SUTHERLAND SHIRE WATERCOURSE ASSESSMENT & REHABILITATION PRIORITISATION

VOLUME 2

CHAPTER 6

WORONORA RIVER CATCHMENT PROFILE

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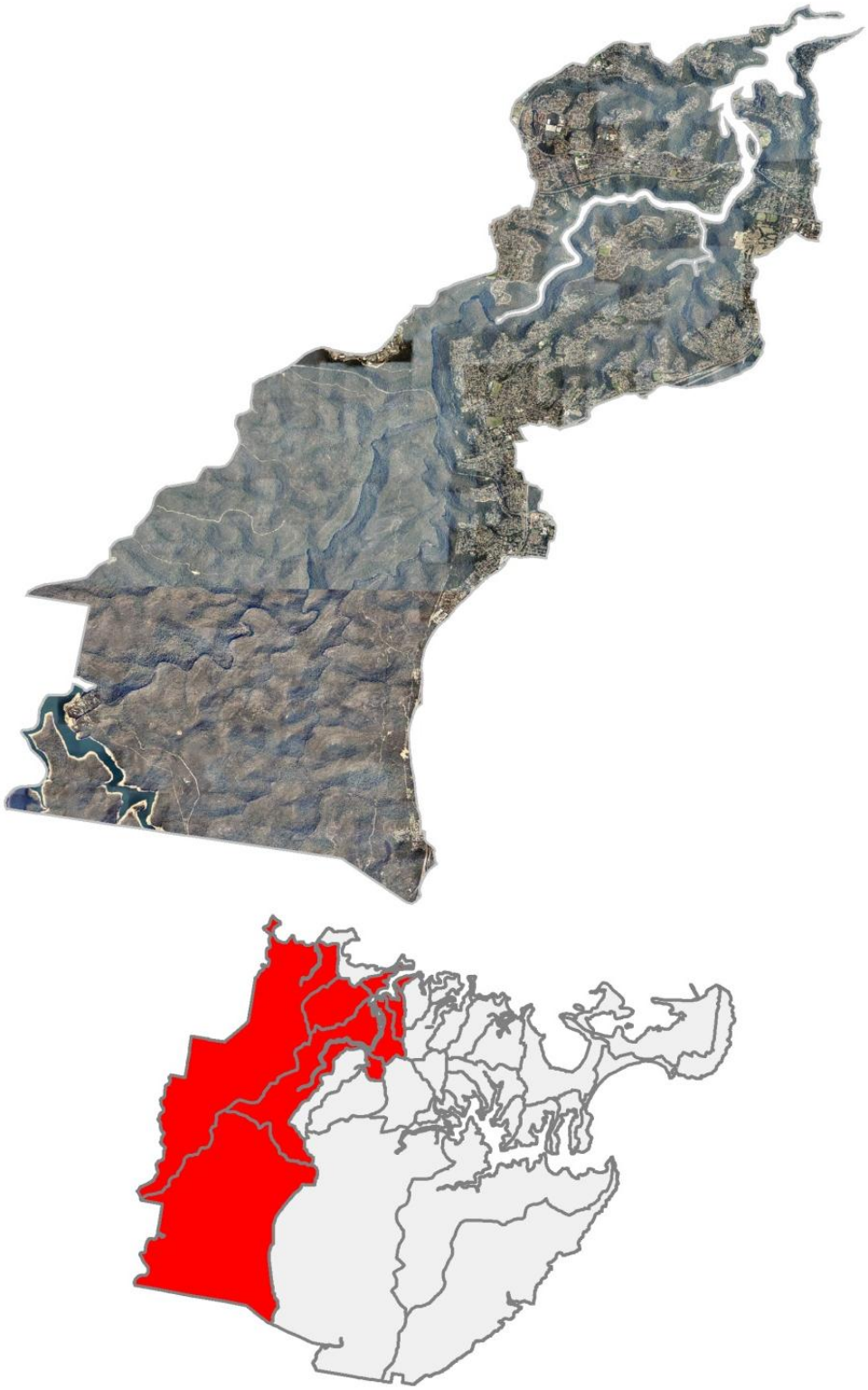
Chapter 6 WORONORA RIVER CATCHMENT

CATCHMENT AREA: 82.57 KM^2



WATERWAYS

SUMMARY OF DRAINAGE SYSTEM

Woronora River catchment includes nine sub-catchments:

WORONORA RIVER (PART1)

WORONORA RIVER (PART 2)

AUDREY BAY / THOMPSONS BAY

LOFTUS CREEK

MANDOWIE CREEK

BOTTLE CREEK

BONNET BAY

FORBES CREEK

STILL CREEK

MAJOR NAMED WATERWAYS

ABAROO GULLY
ADINA GULLY
BAGGARY GULLY
BONDEL GULLY
BOTTLE CREEK
BUNGONIE RILL
GIRRONBA CREEK
GOBURRA GULLY
GUNNERS GULLY
HEATHCOTE CK
HEATHCOTE CREEK
KINGFISHER CREEK
LAKE TOOLOOMA
LOFTUS CREEK
MIARA GULLY
MINDA GULLY
MINKA GULLY
MIRANG GULLY
MOORAY GULLY
MYUNA CREEK
ORIGMA CREEK
PYTHON GULLY
RIPPLE RILL
SARAHS GULLY
SCOUT CREEK
STILL CREEK
TARMAROO RILL
WATERFALL GULLY
WESTMACOTT RILL
WORONORA RIVER

TOTAL LENGTH OF MAPPED WATERWAYS: 159.09 KMs

RIVERS: 15.69 KMs

PRIMARY CREEKS: 4.00 KMs

SECOND ORDER CREEKS: 69.75KMs

FIRST ORDER & MINOR DRAINAGE LINES: 69.53 KMs

OPEN DRAINS: 0.12 KMs

GEOLOGY, GEOMORPHOLOGY AND SOILS

GEOLOGY AND GEOMORPHOLOGY

The Woronora River rises just north of Helensburgh and flows northwards through Heathcote National Park to join the Georges River 30km away. The paths followed by streams down the Woronora Plateau are controlled mainly by the undulations and lineaments in, and the dip of, the plateau surface. Valleys cut entirely in Hawkesbury Sandstone are steep sided, and lined by cliffs or by steep slopes made up of short benches, formations seen along Woronora River and Heathcote Creek. Plateau tops, valley sides and stream floors have been carved from strong, well-jointed rock. Further up the valleys the slope of the sandstone beds brings the Narrabeen Group layers closer to the surface. Streams that have cut through the overlying Hawkesbury Sandstones encounter the softer Narrabeen shales and sandstones, and form wider valleys. Further downstream, the same streams encounter the stronger Hawkesbury Sandstones because of the dip of the sedimentary layers, and form narrow, cliff lined valleys.

The streams of Heathcote Creek and Woronora River have pools on most of their meander bends. The pools are scoured out on the bends of the streams as the water accelerates around the curve. If a small tributary enters near the bend, the added flow from it enhances the power of the river to erode. The flow of water scours the rock on the outside of the bend, cutting down to create the pool. On the inside of the bend, the water travels more slowly and sand is deposited, forming a sand bar known as a point bar.

The Hawkesbury Sandstone has some beds that are quite thick, massive, and made up of sand deposited in flat sheets. These beds form strong clifflines on the valley sides. When a stream cuts down and encounters these flat beds, it has to excavate by etching down along the joints, or down potholes, and then dislodging separated blocks when the flow is strong enough, as happens during floods. In some places, the flat beds can be undercut, and the blocks may topple forward and be easier for the flow of water to move.

Around the upper reaches of the Woronora River and Heathcote Creek the ridges tend to be narrow, with few flat upland areas, and there are fewer swamps here than in other parts of the Woronora Plateau.

SOILS

The main soil landscapes present in Woronora River catchment are Gymea (gy), Hawkesbury (ha), Lucas Heights (lh), Blacktown (bt), Faulconbridge (fb), Bundeena (bu) ,Mangrove Creek (mc), 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 Woronora River catchment these are as follows:

- Gymea: low to moderate capability for urban development
- Hawkesbury: not capable of urban development
- Lucas Heights: high capability for urban development
- Blacktown: high capability for urban development
- Faulconbridge: high capability for urban development
- Bundeena: low capability for urban development
- Mangrove Creek: not capable of 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 Woronora River catchment the following assessments were made:

- Gymea: not capable of regular cultivation or grazing
- Hawkesbury: not capable of regular cultivation or grazing
- Lucas Heights: capable of grazing
- Blacktown: capable of regular cultivation, capable of grazing
- Faulconbridge: capable of regular cultivation, capable of grazing
- Bundeena: not capable of regular cultivation or grazing
- Mangrove Creek: 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. The soil landscapes listed above are described in the following sections:

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).

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).

Lucas Heights (lh): Gently undulating crests, ridges and plateau surfaces of the Mittagong Formation with alternating bands of shale and fine-grained sandstones. Local relief is 10-50m, and slopes <10%. Rock outcropping is absent. Vegetation comprises extensively to completely cleared dry sclerophyll low open forest and low woodland. Soils are moderately deep (50-150cm) hardsetting Yellow Podzolic Soils and Yellow Soloths on ridges and plateau surfaces, Lateritic Podzolic Soils on crests, Yellow Earths on shoulders of plateaus and ridges, and Earthy Sands in valley flats. Limitations for use include stoniness, hardsetting surfaces, and low soil fertility (Hazelton & Tille, 1990).

Blacktown (bt): Gently undulating rises on Wianamatta Group shale with local relief to 30m, and slopes are usually <5%. Broads rounded crests and ridges with gently inclined slopes. Vegetation has been almost completely cleared, but originally was eucalypt woodland, open forest and tall open forest (wet sclerophyll). Soils are shallow to moderately deep (<150cm) Red Podzolic Soils and Brown Podzolic Soils on crests, upper slopes and well drained areas, deep (1.5-3m) Yellow Podzolic Soils and Soloths on lower slopes and in drainage depressions

and localised areas of poor drainage. Limitations include moderately reactive, highly plastic subsoils, and low soil fertility (Hazelton & Tille, 1990).

Faulconbridge (fb): Level to gently undulating crests and ridges on plateau surfaces of Hawkesbury Sandstone. Local relief <20m, slopes <5%. Infrequent rock outcrops. Vegetation is partly cleared eucalypt woodland. Soils are shallow (<50cm) Earthy Sands and Yellow Earths, with very shallow localised (<30cm) Siliceous Sands/Lithosols associated with rock outcrops. Limitations for use include shallow, highly permeable soil, very low soil fertility and isolated rock outcrop.

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).

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).

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

General sources of pollution in the Woronora River catchment that have the potential to affect water quality have been identified as follows:

- stormwater runoff from urban development;

- sewage pollution and runoff;
- sediment from building and development sites;
- nutrients and weeds from open space areas;
- litter, oil, grease, herbicides and weeds from road and rail infrastructure;
- heavy metals and metals (including copper, lead and zinc), oils, greases and litter from roads and motor vehicles;
- litter from commercial areas;
- various pollutants from the industrial area at Heathcote; and
- sediments and nutrients from fire hazard reduction (and bushfires).

Specific sources of potential pollution within the catchment have been identified to include the Lucas Heights Waste Management Centre and ANSTO's nuclear research facilities. The Lucas Heights Waste Management Centre is located off New Illawarra Road, Lucas Heights. The Waste Management Services receives putrescible waste material from more than ten councils plus private tipping. The Waste Management Centre is a non-lined valley landfill with leachate collection system, making the site a potential source of groundwater contamination. The Waste Management Centre has a leachate control system and no record of leachate contamination reaching the Woronora Catchment has been found.

The nuclear research facilities owned by Australian Nuclear Science and Technology Organisation (ANSTO) contain the only nuclear reactor in Australia and the facility discharges treated liquid effluent to the sewer (ANSTO, 1999). Biological and chemical sampling at Mill, Barden and Forbes Creek did not contain significant levels of radioactivity that could be attributed to the operation of the site (ANSTO, 1999). The report concluded that since the levels of detected activity were very low and stormwater does not enter any known human drinking water supply, there are no environmental or health consequences to humans from the measured radioactivity in the stormwater (ANSTO, 1999).

LAND USE

HISTORIC LAND USE

Woronora is derived from an Aboriginal word *wooloonora*, meaning 'black rock'. It is believed to have been named by Surveyor Dixon in 1828. The Woronora River flows north from near Helensburgh into the Georges River between Como and Illawong. Technically, it is within the catchment of the Georges River; however, it is an extensive river system on its own. The Woronora Valley is an area of great natural beauty and regional significance. The valley is home to a number of endangered ecological communities, threatened species and a diverse range of vegetation types including wetlands, saltmarsh, woodlands, forests and heath.

The aborigines that lived in the area were from the Tharawal tribe. They tended to pass through the vast sandstone plateaus on their way to hunting grounds and ceremonial sites, and lived mainly in the valleys where there was a plentiful supply of water and food, and better protection from the elements. There are many aboriginal sites in the area today, including rock engravings of snakes, fish and kangaroos. In the vicinity of Heathcote Creek (Bottle Creek subcatchment) there are drawings of sheep, proving they inhabited the area for a period of time after the arrival of Europeans (Jackson, 2006).

In 1835 when the Parish of Sutherland was first proclaimed, the Woronora River was its western boundary. In 1868 the area around Woronora was assessed as too rocky or too poor for the plough, persuading settlers against moving there. Activities were primarily recreational, utilising the pristine waterways, deep valleys and peaceful surroundings. Weekend visitors were common, and the few permanent residents in the area lived in tents along the shores of the river. These early residents would travel to Como by boat and catch a train to Sydney from there.

Construction of the Woronora Dam began in the early 1920s, but suffered a chequered progression. Work relief schemes in the 1930s provided cheap labour and it was completed in 1941, along with 26 kilometres of pipeline that connected the dam with the Sutherland area. This water supply storage collects water from the catchment of the Woronora River, which is one of the main upstream tributaries of the Georges River. The dam was upgraded to meet international safety standards in 1988 (Jackson, 2006).

Work relief schemes in the 1930s made dredging of the Woronora River possible and it became easier for locals and visitors to navigate the river channel. In 1965 an inquiry was held into the large numbers of dead fish in the river, particularly Fantail Mullet. Fears were held that it might be due to effluent discharge from the nuclear reactor at Lucas Heights. The findings asserted that the fish kill was due to the extended dry period, causing impurities to concentrate in the soil and mud. After heavy rains the impurities entered the river system, poisoning the water.

Raw water from the dam is very clean to start with, as a result of its catchment being 95% natural areas. It passes through the adjacent water filtration plant and then is pumped as the potable water supply to areas south of the Georges River, including Sutherland, Helensburgh, Lucas Heights and Bundeena. Any dam has major ecological downstream impacts by reducing flows, and the Woronora Dam is no exception. In 2001 the Healthy Rivers Commission argued that an 'adaptive regime for management of environmental flows should commence' with regular and planned releases occurring from the dam. (GREEC, 2008).

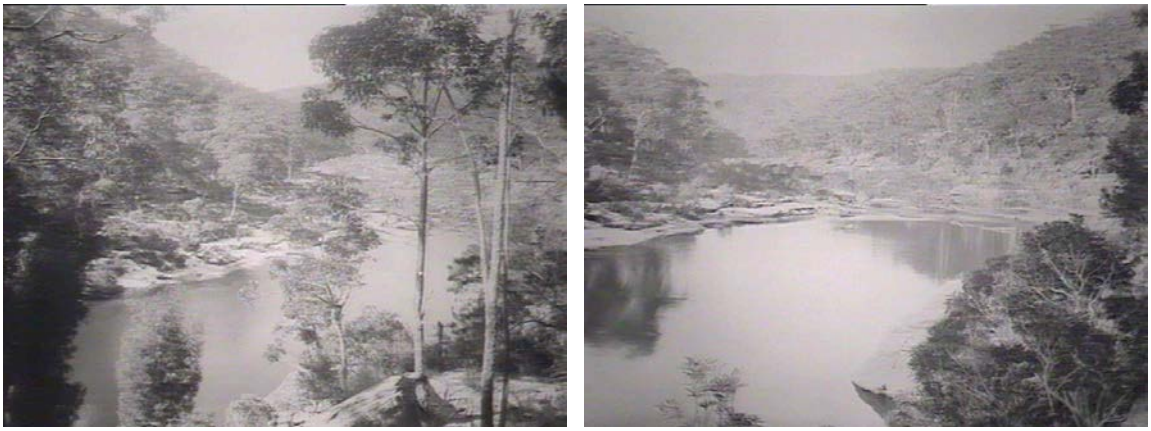
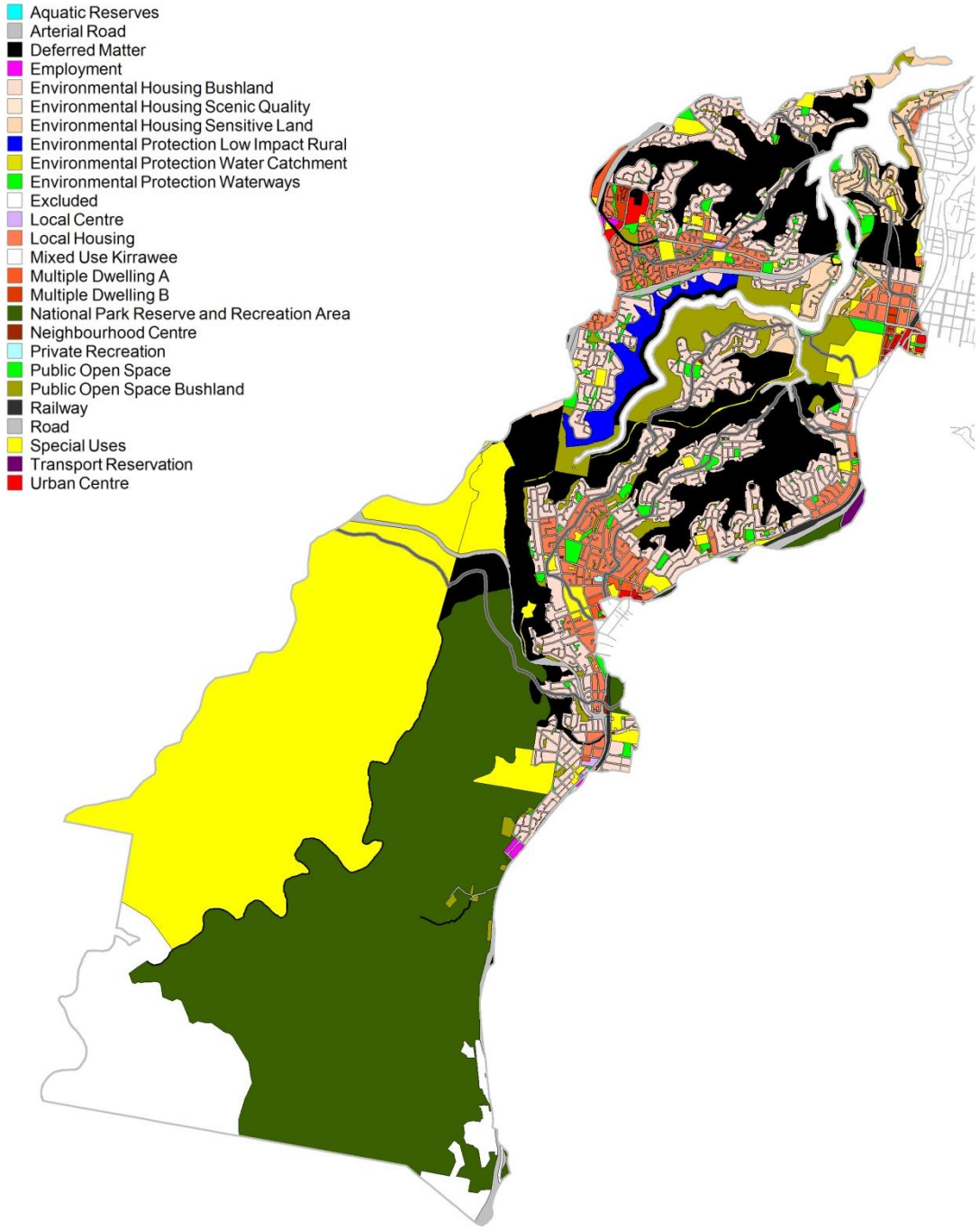


Figure 1. (a) and (b) Woronora River near Engadine, 1925.

CURRENT LAND USE



CATCHMENT IMPERVIOUS SURFACE (% AND DISTRIBUTION)

LEP ZONING DESCRIPTOR	HECTARES	% CATHCHMENT	POTENTIAL IMPERVIOUS	HECTARES IMPERVIOUS
Deferred Matter	1062.72	13%	0%	0.00
Environmental Housing Sensitive Land	176.36	2%	43%	75.83
Environmental Housing Scenic Quality	6.72	0%	57%	3.83
Environmental Housing Bushland	797.04	10%	57%	454.31
Local Housing	286.66	3%	51%	146.19
Multiple Dwelling A	17.98	0%	64%	11.51
Multiple Dwelling B	13.72	0%	64%	8.78
Mixed Use Kirrawee	0.00	0%	64%	0.00
Urban Centre	24.57	0%	94%	23.09
Local Centre	4.45	0%	88%	3.92
Neighbourhood Centre	2.41	0%	86%	2.07
Employment	6.50	0%	95%	6.18
Special Uses	2034.08	24%	33%	237.66
Public Open Space	111.62	1%	5%	5.58
Public Open Space Bushland	317.22	4%	0%	0.00
Private Recreation	3.52	0%	5%	0.18
Environmental Protection Waterways	501.49	6%	0%	0.00
Aquatic Reserves	0.00	0%	0%	0.00
National Park Reserve and Recreation Area	2298.21	28%	0%	0.00
Railway	24.04	0%	33%	7.93
Arterial Road/Road	559.45	7%	66%	369.24
Transport Reservation	7.99	0%	5%	0.40
Environmental Protection Low Impact Rural	82.04	1%	0	0.00
TOTAL	8338.81	100%	16%	1356.71

VEGETATION COMMUNITIES

OVERVIEW OF VEGETATION

Throughout the Woronora River catchment the landscape is dominated by Hawkesbury Sandstone. A strong north-south pattern of jointing creates ridges, cliffs and plateaus. Smaller joints are eroded to form streams, with water moving over the land through points of weakness in the rock mass.

The rugged landscape supports a variety of plant communities. The ridges and drier slopes have open forest dominated by angophoras and eucalypts such as bloodwood, grey gums, Sydney peppermint, and scribbly gum. Grass-trees are common, and low heath, also found on the dry ridges, consists of a mixture of brightly flowering shrubs, including tea-trees, banksias, hakeas, and waxflowers. The tall, red-flowered Gymea lily and the graceful forest oak mostly grow on the moister slopes. Blackbutts and fern-leafed grevilleas grow in the Heathcote Creek valley.

Large sections of the upper catchment are in Heathcote National Park. The vegetation supports sugar gliders, ring tail possums, and possibly eastern pygmy possums y. Swamp wallabies also live in the park. Noisy friar birds and other honeyeaters are often seen, while the notes of the superb lyrebird ring across the gorges in winter.

A number of habitat types are characteristic of the Woronora catchment, including:

- Dry high ridges. These areas are exposed to wind and sun. Rainfall runs quickly off the bare rock outcrops. Shallow pools and joint cracks store enough water to support heath communities with *Banksia ericifolia* thickets, sedges, Christmas Bells (*Blandfordia nobilis*), trigger plants (*Stylidium* species) and insect eating plants (*Drosera* species).
- Moorlands. Occurring on broad ridges and gentle plateau slopes, trees are more common, especially multi-stemmed forms of many eucalypts. Sedges dominate some parts, along with button grass (Gymnoschoenus sphaerocephalus) and grass trees (Xanthorrhea species), and many shorter sedges and shrubs.
- Open valley sides. Some shelter from wind, and flow of water from higher ground makes this environment moister than the ridges. Angophora costata and waratahs are common, along with a wide variety of shrubs, grasses and other groundlayer species.

SIGNIFICANT VEGETATION

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

- Sydney Sandstone Ridgetop Woodland
- Sydney Sandstone Gully Forest
- Riverflat Eucalypt Forest
- Riparian Scrub
- Swamp Oak Floodplain Forest
- Coastal Saltmarsh
- Mangrove
- Sydney Sandstone Heath
- Sydney Freshwater Wetland

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 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.

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.

Hinterland Flats Eucalypt Forest (River Flat Eucalypt Forest)

Hinterland Flats Eucalypt Forest is a tall open eucalypt forest with a scattered mesic shrub layer and a grassy and herbaceous ground cover. It occurs predominantly along the sandy riverbanks of the Georges River and its tributaries. It also occurs on gentle narrowly incised valleys that drain the north western Woronora Plateau west from the Woronora River. It is dominated by both bangalay (*Eucalyptus botryoides*) and its hybrid with Sydney blue gum (*Eucalyptus saligna X botryoides*) where at its tallest it may reach over 35 metres in height.

An open layer of small trees features a number of wattles of which coast myall (*Acacia binervia*) is most common. The hardy rainforest trees grey myrtle (*Backhousia myrtifolia*) and sweet pittosporum occur (*Pittosporum undulatum*). On the banks of the Georges River the small tree layer may include dense stands of the exotic small-leaved privet (*Ligustrum sinense*). Smaller shrubs may have a reduced cover and diversity as a result. Invariably however the taller bracken fern (*Pteridium esculentum*) occurs above an abundant cover of grasses.

Hinterland Flats Eucalypt Forest is situated on gullies that are slightly protected by the incised drainage channel. These are more elevated alluvial systems with a greater proportion of sandy material in the soil than the true broad floodplains of the Georges River and Western Sydney. It is restricted to elevations between 9 and 15 metres above sea level and mean annual rainfall between 850 and 950 millimetres. It is known to occur elsewhere on the Nepean River although regional classifications include it as part of the Cumberland Riverflat Forests.

Threats are high. Clearing is unlikely to have depleted this forest as extensively as other river-flat forests given the narrow areas of habitat and less fertile soils. However urban and industrial land use surrounds most stands and a large proportion of remnants are now characterised by a diverse and abundant cover of invasive weeds. Altered drainage patterns, water pollutions, increased sedimentation and frequent fire remain pervasive threats.

Coastal Sandstone Riparian Scrub (Riparian Scrub)

This low scrub comprises a mix of hardy shrubs growing on rocky creek lines or shallow alluvial soils at the base of deep sandstone gully systems. The vegetation cover is highly variable as it is interspersed by rock pools, rock pavements and open sandy banks. It is a zone of occasional flooding and plants must survive fast moving waters to persist. Water

gums (*Tristaniopsis laurina*, *Tristania neriifolia*) are invariably present often in combination with wattles, hakeas, grevilleas, teatrees and casuarinas.

Two shrub species, river lomatia (*Lomatia myricoides*) and blunt-leaved wattle (*Acacia obtusifolia*) are particularly common in these environments. Both are easily distinguished by their long leaves. Small moisture loving ferns and sedges may form dense clumps on or near stream banks. A sparse cover of overhanging eucalypts may also be present, though these are often rooted in the adjoining slopes rather than the creek line itself.

These narrow strips of riparian vegetation are widespread across the Sydney Basin Bioregion but are naturally restricted in area. Sites situated near urban areas are threatened by weed infestation derived from storm water runoff, garden escapees, and rubbish dumping.

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 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.

MAPPED VEGETATION COMMUNITIES OF WORONORA RIVER CATCHMENT

SYDNEY TURPENTINE IRONBARK FOREST

RIVER-FLAT EUCALYPT FOREST

COASTAL SALTMARSH

SHALE/SANDSTONE TRANSITION FOREST

SWAMP OAK FLOODPLAIN FOREST

NON NATURAL WETLANDS

SYDNEY SANDSTONE RIDGETOP WOODLAND

SYDNEY SANDSTONE GULLY FOREST

SYDNEY SANDSTONE HEATH

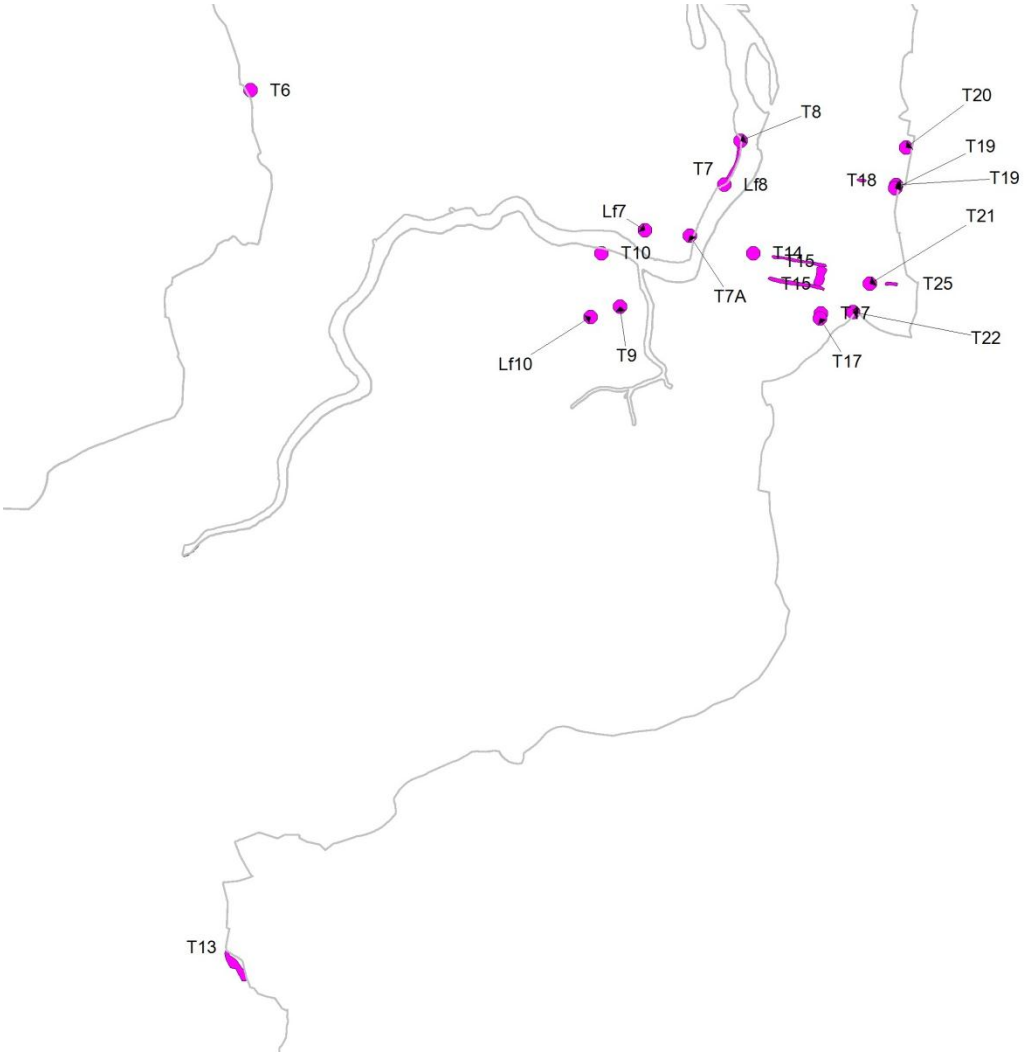
MANGROVE

RIPARIAN SCRUB

LEP 2006 SIGNIFICANT VEGETATION

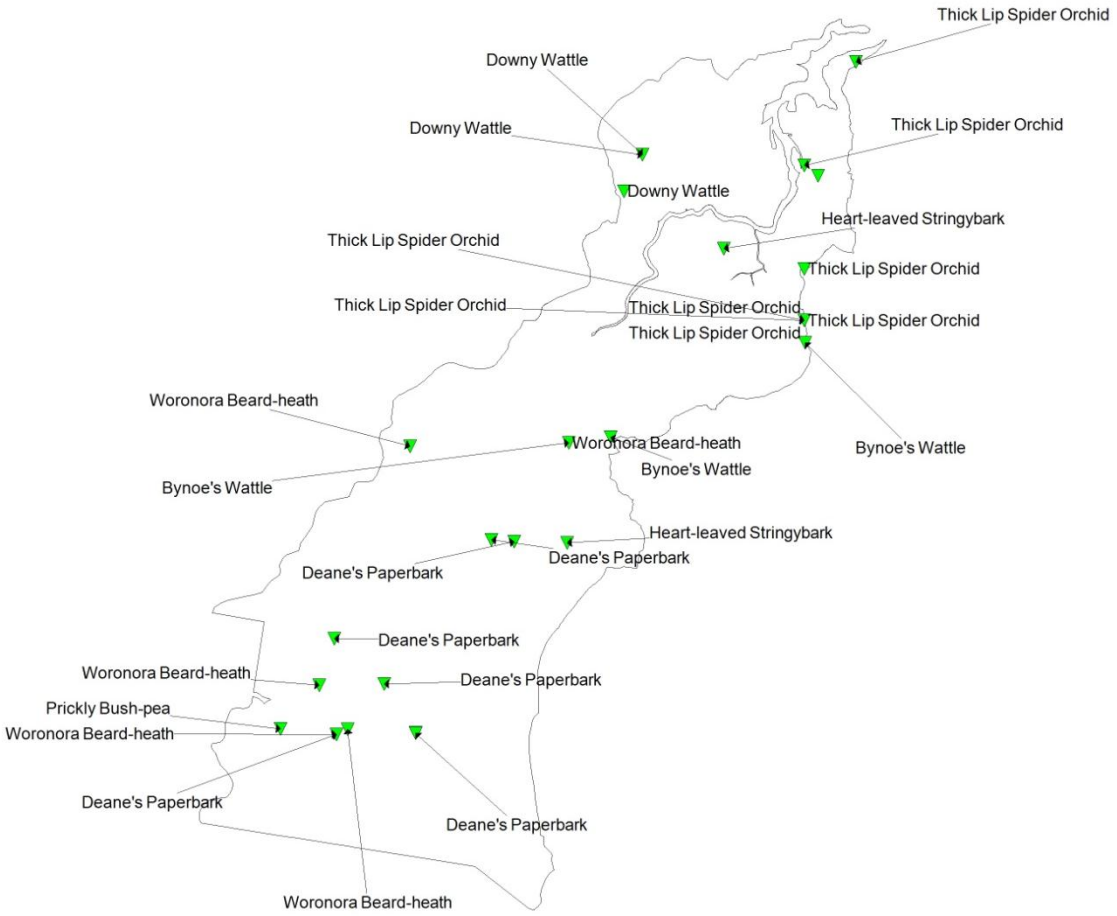
TAG	NAME	CLASS
T6	Moreton Bay Fig	Significant Group of Trees or Vegetation
T8	Eucalyptus Racemosa	Significant Group of Trees or Vegetation
T9	Eucalyptus Pilularis	Significant Group of Trees or Vegetation
T10	Eucalyptus_River Red Gum	Significant Group of Trees or Vegetation
Lf7	Sandstone Steps	Significant Landform
Lf8	Sandstone Formations	Significant Landform
Lf10	Wishing Well	Significant Landform
T14	Eucalyptus Punctata_Grey Gum	Significant Group of Trees or Vegetation
T17	Tristaniopsis Laurina_Water Gum	Significant Group of Trees or Vegetation
T17	Tristaniopsis Laurina_Water Gum	Significant Group of Trees or Vegetation
T19	Eucalyptus Racemosa_Ghost Gum	Significant Group of Trees or Vegetation
T19	Eucalyptus Racemosa_Ghost Gum	Significant Group of Trees or Vegetation
T20	Eucalyptus Microcorys_Tallowwood	Significant Group of Trees or Vegetation
T21	Ficus Rubiginosa_Port Jackson Fig	Significant Group of Trees or Vegetation

TAG	NAME	CLASS
T22	Ficus Rubiginosa_Port Jackson Fig	Significant Group of Trees or Vegetation
T7A	Calodendrum capense_Cape Chestnut	Significant Group of Trees or Vegetation
T25	Lophostemon confertus_Brush Box	Significant Group of Trees or Vegetation
T15	Cultural Plantings_Lophostemon confertus_Brush Box	Significant Group of Trees or Vegetation
T16	Eucalyptus haemastoma_Scribbly and Snappy Gums	Significant Group of Trees or Vegetation
T15	Cultural Plantings_Lophostemon confertus_Brush Box	Significant Group of Trees or Vegetation



THREATENED SPECIES: FLORA RECORDS

SCIENTIFIC	COMMON_NAM	LEGAL_STAT
Pultenaea aristata	Prickly Bush-pea	V
Leucopogon exolasius	Woronora Beard-heath	V
Melaleuca deanei	Deane's Paperbark	V
Grevillea parviflora		V
Eucalyptus camfieldii	Heart-leaved Stringybark	V
Acacia bynoeana	Bynoe's Wattle	E1
Acacia pubescens	Downy Wattle	V
Caladenia tessellata	Thick Lip Spider Orchid	E1
Persoonia hirsuta subsp. evoluta		E1
Genoplesium baueri	Bauer's Midge Orchid	V



THREATENED SPECIES: FAUNA RECORDS

Records of threatened bird species in Woronora 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
Ixobrychus flavicollis	Black Bittern	V
Callocephalon fimbriatum	Gang-gang Cockatoo	V
Calyptorhynchus lathami	Glossy Black-Cockatoo	V
Climacteris picumnus	Brown Treecreeper	V
Ptilinopus superbus	Superb Fruit-Dove	V
Daphoenositta chrysoptera	Varied Sittella	V
Petroica boodang	Scarlet Robin	V
Petroica phoenicea	Flame Robin	V
Petroica rodinogaster	Pink Robin	V
Glossopsitta pusilla	Little Lorikeet	V
Ninox strenua	Powerful Owl	V
Tyto tenebricosa	Sooty Owl	V

Records of threatened mammal species in Woronora 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
Mormopterus norfolkensis	Eastern Freetail-bat	V
Phascolarctos cinereus	Koala	V
Pteropus poliocephalus	Grey-headed Flying-fox	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 Woronora 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

Impacts in Woronora River catchment are limited by the lack of development in large parts of the upper catchment. Key impacts include:

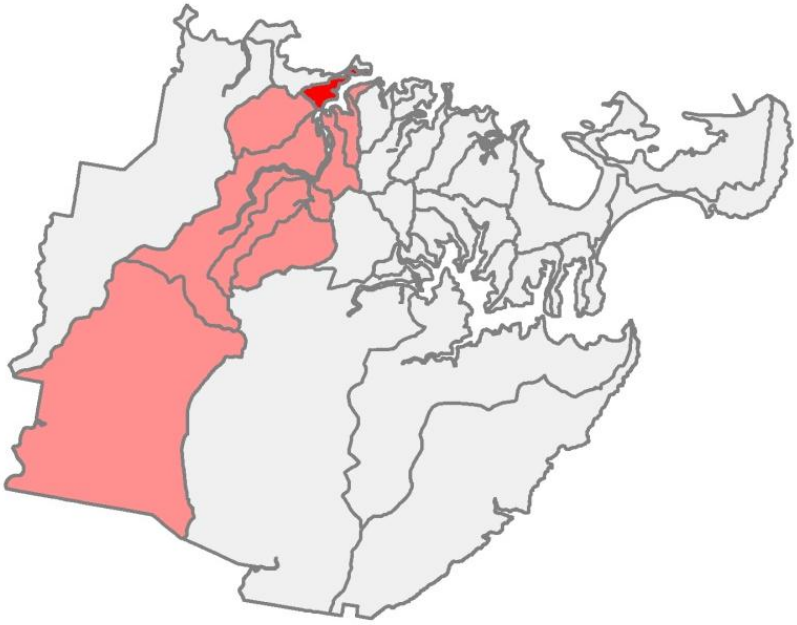
- The lower 16% of the catchment has been developed for residential housing and some commercial/retail uses.
- highly polluted tidal inflows from the Georges River

- unmanaged stormwater discharges and overflows from Forbes, Still and Heathcote Creeks
- lack of freshwater inflows from the upper catchment as a result of the Woronora Dam
- Impacts of storm event flooding associated with the catchment geomorphology
- Potential for flooding associated with failure of Woronora Dam
- Potential for contamination associated with spills and other incidents at ANSTO nuclear reactor
- Contamination from decaying armaments or detonation of live ammunition on the firing range at Holsworthy Army Base
- Impacts associated with urban runoff, including oils and grease, particulates, weed propagules, elevated nutrients, other toxic materials

AUDREY BAY &THOMPSON BAY SUBCATCHMENT

CATCHMENT AREA: 1.11 KM^2

SUBURBS: ILLAWONG



WATERWAYS

MAJOR NAMED WATERWAYS: NIL

TOTAL LENGTH OF MAPPED WATERWAYS: 3.91 KMs

PRIMARY ORDER CREEKS: 0. KMs

SECOND ORDER CREEKS: 0.92 KMs

FIRST ORDER & MINOR DRAINAGE LINES: 2.99 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 (↑) 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.

