restrict water allocations at a lower level of surety before restricting the water take at higher surety. There are presently around 375 water allocations within the catchment ranging from Surety 1 (town water, stock and domestic) to Surety 8 (flood harvesting). A general description of the hierarchy of water allocation surety levels is shown in Table 9.

Surety Level	Description
Surety 1 Water *expected to be available at greater than 95% reliability*	i. Rights for the taking of water for domestic purposes, consumption by livestock or firefighting under Part 5 of the WMA "Rights in Respect of Water" (i.e. no licence required); ii. Rights of councils to take water for town water supplies (allocation at this surety level is two thirds of their actual daily usage in the five years prior to 2000 multiplied by 1.05 with the remaining one third allocated as surety 5).
Surety 2 Water	Water provision to supply the needs of ecosystems dependent on water resource.
Surety 3 Water	Rights of licensees granted a licence by way of replacement of "old" prescriptive rights granted under previous Acts. Under Clause 10 of Schedule 4 of the WMA, these licences are issued for a period of not less than 99 years. The taking of water is generally for commercial purposes.
Surety 4 Water	Rights of special licensees such as Hydro Tasmania. Special licences are granted to a body corporate for the generation of electricity, or for purposes reasonably incidental to that purpose, or for a specified purpose on application in writing to an Advisory Committee, if application consistent with objectives of the WMA.
Surety 5 Water *expected to be available at ~80% reliability 8 yrs in 10*	Rights issued for the taking of water otherwise than for the purposes described above under Surety 1–4. This includes rights issued for the taking of water under Part 6 of the WMA "Licensing and Allocation of Water" for direct extraction, and for winter storage in dams, for use for irrigation or other commercial purposes.
Surety 6 Water *water allocations available at less than ~80% reliability*	Rights at this surety level issued for the taking of water under Part 6 of the WMA "Licensing and Allocation of Water" for direct extraction for use for irrigation and other commercial purposes and for winter storage in dams.
Surety 7 & 8 Water	Water allocations available with a lower level of reliability than a Surety 6 allocation. These allocations include water provided under catchment or site specific limitations and conditions, such as water taken in flood peaks in Hydro Water Districts to fill dam storages.

Table 9 The hierarchy of Surety levels from highest to lowest (table sourced from DPIPWE web site, 2011).

3.3 Water allocation by region

3.3.1 Lower Derwent River and Tributaries

For the purposes of this section of the report, the Lower Derwent catchment includes the main Derwent River and tributaries, between Meadowbank Dam and New Norfolk.

Net flows past Southern Water's offtake at Bryn Estyn are the result of discharge from Meadowbank Dam, tributary inflows including the Styx-Tyenna-Plenty catchments, less any diversions and off-takes (DPIWE, Feb 2004) from the rivers. Direct extraction of water from the Lower Derwent catchment during the summer months is now fully subscribed. Additional water may still be allocated from the main river and its tributaries during the winter months. Winter allocations form the basis of the proposed South-East irrigation scheme which is being developed by the TIDB (see Section 3.5 for further discussions).

Given the interest in increasing extractions of water for town water supplies and irrigation, DPIWE commissioned a study of the environmental water requirements for the Derwent River, as part of a Water Development Plan. The work was undertaken by specialist consultant Dr Peter Davies and the CSIRO, and completed in February 2002. The report recommended that no further water extractions during summer should be allowed from the river, as the river was nearing its sustainable yield. As a result, DPIWE placed a moratorium on further summer allocations of water until further information could be obtained (DPIWE, 2004). Allocations and environmental requirements were reviewed by DPIWE in 2004, as a result of public debate about water availability from the Derwent, the Governments interest in fostering increased irrigation development under the State of Growth initiative, and new methodology for determining environmental water provisions. The review indicated that additional water allocations of up to 175 ML/day of reliable water could be granted from the Derwent River for summer extraction without impinging on environmental water requirements, or on the risk of intrusion of the salt wedge past the Lawitta rapids (downstream of the Bryn Estyn offtake) as long as the allocations were granted with specific conditions (DPIWE, 2004). DPIWE proposed that in light of the above, the moratorium that had been in place on the granting of new summer water allocations from the Derwent River be conditionally lifted.

It was also decided that further water allocations could only be granted if Hobart Water (now Southern Water) and Norske Skog were satisfied that the increased extraction would not result in significant upstream movement of the salt wedge. Expert opinion on this issue had been canvassed with general agreement that the risk of such movement was low. However, there were no quantitative data on which to base such risk assessment, therefore the proposal to grant new allocations included the establishment of a new water monitoring station below the rapids. Monitoring (EC and level) at this site not only allows the collection of data on the position of the salt wedge, but also provides a trigger for restricting the taking of water should the salt level increase significantly at any time.

To ensure that the water was put to good use and to deal with inter-sectoral competition for the water, each applicant for "additional" water was required to provide a report indicating how they intended to meet objective 6(1)(a) of the *Water Management Act 1999*, "to promote sustainable use and facilitate economic development of water resources". This ensured that any allocations supported economic growth, or actual town water supply needs. The report detailed the applicant's proposed use of the water and, where water was to be used to support new development, indicated milestones against which the proposed development could be monitored (e.g. the hectares planted with new cherry trees, purchase of new irrigation infrastructure, new town water connections). Allocations were granted on the condition that milestones listed in the report were met. Discussions between Hydro Tasmania, Hobart Water, the Tasmanian Conservation Trust, irrigators and the author of the initial report focused on analysis of the environmental flows report and new information, and it was agreed that extra water could be conditionally allocated to each new use. Interest in the extra water allocations was high and by 2006, all of the extra 100ML/day water had been allocated. A moratorium is now back in place on further summer allocations for the Lower Derwent River and tributaries.

Water allocations in the Plenty, Styx and Tyenna catchments were generally issued in the early to mid-1900's for the irrigation of hops. Many on these rights were issued as "Prescriptive Rights" and have now been converted to Surety 3 licences (see Table 9). There are also two large aquaculture farms in the Tyenna catchment, and the Inland Fisheries "Salmon Ponds" in the Plenty Catchment. These aquaculture farms use large quantities of water, however the water is returned to the river downstream of operations, and the allocations are classed as being non abstractive.

Purpose	Number of Allocations	Annual Amount (ML)	Daily Rate (ML/day)	Allocation conditional?
Aquaculture	5	94,999	540	No, year round
Irrigation	105	74,591	512	Yes, defined take period
Town Water	5	44,895	230	No, year round
Commercial	4	27,130	80.365	No, year round
Stock & Domestic	9	8	0.0395	No, year round
TOTAL	**128**	**241,623**	**1,363**	

Table 10 Summary of water allocations in the Lower Derwent catchment, by category and number of licences. Data summarized from WIST Water Entitlements database. Aquaculture classed as non-abstractive use, not all licenses active.

Tyenna River below Newbury Rd

Plenty River

There are presently around 130 current direct take allocations in the Lower Derwent Catchment ranging from 1 ML to 31,500 ML per annum with daily allocations ranging from 0.0005 ML/day to 207.12 ML/day and Surety levels ranging from 1 to 6. There are 63 licensed existing dams in the catchment and another 20 proposed, with capacities ranging from less than 1 ML up to 400 ML. Within the Lower Derwent catchment direct take allocation amounts for each major use are shown in Table 10 and Figure 21. The location of direct take allocations is shown in Figure 22 and the locations of licensed dams in Figure 23. Existence of a license indicates an allocation has been made, but does not give information on whether the water is actively being used.

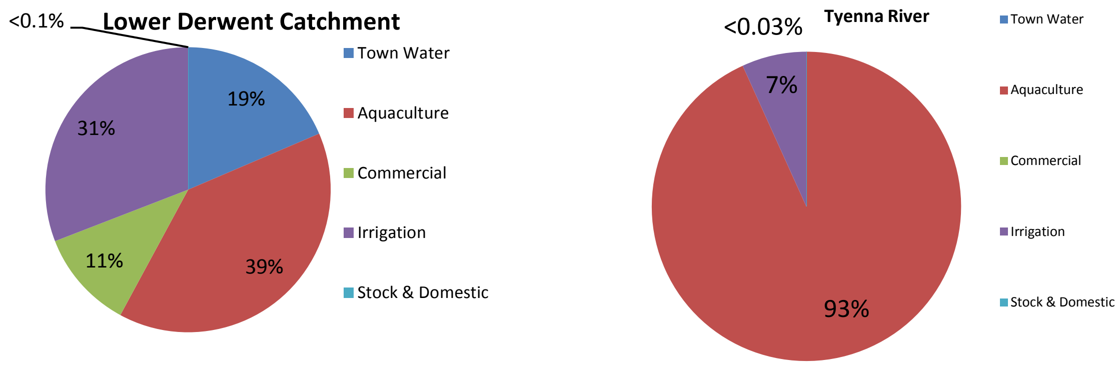


Figure 21 Summary of water allocation amounts by major use as a percentage of total allocations, for Lower Derwent and Tyenna Rivers. Data summarized from the WIST Water Entitlements database.

Water Use Restrictions

Water restriction triggers for irrigation have been developed for parts of the Lower Derwent River catchment, as given in Table 11 below. Compliance is monitored by Regional Water Management Officers and rangers.

Location	ML/day	%	Restriction
Sorell Ck upstream of Lyell Hwy	0.43	100	Ban on direct takes
Lachlan River at Lyell Hwy	0.86	100	Ban on direct takes
Plenty River at Glenora	1.7	100	Ban on direct takes
Tyenna River at Newbury	4.3	100	Ban on direct takes

Table 11 Water restriction triggers for the lower Derwent (DPIW, 2009d).

Styx River at Glenora

Lachlan River

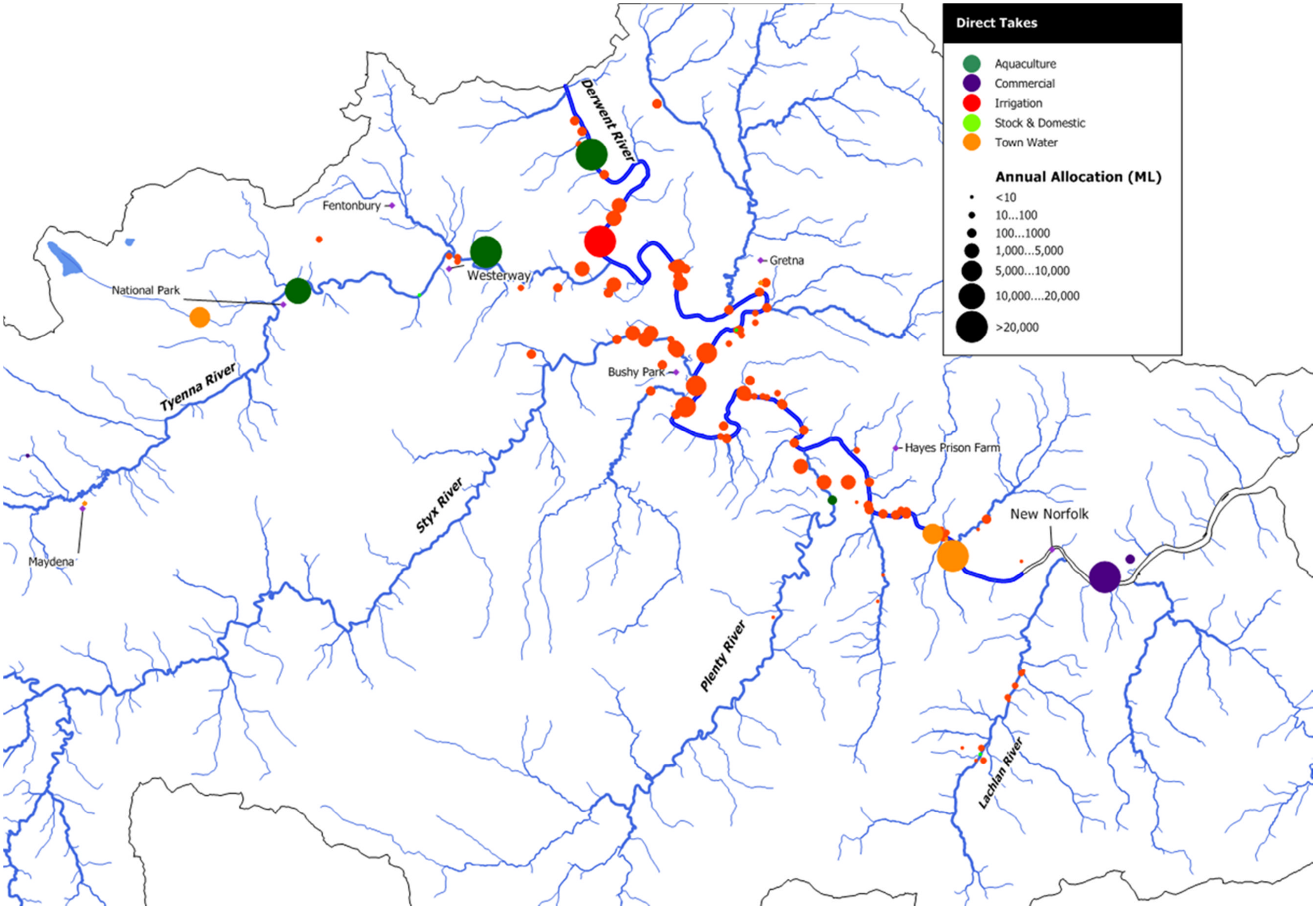


Figure 22 **Licensed direct takes in the Lower Derwent Catchment (Data extracted from WIST Dams database, base layer by CFEV, the LIST © State of Tasmania.**

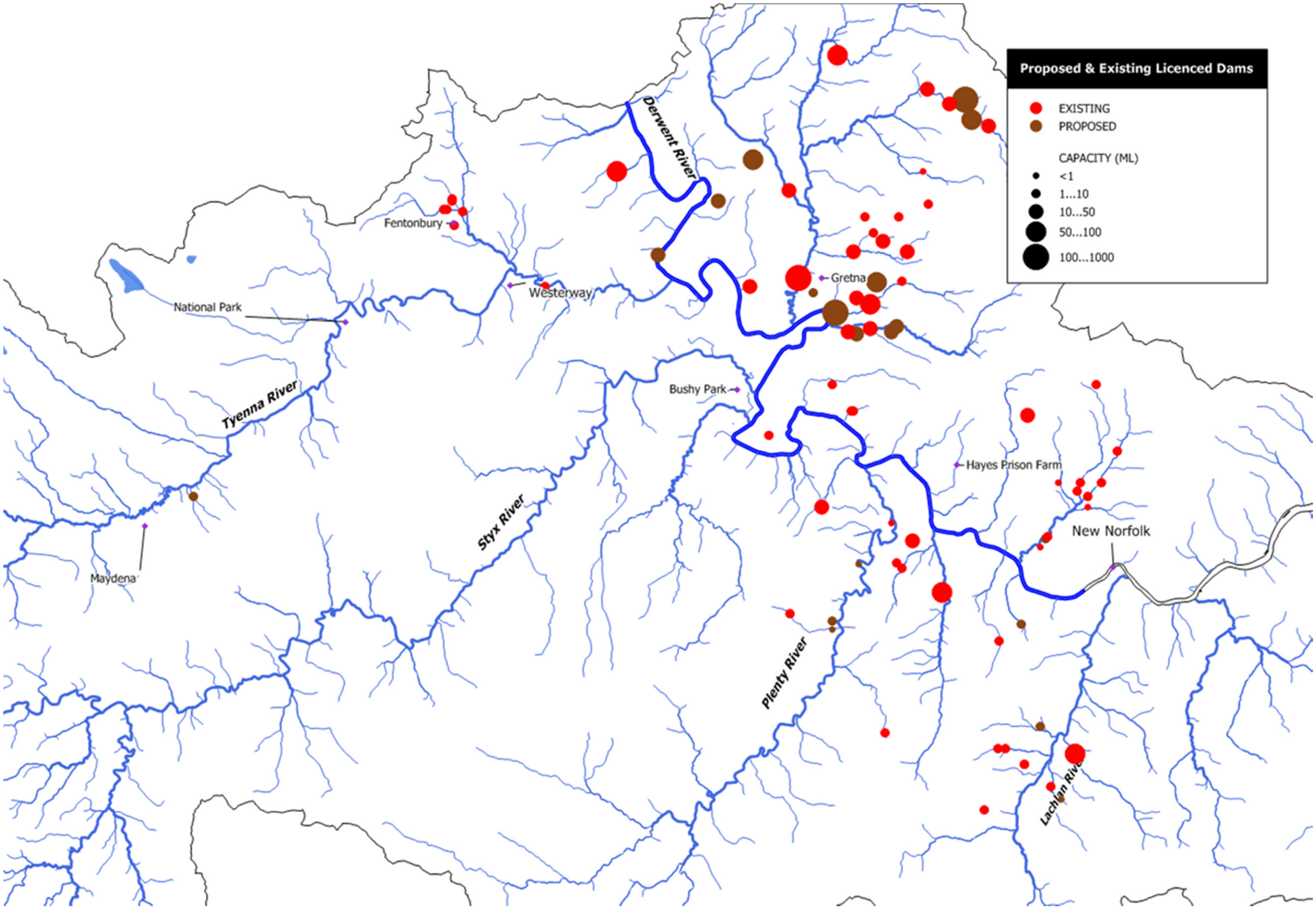


Figure 23 Licensed Dams in the Lower Derwent Catchment (Data extracted from WIST Dams database, base layer by CFEV, the LIST © State of Tasmania.

