# Recovery plan for the endangered RIVER SNAIL (*Notopala sublineata*)

NSW DEPARTMENT OF
**PRIMARY INDUSTRIES**

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Prepared in accordance with the threatened species provisions of the *Fisheries Management Act 1994.*

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Published by NSW Department of Primary Industries

First Published July 2007

For updates to this publication, check http://www.dpi.nsw.gov.au/

ISBN 0 7347 1738 5

Acknowledgements: This recovery plan is based on input from a range of people including Gabrielle Holder, Dr Bob Creese, Bill Talbot, Polly Mitchell and Dr Winston Ponder



Job No: 7483

# Contents

# Executive summary

This document is the NSW recovery plan for the river snail (*Notopala sublineata*). The recovery plan discusses the likely reasons for the decline of the river snail throughout its known range within NSW, and outlines the measures needed to recover the species and ensure its long-term viability. This plan has been developed in accordance with the requirements of the NSW *Fisheries Management Act 1994.*

The river snail is a medium-sized freshwater snail that has been listed as 'endangered' under the *Fisheries Management Act 1994* and as threatened under the Victorian *Flora and Fauna Guarantee Act 1988*. The species is also listed as endangered by the World Conservation Union (IUCN).

The river snail was once common and widely distributed throughout the Murray Darling Basin where it was found along the banks attached to logs and rocks or crawling in the mud. In particular, *N. sublineata hanleyi* is restricted to the Murray and Murrumbidgee drainages, while *N. sublineata sublineata* is restricted to the Darling River and its tributaries. It is clear that the river snail has suffered a dramatic decline in NSW. The species is currently considered extinct throughout its natural range. Over the last decade living specimens have only been recorded from water supply irrigation pipelines.

While there is a lack of definitive research on the fundamental cause(s) of the species' decline, it is likely that a range of factors has contributed, and that some of these factors assume a greater importance in different locations and/or habitats. One of the best-supported hypotheses concerning the species' decline involves changes in the nature of the periphyton (biofilm) community as a result of altered flow regimes**.** Other possible reasons for the species decline include removal of large woody debris from rivers, removal from artificial environments, sedimentation and the introduction of carp.

The NSW Department of Primary Industries will coordinate and lead the implementation of this recovery plan, with support from relevant NSW government agencies, universities, councils, and the community. It is proposed that the recovery plan will be resourced by a combination of recurrent and external funding. Many of the actions identified within the plan can be implemented as part of the core functions of the NSW Department of Primary Industries and other public authorities. Implementation of the recovery plan does not require or propose the need for additional recurrent funds. However, the implementation of some recovery actions will be subject to securing additional funding from grant programs.

# 1. Introduction

## 1.1 Legislative context

The conservation of threatened species of fish, aquatic invertebrates and marine vegetation in NSW is covered by Part 7A of the *Fisheries Management Act 1994*; administered by the NSW Department of Primary Industries (NSW DPI). Part 7A deals with the protection and recovery of threatened species, populations and ecological communities, the listing of key threatening processes, and the preparation of recovery and threat abatement plans.

The river snail is considered:

- Endangered under the *Fisheries Management Act 1994*;
- Threatened under the Victorian *Flora and Fauna Guarantee Act 1988*; and
- Endangered under the IUCN Red List of Threatened Species.

The Commonwealth Threatened Species Scientific Committee recommended the river snail for listing as 'critically endangered' under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. The Minister for the Environment and Heritage rejected the nomination based on a lack of information regarding the species' taxonomy, historical and current distribution and abundance, decline in numbers and the uncertainty about the conservation outcome of the listing.

## 1.2 Preparation of recovery plans

The NSW DPI may prepare recovery plans for all species, populations and ecological communities listed as critically endangered, endangered or vulnerable on the schedules of the *Fisheries Management Act 1994*. Recovery plans aim to recover a species, population or ecological community to a position of viability in nature. The NSW DPI is also required to set out the strategies to recovery species, populations and communities in a Priorities Action Statement. Approved recovery plans are statutory documents. Ministers and public authorities need to take appropriate actions to implement the measures in the plan for which they are responsible, and to ensure their decisions are not inconsistent with the provisions of the plan without consulting the Minister for Primary Industries. The *Fisheries Management Act 1994* also requires public authorities (other than local councils) with identified responsibilities in a recovery plan to report on implementation actions in their annual report to Parliament. Local councils must report on actions in annual State of the Environment reports.

## 1.3 Critical habitat

Critical habitat provisions are established by Division 3 of Part 7A of the *Fisheries Management Act 1994*. The Minister may declare the whole or any part of the habitat critical to the survival of a species, population or ecological community as critical habitat. Public authorities are required to have regard to critical habitat in exercising any of their functions in relation to any land involved. The *Fisheries Management Act 1994* also establishes offences in relation to damaging critical habitat. Once declared, a species impact statement is mandatory for all developments and activities that are likely to affect the critical habitat.

Critical habitat had not been declared for the river snail at the time this plan was prepared. Any future declaration of critical habitat for the river snail will be published in the NSW Government Gazette, and in a newspaper with a state wide circulation. The recovery actions listed in this plan recognise the need to identify habitat that is critical to the survival of the river snail.

## 1.4 Environmental planning and assessment

The *Fisheries Management Act 1994* integrates the conservation of threatened species into development control processes established by the NSW *Environmental Planning and Assessment Act 1979*. As part of the development assessment process, consent authorities are required to assess development impacts on threatened species, and to consider if activities are of a class of development recognised as a threatening process. Recovery plans must also be considered by determining authorities for activities under Part 5 of the *Environmental Planning and Assessment Act 1979*, and by concurrence authorities for developments under Part 4 of the *Environmental Planning and Assessment Act 1979*.

Activities and developments that do not require approval under the *Environmental Planning and Assessment Act 1979* may require licensing under the *Fisheries Management Act 1994* if they are likely to harm a threatened species, population or ecological community, or their habitat.

