

The Importance of Western Australia's Waterways

There are 208 major waterways in Western Australia with a combined length of more than 25000 km. Forty-eight have been identified as 'wild rivers' due to their near pristine condition. Waterways and their fringing vegetation have important ecological, economic and cultural values. They provide habitat for birds, frogs, reptiles, native fish and macroinvertebrates and form important wildlife corridors between patches of remnant bush. Estuaries, where river and ocean waters mix, connect the land to the sea and have their own unique array of aquatic and terrestrial flora and fauna.

Waterways, and water, have important spiritual and cultural significance for Aboriginal people. Many waterbodies such as rivers, soaks, springs, rock holes and billabongs have Aboriginal sites associated with them.

Waterways became a focal point for explorers and settlers with many of the State's towns located near them. Waterways supply us with food and drinking water, irrigation for agriculture and water for aquaculture and horticulture. They are valuable assets for tourism and are prized recreational areas.



An impacted south-west river section - salinisation and erosion on the upper Frankland River. Photo S. Neville ECOTONES.

Many are internationally recognised and protected for their ecological values, such as breeding grounds and migration stopovers for birds. WA has several Ramsar sites including lakes Gore and Warden on the south coast, the Ord River floodplain in the Kimberley and the Peel Harvey Estuarine system, which is the largest Ramsar site in the south west of WA. Some waterways are protected within national parks for their ecosystem values and beauty. Examples are the Fitzgerald River National Park, Geikie Gorge National Park (Fitzroy River), Rudall River National Park and D'Entrecasteaux National Park (Warren River).

Aboriginal significance

Water, and the landscape features it creates, are important in the customs, folklore and spiritual beliefs of Aboriginal people. Waterways and wetlands were important sources of food, such as waterfowl, tortoises, fish, rhizomes, bulbs and roots, and they were also significant trade routes and camping sites. Of special significance are the stories of the serpent-like creatures who created many rivers and wetlands. In the south west this creature is called *Waugal*. Some other names for the serpent include *Beemarra* (parts of the Gascoyne/Murchison), *Warlu* (parts of the Pilbara) and *Wompi* (parts of the Western Desert). Potentially, all rivers, estuaries, wetlands and dunes could be significant Aboriginal sites – for example they could contain objects such as fishtraps or be significant for mythological or ceremonial reasons. These sites are protected under the *Aboriginal Heritage Act 1972*. It is essential that local Aboriginal communities are consulted when undertaking river and wetland management activities. (Reference: *Water Note 30 Safeguarding Aboriginal heritage*, Water and Rivers Commission 2002 and Department of Indigenous Affairs 2003).

The Function of Western Australia's Waterways

A healthy waterway has a stable channel which is supported and maintained by native fringing vegetation. Fringing vegetation such as eucalypts, paperbarks, rushes and sedges, has a number of roles including habitat, shading, holding the banks in place (reducing erosion), filtering material washed from the catchment and slowing water flow. Within waterways, aquatic plants provide food for native fish, waterbirds and frogs as well as breeding habitat and shelter from predators and the harsh summer sun. Areas of fast flow over rocks or logs are known as riffles and are a favoured habitat for many macroinvertebrates. Slower flowing areas such as pools or backwaters are often home to many

native fish. Floodplains provide important habitat for small crustacea, wading birds, frogs and fish. For some species the inundation of the floodplain is crucial to part of their lifecycle.

Transportation and storage of water is one of the most significant functions of waterways. Floodplains and estuary basins help to carry floodwaters during major floods when rivers burst their banks and floodwaters spill out onto the land. Floodplains reduce the amount of water the river channel must carry during the height of a flood, helping to protect the channel from incision and widening. Floodplains are also often prized as highly productive agricultural land where floods transport and deposit nutrient rich sediment, increasing soil fertility.

Western Australia's Waterways are Unique

Climate is a major contributor to the different types of waterway in the State. The sheer size of Western Australia means that the State covers several climatic regions. In the arid inland areas the landscape is so flat and dry that waterways are often no more than a dip in the ground and only flow after sporadic rains. In the north west, waterways range from spectacular gorges, spring-fed pools and complex floodplain channels, to seasonal lakes, dry sand-filled rivers and small rocky headwater creeks. Waterways in the coastal areas of the lower south west experience a Mediterranean climate and can flow all year round.



