Recovery plan for the salt pipewort *Eriocaulon carsonii* 2007–2011

Department of
Environment and Conservation (NSW)

Government
of South Australia
Department for
Environment and Heritage

Queensland
Government
Environmental Protection Agency
Queensland **Parks and Wildlife Service**

Australian Government

Recovery plan for the salt pipewort *Eriocaulon carsonii* 2007–2011

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Species

This recovery plan is for the salt pipewort (*Eriocaulon carsonii* F. Muell.).

Conservation status

This species is listed as 'Endangered' under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and under the Queensland Government *Nature Conservation Act 1992*, the *Threatened Species Conservation Act 1995* in NSW and the South Australian *National Parks and Wildlife Act (1972).*

Habitat and distribution summary

The salt pipewort is dependent upon wetland habitat fed by discharging groundwater mostly within, but not confined to, the Great Artesian Basin (GAB). All likely habitats have been surveyed and the species is known from one complex of springs in NSW, nine in South Australia and 12 in Queensland. Except for two of these in Queensland, all are associated with springs fed by the Great Artesian Basin.

Threat summary

1. Aquifer draw-down
2. Excavation of springs
3. Ponded pastures
4. Rubbervine
5. Stock, goat, donkey and horse disturbance
6. Pig disturbance

Recovery objectives

To prevent further decreases in numbers, populations and habitat of the salt pipewort and to increase numbers, populations and habitat where possible.

Summary of actions

1.1.1 Establish tenure-based security over populations of the salt pipeowort
1.2.1 Ensure that excavation and related direct threatening processes are regulated activities
2.1.1 Control flow from all bores that will enhance groundwater flows to springs containing salt pipewort populations
2.1.2 Develop and implement techniques to increase landholder participation in GABSI
2.1.3 Control new groundwater allocations
2.2.1 Monitor groundwater flows to springs
3.1.1 Eradicate para grass from North Spring and hymen achne from Moses Spring
4.1.1 Eradicate rubbervine *Cryptostegia grandiflora* from Lagoon Spring
5.1.1 Manage stock
5.1.2 Control pigs
5.2.1 Establish and maintain pig fencing
6.1.1 Monitor salt pipewort habitat and populations to better understand threats
6.2.1 Study the ecology of the salt pipewort
6.3.1 Conduct genetic and taxonomic studies of the salt pipewort

Evaluation and review

The EPBC Act identifies that the plan will be reviewed at intervals no longer than five years. Implementation will be reviewed by relevant experts and the plan revised accordingly.

1. General information

Conservation status

This recovery plan is for the salt pipewort *Eriocaulon carsonii* F. Muell. This species is listed as 'Endangered' under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and under the Queensland Government *Nature Conservation Act 1992*, the New South Wales *Threatened Species Conservation Act 1995* and the South Australian *National Parks and Wildlife Act* 1972.

International obligations

This species is currently not present on any international listing.

Affected interests

The following people and organisations may have management responsibilities for the species and its threats as identified in this plan.

- Environmental Protection Agency/Queensland Parks and Wildlife Service (EPA/QPWS)
- Traditional owners of country containing *E. carsonii*
- Agriculture Fisheries and Forestry Australia
- Queensland Department of Natural Resources, Mines and Water
- Desert Channels Queensland Inc. Natural Resource Management Group
- South West Natural Resource Management Group
- Northern Gulf Queensland Inc. Natural Resource Management Group
- Fitzroy Basin Association Inc. Natural Resource Management Group
- Rangelands South Australia Inc. Natural Resource Management Group
- Diamantina Shire Council
- Department of Environment and Conservation (NSW)
- Department of Infrastructure, Planning and Natural Resources (NSW)
- Aboriginal Lands Trust (South Australia)
- WMC Pty Ltd
- Arid Areas Catchment Water Management Board
- Department for Environment and Heritage (South Australia)
- Environmental Protection Authority (South Australia)

Consultation with Indigenous people

The Indigenous Representative on the Great Artesian Basin Advisory Council (Queensland), the Murri Network (Queensland), the Queensland Indigenous Working Group and the Aboriginal Lands Trust (South Australia) were consulted in the development of the recovery plan. Indigenous engagement will be encouraged in the implementation of the plan.

Aboriginal people are actively involved in the management of the spring containing the salt pipewort on Finnis Springs. Mrs Joslin Eatts (a traditional owner of the site) has been consulted regarding the values and management of Elizabeth Springs and she has indicated her desire for ongoing involvement in the future management of the site.

Advice has been sought from the South Australian Crown Solicitors Office in respect to native title issues and this plan. This plan is designed not to affect native title in any way.

Benefits of this plan to other species and communities

A host of other endemic and rare biota is known from salt pipewort locations and these are identified in the recovery plan for ‘The community of native species dependent on natural discharge of groundwater from the Great Artesian Basin’.

Social and economic impacts

The implementation of this recovery plan potentially affects industry reliant on groundwater use. Some properties will be affected by bore capping, which should improve land and stock management.

2. Biological information

Species description

The salt pipewort *Eriocaulon carsonii* is an herbaceous perennial with a basal rosette of leaves and clustered flowers forming a tight head. Short rhizomes join the rosettes and the plant typically forms mat-like colonies. There are several forms including small forms (i.e. individual rosettes up to 10cm across and the flowers less than 10cm tall) with glabrous (hairless) flower heads (South Australia, north western New South Wales, western Queensland), and plants with a range of sizes (i.e. individual rosettes up to 20cm across and the flowers up to 50cm tall) with hairy flower heads (southern, eastern and northern Queensland).

