

7.0 Flora and Fauna

This chapter provides an assessment of the potential impact of the Project on flora and fauna. It includes consideration of terrestrial and aquatic ecology. This assessment identifies potential impacts on threatened species and details measures to avoid or mitigate impacts identified.

Director General's Requirements	Compliance
4. Flora and fauna 4.1 Outline potential impacts on flora and fauna and their habitats (within the meaning of the <i>Threatened Species Conservation Act 1995</i> and the <i>Fisheries Management Act 1994</i>) across the site and, where relevant, provide conservation measures. Specifically address the impact of the open water wetland on fish and their habitats. 4.2 Provide a vegetation management plan that describes the proposed revegetation and regeneration works across the site. Consider the role of the revegetation in the provision of habitat for threatened species including the koala (with reference to Hastings Council's Area 14 Koala Plan of Management). 4.3 Address the potential for the open water wetland to harbour aquatic weeds and, where necessary, identify measures for their management.	An assessment of the potential impact of the Project on flora and fauna has been undertaken; this includes consideration of terrestrial and aquatic ecology. Consideration has also been given to the potential impact on Rainbow Beach littoral rainforest No. 116, the stand of littoral rainforest situated adjacent to the Project Application Area. The potential for the proposed wetland to harbour aquatic weeds has been assessed by Cardno (Appendix N) and by AECOM in Appendix M. Details of their findings are provided within this chapter.

7.1 Methodology

An assessment of potential flora and fauna impacts has been undertaken by Darkheart Eco-Consultancy in respect of terrestrial ecology including potential impacts on the mapped littoral rainforest adjacent to the Project Application Area and the Ecology Lab in respect of aquatic ecology of the existing lagoon. Technical reports prepared by these specialists are including within **Appendix G**, **Appendix H** and **Appendix I** for terrestrial ecology, aquatic ecology and littoral rainforest respectively.

The 'study area' examined for the flora and fauna assessment comprises the area affected by the wider Concept Plan Application, namely the Concept Plan Area, as well as adjacent Crown land to the north east, which is mapped as littoral rainforest pursuant to SEPP 26. This area of littoral rainforest is referred to within this EA as Rainbow Beach littoral rainforest No. 116. The Concept Plan Area is illustrated in **Figure 20** and the Rainbow Beach littoral rainforest No. 116 is illustrated in **Figure 23**.

The methodology used for the assessment involves three key steps, which are:

- desk top study;
- habitat survey; and
- faunal survey.

The desk top study involved the review of previous studies and mapping undertaken in the locality. In 2005, Biolink mapped the vegetation communities of the study area (via aerial photography and some limited ground truthing) as well as adjoining land which fell within the jurisdiction of the Urban Investigation Area 14 – Koala Plan of Management (UIA 14 KPOM). This mapping was generally adopted by Darkheart Eco-Consultancy for this assessment. Formal ground truthing via random meander and plot sampling was undertaken to confirm Biolink's work.

The desk top study also reviewed published information sources including the Commonwealth Government Species Profile and Threats (SPRAT) database and the NSW Government Atlas of NSW Wildlife.

In order to compile background information several databases were searched to provide information on significant flora and fauna species that have been found in the study area, including the EPBC Act Protected Matters Search Tool (DEWHA) online database for Matters of National Environmental Significance) and the National Parks and Wildlife Service (NPWS) Atlas of NSW Wildlife.

General faunal activity was observed during the course of the surveys and recorded. Specific attention was also paid to the potential presence of protected, rare or notable species with specific surveys conducted with respect to threatened species.

Assessments of significance were conducted for threatened species listed under the TSC Act and followed the heads of consideration outlined in the *Draft Guidelines for Threatened Species Assessment* (DEC and DPI, 2005). For threatened species listed under the EPBC Act, assessments of significance were undertaken in accordance with the *Significant Impact Guidelines and Matters of National Significance* (DEH, 2006).

7.2 Existing Environment

7.2.1 Existing Flora

Vegetation Mapping

Darkheart Eco-Consultancy identified ten vegetation communities within 10 km of the study area, based on previous study undertaken by Biolink (2005), use of aerial photography and subsequent ground-truthing.

The extent of these vegetation community types is outlined in **Table 15**. **Figure 20** illustrates the location of this vegetation, based on Biolink's vegetation map which was subsequently ground-truthed as part of this assessment.

Table 15 Vegetation Communities within the Concept Plan Area

Vegetation Community / Habitat	Total Area (ha)
Blackbutt-Tallowood-Needlebark Dry Sclerophyll Forest	1.98
Brushbox Wet Sclerophyll Forest	0.72
Blackbutt Dry Sclerophyll Forest	2.11
Grey Ironbark-Grey Gum Dry Sclerophyll Forest	2.39
Paperbark-Swamp Mahogany - Swamp Oak Swamp Forest/Woodland	10.45
Pasture/Pastoral Woodland	150.12
Dune Scrub	1.19
Swamp Oak Swamp Forest	4.29
Aquatic	5.75
TOTAL	179 (approx)

Source: Darkheart Eco-Consultancy 2008

Threatened Plant Species Recordings

Despite searches for species known to occur in the locality, site surveys did not record the presence of threatened plant species. The Project Application Area has experienced a range of severe disturbances over time as a result of previous activities and agricultural development which have significantly reduced the suitability of the property to support threatened species.

Endangered Ecological Communities (EEC)

Two EECs have been identified within the study area as shown in **Figure 21** and listed as follows:

- Swamp Sclerophyll Forest on Coastal Floodplains (SSFCF) of the NSW North Coast Bioregion. This EEC is considered to constitute the Paperbark/Swamp Mahogany/Swamp Oak swamp forest in the mid south west, north west and south east of the study area. Darkheart Eco-Consultancy concludes that examples of this EEC on the property were considered to only qualify as low to medium quality examples due to the extent of disturbance and modification.
- Swamp Oak Floodplain Forest on Coastal Floodplains of the NSW North Coast Bioregion. This EEC is considered to constitute the portion of Swamp Oak located in the north eastern section of the study area.

Figure 20 Location of Existing Vegetation

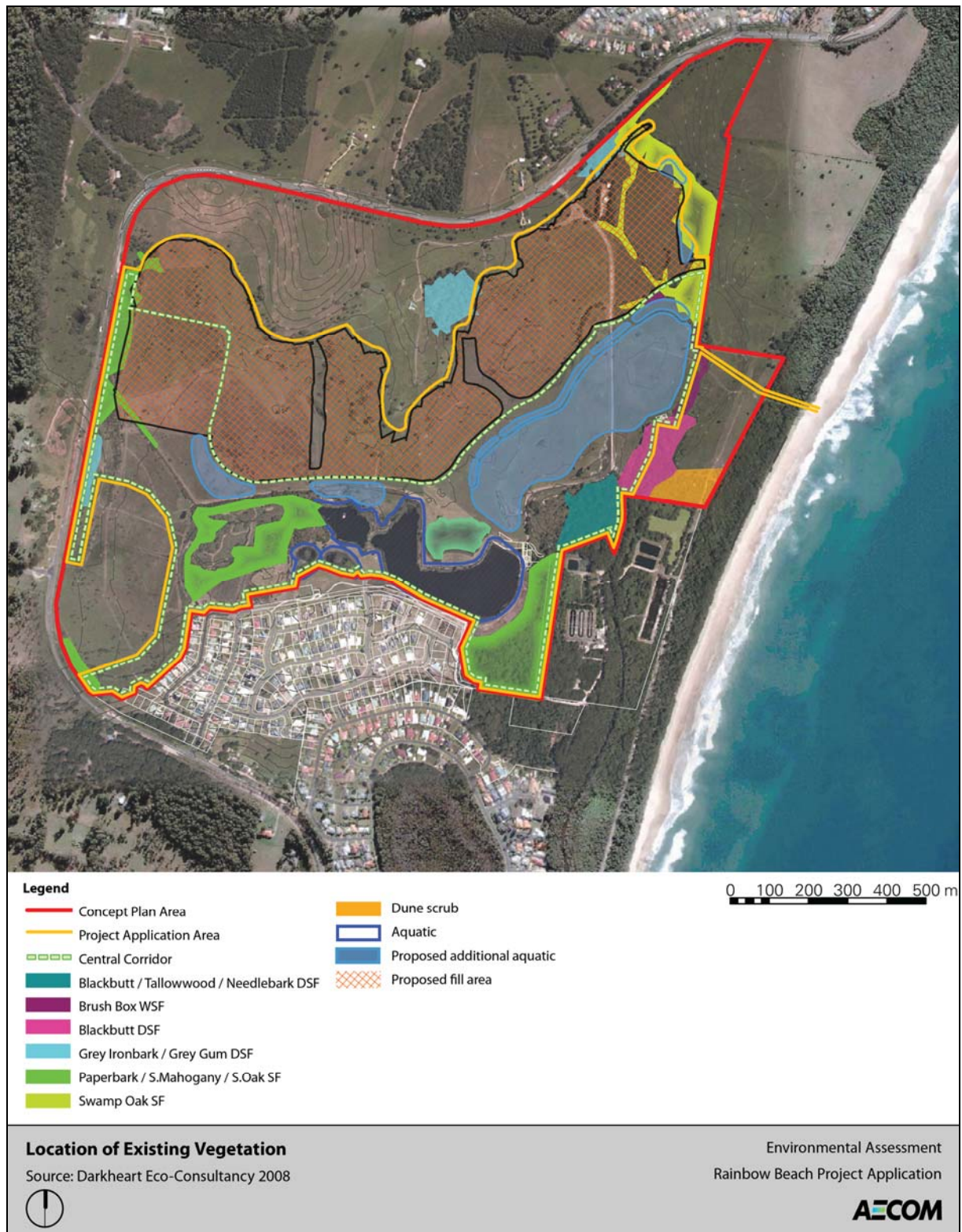
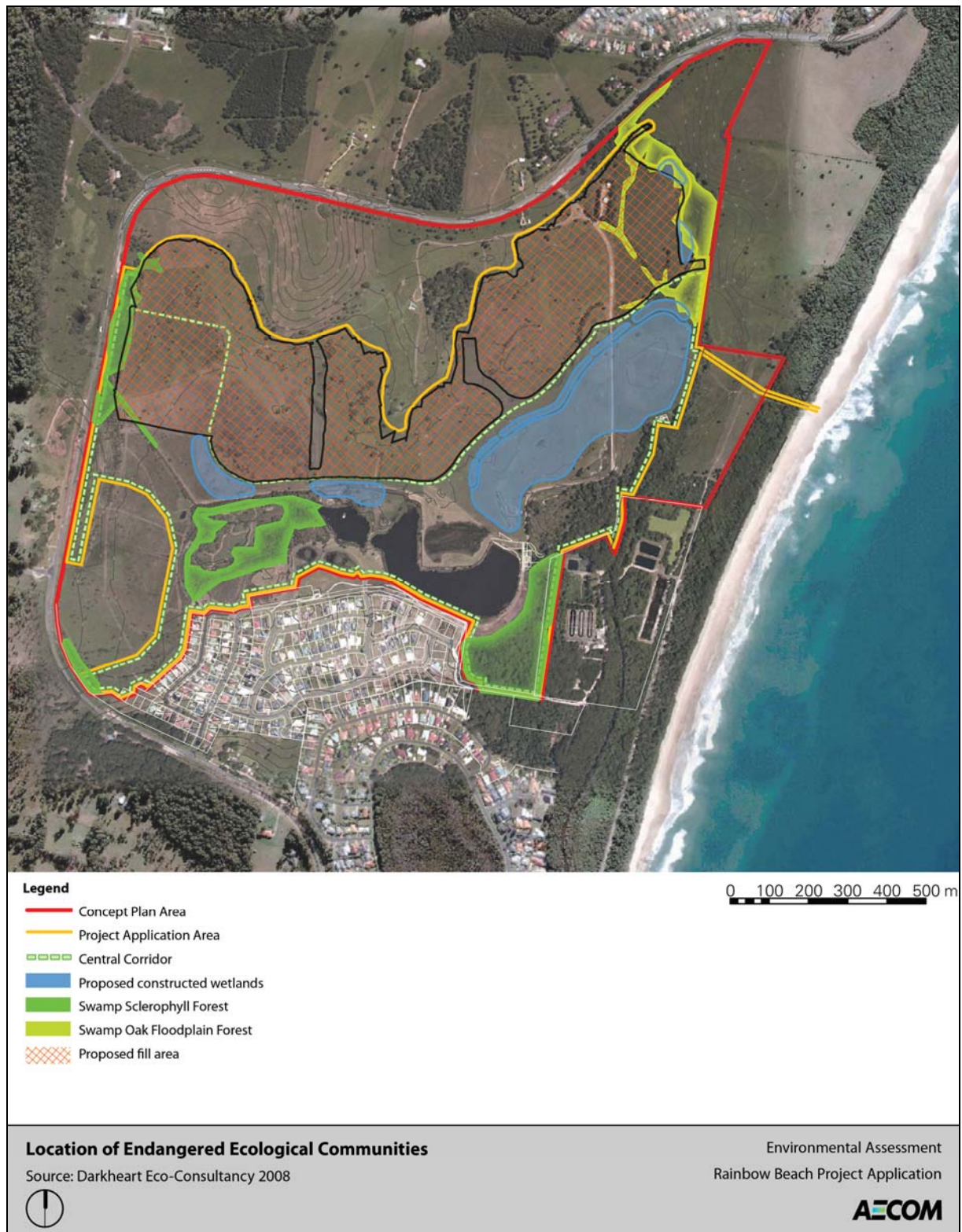


Figure 21 Location of Endangered Ecological Communities



7.2.2 Existing Fauna

Fauna

A total of 65 native species of mammals, birds, reptiles and amphibians have been identified within the study area through analysis of previous survey results, DECCW records and results of fauna surveys undertaken across the study area.

Survey found that bird diversity in the north eastern section of the study area is relatively low, despite the extent of forest in this location. This is most likely due to the low structural diversity of the Swamp Oak vegetation community that makes up the majority of this forested area. Small passerines (perching birds and songbirds) were more common in the Dry Sclerophyll vegetation community in the southeast of the study area and associated swamp forest and dune scrub.

Within the existing lagoon a relative abundance of waterfowl including ducks, moorhens, swans, cormorants and pelicans were observed. Foraging habitat for migratory species is provided by the dense fringe of sedges and grasses of the existing lagoon. Although no sightings were made during site investigations, the two stock dams located in the Pasture/Pastoral Woodland vegetation community are believed to offer potential foraging habitat for the Jabiru and Brolga.

The isolated patch of Dry Sclerophyll Forest in the mid-north of the Project Application Area contains a number of hollow bearing trees, which were dominated by Galahs, Eastern Rosellas and Lorikeets. Hollow bearing trees scattered throughout the Pasture/Pastoral Woodland also provide habitat for these species, as well as more common agricultural woodland bird species.

Site investigations found potential frog habitat within the Project Application Area in the form of drains, waterlogged pasture and around dams. This habitat has however been physically disturbed by grazing, periodic slashing and the presence of the Plague Minnow.

Of the native species identified, eight are listed as threatened fauna species. These threatened species are categorised as "Vulnerable" pursuant to Schedule 2 of the TSC Act. **Figure 22** illustrates the location of these threatened fauna species recordings. These species include:

- Wallum Froglet;
- Wompoo Fruit-Dove;
- Square-Tailed Kite;
- Koala;
- Grey-Headed Flying Fox;
- Eastern Chestnut Mouse;
- Common Planigale; and
- Little Bent-Wing Bat.

The eight threatened species recorded in the study area are described in **Table 16** below.

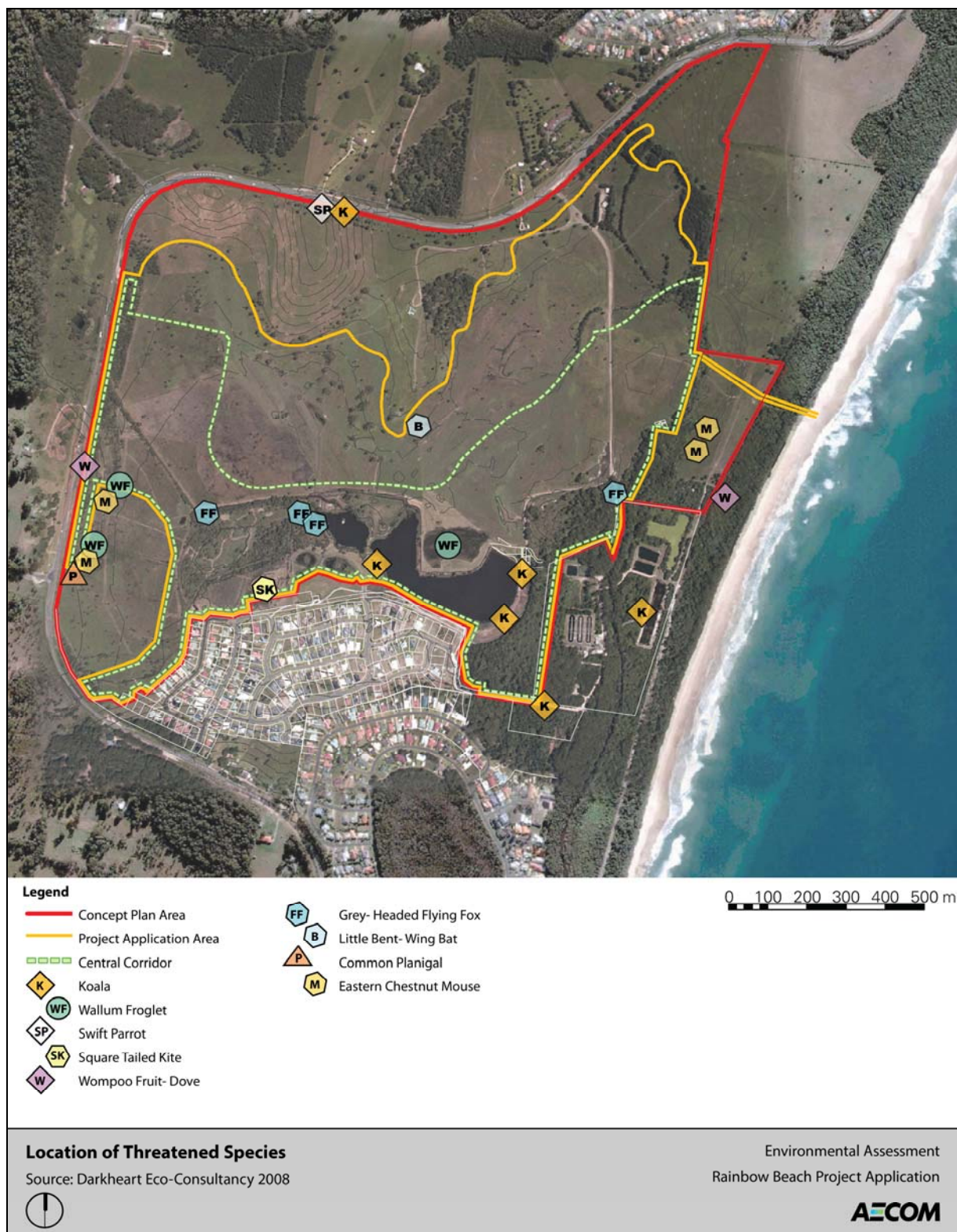
Table 16 Threatened Fauna Recorded

Species	Details
Wallum Froglet	A small population of the Wallum Froglet was located in a drainage line in the west southwest of the study area, while a second population was found in a healthy depression north of the eastern dam southwest of the proposed wetland. The survival of the population in the existing lagoon after apparently several slashing events was unexpected given the major loss of cover and high exposure to predation. If this habitat is allowed to regenerate, the population may recover, however as an isolated population there is a risk of long term genetic degradation, and potential risk of extinction due to catastrophic event. The small population in the drainage line in the southwest is even more at risk of extinction due to limited genetic diversity and/or a catastrophic event.
Wompoo Fruit-Dove	A single Wompoo Fruit-Dove was recorded roosting for a short period in the Blackbutt Dry Sclerophyll Forest adjacent to Ocean Drive in the west south west of study area.

Species	Details
	Apart from a handful of rainforest trees along Duchess Gully which are highly exposed, the study area does not offer significant habitat for this species and its occurrence within the study area is considered incidental. The adjacent littoral rainforest up to Middle Head is considered likely to be used seasonally as part of the species' wider non-breeding foraging range and as a "stepping stone" between larger remnants such as Sea Acres Nature Reserve.
Grey-headed Flying Fox	The property has capacity only to form a small part of the very large foraging range of this species which varies according to incidences of flowering and fruiting.
Square-Tailed Kite	This species was not detected on the subject area during surveys, however was anecdotally recorded flying over the southern portion of the subject area. No nests were observed during surveys and it is considered that the study area offers limited value as potential foraging resource for the species.
Koala	Recently recorded in the Dry Sclerophyll Forest on the western fringe of the sewerage treatment works Koala scats indicating an area of major activity were found in swamp forest in the southeast of the study area adjacent to the sewage treatment plant but were not found elsewhere within the study area, despite specific searches. The southeast corner of the study area is considered to form primary habitat under Draft KPOM.
Eastern Chestnut Mouse	Detected in grassland east of Duchess Gully, and in grassland and drainage line in the west south west of the study area. Due to a lack of suitable habitat within the study area it is considered the southwest population is currently at very high risk of extinction due to intense slashing or extensive fire burnt out the entire habitat area. The southwest population is also essentially isolated from other potential habitat to the west or southwest of the study area, due to the location of Ocean Drive, rural-residential development and pasture. Hence its long term genetic integrity is considered significantly limited without an effective avenue for dispersal.
Common Planigale	Identified within the drainage line in the west south west of the study area the species is isolated in this area and at very high risk of extinction via extensive fire or slashing, breeding failure and inbreeding. The establishment of an effective corridor in the southwest linking to the east would be a positive impact on the long term viability of this population.
Little Bent-Wing Bat	Site investigations resulted in the recording of a Little Bent-Wing Bat along a track under the Dry Sclerophyll Forest canopy in the east southeast of the study area. There are no caves within the Project Application Area, but a relatively large culvert under Ocean Drive in the west has the potential to offer some marginal potential as a roost for bats. Tree hollows potentially suitable for this species such as the Little Bent-Wing Bat are mostly located within the Pastoral Woodland and also in Dry Sclerophyll Forest which collectively offers better potential as non-breeding seasonal roosts.

Source: Darkheart Eco-Consultancy 2008

Figure 22 Location of Threatened Species



7.2.3 Habitat Corridors

The gradual modification of the majority of the study area into pasture has resulted in tenuous linkages between the remaining pockets of remnant habitat. The most noteworthy linkages remaining within the study area is the fragmented vegetation along Duchess Creek, which links the centre and the linear swamp forest regrowth along the main drain in the southwest to the western dry sclerophyll and swamp forest regrowth. These links are considered to be tenuous for arboreal mammals and small terrestrial fauna due to lack of refuge (such as tree hollows, fallen logs, ground cover), fragmentation and high exposure to predators.

A number of coastal links are present adjacent to the study area, connecting the Project Application Area to littoral rainforest to the north east and substantial Blackbutt-dominated Dry Sclerophyll, paperbark swamp forest and dune scrub in the vicinity of Duchess Gully and around the sewage treatment plant. This vegetation provides a broad range of habitats for fauna including the koala and squirrel glider specifically and collectively provides for movement of a diverse range of species and hence, contributes to the biodiversity of the property.

Connectivity to the north and west and southwest is hindered largely by Ocean Road, which presents a physical and mortality barrier to fauna movement. Despite this, the remnant swamp forest and Dry Sclerophyll forest located along the western boundary of the study area provides a link via woodland trees to the west of Ocean Drive by means of a drainage line which flows through a major culvert under the road. This drainage line flows into the Queens Lake Conservation Area and offers the best linkage to the west for frogs, rodents and reptiles.

7.2.4 Existing Aquatic Habitats

A number of aquatic habitats are currently supported within the study area, including the following:

- an existing lagoon system;
- two small existing treatment wetlands to the west of the water body constructed for the purposes of receiving and treating stormwater from the residential development to the south; and
- Duchess Gully which extends along the eastern boundary of the Project Application Area.

Water Quality

Appropriate water quality objectives for key indicators including (but not limited to) pH, turbidity, salinity, dissolved oxygen, nitrogen and phosphorus were adopted for the Site from Council's Aus-Spec Design Specifications and the ANZECC water quality guidelines for fresh and marine waters.

Based on these objectives, water quality within the study area is generally good, with the existing water body generally satisfying the desirable water quality objectives to provide sustainability of an appropriate freshwater coastal ecosystem capable of providing a suitable recreation environment and potential habitat resources.

Aquatic Vegetation

The existing lagoon and the existing treatment wetlands support a variety of native macrophyte species populations, including:

- Jointed twig rush (*Baumea articulata*);
- Bare twig rush (*Baumea juncea*);
- Sag (*Eleocharis equisetina*);
- Sea rush (*Juncus kraussii*);
- Water primrose (*Ludwigia peploides ssp montevidensis*); and
- Water ribbons (*Triglochin sp.*).

Large expanses of the littoral or marginal zone of the existing lagoon support infestations of the introduced Torpedo grass (*Panicum repens*). Wild Things Native Gardens, a local bush regeneration contractor, are currently undertaking extensive regeneration works within the Project Application Area, including actively trialling means of controlling this pest species. At present, Wild Things Native Gardens have successfully removed the majority of its biomass from the lagoon littoral/marginal zone, creating an opportunity for the revegetation and rehabilitation of the existing water body to enhance its biodiversity values and inhibit regrowth of Torpedo grass.

No threatened aquatic flora species were recorded within or adjacent to the existing lagoon.

