Wrack Management Strategy for Tuggerah Lakes

Central Coast Council

December 2023

Central Coast Council

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EcoFutures

Alluvium recognises and acknowledges the unique relationship and deep connection to Country shared by Aboriginal and Torres Strait Islander people, as First Peoples and Traditional Owners of Australia. We pay our respects to their Cultures, Country and Elders past and present.

Artwork by Melissa Barton. This piece was commissioned by Alluvium and tells our story of caring for Country, through different forms of waterbodies, from creeklines to coastlines. The artwork depicts people linked by journey lines, sharing stories, understanding and learning to care for country and the waterways within.

This report has been prepared by Alluvium Consulting Australia Pty Ltd and EcoFutures Consulting Pty Ltd for Central Coast Council under the contract titled 'Tuggerah Lakes Wrack Management Strategy' (CPA/4689).

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Review:	Trish Chadwick, Paul Maxwell
Approved:	Paul Maxwell
Version:	Final
Date issued:	December 2023
Issued to:	Jenna Markwick, Central Coast Council
Citation:	Alluvium and EcoFutures, 2023, Wrack Management Strategy for Tuggerah Lakes report prepared by Alluvium Consulting Australia Pty Ltd and EcoFutures Consulting Pty Ltd for the Central Coast Council, Gosford, NSW. Cover Photo: Paul Maxwell

Executive Summary

Central Coast Council has engaged Alluvium Pty Ltd to develop a Wrack Management Strategy for Tuggerah Lakes estuary through a process of collating and distilling sound scientific information and in-depth community and stakeholder engagement.

Wrack Accumulation and its impact on Tuggerah Lakes

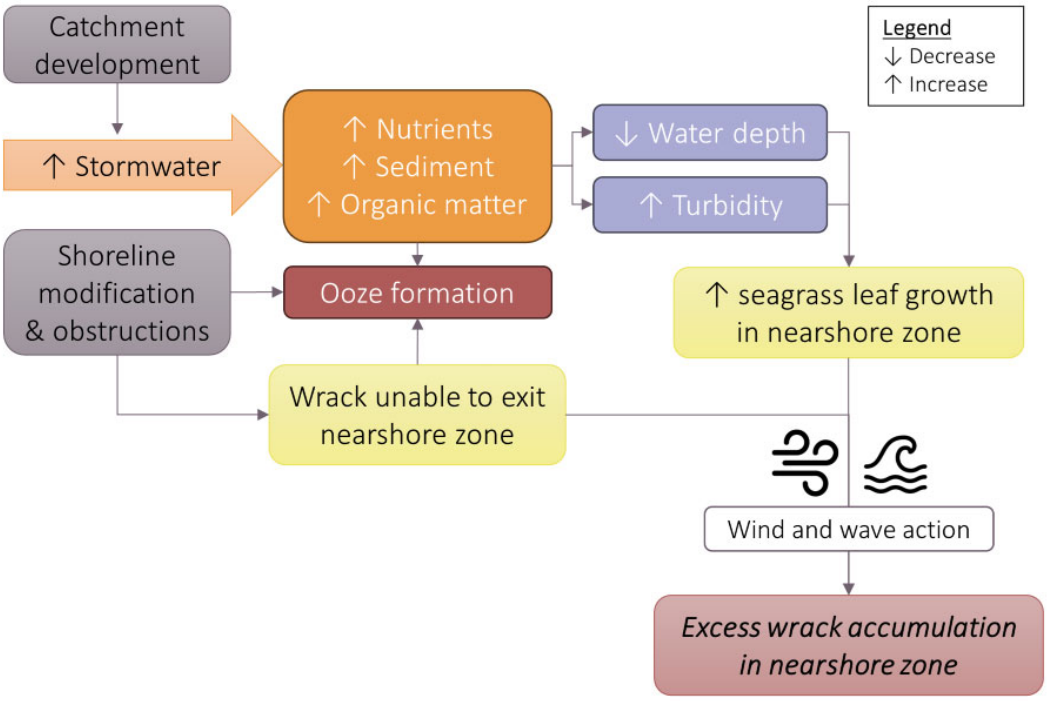
Seagrass is a marine flowering plant that live underwater and need light to photosynthesise. It is highly specialised and has adapted to soft sediments in nearshore parts of lakes, estuaries, and oceans. Seagrass has many special values and provides a wide range of environmental and ecosystem benefits and services. The seagrass meadows of Tuggerah Lakes consist of relatively stable beds of eelgrass *Zostera muelleri subsp. capricorni* and more ephemeral patches, primarily of paddleweed *Halophila ovalis,* but also with stackweed *Rupia megacarpa* (Chapman & Roberts 2004, SKM 2008).

Where there are seagrass habitats you also get wrack. Wrack is composed of seagrass leaves that have been shed seasonally as part of the growth cycle of the seagrass plants. It also contains macroalgae which commonly grows in estuarine environments and is part of the nutrients cycling of the estuary system. Whilst this is a natural process and wrack has environmental benefits, the community and stakeholders see managing wrack as a priority issue primarily to improve nearshore water quality and amenity across the Lakes.

The scientific literature provides a detailed understanding of the processes around seagrass and macroalgal wrack accumulation under natural and modified conditions. Seagrass wrack accumulation is primarily driven by wind direction and velocity along with seasonal variations in seagrass growth. Wrack formation and dispersal is a natural and ecologically important process to the estuary providing various ecosystem services. Unfortunately, the extensive modification of the estuary shorelines (as well as water level fluctuations through entrance management) has altered where wrack accumulates, the rates of accumulation and also how it is broken down over time.

Under natural conditions (before lake/shoreline modifications), it is likely the wrack was deposited higher into the intertidal zone amongst the saltmarsh where it would have been broken down naturally over time. However, under the current shoreline and water level conditions wrack is prone to accumulating along the shoreline. This results in wrack buildup which reduces the aesthetics and recreational qualities of the estuary, in addition to intensifying decoupling of the basin and nearshore zone and subsequently exacerbating monosulfidic black ooze formation and algal blooms.

Further adding to the issues is the input of nutrients and sediments via stormwater, overland flow, and groundwater. Development across the catchment has increased flows and pollutant loads entering the estuary with urban stormwater identified as a key contributor to the current poor water quality. Algal blooms and ooze formation are driven by this input of nutrients notably in areas where stormwater inputs coincide with the decoupling of the nearshore and basin areas through dense seagrass beds and rafts of wrack which act as barriers.



The complex combination of drivers and impacts associated with wrack accumulation in the estuary is illustrated in the flow diagram.

The issue of wrack management in the lakes is multi-faceted. The problem is a compound one for which there is no easy solution.

Currently, some seagrass and algal wrack accumulations are collected by a contractor under Council's NSW Department of Primary Industries and Fisheries Permit. The current permit was issued a Permit Extension ensuring wrack collection activities can occur under the conditions of the current permit until 30 June 2027.

Based on Council's operational data records, between 12 June 2020 and 2 May 2023, a total of 22,220 m^3 of wrack was collected across the three lakes. Majority of the wrack was collected almost evenly between Budgewoi Lake and Tuggerah Lake with only a small amount, less than 3% collected from Lake Munmorah. The data also shows that most of the wrack is collected from the nearshore zone of the lakes from areas with depths of 0mm to 1m. Most of the wrack collection undertaken between June 2020 and May 2023 has been in response to community complaints, and wind patterns. Strategic pre-emptive wrack collection is limited by resources and shoreline constraints, so accumulates and leads to a multitude of issues, resulting in the need for an undated wrack management strategy for the Lakes.

Wrack Management Strategy for Tuggerah Lakes

Approach to Strategy Development

The aim has been to develop a Strategy that is scientifically robust and up to date with the latest scientific literature and recent research. Then to integrate the science with a detailed understanding of the environmental, operational constraints, and social contexts of the estuary, within the requirements of the applicable legislation (approval by Fisheries). Equally as important has been to merge the scientific and operational aspects with the community's views and inputs to ensure the strategy is supported by the community and other key stakeholders.

Although Central Coast Council have made and continue to make substantive investment in the wrack collection program, the program has been targeted with a focus on response to community complaints within the operational constraints of the environment and permit. The community perceptions and expectations around wrack collection are not currently being met, in part due to the responsive approach but also because there is a lack of understanding across the community on the range of issues at play in wrack accumulation and management.

As such, this Strategy has been developed based on this sound scientific understanding of wrack accumulation combined with the community consultation outcomes and Council's operational capabilities.

Legislative Framework behind the strategy

Coastal Management Act 2016

The *Coastal Management Act 2016* is a central component, providing the statutory framework for coastal zone management in NSW and the minimum requirements for the preparation of a Coastal Management Program (CMP). The *Coastal Management Act 2016* states that "the purpose of a coastal management program is to set the long-term strategy for the co-ordinated management of land within the coastal zone with a focus on achieving the objects of this Act". Council is responsible for preparing a CMP in accordance with the requirements of the Coastal Management Act 2016 and the NSW Coastal Management Manual and implementing the gazetted CMP through their IP&R program and land use planning system. In implementing a certified CMP Councils can apply for funding under the NSW Government's Coastal and Estuary Grants Program. This program provides financial support to local government to help manage the coastal zone, while technical support is also provided by NSW Department of Planning and Environment (DPE).

This Wrack Management Strategy was identified as being required to address the issue of foreshore wrack accumulation during the Tuggerah Lakes Estuary CMP Stage 1 Scoping Study. This Strategy is now being prepared as a component of Stage 3 of the same CMP. The intention is for recommendations and actions made as part of this Strategy to subsequently be incorporated into the Tuggerah Lakes Estuary CMP which is certified and then implemented over the following 10 years.

The entire waterbody and foreshore areas are mapped as Coastal Environment and/or Coastal Use areas (with small pockets of coastal wetlands). As such, actions included in the Tuggerah Lakes Estuary CMP to address wrack management may be eligible for funding under the various relevant implementation streams of the NSW Government's Coastal and Estuary Grants Program.

Fisheries Management Act 1994

The *Fisheries Management Act 1994* relates to the management of fishery resources and is primarily administered by the Minister for Primary Industries. The NSW Department of Primary Industries issue permits for activities impacting on aquatic habitats and species as specified under Part 7 of the Fisheries Management Act 1994. One activity that requires a permit is the harming of marine vegetation, which includes the collection of wrack.

DPI Fisheries, a division of NSW Department of Primary Industries, assess applications to harm marine vegetation in accordance with Part 7 of the *Fisheries Management Act 1994*, Part 14 of the *Fisheries Management (General) Regulation 2010* and the *Policy and Guidelines for Aquatic Habitat Management and Fish Conservation (2013).* Central Coast Council currently have a permit issued by DPI Fisheries (permit number PN19/220) to harm marine vegetation associated with seagrass wrack collection in the estuary. This permit will remain active until 30th June 2027.

The current permit will need to be updated in line with the actions recommended in this Strategy. Relevant DPI Fisheries contacts have been consulted throughout the development of this Strategy and their guidance and thoughts on permissible wrack collection actions have been considered when devising recommendations.

Strategic context for the strategy

The Tuggerah Lakes Estuary Coastal Management Program Scoping Study (Central Coast Council, 2021) identified a draft long-term vision for the Central Coast coastal zone which was devised by Council and the two Catchments to Coast Committees (which have since been combined) based on an appreciation of the community's values and aspirations. This draft vision for the coastal zone is:

"Achieve a healthy and sustainable coastal zone for the whole of the Central Coast both now and into the future, encompassing natural assets, community well-being and resilience."

Stakeholder and Community Engagement in development of the strategy

A central activity in the development of this Strategy was the formation of, and engagement with a Community and Stakeholder Reference Group (CSRG) that was established for the duration of this project to provide input to the content and direction of the Strategy. The CSRG was comprised of 15 community participants selected via an Expression of Interest process to ensure diversity amongst participants and to incorporate the views of the whole community as much as possible. Participation in the CSRG was also received from NSW Department of Planning and Environment and NSW Fisheries (with requests for attendance and/or input to the Strategy made to Crown Lands and Darkinjung Local Aboriginal Land Council) without response.

Community vision for the strategy

Acknowledging the long-term direction for the Central Coast's coastal zone and the broad goal of this Strategy to maintain a healthy coastal estuary through addressing wrack accumulation issues, a community lead vision was developed.

The community lead vision for the Strategy has been developed based on participation from the Community and Stakeholder Reference Group (CSRG). The vision was developed and refined across three extensive workshops with the CSRG. The community vision for the Tuggerah Lakes Wrack Management Strategy incorporating the key words identified in the Workshops by the community is:

"Sustainably manage wrack to enhance the amenity, recreational and economic values of the lakes while retaining the critical ecological functions required to support biodiversity".