Different forms of *Eriocaulon carsonii* exist in Great Artesian Basin (GAB) springs and reflect their geographic distribution. This plan includes all forms currently known as *Eriocaulon carsonii,* while recognising that some populations may represent separate, as yet undescribed, species.

Life history and ecology

The salt pipewort produces abundant tiny seeds that germinate readily (R. Davies pers. comm.). It is capable of colonising suitable habitat within complexes where it is known to occur and also to disperse over considerable distances. However, the species has not been recorded on the artificial wetlands habitat created around flowing bores. The salt pipewort is also capable of vegetative spread and will form substantial mats.

The salt pipewort is only known from the spring wetlands fed by permanent groundwater. Fatchen (2000) highlights the association of the salt pipewort in South Australia with groundwater that is high in carbonates and low in sulphates. The species is known from springs with waters with Total Dissolved Solids between 480 and 1100ppm, pH values between 6.6 and 9.1 and conductivity between 550 and 8000µS/cm (Queensland Herbarium unpublished data, D. Niejalke unpublished data, Pickard 1992) although it will survive *ex-situ* on Brisbane tap water, which is below these ranges. It does occur on floodplains subject to infrequent inundation. All populations are in relatively flat landscapes with the exception of one site where the species occurs in a spring-fed area on the side of a gentle range.

Distribution

The salt pipewort currently inhabits nine spring complexes in South Australia, twelve in Queensland and one in New South Wales (Fig. 1). The GAB sustains the wetlands with salt pipewort populations with the exception of two populations in the Einasleigh Uplands region of north Queensland (Routh and Talaroo, Table 1).

Great Artesian Basin spring wetlands have been well surveyed in recent times (see references in Fatchen 2000, Fensham and Fairfax 2003 and Pickard 1992). There is a high level of certainty that no further complexes containing the salt pipewort will be found. Current complexes containing the salt pipewort plus population estimates are summarised in Table 1.

Habitat critical to the survival of the species

Habitat critical to the survival of the salt pipewort is all permanent spring-fed wetlands with a groundwater source from the GAB within a 5km radius of both 145.43E 22.75S and 146.24E 22.08S.

Important populations

Population estimates and location information for the spring complexes containing the salt pipewort are presented in Figure 1 and summarised in Table 1.

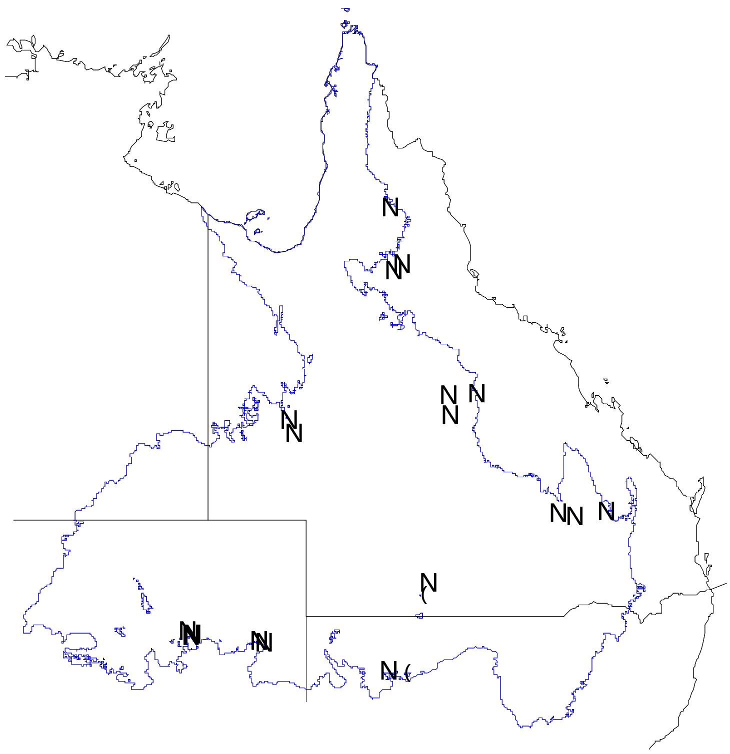

Figure 1. The Great Artesian Basin (blue line) and relevant State boundaries. Extant salt pipewort populations are indicated by crosses and known extinct populations by dots.

Table 1. Population estimates assuming 1ha occupied by the salt pipewort ~ 30,000 plants, and one clump represents a single plant. The recharge/discharge distinction follows Fensham and Fairfax (2003).