Aquatic Fauna

An initial survey of the existing lagoon indicated that it is in a healthy condition with only some minor concerns surrounding the low abundance and diversity of benthic fauna. A variety of aquatic organisms were found to inhabit the water body, including the following:

- Sea mullet (*Mugil cephalus*);
- Freshwater mullet (*Myxus petardi*);
- Snakenecked tortoise (*Chelodina longicollis*);
- Empire gudgeon (*Hypseleotris compressus*);
- Striped gudgeon (*Gobiomorphus australis*);
- Flathead gudgeon (*Philypnodon grandiceps*); and
- Shortfin eel (*Anguilla australis*).

A number of cosmopolitan waterbird species such as Chestnut teal (*Anas castanea*), Cormorants (*Phalacrocorax spp*), Pacific Black duck (*Anas superciliosa*) and Purple swamphen (*Porphyrio porphyrio*) utilise the existing lagoon for habitat resources on a regular basis. The presence of juvenile Snake-necked tortoise (*Chelodina longicollis*) and Short-finned eels also demonstrates that the existing lagoon system provides breeding and/or nursery resources to aquatic organisms. The only introduced species detected in the existing lagoon was the Mosquito fish (*Gambusia holbrooki*).

No threatened aquatic fauna species were recorded within or adjacent to the existing lagoon.

Littoral Rainforest

The Project Application Area is situated adjacent to Crown land to the north east, which is mapped as littoral rainforest pursuant to SEPP 26. This area of littoral rainforest is referred to as Rainbow Beach littoral rainforest No. 116 to within this EA, and is shown in **Figure 23**.

Littoral rainforest is listed as an EEC under the TSC Act, and the EPBC Act. This high conservation value vegetation forms part of a remnant strip of dune succession vegetation, narrowed by historical clearing for pasture to the west. It extends approximately 110 m south adjacent to the north east boundary of the site, degrading to a dune succession to the south of the existing access to Rainbow Beach.

A flora survey of the Crown land vegetation conducted on behalf of Port Macquarie – Hastings Council in 2004 as part of a management plan for the Middle Rock Reserve identified the natives species found within the reserve. The majority of these species were found to be rainforest species best suited to local edaphic conditions and reflective of local genetic diversity.

The threatened plant, *Cynanchum elegans* was identified in the northern end of the littoral rainforest adjacent to Middle Head Road.

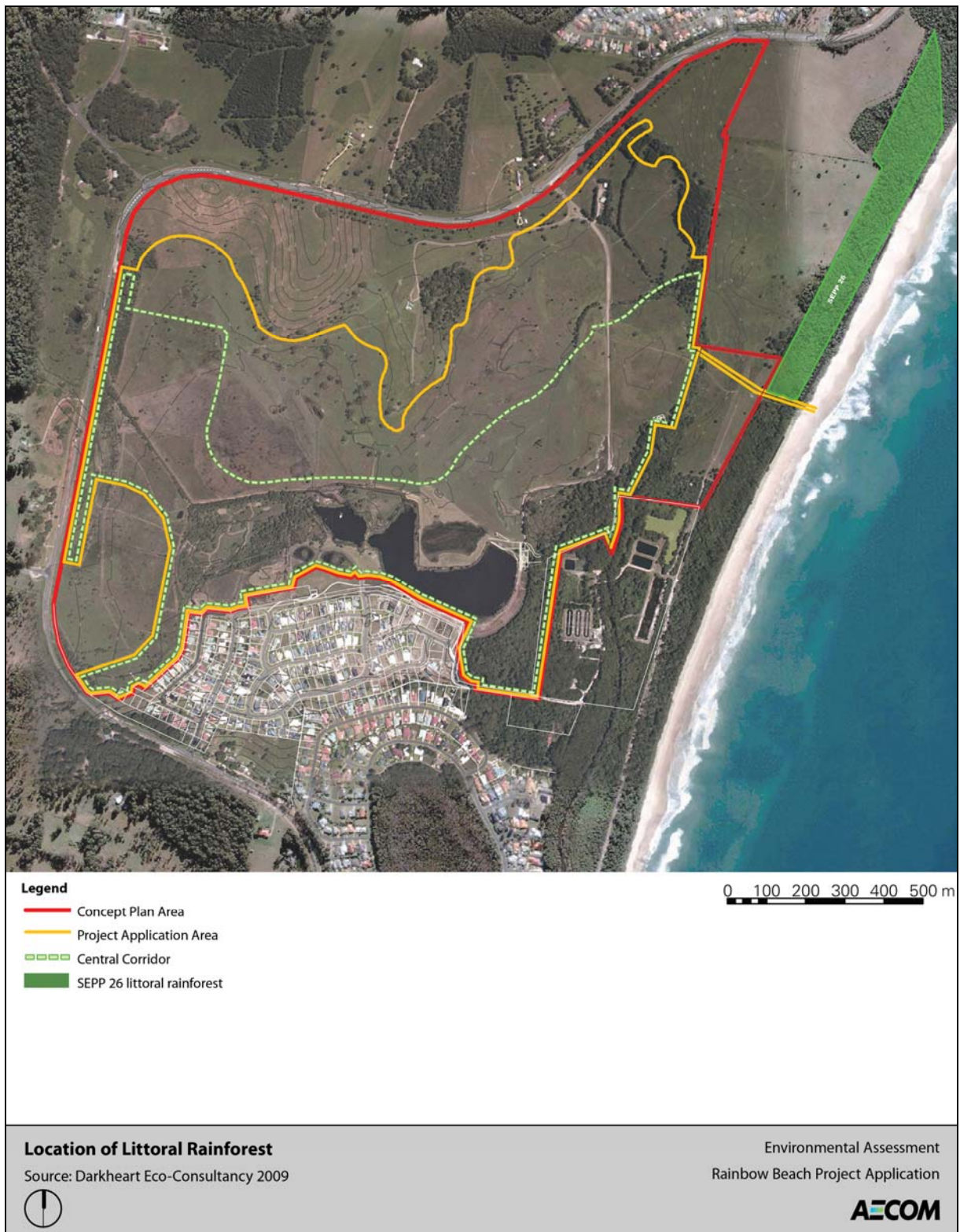
Weeds were observed during the site investigations but are not considered to be a major threat to the littoral rainforest core. The primary weeds noted within the Project Application Area are listed in **Table 17**.

Table 17 Weeds Observed within Littoral Rainforest

Weed Species	Location
Lantana	Localised patch towards the southwest corner of the beach access, spread across the boundary from Crown reserve adjacent.
Bitou Bush	Scattered plants in the pasture and under the boundary fence.
Winter Senna	Few scattered shrubs along the fence line.
Morning Glory and Turkey Rhubarb	Scattered plants on the north western edge of the forest.
Pasture grasses and weeds	Along with Bladey Grass and Spiney Headed Matrush dominate most of the site.

Source: Darkheart Eco-Consultancy 2008

Figure 23 Rainbow Beach Littoral Rainforest No. 116



7.3 Potential Impacts

7.3.1 Impact on Terrestrial Ecology

Within the wider Concept Plan Area, approximately 62.85 ha of Pasture/Pastoral Woodland vegetation is proposed to be removed, as illustrated in **Table 18**. Areas of Grey Ironbark-Grey Gum Dry Sclerophyll Forest, Paperbark-Swamp Mahogany-Swamp Oak and Swamp Oak are also proposed to be removed, however estimated areas of loss for these communities are negligible.

Table 18 Estimated Areas of Loss per Vegetation Community

Vegetation Community / Habitat	Total Area (ha)	Area Removed (ha)	Area Retained (ha)
Blackbutt-Tallowood-Needlebark Dry Sclerophyll Forest	1.98	0	1.98
Brushbox Wet Sclerophyll Forest	0.72	0	0.72
Blackbutt Dry Sclerophyll Forest	2.11	0	2.11
Grey Ironbark-Grey Gum Dry Sclerophyll Forest	2.39	0.02	2.37
Paperbark-Swamp Mahogany - Swamp Oak Swamp Forest/Woodland	10.45	0.86	9.59
Pasture/Pastoral Woodland	150.12	62.85	87.27
Dune Scrub	1.19	0	1.19
Swamp Oak Swamp Forest	4.29	0.7	3.59
Aquatic	5.75	0	5.75
TOTAL	179 (approx)	64.43	114.57

Source: Darkheart Eco-Consultancy 2008

A loss of approximately 0.49ha of low to medium quality Swamp Oak Floodplain Forest EEC is estimated, which comprises around 11.42 % of the entire EEC located within the Concept Plan Area. Approximately 0.43 ha of Swamp Sclerophyll Forest EEC would be lost, comprising 4.11 % of the EECs total occurrence. It is concluded that the loss of Swamp Sclerophyll Forest associated with the proposed development would result in a negligible impact on the EEC. Biodiversity of the EEC is currently severely limited as a result of current practices such as slashing and grazing. As a result the EEC to be removed is of general low quality.

The Project would not affect threatened flora species. No species have been recorded within the Project Application Area, and no significant habitat for threatened flora species is proposed to be removed.

In addition to the loss of some limited Swamp Sclerophyll Forest, the following direct impacts would arise as a result of the Project:

- loss of hollow bearing trees within the Pastoral Woodland;
- loss of two small dams which currently provide limited foraging habitat for some migratory birds;
- loss of seasonally waterlogged grassy floodplain which currently offers potential foraging habitat for the Jabiru, some migratory birds and possibly michiropteran bats; and
- a minor reduction in terrestrial east-west connectivity due to placement of the open water wetland and clearing of scattered woodland trees.

The species specific implications of these impacts are described below.

Koala Habitat

The Project would result in the loss of some potential koala habitat which is currently subject to accelerated natural attrition and where recruitment is being prevented by currently agricultural practices. Notwithstanding this, primary koala habitat and the majority of potential koala habitat, including linkages are proposed to remain as part of the Project. The proposed revegetation activity around the wetland includes the introduction of koala feed tree species, and combined with the establishment of the east-west corridor, would assist the genetic exchange and population size of the koala.

Furthermore, the implementation of the Draft UIA 14 Koala Management Plan which applies to the Project Application Area would positively contribute to the survival of the koala within the Project Application Area and its surrounds.

Bats

With regard to bats, it is considered that the loss of the marginal foraging habitat for these species is considered inconsequential to the extent of more optimum habitat on the remainder of the property and within the species' range.

The loss of potential roosts as a result of the Project is considered more significant as it is a resource that is not particularly abundant within the study area and takes a prolonged period to regenerate. However, potential roosts would remain within the study area as part of the Project and others are known to occur within range of the Project Application Area. Hence the viability of these species should not be compromised as a result of the Project.

Regeneration Strategy

The Project would result in some areas of habitat loss but this would be offset by the substantial revegetation strategy proposed for the Project Application Area. This strategy is integral to the Project which seeks to establish a Central Corridor that makes a positive contribution to the protection of native flora and fauna. The revegetation strategy seeks to formally establish and improve the ecological functioning of the Central Corridor. Through the establishment of proposed revegetation works and ongoing management of vegetated areas (as outlined in the Open Space Management Strategy), the following benefits would be achieved:

- enrichment of the current native biodiversity of existing vegetation within the Central Corridor;
- enhancement of existing vegetation along Duchess Gully;
- creation of better movement opportunities in an east-west direction for native wildlife;
- reduction in existing weed infestations within the Central Corridor;
- protection and enhancement of aquatic habitat values within the existing lagoon and proposed wetland; and
- provision of an appropriate interface between native vegetation and wildlife habitats within the Central Corridor and adjacent areas proposed for urban development.

More specifically, Darkheart Eco-Consultancy has concluded that the revegetation of the Project Application Area and associated Open Space Management Strategy would result in:

- the protection and improvement of the natural environment creating a setting that supports a relatively large Wallum Froglet population just below the proposed wetland;
- increased prevalence of known koala feed trees and other plants with multiple-species values throughout the Central Corridor;
- restoration of the floristic and structural elements of degraded EECs;
- provision of structural complexity and cover for ground-dwelling fauna such as the Eastern Chestnut Mouse and Common Planigale;
- reinstatement of degraded fauna movement corridor values throughout the Central Corridor; and;
- removal and management of weed infestations.

7.3.2 Impact on Aquatic Ecology

Based on aquatic assessment undertaken by the Ecology Lab (**Appendix H**), the potential impacts of the Project on aquatic habitats have been assessed. The degree of direct physical disturbance to existing aquatic habitats as a result of the Project would consist of the realignment of a small section of a constructed drainage line in the western portion of the Project Application Area for the purposes of establishing the district sporting fields. The remaining aquatic habitats within the Project Application Area are to be retained and protected within the proposed Open Space, Drainage and Wildlife Habitat Corridor.

Fish species such as Sea mullet and Shortfin eels, which were found to inhabit the existing lagoon, have a marine life-cycle and hence their presence in the existing lagoon indicates connectivity to the ocean via Duchess Gully. During major storms, when high water levels occur, flow would also continue to discharge from the existing lagoon via the existing "overflow" channel direct to Duchess Gully.

Following construction of the proposed wetland, it is expected that the shallow shoreline zone would develop significant areas of freshwater littoral and emergent macrophyte vegetation. It is likely that freshwater aquatic

species would also grow readily in the proposed wetland. This vegetation is a normal part of the development of a mature freshwater ecosystem and should be maintained.

Vegetation is an integral part of the wetlands stormwater treatment process. The wetlands treatment zones would be planted with appropriate emergent and aquatic species as part of the construction phase.

Aquatic Weeds

An analysis of water quality identified that nutrient levels within the existing lagoon and proposed wetland are expected to be low. As such, it is not anticipated that these water bodies would experience nuisance blooms of algae. While some temporary increases in algal concentrations may occur during wet weather as a result of increased nutrient runoff, water quality simulations show that these incidents would be rare and temporary in nature.

Torpedo grass growth adjacent to the existing lagoon is currently being managed and there may therefore be potential for aquatic weed infestation within the proposed wetland and existing lagoon as a result of the Project. Weed infestations would be largely prevented through the function of the site-wide storm water "treatment train" that would include bio-retention basins, wetlands and vegetated swales to serve as a preventative weed management system, the majority of escaped or dumped weed material would be "collected" within these structures prior to entering the water bodies. By ensuring regular monitoring and maintenance of the "treatment train" during growing seasons and after rainfall events, it would function as an effective weed prevention system.

7.3.3 Impacts on Littoral Rainforest

An assessment report in respect of the potential impacts of the proposed development on the littoral rainforest has been prepared by Darkheart Eco-Consultancy (attached at **Appendix I**). This report identifies the main environmental threats to the Rainbow Beach littoral rainforest No.116 to be:

- westerly winds;
- prolonged exposure to the setting sun; and
- excess salt deposition on the western fringe due to turbulence.

The extent of potential development within the Project Application Area is limited due to setbacks/buffers to the west, south and east for bushfire, watercourse protection and odour buffer in respect of the sewage treatment plant. Further separation of the Project Application Area and the Rainbow Beach littoral rainforest No.116 arises as a result of the existing pedestrian pathway which extends along the eastern boundary of the eco-tourist site proposed by the Concept Plan. The existing beach access would be formalised but would remain in its current position and no encroachment onto neighbouring Crown land would occur.

The Project does not involve clearing of Rainbow Beach littoral rainforest No.116 vegetation nor does it involve intrusion into Crown land adjacent to the Project Application Area where Rainbow Beach littoral rainforest No.116 is located. Consequently, no direct negative impacts would occur on Rainbow Beach littoral rainforest No.116 as a result of the proposed development.

Indirectly, the proposed Project would impact on Rainbow Beach littoral rainforest No.116. The indirect impacts of the Project would be largely positive. Details of the potential impacts associated with the Project are described in **Table 19**.

Table 19 Potential Impacts on Rainbow Beach littoral rainforest No.116

Threat	Details
Weeds	Bitou Bush, Lantana and Winter Senna occur across the site. Other problem weeds such as Coastal Morning Glory, Morning Glory and Turkey Rhubarb also occur. Pasture grasses and weeds dominate the beach access. Specific weed control would be undertaken so that weeds do not re-establish. Current weed infestations in the Crown land vegetation from the beach front to the Project Application Area would be removed to encourage the continuation of ecological process and redevelopment of rainforest vegetation. The proposed development would have a positive impact in respect of weed removal.
Fencing	The Project Application Areas eastern boundary is fenced with standard boundary fencing. To the south of the beach access the fence is largely overgrown with native species, to the north the fence stands out from the forest and poses a minor threat to birds and bats at dusk and dawn and at night during times of limited visibility. The fence adjacent to the beach access is to be retained to encourage use of the beach access and to deter people

Threat	Details
	from straying from the recognised track and into surrounding vegetation. To reinforce the beach access native vegetation would be planted around it to incorporate the fence as a structure within the forest. The proposed development would have a positive impact in respect of fencing. The impact is expected to be positive.
Noise	Increased noise is anticipated as a result of the proposed development due to greater accessibility to the beach through the Project Application Area. General redevelopment of the Project Application Area as proposed may result in a slight increase in human presence which may deter use of habitat in close proximity to the beach access by diurnal birds resulting in a minor negative indirect impact.
Hydrology and Maritime Stress	Local topography is generally flat and as such erosion by water flow is considered to be a minor risk. The existing beach access is highly eroded at the eastern end and requires rehabilitation to prevent penetration by high seas. The Project involves the reconstruction of the beach access to be erosion resistant, mitigate penetration of maritime stresses, prevent wave access and to provide a passable access when wet. Formalisation of the access would include new fencing and the planting of appropriate flora species. This would have a positive impact, acting as a deterrent to the creation of informal tracks and encroachment into land occupied by Rainbow Beach littoral rainforest No.116.
Feral Animals	A number of introduced species are believed to be present within the Project Application Area including deer, foxes and wild dogs. To protect vegetation from species such as deer, plantings are to be protected by tree guards and other suitable measures.
Artificial Light	There is currently no artificial light source in the vicinity of Rainbow Beach littoral rainforest No.116. No lighting is proposed as part of the Project.

Source: Darkheart Eco-Consultancy 2008

While some minor indirect negative impacts may arise as a result of the proposal, associated with increased human activity on balance the proposed development would result in significant positive impacts on Rainbow Beach littoral rainforest No.116. In particular, alongside the positive impacts on biodiversity, the proposed revegetation works within the Central Corridor and associated Open Space Management Strategy would result in positive impacts on the adjacent vegetation communities and Rainbow Beach littoral rainforest No.116 as a result of:

- the provision of appropriate vegetated spatial buffers between proposed residential development and littoral rainforest vegetation to the east;
- stormwater control devices would be implemented within the development footprint and Central Corridor to control the quality and quantity of stormwater run-off generated by the development and minimise its potential impact on surrounding environments; and
- source populations of weed species would be managed as part of a comprehensive weed management program.

7.4 Conclusion

There are no areas of constraint due to threatened flora and fauna within the Project Application Area that would preclude the proposed Project.

The Project would involve the removal of approximately 62.85 ha of Pasture/Pastoral Woodland. This vegetation has low habitat value and removal of vegetation within these areas is not expected to have significant impacts on threatened species within and around the Project Application Area.

The Project also includes the revegetation and enhancement of a significant portion of land within the Central Corridor. The revegetation of such a substantial portion of the Project Application Area as an integral part of the development provides the positive ecological benefit of securing higher value habitat area under conservation that would be appropriately managed.

Revegetation within the Central Corridor includes several vegetation communities which provide high quality habitat for a number of threatened mammals and birds, as well as the Wallum Froglet thereby resulting in positive impacts on these threatened species.

An aquatic assessment has been undertaken by the Ecology Lab, with the results of this assessment informing the design of the proposed wetland and associated works. This assessment concludes that aquatic impacts within the Project Application Area would be minor; the most significant issue relates to the management of weed infestations within the existing lagoon and proposed wetlands.

7.5 Mitigation Measures

A number of amelioration and environmental management measures have been recommended by the ecology specialists involved in the Project. These measures would be implemented as part of the Project to protect and enhance flora and fauna habitats within the Project Application Area. Specifically, it is recommended that ongoing monitoring of water quality within the existing lagoon and proposed wetland be undertaken to assist the adequate management of aquatic weeds and so that water quality remains at levels that support aquatic flora and fauna.

Table 20 provides a summary of the measures to be undertaken in respect of flora and fauna protection and enhancement. The table should be read in conjunction with the Open Space Management Strategy prepared by Cardno (attached at **Appendix D**).

Table 20 Proposed Flora and Fauna Mitigation Measures

Issue	Mitigation Measure
Aquatic weed management	Vegetation management within the existing lagoon and proposed open water wetland is to be undertaken in accordance with the ELUMP outlined within Open Space Management Strategy prepared by Cardno Pty Ltd (April 2010).
Water Quality Monitoring	Ongoing surface water quality monitoring is to be undertaken in accordance with the Surface Water Monitoring Plan prepared by Cardno Pty Ltd (April 2010).
Wetland habitat enhancement	Fallen trees as a result of construction of future urban areas shall be laid in the proposed wetland to provide roosts for Water Dragons, tortoises and waterfowl. Location can be selected according to maintenance requirements to avoid problems. Provision of large rocks along some sections (e.g. around the Duchess Gully linkage to the east) would also enhance habitat opportunities.
	The perimeter of the proposed wetland and adjacent habitat areas where pedestrian paths may pass through are to be designated leashed dogs only to prevent dogs harassing wildlife and swimming.
	Hollow-bearing trees are to be removed via a method which minimises risk of mortality/ injury of occupants. An approved animal handler is to be present during removal of these habitat components to aid injured fauna.

8.0 Water Cycle Management and Watercourses

This chapter provides an assessment of the potential impacts of the Project on water cycle management and watercourses. It includes consideration of groundwater and surface water quality and provides an assessment of the proposed water cycle management system for the Project.

Director General's Requirements	Compliance
5. Water Cycle Management and watercourses 5.1 Address and outline measures for integrated Water Cycle management (including stormwater) based on water sensitive urban design principles with reference to Area 14 integrated water cycle management plan (report to Hastings Councils 2006). Specifically describe the function of the open water wetland within the larger IWCM plan for the site. 5.2 Assess the impacts of the proposal on surface and groundwater hydrology and quality. Specifically address any impacts on Duchess Gully and the ongoing management of the waterway and its riparian zone. Describe any potential impacts to the existing exfiltration system attached to the bonny Hills Sewage Treatment Plant.	An assessment of the potential impact of the Project on surface water and groundwater has been undertaken by Cardno (Appendix N), WRL (Appendix L) and AECOM (Appendix M). Further, an integrated water cycle management plan for the Project has been developed, which is assessed within this chapter.

8.1 Groundwater

8.1.1 Methodology

Cardno has carried out an assessment of groundwater behaviour and potential impacts within the Water Engineering and Environment Assessment (April 2010). The work undertaken by Cardno has been further refined by WRL in the Groundwater Characterisation and Numerical Modelling report (March 2010). WRL's report includes an assessment of the potential value of existing groundwater resources and the impacts of the proposed development on groundwater hydrology and quality. Consideration is also given to the role of ASS on groundwater management, as well as potential impacts of the Project to the existing exfiltration system attached to the STP.

The Cardno assessment and WRL report are included as **Appendix N** and **Appendix L** of the EA respectively. AECOM has also undertaken an assessment of potential impacts on the Wallum Froglet habitat to support Cardno work (see **Appendix K** for full report).

WRL has undertaken a review of available information, including the numerical groundwater model established by Cardno in 2008 using the MODFLOW code to which WRL introduced modifications to calibrate the model with current conditions. Other information reviewed included data relating to ASS, climate, existing ground and surface water characteristics, water quality and the operation of the STP.

Groundwater investigations were undertaken for the wider Concept Application Area, which is referred to as the study area for the purpose of this section.

8.1.2 Existing Environment

The study area is located in a small coastal basin, infilled with sedimentary sequences of estuarine, marine and Aeolian origins. Three groundwater aquifer systems were identified within the sedimentary deposits:

- saturated organic / estuarine clays, which dominate low lying regions to the west of the study area;
- an unconfined aquifer within deposits of silty sands throughout low lying areas in the centre of the study area;
- perched freshwater aquifers within coastal dune systems to the east of Duchess Gully, in the east of the study area adjacent to the coast.

Water quality in the first two systems is typical of an ASS environment, with elevated levels of iron and aluminium and is not generally suitable for drinking or irrigation. Based on similar examples water quality in the perched coastal aquifer is expected to be fresh and of good quality and is expected to play a role in sustaining a small littoral rainforest at the north eastern site perimeter. Surface water samples from the existing lagoon and upstream of Duchess Gully were generally superior to groundwater samples, being fresher with lower iron and aluminium levels and a more neutral pH.

Groundwater levels across the study area are dynamic responding to rainfall events with a gradient falling towards the surface water features (the ocean, Duchess Gully and the existing lagoon). Duchess Gully provides a divide in the aquifer system, with the groundwater levels elevated to the east within the dunal ridge. Additionally, the groundwater is elevated adjacent to the STP due to the disposal of effluent to the aquifer at this location.

The water levels in the existing lagoon are below the water table in the adjacent aquifers indicating flow generally toward the existing lagoon. The proposed open water wetland, with a water level of RL 3.0 mAHD, would similarly be below the current average groundwater table level.

Investigations and sampling indicate that broad coastal aquifers of high quality are not present within the study area. The aquifers are of limited extent and where high quality aquifers could potentially exist they have been significantly impacted on by current land uses. The key groundwater resource that has a beneficial usage and requires upholding is that supporting the littoral rainforest to the north east of the study area and the Project is not expected to impact this existing vegetation.

8.1.3 Groundwater modelling

Modelling was undertaken to replicate observed conditions over the study area (referred to as the 'existing conditions model'). The model was then re-run with the proposed open water wetland in place (referred to as the 'post development model'). The disparity between models was then used to assess the Projects groundwater impacts. The model featured two layers, allowing for changes in geology in the vertical dimension, with layer 1 comprising the upper layer and layer 2 the lower.

The model was comprised of five geological units (zones), with values of hydraulic conductivity and storage assigned to each. Details of the model are provided at Section 4.3 and 6.0 of the WRL report (**Appendix L**). The model was verified through a simulated period from 29 August 2009 to 10 October 2009 being compared to observed groundwater levels. The simulation was found to be reasonable for the silty sand aquifer. However, in the western region of the model the simulated rate of drainage was too low. In the sand dune region (east of Duchess Gully) the simulated drainage rate was higher than observed.

