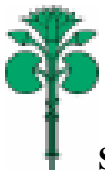
Environmental Constraint Analysis
Lot 22 DP 1070182, Pacific Highway, Sandy Beach North



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1.0 INTRODUCTION

1.1 Purpose of the Report

The subject site, Lot 22 DP 1070182, is on the eastern side of the Pacific Highway, at Sandy Beach, approximately 3km south of the township of Woolgoolga, in the Coffs Harbour City Council Local Government Area.

The site has an area of 49ha. It is bounded to the west by the Pacific Highway, to the south by residential properties in the existing Sandy Beach village, to the north and north west by Hearnes Lake, and to the east by public land adjacent to the beach and ocean. Hearnes Lake and the coastal waters to the east are part of Solitary Islands Marine Park. The Marine Park extends from the coast to the extent of State waters, Solitary Marine Reserve (Commonwealth Waters) extends from the extent of the Marine Park to the 50m depth contour. Hearnes Lake is an ICOLL (Intermittently Closed and Open Lakes and Lagoons) and is identified as a Habitat Protection Zone under the Marine Parks Act 1997 and Solitary Islands Marine Park zoning plan. The southern extent of the lake is included within the site.

The subject site is currently zoned Residential 2A Low Density Zone, Residential 2E Tourist Zone, Environmental Protection 7A Habitat and Catchment Zone and Environmental Protection 7B Scenic Buffer Zone under Coffs Harbour City Local Environmental Plan 2000 (LEP 2000).

An application is currently with the Department of Planning under Part 3A of the EP & A Act for a 295 lot residential subdivision of the land. Coffs Harbour City Council is processing Draft Amendments to LEP 2000 which will result in significantly reduced development yields for this site. The application for subdivision under Part 3A and the proposed changes to LEP 2000 have prompted a review of the conservation status of the land. The Department of Planning has commissioned Geoff Sainty of Sainty and Associates to identify the high conservation lands on the site. The results will be used to determine land suitable for environmental protection and the areas of the least constraints that may be suitable for future residential development.

1.2 Scope of works

The scope of works for this project*, as specified by the Department of Planning, includes:

(1) Review of available documentation on ecological value of land (principally coastal wetlands, ICOLL and other areas of high conservation value) within Hearnes Lake/Sandy Beach and Moonee Beach, Coffs Harbour specifically relating to 3 major development proposals at 45 Hearnes Lake Road (Council application for 51 lots), Sandy Beach (Major project for 295 lots) and Moonee Beach (Major Project for 378 lots),

(2) Undertake consultation with Department of Environment and Conservation, and Department of Natural Resources staff,

(3) Undertake consultation with Coffs Harbour City Council staff,

(4) Identify and provide individual maps of high conservation value lands by onsite survey using a differential GPS. High conservation lands for the purpose of this brief include (but are not necessarily limited to):

- existing SEPP 14 – Coastal wetlands and any additional lands identified as satisfying SEPP 14 – Coastal Wetlands criteria,
- endangered Ecological Communities (as listed under the NSW Threatened Species Conservation Act 1995),
- buffer zones around existing SEPP 14 – Coastal Wetlands, Hearnes Lake ICOLL and any Endangered Ecological Communities

(4) Identify and map lands suitable for environmental protection based on site survey and consideration of existing studies including Council's: Hearnes Lake/Sandy Beach Draft DCP; Draft Vegetation Conservation Strategy; Draft Local Environmental Plans around Hearnes Lake/Sandy Beach and Moonee Beach.

(5) Identify and map land designated for future potential development areas in relation to the 3 development proposals.

* This report relates to lot 22 DP 1070182 Sandy Beach.

2.0 Background and Site Description

2.1 Background

The development site contains and is adjacent to lands of high environmental significance, notably Hearnes Lake ICOLL, the endangered ecological communities (EEC) Swamp Sclerophyll Forest and Coastal Salt Marsh, and Solitary Islands Marine Park.

The site lies on an estuarine plain and is comprised geomorphologically of an estuarine channel with a fringing saline swamp (DMR Quaternary mapping 2004). The western portion of the site is slightly elevated, lying on undifferentiated fluvial sands above marine sands. This is a transitional area between the alluvial plain upstream (west of the highway) and the Hearnes Lake estuarine plain. A coastal dune system lies between the eastern side of the lake and the beach.

