2 OVERVIEW OF KEY ESTUARY PROCESSES AND MANAGEMENT ISSUES

This overview of key estuary processes operating within the Parramatta River estuary presents the key findings of the *Data Compilation and Review Study* (Cardno, 2008) and *Estuary Processes Study* (AECOM, 2010). At the time of preparing this Plan these studies were available online at http://parramattariver.org.au. Table 2.1 lists some of the key parameters for the estuary.

Table 2.1: Key Parameters for the Parramatta River Estuary (Source: Cardno, 2008)

Key Parameters		Source
Estuary Characteristics		
Classification	*Estuary group:* Tide dominated estuary *Estuary type:* Drowned river valley *Evolution stage:* Intermediate	OEH, 2011
Condition	Extensively modified and highly urbanised	Cardno, 2008
Estuary length	Approximately 19km	Cardno, 2008
Entrance conditions	Permanently open	OEH, 2011
Waterway area	13.7km^2	OEH, 2011
Estuary volume	69,700ML	OEH, 2011
Average depth	5.1m AHD	OEH, 2011
Total tidal length of foreshore	Approximately 135km, including all tidal areas of the estuary's tributaries and canals	AECOM, 2010
Length of tidal foreshore protected by seawalls	Total of 36km surveyed as part of the *Estuary Processes Study*: ▪ City of Canada Bay - 16.2km ▪ Parramatta LGA - 5.0km ▪ Auburn LGA - 3.2km ▪ Leichhardt LGA - 3.2km ▪ City of Ryde - 3km ▪ Hunters Hill LGA - 2.2km ▪ Sydney Olympic Park - 2.2km ▪ Ashfield LGA - 1.0km.	AECOM, 2010
Length of tidal foreshore canalised (canals)	Total of 21km surveyed as part of the *Estuary Processes Study.*	AECOM, 2010
Length of natural shoreline	Total of 74km surveyed as part of the *Estuary Processes Study.* Assumed that remaining length is non-natural (seawalls, canals and infrastructure): 61 km.	AECOM, 2010
Catchment Characteristics		
Total catchment area	252.4km^2	OEH, 2011
Main sub-catchments	▪ Upper Parramatta River estuary catchment (108.4km^2); ▪ Duck River (45.3km^2); ▪ Homebush Bay (29.9km^2); ▪ Iron Cove Bay (18.1km^2) ▪ Hen and Chicken Bay (8.5km^2) ▪ The Ponds/Subiaco Creek system (8.5km^2); ▪ Vineyard Creek (4.1km^2).	AECOM, 2010
Major tributaries	26 in total, with the 14 below directly entering the estuary: ▪ Saltwater Creek ▪ Powells Creek	Cardno, 2008

Key Parameters		Source
	▪ Boundary Creek ▪ Haslams Creek ▪ Duck River ▪ Clay Cliff Creek ▪ Vineyard Creek ▪ The Ponds/Subiaco Creek ▪ Archer Creek ▪ Charity Creek ▪ Smalls and Tarban Creeks ▪ Hawthorne Canal ▪ Iron Cove Creek (Dobroyd Canal).	
Main catchment land uses	▪ Residential - 60.7% ▪ Parkland - 16.8% ▪ Industrial - 6.4% ▪ Commercial - 5.8% ▪ Education - 3.5%.	Cardno (calculated from a GIS layer sourced from ABS)
Waterfront reserves	Total area 638.5ha: ▪ Auburn (incl. Sydney Olympic Park) - 419.6ha ▪ City of Ryde - 54.6ha ▪ City of Canada Bay - 53.5ha ▪ Parramatta - 46.9ha ▪ Hunters Hill - 40.7ha ▪ Leichhardt - 23.2ha.	AECOM, 2010
Estuarine Vegetation		
Area of aquatic macrophytes	▪ Mangroves – 149ha ▪ Saltmarsh – 23ha ▪ Seagrass - 10ha approx.	AECOM, 2010; West & Williams, 2008
Riparian vegetation communities	Total area 71ha: ▪ Swamp-oak Floodplain Forest ▪ Coastal Sandstone Gully Forest ▪ Coastal Sandstone Ridgetop Woodland ▪ Sydney Turpentine-Ironbark Forest.	AECOM, 2010

2.1 Catchment Processes

2.1.1 Land Use and Land Tenure

Land use and land tenure are important aspects of estuary management as the land uses determines the type and extent of developments across the catchment, which are the primary stressor on the natural estuarine environment. There is also a strong correlation between land use, sedimentation and water quality in estuaries as pollutants are washed into waterways in stormwater runoff. This is particularly relevant for the Parramatta River estuary as the catchment and its foreshores are highly urbanised.

Land tenure can have implications for management, particularly when responsibility for a contiguous reach of land, such as the estuary foreshore and creek lines, is divided across a number of landowners and governing authorities. In such situations a coordinated management approach is important for ensuring provision of recreational access and amenity, and for biodiversity conservation.

Historical Land Use

The estuary and its catchment have been exposed to persistent stress over the last two centuries due to historical and current anthropogenic impacts. Up until the 1970's the Parramatta River estuary was treated as an open drain for industry in Sydney, and consequently the estuary's embankments and sediments are contaminated with a range of heavy metals and other chemicals. Various industrial developments were situated along the estuary foreshores, some of which continue to be active today, while others have been converted for alternative uses (Figure 2.1). Historically, industrial development has impacted upon the southern side of the estuary substantially more than the northern side (see Figures 2.2 and 2.3).

a) Heavy industry behind mangroves, Silverwater (source: D. Wiecek, date unknown).

b) Industrial site with rail line, Silverwater (source: M. Campanelli, date unknown).

Figure 2.1: Industrial Development along the Parramatta River

There has been a large amount of land reclamation over the years, as analysed by AECOM (2010) based on a comparison of aerial photography from 1943 and the present day. The majority of land reclamation in the study area occurred prior to 1943, primarily within Homebush Bay, Iron Cove Bay, Hen and Chicken Bay, and the Auburn LGA (Figure 2.2, after AECOM, 2010). It is estimated that around 292ha of land was reclaimed in total and approximately 1km of foreshore lost as a result.

The amount of land use change between 1943 and 2009 is shown on Figure 2.3 (after AECOM, 2010). The greatest changes since 1943 have occurred mostly in the western areas of the catchment, where large areas of agricultural land have been subdivided for residential development. Some historical industrial areas, particularly along the foreshore, have been redeveloped since 1943 for residential and open space uses; however a legacy of industrial contamination of these areas is still a concern.

Historically, Auburn LGA encompassed large areas of industrial land use, and also contains large areas of reclaimed land. Therefore, parts of the estuary and foreshores more likely to be contaminated with industrial pollutants and leachates from reclaimed land are located in Parramatta and Auburn LGAs in the Parramatta River, Duck River and Homebush Bay. Other known areas of potential concern include several bays in the City of Canada Bay where land reclamation has also occurred, including Iron Cove Bay and Hen and Chicken Bay.

Contemporary and Future Land Use

Strategic land use planning and land zoning is governed by each of the individual councils through their Local Environment Plans (LEPs). In the present day, the major land use in the Parramatta River estuary catchment is

residential (60.7%), followed by parkland (understood to include all reserves and open space areas, 16.8%), with industrial and commercial land uses making up around 6% each.

All foreshore LGAs within the catchment are primarily residential land use, with open space and recreational land use areas often adjacent to the local waterways or along the estuary foreshore. Much of the residential development within the lower catchment consists of old building stock. Parramatta and Auburn LGAs contain the greatest areas of contemporary industrial land use.

In the future it is likely that parts of the catchment will be re-developed. The *Metropolitan Plan for Sydney 2036* (NSW Government, 2010) identifies the need to accommodate a large number of new dwellings in Sydney primarily within walking distance of centres that are well serviced by public transport. It also identifies Parramatta as Sydney's second Central Business District (CBD). Hence, it is likely there will be significant changes in land use, with an increase in development intensities in some parts of the catchment as brownfields sites are re-developed. Along the estuary foreshores some former industrial sites may be redeveloped for residential use, as has been the case at Rhodes in the City of Canada Bay.

Intensification of development within the catchment, including brownfields (redevelopment) and greenfields development, primarily for residential or commercial purposes has potential to result in increasing pressure on the estuary, which is a key issue for the estuary. However, it also presents an opportunity to ensure measures such as Water Sensitive Urban Design (WSUD) and riparian buffers are incorporated in new developments, as well as enhancing public access to the foreshore. Key areas of concern for land use planning identified by the Committee and the community include:

- Water cycle management;
- Biological connectivity/corridors and sustainable management of the environment;
- Connectivity along the foreshore and the availability of alternative forms of public transport;
- Equity of public access and recreational amenity along the estuary foreshores; and
- Management of coastal hazards, particularly under climate change conditions.

The current fragmented approach to management of the estuary, whereby a number of authorities regulate land use planning and development represents a challenge to efficient integrated management. Planning reforms currently being implemented by the DP&I include the preparation of standard instrument LEPs and DCPs by all local councils. There is opportunity through this process for the member councils of the Committee to work together to integrate some of their strategic planning activities with the objective of improving management and environmental outcomes for the estuary. Coordinating land use planning and development across all governing bodies involved in management of the estuary is the key mechanism to achieving this objective.

Land Tenure

Land tenure describes who owns a particular parcel of land or an asset (e.g. a stormwater channel). Land tenure is important from the perspective of implementation of the CZMP as consent must be obtained from the land owner prior to undertaking any works on their land, or works that affect their asset(s). Permits or approvals required to undertake works may also be dependent on the tenure status of the land in question.

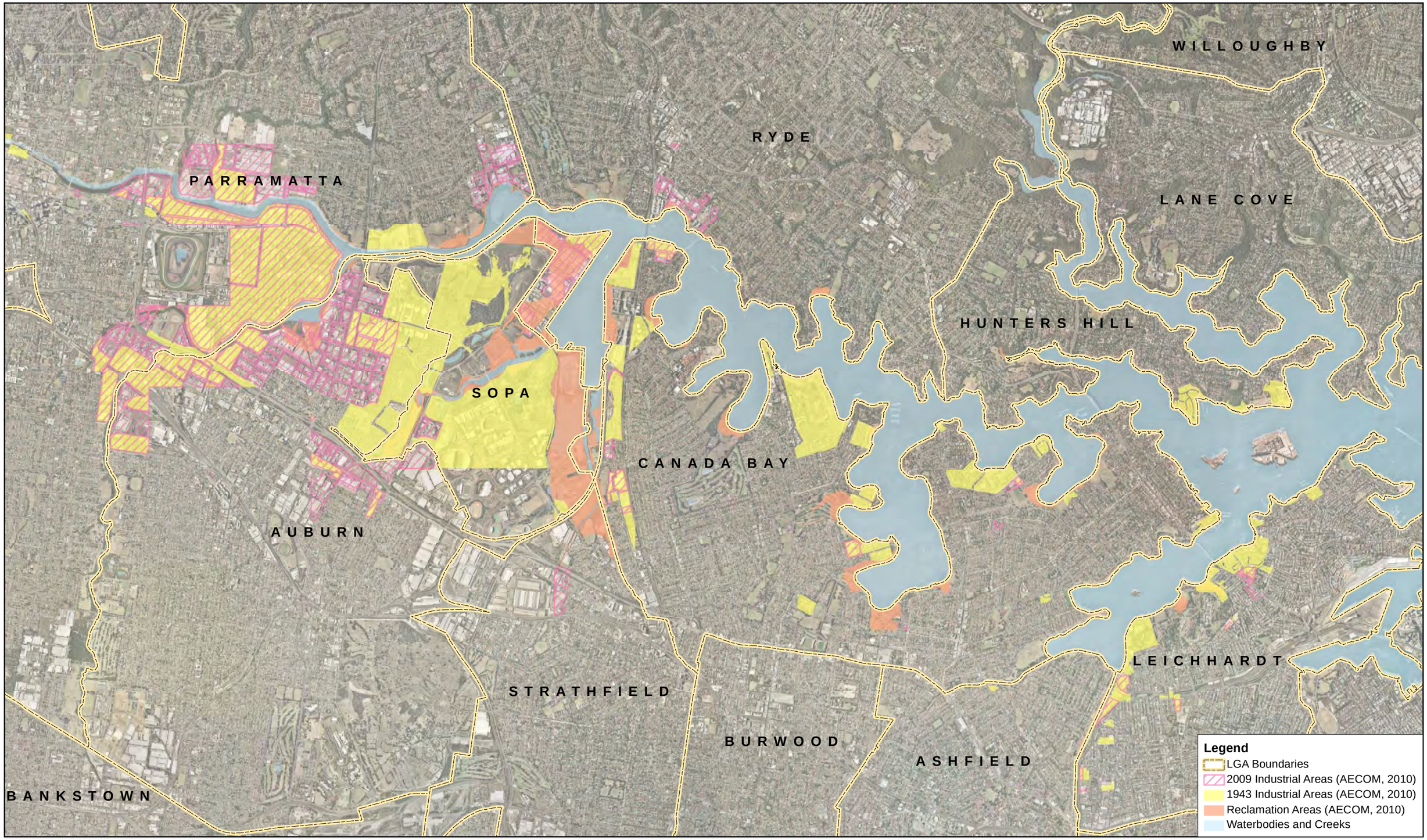
The ownership and control of estuarine foreshore and submerged lands ranges across a spectrum of private landholders, local councils, trustees, the Crown and other NSW Government authorities. Public land tenure has

been mapped for the study area in Figure 2.4 based on available GIS layers (assumed to be of sufficient accuracy and resolution for the purposes of preparing this CZMP), including:

- Crown land – CrownLand.shp (source: Crown Lands);
- Crown land held under tenure – CrownTenure.shp (source: OEH);
- National Parks – NPWS Estate.shp (source: OEH); and
- RMS (Maritime) land/properties – nsw_maritime_title_boundary.shp and premises.shp (source: RMS (Maritime)).

