



ASSESSMENT | PLANNING | MANAGEMENT

# Marsden Park Industrial Precinct Riparian Corridor Vegetation Management Strategy Final Draft

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## 1. Introduction

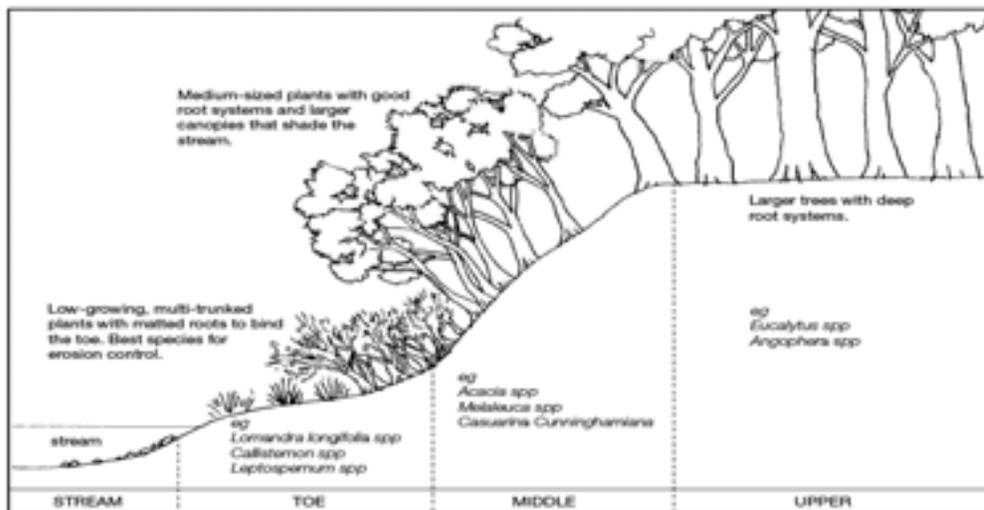
This Vegetation Management Strategy (VMS) has been prepared to guide future restoration and management requirements of riparian corridors across the Marsden Park Industrial Precinct. This has been prepared in-line with requirements of the Growth Centres Development Code and NSW *Water Management Act (2000)* guidelines.

### 1.1 Study area

The study area includes the riparian zones of the Marsden Park Industrial Precinct as shown in Figure 4.

### 1.2 Management Objectives

The overarching objective of the VMS is to provide for a stable watercourse and riparian corridor which emulates the native vegetation communities in the area. Figure 1 below shows a typical riparian cross section.



**Figure 1. Typical riparian cross section - *Rivercare: Guidelines for Ecological Sustainable Management of Rivers and Riparian Vegetation*: Raine, A.W & Gardiner, J.N, (1995), LWRRDC, Canberra.**

The VMS aims to enhance riparian corridors and remnants within the study area and establish sustainable ecosystems. This will be achieved within the framework set out in Table 1.

**Table 1 Management objectives and approaches**

<b>Objectives</b>	<b>Approach</b>
Increase biodiversity by removing invasive weed species and re-introducing native species	Remove and control environmental weeds prior to revegetation Maintenance weed removal Revegetate areas of low natural recovery potential
Improve ecological health and integrity by revegetating with native species	Revegetate the terrestrial, creek, riparian and wetland areas with appropriate species Maintain plant health until established Maintenance weed removal
Enhance habitat values	Protect and enhance existing terrestrial and aquatic habitat Consolidate corridor Use restoration techniques that facilitate fish passage
Stabilise bed and banks	Increase native plant cover  Utilise native vegetation planting and large woody debris to assist in stabilisation In high erosion areas construct rock-rip raps, drop structures or undertake bank armouring

In the short term the VMS aims to:

- Conserve existing native vegetation communities
- Control non-native species, especially weeds
- Revegetate cleared areas using local provenance native species consistent with the natural vegetation communities found in the locality
- Minimise impacts of construction activities

Following the initial works, the VMS aims to:

- Establish a viable habitat corridor for terrestrial and aquatic native fauna through habitat creation, restoration and connectivity
- Maintain and enhance biodiversity
- Minimise impacts associated with nearby urban land use

## 2. Project Description

The VMS is based on the proposed Indicative Layout Plan (ILP) and riparian corridor design in the Marsden Park Industrial Precinct ILP as shown in Figure 2. The majority of the precinct will be zoned for industrial and business purposes, with small pockets of residential areas. A category 1 riparian corridor will extend down the eastern boundary of the precinct along Bells Creek, along with a small riparian area in the north-west corner adjacent to Shane's Park. Each of these category 1 riparian corridors will be part of the proposed conservation zoning within the site. A number of smaller category 3 corridors will also be maintained within the site (see figure 2). All riparian areas will be identified as Riparian Protection Areas.

### 2.1 Potential impacts and mitigation measures

Potential impacts of the proposed development associated with construction activities and long term urban land use include:

- sediment pollution
- stormwater runoff
- altered hydrology
- weeds
- rubbish
- noise pollution
- loss of connectivity
- loss of plants
- altered vegetation structure

To minimise the risk of these impacts, the VMS incorporates the following measures:

- Ensure pollution and sediment controls are in place before commencement of work
- Prevent or control access to sensitive areas, especially creek banks, by establishing a riparian buffer zone
- Maintain and protect existing vegetation
- Monitor runoff
- Protect, maintain and enhance remnant areas

