Travers

bushfire & ecology

waterway impact study

OXFORD FALLS SENIORS
LIVING FACILITY

Lot 1113 DP 752038
BARNES ROAD
FRENCHS FOREST

September 2014
(REF: A14054WIS)

Waterway Impact Study

Oxford Falls Seniors Living Facility
Lot 1113 DP 752038
Barnes Road, Frenchs Forest

Report Authors: Corey Mead *B. App. Sc.*
Lindsay Holmes *B. Sc.*
John Travers *B. App. Sc. / Ass. Dip. / Grad. Dip.*
Plans prepared: Peter Tolley, Trent Matheson
Checked by: John Travers

Date: 05/09/2014
File: A14054WIS

Disclaimer:

This report has been prepared to provide advice to the client on matters pertaining to the particular and specific development proposal as advised by the client and / or their authorised representatives. This report can be used by the client only for its intended purpose and for that purpose only. Should any other use of the advice be made by any person including the client then this firm advises that the advice should not be relied upon. The report and its attachments should be read as a whole and no individual part of the report or its attachments should be interpreted without reference to the entire report.

The mapping is indicative of available space and location of features which may prove critical in assessing the viability of the proposed works. Mapping has been produced on a map base with an inherent level of inaccuracy, the location of all mapped features are to be confirmed by a registered surveyor.

ABN 64 083 086 677
PO Box 7138
Kariong NSW 2250

38A The Avenue
Mt Penang Parklands
Central Coast Highway
Kariong NSW 2250

t: 02 4340 5331
f: 02 4340 2151
e: info@traversecology.com.au

Executive Summary

Travers bushfire & ecology has been engaged by *Dukor 24 Pty Limited* to undertake a Waterway Impact Study for a proposed seniors living facility located within Lot 1113 DP 752038 off Barnes Road, Oxford Falls. This lot will hereafter be referred to as the 'site'.

The proposal involves expanding the capacity of an approved residential aged care facility on the site from 10 beds within the existing dwelling house, to a 45 bed facility contained within the existing building and proposed additional buildings on site.

Three watercourses are relevant to this study given their proximity to the proposal including:

1) A natural watercourse to the south which flows to the east and into a dam and managed rural landscape on the adjacent property. A constructed drainage line exists beyond this dam and flowing east. This watercourse will not be impacted by the proposal in any direct or indirect manner. This watercourse has been identified as Drainage Line 2 in previous studies (see Appendix 1 for description).

2) An ephemeral stormwater channel that has been constructed from a roadside culvert to the south which flows into the natural channel mentioned above. The road entry to the site for the proposal will be modified at this location and the stormwater drainage will be redirected along Barnes Road into the development landscape where the water will be treated. Therefore, the proposal will restore natural drainage in the upper reaches of Drainage Line 2.

3) Middle Creek Tributary (as described by previous studies - see Appendix 1) is a modified drainage channel that bisects the north eastern corner of the site. This drainage will not be directly or indirectly impact by the proposal and improvement works are proposed.

A drainage line described as Drainage Line 1 in previous studies runs east-west and is located approximately 100m to the north of the site boundary. Each of the drainages described are shown on Figure 2.

The proposal will not cause any adverse or altered impacts onto any of the nearby surrounding watercourse mentioned above.

TABLE OF CONTENTS

1 INTRODUCTION & DESCRIPTION OF PROPOSED DEVELOPMENT

1.1 Background to the preparation of this waterway impact study

This Waterway Impact Study (WIS) considers the environmental impacts of the proposed aged care development on the Middle Creek Tributary, its associated drainage lines, the riparian vegetation corridor lining this waterway (Figure 2) and the subsequent downstream impacts on Middle Creek.

This report has been prepared to address the requirements of the proposed development as it relates to the *Water Management Act (2000)* and *Water Management Amendment (Controlled Activities) Regulation 2008*, "the Regulation", which was gazetted on 25 January 2008, at which time the *Rivers and Foreshores Improvement Act 1948* was repealed. This document also addresses the requirements of Warringah Council's Creek Management Study. This WIS also considers the objectives of the Narrabeen Lagoon Estuary Management Plan 2002 and the Northern Beaches Stormwater Management Plan 1999. Both these reports list sedimentation into Middle Creek as being the biggest impact of development within the Oxford Falls locality.

Both the Middle Creek Tributary and its associated drainage lines currently do not contribute to the diverse native habitat required for a healthy creek ecosystem as a result of their deteriorated condition.

1.2 Aims

In accordance with the *Water Management Act* (2000), the WIS will recommend any relevant measures that will uphold the general water management principles of the Act identified as:

(a) water sources, floodplains and dependent ecosystems (including groundwater and wetlands) should be protected and restored and, where possible, land should not be degraded, and

(b) habitats, animals and plants that benefit from water or are potentially affected by managed activities should be protected and (in the case of habitats) restored, and

(c) the water quality of all water sources should be protected and, wherever possible, enhanced, and

(d) the cumulative impacts of water management licences and approvals and other activities on water sources and their dependent ecosystems, should be considered and minimised, and

(e) geographical and other features of indigenous significance should be protected, and

(f) geographical and other features of major cultural, heritage or spiritual significance should be protected, and

(g) the social and economic benefits to the community should be maximised, and

(h) the principles of adaptive management should be applied, which should be

(i) responsive to monitoring and improvements in understanding of ecological water requirements.

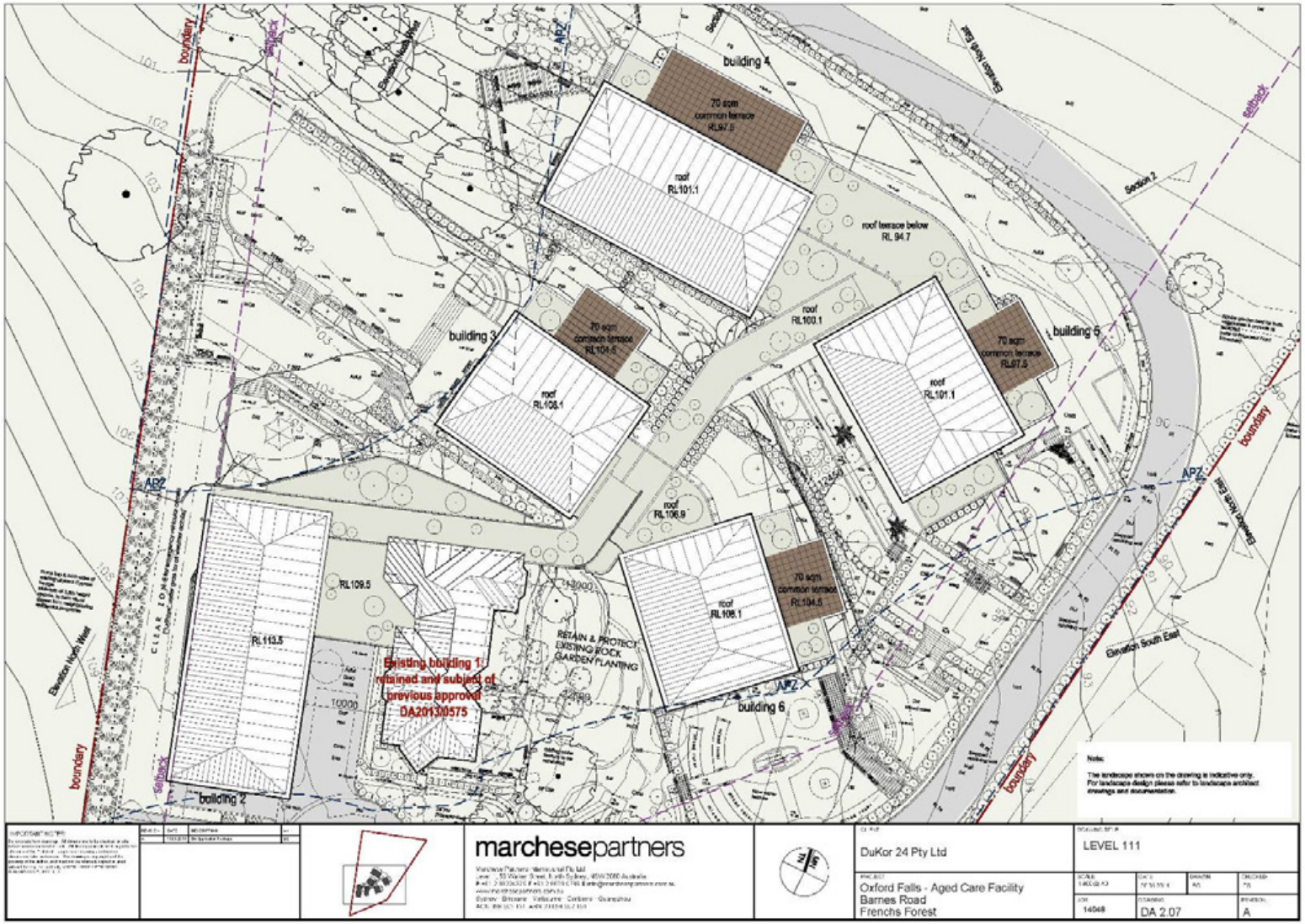


Figure 1 – Proposed development layout

This WIS will aim to address each of these principles to ensure that they are met in the short and long term.

Middle Creek Tributary is a tributary of Middle Creek which eventually drains into Narrabeen lagoon. The Warringah Creek Management Study categorises this creek as Group C.

"Group C Creeks are well above catchment development thresholds and the ecosystems are already substantially modified. Weed growth is a threat to remnant native vegetation and replanted native vegetation in the riparian zone. Water quality is at or above acceptable limits, which can result in occasional stress symptoms (e.g fish kills, nuisance algal growth and high turbidity".

The Warringah Creek Management Study has targeted the site for riparian rehabilitation and stream stabilisation under the 'Staged Implementation Schedule' for Middle Creek, outlining the following works for the medium to long term (2–5 years);

"*Commence riparian revegetation in upper reaches (including removal and replacement of the engineered channel running through the Australian Tennis Academy with stream stabilisation measures)*" (Warringah Council, 2004).

In the nearby surrounds to the site the tributary is artificially constructed and partially cement lined. The edges of the channel are predominantly lined with an aquatic, albeit exotic, herbfield which appears to be regularly mown. A remnant stand of sandstone woodland with a mown understorey lines the southern bank of the channel.

The WIS aims to recreate a natural stream system within the site portion of this tributary by way of 10m revegetation within a Core Riparian Zone and an extended 10m Managed Vegetation Buffer. The revegetation will be undertaken by the applicant and in accordance with the requirements of Warringah Council. Undertaking these works will enable Council to meet their objectives for the management of this portion of the tributary.

1.3 Specialist contributory advice

A previous proposal for the site as well as including five other parcels of land to the north and south for a large scale seniors living resort sought specialist hydrological advice. The following have been considered as relevant information on study area and have been included in Appendices 1 & 2:

- *JMD Development Consultants* - Catchment Plan 2013
- *Evans and Peck* – The Status of Drainage Lines, 2008
- *JMD Development Consultants* – Plan Detailing Extent of 100 Year Flood, 2006.
- *JMD Development Consultants* - Catchment Plan 2005

The following are reports prepared for the current proposal:

- *Travers bushfire & ecology* - Flora and Fauna Assessment, 2014
- *Travers bushfire & ecology* - Bushfire Protection Assessment, 2014

1.3.1 Background studies

Background studies which have been considered in the preparation of this document include the following;

- Warringah Council Creek Management Study (*Montgomery Watson* 2004)
- Narrabeen Lagoon Estuary Management Plan (2002)

- Northern Beaches Stormwater Management Plan (1999)
- A Rehabilitation Manual for Australian Streams Vol. 1 and 2 (Cooperative Research Centre for Catchment Hydrology, Department of Civil Engineering, 2000)
- Australian River Management and Restoration (Land and Water Resources, 2000)
- Steam Channel Processes (Water and Rivers Commission, 2000)
- Native Vegetation Regulation (DECC, 2005)

1.4 Location and zoning

Located within the Warringah Council Local Government Area (LGA), the proposed development is situated within Lot 1113 DP 752038, located on the south-western side of Oxford Falls Road and to the north of Barnes Road. The subject site has frontage to Barnes Road of approximately 370 metres. Approximate co-ordinates of the site are 337700E and 6264700N.

