NATURAL RESOURCE MANAGEMENT PLAN FOR THE BROCKMAN RIVER CATCHMENT

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Water and Rivers Commission

NATURAL RESOURCE MANAGEMENT PLAN FOR THE BROCKMAN RIVER CATCHMENT

Prepared by
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Water and Rivers Commission

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Cover Photograph: Brockman River, Lower Chittering

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The many community members that attended the forum provided valuable input. The community groups within the catchment also provided support, information and feedback.

Chittering LCDC
North Swan LCDC
Wannamal Lake Catchment Group
Gingin LCDC
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The Brockman River catchment, at 1520 square kilometres in area, is the largest catchment in the lower Avon and upper Swan catchments. The Brockman River is approximately 90 kilometres in length and flows through the Chittering Valley along the Darling Scarp.

The economy and livelihood of the landholders in the Brockman River catchment are currently based on the natural resources of land and water. However, the natural resource base of the catchment is already deteriorating and the community are concerned by this deterioration and recognise the implications of declining native vegetation, poor water quality, salinity and soil degradation.

In 1996, discussions between Water and Rivers Commission Regional Services in Northam, Western Australian and local government authorities in the catchment documented their requirements for natural resource management. The Shire of Chittering responded to these discussions by wanting to improve the water quality in what they saw as the much-neglected Brockman River and its catchment. Together they developed a successful funding application through the Natural Heritage Trust Fund to prepare an integrated natural resource management plan for the Brockman River catchment.

The natural resources within the catchment were assessed and documented to establish baseline information. From this information, targets and priorities were set out.

The preparation of this Management Plan followed a forum to which 70 community people attended. The issues and ideas that came from this forum were developed into this management plan. It was developed with community input and is designed for use by the community to address the issues of concern by sorting out what's really relevant and practical and building on that through a catchment approach.

Natural resource management plan for the Brockman River catchment

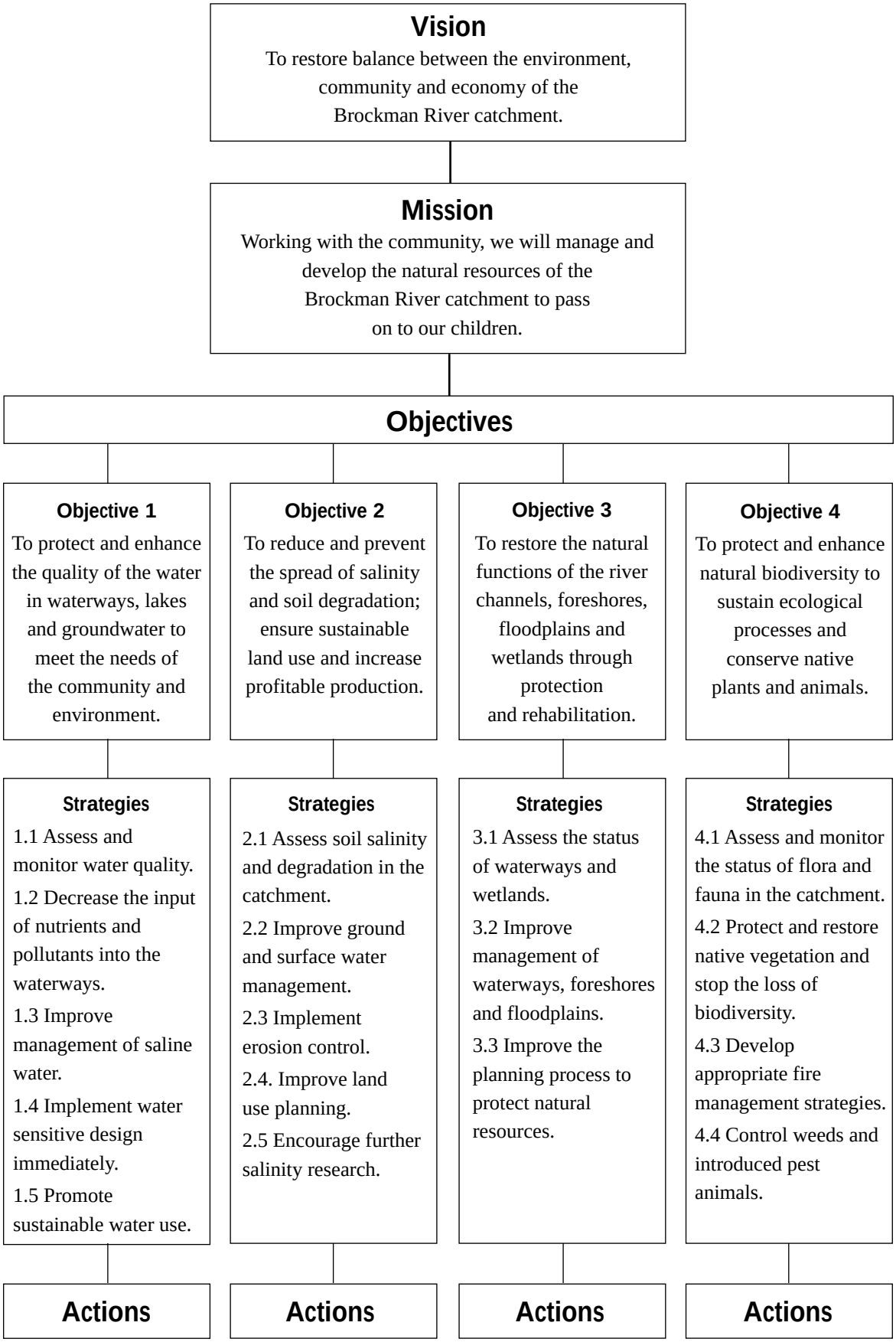


Figure 1: Catchments in the Swan-Canning catchment.

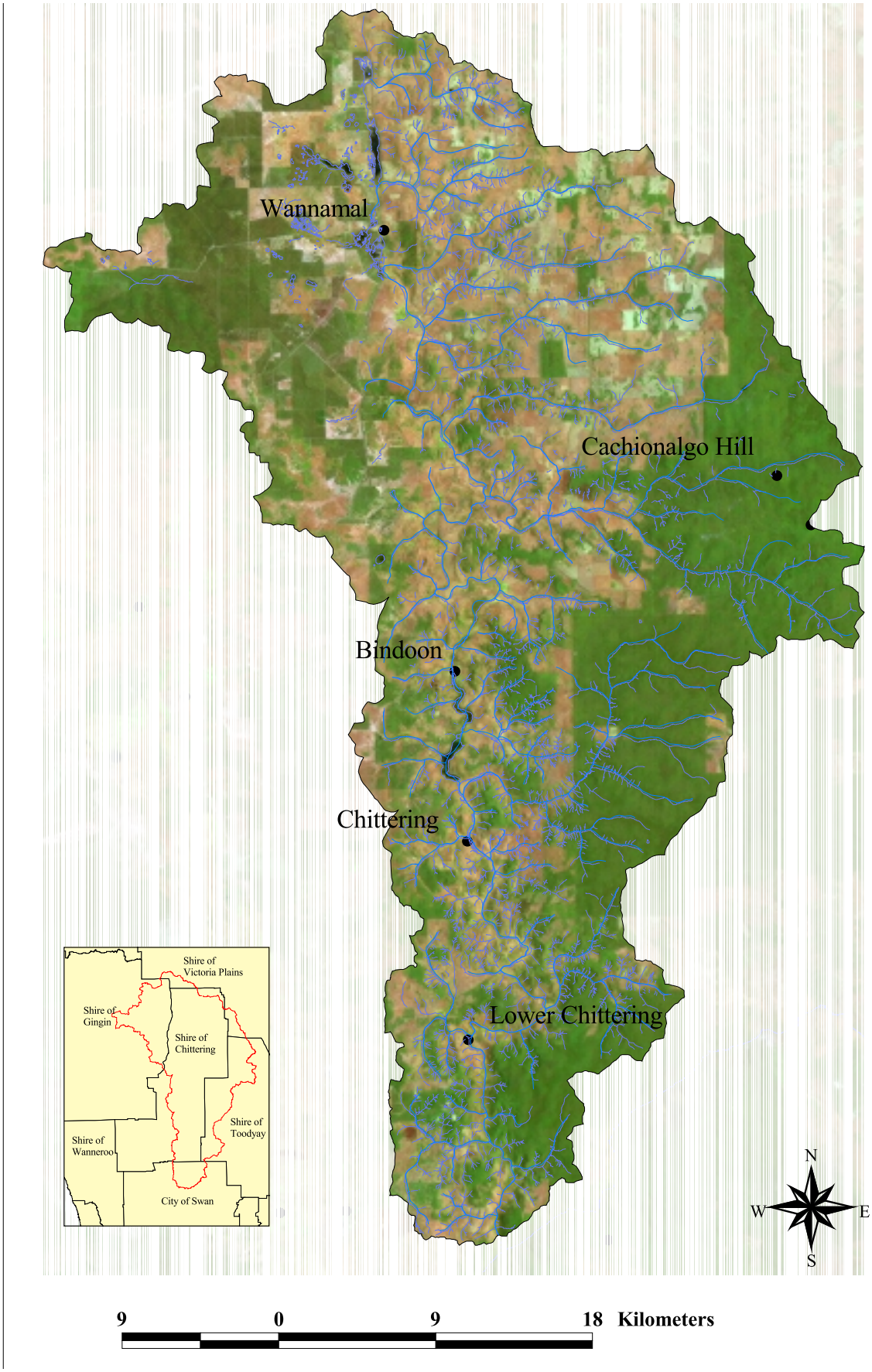
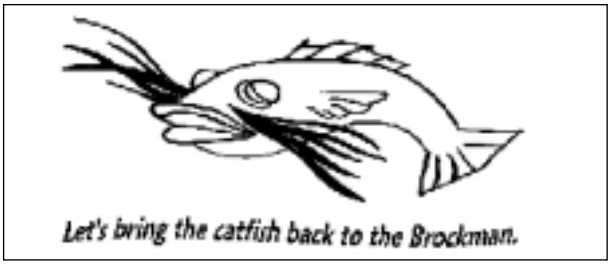


Figure 2: Brockman River catchment.

1. Why we need a natural resource management plan for the Brockman River catchment

Let's bring the catfish back to the Brockman!



1.1 The vision

The Brockman River Catchment Group, made up of representatives from the community, have a shared vision for the future of the Brockman River and its Catchment.

VISION

To restore balance between the environment, community and economy of the Brockman River catchment.

It is hoped that you will all join with them to undertake this mission.

MISSION

Working with the community, we will manage and develop the natural resources of the Brockman River catchment to pass onto our children.

1.2 Our community and their catchment

At 1520 square kilometres, the Brockman River catchment is the largest in the Swan River catchment (figure 1) with sixty-eight sub-catchments identified within the catchment boundary (Lloyd, 2000). While the Brockman River flows into the lower Avon River and is thus, part of the Avon River catchment, its greatest impact is on the Swan River and is therefore considered part of the Swan River catchment. The Brockman River itself follows the Darling Scarp, flowing through the deeply incised Chittering valley to enter the Swan- Avon River 40 kms upstream from Perth.

The greatest part of the Brockman River catchment lies within the Shire of Chittering (figure 2). The principal urban area within the catchment is the township of Bindoon. Other localities within the catchment are Wannamal, Mooliabeenie, Lower Chittering, Maryville Downs and South Chittering.

Currently, an estimated 3,000 people live in the catchment. Most of the population resides in Bindoon, rural residential estates or on farming properties. Generally, farms in the northern portion of the catchment are larger enterprises to about 2000 hectares. Properties in the southern part of the catchment tend to be smaller with many subdivisions containing 2 to 20 hectare lots.

The economy of the Brockman River catchment and the livelihood of its residents are currently based on the natural resources of land and water. Land use in the north of the catchment is mainly sheep and cattle grazing, and cropping of cereals, canola, lupins and hay. In the south, it is mainly horticulture such as citrus and grapes.

Large areas of native vegetation remain in the eastern part of the catchment in the Avon Valley National Park, the proposed Julimar Conservation Park (currently State Forest) and in the Department of Defence Bindoon Training area. Other areas of native vegetation in the catchment are located within the ten CALM nature reserves and on some private property.

The Brockman River meanders through four wetland reserves, the Mogumber, Wannamal Lake, Betts and Chittering Lakes Nature Reserves, as it flows southward to the Avon River.

The natural resource base of the catchment is deteriorating because of widespread clearing of native vegetation and the increased economic pressure on agricultural land to be more productive. This leads to problems of increased salinity, waterlogging, erosion and pest plant and animals. Waterways are also affected by increased sediment loads and reduced water quality.

The Shire of Chittering has an estimated population of 2594 in 1999 with a population growth of 7.1%. Projections suggest that by 2016, 3232 people will reside in the Shire (Bureau of Statistics, 2001). The North East

Corridor Extension Strategy (2000) estimates that by 2026, 9,750 people will reside in that study area of which 5350 would be new residents. However, the Brockman River catchment only includes that part of the study area in east Bullsbrook indicating that the population growth in the catchment probably falls between 3232 and 9,750 over the next 15 to 20 years. Other local government areas within the catchment are mostly farming areas in which population growth is assumed to remain static or decline.

To support this predicted population increase, the southern area of the catchment has been identified in the Avon Arc Sub-Regional Strategy (1999), the Northeast Corridor Extension Strategy (2000), and the Chittering Town Planning Scheme 6 (2002) as an area suitable for rural residential subdivision (Shire of Chittering TPS 6, 2001).

Community members in the Brockman River catchment are concerned by what they see and recognise the implications of declining native vegetation, poor water quality, soil salinity, erosion, nutrient runoff and rural drainage issues. Failure to address these issues in the future will impact on the whole community.

All these issues are related and cannot be looked at in isolation. An integrated plan for action is needed, with a shared vision for the future to prevent the natural resources in the catchment degrading further.

1.3 This action plan and its players

This natural resource management plan is a tool to help individuals, groups, local government authorities and government agencies to first agree on priority issues and then to determine the best actions to address the issues. It will then become a practical blueprint to improve the land and waterways in the Brockman River catchment.

It is presented in a loose-leaf binder in order to ensure it is a working document and not one that sits on a shelf. Sections can be updated, added to, or shuffled in priority as necessary. New supporting information can be filed at the rear of the Plan as it comes to hand.

Individuals living and managing land in the Brockman River catchment are key players in this natural resource management plan. They are the ones who can make the most difference and it’s their resources at stake.

Existing groups of individuals involved in natural resource management are:

- Brockman River Catchment Group, set up as a reference group to gain community input into the planning process
- Chittering LCDC
- Gingin LCDC
- North Swan LCDC
- Wannamal Lake Catchment Group
- Toodyay LCDC

Local government authorities are important stakeholders in natural resource management. The Brockman River catchment encompasses five local government authorities. The Shire of Chittering encompasses the greater proportion of the Brockman River catchment (53%) and is one of the major proponents in the project. The remaining area of the catchment falls within the Shires of Toodyay (19%), Gingin (18%), and Victoria Plains (5%). The southernmost part of the catchment east of Bullsbrook is part of the City of Swan (5%).

State government agencies involved in natural resource management in the Brockman River catchment are:

- Department of Environment, Water and Catchment Protection (DEWCP) (amalgamating Water and Rivers Commission and Department of Environmental Protection);
- Water and Rivers Commission;
- Department of Environmental Protection;
- Department of Agriculture;
- Western Australian Planning Commission, Ministry for Planning (now Department of Planning and Infrastructure;
- Department of Conservation and Land Management;
- Westrail;
- Main Roads Western Australia.

The Water and Rivers Commission is the lead agency for this project.

1.4 The planning process

In 1996, the Water and Rivers Commission Regional Services office in Northam carried out discussions with surrounding local government authorities to document their requirements for natural resource management. The Shire of Chittering responded to the initiative seeing it as an opportunity to improve the water quality in what they saw as the much-neglected Brockman River and its catchment.

Together, the Water and Rivers Commission and the Shire of Chittering applied for funding through the Commonwealth Government Natural Heritage Trust Fund to develop an integrated natural resource management plan for the Brockman River catchment. This application was successful and Water and Rivers Commission appointed a project officer. The following process has been carried out:

- Appointment of a steering committee of five people representing Water and Rivers Commission, Department of Agriculture, Department of Conservation and Land Management, the Shire of Chittering and the community to advise the project officer;
- A public forum and workshop was held in Bindoon on 20th March 2000 to discuss and record community concerns and outline the issues within the Brockman River catchment;
- Community members were invited onto the Brockman River catchment Group as a reference group to provide community input into the planning process;
- The condition of the Brockman River has been assessed by the project officer and documented;
- Completion of the draft Integrated Natural Resource Management Plan;
- A review of the draft management plan by the community and other stakeholders.

The next step is to:

- Prepare a final report incorporating the outcomes of the review process.

To make this plan happen there is a need to:

- Develop an implementation of the plan;
- Outline methods to encourage continued involvement of the wider community, local community groups and all stakeholders in the protection and enhancement of the natural resources in the catchment;
- Ensure endorsement of the plan by other agencies and local government authorities that can influence the recovery of the Brockman River and its catchment and to incorporate the plan into their own goals;
- Undertake appropriate performance monitoring and evaluation that will lead to evaluation and refinement of policies, strategies and management plans.

1.5 Related work

Several plans and strategies relating to the natural resource base of the Brockman catchment have been conducted. These include:

- The Swan Region – *a Natural Resource Management Strategy.* (2002). Swan Catchment Council Western Australia (public comment).
- *Natural Resource Management Plan for the Avon River Basin.* (2001). Avon Working Group.
- *Swan-Canning Clean Up Program Action Plan.* (1999). Swan River Trust.
- *Shire of Chittering Local Planning Strategy.* (2002).
- *Town Planning Scheme 6.* (2002). Shire of Chittering.(public comment).
- *Groundwater Information and Management Options for the Brockman River Catchment.* (2001). Water and Rivers Commission. (Unpublished).
- *Salinity Survey in the Shire of Chittering.* (2002). Ken Angell. Department of Agriculture.
- *Shire of Chittering Land Capability and Management Study.* (1999). Land Assessment Pty Ltd.
- *Degradation in the Brockman River & Ellen Brook Catchments.* (2000). B. Lloyd. Department of Agriculture.
- *Avon Arc Sub-regional Strategy.* (1999). Western Australian Planning Commission.
- *Northeast Corridor Plan.* (2000). Western Australia Planning Commission.
- *Roadside Vegetation; undervalued and under threat. Developing a Management Plan and Code of Practice for the Shire of Chittering, Western Australia.* (2001). Kristy A. Oliver. Curtin University of Technology. 2001.

This plan does not duplicate this work, but rather links with and draws on these studies. It attempts to integrate their findings and management recommendations, sort out what's really relevant and practical, then filter and build on them through a catchment approach from a community point of view – people on the ground.

2. What we have in the Brockman River catchment

2.1 Our natural resources

The major assets of the catchment are identified as the primary natural resources:

- Water;
- Soils and other geological formations, and;
- Natural biodiversity.

In addition, it is necessary to consider related assets when addressing the environmental, economic and social aspects of natural resource management. These are:

- Primary production, and;
- Cultural assets, which include indigenous and non-indigenous aspects and social aspects such as amenity, intrinsic values and landscape values (Mount Lofty Ranges INR management Group, 2002).

2.1.1 Climate

The catchment experiences a typical Mediterranean climate of hot dry summers and cool wet winters. Summer has a range from 33˚C in February to 18˚C in July with a mean average temperature of 32.2˚C. Winter has a range of 18˚C in February to 8.2˚C in July with a mean average temperature of 7.0˚C.

Average rainfall for the southern portion is 800mm/yr decreasing to less than 600mm/yr in the northern regions (Bureau of Meteorology, 1998).

Most water courses in the catchment flow during the winter months and have reduced or no flow during the summer months. Weather patterns typically have strong easterly to north-easterly winds in the morning and south-westerly in the afternoon during summer with thunderstorms and lightning common. During winter the winds come from the northwest to southwest.

2.1.2 The river, major tributaries and wetlands

The Brockman River flows south along the western edge of the Darling Plateau through a deeply incised valley to join the Avon River between the Walyunga and Avon Valley National Parks. The Wannamal Lake system to the north, and seasonal streams flowing from the east and west, drain directly into the Brockman River.

The Wannamal Lake system is listed as a culturally and ecologically significant wetland (Environment Australia, 2001). Analysis of water quality readings (J. Lane, CALM, pers. Comm.) since 1978 indicate that salinity in the lake is increasing (figure 3). Anecdotal information at the time of settlement in the area during the 1890's indicates that the water was fresh enough to support vegetable gardens and fruit trees (Buchanan, 1996). Observations made by long time residents of the area suggest that during the early 1950's the water was relatively fresh and that good clover pastures grew in nearby paddocks that are now bare salt scalds (Pers. Comm. D. Purser). A suite of smaller lakes and wetlands to the west, including Lake Bullingarra, are still fresh.