The CSRG has insisted that the Wrack Management Strategy (WMS) be developed with these key words in mind. These words that the community put forward form the heart of the document and are all included in the vision above.

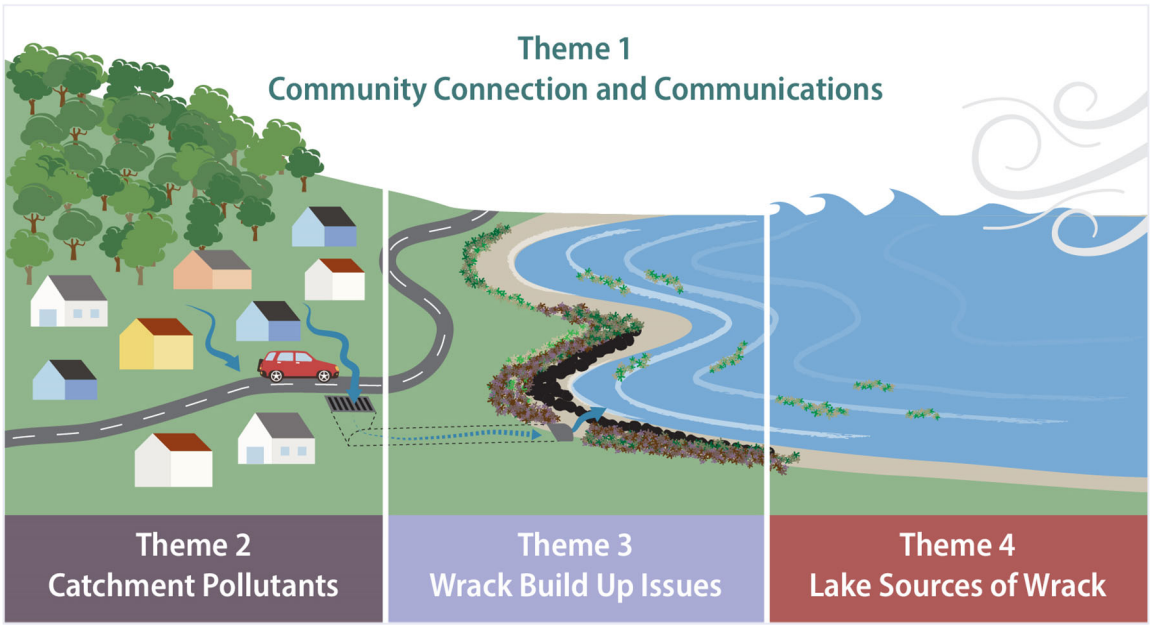
Strategy Targets and Actions

The scientific findings and community views and inputs were reviewed and distilled down to four key themes to address the issues of wrack accumulation that need to be managed.

The action themes include:

- Action theme 1 – Community connections and communication
- Action theme 2 – Catchment pollutant management
- Action theme 3 – Management of wrack build-up (nearshore and onshore)
- Action theme 4 – Lake sources of wrack management

A diagram depicting the interaction of the four key themes is provided below.



The Strategy targets and actions to address each theme are summarised in the following tables. Overall, there are 14 targets to be achieved under the Strategy with 37 individual actions required to be implemented to accomplish this. The tables summarise the actions recommended for each of the 4 themes.

Table 1 The Four Themes for Wrack Management in four tables (more details are provided in Section 4.7)

Target for Wrack Management	Actions to achieve Wrack Management Targets	Action Commencement (Year 1 – 10)									
		1	2	3	4	5	6	7	8	9	10
THEME 1 – Community Connections											
Pre-target - Immediately	Establish Tuggerah Lakes Wrack Management Advisory Panel -Delegates to include community members, council staff and, external stakeholders when applicable										
Target 1 - Improve community awareness - within 4 years convert 50% of community complainants to advocates of the wrack management activities.	1.1 – Develop communication plan that will improve the general knowledge of the community about the estuary, seagrass, algae, ooze, and the systems that are in place for both natural and managed areas.										
	1.2 – Install estuary facts interpretive signage at 5 priority collection locations that each relate to estuary issues/features related to wrack processes or wrack management such as wildlife, saltmarsh, ooze, algae.										
	1.3 – Establish a centralised digital portal for wrack management within Tuggerah Lake.										
	1.4 - Development of information materials for the distribution and communication to the community										
	1.5 – Establish direct communication with lakefront property owners and recreators about wrack										
	1.6 – Identify and liaise with relevant community groups (may include Facebook groups and other groups on social media) with the aim to establish and maintain community links to the centralised portal.										
	1.7 – Investigate and establish community clean up days.										
	1.8- Establish a baseline understanding of the level of community satisfaction/knowledge with wrack management.										
	1.9 – Repeat the community satisfaction social survey and publicise results										

Target for Wrack Management	Actions to achieve Wrack Management Targets	Action Commencement (Year 1 – 10)									
		1	2	3	4	5	6	7	8	9	10
*Target 2 – **To increase state and federal funding for estuary management***	2.1 – Review potential grant funding sources and apply for funding where eligible to implement actions from the Wrack Management Strategy.										

Target for Wrack Management	Actions to achieve Wrack Management Targets	Action Commencement (Year 1 – 10)									
		1	2	3	4	5	6	7	8	9	10
THEME 2 – Catchment Pollutant Management											
Target 3 – Manage impacts from nutrients by collecting wrack at high stormwater impacted foreshores	3.1 – Manage wrack in accordance with the Schedule at foreshores with significant stormwater influence within the Priority Locations.										
Target 4 – Investigate techniques to manage impacts of pollutants entering the estuary (collaborative research projects)	4.1 – Investigate collaborative research projects for stormwater treatment systems on foreshore locations (e.g. Australian Research Council, Universities, etc.)										
	4.2 – Investigate trial of novel stormwater treatment methodology/device at 1 of the Priority Locations - Include monitoring program (sediment/nutrient before-after-control-impact design)										
	4.3 – Investigate collaborative research projects to understand the influence of groundwater on foreshore locations										
	4.4 – Evaluate results of investigations and develop action plan with recommendations for implementation.										

Target for Wrack Management	Actions to achieve Wrack Management Targets	Action Commencement (Year 1 – 10)									
		1	2	3	4	5	6	7	8	9	10
THEME 3 – Management of wrack build up (nearshore and foreshore)											
Target 5 – Improve the efficiency and reduce the impact from current collection processes.	5.1- Collect in accordance with the Schedule (Table 2) and Operations Manual including: Priority Locations, timing and methodology										
	5.2 – Targeted collection at boat ramps and constructed beaches and the locations identified within the Schedule.										
	5.3- Develop remote aerial monitoring program and modify wrack management in accordance with recommendations from evaluation.										
	5.4- Develop real time management decision support tool with built in considerations of water level data, bathymetry, seagrass mapping, wind direction, macroalgae blooms, weather conditions, shoreline limitations.										
	5.5 – Ascertain baseline ecological health data using the indicators: • Syngnathid and aquatic fauna prevalence and distribution • Monosulfidic Black Ooze prevalence and distribution • Seagrass meadows and their changes (leaf length, m^2 etc) • Turbidity/Chlorophyll a (using existing data and MER program as baseline) • Wrack accumulation (m^2, depth, locations, etc). -Trapped wrack -Beached wrack										
	5.6- Evaluate results of ecological health data and develop action/monitoring plan with recommendations for implementation. Implement the recommendations.										
	5.7- Investigate alternate bins/ wrack drying pads to enhance visual amenity										

Target for Wrack Management	Actions to achieve Wrack Management Targets	Action Commencement (Year 1 – 10)									
		1	2	3	4	5	6	7	8	9	10
Target 6 – Investigate alternate wrack collection methods/machinery	6.1 – Review global and investigate alternate machinery/ methodology to access nearshore zones to minimise ecological impact.										
	6.2 – Establish collaborative research group (e.g. Uni Newcastle, Dept Planning and Environment) to test new methods of wrack collection, how to prevent accumulation in certain areas, or how to disperse wrack into areas where collection by machinery can take place in deeper water.										
Target 7 – Establish community group wrack collection program within 2 years	7.1 – Establish volunteer collection pilot program like current Environmental Volunteer Program.										
	7.2 – Investigate collection points/bins (such as skips or other large transportable containers) convenient to Priority Locations for community use.										
Target 8 – Establish network of paid wrack collection groups within 4 years	8.1- Investigate establishing professional paid groups for manual wrack management in areas with limited machinery access (e.g. areas with shallow water levels, rocky shorelines etc.).										
Target 9 – Source ongoing council funding for actions under the WMS	9.1 – Investigate stormwater and environmental levy to fund wrack management.										
	9.2 – Undertake cost benefit analysis for wrack collection plant and equipment owned and operated by Council.										
Target 10- Reduce amount of wrack disposed of at waste management facility.	10.1 – Establish trial sites where wrack can be used as an alternative to leaf/garden mulch										

Target for Wrack Management	Actions to achieve Wrack Management Targets	Action Commencement (Year 1 – 10)									
		1	2	3	4	5	6	7	8	9	10
THEME 4 – Lake Sources of Wrack Management											
Target 11 – Reduce wrack build up in deeper areas of the lake (before build-up in nearshore and on beaches)	11.1 – Collect in accordance with Schedule (Table 2) and Operations Manual including: Priority Locations, timing and methodology										
Target 12 – Investigate options to reduce lake wrack accumulation	12.1 – Investigate and where feasible trial boom designs to prevent wrack washing ashore at 2 priority locations										
	12.2 – Investigate and where feasible trial methods (including nets) to drag wrack into deeper areas										
	12.3 – Investigate and where feasible trial floating wetlands or other offshore barriers to reduce wrack build up in the nearshore and foreshore zones.										
Additional Actions for Wrack Management											
Target 13 – Review Wrack Management Strategy	13.1- Review WMS to ensure the program undertaken is current and meeting the needs of community as well as improving the health of Tuggerah Lakes.										
Target 14 – Long-term management aim	14.1 – Consult with and obtain funding and/or financial support from other responsible authorities such as Crown Lands and DPE with the aim to reduce ongoing expenditure resting with Council.										

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1 Introduction

This document is the Tuggerah Lakes Wrack Management Strategy (WMS). It provides an overarching method to Council and community for ongoing management of seagrass and macroalgal wrack in the estuary for the next 10 years. This document is part of a suite of documents that includes:

1. Wrack Management Strategy for Tuggerah Lakes
2. Operations Manual for Wrack Management
3. Monitoring and Evaluation Program for Wrack Management
4. Literature Review for Tuggerah Lakes Wrack Management Strategy

This document does not act as a control for activities listed outside of the above.

1.1 About the Wrack Management Strategy

This strategy documents the actions recommended for managing wrack in the Tuggerah Lakes estuary and the supporting evidence and rationale for those recommendations. The strategy aims to balance the need for wrack removal with the needs of additional ecological, social, and economic values that the lakes support.

The issue of wrack management in Tuggerah Lakes estuary has many facets. It is primarily an emotionally upsetting matter for residents and regular visitors to the Lakes. They see the condition of the estuary and it disappoints them that such a beautiful place appears to be so unwell. They consider it a living ecosystem and they would like to see it thriving.

The ecology of the Lakes is also out of balance. Previous research clearly shows that there is too much sediment and nutrients flowing into the system and no way for it to leave owing to large scale changes to the hydrology of the catchment and the nearshore dynamics within the lakes themselves. Prior to urbanisation and development within the catchment, the Lakes were deeper and there was nearshore mixing of waters that reduced some of the impacts seen today.

The costs of ongoing wrack collection and disposal have created an economic burden for Council and the community.

Development in the estuary and catchment are also adding to the propensity for flooding and erosion. The impacts of human-induced climate change will likely include an increase in flood events as a result of more frequent and intense rainfall events which will exacerbate the problems.

And all this while seagrasses worldwide are in serious decline. They are the nurseries for our fishes and support marine ecosystems in highly significant ways.

Central Coast Council engaged Alluvium Consulting Australia Pty Ltd to develop a Wrack Management Strategy for the Tuggerah Lakes estuary (the Strategy) through a process of collating and distilling sound scientific information and in-depth community and stakeholder engagement.

This Wrack Management Strategy integrates community aspirations with numerous scientific studies and reports into a document that includes a Plan for Action which is targeted, prioritised, costed, measurable, and achievable. It balances the needs of community with the demands of economics and aims to provide ongoing, consistent, and effective actions towards a sustainable system.

Council is responsible for preparing a Coastal Management Plan (CMP) in accordance with the requirements of the *Coastal Management Act* 2016 and the NSW Coastal Management Manual and implementing the gazetted CMP through their Integrated Planning and Reporting program and/or land use planning system.

