

# **Managing Urban Coastal Lagoons Form, Function and Environment**

## **Using research to communicate historic legacies and the need for catchment specific approaches to estuary management.**

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### **Executive Summary**

The Northern Beaches of Sydney are home to four of the five coastal lagoons within the Sydney Basin. Warringah Council plays a key role in the management of Narrabeen, Dee Why, Curl Curl and Manly Lagoons.

Like all urbanised areas, Warringah has undergone significant land use change, which rapidly increased from the 1920s. Changes include infilling of wetlands and floodplains as well as major catchment clearance to accommodate residential areas, landfill, sports fields, commercial and industrial zones. Catchment modification has been so substantial that three of the four lagoon catchments are now almost 100% altered.

Council has collaborated with NSW State Government estuary experts together with university academics and students to monitor, evaluate and report on the condition of Warringah's lagoons. The results have revealed a higher degree of ecosystem health than previously anticipated.

Using the NSW estuary MER program as a foundation, Council has extended this approach by integrating complimentary research in order to develop catchment specific management approaches. Multiple lines of evidence include aquatic indicators, creek condition, terrestrial biodiversity, catchment land use and social values.

The information has been harmonised into a holistic conceptual model which illustrates the relationship between form, function and environment. The conceptual model articulates the influence of historic legacies on present state and is being used by Council to develop an evidence based management philosophy for each lagoon and its catchment.

This method considers what is both appropriate and achievable for each waterway in the context of its catchment characteristics, ecological value and community value. A key outcome of this approach is that the conceptual model is proving an effective visual tool that explains complex technical information in a way that is clear to all stakeholders.

## Introduction

Waterway management in an urban and metropolitan local government area is both socially and ecologically influenced. It involves the direct management of waterways in response to urban pressures, both historic and future driven, through the implementation of scientific know-how and best practice approaches.

Waterway management also involves the management of community expectations in terms of what is both viable and achievable for an urban waterway as a recreational and ecological asset.

Coastal lagoons and estuaries are considered naturally stressed and physically controlled systems with frequent environmental disturbances and fluctuations. At the same time, their transitional nature (between terrestrial, freshwater and marine influences) makes them especially vulnerable to anthropogenic pressures and stormwater inputs. (Pérez-Ruzafa et al 2013).

This weighty challenge becomes acutely apparent when managing waterways that differ in size, morphology, hydraulic function, degree of catchment modification, ecological condition, local government tenure and social value. To add to the challenge, effective management needs to include the desire and expectation to recreate in coastal lagoons. Recreational activities and the required space to undertake them increases as populations increase.

Water quality is of great concern to the managers of estuaries and coastal waters because unsavoury swimming conditions, poor fishing or a complete ban on contact and bad press translate into reduced spending by tourists and reduced community pride (Rissik and Suthers 2010).

Reduced community pride and value for a natural asset may perpetuate decreasing or capping of expenditure on management. This expenditure can be critical in maintaining, rehabilitating or buffering waterways from urban pressures. Furthermore, a lack in community appreciation can also precipitate changes in planning and development controls which previously provided protection to the waterway.

Sydney's Northern Beaches are a prime example of the pressures that coastal waterways have endured, and will continue to endure, as the environment balances with community.

To assist in identifying and prioritising Council resources, Warringah Council conducts an Environmental Perceptions Survey every three years. Results from the latest survey in 2014 indicate the community's top environmental concerns are water pollution and water quality, and that almost half of the Warringah community don't know what the water quality is like in Warringah lagoons.

Warringah's Community Satisfaction Survey in 2014 indicated that waterway and lagoon management is the second most important environmental services Council should provide. It also identified that the community's satisfaction with the state of our waterways had slightly increased from previous years.

Communicating the state of Warringah lagoons is challenging, particularly as the population is increasing in size and consequently in its expectations and demands as to what the lagoons should be providing for visual and recreational amenity. This is further complicated by the fact that the lagoons and their catchments are highly modified and

their ecological condition and subsequent amenity has been compromised over many decades.

Collective data ranging from monitoring programs to rehabilitation works and estuary modelling to oral histories is enabling Council to better communicate the complexities of estuarine health, recreational suitability and the cause and effect relationship between catchment history and current condition.

