# Nathan Dam Project

## Survey for the Boggomoss Snail

Report to

SKM Pty Ltd

July 2010

jkr ecological

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# 1 Introduction

## 1.1 Background

JKR Ecological was engaged by Sinclair Knight Merz Pty Ltd (Pty Ltd) to lead targeted surveys for the nationally threatened Boggomoss Snail (*Adclarkia dawsonensis*) within the Taroom region in central Queensland. Further information on the snail's distribution, population estimates and potential translocation sites are required to enable SunWater to develop management strategies for the Boggomoss Snail as part of the Nathan Dam and pipeline project on the Dawson River.

This report provides the results of targeted field surveys completed between the 28th June and 2nd July 2010, an assessment of habitat areas in which the snail was found and a discussion of population size and distribution.

## 1.2 Project Background

The Boggomoss Snail is listed as critically endangered under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Prior to the completion of additional studies on the snail as part of the Nathan Dam project, the snail was known only from two locations in the vicinity of the Dawson River. A population is known from a boggomoss (mound spring) adjacent to the Dawson River on Mt. Rose Station approximately 32 kilometres north-east of Taroom and another population is known from the downstream Camping and Stock Reserve at the Isla-Delusion Road crossing of the Dawson River ('Isla-Delusion Camping Reserve'), approximately 29 km south of Theodore. The Isla-Delusion Camping Reserve site covers an area of approximately 44.5 hectares and the boggomoss at Mt. Rose Station cover an area of 0.75 ha. These two historically known populations are separated by approximately 60 km straight line distance.

The Nathan Dam will inundate mound springs on Mt. Rose Station and will impact on a sub-population of Boggomoss Snails. The approved National Recovery Plan for the Boggomoss Snail, *Adclarkia dawsonensis* (Stanisic 2008) notes that it should be possible to relocate snails from the boggomoss site should the dam be approved; however it does not list this as a recommendation.

SunWater has engaged Dr John Stanisic of Biodiversity Assessment and Management (BAAM) to prepare a Translocation Plan for the Boggomoss Snail in line with the Recovery Plan, which will aim to translocate a number of snails to alternative habitat (site(s) to be determined) outside of the project footprint.

The project was declared a controlled action by the Commonwealth Department of Environment, Water, Heritage and the Arts (DEWHA) on the 30th July, 2008 due to potential impacts on the snail as well as other Matters of National Environmental Significance (MNES). DEWHA has advised that the proposed translocation may not proceed until suitable translocation areas are identified. They have also expressed concern that the total population of the snail is unknown and the site to be inundated at Mt Rose appears to be the most robust population. The surveys reported here aimed to provide further information on these issues.

## 1.3 Previous Snail Surveys

### 1.3.1 BAMM (2008, 2009)

A survey for the Boggomoss Snail was completed by Biodiversity Assessment and Management Pty Ltd (BAAM), with field assistance by SKM, in late 2008 within the known sites and within similar habitat areas along the Dawson River from Taroom to Theodore. The objectives of the study were to:

- to determine if the Boggomoss Snail exists at other locations within the Dawson River Valley;
- to assess the condition of the existing Boggomoss Snail populations in an effort to more accurately estimate population sizes;
- to obtain additional information about the habitat and microhabitat requirements of the Boggomoss Snail that would assist in the conduct of translocation trials and the recovery of the species; and
- to select locations based on the above for the conduct of translocation trials that may also act as sites for potential translocation.

A total of 53 sites were searched within the Dawson River and selected major tributaries, including Cockatoo Creek, Palm Tree Creek and Spring Creek. A new location for the snail was found approximately 28 km upstream of the Isla-Delusion Camping Reserve on the Dawson River and two new populations were found on boggomosses on Mt. Rose Station. The population estimate at the existing boggomoss site was also revised to greater than 350 animals, up from an estimated less than 100 animals (Stanisic 2008). Too few snails were collected during these surveys to estimate the population size at other than the original Mt Rose site.

### 1.3.2 SKM (2009)

SKM (2009) surveyed a total of 109 sites for the Boggomoss Snail from the upper Dawson Valley (near Injune), downstream to Theodore. These surveys confirmed that the species is restricted to the Dawson Valley between Mt. Rose Station and Theodore.

SKM (2009) recorded the Boggomoss Snail from 15 “new” sites additional to those reported by BAAM in 2009. The distribution of these sites suggests a more or less continuous occupation of the riparian woodlands downstream of Mt. Rose Station to approximately Theodore. SKM (2009) reported a strong associated of the Boggomoss Snail with the Carnarvon Palm (*Livistonia nitidus*), particularly downstream of Nathan Gorge. The SKM survey confirmed the presence of a breeding population of Snails at the Isla-Delusion Crossing and on adjacent properties, including the property Lagoona.

The SKM report also provided revised population estimates for the Boggomoss Snail, based on the presence of approximately 55ha of suitable habitat at Isla-Delusion Crossing, 0.11ha of habitat on Southend, 7.02ha of habitat on Gyranda and 0.75ha of habitat on Mt. Rose. The total overall population estimate was between 11 497 and 23 323 snails, based on snail densities across 24, 100m transects.

## 1.4 Current Knowledge of the Species

### 1.4.1 Description

The shell of the Boggomoss Snail is light brown, becoming greenish-yellow towards the horn, with a white lip. It is thin and semi-transparent, with an average diameter of about 2.3 cm, and is made up of 5 1/8–5 5/8 whorls. The shell is 1.5 cm high with a slightly elevated spire and a very small central depression. The animal itself is light brown to white, with the amount of grey around the neck, on the sides of the foot and above the tail differing between specimens. Black blotches on the lung roof are visible through the shell (Stanisic 1996, 2008).

### 1.4.2 Distribution

The Boggomoss Snail is found in the Greater Taroom area of south-eastern Queensland. It occurs in the Dawson Valley, north-east of Taroom, on the Dawson River (Stanisic 1996, 2008). The DEWHA Species Profile and Threats (SPRAT) database notes the following in relation to the distribution of the Boggomoss Snail:

- The extent of occurrence of the Boggomoss Snail is estimated to be 0.435 km². The site on private property at Mt. Rose Station is approximately 0.5 ha and the population at the camping and water reserve covers approximately 43 ha (Stanisic 2008).
- The area of occupancy is less than 10 km² (TSSC 2003g).
- The Isla-Delusion camping and water reserve and the boggomoss habitat on private property are the only two locations at which this species is known to occur. There is a record of a Boggomoss Snail shell from a recently deceased snail being found at a third site (Cockatoo Creek, south of Taroom); however no live Boggomoss Snails have been recorded from this site. The Cockatoo Creek site is in poor condition and it is not known if there is a living population at that location (Stanisic 2008).
- The species' distribution can be considered to be highly fragmented as it occurs as only two small and relatively isolated subpopulations.