No sites sampled in this subcatchment

RETICULATED STORMWATER SYSTEM

LOCATION OF SQIDS

NIL

GEOMORPHIC SETTING

Audrey Bay/Thompsons Bay subcatchment soil landscapes include Hawkesbury Soil Landscape (ha) around foreshores. Areas immediately behind the foreshores, and the rest of the catchment are Lucas Heights Soil Landscape (lh) (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

Audrey and Thompsons Bays subcatchment includes a narrow strip along the Woronora River with one minor drainage line. Foreshores are steep and rise quickly to 15m AHD or greater. A small plateau on the western boundary is over 70m, with a maximum height of 77m AHD.

ASS/PASS, URBAN SALINITY

LEP (00 &06) CLASS	HECTARES
CLASS 1	0.09
CLASS 2	0.21
CLASS 5	55.12

Very small areas of Class 1 and 2 ASS are located close to the foreshore, and the larger area of Class 5 ASS forms a band along the foreshores.

OTHER CONTAMINATION ISSUES

None noted

LAND USE

HISTORIC LAND USE

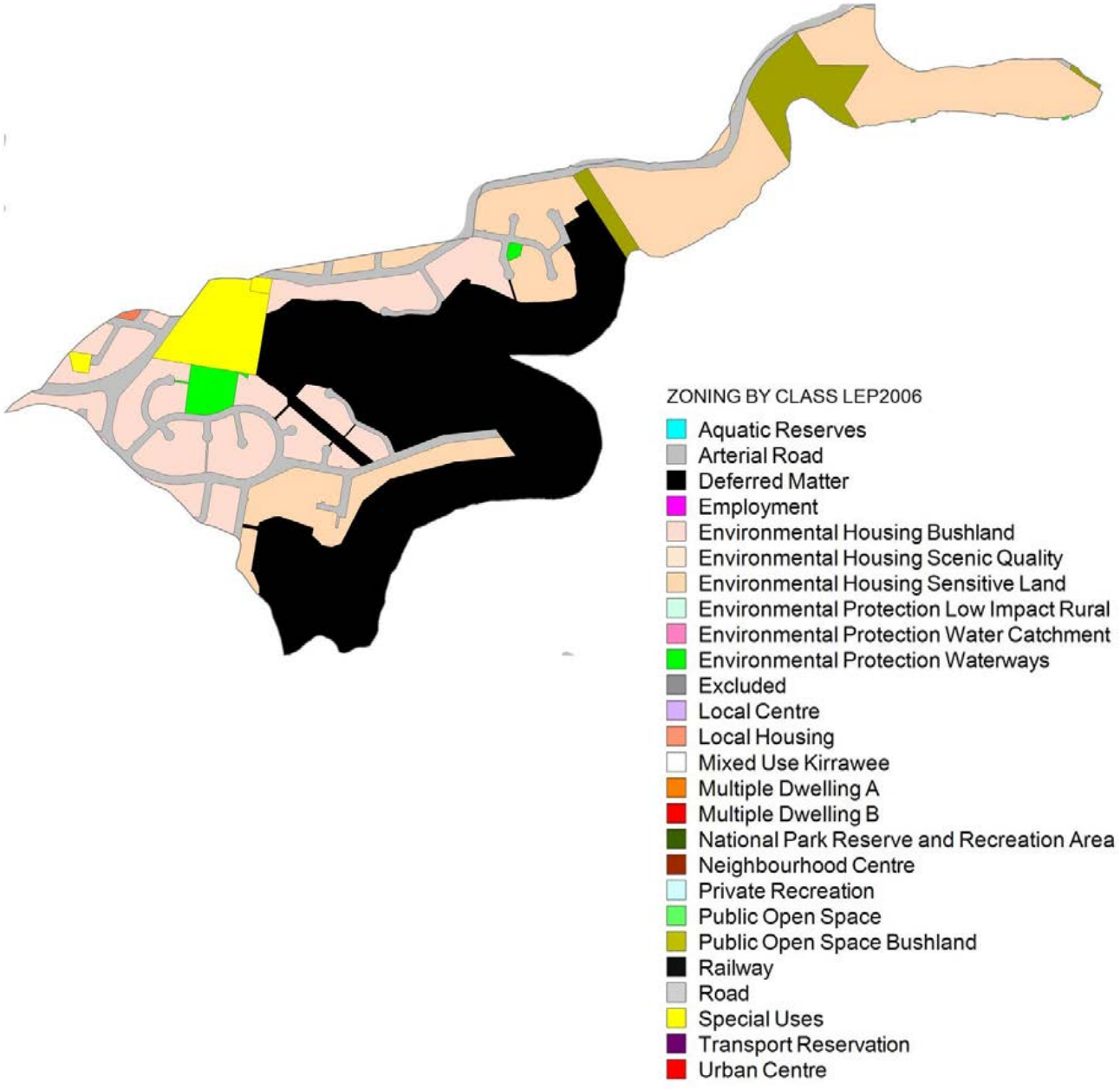
Audrey and Thompsons Bays drain a small catchment on the eastern side of Illawong Peninsula, near the confluence of Woronora and Georges Rivers. Illawong was named for an aboriginal word meaning “land between two rivers”. In the 1880s the area was closely associated with Como. Wealthy people built holiday homes in the area, attracted to its beauty and remoteness. Chief among these was Cranbrook, a nine room sandstone house built on land purchased in 1892 by Robert Fowler, a pottery manufacturer. Today, the gardens still retain Fowlerware urns, terracotta lions and pavers (Jackson, 2006).

During the early years services were fairly sparse. Despite its connection with Como, Illawong was part of Hurstville until 1921, further complicating progress. In the 1940s a ferry service connected the area with Lugarno on the northern side of Georges River, and during the 1950s services such as power and sanitation were introduced. By mid1960s development was frozen in the area following its incorporation into Sydney’s green belt, and also because of difficulties accessing a water supply.

The steep terrain provided excellent views of both the Woronora and Georges Rivers. Rapid growth followed through the 1980s and early 1990s, resulting in clearing of vast tracts of land. By the mid 1990s local residents were working to protect the remaining bushland, and bushcare groups are still active in the area today (Jackson, 2006).

The catchment watershed also drains parts of Bangor, a suburb formed in the 1950s when nearby Menai was subdivided. It was named for an early settler who arrived from Bangor in Wales in 1895. The area remained rural until the 1960s when the population began to grow. Improved access in the 1970s and better facilities in the 1980s supported a steady population growth in the area.

CURRENT LAND USE



CATCHMENT IMPERVIOUS SURFACE (% AND DISTRIBUTION)

LEP ZONING DESCRIPTOR	HECTARES	% CATCHMENT	POTENTIAL IMPERVIOUS	HECTARES IMPERVIOUS
Deferred Matter	41.94	38%	0%	0.00
Environmental Housing Sensitive Land	28.35	26%	43%	12.19
Environmental Housing Scenic Quality	0.00	0%	57%	0.00
Environmental Housing Bushland	17.97	16%	57%	10.24
Local Housing	0.10	0%	51%	0.05
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	4.72	4%	46%	2.17
Public Open Space	1.38	1%	5%	0.07
Public Open Space Bushland	4.79	4%	0%	0.00
Private Recreation	0.00	0%	5%	0.00
Environmental Protection Waterways	0.04	0%	0%	0.00
Aquatic Reserves	0.00	0%	0%	0.00
National Park Reserve and Recreation Area	0.00	0%	0%	0.00
Railway	0.00	0%	33%	0.00
Arterial Road/Road	11.14	10%	66%	7.35
Transport Reservation	0.00	0%	5%	0.00
TOTAL	**110.43**	**100%**	**29%**	**32.08**

VEGETATION COMMUNITIES

MAPPED VEGETATION COMMUNITIES

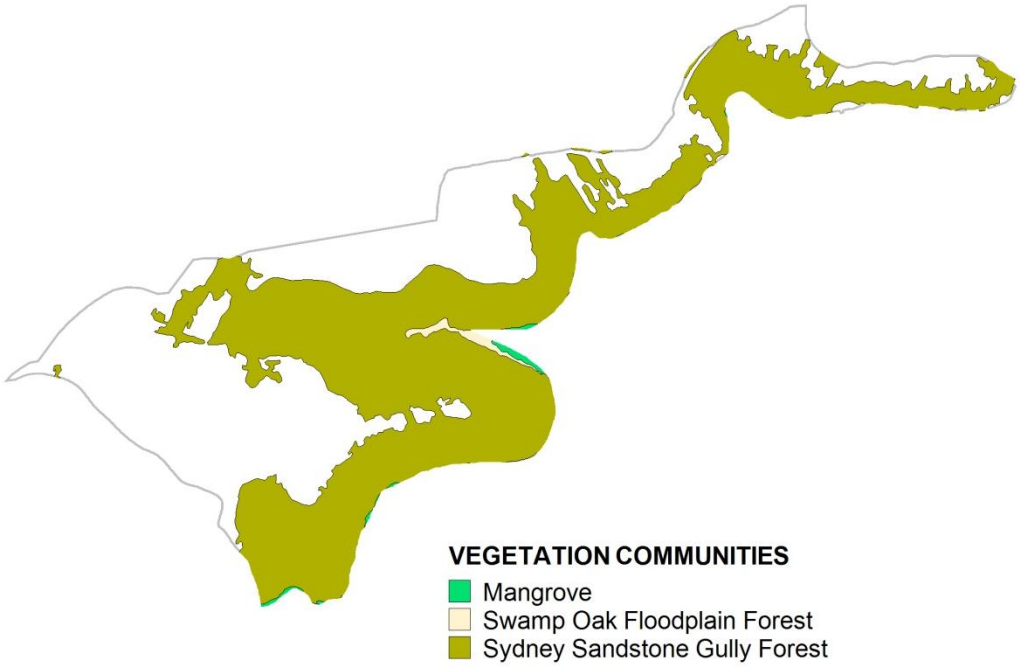
0.41 HECTARES MANGROVE

0.57 HECTARES SWAMP OAK FLOODPLAIN FOREST

57.29 HECTARES SYDNEY SANDSTONE GULLY FOREST

LEP 2006 SIGNIFICANT VEGETATION

NIL



BUSHLAND RESERVES AND RESTORATION

Reserves

1) Greenweb Core areas

- Woronora River foreshores/Fowler Rd

2) Greenweb Support areas

- Stuart Cl/Fowler Rd/Cranbrook Pl/Bignell St
- Kinsella St/Karangi Pl/Gascoyne Pl/Bradley Pl/Fowler Rd
- Austin St/Sproule Rd/Hector St

3) Greenweb Restoration areas

- None noted

Bushcare Groups

- Thompsons Bay Reserve
- Louden Avenue Road Reserve

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
    - Gambusia
    - Carp
    - Cane Toads
    - Koi Carp (goldfish)

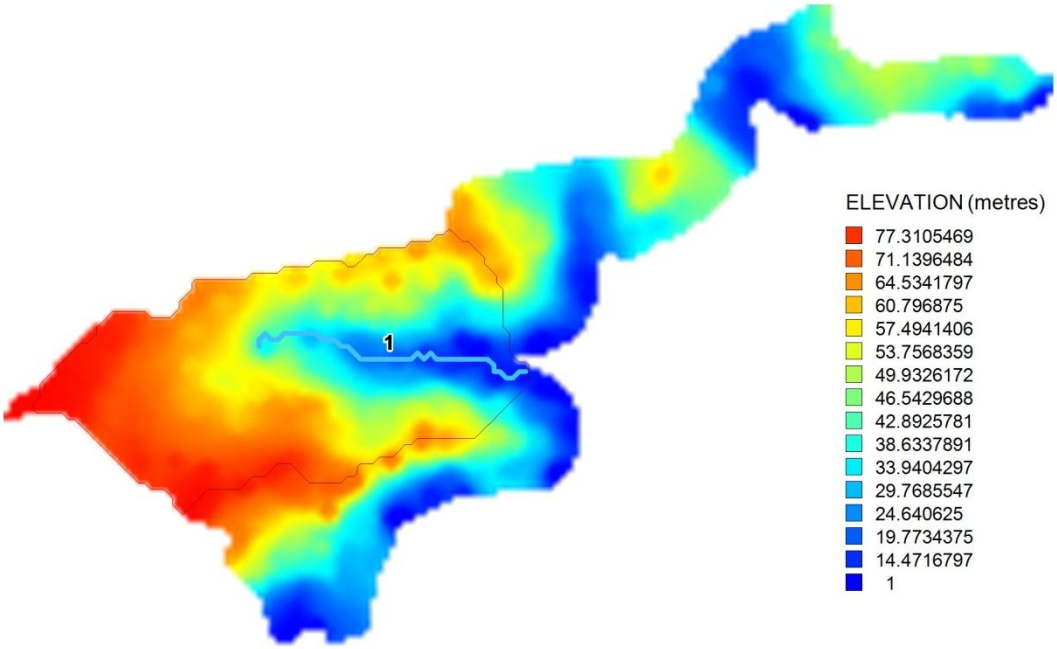
RIPARIAN IMPACTS

- 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
    - Loss of shrub layer
    - Loss of groundcover species
- Removal of habitat elements including
    - Loss of leaf litter
    - Loss of fallen timber
    - Loss of standing dead trees
    - Loss of rocks
    - Loss of microhabitat architecture
- Dumping of rubbish
- Littering
- Vandalism including
    - Damage to plants
    - Damage to abiotic habitat elements
    - Injured or killed animals
- Inappropriate fire regime
- Erosion

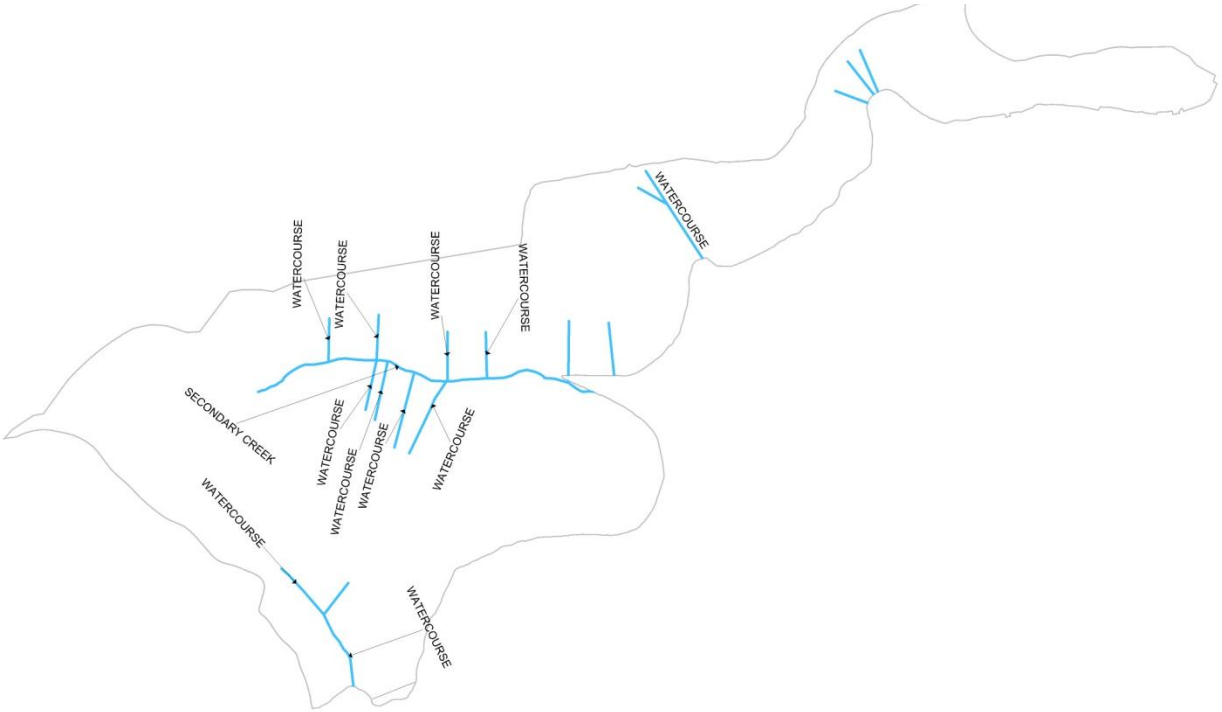
- Sedimentation
- Plant diseases including
    - Phytophthora (dieback)
    - Myrtle rust
    - Smut
    - Common rust
    - Mistletoes
- Feral animals including
    - Foxes
    - Rabbits
    - Deer
    - Cane Toads
    - Wild pigs
    - Feral cats
    - Introduced birds

RECREATED WATERWAYS MAP

ELEVATION MODEL: STREAM ORDER AND CATCHMENT BOUNDARY



CURRENTLY MAPPED WATERWAYS AND CATCHMENT BOUNDARY



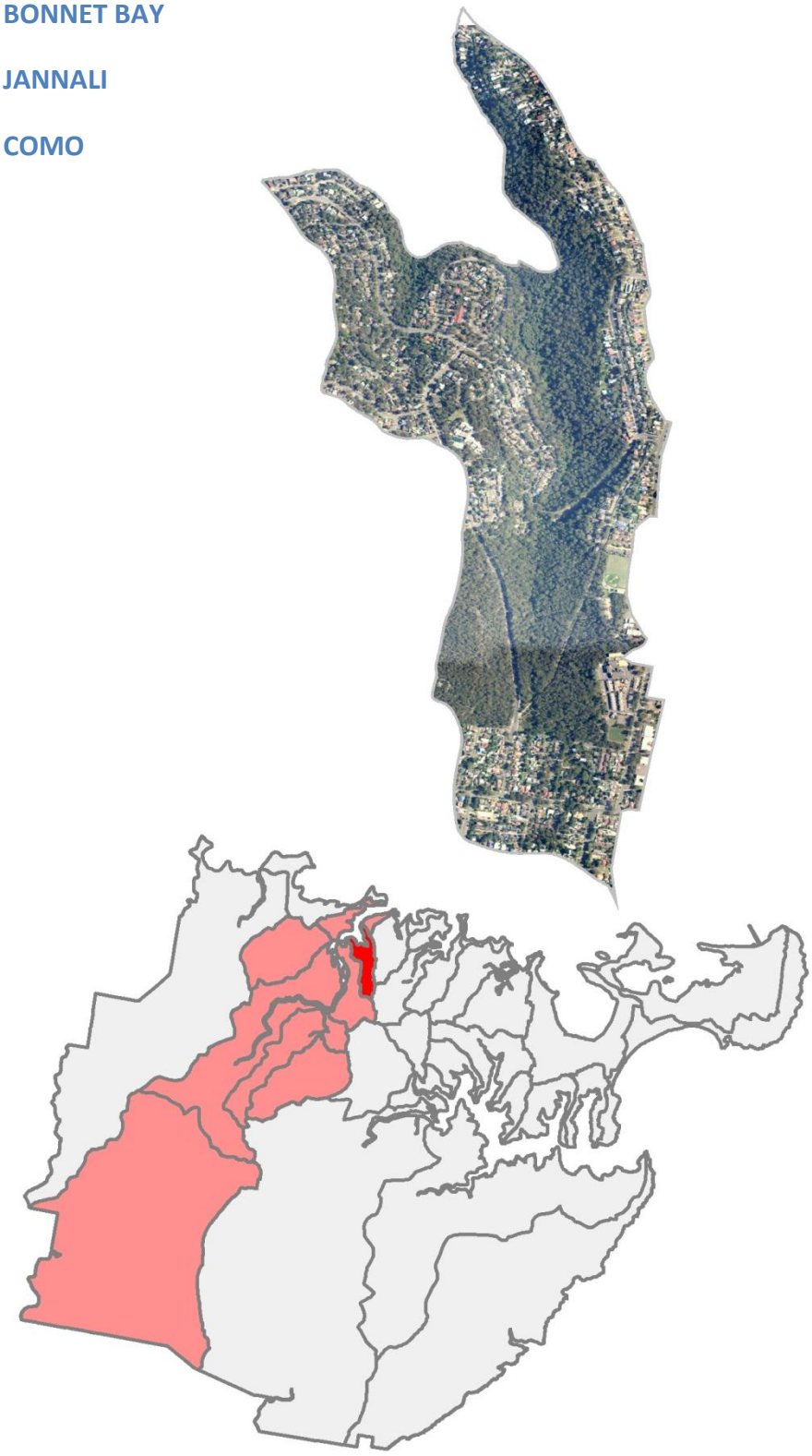
BONNET BAY SUBCATCHMENT

CATCHMENT AREA: 1.39 KM^2

SUBURBS: BONNET BAY

JANNALI

COMO



WATERWAYS

MAJOR NAMED WATERWAYS: NIL

TOTAL LENGTH OF MAPPED WATERWAYS: 3.45 KMs

PRIMARY ORDER CREEKS: 0 KMs

SECOND ORDER CREEKS: 1.80 KMs

FIRST ORDER & MINOR DRAINAGE LINES: 1.65 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).

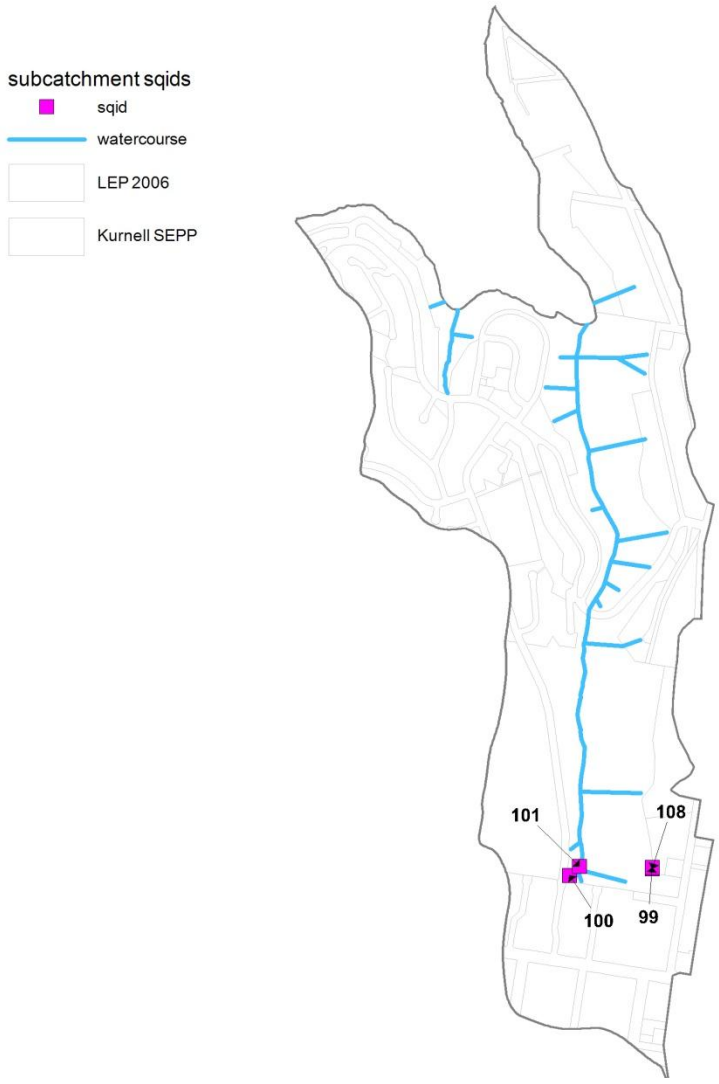
Samples were analysed summer and winter for between three and seven years at each site. This data has been interpreted here to give a brief historic summary of water quality in the subcatchment. First and last reported values for each parameter were assessed as higher (+) than the ANZECC 2000 guideline value, lower (-) than the guideline value, or equivalent (=) to the guideline value. The overall trend during the survey period was identified as increasing (↑) 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.

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

RETICULATED STORMWATER SYSTEM

LOCATION OF SQIDS

ID	DEVICE CATEGORY	DEVICE TYPE	LOCATION	SITE DESCRIPTION	SUBURB	APPROX. CATCHMENT
100	GPT - Other	Ecosol GPT	Tudar Road	Jannali Reserve	Jannali	13.2 Ha
101	Wetland	Wetland	Tudar Road	Jannali Reserve	Sutherland	21 Ha
108	Wetland	Wetland	Sutherland Road	Jannali Private Wetland	Jannali	2 Ha of which 0.65ha is public land
99	GPT - Other	Floating Litter Boom	Sutherland Road	Jannali Private Wetland	Jannali	2 Ha of which 0.65ha is public land



GEOMORPHIC SETTING

Bonnet Bay subcatchment soil landscapes include Mangrove Creek Soil Landscape (mc) around foreshores. Areas immediately behind the foreshores, and the rest of the catchment are Hawkesbury Soil Landscape (ha), with minor areas of Gymea Soil Landscape (gy) on the eastern part of the subcatchment (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

Bonnet Bay is a small subcatchment on the eastern side of the Woronora River, and has one minor drainage line. Most of the subcatchment has an altitude below 40m AHD, rising to a high point on the ridge at 90m.

ASS/PASS, URBAN SALINITY

LEP (00 &06) CLASS	HECTARES
CLASS 1	0.03
CLASS 2	1.72
CLASS 5	89.82

Very small areas of Class 1 and 2 ASS are located close to the foreshore, and the larger area of Class 5 ASS forms a band along the foreshores.

OTHER CONTAMINATION ISSUES

None noted

LAND USE

HISTORIC LAND USE

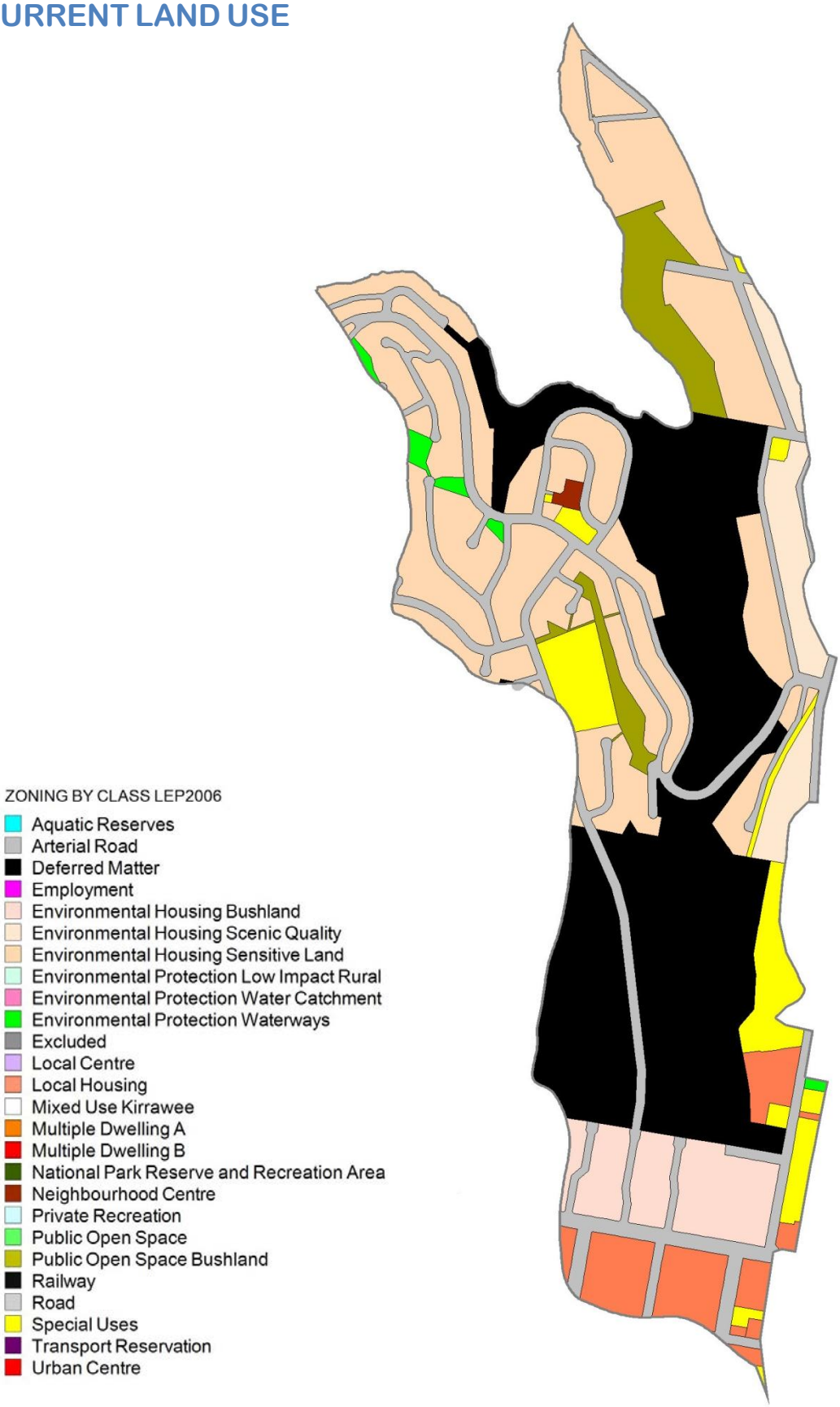
Bonnet Bay was named for the unusual rock cave features known as “The Bonnet”, located at Bonnet Head on the Woronora River. The area became a popular tourist attraction for recreation and to “escape the evils of city living”. In the early 1900s Bonnet Bay was part of Como. Residents of the bay travelled to Como by foot or boat for basic services. In 1907 the new road from Sutherland reduced the area’s isolation, although progress was slow and the village remained small. It was the venue for a number of summer camps by 1928, and over the next ten years the numbers of visitors increased dramatically. By 1940 the water supply was connected from the Sutherland-Como pipeline, and long term holiday makers began to come to the area as well (Jackson, 2006).

In 1957-8 parts of Bonnet Bay were fenced to protect oyster leases, annoying residents with the loss of leisure activities and recreation space. By 1960 the size and location of the oyster leases was under review, partly to facilitate the use of marine channels through the area. Road access to the area was improved during the 1960s, opening the way to suburban development.

Woronora Gardens subdivision, now part of the suburb of Bonnet Bay, was released for development in 1969. Until this time the area had been unspoilt bushland. Early development was slow, until a public school opened in 1979, and a shopping centre opened the following year (Ashton et al, 2006). Nearby Jannali was the site of a number of home unit blocks, part of a trend towards medium density housing following the state government’s urban consolidation policy. Many of these are retained in the area, virtually unchanged.

Burnum Burnum Sanctuary, formerly known as Jannali Reserve, runs from Woronora to Jannali, and covers much of the upper subcatchment area for Bonnet Bay. Along with Honeysuckle Reserve, this forms a significant part of the Greenweb Program in the Shire, and protects a large variety of fauna and flora, and provides an important connectivity corridor for movement of species through the area. The Glen Reserve is another important bushland area, and is well cared for by bushcare volunteers.