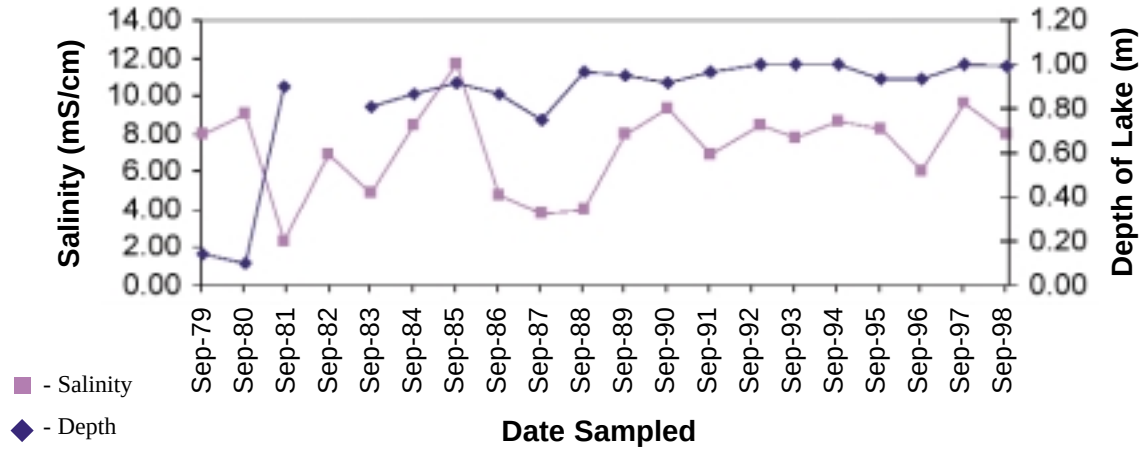


Figure 3: Salinity and depth of Lake Wannamal recorded in spring 1979-1998. (J. Lane, CALM)

The township of Bindoon is situated on the Brockman River where it flows into Lake Needoonga, part of the Chittering Lake system and a listed significant wetland (Environment Australia, 2001).

In 1975, CALM constructed a weir at the end of the Chittering Lakes Nature Reserve to control the levels of Chittering and Needoonga lakes. The gates in the weir regulate the flow of water and the depth of the lakes. The weir was installed after a drain was constructed that caused the lakebed to drain prematurely, impacting on the bird-breeding season.

The aim of the water management is to achieve a desirable water level in the lake throughout the year. The lake should be dry from mid-March to the opening rains and the more saline waters that accumulate during mid to late summer should not be released downstream in an uncontrolled manner (P. Dans, pers. Comm.). Thus, during the summer months, only the catchment south of the weir contributes to the water flow in the Brockman River.

The water levels in Lake Chittering are managed for:

- Wildlife management to sustain the lake vegetation survival and regeneration and the annual bird breeding season;
- The farming industry to avoid excessive flooding of adjoining agricultural land, and;
- The horticultural industry to avoid releasing excessively saline waters down the Brockman River that adversely impacts the opportunity for farmers to irrigate horticultural crops.

Guidelines have been developed to ensure the requirements of conservation, neighbours and downstream users are all considered (CALM, 1999).

2.1.3 Landforms, geology, & soils

The Darling Plateau, an ancient landmass worn down by erosion, underlies most of the eastern portion of the Brockman River catchment. To the west, the catchment extends over the Dandaragan Plateau. A major regional fault line, the Darling Fault, separates these two geomorphic regions.

The Darling Plateau

The Darling Plateau is made up of two major rock sequences. The first sequence is a 10-km wide belt of crystalline rocks referred to as the Chittering Metamorphic belt. Intense erosion within the Chittering Metamorphic belt has produced a major north-south trending valley system in which the Brockman River flows south. The second sequence to the east is granitic rock covered with a lateritic cap referred to as the lateritic uplands(Wild and Low, 1978). Laterite is sometimes referred to as ironstone or coffee rock.

The deeply incised Chittering Valley is characterised by dissected, steep slopes and domed granite outcrops high in the landscape with variable and complex soils. Parent materials may be weathered or unweathered gneiss, granite or dolerite or may occur as colluvium. Colluvial lateritic material from the plateau surface may extend down slope. Yellow duplex and brown duplex and gradational earths are the most common soils. Generally, the yellower soils are associated with the granite, and the red and brown soils with dolerite dykes (King and Wells, 1990). Loamy soils, now extensively cleared for agriculture, are found on the lower valley slopes and floodplain.

The lateritic uplands are typified by undulating, dissected land surfaces with rubbly, pale orange lateritic soils and pea gravels. Red alluvial, clay soils characterise the valley floors while upland remnants of the plateau surface form higher land with sands and sandy gravels interspersed with laterite outcrops. Saline soils occur within the valley floors.

Most of the area outside reserves is cleared for agriculture with small pockets of native vegetation along fence lines and watercourses. Gully erosion is the predominate erosion hazard but landslips have occurred on the steeper slopes of the Chittering Valley.

The Dandaragan Plateau

The Dandaragan Plateau to the west of the Darling Fault is a wedge shaped erosion remnant of the Perth Basin with sediments covered by recent deposits of sand and laterite (Wild and Low, 1978). Sandplain features dominate the landscape with broad U-shaped valleys, sand-filled drainage lines and some breakaways. The soil pattern is closely related to topography (Churchward, 1980). Brown deep sands, yellow deep sands, pale deep sands, sandy gravels and shallow gravels are dominant, with red deep sandy duplex soils on the valley floors (Moore, 1998).

Soil landscapes are outlined in the Shire of Chittering Land Capability and Management Study prepared by

Land Assessment Pty. Ltd. Part 1 – Working Paper. A summary appears in Appendix 1.

2.1.4 Native vegetation

Field studies of the distribution of vegetation complexes in the Brockman River catchment were completed using existing vegetation maps produced as part of the System 6 study (DEP). The extent and condition of native vegetation in the catchment is shown in figure 4 and summarised in table 1. Native vegetation covers approximately 770 km^2, or 51% of the total area of the region (1,520 km^2). The greatest area of native vegetation occurs within the western forest/woodland and eastern heath regions while the central area consists of severely dissected remnants within an agricultural landscape. These areas have been heavily cleared and now the remaining remnants are generally small and dispersed.

Approximately 201 km^2 (13%) is reserved for conservation purposes with much of this conservation land being confined to the eastern Darling Scarp forests and north-western sandplain. The landuse and number of vegetation remnants in the Brockman River catchment is outlined in table 2 and figure 5. Size class of remnants by landuse is shown in table 3.

Twenty System 6 vegetation complexes are recognised in the catchment and are shown in figure 6. Figure 7 and table 4 show the remnant vegetation complexes represented now and the spatial extent of vegetation complexes pre and post clearing and currently reserved. One complex (Williams-Avon-Brockman-Mumballup Complex) has less than 20% remaining of its original area, while twelve complexes have less than 10% of their original extent reserved. The complexes that remain best represented occur in the east and northwest, and correspond to the greatest areas of remnant vegetation (Connell and Ebert, 2001).

Heddle *et al* (1980) identified vegetation complexes for each of the soil landform associations defined by CSIRO (Churchward and McArthur, 1978), and are related to the geomorphic units (see appendix 2).

Table 1: Spatial extent of remnant vegetation in the Brockman River catchment.

Total area (km^2)	1,520
Number of remnants	2,000
Total area of remnant vegetation (km^2)	770
% Total remnant area	51%
Remnant vegetation reserved (km^2)	201
% Original area reserved	13
% Remnant area reserved	26

Source: Connell and Ebert (2001).

Table 2: Landuse of remnant vegetation in the Brockman River catchment.

Tenure	**Number**	**Area km^2 (% of remnant area in brackets)**
Study area	NA	1521
Conservation and Natural Landuse	517*	629 (82%)
Other Landuse	5481*	141 (18%)
CALM Reserved**	31*	201 (13%)
TOTAL	1521	770 (51%)

* the comparatively large number of remnants is due to the road/cadastre/landuse intersections process detailed in the methodology.

Table 3: Size class of native vegetation remnants by landuse.

Remnant size (ha)	**Conservation and Natural Landuse**		**Other Landuse**		**CALM Reserved***		**Total****	
	Number	Area (km^2)	Number	Area (km^2)	Number	Area (km^2)	Number	Area (km^2)
< 1 ha	324	0.67	3667	9.94	1	0.0	3991	10.61
0 to 10	82	2.77	1542	45.48	1	0.0	1624	48.25
10 to 50	43	10.27	231	48.31	4	0.6	274	58.58
50 to 100	16	11.87	31	21.77	7	2.2	47	33.64
100 to 500	34	67.09	10	15.36	2	1.4	44	82.45
> 500	18	536.49	0	0	16	197.0	18	536.49
TOTAL	517	629.18	5481	140.86	31	201.2	5998	770

Note: Remnant area calculations are based on a remnant vegetation – landuse GIS intersection; hence their numbers may not match Remnant counts in some other tables.
* CALM Reserved land is a subset of the Conservation and Natural Landuse category.
** Total Number and Total Area are calculated as the sums of the first two landuse categories.

Table 4: Spatial extent of vegetation complexes pre- and post-clearing and currently reserved.

Vegetation complex	**Pre-clearing**		**Post-clearing**		**Reserved**		**Retained**	**Reserved**
	No.	Area (ha)	No.	Area (ha)	No.	Area (ha)	**(%)**	**(%)**
Bindoon Complex	3	8900	258	2441	6	191	27.4	2.1**
Cook Complex	14	542	22	416	0	0	76.7	0.0**
Coolakin Complex in low rainfall	29	20560	582	9085	20	3270	44.2	15.9
Cullula Complex	1	18977	205	10411	2	826	54.9	4.4**
Darling Scarp Complex	4	80	8	33	0	0	41.7	0.0**
Dwellingup & Yalanbee Complex, low - medium rainfall	2	1164	9	1073	4	688	92.2	59.1
Dwellingup,Yalanbee & Hester Complex, low - medium rainfall	5	1535	8	1532	8	1398	99.8	91.1
Helena Complex, low - medium rainfall	1	4358	71	2127	4	90	48.8	2.1**
Karamal Complex-South	1	5805	36	4180	2	2704	72.0	46.6
Michibin Complex	5	19342	407	7940	6	1353	41.1	7.0**
Mogumber Complex-North	2	2225	8	1428	0	0	64.2	0.0**
Mogumber Complex-South	8	3546	111	1383	0	0	39.0	0.0**
Murray & Bindoon Complex, low - medium rainfall	3	12456	299	5424	14	603	43.6	4.8**
Nooning Complex	1	2698	141	553	2	170	20.5	6.3**
Pindalup & Yarragil Complex, low - medium rainfall	11	4934	76	3514	11	1648	71.2	33.4
Reagan Complex#	1	3	3	0.6	0	0	17.6*	0.0
Wannamal Complex	6	2775	85	888	6	41	32.0	1.5**
Williams-Avon-Brockman-Mumballup Complex	1	959	82	136	1	2	14.2*	0.2**
Yalanbee & Dwellingup Complex, low rainfall	3	16922	153	13714	14	5098	81.0	30.1
Yalanbee Complex in low rainfall	50	24316	804	10730	15	2190	44.1	9.0**
TOTAL	151	152104	3368	77017	115	20272	50.6	13.3

NOTES

vegetation complex found at the periphery of the catchment

* less than 20% of original area remains

** less than 10% of original area reserved

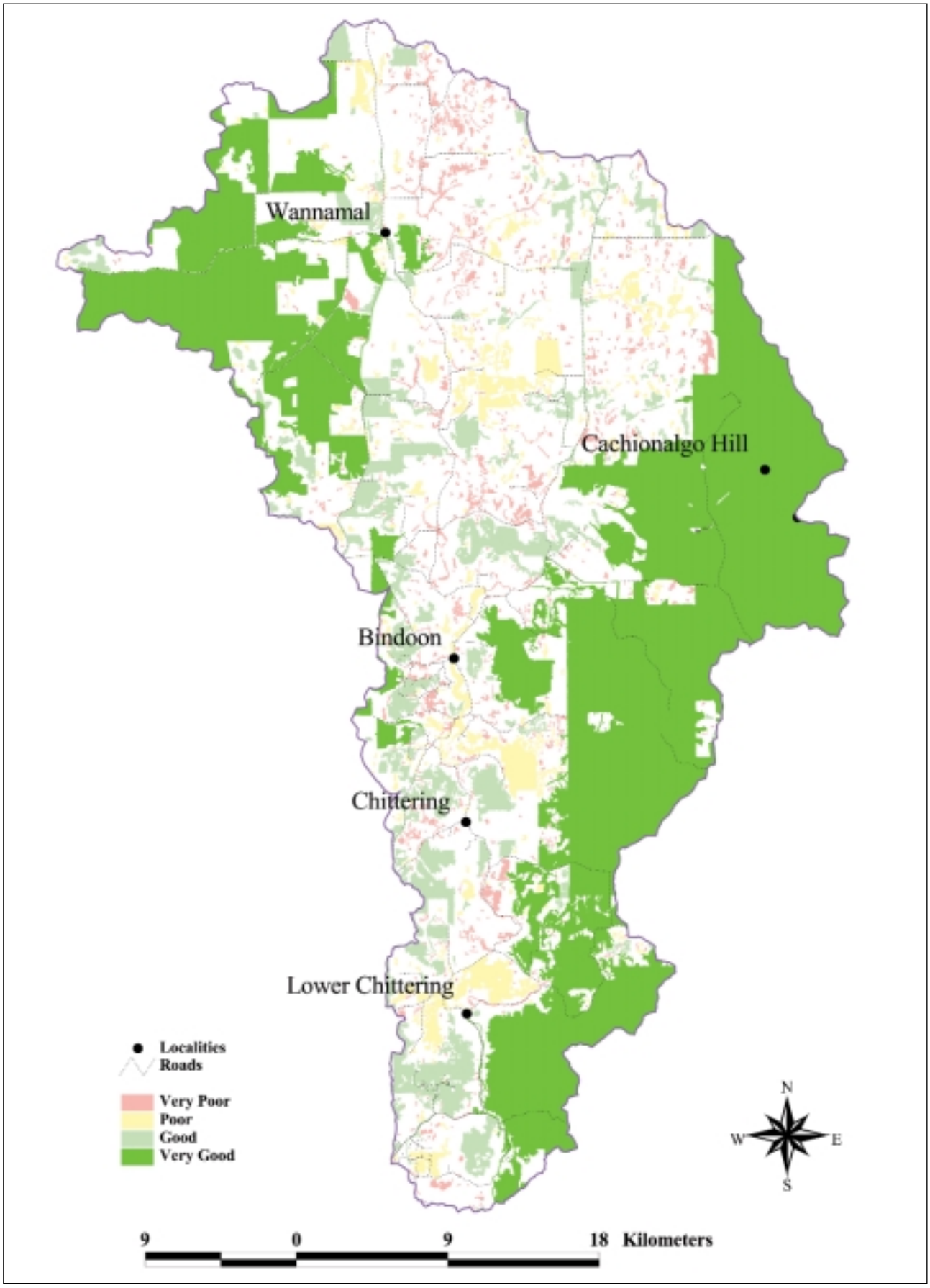


Figure 4: Condition of Remnant Native Vegetation.

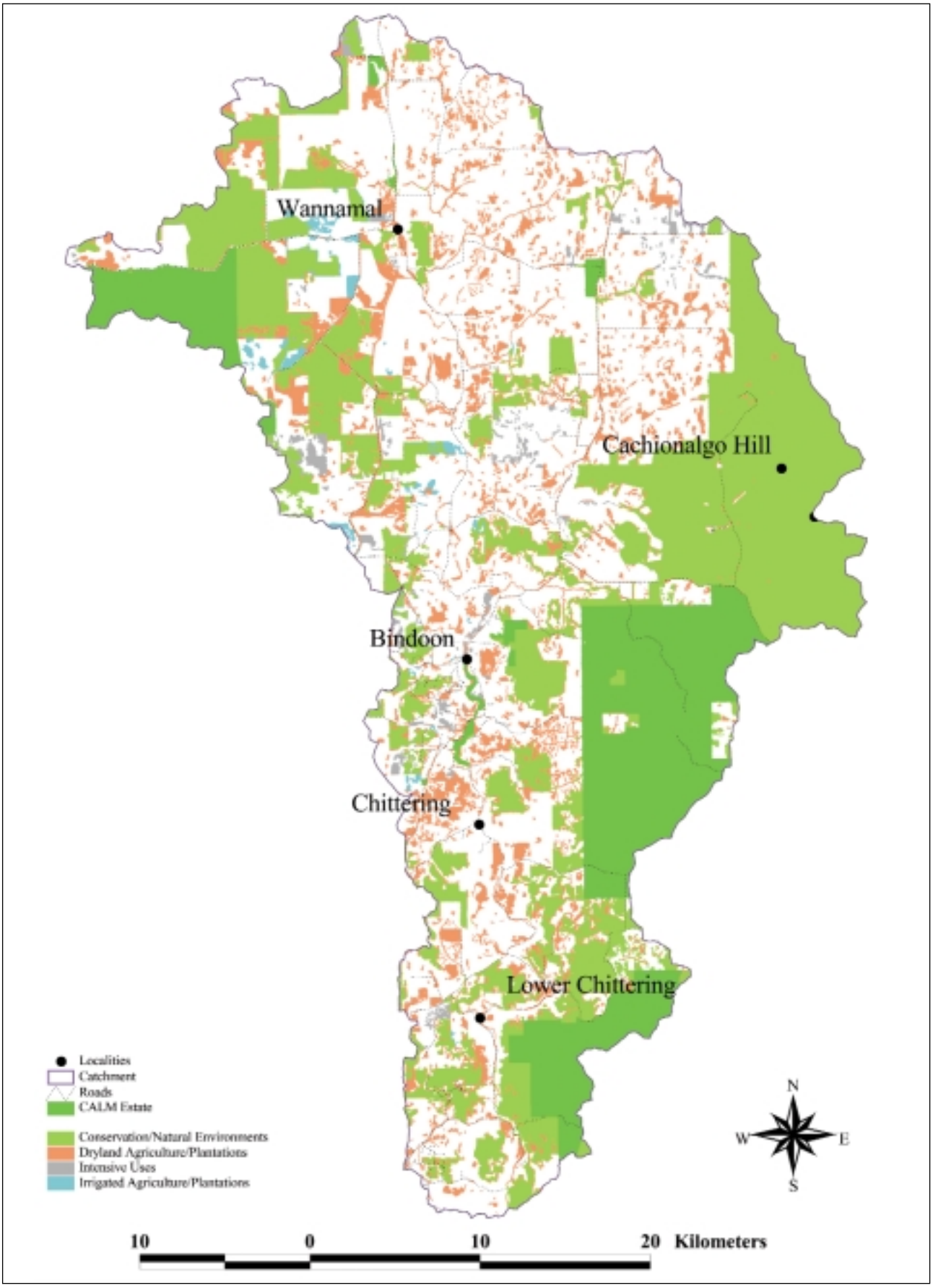


Figure 5: Landuse of remnant vegetation in the Brockman River catchment.

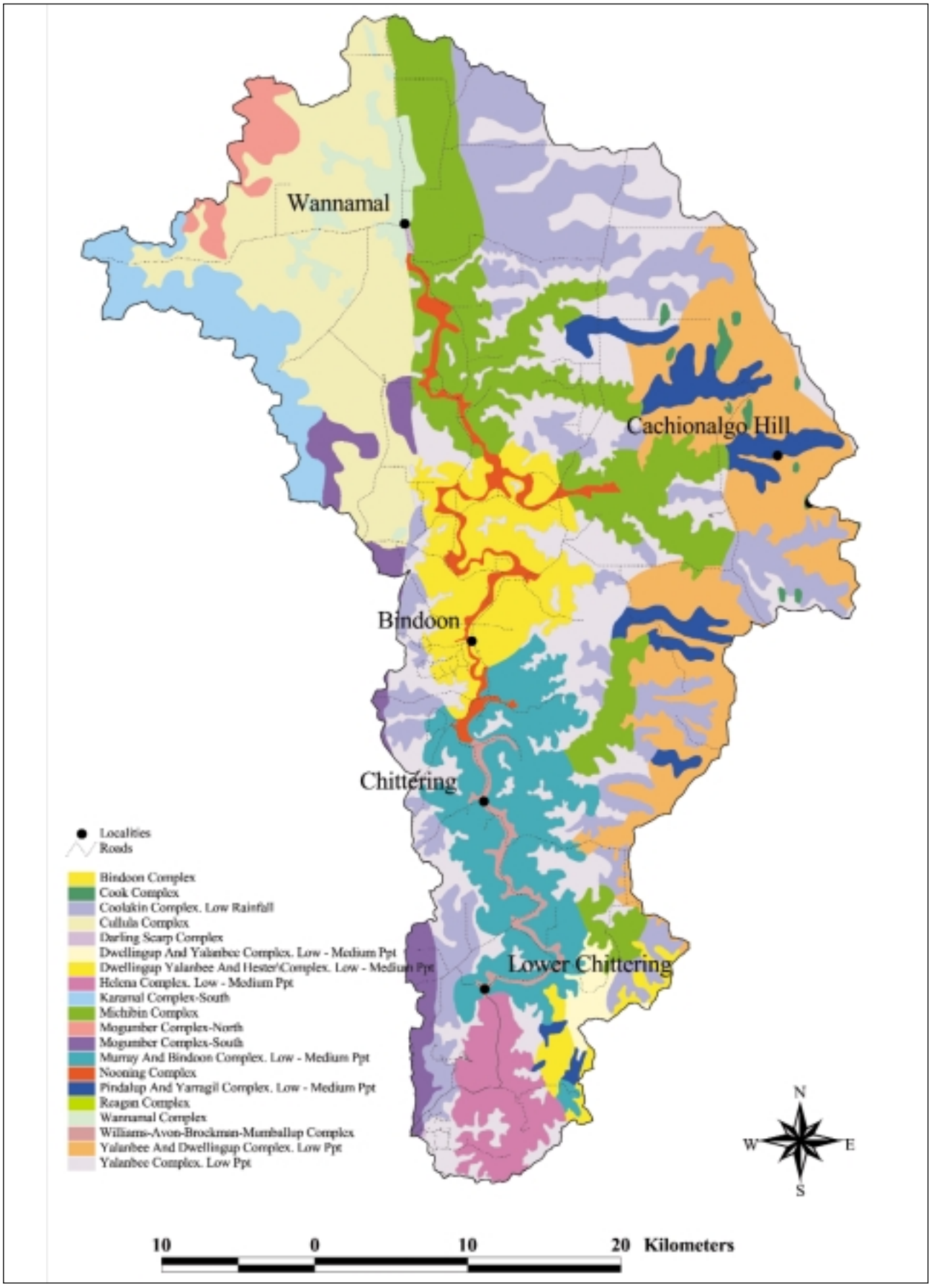


Figure 6: System 6 vegetation complexes in the Brockman River catchment pre-settlement.