## Setting the Scene

Initiating a conversation with the community and concerned stakeholders about the current state of Warringah's lagoons uses three main themes:

- Form, as in the shape of our lagoons, how they have modified, and the modification of their catchments.
- Function, as in how they are functioning ecologically and how the modification of their shape affects their function.
- Environment, as in how the surrounding environment influences function.

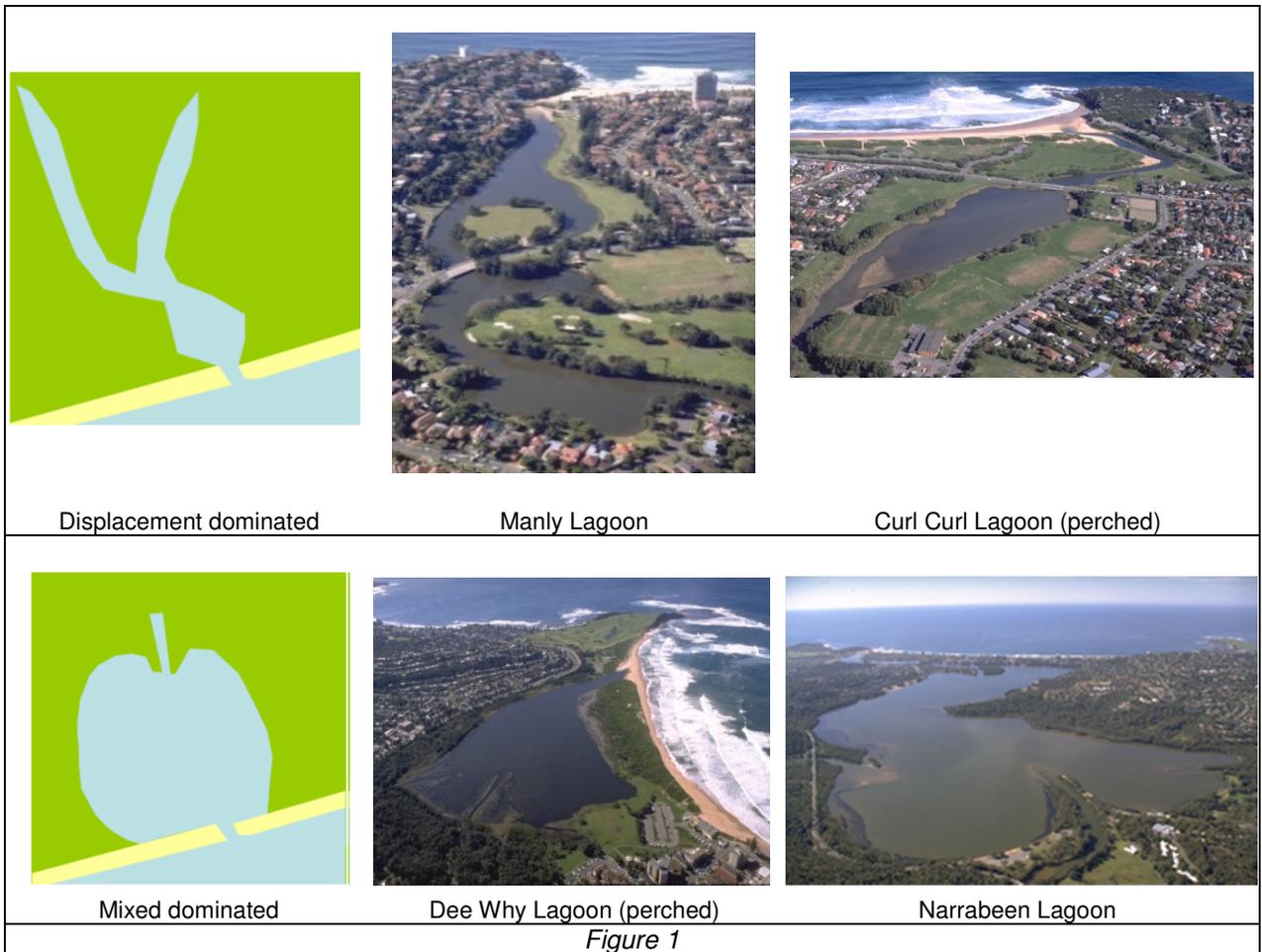
## Form

Over the last 90 years of urbanisation all Warringah's lagoon catchments, and in Manly and Curl Curl's case the lagoons themselves, have undergone massive changes and modifications. Wetlands have been filled in or used as landfill sites, creeks moved, straightened and concrete lined, riparian zones encroached upon, the beds of the lagoons dredged and new shorelines and islands created. These modifications have all had an influence on how the lagoons are functioning now.

