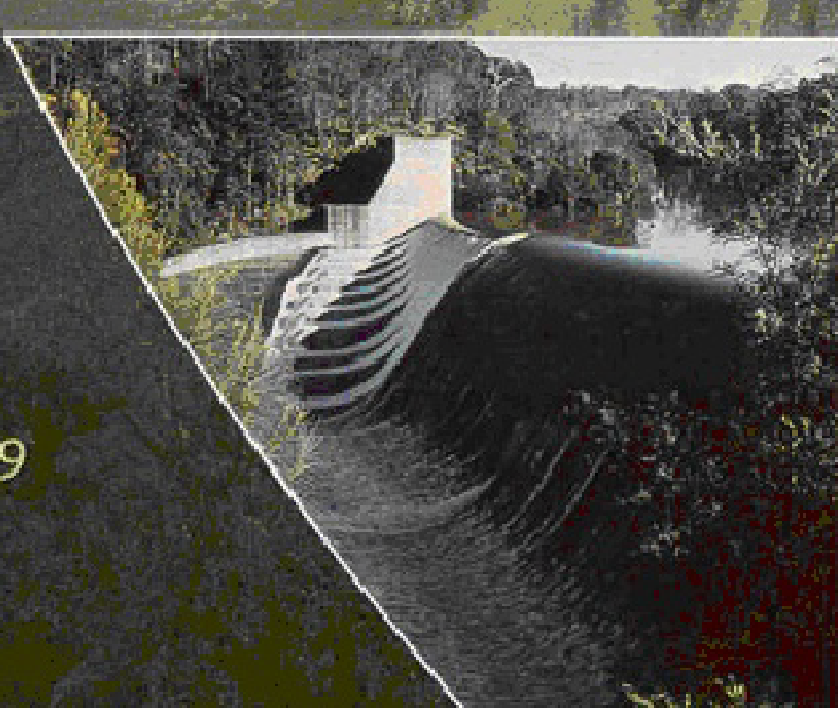
Environmental Review

South Esk – Great Lake Hydro Catchment



November 1999

Hydro

EXECUTIVE SUMMARY

This Environmental Review document is the first of a series which comprehensively describe Hydro operations and provide an overview of related aquatic environmental issues in each of its major catchments. This document fulfils some key commitments of the Hydro's Aquatic Environmental Policy. It will also assist the general public in understanding Hydro operations and issues in the South Esk – Great Lake catchment, as the Hydro commences its Water Management Review in this catchment area.

The South Esk Basin is the largest water catchment in Tasmania, making up almost 15% of Tasmania's land mass. The Basin is comprised of the catchments of the South Esk, Macquarie and Meander Rivers. Water from the Great Lake catchment, which lies on Tasmania's Central Plateau, is diverted into the South Esk Basin for the purposes of hydro-electric power generation.

The Poatina Power Scheme utilises water from the Great Lake catchment, Arthurs Lake (originally in the upper Macquarie River sub-catchment), and diversions of the upper Ouse River, the upper Liffey River and Westons Rivulet – upper Brumbys Creek. It consists of three main storages (Great Lake, Arthurs Lake and Lake Augusta), two power stations (Poatina and Tods Corner) and other water diversion and transfer infrastructure. Also associated with the Poatina Power Scheme is another storage, Woods Lake, the primary function of which is to store water for irrigation. The Poatina Power Scheme diverts between 620 and 730 Mm^3 per year of Great Lake water from the Derwent catchment, via Poatina Power Station, into the South Esk catchment.

The Trevallyn Power Scheme utilises water from the entire South Esk catchment, harnessing the South Esk, Macquarie and Meander Rivers, and re-using water from the Great Lake catchment discharged from Poatina Power Station. The scheme consists of one small storage, Lake Trevallyn, and the Trevallyn Power Station. Water from the power station is discharged into the Tamar Estuary.

The Poatina Power Scheme accounts for 12.1% of Tasmania's long term average power output (142.7 MW), and the Trevallyn Scheme makes up 4.9% (57.5 MW).

The environmental issues relating to the hydro-electric schemes in the South Esk – Great Lake catchment have been outlined in four major categories in this document. These are water quality, biological, geomorphological and multiple use.

Water quality issues in the South Esk – Great Lake catchment are mostly found in the lowlands. Issues which are created by land management practices include high levels of metals in the upper South Esk River above Lake Trevallyn; elevated nutrient concentrations and faecal indicators at isolated sites in the Macquarie River; and bacteriological contamination and potential nutrient problems in Lake Trevallyn. While these particular issues are not created by Hydro operations, they are influenced by the flow variability, and are relevant to the Hydro's operations of Lake Trevallyn as the receiving water body.

Water quality issues in the South Esk and Great Lake catchments that <u>are</u> influenced by Hydro operations include: cool water releases out of Hydro storages; naturally high turbidity and nutrient levels in Woods Lake; slightly elevated turbidity and nutrients in the Lake River resulting from releases from Woods Lake; dilution of water in Back Creek and Brumbys Creek as a result of Poatina discharge; and the potential for stratification of Lake Trevallyn. The Hydro has been managing the level of Woods Lake since 1995 to mitigate the water quality problems.

Biological issues in the South Esk – Great Lake catchment that are known to be affected by Hydro operations include the impact of Trevallyn dam on fish migration, and the effect of high turbidity levels on the saddled galaxias in Woods Lake. The Hydro has installed an elver ladder on Trevallyn Dam to assist in the migration of juvenile eels, and manages the level of Woods Lake to alleviate turbidity.

There are a number of biological issues where the Hydro's influence has not been fully investigated. These include the algal beds and associated unique fauna in Great Lake; the rare freshwater snail species in the Cataract Gorge; the infestation of Central Highland lakes by the exotic weed *Elodea*; separation and translocation issues with native galaxiid populations in Arthurs and Woods lakes; and infestation of waterways with redfin perch.

Known geomorphological issues related to Hydro operations in the Great Lake and South Esk catchment include erosion in Brumbys Creek and minor erosion in Liawenee Canal. Other issues that have not been investigated in relation to Hydro operations are erosion of unique wind-formed lunettes at Lake Augusta; erosion on western shore of Great Lake; and erosion in the Macquarie River.

Multiple use issues occur mostly in relation to conflicting demands from irrigators and anglers and requests from recreational users. Little is known with regard to Hydro influence on cultural heritage sites.

The Hydro is addressing aquatic environmental management issues as part of its ongoing Aquatic Environment Program, which puts into practice commitments made in the Hydro's Aquatic Environmental Policy. Important initiatives are:

- the Waterway Health Monitoring Program;
- targeted investigative studies of issues such as fish migration, threatened species, environmental flows, Brumbys Creek remediation, the Trevallyn Dam elver ladder, and impacts of Basslink; and
- the Hydro's Water Management Review, which will examine current and potential future Hydro operations in light of community issues and concerns, aiming to produce a plan for sustainable water management practices.

ACKNOWLEDGMENTS

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Compilation, writing and editing of this document was coordinated by Helga Pirzl from the Hydro's Environmental Services section. Helen Locher provided valuable guidance and advice on the document as a whole. Assistance in compiling the document was given by Noel Carpenter and Jacqueline Griggs.

The environmental issues chapters were primarily written by Mick Howland, David Blühdorn, Jacqueline Griggs and Helga Pirzl from Hydro Environmental Services, and substantial information was compiled by Lois Koehnken of Technical Advice on Water, and Rachelle Padgett of the University of Tasmania Geography Department. Stephen Stolp from Hydro Systems Control provided advice on Hydro operating practices.

In addition, Dave Graddon from Hydro Environmental Services provided advice on mapping; members of Hydro Water Resources assisted by providing hydrological data and analysis; and members of the Department of Primary Industry Water and the Environment and the Inland Fisheries Commission gave advice on numerous issues.

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LIST OF ABBREVIATIONS

ANCOLD	Australian National Committee on Large Dams
ANZECC	Australian and New Zealand Environment and Conservation Council
ARMCANZ	Agriculture and Resources Management Council of Australia and New Zealand
ASFB	Australian Society for Fish Biology
AUSRIVAS	Australian Riverine Assessment System
$CaCO_3$	calcium carbonate
CAMBA	China-Australia Migratory Bird Agreement
COAG	Council of Australian Governments
DELM	Department of Environment and Land Management
DNRE	Department of Natural Resources and Environment (Victoria)
DPIF	Department of Primary Industries and Fisheries
DPIWE	Department of Primary Industry, Water and Environment
EC	electrical conductivity
ESPA	*Endangered Species Protection Act* 1992 (Commonwealth)
ESAA	Electricity Supply Association of Australia
FNARH	First National Assessment of River Health
FSL	full supply level
HEC	Hydro-Electric Commission/Corporation
IFC	Inland Fisheries Commission
IFCBC	Inland Fisheries Commission Biological Consultancy
IFIM	Instream Flow Incremental Methodology
IUCN	International Union for the Conservation of Nature
JAMBA	Japan-Australia Migratory Bird Agreement
kW/m^3	kilowatt per cubic metre
LCC	Launceston City Council
mASL	metres above sea level
mg/L	milligrams per litre
m^3/s	cubic metres per second (cumecs)
Mm^3	mega cubic metres (10^6 cubic metres)
MW	megawatt
NMOL	normal minimum operating level
NRHP	National River Health Program
NTU	Nephelometric turbidity units (measure of turbidity)
PEV’s	Protected Environmental Values
PWS	Parks and Wildlife Service

RIVPACS	Riverine Predictive Model for Assessing River Health (Britain)
RWSC	Rivers and Water Supply Commission
STP	Sewage Treatment Plant
TALC	Tasmanian Aboriginal Land Council
TASPAWS	Tasmanian Parks and Wildlife Service
TDSC	Tasmania Dams Safety Committee
TFGA	Tasmanian Farmers and Graziers Association
TKN	total kjedhal nitrogen (measure of nitrogen)
TSPA	*Threatened Species Protection Act* 1995 (Tasmania)
µS/cm	micro Siemens per centimetre (measure of conductivity)
WHMP	Waterway Health Monitoring Program (Hydro)

1. INTRODUCTION

1.1 Purpose of this Document

This Environmental Review document is the first in a series of six documents that report on each of the Hydro-Electric Corporation's (Hydro's) six major catchment areas. This 'Environmental Review' series is part of the Hydro's Aquatic Environment Program, the main purpose of which is to meet commitments of the Hydro's Aquatic Environmental Policy. The Hydro developed an Environmental Policy in 1992, and an Aquatic Environmental Policy in 1998, in which it has undertaken to manage the resources it controls in a responsible and sustainable manner. These policies are included as Appendix 1.

The Aquatic Environmental Policy recognises that water is central to the Hydro's business, and emphasises sustainable management of this resource. Under this policy, the Hydro recognises the modifications that its developments have made to the environment. The Hydro commits to responsible environmental management by operating its business in a way that takes into account community views and values, and aims to maintain healthy functioning of aquatic ecosystems. The Hydro endeavours to proactively comply and cooperate with relevant environmental policies and legislation. It commits to making good water management decisions, based on consultation with the community, with other government organisations, and based on good scientific information. The Hydro is also committed to reviews of environmental performance.

This document clearly demonstrates institutional commitment to these policy statements. It presents the Hydro infrastructure and operations in the South Esk – Great Lake catchment in a manner readily understandable by the general public, and openly identifies the impacts and issues surrounding Hydro operations on aspects of the aquatic environment, in-so-far as the Hydro is aware of these issues at the time of writing of this document.

More importantly, release of this document to the general public is a key first step in a review being undertaken by the Hydro of its water management practices. The new Tasmanian *Water Management Act* 1999 allows for the development of Water Management Plans. The Hydro's review of its water management practices is being undertaken in conjunction with the Department of Primary Industry Water and the Environment (DPIWE) and the community, in a manner which will enable the results to be incorporated into DPIWE Water Management Plans for the relevant catchments. At the same time, implementation of the State Water Quality Policy is under way. This policy requires the setting of environmental values for each waterway, and the Hydro is proactively cooperating with DPIWE in this process.

The Hydro's Water Management Review will systematically consider all its operations in Tasmania. The South Esk – Great Lake catchment is the first catchment area to be reviewed.

1.2 Report Content

This document broadly falls into two main parts.

Background information and context are provided in chapters 2 to 4, with a description of the catchment (Chapter 2), a description of the power developments in the catchment (Chapter 3), and an outline of the operation of the Hydro system in the catchment (Chapter 4).

Aquatic environmental issues in the South Esk and Great Lake catchments are discussed in chapters 5 to 8. These issues are divided into water quality (Chapter 5), biological issues (Chapter 6), geomorphological issues (Chapter 7) and multiple use (Chapter 8).

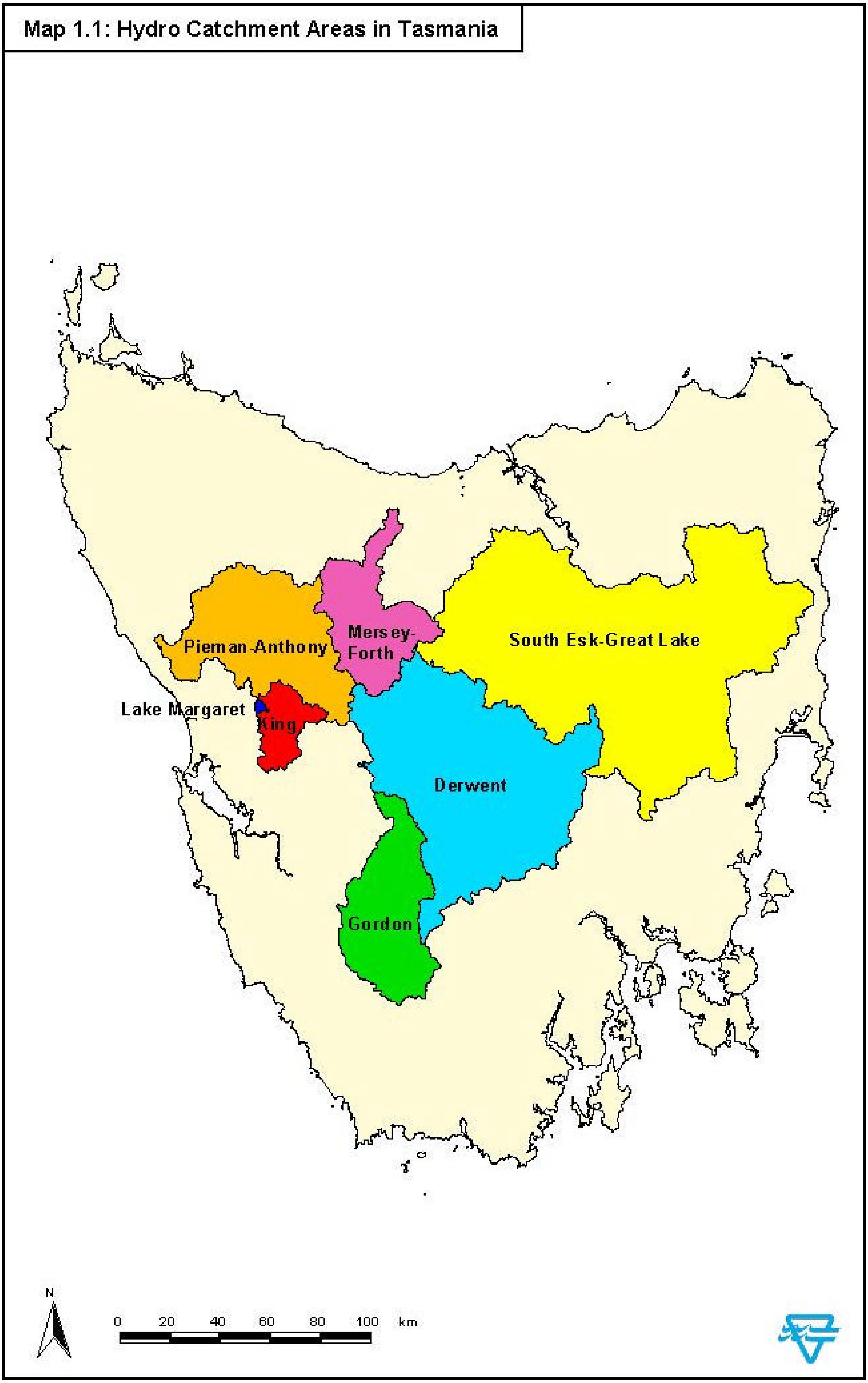
A report summary is provided in Chapter 9.

As already stated, this document is the first of six Environmental Review documents. Similar documents are being produced for the Derwent, Mersey – Forth, Pieman – Anthony and Lake Margaret, King and Gordon Hydro catchments. The six Hydro catchments in Tasmania are shown in Map 1.1. The other documents in this series will follow the same format, and be released to the public as they are completed.

1.3 Uses of this Document

These documents are intended to provide the readers with an overview of catchment features and aquatic environmental issues relevant to Hydro operations for their respective catchments. They do not attempt to record every detail of information available, but rather to make the reader aware of the information that exists, some summary information, and where to find further details. This document summarises the extent of information known to the Hydro at the time of writing of this report. It is expected that members of the community will be able to add additional information on impacts and issues relevant to Hydro-affected waterways in this catchment.

The information contained in this first report is current as of October 1999 and will provide the framework against which any future reviews can be compared. Much of the information in the background section will not need to be updated, except perhaps some of the operating agreements and rules if they have changed within that period. Input of any additional information is welcomed for inclusion in future updates of this document.


Map 1.1: Hydro Catchment Areas in Tasmania
Pieman-Anthony
Mersey-Forth
South Esk-Great Lake
Lake Margaret
King
Derwent
Gordon
N
0
20
40
60
80
100
km

2. CATCHMENT DESCRIPTION AND LAND USES

2.1 Overview

The South Esk Basin is the largest water catchment in Tasmania, covering an area of approximately 8,900 km^2 (Rivers and Water Supply Commission, 1992), which is almost 15% of Tasmania's land mass. It is located in the north-east and midlands of Tasmania. Its principal sub-catchments are the South Esk, Macquarie and Meander Rivers. Water is also diverted into the South Esk Basin from the Great Lake catchment, which lies in the Central Plateau region of Tasmania. A location plan of the catchments showing tributaries and major towns is provided in Map 2.1. Climate, geology, topography and soils, vegetation and land use are described separately for the Great Lake and South Esk catchments in the following sections.

2.2 Climate

Tasmania experiences a cool maritime climate. Situated between latitudes of approximately 41° S and 43° S, the State is positioned on the northern edge of the 'Roaring Forties', a band of moist westerly air stream, which dominates the climate.

Rainfall in the South Esk Basin is variable, with annual averages ranging from 510 mm at Ross to 1200 mm at Gray on the eastern-most catchment boundary. Precipitation may fall as snow in the upper catchment, most commonly in winter. The Macquarie sub-catchment in the northern midlands is drought-prone, with large areas receiving less than 600 mm annual rainfall. Mean minimum and maximum temperatures at Campbell Town in the South Esk catchment range from 0.3 °C to 12.4 °C in winter, and 8.1 °C to 24 °C in summer (http://www.bom.gov.au/climates/averages, 1998).

The Great Lake region experiences a pronounced precipitation gradient. Average annual precipitation varies from 2000 mm in the west and north-west, to 800 mm in the south-east (Pemberton, 1986). Snow accounts for up to 30% of precipitation. Mean minimum and maximum temperatures range from 6 °C to 18 °C in summer, and from -1 °C to 6 °C in winter, although temperatures below -10 °C are common (Pemberton, 1986).

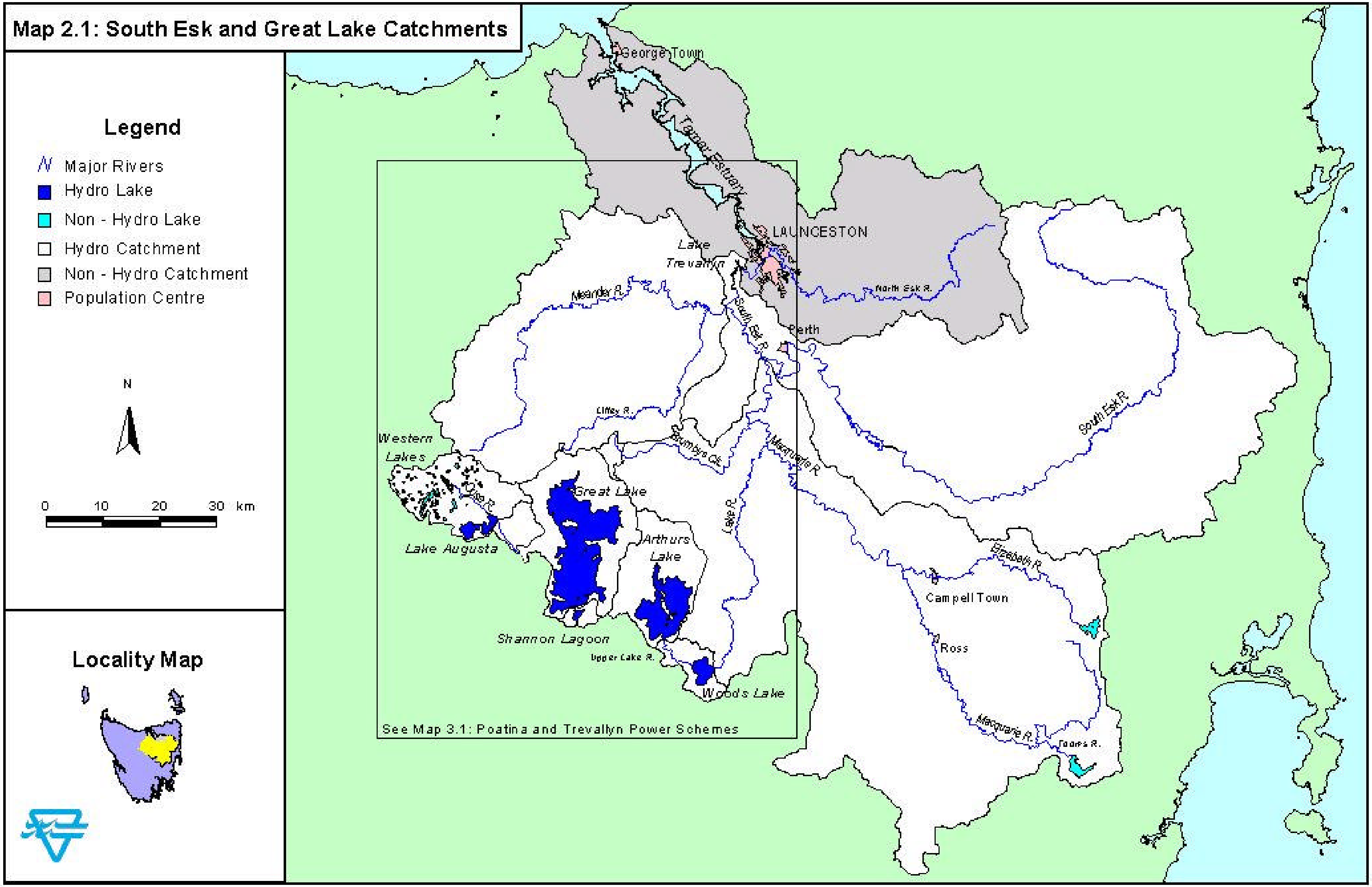
2.3 Geology, Topography and Soils

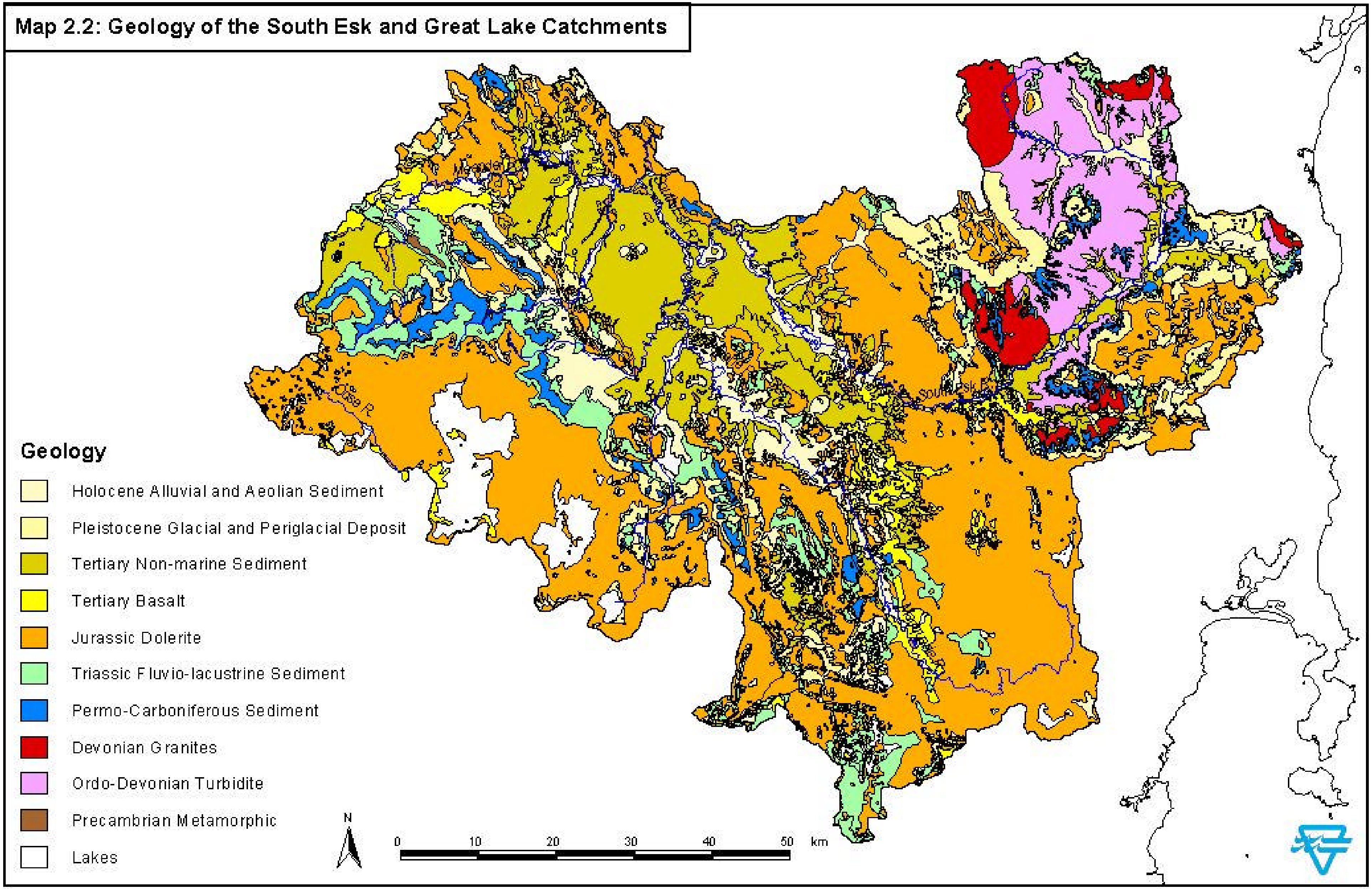
Following is a brief description of the geology, topography and soils in the South Esk and Great Lake catchments. The characteristics of the two catchments are quite distinct and so have been discussed separately. More detailed descriptions are given in Pinkard (1980), Pemberton (1986) and Burrett and Martin (1989). The geology of the catchments is shown in Map 2.2.

2.3.1 South Esk Catchment

The geology of the upper South Esk sub-catchment, in the north-eastern highlands, is characterised by the quartzwacke and mudstone of the Mathinna Beds. Lower in the catchment, the river passes through Jurassic dolerite and Devonian granite, which form the steeper foothills of the Ben Lomond Range and the north-eastern highlands. The lower catchment is characterised by the flat, undulating valleys of the Launceston Tertiary Basin which is made up of alluvial gravel, sands and till, with outcrops of older volcanic and igneous rocks (Burrett and Martin, 1989).

The topography in the Macquarie River sub-catchment is influenced by Jurassic dolerite, which dominates the western and southern area, and the weaker rocks of the Launceston Tertiary Basin to the north. The dolerite forms the cap of the Central Plateau and the Great Western Tiers, and the rugged hills from the Lake River south, and east to the upper Macquarie and Elizabeth Rivers. The lowland areas are typically low relief hills with relict terraces and flood plains.


Map 2.1: South Esk and Great Lake Catchments
Legend
Major Rivers
Hydro Lake
Non - Hydro Lake
Hydro Catchment
Non - Hydro Catchment
Population Centre
N
0 10 20 30 km
Locality Map
George Town
Tamar Estuary
LAUNCESTON
Lake Trevallyn
Meander R.
North Esk R.
South Esk R.
Perth
Liffey R.
Brumbys Ck.
Macquarie R.
Western Lakes
Great Lake
Lake Augusta
Arthurs Lake
Lake R.
Shannon Lagoon
Upper Lake R.
Woods Lake
Elizabeth R.
Campell Town
Ross
Macquarie R.
South Esk R.
See Map 3.1: Poatina and Trevallyn Power Schemes


Map 2.2: Geology of the South Esk and Great Lake Catchments
Geology
Holocene Alluvial and Aeolian Sediment
Pleistocene Glacial and Periglacial Deposit
Tertiary Non-marine Sediment
Tertiary Basalt
Jurassic Dolerite
Triassic Fluvio-lacustrine Sediment
Permo-Carboniferous Sediment
Devonian Granites
Ordo-Devonian Turbidite
Precambrian Metamorphic
Lakes
N
0
10
20
30
40
50
km
South Esk R.

The Meander Valley is characterised by flat plains that lie on recent alluvial sediments, and higher terraces that lie on older clays and gravels. Long rolling hills are underlain by Tertiary basalt and are a feature of the more elevated areas. Steeper hills formed of dolerite, slate and quartzite, with some minor outcropping of sandstone and mudstone, divide the low country and flat plains, and also occur along the foothills of the Great Western Tiers, which themselves are formed of dolerite cliffs and talus.

Soils in the South Esk catchment are quite complex, reflecting the underlying geology. In the highland areas north of Great Lake, the upper Liffey area, and near Woods and Arthurs Lakes, the soils are generally yellowish-brown gradational soils, formed on Jurassic dolerite. These soils are characteristically rocky and have a high permeability. Also in these areas, duplex soils are formed on the sediments of the lower Parmeener Supergroup, these are less rocky and less permeable.

The dolerite mountains of the north-eastern highlands also support mostly shallow, stony gradational soils. The foothills of the north-eastern highlands have mostly stony yellowish-red, yellowish-brown or brown gradational soils. Along the river plains and flats of the upper South Esk River, duplex or uniform clay soils are present. The agricultural plains of the Launceston Tertiary Basin support diverse soils, which vary in colour, depth, structure, texture and general appearance (Pinkard, 1980).

2.3.2 Great Lake Catchment

The Central Plateau is a relatively high region of generally low to moderate relief in the central region of Tasmania. Great Lake occupies a basin on the Central Plateau, on the boundary between two major erosion surfaces, the higher and lower plateau surfaces. The lake is bounded on the eastern and western shores by the monadnocks of Wild Dog Tier and Sandbanks Tier. The northern boundary of the catchment is defined by the Great Western Tiers.

The Central Plateau has been subject to repeated glaciations during the quaternary period and classical glacial landforms are common. Glacial erosion or deposition formed most of the lakes on the Central Plateau. During the most recent glaciation (25 to 10 thousand years ago), the Central Plateau was subject to glacial and intense periglacial activity. Blockstreams and solifluctuation deposits are common (Cullen, 1995).

Geologically, the Central Plateau is relatively uncomplicated, compared with other regions in Tasmania. Basement rocks are probably of Precambrian, Cambrian, Ordovician and Silurian age, and have a restricted occurrence. These metamorphic rocks are overlain by Permo-Triassic sediments (Parmeener Supergroup), which are divided into lower (upper Carboniferous to Permian) and upper (Triassic) units, and which outcrop around the northern boundary of the Great Lake catchment on the edge of the Central Plateau. The outcropping geology is dominated by extensive sheets of Jurassic dolerite (Cullen, 1995; Pemberton, 1986). Tertiary basalts have extruded on the dolerites at various points around Great Lake, particularly on the south-west border of the catchment.

The soils on the Central Plateau are also relatively simple. Rocky gradational soils, derived from the doleritic parent material, are present over most of the catchment on the better drained slopes and ridges. These soils may also occur on Tertiary basalts and Permo-Triassic sediments of the Parmeener Supergroup. The gradational soils may be quite fertile; however, their rocky nature, the rugged terrain and harsh climate make the area unsuited to agricultural development. Permeability is usually moderate to high (Pemberton, 1986). Uniform soils are uncommon and are restricted to the sandy lunette deposits found on the lee shores of some lakes in parts of the Great Lake catchment (e.g. Lake Augusta). These are likely to be glacially-derived aeolian deposits, with uniform, undifferentiated siliceous profiles. In small areas of the catchment, low-lying swamps and bogs support organic soils.

