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PACIFIC OCEAN CATCHMENT PROFILE

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Chapter 5 PACIFIC OCEAN CATCHMENT

CATCHMENT OVERVIEW CATCHMENT AREA: 44.9KM²



WATERWAYS

SUMMARY OF DRAINAGE SYSTEM

The Pacific Ocean catchment includes two sub-catchments:

BATE BAY

PROVIDENTIAL COVE

MAJOR NAMES WATERWAYS	
MAJOR NAMED WATERWAYS:	(BATE BAY ONLY)
MAJOR NAMED WATERWAYS:	BLUE HOLE GAP TABBIGAI GAP YENA GAP
TOTAL LENGTH OF MAPPED WATERWAYS:	0.67 KMs
PRIMARY ORDER CREEKS:	0.00 KMs
SECOND ORDER CREEKS:	0.37 KMs
FIRST ORDER & MINOR DRAINAGE LINES:	0.30 KMs

GEOLOGY, GEOMORPHOLOGY AND SOILS

GEOLOGY AND GEOMORPHOLOGY

The Botany Basin includes two large tidal bays; Botany Bay (forming a separate catchment area in Sutherland Shire), and Bate Bay further south of that and east of Cronulla. Bate Bay is roughly oval with an entrance between Boat Harbour and Jibbon Point that seems to be very wide but three shallow rocky outcrops (Osborn Shoal, Merries Reef and Bombora off Jibbon) conceal an underwater ridge and the real entrance is at the southern end of Osborn Shoal.

The Bay is exposed to the dominant southeasterly storm waves and swells. While extensive dredging has been undertaken in the Port Hacking estuary, Bate Bay has not been so modified so water depths are never more than 20m. except at the rocky shallows over which waves break at high tide. The Hacking River (42 km in length) enters Bate Bay in its south-eastern corner and has a flow rate less than Georges River but greater than Cooks River.

Further south, the cliffs from Jibbon to Curracurrong Creek in Royal National Park are cut into Hawkesbury Sandstone. The sea eroded the cliffs at their base. The wet sandstone is weaker than dry sandstone, so the weight of rock in the cliff tends to crush the rock near sea level. The rock is also dampened by seepage from the land that emerges near sea level. Large joint blocks of sandstone are undercut and collapse, falling in a jumble at the base. Overhanging blocks fall under their own weight, and the piles of fallen blocks are broken up and gradually removed by waves.

Sandstone cliffs above the level of sea wash show undercutting from weathering, and are often decorated with Liesegang rings or honeycombing. In some places, such as Marley and Wattamolla, the cliffs are quite low. The streams running off the plateau have large catchment areas, and they have excavated deep narrow valleys. Small coves have formed at the mouth, and dunes block off the creeks to create lagoons. Further south the tilt of the plateau raises the older and softer Narrabeen Group sandstones to sea level. These cliffs are characterised by more deeply incised streams and sheer faces up to 40m high.



The sand dune system forming the seaward edge of the Kurnell peninsula is estimated to be about 15,000 years old. It was formed when the sea reached its present level and began to stabilise, between 9000 and 6000 BC. The Georges, Cooks and Towra Rivers flowed to the south-east beneath the present sand dune system near Wanda and joined the ocean at Bate Bay. This isolated Kurnell as an island separated from the mainland. The rivers eventually became blocked with accumulating sand and sediment as the sea level rose. As the rivers gradually silted up they were forced into changing their course and were led out to sea via La Perouse rather than continue to maintain an opening in an ever-growing sand barrier near Wanda. This resulted in a tombolo being formed and joined Kurnell with the Cronulla mainland. The deepest part of the ancient river channel now lies 100 meters below the surface at the southern end of the peninsula, near Wanda Beach.

The geology and geomorphology of the area is characterised by an island of outcropping bedrock on the eastern headland and joined to other bedrock outcrops on its western end by a sand spit which forms the main part of the headland. The Peninsula still has quite a view overlapping transgressive barrier dunes and it is believed that they have shifted north from Bate Bay. Older stable parabolic dunes occur on a series of north to south oriented ridges and while most of the vegetation has been cleared, some dry sclerophyll woodland remains.

SOILS

The main soil landscapes present in Pacific Ocean catchment are Kurnell (kn), Bundeena (bu), Gymea (gy), Wollongong (wg), Hawkesbury (ha), Yarrawarrah (ya) and Disturbed Terrain (xx). These are described in more detail below.

As part of the assessment process, Urban Land Capability and Rural Land Capability classes were determined for these soil landscapes. Urban capability is the ability of an area of land to support a particular intensity of urban development without serious erosion and sedimentation occurring during construction, and possible instability and drainage problems in the long term. For soil landscapes in Pacific Ocean catchment these are as follows:

- Kurnell: not capable of urban development
- Bundeena: low to moderate capability for urban development
- Gymea: low to moderate capability for urban development
- Wollongong: not capable of urban development
- Hawkesbury: not capable of urban development
- Yarrawarrah: low to moderate capability for urban development
- Disturbed Terrains are areas of land that have been highly modified through removal, disturbance or burial of the original soils as a result of human activities, and to a depth of 1m

In many parts of Sutherland Shire, areas classified as "not capable of urban development" have been extensively urbanised. These areas have experienced cracking of roads and buildings, sedimentation of streams, blocked drains and flooding.

Rural capability is the ability of an area to sustain permanent agricultural or pastoral production without permanent damage. Land which is used beyond its rural capability will deteriorate rapidly, resulting in permanent loss of soil resources. For soil landscapes in Pacific Ocean catchment the following assessments were made:

- Kurnell: not capable of regular cultivation or grazing
- Bundeena: not capable of regular cultivation or grazing
- Gymea: capable of grazing
- Wollongong: not capable of regular cultivation or grazing
- Hawkesbury: not capable of regular cultivation or grazing
- Yarrawarrah: not capable of regular cultivation or grazing

Much of the land in this part of Sutherland Shire was cleared for grazing, with some minor market gardening. The legacy of this early development is seriously depleted soil resources, particularly around Bate Bay.

Kurnell (kn): Gently undulating to rolling coastal dunefields and relict dunes. Local relief to 15m, slope gradients 1-10%. Dunes are generally north-south oriented with convex narrow crests, broad (1000-2000m) gently inclines concave swales and isolated swamps. Vegetation includes extensive heathland. Soils are deep (>2m) Podzols on dunes and in swales, with Organic Acid Peats in swamps. Limitations to use include extreme wind erosion hazard, highly permeable soils, very low fertility and localised permanently high water tables (Hazelton & Tille, 1990).

Bundeena (bu): Very low rolling rises on exposed Hawkesbury Sandstone coastal headlands, with local relief up to 80m and slope gradients <20%. Ridges and crests are broad, up to 200m wide, and gently inclined slopes with occasional benches are up to 50m wide. Small swamps and seepage areas are common on benches and along drainage lines. Rocky outcrops occur over 30-50% of the land surface. Soils are Siliceous Sands and Earthy Sands occurring on benches, with Yellow Earths on midslope and Gleyed Podzolic Soils on lower slopes. Acid peats occur in areas of poor drainage. Limitations to use include high erosion hazard, highly permeable soils, very low soil fertility and seasonally high watertables (Hazelton & Tille, 1990).

Gymea (gy): Undulating to rolling rises and low hills on Hawkesbury Sandstone with local relief 20-80m, slopes 10-25%, and rock outcrops <25%. Broad convex crests, moderately inclined side slopes with wide benches, localised rock outcrop on low broken scarps. Vegetation includes extensively cleared open forest (dry sclerophyll) and eucalypt woodland. Soils are shallow to moderately deep (30-100cm) Yellow Earths and Earthy Sands on crests and insides of benches, shallow (<20cm)Siliceous Sands on leading edges of benches, localised Gleyed Podzolic Soils and Yellow Podzolic Soils on shale lenses, and shallow to moderately deep (<1m) Siliceous Sands and Leached Sands along drainage lines. Limitations for use of these soils include localised steep slopes, high soil erosion hazard, rocky outcrops, shallow highly permeable soil and very low soil fertility (Hazelton & Tille, 1990).

Wollongong (wg): Beaches and coastal foredunes and hind dunes on Quarternary marine and windblown sands. Beach plains with relief up to 10m, slopes <3%; foredunes with relief <15m and slope gradients up to 35%. Vegetation includes spinifex grasslands and herblands to closed scrub on foredunes. Soils are deep (>2m) Calcareous Sands on beaches, Siliceous Sands on foredunes, and isolated Humus Podzols in swales. Limitations include extreme wind erosion hazard, non cohesive, highly permeable soils, very low soil fertility, localised flooding and permanently high watertables.

Hawkesbury (ha): Rugged, rolling to very steep hills on Hawkesbury Sandstone with local relief 100-200m, slopes >25%, and surface rock >50%. Narrow crests and ridges, narrow incised valleys, steep sideslopes with narrow rocky benches, broken scarps and boulders. Vegetation is mostly uncleared eucalypt woodland, open forest (dry sclerophyll) and tall open forest (wet sclerophyll). Soils are shallow (<50cm) discontinuous Lithosols/Siliceous Sands associated with rocky outcrops, Earthy Sands, Yellow Earths and locally deep sands on inside of benches and along joints and fractures, localised Yellow and Red Podzolic Soils associated with shale lenses, and Siliceous Sands on narrow valley flats. Limitations for use include extreme soil erosion hazard, mass movement (rock fall) hazard, steep slopes, rocky outcrops, shallow, stony, highly permeable soil, and very low soil fertility (Hazelton & Tille, 1990).

