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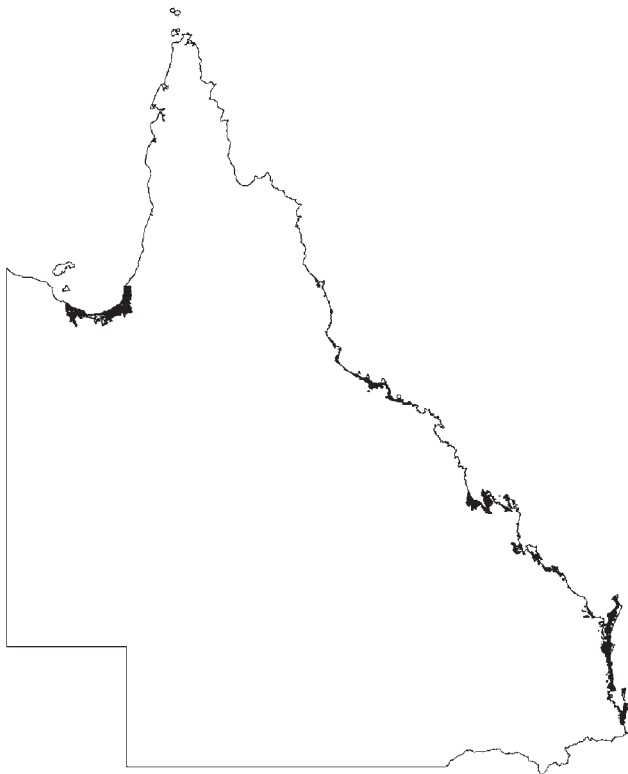


Queensland
Government

WETLAND MANAGEMENT PROFILE

SALTMARSH WETLANDS

Saltmarshes have high biodiversity and economic value, supporting threatened and migratory species and commercially important fish nurseries. They occupy vast areas of Queensland's tropical coast and Australia's largest example adjoins the Gulf of Carpentaria. On the east coast, agricultural, urban and industrial developments have destroyed or degraded many saltmarshes. Improved understanding and management of saltmarsh ecosystems can change this trend.



Map showing saltmarsh wetlands in Queensland.

Map: EPA

Description

Saltmarsh is a major component of coastal landscapes in Queensland. It is situated in the intertidal zone, below the level of Highest Astronomical Tide (HAT) but well above the low tide level. The highest areas of saltmarsh may be inundated with seawater by only the highest spring tides.

Saltmarsh wetlands (saltmarshes) lie on low gradient marine and estuarine plains and so are not usually found where the coast is dominated by sandy beaches, rock or steeply rising landforms. The substrate of saltmarsh is normally deep grey or black clay of marine origin (formed from Quaternary estuarine sediments) and is low in oxygen. Obvious salt crusts may show at the soil surface. The micro-topography of saltmarshes may show complex patterns of small tidal channels and "gilgai" depressions.

In Queensland, saltmarshes are typically situated landward of mangroves although they are not dependent on a co-existence with mangroves. Unlike mangrove wetlands, saltmarshes are devoid of trees and tall shrubs, or support only occasional examples. This may reflect the higher salinity of the saltmarsh substrate, less frequent inundation by saltwater from rising tides and/or infrequent inundation by freshwater running off adjacent higher ground.

Saltmarshes may be bare or vegetated and both forms often occur together either in simple zonation or in complex patterns. Bare saltmarshes are termed "salt flats" or "salt pans" and their existence indicates hypersaline conditions (see Photo 1). Vegetated saltmarshes fall into two categories: those dominated by sparse to medium density dwarf shrubland of semi-woody plants (samphires) (see Photos 2 and 3) and those dominated by sparse to dense, low tussock grassland (see Photo 4). Both vegetation types tolerate high salinity, and temporary inundation that may arise from tides or, less often, from fresh water. The maximum height of vegetation is usually only 10–30cm.

The upper (landward) limits of saltmarshes may be well defined but more often are not easily delineated because saltmarsh may merge into, or form, complex patterns with grass-sedge wetlands that, even though occurring on marine plains, are principally dominated by freshwater regimes. The transitional zone (ecotone) where both tide and freshwater are influential – usually at different times or seasons – may have characteristics of both saltmarshes and freshwater grass-sedge wetlands. Accordingly, these ecotonal wetlands should be included in management planning for wetlands that lie on either side. The saltmarsh boundary is not necessarily static – freshwater plants may invade saltmarsh during wetter periods and salt-tolerant plants may advance landward during drought.

Distribution

Saltmarshes occur discontinuously along the entire coastline of Queensland. They are usually narrowest (tens to hundreds of metres wide) where marine plains are limited, and widest (kilometres to tens of kilometres) where marine plains are broad (see Photos 1 and 5). Saltmarshes are often narrower where rainfall is high or spread through the year, and broader in extent where rainfall is relatively low or where there is a severe dry season.

The largest examples of saltmarshes in Queensland, covering 958,000ha (estimate from the Queensland Department of Primary Industries and Fisheries), are around the Gulf of Carpentaria in the Gulf Plains bioregion and extending into lower western Cape York. These are among the largest in Australia and, reflecting the harsh conditions, bare salt flats dominate. Other extensive examples of this type can be found in the Fitzroy River delta and Broad Sound areas (75,000ha of saltmarsh has been mapped from Keppel Bay to Sand Bay) and along the Brigalow Belt coastline between Townsville and Bowen. More heavily vegetated saltmarshes occur in the Southeast Queensland bioregion (for example Moreton Bay and Great Sandy Strait), Central Queensland Coast bioregion (Corio and Repulse Bays), Wet Tropics bioregion and wetter parts of Cape York Peninsula bioregion.



Photo 1: Salt flats with mangrove channels.
Photo: R. Jaensch, Wetlands International



Photo 2: Inundated samphire, near Broad Sound.
Photo: R. Jaensch, Wetlands International



Photo 3: Samphire saltmarsh vegetation used by foraging yellow chats.
Photo: Wayne Houston, Centre for Environmental Management, CQU

Queensland conservation status

There are nine regional ecosystems (REs) that contain saltmarsh wetlands in Queensland (2.1.4, 3.1.5, 3.1.6, 7.1.2, 8.1.2, 8.1.3, 11.1.1, 11.1.2, 12.1.2). Three of these (REs 7.1.2, 8.1.2, 8.1.3) have been assigned as “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).