The site is bounded to the south-west by residential, to the north and south by rural residential land and to the east by natural bushland. The drainage to the south-west is located within a fragment of natural bushland. Natural vegetation adjoining the study area to the north east includes recreation reserves which extend along Wakehurst Parkway and eventually into Garigal National Park.

Natural vegetation adjoining the north-west boundary of the study area forms a vegetation corridor along Wakehurst Parkway to the west. This corridor extends along Wakehurst Parkway towards the south, across Frenchs Forest Road and Warringah Road into an extensive area of natural vegetation, including Manly Dam Reserve and Garigal National Park.

The site encompasses an area of approximately 3.36 hectares.

Certain parts of Warringah are not covered by the new 2011 LEP. The site is located within the affected land in the B2 Oxford Falls Valley. This area has been 'deferred' by the State Government. They are covered by LEP 2000 until further notice.

The Warringah LEP (2000) requires consideration to be made in accordance with Locality Statements which are particular to designated areas as shown on the Locality Maps. The proposed development is located within Locality B2 (Map 4), known as Narrabeen Lagoon Catchment Locality Statement, Locality B2 - Oxford Falls Valley.

In addition, Clause 60–Watercourse and Aquatic Habitat of the Warringah Local Environment Plan 2000 states:

"Development is to be sited and designed to maintain and enhance natural watercourses and aquatic habitat"

1.5 Description of the proposed development

The proposal involves expanding the capacity of an approved residential aged care facility on the site from 10 beds within the existing dwelling house, to a 45 bed facility contained within the existing building and proposed additional buildings on site.

- Modifications to this building will occur whilst car parking will be provide, landscaping undertaken inclusive of relaxation areas, gardens, putt-putt golf, tennis and bowling greens.

- The restoration of drainage corridors and riparian vegetation within the site.

- A 24m wide corridor is also proposed along the northern boundary to restore east-west connectivity to the riparian zone as shown in Figure 2.

- A row of pine trees will be selectively trimmed by approximately 50% on the western boundary.

- The proposed development layout within the subject site is provided on Figure 1. Figure 2 shows the extent of the proposed APZ area for management in neighbouring areas.

- *JMD* propose to deviate water from the western entry of Barnes Road to within the development landscape and ultimately through the water detention basin proposed external to the northern riparian zone.

2 DESCRIPTION OF THE ENVIRONMENT

2.1 Topography, drainage and catchment characteristics

Covering an area of approximately 3.36 hectares, the site is situated on land that slopes lightly to the east with a steep central band associated with sandstone escarpment edges (see Figure 1). The slopes and surface drainage within the site are directed to a tributary of Middle Creek which flows north.

Gradients of the subject site are generally 5-15% with steeper grades, up to approximately 70% associated with the sandstone escarpment. The approximate elevation of the site is between 78 -114 metres Australian Height Datum (AHD).

A tributary of Middle Creek comprises the main waterway through the site, flowing in a northerly direction toward Middle Creek adjacent to Oxford Falls Road. For the purposes of consistency with previous reports this creek is referred to as the Middle Creek Tributary (see Figure 2).

The Middle Creek Tributary is also fed by two smaller drainage lines which are located on either side of the site. To the north Drainage Line 1 runs from west to east between Lots 1110 and 1111; a significant proportion of which is concrete lined (see Figure 2). To the south and closer to the site is Drainage Line 2 runs in a north-easterly direction toward Middle Creek Tributary (see Figure 2). Several other undefined drainage lines run from west to east in the nearby surrounds which are also feed into the Middle Creek Tributary. The site forms part of the Narrabeen Lakes Catchment which comprises an area of approximately 110 hectares mostly north of the site.

2.2 Geology and soils

The geology of the subject site is characterised by Hawkesbury Sandstones of the Triassic Period. The soils vary from deep to skeletal, with numerous rock outcrops in the areas with steeper gradients.

The Sydney 1:100,000 Soil Landscape map sheet (Chapman, Murphy, Tille, Atkinson & Morse, 1989) shows that the subject site is principally located within the Lucas Heights Soil Landscape, with possible areas of Gymea Soil Landscape on the fringes. However, field inspections indicate that the whole of the site is within the Gymea Soil Landscape. The long history of agricultural activities in the areas of lesser gradient gives the appearance of Lucas Heights Soil Landscape.

The site contains no lands below 10m ASL elevation, so is therefore unaffected by acid sulphate soils (Morse McVey, 2005).

2.3 Vegetation characteristics

The vegetation of the majority of the subject site is dominated by pasture grass with scattered, retained or planted trees. Natural vegetation has been retained in areas without arable soil. Adjacent lands to the north and south contain similar vegetation. Lands to the south west contain residential development, while natural bushland occurs to the north west and east of the site.

The plants and communities observed are listed in the Flora and Fauna Assessment (*Travers bushfire & ecology* 2014). In addition to those species, a number of exotic species were observed in gardens in the vicinity of buildings. It should be noted that a number of trees and shrubs, although native to the locality, appear to have been planted.

Four (4) vegetation communities were identified within the study area through ground truthing. Each of these communities is represented within the subject site with only a very small portion of Community 4 entering the north west portion of the site.

- Vegetation Community 1 – Peppermint – Angophora Woodland / Open Forest
- Vegetation Community 2 – Exotic Grassland with Scattered Trees
- Vegetation Community 3 – Aquatic Herbfield (Creek line and dams)
- Vegetation Community 4 – Kunzea – Tea-tree Tall Heath

The following community descriptions are applied to the study area as a whole.

2.3.1 Peppermint – Angophora Woodland / Open Forest

Occurrence – This vegetation community occurs in sections of the subject site which do not contain arable soil.

Structure – Woodland or Open Forest with a canopy cover of approximately 10-35% and height of approximately 15-23m. The understorey consists of a variable, but generally moderate, shrublayer to 10m high and sparse to moderate groundcover of herbs, ferns and grasses in drier areas. In the moister areas, where the soil depth is skeletal, the understorey consists mostly of dense fern and sedge species, whilst the overstorey cover is reduced and the mid storey replaced with those species favouring wetter conditions such as *Banksia ericifolia.*

The height of the tree species in areas exposed to a high incidence of rock outcropping is reduced, as is the density of trees. This is evident in the central section of the western escarpment area.

Disturbances – This vegetation community has been disturbed by the construction of access roads and moderate to severe incursions of weeds such as Pampas Grass, Senna and Lantana.

This community would have once been equivalent to Sydney Sandstone Gully Forest.

Common species

Trees: *Eucalyptus piperita* (Sydney Peppermint), *Angophora costata* (Smooth-barked Apple) and *Corymbia gummifera* (Red Bloodwood).

Shrubs: *Acacia parramattensis* (Sydney Green Wattle), *Banksia ericifolia* (Heath-leaved Banksia), *Banksia spinulosa* (Hairpin Banksia), *Ceratopetalum gummiferum*, *Elaeocarpus reticulatus* (Blueberry Ash), *Leptospermum polygalifolium* (Tantoon), *Phyllanthus hirtellus*

(Thyme Spurge), *Pittosporum undulatum* (Sweet Pittosporum) and *Platylobium formosum* (Handsome Flat-pea).

Groundcovers: *Cryptostylis erecta* (Bonnet Orchid), *Entolasia marginata* (Bordered Panic), *Gonocarpus teucroides* (Raspwort), *Imperata cylindrica* (Blady Grass), *Lepyrodia scariosa*, *Lomandra longifolia* (Spiky-headed Mat-rush), *Smilax glyciphylla* (Sarsparilla) and *Xanthosia pilosa*.

Weeds: *Ageratina adenophora* (Crofton Weed), *Centaurium erythraea* (Pink Stars), *Conyza sumatrensis* (Tall Fleabane), *Cortaderia selloana* (Pampas Grass), *Hedychium gardnerianum* (Ginger Lily), *Hypochaeris radicata* (Flatweed), *Ipomoea indica* (Blue Morning Glory), *Lantana camara* (Lantana), *Ligustrum sinense* (Small-leaved Privet), *Lonicera japonica* (Honeysuckle), *Nephrolepis cordifolia* (Fishbone Fern), *Plantago lanceolata* (Ribwort) and *Senna pendula* var. *glabrata*.

Photo 1 – Peppermint – Angophora Woodland / Open Forest vegetation adjacent to Oxford Falls Road, part of the better condition vegetation

Photo 2 – Peppermint – Angophora Woodland / Open Forest vegetation in the central western portion of the subject site containing a high level of exotic plant disturbance\

Photo 3 – Heavily impacted zone in the middle of the Peppermint – Angophora Woodland / Open Forest

2.3.2 Vegetation Community 2 – Exotic Grassland with Scattered Trees

Occurrence – This vegetation community occurs in the sections of the subject site with arable soil. This community is highly disturbed and it is likely that it was previously Peppermint – Angophora Woodland / Open Forest.

Structure – Dense groundcover of herbs and grasses with scattered trees and shrubs.

Disturbances – This vegetation community is the result of agricultural activities.

Common species

Trees: *Angophora costata* (Smooth-barked Apple), *Casuarina cunninghamiana* (River Oak), *Eucalyptus piperita* (Sydney Peppermint) and *Eucalyptus punctata* (Grey Gum).

Shrubs: *Acacia parramattensis* (Sydney Green Wattle), *Ceratopetalum gummiferum* (Christmas Bush) and *Pittosporum undulatum* (Sweet Pittosporum).

Groundcovers: *Centella asiatica* (Swamp Pennywort) and *Cynodon dactylon* (Common Couch).

Weeds: *Acacia saligna* (Golden Wreath Wattle), *Axonopus fissifolius* (Narrow-leaf Carpet Grass), *Callistemon sp.* Cultivar (Crimson Bottlebrush), *Centaurium erythraea* (Pink Stars), *Conyza sumatrensis* (Tall Fleabane), *Euphorbia peplus*, *Hydrocotyle bonariensis* (Pennywort), *Hypochaeris radicata* (Flatweed), *Ligustrum sinense* (Small-leaved Privet), *Modiola caroliniana* (Red-flowered Mallow), *Nephrolepis cordifolia* (Fishbone Fern), *Pennisetum clandestinum* (Kikuyu), *Plantago lanceolata* (Ribwort), and *Trifolium repens* (White Clover).

This community would have once been equivalent to Sydney Sandstone Gully Forest. There are many planted specimens of trees within this community, particularly in the northern portion of the subject site in close proximity to the tennis courts.

Photo 4 – Some scattered trees (mostly planted) in close proximity to one of the existing dwellings.

2.3.3 Vegetation Community 3 – Aquatic Herbfield

Occurrence – This vegetation community occurs along the tributary of Middle Creek and on the edge of the farm dam within Lot 1336. There are other dams on site just downslope of the steep section of Vegetation Community 1 in the west that have been included within this vegetation community.

Structure – Moderate to dense herbfield to a height of approximately 1-2m, together with occasional exotic shrubs.

Disturbances – This community has been disturbed by modification of sections of the watercourse and incursions of weeds.

Common species

Native: *Hydrocotyle peduncularis* (Pennywort), *Juncus usitatus* (Common Rush), *Panicum bisulcatum* (Blackseed Panic), *Persicaria hydropiper* (Water Pepper) and *Typha orientalis* (Cumbungi).

Weeds: *Ageratina adenophora* (Crofton Weed), *Erythrina sykessii* (Coral Tree), *Colocasia esculenta* (Taro), *Cyperus eragrostis* (Umbrella Sedge), *Hydrocotyle bonariensis* (Pennywort), *Ludwigia peruviana*, *Ranunculus repens* (Creeping Buttercup), *Salix sp.* (Willow) and *Tradescantia fluminensis* (Wandering Jew).

Photo 5 – Riparian vegetation approximately 30m south of the existing car park for the tennis academy

2.3.4 Vegetation Community 4 – Kunzea – Tea-tree Tall Heath

Occurrence – This vegetation community occurs mostly within Lot 80 to the west of the subject site, with a small portion entering the site. Site visits following initial surveys by Travers bushfire & ecology found this community largely cleared within the neighbouring Lot 80 to the west.

Structure – Heath or scrub type vegetation with a height of generally 2.5-4m. There are very few emergent trees within this community. The shrublayer is thick and dense to approximately 50-75% foliage cover. The understorey is variable in density but usually sparse with very few grasses but does contain low growing shrubs, herbs and sedges.

Disturbances – This vegetation community has some weed influences but not to the extent of Vegetation Community 1.