It is noted that the draw down in groundwater levels between the pre and post development model was assessed as the differential in groundwater heads between the two scenarios. Additionally, the post development model conditions did not include alterations to the recharge rate as a result of development or the impact of fill placed within the residential regions.

8.1.4 Potential Impacts

The establishment of the proposed open water wetland with a water level of RL 3.0 mAHD is seen to result in drawdown of the saturated groundwater level (water table) across the study area. The maximum drawdown of 0.8 m occurs in the vicinity of the proposed open water wetland, with the magnitude diminishing further from the proposed wetland.

Two key regions have been identified as having ecologically significant features that should be protected from changes to groundwater conditions. The first is a strip of littoral rainforest found at the north eastern perimeter of the study area, parallel to the ocean. WRL has concluded that the proposed open water wetland is not expected to impact the littoral rainforest due to minimal additional drawdown of 0.01 m in this region. The second significant region is a small area adjacent to the existing lagoon, which is a potential habitat for the Wallum Froglet. It is not expected that the approximate drawdown of 0.1 m would impact on the marshy surface conditions in which the Wallum Froglet lives, as the marshy conditions are perched and therefore separate from the saturated water table, which is approximately 1.6 m below the existing surface.

AECOM undertook a site visit on 31 May 2010. The site visit confirmed that the 'marshy' surface conditions were perched on a layer of impermeable, high plasticity clays. Consequently, draw down of groundwater is not expected to impact the Wallum Froglet habitat.

Potential for contamination of groundwater through the infiltration of surface water from the proposed open water wetland was also assessed. WRL concludes that the flow would be primarily in the opposite direction and is not expected to impact upon groundwater.

ASS on site would remain below the water table following development. However, two ASS risks are identified as follows:

- Water quality from bores adjacent to the proposed wetland indicate ASS risks and poor water quality due to low pH groundwater. The model indicates that the flow of groundwater would be towards the wetland,

therefore consideration must be given to the impact of ASS seepage on the proposed wetlands water quality.

- A region of shallow ASS deposits exist to the north west of the proposed wetland based on available ASS data, which may be subject to drawdown and subsequent oxidation. While this area would be covered with fill, there is a risk that oxidation would exacerbate groundwater conditions and contribute to water quality issues in the proposed wetland.

The existing lagoon provides a robust test case for the future water quality of the proposed open water wetland, as it is likely to be subject to the same conditions. There is no current indication of the development of ASS conditions in the existing lagoon. A water quality model was undertaken by WRL to examine potential ASS conditions in the wetland. The model produced four groundwater test cases. Results indicated that even the most conservative model predicting pH in the proposed wetland would be acceptable. Additionally, a number of mitigation measures are likely to further reduce the potential for ASS conditions to occur including:

- higher groundwater recharge rates to the clay layer following the placement of fill;
- the placement of fill over this region limiting exposure to ASS;
- increased water levels due to recharge from leaking services, watering of gardens and reduction of evapotranspiration; and
- available ASS data does suggest the presence of a shallow ASS lens, the findings regarding the nature of the lens are not uniformly severe.

It is anticipated that water quality in the proposed open water wetland would be similar to water quality currently observed in the existing lagoon and that buffering and dilution from surface water inflows would be sufficient to maintain near neutral pH levels.

8.1.5 Conclusions

Two sandy aquifer systems exist within the study area, which are separated by a creek gully (Duchess Gully), with a third aquifer system comprised of a saturated clay body found in the west of the study area. The clays in the western region of the study area are considered to comprise a low yielding poor quality aquifer. The sandy aquifers to the east and west of Duchess Gully are of limited extent, with the aquifer to the west being a silty shallow unconfined system and the aquifer to the east being a freshwater compartmentalised aquifer perched above a saline interface of ocean water.

Water quality in the silty sand aquifer to the west is indicative of ASS and exhibits low pH and elevated iron and aluminium concentrations making the water unsuitable for drinking and long term irrigation. Water quality within the saturated clays is similarly poor and has no identifiable beneficial usage. Water quality within the perched coastal aquifers are typically fresh and of high quality, which might support littoral rainforests to the north east of the study area. However, the long term operation of the STP has impacted water quality in this aquifer and it would not be recommended for irrigation use due to risks of contamination.

Consequently, site investigations and water quality sampling do not support the presence of broad coastal aquifers of high quality. Rather the aquifers are of poor quality and limited extent.

The modelling examined the impacts of the proposed wetland on groundwater. The modelling illustrated that drawdown would occur, however is not expected to impact upon the groundwater source that sustains the littoral rainforest or the frog habitat adjacent to the existing wetland.

The risks associated with ASS have been considered and in most cases ASS deposits remain below the water table. However, a risk of drawdown and oxidation of a shallow lens of ASS has been identified, with impacts on the proposed wetland and groundwater quality considered. Risks to the wetland are considered to be low based on the nature and extent of ASS deposits, the processes that are likely to limit the risk of oxidation, such as buffering from surface water inflows and the indications from the existing lagoon.

8.1.6 Mitigation Measures

The following mitigation measures are to be implemented as part of the Project.

Table 21 Proposed Groundwater Mitigation Measures

Issue	Mitigation Measure
Ongoing groundwater quality monitoring	Ongoing groundwater monitoring is to be undertaken in accordance with the Groundwater Monitoring Plan prepared by WRL (refer to Appendix B of the Groundwater Report located at Appendix L).

8.2 Water Quality

8.2.1 Methodology

Cardno has carried out an assessment of surface water behaviour and potential impacts within the Water Engineering and Environment Assessment (April 2010). The work undertaken by Cardno has been further refined by AECOM in the Stormwater Treatment and Wetland Functionality Report (July 2010). AECOM's report includes a study of the proposed surface water management strategy for the Project and recommended refinements of the stormwater management strategy and wetland designs.

The Cardno assessment and AECOM report are included as **Appendix N** and **Appendix M** of the EA respectively.

8.2.2 Existing Environment

Existing Lagoon Water Quality

It is expected that the water quality of the existing lagoon would be a good indicator as to the water quality of the open water wetland due to the similarity of the two in location and configuration. As such, the physical and bacteriological water quality of the existing lagoon has been assessed against appropriate Australian and New Zealand Environment Conservation Council (ANZECC) and Port Macquarie – Hastings Council AUSPEC water quality objectives adopted for the Project Application Area.

The ANZECC and AUSPEC guidelines suggest water quality performance criteria for key indicators, by which water quality can be monitored for potential ecosystem impacts. For this study, key indicators were measured including pH, turbidity, suspended solids, chlorophyll, salinity, dissolved oxygen, total nitrogen, total phosphorus and E.coli. Cardno maintains that if the performance criteria for each of these key indicators are achieved, it is expected that a range of potential impacts from other ecosystem factors can be limited, such as:

- eutrophication;
- reduction in photosynthesis and optical clarity;
- reduction in biodiversity; and
- excess temperature variation.

Results from Cardno's assessment indicate that the water quality of the existing lagoon is good, and that the existing lagoon generally satisfies the desirable water quality objectives that would result in the sustainability of an appropriate freshwater coastal ecosystem capable of providing a suitable recreational environment and potential habitat resource.

Cardno's conclusions have been supported by the assessment undertaken by AECOM. An inspection by AECOM of the existing lagoon concluded that this waterbody appears to deliver good quality water to the existing lagoon, because the lagoon exhibits several indicators of a healthy open water wetland system. These include the dense growth of the submerged macrophyte *Vallisneria nana*. The presence of this plant indicates that the water is mostly clear as it allows for light to penetrate to the bottom of the lagoon. It also indicates that the water quality in the lagoon is of good quality. If the water quality was poor (i.e. high in nutrients), it would be expected that algal epiphytes would smother the leaves of *Vallisneria nana*, reducing the vigour of its growth. The existing lagoon also has clear water. If the water quality was poor (i.e. high in nutrients), then it would be expected to support the growth of planktonic algae, which would reduce water clarity and give the water a greenish colour.

8.2.3 Potential Impacts

As stated above, it is expected that the water quality in the proposed open water wetland would be similar to the high water quality standard of the existing lagoon. Cardno has confirmed this reasoning by undertaking a number of checks as follows:

- comparison of the hydraulic detention (or “residence”) times in the water bodies before and after development (hydraulic detention time is the most important parameter influencing the settling and removal of sediment and nutrients);
- demonstrating that the open water wetland is similar in hydraulic characteristics and mixing regime to the existing lagoon;
- MUSIC modelling;
- POND modelling; and
- comparison with recorded data from Gold Coast water bodies.

Detention times for the existing lagoon and for the Project, including the open water wetland are outlined in **Table 22**.

Table 22 Wetlands Hydraulic Detention Times

Parameter	Existing lagoon		Open water wetlands
	Existing conditions	Developed conditions	Developed conditions
Total Catchment Area (ha)	662	662	708
Effective Catchment Area with overflow diversions (ha)	662	662	354
Average annual runoff (mm)	237	240	240
Water volume (ML)	132	132	165
Detention (residence) time (days)	31	30	61
Surface area (m ²)	69,000	69,000	106,000
Surface area per ha effective catchment (m ² /ha)	104	104	300
Sediment removal rate (%)	77%	77%	85%
TP (phosphorous) removal rate (%)	54%	54%	63%

Source: Cardno 2010, AECOM 2010

Based on results in **Table 22**, the water quality of the open water wetland and of overflows discharging into Duchess Gully would be at least as good as the existing lagoon or better. As outlined by Cardno, the water quality of the open water wetland is expected to exceed the desirable ANZECC and AUSPEC criteria.

The CRC-FE Pond model, which simulates the pollutant interception processes and water quality responses of ponds, was also used to model the performance of the proposed open water wetland. Detailed methodology and results from the Pond model can be found within Cardno’s report (**Appendix N**). Results show that the Pond model was able to reproduce the behaviour of the existing lagoon reasonably well, and confirms that the water quality of the existing lagoon is good. After development, the existing lagoon and the open water wetland should continue to maintain similar levels of good water quality conditions, and while there would be occasional episodes of disturbed water quality associated with some storm runoff events, these episodes are expected to be temporary with water bodies returning to conditions of good water quality.

To further assess the predicted water quality of the Project, Cardno has compared predictions made by the Pond modelling to water quality data recorded over a number of years in other similar water bodies within the Gold Coast City area, from the 2002 Gold Coast City Council report, “*Health of the Gold Coast Waterways*.” Water quality in this report is rated in terms of the ANZECC standard, and as such provides a useful comparison. An examination of this data showed that while some water bodies occasionally showed poorer conditions, ranging from turbidity to excessive plant growth and algal blooms, none of these detracted significantly from the overall quality of the water bodies, which showed consistently good water quality. The data also showed that the main factors influencing water quality were:

- catchment size relative to water body size, as water bodies with large catchments are likely to experience runoff causing poorer conditions; and

- catchment elevation, which showed that episodes of poorer water quality occurred more often in catchments with elevated areas.

Data from the Gold Coast City Council report was also assessed to gain insight into the circulation and stratification of the open water wetland. In this regard, based on existing water body data, and taking into account the shallow water depth, large surface area and exposure to prevailing coastal winds of the open water wetland, it is expected that circulation would be good.

AECOM have reviewed the Cardno assessment made by Cardno in respect to the expected water quality for open water wetland and conclude that the proposed wetland would maintain good water quality following urban and residential development of the Concept Plan Area. The POND model water quality modelling for the existing lagoon accurately predicted the existing water quality conditions for the existing wetlands. Further, the protection of the water quality of the open water wetland is provided through several design measures:

- Catchments draining from the future residential areas would have stormwater treatment devices that would treat runoff to Council's required standards.
- Baseflows from the existing lagoon are to be routed through the open water wetland to re-instate the discharge point of this catchment to Duchess Gully. The water from this lagoon is known to be of good quality as determined by field inspections and the results of Cardno's investigations. Routing of baseflows through the open water wetland would aid the circulation of water in the open water wetland, and would decrease the residence of water in this waterbody. Minimising the residence time of water in the open water wetland reduces the risk that algal blooms may occur.
- Flood flows from the external catchments from large storm events would be conveyed from existing lagoon to discharge directly to Duchess Gully and would not flow into the open water wetland. Bypassing the wetland in this way would protect the wetland from high sediment loads that may be associated with flood waters.
- Other flows from local catchments would pass through sedimentation basins prior to discharge to the open water wetland.
- Stratification is unlikely to be persistent in the proposed open water wetland due to the shallow depth. In shallow water, the stratification breaks down most nights as cold water sinks. Additionally, there are no deep holes that promote stratification. Stratification can be problematic in lakes if anaerobic conditions are created at depth. Persistent anaerobic conditions at depth may lead to the release of nutrients from the sediments to the water column. These nutrients can support the proliferation of algae leading to algal blooms.
- Stratification is also unlikely because the orientation of the wetland axis aligns with dominant spring and summer winds. The orientation of the wetland along this axis provides the wind a long fetch that allows sufficient wind and wave energy to promote turbulence, currents and mixing of the water column. These winds occur at a time when the open water wetland would be most prone to algal blooms – during spring when rainfall is lowest leading to the longest residence times, and during summer when water temperatures and consequently algal growth rates, are highest.
- The benthos of the proposed open water wetland would be planted with submerged aquatic macrophytes. These grow well in the adjacent existing lagoon and are also expected to grow well in the proposed wetland. These help to maintain the water quality by stabilising trapped sediment, and oxygenating the sediment, thus preventing the anaerobic conditions that lead to nutrient releases.

8.2.4 Conclusion

Cardno concludes that the surface water quality of the proposed open water wetland would be of a high standard, given the high standard of the water quality within the existing lagoon within the Project Application Area. Further, the re-direction of overflows from the existing lagoon in the upper reaches of Duchess Gully into the proposed open water wetland would re-establish the Gully's original flow path and is expected to improve conditions in the middle reaches of Duchess Gully. The open water wetland is also expected to establish and maintain an attractive mature freshwater coastal aquatic ecosystem in the long term. AECOM have reviewed Cardno's assessment and support their conclusions. Further, as outlined above, AECOM has detailed a number of design measures that would serve to protect the water quality of the open water wetland.

8.2.5 Mitigation Measures

While results of the surface water quality investigations do not show detrimental impacts to the existing water quality within the Project Application Area, AECOM have recommended that surface water be monitored on a regular basis in each water body within the creek and wetland system.

The following mitigation measures are to be implemented as part of the Project.

Table 23 Proposed Surface Water Mitigation Measures

Issue	Mitigation Measure
Ongoing surface water quality monitoring	Ongoing surface water quality monitoring is to be undertaken in accordance with the Surface Water Monitoring Plan prepared by AECOM (July 2010).

8.3 Water Cycle Management

8.3.1 Methodology

Cardno has developed a stormwater management strategy for the Project Application Area that would treat stormwater from future urban areas following development of the Concept Application Area. The strategy developed by Cardno has been further refined by AECOM (**Appendix N**) who undertook a review of the proposed integrated water cycle management strategy for the Project Application Area. The DGRs require an outline of the measures for integrated Water Cycle management (including stormwater) based on water sensitive urban design. The Cardno assessment and AECOM report are included as **Appendix N** and **Appendix M** of the EA respectively.

Port Macquarie - Hastings Council IWCM policy for Area 14

The Project is required to comply with the Port Macquarie - Hastings Council Integrated Water Cycle Management (IWCM) policy for Area 14. As detailed in Cardno's report, the framework for the implementation of a water cycle management plan has been developed for the Project Application Area and the Project has been designed to comply with the policy requirements of Port Macquarie - Hastings Council and the NSW State Government legislation. Specifically, Council's IWCM policy for Area 14 requires the following of the Project:

- use of reclaimed water to dwellings for outdoor use, toilet flushing and laundry cold water;
- irrigation of district sports fields with reclaimed water sourced from Port Macquarie – Hastings Council; and
- Water Sensitive Urban Design (WSUD) for stormwater management.

While this Project does not include the development of residential or commercial areas within the Project Application Area, a major component of the water cycle management plan for the Project Application Area is the proposed open water wetland, which works as part of an overall WSUD stormwater treatment train for the wider Concept Plan Area. As such, an examination of the proposed water cycle management strategy, including the ability of the open water wetland and treatment train system to manage stormwater runoff from future urban development is required to be assessed as part of this Project Application.

Water Sensitive Urban Design

A number of WSUD measures were considered for the treatment of stormwater for the Project Application Area, with the two primary options being incorporation of end-of-pipe open water wetlands, and the use of bioinfiltration treatment. Bioinfiltration devices are not suited for use in flat areas as they require sufficient grade to allow through flow of water. Therefore bioretention systems have been proposed for the upper areas of the catchment, which have steeper gradients. The open water wetlands are proposed for use in the flat areas of the flood plain as these require flat terrain. Open water wetlands are considered to be complimentary to the ecosystems of the open space drainage corridor.

As outlined by Cardno, the stormwater design for the Project complies with the key principles of WSUD from a stormwater management and planning perspective. In this regard, the proposed stormwater management process integrates stormwater treatment into the landscape by incorporating multiple uses that would provide multiple benefits, such as water quality treatment, wildlife habitat, public open space and recreational and visual amenity for the community. The proposed system protects and enhances natural systems, including creeks and wetlands within urban developments and improves the quality of water draining from urban developments into creeks and

rivers. The proposed open water wetland also provides temporary storage that reduces runoff and peak flows, while reducing potable water demand through stormwater reuse.

AECOM has concluded that stormwater management strategy proposed by Cardno is considered generally appropriate, with additional design detail recommended where appropriate.

8.3.2 Stormwater Management Practices

A wide range of stormwater management practices are available to achieve the principles of WSUD. As part of the development of the stormwater management system for the Project Application Area, Cardno with design updates from AECOM assessed a number of these practices.

Table 24 lists the most common stormwater management practices currently used, along with opportunities and constraints for their use as the Site is developed in the future.

Table 24 WSUD Stormwater Management Practices

Practice	Opportunities			Constraints	Suitability
	Pollutants removed	Scale	Other		
Litter baskets/racks	Litter and debris – M	Local	Pre-treatment for other practices	Require frequent maintenance	The primary purpose for litter baskets is to remove medium sized litter and debris.
Sediment traps	Coarse sediment – H Suspended solids – L	Regional		Aesthetic and safety issues	Sediment pits provide pretreatment of stormwater runoff for the removal of suspended solids before entering other treatment devices such as bioretention systems of wetlands.
Gross pollutant traps (GPTs)	Litter and debris – M Coarse sediment – H Suspended solids – L	Regional	Pre-treatment for other practices	Require regular maintenance	Gross pollutant traps are predominantly used for the removal of litter and debris – although they have been shown to effectively remove coarse sediment and suspended solids.
Filter strips/buffer strips	Litter and debris – M Coarse sediment – H Suspended solids – H Nutrients – M	Lot/Local	Peak flow management	Require flat terrain	Buffer strips are areas of land left in their natural state which act to reduce peak runoff flows and improve the quality of stormwater runoff. This treatment improves the aesthetic and biodiversity value of the development and provides significant quality and quantity improvements. Buffer strips would be adopted as suitable opportunities arise within the development.
Grass swales	Litter and debris – M Coarse sediment – H Suspended solids – H Nutrients – M	Local	Peak flow management	Require flat terrain	Grass swales are considered a highly effective and aesthetic water quality control measure. However, in order to detain flow adequately, grass swales need to be placed on relatively flat slopes. Wherever slopes are sufficiently flat (or where they are able to follow contours), grass swales would be adopted to provide effective stormwater treatment.
Vegetated swales	Litter and debris – M	Local	Peak flow management	Require flat terrain	Vegetated swales require similar conditions as those outlined for

Practice	Opportunities			Constraints	Suitability
	Pollutants removed	Scale	Other		
	Coarse sediment – H Suspended solids – H Nutrients – H				grass swales above. Therefore, the use of vegetated swales is limited by slope. Wherever slopes are sufficiently low the use of a vegetated swale would provide effective stormwater treatment.
Extended detention basins	Coarse sediment – M Suspended solids – M Nutrients – L	Regional	Peak flow management	Requires pretreatment Large land area required	Extended detention basins are designed to generally store runoff for 1-2 days. Their main purpose is the reduction of the peak discharge from the site during a storm event, and the retention of particulate matter.
Infiltration trenches (rock blanket)	Suspended solids – H Nutrients – M	Local	Peak flow management	Requires pretreatment	Infiltration trenches (rock blankets) allow pretreated stormwater runoff to infiltrate to into surrounding soils and groundwater. These devices were not considered in the stormwater treatment train.
Bioretention systems	Coarse sediment – H Suspended solids – H Nutrients – H	Local	Peak flow management	Requires pre-treatment	Bioretention systems effectively combine a grass or vegetated swale with an infiltration trench. They are considered to be extremely effective in removing sediment and nutrients. Although they require a flat area, they can be incorporated in steeper areas using a stepped system. They can also be located within a detention basin, thereby combining the stormwater quality and quantity functions into a smaller area. There are a number of suitable locations where bioretention systems would be adopted to provide stormwater treatment.
Porous pavements	Suspended solids – H Total phosphorus – M Total nitrogen – L	Local	Peak flow management	Not appropriate for steep sites	Porous pavements are not appropriate for high traffic areas due to increased maintenance requirements. They are also less effective in steep areas. However, for relatively flat, low traffic roads they could be suitable for this development. Their perceived expense often leads to the preference of other measures in reaching quantity and quality objectives.
Constructed wetlands	Coarse sediment – H Suspended solids – H Total phosphorus – M Total nitrogen –	Regional	Peak flow management	Requires pre-treatment Not appropriate for steep sites Requires large area of land	Wetlands require reasonably large flat areas of land. The lower part of the catchment consists of flat terrain and shallow lake systems and it is considered an ideal location for the inclusion of wetland systems. Wetlands would be

Practice	Opportunities			Constraints	Suitability
	Pollutants removed	Scale	Other		
	L				included at the end of treatment train to provide final treatment of stormwater before entering the lake systems.
Rainwater tanks	N/A	Lot	Peak flow management	Requires community involvement	Tanks are an extremely useful aid to water conservation, and also have some effect in reducing nitrogen levels. The capacity of the tanks has been discounted in stormwater runoff calculations. Despite having a considerable effect in reducing runoff volumes, they cannot be assumed to be empty when needed. The proposed treatment train for the development assumes that 50% of households would adopt the use of rainwater tanks. Port Macquarie - Hastings Council IWCM policy does not mandate the use of rainwater tanks. Hence, a conservative estimate of 50% utilisation of tanks was adopted.

Note: Data taken from NSW EPA "Managing Urban Stormwater – Treatment Techniques, 1997" and "Managing Urban Stormwater – Council Handbook, 1998".

L = 10 – 50% removal

M = 50 – 75% removal

H = 75 – 100% removal

Scales

Lot less than 1 ha

Local 1 – 10 ha

Regional greater than 10 ha

Source: Cardno 2010

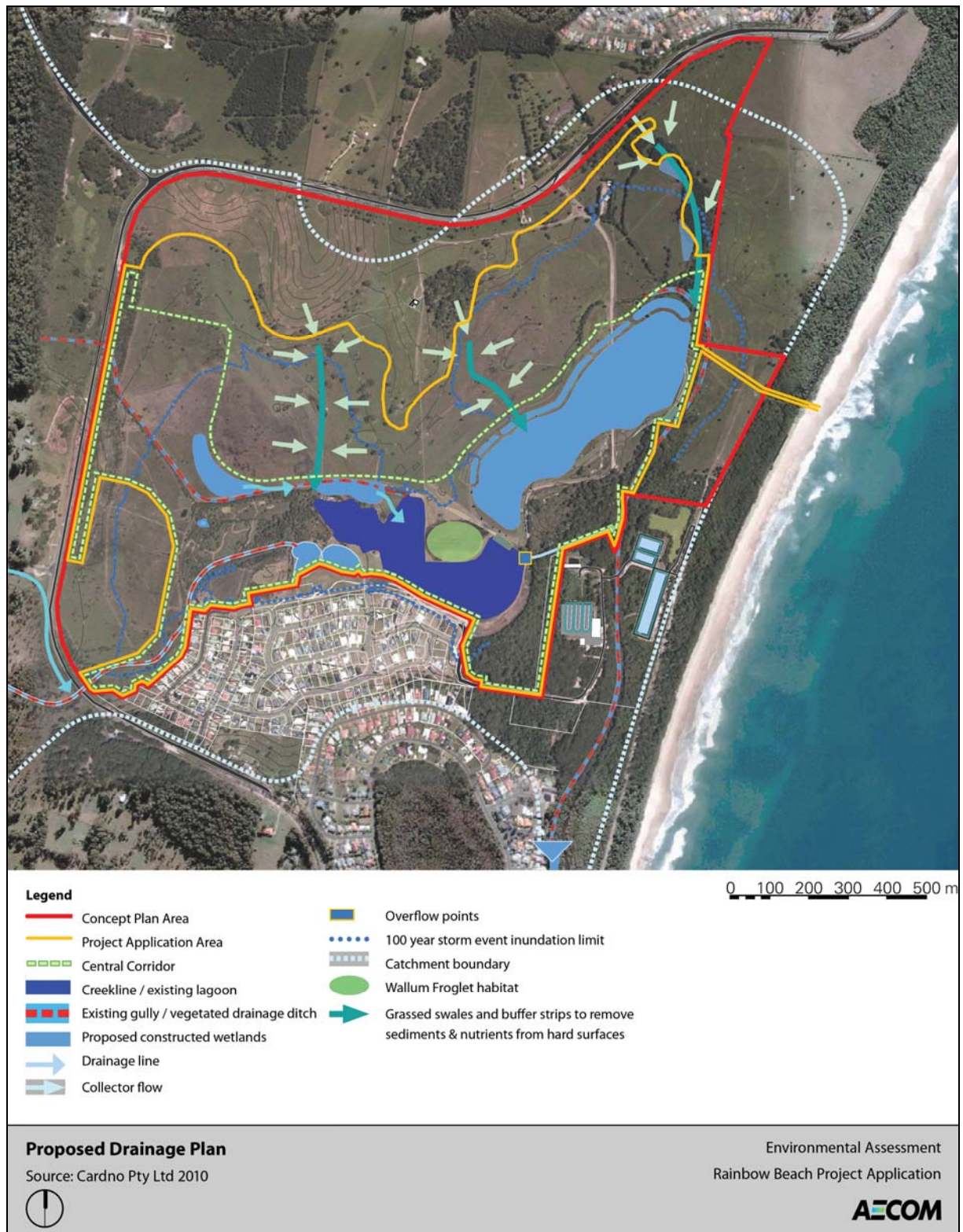
8.3.3 Proposed Treatment Measures

Based on the assessment of available WSUD options for the Project Application Area outlined in **Table 24**, Cardno and AECOM have recommended the following treatment train for the future treatment of runoff from the proposed urban areas of the Project Application Area:

- buffer strips for the removal of sediment and nutrients from impervious surfaces such as foot paths and driveways;
- grassed swales to convey storm flow and provide adequate flow detention prior to downstream treatment devices such as wetlands and bioretention systems;
- bio-retention systems to be utilised where possible (generally in upper reaches of catchment) for the removal of sediment and nutrients;
- open water wetland system to be utilised at the downstream end of the catchment immediately upstream of receiving water bodies;
- rainwater tanks for capture of roof stormwater runoff are expected to be used in approximately 50 % of households.