For each of the six Queensland bioregions that include coastal landscapes, either one or two saltmarsh REs have been described, depending on whether the saline grassland and samphire communities were kept separate or classified as one RE. Several REs that comprise grass-sedge vegetation and occur on marine plains (land zone 1) are not included here as saltmarsh wetlands because essentially they are driven by freshwater regimes.

A number of protected areas in Queensland contain substantial areas of saltmarsh wetlands (see Appendix 1). According to a recent vegetation mapping survey in lower south-east Queensland, 11 percent of salt flat communities and 23 percent of samphire communities were in reserves.

Saltmarsh wetlands are represented in 69 nationally important wetlands listed in *A Directory of Important Wetlands in Australia* (2005) (see Appendix 3). 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. Any activities that may impact on Directory wetlands (and potentially wetlands in general) must be consistent with this legislation.

All marine plants in Queensland are protected under the Queensland *Fisheries Act 1994* and controls on the disturbance of marine plants, including saltmarsh vegetation, exist under that Act and the *Integrated Planning Act 1997*. Fish Habitat Areas declared under the Queensland *Fisheries Act 1994* provide protection to some saltmarshes (for example, Broad Sound Fish Habitat Area includes over 10,000ha of saltmarsh and Morning Inlet to Bynoe River Fish Habitat Area includes 442ha), but many do not include an adequate portion of the saltmarsh component of coastal wetland systems. Large areas of saltmarsh are within pastoral holdings under leasehold tenure and this precludes these areas from being included in declared Fish Habitat Areas.

The *State Coastal Management Plan – Queensland’s Coastal Policy* (2001) and regional coastal management plans provide direction for conserving, protecting and managing coastal wetlands, including saltmarsh wetlands. These plans are statutory documents under the Queensland *Coastal Protection and Management Act 1995* which guide activities undertaken in coastal areas of the state.

National conservation status

The Moreton Bay, Shoalwater and Corio Bays, Great Sandy Strait and Bowling Green Bay Ramsar sites (Wetlands of International Importance under the Ramsar Convention) contain saltmarsh wetlands (see Photo 6). The Fraser Island, Great Barrier Reef and Wet Tropics World Heritage Areas as defined in the World Heritage List maintained by the World Heritage Convention, also include areas of saltmarsh. The Shoalwater Bay Military Training Area (Byfield) is a Commonwealth heritage place under the Commonwealth Heritage List, and it includes saltmarsh. There are also migratory shorebirds that inhabit saltmarsh wetlands in Queensland, which are listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) (that is, they are listed under the Japan-Australia and China-Australia Migratory Bird Agreements (JAMBA/CAMBA respectively) and/or the Bonn Convention) (see Species of conservation significance and Appendix 2).

Four animals that inhabit saltmarshes in Queensland are listed as threatened under the EPBC Act and/or the Queensland *Nature Conservation Act 1992* (NC Act) and/or the IUCN Red List (see Species of conservation significance and Appendix 2).

Ramsar wetlands, listed migratory species, threatened species, World Heritage properties and Commonwealth heritage places are matters 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, listed migratory species, threatened species, World Heritage property, or Commonwealth heritage place will be subject to an environmental assessment and approval regime under the EPBC Act.

For each of these World Heritage and Ramsar sites, management plans or equivalent are in place; in some instances they may not apply to the entire Ramsar site.



Photo 4: Mixed *Xerochloa* and *Sporobolus* saline grassland on a northern salt flat.

Photo: R. Jaensch, Wetlands International

association with neighbouring regional ecosystems such as coastal wet heath/sedgeland and coastal melaleuca swamp wetlands. The clustering of sites along ecotones reflects the concentration of traditional occupation and use within areas of greatest biodiversity.

Some saltmarsh wetlands also have non-Indigenous (historic) cultural heritage significance, although most have not been surveyed or assessed for historic heritage values. The EPA has recorded six historic sites within saltmarsh wetlands. The historic heritage values of saltmarsh wetlands demonstrate evidence of their past limited occupation and use primarily associated with pastoral, agricultural, timber getting and forestry activities including sites such as grazing areas, log dumps, loading ramps and tramways. It is important to note that evidence of traditional occupation and use may also be encountered at historic sites.

Cultural heritage

All wetland ecosystems are of material and cultural importance to Indigenous people and many will have profound cultural significance and values. More than 300 Indigenous cultural heritage sites have been recorded within coastal saltmarsh wetlands in Queensland, most dating from the mid Holocene, being less than 4000 years old. Most saltmarsh wetlands have not been systematically surveyed or assessed for cultural heritage significance.

There is a very high likelihood of encountering cultural heritage sites within and adjacent to saltmarsh wetlands (see Photo 7). Evidence of traditional occupation and use recorded within saltmarsh wetlands include burials, stone and earth arrangements, scarred trees, hearths, middens, stone artefacts and scatters, fish traps, food and fibre resources and historic contact sites. Some saltmarsh wetlands have particular significance as story places and as sites for cultural activities. Evidence of traditional occupation and use may pre-date the formation of saltmarsh areas and reflect activities associated with previous ecosystems.

The most common sites recorded in saltmarsh wetlands are shell middens and stone artefact scatters associated with open camp occupation sites. These sites are likely to be found in areas of higher ground within or adjacent to saltmarshes, often exposed due to weathering and tidal action. Archaeological evidence of cultural sites, such as stone artefacts and shells, are often concentrated along ecotones within and around the margins of saltmarsh areas, and in

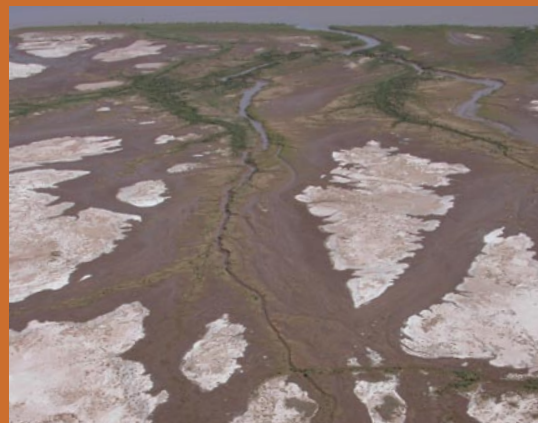


Photo 5: Salt flat with sparse samphire, after high tide.

Photo: R. Jaensch, Wetlands International



Photo 6: Saltmarsh, Boondall Wetlands.

