Sharp rush
Juncus acutus

Draft strategic plan for the Swan NRM Region

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swan catchment council

Natural Heritage Trust
Helping Communities Helping Australia

Department of Environment and Conservation

Australian Government

ACRONYMS

DEC – Department of Environment and Conservation
DAFWA – Department of Agriculture and Food Western Australia
SCC – Swan Catchment Council
SRT – Swan River Trust
LGA – Local Government Authority
NRM – Natural Resource Management
IBRA – Interim Biogeographic Regionalisation of Australia
SERCUL – South East Regional Centre of Urban Landcare WA
NHT – Natural Heritage Trust
CRREPA – Canning River Residents Environment Protection Association

First draft by K. Bettink
Department of Environment and Conservation

Cover photographs (left to right): Sharp rush in fruit (photo: K. Bettink); sharp rush invading the edges of Lake Walyungup, Rockingham Lakes Regional Park (photo: K. Brown) and juvenile plants (photo: K. Bettink).

FOREWORD

Sharp rush or spiny rush (*Juncus acutus*) is a well known weed in New South Wales, Victoria and South Australia and an increasing environmental problem in Western Australia. The species occurs in saline and freshwater areas and is tolerant of waterlogging, salinity and drought. It has not reached its potential range in Western Australia and resources are needed for identification and eradication where it occurs outside the agricultural zone (Keighery and Keighery 2006). The Swan Natural Resource Management Region (NRM) Region in south-west Western Australia is one of these areas.

Here, sharp rush poses a serious threat to environmental, economic, aesthetic and recreational values. It has the potential to severely impact on native flora, fauna and plant communities in the south-western corner of Western Australia, which is considered among the world's biodiversity hotspots. With the described impacts and extensive potential distribution, control of this species is an urgent priority in the region.

Managing sharp rush presents major challenges. Currently in Western Australia it is not declared or listed as a pest plant, so there is no legal requirement for infestations to be eradicated. Some infestations are small and localised, however, many are well established and widespread, occurring in sites of high biodiversity value. Numerous other significant areas are under threat of invasion by sharp rush and many of these have other values, such as recreational and aesthetic, at risk. Once established in bushland or wetlands it is notoriously difficult to control. As with many other weeds, sharp rush occurs across a range of tenures, making communication, coordination and cooperation a challenging but integral part of implementing an effective management program.

A workshop on sharp rush held in August 2006, identified that the large number of sharp rush occurrences makes it difficult to prioritise control (DEC 2006). The aim of this strategy is to prioritise, coordinate and implement actions to control sharp rush infestations for the protection of the region's biodiversity assets. The longer term objective is to eradicate sharp rush from the Swan Coastal Plain and Jarrah Forest Interim Biogeographic Regionalisation of Australia (IBRA) regions and protect the region's borders from invasion.

The strategy provides the following information on sharp rush:

- biology and ecology
- distribution in Australia, Western Australia and the Swan NRM Region
- impacts and threats
- best practice control methods
- management.

The purpose of this strategy is to:

- provide baseline information essential for the strategic control of sharp rush in the region
- facilitate, encourage and provide support to regional and local efforts to control sharp rush
- raise awareness of the species and its impacts among land managers and the public.

CONTENTS

1. CONTEXT AND PREPARATION OF STRATEGY

This strategy has been developed as an outcome of a Natural Heritage Trust-funded Invasive Environmental Weed Project for the Swan NRM Region. The project forms part of the 2006-2008 Swan Catchment Council Investment Plan and is being completed by the Department of Environment and Conservation (DEC). Among the project's outcomes are the development of strategic plans for six of the region's high priority environmental weeds, including sharp rush. Each of the six species presents a major threat to the region's rich biodiversity values. The six species represent a range of life forms and different management objectives and approaches, so they may be used as models to develop strategies for other environmental weeds in the region and beyond.

2. AREA COVERED

This strategy centres on the Swan NRM Region in the southwest of Western Australia. It is made up of the Swan and Jarrah Forest IBRA regions and numerous, overlapping management boundaries. These include NRM sub-regions, DEC regions and district and Local Government Authority (LGA) boundaries, as shown in Figure 1.

3. DESCRIPTION

Taxonomic relationships

Sharp rush belongs to the rush family *Juncaceae* in the genus *Juncus*. The genus consists of about 315 species with a mostly cosmopolitan distribution. Twent- six species of *Juncus* are known from Western Australia, 17 of these are native and 10 are weeds (one of these, *J. bufonis*, is both a native and a weed).

The genus has been the subject of a considerable amount of study over the past decades, howeve,r many *Juncus* species are difficult to distinguish. This is due to the geographical and ecological variants found in species that are widespread, frequently hybridised and with obscure vegetative characteristics to separate taxa. The most obvious and reliable character to identify the species is the leaves (Keighery and Keighery 2006).

Sharp rush has been divided into two subspecies, *J. acutus* subsp*. acutus* and *J. acutus* subsp. *leopoldii* relating to different geographical areas (Snogerup 1993). Both of these subspecies are recorded as weeds in various parts of the world (Keighery and Keighery 2006).

Features

Sharp rush is an erect, robust shortly rhizomatous, tussock-forming perennial herb, growing 1 to 1.5m high and occasionally to 2m high. It has numerous unbranched cylindrical stems 2 to 5mm in diameter. These stems are glabrous, rigid, slightly furrowed and filled with a continuous pith and are similar in appearance to the leaves. The leaves are blue-green in colour and emerge from the base at varying angles, giving the whole plant its distinct hemispherical shape (Parsons and Cuthbertson 1992).

The leaves and bracts terminate in a stiff sharply pointed tip which is painful to touch. It is the sharply pointed leaves and stems which give it its scientific name ('acutus' meaning 'sharpened' or 'pointed') as well as its common names (Parsons and Cuthbertson 1992).

Sharp rush can flower throughout the year but mainly bears flowers during spring and summer. The flowering stems (culms) and leaves are similar in appearance. Inflorescence are 4 to 13cm long, with clusters of one to six green to reddish brown, very small sessile flowers. One or two leaf-like bracts, 4 to 25cm long form at the base of the inflorescence. Fruits are brown ovoid

three celled capsules 5 to 6mm long and pointed at the apex. Seeds are small at 1.3 to 2mm long with a tail at each end (Parsons and Cuthbertson 1992).

Figure 2 (left to right): Entire sharp rush plant showing hemispherical shape; inflorescence showing clusters of up to six flowers; large and prolific fruits: ovoid three celled capsules with containing seed; cross section of pith-filled stem (photo: K. Brown); base of plant showing short rhizomes and tussock-forming root system (photo: K. Brown) and illustration of enlarged single seed showing characteristic tails at either end.

Similar species - native and exotic

Sharp rush is related to several introduced rushes and similar in appearance to native Western Australian rush species, the two main ones being sea rush (*Juncus kraussii*) and pale rush (*J. pallidus*). Growing in saline and brackish environments with a range overlapping sharp rush, sea rush is the most similar native species. A distinguishing feature between native and introduced rushes is the seed capsule of introduced rushes, which protrudes beyond the tepals (equivalent to sepals and petals) surrounding it. In most native rushes the fruit is about the same length as the tepals (NSW Government 2006). Where sharp rush co-occurs with native species, the differences between them tend to be more obvious, however, in isolation sharp rush can be difficult to distinguish.

A recent discovery of hybrid forms of sharp rush and sea rush have made identification and separation of the two at sites where they both occur extremely difficult. Nevertheless, there are several key features which distinguish the species. Fruits of sea rush are significantly smaller (2.5 to 3mm compared to 4 to 6mm long) as well as the seeds (0.5 to 1mm compared to 1.2 to 2mm long) (Australian Weeds Committee 2006). The second most similar native species, pale

rush, also has smaller fruit and seed than sharp rush. A comparison of all three species and identification guide is shown in Figures 3 and 4.

There are other major differences between sharp rush and native species: larger tussocks and wider individual stems make sharp rush more robust than most of the native rushes and it is difficult to squash its leaves between thumb and forefinger compared to many native rushes. One of the most reliable features of sharp rush is the very pointed tips, while most other rushes are sharp they are not painful to touch (NSW Government 2006).

3. HISTORY OF INTRODUCTION AND SPREAD

Sharp rush is naturalised in Australia, New Zealand and parts of southern South America (USDA *et al.* 2006). The first sharp rush herbarium collection in Western Australia was made in 1957 by Charles Gardner near Northam (Western Australian Herbarium 2008). With collections from New Zealand and eastern Australia recorded much earlier, the species introduction to Western Australia is thought to have occurred between 1920 and 1950 (Keighery and Keighery 2006). To date, a total of 54 herbarium collections have been made (Western Australian Herbarium 2008).

The long distance spread is thought to have occurred by planting sharp rush rather than native species (Keighery and Keighery 2006). There have been at least five instances in the region where it has been misidentified and used either in landscape planting or revegetation. It is not known where the material was originally sourced, however, this has been a significant means of spread of the weed throughout the Coastal Plain. At sites where sharp rush was identified and removed early eradication has been achieved (Mathews 2006). At other sites sharp rush has become well established and is out competing native vegetation. Another contributor to its spread is thought to be movement of seed on car tyres (Keighery and Keighery 2006).