Haines (2008) investigated the relationship between lagoon shape and function. Morphometry refers to the physical characteristics of Intermittently Closed and Open Lakes or Lagoons (ICOLLS). Morphometric features of ICOLLS can influence the resilience of the waterway to external loadings. Some of the most significant morphometric parameters of ICOLLS include the Entrance Closure Index (ECI), catchment size, waterway size, and the waterway shape (Haines 2008, Haines et al., 2006).

Haines goes on to describe how relatively linear shaped lagoons have been called *displacement-dominated* and relatively circular shaped ICOLLS are referred to as *mixing-dominated* lagoons. Displacement-dominated lagoons tend to display less resilience than mixing-dominated. Displacement-dominated ICOLLS are naturally more sensitive to inputs, with generally less capacity to accommodate and assimilate pollutants. Warringah's lagoons are great examples of this in action and we have two ICOLLS of each type, with the mixing-dominated lagoons displaying better ecological indicators of condition (Figure 1).

Warringah also has two perched lagoons, Curl Curl and Dee Why Lagoons, with bed levels above sea level. When their entrances are breached, almost complete flushing of the lagoons occurs, exposing estuarine bed sediments.



## Function

Function is the physical and biogeochemical processes that occur in an estuary. It is related to the physical characteristics of the lagoon and influenced by its surrounding environment. It includes water quality, hydrodynamic regime, primary production and higher trophic processes. Good or bad, lagoon function is often what the community sees. However it is a product of a complex array of interrelated process and is difficult to measure. Community concerns are generally a response to the visual state the lagoons and swimability.

## Environment

The influence of the surrounding environment on lagoon form and function is the focal point to communicate the influence of catchment modification and the anthropogenic pressures of the urban landscape. As seen in Figure 2, the environment in the immediate vicinity of Manly Lagoon has been significantly altered over the last 100 years which has had an important influence on the current state of the lagoon.

The following will discuss various environment inputs that help shape the state of Warringah's lagoons including landuse change, creek and catchment condition, catchment inputs and biodiversity.

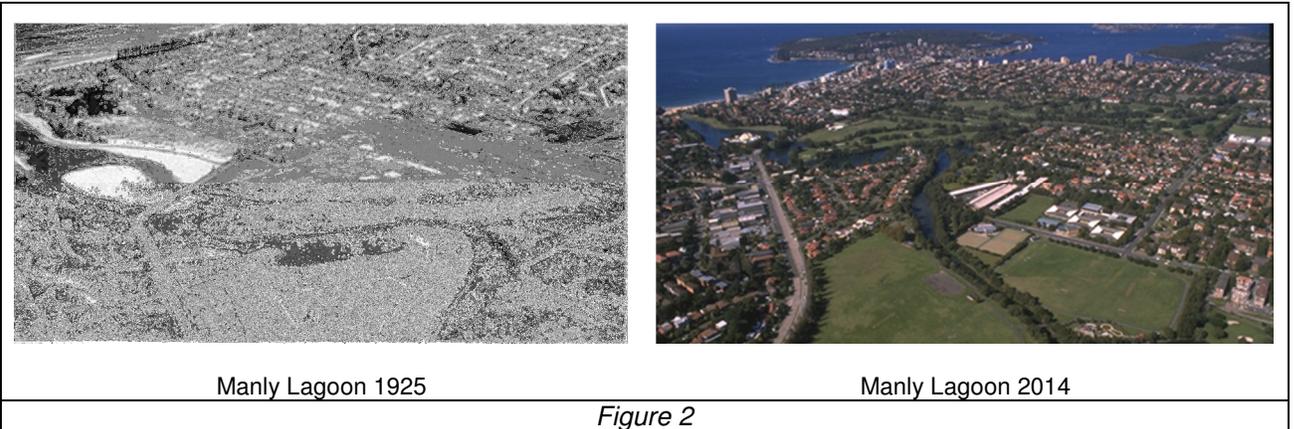


Figure 2

### Let's Talk about the Past

#### *Historic aerial photography*

With a routine monitoring program and the public communication of annual condition rankings, Council is better equipped to open up the conversation on lagoon condition and address the community's satisfaction with the state of the waterways.

