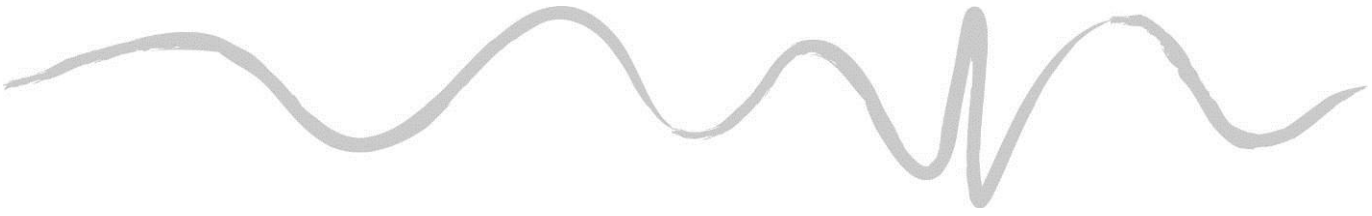
Conservation Zone Management Plan

Pacific Pines, Lennox Head

Part 3A Approval MP_0026



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Conservation Zone Management Plan

Pacific Pines, Lennox Head

Part 3A Approval MP_0026

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Executive Summary

This Conservation Zone Management Plan (CZMP) is prepared to support the approved Pacific Pines urban development. It addresses Condition B2 of the Concept Approval, relating to threatened species / EECs in the designated Conservation Zone.

The Approved Development

MP_0026 was approved in 2008. It includes Concept Approval for the whole of the development, and a Project Approval relating to Stages 1A and 1B. The approval provides for a residential subdivision and associated amenities and infrastructure.

A modification is currently proposed, primarily to increase the area proposed on the site for ecological conservation.

The Conservation Zone

The Conservation Zone covers an area of approximately 14.07 ha. When rehabilitated, the Conservation Zone will create a vegetated corridor for fauna and flora habitat that extends both east-west and north-south across a significant portion of the site.

It is heavily degraded, having been subjected to a combination of disturbances by way of vegetation clearance, cattle grazing and hydrological modification (e.g. drainage channels and dams). The following vegetation communities are present in the Conservation Zone:

Freshwater Wetlands	4.4
Littoral Rainforest	2.4
Swamp Sclerophyll Forest	0.3
Exotic-dominated grassland	7.0

Threatened Species and Endangered Ecological Communities

Freshwater Wetland, Littoral Rainforest and Swamp Sclerophyll Forest are Endangered Ecological Communities (EECs) as listed under the *Threatened Species Conservation Act 1995*. (TSC)

Two threatened species have been identified at the site: Square-stemmed spike Rush (*Eleocharis tetraquetra*), listed under the TSC Act; and Hairy Joint Grass (*Arthraxon hispidus*), listed under the TSC Act and also the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

Hairy Joint Grass (HJG)

HJG is an annual grass, meaning that it completes its lifecycle within a single year. The species germinates from seed in late winter or spring, grows most actively during the summer wet season, flowers and sets seed in March and April, then dies off in May and June.

The primary habitat of HJG is lower slopes that remain damp or are fed by groundwater seepage during the wet season, (Benwell 2012). Nearly all known HJG populations occur on cleared grazing land in pasture dominated by exotic grasses and herbs (Benwell 2012). It is only rarely found in a natural habitat.

Studies by ECOS Environmental (2004) have shown that persistence of HJG in areas of cleared pasture is dependent on ongoing biomass removal by grazing stock and the maintenance of small gaps in ground layer vegetation suitable for HJG germination and establishment. In the absence of biomass removal, HJG is likely to be out-competed by vigorous exotic pasture species.

Studies have noted that HJG has declined when grazing animals are withdrawn. Experiments in areas of declining HJG population at Pottsville, where biomass removal was reintroduced in the form of slashing and mulch removal, resulted in a marked increase in HJG population (Ecos, 2004).

Updated survey / mapping was undertaken at the site in November 2011. Targeted surveys for HJG were undertaken within all areas representing potential habitat for the species.

The total area occupied by HJG within the Conservation Zone was approximately 1.40 ha.

Square-stemmed Spike Rush (SSSR)

SSSR is a clumping species with five to seven new culms, up to one metre in height, arising from a single rhizome (Harden 1993). SSSR completes its flowering and fruiting in a single year, after which the culms die and decay. It is suggested that vegetative reproduction may be an important strategy for maintenance of a local population following initial establishment of seed (G. Elks pers. obs., as stated in NPWS 2009).

Known populations of Square-stemmed Spike Rush occur in and on the margins of freshwater swamps and on the margins of streams, at about the level of the wet season water table (NPWS 2009).

Targeted surveys for SSSR were also undertaken in November 2011, concentrated on known potential habitat for the species. The total area occupied by SSSR within the Conservation Zone was calculated to be approximately 2 ha.

Freshwater Wetland

The boundary of the Freshwater Wetland EEC occurring at the site was derived with reference to the Scientific Determination for Freshwater Wetland EEC (2005). It covers 4.4 ha of the central section of the Conservation Zone, dominated by wetland species including Bunchy Sedge (*Cyperus polystachyos*), a Spikerush (*Eleocharis equisetina*), River Club-rush (*Schoenoplectus validus*), Millet Swamp Millet (*Isachne globosa*) and Swamp Ricegrass (*Leersia hexandra*). HJG and SSSR occur widely within the Conservation Zone but at a lower density.

Littoral Rainforest & Swamp Sclerophyll Forest

The previously mapped distribution of Swamp Sclerophyll EEC and Littoral Rainforest EEC was ground-truthed and found to accord well with the currently observed boundary. The location of the Swamp Oak Forest EEC was readily identifiable on aerial photography, and covered a smaller area than the mapped boundary of the SEPP 14 Coastal Wetland.

Conservation Zone Rehabilitation Strategy

A significant proportion of Freshwater Wetland EEC, Littoral Rainforest EEC, HJG and SSSR at the site are protected within the Conservation Zone. To enhance the ecological values, this CZMP contains a comprehensive rehabilitation strategy to create a mosaic of vegetation and habitat types forming an integrated suite of ecosystems within the Conservation Zone.

The focus of the compensation strategy will be to:

- facilitate the establishment of an integrated suite of ecosystems, representing the distribution pattern of EECs that are expected to have been present in this area pre-clearing;
- minimise maintenance inputs to this area by encouraging self-sustaining vegetation; and
- enhance the inherent ecological values of the EECs and threatened species presently occupying this area.

The management approach for discrete areas within the Conservation Zone consists of a combination of:

- Conservation and enhancement of:
  - existing Swamp Sclerophyll Forest EEC;
  - existing Littoral Rainforest EEC; and
  - mapped HJG (outside of Freshwater Wetland EEC).

- Freshwater Wetland EEC rehabilitation (including enhancement of mapped HJG and SSSR within this EEC);
- Revegetation of EECs:
  - Swamp Sclerophyll Forest EEC revegetation;
  - Swamp Oak Forest EEC revegetation;
  - Littoral Rainforest EEC revegetation;
  - Littoral Rainforest EEC revegetation incorporating HJG; and
- Translocation of threatened species:
  - recipient areas for translocated HJG;
  - recipient areas for translocated SSSR.

The zone will be enhanced through management actions to eliminate highly competitive weeds and thereby encourage natural regeneration of native plant species. Additional enhancement will involve supplementary plantings of suitable native species within canopy gaps. As part of the overall rehabilitation strategy, the sustainability of the existing EEC areas will also be bolstered by encouraging the establishment of additional contiguous areas of EEC by way of revegetation, and thereby limiting the impacts of weed infestation.

Swamp Sclerophyll Forest EEC

The area of Swamp Sclerophyll Forest EEC occurs within the central portion of the Conservation Zone and is dominated by mature Broad-leaved Paperbarks (*Melaleuca quinquenervia*) and Swamp Oak (*Casuarina glauca*). This patch of vegetation is approximately 0.3 ha in size.

Management actions to enhance this community will consist of:

- supplementary plantings of species suitable for Swamp Sclerophyll Forest EEC revegetation in canopy gaps;
- weed control of priority weed species; and
- revegetation, involving plantings of suitable swamp sclerophyll species, in an area of approximately 0.1 ha, located immediately west of the existing Swamp Sclerophyll Forest EEC.

Littoral Rainforest EEC

Littoral Rainforest EEC occurs as two separate regrowth patches in the north-south corridor on the eastern side of the Conservation Zone, and covers an area of approximately 2.4 ha. Enhancement of this community will be achieved by:

- supplementary plantings of suitable species within canopy gaps of these regrowth; and
- weed control of all woody and herbaceous weeds and vines.

Suitable areas are available for revegetation in a small area of the central section of the Conservation Zone on a slightly raised area of ground, as well as over the majority of the southern and northern sections adjacent to existing patches of Littoral Rainforest EEC / Camphor Laurel regrowth.

Suitable areas for revegetation to Littoral Rainforest EEC incorporating HJG are located in slightly elevated areas adjacent to existing areas of HJG. Incorporation of HJG in this area of Littoral Rainforest EEC revegetation is intended to mimic one of the preferred natural habitats for this species on the periphery of rainforest, often near creeks and swamps (DECC 2005).

The layout of the revegetation will consist of dense clumped plantings of rainforest species interspersed with small open areas in which HJG is to be translocated. Centres of the clumped plantings are to be 10 m apart with a minimum 2 m gap between the edges of each clump. The edges of the revegetated area will expand as the vegetation matures, leading to an overall decrease in the open area. This layout will require the minimum level of maintenance by reducing light levels and thereby limiting the potential for weed establishment.

Mapped HJG (outside of Freshwater Wetland EEC)

A number of areas within approximately 25 m outside of the boundary of the mapped Freshwater Wetland EEC contain extensive patches of HJG, which co-exists in these peripheral areas with exotic pasture grasses.

Some mapped areas support only light cover of HJG, while other areas support comparatively dense cover. Enhancement of this community will be achieved by:

- selective weed control of weedy pasture grasses during the non-growing season of HJG; and
- annual slashing / brush-cutting of grass in these areas following seeding of HJG to stimulate recruitment of HJG.

Freshwater Wetland EEC (including enhancement of HJG and SSSR)

Freshwater Wetland EEC covers an area of approximately 4.4 ha in the central section of the Conservation Zone. Existing vegetation comprises a range of wetland habitats, including reedland, sedgeland, areas of dense Swamp Ricegrass (*Leersis hexandra*) and substantial areas supporting HJG and SSSR.

Weed grasses are common in this community. The ongoing viability of the Freshwater Wetland EEC vegetation is challenged by removal of cattle and the probable proliferation of exotic grasses once grazing has ceased.

Rehabilitation of the Freshwater Wetland EEC will be achieved by:

- selective weed control of weedy pasture grasses during late winter (non-growing season of HJG);
- annual slashing / brush-cutting in target areas supporting HJG and SSSR during the dormant period, to stimulate threatened species seedling germination and vegetative spread; and
- supplementary planting of wetland species targeting areas that are not currently occupied by HJG or SSSR, and those areas in which weed treatment has occurred, and/ or where the overall diversity of wetland plants is low.

Biomass reduction enhancement areas for existing areas of HJG and SSSR will be located adjacent and within 25 m of proposed HJG and SSSR translocation recipient sites, because:

- areas are easier to locate;
- time taken for slashing / brushcutting is minimised; and
- managed areas of threatened species habitat are contiguous.

Control of weed species will be achieved by hand-pulling to avoid potential damage to native wetland species, including HJG and SSSR.

Swamp Oak Forest EEC

While the Conservation Zone does not currently contain this community, there are significant nearby locations within the Ballina Nature reserve, and a small areas (approx 0.3 ha) have been identified in the western portion of the Conservation Zone, at relatively low elevation, as being suitable for revegetation to this community.

Translocation of HJG and SSR

Recipient areas suitable for establishing new populations of HJG and SSSR were identified as part of habitat mapping of the Conservation Zone.

Hairy Joint Grass

Translocation of HJG is based on methods employed successfully by Ecos Environmental (Benwell 2012) as part of translocation of this species for the Ballina Bypass Pacific Highway upgrade project.

This proposed methodology is based around:

- seed collection;
- appropriate preparation of recipient sites;

- direct seeding;
- ongoing management of the recipient site; and
- monitoring

Site Preparation
The following strategies are proposed for the preparation of the recipient site:
- noxious and environmental weeds are to be eradicated prior to translocation being undertaken;
- one week prior to direct seeding, the recipient site will be slashed; and
- mulch is to be removed from the recipient sites.

Seed Collection
Seed will be collected from the site between April and May and stored in paper bags in a dry cool place until the time of planting. Seed collection is to be undertaken by a suitably qualified ecologist under a Section 132C Licence issued by OEH for the activity.

Direct Seeding
Direct seeding is to be carried out in winter (June) to mimic the natural cycle of seed dispersal and recruitment in wild populations of HJG. Seed is to be mixed with river sand and spread over target recipient sites.

Post-translocation Maintenance
The results of translocation trials for this species (Benwell 2012) indicate that HJG seedling recruitment is enhanced by biomass reduction. Therefore, post-translocation maintenance of recipient sites will consist of a single annual slashing event aimed at reducing pasture biomass and creating spaces in the ground layer to assist in seed germination. This will occur in June once seeding of HJG has finished.

Square-stemmed Spike Rush

The Recovery Plan for this species states that material was collected from the largest population of SSSR at Boambee to obtain a preliminary understanding of the growth rate and reproductive ecology of the species. This material was successfully propagated ex-situ from division of clumps and continues to grow. This suggests that it is possible to cultivate the species ex-situ (NPWS 1999).

Site Preparation
The following strategies are proposed for the preparation of the recipient site:
- the Conservation Zone (recipient site) is to be marked out prior to translocation occurring; and
- noxious and environmental weeds are to be eradicated prior to translocation being undertaken.

Plant Salvage
Plants to be salvaged will be collected on site by a qualified wetland ecologist. Plants will be kept moist, divided and potted into an appropriate medium for growing on in a nursery until mature enough to be planted out.

Reintroduction
Reintroduction of salvaged plants is to be undertaken in spring to coincide with the natural emergence of this species following the winter dormancy period. Plants are to be planted at an appropriate density as determined by a wetland ecologist.

Post-translocation Care
The Recovery Plan for the species states that light grazing may provide both a seed dispersal mechanism and a disturbance regime suitable for the establishment of new seedlings. It may also prevent established plants from being eliminated by more competitive taller species (NPWS 1999). As little is known of the ongoing maintenance requirements of this species, a trial of two maintenance regimes will be undertaken as part of the monitoring program:

- selective removal of weeds from site; and
- slashing of the recipient sites will be carried out to reduce pasture biomass and open up the ground layer to seed germination.

Translocation Monitoring

Ongoing maintenance and management of the recipient sites and translocated plants will be vital to the success of the translocation project. Accordingly, an ongoing monitoring program will be instigated to track the condition of the recipient sites and individual translocated plants. Results of the monitoring programme will lead to adaptive management responses if required.

The maintenance and monitoring program will incorporate actions that are largely derived from recommendations for monitoring in *Guidelines for the Translocation of Threatened Plants in Australia* (Vallee *et al* 2004). Once established in recipient sites, HJG and SSSR will be maintained via annual biomass removal and weed control. Annual results of the monitoring program will be reported to OEH.

Contingency Measures

Monitoring techniques to measure the success of these indicators are:

- *A reduction in weed cover* – weed cover in the Conservation Zone will be monitored. Any opportunistic observations of weeds will be recorded to inform a 'priority weed map' for the Conservation Zone. The extent of these weed infestations will be recorded. A simple map showing the locations of priority weeds will be prepared to inform future weed control works. A significant increase in weed burden within the Freshwater Wetland EEC area would indicate unsuccessful rehabilitation.
- *Proven enhancement of HJG and SSSR* – an annual survey and mapping of the distribution of HJG and SSSR will be undertaken to establish changes in distribution. A decrease of >20% in the presence of either of these species within their respective habitat area would indicate unsuccessful enhancement.
- *Proven establishment of HJG and SSSR* – recipient translocation sites will be monitored. The distributions of these threatened species across seasons are variable depending on environmental conditions, particularly for HJG. To account for some of this variability, success or failure will be based on a significant deviation from a baseline vegetative cover (decrease of >20%). This baseline vegetative cover will be measured at 12 months following the translocation event.
- No substantial changes in the boundary of the Freshwater Wetlands EEC that cannot be accounted for by seasonal variation (potentially indicating a change in hydrology) – transect surveys will be used to detect potential changes in the boundary of the Freshwater Wetland EEC in the Conservation Zone. The boundary of this community is expected to fluctuate somewhat depending on climatic variability, however; it should be possible to attribute any substantial change in the location of the boundary of this community to climatic conditions or to a change in hydrology.

Results of monitoring will provide the opportunity to modify management techniques where necessary. If it is shown that the indicators are not being met, a modification to vegetation management techniques will be implemented. This modification may include:

- revision of weed control techniques;
- re-assessment of the timing, extent and technique of biomass control for HJG and SSSR; or
- re-establishment of additional HJG and SSSR in poorly performing areas.