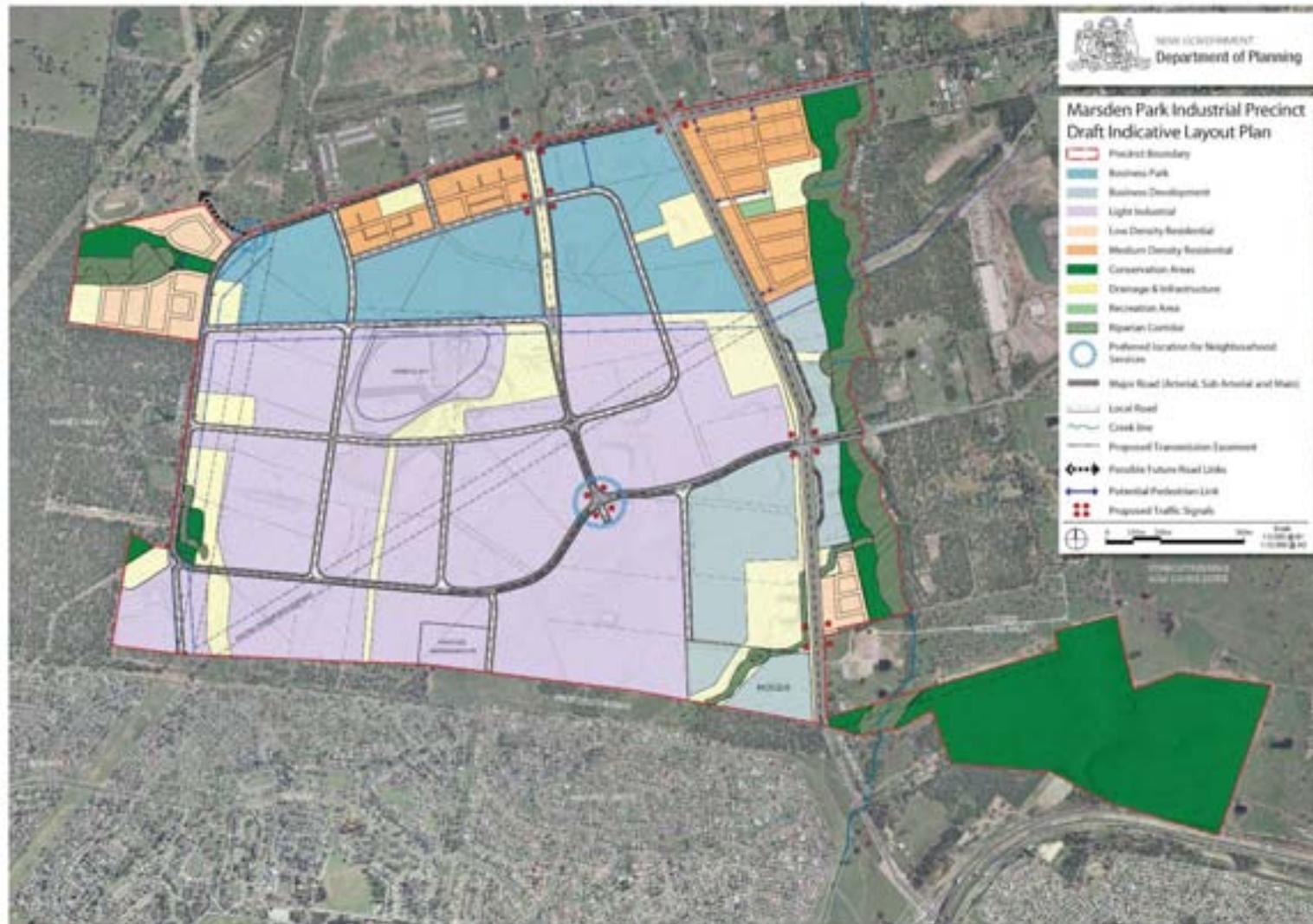


Figure 2 Draft ILP

### 3. Description of the Environment

For a full description of the Marsden Park Precinct environment, refer to chapters 1 to 5 in the body of the ecological report.

#### 3.1 Location and topography

The topography of the site is relatively flat, with low slopes across the site. The eastern side of the precinct drains predominantly to Bells Creek with the western side of the site draining into Shane's Park. Bells Creek is a major creek line, its catchment extends beyond the precinct to the south.

#### 3.2 Hydrology

The Bells Creek catchment lies largely outside of the study area. The catchment upstream of the precinct is a mixture of rural and residential properties with patches of remnant vegetation.

The hydrology of Bells Creek is highly modified, with flow disturbed by private dams, diversions, erosion and rubbish. At the time of the recent site survey a large dam upstream of the tributary south of the Community Centre had been breached by excavating the dam wall. The main channel of Bells Creek is highly eroded in places with steeply incised banks. Generally, the aquatic habitat of Bells Creek is considered to be of good quality.

The remainder of the watercourses within the site are ephemeral, have been significantly modified and are in poor condition. The dam and drainage in the north western corner of the site, drains into Shane's Park and occurs within the non-certified conservation zone. The dam is to be modified as part of the precinct development.

The smaller tributaries in the southern part of the site are considered to be category 3 status and require narrower corridors with an emphasis on maintaining water quality and local geomorphic stability.

#### 3.3 Flora

##### 3.3.1 Regional context

Most remnant vegetation in the immediate vicinity is found in the adjacent Shane's Park and north-south aligned corridors along watercourses. Threatened species information can be found in chapter 2 of the ecological report.

##### 3.3.2 Study area

Figure 3 shows the vegetation communities within the study area which were validated by ELA as part of the ecological assessment in mid 2008.

The remnant vegetation communities within the proposed riparian corridors are;

- Alluvial Woodland (AW) within the study area comprises the endangered ecological community *River-Flat Eucalypt Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions* (River-Flat Forest), which is listed on Schedule 1 of the TSC Act. AW occurs exclusively along, or in close proximity to Bells Creek, along the eastern boundary of the study area.
- Shale Plains Woodland (SPW) is part of the Cumberland Plain Woodland Endangered Ecological Community, listed under both the TSC and EPBC Acts. SPW within the study area consists of a mixture of poor, moderate and good condition vegetation.
- Shale/Gravel Transition Forest (SGTF) occurs primarily in areas where there are shallow deposits of tertiary alluvium overlying shale soils, but also in association with localised concentrations of iron-indurated gravel. SGTF is an endangered ecological community listed on Schedule 1 of the TSC Act.

The vegetation condition across the study areas varies from good condition in areas of larger remnants to poor condition in areas that are dominated by paddock trees and exotic groundcovers.