3.3.2 Upper Derwent River and Tributaries (Above Meadowbank Dam)

For the purposes of this section of the report, the Upper Derwent catchment includes the main Derwent River and tributaries (excluding the Clyde and Ouse Rivers), upstream of the Meadowbank Dam wall.

The entire Derwent River catchment above Meadowbank Dam Wall (including the Ouse and Clyde Catchments) forms part of the Derwent River Basin Hydro-Electric District, and the water resources within the catchment are in effect fully allocated, as Hydro Tasmania holds a Licence under Division 6 of Part 6 of the *Water Management Act 1999*, conferring on it the right to all the water resources of the catchment. While this right is conferred, allocations are also held by other licensees, which were either issued at the commencement of the Act, or replace existing rights or have been issued by means of a transfer from Hydro Tasmania. Therefore any proposed new direct take allocations or storage allocations will typically require a water allocation via transfer from Hydro Tasmania.

Purpose	Number of Allocations	Annual Amount (ML)	Daily Rate (ML/day)	Allocation conditional?
Aesthetic	1	13	-	No, year round
Aquaculture	6	57,970	158	No, year round
Irrigation	53	9,889	93	Yes, defined take period
Fire Fighting	1	3	-	No, year round
Town Water	2	31	-	No, year round
Mining	1	100	-	No, year round
Commercial	4	14,301	-	No, year round
Stock & Domestic	6	12	-	No, year round
TOTAL	**74**	**82,319**	**251**	

Table 12 Summary of water allocations in the Upper Derwent catchment, by category and number of licences. Data summarised from WIST Water Entitlements database. Aquaculture considered non-abstractive take.

Derwent River at Macquarie Plains

Meadowbank Dam at 'Curringa'

There are presently around 74 current allocations in the Upper Derwent Catchment ranging from 0.365 ML to 31,572 ML per annum with daily allocations ranging from 0.001 ML/day to 86.5 ML/day and Surety levels ranging from 1 to 5. The two largest takes are associated with aquaculture farms and these takes are non-abstractive. There are 13 licensed existing dams in the catchment and 1 proposed, with capacities ranging from 1 ML up to 8,700 ML.

Within the Upper Derwent catchment current allocation amounts for each major use are shown in Table 12 and Figure 24. The location of direct take allocations is shown in Figure 25 and the locations of licensed dams in Figure 26. Existence of a license indicates an allocation has been made, but does not give information on whether the water is actively being used.

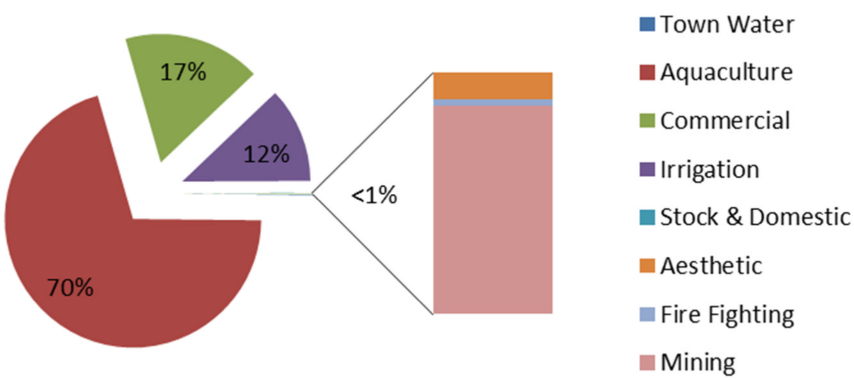


Figure 24 Summary of water allocations by major use as a percentage of total allocations for the Upper Derwent Catchment. Data summarised from the WIST Water Entitlements database. Aquaculture considered non-consumptive use.

Irrigation

Town water supply

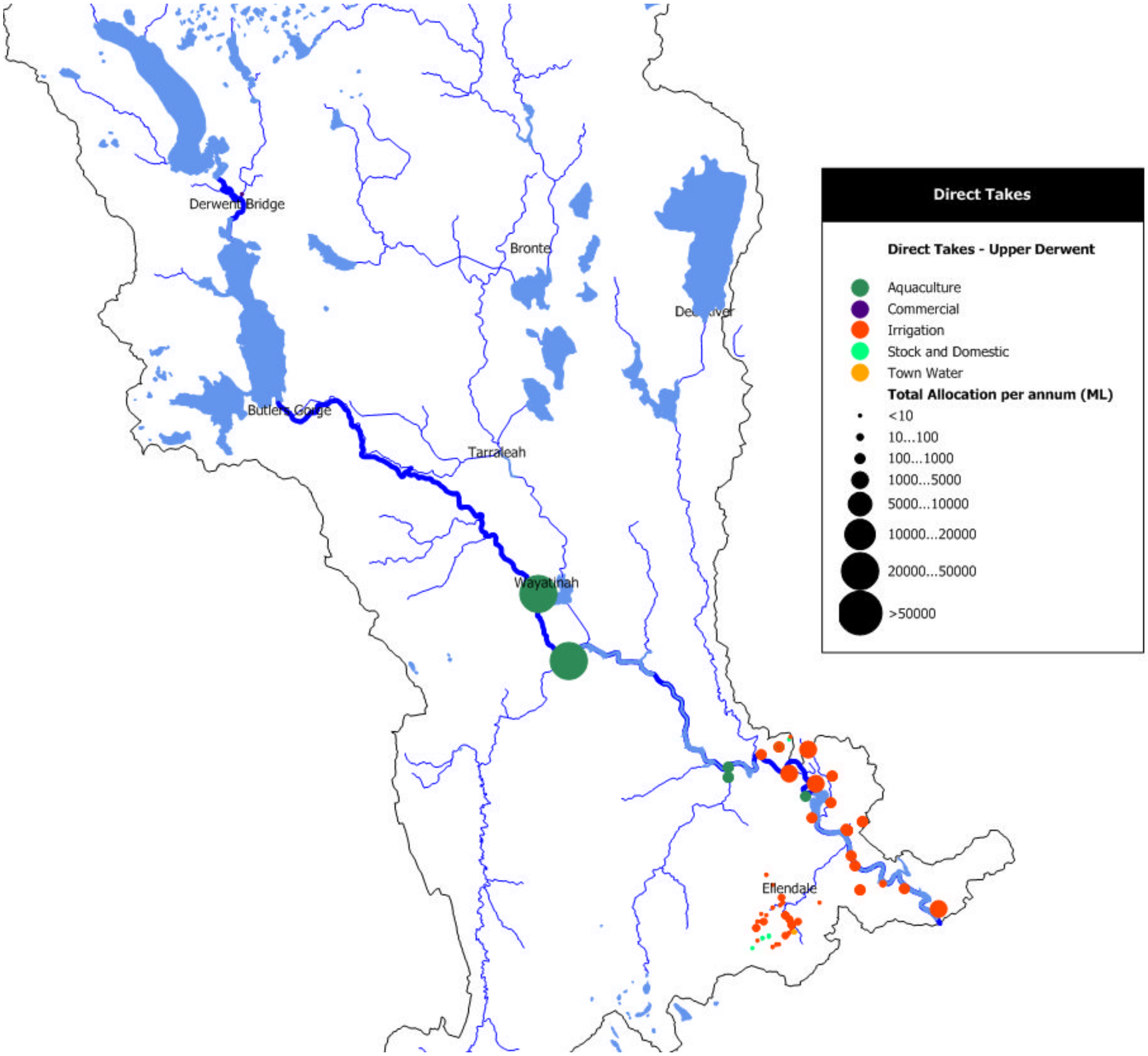


Figure 25 Licensed direct takes in the Upper Derwent Catchment (Data extracted from WIST Dams database, base layer by CFEV, the LIST © State of Tasmania).

3.3.3 Ouse River

Major dams and diversion weirs in the headwaters of the Ouse and Shannon rivers divert water into Great Lake for hydro-electric power generation at the Poatina Power Station (DPIW 2008). Riparian land holders on the Ouse River below Waddamana have a statutory right to take water for irrigation, under the *Electricity Supply Industry Restructuring (Savings and Transitional Provisions) Act 1995* (DEP, 2010). Releases to supply this water are made from Great Lake via Shannon Lagoon and, if necessary, from Little Pine Lagoon. Hydro Tasmania releases between 5000 and 12000 ML of water per year to meet irrigation requirements from downstream users. These comprise irrigators in the Ouse River and a final off-take to supply the Lawrenny Irrigation District below Ouse township (DPIW, 2009a).

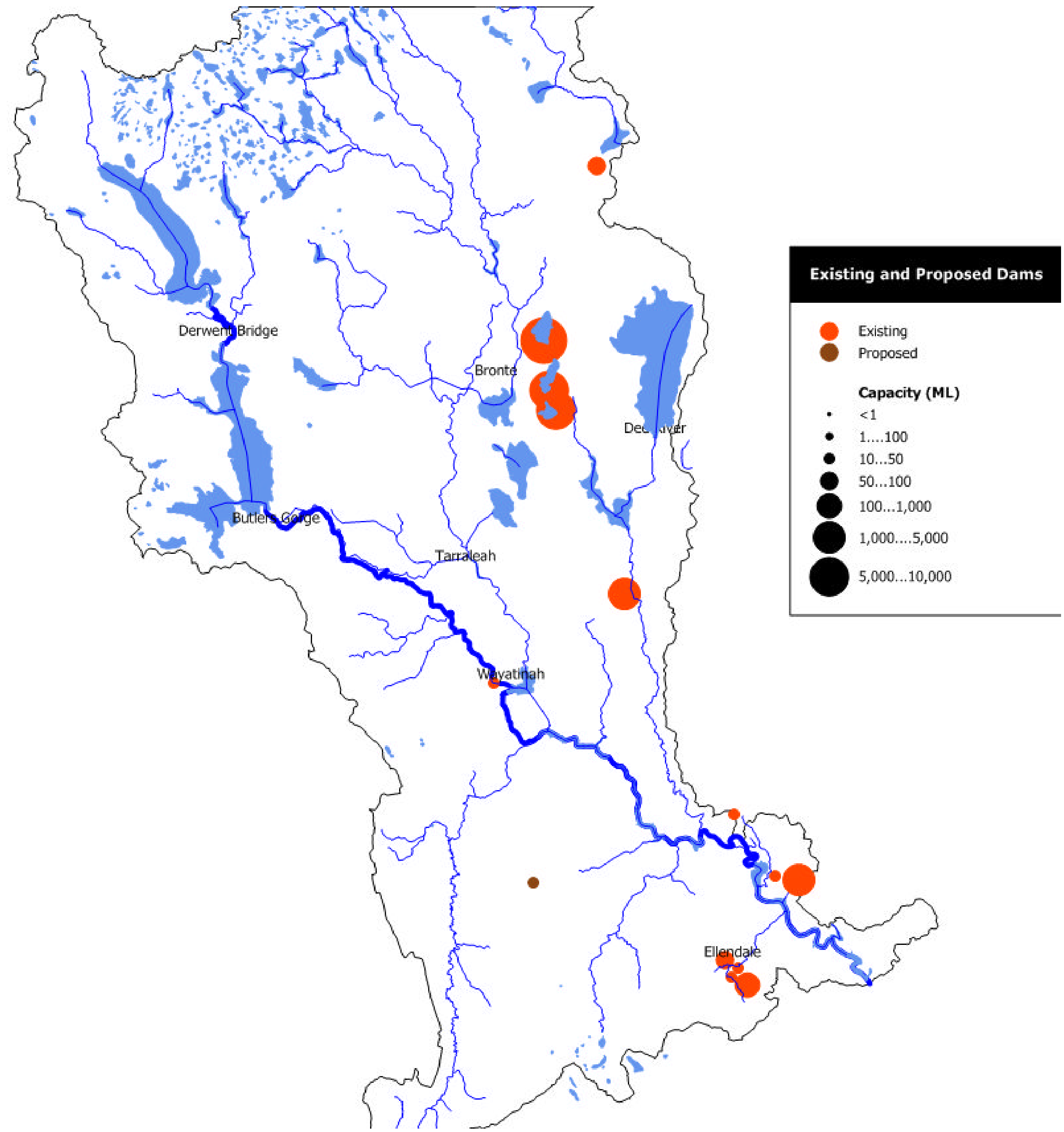


Figure 26 Licensed dams in the Upper Derwent Catchment (Data extracted from WIST Dams database, base layer by CFEV, the LIST © State of Tasmania

Members of the Lawrenny Irrigation Scheme, an independent trust set up in the 1840s also have a right under the *Electricity Supply Industry Restructuring (Savings and Transitional Provisions) Act 1995* to draw water from the channels of the scheme, which is supplied from the Derwent River. No licenses are required for this abstraction. Water is supplied to the Lawrenny irrigation channels from the Derwent River. Brock Weir, located on the Derwent River immediately below the Ouse River junction, backs Derwent River water up into the Ouse River. Pumps draw ponded water and transfer it to a second weir on the Ouse River. The water from this second weir gravity feeds the Lawrenny Irrigation

Scheme. There is generally sufficient water available for the Lawrenny Scheme without requiring a change to Hydro Tasmania's normal operations. Hydro Tasmania does, however, operate Cluny Power Station to ensure that the water retained behind Brock Weir stays above the pump intake level during the irrigation season (DEP, 2010).

There are presently around 50 current allocations in the Ouse Catchment ranging from 2 ML to 1,260 ML per annum with daily allocations ranging from 0.58 ML/day to 23.4 ML/day and Surety levels ranging from 1 to 5. There are 23 licensed existing dams in the catchment and 5 proposed, with capacities ranging from 2 ML up to 161 ML.

Within the Ouse catchment, current allocation amounts for each major use are shown in Table 13 and Figure 27. The location of direct take allocations is shown in Figure 28 and the locations of licensed dams in Figure 29. Existence of a licence indicates an allocation has been made, but does not give information on whether the water is actively being used.

Purpose	Number of Allocations	Annual Amount (ML)	Daily Rate (ML/day)	Allocation conditional?
Aquaculture	1	80	-	No, year round
Irrigation	33	10,638	121.5	Yes, defined take period
Town Water	2	72	-	No, year round
Stock & Domestic	14	166	-	No, year round
TOTAL	**50**	**10,956**	**121.5**	

Table 13 Summary of water allocations in the Ouse catchment, by category and number of licences. Data summarised from WIST Water Entitlements database.

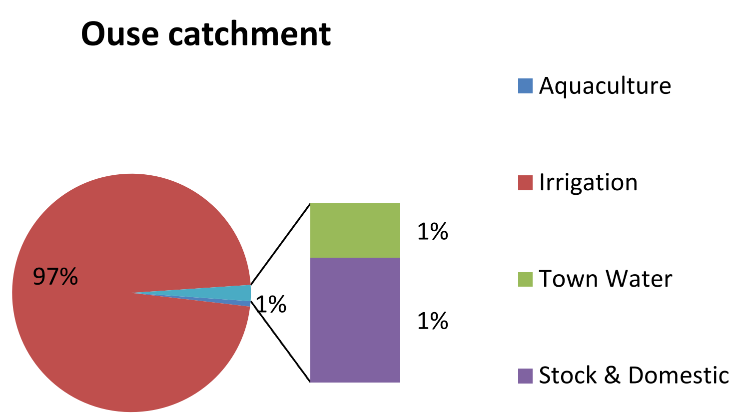


Figure 27 Summary of water allocations by major use as a percentage of total allocations in Ouse Catchment. Data summarised from the WIST Water Entitlements database.