Common species

Shrubs: *Acacia longifolia* (Sydney Golden Wattle), *Banksia ericifolia* (Heath-leaved Banksia), *Epacris crassifolia, Epacris microphylla* (Coral Heath), *Grevillea buxifolia* (Grey Spider Flower), *Kunzea ambigua* (Tick Bush) and *Leptospermum polygalifolium* (Tantoon).

Groundcovers: *Dianella caerulea* (Flax Lily), *Empodisma minus, Imperata cylindrica* (Blady Grass), *Lepidosperma filiforme* and *Lomandra longifolia* (Spiky-headed Mat-rush).

Weeds: *Agapanthus praecox* (Agapanthus), *Andropogon virginicus* (Whisky Grass), *Aristea ecklonii* (Blue Stars), *Asparagus aethiopicus* (Asparagus Fern), *Cortaderia selloana* (Pampas Grass) and *Ligustrum sinense* (Small-leaved Privet).

Photo 6 – Tall Heath vegetation looking westerly on the eastern edge

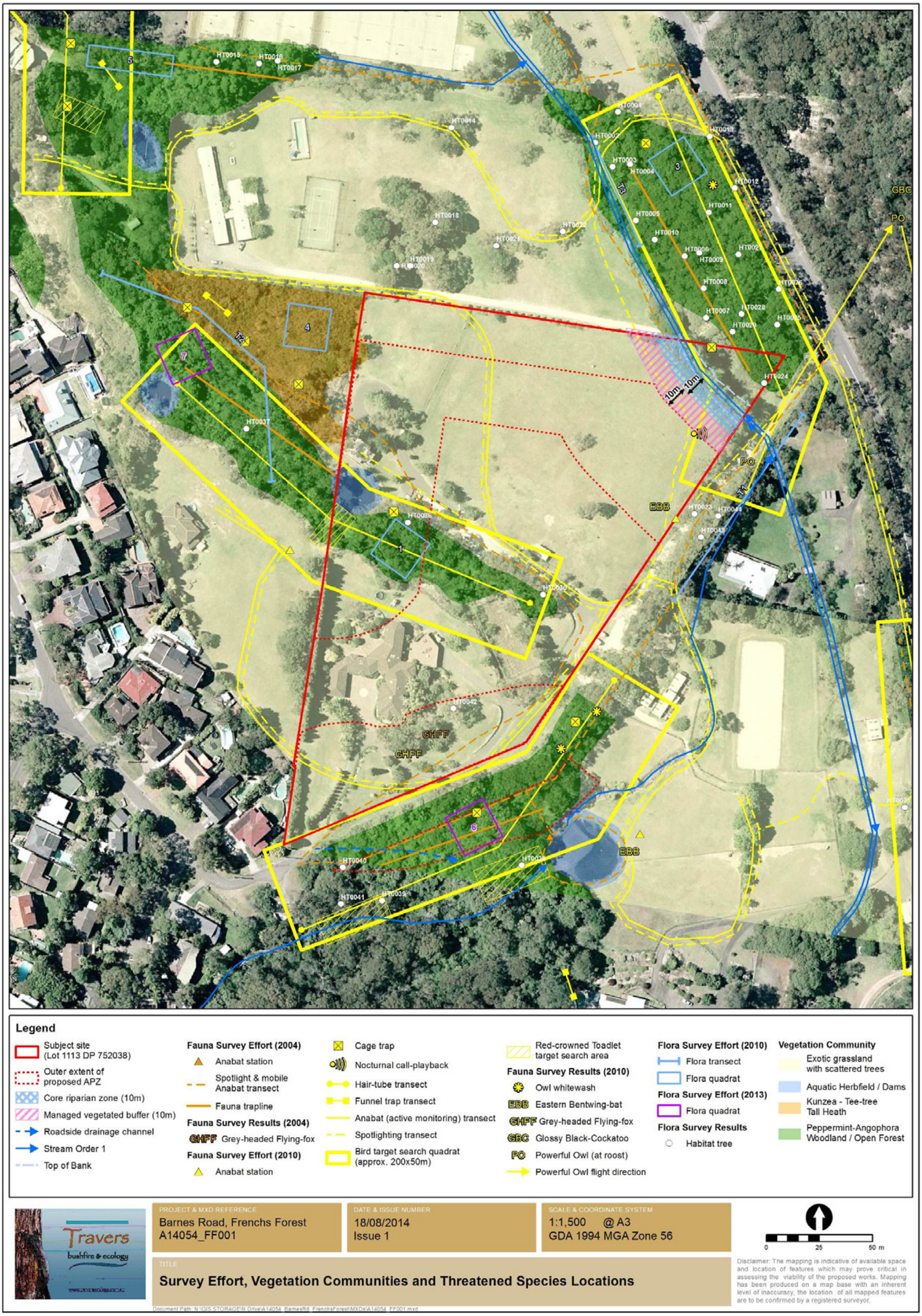


Figure 2 – Proposed development, APZs and surrounding drainages

3 RIPARIAN FUNCTION AND EFFICIENCY

The function and efficiency of a riparian environment is characterised by a series of complex interrelating biotic and abiotic elements which provide a symbiosis of the environmental, ecological and hydrological systems for the benefit of biodiversity.

3.1 Determination of stream order

Dr Steve Perrens of *Evans and Peck* was consulted in relation to the Middle Creek Tributary and its associated drainage lines for the previous proposed seniors living facility over the site and five (5) other parcels (see Appendix 1 for an excerpt of characteristics of these drainages). This total study area incorporated a large extent of the Middle Creek Tributary. In regards to the question of whether or not the tributary and associated drainage lines constitute a watercourse Mr Perrens concluded that;

'Drainage Line 1 is not marked on the 1:25,000 topographic map. Accordingly it does not have status in respect to the core riparian zone recommendations set out in Guidelines for Controlled Activities: Riparian corridors'.

Drainage line 1 is an artificially constructed and partially cement lined channel. The edges of the channel are predominantly lined with an aquatic herbfield which appears to be regularly mown. A remnant stand of sandstone woodland with a mown understorey lines the southern bank of the channel.

In regard to Drainage Line 2, Perrens makes the following conclusion;

'Drainage Line 2 is not marked on the 1:25,000 topographic map. Accordingly it does not have status in respect to the core riparian zone recommendations set out in Guidelines for Controlled Activities: Riparian corridors'.

In regard to the Middle Creek Tributary, Perrens concluded that;

'The Middle Creek Tributary is marked on the 1:25,000 topographic map but has no tributaries joining it within or upstream of the site. Accordingly it is a first order stream as classified by the Strahler System and the core riparian zone recommendations set out in the Guidelines for Controlled Activities: Riparian Corridors are therefore relevant considerations'.

Each of these drainages is shown on Figure 2 relative to the current site.

It is recognised that any possible restoration of the riparian zone and buffer within the site will only contribute a small portion of the total restoration measures required along the extent of this drainage to reach full benefit.

3.2 Riparian functions

Riparian land is any land that adjoins or directly influences a body of water. Riparian vegetation is important to the community for a variety of reasons. These values include: natural heritage, nature conservation, corridor linkage, educational / scientific importance,

recreational and scenic values. Riparian vegetation also provides the following important functions:

- Bed and bank stability
- Water quality improvement
- Water polishing
- Aquatic and riparian habitat
- Light and temperature regulation
- Terrestrial habitat
- Large woody debris and aquatic habitat
- Wildlife corridors (terrestrial and arboreal)

3.2.1 Bed and bank stability

Deep-rooted natural vegetation lining stream banks reinforces the soil and is usually the most important safeguard against bank collapse. Recent experiments have shown that tree roots can substantially increase soil strength to a depth of at least 2 metres, and to a distance equivalent to the canopy drip line (*Land and Water Australia* 2005). Extensive clearing of this deep-rooted, natural vegetation from catchments for agricultural and urban development combined with the removal of native riparian vegetation from along stream banks has resulted in rainfall moving off the land surface at a much faster rate. This increased rate of water flow puts pressure on stream banks that can no longer support flood peaks.

The rehabilitation and maintenance of riparian vegetation within the rehabilitation area (Figure 2) will increase the creek bank stability so that it may support flood peaks and provide increased bank and bed stability.

Photo 7 *- Example of bank collapse of the Middle Creek Tributary*

3.2.2 Water quality improvement

Riparian vegetation provides an important buffer between the urban/rural environment and the sensitive aquatic environment provided by streams and associated water bodies. Recent studies have shown in Australia that under favourable conditions, natural vegetation and grassy filter strips can trap around 90% of the sediment moving from upslope (Land and Water Australia, 2005). These sediments and excess nutrients such as nitrogen, phosphorus and other contaminants would have otherwise been able to enter the waterway leading to siltation of in-stream habitat for native flora and fauna.

Riparian vegetation can also uptake water and dissolved nutrients from contaminated groundwater potentially entering the creek. Trees and deep-rooted vegetation absorb significant amounts of sub surface waters leading to a substantial decrease in the amounts of dissolved nutrients such as nitrogen, phosphorus and salt entering the waterway.

3.2.3 Water polishing

Riparian vegetation provides the waterway with organic matter in the form of leaf litter, flowers, fruits and insects which are important food resources for many aquatic plants and animals. The organic matter entering the waterway is the basis of a complex food web which maintains a healthy and diverse habitat supporting larger fish and other aquatic species such as turtles, crayfish, platypus and other vertebrate species dependent on that habitat.

3.2.4 Aquatic and riparian habitat

Aquatic and riparian habitat interacts to provide an important foraging, roosting, nesting and breeding resource for a diverse range of native flora and fauna within the local area. The quality of riparian vegetation lining a waterway determines the amount of the nutrients entering that waterway, temperature regulation, terrestrial and in-stream habitat and habitat diversity.

3.2.4.1 Light and temperature regulation

The light and temperature regulation provided by riparian vegetation can help to control algal growth, such as blue-green algae, or excessive growth of water plants which can choke up the system. This excessive growth slows up the stream flow, causing sediments to accumulate, resulting in shallower, broader waterbodies and contributing to excessive erosion of stream banks.

The patchy lighting provided by riparian vegetation contributes to habitat for both prey and predators within the stream. Many aquatic species rely on patchy lighting within the water column to camouflage against when either hunting their preying or hiding from their predators.

3.2.4.2 Terrestrial habitat

Riparian vegetation provides habitat in the form of food, water and shelter for terrestrial dwelling native species. The threatened Grey-headed Flying-fox (*Pteropus poliocephalus*) has been recorded within the subject site (*Travers bushfire & ecology* 2014). Grey-headed Flying-foxes congregate in large numbers at roosting sites (camps) that may be found in rainforest patches, Melaleuca stands, mangroves, riparian woodland or modified vegetation areas (NPWS, 2000). The revegetation and rehabilitation of the creekline within the subject site will improve the potential roosting and foraging habitat for this threatened species ensuring its perpetuity within the local area.

Two (2) fauna species listed in the NPWS Urban Bushland Biodiversity Survey (1997) as regionally significant, Brown Antechinus (*Antechinus stuartii*) and Long-nosed Bandicoot (*Perameles nasuta*) were recorded within the subject site (*Travers bushfire & ecology* 2014). Both of these species would utilise the riparian vegetation provided by revegetation of the creekline as both a foraging resource and a corridor through the site.

Many fauna species such as frogs rely on the moist conditions of the riparian zone for the duration of their lives and also proximate to breeding locations, whilst other fauna species use it as a means of shelter or passage through cleared landscapes. They provide a nutrient

rich form of foraging habitat and can act as a lowland shelter during fire events, allowing fauna to recolonise the burnt areas once they become suitable again.

3.2.4.3 Large woody debris and in-stream habitat

Large woody debris within stream channels and on the bank itself is an important component for the functioning of healthy waterways. Large woody debris can help control bank and bed erosion; and provide habitat diversity (shelter, breeding and resting) for a large variety of native aquatic species.

Large woody debris can help to;

- Control erosion as a result of excess runoff or in a flood event by slowing down the increased water flow at a particular point of the stream.
- Reduce stream bank erosion by protecting the bank from excess scour, redirecting the flow of water away from the bank.
- Provide aquatic life with quiet secure spots to rest within the pools created by large woody debris before moving further downstream
- Increase the level of dissolved oxygen in the water by aerating the water as it flows over the debris.

