SUTHERLAND SHIRE WATERCOURSE ASSESSMENT & REHABILITATION PRIORITISATION

VOLUME 2

CHAPTER 3

HACKING RIVER CATCHMENT PROFILE

2012

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DOCUMENT VERIFICATION

Project Title	**Sutherland Shire Watercourse Assessment & Rehabilitation Prioritisation**
Document Title	**Hacking River Catchment Profile**
Description	**Final report**
Client	**Sutherland Shire Council**
Client contact	**Ms Shelley Reed**

Revision	Prepared by	Reviewed by	Date
A	**AC MB**	**SR**	**May 2011**
B			
C			
0			

ACKNOWLEDGMENTS

APPLIED ECOLOGY Pty Limited wishes to thank all representing organisations who contributed to the production or commented on the content of this report, including:

Shelley Reed, Rosemary Kearney, Christine Guthrie Sutherland Shire Council

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Chapter 3 HACKING RIVER CATCHMENT

COMPRISING

KANGAROO CREEK SUBCATCHMENT

CATCHMENT AREA: **67.2 KM^2**

SUBURBS: ENGADINE
HEATHCOTE
GRAYS POINT

WATERWAYS

SUMMARY OF DRAINAGE SYSTEM

The Hacking River catchment includes one sub-catchments:

KANGAROO CREEK

MAJOR NAMED WATERWAYS: UNMAPPED

TOTAL LENGTH OF MAPPED WATERWAYS: UNMAPPED

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 (↑) or decreasing (↓). 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.

Two sites were sampled in Kangaroo Creek subcatchment:

1. Kangaroo Creek

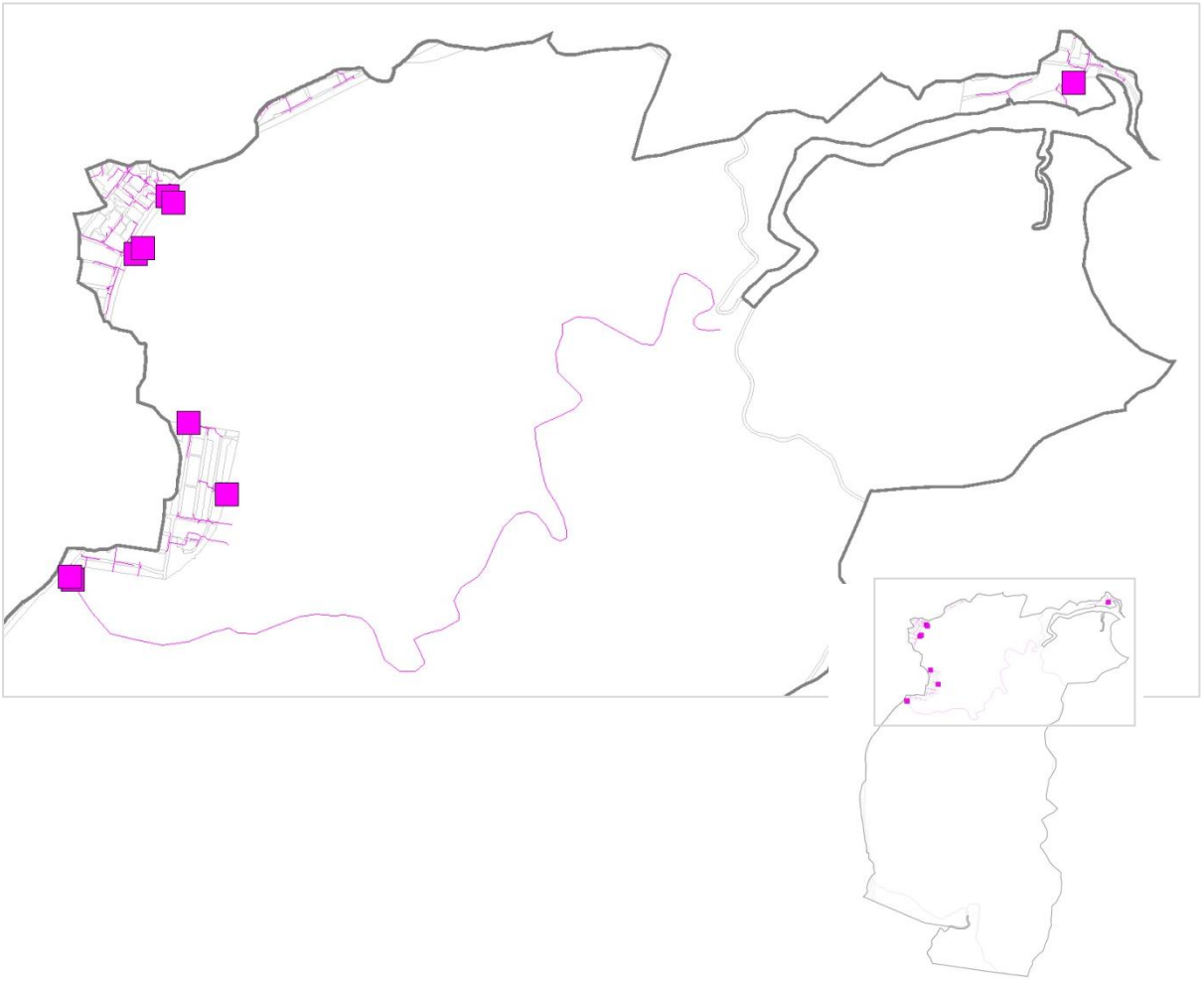
Insufficient data was recorded at this site and results were not reported.