2.4 Vegetation

Following is a brief description of the vegetation in the South Esk and Great Lake catchments. The vegetation characteristics of the two catchments are quite distinct and so have been discussed separately. The vegetation types in the catchments are shown in Map 2.3.

2.4.1 South Esk Catchment

Detailed descriptions of the vegetation in the South Esk catchment are given in Pinkard (1980), Pemberton (1986) and Davies (1988). Riparian and aquatic vegetation communities for some rivers in the South Esk catchment have been described by Askey-Doran (1993).

Much of the natural vegetation in the South Esk catchment has been cleared for agriculture and the land is now used for grazing or cropping. The remaining vegetation is generally inland grassy forest or grassy woodland, dominated by *Eucalyptus pauciflora*, *E. obliqua*, *E. amygdalina*, *E. viminalis* and *E. ovata*. In some of the higher areas to the east and south-east, the vegetation is predominantly eucalypt forest, dominated by *E. delegatensis*. In the far north-east of the South Esk catchment, small pockets of rainforest occur. Isolated areas of native grassland are also present.

2.4.2 Great Lake Catchment

Jackson (1973) and Pemberton (1986) have described the vegetation on parts of the Central Plateau. Kirkpatrick and Dickinson (1984) discuss the alpine vegetation and grasslands of the region.

The distribution of vegetation on the Central Plateau is strongly influenced by the altitude, climate, topographic exposure and soil drainage. Due to the low temperatures and effects of cold air drainage, inverted rather than pronounced treelines are more common. Human activities such as burning, grazing, forestry and road construction have also had a significant influence on vegetation distribution on the Central Plateau (Pemberton, 1986).

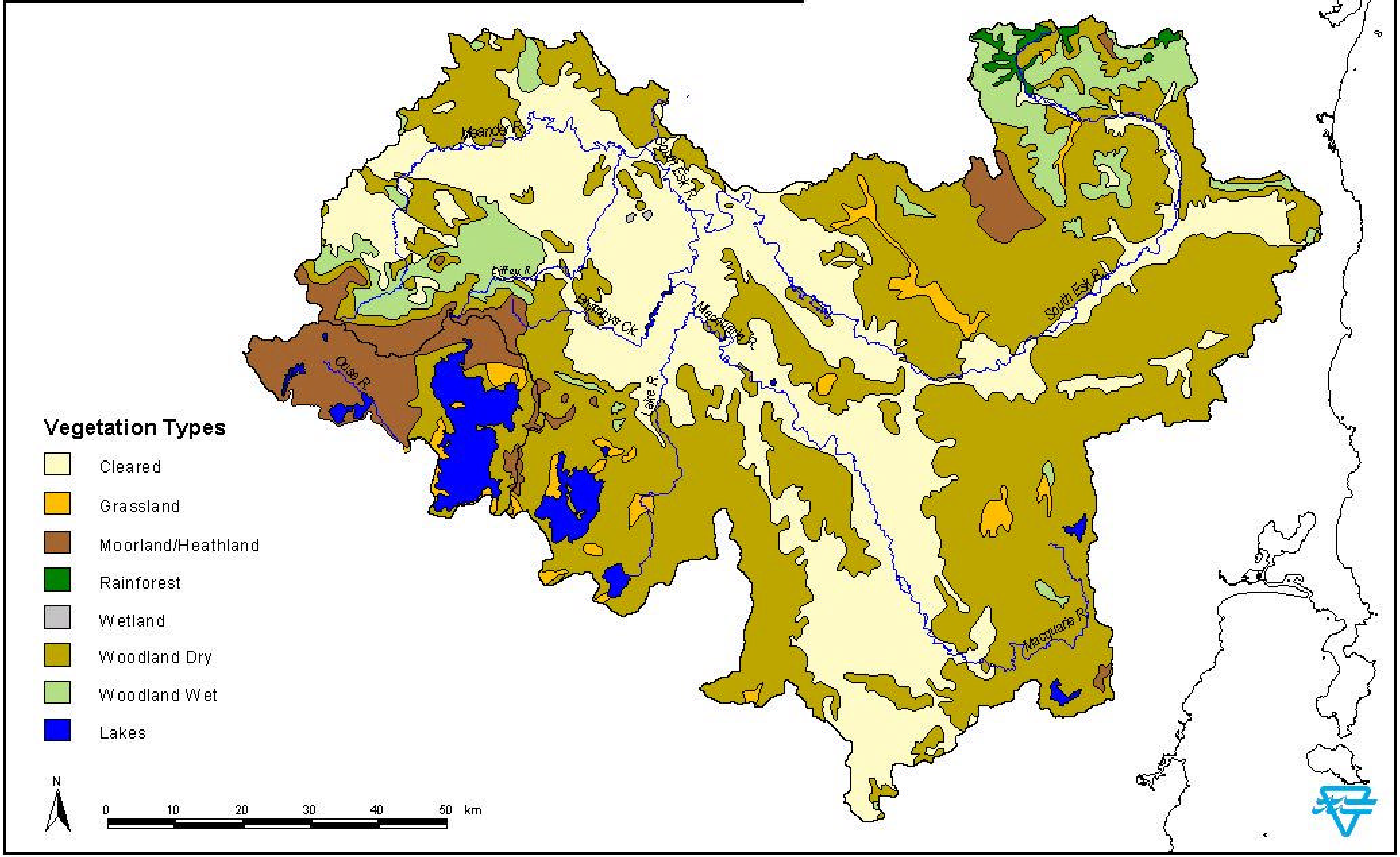
In brief, valley bottoms and kettle holes are occupied by sedge, sphagnum, cushion plant and fern communities. The well drained ridges and slopes support eucalypt forest and woodland (dominated by *Eucalyptus coccifera*) and the intermediate lower slopes support shrublands and grasslands. At the highest elevations on the high monadnocks, the vegetation is largely composed of coniferous or sclerophyllous shrublands and heathlands and, in poorly drained situations, cushion plant moors, herbfields, bogs and sedgelands.

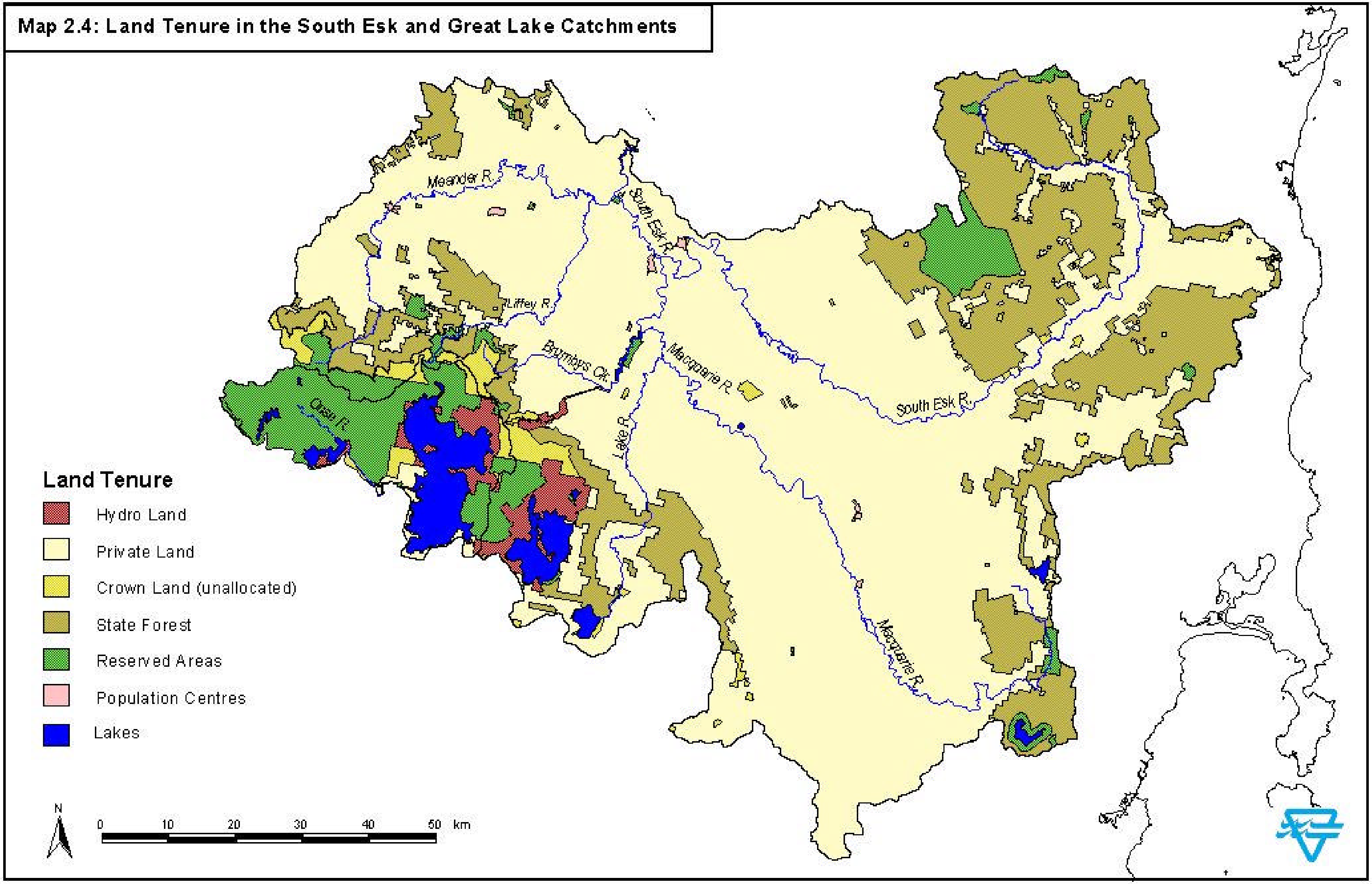
2.5 Land Use

The primary land uses in the South Esk Basin are agriculture and forestry, with wilderness reservations in some of the highland areas of the catchment and limited mining for coal and metals in the upper catchment of the South Esk River. Urban land use and land used in association with the generation and distribution of electricity make up a small proportion of the South Esk catchment. Land uses in the Great Lake catchment include hydro-electric power generation, wilderness recreation and tourism (e.g. fishing, bushwalking), grazing, forestry and fishing shack use. Map 2.4 shows the land tenure in the South Esk and Great Lake catchments.

Private land tenure shown on Map 2.4 is generally indicative of agricultural land use and some private forestry. Agriculture (and some mining) is also carried out on unallocated Crown land leased for this purpose. Agriculture takes up approximately 37% of the South Esk catchment (Department of Environment and Land Management, 1996) and land clearing on private land in the lower areas of the Basin is extensive. Sheep and beef-cattle grazing are the main agricultural activities in the South Esk and Macquarie River sub-catchments; however, the area used for cropping is increasing, particularly with cultivation of high yield crops such as potatoes. Near the bottom of the catchment, the Cressy-Longford area is served by an irrigation scheme (the Cressy-Longford Irrigation Scheme), which has allowed more intensive cultivation of vegetable crops. The lower Meander catchment supports a mixture of cropping and grazing agriculture, and a large percentage of land is under irrigation (Davies and Humphries, 1996; Bobbi *et al*., 1996).

Map 2.3: Vegetation Types in the South Esk and Great Lake Catchments




Map 2.4: Land Tenure in the South Esk and Great Lake Catchments
Meander R.
South Esk R.
Liffey R.
Brumbys Ck.
Macquarie R.
Ouse R.
Lake R.
South Esk R.
Macquarie R.
Land Tenure
Hydro Land
Private Land
Crown Land (unallocated)
State Forest
Reserved Areas
Population Centres
Lakes
N
0 10 20 30 40 50 km

Agriculture in the Great Lake catchment is restricted to grazing of sheep and cattle, mostly on native vegetation, due to the rocky soils and extreme weather conditions. This mostly takes place on small areas of private and leased Crown land near Great Lake.

Woodland, forest and rainforest covers just over half of the catchment, while heath and scrub take up about 9% (Department of Environment and Land Management, 1996). Significant areas of the upper catchment are taken up by State Forests, which are managed for multiple uses by Forestry Tasmania. Forestry is the main land use in these areas, and tends to be centred around the upper South Esk River, the Lake Leake and Tooms Lake area and along the southern parts of the Great Western Tiers in the South Esk catchment. In the Great Lake catchment, most forestry activity is to the east and south of Great Lake. Until harvesting takes place, non-commercial objectives including environmental values are sometimes maintained in these forests.

Reserved areas (National Parks, State, Crown and Forest Reserves, Protected Areas and State Recreation Areas) are also largely forested or covered in heath or scrub. These occur in the upper eastern and western parts of the South Esk catchment. Much of the western region of the Great Lake catchment is reserved for wilderness preservation, and includes part of the Tasmanian World Heritage Area. The main land uses are recreation and the protection of natural values. Controlled use of resources is also carried out in Protected and State Recreation Areas.

Land vested in the Hydro is located mostly around Arthurs Lake, Poatina and Brumbys Creek in the South Esk Basin, and around Great Lake and Lake Augusta in the Great Lake catchment. Significant areas of land in the vicinity of Arthurs and Great lakes are currently subject to investigation by the Hydro's divestment program.

3. DESCRIPTION OF POWER DEVELOPMENTS

A background to this document was provided in the previous chapters, as well as a general description of the catchment and land uses in the South Esk and Great Lake catchments. This chapter gives a description of the history of hydro-power developments in the catchments, followed by descriptions of the power stations, the storages, and then the dams, weirs and other relevant structures.

The power schemes in the South Esk – Great Lake catchment are shown on Map 3.1. These are the Poatina and Trevallyn Power Schemes. A generalised relief map of these schemes is provided in Appendix 2.

3.1 Background

3.1.1 General Description

The Poatina Power Scheme utilises water from the Great Lake catchment and the diversions of the Arthurs Lake catchment, the upper Ouse River, the upper Liffey River, Westons Rivulet – upper Brumbys Creek and Shannon Lagoon (which is in the Derwent catchment). It consists of three main storages (Great Lake, Arthurs Lake and Lake Augusta) and two power stations (Poatina and Tods Corner). Other components of the scheme include Arthurs Lake pumping station, a 5.7 km tunnel through the Great Western Tiers and Poatina Penstock (2.7 km), the 8.8 km long Liawenee Canal, 8.5 km of rising main, canal and penstock from Arthurs Lake to Tods Corner, and other water diversion and transfer infrastructure. Also associated with the Poatina Power Scheme is Woods Lake, the main function of which is storage of water for irrigation supply.

The Poatina Power Scheme is most notable for the diversion of Great Lake water from the Derwent catchment to the South Esk catchment. This diversion takes advantage of the 835 metre head down the face of the Great Western Tiers, thus increasing the energy value of Great Lake water, compared with the alternative route through the Derwent system. The diversion results in between 620 and 730 Mm^3 of water being directed north into the South Esk catchment, rather than flowing into the Derwent system.

The Trevallyn Power Scheme utilises water from the entire South Esk catchment, and from the Great Lake catchment via Poatina Power Station. Trevallyn Power Scheme consists of Lake Trevallyn and the Trevallyn Power Station. Water is transferred from the lake to the power station via a 3.2 km tunnel.

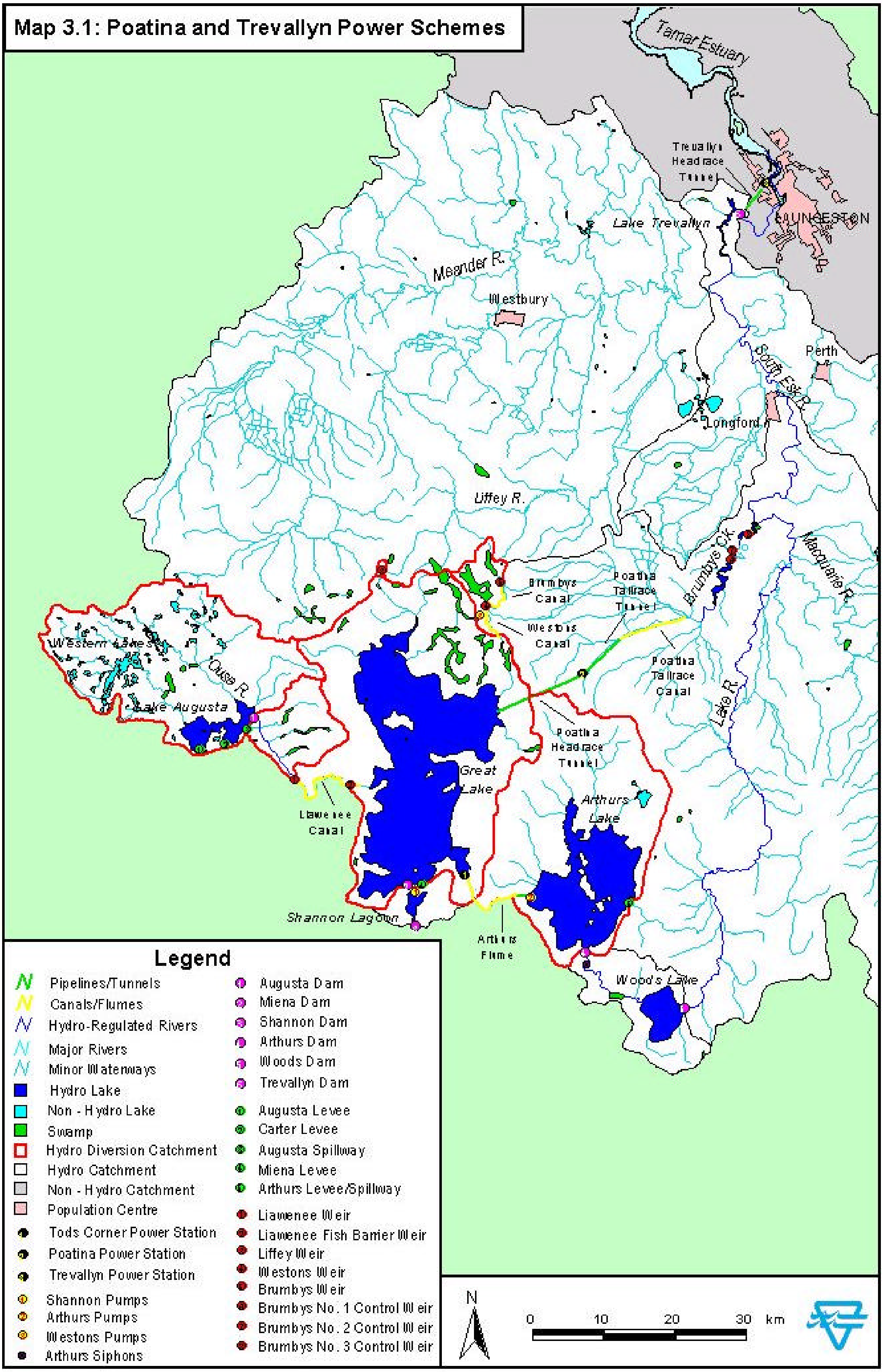
The two power stations in the Poatina Power Scheme (Tods Corner and Poatina) provide 12.1% of Tasmania's long term average power output, and Trevallyn Power Station makes up 4.9%. On a statewide basis, therefore, the South Esk-Great Lake Hydro catchment produces 17% of Tasmania's long term average electricity output (Scanlon, 1995).

3.1.2 History of Power Developments

The Poatina and Trevallyn Power Schemes have not been the only hydro-electric schemes in the South Esk – Great Lake catchment. A brief history of power developments in the catchments is taken from the Hydro's Touring Guides, Scanlon (1995) and French (1994). Each scheme is described in turn, in historical order.

The Launceston City Council built Tasmania's first hydro-electric power station in the late 1800s, on the South Esk River at Duck Reach. Duck Reach Power Station began generating electricity in 1895 and by 1919 it was generating up to 2 MW. The power station used the flow of the South Esk River, supplemented by water from Woods Lake, to generate power.

The Duck Reach Power Station was destroyed by floodwaters in 1929 and, despite an existing proposal for a new higher-level development (proposed in 1906), the station was rebuilt. The Duck Reach station was bought by the Hydro in 1944 and continued to generate power until it was decommissioned in 1955, following the commissioning of the Trevallyn Power Station.



Map 3.1: Poatina and Trevallyn Power Schemes

Construction began on the Trevallyn Power Scheme, near Launceston, in 1950. It was the first scheme built by the Hydro outside of the Central Highlands. Lake Trevallyn was formed on the South Esk River by the building of a concrete dam (Trevallyn Dam) which was designed to cope with flows far in excess of the 1929 floods that destroyed the Duck Reach Power Station. The dam diverts water from Lake Trevallyn through a tunnel to the Trevallyn Power Station. The water then enters the Tamar Estuary through the power station tailrace at Ti-Tree bend, rather than through Cataract Gorge (the natural outlet of the South Esk River) at the head of the estuary.

The Great Lake catchment originally fed water southwards into the Waddamana and Shannon power stations, which were in the Derwent catchment. The Poatina Power Scheme was completed in 1964, and ceased the flow of Great Lake water into the Derwent catchment, diverting it instead into the South Esk (excluding periodic releases into the Derwent catchment via Shannon Lagoon).

As part of the Poatina Power Scheme, Great Lake was raised by the construction of a 22 metre high dam at Miena. Two dams had already been built at Miena as part of the Waddamana and Shannon schemes. The third dam increased the storage capacity of Great Lake, and was raised a further six metres in 1982 to further increase the capacity of the lake. Arthurs Lake was also formed as part of the Poatina power development by the construction of Arthurs Dam on the upper Lake River.

A number of smaller developments and diversions have been undertaken at various times. These are listed below and shown in Map 3.1. Their roles in the system are described later in this chapter.

- 1911 – Woods Lake was first raised by the construction of a levee. The purpose was to supply water to Duck Reach Power Station.
- 1923 – Liawenee Canal was constructed to divert upper Ouse River water into Great Lake, with the purpose of assisting Waddamana Power Station which used to operate in the Derwent catchment.
- 1953 – Augusta Dam and Carter Levee were completed to form Lake Augusta. The purpose was to regulate water into Liawenee Canal.
- 1960's – Liffey and Westons Rivulet diversions were constructed. Their purpose was to increase water yield to Great Lake.
- 1962 – Woods Lake was raised again by the building of Woods Dam. This increased the water available for irrigation.
- 1974 - Arthurs Lake siphons were installed. The siphons were extended in 1996.
- 1983 - Ripple Creek diversion was constructed (feeding primarily into Lagoon of Islands in the Derwent catchment).

3.2 Power Stations

3.2.1 Poatina Power Station

Poatina is the largest power station in the South Esk – Great Lake catchment, and is the second largest in the State. It is situated in the South Esk catchment, to the north-east of the Great Western Tiers (Map 3.1). Water from Great Lake is directed through a tunnel in the Tiers, and falls 835 metres through a tunnel, pipe and shaft, before entering the power station. The power station is underground and houses six 50 MW Pelton turbines. The long term average power output from the station is 141.7 MW (Scanlon, 1995). Water from Poatina is discharged via a 4.4 km tailrace tunnel into the tailrace canal (6.1 km). The canal flows into Brumbys Creek, a tributary of the Macquarie River.

3.2.2 Tods Corner Power Station

Tods Corner Power Station is a small automatic power station, with a single Francis turbine. Water is pumped approximately 140 metres up from Arthurs Lake, to the 7.25 km long Arthurs Flume, which transfers the water to the Tods Corner forebay above the south-east corner of Great Lake. Water is taken into the power station from the forebay and is discharged into Great Lake. Tods Corner Power Station was built to take advantage of the fall of water down to Great Lake after being pumped up from Arthurs Lake, and to recoup some of the energy used in the pumping process. According to the regional Hydro officer, under current operations the energy expended in pumping water from Arthurs Lake is 7 MW at maximum discharge. A maximum of 1.7 MW is recovered at Tods Corner, and the remaining expended energy is recovered many times over at Poatina Power Station and again at Trevallyn. In total, this equates to a gain of approximately 27 MW. The long term average power output from the station is 1.0 MW (Scanlon, 1995).

3.2.3 Trevallyn Power Station

Trevallyn Power Station is situated only 5 km from the centre of Launceston, on the Tamar Estuary. It has very little storage and utilises the daily flows down the South Esk River. Trevallyn Dam diverts water through a 3.2 km tunnel to the power station. Water flows out of the power station into the Tamar Estuary at sea level. The four turbines have a combined capacity of 83.6 MW. The long term average power output from Trevallyn Power Station is 57.5 MW (Scanlon, 1995).

3.3 Storages

3.3.1 Overview

The five Hydro-controlled storages in the South Esk – Great Lake catchment are Great Lake, Arthurs Lake, Lake Augusta, Lake Trevallyn and Woods Lake. The primary function of the first four lakes is power generation, while water releases from Woods Lake are made to satisfy irrigation requirements on the Lake and lower Macquarie rivers. Water released from Woods Lake may also generate power at Trevallyn if it has not been withdrawn from the system for other uses. Water from Shannon Lagoon is pumped into Great Lake, however water may also be released from Shannon Lagoon into the Derwent system.

A summary of the dimensions of the storages in the South Esk – Great Lake system is given in Table 3.1. Operational characteristics of these storages are provided in Chapter 4.

Table 3.1 Dimensions of Hydro Storages in the Poatina and Trevallyn Power Schemes

Scheme	Storages	Surface Area at FSL (km^2)	Reservoir Vol (x $10^6 m^3$)	Approx. Max. Depth at Dam (m)
Poatina	Great Lake	176.12	3178.72	25
	Arthurs Lake	64.59	511.39	18
	Lake Augusta	11.29	23.45	11
Trevallyn	Lake Trevallyn	1.48	12.33	22
Irrigation Storage	Woods Lake	12.63	63.87	7

3.3.2 Great Lake

Great Lake is retained by the Miena Dam, a 28 metre high rockfill structure across the outflow of the Shannon River (Map 3.1). The original lake was much shallower than the current storage, with a maximum depth of only 6 metres. Reed beds were dense throughout the lake, and Tods Corner, Lake Elizabeth, Little Lake Breona and Boggy Marsh (now Cramps Bay) were separate water bodies.

Inflows to Great Lake include the upper Ouse River (diverted via Liawenee Canal from Lake Augusta) from the west, Arthurs Lake water (via Tods Corner Power Station) from the south-east, the Liffey Diversion (via Pine Lake and Halfmoon Creek) from the north-west, the Brumbys – Westons Rivulet diversion from the north, Shannon Lagoon (via pumps) from the south, and several natural streams.

The main outlet of water from Great Lake is through a 5.7 km rock tunnel to the north and down a penstock to the Poatina Power Station. Water may also be released from Great Lake to the Shannon River via discharge gates at Miena Dam. This water then flows through the Derwent catchment.

3.3.3 Arthurs Lake

Arthurs Lake is in the upper South Esk catchment and receives water from its natural catchment. The construction of Arthurs Dam flooded a marsh area (the Morass Marsh) and two smaller natural water bodies, Sand Lake and Blue Lake. The natural outflow from Arthurs Lake was the Lake River, which originally drained through Woods Lake into the Macquarie River.

Arthurs Lake is a diversion storage for Great Lake. The outflow from Arthurs Lake is now pumped from Pumphouse Bay, in the lake’s south-west corner, to Great Lake via the Tods Corner Power Station. Water may be released down the Lake River via a riparian valve and siphons at Arthurs Dam. Arthurs Lake spills only under exceptional circumstances. Under normal circumstances operating procedures prevent the lake from spilling.

3.3.4 Lake Augusta

Lake Augusta is also a diversion storage for Great Lake. It is possible to divert or spill Lake Augusta water into Lake Echo in the Derwent catchment, but this is not generally done. Lake Augusta receives water from its natural catchment including the Ouse River and James Rivers, which were dammed by Augusta Dam. The lake is also retained by Augusta Levee and Carter Levee.

Water is released from Lake Augusta into a section of the Ouse River via a valve, and is then diverted into Liawenee Canal, which transfers the water to Great Lake. Lake Augusta spills into the Ouse River near Augusta Dam.

3.3.5 Lake Trevallyn

Lake Trevallyn is an instream storage that flooded a steep, lightly wooded gully of the South Esk River. The section of the river that was flooded by the Trevallyn Dam was mostly a rock/gravel fastwater, interspersed with several deep pools. Water from the entire South Esk Basin and the associated Great Lake diversion drains into Lake Trevallyn via the South Esk River.

The water stored in Lake Trevallyn is used for electricity generation at Trevallyn Power Station. Water leaves the lake through the intake to the power station, which discharges into the Tamar Estuary. Lake Trevallyn water may also spill or be released into the South Esk River, which is the natural waterway, and then flows through the Cataract Gorge and into the Tamar Estuary upstream of the power station tailrace.

3.3.6 Woods Lake

Woods Lake is primarily an irrigation storage, although these releases may also eventually generate power at Trevallyn, if not withdrawn for irrigation or riparian use. Irrigation releases and spills from Woods Lake go into the Lake River. Inflows to Woods Lake include water from Jacks Creek, which occasionally carries spill from the Ripple Creek diversion in the Derwent catchment, and the upper Lake River.

3.4 Dams, Weirs and Other Structures

The dams and weirs in the Poatina and Trevallyn power schemes are summarised in Table 3.2. There are six ‘referable’ dams in the South Esk – Great Lake system and a number of smaller weirs and levees. Referable dams are those which are on the register of the Australian National Committee on Large Dams (ANCOLD). These dams are registered for control for reasons including height, storage capacity and crest length. The full definition and specification of referable dams is given in the Register of Referable Dams in Tasmania (Tasmania Dams Safety Committee, 1991).

Table 3.2 Hydro Structures on Storages and Waterways in the Poatina and Trevallyn Power Schemes

Scheme	Structure	River	Storage	Crest Length (m)	Height (m)	Construction	Year Completed	Referable
Poatina	Miena Dam [a]	Shannon	Great Lake	1140	28	Clay-cored rockfill	1982	Yes
	Miena Levee B	N/A	Great Lake	300	6	Clay-cored rockfill	1967	No
	Arthurs Dam	Lake	Arthurs Lake	475	19	Zoned rockfill with concrete crest	1965	Yes
	Arthurs Levee	N/A	Arthurs Lake	609	7	Clay-cored earthfill	1963	Yes
	Augusta Dam	Ouse	Lake Augusta	970	13	Clay-cored rockfill	1953	Yes
	Carter Levee	N/A	Lake Augusta	273	2	Clay-cored earthfill	1953	No
	Augusta Levee	N/A	Lake Augusta	564	3	Clay-cored rockfill	1953	No
	Augusta Spillway Levee(s)	N/A	Lake Augusta	610	2	Clay-cored rockfill	1953	No
	Liawenee Weir	Ouse	N/A	~25	?	Concrete	1923	No
	Liawenee Canal Fish Barrier	Liawenee Canal	N/A	20	1.9	Concrete	1999	No
	Westons Weir	Westons Rivulet	N/A	88	2.8	Concrete	1966	No
	Brumbys Diversion Weir	Westons Rivulet	N/A	87	0.9	Concrete	1966	No
	Liffey Weir	Liffey	N/A	2	0.2	Concrete	1964	No
Trevallyn	Trevallyn Dam	South Esk	Lake Trevallyn	176	33	Concrete gravity	1955	Yes
	Brumbys No.1 Control Weir	Brumbys Creek	N/A	~135	?	Concrete	1960s	No
	Brumbys No.2 Control Weir	Brumbys Creek	N/A	~100	?	Concrete	1960s	No
	Brumbys No.3 Control Weir	Brumbys Creek	N/A	~55	?	Concrete	1960s	No
Irrigation Storage	Woods Dam	Lake	Woods Lake	393	7	Clay-cored rockfill	1962	Yes

[a] length of Miena Dam includes Miena Levee A which joins onto the dam to the east

? – data not obtainable at time of writing report

There are also numerous hydrological recording weirs throughout Tasmania. The locations of these weirs have not been shown, as a complete list or database has never been compiled. However, many of these locations are available from Hydrol (the Hydro's hydrology database). While these weirs are generally very small and do not retain or divert large volumes of water, they may represent an issue in terms of fish migration (see section 6.2).

Other structures that influence water flow in the South Esk catchment include Liawenee Canal, Arthurs Pumps, Arthurs Flume and forebay, Arthurs siphons, Shannon Pumps and Westons Pump and diversion. All major structures in the South Esk catchment are shown in Map 3.1.

4. SYSTEM OPERATIONS

A description of the location and physical characteristics of the hydro-electricity system in the South Esk – Great Lake catchments was given in Chapter 3. This chapter provides a description of the system operating patterns and restrictions, first for the storages, then power stations, and finally downstream of other infrastructure.

4.1 Hydro Operating System

The Statewide Hydro generating system consists of a network of 51 dams and 27 hydro-electric power stations. In addition there is one thermal power station located at Bell Bay, which can be used to supplement the Hydro system if there is a shortfall in power supply. The storages and power stations in the South Esk and Great Lake catchments are operated in conjunction with the rest of the system to meet two objectives. These are:

1. to operate a secure power system in order to meet requirements in terms of energy and quality of supply; and

2. to operate the integrated hydro power system efficiently while satisfying hydrological, electrical, social and environmental constraints.