In light of recent findings there appears to be a need to update the distributional information relating to this species.. A third sub-population was recorded from the property “Southend”, located between Isla-Delusion Crossing and Theodore by SKM (2009). SKM also reported the snail from the property “Lagoona”, which is contiguous with the habitat at Isla-Delusion Camping Reserve as well as “Gyranda” to the south and “Kia Ora” to the north.

### 1.4.3 Habitat

Boggomoss Snails are restricted to the moister riparian (riverside) and boggomoss habitats on alluvial flats between Taroom and Theodore (Stanisic 2008). Most of this habitat has been cleared for farming and little original vegetation remains (Clarke & Spier-Ashcroft 2003).

At the Isla-Delusion site, the Boggomoss Snail is found in an area of riparian habitat in a stock and water reserve, which is contiguous with similar vegetation on adjacent private property. The vegetation is representative of Regional Ecosystem 11.3.25 under the Qld Vegetation Management Framework, described as follows:

"*Eucalyptus camaldulensis* or *E. tereticornis* open-forest to woodland. Other tree species such as *Casuarina cunninghamiana, E. coolabah, Melaleuca bracteata, Melaleuca viminalis, Livistona spp*. (in north), *Melaleuca spp*. and *Angophora floribunda* are commonly present and may be locally dominant. An open to sparse, tall shrub layer is frequently present dominated by species including *Acacia salicina, A. stenophylla* or *Lysiphyllum carronii*. Low shrubs are present, but rarely form a conspicuous layer. The ground layer is open to sparse and dominated by perennial grasses, sedges or forbs such as *Imperata cylindrica, Bothriochloa bladhii, B. ewartiana, Chrysopogon fallax, Cyperus dactylotes, C. difformis, C. exaltatus, C. gracilis, C. iria, C. rigidellus, C. victoriensis, Dichanthium sericeum, Leptochloa digitata, Lomandra longifolia* or *Panicum spp*.. Occurs on fringing levees and banks of major rivers and drainage lines of alluvial plains throughout the region. Soils are very deep, alluvial, grey and brown cracking clays with or without some texture contrast. These are usually moderately deep to deep, soft or firm, acid, neutral or alkaline brown sands, loams or black cracking or non-cracking clays, and may be sodic at depth" (Qld Herbarium 2009).

At Mt Rose Station the snail is found associated with a boggomoss. Boggomosses are a series of small, raised peat bogs that form when water from aquifers of the Great Artesian Basin is pushed to the surface through mound springs. The vegetation is dominated by water-tolerant species, such as Coolibah trees (Eucalyptus coolibah), sedges, ferns and mosses (Clarke & Spier-Ashcroft 2003; Noble et al. 1998). At the boggomoss site the snail lives in leaf-litter at the base of sandpaper figs (Stanisic 2008). It should be noted that comparatively few Boggomoss sites are actually suitable for the Boggomoss Snail. Only three mound springs are known to support the species out of some 30 mound springs mapped in the Dawson River Valley.

SKM (2009) recorded the Boggomoss Snail from 15 sites within 11 discrete habitat patches, almost exclusively associated with Qld Blue Gum and Carnarvon Palm (*Livistona nitida*) forest to open forest. Within these forests, the Boggomoss Snail was recorded either under a deep accumulation of palm fronds or at the base of individual Palm trees, where moisture accumulates due to the drainage structure of the fronds and leaves.

### 1.4.4 Lifecycle

The life history of the Boggomoss Snail is unknown. Stanisic (2008) suggests that the species may have a similar lifespan (10–20 years) to that of other land snails in arid northern Australia. The Boggomoss Snail is known to aestivate (hibernate) in very dry periods. It is a free sealer, hibernating in the litter or soil under logs and sealing the opening of the shell with a calcified mucous covering (Stanisic 2008).

### 1.4.5 Feeding

It is assumed that, like many other snails, the Boggomoss Snail feeds on decaying plant matter, bacteria and fungi (Bishop 1981, cited in Clarke & Spier-Ashcroft 2003).

### 1.4.6 Threats

#### *1.4.6.1 Land Clearing*

Land clearing is the main threat to the Boggomoss Snail. Over the last three decades six million hectares of Brigalow-dominated communities have been cleared, and this process is still continuing (Glazning 1995). In 1984, there was an indication that only about 0.5% of the original Brigalow-associated communities still remained in Queensland (Sattler & Webster 1984). Within the Brigalow Belt, only 2.2% of Brigalow-dominated habitats are estimated to be reserved in protected areas (Young et al. 1999). Much of the remaining stands are found on freehold land and are threatened by development (Fensham et al. 1998; Pulsford 1984). This widespread habitat loss is believed to make the small pockets of boggomosses extremely vulnerable to direct land clearing and habitat change, such as drying out, once the surrounding vegetation is removed (Clarke & Spier-Ashcroft 2003).

#### *1.4.6.2 Fire*

Fire is also a major threat (Stanisic 1996). The small size of the boggomoss remnants makes them more vulnerable to the effects of fire, and particularly sensitive to hot fires (Clarke & Spier-Ashcroft 2003). Fire can affect the snail population directly, by incineration and dehydration, or indirectly through destruction of the leaf-litter that forms the snail's habitat (Stanisic 2008).

#### *1.4.6.3 Grazing and trampling*

Current leasing arrangements of the Isla-Delusion site as a stock reserve allow for cattle grazing (Greenslade 2000). Stock grazing has a detrimental effect on the Boggomoss Snail's habitat by introducing weeds to the area and causing compaction of the soils and leaf-litter (Greenslade 2000; Stanisic 2008). Snails may also be directly trampled. Stock grazing has been known to cause damage to boggomoss habitats in the past (Stanisic 1996). The boggomoss on private property has been fenced to protect the habitat from cattle grazing and trampling. However, this has led to more grass at the site, which increases the fuel load and leads to a greater risk of wildfire (Stanisic 2008).