2. Hacking River at Audley Weir

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

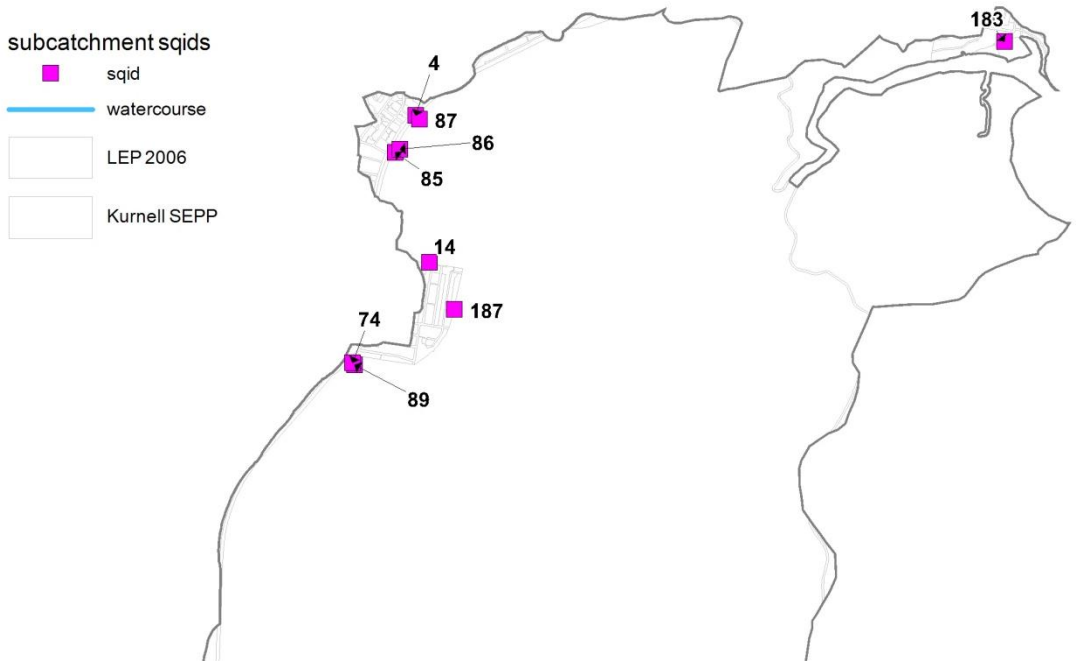
A reduction in values was recorded for most parameters sampled, so that all parameters were reported to be within ANZECC 2000 guideline limits at the end of the survey period.

RETICULATED STORMWATER SYSTEM



LOCATION OF SQIDS

ID	DEVICE CATEGORY	DEVICE TYPE	LOCATION	SITE DESCRIPTION	SUBURB	APPROX. CATCHMENT
4	GPT	GPT	Mianga Avenue (opposite)	National Park (access by locked gate Wilson Parade)	Engadine	16.8 Ha
14	GPT	Ecosol GPT	The Avenue	National Park	Heathcote	8.2 Ha
85	GPT	GPT	Engadine Avenue (opposite)	National Park (access by locked gate Wilson Parade)	Engadine	36 Ha
86	Wetland	Wetland	Engadine Avenue	National Park (access by locked gate Wilson Parade)	Engadine	36 Ha
87	Wetland	Wetland	Mianga Avenue (opposite)	National Park (access by locked gate Wilson Parade)	Engadine	16.8 Ha
89	Wetland	Wetland	Wilson Parade	Emergency Control Centre	Heathcote	1.6 Ha
74	GPT - Other	Sand Filter	Wilson Parade	Emergency Control Centre	Heathcote	1.6 Ha
183	GPT	CDS	Swallow Rock Drive	Western Side of road	Grays Point	7.4 Ha
187	GPT - Other	Trash Rack	Bottle Forest Rd	Near Rear of No.2 Mimosa St in NP	Heathcote	4.9 Ha



GEOLOGY, GEOMORPHOLOGY AND SOILS

GEOLOGY AND GEOMORPHOLOGY

The Hacking River drains an area that forms the southernmost part of the Sydney Basin. On the perimeter of the basin coal crops out at the surface, at Lithgow and Katoomba, and south near Coalcliff. These coal deposits formed around 230-280 million years ago during the Permian period and underlay the existing surface terrain in the Hacking River catchment. During the Triassic period massive rock building took place, forming the dominant geology of the area. Three distinct groups of strata were laid down:

1. Narrabeen shales and sandstones, followed by
2. Hawkesbury sandstones, and then
3. Wianamatta Group of shales

The Narrabeen Group of sediments is actually a complex series of layers of claystones, sandstones, shales and conglomerates. The uppermost layers have been dissected by the Hacking River and Bola Creek, and have underpinned the formation of vegetation communities in lowlying parts of the catchment.

The Hawkesbury Sandstone is the major rock unit in the catchment, and overlays the Narrabeen Group, reaching a maximum thickness of 250 metres. It comprises grains of quartz (sand) cemented together with iron and aluminium minerals, and forms clay after weathering. Iron is the cause of the colouring in sandstone, and helps to differentiate the coloured Hawkesbury sandstones from the pale Narrabeen sandstone. The iron oxides form bands of colours of yellow, orange and dark red, known as Liesegang rings, and are formed by the movement of water through minute holes and cracks in the rock.

Hawkesbury sandstone is a moderately strong rock mechanically, allowing it to stand in high cliffs. It is strongly jointed, with vertical fractures that extend through several layers within the rock. The joints and horizontal beds divide the sandstone into large blocks which can break away from a cliff, leaving a nearly vertical face.

The Wianamatta Group includes the most recent depositional layers, and comprises alternating series of alluvial, estuarine and beach sediments. Deposition was sporadic, and often involved filling depressions in the underlying Hawkesbury sandstone. Midway through the Tertiary period the whole mass of rock was gently uplifted, so that rocks that had been almost flat became tilted. Since then, streams have been eroding the surface of the land, and much of the Wianamatta Group has been stripped from the Woronora Plateau, leaving the Hawkesbury Sandstone exposed to form the catchment's land surface.

SOILS

The main soil landscapes present in Hacking River catchment are Gymea (gy), Hawkesbury (ha), Mangrove Creek (mc), Bundeena (bu) and Yarrawarrah (ya). No areas of disturbed

terrain are currently recorded for this catchment. The soil landscapes present 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 Hacking River catchment these are as follows:

- Gymea: low to moderate capability for urban development
- Hawkesbury: not capable of urban development
- Mangrove Creek: not capable of urban development
- Bundeena: low capability for urban development
- Yarrawarrah: low capability for urban development

Urban development has been largely excluded from this catchment following its incorporation into a national park in 1879. The little residential development that did occur was centred along the major waterways, and tended to be impermanent shanties, and was often accompanied by clearing for rural pursuits.