Seven plant species identified within the study area are listed as noxious weeds within the Blacktown Local Government Area. These noxious weeds include:

- African Boxthorn (*Lycium ferocissimum*) - Noxious Class 4
- Blackberry (*Rubus fruticosus* aggregate) - Noxious Class 4
- Bridal creeper (*Asparagus asparagoides*) - Noxious Class 5
- Broad-leaved Privet (*Ligustrum lucidum*) - Noxious Class 4
- Green Cestrum (*Cestrum parqui*) - Noxious Class 3
- Narrow-leaved Privet (*Ligustrum sinense*) - Noxious Class 4
- Prickly pear (*Opuntia* sp.) - Noxious Class 4

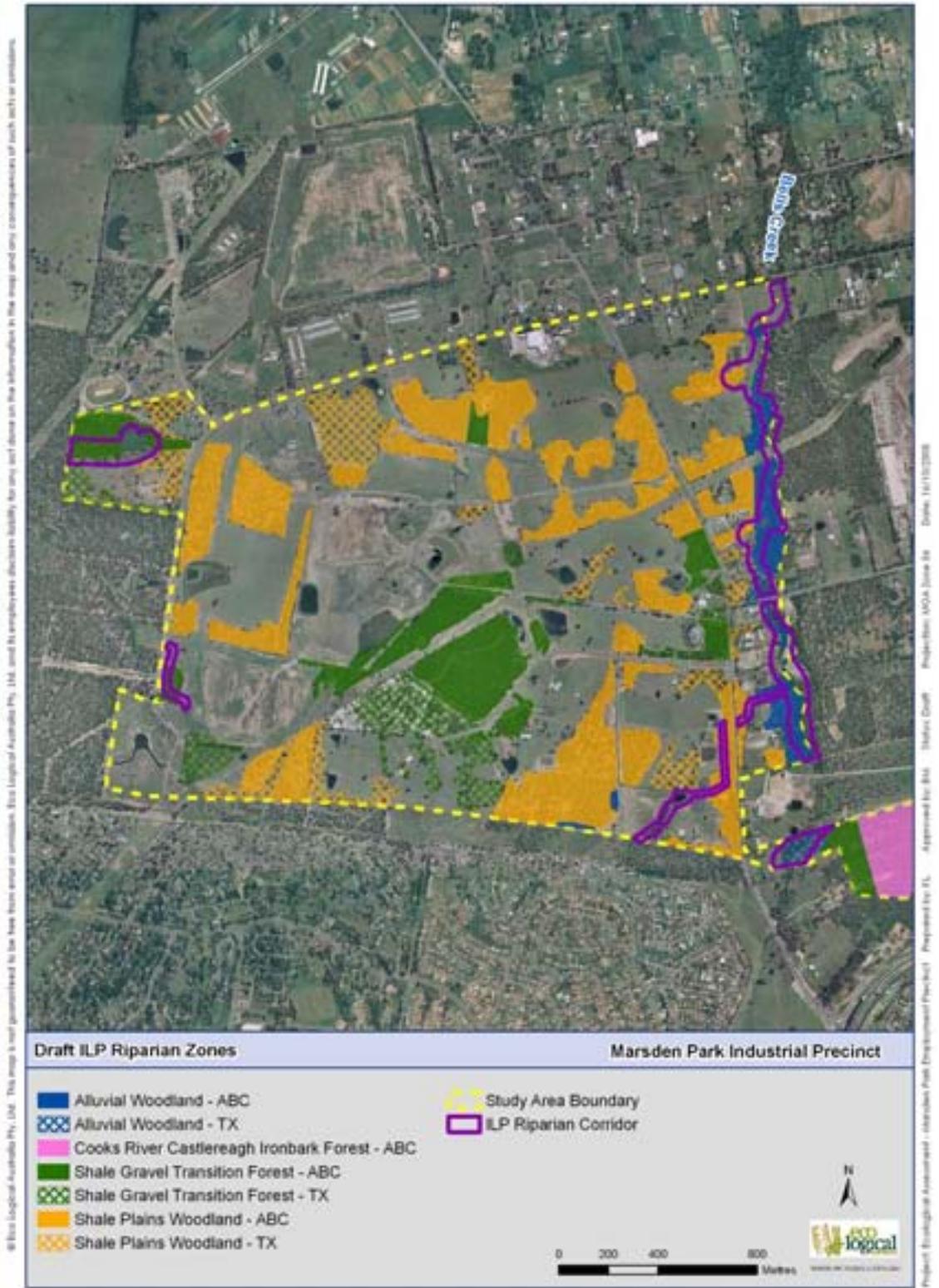


Figure 3 Vegetation Communities

### 3.4 Fauna

The ecological field survey identified 7 species listed under either the TSC Act or the EPBC Act. These species included:

- Eastern bent-wing bat (*Miniopterus schreibersii oceanensis*) - (TSC Act);
- Eastern free-tail bat (*Mormopterus nofolkensis*) - (Act);
- Large-footed fishing bat (*Myotis adversus*) - (TSC Act);
- Yellow-bellied sheath-tail bat (*Saccolaimus flaviventris*) - (TSC Act);
- Greater broad-nosed bat (*Scoteanax rueppellii*) - (TSC Act);
- Grey-headed flying-fox (*Pteropus poliocephalus*) - (TSC and EPBC Act);
- Cattle egret (*Ardea ibis*) - (EPBC Act); and
- Great egret (*Ardea alba*) - (EPBC Act).

## 4. Treatments

### 4.1 Overview

The study area has been divided into treatment areas (refer to Figure 4) to achieve the objectives of the VMS:

- Riparian reconstruction of degraded sections of the channel, banks and ephemeral zone
- Rehabilitation of dams to be retained into constructed wetlands
- Full revegetation of cleared areas
- Tailored bush regeneration in vegetated areas of Poor and Good Condition

The species selection for each treatment type is based on the vegetation community it is seeking to re-establish.

Vegetation Management Plans (VMPs) will need to be prepared for individual development applications. The VMPs are to draw on the objectives, treatments and specifications identified in this VMS.

### 4.2 Riparian reconstruction

The main channel of Bells Creek is highly eroded in places with areas of steeply incised banks. The creek will be stabilised to restore creek function, morphology and habitat.