Land below the Mean High Water Mark (MWHM), including the bed of the Parramatta River estuary, is held under title by RMS (Maritime). RMS (Maritime) also has some foreshore land holdings (Figure 2.4), and is responsible for the management of moorings, wharves and jetties. The Crown Lands Division within the DPI is responsible for the management of Crown lands, which can be held under tenure (lease or licence). There are also some National Parks Estate lands within the study area, which are under the care and control of the National Parks and Wildlife Service (NPWS) within OEH.

The NSW Government has a documented policy in relation to access to the harbour and river foreshores, including public access to intertidal lands where landowners have absolute waterfronts but where the waterfront is exposed at low tide. The process of redevelopment of foreshore land may present opportunities to transfer private land holdings into public ownership, thereby increasing the extent of open space, and improving linkages between existing open space areas.



Note: Inaccuracies may be present in data provided by third parties. It is assumed that all GIS data provided by third party suppliers is sufficient and accurate for the purpose of this map.

1:44,000 Scale at A3

Metres

0 500 1000 1500 2000 2500

Reclaimed Land and Historical Industrial Areas

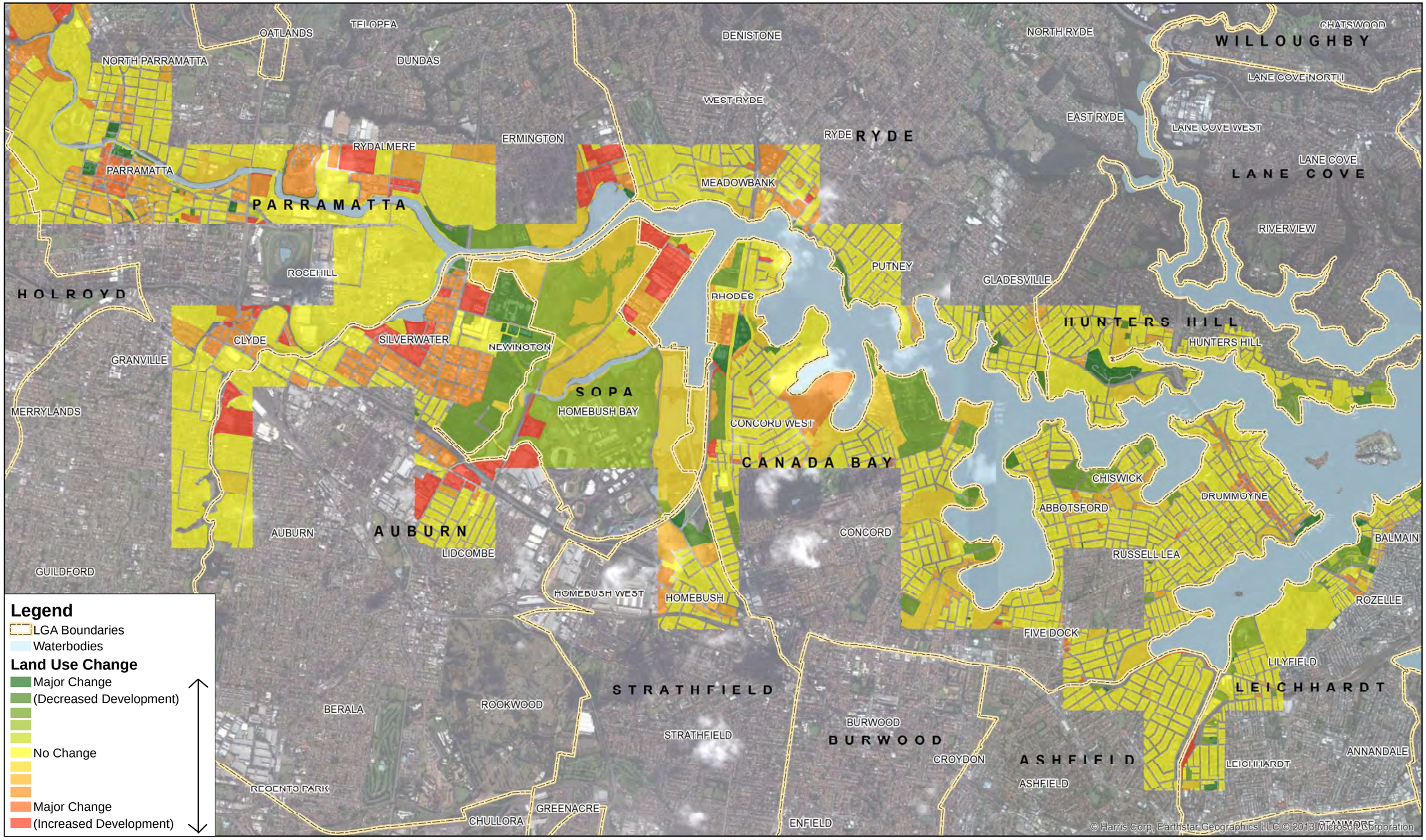
PARRAMATTA RIVER ESTUARY
COASTAL ZONE MANAGEMENT PLAN

FIGURE 2.2

N W E S

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (2812)
Date: 2013-05-31
Coordinate System: GDA 1994 MGA Zone 56
Project: LJ2929
Map: G2002_ReclaimedLand 03.mxd 02
Base Data Source: Land and Property Information NSW (LPI)
Imagery supplied by Google and associated third party suppliers.



Note: Inaccuracies may be present in data provided by third parties. It is assumed that all GIS data provided by third party suppliers is sufficient and accurate for the purpose of this map.

1:44,000 Scale at A3

Metres

0 500 1000 1500 2000 2500

Land Use Changes (1943 - 2009)

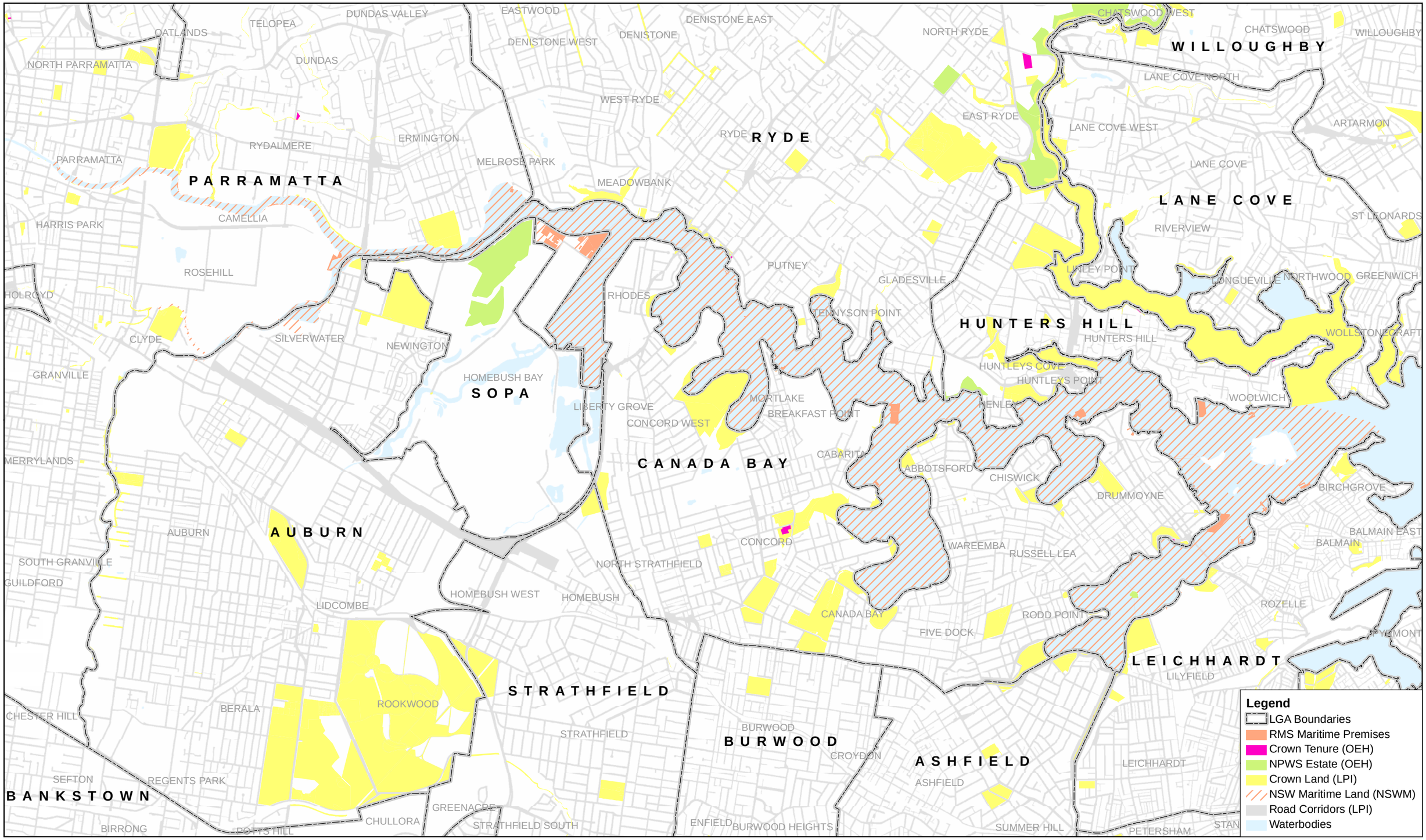
PARRAMATTA RIVER ESTUARY
COASTAL ZONE MANAGEMENT PLAN

FIGURE 2.3

N W E S

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (2812)
Date: 2013-05-31
Coordinate System: GDA 1994 MGA Zone 56
Project: LJ2929
Map: G2003_LandUseChanges 03.mxd 02
Base Data Source: Land and Property Information NSW (LPI)
Imagery supplied by Bing and associated third party suppliers.



Note: Only Public Land Tenure has been mapped.

Inaccuracies may be present in data provided by third parties. It is assumed that all GIS data provided by third party suppliers is sufficient and accurate for the purpose of this map.

1:44,000 Scale at A3

Kilometers

0 0.5 1 1.5 2 2.5

Land Tenure

PARRAMATTA RIVER ESTUARY
COASTAL ZONE MANAGEMENT PLAN

FIGURE 2.4

N W E S

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (2812)
Date: 2013-06-19
Coordinate System: GDA 1994 MGA Zone 56
Project: LJ2929
Map: G2004_LandTenure 03.mxd 02
Base Data Source: Land and Property Information NSW (LPI)

2.1.2 Stormwater Runoff

Stormwater Pollutants

Water and sediment quality within the estuary is generally poor, a key issue for the estuary, and this is largely due to polluted stormwater runoff. The community strongly agreed that this is a key issue, ranking the management of pollution and sedimentation associated with creeks and stormwater outlets in order to protect the natural environment as the number one priority in the community survey (Appendix B).

The urbanisation of the catchment has resulted in a significant increase in hard surfaces as roads, buildings and the like have been constructed in place of vegetated areas. This results in reduced green open space areas for the absorption and filtration of stormwater, and as such a larger volume of stormwater reaches the estuary more quickly than would previously have been the case prior to development of the catchment. These higher velocity flows can cause erosion and sedimentation, although it is noted that some of the larger catchment tributaries are channelised, and therefore there is low potential for erosion from the lower catchment. Land use change has also resulted in a change in the amount and type of pollutants that become entrained in stormwater flows.

There are a large number of different sources of pollutants from urban areas in the Parramatta River estuary catchment, such as:

- Nutrients, e.g. from fertilisers and cleaning products;
- Heavy metals, e.g. from some industrial sites and roads;
- Organochlorine (such as DDT) and organophosphate pesticides;
- Polycyclic aromatic hydrocarbons (PAHs) associated with heavy industry/combustion;
- Phenols used in industrial chemical synthesis; and
- Sewage from sewer overflows.

Some of these pollutants are associated with point sources, that is, they enter the waterbody at a specific location. Types of point sources include sewer overflow points or specific sites (e.g. industrial sites along the foreshore). There are a number of historically contaminated sites located in the catchment and along the estuary foreshores that have potential to act as significant point sources of pollution (Figure 2.5). Illegal dumping and spills can also act as point sources of pollution.

Alternatively, pollutants may originate from diffuse sources and enter the estuary, which are generally more difficult to manage. Diffuse source water pollution is caused when pollutants from a range of dispersed land use activities contaminate waterways. Many activities that people engage in contribute to diffuse pollution, such as littering, fertilising gardens within the catchment or disposal of cleaning products down the drain. Another diffuse source of pollution is atmospheric fallout, whereby dust that contains pollutants (such as heavy metals) falls out of the air and onto the ground where it can be washed into the estuary. The prevalence of old residential areas in the catchment may also act as a diffuse source of pollution due to the use of materials such as lead paint that are harmful to the environment. Education of the community and industry to provide improved awareness of stormwater issues would go some way to addressing diffuse and point sources of pollution.

