

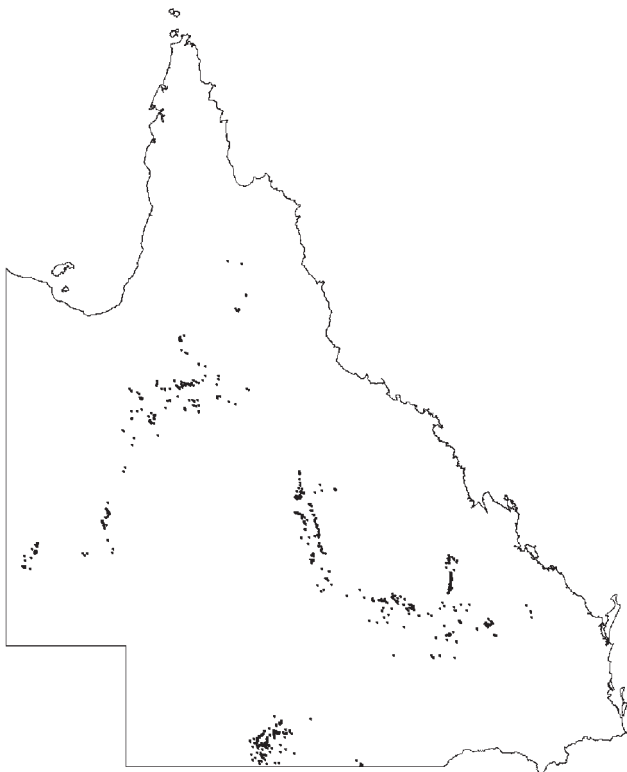


WETLAND MANAGEMENT PROFILE

GREAT ARTESIAN BASIN SPRING WETLANDS

Great Artesian Basin spring wetlands are oases in arid and semi-arid zones. These springs and their surrounding areas are important in environmental, economic and social terms. Threats to these special wetlands include:

- *reduced habitat quality caused by feral pigs, camels and domestic stock;*
- *introduced plant species (particularly ponded pastures);*
- *overuse or misuse of groundwater; and*
- *inappropriate fire and grazing management.*



Map showing all Great Artesian Basin discharge and recharge spring wetlands in Queensland.

Map: EPA

Description

Most artesian spring wetlands occur on the outer edge of the Great Artesian Basin (GAB) aquifers in arid and semi-arid landscapes of Queensland, South Australia and north-western New South Wales. The GAB springs of Queensland are concentrated into eight “supergroups” (see Figure 1), with each supergroup made up of smaller spring-groups and spring-complexes. Other names used for GAB spring wetlands include mud springs, mound springs, water springs and boggomosses.

The majority of spring wetlands are located where the aquifers are shallow or fractured by a fault and where water escapes to the surface.

Mounds sometimes form around the vent of the spring. They occur from a build up of sub-soil, clay and/or precipitates including calcium carbonate brought up by the artesian water, sometimes combined with wind-blown material, or from an accumulation of peat that is derived from vegetation sustained by the spring. Artesian springs are often referred to as mound springs, however mounds are a rare landform in Queensland and the majority of springs are at ground level. The mounds can be vegetated or bare, and vary in size from 0.2–6m in height.

Artesian spring wetlands give rise to wetland systems that are oases in the arid and semi-arid zones. Wetlands from an individual spring can range in size from a puddle up to a wetland as large as a hectare. Some can also provide enough groundwater to sustain a stream. The wetlands support plants such as sedges, reeds, grasses, herbs and algae, and provide habitat for fauna including an array of unique crustaceans, fish and snails. Artesian spring wetlands can support lush vegetation, although some springs (commonly known as mud springs) have an unvegetated, dried exterior from which thick mud occasionally oozes to the surface.

Distribution

Artesian springs are classified as either recharge or discharge springs. The main recharge areas in Queensland are along the eastern margin of the GAB, west of the Great Dividing Range where average rainfall is around 500–600mm a year, and along the northern margin of the GAB on Cape York Peninsula where the average rainfall can be as high as 1800mm a year. Most recharge springs occur where the sandstone aquifer is at the surface, allowing water to be absorbed and discharged again locally in a relatively short period of time. The aquifer slopes slightly downwards in a south-west direction from the recharge areas. All other springs originating from GAB aquifers are known as discharge springs. Discharge springs are found down-gradient of the recharge areas,

where water escapes to the surface through faults in the rock or where the aquifer comes to the surface.

It is estimated that before 1900 there were 545 spring-groups in Queensland, of which 245 were recharge and 300 were discharge spring-groups. Today about 93 percent (228) of the recharge spring-groups remain active, but only 36 percent (108) of the discharge spring-groups are still functioning. In all, there has been a 38 percent reduction in the pre-1900 extent of the GAB spring wetlands.

Around four percent of the artesian springs are contained within reserves in Queensland. As discharge springs are relatively poorly represented in Queensland's protected areas, they are in the most urgent need of greater protection.