Yarrawarrah (ya): Undulating to rolling, low, broad-benched hills on Hawkesbury Sandstone associated with the staged planation of the Woronora Plateau. Ridges, hillcrests, valleys and drainage depressions are broad. Benches contain sedgeland, swamps and prominent sandstone outcrops. Vegetation includes low open woodland, shrubland, wet heath and sedgeland. Soils are Lateritic Yellow Earths and Lateritic Podzolic Soils on crests. Shallow (<20cm) Siliceous Sands/Lithosols are associated with rocky outcrops. Moderately deep Earthy Sands occur on benches. Localised Yellow Podzolic Soils and Gleyed Podzolic Soils in seasonally waterlogged areas, and Acid Peats in drainage depressions. Limitations for use include high erosion hazard, generally shallow soils with low wet bearing strength, highly permeable soils and seasonally high watertables, and very low fertility (Hazelton & Tille, 1990).

Disturbed Terrain (xx): Occurs within other landscapes and is mapped as xx. The topography varies from level plains to undulating terrain, and has been disturbed by human activity to a depth of at least 1m. The original soil has been removed, greatly disturbed or buried. Most of these areas have been levelled to slopes of <5%. Landfill includes oils, rock, building and waste material, and the original vegetation has been completely cleared. Limitations for this soil 'type' are dependent on the nature of fill material, and may result in a mass movement hazard (subsidence), soil impermeability leading to poor drainage, low fertility and toxic material (Hazelton & Tille, 1990).

SUMMARY OF CONTAMINATION ISSUES

In the 1930s the Holt family began its sand mining operations to supply the expanding Sydney building market and continued until 1990 with an estimate of over 70 million tonnes of sand being removed. The sand has been valued for many decades by the Sydney building industry, mainly because of its high crushed shell content and lack of organic matter. The site has now been reduced to a few remnant dunes and deep water-filled pits which are now being filled with demolition waste from Sydney's building sites. Removal of the sand has significantly weakened the peninsula's capacity to resist storms. Ocean waves pounding against the reduced Kurnell dune system have threatened to break through into Botany Bay, especially during the storms of May and June 1974 and August, 1998.

In 1951 Caltex Oil Company approached Sutherland Shire Council for the first time with a proposal to build an oil refinery at Kurnell. It required a large block of land of approximately 400 acres (1.6 km2) in size. At first the Council rejected this proposal. The matter sparked a number of protests from environmental groups and those concerned that the refinery would mar Captain Cook's Landing Place Reserve. Not long after the proposal, Sutherland Shire Council withdrew its objection, and what became known as the Australian Oil Refinery Company, a subsidiary of Caltex, began operating in 1954. Whilst the refinery was being built, the Council also built Captain Cook Drive to allow access to the refinery.

Industrialisation of the Kurnell Peninsula continues to be an ongoing problem amongst community groups and environmentalists. Plans for further development at the site has been cause for continual public protest between developers, locals and environmental groups. A proposal to build a chemical plant by the German pharmaceutical company, Bayer in 1986 resulted in public protests, environmental objections and a Commission of Inquiry. The plan never went ahead on the grounds of both environmental and economic issues.

In 2004 a major industrial development at the Kurnell site just north of Wanda Beach has been given the go-ahead by the Land and Environment Court. This has prompted fears that the State Government will now approve the construction of hundreds of homes on the site. The court upheld an appeal by Australand, allowing it to build on one-third of the 62hectare site, "subject to conditions such as safeguarding the environment." The site is the subject of ongoing debate and court cases as Australand continue to try to push through a major residential development in the area.

Other issues for the Bate Bay subcatchment include:

- Cronulla Sewage Treatment Plant
- Sydney Desalination Plant
- Kurnell Landfill, located in the former sand extraction areas owned by Consolidated Developments. The landfill handles thousands of tonnes of construction and demolition waste from the inner Sydney area each year.
- Ongoing sand mining, and the legacy of past sand mining, which has created holes and lakes up to 8m deep.
- Potter Point and Botany Cone both areas are degraded as a result of uncontrolled access to the area, including impacts from 4WDs, motor bikes and horses.
- Boat Harbour, which has been identified as one of the most polluted beaches in the Sydney basin, largely due to its proximity to the Potter Point sewage outfall.
- Caltex Oil Refinery, which continues to release effluent and cooling water via various ocean outfalls

In contrast to the Bate Bay subcatchment, Providential Cove is comparatively unimpacted. Main impacts are from recreational users of Royal National Park. Unsewered fishing shacks are randomly tenanted at several locations along the national park's coastline, including Garie and South Era.

LAND USE

HISTORIC LAND USE

The Pacific Ocean catchment includes coastal land immediately adjoining the ocean on both sides of Port Hacking. There are some major differences in geographic formation and patterns of modification and development of these areas. Immediately north of Port Hacking is generally low lying, with extensive sand dunes and a long ocean beach forming most of the coast line around Bate Bay. The northern end of Bate Bay is more steep and rough, with sheer sandstone cliffs forming the southern headland of Botany Bay further north again. These sandstone cliffs are replicated in the southern half of the catchment where they form most of the coastline except for several small coves, including Providential Cove (Wattamolla).

Both of these areas were in the more remote parts of Sutherland Shire. In general, the sandy soils were poor and unsuitable for cultivation. Pastures on these soils were also poor, and early attempts to establish grazing herds in the area were also generally unsuccessful. The area around Cronulla was the first to become developed, initially through proximity to better country and access from the developing road network. Earliest land grants included 700 acres around the Kurnell peninsula which were deeded to James Birnie in 1815. Birnie planned to establish a whaling station on the peninsula, and cleared and fenced the area before installing a manager. The farm was moderately successful under the manager, who produced fruit and vegetables and opened a small dairy (Ashton et al, 2006). In 1828 Birnie's holding was bought by John Connell to add to additional land grants in Sutherland Shire. He and his grandsons added to these properties over the next 30 years, and while John Connell did not live in the area, his grandson John Connell Laycock built and resided in Fernleigh, a sandstone house south of Cronulla at Burraneer Bay. By 1868 all of Laycock's lands were purchased by Thomas Holt.

South of Port Hacking did not follow the same pattern of development. It was considered even more remote and infertile than other parts of the shire. In fact, it was the lack of good grazing and farming land that prevented major exploitation of the area in the late 1800s. Despite this, timber gatherers and exploration for coal and minerals continued on a regular basis, and many licences were revoked when the entire area was declared a national park in 1879 (Stanley & Hutton-Neve, 1976).

CURRENT LAND USE

ZONING CLASS LEP 2006 Aquatic Reserves Arterial Road Deferred Matter Employment Environmental Housing Bushland Environmental Housing Scenic Quality Environmental Housing Sensitive Land Environmental Protection Low Impact Rural Environmental Protection Water Catchment Environmental Protection Waterways Excluded Local Centre Local Housing Mixed Use Kirrawee Multiple Dwelling A Multiple Dwelling B National Park Reserve and Recreation Area Neighbourhood Centre Private Recreation Public Open Space Public Open Space Bushland Railway Road Special Uses Transport Reservation Urban Centre

LEP ZONING DESCRIPTOR	HECTARES	% CATCHMENT	POTENTIAL IMPERVIOUS	HECTARES IMPERVIOUS
Deferred Matter	0.00	0%	0%	0.00
Environmental Housing Sensitive Land	0.00	0%	43%	0.00
Environmental Housing Scenic Quality	14.27	0%	57%	8.13
Environmental Housing Bushland	0.00	0%	57%	0.00
Local Housing	23.10	1%	51%	11.78
Multiple Dwelling A	0.58	0%	64%	0.37
Multiple Dwelling B	23.35	1%	64%	14.94
Mixed Use Kirrawee	0.00	0%	64%	0.00
Urban Centre	4.74	0%	94%	4.46
Local Centre	0.00	0%	88%	0.00
Neighbourhood Centre	0.00	0%	86%	0.00
Employment	0.00	0%	95%	0.00
Special Uses	5.33	0%	30%	1.60
Public Open Space	35.93	1%	5%	1.80
Public Open Space Bushland		0%	0%	0.00
Private Recreation	0.53	0%	5%	0.03
Environmental Protection Waterways	0.00	0%	0%	0.00
Aquatic Reserves	0.00	0%	0%	0.00
National Park Reserve and Recreation Area	3741.00	83%	0%	0.00
Railway		0%	33%	0.00
Arterial Road/Road	26.28	1%	66%	17.35
Transport Reservation	0.00	0%	5%	0.00
UNZONED	614.40	14%		0.00
TOTAL	4489.52	100%	1%	60.46

CATCHMENT IMPERVIOUS SURFACE (% AND DISTRIBUTION)

VEGETATION COMMUNITIES

NORTHERN SECTION: BATE BAY

Pacific Ocean catchment comprises two disjunct sections of land, immediately north and south of the entrance to Port Hacking. North of the port there is a range of communities that have developed on the massive sand dunes that once lined the sea coast, and others that line the tops of the sandstone seacliffs, or form perched wetlands in drainage depressions and small streams.

Grassy woodlands: Despite extensive clearing of the land around Botany Bay early last century, remnants of the original Kurnell Dune Forest still remain. These include a few bangalay trees, and small groves of swamp oak, cabbage tree palms and broad-leaved paperbark trees along the creeks. Away from the seacliffs at Kurnell, there is a Dune Forest community of Banksia, Pidgeon Berry and Wattle.

Heathlands: Heath and scrub covers much of the land, and is dominated by species such as tea-trees, banksias, Christmas bushes and some types of eucalypt. The heath and scrub around Kurnell played an important part in the nation's colonial history, as it was here that botanists Joseph Banks and Daniel Solander first explored Australia's native environment. Many of the plants growing in the area are direct descendants of the species that were studied on Cook's expedition. They include banksias, she oaks and grass trees.