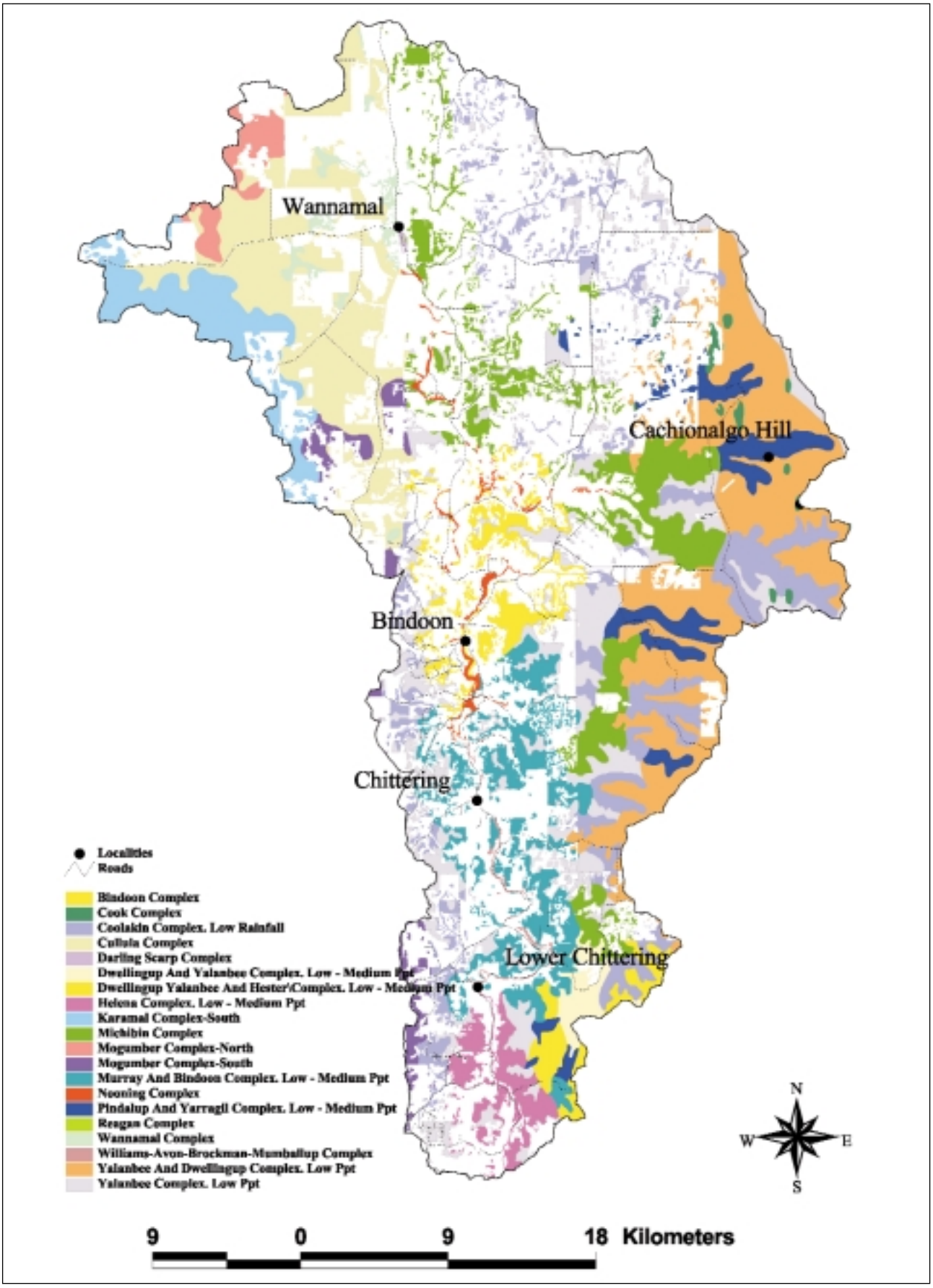


Figure 7: Remnant vegetation complexes in the Brockman River catchment.

2.1.5 Native plants and animals

In the Brockman River catchment, continued destruction and fragmentation of habitat through clearing, grazing, land degradation, declining water quality, introduction of exotic species, disease and changes to fire regimes has contributed to declining native plant and animal populations. This decline has caused loss of native species and will lead to other species becoming vulnerable.

However, some animals have adapted well to the changed landscape and their numbers continue to increase. These include western grey kangaroos (*Macropus fuliginosus*), galahs (*Cactua roseicapilla*), ravens (*Corvus coronoides*), magpies (*Gymnorhina dorsalis*), corellas (*Cacatua tenuirostris*) and the Port Lincoln parrot (*Barnardius zonarius*) and their numbers continue to increase.

Rare and priority flora

There are 8 species of Declared Rare Flora and 50 Priority Flora within the catchment boundary. Most of these are found on the roadside verges, others are found growing on private property and some are within reserves. This makes them particularly vulnerable to extinction. Included in the rare flora is Grass Wattle (*Acacia anomala*) and Star Sun Orchid (*Thelmytra stellata*) (see plate 1) to the south, and to the north, Bindoon Star Bush (*Asterolasia nivea*), *Darwinea acerosa* and *Spirogardnera rubescens* while *Eleocharis keigheryi* is found near watercourses and wetlands. A list of all plants recorded in the Shire of Chittering are listed in appendix 3, included is a list of the rare and priority flora.

Rare and priority fauna

The Western Shield program was initiated by CALM to increase introduced predator control, captive breeding programs and reintroduction of native animals to their former habitat. Fox control using “1080” poison and fauna re-introductions, have been ongoing in Julimar State Forest since 1993. Native species reintroduced are chuditch (*Dasyurus geoffroyii*), quenda (*Isooden obesulus fusciventor*), woylies (*Bettongia penicilliata*), tammar wallaby (*Macropus eugenii*) and brush-tailed possum (*Trichosurus vulpecula*). These native animals are still vulnerable and in need of protection.

The critically endangered western swamp tortoise (*Pseudemydura umbrina*) (see plate 2) has also been released in the north of the catchment at Mogumber. Winter wet clay depressions in the area provide suitable habitat in which twenty tortoises were released in an attempt to establish a wild population. Fox control in the reserves and on surrounding properties is vital for their survival and the population is closely monitored by CALM (table 5).

Birds

Loss of native vegetation on which most land birds in the southwest of Western Australia (83%) depend for all or part of their annual requirements (Smith 1987) will inevitably result in significant changes to populations and possible species loss.

Populations of species such as the Carnaby’s cockatoo (*Calyptorhynchus funereus latirostris*) have been much reduced through habitat loss (Saunders and Ingram, 1987).

Bird species recorded in the Julimar State Forest that are at or near the northern limit of their distributions include the rufous tree creeper (*Climacteris rufa*) and the splendid fairy wren (*Malaurus splendens*).

Bush birds found within the catchment are typical of the jarrah-marri woodland and the wandoo woodland habitats (Department of Defence, 1998).

One hundred and twenty nine species of bird have been recorded from the Wannamal area (Buchanan, 1997) including the Carnaby’s Black Cockatoo (*Calyptorhynchus latirostris*). Wannamal birds have been studied on behalf of CALM and other authorities for some years. The first report included Lake Wannamal and surveys have been kept up for both water birds and bush birds since, though not continuously.

The Wannamal Lake system forms the headwaters of the Brockman River and is a major breeding and drought refuge area for waterbirds. Fifty-two species of water birds have been recorded in the system, seven listed under treaties. Freckled duck (*Stictonetta naevosa*) occurs regularly in the system. The Mogumber Swamp is one of the few wetlands in south-western Australia in which Australian crake (*Porzana fluminea*) is known to breed regularly in low sedges mixed with low shrubs. Other species for which the Wannamal Lake is regionally significant are Australasian grebe

(*Tachybaptus novaehollandiae*), hardhead (*Aytha australis*) and black-tailed native-hen (*Gallinula ventralis*). Wannamal Lake is included on the Register of the National Estate (Environment Australia, 2001).

The Chittering-Needoonga Lakes are part of the Brockman River and are a major breeding area for water birds. Forty-two species have been recorded, four listed under treaties. The Lakes are a major breeding place for the great egret (*Egretta alba*) and the rufous night heron (*Nycticorax caledonicus*) in Western Australia. Freckled duck (*Stictonetta naevosa*) occurs regularly with vegetation and the spring water levels in the lakes making the site suitable for breeding.

Other breeding colonies in Lake Needoonga include the Australian white ibis (*Threskiornis molucca*), yellow-billed spoonbill (*Platalea flavipes*) and little pied cormorant (*Phalacrocorax melanoleucos*). The site is regionally significant for Australasian grebe (*Tachybaptus novaehollandiae*), great egret (*Egretta* and *alba*), yellow-billed spoonbill (*Platealea flavipe*s), maned duck (*Chenonetta jubata*) (Environment Australia, 2001).

Both of these wetland systems are under threat from increasing salinity, siltation and eutrophication. The Wannamal wetland system is also under threat from excessive inundation causing the death of wetland trees.

Reptiles and amphibians

One hundred species of reptiles (83 species, one of which is an introduced exotic (*Hemidactylus frenatus from south-east Asia*) and amphibians (17 species) have been recorded in the Brockman River catchment (appendix 4).

The long-necked tortoise, *Chelodina oblonga*, which is widespread in the southwest, is dependent on wetland or stream habitat. An abundance of these tortoises are found in the Chittering Lake Reserve. However, despite road signs warning motorists of tortoises crossing the roadways, many are killed on Great Northern Highway and Chittering Road as they negotiate traffic to reach suitable egg-laying sites.

A particularly vulnerable species is the Carpet python (*Morelia spilota*) (plate 3). They are rarely seen and are killed in fires including hazard reduction burns on private land. This python pictured in Plate 3 was later killed in a wildfire on private property.

*Plate 1: A Star Sun Orchid (*Thelmytra stellata*) on a road verge.*

*Plate 2: A western swamp tortoise (*Pseudemydura umbrina*) released into the wild in 2000. This animal has a radio transmitter attached to its shell.*

*Plate 3: A vulnerable species, carpet python (*Morelia spilota*).*

Table 5: Category of threat for rare and priority fauna in the Brockman River catchment.

Species	Category of threat		
	State	**Commonwealth**	**IUCN**
Chuditch	Rare or likely to become extinct.	Vulnerable	Vulnerable
Western Swamp Tortoise	Rare or likely to become extinct.	Endangered	Critical
Tammar Wallaby	Priority List P4- Conservation dependent	Nil	Nil
Quenda	Priority List P4- Conservation dependent	Nil	Nil
Woylie	Priority List P4- Conservation dependent	Nil	Nil

Fish

River training in the Brockman River, particularly in the Chittering Valley, in the early twentieth century, land degradation, erosion and loss of riparian vegetation has increased silting of the waterways. The silt fills the deeper pools in the creeks and river reducing the summer and drought refuges for aquatic fauna. Without these refuges, fish such as the freshwater catfish (*Tandanus bostocki*) cannot survive in the river. These catfish are now restricted to the lower Brockman River where it continues to have a summer flow.

The native riverine fishes found in the Brockman River and tributaries include the western minnow (*Galaxias occidentalis*), nightfish (*Bostockia porosa*) a species closely related to the giant Murray cod of the eastern states, pygmy perch (*Edelia vittate*), western hardyhead (*Leptatherina wallacei*) and Swan River goby (*Pseudogobius olorum*) (Allen *et al*, 2002).

A small fish was collected from the drainage system between Mogumber Swamp and Lake Wannamal that belongs to the family Gobiidae. Whether this is a Swan River goby or another species is yet to be determined. The introduced species *Gambusia affinis* is very common within the creeks and wetlands.

Invertebrates

Little study has been carried out on invertebrates within the catchment. A number of invertebrate studies on ants has been done as part of mine site rehabilitation for ALCOA at Pinjarra while recent work in the wheatbelt has looked at the species richness and abundance of invertebrates in trees such as Wandoo (*Eucalyptus wandoo*).

There is a wide range of aquatic invertebrates found in the rivers of the southwest with a range of life cycles, distributions and abundances. Adaptations of these species to specialised niches make them useful indicators of changes in river conditions. For example, Bunn (1982) in Olsen and Skitmore (1991) used the presence of the mayfly nymphs (*Tasmanocoenis tillyardi*), which is often found in sediment rich areas, as an indicator of sedimentation in disturbed catchments in the Darling Range.

Baseline data for the Brockman River has been established using Waterwatch protocol and aquatic invertebrates to monitor the health of the river. Larger invertebrates found within the Brockman River are marron (*Cherax tennuimanis*) and the introduced yabby (*Cherax destructor albidus*).

The importance of invertebrates as key components of a variety of food chains that support other animal populations cannot be underestimated. Further research into the ecology of invertebrates and their role within the ecosystem is needed.

The community has a vital role to play in conserving native wildlife. This can be done by protecting remnants of native vegetation; undertaking revegetation projects and creating linking corridors between remnants, particularly on privately owned land.

2.2 Economic, community and environmental values of our natural resources

2.2.1 Agriculture/horticulture

The Shire of Chittering is a significant contributor to the agricultural production of the south west of Western Australia. In 1996/7 it accounted for 2.5% of all farmland with a gross value of agricultural production (GVAP) estimated at $23.3 million, a total value added impact of agriculture (TVA) estimated at $57 million and 9% of south-west nursery, flower and turf production. This represents the greatest economic input for the Shire of Chittering and employs the largest portion of the population (Bureau of Statistics, 2001).

Animal products derived from pasture are the most extensive agricultural landuse followed by broadscale crops and horticulture (figure 8) (Cook and Hatherly, 1997). The northern part of the catchment is mostly agricultural with cereal, beef, pigs, sheep and wool the major agricultural products with some horticultural products such as grapes and citrus. In the Chittering valley, production is mostly beef, sheep, citrus and grapes.

Expansion of horticulture and viticulture in the catchment is limited by the lack of suitable irrigation water.

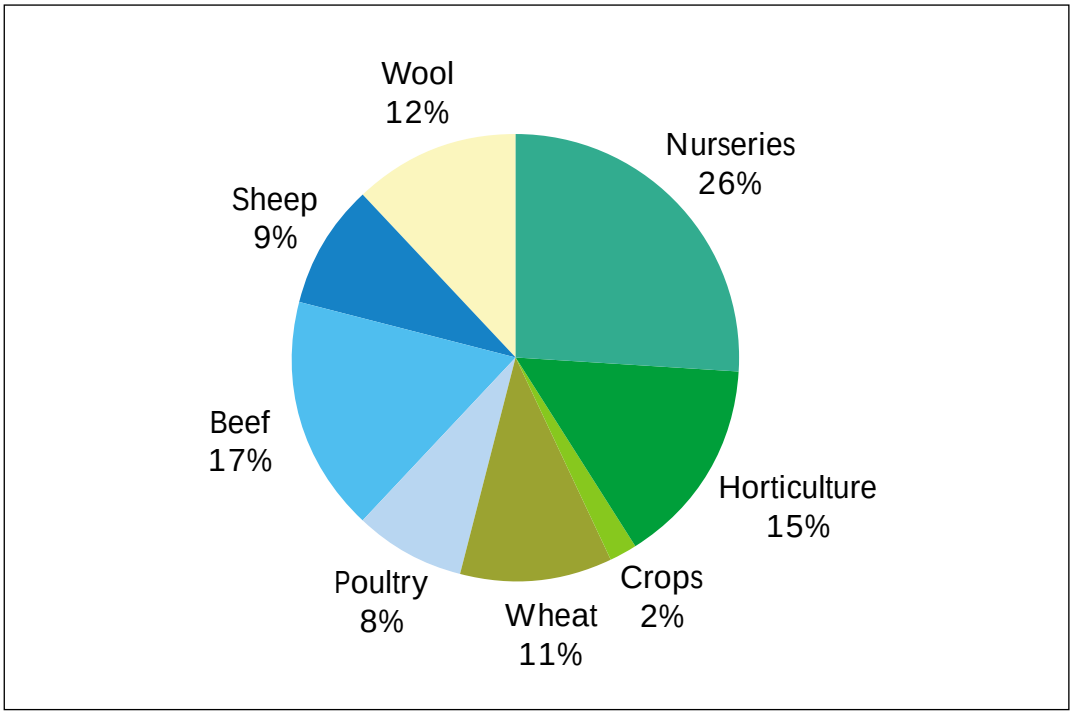


Figure 8: Proportion of Gross Value of Agricultural Production (GVAP) (Total $23 million) by commodity: 1996/97. (Cook and Hatherly, 1997).

2.2.2 Rural living

The opportunity to live and enjoy a rural lifestyle is the major reason why people relocate from the city. Hence, development of rural residential areas have been demand driven in recent times and has grown considerably, particularly in the southern part of the Brockman River catchment. The area provides a rural lifestyle but is close enough to the city for people to travel daily to their place of employment.

Surveys conducted by the Shire of Chittering show that people living in the Shire wish the area to maintain its "rurality". However, a projected population growth from 2,600 in 1996 to 12,046 in 2026 (Ministry for Planning, 1999) indicates considerable expansion will take place. It needs to be noted that not all the Shire of Chittering or North Swan (City of Swan) lies within the catchment boundaries. Careful planning is needed if the area within the Brockman River catchment is to retain this rural lifestyle. The pressure for development will increase to accommodate an increasing population.

2.2.3 Tourism & recreation

Tourism within the area has potential but is under-developed despite its proximity to Perth. The scenic qualities, rural outlook and wildflowers do draw visitors to the area and the Chittering Valley drive is popular for day-trippers. Small enterprises involving farm stays, citrus orchards, vineyards and wineries have some appeal for these visitors with door sales and short-stay accommodation. However, tourist oriented enterprises are generally small and family operated thus tourism may remain small with limited economic benefit to the local economy (Shire of Chittering, 1999).

2.2.4 Landscape amenity

Residents and visitors alike enjoy the landscape of the Brockman River catchment and the Chittering Valley. Important features of that landscape are the major river valley of the Brockman River, the foothills, the waterways and the wetlands.

The lower reach of the Chittering Valley is enclosed with well-vegetated steep valley sides and relatively dense vegetation cover, particularly the area to the east within the Avon Valley National Park. Further north, the middle reaches of the valley widens and is mostly cleared valley floors of a predominantly agricultural landscape. Granite outcrops and boulders protrude from the surrounding landscape. Native vegetation can be seen in the 78-hectare reserve, Blackboy Ridge. The upper reaches of the Brockman River broaden forming the well vegetated, seasonal wetlands of Lake Chittering-Needoonga surrounded by mostly cleared red alluvial valley soils. North of Bindoon the river valley becomes a paleochannel dominated by Lake Wannamal, Lake Mogumber and a suite of seasonal wetlands along the fault line and west on the Dandaragan Plateau. A number of west flowing streams have cut back into the Darling Plateau creating gravelly and rocky valleys.

The Chittering Valley has been designated as a Linear River Greenway under the Avon Arc Strategy and is of the highest scenic value with one of the most attractive rural, hill landscapes in the Avon Arc Strategy Study area (Western Australian Planning Commission, 1999).

2.2.5 Spirit/sense of place. Aboriginal heritage and European settlement.

> *A sense of place shows most clearly in the way the community feels about and uses the landscape.*
>
> George Seddon, 1972

Aboriginal occupation of the Chittering area is at least 38,000 years and the nomadic people probably ranged the Brockman River Valley for food, although this has not been confirmed through specific research in the area. Carbon dating of the campsite at Upper Swan and work undertaken on artefacts from a stone tool factory in Walyunga National Park does substantiate the antiquity of Aboriginal occupation (Graham, 2001).