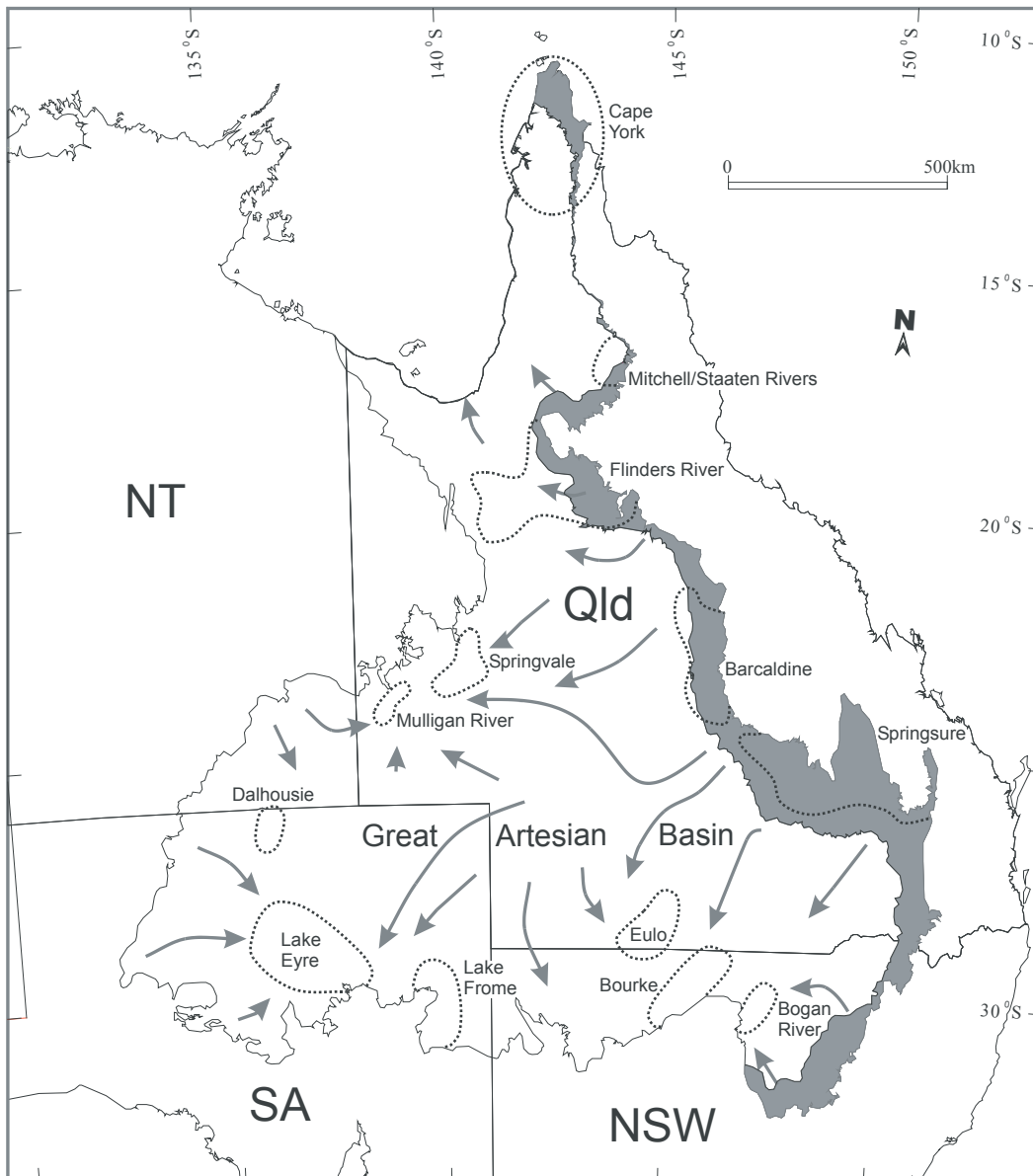


Figure 1: The Great Artesian Basin showing Queensland recharge zones (shaded), spring supergroups (dotted lines), and flow direction (arrows). Source: Fensham and Fairfax (2003), after Habermehl and Lau (1997).

Queensland conservation status

Within Queensland, there are nine GAB spring wetland regional ecosystems (REs) that have been assigned as “endangered” or “of concern” under the Queensland *Vegetation Management Act 1999* (VM Act) and by the Environmental Protection Agency (EPA) (Biodiversity Status, see www.epa.qld.gov.au/nature_conservation/biodiversity/regional_ecosystems/ and Appendix 1).

EPA/QPWS staff are a useful point of contact to assess the condition of GAB spring wetlands. They can also direct you to other sources of information.

The EPA Biodiversity Status, which is based on an assessment of the remaining extent of the RE, the condition it is in and threats it is facing, has been used to determine which REs are addressed in this profile. (Note: The information provided in this profile may also be relevant to other GAB spring wetlands that are not currently endangered or of concern).

There are five nationally important wetlands listed in *A Directory of Important Wetlands in Australia (2001)* that incorporate GAB spring wetland regional ecosystems in Queensland (Boggomoss Springs, Aramac Springs, Doongmabulla Springs, Elizabeth Springs, and Eulo Artesian Springs Supergroup). There are a number of pieces of legislation such as the Queensland *Integrated Planning Act 1997* that include planning, assessment and permit requirements relating to wetlands listed in the Directory.

The Queensland *Water Act 2000* also provides protection for GAB spring wetlands. Under this Act, it is an offence for a person to destroy vegetation, excavate or place fill in a watercourse, lake or spring without a permit.

National conservation status

Six of the nine REs that occur in the Queensland component of the GAB (REs 2.3.39, 4.3.22, 5.3.23, 6.3.23, 10.3.31 and 11.3.22) fall within *The community of native species identified as dependent on natural discharge of groundwater from the Great Artesian Basin*, which is listed as an endangered ecological community under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). (Recharge spring wetlands may

also be found in these REs, however this listing only applies to discharge spring wetlands).

There are species inhabiting the GAB spring wetlands that are listed as threatened under the Queensland *Nature Conservation Act 1992* (NC Act) or the EPBC Act, or on the IUCN Red List (see Appendix 2). Recovery plans, which set out research and management actions to support the recovery of threatened ecological communities and species, are being prepared.

The Currawinya Lakes Ramsar site (a Wetland of International Importance under the Ramsar Convention) lies within the GAB and contains spring wetlands. Ramsar wetlands are a matter of national environmental significance under the EPBC Act and as such are afforded protection under the Act. Any action that will, or is likely to have, a significant impact on a declared Ramsar wetland will be subject to an environmental assessment and approval regime under the EPBC Act.

A framework and guidelines for the management of the Currawinya Lakes has been set out in the Currawinya National Park Management Plan (QPWS, 2001).

Cultural heritage

All wetland ecosystems are of material and cultural importance to Indigenous people and many will have profound cultural significance and values. The Aboriginal peoples of inland Queensland have strong cultural associations with GAB spring wetlands dating back thousands of years. Artesian springs have been critical to the survival of Aboriginal peoples of the arid interior, providing a source of water, food and other material resources, as well as having ceremonial and spiritual values. More than 150 Aboriginal cultural heritage sites have been recorded in association with GAB spring wetlands in Queensland. However, most GAB spring wetlands have not been systematically surveyed or assessed for cultural heritage significance.

