4. Offset Rehabilitation and Management

There are several approaches to restoration of degraded patches of temperate woodland remnants. All involve some form of site amelioration (mitigation measures) and removal of the cause of degradation (e.g. livestock) (Lamb 1994). Depending on the nature of the remnant, remediation may also include a reintroduction of biota (e.g. planting, seeding, fauna introductions) (Lamb 1994). This section details the recommended approach to rehabilitation and management of the proposed landfill offset area.

4.1 Fencing and Removal of Livestock

Livestock shall be removed from the offset and fencing erected as soon as possible. This action alone should substantially improve the condition of the vegetation and quality of the habitat for fauna (Yates & Hobbs 1997). Plant species' richness in temperate eucalypt woodlands is radically affected by livestock grazing (Prober & Thiele 1995). The presence of large numbers of stock on a property (as at the time of the fauna survey in 2005) also causes an unnatural increase in soil nutrients, making it unsuitable for some species of native flora and easing the introduction of exotic weeds (Yates & Hobbs 1997). In general, under heavy grazing pressure, native species become less abundant and are replaced by exotic species. Grazing by hoofed livestock also reduces soil viability through compaction and reduced soil water availability, which in turn leads to tree dieback (Yates & Hobbs 1997). With the removal of stock, these processes will be reversed.

4.2 Rehabilitation and Revegetation

All revegetation works will be undertaken by appropriate personnel and supervised by a qualified ecologist. Revegetation works will include a 2 year maintenance period to ensure effective ground cover has been established. Weed control should continue for at least 5 years post-usage of the site as a landfill.

Pre-clearing collection of locally sourced seeds for direct seeding and/or propagation of tube stock should be undertaken in spring/summer prior to commencement of works. Seeds and saplings should be taken from the landfill pit area and either immediately replanted in the proposed offset area or, in the case of seeds, stored for future replanting of spent cells in the landfill pit.

4.2.1 Rehabilitation of Offset Areas

Fencing will be erected to exclude all stock from the offset area. The native vegetation within the grassland offset area (Figure 1) may regenerate naturally after exclusion of livestock. Native plants that grow from natural regeneration will be well-adapted to the site, have high species diversity, and will represent the original range of plant species in the area.

Most of the area within the Stringybark Woodland offset area should regenerate naturally from the existing seedbank and nearby patches of trees (Vesk *et al.* 2009). However, in some areas recruitment can be slow and may require assistance (Yates & Hobbs 1997; Clarke 2002). If understorey regeneration is not satisfactory in areas left for natural regeneration after one year (see Section 5), selected replanting of shrubs and saplings will be necessary in treeless gaps throughout the Stringybark Woodland. The natural recruitment of shrubs has been shown to episodic and disturbance driven (Clarke 2002), and these species may require planting from tube stock. Planting and seeding is best undertaken following autumn rains in cool, wet conditions to ensure maximum success (Minerals Council of Australia 1998; Vesk & Dorrough 2006).

Ground Preparation:

The southeast corner of the offset area, where few Stringybark trees remain, shall be reseeded and/or replanted. The ground will be prepared using deep ripping to a depth of at least 300 mm to increase water infiltration and to allow for easier root penetration. Deep ripping may also assist in reversing soil structural changes caused by livestock (Yates & Hobbs 1997).

Planting:

Seeds collected from the designated landfill pit area will be used for seeding. Sapling Stringybark trees, if available, should be translocated from the landfill pit area prior to clearing and from the dense Stringybark regrowth area within the offset. An effort should be made to maximise that amount of water available to plants during establishment through reducing competition from weeds. Tree guards may be required to protect the young plants from browsing. Planting in rows and planting of monotypic tube stock should be avoided. Fine-scale patchiness can be developed by spacing trees and shrubs at irregular distances and by not planting in straight rows. In the long-term, management of blocks of vegetation by thinning or strategic burning can be used to enhance patchiness (Bennett *et al.* 2000). Thinning of smaller, immature trees in areas of dense regrowth should be conducted in accordance with DECCW guidelines (Appendix A).

4.2.2 Rehabilitation of Landfill Pit

Areas that are not immediately required for operational purposes should not be cleared until necessary. This means that vegetation on cells 4 and 5 may not be cleared until at least 30 to 40 years respectively, after operation of the landfill has commenced.