As part of the catchment modelling project for Dee Why and Narrabeen Lagoon to estimate annual nutrient and sediment loads, Council acquired historic aerial photographs from NSW Office of Environment and Heritage's (OEH) photogrammetry unit in Newcastle. These historic photographs are a great tool in illustrating the degree of catchment modification that has occurred since 1930.

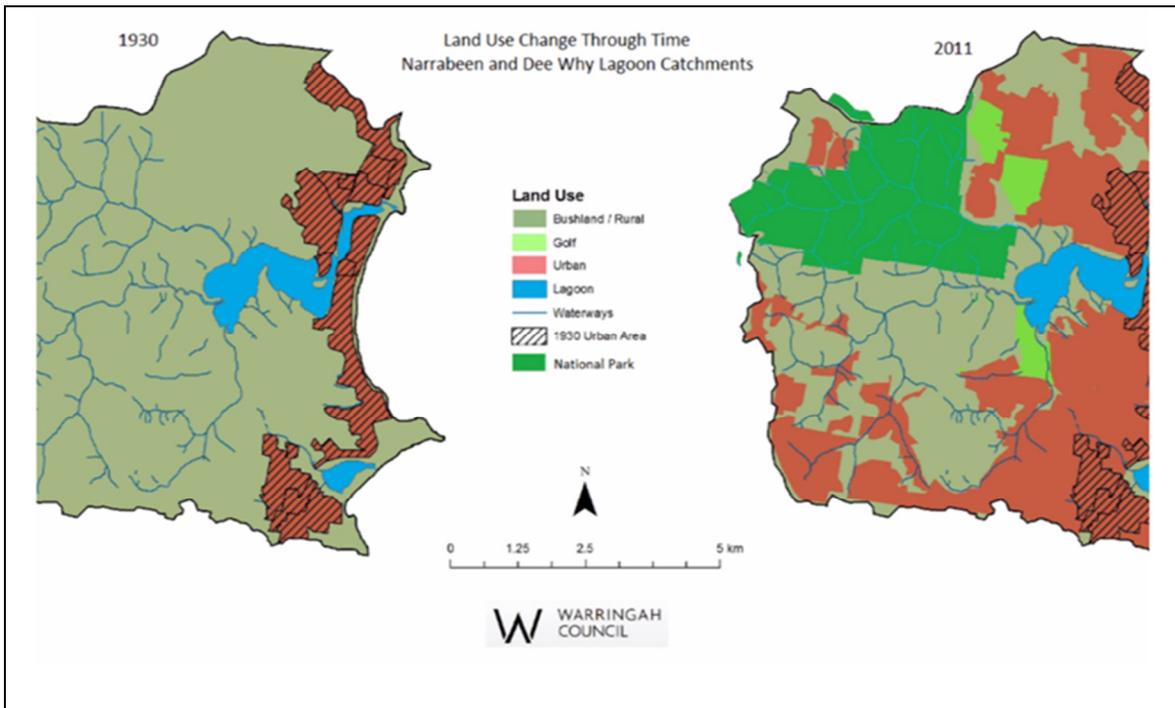


Figure 3 – Land use change over time in the Dee Why and Narrabeen catchments

Landuse delineation has been carried out on numerous historic aerials from 1930 to 2011 to assist in describing the change in urban and bushland areas. The aerials have then been stitched together in chronological order to produce a short animation which illustrates the extent of urban creep across the LGA from 1930 to 2011. The animation has proven to be a very effective tool in illustrating the loss of bushland and spread of urban residential landuse from east to west (Figure 3).

## **First things First – What have we got and what’s its like?**

### ***Identifying Lagoon Condition – Annual Report Card***

In 2010 Warringah Council undertook a comprehensive study of Manly Lagoon that assessed biological indicators of ecological condition, microbial water quality, bird diversity and community perception. The collective data set identified previously unappreciated aspects. These included higher than expected ecological value, bacterial loadings lower than expected and a public opinion more positive than anticipated.