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 Hacking River catchment the following assessments were made:

- Gymea: not capable of regular cultivation or grazing
- Hawkesbury: not capable of regular cultivation or grazing
- Mangrove Creek: not capable of regular cultivation or grazing
- Bundeena: not capable of regular cultivation or grazing
- Yarrawarrah: not capable of regular cultivation or grazing

Some of the land in this part of Sutherland Shire was cleared for grazing, with some minor market gardening and mining of clay for brickmaking and gravels for road construction. Today, much of this is hidden under a layer of regenerated native vegetation. The soil landscapes listed above are described in the following sections:

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).

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).

Mangrove Creek (mc): Level to gently undulating tidal flats/mudflats, mangrove and saltmarsh on Quarternary Marine sediments. Local relief and elevation is <3m, slope gradients <3%. Regularly inundated by tidal waters. Vegetation includes mangrove open scrub, saltmarsh herbfield, sedgeland and low open forest. Soils are deep (>2m) waterlogged Calcareous Sands and Siliceous Sands on mangrove flats, with deep (>2m) Calcareous Sands, occasional Siliceous Sands and Humic Gley Soils on saltmarsh and forest flats. Use of these soils is limited by regular tidal flooding and water logging, acid sulphate potential, saline soils, and very low soil fertility (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).

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).

SUMMARY OF CONTAMINATION ISSUES

The Royal National Park was dedicated in 1879 and included an area of 18 000 acres. Over the years this has grown to 64 000 acres (Albani & Cotis, 2007). Initially the park was a place for pleasure activities such as picnics and socialising. The early approach to management included manicured parks, gardens, lawns, lakes and aviaries. To complete the European setting, deer were introduced. At the time the park had few measures for protection and extractive exploitation was allowed to continue.

More recently the park has become managed as bushland with multiple values, including recreation, conservation and preservation. Interest groups such as bushwalkers achieved considerable expansion into the park. As a result, the park's bushland is not even close to pristine, with remnants of buildings along waterways, and exotic plants testimony to a century of use. The catchment of the Hacking River continues to have an important influence on the Port Hacking estuary, providing its main source of freshwater and sediment.

The township of Helensburgh with a garbage tip, coal mine with coal washing leachate, the Princes Highway, farms including piggeries, the unsewered Garawarra Hospital and horse riding establishments all contribute to the contaminant loading for the Hacking River. Pollutants continue to leach from the garbage tip into the river. Fine particulate matter from coal washing is regularly discharged, and horse urine concentrations in river water during dry spells regularly reach levels that are toxic to native wildlife. A single road crash on the Princes Highway is believed to have caused the demise of the river's platypuses. Wildfire increases the sediment load delivered to the river system for up to 12 months, until revegetation has reached a point where sediments are stabilised in situ.

LAND USE

HISTORIC LAND USE

Prior to the arrival of European settlers the Hacking River area was inhabited by aboriginal people for over 8,500 years (Barton & Turner, 2011). There is evidence to suggest that there was more water in Hacking River at that time and consequently it was wider and deeper. There is also evidence that it was a cleaner river, with a sandy bed rather than a muddy one, and that the lower reaches were rich with seafood. The Dharawal people inhabited the area when Europeans arrived; prior to around 500BC it is believed that another language group of people inhabited the area. Fish were the main food source, and this was supplemented with possums, lace monitors, snakes, eels and turtles, hunted by women, and whales and kangaroos hunted by men. Many varieties of plant foods were available, including figs, yams and other roots, berries and fruits. A large number of occupation sites along Hacking River indicate the area was used by two or three families, totalling 30 to 45 people. Favourite camping places appear to be those with a good northerly aspect and well sheltered from winds and drizzle, and were usually close to the shoreline.

Henry Hacking first arrived in the colony as quartermaster on the Sirius in 1788, part of the First Fleet. After the wreck of the Sirius in 1790 he boarded the Royal Admiral, and returned to Sydney in 1792. Being an adventurous man, he was keen to explore the new land, and led expeditions to try to cross the Blue Mountains in 1794. In 1795 he explored the area south of Sydney that became known as Cowpastures, and later while kangaroo hunting he discovered the port and river that now carry his name (Kavanagh, 2004). Matthew Flinders and George Bass set off in 1796 to explore the river in the Tom Thumb II. After encountering storms on the way they entered Port Hacking and camped in a small bay on the northern shore before exploring some distance up the river.

The lower reaches of the Hacking River were home to a number of families, including the Costens and the Gogerlys. Both these families built houses in the area, and were later commemorated in the naming of places in the area. Upstream was difficult to navigate by boat, and a long way from any established roads, and was comparatively unimpacted by the advancing waves of development and urbanisation that passed through other parts of the Shire in the late 1800s and early 1900s. Most of the Hacking River catchment was incorporated into the national park, declared in 1879. A dam was built at Audley in 1883, and the river cleared of snags. This changed the Hacking River and Kangaroo Creek from tidal estuarine to freshwater streams. The river was navigable above the dam for steam launches of “moderate draught” for almost 7kms. After more than 100 years the dam has caused increased siltation, and today it is difficult to get a rowing boat even 2kms upstream (Stanley & Hutton-Neve, 1976).

From the early 1900s shacks proliferated along the river front, and the area became known for its untidiness, rubbish and rowdiness. The shack dwellers were given permissive

occupancies and regarded with tolerance by the park trustees. Pressure to remove the shacks began in the early 1930s, but was initially frustrated by the onset of the Depression. For some time the number of shacks in the area increased, and it was not until the early 1950s that the last of the shacks around Audley were removed (Stanley & Hutton-Neve, 1976). Following the visit of Queen Elizabeth in 1954 the park became known as Royal National Park, and in 1967 control was ceded to the newly formed National Parks and Wildlife Service.

