

# **Lake Kununurra and Lily Creek Lagoon**

## **Vegetation Management Plan**

**January 2008**



**Prepared for Shire Wyndham East Kimberley  
through funding from the  
National Action Plan for Salinity and Water Quality  
Prepared by Kimberley TAFE, Kununurra Campus and  
SWEK**

## 8. Other Aquatic Plant Management

Submerged aquatic plants have also proliferated in Lake Kununurra and Lily Creek Lagoon. The seasonally dry Ord River probably supported very little submerged aquatic plants prior to the construction of the dam. Present conditions are ideal for the growth of these plants and it was clear after the first five years of stable water levels that the growth of floating and submerged aquatic plants was becoming a problem. As a control measure from 1977 to 1980, the Lake was drained annually for two weeks (Watkins, et al, 1997).

The high level of tourism and recreational use of the Lake has resulted in increased public pressure to manage the growth of wetland plants such as floating pond weed, ribbon weed and water lilies as they interfere with power boat and swimming activities (Watkins, et al, 1997).

The idea of dredging a boating channel to manage the growth of these weeds has previously been suggested by community members and tourism operators. Dredging is digging, gathering, or pulling out material to deepen waterways, create harbours, channels, etc. As it involves disturbance to the waterbody's bed it is therefore not recommended.

Instead, if an aquatic weed harvester became available, it could clear a small boating passage of aquatic vegetation that recreational boat owners and tourism operators could then use (see Figure 13).

As with cumbungi these plants play an important role in wetland ecology. The specifics of their role are not included in this Plan and it is recommended that further research into their growth and control be carried out.



**Fig 13 Area recommended for removal of aquatic weeds should a harvester become available**

## 9. Introduced Weeds

Weeds and exotic species result in the smothering of native plants, and compete for light, water and nutrients. They can also increase fire fuel loads, reduce plant biodiversity, reduce habitat for native animals and increase refuge for feral animals (Dixon, 1997). Some native species can be so successful that they then act as a weed. The most common weeds in the study area are neem, leucaena, date palms, calotropis, passionfruit vine and merrimia which are all introduced. High impact riparian weeds that occur in the study area were identified by Dixon and Douglas (1997) as wild passionfruit, calotropis, parkinsonia, neem and leucaena. These weeds are a priority for removal.

The floating fern, *Salvinia molesta*, was found in Lily Creek Lagoon in 2000. *Salvinia* is a declared P1/P2 weed under the *Agriculture and Related Resources Protection Act 1976*. (This Act will soon be rescinded in favour of a new Biosecurity Agricultural Management Bill. As such all Landholders, including Government will have a responsibility for its eradication.) The classification of P1/P2 prevents the trade, sale or movement of plants into the state and all plants are to be eradicated from the state. The eradication of the declared weed is the responsibility of the landowner. In this case that would be DPI, yet it was decided that a joint coordinated approach between the Shire, DoFA, DPI, OLW and DEC was a more effective approach.

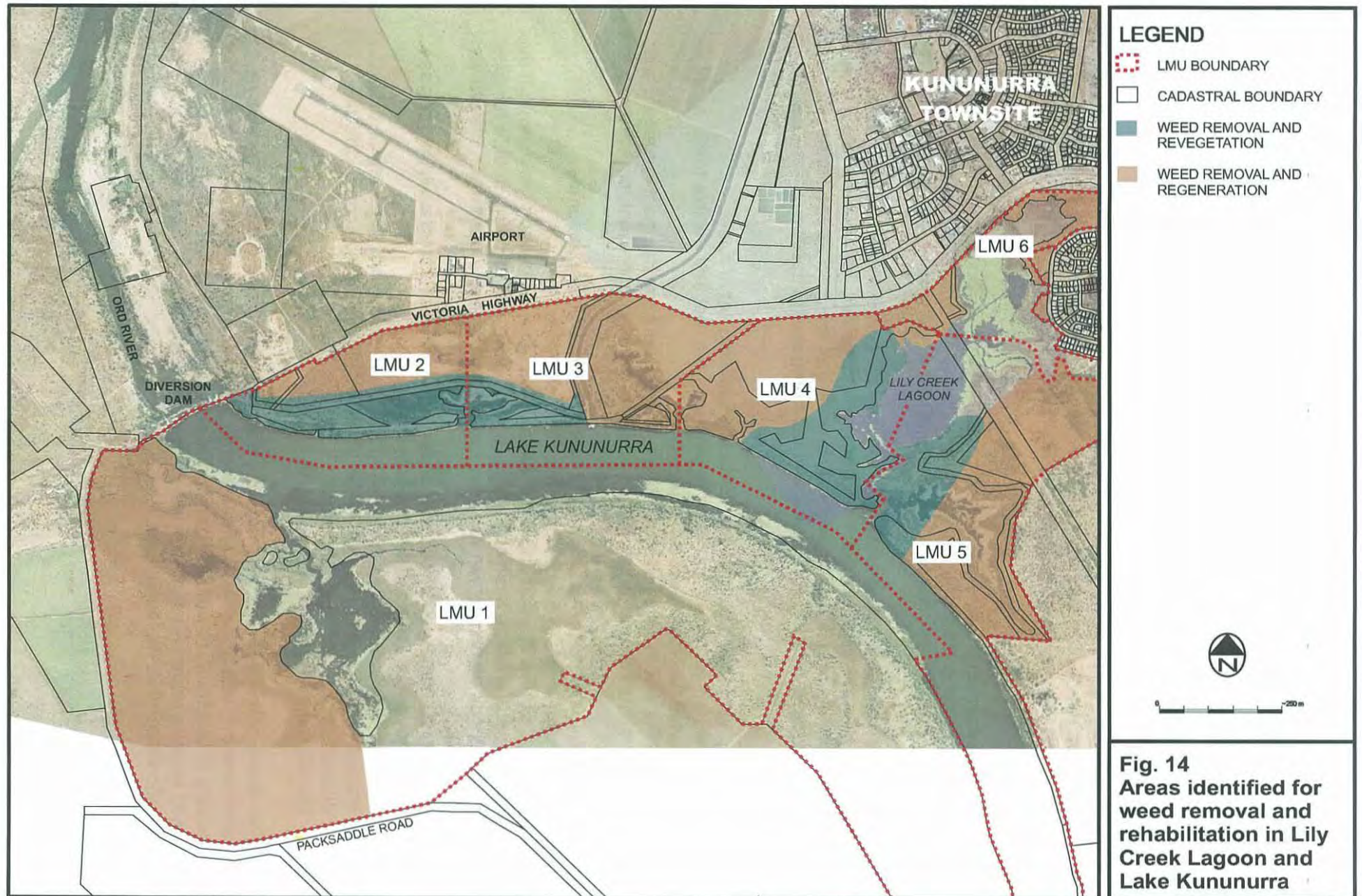
*Salvinia* eradication attempts to date have been hampered by a lack of funding, a lack of co-ordination and access difficulties. This declared weed has the potential to cover the entire surface of Lake Kununurra and Lily Creek Lagoon and severely restrict recreational and commercial water use (Watkins et al 1997). The implications of the infestation getting out of control would be far and wide - infestations block irrigation structures, pollute drinking water, impact wetland biodiversity and prevent recreational activities such as swimming, fishing and boating. Lake Kununurra is not an isolated waterbody and hence *salvinia* also has the potential to spread downstream into the Ramsar listed wetlands of the lower Ord River.

Through the Lake Kununurra NAP funded project, a coordinated, agreed and up to date control and eradication plan has been formed and implemented. This plan was developed in conjunction with the Kununurra Weeds Working Group, a multi-stakeholder group that helps to monitor and guide priority weed projects. Actions under the plan include:

- a second groyne to be built parallel to existing groyne;
- cumbungi to be removed between the two groynes using excavator;
- 2 x 25 metre fence booms to be strung between the two groynes;
- spraying to be carried out to kill any remaining vegetative material in the bunded area;
- the Department of Food and Agriculture to carry-out a yard to yard search of houses that are connected to the drainage system from where it is believed the infestation has originated;
- the Shire of Wyndham East Kimberley to check drainage sumps for *salvinia*;
- signage to be erected in appropriate areas for public awareness and media releases made intermittently to keep public informed and aware of the project; and
- monitoring in 2008 to ensure that another outbreak does not occur.

The potential for aquatic plant introductions such as *salvinia* into Lake Kununurra is high. Water hyacinth, *Eichhornia crassipes*, would be equally devastating if

introduced and not contained. Introduction can occur through escape from aquaria and plant material from boat and boat trailers being brought from other locations particularly the NT. It is therefore important for the quarantine service in WA to be aware of and conduct strict search regimes for such plants.



**Fig. 14**  
**Areas identified for weed removal and rehabilitation in Lily Creek Lagoon and Lake Kununurra**

## 10. Regeneration Principles

The Bradley Method of bush regeneration (Weeds CRC Weed Management Manual, 2004) appears to be the most cost effective, low impact and sustainable form of weed removal and rehabilitation for the study area. This method has as its basis three principles:

1. Work from areas of least disturbance and prioritise areas where significant species occur (ie from areas where indigenous or desired vegetation is at its healthiest with few unwanted species).

Native plant seed will more likely be in the ground in areas where native plants are growing and weed propagules are more likely to be in the ground in areas where weeds are growing.

2. Make minimal disturbance using careful hand removal techniques or herbicides. Even careful weeding will disturb the soil, increase available nutrients and activate weed seed, increasing the opportunity for weed species to propagate.

3. Let native plant regeneration dictate the rate of weed removal. Regeneration slows down as the weed numbers increase so ensure that the weeding rate matches the regeneration rate. Do not over clear. Ensure that the area weeded is not so large that other weeds now have the chance to out-compete the desired indigenous species.

The three principles above are guided by the following set of rules:

1. Watch where you tread. Minimise the impact from foot and vehicle traffic as all disturbance has an impact on vegetation.
2. Disturb the soil as little possible. Simple hand tools have the least impact on soil.
3. Preserve and replace mulch. Mulch acts as a weed suppressant, conserves soil moisture and provides habitat for soil fauna.
4. Mulch with weeds provided they are free of seed, bulbs or rhizomes.
5. Do not pile weeds in heaps. Disperse them as mulch.
6. Never pile or hang weeds on other weeds. The surviving weeds grow through the dead weeds creating a difficult tangle to remove as well as being double handling. Hang weeds on native plants or remove them as piles and burn when they have dried out.
7. Remove all weeds when weeding an area. Do not just remove a single species but remove all weed species simultaneously.
8. Work with the weather. Avoid weeding areas during the wet that may be prone to erosion following a heavy rain event. Weeding in very dry soil conditions can disturb soil until the next rain event.
9. Do not remove a plant that cannot be identified.

The above process, whilst the most cost effective, does require a considerable timeframe and is not always fully achievable, particularly on sites containing a high density of large woody weeds. These principles are recommended as a guide to weed removal within Australia yet will not always be applicable. See below for more specific weed removal techniques.

## 10.1 Weed removal methods (As taken from Weeds CRC Weed Management Manual)

A key consideration to weed removal is possible adverse impacts. Examples of adverse environmental impacts include

- loss of faunal habitat, e.g. leucaena (*Leucaena leucocephala*) provides habitat for flying foxes or parkinsonia (*Parkinsonia aculeate*) protection for small mammals from predation.
- weed substitution – a weed is removed only to be replaced by a weed which is more difficult to remove, e.g. Neem (*Azadirachta indica*) substituted by Luecaena (*Leucaena leucocephala*).
- chemical effects of fauna, e.g. impact on frogs by chemical sprays used for weed control.
- Increased erosion eg when leucaena (*Leucaena leucocephala*) is the most dominant or only vegetation growing on foreshore areas and is acting to control soil erosion.

Many potential adverse impacts of weed management can be prevented by trying to implant the principles and rules listed above and through revegetation with appropriate local species at the same time as weeds are removed. This approach maintains habitat values and reduces the risk of weed substitution.

The following methods are the most widely used and easiest to apply. Figure 14 indicates the areas within SWEK management that require weed removal. At the time of writing, a weed map indicating specific infestations of certain weeds was being developed, informed by OLW.

### **Herbicides**

The use of herbicides near waterways or where herbicides may eventually enter waterways requires careful consideration and care. It is best if possible to avoid or at least minimise herbicide use in these situations. If they are used, then they need to be registered for use near waterways, compliant with the Department of Health's PSC88 and label instructions strictly adhered to. There should be no use of 'weed n feed' products as these contain the chemical dicamba which is harmful to human health.

- Foliar spraying: Application of herbicide diluted with water or sometimes diesel, applied at a specific rate using spray equipment onto the foliage of plants until every leaf is wet (not dripping). High potential for off site damage. Important to check the mode of action of the herbicide; herbicides with surfactants spread across the leaf surface and so a fine spray with less volume can be sufficient.
- Basel bark spraying: This method involves mixing an oil-soluble herbicide in diesel and spraying the full circumference of the base of the trunk or stem right down to the ground. Often used to treat woody weeds. The downfall of this method is that dead wood is left in the area which can reduce access, get covered in weeds and increase fuel loads.
- Cut and paint: Particularly useful for woody weeds. Cut the stem horizontally as close to ground as possible then apply herbicide as soon as possible using a paint brush, sprayer or similar. This method does not always provide a 100% kill rate and follow up and monitoring of treated plants will be required. Remove the cut wood and burning in piles will reduce the fire risk, remove woody debris that may get again covered in weeds and restrict access, and incinerate attached weed seed (or weed seed accumulated on or near to the soil surface surrounding the weed). A cut and painted plant that needs to be re-sprayed at a later date has



an advantage in that less herbicide is used than an initial aerial or foliar spray and there is less chance of an off target kill.

- **Stem injection:** This method targets individual plants. A cordless drill, injection gun or similar is used to drill angled holes into the base of the plant. Herbicide is then injected into the holes within 10 seconds. The downfall of this method is that dead wood is left in the area which can reduce access, get covered in weeds and increase fuel loads which is likely to be undesirable

### ***Hand***

- **Hand pulling:** useful for isolated occurrences of seedlings or other small, soft, non-bulbous weeds.
- **Digging, hoeing or grubbing:** can be effective for isolated weed occurrences and are useful follow up techniques. Larger woody weeds are more effectively treated with herbicides.

### ***Mechanical***

- **Grooming:** earthmoving equipment fitted with specialised grooming arms may be effective for treating large infestations of woody weeds in hard to reach places. The grooming device shreds plant material down to ground level, reducing biomass. Follow up treatments of any regrowth, using herbicides or manual methods, requires far less chemical and effort than would have been the case if the original infestation had been treated. This form of weed removal should only be used where resources exist to carry out necessary follow up work and rehabilitation/restoration of the site with suitable vegetation.

## 10.2 Weed removal and self regeneration

- Weed removal and self regeneration of existing native plant species is recommended in stable areas where large stands of native vegetation still exist and/or where weed species tend to be scattered individual plants or vines. Seed banks and/or remaining or adjacent vegetation will result in self regeneration of species. These trees tend to be very tough, do not need watering and have a high survival rate.
1. Remove weeds using the most low impact yet effective method (see weed removal methods),
  2. If in a slashed area, stake seedlings so that the slasher driver can avoid them.
  3. On-going weed removal and management of the site through follow up spraying and/or hand pulling.

## 10.3 Weed removal and rehabilitation

Weed removal and planting of the site with either seedlings or seed of local native species is recommended in areas that have been identified as parkland and where a weed species has out-competed the native vegetation to become the most dominant species resulting in a low diversity of native vegetation. Physical rehabilitation techniques such as bank stabilisation, mulching, gabion construction, etc may need to be undertaken prior to replanting.

In some instances, due to the high density and physical stature of some weeds (ie rain trees and leucaena) then a mechanical mulching machine may be needed. In this circumstance then a precautionary approach to weed removal should be used with the maximum area of weeds to be cleared at any one time being that which is able to be followed up regularly and be easily replanted with native species (refer to Bradley Regeneration Principles). If accessible then another option would be to remove all seeder (mature) and semi mature trees from an area, plant and then return the following year to remove the remaining immature weeds.

Direct seeding using pioneer species is an option in areas where immediate cover is needed. In a less intact site this would need to be followed up with planting of native seedlings at some stage to increase biodiversity at the site.

It is important for slasher and other machine operators to follow appropriate hygiene practices so that weeds are not spread from one area to another via the slasher.

Rehabilitation in parkland areas should be implemented as outlined below:

1. Remove weeds using the most low impact yet effective method (see weed removal methods)
2. Unless plants will be hand watered, plan weed removal and planting for the wet season (Dec-Feb) as this will give plants the best chance of establishment.
3. Inform and involve the community in planting days as this gives a sense of ownership over the project which helps to prevent vandalism and encourage maintenance of the seedlings.
4. Select species that are most suitable for the location. Seedlings selected for shade, shape, longevity, safety and other parkland/recreational values are best.

5. Select small plants 300-400mm high. These require less work in digging and site preparation and the younger, smaller plants suffer less in transplant shock.
6. Using either a stake or paint, mark out where you want the plants to go.
7. Make sure seedlings are at least 15 meters apart to allow a slasher to manoeuvre between them. Seedlings should be a minimum of 2 meters from a footpath or road.
8. If using more than one species and a particular planting pattern is needed then mark this pattern on a site map and give to the planters.
9. Make sure you dig a large hole. The Shire auger may be available. A large hole gives the seedling's roots room to grow.
10. Fill the hole with good dirt. If the dirt removed is too rocky or clayey then bring in better dirt from elsewhere.
11. Create a shallow bowl or depression around the planted seedling so that any rain that falls is captured and contained by this bowl.
12. Push down hard around the base of the seedling to compact the dirt and remove any air that is trapped.
13. Plant the seedlings with a stake for support and so that they are easily identified by the slasher driver.
14. Water seedlings immediately after planting, this will also help with compaction around the roots.
15. Stake any local native trees that have self generated so that they are not slashed.
16. Inform slasher driver of the new trees that have been planted and staked.
17. Follow up weeding will be needed. Remove stakes once the trees are big enough to be seen by the slasher driver.

#### **10.4 Suitable species for rehabilitation**

Plant species to be used for regeneration of conservation areas should be predominantly endemic to the area. Past documents contain plant lists representing the most common vegetation that used to occur in and around Lake Kununurra (see Information Sheet on Ramsar Wetlands, Gowan, 1981). Table 17 below lists these species.

Due to the modified environment and therefore continual vegetation succession, species may need to be varied to suit the current conditions. Species should however be limited to those that occur within the local Kununurra area.

Areas identified as parkland and that receive regular maintenance can have a more diverse range of species planted including species widely known from the top end and the Kimberley region.

Limiting factors for selection of suitable species are unknown propagation techniques, unreliable germination rates, and difficulty in gaining supply of plant material.

Tree and shrub seeds for rehabilitation work can be sourced from Kimberley Seeds and can be grown by TAFE or contracted out to a commercial grower. Sedge species can be sourced as plants from Greening Australia in the NT although it would be preferable to source and grow seeds from local species.

Kimberley TAFE in conjunction with a number of Aboriginal communities is currently researching and trialling propagation and development of market-ready endemic plant varieties. Work will continue and plants suitable for rehabilitation work and parkland planting will be made available to SWEK.

**Table 17: Local plant species for rehabilitation**

<b>Shrubs</b>	<b>Trees</b>	<b>Trees Cont...</b>	<b>Grasses</b>
<i>Acacia translucens</i> (poverty bush)	<i>Adansonia gregorii</i> (boab)	<i>Ficus opposita</i> (sandpaper fig)	<i>Cyperus albomarginatus</i>
<i>Cochlospermum fraseri</i> (kapok bush)	<i>Atalaya hemiglauca</i> (whitewood)	<i>Grevillea striata</i> (beefwood)	<i>Cyperus macrostachyos</i>
<i>Carissa lanceolata</i> (conkerberry)	<i>Barringtonia acutangula</i> (freshwater mangrove)	<i>Gyrocarpus americanus</i> (helicopter tree)	<i>Echinochloa kimberleyensis</i>
<i>Eucalyptus pruinosa</i> (silver leaf box)	<i>Bauhinia cunninghamii</i>	<i>Lophostemon grandiflorus</i>	<i>Eleocharis atropurpurea</i>
<b>Aquatic</b>	<i>Cathormion umbellatum</i> (Cathormium)	<i>Melaleuca leucadendra</i> (cadjeput)	<i>Eleocharis brassii</i> (spike rush)
<i>Nymphoides indica</i>	<i>Erythrina vespertilio</i> (yulbah)	<i>Melaleuca viridiflora</i> (broad leaf paper bark)	<i>Eleocharis philippinensis</i>
<i>Nymphaea gigantean</i> (giant waterlily)	<i>Erythrophleum chlorostachys</i> (ironwood)	<i>Nauclea orientalis</i> (leichhardt Pine)	<i>Eleocharis spiralis</i>
<i>Hydrilla verticillata</i> (water thyme)	<i>Eucalyptus camaldulensis</i> (river gum)	<i>Owenia vernicosa</i> (emu apple)	<i>Eleocharis sphacelata</i> (tall spike rush)
<i>Myriophyllum verrucosum</i> (red Water Milfoil)	<i>Eucalyptus microtheca</i> (Coolibah/flooded box),	<i>Pandanus spiralis</i> (screwpine)	<i>Eriachne sulcata</i>
<i>Potamogeton tricarinatus</i> (floating pond weed)	<i>Eucalyptus foelscheana</i> (smooth barked bloodwood)	<i>Sesbania Formosa</i> (white dragon tree)	<i>Oryza australiensis</i> (australian wild rice)
<i>Vallisneria spiralis</i> (ribbon weed)	<i>Eucalyptus grandifolia</i>	<i>Tristania grandiflora</i> (wild Plum),	
	<i>Excoecaria parvifolia</i> (guttapercha Tree)		

## 11. Recommendations

In writing this report it became clear that there was a lack of data and information for the wetland ecosystem in general. Increased data and information will lead to a better understanding of Lily Creek Lagoon and Lake Kununurra and enable improved management of the waterbody and its vegetation. Therefore, the Plan also includes additional recommendations aimed at improving water quality of the wetland and increasing available information.

**Recommendation 1.** Form a Lily Creek Lagoon and Lake Kununurra Foreshore working group that focuses specifically on the area in this report. Members should be those responsible for management of the foreshore (DoW, SWEK and DEC) with Water Corporation, Ord Land and Water and other stakeholders if and when needed.