The proposed water treatment concept for the Project Application Area, including the open water wetland is illustrated in **Figure 24**.

Figure 24 Proposed Drainage Plan



8.3.4 Water Quality Objectives and Modelling

The proposed treatment measures outlined above have been modelled by Cardno and AECOM so that water quality objectives for stormwater runoff treatment from the development that have been adopted for the Project Application Area from Council's IWCM policy would be met.

To do this, the MUSIC software package, in combination with the CRC-FE Pond model was utilised to assess the water quality of runoff from future urban development (see **Appendix N** for details).

MUSIC modelling demonstrates that the treatment train system proposed for the Project Application Area comply with Port Macquarie – Hastings Council's adopted criteria in accordance with Council's IWCM policy. The treatment train would allow runoff from future urban development to be treated to meet the adopted water quality objectives. The runoff would then be delivered to the open water wetland at a suitable quality to meet Council guidelines. This would result in the protection of the ecosystem health of the open water wetland and Duchess Gully. The high level stormwater strategy prepared by Cardno has been subsequently refined by AECOM (refer to **Appendix M**) to provide further detail on the design of stormwater treatment devices as illustrated in **Table 25**.

Table 25 Stormwater Treatment Devices

Parameter	Details
Inlet pond volume (m ³)	Set at approximately 10% of the area of the macrophyte zone. Required to trap sediment and dissipate flow energy.
Macrophyte zone surface area (m ²)	Set at the area required to meet the pollutant reduction targets set by Council. Wetland extent was mostly driven by area required to meet TN removal of 45%.
Extended detention (m)	Set at 0.5 m. Deeper than this puts the health of the aquatic vegetation at risk by potential drowning during extended wet periods.
Average Depth (m)	Set at 0.3 m. Deeper than this puts the health of the aquatic vegetation at risk by potential drowning during extended wet periods.
Permanent pool volume (m ³)	Calculated based on average depth.
Equivalent outlet pipe diameter (mm)	Set to control the notional detention time at 72 hours. Detention times shorter than this are unlikely to provide adequate pollutant removal in practice. Detention times longer than this are less efficient due to more frequent bypassing of influent stormwater.

Source: AECOM 2010

Applying these modelling parameters to the existing models resulted in following footprints for the proposed treatment wetlands, as outline in **Table 26**.

Table 26 Treatment Wetlands Footprint

Catchment and Wetland Name	Wetland Area (m ²)
W1a	960
W1b	800
W1c	4050
W1d	1620
W1e	4750
W2	9000
W3	9000
W4a	2200
W4b	1650

Source: AECOM 2010

Since the potential footprints of the proposed wetlands are constrained in many locations, and not sufficiently large to meet Council's water quality criteria, additional treatment would be required. This additional treatment would be provided through the inclusion of bioretention systems located higher in the catchments.

Bioretention systems need to be located in the upper urban catchments in order to take advantage of the grade or hydraulic head (approximately 1 m depth) required to allow water to percolate through the filter media and to be discharged back to the stormwater network. Bioretention systems were sized to complement the treatment provided by the treatment wetlands.

The following design parameters were applied to the bioretention system treatment nodes of the MUSIC modelling as illustrated in **Table 27**.

Table 27 MUSIC Modelling Design Parameters

Parameter	Details
Extended detention (m)	Set at 0.3 or 0.2 m depending on location of bioretention system. A smaller height of extended detention would be required in system incorporated into the streetscape, greater heights would be appropriate for large bioretention basins.
Surface Area (m ²)	Set at the area required to meet the pollutant reduction targets set by Council. Surface of filter media extent was mostly driven by area required to meet TN removal of 45%.
Exfiltration Rate (mm/h)	Set at zero. This is conservative and assumes that the bioretention system would be lined. The bioretention systems may not need to be lined, and if so, water treatment would be better than expected.
Filter Area (m ²)	Same as Surface Area
Filter depth (m)	Set at 0.6 m. Does not include depth of transition and drainage layers (additional 0.3 m, 0.9 m total)
Filter median particle diameter (mm)	0.5
Sat hydraulic conductivity (mm/h)	100
Depth below underdrain (%)	Set at zero. Drainage media was not counted towards the depth of filter media that provides a filtration function.
Overflow weir width (m)	10

Source: AECOM 2010

The extent of bioretention areas required to complement the treatment wetlands and needed to meet the water quality targets for future urban development are illustrated in **Table 28**.

Table 28 Bioretention Area

Catchment and Bioretention System Name	Bioretention Area (not inc. batters) m ²
W4a BR a	450
W4a BR b	750
W4a BR c	850
W3 BR a	800
W3 BR b	150
W1e BR a	350
W1e BR b	150

Source: AECOM 2010

Bioretention systems have not been depicted on the landscape master plan for the Project Application Area because their design would be strongly influenced by the urban design. These would be located as distributed systems within the streetscape or in areas of public open space.

8.3.5 Conclusions

The adopted stormwater treatment measures outlined in **Section 8.3.3** have been modelled by Cardno and AECOM to illustrate that water quality objectives for stormwater runoff treatment have been adopted to meet the Port Macquarie – Hastings Council IWCM policy. To achieve this, the MUSIC software package, in combination with the CRC-FE Pond model was utilised to assess the water quality of runoff from future urban development. The MUSIC modelling demonstrates that the treatment train system proposed complies with Port Macquarie – Hastings Council's adopted criteria in accordance with Council's IWCM policy. The treatment train would allow runoff from future urban development to be treated to meet the adopted water quality objectives. The runoff would then be delivered to the open water wetland at a suitable quality to meet Council guidelines. This would protect the ecosystem health of the open water wetland and Duchess Gully.

8.3.6 Mitigation Measures

The following mitigation measures are to be implemented as part of the Project.

Table 29 Proposed Stormwater Mitigation Measures

Issue	Mitigation Measure
Stormwater management	Stormwater is to be managed in accordance with Port Macquarie - Hastings Council Integrated Water Cycle Management (IWCM) policy for Area 14 and as outlined within Water Engineering and Environment GDR Assessment report dated August 2008 prepared by Cardno and the <i>Rainbow Beach Stormwater Treatment and Wetland Functionality Report</i> prepared by AECOM (2010), located at Appendix M of this report.

9.0 Hazard Management and Mitigation

This chapter provides an assessment of the potential hazards of the Project. It includes consideration of bushfire risk, contamination, acid sulfate soils and flood risk, and details measures to avoid or mitigate impacts identified.

Director General's Requirements	Compliance
6. Hazard management and mitigation 6.1 Address the requirements of <i>Planning for Bush Fire Protection</i> 2006 (RFS) or relevant policy in the design of the proposal with regard to proposed adjacent land uses such as residential land and schools. 6.2 Identify any contamination on site and appropriate mitigation measures in accordance with the provisions of SEPP 55 – Remediation of Land. 6.3 Identify the presence and extent of acid sulfate soils on the site and, where relevant, appropriate mitigation measures. 6.4 Provide an assessment of any flood risk on site in consideration of any relevant provisions of the NSW Floodplain Development Manual (2005). Consider the potential impacts of any filling on the flood regime of the site and adjacent lands. 6.5 Assess the potential impacts of sea level rise and an increase in rainfall intensity on the flood regime of the site and adjacent lands with consideration of Practical Consideration of Climate Change – Floodplain Risk Management Guideline (DECC, October 2007) and the draft NSW Coastal Planning Guideline: Adapting to Sea Level Rise.	This chapter provides an assessment of the Project in relation to bushfire hazard, contamination, acid sulfate soils and flood risk.

9.1 Bushfire

9.1.1 Methodology

Australian Bushfire Protection Planners (ABPP) was engaged to undertake a bushfire assessment of the proposed development. The Bushfire Protection Assessment (September 2008) is included as **Appendix O** of this EA.

The Bushfire Protection Assessment was prepared with regard to the Part 3A Major Development provisions of the EP&A Act and *Planning for Bushfire Protection* 2006. *Planning for Bushfire Protection* 2006 provides guidance for development control measures in relation to bushfire protection for residential development, in particular "Special Fire Protection" and Class 5 – 8 and 10 buildings in bushfire prone areas.

In addition to undertaking the assessment in accordance with the relevant legislative provisions, the assessment also reviewed the following documents:

- Concept Plan, prepared by Luke & Company;
- Preliminary Environmental Assessment & Identification of Issues – Open Space Corridor & Constructed Wetland, prepared by AECOM (December 2006);
- Grants Head 1:25,000 Aerial Photograph;
- Grants Head 1:25,000 Topographical Map;
- Port Macquarie – Hastings Council Bushfire Prone Land Map;
- Open Space Management Strategy, prepared by Cardno (April 2010);
- *Planning for Bushfire Protection* 2006 prepared by the NSW Rural Fire Service;
- Australian Standard AS3959 Construction of Buildings in Bushfire Prone Areas; and
- *Rural Fires Regulation* 2002.

Following revegetation, the proposed Central Corridor would be classified as bushfire prone land. This section assesses the potential bushfire hazard risk impacts of the Central Corridor on proposed residential, eco tourism and educational precincts identified in the Concept Plan Area. As such, the study area for this assessment is the wider Concept Plan Area, as potential impacts would fall largely outside of the Project Application Area.

A site visit was undertaken by ABPP on 24 September 2007. The site visit was intended to assess the topography, slope, and vegetation classification both within and adjoining the Concept Plan Area as well as to test the compliance of the proposed open space layout within the Central Corridor with deemed-to-satisfy asset protection zones (APZs) and access provisions. Properties adjoining the Concept Plan Area were surveyed in order to assist in determining land-use and vegetation communities land management.

Consultation was undertaken with Mr Copeland, Development Control Officer with the NSW Rural Fire Service on 20 November 2007. No issues were raised by Mr Copeland that would warrant modification of the Project or the contents of the report prepared by ABPP, in respect of the provision of fire protection measures and compliance with the deemed-to-satisfy provisions of *Planning for Bushfire Protection 2006*.

9.1.2 Existing Environment

Topography

Under Appendix 2 of *Planning for Bushfire Protection 2006* the topography of a site should be assessed over a distance of no less than 100 m from a development site, and that the gradient should determine which would most significantly affect fire behaviour to the Concept Plan Area.

The floodway to Duchess Gully dominates the landform of the Concept Plan Area, spreading from several multi-cell box culverts in the west and south west of the site, to the alluvial plain, constructed water body system to the east, discharging into Duchess Gully. The floodplain slopes <2 degrees and separates in the west, running to the east and south east of the southern school site.

The existing Rainbow Beach Residential Estate located to the south of the Concept Plan Area rises gently to the south. The location of the proposed future residential precinct to the north of the floodplain forms into low ridge lines and knolls that rise to the north and are separated by gully lines that flow to the north and south across Ocean Drive.

The overland flow path to Duchess Gully North Arm extends along the eastern boundary of the future residential precinct.

Vegetation

Under *Planning for Bushfire Protection 2006* a methodology is provided that determines the predominant vegetation over a distance of at least 140 m in all directions for future development.

As a result of the present agricultural land use, vegetation within the Concept Plan Area consists of predominantly pasture grassland. A narrow strip (less than 50m wide) of remanent forest and wetland vegetation forms a screen along a segment of the western site boundary adjacent to Ocean Drive. An area of Dry Blackbutt Open Forest is located in the south eastern corner of the Concept Plan Area, which extends into the adjoining STP. A narrow corridor of Swamp Oak Forest runs along the drainage line from Duchess Gully north west towards the northern Concept Plan Area boundary.

9.1.3 Potential Impacts

The Central Corridor would be revegetated and overtime would contain mature vegetation eventually forming an area of bushfire prone vegetation within the southern portion of the Project Application Area, linking existing bushfire prone land in the eastern portion of the site and adjacent to the STP.

The DGRs issued for the Project Application require the requirements of *Planning for Bushfire Protection 2001* (since updated to 2006) to be incorporated in the design of the proposed Central Corridor with regard to hazard risk to adjacent land uses. The following section provides an assessment of the potential bushfire risk impacts of the Central Corridor on the proposed residential, eco tourism and educational precincts identified in the Concept Plan Area.

Bushfire protection assessment was undertaken under the provisions of Appendix 2 of *Planning for Bushfire Protection 2006* which provides the requirements associated with the setting of the widths of assessment Protection Zones (APZ) to protect urban development.

APZ to Proposed Residential Precinct

Following sufficient revegetation with Forested Wetland and Dry Sclerophyll Open Forest, the Central Corridor, which is located to the south, southwest and east of the proposed residential precinct, would be deemed as bushfire prone vegetation.

Due to the vegetation classification of Forested Wetland Vegetation, combine with the floodplain slope of <2 degrees, the required width of APZ across the south and south western edge of the proposed residential precinct is between 15 to 20 m. Further, proposed perimeter roads and managed parkland areas illustrated in the Concept Plan would provide an APZ that exceeds the requisite 15 to 20 m. Managed parkland proposed to the southeast of the residential precinct provides separation from the Central Corridors bushfire risk, which combined with the perimeter road and building setback, exceeds the minimum APZ width required to address bushfire threat from vegetation within the Central Corridor.

A 30 m APZ is recommended in order to protect the existing residential lots in the existing Rainbow Beach Residential Estate located directly to the south of the Central Corridor. This APZ is to be managed as parkland by the relevant public authority a minimum of 30 m from buildings located on these lots.

APZ to Proposed Eco Tourism Precinct

The western and north western aspects of the eco-tourism site is exposed to the Central Corridor of Dry Blackbutt Forest to Duchess Gully and within the corridor vegetation located to the west of the creek. For most of its length, this vegetation would be in excess of 50 m wide. As such, a 54 m APZ has been recommended by ABPP to the western aspect of the proposed eco-tourism site. This APZ is to be located outside of the Central Corridor, entirely within the eco-tourism site.

APZ to Proposed Educational Precincts

An existing 50 m corridor of Melaleuca Swamp Forest is located along the western boundary of the northern school site, presenting a bushfire threat. While this portion of vegetation would be connected to the Forested Wetland in the central section of the Central Corridor and therefore, linked to bushfire prone vegetation, under the provision of *Planning for Bushfire Protection 2006*, as this corridor is 50 m wide, it is classed as 'rainforest', requiring a APZ of only 21 m from the future school buildings to the eastern edge of the 50 m corridor.

The abovementioned 50 m 'rainforest' corridor also adjoins the southern school site in the north west, requiring a 21 m APZ along this portion of boundary. As illustrated in **Figure 25**, APZs of 41 m and 47 m are required to the proposed southern school site western and north east/east/south eastern boundaries respectively. These APZs are to be located outside of the Central Corridor, entirely within the school sites.

Water Supplies for Fire Fighting Operations

The existing reticulated water supply that feeds the surrounding residential areas would be extended to service the residential subdivision proposed by the Concept Plan Application. The extension of this same reticulated water system would include the provision of a water supply main with hydrants which would be installed to meet Australian Standard AS 2419.2.

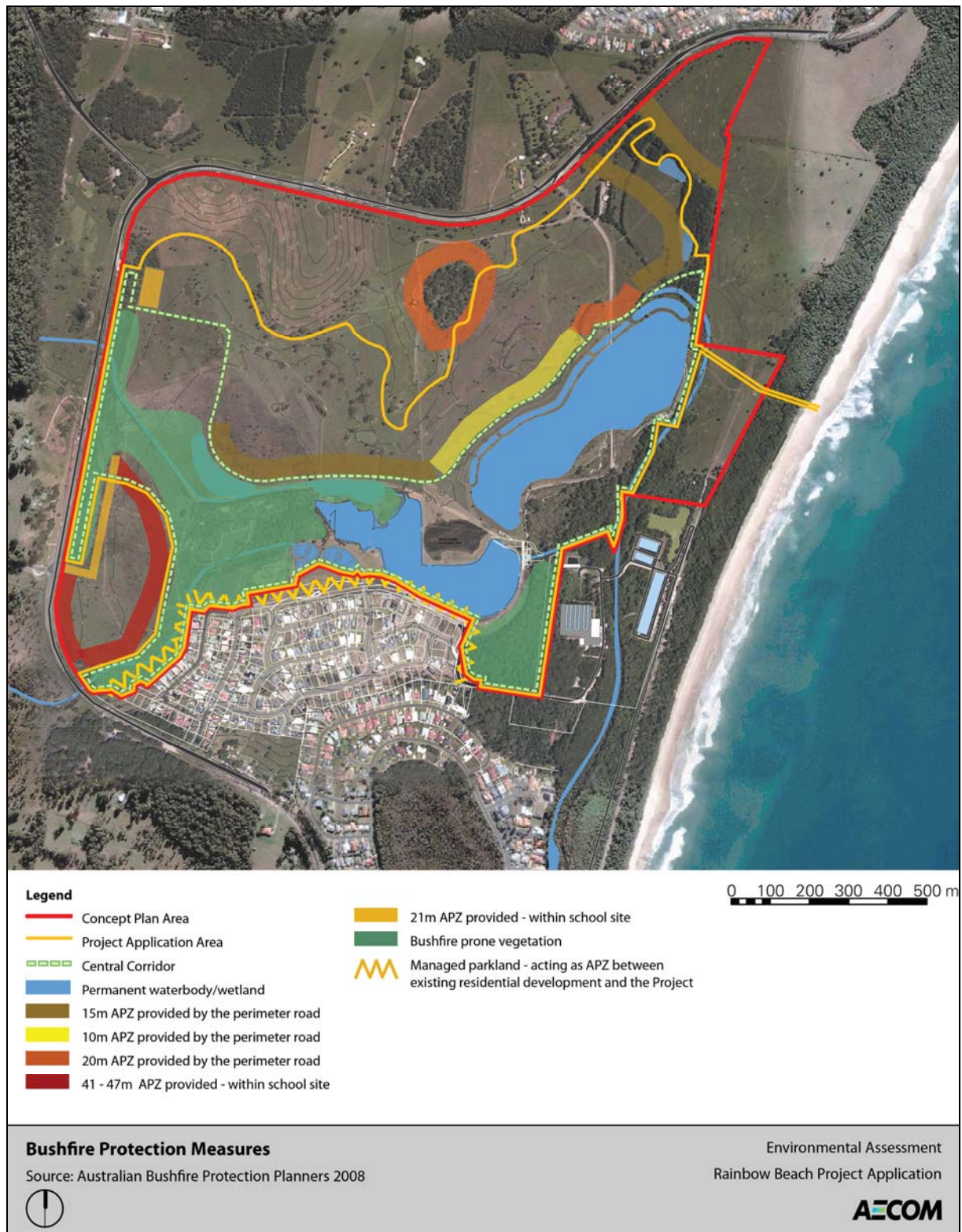
Access for Fire Fighting Operations

Planning for Bushfire Protection 2006 provides requirements for public roads which are designed so that new internal road network in an area that is considered bushfire prone would be able to accommodate traffic in an emergency bushfire event. The road network proposed as part of the Concept Plan Application is to be designed to comply with Section 4.1.3 of *Planning for Bushfire Protection 2006*. In this regard, urban perimeter roads located on the bushfire hazard interface would be two-way, through roads with a minimum paved width of 8 m kerb to kerb.

Bushfire Maintenance Plans and Fire Emergency Procedures

ABPP have recommended that a Fire Management Plan be developed for the Central Corridor, in association with the ELUMP, for the fuel management of the corridors vegetation, as well as the management of the required APZs located within the adjoining future residential, eco tourism and educational precincts. In this regard, it is considered that the Hastings Bushfire Risk Management and Operations Plans do not adequately identify the management protocols required to address the responsibility, under Section 63 of the *Rural Fires Act*, for the management of the Central Corridor.

Figure 25 Bushfire Protection Measures



9.1.4 Conclusions

The assessment undertaken by ABPP, and reported in full in **Appendix O** to this EA Report, found that following revegetation, the proposed Central Corridor would be classified as bushfire prone land. Potential risks associated with this bushfire prone land have been identified and assessed under the provision of *Planning for Bushfire Protection 2006*.

The recommended APZs proposed to be located within the adjoining future residential, eco tourism and educational precincts, together with a number of perimeter roads that would run adjacent to the Central Corridor and the provision of adequate setbacks to future buildings are considered to be adequate in reducing the risk from bushfire to future development within the proposed residential, eco tourism and educational precincts identified in the Concept Plan.

9.1.5 Mitigation Measures

Several recommendations have been made throughout the bushfire assessment prepared by ABPP. These recommendations refer to provision of asset protection zones, road widths, site access/egress, building setbacks, provision for fire-fighting, fuel management and general requirements under *Planning for Bushfire Protection 2006*.

Table 30 provides details of mitigation measures proposed to protect the wider Concept Plan Area from bushfire hazards and reduce the risk to life and property from a bushfire event, with specific reference to the Central Corridor.

Table 30 Proposed Bushfire Mitigation Measures

Issue	Mitigation Measure
Asset Protection Zones	
Wider Concept Plan Area	APZs would be provided in accordance with Figure 25 above.
Maintenance	APZs would be maintained in accordance with Appendix 5 of <i>Planning for Bushfire Protection 2006</i> and Rural Fire Service's <i>Specifications for Asset Protection Zones</i> .
Water Supply	
Hydrants	Hydrants installed are to be installed in accordance with Australian Standard AS 2419.2.
Hydrants	Hydrant markings would be provided on the hydrant side of the road centre line in blue.
Hydrants	Hydrants are to have a minimum flow rate of 10 L/sec.
Hydrant Location	Hydrants would be located such that a tanker can park no more than 20 m from the hydrant.
Hydrant Location	Hydrants would be located so that a fire in the furthest part of a future dwelling can be reached by fire-fighters using two 30 m hose lines and a 10 m water jet.
Hydrant Location	There must be a clear unobstructed path of no more than 90 m between the hydrant and the most distant point on a future building within the Project Application Area,
Access	
Access	Public roads, property access roads and fire trails shall comply with the deemed-to-satisfy specifications of Section 4.1.3 (Access) of <i>Planning for Bushfire Protection 2006</i> .
Urban Perimeter Roads	Perimeter roads adjacent to the bushfire hazard interface shall be two-way, through roads, with a minimum carriageway width of 8 m (kerb to kerb) with shoulders on each side.
Access to Schools	Perimeter road access, or a fire trail would be required to the aspects of the southern school site which adjoin the Forested wetland vegetation in the Central Corridor and also between the

Issue	Mitigation Measure
	school sites (north and south) and the vegetated corridor along Ocean Drive. This can be in the form of an access road or fire trail.
Hazard Management	
Fuel Management	A Fire Management Plan is to be prepared, in concert with the ELUMP. The management prescriptions of the Fire Management Plan shall address those measures required to meet the provisions of Section 63 of the <i>Rural Fires Act 1997</i> whilst specifically recognising the need to protect the plant communities in the low-lying parts of the Site (wetlands, estuarine vegetation and Swamp Mahogany Forest).
Fuel Management	A managed parkland regime is to be maintained on the existing public lands adjoining the existing Rainbow Beach Residential Estate.
Fuel Management	The parkland along the south eastern, southern and south western aspects of the residential precinct and the open space corridors that extend into the residential precinct are fuel managed in order that there is no connection to bushfire prone land within the Central Corridor.

9.2 Contamination

9.2.1 Methodology

Environmental Resources Management Australia Pty Ltd (ERM) has undertaken a Phase 1 Preliminary Site Investigation (PSI) (November 2007) which examines potential site contaminations issues. The full ERM report is included as **Appendix Q** of this EA.

The PSI was carried out in accordance with the *National Environment Protection (Assessment of Site Contamination) Measures* (the 'NEPM') published by the National Environment Protection Council (NEPC), relevant Department of Environment, Climate Change and Water (DECCW) guidance and the NSW EPA (1997) – *Guidelines for Consultants Reporting on Contaminated Sites for a Phase 1 PSI*. The Investigation included the following:

- review of historical and site background information;
- a site inspection to identify evidence of potential site impacts or contaminating activities;
- assessment of soil and contamination issues; and
- management recommendations, including opportunities for impact mitigation and site protection.

A site visit was undertaken by ERM on 24 September 2007 by William Weir, Senior Environmental Engineer and Rachael King, Project Environmental Scientist. Several sites were examined and a number of surface soil samples taken in order to evaluate whether chemical concentrations were present within the Project Application Area as a result of past land use activities.