This Wrack Management Strategy was identified as being required to address the issue of foreshore wrack accumulation during the Tuggerah Lakes Estuary CMP Stage 1 Scoping Study. This Strategy is now being prepared as a component of Stage 3 of the same CMP which Council is concurrently completing Stage 2 reports. The intention is for recommendations

and actions made as part of this Strategy to subsequently be incorporated into the Tuggerah Lakes Estuary CMP which is certified and then implemented over the following 10 years.

An Expert Panel Review into Tuggerah Lakes Water Quality supports the ideals of the community and is highly relevant to this Strategy. It states:

> *Strategic and measurable plans are required or need to be implemented for dredging, wrack management, nearshore water quality, stormwater management, entrance flood management and sustainable catchment development. These plans need to be integrated within the Coastal Management Program so that the development controls, stormwater actions, and entrance management (to name but a few) are aligned and supportive of a healthy and biodiverse coastal lake ecosystem. Furthermore, the plans need to be transparent, well communicated and openly discussed with the community in a proactive manner.*
>
> Glamore et al., 2020

1.2 Integration with Other Studies

There have been many studies, reports, and plans for the estuary, particularly over the last 20 years. The most current Estuary Management Plan will expire in December 2023. Council is now in the process of developing a new Tuggerah Lakes Estuary Coastal Management Program (CMP) that will be the central plan setting the long-term strategy for managing the estuary. The Coastal Management Program – Scoping Study (2021) was the first Stage in the five-stage development process for the Tuggerah Lakes Estuary CMP. This Strategy forms part of Stage 3 of the CMP's development and the alignment of this Strategy with the final CMP is outlined in further detail in Section 3.

The Wrack Management Strategy does not stand alone (refer Figure 1). It is informed by studies that have been completed or are still underway. As part of the development of this Strategy, a literature review was completed and a summary of this is provided in Appendix A.1 of this Strategy. The literature review has informed the understanding of the processes in operation in the Tuggerah Lakes estuary.

The previous Tuggerah Lakes Estuary Management Plan (2006) and the Tuggerah Lakes Water Quality Expert Panel Report (2020) recommendations, along with the Tuggerah Lakes Estuary CMP Scoping Study (2021) have been key documents informing the development of this Strategy.

The Entrance Management Strategy is currently underway with a view to planning the ongoing management activities at the ocean/estuary interface point. While this is a vital Plan, the modelling and historical operations that form its basis, do not recommend any significant alteration to the current Interim Entrance Management Procedure (2022). These are discussed further in the literature review, Section A.1. Catchment and flood management relating to Ourimbah Creek and Wyong River have also been considered.

As part of the Wrack Management Strategy, a Wrack Management Implementation Plan (see Appendix A.4.) has been developed along with a Wrack Management Operations Manual and a Wrack Management Strategy Monitoring and Evaluation Program (each standalone documents). The combination of these documents will guide Council with ongoing wrack management and operations for the next 10 years.

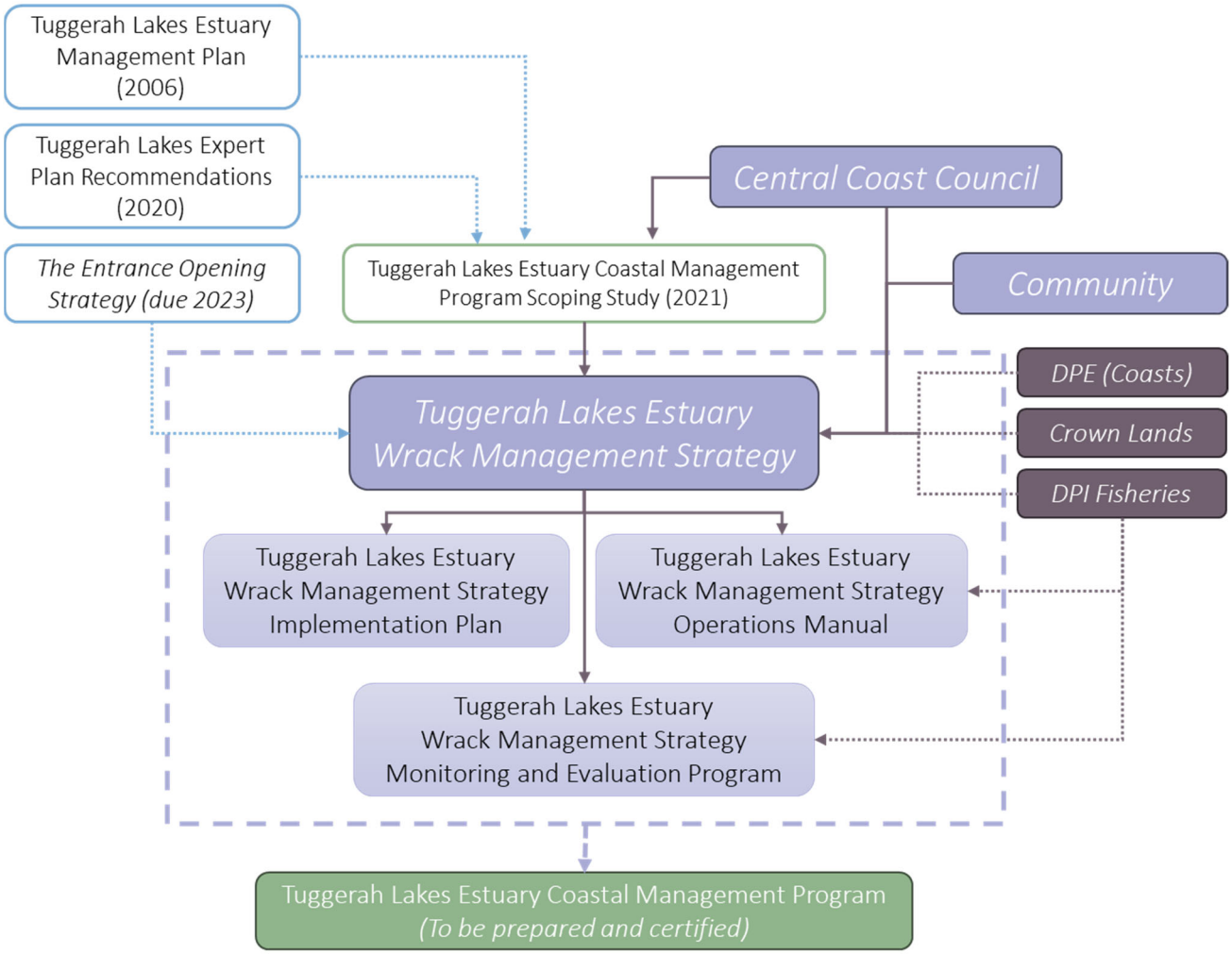

Figure 1 Integration of the Tuggerah Lakes Wrack Management Strategy

2 The Current State of Wrack Management

2.1 About Wrack in Tuggerah Lakes

Wrack is plant material moved about by wind and wave action and washed up on beaches and shallow areas. In the Tuggerah Lakes It is predominantly comprised of seagrass and seaweed (macroalgae).

Seagrass is a marine flowering plant that live underwater and need light to photosynthesise. It is highly specialised and has adapted to soft sediments in nearshore parts of lakes, estuaries, and oceans. Seagrass has many special values and provides a wide range of important services, including:

- Producing oxygen for other aquatic organisms, carbon fixation and nutrient removal.
- Supporting herbivores- and detritivore-based food webs and providing a food source for some species.
- Providing habitat – refuge, food, and reproduction areas for fish
- Contributing to water clarity by trapping sediment and associated nutrients.
- Dissipating wave energy and reducing onshore erosion (DES, 2019).

Seagrass meadows lose their leaves as a part of their natural growth pattern. Leaves float and are moved around by wind and wave action, accumulating around the shoreline areas of the estuary. This is a natural process that forms an integral part of the lake ecosystem with the wrack being carried onto adjacent habitats like saltmarsh where it provides nutrients, habitat for microbes and insects to feed, and in turn providing a food source for birds and other fauna.

Wherever there are seagrass habitats you also get wrack. Seagrass sheds its leaves seasonally in Autumn and Spring which results in leaves floating to the surface and accumulating on the foreshore of the lakes (SKM 2008).

Wrack also contains macroalgae which commonly grows in estuarine environments and is part of the nutrient cycling within the estuary system. Macroalgae grow throughout the year, but often growing rapidly in spring and summer. When excessive nutrients enter the estuary through the stormwater system and ground water leaching, disproportionate growth of macroalgae can occur causing algal blooms. When we refer to wrack in this Strategy, this includes both seagrass and macroalgae.

Whilst wrack build up is a natural process and wrack has environmental benefits, the community see managing wrack as a priority issue primarily to improve amenity and recreational values across the Lakes. Photos supplied by community members as shown in Figure 2 illustrate the impact wrack has on the Community's amenity and recreational values and uses of the estuary.

Figure 2 Community supplied photographs of examples of wrack accumulation around the shoreline of Tuggerah Lakes

In a natural system wrack is typically deposited in the highwater zones during the tidal cycles where it gradually breaks down providing nutrients for the system (Figure 3).

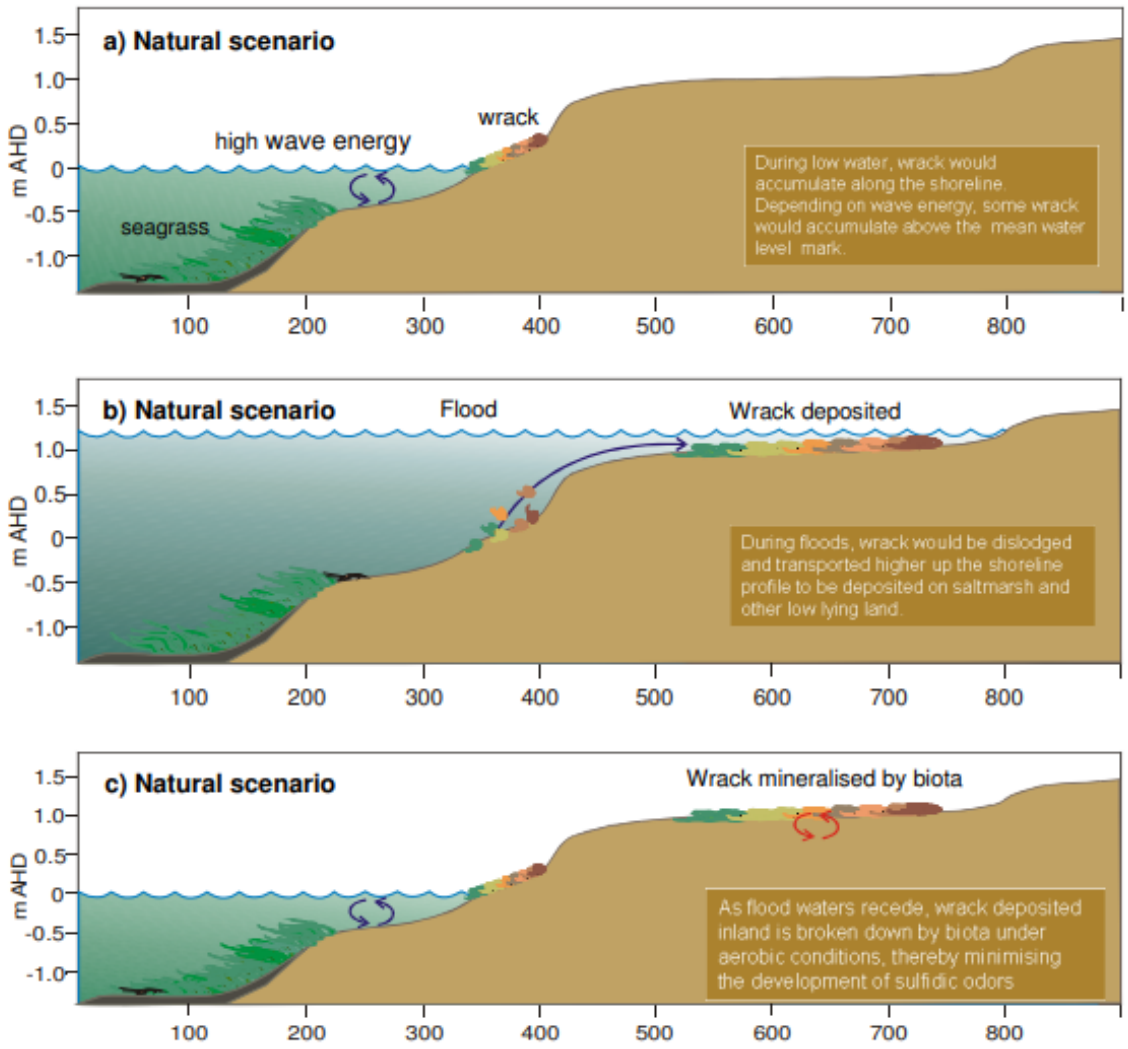

Figure 3 Natural scenario of wrack deposition in the high-water zone (Figure sourced from OEH 2013**)**

The Tuggerah Lakes estuary contains more nutrients and sediments than it would naturally as a result of clearing and development in the catchment. The combination of nutrients and sediment accumulate most frequently near stormwater and creek inflow points and form a heavy sediment which in some locations where water movement is limited, enables the formation of monosulfidic black ooze (OEH 2013).