**Recommendation 2.** Protection of vegetation areas that are largely untouched should be retained for conservation purposes.

**Recommendation 3.** In view of the time required for their establishment, mature native trees should be retained, and seedlings planned as replacements for any that die or are removed.

**Recommendation 4.** Rehabilitate stormwater drains, actively regulate developments through the kerb and footpath deposit policy and employ best management practices for stormwater to reduce sediment loads entering the system.

**Recommendation 5.** Establish Sediment Load Monitoring Points to evaluate sediment loads entering Lily Creek Lagoon.

**Recommendation 6.** Conduct mammal surveys at night and bird surveys at dawn and dusk to update out of date baseline biodiversity information.

**Recommendation 7.** Employment of a Park and Gardens Officer whom also has a role in Bush Regeneration.

**Recommendation 8.** DEC to develop a Ramsar Wetland Management Plan.

## 12. Monitoring, Evaluation and Review

<b>Monitoring and evaluation</b>
Water Quality Monitoring including sediment loads
Photo points and quadrats
Cumbungi regrowth
Cumbungi growth – aerial photography every 3-5 years to monitor growth
Surveys
Weed Map
Rush and sedge growth
Aquatic and fringing vegetation
Mapping of wetland plant communities

'Who' implements these recommendations will depend upon available funding and responsible landholders taking ownership over the management of this waterbody. To implement the various recommendations included in the plan, the many agencies involved in the management of the Foreshore will be required to contribute additional resources. A working group that has a specific focus on the study area (foreshore) and its management has been recommended to be established. This group would need to decide early on who would be implementing the above actions and source of funding.

### **Review**

As this plan is a working document then it should be reviewed annually to add in additional material and update procedures.

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## Appendix 1: Information on the Ramsar wetland *Lakes Argyle and Kununurra*

### Wetland classification

The Ramsar List was established in response to the Convention on Wetlands of International Importance (Ramsar, Iran 1971) and establishes that “wetlands should be selected for the List on account of their international significance in terms of ecology, botany, zoology, limnology or hydrology.”

Lakes Argyle and Kununurra are a declared Ramsar site that were included on the Ramsar list of wetlands according to criteria points 2,3,4, and 5 of the Ramsar Criteria for Justification. The table below gives a description of the criteria and the justification for their inclusion on the Ramsar list.

The Ramsar Information sheet for Lakes Argyle and Kununurra summarise the site and its characteristics (See Appendix 2).

**Table 1: Ramsar criteria and justification for inclusion for Lakes Argyle and Kununurra (Australian Wetlands Database, 2003)**

<b>Ramsar criteria for inclusion</b> A wetland should be considered internationally important if	<b>Justification of criteria</b>
<b>2.</b> The wetland supports vulnerable, endangered, or critically endangered species or threatened ecological communities.	The Site supports a large population of the vulnerable Freshwater Crocodile <i>Crocodylus johnstoni</i> , which is specially protected by the Western Australian Wildlife Conservation Act (1950), and the Commonwealth of Australia's Environment Protection and Biodiversity Conservation Act (1999).
<b>3.</b> The wetland supports populations of plants and/or animal species important for maintaining the biological diversity of a particular biogeographic region.	At least 15 species of freshwater fishes (mainly catfishes, grunters and gudgeons) are known to occur at the Site, while four fishes (two catfish <i>Arius spp.</i> , Strawman <i>Quirichthys stramineus</i> , and Giant Glassfish <i>Parambassis gulliveri</i> ) are known in Western Australia only from the Site and other parts of the Ord River System. Three species of freshwater turtle are known from the Site and one of these, <i>Emydura australis</i> , is restricted to the Kimberley - Victoria River region.
<b>4.</b> The wetland supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions.	Lakes Argyle and Kununurra are important dry-season refuges for waterbirds.
<b>5.</b> The wetland regularly supports 20,000 or more waterbirds.	The Site regularly supports very large numbers of waterbirds. In August 1986, Lake Argyle supported more than 180,000 while in September 1978, 12,000 were recorded using Lake Kununurra

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Information Sheet on Ramsar Wetlands (RIS)

Categories approved by Recommendation 4.7 of the Conference of Contracting Parties.

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### Lakes Argyle and Kununurra, Western Australia - 32

1. Form compiled by: Compiled by the Department of Conservation and Land Management (DCLM). All inquiries should be directed to Jim Lane, Department of Conservation & Land Management (DCLM), 14 Queen Street, Busselton WA 6280, Australia, (Tel: +61-8-9752-1677; Fax: +61-8-9752-1432; email: jiml@calm.wa.gov.au).

2. Sheet last modified: November 2003.

3. Country: Australia

4. Name of Ramsar site: Lakes Argyle and Kununurra, Western Australia

5. Map of site included? a) hard copy: yes

b) digital (electronic) format: yes

6. Geographical coordinates: Latitude: (approx.) 15 degrees 48'S to 16 degrees 50'S; Longitude: (approx.) 128 degrees 28'E to 129 degrees 00'E.

7. General Location: Lakes Argyle and Kununurra are in the Shire of Wyndham - East Kimberley (local authority) in the State of Western Australia (population ca. 1.95 million in 2003). Lake Kununurra is located in and near the town of Kununurra (population ca. 6000 in 2003). Lake Argyle is immediately upstream.

8. Elevation: Lake Argyle - approximately 95m (Australian Height Datum). Lake Kununurra - approximately 41m AHD.

9. Area: 117 495 ha.

10. Overview: A large system of two man-made reservoirs and associated wetlands that is used extensively by waterbirds, especially during the dry season when up to 200 000 waterbirds have been counted.

11. Ramsar Criteria: 2, 3, 4, 5,

12. Justification of criteria under point 11: 2: The Site supports a large population of the vulnerable Freshwater Crocodile *Crocodylus johnstoni*,

which is specially protected by the Western Australian Wildlife Conservation Act (1950) and the Commonwealth of Australia's Environment Protection and Biodiversity Conservation Act (1999).

3: At least 15 species of freshwater fishes (mainly catfishes, grunters and gudgeons) are known to occur at the Site, while four fishes (two catfish *Arius* spp., Strawman Quirichthys *stramineus*, and Giant Glassfish *Parabassia gulliveri*) are known in Western Australia only from the Site and other parts of the Ord River System. Three species of freshwater turtle are known from the Site and one of these, *Emydura australis*, is restricted to the Kimberley - Victoria River region.

4: Lakes Argyle and Kununurra are important dry-season refuges for waterbirds.

5: The Site regularly supports very large numbers of waterbirds. In August 1986, Lake Argyle supported more than 180,000 while in September 1978, 12,000 were recorded using Lake Kununurra.

13a. Biogeographic region: Victoria Bonaparte.

13b. Biogeographic regionalisation scheme: Environment Australia 2000. Revision of the Interim Biogeographic Regionalisation of Australia (IBRA) and the Development of Version 5.1. Summary Report. Department of Environment and Heritage, Canberra.

14. Physical Features: Lakes Argyle and Kununurra were formed by damming of the Ord River in 1963 (Lake Kununurra) and 1972 (Lake Argyle). Many of the associated wetlands which are connected to the lakes were seasonally inundated prior to the damming, however they are now permanent. When full, Lake Kununurra is approximately 25 m deep over the former river channel, with water levels exceeding 1 m in much of the swamp area. Lake Argyle is up to 50m deep over the river channel and large areas in the west exceed 5m while large areas in the south-east are less than 0.5m deep. Prior to 1995, Lake Argyle's water level occasionally fell below the spillway level e.g. briefly in 1979, 1985, 1991-92. In 1995-96, the spillway was raised from 86.7m AHD to 92.2m AHD to accommodate increased water use for hydro-electricity generation. As a result, Lake Argyle retains more nutrients and suspended sediment than previously, because the volume of surface water flushed from the lake has been substantially reduced. The new spillway has a foot valve which releases a small flow down spillway creek when the lake is below the overflow height (LeProvost Dames and Moore 1999).

Water levels in Lake Argyle have an annual fluctuation of about 4 metres. In the past, the water level in Lake Kununurra was lowered for about two

weeks once or twice per year to drain the fringing swamps and thereby control weed growth. However, since the mid 1980s, water levels have been kept relatively constant to meet the needs of tour operators and rural landowners at Packsaddle. Water is fresh throughout the system. Large fluctuation in water levels has prevented the establishment of much vegetation on most of the shore of Lake Argyle, although in some sections dense belts of trees have grown. Many aquatic plants grow in shallow water at the edge of the lake. There are dead trees throughout the wetland system as a result of trees which previously grew in seasonally-inundated or dry areas now being permanently flooded. Because water levels have been stable in Lake Kununurra and the wetlands associated with it since the mid 1980s, they have well developed fringing vegetation consisting of grassland, Typha and other "rushes", or woodland. Savannah woodland grows around the wetland complex.

15. Catchment Area: The Site experiences a dry tropical climate with Kununurra having an average annual rainfall of 779mm per year. Rainfall is monsoonal and is usually restricted to a hot, humid wet season from November to March and, typical of dry-tropics, variability in rainfall between years is pronounced. The dry season is characterised by warm, dry days with periods of steady south-easterly winds. Average maximum temperatures range from 38 degrees C in December to 30 degrees C in July.

16. Hydrological Values: The Site consists of dammed waterbodies which provide water supply to the Ord River Irrigation Area and the Argyle Diamond Mine (Lake Argyle).

17. Wetland Type: O, M, 6

18. Ecological Features: Lakes Argyle and Kununurra are most important as dry-season refuges although 18 species have been recorded breeding in the Lake Kununurra wetlands. Very large numbers of waterbirds occur in the system, which regularly supports more than 20 000 waterbirds. Lake Kununurra and surrounding wetlands contained about 12 000 waterbirds in September 1978 and October 1979 and about 7 000 in November 1980. Lake Argyle contains some of the largest aggregations of waterbirds in northern Australia; 181 400 were counted in August 1986. Records for abundant species include:

Glossy Ibis *Plegadis falcinellus* 6 000 Aug 1979

Magpie Goose *Anseranas semipalmata* 10 500 Aug 1986

Wandering Whistling-Duck *Dendrocygna arcuata* 11 000 Aug 1986

Plumed Whistling-Duck *D. eytoni* 4 300 Jul 1981

Pacific Black Duck *Anas superciliosa* 16 000 Nov 1979

Grey Teal *A. gracilis* 17 200 Aug 1986

Pink-eared Duck *Malacorhynchus membranaceus* 1 800 Sep 1980

Hardhead *Aythya australis* 51 400 Aug 1986

Green Pygmy-goose *Nettapus pulchellus* 1 524 Aug 1986

## Eurasian Coot *Fulica atra* 50 756 Aug 1986

The two lakes are the stronghold of the Comb-crested Jacana *Irediparra gallinacea* in Western Australia; 120 were counted along a small section of the shore of Lake Kununurra in May 1986, while 296 were recorded on aquatic plant mats in Lake Argyle in August 1986.

At least 15 species of freshwater fishes (mainly catfishes, grunters and gudgeons) are known to occur at the Site. The Archerfish *Toxotes chatareus* is abundant, while four fishes (two catfish *Arius* spp., Strawman *Quirichthys stramineus*, Giant Glassfish *Parambassis gulliveri*) are known in Western Australia only from the Site and other parts of the Ord River System. The widespread freshwater crayfish *Macrobrachium rosenbergii* ('Cherrabun') also occurs at the Site. Three species of freshwater turtle are known from the Site, one of these, *Emydura australis*, is restricted to the Kimberley - Victoria River region.

Some of the wetlands associated with the lakes support lush growth of aquatic plants, including *Nymphoides indica*, *Nymphaea gigantea*, *Najas graminea*, *Hydrilla verticillata*, *Potamogeton tricarinatus*, *Myriophyllum verrucosum*, *Vallisneria spiralis* and *Chara* sp. The main "rushes" are *Typha domingensis* and *Eleocharis* spp. Tree species growing on the shores of the lakes and wetlands are *Melaleuca viridiflora*, *Eucalyptus microtheca*, *E. camaldulensis*, *Nauclea orientalis*, *Sesbania formosa* and *Lophostemon grandiflorus*. The main species in the fringing grassland are *Eriachne sulcata*, *Echinochloa kimberleyensis*, *Oryza australiensis* and a large number of ephemeral herbs. The savannah woodland is dominated by *Eucalyptus* spp. and *Bauhinia cunninghamii*.

19. Noteworthy Flora: There are no nationally rare or threatened species known at the Site. Several endemic species of herbs have been found on the periphery of the Lakes, particularly the seasonal wetlands.

Several exotic plants have become established at the Site including: *Leucaena leucaena leucocephala*, Date Palm *Phoenix dactylifera*, Rubber Tree *Calotropis procera* and *Parkinsonia aculeata* at Lake Kununurra; and *Parkinsonia*, Rubber Tree and Bellyache Bush *Jatropha gossypifolia* at Lake Argyle.

20. Noteworthy Fauna: The Site supports large numbers of the vulnerable Freshwater Crocodile *Crocodylus johnstoni* which is specially protected by State and Federal legislation, and is a major breeding area for this species. Breeding occurs predominantly in the upstream (southern) end of Lake Kununurra where soft, sandy substrates for nest excavation occur alongside the river. From surveys conducted in 1988, 1989 and 1994, the

population of Lake Kununurra has been estimated to number 3000 - 5000 individuals. Estimates of the non-hatchling population of Freshwater Crocodiles in Lake Argyle have varied from 6,000-12,000 to 25,000 individuals; it is probably the largest population of this species in the world at one wetland.

Lake Argyle supports the highest number of the specially protected Radjah Shelduck Tadorna radjah counted in Western Australia (900 in May 1980).

The native Water Rat *Hydromys chrysogaster* also occurs at the site.

21. Social and Cultural Values: Principal social values include water supply (for irrigation, domestic and commercial use) and both commercial and recreational fishing. The Lakes ensure a constant water supply to the Ord River Irrigation Area and water discharged at the base of the dam wall is used to generate electricity for the Argyle Diamond Mine and the towns of Kununurra and Wyndham. Plans for piping lake water to southern Australia have been promoted by some, but have not been adopted by Government due to the relatively high cost. The large population of Silver Cobbler *Arius midgleyi* in Lake Argyle supports a commercial fishery, with the annual potential catch of fish, including unmarketable species, being c. 4000 tonnes. The largest of these catfish are c. 20 kg. The crocodile industry has been issued permits to remove saltwater crocodiles and their eggs to stock farms. A pilot Barramundi *Lates calcarifer* aquaculture industry producing up to 100 tonnes per year in penned cages is based at Bamboo Cove in Lake Argyle (LeProvost Dames and Moore 1999). The Western Australian Department of Fisheries has initiated plans to develop an intensive Barramundi aquaculture industry in Lake Argyle capable of producing up to 2000 tonnes annually (LeProvost Dames and Moore 1999). Tourism is a substantial and growing use. All of these values are consistent with the maintenance of current ecological values. Lakes Argyle and Kununurra are within the traditional lands of the Miriuwung and Gajerrong language groups. Past and present cultural significance of the Ord River to the traditional owners is evidenced by the Miriuwung and Gajerrong Native Title claim and hearings, currently before the Federal Court of Australia. Indigenous people have a complex and spiritual tie to the land and waters of the Ord River, and there are numerous significant cultural heritage sites associated with the river that are protected by the Western Australian Aboriginal Heritage Act (1972) (Lane 2003).

22. Land tenure/ownership: (a) within the Ramsar site: Lake Argyle, Lake Kununurra and wetlands directly connected to them have been proposed as reserves for the purpose of water management, except in the case of the Packsaddle Swamps (and the seasonal wetlands south of them) which will also be reserved for nature conservation. All reserves except that

containing Packsaddle Swamps and seasonal wetlands to the south will be vested in the Water Corporation of Western Australia; the latter reserve will be jointly vested in the Water Corporation and the Conservation Commission of Western Australia. The reserves will be managed by the Water Corporation or the Water Corporation and the Department of Conservation & Land Management, according to vesting. The site is within a large area of the eastern Kimberley which is subject to a Native Title claim by the Miriung and Gajerrong people (LeProvost Dames and Moore 1999). This claim is awaiting determination by the Federal Court of Australia and outcomes are expected by 2005. (b) in the surrounding area: The surrounding area includes freehold agricultural land and pastoral leases for rangeland grazing. The surrounding area is subject to Native Title claims by a number of Aboriginal groups including the Miriung and Gajerrong people.

23. Current land use: (a) within the Ramsar site: The lakes provide water for the Ord River Irrigation Area and for hydro-electricity generation for Argyle Diamond Mine and the towns of Kununurra and Wyndham, and their levels are managed for this purpose. Lake Kununurra and associated wetlands have a constant level while that in Lake Argyle (the primary water source) fluctuates according to the balance between rainfall, evaporation and requirements for irrigation. There is recreational boating and a professional and amateur fishery in the lakes, which are increasingly being used for tourism. A float 'plane is based on Lake Kununurra and there are boat tours of both lakes. Approval has been granted to operate ten houseboats on Lake Kununurra (Watkins et al. 1997). Diamond mining currently occurs within the wetland boundary (Bow River Project) and there are other tenements around the southern part of Lake Argyle and between the dam wall of Lake Argyle and Kununurra. Argyle Diamond Mine draws water from the lake near Smoke Creek. (b) in the surroundings/catchment: The surrounding areas are used for irrigated agriculture and horticulture, cattle grazing and diamond mining.

24. Factors adversely affecting ecological character (past, present, potential): (a) within the Ramsar site: The Ord River Irrigation Area Stage 2 (ORIA Stage 2 - the M2 Channel) expansion proposal is currently undergoing feasibility studies. If implemented, it will draw water from Kununurra Dam to irrigate a further 30 500 ha of agricultural land in close proximity to the site (Wesfarmers Sugar Company et al 2000; EPA 2000, 2001).

To balance the environmental flow requirements of the Ord River with the water requirements of the ORIA (Stage 1 and 2) and other commercial users in the area (notably diamond mines), the Department of Environment (formerly the Water and Rivers Commission) is currently determining water



allocations for the river (Water and Rivers Commission 1999a; EPA 1999; Doupe and Pettit 2002, Trayler et al. 2002, Water and Rivers Commission, 2003).

Past (including recent past) management of water levels has proved beneficial to waterbirds. However, it has created a eutrophic system in the wetlands which will probably result in continuing changes in floral composition, some of which may be undesirable. Some active management of the vegetation may be necessary in the future.

When Argyle Dam was originally designed, it was estimated that the average sediment load for the Ord River was 24 Mt per year. Survey work suggests that approximately 380 Mm<sup>3</sup> of sediment was deposited in Lake Argyle in the 16 years following construction of the dam, which represents a sediment transport rate of 24 Mt per year, as predicted (Water and Rivers Commission 1999b). After 23 years, the storage volume in the reservoir below the spillway level was been reduced by 3.3% (Water and Rivers Commission 1999b). Recent studies of severe gully erosion in the upper Ord River catchment have revealed that the area is characterised by very high natural erosion rates, and that gully erosion was a predominant feature of the catchment prior to European settlement, contrary to previous beliefs (Callow 2001; Sandercock 2003). These studies suggest that the revegetation strategy, including declaration of the Ord River Regeneration Area (see item 25) which was adopted to reduce erosion in the catchment, might not substantially reduce the rate of sedimentation in Lake Argyle.

It has been suggested that cultured Barramundi *Lates calcarifer* escaping from fish farms in Lake Argyle could threaten the genetic integrity of the wild population present in the site by interbreeding (Doupe and Lymbery 1999). Tighter controls are needed to minimise escapes from fish farms. Introduced Red Claw, which are also abundant in Lake Argyle, may compete with native species of crustaceans. Cane Toads *Bufo marinus* invading the Northern Territory and (potentially) Western Australia may also have a substantial impact on native wildlife.

(b) in the surrounding area: Exploration and mining for diamonds will continue, subject to appropriate environmental constraints that are consistent with maintenance of the ecological character of the Site.  
25. Conservation measures taken: Some upstream pastoral leases have been relinquished to form the Ord River Regeneration Area to allow regeneration of vegetation in the upper catchment in the expectation that this would assist in reducing severe catchment erosion resulting in siltation of Lake Argyle. The Lakes are listed on the Register of the National Estate.

26. Conservation measures proposed: The proposed Carr Boyd National Park abuts Lake Argyle.

27. Current scientific research and facilities: The impact of damming on the fluvial geomorphology of the lower Ord River, and the rapid siltation of the Ord River Estuary has recently been studied (Warman 1999; Wolanski et al. 2001). Other studies have focussed on the causes and nature of river channel changes and gully erosion in the upper Ord River catchment (Callow 2001; Sandercock 2003). The hydrology of the Ord River and Lakes Argyle and Kununurra, including water quality, water availability, and current and future water demands has been investigated (Water and Rivers Commission 1999b). To assist in the assessment of the expansion of the ORIA, the Water and Rivers Commission undertook a series of studies into the hydrogeological regime of the ORIA including an airborne geophysical survey, installation of monitoring bores, pumping tests, chemical analyses and groundwater modelling (Water and Rivers Commission 2001).

28. Current conservation education: None.

29. Current recreation and tourism: The lakes are used for recreational fishing and boating, charter boat and float plane scenic tours, and birdwatching.

30. Jurisdiction &

31. Management authority: Territorial: State Government of Western Australia. Functional: The Water Corporation of Western Australia, the Department of Environment and the Department of Conservation and Land Management. Management authority: The Lakes are managed by the Water Corporation which controls the supply of water for irrigation. The Department of Environment is responsible for water allocation, water quality aspects and also authorises other uses (tourism, recreation, and irrigation waste water treatment) (Watkins et al. 1997). The Department of Conservation and Land Management is responsible for maintenance of the Site's Ramsar values. There is a local management group, the Ord River Waterways Management Group (ORWMG) comprised of representatives of the Shire of Wyndham - East Kimberley, the Kimberley Regional Economic Aboriginal Corporation, the Department of Environment, the Water Corporation, Ord Land and Water, and the Department of Conservation and Land Management.