4. HABITAT AND DISTRIBUTION

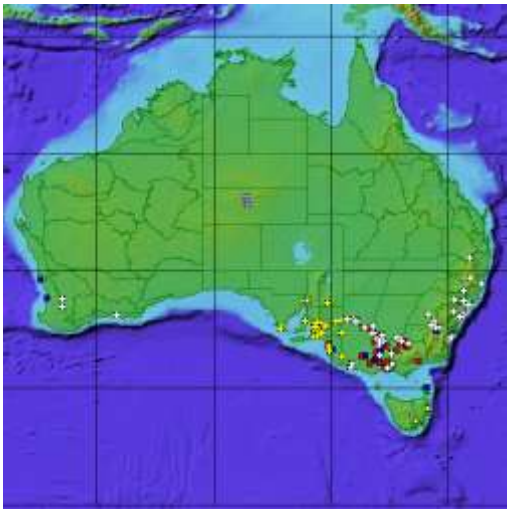
Native range

Sharp rush has a wide native distribution of Europe (United Kingdom, Italy, Greece and Yugosalvia), southern and northern Africa (Algeria, Egypt and Morocco), temperate Asia (Iran, Iraq, Lebanon and Turkey) and northern America (United States and Mexico) (USDA *et al* 2006). It occurs naturally on coastal sand dunes, saline marshes and occasionally in fresh water marshes (Keighery and Keighery 2006). It exhibits the same characteristics in its native range that make it a successful weed elsewhere - it persists long after its habitats have been severely altered and is known to dominate, be extremely tough, resist trampling, be difficult to uproot, and grow so densely and robustly to be contiguous and exclude most other plants (Jones and Richards 1954).

Current distribution - Western Australia and Australia

Sharp rush is widespread in southern Australia (Figure 5.1). It is naturalised in coastal and inland saline or freshwater low-lying, damp, infertile areas of eastern South Australia, throughout Victoria and coastal and inland New South Wales into southern Queensland. Populations are also known from the Northern Territory and Tasmania (Australia's Virtual Herbarium 2008). In Victoria it is a Scheduled Regionally Prohibited Weed and Regionally Controlled Weed in several regions (DPI 2006).

In Western Australia, sharp rush is recorded from Geraldton across the south-west of the state to Esperance, with the majority of populations in the agricultural zone (Figure 5.2). As herbarium collections are unlikely to reflect its true extent, sharp rush is likely to be more abundant in its known range and may potentially occur beyond this range. Populations are already known well south of Perth in the Mandurah and Dunsborough area (Clarke 2007).



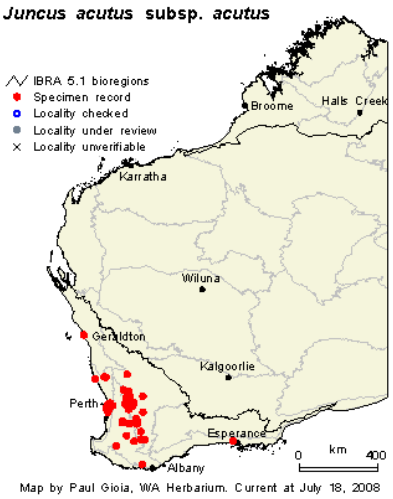


Figure 5.1 (left): Current distribution of sharp rush in Australia according to current herbariam collections (Australia's Virtual Herbarium 2008). **Figure 5.2 (right):** The current distribution of sharp rush in Western Australia based on State herbarium records, DEC (Western Australian Herbarium 2008).

Potential distribution

Models using climate data show sharp rush has the potential to occur across the entire south-west of Western Australia, in addition to significant areas in the eastern states (Figure 6) (Australian Weeds Committee 2005). Although this model does not take into account soil, vegetation and land use data, it shows that significant areas of the Swan NRM Region are at a high risk of sharp rush invasion. This is supported by Keighery and Keighery (2006), who suggest distribution of the related native sea rush is a more accurate indicator of the true potential range of the sharp rush.

Swan NRM Region

Twenty-six populations of sharp rush in Western Australia occur in the boundaries of the Swan NRM Region (Figure 7). These locations are derived from herbarium collections, by Swan River Trust (SRT) survey data (2006) and other recent surveys. Details of populations, including location, size, vesting and managing agency is given in Table 1 (overleaf).

Figure 7: Distribution of sharp rush in the Swan NRM Region and sub-regions based on WA Herbarium collections (2008), Swan River Trust data (2006) and a recent survey

Population	Location description	Suburb	Number of plants (juveniles and seedlings in brackets)	Frequency	Approx area infested (HA)	Tenure/ land class	Managing Agency/ Owner	Notes	Site features	Biodiversity values	Proximity biodiversity values at threat	Conserv Rating	Feas of control	Outlying popn	Threats (adjacent lands	Mgt Priority	Management actions completed to date 2008	Management recommendations - short term (2008-2009)	Management recommendations - medium term (2009-2011)	Management objective-medium tern	Mgt actions long term 2011-2020
2	Lake Cooloongup	Safety Bay	1000+	abundant	10+	Reserve	DEC - Regional Parks		Saline lake, large areas intact Melaleuca and Tuart woodland	BFS 356, Significant flora and fauna, ecological linkage	Lake Walyungup and adjacent bushland, Hillman to Port Kennedy, Leda and adjacent bushland BFS349	1	2	N	1	VH	Mapped and sprayed by DEC Regional Parks. Trials in place by DEC Urban Nature	Continue herbicide spraying	Re-map, continue herbicide spraying program extending to whole of reserve	Eradicate all mature plants	Continue treatment program, monitor site
6	Colpoys Point, Garden Island	Rockingham	100+	abundant	4	Reserve	Department of Defence		Low-lying, limestone headland	BFS63, Threatened ecological community type 30a	Penguin, Seal, Bird and Gull Islands and Shag Rock BFS367, Carna Island BFS473	1	2	N	1	VH	Ongoing herbicide treatment program	Continue herbicide treantment	Continue herbicide treatment, evaluate results, review need to restore site		
14	Boundary Road verges, opposite the Greater Brixton Street Wetlands and Yulebrook Reserve	Kenwick	180	common	2	LGA road reserve	City of Gosnells		Degraded road verge, remant vegetation		Greater Brixton Street Wetlands BFS387, Threatened ecological community type 3a,10a,7,8, Yule Brook Reserve, Hartfield Park bushland BFS 320	2	1	N	1	VH	Mapped and herbicide treated June 2008	Follow-up herbicide treatment	Monitor	Eradicate	
23	30m downstream of Noble Falls waterfall, both sides of riverbank	west of Woorolo	2(6)	uncommon	>0.1	LGA Conservation Reserve	City of Swan		Marri and flooded gum forest, granite outcrops bordering freshwater brook	Outside Bush Forever system, Wooroloo Brook, large area remnant vegetation	Remant vegetation	2	1	Y	2	VH	inspected and mapped 2008	Liasie City of Swan, physical removal, herbicide follow-up	Monitor site, surveillance up and down stream	Eradicate	Monitor site, treat as required
1	Lake Walyungup	Safety Bay	2000+	abundant	20+	Reserve	DEC - Regional Parks		Saline lake	BFS356, Threatened ecological community type 19, JAMBA/CAMBA species	Port Kennedy, Becher Point BFS377, Threatened ecological community type 19, nationally important wetland, Lake Richmond BFS 358, Stakehill Swamp Baldivis BFS275, Leda and adjacent bushland BFS349	1	3	N	1	H	2+ years spraying program by DEC Regional Parks	Continue herbicide spraying	Remap and continue spraying program	Eradicate all mature plants	Continue treatment program, monitor site
4	Beeliar RP - Market Garden Swamp and adjacent wetlands	Coogee	100+	Common	2		City of Cockburn		Chain of wetllands with Melaleuca, Juncus, Ghania, mixed herb understorey	BFS429, 435	Thomsons Lake Nature Reserve (Ramsar wetland), Beeliar Regional Park BFS391, North Lake and Bibra Lake BFS244, Woodman Point BFS341 Threatened ecological community type 30a	1	1	N	1	H	Mapped and sprayed by City of Cockburn and DEC Urban Nature, trials in place	Continue herbicide spraying	Re-map remaining plants, follow up spraying		
5	Beeliar Regional Park - Lake Coogee	Coogee	~20	Uncommon	0.5	Reserve	City of Cockburn	Hybrids observed		Lake Coogee and adjacent bushland BFS261	Woodman Point BFS34 Threatened ecological community type 30a, Beeliar Regional Park BFS391, Thomsons Lake Nature Reserve (Ramsar wetland)	1	2	N	1	H	Some treatment by City of Cockburn	Liasie with City of Cockburn, continue treatment	Continue treatment. Remap after 3 years	Prevent from re-establishing	Monitor site, treat as required