The site encompasses the southern tip and abuts the western edge of Hearnes Lake. Hearnes Lake is identified as an ICOLL (Intermittently Closed and Open Lakes and Lagoons). Most of the time the Lake is closed to the sea, however it can open to the sea when there is either significant rainfall, flooding or when storm generated waves coincide with high tidal levels. Under these circumstances the berm at the mouth of the Lake is breached and water levels within the lake can

change. The Lake can experience rapid changes in salinity, either becoming more fresh with rainfall from the catchment or changing to seawater strength as it exchanges water with the ocean. With evapotranspiration the Lake can become hypersaline (Haines 2005, Haines 2006).

ICOLLs are susceptible to eutrophication when the mouth is closed. Excess nutrient loads in lakes can cause algal blooms which reduce dissolved oxygen and result in the death of aquatic organisms. Agricultural activities, which include livestock, forestry, fruit growing and banana plantations currently dominate the catchment of Hearnes Lake. Typically, nutrients and sediments would be washed from the catchment during rainfall events and make their way to the estuary. High levels of nutrients and pollutants can place stress on an estuary.

2.2 Site Description

2.2.1 Vegetation

The majority of the coastal floodplain west and south of the Hearnes Lake estuary supports swamp sclerophyll forest and woodland dominated principally by Broad-leaved Paperbark (*Melaleuca quinquinervia*) with scattered Swamp Mahogany (*Eucalyptus robusta*) and copses of Swamp Oak (*Casuarina glauca*). Much of this floodplain vegetation is in very poor condition due to prior land use practises. A large proportion of the original Swamp Sclerophyll Forest canopy has been removed or thinned and the understorey slashed. Areas in very poor condition are indicated on the map (Figure 1) as Prior Swamp Sclerophyll Woodland (PSSW). The ground stratum flora has also been extensively modified over much of the site, with introduced grasses (particularly *Axonopus* species) strongly dominating the southern half of the site.

The centre of the site contains the southern upstream extent of the Hearnes Lake estuary with a *Baumea juncea* dominated salt marsh fringing the lake. A coastal dune system supporting Coast Banksia (*Banksia integrifolia*) and Pink Bloodwood (*Corymbia intermedia*) open woodlands occur east of the lake. Parts of these latter communities on the southern hind dunes have a more mesophytic understorey including littoral rainforest species where afforded some protection from the prevailing salt laden sea breeze.

The floodplain lays a metre or so above the estuarine lake bed. A small fringing terrace of mixed fluvial and estuarine origin occurs along the western edge of the lake. The terrace supports coastal heath vegetation with the southern areas characterised by wallum species *Calistemon pachyphyllus*, *Melaleuca thymifolia* and wet heath species such as *Melaleuca nodosa* and *Banksia oblongifolia* to the north.

The western side of the site supports an open forest dominated by Red Mahogany (*Eucalytus resinifera ssp hemilampra*) with associated swamp turpentine (*Lophostemon suaveolens*), swamp mahogany and broad-leaved paperbark.

2.2.2 Endangered Ecological Communities

Identification of endangered ecological communities (EECs) in the field was undertaken by traversing the site noting changes to the composition of the substrate and the floristics, structure and condition of the vegetation. Delineation of the EECs Swamp Sclerophyll Forest and Coastal Saltmarsh across the Sandy Beach North site was determined using canopy species.

EECs identified on site include:

- Coastal Saltmarsh in the NSW North Coast, Sydney Basin and South East Corner Bioregions; and
- Swamp Sclerophyll Forest of the NSW North Coast, Sydney Basin and South East Corner Bioregions.

The EECs are indicated on Figure 1 as SM and SSF respectively.

The Sedgeland fringing the lake is dominated almost exclusively by *Baumea juncea*, with other salt marsh species such as *Zoysia macrantha*, *Samolus repens* and *Triglochin striata* occurring at only low abundance. This represents an interesting but depauparate variant of the EEC Coastal Saltmarsh.

