Shire of Serpentine Jarrahdale

Clay-Based Wetlands Management Plan

With Reserve Action Plans:

Brickwood Reserve

Serpentine Sports Reserve

Yangedi Airfield Reserve

Karnup Road Flora Reserve

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Clay-Based Wetlands Management Plan

1. Executive Summary

1.1 Introduction

Clay-based wetlands are characteristic vegetation types where clay soils form an impermeable layer close to the surface. Wetlands form that rely solely on rainfall to fill, and dry to impervious pans in summer. Their main features are a shrubland over a ground layer of geophytes and annual flora that flower sequentially as the area dries over summer and are floristically diverse.

Clay-based wetlands principally occur in slight depressions where deposits of clay form a dense, compact, fairly impermeable layer in the soil, predominantly on the Pinjarra Plain on the eastern side of the Swan Coastal Plain, and to a lesser extent the Bassendean dunes and the Ridge Hill Shelf. Clay-based wetlands can fall within four floristic communities (sub-communities), which all occur in the Shire of Serpentine Jarrahdale. These four communities, collectively known as the Clay Pans of the Swan Coastal Plain, are:

- 07 (Herb rich saline shrublands in clay pans)
- 08 (Herb rich shrublands in clay pans)
- 09 (Dense shrublands on clay flats)
- 10a (Shrublands on dry clay flats)

All four communities are listed as Endangered under the Western Australian *Biodiversity Conservation Act 2016*, and as Critically Endangered under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999.* The listings mean that clay-based wetlands have been assessed as both having undergone a high degree of loss and being under a continued high level of threat.

In 2017 (the most recent data available), the “Guildford” vegetation complex (which contains the majority of clay-based wetlands) was assessed as having 5% remaining, and only 4% in the Shire of Serpentine Jarrahdale. The threats to clay-based wetlands are many and significant, including:

- Landuse history, including clearing and fragmentation
- Altered hydrology
- Rising groundwater
- Invasive species
- Inappropriate fire regimes
- Pathogens
- Climate change
- Fauna decline

Four Shire natural area reserves contain clay-based wetlands, as well as other vegetation types (banksia woodland and/or marri woodland) and areas with other uses such as sports fields. These reserves, and their approximate area of clay-based wetlands, are:

- Brickwood Reserve, Byford (2.5 ha)
- Serpentine Sports Reserve (Paul Robinson Reserve), Serpentine (0.29 ha)

- Yangedi Airfield Reserve, Hopeland (6.5 ha)
- Karnup Road Flora Reserve, Serpentine (0.66 ha)

The principal uses of the Shire reserves listed are conservation and recreation. The recreational uses include:

- Recreation centre and ovals – Brickwood Reserve
- Horse and pony club – Serpentine Sports Reserve
- Golf club – Serpentine Sports Reserve
- Airfield and aircraft hangars – Yangedi Airfield Reserve
- Clubhouses and community halls – Brickwood Reserve, Serpentine Sports Reserve, Yangedi Airfield Reserve
- Informal recreation – walking, riding, enjoyment of nature

1.2 Objectives

The objectives of this management plan are to:

- Provide background information and site descriptions for informed management of clay-based wetlands.
- Provide a framework for developing action plans for individual reserves.
- Define specific management objectives for maintaining and improving the conservation values of clay-based wetlands.
- Document the actions required to successfully manage clay-based wetlands.
- Identify any management constraints and possible ways to overcome them.
- Ensure consistent management into the future.
- Provide a plan for user groups to follow when managing clay-based wetlands.

1.3 Report Structure

This management plan is structured into the following sections:

- Background:
  - Identifies the location and physical characteristics of clay-based wetlands.
  - Identifies the legislation and policies that apply and have management implications for clay-based wetlands.
- Threats and pressures:
  - Analyses the threats to clay-based wetlands.
- Reserves:
  - Identifies the locations of Shire reserves containing clay-based wetlands, their vesting and tenure, and main user groups.
- Action Plan:
  - Provides guidance to land managers of clay-based wetlands on actions common to management of all clay-based wetlands.
- Reserve Action Plans:
  - Provides background information on Shire reserves containing clay-based wetlands, their vesting and tenure, main user groups, threats and pressures, and relevant actions.

2. Background

2.1 Location

Clay-based wetlands are characteristic vegetation types where clay soils form an impermeable layer close to the surface. Wetlands form that rely solely on rainfall to fill, and dry to impervious pans in summer. Their main features are a shrubland over a ground layer of geophytes and annual flora that flower sequentially as the area dries over summer and are floristically diverse.

Clay-based wetlands principally occur in slight depressions where deposits of clay form a dense, compact, fairly impermeable layer in the soil. They occur predominantly on the Pinjarra Plain on the eastern side of the Swan Coastal Plain, and to a lesser extent the Bassendean dunes and the Ridge Hill Shelf. Clay-based wetlands in the Shire of Serpentine Jarrahdale occur on the Pinjarra Plain (Guildford soil system) and to a lesser extent the Bassendean dunes, Ridge Hill Shelf (Forrestfield soil system), Beermullah and Dardanup soil systems.

The soil types of the coastal plain portion of the Shire of Serpentine Jarrahdale and their associated vegetation complexes are shown in Figure 1.

2.2 Soils

The exceptional biodiversity in clay-based wetlands is due to long-term geological activity, resulting in variations in soil types within relatively short distances. Clay-based wetlands occur on the Swan Coastal Plain, where the soils originate from two sources. Firstly, erosion of the Darling Range formed the Pinjarra Plain soil complex, characterised by grey sandy duplex soils, clays, loams and gravels. Secondly, sea level fluctuations formed a series of sand dunes on top of the plain.

The Swan Coastal Plain has five main soil types, roughly located parallel to the coastline. The first three are sand dune systems with age increasing with distance from the coast (Quindalup, Spearwood and Bassendean systems), followed by the alluvial Pinjarra Plain and the Ridge Hill Shelf (Forrestfield soil system) at the foot of the Darling Scarp.

Clay-based wetlands principally occur in slight depressions where deposits of clay form a dense, compact, fairly impermeable layer in the soil, predominantly on the Pinjarra Plain on the eastern side of the Swan Coastal Plain, and to a lesser extent the Bassendean dunes and the Ridge Hill Shelf. Clay-based wetlands in the Shire of Serpentine Jarrahdale occur on the Pinjarra Plain (Guildford soil system) and to a lesser extent the Bassendean dunes, Ridge Hill Shelf (Forrestfield soil system), Beermullah and Dardanup soil systems.

The coastal plain soil types of the Perth region are shown in Figure 2, and those of the Shire of Serpentine Jarrahdale in Figure 3.

Each general soil type (Pinjarra, Forrestfield etc.) can be further subdivided into soil landscape units (Pinjarra P1 phase, Pinjarra P2 phase etc.). The soil landscape units that occur in each reserve which contains clay-based wetlands are listed in Table 1, with maps for each reserve included in their action plans.

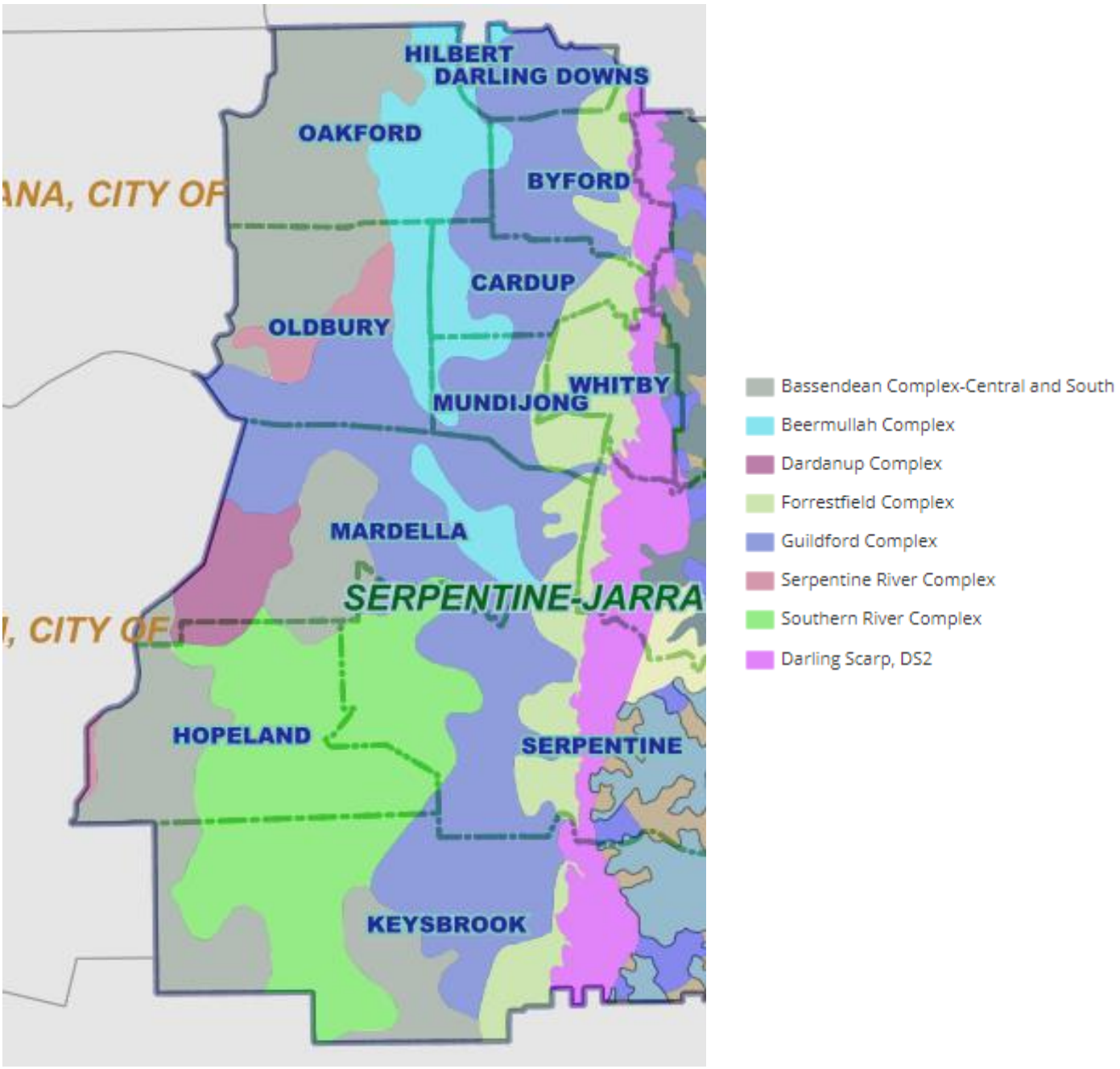

Figure 1: The coastal plain soil types and associated vegetation complexes of the Shire of Serpentine Jarrahdale.

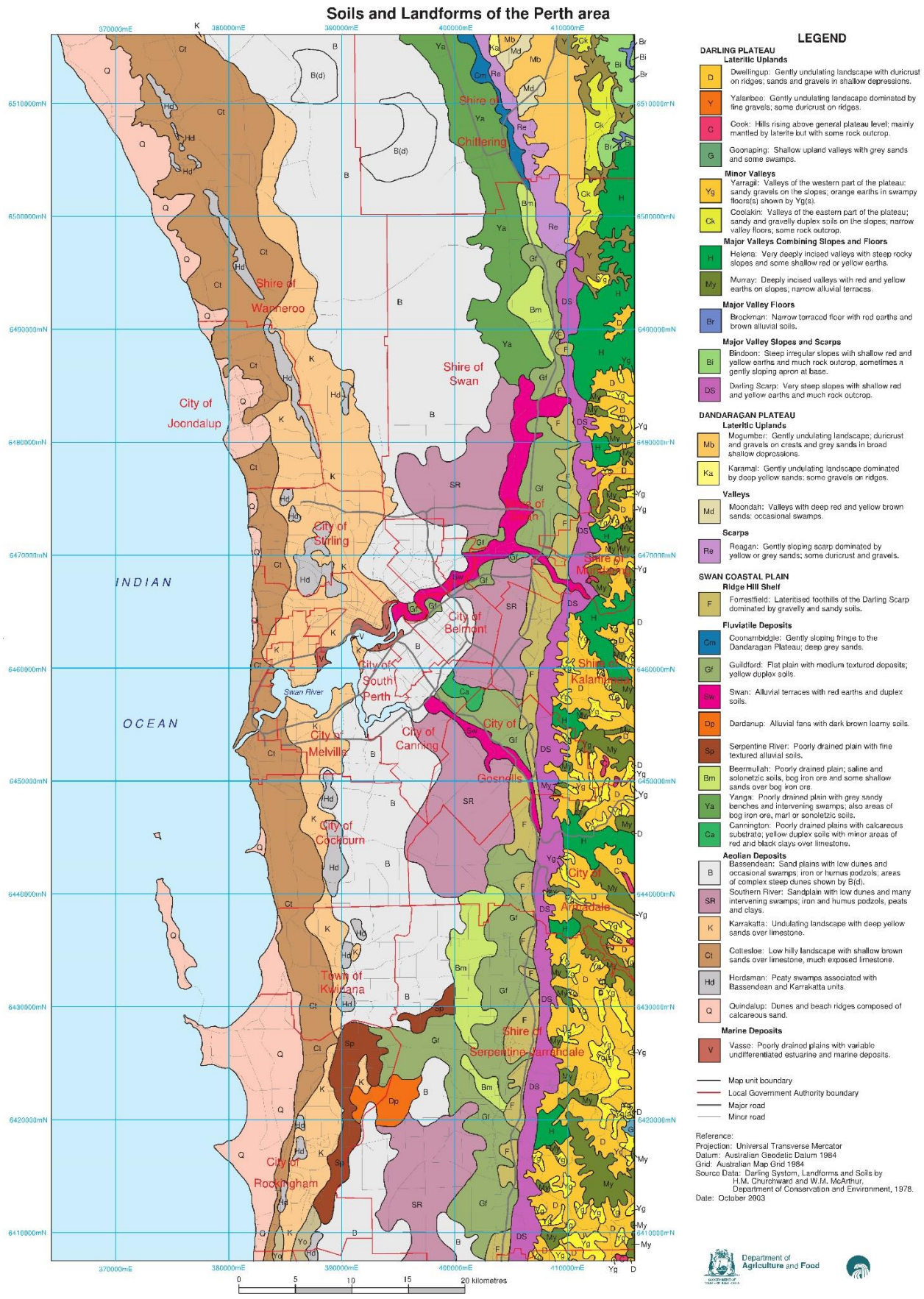

Figure 2: The coastal plain soil types of the Perth region, including the Shire of Serpentine Jarrahdale

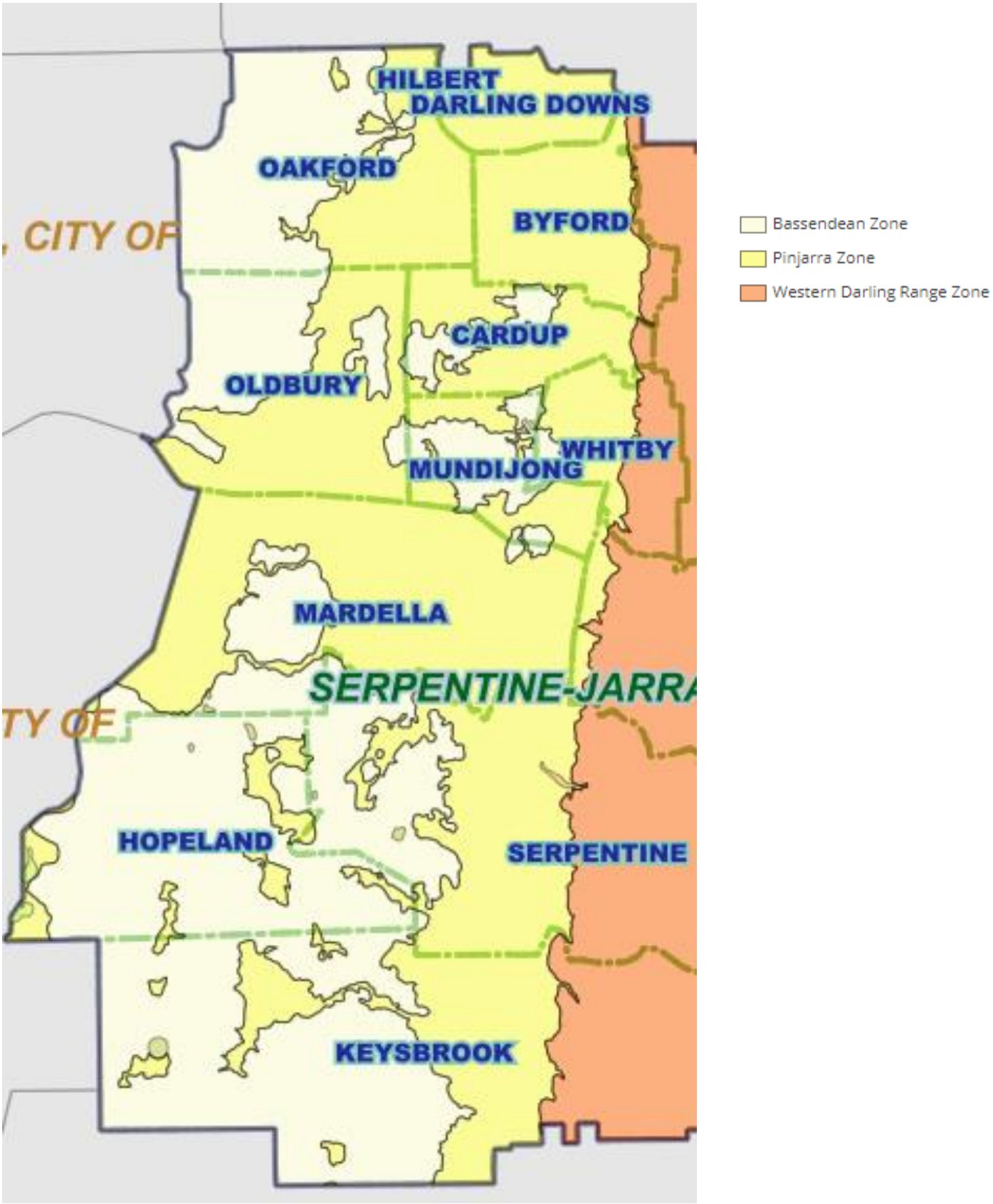

Figure 3: The coastal plain soil type zones of the Shire of Serpentine Jarrahdale.

Table 1: The soil landscape units that occur in each Shire reserve which contains clay-based wetlands (for maps, refer to reserve action plans).

Reserve	Soil landscape unit	Description	Clay-based wetland occurrence
Brickwood Reserve	Forrestfield F5 phase	Poorly defined stream channels on lowest slopes with deep acidic yellow duplex soils and sandy alluvial gradational brown earths.	Yes
	Pinjarra P1a phase	Flat to very gently undulating plain with deep acidic mottled yellow duplex (or effective duplex) soils. Shallow pale sand to sandy loam over clay; imperfect to poorly drained and generally not susceptible to salinity.	No
	Pinjarra P1e phase	Flat to very gently undulating plain with deep acidic mottled yellow duplex (or effective duplex) soils. Shallow pale sand to sandy loam over very gravelly clay; moderately well drained.	No
	Pinjarra B1 phase	Extremely low to very low relief dunes, undulating sandplain and discrete sand rises with deep bleached grey sands sometimes with a pale yellow B horizon or a weak iron-organic hardpan at depths generally greater than 2 m; banksia dominant.	No
Serpentine Sports Reserve	Pinjarra B1 phase	Extremely low to very low relief dunes, undulating sandplain and discrete sand rises with deep bleached grey sands sometimes with a pale yellow B horizon or a weak iron-organic hardpan at depths generally greater than 2 m; banksia dominant.	Partial
	Pinjarra B3 phase	Closed depressions and poorly defined stream channels with moderately deep, poorly to very poorly drained bleached sands with an iron-organic pan, or clay subsoil. Surfaces are dark grey sand or sandy loam.	Partial
	Pinjarra P1b phase	Flat to very gently undulating plain with deep acidic mottled yellow duplex (or effective duplex) soils. Moderately deep pale sand to loamy sand over clay: imperfectly drained and moderately susceptible to salinity in limited areas.	No
	Pinjarra P8 phase	Broad poorly drained flats and poorly defined stream channels with moderately deep to deep sands over mottled clays; acidic or less commonly alkaline gley and yellow duplex soils to uniform bleached or pale brown sands over clay.	No
Yangedi Airfield Reserve	Bassendean B1 phase	Extremely low to very low relief dunes, undulating sandplain and discrete sand rises with deep bleached grey sands sometimes with a pale yellow B horizon or a weak iron-organic hardpan at depths generally greater than 2 m; banksia dominant.	No
	Bassendean B3 phase	Closed depressions and poorly defined stream channels with moderately deep, poorly to very poorly drained bleached sands with an iron-organic pan, or clay subsoil. Surfaces are dark grey sand or sandy loam.	Partial
Karnup Road Flora Reserve	Pinjarra P8 phase	Broad poorly drained flats and poorly defined stream channels with moderately deep to deep sands over mottled clays; acidic or less commonly alkaline gley and yellow duplex soils to uniform bleached or pale brown sands over clay.	Yes

2.3 Biodiversity

2.3.1 Description

Clay-based wetlands are characteristic vegetation types where clay soils form an impermeable layer close to the surface. Wetlands form that rely solely on rainfall to fill, and dry to impervious pans in

summer. Their main features are a shrubland over a ground layer of geophytes and annual flora that flower sequentially as the area dries over summer and are floristically diverse.

Clay-based wetlands lie in the Swan Coastal Plain IBRA region, within which a variety of plant communities occur. The Heddle vegetation classification is based on soil types and landforms with some survey data, under which a vegetation complex contains plant communities that are associated with a single soil landscape system. By the Heddle classification, most clay-based wetlands are Guildford Complex (associated with Pinjarra Plain heavy soils), while others may be Forrestfield Complex (associated with the Ridge Hill Shelf / Foothills soils), Bassendean Complex (associated with the Bassendean Dunes soils), Beermullah or Dardanup Complexes (associated with soils of the same name).

The Gibson analysis of communities on the Swan Coastal Plain (SCP) used the presence or absence of particular species in standard sample areas to define floristic groupings. Clay-based wetlands can fall within four floristic communities (sub-communities), which all occur in the Shire of Serpentine Jarrahdale. These four communities, collectively known as the Clay Pans of the Swan Coastal Plain, are:

- 07 (Herb rich saline shrublands in clay pans)
- 08 (Herb rich shrublands in clay pans)
- 09 (Dense shrublands on clay flats)
- 10a (Shrublands on dry clay flats)

The Shire of Serpentine Jarrahdale has four reserves that contain clay-based wetlands. These reserves, their approximate area of clay-based wetlands, and most likely community, are:

- Brickwood Reserve, Byford (2.5 ha, SCP09)
- Serpentine Sports Reserve (Paul Robinson Reserve), Serpentine (0.29 ha, SCP10a)
- Yangedi Airfield Reserve, Hopeland (6.5 ha, no survey data)
- Karnup Road Flora Reserve (0.66 ha, SCP08 and SCP10a)

All of these reserves also contain other types of vegetation (banksia woodland and/or marri woodland).

2.3.2 Flora

A distinctive feature of clay-based wetlands is the suite of geophytes and annual flora that germinates, grows and flowers sequentially as these areas dry over summer, producing a floral display for over three months. The clay pans have very high species richness, a number of local endemics and are the most floristically diverse of the Swan Coastal Plain wetlands. Typical and common plant species in clay-based wetlands vary according to the community type.

Community 07 (Herb rich saline shrublands in clay pans) occurs on heavy clay soils that are generally inundated from winter to mid-summer. In early spring many sites are covered by free water up to 30cm deep. Aquatic species are common early in the growing season. As the wetland dries a succession of species successively germinate, grow and flower, resulting in an extended flowering period of over three months. Structurally this community is quite variable, ranging from woodlands to herblands. The species saltwater paperbark and swamp sheoak may indicate some saline influence for at least some part of the year.

Typical and common species of community 07 include:

- *Cotula coronopifolia* (water buttons)
- *Ornduffia submersa*
- *Centrolepis* spp.

- *Stylidium* spp. (trigger plants)
- *Melaleuca viminea*
- *Melaleuca uncinata* (broom bush)
- *Melaleuca cuticularis* (saltwater paperbark)
- *Casuarina obesa* (swamp sheoak)
- *Brachyscome bellidioides*
- *Centrolepis polygyna* (wiry centrolepis)
- *Pogonolepis stricta*
- *Angianthus* aff. *drummondii*
- *Eryngium pinnatifidum* subsp. *palustre*
- *Blennospora drummondii*

Community 08 (Herb rich shrublands in clay pans) occurs in low lying flats with a clay impeding layer allowing seasonal inundation. While aquatic annuals are common, the pools are probably not inundated to the same depth or for the same length of time as in community 07. This community has a high percentage of weeds and appears to be the clay pan vegetation community that has the greatest disturbance.

Typical and common species of community 08 include:

- *Viminaria juncea* (swishbush)
- *Melaleuca viminea*
- *Melaleuca lateritia* (robin redbreast)
- *Melaleuca uncinata* (broom bush)
- *Kunzea micrantha*
- *Kunzea recurva*
- *Eucalyptus wandoo* (wandoo)
- *Hypocalymma angustifolium* (white myrtle)
- *Acacia lasiocarpa* var. *bracteolata*
- *Verticordia huegelii* (variegated featherflower)

Community 09 (Dense shrublands on clay flats) consists of shrublands or low open woodlands on clay flats that are inundated for long periods because it usually occurs very low in the landscape. Sedges are more apparent. This community has a lower species richness and weed frequency than in the other clay pan communities, presumably because of the longer inundation times.

Typical and common species of community 09 include:

- *Chorizandra enodis* (black bristlerush)
- *Cyathochaeta avenacea*
- *Lepidosperma longitudinale* (pithy sword-sedge)
- *Meeboldina coangustata*
- *Hakea varia* (variable-leaved hakea)
- *Melaleuca viminea*
- *Xanthorrhoea preissii* (grass tree)
- *Xanthorrhoea drummondii*
- *Kingia australis*

Community 10a (Shrublands on dry clay flats) is the most rapidly drying of the clay flats communities. The microtopography is generally shallower and they have thin skeletal soils. This community has a high species richness and includes the aquatic annuals and geophytes typical of other clay pan and clay flat communities. The shrub layer is dominated by species indicative of a short inundation period.

Typical and common species of community 10a include:

- *Schoenus natans* (floating bog-rush)
- *Crassula natans*
- *Eryngium pinnatifidum* subsp. *palustre*
- *Wurmbea dioica* subsp. *alba*
- *Amphibromus nervosus*
- *Hakea varia* (variable-leaved hakea)
- *Hakea sulcata* (furrowed hakea)
- *Pericalymma ellipticum* (swamp teatree)
- *Verticordia densiflora* (compacted featherflower)
- *Viminaria juncea* (swishbush)
- *Aphelia cyperoides* (hairy aphelia)
- *Centrolepis aristata* (pointed centrolepis)
- *Drosera gigantea* (giant sundew)
- *Drosera menziesii* (pink rainbow)

Flora and vegetation surveys have identified and mapped vegetation units and floristic communities in some areas of clay-based wetlands. Shire staff have carried out flora surveys within many Shire reserves, some associated with permanent monitoring quadrats and others as walk-though surveys. A consolidated list of the flora recorded in the Shire's clay-based wetland reserves can be found in Appendix 1.