The package of information was presented to community stakeholders and internally within Council teams. The information was well received. The study was able to communicate a foundation of knowledge to a broad audience on the current state of the lagoon. The study also built strong working relationships with The Sydney Institute of Marine Science (SIMS), University of New South Wales (UNSW) and University of Technology (UTS). It also identified the feasibility and cost effectiveness of running a routine monitoring program in-house using Council resources whilst partnering with tertiary institutes.

In 2011, Council adopted and implemented the OEH Monitoring, Evaluation and Reporting (MER) protocols over all four lagoons in the LGA: Manly, Curl Curl, Dee Why and Narrabeen (Figures 4).

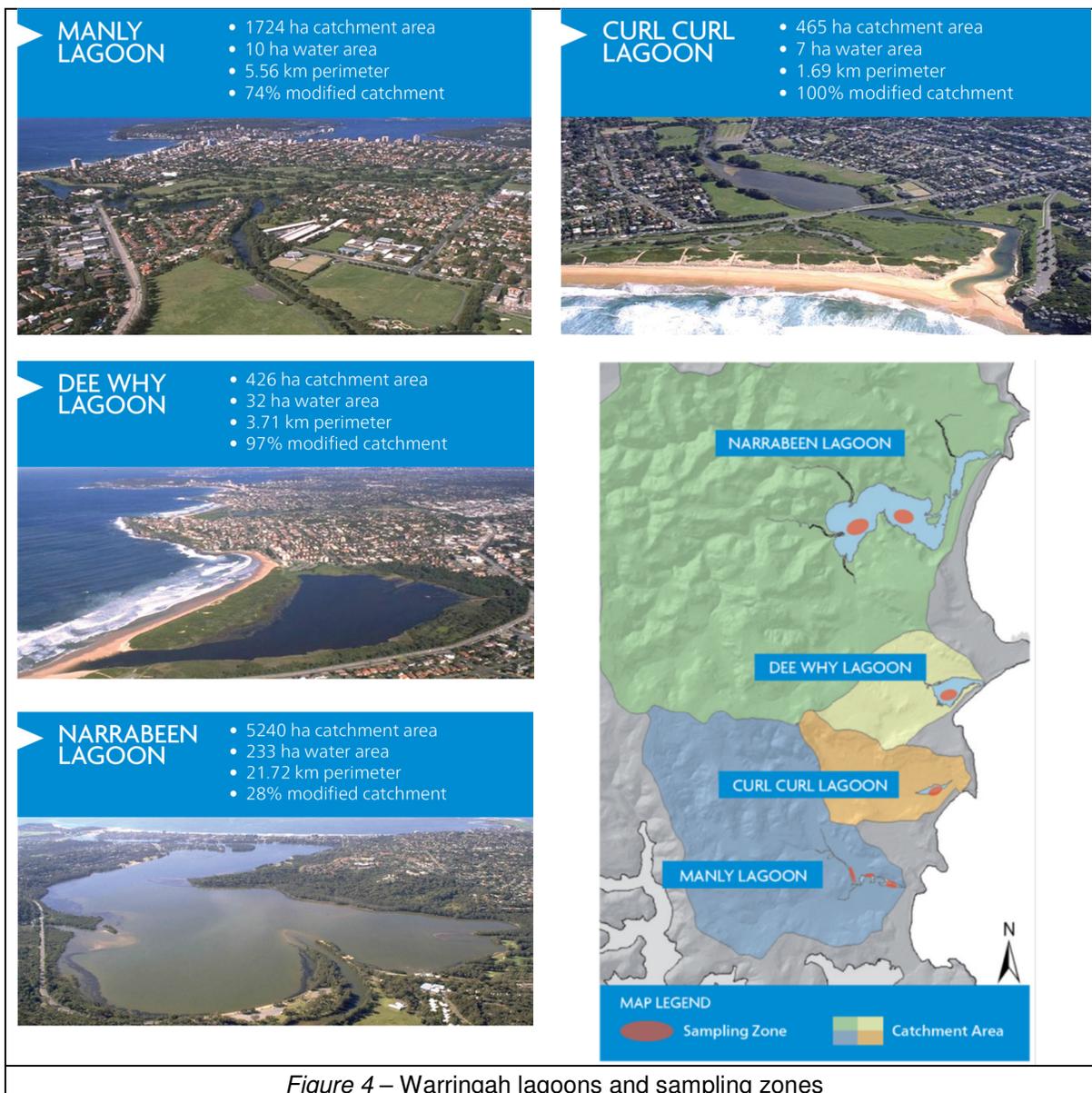


Figure 4 – Warringah lagoons and sampling zones

Chlorophyll a and turbidity are measured in identified zones within each lagoon on which the lagoon condition rankings are developed. These grades allow us to compare our lagoons with the lagoons, estuaries and river mouths that OEHL has been monitoring along the whole NSW coast.