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## Appendix 2: GPS points for quadrats and photo reference points

GPS points for quadrats and photo reference points			
Quadrat	Photo Ref Point	Description	GPS Points
Q1.1		on the western edge of the precinct, accessed from Packsaddle Road.	15 47 54.14S 128 41 126.1E
Q1.2		east of Q1 directly opposite where Lily Creek enters Lake Kununurra. This site was accessed by boat.	15 48 8.06 128 46 51.88E
Q2.1	Yes	to the west of Swim Beach	15 47 32.48S 128 41 57.68E
Q2.2		central to the precinct and on the northern side of the levee bank road.	15 47 27.51S 128 42 17.27E
Q3.1		to the north of the levee bank road opposite Cumbungi Inlet,	15 47 25.47S 128 42 48.54E
Q3.2		to the north of the Kona access road opposite the caravan park.	15 47 26.04S 128 43 16.69E
Q4.1	Yes	south of the Kona access road at the interface of the P1 PDWSA and Kona Inlet Conservation Area.	15 47 23.04S 128 43 20.85E
Q4.2	Yes	on the western edge of Lily Creek Lagoon.	15 47 24.58S 128 44 2.58E
Q5.1		located in the south east of the precinct off the Old Darwin Road adjacent to Hamilton inlet.	15 47 46.49S 128 44 28.66E
Q5.2	Yes	located in the north east corner on the banks of Lily Lagoon adjacent Casuarina Drive, Lakeside.	15 47 24.68S 128 44 40.94E
Q6.1	Yes	adjacent to the T Junction of Messmate Way and the Victoria Highway on the edge of Lily Lagoon heading back into Lily Creek.	15 46 47.67S 128 44 32.16E
Q6.2	Yes	south of the Pump House between Casuarina Drive and Lily Lagoon.	15 47 4.79S 128 44 33.66E

## Appendix 3: Vegetation condition tables for each land management unit (LMU)

### Vegetation Condition Tables

The following tables summarise the condition of the vegetation in each LMU. The overall vegetation condition is dependent upon the levels of disturbance, weed cover and vegetation structure for each of the LMU. This information was used to prioritise recommended management actions for each LMU. These ratings will be used in the future to indicate whether vegetation condition in each LMU has improved or degraded further.

#### Vegetation condition in LMU 1

	Conservation VMU	Riparian VMU
<b>Vegetation condition</b>	Fair – Good	Good – Very Good
<b>Vegetation structure</b>	Modified, some weed species expected to become dominant.	Intact
<b>% weed cover</b>	20%	5%
<b>Disturbance</b>	Vehicle and walking tracks evident.	Minimal signs of disturbance
<b>Dominant indigenous species</b>	Cajuput ( <i>Melaleuca leucadendra</i> ) Water couch grass ( <i>Cynodon dactylon</i> ) Dragon tree ( <i>Sesbania formosa</i> )	Cumbungi ( <i>Typha domingensis</i> ) <i>Ipomoea aquatica</i> Dragon tree ( <i>Sesbania formosa</i> ) Pandanus ( <i>Pandanus sp</i> )
<b>Dominant weed species</b>	Wild passionfruit ( <i>Passiflora foetida</i> ) Rain tree ( <i>Albizia lebbek</i> ) Neem ( <i>Azadirachta indica</i> )	Wild passionfruit ( <i>Passiflora foetida</i> )

#### Vegetation condition of LMU 2

	Conservation VMU	Parkland VMU	Riparian VMU
<b>Vegetation condition</b>	Fair – Good	Poor	Poor
<b>Vegetation structure</b>	Modified, many weed species appear to have spread along levee bank track	Heavily modified, many weed species already dominant	Heavily modified, weed species out competing riparian vegetation
<b>% weed cover</b>	20-40%.	50-60%.	20-50%
<b>Disturbance</b>	Obvious vehicle and walking tracks, rubbish and fire	High disturbance due to recreational use, many walking tracks, some vehicle tracks, rubbish and fire	High disturbance due to recreational use and access to the water
<b>Dominant indigenous species</b>	River red gum ( <i>Eucalyptus camaldulensis</i> ) Eucalyptus sp (1) Dragon tree ( <i>Sesbania formosa</i> ) Pandanus ( <i>Pandanus sp</i> ) Cajuput ( <i>Melaleuca leucadendra</i> ) <i>Ipomea aquatica</i>	River red gum ( <i>E. camaldulensis</i> ) Cajuput ( <i>M. leucadendra</i> ), Water couch grass ( <i>Cynodon dactylon</i> ), Green plum ( <i>T. platyphylla</i> ) Dragon tree ( <i>S. formosa</i> ),	Dragon tree ( <i>S. formosa</i> ), Pandanus ( <i>Pandanus sp</i> ), Cumbungi ( <i>T. domingensis</i> )

	Green plum ( <i>Terminalia platyphylla</i> )		
<b>Dominant weed species</b>	Wild passionfruit ( <i>Passiflora foetida</i> ) Rain tree ( <i>Albizia lebeck</i> ) Mesquite ( <i>Prosopis sp</i> ) Coffee Bush ( <i>Leuceana leucocephala</i> ) Giant rubber bush ( <i>Calatropis gigantea</i> ) Convulvulus creeper ( <i>Merremia dissecta</i> ) Neem ( <i>Azadirachta indica</i> ).	Wild passionfruit ( <i>P. foetida</i> ) Rain tree ( <i>A. lebeck</i> ) Grass sp (1) Coffee Bush ( <i>Leucaena leucocephala</i> ) <i>Sorghum alum</i> <i>Clitoria sp.</i> Giant Rubber Bush ( <i>C. gigantea</i> ) Convulvulus creeper ( <i>M. dissecta</i> ) Neem ( <i>A. indica</i> )	Coffee Bush ( <i>Leuceana leucocephala</i> ) Convulvulus creeper ( <i>Merremia dissecta</i> ) Wild passionfruit ( <i>Passiflora foetida</i> )

### Vegetation condition of LMU 3

Issue	Conservation	Parkland	Riparian
Vegetation condition	Fair – Good	Poor	Fair - Good
Vegetation structure	Modified, many weed species appear to have spread along levee bank track	Heavily Modified, many weed species present	Modified due to tourism use otherwise fairly intact
% weed cover	20-40%	50-60%.	10-20%
Disturbance	Obvious vehicle and walking tracks, rubbish and fire	Landscape heavily modified	Medium levels of disturbance at caravan park otherwise only minor signs of disturbance
Dominant indigenous species	River red gum ( <i>Eucalyptus camaldulensis</i> ) Eucalyptus sp (1) Dragon tree ( <i>Sesbania formosa</i> ) Pandanus ( <i>Pandanus sp</i> ) Cajuput ( <i>Melaleuca leucadendra</i> ) Green plum ( <i>Terminalia platyphylla</i> )	River red gum ( <i>E. camaldulensis</i> ) Eucalyptus sp (1) Cumbungi ( <i>T. domingensis</i> ,) Dragon tree ( <i>S. formosa</i> ) Pandanus ( <i>Pandanus sp</i> ) Cajuput ( <i>M. leucadendra</i> ) Green plum ( <i>T. platyphylla</i> )	Cumbungi ( <i>Typha domingensis</i> ) Pandanus ( <i>Pandanus sp</i> ) Green plum ( <i>Terminalia platyphylla</i> ) <i>Ipomea aquatica</i> Dragon tree ( <i>Sesbania formosa</i> )
Dominant weed species	Wild passionfruit ( <i>Passiflora foetida</i> ) Rain tree ( <i>Albizia lebeck</i> ) Mesquite ( <i>Prosopis sp</i> ) Coffee Bush ( <i>Leuceana leucocephala</i> ) Giant rubber bush ( <i>Calatropis gigantea</i> ) Convulvulus creeper ( <i>Merremia dissecta</i> ) Neem ( <i>Azadirachta indica</i> )	Wild passionfruit ( <i>P. foetida</i> ) Rain tree ( <i>A. lebeck</i> ) Coffee Bush ( <i>Leucaena leucocephala</i> ) Giant rubber bush ( <i>C. gigantea</i> ) Convulvulus creeper ( <i>M. dissecta</i> ) Neem ( <i>A. indica</i> )	Coffee Bush ( <i>Leucaena leucocephala</i> ) Rain tree ( <i>A. lebeck</i> ) Convulvulus creeper ( <i>M. dissecta</i> )



### Vegetation condition of LMU 4

Issue	Conservation	Parkland	Riparian
Vegetation condition	Fair – Good	Poor	Fair
Vegetation structure	Modified, many weed species prevalent	Heavily Modified, many weed species present	Modified, <i>Leucaena</i> Sp dominant
% weed cover	20%	50-60%.	40%
Disturbance	Obvious tracks, rubbish and fire	Landscape heavily modified	Minor disturbance except for Kimberley Land where riparian vegetation has been cleared for access and views.
Dominant indigenous species	River red gum ( <i>Eucalyptus camaldulensis</i> ) Eucalyptus sp (1) Eucalyptus sp (2) Dragon tree ( <i>Sesbania formosa</i> ) Pandanus ( <i>Pandanus</i> sp) Cajuput ( <i>Melaleuca leucadendra</i> ) Green plum ( <i>Terminalia platyphylla</i> ) Bauhinia ( <i>Bauhinia cunninghamii</i> ,)	River red gum ( <i>E. camaldulensis</i> ) Eucalyptus sp (2) Dragon tree ( <i>S. formosa</i> ) Pandanus ( <i>Pandanus</i> sp) Cajuput ( <i>M. leucadendra</i> ) Green plum ( <i>T. platyphylla</i> ) Cumbungi ( <i>T. domingensis</i> ,)	Cumbungi ( <i>T. domingensis</i> ,) Green plum ( <i>T. platyphylla</i> ) Dragon tree ( <i>S. formosa</i> ) Cumbungi ( <i>Typha domingensis</i> ) Pandanus ( <i>Pandanus</i> sp)
Dominant weed species	Wild passionfruit ( <i>Passiflora foetida</i> ) Rain tree ( <i>Albizia lebbek</i> ) Coffee Bush ( <i>Leucaena leucocephala</i> ) Giant rubber bush ( <i>Calatropis gigantea</i> ) Convulvulus creeper ( <i>Merremia dissecta</i> ) Neem ( <i>Azadirachta indica</i> )	Wild passionfruit ( <i>P. foetida</i> ) Rain tree ( <i>A. lebbek</i> ) Coffee Bush ( <i>Leucaena leucocephala</i> ) Giant rubber bush ( <i>C. gigantea</i> ) Convulvulus creeper ( <i>M. dissecta</i> ) Neem ( <i>A. indica</i> )	Coffee Bush ( <i>Leucaena leucocephala</i> ) Date Palm Rain tree ( <i>Albizia lebbek</i> )

### Vegetation condition of LMU 5

	Conservation	Riparian
Vegetation condition	Fair – Good	Fair-Good
Vegetation structure	Modified, some weed species expected to become dominant.	Modified, some weed species expected to become dominant.
% weed cover	20%	20%
Disturbance	Some tracks evident and fire	Minimal
Dominant indigenous species	Dragon tree ( <i>Sesbania formosa</i> ) Cajuput ( <i>Melaleuca leucadendra</i> ) Water couch grass ( <i>Cynodon dactylon</i> ) Cane grass ( <i>Sorghum stipoideum</i> )	Cumbungi ( <i>Typha domingensis</i> ) Dragon tree ( <i>Sesbania formosa</i> )
Dominant weed species	Wild passionfruit ( <i>Passiflora foetida</i> ) Rain tree ( <i>Albizia lebbek</i> ) Neem ( <i>Azadirachta indica</i> ) Giant rubber bush ( <i>Calatropis gigantea</i> ) Purpletop Chloris ( <i>Chloris barbata</i> )	Coffee Bush ( <i>Leucaena leucocephala</i> ) Date Palm Rain tree ( <i>Albizia lebbek</i> ) Neem ( <i>Azadirachta indica</i> )

## Vegetation condition of LMU 6

	Riparian	Parkland
<b>Vegetation condition</b>	Poor	Poor
<b>Vegetation structure</b>	Heavily Modified due to recreational use of the foreshore	Heavily Modified, many weed species dominant.
<b>% weed cover</b>	30-40%	50-60%
<b>Disturbance</b>	Urbanised landscape	Urbanised landscape
<b>Dominant indigenous species</b>	Cumbungi ( <i>Typha domingensis</i> ) Dragon tree ( <i>Sesbania formosa</i> )	Cumbungi ( <i>Typha domingensis</i> ) Dragon tree ( <i>Sesbania formosa</i> ) Cajuput ( <i>Melaleuca leucadendra</i> ) Water couch grass ( <i>Cynodon dactylon</i> ) Green plum ( <i>Terminalia platyphylla</i> )
<b>Dominant weed species</b>	Leucaena ( <i>Leucaena leucocephala</i> ) Wild passionfruit ( <i>Passiflora foetida</i> ) Rain tree ( <i>Albizia lebbek</i> )	Wild passionfruit ( <i>Passiflora foetida</i> ) Rain tree ( <i>Albizia lebbek</i> ) Grass sp (1) Leucaena ( <i>Leucaena leucocephala</i> , <i>Sorghum alum</i> ) Convulvulus creeper ( <i>Merremia dissecta</i> )

## Appendix 4: List of plant species identified from fieldwork undertaken between July 2006 and October 2006

### List of Plant Species Identified from Fieldwork Undertaken Between July 2006 and October 2006

#### Trees & Shrubs

<u>Scientific Name</u>	<u>Common Name</u>
Acacia tumida	Pindan wattle
Adansonia hemiglauca	Boab
Barringtonia acutangula	Whitewood
Brachychiton sp.	Kimberley rose
Buchanania obovata	Darlung
Cathormion umbellatum	
Cochlospermum fraseri	Cotton tree
Ehretia saligna	Coonta
Erythrina vespertilio	Bat wing coral tree
Erythrophleum cholorostachys	Cooktown ironwood
Eucalyptus camldulensis	River redgum
Eucalyptus confertifolia	Cabbage gum
Eucalyptus foelscheana	Smooth barked bloodwood
Eucalyptus microtheca	Coolibah
Eucalyptus polycarpa	Longfruit bloodwood
Eucalyptus pruinosa	Silverleaf box
Excocaria parvifolia	Guttapercha tree
Ficus coronulata	River fig
Ficus opposita	Sandpaper fig
Ficus racemosa	Cluster fig
Ficus sp.	Fig
Gyrocarpus americanus	Stinkwood
Leucaena leucocephala	Leucaena
Bauhinia cunninghamii	Jigal
Melaleuca leucadendron	Cajuput
Nauclea coadunata	Leichhardt pine
Owenia vernicosa	Emu apple
Pandanus spp	Screw pine
Parkinsonia aculeata	Parkinsonia
Petalostigma pubescens	Quinine tree
Sesbania formosa	Swamp cork wood
Terminalia platphylla	Wild plum
Tristania grandiflora	
Acacia farnesiana	Mimosa bush
Acacia nilotica	
Acacia translucens	
Aerva javanica	Kapok bush
Calotropis procera	Rubber Bush
Carissa lanceolata	Konkerberry
Grewia retusifolia	Donkeyberry
Securinega melathesoides	Dogwood
Sesbania cannabina var. cannabina	Sesbania Pea
Sesbania cannabina var. sericea	

## Emergent Riparian Vegetation: Sedges /Rushes

Cyperus albomarginatus	
Cyperus difformis	Dirty dora
Cyperus holoschoenus	
Cyperus marcostachyos	
Cyperus polystachyos	Bunchy sedge
Cyperus vaginatus	Stiffleaf sedge
Eleocharis atropurpurea	
Eleocharis brassii	Spike rush
Eleocharis phillippinensis	
Eleocharis sphacelata	Tall spike rush
Eleocharis spiralis	
Fimbristylis bisumbellata	
Fimbristylis dichotoma	
Fimbristylis littoralis	
Phragmites sp.	
Scirpus laevis	
Typha domingensis	Cumbungi

## Grasses

Cenchrus setiger	Birdwood grass
Chloris barbata	Purpletop chloris
Cynodon dactylon	Couch
Dichanthium annulatum	Sheda grass
Dichanthium fecundum	Curly bluegrass
Diplachne parviflora	Silvertop
Echinochloa colonum	Barnyard grass
Eragrostis spp.	
Eriachne sulcata	
Heteropogon contortus	Black speargrass
Leptochloa neesii	
oryza rufipogon	Wild rice
Panicum cymbiforme	
Sorghum alnum	Columbus grass
sorghum stipoideum	Annual native sorghum
Sorghum kimberleyensis	

## Forbs

Aeschynomene indica	Budda pea
Alternanthera denticulata	Lesser joyweed
Alternanthera nana	Hairy joyweed
Alternanthera repens	Khaki weed
Atylosia mammosa	
Boerhavia diffusa	Tarvine
Cleome viscosa	Tickweed
Crotolaria retusa	Wedgeleaf rattlepod
Crotolaria trifoliastrium	Trefoil rattlepod
Ipomoea aquatica	Potato vine
Ludwigia octovalvis	Willow primrose

*Ludwigia perennis*  
*Macrotillium atropurpureum*  
*Macrotillium lathyroides*  
*Monochoria cyanea*  
*Passiflora foetida*  
*Polygonum attenuatum*  
*Polygonum orientale*  
*Pterigeron odorus*  
*Sida acuta*  
*Sphenoclea zeylanica*  
*Tinospora smilacina*  
*Trianthema portulacastrum*  
*Waltheria indica*

Purple bean  
Phasey bean  
Wild Passionfruit  
Smartweed  
Prince's Feather  
Smelly bush  
Spinyhead sida  
Goonda  
Strangle vine  
Giant pigweed

## Submerged or Surface Aquatics: Waterplants

*Aponogeton elongatus*  
*Hydrilla verticillata*  
*Myriophyllum verrucosum*  
*Najas graminea*  
*Nymphaea gigantea*  
*Nymphaea indica*  
*Potamogeton tricarlinatus*  
*Vallisneria spiralis*

Hydrilla  
Milfoil  
Naiad  
Giant waterlily  
Water snowflake  
Floating pondweed  
Ribbon weed

## Ferns

*Marsilea* spp

Nardoo

## Appendix 5: DEC flora and fauna searches

21/08/2007

**DEPARTMENT OF CONSERVATION AND LAND MANAGEMENT  
DECLARED RARE AND PRIORITY FLORA LIST  
21 December 2006**

Page 1

SPECIES / TAXON	CONS CODE	CALM REGION	DISTRIBUTION	FLOWER PERIOD
<i>Acacia richardsii</i>	3	K,*	Kununurra, Keep River N.P., Northern Carr Boyd Ranges, Gardner Plateau, N.T.	Mar-Aug
<i>Brachychiton tuberculatus</i>	3	K	Ord River, Kununurra	Aug-Nov
<i>Desmodium flagellare</i>	1	K	Kununurra, Ord River Basin	
<i>Eucalyptus ordiana</i>	2	K	Kununurra	Jan,Jun,Jul
<i>Ficus lilliputiana</i>	4	K,*	Ord River, Lake Argyle, Hidden Valley, Kununurra, Northern Territory	Apr-Oct
<i>Fuirena nudiflora</i>	1	GLD,K,*	Rawlinson Range, Kununurra, NT, Qld	Jun
<i>Goodenia durackiana</i>	1	K	Ord River, Kununurra	Mar
<i>Goodenia strangfordii</i>	1	K	Kununurra, Sturt Creek	Sep
<i>Platysace saxatilis</i>	2	K*	Hidden Valley, Kununurra, NT	Mar-May,Sep
<i>Stylidium prophyllum</i>	3	K	Mt Hart Stn, Beverley Springs Stn, Kununurra	May-Jun
<i>Typhonium</i> sp. Kununurra (AN Start 1467)	1	K	Kununurra	

15.3339 °S 128.2462 °E / 16.2557 °S 129.0864 °E Lily Creek Lagoon &amp; Lake Kun. (plus ~50km buffer)

\* *Date* *Certainty* *Seen* *Location Name* *Method***Schedule 1 - Fauna that is rare or is likely to become extinct*****Rhinonictoris aurantius* Orange Leaf-nosed Bat 7 records**

This species of bat occurs in a few scattered locations in the Pilbara, as well as the Kimberley. It roosts in caves and is sensitive to human disturbance.

Date	Certainty	Seen	Location Name	Method
1964	1			
1964	1	1	Kununurra	
1964	1	1	Ivanhoe	
1965	1	1	Kununurra	
1980	1	1	Kununurra	
1999	1	1		Caught or trapped
2006	1	1	Kununurra	Caught or trapped

***Erythroriorchus radiatus* Red Goshawk 2 records**

A rare inhabitant of well-wooded country, this species nests in large trees and preys largely on birds but also on reptiles and mammals.

Date	Certainty	Seen	Location Name
1956	1		Ivanhoe
1992	2	1	Lake Argyle

***Rostratula benghalensis australis* Australian Painted Snipe 6 records**

A rare summer visitor to the watered areas of the north-west and swamps on the Swan Coastal Plain.

Date	Certainty	Seen	Location Name	Method
1986	1	2	Wyndham	Day sighting
1986	1	0	Wyndham	Feathers
1991	1	3	Saw Ranges	Day sighting
1995	1	2	Wyndam	Day sighting
1995	1	5	Wyndam	Day sighting
1996	1	1	Kingston Rest	Day sighting

***Erythrura gouldiae* Gouldian Finch 5 records**

This species of finch inhabits savanna woodlands around permanent waters and has declined dramatically across its range.

Date	Certainty	Seen	Location Name	Method
1955	1		Ivanhoe	Day sighting
1993	1		Kununurra	
1993	1	100		Day sighting
1996	1	6	Saw Ranges	Day sighting
1998	1	1	Lake Argyle	Day sighting

***Falcunculus frontatus whitei* Crested Shrike-tit (northern subsp) 2 records**

This species is a rare inhabitant of woodlands.