Clay-based wetlands may be classified as Conservation Category, Resource Enhancement or Multiple Use. Conservation Category wetlands are protected by State legislation, have high conservation value and should be managed to preserve wetland attributes and functions, while Resource Enhancement wetlands are partially modified with substantial ecological attributes and functions, and should be managed and restored to improve their conservation category. Weed presence varies in wetlands. They are naturally low nutrient environments and any increase affects the vigour of the native plants and delivers a competitive advantage to introduced plants.

2.3.3 Fauna

Clay-based wetlands support a diverse array of fauna that depend on different aspects of the vegetation and surface water to provide shelter, food and suitable breeding conditions. Many of these animals are present seasonally, reflecting the seasonal changes in hydrology and the linked changes in flora.

Five threatened species are known to be dependent on clay pans and other surrounding ecological communities for a portion of their life/breeding cycle. These are the western swamp tortoise and four species of native bee. These species are all endemic to southwest Western Australia.

The western swamp tortoise was rediscovered in 1953. The only remaining natural population is restricted to several clay pans at the Ellen Brook Nature Reserve, with another managed population re-introduced to the Twin Swamps Nature Reserve. The tortoise is wholly carnivorous, and feeds and breeds in winter, living in the seasonally inundated clay pans that have standing water from June to November. It feeds only in winter and early spring on aquatic invertebrates, growing and laying down fat that is important for egg development. It leaves the dry clay pan to aestivate in summer in nearby leaf litter and fallen branches. The cause of decline and continuing threats to the western swamp tortoise include destruction of key habitat (ephemeral wetlands such as the clay pans).

Other threatened or priority fauna that use clay-based wetlands or occur in the vicinity (within 1 km) include:

- Carnaby's black cockatoo
- Forest red-tailed black cockatoo
- Baudin's black cockatoo
- Chuditch
- Quenda, southern brown bandicoot
- Numbat, walpurti
- Western ringtail possum
- Brush-tailed phascogale, Wambenger

The quenda (southern brown bandicoot) inhabits dense undisturbed shrublands, as occurs in some clay-based wetlands, where it seeks protection from predators.

Over 70% of native mammals have become regionally extinct, and others have declined in numbers or reduced in range. Larger patches of clay-based wetland can still support viable populations of small mammals. The quenda (southern bandicoot) occurs in many areas of clay-based wetland, where wide-spread and numerous scratchings can indicate that there may be a breeding population present. Kangaroos can be found in larger remnants, particularly those connected to other natural areas.

There is a large and diverse aquatic fauna in clay-based wetlands, including tadpoles, aquatic invertebrates such as small crustaceans, and insect larvae in the spring and early summer. The invertebrate fauna of the wetlands of the Swan Coastal Plain is taxonomically rich, however local and regional endemism does not contribute markedly to this taxa richness. Where rare taxa do occur they appear to be associated with rare wetland types harbouring very specific (and perhaps unusual) microhabitats. Aquatic invertebrates are important food sources for the western swamp tortoise and migrant waterbirds.

Over 40 bird species have been recorded in clay-based wetlands and many, such as waders and waterbirds, are seasonal visitors during winter and spring when the wetlands contain water. Many of these waterbirds are listed as migratory under the EPBC Act.

The most iconic bird species are the three species of black cockatoos which can be found in clay-based wetlands that contain food plants. These birds are protected under Commonwealth as well as State legislation. Black cockatoos feed on local species such as marri and banksia. Cockatoo breeding has been recorded on the Swan Coastal Plain, requiring large tree hollows which only form in larger trees.

The wetlands are habitat for a number of frogs, including the western banjo frog, which prefers long unburned environments but bases itself in surrounding woodlands. The moaning frog, quacking frog and crawling frog are also common in clay-based wetlands.

The clay-based wetlands are rich in reptile species including the spiny-tailed gecko, legless lizards, dragons (western bearded dragon), skinks, monitors and dugite snake. The Swan Coastal Plain has an exceptional reptile species richness. Some reptile species are endemic, and others are nearly so. There is a distinct change in reptile assemblages across the Plain that reflects the underlying soil structures and their vegetation. Frogs are likely an important dietary component for snakes and lizards.

Rabbits are a major threat in clay-based wetlands, damaging vegetation and introducing weeds. Periodical control of rabbits can occur in larger areas of bushland. Feral cats and foxes predate on native animals.

Fauna surveys, of mammals, reptiles and birds, have occurred in some areas of clay-based wetland. A consolidated list of the fauna recorded in the Shire's clay-based wetland reserves can be found in Appendix 2.

2.4 Water Resources

Water is essential to the survival of clay-based wetlands. Most seasonal wetlands of the Swan Coastal Plain are connected to the regional groundwater, but wetlands on clay substrates rely solely on rainfall to fill, and then dry to impervious pans in summer. The community is composed of both clay pan basins and clay flats.

The ecology of the community is entirely dependent on the hydrological functioning of the clay pan. The clay pans fill during the winter rains and slowly dry over spring and early summer to a hard, almost impenetrable surface. The variation in depth and duration of inundation is a factor in determining the plant species that occur in a particular clay pan, explaining some of the variation in flora across the extent of the community. Any change to the hydrological functioning of the community will significantly alter it. This impact is evident in the loss of more than 90% of the community through clearing and drainage of clay pans since European settlement.

Water resources provide a variety of ecosystem services and include waterways, drains, wetlands, and superficial and artesian groundwater. Groundwater provides storage that interacts with some surface wetlands. During long dry spells the groundwater supports surface water and wetland ecosystems. This relationship, and the inundation of the wetlands, is threatened by groundwater drawdown from increased usage and reduced recharge.

2.4.1 Surface Water

The majority of the coastal plain portion of the Shire of Serpentine Jarrahdale is low-lying and originally formed a variety of wetlands and seasonally inundated lands. From the 1920s, a network of drains was constructed to reduce inundation and enable agriculture. The drains flow west to the Serpentine River and the Peel Inlet.

The Peel Harvey Estuary is of regional, national and international significance and levels of protection. The estuary has been severely degraded by nutrients from the catchment which cause algal blooms (eutrophication), which reduce oxygen levels in the water and contribute to fish deaths and ecosystem changes. The Dawesville Channel increased estuarine flushing, and water quality has also been improved through better land management to reduce nutrient inputs.

Catchment land use is subject to policies that set nutrient export targets. These include a maximum phosphorus load from the Serpentine River, water management plans for recreation facilities, and maximum nutrient (fertiliser) application rates for nitrogen and phosphorus.

Average annual rainfall has decreased, dominated by reduced winter rainfall, and resulting in decreased annual stream flow. Many waterways from the plateau have reduced flow, or flow seasonally or intermittently rather than permanently.

Many of the Shire reserves containing clay-based wetlands are associated with other surface water features, including waterways, drains and water bodies. These features are detailed in Table 2 and maps can be found in the individual reserve action plans. The classification of wetlands as Conservation Category, Resource Enhancement or Multiple Use is described in section 2.6.

Table 2: Surface water features of clay-based wetland reserves in the Shire of Serpentine Jarrahdale.

Reserve	Surface water features
Brickwood Reserve	A clay-based wetland lies in the southeast of the reserve. A waterway drains the wetland to the west. All of the reserve, except the recreational facilities and the banksia woodland, is a Conservation Category wetland.
Serpentine Sports Reserve	A clay based Conservation Category wetland lies to the southeast of the banksia woodland. A drain runs along the boundary between the ovals and the bushland, with a dam towards the western side. The majority of the reserve, except for the northern boundary and the banksia woodland (and some marri to its east) is a Resource Enhancement wetland.
Yangedi Airfield Reserve	A clay-based wetland lies in the northeastern corner of the reserve. A drain runs through the southeastern corner of the reserve. The area southeast of the main runway is Multiple Use wetland, with a Resource Enhancement wetland over the clay-based wetland, and Conservation Category wetlands between the runways and south of the grass runway. A third Conservation Category wetland lies north of the hangars, near the northern boundary of the reserve.
Karnup Road Flora Reserve	All of the reserve is a Resource Enhancement wetland.

2.4.2 Groundwater

Extensive supplies of groundwater are contained in superficial aquifers. In general, Bassendean sands store more water than the Pinjarra soils. One of the most significant threats to ecosystems in the Swan Coastal Plain is declining water tables due to increased groundwater abstraction, patterns in water regulation and decreased rainfall and subsequent groundwater recharge.

Groundwater decline is not only influenced by extraction but also by declining rainfall and recharge rates as a result of climate change. Average annual rainfall has decreased, dominated by reduced winter rainfall, and resulting in decreased annual stream flow.

The older underlying sediments contain substantial quantities of groundwater in confined (artesian) aquifers. Water leaks down and up between the two aquifers. Groundwater movement is generally from east to west, but flows close to the Serpentine River are more complex. The superficial aquifer discharges to the river (and the artificial surface drains), and water leaks upward to recharge it.

2.5 Heritage

2.5.1 Aboriginal Heritage

Local Aboriginal people are part of the Noongar community, whose territory covers the area southwest of a line from Geraldton to Esperance. Prior to European settlement, family groups in the Serpentine Jarrahdale region were part of the Wadjuk tribe. During the post-European settlement period, forced migration to Aboriginal settlement camps or into areas where labour was required resulted in a shift of tribal groups.

Noongar family groups did not have permanent places of habitation and generally moved along major river systems, such as the Serpentine and Murray, or chains of freshwater bodies. The family groups would camp for short periods of time at favoured points where food and water were reliable.

The water systems are spiritual places for Aboriginal people. Local tradition records that Waugal, the dreaming ancestor, created the Murray and Serpentine river systems. The Waugal is a spiritual force with a physical serpentine manifestation that is widespread throughout the southwest region. Most of the major rivers that drain the Darling Range, and many creeks, springs, pools, swamps and lakes within the Swan Coastal Plain, are associated with the Waugal belief.

The Shire's large expanses of level to undulating plain were mostly inundated swamp land during winter. Wetlands would have been a source of food and may have held spiritual meaning for the local Aboriginal people. The higher sandy rises with banksia woodland provided dry areas to camp.

The Swan Coastal Plain has a high density of Aboriginal archaeological sites, associated with the richness of food resources. The State government currently has 23 heritage sites registered in the Shire, and an additional 63 sites are not (or not yet) registered. All places and objects of Aboriginal importance are protected by State legislation. The Serpentine River is listed on the register of mythological and ceremonial sites and includes a wide buffer to cover all the Aboriginal values in the vicinity.

A Native Title Claim was registered over land including the Shire of Serpentine Jarrahdale, to enable local Aboriginal people to have their rights and interests recognised under Australian law. This claim was resolved as part of the South West Native Title Settlement, the details of which are recorded in six Indigenous Land Use Agreements (ILUAs), including the Gnaala Karla Booja ILUA which covers the Shire. The Native Title Registrar registered the ILUAs in October 2018. Applications for judicial review of the Registrar's decision were rejected by the Federal Court in December 2019, and applications seeking special leave to appeal the decision of the Federal Court were rejected by the High Court in November 2020. Resolution of all legal proceedings has cleared the way for implementation of the Settlement. The Gnaala Karla Booja ILUA is being co-ordinated by the South West Aboriginal Land and Sea Council.

To date no formal consultation has occurred with either the South West Aboriginal Land and Sea Council or local Noongar people regarding management of clay-based wetlands. A lack of effective consultation with Noongar people and their representatives could lead to poor management decisions, conflict of use and the degradation of Aboriginal values.

2.5.2 European Heritage

In March 1827, Captain James Stirling arrived in the Swan River, and the Swan River Settlement was founded in June 1829. In 1830, Mandurah was established and settlers moved up the Murray River.

Navigational difficulties on the Serpentine River delayed settlement. The area was part of a massive 250,000 acre land grant to Thomas Peel, but the nature of the land and vegetation, and the availability of good agricultural land elsewhere, ensured that it mostly remained in its natural state for many years.

Some small farms were established below the scarp in 1865. The Serpentine settlement was about 1 km east of its present location, but in 1893, the railway almost complete, the present townsite was gazetted.

Major agricultural development occurred with the group settlement scheme in the early 1920s. Land from the Peel Estate was bought by the Government for settlers from England. The sandy soil and persistent winter inundation made the transition to farmland particularly difficult.

A program to drain the group settlement areas began in 1922. Large drains were cut with the aid of horse-drawn carts and finished by hand, completing 540 km by 1925. The drainage network was

later expanded, with administration and management taken over during the 1950s by the Public Works Department, later to become the Water Corporation.

Comprehensive and accurate records of reserve activities and developments should be kept. There are no obvious historical remains on many reserves, but visitor experience could be enriched by signage on site, museum displays, school programs and other publications.

The biodiversity conservation value of reserves is generally not devalued by their historic or current use. Management plans include actions for establishing, monitoring and managing these assets while allowing for their use in such a way that their conservation value is maintained.

2.6 Policy and Legislation

2.6.1 Federal Legislation

The key item of Federal legislation is the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). In 2012 communities 07 (Herb rich saline shrublands in clay pans), 08 (Herb rich shrublands in clay pans), 09 (Dense shrublands on clay flats) and 10a (Shrublands on dry clay flats) were listed as Critically Endangered under this Act. The listing means that clay-based wetlands have been assessed as both having undergone a high degree of loss and being under a continued high level of threat.

Due to the very localised distribution of these communities in patches that can be very small, no condition or area thresholds have been applied to the listed ecological communities and all areas meeting the relevant descriptions are habitat areas critical to their survival. This means that all of the four Shire reserves containing clay-based wetlands are protected under the EPBC Act.

Buffer zones around clay-based wetlands are important for protecting intact bushland from further weed invasion. The recommendation for protection of clay pans includes a vegetated buffer of 50 m, however the width of the buffer required may be greater, depending on the type of development proposed, the local hydrology, and other factors. Restoration planting in degraded buffer zones should be considered where possible.

The purpose of the buffer zone is to protect and manage the patch and to help avoid potential significant impacts. Its purpose is not specifically to extend the patch through regeneration. If the use of an area that adjoins a patch of the ecological community is going to be intensified then approval under the EPBC Act may be required. Changes in land-use within the buffer zone must not have an adverse significant impact on the community, but there is an exemption for lawful continuation of land use under of the EPBC Act.

The EPBC Act allows for the listing of key threatening processes (as well as threatened communities and species). These are discussed further in section 3.

2.6.2 State Legislation

The key item of State legislation is the *Biodiversity Conservation Act 2016* (BC Act). The BC Act allows for the listing of Threatened Ecological Communities, and of Threatened plants and animals. Communities 07 (Herb rich saline shrublands in clay pans), 08 (Herb rich shrublands in clay pans), 09 (Dense shrublands on clay flats) and 10a (Shrublands on dry clay flats) are listed as Endangered under this Act.

Threatened ecological communities (TECs) are also protected under Western Australian legislation through the *Environmental Protection Act 1986* and *Environmental Protection (Clearing of Native Vegetation) Regulations 2004*. A clearing permit is required for the removal of any native vegetation, with a presumption against the clearing of a TEC.

2.6.3 State Policy and Guidelines

There are two key items of State policy that provide protection to clay-based wetlands. The first is *State Planning Policy 2.8 Bushland Policy for the Perth Metropolitan Region* (SPP2.8, often referred to as the Bush Forever policy). It identifies areas of regionally significant bushland and strategies for their protection. Many clay-based wetland areas are mapped as Bush Forever, sometimes grouped with vegetation on adjacent properties to form a larger, more significant area. Bush Forever areas are afforded a higher level of protection.

Brickwood Reserve, Serpentine Sports Reserve and Yangedi Airfield Reserve are listed as Bush Forever. SPP2.8 classifies bushland that is outside Bush Forever areas as Local Bushland, which should be protected by a local government under a local biodiversity strategy.

The second item of State policy is *Statement of Planning Policy No. 2 Environment and Natural Resources Policy* (SPP2). The objectives of SPP2 are to integrate environmental management with land use planning, to protect the natural environment, and to promote sustainable use of natural resources. This includes avoiding development that may cause unacceptable environmental damage and considering mechanisms to protect areas of high biodiversity and/or conservation value. There are also measures relating to water resources, air quality, soil and land quality, basic raw materials, and greenhouse gas emissions, all of which aid in the protection of biodiversity.

State guidelines have produced the *Geomorphic Wetlands Swan Coastal Plain* dataset, under which wetlands have been evaluated and assigned a management category to provide guidance on how they should be managed and protected. These management categories are:

- Conservation – wetlands which support a high level of attributes and functions
    - Highest priority wetlands.
    - Objective is to preserve and protect the existing conservation values of the wetlands through various mechanisms including:
        - reservation in national parks, crown reserves and State owned land
        - protection under Environmental Protection Policies
        - wetland covenanting by landowners
    - No development or clearing is considered appropriate. These are the most valuable wetlands and any activity that may lead to further loss or degradation is inappropriate.
- Resource Enhancement – Wetlands which may have been partially modified but still support substantial ecological attributes and functions
    - Priority wetlands
    - Ultimate objective is to manage, restore and protect towards improving their conservation value. These wetlands have the potential to be restored to Conservation category. This can be achieved by restoring wetland function, structure and biodiversity.
    - Protection is recommended through a number of mechanisms.
- Multiple Use – Wetlands with few remaining important attributes and functions
    - Use, development and management should be considered in the context of ecologically sustainable development and best management practice catchment planning through landcare.

2.6.4 Local Legislation and Policy

The Shire of Serpentine Jarrahdale has a number of policy measures that assist in the conservation and protection of clay-based wetlands. These include:

- Local Planning Scheme No. 3 – provides protection to all vegetation by requiring development approval for all vegetation removal

- Local Biodiversity Strategy 2008 – protects areas of bushland that are not protected under other measures such as Bush Forever
- Local Planning Policy 2.8 Biodiversity Planning Policy – incorporates biodiversity protection into planning and development decision-making
- Urban and Rural Forest Strategy 2017 – protects trees and canopy cover throughout the Shire
- State of the Environment Report 2019 – protects the environment in the context of expected growth
- Significant Tree Register – allows for the listing of special and significant trees

3. Threats and Pressures

In 2017 (the most recent data available), the “Guildford” vegetation complex (which contains the majority of clay-based wetlands) was assessed as having 5% remaining, and only 4% in the Shire of Serpentine Jarrahdale. The extent of clearing on the coastal plain portion of the Shire of Serpentine Jarrahdale can be seen by comparison of Figures 4 and 5.

Clay-based wetlands are affected by a suite of different threats, including many threats which arise from the fact that the ecological community occurs in the most densely populated region in Western Australia and on some of the most productive agricultural soils in that landscape. The threats to clay-based wetlands include:

- Landuse history, including clearing and fragmentation
- Altered hydrology
- Rising groundwater
- Invasive species
- Inappropriate fire regimes
- Pathogens
- Climate change
- Fauna decline

These threats apply to all areas of clay-based wetland to a greater or lesser extent.

The EPBC Act allows for the listing of key threatening processes, as well as threatened communities and species. The listed key threatening processes that are relevant to clay-based wetlands are:

- Land clearance
- Dieback caused by the root-rot fungus (*Phytophthora cinnamomi*)
- Novel biota and their impact on biodiversity
- Competition and land degradation by rabbits
- Predation by European red fox
- Predation by feral cats
- Predation, habitat degradation, competition and disease transmission by feral pigs
- Fire regimes that cause declines in biodiversity
- Loss of terrestrial climatic habitat caused by anthropogenic emissions of greenhouse gases

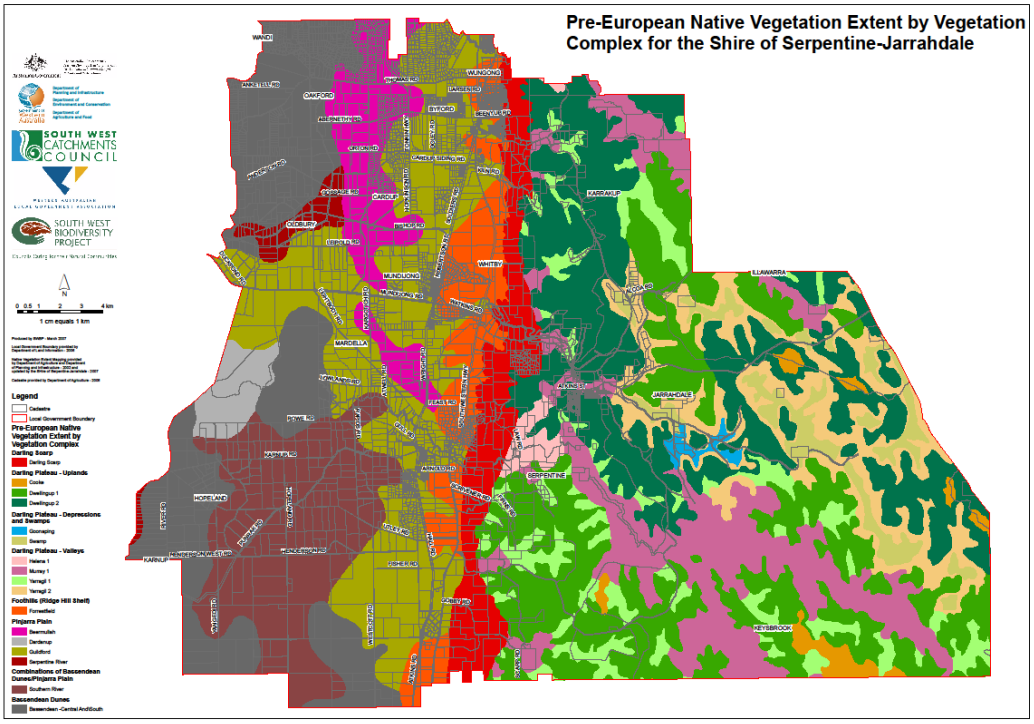

Figure 4: Pre-European Native Vegetation Extent and Complexes for the Shire of Serpentine Jarrahdale (South West Biodiversity Project, 2007).

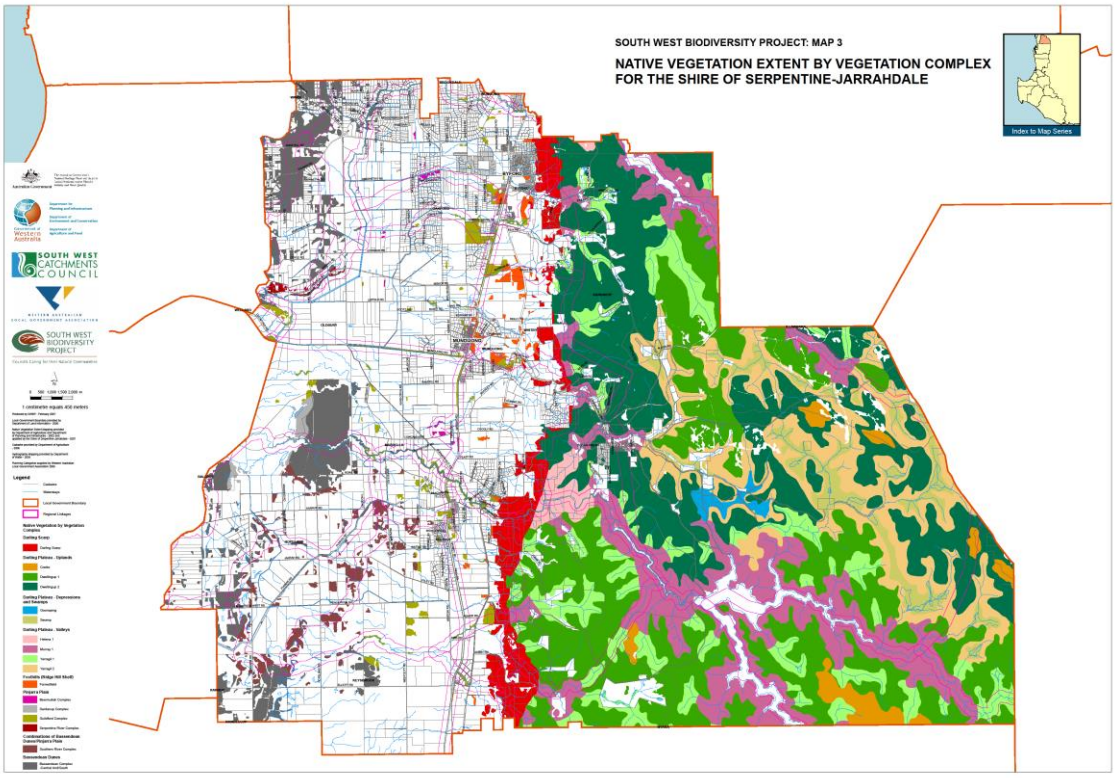

Figure 5: Native Vegetation Extent and Complexes for the Shire of Serpentine Jarrahdale (South West Biodiversity Project, 2007).

3.1 Landuse History, Including Clearing and Fragmentation

The seasonally inundated clays that support these communities are relatively productive agricultural soils and many were cleared and drained soon after settlement. Others were mined for the clay for brick and tile manufacture. Those that remained intact were largely located on the Swan Coastal plain in close proximity to metropolitan Perth. By 2011, large areas had also disappeared under urban development and today the plant communities of seasonal clay-based wetlands are amongst the most threatened in Western Australia.

Fencing off blocks of natural bushland that contain clay-based wetlands generally ameliorates active threats such as rubbish dumping and off-road vehicle use. However, construction of tracks and new fence lines within remnant patches degrades the ecological community by direct damage, increasing fragmentation, and providing easier pathways for weeds and feral animals to access parts of the community previously protected by patch size. Some areas of the community occur where there is recreational use, such as horse riding and bushwalking that can introduce weed species or have other adverse impacts such as trampling.

While 55% of the clay pans occur in conservation reserves these reserves tend to be small. Urban wetland reserves are frequently visited, but only a small number have formal approved management plans or interim management guidelines. Very few reserves have residential staff to provide protection from vandalism, illegal off-road access and driving, or refuse/garden waste dumping.

The clay-based wetland community generally occurs as highly fragmented small remnants (average patch size is 6.2 ha) in a matrix of agricultural and urban lands. Small patch size increases the potential negative impacts from other threats.

Land clearing, development and intensification of land use results in habitat loss, fragmentation and change. Clearing reduces the amount of vegetation and isolates remaining patches, reducing connectivity. Connectivity is important for landscape scale habitat quality for flora and fauna, as well as condition and persistence of clay-based wetlands.

Urbanisation has been the main driver of clay-based wetland clearing and fragmentation. The Shire of Serpentine Jarrahdale is one of the fastest growing local government areas in Australia, with associated rapid urbanisation and development which drives clearing and fragmentation. Impacts are likely to spread as development encroaches on remnant vegetation.

Fragmentation results in reduced connectivity for flora and fauna, impedes movement and dispersal, and causes greater “edge effects” in remaining patches. Edge effects refer to the penetration of disturbance (human impacts, invasive species etc.) relatively further into the vegetation remnant where the patch is smaller and has a greater edge to area ratio. Disturbance is more likely in urban and peri-urban areas due to the proximity to humans, and these patches are prone to impacts such as rubbish dumping, unauthorised vehicle access, walking paths, vegetation removal (e.g. for firewood), more bare ground, inappropriate fire regimes, and animal invasion.

Fragmentation creates barriers to dispersal and fewer opportunities for colonisation. Long distance dispersal is required to adapt to rapid climate change and is less likely in a fragmented landscape. Fragmentation reduces the ability of flora and fauna to escape from or recolonise after disturbances such as fire.

The impacts of fragmentation may take time to become apparent but are generally more rapid in smaller remnants. Plant species richness declines with time since isolation, associated with altered soil properties such as increased litter depth and increased weed invasion. Bird numbers and diversity are related to the amount of other vegetation patches in the immediate surroundings.

Reptiles are more common and diverse in larger areas of bushland. Fragmentation into smaller, more degraded patches limits both plant and animal diversity.