The area lies within the boundaries of the Nyungar and a variety of dialects were spoken. The distribution of these dialects is unknown but the Yued (sometimes spelt Juat) occupied the Wannamal area. In 1833 this area was in the tribal district of Mooro in the territory of Chief Yellagonga (Buchanan, 1997). The Yued are also thought to have occupied the Chittering area with the Whadjuk to the south (Tindale, 1974), the Balardon to the east and the Amanu to the north.

By the early 19th century the Yued had refined their culture in balance with the environment. They did not own the land - they were part of the land. While climate change and fickle seasons created abundance and hardship, the Yued adapted to and were at ease with their environment (Graham, 2001).

The first recorded journey to the Chittering Valley by Europeans was in April 1835 by George Fletcher Moore and William Locke Brockman. They took up land grants in the area in January 1843.

James Byrne was the first European to take a lease in the Wannamal Area in February 1870 (Buchanan, 1997).

Since these times the landscape has changed considerably. With European settlement came clearing for agriculture to produce food for an ever-increasing population of the Swan River Colony. In more recent times peri-urban development has begun to filter into the area as the population of Perth continues to increase.

Chittering Valley. An eden in the hills - a road of many memories.

Lower Chittering is a pocket paradise in the everlasting hills…

Even the extensive piggery which smudges one of its fairest vales is forgotten by the average visitor when he passed it and viewed the orangeries carpeting the rich alluvial soil each side of the singing brook.

The Valley of the Lower Chittering is a continuation of the series of creeks, gorgeous alluvial flats, pools, swamps, and slowly moving streams that have, for centuries, cut and cleansed a way from New Norcia down to where it confluences with the lower Avon and becomes the Upper Swan.

In summer it is a purling though placid stream, shady and verdant and fringed with lovely trees, giant gum and sweet-scented wattle, sheoak, peppermint, willow, pine, stringy bark and banksia and ti-tree or paperbark …..

A few days away in the glorious orchards, forests, farmlands and pine-scented plantations of Lower Chittering is a tonic to the system, and a glance into the glories of the benefactor of all human beings - Mother Nature!

Abridged article from Swan Express, 9 July, 1926

2.2.6 Biodiversity

Biodiversity - the variety of living things, habitats and ecosystems, is under threat, not so much by increasing numbers of people but where they live and what they consume (Meffe and Carroll, 1994). However, people living in the catchment are becoming more informed about the need to maintain and enhance biodiversity and, as a result, have become more concerned by its loss.

Many have responded by protecting and enhancing natural vegetation on their properties through covenanting and the Land for Wildlife Program. This important part of biodiversity conservation has 33 Land for Wildlife properties (1908 Ha) registered in the Shire of Chittering, 20 of these have been assessed and 13 properties are awaiting assessment. This is a total of 993 hectares of remnant native vegetation registered with Land for Wildlife with 665 hectares of remnant vegetation protected (pers. Comm. Penny Hussey, CALM). Other areas are protected through Conservation Reserves, State Forests and other Reserves managed by CALM for the Conservation Commission and allocated locally for specific biological reasons. The Conservation Estate in the Brockman River catchment for the conservation of flora and fauna is listed in table 6.

The Department of Defence Bindoon Training Area (BTA) is treated as a conservation area under the WA Regional Forest Agreement and an environmental Management Plan was prepared in 1998.

2.2.7 Intrinsic

Biodiversity, land and landscape has environmental value. It has value to human well-being providing such things as food, medicine, nutrient cycling, oxygen production, scientific knowledge and natural beauty. But it is also intrinsically valuable as an end in itself. We are capable of valuing other things for their own sakes, as well as for what they do for us. This is our custodial responsibility to future generations and, for this reason, our natural resources need to be managed to avoid decisions that are irreversible (Meffe & Carroll, 1994).

Table 6: Lands managed by the Department of Conservation and Land Management in the Brockman River Catchment.

Reserve No.	Name	Purpose	Class	Area (ha)	Comments
30192	Avon Valley National Park	National Park	A		Includes part of NR 41938 (Moondyne) and NR 30191.
39050	Betts Nature Reserve.	Conservation of flora and fauna	A	24.9	Name is State approved.
42	Burroloo Well Nature Reserve.	Conservation of flora and fauna		10.7	Name is unofficial
29538	Chittering Lakes Nature Reserve	Conservation of fauna	A	241.2	Includes reserves 42560, 42935 and 44713 [5g Conservation and recreation reserve].
State Forest 61	Julimar	State Forest	A	28317	Name is unofficial, proposed Conservation Park: Interim forest conservation area.
32807	Mt Byroomanning Nature Reserve.	Conservation of flora and fauna	A	181.3	
42743	Nature Reserve	Conservation of flora and fauna		155.1	Un-named, known as Mooliabeenie Nature Reserve
965	Udumung Nature Reserve	Conservation of flora and fauna		201.5	
9838	Wannamal Lake Nature Reserve	Conservation of flora and fauna	A	159.6	
38649	Mogumber Nature Reserve.	Conservation of flora and fauna	A	40.5	Additional areas suitable for the short necked swamp tortoise have been purchased in 2001.

Source: P Dans, Department of Conservation and Land Management, Mundaring 2001.

3. What we need to do in the catchment

3.1 Framework for improved natural resource management.

National outcomes

The National Standards and Targets Framework specify eight national outcomes. These are aspirational statements about desired natural resource outcomes, which are;

- The impact of salinity on land and water resources is minimised, avoided or reduced.
- Biodiversity and the extent, diversity and condition of native ecosystems are maintained and rehabilitated.
- Populations of significant species and ecological communities are maintained or rehabilitated.
- Ecosystem services and functions are maintained or rehabilitated.
- Surface and groundwater quality is maintained or enhanced.
- The impact of threatening processes on locations and systems, which are critical for conservation of biodiversity, agricultural production, towns, infrastructure and cultural and social values, is avoided or minimised.
- Surface and groundwater is securely allocated for sustainable production purposes and to support human uses and the environment, within the sustainable capacity of the water resource.
- Sustainable production systems are developed and management practices are in place, which maintain or rehabilitate biodiversity and ecosystem services, maintain or enhance resource quality, maintain productive capacity and prevent and manage degradation.

The Framework also identifies 10 Matters for Targets. These are;

- Land salinity.
- Soil condition.
- Integrity of native vegetation communities.
- Integrity of inland aquatic ecosystems (rivers and other wetlands).
- Integrity of estuarine, coastal and marine habitats.
- Nutrients in aquatic environments.
- Turbidity/suspended particulate matter in aquatic environments.
- Surface water salinity in freshwater aquatic environments.
- Significant native species and ecological communities.
- Ecologically significant invasive species.

Regional outcomes

The key guiding principles for natural resource management in the Swan Region are adopted from Ecologically Sustainable Development (ESD) principles with a focus on;

- Recognizing environmental values in sustaining ecological health conditions and beneficial uses.
- Managing the pressures on environmental values across the whole Region, in particular, recognizing the essential need to conserve the Region's biodiversity through the development and implementation of local, regional and state strategies.
- Efficiently and fairly allocating rights to use and enjoy natural resources across the Region to the benefit of the natural environment and those who live in it – now and in the future.
- Enhancing and supporting the role of local government in planning for environmental management that is consistent with regional and state strategies.
- Integrating the work done by government and community in developing partnerships in managing natural resources with shared responsibilities and resourcing.
- Acknowledging future uncertainties and the need for a capacity to change.
- Incorporating regular audit and review of plans and strategies.
- Adopting a precautionary principle approach (Swan Catchment Council, 2002).

The natural resource outcomes of this management plan need to be linked to the outcomes of the national and regional framework outlined.

3.2 Managing water for improved quality and sustainability.

Landholders and the community are aware of increasing salinity in the waterways, groundwater and dams of the Brockman River catchment. This decline in water quality has reduced the suitability of water for domestic and irrigation use and, in many cases, water is even unsuitable for livestock. The catfish that was once abundant in the upper reaches of the Brockman River and lakes is now found only in the lower, fresher reaches of the river.

Phosphorous and nitrogen from fertiliser use, organic matter, agricultural chemicals draining from farmland and orchards are also degrading water quality in the Brockman River catchment. Hydrocarbons in stormwater washed from roadways and industrial sites, and slow leakages from fuel tanks, are also a concern. Excess nutrients and pollutants degrade aquatic ecosystems making it difficult for plants and animals to survive.

Table 7: Salt loads as recorded at the monitored gauging stations.

Year	Tanamerah (S616006) Salt load kT/year	Yalliawirra (S616019) Salt load kT/year
1992	73	125
1993	73	124
1994	48	83
1995	101	148
1996	84	141
1997	49	88

Source: Water and Rivers Commission (2001)

Note: The salt load is related to annual flow and rainfall in the catchment.

Objective 1

To protect and enhance the quality of the water in the waterways, lakes and groundwater to meet the needs of the community and environment.

Baseline knowledge

- Groundwater levels are rising in the Brockman River catchment, however, as the factors that affect groundwater recharge and movement within the weathered rock profile are not uniform, the rate of groundwater rise is not uniform over the catchment (Water and Rivers Commission, 2001).
- The annual salt loads exported by the Brockman River between 1992 and 1997 are listed in table 7. Tanamerah monitors the upper catchment north of Bindoon and Yalliawirra is at the confluence of the Brockman River and the Avon River.
- Sediment loads have increased as evidenced by the filling of deep pools along the river and sediment slugs present although no scientific data to quantify the sediment loads are available.
- Water sampled in July 2000 from the Yalliawirra gauging station tested below the limits for freshwater aquatic ecosystems and drinking water guidelines for common heavy metals (EPA, 1993).
- Total nitrogen (1.1mg/L) and total phosphorus (0.036 mg/L) are also below the target limits for freshwater aquatic ecosystems (Environment Australia, 2002).
- Total Suspended Solids (32 mg/l) are above the target limits for aquatic ecosystem protection (Environment Australia, 2002).

Targets

- No net increase in the mean annual salinity as measured at Tanamerah and Yalliawirra gauging stations.
- A reduction in turbidity levels and sediment loads in the waterways within the catchment.
- Maintain the levels of heavy metals, total nitrogen and total phosphorus below the target limits set by Environment Australia for aquatic ecosystems.
- Define the limits of sustainable water use for groundwater within 5 years.

- Use water resources below sustainable limits within 10 years.
- Maintain water regimes in wetlands sufficient for wetland ecosystems.
- All schools within the catchment involved in the Ribbons of Blue program.
- All local government town planning schemes to incorporate water sensitive design principles in 10 years.
- Educate 80% of the people in the catchment about current best management practice to reduce saline water, nutrient, sediment and chemical input into the surface and groundwater in the catchment.

Strategies and actions

3.2.1 Assess and monitor water quality

- identify all sources of pollution by establishing a sampling program along the Brockman River and major tributaries then prioritise sources of key pollutants
- continue to use data from the Water and Rivers Commission gauging stations (Tanamerah and Yalliawirra) to monitor changes in the salinity and quantity of water in the Brockman River
- encourage community involvement in continued ground and surface water quality monitoring in the Brockman River catchment to determine changes
- encourage schools to become involved in the Ribbons of Blue program to monitor water quality.

3.2.2 Decrease the input of nutrients and other pollutants into the waterways

- encourage the use of soil and tissue testing to determine the optimum timing, method and rates of application, and types of fertilizers to be applied to productive land
- review with landholders the flight path of aircraft spraying crops or spreading fertiliser to decrease or eliminate the impacts of spray drift on vegetation and nutrients entering the waterways
- encourage landholders to prevent direct access of livestock to watercourses to reduce nutrient input
- manage drains to minimize runoff velocities and volumes to ensure the control of nutrient and sediment loads within acceptable limits
- eliminate or reduce polluting activities by asking landowners who are a source of pollution to clean up. In the case of serious point-source pollution, if encouragement doesn't work, the Local Government Authority will contact the DEP and request their assistance
- ensure that weed and pest control programs in the bushland near watercourses are carried out in a responsible manner to avoid waterway contamination
- implement pollution control measures to ensure discharges of effluent such as agricultural chemicals and intensive agriculture wastewater into receiving waterways are within acceptable limits
- design contingency plans with the Local Government Authority, Water and Rivers Commission and State Emergency Service to handle a major chemical spill in or near a major waterway.

3.2.3 Improve management of saline water

- encourage revegetation of landscape where possible to reduce the recharge into the groundwater and waterways
- publicise and enforce drainage controls for surface and deep drainage to ensure the volume and salinity of the water discharged off-site does not adversely affect neighbouring properties or waterways
- develop and implement current best management practices for retaining on site and managing saline water from agricultural/horticultural property
- organise a meeting involving CALM, landholders and community members to review the artificial maintenance of water levels in Lake Chittering.

3.2.4 Implement Water Sensitive Design immediately

- ensure that new subdivisions (urban, rural living, industrial, and intensive agricultural) are located to minimise nutrient and pollutant input to the water cycle and incorporate water sensitive design
- incorporate water-sensitive design into the Town Planning Schemes

- implement appropriate controls and management measures such as detention basins to strip sediment and other undesirable components from stormwater to ensure runoff quality from urban developments is within acceptable limits
- provide public information and guidelines to residents, industry associations and commercial users on water-sensitive design and best practices.

3.2.5 Promote sustainable water use

- regulate through the appropriate authorities, the abstraction of water from the river, its tributaries and associated wetlands to ensure equitable distribution between landholders, community and environmental requirements
- encourage the community to adopt water conservation principles throughout the catchment.

How the proposed actions respond to the following suggestions from the Brockman River catchment community forum:

- Develop big picture of problem areas (**see Swan Catchment Strategy and this plan**).
- Establish list of contact people.
- Identify chemical composition of water to establish salts (**see Actions 3.2.1**).
- Urban and industrial development in the townsite of Bindoon (**see Actions 3.2.4**).
- Use slotted pipe at base (4 m) trench to catch leached water and divert for irrigation (**see Actions 3.2.5**).
- Divert water from river during floods into storage. Divert saline water to storage for use in saline water applications (eg rainbow trout) (**see Actions 3.2.3**).
- Integration of agency services, such as between lake and river (**see Actions 3.2.3**).
- Proper drainage (**see Actions 3.2.3**).
- Stormwater to be retained on site (s**ee Actions 3.2.4**).

3.3 Managing salinity and soil degradation

Waterlogging and saline seepages are becoming commonplace throughout the Brockman River catchment. This increased soil salinity contributes to the loss of native vegetation and reduces productivity on agricultural land.

Land clearing, cultivation and livestock grazing causes increased compaction and loss of soil structure. This leads to accelerated loss of topsoil through wind and water erosion. Protection of native vegetation and revegetation wherever possible is an important component in preventing erosion and rising groundwater.

Objective 2

To reduce and prevent salinity and soil degradation; ensure sustainable land use and increase profitable production.

Baseline knowledge

- 30 major subcatchments identified in the Shire of Chittering within the Brockman River catchment, 12 of these subcatchments recorded high or severe soil salinity, 8 have low or medium soil salinity, and 7 have no soil salinity.
- Further information on salinity and soil degradation is contained in the following reports.

"Salinity Survey in the Shire of Chittering". (1997) Ken Angell. Department of Agriculture WA.

"Degradation in the Brockman River and Ellen Brook catchments, Western Australia." (2000) Brian Lloyd. Department of Agriculture, WA.

Targets

- Halt the rise in groundwater levels in the catchment within 20 years.
- No net increase in area of soil affected by salinity.
- Reduce the level of in stream salinity within the subcatchments north of Bindoon.
- Increase the productivity of saline land by 50%.

- Identify all areas of potential wind and water erosion and undertake remedial action on 50% of sites in 10 years.
- All subdivision applications assessed according to land capability and suitability.
- Establish 50 hectares of perennial pasture in 5 years.
- Educate 50% of the people in the catchment in current best management practices for irrigated horticulture and erosion control within 5 years.

Strategies and actions

3.3.1 Assess soil salinity and degradation in the catchment.

- identify and monitor areas susceptible to soil salinity and waterlogging within the catchment
- identify and map “hot spots” for soil degradation, nutrient and sediment export
- identify and map areas within the catchment susceptible to wind and water erosion.

3.3.2 Improve ground and surface water management

- use clearing and development controls to protect native vegetation on large and small parcels of land
- rehabilitate and stabilize eroded areas to control recharge and increase water use
- encourage landholders to undertake current best management practices in areas experiencing waterlogging and soil salinity to lower the groundwater and rehabilitate degraded lands
- develop and encourage landholders to undertake current best management practices for irrigated horticulture, pasture and crops to reduce run off and recharge to groundwater
- trial and encourage landholders to undertake alternative farming strategies such as alley farming and woodlots to reduce recharge to groundwater
- develop and encourage landholders to undertake appropriate best management practices such as grade banks for surface water control to manage the quantity and quality of runoff from paddocks
- construct roaded catchments (sealed with clay) on recharge areas to divert fresh water into dams for use in irrigation.

3.3.3 Implement erosion control

- develop and implement current best management practices such as no till farming in consultation with landholders and community to address the loss of topsoil and soil fertility
- encourage landholders to undertake erosion control in areas experiencing wind and water erosion
- encourage landholders to replace annual pasture systems with perennial pastures to ensure continuous soil cover.

3.3.4 Improve land-use planning

- encourage the development of farm management plans that identify land capability and ensure sustainability of land uses
- scrutinise subdivision applications to ensure protection of natural resources in perpetuity
- ensure all re-zoning considers land capability to guarantee the most appropriate and sustainable use
- locate rural residential and urban areas so they do not impinge on agricultural land or remove valuable agricultural soils and microclimates from production.

3.3.5 Encourage further salinity research

- encourage and support further research into saltland agronomy.

How the proposed actions respond to the following suggestions from the Brockman River catchment community forum:

- Identify commercial options for salt tolerant species in the Brockman River catchment (**see Actions 3.3.5**).
- Abstraction of surface water needs to be regulated by the appropriate authorities WRC (**see Actions 3.2.5**).
- Planting of recharge areas (see Action 3.2.3).
- Farm plans to identify land capability, sustainability, impact on environment (**see Actions 3.3.4**).
- Compatible development (**see Actions 3.3.4**).
- Subdivision to be based on landform rather than square blocks, includes all infrastructure (**see Actions 3.3.4**).

3.4 Managing waterways and wetlands

In the early days of settlement from 1843, the Brockman River was shallower and swampy conditions prevailed in the valley during the winter months. Progressive clearing for settlement, deepening of the river, draining of the floodplain and loss of riparian vegetation has altered this condition. The increase in water velocity has changed the course of meander bends and caused undercutting of the banks. This has led to erosion and sedimentation problems in the river. Loss of fringing vegetation has also contributed to increased movement of topsoil and associated nutrients into the waterways.

In the upper catchment at Wannamal, extensive clearing in the 1950s and 1960s and a drainage system constructed in the early twentieth century to drain the Wannamal Lakes has increased the water flow to the Brockman River. Water now entering the river system is becoming progressively saline changing the ecology of the lakes and wetlands along its length. This has resulted in the fringing vegetation becoming degraded and salt sensitive species are being replaced by salt tolerant species thus changing the nature of the communities present today. Without the protection of fringing vegetation, sediment is carried into the waterways and deposited in the lakes that have now become shallower and tend to flood outside the reserve boundaries.

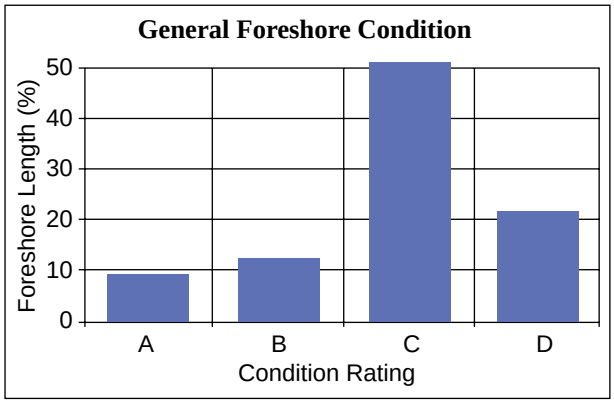


Figure 9: Condition rating of the Brockman River foreshore as a percentage of the full reachof the river.

A Grade: Foreshore vegetation is healthy native bush.
B Grade: Weed invasion, mainly grasses, evident in foreshore vegetation.
C Grade: Some trees present, understorey weeds and pasture, some bank erosion.
D Grade: Eroding and/or weed infested ditch.

Objective 3

To restore the natural functions of the river channels, foreshores, floodplains and wetlands through protection and rehabilitation.

Baseline knowledge

- A foreshore assessment of the main channel of the Brockman River was carried out in 2001. Figure 9 shows the percentage of foreshore in each condition rating using the Pen and Scott method, 1995.
- The environmental condition of the main channel foreshore is mostly moderate to poor as indicated in figure 10.
- The fencing status of the main channel of the Brockman River was carried out in 2001 and is illustrated in figure 11.