## 1.5 Recovery plan implementation

The NSW DPI is the lead agency responsible for coordinating the implementation of the plan however the success of the plan and achievement of its objectives will require action by all levels of government, organisations and the community. The NSW DPI has a statutory obligation to encourage the conservation of threatened species by the adoption of measures involving co-operative management.

Other agencies with responsibility for implementing actions contained in the plan include the NSW Department of Water and Energy (DWE), the NSW Department of Environment and Climate Change (DECC), and local councils. In addition, a range of other organisations will need to be involved including Catchment Management Authorities (CMAs), the Australian Museum, universities and research institutions, irrigators, community groups, and the Murray Darling Basin Commission (MDBC).

## 1.6 Linkages to other recovery and threat abatement plans

The river snail is only one of several aquatic species in the Murray-Darling Basin that have undergone major declines in distribution and abundance and are listed as threatened under the *Fisheries Management Act 1994*. Others include trout cod (*Maccullochella macquariensis*), Macquarie perch (*Macquaria australasica*), silver perch (*Bidyanus bidyanus*), Murray hardyhead (*Craterocephalus fluviatilis*), southern pygmy perch (*Nannoperca australis*), and western population of purple spotted gudgeon (*Mogurnda adspersa*) and olive perchlet (*Ambassis agassizii*). The aquatic ecological community in the natural drainage system of the lower Murray River catchment, the aquatic ecological community in the natural drainage system of the lowland catchment of the Lachlan River and the aquatic ecological community in the natural drainage system of the lowland catchment of the Darling River are also listed as endangered under the *Fisheries Management Act 1994*.

Recovery plans for a number of these species, populations and ecological communities are being developed by NSW DPI. Once recovery plans have been finalised it is likely

that recovery activities for these species, populations and ecological communities will be cross-linked in some areas and will therefore benefit the recovery of the river snail.

In addition, several ‘key threatening processes’ (KTPs) of relevance to the river snail have been listed under the *Fisheries Management Act 1994*. These include 'Degradation of riparian vegetation along NSW water courses', 'Installation and operation of in-stream structures and other mechanisms that alter natural flow regimes of rivers and streams', 'Introduction of fish to waters within a river catchment outside their natural range' and 'Removal of large woody debris from New South Wales rivers and streams'. The preparation and implementation of threat abatement plans for these KTPs will benefit the recovery of the river snail.

A Priorities Action Statement (PAS) must be prepared in accordance with section 220ZVA of the *Fisheries Management Act 1994*. The PAS sets out the strategies and relative priorities for promoting the recovery of threatened species, populations and ecological communities and for managing key threatening processes. There will be links between the PAS, recovery plans and threat abatement plans.

# 2. Biology and ecology

## 2.1 Names

Common: River snail, Blind river snail

Scientific: *Notopala sublineata* (Conrad, 1850)

*Notopala hanleyi* (Frauenfeld, 1864)

## 2.2 Systematic position

The river snail (*Notopala sublineata*) is one of approximately 18 species in the genus *Notopala* found in Australia, mostly in northern Australia (W. Ponder, pers. comm. 2004). Only two of these – the endangered river snail *N. sublineata* and the species *N. suprafasciata* – occur in the Murray-Darling system. The latter species favours temporary pools including billabongs and small natural lakes while *N. sublineata* lives in river channels (W. Ponder, pers. comm. 2004).

*Notopala sublineata* (Conrad 1850) and *Notopala hanleyi* (Frauenfeld 1864) are recognised as distinct in the literature. *Notopala sublineata* is now thought to contain three sub-species; *Notopala sublineata hanleyi, Notopala sublineata sublineata* and *Notopala sublineata alisoni* (W. Ponder in prep.), two of which are restricted to the Murray-Darling drainages. The third sub-species *Notopala sublineata alisoni* has a wide distribution in more northern inland and coastal drainages outside NSW.

## 2.3 Description

The river snail is a medium-sized (20-25mm) freshwater snail with a round shell that ends in a conical spire. Its outer shell is generally dark green but may also be greenish brown or dark brown, without banding. The body of the animal is similar to other snails but possesses a prominent snout and short eye stalks on the outside of the tentacles (DEH 2004).

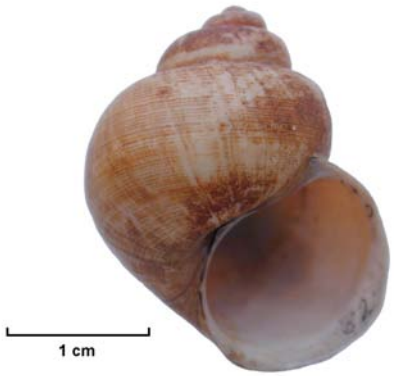


**Figure 1: Shell of the river snail (*Notopala sublineata*)**

Historical records (particularly from the Murray-Darling river system) indicate that most large rivers had high loadings of large woody debris (Treadwell et al. 1999). The amount of large woody debris in NSW rivers and streams has been reduced by de-snagging programs and clearing of riparian vegetation which reduces the supply of large woody debris falling into the river.

## 2.4 Distribution and abundance

The river snail was once common and widely distributed throughout the Murray Darling Basin in NSW, South Australia and Victoria (Cotton 1935b; Sheldon & Walker 1993b; Ponder 1998).

*N. sublineata hanleyi* is restricted to the Murray and Murrumbidgee drainages, while *N. sublineata sublineata* is restricted to the Darling River and its tributaries. The subspecies *sublineata* and *hanleyi*, while being quite distinct in parts of their range, tend to merge around the lower parts of the Darling River (W. Ponder, pers. comm. 2004, DEH 2004). The third sub-species, *N. sublineata alisoni*, have a wide distribution in more northern inland and coastal drainages outside NSW, and is not currently considered to be under significant threat (Clarke & Spier-Ashcroft 2000).

Australian Museum collections from around Australia show 184 historical records of the river snail. Collections and sightings of the species in NSW declined in the 1960s and 1970s such that by the 1980s populations were thought to only occur in a small number of locations. The river snail is currently considered extinct throughout its natural range. Over the last decade living specimens have only been recorded from artificial environments such as water supply irrigation pipelines.

