ATTACHMENT 6 APPLYING BEST MANAGEMENT OPTIONS

Attachment 6 provides detailed management practices, which can be adopted on farm to address specific land degradation issues. This tables highlights the LMUs the options are most applicable to. It also provides some explanation as to how each option can help and whether there are barriers or impediments to adoption. These are presented in four sections:

1. Soil Health
    - Acidity
    - Erosion
    - Soil fertility and soil structure decline
    - Sodicity
    - Sustainable farming systems

2. Ground Water
    - Dryland salinity
    - Groundwater quality

3. Perennial Vegetation
    - Pasture management
    - Weed control
    - Remnant vegetation
    - Revegetation
    - Habitat enhancement
    - Pest management

4. Surface Water
    - Water quality
    - Riparian zone
    - In-stream management

6.1. *BMOs for Soil Health*

BMOs for soil health cover management practices suitable to correct or minimise acidification, erosion, soil structure and fertility decline, soil sodicity, and unsustainable farming systems.

6.2.1. 6.1.1 Acidity (SA)

6.1.1.1. Extent and on-farm implications

Acidity is a very high priority issue in Little River and a driver of many other degradation issues in the catchment. Acidity is a lack of calcium (Ca) in the soil. Ca is required to promote growth, so acidity can reduce crop and pasture yields, and consequently reduce soil water use and ground cover. The off-site affects of acidity include salinity, erosion, water quality decline etc. Some soils are naturally acid, while in other areas, decades of farming have contributed to the increase in acidity problems. Acid subsoils are a significant concern, as reversal at depth is very difficult, both technically and financially. Low pH also causes Aluminium and Magnesium toxicity.

In the Little River Catchment, soils with topsoil pH < 4.5 are found in the north of the Baldry and Yeoval sub catchments on the Yeoval Complex and in the south of the Baldry sub catchment around Yahoo Peaks on the Dulladerry Volcanics. Low pH is also associated with shallow soils and siliceous sands and most of the red podzolics soils, all of which have very low buffering capacity.

The red brown earths and non-calcic browns are moderately acidic, depending on previous land use. The alluvials and strongly structured red soils (euchrozems and terra rossa) are generally not acidic at this stage.

6.1.1.2. Best Management Options to promote healthy and productive soils with reduced acidity (SA).

<u>Broad Strategies</u>

- Adopt land management techniques to reduce the processes contributing to soil acidity - minimise leaching, neutralise acids, deep-rooted perennials, stock rotation;
- Monitor soil condition to identify problems and gauge effectiveness of current or new land management practices; and
- Develop liming systems for non-arable areas.

6.1.1.3. Specific Actions

Code	*Best Management Option*	*Comments*	*Relevant LMUs*
	Crop Management		
SA1	Use crop/pasture rotations	Product removal causes acidification. Acid tolerant species increase the problem. Using acid tolerant species in cropping e.g. barley and triticale is a short to medium-term solution - ultimately resulting in further pH decline as application of lime is postponed.	Particularly relates to LMUs suited to cropping -Red Brown Earths, Euchrozems, Alluvial as well as the arable areas in other LMUs eg. Non Calcic Brown Soils
SA2	Maximise the use of water /minimise deep drainage by reducing fallowing time between crops and after lucerne phase	Reduces deep drainage and the leaching of nitrate nitrogen	
	Grazing Management		
SA3	Manage stock movement and minimise sheep/cattle camps to avoid concentration of organic matter and nutrients.	The use of small paddocks can help to cycle nutrients and organic matter more evenly across the paddock.	Particularly relates to grazing country including the following LMUs - Red Solodics, Red Podzolics, Non Calcic Browns, and Siliceous Sands.
SA4	Maximise use of soil moisture and nitrogen by using deep rooted, perennials, especially grasses.	This will slow down acidification compared to cropping, lucerne and annual legumes.	
SA5	Use acid tolerant species and cultivars eg serradella	This is a short to medium term "bandaid solution" to help maintain production, but will ultimately result in further decline as remedial measures are delayed.	
SA6	Grow lucerne as part of a mixed perennial pasture, including grasses, not as a single species.	Acidification under lucerne can be very high due to leaching of the nitrogen	Particularly in LMUs where crop - lucerne rotations are used - RBE, Alluvials, NCBs, Euchrozems.

Code	*Best Management Option*	*Comments*	*Relevant LMUs*
	Fertiliser/Ameliorants		
SA7	Soil test both topsoil and subsoils regularly for pH, Cation Exchange Capacity (CEC) and Exch. Cations, particularly Al and Mn.	Monitor to assess condition, due to product removal or changed management, and to determine correct amounts of remedial product to apply. Seek further technical advice regarding appropriate management and rates for different soil types.	Applies to both cropping and grazing country in the Little River Catchment.

Code	*Best Management Option*	*Comments*	*Relevant LMUs*
SA8	Apply lime or other carbonate products eg dolomite or lime-fortified bio-solids to neutralise the effects of acidification. Includes strategic use of lime to establish high value crops and pastures.	Lime is relatively expensive but has proven to be a technically feasible remedy to low pH soils. Small amounts of lime applied more regularly may be more cost effective and beneficial to soils.	Arable land ie cropping and improved pasture country.
SA9	Apply phosphorus, other nutrients and trace elements eg. Molybdenum, to maintain production as soils acidify.	Low pH reduces the availability of other minerals and elements. Fertiliser is less effective in acid soils. Short term solution only, but may help reduce deep drainage.	
SA10	Place fertilisers or lime in narrow bands to slow subsequent leaching and / or nitrification.	Reduces amount required. Useful for establishing pastures, where general application may not be necessary for establishment.	
SA11	Split heavy applications of lime and nitrogenous fertilisers ie. Apply lesser amounts more often.	Helps reduce leaching but increases costs. However, may help with cash flow.	Particularly applies to soils with low CEC eg siliceous sands

6.2.2. Soil erosion (SE)

6.1.2.1 Extent and on-farm implications

Soil erosion is a high priority issue in the Little River Catchment, and continues to occur while land is being used beyond its capability. We have using a European farming system in our unique Australian environment, with disastrous effects on erosion hazard, soil structure, fertility and acidity!

The extent and form of erosion depends on landuse, soil type, topography, drainage patterns and geology. The distribution of sheet and gully erosion is detailed in the Stage 1 Report, May 2000. In summary though:

- Around 75% of the Baldry sub catchment was not appreciably eroded when mapped. However, there is nearly 225 kilometres of gullies, along drainage lines and waterways, particularly on the light soils (Siliceous Sands) north of Baldry.
- Nearly 50% of cropping land in the Yeoval sub catchment is affected by sheet erosion. There are small areas of severe sheet erosion in the north east. Sheet erosion is usually only minor in mixed pasture areas. Of the 80 kilometres of gully erosion in this sub catchment the most serious problems occur along drainage lines running into Hanover Creek.
- In the Cumnock sub catchment, erosion is negligible in mixed pasture or timber country – about 65% of the area. There are scattered areas of very severe sheet erosion in the north and south-west and severe sheet erosion in the centre/north east. Sheet erosion is moderate across the north of the sub catchment. There is almost 100 kilometres of gullies in the Cumnock district.
- Erosion hazard in the Suntop/Arthurville sub catchment is closely associated with cropping. Sheet erosion is moderate to severe on more than half the sub catchment

but the river flats are less susceptible to sheet erosion. Some farming areas also have severe rill erosion. Gully erosion is common along tributaries of the creeks and rivers with nearly 90 kilometres affected. Erosion is minimal on the steep Catombal Range, used only for minimal grazing under trees.

6.1.2.2 Best Management Options to minimise soil erosion (SE)

Broad Strategies

The key to reduced erosion is:

- Reducing the amount and rate of runoff by maintaining high levels of groundcover;
- Adopting conservation farming techniques; and
- Where appropriate, using earthworks and engineering solutions in conjunction with vegetative options.