Management will involve:

- Fencing
- Planting into heavy-duty erosion control matting
- Herbicide application over areas dominated by exotic herbs and grasses, avoiding any native species
- Covering sprayed areas with heavy duty erosion control matting to suppress further weed growth. Edges of jute matting to be buried where possible to prevent them from being dislodged by stormwater flows. Jute matting will not be used on highly eroded banks, these will be armoured with woody debris
- Any banks to be planted in accordance with Table 2
- Spreading logs to help stabilise the jute matting
- Irrigating to encourage rapid establishment of plants
- Creating log jams and bank armoring with woody debris

Species to be planted are identified in Table 2 .

**Table 2 Species for riparian reconstruction**

Species	Density
<i>Carex appressa</i>	4 plants/m <sup>2</sup>
<i>Juncus usitatus</i>	4 plants/m <sup>2</sup>
<i>Lachnagrostis filiformis</i>	4 plants/m <sup>2</sup>
<i>Lomandra longifolia</i>	4 plants/m <sup>2</sup>
<i>Microlaena stipoides</i>	4 plants/m <sup>2</sup>

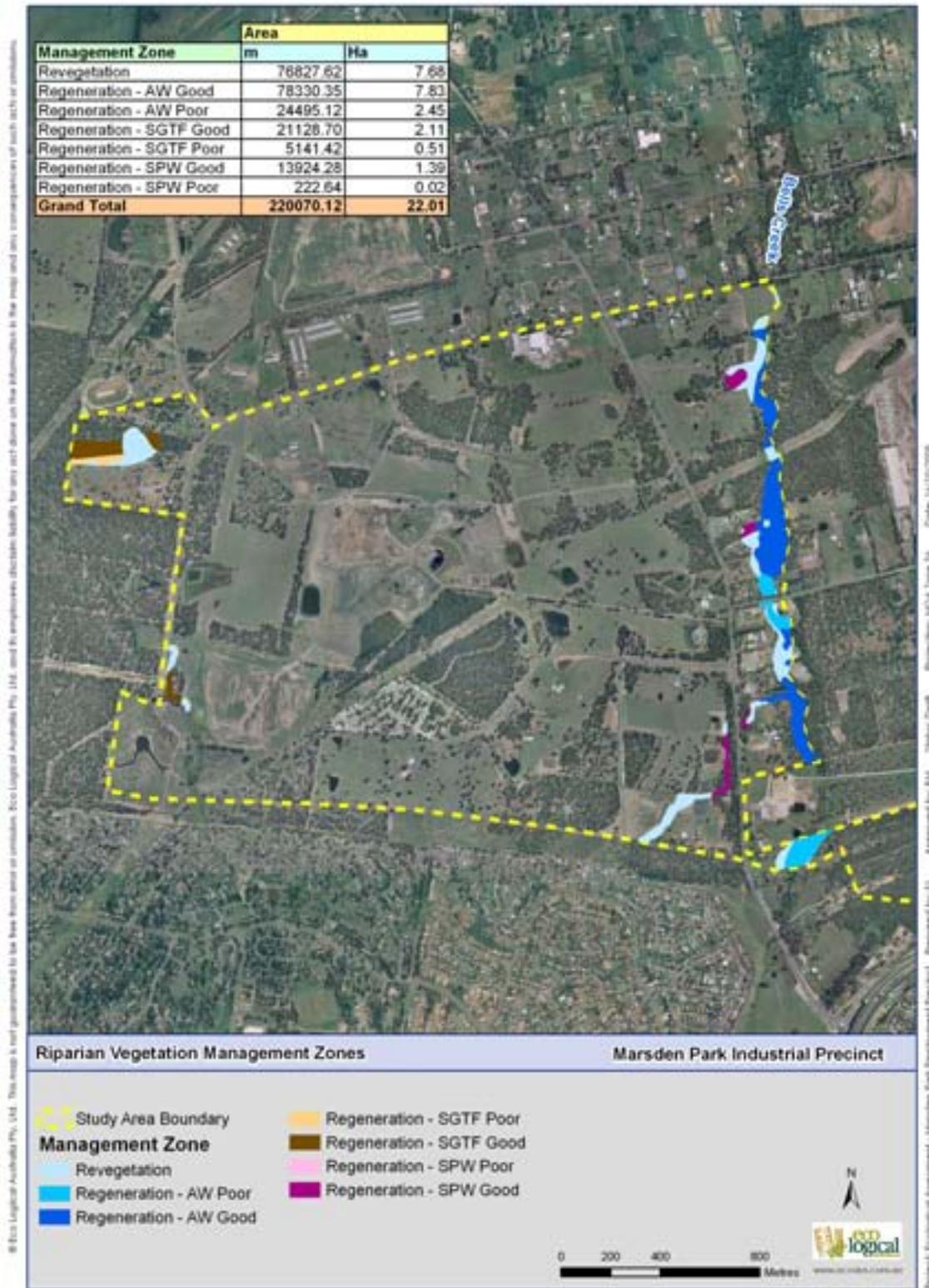


Figure 4 VMS Study Area and Management Zones

### 4.3 Constructed wetlands

Any existing dams to be retained or reshaped are to be planted with emergent macrophytes and other aquatic species for the creation of aquatic habitat. The placement of species and number of plants required is to be confirmed following design of the wetland and associated features. Stock exclusion fences need to be erected prior to establishing any constructed wetland.

**Table 3 Constructed wetland species**

Species	Density	Container size
<i>Baumea articulata</i>	6 plants/m <sup>2</sup>	tubestock
<i>Bolboschoenus caldwellii</i>	6 plants/m <sup>2</sup>	rhizome
<i>Bolboschoenus fluviatilis</i>	6 plants/m <sup>2</sup>	rhizome
<i>Cyperus exaltatus</i>	6 plants/m <sup>2</sup>	tubestock
<i>Eleocharis sphacelata</i>	6 plants/m <sup>2</sup>	rhizome
<i>Juncus usitatus</i>	6 plants/m <sup>2</sup>	tubestock
<i>Schoenoplectus validus</i>	6 plants/m <sup>2</sup>	tubestock
<i>Schoenoplectus mucronatus</i>	6 plants/m <sup>2</sup>	tubestock
<i>Potamogeton tricarinatus</i>	6 plants/m <sup>2</sup>	rhizome
<i>Triglochin procerus</i>	6 plants/m <sup>2</sup>	rhizome

### 4.4 Revegetation

#### Objectives

- Full reinstatement of natural vegetation communities in presently cleared areas.
- Create a stable watercourse with a diverse and effective vegetated corridor.