CURRENT LAND USE



CATCHMENT IMPERVIOUS SURFACE (% AND DISTRIBUTION)

LEP ZONING DESCRIPTOR	HECTARES	% CATCHMENT	POTENTIAL IMPERVIOUS	HECTARES IMPERVIOUS
Deferred Matter	45.18	33%	0%	0.00
Environmental Housing Sensitive Land	38.75	28%	43%	16.66
Environmental Housing Scenic Quality	5.92	4%	57%	3.38
Environmental Housing Bushland	7.32	5%	57%	4.17
Local Housing	7.12	5%	51%	3.63
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	0.26	0%	86%	0.23
Employment	0.00	0%	95%	0.00
Special Uses	7.87	6%	46%	3.62
Public Open Space	0.92	1%	5%	0.05
Public Open Space Bushland	5.67	4%	0%	0.00
Private Recreation	0.00	0%	5%	0.00
Environmental Protection Waterways	0.01	0%	0%	0.00
Aquatic Reserves	0.00	0%	0%	0.00
National Park Reserve and Recreation Area	0.00	0%	0%	0.00
Railway	0.00	0%	33%	0.00
Arterial Road/Road	19.63	14%	66%	12.96
Transport Reservation	0.00	0%	5%	0.00
TOTAL	**138.65**	100%	**32%**	**44.69**

VEGETATION COMMUNITIES

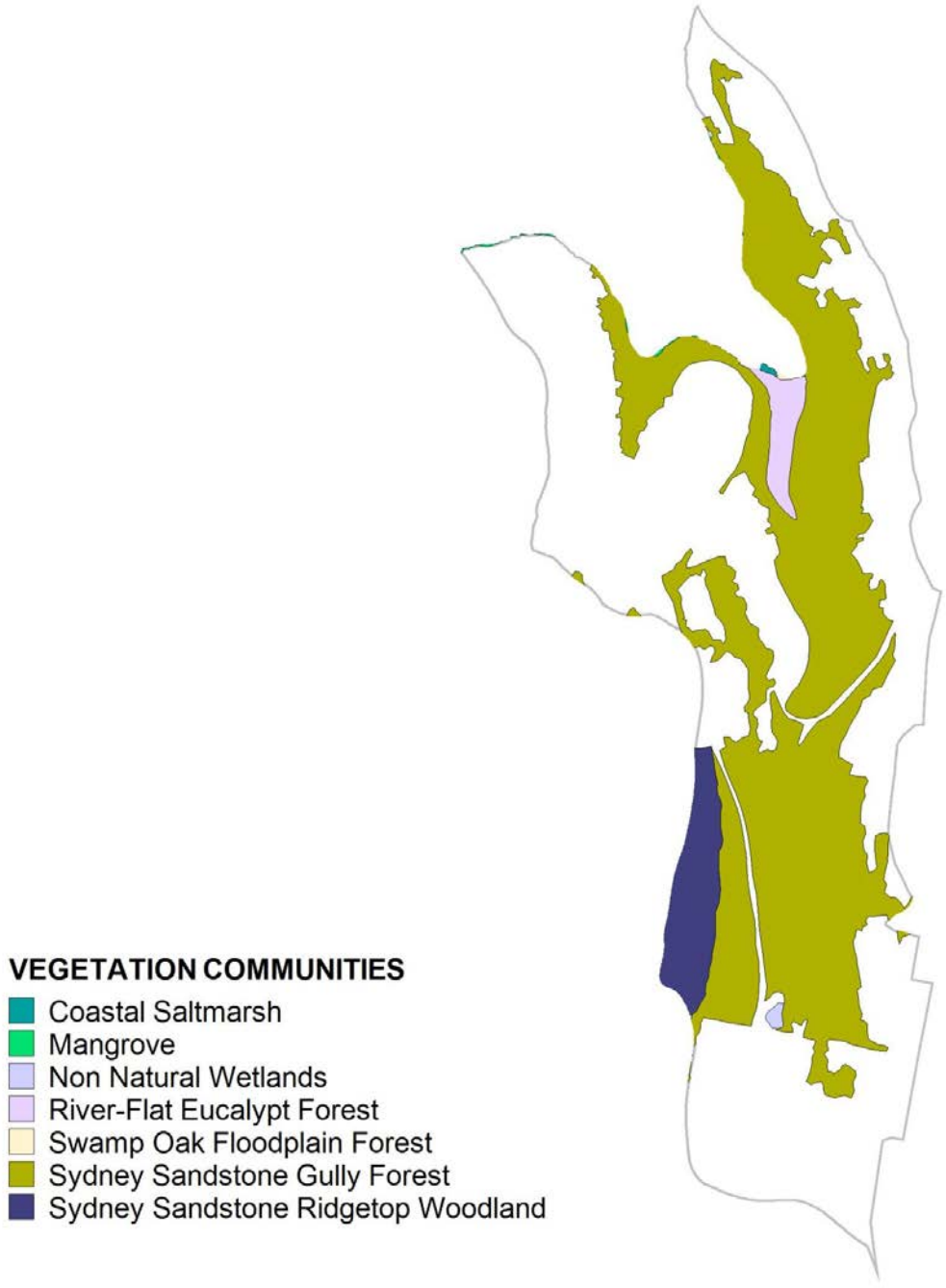
MAPPED VEGETATION COMMUNITIES

0.05 HECTARES COASTAL SALTMARSH
0.08 HECTARES MANGROVE
0.16 HECTARES NON NATURAL WETLANDS
1.89 HECTARES RIVER-FLAT EUCALYPT FOREST
0.05 HECTARES SWAMP OAK FLOODPLAIN FOREST
52.93 HECTARES SYDNEY SANDSTONE GULLY FOREST
4.93 HECTARES SYDNEY SANDSTONE RIDGETOP WOODLAND

LEP 2006 SIGNIFICANT VEGETATION

LEP TAG	NAME	CLASS
T18	Eucalyptus microcory and Eucalyptus pilularis	Significant Group of Trees or Vegetation
T19	Eucalyptus Racemosa_Ghost Gum	Significant Group of Trees or Vegetation
T20	Eucalyptus Microcorys_Tallowwood	Significant Group of Trees or Vegetation

MAPPED VEGETATION COMMUNITIES



BUSHLAND RESERVES AND RESTORATION

Reserves

1) Greenweb Core areas

- Bonnet Bay foreshores/Woronora Cres
- Burnum Burnum Sanctuary – Tyler Place
- Burnum Burnum Sanctuary
- Sutherland Rd/Carol Ave/Jannali Rd

2) Greenweb Support areas

- Woronora Cres
- Bonnet Bay suburb
- Burnum Burnum Sanctuary buffer zone

3) Greenweb Restoration areas

- None noted

Bushcare Groups

- Koolangara Reserve
- The Glen Reserve
- Burnum Burnum Sanctuary – Tyler Place
- Burnum Burnum Sanctuary

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
    - Gambusia
    - Carp
    - Cane Toads
    - Koi Carp (goldfish)

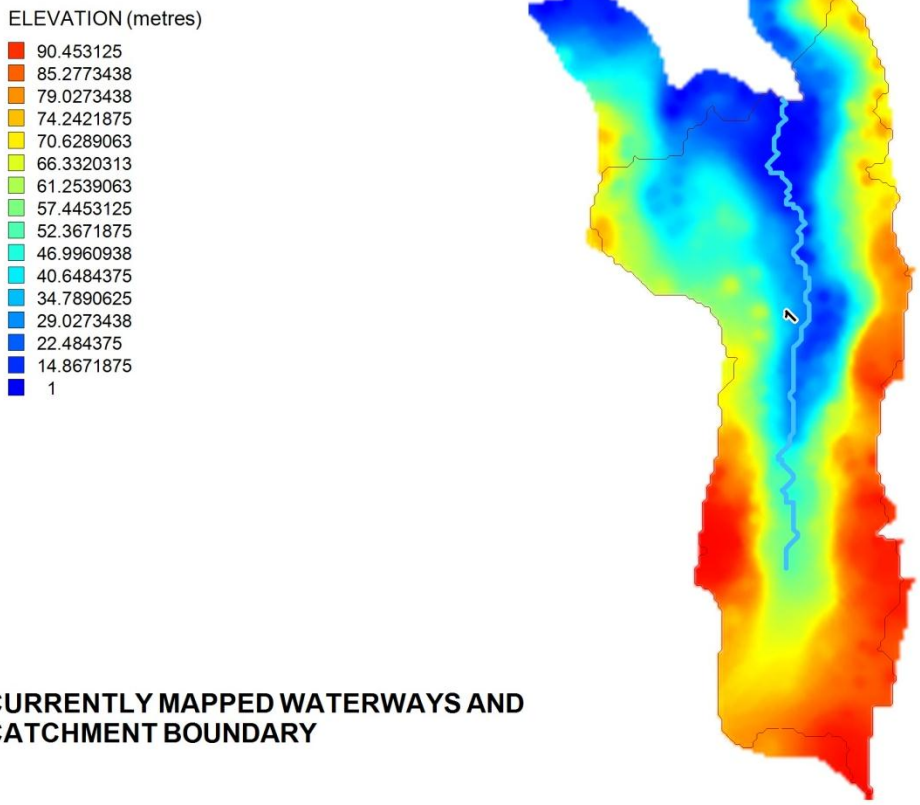
RIPARIAN IMPACTS

- 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
    - Loss of shrub layer
    - Loss of groundcover species
- Removal of habitat elements including
    - Loss of leaf litter
    - Loss of fallen timber
    - Loss of standing dead trees
    - Loss of rocks
    - Loss of microhabitat architecture

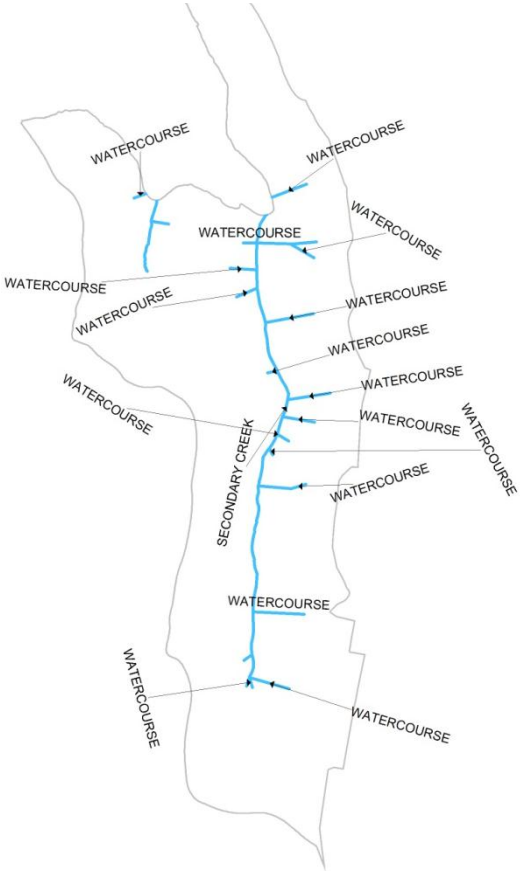
- Dumping of rubbish
- Littering
- Vandalism including
    - Damage to plants
    - Damage to abiotic habitat elements
    - Injured or killed animals
- Inappropriate fire regime
- Erosion
- Sedimentation
- Plant diseases including
    - Phytophthora (dieback)
    - Myrtle rust
    - Smut
    - Common rust
    - Mistletoes
- Feral animals including
    - Foxes
    - Rabbits
    - Deer
    - Cane Toads
    - Wild pigs
    - Feral cats
    - Introduced birds

RECREATED WATERWAYS MAP

CATCHMENT ELEVATION MODEL: STREAM ORDER AND CATCHMENT BOUNDARY



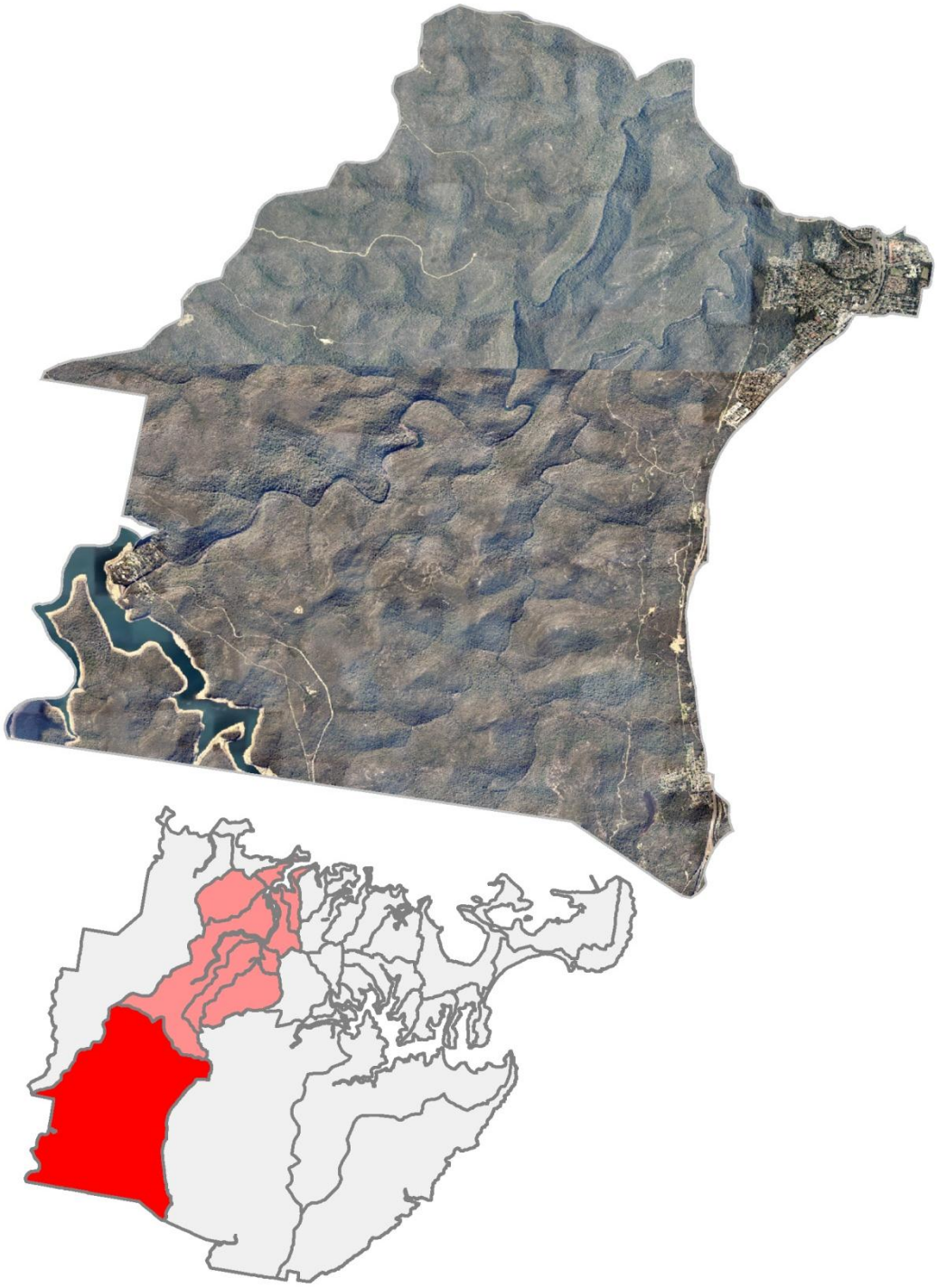
CURRENTLY MAPPED WATERWAYS AND CATCHMENT BOUNDARY



BOTTLE CREEK SUBCATCHMENT

CATCHMENT AREA: 47.31 KM^2

SUBURBS:



WATERWAYS

MAJOR NAMED WATERWAYS:

HEATHCOTE CREEK
WORONORA RIVER
WATERFALL GULLY
HEATHCOTE CK
KINGFISHER CREEK
MYUNA CREEK
MOORAY GULLY
BAGGARY GULLY
ABAROO GULLY
MINDA GULLY
RIPPLE RILL
MIRANG GULLY
SCOUT CREEK
BOTTLE CREEK
GIRRONBA CREEK
BUNGONIE RILL
SARAHS GULLY
PYTHON GULLY
BONDEL GULLY
MIARA GULLY
GUNNERS GULLY
TARMAROO RILL
ADINA GULLY
MINKA GULLY
WESTMACOTT RILL
GOBURRA GULLY
ORIGMA CREEK
LAKE TOOLOOMA

TOTAL LENGTH OF MAPPED WATERWAYS: 60.00 KMs

LAKE: 0.86 KMs

RIVERS: 12.00 KMs

PRIMARY ORDER CREEKS: 4.00 KMs

SECOND ORDER CREEKS: 38.33 KMs

FIRST ORDER & MINOR DRAINAGE LINES: 4.81 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 (↑) 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 the Bottle Creek subcatchment:

1. Woronora River at Heathcote Rd

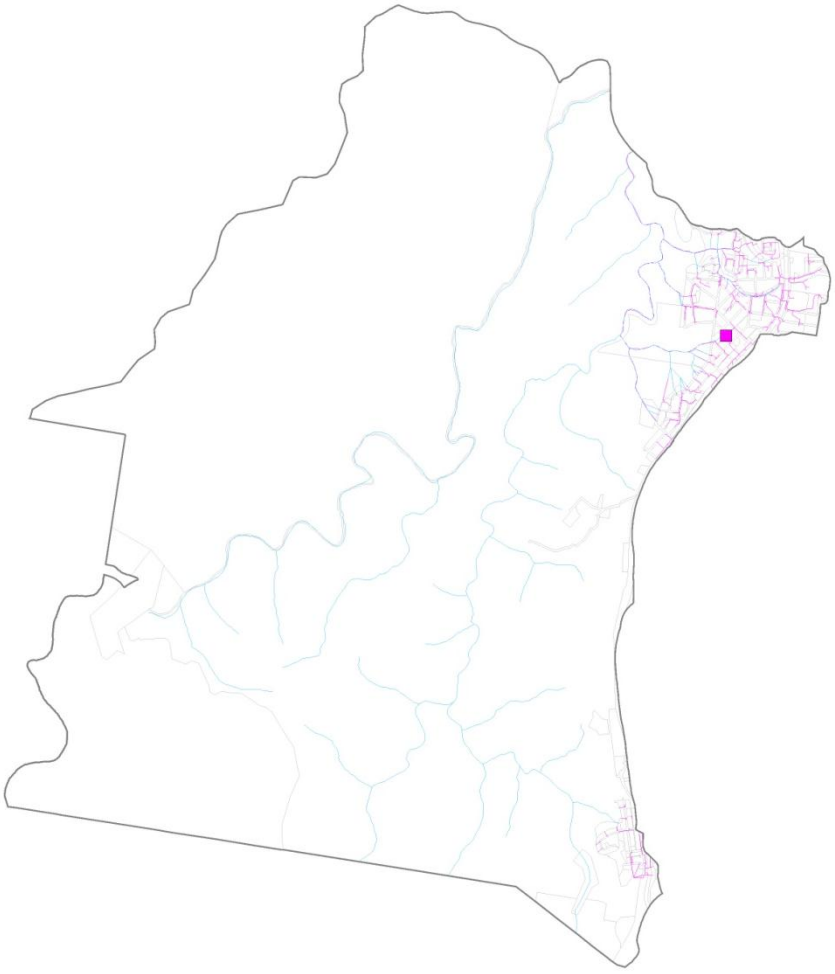
PARAMETER	NH3	BOD	Cu	Pb	Zn
SUMMER 95 +/- ANZECC 2000 values	+	+	-	-	-
WINTER 02 +/- ANZECC 2000 values	-	-	-	-	-
TREND ↓↑	↓	↓	=	↓	↓
PARAMETER	**Enterococci**	**Grease**	**TN**	**TP**	**TSS**
SUMMER 95 +/- ANZECC 2000 values	-	=	-	-	-
WINTER 02 +/- ANZECC 2000 values	-	-	-	-	-
TREND ↓↑	↓	↓	↓	↓	↓

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.

2. Heathcote Creek at Heathcote Rd

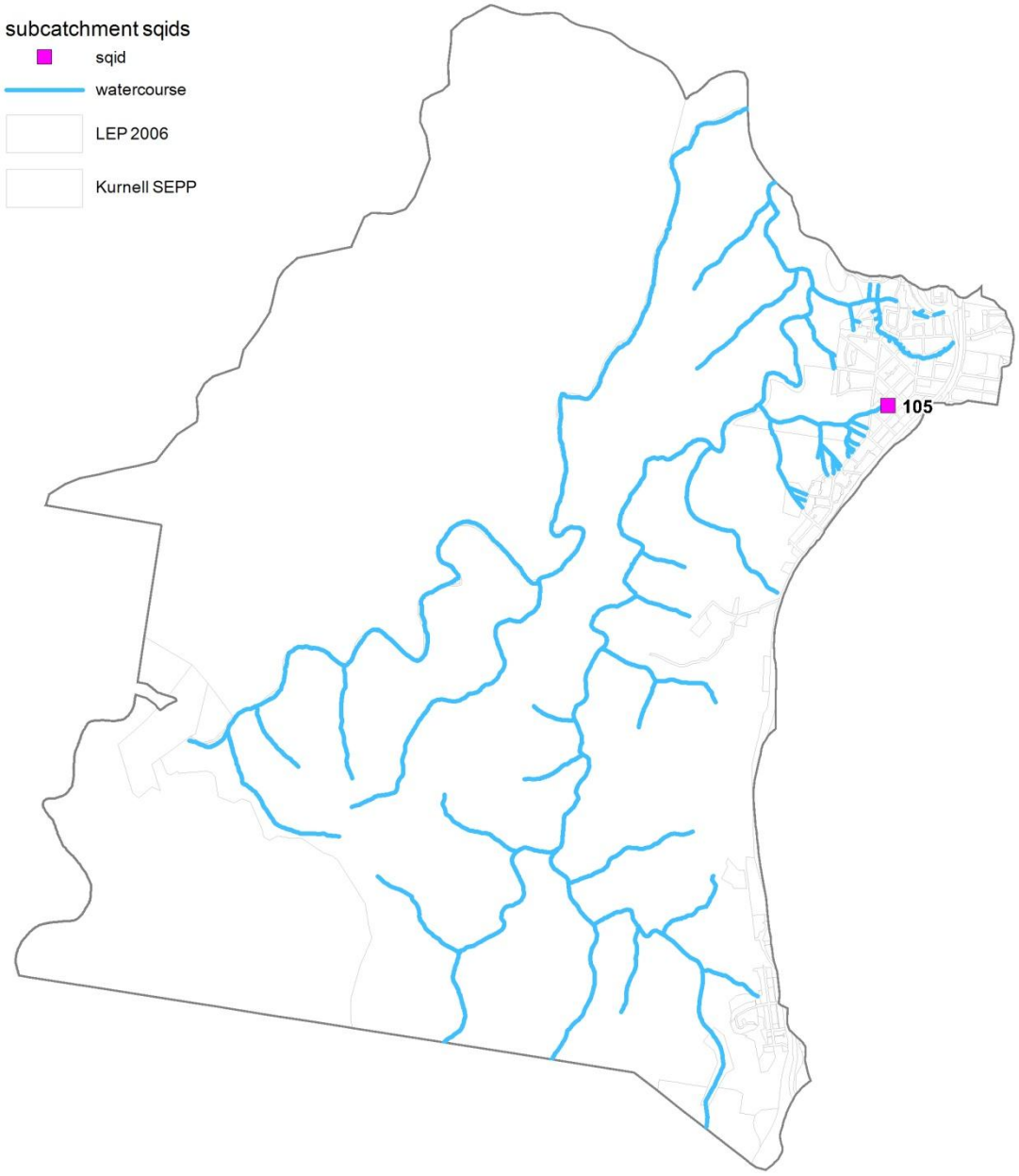
Insufficient data was recorded at this site and trends were not reported.

RETICULATED STORMWATER SYSTEM



LOCATION OF SQIDS

ID	DEVICE CATEGORY	DEVICE TYPE	LOCATION	SITE DESCRIPTION	SUBURB	APPROX. CATCHMENT
105	GPT - Other	Trash Rack	Oliver Street	Located behind Heathcote RSL at top of Martin and Whitton Street Reserve. Also includes a sediment trap.	Heathcote	4.8 Ha



GEOMORPHIC SETTING

Bottle Creek subcatchment soil landscapes include Hawkesbury Soil Landscape (ha) around drainage lines and surrounding areas. Minor areas of Gymea Soil Landscape (gy), Faulconbridge Soil Landscape (fb), Bundeena Soil Landscape (bu) and Lucas Heights Soil Landscape (lh) can be found on surrounding ridges and plateaus (from Soil Landscapes of the Wollongong-Port Hacking 1:100 000 Sheet Map and Report; see summary explanations in Geology and Soils section for Georges River catchment).

TOPOGRAPHY

Bottle Creek subcatchment is the largest in the Woronora River catchment, and has multiple named drainages, including Heathcote Creek and Bottle Creek. It is in the upper catchment, and drainage lines are all 25m AHD or greater. Steep gullies around drainages rise quickly to 90m, and plateau areas reach a maximum height of 232m.

ASS/PASS, URBAN SALINITY

LEP (00 &06) CLASS	HECTARES
NONE MAPPED	

OTHER CONTAMINATION ISSUES

None noted

LAND USE

HISTORIC LAND USE

Francis Seymour Cooper was the first settler in the area in the 1830s. He operated the local horse and cart from Bottle Forest to Sydney. Many generations of Coopers have lived in Sutherland Shire since then, and Coopers Reserve in Sutherland is named in their honour. William Thomas Fleming bought land from the government in 1845, and later sold it to Isaac Harber who built Heathcote Hall in 1887. Poor business judgement in the 1890s left Harber bankrupt and he left the Hall to his creditors.

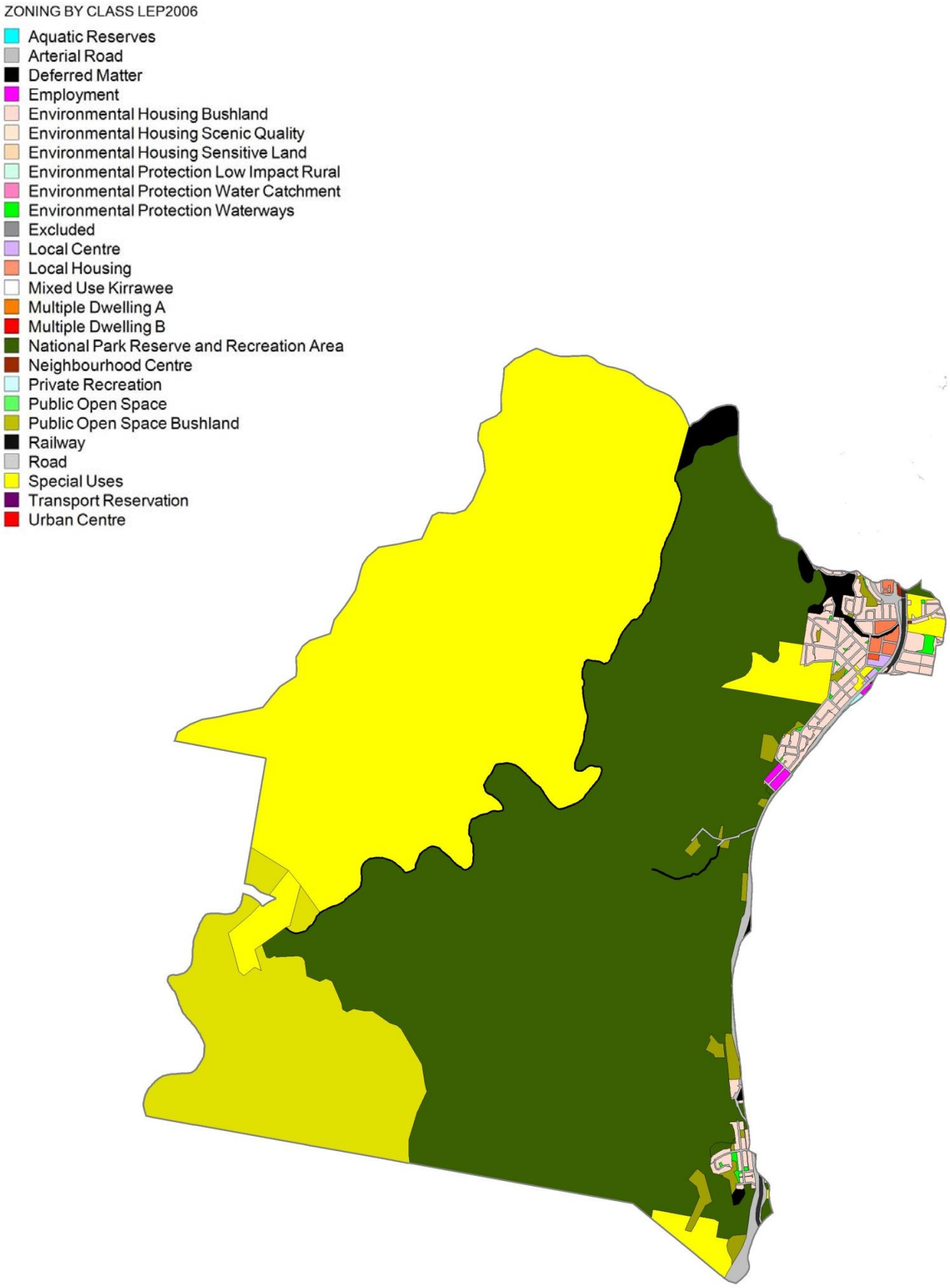
The economic depression of the decade made the Hall difficult to sell and it was disposed of by lottery. Because of its distance from the city the property was not a good proposition, and was sold again to Edmund Lamb Brown. He died in 1925, and the following year much of the land surrounding the house was subdivided by the Heathcote Hall Estate Company. The land release was billed as a model village centred around the Hall as a tourist attraction. Despite limited success with land sales, the company introduced a number of community based facilities including a newsletter, club and putting green at the Hall. The Hall, however, soon returned to private rental until it was sold and restored in 1945, again in 1973, and under National Heritage listing in 2000 (Jackson, 2006).

Bottle Creek drains the Heathcote area, originally known as Bottle Forest and believed to be named after a bottle was found embedded in a tree, apparently left by an early surveyor. There is also evidence that Heathcote, or Bottle Forest, was the location of the Shire's first settlement. During the early 1800s settlers were attracted by the good quality timber, including red cedar, turpentine and ironbark. In 1842 14 lots were surveyed in Bottle Forest, and a year later a guesthouse was constructed on Old Illawarra Road. In 1846 there were 16 adults living in the area. Although the land was good for farming it was difficult to transport goods to market in Sydney. Most travellers went to the Illawarra by boat, bypassing the area altogether. The area remained isolated and the small village of Bottle Forest was abandoned in 1860s. In 1865 Thomas Holt purchased 16 hectares for sheep farming. When dingoes killed more than 300 of his sheep, he retaliated by killing more than 300 dingoes (Jackson, 2006).

Following the relocation of Illawarra Road the village of Heathcote was gazetted in 1886. When the railway station was opened later that year it was known first as Bottle Forest, then National Park, and finally Heathcote. Water was pumped from a dam on a tributary of Kangaroo Creek to supply the steam trains. A brickworks was opened around the same time, but closed in 1894. The remaining clay pit was converted into an artificial lake known now as The Lakes. In 1907 22 portions of land were sold at Heathcote, and soon after a post office was opened. Schoolboys began clearing the land in preparation for the soldiers returning from World War I, but the scheme was dropped.

In 1937 the Mountain Trails Club leased 34 hectares of crown land known as Miara Sanctuary. It became the foundation for Heathcote Primitive Area, gazetted in 1943. In 1974 it became Heathcote National Park, and has been extended to 2250 hectares. From 1950 the demand for land increased, although Heathcote remained out of the way for many people.