Fieldwork was conducted in accordance with ERMs Contaminated Site Investigation and Quality procedures, and relevant NSW EPA guidelines, however given the size and limited historical use of the Project Application Area, a grid based sampling program was not considered to be necessary. Furthermore, as it is not believed that pesticides and herbicides were used on the uncompleted golf course, the soils samples were not collected from this area.

Assessment criteria devised for the Project Application Area was based on relevant NSW EPA guidelines, which outline a number of sensitive land use thresholds and expected background concentration ranges for urban redevelopment sites in NSW. While the selected site assessment criteria is conservative, given the proposed recreational uses within the Project Application Area, the criteria is considered to be appropriate for this assessment.

9.2.2 Existing Environment

Department of Land and Water Conservation (DLWC) aerial photos illustrating the history of the site since 1952 to the present were examined in order to assess how land uses have impacted on and changed the Project Application Area and surrounding area, as well as identify potential sources of land contamination. These photographs illustrate two major noticeable changes within the Project Application Area from the early 1950s to early 1960s and from the early 1980s to early 1990s. Large scale clearing of the Project Application Area and around Lake Cathie is evident in the 1963 photograph, most probably for agricultural uses. This vegetation however, appears to have recovered somewhat by the late 1970s. Potential evidence of sand extraction mining is also illustrated, though not obvious. Noticeable changes are observed in the 1991 photograph, with the addition of the existing lagoon in the south east of the Project Application Area and clearing a golf course which was never developed. The STP is also clearly visible to the south east at this stage.

Title Deed information supports presumed past agricultural land uses as does anecdotal evidence obtained from the sites current Caretaker, who informed ERM that the wider Concept Plan Area has been used for cattle grazing and no development, with the exception of preliminary earthworks for the golf course.

Searches of Council records and certificates, DECCWs POEO Act Register and the Work Cover NSW Dangerous Goods Register did not result in evidence of contaminating activities or storage of dangerous good within the Project Application Area. No registered groundwater bores were identified on the then Department of Natural Resources register.

9.2.3 Potential Impacts

A total of five near surface soil samples (ss01 – SS05) were collected during site investigations across the Project Application Area in order to assess and evaluate the presence of potentially contaminating site activities and chemicals of concern. One location was identified as having potential contamination concern (AS01). **Table 31** provides a summary of potential sources of contamination of soils within the Project Application Area. Locations of the sampling locations and area of potential concern are illustrated in **Figure 26**.

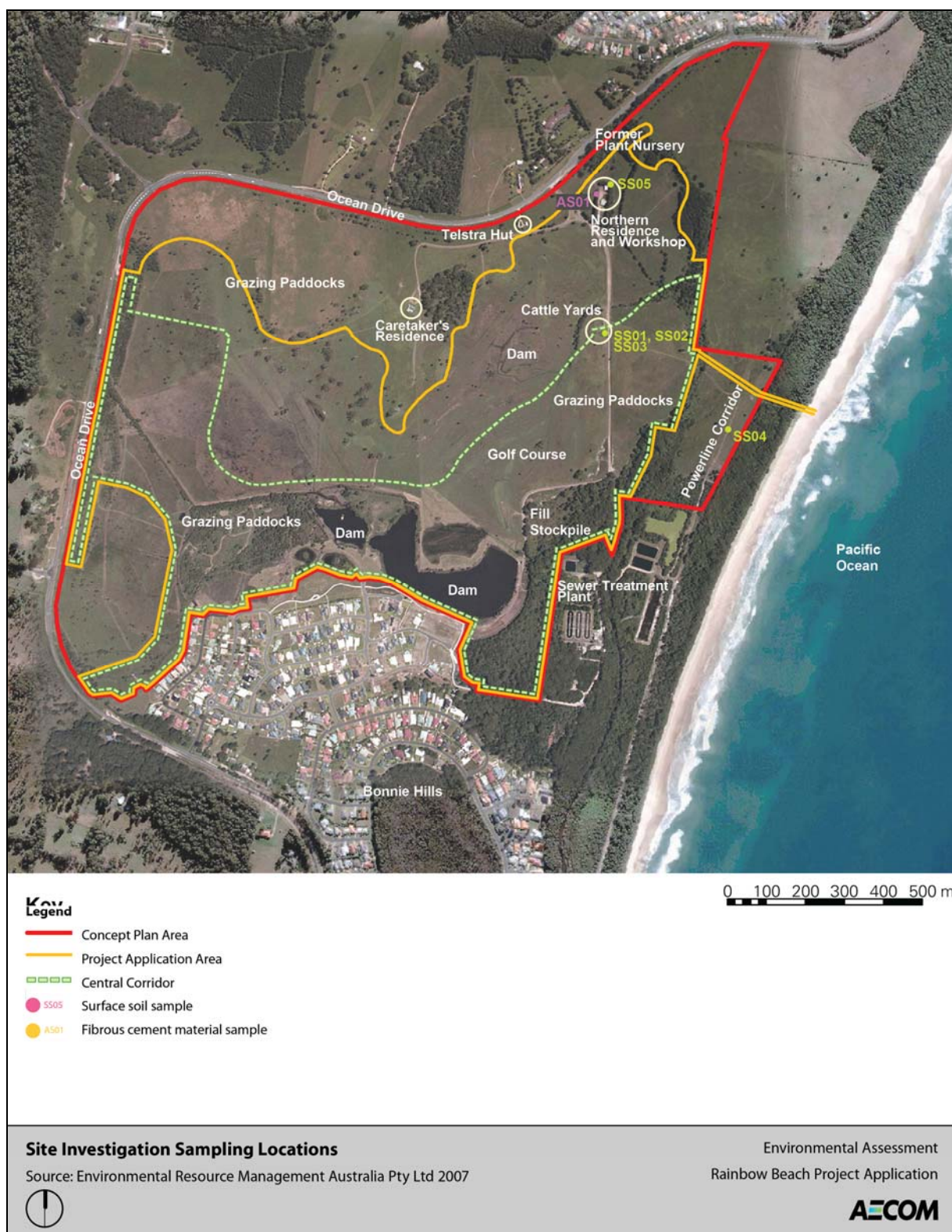
Table 31 Potentially Contaminating Site Activities and Chemicals of Concern

Sample ID	Potentially Contaminating Site Activities	Potential Chemical of Concern	Location
SS01	Cattle yards	TPH, PAH, OCP, OPP, Inorganics	Border of fill area and Central Corridor within Project Application Area.
SS02	Cattle yards	TPH, PAH, OCP, OPP, Inorganics	Border of fill area and Central Corridor within Project Application Area.
SS03	Drums near cattle yards	TPH, PAH, OCP, OPP, Inorganics	Border of fill area and Central Corridor within Project Application Area.
SS04	Electricity easement	OCP/OPP, PCB ⁶ , inorganics (including As & Cr ⁶⁺)	Largely located outside of the Project Application Area within the proposed eco-tourist site, however beach access does traverse easement.
SS05	Compound rear shed	OCP/OPP, TPH, BTEX, PAH	North east corner (fill area) of Project Application Area.
AS01	Northern residence	Asbestos	North east corner (fill area) of Project Application Area.
-	Potential areas of sand extraction	Radioactive minerals	Potential location of sand extraction located outside of the Project Application Area south of proposed eco-tourist site. No evidence recorded.

Note: TPH (total petroleum hydrocarbons), BTEX (benzene, toluene, ethyl benzene and xylenes), PAH (polycyclic aromatic hydrocarbons), OCP (Organochlorine Pesticides), OPP (Organophosphate Pesticides), PCB (Polychlorinated Biphenyls), Inorganics (arsenic, cadmium, chromium, copper, lead, nickel, mercury and zinc).

Source: ERM 2007

Figure 26 Site Investigation Sampling Locations



Results from the near surface soil samples confirmed a number of chemicals of concern located within the Project Application Area.

TPH was reported at levels exceeding the adopted site assessment criteria in the cattle yards and garage/workshop area behind the northern residence; however field observations indicate that these impacts are likely as a result of localised spills of waste oils.

Total PAH's and benzo(a)pyrene were reported in excess of assessment criteria within the electricity easement. These samples were collected from the vicinity of the telegraph poles and are likely to be derived from leaching and / or spraying of timber preservatives.

Fibrous cement samples collected from the northern dwellings internal wall lining tested positive for asbestos fibres and it is considered likely that the sample tested is representative of the remainder of the building material. As such, it is recommended that this building material should be treated as potential asbestos containing material until further testing and an asbestos survey can be completed.

While OCP was recorded in soil samples, levels were recorded as being below the site assessment criteria and samples analysed for inorganics showed levels below site assessment criteria.

No evidence of broad-scale pesticide or herbicide use was apparent on site, aside from the localised use of pesticides at the base of the electricity poles.

Based on site investigations, soil sampling and a review of available historical data, no clear evidence of large scale strip sand mining activities or concentration slurry ponds or stockpiles were observed. As such, it is considered unlikely that dry strip sand mining has occurred within the Project Application Area.

9.2.4 Conclusions

A Phase 1 PSI was undertaken by ERM in order to assess existing contamination issues potentially affecting the Project Application Area and the Project. A number of methods were employed during the Phase 1 PSI including examination and review of documentation relating to previous and current land uses, a detailed site investigation, and testing of near surface soils samples collected from a number of locations within the Project Application Area.

Results of the Phase 1 PSI, identify some minor localised areas of impacted soils and fibrous building materials in the locality of the cattle yards and northern dwelling that are required to be remediated in order for the Project Application Area to be developed for recreational and future residential purposes. No broad-scale contamination threats were identified for the Project Application Area as a result of known past and present land uses.

9.2.5 Mitigation Measures

Appropriate mitigation measures have been recommended in order to mitigate potential contamination impacts within the Project Application Area and the Project. Provided these measures are implemented, contamination threats should not hinder the Project.

Table 32 Proposed Contamination Mitigation Measures

Issue	Mitigation Measure
Soil remediation	Areas of localised soil impact already identified, or additional areas identified during future site works should be appropriately remediated and validated as required under SEPP No. 55 – Remediation of Land.
Asbestos removal	The full extent of the asbestos containing materials within the northern dwelling requires a detailed survey and appropriate management of materials during demolition. Care should be taken so that such material is removed in accordance with statutory requirements such that they do not present a risk to human health.

9.3 Acid Sulfate Soils

9.3.1 Methodology

A Geotechnical Report (June 2010) has been prepared by Luke & Company Pty Ltd (Luke & Co) which examines geotechnical issues, including ASS.

The report includes:

- a review of previously undertaken geotechnical investigations and associated reports and management plans relevant to the Project Application Area;
- an assessment of geotechnical issues; and
- management recommendations, including opportunities for impact mitigation and site protection.

A number of geotechnical investigations have been previously carried out over the wider Concept Plan Area, which were utilised by Luke & Co in order to assess the environmental setting and assess potential acid sulfate soil (ASS) impacts. Details of these geotechnical investigations and previous acid sulfate soil assessments are contained in the following reports:

- Holmes and Holmes Pty Ltd – Geotechnical Appraisal for Development Options at Lake Cathie, November 1993;
- Holmes and Holmes Pty Ltd – Preliminary Acid Sulfate Soil Investigation South of Lake Cathie, December 1998;
- Holmes and Holmes Pty Ltd – Acid Sulfate Soil Investigation, April 2003;
- Holmes and Holmes Pty Ltd – Acid Sulfate Soil Investigation, April 2004; and
- Cardno – Water Engineering and Environment Report, April 2010.

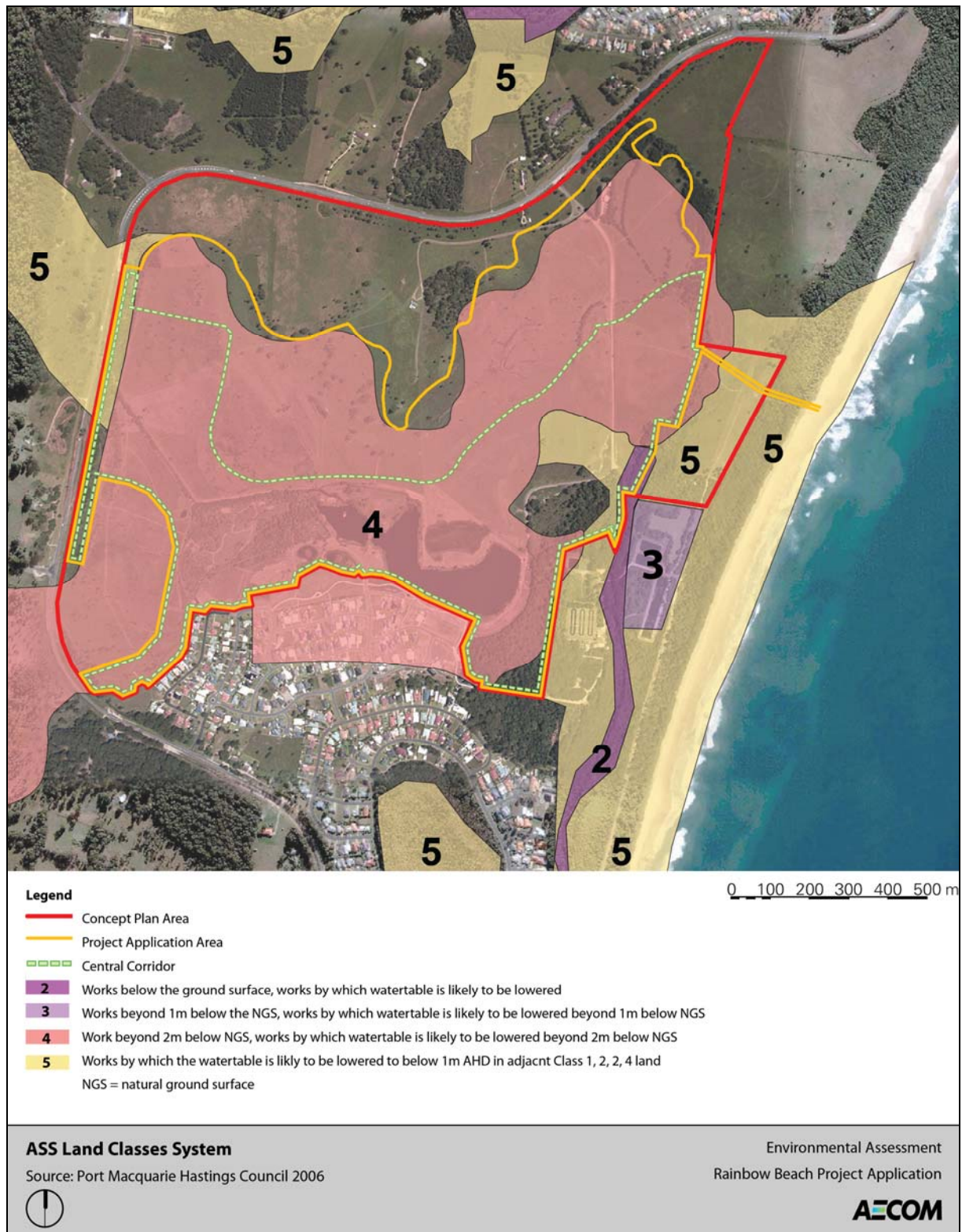
Potential risks associated with acid sulfate soils have been identified and are required to be mitigated.

9.3.2 Existing Environment

Hastings LEP 2001

Clause 26 of Hastings LEP 2001 outlines a land class system for the assessment of development which has PASS hazards. The land class system identifies the required level of assessment for specific works in five principle land classes. As illustrated in **Figure 27**, the Project Application Area covers Class 2, 3, 4 and 5 land classes, however the majority of areas proposed for excavation works lie within Class 4 lands. Council's ASS Development Control Plan requires all works proposed within Class 4 lands involving excavation beyond 2 m, as is proposed in the wetland excavation, requires an ASS Management Plan to be prepared.

Figure 27 ASS Land Classes System



Geotechnical Investigations

A number of geotechnical investigations have previously been carried out over the Project Application Area. Details and results of these investigations are summarised in **Table 33**. Borehole locations are illustrated in **Figure 28** and **Figure 29**.

Table 33 Geotechnical Investigations and Results

Date	Borehole ID	Type	Reference	No. Of Boreholes containing 'low' PASS	No. Of Boreholes containing 'high' PASS	Depth PASS encountered
25-11-93	BH1 – BH26	Backhoe pits	Holmes & Holmes (1993)	25 of 26	13 of 26	2 m below NSL
25-11-93	BH27 – BH40	Auger	Holmes & Holmes (1993)	14 of 14	4 of 14	at NSL
15-12-98	101 - 106	Auger	Holmes & Holmes (1998)	6 of 6	5 of 6	at NSL
21-3-03	107 – 111	Auger	Holmes & Holmes (2003b)	5 of 5	5 of 5	at NSL
3-4-03	29448 – 294498	Auger	Holmes & Holmes (2003c)	13 of 13	9 of 13	at NSL
14-4-04	1 – 4	Auger	Chandler (2004)	-	-	3.5 m below NSL

Note: NSL = natural surface level

Source: Luke & Co 2008b

Results from Holmes & Holmes 1993 investigations identified a variety of soils present within the Project Application Area, arising from a complex geomorphologic history. Testing undertaken during geotechnical investigations have confirm the presence of ASS and PASS throughout the area of the proposed open water wetland excavation. Results also reveal a clear delineation between surface soils that can be classified as 'low' PASS, which would require no or little treatment, and soils at deeper levels considered to have 'high' PASS, which would require significant treatment and management. This distinction corresponds consistently with the occurrence of distinct deeper grey clays of estuarine origin.

Figure 28 Borehole Locations

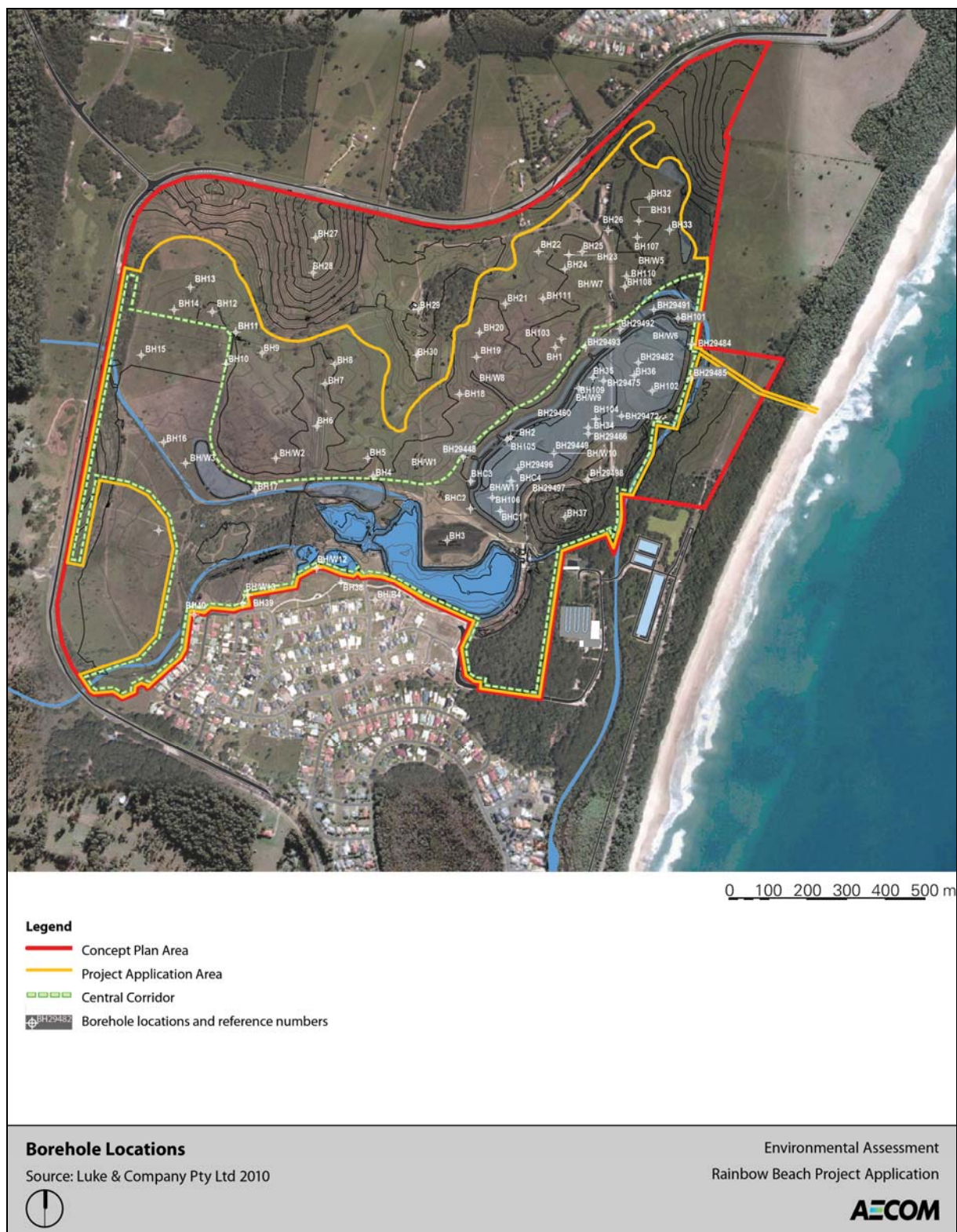
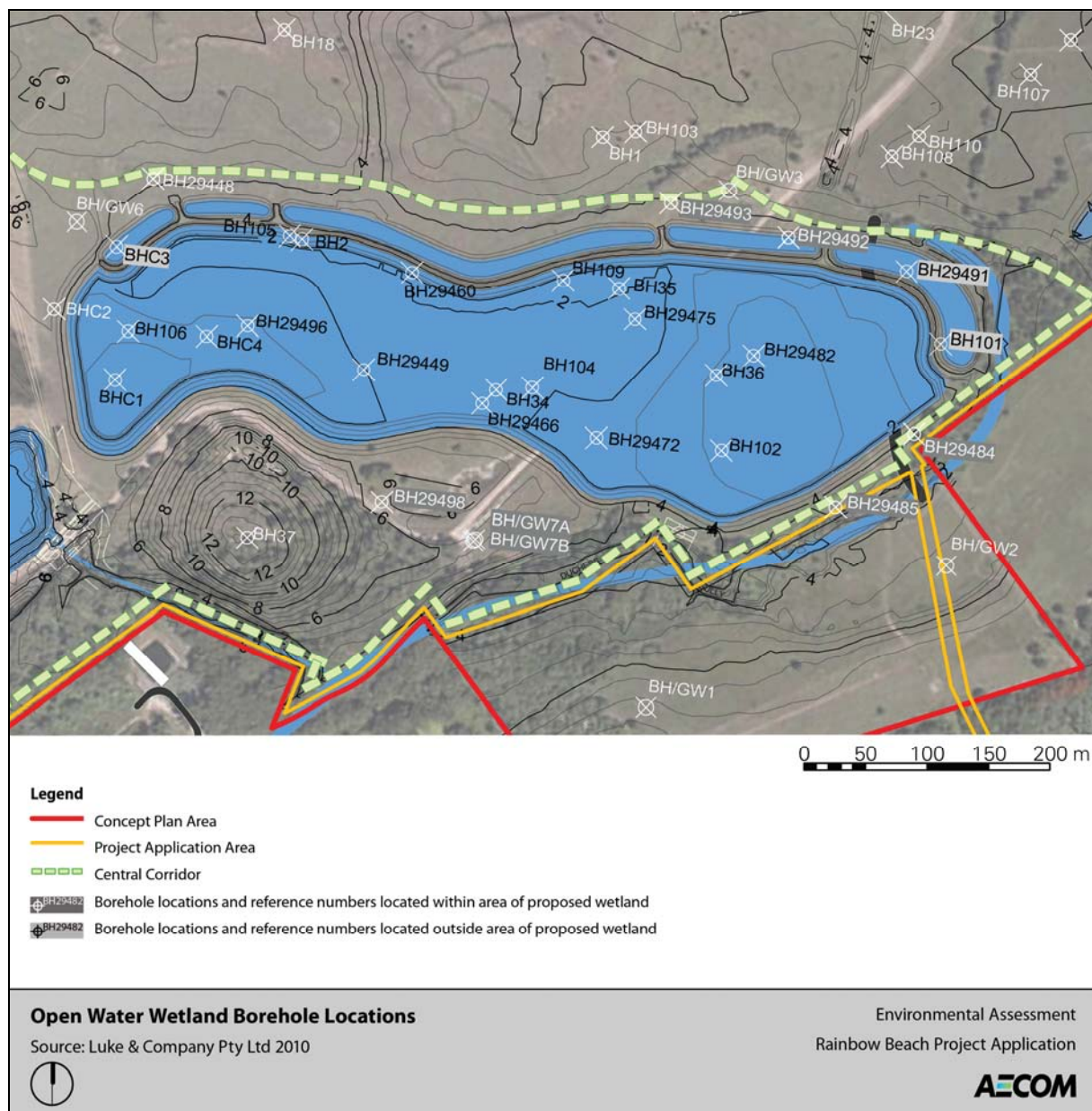


Figure 29 Open Water Wetland Borehole Locations



9.3.3 Potential Impacts

The presence of PASS within the location of the proposed open water wetland presents a number of implications for excavation, including the following:

- avoidance of 'high' PASS material;
- minimisation of drawdown of the water table during excavation operations so that water table levels are not reduced below the 'high' PASS boundary;
- maintenance of the permanent water table at acceptable levels; and
- excavation, handling and placement of material in accordance with relevant statutory regulations for the management of ASS.

In order to avoid the disturbance of PASS during excavation of the proposed open water wetland, an estimated PASS profile has been modelled, based on location of 'low' and 'high' PASS borehole test results. In this regard, results show that the occurrence of 'low' and 'high' PASS is generally in the order of RL 1.25 mAHD (varying in level from between RL 0.1 mAHD and RL 2.0 mAHD). This profile has been used to establish a bed level for the

open water wetland of 0.5 m above the estimated PASS profile, avoiding the disturbance of 'high' PASS and minimising the risk of ASS exposure. As a result of the 0.5 m bed level, excavated material from the open water wetland is expected to show very low acid potential and require no or minimal treatment.