Photo: David Cameron, EPA

Refer to the *Coastal fringe wetlands — cultural heritage* profile www.epa.qld.gov.au/cultural_heritage/ for more information on identifying, assessing and managing cultural heritage values associated with saltmarsh wetlands.



Photo 7: Aboriginal stone arrangements on a salt flat in North Queensland.

Photo: EPA

Ecology

Saltmarsh wetlands are key components of the landscape of the intertidal zone and provide ecosystem services that include:

- regulating services, such as protecting inhabited coastal areas from storm surges; and removing and diluting storm and waste water from urban and irrigation areas;
- cultural services, notably aesthetic values associated with “wilderness areas” that, being inhospitable, are rarely frequented by humans; also education and recreation services where interpretive boardwalks have been built in saltmarshes and mangroves; and
- supporting services, including food web support (supply of nutrients, such as dead saltmarsh plant matter, and crab, gastropod and mosquito larvae, on which marine fauna of the lower intertidal zone may depend), and ecological values (saltmarshes are reservoirs of biodiversity in their own right) as described in detail below.

Compared with some other wetland types, saltmarshes are relatively low in terms of species diversity, both for plants and animals. Plant species diversity in saltmarshes generally decreases with decreasing latitude (towards the equator). Also, no plant or animal species is known to be endemic

to saltmarshes in Queensland. This reflects the wide geographic distribution of saltmarshes; the high mobility of many saltmarsh-inhabiting animal species; and the interchange of species between saltmarshes and adjoining ecosystems (mangroves and sedge wetlands).

The most common saltmarsh grass in Queensland is saltwater couch *Sporobolus virginicus* (also known as sand couch or marine couch), which is found almost worldwide in saltmarshes and is typically associated with tidal regimes. Under favourable conditions it may form closed swards, and hummocks up to 30cm in height due to build up of organic matter. The clay soils in which it occurs are often waterlogged due to elevated water tables and the density of the *Sporobolus* that collects rainfall and restricts saltwater intrusion. Other tussock grasses that may occur in Queensland saltmarshes are beetle grass *Leptochloa fusca*, and *Xerochloa imberbis*, with *Ischaemum australe*, *Zoysia macrantha* and/or *Paspalum vaginatum* or *P. distichum* at the less saline margins.

SALTMARSH wetlands are key components of the intertidal zone and provide ecosystem services such as protecting coastal areas from storm surge, educational opportunities and support of biodiversity.

The most prominent samphires are of the genus *Halosarcia*, with subspecies of *H. halocnemoides*, *H. indica* and *H. pergranulata* being prominent. Certain *Halosarcia* communities dominate where dry hypersaline conditions alternate with wet hyposaline conditions, such as freshwater sheet flow in summer. Other succulent (fleshy) plants that co-exist with samphire in saltmarshes are *Sarcocornia quinqueflora* and sea purslane *Sesuvium portulacastrum* (both commonly prostrate or creeping); and *Suaeda australis*, *Suaeda arbusculoides*, *Batis argillicola*, *Tecticornia australasica* and *Salsola kali* (all commonly erect).

Short sedges such as *Cyperus scariosus*, *C. polystachyos*, *C. victoriensis*, *Fimbristylis ferruginea*, *F. polytrichoides* and/or *Juncus kraussii* are commonly found in Queensland saltmarshes. The taller rush *Schoenoplectus litoralis* frequently occurs in saltmarshes, including in highly saline situations.

Spike-rushes, especially bulkuru *Eleocharis dulcis* and the finer spike-rush *E. spiralis*, may occur as patches in depressions or along channels in saltmarshes, but they tend to occur more extensively in adjacent marine plain ecosystems that are dominated by freshwater influence.

Stunted mangroves, usually grey mangrove *Avicennia marina* or yellow mangrove *Ceriops tagal*, but sometimes club mangrove *Aegialitis annulata* or milky mangrove *Excoecaria agallocha*, may occur as isolated individuals or along small channels in saltmarshes.

IN terms of plant species, two groups dominate saltmarshes in Queensland: salt-tolerant grasses and samphires.

Whilst salt flats may appear to be bare, or have only sparse vegetation, often they support microbial mats (algal and/or bacterial). The exact role that microbial mats play in supporting estuarine and saltmarsh food webs is not fully understood, however recent studies have identified them as important contributors to diets of several common estuarine fish and crustaceans including the banana prawn *Fenneropenaeus merguensis*.

MANY of the migratory shorebirds that visit Queensland's coast from Asian breeding grounds each year feed in saltmarsh wetlands when those habitats are inundated.

Like the softer intertidal mudflats, saltmarshes support invertebrate fauna such as crabs, prawns, molluscs, other crustaceans and worms. Saltmarshes are less rich in diversity and biomass but have among the highest primary production rates for tropical coastal habitats, usually higher than terrestrial habitats of the same latitude (Adam, 1990) and contribute substantially to the world's ecosystem services and functions (Costanza *et al.*, 1997). Saltmarshes provide nursery habitat for crabs and penaeid prawns such as black tiger prawns *Penaeus monodon* and banana

prawns *Fenneropenaeus merguensis*, including species of ecosystem, commercial, recreational and Indigenous food value. Insects are prominent and saltmarsh mosquitoes can be abundant.

Saltmarshes play a significant role as a feeding and/or nursery area for fish, notably the smaller species such as glassfishes, perchlets and gobies, some of which feed on mosquito larvae at high tide. These fishes are important in the estuarine food chain. Some species of commercial and recreational value, such as yellowfin bream *Acanthopagrus australis*, feed on crabs and prawns in inundated saltmarshes, and post-larval and juvenile barramundi *Lates calcarifer* grow in inundated saltmarshes in the early wet season. Export of crab and gastropod larvae from saltmarsh into adjacent tidal habitats also provides key food sources for fish. In the tropics, saltmarsh that has a substantial cover of grasses/sedges is particularly good fish nursery habitat but the bare salt flats are also important, allowing extensive migration of juvenile and spawning fishes.

Waterbirds also use saltmarshes and ducks (for example, chestnut teal *Anas castanea*), herons and storks, shorebirds and gulls/terns are well represented (see also Species of conservation significance section). Few species breed in this wetland type but saltmarsh can be important for migration stop-over by shorebirds and some bare salt flats and saltmarsh grasslands serve as roost sites at high tide. Numbers of waterbirds generally are not high in saltmarshes compared to intertidal mudflats or shallow freshwater wetlands. Survey data on numbers in saltmarsh are sparse but many thousands of waterbirds may occur (at low density) over vast saltmarshes, such as that fringing the Gulf of Carpentaria, when inundation by monsoonal/cyclonic rainfall and/or tides occurs in summer-autumn.