Complex/ Group	**Location name**	**Approximate location**	**Est. cover of salt pipewort (ha)**	**Estimated no. of sub-populations**	**Estimated no. of individuals**	**Groundwater source**	**Security**	**Source**
Queensland								
Elizabeth	Elizabeth Springs National Park	23º21’, 140º35’	0.1-0.2	20-30	>10,000	GAB	Small reserve managed for conservation	Fensham and Fairfax field data
Lagoon	‘Corinda’	22º10’, 145º23’	0.04-0.07	2	>1,000	GAB	EPBC Act	Fensham and Fairfax field data
Lucky Last	‘Spring Rock’	25º48’, 148º46’	<0.01	3	>100	GAB	EPBC Act	Fensham and Fairfax field data
Moses	‘Doongma-bulla’	22º05’, 146º15’	0.3-0.5	5-10	>10,000	GAB	EPBC Act, Nature conservation agreement	Fensham and Fairfax field data
Edgbaston-Myross	‘Edgbaston’, ‘Myross’	22º45’, 145º26’	0.1-0.2	30-40	>10,000	GAB	EPBC Act, Values discussed with landholder	Fensham and Fairfax field data
Reedy	‘Warra’	22º55’, 140º27’	0.01-0.03	1	>1,000	GAB	EPBC Act, Values discussed with landholder	Fensham and Fairfax field data
Routh	‘Routh Park’	18º19’, 143º41’	<0.01	2	>1,000	Non-GAB	EPBC Act	Fensham and Fairfax field data
Salt Flat	‘Moorabinda’	25º54’, 149º17’	0.2-0.4	3	>1,000	GAB	EPBC Act	Fensham and Fairfax field data
Sandy Creek	‘Lakeland’	25º44’, 150º15’	<0.01	2	>1,000	GAB	EPBC Act	Fensham and Fairfax field data
Soda	‘Gamboola’	16º22’, 143º34’	0.1-0.2	5-10	>10,000	GAB	EPBC Act, Nature conservation agreement under negotiation	Fensham and Fairfax field data
Talaroo	‘Talaroo’	18º07’, 143º58’	<0.01	1	>1,000	Non-GAB	EPBC Act	Fensham and Fairfax field data

Complex/ Group	Location name	Approximate location	Est. cover of salt pipewort (ha)	Estimated no. of sub-populations	Estimated no. of individuals	Groundwater source	Security	Source
Yowah	‘Bundoona’	27º57’, 144º46’	0.2-0.4	5-10	>10,000	GAB	EPBC Act	Fensham and Fairfax field data
New South Wales								
Peery	Peery National Park	30º43’, 143º33’	<0.01	1	>100	GAB	National Park	NSW National Parks and Wildlife Service 2002
South Australia								
Hermit Hill	‘Finniss Springs’ (Aboriginal Land Trust)	29º34’, 137º26’	0.3-0.5	30-40	>10,000	GAB	EPBC Act, Values well known by landholders	Niejalke field data, Fatchen and Fatchen 1993
North West	‘Finniss Springs’ (Aboriginal Land Trust)	29º33’, 137º24’	<0.01	1	>10	GAB	EPBC Act, Values well known by landholders	Niejalke field data, Fatchen and Fatchen 1993
Old Finniss	‘Finniss Springs’ (Aboriginal Land Trust)	29º35’, 137º27’	<0.01	1	>10	GAB	EPBC Act, Values well known by landholders	Niejalke field data, Fatchen and Fatchen 1993
Sulphuric	‘Finniss Springs’ (Aboriginal Land Trust)	29º36’, 137º24’	<0.01	2-4	>100	GAB	EPBC Act, Values well known by landholders	Niejalke field data, Fatchen and Fatchen 1993
West Finniss	‘Finniss Springs’ (Aboriginal Land Trust)	29º36’, 137º25’	0.01-0.05	1	>1,000	GAB	EPBC Act, Values well known by landholders	Niejalke field data, Fatchen and Fatchen 1993
Gosse	‘Stuart’s Creek’	29º28’, 137º20’	<0.01	1	>100	GAB	EPBC Act, Values well known by landholder	Niejalke field data
Petermorra	‘Murnpeowie’	29º45’, 139º31’	<0.01	3-5	>100	GAB	EPBC Act	Niejalke field data
Public House	‘Murnpeowie’	29º45’, 139º31’	0.05-0.1	50-60	>10,000	GAB	EPBC Act	Niejalke field data
Twelve	‘Moolawa-tanna’	29º50’, 139º40’	<0.01	3	>100	GAB	EPBC Act	Niejalke field data

Two populations are known to have become extinct as a consequence of GAB springs becoming inactive. One is the type locality of the *Eriocaulon carsonii*, Wee Watta Springs in northern NSW (30º43’S, 144º14’E) (NSW National Parks and Wildlife Service 2002). The other was the largest spring of the Eulo region of southern Queensland (Wiggera Springs, 28º15’ S, 144º45’E) (Fairfax and Fensham 2003).

There is also evidence of recent colonisation and successful deliberate introduction. The salt pipewort has dispersed to Gosse Spring in the last 10 years (D. Niejalke pers. comm.) and to Northwest Spring between 1983 and 1988 (Fatchen and Fatchen 1993). The salt pipewort was deliberately introduced to Sulphuric Spring some time in the 1980s, where the population has spread and persisted. Fatchen and Fatchen (1993) and NSW National Parks and Wildlife Service (2002) describe instances of both colonisation and loss from individual spring wetlands within spring complexes. Further examples of local extinction and colonisation are provided by the monitoring data presented in WMC (2004).

Clearly the salt pipewort has some capacity for dispersal, but there is also evidence that most of the populations at the spring complex level are genetically discrete, suggesting that long-distance dispersal is relatively rare (Davies unpublished data). Fatchen and Fatchen (1993) speculate that the distribution of the salt pipewort in South Australia was more widespread prior to the introduction of domestic stock. These authors also document numerous cases of local extinctions and re-appearances within nine years of monitoring individual spring vents in the Hermit Hills region.

3. Threats

Identification of threats

1. Aquifer draw-down

Drilling of bores for the pastoral industry since the 19th century has resulted in thousands of free flowing artesian bores throughout the Great Artesian Basin (GAB). Spring flows in the discharge areas have declined dramatically with lower aquifer pressure resulting from artificial extraction. In Queensland, Fensham and Fairfax (2003) indicate that 61 percent of spring complexes in the western and southern reaches of the GAB in Queensland are completely inactive.