Freshwater wetlands: There are small pockets of swampland around Kurnell, including hanging swamps along the Cape Baily Coast Walk that are home to the threatened tinkling froglet. A hanging swamp forms when there is a shallow depression next to the edge of a cliff. Water and organic matter collect in the depression, providing conditions in which swamp plants and animals can live. In some hanging swamps, the pile of organic matter regularly builds up higher than the edge of the cliff, causing part of the swamp to slide over the precipice.

SOUTHERN SECTION: PROVIDENTIAL COVE

South of Port Hacking is quite different, with tall seacliffs interspersed with small sandy beaches, usually with a chain of perched wetlands along the main drainage lines. The porous sandstone creates low nutrient, dry soils that form the basis for a diverse set of highly specialised plants. Key among these are those that form the coastal heathlands, littoral rainforests, and cover the exposed uplands.

Coastal heathland: Running the full coastal length of the coastline is coastal heathland, characterized by hardy, low-growing, salt-tolerant shrubs that spread across rocky, hard terrain with very little topsoil. The coast itself is composed mostly of high cliffs reaching a height of nearly one hundred metres at the southern end. These cliffs are punctuated by a number of fine, sandy beaches open to the ocean and providing fine swimming and surfing. Several of the beaches can be reached by road, others only by several hours bush walking.

There are a small number of rocky coves. The beaches, two of which have volunteer surf life saving clubs and large car parks, are amongst the most visited areas of the park. These heath lands are a hotspot for many small birds that have forsaken the suburbs of Sydney such as the beautiful New Holland Honeyeater.

Common vegetation on the exposed heaths on the headlands and cliffside paths include; Coastal Rosemary (*Westringia fruticosa*), Darwinia (*Darwinia fascicularis* ssp. *fascicularis*), Bracelet Honey-myrtle (*Melaleuca armillaris*), She-oak (*Allocasuarina distyla*), White Kunzea (*Kunzea ambigua*), Sundew (*Drosera spathulata*), Grass Trees (*Xanthorrhoea* spp.), Ridged Heath-myrtle (*Baeckea imbricata*), Snakehood Orchids (*Pterostylis* sp.), prostrate forms of Coast Banksia (*Banksia integrifolia*) and Long-Leaf Matrush (*Lomandra longifolia*).

Common Vegetation on top of the ancient sand dunes above the coastal path include: Silver Banksia (Banksia marginata), Scrub-oak (Allocasuarina distyla), Silky Hakea (Hakea sericea) and Pine Heath (Astroloma pinifolium). Sections of rare and threatened clifftop grasslands occur along exposed and windy sites which are generally dominated by Long-leaf Mat-Rush (Lomandra longifolia) and Kangaroo Grass (Themeda australis).

Many heath specialist birds are present in the heaths which include; Lewin Honeyeater (*Meliphaga lewinii*), New Holland Honeyeater (*Phylidonyris novaehollandiae*), Beautiful Firetail (*Stagonopleura bella*), Chestnut-rumped Heathwren (*Hylacola pyrrhopygia*) and the Southern Emu-wren (*Stipiturus malachurus*).

Littoral rainforest: Littoral rainforest that is often the first type of vegetation destroyed upon coastal developments has survived the ravages of the 19th and 20th Century in Royal National Park with an example growing behind Jibbon Beach which contains a typical Tuckeroo (*Cupaniopsis anarcoides*) forest under grown by Coastal Tea Tree (*Leptospermum laevigatum*) and Long-Leaf Matrush (*Lomandra longifolia*).

Exposed uplands: Moving farther inland the terrain rises to a series of very rocky ridges and plateaus characterized by hardy, low-growing shrubs and very poor, rocky soil. These ridges are the remnants of an ancient, much larger plateau that has been deeply eroded into an extensive series of river valleys. This specific ridge land habitat is particularly significant for Sydney as most similar habitat was left unprotected and was subsequently destroyed to make way for cheap development which has made many species only found ridges threatened with extinction due to extreme habitat clearance/fragmentation. Soils on plateau land are often up to 2m deep and consist of on Sandstone ridges: sandy podsol interspersed with pockets of clay derived. Clay Ridges and Plateaus also have deep Soils but are far rarer due to lack of representation in the park on these sites the soil is derived from Wianamatta clay and is considered rich land producing good quality forest.

VEGETATION COMMUNITIES IDENTIFIED

The following vegetation communities have been mapped in the Pacific Ocean catchment by Sutherland Shire Council:

- Sydney Sandstone Ridgetop Woodland
- Sydney Sandstone Gully Forest
- Kurnell Dune Forest
- Coastal Dune Heath
- Sydney Sandstone Heath
- Sydney Freshwater Wetland
- Littoral Rainforest

A brief description of these communities has been extracted from the Sydney Metropolitan CMA's draft Native Vegetation of the Sydney Metropolitan Catchment Management Authority Area, Volume 2: Vegetation Community Profiles (SMCMA, 2009). These are presented below.

Coastal Tea-Tree Banksia Scrub (Littoral Rainforest)

Coastal Tea-tree-Banksia Scrub is a littoral heath and scrub that occupies headlands, coastal foredunes and beach ridges near the open ocean. Typically it comprises a dense cover of coast tea-tree (Leptospermum laevigatum) and coast banksia (Banksia integrifolia subsp. integrifolia). The height of the scrub varies considerably in response to exposure to prevailing winds. This can result in a dramatically different visual appearance between patches. Despite the exposed locations there is usually some development of a soil profile as a result of clay influence in a sandstone headland or sheltering and protection from leeward scrubs on dune systems. This is sufficient to support some waxy-leaved and eucalypt species that otherwise prefer more sheltered environments in the littoral zone. These species may share or penetrate the canopy, but in the case of the former are more likely to be found amongst a shrub layer of hardy coast loving plants.

The distribution of the scrub forms a small and patchy distribution along the coastal zone of the Sydney region between Port Stephens and Wollongong. Elsewhere it is found on the NSW south coast.

Coastal Dune Littoral Rainforest (Littoral Rainforest)

A closed canopy dominated by tuckeroo (*Cupaniopsis anacardioides*) and a sandy substrate helps differentiate this littoral rainforest from others found in the Sydney basin. This community forms a low closed canopy of rainforest trees with an occasional emergent eucalypt, casuarina, banksia or paperbark. It is situated on recent sand deposits, typically in swales or depressions on low lying sheltered hind dunes less than 10 metres in elevation. Many tree species are shared with other littoral rainforest communities. These include lilly pilly (*Acmena smithii*) and cheese tree (*Glochidion ferdinandi*). In the Sydney region the threatened species the magenta lilly pilly (*Syzygium paniculatum*) has also been recorded amongst the small tree layer.

Only small isolated stands of this rainforest occur in the SMCMA on the Kurnell Peninsula. At Towra Point the understorey is threatened by encroaching lantana, spreading from sites of previous disturbance. The lantana can smother the understorey, inhibiting the development of the ferns and vines that are otherwise present in less disturbed sites. While similar habitats are found south of Sydney, tuckeroo is not present and the sand littoral rainforests are considered to form part of the Temperate Littoral Rainforest community (Tozer et al. 2006).

Invasive weeds such as *Lantana camara* and *Chrysanthemoides monilifera* subsp. *monilifera* are prolific in disturbed landscapes that adjoin the remaining stands in the Sydney basin.

Coastal Sand Mantle Heath (Sydney Sandstone Heath)

Coastal Sand Mantle Heath is an open to closed heath found on shallow to moderately deep sand mantles that are perched above some of Sydney's major sandstone headlands. The landscape on which it occurs are a component of the relictual dune systems that are formed from windblown deposits of sand. As a result of their age they have been exposed to long periods of weathering and soil leaching that has produced highly podsolised soils. These shallower dunes support a wallum heath community that is unlike those found on Pleistocene dunes elsewhere in the greater Sydney Region.

The heath tends to have a diverse range of larger shrubs with coast tea-tree (*Leptospermum laevigatum*), wallum banksia (*Banksia aemula*), scrub she-oak (*Allocasuarina distyla*) and heath-leaved banksia (*Banksia ericifolia*) commonly recorded, though no single species dominates at all sites. The composition of the heath, such as the prominence of the heath-leaved banksia, appears to reflect a transitional environment between the sandstone headland heaths nearby and the heaths found on deeper dunes.

Occasionally there are localised patches of emergent low growing eucalypts that include red bloodwood (*Corymbia gummifera*) and smooth-barked apple (*Angophora costata*). More consistent however is the diverse range of woody shrubs such as wattles, geebungs, peas, grevilleas and paperbark amongst others. A number of other smaller plants are indicative of a sand heath assemblage. These include wedding bush (*Ricinocarpos pinifolius*), grass tree (*Xanthorrhoea resinosa*) and tree broom-heath (*Monotoca elliptica*). The cover of vegetation found on the ground is variable depending on disturbance and drainage conditions. On drier sites that carry a more open heath structure a dense cover of ferns can be found whereas poorly drained sites will include a greater abundance and cover of sedge species. This heath community is situated on headlands at North Head, Malabar, La Perouse and the Kurnell Peninsula. It is restricted to elevations between 20-80 metres ASL.

Past clearing has removed a significant proportion of the original extent of this community from headland dune systems in the Eastern Suburbs. The North Head dune system was

cleared and has regenerated since the end of the Second World War. The recovery plan for Eastern Suburbs Banksia Scrub (DEC 2004) indicates that further clearing and habitat fragmentation are continuing threats. Remnants are further impacted by urban related disturbances including weed invasion, heavy recreational pressures, rubbish dumping, inappropriate fire regimes and altered hydrological regimes.