SALTMARSHES support a range of species including fish, crabs, prawns, molluscs, worms and waterbirds. They provide nursery habitat for species of ecosystem, commercial, recreational and Indigenous food value.

Species of conservation significance

In Queensland, few nationally threatened species are known to occur in saltmarsh wetlands. Notable exceptions are the Capricorn (Dawson) subspecies of yellow chat *Epthianura crocea macgregori* (endangered, NC Act and critically endangered, EPBC Act) and water mouse (false water-rat) *Xeromys myoides* (vulnerable, NC and EPBC Acts and IUCN Red List) (see feature boxes). Occasionally, the beach stone-curlew *Esacus neglectus* (vulnerable, NC Act) and secretive Australian painted snipe *Rostratula benghalensis australis* (vulnerable, EPBC Act and NC Act) are recorded in this habitat (see Appendix 2). No threatened plants are known to occur principally or extensively in Queensland saltmarshes.

Migratory species listed under the EPBC Act occur in this wetland type (see Appendix 2). Many of the migratory shorebirds that visit Queensland's coast from Asian breeding grounds each year feed in saltmarsh wetlands when those habitats are inundated by tides, direct rainfall or freshwater inflows. Some bare or sparsely vegetated sites that are either dry or shallowly inundated also provide roosting sites for shorebirds at high tide. Pacific golden plovers *Pluvialis fulva* often roost in saltmarsh vegetation in preference to other roost sites. The saltmarsh wetlands are critical as roosting sites for shorebirds on highest tides when other roosting areas are flooded. Examples of shorebirds that sometimes occur in large numbers in saltmarsh wetlands are red-necked stint *Calidris ruficollis*, marsh sandpiper *Tringa stagnatilis* and sharp-tailed sandpiper *Calidris acuminata* (see Photo 8). A number of coastal wetlands in Queensland qualify for listing in the Shorebird Site Network of the East Asian – Australasian Flyway www.deh.gov.au/biodiversity/migratory/waterbirds/infosn1.html#sites and some include saltmarsh; so far, Moreton Bay has been included in this non-regulatory network. Australian-breeding shorebirds such as black-winged stilt *Himantopus himantopus* and red-capped plover *Charadrius ruficapillus* also feed and may breed in saltmarsh wetlands.

Waterbird species listed as rare in Queensland and that use saltmarsh wetlands are:

- radjah shelduck *Tadorna radjah* (mainly in tropical regions)
- black-necked stork *Ephippiorhynchus asiaticus*
- Lewin's rail *Rallus pectoralis* (east coast)
- eastern curlew *Numenius madagascariensis*
- zitting cisticola *Cisticola juncidis normani* (Normanton subspecies)



Male yellow chat, Curtis Island.

Photo: Wayne Houston, Centre for Environmental Management, CQU

The Capricorn (Dawson) subspecies of yellow chat *Epthianura crocea macgregori* is listed as critically endangered under the EPBC Act and endangered under the NC Act. Counts of this population have revealed less than 700 individuals. This species is known only from Curtis Island, the Torilla Plain and Fitzroy River Delta in central Queensland (Brigalow Belt bioregion), but is seasonally mobile and possibly also occurs in other localities. It frequents freshwater and saline wetlands on marine plains and in the latter it nests and/or raises its young in saltwater couch grassland, samphire shrubland and *Schoenoplectus litoralis* sedgeland. This vegetation can be affected by construction of banks, walls, roads or drains that alter the mixing of saline and fresh water on marine plains. Formal assessment of impacts on known or potential chat habitat should precede any development. Large areas of habitat potentially may be lost to industrial development, notably through the expansion of saltfields. The gulf subspecies of yellow chat *Epthianura crocea crocea* is listed as vulnerable in Queensland (NC Act) and a poorly known population occurs, possibly in samphire and saltmarsh wetlands, on the Gulf Plains.



False water-rat *Xeromys myoides* from Dunrock, 10km south of Mackay.

Photo: Alex Dudley

The false water-rat *Xeromys myoides* is listed as vulnerable under the EPBC Act, the NC Act and on the IUCN Red List. In Queensland it is known from scattered sites in the Proserpine-Mackay, Wide Bay, Great Sandy and Moreton Bay districts but only small numbers have been recorded. It is only 180mm long including an 80mm tail. The false water-rat typically feeds in mangroves on low tides at night, on crabs and other small crustaceans, shellfish and flatworms. It often takes refuge, builds its mud nest mounds (up to 60cm high; alternative nest sites are found in burrows or stumps) and raises its young at sites that are subject to less frequent tidal inundation such as saline grassland, samphire and drier margins. Hence, saltmarsh wetlands may be particularly important for its survival. Alienation or alteration of these wetlands through industrial or urban development, aquaculture projects, acid-sulfate contamination, changes to water regimes or disassociation of mangroves and saltmarshes should be avoided where the false water-rat occurs or potentially may occur. The false water-rat may also be vulnerable to predation from feral pigs and foxes. Pollution of water by oil spills and pesticides threaten its food resources and trampling by cattle may damage nest mounds.

Managing the saltmarsh wetlands

Saltmarsh in Queensland occurs on freehold/ leasehold lands (often managed as part of grazing or other agricultural enterprises) or government land (either local, State or Australian). A single saltmarsh may be managed by more than one of these stakeholders and an integrated management approach is needed to accommodate these varied ownerships and controls.

Freehold and leasehold titles extend to the line of high water mark, which under Queensland legislation is the line of mean high water spring (MHWS).

Therefore, where privately owned or managed land lies between the lines of Highest Astronomical Tide (HAT) and MHWS, its management must comply with relevant legislative provisions and controls such as those that relate to vegetation management, coastal protection, land development and port management.

Barriers to water flows

In both urban and rural areas of Queensland, one of the most dramatic impacts on saltmarshes is the construction of seawalls, levee-banks, channel block banks, weirs and roads. These barriers alter the flows of tidal and fresh water across saltmarshes. In some areas, drains have also contributed to this change as has the inappropriate design, location and operation of floodgates for controlling tidal inundation.



Photo 8: Migratory sharp-tailed sandpipers in saltmarsh.