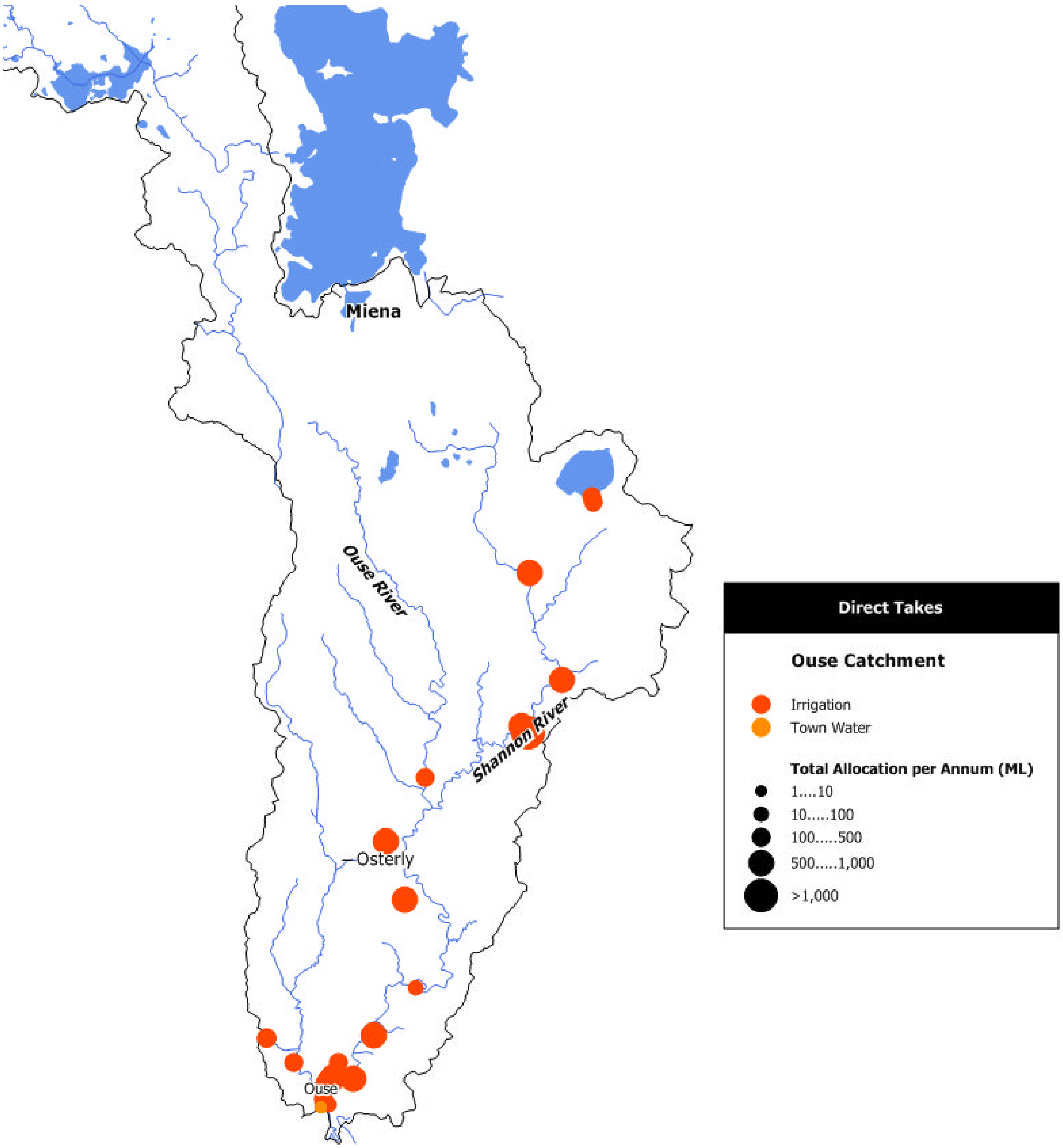


Figure 28 Licenced direct takes in the Ouse Catchment (Data extracted from WIST Dams database, base layer by CFEV, the LIST © State of Tasmania.

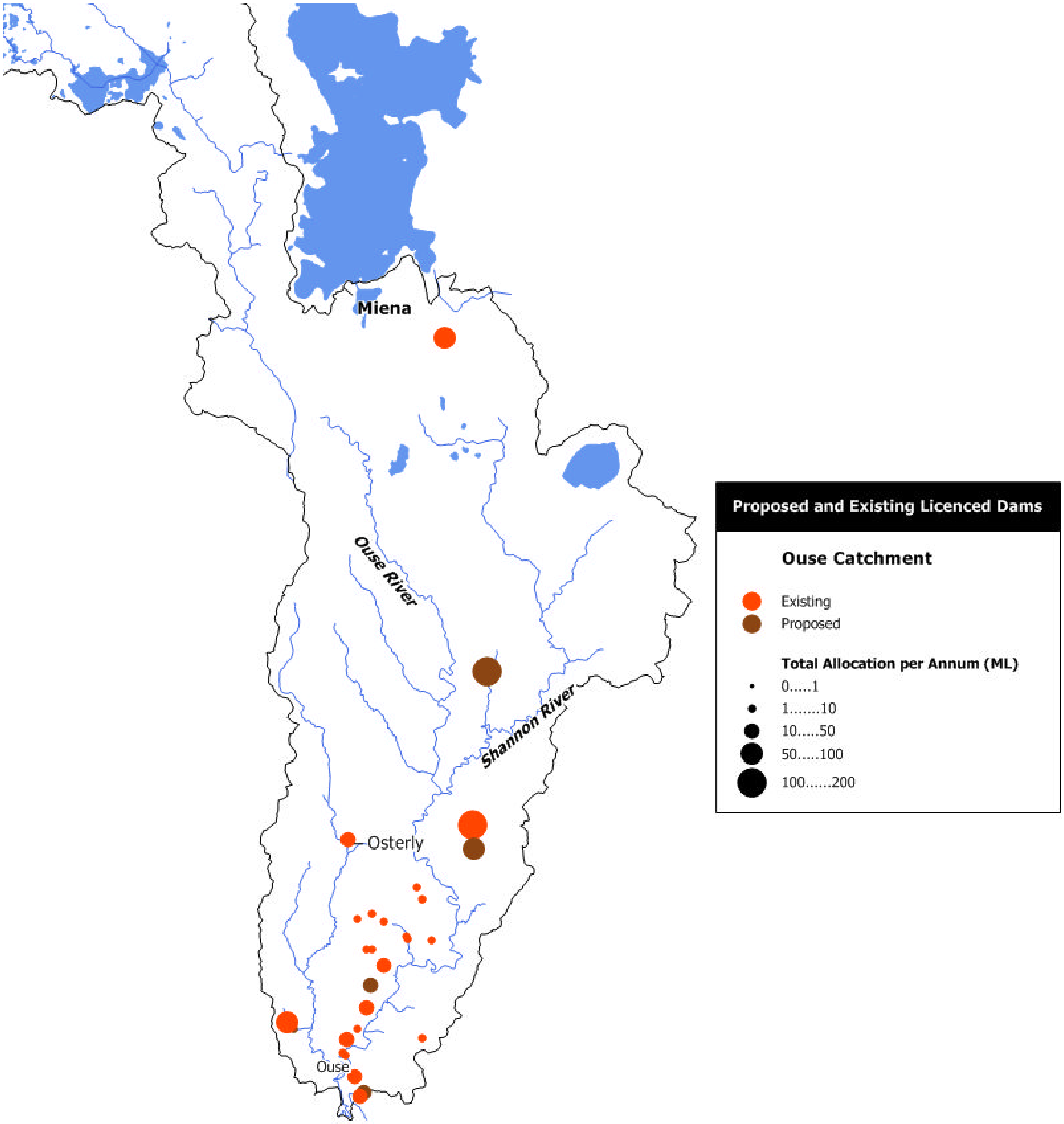


Figure 29 Licenced Dams in the Ouse Catchment (Data extracted from WIST Dams database, base layer by CFEV, the LIST © State of Tasmania

3.3.4 Clyde River

Under the *Clyde Water Act 1898*, the Clyde Water Trust (riparian landowners on the Clyde River) had rights to take water from the Clyde River. While this Act was repealed by the *Water Management Act 1999*, the rights of the Clyde Water Trust were carried over from the previous Act. The head storages for the Clyde River, Lakes Crescent and Sorrel, which are not Hydro Tasmania storages, are being managed by IFS to prevent the spread of carp, a pest fish species which is present in these lakes. As part of the management strategy, water releases into the Clyde River have been restricted (DEP, 2010).

The River Clyde Water Management Plan (RCWMP) was implemented in 2005; this plan outlines the management and allocation of water for the Clyde catchment. The Clyde Water Trust (now the Shannon Clyde Water Company Ltd (SCWC)) were granted 10,000 ML as a 5,000 ML per annum Surety 5 allocation and a 5,000 ML per annum Surety 6 allocation from Lake Crescent. The SCWC also have a water license to take up to 10,000 ML of water from Lake Meadowbank, issued in 2001. The SCWC uses this water to supplement its existing water supplies in the lower section of the Clyde River (around Hamilton). In addition to the statutory irrigation rights outlined above, the Minister may issue licences for irrigation abstraction (Hydro Tasmania 2001; DEP, 2010).

The RCWMP outlines assessing and issuing additional allocation of river flows to the SCWC when the lake levels in Crescent and Sorell are sufficiently high. The plan also states that all storage takes from the tributaries of the River Clyde approved after the commencement of the Act are considered to be Surety 7 Water Allocations. As the reliability of this water is relatively low, applicants may need to demonstrate that the allocation will not adversely affect existing Water Users or the Environmental Water Provisions. New water takes from the tributaries of the River Clyde may only be obtained under transfer from Hydro Tasmania and will be subject to the conditions in Provision 2.4.2 of the plan. The Filling Reliability of Surety 7 storage takes from the tributaries (outlined under the Plan) are not permitted unless at least one of the following conditions is met:

- The flow in the River Clyde at Bothwell is more than 1 cumecs or 86 ML/day; or
- Lake Meadowbank is spilling; or
- the stream is an ephemeral stream.

At all other times the natural flow of a watercourse must be allowed to pass through Surety 7 on-stream storages (DPIWE 2005a*).*

There is presently only one current direct take allocation in the Clyde Catchment to the SCWC, as discussed above. There are 36 licensed existing dams in the catchment and 26 proposed, with capacities ranging from 1 ML up to 5,400 ML. Within the Clyde catchment current allocation amounts for each major use are shown in Table 14 and Figure 30. The location of direct take allocations is shown in Figure 31 and the locations of licensed dams in Figure 32. Existence of a licence indicates an allocation has been made, but does not give information on whether the water is actively being used.

Purpose	**Number of Allocations**	**Annual Amount (ML)**	**Daily Rate (ML/day)**	**Allocation conditional?**
Industrial	1	13	-	Yes, defined take period
Irrigation	63	43,164	-	Yes, defined take period
Stock & Domestic	2	7	-	No, year round
TOTAL				

Table 14 Summary of water allocations in the Clyde catchment, by category and number of licences. Data summarised from WIST Water Entitlements database.

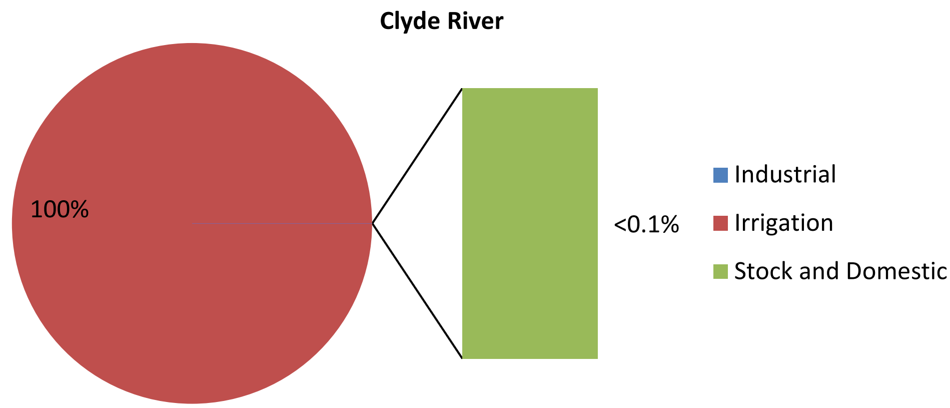


Figure 30 Summary of water allocations by major use as a percentage of total allocations in Clyde Catchment. Data summarised from the WIST Water Entitlements database.

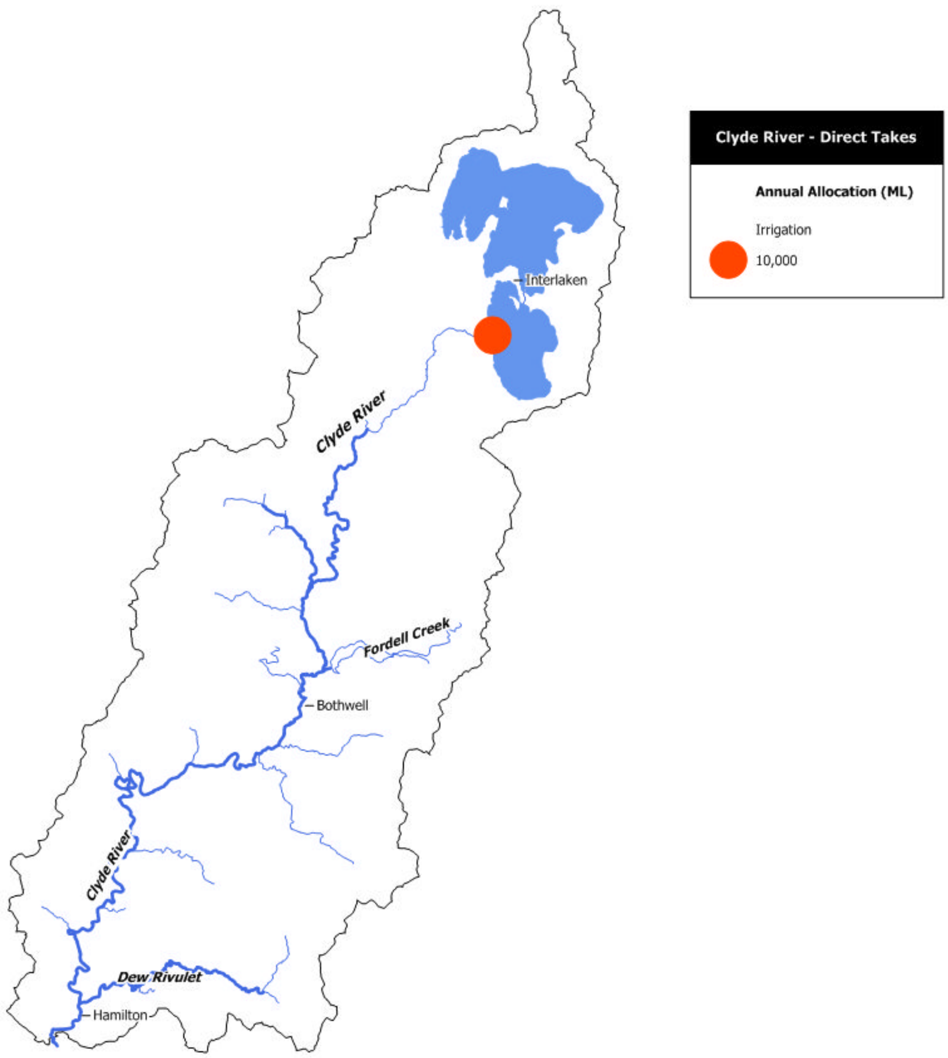


Figure 31 Licensed direct takes in the Clyde Catchment (Data extracted from WIST Dams database). Base layer by CFEV, the LIST © State of Tasmania.

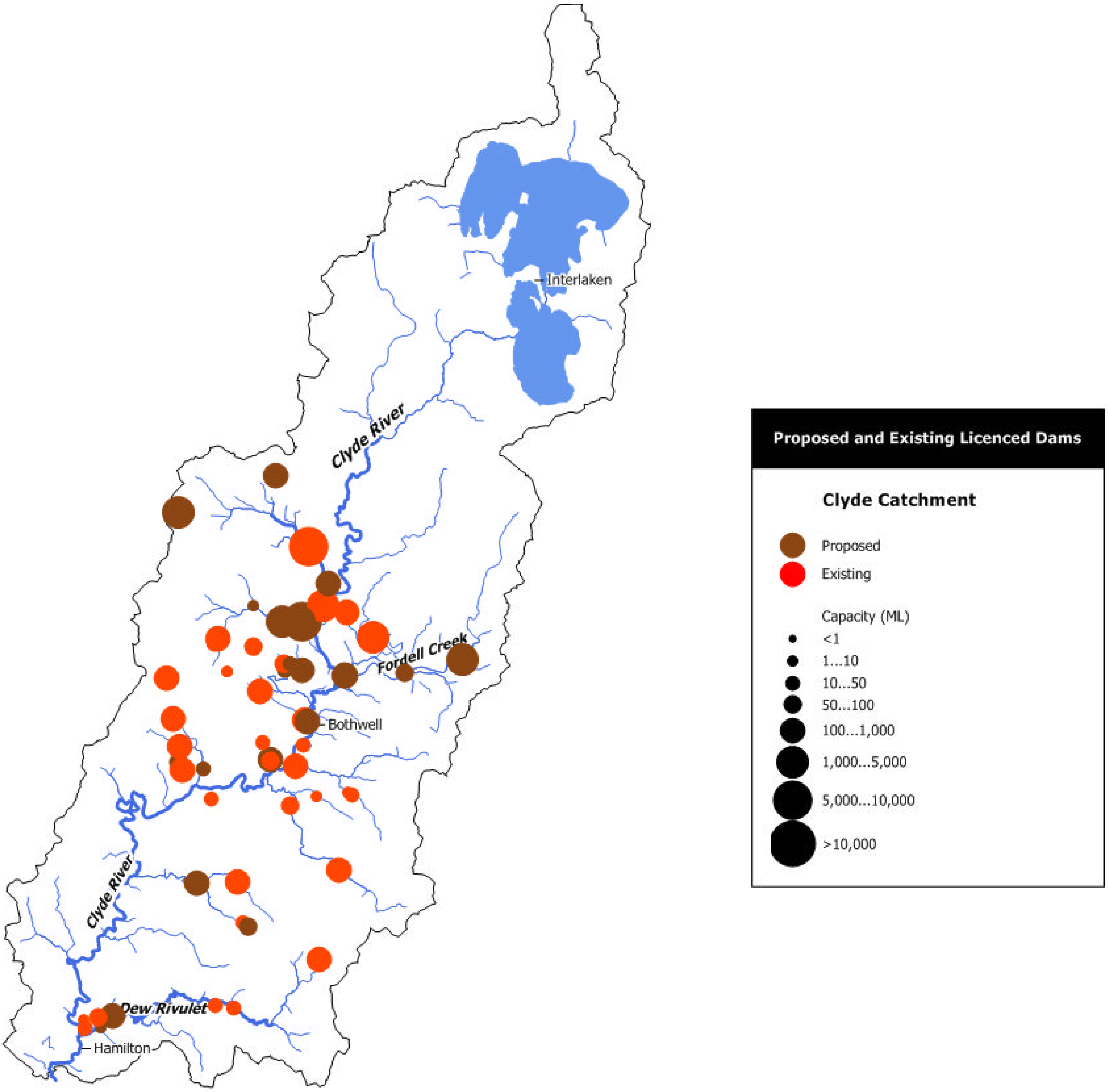


Figure 32 Licensed Dams in the Clyde Catchment (Data extracted from WIST Dams database). Base layer by CFEV, the LIST © State of Tasmania.