Coastal Headland Banksia Heath (Sydney Sandstone Heath)

Coastal Headland Banksia Heath is a closed heath community found on Hawkesbury sandstone rock platforms associated with ocean and harbour headlands and coastal plateau. These exposed environments are underlain by a skeletal and infertile soil. Typically heath-leaved banksia (*Banksia ericifolia* subsp. *ericifolia*) and scrub she-oak (*Allocasuarina distyla*) form the dominant upper strata. Tick bush (*Kunzea ambigua*) may also be common, and sample sites where this species was dominant appear to have been disturbed in the past. These larger shrubs may be overtopped by a sparse cover of emergent mallee-form eucalypts. Other woody shrubs include wattle (*Acacia longifolia*), needlebush (*Hakea teretifolia*), *Darwinia fascicularis*, and pink tea-tree (*Leptospermum squarrosum*). The rare sprawling shrub wrinkled kerrawang (*Rulingia hermanniifolia*) is also encountered in the lower shrub layer. Many sites have impeded drainage because the sandstone bedrock is very close to the surface. The ground cover can at times have a sparse cover of sedges amongst clumps of forbs.

This heath is found at many of the prominent vantage points of Sydney Harbour including Middle, North and South Heads and the Kurnell and Bundeena Peninsulas. These are flat plateau like landforms that have minor sandstone benching and outcropping. It is not restricted to exposed clifflines, but is restricted to lower coastal elevations (10-120metres ASL) in zones of higher rainfall (1200-1400mm per annum).

Past clearing for suburban developments has cleared significant stands of this scrub in the SMCMA particularly in the eastern suburbs and other harbourside suburbs. Threats to remaining stands arise from infection by Phytophthora (a fungus of plant roots resulting in dieback), inappropriate fire regimes, rubbish dumping and heavy recreational impacts at harbourside sites.

Coastal Headland Cliffline Scrub (Sydney Sandstone Heath)

Sandstone Headland Cliffline Scrub is a very restricted community found in a narrow band above Sydney's dramatic coastline cliffs and headlands. These are very exposed locations and the vegetation is pruned by sea-breezes. Bracelet honey-myrtle (*Melaleuca armillaris*), scrub she-oak (*Allocasuarina distyla*), heath-leaved banksia (*Banksia ericifolia* subsp. *ericifolia*) are the most common woody shrubs. The low shrub *Baeckea imbricata* is very common, particularly as the cliff edge nears or where the water table is close to the surface (Adam et al. 1989; Fullerton 1998). Other woody shrubs that are encountered include coastal rosemary (*Westringia fruticosa*), coast wattle (*Acacia longifolia* subsp. *sophorae*), and needlebush (*Hakea teretifolia*) amongst others. The ground cover is sparse and variable in composition. Drier sites feature small herbs such as woolly xanthosia (*Xanthosia pilosa*). Wetter sites may include sedges and rushes such as scale-rush (*Lepyrodia scariosa*) amongst a patchy cover of bryophytes.

This community is closely associated Hawkesbury sandstone rock platforms on headlands; however a small number of sites are located on poorly drained sand mantles on sandstone headlands. Within the SMCMA it is found at headlands at Kurnell, La Perouse, North Head, and in Royal National Park. It extends south to Jervis Bay and north to the Central Coast.

Past clearing for cliff-top developments has cleared significant stands of this scrub in the SMCMA. Although many examples are included with the reserve system, the invasive weed bitou bush (*Chrysanthemoides monilifera* subsp. *rotundata*) was recorded in or adjoining half of the sample sites. Remnants in the urban environment are threatened by rubbish dumping and heavy recreational use.

Coastal Sandstone Heath-Mallee (Sydney Sandstone Heath)

Coastal Sandstone Heath-Mallee is one of several sandstone heath communities that are found within Sydney's coastal zone. It is restricted to the extensive Hawkesbury Sandstone plateaus within Royal NP where there is a unique combination of gently sloping landscape, very high mean annual rainfall (>1200mm) and low elevations (20-200m ASL).

It is located away from the maritime influences found on headlands and cliff edges and occupies areas some distance from the coastline, although close enough to receive high rainfall. It is a dry open to dense shrub community mostly of low height unless fire has been absent for long periods. The upper strata may include low emergent eucalypts including the Port Jackson mallee (*Eucalyptus obstans*) which was found at just under half of the sample sites. Other eucalypts may include species which are more common in sandstone woodland communities, but here they grow in stunted mallee-like forms.

The shrub layer is very diverse. Multiple species are often recorded within a single genus. For example taller shrubs such as old-man banksia (*Banksia serrata*) and slender tea-tree (*Leptospermum trinervium*) grow alongside fern-leaved banksia (*Banksia oblongifolia*) and pink tea-tree (*Leptospermum squarrosum*). Similar patterns are found for the array of hakeas, wattles, grevilleas and geebungs. Other common taller shrub species include scrub she-oak (*Allocasuarina distyla*), and the sprawling dwarf apple (*Angophora hispida*). Open areas of sandy soil and rock are often more extensive that the small herbs and grass-like plants which provide a sparse ground cover.

Much of the original extent of this community is likely to persist today. Extensive areas present in Royal NP are threatened by too frequent intense wildfire leading to extinctions of local populations (Keith 2004). Other pressures are localised in areas of recreation use.

Coastal Sandplain Heath (Coastal Dune Heath)

Coastal Sandplain Heath is an open to dense shrubland community found on large, deep Pleistocene sand dunes along the NSW coast. In the SMCMA area it occurs south of Sydney Harbour. This heath has also adapted to the impoverished podsolised soils that are associated with older hind dunes and headland sand masses found along the coastal zone. It occurs on deep Pleistocene sand dunes such as at Kurnell where depth reaches 40 metres and at Jibbon near Bundeena in Royal NP. It also occurs on smaller though prominent dunes at La Perouse. Deep dunes would have been far more extensive between Botany and Woollhara, however these are now highly modified and urbanised with remaining vegetation very highly disturbed.

In the SMCMA area, the heath layer supports an open cover of stunted old-man banksia (*Banksia serrata*) and scrub sheoak (*Allocasuarina distyla*). At times clumps of low eucalypts may be present. The remainder of the dense shrub layer comprises a wide variety of woody species such as tea-trees, grevilleas, peas and wattles. The ground layer comprises on open cover of sedges and forbs.

Coastal and urban development and sand mining have depleted extensive stands of this heath community across its range in NSW. Within the SMCMA large areas are likely to have been lost in the eastern suburbs. Further clearing and habitat fragmentation are continuing threats. Remnants are impacted by a range of urban related disturbances including weed invasion, heavy recreational pressures, rubbish dumping, inappropriate fire regimes and altered hydrological regimes. In Royal National Park local dune erosion may occur from recreational pressures and trampling by Feral Deer represents. Weed invasion particularly from bitou bush (*Chrysanthemoides monilifera* subsp. *rotundata*) and frequent fire may also impact upon the community.

Coastal Foredune Wattle Scrub (Coastal Dune Heath)

This low dense scrub is found on coastal sandmass frontal dunes and beach ridges along the eastern coastline of NSW. Coast tea-tree (*Leptospermum laevigatum*), coastal wattle (*Acacia longifolia* subsp. *sophorae*) are pruned by the prevailing winds that buffet these exposed scarped dunes. Throughout the SMCMA this assemblage suffers from chronic infestation of bitou bush (*Chrysanthemoides monilifera* subsp. *rotundata*). Some of the small patches that remain are derived from native plantings as part of dune stabilisation works and bush regeneration. As a result some scrubs are species poor. More diverse remnants include salt tolerant succulent herbs and grasses, several of which are unique to these environments.

Coastal foredunes have been heavily cleared and modified by urban development. A high proportion of the total taxa recorded in this community are exotic. Some sites are simplified by profuse regeneration of coast teatree (Leptospermum laevigatum), a species that strongly recolonises disturbed ground (Keith 2004). High levels of disturbance arise from recreational pressures associated with beach and boating leisure.

Coastal Sand Littoral Forest (Kurnell Dune Forest)

Coastal Sand Littoral Forest describes a forest and woodland community that incorporates a prominent component of littoral rainforest species amongst the sclerophyllous shrub and small tree layer. The forest floor is well shaded by tuckeroo (*Cupaniopsis anacardioides*) and other waxy-leaved species often occurring at or below a canopy of banksia, casuarina and/or eucalypt trees. A high diversity of vines can be found across multiple layers of the vegetation. The woody vine cockspur thorn (*Maclura cochinchinensis*), identifiable by its long spikes, is a useful diagnostic species for the community. Habitat and disturbance are both very influential in the structure and composition of the community at any given location. It is restricted to coastal sand deposits receiving greater than 1050 millimeters of mean annual rainfall.

The most extensive areas remain on the older low-lying (c. 1.5-10 metres asl) transgressive barrier dunes along the northern side of the Kurnell Peninsula. On the drier siliceous sands the forest forms a eucalypt dominated forest comprising bangalay (*Eucalyptus botryoides*) and/or swamp mahogany (*Eucalyptus robusta*) with a grassy and ferny ground cover. On the humic podsols associated with poorly drained areas eucalypts are less prominent and are dominated by tall coast banksia (*Banksia integrifolia* subsp. *integrifolia*) and swamp oak (*Casuarina glauca*) above a ground cover of sedges thriving amongst the water logged soils. Above 10 metres asl this community is increasingly restricted to sheltered situations where there is greater protection from prevailing winds and fire. Eucalypts may once have consistently dominated; however, today lower growing banksia scrubs with young regenerating eucalypts are more common.