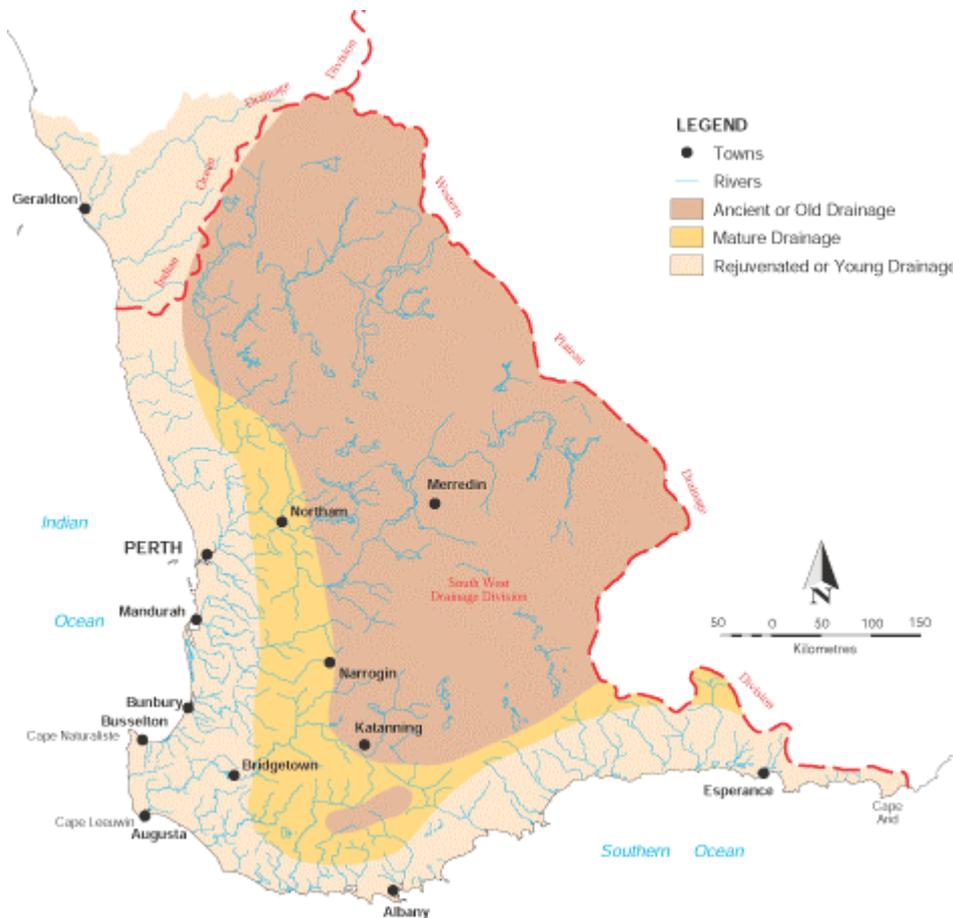
Photo S. Neville, ECOTONES.

Here is a climatic snapshot:

- A north-west river system - tidal mudflats and floodplain on the low Ord River. The north-west Kimberley region has a tropical climate with monsoonal rains and large river flows in summer.
- The Pilbara and Gascoyne regions have a hot dry climate with at times intense rains associated with summer cyclones.
- The Gibson and Great Victoria deserts are hot and dry for most of the year, with evaporation often exceeding rainfall.
- The south-west of the State experiences a Mediterranean climate with winter rain and long dry summers.

A feature of the Western Australian landscape is the water cycle. Most of the State receives less than 400 mm of rain per year and waterways are naturally subjected to alternating flood and dry cycles. The scarcity of water and its distribution in time and space has, however, contributed to a great diversity of plants and animals. In particular, plant species have evolved that can tolerate, even thrive, in cycles of severe drought and flood. River pools form a vital refuge for fauna during long hot summers and dry seasons. In arid and semi-arid areas, the natural cycle is for river pools to recede and water temperatures to increase, causing them to become depleted in oxygen and high in nutrients. In these conditions fish deaths often result, providing water birds with a feast.

Of all the State's waterways, those in the south-west are the most understood. These rivers drain three distinct zones:



- Ancient (dark brown), mature (yellow) and rejuvenated (light brown) drainage zones in the south-west.
A zone of ancient drainage in the inland areas where the climate is semi-arid to arid (<450 mm of rain/year). The landscapes in this region are some of the oldest in the world and have been stable and above sea level for about 400 million years. The region contains chains of salt lakes connected by very broad and diffuse drainage lines. These waterways only flow after widespread, prolonged and/or intense rainfall.
- A zone of mature drainage in regions that receive 450 - 650 mm of rain/year. The rivers are typically ephemeral, with flows following winter rains and only pools remaining in the dry summers.
- A rejuvenated zone receiving >600 mm of rain/year nearer the coast. Rivers in this zone have well defined channels and valleys, are strongly seasonal and are perennial in the high rainfall areas along the coast.

The Flora and Fauna of Western Australia's Waterways

Many of our native flora and fauna have adapted to cope with recurrent periods of drought. For instance, the Western Spotted Frog, which lives in the seasonal waterways of the wheatbelt, survives the hot dry summers by burrowing into moist sand and waiting for winter rains. Some macroinvertebrates lay drought-resistant eggs in the streambed so that when flow resumes, juveniles will hatch and colonise the waterway.

Other species, such as native fish, require permanent water and are behaviourally adapted to seek areas that are permanently wet. They will often leave a drying creek and move downstream in search of deep pools and permanent stream sections during the dry period, then migrate back upstream when flow resumes. 'Resurrection plants' shut down their biological systems in drought conditions, then resurrect them to continue their growth and reproduction when wet weather returns.