As a precaution against loss of genetic diversity, a program of seed collection and propagation for these species will be undertaken so that re-establishment on-site or off-site is possible if required.

The seed of HJG retains adequate viability for up to 3 years (Andrew Benwell pers. comm.). Seed would be collected from across the site prior to construction beginning, and from within the Conservation Zone annually following this, and placed in cool storage.

Prior to construction, SSSR will be salvaged and clumps divided and grown up at an appropriate nursery with experience growing native wetland plants. As these plants mature they will be able to be further divided.

If it is established that the compensatory works have been unsuccessful, further research into the ecology, enhancement and translocation of HJG and SSSR would be initiated. This research would provide valuable information for future projects involving these species.

The methodology and scope of such research would be consistent with that undertaken to investigate translocation of HJG for the Ballina Bypass Highway Upgrade Project (Benwell 2012).

This research extended over two years and included the following components:

- genetic research to determine the extent of genetic variation among populations;
- experimental translocation to establish a new population and research the effect of site factors and follow-up management on establishment and persistence; and
- management of an existing population, including maintenance of habitat conditions favourable for recruitment.

The opportunity exists to engage a local university such as Southern Cross University or Griffith University to undertake this research, potentially as part of a research higher degree. The proponents would make a monetary contribution of $50,000 to enable that research.

Water Management Plan

The Water Management Plan addressing the requirements of the Minister's approval has been prepared by Gilbert and Sutherland, specialist hydrologists. Their detailed report is contained in full in Appendix A.

Gilbert and Sutherland undertook a detailed assessment of the site, resulting in modelling of the existing, pre-development, hydrological regime. This involved a number of sub-surface bores, supplemented by a detailed analysis of existing landform, soils, slope and vegetation.

MEDLI modelling was undertaken to estimate the deep drainage component of the pre-development landscape, providing a basis for identifying the reduction in recharge due to development of hardstand on the site. MEDLI was also used to determine the irrigation requirement to maintain the seepage areas at field capacity.

Based on the detailed site analysis, Gilbert and Sutherland have worked with the project engineers to develop a bio-filtration / infiltration system, to be constructed at the southern edge outside the Conservation Zone as part of the Stage 1A residential subdivision. This system will ensure appropriate seepage protection / replacement that will ensure continued water source for the freshwater wetland.

As outlined in the Gilbert and Sutherland report, MUSIC modelling undertaken to test the proposed system identified that at the completion of development, a total of approximately 229.06 ML/yr will be discharged to the wetland from the bio-filtration / infiltration system. This exceeds both the irrigation requirement and deep drainage replacement estimated by the MEDLI modelling to ensure that the pre-developed field capacity of the seepage areas is maintained. This will ensure the ongoing maintenance of wetland conditions in the central part of the Conservation Zone.

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1 Introduction

1.1 Background

On 12 November 2008, the New South Wales (NSW) Minister for Planning issued an approval under Part 3A of the *Environmental Planning and Assessment Act 1979* (MP_0026) for the future subdivision of the Pacific Pines Estate, located at Lennox Head NSW.

MP_0026 includes Concept Approval for the whole of the development, and a Project Approval relating to Stages 1A and 1B. The development comprises a residential subdivision including:

- residential lots;
- a neighbourhood centre;
- a future retirement community;
- road network and service infrastructure; and
- a green space network including a designated Conservation Zone.

The approvals have been modified, with the most recent modification (MOD 3) approved in September 2011. A further modification (MOD 4) is currently proposed, primarily to increase the area proposed on the site for ecological conservation.

The Concept Plan now proposed for the development is shown in Illustration 1.1.

The Concept Approval requires that an Environmental Management Plan (EMP) be approved by the Director-General of the Department of Planning before the issue of a Construction Certificate for Stage 1A. It further requires that a Conservation Zone Management Plan (CZMP) be approved by the Director-General before the issue of a Construction Certificate for Stage 1B.

The EMP has been completed and submitted to the department under separate cover.

This Conservation Zone Management Plan (CZMP) addresses threatened species / EECs occurring within the designated Conservation Zone and provides a compensatory strategy to ensure the maintenance of ecological values at the site.

1.2 Structure of the CZMP

The requirement for a CZMP is contained within Condition B2 of the Concept Approval. The specific requirements of that condition are listed below in Table 1.1, along with reference to the sections of this CZMP within which each requirement is addressed.

Table 1.1 Requirements of Condition B2 – Conservation Zone Management Plan

Number	*Requirements for CZMP*	*Section in CZMP / associated document*
1	A contemporaneous detailed plan specifying all areas of EECs and threatened species habitat to be retained and the areas proposed to be re-established	All sections of CZMP
2	A program for the mapping and monitoring of the location and density of Hairy Joint Grass and Square-stemmed Spike Rush	Section 10

Number	*Requirements for CZMP*	*Section in CZMP / associated document*
3	The manner in which retained populations of Hairy Joint Grass and Square-stemmed Spike Rush will be enhanced	Section 5
4	A rehabilitation plan that details the manner in which the functions and values of the Freshwater Wetlands EEC will be restored	Section 5
5	Details of an on-site compensation strategy that offsets the loss of Freshwater Wetlands EEC, Hairy Joint Grass and Square-stemmed Spike Rush across the site (determined by terms B1(1) and B2(1), including details of: a) the goal of the on-site compensation; b) details of the compensatory measures to be implemented; c) a timeline for implementation of the measures; d) details of how the success of the compensatory measures are to be measured, including monitoring requirements; e) details of the contingency measures to be undertaken where the compensatory works have been unsuccessful, such as off-site compensation measures, bonding arrangements and the like;	Sections 4, 5, 6 and 7
6	Details of the proposed translocation of Hairy Joint Grass and Square Stem Spike Rush within the Conservation Zone	Section 6
7	A Water Management Plan that addresses the manner in which the hydrological regime of the Freshwater wetlands EEC and associated threatened species will be maintained throughout the life of the project and is to include, but not be limited to: a) an assessment of the pre-development hydrological regime including surface and groundwater inflows and outflows; b) measures to be implemented to ensure the pre-development hydrological regime is maintained; c) mapping of the extent of the seepage areas and measures to ensure their ongoing protection; and d) detailed design, installation and maintenance methods of the proposed weirs and other infrastructure identified in Illustration C7 dated 14/8/2008 to ensure the maintenance of the existing hydrological regime	Section 9 and Appendix A
8	An integrated weed management strategy	Section 8 (also the Weed Management Plan for the EMP)
9	A concise set of ongoing management requirements to achieve a self-sustaining ecological system	Section 4, 5, 6, 7, and 8
10	Methods to be utilised to protect all threatened flora and fauna habitat and EECs on the site throughout the life of the project	Section 4, 5, 6, 7 and 8
11	The manner in which public access will be managed throughout the life of the project	Section 11
12	Details of interpretive signage to be installed	Section11

Information shown is for illustrative purposes only

Drawn by: GJM Checked by: MVE Reviewed by: RVI Date: August 2012
Source of base data: Deicke Richards, Ballina Shire Council

North

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Concept Plan for the Proposal

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2 Site and Conservation Zone Overview

2.1 Locality

In this document, the broad area covered by the proposed Pacific Pines Estate is referred to as "the site" (i.e. Lot 234 DP 1104071).

The site is located at Lennox Head in northern NSW and is situated within the Northern Rivers Catchment Management Authority (CMA) area, South East Queensland Bioregion and Ballina Shire Local Government Area (LGA). The locality of the site is shown in Illustration 2.1. The location and extent of the Conservation Zone within the site is shown in Illustration 2.2.

2.2 Climate

The site experiences a warm-temperate to subtropical climate typical of coastal north-eastern NSW due to its proximity to the relatively warm waters of the Tasman Sea. Average rainfall for the area is approximately 1860 mm, as shown in Table 2.1 (Ballina Airport; Bureau of Meteorology, 2011), with the highest falls in the summer and autumn period (January to May). During these months, high intensity rain events and severe thunderstorms are not uncommon. The prevailing wind is typically from the south-east. However, strong winds from the north can occur sporadically during spring and summer (Anderson, 1999).

Table 2.1 Indicative Climate Data for Ballina Airport (4 km from the site)

Month	*Mean Daily Max Temperature (°C)*	*Mean Daily Min Temp (°C)*	*Mean Monthly Rainfall (mm)*
January	28.2	19.6	164.9
February	28.0	19.4	194.8
March	26.9	18.1	219.9
April	24.9	15.2	183.0
May	22.4	12.1	173.7
June	20.2	9.7	197.4
July	19.9	8.5	119.6
August	21.2	8.7	92.8
September	23.5	11.5	67.4
October	24.7	13.9	108.8
November	26.1	16.5	124.4
December	27.3	18.1	142.9
Annual	24.4	14.3	1860.6

2.3 Geology

The geology of the site is mapped within the Bangalow soil landscape which consists of low rolling hills on basalt with moderately deep to deep (100 - >200 cm), well-drained Kraznozems and brownish red Kraznozems (Morand, 1994). These soils are described as being strongly acidic and moderately erodible.

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Information shown is for illustrative purposes only

Drawn by: TJP Checked by: MVE Reviewed by: DGH Date: July 2012
Source of base data: Ballina Topographic Map 9640-3-N

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North

Site Locality

GeoLINK environmental management and design

Conservation Zone Management Plan: Pacific Pines
1675617

Illustration 2.1

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Information shown is for illustrative purposes only

Drawn by: TJP Checked by: MVE Reviewed by: DGH Date: August 2012
Source of base data: Ballina Shire Council

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Conservation Zone Layout

GeoLINK environmental management and design

Conservation Zone Management Plan: Pacific Pines
1675-1007

Illustration 2.2

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A geotechnical investigation of the entire site was undertaken by Ardill Payne and Partners in 2002. This investigation identified that soils in the valley section of the site, in which the Conservation Zone is situated, are poorly drained alluvial soils.

Further soils assessment was undertaken in 2011 by Gilbert and Sutherland, in the preparation of their Water Management Plan (see Appendix A). Their analysis indicated that the soils in and around the Conservation Zone are most appropriately classified, in accordance with the Australian Soils Classification (Isbell, 1996), as hydrosols and ferrosols. Hydrosols are soils that are saturated in the major part of the solum for at least 2-3 months in most years, while ferrosols are soils with B2 horizons in which the major part has a free iron oxide content greater than 5% in the fine earth fraction.

Gilbert and Sutherland also analysed the soil permeability and concluded that the soils at and around the Conservation Zone are very poorly drained, with groundwater typically found at around 0.2-0.5 m below natural surface level.

2.4 Acid Sulphate Soils

Gilbert and Sutherland conducted an acid sulphate soils assessment for the site in March 2004. In summary, the report found that potential acid sulphate soils (PASS) were observed between 0.75 m and 3.0 m below natural surface levels in the location of the water control ponds.

The report of Gilbert and Sutherland identifies three soil types found at the site that exhibited PASS characteristics. These include coarse sands, silty sands and silty clays in an increasing severity of PASS. A geotechnical investigation of the entire site has been undertaken by Ardill Payne and Partners indicates that the occurrence of PASS is unlikely to occur above the 10 m AHD contour (limit of alluvial soils). This finding is consistent with Sheet 2 of Ballina LEP 1987, which indicates the extent of Class 2 and 5 acid sulphate soils approximately follows the 10 m AHD contour.

The report of Gilbert and Sutherland identified PASS, consisting of highly plastic clays, in the area over which the Conservation Zone is situated.

2.5 Topography

The site effectively encompasses a gently sloping basin that faces towards the south-west. The low-lying area in the central portion of the site supports a freshwater spring, which feeds into the Conservation Zone. The aspect of the Conservation Zone itself is predominantly westerly, with an elevation of approximately 5 m AHD. The topography of the Conservation Zone is generally flat to gently sloping, with a slope of less than 5%.

2.6 Extent and Layout of Conservation Zone

The Conservation Zone covers an area of approximately 14.07 ha (Illustration 2.2). When rehabilitated, the Conservation Zone will create a vegetated corridor for fauna and flora habitat that extends both east-west and north-south across a significant portion of the site.

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3

Ecological Features of the Conservation Zone

3.1 Vegetation Communities

The Conservation Zone is currently heavily degraded, having been subjected to a combination of disturbances by way of vegetation clearance, cattle grazing and hydrological modification (e.g. drainage channels and dams). Table 3.1 summarises the vegetation communities that are present in the Conservation Zone, which are mapped in Illustration 3.1.

Table 3.1 Vegetation Communities in the Conservation Zone

Community	*Area (ha)*
Freshwater Wetlands	4.4
Littoral Rainforest	2.4
Swamp Sclerophyll Forest	0.3
Exotic-dominated grassland	7.0

3.2 Habitat Features of the Conservation Zone

Existing native and exotic vegetation within the Conservation Zone provides habitat for a variety of native fauna by providing foraging and nesting opportunities. Also, a number of drainage channels dissect the Conservation Zone, providing habitat for native birds, amphibians, fish and invertebrates.

3.3 Threatened species and Endangered Ecological Communities

Two threatened species, Square-stemmed spike Rush (*Eleocharis tetraquetra*), listed under the *Threatened Species Conservation Act 1995* (TSC Act) and Hairy Joint Grass (*Arthraxon hispidus*), listed under the TSC Act and also the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), have previously been detected within the Conservation Zone.

Three of the vegetation communities occurring within the Conservation Zone are equivalent to EECs as listed under the TSC Act. These are Freshwater Wetland, Littoral Rainforest and Swamp Sclerophyll Forest. Littoral Rainforest is also listed as critically endangered under the EPBC Act.

Table 3.2 Significant Flora and Vegetation Communities within the Conservation Zone

Scientific Name/ Ecological Community Name	*Common Name*	*TSC Listing*	*EPBC Listing*	*Habitat Description*
Arthraxon hispidus	Hairy Jointgrass	V	V	Damp areas associated with seepages and wetland edges
Eleocharis tetraquetra	Square-stemmed Spike Rush	E	-	Sedgeland / rushland

Scientific Name/ Ecological Community Name	*Common Name*	*TSC Listing*	*EPBC Listing*	*Habitat Description*
Freshwater Wetlands of the NSW North Coast, Sydney Basin and South-east corner Bioregions	-	EEC	-	Sedgeland / rushland
Littoral Rainforest in the NSW North Coast, Sydney Basin and South-east corner Bioregions	-	EEC	CE	Closed forest remnants among Camphor Laurel regrowth
Swamp Sclerophyll Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South-east corner Bioregions	-	EEC	-	Low-lying areas integrated with sedgeland / rushland
Swamp Oak Floodplain Forest of the NSW North Coast, Sydney Basin and South East Corner bioregions (also mapped as SEPP 14 Coastal Wetlands)	-	EEC	-	Low-lying areas integrated with sedgeland/ rushland

Note: EEC – Endangered Ecological Community
V – Vulnerable
E – Endangered
TSC – Threatened Species Conservation Act 1995
EPBC – Environment Protection and Biodiversity Conservation Act 1999
SEPP – State Environmental Planning Policy

3.3.1 Ecology of Hairy Joint Grass (HJG)

HJG in northern NSW is an annual grass, meaning that it completes its lifecycle within a single year. Occasionally, individuals may persist beyond its normal period of annual die-off in winter when flowering has been suppressed by slashing or grazing (Benwell 2012).

The species germinates from seed in late winter or spring, grows most actively during the summer wet season, flowers and sets seed in March and April, then dies off in May and June.

The primary habitat of HJG on the north coast of NSW is lower slopes that remain damp or are fed by groundwater seepage during the wet season, although it can also occur on upper slopes under the right grazing and rainfall conditions (Benwell 2012). Nearly all known HJG populations occur on cleared grazing land in pasture dominated by exotic grasses and herbs (Benwell 2012).

Benwell (2012) discusses why HJG is rarely found in a natural environment. He states that, to the best of his knowledge, out of about 30 known populations on the North Coast of NSW only one occurs in natural vegetation in a woodland site west of Grafton. A number of possible explanations for this are given by Benwell (2012):

- HJG habitat near springs and seepages coincides with intensively utilised sites within grazing land, therefore such habitat is rarely unmodified by human activity;
- the species has adapted to grazing land, effectively widening it niche;
- HJG was originally a short-lived, species that appeared after fire, but due to the cessation of regular burning in its grazed habitat, post-fire populations are rarely seen today (one was observed by Benwell after a fire near Boambee south of Coffs Harbour); and/or
- HJG is actually an exotic species introduced after settlement with the transport of livestock and goods and dispersed locally by soil adhering to hoofs or in the gut of animals.

Studies by ECOS Environmental (2004) at Koala Beach near Pottsville have shown that persistence of HJG in areas of previously cleared pasture is dependent on ongoing biomass removal by grazing stock and the maintenance of small gaps in ground layer vegetation suitable for HJG germination and establishment.

Urban residential areas, such as the proposed Pacific Pines estate, are not practical for incorporating grazing stock due to a number of issues relating to public safety, access and maintenance. In the absence of the option of maintaining HJG by way of the biomass removal action of grazing stock, the only practical option is to mimic this biomass removal via other means; namely slashing / brushcutting or burning. Burning is not a practical option within an urban residential area for obvious safety reasons. Therefore slashing / brushcutting is the only viable maintenance option available to encourage the persistence of HJG in ex-grazing areas.