3.2.5 Wildlife corridors (terrestrial and arboreal)

Retained vegetation alongside stream, creeks and waterways can provide essential habitat for the movement of native flora and fauna through otherwise cleared areas. Ground dwelling species rely on riparian vegetation for foraging habitat, whilst the dense understorey vegetation provides them with a means of passage between areas of breeding and nesting habitat.

Arboreal species rely on the canopy line along waterways for passage through areas of rural, urban and industrial development. The rich soils of riparian areas also provide an energy rich food resource for nectivorous arboreal species in the form of abundantly flowering Eucalypts and other flowering flora species. Long standing trees with hollows may also be abundant in retained riparian vegetation, proving arboreal mammals and some birds with high quality nesting habitat which is secure in the long term.

Many species of bird utilise wildlife corridors as an area between vegetation remnants where they can rest and/or take refuge before moving on. Nectivorous bird species take advantage of the rich food resources provided by these areas to regain their energy levels during long flights between breeding, nesting and foraging areas.

The proposed riparian restoration area is adjacent to a proposed wildlife corridor on the northern boundary that will combine for area available for north-south and east west fauna passage. It is recognised that such widths with facilitate many but not all local species as corridor widths area a reflection of their relative function. These widths are considered adequate in consideration to the fragmented surrounding lands that they link. The east-west passage is particularly of benefit given the otherwise limited potential for this movement by local terrestrial species.

3.3 Watercourse structure

The watercourse structure is critical to providing a stable bed and bank structure that supports a variety of aquatic habitats. Watercourse structure falls into the following categories:

- Design velocity
- Pool and riffle sequence
- Flow channel capacity
- Width of riparian zone and buffer
- Bank and bed substrate

3.3.1 Design velocity

The relationship between velocity of the current and the substrate available within the stream determines the sediment composition of the stream bed. Due to a lack of friction from the bottom and sides of the stream, the maximum current velocity is found in the middle of the stream channel at just below the surface. The relationship of current velocity to sediment composition is outlined in Table 1 below.

Table 1 - Relationship of current velocity to sediment composition*

Velocity Range (cm/sec)	Stream Bed Composition	Approximate Diameter (mm)
3–20	Silt, mud (organic debris)	<0.02
20–40	Fine sand	0.1–0.3
40-60	Coarse sand to fine gravel	0.5–8
60–120	Small, medium to large gravel	8–64
120-200	Large cobbles to boulders	>128

**Modified from Boulton and Brock (1999)*

As can be seen in Table 1, areas of the stream with a low velocity have the opportunity to form rich organic pools. Areas of higher velocity, such as riffles, will consist of coarser substrate and pebbles.

The overall design of the drainage extent should ideally incorporate sufficient channels, width pools, riffles and runs to allow the formation of a varied sediment composition. The watercourse should also allow for 'flushing' during storm events, minimising permanent accumulation of sediments within the stream.

3.3.2 Pools and riffles sequence

A typical stream or creek would consist of an alternating sequence of pools and riffles which are an important dynamic for the health of any creek ecosystem. Pools provide aquatic fauna with an area to rest, breed, take shelter from predators or locate prey. They also provide calm waters allowing aquatic flora to attach to the substrate or large woody debris within the pool. Riffles help to actively aerate the water as it flows over the substrate of the creek bed. As already discussed, this substrate usually consists of small pebbles and boulders which have been carried downstream and deposited from the stream load. Figure 3 below depicts the pool and riffle sequence typical of a healthy creek system.

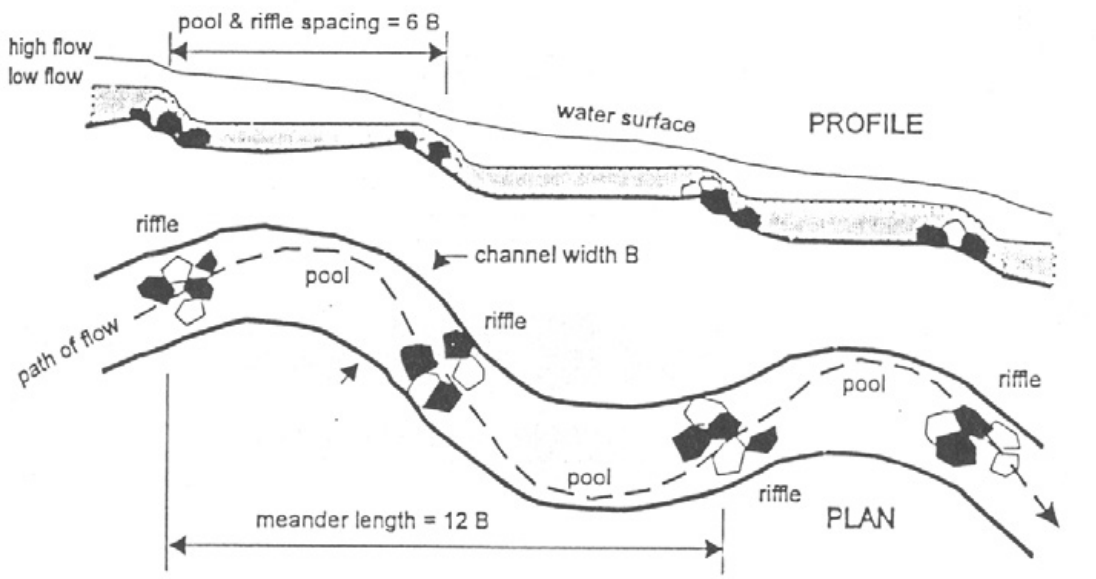


Figure 3: Average meander, pool and riffle dimensions expressed as a ratio to the bankfull width (B).

Figure 3 also demonstrates the relationship between the pool and riffle dimensions of a waterway and how the bankfull width affects the meander length. The average distance between a pool and a riffle is six times the bankfull width. For example, a stream or creek with a bankfull width of 1 metre would have pools and riffles spaced at 6 metres apart. The length of a meander is therefore twelve times the bankfull width and consists of the alternation of two riffles and two pools; in this case the meander would be twelve metres in length.

3.3.3 Width of riparian zone and buffer

The width of the riparian zone will determine the level of protection afforded to the waterway that it surrounds. The required width of any riparian zone will depend on factors such as watercourse bed and bank stability, ecological conditions on either side of the watercourse (width and quality of existing riparian vegetation, fauna migration needs, habitat values, etc.), the potential to restore corridor functions in the future and the relevance to planned eco-corridors and reserves/parks. The riparian zone width must endeavour to represent all elements of the riparian ecotone - i.e. aquatic, bank and floodplain, and is to incorporate the complete transition of wet/damp to dry.

3.3.4 Bank & bed substrates

Substrates used within banks and beds should avoid sand, silt, ash, etc which have high erodibility. However, substrates will be largely determined by the current soil types within the riparian zone. Stabilising structures will need to be used to prevent stream bank and bed erosion. Generally these structures consist of rock drops, rock rubble, timber, logs, rock walls and concrete weirs. Within rehabilitated streams artificial structures should be avoided or utilise stable rock that is placed in a natural layout. Within the low flow channel of the stream, stabilising structures can be used to create the riffle and pool sequence. Within the stream banks deflection bars can be installed at 20^{o}-40^{o} from the top of the bank to create a low flow meander. The size and dimension of rocks are to be consistent with the stream velocity (Table 1) to prevent movement in high flow events.

4.1 Soil erosion and sedimentation impacts

The construction of earthworks, stormwater facilities and buildings will be the period of greatest potential for environmental impact with regard to soil erosion and drainage line sedimentation. As the proposal will utilise the existing building, the earthworks proposed are limited to car parking, landscaping and construction of the existing unformed road 'Barnes Road', adjoining the site's south eastern boundary road. Because of the slope of the land, soil type and area of land disturbance required for the building sites, appropriate soil conservation measures need to be implemented to minimise the potential for soil erosion and off-site sedimentation.

Installation of sediment control fencing will help to ameliorate the impact of sedimentation from construction works and upon downstream aquatic habitats below the proposed development.

Full details in regards to the soil erosion and sedimentation control measures will be provided when development approval is granted and before any construction work is undertaken. More specific measures would be detailed at the Construction Certification stage when the design, exact location and orientation of the development is finalised.

Generally the methods utilised would be in accordance with the guidelines provided in the Soil Conservation Service Publication "Urban Erosion and Sediment Control Handbook" and Council's Code of Practice for Erosion and Sediment Control from Building Sites which requires a detailed soil erosion control plan to be submitted with Building Applications. An erosion and sediment control plan will be developed as part of the detailed design phase and will be submitted for construction certification.

Full details in regards to the extent of excavation and amount of fill will be provided when development approval is granted and before any construction work is undertaken.

4.1.1 Catchment water quality

Aquatic habitats downslope of the site could be adversely affected by sedimentation from soil material eroded from the cleared areas. This is most relevant along the southern edges of the proposed upgrade of Barnes Road given that a stormwater channel runs from this point into the natural nearby drainage 2 to the south (see Figure 2). This channel will be effectively redirected along the roadside and this will restore natural drainage in the upper reaches of Drainage Line 2 (see Figure 2).

It will obviously be best practice to divert this flow prior to any nearby road works so that the water quality can be more effectively managed by in-channel management. This will give a longer extent of management opportunity whilst ensuring that the nearby Drainage line 2 is not impacted at any stage. This is warranted also given that the current stormwater drainage line is directed through the area identified for understory management for APZ's (see Figure 2).

To ensure the appropriate management of aquatic habitats downstream of the site, the soil erosion and sedimentation controls in accordance with the Council's Code of Practice should be implemented throughout all construction stages.

Heavy metals as a result of internal roadway pollution also have the potential to enter the waterway via the stormwater system. The potential impacts due to nitrogen, phosphates, suspended sediment, heavy metals and dissolved oxygen contamination include:

- Increased prevalence of weed species eg: Crofton Weed and Kikuyu.
- Localised siltation in the immediate receiving waters downstream of the stormwater outputs.
- Reduced dissolved oxygen levels.
- Fish kills.
- Decreased diversity of aquatic flora and fauna.

These impacts are not likely to be significant by comparison to the current potential of such impacts along the existing pavement of Barnes Road.

Photo 8 - Drainage Line 2 and associated dam within Lot 1336 to the nearby south

Photo 9 - Example of siltation and weed incursion within the Middle Creek Tributary (2014)

JMD was engaged by *Dukor 24 Pty Ltd* to develop a stormwater drainage concept plan for a proposed aged care facility located off Barnes Road, Frenchs Forest. The Original Stormwater Concept Plan (2013) detailed the proposed water quantity and quality measures required to ensure that the proposed development did not impact on existing water issues in the vicinity.

The additional investigation into the water quality impacts found that the Barnes Road pavement will impact on the quality of water and that such impacts can be addressed by diverting the low flows off the new pavement to be constructed in Barnes Road to the proposed water quantity/quality basin to be provided on site. This investigation found that the originally proposed rain garden had sufficient capacity to treat the flows off Barnes Road without an increase in the original dimensions.

This investigation confirmed that the combination of treatment measures described below will effectively manage the pollutants to result in a net reduction in annual pollutant loads of at least 80% for total suspended solids, 65% Total Phosphorus and 45% Total Nitrogen:

- A 15kL(min) rain water tank collecting roof water flows with stored water being reused for toilet flushing and laundry purposes,
- At least 120m of grassed swales used to collect and direct surface flows to the proposed detention basin, and
- A bio-retention basin incorporating a minimum of 260m² of filter media (0.5m deep) with an extended detention depth above the filter media of 200mm.
- Low flows from the additional pavement in Barnes Road.

4.2 Impact on vegetation

Native understorey will be impacted for APZ purposes. The inner protection zone extends into the small bushland fragment to the north-east of the building and outer protection zone extends up to 25m into the larger fragment on neighbouring land to the south. This area will be subject to an 88b easement agreement. The new edge of understorey further to the south will be subject to similar edge effects such as the existing weed incursions.

The existing riparian vegetation lining the drainage lines and in particular the Middle Creek Tributary are currently highly impacted by weed incursions (Photo 10). It is expected that portions of the Middle Creek Tributary within the site will be subject to weed management and restoration as part of the proposal. Weed management techniques for use in areas of native vegetation retention are outlined in Appendix 3. This will lead to an increase in habitat quality for native flora and fauna as well as an increase in the aesthetic appeal of the development and surrounding area.

