Water to Sustain Riparian Wetlands: A Tasmanian Pilot Study

C.J. Bobbi

Department of Primary Industries, Water and Environment, 13 St Johns Avenue, New Town, 7008 Tasmania, Australia
(E-mail: *Chris.Bobbi@dpiwe.tas.gov.au*)

Abstract
In Tasmania, studies to determine environmental water requirements (more commonly referred to as 'environmental flows') have largely focussed on defining water regimes that will maintain or improve the environmental condition of rivers and lakes. To date, no specific studies have examined the water requirements of wetland systems associated with rivers.

McKerrows Marsh is a coastal blackwood swamp covering about 382 ha at the bottom of the Great Forester River, in northern Tasmania. Although part of the marsh was subject to drainage activities in the past, a substantial portion is relatively unmodified by human activities and the marsh contains a diverse native flora and a healthy community of aquatic fauna. Recent efforts have been made to protect this area from future degradation caused by stock access and the area will soon be listed as a nature reserve.

During the development of a Water Management Plan for the Great Forester catchment in 2003, an environmental water allocation was made for the river, however the needs of the marsh were not considered. Additionally, there is some evidence that the groundwater may help to sustain the wetland during dry periods. The present study was initiated in 2004 to provide information that will allow the development of new water management measures to sustain the wetland when the Water Management Plan is reviewed in 2006. This study is the first of its kind in Tasmania to attempt to integrate inputs from both surface and groundwater in the derivation of a 'holistic water regime' for a riverine wetland.

Keywords
Environmental flows; groundwater; water regime; riparian wetlands

INTRODUCTION

Since the Council of Australian Governments reached agreement on the implementation of water reforms throughout Australia in 1995, Tasmania has been working to identify the environmental water requirements (more commonly referred to as 'environmental flows') for rivers within the State. This is the first key step towards the development of Water Management Plans (WMPs), which are aimed at providing a framework for managing water resources at the catchment level and which recognise the water needs of freshwater ecosystems. The first of these plans to be completed in Tasmania was for the Great Forester River in the north of the state. The final plan was adopted in July 2003, and although this plan contained an environmental water provision for the river, there was a recommendation that additional work be conducted to examine the delivery of water to the lower catchment, particularly in relation to the McKerrows Marsh wetland (DPIWE, 2003).

The Great Forester River has a catchment area of about 520 km^2 and drains northward into Bass Strait about 3 km east of the township of Bridport (Figure 1). McKerrows Marsh is a riparian blackwood swamp covering 382 hectares situated at the bottom of the catchment, just above the limit of tidal influence. At the present time agricultural development and productivity within the catchment is restricted by a lack of available water from the river during the summer months. Although a substantial volume of water is held in small on-farm storages, more than 40% of irrigation water (1,650 megalitres) is drawn directly from the river system between the months of October and April. The estimated average annual yield from the catchment is approximately 170,000 megalitres, 78% of which occurs during the months outside of the irrigation season. As yet there is no large storage in the catchment that would impact higher flows, however there are plans to access this resource in the future.