22	100m west of Lewis Road	Ellis Brook	1	Uncommon		Private	Private	Mapped by Wetlands Branch DEC		Remant vegetation	Ellis Brook Valley Threatened ecological community, Declared Rare Flora	3	1	Y	1	H	Plant treated	Liasie, monitor site	Controlled privately by owner/in conjunction with DEC		
24	Yagan Wetland	Bullcreek	0	Absent		Conservation Reserve	City of Canning/CREEPA	Planted in revegetation		BFS338, Adjacent vegetation Rossmoyne to Bullcreek	Booragoon Lake (important wetland), Mt. Henry Bushland BFS227, Canning River Foreshore, Salter Point to Wilson BFS333, Piney Lakes Reserve BFS339	2	1	N	2	H	Plants removed	Liaise, monitor site		Prevent from re-establishing	
12	Troy Park, Attadale Nature Reserve foreshore, east of Point Walter, and Swan River Estuary Marine Park	Attadale	2	Uncommon	>0.1	Attadale NR/Swan Esturay Marine Park	City of Melville, DEC		Remant foreshore vegetation, disturbed, revegetated	BFS331, Swan River Estuary Marine Park		2	1	N	2	H/M	Inspected 2008, treated previously	Treat new plants	Monitor, treat as required, facilitate cover of native vegetation	Eradicate	Monitor site, treat as required
3	Long Swamp	Baldivis		Locally common	1	LGA Reserve	City of Rockingham		Winter wet flat, Melaleuca woodland over Ghania sedges	BFS 495	Stakehill Swamp Baldivis BFS275, Maramanup Pool BFS419	2	2	N	2	M/H		Liaise with City of Rockingham, inspect and map population	Control in 2009		
15	Extension Tonkin Highway and Gosnells West Road, 16km east of Perth	Maddington	300+	Very common	2	Road reserve	MRWA	large population	Degraded raod verge, remant vegetation		Ellis Brook Valley Threatened ecological community, Declared Rare Flora, Jandakot airport BFS388, Canning and Southern Rivers, Beckenham to Martin/Kelmscott BFS246	3	3	Y	1	M/H	Inspected 2008	Liaise with Main Roads WA. Assess value to native fauna			
16	Wetland adjacent to Waterperry Drive	Gosnells	200+	Abundant	3	LGA reserve	City of Gosnells	Large population, planted	Compensation basin, landscaped wetland		Holmes St Bushland BFS125, Harrisdale Swamp BFS253	3	3	N	1	M/H	Inspected and mapped 2007, treated by City of Gosmells	Liaise with City of Gosnells, continue treatment			
17	Canning River (SRT management area) large section, Bridgeway Park and Mason's Landing, Canning River Regional Park/Hester Park, near Nicholson Rd Bridge	Langford/ Canningt on		Uncommon			City of Canning/SRT		Canning river foreshore, remant vegetation	Canning River Regional Park and adjacent bushland, BFS224	Canning and Southern Rivers, Beckenham to Martin/Kelmscott BFS246	2	3	N	2	M/H					
25	Greentree Promenade, The Boardwalk Estate	Southern River	unknown	Unknown		LGA Reserve	City of Gosnells	Being treated by City of Gosnells 2007	Degraded landscaped site, planted		Balannup Lake and adjacent bushland BFS 413, Threatened ecological community type 8,15,BFS 253, Holmes Street bushland BFS 125, DRF	3	1	N	1	M/H	Treated by City of Gosnells	Liasie with City of Gosnells, monitor site			
8	Preston Point, John Tonkin Park, Gourley Park and Niegarup Reserve, Swan River foreshore	East Fremantle	100	Abundant	3	LGA Reserve?	Town of East Fremantle		Remant vegetation, amongst sea rush and Ficinia	Swan River foreshore, remant vegetation		3	2	N	3	M	Not treated, mapped in 2008	Liaise with Town of East Fremantle for herbicide spraying/physical removal program	Continue treatment, re-map after 3 years	Eradicate all mature plants	Treat/remove new plants, replant/encourage local native species

11	Gilbert Fraser Reserve, foreshore area north of end of Johannah St, near APACE nursery	North Fremantle	100	Common	0.1		Town of Mosman Park		Remant foreshore vegetation, disturbed, revegetated	Swan River foreshore	Minim Cove BFS335	3	1	N	2	M	Inspected 2008	Liasie with Town of Mosman Park for treatment/removal of plants	Check and follow-up control of seedlings/missed plants	Eradicate, increase resilience of ecosystem	Monitor site, treat as required
13	Burswood Public Golf Course	Burswood	200+ plants	Abundant	3	Private		Planted	Golfcourse, degraded remnant vegeation	Swan River foreshore, remant vegetation	Swan River foreshore, Mount Lawley/Maylands BFS314, Swan River saltmarshes, Bayswater/Maylands BFS 313	2	3	N	2	M	Inspected and mapped 2008, informed golf course	Liaise, provide assistance for treatment/removal	Continue control program, re-map in 2011	Eradicate mature plants, prevent new plants establishing	Follow-up treatment of new plants
18	Canning River (SRT mgt area) small western section, Canning River Regional Park, section near Marmot Way/Queens Park St	Ferndale		Uncommon			City of Canning/SRT		Canning river foreshore, remant vegetation	Canning River Regional Park and adjacent bushland, BFS224		2	2	N	3	M					
19	upper Swan River,between Holsten Cl and Cathedral Ave, paddocks and wetland adjacent to State Equestrian Centre, west of Bells Rapids	Upper Swan	500+	Abundant	5	Private property?	Private/City of Swan/SRT		Majority cleared paddock, Eucalyptus rudis overstorey	Upper Swan River foreshore, section of Swan River and Jane Brook BFS302	Swan River and Jane Brook, Ashfield to Upper Swan BFS302, Ellen Brook BFSBFS296, Ellenbrook Nature Reserve BFS301	2	3	Y	2	M					
20	Southern side of Helena River, between Bushmead Road and Stirling Crescent, near Military Road	Hazelmere	unknown			Utlity Reserve?	Western Power?	Access difficult	Degraded foreshore, some revegetation		Helena River foreshore, Stirling Crescent bushland BFS481, Threatened ecological community type 3a, 20c	3	2	N	1	M	Mapped by SRT 2006	Liasie with Western Power, provide assistance for treatment			
21	Southern side of Helena River, east of Great Eastern Highway, near Rosehill	Hazelmere	0	Not present	0		Private	No plants found in 2008.Site has been mulched, controlled for weeds and revegetated	Degraded cleared area	Helena River foreshore	Swan River backwater BFS491, South Guildford bushland BFS31, Perth Airport bushland BFS386, nationally important wetland	2	1	N	2	M	Mapped by SRT 2006, treated and revegetated	Liasie, monitor site			
26	Prior Close, Brookland Greens Estate, at outfall of Lake	Southern River	5	Uncommon	>0.1	LGA Reserve	City of Gosnells	Treated by City of Gosnells 2008	Degraded landscaped site, planted		BFS 125, Gosnells Golf Course bushland BFS 467	3	1	N	2	M	Treated by City of Gosnells	Liasie with City of Gosnells, monitor site			
7	Old quarry site and Playing fields, Garden Island	Rockingham	50	Abundant	1	Reserve	Department of Defence		Highly disturbed, cleared quarry site, reticulated oval edges and sumpland	BFS63, Threatened ecological community type 30a	Penguin, Seal, Bird and Gull Islands and Shag Rock BFS367, Carnac Island BFS474	3	2	N	1	M/L	Ongoing herbicide treatment	Continue herbicide treantment	Continue herbicide treantment	Eradicate all mature plants, prevent new plants establishing	
9	On edge of footpath along Riverside Road, south of Merv Cowan Park	East Fremantle	1	Uncommon	>0.1		Town of East Fremantle		Along rock edge and footpath	Swan River foreshore		3	1	N	2	M/L	Not treated. Mapped in 2008	Cut and spray, remove all material from site	Check site no more than 2 years after treatment	Eradicate	

The majority of sharp rush populations occur on the Swan Coastal Plain on low-lying, damp to wet, sandy wetlands, lakes and foreshore habitats (Figure 8). It is readily found invading plant communities of swamp paperbark (*Melaleuca raphiophylla*), with an understorey of sea rush (*Juncus krausii*), *Ghania trifida* and *Baumea juncea* with mixed annual and perennial herbs.

On the heavier clay-based soils of the eastern side of the Coastal Plain, infestations are found on the upper reaches of the Swan River in Susannah Brook north of Guildford and the upper tributaries of the Canning River, including Ellis Brook and adjacent to Yule Brook. In these areas sharp rush is spreading along river margins, degraded seasonally inundated pastoral land and road reserves.

Several infestations occur in the City of Gosnells, partly due to landscape plantings in constructed wetlands associated with public open space in new housing developments (Bremner 2006) and revegetation undertaken by Main Roads WA.

Aside from a large infestation at Burswood, all other populations on the Coastal Plain are found on wetlands and Swan River foreshore areas on the western side of the region. This includes sites at East Fremantle, Attadale, south along the Beeliar chain of wetlands in Cockburn and through to the Rockingham Lakes Regional Park. One population is unconfirmed from the eastern boundary of Lake Joondalup (DEC 2006).

Only one small satellite population is recorded from the Jarrah Forest IBRA Region east of the Swan Coastal Plain. This is on the edges of the Woorlooloo Brook, a freshwater brook fringed by flooded gum (*Eucalyptus rudis*) and marri (*E. calophylla*) forest.

On the outer eastern edge of the Swan Region boundary in the agricultural zone and Avon Wheatbelt IBRA Region, there are large, numerous infestations. These are found on disturbed and hydrologically altered wetlands, damplands and valley floors that are temporarily or permanently wet and/or salinised (Lyons 2006). The risk these infestations pose to the region's borders is not well known but undoubtedly serious.

5. BIOLOGY AND ECOLOGY

Understanding the biology and ecology of sharp rush is integral to effective management. The calendar below (Table 2) provides a summary of its growth, flowering and germination in south-west Western Australia. This also shows the optimum times for control based on its biology.