Photo 10 - Example of the density of weed incursions lining the Middle Creek Tributary within the neighbouring Lot 1111

4.2.1 Anticipated impact of the development to trees on site

A comprehensive tree assessment has been undertaken by *Travers bushfire & ecology and* is part of the Flora and Fauna Assessment (2014). The trees on this site are a mixture of endemic (naturally occurring local native) species and exotics. The native tree species present include *Acacia floribunda* (Sally Wattle), *Acacia parramattensis* (Sydney Green Wattle), *Allocasuarina torulosa* (Forest Oak), *Angophora costata* (Smooth-barked Apple) *Corymbia maculata* (Spotted Gum), *Eucalyptus piperita* (Sydney Peppermint), *Eucalyptus paniculata* (Grey Ironbark), *Eucalyptus punctata* (Grey Gum) and *Eucalyptus sieberi* (Silvertop Ash).

Exotic species are located in landscaped areas surrounding the existing residence. Many of the native trees within the open forest areas subject to APZ areas are of poor health and condition mainly attributed to natural suppression from neighbouring trees. Only these trees that were considered to be potentially affected by the proposal were assessed.

The construction of roads and parking also creates areas of increased soil compaction with reduced infiltration potential. This can potentially decrease the rooting area of surrounding trees and create water stress. Stressed trees are more susceptible to insect and fungal attack (Florence 1996, Simpfendorfer, 1992) and are more likely to drop dangerous branches.

Several factors have the potential to affect the long-term viability of any tree with the potential to be retained, including:

- Changes to site hydrology characteristics (decreased infiltration from compaction) following development.
- Increased erosion and soil movement following clearing for development.
- Exposure of retained trees to altered wind and light intensities from the removal of neighbouring trees.
- Physical damage to retained trees from the removal of neighbouring trees.

- Damage to rooting areas from the excavation and construction of roads, dwellings and trenches for utility (water/electricity etc.) connections.
- Physical damage from development construction works.
- Damage from future resident/land manager activities.

4.3 Impact on threatened species

In general the potential impact of the proposed development on native fauna and fauna habitats is not considered to be significant as the site has been the subject of previous development and habitat removal is within existing fragments for APZ's. It appears that no hollow-bearing trees will require removal as part of the proposal. Therefore, no breeding impacts on hollow-dependent threatened fauna species with potential to occur are considered likely. Impact on threatened species (including a 7-Part Test of significance) has been addressed in the Flora and Fauna Assessment Report (*Travers bushfire & ecology* 2014).

4.4 Impact on surrounding land uses

The proposed development will have a minimal impact on surrounding land uses. The proposal will conform to Council's requirements for dwellings located adjacent to creeklines. The proposed location of the buildings will ensure compatibility with the existing residences to the north and south west.

4.5 Impacts on catchment hydrology

The subject site is located in a valley within Warringah Shire bounded by Warringah Road in the south, The Wakehurst Parkway in the west and Booker Avenue in the east. The valley collects the stormwater runoff from approximately 110 hectares of catchment. The Catchment Plan (*JMD Development Consultants*, 2013) depicts the catchment for the subject site. The eastern and southern portions of this catchment have been previously developed with residential housing whilst the western portion of this catchment is relatively undisturbed.

The quantity of runoff, discharge velocity and water quality from the site will not be altered as a result of the proposal.

4.6 Impacts of weed incursion

Weeds are competitive and adaptable and tend to multiply readily and spread. They are a problem to native vegetation as they compete for the same basic requirements for growth as native plants. These basic requirements include nutrients, water, space and sunlight.

The worst weed problems are usually areas of recent disturbance where there is bare, soft soil, high nutrient availability, moist conditions and high light intensity. In urban areas, these conditions are usually found along creeks, tracks and fire trails, edges of roads and ovals, behind houses and downslope of road drains or concentrated animal complexes such as stables (Buchanan, 1999).

The vegetation on the subject site includes some weed species. In riparian areas the weeds include, but are not limited to, *Ageratina adenophora* (Crofton Weed), *Colocasia esculenta* (Taro), *Erythrina sykessii* (Coral Tree), *Cyperus eragrostis* (Umbrella Sedge), *Hydrocotyle bonariensis* (Pennywort), *Ludwigia peruviana*, *Ranunculus repens* (Creeping Buttercup), *Salix sp.* (Willow) and *Tradescantia fluminensis* (Wandering Jew).

Weeds within the core riparian zone and remaining areas of the site to the east of the Middle Creek Tributary are to be progressively removed in accordance with techniques recommended by the National Trust, NSW Office of Environment and Heritage and Conservation and the Australian Association of Bush Regenerators. Appendix 3 details specific low impact weed control techniques.

It is recommended that natural recruitment (Appendix 4 – Bush Regeneration Specifications) of the tree, shrub and groundcover layers be facilitated by the removal of weed species within areas presently occupied by native vegetation.

Monitoring of the progress of weed removal, plant growth and natural regeneration should be undertaken on a minimum of a yearly basis for two years.

4.7 Impacts of tree removal

The proposal will require the removal of approximately eleven (11) trees for the construction of Barnes Road access from the west. This includes one planted exotic pine. The proposal also requires the removal of approximately thirty-five (35) planted palms for the provision of car parking facilities.

None of these trees are located near to the identified drainages and therefore removal will not impact on stream bank stability, water temperature, increased nutrients or water quality.

5 CONCLUSION

It is concluded that there will be no likely direct or indirect impacts on the identified natural and modified waterways that are located within or in close proximity to the site.

This is given the significant setbacks of earthworks, landscaping and tree removal associated with the development. Therefore it is considered that a riparian plan of management or any key commitments to maintaining the riparian habitats and water quality are not required.

BIBLIOGRAPHY

Buchanan, R. (1999) *Bush Regeneration, Recovering Australian Landscapes*, Open Training and Education Network, Sydney

Boulton A. J. and Brock M. A. (1999) *Australian Freshwater Ecology: Processes and Management*. Gleneagle Publishing, SA

Chapman, G. A. & Murphy, C. L. *Soil Landscapes of the Sydney 1:100,000 Sheet* (1989) Soil Conservation Service NSW

Environmental Planning and Assessment Act (1979). New South Wales Government.

Evans and Peck (2008) *Status of Drainage Lines*

Evans and Peck (2005a) *Watercourse Opinion Seniors Living Development DA 2004/1402DA, Oxford Falls Road, Oxford Falls*

Evans and Peck (2005b) *Status of Drainage Lines*

Florence, R. G. (1996) *Ecology and silviculture of Eucalypt Forests* CSIRO, Collingwood, Victoria.

JMD Development Consultants (2013) *Revised Stormwater Concept Plan.*

JMD Development Consultants (2008) *Revised Stormwater Concept Plan.*

JMD Development Consultants (2005) *Oxford Falls Retirement Resort, Supplementary Stormwater Concept Plan.*

Land and Water Australia (2005) *Managing Riparian Land,* Australian Government, Canberra.

Land and Water Australia (2005) *River Landscape Fact sheets,* Australian Government, Canberra.

Montgomery Watson (2004) *Warringah Council Creek Management Study.*

Morse McVey and Associates (2005) *Conceptual Water Quality Management Plan for Proposed Retirement Resort Lots 1108, 1110, 1111, 1113, DP752038; Lot 20 DP842523; Lot 80 DP846099 Oxford Falls Road, Barnes Road, Frenchs Forest.*

Morse McVey and Associates (2005) *Conceptual Soil and Water Management Plan for Proposed Retirement Resort Lots 1108, 1110, 1111, 1113, DP752038; Lot 20 DP842523; Lot 80 DP846099 Oxford Falls Road, Barnes Road, Frenchs Forest.*

National Parks and Wildlife Service (1997) *Urban Bushland Biodiversity Survey - Western Sydney*.

New South Wales Government (2005) *Native Vegetation Regulation 2005, Environmental Outcomes Assessment Methodology.*

Patterson Britton (1999) *Northern Beaches Stormwater Management Plan.*

Rutherford, D. Jerie, K. and Nicholas Marsh (2000) *A Rehabilitation Manual for Australian Streams*, Cooperative Research Centre for Catchment Hydrology, ACT and, Land and Water Resources Research and Development Corporation, VIC.

SEEC Morse McVey (2008) *Water Quality Management Concept*

Simpfendorfer, K. J., (1992) *An Introduction to Trees for South-eastern Australia* Inkata Press

Strahan, R. (1998) *The Mammals of Australia* The Australian Museum

Threatened Species Conservation Act (1995) New South Wales Government.

Travers environmental (2008) *Flora and Fauna Assessment of Lots 1110, 1111, 1113 & 1336 DP752038, Lot 20 DP842523 and lot 80 DP846099, Oxford Falls Road and Barnes Road, Frenchs Forest.*

Travers environmental (2008) *Bushfire Protection Assessment for the Proposed Serviced Self Care Apartments and Nursing Home on Lots 1110, 1111, 1113 & 1336 DP752038, Lot 20 DP842523 and Lot 80 DP846099, Oxford Falls Road And Barnes Road, Frenchs Forest*

Travers, J., (2004) *The Ecological Management of Bushfire Asset Protection Zones: A case study at Wallarah Peninsula*

Travers bushfire & ecology (2014) *Flora and Fauna Assessment of Lot 1113 DP752038, Barnes Road, Oxford Falls.*

Travers bushfire & ecology (2014) *Bushfire Protection Assessment of Lot 1113 DP752038, Barnes Road, Oxford Falls.*

WBM (2002) *Narrabeen Lagoon Estuary Management Plan.*

APPENDIX 1

STATUS OF DRAINAGE LINES

(Relevant excepts describing the drainages surrounding the site Evans & Peck, 2008)

1 INTRODUCTION

This report provides an assessment of the characteristics and status of a number of drainage lines within the site of the proposed Oxford Falls Retirement Resort on Oxford Falls Road at Oxford Falls

Figure 1 is an enlarged edited copy of the 1 : 25,000 topographic map of the site for the proposed Retirement Resort and its immediate surrounds. The key amendments made to the map in Figure 1 comprise:

- Addition of a heavy black line to designate the boundary of the site;
- Two green lines to show the approximate location of two drainage lines that cross the site and convey urban runoff to the main creek line.

With reference to Figure 1, the drainage lines considered in this report are:

- **Middle Creek Tributary** represented by the blue line that runs across the figure from the south-east to the north–west approximately parallel to Oxford Falls Road.;
- **Drainage Line 1** represented by the northern most green line running in an easterly direction to Middle Creek Tributary. This drainage line runs along the southern edge of the tennis courts at the Australian Tennis Academy;
- **Drainage Line 2** represented by the southern-most green line running in a north-easterly direction to Middle Creek Tributary. The lower reach of this drainage line runs approximately parallel to the road reserve section of Barnes Road that connects to Oxford Falls Road.

