JAMES WARREN & Associates Pty Ltd

ENVIRONMENTAL CONSULTANTS

REVISED FRESHWATER WETLAND REHABILITATION PLAN

COBAKI LAKES

PREFERRED PROJECT REPORT

OCTOBER 2010

A REPORT TO LEDA MANORSTEAD PTY LTD

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1. INTRODUCTION

1.1 Background

James Warren and Associates (JWA) were engaged by LEDA Manorstead Pty Ltd to prepare a Freshwater Wetland Rehabilitation Plan (FWRP) to accompany the Preferred Project Report for the proposed development at Cobaki Lakes. JWA prepared the FWRP for the Cobaki Lakes site in October 2008 in response to the Director General's Environmental Assessment Requirements (DGEAR's) issued 21st August 2007. The FWRP was placed on public exhibition along with various other reports required under the DGEAR's.

Following submissions from the public and State Agencies, some amendments have occurred to the Concept Plan. This Revised FWRP has been prepared to reflect changes to the Concept Plan and provide additional information where required.

1.2 Site Description

The subject site consists of land described as Lot 1 DP 570076, Lot 2 DP 566529, Lot 1 DP 562222, Lot 1 DP 570077, Lot 1 823679, Lots 46, 54, 55, 199, 200, 201, 202, 205, 206, 209, 228 & 305 DP 755740, Cobaki Lakes, off Pigabeen Road, Tweed Heads. The site covers an area of approximately 605 hectares and is shown in **FIGURE 1**.

The site lies adjacent to private landholdings to the north-west and south-east, and comprises a large portion of land cleared for agricultural purposes (i.e. grazing) throughout which a number of vegetation communities occur. Extensive clearing and subsequent slashing over the drainage basin has resulted in the recruitment of a combination of native and introduced grass species in place of native plants. Forested Crown lands which form the NSW-QLD border also form the northern and western boundary of the Cobaki Lakes site.

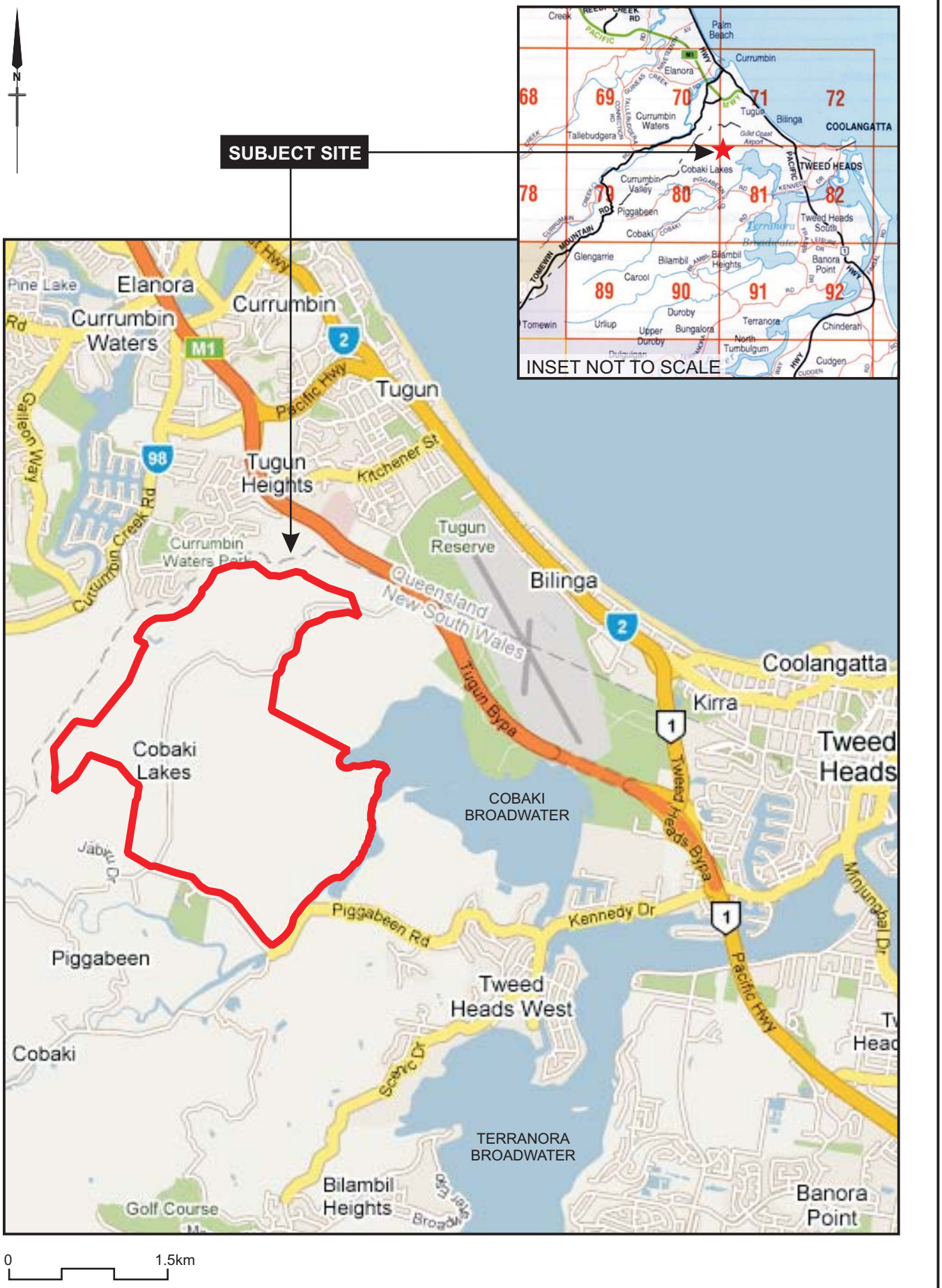
FIGURE 2 shows a recent aerial photograph of the site. Currently sixteen (16) broad vegetation associations comprising twenty-two (22) vegetation communities occur on the site.

It is worth taking into consideration the existing use rights that occur over the subject site. The property has been grazed by cattle since the early 1900's. Existing use rights occur over the subject site for routine agricultural activities including the construction and maintenance of drains, fencing and firebreaks as well as pasture improvement activities.

1.3 Proposed development

The site is proposed to be developed into a master planned residential community. A concept plan for the development is shown as **FIGURE 3**. The proposed development will include the following:

- Town centre/Neighbourhood centre (18.76 hectares);
- Residential (296.86 hectares);



SOURCE: Google Maps SCALE: 1 : 50 000 @ A4 JAMES WARREN & ASSOCIATES PTY LIMITED Environmental Consultants	CLIENT Leda Developments Pty Ltd PROJECT Revised Freshwater Wetland Rehab Plan Cobaki Lakes, Cobaki, NSW Shire of Tweed	**FIGURE 1** PREPARED: BW DATE: 06 October 2010 FILE: 97038_FWRP_Locality.cdr	TITLE **LOCALITY PLAN**

N

LEGEND

Freshwater Wetland Management Area

Site Outline

SOURCE:
Aerial - Michel Group Services (Ref: 6400-197.dwg)
- photo taken March 2010

0 500m

SCALE: 1 : 12 500 @ A3

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FIGURE 2

PREPARED: BW
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TITLE

AERIAL PHOTOGRAPH

BOUNDARY

Queensland

New South Wales

WATER RESERVOR

SANDY ROAD

COBAKI PARKWAY

Piggabeen Road

Cobaki Creek

Environmental Reserve

To Boyd

N

LEGEND

- Town Centre / Neighbourhood Centre
- Residential
- Community Facilities/Education/Utilities
- Open Space
- Environmental Protection Area
- Covenant Protected Areas
- Structured Open Space
- Dam
- Proposed School (approx. 3ha)
- Proposed Community Facilities
- Freshwater Wetland Management Area
- Site Outline

SOURCE:
Layout - Design Forum Pty Ltd
(Ref: SK 01.01 NN Concept Plan.dwg)

0 500m

SCALE: 1 : 12 500 @ A3

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FIGURE 3

PREPARED: BW
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TITLE

DEVELOPMENT CONCEPT PLAN

- Community facilities/Education/Infrastructure (8.35 hectares);
- Public open space (87.12 hectares); and
- Environmental protection areas (194.36 hectares).