6.1.2.3 Specific Actions

Code	*Best Management Option*	*Comments*	*Relevant LMUs*
	Crop Management		
SE1	Reduce the frequency and intensity of cultivation by managing crop rotations and cultivation practices eg. contour farming, pasture phases, strip cropping, inter cropping	Need pasture phase to improve soil structure. This is best done with grass pastures as lucerne has poor ground cover and limited impact on soil structure, but grasses have disease implications for following crops.	Applies to cropping soils - Alluvials, Red Brown Earths and Euchrozems (recommend equal crop: pasture ie. 3-5 yr crop and 3-5 yr pasture phase) and to a lesser extent to Non Calcic Brown Soils (recommend only 3 crops followed by 5-8 years pastures.) Also Red Podzolics and Solodics (recommend maximum 2 years crop followed by 8-10 years mixed perennial pasture.
SE2	Use minimum tillage systems to reduce soil disturbance.	This generally involves chemical control of weed growth, so need to consider trade offs and any potential impacts associated with increasing chemical use, and apply necessary procedures to prevent movement of chemicals away from target area. Weed control can also be partially controlled with stock, but need to consider compaction & soil moisture loss	
SE3	Retain as much stubble as possible - for as long as possible. Use the least aggressive tillage method to achieve desired outcome.	Stubble to protect soil during fallow periods; increase infiltration and reduce run-off and soil erosion. Need > 2t/ha stubble to prevent erosion, so need 3-4 t/ha (100% ground cover) still on surface at sowing time.	
SE4	Trial intercropping practices ie. crops sown into existing pastures, which have been suppressed prior to sowing	Intercropping provides year round ground cover as well as virtually continual use of soil moisture. Inputs should be applied according to long term weather forecasts.	
SE5	Improve and maintain soil structure and fertility.	Crops and pastures grown under "BMP" are more vigorous; provide better ground cover, root development, soil stability and soil moisture use. They also produce higher yields and, in the majority of cases, higher returns.	Applies to both cropping and grazing country.

Code	*Best Management Option*	*Comments*	*Relevant LMUs*
	Grazing Management		
SE6	Adjust grazing rates and strategies to retain at least 70% groundcover year round i.e. remove stock if groundcover falls below 70% and/or where understorey is being heavily damaged	Research has shown that at least 70% cover is necessary to minimise run off and erosion. Grazing management ie. stock density and duration are vital tools to achieve this target. Set stocking can only achieve this at low stocking rates.	Relates to grazing/mixed farming enterprises including: Red Solodics, Shallow Soils, Siliceous sands, Non Calcic Browns and Red Podsolic Contact DLWC for further advice
SE7	Retain, establish and /or maintain mixed perennial pastures to provide year round ground cover and soil water use.	Native pastures provide diversity to withstand a range of climatic conditions, & are best suited to less productive areas, where low inputs help achieve viability.	
SE8	Layout paddocks to minimise the impact of areas of high erosion hazard designed	Appropriately located fences and watering points are important to minimise the development of stock tracks and soil disturbance	
SE9	Use fertilisers/trace elements and ameliorants to boost vegetation growth, and improve ground cover	Need to consider the cost/benefit	Seek further advice for specific recommendations.
SE10	Maintain high levels of litter on soil surface.	Litter improves infiltration, reduces runoff, reduces evaporation, and provides "food" for soil microbes. Best achieved in grazing situations with high density short term stocking.	Applies to both cropping and grazing country
SE11	Ensure that pastures set seed at least annually	Seeding is important to maintain plant population and strength.	All land under perennial pastures
SE12	Grow Lucerne in conjunction with other grass species	Lucerne has poor ground cover, and does not have a fibrous foot system to improve soil structure. Both improve soil stability	Arable land where crop - pasture rotations are used.
	Tree cover		
SE13	Maintain or relace tree cover, (eg as windbreaks, corridors) to reduce wind erosion.	Replanting of trees should have multiple objectives, including erosion control, shade and shelter, recharge control, biodiversity, and aesthetics. Soil type, existing vegetation and other factors will influence the location and nature of planting.	All LMUs except shallow soils are well below their recommended tree cover levels for sustainable agriculture
SE14	Use earthworks and structural works eg. Contour banks and waterways, in conjunction with other management practices that enhance soil conservation.	Depending on the steepness and length of slope, cultural practices may not be adequate to slow run-off enough to prevent erosion. However, earthworks never replace the need for "best management" of crops and pastures.	Applies to both cropping and grazing country. Contact DLWC for further advice.
SE15	Control gully erosion, by diverting runoff away from active gully heads and revegetating gullies, or drowning gully heads with a dam.	Gullies in grazing country may need to be fenced to allow revegetation	Gully erosion particularly prevalent on Red Solodics

6.2.3. Soil Fertility and Soil Structure Decline (SF)

6.1.3.1 Extent and on-farm implications

Long term cropping without a perennial grass pasture phase has resulted in extensive and severe soil structure and soil fertility decline in the Little River Catchment. Most of the cropping soils in the catchment are naturally highly to very highly susceptible to soil structure decline and are only moderately fertile ie. red brown earths, non-calcic brown and alluvial soils. However, the less commonly found euchrozem and terra rosa soils are less susceptible to structural decline.

Grazing land is also subjected to soil structure decline, particularly when continuously grazed. Trampling on bare soil and in wet conditions has led to compaction, low infiltration and restricted root development, which is necessary to maintain soil structure.

The processes controlling soil fertility and structure decline are so closely associated that the same BMOs apply to both. Ideally we should rejuvenate soil beyond its original/inherent state - because our current use of soils is more demanding than the natural vegetation that was originally on them.

6.1.3.2 Best Management Options to promote healthy productive soils with improved fertility and structure (SF)

Broad Strategies

Soil fertility, structure and general health will be greatly improved by:

- Enhancing soil microbial activity through increased carbon cycling. In cropping situations this is best achieved through rotations and careful use and application of fertilisers, chemicals and machinery:

- Maintaining nutrient balances by the use of legumes, crop and pasture management and artificial fertilisers where deficiencies can't be addressed culturally; and

- Using the least aggressive fallowing techniques for the required outcome. While no-till is preferable, from a practical point of view, cultivation or burning may be required eg disease or too much stubble for emergence.

6.1.3.3 Specific actions

Code	***Best Management Option***	***Comments***	***Relevant LMUs***
	Crop Management		
SF 1	Grow high yielding and high biomass pulse crops	Green manure crops will also help to improve organic matter levels and soil structure, as will effective stubble and pasture management.	Applies to cropping soils - Alluvials, Red Brown Earths and Euchrozems Also Red Podzolics and Solodics. Refer to Ch 6 for specific recommendations on rotations.
SF 2	Manipulate the length of fallow by managing stubble		

Code	*Best Management Option*	*Comments*	*Relevant LMUs*
SF 3	Use cultivation implements which are less destructive of the soil structure	This generally involves chemical control of weed growth, so need to consider trade offs and any potential impacts associated with increasing chemical use. Steps will need to be taken to prevent movement of chemicals away from the target area.	There should be a maximum of 2 years crop in 10 on siliceous sands and no cropping on shallow soils.
SF 4	Avoid compaction by only cultivating when soil moisture is appropriate, controlling tillage and minimising other traffic on paddocks.		Relates to cropping soils including Red Brown Earths and Euchrozems.
SF 5	Reduce waterlogging by increasing water use and cropping frequency		
SF7	Apply additional nitrogen to compensate for lower in available nitrogen in reduced tillage situations	Gypsum should be applied where soil structure decline is due to calcium deficiency or imbalance	
SF6	Correct and maintain nutrient deficiencies to ensure vigorous pasture growth	Fertiliser should be applied according to recommended rates and be based on feedback from regular soil tests.	Applies to both cropping and grazing country.

6.2.4. Soil sodicity (SS)

Sodic soils contain a higher than desirable amount of sodium attached to the clay particles. When wet these soils swell and disperse into tiny fragments as the water is absorbed between and separates the clay particles. The more sodium that is attached to the clay, the more water is absorbed between the clay particles and the more likely it is that there will be dispersion when free salt is present. On drying these fragments block the soil pores

Sodic soils are difficult to manage, are often hard setting and are susceptible to waterlogging, poor aeration and erosion. Many soils can be sodic without being saline but most saline soils are also sodic. Given the salinity issue in the Little River Catchment, sodicity obviously has implications for the catchment.

Sodic soils can be managed by various methods but mainly through the use of gypsum, which changes the soil chemistry and minimises the negative effects of the sodium.

Code	*Best Management Option*	*Comments*	*Relevant LMUs*
SS1	Apply gypsum or lime to replace sodium ions	Economic return on application of ameliorants may not always be worthwhile	Red Solodics and other LMUs with sodic topsoils
SS2	Minimal soil disturbance	Highly erodible soils, especially if there has been disturbance / topsoil removal	Especially LMUs with sodic subsoils - NCB, RBE, SS and some RPs
SS3	Caution when constructing earthworks	Susceptible to tunnelling of banks and dam walls	

6.1.5 Sustainable farming (SC) systems

6.1.5.1 Extent and on farm implications

Farming systems need to be more efficient in order to be sustainable both from a production and financial point of view. Years of continuous agricultural production, often using aggressive cultivation methods, has significantly degraded the resource base. Consequently, there is now a greater emphasis on farming systems that can better balance economic, environmental and social aspects and a significant amount of research to this end.

Matching land use to land capability is the basic foundation for sustainable agriculture - irrespective of the farming system. Ground cover and litter retention are also important as are using water where it falls and using appropriate levels of fertilisers and ameliorants.