CURRENT LAND USE



CATCHMENT IMPERVIOUS SURFACE (% AND DISTRIBUTION)

LEP ZONING DESCRIPTOR	HECTARES	% CATCHMENT	POTENTIAL IMPERVIOUS	HECTARES IMPERVIOUS
Deferred Matter	60.27	1%	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	94.94	2%	57%	54.11
Local Housing	9.24	0%	51%	4.71
Multiple Dwelling A	0.74	0%	64%	0.48
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	2.86	0%	88%	2.52
Neighbourhood Centre	0.74	0%	86%	0.64
Employment	4.19	0%	95%	3.98
Special Uses	1676.20	36%	5%	83.81
Public Open Space	5.47	0%	5%	0.27
Public Open Space Bushland	39.51	1%	0%	0.00
Private Recreation	1.74	0%	5%	0.09
Environmental Protection Water Catchment	498.88	11%	0%	0.00
Aquatic Reserves	0.00	0%	0%	0.00
National Park Reserve and Recreation Area	2237.09	47%	0%	0.00
Railway	7.05	0%	33%	2.33
Arterial Road/Road	79.48	2%	66%	52.46
Transport Reservation	0.00	0%	5%	0.00
TOTAL	**4718.41**	100%	**4%**	**205.39**

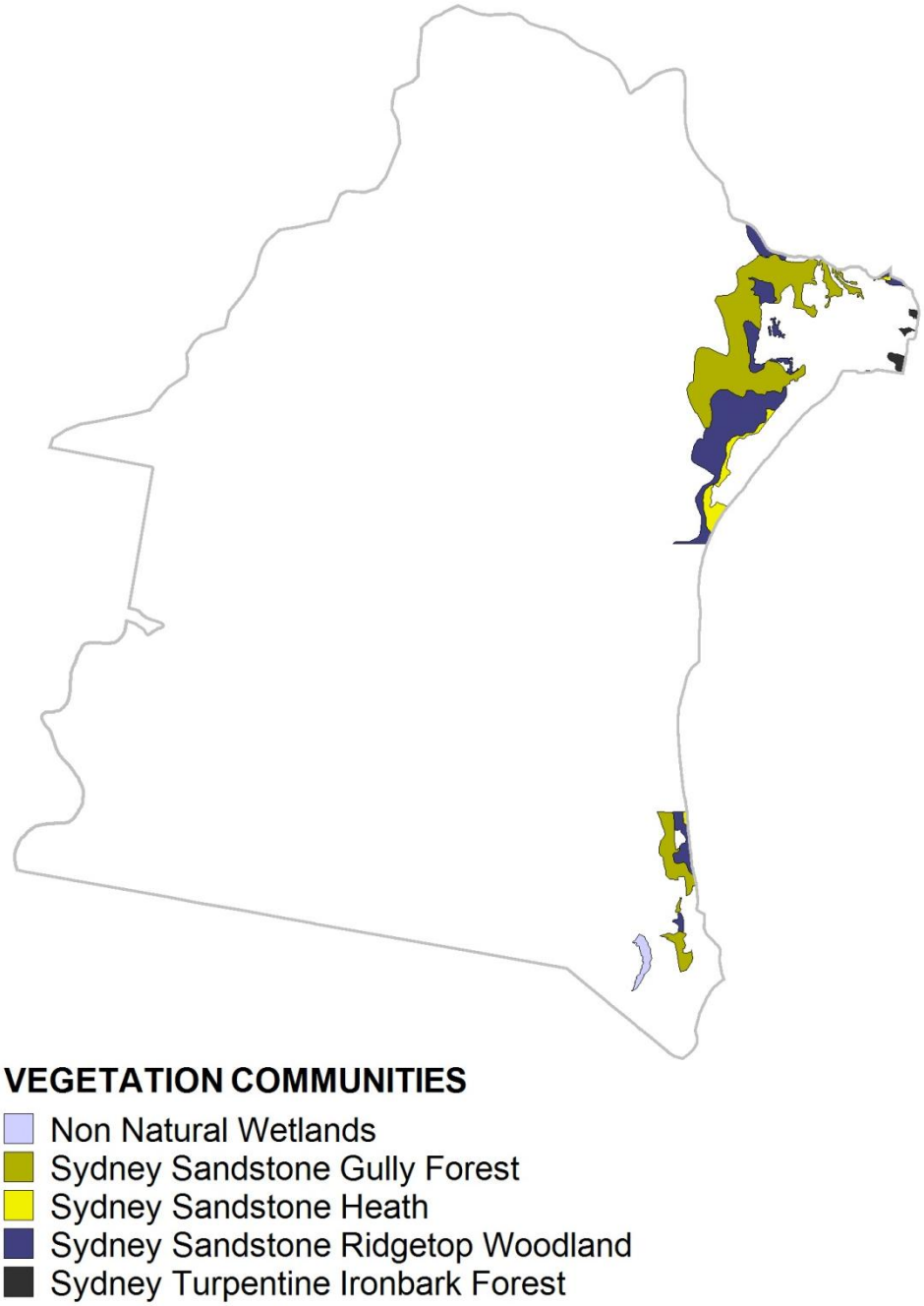
VEGETATION COMMUNITIES

MAPPED VEGETATION COMMUNITIES

4.02	HECTARES	NON NATURAL WETLANDS
0.39	HECTARES	SYDNEY SANDSTONE GULLY FOREST
0.80	HECTARES	SYDNEY SANDSTONE HEATH
2.02	HECTARES	SYDNEY SANDSTONE RIDGETOP WOODLAND
1.39	HECTARES	SYDNEY TURPENTINE IRONBARK FOREST

LEP 2006 SIGNIFICANT VEGETATION

NIL



BUSHLAND RESERVES AND RESTORATION

Reserves

1) Greenweb Core areas

- Heathcote National Park
- Eckersley Rd/Mirang Rd/Goburra Rd

2) Greenweb Support areas

- Railway corridor/Princes Hwy/McKell Ave
- Bundarra St/Warabin St/Yanagang St
- Darangan Cl
- Whitton St/Martin St/Oliver La
- Dillwynnia Gr/Wilson Pde/The Avenue
- Bella Vista St/Dorset Rd/Berrima St/Larkspur Pl
- Willandra Pde/Corinth Rd/Odeon Pl/Heathcote Rd

3) Greenweb Restoration areas

- Princes Hwy/Railway corridor (near Sebastapol St)

Bushcare Groups

- Forum Drive Reserve
- Corinth Road Reserve
- Corinth Gully
- Bottle Creek
- Abbott Road Reserve
- Whitton & Martin Sts Reserve

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
    - Gambusia
    - Carp
    - Cane Toads
    - Koi Carp (goldfish)

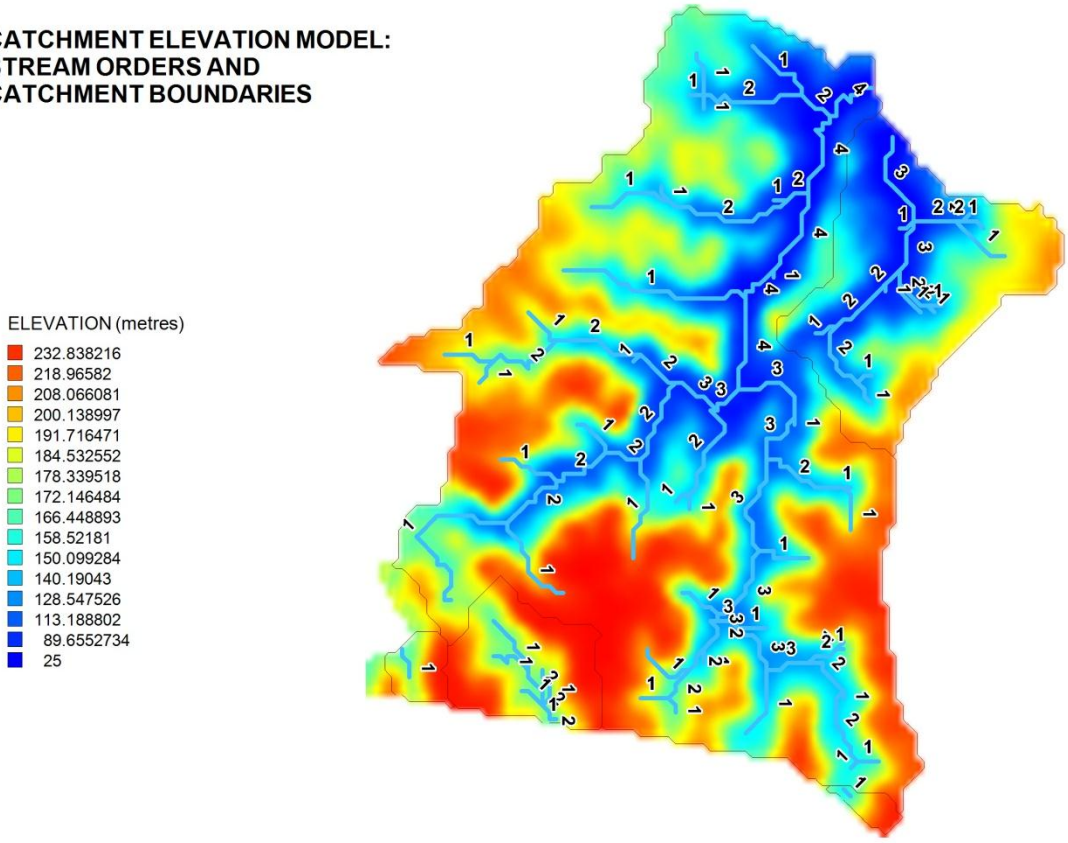
RIPARIAN IMPACTS

- 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

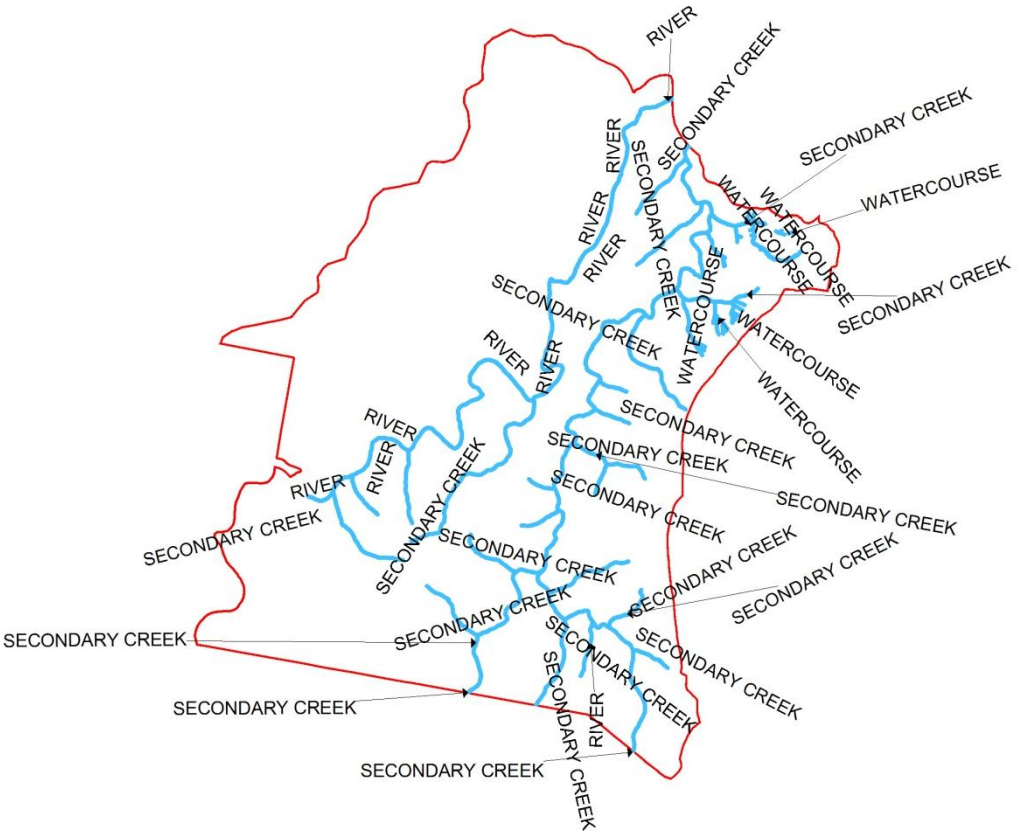
- Disturbance from vehicle access
- Disturbance from excessive use by stock or other animals
- Clearing of vegetation
- Deliberate introduction of exotic plant species
- Selective removal of vegetation including
    - Loss of canopy
    - Loss of shrub layer
    - Loss of groundcover species
- Removal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

RECREATED WATERWAYS MAP

CATCHMENT ELEVATION MODEL: STREAM ORDERS AND CATCHMENT BOUNDARIES



CURRENTLY MAPPED WATERWAYS AND CATCHMENT BOUNDARY

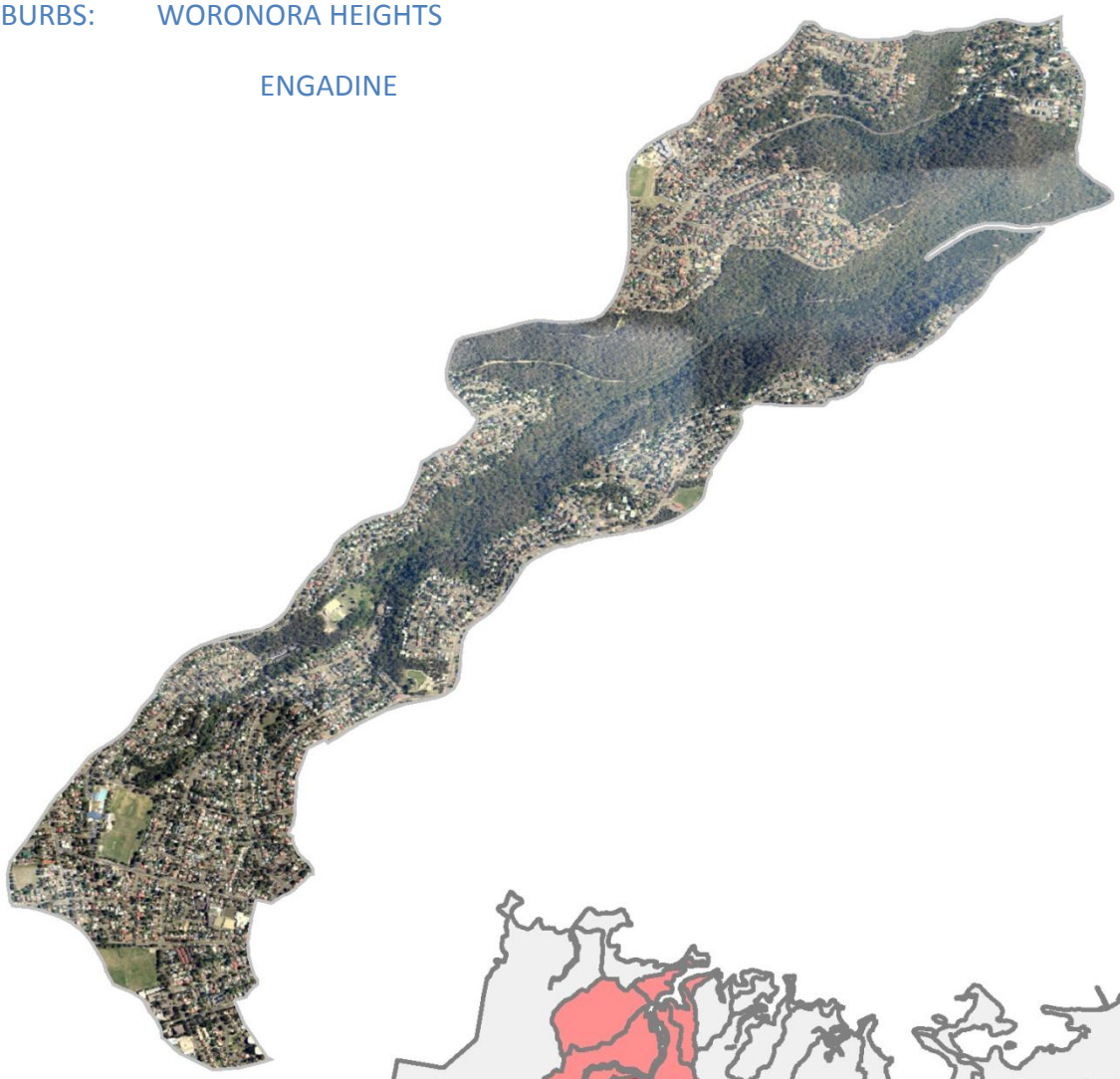


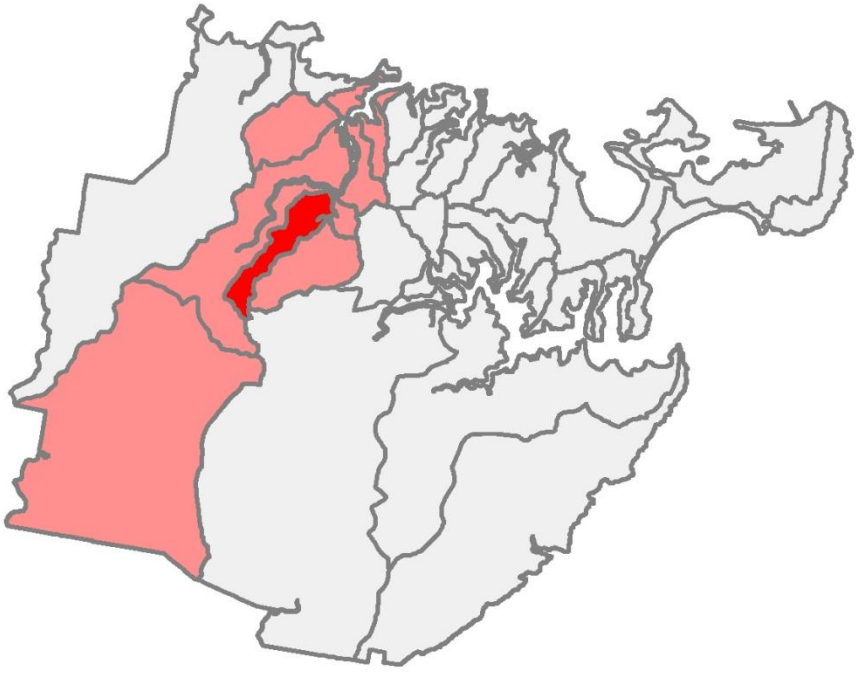
FORBES CREEK SUBCATCHMENT

CATCHMENT AREA: 4.23 KM^2

SUBURBS: WORONORA HEIGHTS

ENGADINE





WATERWAYS

MAJOR NAMED WATERWAYS: FORBES CREEK

TOTAL LENGTH OF MAPPED WATERWAYS: 12.4 KMs

FIRST ORDER & MINOR DRAINAGE LINES: 6.9KMs

SECOND ORDER CREEKS: 5.5KMs

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 Forbes Creek subcatchment:

1. Forbes Creek at North Engadine

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 ↓↑	↓	↓	↓	↓	↑

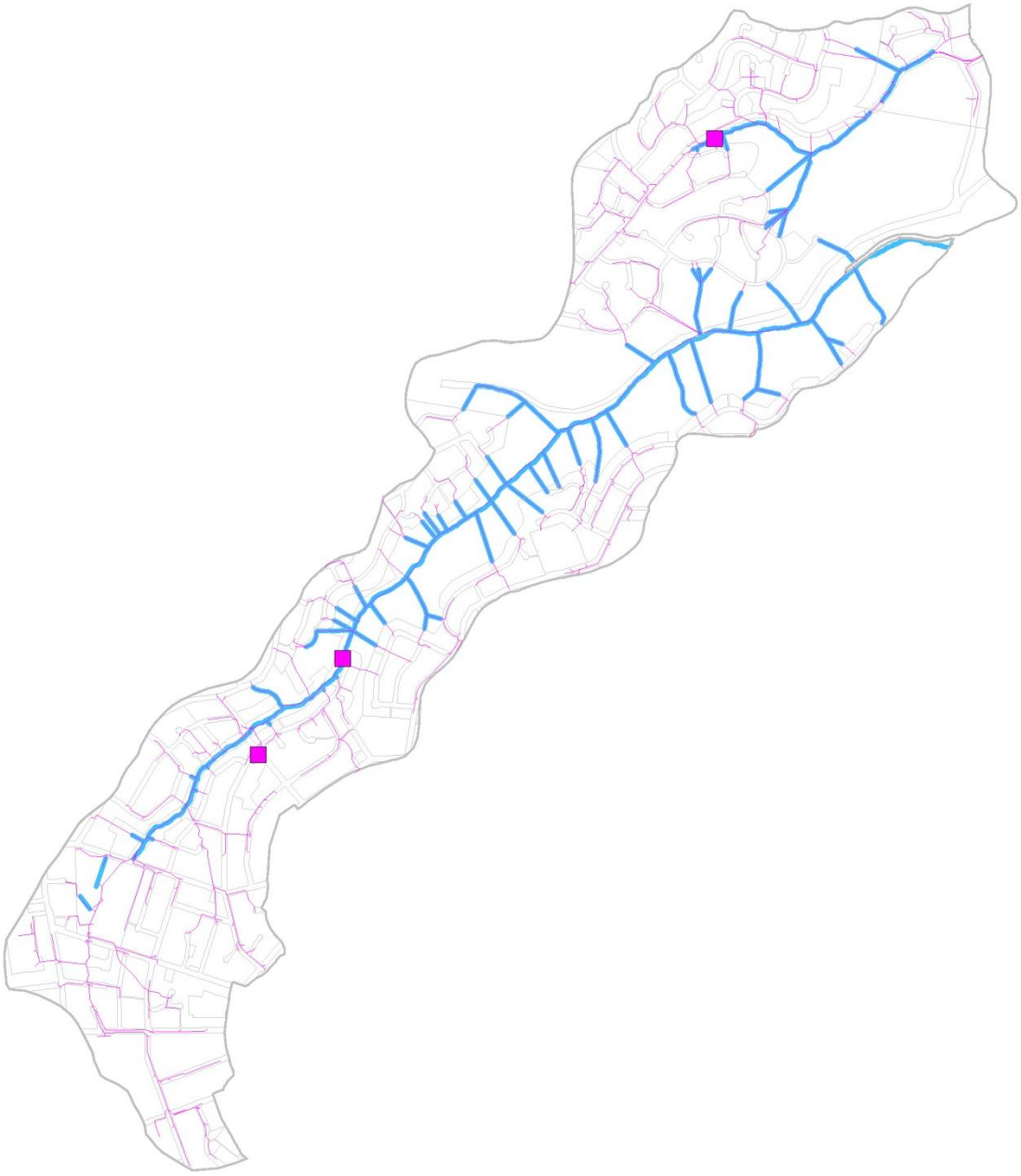
A reduction in values was recorded for most parameters sampled, so that all parameters were reported to be within ANZECC 2000 guideline limits at the end of the survey period.

2. Forbes Creek at Woronora

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 ↓↑	=	↓	↓	↓	↓

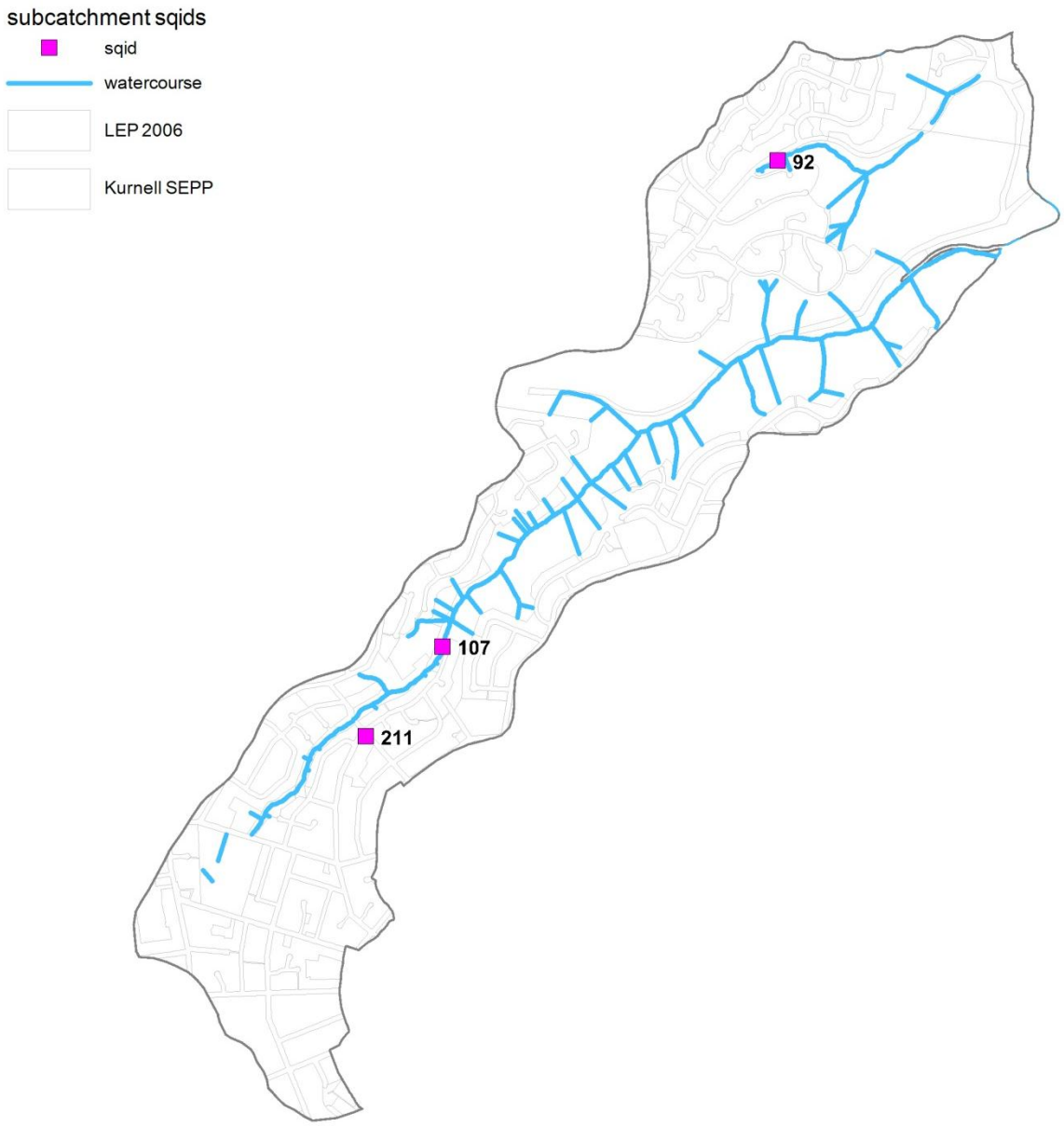
A reduction in values was recorded for most parameters sampled, so that all parameters except copper were reported to be within ANZECC 2000 guideline limits at the end of the survey period.

RETICULATED STORMWATER SYSTEM



LOCATION OF SQIDS

ID	DEVICE CATEGORY	DEVICE TYPE	LOCATION	SITE DESCRIPTION	SUBURB	APPROX. CATCHMENT
92	GPT	GPT	Bundanoon Road	Cresent Creek	Woronora Heights	26 Ha
107	GPT - Other	Trash Rack	Lochiel Road	Forbes Creek	Engadine	131 Ha
211	GPT - Other	Child Proof Grate	Karramarra Rd Reserve	17R Banbal Rd, Engadine	17R Banbal Rd, Engadine	



GEOMORPHIC SETTING

Forbes Creek subcatchment soil landscapes include Hawkesbury Soil Landscape (ha) around drainage lines. Eastern and southern ridges and plateaus are mainly Faulconbridge Soil Landscape (fb), while Lucas Heights Soil Landscape (lh) dominates on western ridgetops (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

Forbes Creek subcatchment is a steep catchment with one main and one minor drainage line. Lower areas around the drainage are between 30-70m AHD, and maximum height is 168m.

ASS/PASS, URBAN SALINITY

LEP (00 &06) CLASS	HECTARES
CLASS 5	70

A small area of Class 5 ASS forms a band along the foreshores of Woronora River.

OTHER CONTAMINATION ISSUES

None noted

LAND USE

HISTORIC LAND USE

The aborigines around Engadine and Sutherland were Dharawal people, and they lived mainly on the rich river flats around Woronora River, near where Forbes Creek joins it. Food was plentiful and water nearby, and they rarely left these areas except to travel to hunting and ceremonial grounds in nearby valleys. In the early years after Europeans the area was heavily timbered and there was no road access from Sydney. Travel was by boat, and settlers preferred the river flats as well. A number of early settlers and tourists stayed near Forbes Creek, and this pattern of occupation continued for the next century (Figure 1).

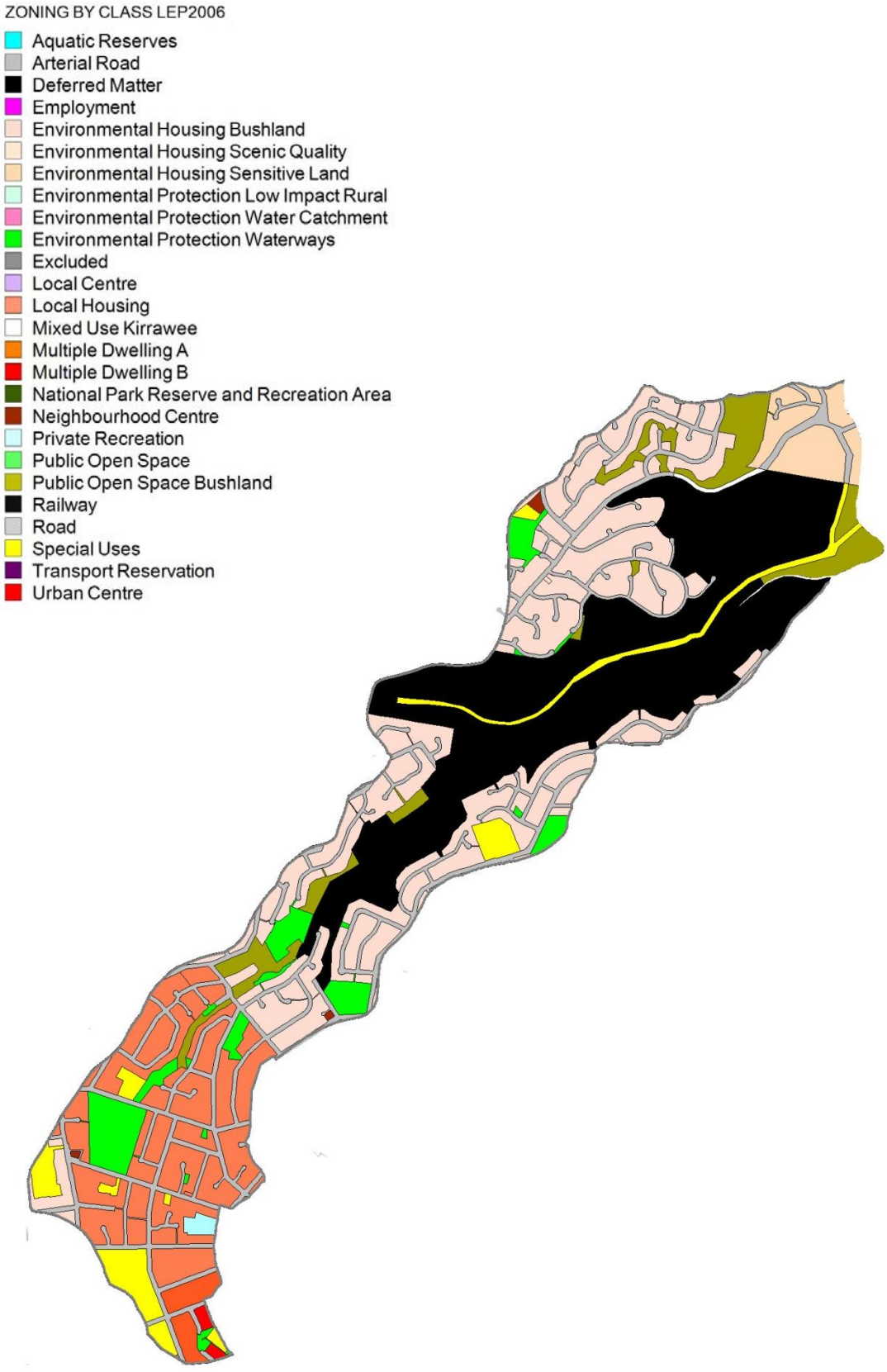
Figure 2. Wy Wurrie house near Forbes Creek on the Woronora River, circa 1920s (MF2134, Sutherland Library Collection).

Much of the land around Engadine was declared national park in 1879, reducing opportunities for development. In 1890 land was released on the western side of the suburb, however, Engadine and the Woronora area were slow to be developed, described in 1868 as too rocky and too poor to plough. The township of Woronora grew in conjunction with the building of the Woronora Dam in the 1920s and 1930s. A large labour force was required, and men brought their families to the area. Residents lived in bungalows made of fibro and conditions were fairly spartan.

In 1925 the local council declared war on the humpies along the river after numerous complaints from these residents. Following the completion of the dam in 1941, over 600 men were retrenched, and many of these moved to camps by the river, including one in Prince Alfred Park. By the 1970s Woronora was still an out of the way place, a condition which suited local residents despite the limited services. In 1985 Woronora Heights was established and by 1991 there were 750 houses in the suburb, with land reserved for schools and parks, and a few small areas left in their native state. Since then, residents have lobbied against further development of bushland, although more recent pressure for additional housing has seen them overturned (Jackson, 2006).

Forbes Creek is still surrounded by a wide buffer of bushland and this has helped to retain much of its natural character. A number of walking tracks follow the creek, and local residents are active in caring for the bush.

CURRENT LAND USE



CATCHMENT IMPERVIOUS SURFACE (% AND DISTRIBUTION)

LEP ZONING DESCRIPTOR	HECTARES	% CATCHMENT	POTENTIAL IMPERVIOUS	HECTARES IMPERVIOUS
Deferred Matter	127.54	30%	0%	0.00
Environmental Housing Sensitive Land	13.17	3%	43%	5.66
Environmental Housing Scenic Quality	0.00	0%	57%	0.00
Environmental Housing Bushland	102.83	24%	57%	58.61
Local Housing	55.32	13%	51%	28.21
Multiple Dwelling A	4.56	1%	64%	2.92
Multiple Dwelling B	0.00	0%	64%	0.00
Mixed Use Kirrawee	0.00	0%	64%	0.00
Urban Centre	1.01	0%	94%	0.95
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	20.33	5%	46%	9.35
Public Open Space	19.89	5%	5%	0.99
Public Open Space Bushland	22.48	5%	0%	0.00
Private Recreation	1.17	0%	5%	0.06
Environmental Protection Waterways	0.00	0%	0%	0.00
Aquatic Reserves	0.00	0%	0%	0.00
National Park Reserve and Recreation Area	0.00	0%	0%	0.00
Railway	0.00	0%	33%	0.00
Arterial Road/Road	54.70	13%	66%	36.10
Transport Reservation	0.00	0%	5%	0.00
TOTAL	**423.00**	**100%**	**34%**	**142.86**

VEGETATION COMMUNITIES

MAPPED VEGETATION COMMUNITIES

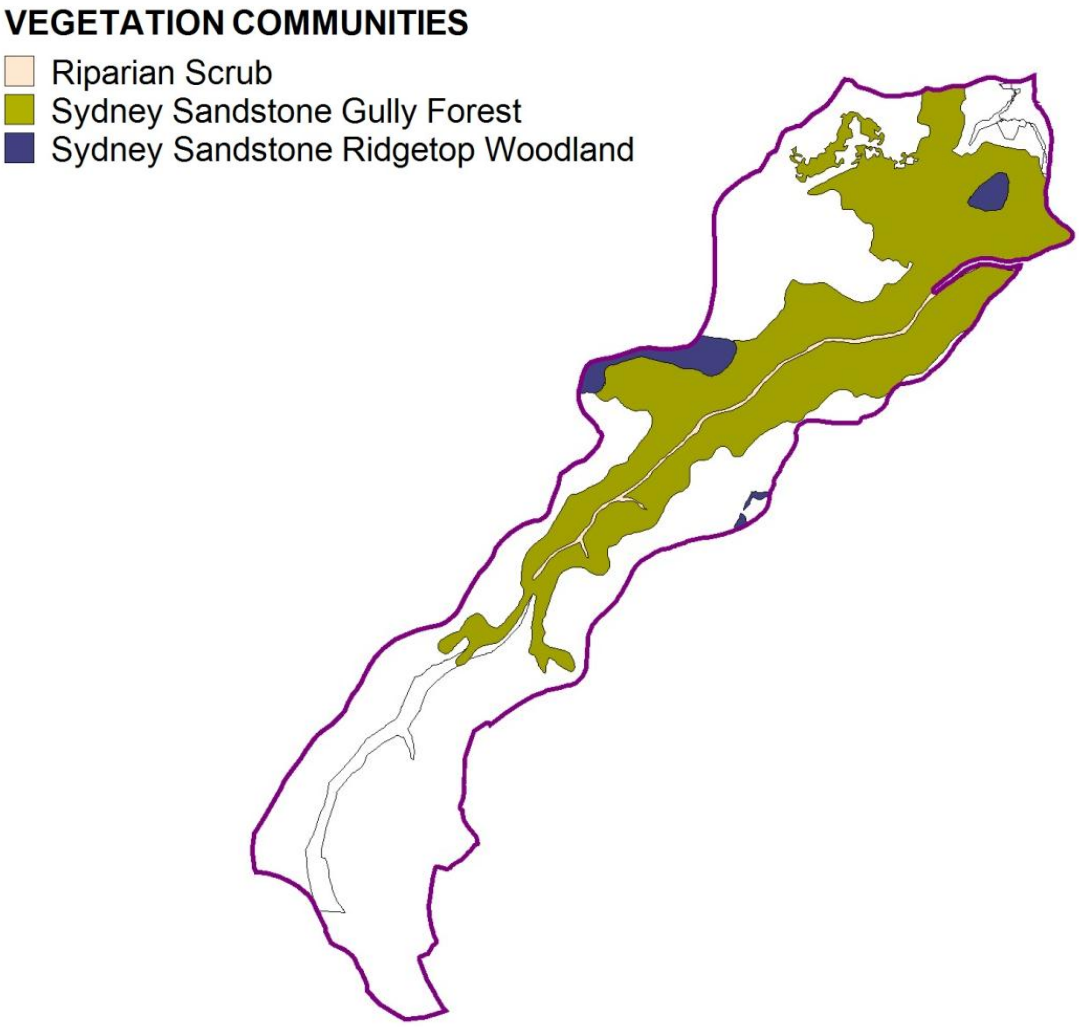
673 HECTARES SYDNEY SANDSTONE GULLY FOREST

14.6 HECTARES SYDNEY SANDSTONE RIDGETOP WOODLAND

13 HECTARES RIPARIAN SCRUB

LEP 2006 SIGNIFICANT VEGETATION

LEP TAG	NAME	CLASS
T9	Eucalyptus Pilularis	Significant Group of Trees or Vegetation



BUSHLAND RESERVES AND RESTORATION

Reserves

1) Greenweb Core areas

- Forbes Creek Reserve
- Cort Rd/Lantana Rd

2) Greenweb Support areas

- Croston Rd/Geelong Rd/Almada St
- Kingswood Rd/Atherton Rd/Lalor Cres
- Lochiel Rd/Lochness Pl
- Burraddar Ave/Forbes Creek Rd
- Ardrossan Rd/Kilmarnock Rd/Albion Pl/Kelso St
- Thorp Rd/The Crescent
- Warrangarree Dr
- Shearwater Ave/Wren Ct/Sandpiper Pl