Fate and Management of Stormwater

As summarised in Table 2.1, there are a number of tributary creeks that drain to the Parramatta River estuary. These convey some of the stormwater flow; however, a significant portion of stormwater flows make their way into the estuary via the stormwater drainage network (Figure 2.6). The larger volumes of stormwater runoff that are generated from the urban catchment are managed via the provision of pipe networks, overland flow paths and open channels discharging to the estuary. Controls on the pollutant loadings take the form of Gross Pollutant Traps (GPTs) and other Stormwater Quality Improvement Devices (SQIDs) that provide pre-treatment of stormwater before it is discharged to the estuary (Figure 2.6 provides the location of many GPTs throughout the catchment, Figure 2.7 provides photographic examples of GPTs and SQIDs present). The type and amount of pollutants removed will depend upon the type of device used, and during very heavy rainfall events, flows may bypass the devices.

Figure 2.6 (after AECOM, 2010) shows the main sub-catchments and the extent of the stormwater drainage network within the study area. Stormwater and stormwater infrastructure can have significant impacts on the estuarine environment, such as:

- Scour around the stormwater outlet due to the discharge of high velocity flows (Figure 2.8);
- Erosion and sedimentation;
- Sedimentary contamination, where pollutants such as heavy metals are bound to sediment particles;
- Water contamination, especially as dissolved pollutants that remain in the water column (do not settle out) can be transported throughout the estuary by tidal flushing;
- Stimulation of primary productivity by increased nutrient loads;
- Blockages to the passage of fish and other aquatic organisms; and
- Smothering of aquatic macrophytes and fauna by sediments discharged from stormwater outlets.

This is a particular issue where stormwater impacts on sensitive estuarine habitats, such as seagrass areas as documented in AECOM (2010).

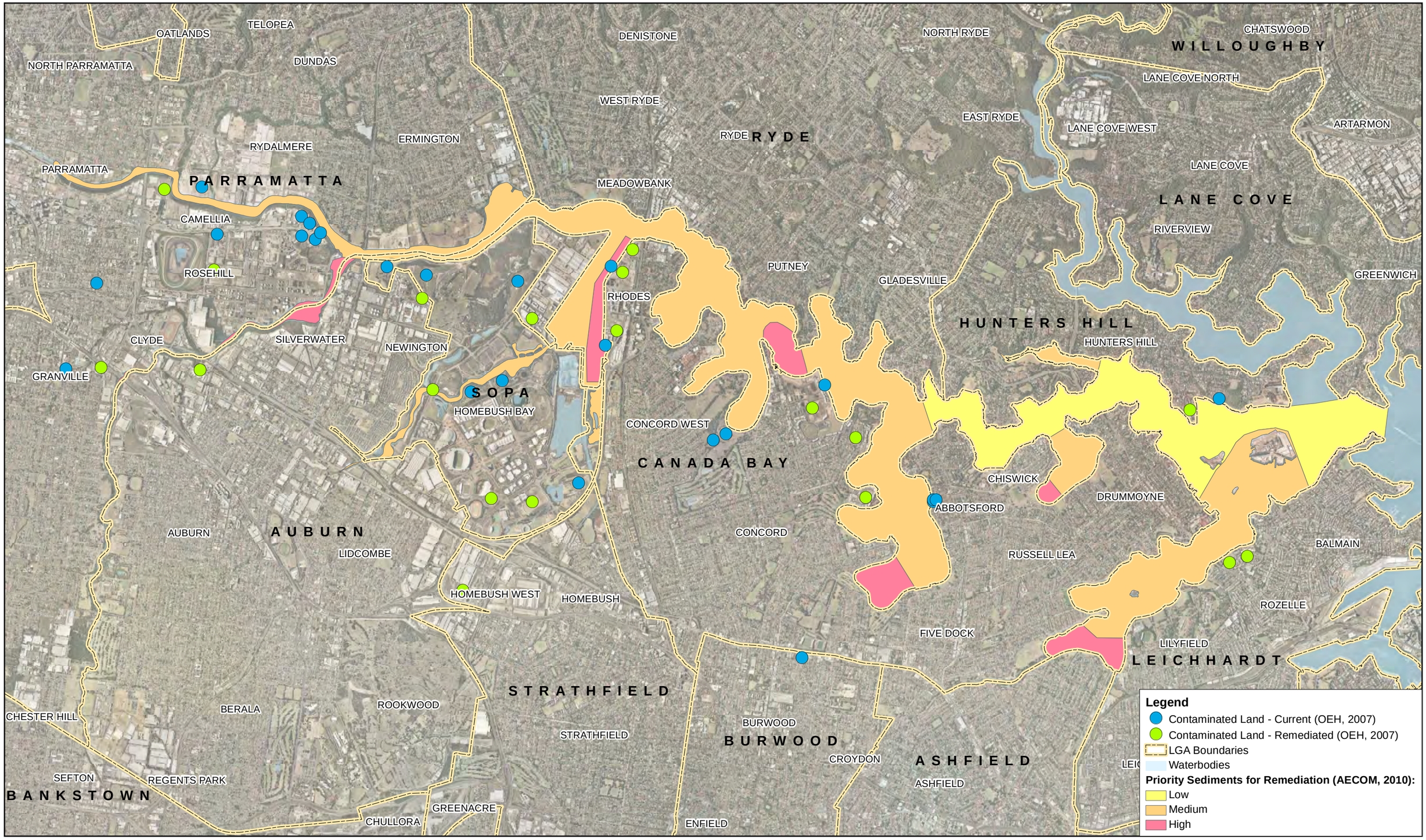
It is the responsibility of councils within the study area to manage gross pollutants, and there are a number of GPTs in place that attempt to capture material from stormwater (Figure 2.6, after AECOM, 2010). However, a large amount of gross pollutants still make their way into the estuary, bypassing GPTs, by blowing onto the waterway, or direct littering. RMS (Maritime) collects gross pollutants directly off the waterway, with a total of more than 3,500m^3 of rubbish collected from the Parramatta and Lane Cove Rivers every year.

In recent years WSUD has been actively implemented within the Parramatta River estuary catchment as a measure to control stormwater issues (see Figure 2.9 for some examples in the catchment). The PRCG recently implemented the Working to Sustain the Parramatta River Project over three years from 2007-2010 under grant funding of $1.9 million. The aim of the project was to implement widespread changes in the way that stormwater is managed within the Parramatta River estuary catchment, through a practical, hands-on approach using WSUD principles and new technology in the collection, treatment and reuse of stormwater runoff. The project involved seven of the eight foreshore local councils in the Parramatta River estuary catchment, involving on-ground demonstration projects and training opportunities for each council involved, such that they had the opportunity to build WSUD skills and capabilities and make changes to their internal policies and practices to manage stormwater (Cardno, 2010).

However, an insufficient number of devices, poor maintenance of these features due to lack of resources and their inconsistent spatial distribution across the catchment means significant volumes of stormwater carrying heavy pollutant loads still enter the estuary. Effective stormwater management can be difficult to achieve as it needs to be managed on a site by site basis, which is difficult to coordinate across such a large catchment area. Changes to internal policies and practices within councils in the catchment to incorporate WSUD into new developments (or redeveloped areas) will assist in coordinating the site by site approach across the catchment and should primarily be focused on pollutant hotspots.

One of the main challenges is that the stormwater network and associated stormwater treatment devices are owned and managed by a number of different stakeholders. Management of stormwater is typically the responsibility of local councils, although ownership of the physical infrastructure is more complicated. Some stormwater infrastructure is owned by Sydney Water, including sections of pipes, pits and some stormwater canals (e.g. Hawthorne and Dobroyd Canals). GPTs and other SQIDs are also typically managed by local councils, but may be placed on land that is subject to a different management regime. Therefore, any stormwater management works proposed within the study area need to confirm the owner and manager of the subject infrastructure, and require significant liaison and coordination between authorities. This is a particular issue where stormwater management is targeting a particular pollution hot spot, such as Iron Cove Bay, where the local drainage catchment includes land falling within five different LGAs and includes significant stormwater infrastructure that is owned and managed by Sydney Water (i.e. Hawthorne and Dobroyd Canals).

The HNCMA is currently leading another project, the *Sydney Harbour Catchment Water Quality Improvement Plan* that aims to develop a catchment scale approach for improving water quality in Sydney Harbour, including the Parramatta River estuary. It involves development of a Catchment Pollutant Export Model and Ecological Response Model to quantify pollutant sources from the catchment and identify the potential waterway response. This project will lead to the identification of additional opportunities for managing stormwater that will improve the quality of discharges to the Parramatta River estuary.



Note: Inaccuracies may be present in data provided by third parties. It is assumed that all GIS data provided by third party suppliers is sufficient and accurate for the purpose of this map.

1:44,000 Scale at A3

Metres

0 500 1000 1500 2000 2500

Areas of Contamination

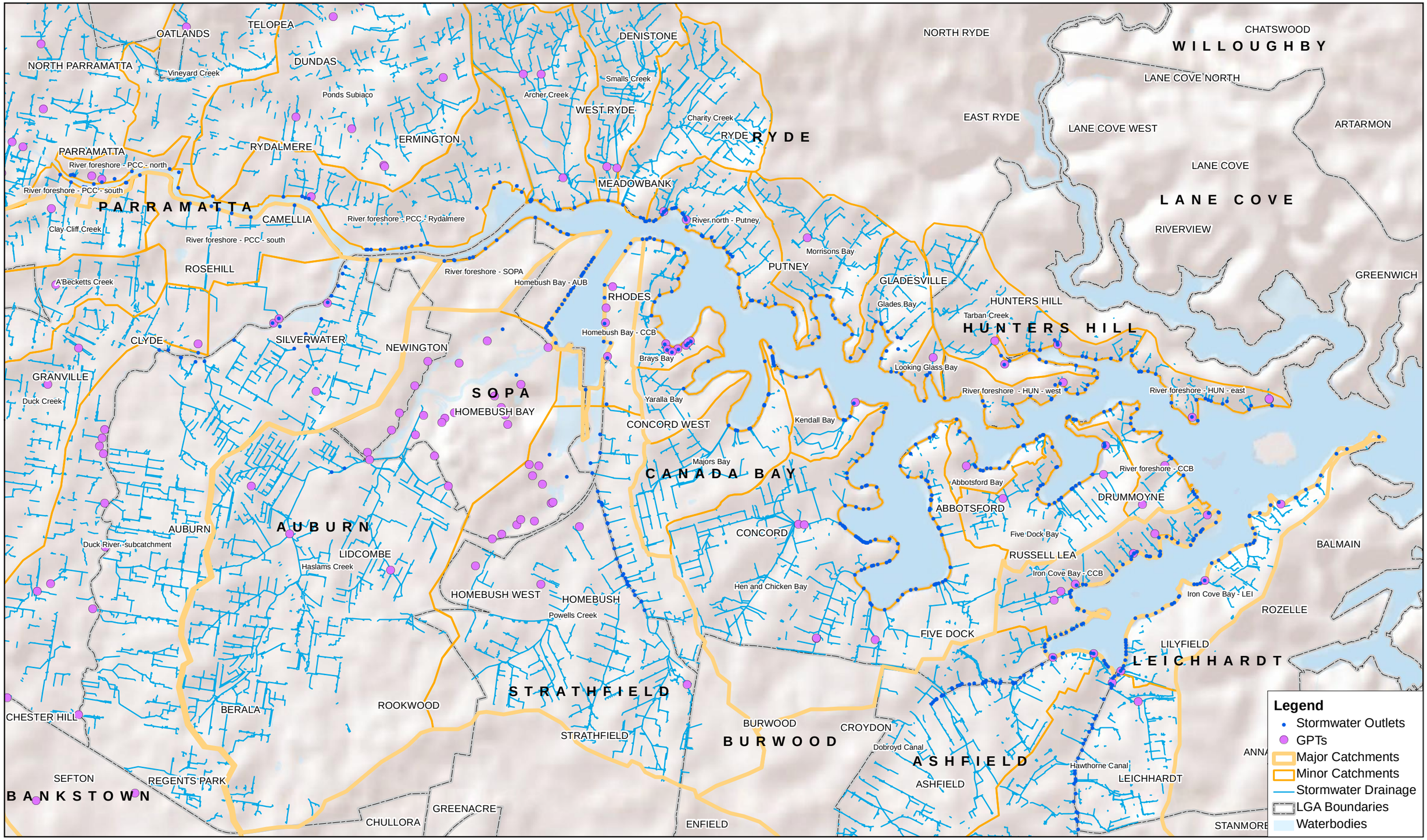
PARRAMATTA RIVER ESTUARY
COASTAL ZONE MANAGEMENT PLAN

FIGURE 2.5

N W E S

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (2812)
Date: 2013-05-31
Coordinate System: GDA 1994 MGA Zone 56
Project: LJ2929
Map: G2005_ContaminatedLand 03.mxd 02
Base Data Source: Land and Property Information NSW (LPI)
Imagery supplied by Google and associated third party suppliers.



Note: Inaccuracies may be present in data provided by third parties. It is assumed that all GIS data provided by third party suppliers is sufficient and accurate for the purpose of this map.

1:44,000 Scale at A3

Metres

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Stormwater Network and Water Quality Controls

PARRAMATTA RIVER ESTUARY
COASTAL ZONE MANAGEMENT PLAN

FIGURE 2.6

N W E S

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (2812)
Date: 2013-05-31
Coordinate System: GDA 1994 MGA Zone 56
Project: LJ2929
Map: G2006_StormwaterNetworkAndWaterQual 03.mxd 02
Base Data Source: Land and Property Information NSW (LPI)
Imagery supplied by Bing and associated third party suppliers.

a) Litter boom, Hawthorne Canal.