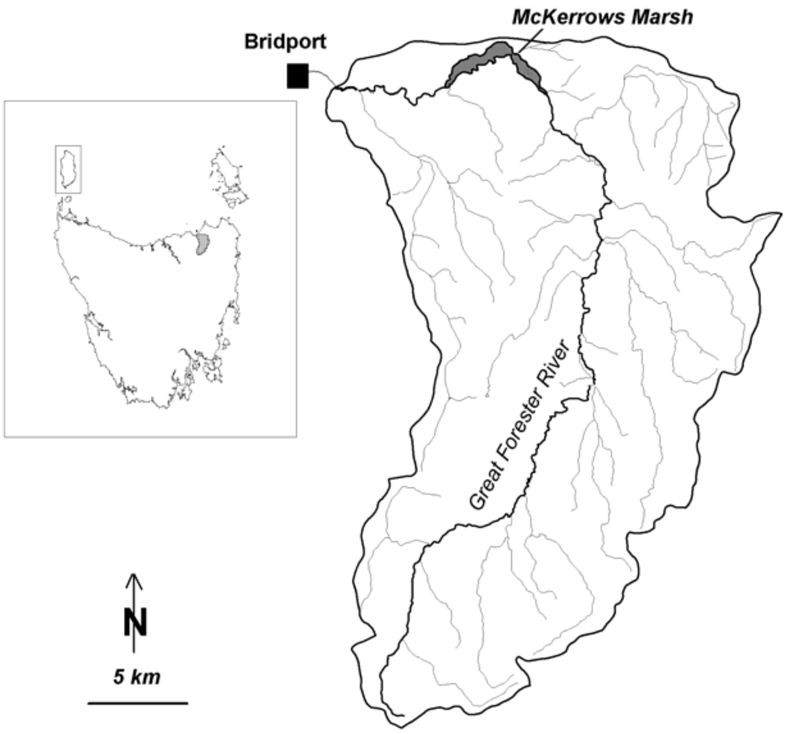

Figure 1. Location of McKerrows Marsh within the Great Forester catchment, northern Tasmania.

The Great Forester catchment also contains an extensive and largely undeveloped groundwater resource that lies within unconsolidated Tertiary sediments, and discharge from this regional aquifer makes a significant contribution to local streamflow during the summer months. Although it has not been substantiated, the presence of this aquifer close to the surface of the ground is one reason given for the location of McKerrows Marsh at the bottom of the catchment.

Prior to the present study, only scant information was available on the flora and fauna inhabiting the Marsh (Bayly-Stark, 1982) and nothing had been documented about the local groundwater and its importance in terms of sustaining the swamp forest and streamflow within the lower Great Forester River. Despite this, the conservation values and regional significance of the forest vegetation within the marsh have been recognised by the local community and some fencing installed to protect it from impacts by livestock.

The aims of this study are to characterise the current pattern and frequency of inundation within McKerrows Marsh, identify key flows events that may be important in maintaining ecosystems within the marsh, and to determine the local links between groundwater and surface water. Considerable data will be collected to characterise groundwater- surface water interactions to help construct accurate conceptual and hydrologic models. The ultimate goal of the study is to develop water provisions for the marsh that can be considered when the WMP for the Great Forester catchment is reviewed in 2006. This is the first such study to be conducted in Tasmania, and will provide a template for future studies of riparian and floodplain wetland systems for the purpose of water management planning.

METHODS

The design of this study is broadly based on the framework for determining environmental water allocations for significant wetlands as outlined in Davis, *et al*., (2001). For the study of McKerrows Marsh, this has been structured as a six-step process;

Step 1: Characterise wetland in terms of ecology and hydrology
Step 2: Describe relationships between biota and the water regime using conceptual models
Step 3: Identify uses, values and threats, and identify management objectives
Step 4: Determine the desired water regime to fulfil the management objectives
Step 5: Refine the desired water regime and develop potential scenarios
Step 6: Recommend performance indicators and options for monitoring

To date, work has focused largely on data gathering under Step 1 and some aspects of Steps 2 and 3. This has comprised a desktop review of existing data on the hydrology and hydrogeology of the system, some data gathering to determine the spatial extent of inundation within the marsh and additional work to identify key flows that might be important in maintaining ecosystem processes and condition. In an effort to better understand the linkage between surface water and local groundwater, an array of nine piezometers have been installed around the marsh and referenced by surveying to a river level monitoring station that is currently maintained within the river channel that transects the marsh. Six of the nine piezometers have water level monitoring equipment installed to record water levels changes on a 15-minute time-step.

To characterise the vegetation within the marsh, aerial photograph interpretation and field surveys have been undertaken and used to form a GIS database and identify important issues for management. A review of the Australian literature has been undertaken to help develop a better understanding of the key components of the hydrological regime that might be critical to maintaining the health of the vegetation communities that were identified.

Semi-quantitative information on the aquatic fauna within the river channel has been collected using a variety of standard sampling techniques. Fish were sampled at five locations within the marsh using single-pass electrofishing, with passes comprising 20 minutes of active searching. Aquatic macroinvertebrates were collected at six locations within the marsh using the AusRivAS sampling methodology for Tasmanian rivers (Krasnicki *et al*., 2001). At each location only edgewater habitat was sampled, as the river within the marsh did not contain suitable riffle habitat. The data from this was then used to derive river health scores using the Tasmanian spring-edgewater AusRivAS model. This model predicts the aquatic macroinvertebrate fauna expected to occur at a site in the absence of environmental stresses, and is widely used in Australia to assess the health of river ecosystems (Ball *et al*., 2001). Additional information on the occurrence of frogs and burrowing crayfish was also collated from existing departmental databases, with some confirmation provided by on-ground surveys.