1.4 Aims & Objectives

The Revised FWRP aims to provide specific completion criteria as well as a detailed maintenance and monitoring program to ensure the long-term persistence of the rehabilitated freshwater wetland community. Rehabilitation works completed in accordance with this plan will result in the creation of approximately 24.27 hectares of freshwater wetland with the aim of providing more intact freshwater wetland communities on the subject site, and to offset the removal of highly degraded freshwater wetlands from the development area.

The location and extent of the Freshwater Wetland Rehabilitation Areas (FWRA's) is provided in **FIGURE 3.** The specific objectives of the rehabilitation are to:

- Replace patches of degraded freshwater wetland on the subject site with more intact wetland areas;
- Increase the habitat potential of the proposed rehabilitation area, particularly for the Wallum froglet;
- Increase fauna movement corridor opportunities by providing a direct link with the adjacent extensive SEPP 14 wetland areas;
- Improve the long-term viability of freshwater wetland communities on the subject site;
- Enhance the visual amenity of the subject site; and
- Allow for educational and adjoining recreation opportunities.

This FWRP has been prepared with consideration of specific wetland issues and management responses identified within the NSW Wetland Management Policy (DLWC 1996).

2. EXISTING WETLAND COMMUNITIES

2.1 Introduction

Twenty-two (22) vegetation communities occur over the Cobaki Lakes site (JWA 2008). Vegetation mapping over the subject site is shown in **FIGURE 4.** A description of the existing wetland community on the subject site is provided below.

2.2 Existing wetland community descriptions

2.2.1 Background

One (1) freshwater wetland community has been identified on the Cobaki Lakes site (i.e. Community 12) and is shown in **FIGURE 5**. A description of this vegetation community is provided below.

2.2.2 Community 12 – Rushland/sedgeland/grassland (mixed aquatic species)

Location and area
Community 12 occurs in the central portion of the site, covering a total area of approximately 35.39 hectares.

Description
Community 12 is comprised of aquatic and semi-aquatic vegetation including Mangrove fern, *Cyperus* sp., Frogsmouth, Swamp water fern, Curly sedge, Bunchy flat sedge, Spike rush, Fringe rush, Tussock rush and Jointed twig rush.

Conservation status
The conservation status of Sedgeland/rushland/grassland communities has not been specifically discussed in the Regional Forestry Agreement document. The most appropriate analogue is NFE 141 Swamp. It is noted that Swamp ecosystems are Rare in the upper north-east section of the NSW North Coast Bioregion.

This community contains species which are indicative of the Endangered Ecological Community (EEC) 'Freshwater Wetlands on Coastal Floodplain'. The conservation value of this community is considered to have been significantly reduced however due a history of drainage construction and maintenance, grazing and slashing. The conservation status of this community on the subject site is considered to be moderate.

2.3 Conservation assessment

A range of conservation assessment techniques have been developed for wetland plant communities in recent times (e.g. Winning 1990). Most of these schemes relate to an assessment of criteria such as size, shape, hydrological integrity and habitat value.

The wetland community that is currently occurring on the subject site has been assessed with regard to:

- Size;

LEGEND

Community 1 - Dry sclerophyll communities

- Community 1a - Very tall open/closed sclerophyll forest (*Eucalyptus pilularis* +/- *E. microcorys* +/- *E. propinqua* +/- *Corymbia intermedia*)
- Community 1b - Tall open/closed sclerophyll forest (*E. propinqua*)
- Community 1c - Tall open sclerophyll woodland (*E. pilularis*)
- Community 1d - Tall open sclerophyll forest (*E. pilularis* +/- *E. siderophloia* +/- *E. tereticornis*)

Community 2 - Rainforest communities

- Community 2a - Tall closed forest (*Lophostemon confertus* +/- *Araucaria cunninghamii*)
- Community 2b - Tall open forest (*Archontophoenix cunninghamiana*)
- Community 2c - Very tall closed forest (*A. cunninghamii*)
- Community 2d - Mid-high open/closed forest (Riparian species +/- Mixed species)
- Community 3 - Tall/very tall open/closed forest (*L. confertus* +/- Mixed rainforest species)
- Community 4 - Low closed forest (Heathland)
- Community 5 - Mid-high open woodland (Mixed rainforest species)
- Community 6 - Mid-high open woodland (*E. robusta*)
- Community 7 - Mid-high open woodland (*E. racemosa*)
- Community 8 - Mid-high open woodland (*E. siderophloia*)
- Community 9 - Low closed forest (Revegetation areas +/- Mixed *Eucalyptus* species)
- Community 10 - Low closed grassland with scattered trees (Pastoral grassess +/- Mixed species)
- Community 11 - Low closed grassland (*Sporobolus virginicus*, *Triglochin striata* +/- *Casuarina glauca*)
- Community 12 - Rushland/sedgeland/ grassland (Mixed aquatic species)
- Community 13 - Low to mid-high open mangrove forest (*Avicennia marina* var *australasica* / *Aegiceras corniculatum* +/- *Casuarina glauca*)
- Community 14 - Dams & drainage lines (Mixed aquatic species)
- Community 15 - Low open forest/woodland (*Casuarina glauca* +/- Mixed species)
- Community 16 - Slashed grassland/ heathland/sedgeland (Mixed Species)
- Unvegetated land
- Freshwater Wetland Management Area
- Site Outline

SOURCE:
Vegetation - James Warren & Associates Pty Ltd
July/Sept 2007 & May 2008
Aerial - Michel Group Services (Ref: 6400-197.dwg)
- photo taken March 2010