To meet the objectives, detailed system planning is undertaken. In planning the operation of the system, various constraints apply, including safety, electrical and hydraulic, maintenance, irrigation, environmental, commercial and recreational considerations.

Operations related to storages are presented in section 4.2, and those related to power stations in section 4.3.

4.2 Storages

The Hydro’s storages above power stations can be categorised into three sizes: major, medium and minor. These categories are based on the life cycle of the storages, that is, the typical time taken to fill or empty the storage under normal weather conditions. These storages are referred to as ‘inter-annual’, ‘inter-seasonal’ and ‘run-of-river’ respectively. In addition, there are a number of ‘diversion’ and ‘irrigation’ storages that the Hydro operates in conjunction with the power station storages.

Most of the minor storages supply run-of-river power stations and have only limited storage. Consequently, these lakes can cycle (fill or empty) over a period of hours to days. Medium storages are usually the top lakes of a run-of-river chain of storages and power stations and can cycle over a monthly or seasonal basis. Major storages cycle over a period of decades. The long term supply security depends on the major storages being utilised during dry periods when the run-of-river stations cannot be used due to a lack of stored water.

Spill of water from storages occurs when the water exceeds the full supply level (FSL) and cannot be controlled by power station discharge. Spills will bypass the turbines of a power station and therefore present a loss of generation revenue. Consequently, the Hydro system is managed to reduce the incidence of spills, and priority of power stations within a schedule is determined largely by the proximity of its storage to spilling.

Great Lake is the main storage for the Poatina Power Scheme. It is one of the two Major Hydro storages in Tasmania (the other being Lake Gordon), as such lake levels fluctuate over a period of several years. Water in Great Lake is stored over the long term, and is used to generate electricity during periods when the smaller storages cannot meet demand.

Lake Trevallyn is a typical run-of-river storage, as it has a relatively small holding capacity and operates according to daily inflows. Water from Lake Trevallyn is used for electricity generation when the flow down the South Esk River is sufficient, either from natural pick-up or from Poatina. Lake levels tend to fluctuate over a period of hours or days according to weather conditions and the operation of Poatina.

Lake Augusta and Arthurs Lake are diversion storages, which increase the catchment yield of Great Lake. Shannon Lagoon, in the Derwent catchment also serves as a diversion storage for Great Lake at times. Woods Lake is used primarily as a storage for irrigation water.

Summary operational statistics for storages in the South Esk system are given in Table 4.1.

Table 4.1 Operational Characteristics of Hydro Storages in the Poatina and Trevallyn Power Schemes

Scheme	**Storage**	**Power Station**	**Operating Range** (m)	**Storage Energy Value** (kW/cumec)	**FSL** (mASL)	**NMOL** (mASL)	**Intake Depth** (m below FSL)	**Storage Type**
Poatina	Great Lake	Poatina	21.34	7663	1039.37	1018.03	23.1	Inter-annual
	Arthurs Lake	Tods Corner	9.77	6378 [a]	952.82	943.05	11.0	Diversion
	Lake Augusta	Poatina [b]	8.99	7663 [b]	1150.62	1141.63	N/A	Diversion
Trevallyn	Lake Trevallyn	Trevallyn	9.53	989	126.49	117.96	16.5	Run-of-river
Irrigation Storage	Woods Lake	Trevallyn [c]	3.81	989 [c]	737.77	733.96	N/A	Irrigation

[a] Average net value allowing for pumping from Great Lake

[b] Water goes to Great Lake and generates energy at Poatina, therefore energy value of the water is the same as for Great Lake

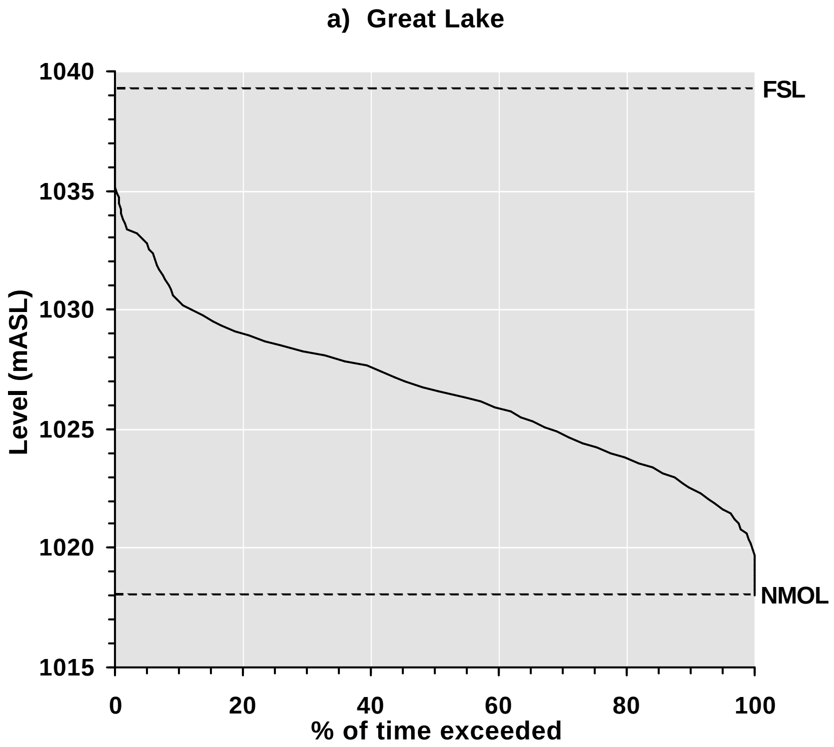
[c] Water may reach Lake Trevallyn (if not withdrawn for irrigation) and generate energy at Trevallyn, therefore the energy value of the water is the same as Lake Trevallyn

4.2.1 Lake Level Duration Curves

Lake level duration curves are provided for each of the five South Esk-Great Lake storages in Figure 4.1. These plots show the frequency of occurrence of specific lake levels. The *y*-axis shows the range of lake levels (expressed as elevations in metres above sea level - mASL) and the *x*-axis shows the percentage of time a particular lake level is exceeded. The plots all have the normal minimum operating level (NMOL) and approximate full supply level (FSL) marked on the *y*-axis, as well as any lake level agreements (LLA). The plotted line indicates lake level fluctuations, and represents the percentage of time that the lake surface was at a particular level during the period of record.

The plot in Figure 4.1a shows that Great Lake has never approached its FSL (1039.37 mASL) during the period of record (1916-1998). Great Lake has also spent very little time near NMOL (1018.03) during the period of record, spending the majority of its time between approximately 1020 and 1030 mASL. The cycling of Great Lake through the middle of the active storage range is a result of the large storage capacity of the lake, which even in extreme conditions (e.g. drought) may take a number of years to fill or empty.

For the period of record (1965-1998), Arthurs Lake has never risen above 952 mASL, and therefore, has never reached FSL (952.82 mASL). The lake has remained below this level because an operating rule prevents the lake from reaching a level where it is at risk of spilling. Despite this, Arthurs Lake spends 90% of the time within the top half of the active storage range (Figure 4.1b). A lake level agreement was introduced in 1993 and further restricts its range to above 948 mASL (section 4.2.3).



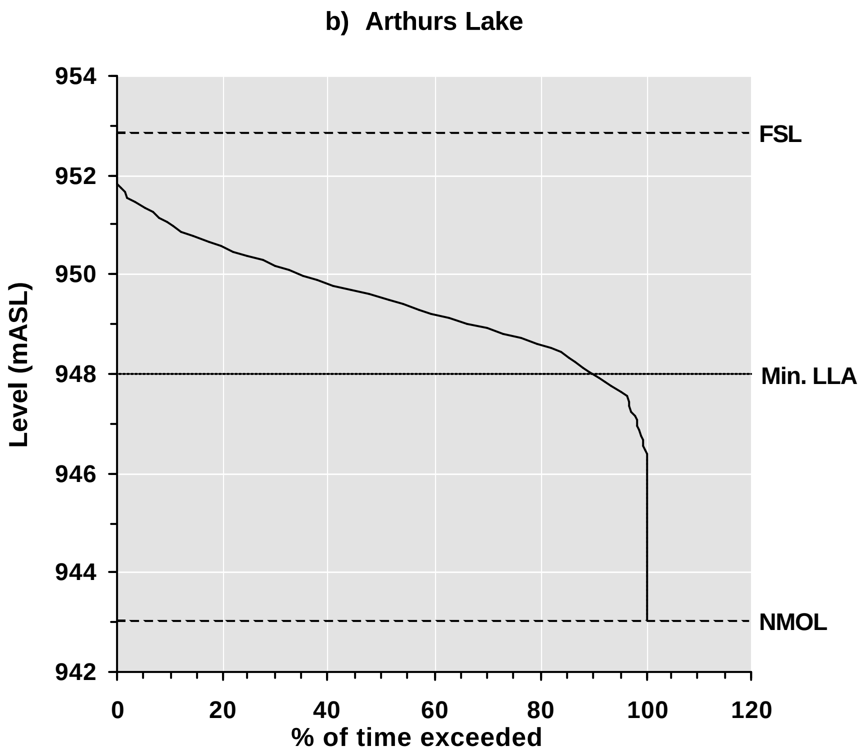
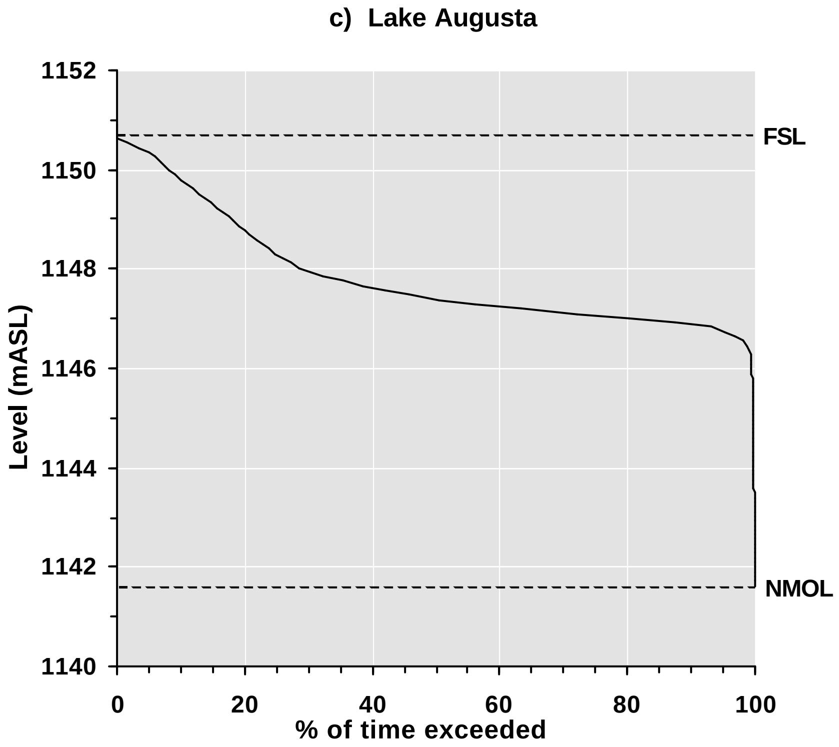


Figure 4.1 Lake Level Duration Curves for Storages in the Poatina and Trevallyn Power Schemes



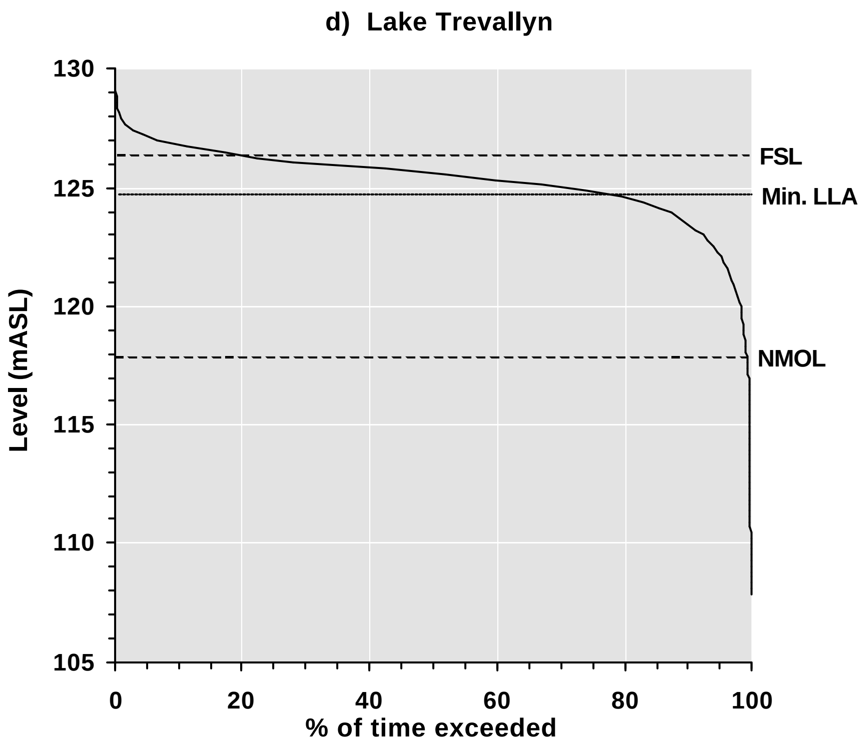


Figure 4.1 cont'd **Lake Level Duration Curves for Storages in the Poatina and Trevallyn Power Schemes**

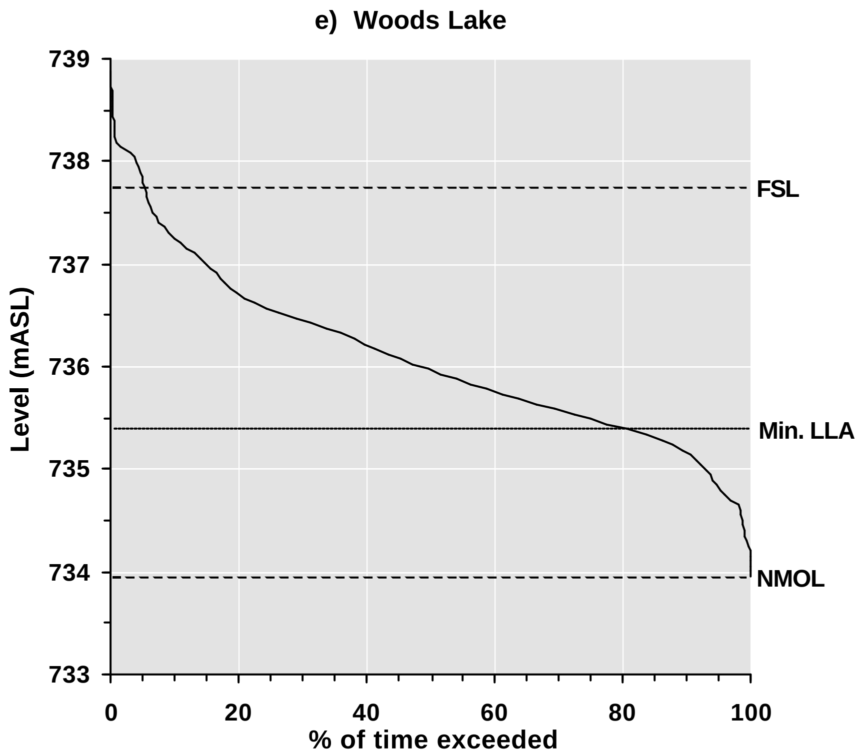


Figure 4.1 cont'd **Lake Level Duration Curves for Storages in the Poatina and Trevallyn Power Schemes**

The level of Lake Augusta (Figure 4.1c) was within the top half of its active storage range for almost 100% of the time during the period of record (1976-1998). The lake does not cycle evenly throughout the top half of the range, spending most of the time between 1146 and 1148 mASL and only about 10% of the time within one metre of FSL (1150.62 mASL).

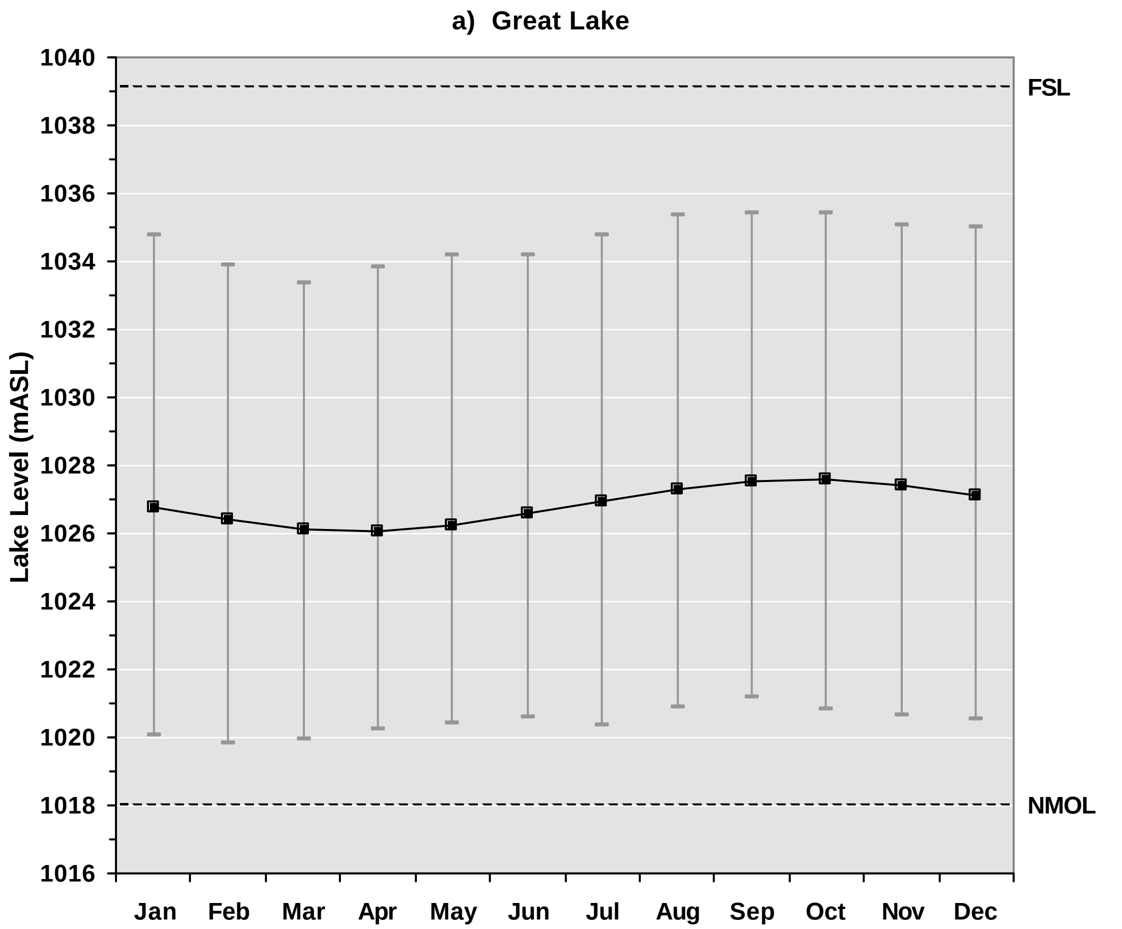
Figure 4.1d indicates that during the period of record (1955-1988), the level of Lake Trevallyn spends a high percentage of its time, approximately 85%, within the top quarter of the operating range. It was at or above FSL (126.49 mASL) for approximately 20% of the time, which indicates that the lake was spilling.

During the period of record (1968-1998) Woods Lake cycled through the whole range of lake levels in a reasonably balanced fashion, although it could be generalised that the majority of time is spent in the middle of the active storage range (Figure 4.1e). Woods Lake is shown as exceeding the FSL for approximately 7% of the time, indicating that the lake was spilling during this time.

4.2.2 Average Monthly Lake Levels

The plots in Figure 4.2 show the average monthly lake levels for the Hydro storages in the South Esk – Great Lake system. The *x*-axis indicates the months and the *y*-axis indicates the lake level in mASL. The mid-point for each month is the median value, using all values obtained in a given month over the entire period of record. The minimum and maximum values for each month were obtained by taking the highest and lowest single values for each month over the entire period of record.

Being an inter-annual storage, Great Lake levels display a relatively small amount of variation on a seasonal basis. Figure 4.2a shows Great Lake levels tend to be relatively lower in the autumn months (March to May) and slightly higher in the spring, following the winter rains. This is consistent with the storage being utilised during the drier periods and refilling over the wetter winter and spring.



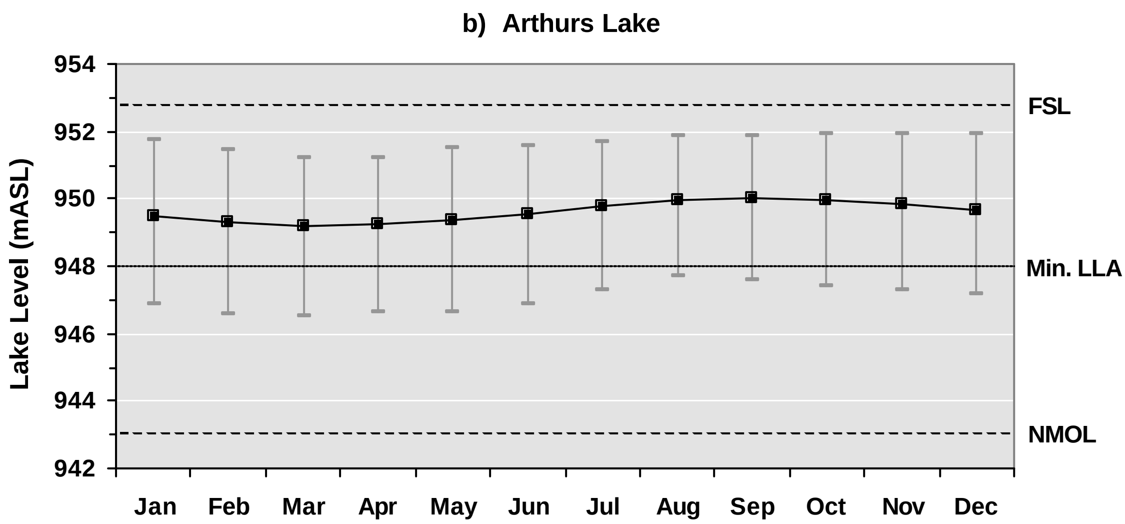
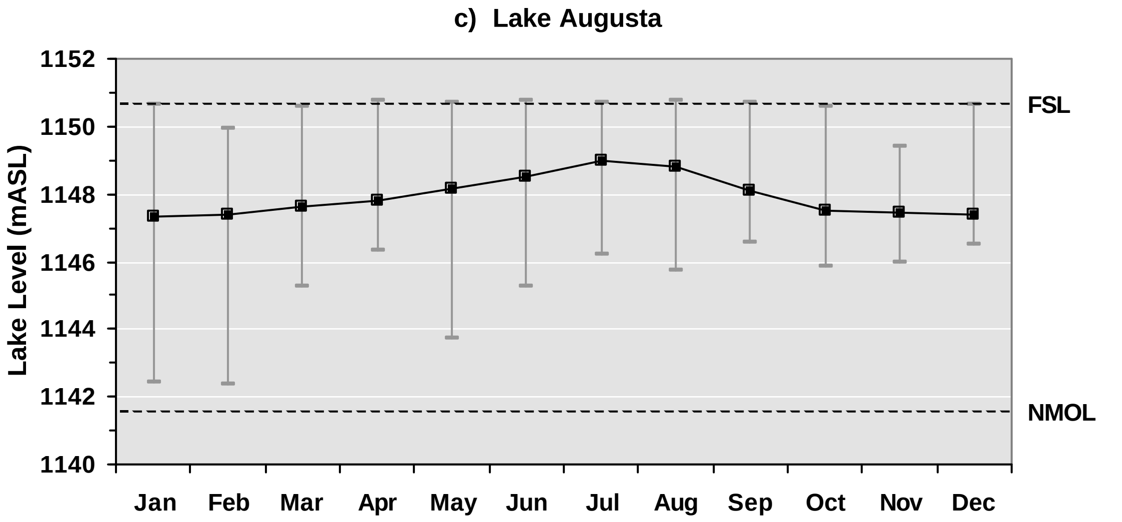


Figure 4.2 Average Monthly Lake Levels for Storages in the Poatina and Trevallyn Power Schemes

(Midpoints show median monthly values, end points show max. & min. monthly values over period of record)



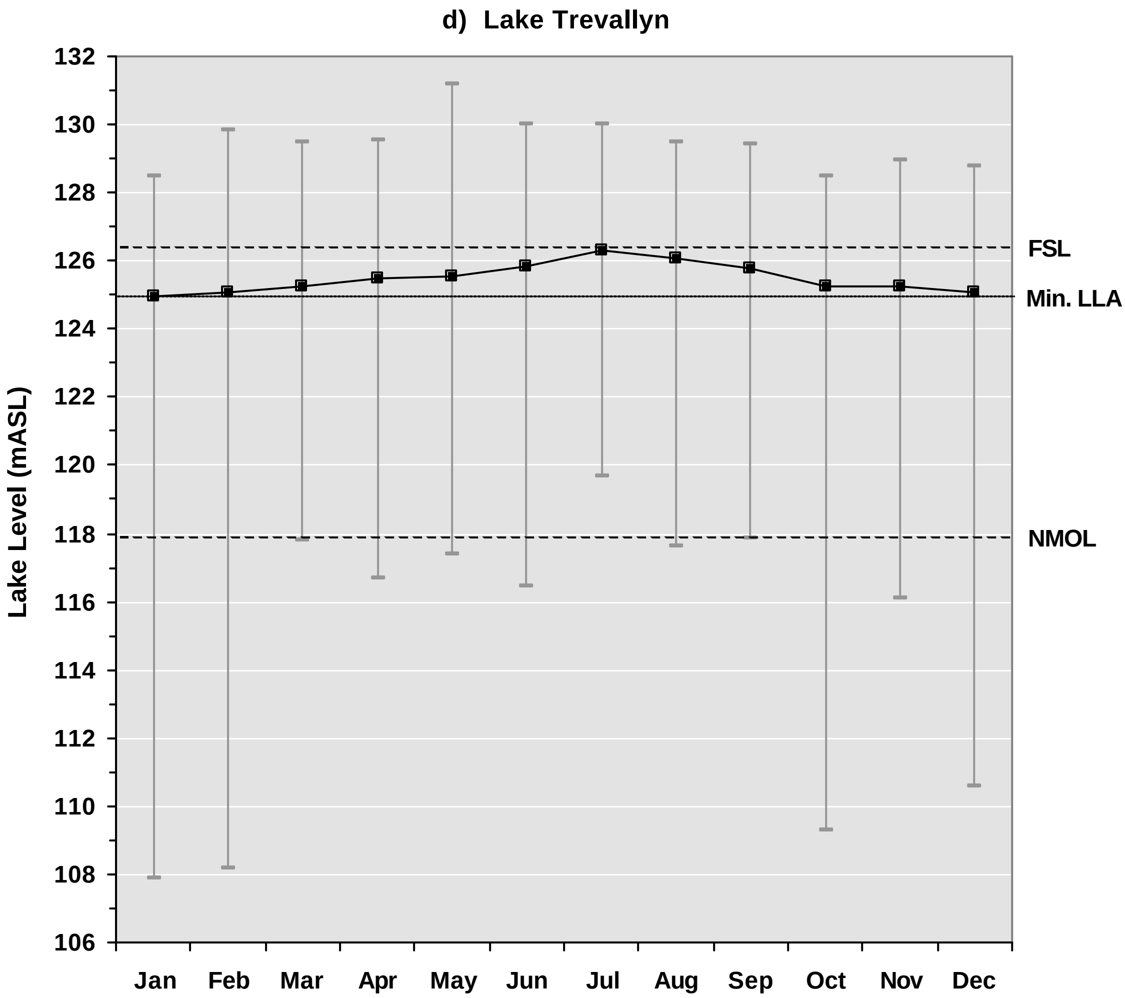


Figure 4.2 cont'd Average Monthly Lake Levels for Storages in the Poatina and Trevallyn Power Schemes

(Midpoints show median monthly values, end points show max. & min. monthly values over period of record)

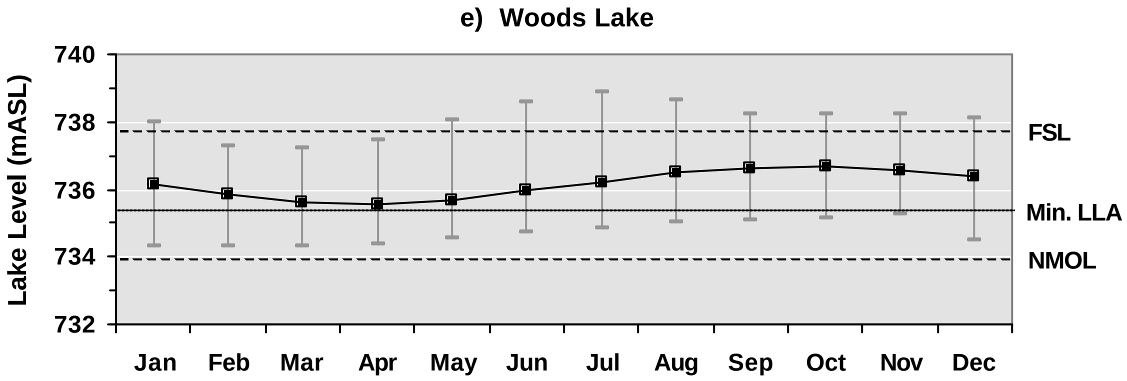


Figure 4.2 cont'd Average Monthly Lake Levels for Storages in the Poatina and Trevallyn Power Schemes

(Midpoints show median monthly values, end points show max. & min. monthly values over period of record)

Arthurs Lake is also lowest in the autumn and highest in the spring (Figure 4.2b). The fluctuation in lake levels in Arthurs Lake is less pronounced than in Great Lake as it is a diversion storage, however as there is more rainfall in winter the lake tends to be higher at this time. The upper level of the range is restricted by an operating rule, and the lower level is now restricted by an agreement with the Inland Fisheries Commission (IFC), in place since 1993.

Lake Augusta (Figure 4.2c) is, on average, at its highest in July and at its lowest in December/January. This is because Lake Augusta is not generally used for storage for long periods, but as a pickup area for Great Lake. The seasonal fluctuations in Lake Augusta reflect the rainfall and rate of pickup and the discharge out of the lake.

Lake Trevallyn (Figure 4.2c) shows only minor seasonal variance as it is a run-of-river storage, and generally drawn down when inflows are anticipated (i.e. it does not stay down for long). The average lake levels are higher during July and August, and relatively lower from October to February.

Woods Lake fluctuates markedly on a seasonal basis (Figure 4.2e). It is drawn down over the irrigation season (October to April) and also receives less inflow during that period. The lake begins to refill in May through to October, due to higher inflows from winter and spring rains and no irrigation demand.

4.2.3 Lake Level Agreements and Restrictions

Great Lake and Lake Augusta

There are no lake level agreements for Great Lake or Lake Augusta.

Arthurs Lake

A minimum lake level for Arthurs Lake of 948.0 metres above sea level (mASL) was set by the Hydro in 1993, in consultation with the Inland Fisheries Commission (IFC), and in response to angler concerns. This level is significantly above the NMOL of 943.05 mASL, and restricts the operating range from 9.77 metres to 4.82 metres. Prior to the current agreement, the level of Arthurs Lake was frequently low, resulting in less favourable fishing conditions. Maintenance of the higher lake level is also considered to be beneficial to the 'vulnerable' native fish species, the saddled galaxias (*Galaxias tanycephalus*). The lake is kept at this level as part of the Hydro's normal operating arrangements and would only be drawn down under unusual circumstances, for instance, an extreme drought throughout the system. Regulation of the level in Arthurs Lake is achieved primarily by the operation of three siphons at the dam.

Lake Trevallyn

Lake Trevallyn is a designated recreational area and under an agreement between the Hydro and the Launceston City Council, the lake is maintained at a minimum level of 124.97 mASL for recreational purposes. The lake is normally operated to this level, but may be drawn down for maintenance purposes or in order to create more storage capacity when a flood event is predicted.

Woods Lake

The Hydro maintains the level of Woods lake above its normal minimum operating level of 733.96 mASL, under an agreement with the IFC. A study by the IFC (Crook, 1995) indicated that by maintaining the lake above 735.4 m, the Hydro could achieve better water quality (related to turbidity) and improve conditions for the 'vulnerable' saddled galaxias. At present, the Hydro maintains this lake level as part of its normal operations.

4.3 Power Stations

4.3.1 Scheduling of Power Station Operations

Power stations are not utilised continuously. The operational schedule for the network of Hydro power stations is determined by the following (in priority order):

- Use any storage spill. This is water that would otherwise spill and therefore bypass turbines.
- Use catchment pickup draining into run-of-river storages. These run-of-river storages have limited capacity and are therefore more likely to spill if not utilised; and
- Storage release. Release of water from dams is prioritised by the size of storage. Small storages are utilised first to maximise their storage potential. Medium storages are scheduled next and are prioritised according to their immediate probability of spill. The major storages are last on the priority list because they are unlikely to spill and can provide the reserve energy when water is not available within the rest of the Hydro system.