The majority of the subject site (i.e. west and south of the Hearnes Lake estuary) previously supported the EEC Swamp Sclerophyll Forest. The composition and pattern of ground stratum flora has been disturbed by repeated slashing and grazing. However, the understorey floristics are suggestive of Swamp Sclerophyll Forest occurring on coastal floodplains with sandy-loam soils. Understorey species recorded include *Sacciolepis indica*, *Melaleuca thymifolia*, *Ptilothrix deusta*, *Schoenus apogon*, *Goodenia paniculata* and the introduced grasses *Axonopus affinis* and *Sporobolos africanus*.

2.2.3 Hearnes Lake Estuary and ICOLL

The major conservation significance of the site lies in the presence of the Hearnes Lake estuary and ICOLL. Estuaries are of immense environmental value as they are the interface between terrestrial and marine ecosystems. ICOLLs are unique ecosystems, characterized by a highly dynamic environment. When an ICOLL entrance is closed, the system can be considered a "terminal lake" as all run-off from the upper catchment is stored in the contained lake. The run-off can cause an increase in water level, with an associated decrease in salinity (Haines et al 2006). During dryer times when the lake is closed, evapotranspiration from the water surface can exceed run-off and create hypersaline conditions in the estuary.

ICOLLS are ecologically complex due to their highly variable geomorphology and hydrology. The high number of environmental variables that characterize an ICOLL over time, make it an environment to which very few species can adapt. The biological communities of ICOLLS reflect these changing conditions and typically comprise fewer species but in higher abundance (Jones and West 2005). This differentiates an ICOLL from other areas along the coast where the environmental conditions are less severe, and the biological communities as a result are different.

ICOLLs support communities which are distinct from other river, lake and estuarine environments. Due to the complexity of the environment, ICOLLs are considered to be the estuary type most sensitive to human intervention (Haines et al 2006) and the provision of an adequate naturally vegetated buffer to the ICOLL is the main conservation priority for this site.

At present the physico-chemical water quality data for the lake falls within the ANZECC (2000) guidelines. The guidelines show salinity to vary over time, as expected with freshwater flows during rainfall events and breached of the sand berm. The other notable water quality variable is dissolved oxygen - that if significantly reduced can lead to the death of many aquatic organisms.

Nutrients are important to estuaries, however, increased loads of nutrients associated with catchment development, can result in eutrophication. Eutrophication of estuarine systems in NSW has been well documented and the problems with excess nutrients are exacerbated within lake systems which are either mostly closed or have narrow entrances which allow only small water exchanges with the ocean. Eutrophication is generally found in lakes with development in both their wider upstream catchments or with adjacent catchments.

WBM Oceanics, engineering and environmental consultants preparing the estuary management assessment and study of the lake for Council and the Department of Natural Resources have examined the nutrient status of the lake. In general, there appears to be very limited data available on the lake system which would allow predictions about future loads to be made. The nutrient data outlined in the estuary process study show that at times the ANZECC guidelines are exceeded for

nitrogen and phosphorous. Any further increases in the nutrient status of the lake could see increased algal growth either in the form of phytoplankton or macroalgae blooms.

2.3 Coffs Harbour City Council Vegetation Strategy

The Coffs Harbour City Council Vegetation Strategy (CHCCVS) was prepared by Coffs Harbour City Council and Vegetation Study Group Representatives (with government, community, industry and scientists). This has identified the ecological status of vegetation on this site of high and/or very high value.

The method for determined priorities for conservation used in the Vegetation Conservation DCP considered the significance of each map unit. The mapping process used the system for creating a Comprehensive Adequate Representative (CAR) Reserve System. This system is a Nationally Agreed Criteria for the establishment of a comprehensive adequate and representative reserve system for forests in Australia. The CAR system aims to conserve 15% of each vegetation type in conservation reserves. The CAR system is informed by the Comprehensive Regional Assessment. CHCCVS has

2.4 Concept Plan for the proposed subdivision

The concept plan comprises 295 residential lots ranging in size from 400m^2 to 2,000m^2 with the average size of 550m^2. The concept plan aims to include a transitional buffer between the allotments and Hearnes Lakes which will be used as a perimeter emergency access way and also function as a combined pedestrian/cycleway (Conacher Travers 2005).

A water quality management system is proposed to incorporate stormwater retention ponds, roadside bio-swales and nutrient filter strips. These works aim to ensure treatment of water quality prior to the water entering the nearby watercourses and coastal lagoons (Conacher Travers 2005).