3.3.5 Other Tributaries

Purpose	Number of Allocations	Type	Annual Amount (ML)	Daily Rate (ML/day)
Florentine River				
Aquaculture[8]	1	Direct	25550	70
TOTAL			**25550**	**70**
Plenty River				
Irrigation	3	Direct	3285.7	9.01
Irrigation	4	Storage	125	3
Stock and Domestic	4	Storage	1.21	-
TOTAL			**3411.91**	**12**
Styx River				
Irrigation	29	Storage	18373.9	-
TOTAL			**18373.9**	**-**
Tyenna River				
Aquaculture[9]	2	Direct	44150.4	121
Aquaculture	2	Storage	7	-
Commercial	2	Direct	2.34	0.01
Irrigation	6	Direct	3204.9	21.7
Stock and Domestic	1	Direct	1.46	0
TOTAL			**47366.1**	**143**
Lachlan River				
Irrigation	8	Direct	119.65	1.2
Stock and Domestic	1	Direct	1.46	0
Stock and Domestic	2	Storage	2.1	-
Town Water	1	Direct	1923.9	5.75
TOTAL			**2047.11**	**6.96**
Jones River				
Irrigation	31	Direct	256.95	2.39
Irrigation	3	Storage	33	-
Stock and Domestic	4	Direct	5.84	0.02
Town Water	1	Direct	25.8	-
TOTAL			**321.59**	**2.41**

Table 15 Summary of allocations for smaller tributaries of the Derwent River Catchment. Data summarised from the WIST database.

Meadowbank Dam below Jones River (Google Earth)

Styx River above Derwent River (Google Earth)

Other Derwent River Tributaries (Broad, Un-named Tributaries)				
Aquaculture	1	Direct	182.5	0.5
Commercial	3	Storage	14300	-
Irrigation	5	Direct	663.3	5.63
Irrigation	45	Storage	1014.4	-
Aesthetic	1	Storage	5	-
Recreation	2	Storage	33	-
Stock and Domestic	15	Storage	63.03	-
Town Water	1	Direct	8000	30
TOTAL			**24261.23**	**30**
Catchment				
Commercial	3	Storage	120	-
Irrigation	6	Storage	30.6	-
Stock and Domestic	3	Storage	12	-
Town Water	1	Direct	60.3	0.17
TOTAL			**222.9**	**0.17**

Table 16 Summary of allocations for smaller tributaries of the Derwent River Catchment. Data summarised from the WIST database.

Table 15 and Table 16 show summaries of allocations for smaller tributaries within the Derwent River catchment.

Broad River above confluence with Cluny

Power generation in the lower Derwent (Repulse)

3.4 Hydro Storages

As discussed previously, Hydro-electric development has resulted in the diversion of flows into and out of the Derwent catchment, through a series of dams and storages. The locations of Hydro licenced storages in the Derwent Catchment is show in Figure 33.

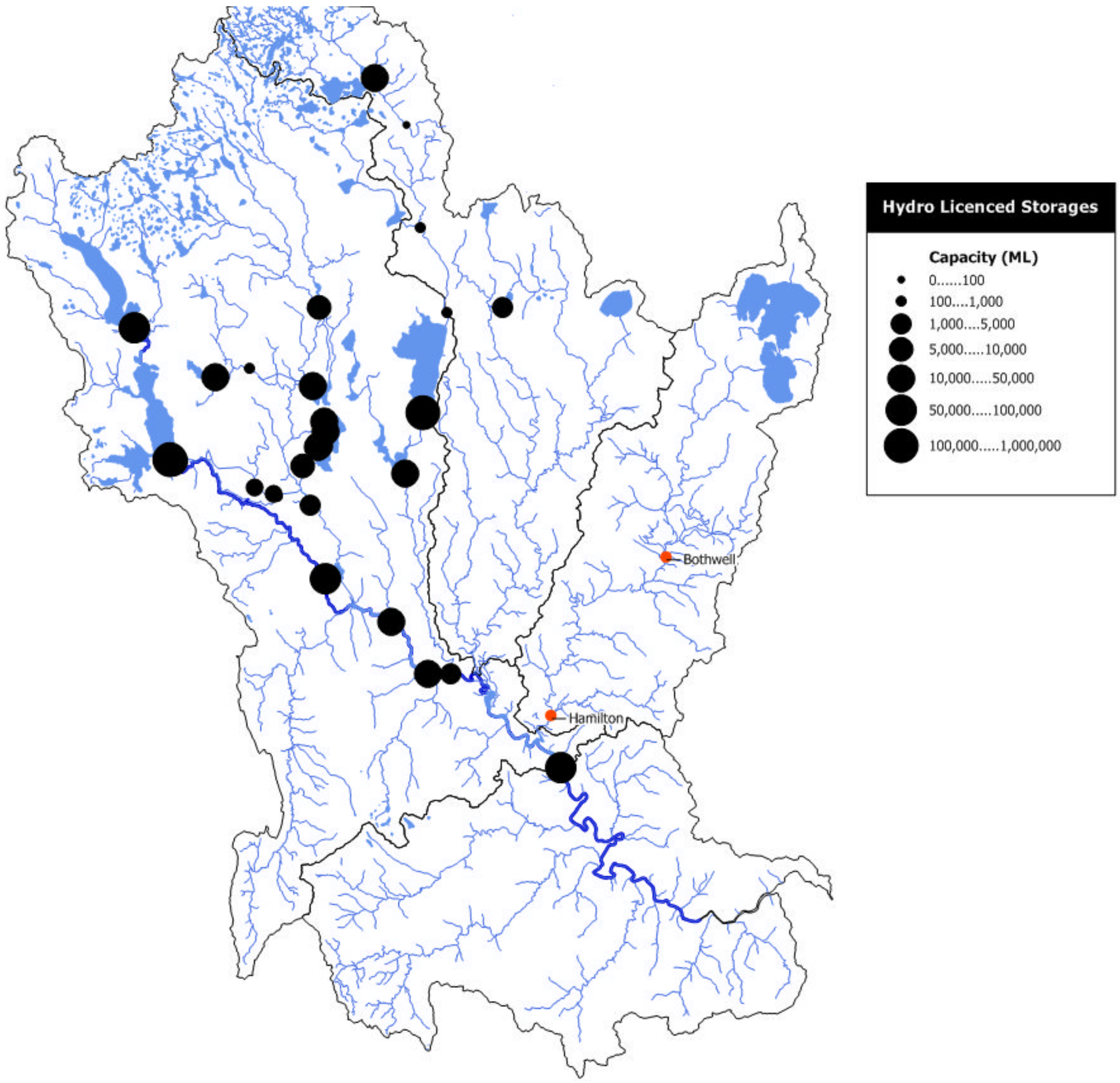


Figure 33 Hydro Licensed Storages in the Derwent Catchment (Data extracted from WIST Dams database, base layer by CFEV, the LIST © State of Tasmania. Lagoon of Islands and Shannon Lagoon are not shown.

3.5 Irrigation schemes (future)

3.5.1 Shannon Clyde Irrigation Scheme

The scheme proposes to develop a pump station on the Shannon River at “Hermitage” and pump water up into a new storage known as “Ruperts Storage”. Water will then be released via a pipeline under gravity for several kilometres before flowing through a mini hydro station, and entering a second new storage known as “Bark Hut Creek Storage”. A pump station will be located on the Clyde

River near the Bark Hut Creek Storage and water will also be able to be pumped from the Clyde River back into the storage during high river flow periods. During the irrigation season, water will be released out of the storage and down the Clyde River allowing farmers to pump water directly out of the river for irrigation. A pump station will also be located downstream of the Bothwell Township which will supply water via a pipeline, known as the "Hollow Tree Pipeline" route. *(Source: TIDB web site).* The Hydro component of the proposal includes extraction of 9000 ML/year from Cluny Lagoon, to the Ouse River via a pipeline resulting in reduced outflows from Lake Meadowbank, the lowest downstream storage in the Derwent system. There is no detail on the location of irrigation extractions but it is assumed that water extracted will be fully utilised on-farm for irrigation (CSIRO, 2009). A River Recovery Plan has been prepared by Greening Australia (2010) for the Ouse, Shannon and Clyde Rivers as part of the development stage of the scheme. Further work on the proposed Shannon Clyde Irrigation Scheme (Figure 33) has been deferred pending resolution of a range of water management issues. These issues are largely external to the TIDB.

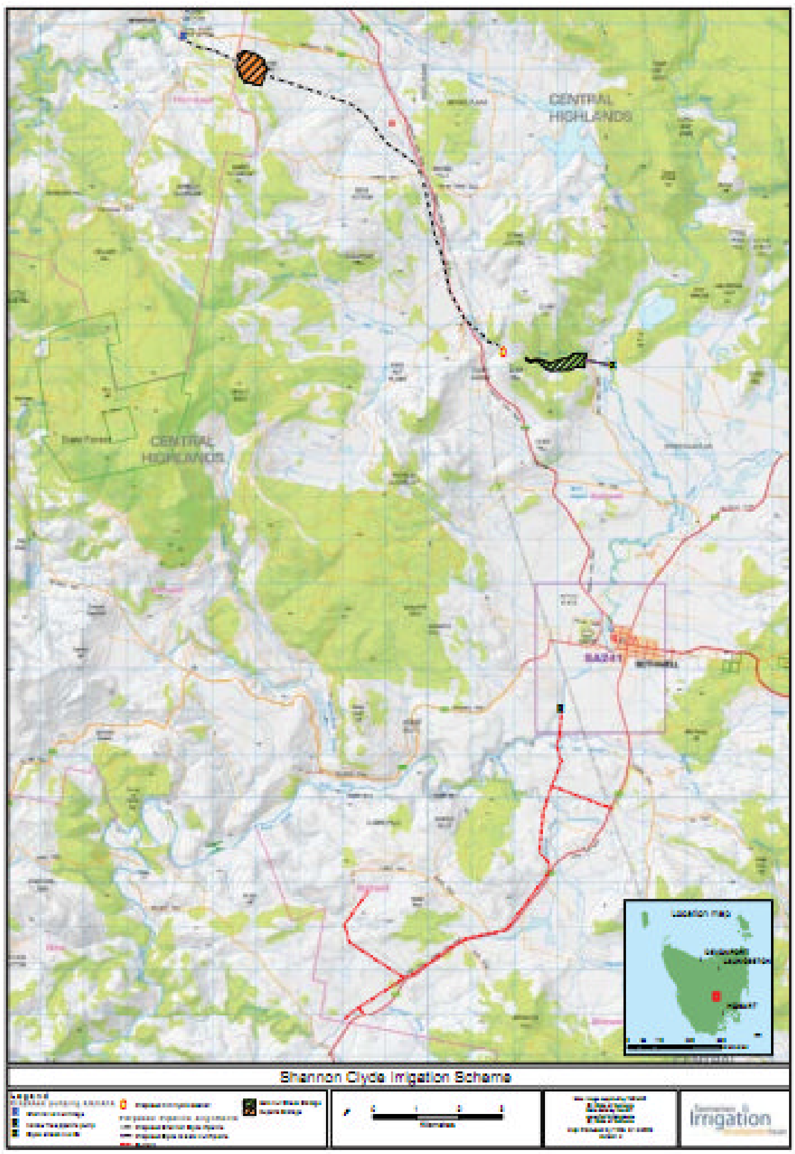


Figure 34 Map of the proposed Shannon Clyde Irrigation Scheme (source TIDB web site).

3.5.2 South East Irrigation Scheme

The South East Irrigation Scheme (SEIS) project focuses on a permanent solution to irrigation needs in the south east from Forcett, through Sorell, Richmond, Tea Tree and Brighton to the lower Jordan valley. This region has a mild climate with relatively low rainfall, which presents an opportunity to significantly expand the South East as a region of high value perennial horticulture and vegetable production. This advantage is already being realised in terms of both the high quality and supply reliability of a diverse variety of horticultural produce from the region.

The design concept is to use excess capacity in the greater Hobart supply system, owned and operated by Southern Water, to supply 5,000 ML / year of untreated water from the Derwent River (Figure 35). Over the winter period, water will be transferred into Craigbourne Dam via new scheme infrastructure, which will include a trans-Derwent pipe near Granton, and pump stations at Tea Tree and below Craigbourne Dam. Distribution to irrigators will be supplied entirely via pipe infrastructure (under gravity) and utilise some of the same infrastructure used to deliver winter water to the dam.

A plan for integration with existing schemes located within the Coal Valley has been developed, and will be further refined during the preparation of the SEIS Business Case. The distance from the water source, and large area covered by the scheme dictate higher capital and operating costs than other schemes investigated by TIDB to date. The principal benefit of the project will be the opportunity to expand high value agriculture in the region rather than to apply the water to traditional broad acre primary industries *(Source: TIDB web site).*

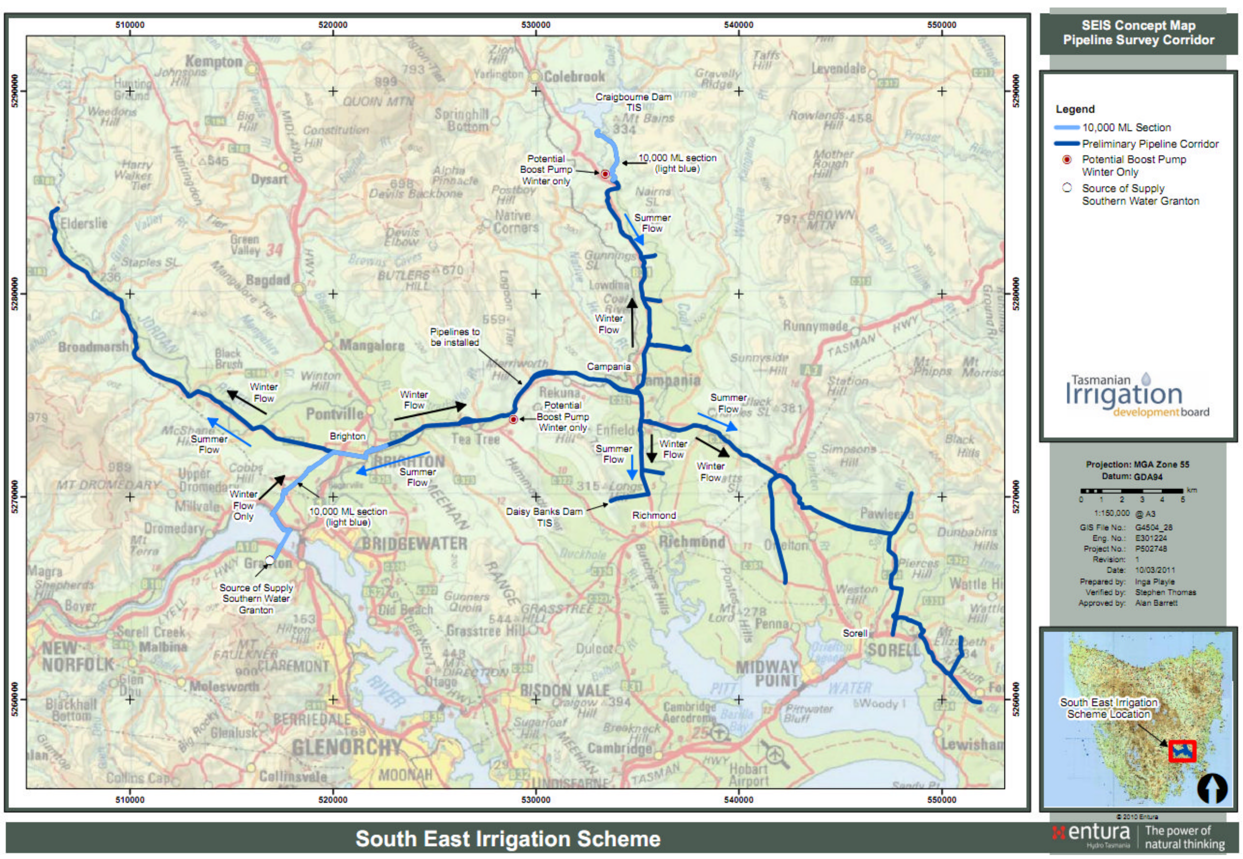


Figure 35 Map of the proposed South East Irrigation Scheme (source TIDB web site).