Lampreys (*Geotria australis*)

Pouched lampreys are primitive eel-like fish that have been in existence for over 280 million years. They are found between Margaret River and Denmark and are usually only seen at night. During the day, lampreys hide under rocks and logs and among fringing vegetation. Adults spend most of their lives at sea, but migrate upstream in winter and spring to the headwaters of permanent fresh creeks to breed. Lamprey guides can be constructed to help lampreys bypass barriers such as dams and weirs and continue their swim upstream. Larval lampreys spend about 4 years filter feeding from



The Lamprey. Photo: L.Pen

burrows in soft sediments before metamorphosing (or changing) into miniature adults (30-80mm long) and moving to the ocean where they grow up to 650mm long. Lampreys

are brilliant cobalt blue with bright greenish lateral stripes in the ocean, but change to drab brown in fresh water streams. They feed on fish by sucking or rasping away blood and flesh using a suctional disk (similar to a leech) lined with tiny teeth surrounding a mouth.

Water Rat (*Hydromys chrysogaster*)

The water rat, or Ngoodjo (a Noongar name for the mammal), is found throughout Australia. It is also known as Rakali. The Ngoodjo lives in fresh, brackish and marine environments and is the only inland aquatic mammal in south-west Australia. Its waterproof fur is black to brown on its back, white to orange on its belly and its tail is black with a white tip. The Ngoodjo is a placental mammal and raises its young in a nest at the end of a long burrow in the riverbank. The opening of the burrow is located beneath the water surface. It eats crayfish, aquatic insects, mussels and fish. Predators include snakes, birds of prey, feral cats and large fish. The Ngoodjo is also under threat from habitat destruction as a result of changes in river condition. The Ngoodjo is the River RATs' mascot. River RATs - river restoration action team members - are people who are actively involved in protecting and restoring our rivers.



The Water Rat. Photo: ©Babs and Bert Wells/ Department of Conservation and Land Management.

Long-necked Tortoise (*Chelodina oblonga*)

Long necked tortoises or Booyi (a Noongar name for them) mainly live in river pools and other permanent stretches of waterways and wetlands in south west WA, and can often be seen resting on woody debris that protrudes from the water surface. Their shells are about 40cm long and are dark brown to black on top and whitish underneath. Booyi eat crayfish, insects, molluscs and fish. Females only leave the water for a short period to bury their eggs in nearby soft sands. The eggs are left undefended to incubate in the soil until about mid-winter when they hatch, and the young dig their way out and



The Long-necked Tortoise
Photo: ©Frank O'Connor

move to the water. The survival of Booyi populations therefore depends on the presence not only of permanent water but also of adjacent areas of soft soil. Booyi increasingly have to lay their eggs in unsafe localities such as sandy ridges, open paddocks and gardens as many of their usual breeding areas are being lost through development and soil compaction. Nests are also prone to inadvertent destruction. In addition, the journeys of the females and the young are hazardous as they often have to cross open ground where they are exposed to the sun, predators and road traffic.

Management of Western Australia's Waterways

Many waterways are degraded as a result of activities such as agriculture, land clearing, urban and industrial landuse, recreation and tourism. Changes in waterway condition can have dramatic consequences that are difficult to reverse. Water quality (eg excess nutrient levels) is generally declining across the State and a large number of waterways are becoming increasingly saline. Freshwater and estuarine fish habitats are being lost as a result of declining water quality and flows. Extensive algal blooms are signalling that aquatic systems are no longer able to accommodate the changes we have made in catchments. Other issues include loss of fringing vegetation, weed infestation, erosion and sedimentation. Construction of dams has had significant impacts. For instance, the Ord River Dam changed the flow in the Ord River from seasonally large flows, to less intense, continual flows resulting in ecological changes and impacts on cultural values. The impacts on our ecological, cultural, aesthetic, recreational and economic values of our waterways are enormous but often go unnoticed until the function or value of a waterway is compromised, such as by algal blooms.

There is a pressing need to manage and protect our waterways. They are a reflection of the landuse, topography, rainfall and geology in a catchment. Conserving and restoring waterways, together with better understanding of waterways and catchment management practices, will help improve water quality and ecosystem health, and reduce environmental problems in estuaries and coastal areas, leading to increased productivity and land values and allowing us to maintain a wide diversity of values and uses. The Department of Environment works closely with the community on activities to protect and manage Western Australia's waterways.

Some Facts and Figures about Waterways in Western Australia

Rivers:

- Most of the State receives less than 400mm of rain per year and has evaporation rates in excess of 3 metres per year. It is therefore not surprising that only 43% of the State's area has defined drainage systems.
- The total average annual discharge from rivers in the South-west, Pilbara-Gascoyne-Murchison and Kimberley regions is about 40,000 Gigalitres. This is less than 1/100th of the Amazon River's average annual discharge.
- The Fitzroy River is the largest river in the State in terms of average annual discharge (about 9,000 Gigalitres).
- The Gascoyne River is the longest river in the State (about 800 kilometres).