A 2D hydrodynamic model of Hearnes Lake and the lower reaches of Double Crossing Creek was developed and used to simulate a number of design flood scenarios. Based on the results of the hydraulic modelling, the applicants recommend that a peak design 100 year recurrence flood level of 2.6m AHD be adopted for the development site. The result of the modelling, integrated with Council's current Flood Policy means that the applicants aim to fill land to achieve a finished surface level of 2.9m AHD for habitable areas.

2.5 Flora and Fauna Assessment, Conacher Travers, 2005

Conacher Travers were contracted as bushfire and environmental consultants on behalf of the proponents. Their flora and fauna assessment identified 10 vegetation communities and nominated nine threatened flora species that may have suitable or sub-optimal habitat on the subject site.

The report identified the Endangered Ecological Community Swamp Sclerophyll Forest. No threatened flora species were identified. Five threatened fauna species were recorded on site, along with a number of habitats that may support other threatened fauna species. Saltmarsh was identified on the site, however, the survey may have predated the listing of Saltmarsh as an Endangered Ecological Community.

Swamp Sclerophyll Forest is described as fringing the southern portion of Hearnes Lake, with fragments along the southern boundary and to the west of Hearnes Lake. There was no map printed with this report to exactly identify the location of the EEC.

The fauna survey found five species listed on the Threatened Species Conservation Act 1995; the Wallum Froglet (*Crinia tinnula*), Black-necked stork (*Ephipioryhnchus asiaticus*), Osprey (*Pandion haliatus*), Greater Broad-nosed Bat (*Scoteanax rueppelli*), and Eastern Freetail-bat (*Mormopterus norfolkensis).* An additional threatened fauna species, the Glossy Black – cockatoo has previously been recorded on site.

The report concludes that the development proposes the retention of habitat areas including the endangered EEC, Swamp Sclerophyll Forest, to aid the conservation of threatened species observed within the subject site.

3.0 RESULTS and DISCUSSION

3.1 Impacts of Climate Change on Hearnes Lake

The scientific community has widely accepted that the global climate is changing with implications for the management of the coastal zone (IPCC 2001, Haines 2005). Regardless of mitigation measures put in place to halt global warming, the inertia generated from the current green house gas levels will result in significant impacts to coastal areas. It is recommended that coastal management decisions made now prepare for future effects of climate change on the coast (Haines 2005).

Sea rise caused by global warming will impact heavily on the structure and function of ICOLLs. With an increase in mean sea level, Haines (2005) suggests that the crest elevation of entrance sand berms within NSW ICOLLs, if left to natural processes, will reach higher levels (and migrate landward) before entrance breakout occurs (Haines 2005). The result will be ICOLLs with water level stretching further inland, increasing the extent of flood prone land.

The predicted extent of Hearnes Lake is identified as the area within the 3.5m AHD contour. This height was determined by consideration of the existing environment and the likely variations of the geomorphology over time. The berm at the mouth of the Lake is currently around 2m AHD (Haines 2005). The berm height could reasonably increase to a height of 3m due to tidal surcharge caused by storms and king tides. An additional 0.5m is added to the 3.0m maximum to accommodate predicted maximum sea level rises to 2050. IPCC (2001) projects a 0.48m sea level rise by 2100.

The 3.5m AHD is supported in scientific literature (IPCC 2001, Haines 2005,2006, Lord and Gibbs 2004). The 3.5m AHD is the height above which development would be likely to remain on dry ground in the years 2050 to 2100. Spot levels were taken across the site to determine the land elevation. Excluding the southern boundary and the south central section of the property, the majority of the elevation readings are less than 3.0m AHD and therefore much of the site could be flood prone.

The 3.5m AHD is higher than the applicants modelled 2.9m level. The 2.9m AHD level was determined from a 1/100 year flood and does not appear to have taken sea level rise into consideration.

Areas of the site potentially suitable for development will need to be established at minimum level of RL3.5m AHD, subject to these areas being outside the endangered ecological communities and outside the environmental buffers discussed below. This will also be subject to an assessment of impacts and suitability of filling of areas of the site to this level where required.