Climatic variability is also a major impediment to achieving sustainable farming systems. But, thanks to improving technology, land managers can access various tools to manage climatic variability. For example, the Bureau of Meteorology provides a service for people and businesses with a planning need dependent on the weather. In the short to medium term, this can help make decisions on which crops to plant and when, stocking rates and assist in drought management. In the long term, this information can assist in soil conservation and prevention of land degradation.

Scientists now have a good picture of the Southern Oscillation Index (SOI) - the major pressure shift between Asia and the Eastern Pacific regions. The SOI is closely linked to rainfall over the Australian/Asian region and the El Nino and La Nina effects. La Nina episodes (positive phases of the SOI) are characterised by more frequent and heavier rain periods, with occasional flooding, while El Nino (negative phases of the SOI) are generally periods of drought over eastern Australia.

Rainfall outlooks can be used to determine the likelihood of rainfall in a particular area being above below or average for a given three-month period. The seasonal outlook also provides information on various predictors of Australian rainfall.

There are also numerous decision support systems for enterprise management. These DSSs allow land managers to analyse complex situations without becoming lost in a maze of complex calculations. For example, commercial software packages, such as RainMan, provide easy access to long-term rainfall records. This information can then be used predict the probability of rainfall at a particular time.

6.1.5.2 Best Management Options to promote healthy productive soils with improved fertility and structure (SF)

Generally, sustainable farming systems can be achieved by:

- Investigating and understanding the relationship between land degradation processes and vegetation loss;
- Developing catchment based vegetation management plans; and
- Rotating crop and legume based perennial pastures according to land capability.

6.1.5.3 Specific strategies

Code	*Best Management Option*	*Comments*	*Relevant LMUs*
	Crop Management		
SC1	Maximise water use efficiency by selecting appropriate crops or pasture for the season and rainfall pattern and climatic variability		All LMUS best suited to cropping including Red Brown Earths, Euchrozems, Alluvial Soils and Non Calcic Browns.
SC2	Implement minimum and no till farming practices, controlled traffic practices, stubble retention and management	This generally involves chemical control of weed growth, so need to consider trade offs and any potential impacts associated with increasing chemical use, and apply necessary procedures to prevent movement of chemicals away from target area.	
SC3	Use crop rotations (summer and winter crops, pulses, oilseeds and cereals) on a seasonal basis to clean up annual winter grass weeds and manage diseases	Weed control can also be partially controlled with stock, but need to consider compaction & soil moisture loss.	Recommended rotations will vary depending on individual LMUs.
SC4	Opportunity crop to optimise soil water use	Need to consider any potential impacts of reduced runoff on the riparian corridor.	Particularly relates to Red Brown Earth and Non Calcic Brown LMUS where longer cropping phase may be possible with inter-cropping or response cropping
SC5	Maintain soil health through increasing cover, litter and organic matter		Relates equally to LMUs best suited to cropping and grazing.
SC6	Avoid residual chemicals where possible in weed control, so as to ensure flexible crop rotations and response cropping options	Minimise the risk of herbicide resistance by using chemicals from different groups and applying them at appropriate rates	
SC7	Include a pasture or Lucerne phase in the cropping cycle –	The length of the pasture phase will be largely influenced by land capability	

Code	*Best Management Option*	*Comments*	*Relevant LMUs*
SC8	Maintain pasture phase in a healthy weed free condition to avoid disease, deep drainage and weed problems in the following crop phase	Length of the pasture phase will vary according to the individual LMU. Generally though the lower the land capability, the longer the cropping phase.	LMUs mostly suited to grazing include the Red Podsolic, Red Solodic and Siliceous Sand LMUs.
	Disease management		
SC9	Manage cereal root diseases through tillage practices, rotations, weed control in fallows and seasonal conditions	If stubble must be burnt for disease control, leave burning until late in the season just prior to sowing	LMUs best suited to cropping include the Alluvial, Euchrozem, Red Brown Earth and Non-Calcic Brown LMUs.
SC10	Use 'break crops' to control diseases - crops such as canola are being used to break the disease cycle	Use crop varieties that have minimal susceptibility to plant disease	
	Grazing Management		
SC11	Use livestock to control weeds		Relates equally to LMUs suited to cropping and grazing.

6.2. *Groundwater Management*

6.2.1 Dryland Salinity (GS)

6.2.1.1 Causes and on farm implications

The main salinity outbreaks in the Little River Catchment are south west of Cumnock, Yeoval sub catchment, east of Baldry, and east of Arthurville and Suntop. (The true extent of salinity in the Baldry sub catchment is unknown).

In 1988, less than 0.12% of the Upper Macquarie Catchment was affected by dryland salinity. In comparison, 0.41% (1075 ha) of the Little River was affected (13). The area affected by salinity in the catchment has increased at least fourfold over the last decade to 4408 ha (not including west of Baldry) (48). Some sites in the catchment are constantly affected by salinity and salt tolerant species have replaced salt sensitive species (13) on nearly 40% of the affected area.

Salinity can vary enormously across a catchment and therefore requires a whole landscape approach to address both recharge and discharge. We need a mixture of tools that vary across the catchment, and take into account total water use. Salinity is also a complex issue that involves many trade offs. The recharge/discharge scenario means that the solution to one person's problem may in fact worsen the situation in another part of the catchment.

6.2.1.2 Best Management Options to reduce the impacts of salinisation (GS1)

Broad Strategies

- Reducing recharge and intercepting water in the transmission area;
- Increasing water use in discharge area;
- Managing the existing situation;
- Using water balance models in cropping systems;
- Considering alternative land uses; and
- Modify existing irrigation practices.

6.2.1.3 Specific actions

Code	*Best Management Option*	*Comments*	*Relevant LMUs*
	Crop and pasture management		
GS1	Minimise deep drainage	Need to consider the trade offs and overall impacts on the system. Maximising soil water use and/or minimising drainage depends on getting soil chemistry and structure right first. Farmers must then learn more about soils, undertake more soil and tissue tests, so they can better understand what is needed to grow vigorous crops and pastures;	

Code	*Best Management Option*	*Comments*	*Relevant LMUs*
GS2	Increase crop and pasture water use, reducing surface runoff and diffuse recharge into aquifers	Deep rooted perennial pastures use more water throughout the year in comparison to annual crops which have more variable water use and, therefore, a less stable impact on the watertable and subsequent salinity problems. Anecdotal evidence suggests that run off into dams in the LRC has also been reduced – these negative impacts must be weighed up against any benefits.	Cropping soils, especially recharge zones including red solodics, shallow soils, siliceous sands, non-calcic brown and red podsolic.
GS3	Rotate crops with Lucerne and perennial pastures to optimize water use		Alluvial soils
GS4	Response crop according to soil moisture availability and rotate with perennial pastures	Phalaris & cocksfoot have water use as high as Lucerne when established, but not in the early growth stages. Phalaris and cocksfoot will grow over winter, which makes them good as pastures, but maybe not well suited to intercropping. Mixed Lucerne / phalaris grows better in the south of the catchment than north. Lucerne grows better in the north, because it is less acidic. New varieties of phalaris may extend its range. The success or otherwise of Lucerne is probably related to acidity, Al and Mn	Red Brown Earths Euchrozems Cropping soils, especially those in recharge areas
GS5	Avoid long fallows, especially in the dominant rainfall period		
GS6	Only continue fallowing until there is sufficient soil moisture for the next available crop		
Perennial vegetation management			
GS7	Plant deep rooted perennial pastures and maintain healthy, vigorous pastures to maximise water use	Perennial pastures need to be promoted - eg. Lucerne, fescue, cocksfoot, phalaris and native grasses -eg. Red grass etc. People think natives have little value for grazing. Warrego (summer grass) has good leaf area (perennial, but behaves like an annual), Danthonia - needs better management and good moisture. This can happen through wetter seasons or the more effective use of rainfall. Native grass seed can be spread by stock. Demonstration sites and more	Management of native grasses is particularly important on siliceous sands. Deep-rooted perennial pastures should be integrated into crop rotations on the Red Brown earths, non-calcic brown soils and

		investigations are needed into native grasses - to better understand how to collect seed, sow, establish and manage these species for production. Improved summer grasses i.e. Bambatsi, Premier digit, and purple pigeon have been shown to be useful, particularly in the north of the catchment. However, more work is required.	red podsolic. Siliceous Sand, Red Brown Earth, Non Calcic Brown and Red Podsolic LMUs.
GS8	Maintain existing tree cover and plant more trees, particularly in recharge zones.	Tree planting should be done with multiple benefits in mind. For example, trees planted for salinity control can also help to improve biodiversity and wildlife habitat if they connect patches of remnant vegetation. Trees can also provide shade and shelter for stock – reducing the impact of climate extremes.	This is particularly relevant in higher parts of the catchment including the Shallow Soil and Siliceous Sand LMUs. However, because of the severe tree deficit across the entire Little River catchment these efforts need to be extended across aall LMUs.
GS9	Revegetate stock routes, fence lines and geomorphic boundaries		
GS10	Investigate the feasibility of agro-forestry plots.	Economics is the biggest barrier - there are no established markets. If markets are developed there must be thorough investigation into viability and logistics of introducing agro forestry in the LRC.	The Red Podsolics LMU may be suitable from a physical perspective but the economics would need to be further investigated.
GS11	Maintain or relace tree cover, (eg as windbreaks, corridors) to reduce wind erosion and address other issues such as salinity	For salinity should focus on recharge areas. Soil type, existing vegetation and other factors will influence the nature of planting. Ideally any tree planting or protection of exiting vegetation should be undertaken to address multiple benefits.	Red podsolics have been identified as being suitable for agro-forestry. Other soils acting as recharge zones include: Red Solodics, Shallow soils, Siliceous Sands, Non-Calcic Brown and Red Podsolic LMUs.