KANGAROO CREEK

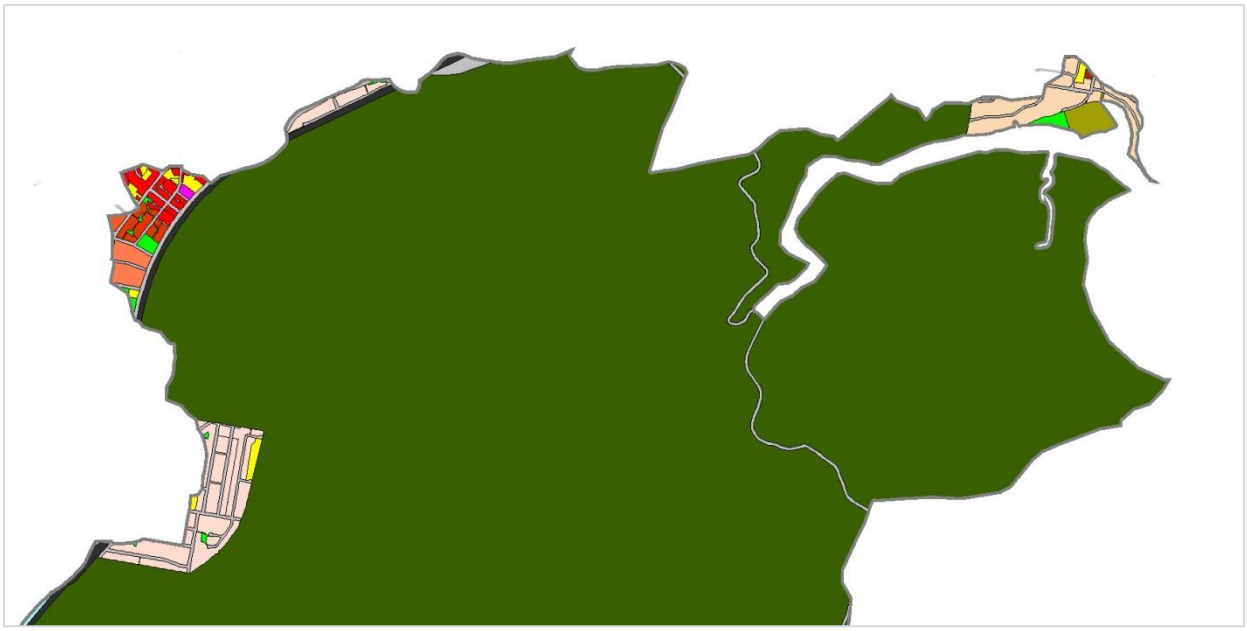
In the late 1790s Flinders, accompanied by George Grimes mapped part of Botany Bay and Port Hacking, and navigated the salt river to its junction with the freshwater stream at the spot now known as Audley. At the time, Kangaroo Creek was influenced by the tidal flows in Port Hacking and could become moderately saline in its lower reaches. Following the construction of the dam at Audley, Kangaroo Creek has become completely freshwater, and has experienced increased siltation.

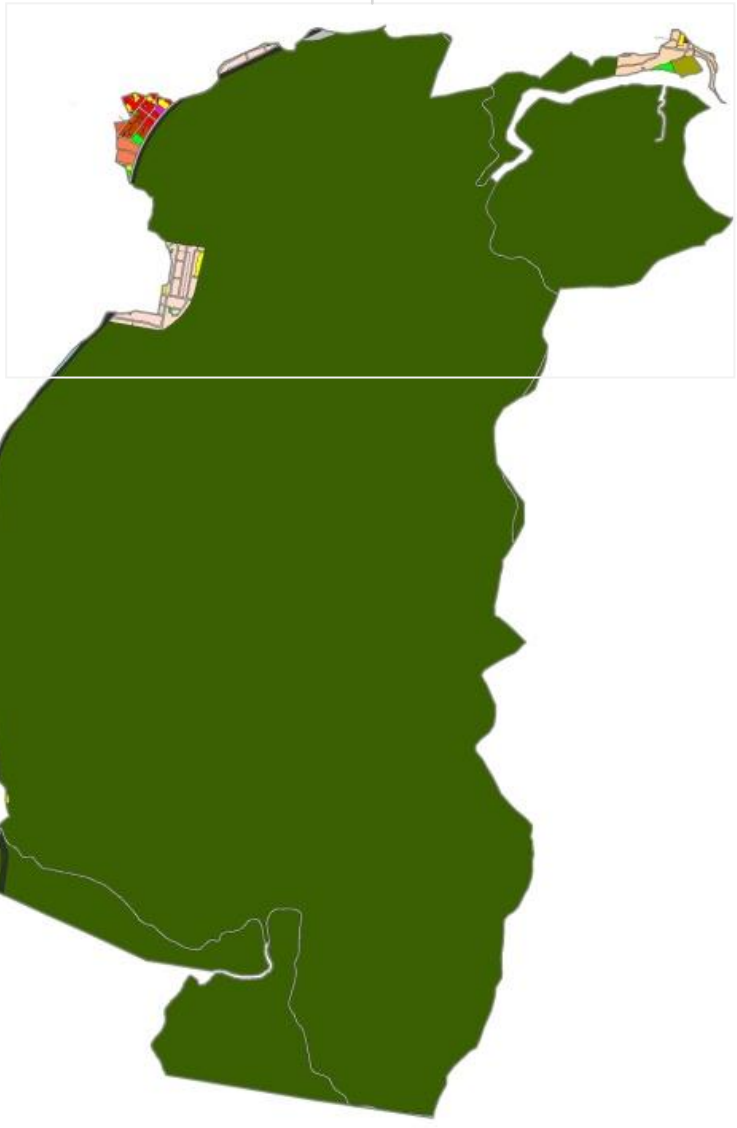
Before the arrival of Europeans to Australia, the land around Kangaroo Creek was occupied by the Tagary people. Middens have been found along the creek with oyster shells, wallaby bones, flint knives and scrapers made from stones. Charcoal drawings of kangaroos have also been recorded in the area, but many of these have been defaced (Jackson, 2006).

Kangaroo Creek drains numerous streams east of Engadine, Heathcote and Waterfall. This land was the more fertile part of the area that became national park, and was most exposed to attempts to colonise and utilise the land. Herds of wild cattle were common in the area, and timber getters regularly felled the tall trees that grew in the moist valleys. Tracks were established to get this timber out, and a number of these form walking tracks in the area today. After the national park was established, numerous leases for timber getters and coal and mineral exploration were revoked. Coal mining still occurs at Helensburgh to the south of the Shire, and this has ongoing impacts on the health of Kangaroo Creek and Hacking River, as well as Port Hacking.