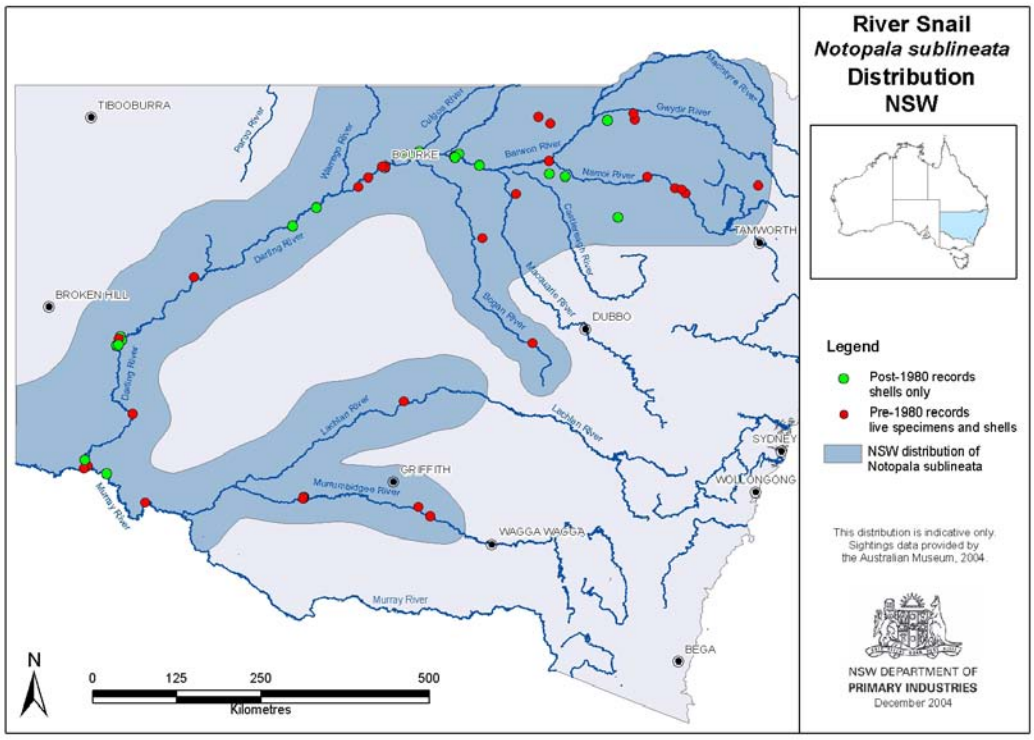


**Figure 2: River snail distribution in NSW**

## 2.5 Habitat

The river snail once occurred in flowing rivers throughout the Murray-Darling system, where it was found along the banks attached to logs and rocks or crawling in the mud.

Artificially introduced hard surfaces now provide habitat for the species with populations being recorded as surviving in irrigation pipelines throughout the Murray and Darling systems (Sheldon & Walker, 1993a, b; Walker, 1996; Ponder, 1997, 1998; Ponder & Walker 2003). The pipeline environment is thought to promote microbial production and organic accumulation (Sheldon & Walker 1993a), which is a highly nutritious food source for the species (see Section 2.6.2).

**Figure 3: River snail shells (*N. s hanleyi*) taken from water supply irrigation pipelines near Mildura.**

## 2.6 Life history and ecology

Very little published information on the biology and ecology of the river snail exists.

### 2.6.1 Reproduction

The family Viviparidae is characterised by the females giving birth to live young (viviparity) rather than the more usual method for freshwater gastropods of laying eggs that hatch in an external environment. Fertilisation is internal, with embryos retained in a pallial oviduct (Stoddart 1982, Sheldon & Walker 1993b).

Viviparids display a consistency in the size at which females begin to carry young. Females of most species do not carry young until they are larger than 15-16 mm (Buckley 1986 cited in Wishart 1994). The young remain with the female until they are large enough to survive independently (Wishart 1994, Clarke & Spier-Ashcroft 2000).

The fecundity of natural populations of viviparous snails is reported to be low compared to other freshwater gastropods (Sheldon & Walker 1997) reflecting the energetic costs associated with viviparity. There is, however, significant variation within and between species and fecundity may vary as much as seven-fold between populations (Browne 1978 cited in Wishart 1994). Wishart (1994) found the fecundity of pipeline derived *N. hanleyi* to be exceptionally high in comparison to most other viviparids.

The fecundity of freshwater viviparids is determined by factors such as periphyton quantity (Brown 1985) and quality (Eisenberg 1966, 1970; McMahon et al. 1974), population density (Eisenberg 1970) and physio-chemical variables including water temperature, dissolved oxygen and calcium concentrations and current velocity (McMahon 1983; Lam & Calow 1989 cited in Wishart 1994). Hence, estimates of the fecundity of pipeline populations of the river snail cannot be extrapolated to infer the fecundity of riverine populations.

### 2.6.2 Diet

The river snail feeds on the bacteria and microflora associated with detritus. In particular, it uses its taenioglossid radula to graze on microbial biofilms similar to those found on snags and in leaf litter (Sheldon & Walker 1997, Walker 1996).

Biofilms include bacteria, fungi and algae that grow attached to rocks, wood and other submerged substrata, particularly in the riverine littoral zone (Wishart 1994). Apart from being grazed upon by a variety of aquatic organisms, biofilms play an important role in generating and recycling organic carbon and other nutrients in the aquatic ecosystem. An index of biofilm food quality is given by the ratio of carbon to nitrogen (C:N). For the river snail, high nitrogen content in a biofilm is thought to provide a higher quality food source (Sheldon & Walker 1997).

The river snail may supplement grazing by filter feeding on bacteria suspended in the water column (Wishart 1994).

### 2.6.3 Growth and longevity

Nothing is currently known of the growth rates or longevity of the river snail.