Code	*Best Management Option*	*Comments*	*Relevant LMUs*
	Managing saline water discharge		
GS12	Increase water use in discharge area	This can be achieved through opportunity cropping, planting perennial pastures and tree planting at strategic locations in the landscape. (Red Brown Earths and Euchrozems LMU have both recharge and discharge. Response cropping may be an option on the Red Brown Earths LMU while crop/pasture/Lucerne rotations should be adopted on Euchrozems.)	The main discharge areas in the LRC are Riparian and Alluvial LMUs. Crop/Lucerne rotations will increase water use in the Alluvial LMU The riparian zone should have strategic grazing of native pastures.
GS13	Sow salt tolerant tree and pasture species in recharge, transmission and discharge areas	Currently know what trees will grow where, but pastures are limited to strawberry clover.	Discharge areas include RBE, Euchrozems, Riparian/alluvials and to a lesser extent, the NCB and RP LMUs
GS14	Introduce high water use land and vegetation management to reduce accessions of rainfall to groundwater (see also GS8)	Could require research into new varieties and management techniques and willingness to change. The Central West Farm Forestry Unit (CWFF) is trying to develop long-term commercial opportunities for farm forestry in the region. Some opportunities may open up in areas like the Central West, if annuities can be provided eg Macquarie Food and Fibre is offering a trial salinity credit trading scheme - where landholders are paid for the use of land. CWFF is looking to develop industry assistance programs, rather than government support	Relates to recharge areas including Recharge areas in the Little River Catchment are generally in the higher parts of the landscape i.e. Red solodics, shallow soils, siliceous sands, non calcic brown and red podzolics

Code	*Best Management Option*	*Comments*	*Relevant LMUs*
GS15	Fence out saline outbreaks and plant high water use perennial and salt tolerant species with strategic grazing	Such areas can be quite productive and suitable for strategic crash grazing once ground over is established. Includes riparian zone and alluvial soils.	Perennial pastures should be integrated into crop rotations on the RBE, NCB and RP LMUs
GS16	Construct subsoil drainage	DLWC has been assessing engineering options for north of Wellington. Many of the subsoils are high in clays, so it is very hard to extract water by pumping. This limits the opportunities. May be possible to pump fresh pressurized aquifers back into the river to reduce upward movement of water table.	Unlikely to be suitable option
GS17	Install drains/pumps to de-water areas with high watertables		Maybe NCB, RBE, Euchrozems - not enough information at this time - each ground water system need assessing
GS18	Use drainage systems to disperse water away from discharge areas		
GS19	Protect salt rich clay soils from erosion recharge and increased through flow		
Groundwater monitoring			
GS20	Monitor piezometers to understand changes in local systems		Especially in discharge areas which include riparian zone, alluvial soils, Euchrozems and to a lesser extent, non calcic brows and Red Podsolics

6.2.2 Groundwater Quality (GQ)

6.2.2.1 Extent and on farm implications

Groundwater quality and contamination from pollutants is largely an unknown quantity in Little River, but includes:

- Calcium salts block water reticulation systems, particularly in limestone areas
- Levels and extent of herbicides, pesticides, and nitrates in ground water is unknown.
- The extent of, or potential for, cross contamination between aquifers -ie. Between fresher local systems and deeper systems has not been considered to any real extent
- Heavy metals in mining areas can contaminate ground water, but extent and potential is unknown in this area (Most town water here is from rivers)
- Rising ground water and leaking septic systems around Cumnock and Yeoval threaten groundwater quality

Currently though, groundwater quality is not a priority issue and, hopefully, applying the guiding principles will prevent long-term problems. To achieve sustainable ground water management, we must achieve integrated catchment management.

6.2.2.2 Best management Options to prevent decline in groundwater quality

Broad strategies

- Monitor shallow groundwater and domestic bores;
- Review groundwater use;
- Address leaking farming systems; and
- Address both point and diffuse sources of nitrates

6.2.2.2 Specific actions to prevent decline in groundwater quality (GQ)

Code	*Best Management Option*	*Comment*	*Relevance to LRC*
	Reduce point and diffuse source contamination of groundwater		
GQ1	Manage chemicals, particularly around bores		All LMUs
GQ2	Ensure ongoing maintenance of bore heads to prevent direct contamination of aquifers		All LMUs.
GQ3	Manage animal waste loadings on paddocks to help minimise the load of nitrate to the watertable		Mainly relates to LMUs suited to grazing.
GQ4	Manage household and industrial effluent, disposal of solid waste and fertiliser applications to household and urban gardens		All LMUs.
GQ5	Apply recommended rates of fertilizers	Fertiliser applications should be based on regular soil tests to accurately identify deficiencies	All LMUs.
GQ6	Appropriately manage landfills and septic tanks	Ratepayers in the Cabonne Shire are now paying increased rates to convert septic systems to sewerage. Any reduction in water entitlements will certainly have negative economic benefits to irrigators. However, there are likely to be very few landholders affected in Little River.	Relates to all soil types and urban communities/villages in the catchment
Groundwater volume management			
GQ7	Reduce groundwater use to match sustainable yield		
GQ8	Minimise the risk of draw down of water levels and potential migration of nitrate contamination into the groundwater extraction zone		

6.3. *Perennial Vegetation*

6.3.1 Pasture degradation and health (VP)

6.3.1.1 Extent and on farm implications

Grazing is the biggest land use in the Little River Catchment and native and improved pastures are found in areas unsuitable for cropping. Pastures are generally improved by aerial seeding and fertilising although there are occasional areas of sown pasture. These pastures are generally stable unless they are excessively stocked. Some areas are sown to lucerne in rotation with cropping. Native pastures are generally found on the poorer soils.

While there is potential for pasture improvement in the catchment this has been limited by poor access and poor stock prices. The role of productive pastures cannot be underestimated. They play a critical role in addressing numerous problems including salinity, erosion, soil health and general water quality. Well managed, productive pastures improve productivity and, ultimately, profitability.

6.3.1.2 Best Management Options to improve pasture health (VP)

Broad Strategies
Undertake remedial action programs including planting salt resistant trees and shrubs. Productive pastures depend on the adoption of integrated grazing systems, not by focussing on individual symptoms such as weed invasion.

6.3.1.3 Specific strategies to improve pasture health.

Code	*Best Management Option*	*Comment*	*Relevant LMUs*
	Grazing management practices		
VP1	Maintain groundcover of desirable species at > 70%.	Research has shown that at least 70% cover is necessary to minimise run off and erosion. Grazing management i.e. stock density and duration are vital tools to achieve this target. Set stocking can only achieve this at low stocking rates.	This should be used as a rule of thumb in all LMUs and grazing stock managed accordingly.
VP2	Manage stock to maintain cover and use rotational grazing	Changes to fencing and farm infrastructure may be required. Such change should be incorporated into individual farm plans.	Enterprise mixes will vary according to the specific LMU
VP3	Use grazing management to manipulate the degree of seeding of different species	This can be used to manage desirable and undesirable species	
VP4	Include a legume component in perennial pastures.		
VP5	Match species to the prevailing conditions, including fertility and climate	For example, native species tolerate low nutrition levels and are better adapted to harsh environments	

Code	*Best Management Option*	*Comment*	*Relevant LMUs*
VP6	Establish permanent pastures in degraded country to prevent further degradation	Pasture degradation can lead to weed infestations, particularly where land is in a crop/Lucerne rotation and Lucerne is allowed to be over-grazed and degraded. Judicious grazing management must therefore be adopted in conjunction with pasture establishment.	In some LMUs changes to the land use mix are necessary. Details of the mixes are included in Ch xx.
VP7	Apply fertilisers strategically, especially phosphorous and sulphur to maintain vigorous growth, maximise water use and ground cover.	Use soil tests to determine requirements.	
VP8	Direct drill or top dress clovers and fertilise to improve native pastures		Native pastures especially suited to red solodics and sallow soils.
VP9	Increase infiltration by disturbing the surface, (eg. Contour ripping) mulching and strategic low profile contour banks. Add gypsum to aid establishment.		Where scalds or surface sealing is present

6.3.2 Weed control (VW)

6.3.2.1 Extent and on farm implications

Weeds impact on production and profitability and eradication is a great aim but, basically, not achievable. Even if eradication were possible, the cost would probably be prohibitive. For example, at the top of catchment, eradication of weeds might be physically feasible, but costs are impossible.