Pre-clearing collection of locally sourced seeds for direct seeding and/or propagation of tube stock should be undertaken in spring/summer prior to commencement of works for the landfill pit. Before collecting seed, consultation must be made with the relevant authorities to establish what permits and licences are required. Seed should only be collected when it is mature. Woody seed cases (e.g. Eucalypts) and pods (e.g. Acacia) change colour from green to brown at maturity and become either brittle or woody (Minerals Council of Australia 1998). Differential ripening within one species or even a single plant may necessitate several visits for seed collection. Seeds should be stored appropriately for future replanting of spent cells in the landfill pit.

Topsoil Management and Preparation:

Topsoil is almost always an essential factor in successful rehabilitation programs. The original soil contains the appropriate seeds, nutrients and microorganisms that are necessary for plant growth and is the best choice to naturally inoculate the site (Dragovich & Patterson 1995; Fiedler & Groom 2006). The top 100-300 mm of soil removed from the landfill pit needs to be retained and stored for later rehabilitation of the pit (Minerals Council of Australia 1998). It may be feasible to double-strip the topsoil and remove the top 50 mm of soil separately. Seed stores are concentrated in the surface layer and separating a thin layer ensures the majority of seeds remain near the surface from where they can successfully germinate and establish. Soil should be stripped at an appropriate moisture content to avoid compaction and loss of structure (Minerals Council of Australia 1998).

Top soil collected from the landfill pit area prior to excavation shall be stored nearby for up to 3 years (Fiedler & Groom 2006). Soil should be stored in low mounds no more than 1-2 m high

(Minerals Council of Australia 1998). The stockpile should be revegetated to protect the soil from erosion, discourage weeds, and maintain active populations of beneficial soil microbes.

To re-establish sustainable native vegetation on the spent landfill cells the rehabilitation will commence with landform design and the reconstruction of a stable land surface prior to replacing the topsoil (Minerals Council of Australia 1998).

The stripped topsoil should be tested prior to reuse as topsoil acidity may increase over time (Dragovich & Patterson 1995). The use of gypsum or lime may be required to amend the soil prior to use (Minerals Council of Australia 1998). Although native species are adapted to the low nutrient levels common in Australian soils, improved growth and establishment has been achieved following fertiliser application (Minerals Council of Australia 1998), and the addition of fertilizers and nutrients may be required. Application rates of inorganic fertilisers should be assessed according to the results of soil analysis. Seedbed assessment and manipulation has a strong effect on the success of seedling emergence (Clarke & Davison 2001). The seedbed should not be "over-prepared" as a rough "cloddy" surface reduces runoff and provides better protection for seeds and seedlings (Minerals Council of Australia 1998).

Planting:

Fencing will be erected around the spent landfill cells prior to planting to protect young seedlings from animals and damage from machinery. Revegetation shall be undertaken through, direct seeding, planting of tube stock and natural regeneration from the topsoil seedbank.

Direct seeding has the advantage that the distribution of plants is random. Relatively low numbers of seeds should be applied (0.5 kg/ ha) to allow for a greater diversity of plants to establish through natural regeneration. Seeds used in reseeding should ideally be those collected from the native vegetation prior to construction of the landfill pit. Alternatively, seed can be purchased from a reliable nursery. Seeds of some species may require pre-sowing heat treatment (Minerals Council of Australia 1998). To reduce ant predation, seeds will be treated with 'Coopex' prior to application (Clarke & Davison 2001; Campbell & Clarke 2006; Lomov *et al.* 2009). Seed inoculation with effective root-nodule bacteria (rhizobia) has also been shown to enhance revegetation success (Thrall *et al.* 2005) and should be implemented if seeds have been stored apart from topsoil for a long period (Minerals Council of Australia 1998). Seeding should be conducted after periods of moderate to heavy rainfall and during periods of consistent rainfall to ensure the maximum success (Vesk & Dorrough 2006).