As required by HLEP 2001, development on land identified as Class 4 in Council's land class system is required to have an accompanying Acid Sulfate Soil Management Plan (ASSMP). As such, an ASSMP has been prepared by Cardno for the Project Application Area and associated open water wetland excavation in accordance the NSW Acid Sulfate Soils Manual 1998 prepared by the Acid Sulfate Soils Management Advisory Committee.

The ASSMP (**Appendix P**) specifies that 'high' PASS material is to be avoided during excavation works. The ASSMP advises that design changes may be required during construction, should un-identified areas of 'high' PASS be located during excavation, and makes provision for fill to be reclaimed in other areas of the wetland if free of 'high' PASS materials, or sourced from alternative off-site resources for minor shortfalls. The ASSMP also recommends that additional boreholes be undertaken within the proposed wetland area to confirm the determined 'high' PASS profile.

9.3.4 Conclusions

A number of geotechnical investigations have been carried out over the Project Application Area in order to assess the potential acid sulfate soil issues affecting the Project Application Area and Project. Results of these investigations have been summarised by Luke & Co within their Geotechnical Report.

Council's existing land class system identifies the Project Application Area as being prone to ASS risks. This classification is confirmed by borehole test results, with investigations showing the occurrence of 'low' and 'high' PASS within the proposed open water wetland area generally in the order of RL 1.25m AHD. The detection of PASS presents a number of implications for the design of the open water wetland and excavation procedures. In order to manage these implications and avoid exposure of ASS and PASS, borehole data has been utilised to set an appropriate wetland bed level of 0.5 m.

9.3.5 Mitigation Measures

Appropriate management practices have been detailed within a site specific Acid Sulfate Soil Management Plan, in order to mitigate potential ASS impacts within the Project Application Area and the Project. Provided these measures are implemented, ASS threats can be safely managed, even though the risks associated with ASS are considered to be low. The following mitigation measure is to be implemented as part of the Project.

Table 34 Proposed Acid Sulfate Soils Mitigation Measures

Issue	Mitigation Measure
ASS management	Excavation work carried out within the Project Application Area are to be undertaken in accordance with the Acid Sulfate Soil Management Plan dated April 2010 prepared by Cardno.
ASS management	Handling, storage and relocation of excavated material from the Project Application Area is to be undertaken in accordance with the Acid Sulfate Soil Management Plan dated April 2010 prepared by Cardno.

9.4 Flood Risk Assessment

9.4.1 Methodology

Cardno has undertaken a flood study (April 2010) to determine the impact of the Project with regard to the increase in the magnitude of runoff and reduced response time associated with urban development, as well as potential impacts of sea level rise and an increase in rainfall intensity (see **Appendix N** for Cardno's full assessment). This flood study involves the assessment of flooding impacts as a result of urbanisation of part of the Duchess Gully Catchment, combined with the mitigating effects of the proposed open water wetland, against the requirements of the NSW Floodplain Management Manual. AECOM has also undertaken an assessment of potential impacts on the Wallum Froglet habitat to support Cardno work (see **Appendix K** for full report).

Although this chapter discusses potential impacts on the Project Application Area, the study area examined for the Cardno flood study comprises the area affected by the Concept Plan as a whole, namely the Concept Plan Area. Throughout this section, the area relating to the flood study is referred to as the study area.

9.4.2 Existing Environment

The Duchess Gully Catchment, which is the subject of the Cardno flood study (the study area) has a catchment area of 782 ha. The western boundary of the catchment is formed by a ridge approximately 2 km west of Ocean Drive with elevations varying from about 80 m to 200 m AHD. The drainage is fairly well defined west of Ocean Drive, but poorly defined east of Ocean Drive, with a number of shallow drains constructed east of Ocean Drive to drain this area. West of Ocean Drive, the catchment is generally timbered and uncleared, except for a rural residential subdivision which occupies approximately 33 ha. East of Ocean Drive, the catchment area is generally cleared. There are some areas of residential subdivision near the southern boundary of the catchment east of Ocean Drive.

9.4.3 Modelling Development Scenarios

Cardno's assessment considered the study area in three conditions of development, as follows:

- natural state – no development;
- existing development, including 33 ha of rural residential subdivision west of Ocean Drive, 28 ha of residential development to south of the Project Application Area (within the catchment area of Duchess Gully), and the existing 6.3 ha lagoon; and
- proposed development of the Concept Plan Area, as above, but including an additional 89.5 ha of urban development comprising residential, village centre and schools, with additional wetlands of 10.5 ha.

Design storm events have been estimated for the study area by the design storm-loss rate-runoff routing method. The Watershed Bounded Network Model (WBNM) has been used for this study in order to maintain consistency, as the WBNM model has been employed in previous drainage studies of the study area.

Five-year, 10-year, 20-year, and 100-year Average Recurrence Interval (ARI) event hydrographs were estimated for a range of storm durations, and catchment development conditions. As there are no actual recorded storm events for this catchment, which could be used for model calibration, the WBNM was "calibrated" against peak discharges estimated by the Probabilistic Rational Method. The probabilistic rational method is the method recommended in Australian Rainfall and Runoff 1987 edition for estimating peak flows in small to medium size rural catchments in eastern New South Wales.

The MIKE-11 model was used for the hydraulic modelling, specifically, to estimate the peak flood levels, the peak velocities along Duchess Gully for the 1 % Annual Exceedance Probability (AEP) storm event, and the changes to these levels and velocities resulting from the proposed development including the construction of the open water wetland.

Existing Development Scenario

This case modelled the existing situation which includes the existing lagoon and outlet arrangement, and the existing extensive drainage network constructed in the middle of last century which included the diversion of the original forested stream at the current overflow channel from the existing lagoon. The existing residential development includes a total of about 9 ha of urban development in sub-area 9 and about 33 ha of rural residential development in the catchment upstream of Ocean Drive.

Results from this model estimated peak outflow to the ocean at 63.3 m³/sec, while the peak level reached in the existing lagoon was estimated at 5.45 m AHD for the 9 hour 1 % AEP event.

Proposed Development Scenario

For this case, it was assumed that a new open water wetland would be constructed north and east of the existing lagoon and would also be a local source of fill material for the proposed residential areas. The open water wetland is 10.5 ha in area with approximate dimensions of 266 m width and 500 m length, and connected to the existing lagoon and at its downstream end connected to the "middle" reaches of Duchess Gully (the original 'forested stream') at Duch-N 1090.

Proposed Outlet Structures and Channel Improvements

The normal top water level in the open water wetland was set at RL 3 m AHD. This level would be maintained by a constructed "base flow" channel at the downstream end of the open water wetland connecting to the "middle" reach of Duchess Gully at the northeast of the study area, re-establishing the original flow path in the "forested gully". This low-capacity channel is sized to carry base flows from the catchment and small runoff events. A new weir structure, with a crest level of RL 3.4 m AHD would be provided to connect the open water wetland to the

existing lagoon and divert base flows from the existing lagoon through the new open water wetland. These control structures would serve to re-establish the original flow path of Duchess Gully.

Minor event flows discharging from the open water wetland up to and including the 5 Year ARI events would be controlled by a weir structure with a crest level of RL 3.7 m AHD and 25 m crest length which connects to Duchess Gully further downstream in the “middle” reach. Minor event flows (up to 5 Year ARI) from the existing lagoon would be divided equally between the open water wetland and the existing “overflow” channel from the existing lagoon which connects directly to the “lower” reach of Duchess Gully by providing a new weir structure with a crest level of RL 3.5 to replace the existing pipe culvert.

During major rainfall events exceeding 5 Year ARI, flows from the existing lagoon and the open water wetlands would overtop the banks around these water bodies at selected locations which have been profiled to control and evenly distribute the flow. The lengths of the profiled overflow sections of the banks have been designed to accommodate depth of overflow for the 100 year ARI storm event is no greater than 300 mm, so that the flow velocity at these overflows does not exceed the scour velocity for grassed surfaces. The dimensions of these weir structures and bank overflow sections are summarised in **Table 35**.

Table 35 MIKE 11 – Flow Control Structures – Development Conditions

Flow Control Description	ID	Dimensions			
		Low Flow Weir		Bank High Flow Overflow	
		Level RL m AHD	Length m	Level RL m AHD	Length m
Existing lagoon outlet to “Overflow”	S3	3.5	5	4.85	100
New open water wetland outlet to “middle” reaches of Duchess Gully	S4, S5	3.7 (S4)	25 (S4)	4.1(S5)	150 (S5)
Connection between existing lagoon and new open water wetland	S2	3.4	5	4.85	100

Source: Cardno 2010

This arrangement of weir structures and overflows provides a “minor/major” system of controls which complies with Port Macquarie - Hastings Council’s drainage guidelines (AUS-SPEC 2003) and the *NSW Floodplain Development Manual* by segregating and confining flows up to 5 Year ARI in defined structures and only allowing controlled overland flows for more severe major storm events.

In addition to the new open water wetland, the development conditions case also incorporated changes to the cross sections of the drains in the Upper Tributary upstream of the existing lagoon. In this regard, to maintain development flood levels at Ocean Drive at no greater than the existing flood levels a channel diversion has been incorporated at the south west corner of the proposed district sporting fields where filling encroaches upon the alignment of a short length of the existing channel.

9.4.4 Potential Impacts

100 Year ARI Rainfall Event – Developed Conditions

The peak outflow to the ocean for this case was estimated at 62.7 m³/sec (about 5 % less than for the existing), and the peak level in the existing lagoon was estimated as RL 5.15 m AHD. The peak level in the open water wetland was estimated as RL 4.56 m AHD.

In the lower reach of Duchess Gully downstream of the overflow junction, peak levels were up to 70 mm lower and peak velocities slightly less than for the existing situation. This decrease comes about because of the re-instatement of the original flow path in the middle reaches of Duchess Gully from the existing lagoon through the open water wetland. The peak flow in the middle reaches of Duchess Gully between the open water wetland outlet and the junction with the overflow from the existing lagoon has significantly increased as flows are re-introduced into the original stream. The peak velocities in this reach are still significantly less than the peak velocities in the “lower” reaches of Duchess Gully downstream of the overflow junction.

Stormwater and stream water levels are not worsened in the upper reaches of Duchess Gully adjacent to the existing residential areas. Maximum water levels are also not worsened at the western boundary of the study area at either of the culverts under Ocean Drive.

Water levels are increased by 110 mm at the boundary of the adjoining Milland property to the north east of the study area, however this afflux reduces to zero only 85 m further upstream within the adjoining Milland property.

Comparison of Results – 5, 10, 20 and 100 Year ARI Events

Table 36 and **Table 37** provide a summary the modelling results, as well as the peak levels and discharges for selected locations for the 5 year, 10 year, 20 year and 100 year events.

Table 36 MIKE 11 Model – Peak Levels at Selected Locations

Location		Peak Water level (RL mAHD) at location for various ARI of:			
Description	Branch & Chainage	5 year	10 year	20 year	100 year
Existing lagoon	Duch-S 1360	4.62	4.94	5.00	5.12
Open water wetland	Newlake2 331	4.06	4.23	4.33	4.54
Near upstream boundary existing lagoon	Duch-S 540	5.29	5.33	5.39	5.50
Ocean Drive – Northern Culverts	Duch-U 0.00	6.71	6.75	6.80	6.91
Ocean Drive – Southern Culverts	Duch-S 0.00	6.51	6.54	6.59	6.69

Source: Cardno 2010

Table 37 MIKE 11 Model – Peak Discharge at Selected Locations

Location		Peak Discharge (m3/sec) at location for various ARI of:			
Description	Branch & Chainage	5 year	10 year	20 year	100 year
Duchess Creek Outlet	Duch-L 1410	14.7	31.7	44.4	69.3
Outlet from existing lagoon to "overflow" (S3)	Duch-S 1495	7.6	14.6	19.7	32.5
Outlet from open water wetland (S5)	Lakelink2 10	7.5	17.2	24.6	40.2
Ocean Drive – Northern Culverts	Duch-U 40	10.6	13.1	16.2	24.7
Ocean Drive – Southern Culverts	Duch-S 35	6.2	17.1	21.4	36.8

Source: Cardno 2010

Flows at Hydraulic Control Structures

Results show that for minor runoff events, most of the outflow occurs through the water level control low flow weir structures and overflow across the embankments only occurs for major storm events. For both the existing lagoon and the open water wetland, the recurrence interval (ARI) for embankment overflow is 5 years ARI, which is in accordance with Council's major/minor recommendations for drainage design. Flows through the low flow control structures increase only moderately as the storm severity increases. Flow conditions on the embankments during overflows in major storm events are generally within the non-scouring limit for grassed surfaces with velocities of less than 1.8 m/sec.

Impacts on Frog Breeding Habitats

Anecdotal evidence from the study area and recent photos show that the Wallum Froglet habitat depression remains waterlogged for extended periods even without major runoff in the existing lagoon and overflow into the depression. These waterlogged conditions can be maintained by rainfall directly onto the habitat area combined with the presence of an impermeable surface clay layer in this area which reduces infiltration losses.

It appears that the existing frog breeding conditions are dependent on local rainfall rather than periodic overflows from the existing lagoon. As such the proposed Project is not expected to change conditions in the habitat and it is expected that the existing habitat site would continue to function as an opportunistic breeding site.

AECOM have also assessed the potential impacts on the Wallum Froglet habitat. This assessment found that the Wallum Froglet marshland is largely an ombrotrophic system developed on heavy clay soils, and surface water pooling is the result of rainfall and impeded drainage. Infiltration into (or out of) the heavy clay soils is minimal and a surface drain controls the depth of pooling in the basin. This pooling depth and the evapotranspiration rate results in the system being ephemeral and supporting the seasonally inundated sedgeland/marshland typical of Wallum Froglet habitats.

The observations made during AECOMs investigation has resulted in support of conclusions made by WRL and Cardno that the Wallum Froglet marshland is supported by impeded drainage over an impermeable clay layer. The catchment for the marshland is limited, and therefore largely rain fed, rather than fed by groundwater or runoff from other areas of the site. Due to the perched nature of the saturated soil, the construction of another wetland in proximity, but further away than the existing lagoon, is unlikely to impact on the marshland. Similarly, the urban development is unlikely to impact on the marshland as runoff from the urbanising catchments would not flow to the marshland.

Impacts on Adjoining Property

As noted above, inundation levels for the design storm event are increased by 110 mm as a result of the development of the study area at the boundary of the adjoining Milland property to the north east, although this afflux reduces to zero only 85 m upstream within the adjoining Milland property.

Cardno has assessed this impact and concludes that the impact is minor, and unlikely to adversely affect future use of the property due to the steepness of land and small volumes of site fill required to offset the effects of the afflux.

Stream Erosion in Duchess Gully

For developed conditions, the flows and velocities in the upper reach of Duchess Gully (DUCH-S Chainages 600 to 790) are increased from 0.4 m/sec to 0.55 m/sec. The increased velocity is described by Cardno as very low, and not likely to cause increased erosion in the stream.

The velocities for the 100 Year ARI storm event in the lower reaches of Duchess Gully (DUCH-L Chainages 157 to 1410) are of the order of 1.5 m/sec. These velocities are below the non-scouring limit for well-vegetated surfaces. The vegetation in this area has survived existing stream velocities and Cardno expects that there would be negligible increase in erosion in this area following development. The flows and velocities in lower reaches of Duchess Gully between the new outlet structure and the junction with the overflow channel (DUCH-L Chainages 35 to 137.43) are increased because of the diversion of flows through the proposed open water wetland. The absolute velocities are around 0.7 m/sec, which is well below the non-scouring limit for well vegetated surfaces and as such, is not expected to cause erosion in this area.

Climate Change Impacts

Cardno's flood study includes consideration of the potential impacts of recommended benchmark climate changes. Relevant factors arising from climate change for the development of the study area include:

- sea level rise;
- catchment runoff flow rates; and
- catchment runoff volumes.

Sea Level Rise

The NSW State Government Sea Level Rise Policy (DECCW 2009) requires that inundation risk assessment allow for a projected 0.9 m rise in average sea level by 2100. This requirement is incorporated in other recent NSW guidelines including the *Floodplain Risk Management Guideline Practical Consideration of Climate Change* (DECCW 2007).

In accordance with this requirement, the MIKE11 storm event model was re-run with adopted boundary ocean level of RL 3.2, being the adopted boundary level of RL 2.3 mAHD with the additional sea level rise of 0.9 m.

The hydraulic controls incorporated into the lagoon and wetland systems which control the water levels in the water bodies during major floods are located at elevations of RL 3.5mAHD and higher. It is therefore concluded

that an increase in the adopted sea level used in storm modelling to RL 3.2 mAHD should not materially alter the behaviour of the hydraulic systems in the study area because the raised sea level at the outlet of Duchess Gully would still be below the hydraulic control structures.

Catchment Runoff Flow Rates and Rainfall Intensities

Catchment runoff rates are directly affected by rainfall intensities, with runoff flow rates changing in proportion to change in rain intensities. Water levels in the streams bordering the study area can in turn be affected by the runoff flow rates.

The DECCW *Floodplain Risk Management Guideline Practical Consideration of Climate Change* recommends that flood modelling should include sensitivity testing with rainfall intensities increased by up to +30 %. It is noted that Port Macquarie – Hastings Council's *Interim Flood Policy* has recently been amended to cater for the NSW Sea Level Rise Policy Statement. The revision includes allowance for sea level rise plus an increased rainfall intensity of 10%.

Catchment Runoff Volumes

Catchment runoff volumes may also be affected by climate change.

The Bureau of Meteorology trend maps of rainfall totals from 1970 to the present for NSW show a decrease in wet days and heavy rain days. Further, other published trends examined by Cardno show declines in average rainfall totals in several regions in Australia, including NSW.

Cardno's flood study found that increasing runoff volumes would not pose an increased risk of inundation as the water bodies are provided with overflows which rapidly discharge excess runoff. These overflows strictly limit the standing water levels in the water bodies.

Modelling Results Including Climate Change Factors

In order to determine potential impacts of recommended climate changes benchmarks, the MIKE11 development conditions model was run with a sea level of RL 3.2 mAHD and catchment model runoff hydrographs incorporating +30 % greater rainfall intensities.

The results of the climate change model show that inundation levels are increased with 30 % greater rain, however continue to remain below the proposed reclaimed fill levels, which have been designed to be 0.5 m higher than the estimated 100 year ARI water levels. The location most sensitive to increased rainfall intensities is the proposed urban area along the western edge of the open water wetland, rising to 368mm.

Inundation immunity for floor levels and reclamation fill at this location were interpolated from this result as shown in **Table 38**. These results show that the floor level inundation immunity would be at least 677 mm for the most likely actual rainfall increase of +10 % under climate change conditions, and a floor level inundation immunity of at least 500 mm could be maintained even with rainfall intensity increases of 24.5 %, which exceeds Council's recently revised Interim Flood Policy of 10%.

Table 38 Floor Level Inundation Immunity with Rainfall Increase

Rainfall increase	Floor Level Immunity (above inundation water level)	Reclamation Fill Level Immunity (above inundation water level)
0%	800 mm	500 mm
10%	677 mm	377 mm
24.5%	500 mm	200 mm
30%	432 mm	132 mm

Source: Cardno 2010

9.4.5 Conclusions

Flood risk, in terms of the *NSW Floodplain Management Manual 2005* was assessed by Cardno using the MIKE11 hydraulic model to simulate storm events for both existing and development conditions. The effect of proposed fill was incorporated in the development model.

This flood modelling illustrates that water levels are not worsened by the development of the study area for the 100 year ARI Designated Event, with the exception of an increase of 110 mm at the boundary of the adjoining

Milland land to the north east. This increase reduces to zero within a short distance further upstream from the Milland property boundary.

A number of flow control structures and channel improvements are included as part of the development of the study area. It is demonstrated that these controls comply with safety requirements of the *Floodplain Management Manual*. Proposed hydraulic structure has been designed to minimise storm damage and maintenance costs and enhance ecological functioning.

The possible effects of climate change have been assessed, and it is concluded that climate change does not adversely affect the development of the Project Application Area.

It can be concluded that flood or inundation risk does not limit the development potential of the Project Application Area and the hydraulic impacts of proposed urban development can be satisfactorily ameliorated by construction of an additional water body (the open water wetland), and other hydraulic control measures, which have been incorporated into the design of the Project.

9.5 Coastal Hazard

9.5.1 Methodology

The coastline is subject to a high energy wave climate which has seen the gradual long term recession of Rainbow Beach. To determine the potential threat to the proposed Project as a result of wave activity a detailed coastal hazard assessment has been undertaken by SMEC (March 2010). A copy of this report is attached at **Appendix R**. The report describes the coastal processes affecting the beach and the impact of these processes on the areas of the beach where future development areas may be at risk. The report quantifies the observed long-term beach change, as well as estimating the beach recession that may be caused by sea level rise as a result of climate change.

A coastal hazard assessment of the section of beach adjacent to the Project Application Area has been undertaken using photogrammetric and Aerial Laser Scan (ALS) data analysis and analytical assessments. The risk to property is defined in terms of the following:

- present day risk;
- 2050 planning period; and
- 2100 planning period.

The assessment is based on the worst case scenario, in accordance with *NSW Coastal Management Manual* (1990), the *NSW Coastal Policy* (1997) and the *Coastal Protection Act 1979* which support the principles of ecologically sustainable development and the need to adopt the precautionary approach to land use planning within the coastal zone.

9.5.2 Potential Impacts

A beach typically comprises unconsolidated sands that can be mobilised under certain meteorological conditions. The dynamic nature of beaches is witnessed often during storms when waves remove the sand from the beach face and the beach berm and transport it by a combination of longshore and rip currents, beyond the breaker zone where it is deposited in the deeper waters as sand bars. During severe storms, comprising long duration of severe wave conditions, the erosion continues into the frontal dune which is attacked and a steep erosion escarpment is formed. This erosion process usually takes place over several days to a few weeks.

Historically Rainbow Beach along with extensive sections of the north coast has been subjected to large storms with some emanating from Queensland due to cyclonic events while others result from low pressure systems.

9.5.3 Conclusion

Using a combination of worst-case scenario assessment parameters it was found that there would be no impact on the proposed Project as a result of coastal hazards as the proposed Project is located landward of the coastal hazard zones for the 2100 planning period.

10.0 Heritage and Archaeology

This chapter discusses the methodology employed, findings and recommendations for indigenous and non-indigenous heritage matters in relation to the Project.

Director General's Requirements	Compliance
7. Heritage and Archaeology 7.1 Identify whether the site has significance to Aboriginal cultural heritage and identify appropriate measures to preserve any significance (refer to <i>draft Guidelines for Aboriginal heritage Impact Assessment and Community Consultation and Interim Community Consultation Requirements for Applicants</i>). 7.2 Identify any other items of European heritage significance and, where relevant, provide measures for conservation of such items.	Aboriginal heritage assessments have been undertaken to inform the EA. The assessments establish the Aboriginal heritage values of the Project Application Area, identify the potential development impacts associated with the Project and provide mitigation measures to minimise potential impact where these arise. A desktop review of European heritage has been undertaken to examine the potential extent of European Heritage within the Project Application Area. The review examined the HLEP 2001 and the State Heritage Register. The review found that the Project Application Area does not contain listed European heritage items.

10.1 Non-Indigenous Heritage

10.1.1 Methodology

As part of this EA, AECOM has undertaken a preliminary desk-top assessment of non-indigenous heritage with respect to the Project. This desktop assessment included a review of the databases listed in **Table 39**.

Table 39 Database Search – Non-Indigenous Heritage

Source	Details
Australian Heritage Database	A search was undertaken of the Australian Heritage Database, formally known as the Register of National Estate. The Australian Heritage Database is a national inventory compiled by the Australian Heritage Commission of natural and cultural heritage places.
NSW State Heritage Register	Heritage places and items of particular importance to the people of NSW are listed on the State Heritage Register. The register was created under the <i>Heritage Act 1977</i> and only lists items that are of State significance.
NSW Heritage Inventory	The State Heritage Inventory is an online database which contains over 20,000 heritage items on statutory lists in NSW. This information is mainly provided by local councils and also includes items listed on the State Heritage Register.
Local Heritage	Schedule 4 of the HLEP 2001 lists heritage items identified in the Port Macquarie – Hastings LGA for protection.

10.1.2 Potential Impacts

There are no State heritage listed items contained within the Project Application Area or within the immediate surrounds.

HLEP 2001 identifies items of local heritage significance in Port Macquarie, Kendall and Wauchope. They include:

- Camden Haven River Training Walls or Breakwaters, Camden Head;
- Camden Head Graves, Camden Head;
- Camden Head Pilot Station, Camden Head;
- St Mary the Virgin Anglican Church, Herons Creek; and
- Two dwelling houses; North Haven.

The Australian Heritage Database identifies four Commonwealth heritage listings within the area including:

- Lake Innes Nature Reserve and Adjacent Areas, listed on the Register of the National Estate;
- Camden Head - Googleys Bay Area, listed on the Register of the National Estate;
- Dicks Hill Area, listed on the Register of the National Estate; and
- Kattang Nature Reserve, listed on the Register of the National Estate.

The local and Commonwealth heritage items identified by the database search are well removed from the Project Application Area. As such there would not be direct or indirect heritage impact on these items as a result of the proposed Project.

10.1.3 Conclusion

The preliminary heritage assessment undertaken found that there are no Commonwealth, Regional, State or locally significant heritage items present on or within close proximity to the Project Application Area. Therefore it is concluded that the proposed Project would not result in adverse impacts on items of non-indigenous heritage significance.

10.2 Aboriginal Heritage and Archaeology

10.2.1 Methodology

Two separate Aboriginal Cultural Heritage Assessments were undertaken by Jacqueline Collins for the Project (July 2006 and July 2009). These assessments can be viewed at **Appendix S** and **T** of this EA respectively. Together these assessments establish the Aboriginal heritage context for the Project Application, consideration of which has been integral to the design process for the Project.