Photo: Queensland Wader Studies Group

The Queensland *Policy for Development and Use of Pounded Pastures* (DNRM, 2001) and the Queensland *Fisheries Act 1994* prevent and control the construction of barriers to tidal flows in saltmarshes. For example, a Waterway Barrier Works Approval is required under the Fisheries Act for the building of new works, or raising an existing structure across a waterway (freshwater or tidal). The Act also protects all intertidal vegetation (including saltcouch, mangroves, and seagrasses). Prior to proceeding with any works on intertidal areas, advice should be sought on whether a permit to remove or otherwise damage intertidal vegetation is required. For further information, contact the Queensland Department of Primary Industries and Fisheries Call Centre on 13 25 23 (for the cost of a local call from anywhere in Queensland).

Substantial areas of saltmarsh were altered or destroyed by artificial barriers to flows before the policy was established. Often the purpose was to stop incursion of saline tidal water and prolong the persistence of freshwater landward of the barrier. Over time this converted large areas of saltmarsh to wetlands of a less saline, or even freshwater, regime facilitating the creation of ponded pastures. Consequently, on some sections of the Queensland coastline, there are few if any remaining areas of functional saltmarsh.

Wherever possible, further loss of saltmarsh should be prevented, especially in urban areas where typically there are few remnant, healthy saltmarsh wetlands. Property, shire and regional planning will be crucial in ensuring that full consideration is given to the ecological impacts of barriers on saltmarsh wetlands. Where it is deemed unavoidable to construct roads or banks on saltmarshes, adequate culverts/pipes for exchange of saline and fresh water should be installed.

Industrial and urban development

Industrial and urban development has occurred in the coastal zone, often partly or fully on saltmarshes. Examples include airports, mineral loading facilities, saltfields, aquaculture farms, port facilities, manufacturing and light industry, sporting fields, urban and industrial rubbish dumps and canal housing estates. While many of these developments have been necessary, better informed planning could reduce the loss of saltmarsh caused by conversion, landfill and drainage. Representative and functional areas of saltmarsh should be retained within any development on saltmarsh and wherever possible, further loss of saltmarsh should not be permitted.

REPRESENTATIVE and functional areas of saltmarsh should be retained within any development on saltmarsh and wherever possible, further loss of saltmarsh should not be permitted.

Many steel and concrete structures built on saltmarshes have suffered the corrosive effects of saline and acid sulfate soils. Local development control plans, regional coastal zone plans and building codes have included some measures that attempt to address this problem.

Mosquito control

The majority of Australians live in the coastal zone and in Queensland this brings many people in close contact with saltmarshes. Saltmarshes are breeding grounds for mosquitoes such as saltmarsh mosquito *Ochlerotatus vigilax*, saltwater anopheles mosquito *Anopheles hilli* and saltwater culex mosquito *Culex sitiens*. These are carriers of arboviruses (particularly Ross River and Barmah Forest viruses), which can cause long-term debilitating arthritis in humans. Some mosquitoes can disperse for tens of kilometres from the wetland. Eggs are laid on damp saline mud, plant bases or in pools and may develop rapidly in brackish saltmarsh pools after heavy summer rainfall and/or high tides. Consequently, local authorities are required to control populations of saltmarsh mosquitoes.

Aerial and backpack spraying of pesticides on saltmarsh wetlands during the six-day period in which mosquito larvae emerge has concerned many people and alternative measures have been explored. A low-impact technique that seems to be effective is “runnelling”, which involves shallow enlargement of natural drainage lines on saltmarshes to increase the efficiency of standing water removal and increase tidal flushing (and thus also access by predatory fishes to mosquito larvae). Impacts to soil and spreading of spoil must be carefully managed to avoid problems such as acid sulfate soils. Guidelines for runnelling have been prepared by the Queensland Department of Primary Industries and Fisheries, and by law, a permit to create runnels is required from the Department (this may at times require consultation with other stakeholder agencies). A self-assessable code applies for maintaining runnels while a code of practice outlines the criteria for new works to construct acceptable runnels.

For further information on mosquito control in coastal wetlands and how to apply for a fisheries development approval and/or resource allocation authority to disturb saltmarsh, mangroves or other marine plants visit www.dpi.qld.gov.au/fishweb/2652.html#2 or contact the Department of Primary Industries and Fisheries Call Centre on 13 25 23.

RUNNELLING TO MAXIMISE IMPACTS ON MOSQUITOES AND MINIMISE IMPACTS ON SALTMARSHES AT COOMERA ISLAND, GOLD COAST

Runnelling is an Australian innovation that involves taking a “mosquito view” of the world, identifying the critical elements in the mosquito environment and modifying them to adversely impact mosquitoes (Hulsman *et al.*, 1989; Dale and Hulsman, 1990). The aim is to maximise the impact on mosquitoes that may be carrying diseases such as Ross River or Barmah Forest viruses and to minimise impact on the environment.

The first runnelling project was carried out in Queensland in November 1985 at Coomera Island on the Gold Coast. A half-hectare portion of saltmarsh was experimentally runnelled after more than three years of field and aerial survey research, to see if a small alteration to the saltmarsh would be enough to reduce the larval population of the saltmarsh mosquito *Ochlerotatus vigilax*.

The runnels were manually constructed to ensure their design complemented the natural patterns of water movement and they did not provide areas where mosquito larvae could hide. Runnels were smooth-sided (see Photo 9) and no more than 30cm deep and three times as wide. This design mimicked the existing natural saltmarsh channels (see Photos 10 and 11).

The project has been monitored for nearly 20 years. After the first three months there were very few mosquito larvae in the runnelled site (an average of 0.6 larvae) compared to the surrounding saltmarsh (an average of 16 larvae). The researchers have concluded that runnels significantly reduce mosquito larval numbers but do not significantly impact the saltmarsh or its processes (Dale *et al.*, 1996; Dale and Dale, 2002).

There are some relatively minor environmental changes related to runnelling at Coomera Island that include:

- increased wetness near runnels (because tides flood the area more often);
- slightly lowered salinity near runnels (because of flushing); and
- increased numbers of some crabs (mainly in the upper saltmarsh).



Photo 9: Smooth-sided runnel that mimics a natural channel, Coomera Island.



Photo 10: Natural channel at Coomera Island.



Photo 11: Layout of runnels at Coomera Island.

Photos: Dr Pat Dale, Australian School of Environmental Studies, Griffith University

However runnelling was not found to affect:

- acidity of soils or water table;
- water table depth and salinity; or
- size or density of the dominant grass, succulents or mangrove pneumatophores.