In the absence of annual biomass removal, HJG is likely to be gradually out-competed by the growth of vigorous exotic pasture species. In such a situation, HJG is likely to have limited germination and establishment success due to few gaps being present in the grass cover. The ongoing viability of HJG would be potentially compromised in the long-term in an environment where biomass removal was not occurring.

Interestingly, Benwell notes that HJG populations have declined when grazing animals are withdrawn from an area. He associates this with an increase in pasture grass height and density, with the build up of vegetation and shading the ground layer and inhibiting HJG seed germination. He notes previous experiments in areas of declining HJG population at Pottsville, NSW where biomass removal was reintroduced in the form of slashing and mulch removal, resulting in a marked increase in HJG population.

3.3.2 Ecology of Square-stemmed Spike Rush (SSSR)

Very little background literature is available on SSSR, with the primary resource being the Recovery Plan for this species (NPWS 2009).

SSSR is a clumping species with four-angled and effectively leafless culms (stems) arising from a short rhizome (Harden 1993). Approximately five to seven new culms, up to one metre in height, arise from a single rhizome. SSSR completes its flowering and fruiting in a single year, after which the culms die and decay. Culms arise from the continued formation of auxiliary buds within established rhizomes suggesting that vegetative reproduction may be an important strategy for maintenance of a local population following initial establishment of seed (G. Elks pers. obs., as stated in NPWS 2009).

SSSR exhibits a reproductive morphology that suggests this species is wind pollinated. Fruits develop from a spikelet on the end of each stem with seed maturing in late summer / early autumn. No germinating seeds or seedlings of this species have been observed (NPWS 2009).

Known populations of Square-stemmed Spike Rush occur in and on the margins of freshwater swamps and on the margins of streams, at about the level of the wet season water table (NPWS 2009).

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Information shown is for illustrative purposes only

Drawn by: TJP Checked by: MVE Reviewed by: DGH Date: August 2012
Source of base data: Ballina Shire Council & Kennedy Surveyors

North

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Vegetation Communities in Conservation Zone

GeoLINK environmental management and design

Conservation Zone Management Plan: Pacific Pines
1675-1008

Illustration 3.1

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3.4 Updated Mapping of Threatened Flora Species / EECs

Updated mapping of the distribution of threatened flora species / EECs occurring at the site was undertaken by GeoLINK as part of the preparation of the EMP. This fieldwork was conducted between 16 November and 23 November 2011. Methods used to map the distribution of the subject species / EECs are discussed in the sections below.

3.4.1 Hairy Jointgrass (HJG)

Targeted surveys for HJG were undertaken within all areas of the site representing potential habitat for the species in northeast NSW. Core habitat in this region appears to be in pasture dominated by exotic grasses on lower slopes that remain damp or are fed by ground water seepage during the wet season (Benwell 2011). At the time of survey, HJG at the site was between 7 cm and 30 cm in height and was highly visible due to the colour of its young foliage (being lighter green in comparison to other commonly occurring exotic grasses).

Surveys for HJG involved walking transects throughout suitable habitat and noting the presence / absence of the species at intervals of 1 to 2 m. Presence of HJG was recorded using a Garmin etrex hand-held unit. Transects were generally orientated parallel to one another at a spacing of 5 to 10 m. However, this spacing was widened to approximately 15 m in areas where HJG was considered unlikely to occur due to unfavourable microclimatic conditions. Conversely in areas where a dense occurrence of HFG was encountered, the transect spacing was decreased to 2 m to allow for a more comprehensive distribution to be recorded.

To improve the accuracy of the GPS data, known survey control points were also sampled prior to surveys being undertaken to allow for subsequent rectification of data by Kennedy Surveyors. The mapped occurrence of HJG in the Conservation Zone in the 2011 / 2012 growing season is shown in Illustration 3.2. The total area occupied by HJG within the Conservation Zone was calculated to be approximately 1.40 ha.

3.4.2 Square-stemmed Spike Rush (SSSR)

Targeted surveys for SSSR were undertaken within all areas of the site representing potential habitat for the species in northeast NSW. Core habitat in this region is seepage areas and association freshwater wetlands. At the time of survey, SSSR was easily detectable due to the presence of distinctive reproductive material being present.

Surveys for SSSR involved walking transects throughout suitable habitat and noting the presence / absence of the species at intervals of 1 to 2 m. Presence of SSSR was recorded using a Garmin etrex hand-held unit. Transects were generally orientated parallel to one another at a spacing of 5 to 10 m. However, this spacing was widened to approximately 15 m in areas where SSSR was considered unlikely to occur due to unfavourable microclimatic conditions. Conversely in areas where a dense occurrence of SSSR was encountered, the transect spacing was decreased to 2 m to allow for a more comprehensive distribution to be recorded.

To improve the accuracy of the GPS data, known survey control points were also sampled prior to surveys being undertaken to allow for subsequent rectification of data by Kennedy Surveyors. The mapped occurrence of SSSR in the Conservation Zone in the 2011/2012 growing season is shown in Illustration 3.3. The total area occupied by SSSR within the Conservation Zone was calculated to be approximately 2.00 ha.

3.4.3 Endangered Ecological Communities (EECs)

Freshwater Wetland

The boundary of the Freshwater Wetland EEC occurring at the site was derived with reference to the Scientific Determination for Freshwater Wetland EEC (2005). A subsequent survey was performed by David Havilah (GeoLINK) and Kennedy Surveyors to accurately position the boundary of the wetland for mapping. The mapped extent of Freshwater Wetland EEC is shown in Illustration 3.1.

Littoral Rainforest & Swamp Sclerophyll Forest

The previously mapped distribution of Swamp Sclerophyll EEC and Littoral Rainforest EEC was ground-truthed and found to accord well with the currently observed boundary. The location of the Swamp Oak Forest EEC was readily identifiable on aerial photography, and covered a smaller area than the mapped boundary of the SEPP 14 Coastal Wetland.

Information shown is for illustrative purposes only

Drawn by: TJP Checked by: MVE Reviewed by: DGH Date: August 2012
Source of base data: Ballina Shire Council & Kennedy Surveyors

North

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Hairy Joint Grass Distribution in Conservation Zone

GeoLINK environmental management and design

Conservation Zone Management Plan: Pacific Pines
1675-1010

Illustration 3.2

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Drawn by: TJP Checked by: MVE Reviewed by: DGH Date: August 2012
Source of base data: Ballina Shire Council & Kennedy Surveyors

Square-stemmed Spike Rush Distribution in Conservation Zone

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4

Conservation Zone Rehabilitation Strategy

4.1 Background

A significant proportion of Freshwater Wetland EEC, Littoral Rainforest EEC, HJG and SSSR at the site are protected by establishing the Conservation Zone. Despite this, some losses of these species / communities are unavoidable in constructing the Pacific Pines estate, and the following compensation strategy aims to address this.

Discussions between GeoLINK, Ballina Shire Council and OEH in February 2012 solidified the viewpoint that the best conservation outcome is to develop a mosaic of vegetation and habitat types forming an integrated suite of ecosystems within the Conservation Zone, as opposed to focusing solely on translocation of threatened species as the major component of the offset requirement.

Therefore, the focus of the compensation strategy will be on enhancing and establishing an integrated suite of ecosystems in the Conservation Zone, as is detailed in the following sections.

4.2 Objective

This rehabilitation strategy details the approach that will be taken to ensure that threatened plant species and communities are protected and enhanced within the defined Conservation Zone. The overall ecological objectives for management of the Conservation Zone are to:

- facilitate the establishment of an integrated suite of ecosystems, representing the distribution pattern of EECs that are expected to have been present in this area pre-clearing;
- minimise maintenance inputs to this area by encouraging self-sustaining vegetation; and
- enhance the inherent ecological values of the constituent EECs and threatened species presently occupying this area.

To facilitate achievement of these objectives, a rehabilitation plan has been developed by:

- identifying the existing vegetation types and other relevant ecological habitats within the Conservation Zone;
- dividing the Conservation Zone into vegetation protection and rehabilitation areas, reflecting the preferred rehabilitation and management options for creating an integrated suite of ecosystems; and
- identifying the required management approach(s) for successfully establishing an integrated suite of ecosystems.

4.3 Rehabilitation Strategy

4.3.1 Mapping of Rehabilitation Areas

At a field visit by GeoLINK ecologists Tom Pollard and David Havilah on May 2012, habitat mapping was carried out to determine preferred options for rehabilitation and management. The aim of this mapping was to determine the layout for the rehabilitation and enhancement of vegetation in the Conservation Zone, to form an integrated suite of ecosystems requiring very little management input into the future.

Areas with distinct habitat characteristics were assigned as discrete areas and these were broadly mapped onto a hardcopy map of the Conservation Zone showing existing EECs and threatened species habitat. Distinct habitat areas were subsequently assigned to a rehabilitation and management treatment option (see

below), determined by factors such as habitat characteristics, likelihood of success of a particular treatment, and consequences for ongoing maintenance, and APZ requirements.

4.3.2 Approach to Rehabilitation

The management approach for discrete areas within the Conservation Zone consists of a combination of:

- Conservation and enhancement of:
  - existing Swamp Sclerophyll Forest EEC;
  - existing Littoral Rainforest EEC; and
  - mapped HJG (outside of Freshwater Wetland EEC).
- Freshwater Wetland EEC rehabilitation (including enhancement of mapped HJG and SSSR within this EEC);
- Revegetation of EECs:
  - Swamp Sclerophyll Forest EEC revegetation;
  - Swamp Oak Forest EEC revegetation;
  - Littoral Rainforest EEC revegetation;
  - Littoral Rainforest EEC revegetation incorporating HJG; and
- Translocation of threatened species:
  - recipient areas for translocated HJG;
  - recipient areas for translocated SSSR.

All areas contributing to the rehabilitation strategy are mapped in Illustration 4.1. Details of the management approach for these areas are the basis of the rehabilitation strategy for the Conservation Zone and are detailed in the following sections.

4.4 Conservation and Enhancement of Communities and Threatened Species

A primary aim of the rehabilitation strategy is to retain all existing habitat occupied by threatened species and EECs within the Conservation Zone.

EECs within the Conservation Zone cover approximately 7.2 ha of a total area of 14.07 ha. The location of these areas is shown on Illustration 3.1, Illustration 3.2 and Illustration 3.3 and detailed in Section 3.1. Further detail of each of these areas is provided in the following subsections.

Individual areas of EEC vegetation at the Pacific Pines site are relatively small. Edge effects, particularly exposure to high light levels, can encourage prolific weed growth and have a serious detrimental effect on vegetation quality and the likelihood of successful unassisted regeneration.

These communities will be enhanced through management actions to eliminate highly competitive weeds and thereby encourage natural regeneration of native plant species. Additional enhancement of this community will be achieved by supplementary plantings of suitable native species within canopy gaps (including those created by treating woody weeds). As part of the overall rehabilitation strategy for the Conservation Zone, the sustainability of these existing EEC areas will also be bolstered by encouraging the establishment of additional contiguous areas of EEC by way of revegetation, and thereby limiting the impacts of weed infestation.

4.4.1 Existing Swamp Sclerophyll Forest EEC

The area of Swamp Sclerophyll Forest EEC occurs within the central portion of the Conservation Zone and is dominated by mature Broad-leaved Paperbarks (*Melaleuca quinquenervia*) and Swamp Oak (*Casuarina glauca*) (see Illustration 4.1). This patch of vegetation is approximately 0.3 ha in size.

Information shown is for illustrative purposes only

Drawn by: TJP Checked by: MVE Reviewed by: DGH Date: August 2012
Source of base data: Ballina Shire Council & Kennedy Surveyors

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North

Conservation Zone Rehabilitation Strategy

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Management actions to enhance this community will consist of:

- supplementary plantings of species suitable for Swamp Sclerophyll Forest EEC revegetation in canopy gaps (refer to Section 7 for detailed revegetation methodology for this area); and
- weed control of priority weed species (as detailed in the Section 8).

Management actions to enhance the existing area of Swamp Sclerophyll Forest EEC are summarised in Table 4.1.

4.4.2 Existing Littoral Rainforest EEC

Littoral Rainforest is the most extensive forested vegetation community at the Pacific Pines site. Littoral Rainforest EEC occurs as two separate regrowth patches in the north-south corridor on the eastern side of the Conservation Zone, and covers an area of approximately 2.4 ha (Illustration 4.1).

The northern patch of littoral rainforest in the Conservation Zone is dominated by tall Guioa (*Guioa semiglauca*) and Camphor Laurel trees. A number of threatened rainforest flora species are present within this remnant, including Rough-shelled Bush Nut, Arrow-head Vine and Red Lilly Pilly. Although native species are present in moderate abundance within the lower strata, vegetation in this area generally lacks the diversity of rainforest remnants occurring elsewhere on the site.

Weeds species dominating this zone include Camphor Laurel, Governors Plum (*Flacourtia indica*), Umbrella Tree (*Schefflera actinophylla)* and Asparagus Fern (*Asparagus densiflorus*). A large amount of general rubbish is present towards the north of this zone.

The southern patch of littoral rainforest in the Conservation Zone comprises a relatively large area of forest centred along a drainage line / ephemeral stream that is dominated by Tuckeroo (*Cupaniopsis anacardioides*) and Guioa. A relatively diverse mixture of native species also occurs within the lower strata. Part of this drainage line, occurring along the southern portion of this patch, provides habitat for the endangered species, Square-stemmed Spike Rush.

Numerous weed species are present within the area including Camphor Laurel saplings, Orange Jessamine (*Murraya paniculata*), Umbrella Tree and Tropical Soda Apple (*Solanum viarum*).

Enhancement of this community will be achieved by a combination of the following broad actions:

- supplementary plantings of suitable species within canopy gaps of these regrowth patches (plantings will also target gaps created by the staged removal of Camphor Laurel) (refer to Section 7 for detailed revegetation methodology for this area); and
- weed control of all woody and herbaceous weeds and vines within the two patches of Littoral Rainforest EEC (as detailed in the Section 8).

Management actions to enhance the existing area of Littoral rainforest EEC are summarised in Table 4.1.

4.4.3 Mapped HJG (outside of Freshwater Wetland EEC)

A number of areas within approximately 25 m outside of the boundary of the mapped Freshwater Wetland EEC contain extensive patches of HJG, as mapped by GeoLINK in 2012. HJG co-exists in these peripheral areas with exotic pasture grasses such as Buffalo Grass (*Stenotaphrum secundatum*), Vasey Grass (*Paspalum urvillei*) and Kikuyu (*Pennisetum clandestinum*), and the native grass Swamp Foxtail (*Pennisetum alopecuroides*).

The mapped area of HJG (GeoLINK 2012) reflects presence-absence rather than density of this species. Consequently, some mapped areas support only light cover of HJG while other areas support comparatively dense cover.

Enhancement of this community will be achieved by a combination of the following broad actions:

- selective weed control of weedy pasture grasses during the non-growing season of HJG (as detailed in the Section 8); and
- annual slashing or brush-cutting of grass in these areas following seeding of HJG to stimulate recruitment of HJG.

Detailed management actions for the HJG outside of the Freshwater Wetland EEC are contained in Table 4.1.

4.4.4 Freshwater Wetland EEC rehabilitation (including enhancement of mapped HJG and SSSR within this EEC)

Freshwater Wetland EEC covers a relatively large area of approximately 4.4 ha in the central section of the Conservation Zone (Illustration 4.1). Existing vegetation within the Conservation Zone comprises a range of wetland habitats including reedland, sedgeland, areas of dense Swamp Ricegrass (*Leersis hexandra*) and substantial areas supporting HJG and SSSR.

Weed grasses are common in this community, with the most significant being Vasey Grass (*Paspalum urvillei*) and Pigeon Grass (*Setaria sphacelata*). A primary risk associated with the ongoing viability of the Freshwater Wetland EEC vegetation relates to removal of cattle and the probable proliferation of these exotic grasses once grazing has ceased.

Rehabilitation of the Freshwater Wetland EEC will be achieved by a combination of the following actions:

- selective weed control of weedy pasture grasses (Vasey Grass, Pigeon Grass and Kikuyu) during late winter (non-growing season of HJG) (as detailed in the Section 8);
- annual slashing or brush-cutting of grass in target areas supporting HJG and SSSR during the dormant period to stimulate threatened species seedling germination and vegetative spread (the effectiveness of this technique in enhancing SSSR populations should be trialled and monitored as detailed in Section 10).
- supplementary planting of suitable wetland species targeting areas that are not currently occupied by HJG or SSSR, and those areas in which weed treatment has occurred, and/ or where the overall diversity of wetland plants is low (refer to Section 7 for detailed revegetation methodology for this area).

Biomass reduction enhancement areas for existing areas of HJG and SSSR will be located adjacent and within 25 m of proposed HJG and SSSR translocation recipient sites. The extent of these areas will be initially marked by GPS by an ecologist for future relocation.