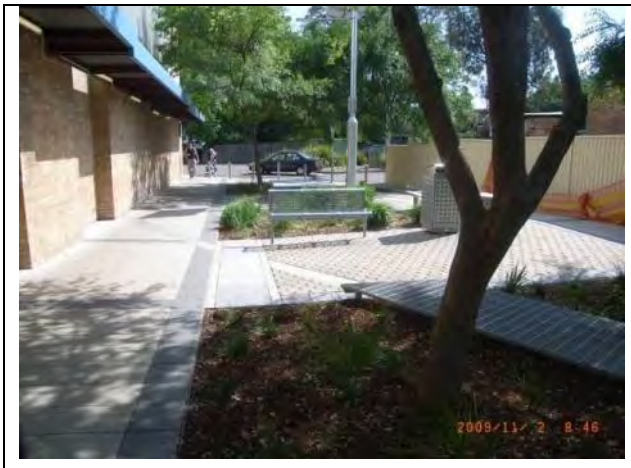
b) Continuous deflection separation device, Clarkes Point.

Figure 2.7: Example SQIDs / GPTs

a) Organic matter and rubbish captured in a GPT, Meadowbank Park.

b) Sedimentation, scour and organic matter around outlet, Kissing Point Bay (source: AECOM, 2010).

Figure 2.8: Examples of Stormwater Impacts on the Parramatta River Estuary



a) Pervious pavers and rain garden, Guildford Lane, Guildford.

b) Rain garden, Meadowbank Park.

Figure 2.9: Examples of Water Sensitive Urban Design (WSUD) Features

Sedimentation

Progressive infilling of estuaries with catchment-derived sediments is a natural process, due to ongoing erosion and sedimentation associated with rainfall events, as well as the mobilisation of larger quantities of sediments from either the banks or the estuary bed during flood events. However, much higher sediment loads are currently entering the Parramatta River estuary compared with pre-European times, exacerbated by urban development, causing significant sedimentation within the estuary. The *Data Compilation and Review Study* (Cardno, 2008) found that there was limited information on rates of sedimentation in the estuary. Investigation of this issue is also complicated by the history of dredging and reclamation works that have been conducted in the estuary. Historical accounts suggest very high rates of sedimentation during the early development of the catchment (e.g. McLoughlin, 2000), but more recent analysis of sediment cores suggests a rate of sedimentation of between 1.5-3.5mm/yr over the last 150-200 years, which is generally en par with other similar estuaries types of a less disturbed nature, in NSW (Geoscience Australia, 2012).

With respect to sedimentation, it is likely that some locations in the estuary were significantly affected by sedimentation due to catchment development or flooding in the past. In more recent years erosion and sedimentation is subject to tight control at development sites and a range of measures have been implemented to reduce sediment inputs (e.g. SQIDs). In addition, the construction of canals, weirs and similar features has probably reduced the amount of sediment that can reach the estuary from the lower catchment. However, erosion and sedimentation may continue to occur from the upper catchment or from natural creek lines. As previously discussed, sediments introduced to the waterway can impact negatively on local water quality and estuarine habitats (e.g. seagrass).

2.2 Physical and Water Quality Processes

2.2.1 Water and Sediments

Hydrodynamic Processes

Key hydrodynamic processes in the Parramatta River estuary include ocean tides (tidal flushing), freshwater inflows, and wind and wave driven flows. These hydrodynamic processes are also influenced by the system bathymetry (bed form of the estuary). The Parramatta River estuary is constantly open to the ocean and as such the water level within the estuary is primarily driven by the ocean water level and the tidal prism. During large catchment inflow events water levels within the estuary would temporarily be elevated (Cardno, 2008).

The tidal limit currently extends to the Charles Street Weir in Parramatta (Figure 2.10), which restricts further tidal influence upstream. Prior to construction of the weir the tidal limit extended further upstream to near Marsden Street at Parramatta. Alterations to and channelisation of previously natural creek lines in the catchment (Figure 2.11) have also changed the tidal limit in other locations. For example, in Duck River and Duck Creek, the tidal range has been limited by weirs at the Clyde Railway Bridge and Martha Street, respectively.

a) Looking upstream towards the weir.

b) Looking downstream from the weir.

Figure 2.10: Charles Street Weir

a) Powells Creek near Mason Park.

b) Tarban Creek, Riverglade Reserve.

Figure 2.11: Channelised Creek Lines

Tidal flushing is a vital mechanism for maintaining water quality within the estuary, particularly as the estuary receives high volumes of stormwater runoff which has potential to contain a range of pollutants. Extensive alteration of the estuary foreshore and its tributaries (reclamation, etc.) has limited tidal flushing in some areas, which can lead to significant impacts on local water quality and the ecological characteristics of the estuary. As the tidal waters of the estuary rise and fall, intertidal vegetation and fauna becomes alternately submerged and exposed with high and low tides. Maintenance of tidal inundation is an important factor in the function of these intertidal habitats and their associated flora and fauna.

Estuarine water levels may also become elevated beyond the typical tidal range due to factors such as king tides, storm surge and freshwater flood flows. At such times the elevated estuarine water levels can present a hazard to human users and assets along the foreshore. A number of foreshore parks are inundated during spring high tides, such as Kissing Point Park and Riverglade Reserve. Some coastal hazards will be exacerbated by climate change, particularly extreme estuarine water levels, which will result in an increase in risk for foreshore users and assets over time (see Section 2.5).

It should be noted that catchment flood hazard is managed under the Floodplain Management Process, and is not subject to management under this Plan. Foreshore inundation due to elevated estuarine water levels would be managed under the coastal and estuary management program.

Sedimentary Contamination

Sediment quality in and around the Parramatta River estuary has a major influence on the overall water quality and aquatic biodiversity. A review of the available literature presented in Cardno (2008) highlighted that the sediments of the Parramatta River estuary are significantly contaminated. Birch and Taylor (2004) provide a summary of the analytical methods and extent of contamination in the Parramatta River estuary, and have prioritised Duck River, the eastern shore of Homebush Bay, Fairmile Cove and the upper reaches of Hen and Chicken Bay, Five Dock Bay and Iron Cove Bay for remediation (Figure 2.5). Sources of these contaminants include reclaimed lands (which were commonly filled with contaminated or waste materials), contaminated lands, industrial activities, and traffic and roadways. Contaminants associated with sediments typically make their way to the estuary either attached to sedimentary particles or via groundwater leachates.

Benthic sediments of the Parramatta River estuary also contain stores of nutrients (Nitrogen, Phosphorous and Organic Carbon) which may be available for mobilisation to the water column, although the mechanisms that control the uptake and release of nutrients are not well understood (Birch *et al.,* 1999). These nutrients are likely derived from stormwater inputs from residential areas, green waste and leaf litter. Sewage overflows can also introduce significant amounts of nutrients into the estuary.

Hydrodynamic and biogeochemically mediated processes are important for regulating the mobilisation of these contaminants/nutrients between the sediments and the water column. Factors such as bioturbation, changes in water chemistry (e.g. pH and/or DO concentrations), uptake and release by organisms, and physical disturbance can contribute to the flux of pollutants between the water column and sediments.

Contaminants in the water column or surficial sediments can have a significant impact on estuarine biota. In their synthesis of the literature relating to possible biological effects of sedimentary contamination Birch and Taylor (2004) state that the spatial extent of the study area within which adverse effects on biota may be anticipated are highly variable dependent upon the contaminant in question, however, almost all of the Parramatta River estuary sediments exceed the ISQG-L (Interim Sediment Quality Guidelines – Low) values for at least one heavy metal, representing the level above which effects on biota may occur. There have been a number of ecotoxicology and bioaccumulation studies in the Parramatta River estuary (see Cardno, 2008), however, the full effects on estuarine ecology are not well understood. Dioxin levels in fish species are elevated to the point where a commercial fishing ban was placed on Sydney Harbour and its tributaries, including the Parramatta River in 2006, and it is prohibited to consume fish caught west of the Harbour Bridge.

Catchment management, particularly for stormwater and contaminated sites, are the primary mechanisms used to regulate the introduction of these pollutants into the estuary. There is, however, a legacy of contaminated sediments from historical activities that may only be addressed by remediation (Figure 2.12), capping or removal of the affected sediments from the estuary. These activities can in themselves have significant impacts on the environment and may increase the risk of mobilisation of contaminants to the water column. Contaminated sites, including those in the estuary, are regulated by the Environment Protection and Regulation Division of OEH.

a) Contaminated site rehabilitation, Rhodes (source: D. Wiecek, OEH, date unknown).

b) Remediation works, Homebush Bay (source: M. Campanelli, NSW Maritime, date unknown).

Figure 2.12: Remediation Works

Water Quality

In-estuary water quality processes are complex and involve biological, physical and chemical processes. These processes mediate the way water moves around the estuary, the exchange between estuarine waters and sediments, and estuarine waters and the atmosphere. In general, in-estuary processes are strongly influenced by climatic and hydrodynamic processes and can significantly impact on local water and sediment quality issues.

Poor water and sediment quality can impact on ecological processes and human recreation. Key water quality parameters of concern for management are:

- Dissolved oxygen (DO);
- pH;
- Turbidity or Total Suspended Solids (TSS);
- Nutrient concentrations (Nitrogen and Phosphorous);
- Algal concentrations; and
- Pathogens (faecal coliforms (FC) and Enterococci).

Heavy metals and other pollutants are discussed previously in relation to sedimentary contamination.

With regards to human recreation, poor water quality has impacted on recreational usage of the estuary for activities such as swimming and fishing. Based on data collected under OEH's Harbourwatch program, water quality in the estuary is often unsuitable for primary contact recreation due to high FC counts (Cardno, 2008). This is believed to result from FCs entering the estuary in stormwater runoff from the catchment or sewer overflows, which can result in water quality issues in certain bays where rates of tidal flushing are low. Overall there are only limited areas of the Parramatta River estuary that are considered suitable for primary and secondary contact recreational activities (Cardno, 2008).

A review of the available information on water quality in the Parramatta River estuary can be found in Cardno (2008) and WRL (2011). Water quality data collected by Sydney Water from the Parramatta River estuary includes monitoring of the following parameters:

- DO;
- pH;
- Nitrogen (TN and biological available forms: ammonia, nitrates/nitrites);
- Phosphorous (TP and biologically available Filterable Reactive Phosphorous);
- Chlorophyll a; and
- FC and Enterococci.

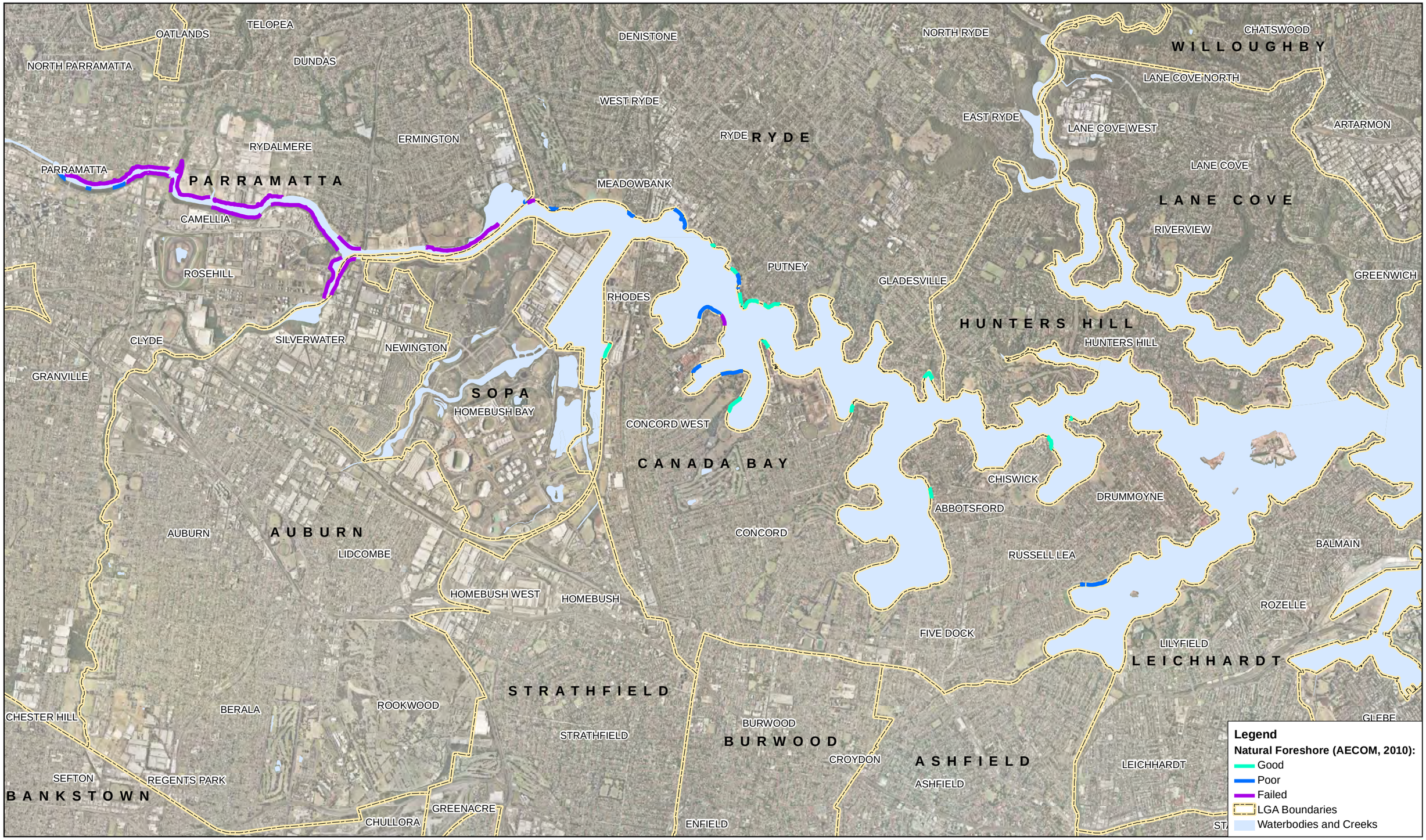
As discussed in WRL (2011), an analysis of the data indicates that average concentrations of these water quality parameters are in excess of the ANZECC (2000) aquatic ecosystem health guidelines for south-east Australian estuaries. The exception is for pH, for which the average values are in the acceptable range. Particular hotspots include Duck River and the Silverwater Bridge area. Based on a review of the data presented in WRL (2011), it is considered likely that these locations are impacted by sewer overflows, due to the high concentrations of nutrients, FC and Enterococci, along with the low DO values. The high levels of nutrients at all sampling sites indicate that stormwater quality is a key issue for estuary management and there is potential for algal blooms.