To efficiently operate the system with the required level of security of supply, the load on the system needs to be estimated in advance. Terms related to load on the system are illustrated in Figure 4.3. These include base load, step load, deficit load, frequency and peak power. Figure 4.3 illustrates a representative 'load curve', as used by the Hydro to schedule power station operation. Time (24 hours) is shown in the *x*-axis and load (in MW) is shown on the *y*-axis. 'Peak load' occurs in the morning and early evening, and is shown by the two peaks in the graph.

Certain power stations are scheduled to provide 'base load', the load that is constantly required during the day, shown at the bottom of the load curve (Figure 4.3). If there is sufficient rainfall to utilise the run-of-river storages, water will be drawn from them to generate base load. Power stations operating in base load generate a constant load all day, and longer if sufficient water is available.

The load above the base load (Figure 4.3) is divided into steps of differing magnitude during different periods of the day. This is known as 'step load'. Specific power stations are turned on for set periods of the day, running at their efficient load (or full gate if the storage is close to spill). Power stations operating in step mode are generally turned on at some point during the day, generate power at a constant load for a certain number of hours (e.g. 6-18), and then turn off. Discharge from power stations operated to generate step load will change significantly at specific times of the day.

'Deficit load' is the additional load above step load that constitutes the remainder of the daily load curve. It is supplied by power stations operating in deficit or frequency mode. These power stations vary their generation within a particular range (somewhere around their efficient load if possible) to meet the fluctuations of the daily load curve. Discharge from these power stations is variable over very short time periods.

‘Efficient load’ relates to a discharge level associated with the most efficient power generation. In some cases, power stations have multiple turbines, in which case there are different efficiency loads depending on how many turbines are in use. Power stations can operate at ‘full gate’ which discharges the maximum amount of water at a lower power generation efficiency.

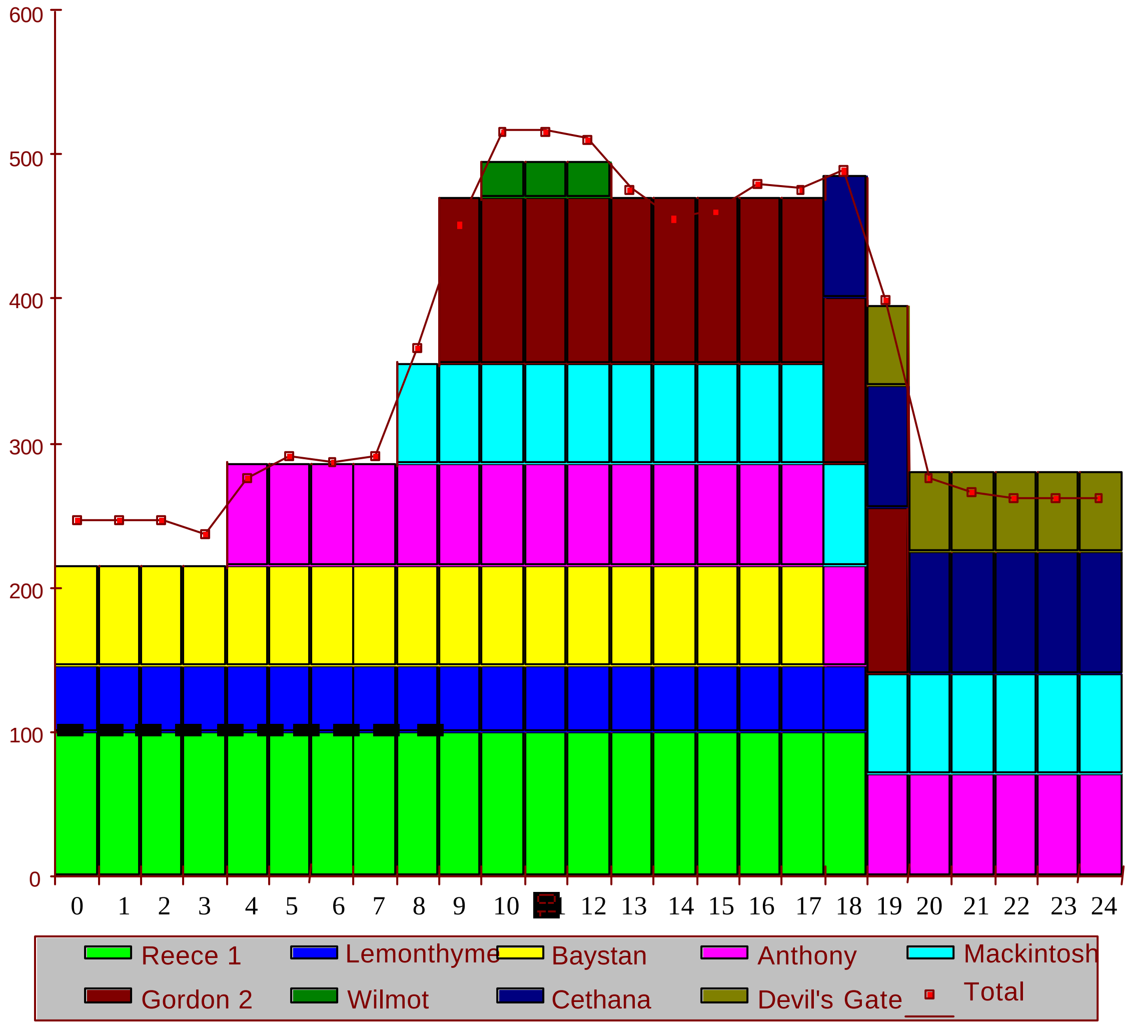


Figure 4.3 Representative Load Curve

4.3.2 Power Station Operations in the Great Lake – South Esk Catchment

Poatina Power Station is commonly operated in base mode during summer, when there is limited water in the run-of-river storages elsewhere in the State. In winter, Poatina is operated in step mode to complement the run-of-river stations.

Trevallyn Power Station is operated in step mode when possible, and is loaded on at its efficient load point. It can only be operated in this way, however, when the inflow to Lake Trevallyn is less than the capacity of the station. When the South Esk River is flowing at a greater rate, Trevallyn provides base load power and is operated at full gate.

Tods Corner Power Station is usually operated when the Arthurs Lake Pump is on, transferring water from Arthurs Lake to Great Lake via the power station. This helps in recovering 16 to 19% of the energy used to pump the water. Arthurs Lake pump is run between 50 and 80% of the time.

Table 4.2 gives the discharge from the three power stations when operating at efficient load and full gate. The values for Tods Corner and Trevallyn are set at FSL (values vary according to lake level), however Poatina values are set below the FSL as Great Lake has never reached its full capacity.

Table 4.2 Discharge from Power Stations in the Poatina and Trevallyn Power Schemes at Efficient Load and Full Gate

Scheme	Power Station	Discharge at Efficient Load (cumecs)	Discharge at Full Gate (cumecs)
Poatina	Poatina	32.3	52.0
	Tods Corner	3.0	4.7
Trevallyn	Trevallyn	61.3	90.0

4.3.3 Power Station Operating Constraints

There are a number of operational constraints for Poatina Power Station. Note that constraints related to infrastructure other than power stations are discussed in section 4.4.1.

The Poatina tailrace is the water supply for the Cressy-Longford Irrigation District. The *Cressy Longford Irrigation Act* 1969 authorises the RWSC to purchase water for the Cressy Longford Irrigation scheme from the Hydro by agreement. Allocations for the scheme allow up to 12,000 ML of water per year (mostly in the summer months) to be abstracted from the tailrace.

The Hydro ensures that the discharge from Poatina is sufficient to maintain a minimum flow of 2.83 cumecs in the Macquarie River at Cressy, in order to ensure security of supply to the Cressy township.

The Hydro restricts the operation of Poatina Power Station to alleviate flooding in the Macquarie River catchment. This limits the maximum discharge from the power station during a flood.

The Hydro may adjust the operation of Poatina in response to an emergency request from the Sevrup fish farm on Brumbys Creek. While there is no formal agreement, the Hydro has offered to supply water to the fish farm for a price equivalent to the cost of lost generation.

4.4 Other Hydro Structures

Hydro infrastructure in the Poatina and Trevallyn power schemes that spills or discharges into a stream or river are listed in Table 4.3.

Pump stations in the Poatina and Trevallyn Power Schemes include Arthurs pumps (maximum 5.1 cumec capacity), Arthurs flume and forebay, Arthurs siphons, Shannon pumps (0.9 cumec capacity) and Westons pumps (1.4 cumec capacity). These flows are indicative only. The Liawenee Canal, which delivers water into Great Lake, has a capacity of 18.5 cumecs.

Table 4.3 Structures with Spillways or Outlets in the Poatina and Trevallyn Power Schemes

Scheme	Structure	River	Storage	**Outlet Capacity** (cumecs) **[Diameter** (mm)**]**	**Spillway Capacity** (cumecs)
Poatina	Miena Dam	Shannon	Great Lake	53 [2130]	N/A
	Arthurs Dam	Lake	Arthurs Lake	0.55 [300]	350
	Arthurs Levee	N/A [a]	Arthurs Lake	N/A	47
	Arthurs Siphons	Upper Lake	Arthurs Lake	Variable	N/A
	Augusta Dam	Ouse	Lake Augusta	[1500 square]	830
	Liawenee Weir	Ouse River	N/A	N/A	?
	Westons Weir	Westons Rivulet	N/A	0.11 [200]	8
	Brumbys Diversion Weir	Brumbys Creek	N/A	0.03 [127]	7
	Liffey Weir	Liffey River	N/A	0.014 [300]	N/A
Trevallyn	Trevallyn Dam	South Esk	Lake Trevallyn	0.5 [610] [b]	8500
Irrigation Storage	Woods Dam	Lake	Woods Lake	2.18 [1500 square]	40

[a] Arthurs Levee spills overland

[b] Also 3 electric annular slide valves 1300 x 1500 mm

? - data not able to be obtained at time of writing report

4.4.1 Operating Constraints for Other Structures

Arthurs Dam/Siphons

The operating rules of Arthurs Lake are designed to minimise spillage. Siphons that transfer water from Arthurs Lake into the Lake River above Woods Lake are operated when the lake is in danger of spilling. The current control levels for the three siphons range from 951.6 mASL in July-October to 952.0 mASL in December-April.

Woods Dam

Releases of water are made down the Lake River from Woods Lake, to meet irrigation requirements. The releases are made via a valve from Woods Lake. The Hydro currently supplies water to owners of tenements on the Lake River in accordance with provisions currently contained in the *Electricity Supply Industry Restructuring (Savings and Transitional Provisions) Act* 1995. The Hydro makes releases in response to information from the district's Water Bailiff, who monitors irrigation requirements and water use. The Water Bailiff position is funded by the Hydro, but the Bailiff is actually employed by the Department of Primary Industry Water and Environment (DPIWE).

Trevallyn Dam

The Hydro maintains a constant minimum flow of 0.43 cumecs of water down the Cataract Gorge in accordance with a statutory provision in the *Water Act* 1957. The release is made through the outlet valve in Trevallyn Dam.

Additional releases from Trevallyn Dam are also made intermittently by the Hydro for recreational events in the Cataract Gorge (e.g. slalom canoeing events and commercial rafting). The Hydro has agreed to release water for commercial rafters who pay for these releases.

Liawenee Weir

The Hydro has undertaken to operate Liawenee Weir to maintain water in Liawenee Canal for fish spawning in an informal arrangement with the IFC. The spawning season for brown trout is from April to June, during which period Lake Augusta is being emptied into Great Lake, in order to create storage capacity prior to the wet season. Consequently, there is usually sufficient water in the canal for spawning. For rainbow trout, the spawning season is in August and September, which is a wet time of year and the canal usually contains sufficient water.

Liffey Weir and Westons and Brumbys Weirs

The upper Liffey River Diversion (Liffey Weir) and the Westons Rivulet Diversion (Westons and Brumbys weirs) are in operation during winter. They are left open during the summer irrigation season to allow the flows to pass down the natural waterways.

4.5 Alterations to Natural Flows Downstream of Hydro Infrastructure

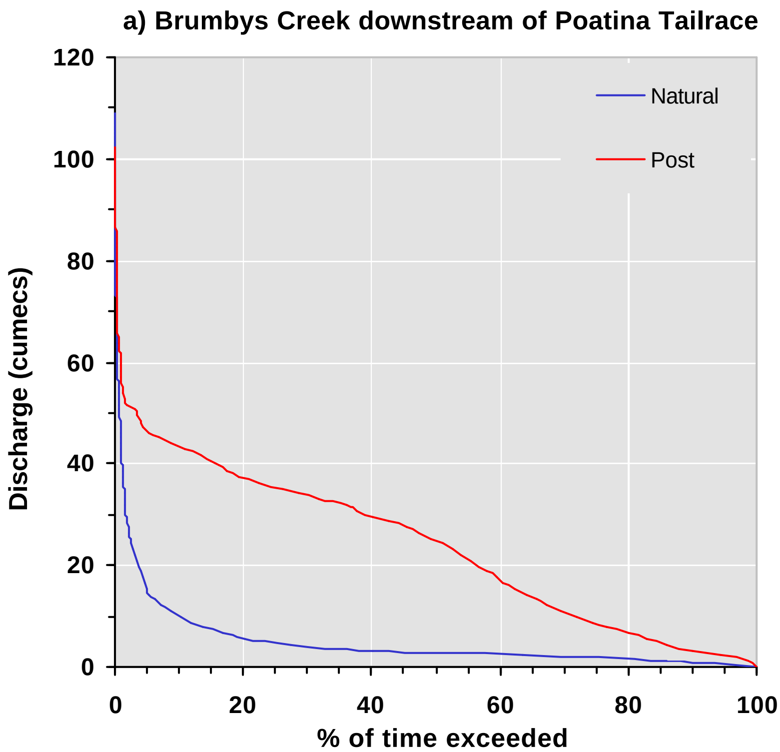
Figure 4.3 shows discharge duration curves for pre- and post- Hydro development periods, downstream of Poatina Power Station and Trevallyn Dam. These plots show the frequency of occurrence of specific flows in cumecs below these structures, and indicate changes to the natural flow regime.

The *y*-axis shows the range of discharges in cumecs and the *x*-axis shows the percentage of time a particular discharge is exceeded. The blue plotted line indicates natural discharges and the red line indicates discharges post-development. These lines represent the percentage of time that discharge was at a particular level over a ten year period. The plots were generated using a mixture of modelled and field derived data.

Figure 4.3a shows the changes to flows in Brumbys Creek, approximately 15 km downstream of Poatina Power Station outlet. Overall, flows have increased as a result of the diversion of Great Lake water into the South Esk catchment via Poatina. Under natural conditions, a zero flow was exceeded approximately 98% of the time (i.e. for 2% of the time the creek had no water), whereas post-development, the flow exceeds 2 cumecs for 98% of the time. Median flows (flows exceeded 50% of the time) have increased from a natural flow of 3 cumecs to approximately 25 cumecs post-development. Higher flows exceeded 5% of the time have increased from 15 to 48 cumecs post-development; however, flood flows exceeded for less than 1% of the time have remained at approximately 60 to 65 cumecs.

Figure 4.3b shows that flows have reduced post-dam in the South Esk River immediately downstream of Trevallyn Dam (in the Cataract Gorge). Under natural conditions, the river flowed between 20 and 100 cumecs for the majority of the time and had a flow of at least 5 cumecs for 95% of the time. Post-dam, however, median flows have decreased from 50 cumecs to approximately 2 cumecs and 5 cumec flows are exceeded for only 20% of the time. In comparison, pre-dam flows exceeded 20% of the time were 80 cumecs. The occurrence of high magnitude flows, of more than 400 cumecs has remained similar, being exceeded less than 2% of the time and peaking at 1200 pre-dam, compared with approximately 1100 cumecs post-dam.

This pattern of decrease in flows below Trevallyn Dam reflects the small capacity of the reservoir. Smaller flows are able to be diverted through the power station or retained in the lake, however, flows which exceed the capacity of the power station and the storage capacity available in the lake, spill over Trevallyn Dam into the Cataract Gorge.


a) Brumbys Creek downstream of Poatina Tailrace
Discharge (cumecs)
120
100
80
60
40
20
0
0
20
40
60
80
100
% of time exceeded
Natural
Post

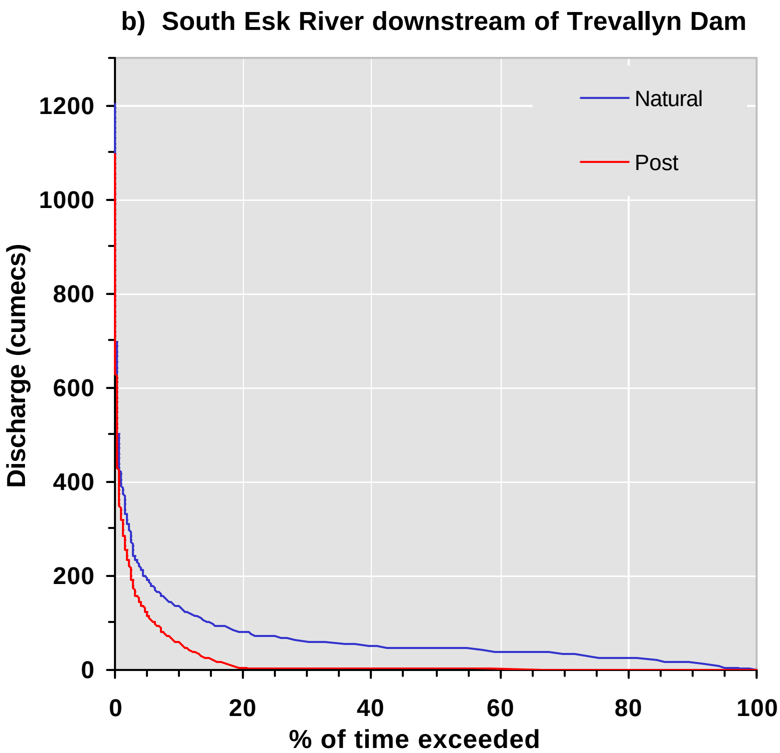

b) South Esk River downstream of Trevallyn Dam
Discharge (cumecs)
1200
1000
800
600
400
200
0
0
20
40
60
80
100
% of time exceeded
Natural
Post

Figure 4.4 Natural and Post Development Flow Duration Curves Downstream of Hydro Structures in the Poatina and Trevallyn Power Schemes

4.5.1 Seasonal Discharge Patterns

As well as altering percentile discharge values, Hydro operations may affect the seasonal patterns of discharge. Under natural conditions, discharge in Tasmanian streams is usually high in the winter and low in the summer. Hydro power stations may be operated in patterns that are different from this. For example, Poatina is generally run at higher capacity during the summer months when smaller power stations may be conserving storage capacity. Similarly, reservoirs used for irrigation supply such as Woods Lake tend to store most of the winter inflows but release larger-than-natural discharges during the irrigation season.

4.5.2 Short-term Discharge Patterns

Hydro operations can have an effect on discharge patterns in the short-term. Relatively sudden surges or recessions in discharge can result from the operation of release valves for riparian or other uses. Power stations that do not operate 24 hours per day will produce pulses in the downstream discharge pattern as the station commences and ceases generation.

5. WATER QUALITY ISSUES

This is the first chapter of four chapters outlining the current state of knowledge on environmental issues in the South Esk – Great Lake catchment. This chapter outlines water quality issues, in Chapter 6, biological issues are discussed, in Chapter 7 geomorphological issues are discussed, and in Chapter 8 multiple use issues are discussed. These issues are summarised in Chapter 9.

This review of water quality in the South Esk – Great Lake catchments is presented with a generally downstream orientation. The water quality and important seasonal cycles and trends are summarised in sections 5.1 to 5.3, and a summary of issues and relevant monitoring and programs is given in section 5.4. The information in this chapter was obtained by a desktop study of information from the Inland Fisheries Commission Biological Consultancy (IFCBC) Annual Progress Reports, and other referenced literature (see references for full citations), and data extracted from Hydrol, the Hydro's Water Quality Database. No new monitoring or field investigations were undertaken.

5.1 Highland Lakes

5.1.1 Great Lake, Lake Augusta and Arthurs Lake

Great Lake, Lake Augusta and Arthurs Lake are located in relatively undisturbed areas, and except for a limited number of dwellings and livestock, there are few sources of contaminants near these water bodies. The water quality of these lakes has been monitored since 1991 as part of the Lake Survey Program done for the Hydro by the IFC Biological Consultancy (IFCBC). Before this work, there had been almost no water quality monitoring of these water bodies, including prior to Hydro development.

A summary of the IFCBC water quality data for surface water samples from Lakes Augusta, Trevallyn and Ada and Great and Arthurs Lakes is presented in Table 5.1. Lake Ada is not a Hydro lake, but has been included in this review to provide an indication of 'natural' water quality characteristics. In general, all of the monitored parameter values are low, and below the indicator values used by the IFCBC to identify problems associated with nutrients and turbidity.

The lakes can be classified as clear, neutral, low productivity waterbodies typical of the Central Highlands region. Dissolved oxygen levels are high, pH values are neutral, conductivity and nutrient levels are low and algal activity, represented by chlorophyll-*a*, is generally very low. Turbidity levels are usually low, but can increase sharply in the shallower lakes (Augusta and Ada) due to weather-generated turbulence.

A number of the measured parameters, including water temperature, dissolved oxygen, turbidity and chlorophyll-*a*, showed seasonal patterns. Turbidity levels tended to peak around spring and autumn and chlorophyll-*a* data indicated peaks in autumn. However, the limited sampling frequency of the Lake Survey Program would not necessarily detect all peaks in these parameters.

5.1.2 Woods Lake

Woods Lake is almost 220 metres lower than Arthurs Lake and has quite a different geomorphology. These factors have produced somewhat different water quality values than those of the Central Highlands lakes. While temperature, pH and dissolved oxygen ranges are similar, turbidity, conductivity, nutrients, iron and manganese recorded much higher values.

Woods Lake was classified as a turbid oligotrophic system as early as the 1960s by P. Tyler (Sanger, 1993), and has received considerable attention from the IFC since 1989. It has been described as a 'naturally turbid' lake, and being relatively shallow, its elevated turbidity is due primarily to wind-induced sediment resuspension.

Table 5.1 Summary of Water Quality Data for Highland Lakes in the South Esk-Great Lake Hydro System (Data Collected by IFCBC)

1991-1998 IFCBC results	**Temp** (°C)	**DO** (mg/l)	**Cond** (µS/cm)	**pH** (units)	**Turbidity** (NTU)	**Secchi** (m)	**Chl-*a*** (µg/l)	**Total N** (mg/l)	**Nitrate** (mg/l)	**Total P** (mg/l)	**Total Fe** (mg/l)	**Total Mn** (mg/l)
Lake Ada												
Max	23.9	11.4	39.0	8.3	25	0.4	7.2	0.75	0.056	0.038	2.58	0.26
Median	11.4	9.7	25.7	6.9	2.7	0.4	1.4	0.24	0.002	0.010	0.36	0.02
Min	1.1	7.6	10.9	6.3	1.1	0.4	0.15	0.16	0.002	0.005	0.19	0.01
N	*32*	*26*	*29*	*33*	*33*	*2*	*36*	*21*	*15*	*21*	*21*	*18*
Arthur's Lake												
Max	18.3	11.9	28.3	7.1	7.2	4.5	3.9	0.30	0.035	0.011	0.37	0.05
Median	11.4	9.6	24.1	7	1.3	3.5	1.9	0.20	0.005	0.008	0.11	0.01
Min	2.7	7.9	19.0	6.3	0.7	2.1	0.4	0.12	0.001	0.002	0.07	0.01
N	*37.0*	*28*	*38*	*33*	*34*	*16*	*42*	*21*	*13*	*21*	*21*	*14*
Lake Augusta												
Max	23.4	11.5	33.0	8.3	52.6		15.8	0.38	0.039	0.023	0.72	0.06
Median	11.8	9.5	17.8	6.7	1.4		0.9	0.17	0.013	0.008	0.15	0.015
Min	1.1	7.6	8.1	6.1	0.5		0.1	0.09	0.001	0.003	0.07	0.01
N	*22.0*	*16*	*21*	*19*	*20*		*24*	*14*	*10*	*13*	*14*	*11*
Great Lake												
Max	16.4	11.7	22.0	7.1	1.9	7.2	2	0.19	0.017	0.01	0.15	0.01
Median	9.8	9.7	16.7	6.9	1.0	4.9	1.2	0.12	0.002	0.005	0.08	0.01
Min	2.4	8.3	14.4	6.3	0.5	4	0.6	0.07	0.001	0.002	0.04	0.01
N	*44.0*	*35*	*44*	*40*	*44*	*12*	*61*	*20*	*14*	*20*	*20*	*8*
Woods Lake												
Max	23.6	13.5	86.6	8	88.8	0.7	28	1.6	0.25	0.16	4.7	0.28
Median	11.4	10.4	58	7.3	32	0.4	5.9	0.5	0.008	0.04	2.6	0.05
Min	3	7.7	47.2	6.7	20.2	0.1	1.4	0.3	0.001	0.006	0.36	0.02
N	*79*	*61*	*79*	*37*	*32*	*50*	*82*	*84*	*65*	*89*	*80*	*80*

Temp = temperature, DO = dissolved oxygen, Cond = conductivity, Chl-*a* = chlorophyll-*a*, Total N is total kjedhal nitrogen (TKN), P = phosphorus, Fe = iron, Mn = manganese, n = no. of samples

A study carried out by the IFCBC for the Hydro in 1995 demonstrated that water depth in Woods Lake was a critical factor in managing extreme turbidity levels (Crook 1995). The study recommended a minimum lake level of 735.4 mASL be maintained in order to limit sediment resuspension, and the Hydro has since maintained this level. Figure 5.1 illustrates the relationship between lake level and turbidity over time. It shows that once the lake was raised above the critical level, turbidity fell and, conversely, that if the lake level fell below 735.4 m, turbidity increased markedly.

Since monitoring by the IFC began in the early 1990s, there has been a gradual increase in silica levels in Woods Lake. The extended period of elevated turbidity (see Figure 5.1) corresponded to a time of increased concentrations of iron, TKN, phosphorous, and silica.

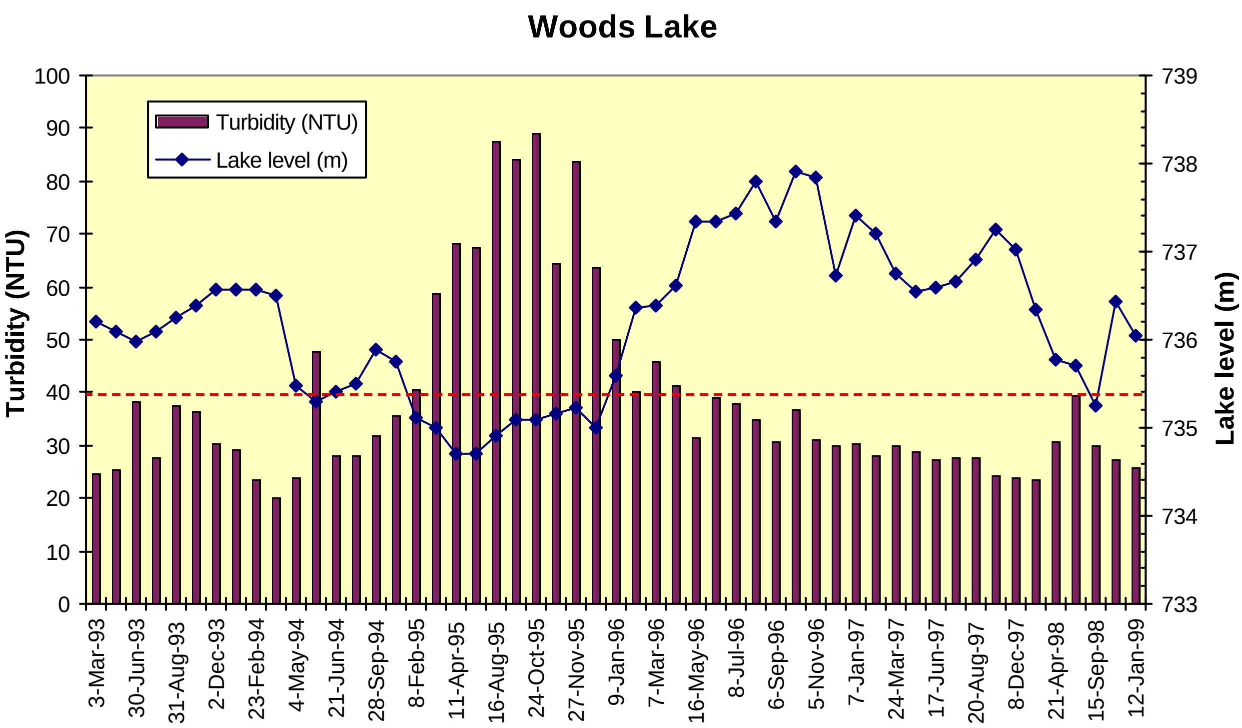


Figure 5.1 **Turbidity and Lake Level Values for Woods Lake from 1993 to Present.**

A curious aspect of the increasing silica concentrations is that in the 1960s, when Tyler studied the lake, he recorded silica values of 8 – 10 mg/L and a diatom population dominated by species other than *Melosira granulata* (unpublished data P. Tyler). IFC investigations in the early and mid 1990s have found lower silica concentrations, and a different diatom population dominated by *M. granulata*. The most recent sampling, July 1998, shows that silica concentrations are once again in the range recorded by Tyler. Whether the revised management procedures of the lake are creating 'silica rich' conditions, or whether the lake is going through a natural cycle is unknown. A continued increase in silica concentrations may warrant a more thorough investigation of the phytoplankton and zooplankton populations of Woods Lake.

5.2 Rivers

The 1996 'South Esk Basin State of Rivers Report' by Bobbi *et al.* summarises investigations undertaken by the then Department of Primary Industries and Fisheries (DPIF), now DPIWE. It provides a comprehensive overview of the water quality status of the rivers in the South Esk catchment.

5.2.1 South Esk River

Bobbi *et al.* (1996) documented 'typical' water quality in the South Esk River catchment above the confluence with the Macquarie and Meander Rivers, summarised as follows:

- low conductivity values (generally < 100 μS/cm);
- low turbidity values (generally < 5 NTU and < 3 mg/L suspended solids);
- low alkalinity (< 10 mg/L $CaCO_3$); and
- low nitrate and total phosphorus concentrations – in the lower range of ANZECC values (ANZECC, 1992).

A water quality 'blackspot' in the catchment is related to historic mining operations in the Rossarden/Storeys Creek area (Norris, 1979). Elevated concentrations of metals, zinc and cadmium in particular are recognised as having an adverse impact on the downstream environment, and Mineral Resources Tasmania is presently managing a remediation effort in the area. More recent analysis and interpretation of historic invertebrate data indicate other factors must be contributing to the environmental degradation further downstream (e.g. catchment degradation and land use practices). In terms of ecological health, this catchment wide degradation has resulted in four resident invertebrates having been identified as endangered or threatened. Of these, three are downstream of Hydro structures (see section 6.1.2).

Drought-breaking rains and associated erosional episodes have been identified as the times of highest nutrient and suspended sediment concentrations in the catchment (Bobbi *et al.,* 1996).

5.2.2 Macquarie River

The DPIF investigations documented the following water quality characteristics for the Macquarie River (Bobbi *et al.,* 1996).

- Highest electrical conductivity (EC) of the three major rivers in the basin (142 – 230 μS/cm). EC is dominated by the release of dilute (low conductivity) Great Lake water through Poatina with great fluctuations occurring over short time periods.
- Turbidity is generally low (< 5 NTU) except in two tributaries, the Lake and Elizabeth rivers.
- Nitrate and total nitrogen values are low.
- Total phosphorus concentrations are low (< 0.002 mg/l) except in the Elizabeth River.
- Large flood events are responsible for the majority of nutrient export from the catchment.
- No evidence of metal contamination was detected during the survey work.

In general, few water quality 'hotspots' were identified, although there were some elevated nutrient concentrations associated with the Ross and Campbelltown sewage treatment plants (STPs).

A brief microbiological contamination indicator survey was completed as part of the DPIF study, in both the main channel of the Macquarie River and its major tributaries. Generally, the upper Macquarie was found to contain unacceptable levels of faecal indicators in areas where stock had direct access to the river. One site in the lower river also had high levels of faecal indicators, although most of the catchment does not appear to be heavily contaminated (Bobbi *et al.*, 1996).

5.2.3 Lake River

The Lake River had the highest median turbidity value of all sites monitored in the Macquarie River catchment (13.5 NTU), with values up to 48 NTU associated with higher flows. Nutrients in Lake River were found to directly reflect conditions in Woods Lake, though were not significantly higher than other sites in the Macquarie River catchment (Bobbi *et al.*, 1996). The temperature of the Lake River was found to be lower than other tributaries due to the highland, colder source of water.