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SCALE: 1 : 12 500 @ A3

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FIGURE 4

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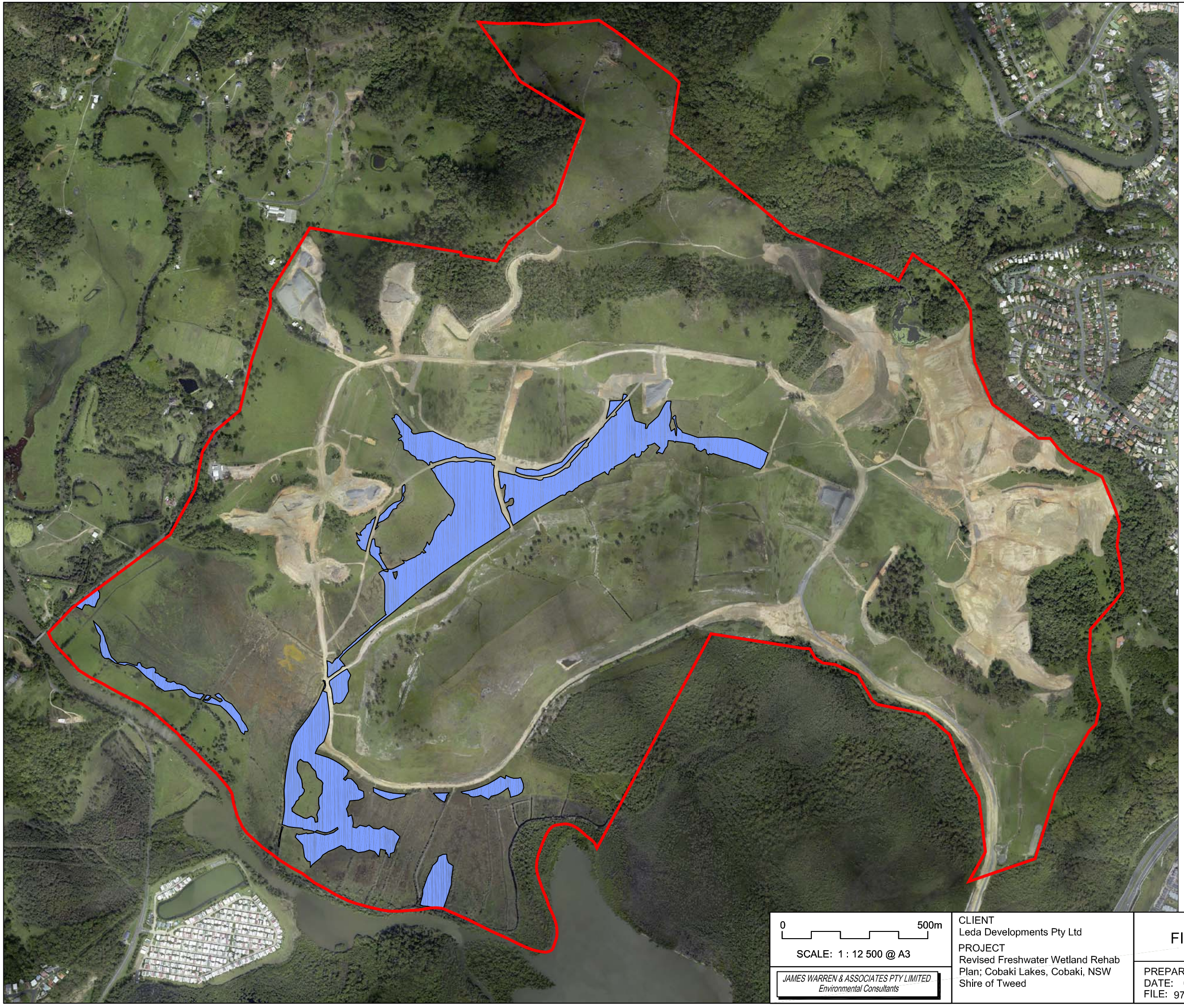
TITLE

VEGETATION COMMUNITIES



LEGEND

- Community 12 - Rushland/sedgeland/ grassland (Mixed aquatic species)
- Site Outline

SOURCE:
Vegetation - James Warren & Associates Pty Ltd
July/Sept 2007 & May 2008
Aerial - Michel Group Services (Ref: 6400-197.dwg)
- photo taken March 2010

0 500m

SCALE: 1 : 12 500 @ A3

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FIGURE 5

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TITLE

EXISTING WETLAND COMMUNITY

- Habitat value;
- Presence of weeds;
- Hydrological integrity; and
- The classification of the community as Endangered Ecological Community (EECs).

TABLE 1 describes the relative conservation values of the wetland community currently occurring on the subject site.

TABLE 1 – CONSERVATION VALUES OF THE WETLAND COMMUNITY OCCURRING ON THE SUBJECT SITE

Vegetation Communities	AREA	Habitat Value	Origin	Hydrological integrity	Current Impacts	EEC	Conservation Value
12. Rushland/sedgeland/ grassland (mixed aquatic species)	35.39 ha	Low - moderate	This community has developed as a result of the clearing of the original Swamp forest, construction of drains and installation of tidal flaps.	Receives fresh water runoff + Tidal flushing on spring tides (in the south-eastern potion of the site).	• Cattle gazing has reduced cover in some areas. • Tidal inundation is also a potential impact on this community type. • Weed species are prevalent over a large area, particularly pasture grasses.	Yes (degraded)	Moderate

3. IMPACT ASSESSMENT

3.1 Introduction

This section addresses the potential impacts of the proposed Cobaki Lakes development on existing Freshwater wetland communities on the site as well as potential impacts on the proposed rehabilitated Freshwater wetland during construction of adjoining stages of the development.

3.2 Impacts on existing wetland communities

The proposed Cobaki Lakes development will potentially have detrimental impacts on the freshwater wetland communities on the subject site, both during and after construction.

Large areas of degraded freshwater wetland in the central portion of the subject site (i.e. Community 12) occur within the designated urban expansion zone and are proposed to be developed for residential, recreational and stormwater treatment purposes.

Direct impacts on the current Freshwater Wetlands may potentially occur as a result of the following activities:

- The construction of Cobaki Parkway;
- Filling and subsequent construction of residential allotments;
- Excavation of constructed lakes for stormwater treatment purposes;
- The provision of stormwater infrastructure; and
- The construction of the proposed sports fields and local park.

Direct impacts of the proposed development on existing Freshwater Wetland communities are shown in **FIGURE 6.**

The proposed development will also remove areas that provide forage habitat for the Wallum froglet – a species listed as Vulnerable within schedules of the *Threatened Species Conservation Act 1995*. No 'core' habitat will be removed. The majority of Wallum froglet habitat to be removed is comprised of exotic grassland which provides some forage opportunities during wet weather.

The Freshwater Wetland Rehabilitation Areas provide an opportunity to create more suitable 'core' habitat areas, linked to adjacent SEPP 14 wetlands via a vegetated corridor and specifically designed culverts, which will provide some benefit for the local population. A detailed Wallum Froglet Compensatory Habitat Plan will be prepared to accompany the Development Application for the Central Open Space Area and will include specific performance and completion criteria as well as a detailed population monitoring program.

N

LEGEND

- Community 12 - Rushland/sedgeland/ grassland (Mixed aquatic species)
- Proposed Development Areas
- Site Outline

SOURCE:
Vegetation - James Warren & Associates Pty Ltd
July/Sept 2007 & May 2008
Layout - Design Forum Pty Ltd
(Ref: SK 01.01 NN Concept Plan.dwg)
Aerial - Michel Group Services (Ref: 6400-197.dwg)
- photo taken March 2010

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FIGURE 6

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TITLE
IMPACT ON EXISTING WETLAND COMMUNITIES

3.3 Potential impacts on rehabilitated wetlands

3.3.1 Background

Rehabilitation works completed in accordance with this plan aim to offset the removal of highly degraded freshwater wetlands from the development area and provide a more intact freshwater wetland community on the subject site. However, construction of adjacent stages of the Cobaki Lakes development may impact on the proposed Freshwater Wetland Rehabilitation Areas (FWRA's). The potential ecological impacts of the development on the proposed FWRA's have been identified and are listed below:

- poor water quality (e.g. sediment load, pH, influx of pollutants);
- inappropriate run-off rates;
- erosion;
- nutrient loading;
- inappropriate drainage and hydraulic regimes;
- introduction of weed species;
- introduction of exotic predators and/or competitors, as well as amphibian diseases (i.e. Chytridiomycosis); and
- Unrestricted access.

