EVANS & PECK

TIFFANY DEVELOPMENTS

Seniors Living Resort:
Oxford Falls Road,
Frenchs Forest

STATUS OF DRAINAGE LINES

Assignment 22831

Final (V4)

October 2008

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*(**Note:** Blank pages inserted as necessary to allow double sided printing with each chapter starting on an odd numbered page)*

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 from the west of the site to the main creek line on the east.

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.

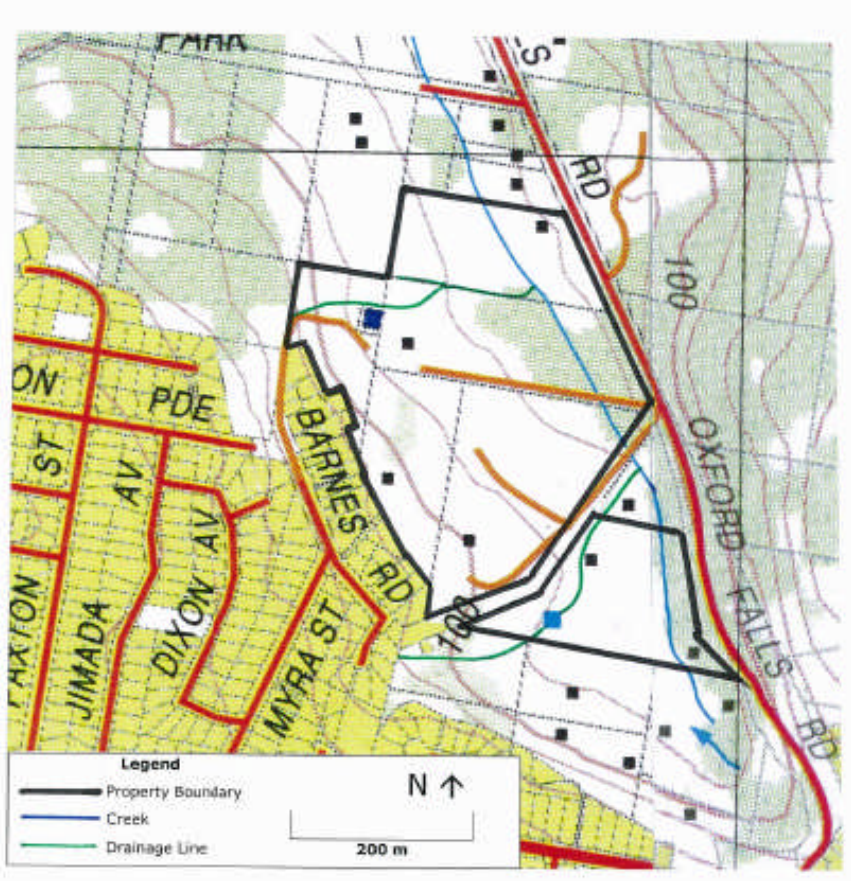

Figure 1
Extract from 1:25000 Topographic Map

1.1 REGULATORY CONTEXT

This report has been prepared to address matters relating to the status of the main drainage systems within the proposed development as they relate to a number of regulations and guidelines published by the NSW Government and Warringah Council:

- The *Water Management Amendment (Controlled Activities) Regulation 2008* which was gazetted on 25 January 2008, at which time the *Rivers and Foreshores Improvement Act 1948* was repealed. For convenience the regulation will simply referred to as "**the Regulation**";
- *Managing Urban Stormwater: Soils & Construction* (Landcom, 2004). For purposes of this report the commonly used designation, the "**Blue Book**", will be used;
- The *Warringah Creek Management Study* which will be simply referred to as "**the Management Study**".

In addition, this report addresses the following aspects of the Director General's Requirements (referred to as "**the DGRs**") issued by the Department of Planning on 16 August 2006:

- "*Demonstrate consistency with the objectives of the* Rivers and Foreshores Improvement Act 1948 (RFI Act), *specifically in the context of the subject site containing a watercourse (an unnamed tributary of Middle creek) which is a "river' for purposes of the RFI Act as well as several natural drainage lines."*
- "*Assess the proposal relative to the Warringah Creek Management Study . . . . .*";
- "*Address impacts on existing natural drainage lines on the site*";
- "*A riparian setback from the watercourse on site (in which no development or built structures can be located) is to be provided. The setback is to be a minimum of 30 m measures horizontally landward from the top of the bank on both sites of the watercourse within the subject site*".