Parts of the catchment have been the site for a number of other impacts, including brickmaking from clay deposits at Bottle Forest, near Heathcote, an industry that commenced in 1883 and produced millions of bricks over many years. Timber for firewood and pit props in the nearby mines continued under licence for many years. Gravel and ironstone were extracted for road making, mainly from around Audley plateau and areas immediately south of there. For many years grazing was encouraged as a means of generating revenue for the national park, although in reality little income eventuated and the cattle became destructive and a nuisance to park users.

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

CATCHMENT IMPERVIOUS SURFACE (% AND DISTRIBUTION)

ZONING DESCRIPTOR	HECTARES	% CATHCHMENT	POTENTIAL IMPERVIOUS	HECTARES IMPERVIOUS
Deferred Matter	0.1	0%	0%	0.00
Environmental Housing Sensitive Land	22.26	0%	43%	9.57
Environmental Housing Scenic Quality	0	0%	57%	0.00
Environmental Housing Bushland	35.49	1%	57%	20.23
Local Housing	5.81	0%	51%	2.96
Multiple Dwelling A	0.94	0%	64%	0.60
Multiple Dwelling B	4.49	0%	64%	2.87
Mixed Use Kirrawee	0	0%	64%	0.00
Urban Centre	7.35	0%	94%	6.91
Local Centre	0	0%	88%	0.00
Neighbourhood Centre	0.24	0%	86%	0.21
Employment	0.62	0%	95%	0.59
Special Uses	11.89	0%	30%	3.57
Public Open Space	5.2	0%	5%	0.26
Public Open Space Bushland	6.68	0%	0%	0.00
Private Recreation	2.03	0%	5%	0.10
Environmental Protection Waterways	0.25	0%	0%	0.00
Aquatic Reserves	0	0%	0%	0.00
National Park Reserve and Recreation Area	6510.39	98%	0%	0.00
Railway	8.71	0%	33%	2.87
Arterial Road/Road	6.14	0%	66%	4.05
Transport Reservation	0	0%	5%	0.00
Total	6628.59	100%	1%	54.80

VEGETATION COMMUNITIES

The catchment has significant areas of valuable riparian and foreshore habitat within the Royal National Park, Garrawarra SRA and other areas of urban bushland. General habitat types include forest, woodlands, heathland and rainforest.

Forest Areas: Dominant canopy species include turpentine (*Syncarpia glomunifera*), grey ironbark (*Eucalyptus paninculata*) and Sydney blue gum (*E. saligna*). Open forest occurs throughout the catchment on east or south-facing slopes, along drainage lines or in places with sandy soils. Species include smooth-barked apple (*Angophora costata*), Sydney peppermint (*E. piperita*) and Grey gum (*E. punctata*).

Woodlands: This sandstone ridgetop ecosystem is well represented in the Royal National Park. Canopy species include scribbly gum (*E. haemastoma*), red bloodwood (*E. gummifera*), with shrub cover including heath banksia (*Banksia ericifolia*), dwarf apple (*Angophora hispida*), dagger hakea (*Hakea* sp.) and bushy needlebush (*Hakea sericea*).

The remaining natural vegetation located within the National Parks and Crown land open space areas is classified as woodland. The species found here include scribbly gum (*E. haemastona*), Sydney red gum (*Angophora costata*), old man banksia (*Banksia serrata*), and red bloodwood (*E. gummifera*) with a diverse shrub layer.

Rainforest: Littoral rainforest occurs in the more moist areas of the Royal National Park. Remnant vegetation occurs at Lilli Pilli Point, Burraneer Point, Darook Park and Yowie Bay. Species include celerywood (*Polyscias elegans*), red-fruited olive plum (*Cassine australis*) and corkwood. Sub-tropical rainforest is found along the Upper Hacking and its tributaries, elements of this are found in Ewey Creek and Gymea Bay. Canopy species include crab apple (*Schizomeria ovata*) and ribbonwood (*Euroschinus falcata*).

The following vegetation communities have been mapped in the Hacking River catchment by Sutherland Shire Council:

- Sydney Sandstone Ridgetop Woodland
- Sydney Sandstone Gully Forest
- Sydney Sandstone Heath
- Sydney Turpentine Ironbark Forest
- Swamp Oak Floodplain Forest
- Coastal Saltmarsh
- Mangrove
- Sydney Freshwater Wetlands

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.

Woronora Sandstone Mallee-Heath Woodland (Sydney Sandstone Ridgetop Woodland)

High annual rainfall (>1200mm) associated with the eastern Woronora Plateau combines with skeletal rocky or ironstone soils to support this distinctive tall mallee heath-woodland. Most sites are characterised by a widely spaced canopy of eucalypt species many of which are found elsewhere in sandstone woodlands however in this community are found growing in a mallee form. However it is the multiple slender stems of several 'true' mallee species such as the yellow-top ash (*Eucalyptus luehmanniana*) and *Eucalyptus apiculata* and that can help distinguish this community where it may found alongside scribbly gum (*Eucalyptus racemosa*/*Eucalyptus haemastoma*), red bloodwood (*Corymbia gummifera*) and silver-top ash (*Eucalyptus sieberi*).

A diverse and thickly growing heath dominates the understorey with banksias prominent. Heath-leaved banksia (*Banksia ericifolia* subsp. *ericifolia*) is particularly characteristic. A moderate cover of grasses and sedges are present on the damp poorly drained sandy loams. The ground cover vegetation mixes with small fragments of the rust coloured ironstone rock to form a thin mantle above the soil.

The community is restricted to the eastern Woronora Plateau where it forms localised stands north from Dharawal NR and Woronora Special Area to Waterfall and Engadine. It can be found on or near poorly drained headwaters, perimeters of upland swamps and rocky exposed slopes. Few threats appear to persist for this community given its occurrence throughout protected areas of the eastern Woronora Plateau. Impacts are likely to be localised where mining or gravel extraction occurs or where illegal trail bike riding occurs.

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.

Coastal Sandstone Gully Moist Heath (Sydney Sandstone Gully Forest)

Coastal Sandstone Gully Moist Heath is a low to moderately tall woodland and forest with a closed wet heath layer found on sandstone gullies and sandy drainage lines. The canopy is open to sparse featuring eucalypts such as red bloodwood (*Corymbia gummifera*), smooth-barked apple (*Angophora costata*) and Sydney peppermint (*Eucalyptus piperita*). More prominent is the dense diverse heath layer that may include several different species of banksias, hakeas, tea-trees and casuarinas. Also found within the heath layer are mesic plants such as black wattle (*Callicoma serratifolia*) and blueberry ash (*Elaeocarpus reticulatus*). Permanent water from rock seepage or creek lines encourages a range of fern species including coral fern (*Gleichenia dicarpa*) and sedges (*Empodisma minus*).