### 2.6.4 Behaviour and movement

The viviparous life history of the river snail means that dispersal via drifting or by dislodged egg capsules is not possible. However, it is possible that juveniles may be dispersed downstream during high flow events either directly or by being attached to dislodged material (leaves, wood etc).

## 2.7 Genetics

To date, no work has been undertaken on the genetic differentiation of *N.sublineata hanleyi* and *N.sublineata sublineata*. This is primarily due to the absence of any known populations of *N.sublineata sublineata*. However, a study on the population genetics of *N.sublineata alisoni*, with a comparison to the population of *N.sublineata hanleyi* taken from the Kingston pipeline near Barmera in South Australia has commenced.

# 3. Current issues and threats

The lack of definitive research and reliable historical records makes the extent, rate and timing of the decline of the river snail difficult to ascertain. However, it is likely that a range of factors has contributed to the decline, and that some of these factors assume a greater importance in different locations and/or habitats. The factors currently thought to be responsible for the species' decline are discussed in the following section.

## 3.1 River regulation

The Murray-Darling Basin is Australia's most regulated drainage division (Walker 1981), with numerous storages and other structures having been constructed to regulate river flows and ensure a more reliable supply of water for irrigation, hydroelectricity generation, urban and rural water supply and diversions to other catchments (Young 2001). River regulation and water extraction throughout the Basin have detrimentally affected the riverine environment as well as surrounding riparian and floodplain habitats. Amongst the casualties of river regulation is the gastropod fauna. Over the past 10-15 years several species of gastropods have disappeared while others have re-appeared only in short-lived, local resurgences (Sheldon & Walker 1993b).

The impacts of river regulation are numerous, complex and often inter-related. With limited information about the river snails' habitat requirements and ecology, it is difficult to determine precisely how the various changes associated with river regulation have contributed to the species' decline. However, the best-supported hypothesis concerns changes in the nature of the periphyton (biofilm) community, as a result of changed flow regimes (Wishart 1994, Sheldon & Walker, 1993, 1997, FSC 2000, Clarke & Spier-Ashcroft 2000, SAC, 2001).

### 3.1.1 Changes to natural flows

In their natural state, inland rivers such as the Murray were characterised by highly variable flows including a pattern of prolonged droughts punctuated by major floods. Native flora and fauna have become adapted to these flow patterns over millions of years, and periods of low and high flow have important ecological functions. The primary flow change in the Murray-Darling Basin reported to have affected river snail populations is the construction of weirs – leading to slower flow velocities – and, in the lower river reaches, extended periods of low flow (Young 2001). Many weirs have been installed throughout the Murray-Darling Basin to create weir pool environments for diversions into irrigation channels, stable pool heights for pump intakes, recreational boating and other aesthetic reasons. Weir pools are characterised by slow flow and warm surface layers. The density of weir pools in many places is such that streams have become a series of continuous pools with characteristics of a flowing river only in high flows (Thoms et al. 2000).

River regulation has resulted in changes to water-level fluctuations and underwater light regimes. This has resulted in changes in the littoral biofilms in the river system whereby biofilms are now much lower in bacterial content than was previously the case, having been replaced with filamentous algae that is less nutritious for the snails (Sheldon & Walker 1997). The shift in the quality of food, represented by the ratio of carbon to nitrogen (C:N), is significant as it determines growth, reproduction and survivorship (McMahon et al. 1974; Russel-Hunter et al. 1972; Aldridge 1983). The productivity of river systems has decreased from a more nutritive, microbial-detrital system (low C:N)

prior to regulation to a less nutritive, post-regulation environment containing a higher proportion of filamentous algae (high C:N) (Wishart 1994). It is likely that the river snail can no longer obtain enough nitrogen to maintain its growth and reproduction.

While the river snail now seems to be extinct throughout its natural range there are records of some populations surviving in irrigation pipelines where water is fed from the river channel. The change in food resources resulting from river regulation is a likely explanation for the species' colonisation of artificial habitats (see Section 3.3).

## 3.2 Removal of large woody debris

Large woody debris – also commonly referred to as 'snags' – consist of whole trees, limbs or root masses that have fallen or been washed into a waterway and have become partly or wholly submerged by water. This debris may have fallen directly in from the riverbank to lie *in situ*, or have been transported in reasonably high flows to accumulate in masses further downstream.

The loading of large woody debris in Australian rivers has been greatly reduced from their natural state by de-snagging programs and clearing of riparian vegetation, which reduces the supply of large woody debris falling into the river. In the past, de-snagging programs have been undertaken for a number of reasons including to improve river navigability and flood mitigation (Gippel 1995).

Large woody debris provide habitat for a range of native species by accumulating debris and creating diverse water depths and velocities (Thoms *et al*. 2000). The wood provides a suitable surface for colonisation by a range of microbes including bacteria. Research, both in Australia and overseas, has also shown that the surfaces of woody habitat support a wide diversity of aquatic invertebrates. Many feed directly on the wood or, as is the case for the river snail, graze on the biofilm attached to snags. The loss of large woody debris represents a reduction in the surface area available for biofilm colonisation and a subsequent reduction in the quantity of suitable food sources. Large woody debris in lowland rivers is particularly important given that other forms of habitat complexity are uncommon.

## 3.3 Removal from artificial habitats

There have been several reports of populations of *Notopala* occurring in artificial environments such as irrigation pipelines. The subspecies *hanleyi* is currently known to occur in the Kingston and Loveday irrigation pipelines near Barmera, South Australia (Sheldon & Walker 1993a) and in water supply pipelines in the Mildura area in NSW. The pipelines are fully enclosed, with water fed from off-take pipes deep within the river. The wetted inner surfaces of the pipes combined with the high oxygen levels maintained during the irrigation season due to persistent flow, provide an area for microbial production and organic accumulations and hence a ready food supply (Sheldon & Walker 1993b). This is consistent with biofilms in unregulated lowland rivers where biomass tends to be microbial due to limited light penetration and natural flow pulses.