1.2 SCOPE OF THIS REPORT

This report provides an assessment of:

1. The status of the drainage lines with respect to the criteria set out in the documents listed above.
2. An assessment of appropriate riparian zone widths for the drainage lines that takes account of their existing and proposed characteristics.

Chapters 2 – 4 of this report provide an assessment of the characteristics of the three drainage lines in question, including an assessment of how the flow regime would have changed as a result of urban development on the catchment. Chapter 5 provides a summary of the criteria for assessment of riparian corridor width provided in the various documents listed in Section 1.1 above and their application to each of the watercourses within the site. An assessment of the relative merits of the various criteria in relation to the stormwater drainage lines within the site is provided in Chapter 6.

1.3 BACKGROUND MATERIALS AND SOURCES

In the course of preparing this report the following materials and sources have been used:

1. Inspection of the drainage lines;
2. Inspection of stormwater drainage arrangements in the vicinity of Cliff Point Place, Poulton Place, Barnes Road, Jaminda Avenue, Dixon Avenue, Myra Street and adjoining streets in Frenchs Forest;
3. Inspection of stereoscopic aerial photographs of the Frenchs Forest/Oxford Falls area (held by the Department of Lands, Sydney) taken in 1961, July 1970, April 1978 and August 1991;
4. Inspection of 1:2000 scale orthophotomap Frenchs Forest (U1860-52) which is based on aerial photography taken in March 1988;
5. Inspection of 1:25,000 scale topographic maps for Hornsby 9130-4S (third edition 2001) and Mona Vale 9130-1S (third edition 2000);
6. Inspection of Parish Maps dates 1914 and 1923 on the Department of Lands web site (Image IDs 14031402 and 14041802);
7. Review of the work as executed plans for the subdivision of 10 residential lots on the north eastern side of Barnes Road prepared by Lovegrove Oxley & Associates (12 July 1994);

2 DRAINAGE LINE 1

2.1 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. This section of the drainage line has no functioning aquatic ecosystem.
- 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). This section of the drainage line has relatively uniform bed with minimal features such as pools or woody debris necessary for a functioning aquatic ecosystem.
- 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. This section of the drainage line has the required characteristics for a function aquatic ecosystem.
- 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.

2.3 CHANGES AS A RESULT OF DEVELOPMENT

The catchment area draining to Drainage Line 1 has been modified significantly by the residential development in the area of Cliff Point Place, Brentwood Avenue, Paxton Street (northern end), Dixon Avenue, Poulton Parade, Bilbette Place, Jaminda Avenue (northern end) and the northern end of Barnes Road. Formalised street drainage in these streets directs runoff from a catchment area of about 16.2 ha to the head of Drainage Line 1. Drainage from a further 1.3 ha of residential development on the north eastern side of Barnes Road is directed into the water quality control pond which then discharges into Drainage Line 1.

The stormwater drainage systems in Paxton St (southern end), Jaminda Avenue (southern end), Dixon Avenue and Myra Street direct drainage from a catchment area of about 10 ha towards the intersection of Myra Street and Barnes Road from where the piped drainage system directs drainage in a southerly direction along Barnes Road. However, from the grading of the road at this location, I consider that in storms that produce runoff in excess of the capacity of the piped drainage system, some of the overland flow down Myra Street is likely to be directed northward along Barnes Road in the direction of Drainage Line 1.

The increase in catchment area above the head of the drainage line together with a significant increase in proportion of impervious surfaces as a result of urban development and the stormwater drainage from the 10 lot subdivision carried out in Barnes Road in about 1994, will have significantly increased the rate of flow in the drainage line compared to pre-existing natural conditions. Drainage Line 1 now acts as an ephemeral urban stormwater drain.