The assessment of Indigenous heritage has been undertaken in accordance with the provisions of the *National Parks and Wildlife Act 1974* and the EP&A Act. The assessment included the following elements:

- a search of the DECCW Aboriginal Heritage Information Management System (AHIMS) database;
- a review of previous archaeological surveys undertaken for the Concept Plan Area;
- identification, registration and consultation with Aboriginal stakeholders;
- archaeological surface surveys of the study area conducted in 1996, 2006, 2007 and 2009; and
- an assessment of Aboriginal cultural heritage was undertaken, consisting of both interviews and field inspections.

Three separate site surveys have been undertaken across the wider Concept Plan Area (2009, 2006 and 1996) to identify the existing site conditions and to confirm the presence of historic assets. These three survey areas are collectively referred to within this chapter as the study area. Surveys targeted reasonably level, well-drained ground, including the sand barrier, bedrock hillcrests and low gradient foot slopes. In addition, test excavations were undertaken in 2007 in respect of 4 recorded sites. Delineation of the survey areas are illustrated in **Figure 30**.

Consultation

Field inspections were conducted in collaboration with the Aboriginal community, and included ground-truthing existing registered AHIMS sites, inspecting lands in proximity to known Aboriginal sites and in areas previously identified as having potential archaeological value. The inspections conducted were done so in consultation with representatives from the Birpai, Bunyah (2009, 2006 and 1996 investigations) and Bril Bril (2009 investigations) Local Aboriginal Land Councils.

Aboriginal community consultation was undertaken in accordance with DECCW's *Interim Community Consultation Requirements for Applicants* (ICCRs) (DEC, 2004).

Under the DECCW Part 3A guidelines (DEC, 2005) consultation with the Aboriginal community is a staged process. Where no constraints are identified in the preliminary assessment, there is no further requirement for consultation and assessment. However it is intended to allow the wider Aboriginal community to provide information on the socio-cultural values of the study area. A programme of full Aboriginal consultation has been integral to the design process to seek wider Aboriginal community input into the Project.

The purpose of the full Aboriginal consultation is to seek information on the cultural (social) heritage values of the study area. The following processes were undertaken in accordance with the ICCR guidelines:

- Notification and registration of interest: Appropriate organisations were notified of the Project with requests for information on suitable Aboriginal stakeholders to be consulted.
- Methodology advice: The assessment methodology was developed in liaison with nominated stakeholder representatives.
- Fieldwork: Nominated stakeholder representatives assisted with field surveys conducted in 1996, 2006 and 2009.
- Assessment: Representatives of the registered stakeholder groups were consulted to determine whether the integrity of sites, places, resources or other values of traditional, historic or contemporary socio-cultural significance, attachment or concern would be adversely affected by the proposed Project.
- Mitigation: Mitigation measures have been prepared in consultation with, and endorsed by stakeholders. In some instances this has involved changes to the overall scheme design.

10.2.2 Existing Environment

The Rainbow Beach locality is located within the North Coast Bioregion, with typical site characteristics consisting of rolling coastal hills, coastal alluvial plains and an inner coastal barrier. The characteristics and environment of the locality would have been conducive to year-round Aboriginal occupation, but periodic inundation of the alluvial plains as a result of heavy summer rains is likely to have influenced site placement choices. Well drained rises on the inner barrier sands close to Duchess Gully and former back swamps appear to have been preferred for traditional occupation, but small camps were also sometimes established on nearby low gradient bedrock soil foot slopes. Site investigations have revealed that sections of the study area believed to be the most likely to contain archaeological finds have been heavily disturbed to the extent that few archaeological deposits would remain.

The traditional inhabitants of the Lake Cathie-Bonny Hills area are generally considered to have belonged to the Birpai tribe. As the coastal area offered resource rich land, clan estates were reasonably small, with availability of water, along with type and abundance of resources generally dictating movement and dispersal of bands within the clan estate. Wood and bark from various trees was used by local Aboriginal people to fashion material items found in the Hastings region, including shields, spears, boomerangs, clubs, digging sticks, containers and canoes. The Birpai people also used fine-grained stones and pebbles to produce a variety of cutting and scraping tools, some of which were used to manufacture and maintain these wooden items.

The majority of the study area has been cleared, either during the course of former development activities or for agricultural purposes. With the exception of a few isolated mature specimens, trees are restricted to pockets of regrowth. Despite clearing and grazing, the coastal hills are generally topographically intact. The alluvial plains and sand barrier have been more substantially altered, featuring a network of excavated drainage channels and existing lagoon. The alluvial plains have suffered high level mechanical disturbance as a result of earthworks associated with an abandoned golf course development.

Figure 30 Aboriginal Heritage Survey Areas



Aboriginal Heritage Sites within the Project Application Area

Searches of the DECC Aboriginal Heritage Information Management System (AHIMS), the Australian Heritage Database, the NSW State Heritage Register, and heritage schedules of the North Coast Regional Environmental Plan and HLEP 2001 identified a total of 15 recorded Aboriginal sites within the study area. Locations of these sites were subsequently identified through a combination of site investigation and database searches. Of the 15 sites, seven sites are located within the Project Application Area as follows:

- Artefact scatter/open campsite 30-6-107 (A2);
- Artefact scatter/open campsite 30-6-108 (A3);
- Artefact scatter/open campsite 30-6-109 (A4);
- Isolated find 30-6-114 (A9);
- Artefact scatter/open campsite 30-6-115 (A10);
- Artefact scatter 30-6-184(A12); and
- Artefact scatter 30-6-32 (A15).

The locations of sites recorded during the surveys are identified in **Figure 30**. Descriptions of these sites are provided in **Table 40**.

Table 40 Aboriginal Heritage

Ref.	AHIMS Ref.	Details	Location within Concept Plan Area	Description	Survey	Within Project Application Area
A1	30-6-106	Artefact scatter/open campsite	Wetland – vegetated area	18 stone artefacts and several unmodified beach pebbles. Flakes, flake pieces, cores and nuclear tools, manufactured on siltstone, quartz, greywacke and chert beach pebble.	2006	No
A2	30-6-107	Artefact scatter/open campsite	Wetland – vegetated area	Two Nuclear tools, three multi-platform cores and scatter of unmodified pebbles.	2006/2009	Yes
A3	30-6-108	Artefact scatter/open campsite	Wetland – vegetated area	Siltstone unifacial pebble tool and quartz multi platform core. Flakes, flake tools and bifacial pebble tool	2006	Yes
A4	30-6-109	Artefact scatter/open campsite	Wetland – vegetated area	115 stone artefacts. Flakes, flaked pieces, cores and nuclear tools made on range of raw materials including siltstone, sandstone, quartz, quartzite, chert, jasper, chalcedony, and unidentified fine-grained volcanic stones derived from beach pebbles.	2006	Yes
A5	30-6-110	Isolated find	Future residential development	Greywacke multi-platform core	2006	No
A6	30-6-111	Artefact scatter/open campsite	Residential zone	Two pebble tools with bifacial end flaking	2006	No

Ref.	AHIMS Ref.	Details	Location within Concept Plan Area	Description	Survey	Within Project Application Area
A7	30-6-112	Artefact scatter/open campsite	Residential zone	Greywacke flake and siltstone unifacial pebble tool	2006	No
A8	30-6-113	Artefact scatter/open campsite	Future residential development	Two pebble tools and a siltstone flake	2006	No
A9	30-6-114	Isolated find	Residential zone	Greywacke flake	2006	Yes
A10	30-6-115	Artefact/open scatter	Wetland – vegetated area	13 stone artefacts. Flakes, multi-platform cores, flake tool made on siltstone, greywacke, chert and quartz beach pebbles	2006	Yes
A11 – located outside the study area						
A12	30-6-184	Artefact scatter	Wetland – vegetated area	Siltstone single platform pebble core with five negative flake scars, siltstone pebble flake, broad cortical platform extending down one lateral margin. Hinge termination, one dorsal negative scar, siltstone flake, broad flaked platform, distal snap. One dorsal negative scar, jasper single platform core, heavily reduced.	2006	Yes
A13 – located outside the study area						
A14 – located outside the study area						
A15	30-6-32	Artefact scatter	Wetland – vegetated area	Silcrete cores and silcrete flakes	2009	No
A16	30-6-12	Midden	Wetland – vegetated area	Pipi shell deposit, charcoal, fire shattered pebbles, places, unworked pebbles	2006	Yes

Source: Collins 2006, 2009

10.2.3 Potential Impacts

The study area has been found to comprise numerous artefact scatters assessed individually to be of low Aboriginal cultural/social and archaeological/scientific significance but which form part of a locally unique and significant site complex. Seven of these artefact groups are located within the Project Application Area (shown as A2, A3, A4, A9, A10, A12 and A16 on **Figure 30**).

Table 41 Heritage Significance of Sites within Project Application Area

Figure Ref.	AHIMS Ref	Description	Significance	Comments	Mitigation Measure
A2	30-6-107	Stone artefact scatter	low	Small size, level of past disturbance, apparent lack of associated cultural deposits and limited opportunities for further research. Site adjacent to existing beach access, proposed works involving formalisation of access would not impact on the site.	Protective measures during construction works required.
A3	30-6-108	Artefact scatter/open campsite	moderate	Assessed to be of moderate archaeological/scientific significance as a result of disturbance context, likely size and research potential. No works proposed in vicinity of this site.	None proposed
A4	30-6-109	Artefact scatter/open campsite	high	Assessed to have high level of archaeological/scientific significance. Permanent conservation warranted. Scheme design amended to protect the site in situ.	Protective measures during construction works required.
A9	30-6-114	Isolated find	low	Assessed as being of low archaeological/scientific significance. Poor representative example of coastal artefact occurrences.	None proposed
A10	30-6-115	Artefact scatter/open campsite	moderate	Assessed as being of moderate archaeological/scientific significance. Comprises homogenous group of artefact types and is believed to represent a small campsite occupied on a one-off or itinerant basis.	Protective measures during construction works required.
A12	30-6-184	Artefact scatter	High	Assessed to be of high social/cultural significance. Site offers a good representative example of a small bedrock sub-coastal campsite and is therefore worthy of preservation.	Site to be retained in situ. Protective measures during construction required.
A16	30-6-032	Stone artefact scatter	low	Believed to have washed downstream from location A16. Low significance owing to its lack of spatial integrity and negligible potential to yield further research information.	None proposed

Source: Collins 2006, 2009

The content and context of the Aboriginal sites within the Project Application Area with regard to their value as physical links with the past, and the sites (as a group) are considered to be of general heritage significance. The cultural/social and scientific/ archaeological significance of these sites is seen to lie more in their grouping together, than in special features exhibited by the individual sites themselves. However even when assessed in terms of their representativeness as a group, the artefact scatters within the Project Application Area are considered to be of low cultural/social and scientific/archaeological significance.

Site 30-6-109 (A4) is the largest of the sites identified within the study area and contains the most extensive record of artefacts. As such it is considered to be of high archaeological/scientific significance, being a well-preserved archaeological collection of substantial future research value, demonstrating a good example of an inner coastal barrier campsite. In consultation with representatives from the stakeholder groups the Project has been designed so that a suitable boundary is provided to the open water wetland, so that the Aboriginal cultural/social and scientific/archaeological significance of the site is conserved.

The archaeological/scientific significance of Aboriginal site 30-6-114 (A9) is considered stronger in its collective grouping (alongside the other sites identified within the study area), rather than unique feature exhibited by individual finds. The site is recognised as being unique at a local level when grouped together, however individually the significance of this site is low. This is largely as a result of disturbance of the area by land clearing and grazing.

Test excavations were undertaken on site 30-6-108 (A3) and site 30-6-115 (A10) to assess the need for comprehensive salvage of archaeological material or scheme design changes to enable artefacts to be retained in situ. Both sites were assessed as being of moderate scientific/archaeological significance. Test excavations revealed a total of 26 stone artefacts within site 30-6-115 (A10). The artefacts occurred in a disturbed context and consisted of unmodified flakes/flake fragments, cores, flaked pieces and split pebbles. One flake tool, one nuclear tool and a block-fractured piece were also recovered. The site is believed to have been a small campsite occupied on a one-off or itinerant basis.

A single siltstone flake was recovered within site 30-6-108(A3). Artefacts contained within this site are believed to comprise part of a low-density background distribution of artefacts lost and/or discarded during the course of resource extraction activities.

Site 30-6-184 (A12) and its wider environment are considered to be of high cultural significance based on the scarcity of known coastal sites within the Bunyah Aboriginal group territory. Due to the effects of erosion and the apparent lack of organisation, there is little or no potential for subsurface archaeological deposits. It is considered however, that should partially undisturbed artefacts be uncovered through erosion exposure, site 30-6-184 (A12) would provide a good example of a small bedrock sub-coastal campsite and would be worthy of preservation. When measuring the possibility of further research value of site 30-6-184 A12 against the fairly limited number of similar sites in the area, the archaeological/scientific significance of the site is considered to be moderate.

Site 30-6-032 (A16) and site 30-6-107 (A2) are assessed individually to be of low Aboriginal cultural/social and scientific/archaeological significance, but which form part of a locally unique and significant site complex. One of these artefact scatters (A16) is (or was once) situated within the Duchess Gully tributary within the STP buffer zone, and would not be affected by the proposed Project.

Site 30-6-107 (A2) lies on the north west corner of the proposed 'eco-tourist' site on land adjacent to the existing public beach access. The Project includes the formalisation of the track to provide a more clearly defined public access to Rainbow Beach. Works would be limited to the extent of the existing track thereby enabling site 30-6-107 (A2) to be retained in situ.

10.2.4 Conclusion

A review of potential European Heritage sites was undertaken for the Project Application Area. No European Heritage items are located within or in the immediate vicinity. As such the proposed development would not result in adverse impacts in respect of European heritage.

No sites of Aboriginal, ceremonial, mythological or other spiritual significance have been recorded in the Project Application Area. A number of artefacts have however, been discovered. A total of seven Aboriginal archaeological sites are located within the Project Application Area. Assessment of these finds vary from low to high levels of cultural and scientific significance. The Project activities involving development of a Central Corridor, as well as the filling of future residential land has the potential to impact a number of the identified sites. While some of these sites are of low significance, in the case of highly significant sites design modifications have been incorporated so that the Project would not adversely impact on Aboriginal cultural heritage.

10.2.5 Mitigation Measures

Mitigation measures have been recommended for sites with moderate or high levels of both scientific and cultural significance. Management recommendations presenting below have been recommended by Collins, based on:

- the provisions of the *National Parks and Wildlife Act 1974*;
- advice from Birpai and Bunyah LALC representatives;
- a review and re-inspection of sites recorded during the 1996 survey and reassessment of these sites in terms of the current Project;
- results of the field inspection conducted in the southern extension area; and
- consideration of the potential impact of the Project on Aboriginal cultural heritage sites and values.

A summary of management recommendations is outlined in **Table 42**.

Table 42 Proposed Indigenous Heritage Mitigation Measures

Issue	Mitigation Measure
General	Prior to the commencement of vegetation clearing, earthworks or other invasive development related activities, construction contractors should be advised of their legal obligations with regard to Aboriginal Cultural Material.
Site protection	Works associated with the upgrading and formalisation of the beach access are to be confined to the easement defined by the existing track cutting to protect site 30-6-12.
	Geofabric matting should be placed across the previously excavated eastern parts of the site (adjacent to the existing gravel road) as necessary to maintain separation of the natural ground surface from fill areas to facilitate site identification in the event of future archaeological investigation.
	To preserve value of A4 temporary fencing is to be erected and maintained along the 6 m contour interval adjacent to known Aboriginal sites within the Works Zone to define the 'no-go' area for the duration of the wetlands construction. No disturbance may occur above the 6 m contour interval without formal approval from the DECCW.
	In the event that identified or suspected Aboriginal cultural materials are detected with during Aboriginal monitoring or elsewhere: • Disturbance in the vicinity of the find should immediately cease and temporary protective fencing would be erected around the find to define a 'no-go' zone. • The developer would contact the Aboriginal stakeholder groups and the DECCW to inspect the find so that appropriate actions and management recommendations can be formulated. In the event that findings consist of or include possible or identified Aboriginal skeletal remains, the NSW Police Department would be contacted. • Work may proceed at an agreed distance from the find, in consultation with Aboriginal stakeholders and the DECCW. If the find is identified as an Aboriginal object, work causing disturbance or destruction of the object may not recommence until an appropriate archaeological inspection/investigation has been carried out to the satisfaction of the DECCW and the DoP.
Work supervision	Works shall be supervised by an appropriately qualified person.
Monitoring	Vegetation clearing and topsoil disturbance associated with road construction and development of the proposal shall be monitored.
Consultation	Aboriginal stakeholders would continue to be engaged in the detailed planning, construction and installation of the project to facilitate public appreciation of Aboriginal values and traditional uses of the area.

11.0 Public Access and Safety

An assessment of risk has been undertaken by Cardno for the Project with regard to potential impacts of the Project on public safety. This chapter summaries this risk assessment and outlines mitigation measures where appropriate.

Director General's Requirements	Compliance
8. Public Access and Safety 8.1 Propose measures for the provision of public access throughout the site, to proposed adjacent residential, retail, tourist and school sites and to Rainbow Beach. 8.2 Provide an assessment of the potential impacts of the open water wetland on public safety and liability and provide, where relevant, appropriate management measures.	This chapter provides an assessment of the potential impacts of the Project on public safety and outlines details of the Open Space Management Strategy prepared for the Project (Appendix D).

11.1 Public Access

Measures for the provision of public access throughout the Project Application Area, as well as to future adjacent residential, retail, tourist and school sites and to Rainbow Beach have been assessed by Luke and Co Pty Ltd within their Traffic Impact Study (**Appendix V**) and have been integrated into the landscape master plan. Details of the shared pedestrian and cycle pathways running throughout the Central Corridor are discussed in **Section 4.1.1** of this EA and the Landscape Master Plan Design Report attached at **Appendix C**.

Rainbow Beach would remain accessible to the public as part of the Project. The existing beach access would be formalised and enhanced and access to Rainbow Beach would be restricted to the existing access point and no new beach access ways would be provided.

Access to the existing Rainbow Beach Residential Estate south of the Central Corridor would be provided via a network of concrete and gravel shared pedestrian and cycle paths around and across the Central Corridor.

Cyclists would be accommodated by both "on road" cycle lanes along Ocean Drive and a network of shared cycle ways within the Central Corridor. A link from north to south would connect Lake Cathie to Bonny Hills and form part of the NSW Coastline Cycle way. Discussions with local user groups are continuing with respect to the integration of cycle paths into a greater network. The overall integration of cycle and pedestrian linkages proposed within the Project Application Area to the wider area is shown in **Figure 14**.

Pedestrians would be accommodated by a network of paved footpaths and shared cycleway paths throughout the Project Application Area. Pathways would provide safe access to the future village centre, schools, and community facilities. Precise routes through residential areas and associated construction details would be the subject of future project/development applications.

11.2 Assessment of Risk

11.2.1 Methodology

Potential impacts of the open water wetland on public safety and liability have been assessed by Cardno (April 2010) and mitigation measures have been recommended where appropriate. These measures have been incorporated within the Open Space Management Strategy for the Project prepared by Cardno (refer to **Appendix D** of this EA).

The proposed open water wetland is part of the stormwater treatment system for the Project Application Area, and provides potential habitat for aquatic flora and fauna. With regards to public safety the principle issue is the risk of accidental drowning. In order to assess the risk of accidental drowning, a risk management assessment was conducted for the proposed open water wetland based on the *Guidelines for Water Safety in Urban Water Developments* published by the Royal Life Saving Society of Australia in January 2004.

11.2.2 Potential Impacts

Cardno has assessed the level of consequence (harm) if an accident happens within the water bodies and the likelihood of that consequence to happen as being:

- Consequence: drowning = catastrophic or Category 1
- Likelihood: unlikely or Category D

This represents a risk combination score of 7 on the risk management matrix, which falls into the medium risk zone shown as yellow on the matrix in **Figure 31**.

Figure 31 Risk Management Matrix

Likelihood						
A	B	C	D	E		
1	2	4	7	11	1	Consequence
3	5	8	12	16	2	
6	9	13	17	20	3	
10	14	18	21	23	4	
15	19	22	24	25	5	

Source: Cardno 2010

The Facility Visitation Rate (FVR) for the water bodies was also calculated as part of the risk assessment. In this regard, the Project can be defined as cleared land with activity based infrastructure, and as a result is rated 3 (development). The estimated population usage was conservatively assumed to be 2 (5 to 50 people at a time), as no formal access to either the existing lagoon or proposed open water wetland would be provided unless there are appropriate barriers and/or safety benching installed and the usage refers to residents walking around the open space areas adjoining the water bodies. Although walkways would exist near the open water wetlands and existing lagoon, vegetative and physical barriers would be placed to prevent access to these water bodies. Signage would also be installed in appropriate locations around the existing lagoon and proposed open water wetland to explain their purpose and deter people from entering into the water. Although no formal gathering spots exist near the water bodies and no water sports or swimming would be encouraged within them, the frequency for the water bodies was conservatively assumed to be 4 (as the possibility exists that some residents might walk around the open space areas adjoining the water bodies on a daily basis).

Based on these parameters, the Facility Visitation Rate (FVR) for the water bodies is then $(3 \times 2) + 4 = 10$, a value which falls into the medium risk category.

11.2.3 Preventative Design Measures

Port Macquarie – Hastings Council's *AUSPEC D7 Stormwater Management Specification* require the side slopes of wet retention basins or ponds to have a maximum grade of 1:6 (V:H) or if side slopes are steeper than 1:6, the basin or pond is to have dense planting or fencing for security purposes.

The requirement for a 1:6 (V:H) slope means that persons accidentally entering the water, particularly children, are unlikely to progress into deeper water, and can easily get back to the shore. This requirement has been included within the design of the wetland. In addition, a combination of densely planted edges and secondary safety benches would further reduce risk of access to wetlands.

In addition to the design of the open water wetlands, other safety measures can be placed around the water bodies to mitigate risk including vegetative barriers, physical barriers and signage. In this regard, the revegetation program for the Project Application Area has been specifically designed to create vegetative barriers to the existing lagoon and proposed open water wetland.

Around the existing lagoon, the vegetative barrier would commence from the terrestrial fringe into the submerged zone. The extent of the barrier has been specifically designed to prevent public access to the water from at least 2 to 3 m back from the Normal Top Water Level (NTWL) mark to reduce the likelihood of unexpected entry into the water body.

Physical barriers have also been incorporated, and no formal access to either the existing lagoon or proposed open water wetland is proposed unless there are appropriate barriers and/or safety benching installed. This would apply to areas where viewing platforms or shared cycle/pathways may be situated along the edge of the existing lagoon or proposed open water wetland. Non-obtrusive and vandalism resistant signage would be installed in appropriate locations around the existing lagoon and proposed open water wetland. Signage would identify the following:

- the purpose of the wetland (i.e. stormwater treatment and wildlife habitat);
- significant environmental features (e.g. waterbird nesting habitat);
- appropriate safety warnings; and
- prohibition of domestic animals such as dogs within the wetland.

As part of the Project, the existing lagoon and open water wetland would also be provided with water level and flow control structures in the form of simple fixed weirs and overflow embankments. The weirs would discharge storm runoff for storms up to and including the 5 Year ARI events with these flows confined to scour-protected channels separated from pedestrian walkways so as to maintain public safety during these events, where necessary pedestrian walkways would span these channels via bridges.

The overflow embankments would discharge storm runoff in excess of the 5 Year ARI events. Although the embankments are designed to carry these flows with no erosion damage, flow conditions on the embankments during these major runoff events would represent high hazard conditions for pedestrians because of the water velocities created. Some pedestrian walkways are located on these embankments. Appropriate signage should be installed at these locations to warn pedestrians and prevent access to these sections of the walkways during major runoff events when embankments are overtopped.

11.3 Conclusion

Assessment of the potential risk of accidental drowning has been assessed by Cardno, based on the estimated population usage of the Project Application Area and access arrangements proposed to the existing lagoon and open water wetland during its operation. Based on these parameters, the Project has been assessed as being a medium risk.

A number of design measures and operational safety controls have been incorporated into the design of the open water wetlands to manage public safety. These measures have been incorporated within the Open Space Management Strategy for the Project.

The Open Space Management Strategy addresses public safety issues associated with the proposed water bodies with a risk minimisation approach based on the principle of not inviting people to danger and ensuring risk is minimised through the reasonable provision of safety measures.

11.4 Mitigation Measures

Table 43 Proposed Public Access and Safety Mitigation Measures

Issue	Mitigation Measure
Operational public access and safety	Public access and safety is to be managed in accordance with the Open Space Management Strategy dated April 2010 prepared by Cardno and final design details would be signed off by Port Macquarie – Hastings Council at the Construction Certificate stage.

12.0 Construction Management

This chapter assesses the potential construction impacts of the Project on the surrounding local area, including consideration of traffic, noise, dust and erosion impacts, and recommends mitigation measures to manage these potential impacts where appropriate.

Director General's Requirements	Compliance
9. Construction management 9.1 Provide an assessment of the potential impacts during construction of the proposal. The assessment should include, but no be limited to, consideration of: - truck movements required and traffic routes proposed for use - impacts on traffic and pedestrians - impacts on the amenity of adjoining properties including, noise, dust and sediment and erosion controls. - where relevant, mitigation measures to manage identified impacts.	This chapter provides an assessment of the potential impacts of construction vehicles on the road network, amenity of nearby properties and pedestrian safety. A Construction Environmental Management Plan has been prepared for the proposed development (see Appendix U).

12.1 Methodology

Cardno (April 2010) were engaged to undertake an assessment of the potential impacts during construction of the Project. This chapter focuses on the potential construction impacts identified by Cardno, including construction impacts on traffic and pedestrians, and impacts on the amenity of adjoining properties with regard to noise, dust, soil and sediment controls. Where relevant, mitigation measures have been recommended to manage identified construction related impacts, which have been formalised in a Construction Environmental Management Plan (CEMP) for the Project.