The potential impacts of the development on the FWRA's are discussed below in more detail.

3.3.2 Decline in Water Quality

Potential impacts of the development on water quality within the FWRA's include:

- high levels of water turbidity;
- high flow rates resulting in erosion and sedimentation and scouring of vegetation;
- high levels of organic and inorganic nutrients, resulting in eutrophication of waterbodies;
- high levels of salinity;
- introduction of pollutants such as oils or chemical residues originating from household activities and sources.

High nutrient levels from domestic sewage and urban run-off are a problem in localised areas of some wetland habitats (Robertson & Alongi 1995). Where water run-off reaches water bodies, nutrients such as nitrates and phosphates can cause significant degradation to water quality (EPA 2005).

3.3.3 Weed Invasion

Many weed species are better adapted to survival in disturbed environments than native plants. The invasion processes rely on primary dispersal vectors such as wind, water animals or insects, and removal of native vegetation. Possible factors allowing the invasion of weed species may include the following events or influences: soil disturbance (natural or human), fire (or alteration to fire regimes), introduction and influence of

specific vectors, altered hydrology, decline of native vegetation cover, or changing climatic conditions.

Development adjacent to the FWRA's may cause alterations to the immediate hydrology which may encourage the occurrence of weeds in the affected area. Runoff may potentially contain water of nutrient levels that are unfavourable for native vegetation and may promote growth of weed species, resulting in increased weed prevalence in the FWRA's.

In relation to weed invasion, Buchanan (1989) notes the following:

- Invasion of weeds is most likely after disturbance;
- The greater the degree of disturbance the greater the degree of invasion;
- The greater the diversity of the natural community the less likely weeds are to invade.

Weeds may reduce native biodiversity within habitat areas (which may affect forage and shelter resources), alter hydrological regimes through dense vegetation, increase competition for resources with vulnerable native species (i.e. light, nutrients, space etc.) and promote fire.

Adjacent stages of the Cobaki Lakes development may create edge effects within the FWRA's including invasion by weeds. Weeds invading areas of the FWRA's will compete with native plant species and may become dominant is some areas.

3.3.4 Introduction of diseases and non-native fauna

Chytrid fungus is a waterborne pathogen that causes the disease Chytridiomycosis in frogs. The fungus grows in the keratinised epidermis of adult frogs and in the keratinised mouthparts of tadpoles, however it is not currently known how the chytrid fungus kills infected frogs. Only adults are susceptible and mortality can be high, depending upon the species infected and local environmental conditions. Once the chytrid zoospores are released into water, they remain viable for up to 24 hours. The fungus is known to be spread by humans through the handling of infected frogs and tadpoles or the transport of zoospores in water.

A range of exotic fauna are likely to occur in the study area and impact on native fauna communities, including the Red fox, Cane toad, Gambusia (Mosquito fish) and domestic Cats and Dogs.

In recent years the impact of cat predation on native Australian fauna has become a prominent public issue. The impacts of domestic dogs are not readily quantified. Dogs are however, known to attack Koalas and thus should be considered a management problem at the urban/bushland interface.

Cane toads are a generalist species that are able to breed in almost any permanent or temporary water source (including acidic and saline waters) and have no specialised dietary requirements. They have a tough, leathery epidermis, (in contrast to most other Australian frogs), which allows them to tolerate water loss up to 50% and variability in ambient temperature. This feature, combined with a tolerance to broad environmental and climatic conditions, has enabled them to occupy a variety of habitats generally to

the detriment of endemic amphibians. Cane toad tadpoles are also known to predate smaller tadpoles of their own or other species (Crossland 1998). Despite their adaptability to the environment, Cane toads prefer habitats with open space, generally avoiding dense ground cover.

Gambusia, or the Mosquito fish, is a small freshwater fish originally introduced into Australian waterways in the 1920's to control mosquito larvae. This species is recognised as a voracious predator that will feed on other fish (adults and larvae), arthropods and amphibians (tadpoles and eggs). The impact of Gambusia on Australian frog populations is such that it has been listed as a key threatening process under the NSW TSCA (1995). The introduction of this species into the FWRA has the potential to permanently exclude amphibians.

3.3.5 Alterations to Drainage and Hydrological Regimes

The development of adjoining stages of development has the potential to affect drainage and hydrological regimes within the FWRA's by altering the amount and entry points of stormwater runoff.

Changes in hydrological regime may have some effect on the composition and distribution of vegetation in the FWRA's. However, the extent of these changes is often difficult to quantify. Alterations to hydrological regimes and increased sedimentation may alter specific conditions required by some species of native flora and fauna.

3.3.6 Unrestricted access

Exclusion of cattle and restrictions on human traffic are vital for successful rehabilitation of the FWRA's.

4. RECOMMENDATIONS FOR IMPACT MITIGATION

4.1 Background

In total 25.68 hectares of Freshwater wetland (72.56%) will be removed from the subject site during construction activities (**FIGURE 6**). Rehabilitation works completed in accordance with this FWRP will result in the creation of approximately 24.27 hectares of freshwater wetland (**FIGURE 3**) with the aim of providing a more intact freshwater wetland community on the subject site, and to offset the removal of highly degraded freshwater wetlands from the development area.

Offsets for the removal of highly degraded Freshwater wetland vegetation from the subject site will include the following:

1. Recreation of approximately 4.75ha of high quality ('core') wetland habitats (**FIGURE 7**). These compensatory Freshwater wetlands will be offline from the stormwater treatment train and will also be specifically designed to provide core (breeding) habitat for the Wallum froglet; and
2. Approximately 19.52ha of Freshwater wetland vegetation will be provided through revegetation works associated with the stormwater conveyance and treatment infrastructure on the subject site (**FIGURE 7**).