The spectacular Windjana Gorge on the Lennard River in the Kimberley. Photo: P. Howard

- The Avon River drains the largest catchment in the State (about 121,000km²).
- There are 208 major rivers extending over more than 25,000 kilometres.
- There are 26 rivers that have been identified as 'wild' (as of the year 2000).
- Less than 1% of the State's rivers can be said to be pristine or near pristine (1998).
- The Kimberley drainage division contributes over 74% of the State's total surface water flow, while the South-west drainage division makes up less than 11% (2001).
- On a State-wide basis 90% of stream flow is allocated to the environment (2000).

Estuaries:

- The State has 169 recognised estuaries (2001).
- The State has only 0.02% of its area in estuaries (1996).

Wetlands:

- There are 9 wetland sites listed on the 'Ramsar list' (2000).
- There are over 10,000 identified wetlands in the Swan Coastal Plain area alone (2001).

Groundwater:

- Groundwater moves very slowly, with some bores tapping water that fell as rain 1-2 million years ago.
- The largest areas of dryland salinity in Australia are in the agricultural zone of south-west Western Australia. Groundwater levels in this region are still rising and over 4 million hectares are at risk. This figure could double by 2050 (estimate made in 2001). Without intervention, 450 endemic plant species may be lost, and up to \$400 million p.a. in agricultural production may be lost (2000).

Management issues:

- In the south-west alone, waterways are a natural resource that contribute to an agricultural industry worth \$5 billion, commercial fisheries worth \$11.2 million, and tourism worth \$2 billion per year (2000).
- There are approximately 300 groups and organisations that have a direct interest in waterways management (2000). Providing adequate support for the important work of these groups, and helping to coordinate their activities is a major challenge.
- Between 1971 and 1991, the population of Perth's outer suburbs increased 6-fold and in doing so became the fastest growing region of Australia (1998).



A coastal south-west river system - the Warren River within the southern Karri forest. Photo S. Neville, ECOTONES.

- The State's population is expected to increase from 1.8 million in 1998 to 2.7 million in 2029 (1999). This growth rate increases the pressure on the State's water resources (e.g. increased demand for high quality water, increased stormwater pollution, increased clearing of land).
- Water use in the last 15 years has roughly doubled to approximately 15GL/year and is expected to double again in the next 20 years (2000). This trend places pressure on existing water resources, given Australia is the driest inhabited continent and has the least run-off to rivers as a percentage of the mean annual continental precipitation (2001).

Waterways of the South Coast Region

Stretching from Walpole to Esperance, the South Coast Region boasts 26 major rivers and more than 30 estuaries, the majority of which are closed by sandbars for at least part of the year. Waterways include the Frankland-Gordon, Shannon, Pallinup, Kalgan and Fitzgerald rivers and the Broke, Wilson, Stokes and Culham inlets. The largest river by volume in the South Coast region is the Frankland River with an average annual flow of 204 gegalitres.

Waterways in the western part of the region (Walpole to Albany) often flow all year round and are generally fresh due to the high annual rainfall of this area (~1200 mm pa). Rainfall is much lower (400-600 mm pa) for the eastern rivers (Albany to Esperance), so they only flow after heavy rainfall events and are naturally brackish to saline. Permanent deep river pools are often found in their lower reaches and many form major corridors linking significant areas of vegetation.

Many of the south coast waterways are prized recreational areas and are also internationally recognised for their ecological values. Fitzgerald Inlet, Beaufort Inlet, the Angove River and Oyster Harbour are registered on the National Estate Database for their biological diversity and their wading bird habitat. Lake Gore and Lake Warden are internationally recognised Ramsar wetlands (Ramsar is an international wetland protection agreement signed by the Federal Government at Ramsar in Iran in 1971). The Deep, Weld and St Mary Rivers are relatively unspoiled river systems entirely protected within national parks. The Fitzgerald River National Park is an internationally recognised biosphere reserve.

There are 10 species of native freshwater fish found in south coast waterways, such as the common jollytail (*Galaxias maculatus*) and the western minnow (*Galaxias occidentalis*). Some of these are highly restricted in their distribution. For instance, in WA, the trout minnow (*Galaxias truttaceus*) is restricted to the Goodga River east of Albany. A fish ladder was built on the Goodga River in 2003 to allow the trout minnow to overcome a weir and travel upstream to reach valuable habitat and breeding areas.

The region supports a variety of primary industries, including agriculture, viticulture, horticulture, aquaculture, forestry and mining. The pressures on waterways from these industries, as well as from urban development, are significant.