In many arid areas, artesian springs are the only permanent water source. These springs enabled Aboriginal peoples to occupy inland regions, particularly during seasonal dry periods. There is a very high likelihood of encountering cultural heritage sites within GAB spring wetlands. Evidence of traditional occupation and use recorded within GAB spring wetlands include painted and engraved (petroglyph) rock art, burials, pathways, scarred trees, stone artefacts and scatters, wells, grinding grooves,

and food and fibre resource sites. Some GAB spring wetlands have particular significance as story places, landscape features and as sites for cultural activities.

THE aboriginal peoples of inland Queensland have strong cultural associations with GAB spring wetlands. Artesian springs have been critical to the survival of Aboriginal peoples – providing a source of water, food and other materials as well as having ceremonial and spiritual values.

The most common sites recorded in GAB spring wetlands are rock art and stone artefact scatters associated with open camp and rock shelter occupation sites. These sites are likely to be found in areas of higher ground adjacent to GAB springs. Archaeological evidence of cultural sites, such as stone artefacts, is often concentrated along ecotones within and around the margins of GAB spring areas. The clustering of sites along ecotones reflects the concentration of traditional occupation and use within areas of greatest biodiversity.

Some GAB spring wetlands also have non-Indigenous (historic) cultural heritage significance, although most have not been surveyed or assessed for historic heritage values. The historic heritage values of GAB spring wetlands demonstrate evidence of their past and present use by the pastoral industry, including stock camps, watering points for cattle and sheep grazing, and for horse, bullock and camel teams. GAB spring wetlands may also have historic heritage values associated with early exploration, surveying, land transport and agriculture. It is important to note that evidence of traditional occupation and use may also be encountered at historic sites.

For further information on identifying, assessing and managing cultural heritage values associated with GAB spring wetlands refer to the *Great Artesian Basin spring wetlands — cultural heritage* profile www.epa.qld.gov.au/cultural_heritage/.

Ecology

The isolation of artesian spring wetlands has led to the evolution of unique species. Many of these species are endemic to the GAB spring wetlands.

There are some fish, plant and snail species that are only known from specific springs in Queensland. Limited surveys have shown that GAB spring wetlands also provide habitat for endemic arachnids (for example spiders), insects, crustaceans (such as prawns, isopods, amphipods and ostracods), cyanobacteria, green algae, and worms.

DOMESTIC and feral animals spread weeds between springs. Weeds may multiply from increased nutrient levels caused by mammal defecation and urination around the wetlands.

A range of plant life forms can be found including trees, shrubs, grasses, sedges, forbs and submerged aquatic plants. Typical plant species include black tea-tree *Melaleuca bracteata*, common reed *Phragmites australis*, narrow leaved cumbungi *Typha domingensis*, spring grass *Sporobolus pamela*, swamp rice grass *Leersia hexandra*, common fringe-rush *Fimbristylis dichotoma*, bore-drain sedge *Cyperus laevigatus*, the sedge *Schoenus falcatus*, and the endangered thornless blue devil *Eryngium fontanum* (NC and EPBC Acts). Submerged aquatic plant species include the salt pipewort *Eriocaulon carsonii*, duckweed *Lemna* spp., and bladderworts *Utricularia dichotoma*, *U. caerulea* and *U. gibba*. Reeds (*Phragmites* spp.) and sedges surrounding artesian springs provide potential habitat and nesting sites for the vulnerable yellow chat *Epthianura crocea crocea* (gulf subspecies; NC Act) and other small birds including insectivorous and grain-eating birds. They are likely to become more reliant on natural artesian spring wetlands as the number of bore drains are reduced due to bore capping and piping.

A STRIP of vegetation around the spring wetland can efficiently trap nutrients, sediments and pesticides on land before they can enter groundwater.

GAB spring wetlands are of particular ecological importance because they provide habitat for species of conservation significance, including threatened flora and fauna that rely on the continued flow of the springs for their existence (see Species of conservation significance section).

Species of conservation significance

Preservation of the GAB spring wetlands habitat is crucial to protect species of conservation significance, particularly those threatened with extinction. Significant fauna and flora that depend on artesian spring wetlands include:

Fauna

Birds

- yellow chat (gulf subspecies) *Epthianura crocea crocea*

Fish

- Edgbaston goby *Chlamydogobius squamigenus*
- Elizabeth Springs goby *C. micropterus*
- red-finned blue-eye *Scaturiginichthys vermeilipinnis*

Snails

- 18 species of freshwater snail (from the hydrobiid, bithyniid and planorbid families) such as *Jardinella isolata*

Crustaceans

- freshwater shrimp *Caridinia thermophila*
- two species of freshwater isopod — *Ponderella bundoona*; *P. ecomanufactia*



Female yellow chat *Epthianura crocea*.

Photo: George Swann

Some of these species are protected under State (NC Act) and Commonwealth (EPBC Act) legislation and/or are recognised under international conventions or agreements (see Appendices 2 and 3).



Red-finned blue-eye *Scaturiginichthys vermeilipinnis*.

Photo: Gunther Schmida

The endemic red-finned blue-eye *Scaturiginichthys vermeilipinnis* is currently known from only one spring-complex in the Barcardine supergroup, making this species vulnerable to extinction. It is classified as critically endangered by the IUCN (World Conservation Union) under the *Red List of Threatened Species* and endangered under the EPBC and NC Acts. The most significant threats to the red-finned blue-eye are the presence of the aggressive mosquitofish *Gambusia holbrooki* (an introduced noxious species), reduced spring flow, and destruction and alteration of its spring habitat. Red-finned blue-eye appear to favour clear water, so increased turbidity from domestic and feral animals grazing in the spring is likely to be detrimental to their survival.

Flora

Herbs

- thornless blue devil *Eryngium fontanum*
- salt pipewort or button grass *Eriocaulon carsonii*
- water or artesian milfoil *Myriophyllum artesium*
- *Hydrocotyle dipleura*
- *Peplidium* sp.