Table 2: Calender of biology and management of sharp rush in south-west Western Australia.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Dormant												
Growth												
Flowering												
Seed production												
Germination												
Physical removal												
Herbicide application	conditional								optimal			

Sharp rush is known to be tolerant of salinity, drought and waterlogging (Parsons and Cuthbertson 1992). However, it appears to be intolerant of permanent waterlogging. It does not

occupy areas which are permanently inundated with water. In areas with higher water levels it appears to avoid the central area, forming a characteristic marginal fringe. It is not known to be able to adapt itself to rapid accretion of sand, although it may persist for a while it ceases to flower (Jones and Richardson 1954). Adult plants are able to re-sprout following fire and, in fact, fire creates optimal conditions (abundant light and bare ground) for germination of seed and expansion of populations.

Plants can flower and develop a perennial crown and rhizomes from two years of age. Any leaves and stems which die each year are replaced by new growth mainly in spring. It has no described allelopathic properties (DPI 2008) and is not readily eaten by grazing animals (Parsons and Cuthbertson 1992).

Sharp rush is wind pollinated and reproduces mainly by seed and also gradually by underground by rhizomes. Seeds are small and numerous and are capable of germinating at most times of the year. Each fruit or capsule can contain up to 200 seeds and each plant up to 4,000 seeds with high rates of germinability between 75 and 95 per cent (Jones and Richardson 1954). The seed needs light to germinate, any darkness or competition from other plants suppresses germination. Wet, sandy, open substrates provide the best sites for it to colonise, as these are areas where seeds can be uncovered and light can penetrate (Parsons and Cuthbertson 1992).

Seed stored in situ have been found to retain their viability for at least four years, however, soil or water-stored seed longevity is unknown. Germination can occur five days after sowing and have been found not to germinate in sea water unless it is considerably diluted with freshwater (Jones and Richardson 1954).

The natural spread of sharp rush populations largely occurs through the spread of numerous lightweight seed in water. The movement of seed in waterways is thought to be from 20 to 200m, which allows it to easily colonise lake, river, creek and drain edges. Sharp rush can also be spread via contaminated seed in revegetation, in soil, agriculture, machinery, vehicles and mud. It may also be re-established through cultivation or activities which drag rhizomes or stem material (Parsons and Cuthbertson 1992).

6. IMPACTS AND THREATS

There is evidence sharp rush is able to severely impact on the biodiversity of the areas it invades, however, the true effects of weedy *Juncus* are poorly documented and require more study (Keighery and Keighery 2006). Of the study that has been done, Parsons and Cuthbertson note that “once firmly established, it completely covers an area and eliminates almost all other vegetation” (2001). Impacts range from direct loss of plant species and structural diversity, to more complex environmental impacts on water quality, erosion, and impacts on invertebrates and native fauna, such as water birds, reptiles, water rats and bandicoots. It has also been known to provide an effective cover for vermin, particularly rabbits, although any nett benefits for native fauna as shelter is unknown.

Sharp rush can have a range of other impacts, including preventing human and native animals access to waterways, restricting the flow of water resulting in flooding and creating a negative visual impact (Parsons and Cuthbertson 2001). In Victoria, it is considered to have moderate to high impacts on recreation, abiotic features, native vegetation, fauna and pest animals, with less data available on the impacts to agriculture (DPI 2006). Recreation sites in the region, such as those along the Swan and Canning River, accessed for activities such as fishing, canoeing, walking and bird watching, are more than likely to be impacted. It also represents an

occupational health and saftey hazard for users of the Garden Island playing fields, managed by the Department of Defence (Jackson and Wann 2006).

Although in Australia it is commonly known as a weed of coastal flats, wasteland and disturbed saline areas in the Swan NRM Region sharp rush has invaded several reserves of high biodiversity and recreational significance. It is invasive in good condition open or closed sedge land plant communities and is able to establish itself in minor disturbed natural ecosystems such as riparian vegetation and wetlands (Carr *et al.* 1992). The disturbance and eutrophication associated with population growth and development close to these habitats has potentially favoured its spread (Keighery and Keighery 2006). Questions have also been raised as to the ecological amplitude of this species in dry land areas, and its ability (current or future) to encroach on more terrestrial habitats (DEC 2006).

Keighery and Keighery (2006) observed that sharp rush is only one of two *Juncus* species currently invading relatively undisturbed calcareous or saline wetlands, which would otherwise have few major weeds. In places such as Market Garden Swamp and Lake Cooloongup, sharp rush readily out-competes and displaces previously good condition, intact areas of native *Juncus*, *Baumea* and herbaceous species. In other sites such as Lake Walyungup, it rapidly colonises naturally open saline lake areas, forming dense monocultures. It could easily displace the native sea rush, which provides foreshore stability and habitat by direct competition and hybridaisation (Keighery and Keighery 2006).

Sharp rush threatens many Ramsar wetlands of south-Western Australia, several of which occur in the Swan Region as well as most coastal estuarine systems, several Threatened Ecological Communities(TEC) and other sites of significance (Keighery and Keighery 2006). Sharp rush currently occurs in six conservation reserves (Table 3). A number of other significant areas occur in close proximity to known locations of sharp rush and are at risk (Table 1) including Ellis Brook Valley Reserve, Forestdale Lake Reserve, Yule Brook Reserve and Brixton Street Wetlands. A larger range of Bush Forever sites, as well as other areas have a long-term risk of invasion.

Table 3: Occurrences of sharp rush in conservation reserves in the region.

Swan Coastal Plain
Beeliar Regional Park (Market Garden Swamp, Lake Coogee)
Rockingham Lakes Regional Park (Lake Walyungup, Lake Cooloongup)
Long Swamp, Baldivis
Swan River Estuary Marine Park
Canning River Regional Park
Garden Island

Table 4: Conservation areas/ecosystems under particular threat from sharp rush in the Region.

Swan Coastal Plain
Lake Richmond Thrombolites (community type 19)
Port Kennedy Scientific Park – sedgelands in Holocene Dune Swales (community type 19)
Thomsons Lake (Ramsar site)
Forestdale Lake and surrounding wetlands (Ramsar site)
Yellagonga Regional Park and Lake Joondalup (unconfirmed population may exist)
Jandakot Regional Park
Brixton St Wetlands
Leda and adjacent bushland
Jarrah Forest
Wooroloo Brook
Ellis Brook Vallley Reserve

7. LEGISLATION

Sharp rush is not currently a declared plant in Western Australia or listed as a pest plant by Local Government Authorities, so there is no legal requirement for infestations to be eradicated.

8. CONTROL METHODS

The two main options for control are herbicides, used at rates dependant on the time of year/growth phase and physical control. A sharp increase in salinity may kill but this would be a difficult method of control. It is worth nothing that because the seed of sharp rush needs light to germinate, once mature plants are killed and/or removed, restoring the site's native vegetation cover may be necessary to help suppress germination and re-establishment. This may be difficult in situations where there are naturally bare areas and/or open plant communities; in this instance ongoing sharp rush control will be required.

The best methods of dealing with large dead stands of sharp rush biomass left behind after herbicide control is yet to be explored. Intensive follow-up may be required for several years for any persistent rhizomes and plants germinated from seed.

Physical control

Physical removal can be effective in certain situations, particularly in the case of small populations and small or isolated plants. Plants and their tussocks may be dug up using a mattock or similar tool, taking care during disposal not to disperse the seed. This form of control may not be viable for large infestations as it can be costly and cause excessive soil disturbance.

Slashing and/or burning sharp rush can result in low levels of mortality and will cause most plants to resprout. Removal of slashed or sprayed material may be needed to reduce the amount of dead biomass and allow access to a site for replanting or to facilitate regeneration of native plant communities. Fire is an underexplored tool which may be useful for reducing the amount of dead biomass and may help mortality rates if needing to spray any sharp rush regrowth with herbicides.

Herbicide control

Where there are large infestations, use of herbicides on sharp rush are effective. Particular care needs to be taken when applying chemicals near wetlands and waterways.

Of the herbicides tested, metsulfuron methyl is the least effective while glyphosate, used at two per cent with a wetting agent gives the highest mortality rate (Brown and Dixon 2008). Burning or slashing and then applying glyphosate to new growth can increase herbicide uptake, making the treatment more effective. Treated plants may take up to two months to die.

Trials conducted at Garden Island in 1996 showed several chemicals, hexazinone, imazapyr, metsulfuron (Aim®, Brush-off®), 2,4-D amine and glyphosate are active on sharp rush (Jackson and Wann 2006). However, due to their residual nature and potential impacts on waterways, use of most of these on sharp rush is not recommended. The most effective and environmentally sound herbicide to use in wetlands is a form of glyphosate, Roundup Biactive®. To limit environmental impacts this would need to be applied during summer and autumn when water levels in wetlands and estuaries are at their lowest. Herbicide uptake is at its highest during these warmer months when the plants are actively growing, however, application during high daytime temperatures, which cause plant stress, greater evaporation and low herbicide, uptake need to be avoided.

8. MANAGEMENT

Vision

The main vision for management is *to contain the spread and eradicate sharp rush at key sites across the region, thereby protecting the region's high biodiversity value assets*.