Revegetation will be used in currently cleared and grazed areas. Figure 4 indicates areas where revegetation is to take place. The species selected for revegetation need to be consistent with the natural communities of the study area and include canopy, shrub and ground layer species (Table 4, 5 and 6).

Exotic grasses will be controlled and replaced with vigorous native tussock grasses such as *Themeda australis* and *Aristida sp.* Each plant will be mulched individually to avoid suppressing native species regenerating in the areas between plantings.

#### Management may involve:

- Fencing
- Soil disturbance in areas that have been compacted by livestock to encourage natural regeneration (where access by equipment is possible without causing damage to native vegetation)
- Hydro-mulching with treated native seed and sterile cover crop.
- Planting into heavy-duty erosion control matting
- Herbicide application over areas dominated by exotic herbs and grasses, avoiding any native species
- Covering sprayed areas with heavy duty erosion control matting to suppress further weed growth. Edges of jute matting to be buried where possible to prevent them from being dislodged by stormwater flows. Jute matting will not be used on highly eroded banks, these will be armoured with woody debris
- Planting densities are provided in section 4.7 as indicative densities for each stratum. The percentage mix of individual species within each stratum will reflect the percentage mix of remnant stands of CPW, SGTF and AW. These are to be determined by the bush regeneration contractor and by the availability of seed

- Spreading logs to help stabilise the jute matting
- Irrigating to encourage rapid establishment of plants
- Creating log jams and bank armouring with woody debris

#### When to use

- In all areas as shown as requiring revegetation in Figure 4
- Any areas within the riparian corridors shown in Figure 4 that is subject to clearing or realignment

### 4.5 Bush Regeneration of Poor Condition Vegetation

#### Objectives

- Combine revegetation techniques with assisted regeneration of groundcovers to encourage full vegetation stratum redevelopment.

#### Management will involve

- Appropriate protective fencing
- Control exotic grasses and replace with appropriate native ground covers
- Slash areas where exotic grasses and herbs form a thick sward and remove biomass
- Herbicide spot spraying, avoiding any native species
- Disturb soil in compacted areas
- Treat noxious and environmental weeds
- Minor regrading to remove steep erosion banks if required
- Install plants, recycled paper disc mat and protective sleeve to tree and shrub plantings
- Spread brush matting
- Spread recovered logs in locations which will not impede mechanical spraying and maintenance regime or what til plants established
- Water plantings appropriately
- Planting densities are provided in section 4.7 as indicative densities for each stratum. The percentage mix of individual species within each stratum will reflect the percentage mix of remnant stands of CPW, SGTF and AW. These are to be determined by the bush regeneration contractor and by the availability of seed

#### When to use

- In all areas within the riparian zone that remain in poor condition (Tx, Txr), shown as requiring revegetation in Figure 4

### 4.6 Bush regeneration in areas of Good Condition

#### Objectives

- To promote the natural regeneration of existing riparian vegetation that remains in moderate to good condition.
- Bush regeneration will be conducted in areas of Alluvial Woodland that currently exist in good condition. Active measures will be used to support natural regeneration.

#### Management

- Fencing
- Implement structured bush regeneration program. Program needs to consider 'natural resilience', level of infestation and types of weed present before determining resources and treatment timeframes.

- Lay recovered logs across the contour to stabilise slopes. Logs to be as long as possible and stabilised by propping up against existing vegetation, other logs or pinned with hardwood stakes and wired in place where necessary
- Spread weed free recovered leaf litter where possible

When to use

- In all vegetated areas within the riparian zone that remain in moderate to good condition (A,B,C), shown as requiring regeneration in Figure 4.

## 4.7 Planting Schedules

**Table 4 Alluvial Woodland**

Species	Density
<b>Canopy</b>	
<i>Acacia parramattensis</i>	1 plant/ 5 m <sup>2</sup>
<i>Casuarina cunninghamiana</i> subsp	1 plant/ 5 m <sup>2</sup>
<i>Cunninghamiana</i>	
<i>Eucalyptus amplifolia</i>	1 plant/ 5 m <sup>2</sup>
<b>Midstorey</b>	
<i>Bursaria spinosa</i>	1 plant/ 1.5 m <sup>2</sup>
<b>Ground layer</b>	
<i>Oplismenus aemulus</i>	4 plants/m <sup>2</sup>
<i>Entolasia marginata</i>	4 plants/m <sup>2</sup>
<i>Echinopogon ovatus</i>	4 plants/m <sup>2</sup>
<i>Solanum prinophyllum</i>	4 plants/m <sup>2</sup>
<i>Dichondra repens</i>	4 plants/m <sup>2</sup>
<i>Microlaena stipoides</i> var. <i>stipoides</i>	4 plants/m <sup>2</sup>
<i>Cheilanthes sieberi</i> subsp. <i>sieberi</i>	4 plants/m <sup>2</sup>
<i>Pratia purpurascens</i>	4 plants/m <sup>2</sup>
<i>Themeda australis</i>	4 plants/m <sup>2</sup>
<i>Commelina cyanea</i>	4 plants/m <sup>2</sup>
<i>Desmodium varians</i>	4 plants/m <sup>2</sup>
<i>Lomandra longifolia</i>	4 plants/m <sup>2</sup>
<i>Oxalis perennans</i>	4 plants/m <sup>2</sup>
<i>Brunoniella australis</i>	4 plants/m <sup>2</sup>
<i>Alisma plantago-aquatica</i>	4 plants/m <sup>2</sup>
<i>Samolus valerandi</i>	4 plants/m <sup>2</sup>
<i>Bolboschoenus caldwellii</i>	4 plants/m <sup>2</sup>
<i>Centipeda cunninghamiae</i>	4 plants/m <sup>2</sup>
<i>Cyperus trinervis</i>	4 plants/m <sup>2</sup>
<i>Fimbristylis velata</i>	4 plants/m <sup>2</sup>
<i>Myriophyllum variifolium</i>	4 plants/m <sup>2</sup>
<i>Persicaria subsessilis</i>	4 plants/m <sup>2</sup>
<i>Scutellaria mollis</i>	4 plants/m <sup>2</sup>
<i>Glycine tabacina</i>	4 plants/m <sup>2</sup>
<i>Glycine clandestina</i>	4 plants/m <sup>2</sup>