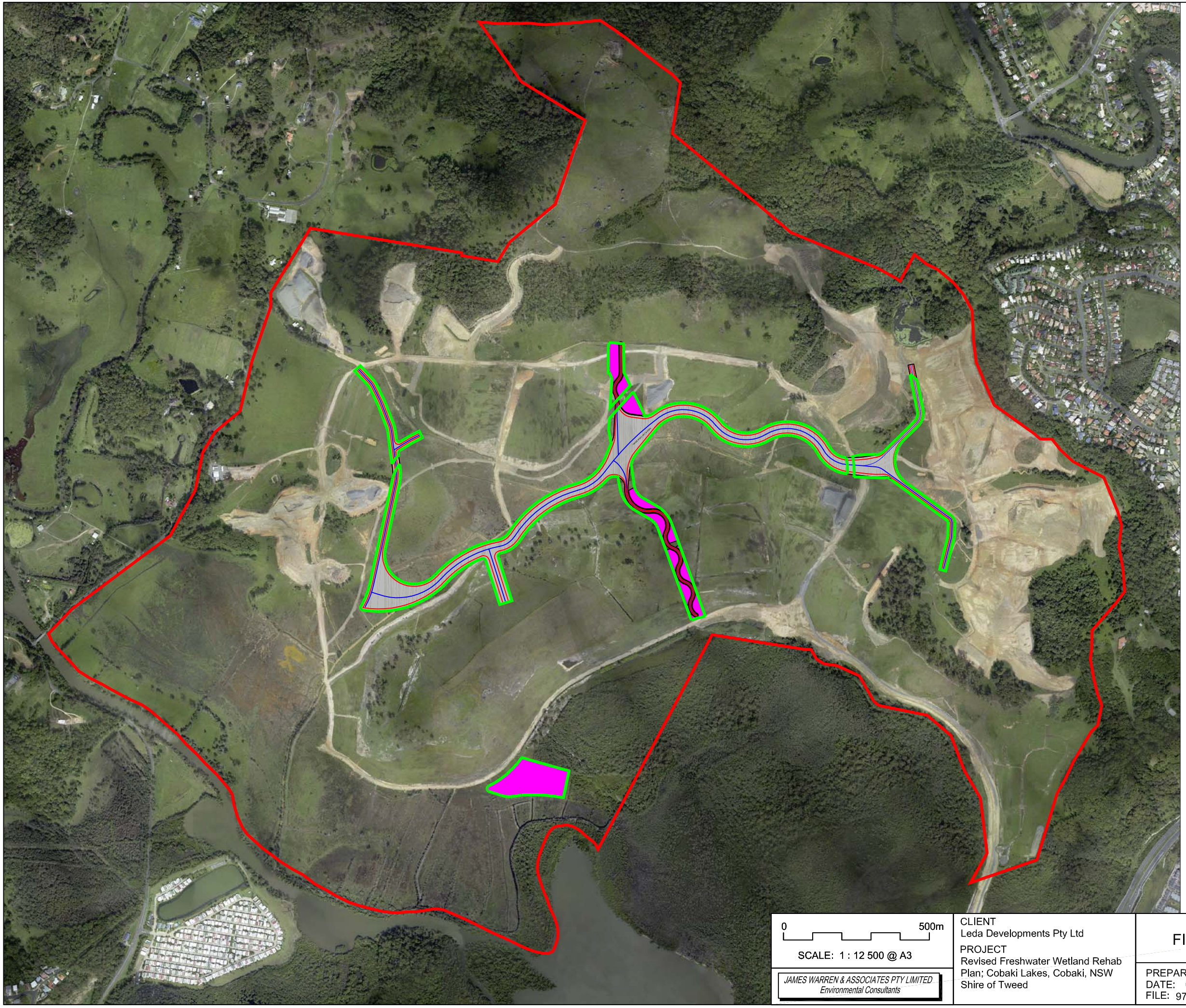
Details of the Freshwater Wetland Rehabilitation Strategy are provided in **Section 5**. Management strategies and amelioration measures designed to prevent detrimental impacts upon the FWRA's as a result of adjacent construction activities are outlined below.

4.2 Recommended Management Strategies

A number of strategies are proposed to prevent detrimental impacts upon the FWRA's during the construction of adjacent development. Proposed management strategies are outlined in **TABLE 2**.

TABLE 2
RECOMMENDED MANAGEMENT STRATEGIES

Potential Impact	Recommended Management/ Amelioration Measures
Decline in Water Quality	• A Stormwater Management Plan (SMP) must be prepared and approved for each adjacent stage of development. Compliance with the recommendations within the approved SMP will prevent increased erosion/sedimentation. • An Erosion and Sediment Control (ESC) program must be prepared and approved for each adjacent stage of development. Compliance with the recommendations within the approved ESC program will be required. • All sediment control devices are to be in place as shown in the ESC Program documents prior to and during construction, and will not be removed post construction until the contractor is satisfied that all disturbed and/or exposed soil has been stabilised. • Water will not be released from detention basins until samples have been analysed and shown to meet the criteria outlined in the



LEGEND

- Core Habitat Areas
- Drainage Line
- Freshwater Wetland Management Area
- Site Outline

SOURCE:
Drainage - Yeates (Ref: YC0229 - SK 76 WEST FAUNA CORRIDOR.dwg)
Aerial - Michel Group Services (Ref: 6400-197.dwg) - photo taken March 2010

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FIGURE 7

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TITLE

REVEGETATION PLAN

Potential Impact	Recommended Management/ Amelioration Measures
	ESC Program. • Regular (three monthly) water quality testing is to be undertaken within the wetland in the vicinity of any discharge points to ensure that acceptable water quality parameters are maintained. Where water levels are insufficient to carry out testing as scheduled due to lack of recent rainfall, testing may occur opportunistically following the next significant rainfall event. Subsequent testing should be completed on schedule where possible.
Weed Invasion	Weed control techniques to be utilised within the FWRA's are detailed in Section 5.3. Monitoring for weeds will also occur in accordance with Section 6.2. The following additional Weed Management strategies apply: • Plant species to be used for landscaping purposes within adjacent stages of development are to be comprised of native species representative of local assemblages. • Mulch created from cleared onsite vegetation must not contain fertile weed material. Weeds should be separated from native species where feasible. • Mulch acquired offsite for use during landscaping or soil stabilisation must be certified as weed free.
Introduction of Diseases and Non-native Fauna	A Fauna Management Plan (JWA 2009) has been prepared for the Cobaki Lakes development. The following additional management strategies apply to the FWRA's: • No dogs or cats are to be allowed access to the wetland. Any cats or dogs will be immediately removed from habitat areas by a qualified animal control officer. • Dense fringing vegetation should be maintained around the perimeter of the wetland in order to restrict access and breeding by Cane toads. • Toad 'round ups' should be conducted bi-annually within the warmer months (i.e. Spring – Autumn) following rainfall events. • Toads collected during round ups are to be humanly euthanized and removed from the site (pending ethics approval). • Acidic conditions within the wetland will be maintained to limit potential breeding sites for Cane toads. • Efforts shall be made to reduce the permanent ponding of water within habitat areas and to retain the natural hydrology (i.e. periodic saturation and drying out) of the habitat areas in order to control potential invasions of Gambusia.
Alterations in Drainage and Hydrological Regime	• Compliance with all requirements of the approved Stormwater Management Plan is required. • Release of water from any detention basins should occur at suitable rates so as to maintain the water table of the wetland, as outlined in the approved Stormwater Management Plan. • Peak stormwater flow rates should not exceed those of a 1 in 2 year storm.

Potential Impact	Recommended Management/ Amelioration Measures
Unrestricted access	• The FWRA's will be fenced to exclude traffic and to clearly identify revegetation areas; • Fences must be erected upon the commencement of the enhancement planting works; • The fencing will be fauna friendly and will consist of 1.2 m star pickets at 4 metre intervals and with three (3) strands of smooth galvanized wire. A top strand of barbed-wire should also be included to prevent access by cattle; • Vehicle access is to be strictly limited to maintenance vehicles; • Any gates are to be locked and maintained/repaired if gates or fences are damaged; • Signage is to be erected on exclusion fencing stating: "No Entry – Freshwater Wetland Rehabilitation Area". All contractors are to be made aware of restrictions applying to the exclusion zones; • Buffer plantings are to be provided where appropriate and designed provide a screen of trees that will reduce human access; • Public access into the Freshwater Wetland Rehabilitation Area is to be limited to designated pathways and/or boardwalks; • Educational signage is to be provided which informs visitors and residents of the importance of Freshwater Wetlands. The signage is to be displayed along the boardwalk; and • Only authorised personnel will be allowed within the Rehabilitation area.