Management objectives

This vision may be achieved with the following strategies:

- coordinating implementation of on-ground works across tenures;
- containing the spread outside the existing range
- identifying, controlling and eradicating outlying populations
- reducing impacts at selected areas
- controlling and eradicating populations at high biodiversity value sites
- excluding from other key high biodiversity value sites, represented in Bush Forever sites, Threatened Ecological Communities (TEC), regionally significant remnant vegetation and areas containing significant flora and/or fauna
- Mapping to show true extent of all populations
- Managing upstream, uphill and adjacent source populations
- Liaising with managers in adjacent regions to control upstream, uphill and other source populations
- Increasing awareness of the weed among land managers and the community
- Fostering and continuing to develop partnerships between friends groups, land managers such as local government and community groups
- Developing partnership commitment– undertake discussion with partner organisations to develop a framework monitor in the long term
- Maintaining a detection and surveillance program.

Targets

To fulfill the aims of the strategy, the following targets should be met in the Swan NRM Region by September 2011, unless otherwise stated:

- *a decrease in the number of populations in the region*
- *no nett increase in extent*
- *eradication of mature plants at all outlying populations*
- *eradication of mature plants at high biodiversity value sites.*

Actions to date

The following actions have been or are currently being implemented:

1. Survey to understand the extent and distribution

After gathering all herbarium collection details and liaising with the SRT during their joint Swan Catchment Council (SCC) Foreshore Assessment Project of 2006, field truthing and surveys were undertaken in 2007 and 2008 to better understand the distribution and extent of populations. Reports were sought from the community and land managers on any new or previously unknown populations.

2. Gaining and disseminating biology and best practice management information

DEC's Urban Nature Program in conjunction with the City of Cockburn, DEC Regional Parks and Community Unit and the Botanic Gardens and Parks Authority has led research trials into the best practice management of sharp rush in reserves on the Swan Coastal Plain. This research focused on effective control measures, impacts on native vegetation and possible

restoration techniques following control of sharp rush. This information fed into development of the information brochure and strategic plan. A workshop was held by DEC in August 2006 to disseminate this information, and bring together stakeholders from across the south-west to discuss the threat posed by sharp rush. Proceedings of this workshop have been recently been published (DEC 2006).

2. Raised industry, landmanager and community awareness
An information brochure was produced and disseminated in August 2006. This was released at a sharp rush workshop held in 2006, published in the workshop proceedings, distributed in hardcopy by mail, released in print media and made available on several websites (DEC 2008).

3. Liaison with land managers to undertake onground control works
Control works have been undertaken at priority sites in liaison with land managers, with funding and resources from the SCC, Urban Nature Program and DEC's Biodiversity Conservation Initiative. To date, over $7,000 has been allocated to herbicide spraying at key sites, including Lake Walyungup, Market Garden Swamp and Boundary Road, Kenwick. Liaison with other land managers is underway. This has shown that many LGA's, the SRT and DEC have had sharp rush control programs in place previously.

4. Mapping of populations at key sites
Mapping has been undertaken by the SRT as part of the Foreshore Assessment Project of 2006. Detailed mapping using differential Global Positioning System (GPS) was undertaken at several other key sites by DEC, particularly where herbicide control was planned.

5. Assessment of biodiversity values of sites containing each population and identification of high conservation value sites in close proximity, which could be at risk from invasion.
Locations were plotted in a Geographic Information System (GIS) with various data layers added, including biodiversity assets such as Bush Forever sites (Figure 8-12). Bush Forever Volumes 1 and 2 (Government of Western Australia 2000) and DEC GIS data was used to assess the conservation values of each site listed. Sites were also inspected and assessed in the field. These give a visual representation of spread and allow assessment of which sites are most at risk.

Each population was then assessed and rated by several criteria (described in Appendix 2):
- conservation value
- feasibility of control
- whether it is an outlying population
- threat posed to nearby biodiversity assets.

Values and ratings are listed in Table 1. This information allows a prioritisation of sites to manage and protect highest biodiversity assets, from which recommendations for management can be developed.

6. Development of plan, aimed at eradicating small to medium-sized populations in, or in close proximity, to high conservation value sites and outlying populations
Specific short-term (2008-2009) and long-term management recommendations have been developed for sites rated very high (VH), high (H) and moderate (M), as well as lower management priority sites. Most of these actions involve liaison, herbicide spraying, monitoring and surveillance.

Recommended actions

The following actions are recommended:

1. Seek funding to implement the strategy, including funds for coordination and on-ground activities

Funding is required in order for the strategy to be implemented and to coordinate and undertake onground activities (including control work, monitoring and mapping). Priority: High

2. Facilitate, fund and provide assistance for strategic on-ground control work

Priority: High

3. Identify and liaise with key stakeholders

Populations of sharp rush occur on private as well as public lands vested in a range of agencies. Developing partnerships with these groups is integral to achieving the outcomes of the strategy. Key stakeholders include:

- SCC
- DEC – WA Herbarium, Regional Parks and Community Unit, Swan Coastal District, Perth Hills District
- SRT
- LGA's – City of Gosnells, City of Swan, City of Cockburn, City of Melville, Town of East Fremantle, City of Rockingham, City of Canning, City of Belmont
- Subregional groups, South eastern Regional Community Urban Landcare (SERCUL)
- Department of Agriculture and Food Western Australia (DAFWA)
- other NRM regional Groups
- private industry
- Main Roads WA
- community groups, including Canning River Residents Environmental Protection Association (CRREPA)
- private landholders.

Priority: High

4. Obtain further biological and ecological information

Information is needed relating to restoring plant communities invaded by sharp rush and preventing re-establishment of infestations, as well as the seed biology of sharp rush. There are other questions which need addressing, some of which were raised in the workshop of August 2006 (DEC). These include hybridization occurrences and effects, the habitat and shelter benefits of sharp rush for native fauna and how the nutrient status of wetlands affect invasion. Improved knowledge will provide a scientific basis for management. Priority: High

5. Increase understanding and awareness of the weed among the general community, land managers, land owners and private industry (including nurseries and the revegetation industry) through workshops, electronic and print media

This includes raising awareness of pathways of spread, ensuring contaminated soil not moved from infested areas taking particular care when sourcing seed for revegetation. Priority: High

6. Monitor known population sites annually and continue mapping program Priority: High

7. Field truth unconfirmed sightings and conduct further surveys

Further surveys should be conducted at high risk regionally significant bushlands within and outside the current known range in the Swan NRM Region. The unconfirmed sighting of sharp rush at Lake Joondalup should be investigated. Priority: High/Medium

8. Establish a process of detecting, reporting and eradicating new infestations

Early detection and eradication of small populations is important to prevent spread and an escalation of threat to biodiversity. Priority: Medium

9. Keep fire and other disturbance factors out of high biodiversity value sites
However, where fire has affected populations, use this as an opportunity to undertake intensive control works. Priority: Medium

Resources

This strategy will help determine funding priorities for SCC's investment planning process. To date, limited funding has been available from the SCC and from DEC's Biodiversity Conservation Initiative for control works to be undertaken in 2006 and 2007. This has been approximately $7,000 in total, with additional work carried out by several LGA's. To implement the strategic plan, including funding an on-ground control program, funding will be required for a period of five to 10 years. As yet, other potential funding sources or contributions are uncertain.

9. MONITORING AND EVALUATION

Monitoring and evaluation are key parts of measuring the successful implementation of this strategy. New information gained from monitoring, as well as new findings that come to hand, can provide the basis to adapt the management program. At the completion of three years (September 2011), this strategy should be reviewed and evaluated against the forementioned management targets. With baseline information already gathered, data needs to be recollected in 2011 to assess the spread/decline of sharp rush in the region and evaluate the success or progress toward management targets. Indicators to show this will be:

- detailed mapping - spatial and numerical data can allow identifying changes in distribution and numbers of plants
- records of numbers of populations and plants (separating adults, juveniles/seedlings)
- survey for expansions in existing populations and new populations.

Because of the long-lived soil seed bank, monitoring and management actions will need to be carried out for up to ten years.

10. CONTACTS

As further information is gathered, the strategy may be altered accordingly. Submissions and comments are encouraged. Please contact the Department of Environment and Conservation phone (08) 9423 2900 or the Swan Catchment Council (08) 9374 3333.