The increased nutrient and sediment loads contribute to a decrease in water clarity (an increase in turbidity) which impacts on seagrass meadows by decreasing available light for the plants to photosynthesise. In response to these conditions, seagrass meadows within the lake are now located in shallower waters where more light is available through the turbid water column (CCC 2021a). These shallower waters often coincide with areas of sedimentation where ooze is also present.

Another exacerbating factor is the impact from wind and wave action whereby all of the above, seagrass leaves, macroalgae, nutrients and sediment, are pushed into foreshore. Part of the natural process for seagrass wrack includes assistance from the varying water levels, waves, and wind to push floating seagrass debris up onto lake beaches and even further into saltmarsh and other vegetation communities. This process has been impeded by alterations to the foreshore

that stop the wrack from leaving the water. In these locations, collection from water may be inhibited because of the shallow water.

The complex combination of drivers and impacts associated with wrack accumulation in the estuary is illustrated in the flow diagram in Figure 4. The problem is a compound one for which there is no single easy solution.

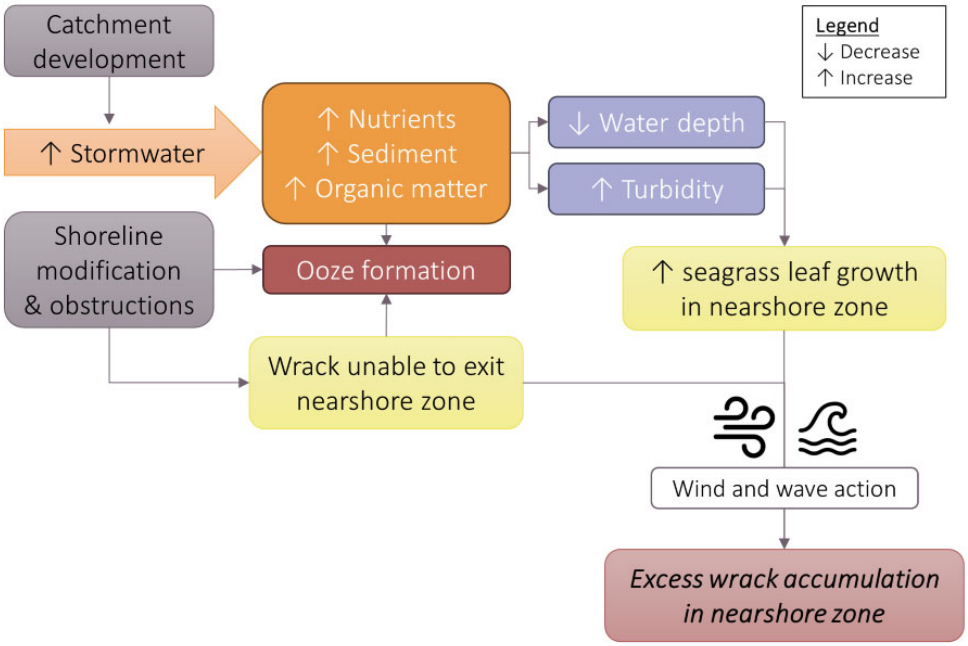

Figure 4 Excess wrack accumulation in nearshore zones. Direction of arrows indicate either an increase (upward) and decrease (downward) of the factors contributing to excess wrack accumulation.

The catchment:

The Tuggerah Lakes estuary is in a catchment that covers an area of 790km^2 and includes five major creeks and rivers (see Figure 5), which has an annual flow of 193,000 million litres per year. The main streams that feed into the estuary includes Wyong River and Ourimbah Creek, which collectively make up 75% of the catchment and form an important component of the Central Coast Water Supply Network (Cardno 2008, Central Coast Council 2021). The smaller tributaries in the catchment include Wallarah Creek, Tumbi Creek and Saltwater Creek (Central Coast Council 2021). The inflow into the estuary is mostly from the catchment during rainfall events that are sufficient to produce overland flow (Central Coast Council 2021).

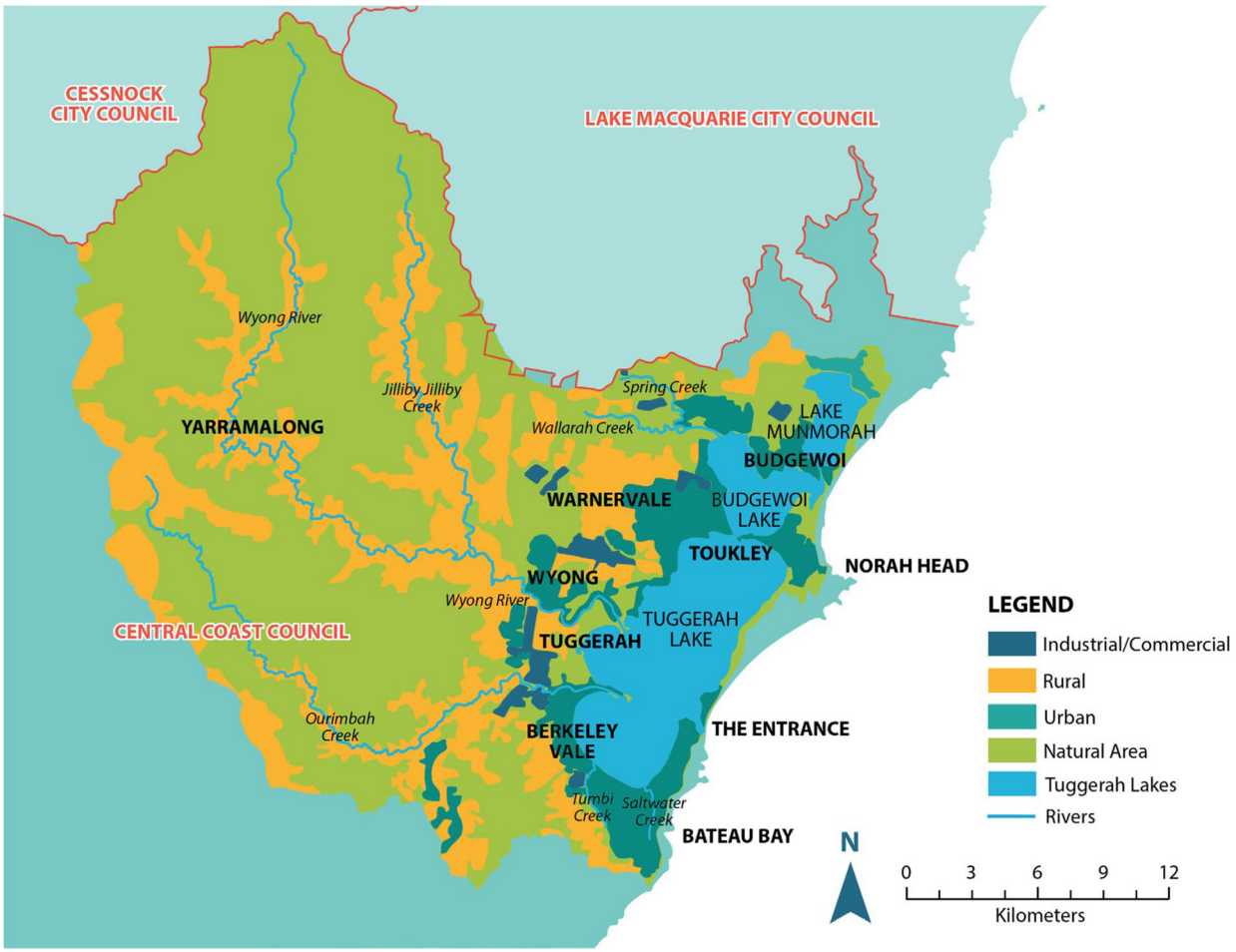

Figure 5 **Tuggerah Lakes catchment map** (Sourced from the CCC EMP Scoping Study 2021)

Tidal inflows only account for approximately 1-3% of the lake volume every day and causes a gradual increase in salinity within the estuary during dry periods. The estuary is considered a non-tidal system with water movement largely driven by wind rather than the tidal forces exerted by the moon. The catchment has been heavily modified over the years, including extensive clearing of river valleys, riparian corridors and has undergone broad-scale urban development (Central Coast Council 2008). This has resulted in a reduction in vegetation, a reduction in natural surfaces that allow rainwater to infiltrate, an increase in the amount of nutrients from farming and waste, an increase in the amount of sediment, and an increase in the amount of water that enters the lower system.

The seagrass:

Seagrass in Tuggerah Lakes consists of relatively stable beds of *Zostera muelleri subsp. capricorni* and more ephemeral patches, primarily of *Halophila ovalis* (Chapman & Roberts 2004, SKM 2008). There are also some small patches of *Ruppia spp.* also present (SKM 2008). Over recent years there has been an increase in fine sediment input into the estuary from the catchment. This has resulted in increased turbidity in the water column and subsequently unfavourable conditions for seagrass. As a result of unfavourable conditions, increased macroalgae and increased bioavailable nutrients, seagrass beds are located closer to the shoreline where there are more favourable light conditions (Central Coast Council 2021). The seagrass meadows may include other structural macrobiota such as encrusting algae, bryozoans, sponges and molluscs, polychaete worms and mobile invertebrate fauna such as sea cucumbers and crabs.

The shoreline:

Where once the seagrass leaves would have blown and washed up onto beaches and saltmarshes, modifications to the shoreline (such as steep banks, rock walls, retaining walls, etc) limit the capacity for seagrass to be naturally deposited

above the high-water level. Figure 6 provides a visual description of the foreshore which consists of the water's edge and the shallow water (up to 50cm in depth).

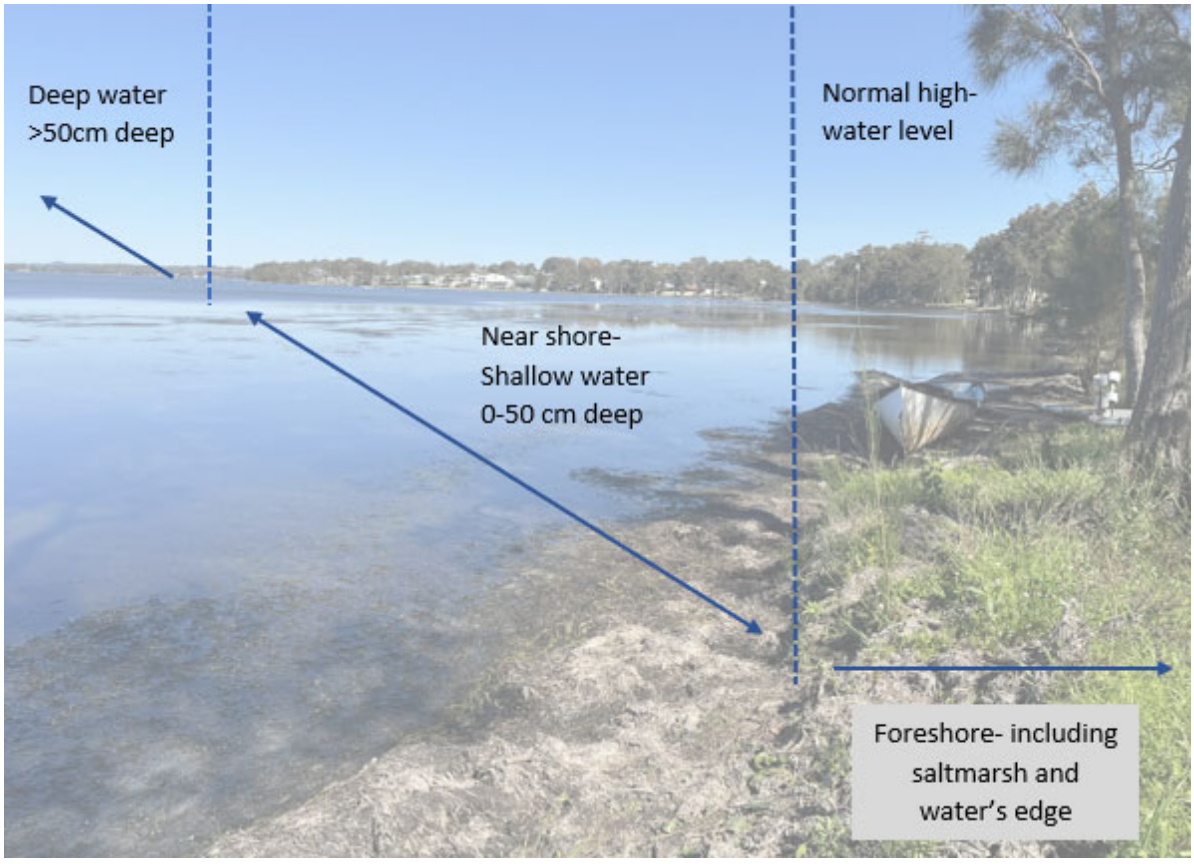

Figure 6 Diagrammatic representation of estuary waters and foreshore area

Groundwater seepage:

In some locations, groundwater containing excess nutrients, seeps to the surface around the shoreline (OEH 2013a). This can result in black sulfidic ooze generated in conditions where there is a lack of oxygen to assist with the breakdown of materials. Seagrass and algal wrack can accumulate over these locations and further reduce the availability of oxygen, thereby increasing the production of black ooze.