4.3 Specific Management Strategies for Threatened Fauna

The proposed Cobaki Lakes development will remove areas that provide forage habitat for the Wallum froglet – a species listed as Vulnerable within schedules of the *Threatened Species Conservation Act 1995*. No 'core' habitat will be removed. The majority of Wallum froglet habitat to be removed is comprised of exotic grassland which provides some forage opportunities during wet weather.

The Freshwater Wetland Rehabilitation Areas provide an opportunity to create more suitable 'core' habitat areas, linked to adjacent SEPP 14 wetlands via a vegetated corridor and specifically designed culverts, which will provide some benefit for the local population (**FIGURE 7**).

A detailed Wallum Froglet Compensatory Habitat Plan will be prepared to accompany the Development Application for the Central Open Space Area. The Wallum Froglet Compensatory Habitat Plan should include:

- Details for the creation of suitable breeding habitat;
- Wallum froglet population monitoring protocols;
- Measures to prevent the introduction of Chytrid fungus to the wetland, and control measures should Chytrid fungus be present;
- Measures for the prevention and control of pest species/competitor invasion; and
- Maintenance of suitable water quality, vegetation and other habitat features within the created Wallum froglet habitat.

5. REHABILITATION WORKS

5.1 Introduction

The location and extent of the proposed Freshwater Wetland Rehabilitation Areas (FWRA's) is depicted in **FIGURE 3**. The proposed FWRA's will be rehabilitated in accordance with this plan.

The objectives of the rehabilitation are to:

- Replace patches of degraded freshwater wetland on the subject site with a more intact wetland area;
- Increase the habitat potential of the proposed rehabilitation area, particularly for the Wallum froglet;
- Increase fauna movement corridor opportunities by providing a direct link with the adjacent extensive SEPP 14 wetland areas;
- Improve the long-term viability of freshwater wetland communities on the subject site;
- Enhance the visual amenity of the subject site; and
- Allow for educational and adjoining recreation opportunities.

Portions of the FWRA's to be rehabilitated as high-quality offline habitat are zoned for Environmental Protection (**FIGURE 7**) and will be dedicated to Council or the relevant State Government Department at the completion of rehabilitation works (subject to their agreement). The remainder of the FWRA's have a secondary function of treating and conveying stormwater and are zoned as Public Open Space (**FIGURE 8**).

5.2 Implementation

This FWRP has been developed in consultation with:

- Gilbert & Sutherland (Soil & water engineers);
- Yeats Consulting Engineers;
- Tweed Shire Council;
- DECC;
- NSW Wetland Management Policy (DLWC 1996); and
- Constructed Wetlands Manual (DLWC 1998).

The specialised rehabilitation program in this section of the plan provides a guide for the correct revegetation techniques to be undertaken within the appropriate areas. The rehabilitation programs have been designed around the planting of endemic native species in appropriate areas to bolster natural recruitment.

The rehabilitation works are to be completed by a regeneration team selected by the landowner. The monitoring program is to be completed by a qualified Ecologist.

5.3 Rehabilitation methodology

5.3.1 Introduction

Wetlands are ecologically, economically and socially important. They are often cited as among the most productive ecosystems on Earth, existing as multiple value systems. Wetlands play an important role in Australian biological diversity with many communities of fauna being associated with them. The functions and services provided by wetlands are many and varied. Wetlands are habitat for a diverse range of animals including waterbirds, frogs, invertebrates and fish species (DLWC 1998).

Rehabilitating wetlands involves identifying the natural processes of the wetland and minimising or decreasing threatening activities (DLWC 1996). The process of rehabilitation involves, but is not limited to:

- assessing existing condition;
- identifying the sources of water;
- identifying the water regime of the wetland in terms of seasonality, frequency and duration of inundation, etc.; and
- consideration of the activities which need to be undertaken to rehabilitate the wetland. For example:
    - excluding grazing;
    - slashing or mowing firebreaks around the perimeter of grassland or woodland wetlands which are not grazed;
    - establishing and maintaining an open area for native ground cover plants and for native wildlife to graze;
    - control pest animals and plants;
    - fencing, earthmoving, blocking drains to divert chemical laden water away from the wetland;
    - determining flora and fauna requirements;
    - considering the "do nothing" option of management in areas where the natural processes will re-establish the wetland (Richardson, 1998).

A detailed wetland rehabilitation plan is outlined below, including a guide to wetland species selection, and a planting plan. The maintenance requirements are also discussed below. The monitoring program and specific performance measures are discussed in Sections 6 and 7 respectively.

5.3.2 Rehabilitation approach

5.3.2.1 Introduction

The freshwater wetland rehabilitation approach on the subject site involves a variety of different methods that have been suggested on the basis of current vegetation condition.

5.3.2.2 Rationale

Existing vegetation within the proposed FWRA has been assessed based on restoration/revegetation potential to ensure that regeneration and revegetation resources will be utilised in the most efficient way. For example, areas where weed

infestation is high will require a different approach than an area where weed infestation is low but native species diversity is also low.

A review of the development proposal has revealed that the entire FWRA will be subject to earthworks for the purposes of creating core habitat areas as well as stormwater treatment and conveyance devices. The entire FWRA will therefore be subject to revegetation works.

5.3.3 Species selection & Planting zones

A palette of species recommended for planting within the FWRA has been developed based on the existing local flora assemblages, habitat requirements of the Wallum froglet, and the recommendations contained in the Constructed Wetlands Manual (DLWC 1998). A comprehensive wetland species list is provided below in **TABLE 3**.

TABLE 3 - WETLAND SPECIES LIST

Planting zone#	Common Name	Botanical Name	Plant Density*
1	Swamp mahogany	*Eucalyptus robusta*	1 per 3m^2
	Broad-leaved paperbark	*Melaleuca quinquenervia*	
	Bare twigrush	*Baumea juncea*	2 – 3 per m^2
	Long-leaved matrush	*Lomandra longifolia*	
	Water Couch	*Paspalum distichum*	
	Common spike-rush	*Eleocharis acuta*	
	Climbing maidenhair	*Lygodium microphyllum*	
	Sawsedge	*Gahnia clarkei*	
	Sawsedge	*Gahnia sieberiana*	
	Wallum grasstree	*Xanthorrhoea fulva*	
	Sundew	*Drosera spathulata*	
	Running postman	*Kennedia rubicunda*	
	Hairy Pea	*Oxylobium robustum*	
	Wallum pea	*Pultenaea retusa*	
	Native violet	*Viola betonicifolia*	
2	Twigrush	*Baumea rubiginosa*	3 – 4 per m^2
		Cyperus exaltatus	
	Giant sedge	*Lepironia articulata*	
	Marsh Clubrush	*Bolboschoenus fluviatilis*	
	River Clubrush	*Schoenoplectus validus*	
	Spike-rush	*Eleocharis equisetina*	
	Gristle fern, Binung fern	*Blechnum cartilagineum*	
	Bungwall Fern	*Blechnum indicum*	
	A wallum fern	*Histiopteris incisa*	
	Harsh ground fern	*Hypolepis muelleri*	
	Soft or false bracken	*Calochlaena dubia*	

Planting zone#	Common Name	Botanical Name	Plant Density*
	A sedge	*Carex maculata*	
	Koala Fern	*Caustis blakei*	
	Curly wigs	*Caustis recurvata*	
	A sedge	*Rhynchospora corymbosa*	
	A sedge	*Juncus polyanthemus*	
	A sedge	*Juncus prismatocarpus*	
	Frogsmouth	*Philydrum lanuginosum*	
	Water primrose	*Ludwigia octovalvis*	
	A smartweed	*Persicaria decipens*	
	A smartweed	*Persicaria strigosa*	
3	Jointed Twigrush	*Baumea articulata*	3 per m^2
		Schoenoplectus mucronatus	
4	Tall spikerush	*Eleocharis sphacelata*	3 – 4 per m^2
	Giant sedge	*Lepironia articulata*	

Planting zones have been derived from the Constructed Wetlands Manual (DLWC 1998) and are as follows:

1) Mostly dry (75%) – some seasonal water logging
2) Wet (50%)/ Dry (50%)
3) 0.25m – 0.5m deep
4) 0.5m – 2m deep

* Denotes total plant density within each zone.