The extraction of basic raw materials results in the loss of vegetation, hydrological impacts and the introduction and spread of dieback and weeds. Demand for basic raw materials such as gravel, shale, clay, sand, limestone and rock for construction and infrastructure development will increase in the future to support population growth. Extraction of clay, in particular, can result in the removal of and/or disturbance to clay-based wetlands.

There is evidence of ongoing degradation and fragmentation of native vegetation within the Swan Coastal Plain. Remnants are smaller, closer to highly modified landscapes, have altered vegetation structures and lose species richness. The impacts are greater in the central and southern parts of Perth due to more intensive development. The metropolitan area effectively bisects the Swan Coastal Plain and represents a significant, often impenetrable barrier to the remnant populations of many species that prevents processes necessary for their future survival. There is an 'extinction debt' inherent in all smaller fragments that is likely to result in ongoing local extinctions and changes in species assemblages.

Clearing, fragmentation and degradation of clay-based wetlands are ongoing in the Shire of Serpentine Jarrahdale. Development often results in hydrological impacts to clay-based wetlands, and remaining buffer areas are fragmented and impacted by the effects of the development, such as declining groundwater. While the Shire endeavours to retain and protect native vegetation, the applicant can appeal a refusal to the State Administrative Tribunal.

Degradation of clay-based wetlands in or near urban areas is a continual issue. The rapid growth of the Shire of Serpentine Jarrahdale means that previously isolated reserves are coming under increasing pressure from encroaching urban development. The pressures are most commonly in the form of increased recreational use (with associated trampling, informal path creation, and impacts on wildlife by dogs) and concern about fire hazard (with associated pressure for control burning).

3.2 Altered Hydrology

Changes to the natural hydrology of the wetlands are potentially the most significant threat to the community, as the vegetation is dependent on the wetlands filling and drying at appropriate times of the year. Altered hydrology in urbanised areas in particular is likely to be an increasing threat to the clay pans. Drainage to lower water tables, urban land clearing resulting in a decline in evapotranspiration and a subsequent increase in surface runoff, and declining water quality are all likely to increasingly impact on the current hydrologic regimes of the community.

Given the very complicated nature of the hydrology of the community, and the reality that many of the clay-based wetlands in the Perth metropolitan region are now isolated remnants within a matrix of urbanisation, the management of and maintenance of the natural hydrological regimes will continue to be a challenge.

One of the most significant threats to ecosystems in the Swan Coastal Plain is declining water tables due to increased groundwater abstraction, patterns in water regulation and decreased rainfall and subsequent groundwater recharge. Impacts range from a gradual change in structure and composition to sudden and widespread vegetation death. Where impacts result in a change in plant composition and structure, there is a shift in community composition.

Groundwater decline is not only influenced by extraction but also by declining rainfall and recharge rates as a result of climate change. Average annual rainfall has decreased, dominated by reduced winter rainfall, and resulting in decreased annual stream flow. Changes in soil temperature and

distribution of surface water will impact on clay-based wetlands that are water-dependent. Climate change may reduce seasonally waterlogged areas as well as increasing the depth to groundwater.

Groundwater decline may also result in flow-on effects which can impact fauna species dependent on seasonal wetlands. Vegetation may be susceptible to death or decline due to increased acidity and aluminium in subsoil water where the water table has rapidly declined. Soils may contain enough iron compounds to create acid sulfate soil conditions when the water table declines and the soil is exposed to air. The acids leach to groundwater, impacting water quality and causing acidity in seasonal wetlands with associated impacts on fauna.

Inflows to wetlands could disrupt their ecological balance. Drains may import nutrients, weeds and disease, and affect water levels. A wetland is an expression of the water table, and any activities that affect the water table impact on it, including alteration of water levels and leaching of nutrients and other pollutants into the groundwater.

Water availability has, and is likely to continue to, decline across the Swan Coastal Plain. Declining water availability is likely to be having severe detrimental impacts on clay-based wetlands. Recent studies have determined that groundwater across most of the Shire of Serpentine Jarrahdale is fully allocated, with no more licences available for human uses. This is partly due to the environmental impacts of the declining water table.

3.3 Rising Groundwater

Inundation from rising saline groundwater is generally not evident in clay-based wetlands. However, in the medium term, it may prove to be a serious threat to the community.

Due to the widespread clearance of native perennial vegetation and its replacement with annual agricultural regimes and urbanisation, rising groundwater in the surrounding region may flow overland into clay-based wetlands. Salinity risk mapping indicates that almost all of the known clay-based wetlands occur on susceptible land.

Salinisation and increased nutrients have been observed at one clay-based wetland in the Drummond Nature Reserve. There is currently no hydrological connection between the wetland and groundwater at this site, but evidence suggests that during heavy rainfall events unnaturally large volumes of surface water (a result of clearing of native vegetation) flow into the area of the wetland. This threatens the community through the introduction of nutrients and altered water regimes. High nitrate levels were identified in the regional groundwater and excessive levels of total nitrogen were identified within the surface and sub-surface waters of the wetland, suggesting that nutrient influxes were increasing.

Surface water flow into the wetlands from cleared farmland also brings topsoil and weed seed into the vegetation around the wetland and is a significant threat to the community.

In some other areas groundwater is very close to the surface. At the Brixton Street site for example, groundwater is 0–3 metres below the surface at the end of spring. Surface waters may link to groundwater in the wetter months at such sites and may influence the quantity and quality of water on the surface of the sites at this time of the year.

Protection of these land systems may require replanting 30–70% of the cleared lands across the landscape and involve a lag of up to 30 years. Groundwater management plans and resources will be needed to mitigate this risk.

3.4 Invasive Species

3.4.1 Plants

Overall, the Swan Coastal Plain has the largest number of weeds recorded from any bioregion in Western Australia – more than 800 species. Introduced taxa represent some 16% of the flora for the clay-based wetlands. Some of these weeds are particularly aggressive, or sleeper weeds.

Bulbs of South African origin that naturally occur in similar habitats and climates are some of the most invasive wetland weeds. Watsonia is frequently seen invading many clay-based wetlands. Watsonia can disperse via cormels (tiny corms that develop along the flowering stem at the end of the flowering season) into relatively undisturbed bush remnants, forming dense stands that effectively displace the herbaceous understorey. Other invasive weeds include the bulb *Sparaxis bulbifera* and the South African perennial grass *Tribolium uniolae*.

Other invasive plants occurring in clay-based wetlands include arum lily (*Zantedeschia aethiopica*), bridal creeper (*Asparagus asparagoides* — a Weed of National Significance), kikuyu (*Pennisetum clandestinum*; formerly *Cenchrus clandestinus*), all of which are very difficult to manage because of underground corms, tuber matts or stolon networks. Annual and perennial alien grasses also pose a threat.

Annual and perennial grasses can increase fuel loads in bushland, resulting in native remnants becoming more prone to fire, and to more frequent fires. Increased fire frequency creates feedback loops that promote the greater presence of weed species due to their shorter generation lengths, higher seedbanks and faster response to postfire ash-bed nutrients than many native species.

Several native species outside their natural range can be invasive within the drier patches in the ecological community, including invasive eucalypts such as the river red gum (*Eucalyptus camaldulensis*) and eastern Australian wattles (e.g. *Acacia melanoxylon*, *Acacia baileyana*).

Weed invasion is a significant threat to clay-based wetlands not only because of the actual presence of weeds, but more importantly, because of the potential for weed invasion once the community is disturbed. All of the occurrences of this community are close to weed sources such as urban or agricultural areas and are vulnerable to weed invasion following any disturbance. However, even small remnants often exhibit surprising resistance to weed invasion particularly if left undisturbed. In this community, such resistance relates to the density of cover, seasonal inundation and the hardness of the soils in summer, and alteration of any of these factors reduces the ability to resist weed invasion.

In general, the larger the patch size of the community the more resistant it is to weed invasion. While 55% of the clay-based wetlands occur in conservation reserves, there is urgent need for active weed management in many wetlands as these reserves tend to be small and highly fragmented in a matrix of agricultural and urban lands making them highly susceptible to weed invasion. However, this community has shown a strong capacity to recover from weed invasion.

The primary means of controlling weeds in remnant vegetation is to avoid disturbance. The second strategy is to reduce the carriers of weed seed, including introduced materials such as soil, and exclude sources such as storm-water runoff that can introduce nutrients and other pollutants. Techniques to control the spread of seed and weed plants range from selective seed head removal to physical or chemical plant removal. Large-scale weed control must be integrated with revegetation, otherwise the bare areas will be recolonised by weeds. The control of weeds that provide significant habitat values also needs to be carefully planned and integrated with revegetation.

3.4.2 Animals

Feral animals present in the region include foxes, rabbits, cats, black rats, and increasingly in the south, pigs. These species are not controlled in any but the largest reserves. Foxes, pigs, black rats and cats predate native animals within the ecological community, including the western swamp tortoise, and rabbits and pigs disturb the vegetation through grazing and by burrowing and rooting behaviours.

The ability to undertake feral animal control programs in urban and semi-urban environments is significantly impeded by the need to protect the surrounding residents from potentially negative physical and social impacts (e.g. the use of toxins and trapping and shooting).

Introduced animals affect biodiversity values through habitat modification, predation, grazing and competition. Common invasive animals include the European rabbit, red fox, cat, black rat, house mouse, long-billed corella, little corella, rainbow lorikeets, laughing kookaburra and the introduced honey bee. There can be many kangaroos in small fragmented reserves, and wild pigs in wetland areas.

Foxes and cats are now the primary predators on remaining native animals (e.g. quenda) and have contributed to local extinctions of other native animals. Non-native herbivores promote non-native herbaceous species, possibly through the disturbance of topsoil through their digging habits. Given that small to medium native mammals are now largely absent from the community, digging by non-native mammals such as the European rabbit now results in weed invasion, due to the large weed seed banks present at many sites. Disturbance of this thin layer in the ancient and impoverished soils of southwestern Australia is known to promote invasion, as it provides an opportunity for establishment by non-native species, which are abundant in the topsoil seed bank, and germinate and grow faster than native species.

Whilst native herbivores suppress non-native herbaceous species abundance, non-native herbivores such as the European rabbit promote non-native herbaceous species abundance as a result of their digging activities that promote germination of the weed soil seed bank.

3.5 Inappropriate Fire Regimes

Fire is a significant threat to the integrity of the community, especially the impact of inappropriate fire regimes. Fire is not known to be a part of the natural ecology of this wetland community and the impacts of fire on the flora should be monitored. It is likely that only very occasional fires historically occurred in the community. As most species in the community are wetland species they tend not to be adapted to fire.

Fire regimes based on biodiversity outcomes are generally absent, and deliberately lit fires can and do occur frequently, depending on the proximity of a reserve to urbanisation. Planned fire regimes are often dominated by the requirement to protect adjoining assets and land values.

Fire is the greatest threat to the survival of the fauna in the clay-based wetlands. State policy is that the wetlands should not be subject to fire.

Prior to European settlement, some fires occurred through lightning strikes and Aboriginal burning of the landscape. It is likely that the Swan Coastal Plan had a mosaic of burning regimes from regular burning to long unburnt, with clay-based wetlands likely subject to only very occasional fires.

Some fire regimes are a major threat to the long-term survival, diversity, viability and conservation of communities, habitats and species populations. These are the result of cool-season prescribed burning and high overall frequency of fires. Recently, fires have occurred as a result of fire

management practices, escapes from prescribed burning, arson, and accidental ignition. There has been a change in fire regime in many areas, with a skewed distribution of frequency to less than seven year intervals.

The richness and diversity of fauna is generally maximised by avoiding widespread intense fires and maintaining a diversity of vegetation successional stages to provide habitat diversity. The fire responses of fauna vary depending on the extent of, and interaction of fire with, habitat fragmentation and other disturbances. In general, many native fauna groups prefer long-unburnt areas (more than 16 years fire interval) and become more abundant with increasing time since fire.

Current fire prescriptions reduce the availability of longer unburnt habitats. There are also few unburnt patches within individual burns, indicating that fire patterns are not mosaics. This reduces the chance of an area of suitable habitat being available. Smaller and more isolated remnants that escape frequent burns are increasingly important.

Remnant clay-based wetlands that are small and isolated are particularly sensitive to fire. A high intensity fire that affects the whole area may change the structure of the community, and the loss of populations of rare plants. Small remnants also have more problems with post-fire recovery, such as kangaroo grazing and weed invasion.

The primary objective of fire hazard management in the Shire of Serpentine Jarrahdale is the protection of people and property. It is unfortunate that prescribed burning recommendations produce such poor outcomes for clay-based wetlands. Control burning should be minimised and followed up by weed control.

3.6 Pathogens

The water mould *Phytophthora cinnamomi* occurs in parts of the marri woodlands community that surround some clay-based wetlands and is a potential threat to the community. This pathogen impacts species of structurally and floristically dominant plant families such as Proteaceae and Myrtaceae. If there are species in a clay-based wetland community that are particularly sensitive to *Phytophthora cinnamomi* then the community can be considered at risk. *Batrachochytrium dendrobatidis* (chytrid fungus) may also offer a significant threat to amphibians if it becomes established in the wetlands.

“Dieback” generally refers to the effects of a plant disease caused by the water mould *Phytophthora cinnamomi* and other *Phytophthora* species. The consequences of *Phytophthora* infection range in severity and include:

- Localised infection affecting one or more individual plants
- Dramatic modification of the structure and composition of the community
- Significant reduction in primary productivity
- Habitat loss and degradation

Dieback disease continues to spread and affect the distribution and abundance of many plant species and their associated fauna in southwest Western Australia. This plant pathogen and a number of related *Phytophthora* species present a significant threat to the health and vitality of many ecosystems on the Swan Coastal Plain. It can alter species composition and ecosystem function by impacting susceptible species and vegetation types, and by increasing vulnerability to invasion by weeds.

There is a strong correlation between dieback and soil type. There are far more dieback centres on the Bassendean Dune System than on soils of the Spearwood and Quindalup Dune Systems. Dieback is also less common in areas with lower soil moisture content and higher in the landscape.

In most areas, canopy closure, basal area and number of plant species are significantly lower in diseased compared with healthy areas. Percentage ground cover and total plant species cover can also be significantly lower in diseased areas. Dieback reduces flowering and fruiting of affected plants, therefore also affecting animals that rely on banksia nectar and seeds as food. Decline in these animals affects their pollination services for other plants.

Diseased sites have reduced plant species richness, litter, shrub, tree and canopy cover, high bare ground and significantly lower flowering scores, than healthy sites. Bird community composition differs significantly between diseased and healthy sites, associated with habitat structural changes. Average species richness of birds and the abundance of nectivores is lower in diseased than healthy sites. Dieback is therefore potentially a serious threat to bird biodiversity and especially for nectarivores, with implications for pollination.

Transmission of plant pathogens occurs through movement of infected soil and plant material, and in surface and ground water. Soil is carried by humans and kangaroos (and other animals such as horses), and contaminated vehicles and machinery. Effective hygiene practices can help to manage human and mechanical transmission.

There is no known way to eliminate dieback once it has been introduced. Dieback control therefore involves minimising its spread by controlling the movement of vehicles, people and stock from affected areas into dieback free areas. It is standard management practice to route pathways to avoid crossing boundaries, provide wash-down or other hygiene facilities for vehicles and pedestrians, provide education, and avoid transporting soil and plant material into dieback free areas.

Phosphite (phosphoric acid), sprayed on vegetation and injected into trees, mitigates the intensity of disease and can delay onset. Mapping of boundaries can monitor the spread and invasion of disease, and locate the areas most at risk and therefore most in need of treatment.

3.7 Climate Change

Winter rainfall has declined significantly over the Swan Coastal Plain and the trend is predicted to continue. This has the potential to significantly affect the community and individual species within clay-based wetlands which rely on a period of submersion during the spring-early summer period.

There has been an observed significant change in rainfall in south-west Western Australia. A sharp drop in rainfall occurred in the mid–1970s, with some of the driest years on record occurring since 1975. This drop in rainfall was most apparent in late autumn and winter, with fewer winter storms and less rainfall per storm. In the driest winters on record the majority of clay-based wetlands remained free of surface water. Temperatures in Western Australia have also risen since 1910.

In the years of below average rainfall, western swamp tortoise hatchlings cannot achieve their critical weight in their first six months in order to survive the period of dormancy during their first summer. This is because the shorter retention of water in the ecological community limits the time available for feeding. There is also evidence that females are not able to produce eggs in low rainfall years. For successful recruitment two successive years of average or above average rainfall are required. The drying trend has required the clay-based wetland at Twin Swamps (where western swamp tortoises had been transferred to increase the extent of the breeding population) to be augmented by groundwater pumping to maintain a viable population of the tortoise.

South-western Australia's significant drying trend is forecast to worsen under climate change. If current climate trends continue, there will be up to 80 per cent more droughts in south-western Australia by 2070.

The natural fragmentation of the community in the landscape and the particular geomorphic structure required for a clay pan to exist means that this community's ability to adapt by moving within the landscape to more appropriate climatic conditions is virtually non-existent.

The reduction in rainfall has an increased effect through decreased streamflow in waterways and in reduced recharge of groundwater. Streamflow has declined by more than 50%, impacting on plant reproduction and seedling recruitment. Human populations are becoming more reliant on groundwater (and desalination plants), increasing water table declines and increased stress on vegetation.

Urban heat islands can affect local climate and impact on nearby remnants. Urban heat islands occur when urban areas are hotter than their surrounds due to built materials trapping heat, machinery producing waste heat, and the removal of trees and vegetation (and their cooling effect from shade and transpiration). Ongoing clearing of native remnants is likely to exacerbate urban heat.

The Shire of Serpentine Jarrahdale is managing its response to climate change through implementation of strategies such as the Climate Change Strategy and Action Plan, and the Urban and Rural Forest Strategy.

3.8 Fauna Decline

Threats also have resulted in decline of the fauna of the clay-based wetlands. This, in turn, feeds back into the decline of native vegetation because fauna are essential to ecological functions of the community. Many animals have habitat or dispersal requirements that are no longer available due to loss, fragmentation and degradation of the natural vegetation and remnants now occurring amongst highly modified, often unsuitable landscapes. The greatest decline in native fauna has been in urban and peri-urban areas, notably the Perth metropolitan region, and this is likely to worsen with ongoing urban sprawl.

Mammals appear to be the most affected group with 52% of the original mammal fauna of the Perth region now considered regionally extinct. 40 native mammals were once present in the Swan Coastal Plain and ten species are now extinct from the region with another eight in serious decline. Regionally extinct mammals include iconic species such as the numbat, bilby and woylie, but also five species of native mice and rats. The decline of marsupials resulted from a combination of the threats outlined above.

Native marsupials would have played a key role in trophic interactions, pollination, seed dispersal, decomposition, mineral nutrient cycling and fuel load reduction (by turnover of the soil and burying of leaf litter through extensive digging). The most common native mammals that now remain in urban bushland remnants are species able to adapt to human presence, such as the western grey kangaroo and common brushtail possum. The quenda is possibly the only medium-sized ground-dwelling native mammal that survives in the Perth metropolitan region, but it is subject to ongoing habitat loss and predation by foxes and cats.

Birds have also been affected by the loss or declining condition of clay-based wetlands. Across the Swan Coastal Plain, nearly 50% of the passerines and 40% of the non-passerines have declined or have become locally extinct since European settlement. These include species that are habitat specialists and generalists.

Reptile species assemblages in the Swan Coastal Plain depend on the size of the bushland remnant. The long-term persistence of reptile populations may be affected by the presence of barriers to dispersal and, consequently, a reduced ability to recolonise a patch if local extinction occurs. For many species of reptiles, roads, buildings and other infrastructures are effective barriers to dispersal.

Impacts to the invertebrate component of the wetland community are poorly studied. Within the Perth metropolitan region, the native earthworm fauna has been mostly replaced by introduced species in disturbed soils. However, introduced species of earthworm were not found in undisturbed bushland remnants. This suggests that the loss of native vegetation remnants has led to a decline of the native earthworm fauna and that remnant vegetation fragments will continue to provide refuges in the future.

4. Reserves

4.1 Location and Description

The Shire of Serpentine Jarrahdale has four reserves that contain clay-based wetlands. These reserves, their approximate area of clay-based wetland, and most likely community, are:

- Brickwood Reserve, Byford (2.5 ha, SCP09)
- Serpentine Sports Reserve (Paul Robinson Reserve), Serpentine (0.29 ha, SCP10a)
- Yangedi Airfield Reserve, Hopeland (6.5 ha, no survey data)
- Karnup Road Flora Reserve, Serpentine (0.66 ha, SCP08 and SCP10a)

Some of these reserves (Brickwood Reserve, Serpentine Sports Reserve and Yangedi Airfield Reserve) also contain other types of vegetation (banksia woodland and/or marri woodland).

The locations of the reserves are shown in Figures 6 – 8, and the reserves and the location of their clay-based wetlands are shown in Figures 9 – 12. More detail on the reserves, such as soil types and vegetation management zones can be found in their individual action plans.

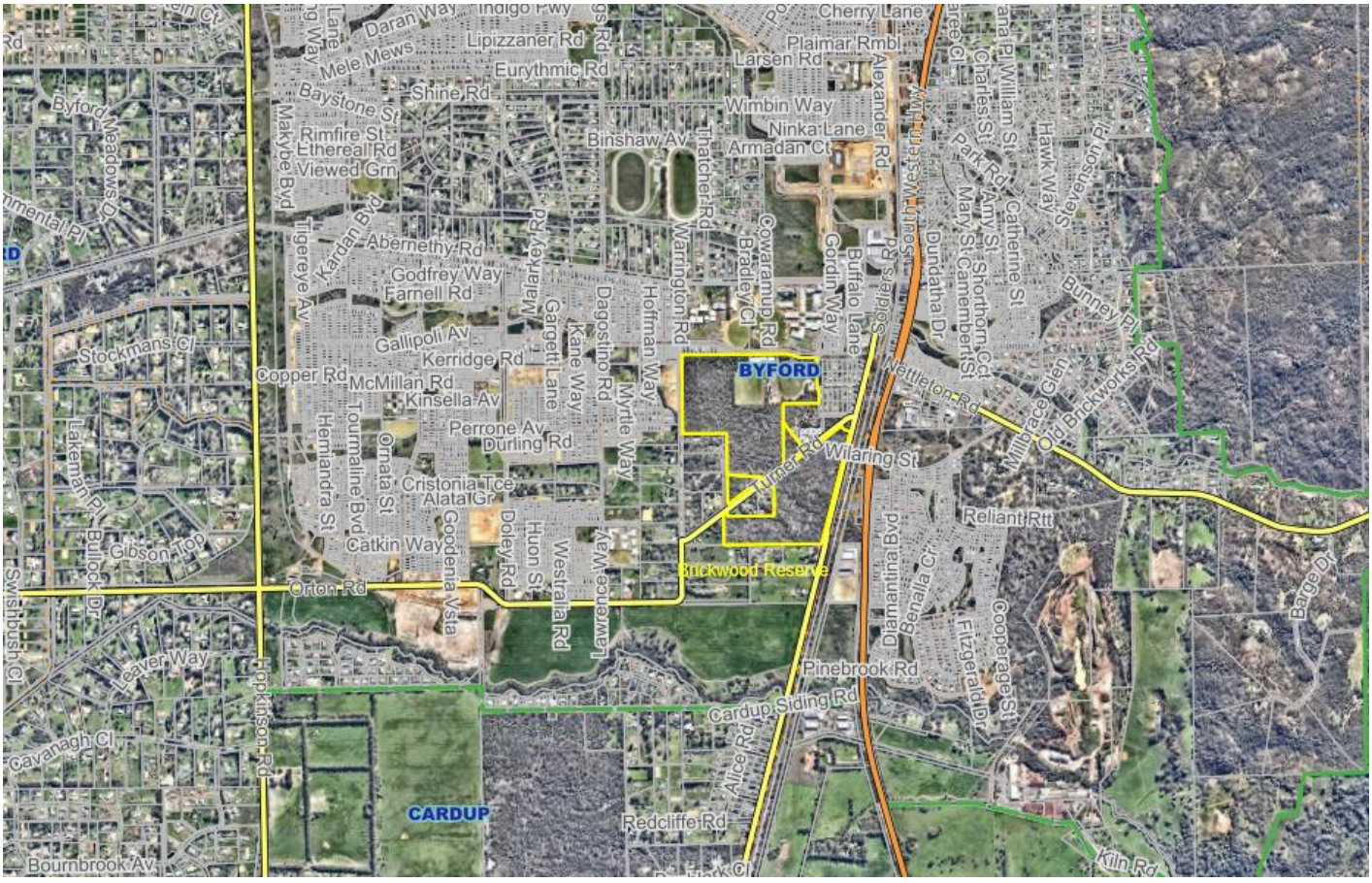

Figure 6: Location of Byford Reserves – Brickwood Reserve.

Figure 7: Location of Serpentine Reserves – Serpentine Sports Reserve and Karnup Road Flora Reserve.

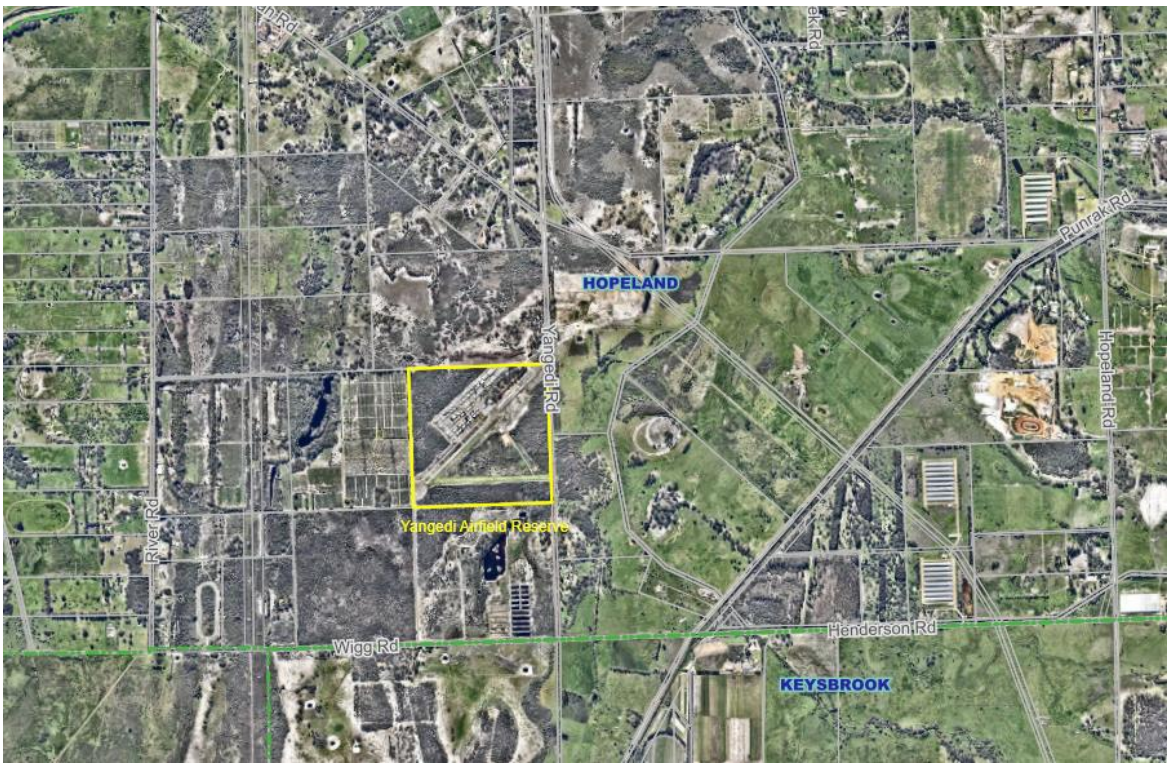

Figure 8: Location of Hopeland Reserves – Yangedi Airfield Reserve.