2.2 Past and Current Wrack Management

2.2.1 Description of current wrack collection

The current wrack collection process is shown diagrammatically in Figure 7. The process is approved by the NSW Department of Primary Industries, Fisheries permit and associated Environmental Management System. Any variation from the approved process requires further approval from Fisheries. The Operations Team at Council receives requests from the community to clear wrack from various locations and responds by collecting when and where possible under the constraints imposed by the equipment, access, and drying pad and mooring locations. The volumes of wrack collected, the associated by-catch are recorded, and the collected wrack is disposed of after drying, to landfill or for treatment before inclusion into a mulch product.

Currently, one contractor is employed by Council to collect all the wrack in this responsive manner. Previously, equipment that was owned by Council collected the wrack.

The process is described in more detail in this section.

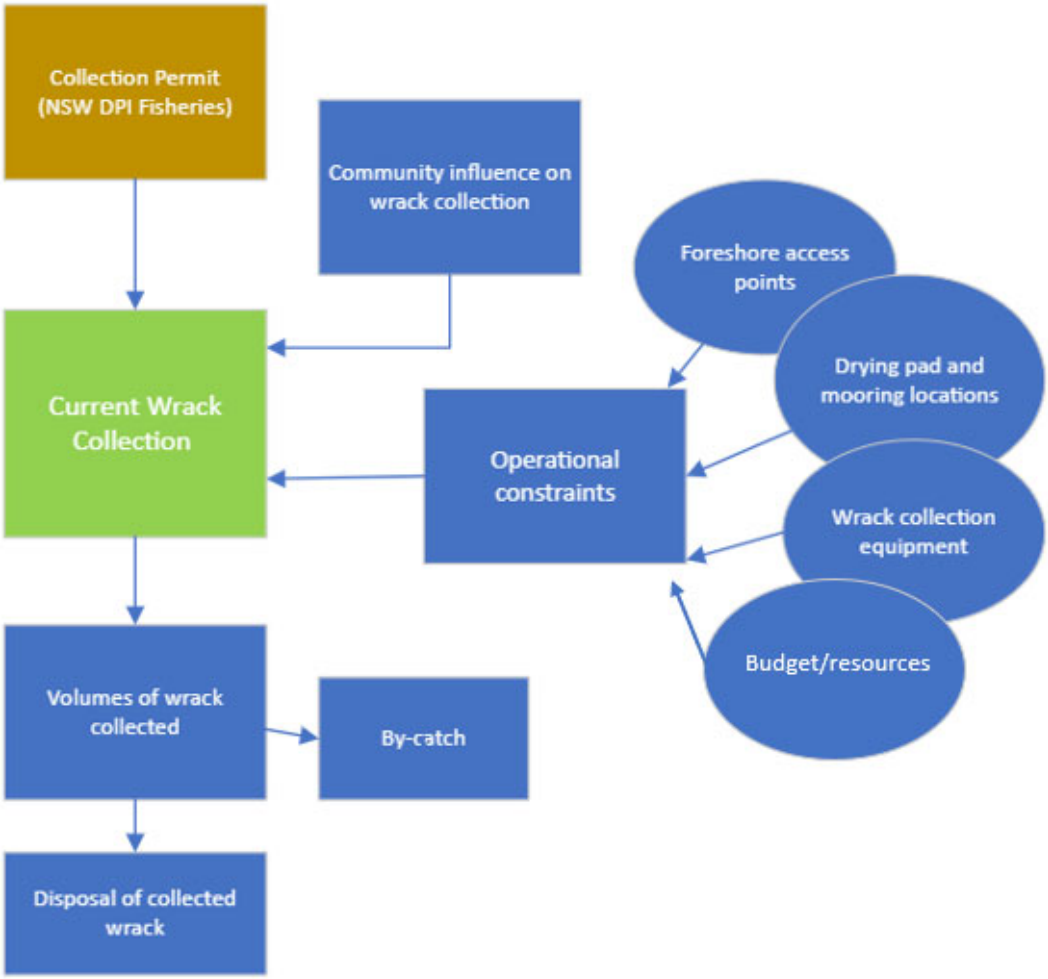

Figure 7 Current wrack collection process

2.2.2 Wrack collection permit

Currently seagrass and algal wrack accumulations are collected by a contractor under Council's NSW Department of Primary Industries -Fisheries permit. The current permit was issued a Permit Extension ensuring wrack collection activities can occur as currently permitted until 30 June 2027.

Wrack collection activities can occur within the permit area which includes foreshores from the HAT (highest astronomical tide) out to and including the middle of the estuary. No wrack is to be collected from within 100m of the HAT at nominated exclusion zones, or offshore from these over live seagrass beds.

There are several conditions stipulated as part of the permit, these include:

- Providing records of operations (locations, methods, volumes, etc.).
- Not collecting from the middle of the estuary October to February (Garfish spawning and hatching time).
- Collection will be based on Council's submitted Environmental Management Plan (EMP) 36 – Wrack and Algae Collection, as well as reported accumulations.
- Not harming any living seagrass.
- Any dead or sick fish to be reported to Fisheries immediately.
- Ensuring equipment management minimises risk of spill incidents.

2.2.3 Wrack collection volumes

Based on Council's operational data records, between 12 June 2020 and 2 May 2023, a total of 22,220 m^3 of wrack was collected across the estuary. Majority of the wrack was collected almost evenly between Budgewoi Lake and Tuggerah

Lake with only a small amount, less than 3% collected from Lake Munmorah as shown in Figure 8. This figure also shows that most of the wrack is collected from the nearshore and deep-water zones of the lakes in areas with depths of 0mm to 1m. The production of wrack is seasonal, spasmodic, and inconsistent. Most seagrass wrack is produced during the natural seasonal leaf shedding events usually occurring in Spring and Autumn although other factors such as stress and wave impacts can result in leaves detaching. Collection between the three lakes seems to be relatively consistently split between the four seasons, except for Tuggerah Lakes which has noticeably more wrack collected during the winter months (Figure 9).

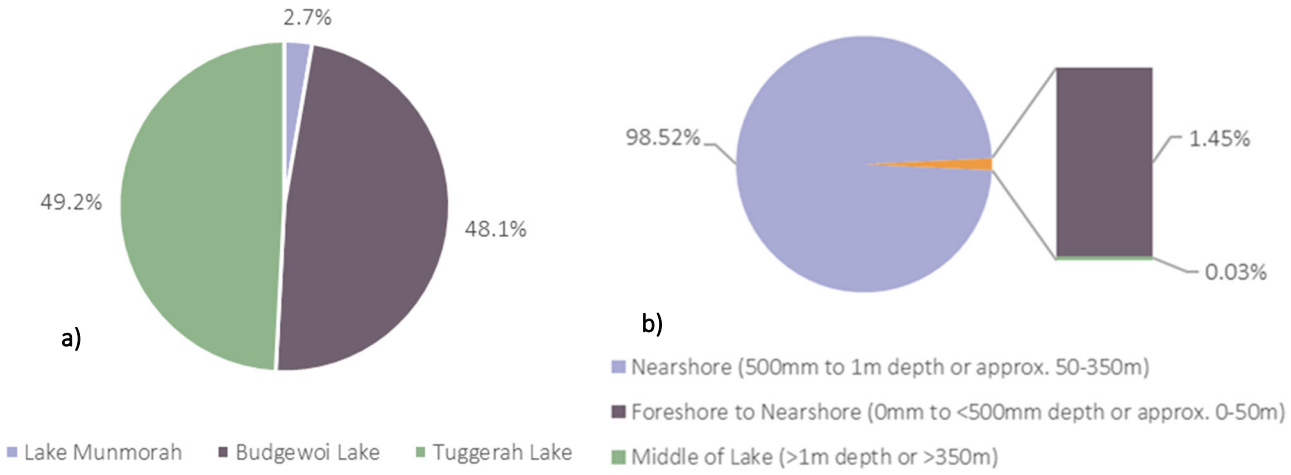

Figure 8 a) % total volume (m^3) collected, and b) % total volume (m^3) collected by lake zone. (note: operational activity reports have been identified as being inaccurate in describing water depth. Nearshore collection 0mm to 50cm).

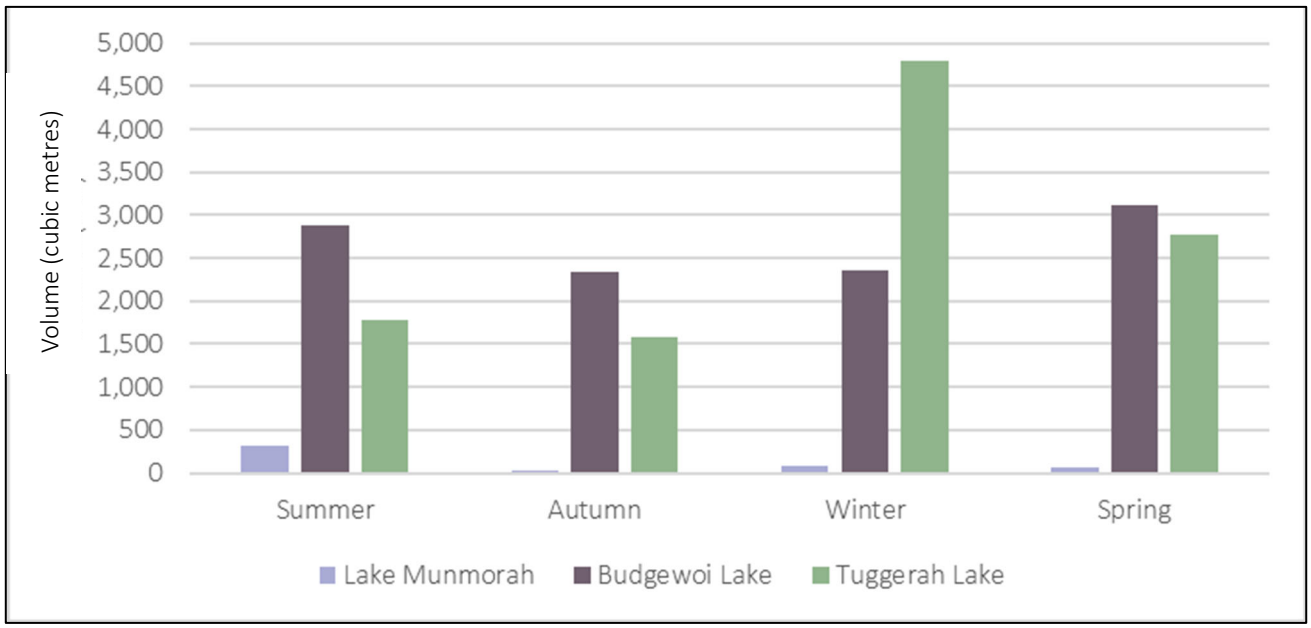

Figure 9 Total wrack volume (by cubic metre) collected by season

2.2.4 Community influence on wrack collection

Most of the wrack collection undertaken between June 2020 and May 2023 is believed to have been in response to community requests for collection, possibly due to numerous flood events and Covid-19 work-from-home orders providing greater opportunity for residents to observe wrack dynamics in the estuary. Strategic pre-emptive wrack collection appears to be limited because of these increased collection requirements. Figure 10 and Figure 11 identify the location of wrack collection (black points) overlaid on a heat map of community service requests received by Council regarding wrack over a five-year period from January 2018 and December 2022. Across this five-year period there were 821 service requests, an average of over 3 individual requests per week. As the figures demonstrate, the existing wrack collection activities closely mirror the location of community complaints regarding wrack accumulation, suggesting wrack collection is largely in response to community complaints.