The distribution of the community is restricted to high rainfall zones along the coast where mean annual rainfall exceeds 1250mm per annum. The soils are generally very infertile rocky siliceous sandstones and sandstone colluvium associated with the Lambert soil landscape in northern Sydney and the Hawkesbury Sandstone Soil Landscape in the South of Sydney. Similar heaths might be expected to occur north of the study area in the hinterland of the Central Coast although no evidence is available from systematic site data available to this project. Broader regional classifications include this unit within coastal sandstone gully forest complexes.

Clearing is likely to have had limited affect on the distribution of the community because of the infertile soils and precipitous nature of the habitat. Current threats are likely to arise from local weed invasion from upstream developments, frequent fire and trail riding.

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.

Sydney Turpentine Ironbark Forest

Sydney Turpentine-Ironbark Forest is a tall open forest found on shale and shale enriched sandstone soils on the coast and hinterland of Sydney. It has been extensively cleared but was once widely distributed between Sutherland and the Hornsby Plateau with outlying examples found on shale rich deposits at Campbelltown, Menai, Kurrajong and Heathcote. The primary distribution of this forest occurs in areas receiving between 900 and 1250 millimetres of mean annual rainfall and at elevations between 10 and 180 metres above sea level.

The forest is characterised by an open layer of mesic and sclerophyllous shrubs and small trees with a grassy ground cover. The composition of the canopy is variable depending on location and substrate. Typically it is recognised by an upper stratum of turpentine (*Syncarpia glomulifera*), red mahogany (*Eucalyptus resinifera*) and various ironbarks species (of which *Eucalyptus paniculata* most often recorded). On the north shore these forests are found on shale enriched sheltered sandstone slopes where ironbark species are far less frequently recorded. Instead blackbutt (*Eucalyptus pilularis*) is more common.

Current distribution for Sydney Turpentine Ironbark Forest are remnants which are small and scattered. Identified threats include clearing, physical damage from recreational activities, rubbish dumping, grazing, mowing, weed invasion.

Estuarine Swamp Oak Forest

In the succession from mangroves and saltmarsh to terrestrial sclerophyll and mesophyll forests and woodlands, Estuarine Swamp Oak Forest occurs as the initial community above tidal influence. It fringes the margins of saline waterbodies that include rivers, lagoons and tidal lakes. Swamp oak (Casuarina glauca) forms dense monospecific stands above a thick ground cover of salt tolerant herbs, rushes and sedges. The shrub layer is low growing and

sparse comprising a mix of terrestrial species while others typical of wetlands. It is a community of relatively low species diversity.

Estuarine Swamp Oak Forest is widespread along the coast of the Sydney Basin where it is rarely found at elevations above two meters above sea level. Waterfront urban and industrial development has occurred on areas likely to have once been occupied by this community. Typically land infill has been used to reclaim estuarine environments to make use of flat accessible lands. Remaining areas often support a conspicuous cover of exotic species such as lantana (*Lantana camara*) and buffalo grass (*Stenotaphrum secundatum*).

Estuarine Mangrove Forest

Stands of Mangroves form a low closed to open forest on mudflats found along Sydney's harbour, river coves and estuaries. There are two mangrove species found in Sydney. Grey mangrove (*Avicennia marina*) is the taller and more common, often seen in pure stands. It comprises very few species other than the canopy, with the understorey mostly an open mudflat sometimes with scattered saltmarsh herbs. The second mangrove species is river mangrove (*Aegiceras corniculatum*). It is more often a small tree or shrub found scattered amongst swathes of grey mangrove or along upper reaches of coastal riverbanks. It occurs where freshwater influences from runoff or rivers cause lower salinity levels in water inundating the mudflats.

Sea level rise associated with climate change poses a significant threat to the current distribution to Estuarine Mangrove Forest in the Sydney basin. While the species appears to be an aggressive recoloniser, opportunities for re-establishment in Sydney are constrained by built environments and steep sandstone banks. Current threats include ongoing recreation pressures, pollution arising from oil spills and outfalls and reclamation.

Estuarine Saltmarsh

Saltmarshes consist of low succulent herbs and rushes on tidally inundated land. These marshes form plains that adjoin open water and mangroves. Throughout the marsh, salinities vary greatly according to tidal influence, evaporation and freshwater accumulation. Some of the areas are flooded regularly, while at slightly higher elevations flooding is rare. After rain freshwater accumulates and adds extra water to the marsh, leaving pools of standing water when the tide recedes. Chenopod species dominate areas more frequently inundated by the tides, while sea rush (*Juncus kraussii*) occupies the more elevated terrestrial margin. Local scalds occur in small depressions where intensely saline deposits accumulate from the evaporation of tidal waters preventing the growth of any plants at all.

Sea-level rise from climate change represents the greatest threat to the long term persistence of the Saltmarsh community. Small rises will permanently inundate these intertidal zones. Reclamation has altered the landscape of estuarine environments. Heavy recreational pressure, rubbish dumping, invasion by weeds and sedimentation are ongoing

threats to the community (Keith 2004). Infestation of saltmarsh plains by the exotic sharp rush (*Juncus acutus*) is prevalent in some areas of the Georges River (Pickthall et al. 2004).

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*).