Widespread and intensive disturbance arising from sand mining, industrial and urban development has resulted in extensive loss of this community. In many instances the original topography of the landscape has irreversibly changed with the loss and migration of sand dunes. Extant areas are often in dynamic stages of succession and heavily cloaked in invasive weeds such as lantana (*Lantana camara*) and bitou bush (*Chrysanthemoides monilifera* subsp. *rotundata*).

Coastal Sand Swamp Paperbark Scrub/Coastal Sand Swamp Sedgeland (Sydney Freshwater Wetlands)

Freshwater wetlands in lagoons and depressions are a feature of the large low-lying sand deposits found along the coast. These sites carry a complex of reedlands, rushlands and herbfields which fringe open water or cover shallower soaks. There are a wide variety of water loving species that can occur at different sites. Generally there is little woody vegetation with only scattered individuals of emergent small trees and shrubs. A complex array of sedgelands may be found including twigrushes (*Baumea* spp.), saw-sedges (*Gahnia* spp.), and tall spike rush (*Eleocharis sphacelata*). Tall reeds such as common reed (*Phragmites australis*) may completely dominate as they do in the highly disturbed Botany

Wetlands. These may obscure smaller herbs such as slender knotweed (*Persicaria decipiens*).

Threats facing this community are high. Coastal sand flats have been extensively cleared and modified on the Kurnell Peninsula, Botany, Sans Souci and around the lagoon systems of the northern beaches. As well, these sites are subject to habitat degradation resulting from altered hydrology/nutrient levels, weed invasion, off-road vehicles, illegal waste dumping and sand extraction.

Illawarra Escarpment Bangalay-Banksia Forest (Sydney Sandstone Gully Forest)

South from Garie in Royal National Park, the coastal escarpment reveals the underlying claystone beneath the Hawkesbury sandstone plateau. The escarpment here is exposed to the open ocean and the full force of the prevailing southerly winds. A stunted sometimes gnarled open forest occurs on these clayey soils. Low growing bangalay (*Eucalyptus botryoides*) and coast banksia (*Banksia integrifolia* subsp. *integrifolia*) mix with turpentine (*Syncarpia glomulifera*) and smooth-barked apple (*Angophora costata*). The latter appears to drop out of the canopy as the influence of the sandstone talus from the eroding clifflines diminishes.

The understorey retains a moist open shrub and small tree layer that closely resembles the taller forests found along the Hacking River and Illawarra escarpment. This mix of rainforest species is retained by a combination of the fertile soils and very high mean annual rainfall. Most locations are less than 300 metres from the open ocean, where on steep southerly slopes, it may extend from sea level to the top of the escarpment at elevations around 250 metres above sea level.

Within the Sydney basin the primary distribution occurs within the boundaries of Royal National Park. Small areas have been cleared during the Depression in the 1930s for shacks. Local weed infestations persist around these areas of human habitation. Trampling and grazing by feral deer imposes local impacts particularly where remnants remain close to open grassy areas. Outside of the Sydney basin around 40% of the remaining stands are heavily disturbed (NPWS 2002c)

Coastal Sandstone Sheltered Peppermint-Apple Forest (Sydney Sandstone Gully Forest)

Coastal Sandstone Apple-Peppermint Gully Forest is widely distributed along the eastern extent of Sydney sandstone plateau. It occupies sheltered aspects on infertile Hawkesbury sandstone geology in areas that receive in excess of 1000mm of mean annual rainfall. Sydney peppermint (*Eucalyptus piperita*) and smooth-barked apple (*Angophora costata*) form a moderately tall open forest. These are rocky environments and the understorey is a diverse mix of heath and shrub species such as banksias, tea-trees and wattles. The taller NSW Christmas bush (*Ceratopetalum gummiferum*) is also commonly encountered and is conspicuous in early summer when it flowers profusely. South of Sydney it is the spectacular large red flower and luxuriant green leaves of the Gymea lily (*Doryanthes excelsa*) that immediately catches the eye. They are found scattered across the forest floor amongst patches of ferns, grasses, sedges and rock outcrops. The community is found distributed below elevations of 500 metres above sea level.

Clearing of this community has not been extensive because the community occurs on infertile sandy soils and steep rocky slopes unsuitable for both agriculture and urban development. Localised impacts however occur where urban development abuts remnant sandstone gullies. Local weed problems and frequent fire are the most common issues.

Coastal Sandstone Exposed Scribbly Gum Woodland (Sydney Sandstone Ridgetop Woodland)

Coastal Sandstone Exposed Scribbly Gum Woodland is a low eucalypt woodland with a diverse heathy understorey found on Hawkesbury Sandstone ridge tops in the north-east of the Woronora Plateau. It is associated with high mean annual rainfall (>1200mm) and coastal elevations (10-250 metres ASL). In these moister climates sites are dominated by scribbly gum (*Eucalyptus haemastoma/Eucalyptus racemosa*) and/or silvertop ash (*Eucalyptus sieberi*) however it is red bloodwood (*Corymbia gummifera*) that occurs amongst the canopy at almost every site.

The rainfall level also appears to encourage a very diverse and dense shrub layer in which five species of banksia are known to occur. The taller old-man banksia (*Banksia serrata*) and heath-leaved banksia (*Banksia ericifolia* subsp. *ericifolia*) are the most common. Other genera are similarly diverse with multiple species of Hakeas, Wattles, Tea-trees and Peas found within the community. The ground cover is a sparse cover of forbs, grasses and sedges. The distinctive Gymea lily (*Doryanthes excelsa*) occurs amongst the ground and lower shrub layers on sites of heavily eroded ironstone laterite. These mantles are a feature of the central and eastern Woronora Plateau.

It occurs extensively throughout Royal National Park, eastern sections of both Woronora catchment area and Dharawal Nature Reserve. The original extent of the community has been diminished by clearing for urban development between Heathcote and Sutherland although a far greater proportion still remains within protected areas on Woronora Plateau. Frequent fire represents the greatest impact, particularly in Royal NP. Other impacts are likely to be highly localised including rubbish dumping, illegal bike trails, weed infestations near urban edges and clearing.

SIGNIFICANT VEGETATION

MAPPED VEGETATION COMMUNITIES OF PACIFIC OCEAN CATCHMENT

COMMUNITY	HECTARES
COASTAL DUNE HEATH	213.76
KURNELL DUNE FOREST	47.43
LITTORAL RAINFOREST	6.44
SYDNEY FRESHWATER WETLAND	26.08
SYDNEY SANDSTONE GULLY FOREST	4.06
SYDNEY SANDSTONE HEATH	184.75
SYDNEY SANDSTONE RIDGETOP WOODLAND	26.14

LEP 2006 SIGNIFICANT VEGETATION

LEP TAG	NAME	CLASS
T71	Cupaniopsis anacardioldes & endangered	Significant Group of Trees or
1/1	rainforest	Vegetation

THREATENED SPECIES: FLORA RECORDS

SCIENTIFIC NAME	COMMON NAME	LEGAL STATUS
Pterostylis sp. Botany Bay	Botany Bay Bearded Orchid	E1
Diuris aequalis	Buttercup Doubletail	E1
Senecio spathulatus	Coast Groundsel	E1
Eucalyptus camfieldii	Heart-leaved Stringybark	V
Syzygium paniculatum	Magenta Lilly Pilly	V
Wilsonia rotundifolia	Round-leafed Wilsonia	E1
Acacia terminalis subsp. terminalis	Sunshine Wattle	E1
Prostanthera densa	Villous Mint-bush	V
Thelymitra atronitida		E4A

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THREATENED SPECIES: FAUNA RECORDS

Records of threatened bird species in Pacific Ocean catchment during the last 30 years include (from NSW Wildlife Atlas, 2011; accessed March, 2011):

SCIENTIFIC NAME	COMMON NAME	LEGAL STATUS
Circus assimilis	Spotted Harrier	V
Hieraaetus morphnoides	Little Eagle	V
Pandion haliaetus	Osprey	V
Esacus neglectus	Beach Stone-curlew	E4A
Charadrius leschenaultii	Greater Sand-plover	V
Charadrius mongolus	Lesser Sand-plover	V
Diomedea exulans	Wandering Albatross	E1

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SCIENTIFIC NAME	COMMON NAME	LEGAL STATUS
Thalassarche cauta	Shy Albatross	V
Thalassarche melanophris	Black-browed Albatross	V
Haematopus fuliginosus	Sooty Oystercatcher	V
Haematopus longirostris	Pied Oystercatcher	E1
Gygis alba	White Tern	V
Sterna albifrons	Little Tern	E1
Sterna fuscata	Sooty Tern	V
Epthianura albifrons	White-fronted Chat	V
Petroica boodang	Scarlet Robin	V
Macronectes giganteus	Southern Giant Petrel	E1
Rtorodroma poglacta poglacta	Kermadec Petrel (west	M
Plerouronna neglecta neglecta	Pacific subspecies)	V
Pterodroma nigripennis	Black-winged Petrel	V
Lathamus discolor	Swift Parrot	E1
Pezoporus wallicus wallicus	Eastern Ground Parrot	V
Polytelis swainsonii	Superb Parrot	V
Calidris alba	Sanderling	V
Calidris tenuirostris	Great Knot	V
Ninox connivens	Barking Owl	V
Ninox strenua	Powerful Owl	V
Tyto tenebricosa	Sooty Owl	V

Records of threatened mammal species in Pacific Ocean catchment during the last 30 years include (from NSW Wildlife Atlas, 2011; accessed March, 2011):