2.2.2 Bank Condition

According to AECOM (2010) the study area contains approximately 135km of foreshore, including all tidal areas of the estuary's tributaries and canals. AECOM (2010) inspected approximately 36km of seawalls and 21km of canals along the shoreline, with foreshore and marine facilities and structures also located along the foreshore for human usage and recreation. Approximately 45% of the foreshore is no longer natural (AECOM, 2010). The current condition of natural shoreline and seawalls reaches was also recently assessed by AECOM (2010) (see Figure 2.13).

Several of the submissions received during the public exhibition of the Draft CZMP considered that the findings of AECOM (2010) were either not entirely accurate for specific locations, or that conditions had changed since the field survey was conducted. This may be the case, noting that three or four years has passed since the AECOM (2010) survey was conducted, and conditions may have changed since that time.

The section of shoreline between Wharf Road in Ryde and Kissing Point was identified in a submission as experiencing erosion issues. This generally concurs with the findings of AECOM (2010), which found several sections of natural shoreline in poor condition through this area (Figure 2.13), and a number of sections of seawall in poor or failed condition. These issues are thought to be due to boat wake and the submission expressed concern about the RiverCat specifically, and more generally the exceedences of boat speed limits in that section of the river.



Note: Inaccuracies may be present in data provided by third parties. It is assumed that all GIS data provided by third party suppliers is sufficient and accurate for the purpose of this map.

1:44,000 Scale at A3

Metres

0 500 1000 1500 2000 2500

Foreshore Condition

PARRAMATTA RIVER ESTUARY
COASTAL ZONE MANAGEMENT PLAN

FIGURE 2.13

N W E S

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (2812)
Date: 2013-06-19
Coordinate System: GDA 1994 MGA Zone 56
Project: LJ2929
Map: G2013_ForeshoreCondition 03.mxd 02
Base Data Source: Land and Property Information NSW (LPI)
Imagery supplied by Google and associated third party suppliers.

Natural Shoreline

Natural foreshore areas within the study area (74km or 55% of the total shoreline surveyed by AECOM (2010)) typically comprise beaches, rock platforms, vegetated and non-vegetated natural shoreline (e.g. mudflats) (Figure 2.14). Natural shoreline occurs predominantly west of the Silverwater Bridge, where significant areas of erosion occur (Figure 2.13, after AECOM, 2010). East of Concord Road there are some isolated sections of natural shoreline in Meadowbank, Putney, Yaralla and Majors Bays, and Iron Cove Bay.

a) Hen and Chicken Bay, City of Canada Bay

b) Iron Cove Bay, City of Canada Bay.

Figure 2.14: Natural Shoreline

Areas of natural foreshore may be vulnerable to short duration or episodic erosion events (severe storms, vessel wash, flooding, high tides and informal public access), or longer term recession or accretion (caused by changes to mean sea level, sediment availability, and changes in river hydrodynamics due to foreshore and channel realignment and dredging). AECOM (2010) located 44 areas of foreshore erosion in the study area, which equates to approximately 13km of shoreline (18% of the total natural shoreline) (Figure 2.13).

Approximately 70% (9.2km) of natural shoreline exhibiting erosion is located upstream of Silverwater Bridge in the Auburn and Parramatta LGAs, with the most extensive foreshore erosion occurring in the Parramatta LGA (approximately 8.6km). This section of the river is characterised by a narrow channel, shallow water depths, banks vegetated with mangroves, and is subject to long period waves from RiverCat movements. RiverCat wash is thought to be the primary source of erosion in this area, causing bank slumping and loss of mangrove vegetation, and must be managed as a priority prior to expenditure of significant funds to rehabilitate these sections of natural foreshore and seawalls. This issue is apparent to the community, and whilst they support the provision of alternative forms of public transport, they have expressed a high level of concern about the impact the RiverCat service is having on the estuary (Appendix B). There were 28,000 individual trips to and from Parramatta, in 2011-12 financial year (Sydney Ferries, 2012), which will inevitably result in a level of damage to the natural foreshore. A key management issue for these upper areas of eroding natural shoreline is instigating modifications to or replacement of the RiverCat with another vessel that generates less wash to reduce further erosion caused by its wash, and subsequently to allocate funding towards remediation of these foreshore areas.

Foreshore erosion can have negative impacts on estuarine water quality as sediments are mobilised and washed into the waterway. This can release nutrients and contaminants into the water column and acts to destabilise foreshore vegetation, leaving it vulnerable to further erosion and subsidence. Nearby seagrass beds can also

become smothered by sedimentation as a result of foreshore erosion. The presence and maintenance of riparian and estuarine foreshore vegetation is very important for the stabilisation of soils to minimise erosion potential.

Seawalls

Seawalls have been constructed extensively along the study area's shoreline to protect foreshore assets, guard against inundation and support reclaimed parklands. The poor condition of many seawalls in the study area was raised by community members in the Community Information Session (Appendix B) as a prominent issue in their locality (particularly the City of Canada Bay). In the community survey the issue of protecting public and private property from coastal hazards was highly ranked by 75% of respondents, which suggests support for the maintenance of seawalls.

The most common functions of seawalls in the study area are the provision of support for other foreshore structures and reclaimed land. Failure of seawalls that structurally support other foreshore facilities (e.g. pathways, jetties) may result in replacement costs of more than just the seawall, and also impact on aesthetics and public amenity, access and safety. Where seawalls protect reclaimed land, seawall failure may result in the liberation of potentially contaminated landfill into the waterway. Furthermore, the potential for loss of land to the estuary may result where unconsolidated landfill is no longer supported (AECOM, 2010).

The majority of seawalls in the study area were inspected and assessed by AECOM as part of the *Estuary Processes Study* (2010), which covered approximately 36km of seawall and 21km of canals. The seawalls have a mixture of public and private ownership, in addition to which some of the canals are owned and maintained by Sydney Water. Types of seawalls in the study area typically include solid concrete, sandstone blocks and loose rubble revetments.

The City of Canada Bay has the greatest extent of seawalls, followed by Auburn and Parramatta LGAs (Table 2.1). A total of 84 seawall sections were either categorised as in 'poor' or 'failed' condition by AECOM (2010), requiring replacement or upgrading due to visual signs of degradation (e.g. cracking, landward subsidence, collapse), which equates to approximately 17.7km of seawalls in total or about half the seawalls in the study area. See Figures 2.15 and 2.16 for examples of failing and failed seawalls.

a) Iron Cove Bay, City of Canada Bay.

b) Waste materials used to stabilise the shoreline, Silverwater (source: M. Campanelli, date unknown).

Figure 2.15: Examples of Failing Seawalls

Failed seawall, Leichardt (source: D. Wiecek, OEH, date unknown).

Figure 2.16: Example of Failed Seawalls

The key constraints on upgrading/replacing certain seawalls include:

- Heritage status, if the seawall is heritage listed under local or state heritage registers, such as the historic seawall at Queens Wharf Reserve in the Parramatta LGA;
- Ongoing erosion potential, particularly in areas where the current RiverCat wash would continue to act to erode or undercut the new seawall; and
- Funding, replacing or upgrading seawall sections can be very costly.

These seawalls and other marine structures provide surfaces for colonisation by benthic organisms and have the potential to supplement natural habitat by supporting natural species assemblages. More recently there has been a move to reintroduce intertidal habitat to urbanised estuaries and the Estuary Processes Study lists the 20 highest priority seawall sections which are considered the most appropriate locations for habitat creation in the Parramatta River estuary (AECOM, 2010).

Wherever seawalls need to be rehabilitated or replaced in the study area this should be undertaken in accordance with the Environmentally Friendly Seawalls Guidelines (DECC and SMCMA, 2009). The guidelines advocate the incorporation of estuarine habitats into seawall and other marine support structures wherever possible, which will provide habitat and help support biodiversity and species abundance at the same time as providing structural support (see Figure 2.17 for examples). Incorporating estuarine habitat into these structures will provide improved ecological value through the upgrading of seawalls.

a) Seawall with low sill and saltmarsh, Ermington (source: D. Wiecek, OEH, date unknown).

c) Artificial intertidal habitat within a seawall, McMahons Point (source: http://cristinabump.wordpress.com/).

Figure 2.17: Examples of Environmentally Friendly Seawalls

2.3 Ecological Processes

Although much of the native habitat along the foreshores of the Parramatta River estuary has been removed for development purposes or has been subject to degradation, the estuary foreshore and its tributaries still support a range of native flora and fauna, including a number of threatened species that are important on a state and national level. The remaining natural vegetation in the catchment is generally associated with creek lines (Cardno, 2008).

The community recognises the need to maintain the ecological health of the estuary, with some of the key threatening processes, such as managing stormwater pollution, ranking very high in importance in the community survey (Appendix B).

Key ongoing management issues regarding ecology include:

- Habitat loss, degradation and fragmentation;
- Poor ecological connectivity along the foreshores;
- Introduced species;
- Stormwater impacts and sewer overflows;
- Changes to natural patterns of tidal inundation;
- Channelisation of natural waterways;
- Loss of foreshore vegetation via mowing or deliberate vandalism; and
- Damage from recreational activities (e.g. from swing moorings, dingy storage or trampling).

2.3.1 Estuarine Vegetation

Estuarine vegetation is vegetation found in the sub-tidal zone and intertidal zones of an estuary. Also of importance for ecological processes is riparian vegetation contiguous with these zones. A high proportion of

vegetation within the riparian zone or supra-tidal zone has tolerance to salinity from sea spray but not from tidal inundation. Estuarine vegetation communities present in the study area include seagrasses, saltmarsh and mangroves (Figure 2.18). Each one of these communities can tolerate a particular range of salinities and regular or permanent inundation. Riparian vegetation communities in the study area include Swamp-oak Floodplain Forest, Sydney Turpentine-ironbark Forest, Coastal Sandstone Gully Forest and Coastal Sandstone Ridgetop Woodland (AECOM, 2010). Swamp-oak Floodplain Forest and Sydney Turpentine-ironbark Forest are considered significant riparian vegetation as they are both Endangered Ecological Communities (EECs). Table 2.2 summarises available information on the condition and extent of significant riparian and estuarine vegetation in the study area.

Table 2.2: Extent and Condition of Significant Riparian and Estuarine Vegetation (After: AECOM, 2010)