The discovery of river snail populations in irrigation pipelines, along with earlier records of the gastropods *Glyptophysa connica* and *Thiara balonnensis* and the bivalve *Corbicula australia* (Deshayes) in other pipelines (Woolford 1984), suggests that these environments are now an important refuge for the species survival (Sheldon & Walker 1993b). The presence of the species in artificial environments is particularly important considering that the species now has no opportunity to recolonise its previous habitat because the substrata now support algal rather than bacterial associations (SAC 2001).

Pipeline populations of snail species (possibly including *Notopala sp.*) are reported to be a considerable problem for irrigators (Sheldon & Walker 1993b), and they are in imminent danger of being exterminated due to their tendency to block spray nozzles. When pumping ceases after the irrigation season oxygen levels decline significantly, killing large numbers of snails, dislodging them from the pipes and blocking filters and spray-heads. For this reason some irrigator's regard the snails as pests (Walker 1996). Dead snails can also foul water sources that are used for household as well as irrigation purposes (Sheldon & Walker 1993b).

The conventional treatment for removing the snails has been to dose the lines with chemicals such as chlorine. However, the response of freshwater snails to chemical control measures is limited by a number of factors including the nutritional status and behavioural adaptations of individuals. There are also limits to chemical use especially where water is used for secondary domestic supply (Walker 1996). Given that the species is apparently extinct in the natural environment the decimation of populations in artificial environments is of major conservation concern. An alternative control method proposed by Woolford (1984) is backflushing and manual removal of the source population, which is usually resident in the pump ducts leading from the river.

The presence of the river snail in artificial environments provides insights into the species' habitat requirements, and by comparison can detail the likely causes for their absence within the natural environment. It also presents a conservation opportunity by allowing investigation into the feasibility of a translocation and breeding program in NSW. Unfortunately the likelihood of successful translocations in the natural environment is prejudiced by the isolation and degradation of the remaining floodplain wetlands, and by the depredations of bottom dwelling fish like the introduced carp (Walker 1996). Given the extent of irrigation practices in the Murray-Darling Basin there is a possibility of discovering additional populations of the river snail in artificial environments in the future.

## 3.4 Sedimentation

Many rivers in the Murray-Darling region would naturally have experienced periods of high turbidity, for example during high flows. Human activities such as land clearing, grazing, cropping and forestry have increased sediment levels in many rivers. Total sediment supply to rivers in the Basin is estimated at 29 million tonnes per year, which is 41 times the natural rate (DeRose et al. 2003). Since much of this material comes from diffuse land runoff from sources such as agriculture, this is a widespread issue throughout the Murray-Darling Basin (Clunie & Koehn 2000).

While research is yet to determine the precise impacts of increased sediment levels on the river snail, it, in conjunction with the impacts of river regulation, is likely to have had a number of adverse impacts (SAC 2001). In suspension, sediment reduces light penetration into the water column reducing the overall productivity of the river system and food sources for organisms. As partial filter feeders, high levels of suspended sediment may impact on the species' feeding abilities. It may also impact on the species' respiration as their sensitive gill structures may be damaged by a localised increase in turbidity (Walker 1996).

Once settled, sediment is known to result in much more uniform habitat, covering material such as snags (Clunie & Koehn 2001), which are important habitat for biofilm colonisation. Sediment deposition also impacts on food resources by preventing both heterotrophic and autotrophic development of biofilms (Burns & Ryder 2001) and decreasing the nutritive value of periphyton, one of the main food sources for gastropods

(Sheldon & Walker 1993b). The subsequent changes in the composition of the substrate associated with increased sediment levels may reduce its suitability as a surface for attachment and lead to substrate instability thereby increasing invertebrate drift (Clunie & Koehn 2001).

Sedimentation may affect the ability of the river snail to withstand desiccation. Stoddart (1982) suggests that the ability of a species to withstand water loss may be determined by the ability to seal the aperture. If the aperture is clogged by sediment the seal will be ineffective, increasing water loss (Wishart 1994). Behavioural adaptations such as retreating beneath logs to increase local humidity and reduce ambient temperatures are also thought to enhance a species' ability to minimise water loss (DeWitt 1955, Jokinen 1978, MacMahon 1983 cited in Wishart 1994). Certain behavioural adaptations may now be limited given the level of habitat degradation and destruction throughout the Murray-Darling Basin.

## 3.5 Introduction of carp

Carp began their rapid expansion throughout the Murray-Darling Basin in the early 1970s and are now widespread and abundant in most areas (Clunie & Koehn 2001). While the precise impacts of carp on the aquatic environment are unclear, perceived problems of carp include increased water turbidity and siltation, decreased macrophyte biomass and diversity, increased water nutrient loads and algal concentrations, reduced species diversity and erosion of streambanks.

Carp have a broad ecological niche and are highly adaptable due to their high fecundity, rapid growth, longevity, tolerance to a range of water quality conditions, ability for rapid dispersal and flexible omnivorous diet (Young 2001, Harris & Gehrke 1997). Carp can tolerate high turbidity, high water temperatures and low water oxygen concentrations. This gives them a biological advantage allowing them to thrive in areas where there is slow flowing water (MDBC 2000).

While there is little direct evidence, high densities of carp are likely to have impacted on river snail populations through predation and via habitat changes. Carp are usually found in still or slowly flowing waters at low altitudes, especially in areas where there is abundant aquatic vegetation. Changes to water flows, declining water quality and other changes to river habitats over the past few decades have negatively affected many native species while favouring carp. In addition, the destructive feeding habits of carp may have impacted on river snail populations. In terms of direct predation carp have been recorded feeding on a variety of organisms including molluscs (Clunie & Koehn 2001). Although the river snails' fecundity is compensated in regard to recruitment by the birth of well-developed young, the low number and soft shells of these young would make them extremely vulnerable to carp predation.

## 3.6 Lack of knowledge

There is a general lack of biological and ecological knowledge on the river snail and, as a result, inferences are often made with Viviparid species elsewhere in the world. In particular, there is very limited information available on the species' past and present distribution, taxonomic status, habitat requirements, biology and responses to particular threats.