Research has also shown that grey mangrove *Avicennia marina* seeds are transported up runnels, however they have not established on the saltmarsh. These mangroves are increasing on Coomera Island but aerial survey analysis between 1982 and 1999 has shown that the increase is not related to runnelling.

Compared to other methods of modifying saltmarshes for mosquito control (for example open marsh water management and drain ditching), runnelling has been shown to have the least impact on saltmarshes (Dale and Knight, in press).

STORMWATER drained from urban areas, farmland and industrial sites on to saltmarshes may alter saltmarsh ecology.

Inflowing stormwater, nutrients and pollutants

Stormwater drained from urban areas, farmland and industrial sites on to saltmarshes may alter the ecology of the saltmarshes. Reducing salinity may harm existing plants and invertebrates and lead to invasion of plants such as cumbungi *Typha* spp. that prefer fresher water. Sediments carried by stormwater may smother saline grasslands. Drainage from industrial sites, canefields and other irrigated agricultural areas may introduce heavy metals, oils and other chemicals into the marine food web and potentially affect commercial fisheries. Wastewater from aquaculture and sewage treatment ponds may have a similar effect. An increase in nutrient inflows may cause proliferation of algae that alter the natural functioning of the saltmarsh ecosystem.

Raised awareness, and planning to divert or pre-treat storm/waste water or changes in use of water may reduce or eliminate these threats. Designation of a 100m wide buffer strip of native vegetation above HAT may help absorb contaminated inflows and halt further cultivation and development to the very edge of the wetlands.

Off-road vehicle use

Where roads and tracks pass close to saltmarshes, especially those that include bare salt flats, users of off-road vehicles and bikes sometimes drive on to the flats, leaving prominent marks on the landscape (see Photo 12). Such marks persist for many years and reduce the aesthetic values of saltmarshes. They also increase soil erosion and create barriers or channels that alter shallow water flows on the flats and may increase areas where saltmarsh mosquitoes can breed. Succulent samphires are particularly prone to damage.

COMMUNITY education and restricted access can reduce the impacts of off-road vehicles.



Photo 12: Wheel track scars on a saltmarsh.
Photo: David Cameron, EPA

Community education programs about the ecosystem services provided by saltmarshes ("saltmarshes are not wastelands") and on the severity of vehicle impacts, coupled with closure of access, could reduce this problem. Boardwalks or walking tracks built in saltmarshes and mangroves at Cairns, Wynnum, Boondall/Nudgee (see Photo 13) and elsewhere have been highly successful educational and recreational facilities, also supporting local communities and tourism.

Grazing and weed management

Landholders have at times used saltwater couch grasslands as an important grazing resource for livestock. Burning of the couch to promote new growth has been practised. Where grazing has declined or ceased, as in some near-urban areas, this grassland has recovered its original structure. Sustainable grazing practices should be applied in saltwater couch grasslands and access limited or excluded at times when the ground is especially wet and boggy to minimise pugging and disturbance of important sites for fauna, especially to nest mounds of the false water-rat.

WHERE ponded pastures have been introduced into natural or artificial freshwater wetlands adjacent to saltmarshes, landholders should ensure that the spread of exotic pasture grasses into saltmarshes is controlled.



Photo 13: Interpretive boardwalk through saltmarsh dominated by saltwater couch, Boondall Wetlands.

Photo: David Cameron, EPA

Where ponded pastures have been introduced into natural or artificial freshwater wetlands adjacent to saltmarshes, landholders should ensure that the spread of exotic pasture grasses such as para grass *Brachiaria mutica* into saltmarshes is controlled. To some extent these grasses are naturally limited by the high salinity of saltmarshes but they may persist where freshwater inflows to saltmarshes are substantial.

Other issues

Several saltmarsh areas on the central Queensland coast are known to lie above shale oil deposits that may be of considerable commercial value. Should demand and technology lead to plans for extraction, the environmental impact on saltmarshes should be fully assessed.

Invasion of saltmarshes by mangroves has been documented on the east coast of Australia and this poses a threat to narrow or declining saltmarshes. Where increases in mean sea-level are predicted to occur as a result of global warming, saltmarshes may migrate landward in areas where topography and landuse allow.

Glossary

Acid sulfate soils (ASS) Soils which are potentially extremely acidic (pH <3.5) because of large amounts of reduced forms of sulfur that are oxidised to sulfuric acid if the soils are exposed to oxygen when they are drained or excavated.

Arbovirus A type of virus that lives in insects like mosquitoes and is passed onto humans through insect bites.

Bonn Convention The Convention on the Conservation of Migratory Species of Wild Animals, to which Australia is a signatory, and a Range State for many migratory species.

Bioregion (biogeographic region) An area of the continent defined by a combination of particular geology, landforms, climate and vegetation. For the definition of regional ecosystems, the bioregions of Sattler and Williams (1999) are adopted.

CAMBA The Agreement between the Government of Australia and the Government of the Peoples Republic of China for the Protection of Migratory Birds and their Environment is a treaty that aims to protect and conserve the birds and their habitat of those species migrate between China and Australia.

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

Cultural services Non-material benefits derived from ecosystems such as recreational, spiritual, religious benefits.

Ecosystem services The benefits people obtain from ecosystems including regulating, cultural and supporting services.

Ecotone A transition zone between two or more ecological communities.

Endemic Found only in one particular area.

Estuarine An area where a freshwater river or stream meets the ocean and tidal influences result in fluctuations in salinity.

Gastropod Organisms such as snails and slugs that lack a backbone and typically have a single coiled shell, a muscular foot, and eyes and feelers located on a distinct head.

Gilgai Hummocky micro-relief pattern on a soil surface produced by expansion and contraction during wetting and drying (usually in regions with distinct, seasonal rainfall); common in heavy alluvial clays.

HAT Highest Astronomical Tide; the highest water level that can be predicted to occur under average meteorological conditions. Note: HAT is higher than MHWS and varies between geographic locations, see www.msq.qld.gov.au/qt/msq.nsf/index/tides_tidal_planes for further information.

Holocene The geological period of time (epoch) from about 11,000 years ago to the present, following the Ice Age (Pleistocene epoch).

Hypersaline Water or soil that is highly saline, typically with greater concentration of salt than sea-water.

Hyposaline Water or soil that is lightly saline, typically with much lower concentration of salt than sea-water (often termed "brackish").