3) Greenweb Restoration areas

- None noted

Bushcare Groups

- Geelong Road Crown Reserve
- Forbes Creek South
- Karamarra Road Reserve
- Upper Forbes Creek
- Cooriengah Heights Reserve
- Upper Crescent Creek Crown Bushland

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
    - Gambusia
    - Carp
    - Cane Toads
    - Koi Carp (goldfish)

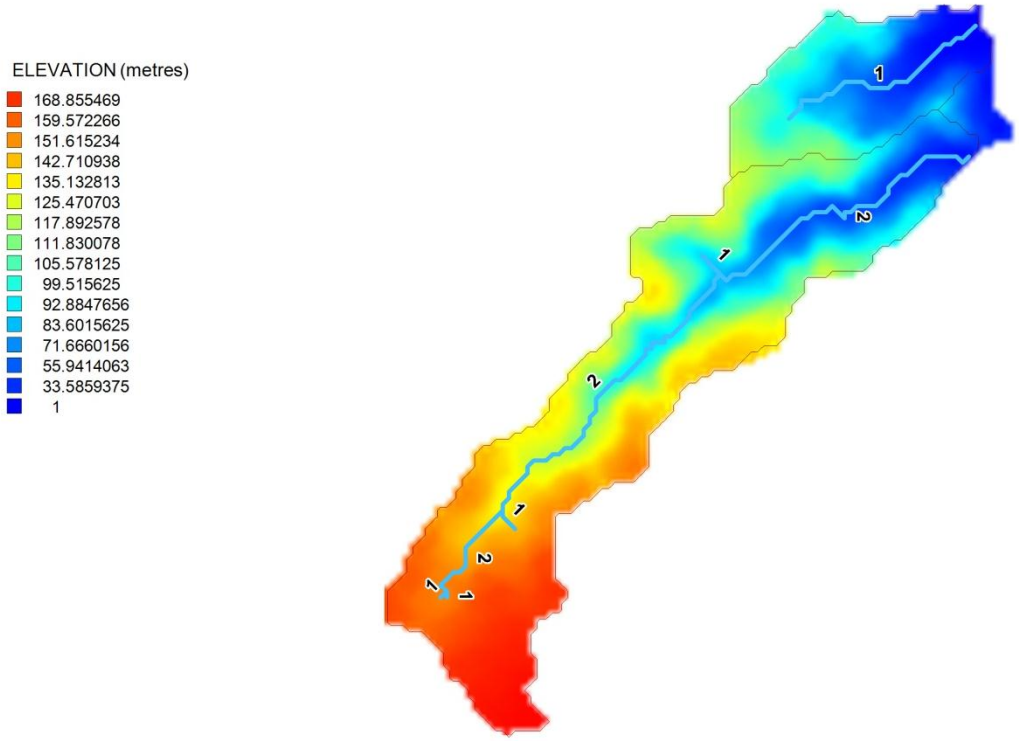
RIPARIAN IMPACTS

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

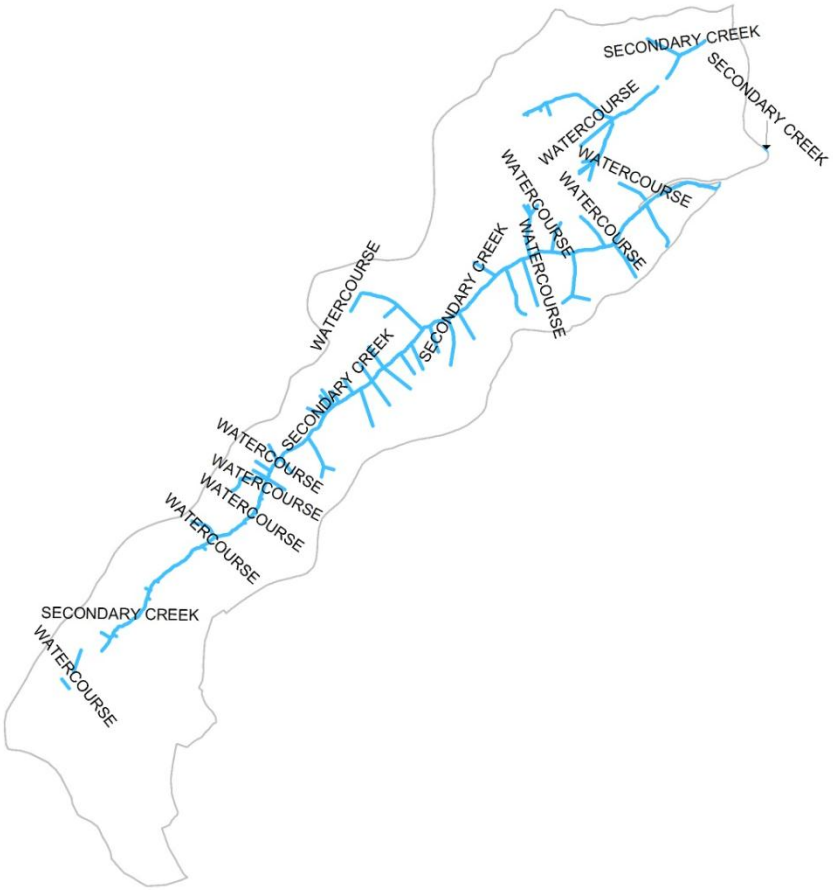
- Disturbance from pedestrian access
- Disturbance from vehicle access
- Disturbance from excessive use by stock or other animals
- Clearing of vegetation
- Deliberate introduction of exotic plant species
- Selective removal of vegetation including
    - Loss of canopy
    - Loss of shrub layer
    -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

RECREATED WATERWAYS MAP

CATCHMENT ELEVATION MODEL: STREAM ORDERS AND CATCHMENT BOUNDARIES



CURRENTLY MAPPED WATERWAYS AND CATCHMENT BOUNDARY



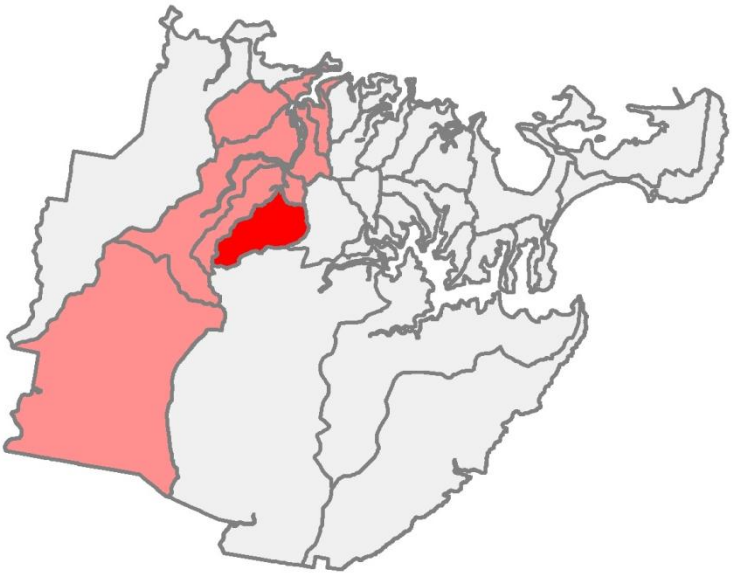
LOFTUS CREEK SUBCATCHMENT

CATCHMENT AREA: 5.88 KM^2

SUBURBS: ENGADINE

LOFTUS

YARRAWARRAH



WATERWAYS

MAJOR NAMED WATERWAYS: LOFTUS CREEK

TOTAL LENGTH OF MAPPED WATERWAYS: 16.75 KMs

PRIMARY ORDER CREEKS: 0 KMs

SECOND ORDER CREEKS: 6.17 KMs

FIRST ORDER & MINOR DRAINAGE LINES: 10.52 KMs

OPEN DRAINS: 0.06 KMs

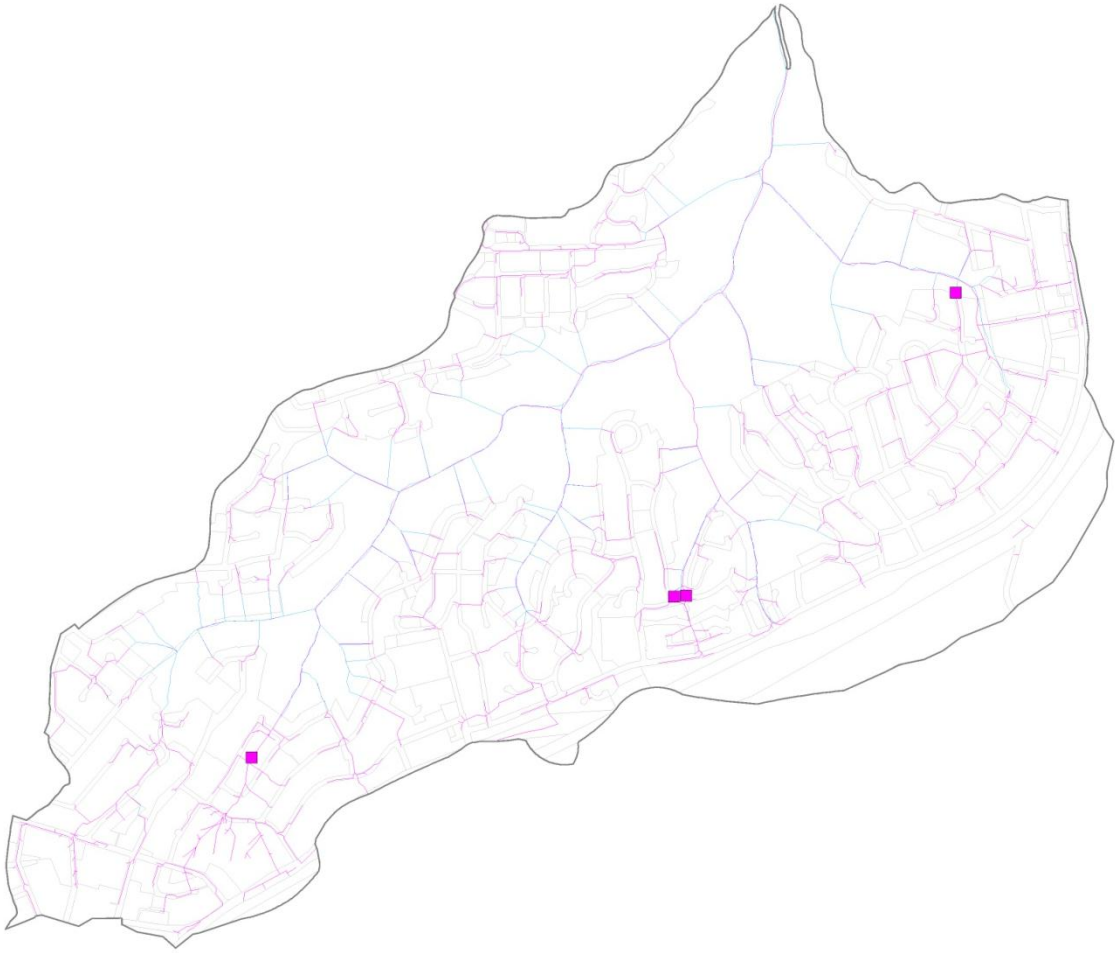
WATER QUALITY ASSESSMENT

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 (↑) 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.

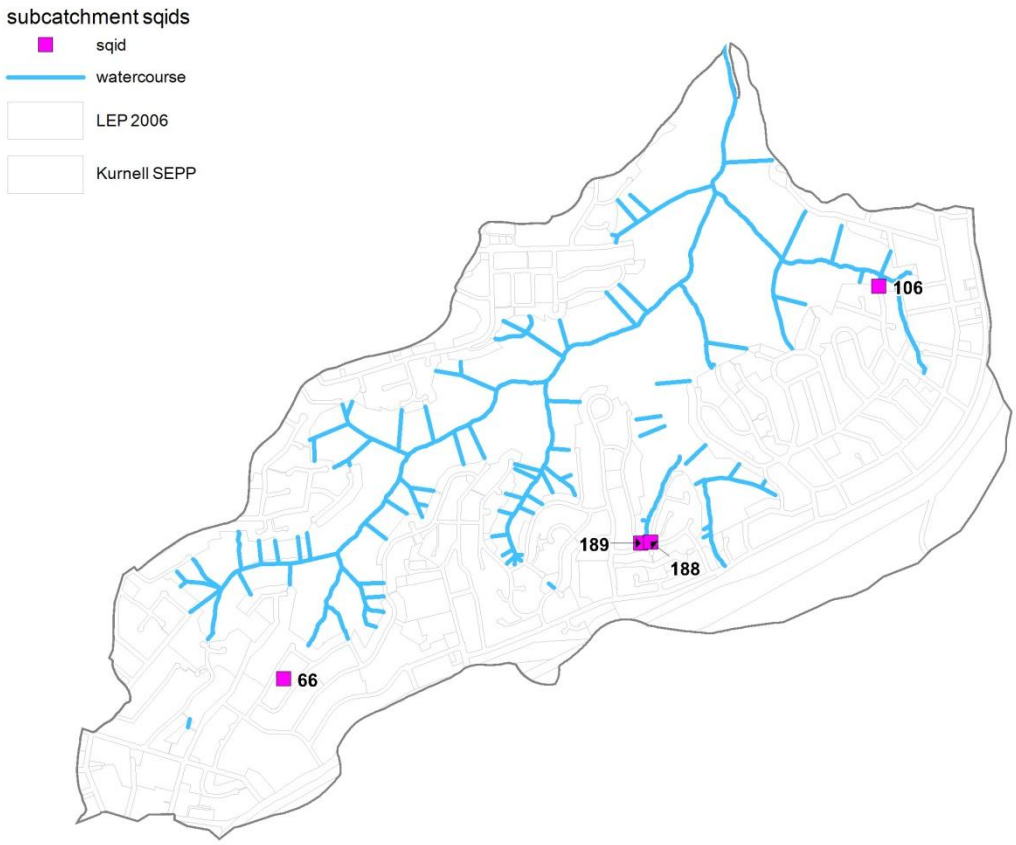
No sites sampled in this subcatchment

RETICULATED STORMWATER SYSTEM



LOCATION OF SQIDS

ID	DEVICE CATEGORY	DEVICE TYPE	LOCATION	SITE DESCRIPTION	SUBURB	APPROX. CATCHMENT
66	Detention Basin	Detention Basin	Dobell Road	Playing Field	Engadine	31 Ha
106	GPT - Other	Trash Rack	Cranberry Street	Cul-de-sac at end of road	Loftus	1.9 Ha
189	End of pipe trap	Nettech Device	Nullabor Place	In reserve opp. 57-59 Nullabor Place	Yarrawarrah	2.65 Ha
188	End of pipe trap	Nettech Device	Fremantle Place	In reserve opp. 29 Fremantle Place	Yarrawarrah	6.5 Ha



GEOMORPHIC SETTING

Loftus Creek subcatchment soil landscapes include Hawkesbury Soil Landscape (ha) around drainage lines. Eastern ridges are generally Gymea Soil Landscape (gy), while western and southern ridges are Faulconbridge Soil Landscape (fb) (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

Loftus Creek subcatchment is a steep catchment with one main drainage system. Lower areas around the drainage are between 30-70m AHD, and maximum height is 168m.

ASS/PASS, URBAN SALINITY

LEP (00 &06) CLASS	HECTARES
CLASS 1	0.25
CLASS 5	22.35

Very small areas of Class 1 ASS are located close to the foreshore, and the larger area of Class 5 ASS forms a band along the foreshores.

OTHER CONTAMINATION ISSUES

None noted

LAND USE

HISTORIC LAND USE

Named for Lord Augustus Loftus, Governor of NSW in the 1880s, Loftus was assessed as having a ridge of good quality clay that ran from there to Cronulla. Farmers were attracted to the area and many residents had poultry farms and orchards. The district was closely associated with the nearby national park, dedicated in 1879. Easter camps were held there from 1886 until 1914 with so many visitors that cattle trucks had to be used to transport them. The first camp had 30,000 visitors who were entertained by military displays (Jackson, 2006).

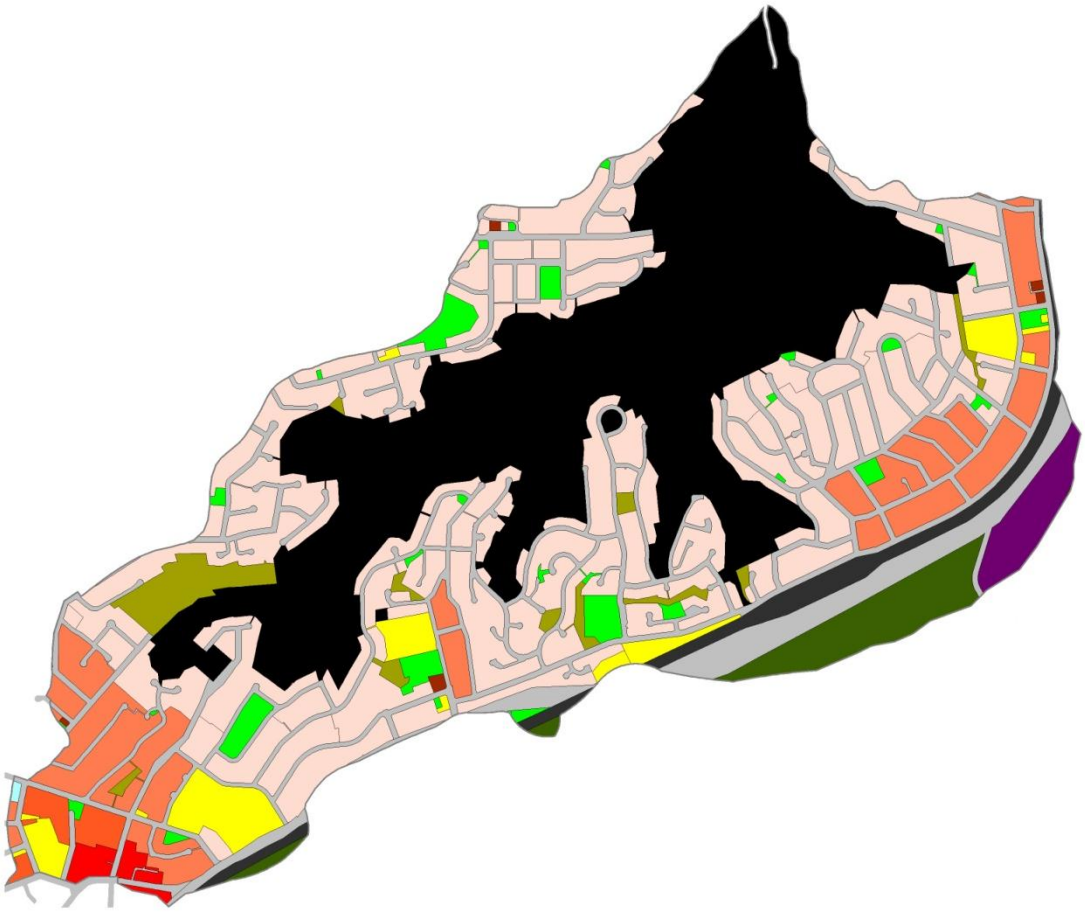
Opening of the railway station in 1886 supported development, and land on the eastern side of the railway was cleared and planted with grasses and ornamental trees. A road from Sutherland to Loftus was commenced in 1910, and a bus service started in 1915 to take visitors from Loftus to Audley. For many years the national park was the main attraction to the area. Day trippers came by train, and then horse drawn coach to Audley. Many early residents in the area derived their income from providing services for tourists, including camping and hotel accommodation nearby at Sutherland.

Cronulla's tramway provided serious competition and growth around Loftus slowed considerably. The first subdivisions were created in 1923, but it wasn't until after the war that home building began in earnest. Many of the early residents in the 1940s were railway workers who lived in tents along the railway line. In 1941 a large military camp was moved to Loftus, near the Audley turnoff, although there were no services to the area. A series of camps followed, with Boy Scouts in 1946, and later accommodation for construction workers on the Cronulla sewerage scheme (Jackson, 2006).

Local residents resented their presence, and there was a move towards restoration of the original bushland in the area. Basic services including a school and post office began to be implemented in the 1950s, although it was a number of years before water and electricity were available. The battle for green space in preference to development continued, and in 1963 there were battles over encroachment into the national park. Finding a balance between conservation and development was an ongoing problem, and led to battles in the 1970s between conservationists and firemen who wanted to backburn a number of sensitive areas. Bushfire is a real and ongoing threat, and locals still remember the bushfire fighters who died in the Grays Point fires of 1983 (Jackson, 2006).

Yarrawarrah Heights, between Engadine and Loftus, was developed in the 1970s. Prior to its subdivision for residential development, the area was untouched bushland. Engadine grew as part of Heathcote, and Loftus grew along with Sutherland, while Yarrawarrah remained part of the national park for many years. However, as pressure for land for housing increased, urban expansion began to fill the gaps between these suburbs.

CURRENT LAND USE



ZONING BY CLASS LEP2006

- 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)

LEP ZONING DESCRIPTOR	HECTARES	% CATCHMENT	POTENTIAL IMPERVIOUS	HECTARES IMPERVIOUS
Deferred Matter	189.99	32%	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	173.42	30%	57%	98.85
Local Housing	45.33	8%	51%	23.12
Multiple Dwelling A	4.69	1%	64%	3.00
Multiple Dwelling B	0.00	0%	64%	0.00
Mixed Use Kirrawee	0.00	0%	64%	0.00
Urban Centre	3.61	1%	94%	3.39
Local Centre	0.00	0%	88%	0.00
Neighbourhood Centre	0.77	0%	86%	0.66
Employment	0.00	0%	95%	0.00
Special Uses	17.41	3%	15%	2.61
Public Open Space	13.06	2%	5%	0.65
Public Open Space Bushland	12.35	2%	0%	0.00
Private Recreation	0.23	0%	5%	0.01
Environmental Protection Waterways	0.00	0%	0%	0.00
Aquatic Reserves	0.00	0%	0%	0.00
National Park Reserve and Recreation Area	15.84	3%	0%	0.00
Railway	12.41	2%	33%	4.10
Arterial Road/Road	90.74	15%	66%	59.89
Transport Reservation	7.99	1%	5%	0.40
TOTAL	**587.83**	100%	**33%**	**196.28**

VEGETATION COMMUNITIES

MAPPED VEGETATION COMMUNITIES

8.30 HECTARES RIPARIAN SCRUB

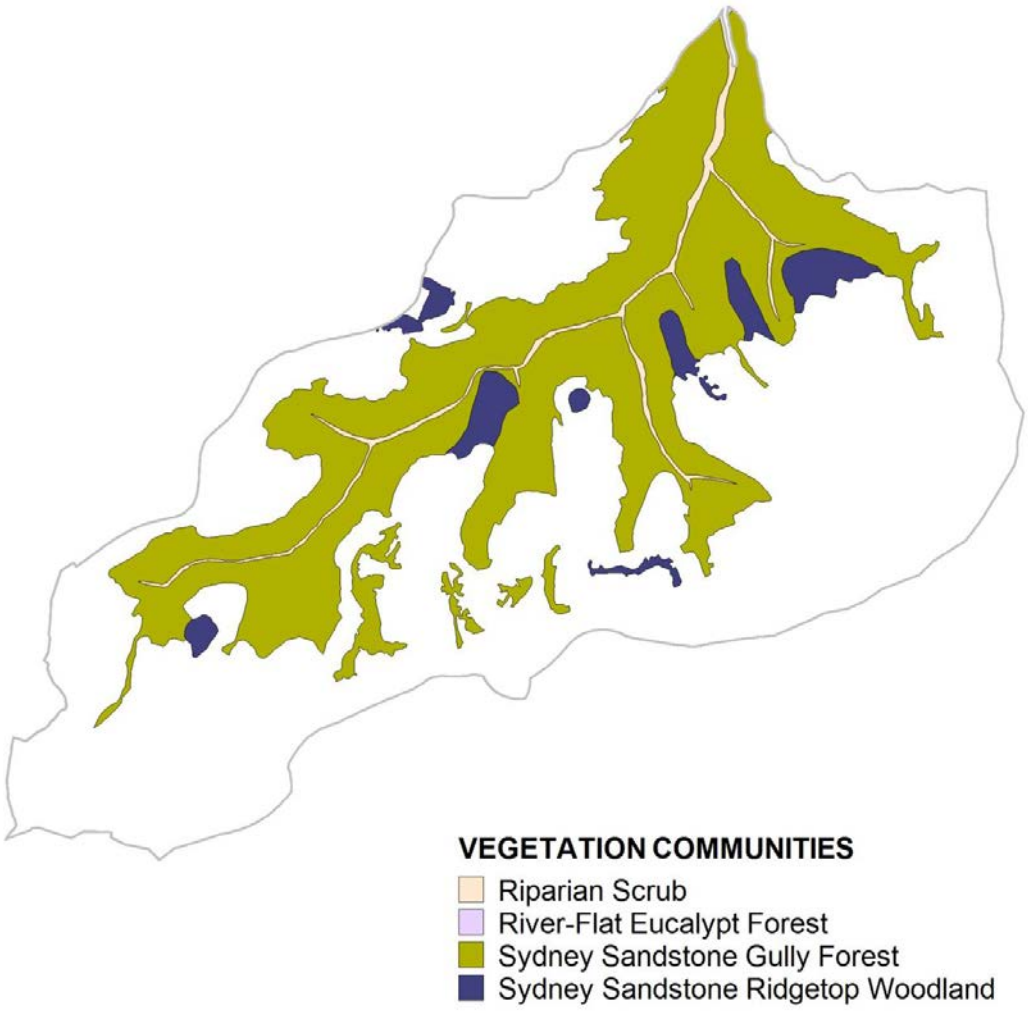
0.06 HECTARES RIVER-FLAT EUCALYPT FOREST

184.05 HECTARES SYDNEY SANDSTONE GULLY FOREST

18.24 HECTARES SYDNEY SANDSTONE RIDGETOP WOODLAND

LEP 2006 SIGNIFICANT VEGETATION

NIL



BUSHLAND RESERVES AND RESTORATION

Reserves

1) Greenweb Core areas

- Victory Reserve

2) Greenweb Support areas

- Lantana Rd/Terrigal Pl/Pambula Rd/Jellingal Rd
- Trafalgar St/Valley View Cres/Bracken Close
- Sladden Rd/ Hakea St/Bisdee Pl/Old Bush Rd
- Giles St/Nullabor Pl
- Esperance Pl/Roebourne St/Celosia Pl
- Myrtle St/Ninth Ave/Broom Pl/Gorse Cl/Eugenia St
- Dunwell Ave/Ninth Ave/Eighth Ave
- Wyang Pl/Culmara Pl/Goondah Rd/Appin Pl/Warilda Ave
- Nambour Rd/Bulba Rd/Bulberry Pl/Gamenya Pl/Croston Rd

3) Greenweb Restoration areas

- Dobell Rd/Brooke St
- Lantana Rd
- Japonica Pl/Tenth Ave

Bushcare Groups

- Eighth Avenue Reserve
- Ninth Avenue Road Reserve
- Ninth Avenue North Road Reserve
- Ninth Avenue North (Dunwell Avenue Reserve)
- Urana Road Crown Reserve
- Derby Place Reserve
- Yarra Vista Court Reserve
- Fremantle Place Crown Reserve
- Fahy Creek Crown Reserve
- Hakea Street Reserve
- Victory Reserve
- Brigalow Place Reserve
- Valley View Crescent Crown Bushland

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
    - Gambusia
    - Carp
    - Cane Toads
    - Koi Carp (goldfish)

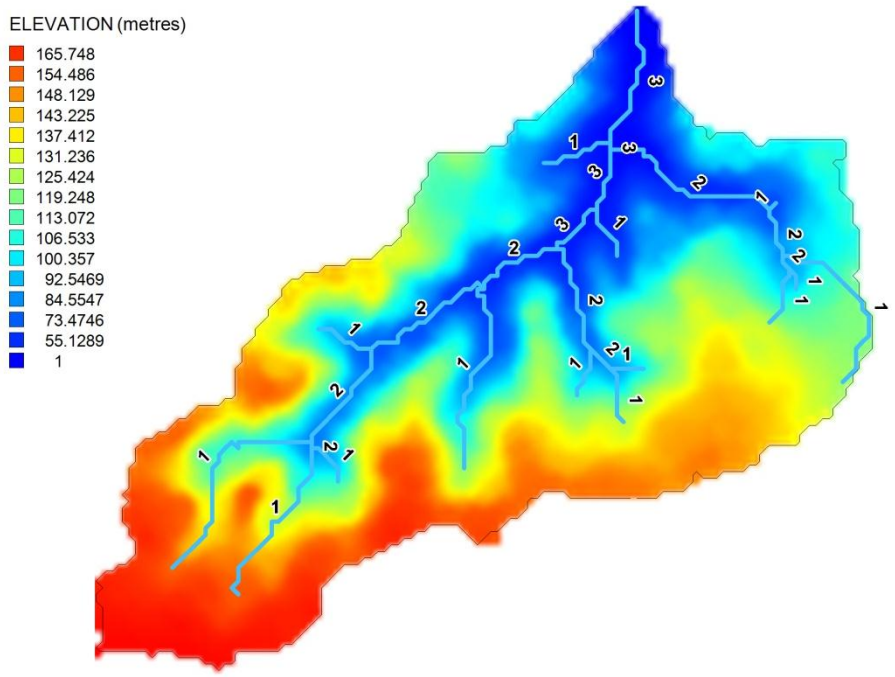
RIPARIAN IMPACTS

- Invasion by weeds
- Loss of species through replacement by others

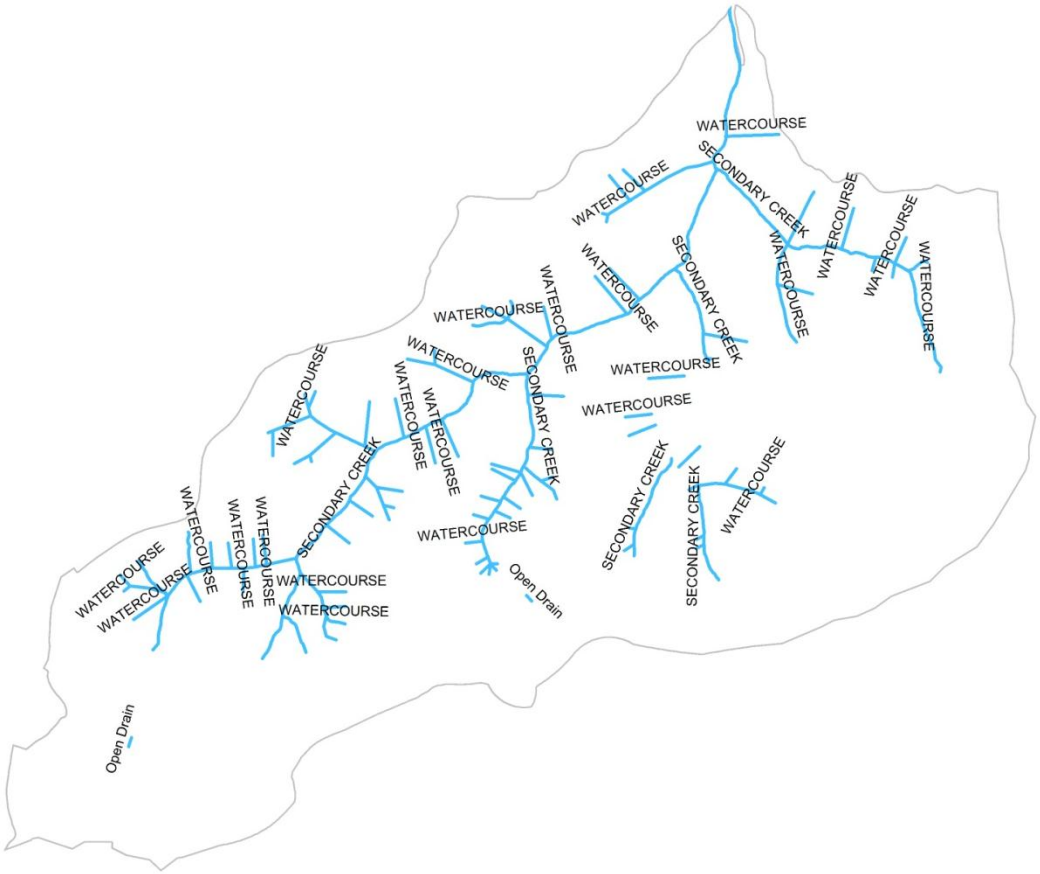
- Loss of diversity (reduction in species numbers)
- Loss of habitat quality
- Disturbance from pedestrian access
- Disturbance from vehicle access
- Disturbance from excessive use by stock or other animals
- Clearing of vegetation
- Deliberate introduction of exotic plant species
- Selective removal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

RECREATED WATERWAYS MAP

CATCHMENT ELEVATION MODEL:
STREAM ORDERS AND CATCHMENT BOUNDARIES



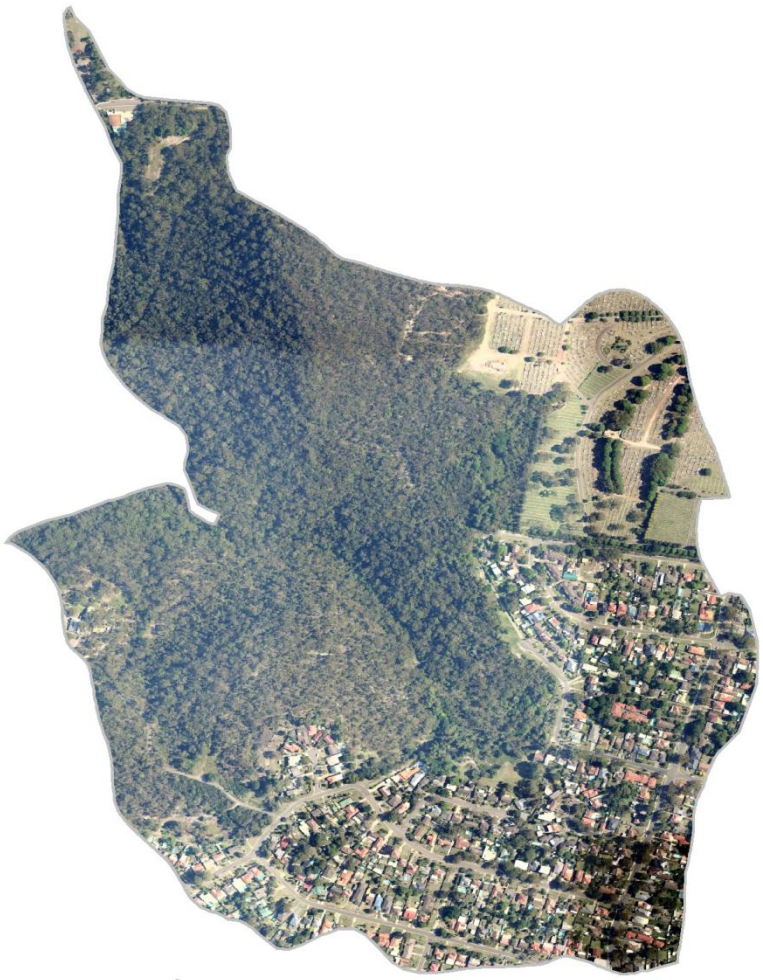
CURRENTLY MAPPED WATERWAYS AND CATCHMENT BOUNDARY

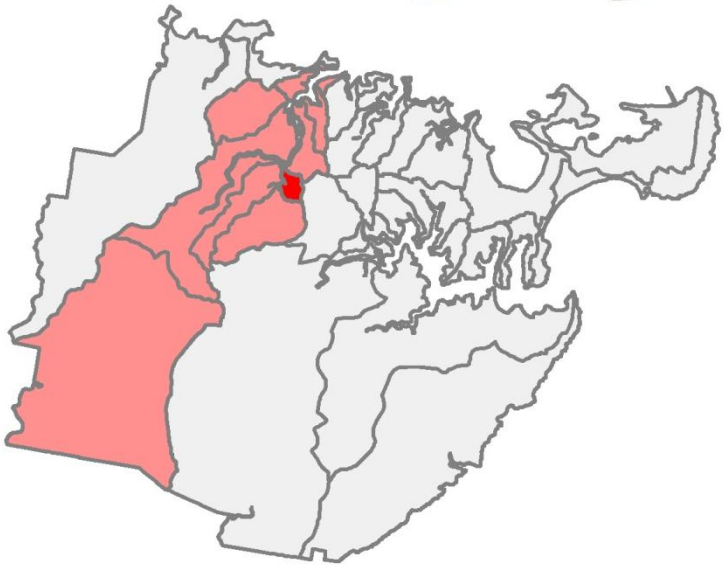


MANDOWIE CREEK SUBCATCHMENT

CATCHMENT AREA: 0.92 KM^2

SUBURBS: LOFTUS





WATERWAYS

MAJOR NAMED WATERWAYS: MANDOWIE CREEK

TOTAL LENGTH OF MAPPED WATERWAYS: 2.77 KMs

PRIMARY ORDER CREEKS: 0 KMs

SECOND ORDER CREEKS: 0.90 KMs

FIRST ORDER & MINOR DRAINAGE LINES: 1.86 KMs

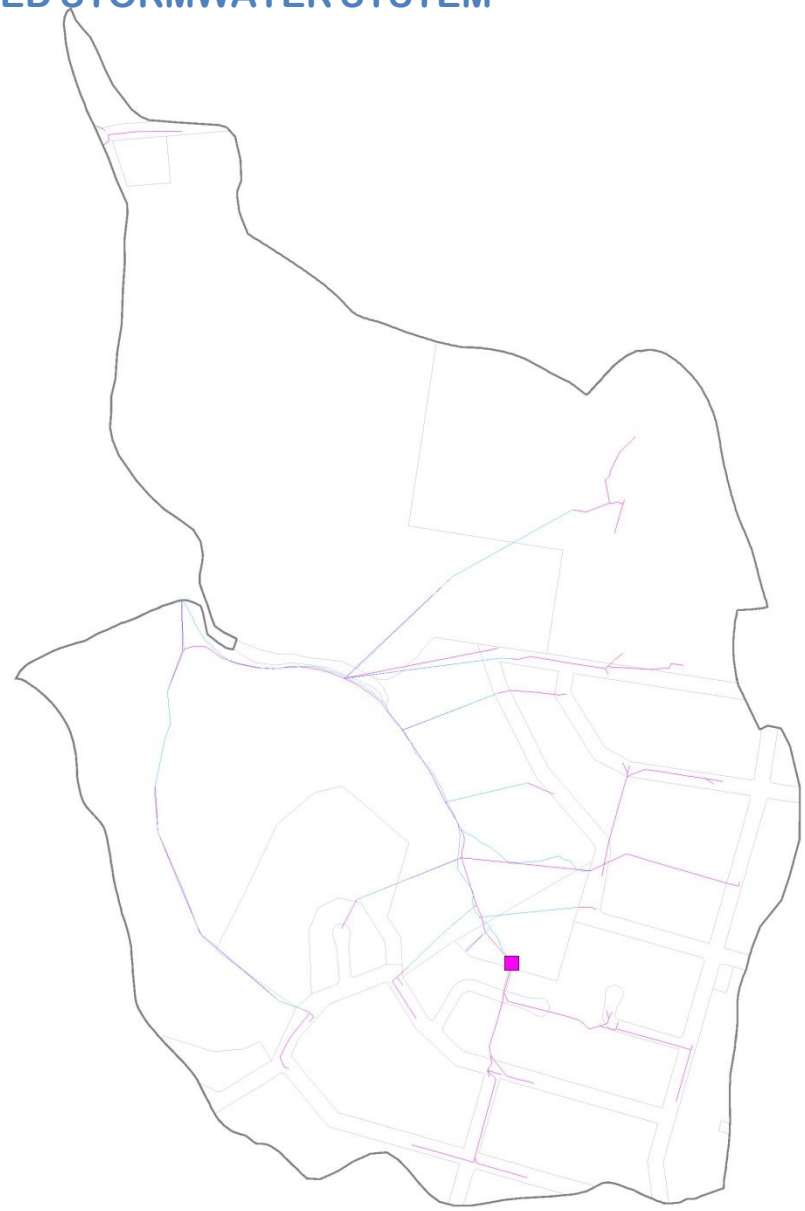
WATER QUALITY ASSESSMENT

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 (↑) 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.