3.2 The need for Environmental Buffers

The prime purpose of a buffer zone is to “insulate areas where biodiversity conservation is the primary objective, from potentially damaging external influences, and particularly from those caused by inappropriate forms of land use” (Bennett and Mulongoy 2006).

A buffer zone will provide (Martino 2001):

1) a physical barrier from human encroachment;
2) protection from storm damage;
3) an increase in natural habitat and reduce edge effects; and
4) an enhancement to the environmental services provided by the nature reserve.

Due to lack of research, the size of a buffer for wetlands and other sensitive ecosystems in Australia should be determined by on a case by case basis after site specific investigations (Winning 1997).

In urbanizing landscapes where there is fragmentation of valuable habitat, buffering the affect of urban development on High Conservation Value lands assists to reduce the edge effect. The 'edge' is the zone on the outer edge of a community where it is noticeably affected by 'outer' influences. Research on edge effects has identified widely variable ingress distances. Tropical Rainforest edges have been shown to penetrate up to 500m (Laurence, 1991), whilst in temperate Rainforest edge effects were recorded up to 12.7m (Fox *et al* 1997). Land form, ecological attributes, climate, threats, and abutting land use will all influence the size of buffer required to protect the integrity of an EEC.

The retention and management of vegetated buffers is important to ensure that healthy ecosystems are maintained and protected. Effective buffers vary from around 20m to 100m and more, depending on the type of development, the habitat being protected, and amongst other things the height and canopy of the plant community, slope and elevation. In a development adjacent to an Endangered Ecological Community, there is usually potential to vary the width of the buffer to allow for site specific practicalities, provided any loss of buffer width can be made by 'offsets' elsewhere on the site.

3.2.1 Migratory Shorebirds and Environmental Buffers

Hearnes Lake is occasionally frequented by migratory Shore birds that are listed under the Threatened Species Conservation Act and International Migratory Bird agreements Japan-Australia Migratory Bird Agreement and (JAMBA) and China-Australia Migratory Bird Agreement (CAMBA) (P. Straw Avifauna pers. comm.. 2006)

Most species of migratory shorebirds need a large area of open mudflats on which to feed as well as a buffer zone that is clear of tall trees or structures that restrict a clear line of site. This is important to enable the birds to view the approach of potential predators. Researchers such as Lawler (1996) and Paton *et al* (2000) found that shorebirds responded to the approach of various threats including people, dogs and boats. Disturbances varied depending on species of shorebird and source of disturbance. While some species tolerated an approach as close as 30m or less by people walking casually others were disturbed at much greater distances, of up to 200m by dogs, and erratically driven noisy watercraft such as jet skis. Lawler (1996) also found that, except for a few species such as Whimbrel and Grey-tailed Tattler that often feed close to mangroves, shorebirds tend to stay clear of areas surrounded by tall trees or structures when feeding or roosting (resting). This is because such obstructions prevent a clear view of the approach of potential predators. Most shorebirds avoid these zones or remain on constant alert instead of spending time feeding (Saintilan 2003, Straw 2003, Straw & Saintilan 2006).

A buffer of 100m around Hearnes Lake will provide a level of visual and noise screening for migratory birds. This is particularly important where the land is level and the vegetation is low.

3.2.2 Endangered Ecological Communities and Environmental Buffers

Key threatening processes have continued to degrade and destroy certain habitats. As loss of those habitats has continued, the need to preserve any remnants of certain communities has become apparent. For certain endangered communities, even an area in poor condition has a high priority for conservation. The majority of conserved habitats continue to be found primarily on steep and rugged terrain, unsuitable for urban expansion or agricultural use.

Since the date of the Coffs Harbour LEP 2000, cumulative loss of habitats on the North Coast has led to new listings of endangered ecological communities, two of which are present on the site, Saltmarsh and Swamp Sclerophyll Forest.

The boundaries and classification of the high conservation lands were determined in the field by personnel with wetland ecology and flora and fauna survey. Ground truthing indicates that the EEC Swamp Sclerophyll Forest and Saltmarsh are distributed across the site and areas that should be

retained have been identified on the *Environmental Constraints and Development Potential Map* attached to this report.

The EECs Saltmarsh and Swamp Sclerophyll Forest also require buffers.