3.5.3 Future irrigation expansion and sustainable yields

A study on sustainable yields from irrigation schemes by CSIRO (2009) investigated water availability through to 2030 under a range of climate change scenarios: wet, medium or dry future. Results of the project are intended to provide a scientific basis for planning a sustainable irrigation industry in Tasmania. Models for each catchment in the greater Derwent showed that stream flow under the “wet extreme” scenario generally exceeded historical stream flow, but that under the median or dry extreme, stream flow fell. Extractions varied by 1% or less in all scenarios (see Figure 36). The upper Derwent was modelled using a different system model, and results were not included in the CSIRO summary below.

The percentage of water extracted from the total predicted flows varies from catchment to catchment, with the drier eastern catchments having between 10 and 15% of the total flow associated with irrigation extractions (Figure 36). Under some scenarios, reliability of storages is affected by rainfall variation.

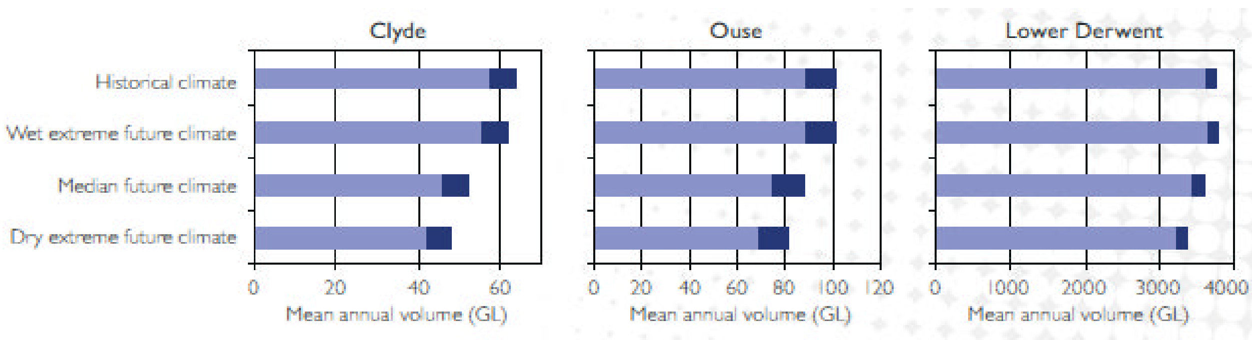


Figure 36 Extracted (dark blue) and non-extracted (light blue) shares of water for catchments in the Derwent-South east region under historical and future 2030 climate scenarios (CSIRO, 2009).

3.6 Drinking Water Supply

Management of drinking water supply has undergone significant change in recent years with the introduction of legislation in 2008 to reform the Tasmanian sewage and water industry (OTTER, 2011). From July 1 2009, assets and delivery of water services were transferred from individual Councils to Southern Water, a regional corporation servicing 12 southern council areas.

The Derwent catchment contributes a significant component of the water supplied by Southern Water for residential and commercial use in southern Tasmania. Drinking water is drawn from the Derwent and treated at the Bryn Estyn Water Treatment Plant located 3.5 km upstream of New Norfolk (Figure 37). Due to the location of the Southern Water off-take in the lower Derwent, the entire catchment upstream of Bryn Estyn is considered the Derwent River Drinking Water Catchment (Hobart Water, 2006). The treatment plant supplies up to 60% of Hobart’s drinking water supply, and is critically dependent on good water quality in order to meet drinking water guidelines and consistency of supply.

Extractions from the Derwent River for drinking water supply are estimated to be on average 80-90 ML/day, with maximum daily extractions of 180 ML/day during peak performance of the Bryn Estyn Plant (*A. Crawford, pers comm*). The intake at Bryn Estyn is located above the influence of the salt wedge, which is controlled by river flow (dependent upon releases from the Meadowbank Dam upstream) and tidal stage. The exclusion of the salt wedge from the intake is ensured by a commitment from Hydro Tasmania to maintain a 20 cumecs discharge at the site. This volume is based on the water quality intake requirements of both Southern Water at Bryn Estyn and Norske Skog at Boyer (Hobart Water 2006).

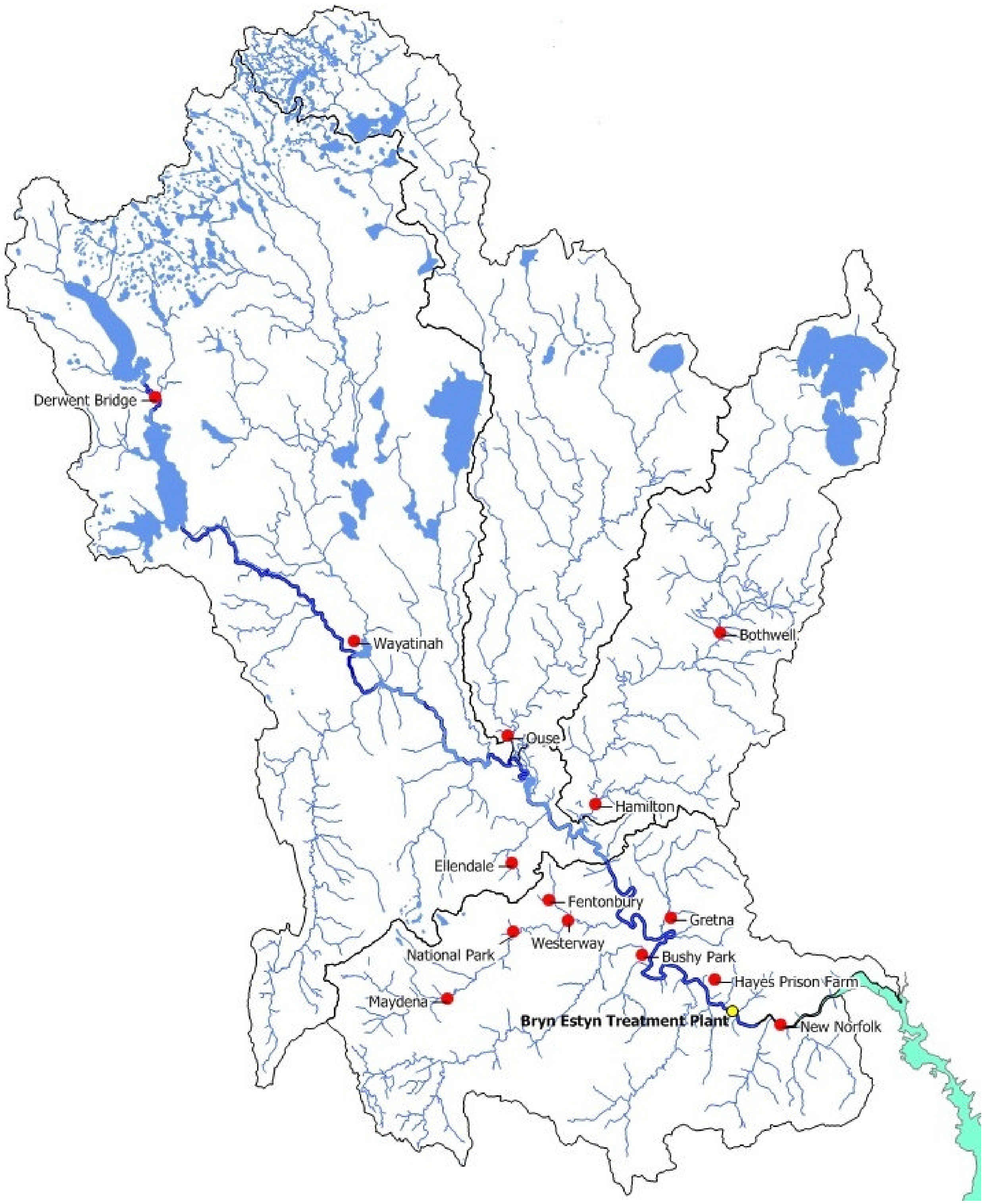


Figure 37 Drinking water supply systems for smaller population centres in the Derwent Catchment.

No flow gauging station is present at Bryn Estyn, although Southern Water proposes to install a flow monitoring system in the near future (*A. Crawford, pers comm*). DPIWE developed a model to estimate flow at the site based on the average daily flow at Derwent below Meadowbank Dam Hydro station) and at the Tyenna River at Newbury Rd site (DPIPWE station) according to the following relationship:

*Modelled Flow (Bryn Estyn) = Previous days average flow at Derwent below Meadowbank (ML/day) + 4.89 * Previous days average flow at Tyenna gauge (ML/day).*

Using this relationship, modelled flow at Bryn Estyn for 2009 – 2010 is presented in Figure 38, and shows the contribution from the Tyenna River is minor except during high winter flow events.

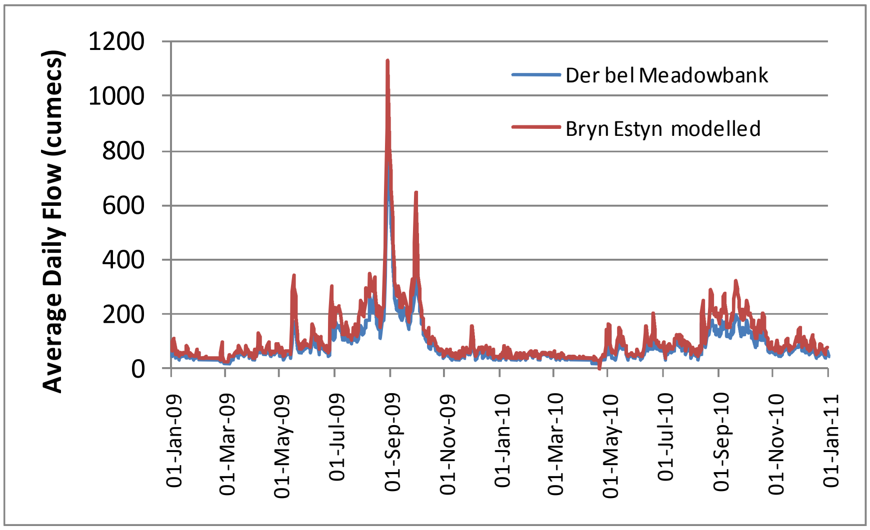


Figure 38 Average daily flow at Derwent below Meadowbank compared to modelled average daily flow at Bryn Estyn, based on DPIPWE model.

The location of drinking water supply systems for areas in the catchment not serviced by Bryn Estyn are shown in Figure 37, and a description of the water treatment system at each town is included in Table 17. A number of towns receive water from the Derwent and its tributaries, with a range of complexity of treatment. The towns of Ellendale and Gretna have permanent boiled water alerts due to the persistent presence of microbial contaminants (Southern Water, 2010). Ellendale, National Park and Bryn Estyn were funded for upgrades in the 2009-2010 capital works program, with Ellendale due to come on-line when intensive testing the of the water treatment system currently underway is completed (*A. Crawford, pers. comm*). Smaller towns such as Miena, Interlaken and Hollow Tree have no centralised supply and rely on rainwater tanks.

Intake for Southern Waters Bryn Estyn Water Treatment Plant on the Derwent River

Additional water to supplement the Derwent intake at Bryn Estyn is taken from Lake Fenton in Mt Field National Park, via an off-take on Lady Barron Creek. Water from this source receives basic treatment (chlorination, fluoridation) at a small treatment plant near National Park. The distribution area includes Westerway and Fentonbury, with the majority of supply piped by gravity to the Waterworks storage outside Hobart.

Townships	Population serviced by supply system	Water supply intake	Treatment system
Wayatinah	115	Liapootah Power Station Penstock	Chlorination only
Gretna	105	Derwent River	None (Permanent boil water alert)
Ellendale	150	Jones River	None (Permanent boil water alert, treatment system waiting to come on-line)
Bothwell	400	Clyde River	Coagulation/flocculation, sand filtration, chlorination
Hamilton	210	Derwent River (Meadowbank)	Chlorination only. Previously supplied from Clyde River.
Ouse	275	Derwent River	Chlorination only
Bushy Park	133	Styx River	
Maydena	300	Maydena range	Chlorination only
National Park/ Westerway	175	Bulk Water from Hobart Water	Coagulation/flocculation, clarification, filtration, pH adjustment, chlorination, fluoridation (at Bryn Estyn WTP)
		Lake Fenton	Fluoridation and chlorination only
New Norfolk	5000	Bulk Water from Hobart Water or	Coagulation/flocculation, clarification, filtration, pH adjustment, chlorination, fluoridation (at Bryn Estyn WTP)
		Illa Brook	Fluoridation and chlorination only
Hayes Prison farm	-	Derwent River	UV-light
Fentonbury	40	Lake Fenton	Fluoridation and chlorination only
Derwent Bridge	23	Lake St Clair	Chlorination only

Table 17 Tasmania drinking water supply systems in smaller population centres in the Derwent Catchment (DHHS, 2009).

3.7 Non-consumptive water use

3.7.1 Hydro-electric power generation

The largest non-consumptive use of water in the Derwent catchment is for production of hydro-power. As detailed in Section 2.5, the flow regime of the Derwent has undergone major flow modification associated with the upper and lower Derwent power schemes. Although the generation of power is a non-consumptive activity, and water quality is not directly affected by passage through a power station, the alterations to the flow regime, storage of water in lakes, and depths at which power station intakes are located can all affect water quality. These issues are more fully described later in the report.

3.7.2 Aquaculture and fisheries

Several large fish hatcheries are located in the Derwent, with the largest operations located at Wayatinah, on the Florentine River, and on the Tyenna River. Smaller hatcheries are present on the Plenty River and the Derwent at New Norfolk. Species cultured include trout and Atlantic salmon. Fish farms have the greatest annual allocation of water in the Derwent catchment, at 102,000 ML or 45 % of the total allocation, (Coughanowr, 2001). Much of this water use is considered "non-consumptive" as water is diverted through the farm and returned some distance downstream. More recently, however, a new operation at New Norfolk has installed recirculation systems, with water requiring a high degree of treatment before being discharged to the environment (*S. Chilcott, pers. comm*). Table 18 lists aquaculture facilities in the study area (Coughanowr, 2001; S. Chilcott IFS).

Location	Species	Discharge point	System
Wayatinah	Atlantic salmon	Wayatinah Lagoon-Derwent (Saltas)	Hatchery, flow- through
National Park Russell Falls	Atlantic salmon	Tyenna River (Tassal)	Hatchery, flow- through
Florentine	Atlantic salmon	Florentine River (Saltas)	Hatchery, flow- through
Karanja	Trout	Tyenna River	Hatchery, flow- through
Salmon Ponds	Trout	Plenty River (IFS)	Hatchery, flow- through
New Norfolk	Trout	Derwent River (IFS)	Hatchery, recirculation

Table 18 Aquaculture operations in the Derwent catchment, species cultured and location of point source discharge.

The Derwent catchment supports a small commercial short-finned eel fishery (*Anguilla australis*), with licenses issued for the Clyde River and its tributaries, and Lakes Crescent and Sorell (IFS). Harvested eels are largely exported as frozen product to Europe, with some live product export to Asia. Fyke nets are used by a limited number of license holders, with some trapping and harvesting of migrating adult eels. The viability of the commercial fishery, and wild populations, is hampered by the many dams and weirs which obstruct upstream migration. The Inland Fisheries Service undertakes annual harvesting and elver restocking programs to promote recruitment in rivers and lakes. Trapping is undertaken at Meadowbank Dam for restocking purposes, with eels relocated to various locations in the Derwent catchment (IFS web page). No water extractions are associated with the eel fishery. A number of private fisheries also operate in the greater catchment. Brown trout (*Salmo trutta*) and rainbow trout (*Oncorhynchus mykiss*) are fished on a limited access basis in the London Lakes and Highland Waters. Public fisheries within the Derwent catchment are numerous, and are primarily based on brown trout, brook trout (*Salvelinus fontinlaus*) and rainbow trout.