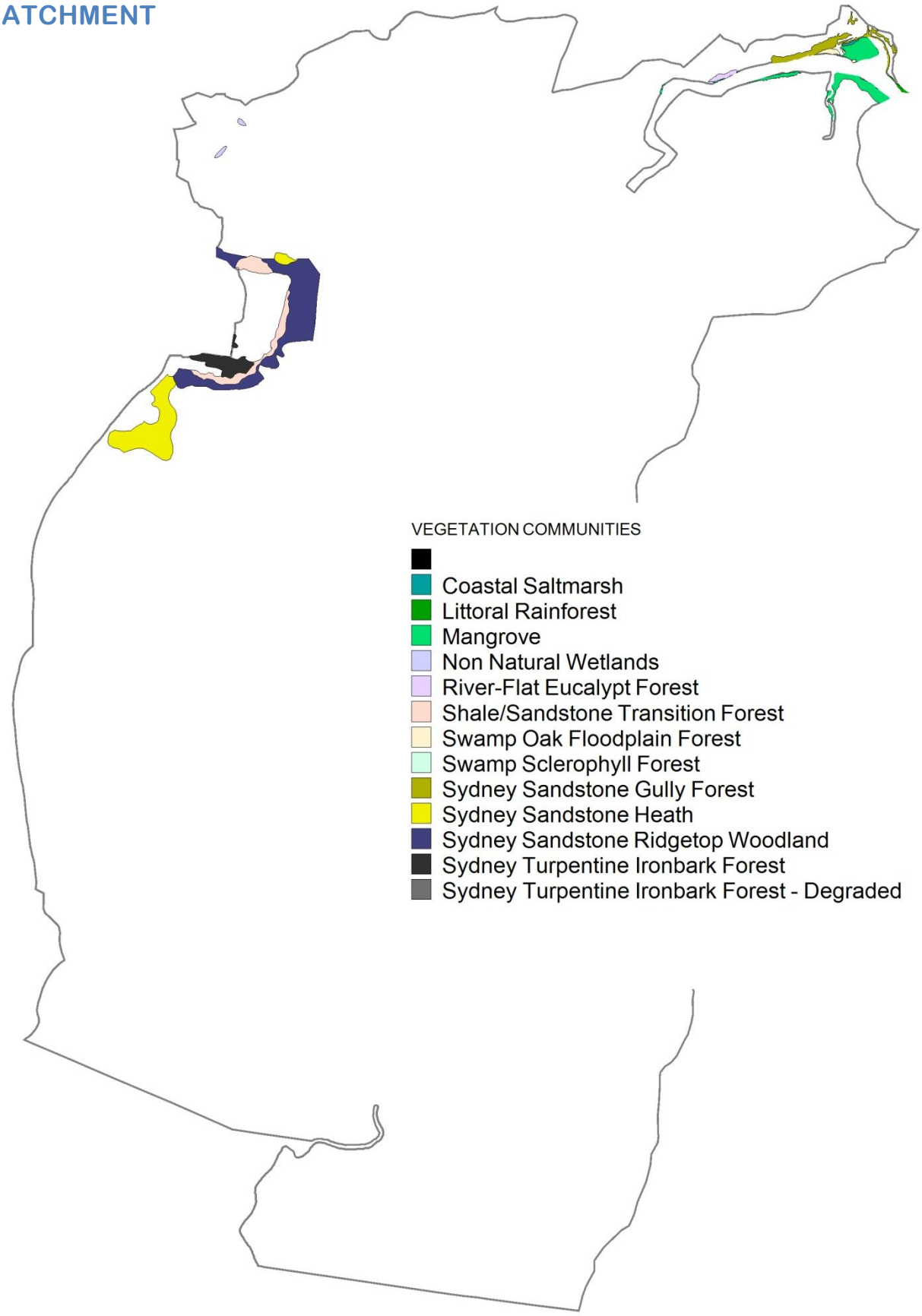
Threats facing this community are high. Coastal sand flats have been extensively cleared and modified on the Kurnell Peninsula, Botany, Sans Souci and around the lagoon systems of the northern beaches. As well, these sites are subject to habitat degradation resulting from altered hydrology/nutrient levels,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

SIGNIFICANT VEGETATION

EXTANT MAPPED VEGETATION COMMUNITIES

0.40	HECTARES	COASTAL SALTMARSH
0.40	HECTARES	LITTORAL RAINFOREST
12.71	HECTARES	MANGROVE
0.79	HECTARES	NON NATURAL WETLANDS
1.21	HECTARES	RIVER-FLAT EUCALYPT FOREST
11.96	HECTARES	SHALE/SANDSTONE TRANSITION FOREST
1.00	HECTARES	SWAMP OAK FLOODPLAIN FOREST
7.57	HECTARES	SYDNEY SANDSTONE GULLY FOREST
24.12	HECTARES	SYDNEY SANDSTONE HEATH
37.65	HECTARES	SYDNEY SANDSTONE RIDGETOP WOODLAND
7.81	HECTARES	SYDNEY TURPENTINE IRONBARK FOREST