In terms of biodiversity, the aim should be to minimise the impact of weeds and feral animals, through a coordinated approach at the catchment level. Such an approach might involve control, maintenance and minimising further spread.

6.3.2.2 Best Management Options to eradicate weeds (VW)

Broad Strategies

- Develop a strategy to determine the area already infested by woody weeds
- Implement a coordinated regional weeds strategy to reduce the impact of weeds on native vegetation communities and address system imbalances
- Provide integrated management principles for control of weeds
- Increase landholder awareness of weeds covering a) early recognition b) management and) the economic cost of woody weeds

6.3.2.3 Specific actions to eradicate weeds

Code	*Best Management Option*	*Comments*	*Relevant LMUs*
	Weed management		
VW1	Avoid unnecessary soil disturbance that leads to weed invasions		All LMUs
VW2	Control weeds with herbicides (where permitted) as necessary	Herbicides need to be used carefully to prevent contamination of nearby creeks and streams.	
VW3	Use stock to control weeds and dense vegetative growth		All LMUs, but particularly relates to areas where the riparian corridor has been fenced.
VW4	Use short term grazing (crash grazing) of fenced areas to combat weeds.		
VW5	Improve competition through perennial species.		Relates to all LMUs .
VW6	Control excessive woody shrubs and pine re-growth - Manually thin woody weeds -		Woody weeds are especially a problem on the poorer shallow soils in the upper catchment.

6.3.3 Biodiversity Management (VB)

6.3.3.1 Extent and on farm implications

Biodiversity is a difficult concept to understand, particularly in an agricultural setting. Many people feel that biodiversity only relates to Australian native flora and fauna and question the role of exotics and introduced species. However, exotic species often threaten native flora and fauna and, therefore, threaten biodiversity.

Natural systems should accommodate processes that support the maintenance of species and its capacity to evolve; changes in population numbers, density, and location; and species richness ie. Number of different species.

Without evolution, we limit future options. The need to encourage variability is quite different to agricultural production requirements. Ultimately though, the processes that keep the agricultural landscape healthy also keep the natural system healthy. So the challenge is to integrate production and natural biodiversity, especially when these two systems have very different needs.

Planning for biodiversity needs to be on a regional scale (not property basis) as does ecosystem function and connectivity. Similarly "common concern" for biodiversity must be regionally focused, because flora (e.g. plant seeds) and fauna (birds) don't stop at property boundaries. However, management also needs to be at property scale.

We can use land capability as a basis for considering landuse and biodiversity requirement. It is possible to have healthy native grazing and natural systems together, but not in crops.

Incorporating local native species into groundwater recharge plantings, rather than exotics such as major plantings of radiata pine, provides benefits for biodiversity as well as recharge, with the aim to prevent further losses of native species of plants and animals

The many causes of tree decline include: clearing and fragmentation, intensive grazing, insects, dieback, chemicals, climatic conditions, management practices, fungi and failed recruitment. Clearing results in the loss of native flora and fauna. Dieback leads to a rapid decline in tree health and these trees may eventually die. Small, disturbed areas of remnant vegetation are the most vulnerable to dieback.

Failed recruitment occurs when new growth is removed due to grazing and the breakdown of natural regeneration processes. Many factors can contribute to this.

Mistletoe also causes tree decline. In a natural, healthy system possums and insects help to maintain a balance between mistletoe and host trees. However, if the system becomes unbalanced mistletoe and tree decline can increase. In turn, tree decline is associated with reduced biodiversity, rising water tables, salinity, soil structural decline and erosion, declining water quality, reduced agricultural stability, loss of habitat for wildlife leading to threatened species and diminishing economic returns.

A State of the Environment (SOE) report showed that almost 90% of temperate woodlands in Australia have been cleared. The majority of the Little River Catchment, with the exception of the Catombal Ranges and Goobang National Park, has been severely affected by tree decline, with almost complete loss of the understorey. This not places vegetation communities under threat and means that many populations of fauna and birds are on the brink of extinction.

Several parts of the Little River Catchment have less than 1% timber cover, particularly around Yeoval. As tree clearing is closely linked to agricultural development and land capability, the areas most suited to cropping have been extensively cleared. This is mirrored in other parts of the catchment where there is little or no tree cover remaining.

Regionally, dieback affects more than half of the Central West Catchment. The Burrendong survey showed that almost 40% of scattered farm trees present in the early 1950s have been lost in 35 years.

Recommended tree cover is generally based on land capability classes. The following guidelines provide targets at the individual farm level.

Classes I to III	5%
Classes IV, V	10%
Class VI	25%
Classes VII, VIII	100%

The Native Vegetation Advisory Committee Guiding has developed broad principles relating to vegetation management. These principles are outlined in Chapter 7 and further elaborated on in Attachment 7.1

6.3.3.2 Best Management Options for the preservation and enhancement of remnant vegetation

Broad Strategies

- Map, survey, describe, and monitor remaining vegetation
- Develop a vegetation management plan, incorporating fire management plan/guidelines to identify and retain protect remaining vegetation and critical habitats.
- Identify site specific causes of tree decline
- Improve biodiversity values by increasing the quality and diversity in remnants.
- Improve conservation value by adding to existing smaller vegetation remnants
- Increase knowledge of native species to ensure effective management
- Encourage the uptake of Voluntary Conservation/Property Agreements
- Address other areas of land degradation which may be affecting tree decline
- Support effective implementation of clearing legislation
- Develop framework for partnership between government, community, landholders, etc (e.g. regional vegetation management plans) to assist in the management of native vegetation

6.3.3.3 Specific actions to prevent further loss of biological diversity and remnant vegetation (VB)

The *original* vegetation in the Little River Catchment varied according to geology, soil type, temperature, rainfall and other factors. The *current* condition and extent of this vegetation depends on the extent of clearing, grazing and disturbance that has occurred since European settlement. Generally though:

- The Cumnock sub catchment has very little remnant vegetation;
- The Yeoval sub Catchment is also largely devoid of large timber, with the only reasonable remnants being found on the infertile shallow soils of the granite soils south of Yeoval;
- Suntop/Arthurville is also extensively cleared with the exception of the granite country between Toongi and Arthurville; and
- The Baldry sub catchment has the largest amount of vegetation remaining.

The remaining isolated patches of vegetation are non-viable in their current state. However, these provide a valuable nucleus to enhance and extend the remnant.

In order to prevent further losses of biodiversity and remnant vegetation, action is required at the catchment scale. This involves understanding what is left; how this fits into the overall picture and how to best manage remnant vegetation.

However, this also requires change at the farm level to contribute to catchment goals. While biodiversity is often considered a low priority, changing our agricultural practices and land management on the rest of the property, to include biodiversity considerations, will improve sustainability. While it is difficult to put numbers on the amount of vegetation needed in specific areas we know that change is inevitable. Consequently we must consider ways to adjust farm management to improve biodiversity outcomes.

Code	*Best Management Option*	*Comments*	*Relevant LMUs*
	Protection of existing vegetation		
VB1	Protect existing areas of significant native vegetation and use corridors to link and reduce the edge effect	Will be largely influenced by economics but the amount of vegetation will be influenced by land capability.	Need to tackle at the overall Catchment level to ensure a coordinated approach. For specific recommendations for various LMUs see Ch 6.
VB2	Conserve large, interconnected and structurally diverse woodland remnants	BMP for vegetation retention and remnant size will vary from area to area and species to species. However, any improvement should be seen as positive.	Need to tackle at the overall Catchment level to ensure a coordinated approach.
VB3	Fence all remnant vegetation downwind for protection and to collect seeds.	The remaining isolated patches of vegetation are non-viable in their current state. However, these provide a valuable nucleus to enhance and extend the remnant.	
VB4	Establish and protect areas of native grasses, groundcover and understorey		Especially relates to the riparian zone
VB5	Manage stock to reduce the impacts of stock on native grassland communities.	Maintaining groundcover will also reduce erosion and runoff and maintain soil health.	Relates to grazing country including the following LMUs: Red Solodic, Shallow soils, Siliceous Sands and, to a lesser extent, Red Podzolics
VB6	Identify and retain threatened plant communities	Voluntary Conservation Agreements (NPWS) and Property Management Agreements (DLWC) can help to cut the costs for preservation.	Relates to all soil types.
VB7	Maintain conservation values in areas between wildlife refuges		
VB8	Integrate native grass management with other aspects of catchment management		Relates to LMUs best suited to grazing including: Red Solodic, Shallow Soils and Siliceous Sands. Other soil types are better suited to perennial grass pastures or crop/pasture rotations.