RESULTS AND DISCUSSION

Vegetation

McKerrows Marsh consists of a healthy and complex mosaic of *Acacia melanoxylon* (blackwood), *Leptospermum lanigerum* (woolly teatree), *Melaleuca squarrosa* and *M. ericifolia* (paperbark), *Eucalyptus ovata* (black gum) and various sedge and health species, the most common being *Carex apressa* (tall sedge). Eight plant communities were mapped (Table 1) and most of these are characteristic of low-lying, riparian environments and are likely to be dependent in some way on flooding by the Great Forester River. The marsh is spatially dominated by three main plant communities; blackwood-paperbark swamp forest that covers almost all of the western arm of the marsh, and grassy-sedge wetland and black gum forest that cover the eastern arm of the marsh. In the eastern arm, the removal of the original blackwood-paperbark swamp forest and the installation of drainage channels has dried out the area and allowed the grassy-sedge wetland community to proliferate. While this area is particularly impacted by the invasion of exotic plant species, most notably Harding grass (*Phalaris aquatica*) and grey willow (*Salix cinerea*), it appears to provide highly suitable habitat for breeding by native waterfowl.

Table 1. Plant communities and the extent of coverage within McKerrows Marsh.

Plant community	Total area (ha)
Blackwood-paperbark swamp forest	222
Grassy-sedge wetland	78
Wooly teatree scrub	2
Black gum forest	39
Coastal black peppermint forest	19
Aquatic wetlands	1.3
Willows	2.7
Pasture	18

Within the marsh there are also numerous small patches of aquatic wetlands that contain typical wetland plant species such as *Myriophyllum* sp., *Eleocharis sphacelata*, *Triglochin procerum*, *Lilaeopsis polyantha* and *Rorippa dictyosperma*. Studies elsewhere have shown that species which occur within these habitats tend to be reliant on seasonal drying (Halse *et al.*, 1993), and that variability in the pattern and magnitude of inundation tends to produce greater biomass and species richness (Casanova and Brock, 2000). In McKerrows Marsh, these small wetland patches tend to occur near to the margins of the blackwood swamp, and where fencing has yet to be installed it is clear that cattle access has significant impacts on their physical condition.

Aquatic Fauna

Fish. A total of 8 species of fish were found within the river channel flowing through McKerrows Marsh. This represents a healthy fish community in the Tasmanian context, and only one of the species found was non-native (*Salmo trutta*). The most common species were the native southern pygmy perch (*Nannoperca australis*), the common jollytail (*Galaxias maculatus*) and the freshwater flathead (*Pseudaphritis urvillii*).

The majority of fish found within the marsh showed a clear preference for flowing, river channel habitat, occurring in open water along the edge of the river, in leaf litter or woody debris habitat or in the soft silt in the bed and along the banks of the river. Although some of these species are likely to move out of the river channels in pursuit of food during periods when the riparian marsh is flooded, for only a single species is this likely to be important for breeding or recruitment. Southern pygmy perch showed a clear preference for 'slack water' habitats, where there was prolific and dense cover of aquatic plants such as *Myriophyllum* sp. and *Rorippa dictyosperma*. The cover and corresponding food supply provided by this habitat within the river channel are important reasons for use of this habitat by adults (Humphries, 1995). However sampling of the off-stream aquatic wetland patches in early spring found considerable numbers of juvenile fish (length < 5 mm), indicating that these areas, which dry out during the summer, are important for breeding and recruitment of this species.

Invertebrates. Forty-six families of aquatic macroinvertebrates were identified in samples collected from edgewater habitats within the river channel flowing through McKerrows Marsh. Highest numbers of taxa (25) were recorded in the river where it flows through the grassy-sedge wetland habitat, and where there was a greater amount of trailing bankside vegetation. Fewest taxa (17) were collected from within the heart of the blackwood-paperbark forest, where the river contains most mud and silt and has less trailing vegetation that could provide good edgewater habitat for aquatic biota. The aquatic invertebrate fauna within the marsh is dominated by water mites (Hydracarina), side swimmers (Parameletidae), diving beetles (Dytiscidae), various families of non-biting midges (Chironomidae), leptophlebiid and oniscigastrid mayflies, corixid and veliid bugs, gripopterygid stoneflies, and several families of caddisflies. Many of these taxa are either cosmopolitan in the range of habitats they inhabit, or are more typical of slow-flowing waterways with substantial supplies of decaying plant material.