Several rivers and estuaries in the region are in pristine (Deep, Weld, St Mary) or near pristine (Bow, Hamersley, Phillips) condition. However, many waterways are showing signs of degradation, in particular loss of fringing vegetation and consequently high levels of erosion and sedimentation. High sediment loads from cleared areas transport large amounts of nutrients downstream, causing eutrophication and algal bloom threats in waterbodies such as the Torbay, Parry and Beaufort inlets. In extreme cases, annual toxic algal blooms present a health risk. Some river systems such as the Kent and Frankland-Gordon Rivers are showing increased stream salinities due to extensive clearing in the upper catchments. There has however been considerable on-ground



Fish ladder on Goodga River. Photo: J. Oates.

works by landowners to protect many of these waterways, for instance 96 per cent of the Kalgan River is now fenced to protect riparian vegetation.

Waterways of the Kimberley Region

The Kimberley Region extends north east from Broome to Kununurra and the WA/Northern Territory border, and south past Halls Creek to the Canning Basin. Waterways are distinctive due to their size and the volume of water they carry – 74% of the State's total surface water flow is carried by Kimberley waterways. Major rivers include the Fitzroy, Ord, Prince Regent, King Edward and Drysdale rivers. The Fitzroy River is the largest river by volume in the State, with an average annual flow of 6,500 gegalitres. The major estuaries are those within King Sound and Cambridge Gulf. Many of our remaining 'wild rivers' are found in the Kimberley.

In the hot summer wet season, monsoonal rains provide tremendous river flows. Many of the smaller streams, dry for many months of the year, become a cascade of waterfalls during the wet season. Flooding is a major feature of the Kimberley, often closing roads and reducing accessibility to more remote areas. Some waterways flow through spectacular gorges while others are broad and sandy. Palm fringed rock pools such as Caroline Pool, Palm Springs and Saw Pit Gorge near Halls Creek provide an oasis in the arid landscape. Most waterways enter the ocean via mudflats and tidal inlets vegetated by mangroves.

Mudflats, tidal creeks and estuaries provide habitat for abundant wildlife, especially saltwater crocodiles, the largest reptiles in the world. Sixteen species of fish are endemic to Kimberley waterways. To survive the harsh climate some fish and frogs bury themselves in mud as inland waters dry up and remain dormant until the next downpour. The spangled grunter can swim long distances in flash floods and has been found many kilometres from the nearest river, having followed a trickle of water in a wheel rut.

Several species of Eucalypt and paperbark (*melaleuca* or *cadjeput*) are found along waterways and pools, providing habitat for birds and bats. The Coolibah (*E. coolabah*) is restricted to inland rivers of the south Kimberley while the river gum (*E. camaldulensis*) is the most widely distributed of all eucalypts in the Kimberley. The Boab (*Adansonia gregorii*) is a distinctive deciduous tree of the Kimberley with its root like branches sprouting from the top of its thick trunk. It occurs along waterways and on sandplains where the watertable is shallow. It is a calendar plant because when its large white flowers appear, it means the wet season is about to begin. The boab is traditionally of great importance to Aboriginal people. Various parts of the tree provide food, medicine, fibre, glue and shelter. The gourd like fruit is rich in protein and Vitamin C and carved as an ornament. The bark of the tree is used for making twine and the gum as glue.

Waterways in the Kimberley are highly valued tourist attractions and are vital lifelines for the flora, fauna and people living and working in the region. They have important spiritual and cultural significance for Aboriginal people. Stretches of waterways are protected within national parks, such as Lennard River (Windjana Gorge National Park), Fitzroy River (Geikie Gorge National Park), Tunnel Creek and Drysdale River. The Ord River Floodplain and Lakes Argyle and Kununurra are internationally recognised Ramsar sites, providing drought refuge, a migration stopover area for many bird species and habitat for freshwater crocodiles and fish.

The major landuses in the region are tourism, recreation, pastoralism and mining. Growth in tourism may increase contamination and erosion, and decrease biodiversity of waterways, and needs to be managed carefully.

The overall condition of Kimberley waterways is good. Waterways are generally fresh with low nutrient levels and estuaries and embayments are typically in near-pristine condition. Fringing vegetation is usually in excellent condition in the relatively robust rocky rivers of the north and north west Kimberley. However, in some areas vegetation changes due to fire, human disturbance, landuse activities and

feral animals have resulted in widespread erosion and sedimentation. Noogoora Burr and other weeds are a significant problem across the Kimberley, particularly on the Ord and Fitzroy Rivers.

The Ord River estuary is notably altered as a result of the construction of the Ord River Dam in 1971. This changed the flow in the Ord River from the usual seasonally large flows that moved large amounts of sediment, to less intense, continual flows with increased deposition of sediment. This has resulted in some positive ecological changes, where the previously overgrazed riparian vegetation has now recovered and the permanent water supply and heavy fringing vegetation provide a refuge to compensate for loss of seasonal wetlands elsewhere. However, it has also resulted in colonisation of exotic species and loss of cultural values. Small areas in the lower Ord and lower Dunham Rivers are being actively managed to minimise the impacts of pesticides used in the irrigation district.