Code	*Best Management Option*	*Comments*	*Relevant LMUs*
VB10	Avoid clearing on sensitive parts of the landscape e.g. Gullies and ridges		
VB11	Locate roads or fences around native vegetation Use pruning and pollarding for short term control of mistletoe		
	Stock Management		
VB12	Minimise stock camps to reduce nutrient build up in native vegetation.		Mainly relates to soils suited to grazing including red solodic, shallow soils and siliceous sands but also riparian zone.
	Fire Management		
VB13	Use fire for the continuation of some native plant species e.g. Acacias.	Fire regimes may have a place but have to be managed. There is a risk of over burning, especially if fire is used frequently. Expert advice is required in relation to fires.	
Code	*Best Management Option*	*Comments*	*Relevant LMUs*
VB14	Use various fire regimes so as not to continually affect similar species		
	Disease Management		
VB15	Consider long term control methods of mistletoe such as * Natural control agents e.g. Possums, parrots and predatory insects * Natural regeneration so there is sufficient trees for on-farm purposes * Select seed from mistletoe resistant trees and species in the local area for revegetation Fire to manage mistletoe species		Relates to all soils but to a lesser extent on cropping country where there is less vegetation.

6.3.4 Revegetation and regeneration (VR)

6.3.4.1 Extent and on farm implications

There is already numerous tree management, tree planting and re-afforestation projects underway across the Macquarie River Catchment. This includes efforts by Greening Australia, the Rural Lands Protection Board and through the Grassy White Box Woodlands Project. One of the most compelling reasons for revegetation is to prevent loss of the most productive soils. Revegetation will also help to meet multiple objectives and address a range of natural resource management problems.

6.3.4.2 Best Management Options for Revegetation and Regeneration (VR)

Broad Strategies

Strategic native vegetation planting and regeneration needs to:

a) Determine priority areas for restoration and revegetation;
b) Investigate economic opportunities using native species;
c) Identify and access appropriate funding sources for fencing, site preparation, site management, tree and understorey planting or regeneration; and
d) Increase the rate of revegetation to contribute to the development of carbon sinks.

Vegetation plays a critical role in addressing many problems in the Little River Catchment. Trees reduce recharge and help balance the water cycle; improve aesthetics; provide shade and shelter; improve connectivity and biodiversity; assist in pest management, and help to maintain agricultural productivity. There are examples of "locking up" 12- 15% country in mixed farming for biodiversity, and ending up with greater agricultural productivity.

However, improvements in vegetation require a change in land management and strategic approach to where to locate. As a rule of thumb, revegetation should be based on land capability and, generally, the priority for is riparian zones, rough country, and in grazing areas.

Revegetated areas must also be managed to achieve maximum benefits. This involves much more than just fencing out. Consideration should be given to the size and shape of patches and their connectivity to other areas of remnant vegetation. For example, patches should be circular rather than linear, to provide as little edge as possible. (Linear sites increase edges).

6.3.4.3 Specific actions to promote strategic native vegetation planting and regeneration.

Code	*Best Management Option*	*Comments*	*Relevant LMUs*
	Perennial vegetation and tree management		
VR1	Fence off sections of land around existing trees to assist in natural regeneration		LMUs most suited to grazing.
VR2	Periodically exclude stock from timbered and sensitive areas to allow regeneration	Grazing pressure and grazing capacity will also be influenced by land capability	Red Solodic and shallow LMUs should only be used for occasional grazing.
VR3	Revegetate so that woodland patches are at least 10ha and have 20% shrub cover - enhance patches that are already 10ha (reduce edge effect)	Research work suggested that 40 hectares is the size needed to maintain healthy remnants. However, realistically, this is more than farmers will	Needs to be considered in an overall context catchment.

		attempt. So, they recommend that current remnants be enhanced to a minimum of 10 ha for revegetation. N.B. This is NOT the minimum size for clearing down to (which would be much larger.)	
VR4	Connect woodland patches to provide corridors for wildlife as well as other benefits	Narrow corridors as connectors, are not necessarily a good thing. Should aim for wide patches and clumps Patch size and shape are important – rounder is better and the larger the better.	Needs to be considered in an overall catchment context.
VR5	Use local native species to address multiple problems. e.g. salinity, erosion and habitat loss	Incorporating local native species into groundwater recharge plantings, rather than exotics such as major plantings of radiata pine, provides benefits for biodiversity as well as recharge, with the aim to prevent further losses of native species of plants and animals.	All LMUs. Contact Greening Australia for further advice on species.
VR6	Maintain and re-establish diverse vegetation i.e. understorey, grasslands and shrub layer	This is necessary for many birds and animals E.g. woodland birds need a complex understorey of indigenous species as well as hollow logs for reptile habitat and hollows in trees etc.	
VR7	Reintroduce local native species by tubestock planting or direct seeding with viable provenant collected from nearby sources (within a 15km radius)	Local native species have the best chance of success, as they are adapted to local conditions.	
VR8	Create appropriate disturbance events e.g. fire, surface disturbance (for acacias)	Fire regimes may have a place but have to be managed. There is a risk of over burning, especially if fire is used frequently. Expert advice is required in relation to fires.	

6.3.5 Habitat Enhancement and fauna (VH)

6.3.5.1 Extent of Habitat loss

Already we have lost 30% of our small mammal species and >50% of small mammals have lost half of their habitat, so the risk of extinction is very high.

6.3.5.2 Broad strategies to enhance habitat and fauna

- Develop management plans for threatened species
- Determine the habitat requirements of threatened species
- Monitor fauna (native and pest) populations

Birds Australia have ten simple guidelines for farmers to make their properties more bird-friendly. They are based on surveys of some 430 bird species over two years on 330 farms in south-eastern Australia - the result of the 'Birds on Farms' project commenced in 1995. Some interesting statistics are scattered through the booklet, including: *Bird diversity increased by 30 percent for every 10 large trees present at a farm site*, and *For every 10 fallen trees present in a farm site, the diversity of ground-foraging birds increased by 30 percent and bark-foraging birds by 70 percent*.

A summary to the guidelines for landholders wishing to improve bird habitat:

1. Local native vegetation should cover at least 30 percent of the total farm area;
2. Re-create local conditions;
3. Exclude high-impact land uses from at least 30 percent of the farm area;
4. Maintain native pastures and avoid heavy grazing;
5. Native vegetation cover should be in patches of > 10 ha, linked by strips > 50 m wide;
6. Manage at least 10 percent of the farm area for wildlife;
7. Maintain a range of tree ages;
8. Leave fallen trees to break down naturally;
9. Maintain shrub cover over at least one-third of the area within a patch of farm trees;
10. Maintain native vegetation around water.

6.3.5.3 Specific actions to enhance habitat and fauna

Code	***Best Management Option***	***Comments***	***Relevant LMUs***
	Species protection		
VH1	Protect rare and uncommon species and their habitat		All LMUs.
	Habitat management and retention		
VH2	Retain native vegetation along rivers, streams, roadsides, etc with particular attention to preserving mature and standing dead trees for habitat.	These areas provide important habitat.	All LMUs.
VH3	Maintain big areas of woodlands, with a variety of local species and healthy under storey. -	Such areas support more viable populations of woodland birds	All LMUs.
VH4	Establish and maintain corridors to assist wildlife movement.		All LMUs.

6.3.6 Pest Management (VF)

6.3.6.1. Extent and on farm implications of pest animals

Many pest animals are introduced species – many bought here by English migrants to remind them of the English landscapes. However, this inevitably led to disaster. For example, rabbits adapted rapidly to the Australian environment and spread quickly. This led to the spread of foxes, which now had a major food source. Plagues such as mice and locusts are also relatively common and can cause major damage to crops and native and introduced pastures.

The presence of pest animals does not necessarily mean that the animals are causing damage. Most damage occurs when there is competition between domestic, native and feral animals. This can lead to land degradation problems such as gully erosion, decreased agricultural production and overgrazing and reduced regeneration of native species.

Pest animals are distributed across the Little River Catchment and landholders consider some native animals such as kangaroos as "pest animals". Carp and Red Fin are found in the river systems, eating smaller fish and muddying the waters, and are dealt with in the Section 17 on Riverine Environment. Native animals such as kangaroos require further control and were identified in the landholder survey as the main animal pests in the catchment. This problem is only moderate. However, numbers are thought to be increasing. The heaviest infestation of kangaroos is reportedly in the Yeoval area and near Goobang National Park.

Suntop appears to have a rabbit problem and the landholders from the Hervey Ranges and Arthurville areas have noted the incidence of wild pigs.