11. ACKNOWLEDGMENTS

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13. FIGURES AND TABLES

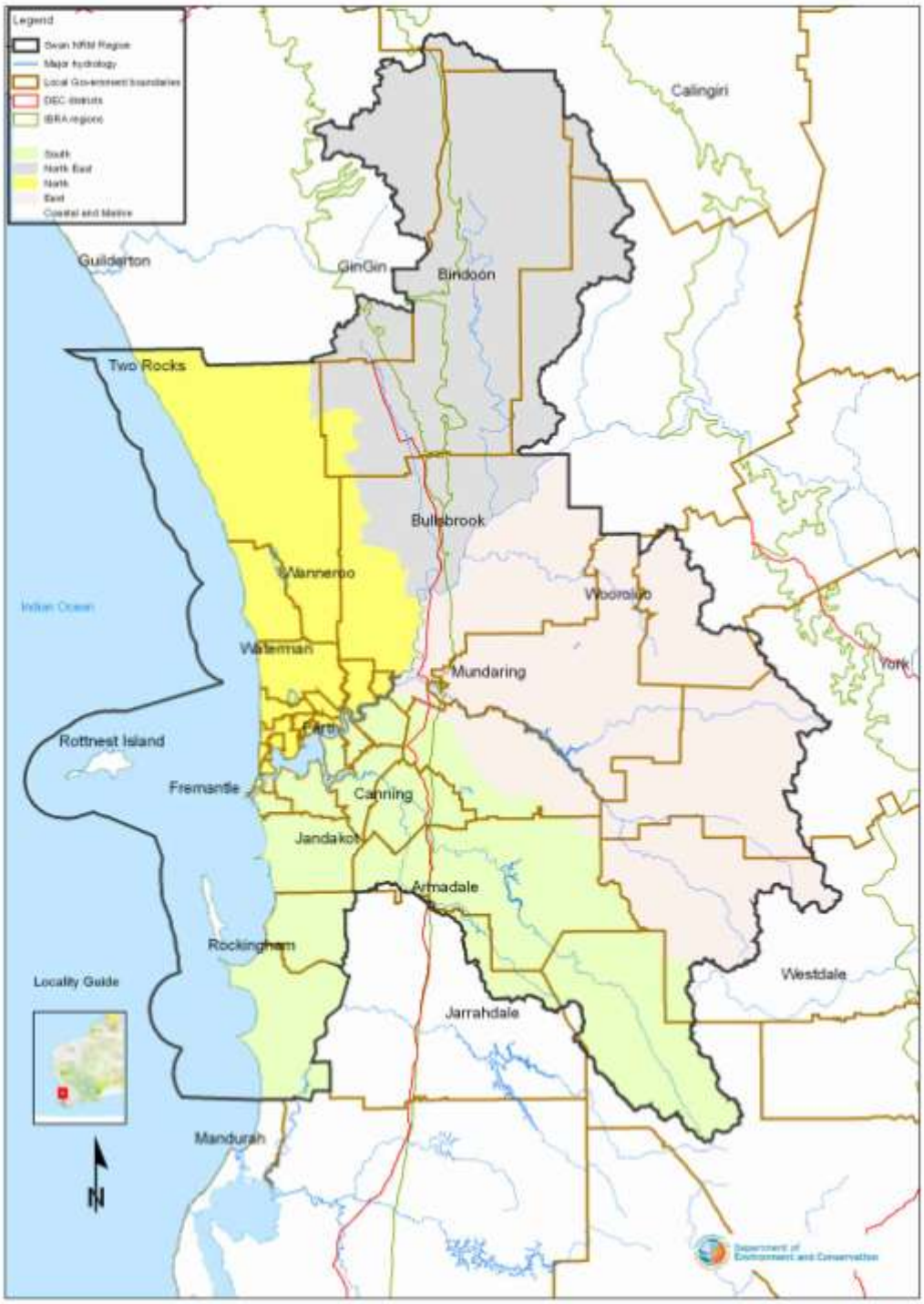

Figure 1: Management boundaries of the Swan NRM Region, including NRM sub-regions, DEC regions, districts and Local Government Authority boundaries.

Figure 3: Comparison of the clusters of fruits of two native rush species, *J. pallidus* (left) and *J. kraussii* (centre), with that of sharp rush (right) (photo by K. Brown).

Feature	*Juncus acutus*	*Juncus kraussii*	*Juncus pallidus*
Height	0.7-1.5 m	0.3-1.2 m	0.5-2 m
Form	hemisphere	erect	erect
Flowering	mainly spring	Oct-Jan	Oct-Dec
Flower colour	red-brown	red-brown	green
Capsule length	5-6 mm	2.5-3 mm	2.8-3.5 mm
Leaf colour	dark blue-green	dark green	pale green
Seed length	1.3 – 2 mm	0.5 – 1 mm	0.5 – 0.7 mm
Seed (x10)			

Figure 4: Major differences between sharp rush and the two most closely related native rush species.

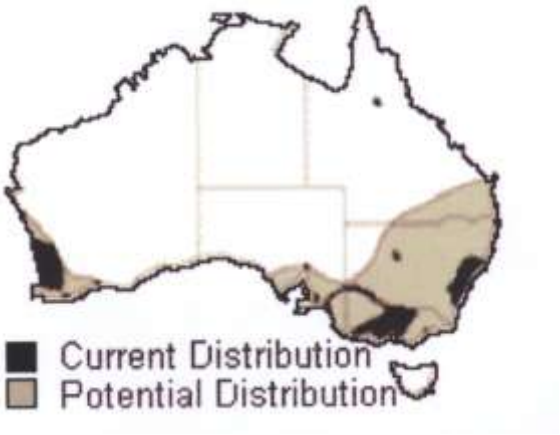

Figure 5: Potential distribution of sharp rush in Australia based on climate modelling (Australian Weeds Committee 2006).

Figure 7: Types of habitat where sharp rush occurs in the Swan Region.

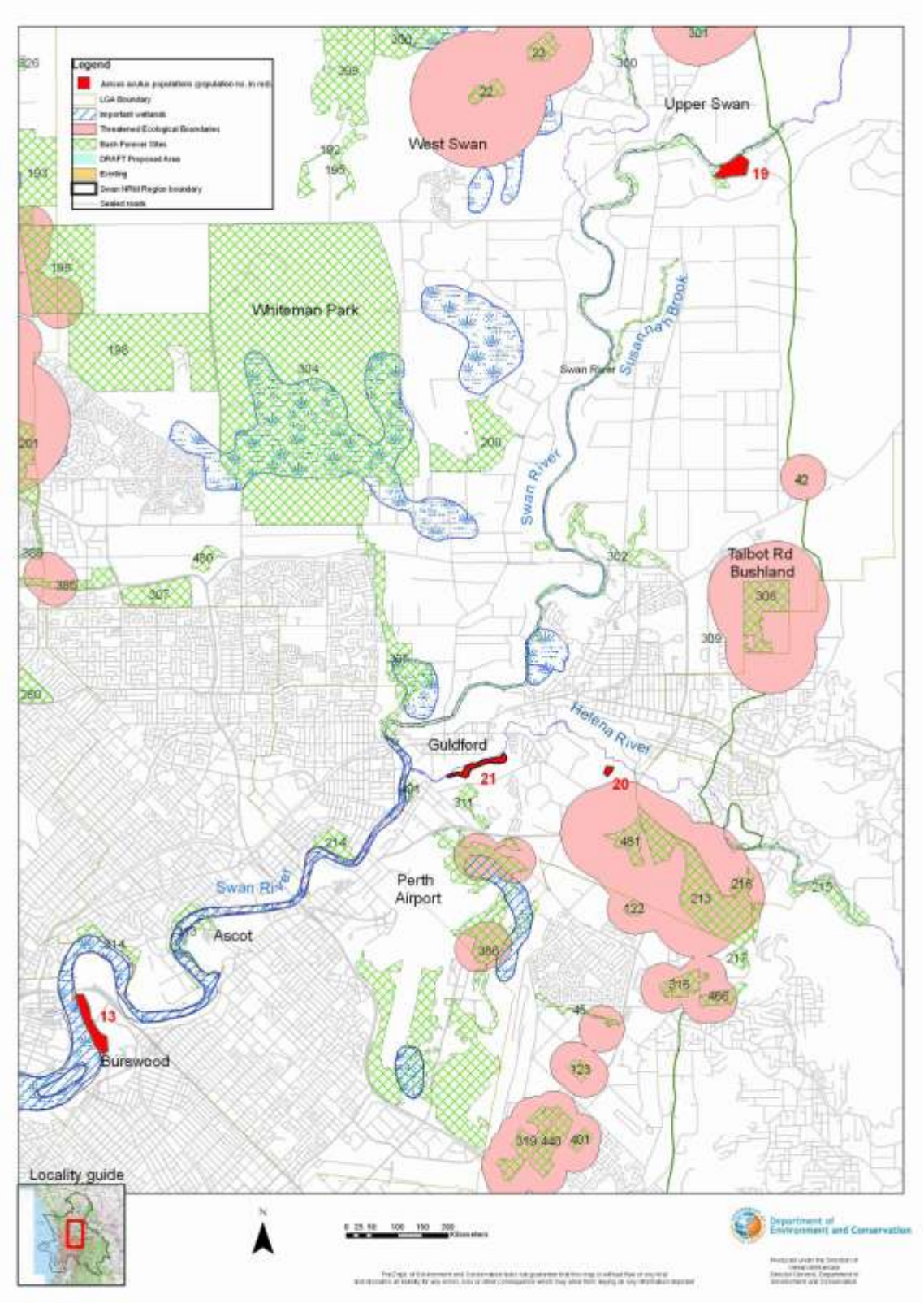

Figure 8: Detail of GIS mapping for the distribution of sharp rush populations against high biodiversity value assets in the north east of the Swan NRM Region.