Waterways of the Pilbara Region

The Pilbara Region includes the coastal towns of Onslow, Karratha and Port Hedland and extends inland across the desert to the State border. Waterways in the Pilbara may be dry for years and then flood overnight. This pattern is driven by episodic rainfall from cyclones during summer and, in some years, by winter rain. The main rivers are the Ashburton, Fortescue, Yule and De Grey rivers. The largest river by volume in the Pilbara is the De Grey River with an average annual flow of 1,480 gigalitres. The De Grey River estuary is the largest shallow estuary in north west Australia.

The waterways of the Pilbara drain the uplands of the Hamersley, Ophthalmia, Chichester and associated ranges. They generally have well-defined courses and are fresh, in contrast with the ill-defined drainages of the desert lands. The waterways characteristically flow through extensive floodplains in their lower reaches, whereas their headwaters often flow through rocky gorges. At their ocean outlet some waterways disperse into broad salt marsh areas before merging with tidal inlets.

During the dry periods, permanent river pools become vital refuges for wildlife. These river pools are teeming with life and their biodiversity may even rival the Amazon rainforest. The Millstream Pools on the Fortescue River are amongst the most culturally and environmentally significant places in the Pilbara. They support several species of flora and fauna that are endemic to the area, such as the Millstream fan palm (*Livistona alfredii*), the Fortescue grunter (*Leiopotherapon apheneus*) and some insects, such as dragonflies and damselflies. The De Grey River also contains permanent pools which provide a significant drought refuge for freshwater fish and 20 species of waterbirds (mostly darters, cormorants, and herons).

The beauty of the waterways are a major tourist attraction, such as the pools, waterfalls, and gorges of Karijini National Park, the oasis-like pools of Millstream National Park, or the virtually unchanged landscape of Rudall River National Park. The Pilbara has a strong cultural heritage and is richly endowed with Aboriginal rock engravings.

Tourism, mining and pastoralism are the major landuses and they exert various impacts. The Harding River Dam, completed in the 1980s, captures 80 per cent of the water from the catchment. This has significantly changed downstream pools and their fringing vegetation. Dewatering from mining operations has resulted in some waterways now having permanent flow resulting in changes to native vegetation and fauna. These effects need to be considered in the long term, as do impacts of discharging groundwater of different quality and characteristics into surface water bodies. Tourism and recreation are largely focussed on river crossings and permanent river pools such as Millstream and Miaree Pool.

Most waterways are fresh with low nutrient levels. Estuaries are largely unmodified. Fringing vegetation is in reasonable condition. There is some deterioration in vegetation health due to drought, fire, grazing and noxious weeds (including Date Palms, Parkinsonia and Mesquite). Impacts from tourism and recreation include bank instability, trampling and removal of vegetation, changes to water quality and reduction in aesthetics due to impacts from recreation and tourism. Significant vegetation loss and associated erosion has occurred at Millstream on the Fortescue River.

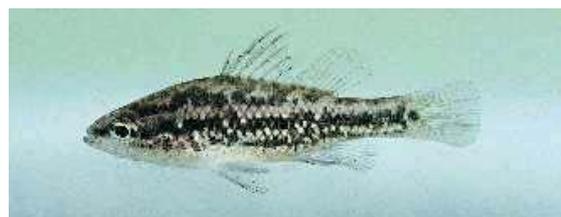
Waterways of the Kwinana-Peel and South West Regions

The Kwinana-Peel and South West Regions extend from Rockingham near Perth, south to Northcliffe and inland east of Katanning. For simplicity we will refer to these two regions collectively as the south west. Major rivers include the Murray, Serpentine, Preston, Collie, Blackwood and Warren rivers. Along the coast, significant estuaries and wetlands are the Peel-Harvey, Leschenault and Hardy inlets and the Vasse-Wonnerup wetlands. Important inland waterbodies include Lakes Muir, Unicup, Dumbleyung and Toolibin. Lake Jasper, in the D'Entrecasteaux National Park, is the largest natural freshwater lake in Western Australia. The largest river by volume in the south west is the Blackwood River with an average annual flow of 740 gegalitres.

Waterways range from naturally brackish or saline intermittent waterways in the low rainfall areas (350 mm), to those that are fresh and permanently flowing near the high rainfall coastal areas (1100 mm). Waterways in the wheatbelt are often broad, shallow valleys and cover ancient drainage lines called palaeochannels, which are buried by sediments up to 60 m deep. Some estuaries are permanently open by intervention. The waterways nearer the coast often flow through Eucalypt forest and are heavily used for recreation and tourism activities, such as white water rafting along the Murray River, canoeing on the Blackwood River, as well as fishing, camping, picnicking and walking. Eucalypts and paperbarks over sedges and rushes commonly make up the fringing vegetation along waterways in the southwest. Many of the ecosystem elements typical of south west waterways include gum leaves, woody debris, shade and tannin stained water. Vegetation dominates river habitats in the southwest, but where the gradient is steep, rock may dominate, creating riffles, rapids or cascades.