4 Land uses and natural values

4.1 Land Use

Land use within the Derwent Catchment reflects conservation, power generation, forestry and agricultural uses. A detailed analysis of land use by sub-catchment was completed by Hydro Consulting (2008), summarised in Table 19. Overall, about 35% of the catchment is protected for conservation purposes, with the majority of this area in the northern and western area of the upper catchment, western area of the lower catchment and in the headwaters of the Ouse River (see Figure 39).

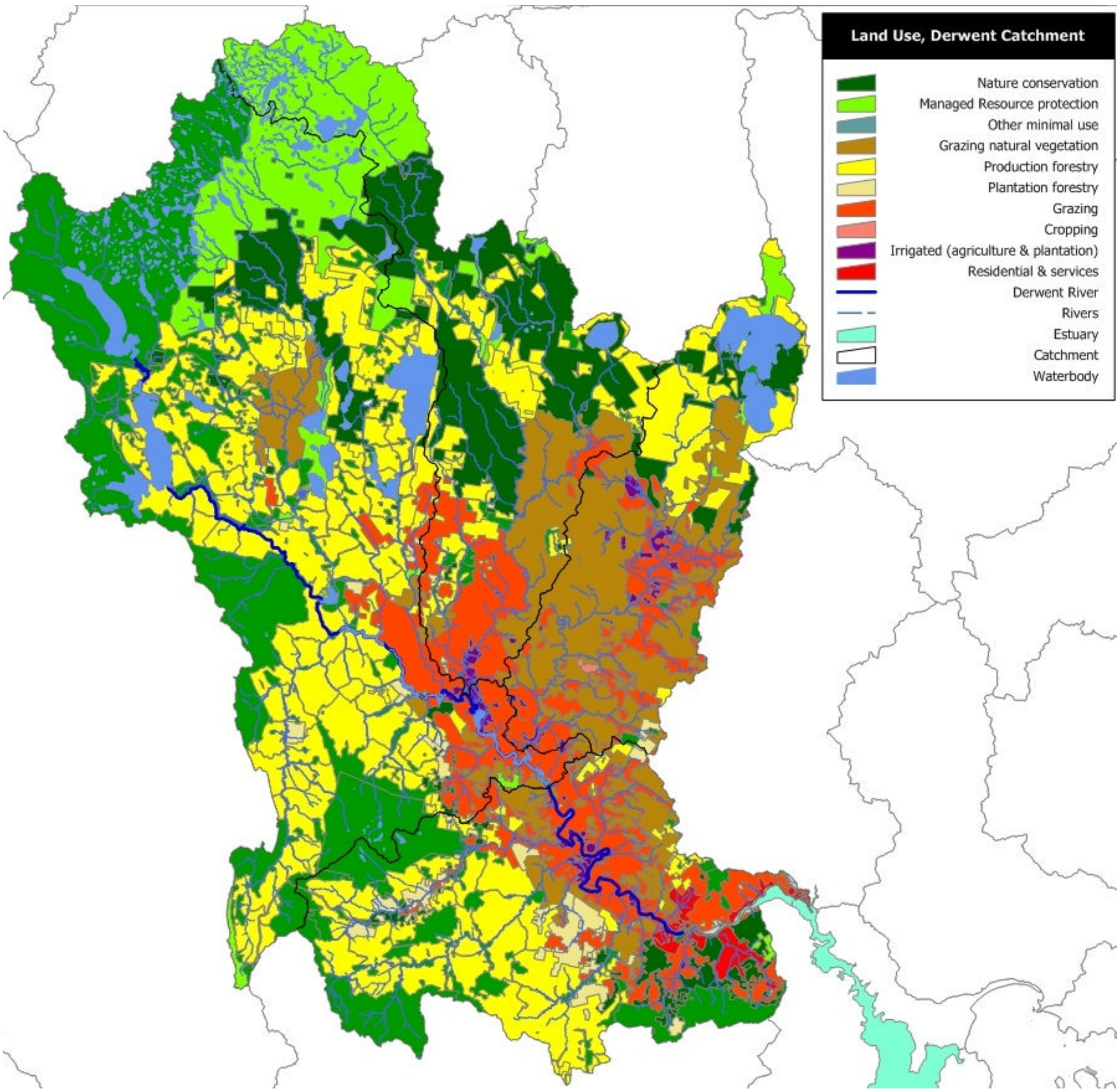


Figure 39 Land use in the Derwent catchment, based on ACLUMP (1:25,000) and ALUM land use codes. Data from 2000-2001 is available Bureau of Rural Sciences website. Base layer CFEV, WIST © State of Tasmania.

These conservations areas include the Tasmanian Southwest World Heritage Area, and numerous National Parks (Cradle Mountain-Lake St Clair, Walls of Jerusalem, Franklin-Gordon Wild Rivers and Southwest National Parks, and Mt Field National Park). Within the Clyde sub-catchment, conservation areas are generally restricted to the headwaters, and the area around Lakes Sorrell and Crescent. A number of Nature, Forest and State Reserves and Conservation Areas occur within the Derwent catchment (Hobart Water, 2006).

Catchment	Area (km^2)	Conservation % (area km^2)	Forestry incl. Plantations % (area km^2)	Grazing & agriculture % (area km^2)	Other: Urban, mining, industrial % (area km^2)
Upper Derwent	3,561	49%(1745)	35 (1,246)	10% (356)	6% (214)
Lower Derwent	1,517	23% (349)	36% (546)	31% (470)	10% (152)
Ouse	1,478	35% (517)	14% (207)	23% (340)	30% (443)
Clyde	1,131	4% (45)	19% (215)	68% (769)	9% (102)
Total (% of total catchment, Km^2)	7687	35%, (2,656)	29% (2,214)	25% (1,935)	12% (911)

Table 19 Summary of land use in Derwent catchment by regions.

Forestry activities predominate in the western area of the upper and lower Derwent catchments. Production forests, rather than plantations, are the most common forestry activity, with plantations estimated at occurring on less than 1% of land area in the upper Derwent, Ouse or Clyde sub-catchments (Hydro Consulting, 2008). In the lower Derwent catchment, plantations are estimated as occupying 6% of the land area (Hydro Consulting, 2008). Details of plantation forestry in the Derwent are summarized in Table 20, using 2007 data.

Catchment	Hardwood (ha)	Softwood (ha)	Total (ha)
Upper Derwent	5,752	5,184	10,937
Lower Derwent	3,427	10,883	14,310
Ouse	1,029	210	1,239
Clyde	1,314	500	1,814

Table 20 Summary of hardwood and softwood plantations in the Derwent catchment. Data sourced from the LIST (Forest Groups layer, 2007) and Bendor et al (2008).

Grazing occurs in the lower and eastern areas of the upper Derwent, the eastern area of the lower Derwent and throughout the Ouse and Clyde catchments. Agriculture accounts for 1% or less of the land area in each of the sub-catchments (Hydro Consulting, 2008). Other uses, such as land associated with hydro power production, urban areas and unallocated Crown Land account for the remaining catchment area. Land tenure (Figure 40) also provides a general indication of land use.

NRM South is currently undertaking a project to map land use at 1:50,000 scale, using Rapid Eye imagery collected between November 2009 and February 2010. The project aims to create a definitive GIS land use layer for the summer of 2009, and also create a record of land use before major TIDB irrigation schemes are operational (see earlier sections for a description of the schemes). The dataset will also provide an opportunity to examine land-use change over the past 10 years. Standard ALUM classification (version 7) codes for the different land-use categories have been used to describe land-use. Output from the project was not available within the time-frame for developing this report, so data from 2000-2001 acquired by the Bureau of Rural Sciences has been presented (Figure 39).

Plantation forestry in the Tyenna catchment

Water diversions in the headwaters of the Junee

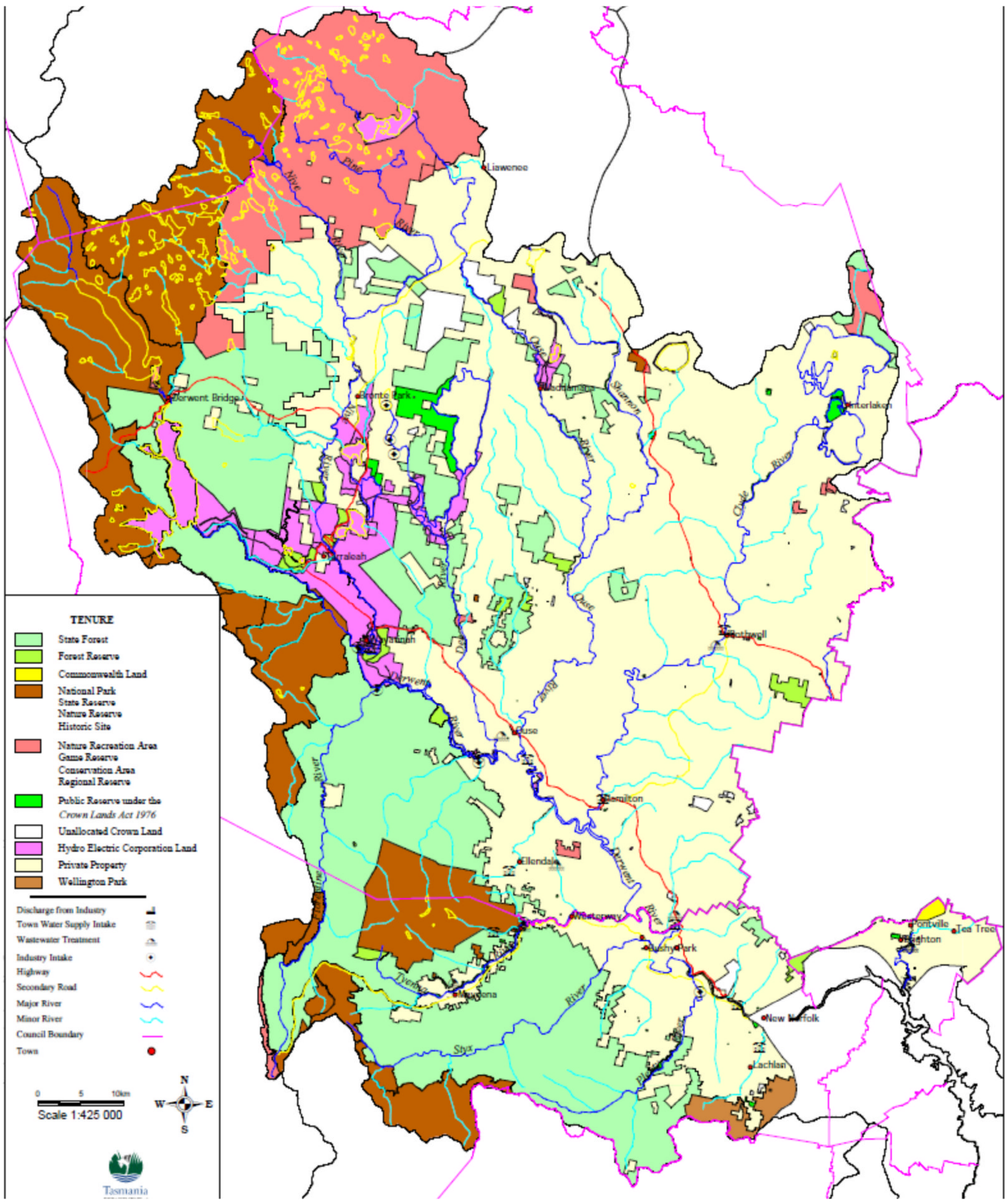


Figure 40 Land tenure in the Derwent catchment (2000). Map produced by DPIPWE and used for identification of Protected Environmental Values in the catchment.

4.1.1 Industry and urban centres

The Derwent catchment lies principally within the Central Highlands municipality, and the Derwent Valley municipality .The largest population centres are the townships of Bothwell, Maydena, Hamilton, Ouse and New Norfolk to the South. Numerous smaller towns are located throughout the catchment (see Table 17, and Figure 2). Water quality issues associated with residential areas and urban centres include stormwater, sewage, industrial and commercial activities. A significant reduction in the permeability of soils through the build-up of hard surfaces (roads, roofs, paths and driveways etc.) results in the transport of particulate and dissolved contaminants and litter into streams and waterways.

The 2006 review of the Derwent Drinking Water Catchment by Hobart Water recorded 30 mining leases, 16 of which had active leases totaling an area of 437 ha. Petrol stations, landfills and transfer stations, sawmills, treated pine facilities, forestry and agriculture were listed as the main industry groups in the catchment.

4.2 Natural values

The Derwent River catchment includes 3 of Tasmania's biogeographic regions: the Central Highlands, Southern Ranges and the South-East (DPIWE, 2003). Native vegetation in these areas includes peatlands, marshlands, button grass moorlands, and other alpine and sub-alpine communities at higher altitudes, and eucalypt forests in the lower altitudes containing many of Tasmania's endemic species. Many endangered species occur in the Derwent catchment. 89 plant species in the Derwent catchment are listed as rare (70), vulnerable (10) or endangered (9). Endangered fauna include the Clarence galaxias, the swift parrot, orange-bellied parrot, grey goshawk and wedge-tailed eagle.

4.2.1 Wetlands

Wetlands are important high biodiversity ecosystems providing breeding grounds for aquatic macro-invertebrates, fish and water birds, and regulate water stress during times of flood or drought. Wetlands may act as filters and clarifiers, removing solids and providing ecosystem services such as nutrient processing e.g. (denitrification) and groundwater recharge. A number of wetlands, including some registered as wetlands of national significance, are located within the greater Derwent catchment. (see Table 21, Figure 41). Some wetlands have been lost due to water diversions for land reclamation purposes, for example the marshes at the headwaters of the Junee River system. Permanent alteration of the hydrological regime in wetlands, especially in areas with distinctive water quality derived from such karst systems, undoubtedly results in the loss of unique ecosystems.

Catchment	Wetland name	Type	Bioregion, area (Ha)
Upper Derwent	Clarence Lagoon	Wetlands of national significance	Southern Ranges,100 Ha
	Eagle Tarn Sphagnum	Wetlands of state significance	Southern Ranges, 1 Ha
	Lake Kay	Wetlands of national significance	Central Highlands, 60 Ha
	Shadow Lake Sphagnum	Wetlands of national significance	Central Highlands, 1 Ha
Ouse	Allwrights Lagoon	Wetlands of national significance	Central Highlands, 6 Ha
Clyde	Interlaken Lakeside reservoir	Ramsar wetlands of national significance	Central Highlands, 520 Ha
	Robertsons Marsh	Wetlands of state significance	Central Highlands
	Kemps Marsh	Wetlands of national significance	Central Highlands, 213 Ha

Table 21 Wetlands of significance in the greater Derwent catchment. Source DPIWE 2003; DPIWE 2000.

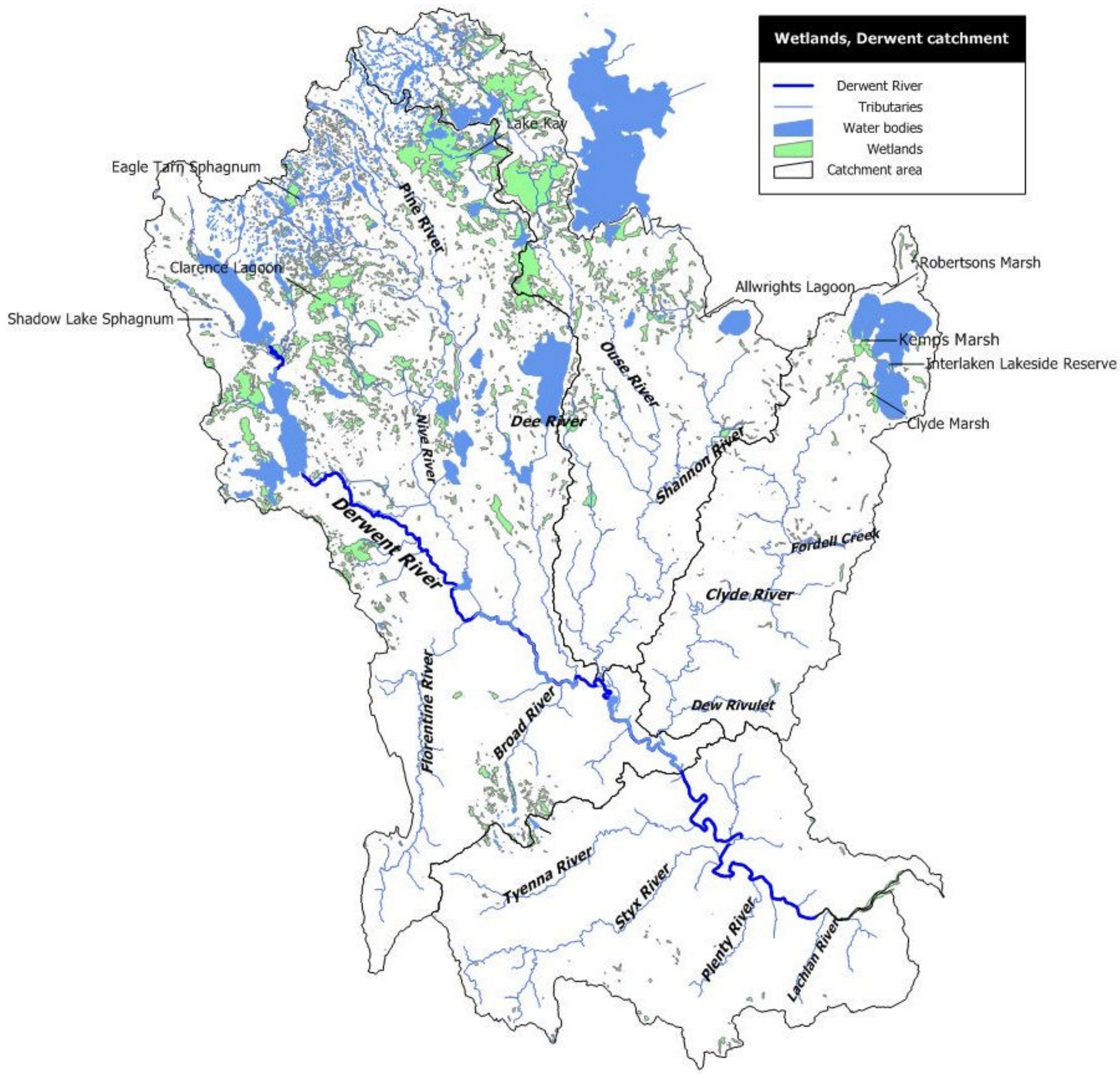


Figure 41 Location of wetlands of significance in the Derwent catchment (base data by CFEV, LIST ©State of Tasmania).