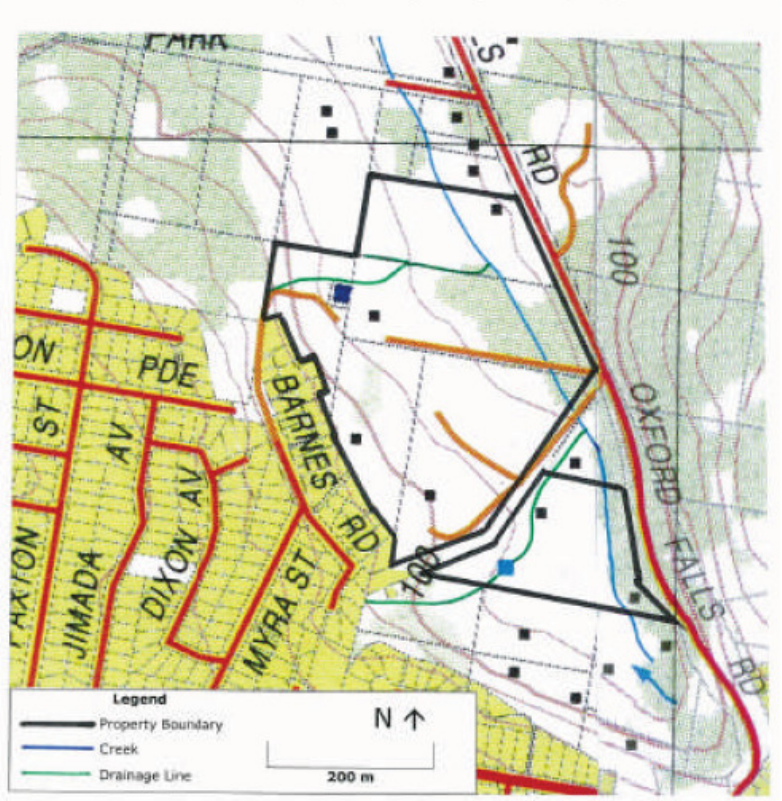


Figure 1
Extract from 1:25000 Topographic Map

2 DRAINAGE LINE 1

2.1 PHYSICAL CHARACTERISTICS

Drainage Line 1, which runs in an easterly direction immediately south of the tennis courts in the Australian Tennis Academy, has a number of distinct reaches with different characteristics:

- For about 100 m upstream of its junction with the Middle Creek Tributary, the drainage line is defined by a regular shaped constructed grass channel with a half round concrete invert that runs along the southern edge of the tennis courts (approximately the southern boundary of Lot 1110). Photo 1 (located at the end of this report) is a view of this section of channel. This drainage line continues as a grassed channel for a further 50 m along the southern edge of the tennis courts with two changes in level corresponding to the changes in levels of the tennis courts.
- A drainage line enters the channel from the south at about the point where the half round concrete invert ends (about 60 m east of the western boundary of Lot 1110). The actual junction of the drainage line with the channel is hidden in dense weed growth. From its junction with the grass lined channel, the drainage line continues in an approximately west-south-westerly direction around the northern side of a water quality control pond that was constructed in about 1994 (in association with the development of 10 house blocks along the north eastern side of Barnes Road). (The location of the water quality control pond is shown on Figure 1 by a blue square located immediately south of Drainage Line 1 near the western boundary of the site.) In this reach, which is approximately 100 m long, the drainage line has a highly irregular shape and varies from having no defined channel to a small channel with bed and banks (about 1 m wide and 500 mm deep).
- Approximately 10 m upstream of the western side of the water quality control pond, water is conveyed under an access track via a 475 mm diameter concrete pipe.
- Between this point and the continuation of Barnes Road, a distance of about 60 m, drainage occurs along the low point between rocks on the hillside, with occasional small pools formed in the rock.
- Flow is conveyed under a driveway that forms an extension to Barnes Road by means of a culvert into which water drains via an inlet pit on the western side of the driveway. This point is located approximately on the boundary of the original Lot 1116 (now Lot 80 Barnes Road?) and marks the upper limit of where a defined drainage line can be identified. From the drainage plans prepared by Lovegrove Oxley & Associates (1994), it appears that drainage from the urban area to the west of Barnes Road is piped along the western side of the northern section of Barnes Road to this point. However, no connection point is noticeable at the surface.
- The rocky hillside above the driveway does not have any distinct drainage pathway and runoff occurs as uncoordinated drainage between the rocks.

The total length of Drainage Line 1 within the project site is about 300 m.

2.2 NATURAL DRAINAGE

The contour data on the 1:2000 orthophoto maps of the area does not indicate any distinct continuous depression that would be associated with a watercourse draining from the plateau area (now developed for housing) anywhere along the south-western boundary of the site. Prior to the residential development, the natural drainage from this section of plateau towards the Site was

primarily by overland flow and minor ephemeral gullies that became active only during runoff events. Based on the contour information on the orthophoto maps, the original natural catchment draining to the head of Drainage Line 1 at the boundary of Lot 80 Barnes Road was approximately 1.5 ha. As discussed in Section 2.3 below, the urban development on the plateau above the site of the proposed Retirement Resort has significantly altered the drainage patterns and the catchment of Drainage Line 1 is now approximately 17.5 ha.

In addition to changes in the catchment area that have occurred over the years, inspection of the Manly Cove parish maps for 1914 and 1923 , historic aerial photography and orthophoto maps indicates the drainage line has been progressively relocated to its current position. All of the drainage line downstream of the water quality control pond has been constructed and relocated at some time in the past.

3 DRAINAGE LINE 2

3.1 PHYSICAL CHARACTERISTICS

Drainage Line 2 runs in a north-easterly direction across Lot 1336 (part of the project site) along an alignment that is approximately parallel to the unmade section of Barnes Road. Drainage Line 2 joins the Middle Creek Tributary near the intersection of Barnes Road and Oxford Falls Road.

Drainage Line 2 exhibits the following characteristics:

- Drainage Line 2 joins the Middle Creek Tributary immediately upstream of the north-eastern section Barnes Road.
- For about 200 m upstream of its junction with Middle Creek Tributary, the drainage line is defined by an irregular shaped channel, some of which is clearly constructed (example shown in Photo 2). This channel, 130 m of which is located on Lot 1336, provides a pathway for overflow from a dam (see below) to reach the Middle Creek Tributary.
- A constructed dam, measuring approximately 30 m by 30 m at the surface, is located at the base of a small cliff. Water from the drainage line above the cliff forms a waterfall that discharges into the dam.
- Immediately above the cliff, which is located close to the southern boundary of Lot 1336, stormwater drains across the low point on a series of sandstone ledges. Photo 3 is a view of this section of this drainage line which has a similar form for a further 120 m to a point adjacent to the south-eastern end of the constructed section of Barnes Road (near Leagay Crescent).

Drainage Line 2 enters Lot 1336 immediately upstream of the dam and drains from Lot 1336 near the north-west corner (near Barnes Road). The total length of Drainage Line 2 within Lot 1336 is about 160 m, including the dam.

3.2 NATURAL DRAINAGE

Although the 1:25000 scale topographic map of the area does not show a blue line to denote a stream along Drainage Line 2, the contours indicate a depression running in the general direction of the current alignment of the drainage line. This depression is more apparent on the 1:2000 orthophoto map of the area on which a depression can be traced for a distance of about 850 m to the south-west from the current junction of Drainage Line 2 with the Middle Creek Tributary. This depression can be traced as far as the intersection of Frenchs Forest Road and Inverness Avenue. I estimate that the original natural catchment area of Drainage Line 2 was about 50 ha.

The Manly Cove parish maps for 1914 and 1923 show a drainage line running across Lot 1336 (approximately parallel to the north-eastern section of the Barnes Road reserve) along the approximate alignment of the existing drainage line. On the basis of this evidence, it appears that the current alignment of Drainage Line 2 has existed at least since the early 1900s, although it has clearly been enhanced by excavation in some locations downstream of the dam.

I consider that, prior to residential development on the plateau above the Site, Drainage Line 2 would have exhibited ephemeral flow immediately after rainfall, with some ongoing groundwater seepage from the underlying sandstone for a few weeks after prolonged rainfall.

4 MIDDLE CREEK TRIBUTARY

4.1 PHYSICAL CHARACTERISTICS

Middle Creek Tributary originates near the intersection of Iris Street and flows in a north-westerly direction parallel to Oxford Falls Road for a distance of about 1.5 km where it flows under the Wakehurst Parkway before joining Middle Creek about 150 m further west.

Middle Creek Tributary exhibits variable channel characteristics along its length:

- To the north of Barnes Road the drainage line comprises a small grassed depression. Photo 4 is a view of a typical section of the creek where it crosses Lot 1336 within the project site.
- For about 150 m downstream of Barnes Road (within the project site), Middle Creek Tributary is heavily overgrown before it drains into the Australian Tennis Academy site.
- Within the Australian Tennis Academy site (also within the project site), drainage is conveyed along a "V" shaped constructed grassed channel with a half round concrete invert. Photo 5 shows a typical view of this section of the Middle Creek Tributary.
- After leaving Australian Tennis Academy site, drainage occurs for approximately 400 m through private property before the channel opens out to a constructed channel on the northern side of Dreadnought Road. Photo 6 is a view of the section of Middle Creek Tributary upstream of Dreadnought Road while Photo 7 shows the channel downstream of the road.

The Middle Creek Tributary flows through two sections of the project site:

- Commencing about 100 m upstream of Barnes Road, Middle Creek Tributary is located within Lot 1336 for a distance of about 150 m.
- Immediately downstream of Barnes Road, Middle Creek Tributary flows through the project site for a distance of approximately 300 m.

4.2 NATURAL DRAINAGE

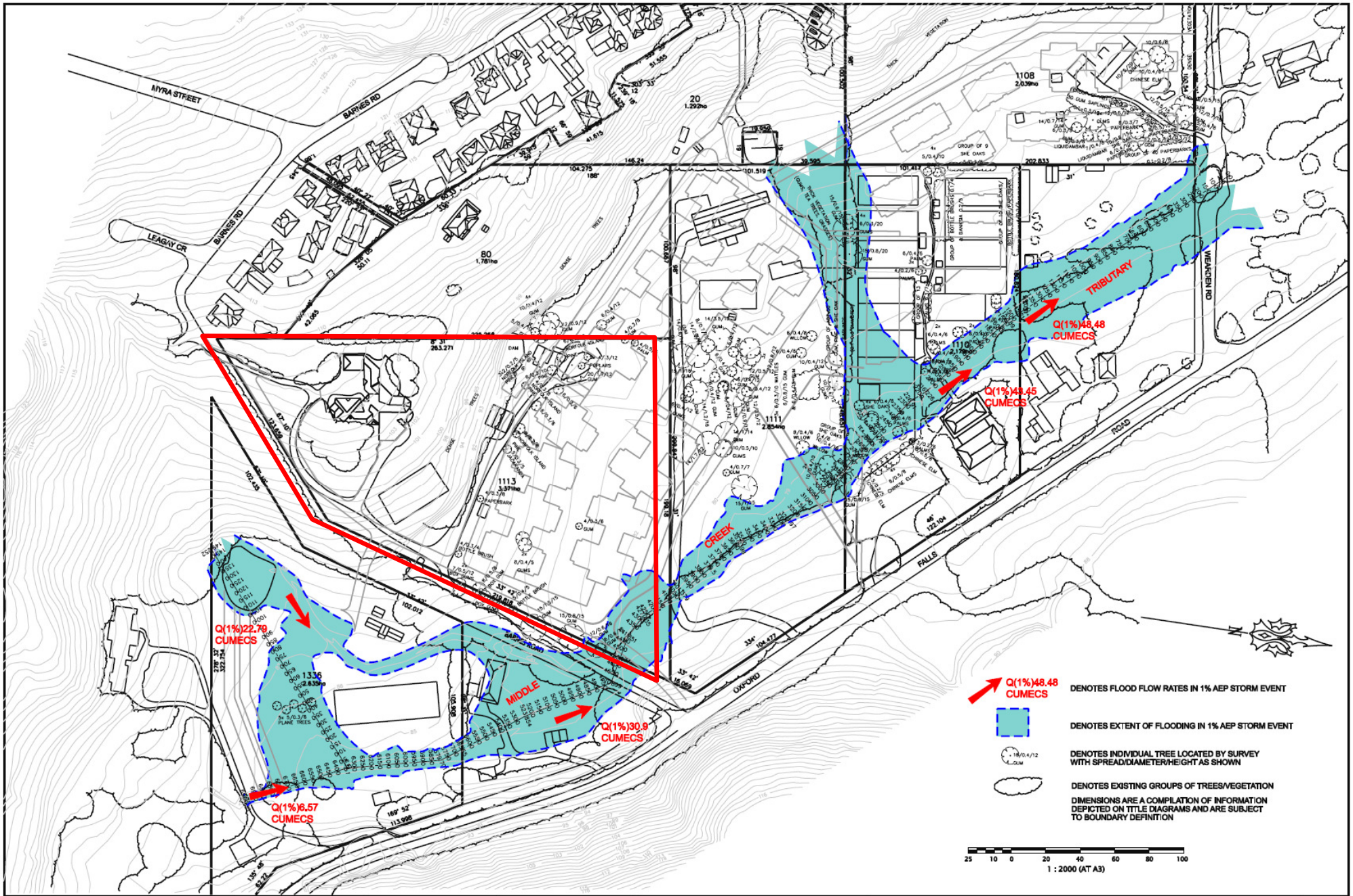
The 1:25000 scale topographic map of the area shows a blue line denoting a stream that commences near the intersection of Iris Street and Oxford Falls Road and continues parallel to Oxford Falls Road, across Dreadnought Road and the Wakehurst Parkway and joins Middle Creek about 150 m west of the Wakehurst Parkway.