Figure 9: Brickwood Reserve, Byford and the location of its area of Clay-Based Wetland.

Figure 10: Serpentine Sports Reserve, Serpentine and the location of its area of Clay-Based Wetland.

Figure 11: Yangedi Airfield Reserve, Hopeland and the location of its area of Clay-Based Wetland.

Figure 12: Karnup Road Flora Reserve, Serpentine and the location of its area of Clay-Based Wetland

4.2 Vesting and Land Tenure

Most of the Shire reserves containing clay-based wetlands are Crown land vested with the Shire of Serpentine Jarrahdale for the purpose of recreation, but their use now includes conservation. Changes to the vesting purpose of the reserves would give greater protection to their clay-based wetlands, but this is being kept in reserve for future offsets for unavoidable clearing by the Shire. The vested purpose and current use of the reserves is listed in Table 3. For reserves that cover more than one lot, only the lot containing the clay-based wetland is listed.

Table 3: Vesting Purpose, Land Tenure and Uses of Shire Reserves.

Reserve	Reserve and Lot Number	Vesting Purpose and Land Tenure	Current Uses
Brickwood Reserve	R17490 L5567, L111 and L112 Mead Street, Byford	Shire of Serpentine Jarrahdale – Recreation	Recreation and Conservation
	R51101 L48 Turner Road, Byford	Shire of Serpentine Jarrahdale – Environmental Conservation, Recreation, Community Centre and Purposes Ancillary Thereto	Recreation and Conservation
BaptistCare Graceford Aged Care Home (Brickwood)	R37404 L106 Turner Road, Byford	WA Baptist Hospital and Homes Trust Inc. – Aged Persons Homes	Buffer Zone and Conservation
Serpentine Sports Reserve	R19134 L778 Karnup Road, Serpentine	Shire of Serpentine Jarrahdale – Recreation	Recreation and Conservation
Yangedi Airfield Reserve	R25911 L164 Yangedi Road, Hopeland	Shire of Serpentine Jarrahdale – Recreation	Recreation and Conservation
Karnup Road Flora Reserve	R18662 L796 Karnup Road, Serpentine	Shire of Serpentine Jarrahdale – Indigenous Vegetation / Protection of Flora	Conservation

4.3 User Groups

4.3.1 User Groups

The user groups of each Shire reserve are related to the current uses, as listed above in Table 3. These range from informal users, for walking and enjoyment of nature, to the three major users of Yangedi Airfield Reserve. The user groups for each reserve are listed in Table 4. More detail is provided in the individual action plans.

Table 4: User Groups of Shire Reserves

Reserve	User groups
Brickwood Reserve	Recreation centre – gym, courts, function rooms etc. Sports fields users, e.g. cricket, football and diamond sports groups Sport pavilion users and hire BMX track Friends of Brickwood Informal users, particularly walking and dog exercise
Serpentine Sports Reserve	Serpentine Horse and Pony Club Polocrosse Club Golf Club Irregular oval hire, e.g. Southside Jumps Club Community events Informal users, particularly walking and dog exercise Community conservation groups, including Landcare SJ Inc., Serpentine Environmental Group
Yangedi Airfield Reserve	Sports Aircraft Builders Club DFES (helipad) BOM (radar tower)
Karnup Road Flora Reserve	Informal, infrequent walkers and enjoyment of nature

4.3.2 Threats and Pressures

4.3.2.1 Risk Management

Increasing insurance premiums and stricter attitudes to liability have made risk management plans mandatory for recreational facilities and clubs. Formal risk management plans must be developed by each user group of a reserve in cooperation with the Shire to avoid exposing participants to unacceptable levels of risk.

4.3.2.2 Membership and Member Involvement

Any community group has a general problem with attracting and maintaining motivated volunteers to fill positions and undertake other tasks. A few people tend to do most of the work.

4.3.2.3 Conflict Among User Groups

Conflict among user groups can lead to a lack of cooperation in management of reserves, and conflicts over the use of resources can lead to ineffective use and possibly degradation. The main conflicts tend to be between user groups' desire to expand, and protection of the conservation values of the remnant vegetation. Nearby residents are frequently concerned about fuel loads in bushland and fire risk, which can lead to pressure for regular control burns and the potential for degradation of the bushland.

Management plans are intended to facilitate broad community input, provide an acceptable level of certainty for all stakeholders, and ensure that Council is fully informed.

4.3.2.4 Compliance with Legislation

The use of reserves and their facilities is subject to health regulations and legislation. Some reserves also host events during which camping occurs. The Shire assesses compliance with legislation, and ensures that the locations used, management of pets, numbers of people per ablution facility during events, litter and other waste management issues are considered.

Compliance with Federal, State and Local environmental legislation and policies is also essential. Many user groups may be unaware of the legislative requirements, or the environmental values they

are intended to protect. It is the Shire's responsibility to ensure that user groups are informed of and comply with relevant requirements.

4.3.2.5 Security of Tenure

Ongoing long-term lease agreements for user groups are essential to ensure that private investment in reserves is supported. User groups and their facilities are mostly developed and maintained entirely by volunteers.

4.4 Infrastructure

4.4.1 Infrastructure

The infrastructure present on each Shire reserve is related to the current uses and user groups, as listed above in Tables 3 and 4. These range from basic fencing to the highly valuable infrastructure of the three major users of Yangedi Airfield Reserve. The main infrastructure present at each reserve is listed in Table 5. More detail is provided in the individual action plans.

4.4.2 Threats and Pressures

4.4.2.1 Facility Maintenance

Most user groups maintain their buildings and other infrastructure by volunteer labour from their members. Other reserve facilities are public and maintained by the Shire, such as sports fields and irrigation systems. Inadequate maintenance would lead to accelerated deterioration and increased risk. Poorly maintained facilities also tend to attract vandalism.

4.4.2.2 Vandalism and Theft

Vandalism and theft are constant but low-level threats. The design of buildings and other structures may incorporate vandalism-resistant features. Use of tough materials, protection of vulnerable surfaces with resistant barriers, visibly high maintenance, removal of objects likely to be used by vandals, high security and appropriate lighting all decrease the likelihood of theft and damage. Surveillance is an effective deterrent. The highly valuable infrastructure and property on Yangedi Airfield Reserve is protected by on-site caretakers.

4.4.2.3 Fire Damage

Fire can threaten people, property and conservation values. Prevention and resistance should be incorporated into the design and management of buildings, other structures and their surrounds. Fires can start inside or adjacent to buildings and structures, and are often the result of vandalism, kitchen accidents or electrical faults. Bush or grass fires threaten buildings and structures through embers, radiant heat and direct contact.

Cleared areas around buildings limit the opportunity for bush and grass fires to reach them. No flammable material should be stored close to buildings, and gutters kept clear. Strategies to limit the frequency and severity of vandalism will reduce the likelihood of arson. Fire in nearby bushland has the potential to damage infrastructure.

4.4.2.4 Public Access

The use of club facilities by the public may lead to conflict with the user group. Some clubs hire out their facilities to other users but may not be satisfied with the level of care taken. Public access to other infrastructure, such as jumps and cross-country courses, may lead to liability issues in the case of injury, leading clubs to limit public access as far as possible and erect warning signage.

Table 5: Infrastructure present at Shire Reserves

Reserve	Infrastructure
Brickwood Reserve	Recreation centre – gym, courts, function rooms etc. Sports pavilion Sports fields BMX track and pavilion Car parks Firebreaks and walking paths Fences and gates Signage Dilapidated building intended for community uses Irrigation systems and bores
Serpentine Sports Reserve	Equestrian clubhouse and storage sheds Two equestrian sports fields (pony club and polocrosse club) Cross-country course Golf Clubhouse and storage sheds Golf course fairways and greens Firebreaks and walking paths Irrigation systems and bores Fences and gates Signage
Yangedi Airfield Reserve	SABC clubhouse and ablution facilities Hangars with stored aircraft and taxiways Two runways Fuel storage DFES helipad and heli-tankers BOM radar tower Firebreaks, fences and gates Signage Irrigation systems and bores
Karnup Road Flora Reserve	Firebreaks, fences and gates

5. Action Plan

5.1 Introduction

An implementation plan is provided in this section. Various divisions within the Shire are responsible for implementation and it is anticipated that the actions will be implemented over several years. All actions arising from this plan are presented below, along with priorities, responsibilities and requirements.

5.2 Priorities and Status

Priorities for implementation of the actions have been classified as follows:

- Key – an essential action for successful management of clay-based wetlands
- High – a significant action which should be implemented in the short term
- Medium – a secondary, longer-term action
- Low – a desired action that is funding dependent

The status of each action has been assessed as Implemented, Implemented in Part, Not Yet Implemented, and Ongoing. In addition, each action has been classified as:

- Business as Usual – an ongoing action that occurs as a matter of course
- Short Term – to be implemented within three years of adoption of the management plan
- Medium Term – to be implemented within seven years of adoption of the management plan
- Long Term – a desired action that is funding dependent and may be implemented within ten years of adoption

5.3 Responsibilities, Monitoring and Review

The Shire of Serpentine Jarrahdale is responsible for actions within this plan. In some instances, the Shire may be assisted in implementing a strategy by a partner who has an interest or responsibility, and there may be opportunities for grants to implement strategies. The management plan actions will be monitored and reviewed, and the management plan will be revised every three years.

The best single point of contact will be the Natural Reserves Specialist. Divisions within the Shire with responsibilities for implementation, sometimes in collaboration with user groups, include:

- Natural Reserves Specialist
- Strategic Environmental Specialist
- Emergency Services
- Community Development
- Development Services
- Environmental Health

Resources are designated as staff time, budget dependent and/or funding (grant) dependent. Costs are not estimated here as they are highly context dependent (particularly on vegetation condition and patch size) but will be estimated for each reserve.

Table 4: Clay-Based Wetland Action Plan

No.	Action	Priority	Timing	Status	Responsibility	Resources
1	**Utilise the planning system to retain and protect remnant clay-based wetlands.**	**Key**	**Business as Usual**	**Ongoing**	**Statutory Planning**	**Staff Time**
2	Keep up to date with the latest research trends and integrate into reserve management.	High	Long Term	Ongoing	Natural Reserves, Emergency Services	Staff Time
3	Formalise access to clay-based wetlands in high use areas through establishment of walking paths that reduce trampling.	Medium	Medium Term	Not Yet Implemented	Operations	Budget Dependent
4	Erect signage in high use areas to inform users of the values of the clay-based wetlands.	Medium	Short Term	Implemented in Part	Operations	Budget Dependent
5	**Survey for dieback presence, and map and treat dieback every three years if present.**	**Key**	**Business as Usual**	**Ongoing**	**Natural Reserves**	**Budget Dependent**
6	Monitor and manage new and emerging pests and diseases such as polyphagous shot hole borer.	High	Medium Term	Ongoing	Natural Reserves	Budget Dependent
7	Control access to clay-based wetlands through boundary fencing, convenient formal access points, and path construction that discourages deviation.	Low	Long Term	Not Yet Implemented	Operations	Budget Dependent
8	Work with user groups to protect and minimize impacts to the remnant vegetation.	High	Business as Usual	Ongoing	Natural Reserves, User Groups	Staff Time
9	Liaise with other landholders to work together and integrate management of all banksia woodland areas.	Medium	Medium Term	Not Yet Implemented	Natural Reserves, Strategic Environmental Specialist	Staff Time
10	Implement measures to exclude motorised vehicles from the remnant vegetation.	High	Medium Term	Implemented in Part	Operations	Budget Dependent
11	Erect fences or other structures to delineate user group areas.	Low	Long Term	Not Yet Implemented	Natural Reserves, User Groups	Budget Dependent
12	Ensure that formalised paths and other access routes cross dieback fronts to the lowest degree possible.	Medium	Medium Term	Not Yet Implemented	Natural Reserves	Staff Time
13	Establish dieback hygiene policies, including vehicle washdown points and foot baths for pedestrians with appropriate signage where appropriate.	High	Long Term	Implemented in Part	Natural Reserves	Budget Dependent
14	Conduct flora surveys and vegetation condition monitoring and mapping every five years.	Low	Business as Usual	Ongoing	Natural Reserves, Strategic Environmental Specialist	Budget Dependent
15	Conduct fauna surveys every five years.	Low	Medium Term	Not Yet Implemented	Natural Reserves	Budget Dependent
16	Monitor weed diversity and distribution annually.	High	Business as Usual	Ongoing	Natural Reserves	Staff Time

No.	Action	Priority	Timing	Status	Responsibility	Resources
17	**Establish and implement a weed control program that utilises best practice methods.**	**Key**	**Business as Usual**	**Ongoing**	**Natural Reserves, Landcare SJ**	**Budget Dependent**
18	Establish and implement a control program for woody weeds.	High	Business as Usual	Ongoing	Natural Reserves	Budget Dependent
19	Conduct feral animal control when required, following all relevant health and safety regulations.	Medium	Business as Usual	Ongoing	Natural Reserves, Landcare SJ	Budget and/or Funding Dependent
20	**Minimise burning and other disturbance of clay-based wetlands.**	**Key**	**Short Term**	**Implemented in Part**	**Emergency Services**	**Staff Time**
21	Avoid disturbance to the Conservation Zone of a reserve and to dieback-free areas.	High	Short Term	Not Yet Implemented	Natural Reserves	Staff Time
22	Avoid fire in clay-based wetlands to the greatest degree possible.	High	Long Term	Not Yet Implemented	Emergency Services	Staff Time
23	Avoid fuel load management unless considered appropriate and necessary.	Medium	Business as Usual	Implemented in Part	Emergency Services, Natural Reserves	Staff Time
24	Restrict any essential fuel load management to the Vegetation Management Zone of a reserve.	High	Short Term	Not Yet Implemented	Emergency Services	Budget Dependent
25	Carry out fuel load management on adjacent road verges to avoid fire entering the reserve from the verge.	High	Medium Term	Not Yet Implemented	Emergency Services	Budget Dependent
26	Ensure that any essential fuel load management utilises weed control as a priority, with control burning as a last resort.	Medium	Short Term	Not Yet Implemented	Emergency Services, Natural Reserves	Budget Dependent
27	Ensure that any control burning is restricted to vegetation boundaries, providing a mosaic of vegetation ages including long unburnt.	High	Business as Usual	Implemented in Part	Emergency Services, Natural Reserves	Budget Dependent
28	**Follow any burning or other disturbance with weed control for at least two years post-fire.**	**Key**	**Business as Usual**	**Implemented in Part**	**Emergency Services, Natural Reserves**	**Budget Dependent**
29	Manage water use and allocations to ensure that environmental water requirements are considered and met.	Medium	Medium Term	Not Yet Implemented	Operations	Staff Time
30	Revegetate with local provenance seedlings as necessary and appropriate.	Medium	Medium Term	Implemented in Part	Friends Groups, Landcare SJ, Natural Reserves	Funding Dependent
31	Monitor implementation of the management plan every three years.	High	Short Term	Not Yet Implemented	Strategic Environmental Specialist	Staff Time
32	Update actions according to best practice management and monitoring outcomes.	High	Medium Term	Not Yet Implemented	Strategic Environmental Specialist	Staff Time
33	Review and revise the management plan every ten years.	High	Long Term	Not Yet Implemented	Strategic Environmental Specialist	Staff Time

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Appendix 1 – Flora Surveys and Lists

The Shire's clay-based wetland reserves have been surveyed, up to five times, by Shire staff. Some reserves were surveyed by quadrat, supplemented by nearby species, and some by a walk-through survey. Yangedi Airfield Reserve has only been surveyed in its banksia woodland, so has not been included here.

The following table includes all of the species recorded in the clay-based wetland reserves, and which reserve(s) they have been recorded in.

A total of 150 species were recorded across the three clay-based wetland reserves, comprising 113 native species and 37 weeds.

Demonstrating the diversity and variability of clay-based wetlands, only eight native species and one weed were recorded in all three reserves, while two-thirds of the species (76 native and 24 weeds) were only recorded in one reserve. Almost one-third of the species (27 native and 18 weeds) were only recorded in Karnup Road Flora Reserve, demonstrating both the greater degree of weed invasion and the influence of the upland species along the edge of the road.

Species (* denotes an introduced/weedy species)	**Brickwood**	**Serpentine Sports**	**Karnup Road**
Acacia lasiocarpa			X
**Acacia longifolia*	X		X
Acacia saligna	X		X
Actinostrobus pyramidalis			X
Adenanthos meisneri			X
**Aira cupaniana*		X	
Anigozanthos manglesii	X		
Anigozanthos viridis	X		X
Aphelia cyperoides			X
**Arctotheca calendula*		X	X
Astartea scoparia	X		X
Austrodanthonia acerosa	X		
Austrostipa flavescens			X
**Avena barbata*		X	X
Banksia nivea			X
Borya scirpoidea	X		
**Briza maxima*		X	X
**Briza minor*	X		X
**Bromus diandrus*			X
**Bromus hordeaceus*	X		
Burchardia congesta	X		
Caesia micrantha	X		
Caladenia flava		X	X
Caladenia longicauda	X		
Calothamnus quadrifidus			X
Cassytha glabella	X		
Cassytha pomiformis			X
Centrolepis aristata	X	X	X
Chaetanthus aristatus	X	X	X
Chamaescilla corymbosa	X		
**Cicendia filiformis*		X	X
Conospermum stoechadis			X
Conostylis aculeata			X

Species (* denotes an introduced/weedy species)	**Brickwood**	**Serpentine Sports**	**Karnup Road**
Conostylis setigera	X		X
**Cotula coronopifolia*			X
**Cotula turbinata*		X	
Cyathochaeta avenacea	X		X
Cyathochaeta clandestina	X		
**Cynodon dactylon*			X
Dampiera linearis	X		X
Dasypogon bromeliifolius	X		X
Daviesia physodes	X		
Desmocladus fasciculatus	X		
Desmocladus flexuosus	X		
**Disa bracteata*		X	X
Drosera erythrorhiza	X		
Drosera gigantea	X	X	
Drosera glanduligera	X	X	X
Drosera menziesii	X	X	X
Drosera nitidula			X
Drosera pallida		X	
**Ehrharta calycina*			X
Elythranthera emarginata	X		
**Eragrostis curvula*		X	X
Eragrostis elongata	X		
**Eucalyptus camaldulensis*			X
Eutaxia virgata		X	X
**Freesia alba x leichtlinii*			X
Gnephosis angianthoides		X	
**Gomphocarpus fruticosus*			X
Gompholobium aristatum			X
Haemodorum laxum	X		
Haemodorum simplex	X		X
Haemodorum sparsiflorum	X		
Hakea ceratophylla	X		
Hakea sulcata	X	X	X
Hakea trifurcata	X		
Hakea varia	X	X	X
**Hesperantha falcata*			X
Hibbertia hypericoides	X		
Hyalosperma cotula	X	X	
**Hypochaeris glabra*		X	X
**Hypochaeris radicata*		X	X
Hypolaena exsulca	X	X	
Hypolaena pubescens			X
Isolepis cernua	X	X	
Isolepis cyperoides	X		
Isotoma hypocrateriformis	X		
Jacksonia sternbergiana	X		
**Juncus capitatus*			X
Juncus kraussii		X	
Juncus pallidus			X
Kingia australis	X		
Kunzea micrantha		X	
Kunzea recurva			X
**Lagurus ovatus*	X		
Lepidosperma leptostachyum	X		
Lepidosperma longitudinale	X		

Species (* denotes an introduced/weedy species)	**Brickwood**	**Serpentine Sports**	**Karnup Road**
Lepyrodia muirii	X		
Levenhookia pusilla			X
Levenhookia stipitata			X
Lobelia tenuior	X		
**Lolium rigidum*			X
Lomandra suaveolens	X		
**Lotus angustissimus*		X	X
Loxocarya cinerea		X	
Meeboldina roycei	X		X
Melaleuca preissiana		X	X
Melaleuca teretifolia			X
Melaleuca uncinata			X
Melaleuca viminea	X	X	X
Mesomelaena tetragona	X		X
Microtis atrata	X		
Microtis media	X		X
**Monopsis debilis*		X	X
Neurachne alopecuroidea	X		
Nuytsia floribunda	X		X
**Oxalis* spp.			X
**Parentucellia viscosa*			X
Patersonia juncea	X		
Patersonia occidentalis	X		X
**Pennisetum villosum*		X	
Pericalymma ellipticum	X		X
**Phalaris* sp.			X
Philydrella pygmaea	X		
**Poa annua*		X	
Quinetia urvillei			X
Regelia ciliata			X
Schoenus clandestinus	X		
Siloxerus humifusus	X	X	X
**Solanum nigrum*			X
**Sonchus oleraceus*			X
Stirlingia latifolia	X		X
Stylidium calcaratum		X	X
Stylidium ecorne	X		X
Stylidium piliferum	X		
Synaphea acutiloba			X
Synaphea petiolaris	X	X	
Synaphea spinulosa			X
Tetraria octandra	X		
Thelymitra antennifera			X
Thelymitra vulgaris		X	X
Thysanotus manglesianus			X
Thysanotus multiflorus	X		
Thysanotus triandrus			X
Tribonanthes australis		X	
Tricoryne elatior	X		
Tricoryne humilis	X		X
Triglochin incurva		X	
**Ursinia anthemoides*			X
Utricularia multifida	X		
**Vellereophyton dealbatum*			X
Verticordia huegelii	X		

Species (* denotes an introduced/weedy species)	**Brickwood**	**Serpentine Sports**	**Karnup Road**
Verticordia lindleyi			X
Verticordia plumosa	X		
Viminaria juncea	X		X
**Wahlenbergia capensis*			X
**Watsonia meriana*	X	X	X
Xanthorrhoea preissii	X		X
Xanthosia huegelii	X		

Appendix 2 – Fauna Surveys and Lists

The primary source of information on fauna inhabiting Shire reserves is Harvey *et al.* (1997) *Ground Fauna of the Bushland Remnants on the Ridge Hill shelf and Pinjarra Landforms Perth*. The reserves have not been surveyed in detail for fauna more recently. While the original document has not been located, individual lists can be found in some reserve management plans, which form the basis for the following table.

Fauna surveys are only known to have occurred in Brickwood Reserve, Serpentine Sports Reserve, and Yangedi Airfield Reserve. Karnup Road Flora Reserve has been omitted here for the sake of simplicity.

Species (* denotes an introduced species)	**Brickwood Reserve**	**Serpentine Sports Reserve**	**Yangedi Airfield Reserve**
Mammals			
Quenda (southern brown bandicoot)	X	X	X
Western grey kangaroo	X		X
*House mouse	X	X	
*Rabbit	X		X
*Cat	X		X
*Fox	X		X
*Rat		X	
Amphibians			
Red-thighed froglet	X		
Sandplain froglet	X	X	
Moaning frog	X	X	
Pobblebonk	X	X	
Guenther's toadlet	X		
Glauert's froglet		X	
Reptiles			
South-western sandplain worm lizard	X		
Western bearded dragon	X		
South-western cool skink	X	X	
Fence skink	X	X	
South-western odd striped ctenotus	X		
West coast four-toed lerista	X		
Common dwarf skink	X	X	
Southern pale-flecked morethia	X		
Bobtail	X	X	
Racehorse goanna	X	X	
Southern blind snake	X	X	
Dugite	X		X
Gould's hooded snake	X		
Two toed earless skink		X	
Tiger snake		X	X
Burton's legless lizard			
Marbled gekko			X
Black-tailed monitor			X
Birds			
Australian magpie	X	X	X
Australian raven	X	X	X
Australian sittella	X		

Species (* denotes an introduced species)	Brickwood Reserve	Serpentine Sports Reserve	Yangedi Airfield Reserve
Baudin's black cockatoo			X
Black swan			X
Black-faced cuckoo-shrike	X	X	X
Black-faced woodswallow	X		
Brown goshawk	X		
Brown honeyeater	X	X	X
Brown thornbill			X
Buff-banded rail			X
Carnaby's black cockatoo	X		X
Common bronzewing		X	X
Crested pigeon			X
*Domestic pigeon	X		
Dusky woodswallow	X		X
Elegant parrot	X		X
Fan-tailed cuckoo			X
Galah	X	X	X
Great egret			X
Grey butcherbird			X
Grey fantail	X	X	X
Grey-breasted white-eye	X		
*Laughing dove	X		
*Laughing kookaburra	X	X	X
Little eagle	X		
Magpie-lark	X		
Misteltoebird	X		
Nankeen kestrel			X
New holland honeyeater			X
Painted button-quail	X		
Pallid cuckoo	X		
Rainbow bee-eater	X	X	X
Red wattlebird	X		X
Red-capped parrot	X	X	X
Red-capped robin			X
Red-tailed black cockatoo	X		
Richard's pipit			X
Ringnecked parrot	X	X	X
Rufous whistler	X	X	X
Sacred kingfisher	X		X
Shining bronze-cuckoo		X	
Silvereye	X	X	X
Singing honeyeater		X	
Splendid fairy wren		X	X
Southern boobook owl			X
*Spotted turtle-dove			X
Straw-necked ibis			X
Striated pardalote	X		
Swamp harrier			X
Tree martin	X		X
Welcome swallow	X		X
Western gerygone	X	X	X
Western rosella	X		
Western spinebill	X		X
Western thornbill			X
White-browed scrub wren			X
White-cheeked honeyeater			X

Species (* denotes an introduced species)	Brickwood Reserve	Serpentine Sports Reserve	Yangedi Airfield Reserve
White-faced heron			X
White-fronted chat	X		
Willy wagtail	X		X
Yellow-rumped thornbill		X	X

Appendix 3 – Threatened and Priority Flora and Fauna

Threatened and priority flora and fauna have been recorded in the Shire's clay-based wetland reserves. The species listed in official records from the Department of Biodiversity, Conservation and Attractions are listed in the table below. Anecdotal or informal records are not listed.

Fauna surveys are only known to have occurred in Brickwood Reserve, Serpentine Sports Reserve and Yangedi Airfield Reserve. Karnup Road Flora Reserve has been omitted here for the sake of simplicity.

Species	**Status T (Threatened) P1-4 (Priority 1-4)**	**Brickwood Reserve**	**Serpentine Sports Reserve**	**Yangedi Airfield Reserve**
Flora				
Acacia oncinophylla	P3		X	
Drosera occidentalis	P4	X	X	
Morelotia australiensis	T		X	
Schoenus pennisetis	P3	X		
Fauna				
Birds				
Calyptorhynchus banksii naso (Forest red-tailed black cockatoo)	T		X	
Calyptorhynchus baudinii (Baudin's black cockatoo)	T	X	X	
Calyptorhynchus latirostris (Carnaby's black cockatoo)	T	X	X	X
Mammals				
Isoodon fusciventer (quenda)	P4	X	X	X
Reptiles				
Acanthophis antarcticus (common death adder)	P3	X		

Appendix 4 – Fire Management Strategy for Clay-Based Wetlands

Principles of Fire Management for Clay-Based Wetlands

1. **For fuel load management, weed control is preferable to control burning and should be the method of choice.**

2. **All fire in clay-based wetlands, whether wildfire or control burning, must be followed by at least two years of thorough weed control.**

3. **Burning of clay-based wetlands increases fire hazard and rate of spread through increased growth and invasion of flammable grassy weeds.**

4. **Any disturbance of clay-based wetlands results in growth and invasion of highly flammable grassy weeds, leading to increased fire hazard.**

5. **Fire should be avoided in clay-based wetlands to the greatest degree possible.**

6. **Fire control in clay-based wetlands should consider dieback disease and avoid spread into uninfected areas by movement of machinery across dieback fronts and other hygiene methods.**

7. **Some wetlands contain peat (partially decayed plant matter) which may continue to burn underground for long periods.**

Brickwood Reserve Action Plan

R17490, R51101, R37404

1. Background

1.1 Location

Brickwood Reserve is located in Byford, associated with the Briggs Park recreation centre and surrounded by urban development (Figure 1). It is also adjacent to the BaptistCare Graceford Aged Care Home.