The eastern populations of the salt pipewort (Lagoon, Lucky Last, Moses, Routh, Saltflat, Sandy Creek, Soda, Tallaroo - see Table 1) in Queensland are in areas where there are few artesian bores and there are no substantial declines in groundwater discharge or spring wetland area to date. At least two inactive springs are known to have contained populations of the salt pipewort (Fig. 1). Many of the existing populations of the salt pipewort would have been more extensive prior to reductions in spring flow. Elizabeth Springs and Lagoon Springs are likely examples (Fairfax and Fensham 2002), although both complexes have recently shown evidence of increased flow since local bores have been capped (R. Fairfax pers. comm.).

The extent to which pastoral bores have reduced spring flows in South Australia has not been quantified. In New South Wales a maximum of 10 out of 33 springs located by Pickard (1992) are still active.

Government sponsored programs such as the current Great Artesian Basin Sustainability Initiative (GABSI) program have led to reductions in groundwater discharge. This has been achieved by capping bores and more efficient water-use in some areas, particularly by containing and directing water using polythene pipe. Hydrological models predict a relatively rapid decline in aquifer pressure after groundwater extraction, and equilibration of aquifer pressure at a lower level within a time frame of several decades (Welsh 2000, Habermehl 2001). It is unlikely that there will be further decline in spring flows in areas where artificial extraction continues to be reduced and in many cases spring flows should show a relatively rapid response as pressure is restored by bore capping

The control of all free flowing bores with potential to affect spring wetlands containing salt pipewort populations is imminent in South Australia and New South Wales, but in 2003 there were about 100 licensed pastoral bores still flowing within 70km of the salt pipewort populations in Queensland (Queensland Department of Natural Resources and Mines unpublished data).

Where bore capping is advanced and pressure restoration has not been compromised by new extractions, there should be some evidence of enhancement to spring flows and expansion of spring wetland habitat within the discharge areas of the basin. These circumstances apply to Elizabeth Springs in Queensland, where an attempt was made to compare the area of spring wetland on available current and historical aerial photography. Comparisons were hampered by the variable scale of available photography, the effect of domestic stock on wetland vegetation and the natural dynamism of spring wetlands (see Fensham *et al.* 2004a). However, an increase in wetland area over the last 50 years can be cautiously interpreted at Elizabeth Springs.

Spring wetlands require permanent groundwater discharge through the spring vent. The maintenance of spring flows is sensitive to the potentiometric surface (groundwater pressure) at the spring, with high pressure at the discharge point generally conferring greater resilience to groundwater extraction in neighbouring areas. The elevation of the spring vent is also critical to the sensitivity of springs to aquifer drawdown. Relatively low elevation springs are less sensitive than those at relatively high elevation, with sub-metre scale changes being potentially critical. Precise elevation data on springs is not currently available for many springs. The maintenance of the potentiometric surface above the elevation of the spring does not necessarily ensure spring flows because extra pressure may be required to maintain the conduit through which groundwater flows to the spring, and discharge may dissipate in sub-surface layers and fail to provide artesian flow through a spring vent.

In Queensland and New South Wales the capping of bores under GABSI requires an Expression of Interest from landholders and then a system of prioritising a waiting list to determine which bores will be capped under the current program. In the recent past this system of prioritising has not effectively favoured bores whose capping could yield a benefit to springs. Such a system will be adopted under the current GABSI arrangements. However, there are currently many flowing pastoral bores that could be negatively impacting salt pipewort populations without submitted Expressions of Interest from landholders. Data for Queensland suggests that only about one third of the registered bores that remain to be capped have Expressions of Interest from landholders.

There are also substantial current controlled uses of groundwater particularly in the mining sector. The most important of these for the salt pipewort is the supply of GAB groundwater to Olympic Dam at Roxby Downs in South Australia. Currently BHP Billiton Pty Ltd. has a licence to extract groundwater from two borefields for the Olympic Dam operation. This licence does not specify an annual water allocation as such, but rather defines an assessment process and monitoring requirements designed to safeguard the health of the springs. These include minimum requirements for potentiometric (groundwater) pressure at designated monitoring points in the vicinity of the borefields. The history of water-use for Olympic Dam is described in WMC Pty Ltd (2003). Extraction commenced in 1983 from Borefield A, peaked at about 15ML/day in 1995-1996 and was about 6ML/day in 2002. Extraction from Borefield B commenced in

1996-1997 and currently delivers about 26ML/day, providing most of the operation's water requirements. Borefield A bores are located 6-25km from populations of the salt pipewort within the Hermit Hill Spring complex and it is likely that the major impacts of that borefield to the groundwater supply to the springs have already been expressed. Borefield B bores are located 70-90km from the Hermit Hill complex. Impact assessment for the springs is performed using several different criteria relevant to the salt pipewort:

- Monitoring of spring flows (WMC Pty Ltd 2003)
- Monitoring of wetland area using remote sensing (WMC Pty Ltd 2004)
- Monitoring of vegetation with field-based sampling (Fatchen and Fatchen 1993)

The results from these studies indicate considerable variability in all monitoring criteria and some of this variability undoubtedly reflects methodological constraints. Furthermore the assessment of springs flows and salt pipewort monitoring are substantially confounded by the coincidence of grazing relief with the first phase of substantial extraction from Borefield A. The removal of stock from the springs near Borefield A had a profound effect on spring dynamics (see threat 5).

Future demands for groundwater are likely to be considerable: there is currently a host of proposals in the mining and power generation sectors that could potentially require substantial GAB groundwater (Arid Areas Catchment Water Management Board 2004).