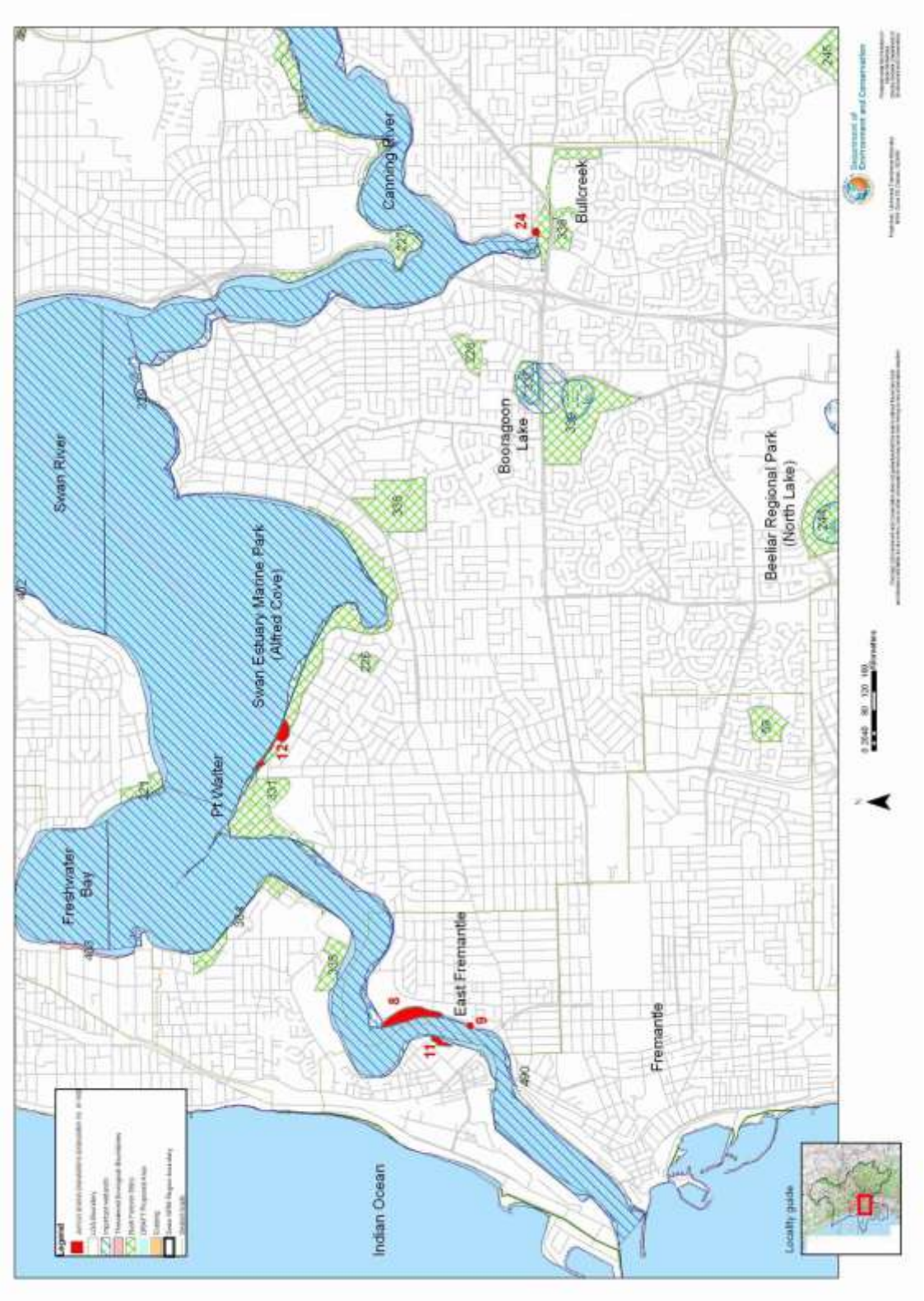

Figure 9: Detail of GIS mapping for the distribution of sharp rush populations against high biodiversity value assets in the west of the Swan NRM Region.

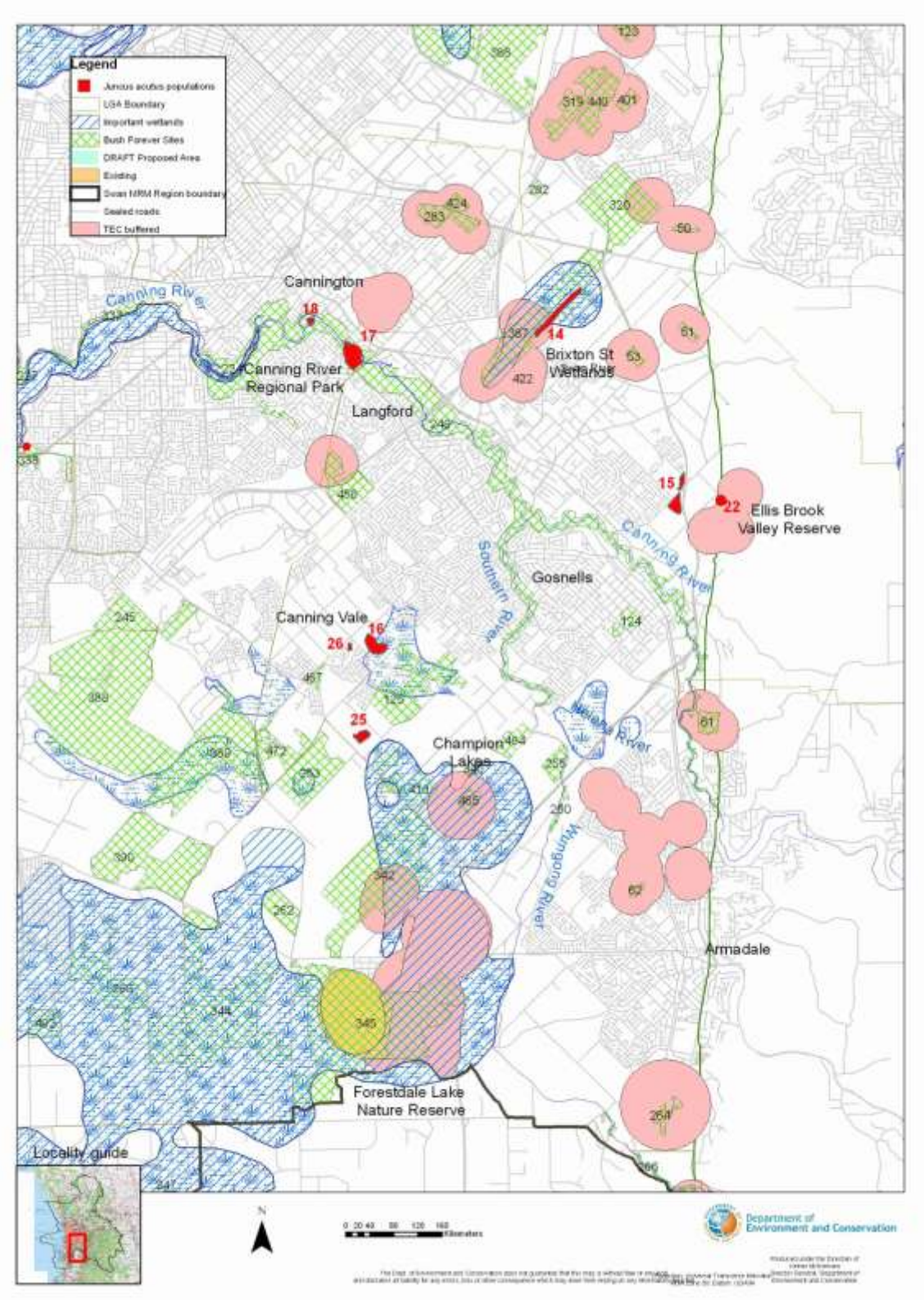

Figure 10: Detail of GIS mapping for the distribution of sharp rush populations against high biodiversity value assets in the south east of the Swan NRM Region.