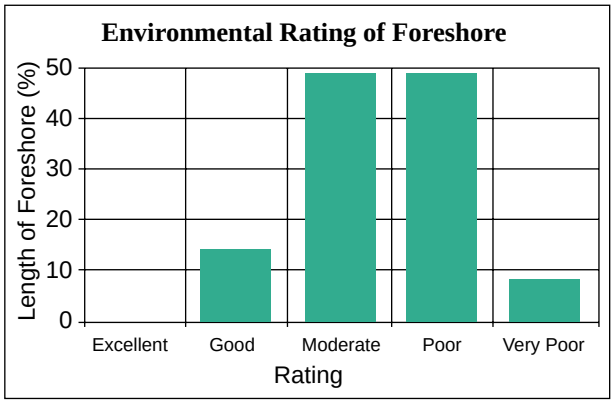


Figure 10: Environmental rating of the Brockman River foreshore as a percentage of the full reach of the river.

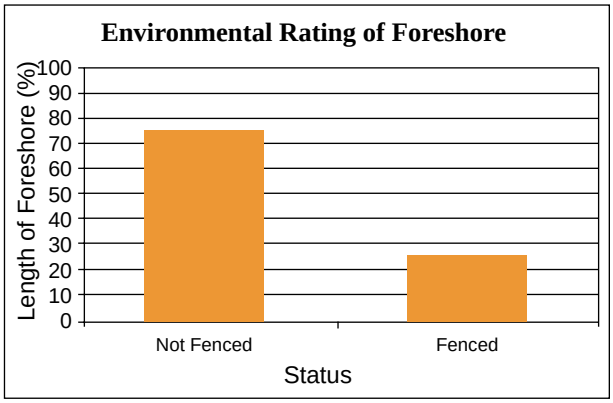


Figure 11: Fencing Status of the main channel of the Brockman River as a percentage of the full reach. Fencing refers to fencing on both sides of the channel and suitable for excluding livestock.

Targets

- Complete foreshore assessments of the major tributaries of the Brockman River in 5 years.
- Fence to exclude livestock and rehabilitate the riparian vegetation on 50% of the main channel of the Brockman River and 30% on major tributaries within 10 years.
- Educate 50% of the people in the catchment about river processes and restoration of riparian habitat.

Strategies and actions

3.4.1 Assess the status of waterways and wetlands

- undertake a review of the foreshore assessment of the Brockman River, its major tributaries and associated wetlands to monitor the status of riparian vegetation
- establish and implement a program to measure and monitor river and wetland health using aquatic fauna.

3.4.2 Improve management of waterways, foreshores and floodplains

- encourge landholders to fence off and rehabilitate all defined watercourses
- identify costs and provide economic incentives to support and encourage landholders to manage, protect and rehabilitate foreshores and waterways to enhance their natural functions
- protect river banks, wetlands and foreshores by permanently excluding livestock
- develop methods of fuel reduction in foreshore areas to minimise fire risk
- encourage the strategic planting of floodplains using either native plants or agro forestry woodlots to restore floodplain function and prevent the main river channels from creating alternative courses
- encourage the use of perennial pasture species on floodplains to ensure sustainable summer grazing by livestock and maximum water uptake
- research and trial native pasture species for use on the floodplains
- promote sustainable grazing practices on the floodplains to prevent overgrazing and compaction
- raise landholder and community awareness of river processes and restoration of the riverine habitat through field days and workshops
- ensure that infrastructure such as bridges, river crossings, culverts and fencing across channels doesn't interfere with the natural flow of the waterways and cause local flooding or contribute to erosion.

3.4.3 Improve the planning process to protect waterways and wetlands

- develop and implement river restoration plans for the Brockman River, major tributaries and wetlands to restore and prevent further damage to the riverbed and banks and protect assets such as fringing vegetation, fences and buildings
- negotiate with Local Government Authorities to ensure adequate setbacks from waterways of new horticultural enterprises are enforced as conditions of development
- negotiate with Local Government Authorities to include fencing of waterways, rehabilitation and protection of foreshores, and designated building envelopes to prevent building on floodplains as conditions for subdivision
- negotiate restrictive covenants between those holding land tenure and the Water and Rivers Commission to ensure protection and management of floodplain, foreshore, riverbanks and channel
- ensure construction of the Perth-Darwin Highway and others roads cause minimal disturbance to the environment and that construction in no way affects the quality of runoff, causes erosion or exacerbates drainage.

How the proposed actions respond to the following suggestions from the Brockman River catchment community forum:

- Keep fences out of floodway (**see Action 3.4.2**)
- Develop booklet or river processes to raise awareness (**see WRC Water Notes & Water Facts**)
- Fence off the river using foreshore agreement, caveat or covenant (**see Actions 3.4.2 and Actions 3.4.3**)

- 50 metre protection caveats from stock (**see Actions 3.4.2 and Actions 3.4.3**)
- Easement on all waterways (**see Actions 3.4.2 and Actions 3.4.3**)
- Establish/maintain deep rooted perennials (**see Actions 3.4.2**)
- Seek and use advice from locals (**this Action Plan**!)
- Hold walk and talk activities (**see Actions 3.4.2**)
- Identify costs of getting involved (**see Actions 3.4.2**)
- Agencies to fence off crown land (**see Actions 3.4.3**)
- Clearing of artificial constrictions (**see Actions 3.4.2**)
- Ban building on floodplains (**see Actions 3.4.3**)
- Properly manage grazing (**see Actions 3.4.2**)
- Fence off main channel (**see Actions 3.4.2**)
- Removal of levee spoil from river banks (**see Actions 3.4.2**)
- Fencing (**see Actions 3.4.2**)
- Foreshore surveys to identify priority areas (**see Actions 3.4.1**)
- Establish land tenure (**see Actions 3.4.3**)
- Field days on particular landscape regions (**see Actions 3.4.2**)
- Protection of wetlands through reserves, covenanting scheme **(see Actions 3.4.2 & 3.4.3**).
- Streamlining and maintenance/protection of remnant vegetation (**see Actions 3.4.2 & 3.4.3**).
- Fencing for stock and animal control (**see Actions 3.4.2 & 2.2.2**).
- Building envelopes identified (**see Actions 3.4.3**).

3.5 Managing and Protecting Native Vegetation and Fauna.

The condition of native vegetation remaining within the Brockman River catchment varies greatly, ranging from severely degraded to excellent with a diverse range of species. Native understorey species are particularly scarce due to grazing pressure. Several areas of excellent vegetation lie within Public Open Space areas and CALM reserves. Some remnants on private property are also in good condition and a number of them are permanently protected under covenant agreements.

The small size and isolation of remnant vegetation blocks is of concern as this limits breeding success and animal movement between remnants increasing the likelihood of local species extinction. Endangered species such as the Chuditch, Western Swamp Tortoise and the Black Flanked Rock Wallaby have been reintroduced into reserves within the Brockman River catchment. The success of these translocations depends on maintaining the native vegetation remaining and creating linkages between patches.

Weeds and pest animals are also of concern not only for nature conservation areas but also on private property where they can reduce productivity for agricultural and horticultural enterprises. The control and, if possible, eradication of Patterson's Curse, rabbits, feral cats and foxes is seen by the community as most important in protecting rural enterprise and nature conservation areas.

Objective 4

To protect and enhance natural biodiversity to sustain ecological processes and conserve native plants and animals.

Baseline knowledge

In the Brockman River catchment;

- 51% of the original vegetation remains; a total of 770 km^2;
- 26% of remaining vegetation is reserved, but this reservation is not comprehensive in terms of vegetation types;
- The native vegetation is located within a very large number of remnants (1,521);
- 85% of the remnants are less than 10ha in size, representing 5% of the native vegetation;
- 91% of the remnants are unreserved, representing 18% of the vegetation;
- 1 vegetation complex has less than 20% of its original area remaining, while 12 complexes have less than 10% of their original area reserved.

Targets

- No further loss of native vegetation.
- 10% increase in native vegetation through revegetation, protection and enhancement of remnants within 10 years.
- All public open space to have management plans within 10 years.
- A fire management strategy that includes deliberate use of fire for ecological regeneration as well as hazard reduction and protection of property without undue risk to native vegetation.
- Decrease in distribution and abundance of introduced pests and diseases.
- Educate 80% of people to recognise weeds and techniques for their control.

Strategies and actions

3.5.1 Assess and monitor the status of flora and fauna in the catchment

- monitor the status and extent of remnant vegetation throughout the Brockman River catchment
- identify flora and fauna in the Brockman River catchment and develop community information sheets
- establish a regional herbarium within the catchment
- review weed maps for the foreshore of the Brockman River and roadside reserves to identify priority areas for eradication and rehabilitation.

3.5.2 Protect and restore native vegetation and reduce loss of biodiversity

- protect and enhance roadside vegetation to reduce loss of biodiversity
- protect existing and increase the number of “flora” roads
- educate the community about the value of riparian and other bushland vegetation
- encourage the restoration of degraded remnants by replanting to provide linkages and corridors between remnants on private land, Nature Reserves and the riparian vegetation
- provide advice and guidance on best plant species to use in revegetation projects
- protect and enhance native vegetation areas and encourage landholders to prepare vegetation management plans in consultation with Land for Wildlife officers for all remnants larger than 1 hectare
- promote covenanting schemes to protect remnant native vegetation on private land
- ensure public access to areas where appropriate recreational and tourist activities can be enjoyed by the public is managed to minimise any disturbance on the waterways and bushland areas
- encourage the development of woodlots as a fuel/firewood source to reduce the pressure of collection from areas of remnant vegetation.

3.5.3 Develop appropriate fire management strategies

- include fire management strategies in FESA and local government fire management plans to minimize the threat to natural vegetation that may result in potential soil and nutrient loss, and encourage weed growth
- educate the community about bush fire risk and encourage them to take responsibility for protecting their own assets by managing fuel loads, installing and maintain firebreaks, ensuring emergency water supplies for fire fighting and ensuring emergency vehicle access
- ensure that Local Government Authority plans recognise that the deliberate use of fire for ecological regeneration may require a different fire regime from the current standard used by the bushfire brigades and allowances need to be made for it in conservation areas (including private land).

3.5.4 Control weeds and introduced pest animals

- identify priority environmental and agricultural weeds and develop management plans for their eradication or containment
- encourage landholders to eradicate and control pest plants on their property, particularly the declared pest plants
- Increase awareness and education of landholders in the best methods to carry out weed control
- eliminate feral animals from bushland along the river, other bushland in the catchment and reserves, and to control re-invasion with ongoing control programs

- consult with CALM to reduce excessive numbers of kangaroos on private property
- provide information on baiting programs and techniques to control feral animals
- encourage community participation in activities such as Weedbuster Week to increase awareness of the weeds present in the Brockman River catchment
- coordinate the weed control activities of Local Government Authorities, State and Commonwealth agencies, landholders and community groups
- increase awareness of dog and cat control/management and enforce the appropriate council bylaws.

How the proposed actions respond to the following suggestions from the Brockman River catchment community forum:

- Carry out biological surveys (**see Actions 3.5.1**).
- Fox control (**see actions 3.5.4**).
- Information on the effects of poison (**see Actions 3.5.3**).
- Habitat creation and protection (**see Actions 3.5.2**).
- Visual diagrams of typical native flora for the region (**see Actions 3.5.1**).
- Get involved with weedbuster week (**see Actions 3.5.4**).
- Identify areas of infestation (**see Actions 3.5.1**).
- Weed wiping (**see Actions 3.5.4**).
- Volunteer weed control days (**see Actions 3.5.4**).
- Coordinated community baiting programs within and across catchments, involving all landholders including agencies (**see Actions 3.5.4**).
- Information on baiting programs and techniques (**see Actions 3..5.4**).
- Join landcare group (**see Section 1.3**).
- Establish and maintain vegetative cover (**see Actions 3.5.2**).
- Accessible advice and guidance on what to plant and where (**see Actions 3.5.2**).
- Weed control (**see Actions 3.5.4**).
- Enforcement of environmental remedial works (**see Actions 3.5.2**).

4. Making it happen

4.1 The priority process

It is impossible to address all issues at the same time, although different groups can carry out several actions simultaneously. To determine the priorities amongst many issues and actions in this management plan, the following guidelines are proposed as a basis for making decisions.

High priority should go to high impact actions that;

- have many positive outcomes rather than few (examples - fencing the waterways, revegetation of high water recharge areas);
- ensure protection for the least degraded features in the catchment (examples - streams that still contribute fresh water to the river, least disturbed and largest parcels of remnant vegetation), and;
- can involve and educate many members of the community rather than few (example field days, fostering community and “friends of” groups).

The difficulty in accomplishing the actions also needs to be taken into account.

The actions listed in tables 8-11 have been prioritised using the following method.

	Action easy to accomplish	**Action difficult to accomplish**
Action has high impact	Priority 1	Priority 2
Action has low impact	Priority 3	Priority 4

Figure 12: Method used to set priorities for actions.

4.2 Time frames

A time frame for each action in tables 8 to 11 has been designated using the following criteria as a guide.

S Short term. Actions that can be accomplished within 5 years.

M Medium term. Actions that can be accomplished within 10 years.

L Long term. Actions that may take 15 years or more to accomplish.

Some actions will be on-going and these have been designated as ML or SML.

4.3 Roles and responsibilities

Effective participation in managing natural resources relies on developing an integrating process that involves partnerships with the wider community and all levels of government. This ensures that a balance between economic, social and environmental values is achieved within the Brockman River catchment. It is therefore important to establish the roles and responsibilities of the various stakeholders in this plan. It is also important to ensure that this management plan links with the players involved in regional and other local planning strategies such as those listed in section 1.5.

4.3.1 Individuals

Increased awareness of the catchment issues needs to be developed within the community to ensure that individuals are well informed. This will bring about a change in attitude on how natural resources are used and managed at all levels and encourage informed decision making.

Leaders can be identified who will encourage support and participation in developing a new community culture and achieving the objectives of the management plan.

4.3.2 Landholders

Landholders have an invaluable knowledge and understanding of the issues involved in natural resource management. Since management planning and actions take place at the farm and paddock level, sustainable natural resource management will only be achieved through participation of landholders in the management process and effective community ownership.

4.3.3 Community groups

A number of community groups within the Brockman River catchment are directly involved in natural resource

management and landcare. These groups include Land Conservation District Committees and Catchment groups.

It is through these groups that leadership, support and participation in natural resource management occurs. Funding to carry out on-ground work is usually received and managed through these groups.

How the proposed actions respond to the following suggestions from the Brockman Catchment community forum:

- Lobby/write to local government and local member re improving resources for catchment management in the Brockman River catchment. Highlight inefficient water use on inappropriate land types to WRC (eg allocation of 10ML/ha to grow lucerne on sandy soils. Could have been achieved with lower allocation on heavier soil type), Take issue to next level (ministerial) if required.
- Approach state government re interest subsidy to farmers to enable management of landcare issues.
- Develop an incentive/ penalty scheme on shire based environmental tax.
- Motivate and interest landholders.

4.3.4 Local government

Local Government Authorities can make decisions on developments through their Town Planning Schemes and adoption of policies that protect and enhance natural resources.

Development proposals that do not undergo formal environmental assessment by state agencies are dealt with at the local government level. Public comment through this planning process can contribute to development that ensures sustainability.

Shire of Chittering should be encouraged to develop an Environmental Management Plan and an Environmental Advisory Committee similar to Shire of Mundaring and Toodyay.

4.3.5 State government agencies

CALM

CALM is responsible for biodiversity conservation throughout the whole state, i.e. on all land tenures. They issue licences for the taking of native flora and fauna and provide detailed regulations for threatened flora and fauna and ecological communities. They also provide bushland management ands revegetation advice on private property through the Land for Wildlife scheme. A Conservation Covenant scheme is also operated through CALM. Plant identification can be carried out through the Community Herbarium program in the State Herbarium, Perth.

CALM is also a major manager in the catchment, as it undertakes the day-to-day management of lands under the care, control and management of the Conservation Commission.

Water and Rivers Commission (DEWCP)

Water and River Commission is responsible for the management of all Western Australia's surface and groundwater resources. In the Brockman River catchment this involves:

- Managing state water resources;
- Planning to ensure a balance between the water requirements of the community and those of the natural environment;
- Ensuring the protection of vital water resources, and;
- Conserving and restoring wetland ecosystems and enhancing waterway environments.

Department of Environmental Protection (DEWCP)

The DEP is responsible for the protection of the environment on behalf of the Minister for the Environment. Management of the Brockman River catchment can be influenced by:

- The Environmental Impact Assessment process (Evaluation);
- Pollution licencing (Pollution Prevention); and
- Formulation of specific Environmental Protection Policies (Policy Coordination)

Department of Planning and Infrastructure

The Department of Planning and Infrastructure provides technical advice to the Western Australian Planning Commission and the Minister of Planning and Infrastructure. In catchment management, the Department of Planning and Infrastructure has important regulatory and supervisory roles in ensuring Town

Planning Schemes reflect the principles, actions and policies of this Catchment Management Plan. It is, therefore, most important that the Department of Planning and Infrastructure is fully informed of the issues affecting the Brockman River catchment and the management plan.

Department of Agriculture

The Department of Agriculture has an important role to play in the management of the Brockman River catchment through its agricultural production and the Landcare Program.

The Department of Agriculture promotes the sustainable development of farm business, agricultural business and rural communities that are capable of meeting the economic, ecological and social challenges in a rapidly changing world.

The landcare program supports the Land Conservation District Committees within the catchment and focuses on actions that achieve sustainable development and soil conservation.

4.3.6 Regional NRM groups

Swan Catchment Council

The Swan Catchment Council is responsible for the delivery of natural resource management within the Swan region. The Brockman River catchment is part of this region and future Commonwealth Government funding will be directed through the council.

A Memorandum of Understanding has been signed between the Avon and Swan Catchment Councils to include the Brockman River catchment in the National Action Plan for Salinity and Water Quality.

4.3.7 Commonwealth Government

Department of Defence

The Department of Defence has a management plan for the Bindoon Training Area. As part of this area falls within the Brockman River catchment it is important that it is integrated with the catchment management plan and addresses the issues raised.

4.4 Implementation

4.4.1 Zones

Based upon community and land use boundaries the Brockman River catchment can be divided into 5 distinct zones for the purpose of natural resource management. These zones are:

Zone 1: North - Wannamal. Mostly broad acre farms growing cereals and canola, wool, sheep and cattle.

Zone 2: Central North - Mooliabeenie. Smaller farms growing some cereal crops and grapes but mostly sheep and cattle grazing, citrus and other fruit.

Zone 3: Central - Bindoon. This is the administrative centre, main commercial and urban area of the catchment surrounded by rural residential and citrus orchards with some sheep and cattle grazing.

Zone 4: Central South - Chittering Valley. Mostly sheep and cattle grazing and citrus orchards with vineyards increasing rapidly. Areas of rural residential are adjacent to the scenic valley.

Zone 5: South - Lower Chittering Valley. Enterprises are mostly citrus orchards and vineyards, some sheep and cattle grazing. A big demand for rural residential has seen considerable subdivision in this area.

Working within these zones will make for easier and more manageable groups to undertake community actions.

Implementation of on-ground work has already begun with many landholders undertaking work following workshops to further discuss natural resource management issues. Some of these projects have been reported in;

Torre, A. (2002) *Demonstration sites of waterways restoration in WA.* Water Note 27. Water and Rivers Commission, Perth.

4.4.2 Communicating the plan and its priority actions

A communication strategy is being put in place to develop and implement effective communication and coordination between community, landholders, government agencies and local government authorities.

This is being done through

- Workshops
- Newsletters and newspaper articles.
- Field days
- Local Shows
- Posters
- Displays
- Presentations

4.4.3 Coordinator

Integrated Natural Resource Management is dependant on the goodwill and continuing support of community organisations, government agencies and individual landholders. It is also dependant on understanding the networks that have been established between these stakeholders. A coordinator is needed to ensure the continuation of these networks and implementation of Integrated Natural Resource Management in the Brockman River catchment.

4.4.4 Getting people involved in implementation

The community needs to be encouraged to participate in implementing the Management Plan. Getting involved can be encouraged by;

- providing opportunities for the community to enjoy the natural and built environment;
- encouraging community involvement in management of remnant vegetation, conservation areas and public open space areas;
- encouraging and supporting the formation of sub-catchment and friends groups involved in natural resource protection and enhancement;
- maintaining the flow of information to the community and evaluate feedback, and;
- involving young people in management through encouraging schools to be involved in the Waterwatch and Weedbuster programs, and community tree planting programs.

4.5 Monitoring and review

To ensure the Natural Resource Management actions are achieved it will be necessary to;

- undertake regular performance evaluation and monitoring of the catchment management plan (including targets and actions);
- undertake regular evaluation of the implementation and success of best management practices at broad scale and paddock scale;
- use the results of performance monitoring to review and refine the Brockman River catchment Management Plan at all scales, and;
- review and revise this management plan every 5 years.

Catchment management depends upon our commitment.

Let's all work together to bring the catfish back to the Brockman.

Table 8: Actions to protect and enhance water quality.

Objective 1

To protect and enhance the quality of the water in the waterways, lakes and groundwater to meet the needs of the community and environment.