Direct seeding will be used to establish shallow-rooted native grasses, herbs and shrubs. However, deep-rooted overstorey species cannot be planted directly on the landfill footprint, as their roots may damage the final capping layer over the spent cells. The seed mixture should comprise the most common grasses currently present on the side, potentially including Slender Rat's Tail Grass (*Sporobolus creber*), Red-leg Grass (*Bothriochloa macra*), Rough Speargrass (*Austrostipa scabra*), Couch (*Cynodon dactylon*), Snow Grass (*Poa sieberiana*), Small Lovegrass (*Eragrostis leptostachya*), Purple Wiregrass (*Aristida ramosa*) and Slender Wallaby Grass (*Austrodanthonia racemosa*). Shrubs are currently not common on-site. Provided the topsoil used to rehabilitate the spent landfill cells is from the existing site, the seedbank should allow shrubs to establish naturally. Seeding with Australian Blackthorn (*Bursaria spinosa*) may assist the shrub layer to establish faster. The shrub layer should be closely monitored to ensure that flora species of value to the threatened fauna species identified on the site are established (Bennett *et al.* 2000). Tree guards may be required to protect shrubs from browsing (Kasel 2008).

Planting in rows and planting of monotypic tube stock should be avoided (Munro *et al.* 2009). Direct seeding sourced from adjacent patches and regeneration of native plants will result in the most natural outcome. Fine-scale patchiness can be developed by spacing trees and shrubs at irregular distances and by not planting in straight rows. In the long-term, management of blocks

of vegetation by thinning or the use of fire can be used to enhance patchiness (Bennett *et al.* 2000).

Recent studies have shown that the use of mulch after replanting reduces the diversity of re-established flora (Fiedler & Groom 2006). Given the relatively mesic environment of the Armidale area, mulch should not be required and its use should be avoided. Instead, an effort should be made to maximise that amount of water available to plants and seeds through reducing competition from weeds. Care must be taken to not disturb the topsoil after seeds have started to germinate as this will cause a substantial reduction in plant establishment (Minerals Council of Australia 1998).

For one year after planting the survival rates of plants will be assessed to determine the necessity for replacing dead plants. It is assumed that 10% of the seedlings will require replanting.

Management of the landfill area will be adaptive depending on the responses of native flora and fauna to rehabilitation and management actions. Unforeseen changes in conditions may result in minor adaptations to management actions in order to improve the chances of favourable outcomes from year to year.

4.2.3 Buffers

Vegetated buffers will be planted along the access road and around the landfill pit and infrastructure areas (within the offset areas and outside the landfill perimeter fencing). These areas should be established and planted in the early stages of project construction and removal of existing vegetation from the landfill pit be delayed as long as possible to achieve maximal overlap.

Buffer plantings along the access road will be designed to supplement existing native stands and enhance connectivity between patches of remnant vegetation, including the Gara TSR. Native trees and shrubs will be planted in a configuration to mimic the natural landscape and will occupy the maximum width of the road corridor.

All plantings will consist of locally occurring native species, propagated from locally collected seed or other propagules. Shrubs, herbs and grasses will mostly be allowed to regenerate naturally.

Planted buffer areas should be maintained by a horticulturist for a period of 24 months. During this period any trees that die will be replaced. Additional seeding will be implemented as necessary. Wooded areas shall be monitored to ensure regeneration includes all facets of native vegetation and the establishment of weeds is prevented (see Section 5).

A firebreak shall be constructed around the perimeter of the Stringybark Woodland offset, and around the perimeter of the grassland offset.

4.3 Removal of Mature Trees

The number of mature trees requiring removal within proposed irrigation areas will be limited to the minimum necessary for the safe construction and use of the proposed development. Mature trees to be retained will be marked to ensure machinery operators take due care in their vicinity and minimise any damage that may otherwise occur.

Prior to removal of hollow-bearing trees in woodlands and grasslands, hollows will be checked for nestlings and arboreal mammals, such as possums and insectivorous bats. Diurnal and nocturnal stag watches should be undertaken for each hollow-bearing tree or cluster of trees.

Tree hollows should be re-checked for animals after felling or pushing. All fauna found will be safely relocated to the offset areas with the supervision of a zoologist or wildlife rescuer. Injured or sick animals will be taken directly to a local veterinarian for treatment.

4.4 Weed Control

The control of exotic plant species is one of the most important issues for any eucalypt woodland restoration program (Yates & Hobbs 1997). Without adequate control of weed species, any areas left for natural regeneration may rapidly become overrun by exotics.

Twenty-eight (28) weed species were recorded in the grassland, sedgeland and Stringybark Woodland communities within the landfill development area. The dominant species were Spear Thistle (*Cirsium vulgare*), which dominated some areas of grassland, and Hawthorn (*Crataegus monogyna*), Blackberry (*Rubus fruticosus*) and Sweet Briar (*Rosa rubiginosa*) mostly within the numerous large log piles in the Stringybark Woodland.