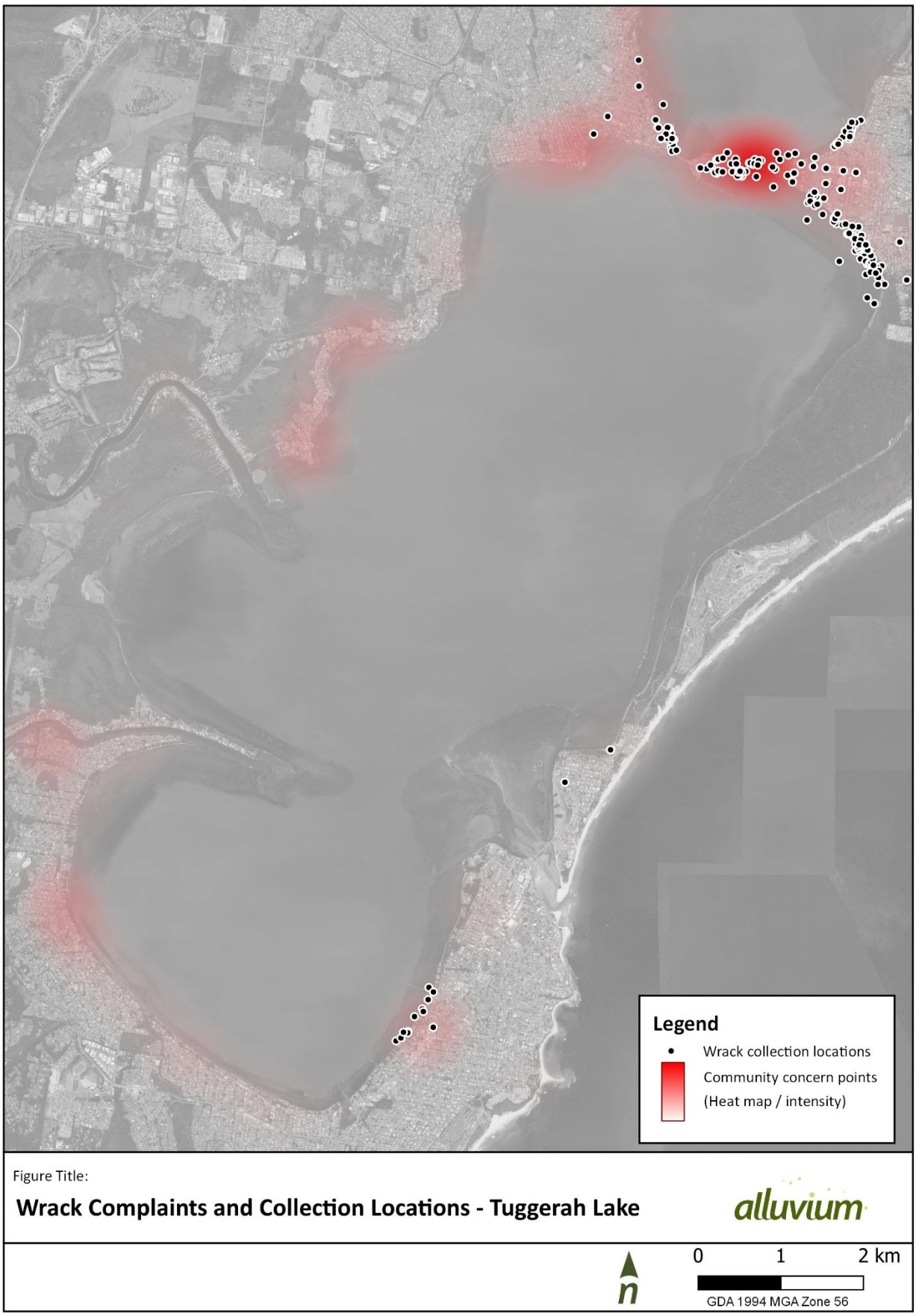

Figure 10 Wrack complaints and collection locations – Tuggerah Lake

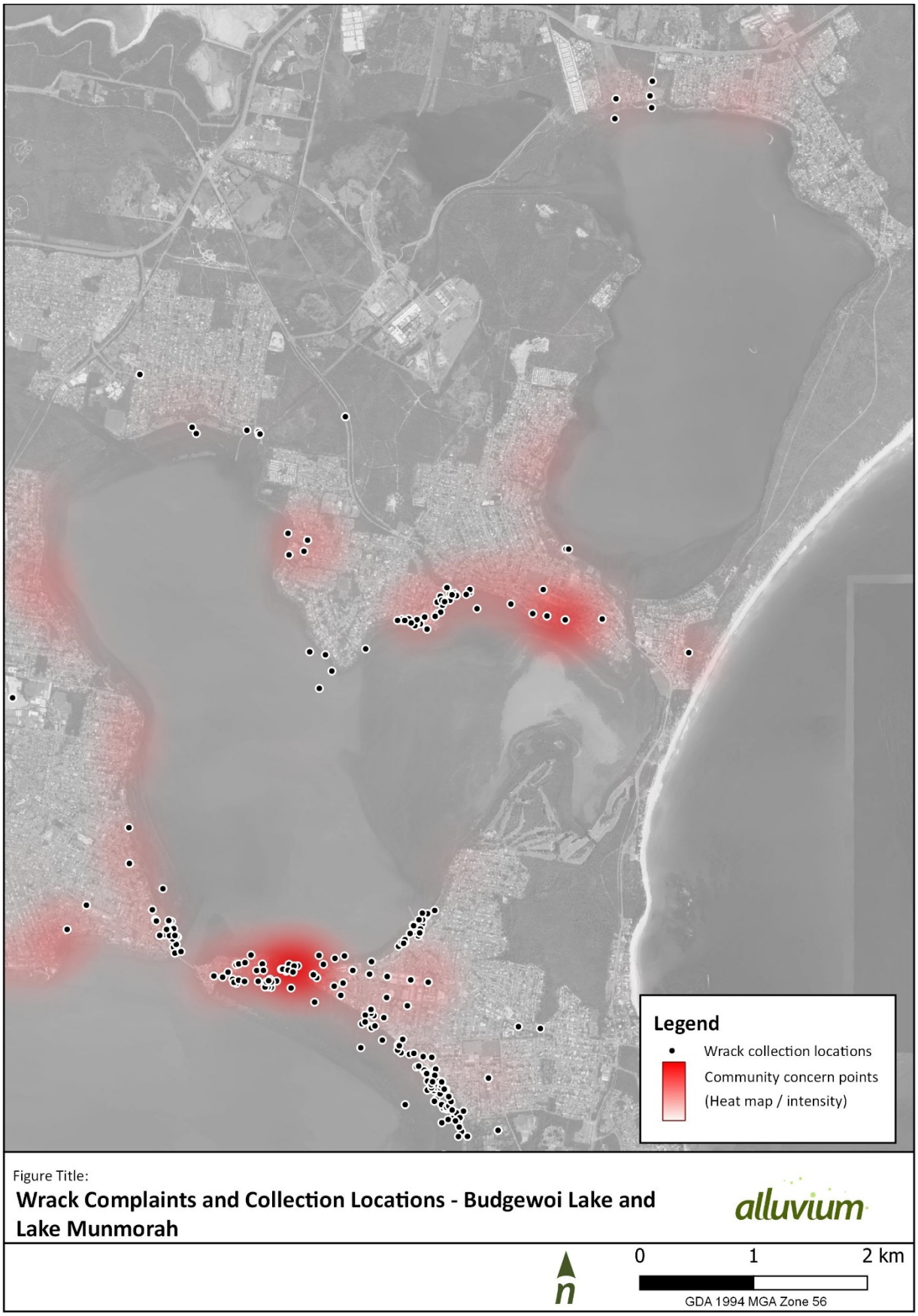

Figure 11 Wrack complaints and collection locations – Budgewoi Lake and Lake Munmorah

2.2.5 Operational constraints

There are numerous constraints on the current wrack management program that have contributed to the development of this strategy. The Tuggerah Lakes Coastal Management Program Scoping Study Appendix D – Environmental Context (Central Coast Council, 2021 p.22) stated that managing wrack in both a responsive and a proactive/strategic way is not possible within the constraints of the available resources.

"As it currently stands, managing wrack in both a responsive and proactive/strategic way is not possible within the constraints of the available resources. A review of wrack management will be a key feature of the CMP and a key touch point in the community and stakeholder engagement activities. It will be important for all parties to evaluate the challenges of developing and delivering an effective wrack management program holistically, and together formulate a new, collaborative way forward."

The operational limitations are not just based on available budget and resources. Constraints also include physical elements of the lake, such as water depth, bed materials, rocky shorelines, the presence of saltmarsh, presence of seagrass beds, presence of phragmites near stormwater outlets, the presence of ooze and infrastructure such as jetties and wharves. Mapped physical wrack collection constraints are illustrated on

Figure 12 Areas of Tuggerah Lakes where wrack collection is physically constrained by lake features

. Permit conditions do not allow for the disturbance of sediment, harm to live seagrass, saltmarsh or bed materials such as ooze. Machinery cannot reach in close when the water is too shallow, where the shorelines are rocky, or where endangered ecological communities such as saltmarsh or swamp oak floodplain forest or tall reeds such as phragmites have built up.

Previously tried methods that have not been adopted have included:

Raking to deeper water: can be of assistance in some locations, however, disturbance to the lakebed and to existing seagrass in very shallow waters can be damaging.

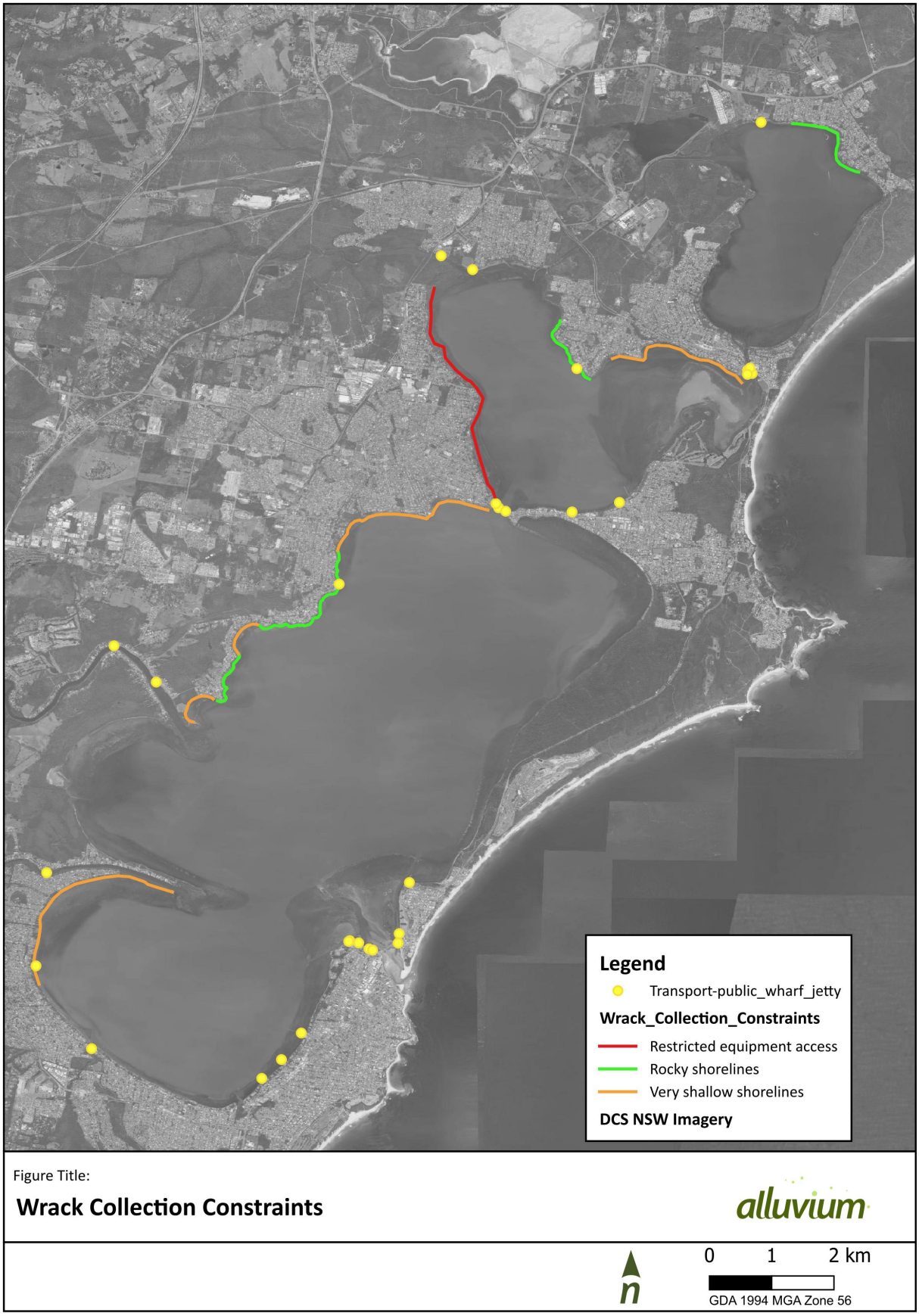

Figure 12 Areas of Tuggerah Lakes where wrack collection is physically constrained by lake features

2.2.6 By-catch

The DPI Fisheries Permit stipulates adherence to Council's Construction Environmental Management Plan (CEMP) (EMP-36 – refer to Section 3.2) which includes several methods that will be used to reduce by-catch of Syngnathiformes. These include the use of straight bar mesh across the conveyor with an aperture of 15.5mm and sprayers to be fitted above the conveyor to dislodge any small fish.