Grasses

- spring grass or spring dropseed *Sporobolus pamelae*
- springs lovegrass *Eragrostis fenshamii*
- hairy-joint grass *Arthraxon hispidus*
- *Fimbristylis* sp.
- *Fimbristylis blakei*

Tree/shrub

- *Calophyllum bicolor*

Ferns and tree-like ferns

- *Thelypteris confluens*
- *Cyathea exilis*
- *Cyathea felina*



Salt pipewort *Eriocaulon carsonii*.

Photo: Queensland Herbarium

The nationally endangered salt pipewort or button grass *Eriocaulon carsonii* is a perennial aquatic plant that is restricted to flowing spring wetlands on the edge of the GAB. In Queensland, it is only known from two spring-groups, generally in slow moving shallow water. Other species of the *Eriocaulon* genus are mainly found in the tropics and subtropics. The salt pipewort is at risk of extinction in Queensland as it requires flowing artesian spring water and is susceptible to impacts from excavation, reduced spring flow, and trampling by feral or domestic animals. Appropriate grazing and fire regimes are important management considerations (see Grazing management section).

Managing the Great Artesian Basin spring wetlands

Most of the spring wetlands of the GAB in Queensland are under private ownership or management. Land managers are using a range of tools to integrate sustainable pastoral practices with wetland conservation. Adopting appropriate strategies that consider stock and water management, controlling weeds and feral animals, and managing fire will ensure that the exceptional ecological and cultural values (including tourism) of these wetlands are maintained.

Water management

The long-term sustainability of the GAB resource is under pressure due to increasing demand from groundwater users. Since the GAB was discovered as a water resource in 1878, around 5000 artesian bores have been sunk across the Basin. Around 2700 artesian bores are still in use. Water from the GAB is used for stock watering, domestic water supply for rural properties and townships, feedlots, irrigation and mining operations.

The peak in flow rate from the bores was around 750,000 megalitres (ML) a year in 1914. Since then the number of bores has steadily increased and flow rates have declined. Recent estimates of flow rate are about 350,000ML a year. The declining flow rates from bores and natural springs are due to the lowered artesian pressure from continued water extraction. This effect is called “draw-down” and its impact is felt across the entire basin, not just at the point of water extraction.

Historically, water supply from GAB spring wetlands was permanent and flow was constant but varied across seasons. Eighty percent of natural springs in the more arid regions have become completely or partially inactive, with the principal cause likely to be draw-down. The reduced water flow results in a loss of flora and fauna species, especially those species that require permanent water.

Until a change of government policy in 1954, the development of the GAB on large pastoral properties traditionally resulted in the construction of bore drains many kilometres long for watering stock. It is estimated that up to 95 percent of this water is lost to evaporation and/or seepage through the use of these distribution systems. To preserve or maintain artesian pressure and to conserve the valuable GAB resource that is fundamental for many farming enterprises, free-flowing bores are being progressively capped and open drains replaced with pipes that reticulate the water to tanks and troughs.

Benefits of capping and piping can include:

- cleaner water for stock and domestic use;
- reduced stock mortality due to greater reliability of water supply;
- improved water distribution;
- improved method of spelling paddocks by controlling water points;
- improved drought resistance;
- improved stock carrying capacity;
- elimination of costs associated with maintaining and repairing bore drains;
- reduced time spent on cattle management;
- increased property values;
- reduced water loss/wastage;
- improved water flows of surrounding natural springs;
- reduced feral animal populations and associated control costs by limiting their water supply;
- reduced costs for controlling weeds along bore drains;
- reduced cumulative impact of draw-down;
- restoration of native vegetation along bore drains; and
- reduced erosion and degradation of the land around bore drains from flooding.

Capping of 498 bores and piping of 4600km of drains between 1989 and 2005 has resulted in an annual saving of more than 120,000ML of artesian water, but there are about 486 uncontrolled bores with an estimated 13,600km of open bore drains in Queensland.

Since 1999, the Australian and state governments have provided funds through the Great Artesian Basin Sustainability Initiative (GABSI) to subsidise the cost of rehabilitating free-flowing bores and the piping of bore drains. To be eligible to receive the subsidy provided under GABSI, the landholder must have a bore that was constructed prior to 1954, or the bore must be located within the identified corrosive water areas as defined by the Queensland Department of Natural Resources and Mines (NR&M). For those landholders eligible under GABSI, the subsidies currently available in Queensland are 80 percent of the bore rehabilitation costs and 60 percent of piping costs. For full details on subsidies or to obtain an application form, contact NR&M in Longreach on 07 4652 7100 or Charleville on 07 4654 4276.

To prevent further impacts on spring flows and to provide security to existing groundwater users in the GAB, the Queensland Government has introduced a moratorium, under the *Water Act 2000*, on dealing with applications for or about water licences to take underground water from the GAB. The moratorium is in response to increasing demand for water from the GAB, with NR&M receiving more applications to take water in recent years. This demand has resulted in the need to ensure sustainable and effective allocation and management strategies are developed and implemented in the GAB. The moratorium will allow NR&M to develop these strategies formally through a Water Resource Plan (WRP) for the GAB. Further information on the moratorium is available at www.nrm.qld.gov.au/factsheets/pdf/water/w89.pdf.

The WRP process for the GAB will assess the potential impact that granting further applications would have on the sustainability of the GAB, and will clearly define future management strategies for each of the Basin's aquifers. The final WRP will provide security for existing groundwater users, provide scope for potential further entitlements in the Basin, protect the natural heritage and biodiversity values associated with the Basin, and ensure the State's future prosperity.

The WRP will be completed before further allocation of water from the GAB, or decisions on individual applications are considered. This final WRP will be completed in early 2006. Further information on the GAB WRP is available at www.nrm.qld.gov.au/factsheets/pdf/water/w89.pdf.

NO FLOW FOR 100 YEARS

There are many operational benefits for landowners from capping and piping bores, such as cleaner water, improved water flows and reduced maintenance. In many cases, artesian spring wetlands also benefit.

The Flinders River supergroup contains a group of six springs on a 128,000ha cattle station (RE 2.3.39) north of Julia Creek in north-west Queensland. In 1884, the property was recorded as having extensive mound springs and an open spring containing fish. A bore was drilled in 1891, and by 1896, two of the springs closest to the bore had dried up. In 1992, the springs were reported to be inactive and only occasionally muddy.