The ionic characteristics of the Lake River were generally found to be more dilute than for the other tributaries of the Macquarie River. Median alkalinity and hardness values for the Lake River of 12.5 and 32 mg/L were reported, respectively, compared with 25 and 75 mg/L for the Macquarie River at Ross. This is attributable to the doleritic geology underlying these tributaries (Bobbi *et al.*, 1996).

5.2.4 Back Creek

Back Creek receives water from Great Lake via the diversion of water from Poatina into the Cressy-Longford Irrigation Scheme. Back Creek enters the South Esk River below its confluence with the Macquarie River. The area serviced by the irrigation scheme is affected by high salinity and land use degradation, and this is reflected in EC levels in Back Creek when the irrigation diversion is not operating (Bobbi *et al.*, 1996). The presence of a STP in the catchment also contributes significant nutrient loads, and dilution from the irrigation scheme is the major factor controlling downstream water quality concentrations.

Overall, the water quality in Back Creek was found to be the most degraded of any of the tributaries in the South Esk Basin (Bobbi *et al.*, 1996).

5.2.5 Brumbys Creek

Bobbi *et al.* (1996) found that EC in Brumbys Creek and the lower Macquarie River were also controlled by releases from the Poatina Power Station. Because the water exiting the power station is derived from the higher and generally colder Great Lake, water temperature in Brumbys Creek was also found to be lower than other tributaries.

5.2.6 Meander River

The DPIF investigations found the following ‘typical’ water quality characteristics in the Meander River:

- EC ranged between 29 and 86 μS/cm except for lower Quamby Brook;
- nutrient concentrations in the Meander catchment were the highest in the South Esk Basin;
- Quamby Brook showed evidence of eutrophication based on total phosphorus concentrations, and had low dissolved oxygen values;
- median pH values in the catchment ranged between 6.5 and 7.5; and
- metal concentrations for cadmium, copper, lead, zinc and arsenic were generally below detection limits.

Similar to the South Esk River, microbiological sampling indicated elevated faecal coliform counts throughout the lower reaches of the catchment.

5.3 Lowland Lakes

Lake Trevallyn is the only lowland lake in the South Esk catchment. Water quality data for Lake Trevallyn, as is the case with the rest of the waterbodies in the catchment, is limited. Surface water quality data have been collected twice as part of the ongoing Lake Survey Program, in 1992-1993 and 1995-1996, and there is some historical data (Table 5.2).

Measured levels of water quality parameters in Lake Trevallyn are higher than those documented in the highland lakes (except Woods Lake), and reflect the nutrient characteristics of the South Esk Basin rivers. There is very good correlation between the historical and the more recent monitoring data, except for ammonia where the more recent data indicate higher levels.

One of the recent samplings coincided with a large flood event that resulted in elevated concentrations of many parameters. These results again underscore the importance of large flood events on nutrient and sediment transport in the catchment.

Table 5.2 Maximum, Median and Minimum Values for Water Quality Parameters Measured at Lake Trevallyn

	Temp (°C)	**EC** (µS/cm)	**DO** (mg/L)	**pH** (units)	**Turb** (NTU)	**S. Sol** (mg/L)	**TKN** (mg/L)	**Nitrate** (mg/L)	**Total P** (mg/L)	**Total Fe** (mg/L)	**Total Mn** (mg/L)
IFC											
Max	22.6	135	11.5	7.35	37.6		0.72	0.29	0.07	2.1	0.03
Median	17.2	112	10.2	7.14	5.85		0.28	0.053	0.0215	0.64	0.02
Min	5.3	44.1	7	6.38	1.1		0.01	0.002	0.013	0.2	0.01
n	*15*	*15*	*5*	*9*	*10*		*12*	*11*	*12*	*12*	*12*
HYDROL											
Max	21.8	206		7.5		17		0.26	0.063		
Median	13.1	85		7.1		2		0.035	0.019		
Min	6.1	34		5.7		1		0.001	0.01		
n	*23*	*23*		*25*		*24*		*24*	*24*		
ANZECC guidelines		<1500	> 6.0	6.5-9.0			0.1-0.5		0.005-0.05	< 1.0	

Temp = temperature, EC = electrical conductivity, DO = dissolved oxygen, Turb = turbidity, TKN = total kjedhal nitrogen, P = phosphorus, Fe = iron, Mn = magnesium, n = number of samples

Data from IFC Lake Survey monitoring (1992 – 1996), and from Hydrol database (mostly 1992 – 1994, with a few as early as 1976).

Generally all of the parameters fall within ANZECC (1992) water quality guidelines for aquatic ecosystems, although the maximum iron value exceeds the recommended values. The higher total phosphorus values and iron values also exceed the IFC developed indicators for potential water quality problems.

During 1976-1977 and 1990-1991, microbiological sampling was completed in Lake Trevallyn. While insufficiently sampled to compare properly with ANZECC (1992) guidelines, these results suggest there are times during which Recreational Primary Contact (swimming etc.) should be restricted within the lake. The source of the bacteriological contamination could be from the surrounding developed land immediately adjacent to Lake Trevallyn, or it could be from upstream sources, as documented by DPIF (Bobbi *et al.*, 1996).

5.4 Summary of Water Quality Issues

As outlined in this chapter, there are a number of water quality-related issues in the South Esk – Great Lake catchment. These issues are not necessarily related to Hydro operations but may be linked to other land use practices and environmental conditions. Some of these water quality issues are relevant to the Hydro and relate both to its role as a provider of water to downstream rivers and irrigators, and to its role as the recipient of water in Lake Trevallyn. Specific impacts of Hydro operations on water quality in the catchments are difficult to determine, as water quality information prior to development of the Poatina and Trevallyn schemes is limited or not available.

According to the available data, water quality in the highland lakes on the Central Plateau (Great Lake, Arthurs Lake and Lake Augusta) is generally good, and water quality parameters display levels consistent with those in the 'natural' Lake Ada. Water quality in the rivers in the South Esk catchment is somewhat variable and is related to land use practices. The water quality issues in the Great Lake and South Esk catchments include (but may not be limited to) the following:

- high turbidity in Woods Lake and at times in the Lake River (reflecting conditions in Woods Lake);
- cool water releases from highland lakes into Brumbys Creek (via Poatina) and into the Lake River (via Woods Lake), resulting in lower water temperatures;
- an historic mining source of heavy metals in the upper South Esk River at Rossarden/Storys Creek;
- high EC and faecal indicator levels in Back Creek, a tributary of the South Esk which receives runoff from the Cressy-Longford Irrigation Scheme;
- high levels of faecal indicators in the lower South Esk catchment (including the lower Meander catchment and Lake Trevallyn) and the upper Macquarie River (sources include stock access and sewage outlets); and
- elevated nutrients in the Meander River and tributaries and in Lake Trevallyn.

In general in the South Esk catchment, water quality problems are magnified by higher flows and flood events.

Map 5.1 shows the Hydro waterways in the in the Great Lake South Esk catchment with key water quality issues noted.

The Hydro in recent years has taken significant steps to maintain acceptable levels of turbidity in Woods Lake, thus improving water quality of irrigation releases down the Lake River. The Hydro raised the minimum level of Woods Lake in the mid 1990s, which resulted in a reduction in turbidity caused by wind-induced sediment suspension.

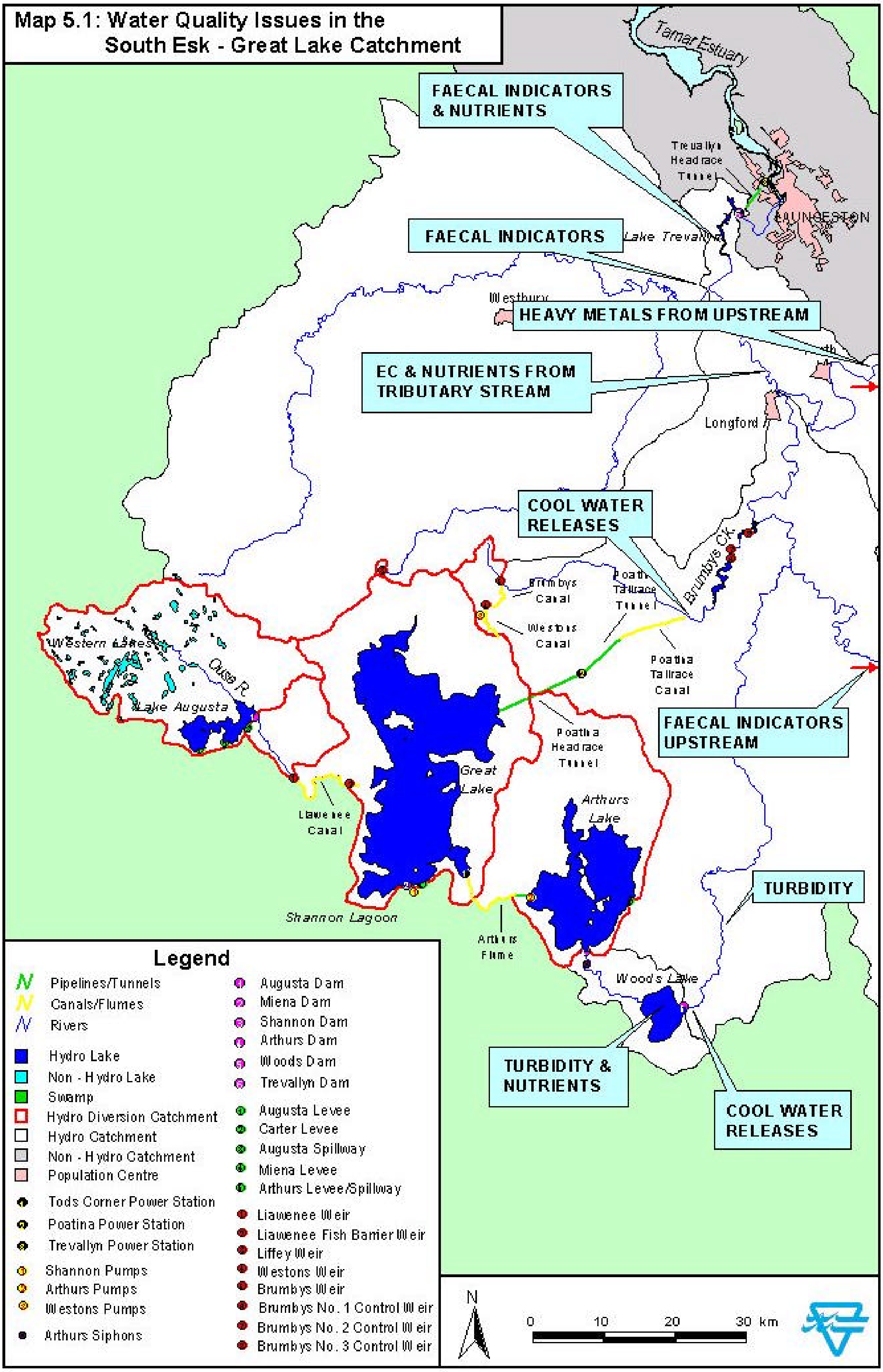
The Hydro's Aquatic Environmental Policy sets the framework for the Hydro to review its environmental performance. The Hydro has committed to investigate the influence of its operations on affected lakes and rivers and report on performance in an open and systematic manner. This allows the Hydro to make decisions on water management based on good scientific information.

The Hydro is currently implementing a Waterway Health Monitoring Program (WHMP), which began in the 1998-1999 financial year. This program involves implementing a routine monitoring program that contains three major elements: water quality, biological assessment and physical condition (Gamble and Locher, 1998).

The water quality component of the WHMP involves monitoring physico-chemical water quality parameters, and is based on three levels of monitoring; routine, investigative and detailed study. The level and frequency of monitoring in Hydro waterways and the parameters to be monitored for are based on an assessment of the waterway characteristics and the current level of knowledge of environmental impact to those waterways.

Most Hydro waterways are subject to a routine monitoring program at minimum. Higher levels of monitoring (i.e. investigation monitoring or detailed study) will be required for a waterway if the monitoring results show elevations or irregularities in parameters of concern.

Currently in the South Esk – Great Lake catchment, Lake Trevallyn is being routinely monitored at high frequency and Woods Lake is being monitored investigatively at high frequency. Lake Trevallyn and Woods Lake also have depth profiles taken in the mid point of the lake for physico-chemical parameters. Water quality is routinely monitored with low frequency sampling in Great Lake, Lake Augusta and Arthurs Lake. Brumbys Creek is currently being monitored investigatively and has planned future routine monitoring for water quality.



Map 5.1: Water Quality Issues in the South Esk - Great Lake Catchment
Tamar Estuary
FAECAL INDICATORS & NUTRIENTS
Trevallyn Headrace Tunnel
LAUNCESTON
FAECAL INDICATORS
Lake Trevallyn
Westbury
HEAVY METALS FROM UPSTREAM
EC & NUTRIENTS FROM TRIBUTARY STREAM
Longford
COOL WATER RELEASES
Brumbys Ck.
Brumbys Canal
Poatina Tailrace Tunnel
Westons Canal
Poatina Tailrace Canal
Western Lakes
Ouse R.
Lake Augusta
FAECAL INDICATORS UPSTREAM
Poatina Headrace Tunnel
Great Lake
Arthurs Lake
Liawenee Canal
TURBIDITY
Shannon Lagoon
Arthurs Flume
Woods Lake
TURBIDITY & NUTRIENTS
COOL WATER RELEASES
Legend
Pipelines/Tunnels
Canals/Flumes
Rivers
Hydro Lake
Non - Hydro Lake
Swamp
Hydro Diversion Catchment
Hydro Catchment
Non - Hydro Catchment
Population Centre
Tods Corner Power Station
Poatina Power Station
Trevallyn Power Station
Shannon Pumps
Arthurs Pumps
Westons Pumps
Arthurs Siphons
Augusta Dam
Miena Dam
Shannon Dam
Arthurs Dam
Woods Dam
Trevallyn Dam
Augusta Levee
Carter Levee
Augusta Spillway
Miena Levee
Arthurs Levee/Spillway
Liawenee Weir
Liawenee Fish Barrier Weir
Liffey Weir
Westons Weir
Brumbys Weir
Brumbys No. 1 Control Weir
Brumbys No. 2 Control Weir
Brumbys No. 3 Control Weir
N
0 10 20 30 km

6. BIOLOGICAL ISSUES

This chapter of the document is the second of four chapters discussing environmental issues in the South Esk – Great Lake catchment. The previous chapter examined water quality, and this chapter considers biological issues related to the aquatic environment. Chapters 7 and 8 outline geomorphological issues and multiple use issues respectively. This chapter is structured into sections on threatened species (6.1), native fish migration (6.2), and exotic species (6.3). A summary of biological indicators of waterway health is also given in section 6.4 as an overview of biological monitoring within the South Esk – Great Lake catchment. The biological issues and current monitoring and programs are summarised in section 6.5.

The information in this chapter was obtained by a desktop study that canvassed issues using information obtained from interviews and the available literature. No field investigations were carried out.

6.1 Threatened Species

6.1.1 Threatened Species Classification

This document focuses on threatened species as listed by the Tasmanian *Threatened Species Protection Act* 1995 which defines threatened in three commonly used progressive categories (based on the International Union for the Conservation of Nature (IUCN)) classification scheme with adjustments for Tasmanian conditions. These are:

- Endangered (Schedule 3);
- Vulnerable (Schedule 4); and
- Rare (Schedule 5).

Other widely applied schemes are also used, but these do not maintain a purely Tasmanian focus. Of particular interest is the Australian Society for Fish Biology (ASFB) classification scheme.

In addition to the Tasmanian *Threatened Species Protection Act* 1995, there is the Commonwealth *Endangered Species Protection Act* 1992. Some threatened species are listed with both acts, indicating their recovery programs are of national importance (e.g. the Pedder galaxias and the Wedge-tailed eagle).

There are a number of species which are not currently listed on the *Threatened Species Protection Act* 1995, but which have conservation significance. A variety of international, Commonwealth and State agreements and legislation protect international migratory birds. International migratory birds listed with the Japan-Australia Migratory Bird Agreement (JAMBA) and the China-Australia Migratory Bird Agreement (CAMBA) are protected by these international treaties and the *National Parks and Wildlife Act* 1970. There are 37 bird species listed in these agreements which have been recorded for Tasmania (http://www.parks.tas.gov.au/wildlife/birds/tasbirds.html, 1999). Some JAMBA and CAMBA species frequent inland wetlands and thus may be found in Hydro managed areas. In addition, Australia is a signatory to the Ramsar Convention, an international treaty to protect critical habitat for international migratory birds. There are 10 Ramsar sites in Tasmania. None of these occur in the South Esk Catchment.

Additional to the above classifications, the Tasmanian Parks and Wildlife Service (TASPAWS) maintains lists of rare or conservation significant species under the following classifications:

- Indeterminate: Taxa which are likely to fall into the endangered, vulnerable or rare (potentially threatened) category but for which insufficient data are available to make an assessment (require investigation).
- Restricted: Taxa which are not presently in danger but which occur in restricted areas, or which have suffered long term reduction in distribution and/or abundance and are now uncommon.

- Uncertain Status: Taxa whose taxonomy, distribution and/or abundance are uncertain but which are suspected of being restricted.

6.1.2 Threatened Species and Habitats in the South Esk – Great Lake Catchment

A total of 244 threatened species have been identified in the South Esk – Great Lake catchment by the GTSPOT database maintained by TASPAWS. These include 2 mammals, 1 amphibian, 3 birds, 3 fish, 210 plants and 25 invertebrates. Table 6.1 lists the number of species found in each category of endangered, vulnerable, rare and presumed extinct, in relation to Hydro controlled areas. Little is known about many of these species, including the degree of dependence on Hydro affected waterways (if any). Many of these species are known to be fully terrestrial and therefore, are not directly affected by Hydro operations of waterways. However, they may need to be considered in broader management plans. Species presumed extinct are listed but not discussed as these may be rediscovered during the course of future work. Bryant (1999) provides detailed information on Tasmanian threatened fauna, including distributional details.

Table 6.1 Classification of Threatened Species which are recorded in the GTSPOT Database for the South Esk – Great Lake Catchment

		Endangered			Vulnerable			Rare			Presumed Extinct		
Type	**Total**	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**
Amphibian	1	-	-	-	1	1	1	-	-	-	-	-	-
Bird	3	-	-	-	2	2	2	1	1	1	-	-	-
Fish	3	1	1	-	2	2	1	-	-	-	-	-	-
Flora	210	19	17	2	32	28	17	159	131	79	5	3	2
Invertebrate	25	1	1	-	7	5	3	18	15	3	1	1	-
Mammal	2	-	-	-	-	-	-	1	-	1	1	1	1
Total	244	21	19	2	44	38	24	179	147	84	7	5	3

- = none recorded to date for this category in the GTSPOT database

A – catchment area includes all land, rivers and lakes upstream of Hydro storages

B – land and waterways within a 2500 or 3000m buffer zone around Hydro assets

C – land and waterways within a 2500m buffer zone around main river channels downstream of Hydro storages

Great Lake Species

Great Lake is recognised as being one of the Nation's most biodiverse aquatic ecosystems. Great Lake's listing in the Directory of Important Wetlands in Australia (Blackley *et al*., 1996) is due to its high biodiversity of invertebrates. Many of these invertebrates are associated with aquatic algal beds consisting primarily of *Chara* and *Nitella* spp. (Davies and Fulton, 1987) and are considered threatened under the *Threatened Species Protection Act* 1995. At least one native fish, *Paragalaxias eleotroides*, appears to be closely linked to these algal beds. Table 6.2 lists the species of high conservation significance within Great Lake. The preservation of Great Lakes algal beds is of great importance in maintaining the unique status of the aquatic ecosystems in this catchment.

The algal beds occupy areas concentrated in the north east, eastern and southern shores of the lake mainly in areas protected from the predominant north-westerly winds (Davies and Fulton, 1987). They occur in a limited depth range restricted between 15 and 19 metres below FSL (1024-1020 mASL; Davies and Fulton, 1987). This range begins approximately two metres above the NMOL. Threats to these algal beds and their associated fauna currently consist of lake level changes (particularly large drawdowns), siltation and introduction of aquatic weeds. The influence of Hydro operations on the distribution of these algal beds is not known.

Table 6.2 Fauna in Great Lake which is of High Conservation Significance

Species	Common Name	Distribution	Habitat	Status
Paragalaxias dissimilis	Shannon paragalaxias	Endemic to Great Lake, Shannon and Penstock Lagoon	Most common around rocky shoreline	restricted distribution
Paragalaxias eleotroides	Great Lake paragalaxias	Endemic to Great Lake, Shannon and Penstock Lagoons	Most common in weed beds, also occurs around shoreline.	restricted distribution
Triplectides elongatus	Great Lake Caddis 1	Great Lake area	Weedy areas of lake and tributaries	restricted distribution
Costora iena	Great Lake Caddis 2	Endemic caddisfly to Great Lake area only	Weedy area of lake and tributaries	Extinct – not collected since 1930's X
Asmicridea grisea	Great Lake Caddis 3	Endemic caddisfly to Great Lake area only.	Weedy area of lake and tributaries	Restricted distribution
Glacidorba pawpela	Great Lake Snail	Endemic to Great Lake area and Pelion	Benthos and soft sediments	Rare X
Tasniphargus tyleri	Great Lake Amphipod	Endemic to Great Lake	Weed beds	Rare X
Uramphisopus pearsoni	Great Lake Phreatoicid 1	Endemic to Great Lake	Lake benthos	Rare X
Onchotelson brevicaudatus	Great Lake Phreatoicid 2	Endemic to Great Lake and Shannon Lagoon	Lake benthos	Rare X
Onchotelson spatulatus	Great Lake Phreatoicid 3	Endemic to Great Lake	Lake benthos	Rare X
Mesacanthotelson setosus	Great Lake Phreatoicid 4	Endemic to Great Lake and Shannon Lagoon	Lake benthos	Rare X
Mesacanthotelson tasmaniae	Great Lake Phreatoicid 5	Endemic to Great Lake	Deep sections of lake benthos	Rare X
Beddomia tumida	Great Lake Hydrobiid	Endemic to Great Lake	Unknown	Vulnerable X
Ancylastrum cumingianus	Planorbid Limpet	Endemic to Great Lake, Shannon Lagoon, Lake St Clair and Mt Field	Weed beds	Restricted distribution

X = Status according to the Tasmanian *Threatened Species Protection Act* 1995.
Others as classified by Invertebrate and Vertebrate Advisory Committees (TASPAWS 1994a, b, c).

Arthurs and Woods Lake Galaxiids

The Arthurs paragalaxias (*Paragalaxias mesotes*) and saddled galaxias (*Galaxias tanycephalus*) are found only in Arthurs Lake and Woods Lake in the Central Highlands as natural populations. The saddled galaxias is listed as vulnerable in the Tasmanian Threatened Species Protection Act 1995 due to its restricted distribution, low number of populations and the low densities of individuals, particularly within Arthurs Lake. *P. mesotes* is not currently listed in the Act but has been nominated for listing by the IFC (Jackson, 1998).

Although habitat modifications have occurred in Arthurs and Woods lakes as a result of Hydro development, the major threat to these species appears to be predation by brown trout, *Salmo trutta* (Crook and Sanger, 1997). The population of *G. tanycephalus* is less abundant in Arthurs Lake, possibly due to lower turbidity waters increasing the predation by trout and possibly other organisms during the larval stage. Woods Lake also supports a sizeable trout population, but is characterised by higher turbidities which are thought to contribute to the higher populations of saddled galaxias in this lake (Sanger and Fulton, 1991).

Currently there are no plans to extend the range of this species through translocation or provision of fish migration facilities. Two small natural waterbodies to the north of Arthurs Lake have been identified as possibilities for the purpose of translocation. Gunns Lake may dry up during drought times although Little Lake is thought to be permanent (Jackson and Chilcott, 1998). These lakes have not been fully surveyed to determine their suitability for translocation of the Arthurs or saddled galaxiids and may prove unsatisfactory.

Arthurs Dam now separates Arthurs paragalaxias and saddled galaxias populations located in Arthurs and Woods lakes. The degree of linkage between these two waterbodies prior to the construction of Arthurs Dam is not known, and therefore the effects of the dam on these species cannot be determined from the information currently available.

Swan Galaxias

The Swan galaxias (*Galaxias fontanus*) is listed as endangered under the *Threatened Species Protection Act* 1995 and was first described by Fulton (1978). The distribution of *G. fontanus* in the South Esk catchment is well above areas influenced by Hydro operations, and this species is therefore not threatened by the current management of the Hydro system. Surveys of the Swan River area showed that the distribution of this species was limited to the upper Macquarie River catchment and the Swan River catchment and that the downstream boundaries of its distribution coincided with the presence of brown trout (*Salmo trutta*). Currently twelve breeding populations of Swan galaxias exist including 3 natural and 9 translocated sites (Sanger and Fulton, 1991).

Australian Grayling

The Australian grayling (*Prototroctes maraena*) is a diadromous species and needs unimpeded access from salt water to fresh water to complete its life cycle. It is listed as “vulnerable” in the *Threatened Species Protection Act* 1995 and the *Endangered Species Protection Act* 1992. These classifications are due to concerns raised by the extinction of its New Zealand counterpart which has never been fully explained (McDowall, 1996), and to the decrease in available habitat resulting from instream barriers to migration. *P. maraena* occurs in coastal rivers Statewide and is widespread in eastern and northern coastal areas and occasionally on the west coast. The exact spawning area of *P. maraena* is unknown but is assumed to be in freshwater. Larvae are washed downstream and have a marine stage lasting up to 6 months. Juveniles then migrate upstream to inhabit the upper zones of estuaries and clear freshwater streams (McDowall, 1996).

Hydro influence on *P. maraena* in the South Esk catchment may result from Trevallyn Dam preventing migration. However the effect that this has on the regional viability of the species is largely unknown, as there has been little research done into its current and probable past distributions and habitat utilisation. Recent study has revealed that the species is more common than was earlier believed, however it is still listed as potentially threatened by ASFB.

Cataract Gorge Snails

One species of threatened freshwater snail (*Beddomeia launcestonensis*) has been recorded from Cataract Gorge downstream of Trevallyn Dam. This is one of around 40 hydrobiid species that are considered rare due to their restricted distributions. The habitat requirements for this species are largely unknown, however, a report for the Launceston City Council (LCC) (Jerry De Gryse Pty. Ltd., 1996) suggests that this species requires deep stable habitats that are least vulnerable to fluctuations in water level. The pre-Hydro distributions of this species, and the effect of the current flow regime on habitat availability are unknown.

Amphibians

There are a total of ten known amphibian species in Tasmania, with two endemics and one species with a restricted range. These species have different habitat requirements, some requiring stream systems, others requiring permanent water. The only listed endangered amphibian in Tasmania is *Litoria raniformis*, the green and gold frog, which does occur in Hydro affected areas in the South Esk – Great Lake catchment. The protected green and gold frog appears to prefer permanent water such as large well-vegetated swamps and dams (Taylor, 1991). In this case, Hydro operations may benefit and enhance their habitat, however, frequent large fluctuations in lake levels may not.

Birds

Four threatened species of birds occur within the South Esk – Great Lake catchments. These are the wedge tailed eagle (*Aquila audax fleayi*), the swift parrot (*Lathamus discolor*), the great crested grebe (*Podiceps cristatus*) (not listed by GTSPOT for this catchment), and the grey goshawk (*Accipiter novaehollandiae*). Of these species, only the great crested grebe and the grey goshawk are likely to be affected by Hydro water management regimes.

The great crested grebe is a highly specialised freshwater bird and lives mostly on lakes, reservoirs, large lagoons and swamps. It is dependent on large, well-vegetated wetlands for breeding (August to February), and feeds on small fish, tadpoles and aquatic invertebrates. It has nomadic habits and an erratic distribution, and when not breeding it prefers areas of greater and more exposed surface water, such as highland lakes and the Derwent and Tamar River estuaries (Green, 1995).

The grey goshawk is a small hawk dependent on dense mature blackwood swamps for breeding and foraging. It preys primarily on other birds, but small mammals, reptiles and insects are also included in its diet. It has habitat requirements (habitat and prey species) which are dependent on a wetland ecosystem, which could be affected by Hydro waterway operations.

Waterway management can result in changes in the local biodiversity and food webs of wetland and riverine ecosystems, including bird life. For example, alterations in the hydrological regime in wetlands from variable to permanent flooding may change the dominant bird species from those dependent on invertebrate and aquatic flora as a food source to those which feed on fish (Kingsford, 1995). Another impact on water birds as a result of hydrological change can be the loss of structural vegetation necessary for nesting and roosting. These factors may influence some species of migratory water bird listed in the JAMBA and CAMBA agreements and non-migratory native species dependent on wetlands for breeding and foraging requirements.

How much of the composition of the local waterbird population is due to Hydro operations or to natural conditions is unknown. In general, Hydro waterway operations have not been assessed for impacts on Tasmanian bird species.

Other Invertebrates

There are two species of Trichoptera (caddisfly) listed for the South Esk catchment, *Hydroptila scamandra* and *Leptocerus souta*. Both species are considered rare, with the main threat being agricultural activities that affect water quality. They are found in their type locality in the Macquarie River and have also been recorded in the South Esk River near Evandale by Bobbi *et al.* (1996), however there is some doubt to the validity of this record (Dr. P. Davies, Freshwater Systems, *pers. comm.*).

Flora

Of the 272 listed threatened species of flora that have been recorded by the GTSPOT database for the South Esk – Great Lake catchment, 10 are aquatic plants and 62 are wetland plants. Compared to the mobility of animal species, plants have restricted ranges and expansion, which may lead to simpler management strategies. Many of the listed plant species may not be directly impacted by Hydro operational activities. Hydro water management operational regimes will have the most influence on aquatic species, followed by wetland and riparian species.

6.2 Native Fish Migration and Dispersal

6.2.1 Background

Migration and dispersal are important parts in the life cycles of native Australian fish and therefore any disruption to these processes may impact on stocks of these species. This is particularly true for the Tasmanian fish fauna, which are typically restricted in range and are adapted to very specific hydrological conditions.

There are several known impediments to fish migration within the South Esk – Great Lake catchment. The most notable is Trevallyn Dam on the lower South Esk River, located not far from estuarine waters. The other major dams in the catchment, Arthurs, Augusta and Miena, are all much further inland. Little is known about the barriers presented by other levees, weirs and culverts within the catchment.

Whilst dams can be barriers to native fish movements, canals, pipelines and inundations may present dispersal mechanisms that did not exist naturally. This connection of waterways may result in the introduction of native fish and other biota, such as algae, macrophytes and microinvertebrates, into areas where they were not previously found. However due to a general lack of pre-regulation data, past distributions of biota are often unknown.

Other barriers to fish movement may be presented by altered flow regimes or water quality. High river flows may impose a water 'velocity barrier' against which fish cannot swim. Reduced flows may lower water levels such that small barriers become insurmountable or the depth of water available for fish passage is not adequate. Low dissolved oxygen levels or high (or low) temperatures may pose a barrier through which fish may not migrate. Occurrences of this nature have not been documented in this catchment. Consequently, most issues relating to native fish dispersal relate to the barriers presented by instream structures and the associated changes in channel hydrology.

Exotic fish migration and dispersal issues are discussed in section 6.3.

6.2.2 Diadromous species

Diadromous species are those that migrate between fresh and salt water, usually for the purpose of breeding. Many native fish found within Hydro affected waters are migratory and are thought to rely on diadromous migration as part of their life cycle. Two of these species (*G. truttaceus* and *G. brevipinnis*) also occur as landlocked populations within Hydro waters and can be considered as separate stocks to the diadromous populations. Table 6.3 lists the native diadromous species found in the South Esk catchment, their distributions and conservation status. Of the species shown in Table 6.3, only the Australian grayling is classified as 'vulnerable'.

Trevallyn Dam is likely to be the most significant barrier to diadromous species in the South Esk catchment, such as the Australian grayling (section 6.1.2). The dam was identified as a major barrier to elvers of *Anguilla australis* and *A. reinhardtii*, thus providing justification for the construction of an elver ladder by the Hydro in 1996. An IFC study supported by the Hydro is being initiated to assess the effectiveness of this ladder. It should provide a valuable tool for further research into the needs of migrating elvers.