It should be noted that planting densities shown are the estimated maximum planting density for each planting zone. Natural recruitment of native species in some areas will reduce necessary planting densities.

Furthermore, species for planting have been based on species currently occurring within Freshwater wetland communities on the site. Further detailed information should be collected from a reference site prior to the commencement of the rehabilitation works. Planting species must include ground, mid and canopy species and species composition must be benchmarked against a reference EEC community.

5.3.4 Planting plan

The constructed wetlands manual recommends planting into damp or dry soil and then to irrigate after planting. Planting into wet mud or shallow free water is also possible (DLWC 1998). The manual provides the following information on planting wetland species:

- Where possible planting is to occur into the available dry substrates, when this is not practical, planting will occur in the shallow water.
- Wetland plants should be planted in the appropriate zones with regard to water depth.

- Plants are to be manually planted to ensure that recommended densities are achieved.
- The manual planting methods to be undertaken involve:
    - Selection of planting area;
    - Selection of species to be planted and appropriate density;
    - Using string line to determine area for each planting zone;
    - Digging small spade holes in the appropriate mean water depth;
    - Place roots zones into small spade holes;
    - Cover and compress the sediment around the roots.
- The planting out of the aquatic species is to be completed by the regeneration team.

5.3.5 Maintenance

The maintenance requirements of the wetland plantings will include:

- Maintenance to be completed once every three (3) months until plants have become well established. This is expected to take between two (2) – three (3) years.
- Maintenance is to be carried out by the regeneration team and will include:
    - Removal of invasive weeds (refer Section 5.4); and
    - Replacement of dead plants.
- Weed invasion of the wetland will require diligent monitoring to ensure control measures remain minimal.
- Comprehensive maintenance will be required to eradicate any noxious aquatic weeds that may occur.

5.4 Weed Control

5.4.1 General weed control

General weed control measures are as follows:

- Roundup Biactive© only will be utilised in all weed control activities within and adjacent to the FWRA. Other glyphosate-based products contain surfactants that can be harmful to aquatic organisms. These products should not be used in aquatic areas. Glyphosate is considered slightly toxic to birds, fish, invertebrates and mammals however, Roundup Biactive© will be applied according to the recommended rate to avoid high toxicities.
- All nursery stock for landscaping purposes shall be weed, pest and disease free and certified as such by the supplier where feasible.
- All mulch produced on site from cleared vegetation and trees shall specifically exclude material from weed species. Vegetation mulching will be suitably controlled to avoid contamination. Mulch containing weed species material shall be treated separately and not used on site for landscaping works.

- Soil disturbance within retained vegetation shall be kept to a minimum to avoid weed recruitment. Areas to be landscaped shall be completed under supervision to avoid unnecessary soil disturbance.
- Weed or potential weed species shall not be planted during landscaping operations.

5.4.2 Primary Weeding

1. Weed eradication will be undertaken on a progressive basis through localised treatment of grass species via mechanical removal (hoe/rake, hand pulling and/or slashing) or by spraying Roundup Biactive©. Woody weed species under 20 cm tall will be hand pulled or controlled using weed control techniques detailed in Section 5.4.4.

2. All chemical users should be experienced and appropriately licensed.

3. Primary weeding should commence at the start of the active growing period (approximately November), or on an as needed basis.

4. Preparation before spraying, in the form of manual clearing weeds from around native plants, must be carried out. Small native plants less than 20 cm in height are to be marked with a stake.

5. Weed material will be disposed of at an approved waste disposal facility such as Council landfills or transfer stations.

5.4.3 Secondary Weeding

Secondary weeding involves the eradication of weeds that have been overlooked or re-shot after Primary treatment. Secondary weeding will occur 3 to 4 months after Primary Weeding and no later than 6 months.

Areas requiring secondary weeding will be noted and mapped through consultation between the Regeneration Site Manager and the Ecologist. Indications of herbicide resistance will be documented as well as signs of native regeneration.

5.4.4 Weed Control Methods

The treatment of weeds will vary depending on:

- their location;
- type of weed;
- extent of infestation; and
- weather conditions.

Roundup Biactive© only will be utilised in all weed control activities within and adjacent to the FWRA. Other glyphosate-based products contain surfactants that can be harmful to aquatic organisms. These products should not be used in aquatic areas. Glyphosate is

considered slightly toxic to birds, fish, invertebrates and mammals however, Roundup Biactive© will be applied according to the recommended rate to avoid high toxicities.

The following are control techniques that are to be utilised during site regeneration works:

- **Cut Stump Method** - This method involves cutting plant stems as close to ground level as possible and immediately painting the cut stump with herbicide. This treatment can also be applied as a basal bark application to the first 15-20 cm (entire circumference) of an uncut stem if the adult bark has not yet developed.

- **Basal Bark Method** - This method involves applying herbicide to the lower 35-45 cm bark around the entire stem using a hand-pump backpack sprayer fitted with a shut-off at the wand tip and an adjustable cone nozzle or a small, ATV (All Terrain Vehicle)-mounted sprayer with a shut-off at the wand tip and an adjustable cone nozzle.

- **Ring Barking -** This method involves removing the lower bark from the stem using a sharp implement to expose the phloem and xylem tissue to the outer environment thereby destroying it.

- **Spray Method** - There are two (2) types of spraying methods that will be employed where appropriate:

    - Selective blanket spraying: The area must initially be checked for the presence of any native species. Any weeds within 2 m of the drip zone of existing native species will be removed by hand. Alternatively, native species will be covered with impermeable material (e.g. a tarpaulin) for protection during spraying;
    - Spot spraying: The spray nozzle will be kept close to ground to avoid any overspray. Individual weeds will be spot-sprayed at the site. This method of spraying will be employed where native species are interspersed throughout the exotic grasses.

- **Stem Injection** - Herbicides may be applied directly to the plant via stem injection. This involves applying herbicide to the plant directly through drilling a hole into the stem and inserting the chemical.

- **Wick Wiping** - This method employs vehicle-mounted (broad acre application) or hand-held equipment (small area/single plant application) to wipe or brush concentrated herbicide onto weeds. The herbicide is applied from permeable rope that is permanently connected to a reservoir. For purposes of weed control where accessibility to the infestation is low, a hand held 'wick wipe' will be used. This will also be incorporated for the control of emergent species. This method is particularly safe to use in areas where weed species are interspersed with native plants as there is no spray drift of herbicide.

- **Hand Pulling and Chipping** - Manual weeding may involve chipping, pulling, digging or slashing and is preferred, depending on the growth stage and situation as detailed:

- where native plants are growing within a weed infestation and the use of selective herbicide is not possible;
- where inadequate foliage is present to allow for successful uptake of herbicide e.g. Mile-a-minute runners typically exhibit this trait.