Brickwood Reserve contains three main vegetation communities: marri woodland, banksia woodland and clay-based wetlands. The reserve is 53.1 ha with 45.5 ha remnant vegetation, of which approximately 2.5 ha is clay-based wetland. This action plan specifically deals with the clay-based wetland area, while the other communities are addressed in the other management plans.

The majority of the reserve (including the clay-based wetland) is vested with the Shire for the purpose of Recreation, but current uses also include Conservation. There are numerous user groups for the reserve, particularly associated with the Briggs Park recreation centre, and significant infrastructure.

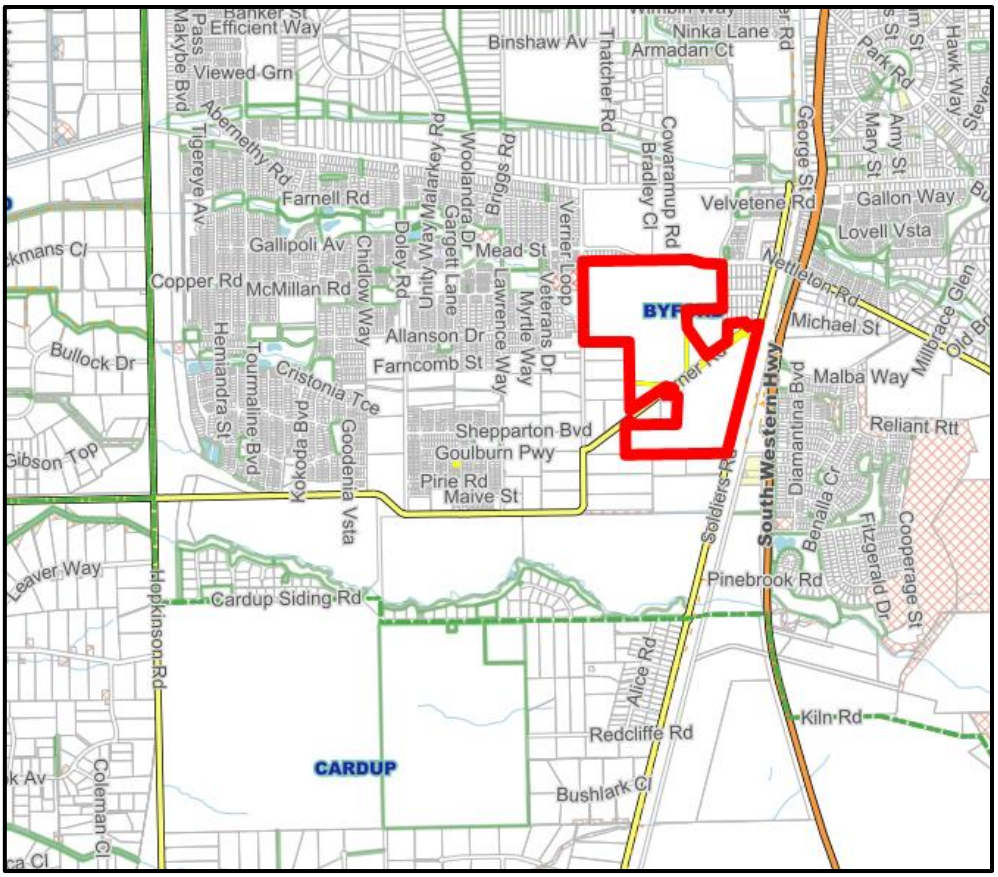


Figure 1: Location of Brickwood Reserve

Brickwood Reserve is classified into four main management zones (Figure 2). These are:

Conservation Zone (green): Areas of remnant vegetation of high biodiversity and scientific reference value which include both dieback free and dieback infected areas. Management may include dieback treatment, weed control and revegetation as considered appropriate by officers and as required. Access within this area must utilise dieback hygiene procedures such as clean-down and take extreme care to prevent spread of dieback from infected to uninfected areas.

Vegetation Management Zone (red): Areas of remnant vegetation of biodiversity and scientific reference value which may be disturbed, or dieback or weed infested. This is a buffer zone and may receive fuel load management for protection of people, property and conservation values by weed control or control burning on assessment by officers as required and appropriate. Management may include dieback treatment, weed control and revegetation as considered appropriate by officers and as required. Access within this area must consider movement and reduce spread of dieback from infected to uninfected areas through clean down procedures.

Recreation Zone (yellow): This is largely the areas of Briggs Park used for active and passive recreation. Management of this zone is principally for the purpose of recreation, while minimising impacts on the adjacent remnant vegetation.

Community Zone (blue): This zone contains the BaptistCare Graceford Aged Care Home. The high vulnerability of the residents means that management of the adjacent vegetation prioritises the protection of people and property.

This Action Plan applies to the Conservation and Vegetation Management Zones.

1.2 Soils

Four soil types occur in Brickwood Reserve: Forrestfield F5, Pinjarra P1a, Pinjarra P1e and Pinjarra B1 (Table 1 and Figure 3). Clay-based wetlands occur the Forrestfield F5 soil type.

Table 1: Soil Types of Brickwood Reserve.

Reserve	Soil landscape unit	Description	Clay-based wetland occurrence
Brickwood Reserve	Forrestfield F5 phase	Poorly defined stream channels on lowest slopes with deep acidic yellow duplex soils and sandy alluvial gradational brown earths.	Yes
	Pinjarra P1a phase	Flat to very gently undulating plain with deep acidic mottled yellow duplex (or effective duplex) soils. Shallow pale sand to sandy loam over clay; imperfect to poorly drained and generally not susceptible to salinity.	No
	Pinjarra P1e phase	Flat to very gently undulating plain with deep acidic mottled yellow duplex (or effective duplex) soils. Shallow pale sand to sandy loam over very gravelly clay; moderately well drained.	No
	Pinjarra B1 phase	Extremely low to very low relief dunes, undulating sandplain and discrete sand rises with deep bleached grey sands sometimes with a pale yellow B horizon or a weak iron-organic hardpan at depths generally greater than 2 m; banksia dominant.	No

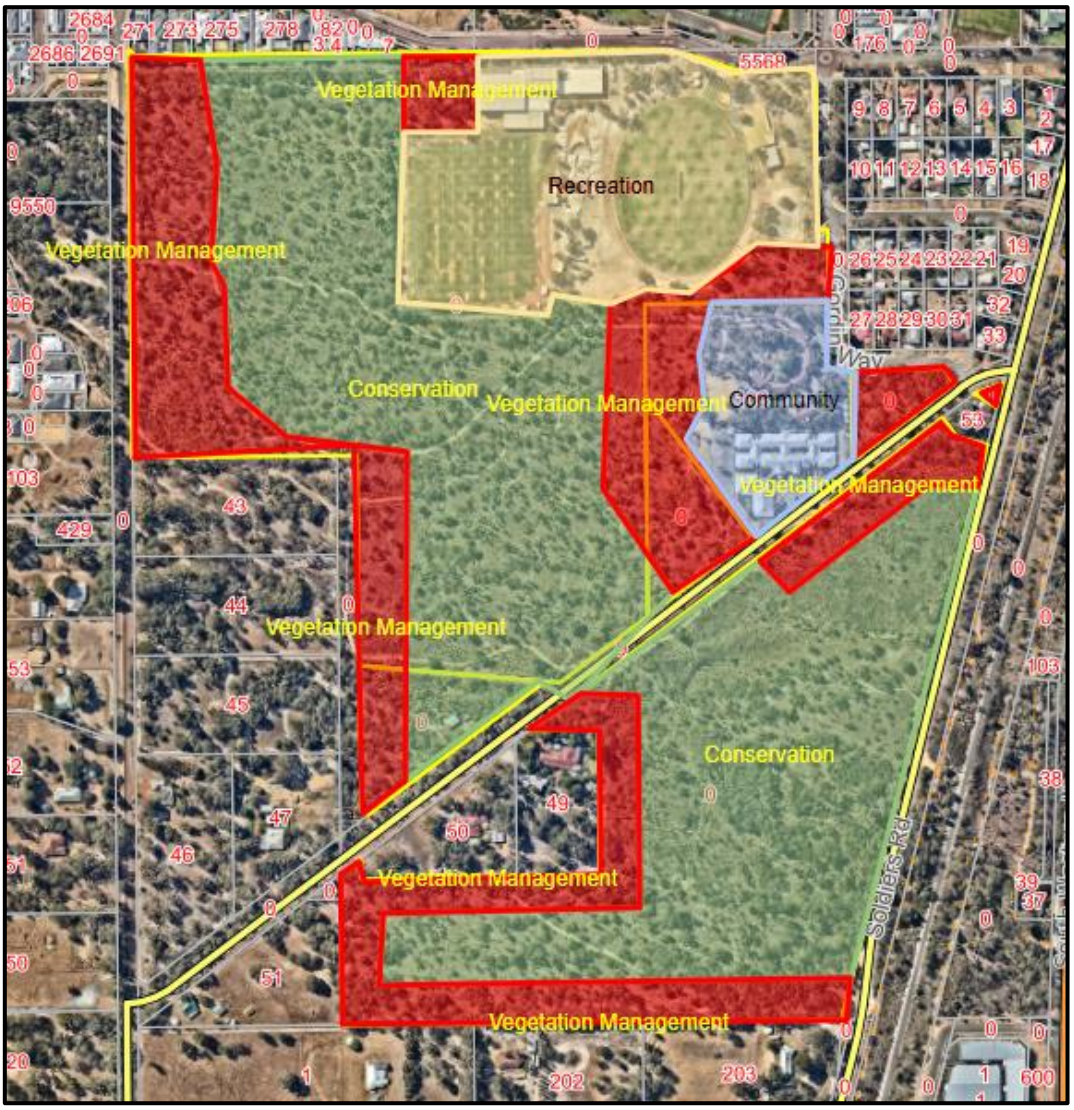


Figure 2: Uses and Management Zones of Brickwood Reserve.

1.3 Biodiversity

Brickwood Reserve contains three main vegetation communities: marri woodland, banksia woodland and clay-based wetlands. The clay-based wetland is approximately 2.5 ha in area (Figure 4) and belongs to the vegetation complex SCP09 (Dense shrublands on clay flats).

The entire reserve belongs to Threatened Ecological Communities and is an Environmentally Sensitive Area. Bush Forever site 321 includes the reserve and adjacent vegetated corridors.

The vegetation in Brickwood Reserve is in Very Good to Excellent condition overall. The flora of Brickwood Reserve has been frequently surveyed and is diverse. A number of Threatened and Priority flora species have been recorded in the area.

The fauna of Brickwood Reserve has not been thoroughly surveyed since 1997. The fauna recorded at the time was diverse, and anecdotal evidence suggests that the majority are still present. A number of Threatened and Priority fauna species have been recorded, including all three species of black cockatoos, and quenda (southern brown bandicoot).

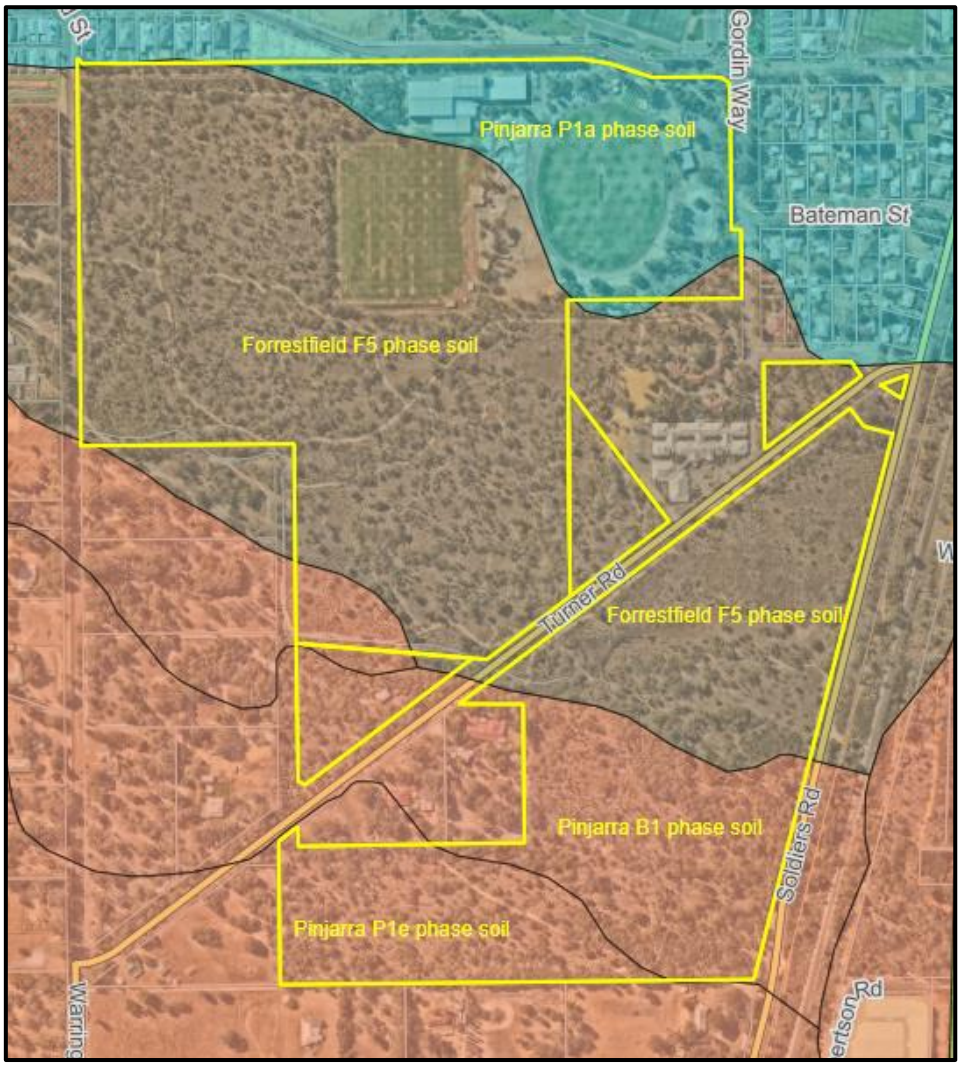


Figure 3: Soil types of Brickwood Reserve.

1.4 Water Resources

Brickwood Reserve is generally low-lying, and as such much of it is seasonally waterlogged. The clay-based wetland lies in the south-east of the reserve, with a watercourse (drain) running from the wetland along the boundary of the reserve to discharge across Warrington Road to the west.

The entire reserve, except for the recreational facilities and the banksia woodland, is a Conservation Category wetland (Figure 5). A small area of Resource Enhancement wetland lies between the reserve and the BaptistCare Graceford Aged Care Home, while the recreational facilities and the land surrounding the reserve is classified as a Multiple Use wetland.

Figure 4: Location of Marri Woodland of Brickwood Reserve.

2. Threats and Pressures

Threats and pressures to the conservation values of Brickwood Reserve include:

- Recreational pressure from surrounding urban areas
- Community anxiety about fire hazard and pressure for control burning
- Arson, vandalism and degradation
- Illegal dumping of rubbish and garden waste
- Illegal access by motorised vehicles and associated damage to fences and vegetation
- Weed invasion, from ovals, dumping, surrounding urban areas, and carried in by users
- Feral and domestic animals (foxes, rabbits, cats) predating fauna and damaging vegetation
- Dieback disease (*Phytophthora cinnamomi*)
- Nutrient runoff from ovals

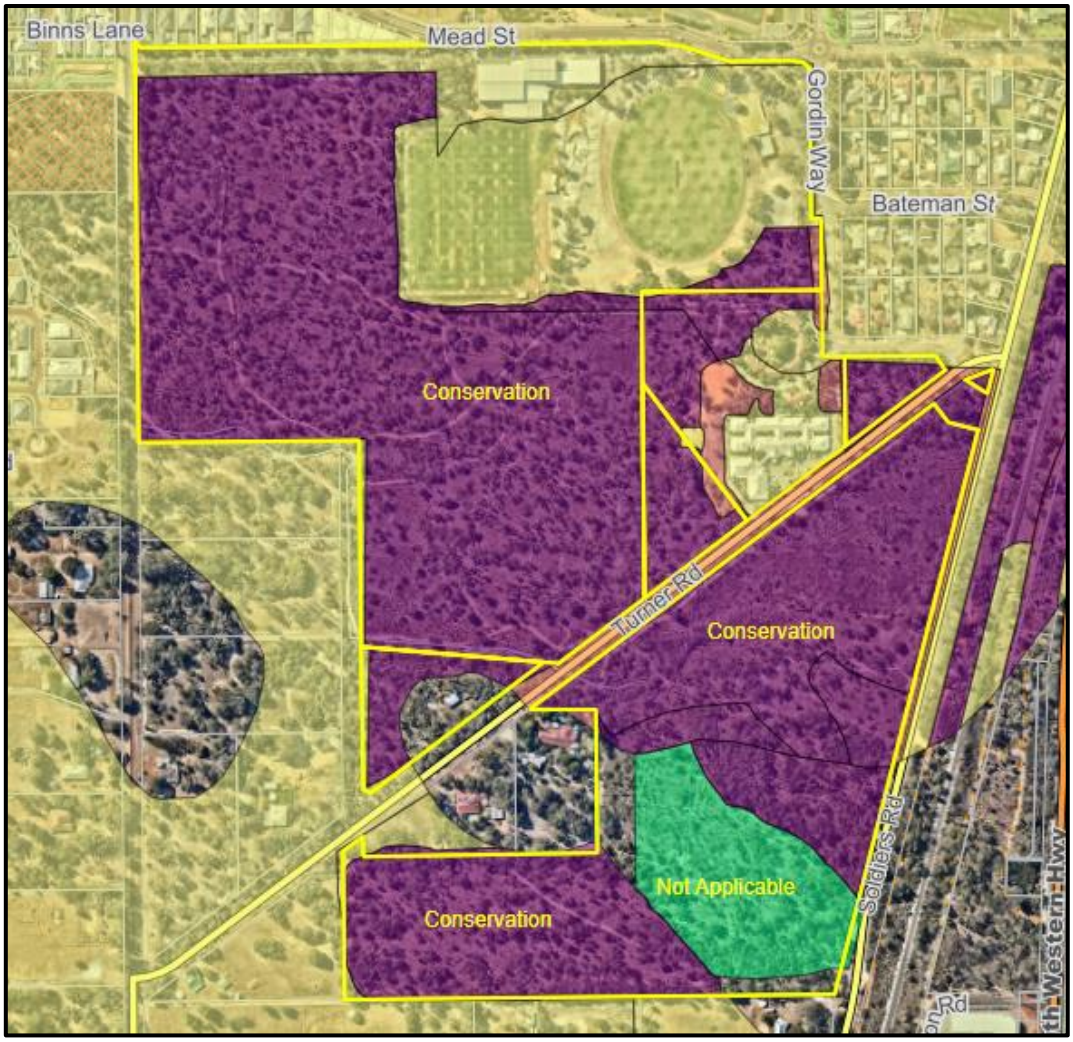


Figure 5: Geomorphic Wetland Types of Brickwood Reserve.

3. Reserve Usage

3.1 Vesting and Land Tenure

The vesting purpose, land tenure and current uses of the various lots that make up Brickwood Reserve are listed below in Table 2, and the land parcels shown in Figure 6. While R37404 (L106, in two parcels on either side of Graceford) is not vested with the Shire, it is traditionally managed as part of Brickwood Reserve and so is included here.

Table 2: Vesting Purpose, Land Tenure and Uses of Brickwood Reserve.

Reserve	Reserve and Lot Number	Vesting Purpose and Land Tenure	Current Uses
Brickwood Reserve	R17490 L5567, L111 and L112 Mead Street, Byford	Shire of Serpentine Jarrahdale – Recreation	Recreation and Conservation
	R51101 L48 Turner Road, Byford	Shire of Serpentine Jarrahdale – Environmental Conservation, Recreation, Community Centre and Purposes Ancillary Thereto	Recreation and Conservation
BaptistCare Graceford Aged Care Home	R37404 L106 Turner Road, Byford	WA Baptist Hospital and Homes Trust Inc. – Aged Persons Homes	Buffer Zone and Conservation

Figure 6: Reserve Numbers and Locations of Brickwood Reserve.

3.2 User Groups

The principal users of Brickwood Reserve are:

- Users of the recreation centre's facilities (gym, courts and function rooms), including school children in out of school hours care and coaching
- Sports groups, including cricket, football and diamond sports groups
- BMX club
- Friends of Brickwood
- Landcare SJ Inc.
- Informal users, particularly for walking and dog exercise
- BaptistCare Graceford Aged Care Home management, for R37404 vegetation management

Conflict between user groups with differing priorities can cause issues for management of the reserve. Informal users, particularly as pressure grows with the expanding urban development around the reserve, can degrade the vegetation and conflict with the conservation groups. BaptistCare's management of the vegetation around Graceford for protection of people and property can also conflict with conservation.

3.3 Infrastructure

The infrastructure located in Brickwood Reserve includes:

- Recreation centre (gym, courts and function rooms) managed by The Y (formerly YMCA)
- Sports pavilions and associated storage sheds
- Cricket nets
- Tennis courts (dilapidated and unused)
- Skate park
- BMX track
- Car parks
- Dilapidated building intended for community uses (R51101)
- Sports fields
- Bores and irrigation systems
- Fences and gates
- Signage, relating to entry and use, and conservation
- Firebreaks, some surfaced with limestone for trafficability
- Informal walking paths

The infrastructure is mostly maintained by the Shire. Despite a high standard of maintenance. good lighting and high community use and surveillance, vandalism and theft are constant but low-level threats.

Fire can threaten people, property and conservation values. Fires can start inside or adjacent to buildings and structures, and are often the result of vandalism, kitchen accidents or electrical faults. Bush or grass fires threaten buildings and structures through embers, radiant heat and direct contact. Cleared areas around buildings limit the opportunity for bush and grass fires to reach them. Fire in nearby bushland has the potential to damage infrastructure.

4. Action Plan

Table 3: Action Plan for Brickwood Reserve.

No.	Action	Priority	Timing	Status	Responsibility	Resources
1	**Utilise the planning system to retain and protect remnant clay-based wetlands.**	**Key**	**Business as Usual**	**Ongoing**	**Statutory Planning**	**Staff Time**
2	Keep up to date with the latest research trends and integrate into reserve management.	High	Long Term	Ongoing	Natural Reserves, Emergency Services	Staff Time
3	Formalise access to clay-based wetlands in high use areas through establishment of walking paths that reduce trampling.	Medium	Medium Term	Not Yet Implemented	Operations	Budget Dependent - $3,000
4	Erect signage in high use areas to inform users of the values of the clay-based wetlands.	Medium	Short Term	Implemented in Part	Operations	Budget Dependent - $2,000
5	**Survey for dieback presence, and map and treat dieback every three years if present.**	**Key**	**Business as Usual**	**Ongoing**	**Natural Reserves**	**Budget Dependent - $6,000**
6	Monitor and manage new and emerging pests and diseases such as polyphagous shot hole borer.	High	Medium Term	Ongoing	Natural Reserves	Budget Dependent - $2,000
7	Control access to clay-based wetlands through boundary fencing, convenient formal access points, and path construction that discourages deviation.	Low	Long Term	Not Yet Implemented	Operations	Budget Dependent - $3,000
8	Work with user groups to protect and minimize impacts to the remnant vegetation.	High	Business as Usual	Ongoing	Natural Reserves, User Groups	Staff Time
9	Liaise with other landholders to work together and integrate management of all banksia woodland areas.	Medium	Medium Term	Not Yet Implemented	Natural Reserves, Strategic Environmental Specialist	Staff Time
10	Implement measures to exclude motorised vehicles from the remnant vegetation.	High	Medium Term	Implemented in Part	Operations	Budget Dependent - $2,000
11	Erect fences or other structures to delineate user group areas.	Low	Long Term	Not Yet Implemented	Natural Reserves, User Groups	Budget Dependent - $2,000
12	Ensure that formalised paths and other access routes cross dieback fronts to the lowest degree possible.	Medium	Medium Term	Not Yet Implemented	Natural Reserves	Staff Time
13	Establish dieback hygiene policies, including vehicle washdown points and foot baths for pedestrians with appropriate signage where appropriate.	High	Long Term	Implemented in Part	Natural Reserves	Budget Dependent - $2,000
14	Conduct flora surveys and vegetation condition monitoring and mapping every five years.	Low	Business as Usual	Ongoing	Natural Reserves, Strategic Environmental Specialist	Budget Dependent - $3,000