Improving our knowledge is fundamental to the recovery of the river snail as it will provide insights into the causes of the species decline, which could be used as a basis for future management decisions. For example, information on critical habitat requirements

and recruitment success could be used to assess the feasibility of a translocation program into natural and/or artificial environments.

### 3.7 Community awareness and support

Community awareness and support for river snail recovery actions and invertebrate conservation in general, is low. There is a perception within some sections of the community and government that invertebrates are inconsequential, and therefore not worthy of conservation attention (Clarke 2001). Clarke (2001) also suggests that there is a commonly held belief that invertebrates are so numerous and widely distributed that they cannot be of major conservation concern. This perception is exacerbated by the fact that invertebrates generally lack aesthetic appeal, particularly compared to other iconic aquatic species such as Murray cod. Invertebrate species are also often considered nuisances or pests.

Yen & Butcher (1992) highlight the need to increase public awareness of invertebrates to promote the message that the majority of invertebrate species are harmless, ecologically vital, and that their conservation is an important issue. The involvement of community groups in river snail recovery actions is particularly important given their intimate local knowledge, and the potential flow on benefits such as developing a sense of ownership and long-term stewardship of the recovery program.

## 4. Recovery actions to date

### 4.1 Habitat protection and restoration

There are a range of on-going government programs and initiatives aimed at protecting and/or restoring river habitats, which, in turn will assist in reducing the various threats to the river snail. Examples include the Water Reform Program, the Weir Removal Program, and the Murray-Darling Basin Native Fish Strategy.

### 4.2 Survey and monitoring

There have been no extensive dedicated surveys for the river snail in NSW. However, some survey work has been done as part of a postgraduate research project at Macquarie University.

A range of research programs undertaken by NSW DPI and other organisations such as the Australian Museum has provided valuable incidental data on the presence or absence of the river snail.

### 4.3 Community education

The NSW DPI has undertaken a number of activities targeted at increasing public awareness of river snail conservation issues including for example, producing and disseminating advisory material, and implementing a Threatened, Protected and Pest Sighting Program where members of the community are encouraged to report sightings of threatened species.

### 4.4 Breeding and translocation

A conservation initiative of Banrock Vineyards and the South Australian Field and Game Association commenced in 2000. This initiative involved introducing the river snail into a

rehabilitated wetland on Banrock Station and a manually operated wetland. The reintroduced snails were sourced from the population of *N. sublineata hanleyi* within the Kingston irrigation pipeline. As yet there is no evidence to suggest that the snails are breeding within the wetlands. Populations are periodically re-stocked from the pipeline environment.

Bookmark Biosphere in collaboration with the Australian Landscape Trust (ALT) has also initiated a rehabilitation effort for *N. sublineata hanleyi*. The ALT manages various pastoral leases owned by the government including Calperum Station in South Australia. On Calperum Station the ALT has maintained three populations of snail in individual tanks, five populations in holding drums and three populations in artificial habitats, PVC piping, in a creek off the Murray River. Each of the colonies ranges from approximately 25-40 snails. The snails were sourced directly from the Kingston-on-Murray pipelines. The main aim of this rehabilitation project is to create a structure that can be relatively easy to reproduce with the possibility of creating local interest in the rehabilitation of the snails into the natural environment. A further experiment is to be conducted with the snails being placed directly into the natural habitat of the creek but with a carp screen to prevent predation.

The feasibility of establishing a breeding and translocation program will be investigated as part of this recovery plan. The NSW DPI has commenced a preliminary breeding trial with individuals sourced from water supply irrigation pipelines in the Mildura area.

# 5. Recovery objectives and performance criteria

## 5.1 Recovery plan objectives

The overall objective of this recovery plan is to prevent the extinction and promote the recovery of river snail populations in NSW.

The specific objectives of this recovery plan are to:

- Increase awareness of the current status of the river snail throughout its former natural range.
- Locate and protect remnant populations in natural habitats or translocated populations in artificial habitats.
- Investigate the feasibility of establishing an artificial breeding and translocation program for the river snail in NSW.
- Increase our understanding of the threats to the river snail and undertake management actions to ameliorate threats.
- Establish a program to monitor the status of the river snail populations (either natural or introduced) and assess the effectiveness of recovery actions.

## 5.2 Performance criteria

The success of the plan will be measured against the criterion that:

- The status of the river snail is revised from ‘endangered’ to ‘vulnerable’ on the schedules of the *Fisheries Management Act 1994* within 15 years.

# 6. Recovery actions

## 6.1 Research & Investigation Activities (RIA)

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| **Strategy 1:** | **Collate existing information and conduct targeted sampling to identify the distribution of the river snail in NSW** |
| **RIA 1:** | Collate data on the historical distribution of the river snail. |
| **RIA 2:** | Conduct targeted surveys to determine the current distribution of the river snail in natural and artificial habitats. |
| **RIA 3:** | Continue to collect data on the presence/absence of the river snail during incidental surveys. |
| **RIA 4:** | Ensure that all river snail records are confirmed by an expert and included in the Australian Museum collection. |
| **Responsibility:** | RIA 1 - 4: NSW DPI |
| **Partners:** | Australian Museum, universities and research institutions, CMAs, DECC |
| **Timeframe:** | RIA 1 - 4: Year 1, Ongoing |

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| **Strategy 2:** | **Support research into the habitat requirements and ecology of the river snail and key threats to the species** |
| **RIA 5:** | Where possible, encourage scientific investigation into key aspects of the biology and ecology of the river snail. This may include work to establish environmental tolerances, recruitment success, factors influencing population dynamics and variability, age and growth, diet etc. |
| **RIA 6:** | Where possible, ensure that elements of this research are incorporated into funded survey programs. In other cases, actively encourage and support university students (honours or postgraduate) to undertake relevant projects. |
| **Responsibility:** | RIA 5 - 6: NSW DPI |
| **Partners:** | Australian Museum, universities and research institutions, CMAs, DECC |
| **Timeframe:** | RIA 5 - 6: Years 2 – 5 (or as soon as possible after a population is located in NSW) |