Benefits of locating enhancement areas in the manner described will mean that:

- areas are easier to locate;
- time taken for slashing / brushcutting is minimised; and
- managed areas of threatened species habitat are contiguous.

Management actions for rehabilitating the Freshwater Wetland EEC are contained in Table 4.1. Further detail on the rehabilitation strategy for Freshwater Wetlands EEC is contained in Section 5.

4.5 Management Actions for Conservation and Enhancement of Existing Communities and Threatened Species

A summary of management actions for the Conservation and Enhancement of existing communities and threatened species, as part of the rehabilitation strategy, is shown in Table 4.1.

Further detail on weed control, revegetation methodology and planting lists is provided in Section 7 and Section 8.

Table 4.1 Summary of Management Actions for the Conservation and Enhancement of Existing Communities and Threatened Species in the Conservation Zone

Area of Conservation Zone	*Number*	*Management Action*	*Timing*	*Detail*
Existing Swamp Sclerophyll Forest EEC	1	Weed Control	As soon as possible following adoption of EMP and CZMP	▪ staged treatment of Camphor Laurel. ▪ removal of potentially dangerous standing dead wood. ▪ removal of areas of Lantana.
	2	Revegetation	As soon as possible following adoption of EMP and CZMP	▪ supplementary planting of suitable species
	3	Maintenance	Ongoing until handover of land to council	▪ ongoing weed control
	4		Ongoing until handover of land to council	▪ replacement plantings (for losses)
Existing Littoral Rainforest EEC	5	Weed Control	As soon as possible following adoption of EMP and CZMP	▪ eradicate exotic vine and understorey weeds, focusing on Tropical Soda Apple, Lantana, Governors Plum, Crofton Weed, Mistflower, Fishbone Fern, Asparagus Fern and Silver-leafed Desmodium. ▪ treat mature Camphor Laurel, African Olive and Orange Jessamine.
	6	Revegetation	As soon as possible following adoption of EMP and CZMP	▪ supplementary plantings of suitable species within canopy gaps of these regrowth patches (supplementary plantings will also target gaps created by the staged removal of Camphor Laurel).
	7	Maintenance	Ongoing until handover of land to council	▪ ongoing weed control
	8		Ongoing until handover of land to council	▪ replacement plantings (for losses)
Mapped HJG (outside of Freshwater Wetland EEC)	9	Weed Control	As soon as possible following adoption of EMP and CZMP	▪ treat weedy pasture grasses during the non-growing season of HJG.
	10	Biomass Reduction	Annually during June	▪ annual slashing or brush-cutting of grass in these areas following seeding of HJG to stimulate recruitment of HJG.

Area of Conservation Zone	*Number*	*Management Action*	*Timing*	*Detail*
Freshwater Wetland EEC	11	Weed Control	As soon as possible following adoption of EMP and CZMP	▪ treat weedy pasture grasses during the non-growing season of HJG.
	12	Revegetation	Ongoing until handover of land to council	▪ supplementary planting of suitable wetland species targeting areas that are not currently occupied by HJG or SSSR.
	13	Maintenance	Ongoing until handover of land to council	▪ ongoing weed control
	14		Ongoing until handover of land to council	▪ replacement plantings (for losses)
	15	Biomass Reduction	Annually during June Monitoring is ongoing until handover to council	▪ annual slashing or brush-cutting of grass/wetland plants in target biomass reduction enhancement areas following seeding of HJG to stimulate recruitment of HJG. ▪ trial and monitor effectiveness of enhancing SSSR populations through biomass reduction.

4.6 Revegetation to Forested EECs

A primary aim of the rehabilitation strategy is to revegetate areas of the Conservation Zone with suitable species from relevant forested EECs to reproduce the vegetation patterns that are expected to have been present at the Pacific Pines site prior to clearing.

Areas suitable for revegetation to forested EECs within the Conservation Zone were identified on the following basis:

- areas not currently occupied by EECs (wetland or forested);
- areas not currently occupied, or only to a minor degree, by HJG and SSSR ('to a minor degree' was defined as being <10% cover);
- areas not identified as being suitable HJG or SSSR translocation recipient sites; and
- areas not currently occupied by existing water infrastructure (e.g. drainage channels).

Suitable revegetation areas cover approximately 4.3 ha of a total area of 14.07 ha, consisting of the following components:

- 0.1 ha of Swamp Sclerophyll Forest EEC;
- 0.3 ha of Swamp Oak Forest EEC;
- 3.3 ha of Littoral Rainforest EEC revegetation; and
- 0.6 ha of Littoral Rainforest EEC revegetation incorporating HJG.

The location of these areas is shown on Illustration 4.1.

Ecological and maintenance benefits of revegetating areas in the Conservation Zone include:

- forming larger, and more resilient areas of forested EECs,
- creating more diverse habitat for native fauna; and
- limiting maintenance requirements associated with slashing and brushcutting grass growth in the absence of cattle.

Further detail of each of the revegetation areas is provided in the following subsections. Revegetation methodology and planting lists for each community are given in Section 7.

4.6.1 Revegetation to Swamp Sclerophyll Forest EEC

Suitable areas for revegetation to Swamp Sclerophyll Forest EEC are located immediately west of the existing Swamp Sclerophyll Forest EEC (see Illustration 4.1).

This area was identified on the basis of being located at mid elevation between existing areas of Swamp Oak Forest EEC (low elevation) and Littoral Rainforest EEC (slopes). Existing Swamp Sclerophyll Forest EEC in the central portion of the Conservation Zone also indicates the suitability of these areas for revegetation to this community.

4.6.2 Revegetation to Swamp Oak Forest EEC

A suitable area for revegetation to Swamp Oak Forest EEC is in the western portion of the Conservation Zone at relatively low elevation (refer to Illustration 4.1).

The suitability of this area for revegetation to Swamp Oak Forest EEC was identified on the basis of being located at low elevation and in general proximity to existing Swamp Oak Forest EEC in a similar situation in Ballina Nature Reserve.

4.6.3 Revegetation to Littoral Rainforest EEC

Suitable areas for revegetation to Littoral Rainforest EEC are located in a small area of the central section of the Conservation Zone on a slightly raised area of ground, as well as over the majority of the southern and northern sections (refer to Illustration 4.1) adjacent to existing patches of Littoral Rainforest EEC / Camphor Laurel regrowth.

These areas were identified as suitable for revegetation to Littoral Rainforest EEC on the basis of being located on slightly elevated areas or mid-slopes and being in proximity to existing areas of Littoral Rainforest EEC.

4.6.4 Revegetation to Littoral Rainforest EEC incorporating HJG

Suitable areas for revegetation to Littoral Rainforest EEC incorporating HJG are located in slightly elevated areas adjacent to existing areas of HJG, (refer to Illustration 4.1). Incorporation of HJG in this area of Littoral Rainforest EEC revegetation is intended to mimic one of the preferred natural habitats for this species on the periphery of rainforest, often near creeks and swamps (DECC 2005).

The layout of the revegetation will consist of dense clumped plantings of rainforest species interspersed with small open areas in which HJG is to be translocated. Centres of the clumped plantings are to be 10 m apart with a minimum 2 m gap between the edges of each clump. The edges of the revegetated area will expand as the vegetation matures, leading to an overall decrease in the open area. This layout will require the minimum level of maintenance by reducing light levels and thereby limiting the potential for weed establishment. Management of the HJG areas will follow the biomass reduction method outlined in Section 5.3. Slashing such an area is not practical due to the restricted open space and therefore brushcutting is the preferred grass reduction technique in this situation.

These areas were identified as suitable for revegetation to Littoral Rainforest EEC with HJG on the basis of having the habitat characteristics for both Littoral Rainforest EEC revegetation and HJG establishment.

Management actions for rehabilitating the Freshwater Wetland EEC are contained in Table 4.1. Further detail on the rehabilitation strategy for Freshwater Wetlands EEC is contained in Section 5.

4.7 Management Actions for Revegetation to Forested EECs

A summary of management actions for revegetation to forested EECs, as part of the rehabilitation strategy, is shown in Table 4.1.

Further detail on weed control and revegetation methodology and planting schedules is provided in Section 7 and Section 8. Methods for biomass reduction in HJG establishment areas are outlined in Section 5.3.

Table 4.2 Summary of Management Actions for Revegetation to Forested EECs in the Conservation Zone

Area of Conservation Zone	*Number*	*Management Action*	*Timing*	*Detail*
Revegetation to Swamp Sclerophyll Forest EEC	1	Weed Control	As soon as possible following adoption of EMP and CZMP	▪ preparatory spraying of grass and herbaceous weeds in planting zone
	2	Revegetation	As soon as possible following adoption of EMP and CZMP	▪ undertake plantings of suitable species
	3	Maintenance	Ongoing until handover of land to council	▪ ongoing weed control
	4		Ongoing until handover of land to council	▪ replacement plantings (for losses)
Revegetation to Swamp Oak Forest EEC	5	Weed Control	As soon as possible following adoption of EMP and CZMP	▪ preparatory spraying of grass and herbaceous weeds in planting zone
	6	Revegetation	As soon as possible following adoption of EMP and CZMP	▪ undertake plantings of suitable species
	7	Maintenance	Ongoing until handover of land to council	▪ ongoing weed control

Area of Conservation Zone	*Number*	*Management Action*	*Timing*	*Detail*
	8	Maintenance	Ongoing until handover of land to council	▪ replacement plantings (for losses)
Revegetation to Littoral Rainforest EEC	9	Weed Control	As soon as possible following adoption of EMP and CZMP	▪ preparatory spraying of grass and herbaceous weeds in planting zone
	10	Revegetation	As soon as possible following adoption of EMP and CZMP	▪ undertake plantings of suitable species
	11	Maintenance	Ongoing until handover of land to council	▪ ongoing weed control
	12		Ongoing until handover of land to council	▪ replacement plantings (for losses)
Revegetation to Littoral Rainforest EEC incorporating HJG	13	Weed Control	As soon as possible following adoption of EMP and CZMP	▪ low slashing or brush-cutting of grass/wetland plants prior to hand broadcasting of HJG seed. ▪ preparatory spraying of grass and herbaceous weeds in planting zone of rainforest revegetation patches.
	14	Revegetation	As soon as possible following adoption of EMP and CZMP	▪ undertake plantings of suitable species in rainforest revegetation patches
	15		June in first year – 1 week after biomass reduction	▪ hand broadcast HJG seed in spaces between rainforest revegetation patches.
	16	Maintenance	Ongoing until handover of land to council	▪ ongoing weed control
	17		Annually in June	▪ annual slashing or brush-cutting of grass/wetland plants in target biomass reduction enhancement areas following seeding of HJG to stimulate recruitment of HJG.
	18		Ongoing until handover of land to council	▪ replacement plantings of tubestock (for losses)

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5

Rehabilitation Plan for Freshwater Wetlands EEC

A rehabilitation plan for the area of Freshwater Wetlands EEC within the Conservation Zone (refer to Illustration 3.1) has been developed with the aims of reducing weed infestation, enhancing the vegetation quality, and ensuring the ongoing survival of HJG and SSSR.

The rehabilitation plan incorporates:

- weed control;
- enhancement of existing areas of HJG and SSSR;
- establishing new areas of HJG and SSSR; and
- revegetation of degraded areas.

These components are expanded on in Section 5.2 to Section 5.5.

5.1 Species Composition of the Freshwater Wetlands EEC

Freshwater Wetlands EEC covers 4.4 ha of the central section of the Conservation Zone. This area is dominated by a variety of wetland species including Bunchy Sedge (*Cyperus polystachyos*), a Spikerush (*Eleocharis equisetina*), River Club-rush (*Schoenoplectus validus*), Millet Swamp Millet (*Isachne globosa*) and Swamp Ricegrass (*Leersia hexandra*). The threatened species HJG and SSSR occur widely within the Conservation Zone but at a lower density.

5.2 Weed Species and Control

A variety of weed species are found within the Freshwater Wetlands EEC area, the most dominant of which are Vasey Grass (*Paspalum urvillei*), Pigeon Grass (*Setaria sphacelata* subsp. *sphacelata*) and Kikuyu (*Paspalum clandestinum*). Vasey Grass and Pigeon Grass are both relatively large upright clumping grass species. Control of these species will be achieved by hand-pulling where possible to avoid potential damage to native wetland species, including HJG and SSSR. Where this is impractical, it is recommended that the control approach be to undertake careful targeted hand-spraying with herbicide of grass clumps using a knapsack coinciding with the dormant season of both threatened species in late winter.

Control of Kikuyu is impractical where they are mixed among native wetland species due to its low habit. In areas in which Kikuyu dominates and has formed a dense sward, some broad control with herbicide may be possible while avoiding overspray damage to native wetland species. The presence of HJG or SSSR in these swards should be established by an ecologist prior to spraying activities. Alternatively, as for the larger grass species, spraying should be timed to coincide with the dormant season of the threatened species in late winter.

Weed control activities are to be prioritised in areas supporting existing populations of HJG and SSSR. Further detail of weed treatments is given in Section 8.

5.3 Enhancement of existing areas of HJG and SSSR

Two threatened species located within the Freshwater Wetlands EEC community are HJG and SSSR. These species are not dominant components of the community, based on cover within any given area. However, the total area occupied by one or both of these species is significant (3.1 ha out of a total size of the Conservation Zone of 14.07 ha).

HJG generally occurs on the periphery of the Freshwater Wetlands EEC or a short distance within the boundary, and also occurs in adjacent better drained areas upslope. SSSR is predominantly found within the boundary of the Freshwater Wetlands EEC in lower swampy areas, and in most cases does not co-occur with HJG. However, there are some minor areas in which there is overlap.

It has been surmised from establishment trials for HJG (Benwell 2012) that a restriction to the successful germination of HJG seed is related to competition by exotic pasture grasses. Management of HJG therefore centres on methods to limit some of this competition stress and therefore improve establishment and spread.

Enhancement is therefore achieved (in situations where stock have been excluded), by established areas of HJG being maintained and enhanced by annual slashing / brushcutting (just after the seeding period – May or June). Benwell (2012) found that mean percent crown cover can increase from 6-15% in Year 1 to 40-90% in Year 2 under this annual grass reduction management regime.

Although no similar establishment trials have been undertaken for SSSR, the Recovery Plan for the species states that light grazing may provide both a seed dispersal mechanism and a disturbance regime suitable for the establishment of new seedlings. It may also prevent established plants from being eliminated by more competitive taller species (NPWS 1999). On this basis, it is also probable that active biomass removal by way of annual slashing / brushcutting as previously described for HJG may also prove successful in enhancing the establishment and spread of SSSR.

Undertaking such a management regime across all areas of HJG and SSSR in the Conservation Zone is likely to be time-consuming and potentially expensive. Therefore, a subset of areas has been selected within which slashing / brushcutting is to be undertaken as previously specified in Section 4.4.4.

These areas are located adjacent to and within 25 m of proposed HJG and SSSR translocation recipient sites. The extent of these areas will be initially marked by GPS by an ecologist for future relocation.

Benefits of locating enhancement areas in the manner described is that:

- areas are easier to locate;
- time taken for slashing / brushcutting is minimised; and
- managed areas of threatened species habitat are contiguous.

Brushcutting is the preferred technique where access is difficult for a standard tractor with slasher due to the presence of boggy ground.

5.4 Establishing new areas of HJG and SSSR

In order to enhance the viability of HJG and SSSR at the Pacific Pines site, existing populations of these species within the Conservation Zone will be supplemented by translocation into strategic recipient areas.

Recipient areas suitable for establishing new populations of HJG and SSSR were identified as part of habitat mapping of the Conservation Zone (Illustration 6.1). Full details of establishment of HJG and SSSR in the Conservation Zone are provided in Section 6.

5.5 Supplementary Plantings in Degraded Areas

Degraded areas of Freshwater Wetlands EEC that have significant infestation of weeds will be targeted for revegetation. In these areas supplementary plantings of species will be undertaken with the aim of discouraging future weed infestations, improving native plant cover and enhancing native species composition. At a minimum it is recommended that 0.5 ha be targeted for revegetation. Specific revegetation methods and a plant list for degraded sections of the Freshwater Wetlands EEC are detailed in Section 7.

6

Translocation Plans for Hairy Joint Grass and Square-stemmed Spike Rush

6.1 Overview

This section details a strategy for translocation of HJG and SSSR from impacted areas of the site to within the Conservation Zone and recommendations on the subsequent monitoring and reporting of the success of the translocations.

The strategies outlined in the Plan are in accordance with the relevant Australian guidelines for undertaking translocation: *Guidelines for the Translocation of Threatened Plants in Australia* (Vallee *et al*. 2004).

The primary objectives of the translocation strategy are to:

- summarise existing information relevant to the translocation of the subject species;
- provide clear and concise guidance on the best methods to undertake successful translocation of the subject species;
- provide guidance on the procedures required for the successful removal and/or propagation of designated areas of the subject species from the proposed area of disturbance and subsequent establishment at an appropriate recipient site;
- determine suitable milestones during the process;
- provide clear and concise procedures to be implemented relating to ongoing maintenance of the subject translocated / propagated specimens; and
- develop a simple and practical monitoring programme for the subject specimens that will aid in the overall success of the translocation process.