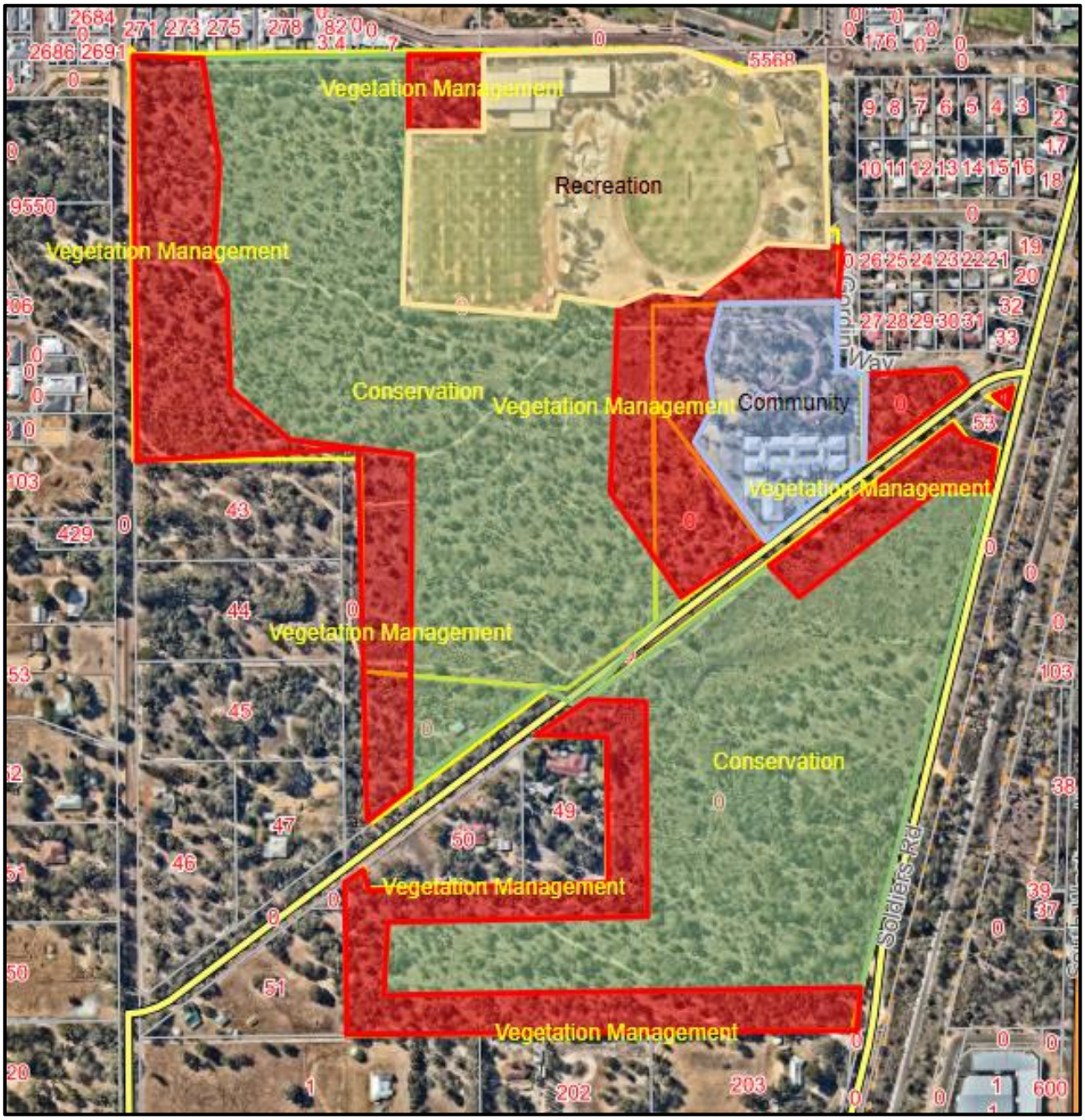
No.	Action	Priority	Timing	Status	Responsibility	Resources
15	Conduct fauna surveys every five years.	Low	Medium Term	Not Yet Implemented	Natural Reserves	Budget Dependent - $3,000
16	Monitor weed diversity and distribution annually.	High	Business as Usual	Ongoing	Natural Reserves	Staff Time
17	**Establish and implement a weed control program that utilises best practice methods.**	**Key**	**Business as Usual**	**Ongoing**	**Natural Reserves, Landcare SJ**	**Budget Dependent - $3,000**
18	Establish and implement a control program for woody weeds.	High	Business as Usual	Ongoing	Natural Reserves	Budget Dependent - $2,000
19	Conduct feral animal control when required, following all relevant health and safety regulations.	Medium	Business as Usual	Ongoing	Natural Reserves, Landcare SJ	Budget and/or Funding Dependent - $1,500
20	**Minimise burning and other disturbance of clay-based wetlands.**	**Key**	**Short Term**	**Implemented in Part**	**Emergency Services**	**Staff Time**
21	Avoid disturbance to the Conservation Zone and to dieback-free areas.	High	Short Term	Not Yet Implemented	Natural Reserves	Staff Time
22	Avoid fire in clay-based wetlands to the greatest degree possible.	High	Long Term	Not Yet Implemented	Emergency Services	Staff Time
23	Avoid fuel load management unless considered appropriate and necessary.	Medium	Business as Usual	Implemented in Part	Emergency Services, Natural Reserves	Staff Time
24	Restrict any essential fuel load management to the Vegetation Management Zone.	High	Short Term	Not Yet Implemented	Emergency Services	Budget Dependent - $1,500
25	Carry out fuel load management on adjacent road verges to avoid fire entering the reserve from the verge.	High	Medium Term	Not Yet Implemented	Emergency Services	Budget Dependent - $2,000
26	Ensure that any essential fuel load management utilises weed control as a priority, with control burning as a last resort.	Medium	Short Term	Not Yet Implemented	Emergency Services, Natural Reserves	Budget Dependent - $3,000
27	Ensure that any control burning is restricted to vegetation boundaries, providing a mosaic of vegetation ages including long unburnt.	High	Business as Usual	Implemented in Part	Emergency Services, Natural Reserves	Budget Dependent - $1,500
28	**Follow any burning or other disturbance with weed control for at least two years post-fire.**	**Key**	**Business as Usual**	**Implemented in Part**	**Emergency Services, Natural Reserves**	**Budget Dependent - $3,000**
29	Manage water use and allocations to ensure that environmental water requirements are considered and met.	Medium	Medium Term	Not Yet Implemented	Operations	Staff Time
30	Revegetate with local provenance seedlings as necessary and appropriate.	Medium	Medium Term	Implemented in Part	Friends Groups, Landcare SJ, Natural Reserves	Funding Dependent - $2,500
31	Monitor implementation of the management plan every three years.	High	Short Term	Not Yet Implemented	Strategic Environmental Specialist	Staff Time

No.	Action	Priority	Timing	Status	Responsibility	Resources
32	Update actions according to best practice management and monitoring outcomes.	High	Medium Term	Not Yet Implemented	Strategic Environmental Specialist	Staff Time
33	Review and revise the management plan every ten years.	High	Long Term	Not Yet Implemented	Strategic Environmental Specialist	Staff Time

5. Fire Management Strategy for Brickwood Reserve

Conservation Zone (green) – works exclusion; avoid disturbance

Vegetation Management Zone (red) – fuel load management if deemed appropriate and necessary by weed control and/or control burning followed by weed control



Dieback – present in some areas

Weeds – control required following disturbance

Firebreaks – present along boundaries

Serpentine Sports Reserve Action Plan

R19134

1. Background

1.1 Location

Serpentine Sports Reserve is located in Serpentine (Figure 1). It consists of two land parcels, one on each side of Karnup Road. The northern side contains holes 10-18 of the golf course, while the southern side contains the first nine holes, the David Buttfield Equestrian Park, the John Lyster Polocrosse Ground and a small area leased for a communications tower (Figure 2). It also includes regionally significant areas of remnant vegetation in the Paul Robinson Reserve and nearby woodland. This action plan applies to the southern land parcel only.

The reserve contains three main vegetation complexes: banksia woodland, marri woodland and a clay-based wetland. The reserve is 46.4 ha with 10.1 ha remnant vegetation of which 0.29 ha is clay-based wetland. This action plan specifically deals with the clay-based wetland area.

The reserve is vested with the Shire for the purpose of Recreation, Racecourse and Showground, but current uses also include Conservation. The principal user groups for the reserve are the Serpentine Horse and Pony Club, the Serpentine/Foothills Polocrosse Club, the Serpentine and Districts Golf Club, and the Serpentine Environmental Group. Each user group uses and maintains significant infrastructure.

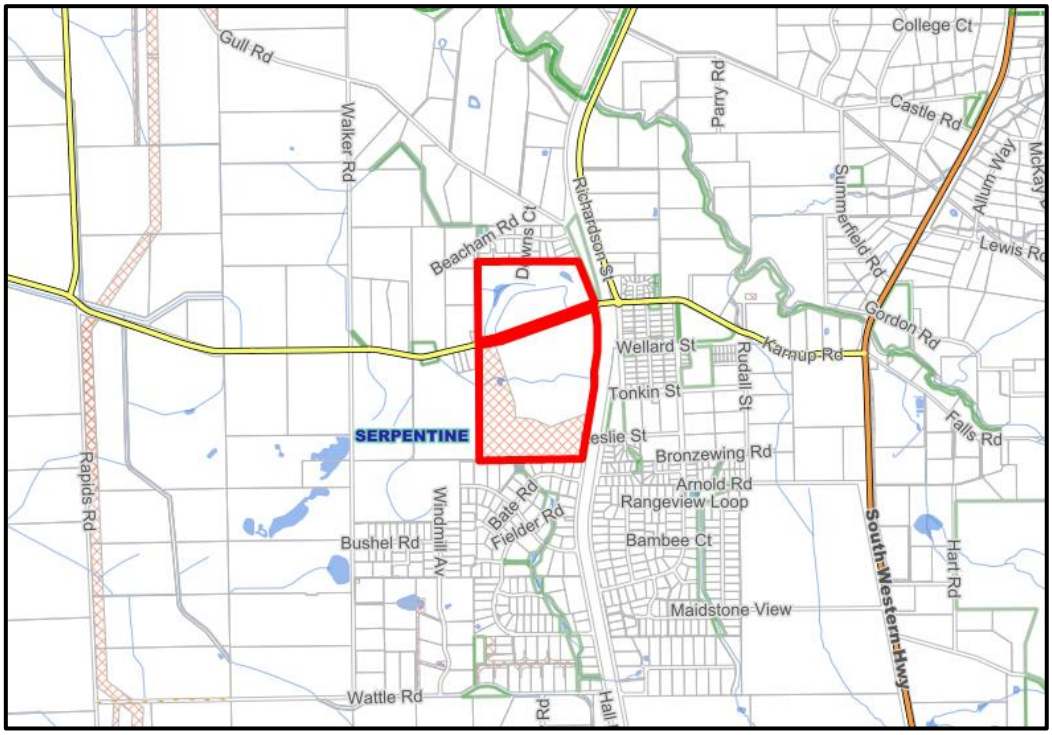


Figure 1: Location of Serpentine Sports Reserve.

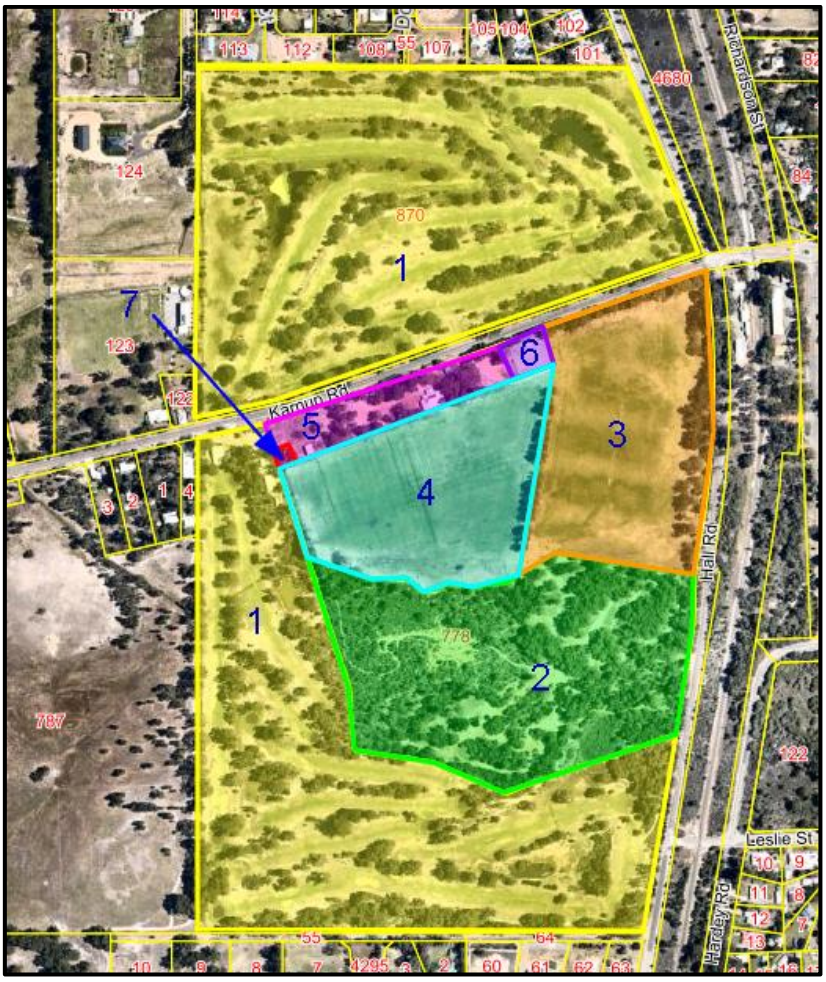


Figure 2: Land Uses of Serpentine Sports Reserve.

1 – Golf course
2 – Conservation area
3 – John Lyster Polocrosse Ground
4 – David Buttfield Equestrian Park
5 – Equestrian clubhouses and parking
6 – Netball courts (disused)
7 – Communications tower

Serpentine Sports Reserve is classified into three main management zones (Figure 3). These are:

Conservation Zone (green): Areas of remnant vegetation of high biodiversity and scientific reference value which include both dieback free and dieback infected areas. Management may include dieback treatment, weed control and revegetation as considered appropriate by officers and as required. Access within this area must utilise dieback hygiene procedures such as clean-down and take extreme care to prevent spread of dieback from infected to uninfected areas.

Vegetation Management Zone (red): Areas of remnant vegetation of biodiversity and scientific reference value which may be disturbed, or dieback or weed infested. This is a buffer zone and may receive fuel load management for protection of people, property and conservation values by weed control or control burning on assessment by officers as required and appropriate. Management may

include dieback treatment, weed control and revegetation as considered appropriate by officers and as required. Access within this area must consider movement and reduce spread of dieback from infected to uninfected areas through clean down procedures.

Recreation Zone (yellow): This is the area in use by the Serpentine Horse and Pony Club, the Serpentine/Foothills Polocrosse Club, and the Serpentine and Districts Golf Club. Management of this zone is principally for the purpose of recreation, while minimising impacts on the adjacent remnant vegetation.

This Action Plan applies to the Conservation and Vegetation Management Zones.

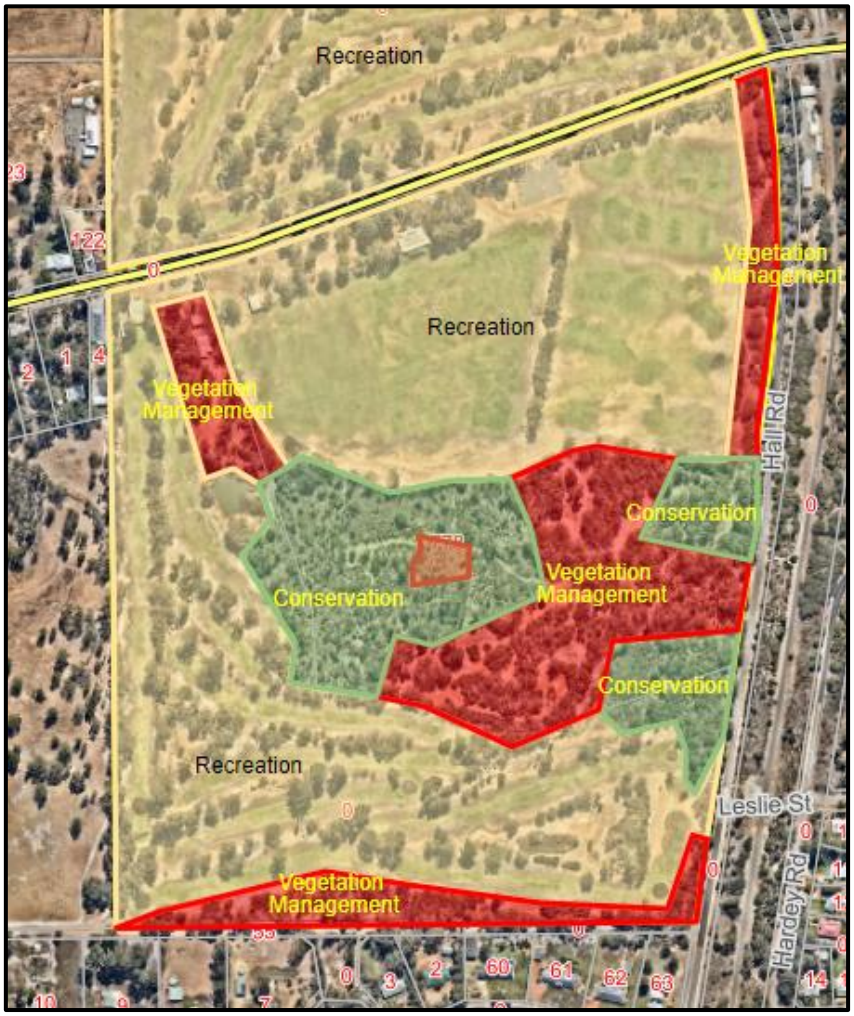


Figure 3: Management Zones of Serpentine Sports Reserve.

1.2 Soils

Four soil types occur in Serpentine Sports Reserve: Pinjarra B1, Pinjarra B3, Pinjarra P1b and Pinjarra P8 (Table 1 and Figure 4). The clay-based wetland occurs on the boundary of the Pinjarra B1 and Pinjarra B3 soil types.

Table 1: Soil Types of Serpentine Sports Reserve.

Reserve	Soil landscape unit	Description	Clay-based wetland occurrence
Serpentine Sports Reserve	Pinjarra B1 phase	Extremely low to very low relief dunes, undulating sandplain and discrete sand rises with deep bleached grey sands sometimes with a pale yellow B horizon or a weak iron-organic hardpan at depths generally greater than 2 m; banksia dominant.	Partial
	Pinjarra B3 phase	Closed depressions and poorly defined stream channels with moderately deep, poorly to very poorly drained bleached sands with an iron-organic pan, or clay subsoil. Surfaces are dark grey sand or sandy loam.	Partial
	Pinjarra P1b phase	Flat to very gently undulating plain with deep acidic mottled yellow duplex (or effective duplex) soils. Moderately deep pale sand to loamy sand over clay: imperfectly drained and moderately susceptible to salinity in limited areas.	No
	Pinjarra P8 phase	Broad poorly drained flats and poorly defined stream channels with moderately deep to deep sands over mottled clays; acidic or less commonly alkaline gley and yellow duplex soils to uniform bleached or pale brown sands over clay.	No

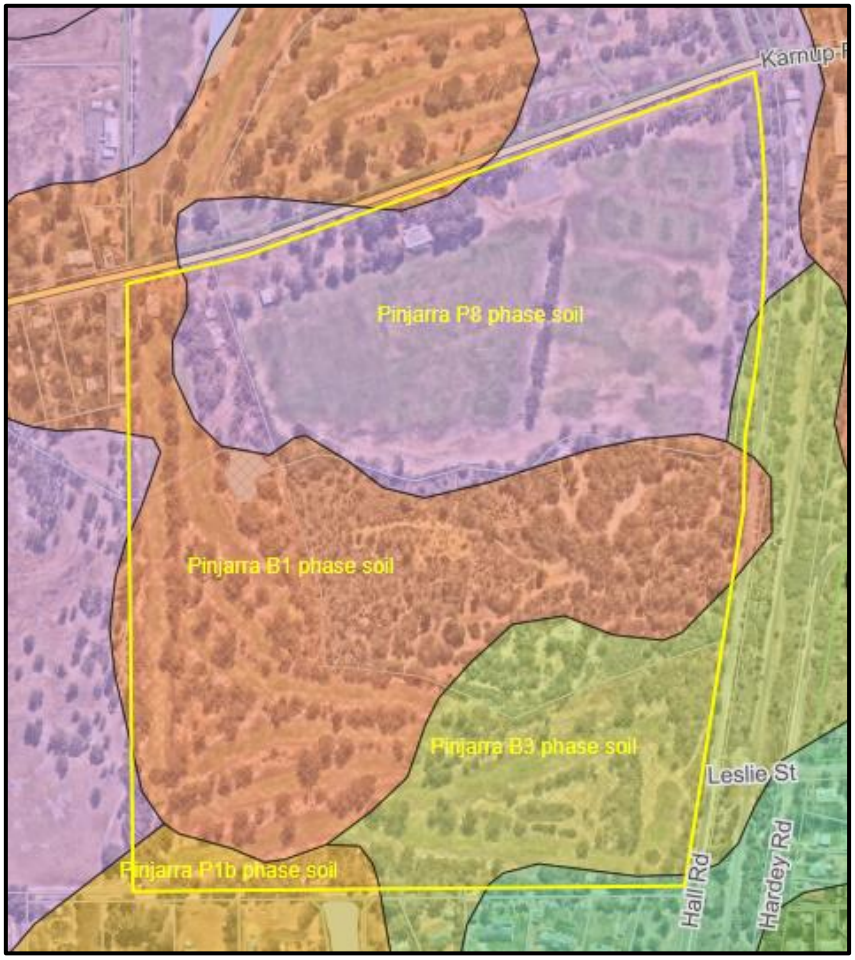


Figure 4: Soil Types of Serpentine Sports Reserve.

1.3 Biodiversity

Serpentine Sports Reserve contains three vegetation communities: banksia woodland, marri woodland and a clay-based wetland. The reserve is 46.4 ha with 10.1 ha remnant vegetation of which 0.29 ha is clay-based wetland (Figure 5) that belongs to the vegetation complex SCP10a (Shrublands on dry clay flats).

The areas classified as Conservation Zone for management (Figure 3) belong to Threatened Ecological Communities, and the entire reserve is an Environmentally Sensitive Area. The remnant vegetation in the reserve forms part of Bush Forever site 375, along with adjoining vegetation which forms a corridor along the railway to other reserves. The vegetation is in Very Good to Good condition overall.

The flora of Serpentine Sports Reserve has been frequently surveyed and is diverse. A number of Threatened and Priority flora species have been recorded in the area.

The fauna of Serpentine Sports Reserve has not been thoroughly surveyed since 1997. The fauna recorded at the time was diverse, and anecdotal evidence suggests that the majority are still present. A number of Threatened and Priority fauna species have been recorded, including black cockatoos and quenda (southern brown bandicoot).

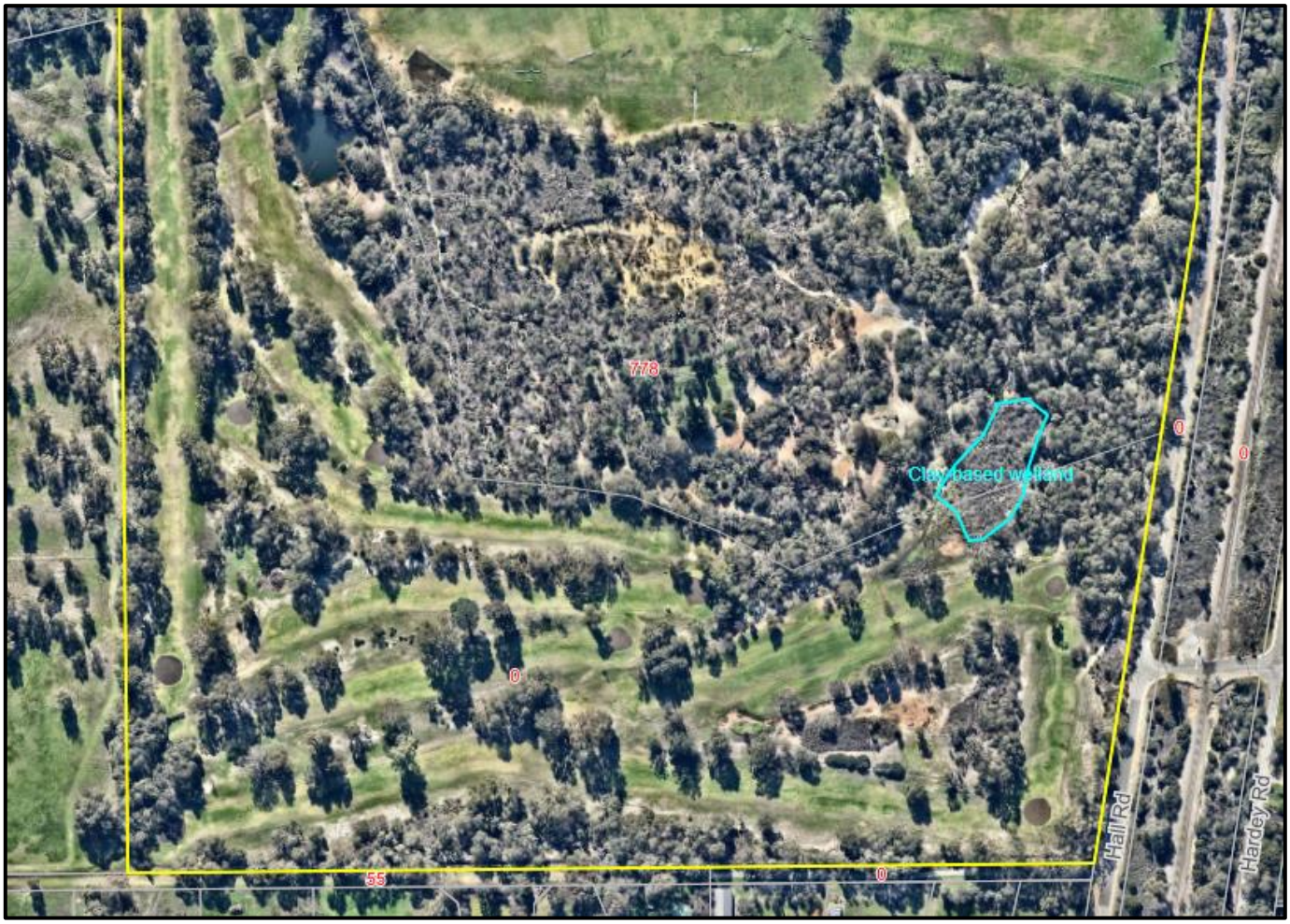


Figure 5: Location of Clay-Based Wetland of Serpentine Sports Reserve.

1.4 Water Resources

The clay-based wetland of Serpentine Sports Reserve is low in the landscape, sitting adjacent to a sand dune, with the other vegetation types occupying higher areas. Both the marri woodland and the clay-based wetland are frequently waterlogged in winter (and inundated in the case of the wetland). A major watercourse (drain) runs along the boundary between the equine areas and the bushland, flowing from east to west to a dam, and then across the golf course to discharge ultimately into the Serpentine River.

The clay-based wetland in the east of the reserve is classified as Conservation Category, while the majority of the reserve (other than the banksia woodland and the northern boundary) is a Resource Enhancement wetland (Figure 6).

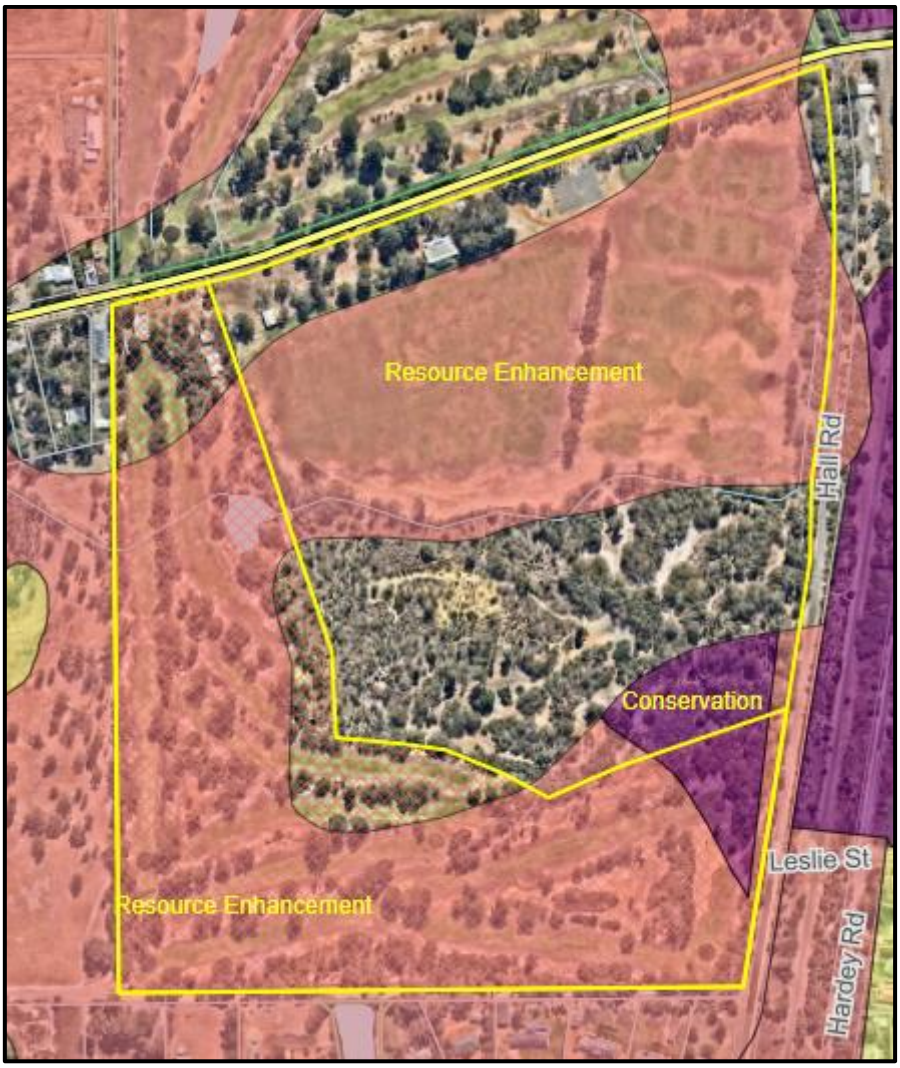


Figure 6: Geomorphic Wetlands of Serpentine Sports Reserve.