Table 6.3 Migratory Native Fish Species occurring in the South Esk – Great Lake Catchment (adapted from Hydro-Electric Corporation, 1999a)

Species	Common name	Tasmanian distribution	Conservation status
Mordacia mordax	Short-headed lamprey	Widespread around the state	Not listed in state or federal legislation. Abundant throughout the state.
Geotria australis	Pouched lamprey	Widespread around the state	Not listed in state or federal legislation. Widespread
Anguilla australis	Short-finned eel	Widespread around the state	Not listed in state or federal legislation. Abundant throughout the state.
Anguilla reinhardtii	Long-finned eel	North-east Tasmania	Not listed in state or federal legislation. Abundant along the northern and eastern coasts of the state.
Prototroctes maraena	Australian grayling	State-wide coastal rivers	Vulnerable (TSPA & ESPA). Widely distributed along north and east coasts of Tasmania, and occasionally on the west coast.
Galaxias maculatus	Common jollytail	State-wide in lower reaches of rivers and coastal streams	Not listed in state or federal legislation. Common.
Galaxias truttaceus	Spotted galaxias	Locally abundant throughout the state.	Not listed in state or federal legislation. Some self sustaining landlocked populations
Galaxias brevipinnis	Climbing galaxias	Tasmania wide distribution	Not listed in state or federal legislation. Some self sustaining landlocked populations
Neochanna cleaveri	Tasmanian mudfish	Lower reaches of rivers and estuaries around the state except east coast	Not listed in state or federal legislation. Swamp drainage and reclamation threaten populations
Lovettia sealii	Tasmanian whitebait	Lower reaches of rivers and estuaries around the state except east coast	Not listed in state or federal legislation. Abundance declined with overfishing, closure of fishery has allowed populations to increase.
Retropinna tasmanica	Tasmanian smelt	State-wide in lower reaches of rivers and coastal streams	Not listed in state or federal legislation. Fragmented distribution, may form landlocked populations in lowland areas
Pseudaphritis urvillii	Sandy (Tupong or Freshwater Flathead)	State-wide in lower reaches of rivers and coastal streams	Not listed in state or federal legislation. Widespread and abundant

TSPA – the Tasmanian *Threatened Species Protection Act* 1995

ESPA – the Commonwealth *Endangered Species Protection Act* 1992

Downstream spawning migrations of adult eels (silver eels) are also likely to be hindered by Trevallyn Dam. Dead silver eels have been found downstream of the Trevallyn Power Station by researchers, the cause of death postulated to be physical impact and the rapid decompression of eels drawn through the turbines. It is not known whether eels can utilise the riparian release at the bottom of Trevallyn Dam, however, rapid decompression may limit the usefulness of this. Consequently, the major downstream passage for silver eels would appear to be with spillway flows. While these are frequent at Trevallyn, the timing may or may not correspond with eel movements.

The rapids in Cataract Gorge downstream of the dam are likely to naturally restrict the upstream movements of some fish species whilst allowing passage for others. Reduced flows associated with the Trevallyn Power Scheme may act to hinder fish movement up the Gorge. Currently, a 0.43 cumec flow is regularly released, however this flow is not specifically for fish migration.

Little is known about pre-Hydro distributions of native fish species, and therefore, the true effect of the dam and water diversion on fish migration can only be examined retrospectively. Similarly, the current distributions of migratory fish in relation to Hydro infrastructure and the swimming/climbing abilities of these fish are also poorly understood.

6.2.3 Land-locked species

Native species within Hydro waters that form landlocked populations are listed in Table 6.4. These species may undertake within-storage and storage drainage system migrations for spawning and dispersal, which could be disrupted by lake level fluctuations or altered river flows. Artificial barriers to movement may restrict access to spawning sites, or may separate populations of rare fish such that genetic viability within the separated populations is compromised. A specific example in the Hydro system is the division of the saddled galaxias (*G. tanycephalus*) and Arthurs paragalaxias (*P. mesotes*) populations between Woods and Arthurs lakes. Both of these species occur in low numbers and only in these two lakes.

The potential for translocation of *G. tanycephalus* and *P. mesotes* to Great Lake, which does not naturally support these species, is not known, however fish thought, but not confirmed, to be *P. mesotes* have been captured in Arthurs Flume. The pumping of water from Arthurs Lake to Great Lake has been occurring since the 1960s, and if translocation were likely, it would probably have already occurred. The chance of the movement of another native fish, *Paragalaxias julianus* from the Western Lakes to Great Lake via Lake Augusta and Liawenee Canal has also not been properly assessed. Tasmanian galaxiids have adapted to specific niches and their geographical separation has allowed these fish to evolve without competition with similar species. The environmental implications of translocation, in regard to native fish species and the threatened invertebrate populations in Great Lake are not known.

Table 6.4 Land-locked and Riverine Native Fish Species occurring in the South Esk – Great Lake Catchment (adapted from Hydro-Electric Corporation, 1999a)

Species	Common name	Tasmanian distribution	Conservation status
Paragalaxias eleotroides	Great Lake paragalaxias	Great Lake, Shannon & Penstock Lagoons	Restricted distribution (ASFB) Vulnerable (IUCN) Nominated for TSPA listing
Paragalaxias dissimilis	Shannon paragalaxias	Great Lake, Shannon & Penstock Lagoons	Restricted distribution (ASFB) Vulnerable (IUCN) Nominated for TSPA listing
Paragalaxias mesotes	Arthurs paragalaxias	Arthurs & Woods Lakes	Restricted distribution (ASFB) Vulnerable (IUCN) Nominated for TSPA listing
Galaxias tanycephalus	Saddled galaxias	Arthurs & Woods Lakes	Vulnerable (ASFB, ESPA, TSPA, IUCN)
Gadopsis marmoratus	Blackfish	Various streams, rivers and lakes primarily in the north of the state, inc. South Esk River	Not listed in state or federal legislation. Reduced range and decline in abundance due to habitat modification and siltation
Nannoperca australis	Pygmy perch	Northern Tasmania, inc. S. Esk and Macquarie Rivers	Not listed in state or federal legislation. Habitat fragmentation (macrophytes) separating populations.

ASFB – Australian Society for Fish Biology;

ESPA – the Commonwealth Government's *Endangered Species Protection Act* 1992;

IUCN –world Conservation Union

TSPA – the Tasmanian Government's *Threatened Species Protection Act* 1995.

6.3 Exotic Species

Numerous exotic species are present in the South Esk – Great Lake catchment. Many are terrestrial weeds or diseases that are not likely to be affected by the operation of Hydro aquatic systems, and so are not discussed here.

The major concerns for exotic aquatic species relate to dispersal via waterways. Six exotic aquatic/riparian species are discussed in the following sections.

6.3.1 Redfin Perch (Redfin, European Perch, English Perch)

Redfin are an introduced fish that are highly predatory and therefore present a threat to many of Tasmania's native fish. They have strong dispersal tendencies and may form dense, stunted populations of little angling value (Andrews and Jack, 1998). Occurrence of redfin has been confirmed in Brumbys Creek, Lake River, Lake Trevallyn, Macquarie River, Meander River and South Esk River. Other possible locations are the Blackman River and Elizabeth River.

There is every reason to believe that redfin have invaded Great Lake, although this has not been confirmed by survey. During the summer of 1996, redfin perch were discovered in a small privately owned dam near Great Lake, connected by a drain leading into the lake. The drain was originally unscreened, and provided opportunities for dispersal of this species into the lake. The presence of several year classes of redfin within the adjoining dam indicated that redfin perch had been in the dam for some time and had probably also moved into Great Lake.

There is further concern that should redfin be present in Great Lake, the species could move up Liawenee Canal to invade the World Heritage listed wetlands to the west. An existing fish migration barrier at the base of Liawenee Canal became submerged and ineffective due to the rising waters of Great Lake. A new barrier, further upstream, was completed by the Hydro in late February 1999, specifically to prevent the migration of redfin into the Western Lakes. Electrofishing surveys by the IFC prior to construction of the barrier failed to capture any redfin in Great Lake or Liawenee Canal, which indicates that it is unlikely that redfin have moved up Liawenee Canal prior to completion of this new barrier.

6.3.2 Trout

Both brown (*Salmo trutta*) and rainbow (*Oncorhynchus mykiss*) trout are widely dispersed within the South Esk – Great Lake catchment. Great Lake forms a major trout fishery and caters for around 32% of all trout anglers in the State. Fluctuations in the level of Great Lake improve fishing success, in that lowered lake levels give anglers access to trout feeding in the near shore algae beds which may otherwise be too deep to be fished effectively. Rising lake levels inundate riparian vegetation, which attract trout to shallow water invertebrate hatches, and increases their accessibility to anglers.

6.3.3 Tench

Tench (*Tinca tinca*) are a native of Europe and were introduced to Australia in 1876, and reported by Fulton (1990) to be firmly established in Tasmania by 1882. They are generally found in slow moving waters and are usually only encountered in large numbers during the spawning period in spring. Tench is not a species favoured as a sport fish in Tasmania and is regarded as a pest.

No information is available with respect to the effects of Tench on Tasmanian aquatic ecosystems. Although not confirmed, it is not likely that this species represents a threat to the native fish population through direct predation. Fulton (1990) lists confirmed occurrences in various parts of the South Esk catchment. Some distributional data are held by TASPAWS.

6.3.4 Carp

Carp (*Cyprinus carpio*) are considered to be the world's most widely distributed fish. Fulton (1990) notes that a successful eradication program was undertaken against the species in 1974, implying that the species was thought to have been removed from Tasmanian waters at that time. However, the discovery of a large population of carp in Lakes Sorell and Crescent (non-Hydro lakes in the Derwent catchment) has led to the creation of a Carp Management Program, administered by the IFC. Currently, carp are not an issue within the South Esk – Great Lake catchment, however the proximity of Lakes Crescent and Sorell is of concern due to the possibility of manual translocation by ill-informed anglers.

6.3.5 Willows

Willows are an exotic species, which typically occur in riparian areas and were originally planted as a means of controlling erosion along rivers. Large infestations occur on the Macquarie, Elizabeth, St. Pauls, South Esk, Blackman and Nile rivers (Askey-Doran, 1993). Brumbys Creek downstream of the Poatina tailrace contains extensive stands of willows.

Willows exclude native riparian vegetation through competition and alteration of habitat. Willow encroachment of river channels, particularly in areas with reduced flows, leads to channel braiding and log jams. Rivers blocked in this manner flood easily and cause excessive erosion in areas of diverted channel flow. High rates of sedimentation are apparent in areas of dense willow infestation leading to burial of riparian plant communities. It has also been postulated that the high seasonal leaf drop from willows during autumn has detrimental effects on aquatic communities that are adapted to a constant nutrient input throughout the year (Parker and Bower, 1996).

Catchment community groups are actively involved in eradication of willows throughout the South Esk catchment and the State as a whole, and are coordinated through DPIWE. Recent efforts by a local Landcare group have been successful in eradicating large willow infestations from the Lake River.

6.3.6 Aquatic weeds

Canadian pondweed (*Elodea canadensis*) is a secondary prohibited aquatic weed introduced from North America. It prefers warm, shallow, slow moving water and forms fast growing, dense beds which out-compete native macrophytes. As a result, the distribution of native instream vegetation is reduced and the habitats available to other aquatic organisms are lessened. *Elodea* is known to clog canals and intake screens to such an extent that regular manual removal is required. It has a wide-ranging distribution throughout Tasmania.

Elodea has been reported from Arthurs Lake (French, 1994), and a 1998 field survey has confirmed its presence in Lake Augusta, Arthurs Flume, and in Tods Corner at Great Lake. It has almost certainly come from Arthurs Lake but it is unknown how recent this infestation is. This weed may present a threat to the native algae beds in Great Lake. No comprehensive surveys of the extent of *Elodea* in Hydro waterways have been undertaken to date.

Little is known about the distribution of other aquatic weeds in the state. Alligator weed (*Alternanthera philoxeroides*) and the introduced Bulrush (*Typha latifolia*) may cause localised issues within the catchment; however no coordinated reporting concerning these species is currently being undertaken. A list of macrophyte species which includes Canadian pondweed and Creeping Jenny (*Lysimachia nummularia*) is given for the Macquarie River in Davies and Humphries (1996).

6.4 Biological Indicators

The definition of 'waterway health' is a complex and essentially notional concept that is assessed differently depending on the objectives of the assessment, the reasons for monitoring and the desired deliverables (e.g. aquatic management plans, state of the environment reports, environmental flow criteria). Health of an ecosystem can be assessed subjectively by expert opinion in various fields, generalised habitat assessment protocols or even on aesthetic values. Objective measures are harder to interpret, but generally rely on the premise that higher species diversity (i.e. the number of species compared to the number of individuals) constitutes better ecosystem health, and the presence of exotic or weed organisms is considered detrimental to waterway health.

The response of living organisms to abiotic factors is multi-faceted and therefore problematic in defining cause and effect relationships. Biological monitoring is probably most useful in providing an "ecological average" of the environmental conditions existing within an environment of interest and is particularly useful when combined with habitat assessment and channel morphology studies. This is in contrast with abiotic (e.g. water quality) sampling that provides only a limited snapshot of the conditions of the waterway at a particular point in time.

The First National Assessment of River Health (FNARH) is an attempt to standardise river health monitoring in which the Hydro is actively involved as part of its Waterway Health Monitoring Program.

6.4.1 Phytoplankton, macrophytes and attached algae

Sampling of phytoplankton, macrophytes or attached algae is primarily focussed on issues associated with nutrient input and flows, and provides an indication of the level of primary production within the system.

Little is known about the current distribution of aquatic macrophytes within this catchment in general, and currently surveys are being conducted by the IFCBC on behalf of the Hydro to fill this information gap.

Measurement of phytoplankton densities can be done chemically (e.g. chlorophyll-*a* concentrations) or through direct counting of phytoplankton cells from water samples. Chemical analysis generally only gives a relative abundance of phytoplankton within a water sample. Counting and visual identification provide more data that may be potentially useful for biological monitoring. Currently chlorophyll-*a* determinations are regularly used, and visual assessment of algal cover is also carried out.

6.4.2 Macro-invertebrates

To date macro-invertebrates have been most widely used as biological indicators, due to their ease of sampling. There are generally high numbers present with reasonable species diversity (in low or unimpacted sites), and there are many invertebrates with varying sensitivities to environmental factors. Also, the responses of invertebrates to environmental factors can be tested experimentally without the need for large-scale habitat alterations and without undue ethical considerations.

Unfortunately, measurements associated with macro-invertebrate sampling can be prone to misuse and are often used to predict the status of entire ecosystems without any consideration of the upper levels of the food chain. In particular the presence of large carnivores, exotic species and alterations in energy input into the waterway can influence the concept of waterway health without being immediately apparent in limited macro-invertebrate sampling. Similarly, sampling true replicates is difficult due to micro-habitat differences and localised differences in (particularly) flow, substrate, depth and instream cover.

The Australian River Assessment Scheme (AUSRIVAS) concentrates on macro-invertebrate indicators and uses the Riverine Invertebrate Prediction and Classification Scheme (RIVPACS) in order to compare invertebrate populations between reference and test sites. Macro-invertebrates are also commonly used in Instream Flow Incremental Methodology (IFIM) analyses of environmental flows. Consequently, macro-invertebrates presently represent the most powerful tool in biological monitoring of waterway health.

Early work by Thorp (1973), Thorp and Lake (1973) and Norris *et al.* (1982) provide some historical information on the distribution and abundance of macroinvertebrate taxa in the South Esk River, and relate this to the effect of heavy metal contamination in the South Esk below Storeys Creek. However, due to variations in collection, analysis and reporting methods and limited coverage both spatially and temporally this information cannot be used as comprehensive background data for environmental monitoring purposes.

An environmental flow study by Davies and Humphries (1996) investigated the relationship between biota and instream habitats and found high macroinvertebrate density and diversity, particularly in habitat types vulnerable to declining flows. Risk assessment of instream flows for the summer months have been made for the Meander, Macquarie and South Esk rivers based on IFIM analysis of molluscs, macroinvertebrates, and fish and their relationship to habitats vulnerable to low flows. They recommended a flow regime to maintain ecological values and recreational trout fisheries.

Davies and Humphries (1996) also found that the abundance and diversity of odonates (dragonflies and damselflies) in the Macquarie and South Esk rivers may provide a good indicator of the health of the riparian wetland communities as many species of odonate had close associations with macrophyte beds.

DPIWE is in the process of compiling numerous reference sites throughout Tasmania and are calibrating RIVPACS models for different zones within the state (Oldmeadow *et al.,* 1998). Models for the north and north-west of Tasmania (including the South Esk and Mersey – Forth catchments) are almost complete based on autumn and spring samples. Many of the test sites correspond with Hydro WHMP sites and additional Hydro sites were added for the spring and autumn sampling in 1998/99. These will provide valuable data in assessing the effects of flow regulation on the aquatic environment. The IFCBC team has undergone training to standardise sampling protocols with DPIWE and will be able to add Hydro specific sites to these models.

A joint Hydro – ESAA funded study into the downstream effects of hydro storages and power stations, carried out by Davies, Cook and McKenny (1999.), included a number of test and reference sites in the South Esk – Great Lake catchment. Bioassessment of each test site was carried out by sampling the macroinvertebrate community and then comparing the number and abundance of taxa with those of reference sites. This program used a combination of IFIM and RIVPACS methodologies to investigate environmental flow requirements for Hydro affected waters.

The findings of the study for the South Esk sites indicated that macroinvertebrate communities immediately downstream of Trevallyn Dam comprised significantly fewer taxa than at the reference sites. Test sites further downstream were also modified, but to a lesser degree. Brumbys Creek test sites showed a similar level of modification. However, sites in the Lake River had similar macroinvertebrate communities to the reference sites, with no reduction in taxa.

6.4.3 Other Potential Biological Indicators

Zooplankton may be potential biological indicators for lakes as they are the dominant form of invertebrates in the pelagic zone but there are no studies at this stage measuring their presence or abundance.

Monitoring of fish communities for the purposes of assessing waterway health is generally not conducted due to the logistics of adequate and unbiased sampling in stratified and replicated surveys. In addition to this, the response of fish to subtle environmental variables, particularly in the short term, is largely unknown and therefore poses problems for environmental monitoring programs. Similarly, the effect of exotic species introduction, fishing pressure, and gear selectivity confounds results and need to be accounted for. No dedicated sampling of fish for river health monitoring is taking place within Tasmania, although research programs have been conducted on the mainland (e.g. Arthington *et al.,* 1997).

6.5 Summary of Biological Issues

As described in this chapter, there are a number of biological issues in the South Esk – Great Lake catchment. These issues may not relate to Hydro operations, but may be related to other activities in the catchment and managed by other organisations. The known issues are summarised under the groupings of rare and threatened species, fish migration and exotic species:

Rare and threatened species issues include (but may not be limited to) the following:

- algal beds in Great Lake represent a rare habitat, and support a high biodiversity of invertebrates, including some species that are listed as rare – the influence of Hydro operations on these algal beds is unknown;
- two native fish species, the saddled galaxias (listed as vulnerable) and the Arthurs paragalaxias (currently nominated for listing) occur only in Arthurs and Woods Lakes – predation by brown trout and possibly turbidity in Woods Lake are thought to be the major threats to these species;
- a migratory native fish, the Australian grayling (listed as vulnerable) occurs in coastal rivers in the South Esk region and requires unimpeded access from salt to fresh water to complete its life cycle – barriers such as the Trevallyn Dam may prevent this migration;
- a native fish species occurring in the upper South Esk catchment, the Swan galaxias, is listed as endangered – the primary threat to this species is thought to be predation by brown trout;
- a threatened species of snail has been identified in the South Esk River below Trevallyn Dam in the Cataract Gorge – potential threats to this species are not fully understood; and
- other rare and threatened species associated with aquatic environments which occur in the South Esk and Great Lake catchment include the grey goshawk, great crested grebe, green and gold frog, and a number of invertebrates, and plant species – threats to these species are unknown.

Fish migration issues include (but may not be limited to) the following:

- Trevallyn Dam may be an impediment to both the upstream and downstream migration of eels and diadromous fish species (including the ‘vulnerable’ Australian grayling);
- structures such as weirs and dams may prevent migration of land locked fish species within drainage systems; and
- artificial waterways may provide pathways for the migration of native (and exotic) fish into waterways where they are not naturally occurring (e.g. the potential for translocation of Arthurs and saddled galaxiids from Arthurs to Great Lake via Arthurs Flume).

Exotic species issues include (but may not be limited to) the following:

- redfin perch are present in most of the larger rivers in the South Esk catchment and are also though to be in Great Lake – there is a potential for the species to move up through Liawenee Canal to Lake Augusta and the Western Lakes if a barrier is not maintained;
- trout are present in most waterways in the catchment and are known to prey on native fish species, however trout also provide a valuable fishery;
- there is extensive infestation of willows in many rivers in the South Esk catchment; and
- the aquatic weed *Elodea* (Canadian pondweed) is present in Arthurs Lake, Arthurs Flume, Great Lake at Tods Corner and Lake Augusta.

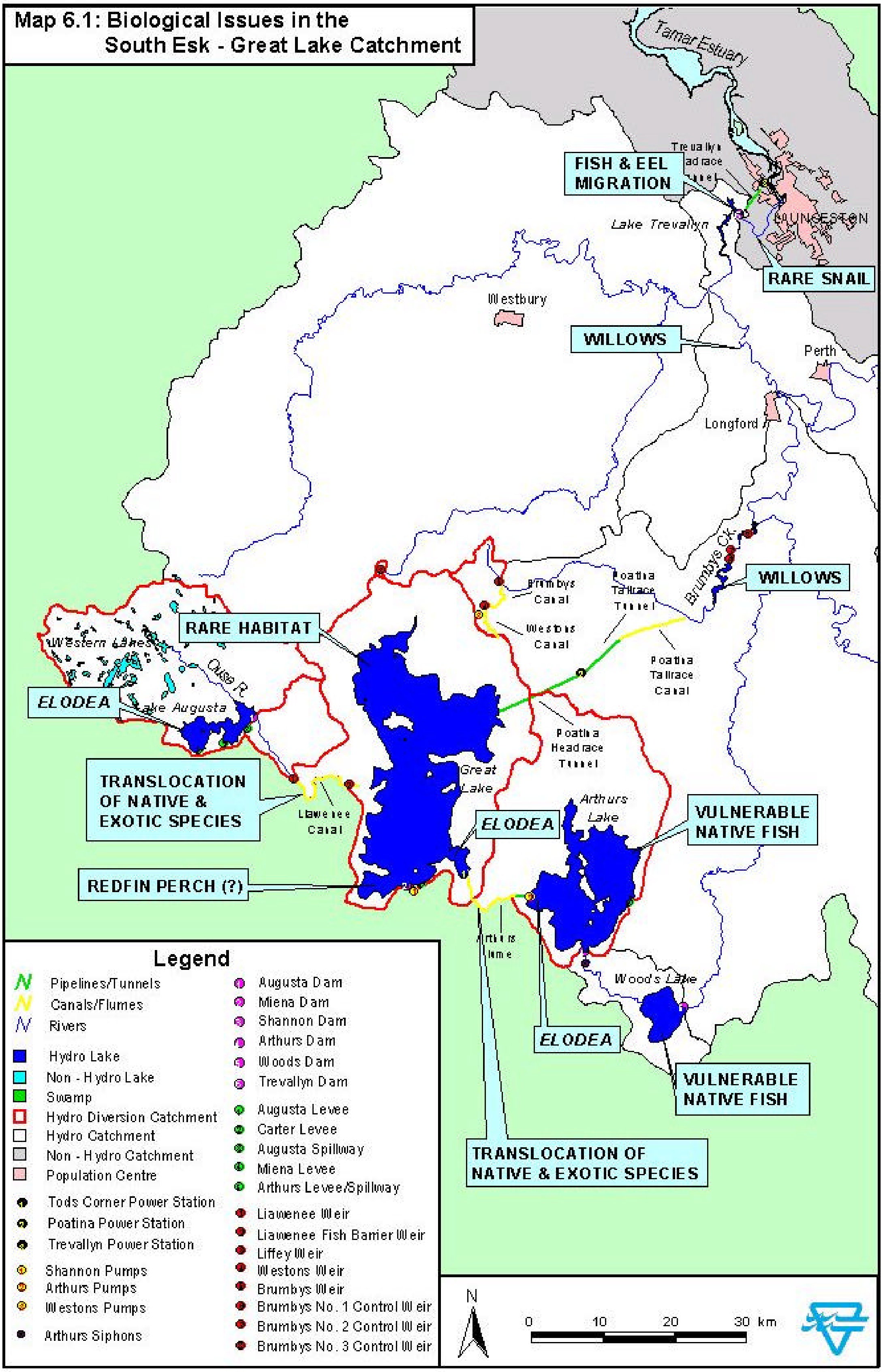
Map 6.1 shows the Hydro waterways in the Great Lake – South Esk catchment with key biological issues noted.

The Hydro undertakes a number of actions which address some of these issues. The Hydro installed an eel ladder on the Trevallyn Dam in 1996 to provide passage for elvers. An IFC study, supported by the Hydro has recently been initiated to evaluate the effectiveness of the elver ladder. The Hydro also constructed a barrier on Liawenee Canal in 1999 to prevent upstream migration of redfin perch into the sensitive Western Lakes in the World Heritage Area, should this species be present in Great Lake. Extensive willow removal from Brumbys Creek is currently being carried out by the Hydro.

The Hydro's Aquatic Environmental Policy recognises the importance of the biological ecosystem. As stated in this policy, the Hydro is committed to operate its business in a manner that aims to maintain a healthy functioning of aquatic ecosystems. The Hydro is also committed to investigate the influence of its operations so as to allow the Hydro to make management decisions based on good scientific information.

The Hydro's Aquatic Environment Program aims to fill many of the information gaps regarding threatened and exotic species and fish migration in the South Esk catchment. The Hydro has recently run a workshop with local experts as part of an internal review on fish migration and threatened species issues in its catchments. This provides the Hydro with better information on which to assess the effects of Hydro infrastructure and operations.

Biological monitoring is currently being conducted by Hydro through the IFC Biological Consultancy in the South Esk catchment. Reference sites for the AUSRIVAS program in the South Esk catchment are currently being compiled by DPIWE, and the IFCBC sites are being added to this program for ongoing monitoring to assess the biological health of the catchment.



Map 6.1: Biological Issues in the South Esk - Great Lake Catchment

7. GEOMORPHOLOGICAL ISSUES

This chapter discusses geomorphological issues in the South Esk – Great Lake catchment. The previous two chapters discussed the water quality issues (Chapter 5) and the biological issues (Chapter 6), and the following chapter outlines multiple use issues in the catchments.

Geomorphology can be defined as the study of land surfaces and the processes that create them. The Hydro has modified the natural processes that operate in water systems through regulation, which may contribute to geomorphic change. This geomorphic change may take a number of forms including river bank erosion, channel changes, sedimentation, vegetation encroachment, and lake shoreline destabilisation and erosion.

This chapter outlines the general effects that reservoirs and regulation can have on the geomorphology of waterways (section 7.1), and discusses the geomorphological issues associated with Hydro waterways in the Great Lake – South Esk catchment (sections 7.2 to 7.5). These issues are summarised in section 7.6.

The method used to obtain the information presented below was a desktop survey that gained information from interviews and the available literature.

7.1 Background

7.1.1 Types of Geomorphic Change Associated with Dams

The geomorphic response of rivers in relation to dams is well documented. The nature of these responses has been discussed in detail by Petts (1979, 1984), who concluded that the most significant changes following the damming of rivers are alterations to downstream flow and sediment load. Changes to these two parameters result in adjustments to channel morphology. Rivers may respond to such changes in a number of ways, as summarised by Locher (1997) and presented in Table 7.1.

Table 7.1 The Effects of Regulation on Rivers

Type of Change	Response of River
Flow	• Modified flooding regime • Altered frequency, distribution and variability of flows • More frequent discharge pulses
Sediment Load	• Trapping of bed load sediments in the reservoir • Suspended sediments may settle out in the reservoir • Tributary rejuvenation can increase tributary sediment contribution to streams
Channel morphology	• Degradation which can cause bank instability and/or • Aggradation which can reduce channel capacity, increase lateral erosion, and increase the flooding potential (Simons *et al.*, 1981) • Channel change including width increase or decrease • Channel bed armouring • Lateral migration of bends

Geomorphic changes in lakes as a result of damming may also occur. Inundation of lake shore vegetation and waterlogging of roots may lead to the roots dying off, resulting in destabilisation of lake shores. Lake shoreline erosion may also occur as a result of fluctuating water levels due to the lake's operational regime, wind-driven wave splash or wind-driven turbulence, particularly in shallow lakes. In areas where bank materials sitting at water-level are erodible, undercutting and eventual bank collapse may occur. Shoreline erosion due to draw down effect (which can also take place in rivers) can occur when water levels are drawn down very rapidly. The pore water pressures in the saturated bank sediments destabilise the recently drained banks and this can cause bank slumping.

7.1.2 The South Esk Catchment

A general description of the South Esk – Great Lake catchment is given in Chapter 2, including the geology (Map 2.2) and land uses (Map 2.4). These two catchment characteristics combined with the hydrology play an important role in influencing the nature and extent of geomorphological changes to waterways.

The geology of the catchment is a significant factor influencing the erodibility of the substrate. The upper South Esk catchment is characterised by quartzwacke and mudstone; Jurassic dolerite and Carboniferous granite in the middle parts of the catchment; and alluvial gravel, sands and till, with outcrops of older volcanic and igneous rocks in the lower parts of the catchment. Whilst dolerite is relatively resistant to erosion, unconsolidated alluvial materials are more susceptible.

The Macquarie River sub-catchment is composed of Jurassic dolerite in the highlands, but erodible alluvial and glacial sediments in the lowlands. The Meander valley is characterised by flat plains of recent alluvial sediments and higher terraces of older clays and gravels. The unconsolidated materials in the Meander Valley are more susceptible to erosion**.** The Great Lake catchment has a relatively resistant geology, composed of Jurassic dolerite with extrusion of Tertiary basalts over dolerite on the south-west border of the catchment.

The nature and extent to which Hydro operations affect the morphology of waterways is greatly influenced by other land uses. For example, land clearing and loss of vegetation cover may increase sediment yield to rivers, and urbanisation can result in an increase in run-off. The South Esk catchment is characterised by a wide range of land uses, including agriculture and forestry. Land uses in the Great Lake catchment also include forestry, some grazing agriculture and wilderness and tourism activities. As a result of diverse land uses, it can be difficult to ascertain the extent of the Hydro's responsibility towards geomorphological issues that may arise.

An issue of concern in the South Esk catchment is the extensive willow infestation. Willows were initially planted to stabilise river channels but they have spread profusely. Reduced flow allows willows to take root more easily and subsequently, they may cause channel constriction, increased sediment build-up, significant channel modifications such as braiding, and increased flooding. The infestation of willows has not been mapped in the South Esk catchment to date.

The geomorphological impact of the Hydro on the waterways in the South Esk – Great Lake catchment has not been extensively investigated. Studies carried out by Clerk (1994) and Hydro-Electric Corporation (1998) in the Macquarie River and Brumbys Creek highlight several areas of concern. These studies suggest that the operation of Poatina Power Station has resulted in changes to the hydrological regimes, channel bank soil erodibility, and channel morphology of the two waterways. An investigation into geomorphic change in unique lunettes at Lake Augusta has also been carried out (Bradbury, 1994).

7.2 Highland Lakes

7.2.1 Lake Augusta

Lake Augusta has an operating range of 9 metres and its lake levels fluctuate on a weekly to monthly basis. The main features of geomorphological interest at Lake Augusta are some unique aeolian (wind-formed) landforms referred to as lunettes, on the eastern shore of the lake. These landforms consist of lake shore sand dunes up to 5-6 metres in height; which are derived from doleritic sand and were formed between 4000-5000 years ago (J. Bradbury, DPIWE, *pers. comm.*). The formation of Lake Augusta and the periodic raising of the lake level has resulted in some degradation of the lunettes through lake-shore erosion (Bradbury, 1994). A new lunette of up to 4 metres in height has formed more recently (since the 1950s) and is also subject to erosion (Bradbury, 1994).

Periodic raising of the lake level has also resulted in loss of vegetation by waterlogging and this has caused the underlying morainal material to be exposed to wind erosion, creating a deflation lag (Bradbury, 1994). A deflation lag occurs as a result of the removal by wind of fine, loose materials from a deposit of initially mixed grain size, leaving the coarse materials as a lag or residue at the surface (Goudie, 1993; Bloom, 1978).

7.2.2 Liawenee Canal

Liawenee Canal is subject to erosion just before the canal meets Great Lake. However, according to the regional IFC Inspector the amount of erosion is minimal, only occurs in winter when there are frost events and is not causing any management problems in relation to the spawning of trout at present. There is a sediment delta at the mouth of the canal's entrance into Great Lake composed of coarse gravel and fine sediments. The extent of the delta is unknown.

7.2.3 Great Lake

Lake levels in Great Lake fluctuate through a large range over a cycle of about 10 years. Regional Hydro officers have observed some erosion on the western side of Great Lake. The wave-wash gravel that settles on the shores of the lake when the lake is low washes out when the lake levels are high. Associated with this washing out of the gravel are wave-induced erosion and sedimentation issues. Tasmanian Parks and Wildlife officers have also confirmed the occurrence of shoreline erosion.

7.2.4 Arthurs Lake and Woods Lake

The potential for shoreline erosion at Arthurs and Woods lakes has never been investigated, however the doleritic geology of these storages suggests that the shorelines are relatively erosion-resistant.

7.3 Rivers

7.3.1 Macquarie River

The hydrological regime of the Macquarie River has been altered by the Poatina Power Station, as outlined in Chapter 4. The river receives higher than natural regulated flows from the power station via Brumbys Creek, which influence a 20 km reach from Brumbys Creek to the South Esk River. Such alterations to river hydrology can produce a range of geomorphic changes.