6.1.1 Definitions

Donor Site	site from which transplanted specimen is removed
Gene Pool	the sum of all genes possessed by the individuals of a population
Photo-point Monitoring	monitoring the progress of translocated specimens by comparing photographs taken over time at pre-determined locations
Propagation	to reproduce by asexual means such as cuttings, layering, grafting, or tissue culture, or less commonly by sexual means
Recipient Site	the site at which transplanted specimen are established
Translocation	'the deliberate transfer of plants or regenerative plant material from an ex situ collection or natural population to a location in the wild, including existing or new sites or those where the taxon is locally extinct' (Vallee *et al*. 2004)

6.2 Translocation of Hairy Joint Grass (HJG)

6.2.1 Previous Translocation of HJG

Recent experimental translocation of this species for the Ballina Bypass Pacific Highway Upgrade has been successful in establishing a new sub-population of HJG using seed and propagated seedlings (Benwell 2011; 2012). The final results of this trial (Benwell 2012) indicate that, in situations where grazing stock is excluded:

- low slashing of the translocation area immediately before seeding / planting allows a reduction in competition between the emerging HJG seedlings and other pasture species;
- direct seeding of HJG is the most effective establishment method, compared with planting seedlings (seeding occurred in June);
- HJG establishment was promoted by pasture disturbance consisting of slashing or slashing with mulch removal and to a lesser degree by herbicide spraying treatments;
- slashing then removal of mulch is not significantly more successful compared with slashing alone in promoting HJG establishment (however, this may not be the case in areas that have a heavy weedy groundcover that when slashed produces a dense layer of mulch that will need to break down later in the season in order for HJG seedlings to germinate); and
- established areas of HJG can be maintained and enhanced by annual slashing (just after the seeding period – May or June), and mean percent crown cover increased from 6-15% in Year 1 to 40-90% in Year 2 with annual slashing.

Plate 6.1 Hairy Joint-grass at the Pacific Pines Site (October, 2011)

6.2.2 Translocation Methodology

Recipient areas suitable for establishing new populations of HJG were identified as part of habitat mapping of the Conservation Zone (refer to Section 4.3.1 and Illustration 6.1).

The proposed methodology for the translocation of HJG is based on methods employed successfully by Ecos Environmental (Benwell 2012) as part of experimental translocation of this species for the Ballina Bypass Pacific Highway upgrade project.

This proposed methodology is based around:

- seed collection;
- appropriate preparation of recipient sites;
- direct seeding;

- ongoing management of the recipient site; and
- monitoring

Donor and Recipient Sites

As the proposed methodology for translocation of this species consists of seed collection, the donor site is considered to be all areas of HJG occurring on the site, as mapped by GeoLINK in 2011-2012 and shown in Illustration 3.1.

While it is envisaged that sufficient seed will be able to be collected from the site, if additional seed is required, collection from nearby areas within 5 km of the site will be investigated further.

The proposed recipient sites are contained within the designated Conservation Zone occurring within the approved Pacific Pines Estate.

The main selection criteria for the recipient sites are:

- the Conservation Zone is a designated area for the enhancement and conservation of threatened flora species occurring on the site;
- it is known habitat for this species;
- it will be secure in terms of tenure as part of the development; and
- management of threatened species / habitat occurring within the Conservation Zone is ensured under the over-arching Environmental Management Plans for the site.

Potential HJG recipient sites within the Conservation Zone were determined to display some or all of the following characteristics:

- existing cover of HJG <10%;
- on the margin of, or just within the margin of, Freshwater Wetland EEC; and/or
- on a lower slope around or within a soak

Significant areas within the Conservation Zone were ruled out as recipient sites on the following basis:

- most of the core area of Freshwater Wetland EEC;
- existing areas already dominated by HJG or SSSR (greater than 10% cover of either);
- Swamp Sclerophyll Forest EEC; or
- more suitable to be replanted to a forested EEC.

HJG recipient sites to be reseeded are shown in Illustration 6.1. The total area is 1.33 ha.

Site Preparation

The following strategies are proposed for the preparation of the recipient site:

- recipient sites are to be marked out prior to translocation occurring;
- noxious and environmental weeds are to be eradicated prior to translocation being undertaken (refer to Section 8);
- one week prior to direct seeding occurring, the recipient site is to be slashed or manually brush cut (in areas difficult to access), grass is to be cut as low as possible; and
- if substantial mulch is generated by this activity, mulch is to be removed from the recipient sites.

Seed Collection

Seed will be collected from the site between April and May and stored in paper bags in a dry cool place until the time of planting. Seed collection is to be undertaken by a suitably qualified ecologist under a Section 132C Licence issued by OEH for the activity.

Direct Seeding

Direct seeding is to be carried out in winter (June) to mimic the natural cycle of seed dispersal and recruitment in wild populations of HJG. Seed is to be mixed with river sand at the ratio of 5 grams to 20 litres of river sand and spread over target recipient sites.

Post-translocation Maintenance

The results of translocation trials for this species (Benwell 2012) have indicated that HJG seedling recruitment is enhanced by biomass reduction. Therefore, post-translocation maintenance of recipient sites will consist of a single annual slashing event aimed at reducing pasture biomass and creating spaces in the ground layer to assist in seed germination. This will occur in June once seeding of HJG has finished. Details of the monitoring of both the recipient site and translocated plants are outlined in Section 10.

6.3 Translocation of Square-stemmed Spike Rush (SSSR)

6.3.1 Translocation methodology

Recipient areas suitable for establishing new populations of SSSR were identified as part of habitat mapping of the Conservation Zone (refer to Section 4.3.1 and Illustration 6.1).

To date, no translocation studies for this species are known to have been undertaken.

The Recovery Plan for this species states that material was collected from the largest population of SSSR at Boambee to obtain a preliminary understanding of the growth rate and reproductive ecology of the species. This material was successfully propagated ex-situ from division of clumps and continues to grow. This suggests that it is possible to cultivate the species ex-situ (NPWS 1999).

Donor and Recipient Site

As the proposed methodology for translocation of this species consists of salvage translocation, the donor site for this species is considered to be all plants occurring within the approved footprint of the development, as mapped by GeoLINK in 2011-2012.

While it is envisaged that sufficient plant material will be able to be collected from the site for translocation, if additional material is required, collection from nearby areas within 5 km of the site will be investigated further.

The proposed recipient sites are contained within the designated Conservation Zone occurring within the approved Pacific Pines Estate.

The main selection criteria for the recipient sites can be summarised as follows:

- the Conservation Zone is a designated area for the enhancement and conservation of threatened flora species occurring on the site;
- it is known habitat for this species;
- it will be secure in terms of tenure as part of the development; and
- management of threatened species / habitat occurring within the Conservation Zone is ensured under the over-arching Environmental Management Plans for the site.

Potential SSSR recipient sites within the Conservation Zone were determined to display some or all of the following characteristics:

- existing cover of SSSR <10%;
- within the mapped boundary of the Freshwater Wetland EEC ; and
- areas of Freshwater Wetland EEC with low to moderate vegetation condition (predominantly resulting from weed invasion).

Significant areas within the Conservation Zone were ruled out as recipient sites on the following basis:

- existing areas already dominated by HJG or SSSR (greater than 10% cover of either);
- Swamp Sclerophyll Forest EEC; or
- more suitable to be replanted to a forested EEC.

Recipient sites that SSSR is to be translocated into are shown in Illustration 6.1. The total area is 0.1 ha.

Site Preparation

The following strategies are proposed for the preparation of the recipient site:

- the Conservation Zone (recipient site) is to be marked out prior to translocation occurring; and
- noxious and environmental weeds are to be eradicated prior to translocation being undertaken (refer to Section 8).

Plant Salvage

Upon approval of the translocation strategy for SSSR, proposed plants to be salvaged will be collected on site by a qualified wetland ecologist. Plants will be kept moist, divided and potted into an appropriate medium for growing on in a nursery until mature enough to be planted out.

Reintroduction

Reintroduction of salvaged plants is to be undertaken in spring to coincide with the natural emergence of this species following the winter dormancy period. Plants are to be planted at an appropriate density as determined by a wetland ecologist.

Post-translocation Care

The Recovery Plan for the species states that light grazing may provide both a seed dispersal mechanism and a disturbance regime suitable for the establishment of new seedlings. It may also prevent established plants from being eliminated by more competitive taller species (NPWS 1999). As little is known of the ongoing maintenance requirements of this species, a trial of two maintenance regimes will be undertaken as part of the monitoring program:

- selective removal of weeds from site; and
- slashing of the recipient sites will be carried out to reduce pasture biomass and open up the ground layer to seed germination as has been successful for Hairy Jointgrass.

Details of the monitoring of both the recipient site and translocated plants our outlined in Section 10.

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Information shown is for illustrative purposes only

Drawn by: TJP Checked by: MVE Reviewed by: DGH Date: August 2012
Source of base data: Ballina Shire Council

North

0 100

Location of Threatened Species Recipient Sites

GeoLINK environmental management and design

Conservation Zone Management Plan: Pacific Pines
1675-1013

Illustration 6.1

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6.4 Timing of Translocation Process

A schedule for the timing of the translocation process is provided in Table 6.1. The schedule may require reconfiguring if there are any delays in this process.

Table 6.1 Timing of Translocation Process

Action	*Timing*	*Personnel Responsible*
Hairy Jointgrass		
Weed control in areas supporting HJG	Commencing upon approval of Environmental Management Plans – ongoing (refer to Weed Management Plan and Section 8)	Developer
Seed collection	April-May	Ecologist
Pegging out recipient site	Prior to slashing and seeding	Ecologist
Slashing of recipient site	June (first 2 weeks)	Developer
Direct seeding	June (last 2 weeks)	Ecologist
Monitoring and reporting to OEH	Annually	Ecologist
Square-stemmed Spike Rush		
Weed control in areas supporting SSSR	Commencing upon approval of Environmental Management Plans – ongoing (refer to Weed Management Plan and Section 8)	Developer
Salvage of impacted plants	TBA	Wetland Ecologist
Propagation	TBA	Wetland Ecologist
Pegging out recipient site	Prior to October	Wetland Ecologist
Replanting of propagules	October	Wetland Ecologist
Monitoring and reporting to OEH	Annually	Wetland Ecologist

6.5 Translocation Project Monitoring

Ongoing monitoring to be undertaken for the translocation project is detailed in Section 10.

Ongoing maintenance and management of the recipient sites and translocated plants will be vital to the success of the translocation project. Accordingly, an ongoing monitoring program will be instigated to track the condition of the recipient site and individual translocated plants. Results of the monitoring programme will lead to adaptive management responses if required.

The maintenance and monitoring program for the translocated plants will incorporate actions that are largely derived from recommendations for monitoring in Guidelines for the Translocation of Threatened Plants in Australia (Vallee *et al* 2004). Once established in recipient sites, HJG and SSSR will be maintained in the same manner as existing enhancement of existing HJG and SSSR (via annual biomass removal and weed control) as detailed in Section 5.3. Annual results of the monitoring program will be reported to OEH.

6.6 Contingency Measures

In the case that the compensatory works to offset the loss of Freshwater Wetlands EEC, HJG and SSSR across the site are unsuccessful, a number of contingency measures will be undertaken as mitigation. The following sections detail the procedure that will be used to determine the success of the compensatory works and the proposed contingency measures.

6.6.1 Measuring Success of Compensatory Works

Establishing whether or not the compensatory works have been successful will rely on effective monitoring. Full details of monitoring methods that will be used are provided in Section 10.

Regarding Freshwater Wetlands EEC, Part 4 of Condition B2 requires the development of a rehabilitation plan that details the manner in which the functions and values of the Freshwater Wetlands EEC will be restored. Indicators of success for the restoration of functions and values of this community are:

1. A reduction in weed cover;
2. Proven enhancement of HJG and SSSR;
3. Proven establishment of HJG and SSSR; and
4. No substantial changes in the boundary of the Freshwater Wetlands EEC that cannot be accounted for by seasonal variation (potentially indicating a change in hydrology).

Points 2 and 3 are also relevant to the success of compensatory works relating to HJG and SSSR.

Monitoring techniques to measure the success of these indicators are:

- *A reduction in weed cover* – weed cover in the Conservation Zone will be monitored within quadrats / transects. Any opportunistic observations of weeds that are located outside of specific quadrat / transects will be recorded to inform a 'priority weed map' for the Conservation Zone. The extent of these weed infestations will be recorded with a hand-held GPS unit. A simple map showing the locations of priority weeds will be prepared for each monitoring report. This map will be provided to weed control contractors to inform future weed control works. A significant increase in weed burden within the Freshwater Wetland EEC area would be considered to indicate unsuccessful rehabilitation.
- *Proven enhancement of HJG and SSSR* – conduct an annual survey and mapping of the distribution of HJG and SSSR to establish changes in distribution of these species. A decrease of >20% in the presence of either of these species within their respective habitat area would be considered to be unsuccessful enhancement.
- *Proven establishment of HJG and SSSR* – recipient sites in which HJG or SSSR have been translocated are to be monitored within quadrats to record the success of the translocation. The distributions of these threatened species across seasons are variable depending on environmental conditions, particularly for HJG. To account for some of this variability, success or failure will be based on a significant deviation from a baseline vegetative cover (decrease of >20%). This baseline vegetative cover will be measured at 12 months following the translocation event.
- No substantial changes in the boundary of the Freshwater Wetlands EEC that cannot be accounted for by seasonal variation (potentially indicating a change in hydrology) – transect surveys will be used to detect potential changes in the boundary of the Freshwater Wetland EEC in the Conservation Zone. The boundary of this community is expected to fluctuate somewhat depending on climatic variability, however; it should be possible to attribute any substantial change in the location of the boundary of this community to climatic conditions or to a change in hydrology.

6.6.2 Adaptive Management

Results of monitoring will provide the opportunity to modify management techniques regularly where necessary to ensure greatest likelihood of the compensatory works being successful.

If it is shown through monitoring that any of above indicators are at risk of not being met, a modification to vegetation management techniques will be implemented. This modification may include, but is not limited to:

- revision of weed control techniques;
- re-assessment of the timing, extent and technique of biomass control for HJG and SSSR; or
- re-establishment of additional HJG and SSSR in poorly performing areas.

6.6.3 Retention of Genetic Material

As a precaution against loss of genetic diversity if the compensatory measures for HJG and / or SSSR should prove to be unsuccessful, a program of seed collection and propagation for these species will be undertaken so that re-establishment on-site or off-site is possible if required.

The seed of HJG retains adequate viability for up to 3 years (Andrew Benwell pers. comm.). To use the precautionary principle, seed would be collected from across the site prior to construction beginning, and from within the Conservation Zone annually following this, and placed in cool storage.

Little information is known on the ecology or germination of SSSR. However, it has been established that propagation is successful by way of division (Greg Elks pers. comm.). Therefore, prior to construction occurring at the Pacific Pines site, SSSR will be salvaged and clumps divided and grown up at an appropriate nursery with experience growing native wetland plants. As these plants mature they will be able to be further divided.

6.6.4 Research Opportunities to Investigate the Ecology and Translocation of SSSR

If it is established that the compensatory works have been unsuccessful, it is proposed that a compensatory measure be established to undertake research into the ecology, enhancement and translocation of SSSR. This research would provide valuable information for future projects involving this species. As mentioned previously there is little information available on the ecology and establishment of SSSR.

The methodology and scope of such a project for SSSR would be similar to that undertaken to investigate translocation of HJG for the Ballina Bypass Highway Upgrade Project (Benwell 2012).

This research extended over two years and included the following components:

- genetic research to determine the extent of genetic variation among populations;
- experimental translocation to establish a new population and research the effect of site factors and follow-up management on establishment and persistence; and
- management of an existing population, including maintenance of habitat conditions favourable for recruitment.

The opportunity exists to engage a local university such as Southern Cross University or Griffith University to undertake this research, potentially as part of a research higher degree. The proponents would make a monetary contribution of $50,000 to enable that research.

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7

Revegetation Approach

As specified in Section 4.6 a primary aim of the rehabilitation strategy is to revegetate areas of the Conservation Zone with suitable species from relevant forested EECs to reproduce the vegetation patterns that are expected to have been present at the Pacific Pines site prior to clearing.

Revegetation will also occur as supplementary plantings within existing forested EEC areas and supplementary plantings within the Freshwater Wetland EEC, including translocation of HJG and SSSR into recipient sites. Therefore the components of the revegetation approach for the Conservation Zone consist of:

- revegetation to forested EECs;
- supplementary plantings in existing forested EECs; and
- supplementary plantings in Freshwater Wetlands EEC.

This revegetation approach aims to create a mosaic of forested, grassland and wetland habitats for the purpose of protecting threatened species and communities and providing habitat for a range of native fauna.

Revegetation method, plant lists, maintenance and monitoring are each detailed in the following sections.

7.1 Revegetation Method

The following subsections detail the broad methods to be used for revegetation within forested EECs (both supplementary plantings and revegetation) and Freshwater Wetlands EEC (supplementary plantings).