2. Threats and Pressures

Threats and pressures to the conservation values of Serpentine Sports Reserve include:

- Recreational pressure from users
- Community anxiety about fire hazard and pressure for control burning
- Illegal access by motorised vehicles and associated damage to fences and vegetation
- Arson and vandalism, to vegetation and infrastructure
- Weed invasion, from surrounding land and carried in by users
- Nutrient rich drainage from ovals and golf course, particularly into the wetland
- Feral and domestic animals (foxes, rabbits, cats) predating fauna and damaging vegetation
- Dieback disease (*Phytophthora cinnamomi*)
- Pony club's cross-country course, which passes through infected and dieback free zones

3. Reserve Usage

3.1 Vesting and Land Tenure

The vesting purpose, land tenure and current uses of Serpentine Sports Reserve are listed below in Table 2.

Table 2: Vesting Purpose, Land Tenure and Current Uses of Serpentine Sports Reserve.

Reserve	Reserve and Lot Number	Vesting and Land Tenure	Current Uses
Serpentine Sports Reserve	R19134 L778 Karnup Road, Serpentine	Shire of Serpentine Jarrahdale – Recreation, Racecourse and Showground	Recreation and Conservation

3.2 User Groups

The user groups of Serpentine Sports Reserve include:

- Serpentine and Districts Golf Club
- Serpentine Horse and Pony Club
- Serpentine/Foothills Polocrosse Club
- Serpentine Environmental Group
- Landcare SJ Inc., with frequent revegetation planting events
- Serpentine Primary School historically participated in planting events
- Occasional oval hire, e.g. Southside Jumps Club
- Facility hire (pony club and golf club clubhouses)
- Community events
- Informal users, particularly walking, dog exercise and horse riders

Conflict between user groups with differing priorities can cause issues for management of the reserve. Clubs who use the same facilities (e.g. pony club, polocrosse camping around both ovals, oval and clubhouse hire) can experience conflict around dates of use, or expectations of facility maintenance. Clubs can feel proprietorial about public facilities, with associated reluctance to allow other users. Liability issues over the use of jumps makes the pony club reluctant to allow casual riders onto the reserve.

Many users of the reserve can conflict with conservation groups. The golf club has historically discharged nutrient-rich water into the wetland. The pony club's cross-country course passes through the banksia woodland, with potential to spread dieback into clean areas. The polocrosse club historically camped and tethered horses within the marri woodland. Informal users have created new footpaths through the banksia woodland, degrading the vegetation and increasing the potential for the spread of dieback. There has even been conflict between conservation groups, with local enthusiasts believing that Landcare's weed control had killed orchid populations.

Other threats and pressures for the user groups include:

- Risk management and insurance, with stricter liability and higher premiums.
- Membership and member involvement, as any community group has a general problem with attracting and maintaining motivated volunteers to fill positions and undertake other tasks, with a few people tending to do most of the work.
- Compliance with legislation, such as health regulations.
- Security of tenure with ongoing long-term lease agreements essential to ensure that private investment in reserves is supported. User groups' facilities are mostly developed and maintained entirely by volunteers.

3.3 Infrastructure

The infrastructure located in Serpentine Sports Reserve includes:

- Communications tower
- Clubhouses for the pony club, golf club and polocrosse club, with associated storage sheds and a shared ablution facility
- Car parking areas
- Two equestrian sports fields and one fenced arena
- Horse yards, wash bays, stock ramp and manure bay
- Bores, water tanks, dams and irrigation systems
- Cross-country course with permanent jumps
- Golf course fairways and greens
- Dilapidated, unused netball courts
- Firebreaks and informal walking paths
- Fences and gates
- Signage, for conditions of entry and environmental education
- Drainage network

The golf club has built and maintains its own infrastructure by volunteer labour from members. The pony club and polocrosse club clubhouses (Eric Senior and Ivan Elliott Pavilions respectively) are public facilities and maintained by the Shire. The sports fields are maintained by the Shire, but the equine clubs maintain their other infrastructure. Despite fences and locked gates, good lighting and high usage providing surveillance, vandalism and theft are constant but low-level threats.

Fire can threaten people, property and conservation values. Fires can start inside or adjacent to buildings and structures, and are often the result of vandalism, kitchen accidents or electrical faults. Bush or grass fires threaten buildings and structures through embers, radiant heat and direct contact. Cleared areas around buildings limit the opportunity for bush and grass fires to reach them. Fire in nearby bushland has the potential to damage infrastructure.

4. Action Plan

Table 3: Action Plan for Serpentine Sports Reserve.

No.	Action	Priority	Timing	Status	Responsibility	Resources
1	**Utilise the planning system to retain and protect remnant clay-based wetlands.**	**Key**	**Business as Usual**	**Ongoing**	**Statutory Planning**	**Staff Time**
2	Keep up to date with the latest research trends and integrate into reserve management.	High	Long Term	Ongoing	Natural Reserves, Emergency Services	Staff Time
3	Formalise access to clay-based wetlands in high use areas through establishment of walking paths that reduce trampling.	Medium	Medium Term	Not Yet Implemented	Operations	Budget Dependent - $3,000
4	Erect signage in high use areas to inform users of the values of the clay-based wetlands.	Medium	Short Term	Implemented in Part	Operations	Budget Dependent - $2,000
5	**Survey for dieback presence, and map and treat dieback every three years if present.**	**Key**	**Business as Usual**	**Ongoing**	**Natural Reserves**	**Budget Dependent - $6,000**
6	Monitor and manage new and emerging pests and diseases such as polyphagous shot hole borer.	High	Medium Term	Ongoing	Natural Reserves	Budget Dependent - $2,000
7	Control access to clay-based wetlands through boundary fencing, convenient formal access points, and path construction that discourages deviation.	Low	Long Term	Not Yet Implemented	Operations	Budget Dependent - $3,000
8	Work with user groups to protect and minimize impacts to the remnant vegetation.	High	Business as Usual	Ongoing	Natural Reserves, User Groups	Staff Time
9	Liaise with other landholders to work together and integrate management of all banksia woodland areas.	Medium	Medium Term	Not Yet Implemented	Natural Reserves, Strategic Environmental Specialist	Staff Time
10	Implement measures to exclude motorised vehicles from the remnant vegetation.	High	Medium Term	Implemented in Part	Operations	Budget Dependent - $2,000
11	Erect fences or other structures to delineate user group areas.	Low	Long Term	Not Yet Implemented	Natural Reserves, User Groups	Budget Dependent - $2,000
12	Ensure that formalised paths and other access routes cross dieback fronts to the lowest degree possible.	Medium	Medium Term	Not Yet Implemented	Natural Reserves	Staff Time
13	Establish dieback hygiene policies, including vehicle washdown points and foot baths for pedestrians with	High	Long Term	Implemented in Part	Natural Reserves	Budget Dependent - $2,000

No.	Action	Priority	Timing	Status	Responsibility	Resources
	appropriate signage where appropriate.					
14	Conduct flora surveys and vegetation condition monitoring and mapping every five years.	Low	Business as Usual	Ongoing	Natural Reserves, Strategic Environmental Specialist	Budget Dependent - $3,000
15	Conduct fauna surveys every five years.	Low	Medium Term	Not Yet Implemented	Natural Reserves	Budget Dependent - $3,000
16	Monitor weed diversity and distribution annually.	High	Business as Usual	Ongoing	Natural Reserves	Staff Time
17	**Establish and implement a weed control program that utilises best practice methods.**	**Key**	**Business as Usual**	**Ongoing**	**Natural Reserves, Landcare SJ**	**Budget Dependent - $3,000**
18	Establish and implement a control program for woody weeds.	High	Business as Usual	Ongoing	Natural Reserves	Budget Dependent - $2,000
19	Conduct feral animal control when required, following all relevant health and safety regulations.	Medium	Business as Usual	Ongoing	Natural Reserves, Landcare SJ	Budget and/or Funding Dependent - $1,500
20	**Minimise burning and other disturbance of clay-based wetlands.**	**Key**	**Short Term**	**Implemented in Part**	**Emergency Services**	**Staff Time**
21	Avoid disturbance to the Conservation Zone and to dieback-free areas.	High	Short Term	Not Yet Implemented	Natural Reserves	Staff Time
22	Avoid fire in clay-based wetlands to the greatest degree possible.	High	Long Term	Not Yet Implemented	Emergency Services	Staff Time
23	Avoid fuel load management unless considered appropriate and necessary.	Medium	Business as Usual	Implemented in Part	Emergency Services, Natural Reserves	Staff Time
24	Restrict any essential fuel load management to the Vegetation Management Zone.	High	Short Term	Not Yet Implemented	Emergency Services	Budget Dependent - $1,500
25	Carry out fuel load management on adjacent road verges to avoid fire entering the reserve from the verge.	High	Medium Term	Not Yet Implemented	Emergency Services	Budget Dependent - $2,000
26	Ensure that any essential fuel load management utilises weed control as a priority, with control burning as a last resort.	Medium	Short Term	Not Yet Implemented	Emergency Services, Natural Reserves	Budget Dependent - $1,500
27	Ensure that any control burning is restricted to vegetation boundaries, providing a mosaic of vegetation ages including long unburnt.	High	Business as Usual	Implemented in Part	Emergency Services, Natural Reserves	Budget Dependent - $1,500
28	**Follow any burning or other disturbance with weed control for at least two years post-fire.**	**Key**	**Business as Usual**	**Implemented in Part**	**Emergency Services, Natural Reserves**	**Budget Dependent - $3,000**
29	Manage water use and allocations to ensure that environmental water requirements are considered and met.	Medium	Medium Term	Not Yet Implemented	Operations	Staff Time
30	Revegetate with local provenance seedlings as necessary and appropriate.	Medium	Medium Term	Implemented in Part	Friends Groups, Landcare SJ,	Funding Dependent - $2,500

No.	Action	Priority	Timing	Status	Responsibility	Resources
					Natural Reserves	
31	Monitor implementation of the management plan every three years.	High	Short Term	Not Yet Implemented	Strategic Environmental Specialist	Staff Time
32	Update actions according to best practice management and monitoring outcomes.	High	Medium Term	Not Yet Implemented	Strategic Environmental Specialist	Staff Time
33	Review and revise the management plan every ten years.	High	Long Term	Not Yet Implemented	Strategic Environmental Specialist	Staff Time

5. Fire Management Strategy for Serpentine Sports Reserve

Conservation Zone (green) – works exclusion; avoid disturbance

Vegetation Management Zone (red) – fuel load management if deemed appropriate and necessary by weed control and/or control burning followed by weed control

Dieback – present in some areas

Weeds – control required following disturbance

Firebreaks – present along boundaries

Yangedi Airfield Reserve Action Plan

R25911

1. Background

1.1 Location

Yangedi Airfield Reserve is located in Hopeland (Figure 1). The reserve contains three vegetation types: banksia woodland, marri woodland and a clay-based wetland. The reserve is 64.7 ha with 32.9 ha remnant vegetation, of which approximately 6.5 ha is clay-based wetland. This action plan specifically deals with the clay-based wetland area.

The reserve is vested with the Shire for the purpose of Recreation, but current uses also include Conservation. The principal user groups for the reserve are the Sport Aircraft Builders Club, the Bureau of Meteorology and the Department of Fire and Emergency Services, which all maintain significant infrastructure. The areas used by each group are shown in Figure 2.

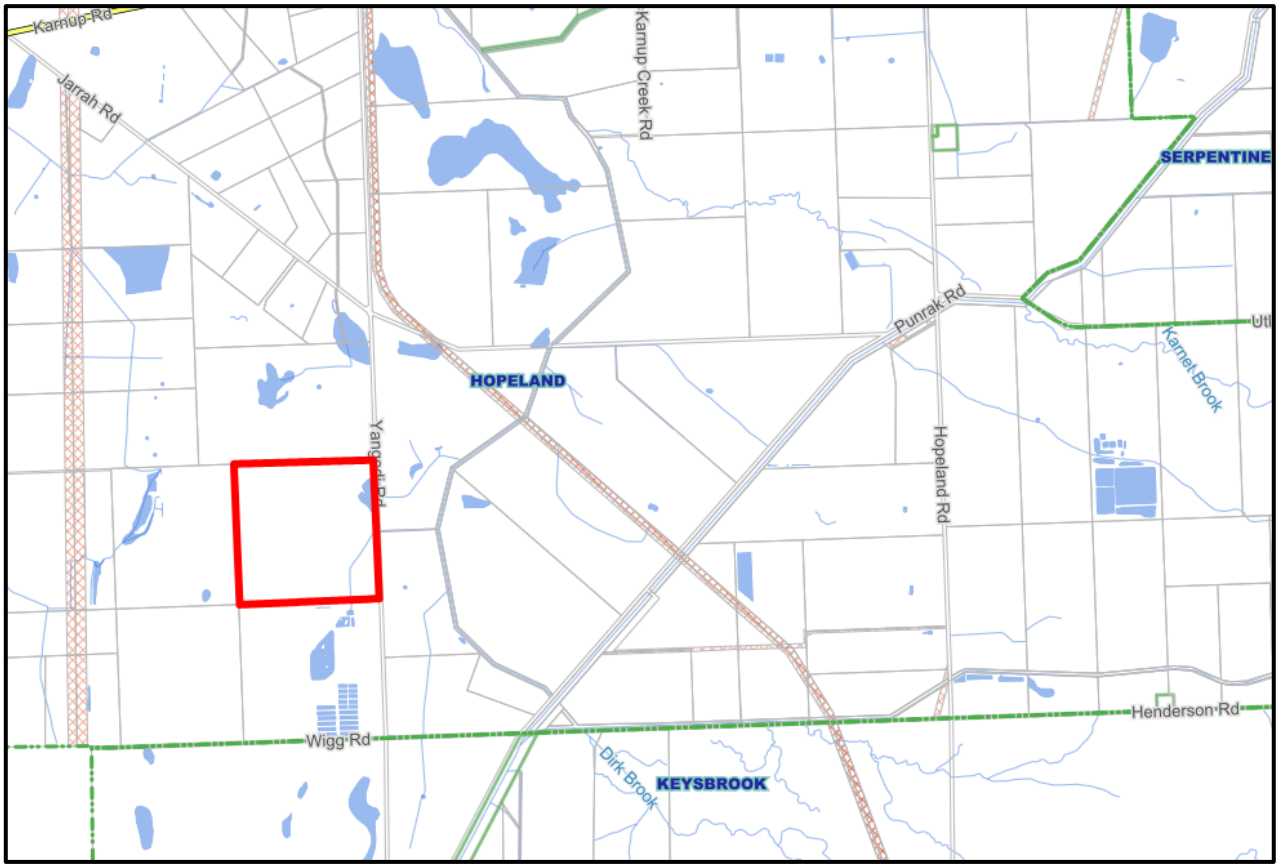


Figure 1: Location of Yangedi Airfield Reserve.

Yangedi Airfield Reserve is classified into four main management zones (Figure 2). These are:

Conservation Zone (green): Areas of remnant vegetation of high biodiversity and scientific reference value which include both dieback free and dieback infected areas. Management may include dieback treatment, weed control and revegetation as considered appropriate by officers and as required. Access within this area must utilise dieback hygiene procedures such as clean-down and take extreme care to prevent spread of dieback from infected to uninfected areas.

Vegetation Management Zone (red): Areas of remnant vegetation of biodiversity and scientific reference value which may be disturbed, or dieback or weed infested. This is a buffer zone and may receive fuel load management for protection of people, property and conservation values by weed control or control burning on assessment by officers as required and appropriate. Management may include dieback treatment, weed control and revegetation as considered appropriate by officers and as required. Access within this area must consider movement and reduce spread of dieback from infected to uninfected areas through clean down procedures.

Recreation Zone (yellow): This is the area in use by the Sport Aircraft Builders Club. Management of this zone is principally for the purpose of recreation and aviation safety, while minimising impacts on the adjacent remnant vegetation. Access to this zone must be negotiated with the SABC to maintain safety of aircraft and visitors.

Leased Zone (purple and blue): Areas leased by the Bureau of Meteorology (purple) and the Department of Fire and Emergency Services (blue). Management of these areas is principally for maintenance of infrastructure and protection of people and property.

This Action Plan applies to the Conservation and Vegetation Management Zones.

Figure 2: Land Uses and Management Zones of Yangedi Airfield Reserve.

1.2 Soils

Two soil types occur in Yangedi Airfield Reserve: Bassendean B1 and Bassendean B3 (Table 1 and Figure 3). The clay-based wetland occurs on the Bassendean B3 soil type.

Table 1: Soil Types of Yangedi Airfield Reserve.

Reserve	Soil landscape unit	Description	Marri occurrence
Yangedi Airfield Reserve	Bassendean B1 phase	Extremely low to very low relief dunes, undulating sandplain and discrete sand rises with deep bleached grey sands sometimes with a pale yellow B horizon or a weak iron-organic hardpan at depths generally greater than 2 m; banksia dominant.	No
	Bassendean B3 phase	Closed depressions and poorly defined stream channels with moderately deep, poorly to very poorly drained bleached sands with an iron-organic pan, or clay subsoil. Surfaces are dark grey sand or sandy loam.	Partial

Figure 3: Soil Types of Yangedi Airfield Reserve.

1.3 Biodiversity

Yangedi Airfield Reserve contains three vegetation communities: banksia woodland in the northwest and southwest, a clay-based wetland in the east, and marri woodland in the southeast. The clay-based wetland is approximately 6.5 ha in area (Figure 4) although its vegetation complex is uncertain as the clay-based wetland area has not been surveyed.

The vegetated areas of the reserve belong to Threatened Ecological Communities, and all but the northeastern corner is an Environmentally Sensitive Area. The majority of the reserve (except for the northeastern corner) belongs to Bush Forever site 378, which extends into several neighbouring properties to provide a larger area of habitat. The vegetation is in Very Good to Good condition overall.

The flora of Yangedi Airfield Reserve has been frequently surveyed and is diverse. No Threatened and Priority flora species have been recorded in the area. The fauna has not been formally surveyed since 1997, although anecdotally most species still remain, including Threatened and Priority fauna such as black cockatoos and quenda (southern brown bandicoot). Kangaroos have also been observed in the reserve.

Figure 4: Location of Clay-Based Wetland of Yangedi Airfield Reserve.

1.4 Water Resources

Yangedi Airfield Reserve is generally low in the landscape, containing the more low-lying types of woodland and wetlands. A watercourse (drain) runs through the southeastern corner of the reserve to discharge southwards into the water bodies on the adjacent property.

The southeastern half of the reserve, southeast of the main runway, is classified as a Multiple Use wetland (Figure 5), with a Resource Enhancement classification on the clay-based wetland on the eastern boundary and Conservation Category wetlands between the runways and south of the secondary grass runway. A third Conservation Category wetland lies north of the hangars, near the northern boundary of the reserve.

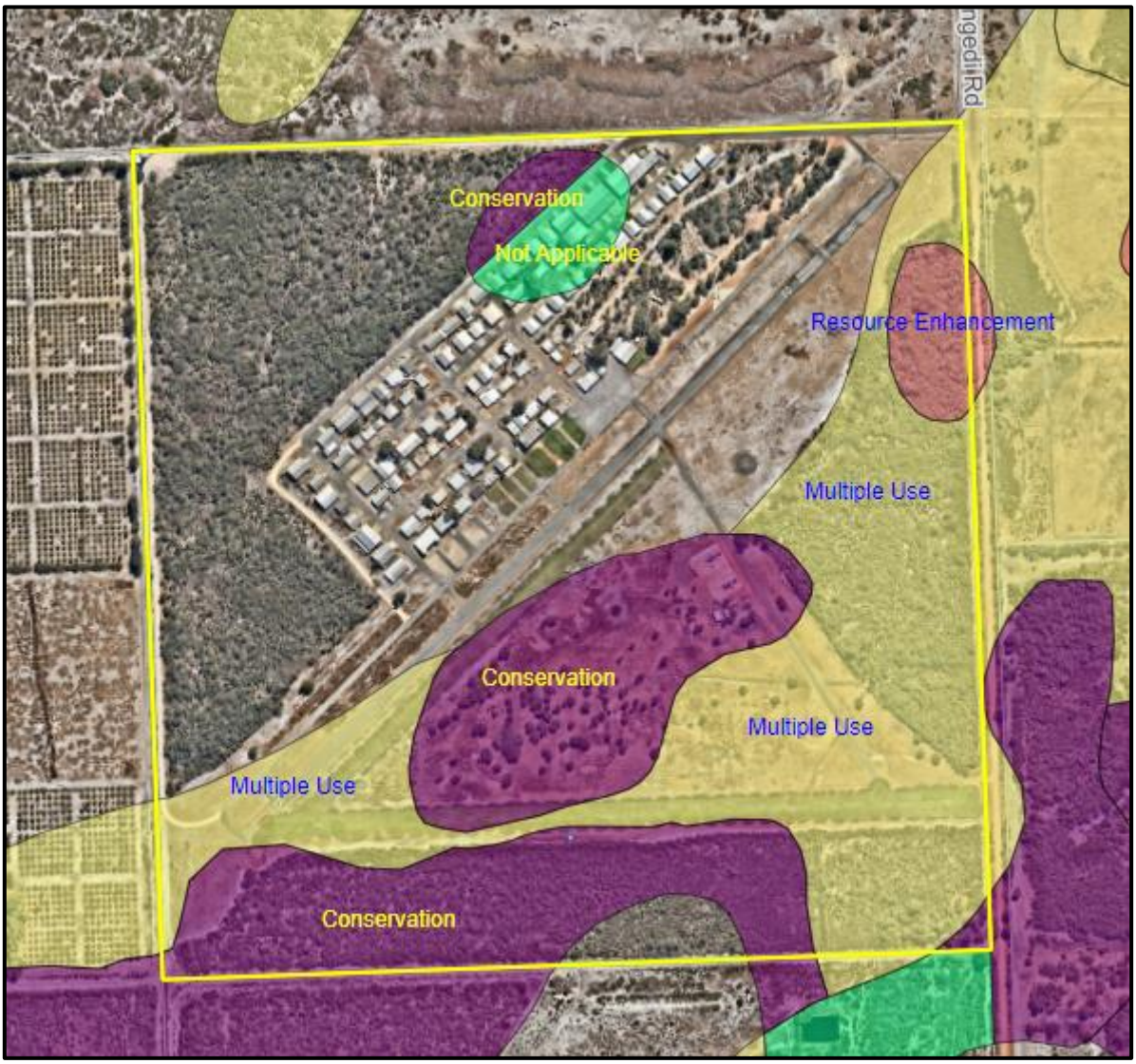


Figure 5: Geomorphic Wetlands of Yangedi Airfield Reserve.

2. Threats and Pressures

Threats and pressures to the conservation values of Yangedi Airfield Reserve include:

- Recreational and development pressure from users, including pressure for expansion into bushland for more aircraft hangars
- Community anxiety about fire hazard and pressure for control burning, particularly considering the high value of the aircraft and the BoM tower
- Fire threat of highly flammable aircraft fuel
- Weed invasion, from surrounding land and carried in by users
- Feral and domestic animals (foxes, rabbits, cats) predating fauna and damaging vegetation
- Dieback disease (*Phytophthora cinnamomi*) and marri canker
- Contaminated runoff from runways, aircraft hangars, helipad etc. entering wetland and other bushland areas

3. Reserve Usage

3.1 Vesting and Land Tenure

The vesting purpose, land tenure and current uses of Yangedi Airfield Reserve are listed below in Table 2.

Table 2: Vesting Purpose, Land Tenure and Current Uses of Yangedi Airfield Reserve.

Reserve	Reserve and Lot Number	Vesting and Land Tenure	Current Uses
Yangedi Airfield Reserve	R25911 L164 Yangedi Road, Hopeland	Shire of Serpentine Jarrahdale – Recreation	Recreation (Airfield, DFES Helipad, BoM tower) and Conservation

3.2 User Groups

The principal user groups of Yangedi Airfield Reserve are the Sport Aircraft Builders Club, the Bureau of Meteorology and the Department of Fire and Emergency Services. Casual usage is negligible, as the reserve has an electronic gate to control access due to the valuable infrastructure and public safety concerns. Maintenance of conservation values is limited to Shire staff.

Threats and pressures for the user groups include:

- Risk management and insurance, with strict liability and high premiums.
- Membership and member involvement, as any community group has a general problem with attracting and maintaining motivated volunteers to fill positions and undertake other tasks, with a few people tending to do most of the work.
- Conflict among user groups with differing priorities, such as potential conflict between the SABC's desire to expand and the conservation values of the bushland.
- Compliance with legislation, such as health regulations.

- Security of tenure, with ongoing long-term lease agreements essential to ensure that private investment in reserves is supported. User groups' facilities are mostly developed and maintained entirely by volunteers.

An airfield is an inherently hazardous place to which public access must be restricted. On a day-to-day basis, visitors can only access the reserve in the company of a club member, or by prior arrangement to be let through the electric gate. Aircraft have right of way on the taxiways, which may not be apparent to visitors. Public access is only granted on open days, and even then, is strictly controlled. Public access protocols are under continuous improvement as more people become aware of the airfield.

3.3 Infrastructure

The infrastructure located in Yangedi Airfield Reserve includes:

- SABC clubhouse, ablution facilities and associated storage sheds
- SABC centralised fuel storage facility
- Aircraft hangars (about 100) with stored aircraft, parts and tools
- Hangar living quarters, toilets and treatment units, and water tanks
- Taxiways (bitumised) and two runways (one bitumised, one irrigated grass)
- Airfield-associated infrastructure such as wind socks
- Car parking area
- BoM communications tower (providing rain radar data) with maintenance access
- DFES helipad for water bombing aircraft and associated facilities
- Bores, storage dams, water tanks and irrigation
- Firebreaks and fences
- Electronic gate
- Signage, including conditions of entry and safety precautions, and bushland entry prohibition

The airfield infrastructure is maintained by the SABC, with each hangar maintained by its owner. As the hangars contain valuable aircraft, tools and spare parts, maintenance tends to be regular and focused on security and safety. Inadequate maintenance would lead to accelerated deterioration and increased risk. Poorly maintained facilities also tend to attract vandalism. The BoM and DFES also have valuable facilities which require regular maintenance and security, assisted by access to the reserve being restricted by the SABC's electronic gate. The Shire manages the bushland and maintains the firebreaks.

Despite fences and locked gates, vandalism and theft are constant but low-level threats. Surveillance is an effective deterrent. The SABC has a roster system for its members to ensure a constant presence on site for security purposes. This also assists in protection of the BoM and DFES facilities.

Fire can threaten people, property and conservation values. Fires can start inside or adjacent to buildings and structures, and are often the result of vandalism, kitchen accidents or electrical faults. Bush or grass fires threaten buildings and structures through embers, radiant heat and direct contact. Cleared areas around buildings limit the opportunity for bush and grass fires to reach them. Fire in nearby bushland has the potential to damage infrastructure.

An additional hazard at the airfield is the storage of highly flammable aircraft fuel, which greatly increases the risks and consequences of fire. Fuel is stored in a central location with the hangars only containing fuel within the aircraft. A fire within a hangar or from the bushland could quickly spread if fuel ignited and cause significant damage to or destruction of valuable property.

4. Action Plan

Table 3: Action Plan for Yangedi Airfield Reserve.