TARGETS	STRATEGY	ACTIONS	STAKE-HOLDERS	TIME FRAME	PRIORITY
No net increase in the mean annual salinity as measured at Tanamerah and Yalliawirra gauging stations. A reduction in turbidity levels and sediment loads in the waterways within the catchment. Maintain the levels of heavy metals, total nitrogen and total phosphorus below the target limits set by Environment Australia for aquatic ecosystems.	Assess and monitor water quality.	Identify all sources of pollution by establishing a sampling program along the Brockman River and major tributaries then prioritise sources of key pollutants.	WRC, LCDCs, CMGs, Landholders	S	1
		Continue to use data from the Water and Rivers Commission gauging stations (Tanamerah and Yalliawirra) to monitor changes in the salinity and quantity of water in the Brockman River.	WRC, CMG	SML	1
		Encourage community involvement in continued ground and surface water quality monitoring in the Brockman River catchment to determine changes.	LCDCs, CMGs Landholders, Community	SML	2
		Encourage schools to become involved in the Ribbons of Blue program to monitor water quality.	LCDCs, CMGs	S	1
	Decrease the input of nutrients and other pollutants into the waterways.	Encourage the use of soil and tissue testing to determine the optimum timing, method and rates of application, and types of fertilizers to be applied.	AgWA Land holders	SML	2
		Review with landholders the flight path of aircraft spraying crops or spreading fertiliser to decrease or eliminate the impacts of spray drift on vegetation and nutrients entering waterways.	LGAs Landholders	SML	12
		Encourage landholders to prevent direct access of livestock to watercourses to reduce nutrient input.	CMGs, Landholders. LGAs	M	1

TARGETS	STRATEGY	ACTIONS	STAKE-HOLDERS	TIME FRAME	PRIORITY
Define the limits of sustainable water use for groundwater within 5 years. Use water resources below sustainable limits within 10 years. Maintain water regimes in wetlands sufficient for wetland ecosystems. All schools within the catchment involved in the Ribbons of Blue program. All local government town planning schemes to incorporate water sensitive design principles in 10 years.		Manage drains to minimize runoff velocities and volumes to ensure the control of nutrient and sediment loads within acceptable limits.	WRC, AgWA Landholders	SML	2
		Eliminate or reduce polluting activities by asking landholders to clean up any source of pollution on their property. In the case of serious point-source pollution and encouragement doesn't work, the Local Government Authority will contact the DEP to request their assistance.	WRC, DEP LGAs Landholders	SML	2
		Ensure that weed and pest control programs in the bushland near rivers and creeks are carried out in a responsible manner to avoid waterway contamination.	CALM LGAs Landholders	SML	1
		Implement pollution control measures to ensure discharges of effluent such as agricultural chemicals and intensive agriculture wastewater into receiving waterways are within acceptable levels.	WRC, DEP LGAs Landholders	SML	2
		Design contingency plans with the Local Government Authority, Water and Rivers Commission and State Emergency Service to handle a major chemical spill in or near a major waterway.	SES WRC LGAs	SML	1
	Improve management of saline water.	Encourage revegetation of landscape where possible to reduce the recharge into the groundwater and waterways.	LGAs LCDCs, Landholders	ML	2
		Publicise and enforce drainage controls for surface and deep drainage to ensure the volume and salinity of the water discharged off-site does not adversely affect neighbouring properties or waterways.	WRC DEP LGAs	SML	2

TARGETS	STRATEGY	ACTIONS	STAKE-HOLDERS	TIME FRAME	PRIORITY
Educate 80% of the people in the catchment about current best management practice to reduce saline water, nutrient, sediment and chemical input into the surface and groundwater in the catchment.		Develop and implement current best management practices for retaining on-site and managing saline water from agricultural/horticultural property.	AgWA, WRC, DEP, LGAs	S	1
		Organise a meeting involving CALM, landholders and community members to review the artificial maintenance of water levels in Lake Chittering.	CALM, LGAs, WRC Landholders Community, CMGs	S	3
	Implement water sensitive design immediately.	Ensure that new subdivisions (urban, rural living, industrial, and intensive agricultural) are located to minimise nutrient and pollutant input to the water cycle and incorporates water sensitive design.	WAPC LGAs AgWA	SML	1
		Incorporate water-sensitive design into Town Planning Schemes.	LGAs WAPC	M	1
		Implement appropriate controls and management measures such as retention basins to strip sediment and other undesirable components from stormwater to ensure runoff quality from urban developments is within acceptable limits.	LGAs DEP WRC	ML	2
		Provide public information and guidelines to residents, industry associations and commercial users on water-sensitive design and best practices	LGAs DEP WAPC	SML	3
	Promote sustainable water use.	Regulate through the appropriate authorities, the pumping of water from the river to ensure equitable distribution between landholders, community and environmental requirements.	WRC OWR	SML	2
		Encourage the community to adopt water conservation principles throughout the catchment.	WRC, LGAs, LCDCs, CMGs, Community	SML	1

Table 9: Actions to reduce and prevent the spread of salinity and soil degradation.

Objective 2

To reduce and prevent the spread of salinity and soil degradation; ensure sustainable land use and increase profitable production.

TARGETS	STRATEGY	ACTIONS	STAKE-HOLDERS	TIME FRAME	PRIORITY
Halt the rise of groundwater levels in the catchment in 20 years. No net increase in area of soil affected by salinity.	Assess soil salinity and degradation in the catchment.	Identify areas susceptible to soil salinity and waterlogging within the catchment.	AGWA, LCDCs, CMGs, Landholders LGAs	S	1
		Identify and manage “hot spots” for soil degradation, nutrient and sediment export.	AGWA WRC, Landholders LCDCs, CMGs	SM	2
		Identify areas within the catchment susceptible to wind and water erosion.	AGWA, LGAs LCDCs, CMGs Landholders	S	1
Reduce the level of in stream salinity within the subcatchments north of Bindoon. Increase the productivity of saline land by 50%. Identify all areas of potential wind and water erosion and undertake remedial action on 50% of sites in 10 years.	Improve ground and surface water management.	Use clearing and development controls to protect native vegetation on large and small parcels of land.	AGWA, LGAs	SML	1
		Rehabilitate and stabilize eroded areas to control recharge and increase water use.	LCDCs, CMGs Landholders, AGWA, LGAs	ML	2
		Encourage landholders to undertake current best management practices in areas experiencing waterlogging and soil salinity to lower the groundwater and rehabilitate degraded lands.	AGWA LCDCs, CMGs LGAs	ML	2
		Develop and encourage landholders to undertake current best management practices for irrigated horticulture, pasture and crops to reduce run off and recharge to groundwater.	AGWA, CMGs LCDCs, LGAs Landholders	SM	2
		Trial and encourage landholders to undertake alternative farming strategies such as alley farming and woodlots to reduce recharge to groundwater.	AGWA Landholders	ML	2

TARGETS	STRATEGY	ACTIONS	STAKE-HOLDERS	TIME FRAME	PRIORITY
All subdivision applications assessed according to land capability and suitability. Establish 50 hectares of perennial pasture in 5 years.		Develop and encourage landholders to undertake appropriate best management practices such as grade banks for surface water control to manage the quantity and quality of runoff from paddocks.	AGWA Landholders LCDCs, CMGs	SM	2
		Construct roaded catchments (sealed with clay) on recharge areas to divert fresh water into dams for use in irrigation.	Landholders CMGs	SM	4
Educate 50% of the people in the catchment in current best management practices for irrigated horticulture and erosion control within 5 years.	Implement erosion control.	Develop and implement best management practices such as no till farming in consultation with landholders and community to address the loss of topsoil and soil fertility.	AGWA, LCDCs, Landholders	ML	2
		Encourage landholders to under-take erosion control in areas exp-eriencing wind and water erosion.	AGWA, Landholders LCDCs, CMGs	SML	1
		Encourage landholders to replace annual pasture systems with perennial pastures to ensure continuous soil cover.	AGWA Landholders LCDC, CMGs	ML	3
	Improve land use planning.	Encourage the development of farm management plans that identify land capability and ensure sustainability of land uses.	AGWA, LGAs LCDCs, CMGs Landholders	S	1
		Scrutinise subdivision applications to ensure protection of natural resources in perpetuity.	LGAs, DEP, WAPC, AGWA, WRC Community	SML	3
		Ensure all re zoning considers land capability to guarantee the most appropriate and sustainable use of land.	LGAs, DEP WAPC	SML	1
		Locate rural residential and urban areas so they do not impinge on agricultural land or remove valuable agricultural soils and microclimates from production.	LGAs, WAPC.	SML	4
	Encourage further salinity research.	Encourage and support further research into saltland agronomy.	AGWA	ML	2

Table 10: Actions to restore the natural functions of the river channels, foreshores, floodplains and wetlands.

Objective 3

To restore the natural functions of the river channels, foreshores, floodplains and wetlands through protection and rehabilitation.

TARGETS	STRATEGY	ACTIONS	STAKE-HOLDERS	TIME FRAME	PRIORITY
Complete foreshore assessments of the major tributaries of the Brockman River in 5 years.	Assess the status of waterways and wetlands.	Undertake a review of the foreshore assessment of the Brockman River, its major tributaries and associated wetlands to monitor the status of riparian vegetation.	WRC, CALM. LCDCs Community, CMGs	S	1
		Establish and implement a program to measure and monitor river and wetland health using aquatic fauna.	WRC, CALM, LCDCs Community, CMGs	S	1
Fence to exclude livestock and rehabilitate the riparian vegetation on 50% of the main channel of the Brockman River and 30% on major tributaries within 10 years.	Improve management of waterways, foreshores and floodplains.	Encourage landholders to fence off and rehabilitate all defined watercourses.	LCDCs, CMGs, Community, WRC	SML	1
		Identify costs and provide economic incentives to support and encourage landholders to manage protect and rehabilitate foreshores and waterways to enhance their natural functions.	LGAs Community LCDCs	SM	1
		Protect riverbanks, wetlands and foreshores by excluding livestock.	WRC, LGAs, LCDCs Landholders, CMGs	SML	1
		Develop methods of fuel reduction in foreshore areas to minimise fire risk.	FESA, LGAs, Landholders	S	3
Educate 50% of the people in the catchment about river processes and restoration of riparian habitat		Encourage the strategic planting of floodplains using either native plants or agro forestry woodlots to restore floodplain function and prevent the main river channels from creating alternative courses.	AGWA, LCDCs Landholders. CMGs	SML	2
		Encourage the use of perennial pasture species on floodplains to ensure sustainable summer grazing by livestock and maximum water uptake.	AGWA, Landowners LCDCs, CMGs	ML	2

TARGETS	STRATEGY	ACTIONS	STAKE-HOLDERS	TIME FRAME	PRIORITY
		Research and trial native pasture species for use on the floodplains.	AGWA	ML	2
		Promote sustainable grazing practices on the floodplains to prevent overgrazing and compaction.	AGWA LCDCs, CMGs	S	1
		Raise landholder and community awareness of river processes and restoration of the riverine habitat through field days and workshops.	WRC LCDCs, CMGs	SM	1
		Ensure that infrastructure such as bridges, river crossings, culverts and fencing across channels doesn't interfere with the natural flow of the waterways and cause local flooding or contribute to erosion.	WRC, LGAs, MRWA Landholders	SML	4
	Improve the planning process to protect natural resources.	Develop and implement river restoration plans for the Brockman River, major tributaries and wetlands to restore and prevent further damage to the riverbed and banks and protect assets such as fringing vegetation, fences and buildings.	WRC, Rivercare Officer, LGAs CMGs	SM	1
		Negotiate with Local Government to ensure adequate setbacks from waterways of new horticultural enterprises are enforced as conditions of development.	LGAs, WRC, AGWA CMGs	S	1
		Negotiate with Local Government to include fencing of waterways, rehabilitation and protection of foreshores, and building envelopes to prevent building on floodplains as conditions for subdivision.	LGAs WRC CMGs	S	1

TARGETS	STRATEGY	ACTIONS	STAKE-HOLDERS	TIME FRAME	PRIORITY
		Negotiate restrictive covenants between those holding land tenure and the Water and Rivers Commission to ensure protection and management of floodplain, foreshore, riverbanks and channel.	WRC, LGAs, Landholders	SML	2
		Ensure construction of the Perth-Darwin Highway and others roads cause minimal disturbance to the environment and that construction in no way affects the quality of runoff, causes erosion or exacerbates drainage.	MRWA DEP, LGAs, WAPC	ML	2

Table 11: Actions to protect and enhance natural biodiversity to sustain ecological processes and conserve native plants and animals.

Objective 4

To protect and enhance natural biodiversity to sustain ecological processes and conserve native plants and animals.

TARGETS	STRATEGY	ACTIONS	STAKE-HOLDERS	TIME FRAME	PRIORITY
No further loss of native vegetation. 10% increase in native vegetation through revegetation, protection and enhancement or remnants within 10 years. All public open space to have management plans within 10 years. A fire management strategy that includes deliberate use of fire for ecological regeneration as well as hazard reduction and protection of property without undue risk to native vegetation.	Assess and monitor the status of flora and fauna in the catchment.	Monitor the status and extent of remnant vegetation throughout the Brockman River catchment.	AGWA, LGAs LCDCs, CMGs Landholders	ML	1
		Identify flora and fauna specific to the Brockman Catchment and develop community information sheets.	CALM, LCDCs Community, CMGs Landholders	S	3
		Establish a regional herbarium within the catchment.	CALM, LCDCs Community, CMGs	S	3
		Review weed maps for the foreshore of the Brockman River and roadside verges to identify priority areas for eradication and rehabilitation.	CALM, MRWA, WRC, LCDCs, LGAs, CMGs	S	1
	Protect and restore native vegetation and reduce loss of biodiversity.	Protect and enhance roadside vegetation to reduce loss of biodiversity.	LGAs, MRWA CALM	SML	2
		Protect existing, and increase, the number of “flora” roads.	LGAs, MRWA CALM	SM	2
		Educate the community about the value of riparian and other bushland vegetation.	WRC, LCDCs, CMGs	SM	1
		Encourage the restoration of degraded remnants by replanting to provide linkages and corridors between remnants on private land, Nature Reserves and the riparian vegetation.	LCDCs, CALM LGAs, CMGs Landholders	ML	2
		Provide advice and guidance on best plant species to use in revegetation projects.	LCDCs, AGWA CMGs	S	1

TARGETS	STRATEGY	ACTIONS	STAKE-HOLDERS	TIME FRAME	PRIORITY
		Protect and enhance native vegetation areas and encourage landholders to prepare vegetation management plans in consultation with Land for Wildlife officers for all remnants larger than 1 hectare.	CALM Landholder LCDCs, CMGs Community	SML	2
		Promote covenanting schemes to protect remnant native vegetation on private land.	LCDCs, CALM, AGWA, CMGs National Trust	SML	1
		Ensure public access to areas where appropriate recreational and tourist activities can be enjoyed and ensure that any degradation of the waterways and bushland areas is minimal.	CALM LGAs	SM	3
Decrease in distribution and abundance of introduced pests and diseases. Educate 80% of the people to recognise weeds and techniques for their control.	Develop appropriate fire management strategies.	Include fire management strategies in FESA and local government fire management plans to minimize the threat to natural vegetation that may result in potential soil and nutrient loss, and encourage weed growth.	FESA LGAs Local FAC	S	1
		Educate the community about bush fire risk and encourage them to take responsibility for protecting their own assets by managing fuel loads, installing and maintain strategic firebreaks, ensuring emergency water supplies for fire fighting and ensuring emergency vehicle access.	FESA, LGAs, CMGs	SML	1
		Ensure that Local Government Authority plans recognise that the deliberate use of fire for ecological regeneration may require a different fire regime from the current standard used by the bushfire brigades and allowances need to be made for it in conservation areas (including private land)	FESA LGAs	S	1

TARGETS	STRATEGY	ACTIONS	STAKE-HOLDERS	TIME FRAME	PRIORITY
	Control and, if possible, eradicate weeds and pest animals.	Identify priority environmental and agricultural weeds and develop management plans for their eradication or containment.	LGAs, CMGs, LCDCs, CALM, Community, Landholders	SM	1
		Encourage landholders to eradicate and control pest plants on their property, particularly the declared pest plants.	LGAs, AGWA, LCDCs, CMGs, Community	SML	2
		Increase the awareness and education of landholders in the best methods to carry out weed control.	LCDCs, CMGs, AGWA	SML	1
		Eliminate feral animals from the bushland along the river, other bushland in the catchment and reserves, and to control re-invasion with ongoing control programs.	AGWA, CALM, Landholders LGAs	ML	2
		Consult with CALM to reduce excessive numbers of kangaroos on private property.	CALM, Landholders	SML	31
		Provide information on baiting programs and techniques to control feral animals.	AGWA	SML	1
		Encourage community participation in activities such as Weedbuster Week to increase awareness of the weeds present in the Brockman Catchment.	LCDCs, CMGs Community	SML	1
		Coordinate the weed control activities of local government, State and Commonwealth agencies, landholders and community groups.	All Agencies	SML	2
		Increase awareness of dog and cat control/management and enforce the appropriate council bylaws.	LGAs	SML	1

5. Glossary

Algal Bloom A sudden growth of algae in a body of water due to nutrient enrichment. The algae use considerable oxygen to the detriment of other organisms and when it dies, some species release dangerous toxins into the water.

Alleys Lanes of pasture or crop established between belts of trees, usually arranged at regular intervals, at least one or two 'machine widths' wide.

Biodiversity The variety of living things at all levels, from genetics to higher groups and including the variety of habitats and ecosystems. Sometimes includes the variety of ecological processes within communities and ecosystems.

Catchment The area from which a surface watercourse and/or groundwater system derives its water.

Covenant A legally binding agreement between a landholder and body such as CALM, to protect and enhance nature conservation values on private property. They are backed by an Act of Parliament and enable the covenanting body to enforce the covenant.

Critically Endangered A native species that is facing an extremely high risk of extinction in the wild in the immediate future.

Drainage The act of transferring water and the substances in it from one area to another.

Ecological Processes The complex of biological and physical processes such as growth, nutrient cycling, water cycling, long-term climate change, photosynthesis, predation, competition, reproduction and speciation, which occur in the environment.

Ecosystem A discrete environmental unit that consists of living and non-living things interacting to form a stable system. For example, the lake ecosystem.

Endangered A native species that is facing a very high risk of extinction in the wild in the near future.

Environmental Values Particular values or uses of the environment that are of benefit to public welfare, safety or health and require protection from the effects of pollution, waste discharges and deposits.

Erosion The movement of soil and rock material by running water, wind or gravitational creep (eg land slip).

Eutrophication The process of nutrient enrichment (usually by nitrates and phosphates) in aquatic ecosystems. This can cause algal blooms that may be detrimental to the ecosystem.

Exotic Species A non-native species of plant or animal that has been brought into an area.

Extinct A species where there is no reasonable doubt that the last member of the species has died.

Feral Species A domesticated species that has become wild.

Groundwater Water in saturated soil; this may be at the soil surface itself or it may be many metres below the surface.

Habitat The living place for an organism or community.

Herbarium A collection of named species of plants, usually pressed and mounted as a permanent record.

Infrastructure Buildings and other permanent structures such as roads, bridges, fences and dwellings.

Integrated Natural Resource Management Plan A broad-based or "umbrella" plan, which coordinates community and government activities to sustain all natural resources throughout the catchment.

Intrinsic Value The worth of something independent from external circumstances or its value to humans.

Macro-invertebrates The larger invertebrates (animals without backbones) found in the river and lakes.

Native Vegetation Any local indigenous plant community containing throughout its growth the complement of native species and habitats normally associated with that vegetation type or having the potential to develop these characteristics. It includes vegetation with these characteristics that has been regenerated with human assistance following disturbance. It excludes plantations and vegetation that has been established for commercial purposes.

Natural Resources The land, water, air and the living things found within a particular area.

Palaeochannel An ancient watercourse, which may have flowed in another direction.

Perennial Plants A plant that lives for more than two seasons and after an initial period, flowers each year.

Recharge The process of replenishment of the groundwater bodies due to filtering of water from rainfall.

Remnant Vegetation Native vegetation that is still remaining and is usually surrounded by developed land such as land cultivated for agriculture. The quality of remnant vegetation can vary from pristine (very little or no disturbance) to parkland cleared where only the old large trees are left standing.

Riparian Vegetation Vegetation that is growing along the banks of a watercourse.

Sedimentation The process whereby soil and other suspended material carried by water is deposited in the river channels and floodplain.

Soil Salinity The salt that is brought to the surface layers of soil by a rising watertable followed by evaporation. Salt crystals may be seen forming a crust on the surface.

Species A group of organisms capable of interbreeding freely with each other but not with members of other species.

Stakeholders Everyone from individuals to government bodies that have any stake or interest in the study area.

Threatened A species or community that is vulnerable, endangered or presumed extinct.

Topography The surface features and relief of a particular area.

Translocated Species Native species introduced into suitable habitats within their own country, having been previously excluded from these habitats by natural barriers.

Water Balance Under natural conditions, the amount of water entering a system or catchment via rainfall is used by plants and animals, recharges the groundwater to its natural level and maintains the streams and river.

Watertable The upper surface of the groundwater or the level below which the material is permanently saturated with water.

Wetlands Open water habitats and areas containing water for part of a year or permanently waterlogged land.