7.1.1 Supplementary Plantings within Forested EECs

Supplementary plantings of species within forested EECs will be targeted into areas that are susceptible to weed infiltration. These areas consist of either existing canopy gaps, gaps created by weed control activities (particularly the removal of mature woody weeds). The aims of undertaking these supplementary plantings within forested EECs are to:

- improve the diversity and integrity of the constituent native vegetation;
- form a buffer for threatened species (within Littoral Rainforest EEC areas); and
- reduce ongoing weed maintenance by reducing light levels.

Table 7.1 details the methodology and timing for undertaking supplementary plantings within forested EECs and revegetation for the purpose of recreating forested EECs.

Table 7.1 Actions and Timing for Supplementary Plantings/ Revegetation of Forested EECs

Number	*Action*	*Methodology*	*Timing*
Site Preparation			
1	Site Selection	Suitable areas for supplementary plantings shall be determined based on Section 7.1.1 by a suitably qualified ecologist or bush regenerator. Areas selected are to be marked by flagging tape or pegs.	Immediately prior to preparatory weed control.

Number	Action	Methodology	Timing
2	Weed Control	All noxious weeds shall be managed in accordance with the relevant legal requirements for the far North Coast County Council weed control area and control methods shall follow Section 8.6.	Ongoing until handover to Council according to the schedule in
3	Weed Control	Treat groundcover weeds (grass and herbaceous weeds) with a glyphosate-based herbicide. Herbicides such as Roundup Biactive®, Weedmaster® Duo are recommended for use in proximity to waterways or wetland areas. ▪ The area to be free of weeds consists of a minimum 50 cm diameter around each location to receive tubestock. ▪ Ensure that the area to be sprayed does not support HJG.	Prior to planting – ensuring enough time (minimum 2 weeks) has elapsed for the herbicide to take full effect.
Planting			
4	Ground preparation	▪ The planting hole should be prepared by loosening the soil to at least twice the depth of the plant tube. ▪ 100-150 grams of slow-release fertiliser suitable for native plants with appropriate low phosphorus levels should be added to each planting hole to assist in plant establishment.	Immediately prior to planting and fertilising.
5	Planting	▪ Planting of suitable species is to be undertaken according to the species in Table 7.3 at the densities specified. ▪ Planting is to be carried out when soil moisture is high – either in the second half of summer or autumn, or following a substantial rainfall event in excess of 50 mm.	Late summer or autumn or alternatively following a substantial rainfall event of 50 mm or more.
6	Watering	Water plants during and after planting. At least 5 litres of water should be allowed per plant to settle soil and provide moisture for establishment.	Immediately following planting and prior to mulching.
7	Mulching	▪ Apply weed-free organic mulch to bare areas to limit weed regrowth. ▪ Replenish mulch around each plant (each spring)	Mulching would continue until handover to Council.
8	Installation of tree guards	Immediately after planting and mulching	Immediately following planting and mulching
Maintenance			
9	Watering	▪ Water plants during and after planting. At least 5 litres of water should be allowed per plant to settle soil and provide moisture for establishment. ▪ Watch closely for early signs of wilting and rewater the trees at approximately weekly intervals until good rain has occurred	Watering should not be necessary after 2 months and / or a reasonable wet season

Number	Action	Methodology	Timing
10	Weed Control	▪ Keep the planting areas free of weeds (treatment methods as specified in Section 8.6. Recommend a glyphosate-based herbicide to treat generic grass and herbaceous weed regrowth). ▪ Herbicides such as Roundup Biactive®, Weedmaster® Duo are recommended for use in proximity to waterways or wetland areas.	Quarterly for the first 24 months and every 6 months following this once established and until handover to Council (as part of the standard weed control for the site that will be undertaken – Section 8 and WMP of the EMP). Regular monitoring of weeds as per Section 10 to be undertaken, with the results of weed monitoring to be incorporated into routine weed control activities.
11	Replanting and Replacing Tree Guards	▪ Replant to replace for losses where more than 10% of plants have perished. ▪ Use planting methods above and refer to the plant lists which follow. ▪ Straighten or replace tree guards that have become detached or which have been damaged.	Ongoing until handover to Council.
12	Monitoring and reporting	As prescribed in Section 10.	▪ As part of the annual monitoring report provided to OEH. ▪ A report would also be provided to Council on handover.

Note: a number of the measures in this table are sourced from 'Bush Regeneration – Recovering Australian Landscapes' (Buchanan 1994)

7.1.2 Supplementary Plantings within Freshwater Wetlands EEC

Supplementary plantings of species within the area of the Conservation Zone supporting Freshwater Wetlands EEC will be targeted into areas that are degraded and have significant weed infestation. The aims of undertaking these supplementary plantings are to:

- discourage future weed infestations;
- improve native plant cover; and
- enhance native species composition.

The methodology for undertaking supplementary plantings within Freshwater Wetlands EEC is distinct from that for revegetation within forested EECs and therefore is specified separately in Table 7.2.

Table 7.2 Actions and Timing for Supplementary Plantings in Freshwater Wetlands EEC

Number	*Action*	*Methodology*	*Timing*
Site Preparation			
1	Site Selection	Suitable areas for supplementary plantings shall be determined based on Section 7.1.2 by a suitably qualified ecologist or bush regenerator. Areas selected are to be marked by flagging tape or pegs.	Immediately prior to preparatory weed control.
2	Weed Control	All noxious weeds shall be managed in accordance with the relevant legal requirements for the far North Coast County Council weed control area and control methods shall follow Section 8.6.	Ongoing until handover to Council according to the schedule in
3	Weed Control	Hand-weed areas to be replanted. If herbicide-based control is necessary, use an approved herbicide that has a low impact on waterways and wetlands such as Roundup Biactive®, Weedmaster® Duo. Due to the relatively small size of the wetland plants to be planted, the area to be free of weeds consists of a minimum 25 cm diameter around each location to receive tubestock. ▪ Ensure that the area to be planted do not support existing populations of HJG or SSSR.	Prior to planting – ensuring enough time (minimum 2 weeks) has elapsed for any herbicide used to take full effect.
Planting			
4	Planting	▪ Planting of suitable species is to be undertaken according to the species in Table 7.3 at the densities specified. ▪ In areas of standing water, ensure that roots are firmly rooted in the soil beneath the water surface. In drier areas hand dig a small hole to plant into. ▪ Planting is to be carried out when soil moisture is adequate and not during the dry spring period. ▪ No fertiliser is to be added to plant holes as this could adversely effect on the nutrient balance of the wetland and encourage weed growth.	Any time of year excluding the dry spring period.
5	Mulching	Apply weed-free organic tea-tree mulch to bare areas to limit weed regrowth.	Annually
6	Installation of Plant Protection	For smaller plants it may be necessary to net over the planted area to discourage water birds from ripping the plants out.	Immediately following planting

Number	Action	Methodology	Timing
Maintenance			
7	Weed Control	▪ Keep the planting areas free of weeds (treatment methods as specified in Section 8.6. for noxious and environmental weeds. ▪ Hand-weed where possible and where not use an approved herbicide that has a low impact on waterways and wetlands such as Roundup Biactive®, Weedmaster® Duo.	Quarterly for the first 24 months and every 6 months following this once established and until handover to Council (as part of the standard weed control for the site that will be undertaken – Section 8 and WMP of the EMP). Regular monitoring of weeds as per Section 10 to be undertaken, with the results of weed monitoring to be incorporated into routine weed control activities.
8	Replanting	▪ Replant to replace for losses where more than 10% of plants have perished. ▪ Use planting methods above and refer to the plant lists which follow.	Ongoing until handover to Council.
9	Mulch	Apply weed-free organic mulch to bare areas	Annually
10	Monitoring and reporting	As prescribed in Section 10	▪ As part of the annual monitoring report provided to OEH. ▪ A report would also be provided to Council on handover.

7.2 Species Selection

7.2.1.1 Species Selection

Plants are to be sourced from local, licensed nurseries to avoid planting stock with inadequate genetic diversity. Plants will have local provenance from seed sourced from natural wild populations as close as possible to the site. Plants will be supplied as tubestock that is healthy, sun-hardened and not root-bound.

Planting densities were determined on the following basis:

- Littoral Rainforest EEC planting density was determined according to the suggested spacing of plants in the manual "*Subtropical Rainforest Restoration*" produced by the Big Scrub Rainforest Landcare Group [BSRLG] (2005). An average density for rainforest plantings of 2.5 m was selected, which is in the middle of the range of 1.5 – 4 m suggested in the BSRLG guidelines.
- Littoral Rainforest EEC incorporating HJG is to be planted at the same density as that specified for Littoral Rainforest. The overall density of the entire revegetated area will be lower, because the HJG areas between the planted patches of vegetation effectively lower the overall density.
- Swamp Oak Forest EEC and Swamp Sclerophyll Forest EEC planting density was determined to be 4 m, less than that for Littoral Rainforest EEC, reflecting the more open nature of these communities.
- Freshwater Wetlands planting density reflects the dense nature of wetland vegetation and was determined to be 1 m.

Species lists and planting densities for each community to be revegetated is provided in Table 7.3.

Table 7.3 Species List for each Community to be Revegetated and density of Plantings

Community		
Common Name	***Scientific Name***	***Number Of Plants / Planting Area***
Littoral Rainforest EEC (and Littoral Rainforest EEC incorporating HJG)		
Beach Acronychia	*Acronychia imperforata*	300
Beach Bird's Eye	*Alectryon coreaceus*	300
Black Wood	*Acacia melanoxylon*	240
Blue Lilly Pilly	*Syzygium oleosum*	300
Brown Kurrajong	*Commersonia bartramia*	480
Celery Wood	*Polyscias elegans*	300
Foambark	*Jagera pseudorhus*	300
Guioa	*Guioa semiglauca*	600
Hairy Walnut	*Endiandra pubens*	300
Large Mock Olive	*Notelaea longifolia*	300
Red Kamala	*Mallotus phillipensis*	480
Riberry	*Syzygium leuhmannii*	300
Scentless Rosewood	*Synoum glandulosum*	300
Three-Veined Cryptocarya	*Cryptocarya triplinervis* var. *triplinervis*	600
Tuckeroo	*Cupaniopsis anacardiodes*	600
Umbrella Cheese Tree	*Glochidion sumatranum*	480
White Bean	*Ailanthus triphysa*	300
		5940 (3.3 ha) within Littoral Rainforest EEC revegetation areas and 540 (0.6 ha) within areas incorporating HJG = 6480 in Total
Swamp Oak Forest EEC		
Swamp Oak	*Casuarina glauca*	60
Umbrella Cheese Tree	*Glochidion sumatranum*	40
Cheese Tree	*Glochidion ferdinandi*	20
Broad-leaved Paperbark	*Melaleuca quinquenervia*	10
Red Ash	*Alphitonia excelsa*	30
Tuckeroo	*Cupaniopsis anacardioides*	20
		180 (0.3 ha)
Swamp Sclerophyll Forest EEC		
Pink-flowered Doughwood	*Melicope elleryana*	8
Umbrella Cheese Tree	*Glochidion sumatranum*	6
Swamp Oak	*Casuarina glauca*	6
Small-leaved Fig	*Ficus obliqua*	4
Blackwood	*Acacia melanoxylon*	4
Brush Ironbark Wattle	*Acacia disparrima*	4
Swamp Turpentine	*Lophostemon suaveolens*	4
Willow Bottlebrush	*Callistemon salignus*	4
Broad-leaved Paperbark	*Melaleuca quinquenervia*	20

Community		
Common Name	***Scientific Name***	***Number Of Plants / Planting Area***
		60 (0.1 ha)
Freshwater Wetlands EEC		
Soft Twigrush	*Baumea rubiginosa*	800
Bunchy Sedge	*Cyperus polystachyos*	800
a Spikerush	*Eleocharis equisetina*	800
Red-fruit Saw-sedge	*Gahnia sieberiana*	100
Juncus	*Juncus usitatis*	100
Frogsmouth	*Philydrum lanuginosum*	400
Restio	*Restio tetraphullus* subsp. *meiostachyus*	700
River Club-rush	*Schoenoplectus validus*	700
A Rush	*Schoenus brevifolius*	700
		5000 (0.5 ha)

7.3 Summary of EEC Establishment

Over time, as the areas of revegetation establish and mature, the total area of EECs across the Pacific Pines site will be increased. The area of existing EEC in the Conservation Zone and the extra established areas are summarised in Table 7.4.

Table 7.4 Summary of EECs Retained and Established within the Conservation Zone

EEC	***Existing area within the Conservation Zone (ha)***	***Additional area established by revegetation (ha)***
Littoral Rainforest	2.4	3.9
Swamp Sclerophyll Forest EEC	0.3	0.1
Swamp Oak Forest EEC	0.0	0.3
Freshwater Wetland EEC	4.4	0

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8

Weed Management Strategy

8.1 Aim and Introduction

This weed management strategy provides an overview of weed infestation in the Conservation Zone and details treatment approaches to minimise the negative impacts of weeds on the ecological values of this area.

The primary aims of this strategy are to:

- control declared noxious weeds;
- minimise the extent of environmental weed infestation in existing areas of native vegetation;
- create a weed-free area prior to revegetation; and
- minimise negative impacts of weed grasses on HJG and SSSR recovery and establishment.

A detailed weed survey of the entire site was conducted by a GeoLINK ecologist in spring 2011. Significant weed species recorded during this survey in the Conservation Zone are listed in Table 8.1.

Table 8.1 Significant Weed Species in the Conservation Zone

Family	***Scientific Name***	***Common Name***
Asteraceae	*Ageratina adenophora*	Crofton Weed
Asteraceae	*Ageratina riparia*	Mistflower
Asparagaceae	*Asparagus aethiopicus*	Asparagus Fern
Asteraceae	*Baccharis halimifolia*	Groundsel Bush
Lauraceae	*Cinnamomum camphora*	Camphor Laurel
Fabaceae	*Desmodium uncinatum*	Silver-leaved Desmodium
Saliaceae	*Flacourtia indica*	Governors Plum
Convolvulaceae.	*Ipomoea cairica*	Coastal Morning Glory
Poaceae	*Kikuyu clandestinum*	Kikuyu
Verbenaceae	*Lantana camara*	Lantana
Rutaceae	*Murraya paniculata*	Orange Jessamine
Haloragaceae	*Myriophyllum aquaticum*	Parrots Feather
Davalliaceae	*Nephrolepis cordifolia*	Fishbone Fern
Oleaceae.	*Olea europaea subspecies cuspidata*	African Olive
Commelinaceae	*Tradescantia fluminensis*	Wandering Jew
Poaceae	*Paspalum urvillei*	Vasey Grass
Fabaceae (Caesalpinioideae)	*Senna pendula var. glabrata*	Winter Senna
Poaceae	*Setaria sphacelata*	South African Pigeon Grass
Solanaceae	*Solanum mauritianum*	Wild Tobacco Bush
Solanaceae	*Solanum viarum*	Tropical Soda Apple
Solanaceae	*Solanum seaforthianum*	Climbing Nightshade

Weeds are classed into broad groups depending on their characteristics and potential impacts. The main groups of weeds are:

- Noxious Weeds (as listed under the *Noxious Weeds Act 1993*).
- Weeds of National Significance (WoNS).

- National Environmental Alert List Weeds.
- Environmental Weeds.
- Agricultural Weeds.

8.2 Noxious Weeds

Noxious weeds declared under the *Noxious Weeds Act 1993* are required by law to be controlled by all landholders within a given control area. Five listed 'noxious weed' species listed under the Ballina Control Area (NSW DPI 2011) were detected at the site. One of these species, Lantana is also listed as a 'Weed of National Significance'.

No listed 'National Environmental Alert List Weeds' were detected in the Conservation Zone. Noxious Weeds / WoNS and relevant control requirements are listed in Table 8.2.

Table 8.2 Noxious Weeds in the Conservation Zone with Control Requirements

Scientific Name	*Common Name*	*Listing*	*Control Requirements*
Ageratina adenophora	Crofton Weed	N4	The growth and spread of the plant must be controlled according to the measures specified in a management plan published by the local control authority.
Baccharis halimifolia	Groundsel Bush	N3	The plant must be fully and continuously suppressed and destroyed.
Cinnamomum camphora	Camphor laurel	N4	As for other N4 weeds.
Lantana camara	Lantana	N4, WONS	As for other N4 weeds.
Solanum viarum	Tropical Soda Apple	N2	The plant must be eradicated from the land and the land must be kept free of the plant. The weeds are also "notifiable" and a range of restrictions on their sale and movement exist.