#### *1.4.6.4 Other land uses*

Tree removal, development work for pastoral purposes, and quarrying are also permitted at the Isla-Delusion reserve. These processes could have a negative impact on the habitat of the Boggomoss Snail and threaten the species' survival.

#### *1.4.6.5 Hydrological changes*

Since the Boggomoss Snail is reliant on moist habitat, changes in hydrology could threaten the species' survival (Clark & Spier-Ashcroft 2003; Stanisic 2008).

#### *1.4.6.6 Predation*

The Boggomoss Snail is not known to be under threat from predation. Land snails are known to be preyed on by rodents, birds, beetles, ants and other snails, and these are present in the Boggomoss Snail habitat (Stanisic 2008). Land snails also form a part of the diet of the Cane Toad (*Bufo marinus*) and this species may be a threat at some sites.

## 1.5 Aim and Objectives

The aim of this survey was to gather further information on the spatial distribution and population size of the Boggomoss Snail within the Dawson River catchment. The objectives of this survey were:

- to locate any additional populations of the Boggomoss Snail throughout the Dawson River catchment, including outside the range of historic search effort and within areas considered to represent marginal habitat;
- to discuss previous estimates of the size of the population within its distribution and make comparison between the methodologies employed by BAMM and SKM;
- to provide population estimates for newly discovered sub-populations; and
- to provide a preliminary assessment of newly identified habitat areas for translocation purposes.

# 2 Field Investigations

## 2.1 Introduction

This section provides the details of the methodology used to identify potential habitat areas, search for the Boggomoss Snail and to determine snail densities in preferred habitats. Potential and suitable habitats (for the purposes of this assessment) are considered to be moist riparian and floodplain vegetation types, and vegetated mound springs. Preferred habitats are considered to be those patches of vegetation found to support the Boggomoss Snail.

## 2.2 Site Selection

The Boggomoss Snail is thought to be historically associated with the alluvial systems of the Dawson River catchment. To provide a 'first cut' of potential search areas the regional ecosystem data for the Taroom and Banana Shire local government areas were reviewed. A map was produced showing all remnant vegetation patches occurring on land zone 3 within an 80 km radius of Taroom township. Land zone 3 is described as "Quaternary alluvial systems, including floodplains, alluvial plains, alluvial fans, terraces, levees, swamps, channels, closed depressions and fine textured palaeo-estuarine deposits" (Sattler & Williams, 1999). These areas were preferentially targeted during the field survey.

Following a review of the alluvial system mapping, sites were selected that had not been subject to previous surveys, and which contained apparently dense vegetation and/or ephemeral or permanent wetlands or mound springs. As such, the following sites were targeted:

- Areas within the inundation area which support mound springs but which had not been formerly targeted;
- Ephemeral wetlands within and outside the inundation area of the proposed Nathan Dam which had not been targeted in previous surveys;
- Riparian and alluvial habitats downstream of Theodore on the Dawson River;
- Riparian and alluvial habitats on tributaries of the Dawson River, both upstream and downstream of the proposed Nathan Dam.

## 2.3 Search Methodology

All sites were searched by four persons using garden implements (rakes, forks) to sift through leaf litter and debris. The minimum search effort at each site was 15 minutes, and the maximum search effort was 1 hour. As such, search effort ranged from 1 person hour to 4 person hours per search site. The variation in survey effort across sites was driven by the availability of suitable microhabitats for the snail. Sites with abundant leaf litter and debris were searched for longer than those sites with little or no available microhabitat.

## 2.4 Population Estimates

### 2.4.1 Population Transects

An estimate of population size was completed within discrete habitat patches where live specimens of the Boggomoss Snail were positively identified. This involved the erection of a 100 m transect (placed along the contour gradient, where possible) through similar habitat commencing at the location of the positively identified snail so as to include the presence within the overall transect result.

At every 10 m along the 100 m transect a 1 m by 1 m plot (giving a total search area of 10 $m^2$ per transect) was thoroughly searched by the methods described previously, whether that plot contained suitable habitat for the snail or not. This methodology accommodates the patchiness of suitable microhabitats for the Boggomoss Snail through the random placement of individual search quadrats. That is, suitable microhabitat for the Boggomoss Snail is unevenly distributed within preferred habitats, and selecting towards suitable microhabitats would exaggerate snail densities. Search quadrats placed on a transect have an equal chance of including or excluding suitable microhabitats, and therefore are more likely to produce a realistic population density.

Where possible, parallel transects were erected at varying distances from the river edge depending upon local topography and the total area of available habitat. If the habitat was homogenous, additional transects were added on the same gradient.

A population estimate for each habitat patch could then be calculated by multiplying the average density of snails by the total area of the habitat patch. The standard error (SE) for the dataset was then calculated and applied to the population estimate to give a population range.

The estimate of the total population of the species was the sum of the estimates from the identified suitable habitat patches where live snails were found.

### 2.4.2 Targeted Searches of Sandpaper Figs

At survey site SS12, where the Boggomoss Snail was recorded, the methodology employed by BAMM (2009) to estimate the population size of Boggomoss Snails at Mt. Rose Station (Boggomoss No. 5) was utilised to allow a cross-comparison of results. The methodology involved the careful removal of leaf litter and debris from the base of Sandpaper Figs (*Ficus opposita*). The same methodology was utilised at the Isla-Delusion Camping Reserve, where the Boggomoss Snail was recorded by SKM in 2009.

# 3 Results

## 3.1 Introduction

This section provides the results of the targeted field survey and presents an estimate of the total population size of the Boggomoss Snail within habitat patches searched. Previous population estimates from the BAMM and SKM studies supplement the results of this survey to provide an overall population estimate.

## 3.2 Site Descriptions

A total of 25 additional sites were searched for the Boggomoss Snail in 2010 (**Figure 1**). Searches were conducted within the middle Dawson River catchment including the Dawson River itself between Taroom and Baralaba. A description of the survey sites is provided in **Table 1** below.