Date	Certainty	Seen	Location Name
1955	1		Ord River
1956	1		Ivanhoe

***Cristilabrum isolatum* Cristilabrum isolatum 6 records**

Date	Certainty	Seen	Location Name	Method
1980	1	0	Ningbing Ranges	Caught or trapped
1980	1	0	Ningbing Ranges	Caught or trapped
1984	1	0	Ningbing Ranges	Caught or trapped

15.3339 °S 128.2462 °E / 16.2557 °S 129.0864 °E Lily Creek Lagoon &amp; Lake Kun. (plus ~50km buffer)

* Date	Certainty	Seen	Location Name	Method
1984	1	0	Ningbing Ranges	Caught or trapped
1986	1		Limestone Mill	Caught or trapped
1986	1		Limestone Mill	Caught or trapped

<i>Cristilabrum spectaculum</i>	<b>Cristilabrum spectaculum</b>	9 records
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1980	1	0	Ningbing Ranges	Caught or trapped
1980	1	0	Ningbing Ranges	Caught or trapped
1980	1	0	Ningbing Ranges	Caught or trapped
1980	1	0	Ningbing Ranges	Caught or trapped
1984	1		Jeremiah Hills	Caught or trapped
1984	1		Jeremiah Hills	Caught or trapped
1986	1		Jermiah Hills	Caught or trapped
1995	1	0	Ningbing Ranges	Caught or trapped
1996	1	0	Ningbing Ranges	Caught or trapped

<i>Ordtrachia elegans</i>	<b>Ordtrachia elegans</b>	1 records
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1988	1		Point Spring	Caught or trapped
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#### Schedule 4 - Other specially protected fauna

<i>Falco peregrinus</i>	<b>Peregrine Falcon</b>	2 records
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This species is uncommon and prefers areas with rocky ledges, cliffs, watercourses, open woodland or margins with cleared land.

1956	1		Ivanhoe	
1999	1	2	Kingston Rest	Day sighting

<i>Tadorna radjah rufitergum</i>	<b>Burdekin Duck</b>	1 records
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This uncommon species inhabits freshwater lagoons and river pools and occurs along the middle and lower Ord River.

1999	1	400	Kununurra	Day sighting
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#### Priority One: Taxa with few, poorly known populations on threatened lands

<i>Lonchura flaviprymna</i>	<b>Yellow-rumped Mannikin</b>	1 records
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1996	1	44		Day sighting
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#### Priority Four: Taxa in need of monitoring

<i>Macroderma gigas</i>	<b>Ghost Bat</b>	1 records
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This species is Australia's only carnivorous bat and has a patchy distribution across northern Australia. It shelters in caves, mine shafts and deep rock fissures and is sensitive to disturbance.

1999	1	1		Caught or trapped
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<i>Hydromys chrysogaster</i>	<b>Water-rat (Rakali)</b>	7 records
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This species occurs in waterways and wetlands that support its main prey items such as molluscs and crustaceans.

1	1		Kununurra	
1	1		Kununurra	



15.3339 °S 128.2462 °E / 16.2557 °S 129.0864 °E Lily Creek Lagoon & Lake Kun. (plus ~50km buffer)

* Date	Certainty	Seen	Location Name	Method
1982	1	1	Kununurra	
1995	1	1	Kununurra	
2000	1	1	Kununurra	
2000	1	1	Kununurra	
2002	1	1	Kununurra	
<hr/>				
<b><i>Ixobrychus minutus</i></b>		<b>Little Bittern</b>		<b>1 records</b>
This cryptic species inhabits dense reeds and rushes bordering swamps, lakes and watercourses.				
1982	1	7	Lake Kununurra	Day sighting
<hr/>				
<b><i>Ardeotis australis</i></b>		<b>Australian Bustard</b>		<b>2 records</b>
This species is uncommon and may occur in open or lightly wooded grasslands.				
1998	1	81	Kingston Rest	Day sighting
1999	1	20	Kingston Rest	Day sighting
<hr/>				
<b><i>Burhinus grallarius</i></b>		<b>Bush Stonecurlew</b>		<b>2 records</b>
A well camouflaged, ground nesting bird which prefers to 'freeze' rather than fly when disturbed. It inhabits lightly timbered open woodlands.				
1956	1		Ivanhoe	
1999	1		Kingston Rest	Heard
<hr/>				
<b><i>Numenius madagascariensis</i></b>		<b>Eastern Curlew</b>		<b>1 records</b>
This species is a migratory visitor and has been observed on reef flats and sandy beaches along the West Australian coast and in coastal estuaries.				
1956	1		Ivanhoe	
<hr/>				
<b><i>Geophaps smithii smithii</i></b>		<b>Partridge Pigeon (eastern ssp)</b>		<b>1 records</b>
1902	1		Kununurra	
<hr/>				
<b><i>Phaps histrionica</i></b>		<b>Flock Bronzewing</b>		<b>5 records</b>
This species is gregarious and occurs in treeless or sparsely wooded grassy plains within reach of open water.				
1985	1	3	Kununurra	Day sighting
1986	1	200	Wyndham	Day sighting
1986	1	150		Day sighting
1988	1		Wyndham	Day sighting
1988	1	50	Lake Argyle	Day sighting
<hr/>				
<b><i>Heteromunia pectoralis</i></b>		<b>Pictorella Mannikin</b>		<b>1 records</b>
This species of finch occurs in the drier northern tropical grasslands of Australia.				
1996	1		Saw Ranges	Day sighting
<hr/>				
<b><i>Malurus coronatus coronatus</i></b>		<b>Purple-crowned Fairy-wren (western ssp)</b>		<b>1 records</b>
This subspecies is found in riverine habitats but has become very rare in the Kimberley.				
1981	1		Lake Argyle	Day sighting

15.3339 °S 128.2462 °E / 16.2557 °S 129.0864 °E Lily Creek Lagoon & Lake Kun. (plus ~50km buffer)

<i>Date</i>	<i>Certainty</i>	<i>Seen</i>	<i>Location Name</i>	<i>Method</i>
			<b>Star Finch (western)</b>	
			<i>Neochima ruficauda subclarescens</i>	3 records
A nomadic species inhabiting grasslands and eucalypt woodlands near water.				
1996	1		Saw Ranges	Day sighting
1999	1		Kingston Rest	Day sighting
1999	1	100	Kingston Rest	Night sighting

\* Information relating to any records provided for listed species:-

Date: date of recorded observation

Certainty (of correct species identification): 1=Very certain; 2=Moderately certain; and 3=Not sure.

Seen: Number of individuals observed.

Location Name: Name of reserve or nearest locality where observation was made

Method: Method or type of observation

Appendix 6: fire scar map 2006



# Appendix 7: fire scar 2005



Appendix 8: SWEK maintenance program



WET SEASON - FORTNIGHTLY, DRY SEASON - 3 to 4 WEEKLY CYCLE

Appendix 8: SWEK maintenance program



Appendix 8: SWEK vegetation maintenance program



LAKESIDE CARAVAN PARK

LAKESIDE



- LEGEND**
- AREAS TO BE MOWED
  - AREAS TO BE SLASHED
  - AREAS TO BE MAINTAINED BY LEASE HOLDERS

WET SEASON - WEEKLY, DRY SEASON - VARIES

## **Appendix 9: Cumbungi removal options**

### **Cumbungi Removal Options**

Many control techniques for cumbungi exist and include, maintaining water depths of greater than 2 metres, cutting back the actively growing plants regularly below water level, mechanically removing the whole plant and spraying with frog sensitive *Bioactive Roundup*.(Watson, Phil)

It has been reported that reliable control is achieved by any method reducing and maintaining the stature of live and dead cumbungi stems below water levels for a period of one to three years (Apfelbaum, Steven)

As cumbungi is dormant or at the very least at its slowest in growth during the cooler dry months then this presents the best time for control. Therefore with all options discussed below it is recommended these are carried out during the cooler part of the year (June – July) when harvesting or destruction will have the most impact and the cumbungi is less likely to grow back.

Cumbungi quickly becomes a large and vigorous plant, therefore any new infestation should be treated as early as possible. Destroying the young plants at an early growth stage, before they have become established or produce seed, is the most economical and effective method of control. If control is delayed until the infestation is established, eradication in one season is improbable and follow-up work over two or three seasons at least will be required (Department of Primary Industries and Water, 2007)

Continued monitoring of increases in growth of area of cumbungi is recommended, as is research into soil stabilisation/erosion control benefits and nutrient stripping and management benefits.

Sinclair Knight Mertz explored two options for cumbungi management. One was using a combination of mechanical removal, chemical poisoning and subsequent burning and landfilling. This option included the use of trenches and landfill. The second option was through controlled draw down of the water level and the building of another dam, burning of cumbungi and modification of the lagoon's bed profile. This option is not recommended. (see report for more details)

Methods of control that are considered most suitable are discussed below with the preferred option being mechanical harvest from the water.

### **Lowering of Lake and Lagoon**

From past reports and media article it appears that Lake Kununurra was drained annually during the late wet season for approximately 2 weeks as a method to control excess weed growth. This ceased in 1981. (Sinclair Knight Mertz, 1995) yet in 1994 it was again lowered for maintenance works to occur. It was noticed that the lowering of the lake during a low pressure storm event resulted in a noticeable reduction of cumbungi and other aquatic vegetation. The exercise was therefore repeated again in 1995 yet there was opposition to the exercise in particular from government agencies so the exercise ceased.



It was recommended in the Sinclair Knight report that removal of cumbungi be undertaken from Lily Creek by controlled drawdown of the water level and modification to bed profile to prevent any regrowth. However this recommendation included the building of another dam which was highly expensive. (Sinclair Knight Mertz 1995).

There is also a prediction that lowering of the Lake will help with a reduction of weed growth in the M1 channel. (see OIC letter attached). According to Water Corp it would take 2-3 days to lower the lake and the same to refill it when spill way was flowing. It would need to occur when a tropical low was overhead and could be emptied for a period of a week or more.

### **Excavation**

This is the present method of control which has been carried out in specific areas for the past several years. Problems associated with this method of removal include the cost of the equipment and the removal of the material, the disturbance to the bed and banks and the limited reach of machinery.

This method can however be useful at reducing the size of large infestations, allowing easier follow up by manual removal of small plants and regrowth. Mechanical excavation has the advantages that there are neither herbicide residues left in the water nor problems arising from decomposition of dying plant material. It also has the obvious advantage of an immediate visual impact when compared to other methods of management.

### **Hand Removal**

Manual removal works best with small plants. They are often easy to pull out due to the moist soil around their roots. Spades can help when hand removal is difficult. Any manual removal must aim to remove all pieces of the roots and rhizomes, otherwise the plant may quickly regrow (Department of Primary Industries and Water. 2007). This method is good for small infestations of young plants but is not suitable for larger and older infestations.

### **Cutting**

Repeated cutting of all leaves 50-150mm below the water surface can be used effectively to control infestations. This removes the oxygen supply to the lower and underground parts of the plant. A high proportion of plants will die in the first year due to this method. A second year of treatment should finish off any plants which survived the first treatment (Department of Primary Industries and Water. 2007).

The Sinclair Knight Mertz report also claims cutting the plant as close to ground level as possible as the most efficient method. It reports on field trials in Cuba where cutting resulted in less than 5% of the original biomass regrowing after 12 months (Sinclair Knight Mertz. 1995).

Aquatic Weed Harvesters are used in America, Europe and even the Eastern States of Australia to control cumbungi. Harvesters have the ability to cut cumbungi well below water levels. They can also avoid any disturbance to the water bodies bed and banks. The other benefit of a harvester is that it operates from the water and therefore can remove cumbungi stands that are

otherwise unreachable from the waters edge. This also means that a buffer of cumbungi can be left around the waters edge to act as a filter and to protect banks.

Harvesters are expensive to buy and currently there are no suitable aquatic harvesters available in Western Australia to lease. Suitable harvesters are available in the Eastern states yet mobilisation costs would be expensive.

By cutting leaves off below water level during the dormant growth period in the coolest part of the year there is substantial death of the rhizome. This would lead to less growth the following season. However if not re-harvested on a regular basis the literature and discussions with other cumbungi managers suggest that regrowth would eventually return to normal.

There are several different types of weed harvesters depending upon the targeted weed. The cut plants are collected so that organic material is not left to decay. Unlike manual cutting with shears or brush cutters, harvesters will save time and are therefore more economical for large areas

### **Chemical Control**

Where a large area has been invaded environmentally friendly' Glyphosate or other herbicide preparations kill most leaves and are translocated through all parts of the plant, including the deep rhizomes (Department of Primary Industries and Water. 2007). A complete coverage of all foliage is necessary. Correct timing of application is essential. The spray should not be applied before the male flowers have started to open and treatment should not be continued beyond 6 weeks after the female flowers have opened. Follow up applications 4 to 6 weeks after the first spray may be necessary (Department of Primary Industries and Water. 2007).

Plants which have more than about one-third of their stems below water may not be killed by herbicide and the plant will re-shoot so regular application is necessary. Whenever practicable the water level should be lowered to give the maximum possible plant exposure before treatment, and kept down for at least 12 hours after application (Department of Primary Industries and Water. 2007).

If not removed then the mass of decaying vegetation after spraying may affect water quality. Such regular and high amount of spray is not recommended.

### **Fire Control**

This method can be used in conjunction with herbicide applications or on its own provided there are enough dead leaves during the cooler dry months to sustain a fire.

Fire was found to provide little or no control (Nelson and Dietz.1966). Fires that destroyed rhizomes offered control; however, most fires only burned above-ground biomass and did little to control (Apfelbaum, Steven)

This method is only recommended to remove dead material following spraying.

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Community consultation was based on the Lake Kununurra Foreshore Plan 2006. In addition to this the following community members made comment:

- Dick Pasfield – Coordinator for OLW
- Colleen Dupe – Kimberley Seeds
- Louise Williams – Kimberley Community Weed Project Officer

The following departments and organisations were consulted throughout the process and have all provided input and advice into the final document:

- Department of Water;
- Department of Environment and Conservation;
- Water Corporation;
- Department for Planning and Infrastructure; and
- Shire of Wyndham East Kimberley.

## **Acronyms**

DEC	Department of Environment and Conservation
DoFA	Department of Food and Agriculture
DoW	Department of Water
DPI	Department for Planning and Infrastructure
LMU	Land Management Unit
M1	Main Irrigation Channel
MG	Miriuwung Gajerrong people
NAP	National Action Plan for Salinity and Water Quality
OLW	Ord Land and Water
PDWSA	Public Drinking Water Source Area
SEEKS	Save Endangered East Kimberley Species
SWEK	Shire of Wyndham East Kimberley
UCL	Unallocated Crown Land
VMU	Vegetation Management Unit
WRC	Water and Rivers Commission

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## **Definitions**

### **Aquatic vegetation**

Vegetation that is living or growing in water

### **Conservation area**

An area set aside for conservation and preservation purposes due to its high conservation value. In the context of the study area, vegetation exhibiting high conservation value is that which is in good to very good condition (see Table 2).

### **Foreshore**

The ground between the water's edge and cultivated land; land along the edge of a body of water.

### **P1**

Kununurra's public drinking water source area has been classified as a Priority One (P1) area. Land use activities within the PDWSA must be compatible with the WA Planning Commission's *Statement of Planning Policy 2.7 – Public Drinking Water Source Policy 2003* prepared under the *Town Planning and Development Act 1928*.

### **Parkland**

An area used as a park and for recreation. These areas have high amenity value and usually require the highest amount of maintenance.

### **Riparian zone**

The riparian zone, commonly called the river bank, is the interface between land and the water body. The riparian vegetation is the flora growing beside the waters edge.

### **Weeds**

For the purpose of this document weeds are a plant growing out of place. This may be either non-native (exotic) plants or native Australian plants that are not local (indigenous) to the area they are growing in. Plants that invade our natural ecosystems are sometimes known as 'environmental weeds'. A plant may be considered a weed because it:

- competes with or displaces native species;
- affects natural processes e.g. fire intensity, stream flows;
- appears unnatural;
- restricts the recreational movement of people; or
- causes injury to animals or humans.

Many plant species may be useful in some situations but are troublesome weeds when growing where they are not wanted.

## Executive Summary

The purpose of this plan is to identify management actions for aquatic and foreshore vegetation within the study area.

There are several plans and reports for the area of Lily Creek Lagoon and Lake Kununurra (1987, 1995 and 2006). Unfortunately, recommendations from these plans have been implemented sporadically and many of the issues identified as far back as 1987 remain.

The main issues that the vegetation management actions identified in this Plan are seeking to address include:

- weed control (aquatic, riparian and terrestrial) including the management of cumbungi and other flourishing aquatic plants; and
- protection and rehabilitation of riparian and foreshore vegetation.

In addition, this Plan recommends some guiding principles that should be followed when managing vegetation within the study area:

- |             |   |
|-------------|---|
| Principle 1 | Large scale clearing of weed species that are performing environmental functions will be avoided unless a long term weed removal and rehabilitation plan is developed for the area. |
| Principle 2 | Rehabilitation and follow up control on weed removal areas will be provided for in vegetation management programs.  |
| Principle 3 | Clearing of cumbungi will be limited to areas determined for recreation and amenity or areas identified as having experienced large scale increases in cumbungi growth              |
| Principle 4 | Removal of cumbungi will be areas no longer than 100m with areas of no less than 20m long left in between the removed 100m areas.   |
| Principle 5 | If cleared, banks will be replanted with small local native rushes and riparian areas with scattered trees.   |
| Principle 6 | The use of chemicals in and close to the water will be avoided.   |
| Principle 7 | Riparian vegetation and cumbungi around drainage outlets will be retained unless it can be shown to be contributing to upstream flooding.   |

Native vegetation is protected under the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004* and therefore any removal of native vegetation within the study area requires a permit from the Department of Environment and Conservation.

## **1. Introduction**

### **1.1 Purpose**

Weeds, ad hoc development and increased visitor use and access place pressure on the study area and require ongoing management. The development of this Plan arose in response to conflict between the current management of these pressures and community and agency concern over slashing boundaries, weed removal without rehabilitation and unauthorised cumbungi removal.

The purpose of this Plan is to identify management actions for aquatic and foreshore vegetation that meets community expectations, as identified in the Foreshore Plan (2006), for the study area and retains the ecosystem values associated with the waterbody. This also includes clearly identifying the responsibilities, policies, actions and regulations that are in place to ensure effective vegetation management within the study area. The Plan is therefore to provide for the management of vegetation in and around the Lake Kununurra town foreshore and Lily Creek Lagoon that is compliant with all relevant regulatory and planning bodies.

This Plan is intended to be updated as future developments occur, new strategies and techniques arise or as the floristic structure of an area changes.

### **1.2 Overview of study area**

Lily Creek Lagoon and Lake Kununurra are permanent waterbodies formed by the damming of the Ord River. Built in 1963 to supply water to the Ord River Irrigation Area, water levels of Lake Kununurra are regulated and managed primarily for this purpose by the Water Corporation.

Biophysical conditions within the waterbodies include high water temperatures, an intense sunlight regime, high water clarity, relatively high concentrations of total nitrogen and phosphorus and fertile sediments. These conditions are ideal for growth of aquatic plants and the lake, including Lily Creek Lagoon, becomes eutrophic at various times in the year (Watkins *et al*, 1997).

The Lake Kununurra and Lily Creek Lagoon Vegetation Management Plan focuses on the vegetation surrounding and within these water bodies. The study area extends from upstream of the Diversion Dam to the upper reaches of Lily Creek Lagoon bordered by the Victoria Highway to the eastern most edge of Hamilton Inlet (see Figure 1).

The study area is comprised of numerous parcels of Crown land including Reserve 41812, Unallocated Crown Land (UCL), and a number of smaller reserves adjacent to the Lake and Lagoon foreshore; freehold land; the proposed Packsaddle Conservation Area and leases to community and private organisations.

### **1.3 Significance of the wetland**

Lake Kununurra and Lily Creek Lagoon are listed under the Convention on Wetlands of International Importance (Ramsar Convention) – as components of the listing 'Lakes Argyle and Kununurra', Western Australia site no. 32 – and are therefore afforded protection under both State and Commonwealth legislation. The Lake supports habitat for waterbirds, freshwater fish, and the freshwater crocodile and is an important dry season refuge. Twenty-one species of fish are known to occur in Lake Kununurra (Centre for Fish and Fisheries Research, 2000).



Lake Kununurra and Lily Creek Lagoon are used extensively for a variety of industry purposes and recreational activities and the area considered by this plan is central to the character of Kununurra. The waterbody and its environs are highly valued by the community (both residents and visitors alike).

Over the years, in absence of an overarching strategic plan, developments have occurred within the study area. These include several caravan parks, a golf course, boating and yachting facilities, areas for swimming and water-skiing and an amphitheatre (Lake Kununurra Foreshore Committee, 2006).

Water from Lake Kununurra is currently used to irrigate farms under Stage 1 of the Ord Irrigation Scheme with a view to irrigating the planned Stage 2 farms in the future. These allocation arrangements are outlined in the Ord River Water Management Plan (2006).

The water from Lake Kununurra and Lily Creek Lagoon also recharges the bores from which Kununurra's potable water is supplied. The study area includes the well-head protection zone around the bores and a larger P1 classification area designed to ensure the town's water supply is not compromised.

The waterbody and its environs are important to the local Aboriginal people and a number of significant Aboriginal Heritage Sites are located within the study area.

The foreshore and waterway directly supports a thriving tourism industry. People who visit Kununurra often utilise commercial tourism opportunities during their stay. These tourism enterprises, such as caravan parks, tour boat operators and the annual Ord Valley Muster's Kimberley Moon Experience, directly contribute to the local economy and provide local employment

The foreshore and waterbodies are used extensively by residents and visitors for both passive and active recreational pursuits. These include:

- walking;
- bird watching;
- dog exercising;
- picnicking;
- swimming;
- sightseeing;
- boating;
- water-skiing;
- local events;
- sailing;
- fishing; and
- canoeing / kayaking

Balancing these activities and values while maintaining the ecological and amenity values upon which these activities rely is a challenge.

#### **1.4 Legislation and policies**

The study area covers a wide range of land tenures, and many agencies have Acts, Regulations and policies that will guide any vegetation use and management . These include:

- *Land Administration Act 1997;*
- *Country Area Water Supply Act 1947;*
- *Rights in Water and Irrigation Act 1914 (RIWI Act);*
- *Environment Protection and Biodiversity Conservation Act 1999 (Cth);*
- *Aboriginal Heritage Act 1972;*
- *Environmental Protection Act 1986 (EP Act);*
- *Environmental Protection (Clearing of Native Vegetation) Regulations 2004;*
- *Wildlife Conservation Act 1950*
- *Town Planning and Development Act 1928;* and
- *Statement of Planning Policies.*

These acts relate to actions such as clearing of native vegetation, taking of water, flora and/or fauna, disturbance to bed and banks, protection of heritage and aboriginal sites and developments. Consultation with relevant agencies and departments should occur before any new actions or activities take place within the study area.