The Truxor uses attachments such as rakes, baskets, and buckets to remove the accumulated wrack. It is proposed that these fittings allow time for any by-catch caught up in the wrack mat to escape before the wrack is deposited onshore (GHD 2020).

Part of the wrack collection process involves recording by-catch during collection and during storage on drying pads (CCC 2023). There is very little data available which indicates the monitoring method may be inadequate, as it is unlikely that there would be no by-catch of any species caught as part of the process.

NGH (2021) surveyed, reported, and concluded that the use of the Truxor was resulting in Syngnathids and Sea Garfish eggs by-catch. Although the study was limited by location, environmental variations and suitability of habitat surveyed, Syngnathids were present in the floating wrack over seagrass beds, but not in decaying wrack onshore.

2.2.7 Foreshore access points

The three lakes that make up the estuary cover a considerable distance. Travelling around the estuary to access the estuary, and then travelling within the estuary to the wrack is a significant time constraint on the wrack collection process. Travel within the estuary from the points of collection to the exit points or to the wrack drying pads, is necessarily slow because of the distances between and the design of the collection equipment. Collection by the amphibious equipment is restricted by access points as it is not designed for traveling long distances.

2.2.8 Drying pad locations and efficiencies

There are 44 drying pads across the estuary, however, seven of them are most frequently used by the collection contractor because of their accessibility and size. The distances that require covering between access points, mooring locations, and drying pads contribute significantly to the time required to complete collection operations.

The drying pads are shown in Figure 13 and listed below:

- Long Jetty – Saltwater Creek boat ramp, corner of Tuggerah Parade,
- Gorokan – Peace Park near Toukley Bridge and Gorokan Fishing Co-Op,
- Oleander Street Toukley – on foreshore in Tourist Park, Council will issue swipe card which is required to gain access through the boom gate,
- Natuna Avenue, Budgewoi West of toilet block on foreshore,
- Mimosa Road, Budgewoi behind Landcare site on foreshore,
- Kamilaroo Avenue, Lake Munmorah, Lane access way to foreshore opposite mobile home village/caravan park,
- Buff Point- Access via reserve on Woodland Parkway, and
- Lake Munmorah, off Colongra Bay boat ramp – ID No. CL8367.

Figure 13 Drying pad locations most frequently used

2.2.9 Disposal of wrack

The wrack is collected and stored on drying pads at various locations around the estuary (see Figure 13). After a period of drying, depending on prevailing conditions (e.g. hot dry weather results in wrack drying out enough to transport within a few weeks), the dewatered wrack is loaded onto Council trucks and transported to Australian Native Landscapes (ANL)

where it is processed at Buttonderry Waste Management Facility as either an addition to a mulch product or as landfill if contaminated with sand or other materials.

Disposal of the wrack within the estuary system includes its use as mulch on gardens in adjacent areas, and its decomposition as part of the natural process, especially in relation to saltmarsh areas where it is part of the nutrient cycle in the estuary. Wrack left on shorelines in Reserve and National Park areas provides habitat and a food source for insects, birds, and other wildlife.

2.2.10 Commercial mooring locations

There are eight commercial mooring locations that are provided and paid for by Council to facilitate the wrack collection operations. These are required for use by the Contractor to create time efficiencies when working in the same area over multiple days. The distances required to be travelled between access points and drying pads as well as mooring locations contribute significantly to limitations on efficiency.

Full details of wrack collector Commercial Mooring Locations can be obtained from Council, however, the following general locations are:

- 2 locations at Wyong River, South Tacoma – ID No. CL5233 & CL5439
- Saltwater Creek, Long Jetty – ID No. CL5437
- Tuggerah Lakes of Canton Beach Holiday Park, Canton Beach – ID No. CL5463
- 2 locations in Budgewoi Lake – off the wrack drying pad at Peace Park, 1 The Corso, Gorokan, and another off the Marine Rescue at Osbourne Park, Peel Street, Budgewoi – ID No. CL8368
- Jetty and mooring piles, Diamond Head Drive, Budgewoi – License No. 383958

3 Legislative context for wrack management

3.1 Coastal Management Act 2016 (and associated framework)

The NSW Coastal Management Framework, which comprises various key elements including legislation (Figure 14), governs the management of the open coast, estuaries, and marine estate of NSW (NSW Government, 2018). It is the framework that provides the context for the wrack management strategy.

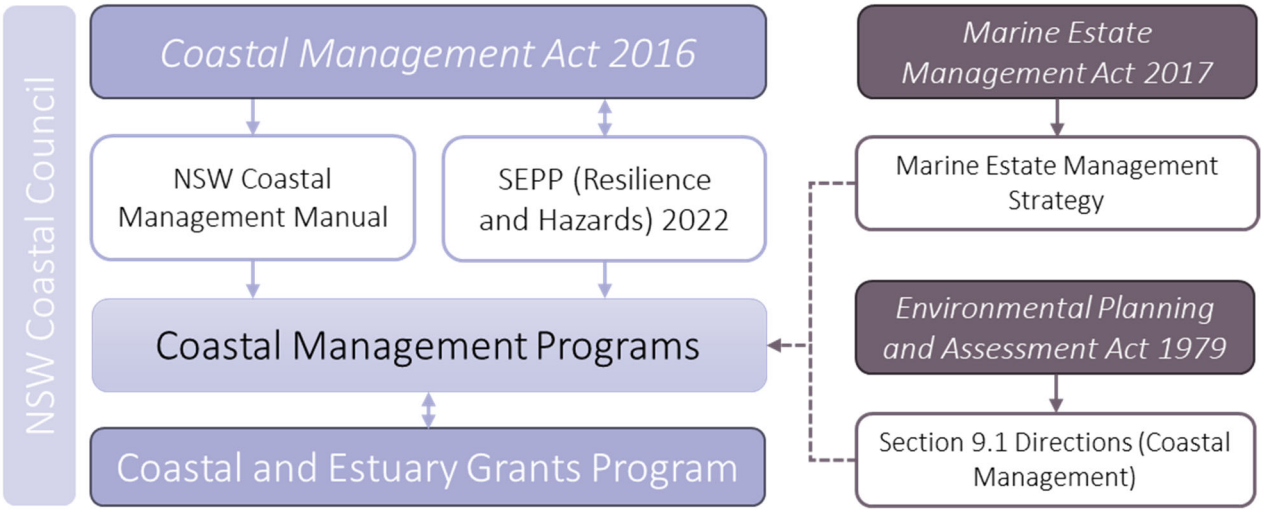

Figure 14 NSW Coastal Management Framework

The *Coastal Management Act 2016* is a central component, providing the statutory framework for coastal zone management in NSW and the minimum requirements for the preparation of a Coastal Management Program (CMP). The *Coastal Management Act 2016* states that "the purpose of a coastal management program is to set the long-term strategy for the co-ordinated management of land within the coastal zone with a focus on achieving the objects of this Act".

The NSW Coastal Management Manual sets out the stages to preparing a CMP (Figure 15) and mandatory requirements for completing each stage. It also provides guidance and information to Council in completing each stage of the CMP and integrating a CMP into the Integrated Planning and Reporting (IP&R) framework.

Council is responsible for preparing a CMP in accordance with the requirements of the Coastal Management Act 2016 and the NSW Coastal Management Manual and implementing the gazetted CMP through their IP&R program and/or land use planning system.

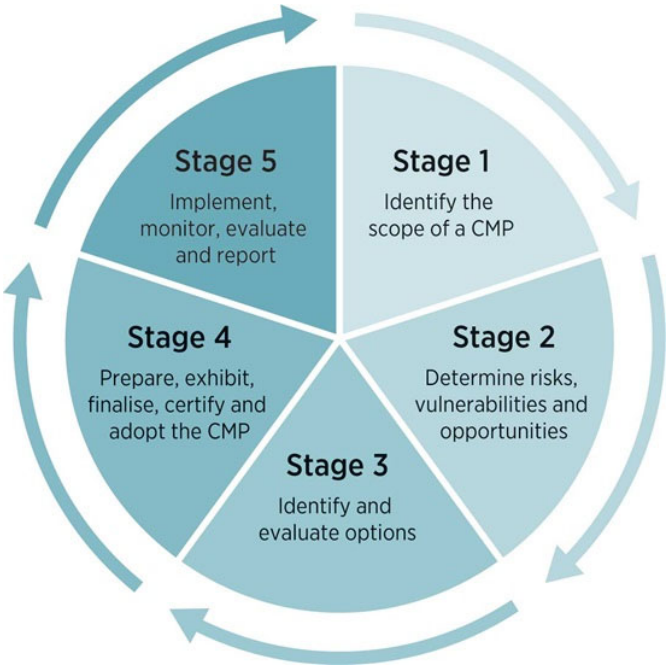

Figure 15 CMP Development Stages (OEH, 2018)

In implementing a certified CMP Councils can apply for funding under the NSW Government's Coastal and Estuary Grants Program. This program provides technical and financial support to local government to help manage the coastal zone.

The program is intended to support coastal and estuary planning projects and the implementation of works identified in certified CMPs, however grant offers are subject to statewide priorities and availability of funds each financial year.

Funding is available under streams and in terms of implementation of CMP, projects need to fit into 1 of 4 streams being, coastal vulnerability area, coastal wetland and littoral rainforest areas, coastal environment area or coastal use area (these areas referred to those mapped as part of the SEPP (Hazards and Resilience) 2021).

This Wrack Management Strategy was identified as being required to address the issue of foreshore wrack accumulation during the Tuggerah Lakes Estuary CMP Stage 1 Scoping Study. This Strategy is now being prepared as a component of Stage 3 of the same CMP which Council is concurrently completing Stage 2 reports. The intention is for recommendations and actions made as part of this Strategy to subsequently be incorporated into the Tuggerah Lakes Estuary CMP which is certified and then implemented over the following 10 years.

The entire Tuggerah Lakes waterbody and foreshore areas are mapped as Coastal Environment and/or Coastal Use areas (with small pockets of coastal wetlands) as shown in Figure 16. As such, actions included in the Tuggerah Lakes Estuary CMP to address wrack management will be eligible for funding under the various relevant implementation streams of the NSW Government's Coastal and Estuary Grants Program. Noting that, the grant applications for these actions will also be required to meet the other eligibility criteria, objectives and priorities outlined by the program. Currently the NSW Government will provide $2 for every $1 provided by Council (2:1 ratio). However, it should be noted that the Coastal and Estuary Grants Program ***will not fund the proportion of works of an application that are deemed to be for private asset protection or private benefit****, which* constrains the activities that can be included in the wrack management strategy.