SCIENTIFIC NAME	COMMON NAME	LEGAL STATUS
Eubalaena australis	Southern Right Whale	V
Megaptera novaeangliae	Humpback Whale	V
Cercartetus nanus	Eastern Pygmy-possum	V
Dugong dugon	Dugong	E1
Arctocephalus forsteri	New Zealand Fur-seal	V
Arctocephalus pusillus doriferus	Australian Fur-seal	V
Pteropus poliocephalus	Grey-headed Flying-fox	V
Miniopterus schreibersii	Eastern Pontwing bat	M
oceanensis	Eastern Bentwing-Dat	V
Chelonia mydas	Green Turtle	V
Varanus rosenbergi	Rosenberg's Goanna	V

Records of threatened frog, reptile and invertebrate species in Pacific Ocean catchment during the last 30 years include (from NSW Wildlife Atlas, 2011; accessed March, 2011):

SCIENTIFIC NAME	COMMON NAME	LEGAL STATUS
Litoria aurea	Green and Golden Bell Frog	E1
Crinia tinnula	Wallum Froglet	V
Heleioporus australiacus	Giant Burrowing Frog	V
Pseudophryne australis	Red-crowned Toadlet	V

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THREATENING PROCESSES

SUMMARY OF IMPACTS

The following key impacts have been identified for the Bate Bay section of the catchment:

- Accidental discharges from Cronulla Sewage Treatment Plant, especially during high rainfall periods
- Release of highly saline water, and risk of spills from Sydney Desalination Plant
- Leachates and risk of spills from Kurnell Landfill, which handles construction and demolition waste.
- Ongoing sand mining, and the legacy of past sand mining, which has created holes and lakes up to 8m deep.
- Potter Point and Botany Cone both areas are degraded as a result of uncontrolled access to the area, including impacts from 4WDs, motor bikes and horses.
- Boat Harbour, which has been identified as one of the most polluted beaches in the Sydney basin, largely due to its proximity to the Potter Point sewage outfall.
- Caltex Oil Refinery, which continues to release effluent and cooling water via various ocean outfalls
- Accidental spills and toxic discharges from other industries on the Kurnell peninsula, including the recent chemical spill during a fire in a water treatment plant adjoining the refinery site.

BATE BAY SUBCATCHMENT

SUBCATCHMENT OVERVIEW CATCHMENT AREA: 7.49 KM²

SUBURBS: CRONULLA

Chapter: BATE BAY SUBCATCHMENT

WATERWAYS MAJOR NAMED WATERWAYS: BLUE HOLE GAP TABBIGAI GAP YENA GAP TOTAL LENGTH OF MAPPED WATERWAYS: 0.67 KMs PRIMARY ORDER CREEKS: 0.00 KMs SECOND ORDER CREEKS: 0.37 KMs FIRST ORDER & MINOR DRAINAGE LINES: 0.30 KMs

WATER QUALITY ASSESSMENT

As part of their Strategic Water Quality Monitoring Plan, Sutherland Shire Council commenced monitoring water quality in a number of streams across the shire. Trends in water quality data collected from each stream were assessed and ranked against the ANZECC 2000 guidelines for recreational water quality in urban streams (SSC, 2004).

Samples were analysed summer and winter for between three and seven years at each site. This data has been interpreted here to give a brief historic summary of water quality in the subcatchment. First and last reported values for each parameter were assessed as higher (+) than the ANZECC 2000 guideline value, lower (-) than the guideline value, or equivalent (=) to the guideline value. The overall trend during the survey period was identified as increasing (\uparrow) or decreasing (\downarrow). This provides an indication whether management actions are having a positive effect on water quality, and whether further actions are required, for example, a parameter that exceeds the guideline value at the start of the survey period may still exceed it at the end of the period, but have shown significant improvements during the reporting period.

Three sites were sampled in Bate Bay subcatchment:

PARAMETER	NH3	BOD	Cu	Pb	Zn	
SUMMER 95	+	+	+	+	=	E
+/- ANZECC						1EN
2000 values						
WINTER 02	+	+	-	-	+	
+/- ANZECC						Ja
2000 values						
TREND $\downarrow \uparrow$	\uparrow	\checkmark	\checkmark	\checkmark	\uparrow	
PARAMETER	Enterococci	Grease	TN	ТР	TSS	ц Ц
SUMMER 95	+	=	+	+	+	
+/- ANZECC						
2000 values						nte
						c q J

1. North Cronulla Beach

WINTER 02	+	-	+	+	-
+/- ANZECC					
2000 values					
TREND $\downarrow \uparrow$	\wedge	\rightarrow	\downarrow	\uparrow	\checkmark

A number of parameters showed an increase in values during the survey period, notably enterococci and total phosphorus which were consistently outside ANZECC 2000 guideline values. Decreases in values for other parameters were reported, a number of which were within guideline values at the end of the survey period.

2. South Cronulla GPT

PARAMETER	NH3	BOD	Cu	Pb	Zn
SUMMER 95	+	+	+	+	=
+/- ANZECC					
2000 values					
SUMMER 00	+	+	+	+	+
+/- ANZECC					
2000 values					
TREND ↓↑	\rightarrow	\rightarrow	\rightarrow	\rightarrow	\uparrow
		-			
PARAMETER	Enterococci	Grease	TN	ТР	TSS
PARAMETERSUMMER 95	+	Grease =	TN +	- TP	TSS +
PARAMETER SUMMER 95 +/- ANZECC	+	Grease =	<u>TN</u> +	- -	+
SUMMER 95 +/- ANZECC 2000 values	+	Grease =	<u>TN</u> +	- -	+
PARAMETER SUMMER 95 +/- ANZECC 2000 values SUMMER 00	+ ++	Grease = -	+ +	- +	+ +
PARAMETER SUMMER 95 +/- ANZECC 2000 values SUMMER 00 +/- ANZECC	+ ++	Grease = -	<u>+</u> +	- +	+ +
PARAMETERSUMMER 95+/- ANZECC2000 valuesSUMMER 00+/- ANZECC2000 values	+ + ++	Grease = -	+ +	- +	+ +

A number of parameters showed an increase in values during the survey period, notably enterococci, total nitrogen and total phosphorus, which were consistently outside ANZECC 2000 guideline values. Decreases in values for other parameters were reported, a number of which were within guideline values at the end of the survey period.

3. Shelly Beach Cronulla

PARAMETER	NH3	BOD	Cu	Pb	Zn
SUMMER 95	+	+	+	+	+
+/- ANZECC					
2000 values					
WINTER 02	=	-	+	-	-
+/- ANZECC					
2000 values					
TREND↓↑	\rightarrow	\rightarrow	\checkmark	\checkmark	\checkmark
PARAMETER	Enterococci	Grease	TN	ТР	TSS
SUMMER 95	+	+	+	+	+
+/- ANZECC					
2000 values					

C 2

WINTER 02	+	-	+	-	-
+/- ANZECC					
↓2000					
values					
TREND $\downarrow \uparrow$	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark

A reduction in values were reported for all parameters surveyed, resulting in many falling within ANZECC 2000 guidelines at the end of the sampling period.

Chapter: BATE BAY SUBCATCHMENT

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LOCATION OF SQIDS

ID	DEVICE CATEGORY	DEVICE TYPE	LOCATION	SITE DESCRIPTION	SUBURB	APPROX. CATCHME NT
12	GPT	GPT	Kingsway	North Cronulla	Cronulla	3 7 Ha
57	End of pipe trap	Nettech Device	The Esplanade	Blackwood Beach, Northern	Cronulla	2.4 Ha
58	End of pipe trap	Nettech Device	The Esplanade	Blackwood Beach, Southern	Cronulla	1.2 Ha
59	End of pipe trap	Nettech Device	The Esplanade	Shelley Beach, opposite middle of park	Cronulla	23.6 Ha
60	End of pipe trap	Nettech Device	Beach Street	Oak Park	Cronulla	5.0 Ha
110	End of pipe trap	Nettech Device	The Esplanade	Shelley Beach, south of tidal pool	Cronulla	2.3 Ha
6	GPT	GPT	The Esplanade	Cronulla Beach	Cronulla	7.7 Ha
161	GPT	GPT	Marine Esplanade	Beach	Cronulla	1.8 Ha
174	GPT - Other	Ecosol GPT	Ingalara Avenue	Coastal	Cronulla	4.2 Ha
190	GPT - Other	Litter Basket	Mitchell Rd	20-34 Mitchell Rd - carpark	Cronulla	0.18 Ha
191	GPT - Other	Litter Basket	Mitchell Rd	20-34 Mitchell Rd - carpark	Cronulla	0.18 Ha
192	GPT - Other	Infiltration Trench	Mitchell Rd	20-34 Mitchell Rd - grassed area below carpark	Cronulla	0.18 Ha
193	GPT - Other	Infiltration Trench	Mitchell Rd	20-34 Mitchell Rd - grassed area below carpark	Cronulla	0.18 Ha
11	GPT	GPT	Kingsway (Dunningham Park)	North Cronulla Beach	Cronulla	2 На
198	GPT	CDS	Gerrale St	Gerrale St Carkpark	Cronulla	3.5 Ha

GEOLOGY, GEOMORPHOLOGY AND SOILS

Bate Bay subcatchment soil landscapes include Wollongong Soil Landscape (wg) around foreshore areas, along with small areas of Kurnell Soil Landscape (kn). Central parts of the Kurnell Peninsula were also Kurnell Soil Landscape (kn), while the peninsula headland had a narrow strip of Hawkesbury Soil Landscape (ha) along the ocean foreshore, with Bundeena Soil Landscapes (bu) forming the bulk of the headland soils. Areas around Cronulla and Wanda beaches had Gymea Soil Landscape (gy) immediately behind the foreshore and toward Glaisher Point, while the suburban centre of Cronulla is described as Disturbed Terrain (xx) (from Soil Landscapes of the Wollongong-Port Hacking 1:100 000 Sheet Map and Report; see summary explanations in Geology and Soils section for Woronora River catchment).