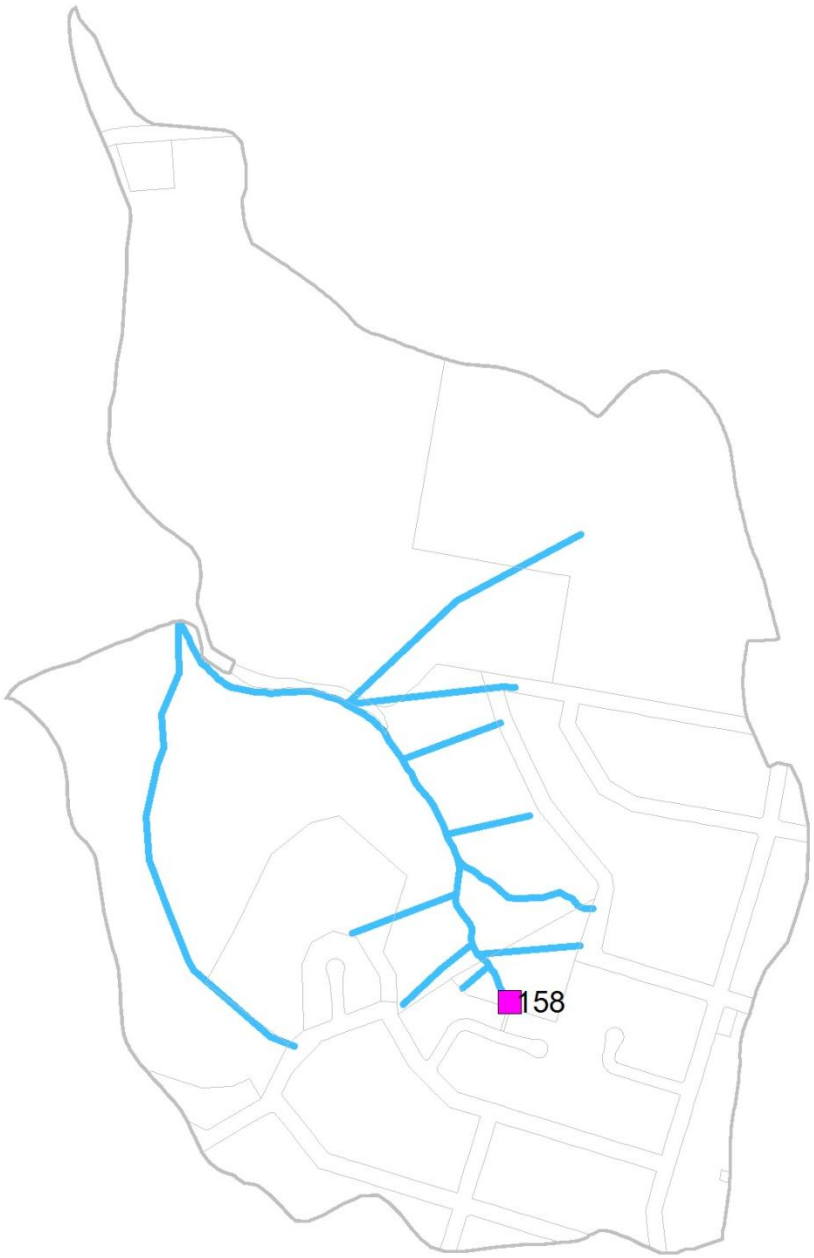
No sites sampled in this subcatchment

RETICULATED STORMWATER SYSTEM



LOCATION OF SQIDS

ID	DEVICE CATEGORY	DEVICE TYPE	LOCATION	SITE DESCRIPTION	SUBURB	APPROX. CATCHMENT
158	GPT - Other	Trash Rack	Veronica Place	Reserve	Loftus	11.3 Ha



GEOMORPHIC SETTING

Mandowie Creek subcatchment soil landscapes include Hawkesbury Soil Landscape (ha) around drainage lines, while the rest of the catchment has Gymea Soil Landscape (gy) (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

Mandowie Creek subcatchment is a steep catchment with one main and one minor drainage line. Lower areas around the drainage are between 20-50m AHD, and maximum height is 150m.

ASS/PASS, URBAN SALINITY

LEP (00 &06) CLASS	HECTARES
CLASS 1	0.44
CLASS 3	1.69
CLASS 5	50.22

Very small areas of Class 1 and 2 ASS are located close to the foreshore of Woronora River, and the larger area of Class 5 ASS forms a band along the foreshores.

OTHER CONTAMINATION ISSUES

None noted

LAND USE

HISTORIC LAND USE

Mandowie Creek drains the north western corner of Loftus and below Woronora cemetery. Early assessment of land in Sutherland found a ridge of good quality clay near Loftus, and running towards Cronulla. This brought a number of early residents to the area to raise poultry and plant orchards and market gardens. The western side of the ridge was spared the restrictions associated with the national park, declared in 1879. However, most of the area relied on the tourist trade to support the local economy.

Woronora cemetery came into being after land that had been a brickworks and then proposed for a racecourse was gazetted as a general cemetery on April 2 1895. A short rail line linking the cemetery with Sutherland Station was opened for use in July, 1900. The first funeral had taken place earlier that year, with the casket arriving by train from Mortuary Station in the city. The advent of the motor funeral saw the decline in the use of the funeral train, with the last service running in 1944, although the occasional circus train was said to have been shunted onto the line. The line finally closed in 1947.

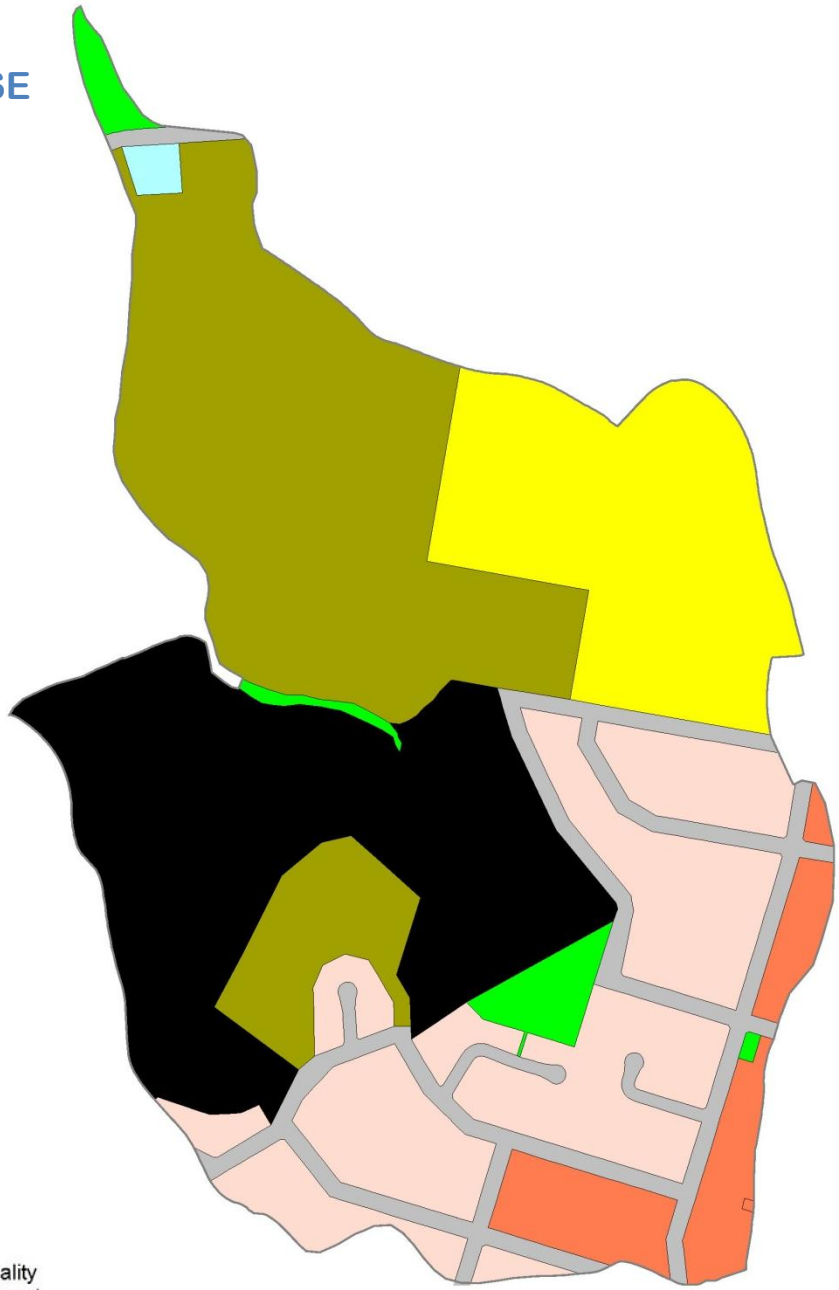
Up to 1950s graves were usually surrounded by kerbing with a headstone attached, size and ornamentation more often than not reflected the economic circumstances of the deceased. Around this time the lawn cemetery concept was introduced, with a plain flat bronze

plaque, signalling the loss of the headstone as a story telling epitaph and an indicator of society. As time went by the cultural diversity of the district was changing. In the 1970's above ground entombment was introduced. The Woronora Cemetery Trust in the late 1990's constructed the Crypts of Christ the Redeemer, this building is designed to cater for 424 above ground entombments.

In 1929 the Trust discussed the building of a crematorium. The building was completed and officially opened in 1934. The building, with several additions in keeping with the original design, is considered significant in the Art Deco style and is listed with the National Trust. The memorial gardens keep expanding as cremation becomes more popular. These include the Garden Court built in the 1950s, followed by the Floral Court and the Palm Court in 1970 and the largest, the Centenary Court was built in 1995 which has over 8000 memorial niches.

Today, the cemetery is situation on crown land, and is governed by a board of management. Key issues for cemeteries include management of water, both on site and as discharged to the downstream environment.

CURRENT LAND USE



ZONING BY CLASS LEP2006

- 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)

LEP ZONING DESCRIPTOR	HECTARES	% CATCHMENT	POTENTIAL IMPERVIOUS	HECTARES IMPERVIOUS
Deferred Matter	20.97	23%	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	17.66	19%	57%	10.07
Local Housing	5.03	5%	51%	2.57
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	13.13	14%	5%	0.66
Public Open Space	1.96	2%	5%	0.10
Public Open Space Bushland	25.28	27%	0%	0.00
Private Recreation	0.38	0%	5%	0.02
Environmental Protection Waterways	0.27	0%	0%	0.00
Aquatic Reserves	0.00	0%	0%	0.00
National Park Reserve and Recreation Area	0.00	0%	0%	0.00
Railway	0.00	0%	33%	0.00
Arterial Road/Road	7.54	8%	66%	4.98
Transport Reservation	0.00	0%	5%	0.00
TOTAL	**92.23**	100%	**20%**	**18.39**

VEGETATION COMMUNITIES

MAPPED VEGETATION COMMUNITIES

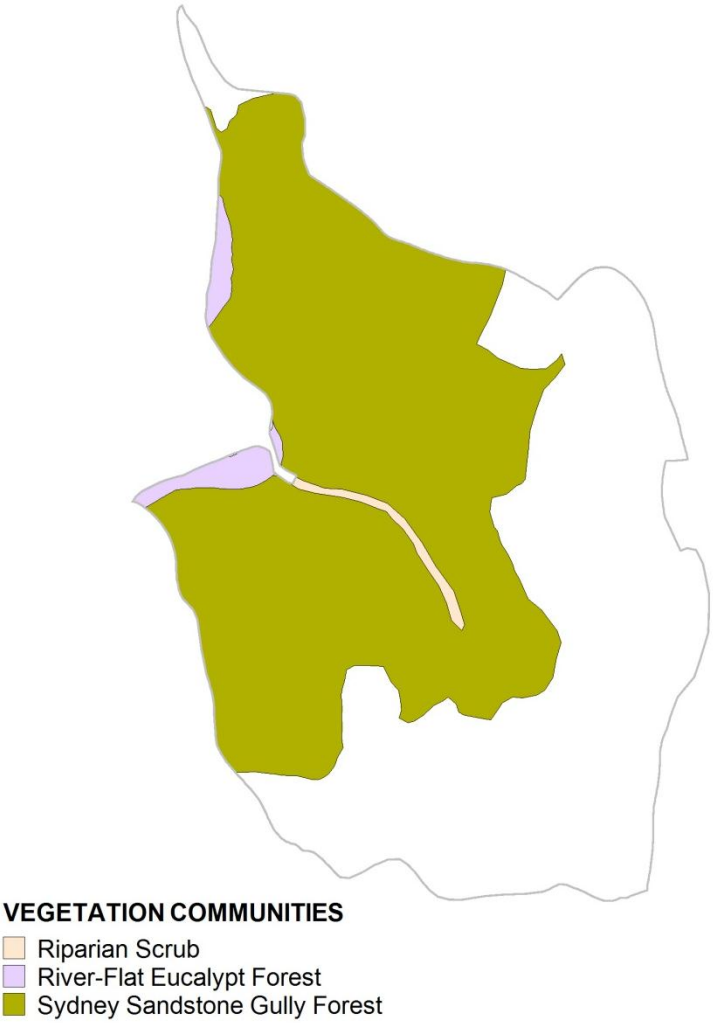
0.65 HECTARES RIPARIAN SCRUB

2.21 HECTARES RIVER-FLAT EUCALYPT FOREST

48.39 HECTARES SYDNEY SANDSTONE GULLY FOREST

LEP 2006 SIGNIFICANT VEGETATION

NIL



BUSHLAND RESERVES AND RESTORATION

Reserves

1) Greenweb Core areas

- Prince Edward Park
- Camp Wanawong

2) Greenweb Support areas

- Coreen Ave
- Columbine Cl
- Veronica Pl

3) Greenweb Restoration areas

- None noted

Bushcare Groups

- Forbes Creek Woronora
- Columbine Close Crown Bushland
- Myra Creek

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
    - Gambusia
    - Carp
    - Cane Toads
    - Koi Carp (goldfish)

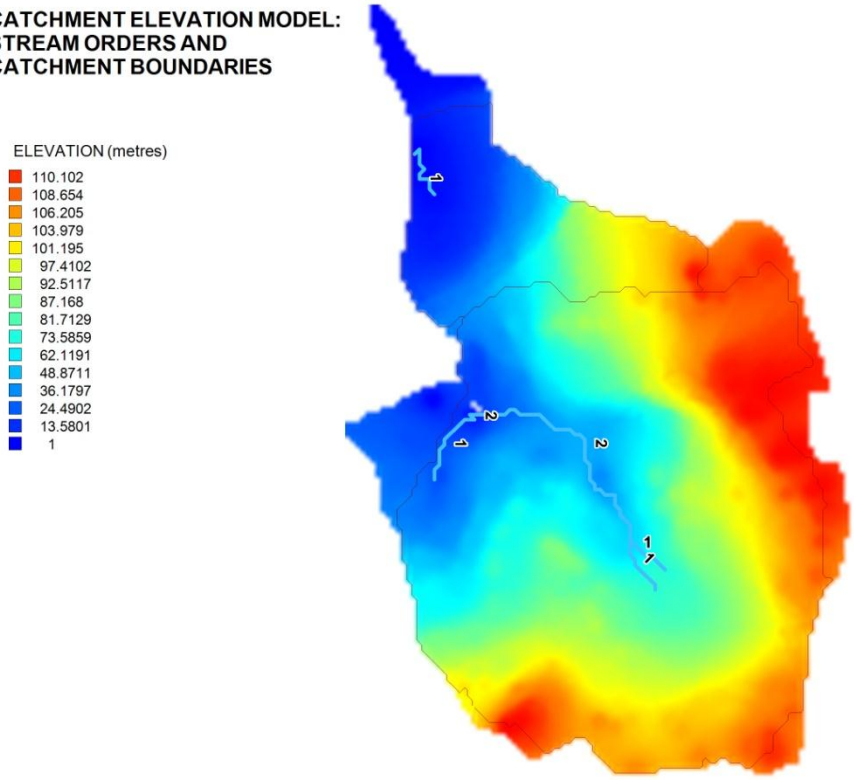
RIPARIAN IMPACTS

- 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
    - Loss of shrub layer

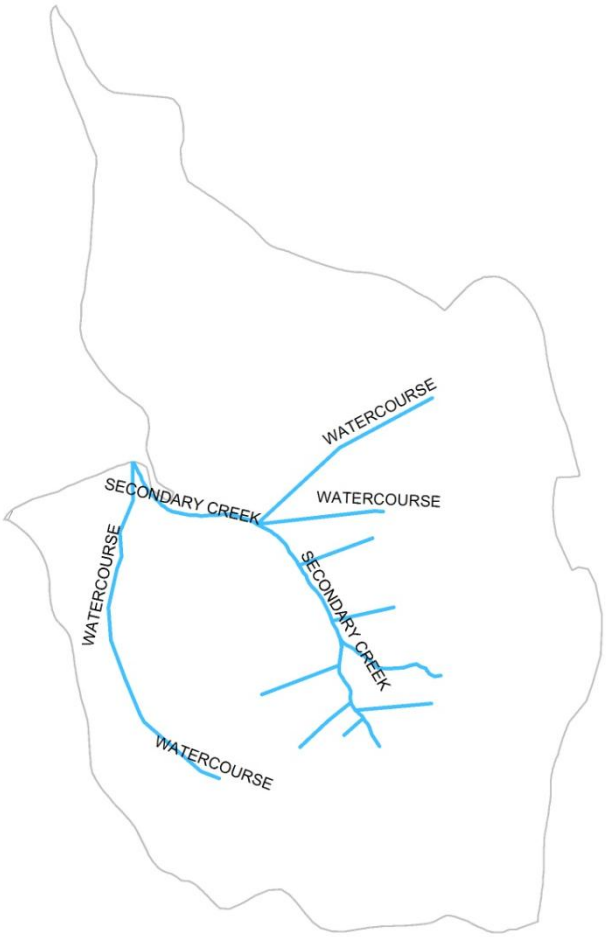
    - Loss of groundcover species
- Removal of habitat elements including
    - Loss of leaf litter
    - Loss of fallen timber
    - Loss of standing dead trees
    - Loss of rocks
    - Loss of microhabitat architecture
- Dumping of rubbish
- Littering
- Vandalism including
    - Damage to plants
    - Damage to abiotic habitat elements
    - Injured or killed animals
- Inappropriate fire regime
- Erosion
- Sedimentation
- Plant diseases including
    - Phytophthora (dieback)
    - Myrtle rust
    - Smut
    - Common rust
    - Mistletoes
- Feral animals including
    - Foxes
    - Rabbits
    - Deer
    - Cane Toads
    - Wild pigs
    - Feral cats
    - Introduced birds

RECREATED WATERWAYS MAP

CATCHMENT ELEVATION MODEL: STREAM ORDERS AND CATCHMENT BOUNDARIES



CURRENTLY MAPPED WATERWAYS AND CATCHMENT BOUNDARIES



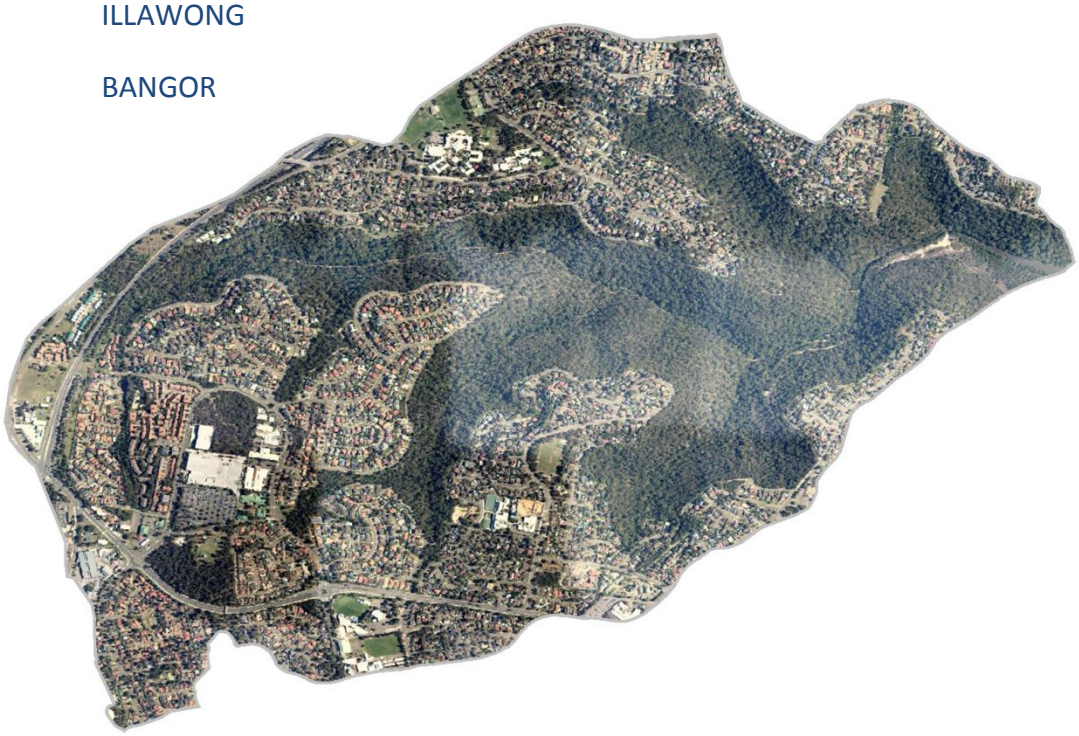
STILL CREEK SUBCATCHMENT

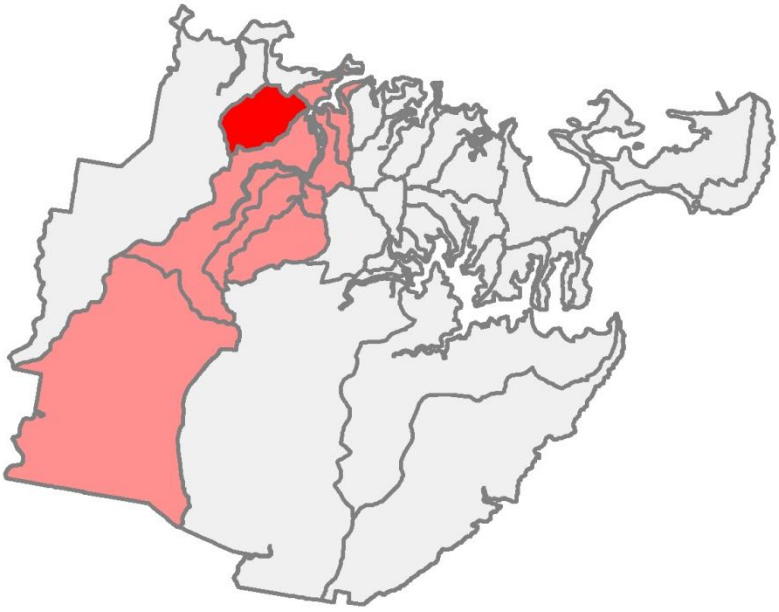
CATCHMENT AREA: 5.18 KM^2

SUBURBS: MENAI

ILLAWONG

BANGOR





WATERWAYS

MAJOR NAMED WATERWAYS: STILL CREEK

TOTAL LENGTH OF MAPPED WATERWAYS: 16.96 KMs

PRIMARY ORDER CREEKS: 0 KMs

SECOND ORDER CREEKS: 6.91 KMs

FIRST ORDER & MINOR DRAINAGE LINES: 10.06 KMs

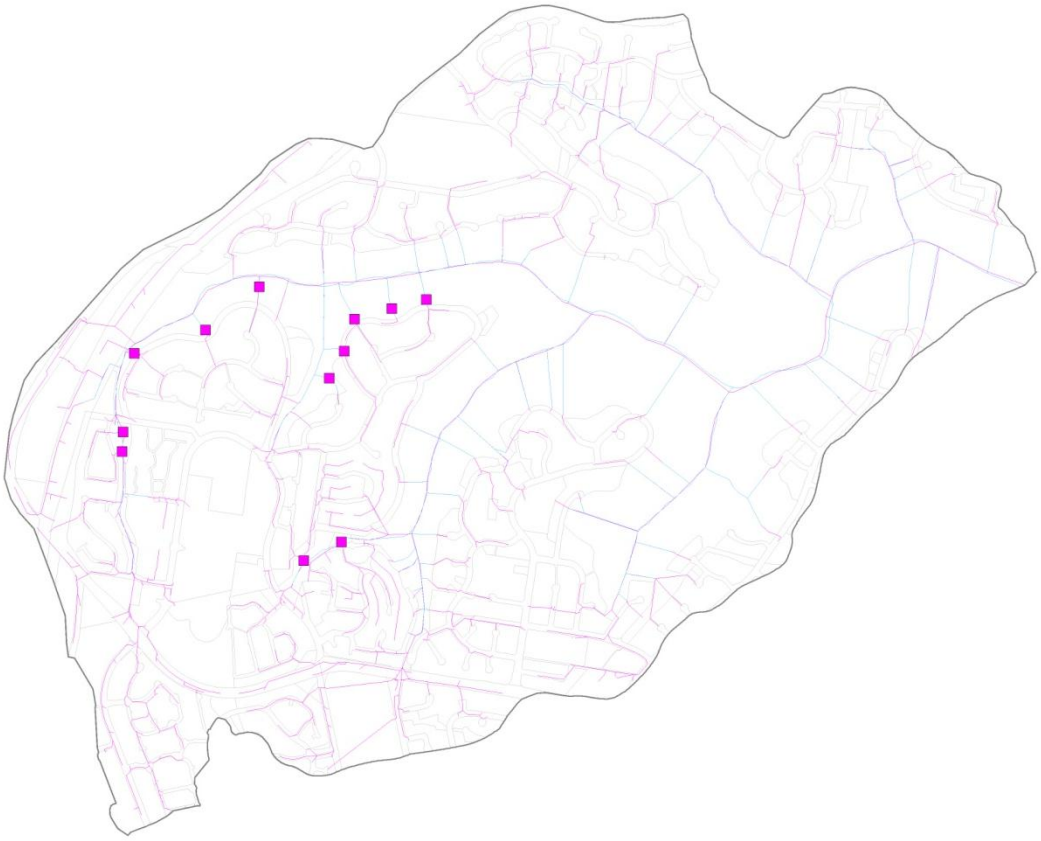
WATER QUALITY ASSESSMENT

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 (↑) 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.

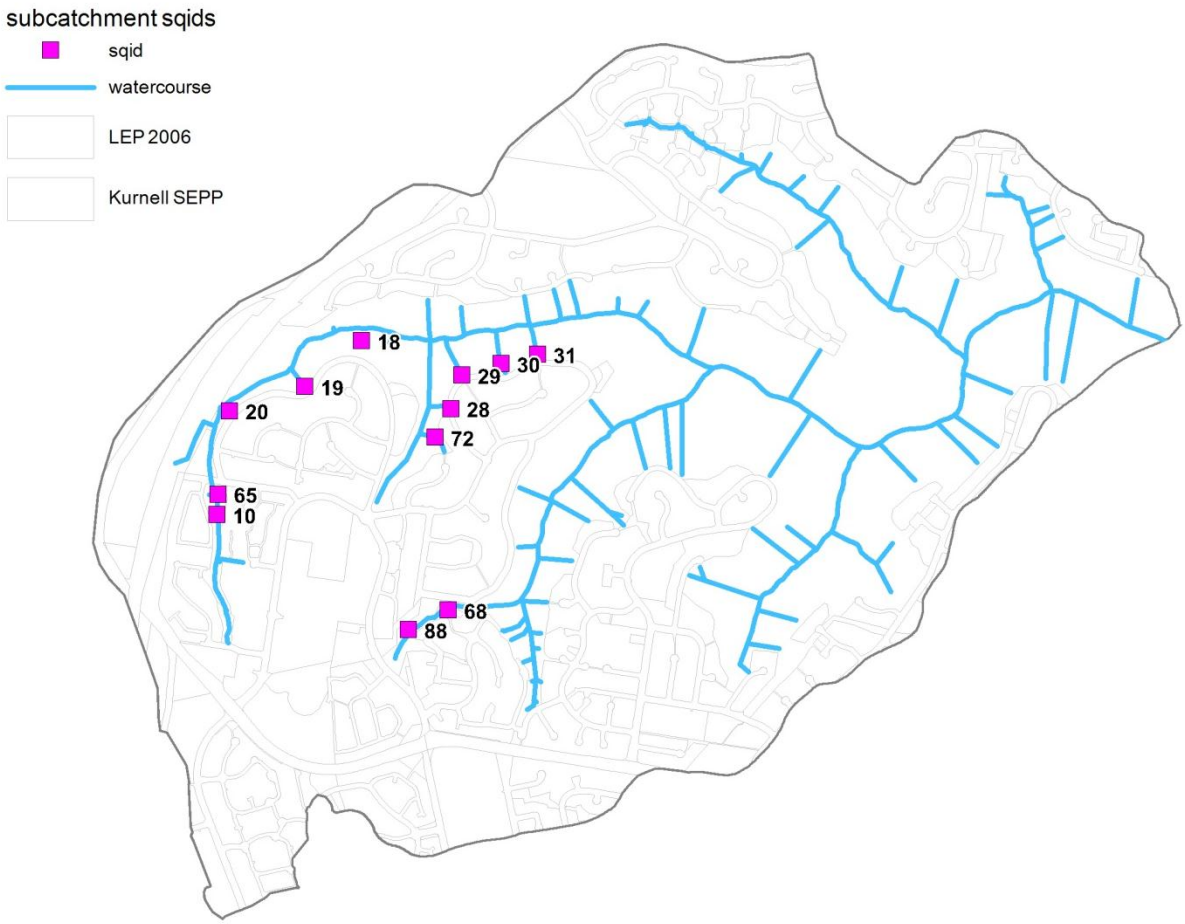
Insufficient data was recorded at this site and results were not reported

RETICULATED STORMWATER SYSTEM



LOCATION OF SQIDS

ID	DEVICE CATEGORY	DEVICE TYPE	LOCATION	SITE DESCRIPTION	SUBURB	APPROX. CATCHMENT
18	GPT - Other	Silt Trap	Beaumaris Drive	Bushland	Menai	1.3 Ha
19	GPT - Other	Silt Trap	Beaumaris Drive	Bushland	Menai	5.2 Ha
20	GPT - Other	Silt Trap	Beaumaris Drive	Bushland	Menai	4.6 Ha
28	GPT - Other	Silt Trap	Llanberis Drive	Bushland	Menai	2.3 Ha
29	GPT - Other	Silt Trap	Llanberis Drive	Bushland	Menai	0.9 Ha
30	GPT - Other	Silt Trap	Llanberis Drive	Bushland	Menai	1.6 Ha
31	GPT - Other	Silt Trap	Llanberis Drive	Bushland	Menai	3 Ha
68	Detention Basin	Detention Basin	Tonkies Place	YEO's Subdivision	Menai	21.5 Ha
10	GPT	GPT	Mina Road	Still Creek	Menai	55 Ha
65	Detention Basin and Wetland	Detention Basin and Wetland	Mina Road	Recreation area	Menai	55 Ha
72	GPT - Other	Silt Trap	Llanberis Drive	Bushland	Menai	2.7 Ha
88	Detention Basin	Detention Basin	Boxsell Close	Next to Tonkies Place Wetland	Menai	13.5 Ha



GEOMORPHIC SETTNG

Still Creek subcatchment soil landscapes include Hawkesbury Soil Landscape (ha) around drainage lines. Eastern and northern ridges and plateaus are mainly Lucas Heights Soil Landscape (lh), while Blacktown Soil Landscape (bt) dominates on southwestern ridgetop plateaus (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

Forbes Creek subcatchment is a steep catchment with one main and one minor drainage line. Lower areas around the drainage are between 30-70m AHD, and maximum height is 116m.