## 6.2 Compliance and Regulatory Activities (CRA)

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| **Strategy 3:** | **Protect habitats known to support, or with the potential to support river snail populations** |
| **CRA 1:** | Review regulatory and voluntary incentive based mechanisms available to enhance protection for key habitat areas and apply as required. This may include the use of critical habitat provisions, aquatic reserves, voluntary conservation agreements etc. |
| **CRA 2:** | Actively encourage the reporting and protection of river snail populations found in artificial environments such as irrigation pipelines. |
| **Responsibility:** | CRA 1 - 2: NSW DPI |
| **Partners:** | CMAs, DECC, local councils, community groups, irrigators |
| **Timeframe:** | CRA 1 - 2: Year 2, ongoing |

## 6.3 Management Activities (MA)

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| **Strategy 4:** | **Increase the capacity of consent and determining authorities to adequately protect river snail habitats** |
| **MA 1:** | Ensure that councils, government agencies and other relevant organisations are aware of the location of important areas for the river snail by providing maps and advisory materials of known and/or potential habitat. |
| **MA 2:** | Provide other relevant information to support appropriate planning and impact assessment (e.g. Environmental Impact Assessment Guidelines). |
| **MA 3:** | Negotiate with local councils and industry groups regarding they type and scale of development near key areas either known to support remnant populations of the river snail or suitable habitat. |
| **MA 4:** | Encourage the identification, assessment and modification of natural resource management plans and policies (including Catchment Action Plans, water management plans, vegetation management plans and other land management plans) which may impact on river snail habitats to minimise impacts on stream flow, water quality and riparian vegetation etc. |
| **Responsibility:** | MA 1 – 3: NSW DPI<br>MA 4: NSW DPI, local councils, DECC, DWE |
| **Partners:** | CMAs, DECC, water user associations, local councils |
| **Timeframe:** | MA 1 – 4: Year 3, ongoing |

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| **Strategy 5:** | **Investigate an artificial breeding and translocation program for river snails in NSW** |
| **MA 5:** | Conduct targeted surveys to locate remnant river snail populations from either natural or artificial habitats. |
| **MA 6:** | Using information obtained from Objective 1 and 6 investigate the feasibility of establishing a breeding and translocation program in NSW. |
| **Responsibility:** | MA 5 - 6: NSW DPI |
| **Partners:** | Australian Museum, universities & research institutions, irrigators, CMAs, DECC, DWE |
| **Timeframe:** | MA 5 – 6: Years 1 - 5 |

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| **Strategy 6:** | **Promote actions to ameliorate the impacts of altered river flows on the river snail, giving priority to areas in the vicinity of any remnant natural populations** |
| **MA 7:** | Develop and distribute guidelines regarding flow requirements of the river snail and distribute this information to relevant natural resource management authorities. |
| **MA 8:** | Advocate appropriate allocation and improved management of environmental flows, particularly in areas known to support, or that could potentially support remnant river snail populations. |
| **Responsibility:** | MA 7: NSW DPI<br>MA 8: NSW DPI, DWE |
| **Partners:** | MDBC, CMAs, DECC, universities and research institutions |
| **Timeframe:** | MA 7 – 8: Year 3, ongoing |

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| **Strategy 7:** | **Encourage rehabilitation of river reaches known to support, or with the potential to support river snail populations** |
| **MA 9:** | Provide technical support to community groups, natural resource management authorities, local councils and landholders to protect and rehabilitate riparian vegetation and in-stream habitats along key river stretches where remnant river snail populations are known or may potentially occur. |
| **Responsibility:** | MA 9: NSW DPI |
| **Partners:** | CMAs, MDBC, Australian Museum, DECC |
| **Timeframe:** | MA 9: Year 1, ongoing |

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| **Strategy 8:** | **Continue to work on reducing the impacts of weirs throughout the Murray Darling Basin** |
| **MA 10:** | Continue to implement the NSW Weirs Policy to remove, or reduce/mitigate the impacts of weirs throughout the Murray-Darling Basin. |
| **MA 11:** | Identify priority barriers to the river snail based on the location of remnant populations in natural or artificial (pipeline) environments and/or areas identified as potentially suitable, and seek funding for capital works for removal or other remediation works. |
| **MA 12:** | Work with councils and relevant government agencies to mitigate the effects of barriers on remnant river snail populations and/or habitats. |
| **Responsibility:** | MA 10 – 12: NSW DPI, DWE |
| **Partners:** | MDBC, CMAs, community groups, DECC, local councils |
| **Timeframe:** | MA 10 – 12: Year 1, ongoing |

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| **Strategy 9:** | **Integrate information on the location of river snail populations and/or suitable habitats into state and national carp pest management programs** |
| **MA 13:** | Identify priority areas for targeting of carp eradication and control programs, based on areas where remnant river snail populations occur or where suitable habitat exists. |
| **Responsibility:** | MA 13: NSW DPI |
| **Partners:** | CMAs, MDBC |
| **Timeframe:** | MA 13: Year 5 |

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| **Strategy 10:** | **Increase community awareness and support for river snail recovery actions** |
| **MA 14:** | Review and report on the status and effectiveness of recovery actions in achieving the plans objectives against the performance criteria, and report this information in recovery statements on a three yearly basis. |
| **MA 15:** | Ensure that the Threatened, Protected and Pest Species Sighting Program is widely promoted throughout the Murray-Darling Basin, and encourage reporting of any sightings of the river snail in NSW. |
| **MA 16:** | Develop and distribute an education kit for use in schools. |
| **MA 17:** | Where possible, actively encourage community involvement in aspects of river snail recovery including for example, establishment of a breeding and translocation program. |
| **Responsibility:** | MA 14 - 17: NSW DPI |
| **Partners:** | MDBC, CMAs, Australian Museum, community groups, local councils, DECC |
| **Timeframe:** | MA 14 – 17: Year 2, ongoing |