The NPWS profile for the Saltmarsh EEC identifies the following priority actions for the recovery of the community:

- Protect areas of saltmarsh from run-off that contains high levels of nutrients or pollutants.
- Maintain buffer zones of terrestrial vegetation adjacent to saltmarsh to allow for expansion of saltmarsh and to minimise nutrient flow.
- Allow areas of saltmarsh to regenerate naturally where possible.
- Protect from clearing and development through fencing, signage and active management.
- Erect educational signs to provide information to visitors and residents of the importance of coastal saltmarsh.

Saltmarsh, being a low growing community, usually requires a buffer of 30m, which brings it within the buffer of Hearnes Lake. The migratory shorebirds using this habitat will require that this buffer be extended to 100m due to their sensitivity to noise and visual disturbance (Saintilan 2003, Straw 2003, Straw & Saintilan 2006).

Swamp Sclerophyll Forest requires a buffer to reduce the edge effect on the community and allow for regeneration. Being comprised of taller tree species, the SSF, requires a buffer of 50m. The fire sensitivity of SSF should be considered when hazard reduction burning is required. Bushfire protection buffer for development should be designated outside of the community and buffer zones. The 50m buffer for SSF communities is marked on the *Environmental Constraints and Development Potential Map*, attached to this report.

3.2.3. Hearnes Lake and Environmental Buffers

Hearnes Lake is currently receiving anthropogenic sources of nutrients, sediments and other pollutants from its catchment. The ephemeral nature of the entrance to the lake causes increased variability in the salinity of the estuary. Any increase in the current loads of nutrients may result in greater symptoms of eutrophication (blooms of phytoplankton and/or macroalgae). This in turn may lead to a breakdown in the nutrient cycling capacity of the estuary as various benthic flora and fauna are impacted. At this stage Hearnes Lake appears to be in reasonably good “health” however it is predicted that any further development of the catchment will result in the estuary becoming eutrophic with poor “health”.

A buffer is required to protect the ICOLL from impacts associated with urban development (e.g. eutrophication) and from the hydrological pressure applied from the processes associated with global warming and sea level rises. The buffer will also provide riparian habitat for fauna and protect water bird habitat, particularly for waders that are easily spooked by noise and visual disturbance. Haines (2005) has recommended that a buffer of 50m to 100m be applied around the full extent of the lake measured from the RL 3.5M AHD contour. The 3.5m AHD level is the assumed extent of the ICOLL based on the projection for global warming combined with tidal surcharges (Haines 2005).

The implementation of a 50m to 100m buffer around the lake based upon the 3.5m AHD contour would preclude development from much of this site. This should however be considered in context of the combined implementation of a 100m environmental buffer around the lake on this site, for migratory shorebirds and 50m environmental buffers for the endangered ecological communities. These combined buffers will be consistent and contiguous with the minimum required to provide an effective environmental buffer for the lake. This would leave areas of the site potentially suitable for development, but subject to the 3.5m AHD level to take account of predicated sea level rise and

the predicted future extent of the lake. This is also subject to an assessment of the impacts and suitability of any filling of the site.

3.2.4. Frontal Dunes and Environmental Buffers

The existing fence along the eastern boundary is partly within the frontal dune system with areas cleared of vegetation. A 30m environmental buffer will be required as a minimum setback from the eastern boundary to protect to the dunes fronting the beach and the areas within Coffs Coast Regional Park.

4.0 CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

The boundaries and classification of the high conservation lands were determined in the field by personnel with wetland ecology and flora and fauna survey. Ground truthing indicates that the EEC Swamp Sclerophyll Forest and Saltmarsh are distributed across the site, and areas which should be retained and protected from future development have been identified and mapped. Expert opinion identifies the need for a 100m buffer around the saltmarsh to protect habitat for migratory shore birds or waders. The areas of Swamp Sclerophyll Forest require a 50m buffer to reduce edge effect and encourage regeneration of the community.

The significance of Hearnes Lake was considered by Dr Dan Roberts, an expert in coastal processes. Projections were made as to likely fluctuations in the lake's character over the immediate time and forward 50 years. As a result a development buffer based on the 3.5m AHD contour is proposed, and is consistent and contiguous with the above buffers to protect endangered ecological communities and habitat for migratory birds.