2. Excavation of springs

Fensham and Fairfax (2003) estimate that 26 percent of active spring groups in the Queensland GAB have suffered total or major damage by excavation and related modification (e.g. damming). Many of the New South Wales springs have been damaged in this way in the past (Pickard 1992). Excavation appears to be of less concern in South Australia, though there are a few examples of excavation undertaken many years ago (McLaren *et al*. 1986). Springs are usually excavated because of the perception that this will enhance flows and improve access of stock to water.

Excavation has completely eradicated the natural wetland associated with a large spring within the Moses Springs complex, the likely location of a sub-population of the salt pipewort.

In Queensland, nature conservation agreements are legally binding covenants on the land title, providing management conditions over defined areas of land. Existing nature conservation agreements, including one over the population of the salt pipewort at Moses Springs, specifically exclude future excavation activities within intact wetland areas. However, not all the springs with salt pipewort populations at Moses Springs are within the nature refuge.

3. Ponded pastures

The exotic ponded pasture species hymenachne, *Hymenachne amplexicaulis* has been planted on the outflow of the excavated spring within the Moses Spring complex. In October 2000 the hymenachne infestation occupied an area of approximately 550sq.m (92m × 6m), where the dense mono-specific sward excluded nearly all native plants. In August 2004 it had not spread substantially, although an occurrence of about five plants was located about 50m from the main infestation. Populations of salt pipewort at Moses Spring are within spring wetlands about 2.5km to the south of the hymenachne infestation, although not connected by downstream flow. Wetland birds travelling between these nearby wetlands could spread the hymenachne. The existence of the stand of hymenachne poses a considerable threat to the natural values of the spring wetlands at Moses Springs including the salt pipewort population.

Another ponded pasture species, para grass *Brachiaria mutica* has been planted within one of the wetland complexes at Edgbaston Springs. The sward appears to be relatively stable since it was planted approximately 50 years ago (A. Wills pers. comm.) but should be removed to prevent potential spread.

The conservation agreement over Moses Springs specifies that ponded pasture shall not be deliberately planted within the wetlands with the salt pipewort populations.

4. Rubbervine

The Lagoon Springs and Routh Springs populations include sites where woody species dominate. This results in a substantially more fragmented and lower density salt pipewort population than is typical at more open sites. This seems to be the natural state for the Routh Springs population. However, at one spring within the Lagoon Springs complex the dominant black tea-tree *Melaleuca bracteata* is festooned with the exotic rubbervine, *Cryptostegia grandiflora*. This increases canopy cover and seems to have resulted in extremely low densities of the salt pipewort. Burning to control rubbervine at this site would open up the canopy and probably benefit the salt pipewort.

5. Stock, goat, donkey and horse disturbance

Impacts of grazing animals can have a detrimental effect on salt pipewort populations. Trampling can be a major disturbance around the edge of the spring wetlands. These effects can be particularly severe in small spring wetlands where animals can gain complete access. The interior of some large spring wetlands is generally immune from damage because the amorphous substrates are often boggy and can be a death trap for large animals. Fencing to manage stock grazing may be appropriate in some circumstances.

The 'Finniss Springs' property which includes several springs containing salt pipewort populations (Table 1) was destocked in 1984. Subsequently and probably as a result of stock removal, salt pipewort populations have expanded substantially at West Finniss Springs. At Hermit Hill Springs, however, the tall reed *Phragmites* has proliferated after stock removal (Fig. 2). In some parts of these wetlands, particularly near the spring vents, the growth and spread of *Phragmites* has resulted in the displacement of the salt pipewort and substantial decline in the area covered by the species within the spring complex (See Fatchen and Fatchen 1993). Fensham *et al.* (2004a) suggest that this may not be a universal phenomenon with grazing relief, even when *Phragmites* and the salt pipewort are both present at a site. The idiosyncratic effects of fencing are highlighted in the case studies described from South Australia by Fatchen (2000).

Figure 2. Comparison of a spring vent at Hermit Hill 13 years after the removal of stock (Modified from Fatchen 2001b, photos courtesy T. Fatchen)

At Hermit Hill a burning trial has been conducted to assess the role of fire for managing *Phragmites* (Davies 2001). The trial involved winter burning and yielded no negative impact on *Phragmites*, nor positive impact for the salt pipewort. Burning at different times and repeat burning also needs to be trialed and results documented. The co-operation and advice of Indigenous custodians will be essential in these efforts.

Negative impacts of *Phragmites* seem to have stabilised over the last five years of monitoring at Hermit Hill with the salt pipewort forming dense mats in the tails of the larger spring wetlands, where cover would have been substantially reduced with heavy stock impacts. The ongoing response of the salt pipewort to grazing relief requires further monitoring at Hermit Hill and further substantial declines may require intensive management of *Phragmites* if fire proves unsuccessful.

Fensham *et al.* (2004a) have highlighted the probability that the response of *Phragmites* and subsequent negative impact on the salt pipewort does not seem likely with the removal of stock at Elizabeth Springs in Queensland. They highlight the preference of *Phragmites* around spring-heads and suggest that habitat conditions within the spring wetlands are also important for determining species patterns. The role of disturbance in controlling species patterns, and in particular the proliferation of *Phragmites,* requires further evaluation at a range of sites.

6. Pig disturbance
Pig rooting is a major cause of disturbance for salt pipewort populations in Queensland and New South Wales. These activities occur in localised areas up to 200sq.m. The vegetation of individual small wetlands can be completely eradicated by a single mob of pigs. The activities of pigs may have resulted in the eradication of the salt pipewort from individual spring wetlands.