**Table 5 Cumberland Plain Woodland**

Species	Density
<b>Canopy</b>	
<i>Eucalyptus moluccana</i>	1 plant/ 5 m <sup>2</sup>
<i>Eucalyptus tereticornis</i>	1 plant/ 5 m <sup>2</sup>
<i>Eucalyptus eugenioides</i>	1 plant/ 5 m <sup>2</sup>
<b>Midstorey and climbers</b>	
<i>Acacia decurrens</i>	1 plant/ 1.5 m <sup>2</sup>
<i>Acacia parramattensis</i>	1 plant/ 1.5 m <sup>2</sup>
<i>Bursaria spinosa</i>	1 plant/ 1.5 m <sup>2</sup>
<i>Daviesia ulicifolia</i>	1 plant/ 1.5 m <sup>2</sup>
<i>Dillwynia juniperina</i>	1 plant/ 1.5 m <sup>2</sup>
<i>Dodonaea viscosa</i> ssp <i>cuneata</i>	1 plant/ 1.5 m <sup>2</sup>
<i>Ozothamnus diosmifolius</i>	1 plant/ 1.5 m <sup>2</sup>

Species	Density
<b>Ground layer</b>	
<i>Aristida sp.</i>	4 plants/m <sup>2</sup>
<i>Austrodanthonia fulva</i>	4 plants/m <sup>2</sup>
<i>Poa labillardieri</i>	4 plants/m <sup>2</sup>
<i>Themeda australis</i>	4 plants/m <sup>2</sup>

**Table 6 Shale Gravel Transition Forest**

Species	Density
<b>Canopy</b>	
<i>Eucalyptus fibrosa</i>	1 plant/ 5 m <sup>2</sup>
<i>Melaleuca decora</i>	1 plant/ 5 m <sup>2</sup>
<b>Midstorey</b>	
<i>Bursaria spinosa</i>	1 plant/ 1.5 m <sup>2</sup>
<i>Lissanthe strigosa</i>	1 plant/ 1.5 m <sup>2</sup>
<i>Daviesia ulicifolia</i>	1 plant/ 1.5 m <sup>2</sup>
<b>Ground layer</b>	
<i>Lomandra multiflora subsp. multiflora</i>	4 plants/m <sup>2</sup>
<i>Aristida vagans</i>	4 plants/m <sup>2</sup>
<i>Pratia purourascens</i>	4 plants/m <sup>2</sup>
<i>Desmodium varians</i>	4 plants/m <sup>2</sup>
<i>Dichelachne micrantha</i>	4 plants/m <sup>2</sup>
<i>Goodenia hederacea supsp hederacea</i>	4 plants/m <sup>2</sup>
<i>Lomandra filiformis supsp filiformis</i>	4 plants/m <sup>2</sup>
<i>Bruniella australis</i>	4 plants/m <sup>2</sup>
<i>Dianella revolute var. revolute</i>	4 plants/m <sup>2</sup>
<i>Lepidosperma laterale</i>	4 plants/m <sup>2</sup>
<i>Desmodium varians</i>	4 plants/m <sup>2</sup>
<i>Danthonia tenuior</i>	4 plants/m <sup>2</sup>
<i>Dianella longifolia</i>	4 plants/m <sup>2</sup>
<i>Microlaena stipoides var stipoides</i>	4 plants/m <sup>2</sup>
<i>Themeda australis</i>	4 plants/m <sup>2</sup>
<i>Dichondra repens</i>	4 plants/m <sup>2</sup>

## 5. Methods

This section describes the methods to be used to implement the VMS.

### 5.1 Fencing

Fencing need to be considered prior to commencing work within each treatment area.

#### 5.1.1 Stock fencing

Fencing is required to exclude livestock from all areas of proposed vegetation management works. Significant improvements in the condition of remnant native vegetation are expected following the exclusion of stock. Stock fencing will consist of strained wire fences and will include barbed wire. It is to be installed as soon as possible and prior to any vegetation management works.

#### 5.1.2 Construction fencing

Construction fencing is required to delineate the boundary between construction activities and vegetation management works along Riparian Protection Areas and to prevent unnecessary damage to remnant vegetation from construction activities. It will exclude all construction machinery, activities, materials and staff from the areas of vegetation management. It will be installed beyond the drip line of all trees to be retained and as close to the limit of construction works as possible.

Construction fencing will consist of temporary, cyclone style fencing. Construction fencing may also double as stock exclusion fencing. It is to be installed prior to the commencement of any construction works.

#### 5.1.3 Tree protection fencing

Tree protection fencing is required around the drip line of all isolated trees to protect the retained trees from construction activities and prevent soil compaction within their drip line. Tree protection fencing will consist of temporary star picket fencing with heavy duty orange plastic mesh. Fencing will be installed prior to the commencement of any construction works.

### 5.2 Weed control and bush regeneration

Detail of specific weed control techniques to be used such as cut and paint, scrape and paint, herbicide spraying and hand weeding are given in Brodie (1999). The principles of bush regeneration and techniques to trigger natural regeneration are to be in accordance with the Bradley Method and other techniques described in Buchanan (2000).

Techniques of primary weed control particularly for woody weeds will use techniques that will not encourage flushes of secondary weed growth following primary work. This includes leaving treated, non-seeding weed biomass in situ rather than creating piles.