4.2 Recommendations

The areas of the site for environmental protection, provision of environmental buffers and the areas of future development potential are as indicated on *Environmental Constraints and Development Potential Map*, and provides that:

(1) all Endangered Ecological Communities on site be retained and a 50m environmental buffer be implemented around these areas.
(2) a 100m environmental buffer be implemented from the saltmarsh edge to protect the habitat of migratory shorebirds.
(3) a 30m environmental buffer be implemented along the eastern boundary of the site to protect the frontal dunes to the beach.
(4) an environmental buffer be implemented to protect the environment and ecology of Hearnes Lake based upon the 3.5m AHD contour, and being as a minimum a buffer consistent with the combined areas of the environmental buffers in points (1) and (2)
(5) areas of the site potentially suitable for development be established at minimum level of RL 3.5m AHD to protect development from predicted sea level rise, with these areas being outside the endangered ecological communities and outside the combined areas of the environmental buffer areas. This is subject to the assessment of impacts and suitability of any site filling to this level where required.
(6) variations to reduce the width of the environmental buffers may be considered where these would provide more practical development outcomes and where further assessment justifies any variations, and where any variations may be offset by increasing the size and/or width of the environmental buffers elsewhere on the site.

5.0 REFERENCES

Adam, P., Urwin,N., Weiner, P., and Sim, I. (1985) Coastal Wetlands of New South Wales. Coastal Council of New South Wales, Sydney.

Bennet, G., and Mulongoy, KJ, (2006) Review of Experience with Ecological Networks, Corridors and Buffer Zones. Secretariat of the Convention on Biological Diversity, Montreal, Technical Series No 23, 100 pages.

Conacher Travers. Flora and Fauna Assessment report, October 2005.

Haines, P.E., Tomlinson R, B., and Thom, B.G., 2006 Morphometric assessment of intermittently open/closed coastal lagoons in New South Wales, Australia. Estuarine, Coastal and Shelf Science 67, 321-332.

Haines, P.E. (2005) Determining appropriate setbacks for future development around ICOLLs 14th NSW Coastal Conference, Narooma, 8-11 November, 2005.

Jones, M. V., West, R.J., 2005 Spatial and temporal variability of seagrass fishes in intermittently closed and open lakes in southeastern Australia. Estuarine, Coastal and Shelf Science 64 (2-3), 277-288.

Lord, D. and Gibbs,J. (2004) "The day after tomorrow, the reality of climate change for Coastal NSW" Proc. 13th ann. NSW Coastal Conference, Lake Macquarie, 9-12 Nov. 2004, pp 187-197.

Lawler, W. 1996. Guidelines for Management of Migratory Shorebird Habitat in Southern East Coast Estuaries, Australia. Mater of Resource Science thesis, University of New England

Martino, D. (2001) Buffer Zones Around Protected Areas: A Brief Literature Review. Electronic Green Journal, Issue 15. ISSN: 1076-7075.

Intergovernmental Panel on Climate Change (2001), Climate Change 2001: Synthesis Report. Cambridge University Press, Cambridge.

Paton, D.C.,Ziembicki, M., Owen, P. and Heddle, C. (2000). Disturbance Distances for Waterbirds and the Management of Human Recreation with Special Reference to the Coorong Region of South of South Australia. Report to the Migratory Waterbird component of the National Wetlands Program, Environment Australia. Department of Environmental Biology, the University of Adelaide.

Saintilan, N. 2003. Balancing shorebird habitat requirements with mangrove conservation. In Straw, P. (Ed.) Status and Management of Migratory Shorebirds in Sydney. Sydney Olympic Park Authority, Sydney.

Straw, P. 2003. Habitat restoration – trials, tribulations & successes. In Straw, P. (Ed.) Status and Management of Migratory Shorebirds in Sydney. Sydney Olympic Park Authority, Sydney.

Straw, P. & Saintilan, N. 2006. Loss of shorebird habitat as a result of mangrove incursion due to sea-level rise and urbanization. In Waterbirds Around the World, proceedings of the Global Flyway Conference, Edinburgh, Scotland.

Winning, G. 1997. The functions and widths of wetland buffers, Hunter Wetlands Research Technical Memorandum No. 1. Unpublished.