Using these data as input, 'riverine health' within the marsh was assessed using the spring-edgewater AusRivAS model for Tasmania. The results show that the health of the aquatic macroinvertebrate community inhabiting the Great Forester River within McKerrows Marsh is generally good (Table 2). Results which have resulted in an 'A' classification are essentially healthy, while the site that has been given a 'B' classification indicates slight impairment. This location lies within the blackwood-paperbark forest, where natural conditions do not provide abundant or suitable 'edgewater' habitat for macroinvertebrates, and the results reflect this rather than any degradation in riverine habitat.

Table 2. River health assessment outputs from the AusRivAS spring, edgewater model for Tasmania.

Site Name	OE50 Taxa	OE50 SIGNAL	OE0SIGNAL	Band
McKerrows at Forester Lodge	1.09	0.95	0.97	A
McKerrows at Boat Hole	1.09	0.89	0.97	A
McKerrows at small wetland	0.86	0.93	0.94	A
McKerrows at Cut-off Channel	0.86	1.21	1.23	A
McKerrows at Lovers Reach	0.75	1.03	1.15	B
McKerrows u/s Billabong	1.18	0.93	0.98	A

The other significant feature of McKerrows Marsh is the overwhelming abundance of crayfish burrows. Northeast Tasmania is noted for its exceptionally diverse burrowing crayfish fauna (Doran & Richards, 1996), and burrows of *Engaeus* spp. were found scattered throughout the western arm of McKerrows Marsh, where blackwood-paperbark swamp forest dominates. All of the *Engaeus* species are distinguished by their ability to burrow, sometimes to depths exceeding 2 m.

Based on a review of existing knowledge regarding the distribution of burrowing crayfish in Tasmania, three species are likely to have been responsible for the burrows observed in McKerrows Marsh. All three species are described as mainly occurring in "floodplains and riparian areas of streams" and tend to prefer "organic, permanently saturated surface soils" (Bryant & Jackson, 1999). It is therefore important that in the absence of surface water, crayfish are able reach the local groundwater table.

Groundwater

The installation of nine boreholes in and around the marsh has provided substantial information about the local groundwater and sedimentology of the area. The drilling logs showed that there is approximately 2 m of organic-rich loamy clay underlying the marsh, and that this sits on top of the Tertiary gravels that contain the regional aquifer. Outside the northern boundary of the marsh, the upper strata are composed primarily of water-bearing, fine wind-blown sands that sit on top of dark, organic sandy clay that is indicative of marine-estuarine sediments. Below this band, the Tertiary gravels of the regional aquifer are once again encountered. Early results from water level monitoring within these boreholes suggest that the fine sands contain a local groundwater resource that lies above the level of the marsh, is more reactive to local rain events and may supply water to the marsh during dry periods.

On the southern boundary of the marsh the Tertiary gravels of the regional aquifer are generally closer to the surface, and water levels within these are at or below water levels in the river within the marsh. Further monitoring is required to determine the nature of the linkage between water level in the river and the regional groundwater aquifer.

Conceptual Models

From the information that has been collected during the study to date, some simple conceptual models have been developed to illustrate key processes and interactions within the ecosystem. Models have been constructed to illustrate the local lithology of the sediments and predict the main pathways for water flow through the system, and a model has also been developed to highlight what are presently perceived to be key ecological issues and environmental dependencies. This model is shown in Figure 2, and illustrates hypotheses relating to the reliance of blackwood-paperbark forest and burrowing crayfish communities on groundwater levels within the marsh. Models such as this will be further refined as additional data are collected, and the hypotheses that are generated will later be tested using linked groundwater – surface water hydrologic models with the ultimate aim of developing water management options for the lower Great Forester River.