2.4 STRAHLER SYSTEM CLASSIFICATION

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*".

3 DRAINAGE LINE 2

3.1 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, most 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. Although this section of channel contains a number of pools, the existence of steep, rock armoured, banks and absence of riparian vegetation meant that this section of channel has limited value for aquatic habitat.
- 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). The natural pools and rock ledges, combined with the dense shading provided by the vegetation indicate this section of the drainage line has value as aquatic habitat.

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 1:25,000 scale topographic map of the area does not show a blue line to denote a stream along Drainage Line 2, the contours on the topographic map indicate a depression running in the general direction of the current alignment of the drainage line. This depression is more apparent on the 1:2,000 orthophoto map 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). It appears that the construction of the dam at the base of the cliff was accompanied by realignment of the downstream channel.

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.

3.3 CHANGES AS A RESULT OF DEVELOPMENT

The current catchment contributing to Drainage Line 2 is about 39.7 ha. An additional area of about 3.5 ha also drains towards the junction of Drainage Line 2 with the Middle Creek Tributary from the escarpment area to the north-west of the unmade section of Barnes Road.

Based on the underlying topography shown on the orthophoto maps it appears that the surrounding urban development has redirected a catchment area of about 10.5 ha from Drainage Line 2 to Drainage Line 1.

3.4 STRAHLER SYSTEM CLASSIFICATION

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*".

4 MIDDLE CREEK TRIBUTARY

4.1 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.

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.

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. The closely cropped grass and absence of any significant shading or pools indicates that this section of the drainage line has negligible aquatic ecology value.
- Between Barnes Road and the Australian Tennis Academy (about 150 m within the project site), Middle Creek Tributary has bushland on the eastern bank extending to Oxford Falls Road. On the western bank, a strip of weedy vegetation, approximately 5 m wide, (heavily infested with lantana) provides a buffer between the drainage line and the open grass paddocks. Although this section of the drainage line is well shaded by the overgrown lantana and privet, its aquatic habitat vale is severely compromised by heavy siltation of the channel and the invasion of weed species in the bed and banks.
- Within the Australian Tennis Academy site, drainage is conveyed along a "V" shaped constructed grassed channel with a half round concrete invert. Photo 5 is a typical view of this section of the Middle Creek Tributary which shows the mown grass banks and concrete channel which provide no aquatic habitat of value.
- 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 photographs show that these sections of Middle Creek Tributary have limited aquatic habitat value.

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.

4.3 CHANGES AS A RESULT OF DEVELOPMENT

Based on an inspection of the natural topography shown in the orthophoto maps it appears that the main effects of urban development within the catchment of Middle Creek Tributary have been to:

- Channelise the section of the creek that runs through the Tennis Academy site. In the early 1900's this area is shown as a swampy area, possibly a hanging swamp that is characteristic of some drainage lines in sandstone landscapes. The current regular V shaped channel and straight alignment occur in the area where the swampy area was marked on the 1914 and 1923 Parish maps.
- Alter the point at which sub-catchment drainage from Drainage Line 1 enters the Middle Creek Tributary;
- Alter the point at which sub-catchment drainage from Draiange Line 2 enters the Middle Creek Tributary;
- Increase the overall flow in the creek as a result of the increase in impervious surfaces within the catchment;
- Slightly increase in the catchment area draining to the upper reach of Middle Creek Tributary (upstream of Barnes Road) by about 1.8 ha.

4.4 STRAHLER SYSTEM CLASSIFICATION

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 a first order stream as classified by the Strahler System and the core riparian zone recommendations set out in "*Guidelines for Controlled Activities: Riparian Corridors*" are, therefore, relevant considerations.

5 RELEVANT REGULATIONS AND GUIDELINES

This Chapter provides a review of various regulations and guidelines that set out the criteria for assessing the status of a drainage line and the resulting requirements for management of any riparian zone. A key factor in determining the status of a drainage line is whether it meets the criteria for being a "river" as defined in *Water Management Act 2000.* A further consideration in the context of the proposed development is the quality of the existing aquatic habitat.