IUCN Red List A list of globally threatened species assessed and maintained by the World Conservation Union (IUCN). The 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.

JAMBA The Agreement between the Government of Australia and the Government of Japan for the Protection of Migratory Birds in Danger of Extinction and their Environment is a treaty that aims to protect and conserve the birds and their habitat of those species that migrate between Japan and Australia.

Land zone 1 Marine tidal clay plains.

Mangrove Tall woody vegetation, usually trees (woodland to forest) but also shrubs, growing in the intertidal zone and thus able to withstand periods of inundation by seawater each day.

Marine Pertaining to seas or oceans.

MHWS The mean high water spring is the highest level to which spring tides reach on the average over a period of time (often 19 years). This level is generally known as “high water mark”. Note: In Queensland, MHWS is specifically defined by legislation. Refer to www.msq.qld.gov.au/qt/msq.nsf/index/tides_notes. MHWS is lower than HAT, see www.msq.qld.gov.au/qt/msq.nsf/index/tides_tidal_planes for further information.

Microbial mats Dense growth of algae and/or cyanobacteria in the surface layer of soil on salt flats, giving a mat or crust effect.

Mollusc Soft-bodied organisms that usually have a hard shell that may be external and obvious, for example snails (gastropods) and mussels (bivalves), or internal and small, for example squids (cephalopods).

Pneumatophores Aerial roots of a mangrove that typically rise into the air above the low tide level, allowing the plant to obtain oxygen directly from the air.

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.

Pugging Soil damage (compaction) caused by grazing animals when their weight cannot be supported by the soil surface, such as deep footprints of cattle in muddy areas.

Quaternary The geological period of time from about two million years ago to the present, characterised by the appearance and development of humans (consisting of the Pleistocene and Holocene epochs).

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.

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

Regulating services Benefits obtained from the regulation of ecosystems processes such as regulation of floods, drought, land degradation and disease.

Saltmarsh Saltwater wetland occupied mainly by herbs and dwarf shrubs, characteristically able to tolerate extremes of environmental conditions, notably waterlogging and salinity.

Samphire Semi-woody plants of low shrub or prostrate habit, tolerant of saline conditions and brief inundation (daily or intermittently), many of which have succulent stems.

Substrate The surface or material on which an organism lives — rock, sand, mud, pilings, shells.

Supporting services Ecosystem services that are necessary for the production of all other services such as soil formation, nutrient cycling and primary production.

Topography The shape of the land in terms of elevation, slope, and orientation.

World Heritage Convention The Convention Concerning the Protection of the World Cultural and Natural Heritage is an international treaty that seeks to encourage the identification, protection and preservation of cultural and natural heritage around the world considered to be of outstanding value to humanity.

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Appendices

Appendix 1: Description and status of saltmarsh wetland regional ecosystems (REs) in Queensland and examples in protected areas.

Bioregion	Regional ecosystem (RE)	RE description	Queensland Biodiversity Status*	Queensland Vegetation Management Status**	Examples of protected areas that include saltmarsh wetlands^
Gulf Plains	2.1.4	Infrequently inundated clay plains and low samphire rises.	No concern at present	Not of concern	Morning Inlet-Bynoe River FHA.
Cape York Peninsula	3.1.5	<i>Sporobolus virginicus</i> closed tussock grassland. Occurs on coastal plains.	No concern at present	Not of concern	Lakefield NP.
	3.1.6	Sparse herbland or bare saltpans. Associated with salt plains and saline flats.	No concern at present	Not of concern	Cape Melville NP, Endeavour River NP, Iron Range NP, Jardine River NP, Lakefield NP, Annan River FHA, Great Barrier Reef WHA.
Wet Tropics	7.1.2	Salt meadow/ herbfield on coastal lowland hyper-saline alluvial soils.	Of concern	Of concern	Daintree NP Edmund Kennedy NP Lumholtz NP, Halifax Bay Wetlands NP, Palm Creek CP, Trinity Inlet FHA, Dallachy Creek FHA, Hinchinbrook FHA, Cattle Creek FHA, Palm Creek FHA, Wet Tropics WHA, Great Barrier Reef WHA.
Central Queensland Coast	8.1.2	Samphire open forbland to isolated clumps of forbs on saltpans and plains adjacent to mangroves. Estuarine wetland.	Of concern	Of concern	Cape Palmerston NP, Conway NP, Dryander NP, Newry Islands NP, West Hill NP, Whitsunday Islands NP, West Hill FHA, Repulse FHA, Sand Bay FHA, Cape Palmerston FHA, Rocky Dam FHA, Great Barrier Reef WHA.
	8.1.3	<i>Sporobolus virginicus</i> grassland on marine sediments. Estuarine wetland.	Of concern	Of concern	West Hill NP, Cape Palmerston NP, Whitsunday Islands NP, Sand Bay FHA, Repulse FHA, Midge FHA, Edgcombe Bay FHA, Corio Bay FHA, Great Barrier Reef WHA.

Bioregion	Regional ecosystem (RE)	RE description	Queensland Biodiversity Status*	Queensland Vegetation Management Status**	Examples of protected areas that include saltmarsh wetlands^
Brigalow Belt	11.1.1	<i>Sporobolus virginicus</i> grassland on marine clay plains.	No concern at present	Not of concern	Bowling Green Bay NP, Broadsound Islands NP, Cape Upstart NP, Charon Point CP, Townsville Town Common CP, Burdekin FHA, Edgumbe Bay FHA, Broad Sound FHA, Cawarral Creek FHA, Bowling Green Bay FHA, Great Barrier Reef WHA.
	11.1.2	Samphire forbland on marine clay plains.	No concern at present	Not of concern	Bowling Green Bay NP, Broadsound Islands NP, Cape Upstart NP, Charon Point CP, Newport CP, Shoalwater Bay CP, Townsville Town Common CP, Burdekin FHA, Edgumbe Bay FHA, Broad Sound FHA, Bowling Green Bay FHA, Bohle River FHA, Great Barrier Reef WHA.
Southeast Queensland	12.1.2	Saltpan vegetation including grassland and herbland on marine clay plains.	No concern at present	Not of concern	Bribie Island NP, Bullock Creek CP, Burrum Coast NP, Curtis Island NP, Eurimbula NP, Eurimbula RR, Great Sandy CP, Great Sandy NP, Hays Inlet CP 1, Hays Inlet CP 2, Mouth Of Baffle Creek CP, Oregon Creek CP, Poona NP, South Stradbroke Island CP, Kippa-Ring FHA, Colosseum Inlet FHA, Kauri Creek FHA, Rodds Bay FHA, Hay's Inlet FHA, Fraser Island WHA, Great Barrier Reef WHA.