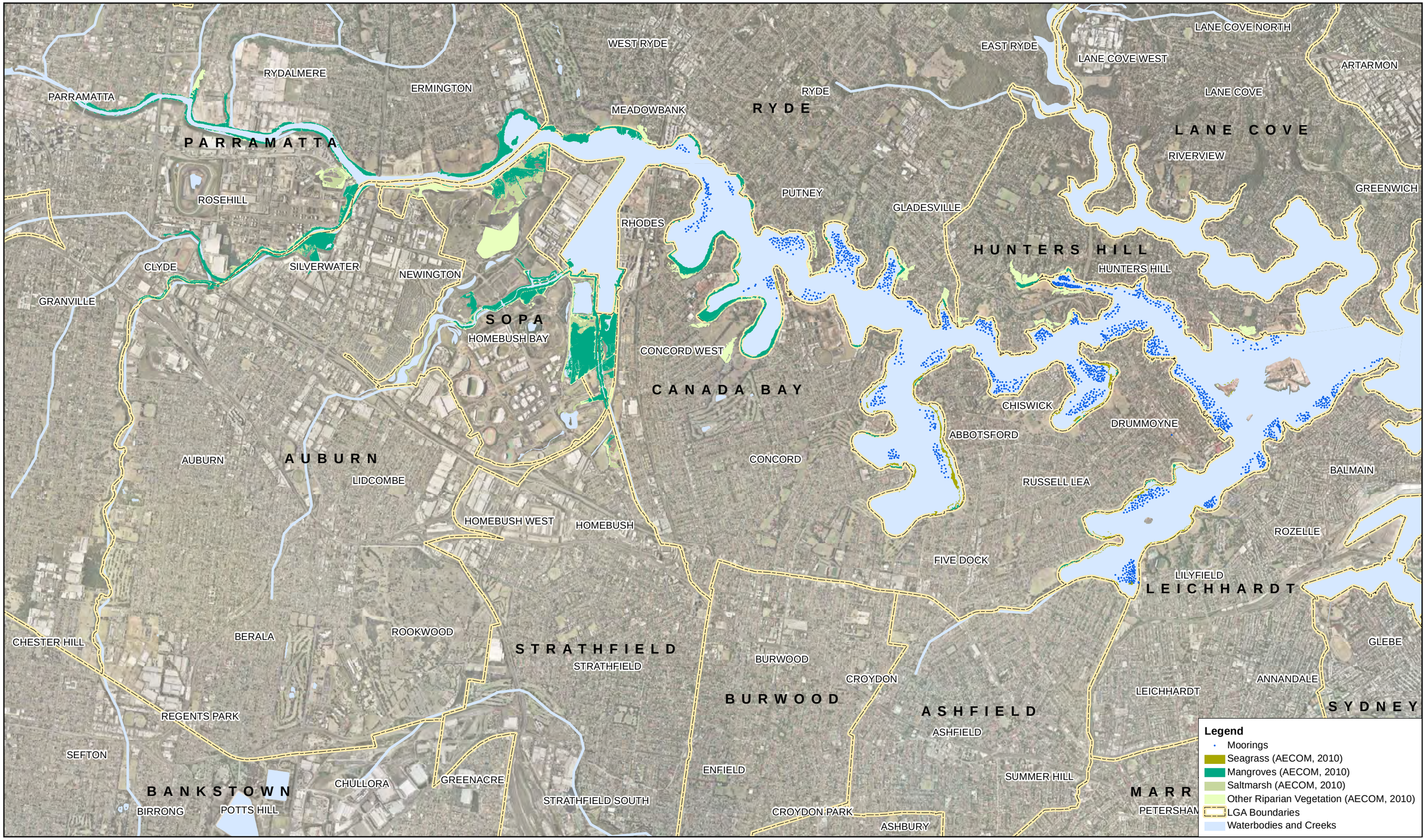
Estimated Total Extent	Extent	Threats	Trends in Extent & Condition
Seagrasses (Figure 2.19)			
10.3ha	Confirmed areas (based on field verification, AECOM, 2010) total 9.26ha, including: ▪ 8.58ha within waterways adjacent to the City of Canada Bay, ▪ 0.62ha adjacent to Leichhardt LGA, and ▪ 0.06ha adjacent to the City of Ryde.	Poor water quality, smothering by sediments, erosion of beds through changed water movements and damage from water-based recreational activities (i.e. boat propellers and moorings).	Seagrass cover has declined since mapping was first produced in the 1970's (West et al., 1985; West *et al.*, 2004; West and Williams, 2008).
Saltmarsh (EEC) (Figure 2.21)			
23ha	▪ The largest area is in Homebush Bay (18.6ha in Sydney Olympic Park); ▪ 1.32ha in Mason Park Wetlands in Strathfield LGA; ▪ 1.31ha in Duck River and Wentworth Point Homebush Bay; and ▪ 0.89ha in Parramatta LGA.	Inter-specific competition (e.g. with mangroves), poor water quality, changes to the hydrological regime, weed infestations and trampling at more locations.	There has been both a historical and a contemporary loss of saltmarsh habitat recorded in the study area.
Mangroves (Figure 2.22)			
149ha	▪ 63.8ha in Homebush Bay and its tributaries (within the Sydney Olympic Park); ▪ 40.0ha in the Parramatta LGA;	Illegal clearing by residents and for development activities, bank subsidence in locations affected by RiverCat wash, informal dinghy storage and trampling at some locations.	Mangroves are believed to be more widely distributed and abundant in comparison to pre-European settlement along the Parramatta River (McLoughlin, 2000). Mangroves previously would have

Estimated Total Extent	Extent	Threats	Trends in Extent & Condition
	▪ 19.8ha in the City of Canada Bay; ▪ 13.2ha in the Auburn LGA; and ▪ 10.2ha in the City of Ryde.		formed a ring around the river and bays. Sedimentation that has occurred since European settlement has assisted mangroves to grow on the sedimentation deltas. However, connectivity of mangrove habitats in the catchment still needs to be improved.
Riparian Vegetation			
Swamp-oak Floodplain Forest 30ha): ▪ 18.2ha in Sydney Olympic Park; ▪ 5.5ha in Parramatta LGA; and ▪ 4.1ha in the City of Canada Bay. Sydney Turpentine-Ironbark Forest (22 ha): ▪ 15.8ha in Sydney Olympic Park; ▪ 1.6ha in the City of Ryde; and ▪ 4.5ha in the City of Canada Bay.		Infestations of introduced species and trampling at some locations, which is exacerbated by their degraded and highly fragmented condition.	Historically these EECs have been cleared or reclaimed for industrial, residential or open space requirements. Subsequently remnant communities are highly fragmented and restricted to narrow bands of growth fringing the intertidal zone within the highly urbanised environment.

Seagrasses, saltmarshes and mangroves are highly productive and support a wide range of estuarine fauna, including fish, avifauna, and macroinvertebrates such as crabs and snails. Estuarine vegetation is used as a shelter, food source, breeding ground and/or nursery ground by many animals, including commercially and recreationally important species. Other ecosystem functions performed by estuarine vegetation may include:

- Buffering water quality;
- Stabilising sediments and buffering wave action;
- Sediment trapping;
- Nutrient cycling;
- Regulating hydrological flows;
- Acting as an indicator for environmental change; and
- Acting as sinks of organic carbon.

Non-vegetated habitats such as mudflats and rock platforms are also important habitats. It is likely that significant areas of these two habitats have been lost due to reclamation, dredging and the construction of seawalls.



Note: Inaccuracies may be present in data provided by third parties. It is assumed that all GIS data provided by third party suppliers is sufficient and accurate for the purpose of this map.

1:44,000 Scale at A3

Metres

0 500 1000 1500 2000 2500

Estuarine Vegetation

PARRAMATTA RIVER ESTUARY
COASTAL ZONE MANAGEMENT PLAN

FIGURE 2.18

N W E S

Cardno

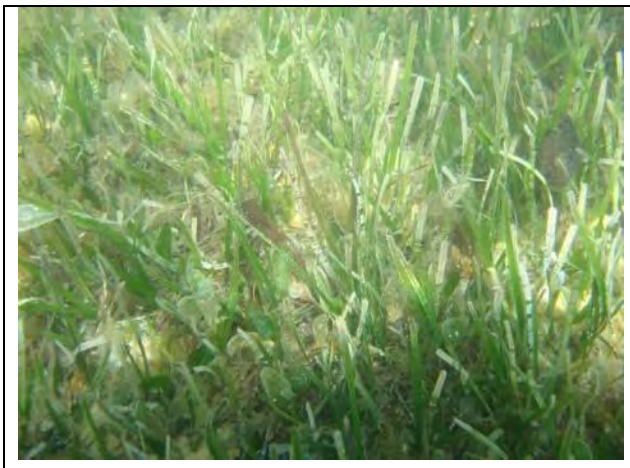
Map Produced by Cardno NSW/ACT Pty Ltd (2812)
Date: 2013-06-05
Coordinate System: GDA 1994 MGA Zone 56
Project: LJ2929
Map: G2018_EstuarineVeg 03.mxd
Base Data Source: Land and Property Information NSW (LPI)
Imagery supplied by Bing and associated third party suppliers.

Water and sediment quality can also have significant impacts on estuarine vegetation. Poor water and sediment quality can impact saltmarsh and mangrove communities mainly through growth inhibition. High velocity stormwater entering the estuary also erodes these areas of vegetation, with a significant amount of fine material being lost from between Mangrove pneumatophores due to stormwater scour and also vessel wash.

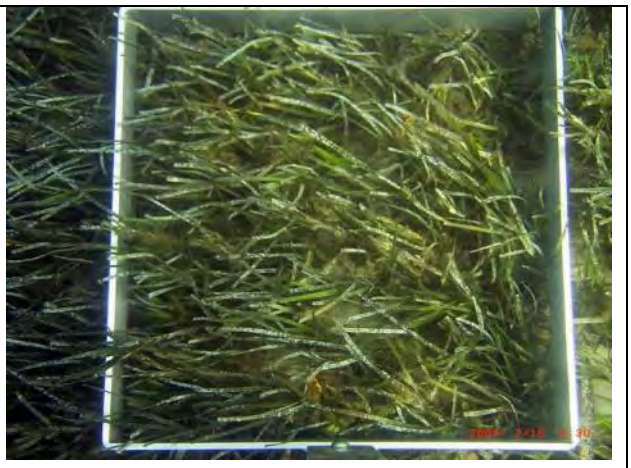
Seagrass is the estuarine community most acutely affected by poor water quality. Seagrass beds in the study area are particularly affected by excessive quantities of gross pollutants (organic materials) smothering seagrass beds and reducing light penetration, which inhibits seagrass growth. Excessive nutrients and sediments leading to algal blooms and high turbidity levels in the water column can also reduce light penetration to seagrass beds, as does shading from jetties and wharves. Other impacts on seagrass beds include damage by boat propellers, anchors, moorings (see Figure 2.20) and launching of watercraft. These issues are particularly evident in the southern end of embayments, including Iron Cove Bay, Hen and Chicken Bay and Five Dock Bay (AECOM, 2010).

Saltmarsh and mangroves in the study area are commonly impacted by trampling as people create informal access routes along the foreshore, and in some locations store their non-motorised watercraft (e.g. dinghies) informally on vegetated areas. Saltmarsh is often also impacted by mowing of residential and public open space areas, when saltmarsh itself is mowed (either purposefully or inadvertently).

Illegal clearing of mangroves is a particular issue where they front private residences, as many councils have noted residents deliberately lop off tree limbs or poison the mangroves where such growth is impinging on their views of the waterway (Figure 2.23). Stormwater impacts, including pollution and changes to the hydrological regime (both freshwater inflows and tidal inundation) have also resulted in degradation and loss of these communities.



a) Seagrass bed of Zostera and Halophila.



b) Healthy, dense bed of Zostera.

Figure 2.19: Estuarine Vegetation - Seagrass

Scouring by swing mooring.

Figure 2.20: Observed Impacts on Seagrass

a) Saltmarsh (low groundcover), Iron Cove Bay.

b) *Sarcocornia quinqueflora*.

Figure 2.21: Estuarine Vegetation - Saltmarsh

a) Mangroves lining the upper Parramatta River estuary.

b) Mangrove forest, Bicentennial Park.

Figure 2.22: Estuarine Vegetation – Mangroves

a) Mangroves subsidence due to bank erosion (source: D. Wiecek, OEH).

b) Evidence of illegal mangrove clearing, Five Dock Bay (source: D. Wiecek, OEH).

Figure 2.23: Observed Impacts on Intertidal Estuarine Vegetation

2.3.2 Conservation Significant Communities, Flora and Fauna

Seagrasses, saltmarsh, mangroves and macroalgae are protected under the *Fisheries Management Act 1994*. Coastal Saltmarsh, Swamp-oak Floodplain Forest and Sydney Turpentine-ironbark Forest which is also present in the study area, are listed as EECs under the *Threatened Species Conservation Act 1995*. Sydney Turpentine-ironbark Forest is one of the communities that form the nationally significant Turpentine-ironbark Forest, which is listed as a critically endangered ecological community under the EPBC Act. Hence the ecological communities present in the study are significant on both a local, NSW state-wide and national scale as indicated by the legislation.

Habitat restoration and/or enhancement works will be a valuable exercise for enhancing existing vegetation and re-establishing areas of habitat that have been lost (Figure 2.24). This is a particular challenge for diminished intertidal communities, such as rock platforms and mudflats and channelised drainage lines. Consideration should be given to naturalising these concreted drainage lines and shorelines when the structures come to the end of their design life, to improve the ecological value of the estuary and extend biodiversity corridors. Protecting areas consisting of EECs and threatened flora and fauna species should be considered a priority. Management actions should also focus on creating biodiversity corridors throughout the catchment and along foreshore areas, to connect existing fragmented areas of vegetation.

The study area contains nine nationally significant wetlands which together form an extensive wetland system bordering the Parramatta River estuary, including Brays Bay, Ermington Bay, Haslams Creek, Homebush Bay, Lower Duck River, Majors Bay, Mason Park, Meadowbank Park Foreshore and Yaralla Bay Wetlands and Silverwater Saltmarsh. In particular, the mangroves lining the Parramatta River represent a significant proportion of those remaining in the Sydney region and those in the Lower Duck River represent the oldest known stand of mangroves in NSW. The Silverwater Saltmarsh complex incorporates highly significant saltmarsh species that do not commonly occur in the Sydney region. This saltmarsh complex is in excellent health and comprises a small intact ecosystem that is representative of pre-European vegetation that can no longer be found in the study area. The Bicentennial Park and Newington Nature Reserve Wetland are also listed as nationally significant wetland sites, and support a wide range of fauna.

a) Mangrove planting, Homebush Bay (source: D. Wiecek, OEH).

b) Riparian revegetation behind a seawall (source: D. Wiecek, OEH).

Figure 2.24: Examples of Habitat Restoration Works

The Parramatta River estuary provides habitat to a variety of shorebirds, waterbirds, wader birds and forest birds. The estuary is on the route of the East Asian-Australasian Flyway which is used by shorebirds to move between Australia / New Zealand, East Asia and the Arctic region of the northern hemisphere. Key habitat areas of mangroves and saltmarsh in the estuary such as Sydney Olympic Parklands and the Mason Park Wetlands provide important and vital stopover areas for these migratory birds to rest and feed. Australia is party to international conventions and agreements to protect many migratory species, such as the China-Australia Migratory Bird Agreement (CAMBA), Japan-Australia Migratory Bird Agreement (JAMBA) and Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA).

a) Ibis (*Threskiornis molucca*) in the mangroves in Bicentennial Park.

b) Pied Stilt (*Himantopus himantopus*), Homebush (source: D. Wiecek, OEH).