### 5.3 Plant, log, brush matting and topsoil recovery

The recovery of these resources will be undertaken prior to construction works and will be used in works along Bells Creek or within adjoining bushland.

#### 5.3.1 Plant recovery

Areas within the proposed development footprint have remnant native plants which will be recovered and transplanted directly into areas along Bells Creek or stored in an on site nursery

for use in later revegetation works. Plants suitable for transplanting include the less common groundcover species and seedlings of trees and shrubs.

Recovered transplants will be planted using appropriate methods and irrigated to maximise their chance of survival.

### 5.3.2 *Log recovery*

There is potential for some of the large trees to be harvested then milled as dressed timbers. Other logs from cleared trees will be recovered and strategically used in creek line stabilisation works or as habitat along Bells Creek. Excess logs will be used in the adjoining bushland as habitat and to assist in erosion control. To make them effective as habitat or for erosion control, recovered logs will be kept as long as possible and not cut up into short sections even though it makes them easier to handle.

### 5.3.3 *Brush matting recovery*

Brush matting will be recovered during clearing works and used in erosion control works and as rough mulch. Brush matting consists of branches cut from trees and shrubs, which are ideally, seed bearing. These cut branches will be spread in selected areas to reintroduce seed of native species and create rough mulch that assists in erosion control and reflects the litter layer of intact ecosystems.

### 5.3.4 *Topsoil recovery*

In areas that are to be cleared of native vegetation, the top few centimetres of soil will be stripped and spread in areas that are degraded or dominated by weeds. The use of the topsoil will introduce seed and other propagules of native plants to a degraded area and improve the soil profile.

## 5.4 **Revegetation**

All revegetation must use plant stock propagated from provenance seed. Species selected for revegetation are consistent with the natural vegetation communities of the study area as described by NSW NPWS (2002). Any required species substitutions will need to be consistent with these vegetation communities.

All plants will be installed as tube stock or an equivalent size. All plants will be watered in to assist establishment.

## 5.5 **Creating log jams and bank armouring with woody debris**

Logs recovered from vegetation clearance works will be spread in areas of revegetation to provide potential habitat.

Log jams and bank armouring with woody debris will be used to help stabilise and prevent further erosion in areas where gully erosion is occurring. Log jams and woody debris are natural accumulations of large logs and branches which collect in the creek line and provide stability to the channel by deflecting and slowing stormwater flows. Examples of natural log jams and bank armouring with woody debris already exist in areas of Bells Creek. These features will be retained.

The incorrect placement of material in the flow path of a creek can worsen erosion problems. Woody debris will not simply be dumped into the gully. Logs and branches will be strategically placed to resemble log jams already present within the creek line.

Logs and woody debris will be sourced from vegetation to be cleared as part of construction works.

Planting will be undertaken in and around log jams to help stabilise the area further. Planting may be delayed by 6-12 months in some areas to allow the woody debris to settle, for finer organic matter to begin decomposition and for local soil moisture to increase below the protection of the debris.

## 5.6 Erosion and sediment control

These matters will be addressed in more detail in a Soil and Water Management Plan to be prepared prior to construction. Measures to be considered include:

- Minimising the area of disturbance at any one time
- Rapid covering and restoration of disturbed areas
- Location and type of temporary sediment controls
- Careful placement of stockpiles of soil and other materials away from drainage lines and protected by erosion controls
- Restricting vehicle access to designated areas
- Maintenance of all controls until earthworks are complete and the site is rehabilitated

**Table 7 Erosion controls**

Type	Benefits	Limitations
Erosion control fencing	Rapid control of runoff and suspended sediment	Short term solution. Requires periodic maintenance
Straw bales	Rapid control of runoff and suspended sediment	Breaks down in a few weeks. Hay bales should not be used because they are a source of weeds. Use straw instead
Jute-matting	Immediate soil protection. Can be used over large areas	Breaks down over time; quickly when used in water. Can be unsightly
Hydro-seeding/soil binding sprays	Effective and relative inexpensive over large areas	Native seed germination can be inconsistent. Will not offer protection from high velocity flows
Coir logs	Biodegradable. Can be planted with native species	Price. Difficult to move once wet. Can be unsightly
Turf	Rapid and cost-effective means of permanently protecting against erosion	Turf species may not be suitable in natural areas. Will not offer protection from high velocity flows
Planting	Permanent, natural solution to erosion control	Will not control short term erosion risks. Needs maintenance until established

## 6. Specifications and standards

### 6.1 Bush regeneration contractors

Suitably qualified and experienced bush regeneration contractors will undertake all vegetation management works.

### 6.2 Seed collection

Seed for revegetation works and direct seeding will be collected from the adjoining bushland and the local area. All seed used in revegetation will be of appropriate provenance with seed collection undertaken in accordance with Florabank Guidelines (Mortlock 2000). A Section 132C licence under the *National Parks and Wildlife Act 1974* will be required to undertake seed collection works.

### 6.3 Herbicide use

Herbicides are required for use with the cut and paint technique to control woody weeds and for spraying exotic herbs and grasses.

All staff using herbicide will have appropriate training and appropriate records will be kept in accordance with the *Pesticide Regulation 1995*.

Herbicide use near waterways including ephemeral areas is to be minimised and only herbicides and other additives formulated for use near waterways (e.g. Round-Up Biactive™) are to be used.

## 7. Monitoring, maintenance and reporting

Bush regeneration contractors will monitor the vegetation for changes over time. The objective of the monitoring and reporting program is to record changes to the vegetation as a result of vegetation management works.

The bush regeneration contractor will establish photo monitoring points and prepare regular quarterly reports to describe the progress of their work and demonstrate compliance with the VMS. Reports will include a brief quarterly work report and an annual audit and assessment of compliance with the performance criteria in section 7.4.

### 7.1 Maintenance

Ongoing maintenance will be required to control weed regrowth from the seed bank particularly for persistent species. Maintenance work is to be undertaken by the bush regeneration contractor to meet the performance criteria stated in section 7.4. Maintenance work will include actions to encourage native regeneration where it is not occurring naturally. These actions include techniques such as soil disturbance, direct seeding and transplanting native plants.