4.2.2 Geoconservation

Karst

Karst systems are associated with distinctive terrain, landforms and drainage characteristics resulting from the relatively high solubility of certain rock types in natural waters (DPIW, 2008a). The geological process of dissolution results in sinkholes, disappearing streams, springs and complex cave systems. In Tasmania Karst systems are strongly associated with limestone and dolomite areas with carbonate lithologies. These fragile ecosystems contain important biological communities uniquely associated with karst systems, including aquatic snails, worms, mites, crustacean, and blind cave beetles.

The Junee Cave major karst spring in the Tyenna River catchment near Mt Field National Park is one of the most extensive and hydrologically complex karst systems in Tasmania, and is fed by as many as 80 tributary stream sinks (see Figure 5) . Where streams re-surface, the water chemistry is often distinct from surrounding surface streams, with high concentrations of nitrate. Another karst system, Rough Hills occurs in the Clyde River catchment, but is considered to be in a disturbed state (CFEV database v1.0, 2005).

Glacial features

Glacial and perioglacial features are common on the Central Plateau and slopes of the Derwent catchment (Figure 42). These features reflect an important era in Tasmania's history and are recognized in the listing for the Tasmanian Southwest Wilderness World Heritage Area. The Cainozoic

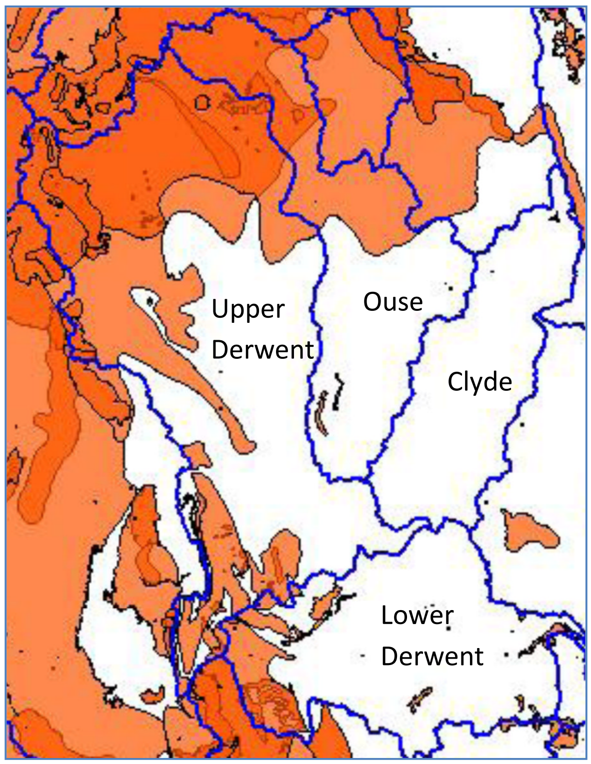


Figure 42 Areas of geoconservation significance in the Derwent catchment. Dark orange area in upper Derwent shows the Cainozoic glacial area, lighter orange area in upper catchment shows extent of Central Plateau Terrain. Geoconservation areas in the lower catchment include the Mt Field massif glacial area and the Junee-Florentine karst system.

glacial area, the Central Plateau Terrain and the Mt Field Massif Glacial Area are all recognized as significant geoconservation areas and listed in the Geoconservation data base (V7, DPIWE, 2008a;b). The Junee-Florentine karst system is also recognized for its geoconservation significance.

The Tyler Corridor

The Tyler corridor is named after the work of Professor Peter Tyler and other researchers, and describes a coarse scale biogeochemical "divide" within Tasmania. Surface water characteristics (pH, colour, ionic composition) vary with respect to their location relative to the Tyler corridor, with the following groupings used in the CFEV database:

- West of corridor – predominantly dark in colour, high in dissolved organic carbon and low in pH
- Within corridor – intermediate between the two states
- East of corridor – mainly low colour, low dissolved organic carbon and high pH

The classification of river sections and water bodies relative to the Tyler corridor are shown in Figure 43 (CFEV database v1.0, 2005). Only a small number of streams and waterbodies within the Derwent catchment are considered to have characteristics of the western group.

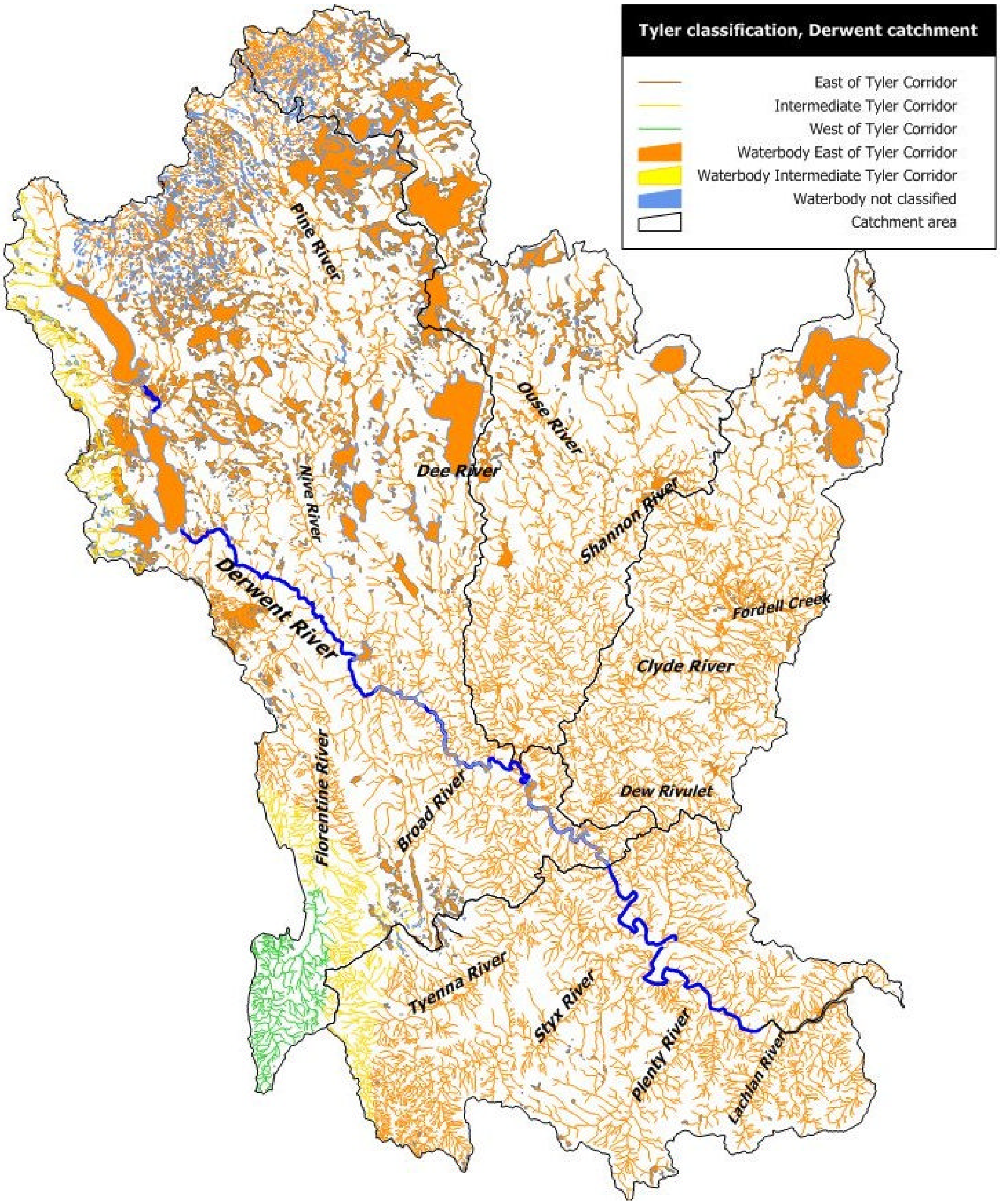


Figure 43 Tyler classification of river sections, lakes, and wetlands within the greater Derwent catchment (Base data by CFEV, LIST © State of Tasmania).

5 Water quality and quantity management

5.1 Overview

Water quality and water quantity are managed via the *Environmental Management and Pollution Control Act (EMPCA 1994)*, the *State Policy on Water Quality Management 1997*, and the *Water Management Act, 1999*. In addition, Hydro Tasmania holds a Special Water License which enables the company to manage water in six major river basins, including the Derwent.

5.2 Protected Environmental Values

Under the *State Policy on Water Quality Management*, the Protected Environmental Values (PEVs) of a catchment are identified, and water quality objectives (guidelines) are developed which ensure protection of these values. PEVs for the Derwent catchment were identified in 2003 (DPIWE, 2003) and a summary of protected values for the most common land tenure in the catchment is presented in Table 22. The PEV paper (DPIWE, 2003) should be consulted for a more detailed description of PEVs for other land tenure in the catchment.

PEV	Private Land	National Parks and Forest Reserves	Hydro-electric land	State Forests
Protection of aquatic ecosystems				
Pristine or nearly pristine		X		
Modified – from which fish are harvested	X		X	X
Recreational water quality				
Primary contact	X	X	X	X
Secondary contact	X	X	X	X
Aesthetics	X	X	X	X
Raw drinking water supply				
Subject to coarse screening and disinfection	X	X		X
Agricultural				
Irrigation	X			
Stock watering	X			
Industrial water supply				
Aquaculture, hydro-electric, Pulp and paper mill	X	X	X	X

Table 22. Summary of Protected Environmental Values (PEVs) for the Derwent River catchment. (DPIWE 2003).

5.3 Water quality guidelines

Physical and chemical water quality parameters such as turbidity, salinity, pH, dissolved oxygen and nutrients can be used to measure changes as a result of surrounding land use within a catchment, and these indicators are frequently monitored to identify and assess actual or potential ecosystem degradation (DPIW, 2008c). Water quality parameters such as heavy metals, pesticides and other contaminants that can exert a direct toxic effect are also used to determine water quality and catchment health. These parameters are generally not monitored on a catchment-wide scale, and limited data specific to a small number of sites are available.

A range of water quality guidelines have been developed and used by various stakeholders which reflect the PEVs of the catchments. The following national guidelines have been used in this report to assess water quality trends in the Derwent catchment:

- the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC, 2000) supply trigger values and expected values for a range of aquatic ecosystem conditions (high conservation/ecological value, slightly to moderately disturbed, or highly disturbed), and for a range of protection levels. These guidelines also refer to recreational and irrigation water quality;
- the Australian Drinking Water Guidelines (NHMRC , 2004) provide guidelines and information on acceptable water quality from a human health perspective, as well as aesthetic values.

Trigger levels from these guidelines are presented in Table 23 and Table 24.

Site specific trigger levels for 2 sites in the Derwent catchment monitored by DPIPWE have been developed to allow assessment of the current status of water quality (Table 25). The triggers were developed using data collected between 2003 and 2006 as part of the Baseline Water Quality Monitoring Program, from the Clyde and Tyenna Rivers. Neither site is considered suitable for use as 'reference condition' systems for slightly -moderately disturbed ecosystems, rather they are intended to be used to monitor change over time. Trigger levels apply to base-flow conditions, and are not necessarily applicable to high or very low flow events (DPIW, 2008).

Southern Water primarily use the Australian Drinking Water Guidelines to assess chemical, physical and microbiological water quality for domestic supply, but have also developed a range of operational targets for parameters that influence the treatment process (pH, turbidity, colour). These are summarized in Table 26 for the Bryn Estyn treatment plant. Turbidity levels in water extracted from the Derwent dictate the process stream at Bryn Estyn, with low turbidity water (< 8 NTU) requiring less treatment that high turbidity water. Guidelines for pesticides (environmental, and health) are summarised in Table 27.

Additionally, premises with licenses from either the local Council or the EPA will generally be required to operate within discharge limits for a range of parameters relevant to the expected impacts on the receiving environment. Details of individual permits are not described here.

Ecosystem type	Chlorophyll a (µg/L)	TP (µg/L)	FRP (µg/L-P)	TN (µg/L)	Nitrate + nitrite (µg/L-N)	Ammonia + ammonium (µg/L-N)	DO % saturation range	pH range	EC µS/cm range	Turbidity (lower/ upper NTU)
Upland River	No data	13	5	480	190	13	90 - 110	6.5 - 7.5	30-350	2 - 25
Lowland River	5	50	20	500	40	20	85 - 110	6.5 - 8	125-2200	6 - 50
Freshwater lakes & reservoirs	3	10	5	350	10	10	90 - 110	6.5 - 8	20 - 30	1 - 20
Wetlands	No data	No data	No data	No data	No data	No data	No data	No data	No data	No data

Table 23 Default trigger values for SE Australia, for parameters assessed in this report (ANZECC, 2000). pH values for humic rich Tasmanian rivers are 4.0 – 6.5

	Chloride (mg/L)	Copper (mg/L)	Hardness (mg/L Ca CO_3)	Iron (mg/L)	Nitrate / nitrite (mg/L)	Ammonia + ammonium (mg/L)	TDS (mg/L)	pH range	Sulphate (mg/L)	Turbidity NTU)
Health	No data	2	n/a	n/a	50 / 3	No data	n/a	4 - 11	500	No data
Aesthetic	250	1	200	0.3	n/a	0.5	500	6.5 - 8.5	250	5

Table 24 Australian Drinking Water Guidelines (2004). Note units are mg/L.

	Chlorophyll a (µg/L)	TP (µg/L)	FRP (µg/L-P)	TN (µg/L)	Nitrate / nitrite (µg/L-N)	Ammonia + ammonium (µg/L-N)	DO % range	pH range	EC uS/cm range	Turbidity NTU range
Clyde River ds Crescent	No data	175	5	3500	566 / 3	115	86 - 106	6.5 - 7.4	117 - 135	-/175
Tyenna at Newbury	No data	17	4	362	74 / 2	10	93 - 104	7.2 - 8.0	95 - 178	7

Table 25 Site specific "current status" trigger values developed for Derwent catchment sites, using 2003-2006 data (DPIW, 2008).

	Colour (Hazen units)	Turbidity (NTU)	pH range
Operational	< 70	< 8[7]	6.5 – 8.5

Table 26 Operational targets for Bryn Estyn at intake (Hobart Water, 2006).

[7] > 200 NTU triggers shut- down of intake valve at Bryn Estyn.

Chemical	ANZECC guideline (µg/L)	ADW guideline (µg/L)	ADW health value (µg/L)	Analytical detection limit (µg/L)
Alpha-cypermethrin**	-	-	-	0.1
Atrazine	0.7***	0.1	40	0.05
Chlorothalonil	-	0.1	30	0.1
Clopyralid	-	1000	1000	0.1
Chlorpyrifos	0.00004***	-	10	0.1
Fenitrothion	0.1***	-	10	0.1
Glyphosate	370	10	1000	10
Haloxyfop-methyl**	-	-	-	0.05
Hexazinone	75*	2	300	0.05
MCPA	1.4*	-	2 (WHO)	0.1
Metsulfuron-methyl	8 *	-	30	0.1
Pendimethalin	-	-	300	0.1
Permethrin	-	1	100	0.1
Picloram	-	-	300	0.1
Simazine	0.2***	0.5	20	0.05
Spinosad**	-	-	-	0.1
Sulfometuron-methyl**	-	-	-	0.1
Terbacil	-	10	30	0.1
2,4-D	140***	0.1	30	0.1

Table 27 Summary of pesticide guideline values for suite monitored in Tasmania. * low reliability interim value-see ANZECC; ** analysed by SW/DPIW but no guideline available; * 99% protection level –see ANZECC (2000).ADW = Australian Drinking Water guidelines.**

5.4 Water Management Plans

Water Management Plans have been completed for the River Clyde (DPIWE & IFS, 2005b) and Lakes Sorell and Crescent (DPIPWE & IFS, 2005a). The Plans identify environmental objectives for the catchment and specify operating rules and lake level ranges to achieve these aims. This water quality analysis reflects the flow regimes mandated by these water management plans, but does not specifically review the impact of the Plan on water quality issues.