Council extends this approach by integrating complimentary research to value-add to the MER data set. Collaborations with research staff at SIMS, UNSW and UTS builds phytoplankton abundance and diversity and zooplankton biomass into the knowledge base. The information gained from this effort further improves our understanding of chlorophyll a levels in the lagoons and the species responsible for it. It is also proving to be valuable by characterising each lagoon through the presence or absence of key plankton species or the dominance of others. The final annual reporting product consists of a condition ranking for each of the lagoons (A-F) and an accompanying report card.

The key outcomes achieved from this are:

- 1) Improved stakeholder buy-in through credible partnerships - Council is able to inform the community that it has aligned with state government authorities and tertiary institutes, and demonstrate a consistent method for monitoring and measuring future change in ecological condition for Warringah's Lagoon.
- 2) A solid evidence based decision making platform - The robust data set acquired for each lagoon is providing Council with a baseline from which to more effectively allocate resources to maintain or improve the ecological condition of the lagoons on a prioritised basis.
- 3) Improved satisfaction in the community through the knowledge that Council:
  - a. has dedicated resources to address and investigate the community's concerns regarding the lagoons
  - b. has a thorough understanding of its natural areas
  - c. is actively and regularly doing work in the environment, in a stewardship role that is underpinned by a drive to maintain and improve the state of the waterways.

### **Building the conceptual model**

Collating the lagoon condition rankings with knowledge of the level of catchment modification has facilitated an increased understanding of lagoon condition within the community. This has been noted by a positive response at community meetings and in the local media. Pulling together data from different disciplines (for example creek condition, biodiversity and recreational amenity) strengthens the discussion. The end result is a defensible and realistic management philosophy for each lagoon based on multiple lines of evidence and justification of what is achievable in the context of catchment land use and future pressures.

### ***Creeks and their Condition***

The Warringah Creek Management Study (2004) and landuse mapping indicates that creeks that are significantly modified and impacted often flow to poor condition lagoons. For example Curl Curl Lagoon's catchment is essentially 100% modified, is dominated by Group C creeks which are largely piped and travel through the most intense industrial estate in Warringah. Group C creeks are generally of low to moderate ecological value with moderate to highly developed catchments (15-20% connected impervious area). A poor lagoon condition ranking therefore becomes easier to understand and appreciate (Lagoon condition ranking 'F').

Narrabeen's catchment on the other hand is only 28% modified, contains more bushland, less hard surfaces and is fed by Group A and B creeks (Group A creeks have very high ecological value: with less than 10% connected impervious area and Group B creeks have some degradation in the upper catchments but high ecological value downstream, generally 10-15% connected impervious area). Narrabeen Lagoon is consequently in better ecological condition (Lagoon condition ranking 'B').