No.	Action	Priority	Timing	Status	Responsibility	Resources
1	**Utilise the planning system to retain and protect remnant clay-based wetlands.**	**Key**	**Business as Usual**	**Ongoing**	**Statutory Planning**	**Staff Time**
2	Keep up to date with the latest research trends, particularly with regard to banksia woodland and fire, and integrate into reserve management.	High	Long Term	Ongoing	Natural Reserves, Emergency Services	Staff Time
3	Formalise access to clay-based wetlands in high use areas through establishment of walking paths that reduce trampling.	Medium	Medium Term	Not Yet Implemented	Operations	Budget Dependent - $3,000
4	Erect signage in high use areas to inform users of the values of the clay-based wetlands.	Medium	Short Term	Implemented in Part	Operations	Budget Dependent - $2,000
5	**Survey for dieback presence, and map and treat dieback every three years if present.**	**Key**	**Business as Usual**	**Ongoing**	**Natural Reserves**	**Budget Dependent - $9,500**
6	Monitor and manage new and emerging pests and diseases such as polyphagous shot hole borer.	High	Medium Term	Ongoing	Natural Reserves	Budget Dependent - $2,000
7	Control access to clay-based wetlands through boundary fencing, convenient formal access points, and path construction that discourages deviation.	Low	Long Term	Not Yet Implemented	Operations	Budget Dependent - $3,000
8	Work with user groups to protect and minimize impacts to the remnant vegetation.	High	Business as Usual	Ongoing	Natural Reserves, User Groups	Staff Time
9	Liaise with other landholders to work together and integrate management of all banksia woodland areas.	Medium	Medium Term	Not Yet Implemented	Natural Reserves, Strategic Environmental Specialist	Staff Time
10	Implement measures to exclude motorised vehicles from the remnant vegetation.	High	Medium Term	Implemented in Part	Operations	Budget Dependent - $2,000
11	Erect fences or other structures to delineate user group areas.	Low	Long Term	Not Yet Implemented	Natural Reserves, User Groups	Budget Dependent - $2,000
12	Ensure that formalised paths and other access routes cross dieback fronts to the lowest degree possible.	Medium	Medium Term	Not Yet Implemented	Natural Reserves	Staff Time
13	Establish dieback hygiene policies, including vehicle washdown points and foot baths for pedestrians with appropriate signage where appropriate.	High	Long Term	Implemented in Part	Natural Reserves	Budget Dependent - $2,000
14	Conduct flora surveys and vegetation condition monitoring and mapping every five years.	Low	Business as Usual	Ongoing	Natural Reserves, Strategic	Budget Dependent - $3,000

No.	Action	Priority	Timing	Status	Responsibility	Resources
					Environmental Specialist	
15	Conduct fauna surveys every five years.	Low	Medium Term	Not Yet Implemented	Natural Reserves	Budget Dependent - $3,000
16	Monitor weed diversity and distribution annually.	High	Business as Usual	Ongoing	Natural Reserves	Staff Time
17	**Establish and implement a weed control program that utilises best practice methods.**	**Key**	**Business as Usual**	**Ongoing**	**Natural Reserves, Landcare SJ**	**Budget Dependent - $8,000**
18	Establish and implement a control program for woody weeds.	High	Business as Usual	Ongoing	Natural Reserves	Budget Dependent - $3,000
19	Conduct feral animal control when required, following all relevant health and safety regulations.	Medium	Business as Usual	Ongoing	Natural Reserves, Landcare SJ	Budget and/or Funding Dependent - $1,500
20	**Minimise burning and other disturbance of clay-based wetlands.**	**Key**	**Short Term**	**Implemented in Part**	**Emergency Services**	**Staff Time**
21	Avoid disturbance to the Conservation Zone and to dieback-free areas.	High	Short Term	Not Yet Implemented	Natural Reserves	Staff Time
22	Avoid fire in clay-based wetlands to the greatest degree possible.	High	Long Term	Not Yet Implemented	Emergency Services	Staff Time
23	Avoid fuel load management unless considered appropriate and necessary.	Medium	Business as Usual	Implemented in Part	Emergency Services, Natural Reserves	Staff Time
24	Restrict any essential fuel load management to the Vegetation Management Zone.	High	Short Term	Not Yet Implemented	Emergency Services	Budget Dependent - $1,500
25	Carry out fuel load management on adjacent road verges to avoid fire entering the reserve from the verge.	High	Medium Term	Not Yet Implemented	Emergency Services	Budget Dependent - $2,000
26	Ensure that any essential fuel load management utilises weed control as a priority, with control burning as a last resort.	Medium	Short Term	Not Yet Implemented	Emergency Services, Natural Reserves	Budget Dependent - $8,000
27	Ensure that any control burning is restricted to vegetation boundaries, providing a mosaic of vegetation ages including long unburnt.	High	Business as Usual	Implemented in Part	Emergency Services, Natural Reserves	Budget Dependent - $1,500
28	**Follow any burning or other disturbance with weed control for at least two years post-fire.**	**Key**	**Business as Usual**	**Implemented in Part**	**Emergency Services, Natural Reserves**	**Budget Dependent - $8,000**
29	Manage water use and allocations to ensure that environmental water requirements are considered and met.	Medium	Medium Term	Not Yet Implemented	Operations	Staff Time
30	Revegetate with local provenance seedlings as necessary and appropriate.	Medium	Medium Term	Implemented in Part	Friends Groups, Landcare SJ, Natural Reserves	Funding Dependent - $2,500
31	Monitor implementation of the management plan every three years.	High	Short Term	Not Yet Implemented	Strategic Environmental Specialist	Staff Time

No.	Action	Priority	Timing	Status	Responsibility	Resources
32	Update actions according to best practice management and monitoring outcomes.	High	Medium Term	Not Yet Implemented	Strategic Environmental Specialist	Staff Time
33	Review and revise the management plan every ten years.	High	Long Term	Not Yet Implemented	Strategic Environmental Specialist	Staff Time

5. Fire Management Strategy for Yangedi Airfield Reserve

Conservation Zone (green) – works exclusion; avoid disturbance

Vegetation Management Zone (red) – fuel load management if deemed appropriate and necessary by weed control and/or control burning followed by weed control

Dieback – present in some areas

Weeds – control required following disturbance

Firebreaks – present along boundaries

Karnup Road Flora Reserve Action Plan

R18662

1. Background

1.1 Location

Karnup Road Flora Reserve is located in Serpentine (Figure 1). The reserve is dominated by the clay-based wetland with a narrow fringe of upland vegetation along the road verge. The reserve is 0.87 ha with 0.66 ha remnant vegetation (clay-based wetland). This action plan specifically deals with the clay-based wetland area.

The reserve is vested with the Shire for the purpose of Indigenous Vegetation / Protection of Flora, with the current use principally Conservation. The principal users of the reserve are informal, infrequent walkers.

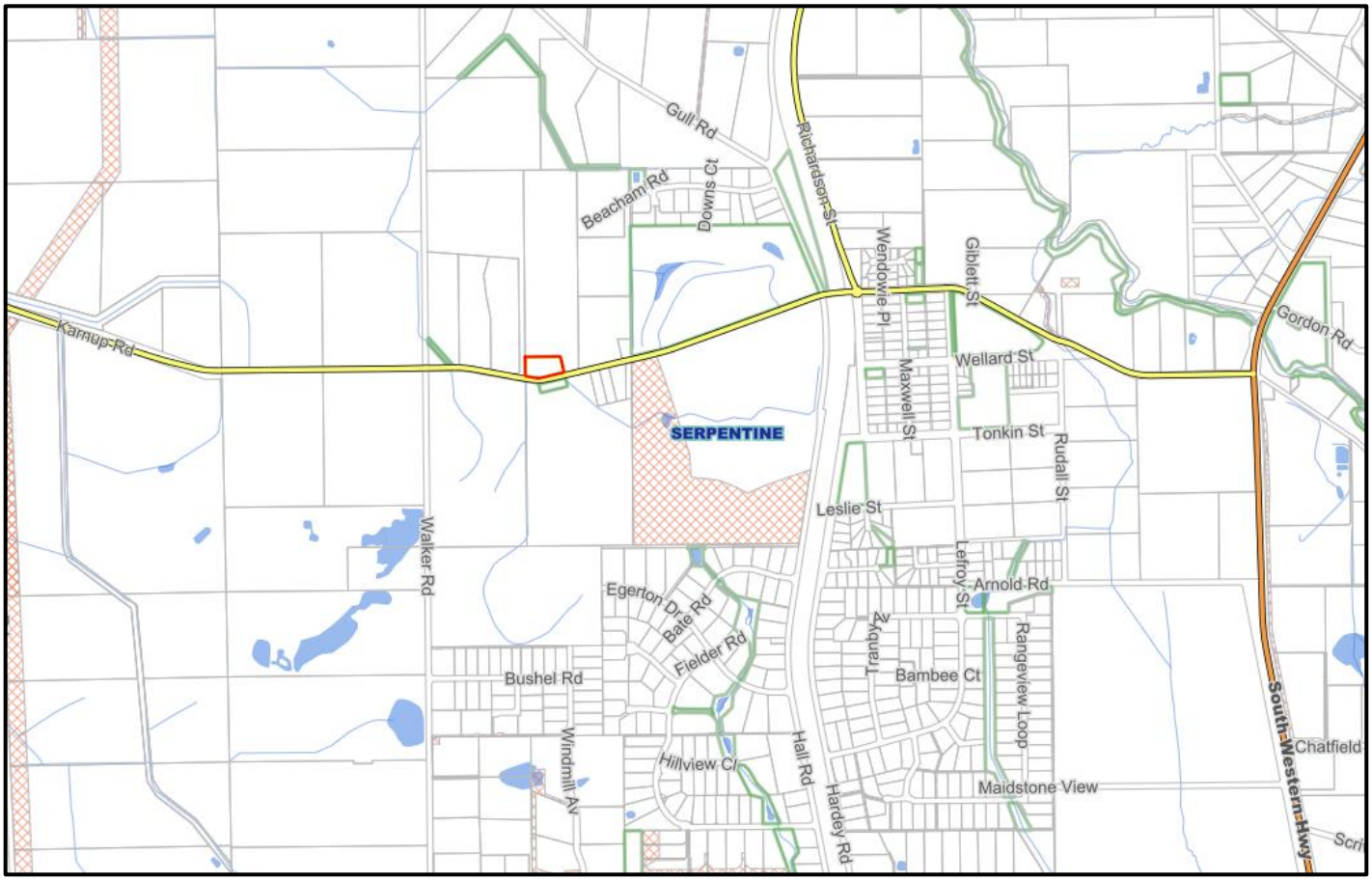


Figure 1: Location of Karnup Road Flora Reserve.

Karnup Road Flora Reserve is classified into two main management zones (Figure 2). These are:

Conservation Zone (green): Areas of remnant vegetation of high biodiversity and scientific reference value which include both dieback free and dieback infected areas. Management may include dieback treatment, weed control and revegetation as considered appropriate by officers and as required. Access within this area must utilise dieback hygiene procedures such as clean-down and take extreme care to prevent spread of dieback from infected to uninfected areas.

Vegetation Management Zone (red): Areas of remnant vegetation of biodiversity and scientific reference value which may be disturbed, or dieback or weed infested. This is a buffer zone and may receive fuel load management for protection of people, property and conservation values by weed control or control burning on assessment by officers as required and appropriate. Management may include dieback treatment, weed control and revegetation as considered appropriate by officers and as required. Access within this area must consider movement and reduce spread of dieback from infected to uninfected areas through clean down procedures.

This Action Plan applies to the Conservation and Vegetation Management Zones.

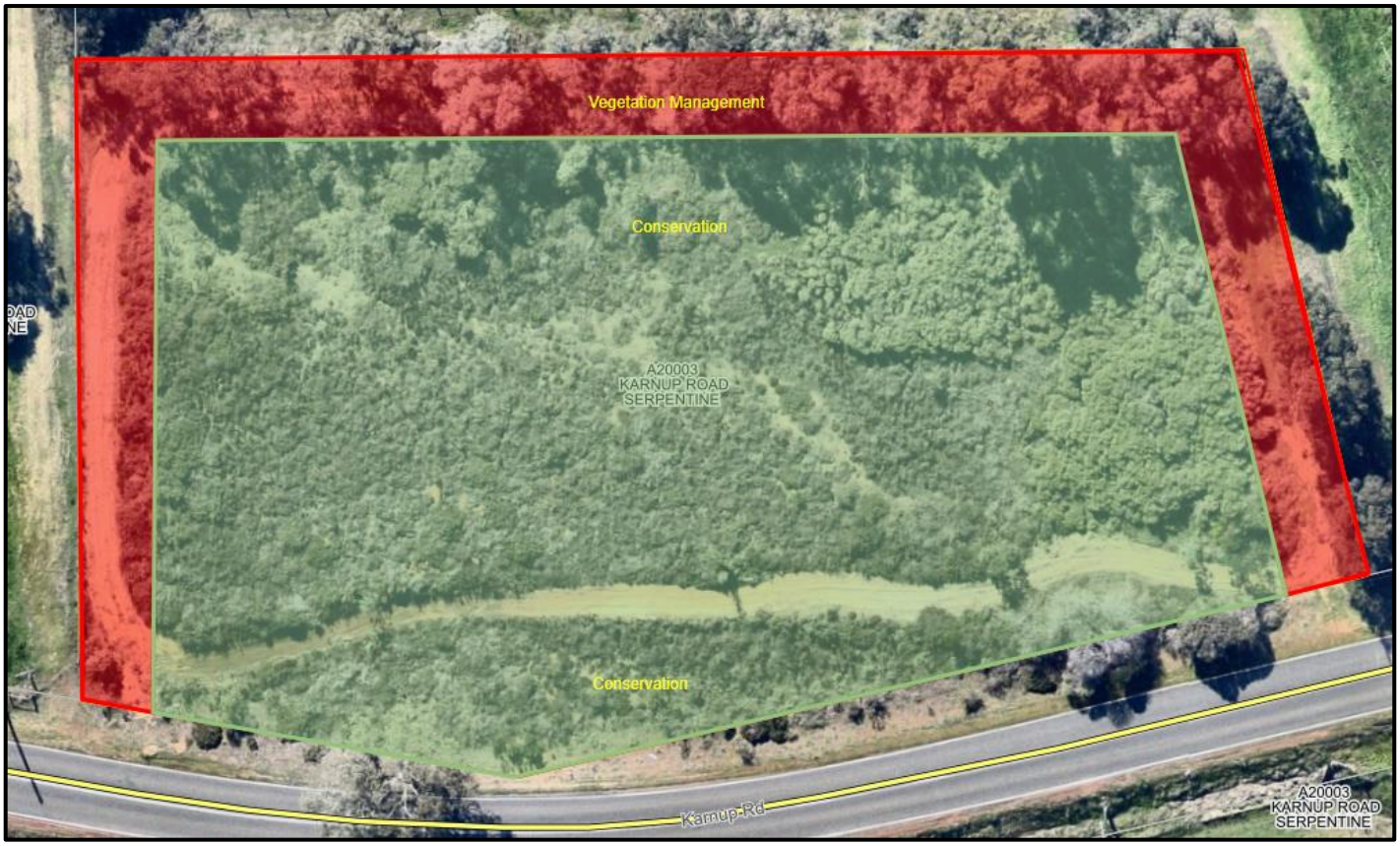


Figure 2: Management Zones of Karnup Road Flora Reserve.

1.2 Soils

One soil type occurs in Karnup Road Flora Reserve, Pinjarra P8 (Table 1 and Figure 3), on which the clay-based wetland occurs.

Table 1: Soil Types of Karnup Road Flora Reserve.

Reserve	Soil landscape unit	Description	Clay-based wetland occurrence
Karnup Road Flora Reserve	Pinjarra P8 phase	Broad poorly drained flats and poorly defined stream channels with moderately deep to deep sands over mottled clays; acidic or less commonly alkaline gley and yellow duplex soils to uniform bleached or pale brown sands over clay.	Yes

Figure 3: Soil Types of Karnup Road Flora Reserve.

1.3 Biodiversity

Karnup Road Flora Reserve is dominated by the clay-based wetland with a narrow fringe of upland vegetation along the road verge. The clay-based wetland is approximately 0.66 ha in area (Figure 4) and belongs to the vegetation complexes SCP08 (Herb rich shrublands in clay pans) and SCP10a (Shrublands on dry clay flats).

The reserve is not registered as a Threatened Ecological Community, but the vegetation indicates that it should be. The eastern half of the reserve is an Environmentally Sensitive Area. The vegetation is in Good to Degraded condition overall.

The flora of Karnup Road Flora Reserve has been surveyed and is diverse. No Threatened and Priority flora species have been recorded in the area. The fauna has never been formally surveyed, although anecdotally some Threatened and Priority fauna species may occur, such as quenda (southern brown bandicoot).

Figure 4: Location of Clay-Based Wetland of Karnup Road Flora Reserve.

1.4 Water Resources

Karnup Road Flora Reserve is low in the landscape, sitting on a claypan and containing wetland vegetation types.

The entire reserve is a Resource Enhancement wetland (Figure 5).

Figure 5: Geomorphic Wetlands of Karnup Road Flora Reserve.

2. Threats and Pressures

Threats and pressures to the conservation values of Karnup Road Flora Reserve include:

- Community anxiety about fire hazard and pressure for control burning
- Arson and vandalism
- Weed invasion, from surrounding land and carried in by users
- Feral and domestic animals (foxes, rabbits, cats) predating fauna and damaging vegetation
- Very wide firebreak for a very small reserve

3. Reserve Usage

3.1 Vesting and Land Tenure

The vesting purpose, land tenure and current uses of Karnup Road Flora Reserve are listed below in Table 2.

Table 2: Vesting Purpose, Land Tenure and Current Uses of Karnup Road Flora Reserve.

Reserve	Reserve and Lot Number	Vesting and Land Tenure	Current Uses
Karnup Road Flora Reserve	R34460 L796 Karnup Road, Serpentine	Shire of Serpentine Jarrahdale – Indigenous Vegetation / Protection of Flora	Conservation

3.2 User Groups

The principal users of Karnup Road Flora Reserve are informal, infrequent walkers and enjoyment of nature.

There are minimal threats and pressures for the users.

3.3 Infrastructure

The infrastructure located in Karnup Road Flora Reserve includes firebreaks, fences and gates. The infrastructure is maintained by the Shire. Vandalism is a constant but low-level threat.

Fire can threaten people, property and conservation values. Bush or grass fires threaten buildings and structures through embers, radiant heat and direct contact. Cleared areas around buildings limit the opportunity for bush and grass fires to reach them. Fire in the reserve's bushland has the potential to damage nearby infrastructure.

4. Action Plan

Table 3: Action Plan for Karnup Road Flora Reserve.

No.	Action	Priority	Timing	Status	Responsibility	Resources
1	**Utilise the planning system to retain and protect remnant clay-based wetlands.**	**Key**	**Business as Usual**	**Ongoing**	**Statutory Planning**	**Staff Time**
2	Keep up to date with the latest research trends, particularly with regard to banksia woodland and fire, and integrate into reserve management.	High	Long Term	Ongoing	Natural Reserves, Emergency Services	Staff Time
3	Erect signage in high use areas to inform users of the values of the clay-based wetlands.	Medium	Short Term	Implemented in Part	Operations	Budget Dependent - $2,000
4	**Survey for dieback presence, and map and treat dieback every three years if present.**	**Key**	**Business as Usual**	**Ongoing**	**Natural Reserves**	**Budget Dependent – $2,500**
5	Monitor and manage new and emerging pests and diseases such as polyphagous shot hole borer.	High	Medium Term	Ongoing	Natural Reserves	Budget Dependent - $2,000
6	Control access to clay-based wetlands through boundary fencing, convenient formal access points, and path construction that discourages deviation.	Low	Long Term	Not Yet Implemented	Operations	Budget Dependent - $3,000

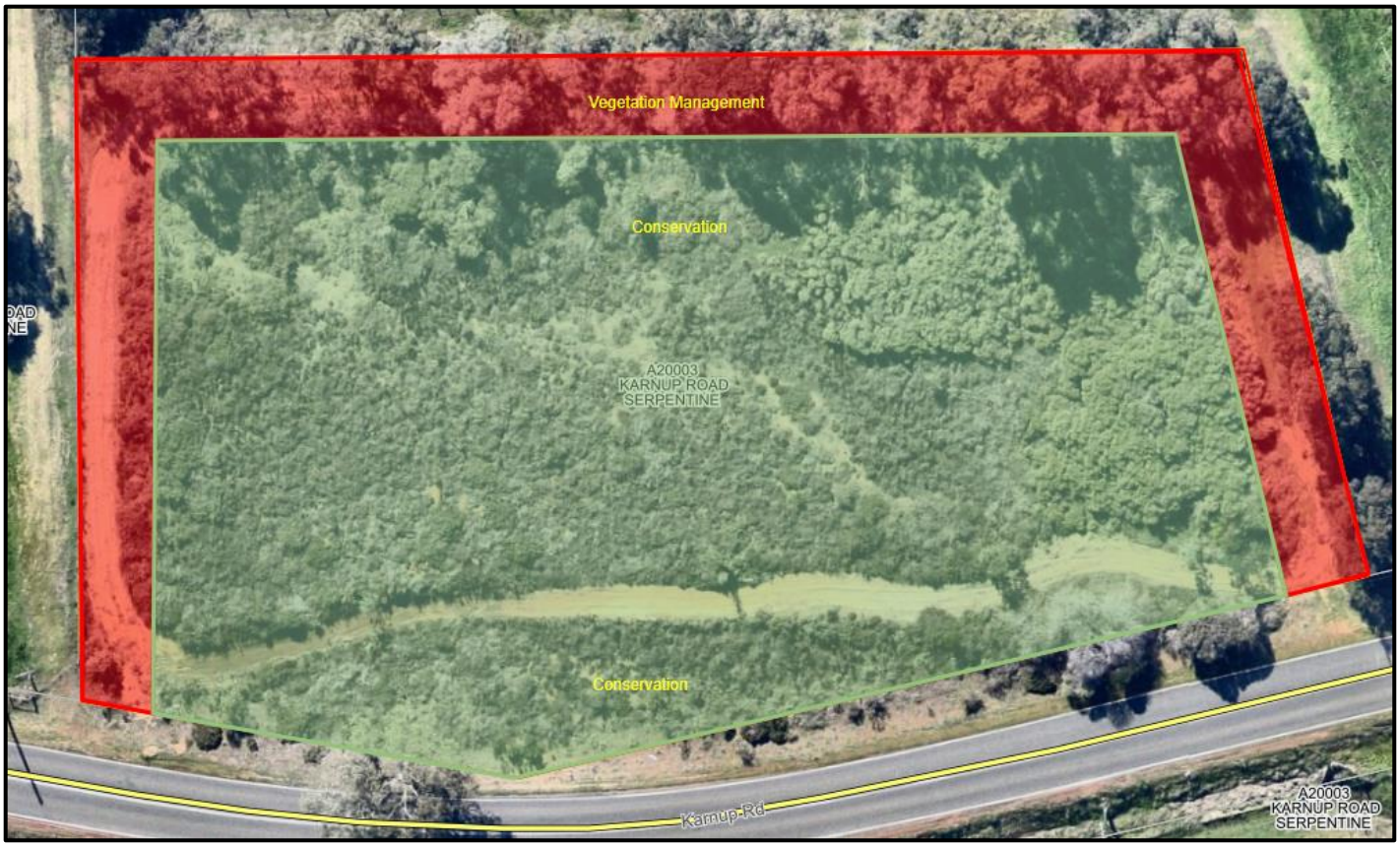
No.	Action	Priority	Timing	Status	Responsibility	Resources
7	Liaise with other landholders to work together and integrate management of all banksia woodland areas.	Medium	Medium Term	Not Yet Implemented	Natural Reserves, Strategic Environmental Specialist	Staff Time
8	Implement measures to exclude motorised vehicles from the remnant vegetation.	High	Medium Term	Implemented in Part	Operations	Budget Dependent - $2,000
9	Conduct flora surveys and vegetation condition monitoring and mapping every five years.	Low	Business as Usual	Ongoing	Natural Reserves, Strategic Environmental Specialist	Budget Dependent - $3,000
10	Conduct fauna surveys every five years.	Low	Medium Term	Not Yet Implemented	Natural Reserves	Budget Dependent - $3,000
11	Monitor weed diversity and distribution annually.	High	Business as Usual	Ongoing	Natural Reserves	Staff Time
12	**Establish and implement a weed control program that utilises best practice methods.**	**Key**	**Business as Usual**	**Ongoing**	**Natural Reserves, Landcare SJ**	**Budget Dependent - $3,000**
13	Establish and implement a control program for woody weeds.	High	Business as Usual	Ongoing	Natural Reserves	Budget Dependent - $2,000
14	Conduct feral animal control when required, following all relevant health and safety regulations.	Medium	Business as Usual	Ongoing	Natural Reserves, Landcare SJ	Budget and/or Funding Dependent - $800
15	**Minimise burning and other disturbance of clay-based wetlands.**	**Key**	**Short Term**	**Implemented in Part**	**Emergency Services**	**Staff Time**
16	Avoid disturbance to the Conservation Zone and to dieback-free areas.	High	Short Term	Not Yet Implemented	Natural Reserves	Staff Time
17	Avoid fire in clay-based wetlands to the greatest degree possible.	High	Long Term	Not Yet Implemented	Emergency Services	Staff Time
18	Avoid fuel load management unless considered appropriate and necessary.	Medium	Business as Usual	Implemented in Part	Emergency Services, Natural Reserves	Staff Time
19	Restrict any essential fuel load management to the Vegetation Management Zone.	High	Short Term	Not Yet Implemented	Emergency Services	Budget Dependent - $1,500
20	Carry out fuel load management on adjacent road verges to avoid fire entering the reserve from the verge.	High	Medium Term	Not Yet Implemented	Emergency Services	Budget Dependent - $2,000
21	Ensure that any essential fuel load management utilises weed control as a priority, with control burning as a last resort.	Medium	Short Term	Not Yet Implemented	Emergency Services, Natural Reserves	Budget Dependent - $1,500
22	Ensure that any control burning is restricted to vegetation boundaries, providing a mosaic of vegetation ages including long unburnt.	High	Business as Usual	Implemented in Part	Emergency Services, Natural Reserves	Budget Dependent - $1,500
23	**Follow any burning or other disturbance with weed control for at least two years post-fire.**	**Key**	**Business as Usual**	**Implemented in Part**	**Emergency Services, Natural Reserves**	**Budget Dependent - $3,000**

No.	Action	Priority	Timing	Status	Responsibility	Resources
24	Manage water use and allocations to ensure that environmental water requirements are considered and met.	Medium	Medium Term	Not Yet Implemented	Operations	Staff Time
25	Revegetate with local provenance seedlings as necessary and appropriate.	Medium	Medium Term	Implemented in Part	Friends Groups, Landcare SJ, Natural Reserves	Funding Dependent - $3,000
26	Monitor implementation of the management plan every three years.	High	Short Term	Not Yet Implemented	Strategic Environmental Specialist	Staff Time
27	Update actions according to best practice management and monitoring outcomes.	High	Medium Term	Not Yet Implemented	Strategic Environmental Specialist	Staff Time
28	Review and revise the management plan every ten years.	High	Long Term	Not Yet Implemented	Strategic Environmental Specialist	Staff Time

5. Fire Management Strategy for Karnup Road Flora Reserve

Conservation Zone (green) – works exclusion; avoid disturbance

Vegetation Management Zone (red) – fuel load management if deemed appropriate and necessary by weed control and/or control burning followed by weed control



Dieback – present in some areas

Weeds – control required following disturbance

Firebreaks – present along boundaries