Woodlot A tree plantation, up to several hectares in size, usually surrounded by pasture or crops and distinct from a large contiguous plantation which covers a large proportion of the landscape. Woodlots are distinct from tree belts in that the 'edge effect' on the supply of water and light is minimal when averaged over the whole stand.

Acronyms used

AGWA Department of Agriculture

CALM Department of Conservation and Land Management

CMG Catchment Management Group

DEP Department of Environmental Protection. (Amalgamating to form DEWCP)

DEWCP Department of Environment, Water and Catchment Protection (Amalgamation of WRC and DEP)

FAC Fire Advisory Committee

FESA Fire Emergency Services Authority

INRM Integrated Natural Resource Management

LCDC Land Conservation District Committee.

LGA Local Government Authority

MfP Ministry for Planning (Now the Department for Planning and Infrastructure)

MRWA Main Roads Western Australia

NRM Natural Resource Management

OWR Office of Water Regulation

SES State Emergency Service

WAPC Western Australian Planning Commission

WRC Water and Rivers Commission (Amalgamating to form DEWCP)

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7. Appendix 1: Geomorphology and soil landscapes

GEOMORPHIC REGION/ELEMENT	SOIL	LANDSCAPE SYSTEM
Dandaragan Plateau		
Gentle Scarp	Re/Rg	Reagan
	Gg	Gingin
	Cm/Cb	Coonambidgee
Sandy (Lateritic) uplands	Mb/Mg	Mogumber
	Cp*	Capitella
	Ka	Karamal
Valleys	Md	Moondah
	Yy*	Yalyal
Darling Plateau		
Lateritic uplands	Yb	Yalanbee
	C	Cook
	Ug*	Udamong
Major valleys - slopes	Bi/Bn	Bindoon
	Mn/Mi	Michibin
Major valleys - floors	No/Nn	Nooning
	Br	Brockman
	BV*	Berkshire Valley
Minor Valleys and drainage depressions	Ck	Coolakin
	Pn	Pindalup
	Yg	Yarragil
	Yh*	Yarawindah

Reference: Evangelisti and Associates (1999) Shire of Chittering land capability and management study. Part 1 – working paper.

*Source Agriculture WA surveys in progress, all others CSIRO (Churchward and McArthur, 1978)

Soil-landscape systems

The system of nomenclature for soils and soil landscapes within Western Australia is currently being revised by Agriculture WA. Some soil landscape 'systems' referred to here may be renamed as soil landscape 'subsystems' and many have previously been referred to as 'soil/landform associations' by CSIRO.

DANDARAGAN PLATEAU	
Gentle Scarp	
Reagan	Gently sloping scarp dominated by yellow or grey sands; some duricrust or gravels.
Gingin	Gently sloping irregular scarp; mainly red sandy soils with associated small areas of red duplex soils and shallow black clays.
Coonambidgee	Gently sloping fringe to the Dandaragan Plateau; deep grey sands.
Sandy (lateritic) uplands	
Mogumber	Gently undulating landscape; duricrust and gravels on crests and grey sands in broad shallow depressions.
Karamal	Gently undulating landscape dominated by deep yellow sands; some gravels on ridges.
Capitella*	Subdued stripped lateritic plateau with undulating to gently undulating low rises and gently undulating plain including dunes. Geology is sandstone plus alluvial and aeolian deposits. Pale and yellow sands, sandy gravels and some duplex.
Valleys	
Moondah	Valleys with deep red and yellow brown sands; occasional swamps.
Yalyal*	Drainage depressions in very gently sloping plain but gently sloping in the upper reaches.

DARLING PLATEAU	
Lateritic Uplands	
Yalanbee	Gently undulating landscape dominated by fine gravels; some duricrust on ridges.
Cook	Hills rising above general plateau level; mainly mantled by ;laterite but with some rock outcrop.
Udamong*	Partially stripped lateritic plateau with undulating low hills and undulating to gently undulating rises. Parent material is deep weathered granitic gneiss, gneiss and schist. Soils are loamy gravel with minor pale sand and clay.

Major Valley Slopes	
Bindoon	Steep irregular slopes with shallow red and yellow earths and much rock outcrop. Sometimes a gently sloping apron at base.
Michibin*	Stripped deep weathered plateau with rolling and undulating low hills. Parent rock is weathered granitic gneiss and granite. Soils are loamy (some loamy earths) with gravels and rock outcrops.
Major Valley Floors	
Nooning	Terraced floors of upper Brockman River; yellow duplex soils and sandy deposits; some swamps.
Berkshire Valley*	Partially rejuvenated level to gently undulating plain (relict flood plain). Parent material is alluvium. Soils are predominantly loamy earths and clay, with some duplex types.
Minor Valleys and Drainage Depressions	
Coolakin	Valleys near the junction of the Darling and Dandaragan Plateaux; sandy and gravelly duplex soils on the slopes; narrow valley floors; some rock outcrop.
Pindalup	Valleys of the western part of the plateau; gravelly duplex soils on slopes; some rock outcrop; grey sands, duplex yellow soils and orange earths in the broad floors.
Yarawindah*	Dissected lateritic plateau with rolling to undulating low hills and undulating rises. Parent material is weathered schist and some gneiss. Soils are predominantly loamy gravel, loamy earth, and loamy duplex, with some rock occurring.

Reference: Evangelisti and Associates (1999) Shire of Chittering land capability and management study. Part 1 – working paper.

*As described within Agriculture WA survey areas and generally not mapped by CSIRO.

Appendix 2: Vegetation complexes in the Brockman River catchment

The following descriptions of the vegetation complexes of the Darling System of Western Australia are those outlined by E. M. Heddle, O. W. Loneragan and J. J. Havel (1980).

DANDARAGAN PLATEAU	
Mogumber Complex –North	This complex is dominated by open and closed-heaths. These heaths are the southerly extension of the northern heathlands. The marked absence of jarrah (*Eucalyptus marginata*) and marri (*Corymbia callophylla*) in this drier northern section distinguishes it from the southern section. The open and closed heath-heath of *Casuarina humilis*, *Banksia sphaerocarpa*, several unnamed species of *Banksia*, *Xanthorrhoea preissi* and many other species, in particular *Myrtaceae*, *Proteaceae*, *Paplionaceae* and *Epacridaceae* occur on the low rises. The plant species in this heath include *Dryandra carlinoides*, *Dryandra kippistiana*, *D. shuttleworthii*, *Conospermum incurvum*, *C. stoechadis*, *C. acerosum*, *Mesomelaena stygia*, *M. tetragona* and species of *Eremaea*, *Calothamnus*, *Verticordia*, *Calytrix*, *Daviesia*, *Oxylobium* and *Andersonia*. Several rare species have been recorded and include *Stachystemon axillaris*, *Cryptandra humilis* and an unnamed prostrate species of *Banksia*. Swales and shallow valleys that support a low open-forest to low open-woodland of banksia on the valley floors surround the low rises. Associated with *Banksia attenuata*, *B. menziesii* and *B. prionotes* are *B. burdettii*, the pricklybark (*Eucalyptus todtiana*) and an occasional marri.
Mogumber Complex –South	An open-woodland of marri with a well-defined second storey of pricklybark-banksia (*E. todtiana-B. attenuata-B. menziesii-B. ilicifolia*) dominates this complex. The same pattern of marri extending further north than jarrah, seen on the Swan Coastal Plain, is repeated in this area. Although localised patches of jarrah can be found they are restricted in size and number. Jarrah disappears first then marri as the rainfall decreases going northward. Understorey species vary considerably depending on proportion of sand and gravel; depth of sand and moisture levels but include species as *Nuytsia floribunda*, *Stirlingia latifolia*, *Petrophile linearis*, *Daviesia pectinata*, *Calothamnus sanguineus*, *Mesomelaena tetragona*, *Baekea camphorosmae*, *Hypocalymma angustifolium*, *Leptocarpus scariosus*, *Casuarina humilis*, *Lyginia tenax* and *Bossiaea eriocarpa*.
Karamal Complex –South	An open-forest of jarrah-marri with a definite second storey of *B. grandis* on the gravely soils and *B. attenuata*, and *B. menziesii* on the sandier soils. Small areas of wandoo occur in pockets. Other species that occur include *Stirlingia latifolia*, *Dryandra sessilis*, *D. nivea*, *Hakea ruscifolia*, *Petrophile linearis*, *Jacksonia floribunda* and species of *Calytrix*, *Conostephium* and *Hakea*.
Cullala Complex	A mixture of low open-forest of banksia-pricklybark and an open-woodland of marri with a well defined second storey of *B. attenuata-B. menziesii-B. ilicifolia* characterises this complex. Other species include *Nuytsia floribunda*, *Stirlingia latifolia*, *Calothamnus sanguineus*, *Casuarina humilis*.

Wannamal Complex	This complex is distinguished by the extensive areas of low shrubland of *Melaleuca* spp. On the swamps located to the west of the Wannamal township. A minor component is the sedgelands associated with the areas subject to inundation. On the low dunes the vegetation consists of extensions of the Cullala complex, while to the east and north, the open-woodland of wandoo and less consistently, York gum, adjoins the swamp vegetation.
Reagan Complex	This complex supports vegetation ranging from low open-woodland of *B. attenuata-B. menziesii-E. todtiana* to closed-heath, depending on the soil depth. The composition of the understorey varies slightly depending on the proportion of sand and gravel. Plant species include *Adenanthos cygnorum*, *Petrophile linearis*, *Mesomelaena tetragona*, *Casuarina humilis*, *Mesomelaena stygia*, *Hakea trifurcata*, *Daviesia juncea*, and species of *Hibbertia*, *Eremaea*, *Conospermum* and *Conostephium*.

	DARLING PLATEAU
Dwellingup and Yalanbee Complex in low to medium rainfall	Restricted in occurrence to the ridges surrounding the Avon River Valley. It appears to be a transitional complex with a mosaic of understorey species from adjacent complexes. The dominant vegetation is open forest of jarrah-marri, (*Eucalyptus marginata*, *Corymbia calophylla*). Other species include *Daviesia pectinata*, *Stirlingia latifolia*, *Acacia browniana*, *Adenanthos barbigerus*, *Banksia grandis*, *Grevillea wilsonii*, *Persoonia longifolia*, *Lepidosperma angustatum*, *Hakea lissocarpha*, *Macrozamia reidlei* and *Casuarina humilis*.
Dwellingup , Yalanbee and Hester Complex in low medium rainfall	Compared to the previous complex, the floristic composition of the understorey species reflects the lower rainfall and warmer conditions in the northern and to eastern sections of the jarrah forest. The dominant vegetation is open forest of jarrah-marri, (*Eucalyptus marginata*, *Corymbia calophylla*). Other species include *Daviesia pectinata*, *Stirlingia latifolia*, *Lepidosperma angustatum* and *Hakea lissocarpha*.
Yalanbee and Dwellingup Complex in low rainfall	This complex consists of a mixture of open forest of jarrah-marri, *Eucalyptus marginata*, *Corymbia calophylla* and wandoo-marri woodlands of *E, wandoo* and *Corymbia calophylla*. Other species include *Daviesia pectinata*, *Stirlingia latifolia*, *Lepidosperma angustatum*, *Hakea lissocarpha*, *Hibbertia lineata* and *Hypocalymma angustifolium*. Localised patches consist of a low open-forest of rock sheoak (*Casuarina heugeliana*) and herblands on the shallow soils overlying granitic rocks.
Yalanbee Complex in low rainfall	This complex is restricted to the uplands in the low rainfall areas to the north and east of the Darling Plateau. It uniquely supports a mainly wandoo-powderpark wandoo (*E. wandoo-E. accedens*) woodland. It overlaps with adjacent complexes by the minor occurrences of wandoo-marri woodland and open forest of jarrah-marri. The dominant site vegetation consists of *E. wandoo*, *Hakea lissocarpha*, *Hibbertia lineata* and *Hypocalymma angustifolium*.

Cooke Complex	This complex occurs over a wide area with a large variation in depth of soil and very varied associated vegetation. Vegetation consists of lichens *Borya nitida, Grevillea bipinnatifida, Hakea elliptica, Hakea undulata, Hakea lissocarpha, Eucalyptus wandoo* and *Casuarina heuegliana*. Several species of *Acacia, Melaleuca* and *Verticordia* also occur in the complex.
Pindalup and Yarragil Complex in low to medium rainfall	This complex defines the distribution of the most westerly extension of wandoo in the shallow upper valleys and in the north, the wandoo woodlands extend through the deeply dissected Bindoon and Murray units. The vegetation complex consists predominantly of an open-woodland of wandoo with some admixture of marri, yarri and jarrah and an open forest of jarrah-marri. As the valleys carrying wandoo-yarri woodlands occupy more fertile sites, most have been cleared for agricultural purposes. The dominant vegetation consists of *Daviesia pectinata, Eucalyptus marginata, Stirlingia latifolia, E. wandoo, Hakea lissocarpha, Hypocalymma angustifolium, Baeckea camphorosmae, Dampiera alata,* and *Hibbertia lineata*.
Coolakin Complex in low rainfall	Wandoo woodland dominates this complex with a mixture of jarrah, marri and yarri. The vegetation consists of *Daviesia pectinata, Eucalyptus marginata, Stirlingia latifolia, E. wandoo, Hakea lissocarpha, Hypocalymma angustifolium, Baeckea camphorosmae, Dampiera alata, Hibbertia lineata, Diplolaena drummondii, Hibbertia polystachya, Lyginia tenax, Mesomelaena tetragona, Styphelia tenuifolia, Patersonia rudis, Macrozamia reidlei, Leucopogon propinquus* and *Leucopogon capitellatus*.
Helena Complex in low medium rainfall	Restricted to the western fringes of the Darling Plateau, it reaches maximum to development along the Avon River. The vegetation is variable, depending on the depth of soil and ranges from open-forests to lichens. The distinctive feature of this complex is the open-woodland of wandoo on the valley slopes and floors which provides the east-west link between wandoo in the eastern valleys and on the scarp. The dominant vegetation consists of lichens *Borya nitida, Grevillea bipinnatifida, Hakea elliptica, Hakea undulata, Hakea lissocarpha, Eucalyptus wandoo* and *Casuarina heugeliana*. Several species of *Acacia, Melaleuca* and *Verticordia* also occur in the complex.
Murray and Bindoon Complex in low to medium rainfall	This complex occurs in the moderately incised valleys of the Murray and Bindoon units (less than 1100mm annual average rainfall)in the eastern and northern areas of the Darling Plateau. The distinctive vegetation feature is the wandoo woodland on the valley slopes, intermixed with some open forest of jarrah-marri-yarri and a woodland of *E. rudis-M. rhaphiophylla* on the fringes of the water courses. The dominant vegetation consists of lichens *Borya nitida, Grevillea bipinnatifida, Hakea elliptica, Hakea undulata, Hakea lissocarpha, Eucalyptus wandoo, Baekea camphorosmae, Dampiera alata, Hibbertia lineata, Hypocalymma angustifolium* and *Casuarina heugelian*a. Several species of *Acacia, Melaleuca* and *Verticordia* also occur in the complex.
Williams-Avon-Brockman-Mumballup Complex	This complex occurs on the Valley floors of the Williams, Avon, Brockman and Preston Rivers. Despite the large variation in rainfall the vegetation in these valleys is similar, consisting of a fringing woodland of *E. rudis-M. rhaphiophylla*. On the fringes of this woodland the vegetation relates to the adjacent complexes.

Nooning Complex	This complex is restricted to the upper valley floors of the Brockman River that are subject to inundation. The distinctive feature of this complex is the occurrence of low open-forest of *Casuarina obes*a and the open scrub of *C.obesa-Acacia* spp-*Melaleuca* spp. Localised patches of *E. rudis-M. rhaphiophylla* woodland occur along the streams.
Bindoon Complex	This complex coincides in the main with the Bindoon unit except for sections in the Chittering Valley. The vegetation is unique in the Darling System consisting predominantly of York gum (*E. loxophleba*) woodland which is flanked by wandoo woodland on the upper slopes. *C. heugeliana* is associated with rock outcrops. This complex is best developed in the Darling System in the valleys near Bindoon and Toodyay.
Michibin Complex	This complex coincides with the Michibin unit in the low rainfall area along the eastern and northern fringes of the Darling Plateau. Its distinctive feature is the dominance of wandoo woodland. York gum is located only in small patches and mixed with wandoo. *Acacia acuminata*, *Casuarina heugeliana* and *A. microbotrya* dominate the understorey, with *C. heugeliana* restricted to rock outcrops.
Darling Scarp Complex	A large variety of flora on a unique geological feature characterises this complex. Several features are evident in this vegetation complex that coincides with the Darling Scarp unit. These include a dominance of wandoo along the entire length of the Darling Scarp with an admixture of marri, the occurrence of the rare butter gum (*E. laeliae*) on the northern areas, the occurrence of mountain gum (*E. haematoxylon*) on the southern areas, the intermingling of all these species and the rare *E. lane-poolei*. The vegetation ranges from low open-woodland of wandoo with admixtures of marri, butter gum and mountain gum, through to low open-forest of *C. heugeliana*, through to heath, herblands of *Borya nitida* and lithic complex on the granite rocks. Shrub species include *Thomasia glutinosa*, *Verticordia acerosa*, *Hakea incrassata*, *H. stenocarpa*, *Grevillea bipinnatifida*, *Hovea pungens*, *Goodenia fasciculata*, *Petrophile biloba*, *Conospermum huegelii* and *Grevillea endlicherana*.

Appendix 3: Flora of the Brockman River catchment

DECLARED RARE FLORA	
Priority Species	**Conservation code**
Acacia anomala	R
Anigozanthos humilis subsp. *chrysanthus*	R
Asterolasia nivea	R
Darwinia acerosa	R
Drakaea elastica	R
Eleocharis keigheryi	R
Spirogardnera rubescens	R
Thelymitra stellata	R
Baeckea sp.Chittering (R.J.Cranfield 1983)	1
Goodenia arthrotricha	1
Grevillea corrugata	1
Johnsonia inconspicua	1
Nemcia sparsa	1
Stylidium carlquistii	1
Synaphea panhesya	1
Acacia browniana var. *glaucescens*	2
Hakea sp.Walyunga (L.Penn s.n.)	2
Millotia tenuifolia var. *laevis*	2
Nemcia axillaris	2
Stylidium semaphorum	2
Trymalium urceolare	2
Verticordia bifimbriata	2
Verticordia serrata var. *Udumung* (D.Hunter & B.Yarran 941006)	2
Acacia anarthros	3
Acacia drummondii subsp. *affinis*	3
Acacia oncinophylla subsp. *oncinophylla*	3
Adenanthos cygnorum subsp. *chamaephyton*	3
Banksia micrantha	3
Dryandra drummondii subsp. *hiemalis*	3
Dryandra echinata	3
Grevillea uncinulata subsp. *florida*	3
Hakea myrtoides	3
Lambertia multiflora var. *darlingensis*	3
Monotoca leucantha	3
Nemcia acuta	3
Olax scalariformis	3

Priority Species	Conservation code
Persoonia sulcata	3
Petrophile plumosa	3
Synaphea grandis	3
Acacia clydonophora	4
Boronia tenuis	4
Calytrix sylvana	4
Dryandra polycephala	4
Grevillea drummondii	4
Hydrocotyle lemnoides	4
Schoenus natans	4
Verticordia lindleyi subsp. *lindleyi*	4
Verticordia paludosa	4
Lysinema elegans	C

Typical flora in the Brockman River catchment

Jarrah forest		
Botanical name	**Common name (if known)**	**Notes**
Allocasuarina fraseriana	sheoak	small tree
Banksia grandis	bull banksia	small tree
Eucalyptus accedens	powerbark wandoo	tree, some sites only
Corymbia calophylla	marri	tree, usually <50% of tree cover
Eucalyptus marginata	jarrah	dominant tree
Eucalyptus patens	blackbutt	tree, some sites
Eucalyptus wandoo	wandoo	trees, some sites
Grevillea wilsonii	native fuchsia	shrub
Personnia longifolia	snottygobble	small tree
Marri-wandoo		
Corymbia calophylla	marri	tree
Eucalyptus wandoo	wandoo	tree
Eucalyptus laeliae	Darling Range ghost gum	tree
Xanthorrhoea preissii	grasstree	small tree
Macrozamia riedlei	samia	small tree
Nuytsia floribunda	Christmas tree	small tree
Dryandra sessilis	parrot bush	tall shrub
Daviesia horrida	prickly bitter pea	tall shrub
Hakea cristata	snail hakea	tall shrub
Hakea trifurcata	two-leaf hakea	tall shrub
Acacia pulchella	prickly Moses	small shrub
Dryandra nivea	couch honeypot	small shrub
Hibbertia hpericoides	yellow buttercups	small shrub
Hibbertia montana		