**Figure 1 Distribution of Survey Sites**

**Table 1 – Survey Site Descriptions**

| Site Name | Location | Description | Photograph | Boggomoss Snail Recorded |
|---|---|---|---|---|
| Ad1 | S25 32.905 E149 48.397 | Open Forest of Carnarvon Palm on Palm Tree Creek. Carnarvon Palm dominates the upper strata of vegetation, with limited midstorey and degraded understorey due to grazing. Palm Tree Creek is sandy and heavily eroded at this location. Limited accumulation of palm fronds and other leaf litter due to recent flooding. Some piles of flood debris which accommodate common snail species. |  | No |
| Ad2 | S25 31.887 E149 48.172 | Open Forest of Carnarvon Palm on Palm Tree Creek. Carnarvon Palm dominates the upper strata of vegetation, with limited midstorey and degraded understorey due to grazing. Palm Tree Creek is sandy and heavily eroded at this location. Limited accumulation of palm fronds and other leaf litter due to recent flooding. Some piles of flood debris which accommodate common snail species. Evidence of relatively recent fire. |  | No |

| Site Name | Location | Description | Photograph | Boggomoss Snail Recorded |
|---|---|---|---|---|
| Ad3 | S25 34.451 E149 50.451 | Woodland of Coolabah (*Eucalyptus coolabah*) on Palm Tree Creek. Evidence of prolonged inundation at depths of greater than 5m during recent flooding. Limited or no development of leaf litter layers of midstorey vegetation. Paucity of logs and other debris. |  | No |
| Ad4 | S25 34.150 E149 54.394 | Woodland of Coolabah (*Eucalyptus coolabah*) and Queensland Blue Gum (*Eucalyptus tereticornis*) on the Dawson River. Evidence of prolonged inundation at depths of greater than 5m during recent flooding. Limited or no development of leaf litter layers of midstorey vegetation. Paucity of logs and other debris. Many ephemeral wetlands across floodplain at this location. |  | No |

| Site Name | Location | Description | Photograph | Boggomoss Snail Recorded |
|---|---|---|---|---|
| Ad5 | S25 25.302 E150 01.362 | Small mound spring on Boggomoss Station. Fringed by Qld Blue Gum, heavily degraded by stock trampling, grazing and invasion of exotic grasses. Limited or no accumulated leaf litter and other woody debris. |  | No |
| Ad6 | S25 24.749 E150 01.269 | Small mound spring on Boggomoss Station. Fringed by Qld Blue Gum. Although partially fenced, heavily degraded by stock trampling, grazing and invasion of exotic grasses. Limited or no accumulated leaf litter and other woody debris. Evidence of recent destructive fire. |  | No |

| Site Name | Location | Description | Photograph | Boggomoss Snail Recorded |
|---|---|---|---|---|
| Ad7 | S25 25.642 E150 01.360 | Large mound spring within Boggomoss Nature Refuge, site previously surveyed by BAMM. High level of invasion of pasture grasses, grazing impacts and very open canopy. Limited or no accumulation of leaf litter and woody debris. |  | No |
| Ad8 | | Riparian Woodland of Carnarvon Palm on Gyranda. Evidence of prolonged inundation at depths of greater than 3m during recent flooding. Limited or no development of leaf litter layers of midstorey vegetation. Paucity of logs and other debris. |  | No |

| Site Name | Location | Description | Photograph | Boggomoss Snail Recorded |
|---|---|---|---|---|
| Ad9 | S25 06.902 E150 07.679 | Anabranch of Dawson River on Southend. Relatively narrow fringe of Carnarvon Palm with accumulated palm fronds and flood debris in many locations. Some stock damage evident. No midstorey or understorey development other than juvenile Carnarvon Palm. No accumulated leaf litter (other than Palm Fronds) and few logs. |  | Yes |
| Ss1 | S25 32.734 E149 48.267 | Very large mound spring on Rosevale Station with limited fringing vegetation. Closed sedgeland with variety of aquatic macrophytes. No tree cover, accumulated leaf litter and sparse log cover on margins. |  | No |

| Site Name | Location | Description | Photograph | Boggomoss Snail Recorded |
|---|---|---|---|---|
| Ss3 | S25 35.678 E149 51.190 | Riparian Woodland of Coolabah and Qld Blue Gum on the Dawson River. Some midstorey development with Melaleucas present. Grassy understorey with Matrushes and a variety of sedge species present. Abundant woody debris, but limited litter development due to recent flooding. |  | No |
| Ss5 | S25 34.104 E149 53.060 | Riparian Woodland of Coolabah and Qld Blue Gum on the Dawson River. Some midstorey development with Melaleucas present. Grassy understorey with Matrushes and a variety of sedge species present. Abundant woody debris, but limited litter development due to recent flooding. Abundant rock cover on banks of Dawson River with moist crevices present. |  | No |

| Site Name | Location | Description | Photograph | Boggomoss Snail Recorded |
|---|---|---|---|---|
| Ss6 | S25 33.010 E149 55.440 | Large ephemeral wetland on Dawson River Floodplain. Fringed by remnant Coolabah. Limited or no midstorey development and very sparse groundcover. Abundant logs on margins but no vegetative cover, reducing potential shelter sites. Evidence of stock impacts. |  | No |
| Ss7 | S25 34.780 E149 58.972 | Open Woodland of Queensland Blue Gum fringing large mound spring. No accumulated leaf litter and very few logs on ground. Area heavily grazed. |  | No |

| Site Name | Location | Description | Photograph | Boggomoss Snail Recorded |
|---|---|---|---|---|
| Ss10 | S25 25.039 E150 01.500 | Mound Spring on Boggomoss Station, corresponding with Survey Site 48 of BAMM (2009). Permanently moist to wet conditions underfoot with deep leaf litter, abundant logs and well-developed fernland of Bungwall fern and associated sedge species. Sandpaper Figs present on margins of Spring. |  | No |
| Ss11 | S25 24.941 E150 01.398 | Mound Spring on Boggomoss Station, corresponding with Survey Site 47 of BAMM (2009). Permanently moist to wet conditions underfoot with deep leaf litter, abundant logs and well-developed fernland of Bungwall fern and associated sedge species. Sandpaper Figs present on margins of Spring. Evidence of relatively recent fire on margins of spring. |  | No |

| Site Name | Location | Description | Photograph | Boggomoss Snail Recorded |
|---|---|---|---|---|
| Ss12 | S25 06.860 E150 07.963 | Woodland of Coolabah and Qld Blue Gum fringing ephemeral wetland. Midstorey of Carnarvon Palm and regenerating canopy species. Despite evidence of inundation to 4m during recent flooding, reasonable abundance of leaf litter and accumulated palm fronds in particular. Many logs and piles of flood debris. |  | Yes |
| Ss13 | S25 15.464 E150 09.984 | Ephemeral wetland/dam on Gyranda. Fringed by Qld Blue Gum and Coolabah, with very narrow band of Carnarvon Palm. High level of stock impact and very narrow width of vegetation. Abundant logs and accumulated leaf litter. |  | No |