Four (4) species of noxious weeds declared under the *Noxious Weeds Act 1993* for the Armidale Dumaresq Local Government Area (LGA) are present on the study area: African lovegrass (*Eragrostis curvula*), Bathurst Burr (*Xanthium spinosum*), Blackberry and Sweet Briar. Although not currently present on site, control and monitoring of invasive exotic grasses, such as Coolatai Grass, Serrated Tussock, and Chilean Needlegrass, which may spread from the Waterfall Way access route to the new landfill site should also be undertaken. Management of weeds shall be undertaken as required by law under the *Noxious Weeds Act* 1993.

Noxious weeds will be treated with spot-spraying of glyphosate and thinning/slashing/pulling implemented where required. All use of herbicide must comply with the directions on the attached labeling and with regard to the provisions of the *Protection of the Environment Operations Act* 1997. The ‘cut-and-paint-stump’ method is recommended for removal woody weeds (Blackberry, Sweet Briar and Hawthorn). This involves completely cutting the trunk or stem of the plant as near as practical to ground level and applying a herbicide to the cut surface within 30 seconds.

Weeds control should continue for up to 5 years after planting/seeding of offset areas and spent landfill cells. Two comprehensive searches for weeds will be implemented each year, one in late spring (November) and another in late summer (February).

It is unlikely that weeds will spread neither from landfill waste placed in the operational pit areas nor from rehabilitated pit areas since green (garden) waste will be processed at the Long Swamp Road Waste Transfer Station. It is understood that Council does not intend to landfill any green waste at the proposed development site on Waterfall Way. The potential introduction and spread of weeds from the landfill is more likely to be associated with soil disturbance and earthworks during the construction and rehabilitation phases of the landfill operation.

It is recommended that the following mitigation measures be undertaken during development works to prevent the spread of weeds:

- Wash down vehicles to remove weeds and weed seeds to prevent spread to new areas. Wash down should occur in a dedicated area where runoff can be contained and weeds treated.
- Ensure that all materials imported onto the site are weed and disease free.
- Do not transport topsoil. Re-spread topsoil as close as possible to the area it was stripped from.
- Monitor and control weeds following ground disturbance and construction works: use only non-residual herbicides and those without surfactants (spreading agents) in the vicinity of drainage lines (surfactants can lead to suffocation of amphibians).

- Residual herbicides may be used in table drains only if they are used in a spot spray manner (residual herbicides persist in the soil and can be washed into watercourses).
- Appropriate control of drainage and run-off that may spread weed seeds or high levels of nutrients.

4.5 Feral Animal Control

Habitat modification may be the most suitable technique for Rabbit control. Removal of surface refuge greatly enhances the effectiveness of control programs and slows recolonisation. This may be achieved through measures such as dismantling existing log piles and removing blackberry thickets. Due to the presence of raptors (e.g. Little Eagle) at the site, baiting with 'Pindone' is not recommended, however the use of 1080 may be suitable. Log piles should be dispersed as individual logs scattered throughout the offset areas (both Stringybark and grassland), to retain fauna habitat (e.g. foraging substrate for threatened birds) while minimising shelter for Rabbits.

The reduction of Rabbits at the site will help to control Fox and potential cat populations in the area. The removal of log piles will also serve to reduce harbour available for these species. Covering waste in a timely manner should reduce exposure of waste to these pest species and minimize enticement.

A specialist in feral animal control should be consulted to determine the best management approach for existing and potential feral animals at the site. If an outbreak is detected, a professional exterminator shall be employed.

4.6 Relocation of Dead Wood and Dead Trees

Hollow-bearing stags in the grassland and hollow-bearing trees from Stringybark Woodland in the landfill area will be relocated to offset areas as logs, or erect as stags if feasible, in line with DECCW recommendations (Appendix A).

Log piles within the landfill pit area of the Stringybark Woodland should be redistributed to the offset areas and dispersed as single logs to emulate natural conditions (Munro *et al.* 2009). Fallen branches and timber should be allowed to accumulate over time in the offset area. Stumps with the potential to stand upright should be positioned to allow for birds and arboreal mammals to use the hollows for nesting and roosting.