The Manly Cove parish maps for 1914 and 1923 show a drainage line crossing Barnes Road in about the current position of Middle Creek Tributary. Approximately 100 m downstream of Barnes Road, the maps show a swampy area (approximately 50 m wide) that continues parallel to Oxford Falls Road to just past Dreadnought Road (a distance of about 700 m). On the basis of this evidence, it appears that the current alignment of Middle Creek Tributary has remained substantially the same since the early 1900s, except that the original swampy area downstream of Barnes Road has been drained at some stage between about 1920 and 1960. From the fact that the significant sections of the creek are relatively straight have a very regular V shaped channel, it appears likely that the location and shape of creek were formed as a result of human activity to drain the swampy area that is shown on the Parish maps of 1917 and 1924.

APPENDIX 2

CATCHMENT PLAN & 100 YEAR FLOOD PLAN

(JMD Development Consultants, 2008)



Revision	Date	Remarks
A	29-3-06	INITIAL ISSUE

Client: TIFFANY DEVELOPMENTS
Origin of Levels: N/A
Date of Survey : VARIOUS
Ratio (A1) : 1:2000 (A3)
Datum : AHD
Designed by : N/A
Drawn by : N/A
Approved for Issue : TH 29-03-2006

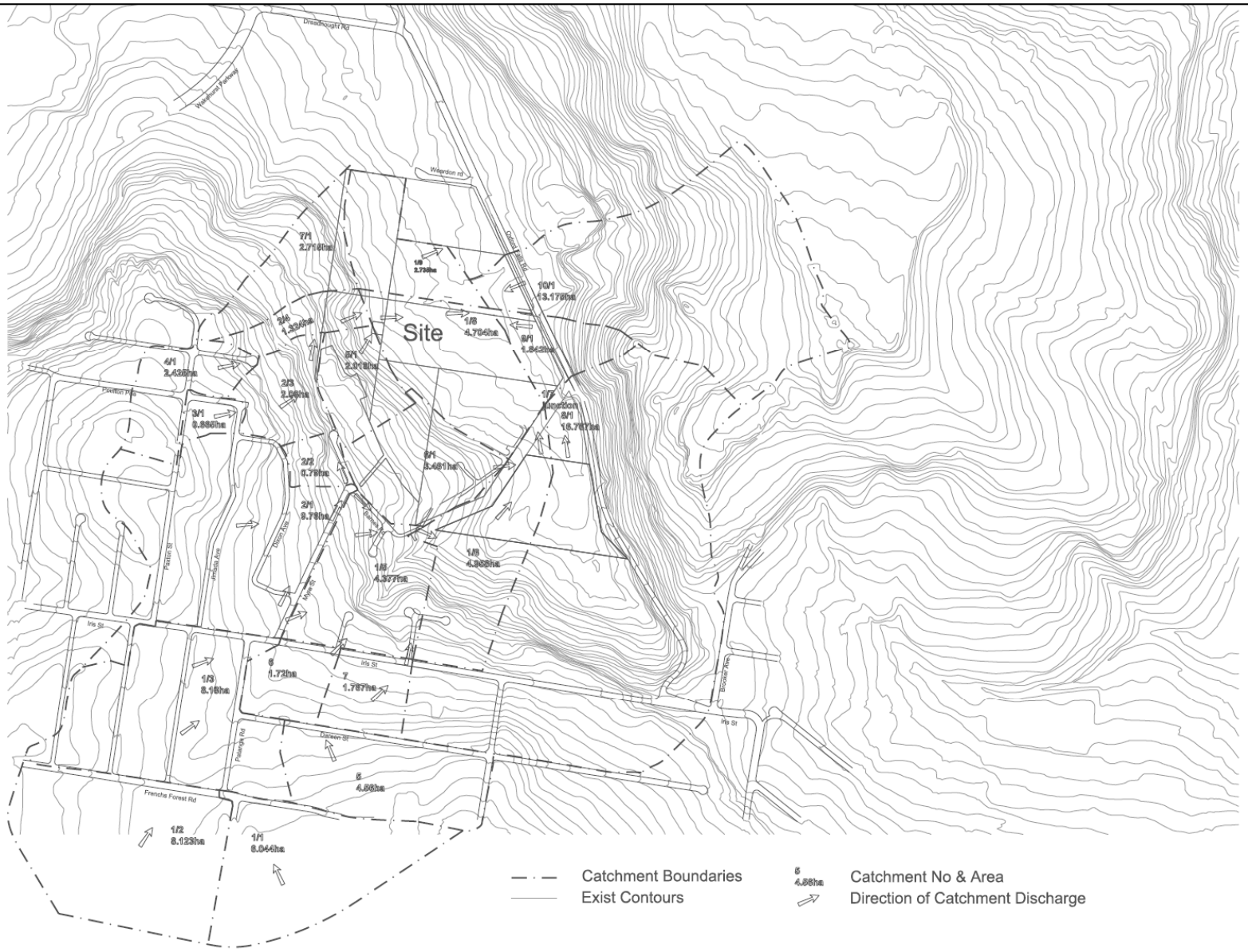
JMD Development Consultants

John M Daly & Associates PTY LTD
ABN 88051977989
Surveying
Engineering
Project Management
Licensed Water Service Co ordinators
32 Iolanthe Street
PO BOX 25/DX 5112
CAMPBELLTOWN NSW 2560
PH (02) 4625 5055
FAX (02) 4628 2013
email: admin@jmd.com.au

Project :
PLAN DETAILING EXTENT OF 100 YEAR FLOOD OVER LOTS 1108, 1110, 1111, 1113 & 1336 IN D.P.752038, LOT 20 IN D.P.842523 & LOT 80 D.P.846099 OXFORD FALLS ROAD, FRENCHS FOREST UNDER EXISTING CONDITIONS

Locality : FRENCHS FOREST
L.G.A. : WARRINGAH

Sheet 1 of 2sheets
Ref: 03508E7
CAD Ref: S:\DATA\03\0F\FEB08\FLOOD.DGN



Issue	App	Date	Description

Client: TIFFANY DEVELOPMENTS

Designed by : TH

Date of Drawing : MAY 2005

Ratio (A1) : 1:3000

Datum : AHD

Origin of Levels :

Date of Survey : 2004

JMD Development Consultants

John M. Daly & Associates PTY LTD
A.B.N. 88051977989
Surveying
Engineering
Project Management
Licensed Water Service Co ordinators
32 Iolanthe Street
P.O. BOX 25 (DX 5112
CAMPBELLTOWN N.S.W. 2560
PH. (02) 4625 5055
FAX (02) 4628 2013
email: admin@jmd.com.au

Project : OXFORD FALLS RET|REMENT RESORT

CATCHMENT PLAN - DEVELOPED CONDITIONS

Sheet 1 of 1 sheets

Ref: 03508E6

Locality : FRENCHS FOREST

L.G.A. : WARRINGAH

CAD Ref: S:\~\eng\aug 08\03508E6.DGN

APPENDIX 3

WEED CONTROL TECHNIQUES

WEED MANAGEMENT TECHNIQUES
FOR USE IN AREAS OF NATIVE VEGETATION RETENTION

Weeds are to be progressively removed in accordance with the following techniques recommended by the National Trust, NSW Department of Environment and Conservation and the Australian Association of Bush Regenerators.

Woody Weeds Removal Techniques:

Cut and Paint (Woody weeds to 10 cm basal diameter)

- Make a horizontal cut close to the ground using secateurs, loppers or a bush saw; and
- Immediately apply herbicide to the exposed flat stump surface.

Considerations:

- Cuts should be horizontal to prevent herbicide from running off the stump, sharp angle cuts are hazardous;
- Herbicide must be applied immediately before the plant cells close (within 30 seconds) and translocation of herbicide ceases;
- If plants resprout, cut and paint the shoots after sufficient re-growth has occurred; and
- Stem scraping can be more effective on some woody weeds.

Stem Injection

- At the base of the tree drill holes at a 45 degree angle into the sapwood;
- Fill each hole with herbicide immediately; and
- Repeat the process at 5 cm intervals around the tree.

Frilling or Chipping

- At the base of the tree make a cut into the sapwood with a chisel or axe;
- Fill each cut with herbicide immediately; and
- Repeat the process at 5 cm intervals around the tree.

Considerations:

- Plants should be actively growing and in good health;
- Deciduous plants should be treated in spring and autumn when leaves are fully formed;
- For multi-stemmed plants, inject or chip below the lowest branch or treat each stem individually; and
- Herbicides must be injected immediately before plant cells close (within 30 seconds) and translocation of herbicide ceases.

Small Hand-Pullable Plants Removal Techniques:

Hand Removal

- Remove any seeds or fruits and carefully place into a bag,
- Grasp stem at ground level, rock plant backwards and forwards to loosen roots and pull out, and
- Tap the roots to dislodge any soil, replace disturbed soil and pat down.

Considerations:

- Leave weeds so roots are not in contact with the soil, e.g. hang in a tree, remove from site or leave on a rock.

Vines and Scramblers Removal Techniques:

Hand Removal

- Take hold of one runner and pull towards yourself,
- Check points of resistance where fibrous roots grow from the nodes,
- Cut roots with a knife or dig out with a trowel and continue to follow the runner,

- The major root systems need to be removed manually or scrape/cut and painted with herbicide, and
- Any reproductive parts need to be bagged.

Stem Scraping
- Scrape 15 to 30 cm of the stem with a knife to reach the layer below the bark/outer layer, and
- Immediately apply herbicide along the length of the scrape.

Considerations:
- A maximum of half the stem diameter should be scraped. Do not ringbark,
- Larger stems should have two scrapes opposite each other, and
- Vines can be left hanging in trees after treatment.

Weeds with Underground Reproductive Structures Removal Techniques:

Hand Removal of Plants with a Taproot
- Remove and bag seeds or fruits,
- Push a narrow trowel or knife into the ground beside the tap root, carefully loosen the soil and repeat this step around the taproot,
- Grasp the stem at ground level, rock plant backwards and forwards and gently pull removing the plant, and
- Tap the roots to dislodge soil, replace disturbed soil and pat down.

Crowning
- Remove and bag stems with seed or fruit,
- Grasp the leaves or stems together so the base of the plant is visible,
- Insert the knife or lever at an angle close to the crown,
- Cut through all the roots around the crown, and
- Remove and bag the crown.

Herbicide Treatment – Stem Swiping
- Remove any seed or fruit and bag; and
- Using an herbicide applicator, swipe the stems/leaves.

Considerations:
- Further digging may be required for plants with more than one tuber,
- Some bulbs may have small bulbils attached or present in the soil around them which need to be removed,
- It may be quicker and more effective to dig out the weed,
- Protect native plants and seedlings, and
- For bulb and corm species the most effective time to apply herbicide is after flowering and before fruit is set.

Exotic vegetation should be removed and stockpiled in a clear area away from adjoining bushland. This stockpile should be removed from the site at a convenient time. As part of the regular maintenance of the restored area any re-growth of the exotic plant species should be removed and disposed of appropriately.

Use of Herbicides
Herbicides should not be applied prior to rain occurring. This reduces the herbicides effectiveness as well as being transported in runoff to creeklines and waterways.

An advantage of herbicide use is the low time taken to spray weeds as compared to physically removing them, particularly for large infestations of weeds.

Travers bushfire & ecology recommend that the use of herbicides should be considered when:

- there are small areas of dense weeds with few or no native plants to protect.
- there are large areas of weeds.

- the weeds are growing too rapidly for physical removal.

The spraying of weeds must only be undertaken by experienced persons with *Chemcert* or equivalent qualifications. The success of each treatment must be evaluated by the operator after a set period of time and re-applied (if necessary) according to the labelled effectiveness for each herbicide. Care must be taken when applying herbicides near drainage corridors to avoid excess use due to the sensitivity of the waterbodies into which runoff will eventually flow.

APPENDIX 4

BUSH REGENERATION SPECIFICATIONS

REVEGETATION REQUIREMENTS

1 REVEGETATION OF DISTURBED AREAS

The revegetation of the site can be undertaken within highly disturbed areas with native species that are considered to be endemic to the local area. It is highly recommended that sufficient material is collected while plants are in seed (early in the calendar year).

In order to supplement the natural regeneration process and protect the soils from erosion it is proposed to plant and seed the disturbed and rehabilitated areas with appropriate indigenous tree, shrub and groundcover species in addition to the stabilising cover. All other vegetation, fauna habitats, groundcover, etc. on the site is to be retained in an undisturbed condition.