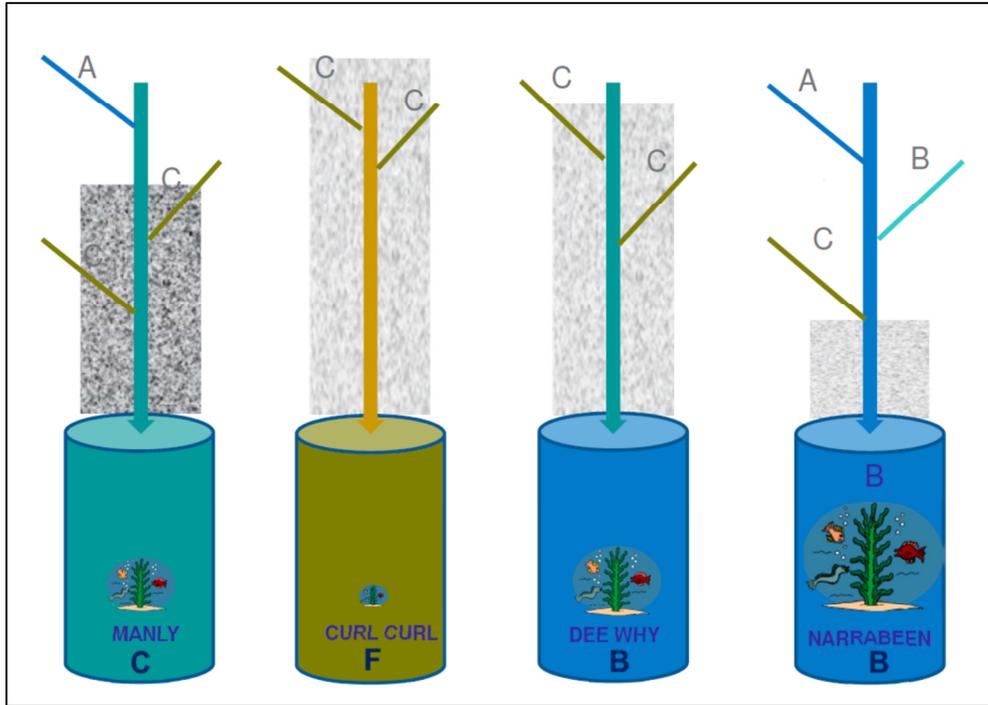


Figure 5 – Creek and land use inputs

### **Catchment Biodiversity**

Incorporation of terrestrial biodiversity value to each lagoon catchment was achieved through the Warringah Biodiversity Conservation Study (2011).

Warringah contains 3227 ha of remnant vegetation including biodiversity of state, federal and international significance. Not surprisingly, areas of high biodiversity value are also those that have not been cleared and developed. The lagoon catchments of highest diversity also correlate to the three healthiest lagoons in Warringah. This is another tool for the communication toolbox. Council can confidently provide evidence that more bushland results in increased biodiversity. More bushland also results in less impervious surfaces which mean less stormwater runoff. And so the story continues, reduced stormwater means lower loads into our lagoons and the resulting lagoon conditions illustrate this.

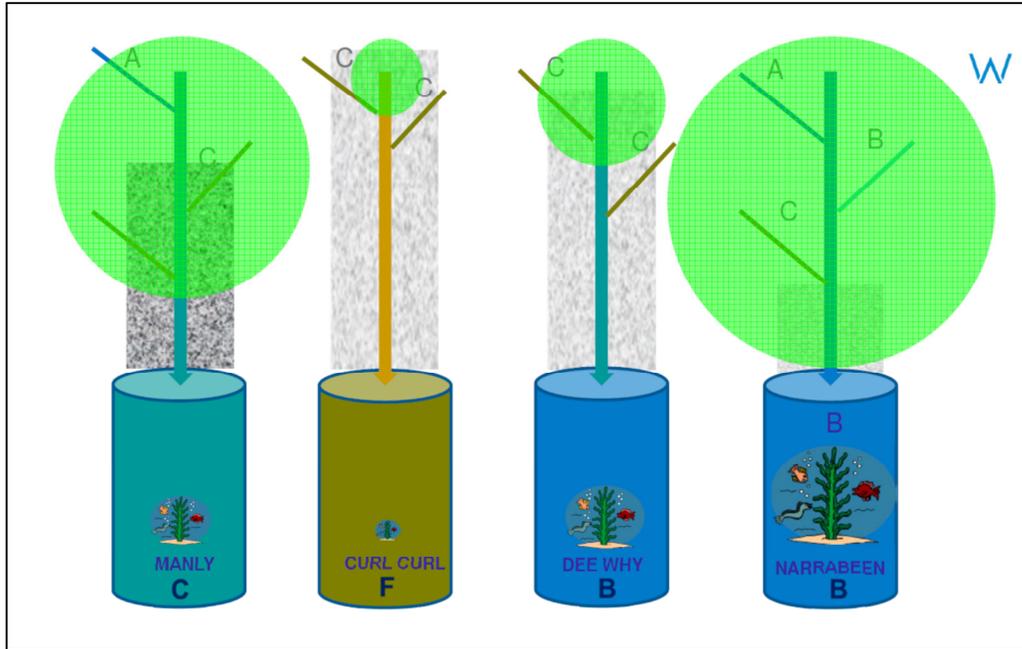


Figure 6 – Creek, land use and biodiversity inputs

**Wrapping it all up, Finding a way forward**

Two themes arise when considering all the available information. The lagoons with the greatest ecological value possess more resilience through their catchment, environment and morphometrics, and this is reflected in how the community use and perceive their function and value. These areas cry out for an environmental priority status with management actions are focused on conservation and protection. They are the lagoons with the most to lose and are the ones that would respond the best to protective management strategies.