#### **1.5 Related documents**

In addition to statutory obligations, this plan is guided by the following documents. Each of these documents were prepared with a high level of community consultation and each should be considered in future management of the study area:

- *Ord Land and Water Management Plan (2000);*
- *Lake Kununurra Foreshore Plan (2006);*
- *Kimberley Natural Resource Management Plan (2005);*
- *Rangelands Natural Resource Management Strategy (2006);and*
- *Preparing a Management Plan for the Ord River (2005).*

Consideration of and consistency with these above documents contributes to ensuring that this plan fulfils community expectations.

## **2. Vision and Objectives**

### **Vision**

To manage Lily Creek Lagoon and Lake Kununurra in a manner that satisfies conservation requirements whilst maintaining aesthetic and recreational values.

### **Objectives**

- To maintain the ecological values of Lily Creek Lagoon and Lake Kununurra whilst still enabling the management and maintenance of public open space for recreation purposes.
- To integrate the town development with that of the Lake foreshore and provide appropriate recreational and tourism facilities while avoiding degradation of the Lake's and Lagoon's ecological values.
- To outline a cooperative and coordinated approach to the management of vegetation in and around Lake Kununurra and Lily Creek Lagoon that meets legislative requirements as well as community expectations.
- To conserve the natural, scenic and wildlife resources.
- To protect the foreshore from fire, erosion and general misuse.

### **3. Management Responsibilities and Arrangements** (extract from the Lake Kununurra Foreshore Plan, 2006)

The study area is comprised of several different land tenures including freehold land, Crown land (reserves, unallocated crown land) and private and community lease areas. Each land parcel is managed by a different organisation, according to relevant legislative and policy prescriptions and management objectives.

Management of Reserve 41812 is jointly vested in the Shire of Wyndham East Kimberley and the Water and Rivers Commission (the Department of Water is acting on behalf of the Water and Rivers Commission until such time as the new statutory and management arrangements are in place). This Reserve adjoins the waterfront for the majority of the study area and ranges from 5 metres to 50 metres wide. The Reserve covers most of the riparian zone in the study area.

King Location 715 is UCL and is administered and managed by the Department for Planning and Infrastructure (DPI).

Currently part of the study area overlies Kununurra's drinking water source area (originally proclaimed under the *Country Areas Water Supply Act 1947* in 1970, and subsequently reproclaimed with a substantially reduced area in 2003). The immediate area where the bores are located (Reserve 30211) is vested in the Minister for Water Resources and managed by the Water Corporation for the purpose of water supply. The larger P1 PDWSA comprises UCL, freehold and Crown Reserves and together, the Department of Water (DoW) and the Water Corporation manage activities within the water reserve.

Native title is largely extinguished over the study area. The Ord Final Agreement, reached between the Miriuwung Gajerrong Aboriginal Corporation (Native title holders) and the State of Western Australia, provides for the reservation of Packsaddle Conservation Area, and subsequent joint management by the Department of Environment and Conservation (DEC) and MG Corporation as a co-managed reserve. The Shire is seeking to relocate the current public drinking water source area into this reserve to enable some sustainable land development within the current P1 drinking water source area.

The Plan also covers a number of private landholdings, including three caravan parks with leases over portions of Reserve 41812, and land held in freehold title by the Water Corporation.

Some of the recreational clubs such as the Golf Club and Water-ski Club have formalised leases on Crown Reserves.

All works within the foreshore Reserve 41812 need to be approved by the DoW and the Shire. Works within UCL need the approval of DPI. Any works may need permits such as bed and banks (RIWI Act) or native vegetation clearing (EP Act).

Appendix 2 provides a map of the land tenures within the study area and Section 5.8 outlines the current vegetation management arrangements in place.

## 4. Potential Threats

Threats to the maintenance of the ecological, social, economic and cultural values of the lake include:

- fire;
- ad hoc development;
- weeds; in particular *Salvinia molesta* (salvinia) and *Leucaena leucocephala* (leucaena);
- increased visitor use and access including increases in power boat activities;
- unmanaged visitor use and access;
- stormwater runoff;
- feral animals;
- use of pesticides and herbicides near the waterbody;
- unauthorised clearing;
- Cumbungi (*Typha domingensis*) and other aquatic vegetation that has become weedy, resulting in the loss of wading habitat, reduced biodiversity or reduced access;
- absence of a statutory Ramsar Management Plan; and
- lack of resource allocation from land managers;

## 5. The Planning Framework

### 5.1 Land Management Units

In order to link this report with the Lake Kununurra Foreshore Plan, the six precincts used in the LKFP are replicated here as Land Management Units (LMUs) (see Figure 1).

### 5.2 Vegetation Management Units

To gain an understanding of the floristic components of the study area, each LMU has been broken down into Vegetation Management Units (VMUs). These are Parkland, Conservation and Riparian areas. The Parkland and Conservation VMUs were replicated from the Lake Kununurra Foreshore Plan. Definitions for these Vegetation Management Units are listed at the start of the document whilst Figure 1 presents the VMUs and LMUs as a map.

### 5.3 Vegetation mapping

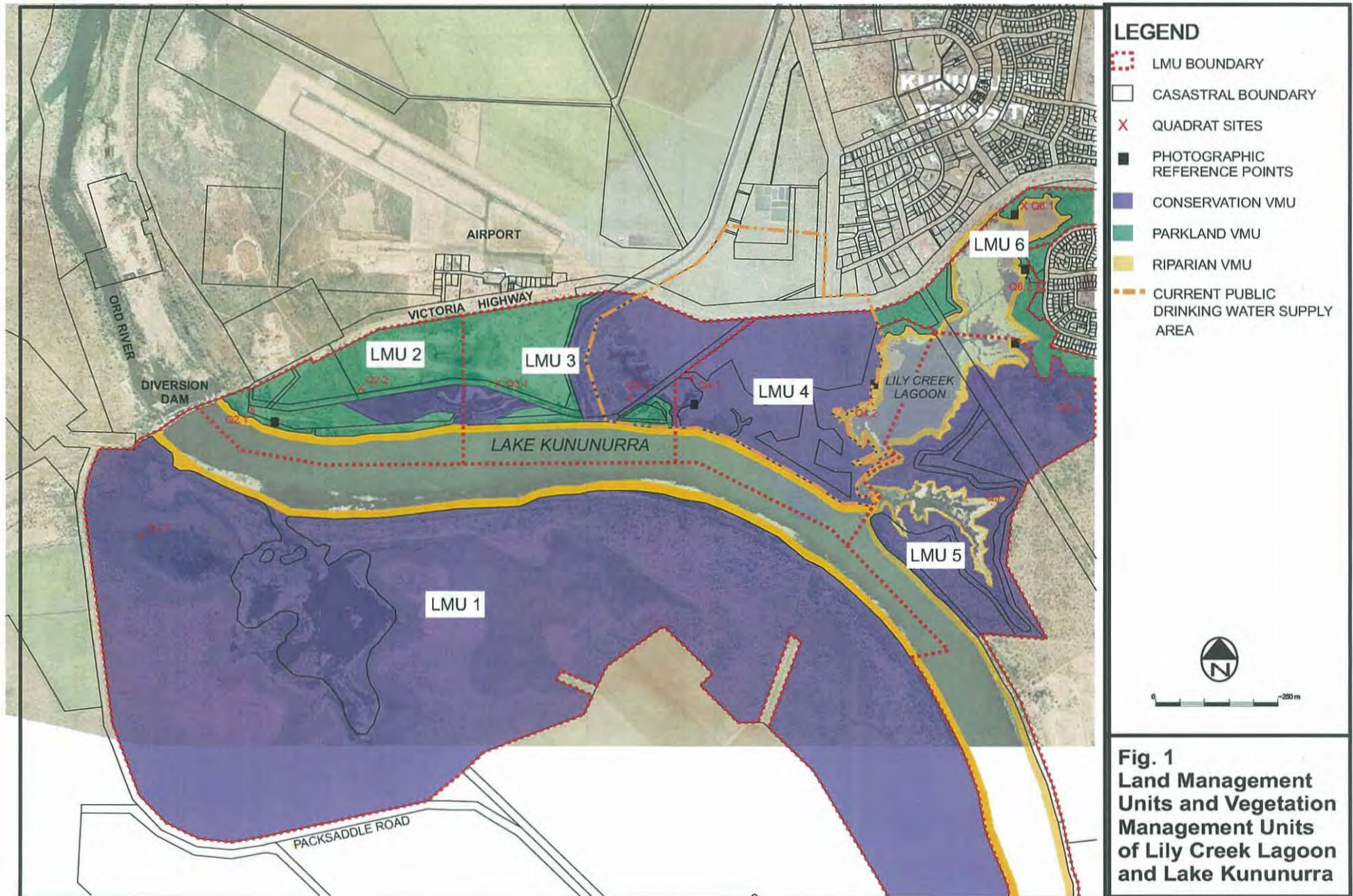
To map the extent and floristic structure of the vegetation within the study area, students from Kimberley TAFE\ helped collect data from transects and quadrats which were then interpreted using a modified Vegetation Condition Scale as presented below. This scale used both quantitative and qualitative assessment procedures to describe the state of the vegetation in a particular area. The vegetation condition tables for each LMU can be found in appendix 3.

**Table 2: Vegetation Condition Scale (Adapted from Trudgen, 1991)**

Good - Very Good	<ul style="list-style-type: none"><li>• 80-100% native flora composition.</li><li>• Vegetation structure intact or nearly so.</li><li>• Cover/abundance of weeds less than 5%.</li><li>• No or minimal signs of disturbance.</li></ul>
Fair – Good	<ul style="list-style-type: none"><li>• 50-80% native flora composition.</li><li>• Vegetation structure modified.</li><li>• Cover/abundance of weeds 5-20%.</li><li>• Minor signs of disturbance.</li></ul>
Poor	<ul style="list-style-type: none"><li>• 20-50 % native flora composition.</li><li>• Vegetation structure completely modified.</li><li>• Cover/abundance of weeds 20-60%.</li><li>• High level of disturbance.</li></ul>
Very Poor	<ul style="list-style-type: none"><li>• 0-20% native flora composition.</li><li>• Vegetation structure disappeared.</li><li>• Cover/abundance of weeds 60-100%.</li><li>• Very high level of disturbance.</li></ul>

Transects were carried out on foot or by boat in each of the six precincts to determine placement of vegetation sampling quadrats. Areas with differing forms of vegetation or areas that appeared to represent the dominant vegetation within the precinct were chosen as quadrat sites (see Figure 2). The location of these sites was recorded with GPS (see Appendix 2). These 100m<sup>2</sup> quadrat sites were used to determine:

- composition and percentage of native flora;
- composition and percentage cover of weeds;
- vegetation structure; and
- signs of disturbance such as clearing, rubbish disposal, fire and tracks.



For each quadrat, the plant species and their numbers were used to give an indication of dominant species within each precinct.

This information forms the Vegetation Condition Tables for each Land Management Unit (LMU) (see Appendix 3) which in turn was used to help guide the recommended management actions. Improvement in the management of the LMUs should result in an improvement in vegetation condition and hence these condition ratings and species information can be used in the future to help assess whether vegetation condition has improved or degraded.

See Appendix 4 for the full species list.

### ***Photographic Reference Points***

To be able to better determine changes and rates of growth of target species such as weeds or recovery of endemic species, sites for Photographic Reference Points have been identified (see Figure 2). These sites have been chosen in areas of high activity, and therefore maintenance or where the vegetation is of high conservation value. These sites should be photographed each year to help assess whether vegetation of the area is improving, declining or remaining stable.

### ***Aerial Mapping***

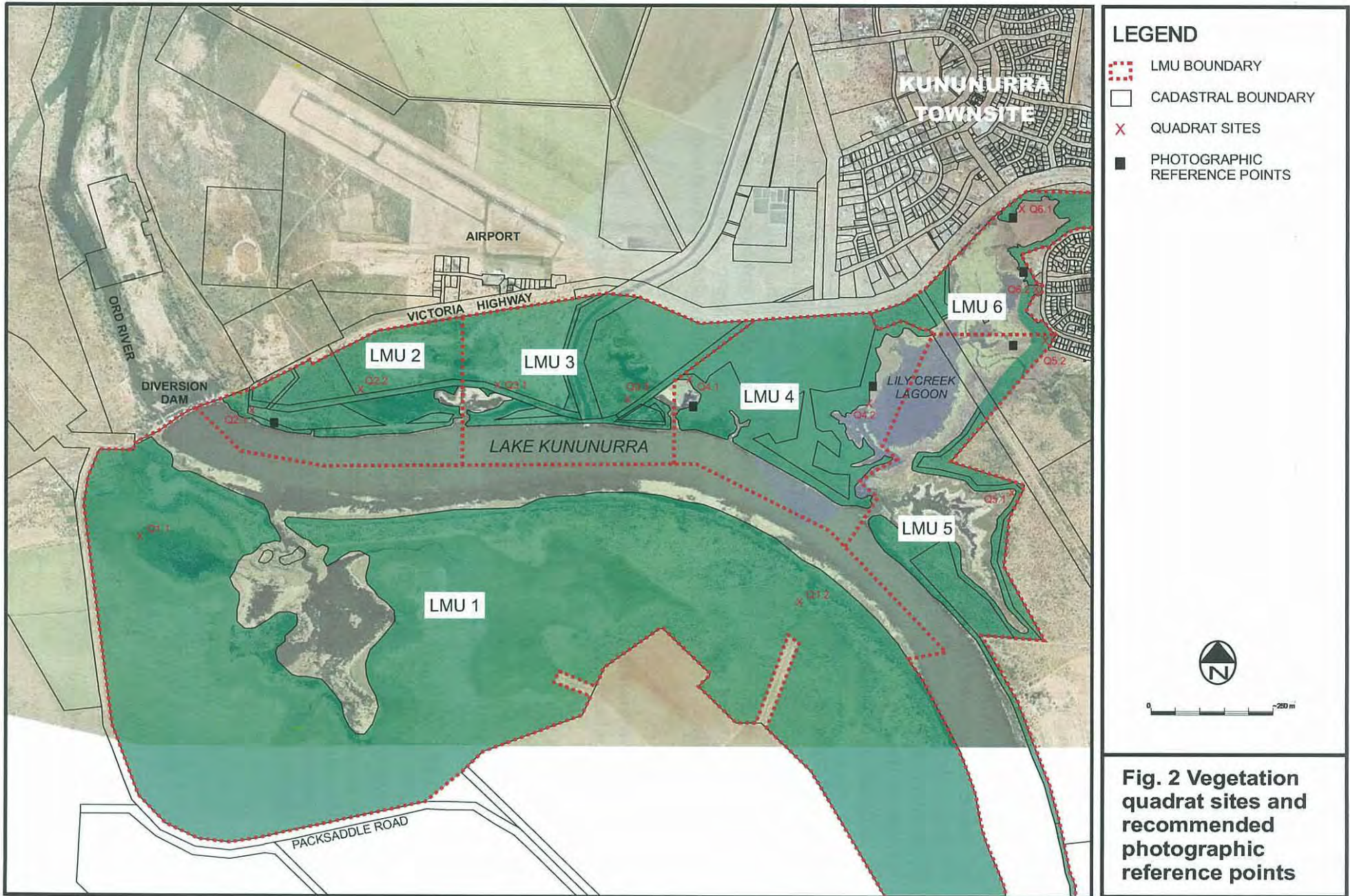
Past and present photographs were used to map the extent of cumbungi. This process was limited by the quality and different scales of the aerial photographs. However, when combined with ground-truthing, the photographs provided a useful starting point for the on-ground analysis as well as portraying some patternistic changes. See Section 7 for further information and discussion on cumbungi.

## **5.4 Environmental values and general management of VMUs**

Native vegetation is crucial to the ecological and social values of the study area. It provides habitat for terrestrial and aquatic wildlife, filters nutrients and other pollutants from the water, stabilises soil thereby reducing the sediment load entering the waterbody, provides material for food and cultural purposes, and increases the amenity value of the area by shading recreational areas. Exotic vegetation can also contribute to these values.

In all VMUs, and in particular the Conservation VMU where disturbance and weed invasion is minimal, remnant native vegetation contributes to and supports biodiversity within the study area. Native vegetation endemic to the local environment also provides a sense of 'place' to the community (for example, boab trees are an iconic species around Kununurra). Retention of remnant vegetation helps to foster this feeling and can be used to facilitate greater understanding of the natural environment.





- LEGEND**
- LMU BOUNDARY
  - CADASTRAL BOUNDARY
  - X QUADRAT SITES
  - PHOTOGRAPHIC REFERENCE POINTS

**Fig. 2** Vegetation quadrat sites and recommended photographic reference points

### ***Conservation Vegetation Management Unit***

The primary role of the Conservation VMU is the conservation and preservation of native vegetation, the key environmental values of the vegetation include:

- habitat for fauna and flora;
- a source of ethnobotanical material for traditional owners;
- a sense of 'place' that is synonymous with Kununurra and the Ord River and
- values as listed under the riparian VMU such as erosion control and filtering of nutrients.

To maintain consistency with the Foreshore Plan, no vegetation removal or slashing is permitted within Conservation Vegetation Management Units, with the exception of road verges, fire breaks and weeds. No development is permitted, with the exception of interpretation facilities such as path ways, signage and bird hides. Rehabilitation should use local native species only.

### ***Parkland Vegetation Management Unit***

The Parkland VMU is specifically recognised as providing a place for people to enjoy the environment including space for recreational pursuits. The values of the vegetation in contributing to this experience include:

- providing the opportunity to gain knowledge on plants, eg Celebrity Tree Park;
- providing structure and
- providing shade, wind protection and temperature mitigation for plants, animals and people.

Due to these values and in order to maintain consistency with the Foreshore Plan, vegetation removal shall be limited to slashing or mowing, and trees shall not be removed unless specifically recommended. Weeds shall be removed. Pockets of remnant bushland (unslashed) can also be maintained within a parkland area as conservation.

### ***Riparian Vegetation Management Unit***

The riparian zone within the study area provides both conservation and social values. As a VMU, the riparian area includes the vegetation of the foreshore and the waterbody. Key values of the native vegetation within the Riparian VMU include:

- habitat (food, shelter and breeding sites) for aquatic and semi-aquatic animals;
- nutrient reduction and management through the filtering of sediments, nutrients and pollutants and trapping of gross pollutants (rubbish);
- bank stability and erosion control during storm events and from the ongoing impact of waves from motorised vessels; and
- aesthetic enhancement of the waterbody by defining the waters edge as well as providing screening of developments along the foreshore.

Observation along the foreshore strongly suggests that development precipitates a large reduction in habitat complexity of riparian vegetation. Clearing of riparian areas can result in increased sediment and nutrient inputs, increased surface water runoff, reduced habitat, decreased canopy cover, increased weed invasion and increased erosion potential. Therefore, in order to retain the values identified above, it is recommended that riparian habitats be managed to maintain them in good condition, as defined by the Vegetation Condition Scale (see Table 2).

**Recommendation 1.** Intact riparian vegetation should be managed to ensure 50-80% native flora composition and cover / abundance of weeds kept below 5-20%.

**Recommendation 2.** Where areas identified for access and views in the Foreshore Plan are hindered by cumbungi resulting in its removal, then revegetation with suitable alternative native sedges and scattered trees should occur.

**Recommendation 3.** Continued monitoring of sediment, nutrient and chemical concentrations in Lily Creek Lagoon. Identify pollutant inputs and sources. Implement actions to manage and reduce these.

**Recommendation 4.** Conduct local research into the importance of cumbungi as habitat for endemic flora and fauna.

**Recommendation 5.** Research tropical native aquatic flora species that may be increased with the removal of the dominant aquatic vegetation species of cumbungi, lilies, pond and ribbon weed.

**Recommendation 6.** Trial cumbungi and other aquatic plant harvesting. Monitor effects of this on water quality.

**Recommendation 7.** Encourage the establishment of a local 'Friends of Lily Creek Lagoon' group to help manage and control weeds.

## 5.5 Plants of ethnobotanical importance

Lily Creek Lagoon and Lake Kununurra contain many plants of indigenous cultural importance. The majority of these species are endemic to the region; however some weed species are now also part of Aboriginal culture.

Elders have expressed their desire to conserve endemic species in the study area. There is recognition that not all species have an ethnobotanical use but Aboriginal belief is that all the endemic species are of importance in maintaining a healthy landscape.

Whilst weed control within the study area is seen as important, some weed species, like the wild passionfruit (*Passiflora foetida*), have contemporary value to local aboriginal people.

## 5.6 Rare flora, fauna and ecological communities

A desktop flora search found no declared rare flora within the study area. One species, *Brachychiton tuberculatus*, is a priority 3 conservation species yet is not believed to be under immediate threat or endangerment (see Appendix 5).

The desktop search returned no known occurrences of threatened ecological communities within the study area however the Gouldian Finch (*Erythrura gouldiae*) (Kununurra 1993) is classified as rare or likely to become extinct and the Burdekin Duck / Radjah Shelduck (*Tadorna radjah rufitergum*) (Kununurra 1999) is listed as other specially protected fauna. Both of these species may occur within the study area.

The search also produced several species of fauna that may occur within the study area and that are classified as: in need of monitoring. These species and their known locations include:

- Purple-crowned fairy-wren (*Malurus coronatus coronatus*) (Lake Argyle 1981),

- Flock bronzewing (*Phaps histrionica*) (Kununurra 1985),
- Partridge pigeon (*Geophaps smithii smithii*) (Kununurra 1902),
- Little bittern (*Ixobrychus minutus*) (Lake Kununurra 1982), and
- Water rat (*Hydromys chrysogaster*) (Kununurra 2002),

Due to the age of most of these dates the local office of the Department of Environment and Conservation was approached for further confirmation. Local DEC wildlife officers could not conclude if these species occurred specifically within the study area and recommended that night surveys and bird surveys be carried out so that recent data on these species could be collected and a suitable monitoring plan implemented. See Appendix 5 for details on searches.

### **5.7 Fire**

Fire scar mapping (see Appendices 6 and 7) indicates that areas within the study area were burnt in both 2005 and 2006. From observation there was also the occurrence of spot fires in 2007. The fires in 2005 occurred during Nov-Dec while the fires in 2006 occurred during August. At the time of writing (September 2007) fires had also occurred within the study site during June 2007.

Impacts of hot, late dry season fires include the removal of understory and sensitive riparian species and ultimately a change in the vegetation composition including an increase in weeds and cane grass. Cool burns maintain these more sensitive species and therefore result in less loss of biodiversity.