When hand weeding, the stem must be grasped firmly at the base of the plant and pulled. A trowel, mattock or sharp knife may be needed to loosen the soil. Care must be taken not to leave behind stems or other plant pieces that may re-shoot. Hand weeding should be undertaken at times when weeds are not seeding to reduce dispersal and spread. Hand pulling is not recommended for some weed species as they readily sucker if their roots are disturbed e.g. *Lantana camara*. This method will be employed when removing exotic grass species within retained vegetation.

6. MONITORING PROGRAMS

6.1 Introduction

Monitoring is an ongoing part of wetland management. The condition of wetlands can be assessed by checking environmental conditions and matching these with management aims and objectives. In a wetland environment, many different attributes can be monitored depending on the purpose of the monitoring project. The results obtained through monitoring can help managers to prioritise management actions and keep track of the health of the wetland (DLWC 1996).

A well-designed monitoring program will allow project managers to detect results months, years, or decades following implementation of a plan. This section outlines the monitoring requirements for the FWRA.

6.2 Rehabilitation Monitoring

6.2.1 Monitoring requirements

The monitoring of the FWRA will include regular monitoring by a qualified ecologist who is to complete the following:

- **Transects**
  - Fifteen (15) transects are to be evenly placed within the FWRA;
  - Transect locations are to be permanently marked;
  - Transects are to be 50 metres in length;
  - During monitoring visits tape measures are to be placed on the ground and the specific measureable features recorded along the transects;
  - Specific measurable features include:
    - Areas of vegetation cover (Freshwater wetland species);
    - Areas of vegetation cover (other native species);
    - Areas of weed cover;
    - Areas of bare ground/mud;
    - Number, percentage and species of planted stems surviving;
  - Results are to be shown in a table which is to be presented in the monitoring reports.

- **Quadrats**
  - Five (5) Quadrats ($1m^2$) are to be placed along each of the transects;
  - Quadrats must be placed 10m apart along the length of the transect ;
  - Quadrats are to be placed randomly within five (5) meters of the transect line;
  - The boundary of the quadrat with respect to the tape measure (e.g. between 3.5 – 4.5 metres on tape measure) will be recorded;
  - For each quadrat the following specific measurable features will be recorded:
    - Plant species occurring
    - Percentage cover
    - Height

        - Relative abundance of Freshwater wetland species
        - Weed cover
        - Number, percentage and species of planted stems surviving
    - Results are to be shown in a table which is to be presented in the monitoring reports.

- **Fixed Photo points**
    - A central transect marker on each established monitoring transect is to be used as permanent photo station for photographic monitoring;
    - Four (4) photos are to be taken from each central transect marker. Photos are to be taken to the north, south, east and west;
    - Photos should be labelled with the:
        - Transect code
        - Direction of view
        - The date & time
    - Photos must be supplied in the monitoring reports in a form of prints no smaller than 4" x 6" and must be colour.

6.2.2 Timing of monitoring visits

The monitoring is to be completed by a suitably qualified ecologist. Site visits should occur:

- Six (6) weeks after primary weeding;
- Six (6) weeks after initial plant-out;
- Every three (3) months thereafter until groundcovers are sufficiently established (i.e. between two (2) - three (3) years)
- Every six (6) months after establishment until completion criteria are met (refer Section 7).

6.2.3 Long term Monitoring

Along with the regular monitoring within the FWRA, the overall vegetation composition is to be regularly assessed and recorded. Long term monitoring will use both aerial photos and yearly assessments (ground truthing) of the vegetation communities using a hand held GPS.

The Long term monitoring of the vegetation composition with the FWRA will include:

- A detailed vegetation map at a scale of 1:5,000 is to be completed within the FWRA every twelve (12) months;
- Each year, after completion of vegetation mapping, a report is to be completed showing the changes in the composition of the vegetation communities within the FWRA. The results are to be shown in a table that shows the vegetation community and the area of the vegetation community as a percentage of the FWRA. Monitoring will continue until completion criteria are met (refer Section 7).

6.3 Water quality monitoring

The following water quality parameters will be used to determine the relative health of the FWRA. These parameters have been adapted from Australia and New Zealand Environment and Conservation Council (ANZECC) Guidelines. The following key water quality indicators will be utilised as a minimum:

- pH;
- turbidity;
- suspended solids;
- salinity;
- dissolved Oxygen;
- dissolved organic compounds;
- magnesium and calcium hardness; and
- temperature.

Thresholds for key water quality indicators on the subject site will need to be determined from baseline water quality monitoring.

A suitably qualified and experienced person or company will be engaged to complete all water quality monitoring within the FWRA. Monitoring of both surface waters and groundwater will need to be completed within and immediately adjacent to the FWRA. The location and number of sampling locations should be determined by the suitably qualified company engaged to complete the monitoring works.

Monitoring will continue immediately after rehabilitation commences at the following intervals:

- Quarterly for two (2) years;
- Six (6) monthly intervals for the period 2 - 5 years; and
- Monitoring of water levels within the FWRA will be completed opportunistically at least once a year for 5 years.

Any changes detected for these parameters that exceed identified habitat preference thresholds will trigger an immediate investigation by suitably qualified persons under the direction of an Ecologist. If there is a continued exceedence of the thresholds an investigation will be undertaken to determine the reason and the appropriate actions to take to correct it.

7. COMPLETION CRITERIA

A number of criteria will indicate successful rehabilitation of the FWRA, including:

- Survival of 95% of stems planted;
- Establishment of a 70% native ground cover after 2-3 years;
- Average percentage cover of 90% native ground cover at the 5th year;
- Height of any planted trees is to be a minimum of 1.5 metres at year 3 and 2.5 m at year 5;
- Noxious weeds are to be eradicated and environmental weeds less than 1% of the Site;
- Infrastructure functional and well-maintained in a state suitable for hand over to Tweed Shire Council;
- Natural recruitment of native seedlings throughout planting areas.
- Maintenance of 100% of planted diversity; and
- Wetland plantings providing variable wetland habitats.

Completion criteria will be assessed for the FWRA as follows:

- The photos taken during monitoring visits, in combination with the annual monitoring and mapping of native vegetation composition, will be used to determine the extent of native wetland plant species and the levels of biodiversity the area is supporting.
- When it is determined that all completion criteria have been met, completion will have occurred.

8. REPORTING

8.1 Rehabilitation monitoring reports

Following each inspection by the qualified ecologist, a report will be prepared that will include tables and photographs from the monitoring visits. At the end of each year a detailed report will be prepared for the Department of Environment and Climate Change (DECC) and Tweed Shire Council. The report will discuss the following:

- Works undertaken;
- Progress of regeneration/revegetation areas against completion criteria using photos and tables showing the results of the monitoring visits;
- Significant problems encountered (death of seedlings, broken fences, vandalism etc.) and the effect of these on the plantings and aims of the revegetation or regeneration strategy;
- Success or failures of measures implemented to rectify previously identified problems; and
- Measures to be taken to rectify new problems.

8.2 Water quality monitoring reports

At the end of each year a detailed water quality monitoring report will be prepared for the Department of Environment and Climate Change (DECC) and Tweed Shire Council. The report will discuss the following:

- an analysis of water quality data collected from the FWRA in relation to baseline Thresholds for Key Water Quality Indicators; and
- details of any issues encountered and the recommendation of corrective actions.

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