Those with lower ecological value have catchments with little or no room for augmentation of stormwater infrastructure, landfill remediation or catchment revegetation. In addition, these strategies are often not financially viable and difficult to justify. The best cost/benefit solution for these lagoons is to maintain condition whilst implementing improvements to the social and recreational value of these waterways.

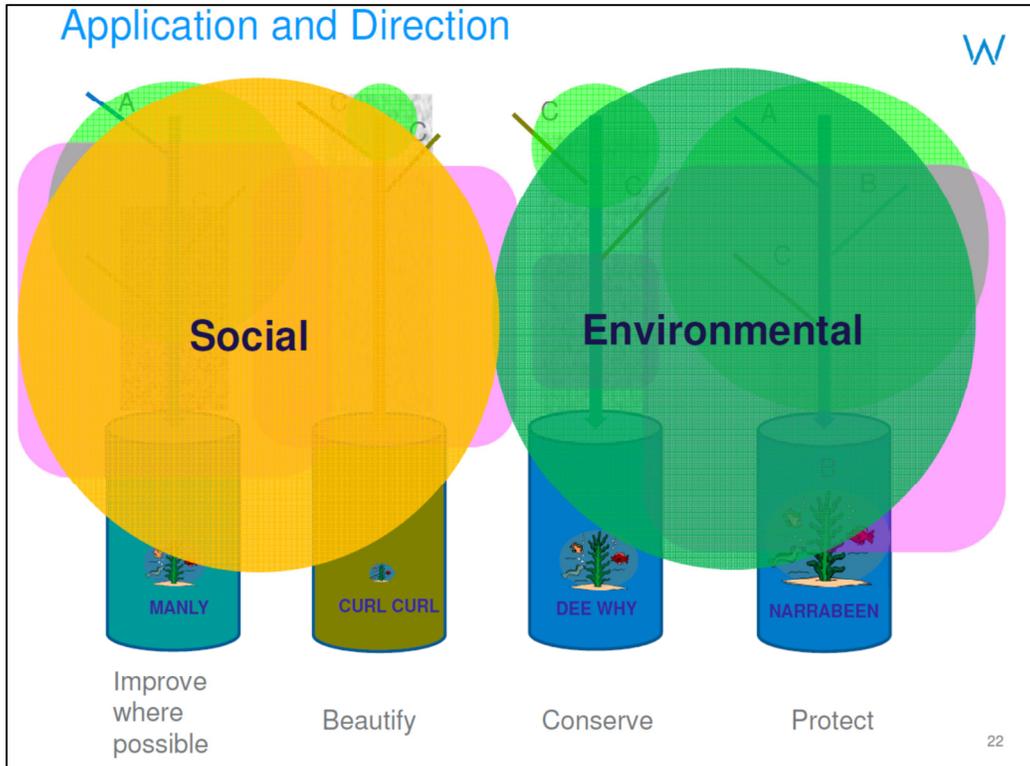


Figure 7 – Catchment condition and management model

### What comes out in the wash?

Warringah has four lagoons and each one differs in shape, size, entrance condition, catchment modification and social amenity. They each hold varying degrees of ecological value and resilience to catchment inputs. Some lagoons have undergone such extensive modification that the required measures to lift their ecological condition out of the “poor” category are cost prohibitive. Better outcomes can be achieved through maintenance of current condition and improvements in social, visual and recreation amenity around their foreshores. Some lagoons possess the attributes that warrant environmental priority status with targeted conservation and protection measures and strict development controls.

What has been achieved through this process is a robust and defensible model on which to develop and communicate lagoon specific management strategies that Council is confident in proceeding with. This method communicates what is appropriate and achievable for each lagoon in the context of form, function and environment.

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