Figure 2.25: Wading Birds

2.3.3 Impacts on Estuarine Ecology

The study area also contains locally and regionally significant fauna species (Figure 2.25). For example, a number of regionally rare bird species, including the White-fronted Chat, Red-rumped Parrot, Osprey, White-bellied Sea Eagle, Marsh Harrier and Peregrine Falcon have been found in Homebush Bay. Human-induced threats to avifauna in the study area include significant loss of habitat through vegetation removal and predation by domestic animals, with off-leash dog walking being an issue in certain areas of the foreshore. It is understood that there are also concerns about bioaccumulation of toxins affecting the health of birds living around the estuary.

In 1972, a survey failed to catch a single fish upstream of Silverwater Bridge (Paxton and Collett, 1975). However, more recent data would suggest that fish populations have been making a recovery in recent decades due to improvements in water quality associated with improved catchment management practices, better regulation of industry and a decrease in the intensity of industrial activity along the estuary foreshores. A review of the available literature on fish populations in the estuary presented in Cardno (2008) suggests that the estuary currently supports a diverse fish fauna, despite evidence of poor water quality and pollution impacting on fish.

Nonetheless, the bioaccumulation of toxins from contaminated sediments remains an issue, and the true impact on estuarine ecology is unknown. Recreational fishing is still allowed in the Parramatta River estuary, although limited consumption of fish caught in the estuary is recommended due to elevated dioxin levels in fish (Figure 2.26). In addition, weirs and other structures that change flow regimes or prohibit fish passage have also impacted fish populations.

a) Recreational fishing dietary advice signage in the catchment (source: P. Hackney, PCC).

b) Signage indicating total fishing ban in Duck Creek (source: P. Hackney, PCC).

Figure 2.26: Recreational Fishing Restrictions

Estuarine ecology in the study area has been seriously degraded and fragmented over time due to extensive clearing of foreshore and catchment vegetation for residential, industrial, commercial and open space

development purposes since European settlement. This has resulted in a loss of biodiversity and fragmentation of the remaining habitat, leaving the ecology vulnerable to natural and human induced stressors, such as infestations by introduced species, inter-specific competition and climate change. Nevertheless, biodiversity in Sydney, the Parramatta River estuary catchment included, is still high compared to many other parts of Australia and the world and hence biodiversity conservation is a key management issue. Estuarine hydrodynamic processes, in particular tidal inundation, are vital to the maintenance and functioning of estuarine ecosystems. Alteration to natural flow regimes of waterways, and their floodplains and wetlands, is recognised as a major factor contributing to the loss of biological diversity and ecological function in aquatic ecosystems.

A significant long term threat to the ecology of the study area is climate change and SLR in particular. As mean sea levels rise, this will reduce light penetration to seagrass beds in deeper areas of the estuary, potentially resulting in their loss, although it is noted that there may also be gains elsewhere. Intertidal vegetation such as mangroves and saltmarsh may have potential to migrate landward to higher elevations, provided infrastructure and other land uses are not currently occupying suitable areas for colonisation. In order to facilitate landward migration in priority areas management interventions may be required, such as vegetation management and/or the relocation/decommissioning of infrastructure. AECOM (2010) identified priority areas where vegetation enhancement efforts should be focused by quantifying the potential for landward migration of intertidal vegetation with SLR in the catchment as follows:

- An estimated 65% of existing saltmarsh communities have some potential for landward migration, of which a large proportion is located within Newington Nature Reserve Wetland (Sydney Olympic Park); and
- An estimated 22% of existing mangrove communities have some potential for landward migration, based on the presence of obvious impediments to landward migration for the remaining 78%. Of further concern, is that areas in which mangroves have some potential to migrate landwards are presently occupied by EECs such as saltmarsh and Swamp-oak Floodplain Forest, thereby forcing competition between and loss within these communities.

2.4 Human Usage and Recreation

2.4.1 Recreation

Public access along the foreshore, via cycle paths and walking tracks, was identified by the community as being the second most important issue in the community survey undertaken in the preparation of this CZMP (Appendix B). The availability of recreational facilities and infrastructure, including BBQ areas, seating, public toilets, jetties and boat ramps along the foreshore was also raised by the community as a high priority management issue, with 64% of the community surveyed ranking this of high importance. A key issue for the estuary is the inconsistency of accessibility to the foreshore as well as the availability and suitability of recreational facilities throughout the catchment.

As the study area has developed and moved away from its industrial past, the foreshore has been increasingly reclaimed for recreational uses with considerable investment at both the state and local government levels. However, a large proportion of the foreshore is still in the hands of industry and individuals as private residences. As part of the Parramatta River Foreshores Improvement Program an audit of the estuary foreshore was

undertaken. This audit reported that approximately 46.6km of foreshore in the study area is publicly owned, while 24.9km is privately owned, not including tidal tributaries (Cardno, 2008).

Over the last decade significant works have been undertaken around the Parramatta River estuary foreshore to improve public access to the waterway, as part of DIPNR's (2003) *Sharing Sydney Harbour Regional Action Plan*. Significant funding for the Parramatta River estuary was also provided in 2007 under the *Sharing Sydney Harbour Access Program*, a NSW government initiative to improve public access to and enhance the recreational enjoyment of Sydney Harbour and its tributaries. Many projects across the eight foreshore LGAs have been undertaken to date under this program, providing access and recreational improvements (Cardno, 2008). In 2007 the NSW Government also announced the provision of additional funding to extend its support for public walking and cycling tracks, and recreational boating facilities around Sydney Harbour to at least 2013 (Cardno, 2008). However, certain cycleway/walkway facilities, such as the Parramatta Valley Cycleway Shared Path, are discontinuous in sections and still require further work to complete and improve connectivity throughout the study area and across LGAs (Figure 2.27).

a) Shared cycleway/walkway in the catchment.

b) Dedicated bike lanes along the estuary foreshore.

Figure 2.27: Examples of Public Access

The open space areas and recreational infrastructure are mapped in Figure 2.31. There are six major foreshore parks in the study area that primarily provide for passive recreation opportunities:

- Sydney Olympic Park (Auburn LGA);
- George Kendall Riverside Park (Parramatta LGA);
- Meadowbank Park (City of Ryde);
- Kissing Point Park (City of Ryde);
- Putney Park (City of Ryde); and
- Cabarita Park (City of Canada Bay).

These major foreshore parks and other reserves have significant recreational value as they service the passive recreational needs of the approximately 561,200 people living in the foreshore LGAs (according to ABS statistics from the 2011 census), as well as visitors to the area (Cardno, 2008). The largest areas of foreshore parks and reserves are found in Auburn LGA, followed by the Cities of Ryde and Canada Bay. Foreshore recreational activities include walking, jogging, fishing, family gatherings and picnics undertaken in foreshore parks.

A number of capital works projects have been funded under the Parramatta River Foreshores Improvement and Metropolitan Greenspace Programs, including foreshore parks, cycle and pedestrian paths and foreshore access points; however, further works are still required in order to provide adequate facilities to service demand, particularly in foreshore sites that are proposed for medium to high density residential development.

The Parramatta River estuary is an important recreational waterway, particularly for the western suburbs of Sydney. Water-based recreational activities in designated areas of the estuary include power boating, sailing, sail-boarding and rowing, as evidenced by a number of active, long-term sailing and yachting clubs in the study area. The estuary has a long historical association with sailing and in particular with rowing, as evidenced by the large number of boat sheds and club houses along the river. Several local schools and universities also row along the Parramatta River for sport. In September 2007 the Parramatta River estuary hosted the World Dragon Boat Racing Championships (Cardno, 2008). RMS (Maritime) produced a boating guide that identifies rules and regulations (e.g. speed zones) and shows the location of boating infrastructure.

Many planning policies, such as the *Sydney Regional Environment Plan (Sydney Harbour Catchment) 2005* are in place that cover the Parramatta River estuary and aim to establish a balance between maintaining a healthy and ecologically sustainable estuary, and promoting recreational access to the foreshore and waterways.

The Parramatta River estuary is used as a public transport link by ferries and the RiverCat (Figure 2.28), linking Sydney and Parramatta. Many commercial businesses, such as marinas, restaurants, cafes, slipway services, and activities are also located along the foreshore, servicing the local and wider community and also visitors to the area i.e. the tourism industry. Issues caused by the RiverCat's wash have been discussed previously in Section 2.2.2.

a) RiverCat in the estuary, Parramatta.

b) RiverCat in the estuary, Parramatta.

Figure 2.28: RiverCat

Associated with the development of the estuary foreshore has been the construction of waterway recreational assets along the foreshore, including boat ramps, wharves, jetties, landings, informal and formal dinghy storage areas and temporary mooring facilities. There may also be opportunities to improve connectivity between the waterway and the foreshore, and to better service the boating community. However, there are concerns amongst the community that this would lead to overcrowding of the waterway and increased conflicts between users (Appendix B). There is also potential for impacts on estuarine ecology and water quality if not properly managed. Some of the ongoing impacts of human activities have been identified in previous sections (Sections 2.1, 2.2 and 2.3).

One of the most prominent issues associated with waterway recreation facilities is the lack of formal dinghy storage facilities. Dinghies are scattered along the foreshore (Figure 2.29), leaning against walls, rock shelves and trees and such informal access and informal storage at these locations is resulting in the degradation of foreshore vegetation, primarily by trampling (AECOM, 2010).

a) Private jetties accessing the estuary waterway.

b) Informal dinghy storage along the estuary foreshores.

Figure 2.29: Boating Infrastructure

There may be opportunities to improve recreational amenity/facilities through the process of re-development of foreshore lands. However, in some cases it may be more appropriate to de-commission infrastructure and/or relocate it to a more suitable location where impacts on the environment can be minimised.

Waterway recreational facilities are prone to deterioration over time due to the physical and chemical stresses they are under, including exposure to saline waters, waves and changes in water levels (e.g. for structures with a connection to the foreshore). A total of 84 facilities were inspected by ACEOM (2010) and their locations are mapped in Figure 2.31. The highest concentration was in the City of Canada Bay (28), followed by the City of Ryde (17) and Hunters Hill LGA (16). The condition assessment found that there were a number of facilities in poor condition or subject to failure (AECOM, 2010), which represents a risk to public safety and the environment (Figure 2.30).

Climate change and the projected increases in estuarine water levels are also of concern for management of recreation and public access across the estuary. Foreshore assets, particularly those located on the waterway but with a fixed connection to the foreshore, may require modification and/or relocation with rising sea levels, as some locations are already subject to inundation during king tides.

Management actions proposed to address the recreational needs of the estuary users must aim to achieve a harmony between the competing demands of meeting the community's needs for recreational access and amenity, and providing for conservation and enhancement of estuarine ecosystems. Achieving this balance was raised as one of the most important issues for the Parramatta River estuary in the community survey undertaken for this Study (Appendix B).

a) Failing pylons in the estuary.

b) Failing wall along the estuary foreshores (source: P. Hackney, PCC).

Figure 2.30: Failing Foreshore Infrastructure

2.4.2 Cultural Heritage

With regards to Non-Aboriginal cultural heritage, the Parramatta River estuary is considered to be culturally the most significant waterway in Sydney and has been critical in the development of Sydney from the first settlement. The River acted as a crucial communication and transport link between Sydney and Parramatta. Initially settlement followed the river and then spread into the surrounding districts. Hence, the Parramatta River estuary foreshores contain some of Australia's earliest Non-Aboriginal historical monuments and features (Cardno, 2008).

There are a significant number of commonwealth, state and local heritage listed items located within the eight foreshore LGAs, and there is also a sizeable volume of literature relating to the heritage and cultural values of the Parramatta River estuary and its foreshores (Cardno, 2008).

Cockatoo Island represents a highly significant heritage site located within the Lower Parramatta River estuary, relating to its maritime heritage and history, and it also contributes to the visual character of the estuary. Both Cockatoo Island itself and a number of features located on the Island are protected under the EPBC Act as Commonwealth Heritage Listed sites. Cockatoo Island also has enormous cultural heritage significance as a shipbuilding facility, operating for 134 years until 1991 as the nation's primary shipbuilding facility (Cardno, 2008).

The Parramatta River estuary lies within some of the most developed and urbanised areas of Australia. As such, the Aboriginal cultural heritage of the area has been under severe pressure since the settlement and subsequent development of the area by Non-Aboriginals. Aboriginal groups in the study area today include the Darug Tribal Aboriginal Corporation and the Deerubbin LALC (Cardno, 2008).

A number of Aboriginal heritage sites and places of significance are located within the estuary and foreshore areas, which highlights both the size of the study area and also the importance of the study area for Aboriginal people. It is also recognised that there is significant potential for previously unrecorded Aboriginal heritage items to occur in the study area.

One of the most culturally significant sites in the study area is the Parklands at Sydney Olympic Park, which covers 432ha. The Parklands contain stands of remnant woodlands, rare saltmarshes and mangroves alongside

constructed places of historical significance. The Parklands are also a place of Aboriginal significance and are of historic naval importance.

The community survey results indicated that cultural and heritage values associated with the estuary and its foreshores were ranked as being of high importance to 64% of respondents and of medium importance to 33% of respondents (Appendix B). Hence, the community largely recognises the need to protect and promote the cultural values and significance associated with the Parramatta River estuary.

Note: Inaccuracies may be present in data provided by third parties. It is assumed that all GIS data provided by third party suppliers is sufficient and accurate for the purpose of this map.