* Biodiversity Status as listed by the Environmental Protection Agency.

** Queensland *Vegetation Management Act 1999* status as of September 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 and migratory fauna commonly associated with Queensland's saltmarsh wetlands.

Taxon group	Common name	Scientific name	NC Act status*	EPBC Act status*	IUCN Red List of threatened species status**
Mammals	False water-rat	<i>Xeromys myoides</i>	vulnerable	vulnerable	vulnerable
Birds	black-tailed godwit	<i>Limosa limosa</i>	–	listed migratory species [‡]	–
	whimbrel	<i>Numenius phaeopus</i>	–	listed migratory species [‡]	–
	eastern curlew	<i>Numenius madagascariensis</i>	–	listed migratory species [‡]	–
	marsh sandpiper	<i>Tringa stagnatilis</i>	–	listed migratory species [‡]	–
	red-necked stint	<i>Calidris ruficollis</i>	–	listed migratory species [‡]	–
	sharp-tailed sandpiper	<i>Calidris acuminata</i>	–	listed migratory species [‡]	–
	curlew sandpiper	<i>Calidris ferruginea</i>	–	listed migratory species [‡]	–
	Pacific golden plover	<i>Pluvialis fulva</i>	–	listed migratory species [‡]	–
	lesser sand plover	<i>Charadrius mongolus</i>	–	listed migratory species [‡]	–
	Australian painted snipe	<i>Rostratula benghalensis australis</i>	vulnerable	vulnerable	–
	beach stone-curlew	<i>Esacus neglectus</i>	vulnerable	–	–
	yellow chat (Dawson)	<i>Epthianura crocea macgregori</i>	endangered	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.

‡ Under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* listed migratory species include those species listed in appendices to the Bonn Convention, and in CAMBA and JAMBA.

Appendix 3: Wetlands in Queensland that include saltmarsh wetlands and are listed in *A Directory of Important Wetlands in Australia* (2005) and/or are Ramsar sites and that include saltmarsh wetlands.

Bioregion	Directory reference	Directory wetlands	Ramsar wetlands	
Brigalow Belt North	QLD001	Abbot Point – Caley Valley	–	
	QLD002	Bowling Green Bay	Bowling Green Bay	
	QLD003	Broad Sound	–	
	QLD004	Burdekin Delta Aggregation	Bowling Green Bay	
	QLD005	Burdekin – Townsville Coastal Aggregation	Bowling Green Bay	
	QLD009	Southern Upstart Bay	–	
	QLD012	Fitzroy River Delta	–	
	QLD017	Northeast Curtis Island	–	
	QLD019	Port Curtis	–	
	QLD021	The Narrows	–	
	QLD022	Yeppoon – Keppel Sands Tidal Wetlands	–	
	QLD181	RAAF Townsville	–	
	Central Mackay Coast	QLD043	Corio Bay Wetlands	Shoalwater and Corio Bays
		QLD045	Edgecumbe Bay	–
QLD047		Four Mile Beach	–	
QLD048		Island Head Creek – Port Clinton Area	Shoalwater and Corio Bays	
QLD049		Iwasaki Wetlands	–	
QLD050		Proserpine – Goorganga Plain	–	
QLD051		Sand Bay	–	
QLD052		Sandringham Bay – Bakers Creek Aggregation	–	
QLD053		Sarina Inlet-Ince Bay Aggregation	–	
QLD054		Shoalwater Bay	Shoalwater and Corio Bays	
QLD055		St. Helens Bay Area	–	
QLD178		Shoalwater Bay Training Area Overview	Shoalwater and Corio Bays	
Cape York Peninsula		QLD056	Archer Bay Aggregation	–
	QLD061	Cape Melville – Bathurst Bay	–	
	QLD063	Jardine River Wetlands Aggregation	–	
	QLD064	Lloyd Bay	–	
	QLD066	Newcastle Bay – Escape River Estuarine Complex	–	
	QLD067	Northeast Karumba Plain Aggregation	–	
	QLD069	Olive River	–	
	QLD071	Port Musgrave Aggregation	–	
	QLD072	Princess Charlotte Bay Marine Area	–	

Bioregion	Directory reference	Directory wetlands	Ramsar wetlands
	QLD073	Silver Plains – Nesbit River Aggregation	–
	QLD074	Skardon River – Cotterell River Aggregation	–
Gulf Plains	QLD103	Buffalo Lake Aggregation	–
	QLD111	Nicholson Delta Aggregation	–
	QLD112	Smithburne – Gilbert Fan Aggregation	–
	QLD113	Southeast Karumba Plain Aggregation	–
	QLD114	Southern Gulf Aggregation	–
	QLD115	Stranded Fish Lake	–
	QLD116	Wentworth Aggregation	–
South East Queensland	QLD126	Burrum Coast	–
	QLD127	Bustard Bay Wetlands	–
	QLD129	Colosseum Inlet – Rodds Bay	–
	QLD131	Fraser Island	Great Sandy Strait
	QLD132	Great Sandy Strait	Great Sandy Strait
	QLD133	Lake Weyba	–
	QLD134	Moreton Bay	Moreton Bay
	QLD135	Noosa River Wetlands	–
	QLD136	Pumicestone Passage	Moreton Bay
	QLD179	Wide Bay Military Training Area	–
	QLD185	Coolum Creek and Lower Maroochy River	–
	QLD188	Upper Pumicestone Coastal Plain	Moreton Bay
	QLD189	Bribie Island	Moreton Bay
	QLD190	Pine River and Hays Inlet	Moreton Bay
	QLD191	North Stradbroke Island	Moreton Bay
	QLD194	Lake Coombabah	Moreton Bay
Wet Tropics	QLD139	Bambaroo Coastal Aggregation	–
	QLD142	Cowley Area	–
	QLD143	Edmund Kennedy Wetlands	–
	QLD144	Ella Bay Swamp	–
	QLD146	Herbert River Floodplain	–
	QLD148	Hinchinbrook Channel	–
	QLD154	Lower Daintree River	–
	QLD155	Missionary Bay	–
	QLD157	Port of Cairns and Trinity Inlet	–
	QLD158	Russell River	–
	QLD160	Sunday Creek, Broad-leaved Paperbark Site	–