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| **Strategy 11:** | **Establish a long-term monitoring program to assess the ongoing status of the river snail and the effectiveness of recovery actions** |
| **MA 18:** | Design and implement a targeted monitoring program for river snail populations in natural and artificial habitats to enable the effectiveness of recovery actions to be evaluated. |
| **Responsibility:** | MA 18: NSW DPI |
| **Partners:** | Community groups, universities and research institutions, DECC |
| **Timeframe:** | MA 18: Years 3, 6 & 9 |

| **Acronyms** | |
|---|---|
| NSW DPI | NSW Department of Primary Industries |
| DWE | Department of Water and Energy |
| DECC | Department of Environment and Climate Change |
| CMAs | Catchment Management Authorities |
| MDBC | Murray Darling Basin Commission |
| RIA | Research and Information Action |
| CRA | Compliance and Regulatory Action |
| MA | Management Action |

# 7. Monitoring, evaluation and review

The overall performance criteria of down-listing the river snail from endangered to vulnerable on the Schedules of the *Fisheries Management Act 1994* will be the primary measure used to assess the success of the actions within this plan.

Progress in implementing this recovery plan will be evaluated and reported on annually to Parliament and triennially in the PAS review. Summary information will include details of implementation activities, investment, program outcomes, and review against the performance criteria.

The recovery plan will be subject to major statutory review within ten (10) years of the date of publication.

# 8. Social, economic and cultural issues

Potential social and economic impacts have been considered during the development of this recovery plan, and the objectives and actions have been formulated with the aim of minimising any potential adverse impacts.

The overall effects of this recovery plan are expected to be positive. However, some social and economic effects may result from the management of water flows and development proposals in general. Continued liaison with relevant stakeholders including irrigators, landholders, local councils and the community will help to minimise any social effects associated with the implementation of the river snail recovery plan.

## 8.1 Environmental flows

The effects of river regulation – including the construction of weirs leading to slower flow velocities and, in the lower river reaches, and extended periods of low flow – are a key threat to the river snail. There is a need for the recovery program to work within broader natural resource management programs in NSW to ameliorate the impacts of these changes. Responsibility has been allocated to all agencies involved in the water reform process, as well as community-based natural resource management committees and public utilities to address these issues.

In NSW, flow management rules (including bulk access regimes and environmental flows) are being formalised through 10-year water sharing plans, developed by regional Water Management Committees under the NSW *Water Management Act 2000*. Water sharing plans have already been gazetted for 35 areas, and implementation programs have been developed. The consideration of social and economic impacts of water sharing plans and changes to allocations or flow management rules have been considered as part of the development of water sharing plans.

The decision-making process for the establishment of the water sharing plans includes a requirement to undertake a socio-economic assessment of the impact of the plan. In most cases, flow modelling and water use information is limited. The assessments are generally qualitative, using demographic and economic information to indicate the possible impacts on each region's extractive and non-extractive use for water and their trade-offs. While the needs of threatened species must be considered in this process, these needs are weighted against other social and economic factors. Since water sharing plans have already been gazetted for 35 areas, the impact of this recovery plan may be limited to influencing the delivery of environmental water allocations or the review of plans over the longer term.

## 8.2 Development

The *Environmental Planning and Assessment Act 1979* requires the potential impacts of a development on any threatened species to be considered by the authorities responsible for its approval. If a major impact is likely, the developer must prepare a species impact statement (SIS) as part of their proposal. Any decision about this type of development by a consent authority must also be approved by the Director-General of the NSW DPI.

These protective laws may be seen as an economic burden by developers who may be required to contract consultants to prepare a species impact statement as well as bear the costs involved in the delay, conditional approval or rejection of a proposal. The legislation may also represent a burden to the consent or determining authorities if they lack the appropriate expertise and information needed to assess development proposals.

However, these legal requirements arise from the 'endangered' status of the river snail under the *Fisheries Management Act 1994*, rather than as a consequence of the recovery plan. This recovery plan will help to ease some of the economic effects by distributing relevant information to those involved in the assessment of impacts, particularly to consent and determining authorities.

## 8.3 Indigenous cultural issues

Shells of the river snail have been found scattered throughout the middens left by Aboriginal Australians (Cotton 1935a). However, unlike freshwater mussels, it is unlikely

that river snails formed an important part of the Aboriginal diet but were rather scooped up from the same river edge habitat by accident (Walker 1996).

Consultation with local indigenous communities will be undertaken as part of this recovery plan to assist in better defining the cultural and spiritual values of the river snail. This will involve consideration of the social and economic effects of the recovery program and the level of community interest in recovery activities.

Local Aboriginal groups will be encouraged to take part in recovery activities. Any proposal that could affect places of cultural importance will be discussed in direct consultation with local groups.

# 9. Further Information

Copies of the recovery plan and additional information can be obtained from:

NSW Department of Primary Industries
Threatened Species Unit
Port Stephens Fisheries Centre
Locked Bag 1
Nelson Bay NSW 2315
Ph: (02) 4982 1232

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# Appendix 1 – Required contents of a recovery plan

**Extract from *Fisheries Management Act 1994*, Part 7A**

**220ZN Contents of recovery or threat abatement plans**

**(1) Recovery plans**

A recovery plan must:

a) identify the threatened species, population or ecological community to which it applies, and

b) identify any critical habitat declared in relation to the threatened species, population or ecological community, and

c) identify any threatening process or processes threatening the threatened species, population or ecological community, and

d) identify methods by which adverse social and economic consequences of the making of the plan can be minimised, and

e) state what must be done to ensure the recovery of the threatened species, population or ecological community, and

f) state what must be done to protect the critical habitat (if any) identified in the plan, and

g) state, with reference to the objects of this Part:

   (i) the way in which those objects are to be implemented or promoted for the benefit of the threatened species, population or ecological community, and

   (ii) the method by which progress towards achieving those objects is to be assessed, and

h) identify the persons or public authorities who are responsible for the implementation of the measures included in the plan, and

i) state the date by which the recovery plan should be subject to review by the Director-General.