Details of Cardno's construction impact assessment are contained within the Cardno Water and Engineering and Environment Report. The CEMP for the Project is included in **Appendix U** of this EA.

The potential impacts resulting for construction works have been identified by Cardno as follows:

- traffic impacts from truck movements and defined traffic routes;
- impacts on local traffic and pedestrians;
- amenity impacts from noise;
- amenity impacts from dust;
- impacts of sediment and soil erosion; and
- impacts on water quality of natural wetland during weir construction.

12.2 Potential Impacts

12.2.1 Traffic Impacts from Truck Movements

Traffic movement that may impact the local road network surrounding the Project Application Area would arise primarily from the initial arrival of earthmoving machinery and delivery of construction and landscaping materials. Other anticipated traffic movement requirements are associated with vehicle movements for arrival and departure of workers to the site during construction times. As fill would be sourced from within the Project Application Area, are not expected to be necessary to import fill to the Project Application Area.

In order to minimise impacts of traffic entering and leaving the Project Application Area, a single entry point would be designated on the northern boundary of the Project Application Area, with one entry point along Ocean Drive. This entry point has been selected to direct traffic away from established residential areas.

Main truck movements throughout the Project Application Area would use the existing gravel road within the site. Where new roads are required, internalised tracks would be formalised with gravel to avoid bogging and dust emissions.

12.2.2 Impacts on Local Traffic and Pedestrians

Traffic volume increases are expected to be minor, and mainly associated with arrival and departure of workers. This would increase traffic volumes during peak traffic hours. Delivery trucks are not anticipated to be frequent. Traffic impacts on pedestrians as a result of the Project are not anticipated to affect pedestrians crossing the entry point to the Project Application Area via Ocean Drive.

To control traffic and pedestrians within the Project Application Area, traffic would be managed in accordance with the Port Macquarie - Hastings Council *Aus-Spec Development Construction Specification C201 - Control of Traffic*. The Project's CEMP details specific methods of managing impacts on pedestrians and traffic, including:

- media releases to local residents and the wider community to advise of the nature of the proposed works and likely traffic disruptions;
- appropriate scheduling to minimise impact to traffic from activities that may cause traffic disruptions; and
- traffic controllers at the site entrance to control traffic and pedestrians around delivery trucks.

12.2.3 Amenity Impacts from Noise

Construction to establish the Project would involve the use of powered mechanical equipment and internal vehicle movements to achieve the desired landform. The Project Application Area largely comprises agricultural land and the nearest sensitive receptors are within the Rainbow Beach Residential Estate to the south of the Project Application Area. Potential noise impacts would remain within allowable limits but it is acknowledged that there is some potential for construction activity associated with the Project to affect noise amenity in the locality. As such, construction would be managed to minimal noise nuisance. Regard would be given to the following guidelines:

- AS2436 – 1981 - *Guide to Noise Control on Construction, Maintenance and Demolition Sites*; and
- The current Port Macquarie – Hastings Council *Aus-Spec Development Construction Specification C101 – General*; specifically clauses C101.17 and C101.18 which detail noise limits.

The location of the controlled access point to Ocean Drive means noise associated with vehicles entering or leaving the Project Application Area are located away from established residential areas to the south. Further, vehicles entering or leaving or used within the Project Application Area would be operated and maintained in a manner so that the noise levels produced by construction vehicles remain within the limits of the *Commonwealth Department of Transport and Regional Services Federal Office of Road Safety Australian Design Rule ADR28- External Noise of Motor Vehicles*.

Working hours at the Project Application Area would be limited to between 7am and 6pm Monday to Saturday or as otherwise agreed with Port Macquarie – Hastings Council. No works would be conducted at the Project Application Area on Sunday or during public holidays.

12.2.4 Amenity Impacts from Dust

Construction of the Project would involve the use of powered mechanical equipment for movement of sandy earth material to achieve the required land formations. The bulk handling of this material has the potential to create air impurity nuisances by release of dust as suspended then deposited particulate matter.

In order to manage these impacts, earthworks would be undertaken in accordance with relevant requirements of Port Macquarie - Hastings Council *Aus-Spec Development Construction Specification C101- General and C213 – Earthworks* which details measures to manage dust associated with earthworks.

In addition, the CEMP for the Project outlines measures for compliance with the *Protection of the Environment Operations (Clean Air) Regulation 2002 Act*, Council By-Laws and health and safety requirements.

12.2.5 Impacts of Sediment and Soil Erosion

Construction of the Central Corridor would involve excavation of soils and the alteration of landform at the Project Application Area. Environmental vectors including wind and stormwater coming in contact with this material has the potential to transport sediment and/or other contaminants off site.

Erosion and sedimentation control measures would be undertaken in an approved manner and sediment released from the Project Application Area would be within approved limits. Construction works would be planned and undertaken in accordance with relevant aspects of the:

- *Soil Erosion and Sediment Control Guidelines*, Institute of Engineers Australia;
- Port Macquarie - Hastings Council *Aus-Spec Development Construction Specification C211-Control of Erosion and Sedimentation*;
- Port Macquarie - Hastings Council *Aus-Spec – Development Construction Specification C213 – Earthworks*; and
- *Hastings Development Control Plan No. 17 - Subdivision Code*.

12.2.6 Impacts on Water Quality of Wetland During Weir Construction

The construction of the weir at the eastern outfall of the existing lagoon has potential to increase turbidity levels via disturbance of sediments. To prevent the direct release of disturbed sediments into surrounding waters, the weir would be constructed in dry conditions. Dry conditions would be established via the following method:

- a floating sediment fence would be established around the weir construction area;
- a watertight barrier would be installed around the weir construction area;
- the weir construction area would be dewatered; and
- the water tight barrier would not be removed until the weir is stabilised appropriately.

12.3 Conclusions

Potential construction impacts that may arise as a result of the Project, including impacts as a result of increased traffic, dust and noise impacts, erosion control and water quality management, have been identified and assessed by Cardno.

These construction impacts are considered to be minor and are not expected to cause detrimental amenity impacts to surrounding residential areas or users of the local road network. Fill material would be sourced within the Project Application Area thereby reducing the need to transport fill material into the Project Application Area.

12.4 Mitigation Measures

Cardno has recommended mitigation measures to manage impact during construction, as outlined in **Table 44**.

Table 44 Proposed Construction Management Mitigation Measures

Issue	Mitigation Measure
Traffic impacts	A single entry point would be designated on the northern boundary of the site, with access to Ocean Drive.
Traffic and dust impacts	Main truck movements throughout the Project Application Area would use the existing gravel road on the property. Where new roads are required, internalised tracks would be formalised with gravel to avoid bogging and dust emissions.
Traffic and pedestrian impacts	Traffic is to be managed in accordance with the Port Macquarie - Hastings Council <i>Aus-Spec Development Construction Specification C201 - Control of Traffic</i> .
Noise impacts	Construction noise would managed through the implementation of: • <i>AS2436 – 1981 - Guide to Noise Control on Construction, Maintenance and Demolition Sites</i>; and • Port Macquarie - Hastings Council <i>Aus-Spec Development Construction Specification C101 – General</i>.
Noise impacts	Working hours at the site are limited to between 7am and 6pm Monday to Saturday or as specified by Port Macquarie - Hastings Council. No works would be conducted at the site on Sunday or during public holidays.

Issue	Mitigation Measure
Dust Impacts	Dust pollution is to be managed in accordance with Port Macquarie - Hastings Council <i>Aus-Spec Development Construction Specification C101-General and C213 – Earthworks</i> .
Erosion Control	Erosion is to be managed in accordance with: • <i>Soil Erosion and Sediment Control Guidelines</i>, Institute of Engineers Australia; • most current Port Macquarie - Hastings Council <i>Aus-Spec Development Construction Specification C211-Control of Erosion and Sedimentation</i>; • most current Port Macquarie - Hastings Council <i>Aus-Spec – Development Construction Specification C213 – Earthworks</i>; and • <i>Hastings Development Control Plan No. 17 - Subdivision Code</i>.
Water Quality	The weir is to be constructed under dry conditions via the following methods: • a floating sediment fence would be established around the weir construction area; • a watertight barrier would be installed around the weir construction area; • the weir construction area would be dewatered; • the water tight barrier would not be removed until the weir is stabilised appropriately.

13.0 Statement of Commitments

The Statement of Commitments prepared for the project has been compiled on an issues basis and is informed by the impact assessment undertaken as part of this EA.

Director General's Requirements	Compliance
5. An assessment of the potential impacts of the project and a draft Statement of Commitments, outlining environmental management, mitigation and monitoring measures to be implemented to minimise any potential impacts of the project.	In accordance with the DGRs issued under Part 3A of the EP&A Act the following Statement of Commitments has been developed for the project. The Statement of Commitments states the Proponent's environmental commitments and details the environmental management of the proposed Project.

13.1 Statement of Commitments

In accordance with the EA requirements under part 3A of the EP&A Act, the following Statement of Commitments (SoC) is provided. The SoC states the Proponent's environmental commitments and details the environmental management and monitoring of the proposed Project.

The SoC prepared in respect of the proposed construction and operation of the proposed Project has been compiled on an issues basis and is informed by the environmental impact assessment undertaken as part of this EA. The SoC has been written in a format which can be incorporated into project approval issued to act as the conditions of that approval.

Table 45 Statement of Commitments

Issue	Commitment
Construction documentation	Final detailed design and specifications for the Central Corridor, including the open water wetlands, would be completed at the Construction Certificate stage and final sign-off would be required from Port Macquarie – Hastings Council, being the Principal Certifying Authority (civil works) for the Project.
Open Space Management	The Proponent is to enter into a Voluntary Planning Agreement (VPA) with Port Macquarie – Hastings Council under Section 75F(6) of the EP&A Act in regards to the management and dedication of the Central Corridor. The Central Corridor is to be managed in accordance with the Open Space Management Strategy prepared by Cardno (April 2010) and in accordance with Council requirements as per the VPA.
Ecology	The rehabilitation of the Central Corridor is to be undertaken in accordance with the Open Space Management Strategy prepared by Cardno (April 2010).
Surface water quality monitoring	Ongoing surface water quality monitoring is to be undertaken in accordance with the Surface Water Monitoring Plan prepared by AECOM (July 2010).
Groundwater quality monitoring	Ongoing groundwater monitoring is to be undertaken in accordance with the Groundwater Monitoring Plan prepared by WRL (March 2010).
Stormwater management	Stormwater is to be managed in accordance with Port Macquarie - Hastings Council Integrated Water Cycle Management (IWCM) policy for Area 14 and as outlined within Water Engineering and Environment Report prepared by Cardno (April 2010) and the Stormwater Treatment and Wetland Functionality Report prepared by AECOM (2010).

Issue	Commitment
Bushfire Management	A Fire Management Plan is to be prepared in coordination with the Open Space Management Strategy prepared by Cardno (April 2010). The management prescriptions of the Fire Management Plan shall address those measures required to meet the provisions of Section 63 of the <i>Rural Fires Act 1997</i> whilst specifically recognising the need to protect the plant communities in the low-lying parts of the Project Application Area.
Contamination	Areas of localised soil impact identified, or additional areas identified during future site works are to be appropriately remediated and validated as required under SEPP No. 55 – Remediation of Land. A detailed survey of the northern dwelling is to be undertaken to determine the full extent of asbestos containing materials and appropriate management of materials during demolition.
ASS Management	Excavation work, including handling, storage and relocation of excavated material is to be carried out within the Project Application Area is to be undertaken in accordance with the Acid Sulfate Soil Management Plan prepared by Cardno (April 2010) and the Groundwater Monitoring Plan prepared by WRL (March 2010).
Indigenous Heritage	Prior to the commencement of vegetation clearing, earthworks or other invasive development-related activities, construction contractors should be advised of their legal obligations with regard to Aboriginal Cultural Material. In the event that identified or suspected Aboriginal cultural materials are detected with during Aboriginal monitoring or elsewhere: - Disturbance in the vicinity of the find should immediately cease and temporary protective fencing would be erected around the find to define a 'no-go' zone. - The developer would contact the Aboriginal stakeholder groups and the DECCW to inspect the find so that appropriate actions and management recommendations can be formulated, In the event that findings consist of or include possible or identified Aboriginal skeletal remains, the NSW Police Department would be contacted. - Work may proceed at an agreed distance from the find, in consultation with Aboriginal stakeholders and the DECCW. If the find is identified as an Aboriginal object, work causing disturbance or destruction of the object may not recommence until an appropriate archaeological inspection/investigation has been carried out to the satisfaction of the DECCW and the DoP. Works shall be supervised by an appropriately qualified person. Vegetation clearing and topsoil disturbance associated with road construction and development of the proposal shall be monitored. Aboriginal stakeholders would continue to be engaged in the detailed planning, construction and installation of the project to facilitate public appreciation of Aboriginal values and traditional uses of the Rainbow Beach area.

Issue	Commitment
Construction Management	Construction works are to be managed in accordance with the Construction Environment Management Plan prepared by Cardno (April 2010), which would be finalised with PMHC at the Construction Certification stage.

14.0 Ecologically Sustainable Development

Schedule 2 of the Environment Planning and Assessment Regulation 2000 sets out the matters which an environmental impact assessment must consider, and includes a requirement for consideration of the principles of Ecologically Sustainable Development (ESD). This requirement is reiterated in respect of the proposed Project in the DGRs.

This chapter provides a discussion of ESD principles and climate change impacts, and outlines their relevance and application to the Project throughout the design, development and EA stages of the process. This chapter also provides a justification for the Project in line with the requirements of the EP&A Regulation and the DGRs for the Project.

14.1 ESD Principles

The intent of ESD is to apply an approach to development that ensures new development in all sectors and the ongoing operation of these activities meets the needs of the present generation without compromising the ability of future generations to meet their needs.

The application of ESD to decision-making in Australia has been refined in the *National Strategy for Ecologically Sustainable Development*, and as a result requirements for ESD to be considered in the life-cycle of development have been built into the various Commonwealth, State and regional strategies and policy documents that govern development within Australia and NSW.

The four principles of ESD are:

- The Precautionary Principle;
- Intergenerational Equity;
- Conservation of Biological Diversity and Ecological Integrity; and
- Improved Valuation and Pricing of Environmental Resources.

The application of these principles to the Project is discussed below.

14.1.1 Precautionary Principle

The Precautionary Principle provides that:

“if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation”.

When applying the Precautionary Principle decisions should be guided by

“careful evaluation to avoid, serious or irreversible damage to the environment, and an assessment of the risk-weighted consequences of various options”.

An environmental assessment of the potential impacts of the Project has been undertaken. **Chapters 7.0 to 12.0** of this EA Report examine the Project Application Areas existing conditions and assess the anticipated impacts of Project.

Mitigation and management measures have been recommended for the construction and operational phases of the Project. These measures would be implemented so that potential environmental impacts associated with the Project are minimised.

Based on the specialist investigations that have been undertaken throughout the development of the Project, it is determined that potential threats of serious or irreversible environmental damage have been assessed and can be managed where appropriate.

14.1.2 Intergenerational Equality

Inter-generational equity is the application of the concept that the present generation should ensure that the health, diversity and productivity of the environment are maintained or enhanced for the benefit of future generations.

The Project would enhance the Project Application Area for current and future generations through the regeneration of existing vegetation communities as well as the creation of a freshwater open water wetland, which has the potential to mimic an EEC (freshwater wetlands on coastal floodplains). Through the creation of a potentially new EEC on site, the Project would enhance diversity for future generations who may not have had the opportunity to experience such environments.

14.1.3 Conservation of Biological Diversity and Ecological Integrity

This ESD principle intends that conservation of biological diversity and ecological integrity should be a fundamental consideration of proposed development.

In its existing state, parts of the Project Application Area present biodiversity and ecological integrity. Overall however, much of the Project Application Area is cleared as a result of pastoral land management practices and land clearing. The Project seeks to conserve and revegetate parts of the site. By regenerating the existing vegetation, biological diversity and ecological integrity is improved, as healthier environments allow for greater variety, number and abundance of species which in turn increases ecological value. The inclusion of additional freshwater environment would aid in the variety and abundance of plant and animal species that were not previously located within the Project Application Area or surrounding area, which would improve biodiversity and ecological integrity.

14.1.4 Improved Valuation and Pricing of Environmental Resources

Improved valuation, pricing and incentive mechanisms refer to requirement of environmental factors being included in the valuation of assets and services, such as:

“(i) polluter pays, that is, those who generate pollution and waste should bear the cost of containment, avoidance or abatement,

(ii) the users of goods and services should pay prices based on the full life cycle of costs of providing goods and services, including the use of natural resources and assets and the ultimate disposal of any waste, and

(iii) environmental goals, having been established, should be pursued in the most cost effective way, by establishing incentive structures, including market mechanisms, that enable those best placed to maximise benefits or minimise costs to develop their own solutions and responses to environmental problems”.

A revegetation strategy would be implemented to increase the value of natural resources through protection and conservation. The Water Cycle Management Plan developed for the Project Application Area would aid in pollution control by treating stormwater.

14.2 Climate Change

Greenhouse Gases (GHGs) are gases found in the atmosphere that absorb outgoing heat reflected from the earth. The absorption of the heat energy warms the air, enabling life to survive, and is known as the Greenhouse Effect. The primary GHG is carbon dioxide (CO₂).

Human activities, such as the combustion of carbon-based fuels, increase the amount of GHGs in the atmosphere. This leads to greater absorption of heat resulting in increased atmospheric temperature, known as the Enhanced Greenhouse Effect. The atmospheric concentration of CO₂ has risen from 280 parts per million (ppm) in 1860 to approximately 388 ppm in January 2010 (NOAA 2010). At the same time, the average global temperature has increased by nearly 1 °C. Projections show that if this trend continues, global temperatures could rise between one and four °C by the end of the 21st century, with annual average temperatures in Australia projected to increase by 0.4 - 2.0 °C by 2030 and by 1 – 6 °C by 2070 compared to 1990 levels (WBCSD 2004).

Australia's per capita GHG emissions are among the highest in the world (AGO, 1998) and, overall, the total net GHG emissions in Australia increased by 2.2% between 1990 and 2005. Most of the increases resulted from energy generation and industrial processes.

The NSW Government has committed to a long-term target of a 60% reduction in GHG emissions by 2050 and a return to year 2000 GHG emission levels in NSW by 2025. There are, however, no legislative limits for emissions of GHGs.

The Project would help to mitigate GHG build up and the resultant climate change effects primarily through the creation of a 75.2 ha vegetated Central Corridor, due to vegetation absorbing CO² and therefore acting as a carbon “sink” reducing atmospheric concentrations.

A number of measures have been put in place to limit potential GHG emissions during construction including the generation of on-site fill for use on the residential land, which would lead to a reduction in GHG emissions associated with the extensive truck movements that would have been required to transport material to the site. Furthermore, the use of fill would help to limit potential sea level rise impacts on the development.

Additionally, the overall Concept Plan of which the Project is a key element provides for a rationalised land use layout that locates residential areas in proximity to key services and facilities including schools, shops and open space recreation areas. The collocation of facilities would help to reduce transport emissions including associated GHGs, due to reduced travel distances and the opportunity to use active travel including walking and cycling.

14.3 Conclusions

The principles of ESD have been considered throughout the design and development stages of the Project. The assessment of potential environmental, social and economic considerations has been undertaken in line with precautionary, equality, biodiversity and valuation principles. Based on the social benefits accruing from the Project, and assessed impacts on the environment, it is considered that the development is in line with the principles of ESD and would present an ecologically sustainable outcome.

15.0 Conclusion

15.1 The Project

This Project Application involves the design of land uses occupying the Central Corridor, as well as the excavation and placement of fill to reclaim a portion of the site which is currently low lying and is subject to periodic inundation. The Project Application also seeks approval for formalised access to Rainbow Beach.

Completion of the works described in this Project Application would advance the development of the Project Application Area to the following stage:

- future urban and residential development areas are filled to elevations above inundation levels and appropriately protected and vegetated;
- the open space, habitat and drainage corridor areas of the site are rehabilitated with locally-sourced indigenous coastal habitats appropriate to the location and the incorporation of passive recreational facilities; and
- the district sporting fields land is filled, topsoiled, stabilised and readied for transfer to Port Macquarie – Hastings Council.

15.2 Environmental Assessment Issues

This Project has been subject to environmental assessment in accordance with Part 3A of the EP&A Act and the requirements issued by the Director General. Specialist investigations have been undertaken within the Project Application Area, resulting in a number of potential environmental impacts in relation to:

- Flora and fauna;
- Water cycle management and watercourses;
- Hazard management and mitigation;
- Heritage and archaeology;
- Public access and safety; and
- Construction management.

The management of potential environmental impacts has shaped the design of the Project and as a result, the Project responds to the environmental constraints of the Project Application Area. Furthermore, a number of mitigation measures have been recommended in order to manage potential impacts.

15.3 Justification for the Project

The Area 14 Structure Plan supports the development of the Project Application Area for future residential, commercial, educational, recreational and community facilities. This Project Application is consistent with the Concept Plan Application, which seeks approval for the delineation of future land uses which are guided by the Area 14 Structure Plan. This Project Application is critical to the Concept Plan Application, as without the approval of this Project there is no possibility to develop the Concept Plan in its current form.

The Project would create flood free development area required to meet the Area 14 Structure Plan population targets. The Project would also enhance the biodiversity of the Project Application Area by regenerating significant areas of pastureland to native bushland, while providing for the ongoing management of the Central Corridor.

The Project is considered to be in the public interest by providing quality passive and active recreational opportunities and open space areas. The Project includes earthworks for the future district playing fields which are described in Council's Section 94 Open Space Contributions Plan as the Lake Cathie Regional Sporting Complex. These facilities are essential in order to provide adequate facilities to the incoming future residential population of Area 14, as well as servicing the existing communities of Bonny Hills and Lake Cathie.

15.4 Conclusion

Potential environmental impacts resulting from the Project have been identified and measures and safeguards have been incorporated throughout the EA to manage these. The Project would be constructed and operated to meet existing environmental standards and the environmental performance of the Project would be monitored.

References

- Australian Greenhouse Office, 1998, *National Greenhouse Strategy, Strategic Framework for Advancing Australia's Greenhouse Response*
- Biolink, 2005, *Area 14 Structure Planning Area - Koala Plan of Management*, unpublished report to Port Macquarie- Hastings Council, Port Macquarie
- Clancy G and Ayres R, 1983, *Vegetation Survey and Fauna Survey*, Report to Cox and Corkhill Pty Ltd
- Commonwealth Department of Transport and Regional Services, *Federal Office of Road Safety Australian Design Rule ADR28- External Noise of Motor Vehicles*
- Commonwealth Department of Environment and Heritage, 2006, *Significant Impact Guidelines and Matters of National Significance*
- Ecologically Sustainable Development Steering Committee, 1992, *National Strategy for Ecologically Sustainable Development*
- EDAW, 2006, *Preliminary Environmental Assessment & Identification of Issues – Open Space Corridor & Constructed Wetland*, December
- Holmes and Holmes, 1993, *Geotechnical Appraisal for Development Options at Lake Cathie*, November
- Holmes and Holmes, 1998, *Preliminary Acid Sulfate Soil Investigation South of Lake Cathie*, December
- Holmes and Holmes, 2003, *Acid Sulfate Soil Investigation*, April
- Holmes and Holmes, 2004, *Acid Sulfate Soil Investigation*, April
- Mackay K and Bray D, 1997, *Threatened Species Impact Assessment*
- National Environment Protection Council, 1999, *National Environmental Protection Measure (Assessment of Site Contamination)*, December
- NSW Environment Protection Agency, 1994, *Guidelines for Consultants Reporting of Contaminated Sites*, November
- NSW Department of Planning, 2005, *Draft Guidelines for Assessment of Impacts on Threatened Species Under Part 3A*
- NSW Department of Environment, Climate Change and Water, 2007, *Floodplain Risk Management Guideline Practical Consideration of Climate Change*
- NSW Department of Environment and Conservation, 2004, *Draft Threatened Species Survey and Assessment – Guidelines for Developments and Activities*
- NSW Department of Environment and Conservation, 2004, *DECCW's Interim Community Consultation Requirements for Applicants*
- NSW Government, 1990, *NSW Coastal Management Manual*
- NSW Rural Fire Service, 2006, *Planning for Bushfire Protection 2006*
- Port Macquarie – Hastings Council, *Integrated Water Cycle Management (IWCM) Policy for Area 14*
- Port Macquarie – Hastings Council, 2001, *Hastings Urban Growth Strategy*
- Port Macquarie – Hastings Council, 2003, *Aus-Spec D7 Stormwater Management Specification*
- Port Macquarie – Hastings Council, 1997, *Aus-Spec Development Construction Specification C101 – General*
- Port Macquarie – Hastings Council, 1997, *Aus-Spec Development Construction Specification C201 – Control of Traffic*
- Port Macquarie – Hastings Council, 1997, *Aus-Spec Development Construction Specification C213 – Earthworks*
- Port Macquarie – Hastings Council, 1997, *Aus-Spec Development Construction Specification C211 – Control of Erosion and Sedimentation*

Port Macquarie – Hastings Council, 1997, *Aus-Spec Development Construction Specification C220 – Stormwater Drainage*

Royal Life Saving Society, *Guidelines for Water Safety in Urban Water Developments*

US Department of Commerce, National Oceanic and Atmospheric Administration,
[ftp://ftp.cmdl.noaa.gov/ccg/co2/trends/co2 mm mlo.txt](ftp://ftp.cmdl.noaa.gov/ccg/co2/trends/co2_mm_mlo.txt); accessed 16 February 2010

World Business Council for Sustainable Development, 2004, *The Greenhouse Gas Protocol, A Corporate Accounting and Reporting Standard*, Revised edition.