During the 1990s the landowners began rehabilitating the bores and drains across the property. By 1999 three bores were capped and 14km of pipe installed, with some costs subsidised by the NR&M bore capping project.



Renewed flow of a spring near Julia Creek, north-west Queensland, that had ceased flowing for around a century. The renewed flow and wetland appeared after rehabilitation of local bores and drains.

Photo: EPA

Since completing these works, one of the springs has reactivated to a flow rate of around 0.62L/sec. This is a significant flow rate for a natural spring, which now supports a wetland of around 0.25ha.

Spring modification

Sixteen percent of all active spring-group wetlands in Queensland have been totally destroyed by excavation and more than 40 percent have sustained damage through modification, including excavation. These springs have been excavated and dredged to create dams, wells and drains. In extreme cases, explosives have been used to widen existing rock fissures in an attempt to increase flow rates.

Modified springs generally have an extremely poor representation of the endemic species found in natural spring wetlands, and in some cases modification has caused the springs to cease flowing altogether. Additionally, Aboriginal peoples may be affected by the loss of cultural artefacts and alteration of spiritually significant sites.

SIMPLY fencing around the actual spring vent involves minimal cost and may help to protect the valuable spring resource.

It is often impossible to restore the wetlands to a functioning condition where excavation or dredging has occurred, and excavation does not necessarily improve flow. Any action that may adversely affect the community of native species reliant on natural spring wetlands in the GAB (which may include excavation or dredging of spring wetlands) must be forwarded to the Australian Government for consideration under the EPBC Act.

The Queensland *Water Act 2000* also provides protection for GAB spring wetlands. Under this Act, it is an offence for a person to destroy vegetation, excavate or place fill in a watercourse, lake or spring without a permit under the Act. Due to the environmental and cultural significance of the GAB springs, it is unlikely that a permit would be issued for this purpose.

Grazing management

Controlled grazing can be an important factor in managing artesian spring vegetation. While grazing is known to have some benefits in managing GAB springs, both under-grazing and over-grazing may result in undesirable changes to the ecology of the springs.

HEAVY-DUTY fencing to exclude all animals may be costly, but this will be offset by cleaner spring water.

Detrimental impacts of stock on spring wetland biodiversity and water quality include:

- trampling of vegetation and soil;
- destabilisation and erosion of wetland edges;
- over-grazing of new plant growth, preventing flowering or seed setting;
- increased water turbidity; and
- increased nutrients through defecation and urination, which can foul water, favour weed invasion and potentially harm native species that depend on the spring water.

Managing the water supply to stock can bring significant benefits to spring wetlands. Providing water troughs at a distance from the springs, ideally with a reticulated system to conserve spring water, provides an alternative to direct access by stock.

HEAVY-DUTY galvanised steel posts should be used for fencing in areas of high salinity or acidity.

Fencing around the spring wetlands may be desirable in some instances, for example, where it is appropriate to protect significant species; where clean water is required for domestic use; where it may prevent stock from getting bogged; or where it helps with mustering. Standard fencing that still allows access by native animals can help control grass growth. However, in areas where feral pigs are a significant problem, a fence that excludes feral pigs may be warranted.

Grazing can be used to manage vegetation, and strategic sustainable grazing of wetlands can be effective for inhibiting the dominance of perennial species such as the native common reed *Phragmites australis*. Retaining *P. australis* is desirable, as it is a highly palatable fodder and provides habitat for several animal species. However an overabundance of *P. australis* can reduce the diversity of plant species, obstruct spring discharge, and decrease water levels due to the high evapotranspiration rate of this large reed.

Fire has been trialed to control strong growth of *Phragmites*. Monitoring in South Australia suggests *Phragmites* species recover rapidly after burning and that grazing is a more effective means of inhibiting its dominance. Appropriate grazing strategies vary between properties and location, and are generally determined by testing a range of grazing regimes at different times of the year.

Fire and grazing management are often closely linked, though little is known about the use of fire as a management tool for artesian spring vegetation. Both may be potentially damaging if misused, and if a spring surface has become dry from reduced water flow, there is a risk that fire can spread into the underground peat layer. Fires should be carefully planned around the season and conditions for burning.

Feral animals

Feral animals can impact upon the ecology of spring wetlands. Feral pigs cause the greatest damage, though camels, goats and horses also affect these sensitive wetland areas.

The feral pig *Sus scrofa* feeds on plants and animals within the mud of the spring wetlands, upturning and killing large areas of vegetation during a single feeding episode. Vegetation of individual small wetlands can be completely eradicated from a single feeding event by a mob of pigs. The rooting and wallowing of feral pigs causes significant damage to wetland areas from fouling and muddying of water, destroying vegetation and destabilising wetland banks. This may have considerable impact on flora and fauna, particularly the threatened plant, snail and fish species endemic to the spring wetlands. Additionally, pigs are thought to carry the bacteria that cause vibriosis and leptospirosis — diseases that can be passed on to cattle through water.

A LANDOWNER near quilpie in south-west Queensland reported a dramatic reduction in feral pigs after capping the artesian bore and piping the open drains.

Most landowners have a feral pig control program in place, usually involving a combination of shooting, trapping and baiting to reduce pig numbers. In warm and dry climates, feral pigs require water daily so their distribution is centred on natural or artificial water sources. Preventing access to water, for example by fencing or replacing open bore drains with pipe,

may help to reduce pig numbers in the semi-arid regions of Queensland where spring wetlands occur. For information on control programs call your local government weeds and pest officer or your local NR&M Land Protection Officer. Control programs may be most effective when considered as a part of a co-operative approach across a local area.

GROUND PLANTS SPRING BACK

Fencing of sensitive areas can be one component of an effective feral pig control program. In November 2003, Queensland Parks and Wildlife Service (QPWS) rangers constructed a pig- and goat-proof fence around a 4ha cluster of mud springs, known locally as Tego Springs (RE 6.3.23), in Culgoa Floodplain National Park, south west of Dirranbandi on the Queensland-New South Wales border. Tego Springs is one of only two Queensland examples of the Bourke supergroup of springs. Most of these springs occurred in NSW but are now believed to be extinct, highlighting the significance of Tego Springs.