6.3.6.2 Broad strategies to control pests and minimize their impact (VF)

- Develop and implement an integrated pest management approach to:

a) Reduce the impacts of pest animals on vegetation communities - rather than pest animal numbers
b) Manage the actual rather than perceived problems
c) Determine key areas where management should occur and when (i.e. sustained or one-off)
d) Implement a long-term strategy rather than one-off management
e) Use a combination of control techniques
f) Involve all stakeholders - rather than just the individual landholder
g) Provide benefits which exceed the costs
h) Incorporate commercial use of pests to offset some management costs

- No management may be a management option
- Employ effective and humane pest animal management techniques
- Increased emphasis on risk assessment to prevent future pest and disease problems

Effective pest management requires a coordinated, catchment wide approach, even though pests are a property scale issue. Despite their potential impact, there is no legislative provision for culling except for certain species of kangaroos. Eg galahs, cockatoos, noisy minors are not covered by culling licenses.

Pest management techniques also need to consider the impact on the overall ecosystem and other pests. For example, if only foxes are removed, then cats will increase. Vegetation management can also help in managing pest birds. Eg. Increasing the size of remnants will

reduce the effect of pest birds, eg. Cockatoos, mistletoes, noisy minors, galahs, because they are all advantaged by edge effects.

6.3.6.3 Specific actions to control pests

Code	*Best Management Option*	*Comments*	*Relevant LMU*
VF1	Control pest animals, particularly in areas of high conservation value		All LMUs.
VF2	Understand your obligations to control noxious weeds		All soil types
VF3	Harvest carp from river systems	See also riparian zone	This needs to be undertaken at the catchment scale.
VF4	Participate in coordinated weed and vermin control within your local area.		All LMUs.
VF5	Develop commercial opportunities for feral pests and their products		This is probably beyond the scope of the individual landholder and would require a cooperative approach at a much higher level.

6.4. *Surface Water Management*

6.4.1 Water Quality (WQ)

6.4.1.1 Causes and on farm implications

Various contaminants, including sediment, agricultural chemicals, intensive livestock industries, industrial waste, urban waste and run-off and salinisation, affect water quality.

The accumulation of nutrients, particularly phosphorus, can lead to algal blooms and eutrophication. Increased runoff from cleared catchments can increase sedimentation, local flooding/erosion and divert flow. Chemicals in waterways threaten human and ecosystem health and can lead to costly remedial works. High salinity levels reduce the suitability of water for human consumption and can also adversely affect aquatic ecosystems.

Blue-green algae are not common on Burrendong Dam even though nutrient levels in the Macquarie are conducive to algal growth and blooms. Typically, turbidity and phosphorus levels in the Macquarie River increase downstream direction.

In-stream salinity is a significant issue. There are serious concerns about water quality in Yeoval due to rising watertables and septic systems causing waterlogging and seepages, particularly in winter. Similarly, declining water quality is a significant cost to Local government for treatment of town water supplies. Costs to irrigators in the short term for infrastructure repair are likely to be massive.

Water quality decline reflects the cumulative impact of activities in the catchment. Clearly then, improving water quality requires a coordinated, catchment wide approach. Consequently, every land manager in the Little River Catchment has some role to play in improving water quality. The suitability and practicality of the following strategies need to be reviewed at the individual farm level.

6.4.1.2 Best Management Options to improve water quality

Broad strategies

Water quality will be generally improved by:

- Identifying possible sources of pollution;
- Investigating flow of saline groundwater into river system;
- Adopting a coordinated approach involving landholders, community, local government and, government agencies; and
- Minimising nutrient access to waterways by improved land use and management practices.

Ultimately though, these strategies, and any others to improve water quality, should be consistent with the following overarching principles:

- Use land according to its capability (includes topography, soils etc);
- Optimise social economic and biophysical outcomes simultaneously;

6.4.1.3 Specific actions to improve water quality (WQ)

Code	*Best Management Option*	*Comment*	*Relevant LMUs*
	Water use/extraction		
WQ1	Minimise water extraction	The Macquarie Water Quality Action Plan should be available in September. LRLG needs to make sure the Unregulated River Management Committee (URMC) is aware of this plan in order to gain resourcing / implementation support. However, the URMC plan will be flow oriented, so there will be a need to integrate flow management with catchment management ie connect dryland salinity and in stream water quality. River regulation and allocated flows have changed flow patterns - because a constant supply is provided for stock & domestic supplies and the Macquarie Marshes, the winter "lows" are now more constant and higher than in a natural low flow. This prevents the environmental cycle from functioning as it naturally did - the river would have completely dried up occasionally during drought conditions.	
	Stock management		
WQ2	Keep river/creek banks well vegetated and revegetate eroded country	Streambanks should be vegetated with a good cover of trees, grass and shrubs to provide protection. Native species, indigenous to the area, should be used in revegetation, except where the landscape is so drastically altered, they would not survive. There is some "push" to see agro-foresty developed in the riparian zone. However, the use of radiata pine is strongly discouraged, due to increased acidity of soil and water, which lowers the pH of the water. This significantly affects aquatic health and suitability for fish and other aquatic life.	All LMUs however first and second order streams are the main areas of concern for nutrients and turbidity. It is unlikely that sedimentation will be improved unless erosion is addressed in these areas.
WQ3	Practice stock rotation to avoid over grazing	Riparian zones require intensive and active management as stock are a major cause of erosion. Fencing out may be necessary to keep stock away from active or denuded gullies and to allow revegetation of both grasses and trees.	All LMUs.
WQ4	Consider watering and grazing stock away from stream banks	Under legislation, improved pasture and cropping should be an absolute minimum of 20 metres from the creek. The width of the zone should be site specific – generally becoming wider down the catchment.	All LMUs but particularly riparian zone and the alluvial LMU.

Code	*Best Management Option*	*Comments*	*Relevant LMUs*
	Crop management		
WQ5	Use zero or low tillage seedbed preparation to minimise soil disturbance	This will also have numerous advantages in terms of improving soil health.	There should be no cropping in the riparian zone –only strategic grazing of improved pastures.
WQ6	Use controlled traffic farming to minimise run off and erosion	Can help to reduce compaction but stock and controlled traffic don't mix. Most farmers in LRC are mixed farmers.	Relates to LMUs most suited to grazing including Red Brown Earths, Euchrozems and Alluvial LMUs.
WQ7	Prevent tailwater discharges and run-off from irrigation fields	Centre pivot irrigation has expanded over the past few years in the LRC. Generally, fertiliser is applied through the system. Small intensive enterprises are not under control / licensed by local council. This plan needs to highlight potential issues of point source pollution from intensive industries and encourage local ownership of problems.	Irrigation mainly occurs on the alluvial LMU.
	Water quality monitoring		
WQ8	Use microbial indicators to determine river health	Little River is one of many without adequate water quality monitoring. Due to much greater demands from other sub catchments in the future it is unlikely that any additional sites will be funded by the DLWC.	
	Urban nutrient management		
WQ9	Reduce pollution from urban environment	Point source pollution from nutrients, including septic systems, can be very important, particularly in times of low flow. Bacterial counts are an issue where homesteads use stream water for domestic use. Cumnock and Yeoval draw their town supply from Buckinbah Ck, and nutrient levels from septic tank leakage and stock faecal matter may be an issue. There is anecdotal evidence that 5000 people access water from the river between Dubbo and Warren ie. Domestic use is significant.	The main urban environments in the Little River Catchment are Yeoval and Cumnock. However, urban nutrient management needs to extend beyond the Little River Catchment boundary.

Code	*Best Management Option*	*Comments*	*Relevant LMUs*
WQ10	Wash vehicles on porous surfaces and use zero or low phosphorous detergents	Phosphorus in the Little River is mainly coming from streambank erosion. Fertiliser is unlikely to be a major contributor, as P binds rapidly to soil particles. However, the urban community should take some responsibility in reducing any potential impact of phosphorus.	
WQ11	Fertilise lawns, greens and gardens sparingly and compost all garden and food waste		
WQ12	Wash only full machine loads		
WQ13	Collect and bury pet poo		
	Carp management		
WQ14	Control carp numbers by: fishing (targeted fishing, Electro-fishing, commercial carp ventures eg. Charlie Carp fertiliser)	Although carp are an exploitable resource (eg. bounties, fertiliser), total numbers mean harvesting is unlikely to be a financially viable proposition in Little River	This action is more relevant at the catchment scale rather than on the individual farm.
WQ15	Rehabilitate the environment and restore the rivers by reversing human disturbances eg. fish ways, improving river flows)	Large woody debris is very important for fish habitat. Snag management is important and while DLWC agree that some snags should be removed, NSW Fisheries generally disagree with this.	These specific actions should be at the catchment scale but there are other options at the individual farm level
	In stream erosion prevention		
WQ16	Prevent further clearing within the riparian zones.	The extent of required revegetation and reduced clearing will vary across the catchment. Failure to prevent further clearing will lead to further decline in river health.	Relates specifically to the riparian zone
WQ17	Exclude stock from grazing along the stream banks and limit stock access	Faecal matter is a major source of nutrients where stock has direct access to creeks and rivers.	Relates to LMUs most suited to grazing, especially the riparian zone and alluvial LMUs.
WQ18	Protect actively eroding banks and realign obstructions that are diverting water and causing erosion	First and second order streams are the main areas of concern for nutrients and turbidity. If erosion issues aren't addressed in this area, then it is unlikely that sedimentation can be corrected.	