TOPOGRAPHY

Land adjoining the beach areas of Cronulla and Wanda are all below 15m AHD, with higher areas up to 25m at the southern end of Glaisher Point. Highest parts of the subcatchment are in the north, with plateaus behind the sea cliffs reaching heights up to 36m AHD.

LEP (00 &06) CLASS	HECTARES
CLASS 1	.02
CLASS 2	2.09
CLASS 3	38.70
CLASS 4	89.95
CLASS 5	602.58

ASS/PASS, URBAN SALINITY

Most of the Bate Bay subcatchment is considered Class 5 ASS, with areas of Class 4 ASS behind Cronulla and Wanda Beaches. Smaller areas of Class 3 ASS are dispersed behind the Class 4 areas.

OTHER CONTAMINATION ISSUES None noted

LAND USE

HISTORIC LAND USE

Bate Bay was once known as Whale Bay, after the great herds of whales that passed here as they migrated from the southern seas to the north Pacific seas to breed. While the area has been commonly known as Bate Bay for all the 20th century, it was not officially recognised until 1973 (Lawrence, 1997). Bate Bay drains the areas of Cronulla, Oak Park and parts of Woolaware. Up until the 1890s the Cronulla area was characterised by windswept coastal heath and magnificent sandhills. Removal of sand dunes from what is now North Cronulla beach has had a significant impact.

The Cronulla area was once part of the Holt-Sutherland Estate. They leased land to Captain Springall who built a hotel in 1888. Springall's Oriental Hotel was a wooden building in an isolated area, and his main customers were mainly sportsmen and Sydney residents wanting a change of air. The beaches and sea air were a popular attraction. By 1895 the government was subdividing land on the peninsular south from Surf Road and lots were offered for public auction. There was only the hotel, a few huts and a wharf in the area at the time. Land was set aside for public buildings including a school and mechanics institute. There were further land auctions in 1897 and 1900, and the area was officially named Cronulla in 1908 (Lawrence, 1997).

By 1910 Cronulla was a small fishing village and a popular but sleepy holiday resort. The opening of the Sutherland-Cronulla tramway in 1911 increased visitors to the area, but even in 1915 it was still considered a country area. For many years Cronulla retained its village atmosphere, with several dairies and a pig farm at the current site of Cronulla High School. Despite the flurry of speculative subdivisions, Cronulla remained a resort of weatherboard and fibro holiday cottages until the 1960s. By the 1980s the holiday guest houses had vanished and were being replaced by high rise units and hotels. The trend towards high density development has continued into the 21st century.

CURRENT LAND USE

CATCHMENT IMPERVIOUS SURFACE (% AND DISTRIBUTION)

LEP ZONING DESCRIPTOR	HECTARES	% CATCHMENT	POTENTIAL IMPERVIOUS	HECTARES IMPERVIOUS
Deferred Matter	0.00	0%	0%	0.00
Environmental Housing Sensitive Land	0.00	0%	43%	0.00
Environmental Housing Scenic Quality	14.27	2%	57%	8.13
Environmental Housing Bushland	0.00	0%	57%	0.00
Local Housing	23.10	3%	51%	11.78
Multiple Dwelling A	0.58	0%	64%	0.37
Multiple Dwelling B	23.35	3%	64%	14.94
Mixed Use Kirrawee	0.00	0%	64%	0.00
Urban Centre	4.74	1%	94%	4.46
Local Centre	0.00	0%	88%	0.00
Neighbourhood Centre	0.00	0%	86%	0.00
Employment	0.00	0%	95%	0.00
Special Uses	5.33	1%	30%	1.60
Public Open Space	35.93	5%	5%	1.80
Public Open Space Bushland		0%	0%	0.00
Private Recreation	0.53	0%	5%	0.03
Environmental Protection Waterways	0.00	0%	0%	0.00
, Aquatic Reserves	0.00	0%	0%	0.00
National Park Reserve and Recreation Area		0%	0%	0.00
Railway		0%	33%	0.00
Arterial Road/Road	26.28	4%	66%	17.35
Transport Reservation	0.00	0%	5%	0.00
UNZONED	614.40	82%	0%	0.00
TOTAL	748.52	100%	8%	60.46

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VEGETATION COMMUNITIES

MAPPED VEGETATION COMMUNITIES

- 213.76 HECTARES COASTAL DUNE HEATH
- 47.43 HECTARES KURNELL DUNE FOREST
- 6.44 **HECTARES** LITTORAL RAINFOREST
- 26.08 **HECTARES** SYDNEY FRESHWATER WETLAND
- 4.06 **HECTARES** SYDNEY SANDSTONE GULLY FOREST
- 184.75 HECTARES SYDNEY SANDSTONE HEATH
- 26.14 HECTARES SYDNEY SANDSTONE RIDGETOP WOODLAND

- **Coastal Dune Heath Kurnell Dune Forest**
- Littoral Rainforest
- Sydney Freshwater Wetland Sydney Sandstone Gully Forest
- Sydney Sandstone Heath
- Sydney Sandstone Ridgetop Woodland

Chapter: BATE BAY SUBCATCHMENT

LEP 2006 SIGNIFICANT VEGETATION

LEP		
TAG	NAME	CLASS
	Cupaniopsis anacardioldes & endangered	
T71	rainforest	Significant Group of Trees or Vegetation

BUSHLAND RESERVES AND RESTORATION

Reserves

1) Greenweb Core areas

- Bate Bay sand dunes
- Wanda Reserve

2) Greenweb Support areas

• Captain Cook Dr/Bay Bay Rd

3) Greenweb Restoration areas

- Hume Rd/Mitchell Rd/Girrilang Rd/Tullimbar Rd/Wyanbah Rd/Seaview St/Judd St/Ocean St/Burke Rd/Gosport St
- Railway corridor
- Cronulla Park/Cronulla Point foreshores/Shelly Park/The Esplanade/Oak Park/Bass and Flinders Point

Bushcare Groups

- Bass and Flinders Point
- The Esplanade Cronulla
- John McKinn Park

THREATENING PROCESSES

INSTREAM IMPACTS

- Loss of riparian habitat
- Degradation of riparian habitat
- Loss of emergent vegetation
- Removal of large woody debris
- Loss or reduction of allochthonous material as a stream input
- Loss or reduction of shading of stream
- Changes to the proportion of catchment impervious surface
- Changes to infiltration patterns
- Construction of dams and other impediments to flow

- Draining of wetland areas
- Channelization
- Modification of channel bedform
- Modification of bank configuration
- Pipe replacement of channel
- Erosion
- Sedimentation
- Point source pollution
- Non-point (diffuse) source pollution
- Increased nutrient loads
- Introduction of toxic compounds
- Introduction of oils and organobenzenes
- Introduction of herbicides and pesticides in runoff
- Reduction of light penetration
- Algal bloom
- Emergent aquatic weeds
- Floating aquatic weeds
- Change in temperature regime
- Barriers to fish passage
- Change to hydrological flow regimes
- Change to pH through mobilisation of ASS/PASS
- Stormwater deposition of litter
- Dumping of rubbish
- Increased allocthonous inputs immediately following fire or clearing
- Increased peak discharges associated with storm flows
- Decreased baseflows
- Diseases from untreated or poorly treated sewage
- Reduction in water through extraction
- Introduction of invasive species including
 - o Gambusia
 - o Carp
 - o Cane Toads
 - o Koi Carp (goldfish)

RIPARIAN IMPACTS

- Invasion by weeds
- Loss of species through replacement by others
- Loss of diversity (reduction in species numbers)
- Loss of habitat quality

Chapter: BATE BAY SUBCATCHMENT

- Disturbance from pedestrian access
- Disturbance from vehicle access
- Disturbance from excessive use by stock or other animals
- Clearing of vegetation
- Deliberate introduction of exotic plant species
- Selective removal of vegetation including
 - Loss of canopy
 - o Loss of shrub layer
 - o Loss of groundcover species
- Removal of habitat elements including
 - o Loss of leaf litter
 - Loss of fallen timber
 - Loss of standing dead trees
 - o Loss of rocks
 - Loss of microhabitat architecture
- Dumping of rubbish
- Littering
- Vandalism including
 - o Damage to plants
 - o Damage to abiotic habitat elements
 - Injured or killed animals
- Inappropriate fire regime
- Erosion
- Sedimentation
- Plant diseases including
 - Phytophthora (dieback)
 - o Myrtle rust
 - o Smut
 - o Common rust
 - o Mistletoes
- Feral animals including
 - o Foxes
 - o Rabbits
 - o Deer
 - o Cane Toads
 - $\circ \quad \text{Wild pigs} \quad$
 - o Feral cats
 - Introduced birds

Chapter: BATE BAY SUBCATCHMENT

RECREATED WATERWAYS MAP

CURRENTLY MAPPED WATERWAYS AND CATCHMENT BOUNDARY

PROVIDENTIAL COVE SUBCATCHMENT

SUBCATCHMENT OVERVIEW

CATCHMENT AREA: 37.41

SUBURBS:

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TOTAL LENGTH OF MAPPED WATERWAYS: NIL MAPPED

WATER QUALITY ASSESSMENT

As part of their Strategic Water Quality Monitoring Plan, Sutherland Shire Council commenced monitoring water quality in a number of streams across the shire. Trends in water quality data collected from each stream were assessed and ranked against the ANZECC 2000 guidelines for recreational water quality in urban streams (SSC, 2004).