Foraging and wallowing by feral pigs, grazing and trampling by feral goats, and grazing by kangaroos has caused extensive damage to Tego Springs. A survey in 1999 reported the area to be effectively denuded of vegetation. After 12 months of good local rainfall, there has been spectacular regeneration of grasses, herbs and saltbushes within the fenced area, with the diversity of native plants increasing threefold. Flora associated with these spring wetlands, including spiny flatsedge *Cyperus gymnocaulos*, couch grass *Cynodon dactylon* and brown beetle grass *Leptochloa fusca* has increased in abundance and density at almost all vents.

An exciting development was observed just six months after the fence was installed. The rare grass species, smooth dropseed *Sporobolus partimpatens*, that was initially represented by less than a dozen plants around one vent has increased to hundreds of plants across a wider area. *S. partimpatens* has not been recorded outside the fence, perhaps indicating that feral and native animals were preferentially grazing this species, and that its regeneration is not related to increased rainfall alone.



Condition of a spring (Tego Springs) in Culgoa Floodplain National Park prior to fencing.

Photo: EPA



The same spring 12 months after fencing to exclude feral pigs.

Photo: EPA

In November 2004, coolabah seedlings *Eucalyptus coolabah* were found for the first time near the springs, growing only inside the fenced area. The number of weed species has not increased since the fencing and, although the weeds are not currently inhibiting recruitment of native species, QPWS rangers are monitoring the area and will initiate a weed control program if necessary. Recent monitoring indicates that the diversity of native plants is still increasing.

The results of this project illustrate that wetlands can be restored to a more natural condition by removing or excluding feral pigs and goats.

Weed management

Around 23 exotic plant species, including 11 grasses, are known to occur in GAB spring wetlands. The greatest threat from exotic species comes from three grasses commonly used as ponded pastures — aleman grass *Echinochloa polystachya*, Olive hymenachne *Hymenachne amplexicaulis* and para grass *Brachiaria mutica*. These are vigorous species that have been identified as environmental weeds in Australia due to the ecological harm they can cause. These aggressive grasses can completely dominate spring wetlands to the exclusion of all other species and choke the springs, even when being grazed. Pondered pastures should not be established in or near natural wetlands due to their unacceptable impacts on these areas, as outlined under the Queensland *Policy for Development and Use of Pondered Pastures* (DNRM, 2001).

Olive hymenachne *Hymenachne amplexicaulis*, rubber vine *Cryptostegia grandiflora* and parkinsonia *Parkinsonia aculeata* (also commonly known as jelly bean tree or Jerusalem thorn) are three of 20 pest species classified as Weeds of National Significance (WoNS), and it is an offence to sell, keep or release these species under the Queensland *Land Protection (Pest and Stock Route Management) Regulation 2003*. Parkinsonia is another species that can dominate areas around wetlands and create dense thickets that restrict access to water. Control methods can include fire and manual removal when the plant is small, or mechanical removal or the application of herbicides for larger plants. A combination of all methods may be needed to manage dense thickets. It is important to remove roots up to 20cm below the ground to avoid regrowth.

It is also extremely important to be well-informed about any chemical being considered for use in weed control, as there can be penalties if native plants and animals are harmed, particularly around the natural spring wetland areas. Particular care should be taken when using herbicides near wetlands.

Details about suitable herbicides and appropriate timing and methods to control most weeds can be obtained from your local NR&M Land Protection Officer, or from the NR&M or Department of the Environment and Heritage websites www.nrm.qld.gov.au/pests/weeds/environmental/index.html.



Parkinsonia *Parkinsonia aculeata* is a Weed of National Significance that can infest Great Artesian Basin spring wetlands.
Photo: Roger Jaensch, Wetlands International

SPRING, CATTLE AND LANDHOLDERS BENEFIT FROM FENCING

A cattle station about 175km north-east of Longreach in Aramac Shire contains a 6ha spring wetland that supports the threatened endemic spring milfoil *Myriophyllum artesium*. This spring provides a reliable supply of water for stock.

The owners decided to provide troughs away from the spring to reduce muddying of the water by stock. Stock exclusion fencing was erected in 2001 with financial assistance from the Natural Heritage Trust and a solar pump, poly pipe, tank and troughs allowed water to be supplied to the cattle away from the spring. Benefits to date include:

- a substantial decrease in water turbidity, with fish and invertebrates clearly visible at a depth of 15cm;
- healthier trees and shrubs that are recovering from rubbing and chewing by cattle;
- increased health and abundance of native grasses, forbs and sedges around the water edge; and
- a virtually undisturbed surface soil around the edge of the wetland.

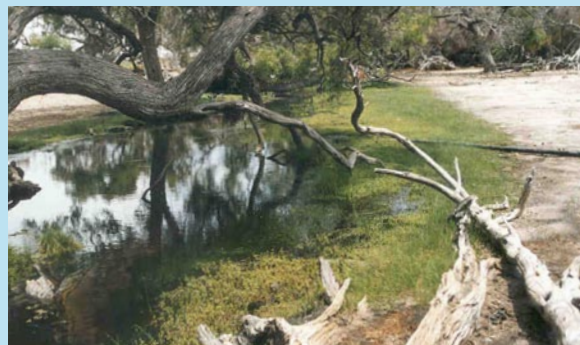
The property owners believe the project has improved the ecological health of the spring and helped to better manage cattle by controlling their access to water.

It is thought that grazing by kangaroos is helping to control growth of common reed *Phragmites australis* that often takes over springs when cattle are removed. A survey in 2004 revealed no imminent threat of choking of the spring by aquatic vegetation. The growth of aquatic vegetation will continue to be monitored during future surveys.



A spring wetland north-east of Longreach shows the disturbance caused by cattle prior to fencing.

Photo: EPA



The same area shows a substantial improvement three years later, with noticeably clearer water and increased vegetation, in particular the endangered spring milfoil *Myriophyllum artesium* and bore-drain sedge *Cyperus laevigatus*.