6.4.2 Riparian Zone Management (including in-stream management) (WR)

6.4.2.1 Causes and on farm implications

Little River and Bell River are the only two major tributaries that flow into the Macquarie downstream of Burrendong Dam and upstream of Dubbo.

Riparian vegetation is particularly important to river health. It filters nutrients, stabilises and protects riverbanks, acts as a wildlife corridor and provides habitat, food and shelter for fish and other aquatic species and native fauna. Vegetation removal increases nutrient, sediment and pesticide inputs to rivers.

Clearing and landuse practices result in habitat loss and degradation. Riparian zones are distinctive due to their high nutrient and water availability and play a significant role in maintaining regional biodiversity. However, their overall productivity makes the riparian zone attractive to competing agricultural activities.

In high flood times, excess water in Little River can cause flooding in the Macquarie River. The Macquarie Marshes are also affected by upstream impacts because they act as a filtering and collection point for all contaminants.

The health of Little River itself varies from its origin to where it joins the Macquarie River. At its origin, the river has vertical banks, no understorey and weedy groundcover. Typha helps to stabilise the streambed but also indicates salinity. Carp are adding to turbidity but, further downstream, the banks are generally stable. There is numerous introduced plant species, reduced vegetation, the river has wider channels and there is also sediment transfer.

Near Obley, there is good vegetation and little erosion. Downstream of where it joins Buckinbah Creek, there is more agriculture, more weeds and some bank scours and slumps. Flowing past Bushrangers Hill, there is a defined bank and floodplain with good overstorey but weedy groundcover. Where the river joins the Macquarie, it narrows with steep, sloping banks, which are in good condition.

Where Buckinbah Creek joins Little River north of Yeoval there is limited bank instability and good vegetation. Further downstream it becomes highly disturbed with carp and typha. North of Yeoval there is increased sedimentation, sand bars and highly disturbed vegetation.

Gundy Creek joins Little River in the Arthurville region. It has steep to vertical banks with good grass cover. Although Typha helps to stabilise the bed there is a weedy groundcover and the lower part of the creek is highly disturbed.

Sandy Creek flows into Buckinbah Creek near Yeoval. There is extensive bank erosion due to clearing and poor stock management. Degradation in the upper catchment has caused sediment transfer. The steep sloping banks of the river are grassed with Typha in stream. Closer to Yeoval, there is more grass on the banks, which are still eroded. (85).

Riparian vegetation is made up of River She-oak (*Casuarina cunninghamiana*) and River Red Gum (*Eucalyptus camaldulensis*). The River She-oak forms single species stands along watercourses of the slopes and tablelands in the catchment. There is very little understorey in most areas.

There are limited floodplains in the catchment due to the topography. This means that flood damage only occurs when the river breaks its banks or reaches floodplains. Heavy rainfall events above Burrendong Dam may cause flooding in the lower parts of the catchment.

6.4.2.2 Best Management Options to improve riparian zone management (WR)

Broad strategies

Riparian zone management can be improved by:

- Maintaining >70% groundcover in the riparian zone; and
- Coordinated action, involving community, landholders, state and local governments along the length of rivers and streams;

Any strategy to improve riparian zone management, should be consistent with these overarching principles:

- Use land according to its capability (includes topography, soils etc)
- Optimise social economic and biophysical outcomes simultaneously

The following management principles must also be considered:

1. Prevent contamination of water supplies
2. Limit extraction of water supplies to sustainable levels which maintain aquatic health
3. Maximise biodiversity

6.4.2.3 Specific actions to improve riparian zone (WR) management

Code	*Best Management Option*	*Comments*	*Relevant LMUs*
	Vegetation management		
WR1	Allow natural regeneration where suitable and protect areas of remnant vegetation incl native grasses and understorey	Revegetation will also help to address streambank erosion and loss of biodiversity. Native species, indigenous to the area, should be used in revegetation, except where the landscape is so drastically altered that they would not survive.	Relates to all soil types but particularly the riparian zone.
WR2	Revegetate (direct seed or tube stock) with suitable species in the right place eg. Replant deep rooted species to help stabilise banks, establish vegetation in gullies to minimise erosion		
WR3	Maintain buffer zones between paddocks and drainage lines to help reduce sediment and nutrient delivery to streams	Vegetation decline is a major issue across all soil types in the Little River Catchment. There is a need to increase tree cover along larger streams. Major creeks, streams and rivers are more important for habitat than the upper catchment drainage lines. Tree cover needs to be considered more strategically, eg location within the zone, rather than just as a %.	Although this strategy relates specifically to riparian zone and the alluvial LMU, buffer zones should be incorporated into both grazing and cropping systems in the catchment.

Code	*Best Management Option*	*Comments*	*Relevant LMUs*
WR4	Map, survey and regularly monitor the extent and condition of remaining riparian vegetation	Each landholder can do this at their own property level to gauge changes in the extent and condition of riparian vegetation.	Relates to all LMUs but particularly the riparian zone.
	Vegetation management		
WR5	Avoid female willow plants, plant males with non-fragile branches and short stems	Willows growing in-stream can de-oxygenate water and divert flows. Where practical they should be removed - providing this doesn't denude stream banks. Weeping Willows are mainly a problem in the Buckinbah Creek. The more destructive basket willows are less of a problem, which means that willow removal may not be a priority. Poplars present similar problems as willows. Large quantities of leaves from deciduous trees, like willows, fall into the stream all at once, reducing oxygen in the water. In comparison, the carbon cycle of natives provides leaf drop spread throughout the year	Relates particularly to the riparian zone.
WR6	Remove weeds from riparian corridors to facilitate regeneration of native species and reduce streambank erosion	Vigilance is needed to control weeds at sites where the riparian zone is fenced. Strategic grazing should be practiced in these cases Lipia is a particular concern because of its long tap root, which shrinks in drought, and because it diverts water during flooding – this can cause bank slumping. Lipia also out-competes grasses and other understorey plants, making the area useless for grazing or as habitat.	Relates particularly to the riparian zone.

Code	*Best Management Option*	*Comments*	*Relevant LMUs*
WR7	Minimise chemical use and apply only under suitable weather conditions	Pesticides from aerial drift are a possible contaminant. Pesticides bind readily to soil particles, once they hit the ground, so movement into the water is attached to soil during a storm event – minimizing soil erosion can prevent this. It is unlikely that pesticides are moving into the alluvial gravels as they bind quickly to sediment. This could only occur where surface water disappears into gravel aquifers eg at Barney's gully. BMPs should be referred to for recommended distances away from water when spraying	Given the potential impact of chemicals on water quality this strategy relates to all LMUs in the Little River Catchment
	Stock management		
WR8	Fence river banks and existing vegetation in riparian zones to better manage grazing stock eg. Avoid grazing during high moisture times or growing/flowering season	Riparian zones require intensive and active stock management as stock cause of erosion. Fencing may be necessary to keep stock away from active erosion and to allow revegetation.	Relates particularly to the riparian zone.
WR9	Fence area to suit floods and land use and provide alternative water and shade for grazing stock.	Fence design and layout needs to be incorporated into individual property plans. Ideally, land should be fenced according to capability.	Relates particularly to the riparian zone but the concept of fencing to land capability should be applied to all LMUs.
WR10	Manage riparian land for terrestrial wildlife and plan roads/fences to allow for movement of native animals.		Relates particularly to the riparian zone.
	Soil management		
WR11	Minimise cultivation along riverbanks and on 8-20% slopes, reduce depth of soil tillage		Relates particularly to the riparian zone but also needs to be considered on LMUs most suited to cropping ie Red Brown Earth, Euchrozems, Riparian & Alluvial

Code	*Best Management Option*	*Comments*	*Relevant LMUs*
WR12	Apply fertiliser at appropriate times ie. Avoid high rainfall and bare ground	This will help to improve productivity and profitability.	Given the potential impact of nutrients on water quality this strategy relates to all LMUs in the Little River Catchment
WR13	Buffer groundwater sources	Buffer zones are needed where bio solids are applied, although the risk of contamination depends on the soil type and depth to the water table. Bio-solids have the potential to increase carbon, nutrients and OM and there is also a minor risk of heavy metals leaching into groundwater resources.	Bio solids should only be applied where the watertable is greater than 3m