Active management of pigs has occurred on some properties with the salt pipewort, including Peery Lakes National Park and Myross station, and two pig fences were established at Edgbaston Springs in the mid-1990s but have since fallen into disrepair.

Areas and populations under threat

Threats pertaining to the salt pipewort for each population are identified in Table 2.

Table 2. Threats (numbering according to text) as they pertain to the populations of the salt pipewort (Table 1).

Complex/Group (in South Australia)	Future threats (see above for numbers)	Complex/Group (in South Australia)	Future threats (see above for numbers)
Queensland		**New South Wales**	
Elizabeth	1	Peery	1, 5, 6
Lagoon	1, 2, 3, 4, 5, 6		
Lucky Last	2, 3, 5, 6	**South Australia**	
Moses	2, 3, 5, 6	Hermit Hill	1, 2, 3, 5
Edgbaston-Myross	1, 2, 3, 5, 6	Northwest	1, 2, 3, 5
Reedy	1, 2, 3, 5, 6	Old Finniss	1, 2, 3, 5
Routh	2, 3, 5, 6	Sulphuric	1, 2, 3, 5
Salt Flat	2, 3, 5, 6	West Finniss	1, 2, 3, 5
Sandy Creek	2, 3, 5, 6	Lake Eyre (Gosse)	1, 2, 3, 5
Soda	1, 2, 3, 5, 6	Petermorra	1, 2, 3, 5
Talaroo	2, 3, 5, 6	Public House	1, 2, 3, 5
Yowah	2, 3, 5, 6	Twelve	1, 2, 3, 5

Threats summary

Type of threat	Current actions to reduce threats	Future actions to reduce threats
Aquifer draw-down	Implementation of GABSI	Completion of GABSI. Sustainable use of the aquifer at levels ensuring survival of remaining salt pipewort populations
Excavation of springs	In some cases landholders/managers have been made aware of the threats to the target species and relevance of the EPBC Act	Perpetual arrangements that prohibit excavation
Ponded pastures	In some cases landholder/managers have been made aware of the threats to the target species and relevance of the EPBC Act	Eradicate all known populations of ponded pasture species
Stock and feral animal disturbance	Some springs have been fenced. There is some monitoring and research being conducted to document the effects of fencing and stock removal	Fence certain springs. Provide alternative water sources. Regulate stock use. Monitor effects
Pig disturbance	Pig control is conducted on the properties of some salt pipewort populations.	Repair and maintain existing pig fences and continue pig control program
Managing woody vegetation around springs	None	Actively remove and control rubbervine

4. Objectives and criteria

Overall objective

To maintain or enhance groundwater supplies to spring wetlands containing the salt pipewort, to maintain or increase population sizes of salt pipewort populations, except in situations where management directed to preserving natural spring values results in acceptable local decline.

Specific objectives

1. Achieve appropriate security to protect against future threatening excavation and planting of exotic plant species
2. Ensure flows from springs do not decrease
3. Minimise effect of ponded pasture species
4. Minimise impact of rubbervine
5. Minimise impact of stock and feral animals
6. Better understand the biology of the salt pipewort

Evaluation of recovery plan

Progress of actions detailed in this plan will be reviewed and publicly reported on by 2012.

5. Recovery actions

The implementation of the following recovery actions will require the voluntary co-operation of the landholders managing salt pipewort populations. In many cases existing management is adequate, explaining the persistence of healthy populations of the salt pipewort. Where actions are recommended they may require external resources beyond the responsibilities of landholders.

Objective 1: Achieve appropriate security to protect against future excavation and planting of exotic plant species

Performance criteria 1.1. Relevant threats have been mitigated with tenure-based security

Action 1.1.1. Establish tenure-based security over populations of the salt pipewort

A tenure-based conservation agreement between the landholders and the appropriate state agency is an appropriate model in most cases. These voluntary agreements are negotiated with the landholders to create a Nature Refuge/Heritage Agreement over part or all of a property, which is then registered on the land title. These agreements may allow for continued production and land management activities such as sustainable grazing and water use, but prohibit further excavation, the introduction of exotic species to the springs and groundwater extraction that will impact on spring flows. It is possible for extension officers to undertake property assessments, negotiation of the conservation agreement and provide follow-up advice and assistance with management. Conservation agreements ensure recovery-effective management techniques of current land-managers are carried on by future managers.

The appropriate model in Queensland is a Nature Refuge conservation agreement and in South Australia is a Heritage Agreement. The merits of this approach are that it fosters ownership of appropriate management with the landholders, and ensures that spring custodians are aware of their responsibilities. The New South Wales population of the salt pipewort is protected within an existing National Park.

Potential contributors: Queensland Department of Natural Resources, Mines and Water (QDNRM&W), EPA/QPWS, SA Department for Environment and Heritage and SA Environmental Protection Authority.

Performance criteria 1.2. Landholders are aware of their obligations under appropriate regulation
Action 1.2.1. Ensure that excavation and related direct threatening processes are regulated activities.

These activities are regulated under the *Water Act 2000* (Queensland) and the *National Resources Management Act 2004* (South Australia). Landholders will need to be made aware of their obligations under these regulations.

Potential contributors: EPA/QPWS, QDNRM&W, SA Department of Water, Land and Biodiversity Conservation.