4.7 Enhancing the value of the offset for native fauna: structural complexity

Fauna depend on a diversity of vegetation types and structural complexity to provide foraging substrate, shelter and nesting habitat (Bennett *et al.* 2000; Kavanagh *et al.* 2007) and structurally complex revegetation will support a greater diversity of species (Munro *et al.* 2007). To support fauna that may be displaced and negatively impacted by the development, natural layers of structural complexity and patchiness of vegetation must be re-established in the offset area through a mixture of plant species regrowth (Munro *et al.* 2009). Layers of vegetation can be established by selecting plants that grow to different heights, such as trees, tall shrubs, low shrubs and groundcover. Fine-scale patchiness can be developed by spacing trees and shrubs at irregular distances and by not planting in straight rows. In the long-term, management of blocks of vegetation by thinning or the use of fire can be used to enhance patchiness (Bennett *et al.* 2000).

The habitat requirements of animal assemblages and species differ widely. Studies of arboreal marsupials have shown that some members of this group can recolonise revegetated areas if hollows are present or provided as nest boxes (Suckling & Goldstraw 1989). Complex

groundcover elements, including fallen logs and debris, are essential for recolonisation by small native terrestrial mammals (Munro *et al.* 2007). The number and diversity of avian species inhabiting revegetated woodland appears to be directly related to the composition of the vegetation layers with the development of the understorey being of particular importance (Munro *et al.* 2007). Studies show that common bird species can recolonise revegetation within 2-3 years provided the understorey is well-developed (Munro *et al.* 2007). Bird species richness tends to increase with revegetation age and declining and uncommon birds may take more than 8 years to recolonise (Taws *et al.* 2001).

Several threatened species of birds are likely to be displaced due to construction of the landfill pit. However, the impacts will be minimised through the staged clearing required for construction of the landfill over its proposed 50 year lifespan. This will allow the maximum possible amount of habitat to remain while the Stringybark offset area becomes progressively more established. A complex structural habitat, with multiple layers of vegetation, should be established in the offset areas prior to extensive clearing for the landfill pit and associated infrastructure. The habitat requirement for each of these species differs:

The Diamond Firetail Finch (*Stagonopleura guttata*) builds bottle-shaped nests in trees and bushes, but largely forages on the ground for grass seeds and insects. This species will require well-established overstorey, shrubs and groundcover to successfully inhabit the offset area.

The Speckled Warbler (*Pyrrholaemus sagittata*) nests and forages on the ground for arthropods and seeds in grassy patches, leaf litter and shrub cover (Ford *et al.* 1986) and are thus very susceptible to predation. The successful assessment of groundcover and a shrub layer is important for the survival of this species. However, more important for the survival of this species are the removal of existing introduced predators on the site (Foxes) and the prevention of an increase of cat numbers on the site as a result of the landfill. Speckled Warblers are known to respond well to replanted eucalypt woodlands (Kavanagh *et al.* 2007).

Varied Sittellas (*Daphoenositta chrysoptera)* forage socially on insects, by clambering among tree branches and probing bark and dead wood. They build an open, fibrous nest in upright dead forks of trees (Higgins & Peter 2002). The successful established and retention of mature trees on the site is paramount to the survival of this species.

Scarlet Robins (*Petroica boodang*) forage on insects, mostly by pouncing to the ground from a low perch. They build an open, fibrous nest, typically in a fork of a mature living tree and sometimes on a dead branch (Debus 2006). Both a well-established groundcover layer and tree canopy are required by this species.

It is expected that the Little Eagle (*Hieraaetus morphnoides*) pair on the site will move to a new nest location when: a) their nestling has fledged and disturbance near the nest/roost tree increases; and b) the number of Rabbits, their primary food source on the site, is reduced. Thus, we predicted that the Little Eagles will not be significantly impacted by the development provided several large mature trees, such as Yellow Boxes are retained on the site (Broese *et al.* 2009). Little Eagles breed in a stick nest in a living woodland tree and the long nesting cycle lasts from late winter to early summer (Debus *et al.* 2007; Debus & Ley 2009).