A management plan for the purposes of minimising the impact of frequent uncontrolled burning of 'non-management' areas of vegetation within the six LMU areas is to be prepared in conjunction with FESA, DEC, SWEK, local fire brigades and the relevant land management agency.

The plan will be prepared early 2008 with a view to implementation for the end of the 2007/08 wet season. Elements of the plan will include designation of 'cool burn' areas, development of strategic fire breaks (slashed or mown), designation of protection areas and fire response protocols.

Due to fire vulnerable vegetation occurring within riparian zones, careful consideration will need to be given to these areas and may require the use of breaks rather than regular preventative burning.

### **5.8 Current vegetation management**

The table below outlines the current vegetation management activities within the study area as well as authorities responsible for parcels of land.

In general, DEC is responsible for ensuring that the Ramsar values of the site Lakes Argyle and Kununurra are maintained. This includes the management of native vegetation. In order to remove native vegetation that is acting as a weed, such as Cumbungi (*Typha domingensis*), then a native vegetation clearing permit needs to be applied for through DEC. If interference with the bed and banks is likely then a permit to interfere with the bed and banks needs to be obtained through the DoW.

There are also various other agencies and land managers responsible for specific areas of land within the study area.

From this table it can be seen that much of the management of the study area is undertaken by SWEK, recreational clubs with leases or freehold land owners.

A comparison of this table to the recommended activities table (Table 16) indicates that greater vegetation management is required than what is currently occurring. In particular, weed removal, rehabilitation and fire control is lacking.

Maps indicating the current areas of slashed land by SWEK can be found in Appendix 8.

**Table 3: Current vegetation management activities**

Land Management Unit	Reserve/Lot No.	Managing Authority	Current Management Tasks
<b>LMU 1</b>			
Packsaddle Conservation Area	Lot 959 on Deposited Plan 31611 (UCL)	DEC / MG Corp	As detailed by DEC and MG Corporation
<b>LMU 2</b>			
Swim Beach Park	Reserve 41812	SWEK DoW	Mowing and slashing of 'park land' area, retention of trees, planting of local tree species. Nil
Proposed Commercial Boat Harbour site	Reserve 41812	SWEK DoW	Present – slashing of access road verges, control/removal of neem trees Future – mowing and slashing of 'park land' area, retention of trees, planting of local tree species Nil
Water Ski Club Lease	Reserve 41812	SWEK DoW Ski Club	Nil Nil As detailed by Ski Club – mowing and slashing, control/removal of neem trees.
Golf Course Lease	Reserve 29167	SWEK Golf Club Muster Committee	Nil As detailed by Golf Club – mowing and slashing, control/removal of neem trees. Removal of passionfruit vine and cumbungi removal
UCL (Lake Kununurra)		DPI SWEK	Nil Removal of cumbungi from swimming area
Botanic gardens site	Reserve 38368	SWEK	Mowing and slashing of park land area, retention of trees, planting of local tree species, removal of neems, and control of luecaena.
Levee bank	Reserve 46172	Water Corp SWEK	Nil Nil
<b>LMU 3</b>			
Golf Course Lease	Reserve 29167	SWEK Golf Club	Nil As detailed by Golf Club – mowing and slashing, control/removal of neem trees.
Kona Caravan Park	King Locations 274, 439,440 & 441	Caravan Park	As detailed by Caravan Park – mowing and slashing, control/removal of neem trees.
Foreshore	Reserve 41812	SWEK DoW	Nil Nil
UCL (Lake Kununurra)		DPI	Nil Control/removal of cumbungi by Kona.
P1 area	King Location 324 Reserve 30211	DoW Water Corp	Nil Management of Town Water Supply
M1 Channel	Reserve X (or is it freehold?)	OIC Water Corp	Spraying of weeds Nil
Levee bank	Reserve 46172	Water Corp SWEK	Nil Nil
<b>LMU 4</b>			
Kimberley Land Caravan Park	Kununurra Lot 1519	Caravan Park	As detailed by Caravan Park – mowing and slashing, control/removal of neem trees.
Foreshore	Reserve 41812	SWEK DoW	Nil Nil
UCL (Lily Creek Lagoon)		DPI	Nil Cumbungi control by Kimberley Land
P1 area	King Location 715 and 324 (Reserve 30211)	DoW Water Corp	Nil Management of Town Water Supply

<b>LMU 5</b>			
Foreshore	Reserve 41812	SWEK DoW	Nil Nil
UCL (Lily Creek Lagoon / Lake Kununurra)		DPI	Nil
<b>LMU 6</b>			
Celebrity Tree Park	Reserve 42371	SWEK	Mowing and slashing of 'park land' area, retention of trees, occasional planting of trees
Foreshore	Reserve 41812	SWEK  DoW	Mowing and slashing of 'park land' area, retention of trees, planting of local tree species, control/removal of neem trees. Nil
Lakeside Resort and Caravan Park	Kununurra Lot 2263	Caravan Park	As detailed by Caravan Park – mowing and slashing, control/removal of neem trees.
UCL (Lily Creek Lagoon)		DPI	Nil SWEK carries out cumbungi removal along Vic Hwy and around celebrity Tree Park and Boat ramp. Lakeside Resort and Celliston Nominees also carry out cumbungi control.

## 6. Land Management Units

### 6.1 Land Management Unit 1 (Precinct 1)

LMU 1 is on the southern side of Lake Kununurra and includes Packsaddle Lagoon and the land bounded on the south by Packsaddle Road and private property (see Figure 3). This area is currently undeveloped and subject to provisions under the Ord Final Agreement. Vegetation was sampled from two quadrats (see Figure 2).

As in the Foreshore Plan (2006) this LMU has been allocated as conservation with the addition of a riparian VMU. The only future development discussed by the Foreshore Group was the potential for the relocation of the current P1 drinking water source area to this LMU and the installation of eco-recreational and interpretive facilities such as a bird hide, trail and jetty.

The vegetation in LMU 1 is predominantly endemic to the region. Vegetation is most dense nearest the water's edge. The heavily vegetated riparian component is dominated by cumbungi (*Typha domingensis*), dragon tree (*Sesbania formosa*) and pandanus (*Pandanus aquatica*). Moving away from the water's edge there are dense stands of dragon tree (*Sesbania Formosa*), cajuput (*Melaleuca leucadendra*) and the introduced rain tree (*Albizia lebbek*).

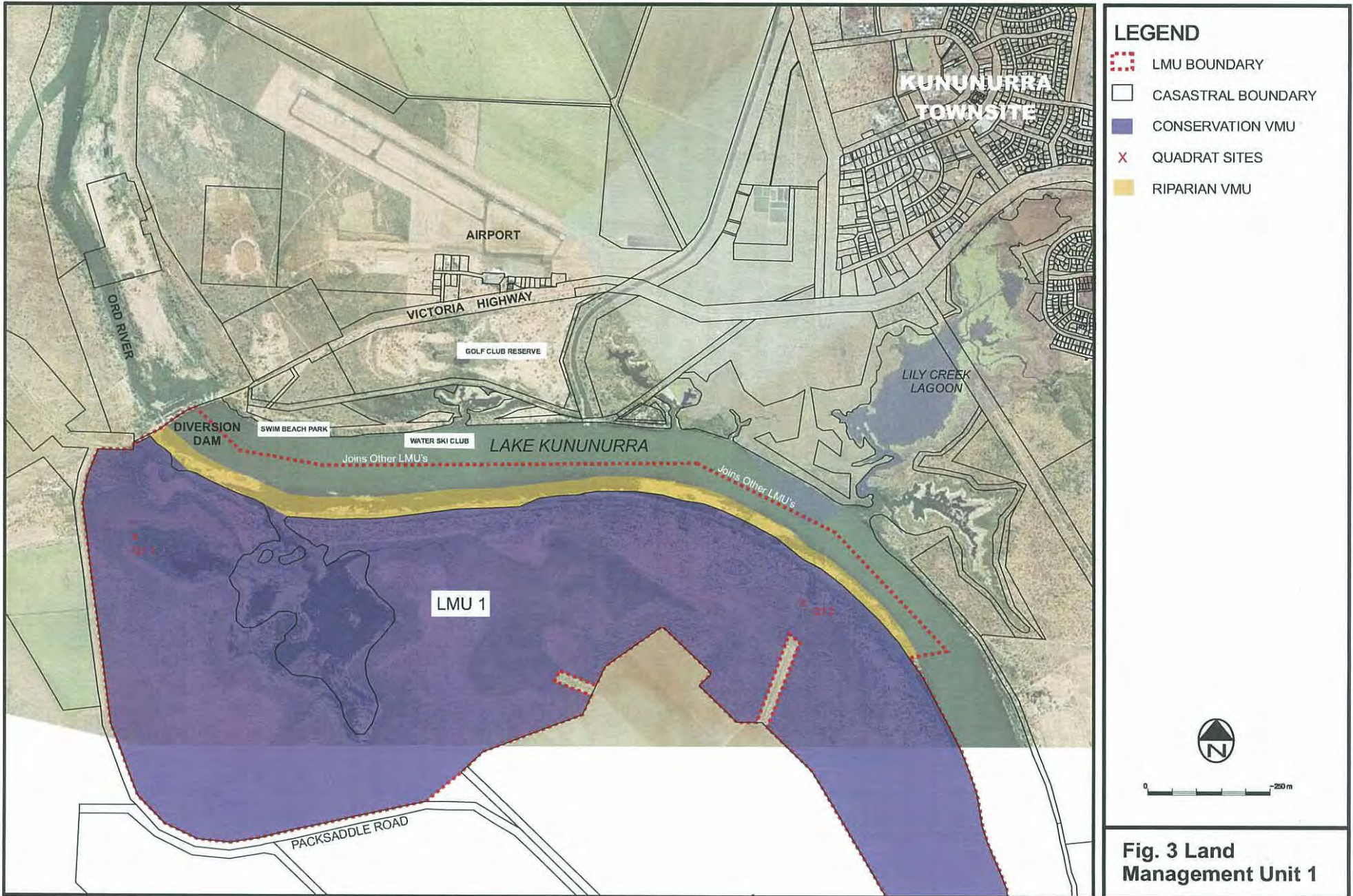
There is some weed encroachment along the water's edge, the most dominant being the wild passionfruit (*Passiflora foetida*). The majority of the weeds in this LMU appear to be establishing themselves away from the water's edge including occurrences of neem (*Azadirachta indica*) which are the subject of a local eradication program. This could be due to the susceptibility of the endemic vegetation to fires, higher likelihood of human activity and the more open nature of the vegetation allowing weed species to get a foothold more easily than in the dense riparian zone.

LMU 1 is in fair to good condition showing good native flora composition and only minor signs of disturbance (mainly access tracks and weeds). Management of this area should focus on controlling weeds, fire and access to the site.

**Table 5: Recommended actions**

Issue	Action and targets	Who	When
Weeds	Eradicate neem infestations.	OLW	once yearly
	Control and if possible reduce weed infestations. Follow up control.	DEC/MG Corp	
Access	Control and if possible reduce traffic access	DEC/MG Corp	next 3 months
Fire	Write Fire Management Plan	DEC/MG Corp	Feb 08
	Implement preventative burning regime	DEC/MG Corp	once yearly





**LEGEND**

-  LMU BOUNDARY
-  CASASTRAL BOUNDARY
-  CONSERVATION VMU
-  QUADRAT SITES
-  RIPARIAN VMU



0 ————— 250 m

**Fig. 3 Land Management Unit 1**

## 6.2 Land Management Unit 2 (Precinct 2)

LMU 2 is on the western part of the area north of Lake Kununurra immediately adjacent to the Diversion Dam, bounded by the Victoria Highway to the north and LMU 3 to the east. It currently contains part of the Golf Club, Swim Beach, Water-ski Club and Sailing Club (see Figure 4). Two vegetation quadrats were identified (see Figure 2).

LMU 2 contains conservation, parkland and riparian areas. Areas identified as parkland include the existing golf course, swim beach, and ski club as well as the future botanical gardens site and commercial boating facility site. These areas are used heavily for recreational purposes and are highly modified with cleared access to the water and grassed areas. As such, from a vegetation condition point of view, these areas are in fairly poor condition with poor native vegetation flora composition. The dominant endemic upper-storey vegetation consists of river red gums (*Eucalyptus camaldulensis*) and dragon trees (*Sesbania formosa*). The weed species include wild passionfruit (*Passiflora foetida*), rubber bush (*Calatropis gigantean*), many grasses, leucaena (*Leucaena leucocephala*) and neem (*Azadirachta indica*). It appears that the levee bank road may be helping spread weeds, either by traffic moving plant material along the road or just the easier mobility for plant material along this cleared zone.

As with the Parkland, the Riparian VMU is also heavily impacted by human activity. The water's edge has been cleared for human access and weed species appear to compete with the riparian vegetation. Dominant endemic vegetation includes cumbungi (*Typha domingensis*), pandanus (*Pandanus aquaticus*) and river red gum (*Eucalyptus camaldulensis*). Dominant weed species are wild passionfruit (*Passiflora foetida*) and convulvulus creeper (*Merrimia dissecta*).

The Foreshore plan recommends the swim beach area be expanded to allow for a separate dog swimming area. If this was to occur riparian vegetation would need to be removed to allow access for swimming yet it is recommended that intact areas of riparian vegetation be left between the cleared areas.

The area set aside for conservation is the undeveloped Cumbungi Inlet which is almost completely full of cumbungi (estimated at 75 – 95% full). This area has been recommended in the Foreshore Plan to be reserved and vested in DEC for conservation. Apart from the inlet itself, this area appears to be in fairly good condition. The adjacent terrestrial vegetation is a mixture of endemic species such as river red gum (*Eucalyptus camaldulensis*), green plum (*Terminallia platyphylla*) and another unidentified gum (*Eucalyptus*) tree. The weed species amongst the endemic species is dominated by leucaena (*Leucaena leucocephala*) with many other species present in small numbers. The relatively low weed cover and high native flora composition suggests that management in this area is of lower priority than the Parkland and Riparian VMUs.

Management of this LMU should focus on removal of the weed species that are out-competing native vegetation, such as leucaena (*Leucaena leucocephala*) and the convulvulus creeper (*Merrimia dissecta*), and the replacement of these weeds with local native species. A small area of parkinsonia (*Parkinsonia aculeate*) has been found in this LMU and needs follow up control and monitoring.

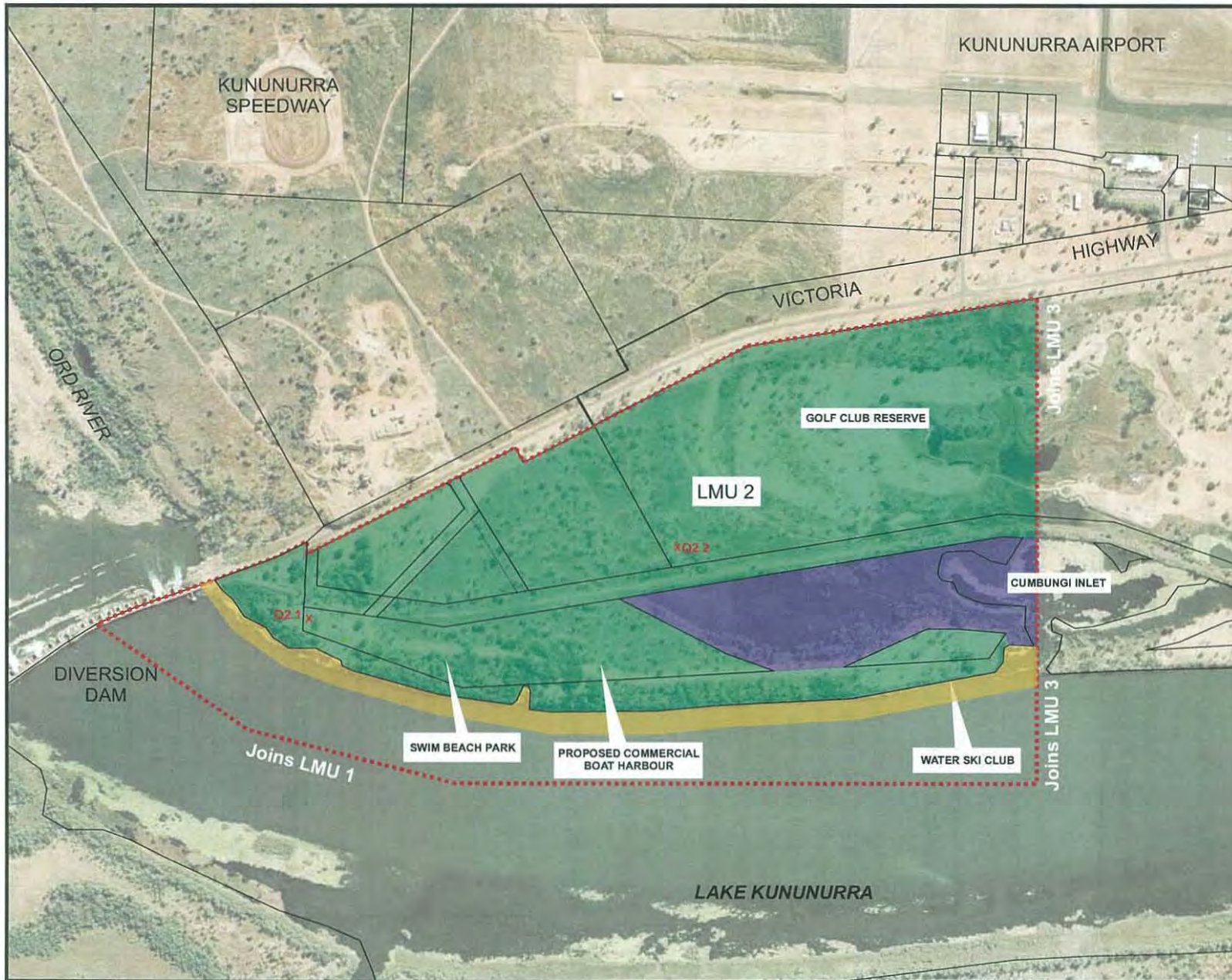
Improvement in the condition of the riparian area through the planting of riparian vegetation is recommended for points that are not required for recreational access, yet the maintenance of recreational access points to the waterbody at Swim Beach,

the Sailing Club and the Water-ski Club is required. These actions of weed removal and maintaining access are in line with the specific actions listed in the Foreshore Plan.

The Golf Club and Water-ski Club have leases over areas within this LMU and therefore need to manage these areas in accordance with this and the Foreshore Plans. The Foreshore Plan recommended that these Clubs develop a simple Vegetation Management Plan. These clubs should be able to use this plan to guide their vegetation management activities.

**Table 7: Recommended actions**

<b>Issue</b>	<b>Action and targets</b>	<b>Who</b>	<b>When</b>
Weeds	Reduce weed infestations. Focus on leucaena, neem, the convulvulus creeper and passionfruit vine covering riparian vegetation. Areas of concern are the riparian area and levee bank. Undertake follow-up control. Follow up control of Parkinsonia.	SWEK/DoW /OLW/Water Corp (levee)/ Golf Course	Once yearly
Cumbungi Management	Remove cumbungi from swimming areas	SWEK	Once yearly
Rehabilitation	Plant native species following weed removal Plant native botanical gardens Remove weeds and rehabilitate with native species	SWEK/SEEKS Golf Club/Ski Club	Once yearly March 08 Once yearly
Slashing	Maintain slashed areas	SWEK	3 times yearly
Fire	Write Fire Management Plan Implement preventative burning regime	DEC/SWEK SWEK/Local Fire Brigades	Feb 08 once yearly



**LEGEND**

-  LMU BOUNDARY
-  CADASTRAL BOUNDARY
-  CONSERVATION VMU
-  PARKLAND VMU
-  RIPARIAN VMU
-  QUADRAT SITES


**Fig. 4 Land Management Unit 2**

### 6.3 Land Management Unit 3 (Precinct 3)

LMU 3 is the central part of the area north of Lake Kununurra, bounded by the Victoria Highway and the Kona access road. This precinct contains the remainder of the golf course, the amphitheatre, M1 pump house, the PDWSA and bore field and a caravan park (see Figure 5). Two vegetation sampling quadrats were established (see Figure 2).

This LMU contains both parkland conservation and riparian areas. The P1 drinking water source area is considered conservation and is managed by the Department of Water and Water Corporation. The only vegetation management within this area is around the bore field for fire prevention. SWEK would like to see this area more actively managed in terms of access, weeds and rehabilitation.

The other area identified for conservation is Cumbungi Inlet which has been recommended in the Foreshore Plan to be reserved and vested in DEC for conservation. The issues associated with Cumbungi Inlet are as stated for LMU 2.