5.1 WHEN IS A DRAINAGE LINE A "RIVER"?

Until 2008 the *Rivers and Foreshores Improvement Act 1948* (RFI Act) was the main statutory instrument for the protection of "rivers" and any associated riparian zones. Following gazettal of the *Water Management Amendment (Controlled Activities) Regulation 2008* in January 2008, the relevant definition of a "river" is provided by the *Water Management Act 2000* (WMA) which gives the following definition:

> *"river" includes:*
>
> *(a) any watercourse, whether perennial or intermittent and whether comprising a natural channel or a natural channel artificially improved, and*
>
> *(b) any tributary, branch or other watercourse into or from which a watercourse referred to in paragraph (a) flows, and*
>
> *(c) anything declared by the regulations to be a river,*
>
> *whether or not it also forms part of a lake or estuary, but does not include anything declared by the regulations not to be a river.*

This definition of a "river" contains the same key elements as the definition in the old RFI Act.

Two "rules of thumb" have commonly been adopted by officers of the relevant NSW agency (DWE and its predecessors), namely that a prima facie case for a drainage line being a "river" exists if a drainage line appears as a blue line on a 1:25,000 topographic map or has a catchment area of greater than 20 ha. Both criteria are, clearly, arbitrary. As noted in Maule v Liprioni & Anor [2002] NSWLEC 25, where Lloyd J held that,

> *"Neither do I regard the fact that that a river is shown on the land on a topographical map as being conclusive. The criteria used by the Land Information Centre for determining the presence of a river may be different from that which is employed under the Rivers and Foreshores Improvement Act."*

Similarly, the commonly used rule that a "river" is denoted by the presence of defined "bed and banks" has to be interpreted in the context of the requirement of the above definition, which requires a natural "perennial" or "intermittent" flow to have been present at some time. In Warringah Council v Ardel Limited & Anor [2000], NSWLEC 7, the Court found that,

> *"There is no proof that it is a natural channel, artificially improved, or an artificial channel which has changed the course of the stream of water. The Court needs to be satisfied that if the pipes and drains constructed above the site for the purpose of collecting and disposing of the stormwater were not there, water would have flowed across the land, through the channel inspected by Dr Perrens. The applicant has not discharged the onus in this respect. Instead it has relied solely on the characteristics of the channel itself without due regard being paid to the historical source and course of the stream. There is no evidence which demonstrates where the stream may have been if council drainage works in connection with the industrial area had not been built. There is no proof there would have been a stream of any significance, if at all."*

Following the Land & Environment Court case, the site vegetation on the Ardel site was cleared to leave a total riparian zone width of 25 m (12.5 m either side of the centre line of the drainage line). There are a number of significant similarities between the facts of the Ardel matter and the two drainage lines on the Site. In particular, it is clear that as a result of urban development there has been significant redirection of flow into Drainage Line 1. In addition, there has been a significant increase in impervious area leading to an increase in flow into both Drainage Line 1 and Drainage Line 2. It should be noted, however, that in contrast to Drainage Lines 1 and 2 which drain through predominantly cleared land, at the Ardel site vegetation was cleared to leave a remnant vegetated riparian zone that directly abuts the rear yard of the houses.

A further key consideration in determining whether a drainage line falls within the definition of a "river" is highlighted in the judgement of a number of Land & Environment Court cases (eg Maule v Liprioni & Anor [2002] NSWLEC 25; Don Bourke & Others v Hawkesbury City Council & Ors [2001] NSWLEC 222). That is, there is an important distinction to be made between "intermittent" and "ephemeral" flow in a creek. A drainage line may only be classified as a "river" if it exhibits "intermittent" (or "perennial") flow. A drainage line is not a "river" if it exhibits "ephemeral" flow.

5.2 WATER MANAGEMENT AMENDMENT (CONTROLLED ACTIVITIES) REGULATION 2008

The *Water Management Amendment (Controlled Activities) Regulation 2008* requires a "controlled activity approval" to be obtained to carry out a range of activities on waterfront land. For the purposes of this report, the key features of the definition of water front land are:

- *The bed of any river, together with any land lying between the bed of a river and a line drawn parallel to, and the prescribed distance inland of, the highest bank of a river.*

The prescribed distance is currently 40 m.