The successful establishment of a multi-layer complex habitat may also offer the native species some protection from exotic and native pest species. For example, Noisy Miners (*Manorina melanocephala*) are an increasing problem in Australian landscapes and dominate small patches and competitively exclude other small woodland birds (Ford *et al.* 2001). The establishment of shrubs, such as native Acacias, in the offset woodland may reduce the number of Noisy Miners (Hastings & Beattie 2006). In a study by Hastings and Beattie (2006), the greatest abundance and richness of small birds occurred in plantings combining eucalypts with at least 15% Acacias. Hastings and Beattie (2006) recommend that eucalypt plantings be supplemented with both Acacias (preferably bipinnate) and a shrubby understorey to deter Noisy Miners.

5. Offset Monitoring

On-going annual monitoring of revegetation is required to determine the success of regeneration within the offset areas and within the landfill pit as each cell is rehabilitated. Vegetation surveys of established monitoring plots should be undertaken in late spring-summer to maximize the numbers of species recorded and ensure accurate identification. Monitoring plots should be established in the offset area prior to vegetation removal for the landfill pit and infrastructure.

Understorey response to grazing removal should be monitored from the outset. If understorey response is minimal, assisted regeneration (revegetate with local tree and shrubs seeds or seedlings) will be required, especially in treeless areas. A density of >2,000 stems per 5 ha is considered adequate regrowth. Growth and stand structure response shall also be monitored to assess the response of the understorey to thinning.

5.1 Establishment of plots for ongoing vegetation monitoring

Prior to vegetation removal for the landfill pit and infrastructure, vegetation monitoring plots (20 x 50 m) will be established in the designated offset areas. A minimum of three plots shall be established in representative vegetation for the grassland area, three plots established in the Stringybark vegetation in good condition (regrowth), and three in the areas that will likely required revegetation (areas near Stringybark Woodland currently designated as grassland; Figure 1) for a total of nine monitoring plots.

These plots aim to detect changes in response to site rehabilitation and monitoring shall commence with the collection of baseline data. This information will provide the benchmark from which ongoing monitoring will be measured and assessed in terms of the success of the rehabilitation works.

5.2 Monitoring vegetation regeneration (diversity assessment)

Within the 50 x 20 m plot, numbers of individual stems of native trees and shrubs by species will be counted to determine diversity. Dead trees or stumps >1 m high will also be counted and denoted as ‘dead tree’.

Trees less than 10 cm in diameter will be further classified in terms of height. This will assist with the monitoring of seedling growth and regeneration. A density of >2,000 stems per 5 ha is considered adequate regrowth. Less than 2,000 stems per 5 ha area will require assisted rehabilitation by planting or seeding of native species.

The number of vegetation layers (strata) should be noted and described in categories for trees, tall shrubs, low shrubs and groundcover (Thackway *et al.* 2006). Notes will be made of the presence of exotic weed species where appropriate.

The abundance of fallen timber >10 cm diameter will be recorded in terms of the total length of logs present in each transect. Logs will be separated into diameter size classes related to the tree diameter at breast height (DBH).

5.3 Monitoring Groundcover

Vegetation groundcover will be assessed within the 20 x 20m plot as percentage of native grasses, native shrubs, native other (forbes and herbs) and exotic plant cover. For the baseline study, all native and exotic species will be identified to species. The quality of the remnant vegetation community present will also be assessed for the level of ground disturbance (from animals or human activity) and organic litter coverage.