1:40,000 Scale at A3

Metres

0 500 1000 1500 2000 2500

Recreational Assets

PARRAMATTA RIVER ESTUARY
COASTAL ZONE MANAGEMENT PLAN

FIGURE 2.31

N W E S

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (2812)
Date: 2013-06-19
Coordinate System: GDA 1994 MGA Zone 56
Project: LJ2929
Map: G2031_RecreationAreas 03.mxd 02
Base Data Source: Land and Property Information NSW (LPI)

2.5 Climate Change

2.5.1 Climate Change Science and Policy

It is generally accepted amongst the scientific community that global warming of the Earth's atmosphere will lead to a rise in mean sea level due to the Greenhouse effect. The most recent climate change projections indicate increased temperature and evaporation rates for coastal NSW, along with changes to seasonal rainfall patterns, runoff and therefore subsequent impacts on bushfire regimes, biodiversity, soils, erosion and flooding (DoP, 2010). It is predicted that current weather patterns will be altered; leading to more frequent extreme weather events (i.e. floods, droughts, tropical cyclones, etc.). SLR projections of 0.4 m by 2050 and 0.9 m by 2100 were previously adopted by the NSW Government for planning purposes (DECCW, 2009), and although the formal endorsement by the government has now been repealed, it is noted that these values are still considered to represent the best available science (CSE, 2012) and have been adopted in this study.

Coastal communities and environments are particularly vulnerable to climate change due to the potential for permanent coastal inundation and increasing coastal hazards associated with changing weather patterns and extreme weather events. Costal hazards include risks from coastal erosion, tidal inundation and coastal flooding, including the impacts of SLR.

Water level analyses have been conducted on tide gauge water level data collected over a 122 year period at Fort Denison, Sydney Harbour (You *et al*., 2009). An analysis of the full data set from 1886 to 2007 identified a rate of rise in water levels in Sydney Harbour of 0.63±1.4 mm/yr. However, where the analysis was limited to the more reliable data collected from 1950 to 2007, the rate of rise was determined as 0.58±0.38 mm/yr (You *et al*., 2009).

2.5.2 Potential Impacts of Climate Change on Estuary Processes

A brief overview of the key potential implications of climate change on estuary processes is outlined below, as identified by Cardno (2008) and AECOM (2010):

- *Increased water levels:* SLR would lead to higher estuarine water levels and may also result in changes to the tidal prism. This would have the effect of increasing tidal penetration of tributary creeks and canals, provided that the tidal flows are not impeded by physical infrastructure;
- *More frequent or permanent inundation of foreshore areas:* Some facilities and foreshore areas along the Parramatta River estuary may be inundated more frequently or permanently as the elevated water level events of today will become more common in the future. Seawalls have been used extensively in the study area to support the foreshore and reclaimed lands; however, where these seawalls are not high enough to combat rising sea levels, they may be overtopped and the assets they protect may become inundated. Frequent overtopping or permanent inundation would compromise the function of these seawalls or other affected infrastructure, potentially leading to economic damage of public and private assets and further water quality issues, such as leachate from contaminated reclaimed lands may be released into the estuary;
- *Changes to rainfall patterns:* Extreme weather events, in particular more frequent flood and drought periods, may impact on catchment processes and there is potential for a wider range of water quality

conditions to occur in the estuary. Changes in rainfall patterns could change the water balance of the estuary tributaries;

- *Erosion of unconsolidated foreshores:* Increased water levels could contribute to the erosion of unconsolidated shorelines. Where there is sufficient fetch, changes in wind patterns could result in increased erosion of affected shorelines by wind waves;
- *Impacts on estuarine ecology:* The impacts of climate change on estuarine ecology will be complex and are difficult to predict. Changes to the intertidal zone due to SLR will significantly limit the present extent of intertidal estuarine vegetation in many locations, as potential areas for landward migration are limited by existing infrastructure. For example, AECOM (2010) estimated that 78% of existing mangrove communities will potentially be impacted upon by SLR based on impediments to landward migration. This will also impact on other intertidal habitats, such as mudflats and rock platforms, which have already been significantly reduced in extent. A rise in mean sea level would also result in a gradual shift in the locations where seagrasses could survive.

2.5.3 Coastal Hazard Assessment

A Coastal Hazard Assessment (CHA) was recently undertaken by Cardno to assess the potential impacts of elevated estuarine water levels in both the present day and under SLR conditions in the Parramatta River. The assessment was conducted in accordance with the *Coastal Risk Management Guide* (DECCW, 2010d) and adopting SLR projections of 0.4m by 2050 and 0.9m by 2100. The CHA report is provided in Appendix C.

The CHA provides a series of maps to depict the projected impacts of SLR on ocean still water levels in the estuary, for higher water level events due to storm surge (1-year and 100-years ARI). Three scenarios were investigated (existing, 0.4m SLR and 0.9m SLR), and the results indicate that, as anticipated, the effects of inundation on the estuary foreshores will increase under SLR conditions. Based on the mapping, several key areas have been identified as being subject to risk from coastal hazards in the future and a discussion of these areas has been provided for each scenario (Appendix C). A range of land uses are likely to be affected including residential, commercial/industrial, road infrastructure and open space/parkland.

Protecting public and private property in relation to wave inundation, flooding, erosion and/or SLR (e.g. via seawalls or flood control works) was ranked as an issue of high importance by 75% of the community surveyed (Appendix B). The Parramatta River estuary foreshore is subject to a number of coastal hazards, including tidal and wave inundation, flooding, shoreline erosion and SLR. The co-occurrence of a number of these factors at the same time significantly increases hazard. As discussed above, coastal hazards such as inundation due to storm surge represent a potential threat to public and private assets and human users of the foreshore and will be exacerbated with climate change and SLR.

In the long term, permanent tidal inundation due to SLR will become a significant challenge. There are limited locations around the foreshore where increased tidal inundation can be accommodated without risk to public and private assets, and the management authorities will need to consider an appropriate management response. Under climate change conditions, rising groundwater levels, salinisation of groundwater and soils, and changes in rainfall intensities will also impact on the functioning and maintenance regimes of the stormwater network as well as other services and utilities. Alternatives involve relocation of assets out of the impacted area, or increasing levels of protection. In many instances this may involve raising the crest height of seawalls to combat future SLR as seawalls require repair and/or replacement. It may be desirable to seek opportunities to build

resilience or adapt to these impacts during the course of regular capital works (e.g. by increasing the hydraulic capacity of stormwater pipes). Planning for coastal hazards should consider both current and future levels of risk. The most effective means of managing risk from coastal hazards is via strategic land use planning.

It is anticipated that the results of the CHA can be utilised in various strategic land use planning and management frameworks for the estuary. Action 39_COM21 of the Parramatta River Estuary CZMP specifies the consideration of the implications of the CHA when updating the CZMP in the future.

2.6 Estuarine Health, Monitoring and Community Awareness

Monitoring of estuarine health is necessary to track positive and/or negative trends and locations or issues that require active management. Development of an estuarine monitoring program consistent with the NSW MER Strategy (DECCW, 2010c) is a requirement of CZMPs. Further discussion on proposed future monitoring is provided in Section 6.2.

A large number of existing studies have been conducted in the study area to investigate key issues such as water and sediment quality, and the extent, condition and composition of estuarine flora and fauna. However, many of these are limited in spatio-temporal scale. Generally these studies have had a variety of aims (often for development approvals, as opposed to estuarine health assessments), have used a variety of methodologies and techniques, and have occurred in an ad hoc manner across the study area. As such these studies are very limited in their ability to provide accurate baseline information on estuary health. AECOM (2010) also highlighted data deficiencies and inconsistent approaches to data collection and reporting in relation to stormwater management activities/devices, which makes comparison of data across the catchment difficult. Further review of available monitoring data has been undertaken in relation to development of an estuarine health monitoring program (Section 6.2 and Appendix I).

Commensurate with monitoring, the community and the Committee have also identified that communication with the community and raising awareness on estuarine management is a high priority. As previously indicated, there is potential for improved catchment management and compliance with regulations as a result of community education. Lot-based water cycle management (e.g. through the use of rainwater tanks, water conservation and re-use), weed management by 'looking after your own lot', littering and inappropriate disposal of waste products represent opportunities for individuals to reduce their impacts on the estuarine environment, provided they have support from local authorities. Raising awareness, particularly amongst the community in the study area, about the importance of estuary management and why the estuary needs to be conserved will be an important part of this process. The community has a high level of awareness and concern about environmental degradation and pollution of the Parramatta River estuary, and it would be beneficial to communicate to them trends in estuarine health. It is recommended that the Committee seek means to address this issue by improving direct communication with the community, and involving them in the implementation of the Plan.

2.7 Summary of Estuary Values and Significance

Sections 2.1 to 2.6 have discussed the significance of the Parramatta River estuary based on the key findings of the *Data Compilation and Review Study* (Cardno, 2008) and the *Estuary Processes Study* (AECOM, 2010).

Feedback on estuary values was obtained and complied as part of the community survey to establish the current view on which attributes of the estuary are most valued (Appendix B).

A summary of the local, regional, national and international significance of the Parramatta River estuary and values identified by the community are detailed in Table 2.3.

Table 2.3: Values and Significance of the Parramatta River Estuary

Scale	Significance of the Parramatta River Estuary
Local	▪ Significant for the local Aboriginal people and traditional owners, with over 250 known Aboriginal places or objects recorded in or near the study area. ▪ Extensive usage of the estuary and foreshores by local people on a regular basis for passive recreation. ▪ Provides a place for activities for various water-based clubs and organisations. In particular, the estuary is, and has been, used by local sailing and rowing recreation clubs. ▪ Native habitat in the study area supports local biodiversity including fish, birds and invertebrate fauna.
Regional	▪ Most culturally significant waterway in Sydney, critical in the development of Sydney from the first settlement. ▪ High State heritage significance with over 130 listings under the NSW *Heritage Act 1977* within the eight foreshore LGAs. ▪ The study area contains regionally significant fauna species, in particular regionally rare bird species in Homebush Bay. ▪ In terms of NSW state significance, the study area contains seagrasses and mangroves, which are protected under the *Fisheries Management Act 1994* and Coastal Saltmarsh, Swamp-oak Floodplain Forest and Sydney Turpentine-ironbark Forest, which are listed as EECs under the TSC Act.
National	▪ High national heritage significance with over 500 listings on the Register of the National Estate and Commonwealth Heritage List within the eight foreshore LGAs. ▪ The study area contains a number of nationally significant wetlands listed on the Directory of Important Wetlands in Australia, and Turpentine-ironbark Forest, which is listed as a critically Endangered Ecological Community under the EPBC Act.
International	▪ Migratory birds listed under bilateral and multilateral agreements (e.g. JAMBA, CAMBA and ROKAMBA) use the wetlands in the study area as important stopover areas. ▪ Important international sporting competitions have been held in the study area, the most prominent being the Sydney Olympics in 2000. The World Dragon Boat Regatta was also held in the study area.
Values Identified by the Community	
▪ Public access to and along the foreshore. ▪ Connectivity between the waterway, foreshore and surrounding areas. ▪ Being able to enjoy the public open space areas. ▪ Being able to engage in a range of passive and active recreational activities. ▪ Water quality suitable for recreational usage. ▪ Harmony between different recreational user groups. ▪ The presence of native animals and vegetation. ▪ Enjoyment of the natural environment. ▪ The promotion of environmental education. ▪ The recognition of Aboriginal and European cultural heritage. ▪ Sustainable approaches to managing the estuary. ▪ Opportunities to understand how the estuary functions and hear about trends in estuarine health.	

2.8 Summary of Key Estuary Issues

Through the estuary management process the *Data Compilation and Review Study* (Cardno, 2008) and *Estuary Processes Study* (AECOM, 2010) identified a comprehensive list of 107 management issues associated with the Parramatta River estuary, many of which have been discussed in Sections 2.1 to 2.6. The issues identified in these studies were collated and consolidated to 70 issues for discussion and review with the Committee during Committee Workshop 1 (see Table D.1 in Appendix D).

One of the aims of Committee Workshop 1 (held on 2 March 2011) was to identify the top 10 key management issues to guide the management framework in the CZMP. These top 10 management issues have been identified as follows:

1. Increased pressure is being put on the estuary due to large foreshore developments and land use changes as industrial areas are re-developed;
2. Water and sediment quality within the estuary is generally poor;
3. Much higher sediment loads are entering the estuary than in pre-European times;
4. There have been historic and ongoing declines in ecological values due to a range of threatening processes;
5. Erosion is impacting on bank stability and estuarine and riparian vegetation in a number of locations;
6. Seawalls line a substantial proportion of the Parramatta River estuary and have led to a significant loss of foreshore habitat. Much of this infrastructure is dated and the need for maintenance and repair is likely to further increase with SLR;
7. Accessibility of the foreshore, as well as the availability and suitability of recreational facilities is not consistent across the estuary, particularly in the context of residential development of former industrial sites along the foreshores;
8. There is currently no baseline information on estuary health, or any coordinated monitoring programs within the Parramatta River estuary;
9. There is a need for improved education of the community and other stakeholders in relation to estuary processes and their linkages to catchment processes. There is also a need to improve communication and reporting on estuary management initiatives; and
10. The Parramatta River estuary foreshore is subject to coastal hazards such as storm surge that will increase with climate change and have the potential to negatively impact on public and private assets.

Detailed discussion of the management issues facing the Parramatta River estuary (including the 10 key issues listed above) has been provided in Sections 2.1 to 2.6.