Long necked tortoises (*Chelodina oblonga*) can often be seen resting on woody debris in river pools and other permanent stretches of waterways and wetlands. Native fish such as the pygmy perch (*Edelia vittata*), the nightfish (*Bostockia porosa*) and the western minnow (*Galaxias occidentalis*) are also common. Like the lamprey, native fish migrate upstream to spawn. Barriers in waterways such as dams and gauging stations prevent the migration of fish and interrupt their life cycles. Fishways or fish ladders (low gradient channels) can be constructed to help fish move upstream. A rock ramp fishway was built to provide passage past the Margaret River Weir for lampreys and other native fish that traditionally migrate upstream to breed. The fishway creates a series of step pools to assist fish climb over the two metre rise from the riverbed to the weir. A similar fishway was also built at the Hotham River weir in Boddington.

Waterways are prized recreation and tourism areas and supply water to agriculture, fisheries, and mining. They also have significant ecological values. Waterways that are protected for their significant ecological values include Lefroy Brook (Gloucester National Park), Warren River (D'Entrecasteaux National Park), the Vasse-Wonnerup wetlands and the Peel Harvey Estuarine system. The Vasse-Wonnerup wetland system was listed in 1990 as a wetland of ecological importance under the Ramsar Convention (an international wetland protection agreement signed by the Federal Government at Ramsar in Iran in 1971) due to its significance as habitat and breeding grounds for many species of birds, particularly the Black Swan. The wetland system is unique in WA as an example of a system of formerly estuarine basins now functioning as season-brackish lakes. The Peel Harvey Estuarine system is the largest Ramsar site in the south west of WA.



Pygmy Perch. Photo: L.Pen

Lake Toolibin near Narrogin is the only freshwater lake left in the wheatbelt as a consequence of vegetation clearing increasing salinity levels. It is a very important flora and fauna refuge. The wetland supports vegetation which is dominated by Sheoaks (*Casuarina obesa*) and Paper barks (*Melaleuca strobophylla*) and it is an important breeding area for many waterbirds including the rare Freckled Duck (*Stictonetta naevosa*). It is under threat from salinity and is being managed by the State Government and local landholders to halt the threat of salinity.

The south west supports a range of landuses including urban development, horticulture, broadacre farming, intensive animal industries, plantations and mining.

The condition of the waterways is variable. There is some increased salinisation in the upper parts of the Warren River and the upper and middle parts of the Blackwood River. Fringing vegetation is generally degraded in cleared agricultural areas but is in good condition in the forested areas. Sedimentation levels are high in all coastal plain rivers and estuaries. Many of the rivers have been incised due to major changes in the catchments (clearing, loss of fringing vegetation, uncontrolled stock access, erosion, and sedimentation) and no longer have the characteristic deep pools. Weed infestations are also a major problem in south west rivers. Potential contamination of rivers with pesticides used in horticultural areas is of concern.

Water quality is the major environmental problem throughout the region. High levels of nutrients as a result of the limited nutrient-holding capacity of the sandy soils, clearing and high rates of fertiliser application and effluent discharge result in eutrophication. Regular toxic and nuisance algal blooms and fish deaths occur in many of the river and estuary systems, notably the Vasse-Wonnerup and the Serpentine. In addition, abundant introduced feral fish (redfin perch, gambusia and carp) compete with native fish populations in the rivers and impact on the biological diversity. The south west estuaries suffer degrees of modification and degradation, as many drain agricultural and urban areas.

More Information on South-west Streams

More information on river function and management can be obtained by ordering the book [Managing Our Rivers - A Guide to the Nature and Management of the Steams of South West Western Australia](#).

Waterways of the Midwest Gascoyne Region

The Midwest Gascoyne Region begins on the coast near Cervantes and ends just north of Exmouth, extending inland to Mt Magnet. Major rivers include the Murchison, Hutt, Hill, Moore and Gascoyne rivers. The major estuaries include those of the Greenough, Chapman, Hill, and Moore rivers. The Gascoyne River is the longest river in WA at about 800 km. It is also the largest river by volume in the Midwest Gascoyne, with an average annual flow of 766 gegalitres.

Annual rainfall ranges from 200-500 mm, so it is usual for waterways to flow only after it rains. River flow in the semi arid north (near Carnarvon and Exmouth) is driven by cyclonic rain and in the temperate south (near Geraldton) by winter rains. Many waterways are naturally brackish. There are a wide range of forms, including red sandstone gorges such as Yardie Creek and the Murchison River, broad valleys such as the Wooramel, Gascoyne, Lyons, Minilya, Lyndon and Ashburton rivers and meandering coastal plain waterways such as the Irwin and Moore rivers.

Lake MacLeod, a near pristine natural salt lake 30 km north of Carnarvon, is home to diverse bird species and an important resting spot for transequatorial migratory waders. Other inland waterbodies provide important refuges for many species. Lake Wooleen, a floodplain lake on the Roderick River which outflows to the Murchison River, holds shallow water in most years but once every 5-10 years it fills and becomes a major breeding ground for the gull-billed tern (*Gelochelidon nilotica*) and many other waterbirds. The Murchison River gorge is the only known location of the primitive fern *Psilotum nudum*.