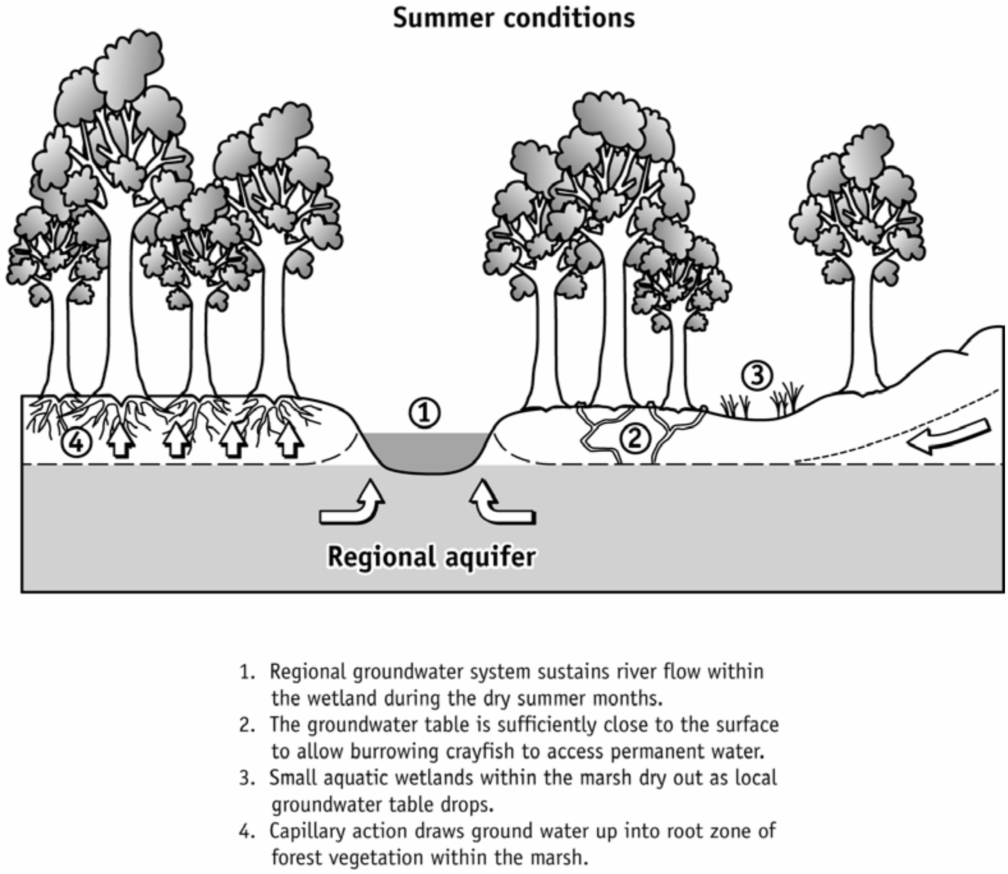

Figure 2: Conceptual model for McKerrows Marsh & groundwater.

CONCLUSION

Although the study has been underway for only a short period of time, the work undertaken so far has identified as number of ecological issues that will be important to consider during the development of water management measures for the lower Great Forester River. One of the priorities for any water management regime will be the preservation of streamflows that are likely to be important for the long-term health of the blackwood-paperbark swamp forest, which is a significant forest community in the region (Pannell, 1992). It also appears that there may be strong links between this forest community and the population of burrowing crayfish inhabiting the swamp, and it is likely that both these communities are reliant to some degree on local groundwater levels during dry periods. This aspect will require further investigation during the course of the study.

While the blackwood-paperbark forest may have a higher priority for conservation because of its regional importance, the small wetland patches that occur within the marsh are obviously important both in terms of maintaining local plant diversity, and in providing habitat for aquatic fauna. These patches are likely to be local hotspots for productivity during the spring and early summer, and are important as off-stream nursery areas for southern pygmy perch, where aquatic predators can also be avoided. It is also likely that these patches are seasonally important as breeding areas for frogs as well.

Now that there is a better understanding of the marsh ecosystem and the flora and fauna that occupy it, work has begun on the construction of a detailed hydrological model for the wetland incorporating linkages to groundwater and using input from a larger catchment runoff model. Through this it is hoped that the relative contributions from groundwater and surface water can be quantified. Using this tool it will then be possible to develop a water management regime for the marsh that is likely to sustain the ecosystem into the future whilst allowing for further agricultural development upstream in the Great Forester catchment.

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