Photo: EPA

Feral pigs have caused some damage by wallowing and rooting. The landowners, assisted by QPWS extension staff, have applied for funding for a feral pig control program with the Desert Channels Queensland Inc. natural resource management group. The feral pig control program will extend to neighbouring properties to maximise its effectiveness.

Glossary

Aquifer Layer of rock (predominantly sandstone) that holds water and allows water to percolate through it.

Crustaceans Animals with jointed legs and segmented bodies that have a hardened outer shell and usually live in water, such as prawns, crabs and crayfish.

Discharge spring Occurs where water that has travelled underground from recharge areas over an extended period escapes to the surface through faults in underlying rock or where the aquifer reaches the surface.

Ecotone A transition zone between two or more ecological communities.

Endemic Found only in one particular area.

IUCN Red List A list of globally threatened species assessed and maintained by the World Conservation Union (IUCN). The Red List provides taxonomic, conservation status and distribution information and highlights those species or groups of species that are facing a higher risk of global extinction.

Megalitre (ML) 1 million litres.

Peat A mixture of decomposed or decomposing plant material that has accumulated in water-saturated environments, in the absence of oxygen.

Ponded pasture The practice developed by pastoralists to create an environment by either the construction of banks or the modification of naturally wet areas, in which fresh water is impounded or used primarily to grow suitably adapted plant species and produce fodder for grazing.

Precipitates Solids that separate from a liquid such as groundwater.

Ramsar Convention The Convention on Wetlands (Ramsar, Iran, 1971) is an international treaty that aims to halt the worldwide loss of wetlands and to conserve those that remain through wise use and management.

Recharge spring A spring where water is absorbed into sandstone sediments that outcrop on the margins of the Great Artesian Basin and discharge water locally after relatively short residence times.

Regional ecosystem The vegetation community that is consistently associated with a particular combination of geology, landform and soil (see Sattler and Williams 1999, below).

Spring A vent or vents where subterranean water outflow forms a wetland.

Spring-group Multiple springs with less than 1km distance between any two springs.

Spring-complexes Multiple spring-groups with less than 6km distance between any two spring-groups.

Supergroup Large cluster of spring-groups and spring-complexes.

Turbidity A measure of the cloudiness or muddiness of water due to the presence of suspended particles such as silt, clay and microscopic organisms.

Vent Point of water discharge at the ground surface.

Information sources

Australian Government Department of Agriculture, Fisheries and Forestry (2004), Great Artesian Basin Sustainability Initiative (GABSI).

www.affa.gov.au/content/output.cfm?ObjectID=D2C48F86-BA1A-11A1-A2200060B0A05660, 2005.

Australian Government Department of the Environment and Heritage and the CRC for Australian Weed Management (2003), Invasive Species Publications, *Weeds of National Significance: Weed Management Guides*.

www.deh.gov.au/biodiversity/invasive/publications/#weeds, March 2005.

Australian Government Department of the Environment and Heritage (2004a), *Chlamydogobius micropterus* in Species Profile and Threats Database, Department of the Environment and Heritage, Canberra.

www.deh.gov.au/sprat, 10 March 2005.

Australian Government Department of the Environment and Heritage (2004b), *Chlamydogobius squamigenus* in Species Profile and Threats Database, Department of the Environment and Heritage, Canberra.

www.deh.gov.au/sprat, 10 March 2005.

Australian Government Department of the Environment and Heritage (2004c), *Scaturiginichthys vermeilipinnis* in Species Profile and Threats Database, Department of the Environment and Heritage, Canberra.

www.deh.gov.au/sprat, 10 March 2005.

Commonwealth Department of the Environment, Sport and Territories (1996), *Australia: State of the Environment 1996*, CSIRO Publishing, Collingwood, Australia, Chapter 7.

CSIRO (Commonwealth Scientific and Industrial Research Organisation) (2001), *Left-handed pond snails, flat-coils, ramshorns*, Australian Aquatic Invertebrates Web Keys. www.lucidcentral.com/keys/lwrrdc/public/Aquatics/aemoll/html/MOLL11.html, 2005.

Environment Australia (2001), *A Directory of Important Wetlands in Australia, Third Edition*, Environment Australia, Canberra.

Fairfax, R.J. and Fensham, R.J. (2002a), "A conservation strategy for springs in Queensland", *Proceedings of the 5th Spring Researchers Forum*, Environment Australia, Toowoomba, Australia, pp. 9–14.

Fairfax, R.J. and Fensham, R.J. (2002b), "In the Footsteps of J. Alfred Griffiths: a Cataclysmic History of Great Artesian Basin Springs in Queensland", *Australian Geographical Studies* 40(2):210–230.

Fensham, R.J. and Fairfax, R.J. (2003), "Spring wetlands of the Great Artesian Basin, Queensland, Australia", *Wetlands Ecology and Management* 11:343–362.

Fensham, R.J. and Price, R.J. (2004), "Ranking spring wetlands in the Great Artesian Basin of Australia using endemism and isolation of plant species", *Biological Conservation* 119:41–50.

Fensham, R.J. and Fairfax, R.J. (2004), "Vegetation patterns of permanent spring wetlands of arid Australia", *Australian Journal of Botany* 52:719–728.

Graham, S. (1998), "An assessment of the effects of reduced flow on the invertebrate fauna on the Hermit Hill Spring Complex", *Proceedings to the 2nd Mound Spring Researchers Forum and Spring Management Workshop*, Mound Spring Researchers Group, Adelaide, Australia, pp. 13–14.

Habermehl, M.A. and Lau, J.E. (1997), *Hydrogeology of the Great Artesian Basin (Map at scale 1:2500000)*, Australian Geological Survey Organisation, Canberra, Australia.

Lorimer, M.S. (2003), *Protection of artesian springs and associated endemic species — final report NHT project no. 97 2125*, Environmental Protection Agency, Queensland, Australia.

Palmer, E. (1884), "Hot springs and mud eruptions on the lower Flinders River", *Proceedings of the Royal Society of Queensland* 1:19–23.

Ponder, W.F. (2004), *Queensland Mound Spring Aquatic Invertebrates — a report on the Barcardine and Eulo Spring Supergroups*, unpublished report to Australian Government Department of the Environment and Heritage.