Objective 2: Ensure flows from springs do not decrease

Performance criteria 2.1. Bores potentially affecting flows have been capped
Action 2.1.1. Control flow from all bores that will enhance groundwater flows to springs containing salt pipewort populations

A useful target for this action may be to cap all bores that will contribute to recovery equivalent to greater than 0.1m pressure surface. Existing hydrological models can generally be employed to determine this criterion. The bore-capping program as administered under GABSI Phase 1 did not target any bore capping for the purposes of spring flow enhancement in Queensland. Springs resource information for Queensland has improved and targeted bore-capping under GABSI Phase 2 to enhance spring flows should be incorporated as a priority under the program.

This should significantly enhance suitable habitat for *E. carsonii*. One major impediment to this objective is that only a small percentage of landholders managing flowing bores within 70km of *E. carsonii* populations in Queensland have registered an Expression of Interest under GABSI.

Action 2.1.2. Develop and implement techniques to increase landholder participation in GABSI

Incentive, extension and regulatory mechanisms may be required to enhance participation in GABSI.

Potential contributors: GABSI Phase 2, QDNRM&W, Department of Infrastructure, Planning and Natural Resources (NSW), Department of Water, Land and Biodiversity Conservation (South Australia).

Action 2.1.3. Control new groundwater allocations

Future groundwater extraction needs to be carefully controlled to ensure impacts on groundwater flows do not compromise salt pipewort populations. The draft Water Allocation Plan for the GAB in South Australia has been released and seeks to preserve groundwater flows to spring wetlands such that impacts are negligible and may serve as a useful guide for future groundwater licensing. It relies heavily on groundwater modelling to predict impacts. Thus there is an urgent need to ensure that groundwater modelling is adequate to effectively predict impacts on springs. Uncertainties must be considered in licensing new groundwater allocations and a precautionary approach adopted that will ensure that spring wetland values are not compromised.

Potential contributors: GABSI Phase 2, QDNRM&W, Department of Infrastructure, Planning and Natural Resources (NSW), SA Department for Environment and Heritage and SA Environmental Protection Authority.

Performance criteria 2.2. Reports on spring flows are completed
Action 2.2.1. Monitor groundwater flows to springs

Monitoring of springs should document recovery with bore-capping and highlight future draw-down. Wetland area provides a surrogate for spring flows (see Fensham and Fairfax 2003) and may be monitored at useful resolution using low-level 1:10,000 aerial photography. Selected spring wetlands should be the subject of regular (~10 years) aerial photography.

Potential contributors: Relevant landholders, EPA/QPWS, QDNRM&W, Department of Infrastructure, Planning and Natural Resources (NSW), SA Department for Environment and Heritage and SA Environmental Protection Authority

Objective 3: Minimise effect of ponded pasture species.

Performance criteria 3.1. Ponded pastures are eradicated from springs containing the salt pipewort
Action 3.1.1. Eradicate para grass *Brachiaria mutica* from North Springs and hymenachne *Hymenachne amplexicaulis* from Moses Springs

Potential contributors: Landholders, local landcare groups, a conservation-orientated non-government organisation, EPA/QPWS, Desert Channels Queensland Inc. Natural Resource Management Group and the Australian Government Green Corps program.

Objective 4: Minimise impact of rubbervine

Performance criteria 4.1. Rubbervine has been eradicated from springs containing the salt pipewort
Action 4.1.1. Eradicate rubbervine *Cryptostegia grandiflora* from Lagoon Springs, with subsequent monitoring until the seed bank has been exhausted.

Potential contributors: The Desert Channels Queensland Inc. Natural Resource Management Group, landholders, a conservation-orientated non-government organisation, EPA/QPWS and the Australian Government Green Corps program.

Objective 5: Minimise impact of stock and feral animals

Performance criteria 5.1. No more than 10 percent of any individual wetland at any time shows visible pugging by stock or rooting by pigs.
Action 5.1.1. Manage stock

Negotiate the practicalities and desirability of fencing with individual landholders. Discussions need to include the impact of stock on the natural values of the spring wetlands and the populations of *E. carsonii.* Fencing erected should include the option to regulate stock-use rather than exclude stock. In some cases it may well be appropriate to maintain a grazing regime on spring wetlands and the results of fencing should be monitored to determine negative and positive effects. A gate in a fence provides flexibility for future management.

Potential contributors: Landholders, Desert Channels Queensland Inc. Natural Resource Management Group, Northern Gulf Regional Management Group (Qld), Desert Channels Queensland Inc., South West NRM group. (Qld), Fitzroy Basin Association (Qld), Aboriginal Lands Integrated Natural Resource Management Group

(SA), Rangelands Integrated Natural Resource Management Group (SA), Western Region Natural Resource Management Group (NSW).

Action 5.1.2. Control pigs

Ongoing control of pigs is recommended at all sites where feral pigs occur (all salt pipewort populations in Queensland and New South Wales). Trapping, shooting and baiting may be desirable.

Potential contributors: Landholders, Desert Channels Queensland Inc. Natural Resource Management Group, Northern Gulf Regional Management Group (Qld), Desert Channels Queensland Inc., South West NRM Inc. (Qld), Fitzroy Basin Association (Qld), Western Region Natural Resource Management Group (NSW).

Performance criteria 5.2. Pig fences are established and maintained
Action 5.2.1. Establish and maintain pig fencing

Fencing to exclude pigs should be trialed in some locations to determine its effectiveness. Some of the populations at Edgbaston and Doongmabulla are suitable.

Potential contributors: Landholders, Desert Channels Queensland Inc. Natural Resource Management Group, Northern Gulf Regional Management Group (Qld), Desert Channels Queensland Inc., South West NRM Inc. (Qld), Fitzroy Basin Association (Qld), Western Region Natural Resource Management Group (NSW).