Jarrah- wandoo – powerbark		
Botanical name	**Common name (if known)**	**Notes**
Acacia acuminata	jam	small tree in drier eastern areas
Acacia varia var. *affinis*		large shrub
Adenanthos cygonorum	common woollybush	large shrub
Allocasuarina fraseriana	sheoak	small tree
Allocasuarina humilis	dwarf sheoak	large shrub
Anigozanthos humilis	catspaw	herb
Anigozanthos mangelisii	Mangle's kangaroo paw	herb
Astroloma pallidum	kickbush	small shrub
Baeckea crispiflora		small shrub
Banksia grandis	bull banksia	small tree
Bossiaea armata		small shrub
Bossiaea eriocarpa	common brown pea	small shrub
Burchardia umbellata	milkmaids	herb
Calothamnus quadrifidus	one sided bottlebrush	tall shrub, drier eastern parts
Calothamnus sanguineus	pindak	large shrub
Calytrix brachyphylla		small shrub
Calytrix sappirina		small shrub
Chorizema dicksonii	yellow-eyed flame pea	small shrub
Comesperma volubile	love creeper	creeper
Conospermum densiflorum	common smokebush	small shrub
Conospermum glumaceum	hooded smokebush	small shrub
Conostylis setosa	white cottonhead	herb
Darwinia sp.		
Daviesia divaricata	marno	large shrub
Daviesia pectinata	prickly bitter pea	large shrub
Dianella revoluta	blueberry lily	herb
Dillwynia cinerascens	grey parrot-pea	small shrub
Dryandra polycephala	many-headed dryandra	large shrub
Dryandra nivea	couch honeypot	small shrub, wetter western part
Dryandra sessilis	parrot bush	tall shrub, wetter western parts
Eucalyptus accedens	powderbark wandoo	tree in drier eastern parts
Eucalyptus marginata	jarrah	occasional, western parts
Eucalyptus patens	Swan River blackbutt	tree, in some valleys
Eucalyptus wandoo	wandoo	tree, wetter western parts
Gastrologium spinosum	prickly poison	medium shrub, drier eastern parts
Gastrolobium villosum	crinkle-leaved poison	small shrub
Gompholobium knightianum		small shrub
Grevillea synapheae	catkin grevillea	small shrub
Grevillea pilulifera	woolly-flowered grevillea	large shrub
Haemodorum sp.		herb
Hakea ruscifolia	candle hakea	large shrub
Hakea lissocarpha	honey bush	large scrub
Hakea cristata	thick leaved hakea	tall shrub, wetter eastern parts
Hakea undulata	wavy-leaved hakea	tall shrub, wetter eastern parts
Hakea trifurcata	two leaved hakea	tall shrub, wetter eastern parts

Botanical name	Common name (if known)	Notes
Hibbertia hypericoides	yellow buttercups	small shrub, wetter eastern parts
Hibbertia montana	mountain primrose	small shrub, wetter eastern parts
Hibbertia lasiopus	large hibbertia	small shrub
Kennedia prostrata	scarlet runner	creeper
Lechenaultia biloba	blue lechenaultia	small shrub
Leucopogon pulchellus	beard-heath	small shrub
Leptospermum erubescens	roadside tea tree	tall shrub, drier eastern parts
Macrozamia riedlei	zamia	wetter eastern parts
Melaleuca scabra	rough honeymyrtle	large scrub
Nuytsia floribund	Christmas tree	small tree, western eastern parts
Orthrosanthus laxiflorus		herb
Oxylobium parviflorum	box poison	shrub, drier eastern parts
Patersonia occidentalis	purple flag	herb
Petrophile serruriae		large shrub
Petrophile striata		large shrub
Ptilotus mangelsii	pom poms	herb
Phyllanthus calycinus	false bornia	small shrub
Spaerolobium vimineun	leafless glove pea	small shrub
Stackhousia sp.		herb
Tetratheca sp.		herb
Xanthorrhoea prissii	grass tree	shrub
Riverine woodland		
Eucalyptus loxophleba	York gum	in drier areas on and close to drainage
Eucalyptus rudis	flooded gum	along streams in wetter areas
Melaleuca rhaphiophylla	swamp paperbark	narrow strips along streams
Melaleuca uncinata		
Melaleuca viminea		
Granite outcrops in drier areas		
Allocasuarina huegeliana	rock sheoak	small tree, peripheral groves
Borya spaerocephala	pincushions	tussocks
Grevillea bipinnatifida	Fuchsia grevillea	shrub
Hakea elliptica	two leaf hakea	shrub
Hakea undulata	wavy-leaf hakea	shrub
York gum, wandoo and salmon gum woodlands and heath		
Acacia acuminata	jam	small tree
Acacia micorbotrya	manna wattle	shrub
Acacia pulchella	prickly Moses	understorey species
Allocasuarina campestris	tamma	shrub
Allocasuarina humilis	dwarf sheoak	shrub
Allocasuarina huegeliana	rock sheoak	medium tree
Casuarina obesa	swamp sheoak	small tree, along streams
Eucalyptus accedens	powerbark wandoo	tree, associated with breakaways

Botanical name	Common name (if known)	Notes
Eucalyptus loxophleba	York gum	tree
Eucalyptus rudis	flooded gum	tree, along stream
Eucalyptus salmonophloia	salmon gum	tree
Eucalyptus wandoo	wandoo	tree
Adenanthos cygnorum	common wollybush	heath species
Banksia attenuata	slender banksia	heath species
Calathamnus quadrifidus	one-sided bottlebrush	understorey species
Conospermum sp.	smoke bush	heath species
Dryandra nivea	couch honey pot	heath species
Eucalyptus drummondii	Drummond's mallee	heath species/mallee
Eucalyptus macrocarpa	mottlecah	heath species/mallee
Leptospermum erubescens	roadside tea-tree	heath species
Isopogon dubius	pin custion cornflower	heath species
Jackson sp.		heath species
Stirling latifolia	blueboy	heath species
Nuytsia floribunda	Christmas tree	heath species
Pericalymma ellipticum		understorey species
Gastrolobium spinosum	prickly poison	shrub
Hakea priessi	needle tree	small tree
Pericalymma ellipticum	swamp tea-tree	shrub
Xanthorrhoea preissi	grass tree	understory species
Scrub-heath and banksia low woodland		
Actinostrobus arearius	sandplain cypress	shrub
Adnanthos cygnorum	common woollybush	tall shrub
Adenanthos drummondii		
Allocasuarina campestris		shrub
Allocasuarina humilis	dwarf sheoak	shrub
Astroloma sp.		shrub
Banksia attenuata	slender banksia	small tree
Banksia menziesii	firewood banksia	small tree
Banksia prionotes	acorn banksia	medium tree
Comesperma volubile	love creeper	low shrub
Chorizema dicksonii	Flame pea	low shrub
Diannella revoluta	blueberry lily	herb
Dryandra sp.		shrub
Eremaea sp.		
Gastrolobium spinosum	prickly poison	medium shrub
Grevillea eriostachya	flame grevillea	shrub
Grevillea integrifolia	entire-leaved grevillea	shrub
Hakea trifurcata	tow-leaf hakea	shrub
Isopogon dubius	pincushion coneflower	small shrub
Leptospermum ellipticum	swamp tea tree	shrub
Melaleuca radula	graceful honeymyrtle	shrub
Melaleuca scabra	rough honeymyrtle	large shrub
Nuytsia floribunda	Christmas tree	small tree, parastici

Botanical name	Common name (if known)	Notes
Petrophile sp.		shrub
Verticordia chrysantha		low shrub
Verticordia picta	painted featherflower	low shrub
Xanthorrhoea preissii	grasstree	shrub
Salt flats		
Halosarcia sp	samphire	small tree, adjacent salt flats
Casuarina obesa	swamp sheoak	medium to large shrub
Melaleuca thyoides		medium shrub
Melaleuca uncinata	broombrush	

This list was modified from list published in the Weaving, S. (1999). Native vegetation handbook for the Shire of Toodyay.

Appendix 4: Fauna of the Brockman River catchment

Birds found in the Brockman River catchment

This list has been compiled from known observations in the catchment and Western Australian Museum records.

Scientific Name	Common Name
Acanthagenys rufogularis	spiny-cheeked honeyeater
Acanthiza apicalis	inland thornbill
Acanthiza chrysorrhoa	yellow-rumped thornbill
Acanthiza uropygialsi	chestnut-rumped thornbill
Acanthorhynchus superciliosus	western spinebill
Acantiza inornata	western thornbill
Accipiter cirrhocephalus	collared sparrowhawk
Accipiter fasciatus	brown goshawk
Acrocephalus stentoreus	clamorous reed-warbled
Aegotheles cristatus	australian owlet-nightjar
Anas castaea	chestnut teal
Anas givverifrons	grey teal
Anas rhynhotis	australian shoveler
Anas superciliosa	pacific black duck
Anthinga melanogaster	darter
Anthochaera carunculata	red wattlebird
Anthochaera chrysoptera	little waterbird
Anthus novaeseelandiae	richard’s pipit
Apus pacificus	fork tailed swift
Aquila audax	wedge-tailed eagle
Aquila morphnoides	little eagle
Ardea noveahollandiae	white-faced heron
Ardea pacifica	pacific heron
Ardeotis australis	australian bustard
Artamus personatus	masked woodswallow
Artamus cyanopterus	dusky woodswallow
Artamus cinereus	black-faced woodswallow
Aythya australis	hardhead
Barnardius zonarius	port lincoln parrot (‘28’)
Biziura lobata	musk duck
Botaurus poiciloptilus	australasian bittern
Burhinus magnirostris	bush stone curlew
Cacatua galerita	sulphur-crested cockatoo
Cacatua leadbeteri	major mitchell cockatoo
Cacatua roseicapilla	galah
Cacatua tenuirostris	long-billed corella
Calidris acuminata	sharp tailed sandpiper
Calidris ruficollis	red-necked stint
Calidris melanotos	pectoral sandpiper

Scientific Name	Common Name
Calyptorhynchus magnificus	red-tailed black cockatoo
Calyptorhynchus latirostris	white-tailed back cockatoo
Caprimulgus guttatus	spotted nightjar
Cecropis ariel	fairy martin
Charadrius ruficappilulus	red-capped plover
Charadrius melanops	black fronted plover
Chenonetta jubata	maned duck
Cheramoeca leucosternum	white-backed swallow
Chlidonias hybrida	whiskered tern
Chrysococcyx basalis	horsfield's bronze cuckoo
Chrysococcyx lucidus	shining bronze cuckoo
Cincloramphus mathewsi	rufous songlark
Cincloramphus cruralis	brown songlark
Circus aeruginosus	marsh harrier
Circus assimilis	spotted harrier
Cladorhynchus leucocephalus	banded stilt
Climacteris rufa	rufous tree-creeper
Colluricincla harmonica	grey shrike-thrush
Coracina maxima	ground cuckoo-shrike
Coracina novaehollandiae	black-faced cuckoo shrike
Corvus bennetti	little crow
Corvus cornoides	australian raven
Coturnix novaezelandiae	stubble quail
Coturnix varia	painted quail
Coturnix velox	little-button quail
Cracicus torquatus	grey butcherbird
Cracticus nigrogularis	pied butcherbird
Cuculus flabelliformis	fan-tailed cuckoo
Cuculus pallidus	pallid cuckoo
Cygnus atratus	black swan
Dacelo novaeguineae	kookaburra
Daphoenositta chrysoptera	varied sitella
Dicaeum hirundinaceum	mistloetoebird
Dromaius novahollandiae	emu
Drymodes brunneopygia	southern scrub robin
Dupetor flavicollis	black bittern
Egretta alba	great egret
Egretta garzetta	little egret
Elanus caeruleus	black-shouldered kite
Eopsaltria georgiana	white breasted robin
Eopsaltria griseogularis	western yellow robin
Ephthianura tricolor	crimson chat
Ephthianura albifrons	white-fronted chat
Erythrogonys cinctus	red-kneed dotterel
Falco berigora	brown falcon
Falco cenchroides	australian kestrel

Scientific Name	Common Name
Falco hypoleucos	grey falcon
Falco longipennis	australian hobby
Falco peregrinus	peregrine
Falco subniger	black falso
Fulica atra	eurasian coot
Gallinula tenebrosa	dusky mooren
Gallinula ventralis	black-tailed native hen
Gelochelidon nilotica	gull-billed tern
Geopelia cuneata	diamond dove
Gerygone fusca	western gerygone
Glossopsitta porphyrocephala	purple-crowned lorikeet
Grallina cyanoleuca	magpie lark
Gymnorhina tibicen	australian magpie
Haliastur spenurus	whistling kite
Halycon sancta	sacred kingfisher
Hamirostra melanosternon	black breasted buzzard
Himantopus himantopus	black winged stilt
Hirundo neoxena	welcome swallow
Hirundo nigricans	tree martin
Lalage suerii	white winger triller
Larus novaehollandiae	silver gull
Lichenostomus orantus	yellow-plumed honeyeater
Lichenostomus virescens	singing honeyeater
Lichmera indistincta	brown honeyeater
Lophoictinia isura	square-tailed kite
Malacorhynchus membranaceus	pink-eared duck
Malurus splendens	splendid fairy-wren
Malurus lambertii	variegated fairy-wren
Malurus leucopterus	white-winged fairy-wren
Manorina flavigula	yellow-throated miner
Melalurus gramineus	little grassbird
Melanodryas cululata	hooded robin
Melithreptus lunatus	white-naped honeyeater
Melithreptus brevirostris	brown-headed honeyeater
Melopsittacus undulatus	budgerigar
Merops ornatus	rainbow bee-eater
Microeca leucophaea	jacky winter
Milvus migrans	black kite
Myiagra inquieta	restless flycatcher
Neophema elegans	elegant parrot
Ninox novaeseelandiae	boobook owl
Ninox connivens	barking owl
Nycticorax caledonicus	rufous night heron
Nymphicus hollandicus	cockatiel
Ocyphaps lophotes	crested pigeon
Oreoica gutturalis	crested bellbird
Oxyura australis	blue-billed duck

Scientific Name	Common Name
Pachycephala pectarlis	golden whistler
Pachycephala rufiventris	rufous whistler
Paradalotus punctatus	spotted pardalote
Pardalotus striatus	striated pardalote
Pelecanus conspicillatus	pelican
Peltohyas australis	inland dotterel
Petroica goodenovii	red-capped robin
Petroica multicolor	scarlet robin
Phalacrocorax sulcirostris	little black cormorant
Phalacrocorax carbo	great cormorant
Phalacrocorax melanoleucos	little pied cormorant
Phalacrocorax varius	pied cormorant
Phaps chalcoptera	common bronzewing
Phylidonyris albifrons	white fronted honeyeater
Phylidonyris melanops	tawny-crowned honeyeater
Phylidonyris nigra	white cheeked honeyeater
Phylidonyris novaehollandiae	new holland honeyeater
Platalea flavipes	yellow-billed spoonbill
Platalea regia	royal spoonbill
Platycerus icterotis	western rosella
Platycerus spurius	red-capped parrot
Podargus strigoides	tawny frogmouth
Podiceps crstatus	great crested grebe
Poephila guttata	zebra finch
Poliocephalus poliocephalus	hoary-headed grebe
Polytelis anthopeplus	regent parrot
Pomatostomus superviliosus	white-browed babbler
Porphyrio porphrio	purple swamphen
Porzana fluminea	australian crane
Porzana pusilla	baillon’s crake
Porzana tabuensis	spotless crake
Psephotus varius	mulga parrot
Rallus philippensis	buff-banded rail
Revurirostra novaehollandiae	red-necked avocet
Rhipidura fuliginosa	grey fantail
Rhipidura leucophrys	willie wagtail
Sericornis fuliginosus	fieldwren
Smicrornis brevirostris	weebill
Stictonetta naevosa	freckled duck
Strepera versicolor	grey currawong
Streptopelia sensgalensis	laughing turtle dove
Tachybaptus novaehollandiae	little grebe
Tadorna tadornoides	mountain duck
Threskiornis aethiopica	sacred ibis
Threskiornis spinicollis	straw necked ibis
Tringa glareola	wood sandpiper
Tringa hypoleucos	common sandpiper

Scientific Name	Common Name
Tringa nebularia	greenshank
Tyto alba	barn owl
Tyto novaehollandiae	masked owl
Vanelus tricolor	banded lapwing
Zosterops lateralis	silvereye

Fauna found in the Brockman River catchment

This list has been compiled from observations made and a search of the Western Australian Museum database.

MAMMALS	
Scientific Name	**Common Name**
Monotremes	
Tachyglossus aculeatus	echidna
Marsupials	
Anthechinus flavipes	yellow-footed antechnius/mardo
Cerecartetus concinnus	western pygmy possum
Dasyurus geoffroii	western quoll/chuditch
Isoodon obesulus fusciventer	southern brown bandicoot
Macropus eugenii	tammar wallaby
Macropus fulignosus	western grey kangaroo
Macropus irma	western brush wallaby
Macropus robustus	euro
Phascogale tapoatafa	brush-tailed phscogale
Sminthopsis crassicaudata	fat-tailed dunnart
Sminthopsis dolichura	dunnart
Tarsipes rostratus	honey possum
Trichosurus vulpecula	brushtail possum

PLACENTAL MAMMALS	
Microchiroptera (Bats)	
Tadarida australis	white-striped mastiff bat
Mormopterus planicpes	little mastiff bat
Chalinolobus gouldii	Gould’s wattled bat
Chalinolobus morio	chocolate wattled bat
Nyctophilus timoriensis	greater long-eared bat
Nyctophilus gouldii	Gould’s long-eared bat
Nyctophilus geoffroyii	lesser long-eared bat
Rodents	
Pseudomys albocinereus	ash-grey mouse
Rattus fuscipes fuscipes	western bush rat
Hydromys chrysogaster	water rat

Scientific Name	Common Name
Introduced Mammals	
Mus musculus	house mouse
Rattus rattus	black rat
Orycotolagus cuniculus	rabbit
Bulpes vulpes	fox
Felis catus	feral cat
Amphibians	
Heleioporus albopunctatus	spotted burrowing frog
Heleioporus barycragus	western mash frog
Limnodynastes dorsalis	western banjo frog
Neobatrachus pelobatoides	humming frog
Pseudophryne guentheri	Guenther's toadlet
Litorai moorei	western green and golden tree frog
Litoria adelaidensis	slender tree frog
Crinia georgiana	quacking frog
Ranidella glauerti	Glauert's froglet
Ranidella insignifera	quelching frog
Heleioporus inornatus	plain frog
Heleioporus psammophilus	sand frog
Myobatrachus gouldii	turtle frog
Geocrinia leai	Lea's frog
Heleioporus Eyrei	moaning frog
Reptiles	
Chelodina oblonga	long-necked turtle
Pseudemydura umbrina	Western swamp tortoise.
Geckonidae (Geckos)	
Creandoctylus occaltus	clawless gecko
Diplodactylus granariensis	wood gecko
Diplodactylus pulcher	
Gehyra variegata	
Oedura reticulata	reticulated velvet gecko
Phyllodactylus marmoratus	marbled gecko
Phyllurus millii	barking gecko
Pygopodidae (Legless Lizards)	
Aprasia pulchella	
Aprasia repens	
Delma fraseri	
Lialis burtonis	Burton's snake lizard
Pygopus lepidopdus	common scaly-foot

Scientific Name	Common Name
Agamidae (Dragon Lizards)	
Ctenophorus ornatus	ornate dragon
Ctenophorus reticulatus	netted dragon
Pogona minor	western bearded dragon
Tympanocryptis adelaidensis	
Varanidae (Goanna/Monitors)	
Varanus gouldii	bungarra
Varanus tristis	racehorse goanna
Skincidae (Skinks)	
Crytoblepharus plagiocephalus	wood skink
Ctenotus pantherinus	
Egernia multiscutata	
Eremiascincus richardsonii	
Lerista distinguenda	
Mentia greyii	
Morethia obscura	
Tiliqua rugosa	bobtail
Tiliqua occipitalis	western blue tongue
Typhloidae (Blind snakes)	
Typhlina australis	
Typhlina pinguis	
Ramphotyphlops australis	
Ramphotyphlops pinguis	
Elapidae (Elapid Snakes – venomous)	
Vermicella semifasciata	Gould’s snake
Vermicella nigriceps	
Vermicella bertholdi	bandy bandy
Vermicella semifasciata	half-girdled snake
Vermicella bimaculata	black napped snake
Vermicella calonotos	
Demansia reticulata	yellow-faced whip snake
Denisonia bouldii	little whip snake
Pseudechis autralis	king brown snake
Pseudonaja modesta	five ringed
Pseudonaja affinis	dugite
Pseudonaja nuchalis	gwardar
Notechis scutatus	tiger snake
Brachyurophis fasciolata	

Scientific Name	Common Name
Boidae (Pythons)	
Python spilotis	carpet python
Liasis childreni	children's python
Introduced (exotic) Species	
Hemidactylus frenatus	
Fish	
Leptatherina wallacei	western hardyhead
Bostockia porosa	night Fish
Edlia vittata	western pygmy perch
Galaxias occidentalis	western minnow
Glossogobius giurus	flathead goby
Pseudogobius olorum	Swan River goby
Introduced Species	
Carassius auratus	goldfish
Cyprinus carpio	carp
Gambusia affinis	gambusia, mosquito fish
Perca fluviatisis	redfin perch

INVERTEBRATES	
Freshwater Crustaceans	
Cherax tenuimanus	marron
Cherax preissii	koonac
Cherax quinquecarinatus	gilgy, gilgie
Introduced Species	
Cherax destructor	yabby