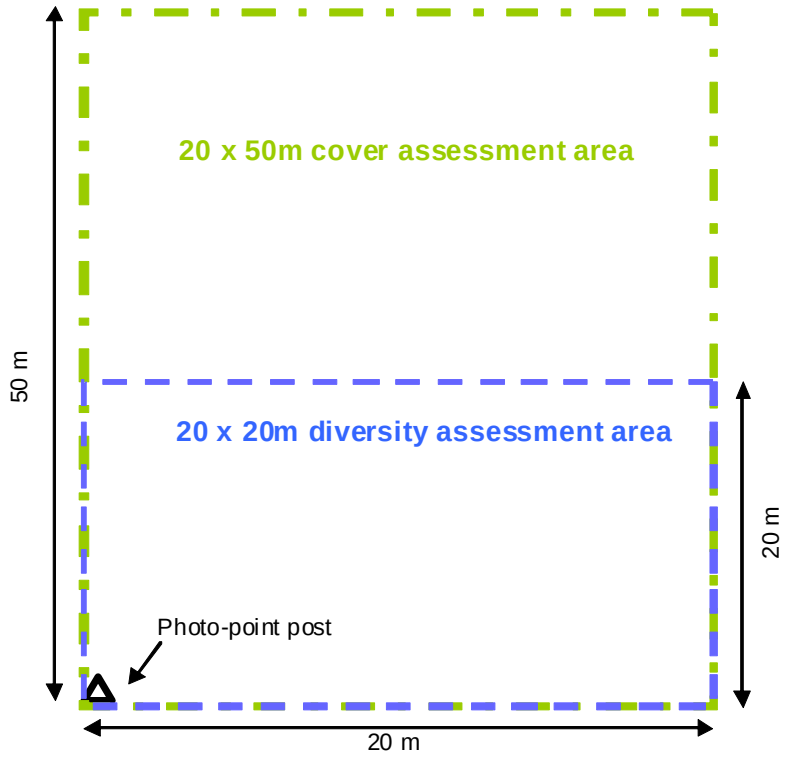

Figure 4. Monitoring plot layout

5.4 Photo Points

A digital photo will be taken at the southwest corner of each plot and the location and aspect recorded using a GPS and compass. The location of the photo point will be marked using a labelled star picket as a permanent marker.

5.5 Reporting

An annual report of the assessment will be produced detailing the following:

- Digital photos with GPS locations and aspect for each monitoring plot;
- Ground cover assessment;
- Tree & shrub diversity;
- Tree height for trees less than 10 cm in diameter (regeneration measure);
- Calculation of total number of species, total stems (20 x50 m), and estimated stems per 5 ha for each plot;
- Fallen timber;
- Ground disturbance;
- Organic leaf litter coverage;
- Presence and estimated density of exotic weed species; and
- A discussion on the density and diversity of natural regeneration occurring in each plot.

6. Statement Addressing the Principals of Biodiversity Offsetting

DECCW (previously the Department of Environment and Conservation DEC) has outlined a number of principles for biodiversity offsetting (Appendix A). We have briefly addressed each of these criteria in terms of the conditions on the proposed landfill site.

1. Offsets are used to address residual impacts following consideration and implementation of options to avoid, minimise and mitigate impacts.

Options to avoid, minimise and mitigate impacts of the proposed landfill on threatened species and ecological communities have been taken into consideration and are discussed in Broese *et al*. (2009). Offsets will be used to create additional habitat for four species of woodland birds that will lose territories for individual pairs as a result of landfill construction.

The area designated for the landfill is currently highly degraded. The condition of the proposed offset areas will be rehabilitated according to DECCW's recommendations (DEC 2006) and the condition will gradually improve to a status more suitable for species conservation.

The construction of the landfill pit will be completed on a cell-by-cell basis. Thus, vegetation in the final cells will not be cleared for 30-40 years after commencement of landfill use. After each cell is full, it will be covered and rehabilitated. This will minimise the size of the area impacted at any given point in time.

2. Offsets should be based on an agreed understanding of the conservation significance of the impact and offset values.

A full assessment of the conservation significance of threatened species and vegetation communities was conducted as part of the flora and fauna assessment (Broese *et al.* 2009). The proposed offset areas are of the same vegetation types as the proposed clearing, a 3:1 ratio of offset to impact area for Stringybark Woodland and native grassland.

An important component of the offset is their potential to maintain or increase the connectivity value of the landscape. The vegetated buffer to be reconstructed along the access track will link habitat between the Stringybark Woodland in the south of the site with Box-Gum Woodland in the north in the Gara TSR (Figure 1).

3. Offsets should maintain or improve identified biodiversity values secured into the future.

Mitigation measures and rehabilitation of the offset area should compensate for the loss of biodiversity within the impact area. DECCW has agreed to a 3:1 offset ratio to provide habitat for the woodland bird species to be impacted by the development. The mitigation measures proposed for the offsets, including exclusion of grazing, redistribution of fallen timber (as single logs), and weed and pest control will improve the conservation value of the site overall. These mitigation measures should improve tree recruitment and understorey condition and diversity in the landfill and offset areas (Yates & Hobbs 1997).

4. Offsets should be based on a "like for like" basis.

Clearing of 12.7 ha of Stringybark Woodland and 0.6 ha of Box Gum Woodland will be replaced by the conservation and improvement of 40 ha of similar Stringybark Woodland regrowth area. As the Stringybark Woodland in the proposed landfill area contains Box Gum Woodland elements, the Stringybark Woodland offset area will be enhancement planted with Yellow Box and Blakely's Red Gum trees, particularly in the vicinity of existing trees of these species in the Stringybark offset area.