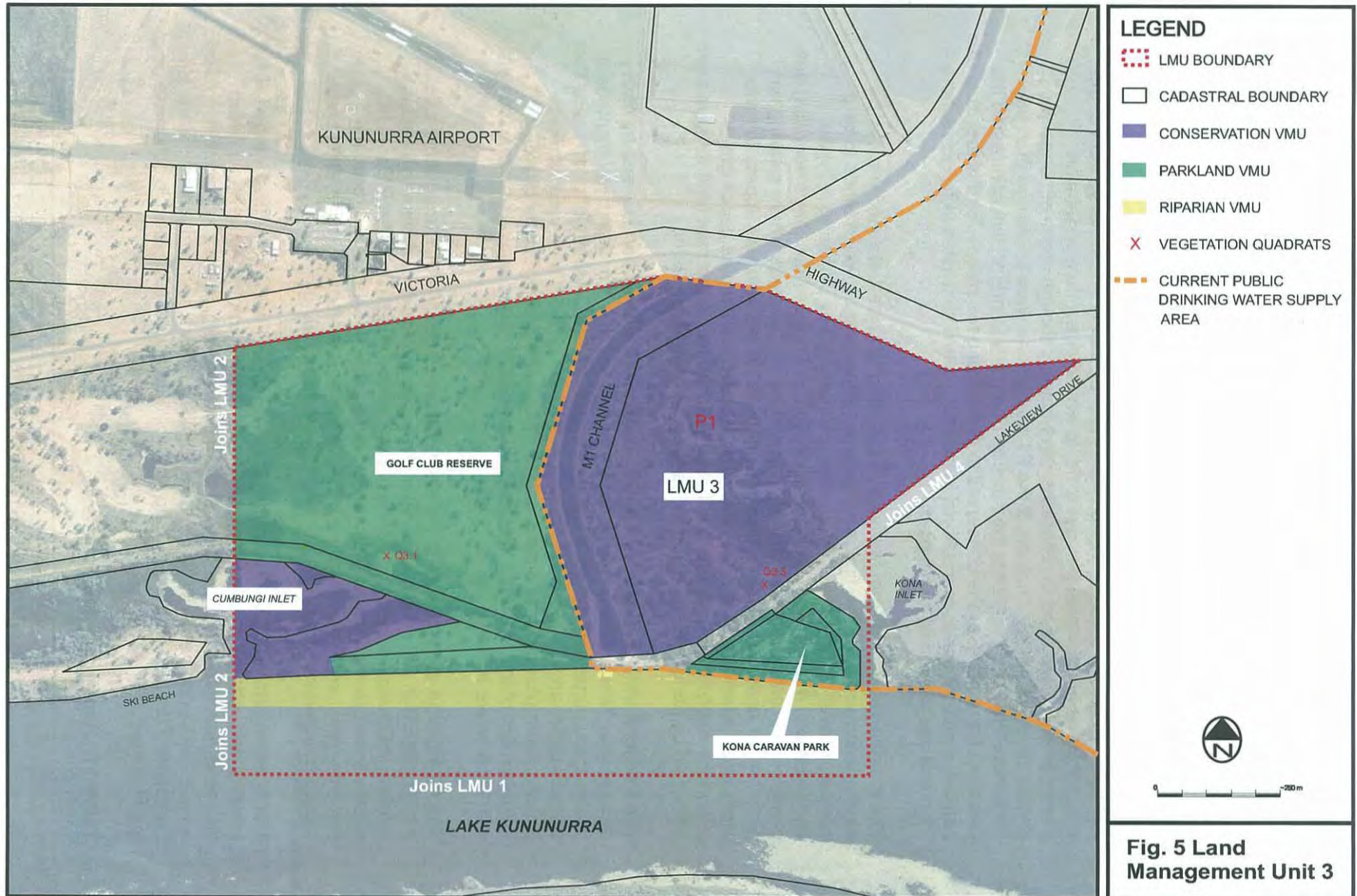
The riparian zone in this LMU is well vegetated predominantly with endemic species including cumbungi (*Typha domingensis*), dragon tree (*Sesbania formosa*), green plum (*Terminallia platyphylla*) and pandanus (*Pandanus aquatica*). Some pockets of weed species include a dense stand of leucaena (*Leucaena leucocephala*) and rain trees (*Albizia lebbbeck*).

The Golf Course and Kona Caravan Park are considered Parkland due to the highly maintained grounds and recreational use. The majority of weeds within these Parkland areas occur within the remnant bushland. The dominant species here consist of leucaena (*Leucaena leucocephala*), rubber bush (*Calatropis gigantean*), rain tree (*Albizia lebbbeck*) and many vine species. The endemic vegetation consists of river red gum (*Eucalyptus camaldulensis*), an unidentified Eucalypt species and cajuput (*Melaleuca leucadendra*).

Management should focus on weed control and rehabilitation in the P1 area, the riparian area and the remnant bushland areas found within the Golf Course.

**Table 9: Recommended actions**

Issue	Action and targets	Who	When
Weeds	Prepare a weed management plan for the P1 area.	Water Corp/DoW	Mid 08
	Reduce weed infestations in P1 area.	Water Corp/DoW	Ongoing yet at least once a year
	Focus on leucaena and neem.	SWEK/DoW	once yearly
	Remove weeds along foreshore reserve. Follow up control. Remove weeds and rehabilitate with native species.	Kona CP/Golf Club	
Rehabilitation	Plant native species following weed removal.	Water Corp/DoW/SWEK	As needed
Access	Control and reduce unnecessary access into P1 area and install signage as recommended in the Kununurra Water Reserve Drinking Water Source Protection Plan.	Water Corporation	Feb 08
Fire	Implement preventative burning regime.	Water Corp/Local Fire Brigades	once yearly



- LEGEND**
-  LMU BOUNDARY
  -  CADASTRAL BOUNDARY
  -  CONSERVATION VMU
  -  PARKLAND VMU
  -  RIPARIAN VMU
  -  VEGETATION QUADRATS
  -  CURRENT PUBLIC DRINKING WATER SUPPLY AREA



**Fig. 5 Land Management Unit 3**

#### 6.4 Land Management Unit 4 (Precinct 4)

LMU 4 consists of the eastern part of the area north of Lake Kununurra, bounded by the Victoria Highway, Lily Creek Lagoon and the Old Darwin Road. LMU 4 currently contains part of the PDWSA bore field and a caravan park (see Figure 6). Two vegetation sampling quadrats were established (see Figure 2).

The P1 drinking Water Source Area covers most of this LMU and is considered Conservation. The only Parkland in this LMU is Kimberleyland Caravan Park which is developed and utilised for tourism activities and accommodation. The Foreshore Plan highlights the preference for changes to the P1 boundary and development of the area for tourism/residential purposes. If this was to occur then vegetation management would need to reflect the development though areas of conservation should be identified and retained. If the P1 boundaries were to change then the Foreshore Plan also highlights the building of a cultural/interpretive centre and the creation of a reserve for the conservation of the flying fox colony. Bird hides, dual use pathways and other eco recreational infrastructure are also listed in the Foreshore Plan and are supported in this plan.

The riparian vegetation from the public boat ramp to Kona Caravan Park can be divided into two parts. The first is an endemic species suite which tends to be a complete cover of the water's edge. This is dominated by cumbungi, (*Typha domingensis*), dragon tree (*Sesbania formosa*), pandanus (*Pandanus aquatica*) and green plum (*Terminallia platyphylla*). The second part is areas where clearing has occurred for access or visual amenity. The present cleared areas appear to have more weed species and include planted exotic species such as couch grass (*Cynodon dactylon*). The areas that have been cleared in the past tend to have been colonised by dense stands of leucaena (*Leucaena leucocephala*).

The Parkland VMU is Kimberley Land Caravan Park and is characterised by heavy disturbance. There are also many exotic species which were most likely planted for landscaping purposes within the Caravan Park. There is a variety of exotic trees that do not appear anywhere else at present in the vicinity. Dominant weed species include neem (*Azadirachta indica*) and leucaena (*Leucaena leucocephala*). Management of this Parkland VMU should focus on weed removal and replacement with local native species

The P1 PDWSA area makes up the entire Conservation VMU. The endemic species composition is in fair condition with eucalypt (*Eucalyptus camaldulensis*), cajuput (*Melaleuca leucadendra*), and bauhinia (*Buhinia cunninghamii*). The P1 area is relatively undisturbed yet has high amounts of weed infestations particularly leucaena (*Leucaena leucocephala*). The bat colony is also within this VMU and is heavily infested with leucaena (*leucaena leucocephala*).

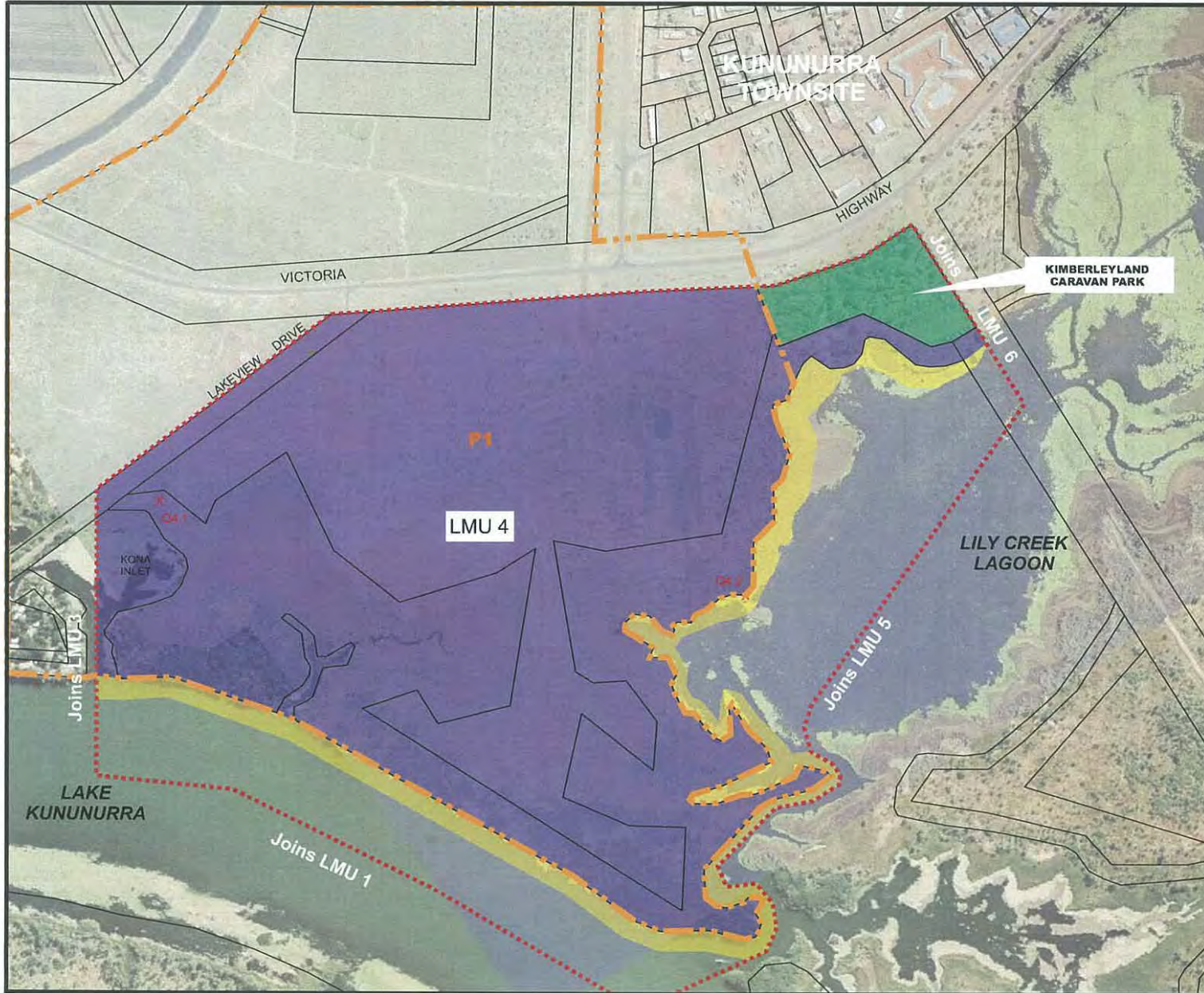
Management actions should therefore focus on the P1 area, in particular weed removal and rehabilitation and control of access. Due to the habitat value of the leucaena (*leucaena leucocephala*) at the bat colony site, weed management in this area of the Conservation VMU needs a specific removal and replacement plan. The Foreshore Plan also lists weed removal and limited access as specific actions to be implemented.

**Table 11: Recommended actions**





Issue	Action and targets	Who	When
Weeds	Prepare a weed management plan for the	Water Corp/DoW	Mid 08

	<p>P1 area.  Remove dense stands of leucaena in P1 area and levee bank. Follow up control.  Reduce weed infestations and replant with local native species.  Develop plan to systematically remove woody weeds and replace with native vegetation for bat colony.</p>	<p>Water Corp/DoW  Kimberleyland Caravan Park  SWEK/DoW/DEC</p>	<p>Once year  Once year  Feb 08</p>
Rehabilitation	Plant native species following weed removal in P1 area.	Water Corp/DoW	Once year
Access	Control and reduce unnecessary access into P1 area and install signage as recommended in the Kununurra Water Reserve Drinking Water Source Protection Plan.	Water Corp	Dec 07
Conservation of remnant vegetation	Identify and protect stands of remnant vegetation to be conserved if development of P1 area is approved.	SWEK/DoW/DEC	Before development occurs.
Cumbungi Management	<p>Remove cumbungi where it has been shown to have rapidly increased. Leave buffer.  Remove cumbungi where access and views are needed. Replant banks with smaller native sedges.</p>	<p>SWEK  Kimberleyland Caravan Park</p>	Once year
Fire	Implement preventative burning regime.	DEC/DoW/Water Corp	once yearly





**LEGEND**

-  LMU BOUNDARY
-  CADASTRAL BOUNDARY
-  CONSERVATION VMU
-  PARKLAND VMU
-  RIPARIAN VMU
-  P1 BOUNDARY
-  QUADRAT SITES
-  CURRENT PUBLIC DRINKING WATER SUPPLY AREA



0 250 m

**Fig. 6 Land Management Unit 4**

## 6.5 Land Management Unit 5 (Precinct 5)

LMU 5 contains the southern shore of Lily Creek Lagoon including Hamilton Inlet and surrounds, southeast to the Rowing Club. The area is currently undeveloped (see Figure 7). Two vegetation sampling quadrats were established (see Figure 2).

As in the Foreshore Plan, LMU 5 is primarily for conservation purposes. The Foreshore Plan highlights the water in the LMU as a cumbungi control area and the need for implementation of a cumbungi management plan. Cumbungi management is discussed in Section 7. The Foreshore Plan also refers to the use of this LMU for eco-recreation such as the building of a bird hide and interpretive signage.

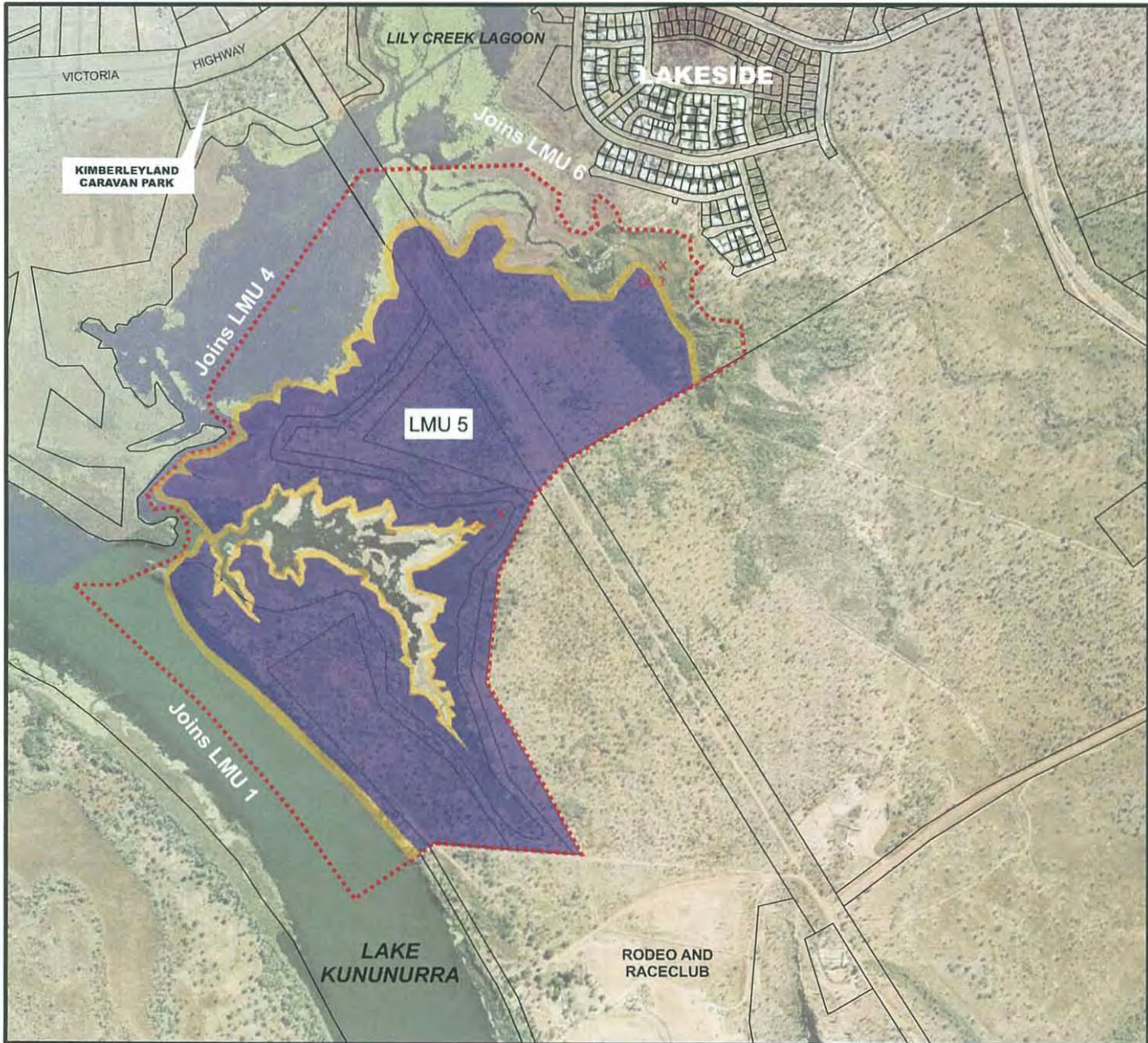
Vegetation within this Conservation VMU and respective riparian areas (Hamilton Inlet and Rowing Club) is dominated by endemic species, most noticeably cumbungi (*Typha domingensis*) and dragon trees (*Sesbania formosa*) along the lagoon's edge and raintree (*Albizia lebbek*), cajuput (*Melaleuca leucadendra*) bauhinia (*Buhinia cunninghamii*) and cane grass (*Sorghum stipoideum*) further inland. Cumbungi (*Typha domingensis*) is dominant in the drains and inlets into Lily Creek Lagoon completely removing open water habitat from a large creek inlet.

The areas closer to the Old Darwin Road and Casuarina Drive contain a higher proportion of weed species, in particular neem (*Azadirachta indica*), purpletop chloris (*Chloris barbata*) and rubber bush (*Calatropis gigantean*).






This LMU is all Conservation and respective Riparian VMUs and is in good condition with relatively few weed species. Weed species seem to be occurring close to the residential development of Lakeside and the creek inlet has become choked with cumbungi. Management should therefore focus on the weed and cumbungi removal in these areas. This is consistent with specific actions listed in the Foreshore Plan.

**Table 13: Recommended actions**

Issue	Action and targets	Who	When
Weeds	Reduce neem infestations. Follow up control.	OLW	Ongoing
Cumbungi management	Reduce cumbungi infestation but leave cumbungi in and around drain outlets.	SWEK	Once year
Fire	Implement preventative burning regime.	DEC/SWEK	Once yearly



**LEGEND**

-  LMU BOUNDARY
-  CASASTRAL BOUNDARY
-  CONSERVATION VMU
-  RIPARIAN VMU
-  QUADRAT SITES



**Fig. 7 Land Management Unit 5**

## 6.6 Land Management Unit 6 (Precincts 6)

This LMU encompasses the northern shore of Lily Creek Lagoon, bounded on the west by the Old Darwin Road. It contains Celebrity Tree Park, the current public boat ramp (Town Jetty) and the eastern side of Lily Creek Lagoon including the Lakeside foreshore (see Figure 9). Two vegetation sampling quadrats were determined 6 (see Figure 2).

This LMU is mainly parkland and riparian with a small amount of conservation. In the Foreshore Plan there is reference to the future visitors centre, Rotary Park and Casuarina Foreshore Park. The zoning of this precinct as Parkland caters for these future developments and their associated infrastructure such as BBQs, play and picnic areas and pathways. The Foreshore Plan also highlights all of the water in the LMU as a cumbungi control zone and the need for implementation of a cumbungi management plan. Cumbungi management is discussed in Section 7.

The Riparian VMU is dominated by endemic species cumbungi (*Typha domingensis*), dragon tree (*Sesbania formosa*) and some cajuput (*Melaleuca leucadendra*). Some weed species are present, particularly in areas where the native vegetation at the waters edge has been cleared. The more common weed species are wild passionfruit (*Passiflora foetida*), rain tree (*Albizia lebbek*) and leucaena (*Leucaena leucocephala*). The declared aquatic weed salvinia (*Salvinia molesta*) was found in an area of the lagoon in 2000. A collaborative control and eradication program is underway. The whole riparian area of this LMU is dominated with cumbungi (*Typha domingensis*) which has been allowed to flourish unchecked. Such high abundance of cumbungi creates environmental and recreational issues which are discussed in Section 7.

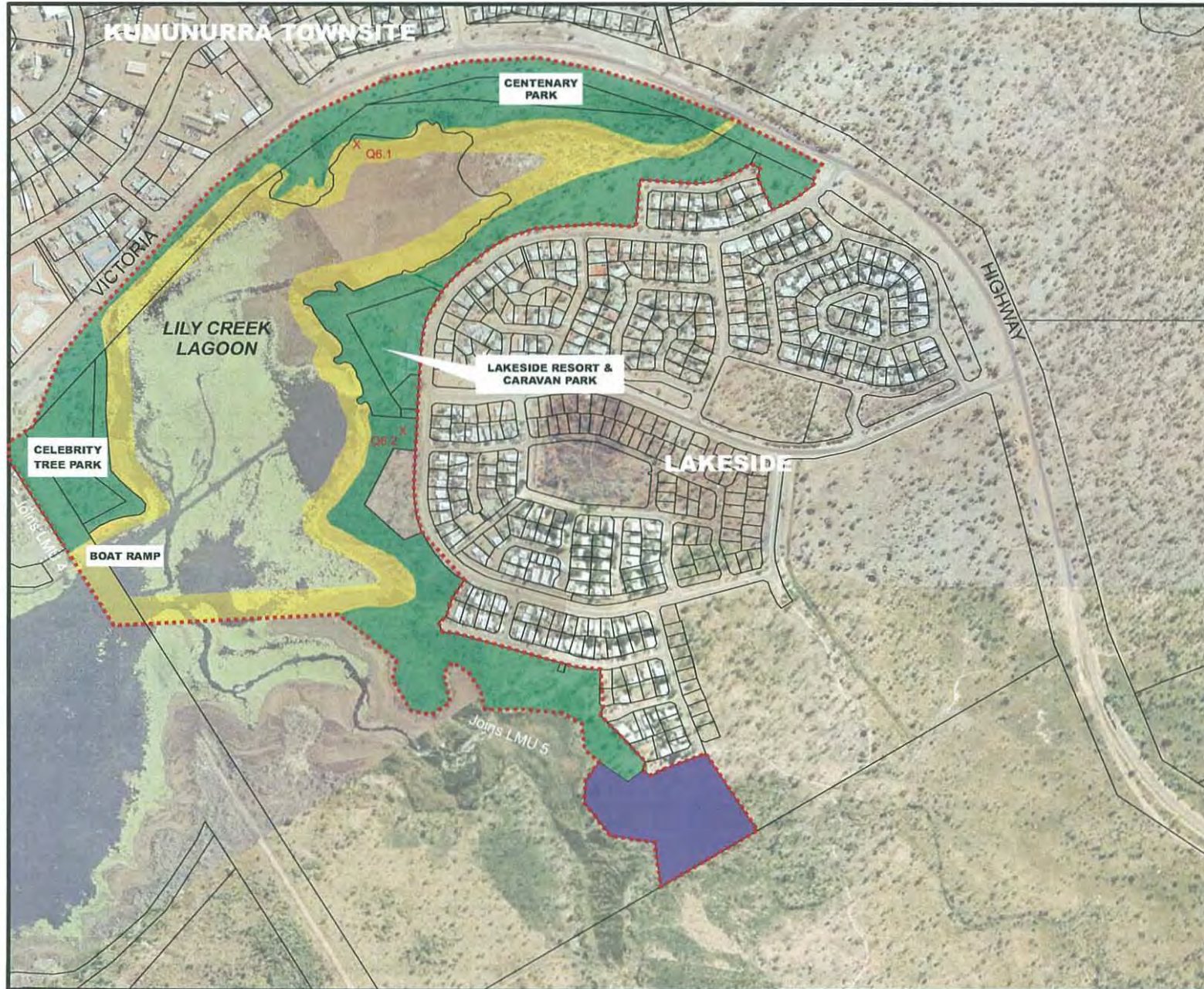
The Parkland VMU consists of many deliberately planted exotic species, weeds and endemic species. Endemic species are predominately cajuput (*Melaleuca leucadendra*), dragon tree (*Sesbania formosa*), green plum (*Terminallia platyphylla*) and river red gum (*Eucalyptus camaldulensis*). Weed species include many vines, rain tree (*Albizia lebbek*), leucaena (*Leucaena leucocephala*) and a variety of grasses.