8.3 Agricultural and Environmental Weeds

A variety of weed species that are not listed under the Noxious Weeds Act but are considered to be environmental or agricultural weeds were identified at the site. Occurrences of such species are summarised as follows:

- A number of infestations of Governors Plum (*Flacourtia indica*) are located in the lower stratum of littoral rainforest remnants occurring at the site. This species appears to proliferating at the site and should be a control priority.
- Occurrences of Asparagus Fern (*Asparagus aethiopicus*) and Silver-leaved Desmodium (*Desmodium uncinatum*) are present within the understorey of littoral rainforest remnants. These species are expected to proliferate after the exclusion of cattle.
- Infestations of Coastal Morning Glory (*Ipomoea cairica*) and Climbing Nightshade (*Solanum seaforthianum*) are present within areas of Swamp Oak (*Casuarina glauca*) forest. Dense infestations of woody weeds including Lantana, Groundsel Bush, Wild Tobacco Bush (*Solanum mauritianum*) and Winter Senna (*Senna pendula var. glabrata*) are also present.
- Occurrences of Vasey Grass (*Paspalum urvillei*) and Pigeon Grass (*Setaria sphacelata*) are present around the fringes of the freshwater wetland. These species are expected to proliferate after the exclusion of cattle from the site and have the potential to out-compete the threatened species, Hairy Jointgrass (*Arthraxon hispidus*) and Square-stemmed Spike Rush (*Eleocharis tetraquetra*) which occur within the Conservation Zone.

8.4 Aquatic Weeds

A number of aquatic weeds were detected within drainage lines and in the water quality control ponds which are surrounded by the Conservation Zone. There is a risk that these aquatic weeds may proliferate during favourable conditions. At the time of survey (spring 2011), the dominant aquatic weed species recorded were Parrots Feather (*Myriophyllum aquaticum*) within drainage channels associated with the site and Cape Water Lily (*Nymphaea caurulea*) within the water quality control ponds.

The water control ponds at the site are known to have regular infestations of Cape Water Lily and Hairy Commelina (*Commelina benghalensisi*), which require removal to maintain the functioning of the ponds.

8.5 Potential Weed Impacts

8.5.1 General Impacts

The principle mechanisms for weeds establishing in areas associated with developments include:

- elevated nutrients entering natural environments from stormwater run-off;
- physical disturbance to the soil from the general construction process;
- increased soil moisture from shading / reduced water infiltration;
- increased light at the margins of vegetation;
- disposal of garden waste into natural environments; and
- planting of invasive plants in new gardens.

Additionally, the removal of cattle from the site may favour the proliferation of certain weed species, particularly in areas of vegetation to be retained at the site and open areas, including within the designated Conservation Zone.

8.5.2 Impacts During Construction

The construction phase of the project represents a high risk period for the spread and proliferation of weeds at the site. Key risks related to the spread of weeds during this stage of the project are:

- spread of weeds to / from the site or throughout the site by plant and machinery;
- weeds proliferating in exposed areas of soil after clearing or stripping of groundcovers; and
- inappropriate treatment / disposal of weeds.

8.5.3 Impacts within Areas of Retained Vegetation

There is a significant risk of weed proliferation in areas of retained vegetation within the Conservation Zone. Areas of littoral rainforest and Camphor Laurel forest are expected to experience an increase in lower storey and vine weeds, including Asparagus Fern and Silver-leaved Desmodium. Additionally, shrubby weeds such as Privet, Lantana, Camphor Laurel and Governors Plum are expected to spread if not controlled. The removal of cattle will favour the spread of weeds, including Pigeon Grass and Vasey Grass.

8.6 Weed Control Techniques

A summary of weed control actions for the Conservation Zone are detailed in Table 8.3. Recommended weed control techniques for weed species occurring within the Conservation Zone are included within 0. Some of the factors that have been taken into account in selecting weed control techniques include the following (Big Scrub Rainforest Landcare, 2005):

- the growth habit of the weed and its means of propagation;
- the size of the weed and the time in its lifecycle;
- predicted weather / climatic conditions;
- adjacent plants including threatened species / EECs;

- whether the use of herbicide is deemed appropriate;
- the value of the weed as habitat for fauna.

Table 8.3 Summary of Weed Control Actions for the Conservation Zone

Primary Target Species		***Actions Required***
Exotic Vine and Understorey Species	Tropical Soda Apple, Lantana, Orange Jessamine, Asparagus Fern, Winter Senna, Silver-leaved Desmodium, Crofton Weed, Mistflower, , Governors Plum, Fishbone Fern.	▪ Eradication of all exotic vine and understorey weeds occurring associated with remnant vegetation. Priority weed species include Tropical Soda Apple, Camphor Laurel saplings, Silver-leafed Desmodium, Winter Senna, Lantana, Asparagus Fern, Governors Plum and Fishbone Fern ▪ Selective spot-spraying of weeds associated with the drainage line in suitable conditions to avoid spraying of threatened species. These works are to be supervised by an ecologist to ensure overspray is minimised. Some hand-weeding may also be required and will be specified by the ecologist. ▪ Spot spraying of Lantana, Crofton Weed and Mistflower located around the periphery of remnant vegetation.
Mature Woody Weeds	Camphor Laurel, African Olive, Tobacco Bush.	▪ Spray, cut and paint and hand weed species (including Lantana, Tobacco Bush etc.) occurring within the zone during winter to avoid impacts to Hairy Jointgrass and Square-stemmed Spike Rush. ▪ Control of all Camphor Laurel and African Olive trees within the Conservation Zone using stem injection of herbicide. NB. Dead woody weed material is to be removed from the site to maximise areas for rehabilitation of Hairy Jointgrass and Square-stemmed Spike Rush.
Grass Weeds	Pigeon Grass, Vasey Grass, and Kikuyu	▪ Target spot spraying of Pigeon Grass and Vasey Grass during winter using a knapsack to avoid impacts to threatened species.

Table 8.4 Weed Control Techniques

Weed Species		***Treatment***	***Notes***
Common Name	***Scientific Name***		
Asparagus Fern	*Asparigus africanus*	Crowning, cut stems at chest height, then at ground level, spray regrowth *glyphosate* 1:50 +Protec.	Best done summer / autumn
Camphor Laurel	*Camphora cinnamomum*	Stem inject 1:1.5 larger trees, cut scrape and paint 1:1.5 small plants. Spray seedlings *glyphosate* 1:50+Protec.	Larger plants may require several treatments. Best treated during growing periods
Coastal Morning Glory	*Ipomoea cairica*	Hand pull, cut scrape and paint 1:1.5 *glyphosate*. Roll up vines, spray	
Crofton Weed	*Ageratina adenophora*	Spray *glyphosate* 1:100+Protec. Alternatively hand pull and hang up.	Treat all year round.
Fishbone Fern	*Nephrolepis cordifolia*	Hand-pull plant; follow up required: spray with metsulfuron (1.5 g:10 ltrs)	

Weed Species		Treatment	Notes
Common Name	**Scientific Name**		
Groundsel Bush	*Baccharis halimifolia*	Cut and paint 1:1.5 *glyphosate.*	Best done before flowering in autumn
Lantana	*Lantana camara*	Lop and cut, scrape and paint base 1:1.5 . Spray regrowth *glyphosate* 1:100+Protec.	Treat all year round.
Madeira Vine	*Andredera cordifolia*	Scrape as much stem as possible (on one side) and paint with 100% *glyphosate*, tubers: scrape/gouge and paint (100%): spray ground infestation 1:50 +Protec. Bag tubers.	Do not cut the stem. Treat all year round.
Mist Weed	*Ageratina riparia*	Spray *glyphosate* 1:100+Protec. Hand pull and hang up.	Treat all year round.
Orange Jessamine	*Muraya paniculata*	Cut, scrape and paint (1:1.5) *glyphosate* or spray *glyphosate* 1:100	
Pigeon Grass	*Setaria sphacelata*	Hand pull or dig up. Spray *glyphosate* 1:100+Protec.	
Silver-leaved Desmodium	*Desmodium uncinatum*	Plants : hand pull or crown, cut, scrape and paint tuberous roots (G 1:1.5). Spray *glyphosate* 1:50+Protec.	
Tobacco Bush	*Solanum mauritianum*	Stem inject 1:1.5 larger trees. Cut scrape and paint 1:1.5. Spray seedlings *glyphosate* 1:100+Protec.	Treat all year round.
Vasey Grass	*Paspalum urvillei*	Hand pull or dig up. Spray *glyphosate* 1:100+Protec.	
Wandering Jew	*Tradescantia fluminensis*	Collect and bag or roll and rake carefully, then compost or place in bin, or spray *glyphosate* 1:100+Protec.	
Winter Senna	*Senna pendula*	Hand pull young plants or spray seedlings *glyphosate* 1:50+Protec. Cut, scrape and paint 1:1.5. Stem inject large specimens 1:1.5.	

8.7 General Weed Management Actions

Regular weed control works to be undertaken every six months, targeting the control of noxious and environmental weeds occurring throughout the Conservation Zone. Additionally, a number of broad measures have been developed to ameliorate the potential impacts of the proposal on weeds. General weed management actions are provided in Table 8.5.

Table 8.5 Weed Management Actions for the Conservation Zone

Number	*Management Action*
Construction Phase	
1	All noxious weeds shall be managed in accordance with the relevant legal requirements for the far North Coast County Council weed control area and control methods shall follow Section 8.6.
2	Environmental weeds to be targeted for control along with recommended treatment methods shall follow Section 8.6.
3	Sub-contractors to be used for weed control works are to be advised of all requirements stated within this weed management plan and ecological constraints associated with the site. These should be conveyed to the contractor as part of a toolbox induction.
4	Weeds species cleared are to be disposed of at an appropriate green waste facility. Any vehicle transporting weeds to a green waste facility are to be covered to prevent the spread of weeds.
5	All vehicles / plant are to be cleaned prior to working on site and before leaving site to minimise the spread of weeds.
Operational Phase	
6	The use of herbicides within the Conservation Zone is to be undertaken primarily in winter to minimise potential impacts on threatened species.
7	Regular monitoring of weeds as per Section 9 to be undertaken, with the results of weed monitoring to be incorporated into routine weed control activities.
8	Residents are to be provided with the Ballina Shire list of suitable and unsuitable garden plants and information on appropriate disposal of garden waste at an approved waste transfer facility rather than within natural environments.
9	Lawn fertilisers are not be stockpiled / spread within 40 m of drainage lines to control the release of excess nutrients into natural environments.
General Requirements	
10	Herbicide is not to be sprayed in windy conditions (>16 km/h) to prevent overspray entering waterways or impacting threatened flora species habitat.
11	Weedmaster Duo or Roundup Biactive is to be used in proximity to waterways / drainage lines to reduce potential toxicity on aquatic fauna and ecosystems.
12	Weed control within the Conservation Zone and buffer is to be preferably undertaken using the cut/paint method or manual removal to avoid overspray affecting threatened flora species. If spraying is required, works are to be undertaken during suitable conditions with a knapsack sprayer during winter (the dormancy period for HJG and SSSR) to minimise potential impacts to these species.
13	Sub-contractors to be used for weed control works are to be advised of all requirements stated within this CZMP and ecological constraints associated with the site as part of an induction.

8.8 Timing of Weed Control Works

Weed control works prescribed by this strategy are to commence upon approval of the CZMP. At least two weed control sessions are to be conducted each year, one being in winter to allow for some limited weed control works within areas of the Conservation Zone supporting HJG and SSRR(during the dormancy period of these species).

Weed control at the site will continue until handover of the public areas, or as otherwise agreed by the Department, following consideration of the results of monitoring.

The developer will be responsible for ensuring that the measures contained within this weed strategy are undertaken in accordance with the timeframes proposed.

Given that primary weed control areas are located largely within areas of retained vegetation on the site, weed control works are to be undertaken by a qualified bush regenerator with a current Section 132 C license as required by the Office of Environment and Heritage (OEH) to ensure that appropriate techniques are utilised.

The selected sub-contractor is to be briefed on ecologically significant areas occurring at the site and the requirements of this CZMP.

8.9 Monitoring

Regular monitoring of weeds will be undertaken as detailed in Section 10 (also refer to the Monitoring Plan for the site [Appendix D of the EMP]). The results of monitoring sessions will generate recommendations for future weed control works which are to be actioned as part of ongoing weed management at the site. The developer is to be responsible for ensuring recommendations developed as part of weed monitoring are undertaken as part of weed control activities.

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9

Water Management Plan

9.1 Approval Requirement

Part 7 of Condition B2 outlines the requirements for a Water management Plan:

> *A Water Management Plan that addresses the manner in which the hydrological regime of the Freshwater wetlands EEC and associated threatened species will be maintained throughout the life of the project and is to include, but not be limited to:*
>
> *a) An assessment of the pre-development hydrological regime including surface and groundwater inflows and outflows;*
>
> *b) Measures to be implemented to ensure the pre-development hydrological regime is maintained;*
>
> *c) Mapping of the extent of the seepage areas and measures to ensure their ongoing protection; and*
>
> *d) Detailed design, installation and maintenance methods of the proposed weirs and other infrastructure identified in Illustration C7 dated 14/8/2008 to ensure the maintenance of the existing hydrological regime.*

9.2 Management Plan

The Water Management Plan addressing the requirements of the Minister's approval has been prepared by Gilbert and Sutherland, specialist hydrologists. Their report is contained in full in Appendix A.

Gilbert and Sutherland undertook a detailed assessment of the site, resulting in modelling of the existing, pre-development, hydrological regime. This involved a number of sub-surface bores, supplemented by a detailed analysis of existing landform, soils, slope and vegetation.

MEDLI modelling was undertaken to estimate the deep drainage component of the pre-development landscape, providing a basis for identifying the reduction in recharge due to development of hardstand on the site. MEDLI was also used to determine the irrigation requirement to maintain the seepage areas at field capacity.

Based on the detailed site analysis, Gilbert and Sutherland have worked with the project engineers to develop a bio-filtration / infiltration system, to be constructed at the southern edge outside the Conservation Zone as part of the Stage 1A residential subdivision. This system will ensure appropriate seepage replacement that will ensure continued water source for the freshwater wetland.

As outlined in the Gilbert and Sutherland report (Appendix A), the MUSIC modelling undertaken to test the proposed system identified that at the completion of development, a total of approximately 229.06 ML/yr will be discharged to the wetland from the bio-filtration / infiltration system. This exceeds both the irrigation requirement and deep drainage replacement estimated by the MEDLI modelling to ensure that the pre-developed field capacity of the seepage areas is maintained. This will ensure the ongoing maintenance of wetland conditions in the central part of the Conservation Zone.

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10

Mapping and Monitoring of Conservation Zone Outcomes

10.1 Background

An important component of the Conservation Zone rehabilitation strategy is ensuring that an adequate mapping and monitoring program is in place to identify ecological changes that will occur within the Conservation Zone over time.

Part 2 of Condition B2 outlines the requirements for monitoring and mapping of HJG and SSSR in the Conservation Zone:

> *A program for the mapping and monitoring of the location and density of Hairy Joint Grass and Square-stemmed Spike Rush*

This section will address this condition, and also more broadly outline a monitoring strategy for identifying changes in the vegetation within the Conservation Zone.

The monitoring plan will comprise the following stages:

- Pre-development: Baseline data will be collected prior to the commencement of any construction activities.
- Construction Phase: Monitoring events will be undertaken every six months during the construction phase of the project until all major construction works are completed at the site.
- Operational Phase: This monitoring phase will consist of biannual monitoring for five years after the release of the final subdivision certificate or as otherwise agreed by the Department of Planning (DoP) following on from the results of the monitoring plan.

10.2 Monitoring Methods

The primary methods for monitoring will comprise quadrat sampling, transect sampling and photo point monitoring. Monitoring will be undertaken annually.

10.2.1 Quadrat Sampling

Quadrat sampling will involve establishment of a number of 10 m x 10 m quadrats within representative areas of forested vegetation (including revegetation areas) and 5 m x 5 m quadrats at monitoring locations within treeless communities (such as Freshwater Wetland EEC and HJG/ SSSR translocation areas) as shown in Illustration 10.1. Where locating a 10 m x 10 m quadrat is not feasible due to the linear nature of an area, an elongated monitoring plot of equal area will suffice.

A permanent marker consisting of a steel star-post will be established on the north-east corner of each quadrat and a metal tag attached indicating the quadrat number and size. The following data will be collected within each quadrat:

- Flora species present (including weeds).
- Life form of species (tree, tall shrub, low shrub, grass/ lily).
- Percentage cover of all flora species, using a Braun Blanquet cover class rating as shown in Table 10.1.
- The diameter at breast height (DBH) of all trees (woody plants with a DBH >10 cm).

- Presence of dead plants (and identification of species if possible).
- Signs of plant discoloration / disease.
- Notes of any regeneration of native species occurring.
- General comments on the condition / health of vegetation community.

Table 10.1 Braun Blanquet Cover Classes

Braun Blanquet Score	*Cover Class*
1	<5%
2	5-25%
3	25-50%
4	50-75%
5	>75%

Datasheet proformas to be used for quadrat monitoring are provided in Appendix B.

10.2.2 Transect Sampling

In addition to 5 m x 5m quadrats which will be used to monitor HJG and SSSR, transects will be used to monitor changes in the condition and composition of vegetation within the Conservation Zone and to identify any changes in the boundaries of vegetation communities that may occur following removal of cattle from the site and construction of the estate. This will involve establishment of three 25 m x 5 m transects at monitoring locations shown in Illustration 10.1. Each transect will effectively consists of 5 contiguous quadrats with dimensions of 5 m x 5 m (total transect length 25 m).