| Site Name | Location | Description | Photograph | Boggomoss Snail Recorded |
|---|---|---|---|---|
| Ss14 | S24 59.962 E150 04.362 | Riparian woodland of Dawson River. River banks with mature Qld Blue Gum and/or River Red Gum. Well developed midstorey of Melaleuca but paucity of groundcover due to recent flooding. Virtually no accumulation of leaf litter of woody debris and many open areas of bare soil |  | No |
| Ss16 | S24 58.454 E149 56.442 | Gap Creek, on Sawmill Road. Ephemeral Creek with overtopping Qld Blue Gums. Very well developed mid and lower strata of Sandpaper Fig. Much accumulated leaf litter, woody debris and flood debris. |  | No |

| Site Name | Location | Description | Photograph | Boggomoss Snail Recorded |
|---|---|---|---|---|
| Ss18 | S24 32.955 E149 51.885 | Dawson River downstream of Moura. Riparian Woodland of Qld Blue Gum and Coolabah. Fringing woodland of Melaleuca on river channel. Limited accumulation of leaf litter or woody debris. Few logs and open canopy reducing shading. |  | No |
| Ss19 | S24 29.957 E149 48.348 | Floodplain woodland of Dawson River dominated by Coolabah. Midstorey dominated by Sandpaper Figs. Well developed groundlayer of native grasses. Limited accumulation of leaf litter due to flooding. Reasonable abundance of logs and woody debris. |  | No |

| Site Name | Location | Description | Photograph | Boggomoss Snail Recorded |
|---|---|---|---|---|
| Ss20 | S24 30.585 E149 48.358 | Floodplain woodland of Dawson River dominated by Coolabah. Midstorey dominated by Sandpaper Figs. Well developed groundlayer of native grasses. Limited accumulation of leaf litter due to flooding. Reasonable abundance of logs and woody debris. |  | No |
| Ss21 | S24 35.539 E149 53.638 | Floodplain woodland of Dawson River dominated by Coolabah. Abundance of ephemeral wetlands with well developed macrophyte cover. Soil conditions very moist and deep mulch present in many locations. |  | No |

| Site Name | Location | Description | Photograph | Boggomoss Snail Recorded |
|---|---|---|---|---|
| Ss22 | S24 11.373 E149 48.352 | Riparian woodland of Dawson River at Baralaba. Understorey completely compromised by pasture grasses. Midstorey with Sandpaper Figs and canopy of Qld Blue Gum and Coolabah. No accumulated leaf litter and restricted woody debris. |  | No |

## 3.3 New Sites for the Boggomoss Snail

The Boggomoss Snail was recorded from two new sites during the present study, both of which are located on the property Southend. Significantly, one site was found to support a relative abundance of Boggmoss Snails, with five live adult and one live sub-adult snails recorded in less than 1 hour of search effort. In addition, two deceased adult and one deceased adult snail were recorded at the same site.

Although clearly affected by flooding and extended inundation, the occupied habitat at Southend supported a reasonable abundance of leaf litter and flood debris. This is likely to be due to the channel morphology of the Dawson River at this location, with the primary channel splitting across two Anabranch systems, which are presumably lower velocity flows during flood events that other reaches of the Dawson .

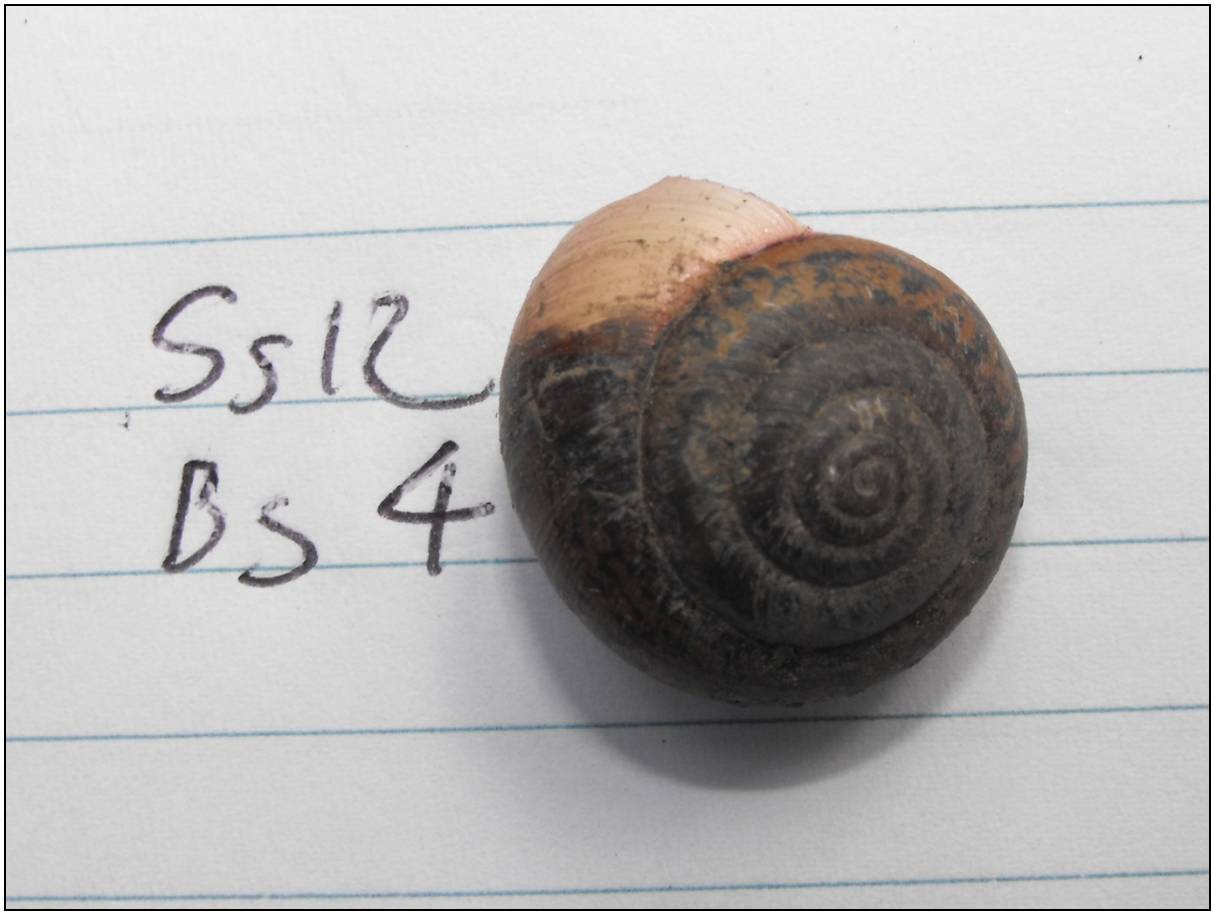


**Plate 1 - One of 6 Boggomoss Snails Recorded from SS12**

**Plate 2 Habitat at SS12, found to support Boggomoss Snail**

The habitat at SS12 differs from other sites where the Boggomoss Snail has been recorded, namely by supporting a canopy of *Eucalyptus coolabah* with a midstorey of Carnarvon Palm. This is representative of Regional Ecosystem 11.3.36, described as follows:

"*Eucalyptus coolabah* with *Eucalyptus camaldulensis* form a distinct but discontinuous woodland to low woodland canopy layer (7-11m high). Other scattered trees such as *Lysiphyllum gilvum, Melaleuca trichostachya, Melaleuca bracteata* and *Eucalyptus populnea* may occur. The mid layer varies from absent to a tall shrubland dominated by species such as *Acacia stenophylla* and *Acacia*

*salicina*. Ground cover is variable composed of grasses and sedges. Includes larger waterholes within the stream channels. Occurs on fringing stream channels, usually braided. Soils are bed loads of clay or silt with cobbles and boulders in some areas" (Qld Herbarum 2009).

A single live adult Boggmoss Snail was recorded from a small Anabranch of the Dawson River on Southend (**Plate 3**), some 1.2km from the Dawson River (in a straight line from the site to the main channel of the Dawson). There is a cluster of records of the Boggomoss Snail at Southend, with numerous adult snails recorded at several sites by SKM (2009) and this survey.

**Plate 3 Habitat on the Dawson River Anabranch**

## 3.4 Population Estimates

### 3.4.1 Population Transects

Population transects were completed at Ss12 and Ad9, the two new locations for the Boggomoss Snail found during the present study. At Ss12, 2 live snails were recorded on each of two transects, for a total of 4 snails in 20$m^2$ of search area, or a density of 0.2/$m^2$ of Boggomoss Snails. At Ad9, 1 snail was observed in 10 $m^2$ of search area at a density of 0.1/$m^2$. For the purposes of this assessment, this is considered a single patch of habitat with a density of 0.166/ $m^2$. These densities are consistent with the observations of SKM (2009) at Southend who recorded densities of 0.3/$m^2$ surrounding an ephemeral wetland.

### 3.4.2 Targeted Searches of Sandpaper Figs

Searches under 6 Sandpaper Figs at survey site SS12 found no live Boggmoss Snails and only one dead sub-adult Boggomoss Snail. Searches under Sandpaper Figs at Isla Delusion Crossing also yielded zero return. As no data were obtained from this method, no attempt was made to extrapolate population estimates for the patch.

**Figure 2 Boggomoss Snail Locations**

# 4 Discussion

## 4.1 Distribution

With the exception of the Treed Mound Springs located on Mt. Rose Station, the Boggomoss Snail is restricted to alluvial Forests either dominated or co-dominated by Carnarvon Palm. In fact, the distributional limits of the Boggomoss Snail coincide almost precisely with that of the Carnarvon Palm on the Dawson River. The Carnarvon Palm is not found north of Theodore on the Dawson, and the Boggomoss Snail reaches its northern limit there. The upstream limit of the Boggomoss Snail appears to be Mt. Rose Station, which, although devoid of Carnarvon Palm, supports a perennially moist environment which is suitable for the snail.

The relatively extensive Palm Forests on Palm Tree Creek have been intensively surveyed for the Boggomoss Snail with no result. These forests are however, located on a sandy substrate which contrasts markedly with the self-mulching clays of the middle and lower Dawson floodplain.

There are additional sub-populations of the Boggmoss Snail to those acknowledged in the Recovery Plan for the species, particularly within habitats on and around (upstream and downstream) of "Southend", between the Isla Delusion Crossing Road and Theodore.

In addition to the core sites which are now known for the species, a large block of suitable habitat occurs to the north of "Southend". This patch covers an area of some 55ha in total and supports very similar conditions to Southend itself.

## 4.2 Population Size Estimates

### 4.2.1 Literature Review

There is scant literature relating to population estimates for endangered molluscs. A recent paper in Animal Biodiversity and Conservation (Moreno-Rueda and Pizzaro 2007) provided a census method for estimating the population size of an endemic and threatened land snail in Spain. This approach was adopted by SKM (2009) and considered appropriate for this study. The methodology presented by Moreno-Rueda and Pizzaro 2007 was as follows:

*"For sampling, we randomly assigned 33 points within the distribution area of Iberus g. Gualtieranus. During 2002–2004, we reached these points using maps and a GPS, and we delineated a 9 $m^2$ (3 x 3 m) plot at each point. Therefore, a surface area of 297 $m^2$ was sampled. Live specimens (adult or immature) were exhaustively searched for inside the plots, placing special attention to positions inside fissures, under stones, and in vegetation. With these data, we estimated the average density ± standard error of the mean. Assuming that snail density is homogeneous within its distribution area, we estimated the population size (with an associated error according to the standard error of the mean) in Sierra Elvira with a simple multiplication: density × distribution area."*

The issue of patchiness of microhabitats was an important consideration the design of the survey methodology. Searching only preferred microhabitats (logs, leaf litter, debris) for the Boggomoss

Snail would have undoubtedly resulted in density overestimates. To account for this patchiness, it was decided to employ a transect and sub-plot design which essentially imposed sampling of unsuitable microhabitats. The transect itself was located within preferred habitat for the snail, with quadrats at set intervals of 10m. Each quadrat was equally likely to sample suitable and unsuitable microhabitat, thus avoiding bias to either sites containing no suitable microhabitat (resulting in underestimate) or only suitable microhabitat (resulting in overestimate).

### 4.2.2 Application to the Boggomoss Snail

There is great disparity between the numbers of individual snails observed by BAMM (2009), SKM (2009) and in this study at known sites and, as a result, there are varying population estimates. For example, at the Isla-Delusion site (BAMM Site 11) 3 sub-adult snails were found after approximately 16 hours of searching by BAMM. At exactly the same site, SKM (2009) recorded 1 live adult Boggomoss Snails within 30 min of searching and, in the same patch of habitat further downstream, SKM (2009) recorded 10 live adults, 1 live sub-adult and 18 dead shells of adult and sub-adult snails in less than 5 hours of searching.