Clearing of 6.5 ha of grassland and 0.5 ha of sedgeland will be replaced by the conservation and improvement of 21 ha of cleared grassland.

5. Offset area should be greater than the area impacted.

A 3:1 offset to impact ratio has been proposed for the landfill site (DEC 2006).

The area proposed for the offset of both Stringybark Woodland and grassland is in similar condition to the area to be cleared. The condition of the offset areas will be improved by mitigation.

6. Offsets should generally be in proximity to the area impacted.

The offsets will be adjacent to the Stringybark Woodland and grassland to be impacted, respectively. Applying the offset locally minimizes the risk that any one area receives an unreasonable burden of impacts without receiving the benefits that offsetting can provide. Providing offsets and improving habitat condition adjacent to the impact areas should allow the four threatened bird species at the site to relocate from the impact area to the offset area and the genetic diversity of the populations in the local area will be retained.

7. Offset actions should be located in areas of strategic regional conservation value where Principle 6 does not apply.

Principal 4 (like-for-like) and principal 6 (offset adjacent to impact area) have been satisfied for this proposal.

8. Offsets should be in addition to existing initiatives.

The proposed offset areas are in addition to mitigation measures proposed for the site in the flora and fauna assessment (Broese *et al.* 2009). Initiatives include assisted regeneration of degraded habitat, relocation of logs from log-piles, fencing, and pest and weed control.

9. Offsets should minimise ecological risks from time lags.

Construction of the landfill pit and infrastructure should not commence until offsets have been designated and rehabilitation of suitable areas of the site has commenced. Fencing and rehabilitation of the offset areas should commence as early as possible.

Each cell of the landfill will be rehabilitated as it is completed and unused cells will not be cleared until they are needed.

10. Offsets should be secure, long term and auditable.

Offset areas can be protected in perpetuity through:

- Vesting ownership in Council, Land Trust or BioBank;
- A formal conservation agreement (Voluntary Conservation Agreement (VCA) under the NPW Act bound to title prior to on-selling; or
- A covenant on title placed on the land under section 88b of the Conveyancing Act 1919.

The appropriateness of targets and strategies of the management plan will be reviewed every 5 years.

Mandatory documentation of offset agreements must convey full details about all locations and actions involved in an agreement. A spatial record on a centralised GIS spatial database, managed by DECCW and accessible by DECCW officers is also required (DEC 2006).

7. Summary of Mitigation Measures

After extensive negotiation between the Department of Environment, Climate Change and Water, Armidale Dumaresq Council and E. A. Systems consultants it has been agreed to implement the following beneficial management actions:

- Progressive clearing of trees on the landfill area on a cell by cell basis;
- Fencing of offset areas with livestock-proof but wildlife-friendly fencing (avoiding barbed wire if possible);
- Control of exotic herbivores (Rabbits) in the offset areas. (A Rabbit control plan will include close monitoring of densities of Rabbits and immediate control of new irruptions);
- Control of any cat populations associated with the landfill;
- Control of Foxes in the offset area, especially if part of a broader regional program with neighbouring properties. Localised control of Foxes reliant upon the landfill is required;
- Ongoing control of noxious weeds;
- No burning for hazard reduction in offset areas, and construction of perimeter firebreaks around the offset areas. (If hazard reduction burning is required as a buffer to the landfill, the design must minimize the area burned or preferably use slashing to achieve a narrow buffer);
- Relocation of hollow trees from landfill area to offset areas as single logs (not log piles which create Rabbit harbour), or erect as stags if feasible;
- Relocation of all logs that are >20 cm diameter at any point off the landfill site to the offset area, as single dispersed logs (not log piles);
- Rehabilitation of tree cover in selected areas to begin as soon as possible after stock removal;
- Monitoring of understorey response to grazing removal to be initiated prior to the commencement of development;
- Assisted rehabilitation will be required if understorey response is minimal, (selected replanting of shrubs and seeding if feasible) especially in treeless areas;
- Low intensity thinning of dense stands of young trees to be applied in a small-scale mosaic pattern if carefully designed to have ecological benefit. Growth and stand structure response to be monitored. Draft protocols for such thinning are provided in Appendix A (Thinning is not a required action, but should be applied if judged to be beneficial).

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