The current level of water allocations in the catchment is considered moderate, and an absolute cap has been placed on surface water usage (see Section 3). Future allocation pressures are expected due to an increase in demand for drinking and town water supply, agriculture and industry.

5.5 Rivercare and Conservation Action Plans

A number of Rivercare or River Recovery plans have been prepared for tributaries of the Derwent (Ouse, Shannon, Clyde, Plenty Rivers, Dew Rivulet; Greening Australia 2008; 2009a; 2009b; 2010). These plans are based on detailed geomorphological assessment of the tributaries, along with an assessment of land-use or management practices that affect riparian condition and water quality. In addition, a Conservation Action Plan for the lower Derwent River which includes the lower reaches of the Broad, Tyenna, Plenty and Styx Rivers, is currently being prepared by Greening Australia to provide a targeted approach to a number of environmental issues in this section of the Derwent. Threats to water quality was highlighted as a key issue in the development of the CAP.

5.6 Hydro Tasmania management and issues

The Special Water License held by Hydro Tasmania enables the company to manage water resources in the Derwent for the production of hydro-electricity, and outlines obligations of the company to supply water for irrigation schemes in the Great Lake and South Esk Derwent Catchments, including some allocations in the Ouse catchment which are undefined (Hydro Tasmania, 2010). The Special Water License also outlines water quality and flow monitoring requirements and reporting.

As manager of much of the flow in the Derwent, Hydro Tasmania has a long-history of investigating and managing water quality issues in the Derwent associated with flow modifications. Water quality strategies employed by Hydro include the maintenance of minimum water levels in lakes and minimum flows in some reaches, such as the lower Derwent for maintenance of fresh water at the Bryn Estyn off-take. Recent water quality investigations of Hydro Tasmania include:

- Low lake levels: During the recent (and historic) droughts, Hydro Tasmania has conducted water quality monitoring at numerous lakes within the Derwent during periods of low lake levels. These include Lake Echo, Lake King William, Arthurs Lake and Woods Lake;
- Algal blooms: Monitoring for algal blooms in Dee Lagoon, Bradys Lake, Lake Binney, Catagunya and Meadowbank Dam was initiated by the Hydro after algal blooms were detected in Lake Echo;
- Lagoon of Islands: Poor water quality in the Lagoon associated with nutrient levels and algal blooms has been an on-going problem, and has been monitored extensively. A

strategy to improve water quality and the condition of the Lagoon is being developed by Hydro Tasmania (Hydro Tasmania, 2008; *M. Egerrup, pers. comm*).

The results from some of these investigations are included in the data analysis in PART 2 of this report.

6 Known inputs to the Derwent and identified water quality threats

6.1 Land Use driven inputs

The multiple of land uses in the Derwent River catchment results in a wide range of potential pollutant sources. Recognised pollution sources include sewage effluent, organic wastes, nutrients and pesticides, oil spills, leachates from rubbish dumping, fish farm effluents, chemical use within forestry areas, and erosion from agricultural and other disturbances (Hobart Water 2006).

Hobart Water (2006) identified the following impacts as concern to maintaining water quality:

- Stormwater runoff from impervious areas such as roads and carparks
- Agricultural fertiliser usage and increased runoff from gardens, gardens golf courses, race-tracks, ovals and other recreational areas
- Nutrients, soil sediments, chemicals as a result of washing down vehicles and machinery and the use of detergents
- Sediment loss from construction sites and unsealed roads
- Septic tank discharge
- Discharge from waste water treatment plants
- Leachate and runoff from landfill site, industrial areas (e.g. petrol stations).

Few details are available concerning the quantity or extent of these impacts. Information which is available is summarized in the following sections, along with a discussion of potential impacts associated with each activity.

6.2 Sewage Treatment Plants

Location	Description	Comments
Arthurs Lake	Level 1 WWTP	No re-use
Gretna	Level 1 WWTP	Maxicon, no re-use
Maydena	Level 1 WWTP	Imhoff tank, trickle filter and chlorination, no re-use
Hamilton	Level 1 lagoon	Three-cell lagoon with aeration in primary cell, no re-use
Ouse	Level 1 lagoon	Single cell lagoon with sand filter, no re-use
Karanja	Level 1 lagoon	Two settlement lagoons, no re-use
Wayatinah	Level 1 WWTP	
Wayatinah Caravan Park	Level 1 WWTP	Ossiklean system
Derwent Bridge Wilderness Resort	Level 1 WWTP	Effluent disposed through spray us of discharge.
Flintstone	Level 1 WWTP	Intermittent aeration
Tarraleah	Level 1 WWTP	
Hayes Prison farm	Level 1 WWTP	2 settling ponds, chlorination, no re-use
Mt Field	Level 1 WWTP	Double lagoon system
Bothwell	Level 2 lagoon	Two-cell lagoon, secondary treatment, re-use since 2005.
New Norfolk (Turiff Lodge)	Level 2 WWTP	No reuse
Lake St Clair (Cynthia Bay)	Level 2 WWTP	Tertiary treatment, no reuse

Table 28 Waste water treatment plants within the Derwent catchment and brief summary of treatment level (Hobart Water 2006).

There are 16 identified wastewater treatment plants located within the Derwent River catchment, 14 of these within the Hobart Drinking Water Catchment. These are listed in Table 28. Issues associated with STPs include: increased nutrient and noxious algal growth downstream, the spread of water borne viruses and bacteria, and risks to recreational contact (primary contact). Increased suspended solids or oxygen demand may also be associated with some STP effluents.

6.3 Level 2 activities

Level 2 activities are listed under Schedule 2 of EMPCA (1994), and include larger industries, mining, or other activities deemed to have a greater potential to cause significant environmental harm than Level 1 activities. A summary of the Level 2 activities regulated by the EPA in the Derwent catchment are listed in Table 29, along with the production limit associated with each permit. The majority of activities listed are extractive or materials handling facilities (category 5), commonly rock/gravel pits and associated crusher facilities. Two mines (coal, peat) are located in the catchment.

Premises such as waste depots and refuse disposal sites have potential to generate contaminated leachates, which may impact both surface and groundwater (Ezzy, 2002). The number and location of historic tips and landfills is not known (Hobart Water, 2006).

6.4 Forestry

Forestry activities within the greater Derwent catchment are predominantly based on native forest production with a relatively low area of plantations occurring in the catchment (see *Land Use*). The lower Derwent has the greatest area under softwood (pine) plantations (Table 20).

The main water quality concerns associated with forestry operations are increases in turbidity and suspended solids associated with harvesting or access routes, and the use of chemicals such as pesticides (herbicides and insecticides) on plantations (*S. Roberts, pers comm*). Addition of nutrients through fertiliser use, impacts from burning and clearing of vegetation are other impacts associated with forestry activity. In Tasmania, the forest practices system is regulated on both public land (mainly State forest) and private land, through the Forest Practices Authority. Formal agreements between FPA, the EPA, and DPIPWE assist in the management of pollution, smoke, and threatened species are in place to assist in matters overlapping jurisdiction. Forest Management Plans for each district describe management priorities for State forest and other land managed by Forestry Tasmania (Forestry Tasmania, 1999).

6.5 Agriculture

Grazing and agriculture accounts for approximately one quarter of all land use in the Derwent catchment, and can contribute to poor water quality through land clearing, waste water discharges, and removal of riparian vegetation. High nutrient levels may be associated with agricultural land use, stock access to waterways, willows, and water extraction for irrigation. Land use mapping (Figure 39) shows the eastern, drier part of the catchment, and low lying areas have a greater percentage of land used for agriculture and grazing, with the Clyde having almost 70% in this category.

Activity	Location	Activity	Production limit
1A1	New Norfolk	Biodiesel plant	738 t/yr
2F	Boyer	Pulp and paper facility	310,000 t/yr
2G	Karanja	Sawmill	999 m^3/yr
2G	Boyer	Timber processing plant	15,000 m^3/yr
2I	Boyer	Woodchip mill	25,000 t/yr
3A	Turiff Lodge	Wastewater treatment plant	4,100 kL/day
3A	Bothwell	Wastewater treatment plant,	155 kL/day
3A	Lake St Clair (PWS)	Wastewater treatment plant	120 kL/day
3B1	Bothwell	Refuse disposal site	300 t/yr
3B1	New Norfolk	Refuse disposal site	65,00 t/yr
3B2	Hamilton	Waste depot	2,400 t/yr
3B2	New Norfolk	Waste depot	6,500 t/yr
3C1	Salmon Ponds	Composting site	50,000 t/yr
4A	Bushy Park	Hop kiln and a hop pellet plant	200 t/yr
5A	Lake Repulse	Quarry	8,000 m^3/yr
5A	Arthurs Lake	Quarry and crusher	5,000 m^3/yr
5A	Bothwell	Gravel pits	10,000 m^3/yr
5A	Hamilton	Quarry	10,000 m^3/yr
5A	Interlaken	Quarry	5,000 m^3/yr
5A	Ellendale	Quarry	20,000 m^3/yr
5A	Nive plains	Quarry	5,600 m^3/yr
5A	Karanja	Quarry and crusher	18,000 m^3/yr
5A	Molesworth	Quarry	5,600 m^3/yr
5A	Maydena	Quarry and crusher	5,000 m^3/yr
5B	Lachlan	Gravel pit	6,200 m^3/yr
5B	Bothwell	Gravel pit	15,000 m^3/yr
5B	Interlaken	Gravel pit	10,000 m^3/yr
5C	Hamilton	Colliery	200,000 t/yr
5C	Browns Marsh	Peat mine	5,000 t/yr
6A2	Butlers Gorge	Materials handling ;quarry and crusher	10,000 m^3/yr
6A2	Bothwell	Quarry and materials handling crushing	5,000 m^3/yr
6A2	Lake Echo	Quarry and crusher	3,000 m^3/yr
6A2	Bothwell	Quarry, crusher and gravel pits	12,000 m^3/yr
6A2	Lake Echo	Quarry and crusher	24,000 m^3/yr
6A2	Catagunya dam	Quarry	10,000 m^3/yr
6A2	Lachlan	Quarry	20,000 m^3/yr
6A2	Wayatinah	Quarry and crusher	5,000 m^3/yr
6A2	Mt Lloyd	Quarry and crusher	5000 m^3/yr
6A2	Lachlan	Quarry and crushing plant	10,000 m^3/yr
7A	Meadowbank	Supplementary power generation plant	7.3 t/hr
7A	Wayatinah	Supplementary power generation plant	4.8 t/hr

7F	Waddamana	Wind farm	225 MW

Table 29 Level 2 activities for the Derwent catchment.

6.6 Pesticides

Presence of pesticides is generally due to direct application to the environment through agricultural or domestic activities (Coughanowr, 2001). Pesticide usage may result in movement into waterways, via spray drift, accidental spillage, agricultural runoff after rain or via atmospheric deposition. In a broader context, pesticide use can reflect industry and agronomic trends, including over-use and the development of pesticide resistance in target species, and the effectiveness of integrated pest management strategies designed to reduce pesticide use (Bendor et al, 2008).

Pesticides are used in forestry plantations to reduce weed and pest infestations, thus enhancing growth rates and survival of plantation species (Roberts, 2010). Herbicides are used to remove weeds that compete for light, moisture, space and nutrients, both before and after seedlings are planted. Where soil nutrient levels are low, fertilisers may also be applied (Roberts, 2010). Except in rare circumstances, chemical treatments are not used in native forests.

Extensive monitoring of pesticide usage, and the development of the Pesticide Impact Rating Index (PIRI) risk assessment tool have resulted in a review of both the type of pesticides used in forestry operations, and the way water quality monitoring is undertaken. Pesticide use is generally highest in spring and summer for food crops, whilst forestry operations may use pesticides year-round in hardwood and softwood plantations (Bendor et al, 2008).

Coughanowr (2001) reported detectable levels of organochlorine pesticides had been detected in brown trout (*Salmo trutta*) in the upper Derwent estuary in 1989, however no systematic follow up monitoring of pesticide residues in fauna with in the catchment seems to have been undertaken. Organochlorine pesticides may bioaccumulate through the food chain, thus resulting in secondary toxicity to no-target species.

6.7 Fish farms

Fish hatcheries in the Derwent use large volumes of water in both through-flow and recirculation operations. Water quality concerns associated with fish hatcheries include nutrient enrichment, particularly with respect to the release of biologically available nutrients such as phosphate and ammonia, organic enrichment, pathogens, increased turbidity and total suspended solids and the release of therapeutic agents used in managing fish health.

Monitoring of nutrients in by DEP as part of the Upper Derwent Nutrient Study found increased levels of nutrients, particularly phosphate and ammonia in waters downstream of fish farms on the Tyenna River (Coughanowr, 2001), details of which are presented in PART 2. No follow up assessment appears to have been done to determine the current status of fish farm effluents.

6.8 Threats to natural systems and conservation areas

Within parks and conservation areas, there are a number of potential water quality threats, including:

- the establishment of tracks, camp grounds, roads, houses and facilities within surface water catchments may cause enhanced loads of suspended solids;
- infrastructure such as visitor centres, lodges etc. may lead to potential for risks associated with stormwater and sewage discharge (Davies and Driessen, 1997), leading to mild nutrient enrichment or increased bacteria and pathogen loads;
- broad-scale erosion on the Central Plateau (associated with grazing, fire and rabbits) has been identified as adversely impacting hydrology, water quality, and aquatic habitats through increased sediment delivery to wetlands, rivers and dams;
- threats to wetland water quality include altered flow regimes due to draining or damming, impacts due to surrounding land use activities such as grazing or forestry;

6.9 Climate change

Flows in the lower Derwent River are regulated by discharge from the Meadowbank Power Station. Climate change (through sea level rise, rainfall variation and associated changes in flow regulation and abstractions) poses a threat to the reliability of the freshwater resource due to encroachment of the salt wedge into the lower Derwent. Regional variation in rainfall is predicted within the Derwent catchment, which will have some significant impact on storage reliability in the eastern, drier part of the catchment. Changes to the seasonality and intensity of rainfall are predicted, however the resulting stress to ecological communities has not been well defined.

6.10 Salinity

Significant areas of the Clyde and Ouse catchments between Hamilton and Ouse are affected by salinity, resulting in an increase in electrical conductivity and change in ionic composition of both surface and groundwater. The region around Hamilton is where groundwater intersects saline Triassic or Permo-carboniferous sedimentary rock (Andrew, 2002). Increased EC in tributary streams of the Clyde have been recorded, and if levels elevate sufficiently, then both the natural environment and the potential use of the water (e.g. irrigation and stock watering) are impaired.

6.11 Impacts of regulated flow regimes

The Derwent catchment has undergone significant flow modification. Alterations to flow regimes, including diversion, storage, channeling and pumping affect the five flow components which control water quality and ecological functioning : flow magnitude, flow duration, flow frequency, rate of water level rise and fall, and seasonality. For example, significant reductions in flow have the potential to increase water temperature and limit the amount of habitat for aquatic fauna, especially in warmer months (DPIW, 2008a). Similarly, the altered seasonality of the Upper Clyde River can affect downstream water quality and ecological processes. Decreased water flow can also promote the growth of noxious weeds and increase impacts associated with run-off or municipal or industrial discharge.

Water storages affect the movement of water downstream, and the cycling of nutrients and metals due to seasonal thermal stratification and associated reduction of oxygen levels at depth. Storages may also interfere with the migratory movements of native species, by physically preventing up or downstream movement during critical events such as reproductive cycles. For example, elvers migrating up the Derwent River between late November and mid-February are captured at Meadowbank and transported upstream into other catchments. (Hydro Tasmania, 2010).

Fluctuation in water levels in managed lakes and storages can impact water quality. Low lake levels in several catchments have been associated with increased suspended sediment and turbidity and nutrient levels. Once mobilized, the suspended sediment and nutrients may be transported downstream as flow is managed through connected impoundments. This also have the potential to spread algal blooms downstream. Populations of native fish (galaxids) have also been identified as being at risk from low water levels, following isolation of ponded of water as water levels declined (Hydro Tasmania 2008).

Fluctuating lake levels can also affect the aesthetics of the environment, through the exposure of denuded 'bath-tub-rings' and / or the inundation of lake shore vegetation. Exposed lake beds can also be a source of wind induced dust. Lake level and local management strategies can often be of intense public interest, and can contribute significantly to how lakes and storages are operated.

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Detailed data analysis on datasets made available for this project is presented in PART 2 of this document, with discussion, summary and recommendations in PART 3. References for all sections are located at the end of PART 3.