Each of the surveys has been completed in different seasons (potentially influencing observed population structure) and at different intervals post flooding. The current survey was completed following a major flooding event which is likely to have impacted population numbers at several sites. Surveys completed during the drier seasons of the year may also underestimate the density of hatchling and sub-adult snails.

New sub-populations of the Boggomoss Snail continue to be discovered. This study found a comparative abundance of Boggomoss Snails at SS12 on Southend, a patch of habitat which had not been considered during previous surveys.

As an experimental exercise, and to provide a conservative population estimate, the lowest observed density of Boggomoss Snails (across the three studies of BAMM, SKM and this study) was used to calculate potential population sizes in the major blocks of habitat for the species. The habitat areas considered in the table below represent the largest blocks of known habitat for this species, and do not consider small and isolated patches (linear remnants of less than 50m in width, or patches less than approximately 5ha in area).

**Table 2 Population estimate based on minimum observed density (0.02/m$^2$)**

| Habitat Patch | Area (ha) | Potential Population Size |
|---|---|---|
| Isla Delusion (SKM 2009) | 14.4 | 2880 |
| Southend (SKM 2009) | 10.63 | 2126 |
| Southend (this study) | 6.01 | 1203 |
| Mt. Rose (BAMM 2009) | 0.75 | 350 |
| Gyranda (SKM 2009) | 7.1 | 1420 |
| **TOTAL** | **38.81** | **7979** |

As a comparative exercise, the density of Boggomoss Snails observed by BAMM (2009) (0.04/$m^2$) was applied to the patch areas given above. The results are presented in Table 3 below.

**Table 3 Population estimate based on density observed by BAMM (2009)**

| Habitat Patch | Area (ha) | Potential Population Size |
|---|---|---|
| Isla Delusion (SKM 2009) | 14.4 | 5760 |
| Southend (SKM 2009) | 10.63 | 4252 |
| Southend (this study) | 6.01 | 2407 |
| Mt. Rose (BAMM 2009) | 0.75 | 350 |
| Gyranda (SKM 2009) | 7.1 | 2840 |
| **TOTAL** | **38.81** | **15609** |

Applying a uniform density across all patches appears to exaggerate population estimates. As such, population estimates which are patch-specific are considered more appropriate. Table 4 below presents patch specific estimates.

**Table 4 Population estimates based on patch specific densities**

| Habitat Patch | Area ($m^2$) | Snail Density ($m^2$) | Potential Population Size |
|---|---|---|---|
| Isla Delusion (SKM 2009) | 143,986 | 0.08 | 11, 519 (8,844-14,193) |
| Southend Wetland (SKM 2009) | 1,073 | 0.3 | 322 (302-342) |
| Southend (this study) | 60,180 | 0.166 | 12,036 (11,454– 13,157) |
| Mt. Rose (BAMM 2009) | 7500 | NA | NA |
| Gyranda (SKM 2009) | 70,164 | 0.05 | 3,508 (2,204-4811) |
| Southend (palm grove) | 103,071 | 0.02 | 2,061 (147-3,976) |
| **TOTAL** | | | **26169-36479** |

Based on patch-specific snail densities, a revised population estimate for the Boggomoss Snail has been calculated at 26169-36479 individuals across all sub-populations. If a precautionary approach is adopted which assumes the lowest observed snail density of 0.02/$m^2$ in preferred habitat, the population estimate is 18095 Boggomoss Snails across all sub-populations.

## 4.3 Microhabitat Preferences

BAMM (2009) reported that "the preferred microhabitat of the species appears to be deep, moist, accumulated litter" and furthermore that "under fallen timber is also a source of living space for the species." BAMM also note that "these provide food, shelter and egg-laying sites for the snail. A closed or relatively closed canopy appears vital to maintaining a stable moist environment." Contrary to this view, the population surveys completed by BAMM at the Boggomoss sites emphasised the importance of Sandpaper Figs.

Few data have been presented on the specific preferences of individual Boggomoss Snails at their point of capture. However, of 38 live Boggomoss Snails observed by SKM (2009) and in this study, not a single live snail was captured beneath or in association with Sandpaper Figs.

In contrast, 100% of snails at Southend Lagoon (SKM 2009) were recorded under leaf litter at the base of Qld Blue Gum and all 6 (100%) live snails recorded in this study were located beneath palm fronds of Carnarvon Palm. The snails are typically retrieved from the moist soil surface beneath accumulated litter.

From the observations of BAMM (2009), SKM (2009) and this study, the microhabitat preferences of the Boggomoss Snail are considered as follows:

- Accumulated leaf litter under Sandpaper Figs on the Mound Springs of Mt. Rose Station;
- Partially buried logs in moist situations at all known sites;
- Accumulated leaf litter and Qld Blue Gum at all known sites;
- Palm fronds of Carnarvon Palm in riparian forests of the Dawson River; and
- Accumulated litter (including Palm fronds) at the base of Carnarvon palm in the riparian forests of the Dawson River.

## 4.4 Sub-population Structure

The number of individuals does not define population viability, which is determined by the relationship between the number of extant individuals and those necessary for a viable population. The latter depends on specific characteristics of the species. Studies of population dynamics are typically required to conclude whether any population is stable or in decline and these data have not been obtained for the Boggomoss Snail. Existing data collected by BAMM, SKM and this study provide an insight into population structure of the Boggomoss Snail Sub-populations and allow discussion of the following traits:

- Juvenile and sub-adult mortality. As Boggomoss Snails reach maturity in their second year, juveniles contribute nothing to the reproductive success of the population and sub-adults may not contribute to breeding unless they survive for two or more “wet” seasons.
- Survival to adulthood. The number of reproducing adults in any population is critical to the viability of that population.

The data collected by BAMM (2009), SKM (2009) and this study are presented in Figure 3 below as they relate to population structure of the sub-populations.