Clerk (1994) investigated bank erosion and channel changes over a six month period at eight sites along approximately 9 km of the Macquarie River. Two sites were located within ¾ km above the Brumbys Creek junction, and six sites were located within 8 km below the junction.

Aerial photographs taken in 1947, 1966, 1974, 1990 and 1994 were used to assess the degree of channel adjustment in the Macquarie River's lower reaches (Clerk, 1994). The results indicated that changes were not as significant as expected, probably due to the high clay content of the floodplain soils and the presence of three weirs in Brumbys Creek, designed to help reduce the velocity and peakedness of the water entering Macquarie River.

Under natural flow conditions, the potential for channel bank erosion in the Macquarie River is limited due to the high percentage of clay in the channel bank soils, the relatively erosion resistant floodplain sediments and the river's low natural flows (Clerk, 1994). An increased potential for erosion would be expected as a result of the high flows released form Poatina, however Clerk found that the rates of channel bank erosion in the reach of the Macquarie River studied were relatively low. This may be attributed to the timing of the investigation which took place during the months when discharge from the power station is typically at its lowest (May – November). Clerk suggested that the main mechanisms for erosion in the area studied include:

- the mechanical removal of the non-cohesive clay peds in the B horizon;
- slumping of the A1 and A2 horizons; and
- dispersion of clay fraction and subsequent mechanical removal of the sand fraction in the C horizon.

7.3.2 Brumbys Creek

The operations of Poatina Power Station have influenced the hydrology and channel morphology of Brumbys Creek, which directly receives the power station discharge. Geomorphological issues that have been identified in Brumbys Creek include bank erosion, sedimentation and channel changes, and weed invasion along the riparian zone and instream. A recent study on erosion in Brumbys Creek was sponsored by the Hydro's Generation North division (Hydro-Electric Corporation, 1998). The study area extended from the commencement of the Poatina Power Station tailrace canal to the junction of Brumbys Creek and Macquarie River (approximately 22 km).

This study found that the following hydrological changes have occurred in Brumbys Creek with the commissioning of the Poatina Power Station:

- higher than natural summer flows;
- increased occurrence of small floods;
- increased flow variability; and
- increased mean annual discharge from 101,000 ML pre-Poatina to 738,500 ML post-Poatina.

One of the implications of these hydrological changes is that the Brumbys Creek channel has enlarged (widened and deepened) to accommodate greater flows, resulting in bank erosion and increased sediment loads. Possible contributing influences are increased flow variability creating frequent water level fluctuations which exacerbate bank erosion, and rapid water level drawdown increasing pore pressures in bank soils which can lead to bank collapse (Hydro-Electric Corporation, 1998).

Several observations regarding the susceptibility of the soils in the lower end of Brumbys Creek to erosion and dispersivity were made by Clerk (1994). For example, the B horizon, consisting of sandy clay soils was found to be the most susceptible to erosion during periods of high flows. It was also noted that the slaking of soils along lower Brumbys Creek might be an important process by which the channel bank soils are eroded. A more detailed discussion of the erodibility and dispersivity of each soil horizon is provided in Clerk (1994).

The extent of erosion along Brumbys Creek was investigated in 1998 as part of the study done by the Hydro. Seven zones were defined based on geomorphological characteristics and extent of weed infestation. These zones were numbered from Zone 1 to Zone 7 in a downstream order and are mapped in the report by Hydro-Electric Corporation (1998). The most severe erosion was found to be between the No.16 tailrace drop structure and the confluence with Dairy Creek and Woodside Rivulet (Zone 2). This zone receives 93% of the inflows to Brumbys Creek and consists of highly erodible alluvial and aeolian sediments. Moderate to severe erosion was also found to be occurring between Weir 2 and Weir 3 pondage (Zone 5), where the bank consists of organic/silty material. The meandering nature of Brumbys Creek below Weir 2 has eroded the inside and outside of bends due to lateral flow and areas of weak bank material. Erosion was also found to be occurring to a lesser extent in other zones in Brumbys Creek, however the report concluded that it would be most effective to focus on mitigation measures in the more highly eroded sections (in Zones 2 and 5), and to evaluate their success before commencing works in the other areas (Hydro-Electric Corporation, 1998).

The study found that most of the soil dislodged by bank and streambed erosion in the first three zones of investigation is being deposited amongst willows which occur above Weir 1 (Zone 4) and that sediment is also building up behind Weir 2. Further observations were that the material from the erosion in Zone 5 is being deposited upstream of Weir 3 (Zone 6) and that the island at the Brumbys Creek/Macquarie River junction is acting as a ‘sediment trap’, collecting eroded material from along the banks and streambed of Zone 7. Long-term accumulation of sediments in the weir ponds is a major concern since it reduces their utility as flood retarding basins and provides a platform for willow colonisation (Hydro-Electric Corporation, 1998).

The degree of channel adjustments in Brumbys Creek were also assessed by comparing historical aerial photographs taken in 1958, 1966, 1979, 1981 and 1985. These photographs suggest that some channel widening has occurred in Zones 2 and 3, the extent of which is unknown. The morphology of Brumbys Creek in Zones 4 and 6 has changed dramatically, particularly with regard to willow infestation. The stream channel has undergone a significant adjustment between Weir 3 and the Macquarie River (Zone 6) (Hydro-Electric Corporation, 1998; Clerk, 1994).

The report by Hydro-Electric Corporation (1998) proposed rehabilitation priorities for the Hydro’s management of erosion in Brumbys Creek. For example, Zone 2 was given high priority as it is the most significant erosion zone, has highly erodible banks, and receives 93% of annual discharge. The report also outlines the engineering, vegetation management and further study and investigation options for Brumbys Creek.

7.3.3 South Esk River, Lake River and Meander River

The influence of Hydro operations on the geomorphology of the South Esk, Lake and Meander rivers is not well known.

The South Esk River has been modified by engineering works and land use practices throughout its length. However, the Hydro’s influence is limited to the reach downstream of the Macquarie River. The geology of the lower reaches of the South Esk River, from the Meander River to Lake Trevallyn consists of unconsolidated sediments and dolerite. Dolerite is erosion resistant, however the unconsolidated sediments are more erodible.

Erosion problems are compounded by catchment land uses such as agriculture, water extraction and extensive willow infestation. No studies have been conducted which look at relative contributions of these different influences to the geomorphological changes in the South Esk River.

The lower Lake River receives spills and irrigation releases from Woods Dam. The predominantly dolerite geology of the upper section of the river makes it relatively resistant to erosion, however further downstream, the geology of the Lake River consists of more erodible unconsolidated sediments. The geomorphological effect of regulated flows in the Lake River is unknown.

The Hydro has very little influence on flows in the Meander River. A minor diversion weir on the Liffey River (a tributary of the Meander) operates during summer.

7.4 Lowland Lakes

Lake Trevallyn is the sole lowland lake in the South Esk – Great Lake catchment. It is a run-of-the-river storage with a small storage capacity and an operating range of 8.5 metres. Therefore the lake level fluctuates over a short period (hours or days). Shoreline erosion related to draw down or wind-driven wave attack on shoreline sediments within the operating range does not appear to be an issue, probably because of the relative resistance of the dolerite geology in this region.

7.5 Tamar Estuary

The Tamar Estuary has a high sedimentation rate, evidenced by the fact that extensive dredging of the estuary is undertaken on a regular basis. The rationale behind the dredging is to maintain the navigability of the channel and the aesthetic quality of the estuary. The South Esk River is thought to be the main source of sediments to the estuary, and has been estimated to deliver approximately 39,300 tonnes per year (Foster *et al*., 1986). Sediment input to the Tamar Estuary from the South Esk catchment is highest during floods. The sedimentation issue in the Tamar Estuary is closely related to catchment management practices.

The influence of the Poatina and Trevallyn power schemes on sedimentation in the Tamar Estuary was investigated in 1986 (Foster *et al*., 1986). According to the report, the overall effect of the Poatina and Trevallyn power schemes has been to reduce the incidence of low flows in the estuary (as a large volume of water is contributed to the catchment via Poatina), and to divert sediment input under low flow conditions to a point further down the river (at the Trevallyn Power Station tailrace rather than Cataract Gorge). This results in a significant reduction in the sedimentation rate in the upper estuary.

In addition, the study measured sediment discharges over a range of tidal conditions and flows through Trevallyn Power Station, and suggested that sedimentation in the upper estuary could be further reduced by modifying the operation of the power station to work in phase with the tides. These recommendations have not been incorporated into the normal operating rules for the power station.

7.6 Summary of Geomorphic Issues

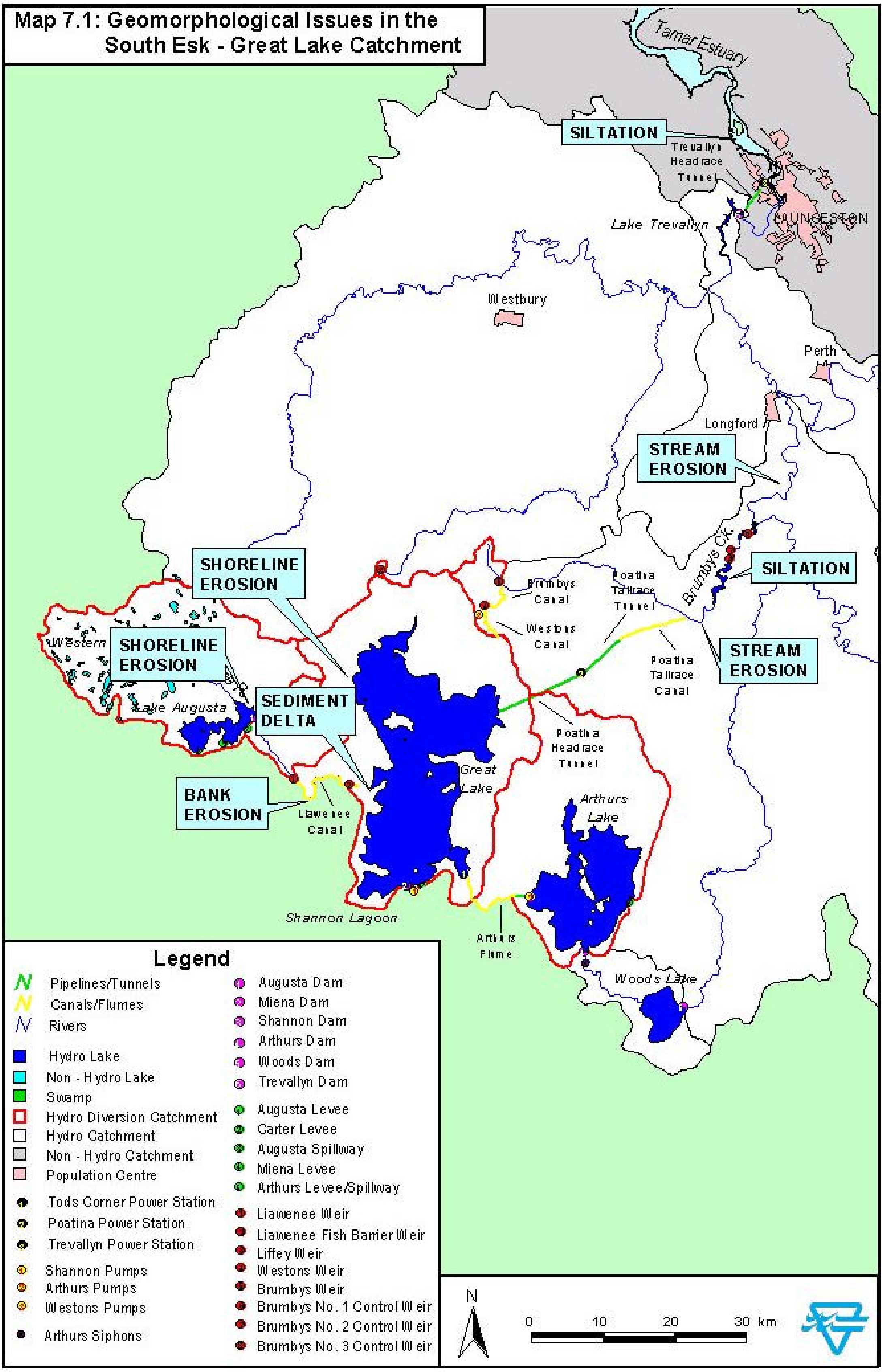
Development of the Hydro scheme resulted in fundamental geomorphic changes to waterways in the South Esk and Great Lake catchments, notably enlarging of Lake Augusta, Great Lake, Arthurs Lakes and Woods Lake, creation of weir ponds in Brumbys Creek, and creation of Lake Trevallyn. The geomorphological issues linked to Hydro water management practices have not generally been extensively investigated, with the exception of Brumbys Creek. There are no known geomorphological issues at Arthurs and Woods lakes and Lake Trevallyn or in the Meander and South Esk rivers. However there are a number of issues related to Hydro waterways evident elsewhere in the catchment, these include (but may not be limited to) the following:

- shoreline erosion on the western shore of Great Lake;
- shoreline erosion resulting in degradation of ancient geomorphic features (aeolian sand-dunes) on the eastern shore of Lake Augusta;
- minor erosion in Liawenee Canal and a sediment delta in Great Lake at the mouth of the canal;
- extensive erosion and sedimentation in Brumbys Creek;
- erosion in the lower reaches of the Macquarie River below Brumbys Creek;
- geomorphic changes to stream channels associated with willow infestation; and
- sedimentation in the upper reaches of the Tamar Estuary.

Map 7.1 shows the Hydro waterways in the Great Lake – South Esk catchment with key geomorphological issues noted.

The Hydro, through its Aquatic Environmental Policy, is committed to responsible environmental management and recognises the changes that its assets and operations have made to the States waterways. It is committed to reviews of its environmental performance and to investigate the influence of its operations on affected lakes and rivers in a systematic manner.

To date, the Hydro has funded one geomorphology study in the South Esk catchment at Brumbys Creek. The Hydro's WHMP includes routine monitoring of three major elements, one of which is physical condition (the others being water quality and biological assessment). The physical condition of lakes will be assessed by examining bank stability, and of river channels by looking at bank stability and bed condition (Gamble and Locher, 1998). A combination of the River Styles methodology (Brierley and Fryirs, 1998), and the Victorian Department of Natural Resources and Environment's (DNRE) Index of Stream Condition (Ladson *et al.*, 1996) will be adapted to suit Tasmanian conditions and used to obtain physical health score sheets for all sites. This index represents one way of integrating different streams of research into an assessment of stream condition and is made up of five components: hydrology, physical form, riparian zone, water quality and aquatic life.



Map 7.1: Geomorphological Issues in the South Esk - Great Lake Catchment
Tamar Estuary
SILTATION
Trevallyn Headrace Tunnel
LAUNCESTON
Lake Trevallyn
Westbury
Perth
Longford
STREAM EROSION
Brumbys Ck
SILTATION
SHORELINE EROSION
SHORELINE EROSION
Western
Lake Augusta
SEDIMENT DELTA
Brumbys Canal
Poatina Tailrace Tunnel
Westons Canal
Poatina Tailrace Canal
STREAM EROSION
Poatina Headrace Tunnel
Great Lake
BANK EROSION
Liawenee Canal
Arthurs Lake
Shannon Lagoon
Arthurs Flume
Wood's Lake
Legend
Pipelines/Tunnels
Canals/Flumes
Rivers
Hydro Lake
Non - Hydro Lake
Swamp
Hydro Diversion Catchment
Hydro Catchment
Non - Hydro Catchment
Population Centre
Tods Corner Power Station
Poatina Power Station
Trevallyn Power Station
Shannon Pumps
Arthurs Pumps
Westons Pumps
Arthurs Siphons
Augusta Dam
Miena Dam
Shannon Dam
Arthurs Dam
Woods Dam
Trevallyn Dam
Augusta Levee
Carter Levee
Augusta Spillway
Miena Levee
Arthurs Levee/Spillway
Liawenee Weir
Liawenee Fish Barrier Weir
Liffey Weir
Westons Weir
Brumbys Weir
Brumbys No. 1 Control Weir
Brumbys No. 2 Control Weir
Brumbys No. 3 Control Weir
N
0
10
20
30 km

8. MULTIPLE USE

In the previous three chapters, issues in the South Esk – Great Lake catchment relating to water quality, biology and geomorphology were discussed. Issues discussed in this chapter include multiple use and other miscellaneous issues that do not obviously fall into any of the previous three chapters. These are grouped under irrigation and agricultural water use (8.1), township and domestic water supply (8.2), recreation (8.3), fisheries (8.4) and cultural heritage (8.5). A summary of issues is given in section 8.6. The information in this chapter was obtained by a desktop study that collated information gained from interviews and the available literature.

Water uses in the South Esk Basin are quite diverse, and include power generation, mining, irrigation, industry, town water supplies, tourism and recreation. In the Great Lake catchment, the primary water uses are electricity generation, recreation and conservation. At times, different water uses in the catchments may conflict with one another, therefore water management for multiple uses is an important issue.

At the time of writing this report, the principal piece of legislation governing water management in Tasmania was the *Water Act* 1957, assisted by a number of other poorly coordinated Acts. However, the new *Water Management Act* 1999 (which will repeal the *Water Act* 1957 and some other related water management legislation) has been passed by Parliament and is expected to come into force in January 2000. Other important legislation that relates to the Hydro's water management in the South Esk catchment includes the *Cressy-Longford Irrigation Act* 1969 and the *Electricity Supply Industry Restructuring (Savings and Transitional Provisions) Act* 1995.

The Hydro has rights to all the water in the South Esk River Hydro-Electric Water District, which includes the whole catchment area of the South Esk River and its tributaries upstream of the Trevallyn Dam. The Hydro also has rights to all the water in the Great Lake catchment, which is included in the River Shannon Hydro-Electric Water District. However there are a number of water users (right-holders) in the catchment to whom the Hydro must supply water. In addition the Hydro also has a number of short-term agreements to supply additional water. These rights and conditions are retained under the new *Water Management Act* 1999.

The Hydro makes water available for uses including irrigation and agricultural use, township and domestic supply and industry. In addition, the Hydro manages it waterways to accommodate recreational use and fishing where possible.

8.1 Irrigation and Agricultural Water Use

Under the *Water Act* 1957, water entitlements for irrigation in the South Esk Basin vary substantially and may be Commissional, Statutory, Irrigation or Prescriptive. Under the new water management legislation, these rights will be converted into licences which will carry over the existing terms and conditions.

The Hydro makes available a quantity of water (approximately 18,000 ML per annum) in the South Esk catchment, for allocation by the Rivers and Water Supply Commission (RWSC) in DPIWE. Most of this water is used for irrigation and is abstracted throughout the catchment. The RWSC allocates the available water to individual users. These allocations were issued in the form of Commissional Water Rights (CWR's) under the *Water Act* 1957 and will be converted to water licences under the *Water Management Act* 1999. An additional annual amount may be made available by the Hydro, following discussions between the Hydro and the RWSC. In such short-term agreements, the Hydro is paid for the additional water allocated, priced on the basis of lost electricity generation at Trevallyn.

In addition to the RWSC allocations, the Hydro also supplies the Cressy-Longford irrigation scheme with 12,000 ML of water per annum. The source of this water is the Poatina tailrace canal. The Cressy-Longford Irrigation District is supplied by the scheme, and was defined by proclamation in 1970 (*Cressy-*

Longford Irrigation Act 1969). The district covers a total area of about 10,000 ha in the Macquarie sub-catchment. The Hydro is paid for water used, priced on the basis of lost electricity generation at Trevallyn.

Properties in the Cressy-Longford Irrigation District require an Irrigation Right to take water from the Scheme. Irrigation Rights are allocated to about 80 properties within the district on the basis of property area. The major use for irrigation is pasture production and vegetable crops. The trend for irrigation water use is increasing due to increased cropping activities and strong interest by the dairying industry to establish in the district (Bobbi *et al.*, 1996).

Peak demand for water from the tailrace occurs from December to January. The current system has no buffering storage and therefore requires flow throughout the irrigation season, with a peak demand of 150 ML/day (approximately 1.2 cumecs). The amount of water abstracted can be measured at the offtake canal. Security of supply is a matter of major concern to the scheme's management committee, as well as the issue of price. Individual licence holders pay for their full allocation even if it is not used.

Under a separate obligation, the Hydro supplies irrigation water to property holders along the Lake River. These irrigators are not required to hold a CWR, but have a Statutory Right under the *Electricity Supply Industry Restructuring (Savings and Transitional Provisions) Act* 1995. This right will be converted to a water licence under the *Water Management Act* 1999. Land holders on the Ouse River in the Derwent catchment hold similar Statutory Rights, and water from Great Lake is occasionally used to supply the Ouse River irrigators when there is not sufficient water in the Derwent irrigation storages.

8.2 Township and Domestic Water Supply

Towns or dwellings in the South Esk and Great Lake Hydro catchments are supplied with water under either the *Local Government (Building and Miscellaneous Provisions) Act* 1993, or the *Esk Water Act* 1997.

The City of Launceston, the towns in the West Tamar region, and the town of Hadspen are supplied by Esk Water under the *Esk Water Act* 1997. Esk Water was formed in 1997 by the amalgamation of parts of the RWSC and the Launceston City Council, and it has a CWR which allows it to take 6000 ML per year in the South Esk catchment for domestic supplies. This water right will be converted to a water licence under the *Water Management Act* 1999.

Smaller towns or communities will be licensed under the new *Water Management Act* 1999, to take water from local waterways. These towns are presently authorised under the *Local Government (Building and Miscellaneous Provisions) Act* 1993 to take water. Town water supplies are extracted from rivers in the South Esk catchment including the Liffey, Meander, Macquarie, Elizabeth and Blackman rivers. The Hydro maintains a minimum flow of 2.83 cumecs in the Macquarie River at Cressy to ensure a reliable water supply for Cressy township.

8.3 Recreation

Recreational uses of Hydro waterways are diverse across Tasmania and include recreational angling, duck shooting, boating, water skiing, canoeing, rafting, jet boating and other tourism activities such as wilderness flights and cruises. The Hydro is generally in favour of recreational utilisation of its waterways, and there are a number of cases where it has changed its operations to accommodate recreational activities.

In the South Esk – Great Lake catchment, fishing is a major recreational use and the Hydro has several lake level agreements in place with the IFC to enhance fisheries (section 4.2.3).

Lake Trevallyn is a designated recreational area and has operational level restrictions for recreational purposes. Under an agreement with the Launceston City Council, the Hydro maintains a minimum lake level for recreational purposes when possible (section 4.2.3).

The Cataract Gorge Reserve in Launceston is also a recreational area, which is highly utilised by the local community and tourists. The Reserve is used for walking, picnicking and other land based recreational activities. The Cataract Gorge below Trevallyn Dam is a popular site for white water rafting clubs and canoeing events, due to its steep rocky character and its proximity to Launceston. The Hydro may release water for these sports if sufficient water is available and if it is reimbursed for lost generating potential. The Hydro maintains a minimum flow of 0.43 cumecs down the Cataract Gorge (section 4.4.1).

Duck hunting is permitted on Hydro lakes in accordance with a negotiated agreement between the Hydro and the Tasmanian Farmers and Graziers Association (TFGA). The Hydro lakes which are open to duck hunting vary from year to year. No operational restrictions are associated with duck hunting (Hydro-Electric Corporation, 1999b).

8.4 Fisheries

8.4.1 Recreational Angling

One of the most frequent shared uses of Hydro waterways is for fishing. The Hydro has made efforts to accommodate angling requirements, and a number of lake level agreements with the IFC are currently in place (section 4.2.3).

Highland lakes on the Central Plateau including those in the Great Lake catchment are popular for trout fishing, as are the waterways of the South Esk catchment. Table 8.1 indicates the popularity of fisheries and number of fish caught in waterways in the Great Lake and South Esk catchments. The data in Table 8.1 were collected by the IFC in an annual questionnaire to anglers and reported in Davies (1992). The numbers gleaned from the surveys are thought to be within approximately 30% of the true figures, and should be regarded as indicative only. The data are averaged over seven fishing seasons between 1985/86 and 1991/92.

Table 8.1 Average Annual Fishing Effort and Catch Rate in South Esk-Great Lake Waterways (Davies, 1992)

Storage/River	Angler Effort [a]	Angler Numbers [b]	Harvest [c] (brown)	Harvest [c] (rainbow)
Great Lake	50,390	9,140	39,200	15,010
Arthurs Lake	49,860	9,690	121,410	410
Lake Augusta	2,890	1,160	3,850	1,360
Woods Lake	5,280	1,820	8,590	130
Brumbys Creek	14,980	2,110	16,680	1,430
Lake River	5,200	1,170	11,230	250
South Esk River	17,990	2,940	28,690	580

[a] Angler Effort – Total number of angler days per season

[b] Angler Numbers – Number of individual fishers per season

[c] Harvest – Number of fish caught per season

NB the statistics for the rivers include the entire length of river – not only the Hydro-affected reaches

The most popular lakes for fishing are Great Lake and Arthurs Lake, both of which yield a high catch rate. The Cow Paddock at Arthurs Lake is a particularly popular fishing spot. Brumbys Creek, particularly the stretch known as Fisheries Lane, is a significant waterway for fishing and highly utilised by anglers due to its high catch rate and its accessibility.

8.4.2 Commercial Fisheries

A commercial trout farm licence at Brumbys Creek was approved by the IFC in 1979, and the aquaculture venture, Sevrup Fisheries, was operational by 1980. Sevrup Fisheries produces rainbow trout. Sevrup has Commissional Water Rights and is dependent on Brumbys Creek for its water supply. Water is drawn from Brumbys Creek above Weir 3 via a culvert (constructed in late 1997) and via an open channel to the fish farm. The Company is permitted to take a maximum of 345 ML per day via this inlet. The farm also pumps a volume of up to 130 ML per day from a site on the eastern fork of the Brumbys Creek/Macquarie River junction, a distance of some 750 metres (Hydro-Electric Corporation, 1998). Water used at the fish farm is eventually returned to the creek. The Hydro is under no obligation to supply the fish farm with water, but may do so voluntarily under emergency circumstances and has offered Sevrup a purchasing arrangement.

Short-finned eels form the basis of a commercial fishery in Tasmania, with an annual catch of around 30 tonnes. The fishery encompasses most lakes and rivers in Tasmania, and each of the approximately 10 license holders has a discrete area to fish. The catch is largely exported, with some value-adding such as smoking.

Restocking of Tasmanian waterways by the IFC helps to support the commercial eel fishery, which is seen as having major sustainability problems. The sustainability problem stems from the construction of dams across many waterways in the State, which create barriers that are often impassible to migrating fish species, including eels (section 6.2.2). The IFC undertakes annual harvesting of elvers (juvenile eels) at the Trevallyn Power Station Tailrace and have a trapping facility at the base of Meadowbank Dam in the Derwent catchment, for restocking of Tasmanian lakes and rivers. Some elvers are also sold for restocking of interstate waterways and private dams. An elver ladder has been installed on Trevallyn Dam, which is intended to facilitate the passage of elvers over the dam. The effectiveness of this elver ladder will be the subject of a recently initiated study by the IFC with Hydro support.

8.5 Cultural Heritage

8.5.1 Aboriginal Heritage

The Hydro has a legal obligation to protect Aboriginal artefacts and sites under the *Aboriginal Relicts Act* 1975. Maintaining the integrity of Aboriginal sites is important because of the significance of the physical site itself to the Tasmanian Aboriginal community, and the archaeological information that is contained within the site.

There is only limited information regarding the occurrence of Aboriginal sites near waterways in the South Esk catchment. However, it is known that much of the region was well used by Aborigines due to the favourable topography, vegetation cover and climate. Relatively more information is available for the Great Lake catchment, and several surveys of Aboriginal sites around lake shores on the Central Plateau have recorded a high density of sites.

Many surveys of Aboriginal sites in Tasmania have been carried out in response to development proposals and few studies have assessed the level of disturbance of the sites identified. Assessment of the sites has often been on a scientific basis and prioritised as such, with limited consideration given to Aboriginal cultural values.

There is little documented evidence regarding the influence of waterway regulation on Aboriginal site integrity in Tasmania, and the specific effects of Hydro water management in the South Esk – Great Lake catchment are virtually unknown. However, the primary concerns in relation to Aboriginal sites are inundation and erosion of sites (D. Ranson, DPIWE, *pers. comm.*).

Flooding of Aboriginal sites during the creation of water storages has occurred during Hydro development. The number of flooded sites and the extent of impact are unknown, however, the relatively high density of sites around Great Lake suggests that a significant number may have been flooded during the raising of the

Central Plateau lakes. Once sites have been inundated management options are limited, although sites may remain relatively undisturbed under water.

Sites located around lake shores may be subject to wave action and periodic wetting and drying due to fluctuations in water levels. Wave action may disturb site integrity by erosion of the site and exposure of artefacts, and by washing the artefacts up and down resulting in sorting into size classes. Periodic wetting and drying of sites in the littoral zone of lakes may also encourage erosion, exposing artefacts. Becker (1997) identified wave action and siltation around shorelines as threats to site integrity in the Great Lake area, and Thomas (1983) recorded damage to sites on the shores of Great Lake as a result of fluctuating water levels (Smith, 1997). Some shoreline erosion on the western shore of Great Lake has been identified, but has not been investigated (section 7.2.3).

Ancient wind-formed dunes found adjacent to lakes, such as those near Lake Augusta, have a potentially high density of Aboriginal sites. The dunes near Lake Augusta are subject to erosion (section 7.2.1), however, their significance in regard to cultural heritage has not been examined.

Smith (1997) identified recreational users of Hydro waterways as having significant impacts on Aboriginal sites through vehicle access and limited fossicking.

8.5.2 European Heritage

The historic Duck Reach Power Station, Tasmania's first hydro-electric power station, is located on the South Esk River in the Cataract Gorge, downstream of Trevallyn Dam. It was built by the Launceston City Council in the late 1800s and began generating electricity in 1895. Floodwaters destroyed the power station in 1929, but it was rebuilt and bought by the Hydro in 1944. It continued to generate power until it was decommissioned in 1955, when the Trevallyn Power Scheme was brought on line. The Duck Reach Power Station is now operated as a heritage museum.

Other Hydro infrastructure may be considered significant in terms of cultural heritage. An inventory of power stations in Australia (including Hydro power stations) and discussion on management of such cultural heritage assets is contained in Godden-MacKay (1995a; 1995b; 1995c; 1995d).

8.6 Summary of Multiple Use Issues

As discussed in this chapter, water resources in the South Esk and Great Lake catchments are used for a number of purposes in addition to hydro-electricity generation. These include irrigation, recreational and commercial fisheries, other recreational activities and tourism. In addition, the land adjacent to the waterways may support uses or values such as cultural heritage, that could be affected by waterway use.

Issues associated with multiple uses in the South Esk and Great Lake catchments are summarised in Map 8.1 and include (but may not be limited to) the following:

- availability of water for irrigation;
- availability of water for township supply;
- suitable flows and lake levels for recreational uses;
- water supply and fish passage for commercial fisheries;
- optimal lake levels for fisheries; and
- management of cultural heritage sites around lake shores.

There are a number of actions which the Hydro currently undertakes which address some of these issues.