The estuaries in the region are the focus of recreation and tourism. Regional waterways also supply water to agriculture, pastoral, fisheries, and mining landuses. Waterways that are protected for their significant ecological values include Greenough, Chapman, Hill and Moore river estuaries, which are significant migratory bird feeding areas and Yardie Creek Estuary at the entrance to the unique Ningaloo Reef Marine Park. The Bully and Woonana Pools (in Kalbarri National Park) are nationally recognised because of their outstanding natural beauty. These, and Cattle Pool on the Lyons River (Mt Augustus National Park), are good examples of permanent river pools.

The region has been extensively cleared for agriculture in the southern portion where fresh groundwater is relatively plentiful. In the north, the Gascoyne region is largely uncleared although horticultural activity occurs in areas adjacent the Gascoyne River. Urban centres, mining, pastoralism and aquaculture are also important landuses.

Waterways and estuaries in the south are impacted by urban and rural landuse resulting in high levels of erosion, sedimentation and nutrients. The Moore River estuary is subject to algal blooms during summer, particularly when the sand bar remains closed. Few fresh streams remain in the Greenough and Murchison basins and many are increasing in salinity as a result of catchment clearing. The condition of fringing vegetation is generally moderate to poor and continues to deteriorate from land uses such as grazing. The Hill River estuary, for example, has good quality water and extensive intact fringing remnant vegetation and is therefore of high ecological value. Further north, the waterways generally have low nutrient levels and estuaries in the Gascoyne region are largely unchanged.

Waterways of the Swan Goldfields Agricultural Region

Beginning in Perth, the Swan Goldfields Agricultural Region extends east through the wheatbelt and past Kalgoorlie to the South Australian border. Major waterways include the Swan-Canning, Helena and Ellen Brook on the coastal plain, the Avon, Dale, Lockhart, Yilgarn and Mortlock Rivers in the Avon Catchment and Ponton Creek, a wild river in the goldfields. The Avon River drains the largest catchment area in the State (about 121,000 km²). The largest river by volume in the Swan Goldfields Agricultural Region is the Swan River with an average annual flow of 506 gigitalitres.

Waterways in the eastern arid shrublands (<230 mm rainfall pa) are short, ill-defined, flow only after sporadic cyclone rainfall events and usually disappear in flat lands or shallow lakes. In the Avon Basin (300-700 mm rainfall pa) waterways are often braided (more than one channel) and are broad and shallow, with some channels only flowing after high rainfall. The majority of river flows are naturally brackish to saline. Chains of natural salt lakes link together across broad flat valley floors following high rainfall events. The higher rainfall (900-1100 mm pa) and increased gradient over the Darling Scarp give the waterways defined channels and pools often form between rocky rapids with the occasional waterfall. The Avon River becomes the Swan River at Wooroloo Brook and waterways meander across the flat coastal plain to become the Swan-Canning Estuary.

Paperbarks, flooded gums and sheoaks are the main trees to be found along waterways in the higher rainfall areas. The upper section of the Swan River flowing through the Darling Range provides habitat for waterbirds and native fish, particularly when waters on the coastal plain and in the wheatbelt dry up in summer and autumn. Riparian vegetation becomes more salt and drought tolerant in the eastern parts of the region. Numerous salt lake systems, such as Lake Deborah, are found in the arid shrublands which fill about once every 10 years, and are major breeding grounds for waterbirds.

The Swan-Canning River is perhaps the most well known in Western Australia, being the major point of settlement and the social, cultural and environmental focus for more than 1.4 million Perth residents. During winter, the Swan-Avon rivers in the Walyunga and Avon Valley national parks provide one of Australia's best white water canoeing courses. Inland waterbodies such as Yenyening Lakes are important social resources, with a strong recreational focus (water skiing) and are important habitat for waterbirds and other native fauna.

Landuses include pastoral and mining activities, agriculture (mainly broadacre farming) and urban development, and place significant pressures on waterways.

The condition of waterways has changed significantly in the last 170 years. The Swan-Canning Estuary had its shallow mud flats dredged, dense fringing vegetation cleared and land reclaimed during the 1800s. Most of the pools in the Avon River have filled with sediment as a result of river training from the mid 1950s to early 1970s to reduce flooding in the town sites. Channels were re-aligned and bed vegetation and debris removed. Flooding is an issue in the Avon Basin, and has the potential to impact towns such as Northam, York, Beverley and Toodyay. Salinisation of Avon



waterways is a significant issue. Both Helena and Canning River systems have high levels of water extraction which impacts on the downstream ecology of the waterways.

Water quality is an issue as high levels of nutrients enter the Swan-Canning Estuary from sources such as leached fertilisers, urban stormwater runoff and agricultural activities. High nutrient use has resulted in infestation of weeds and algal blooms in the Swan-Canning system and fish kills in the Swan-Avon system. The highest nutrient contribution comes from Ellen Brook.



The Swan River. Photo: ©Suzie Wild