MAPPED VEGETATION COMMUNITIES OF HACKING RIVER CATCHMENT



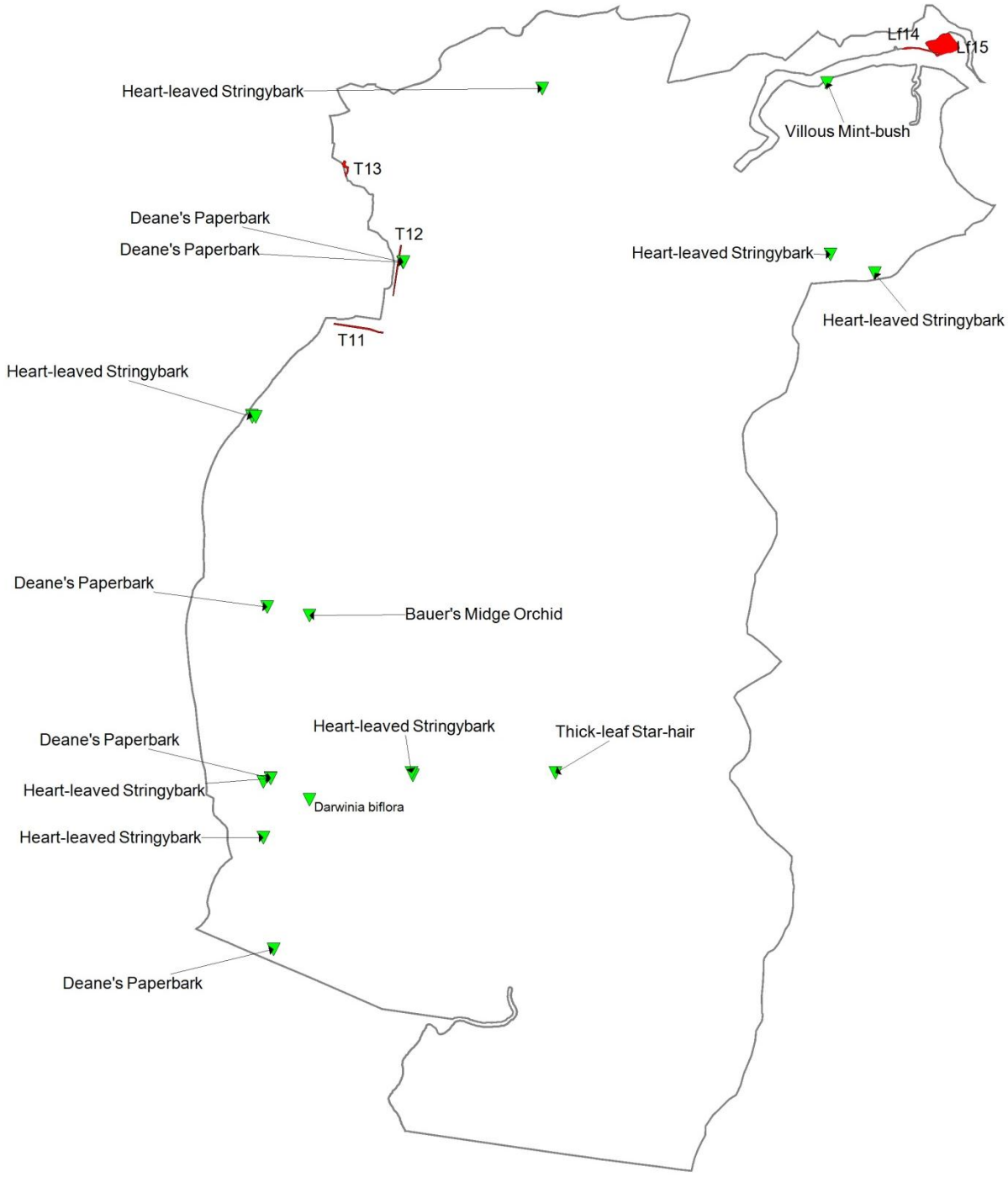
LEP 2006 SIGNIFICANT VEGETATION

LEP TAG	NAME	CLASS
T11	Cultural Street Trees	Significant Group of Trees or Vegetation
T12	Natural Street Planting	Significant Group of Trees or Vegetation
T13	*Lophosfemon confertus*	Significant Group of Trees or Vegetation
Lf15	Mangrove	Significant Landform

THREATENED SPECIES: FLORA RECORDS

SCIENTIFIC NAME	COMMON NAME	LEGAL STATUS
Astrotricha crassifolia	Thick-leaf Star-hair	V
Darwinia biflora		V
Eucalyptus camfieldii	Heart-leaved Stringybark	V
Genoplesium baueri	Bauer's Midge Orchid	V
Grevillea parviflora		V
Melaleuca deanei	Deane's Paperbark	V
Persoonia hirsuta subsp. hirsuta		E1
Prostanthera densa	Villous Mint-bush	V
Prostanthera marifolia		E4A

LEP 2006 SIGNIFICANT VEGETATION AND THREATENED SPECIES (FLORA) RECORDS MAP



THREATENED SPECIES: FAUNA RECORDS

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

SCIENTIFIC NAME	COMMON NAME	LEGAL STATUS
Hieraaetus morphnoides	Little Eagle	V
Lophoictinia isura	Square-tailed Kite	V
Pandion haliaetus	Osprey	V
Callocephalon fimbriatum	Gang-gang Cockatoo	V
Ptilinopus regina	Rose-crowned Fruit-Dove	V
Epthianura albifrons	White-fronted Chat	V
Daphoenositta chrysoptera	Varied Sittella	V
Puffinus assimilis	Little Shearwater	V
Limicola falcinellus	Broad-billed Sandpiper	V
Xenus cinereus	Terek Sandpiper	V
Ninox strenua	Powerful Owl	V
Tyto novaehollandiae	Masked Owl	V
Tyto tenebricosa	Sooty Owl	V

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

SCIENTIFIC NAME	COMMON NAME	LEGAL STATUS
Cercartetus nanus	Eastern Pygmy-possum	V
Dasyurus maculatus	Spotted-tailed Quoll	V
Phascolarctos cinereus	Koala	V
Pteropus poliocephalus	Grey-headed Flying-fox	V
Chalinolobus dwyeri	Large-eared Pied Bat	V
Falsistrellus tasmaniensis	Eastern False Pipistrelle	V
Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	V
Myotis macropus	Southern Myotis	V
Scoteanax rueppellii	Greater Broad-nosed Bat	V

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

SCIENTIFIC NAME	COMMON NAME	LEGAL STATUS
Hoplocephalus bungaroides	Broad-headed Snake	E1
Varanus rosenbergi	Rosenberg's Goanna	V

THREATENING PROCESSES

SUMMARY OF IMPACTS

The Royal National Park was dedicated in 1879 and included an area of 18 000 acres. Over the years this has grown to 64 000 acres (Albani & Cotis, 2007). Initially the park was a place for pleasure activities such as picnics and socialising. The early approach to management included manicured parks, gardens, lawns, lakes and aviaries. To complete the European setting, deer were introduced. At the time the park had few measures for protection and extractive exploitation was allowed to continue.

More recently the park has become managed as bushland with multiple values, including recreation, conservation and preservation. Interest groups such as bushwalkers achieved considerable expansion into the park. As a result, the park's bushland is not even close to pristine, with remnants of buildings along waterways, and exotic plants testimony to a century of use. The catchment of the Hacking River continues to have an important influence on the Port Hacking estuary, providing its main source of freshwater and sediment.

The township of Helensburgh with a garbage tip, coal mine with coal washing leachate, the Princes Highway, farms including piggeries, the unsewered Garawarra Hospital and horse riding establishments all contribute to the contaminant loading for the Hacking River. Pollutants continue to leach from the garbage tip into the river. Fine particulate matter from coal washing is regularly discharged, and horse urine concentrations in river water during dry spells regularly reach levels that are toxic to native wildlife. A single road crash on the Princes Highway is believed to have caused the demise of the river's platypuses. Wildfire increases the sediment load delivered to the river system for up to 12 months, until revegetation has reached a point where sediments are stabilised in situ.

RECREATED WATERWAYS MAP

CATCHMENT ELEVATION MODEL: STREAM ORDERS AND CATCHMENT BOUNDARIES