In selecting appropriate species for planting and seeding it was determined that the primary purpose of the revegetation was to establish a quick growing plant community which would provide sufficient canopy cover to enable establishment in later years of species typical of the conditions present throughout the site. Plant species diversity is expected to increase in later years through natural colonisation of suitable species into stabilised areas.

Revegetation of degraded areas is an integral part of the restoration process. Re-establishing vegetation can be undertaken via:

- Direct seeding
- Leaf litter / mulching
- Natural regeneration

Direct Seeding

Direct seeding is a quick and efficient method. The seeds germinate when conditions are suitable and at higher densities than those plants that are planted as seedlings. However, there are disadvantages to this method. The seed requires an exact temperature range to germinate and if this range is not met the seed will not germinate.

This method is only suitable to supplement direct planting for the revegetation of shrublayer and groundlayer species. That is, seeds should be used to supplement growth of understorey species that have been directly planted.

The density of planting of each species must be defined in order to revegetate the sites to a 'near natural' state. Species classified as trees are to be placed at 6 metre spacings, with the remainder of the 2 metre spacings to be planted with shrubs, which will allow each tree room to mature properly. Revegetation specifications outlining planting densities and methods are listed in Attachment 1.

Utilisation of Leaf Litter and Mulch

Another effective way of re-establishing native vegetation into an area is to collect bush litter from local healthy bushland that contains similar species to that which is desired within the revegetation area. This litter must be weed free and can then be scattered throughout revegetation areas over weed free soil. Beneficial micro-organisms and spores are transported to the soil via the mulch and aid in the regeneration process. Seeds of desired plant species can also be transported within this mulch / leaf litter which again aids the regeneration process.

It is recommended that as much vegetative material as possible be salvaged from the proposed development site prior to clearing. This material may be in the form of seeds, individual plants for transplanting or material to be used for mulch.

This method is suitable for use on the subject site and is to be used to cover all disturbed soil areas. The mulch shall be a minimum of 50 mm thick.

Timetable of Work

The Contractor shall provide a preliminary planting schedule which incorporates a draft timetable of works for the planting activities. This shall be submitted at the time of tendering. A final planting schedule shall be prepared in consultation with the Project Manager, and approved by the Project Manager within 14 days of award of Contract. This schedule should be designed to minimise the time the sites are exposed and take into account seasonal factors, availability of tubestock plants, and timing of construction works.

Site Preparation

Site preparation activities for all planting sites will include preliminary weed control, rubbish removal and (where necessary) minor earthworks (levelling, ripping). It is expected that any bare soil areas will be sown with a nurse crop to provide temporary soil stabilisation, and (where applicable) soil erosion control measures installed.

Plant Material

Plant material used to revegetate within the project area shall be sourced only from local bushland areas. Contractors are responsible for obtaining all necessary permits and licenses.

All plants are to be provided in a healthy condition. They must have good root development and a sturdy shoot system. Plant with an elongated or yellowed shoot system shall not be accepted.

Planting shall be undertaken immediately after delivery. If this is not possible, the Contractor shall be required to provide appropriate storage to keep the plants in good condition on the site, adequately protected from frost, wind, sun and vermin, and secured from vandals.

2 PLANTING GUIDELINES

PLANTING DENSITIES AND NICHE SPECIES

The Contractor shall be responsible for planting according to the Site Planting Plan prepared by the client. This Plan will detail the required species and their distribution across the bushland reconstruction and landscaping sites and will be supplied to the successful Contractor. The Contractor shall be responsible for ensuring planting densities and appropriate niche species.

Only locally indigenous plants will be used. Niche preferences shall be considered in planting, with plants being placed in the correct position with regard to soil type, moisture, aspect and slope.

Plantings should be at a density which will result in a near natural canopy density at all structural levels (strata). Plants will be placed at average 2-3 units/m^2 in order to achieve the following densities.

- Canopy Trees @ 1 unit / 5m^2
- Sub-canopy (small trees / large shrubs) @ 1 unit / 2 m^2
- Shrubs @ 1 unit / 1.5 m^2
- Grasses and Ground Covers @ 1 unit / m^2
- To achieve a planting density of 5 units/m^2, the grasses and groundcovers should be increased to 3 units/m^2

PLANTING METHODS

Planting holes shall be excavated to a depth of 150 mm and a diameter of 200 mm. Slow-release native plant fertiliser (low phosphorous formulated native plant fertiliser tablet/granules) shall be placed into the planting hole. In poorly structured soils, approximately 200 cubic centimetres of native plant soil mix is to be placed and incorporated into the planting hole with fertiliser and water storing granules.

Plants must be placed into moistened soil preferably by soaking 1-2 litres of water into each hole. After planting the soil shall be replaced and carefully firmed, leaving a slight depression around each plant to allow for water collection. Soil is to be replaced in the hole so that the base of the stem is level with the soil surface, not set below the soil, or sitting above.

All plants are to be thoroughly watered before planting and again after planting. If the weather is hot, a third watering shall be carried out within two (2) days or a t-tape or drip irrigation system set up to water plants on a weekly basis.

PLANT PROTECTION

The Contractor shall be responsible for adequately protecting plant material from frost, wind, sun, vermin and animals. Two (2) Litre cardboard guards (including 2 stakes) shall be placed around each plant and maintained throughout the maintenance period of up to 3 years. The use of Jute mats (mulch mats) is recommended where annual or grass regrowth is expected.

MULCHING

After planting, the exposed ground should be thickly mulched with low-nutrient mulch such as chipped eucalyptus. A depth of approximately 75 mm and a diameter of 400 mm around each plant are recommended. No exotic plant material is to be used. Pine bark is not considered to be a suitable mulch material. The provenance of all mulch material must be known and approved by the Project Manager.

Mulch is not to be used in sand dunes ecosystems as the mulch inhibits plant establishment and provides a nutrient source for the growth of weeds in dune ecosystems.

Care should be taken to keep mulch material away from the stems of the newly planted tubestock. Alternatively, a light sowing of a suitable nurse crop (Rye Corn or Japanese Millet) can be made between plantings to provide a protective microclimate. Sowing rates to be used are those recommended by the supplier and agreed with the Project Manager.

MAINTENANCE AND WEED CONTROL

Tube stock must be suitably maintained (watering and weeding) are to be maintained over a 3 year period on the following basis:-

- 1-3 months post planting – weekly watering and maintenance.
- 4-12 months post planting – monthly watering and maintenance.
- 13-36 months post planting – quarterly watering and maintenance.

During the maintenance phase any plant losses in excess of 15% of the total number planted must be replaced at the expense of the Contractor.

Site maintenance shall consist of the following tasks:

- Weeding throughout the planting area
- Watering tubestock
- Replacing lost plants (as required)
- Removing wind-blown or other rubbish from the planting area

The Contractor shall provide a preliminary maintenance schedule which incorporates a timetable of works for each of the activities listed above.

3. GENERAL DESCRIPTION OF WORK

This document outlines the general principles to be used in a bush regeneration and rehabilitation program. The term bush regeneration includes both weed control and re-vegetation (planting) in bushland and semi-bushland areas.

DEFINITIONS

Bush regeneration is defined as "the practice of restoring bushland by focusing on reinforcing and reinstating the ecosystem's on-going natural regenerative processes (Australian Association of Bush Regenerators).

AIMS OF BUSH REGENERATION

To create an environment where native plants are able to re-colonise degraded/cleared areas

- To restore degraded areas far as possible, to viable, manageable ecosystems.
- To protect the bushland from further external disturbance events.
- To preserve and enhance local and regional biodiversity.
- To enhance and extend habitat for native fauna.
- To protect the site's special features (natural, geological, landscape and cultural).

PROCESS

The Bush Regeneration process involves:

- *Primary Weeding* - initial weed clearance, through hand weeding and/or the use of herbicides.
- *Secondary or Follow-up Weeding* - maintenance of sites which have already received primary weeding.
- *Maintenance weeding* - monitoring/removal of weed re-growth and care of native plant seedlings (naturally occurring and planted).
- *Re-vegetation* - the use of locally indigenous species to restore an area via tubestock planting, direct seeding, transplanting and/or brush matting.

In areas where degradation has been serious enough to severely deplete or extinguish native regenerative capacity, it may be necessary to reconstruct or fabricate a plant community as close as possible to the original. This will involve a variety of techniques, including weeding, soil remediation, planting and on-going site maintenance. Scale-scale soil stabilisation, earthworks, and remedial drainage works are often required.

WEED CONTROL

Weed removal shall include any species likely to significantly invade bushland, prevent natural regeneration, or impede native seedling growth. Priority shall be given to species listed as 'noxious plants' in Warringah LGA in the Schedules of the *NSW Noxious Weeds Act 1993*.

WEEDING TECHNIQUES

See Appendix 7 for detailed weed control techniques. Within the bush regeneration context weed control is described as the removal or control of weeds using hand removal and / or the application of selected herbicides. In specific circumstances, the use of machinery is used when the extent of the

infestation is very large and will not cause significant erosion or destabilisation. Weeding techniques should be appropriate to the weed type, growth form and to the existing site conditions.

Wherever possible, weed removal should be carried out prior to annual seed set. Herbicide application via stem injection or foliar spray must not be applied to plants bearing ripe or semi-ripe fruit. It is important to plan herbicide control of target species according to a weeding calendar that recognises the weed's life form and seasonality (i.e. flowering, fruiting and seed set).

The techniques and methodologies used for bush regeneration shall conform to those identified in the National Trust Bush Regenerators Handbook (1991) and currently taught through the NSW TAFE Bushland Regeneration Certificate Course.

LABOUR

Bush regeneration work shall be carried out in a competent manner by experienced and qualified bush regenerators. A minimum 50% of the workforce must have completed a TAFE Bushland Regeneration Certificate Course or equivalent, and have suitable field experience (e.g. Minimum 200 hour's prior employment as a bush regenerator).

In assessing tenders, preference will be given to bush regeneration contractors with prior experience in the rehabilitation of bushland in the Western Sydney Region.

USE OF HERBICIDES

The herbicide of choice for bush regeneration work is glyphosate (*Roundup)*. *Roundup Biactive* shall be used in wet areas (e.g. drainage corridors, sediment basin).

The Contractor shall not use any other herbicide or chemical without the written consent of the Project Superintendent or their appointed representative.

Unless otherwise agreed with the Project Superintendent, herbicides application shall be limited to the following techniques:

- Cut-stump and poison (cut and dab)
- Stem injection
- Stem-scrape and poison
- Basal bark painting
- Selective spot-spraying

MULCH AND CUT BRUSH

Any mulch imported onto the site shall be weed-free eucalyptus leaf mulch or woodchip. Mulch from Privet, Camphor laurel, Coral Tree, Poplar, Willow, aquatic or declared noxious weeds are not to be used. The Contractor shall ensure that any mulch used is properly composted before use.

Brush cut for erosion control and / or re-vegetation purposes shall be used only when cut branches are seed-laden. Branches shall be spread as quickly as possible to reduce seed loss during stockpiling. The collection of cut brush shall be limited to species occurring naturally in the bushland area. Collection sites are to be agreed between the land owner and the Project Ecologist prior to any collection of brush.

WEED DEBRIS AND RUBBISH

Disposal of weed debris and other rubbish generated as a result of the work shall be the responsibility of the Contractor. Costs for disposal of rubbish (collection and tipping fees) shall be clearly stated in the tender proposal.

Disposal of weed material via burns piles is permitted only after approval has been obtained from the Project Superintendent. Any burning must be carried out as advised by the Environment Protection Authority and NSW Fire Brigades.

SOIL EROSION

Where bush regeneration works have the potential to destabilise slopes or embankments, action such as the use of fibre matting and/or the placing of logs across the slope and fixing in place shall be employed to minimise the problem. Erosion matting and/or silt fencing may be required in a number of sites. These sites are to be identified in the tender document and allowance made for the purchase and placement of erosion control matting.

CONSTRUCTION OF BUSHLAND (PLANTING)

It is expected that the proposed development will require replanting due to the level of disturbance as a result of weed invasion.

The Contractor may be required to supply a set number of endemic (locally occurring native) plants to be used in the bushland reconstruction or other landscaped areas. All plant material used on-site shall be grown from seed or cuttings collected in local bushland.

Plant material may be supplied as tubestock, hikos or virocells depending on the species and planting conditions. The method of delivery should be clearly stated in the tender documents.