In support of the Regulation, the Department of Water and Energy (DWE) has issued a number of guidelines. For purposes of this report, the relevant guidelines are:

- "*Guidelines for Controlled Activities: Riparian Corridors*";
- "*Guidelines for Controlled Activities: In-stream Works*".
- "*Guidelines for Controlled Activities: Outlet Structures*".

Although the guidelines have been issued as official Departmental guidelines, it is understood that they are advisory only and have no regulatory force.

Table 1 below summarises the relevant recommendations for the width of core riparian zone (CRZ) that are set out in the *Guidelines for Controlled Activities: Riparian Corridors* with reference to the Strahler stream ordering system. Note that these widths apply to each side of the creek and are measured from the top of the bank.

Table 1: Recommended CRZ Widths

Types of Watercourses	Core Riparian Zone Width
Any first order watercourse where there is a defined channel and where water flows intermittently	10 m
• Any permanently flowing first order watercourse, or • Any second order watercourse And where there is a defined channel where water flows intermittently or permanently	20 m
Any third order or greater watercourse and where there is a defined channel where water flows intermittently or permanently. Includes estuaries, wetlands and any parts of rivers influenced by tidal waters	20 – 40 m

5.2.1 Drainage Line 1

Drainage Line 1 is not shown on the 1:25,000 topographic map and, accordingly, is not classified under the Strahler System. Also, on the basis of the finding of the Land & Environment Court in the Ardel matter and the characteristics of the drainage line and its catchment as set out in Section 2 above, Drainage Line 1 does not constitute a "river" for the purposes of the WMA and the Regulation. This assessment is based on the fact that the flow is ephemeral and significant flow has been re-directed to Drainage Line 1 as a result of the construction of stormwater drainage pipes within the adjoining residential land which has substantially increased the catchment area.

Accordingly, there is no obligation derived from the *Water Management Amendment (Controlled Activities) Regulation 2008* for provision of a riparian zone either side of this drainage line.

5.2.2 Drainage Line 2

Drainage Line 2 is not shown on the 1:25,000 topographic map and, accordingly, is not classified under the Strahler System. Also, Drainage Line 2 exhibits ephemeral flow and, accordingly, is not a "river" for purposes of the WMA, the Regulation and the associated guidelines. Accordingly, there is no obligation derived from the *Water Management Amendment (Controlled Activities) Regulation 2008* for provision of a riparian zone either side of this drainage line.

5.2.3 Middle Creek Tributary

The Middle Creek Tributary appears as a blue line on the 1:25000 topographic map and is classified as a first order stream under the Strahler System. Prior to development of the catchment, the flow regime in Middle Creek Tributary at Dreadnaught Road would have included a more persistent base flow from the swamp areas shown on 1914 and 1923 Parish Maps the and would therefore be classified as having "intermittent" flow. Under the *Water Management Amendment (Controlled Activities) Regulation 2008*, a CRZ of 10 m is required either side of the creek.

5.3 MANAGING URBAN STORMWATER: SOILS AND CONSTRUCTION

Section 5.2 of "*Managing Urban Stormwater: Soils and Construction*" (Landcom, 2004) (the Manual) contains a drainage line classification scheme and proposed objectives for the associated riparian lands. The text notes that,

> "*As riparian environments are very diverse, defining a standard width for riparian lands is difficult. Nevertheless, three broad categories for riparian land are identified by the Department of Infrastructure Planning and Natural Resources that reflect the relative importance of watercourses.*"

The classification system proposed in the Manual defines three categories based on the ecological/environmental function of the riparian zone, namely:

1. Environmental corridor,
2. Terrestrial and aquatic habitat,
3. Bank stability and water quality.

Unfortunately, the Manual provides no objective criteria to define the "*relative importance of watercourses*" or the circumstances in which a particular category should be adopted.

Table 2 below summarises the functional objectives for the three categories identified in the Manual.