This LMU is heavily modified consisting of Parkland and Riparian VMUs with no Conservation VMU. This LMU is allocated as parks and recreational areas in the foreshore plan and therefore should be managed accordingly. Vegetation management should focus on cumbungi removal, slashing, weed removal, conservation of remnant stands of vegetation and increased planting of native species. In particular eradication of the salvinia is a priority. Weed, cumbungi removal and the maintenance of this area as parkland for recreation is consistent with actions listed in the Foreshore Plan.

**Table 15: Recommended actions**

Issue	Action and targets	Who	When
Weeds	Reduce weed infestations with a focus on leucaena, exotic vines and neem. Eradicate salvinia.	SWEK/OLW/DEC/DoW	Once a year
		OLW/SWEK/DAFWA	2009
Slashing	Maintain slashed areas.	SWEK	3 per year
Cumbungi management	Remove cumbungi in front of caravan park, proposed tourist bureau, boat ramp and other infrastructure such as pump intakes, Celebrity Tree Park, creek inlet and any floating islands.	SWEK/Lakeside Resort	Once a year

Conservation of remnant vegetation	Identify and protect stands of remnant vegetation to be conserved.	SWEK/DoW/DEC	Before development occurs
Rehabilitation	Plant a smaller native rush/sedge where cumbungi has been removed from banks. Replant riparian vegetation using native species.	SWEK/SEEKS	Once a year
		SWEK/Lakeside Resort	Once a year
Fire	Implement preventative burning regime.	DEC/SWEK	Once yearly



**LEGEND**

-  LMU BOUNDARY
-  CASASTRAL BOUNDARY
-  PARKLAND VMU
-  RIPARIAN VMU
-  QUADRAT SITES



0 ————— 200 m

**Fig. 8 Land Management Unit 6**

**Table 16: Summary of recommended vegetation management activities**

Issue	LMU1	LMU 2	LMU 3	LMU 4	LMU 5	LMU 6
<b>Weed removal and control (includes follow up control)</b>	Eradicate neem infestations.  Control and if possible reduce weed infestations. Follow up control.	Reduce weed infestations. Focus on leucaena, neem the convulvulus creeper and passionfruit vine covering riparian vegetation. Areas of concern are the riparian area and levee bank. Undertake follow up control.	Prepare a weed management plan for the P1 area.  Reduce weed infestations in P1 area. Focus on leucaena and neem. Follow up control.  Remove weeds along foreshore reserve. Follow up control.	Prepare a weed management plan for the P1 area.  Remove dense stands of leucaena in P1 area and levee bank. Follow up control.  Reduce weed infestations in Parkland and Conservation VMUs managed for Kimberleyland and replant with local native species.  Develop plan to systematically remove woody weeds and replace with native vegetation for bat colony	Reduce neem infestations. Follow up control.	Reduce weed infestations with a focus on leucaena, exotic vines and neem. Eradicate salvinia
<b>Cumbungi management (see section 6.8)</b>		Remove cumbungi from swimming areas		Remove cumbungi where it has been shown in aerial photos and mapping to have rapidly increased. Leave buffer.  Remove cumbungi where access and views are impeded. Replant banks with smaller less invasive native sedges.	Reduce cumbungi infestation where it has been shown in aerial photos and mapping to have rapidly increased ie around creek inlet but leave cumbungi in and around drain outlets.	Remove cumbungi in front of caravan parks, proposed tourist bureau, boat ramp, Celebrity Tree Park.
<b>Slashing</b>	SWEK to maintain current slashed areas					
<b>Rehabilitation</b>		Plant native species following weed removal.  Plant native botanical gardens.  Golf course and Water-ski area – remove weeds and rehabilitate with native species.	Plant native species following weed removal.  Golf course and Kona CP – remove weeds and rehabilitate with native species.	Plant native species following weed removal		Plant a smaller native rush/sedge where cumbungi has been removed from banks. Replant riparian vegetation using native species. Identify and protect stands of remnant vegetation to be conserved.
<b>Fire Management</b>	<b>DEC to assist in developing Fire Management Plan for the area. SWEK and Local Fire Brigades to implement.</b>					
<b>Access</b>	Water Corporation and Dept of Water to control and reduce access into P1 area.  DEC and MG Corp to control and reduce access into Conservation Areas					

## 7. Cumbungi Management

### 7.1 Introduction

Narrow leafed cumbungi (*Typha domingensis*) is native to the Ord River. The damming of the Ord River created Lake Kununurra and Lily Creek Lagoon with the resultant permanent, slow flowing, shallow water, warm temperatures, and high nutrient levels providing optimum conditions for rapid cumbungi establishment and growth.

Within the study area, cumbungi has flourished and is considered by many to be a nuisance, particularly in Lily Creek Lagoon. Its tendency to dominate, its rapid spread and the need for management was noted to be of concern in the Lake Kununurra Foreshore Draft Management Plan (1987) and then again in the Draft Management Plan for Lake Kununurra (1995).

As *Typha domingensis* is native to the Ord River and its associated wetlands, a permit to clear native vegetation is required. These permits can be applied for through the DEC. A permit to disturb the bed and banks may also be required and can be obtained through the Department of Water.

The following section of the report focuses on cumbungi; its biology, the change in the study area covered by cumbungi, the advantages and disadvantages it can provide as well as recommendations for its control.

### 7.2 Biology

Cumbungi is a tough, rapid growing perennial sedge that can eventually become the dominant or climax species within shallow wetlands. It is an aggressive colonizer of wetlands with a muddy substrate, especially following disturbance such as cultivation of the soil surface (Watkins & McNee, 1985).

It is a prolific seed producer that can produce 300,000 to 400,000 seeds per plant. Seeds can live for four years before germination, are very light and are easily spread by wind or water movement (SWEK, 1987). The seed is also carried to new places by animals and birds, and on earth moving or agricultural equipment.

Cumbungi colonises new areas from both seed and rhizome growth. Seeds germinate in 5 to 20cm of water and a single seed can produce a rhizome (running root) system up to 3m in length (SWEK, 1987). These rhizomes can move from relatively shallow water to water depths in excess of 2m as they grow. These rhizomes can increase the size of existing colonies each year. Rhizomes survive from harvest most of the year, however less growth and recovery occurs if the plant is harvested during the cool dormant period.

Cumbungi thrives in fresh or lightly brackish water of less than 2 metres in depth. Nutrient rich sediment provides the ideal substrate for flourishing cumbungi plants. Their thick fast growing rhizomes act to trap more and more sediment, thus promoting their further exploitation of these ideal conditions. Its ability to use slow flowing, nutrient rich water in irrigation channels, dams, lakes and along river banks, enables it to dominate these preferred habitats.



### **7.3 Disadvantages of cumbungi**

Cumbungi is a troublesome weed in most states of Australia, as well as countries such as Papua New Guinea, New Zealand, Indonesia, Malaysia and the Philippines (Tasmanian Department of Primary Industries and Water, 2007).

Disadvantages or adverse effects associated with the spread of cumbungi include:

- formation of dense monocultures that may reduce habitat heterogeneity and eliminate other plants (Apfelbaum, S);
- reduction in the holding capacity and access to dams and waterways (Department of Primary Industries and Water);
- restriction and, in extreme cases, almost totally blockage of water flow in rivers, creeks, and irrigation and drainage channels (Department of Primary Industries and Water);
- destruction of the weed can result in a large amount of decaying vegetation which may pollute the water, increase nutrients or block pump intakes, channels and ditches;
- the dark, thick environment of cumbungi stands create suitable environments for mosquito larvae and other pests;
- reduce waterbird habitat and adversely affect fringing vegetation (Bartle, J et al)
- creation of a fire hazard (eg each dry season a number of unplanned cumbungi fires occur around Lake Kununurra and Lily Creek Lagoon and these fires can have a detrimental effect on sensitive riparian vegetation) (Watkins, D et al); and
- restricted views over the water and access to the water's edge.

### **7.4 Advantages of cumbungi**

Cumbungi is a natural part of many Australian wetland systems and has a number of important attributes. Cumbungi:

- stabilises banks to prevent erosion;
- uses nutrients and acts to strip nutrients from run off;
- provides a natural looking wetland fringe;
- acts as a litter trap; and
- provides cover, food, nesting places and habitat for water birds, aquatic insects, native fishes, freshwater invertebrates (eg chironomid) and frogs etc.

### **7.5 Change in area of cumbungi**

From relative obscurity, cumbungi now occupies broad tracts around the margins of Lake Kununurra and Lily Creek Lagoon. For example, the perimeter of Lily Creek Lagoon was over 75% cumbungi free in 1978 but by 1993 almost the entire margin was colonised (Watkins, D et al, 1997).

A survey by Gowland in 1981 estimated that the total area of cumbungi in Lily Creek Lagoon had increased approximately 100% between 1978 and 1981 (Sinclair Knight Mertz, 1995). The same report produced a diagram, which identified the changes in area covered by cumbungi from 1978 to 1993. Estimates in the change of cover between 1978 and 1993 indicated a 500% increase to an area of approximately 39.5ha (Sinclair Knight Mertz, 1995).

In an attempt to understand the changes that have occurred to the growth of cumbungi in Lily Creek Lagoon, the Sinclair Knight Mertz diagram was compared to a

set of aerial photographs from 1999, 2002 and 2006. Followed by ground-truthing, this enabled the production of a new map that included the changes from 1993 to 2006 (see Figure 9 below).

In the period from 1978 to 1993, cumbungi growth spread rapidly along the water's edge. Much of this growth mirrors the Lagoon edge contour. Since then, the growth has not been as rapid yet the growth that has occurred has tended to fill the contoured edges and small inlets. This appears to be creating a more uniform edge to the Lagoon.

This may be a result of natural colonisation (whereby cumbungi is growing out to cover water depths less than 2 meters) or there may be excessive amounts of sediment entering the lagoon which is trapped by the cumbungi enabling further growth into the lake.

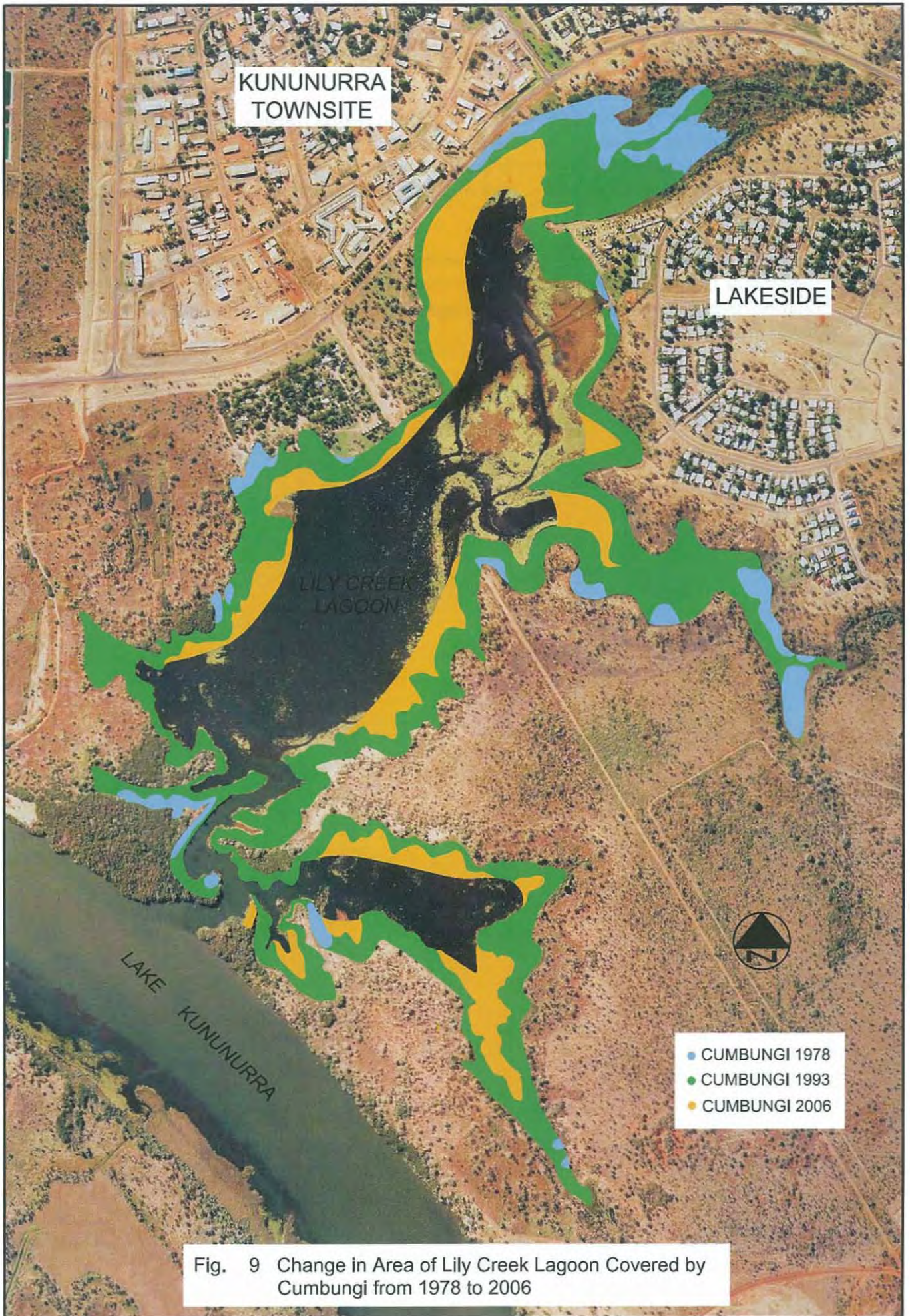


Fig. 9 Change in Area of Lily Creek Lagoon Covered by Cumbungi from 1978 to 2006

## **7.6 Predicted area available for colonisation by cumbungi**

It was predicted in the Sinclair Knight Mertz report that, if left unchecked, cumbungi would continue to spread until all areas of Lily Creek Lagoon less than 2 meters in depth were colonised. Its ability to trap sediment will increase the area of the Lagoon suitable for colonisation whilst the floating rhizomatous rafts will allow it to encroach into deeper waters.

The total area of the lagoon is estimated to be 135ha. The area currently colonised by cumbungi is estimated to be 71.43ha or 52.91%. This was estimated using aerial photography and mapping. In order to estimate the potential areas for cumbungi to spread to, depth readings of the lagoon were undertaken by boat. Figure 10 presents the points where depth was measured and the area available for colonisation estimated.

It is interesting to note that in areas of LMUs 4 and 5 where the depth was greater than 2 meters the cumbungi growth had seemed to reach its limit of growth. This area could be assumed to be stable in that cumbungi should not continue to grow out over the lagoon. However, the other end of the lagoon, upstream of the current boat ramp at Celebrity Tree Park, was shallow with the majority being less than two meters in depth. It can therefore be assumed that cumbungi has the potential to cover this area completely if not controlled.

## **7.7 Management Strategies**

The Sinclair Knight Mertz report (2005) recommended the short term management of cumbungi through the removal of 23.5ha of cumbungi or 60% of the existing cumbungi in Lily Creek Lagoon at the time. Removal was recommended in areas from which views and access are desired and for the prevention of further expanse of cumbungi dominated areas. It also recommended maintaining areas of untouched riparian vegetation.

In the Lake Kununurra Foreshore Draft Management Plan (1987) it was stated that "cumbungi's prolific growth represents a problem in areas where there is a need for foreshore access for recreational activities or tourism development. Priority areas will need to be established in eradicating the weed".

In response to this recognised problem, some locals take cumbungi control into their own hands through unauthorised and illegal spraying, fires and mechanical excavation. In order to manage this, a plan that outlines a coordinated approach to cumbungi control and removal is needed.

It is recognised that some removal of cumbungi needs to be performed. Removal should occur in sections where the need has been identified (as below) whilst other areas of untouched riparian vegetation of sufficient size should be maintained to support the reliant biological community. To have only cumbungi or open water reduces habitat diversity and biodiversity. Therefore, the aim of cumbungi removal is control not eradication. Planned cumbungi control should address community concerns as well as increase the interface between open water and cumbungi to provide a diversity of habitats and in turn increasing biodiversity.



Figure 10: Depth measurements and estimated area available for cumbungi growth in Lily Creek Lagoon

## 7.8 Areas and amounts for control

Total exclusion of cumbungi will not be possible nor would it be desirable as cumbungi provides a number of key roles in the waterbody.

The Foreshore Plan (2006) highlighted a large portion of Lily Creek Lagoon for cumbungi control (see figure 11). Specific areas of high motor traffic and high aesthetic values or commercial and recreational use were listed within the lagoon for specific cumbungi removal. The specific areas identified are:

- Lily Creek Lagoon boat ramp;
- Kimberleyland Caravan Park;
- Lakeside Resort;
- Celebrity Tree Park;
- Celestin Nominees lease area;
- Swim Beach; and
- Ski Beach.

Another area identified was parallel to the Victorian Highway yet due to erosion of the steep banks this plan recommends that the cumbungi be left along here until the banks can be stabilised and reshaped through infilling.

The initial areas highlighted for ongoing control (see Figure 12) make up a total approximate area of 5.5ha or 0.076% of the area currently colonised by cumbungi. This area is recommended for immediate and ongoing removal of cumbungi. Available removal methods, the effect of cumbungi removal on water quality, and the need for planned future developments (such as the Visitors Centre) will all guide the identification of additional future cumbungi removal areas within the cumbungi control zone highlighted in the Foreshore Plan (2006) and presented in Figure 11.

From discussions with DEC it was recommended that a precautionary approach be taken and that some uncleared strips be left between the cleared areas, to provide alternate habitats for biodiversity. Along the banks of the wetland it is recommended that cumbungi stands of no larger than 100m in length be removed. In between these areas cumbungi stands of no less than 10 meters in length should be left.

By targeting cumbungi removal in specific areas, the majority of cumbungi in Lake Kununurra and Lily Creek Lagoon will remain as uninterrupted and undisturbed. Due to its effectiveness in nutrient stripping and sediment control, cumbungi should not be removed around drains or in areas prone to erosion.

Where cumbungi is to be removed right to the foreshore then other species of rushes and sedges that will not obstruct access and view should be planted. Some recommended species are listed in Table 17 yet others may also be suitable as long as they are locally native. If the bank is not suitable for this type of planting then a formalised structure such as a retaining wall may be considered yet is not preferred. Bank treatment and protection is necessary to prevent undercutting of banks from boat wash and change in water levels.

A permit to clear native vegetation as well as a permit to interfere with the bed and banks of a waterway will be needed for ongoing cumbungi control. These permits can be applied for through the Department of Environment and Conservation and the Department of Water respectively.



Figure 11 Cumbungi Control areas as identified in Lake Kununurra Foreshore Plan (2006)



**Fig 12 Cumbungi control areas for Lily Creek Lagoon**





## **7.9 Recommended control methods** (for a full list of removal options please see Appendix 9)

### ***Harvester (preferred)***

With the use of an aquatic weed harvester, cumbungi and other water plants and weeds could be harvested below water level throughout most areas of Lily Creek Lagoon and Lake Kununurra. Harvesting is recommended for the cooler months of June and July when growth is slowest and removal will impact least on the comb crested jacana and purple swamp hen that use the cumbungi for breeding (WA Museum, 2005).

This method has the least physical impact and does not add chemical residue or decomposing biomass to the water. Mechanical harvesting could also reduce populations of ribbon weed and Potamogeton, subsurface weeds that can be a nuisance in critical areas of boating and recreation (see Foreshore Plan or Sinclair Knight Mertz report).

Kimberley Environmental Solutions has expressed interest in providing a service by contract to harvest cumbungi and other aquatic weeds such as pond and ribbon weed. The proposal involves the construction of a suitable harvester and the use of the harvested weed for cattle feed. Such a commercial venture would be welcomed.

### ***Excavation and removal of rafts (if harvester not available or economically viable)***

- Excavation of cumbungi with long reach excavator from areas that have historically been controlled. Manual mechanical cutting of regrowth with whipper snipper or shears. Digging of bed next to banks to a depth of 2 metres or more to ensure the whole plant is removed and to prevent rapid regrowth.
- Machete rafts from main colonisation. Loop chain or rope around raft and then drag out to lake with boat so that rafts go through Diversion Dam gates. This would need to be approved by Water Corporation.
- Care must be taken when using heavy equipment near waterways to avoid damage to the structure of the waterway.