Permanent markers consisting of steel star-posts will be established at the start and end of each transect and a metal tag attached indicating the transect number and start / finish point. Data collected within each 25 m x 5 m transect will consist of the same components collected in quadrats.

Datasheet proformas to be used for transect monitoring are provided in Appendix B.

10.2.3 Photo Point Monitoring

Photo point monitoring will be undertaken to assist in the determination of vegetation condition change. During each monitoring survey, photos will be taken at both ends of all transects (facing parallel to the transect) and at the north-east corner of each quadrat (facing south-west).

All photos will be taken from approximately 1.6 m above the ground and effectively display the nature of the vegetation within the quadrat or transect.

Information shown is for illustrative purposes only

Drawn by: TJP Checked by: MVE Reviewed by: DGH Date: August 2012
Source of base data: Ballina Shire Council

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North

Proposed Monitoring Locations

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10.3 Specific Procedures

10.3.1 Threatened Flora Species

10.3.1.1 Rough-shelled Bush Nut, Red Lilly Pilly and Arrow-head Vine

A selection of locations supporting subject threatened flora species will be monitored using 10 m x 10 m quadrat surveys. The quadrat locations have been positioned to include these species (refer to Illustration 10.1). A number of the threatened species monitoring locations purposefully coincide with EEC monitoring locations, and are labelled as combined EEC and threatened species quadrats in Illustration 10.1. Data collected within each of these quadrats will include:

- confirmation of the presence of all threatened flora species. These will be numbered and marked (with metal tags) during baseline surveys to allow for comparisons of survey results;
- an assessment of foliage vigour for threatened flora species within the quadrat using the following scoring method (*1-dead, 2-poor condition / discoloured, 3-minor discoloration, 4-good condition, 5-excellent condition*);
- vegetation community composition (using parameters stated in Section 10.2.1);
- an assessment of general vegetation community health using the scoring method as stated above;
- degree of weed infestation; and
- photographs of all threatened flora individuals within the quadrat to allow for comparisons of health / condition over time.

10.3.1.2 Hairy Jointgrass (HJG) and Square-stemmed Spike Rush (SSSR)

Two primary methods will be used to monitor these species:

- annual survey and mapping of the distribution of HJG and SSSR within the designated Conservation Zone; and
- quadrat surveys utilising 5 m x 5 m quadrats.

Distribution Mapping

A target survey and mapping of HJG and SSSR will be undertaken within the Conservation Zone to coincide with the growing / seeding period for both species (February-April). Survey methods for both species will replicate the methodology used previously at this site by GeoLINK in 2011-2012. A summary of these methods is provided below.

Line transects 5 m apart will be walked within the Conservation Zone, with all locations of SSSR and HJG marked with a hand-held GPS. Where larger areas of HJG and SSSR are encountered GPS points will be taken every 2-3 m to allow for the distribution of occurrences to be identified. A GIS map layer of the distribution of threatened species within the Conservation Zone will be generated and overlayed on previous years distributions to detect changes over time.

Quadrat Surveys

Quadrats (5 m x 5 m) will be established within known areas of HJG and SSSR in the Conservation Zone. Data collected within the quadrat will include:

- counts of HJG and SSSR plants occurring within the quadrat;
- an assessment of foliage vigour for HJG and SSSR within the quadrat using the following scoring method (*1-dead, 2-poor condition / discoloured, 3-minor discoloration, 4-good condition, 5-excellent condition*);
- vegetation community composition (using parameters stated in Section 10.2.1);
- photographs of example HJG and SSSR individuals within the quadrat; and
- photographs of the general vegetation within the quadrat (taken from the north-east corner).

Quadrat Surveys will also aim to provide information on the success or otherwise of SSSR enhancement by biomass removal using the same method as outlined for HJG (refer to Section 5.3). If successful, this management technique will be adopted for future enhancement of SSSR. If unsuccessful, other methods of enhancement may need to be trialled including for example, improved weed control or removal of competitive wetland species.

10.4 Endangered Ecological Communities (EECs)

Monitoring of retained EECs within the Conservation Zone will be undertaken using quadrat surveys. Data to be collected will be as stated in Section 10.2.1. Transect surveys will also be used to detect changes in the Freshwater Wetland EEC in the Conservation Zone as detailed in Section 10.2.2. The location of proposed EEC monitoring locations is shown in Illustration 10.1.

10.5 Weeds

The density of weeds within monitoring quadrats/ transects will be collected during each monitoring session. Any opportunistic observations of weeds that are located outside of specific quadrat/ transects will be recorded to inform a 'priority weed map' for the Conservation Zone. The extent of these weed infestations will be recorded with a hand-held GPS unit.

A simple map showing the locations of priority weeds will be prepared for each monitoring report. This map will be provided to weed control contractors to inform future weed control works.

10.6 Translocation of Threatened Species

Recipient sites in which HJG or SSSR have been translocated are to be monitored to record the success of the translocation. The following methodology will be undertaken:

A quadrat (5 m x 5 m) will be established within each HJG and SSSR recipient site in the Conservation Zone as shown in Illustration 10.1. Data collected within the quadrat will include:

- counts of HJG/ SSSR plants occurring within the quadrat;
- density of HJG/ SSSR plants occurring within the quadrat;
- an assessment of foliage vigour for HJG/ SSSR within the quadrat using the following scoring method (*1-dead, 2-poor condition / discoloured, 3-minor discoloration, 4-good condition, 5-excellent condition*);
- vegetation community composition (using parameters stated in Section 10.2.1); and
- photographs of the general vegetation within the quadrat (taken from the north-east corner).

The distributions of these threatened species across seasons are variable depending on environmental conditions, particularly for HJG. To account for some of this variability, success or failure will be based on a significant deviation from a baseline vegetative cover. This baseline vegetative cover will be measured at 12 months following the translocation event. Subsequent monitoring events will re-measure this vegetative cover and if a reduction of more than 20% is recorded remedial management actions should be developed.

These management actions will be based around:

- improved weed management techniques; and
- re-assessment of biomass removal techniques.

10.7 Revegetation Areas

Monitoring data will be broadly collected on the state of the revegetation areas. This information will provide information on the success or otherwise of these revegetation plantings. No set monitoring quadrats will be established for revegetation area, and instead information collected will be qualitative and consist of information such as the health of plants, evidence or damage or death of plants, the need to replace tree-guards or mulch, and the degree of weed infestation. This data will feed into maintenance requirements for the revegetation areas, including weed control and replacement plantings.

10.8 Data Analysis

Data collected during the construction and operational phases will be directly compared to baseline data to detect changes in the health / condition of vegetation of the Conservation Zone. Key indicators of change are as follows:

- changes in native vegetation species numbers and structure;
- changes in exotic species numbers, cover and structure;
- changes in species assemblage;
- changes in EEC boundaries;
- changes in the ratio of dead and living planting specimens; and
- signs of discolouring or poor health in plants.

After the initial baseline monitoring data collection, the ecologist/ botanist will be required to compare monitoring results to baseline data to determine:

- if any of the above changes are occurring;
- if the change is positive or negative in terms of biodiversity values; and
- if required, to identify necessary management actions to mitigate against negative impacts on biodiversity values. Any required additions or modifications to the monitoring plan should also be stated.

When changes in vegetation condition have been identified through monitoring, it is important to remember that ecosystems are dynamic and ecological changes occur in response to natural process (e.g. drought, HJG dies off over winter). Therefore natural variations in vegetation will be considered during data analysis.

10.9 Reporting

The results of monitoring events will be incorporated into annual reports to be provided to OEH and BSC, no later than two months after monitoring sessions are undertaken.

Monitoring reports will include but not be limited to the following key sections:

- Monitoring Results – including(but not limited to) summary of findings, raw data, and sample comparisons of photo monitoring points;
- Analysis - including (but not limited to) a direct comparison of previous monitoring results, with a particular focus on the indicators of change listed in Section 10.8. Analysis will also include identification of any changes to subject components of the Conservation Zone and a discussion of the likely causes of such changes; and
- Recommendations - including (but not limited to) management actions required to be implemented to ameliorate any potential negative impacts that are identified as part of monitoring, including the provision of a simple priority weed map to be provided to weed control contractors.

10.10 Project Responsibility

10.10.1 The Developer

The developer will be responsible for funding and managing the monitoring program. They will be responsible for engaging a suitably qualified ecologist or botanist to undertake the monitoring work and ensure that regular reports are submitted to OEH and BSC within two months of completing each monitoring event.

10.10.2 Ecological/ Botanical Consultant

Any ecological/ botanical consultant contracted to undertake the monitoring work will be responsible for ensuring consistency with the monitoring methodology as detailed in this monitoring plan. This is important to ensure that data derived from the monitoring program is accurate and comparable and can readily detect changes in vegetation condition of the site.

11

Public Access and Education

11.1 Public Access

The aim of creating a self-sustaining ecosystem within the Conservation Zone could be compromised by having unmanaged public access. Therefore, public access into the Conservation Zone will generally be restricted throughout the life of the project through the following actions:

- Prior to construction commencing temporary fencing (parawebbing and star pickets or similar) will be erected round the Conservation Zone. Fencing is to be supervised / checked by an ecologist as a hold-point prior to construction commencing to ensure that all retained areas are sufficiently protected.
- Permanent fencing would not be erected during the operational phase. If particular access points are likely to attract unauthorised entry, bollards are to be erected to obstruct vehicles.
- Peripheral paths would be considered around the edge of the Conservation Zone if suitable areas are identified around the retained wetland area and outside of known threatened species habitat. Alternatively the peripheral path would be located within the APZ surrounding the Conservation Zone. The locations of peripheral pathways are to be determined in consultation with an ecologist to minimise direct and indirect impacts to native vegetation and threatened flora habitat.
- Signage will be erected adjacent to peripheral paths to notify residents of potential negative environmental impacts of walking off the pathway.

11.2 Interpretive Signage

Interpretive signage is to be installed adjacent to management paths associated with the Conservation Zone. These signs will aim to assist in educating residents of the ecological values of the site.

It is recommended that signage include, at minimum, the following information on aspects of the Conservation Zone:

1. Threatened Species – the Conservation Zone supports a number of state and/or federally listed threatened species
   - Hairy Joint Grass
   - Square-stemmed Spike Rush
   - Rough-shelled Bush Nut
   - Arrowhead Vine
   - Red Lilly Pilly
2. EECs – the Conservation Zone supports a number of state and/or federally listed threatened ecological communities
   - Freshwater Wetlands of the NSW North Coast, Sydney Basin and South-east corner Bioregions
   - Littoral Rainforest in the NSW North Coast, Sydney Basin and South-east corner Bioregions
   - Swamp Sclerophyll Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South-east corner Bioregions
   - Swamp Oak Floodplain Forest of the NSW North Coast, Sydney Basin and South-east corner Bioregions
3. Threats to the Conservation Zone
   - Weeds
   - Change in hydrology and nutrient inputs into the wetland
   - Removal of cattle from site (detrimental impact on HJG)

4. Rehabilitation Plan for the Conservation Zone
    - Revegetation and rehabilitation of the Conservation Zone to create an integrated mosaic of EECs and habitat for threatened species.
    - Translocation of HJG and SSSR impacted on by the construction into the Conservation Zone.

Project Team

The project team members included:

Dr Tom Pollard
Ecologist

David Havilah
Ecologist

Rob Van Iersel
Senior Planner, GeoLINK Principal

Sean Cochran
Planner

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References

Anderson, A. (1999). *An Assessment and Inventory of the Wetland at Boulder Beach, Northern New South Wales*. Southern Cross University, Lismore.

Benwell (2011). Experimental Translocation of Arthraxon hispidus (Hairy Joint Grass) for the Ballina Bypass Project: Monitoring Report Year 1. Prepared for Ballina Bypass Alliance. Ecos Environmental, Mullumbimby, Australia

Benwell (2012). Ballina Bypass *Arthraxon hispidus* (Hairy Joint Grass) Translocation and Management Project: Final Report. Prepared for Ballina Bypass Alliance. Ecos Environmental, Mullumbimby, Australia.

Big Scrub Rainforest Landcare Group (2005). *Subtropical Rainforest Restoration – A practice manual and data source for landcare groups, land managers and rainforest regenerators* (Second Edition).

Buchanan, R.A. (1989). *Bush Regeneration. Recovering Australian Landscapes.* TAFE NSW.

Bureau of Meteorology (2011). Climate Data Online. http://www.bom.gov.au/climate/data/. Accessed November 2011.

Department of Environment & Climate Change (DECC) NSW (2005), Hairy Jointgrass profile, available at http://threatenedspecies.environment.nsw.gov.au/tsprofile/profile.aspx?id=10066 Accessed July 2012.

ECOS Environmental P/L (2004). Population Management Plan for the Threatened Grass *Arthraxon hispidus* at Koala Beach Estate, Tweed Shire. Report to the Australian Koala Foundation on behalf of the Ray Group.

Gilbert & Sutherland (2004). *Soil Survey, Acid Sulfate Assessment, Stormwater Management Plan, Surface Water Assessment and Environmental Management Plan Pacific Pines, Lennox Heads.* Prepared for Ardill Payne and Partners Pty. Ltd

Isbell (1996). Australian Soil Classification. CSIRO Publishing, Melbourne, Australia.

L. Vallee, T. Hogbin, L. Monks, B. Makinson, M. Matthes and M. Rossetto. (2004). . *Guidelines for the Translocation of Threatened Plants in Australia.* Australian Network for Plant Conservation, Canberra

Morand, D. T. (1994). *Soil Landscapes of the Lismore – Ballina 1:100 000 Sheet*. Department of Conservation and land Management, Sydney

NSW National Parks and Wildlife Service (NPWS) (1999). *Eleocharis tetraquetra* Nees Recovery Plan. NSW National Parks and Wildlife Service, Coffs Harbour. http://www.nationalparks.nsw.gov.au/PDFs/Eleoch.pdf

NSW Scientific Committee (2005). Final Determination to list Freshwater Wetlands on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions as an Endangered Ecological Community in Part 3 of Schedule 1 of the Threatened Species Conservation Act.. NSW Scientific Committee, Sydney, NSW.

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Appendix A

Water Management Plan

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Appendix B

Monitoring Datasheets / Proformas

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Table B1: Quadrat Monitoring Field Data Sheet

Date:	Person/s undertaking monitoring:	Quadrat Number:	Easting and northing of north-eastern corner (GDA 94):		
Vegetation Community:					
General comments on degree of weed infestation, health of vegetation etc.:					
Photo point details:					
Canopy					
Species	^Cover Class (Braun-Blanquet)	*Life-form	Average Height (m)	Diameter at Breast Height (DBH) (cm)	Comments
Mid-Stratum					
Species	^Cover Class (Braun-Blanquet)	*Life-form	Average Height (m)	Diameter at Breast Height (DBH) (cm)	Comments

Ground Cover					
Species	^Cover Class (Braun-Blanquet)	*Life-form	Average height (m)	n/a	Comments
Threatened Species					
Species	Code/Number	Height (m)	Diameter at Breast Height (DBH) (cm)	#Foliage Vigour (1-5)	Evidence of Recruitment / Reproduction

Foliage Vigour (1-dead, 2-poor condition / discoloured, 3-minor discoloration, 4-good condition, 5-excellent condition).

^ Braun Blanquet Cover Classes (1 - <5%, 2 – 5-<25%, 3 – 25-<50%, 4 – 50-75%, 5 - >75%)

* Life-forms (tree - >10 cm DBH and >5 m height; tall shrub - 1-5 m height; small shrub - <1 m height; grass/lily – low-growing monocots)

Table B2: Transect Monitoring Field Data Sheet

Date:	Person/s undertaking monitoring:	Transect Number:	Easting and northing of transect start (GDA 94):	Easting and northing of transect end (GDA 94):	
General comments on the degree of weed infestation, health of vegetation etc.:					
Photo point details:					
Quadrat 1					
Vegetation Community:				Comments on health of vegetation in quadrat:	
Species	^Cover Class (Braun - Blanquet)	*Life-form	Average Height (m)	Diameter at Breast Height (DBH) (cm) (where applicable)	Comments
Quadrat 2					
Vegetation Community:				Comments on health of vegetation in quadrat:	
Species	^Cover Class (Braun-Blanquet)	*Life-form	Average Height (m)	Diameter at Breast Height (DBH) (cm) (where applicable)	Comments

Quadrat 3 (etc. up to Quadrat 25)					
Vegetation Community:				Comments on health of vegetation in quadrat:	
Species	^Cover Class (Braun-Blanquet)	*Life-form	Average Height (m)	Diameter at Breast Height (DBH) (cm) (where applicable)	Comments

Foliage Vigour (1-dead, 2-poor condition / discoloured, 3-minor discoloration, 4-good condition, 5-excellent condition).

^ Braun Blanquet Cover Classes (1 - <5%, 2 – 5-<25%, 3 – 25-<50%, 4 – 50-75%, 5 - >75%)

* Life-forms (tree - >10 cm DBH and >5 m height; tall shrub - 1-5 m height; small shrub - <1 m height; grass/lily – low-growing monocots)