Table 2: Riparian Management Objectives

Objectives & Requirements	Category		
	1	2	3
Provide a continuous corridor for the movement of flora and fauna	✓		
Provide extensive habitats (and connectivity between habitat nodes) for terrestrial and aquatic fauna	✓		
Provide suitable habitat for terrestrial and aquatic fauna		✓	
Maintain the viability of native riparian vegetation	✓	✓	
Protect native vegetation			✓
Manage edge effects at the riparian/urban interface	✓		
Provide bank stability	✓	✓	✓
Protect water quality	✓	✓	✓
Minimum core riparian zone (measured from top of the bank)	40	20	No minimum – pipes as last resort
Additional width to counter edge effects	10	10	Generally not required

(Source: Section 5.2 and Table 5.1 of "*Managing Urban Stormwater: Soils and Construction*", Landcom, 2004)

5.3.1 Drainage Line 1

Based on the objectives in Table 2, Drainage Line 1 is a Category 3 drainage line that requires no core riparian zone or buffer to counter edge effects.

5.3.2 Drainage Line 2

Based on the objectives in Table 2, Drainage Line 2 is a Category 3 drainage line that requires no core riparian zone or buffer to counter edge effects.

5.3.3 Middle Creek Tributary

Based on the objectives in Table 2, Middle Creek Tributary upstream of the Australian Tennis Academy is a Category 2 drainage line for which a core riparian zone of 20 m and a buffer to counter edge effects of 10 m would be appropriate. The reach of Middle Creek Tributary within the Australian Tennis Academy is a Category 3 channel which requires no core riparian zone or buffer to counter edge effects.

5.4 WARRINGAH CREEK MANAGEMENT STUDY

5.4.1 Overview

The *Warringah Creek Management Study,* which was prepared by consultants for Council and finalised in March 2004, contained proposed amendments to Council's LEP and recommendations for matters to be included in a proposed *Watercourses and Aquatic Habitat Policy*. None of the recommendations from the Study are reflected in the current LEP and Council does not yet have a *Watercourses and Aquatic Habitat Policy.* Accordingly, whilst the Study contains matters for consideration in determining appropriate riparian management zones on the Site, it lack any regulatory status and the recommendations of the Study deserve less weight than other published guidelines.

For purposes of the Study a definition of a "creek" was adopted that is significantly wider than the definition of a "river" in *Water Management Act 2000* (quoted in Section 5.1 above):

> *"**Creek** – any watercourse, whether ephemeral, intermittent or perennial, whether on its natural course or altered by human interference, whether channelled or not. It also includes any drainage line able to be identified by a linear vegetation assemblage reflective of regularly moist conditions or by a weed plume consistent with regularly moist conditions."*

The Study does not provide any justification for adopting this definition or seek to reconcile its definition with the definition adopted in the relevant Act which itself has been the subject to judicial interpretation (See Section 5.1).

The study has adopted a modification of the River Styles methodology developed by Macquarie University. The Study involved on site assessment at 35 locations within the Warringah LGA from which the results were extrapolated to all the other "creeks" based on a mapping and aerial photograph interpretation. The limited range of sites used to "benchmark" the "river styles" and a number of inconsistencies in the classification of drainage lines within the site (see Sections 5.4.2 to 5.4.4 below) do not give confidence in the accuracy of the classification shown on the maps.

For purposes of the future management, the Study classifies "creeks" in the LGA into three groups; A – C, with A having the highest ecological value and C the lowest. Middle Creek and its tributaries are all classified as Group C. The Study summarises the status of Group C creeks as follows:

> *"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 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)."*

For Group C catchments, no additional constraints are recommended on future development intensity.

Maps accompanying the Study show the recommended widths of core riparian zones ad vegetated buffers for all of the identified "creeks" within the LGA. Appendix D of the Study outlines the thinking behind the assessment of widths of riparian zones and riparian buffers (taken to have the same meaning as CRZ and VB in the *Guidelines for Controlled Activities: Riparian Corridors)*. The suggested widths for VBs are:

- Cleared or degraded open space 5 m;
- Weed infested riparian zones in bushland 20 m;
- Relatively undisturbed riparian zones 100 m.