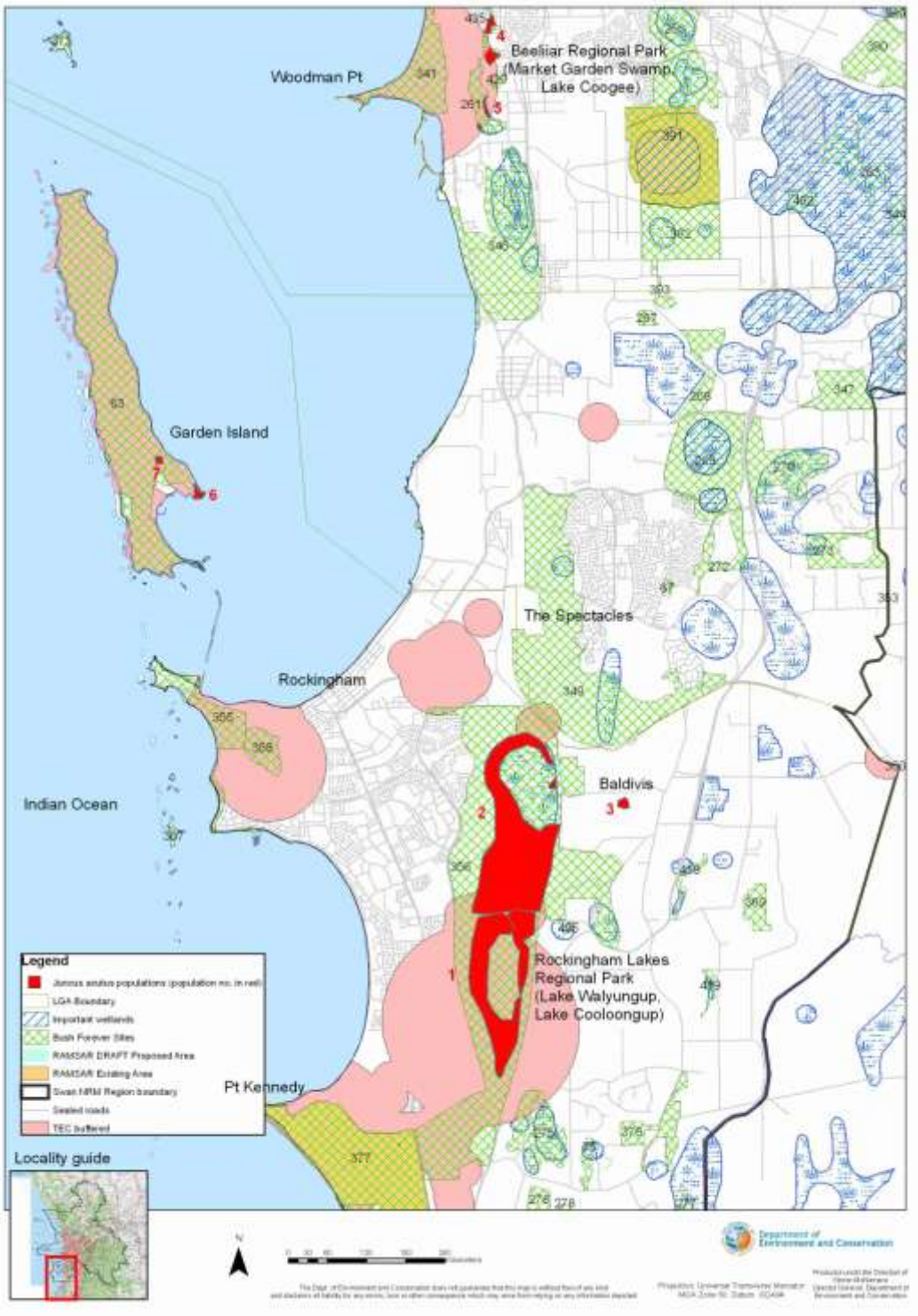

Figure 11: Detail of GIS mapping for the distribution of sharp rush populations against high biodiversity value assets in the south of the Swan NRM Region.

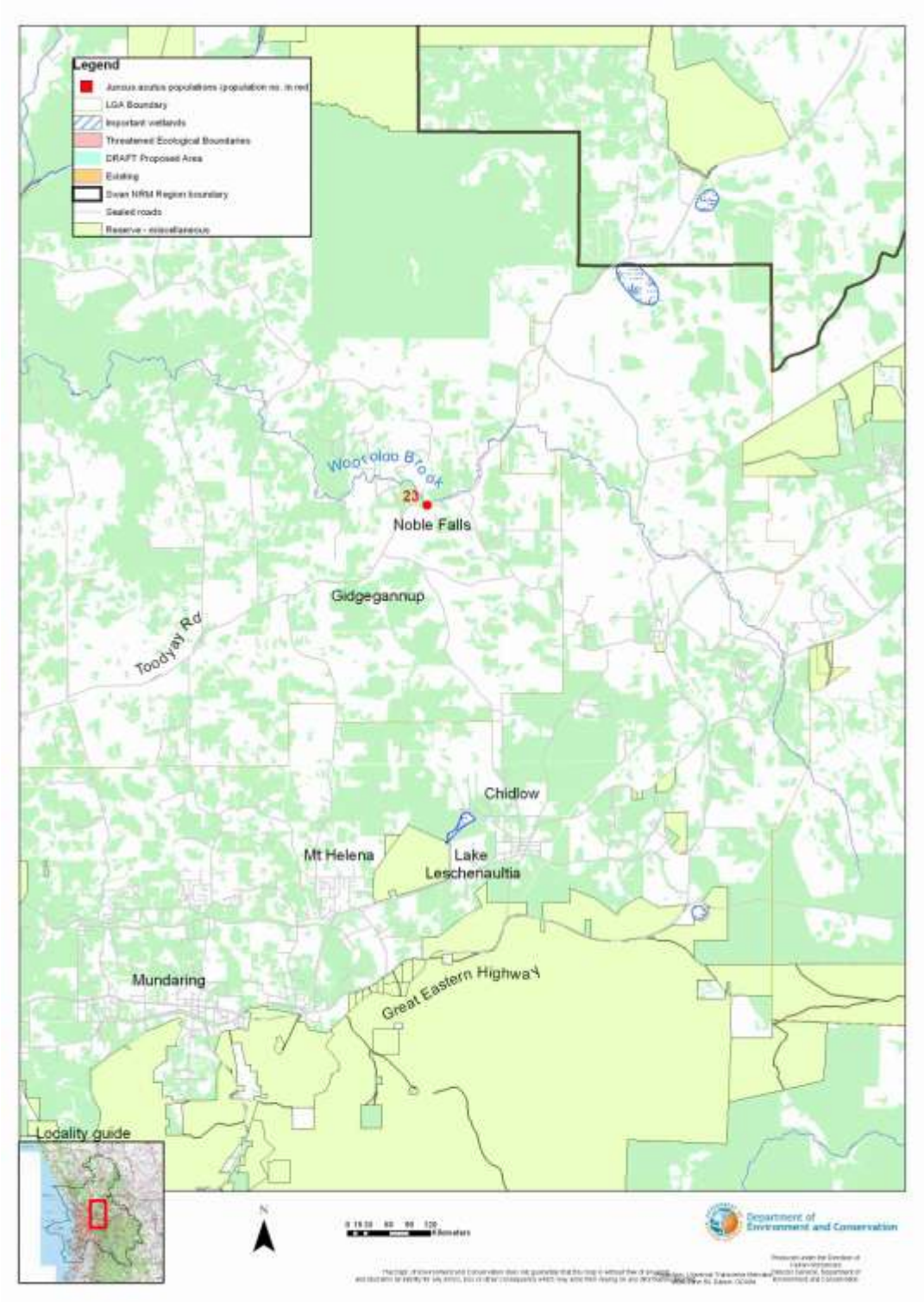

Figure 12: Detail of GIS mapping for the distribution of sharp rush populations against high biodiversity value assets in the far north east of the Swan NRM Region.

15. APPENDICES

Appendix 1: Full description of sharp rush (Wilson *et al.* 1993).

Juncus acutus L.

Description: Tussock-forming, shortly rhizomatous perennial. Culms terete, 30–160 cm long, 2.0–4.0 mm diam.

Leaves terete, basal, shorter than culms, pungent; auricles absent; sheath yellow-brown to golden brown, adaxially coppery.

Inflorescence terminal or pseudolateral, diffuse, 4–13 cm long; flowers clustered, 1–6 per cluster and 5–50 clusters per inflorescence; involucral bracts 1 or 2, well-developed, 4–25 cm long, shorter than to longer than inflorescence. Tepals straw-brown, often tinged darker chestnut-brown; outer tepals (rarely 2.0) 2.5–3.7 mm long, shorter than or equalling inner tepals, often with narrow whitish margin near apex; inner tepals with broad white margin near apex. Stamens 6, shorter than outer tepals; anthers 1.2–1.7 mm long.

Capsule much longer than outer tepals, ellipsoid to ovoid, acute to acuminate, apiculate, yellow-brown to chestnut-brown; seeds membranous-tailed.

Juncus acutus subsp. *acutus* L.

Description: Tussock-forming, shortly rhizomatous perennial. Culms terete, 30–160 cm long, 2.0–4.0 mm diam.

Leaves terete, basal, shorter than culms, pungent; auricles absent; sheath yellow-brown to golden brown, adaxially coppery.

Inflorescence terminal or pseudolateral, diffuse, 4–13 cm long; flowers clustered, 1–6 per cluster and 5–50 clusters per inflorescence; involucral bracts 1 or 2, well-developed, 4–25 cm long, shorter than to longer than inflorescence. Tepals straw-brown, often tinged darker chestnut-brown; outer tepals (rarely 2.0) 2.5–3.7 mm long, shorter than or equalling inner tepals, often with narrow whitish margin near apex; inner tepals with broad white margin near apex. Stamens 6, shorter than

Capsule much longer than outer tepals, ellipsoid to ovoid, acute to acuminate, apiculate, yellow-brown to chestnut-brown; seeds membranous-tailed.

Appendix 2: Criteria for assessing sites.

Table below: Criteria for ranking threat to biodiversity values of site (from highest to lowest).

Ranking	Criteria (serves as a guide only)
1	TEC **and/or** Declared Rare Flora (DRF) present Priority/significant flora species present Regionally significant. Bush Forever site Vegetation in good, very good to excellent condition in majority of site International/nationally significant Contains other special attributes (eg, scientific importance)
2	No TEC **or** DRF present Priority/significant flora species may be present May be regionally significant May contain other special attributes Vegetation in good to degraded condition Occurs on road verge/buffer adjoining and threatening sites ranked 1 Is outlier population at known extent of range
3	No TEC, DRF or priority/significant flora species present Not recognised as regionally significant No other special attributes Vegetation degraded to poor, completely disturbed or very poor condition (vegetation structure disappeared, few, if any, native species, high percentage cover and abundance of weeds) Does not threaten high biodiversity value sites

Table below: Criteria for ranking feasibility of control of weed species (from high to low feasibility).

Ranking	Criteria (serves as a guide only)
1	Weed in low numbers and/or low density Occasional and localized/confined to a specific area of site and in low density Possibility population/s eradicated in two to three years Site easily accessible
2	Weed in low numbers and/or low density Occasional and widespread-present in most or all of site Weed in medium densities Common and localised-confined to specific areas of site Possibility population/s severely reduced or eradicated within 2 to 3 years Site accessible/moderately accessible
3	Weed in high density Widespread or localised and abundant Infestation difficult to control, eradication unlikely Likelihood infestation would require intensive treatment for over three years Site may be difficult to access Site has complication for management – e.g, sensitive site, permanent water