Samples were analysed summer and winter for between three and seven years at each site. This data has been interpreted here to give a brief historic summary of water quality in the subcatchment. First and last reported values for each parameter were assessed as higher (+) than the ANZECC 2000 guideline value, lower (-) than the guideline value, or equivalent (=) to the guideline value. The overall trend during the survey period was identified as increasing (\uparrow) or decreasing (\downarrow). This provides an indication whether management actions are having a positive effect on water quality, and whether further actions are required, for example, a parameter that exceeds the guideline value at the start of the survey period may still exceed it at the end of the period, but have shown significant improvements during the reporting period.

No sites were sampled in this subcatchment.

RETICULATED STORMWATER SYSTEM LOCATION OF SQIDS

NIL

GEOMORPHIC SETTING

GEOLOGY, GEOMORPHOLOGY AND SOILS

Providential Cove subcatchment soil landscapes include areas of Bundeena Soil Landscape (bu) behind foreshores at Jibbon Head, with Hawkesbury Soil Landscape (ha) in areas south from there. Minor areas of Kurnell Soil Landscape (kn) occur at Marley Beach, and Wollongong Soil Landscape (wg) around Wattamolla Lagoon. Inland parts of the catchment have Hawkesbury Soil Landscape (ha) along major drainage lines, with alternating ridges of Yarrawarrah Soil Landscape (ya) and Bundeena Soil Landscape (bu) on the plateaus of the escarpment (from Soil Landscapes of the Wollongong-Port Hacking 1:100 000 Sheet Map and Report; see summary explanations in Geology and Soils section for Woronora River catchment).

TOPOGRAPHY

Low points associated with major waterways reach altitudes of 30m AHD. The land then rises to the plateaus in the west, with a maximum height of 150m AHD.

ASS/PASS, URBAN SALINITY

LEP (00 &06) CLASS	HECTARES
CLASS 5	19

A small area of Class 5 ASS is associated with dune areas around Jibbon Head; the remainder of the subcatchment has not been mapped for potential acid sulphate soils.

OTHER CONTAMINATION ISSUES

None noted

LAND USE

HISTORIC LAND USE

All of the Providential Cove catchment falls within the Royal National Park. In 1796 Matthew Flinders and George Bass set out in the Tom Thumb to investigate Port Hacking. Strong winds swept them about 40km south from the Port, and they battled for 3 or 4 days before anchoring under sheltered cliffs about 30km from Port Hacking. More bad weather followed and they ran north, despairing if they would survive (Stanley & Hutton-Neve, 1976). Sighting breakers, they ran Tom Thumb through them and found themselves in a natural harbour which they named Providential Cove. Flinders preferred the aboriginal name for the area, Wollo Mowlee, and it became known as Wattamolla.

Further exploration of the area continued over the next few years. Bass arrived at Wattamolla after crossing from near Camden. He later returned on orders from Governor Hunter to examine coal seams visible around Coal Cliff, south of the national park. In his opinion, and others, the land south of Port Hacking was not suitable for agriculture, with porous and infertile sandy soils that would not support crops or stock.

Despite this, when it was taken over by the National Park Trust in 1879, wild herds of cattle roamed the area. Timber had been logged, and there were leases for the extraction of timber and minerals in the area (Stanley & Hutton-Neve, 1976). A number of parcels of land were privately owned, including land at Bundeena, Wattamolla, Costens Point, Gogerly's Point and Warumbul. The land at Wattamolla was later incorporated into Royal National Park and today the whole of this subcatchment is contained within the park. Most of the land in this area is considered unsuitable for cultivation or grazing, with porous soils derived from the underlying sandstone on clifftops exposed to the influences of the sea. As a result, little serious development took place in the area and it remains comparatively unchanged.

A number of shanty towns comprising fishing shacks began to develop in the late 1800s, and were tolerated by the Park's trustees. By 1919 these weekend camps were a popular institution in the park (Ashton et al, 2006). These proliferated in the early 1930s following the Depression, and lined the coast between Jibbon and Garie. Their presence in the park was cause for considerable contention as the residents lived off the resources of the park. Picking and selling wildflowers such as waratahs and Christmas Bush was particularly widespread. While most of these shacks have gone, some remain around Garie, and their presence is still a contentious issue within the park.

CURRENT LAND USE

ZONING CLASS LEP 2006

Aquatic Reserves Arterial Road Environ Deferred Matter Employment
 Environmental Housing Bushland
 Environmental Housing Scenic Quality
 Environmental Housing Sensitive Land
 Environmental Protection Low Impact Rural Environmental Protection Water Catchment Environmental Protection Waterways Excluded Local Centre Local Housing Mixed Use Kirrawee Multiple Dwelling A Multiple Dwelling B National Park Reserve and Recreation Area Neighbourhood Centre Private Recreation Public Open Space Public Open Space Bushland Railway Road Special Uses Transport Reservation Urban Centre

Chapter: PROVIDENTIAL COVE SUBCATCHMENT

CATCHMENT IMPERVIOUS SURFACE (% AND DISTRIBUTION)

LEP ZONING DESCRIPTOR	HECTARES	% CATCHMENT	POTENTIAL IMPERVIOUS	HECTARES IMPERVIOUS
Deferred Matter	0.00	0%	0%	0.00
Environmental Housing Sensitive Land	0.00	0%	43%	0.00
Environmental Housing Scenic Quality	0.00	0%	57%	0.00
Environmental Housing Bushland	0.00	0%	57%	0.00
Local Housing	0.00	0%	51%	0.00
Multiple Dwelling A	0.00	0%	64%	0.00
Multiple Dwelling B	0.00	0%	64%	0.00
Mixed Use Kirrawee	0.00	0%	64%	0.00
Urban Centre	0.00	0%	94%	0.00
Local Centre	0.00	0%	88%	0.00
Neighbourhood Centre	0.00	0%	86%	0.00
Employment	0.00	0%	95%	0.00
Special Uses	0.00	0%	30%	0.00
Public Open Space Public Open Space Bushland	0.00	0%	0%	0.00
Private Recreation	0.00	0%	5%	0.00
Environmental Protection Waterways	0.00	0%	0%	0.00
Aquatic Reserves	0.00	0%	0%	0.00
National Park Reserve and Recreation Area	3741.00	100%	0%	0.00
Railway	0.00	0%	33%	0.00
Arterial Road/Road	0.00	0%	66%	0.00
Transport Reservation	0.00	0%	5%	0.00
TOTAL	3741.00	100%	0%	0.00

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VEGETATION COMMUNITIES

MAPPED VEGETATION COMMUNITIES NIL MAPPED

LEP 2006 SIGNIFICANT VEGETATION NIL

BUSHLAND RESERVES AND RESTORATION

Reserves

1) Greenweb Core areas

Royal National Park

2) Greenweb Support areas

- None noted
- 3) Greenweb Restoration areas
 - None noted

Bushcare Groups

• Friends of Royal National Park

THREATENING PROCESSES

INSTREAM IMPACTS

- Loss of riparian habitat
- Degradation of riparian habitat
- Loss of emergent vegetation
- Removal of large woody debris
- Loss or reduction of allochthonous material as a stream input
- Loss or reduction of shading of stream
- Changes to the proportion of catchment impervious surface
- Changes to infiltration patterns
- Construction of dams and other impediments to flow
- Draining of wetland areas
- Channelization
- Modification of channel bedform

Chapter: PROVIDENTIAL COVE SUBCATCHMENT

- Modification of bank configuration
- Pipe replacement of channel
- Erosion
- Sedimentation
- Point source pollution
- Non-point (diffuse) source pollution
- Increased nutrient loads
- Introduction of toxic compounds
- Introduction of oils and organobenzenes
- Introduction of herbicides and pesticides in runoff
- Reduction of light penetration
- Algal bloom
- Emergent aquatic weeds
- Floating aquatic weeds
- Change in temperature regime
- Barriers to fish passage
- Change to hydrological flow regimes
- Change to pH through mobilisation of ASS/PASS
- Stormwater deposition of litter
- Dumping of rubbish
- Increased allocthonous inputs immediately following fire or clearing
- Increased peak discharges associated with storm flows
- Decreased baseflows
- Diseases from untreated or poorly treated sewage
- Reduction in water through extraction
- Introduction of invasive species including
 - o Gambusia
 - o Carp
 - o Cane Toads
 - o Koi Carp (goldfish)

RIPARIAN IMPACTS

- Invasion by weeds
- Loss of species through replacement by others
- Loss of diversity (reduction in species numbers)
- Loss of habitat quality
- Disturbance from pedestrian access
- Disturbance from vehicle access
- Disturbance from excessive use by stock or other animals

- Clearing of vegetation
- Deliberate introduction of exotic plant species
- Selective removal of vegetation including
 - Loss of canopy
 - o Loss of shrub layer
 - o Loss of groundcover species
- Removal of habitat elements including
 - o Loss of leaf litter
 - o Loss of fallen timber
 - Loss of standing dead trees
 - \circ Loss of rocks
 - o Loss of microhabitat architecture
- Dumping of rubbish
- Littering
- Vandalism including
 - o Damage to plants
 - o Damage to abiotic habitat elements
 - o Injured or killed animals
- Inappropriate fire regime
- Erosion
- Sedimentation
- Plant diseases including
 - Phytophthora (dieback)
 - o Myrtle rust
 - o Smut
 - o Common rust
 - o Mistletoes
- Feral animals including
 - o Foxes
 - o Rabbits
 - o Deer
 - o Cane Toads
 - $\circ \quad \text{Wild pigs} \quad$
 - o Feral cats
 - o Introduced birds

RECREATED WATERWAYS MAP

CATCHMENT ELEVATION MODEL: STREAM ORDERS AND CATCHMENT BOUNDARIES

ELEVATION (metres)

155.749349
138.128255
124.573568
113.052083
100.852865
90.4609375
81.6503906
73.0657552
66.9661458
60.4147135
53.8632812
45.9563802
38.2753906
29.6907552
18.3951823
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