Maintenance will be undertaken on a regular basis of at least weekly in the peak growing seasons monthly in the cooler periods. Maintenance will be undertaken for five years after completion of planting works, or until such time as a minimum 80% survival rate for all plantings and a maximum five percent (5%) weed cover for the treated riparian corridor is achieved. A summary of maintenance activities is presented in Table 8.

### Table 8 Maintenance

Procedure	Inspection/Frequency	Maintenance
<b>ESTABLISHMENT PHASE</b>		
Juvenile plant protection	As required	Install guard bags and bamboo stakes to protect establishing plants from grazing or weed competition Remove the bags once plants are established
Watering	Every three days during the first month, progressively harden the plant to natural climatic conditions	Irrigate juvenile plants
Weed control	Monthly, fortnightly in summer	Remove weeds manually before excessive growth requires herbicide use
Replanting	In response to monthly monitoring	Replace damaged or failed native plants
Monitoring plant establishment	Monthly	Consider plant replacement if survival rate is below 90%
Restrict public access	As required	Use fences to restrict public access from revegetated areas
<b>MEDIUM TO LONG TERM</b>		
Weed control	As required	Weeds are not anticipated to be a major problem once plants are well established
Plant replacement	As required	Replant is vegetation is dead or unhealthy
Watering	As required	Established plants should not need watering. Only water if plants are stressed
Erosion control	After floods and heavy rainfall	Check terrestrial habitats for soil erosion and scouring of slopes. Install erosion controls if needed
Rubbish removal	After heavy rainfall or monthly	Collect rubbish and dispose of appropriately

Source: Australian Wetlands (2004)

## 7.2 Photo monitoring points

Photo points will be established across the site to provide a visual reference of changes in the vegetation. This will be undertaken prior to the commencement of works and then at the beginning of each summer season. The bush regeneration contractor will:

- set up photo points
- mark the photo point with a six foot star picket and map the location of each photo point
- take a digital photo of each photo point facing south-east with the whole length of the star picket to be visible in the photo to act as a reference point
- organise the digital photos logically with each image labelled with a unique reference number indicating the location of the photo point and the date the photo is taken

## 7.3 Reporting

A brief report outlining work undertaken by the bush regeneration contractor will be prepared quarterly (i.e. every third month). Reports will include:

- a summary of works carried out within the period
- an approximation of the time spent on each task

- mapping of areas worked presented in a GIS compatible format
- a description of any problems encountered in implementing the works recommended in the VMP and how they were overcome; and
- any observations made including new species, particularly threatened entities, comments on rates of regeneration and problems beyond the scope of the VMP which impact on the study area

#### 7.4 Performance criteria

The progress and compliance with the VMS will be monitored and reviewed annually. This process will involve the bush regeneration contractor, Marsden Park Developments or their appointed representative, a Blacktown City Council and DWE representative. A report will be prepared commenting on each performance criteria. This will be followed by a site visit to discuss.

The performance criteria are:

- Commencement of all tasks outlined in the VMP or evidence of planning for their implementation
- Demonstrated control of all noxious weeds across the site
- No adult seeding woody weeds present by the end of the first year of works
- No evidence of seeding annual weeds present across the site (within reason)
- No areas with a thick sward of exotic pasture grasses
- Evidence that existing weed patches have been contained and are not spreading
- Suitable evidence of the collection location of all seed used in revegetation
- Demonstrated increase in the cover of native species in disturbed areas
- Minimum of 85% survival rate of all revegetation
- Evidence that any localised plant failure within planting areas has been addressed with no area larger than 2 m x 2 m left without surviving plants
- Monitoring and reporting undertaken in accordance with section 7.3

### 8. Recommendations

It is acknowledged that the design process is in its early stages and the following are recommendations to be considered for issues which will impact on the implementation and long term security of the vegetation management works proposed in this report.

- Minimise the volume of stormwater run-off entering Bells Creek from the hardstand areas of the proposed development
- Implement Water Sensitive Urban Design (WSUD) principles to improve the quality of stormwater run off and increase the volume of temporary on site detention to minimise peak stormwater flows from hardstand areas
- Ensure the construction of all stormwater input points into Bells Creek avoids disturbance to any native vegetation and is designed to prevent erosion or scouring

## 9. Cost estimate

Table 9 indicates costs for works associated with the VMS. It does **not** include costs for items to be covered in the Soil and Water Management Plan, including erosion controls, and earthworks associated with any constructed wetlands.

**Table 9 Cost Estimate**

	Year 1		Year 2		Year 3		Year 4		Year 5 Ongoing	
	rate (\$/ha)	cost (\$)	rate (\$/ha)	cost (\$)	rate (\$/ha)	cost (\$)	rate (\$/ha)	cost (\$)	rate (\$/ha)	cost (\$)
<b>Revegetation</b>	250 000	1 920 690	10 000	76 830	10 000	76 830	5 000	38 410	2 000	15 370
<b>Regeneration - Poor Condition</b>	25 000	74 650	12 500	37 320	6 000	17 920	3 000	8 960	2 000	5 970
<b>Regeneration - Good Condition</b>	10 000	113 380	5 000	56 690	2 500	28 350	2 000	22 680	2 000	22 680
<b>Total</b>		<b>2 108 720</b>		<b>170 840</b>		<b>123 090</b>		<b>70 050</b>		<b>44 010</b>

## 10. References

Brodie L, 1999. *The National Trust Bush Regenerators Handbook*. National Trust of Australia (NSW).

Buchanan R.A, 2000. *Bush regeneration: recovering Australian landscapes*. 2<sup>nd</sup> edn, TAFE NSW, Sydney.

Mortlock W The Hawkesbury-Nepean Catchment Management Authority (2000) *Florabank Guideline 10: Seed collection ranges for revegetation*. <http://www.florabank.org.au/> Florabank, Yarralumla, ACT [20 August 2001]

New South Wales National Parks and Wildlife Service, 2002. *Interpretation Guidelines for the Native Vegetation Maps of the Cumberland Plain, Western Sydney*, Final Edition NSW NPWS, Hurstville.