QPWS (2001), *Currawinya National Park Management Plan*, Queensland Parks and Wildlife Service, Brisbane, Australia. www.epa.qld.gov.au/publications/p00200aa.pdf/
Currawinya_National_Park_management_plan.pdf, April 2005.

Queensland Department of Natural Resources and Mines (DNRM) (2001), *Policy for Development and Use of Poned Pastures*, Department of Natural Resources and Mines, Brisbane.

Queensland Department of Natural Resources, Mines and Energy (2003), *Environmental Weeds Information Series*. www.nrm.qld.gov.au/pests/environmental_weeds/weed_info_series.html, 2005.

Queensland Environmental Protection Agency (EPA) (1999), *Wetlands of south-western Queensland*, Brisbane, Australia.

Sattler, P. and Williams, R. (eds) (1999), *The Conservation Status of Queensland's Bioregional Ecosystems*, Queensland Environmental Protection Agency, Brisbane, Australia.

Wilson, B.A. (1995), *Artesian Springs of the Great Artesian Basin in Queensland*, Queensland Department of Environment and Heritage, Toowoomba, Australia.

Wilson, G.D.F. and Keable, S.J. (2004), "A new family and genus of Phreatoicidea (Crustacea: Isopoda) from Artesian Springs in South-western Queensland, Australia", *Memoirs of the Queensland Museum* 49(2):741–759.

Appendices

Appendix 1: Description and status of Queensland's Great Artesian Basin spring wetland regional ecosystems (REs).

Bioregion	Regional ecosystem (RE)	RE description	Queensland Biodiversity Status*	Queensland Vegetation Management Status**	Examples of GAB spring wetlands in protected areas^
Gulf Plains	2.3.39	Springs on recent alluvium.	endangered	endangered	–
	2.10.8	Springs associated with quartzose sandstone or lateritised sandstone gullies and gorges.	endangered	of concern	Bulleringa NP
Mitchell Grass Downs	4.3.22	Springs on recent alluvia and fine-grained sedimentary rock.	endangered	endangered	Elizabeth Springs CP
Channel Country	5.3.23	Springs on recent alluvia and fine-grained sedimentary rocks.	endangered	of concern	Elizabeth Springs CP
Mulga Lands	6.3.23	Springs on recent alluvia, ancient alluvia and fine-grained sedimentary rock.	endangered	endangered	Currawinya NP
Desert Uplands	10.3.31	Artesian springs emerging on alluvial plains.	of concern	of concern	–
	10.10.6	Springs associated with margins of sandstone plateaus.	endangered	of concern	White Mountains NP
Brigalow Belt	11.3.22	Springs associated with recent alluvia, but also including those on fine-grained sedimentary rocks, basalt, ancient alluvia and metamorphic rocks.	endangered (under review)	of concern	Carnarvon NP
	11.10.14	Springs associated with sandstone.	endangered	of concern	Blackdown Tableland NP, Carnarvon NP, Palm Grove NP, Expedition NP and Precipice NP

* Biodiversity Status as listed by the Environmental Protection Agency.

** Queensland *Vegetation Management Act 1999* status as of Sept 2003.

^ Protected areas include national parks (NP), resources reserves (RR), conservation parks (CP), Fish Habitat Areas (FHA) and World Heritage areas (WHA).

Appendix 2: Threatened fauna associated with Queensland's Great Artesian Basin spring wetlands.

Taxon group	Common name	Scientific name	NC Act status*	EPBC Act status*	IUCN Red List of threatened species status**
Birds	yellow chat (gulf)	<i>Epthianura crocea crocea</i>	vulnerable	–	–
Fish	Edgbaston goby	<i>Chlamydogobius squamigenus</i>	endangered	vulnerable	critically endangered
	Elizabeth Springs goby	<i>Chlamydogobius micropterus</i>	endangered	endangered	critically endangered
	red-finned blue-eye	<i>Scaturiginichthys vermeilipinnis</i>	endangered	endangered	critically endangered
Snails		<i>Jardinella acuminata</i>	–	–	endangered
		<i>Jardinella jesswiseae</i>	–	–	endangered
		<i>Jardinella pallida</i>	–	–	endangered
		<i>Jardinella isolata</i>	–	–	vulnerable
		<i>Jardinella carnarvonensis</i>	–	–	vulnerable
		<i>Jardinella coreena</i>	–	–	vulnerable
		<i>Jardinella corrugata</i>	–	–	vulnerable
		<i>Jardinella edgbastonensis</i>	–	–	vulnerable
		<i>Jardinella eulo</i>	–	–	vulnerable
	boggomoss snail (Dawson Valley snail)	<i>Adclarkia dawsonensis</i>	–	critically endangered	–

* Under the Queensland *Nature Conservation Act 1992* threatened wildlife are those species listed as presumed extinct, endangered or vulnerable. Under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* threatened wildlife includes species listed as extinct, extinct in the wild, critically endangered, endangered, vulnerable or conservation dependent.

** The IUCN Red List of threatened species is an internationally recognised inventory for the conservation status of plant and animal species worldwide.

Appendix 3: Threatened flora associated with Queensland's Great Artesian Basin spring wetlands.

Taxon group	Common name	Scientific name	NC Act status*	EPBC Act status*
Herbs	thornless blue devil	<i>Eryngium fontanum</i>	endangered	endangered
	salt pipewort or button grass	<i>Eriocaulon carsonii</i>	endangered	endangered
	water or artesian milfoil	<i>Myriophyllum artesium</i>	endangered	–
Grasses	spring grass or spring dropseed	<i>Sporobolus pamela</i>	endangered	–
	hairy-joint grass	<i>Arthraxon hispidus</i>	vulnerable	vulnerable
Fern	–	<i>Thelypteris confluens</i>	vulnerable	–

* Under the Queensland *Nature Conservation Act 1992* threatened wildlife are those species listed as presumed extinct, endangered or vulnerable. Under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* threatened wildlife includes species listed as extinct, extinct in the wild, critically endangered, endangered, vulnerable or conservation dependent.