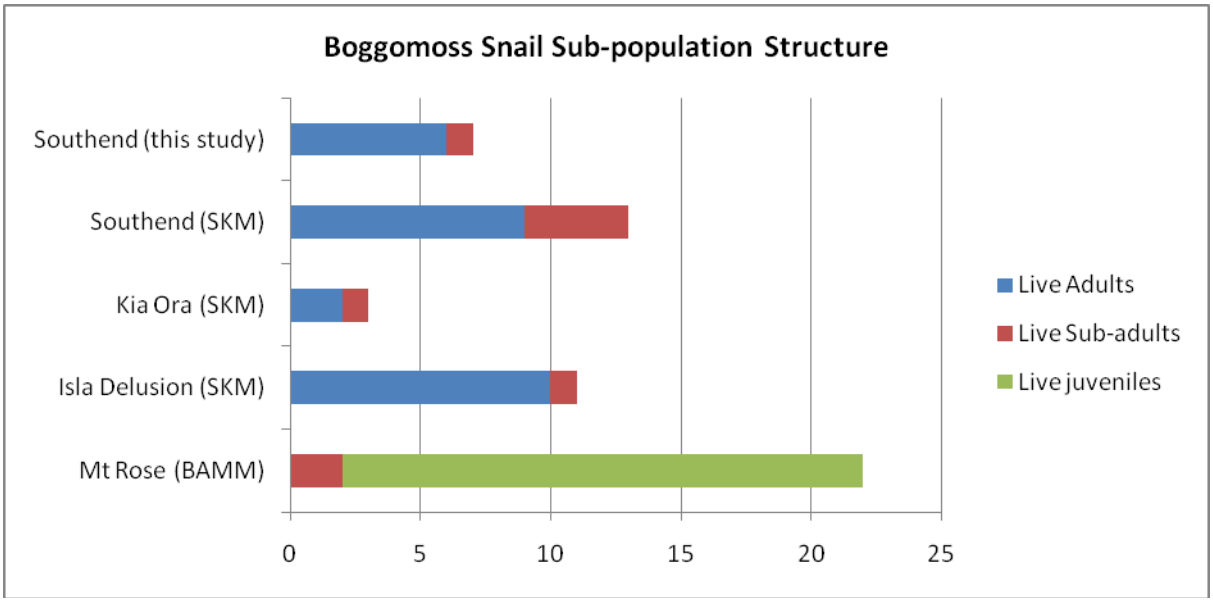


**Figure 3 Boggomoss Snail Sub-population Structure**

Figure 3 above indicates some very strong trends in the sub-populations around mortality and persistence. Key features of the comparison are as follows:

- BAMM (2009) observed no live adults of the Boggomoss Snail in their sample of Mt. Rose Boggomoss site 14. This may be indicative of very high juvenile and sub-adult mortality or an artefact of sampling bias away from the preferred habitats of adult Boggomoss Snails.

- SKM (2009) found a high proportion of live adults, smaller proportion of sub-adults and no live juveniles in their sample of Southend, Kia Ora and Isla-Delusion. The high proportion of adults indicates a high reproductive potential although the lack of juveniles suggests that breeding had not occurred immediately prior to the sampling event. The presence of live sub-adults at Southend, Kia Ora and Isla-Delusion indicates successful recruitment in the 12 months prior to the sampling event.
- This study found live adults and sub-adult snails in additional habitat patches on Southend. As above, the high proportion of surviving adults and presence of sub-adults indicates that a stable, breeding population is present. The fact that this habitat had been inundated for an extended period of time during recent flooding (as evidenced by water staining on Coolabah trees, see Plate 4 below) suggests that the Boggomoss Snail can and does persist in the riparian and floodplain zones of the Dawson despite the impacts of flooding.

**Plate 4 Photo Showing Flood Level at Southend**

Each of the sub-populations of Boggomoss Snails has been found to contain a mix of age classes of individuals. It is therefore known that successful breeding and recruitment continues to occur at these locations.

# 5 Summary and Conclusions

A total of 187 sites in the Dawson River catchment have been surveyed for the Boggomoss Snail between 2008 and 2010 through the collective efforts of BAMM, SKM and this study. The species has been recorded from 17 sites, increased from the original two sites considered in the Recovery Plan for the species (Stanisic 2008). There are breeding sub-populations of the Boggomoss Snail now known from Mount Rose Station, Isla-Delusion Crossing, Southend Station, Kia Ora Station and Gyranda.

Based on the discovery of an additional sub-population of Boggomoss Snails at Southend, and additional area of habitat has been included within the estimate of overall habitat for the species. Approximately 6 hectares of additional habitat is present at this location, supporting a density of snails of 0.166/$m^2$. An estimate of 12,036 snails was calculated for this patch.

As a comparative exercise, the lowest density of Boggomoss Snails observed at any site (0.02/$m^2$) was adopted and used to calculate a conservative population estimate (using *density × distribution area* [31.81ha]) of 7979 snails across all known sub-populations.

The macro and microhabitat preferences of the species are broader than those considered historically. Broad habitat types in which the species has been found include the following:

- Mound Springs with a canopy of Qld Blue Gum and midstorey of Sandpaper Figs at Mt. Rose Station;
- Riparian forest associations within Regional Ecosystem 11.3.25 on the Dawson River which support Qld Blue Gum or River Red Gum with Carnarvon Palm as a co-dominant species in the canopy or a dominant sub-canopy species;
- Monospecific stands of Carnarvon Palm on the Dawson River, including minor Anabranch systems; and
- Open forest of Qld Blue Gum fringing ephemeral wetlands on the Dawson River Floodplain.

The microhabitat preferences of the species include accumulated leaf litter under Sandpaper Figs (at Mt. Rose in particular) and Qld Blue Gums (Mt. Rose and Southend). The majority of specimens located by SKM and during this study were found beneath the accumulated mat of fronds associated with Carnarvon Palm or at the base of Carnarvon Palms themselves.

The completion of this study following a major flood event provided an insight into population persistence in the more dynamic riparian environments of the Dawson River. Live snails were located in a riparian woodland which had been inundated to a depth of at least 4m for an extended period of time, indicating that riparian sub-populations can and do survive major flooding events.

In terms of long-term population viability, the largest and most intact habitat systems occur downstream of the Isla-Delusion Crossing, particularly on the properties Lagoona (which is a part of the Isla-Delusion habitat) and Southend. These sites are considered suitable as receiving sites for translocated individuals.

A mix of adult and sub-adult snails has been reported from all of the known sub-populations over time, indicating that conditions remain suitable for recruitment of individuals to those populations.

As such, there are multiple sites considered appropriate for the translocation of individuals from the Nathan Dam inundation area.

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