ASS/PASS, URBAN SALINITY

LEP (00 &06) CLASS	HECTARES
CLASS 1	2.26
CLASS 2	4.68
CLASS 5	77.34

Very small areas of Class 1 and 2 ASS are located close to the Woronora River foreshore, and the larger area of Class 5 ASS forms a band along the foreshores.

OTHER CONTAMINATION ISSUES

None noted

LAND USE

HISTORIC LAND USE

Early assessment of the area around Menai described it as generally rugged with high plateaus, cut in place by deep ravines. In 1895 Owen James named the Menai area 'Bangor' after his home town in Wales. Bangor-Menai started off as a small settlement, consisting mainly of poultry and vegetable farms. Land was cheaper here than anywhere else in Sutherland, and larger holdings could be purchased. Many market gardeners moved to Menai from Miranda for this reason, but maintained business ties with more populated parts of Sutherland.

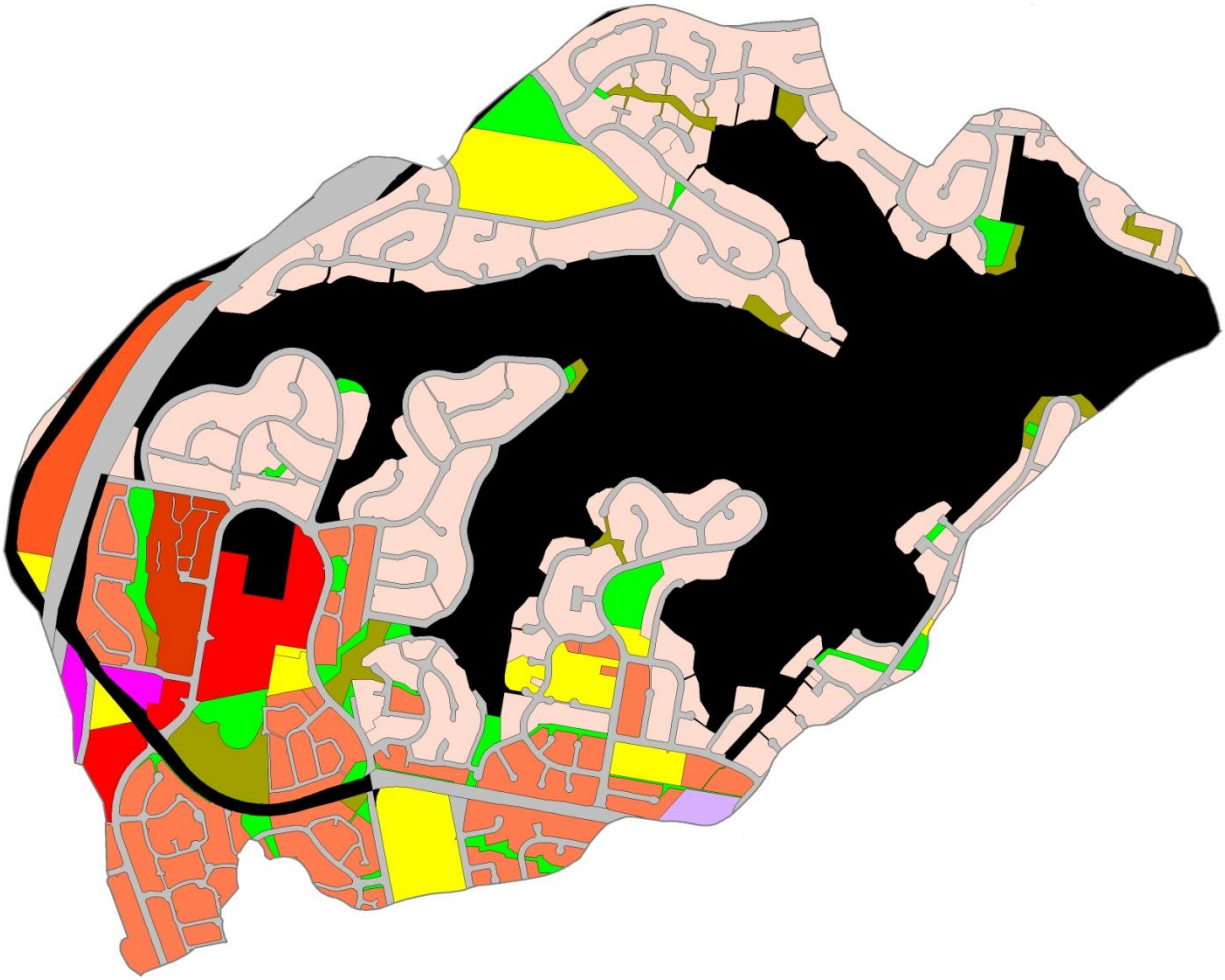
The area was renamed Menai in 1910 after the Menai Straits between Wales and the Isle of Anglesey, as there was already a town called Bangor in Tasmania. Menai was 8km from Sutherland, and rather isolated. Local needs were growing and residents wanted road access to Sutherland. Farmers were obliged to catch the ferry to Lugarno and then travel by road at night to deliver their produce to Sydney markets. Water supply was also a concern for the small community, and extended droughts took a toll on the locals.

By the 1930s Menai was a well established rural community with some industry. There was a factory manufacturing gut-rope, near the home of a carpenter. The gut was stretched out between trees, then twisted by hand and smoothed down with sandpaper. In 1945 Illawarra Road was completed, giving better access to Sydney markets. By the 1950s Bangor had been declared a separate suburb, and the whole area was in desperate need of reliable water. Flooding after heavy rains affected the sanitary services of the area, and damaged roads, including the road to Sutherland.

When Menai tip opened in 1965 there were concerns about the type of waste and level of toxicity. These were further exacerbated when it was discovered that over a 20 year period around 300 tonnes of toxic by-products from the manufacture of 245-T had been dumped in the area. Tests for dioxin, a by-product residue, were negative, but concerns remained.

Menai continued to maintain a rural atmosphere into the 1970s, when a development plan for the area was suggested. It recommended urban centres linked by a network of roads, with land set aside for parks, sporting fields and reserves. A further land release in 1983 added 4000 homes to the area, and it continues to expand today. Nearby Bangor has followed the same progression, with land releases adding to the local population. For both suburbs, bushfire is an ever-present threat, and management of the bush needs to compete with management of bushfire danger.

CURRENT LAND USE



ZONING BY CLASS LEP2006

- 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)

LEP ZONING DESCRIPTOR	HECTARES	% CATCHMENT	POTENTIAL IMPERVIOUS	HECTARES IMPERVIOUS
Deferred Matter	189.74	37%	0%	0.00
Environmental Housing Sensitive Land	0.18	0%	43%	0.08
Environmental Housing Scenic Quality	0.00	0%	57%	0.00
Environmental Housing Bushland	128.17	25%	57%	73.06
Local Housing	46.11	9%	51%	23.51
Multiple Dwelling A	6.80	1%	64%	4.35
Multiple Dwelling B	6.90	1%	64%	4.41
Mixed Use Kirrawee	0.00	0%	64%	0.00
Urban Centre	12.21	2%	94%	11.48
Local Centre	1.49	0%	88%	1.31
Neighbourhood Centre	0.00	0%	86%	0.00
Employment	2.31	0%	95%	2.20
Special Uses	23.05	4%	46%	10.60
Public Open Space	14.97	3%	5%	0.75
Public Open Space Bushland	10.20	2%	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	0.00	0%	0%	0.00
Railway	0.00	0%	33%	0.00
Arterial Road/Road	75.99	15%	66%	50.16
Transport Reservation	0.00	0%	5%	0.00
TOTAL	**518.11**	100%	**35%**	**181.91**

VEGETATION COMMUNITIES

MAPPED VEGETATION COMMUNITIES

1.12 HECTARES COASTAL SALTMARSH

2.75 HECTARES MANGROVE

0.19 HECTARES NON NATURAL WETLANDS

5.17 HECTARES RIPARIAN SCRUB

4.72 HECTARES SHALE/SANDSTONE TRANSITION FOREST

0.37 HECTARES SWAMP OAK FLOODPLAIN FOREST

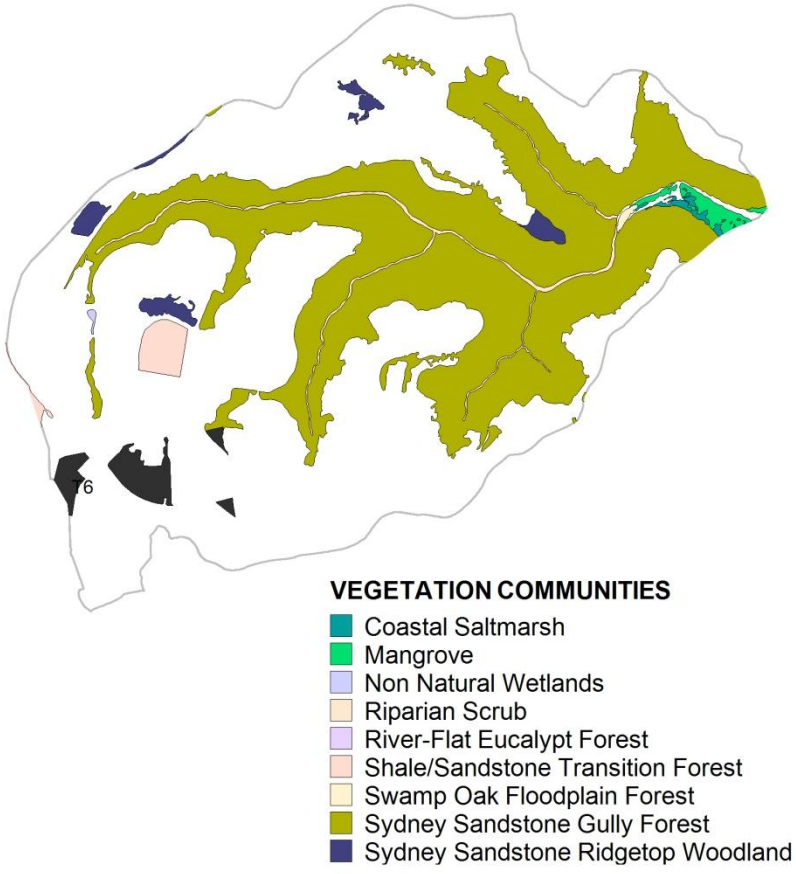
171.21 HECTARES SYDNEY SANDSTONE GULLY FOREST

6.06 HECTARES SYDNEY SANDSTONE RIDGETOP WOODLAND

7.22 HECTARES SYDNEY TURPENTINE IRONBARK FOREST

LEP 2006 SIGNIFICANT VEGETATION

LEP TAG	NAME	CLASS
T6	EucMoreton Bay Fig	Significant Group of Trees or Vegetation



BUSHLAND RESERVES AND RESTORATION

Reserves

1) Greenweb Core areas

- Moreton Rd Reserve
- Still Creek Reserve
- Allison Cres Reserve

2) Greenweb Support areas

- Stanley Walk/Stanley Pl/Redman Ave/Osprey Dr/Friendship Pl/Bond Pl/Osprey La/Portland Cl
- Wales Cl/Tabard Pl
- Hamelin Pl/Blaxland Dr/Walsh Cl
- Tenna/nt Pl/Gerald Rd/Bampton Ave/West Cl/Sail Pl/Blaxland Dr/Oriana Dr/Orford Pl
- Jervis Dr
- Alfords Point Rd
- Mayman Rwo/Catalpa Gr/Allison Cres/Tupelo Gr/Laurel Gr/Alder Gr/The Woods Crct
- Hilloak Way/Appletree Pl/Dewberry Cl/Carter Rd
- James Cl/Pioneer Dr
- Beltana Cl/Ballina Pl/Boronga Cl/Belarada Cl/Belbowrie Cl/Bangalee Pl/Bandalong Cr/Bujarra Pl
- Torumba Cl/Yala Rd/Terranora Pl/Towradgi Pl
- Parys Cl/Llanberis Dr/Allison Cres/Beaumaris Dr/Conway St/Colwyn Cl/Carmarthen St

3) Greenweb Restoration areas

- Alfords Point Rd/Old Illawarra Rd (near Rosewall Dr)
- Beaumaris Drive

Bushcare Groups

- Bimbai Close Crown Reserve
- Bangaroo St Reserve
- Berry Grove Reserve
- Parc Menai
- Beaumaris Drive Reserve

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
    - Gambusia
    - Carp
    - Cane Toads
    - Koi Carp (goldfish)

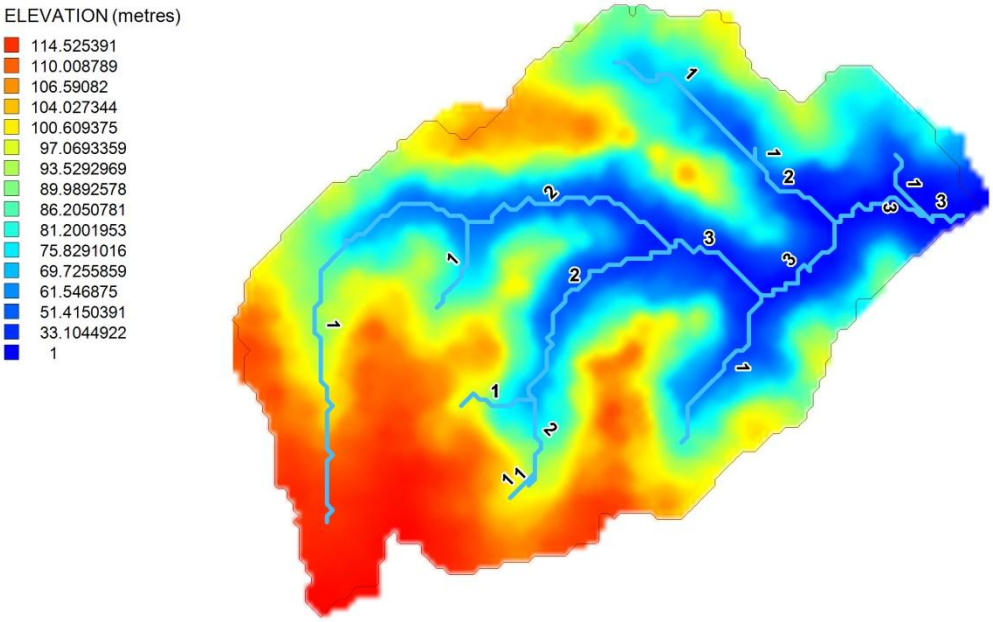
RIPARIAN IMPACTS

- 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

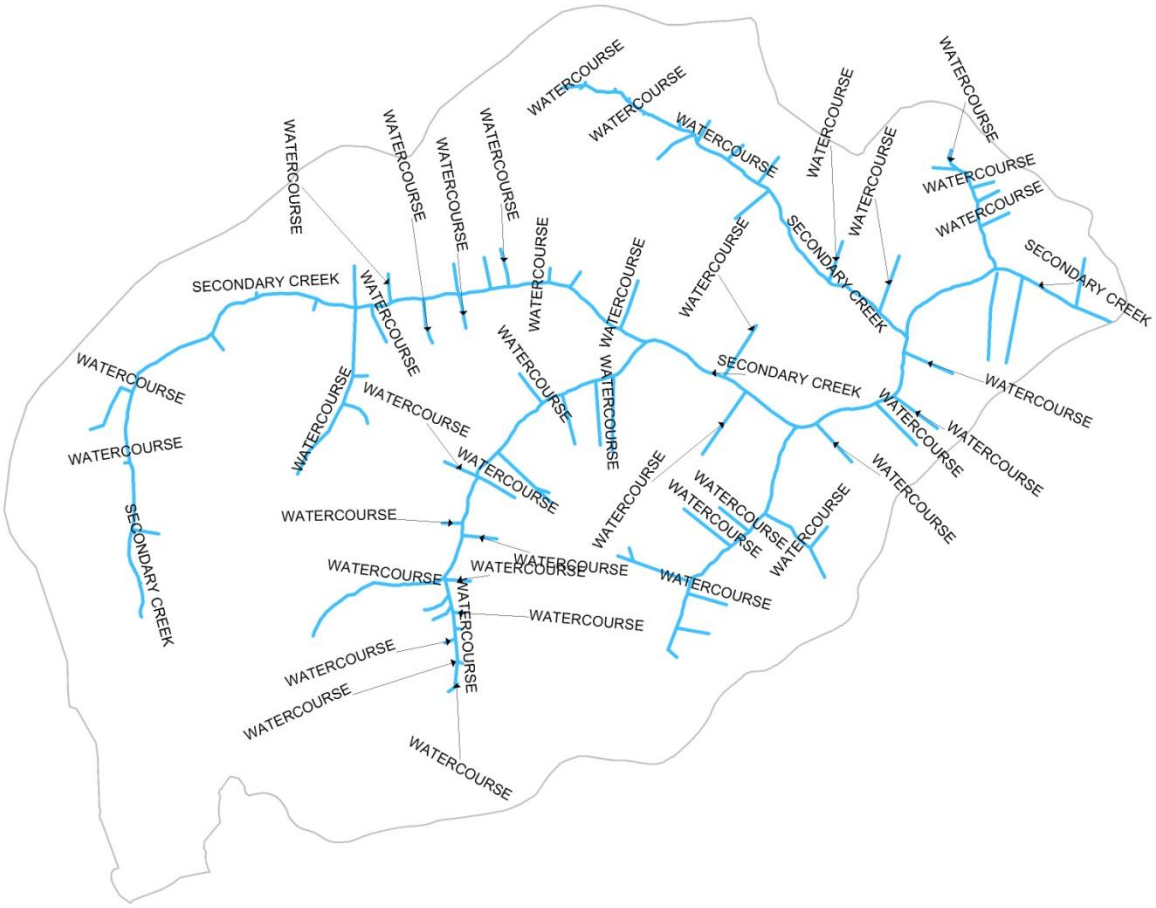
- Disturbance from vehicle access
- Disturbance from excessive use by stock or other animals
- Clearing of vegetation
- Deliberate introduction of exotic plant species
- Selective removal of vegetation including
    - Loss of canopy
    - Loss of shrub layer
    - Loss of groundcover species
- Removal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

RECREATED WATERWAYS MAP

CATCHMENT ELEVATION MODEL: STREAM ORDERS AND CATCHMENT BOUNDARIES



CURRENTLY MAPPED WATERWAYS AND CATCHMENT BOUNDARY

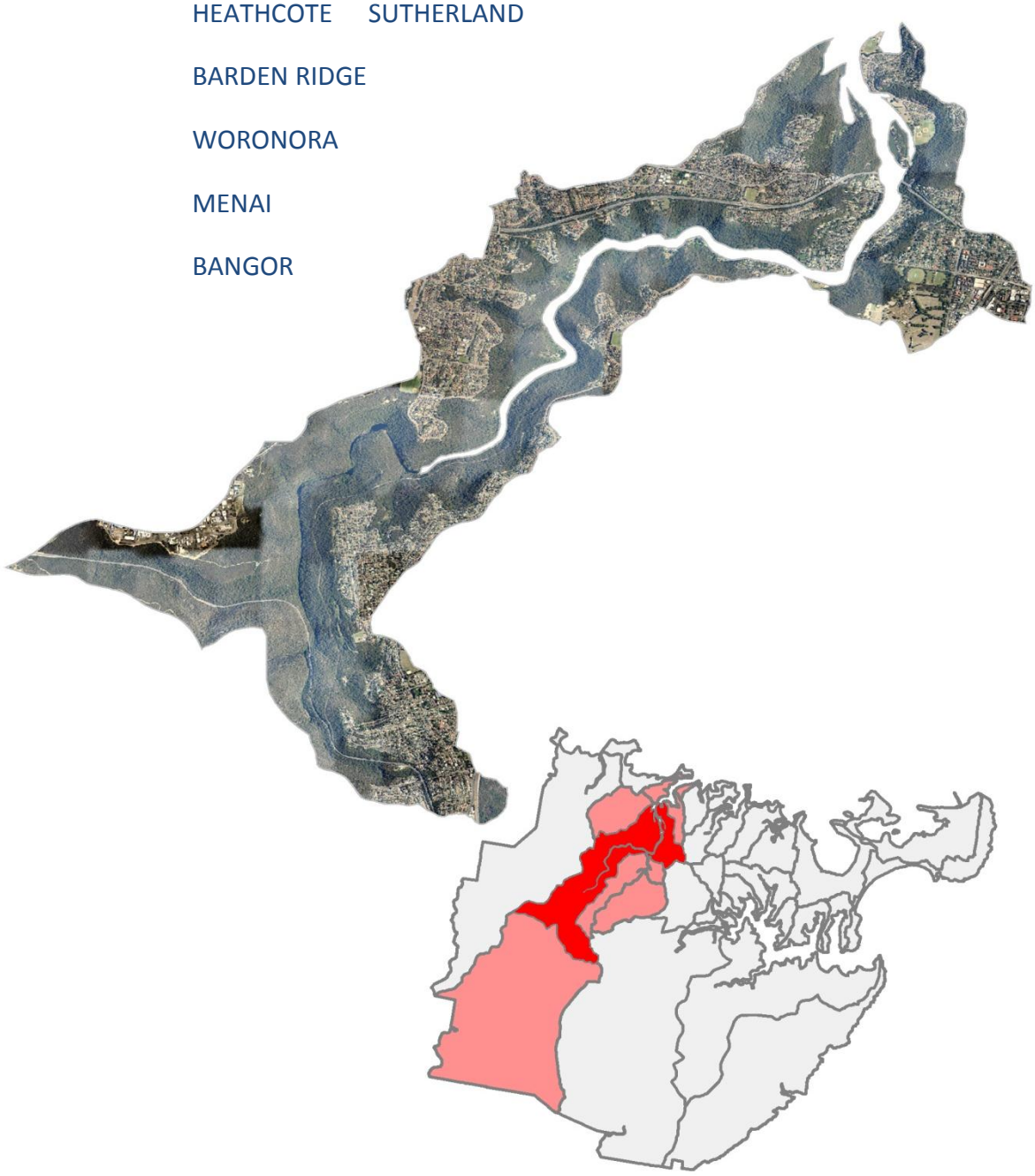


WORONORA SUBCATCHMENT 1

CATCHMENT AREA: **17.17 KM^2**

SUBURBS:

ENGADINE
LUCAS HEIGHTS
COMO
WORONORA HEIGHTS
HEATHCOTE
SUTHERLAND
BARDEN RIDGE
WORONORA
MENAI
BANGOR



WATERWAYS

MAJOR NAMED WATERWAYS: KALLALA GULLY

PRESTONS GULLY

WORONORA RIVER

SABUGAL GULLY

STILL CREEK

HEATHCOTE CREEK

MELINGA MOLONG GULLY

TOTAL LENGTH OF MAPPED WATERWAYS: 42.90 KMs

RIVER: 4.73

PRIMARY ORDER CREEKS: 0 KMs

SECOND ORDER CREEKS: 8.67 KMs

FIRST ORDER & MINOR DRAINAGE LINES: 29.50 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 (↑) 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.

Four sites were sampled in the Woronora River subcatchment:

1. Engadine Avenue wetland

Insufficient data was reported for this site

2. Mianga Avenue wetland

I Insufficient data was reported for this site

3. Menai Rd GPT

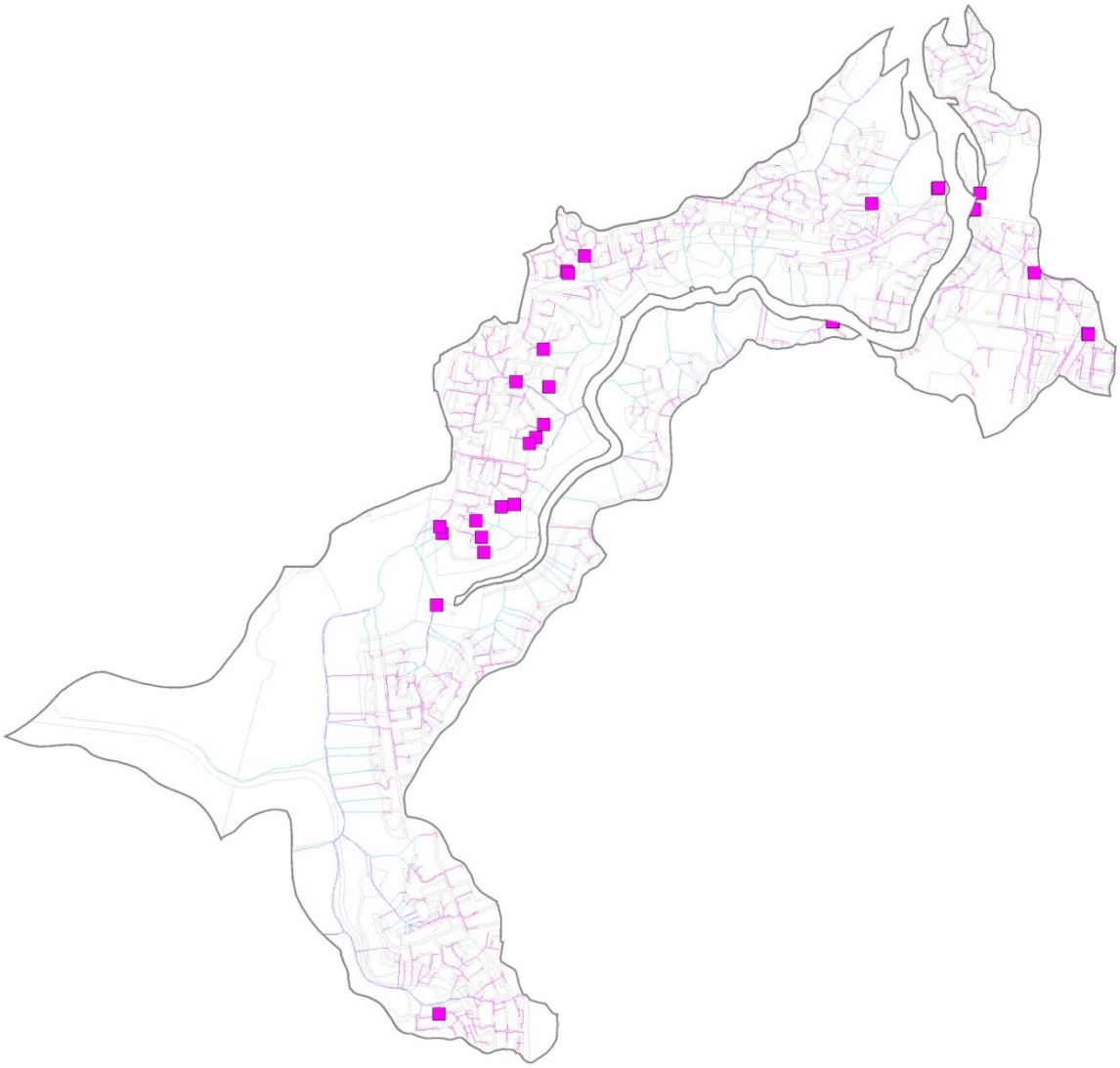
Insufficient data was reported for this site

4. The Crescent Woronora

PARAMETER	NH3	BOD	Cu	Pb	Zn
SUMMER 95 +/- ANZECC 2000 values	+	+	-	-	-
SUMMER 00 +/- ANZECC 2000 values	-	-	-	-	-
TREND ↓↑	↓	↓	=	↑	↑
PARAMETER	**Enterococci**	**Grease**	**TN**	**TP**	**TSS**
SUMMER 95 +/- ANZECC 2000 values	-	+	-	-	-
SUMMER 00 +/- ANZECC 2000 values	+	-	-	-	-
TREND ↓↑	↑	↓	↓	↓	=

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

RETICULATED STORMWATER SYSTEM

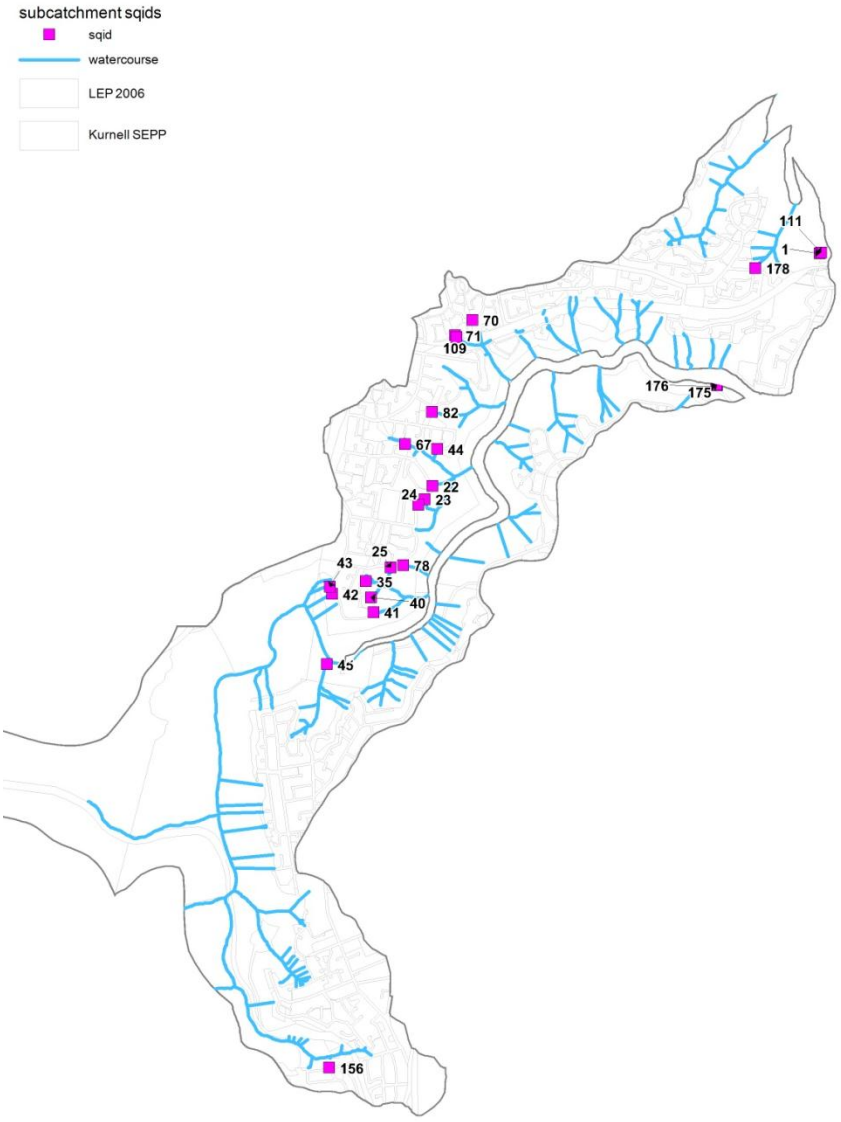


LOCATION OF SQIDS

ID	DEVICE CATEGORY	DEVICE TYPE	LOCATION	SITE DESCRIPTION	SUBURB	APPROX. CATCHMENT
1	GPT	GPT	Menai Road	Bushland	Woronora	20.8 Ha
22	GPT - Other	Silt Trap	David Road	Bushland	Barden Ridge	1.7 Ha
23	GPT - Other	Silt Trap	David Road	Bushland	Barden Ridge	0.9 Ha
24	GPT - Other	Silt Trap	David Road	Bushland	Barden Ridge	7 Ha
25	GPT - Other	Silt Trap	David Road	Bushland	Barden Ridge	2.6 Ha
35	GPT - Other	Silt Trap	Reeve Place	Behind No. 10 Thomas	Barden Ridge	3 Ha

ID	DEVICE CATEGORY	DEVICE TYPE	LOCATION	SITE DESCRIPTION	SUBURB	APPROX. CATCHMENT
				Mitchell Drive		
40	GPT - Other	Silt Trap	Thomas Mitchell Drive	Bushland	Barden Ridge	3.5 Ha
41	GPT - Other	Silt Trap	Thomas Mitchell Drive	Bushland	Barden Ridge	1.1 Ha
42	GPT - Other	Silt Trap	Thomas Mitchell Drive	Bushland	Barden Ridge	0.5 Ha
43	GPT - Other	Silt Trap	Thomas Mitchell Drive	Bushland	Barden Ridge	0.5 Ha
44	GPT - Other	Silt Trap	Wardell Drive (Water Board Track)	Opposite Angas Close	Barden Ridge	1.4 Ha
45	GPT - Other	Silt Trap	Woronora Road	At end of road close to Woronora River	Engadine	54 Ha
67	Wetland	Wetland	Australia Road	Down fire trail of Wardell Drive	Menai	48 Ha
70	Detention Basin	Detention Basin	The Woods Circuit	Bushland	Menai	10 Ha
71	GPT - Other	Trash Rack	Silverleaf Row	Inconjuntion with wetland	Menai	8.6 Ha
78	GPT - Other	Silt Trap	David Road	Bushland	Barden Ridge	0.3 Ha
82	GPT - Other	Silt Trap	Landor Road	Bushland	Barden Ridge	10.6 Ha
98	GPT	Humeceptor	Toronto Parade	Sutherland Carpark	Sutherland	14.1 Ha
121	Wetland	Wetland	River Road	Jannali Reserve - SW corner	Woronora	7.7 Ha
109	Wetland	Wetland	Silverleaf Row	Reserve	Menai	8.6 Ha
111	GPT - Other	Humeceptor	Menai Road	Offline and downstream of Council GPT	Woronora	20.8 Ha
119	GPT - Other	Humeceptor	River Road	Near Wetland	Woronora	2 Ha
120	GPT -	GPT	River Road	In Line Litter	Woronora	2 Ha

ID	DEVICE CATEGORY	DEVICE TYPE	LOCATION	SITE DESCRIPTION	SUBURB	APPROX. CATCHMENT
	Other			Separator, near Wetland		
48	GPT - Other	Ecosol GPT	Linden Street	Corner of Linden and Galga Street	Sutherland	23 Ha
143	GPT - Other	Litter Basket	Toronto Parade	Sutherland Carpark	Sutherland	0.48 Ha
156	GPT	CDS	Forum Drive	Residential	Heathcote	14 Ha
175	GPT - Other	Iplex GPT	River Road	Woronora River	Woronora	1.6 Ha
176	GPT - Other	Iplex GPT	River Road	Woronora River	Woronora	5 Ha
178	GPT - Other	Trash Rack	Goorgool Road	Reserve in residential area	Bangor	3.2 Ha



GEOMORPHIC SETTING

Woronora River subcatchment soil landscapes include Hawkesbury Soil Landscape (ha) around drainage lines and foreshores. The eastern ridges of the surrounding plateaus are Gymea Soil Landscapes (gy), while the western ridges are mainly Lucas Heights Soil Landscape (lh), with some Blacktown Soil Landscape (bt) on western ridges and plateaus. There are areas of Disturbed Terrain Soil Landscape (xx) on Woronora River upstream from Bonnet Bay (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

This subcatchment includes a large area on both sides of the Woronora River. It is a steep subcatchment that includes one major drainage line with numerous ephemeral drainages entering it. Lower areas around the drainage are between 20-50m AHD, and maximum height is 120m.