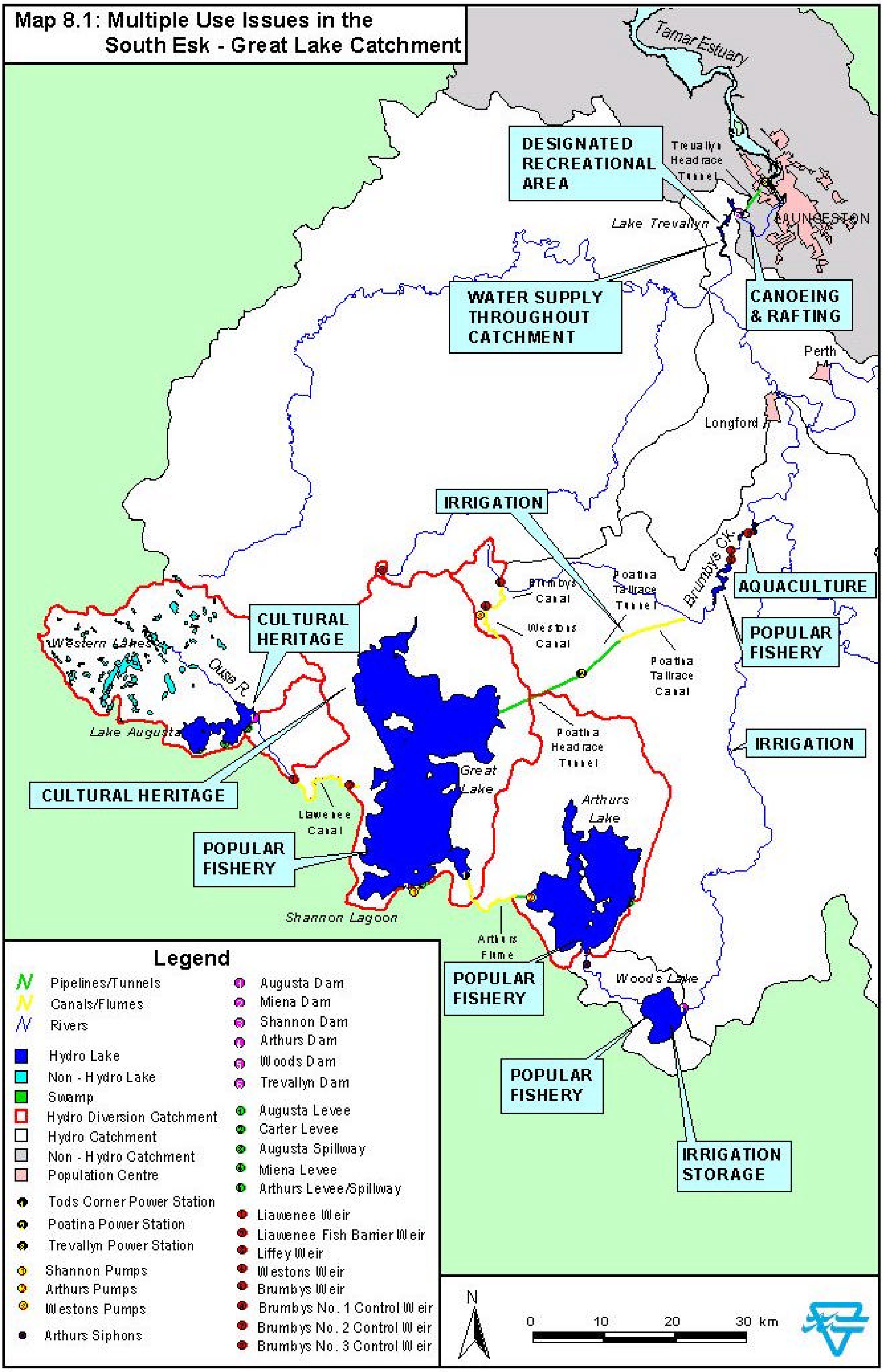
The Hydro makes a quantity of water available for allocation by the RWSC in the South Esk catchment, and supplies the Cressy-Longford Irrigation District with water from the Poatina tailrace canal. The Hydro also supplies irrigators on the Lake River with water for irrigation. A minimum flow is maintained by the Hydro in the Macquarie River at Cressy and in the South Esk River down the Cataract Gorge.

The Hydro has installed an elver ladder at the dam to assist the commercial eel fishery. The Hydro maintains Arthurs and Woods Lakes at suitable levels for fishing. It also maintains lake levels in Lake Trevallyn, when possible, for recreation. Water is also released for rafting in the Cataract Gorge in a commercial arrangement with rafting organisations.

The Hydro in its Aquatic Environmental Policy recognises the multiple uses of its waterways. It has committed to operate its business in a manner which takes community views and values into account; to work cooperatively with other government agencies and the community to find practical solutions to water management; and to make decisions based on consultation with stakeholders and with community involvement.

The Hydro has begun a review of its water management practices in the South Esk – Great Lake catchment. This review is a consultative process involving stakeholders and DPIWE and further issues may become evident as part of this process. The Hydro water management review process aims to ensure that the Hydro's water management practices are environmentally and economically sustainable, and can link into the DPIWE Water Management Plans as appropriate.

Map 8.1: Multiple Use Issues in the South Esk - Great Lake Catchment



9. SUMMARY AND CONCLUSIONS

9.1 Hydro Assets and Operations

The information presented in this report describes the Hydro's infrastructure and operations in the Great Lake – South Esk catchment, and presents the current state of knowledge on environmental impacts and issues associated with Hydro-affected waterways.

Utilisation of Great Lake water for hydro-electric power generation dates back to the early part of this century, and the Poatina and Trevallyn Power Schemes were developed during the 1950s and 1960s. Together these two schemes presently account for 17% of Tasmania's long-term average power output, and to generate this power the Hydro extensively utilises the water resources of the Great Lake – South Esk catchment. The Hydro created two new lakes, Lake Augusta and Lake Trevallyn, and enlarged natural lakes to form the current Great Lake, Arthurs Lake and Woods Lake. It has diverted water out of the headwaters of the Derwent catchment via these lakes plus some smaller weirs; directed most of it into Great Lake via a system of canals, pumps and flumes; and delivers it into the South Esk catchment via the Poatina Power Station. The Hydro also regulates flow in the Lake River via Woods Lake for release during the summer season for downstream irrigators. All of this water passes through Lake Trevallyn at the mouth of the South Esk River, where most of it is fed into Trevallyn Power Station.

9.2 Known Environmental Issues

This report identifies known impacts and issues associated with Hydro operations in this catchment in the areas of water quality (Chapter 5), biological issues (Chapter 6), geomorphological issues (Chapter 7), and multiple use issues (Chapter 8). These issues are summarised at the end of their respective chapters.

In this summary chapter, identified issues are summarised in relation to each waterbody. This summary is provided in Table 9.1, and depicted in Map 9.1.

9.3 Hydro Response

The Hydro's Aquatic Environmental Policy was written in recognition of the modifications which have been made to the State's water resources, the multiple use nature of these resources, and the complexity and variability of issues associated with these waterways. The Hydro's Aquatic Environment Program aims to put policy statements into practice. It does this on three broad fronts:

1. A Waterway Health Monitoring Program;
2. Targeted investigative studies; and
3. The Hydro Water Management Review.

The Waterway Health Monitoring Program provides good baseline information on the health of Hydro-affected waterways. It monitors not only water quality, but also biological indicators and physical condition of streams and lakes. Data and resultant analyses will be publicly available for review through annual State of the Hydro Waterways reports.

Targeted investigative studies include those such as was done on Brumbys Creek during 1998. This study worked in consultation with the local community to identify key issues, mostly in relation to weeds and channel erosion/siltation, and resulted in a proposed plan to address these issues. Other targeted studies have included overview assessments of threatened species and fish migrations in Hydro-impacted waterways, initial assessments of environmental flows, and more recently an assessment of the effectiveness of the Trevallyn eel ladder.

Table 9.1 Summary of Issues in Hydro Waterways in the Great Lake – South Esk Catchment

Waterbody	Known Issues
Lake Augusta	*Elodea*; erosion of aeolian sand dunes on eastern shore; cultural heritage sites; popular for fishing
Liawenee Canal	conduit for redfin perch into western lakes (prevented now by installed barrier); minor erosion; sediment delta at mouth in Great Lake
Great Lake	algal beds are rare habitat & support important invertebrates; redfin perch (unconfirmed); *Elodea* at Tods Corner; erosion on western shore; cultural heritage sites; popular for fishing, boating and recreation
Arthurs Lake	saddled galaxias & Arthurs paragalaxias; *Elodea*; popular for fishing, boating and recreation
Arthurs Canal/Flume	possible species translocation issues; *Elodea*
Woods Lake	turbidity; saddled galaxias & Arthurs paragalaxias; source of water for downstream irrigation needs; popular for fishing; lake level agreement in place for water quality and galaxiids
Lake River	turbidity at times, cool water releases; willow infestation (now eradicated); water supply for irrigation
Brumbys Creek	cool water releases; willow infestation; extensive erosion and sedimentation issues; water supply for irrigation, fish farm and townships; many recreational uses notably fishing
lower Macquarie River	high faecal indicators upstream; willow infestation; erosion and channel change issues; recreational uses including fishing and boating; water supply for irrigation and townships
lower South Esk River	heavy metals from upper South Esk, high faecal indicators; willow infestation; recreational uses including fishing and boating; water supply for irrigation and townships
Lake Trevallyn	high faecal indicators, elevated nutrients; fish migration barrier (elver passage provided); designated recreational area (lake levels often controlled for recreation); special boating and cultural events
Cataract Gorge	threatened freshwater snail; designated recreational area; special boating events; environmental flow release (0.43 m3/s)
Tamar Estuary	sedimentation issues in upper reaches

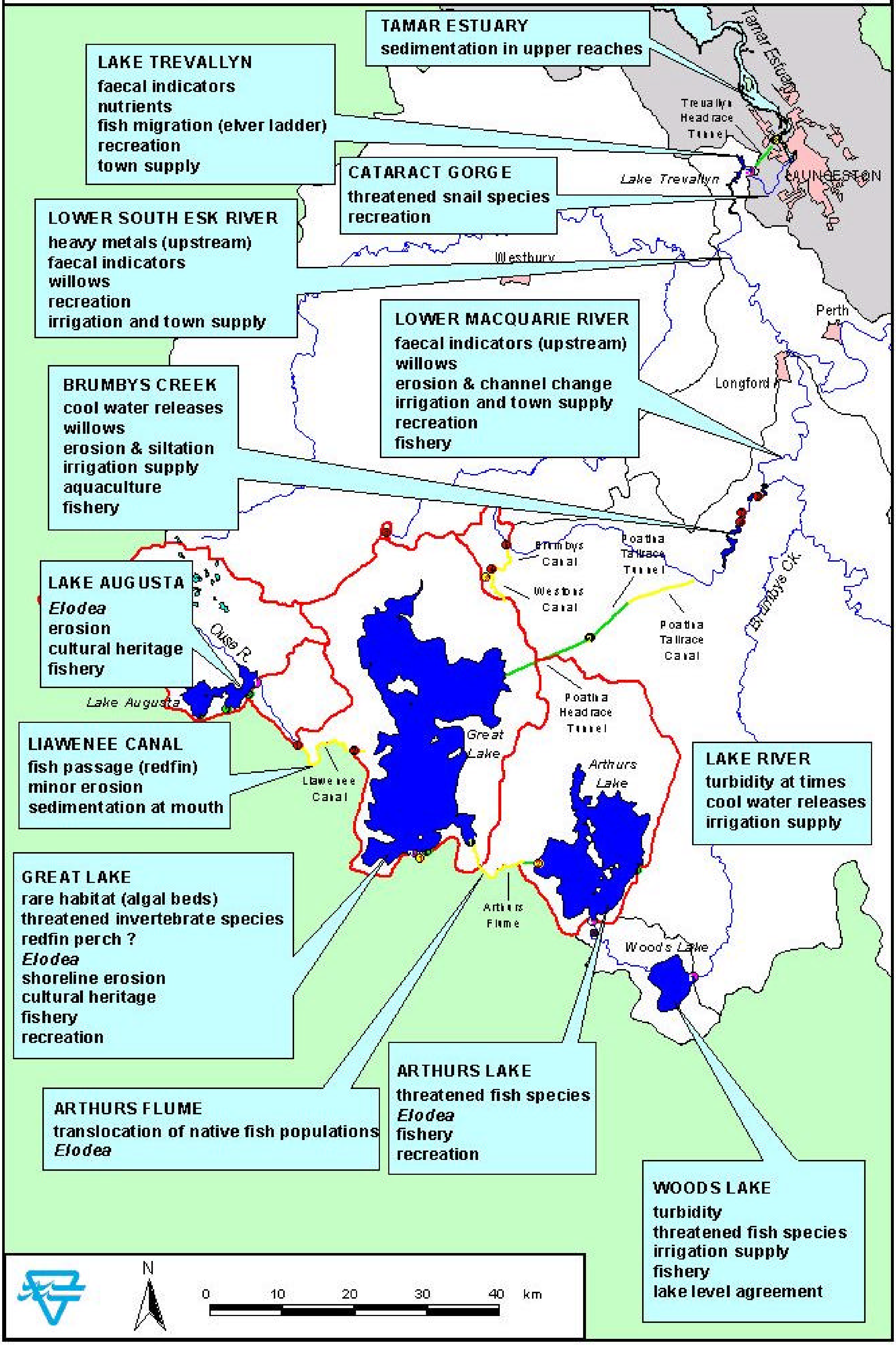
Targeted studies in this catchment will be done as part of the Basslink environmental studies; notably investigations of geomorphology, instream biota, water quality, and public use issues downstream of Poatina power station.

The Hydro Water Management Review is a process to systematically re-assess the Hydro's water management operations on a catchment by catchment basis, in consideration of all issues raised by the general community and information brought forward through the Waterway Health Monitoring Program and targeted investigative studies. The Great Lake – South Esk catchment is first to be reviewed. The outcome will be a Hydro plan which aims to demonstrate that the Hydro is sustainably managing the water resources in this catchment, a plan which can easily be slotted into a Water Management Plan for the relevant waterways as allowed for under the *Water Management Act* 1999.

The business has demonstrated already its willingness to work with stakeholders to achieve solutions and improve the values of its waterways. Lake level agreements are in place for both Woods Lake and Lake Trevallyn, a barrier to redfin perch migration has been constructed in Liawenee Canal; an elver ladder can be found on Trevallyn Dam; the Hydro meets minimum flow requirements in the Macquarie River and Cataract Gorge; and it considers flood risks with its releases from Poatina power station. The Hydro has also provided water in Lake Trevallyn and Cataract Gorge for special events.

The Hydro fully recognises that aquatic environment issues are inherently complex, that underlying processes and factors need to be carefully discerned and analysed, and that options to address these issues need to be considered in close consultation with users. Solutions should consider community based water management values and goals as well as business needs and goals. This document is seen as an important step towards achieving this balance.

Map 9.1: Summary of Environmental Issues in the South Esk - Great Lake Catchment



GLOSSARY

Term	Definition
Algae	Unicellular or multicellular plants, occurring in water or moist ground, that have chlorophyll but lack true stems, roots and leaves. Microscopic forms also known as phytoplankton.
Alkalinity	Measure of soluble mineral salts which increase the pH of water, in particular calcium carbonate ($CaCO_3$).
Anoxic	Absence or deficiency of oxygen.
Biodiversity (biodiverse)	The number and variety of species in a community; species richness.
Biological indicator	A species or organism which is used to grade environmental quality or change.
Chlorophyll-*a*	A green pigment present in algae. The amount present can be measured by spectrophotometer to determine the amount of algae present in a water sample.
Conductivity	A measure of the ability of a substance to conduct electricity. In water analysis, it indicates the amount of ions present in the water. Also known as electrical conductivity. Measured in µS/cm.
Critical Habitat	An area of land defined under Tasmania's Threatened Species Protection Act as critical for the survival of listed endangered flora or fauna.
Cumec	1 cubic metre per second (m^3/s).
Deflation lag	A deflation lag occurs as a result of the removal by wind of fine, loose materials from a deposit of initially mixed grain size, leaving the coarse materials as a lag or residue at the surface.
Diadromous	Fish which migrate between fresh water and salt water environments to complete their life cycles.
Diatom	Algae that have siliceous and often highly sculptured cell walls.
Ecosystem	A community of interdependent organisms together with the environment they inhabit and with which they interact, and which is distinct form adjacent communities and environments.
Electrical conductivity	See conductivity.
Endemic	Organism having a distribution limited to a particular geographical area such as an island. The isolation of islands has led to the evolution of endemic forms.
Eutrophic	Applies to waterbodies which are high in plant nutrients, usually through pollution. This often leads to algal blooms that may smother higher plants, reduced light intensity and through the aerobic decomposition of organic matter, deoxygenate the water, causing the death of many aquatic animals and higher plants.
Exotic	Not native, introduced, a species not naturally found where it occurs.
Faecal coliforms	A group of bacteria normally abundant in intestinal tracts of warm-blooded animals including humans, indicators of contamination of water by faeces.
Fauna	Any taxon of animal, whether vertebrate or invertebrate, in any stage of

	biological development and includes eggs and any part of such taxon.
Flora	Any taxon of plant, whether vascular or non-vascular, in any stage of biological development and any part of any such taxon.
Galaxiid(s)	Fish that are members of the Family Galaxiidae (includes the genera *Galaxias*, *Galaxiella* and *Paragalaxias*).
Habitat	Part of the environment which is occupied by an organism (plant or animal). A habitat supplies the organism's basic life requirements for survival (e.g. Food, cover, water).
Halocline	A salinity discontinuity, a zone of marked salinity gradient.
Hardness	A measure of the amount of dissolved mineral salts, the more salts present the harder the water is said to be.
Hyporheic	Pertaining to saturated sediments beneath or beside streams and rivers.
Interstitial	Pertaining to, or occurring within, the pore spaces (interstices) between sediment particles.
Kettle holes	A depression in glacial drift caused by the melting of ice which once formed part of the deposit.
k.y.a	Thousand years ago.
Listed Species	A species of flora or fauna which is listed with the *Threatened Species Protection Act 1995* or any other Commonwealth or State protective legislation.
Macroinvertebrate	Those invertebrates, usually with an aquatic phase, that are greater than 2 mm in size when fully developed. Includes caddisflies, dragonflies, mayflies, chironomids, oligochaetes, molluscs etc.
Meromictic. meromixis	Refers to lakes which are permanently stratified. This occurs when dissolved substances such as ions, create a gradient of density differences with depth, such that the complete mixing and circulation of water masses is prevented.
Mesotrophic	Applied to freshwater bodies which contain moderate amounts of plant nutrients and are therefor moderately productive (see eutropic).
Microbial	Referring to microscopic organisms, usually bacteria.
Monimolimnetic	The stagnant high density deep water layer in a meromictic lake.
Monomictic	Used of a lake having a single period of free circulation or overturn per year, with consequent disruption of the thermocline; may be either cold monomictic or warm monomictic.
Monadnocks	A residual hill of hard rock in an otherwise eroded area.
Native	A species found naturally in Tasmanian waters.
Oligotrophic	A freshwater body which is poor in plant nutrients. Oligotrophic water bodies are unproductive and their waters are usually clear as planktonic organisms are sparse.
Periglacial	Applied to the area surrounding the limit of glaciation and subject to intense frost action, and to the living organisms typical of such areas.
pH	Measure of the acidity or alkalinity of a sample: 7 is neutral, less than 7 is more acidic, greater than 7 is more alkaline.

Phytoplankton	Microscopic plants (algae) which are found in water. The basis of aquatic food chains.
Recovery Plan	A plan made for the improvement of conservation status for any species of flora or fauna which is under the threat of extinction.
Scarping	To wear or cut so as to form a steep slope.
Secchi	A method used for estimating the transparency of water by submerging a white disc (Secchi disc) of standard size and recording the depth at which it disappears from view.
Solifluctuation deposits	Deposits resulting from the gradual downhill flow of fragmented surface material, typically over a frozen substrate.
Species	A population or group of individual flora or fauna which interbreed to produce fertile offspring or which possess common characteristics derived from a common gene pool.
Stratification	The vertical structuring of a waterbody into horizontal layers, usually with distinct layers of temperature, oxygen or conductivity.
Taxa/Taxon	A grouping within the classification of organisms, e.g. species, genus, order, etc.
Thermocline	A boundary layer in a waterbody in which the temperature changes sharply by at least 1°C.
Threatened	A generic label which covers any species which is listed with the *Threatened Species Act 1995*, regardless of category. A species of flora or fauna at risk of extinction.
Threatening Process	Any process which poses a threat to the natural survival of any native taxon of flora or fauna.
Total Kjedhal Nitrogen (TKN)	A measure of total nitrogen, one of the plant nutrients. High levels in water have been associated with algal blooms.
Turbidity	The cloudiness in a fluid caused by the presence of finely divided, suspended material. Measured using nephelometric turbidity units (NTU).
Type Locality	The exact geographical site at which the type of a species or sub-species was collected.
Wetland Ecosystem	Any areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres.
Zooplankton	Microscopic animals (microinvertebrates) which are found in water. Consume algae and bacteria, and in turn are eaten by macroinvertebrates and fish.

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LIST OF LEGISLATION

Aboriginal Relicts Act 1975 (Tasmania)

Cressy Longford Irrigation Act 1969 (Tasmania)

Draft Water Management Bill 1997 (Tasmania)

Electricity Supply Industry Restructuring (Savings and Transitional Provisions) Act 1995 (Tasmania)

Endangered Species Protection Act 1992 (Commonwealth)

Esk Water Act 1997 (Tasmania)

Local Government (Building and Miscellaneous Provisions) Act 1993 (Tasmania)

National Parks and Wildlife Act 1970 (Commonwealth)

State Policy on Water Quality Management 1997 (Tasmania)

State Policies and Projects Act 1993 (Tasmania)

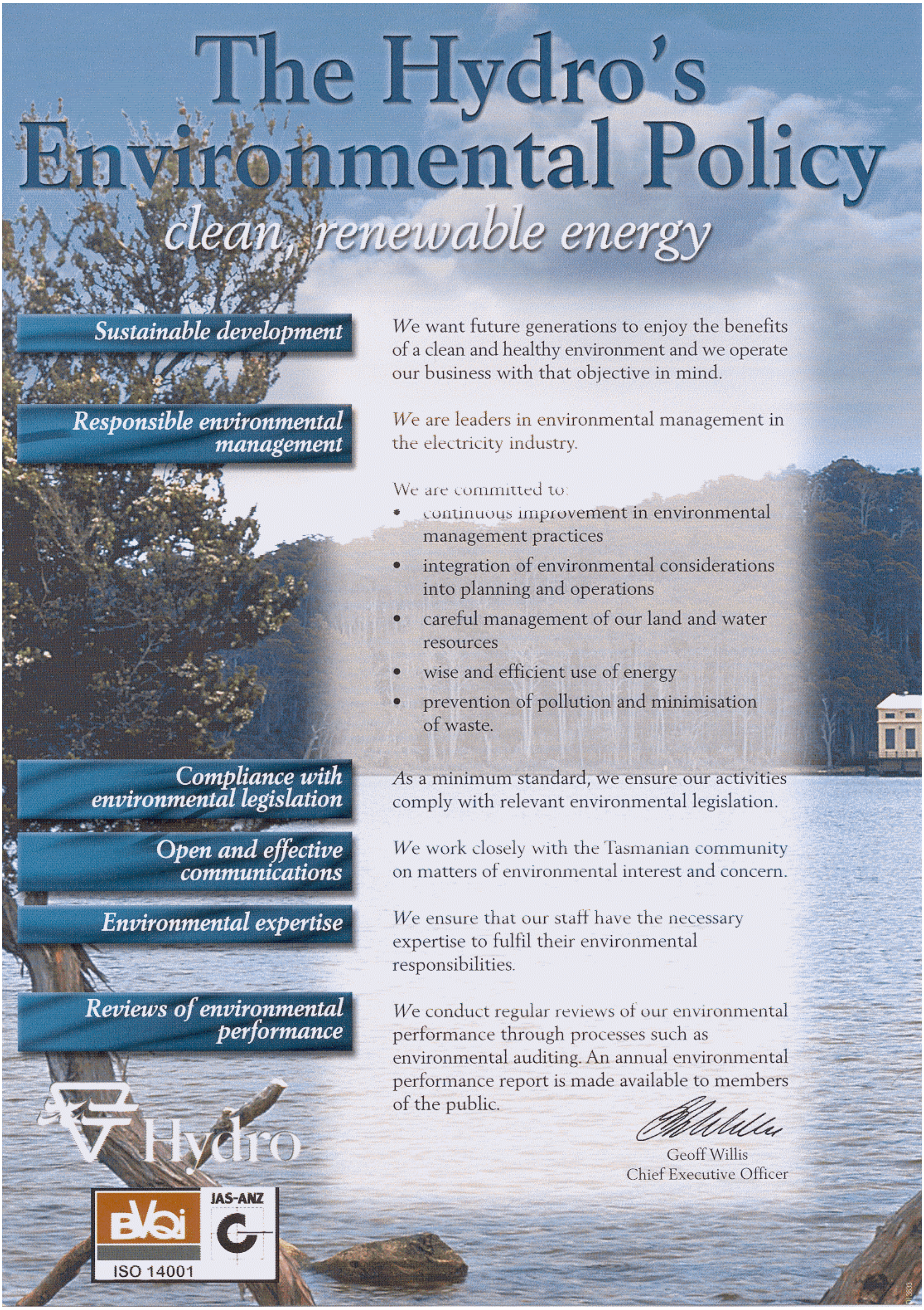
Threatened Species Protection Act 1995 (Tasmania)

Water Act 1957 (Tasmania)

Water Management Act 1999 (Tasmania)

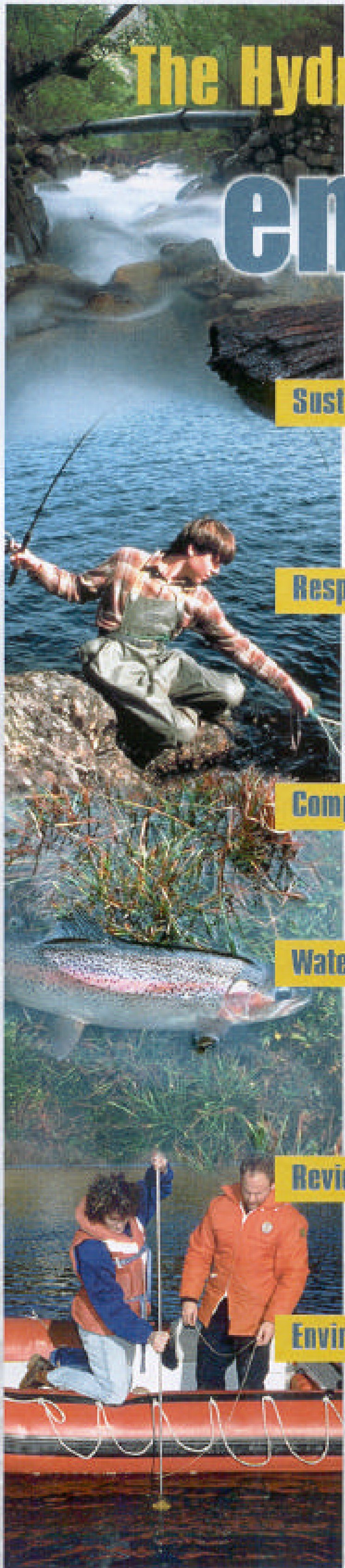
Appendix 1

The Hydro's Environmental Policy and
The Hydro's Aquatic Environmental Policy



The Hydro's Environmental Policy
clean, renewable energy
Sustainable development
We want future generations to enjoy the benefits of a clean and healthy environment and we operate our business with that objective in mind.
Responsible environmental management
We are leaders in environmental management in the electricity industry.
We are committed to:
• continuous improvement in environmental management practices
• integration of environmental considerations into planning and operations
• careful management of our land and water resources
• wise and efficient use of energy
• prevention of pollution and minimisation of waste.
Compliance with environmental legislation
As a minimum standard, we ensure our activities comply with relevant environmental legislation.
Open and effective communications
We work closely with the Tasmanian community on matters of environmental interest and concern.
Environmental expertise
We ensure that our staff have the necessary expertise to fulfil their environmental responsibilities.
Reviews of environmental performance
We conduct regular reviews of our environmental performance through processes such as environmental auditing. An annual environmental performance report is made available to members of the public.
Geoff Willis
Chief Executive Officer
Hydro
BVQi
ISO 14001
JAS-ANZ

The Hydro's aquatic environmental policy



Sustainable Development

We recognise that water is central to our business, and needs to be managed so that future generations can enjoy the benefits of a clean renewable energy source which is environmentally and economically sustainable for Tasmania.

Responsible Environmental Management

We recognise the modifications our assets and operations have made to the State's natural wetlands, and the multiple uses of lakes and rivers in the Hydro system. We operate our business in a manner which takes into account community views and values, and aims to maintain healthy functioning aquatic ecosystems.

Compliance with Environmental Policy and Legislation

We are committed at a minimum to compliance and co-operation with legislative and policy developments relating to environmental management of the Hydro's waterways.

Water Management Decisions

We work co-operatively with other government agencies and members of the community to find practical solutions to water management issues. We are committed to decision-making based on good scientific information, and involvement and consultation with relevant stakeholders.

Reviews of Environmental Performance

We investigate the influence of our operations on affected lakes and rivers in a systematic manner, and report on our performance in an open and transparent fashion.

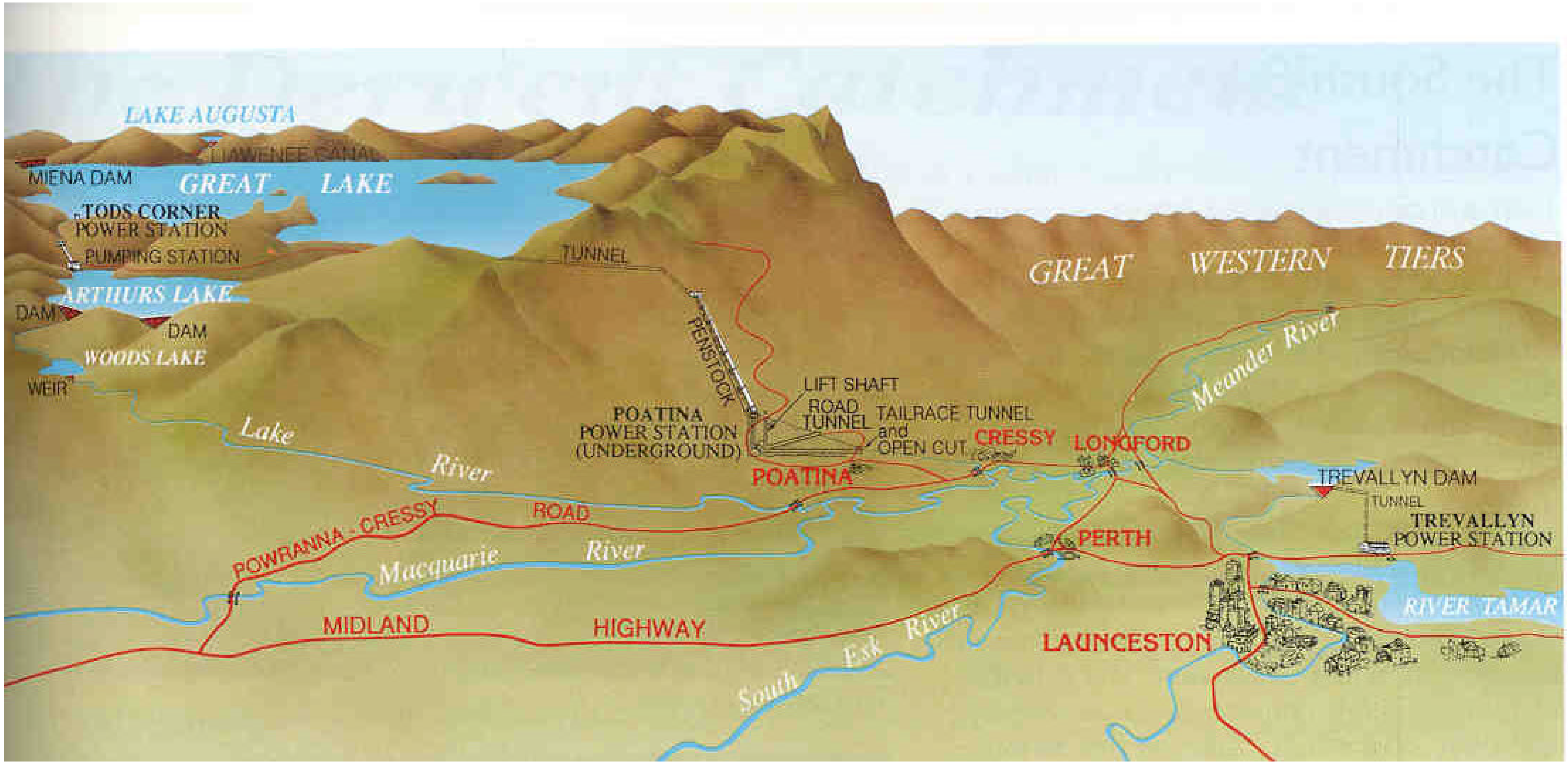
Environmental Expertise and Availability

We ensure that our staff have the necessary expertise to fulfil our commitments to management of aquatic environmental issues, and that these staff are available to the community and other agencies to address relevant issues as they arise.

Hydro

Appendix 2

Generalised relief map of the
Poatina and Trevallyn Power Schemes


LAKE AUGUSTA
LIAWENEE CANAL
MIENA DAM
GREAT LAKE
TODS CORNER POWER STATION
PUMPING STATION
ARTHURS LAKE
DAM
DAM
WOODS LAKE
WEIR
TUNNEL
PENSTOCK
LIFT SHAFT
ROAD TUNNEL
TAILRACE TUNNEL and OPEN CUT
POATINA POWER STATION (UNDERGROUND)
POATINA
CRESSY
LONGFORD
GREAT WESTERN TIERS
Meander River
Lake River
POWRANNA - CRESSY ROAD
Macquarie River
MIDLAND HIGHWAY
South Esk River
PERTH
TREVALLYN DAM
TUNNEL
TREVALLYN POWER STATION
RIVER TAMAR
LAUNCESTON

CONTACT AND FEEDBACK

THIS IS THE FIRST ENVIRONMENTAL REVIEW DOCUMENT FOR THE SOUTH ESK – GREAT LAKE HYDRO CATCHMENT. IT WILL BE UPDATED AT INTERVALS AND FEEDBACK ON ITS CONTENT IS WELCOME.

PLEASE CONTACT
HYDRO ENVIRONMENTAL SERVICES

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