Objective 6: Better understand the biology of the salt pipewort

Performance criteria 6.1. Reports on salt pipewort demographics are developed.
Action 6.1.1. Monitor salt pipewort habitat and populations to better understand threats.

Potential contributors: Landholders, Queensland, South Australian and New South Wales Parks and Wildlife Services, University personnel.

Performance criteria 6.2. Reports on salt pipewort ecology are developed
Action 6.2.1. Study the ecology of the salt pipewort

Ecological studies would include a more detailed understanding of habitat requirements and responses to management.

Potential contributors: Landholders, Queensland, South Australian and New South Wales Parks and Wildlife Services, University personnel.

Performance criteria 6.3. Report on the taxonomy of the salt pipewort is developed.
Action 6.3.1. Conduct genetic and taxonomic studies of the salt pipewort

Given the morphological differences between some of salt pipewort populations and their geographic isolation it is recommended that research be conducted into the taxonomy and genetic relationships within the salt pipewort. The Recovery Plan will be reviewed in relation to published literature on the taxonomy of the salt pipewort and its relatives in GAB springs.

Potential contributors: Government agency and University personnel.

Summary

Specific objectives	Performance criteria	Actions
1. Achieve appropriate security to protect against future excavation and planting of exotic plant species	1.1. Relevant threats have been mitigated with tenure-based security	1.1.1. Establish tenure-based security over populations of the salt pipewort
	1.2. Landholders are aware of their obligations under appropriate regulation	1.2.1. Ensure that excavation and related direct threatening processes are regulated activities
2. Ensure flows from springs do not decrease	2.1. Bores potentially affecting flows have been capped	2.1.1. Control flow from all bores that will enhance groundwater flows to springs containing salt pipewort populations
		2.1.2. Develop and implement techniques to increase landholder participation in GABSI
		2.1.3. Control new groundwater allocations
	2.2. Reports on spring flows are completed	2.2.1. Monitor groundwater flows to springs
3. Minimise effect of ponded pasture species	3.1. Ponded pasture species have been eradicated from springs containing the salt pipewort	3.1.1. Eradicate para grass *Brachiaria mutica* from North Springs and hymenachne *Hymenachne amplexicaulis* from Moses Springs
4. Minimise impact of rubbervine	4.1. Rubbervine has been eradicated from springs containing the salt pipewort	4.1.1. Eradicate rubbervine *Cryptostegia grandiflora* from Lagoon Springs, with subsequent monitoring until the seed bank has been exhausted
5. Minimise impact of stock and feral animals	5.1. No more than 10 percent of any individual wetland at any time shows visible pugging by stock or rooting by pigs	5.1.1. Manage stock
		5.1.2. Control pigs
	5.2. Pig fences are established and maintained	5.2.1. Establish and maintain pig fencing
6. Better understand the biology of the salt pipewort	6.1. Reports on salt pipewort demographics are developed	6.1.1. Monitor salt pipewort habitat and populations to better understand threats
	6.2. Reports on salt pipewort ecology are developed	6.2.1. Study the ecology of the salt pipewort
	6.3. Report on the taxonomy of the salt pipewort is developed	6.3.1. Conduct genetic and taxonomic studies of the salt pipewort

6. Management practices

The following practices can lead to unacceptable impacts on the salt pipewort and as such should be prohibited.

- Development of new bores for groundwater extraction or use from existing bores that have the potential to result in pressure/discharge declines that will negatively affect populations of the salt pipewort.
- Excavation of spring wetlands containing the salt pipewort.
- Planting of ponded pastures or other exotic species in the spring wetlands.
- Construction of dams that would result in the inundation of springs

7. Cost of recovery ($)

Action No.	Action description	2007	2008	2009	2010	2011	TOTAL
1.1	Establish tenure-based security over populations of the salt pipewort	Unknown	Unknown	Unknown	Unknown	Unknown	**Unknown**
1.2	Ensure that excavation and related direct threatening processes are regulated activities	Unknown	Unknown	Unknown	Unknown	Unknown	**Unknown**
2.1.1	Control flow from all bores that will enhance groundwater flows to springs containing salt pipewort populations	1,000,000	1,500,000	0	0	0	**2,500,000**
2.1.2	Develop and implement techniques to increase landholder participation in GABSI	na	na	na	na	na	**na**
2.1.3	Control new groundwater allocations	330,000	330,000	0	0	0	**660,000**
2.2.1	Monitor groundwater flows to springs	18,000	0	0	0	0	**18,000**
3.1.1	Eradicate para grass from North Springs and hymenachne from Moses Springs	1000	500	200	0	0	**1700**
4.1.1	Eradicate rubbervine from Lagoon Springs	4000	4000	2000	800	800	**11,600**
5.1.1	Manage stock	0	10,000	500	500	500	**11,500**
5.1.2	Pig control	1000	1000	1000	1000	1000	**5000**
5.2.1	Establish and maintain pig fencing	5000	0	0	0	0	**5000**
6.1.1	Monitor salt pipewort habitat and populations to better understand threats	6000	3000	6000	3000	6000	**24,000**
6.2.1	Study the ecology of the salt pipewort	0	18,000	6000	6000	6000	**36,000**
6.3.1	Conduct genetic and taxonomic studies of the salt pipewort	0	6000	0	0	0	**6000**
Total $		**1,365,000**[1]	**1,872,500**[1]	**15,700**[1]	**11,300**[1]	**14,300**[1]	**3,278,800**

[1] Does not include options for tenure security

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