ASS/PASS, URBAN SALINITY

LEP (00 &06) CLASS	HECTARES
CLASS 1	6.40
CLASS 2	8.93
CLASS 3	46.64
CLASS 4	6.76
CLASS 5	668.97

Small areas of Class 1, 2 and 3 ASS are located close to the foreshore of Woronora River. The patch of Class 4 ASS and the larger area of Class 5 ASS form a band along the foreshores.

OTHER CONTAMINATION ISSUES

None noted

LAND USE

HISTORIC LAND USE

The Woronora River subcatchment drains the areas below Sutherland, Engadine and Woronora on the eastern bank, and Barden Ridge and Lucas Heights on the west. Engadine area was opened up when Governor Sir Thomas Brisbane granted 60 hectares to John Lucas in 1825. Lucas built a water mill to grind grain for flour, just near the confluence with Georges River. In the early years the land was heavily timbered and there was no road access to Sydney. Lucas and others relied on boats to transport goods to the markets in Sydney.

Much of the land around Engadine and Sutherland was national park after 1879, preventing its development. In 1890 land was released on the western side of the suburb, and Charles

McAllister purchased several hectares of land and built a home on Woronora Rd. Homelea still stands on the corner of Fairview Avenue and Woronora Rd. Woronora was also slow to be developed, described in 1868 as too rocky and too poor to plough. The township of Woronora grew in conjunction with the building of the Woronora Dam in the 1920s and 1930s. A large labour force was required, and men brought their families to the area. Residents lived in bungalows made of fibro and conditions were fairly spartan.

In 1925 the local council declared war on the humpies along the river after numerous complaints from these residents. Following the completion of the dam in 1941, over 600 men were retrenched, and many of these moved to camps by the river, including one in Prince Alfred Park. By the 1970s Woronora was still an out of the way place, a condition which suited local residents despite the limited services. In 1985 Woronora Heights was established and by 1991 there were 750 houses in the suburb, with land reserved for schools and parks, and a few small areas left in their native state. Since then, residents have lobbied against further development of bushland, although more recent pressure for additional housing has seen them overturned (Jackson, 2006).

On the other side of the river, conditions were very similar. John Lucas received a grant of 60 hectares on the Woronora River, and gave his name to the area. The mill was destroyed by fire in 1830 but settlement persisted and grew slowly over the next century. The area was mainly utilised by visitors from Sydney, in search of picturesque scenery and a break from the city life. They visited by train from Sydney and then boat from Como. A few stayed and lived in tents and humpies by the river's edge.

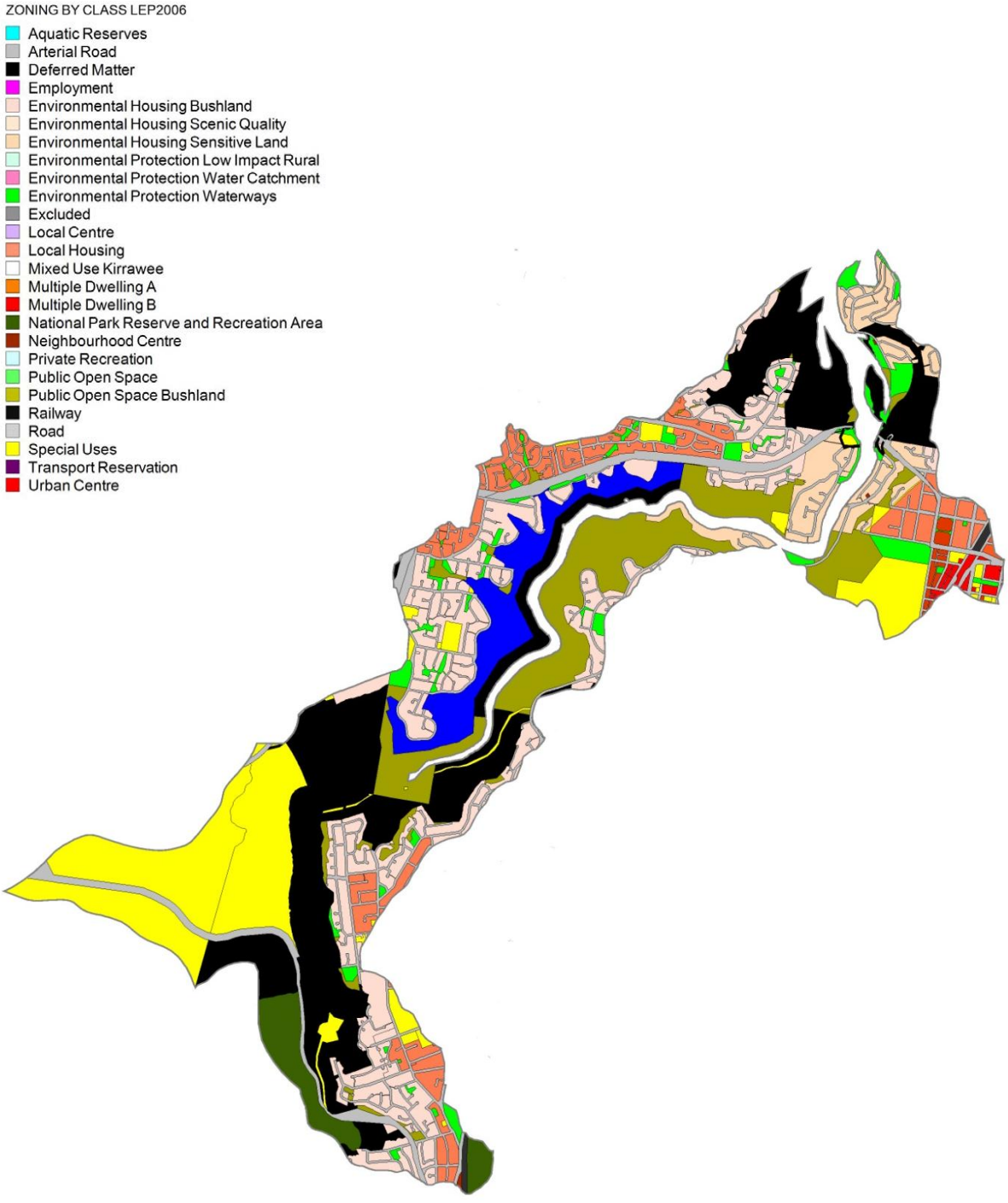
In 1958 Australia's first nuclear reactor was completed at Lucas Heights. The remoteness of Lucas Heights was seen as a favourable aspect of its location, and this site was selected over others including Malabar and Jervis Bay. After two years of testing the reactor commenced routine full power operations. It provided medical radioisotopes for over 30 years, and has supported scientific investigations for many university and government authorities.

The presence of the reactor has always been controversial, partly due to the toxic waste it produces. An attempt was made to transport spent fuel rods to France for processing, but licensing problems prevented this. Following major protests in the early 21st century and unlawful entry by protestors into the facility, security was completely redesigned. The reactor itself was due for replacement around this time, and this has been a lengthy process to ensure that the new facility is completely safe. Key areas of research for the facility today include climate change monitoring and modelling, groundwater research and production of cleaner building materials with reduced waste products.

The emphasis on maintaining a safe environment has meant that an area 1.6km wide around the reactor site has been retained as bushland. This is managed by ANSTO in conjunction with a number of community organisations including Menai Wildflower Group (part of the Australian Plant Society).

Barden Ridge is a comparatively new development just down the road from Lucas Heights. The name was originally to replace Lucas Heights for the suburb as an attempt to improve public opinion of the area. As urbanisation spread in the area Barden Ridge became the name associated with a new development north of the original Lucas Heights, and today both are considered separate suburbs. Much of the planning for Barden Ridge has been directed towards maintaining an environmentally sustainable development.

CURRENT LAND USE



CATCHMENT IMPERVIOUS SURFACE (% AND DISTRIBUTION)

LEP ZONING DESCRIPTOR	HECTARES	% CATHCHMENT	POTENTIAL IMPERVIOUS	HECTARES IMPERVIOUS
Deferred Matter	387.10	23%	0%	0.00
Environmental Housing Sensitive Land	80.37	5%	43%	34.56
Environmental Housing Scenic Quality	0.00	0%	57%	0.00
Environmental Housing Bushland	254.73	15%	57%	145.20
Local Housing	113.12	7%	51%	57.69
Multiple Dwelling A	1.20	0%	64%	0.77
Multiple Dwelling B	6.83	0%	64%	4.37
Mixed Use Kirrawee	0.00	0%	64%	0.00
Urban Centre	7.73	0%	94%	7.27
Local Centre	0.10	0%	88%	0.09
Neighbourhood Centre	0.63	0%	86%	0.55
Employment	0.00	0%	95%	0.00
Special Uses	271.30	16%	46%	124.80
Public Open Space	53.94	3%	5%	2.70
Public Open Space Bushland	192.71	11%	0%	0.00
Private Recreation	0.00	0%	5%	0.00
Environmental Protection Waterways	2.29	0%	0%	0.00
Aquatic Reserves	0.00	0%	0%	0.00
National Park Reserve and Recreation Area	45.28	3%	0%	0.00
Railway	3.79	0%	33%	1.25
Arterial Road/Road	214.10	12%	66%	141.31
Transport Reservation	0.00	0%	5%	0.00
Environmental Protection Low Impact Rural	82.04	5%	**0%**	0.00
TOTAL	**1717.24**	100%	**30%**	**520.54**

VEGETATION COMMUNITIES

MAPPED VEGETATION COMMUNITIES

1.34 HECTARES COASTAL SALTMARSH

5.13 HECTARES MANGROVE

12.46 HECTARES RIPARIAN SCRUB

14.17 HECTARES RIVER-FLAT EUCALYPT FOREST

1.86 HECTARES SHALE/SANDSTONE TRANSITION FOREST

6.39 HECTARES SWAMP OAK FLOODPLAIN FOREST

682.48 HECTARES SYDNEY SANDSTONE GULLY FOREST

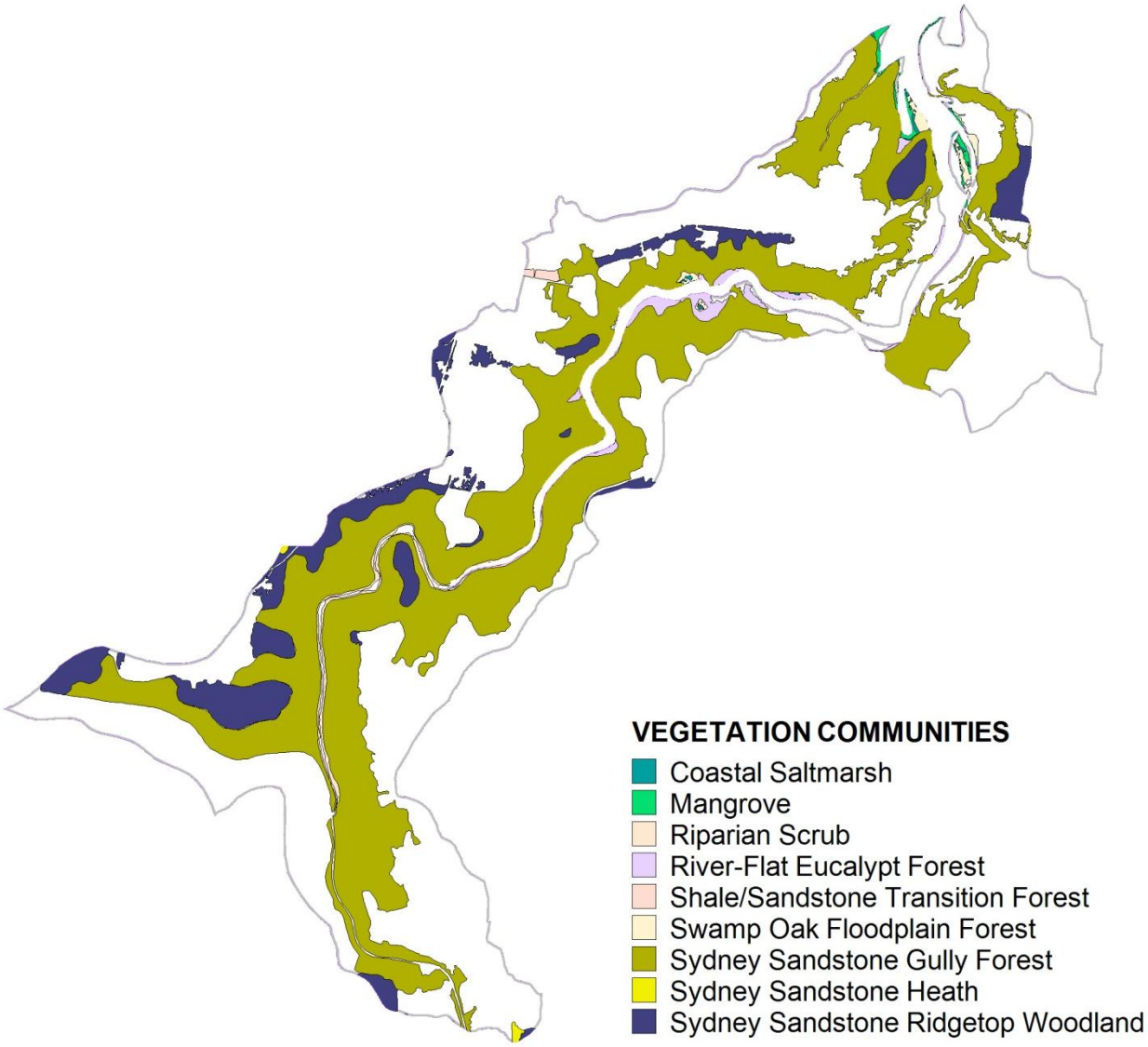
1.25 HECTARES SYDNEY SANDSTONE HEATH

125.69 HECTARES SYDNEY SANDSTONE RIDGETOP WOODLAND

LEP 2006 SIGNIFICANT VEGETATION

LEP TAG	NAME	CLASS
T10	Eucalyptus_River Red Gum	Significant Group of Trees or Vegetation
Lf7	Sandstone Steps	Significant Landform
T7A	Calodendrum capense_Cape Chestnut	Significant Group of Trees or Vegetation
Lf8	Sandstone Formations	Significant Landform
T8	Eucalyptus Racemosa	Significant Group of Trees or Vegetation
T14	Eucalyptus Punctata_Grey Gum	Significant Group of Trees or Vegetation
T17	Tristaniopsis Laurina_Water Gum	Significant Group of Trees or Vegetation
T17	Tristaniopsis Laurina_Water Gum	Significant Group of Trees or Vegetation
T22	Ficus Rubiginosa_Port Jackson Fig	Significant Group of Trees or Vegetation
T21	Ficus Rubiginosa_Port Jackson Fig	Significant Group of Trees or Vegetation
T15	Cultural Plantings_Lophostemon confertus_Brush Box	Significant Group of Trees or Vegetation
T16	Eucalyptus haemastoma_Scribbly and Snappy Gums	Significant Group of Trees or Vegetation
T25	Lophostemon confertus_Brush Box	Significant Group of Trees or Vegetation

MAPPED VEGETATION COMMUNITIES



BUSHLAND RESERVES AND RESTORATION

Reserves

1) Greenweb Core areas

- Paruna Reserve/Woronora Cres
- River Rd/Prince Edward Park Rd
- Prince Edward Park
- Woronora River foreshores
- Heathcote National Park
- Royal National Park

- Bangor Bypass

2) Greenweb Support areas

- Woronora Cres/Rata Rd/Delta St
- Thurlgona Rd/Cooriengah Heights Rd/Mirang Pl/Arkana Pl
- Willaroo Ave/Jaeger Pl/Mannikin Dr
- Marooba Pl/Holmlea Pl/Gwydir St
- Andromeda Cres/Orion St/Sirius Pl/Sierra Rd/Mountain St/Ferntree Rd/Woronora Rd
- Cutler Rd/Fairview Ave/Beethoven St/Forum Dr
- Railway corridor
- ANSTO, Lucas Heights
- Reeve Pl/Thomas Mitchell Dr
- Melville Pl/Wynyard Pl/Bain Pl/O'Brien Pl/Tunks Pl/Hatton Pl/Wardell Dr
- Barden Rd/Priest Pl/Doyle St
- Dilkara Crct/Dunbil Ct/Dulin Cl/Shackel Rd
- Arunta Cl/Arika Cl/Achilpa Cl/Allawah Cl
- Yala Rd/Turuga Pl/Turi Cl/Tongarra Cl/Terranora Pl/Towradgi Pl/Tycannah Pl
- Yanderra Ave/Yates Rd

3) Greenweb Restoration areas

- Central Ave/Wolger St
- Cooriengah Heights Rd/Kulinia St/Leawarra St/Thurlgona Rd
- Higgerson Ave/Raymond Pl/Naranga Ave/Woronora Rd

Bushcare Groups

- Paruna Reserve, Como
- Burnum Burnum Sanctuary
- Burnum Burnum Sanctuary – Boatramp
- Prince Edward Park
- Sirius Place Reserve
- Prestons Gully
- Throsby Close Reserve
- Australia Road Reserve
- Sorrel Place Reserve
- Gooyong Reserve (Koorabar Rd)
- Akuna Avenue Oval
- Yanderra Avenue Bushland
- Yala Rd Crown Reserve
- Prices Reserve South

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
    - Gambusia
    - Carp
    - Cane Toads
    - Koi Carp (goldfish)

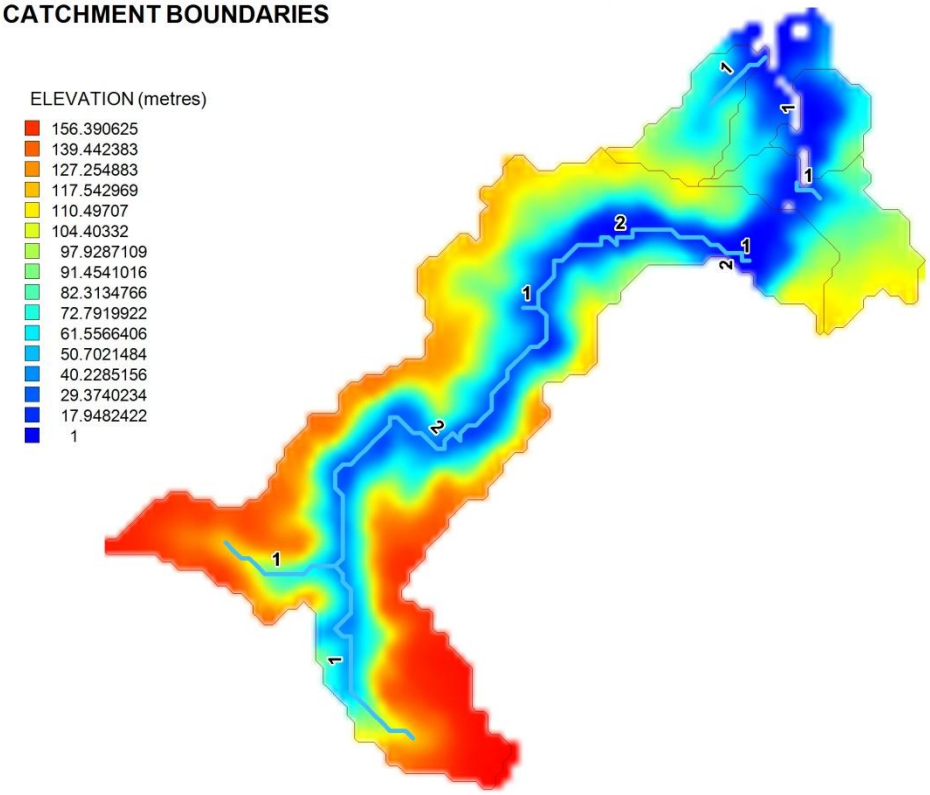
RIPARIAN IMPACTS

- 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
    - Loss of shrub layer
    - Loss of groundcover species
- Removal of habitat elements including
    - Loss of leaf litter
    - Loss of fallen timber
    - Loss of standing dead trees
    - Loss of rocks
    - Loss of microhabitat architecture
- Dumping of rubbish
- Littering
- Vandalism including
    - Damage to plants
    - Damage to abiotic habitat elements
    - Injured or killed animals
- Inappropriate fire regime
- Erosion
- Sedimentation
- Plant diseases including
    - Phytophthora (dieback)
    - Myrtle rust
    - Smut
    - Common rust

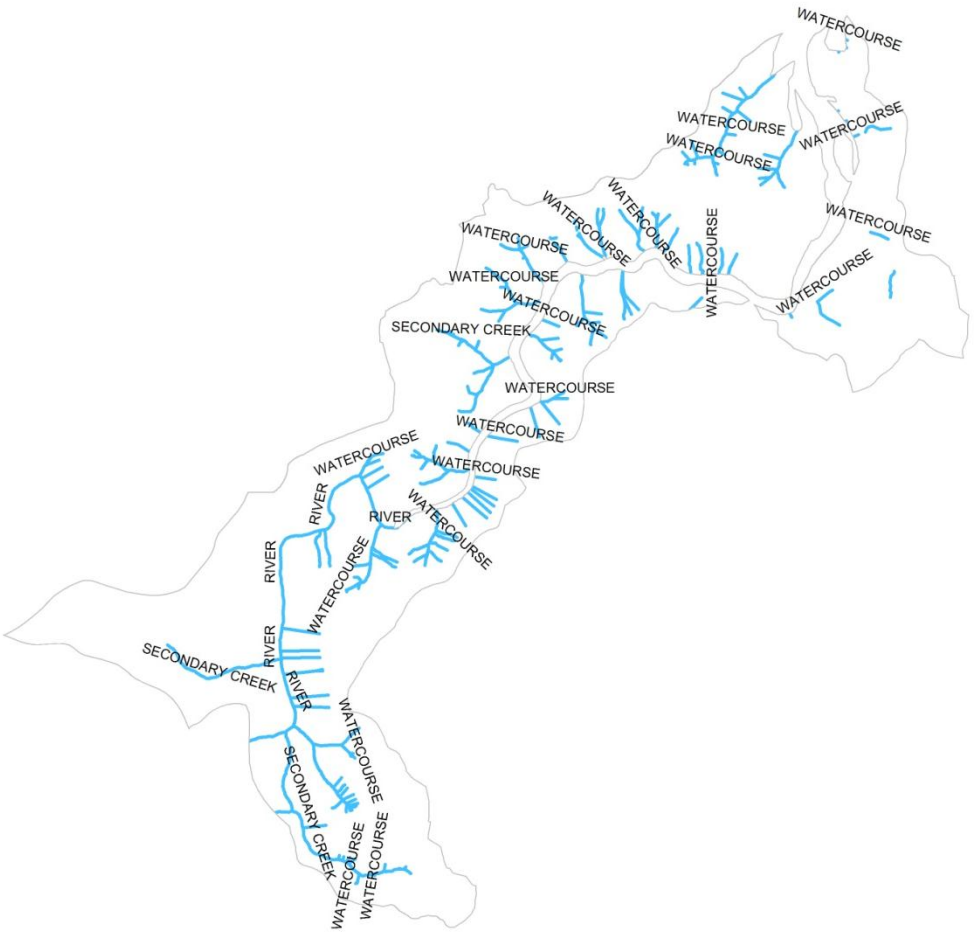
    - Mistletoes
- Feral animals including
    - Foxes
    - Rabbits
    - Deer
    - Cane Toads
    - Wild pigs
    - Feral cats
    - Introduced birds

RECREATED WATERWAYS MAP

CATCHMENT ELEVATION MODEL: STREAM ORDERS AND CATCHMENT BOUNDARIES



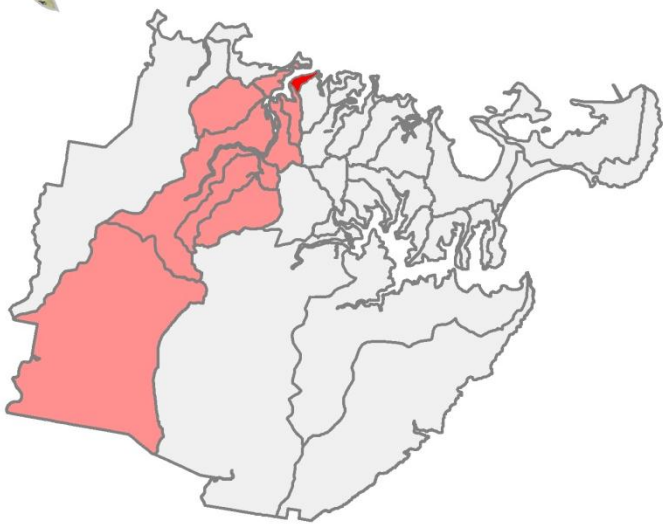
CURRENTLY MAPPED WATERWAYS AND CATCHMENT BOUNDARIES



WORONORA SUBCATCHMENT 2

CATCHMENT AREA: 0.34 KM^2

SUBURBS:



WATERWAYS

MAJOR NAMED WATERWAYS: NIL

TOTAL LENGTH OF MAPPED WATERWAYS: 0.33 KMs

PRIMARY ORDER CREEKS: 0 KMs

SECOND ORDER CREEKS: 0.18 KMs

FIRST ORDER & MINOR DRAINAGE LINES: 0.15 KMs

WATER QUALITY ASSESSMENT

See section in Woronora River Subcatchment 1

RETICULATED STORMWATER SYSTEM

LOCATION OF SQIDS

NIL

GEOMORPHIC SETTING

See Woronora River Subcatchment 1

ASS/PASS, URBAN SALINITY

LEP (00 &06) CLASS	HECTARES
CLASS 1	0.04
CLASS 5	32.86

OTHER CONTAMINATION ISSUES

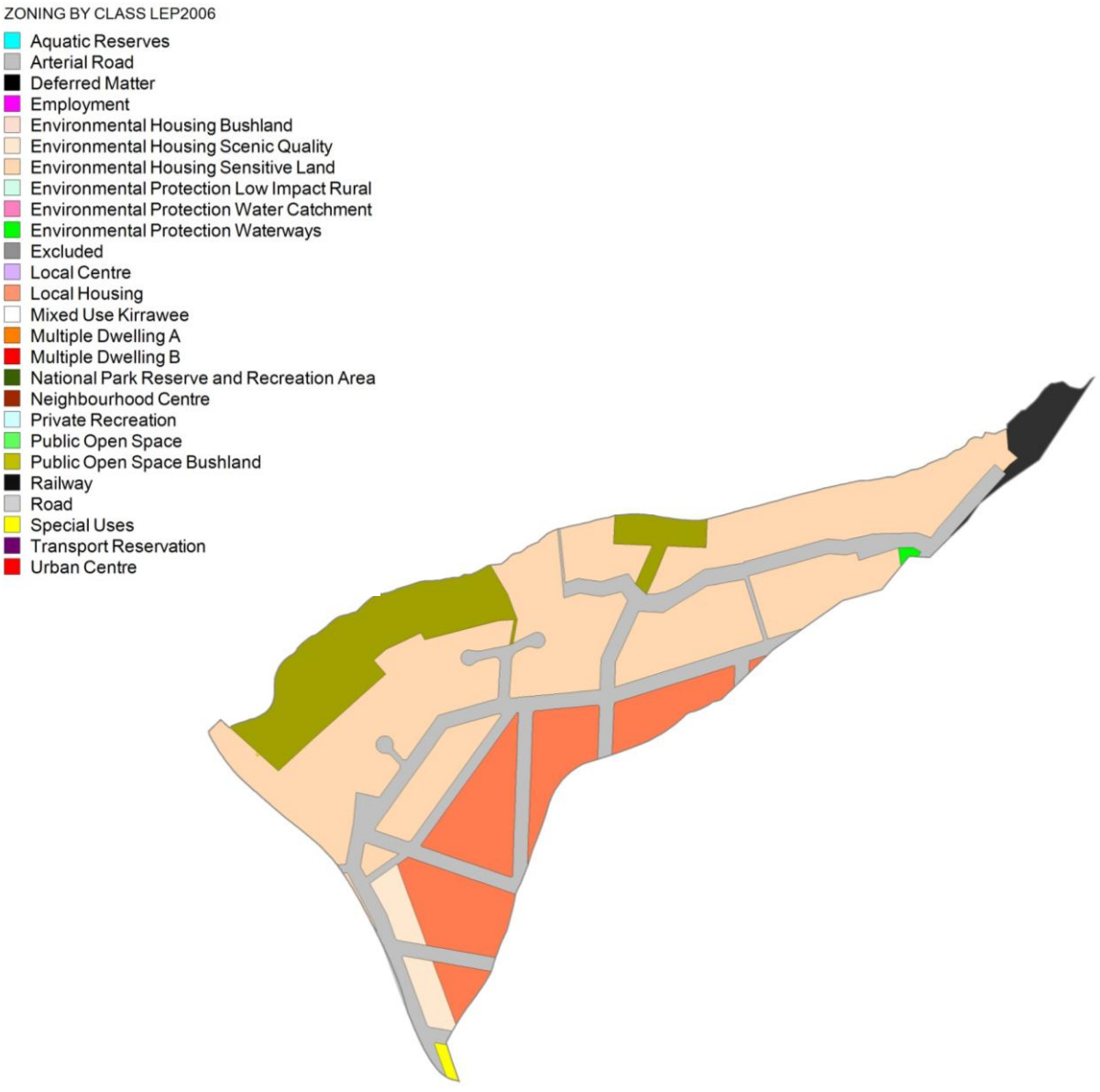
None noted

LAND USE

HISTORIC LAND USE

See Woronora River Subcatchment 1

CURRENT LAND USE



CATCHMENT IMPERVIOUS SURFACE (% AND DISTRIBUTION)

LEP ZONING DESCRIPTOR	HECTARES	% CATHCHMENT	POTENTIAL IMPERVIOUS	HECTARES IMPERVIOUS
Deferred Matter	0.00	0%	0%	0.00
Environmental Housing Sensitive Land	15.54	47%	43%	6.68
Environmental Housing Scenic Quality	0.80	2%	57%	0.46
Environmental Housing Bushland	0.00	0%	57%	0.00
Local Housing	5.28	16%	51%	2.69
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	0.09	0%	46%	0.04
Public Open Space	0.04	0%	5%	0.00
Public Open Space Bushland	4.24	13%	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	0.00	0%	0%	0.00
Railway	0.78	2%	33%	0.26
Arterial Road/Road	6.13	19%	66%	4.05
Transport Reservation	0.00	0%	5%	0.00
TOTAL	**32.91**	100%	**43%**	**14.18**

VEGETATION COMMUNITIES

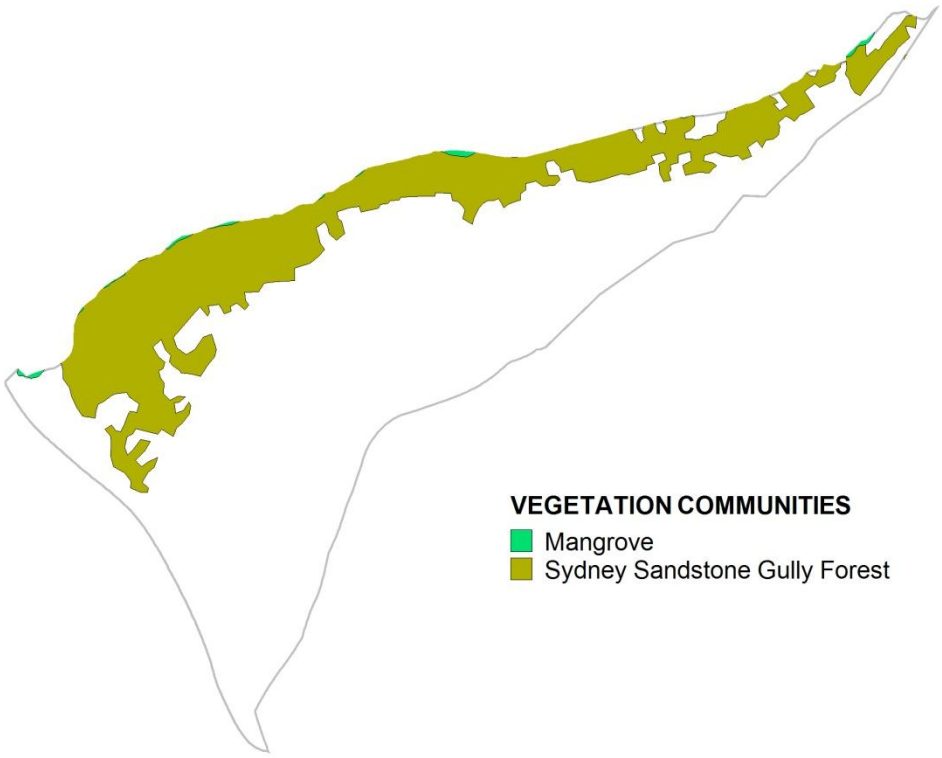
MAPPED VEGETATION COMMUNITIES

0.08 HECTARES MANGROVE

8.36 HECTARES SYDNEY SANDSTONE GULLY FOREST

LEP 2006 SIGNIFICANT VEGETATION

NIL



BUSHLAND RESERVES AND RESTORATION

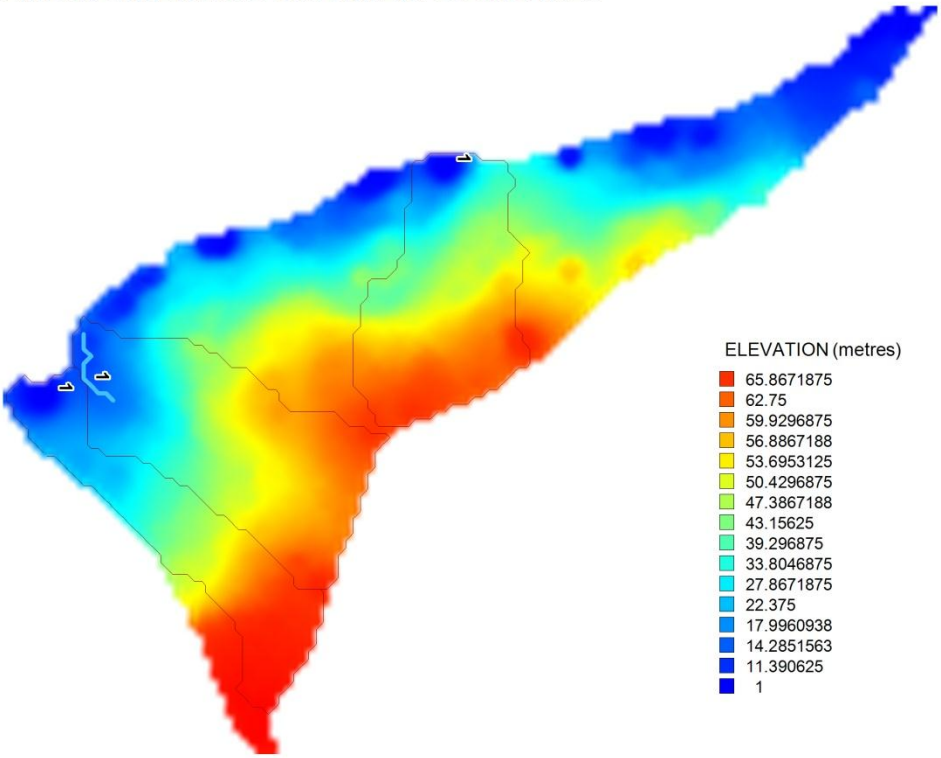
See Woronora River Subcatchment 1

THREATENING PROCESSES

See Woronora River Subcatchment 1

RECREATED WATERWAYS MAP

CATCHMENT ELEVATION MODEL:
STREAM ORDERS AND CATCHMENT BOUNDARIES



CURRENTLY MAPPED WATERWAYS AND CATCHMENT BOUNDARIES