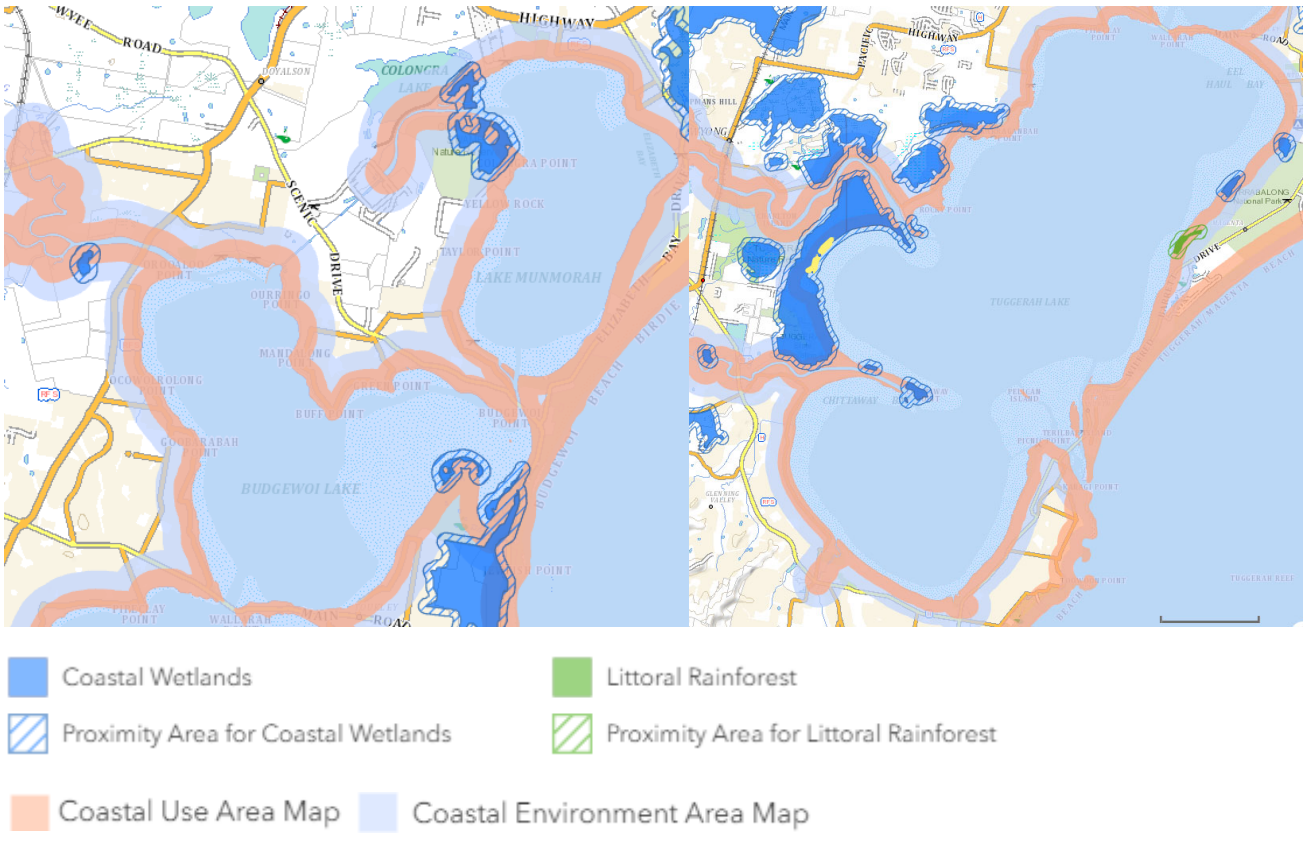

Figure 16 SEPP (Resilience and Hazards) 2021 Mapping

3.2 Fisheries Management Act 1994

The *Fisheries Management Act 1994* relates to the management of fishery resources and is primarily administered by the Minister for Primary Industries. The NSW Department of Primary Industries issue permits for activities impacting on aquatic habitats and species as specified under Part 7 of the Fisheries Management Act 1994. Activities that require a permit relate to dredging and reclamation work, obstructing fish passage, using explosives and dangerous substances or harming marine vegetation.

DPI Fisheries, a division of NSW Department of Primary Industries, assess applications to harm marine vegetation in accordance with Part 7 of the *Fisheries Management Act 1994*, Part 14 of the *Fisheries Management (General) Regulation 2010* and the *Policy and Guidelines for Aquatic Habitat Management and Fish Conservation (2013).* Central Coast Council currently have a permit issued by DPI Fisheries, permit number PN19/220 to harm marine vegetation associated with seagrass wrack collection in Tuggerah Lakes. This permit will maintain active until 30th June 2027.

As part of the development of this Strategy the project team met with the relevant DPI Fisheries point of contact who is responsible for reviewing and issuing permits across the central coast region. Key findings from this engagement in relation to the Tuggerah Lakes Wrack Management Strategy include:

- Fisheries prefer wrack remains untouched and consider Tuggerah Lakes to be a one-off situation and somewhat unprecedented in terms of wrack collection permitting.
- When reviewing the Strategy, Fisheries are looking to see that disturbance is minimised and that there is no disturbance or damage to seagrass, saltmarsh and wildlife.
- Fisheries will consider any approach that is put forward to them for permitting as long as it considers all impacts and is fair and reasonable.
- Confirmed that Fisheries allow individuals to remove up to 20 kg/day of dead seagrass or macroalgae (wrack) for personal use without a permit.
- Post collection if the wrack becomes a commercial use product e.g. mulching, composting, biochar etc. then a separate permit would be required.

The NSW DPI *Policy and guidelines for fish habitat conservation and management (2013)* confirms Fisheries policies on gathering and collecting of marine vegetation. Section 3.2.3.3 item 3) states that *"NSW DPI will generally allow persons to remove up to 20kg/day of dead or dislodged seagrass or macroalgae (wrack) from beaches or the intertidal zone for personal use (e.g. as mulch, fertiliser)".* Additionally, this document outlines the following guidelines for implementing policies related to marine vegetation collection under Section 3.2.3.3:

a) Where wrack is causing a public nuisance, NSW DPI will encourage members of the community to work with their local Council to coordinate local solutions, where feasible.

b) For proponents (e.g. Councils, local landholders) wishing to remove wrack that is causing a public nuisance, NSW DPI will generally include a permit condition requiring the wrack to be retained in situ by moving it along the foreshore and/or burying it under sand away from areas where it is considered a nuisance. However, where this is not a feasible option, NSW DPI may approve other options to remove and dispose of the vegetation. NSW DPI will also generally include a permit condition requiring a management plan outlining management and disposal arrangements for wrack in areas where it is known to be problematic to the community. The plan, submitted with a permit application for assessment, should outline quantities of wrack to be removed, where, when and how the wrack is to be removed and methods of disposal.

3.2.1 Environment Protection Authority

The Environment Protection Authority (EPA) provides an exemption on the disposal levy for community services or activities such as wrack disposal. The EPA Raw Mulch Exemption obtained by Council lasts for two years and is renewed on an ongoing basis. Council has a risk management protocol entitled Mulch Guidelines.

4 The Strategy

4.1 Aims of the Strategy

The core aims of the Strategy ascertained from the literature and the CSRG are to:

- Conserve seagrass meadows within the estuary,
- Improve nearshore water quality for ecological outcomes,
- Improve access for community use of the estuary by reducing wrack accumulation,
- Observe the legislation and comply with the conditions of the Fisheries Permit PN19/220,
- Improve community perceptions for future wrack management,
- Improve community satisfaction,
- Establish monitoring, evaluation, and reporting that is reportable to community, and
- Improve biodiversity within the Lakes.

4.2 Limits and boundaries of the Strategy

Although it is well recognised that there are multiple issues impacting on Tuggerah Lakes and how seagrass and algae wrack is produced, the main aim of this Strategy is wrack management. Where the cause of wrack development and its accumulation is generated higher in the catchment, implementation activities have not been included in the assumption that these will be considered as part of Council's CMP and Council's Development Control Plans for future developments.

Suggestions have been included for consideration and investigation around nutrient reduction in the estuary and some consideration is also given to ooze management, although implementation of this falls outside the scope of this Strategy. Further studies and investigations form part of the Strategy but have been limited to those that are directly associated with seagrass and algae wrack management and collection.

4.3 Development of the Wrack Management Strategy

The approach taken in developing the Wrack Management Strategy for the estuary centred on integrating up to date scientific knowledge with community views and aspirations for the estuary. The two key components that formed the basis of Strategy development include:

1. Literature Review – a literature review investigating aspects that influence wrack management was undertaken. The literature review covered: the current program (drivers, methodology, collection activities, limitations, and impacts), previous scientific studies and research relevant to wrack collection activities, Tuggerah Lakes estuary dynamics and scientifically sound and feasible recommendations, contract arrangements, machine and equipment suitability, permitting and approval conditions and cost and sustainability opportunities. The review collated the recommendations, constraints and conclusions from these studies which formed the basis of the Strategy's development. A summary of key literature review findings is provided in Appendix A.1.

2. **Community and Stakeholder Engagement** – a range of community and stakeholder engagement activities were undertaken to ensure that the Strategy developed was community and stakeholder driven and supported. One on one consultation was conducted with core Central Coast Council employees that are central to wrack management along with key state government departments most notably the Department of Planning and Environment (DPE) Coastal division responsible for overseeing CMP development and the Department of Primary Industries (Fisheries) who is responsible for permitting wrack collection activities. A Community and Stakeholder Reference Group was formed, and three extensive workshops carried out with them throughout the Strategy's development. Community drop-in sessions were also held to discuss the draft Strategy with the broader general public. Further detail on stakeholder and community engagement outcomes are discussed in Appendix A.2.

The result is a Strategy based on the latest scientific literature and recent research integrated with a detailed understanding of the environmental, social and economic contexts of the Tuggerah Lakes estuary and catchment whilst being legislatively permissible (e.g. approved by Fisheries) and supported by the community and stakeholders.

The scientific literature provides a detailed understanding of the processes around seagrass and macroalgal wrack accumulation under natural and modified conditions. Wrack accumulation is primarily driven by wind direction and velocity along with seasonal variations in seagrass growth. Wrack formation and dispersal is a natural and ecologically important process to the Tuggerah estuary providing various ecosystem services. Unfortunately, the extensive modification of the estuary shorelines (as well as changes in the water levels through entrance management) has altered where wrack accumulates, the rates of accumulation and how it is broken down over time.

Under natural conditions (before lake/shoreline modifications, it is likely that there were more frequent fluctuations in lake height in which the wrack was deposited higher into the saltmarsh and swamp oak floodplain forests where it would have been broken down naturally over time. However, under the current shoreline and water level conditions wrack is prone to accumulating in front of barriers along the shoreline. This results in wrack buildup which reduces the estuary's aesthetic and recreational qualities in addition to exacerbating the decoupling of the basin and nearshore zone and subsequently exacerbating ooze formation and algal blooms.

Further adding to the issues is the input of nutrients, organic matter, pollutants and sediments via stormwater, overland flow, and groundwater. Development across the catchment has increased flows and pollutant loads entering Tuggerah Lakes with urban stormwater identified as a key contributor to the current poor water quality. Algal blooms and ooze formation are driven by this input of nutrients notably in areas where stormwater inputs coincide with the decoupling of the nearshore and basin areas through wrack barriers.

4.4 Community vision for wrack management

The community lead vision for the Wrack Management Strategy has been developed based on participation from the Community and Stakeholder Reference Group (CSRG). The vision was developed and refined across three extensive workshops with the CSRG. The community vision for the Tuggerah Lakes Wrack Management Strategy was developed acknowledging the long-term vision for the Central Coast's coastal zone.

"Sustainably manage wrack to enhance the amenity, recreational and economic values of the lakes while retaining the critical ecological functions required to support biodiversity".

The strategy has been developed to help achieve this vision.

4.5 Themes for action under the strategy

Central Coast Council have made and continue to make substantive investment in the wrack collection program, the program is largely responsive, focusing on community complaints rather than following a specific strategy. The community perceptions and expectations around wrack collection are not currently being met, in part due to the responsive approach but also because there is a lack of understanding across the community on the range of issues at play in wrack accumulation and its management. As a result, the strategy seeks to address the multiple issues that impact wrack and its management that emerged through the literature and community engagement process.

There are four key action themes addressed in the strategy that relate to wrack accumulation and collection to ensure holistic management of the issue. The action themes (Figure 17) and their relationships are:

- Theme 1 – Community connections

One of the main points gleaned from reports of previous research and consultation, and also during the WMS CSG Workshops and community pop-ups sessions, was the lack of information sharing between Council and community, both ways. This theme aims to improve communications.

- Theme 2 – Catchment pollutant management

The level of nutrients and sediment that is collected at the bottom of the catchment in the estuary is impacting on the water quality, seagrass distribution and growth, conditions that support monosulfidic black ooze, and operational constraints for wrack collection. This theme aims to identify and address the source at the estuary of catchment inputs and develop methods to reduce the level of input and improve the health of the estuary.

- Theme 3 – Management of wrack build up (nearshore and foreshore)

Seagrass and macroalgal wrack accumulates as part of the natural process within the estuary, however there are locations where this process is restricted by alterations to the foreshore or because of high levels of recreational use. This theme aims to address accumulation at identified locations on a scheduled basis as well as in response to community requests.

- Theme 4 – Lake sources of wrack management

Seasonal conditions, wind driven waves and response to in-estuary activities all contribute to the accumulation of wrack. This theme aims to address some of the in-estuary sources by adapting collection to target deep water, preventing wrack from accumulating in the foreshore, and trial mitigation measures such as purpose-built booms to restrict the movement of wrack into key locations.

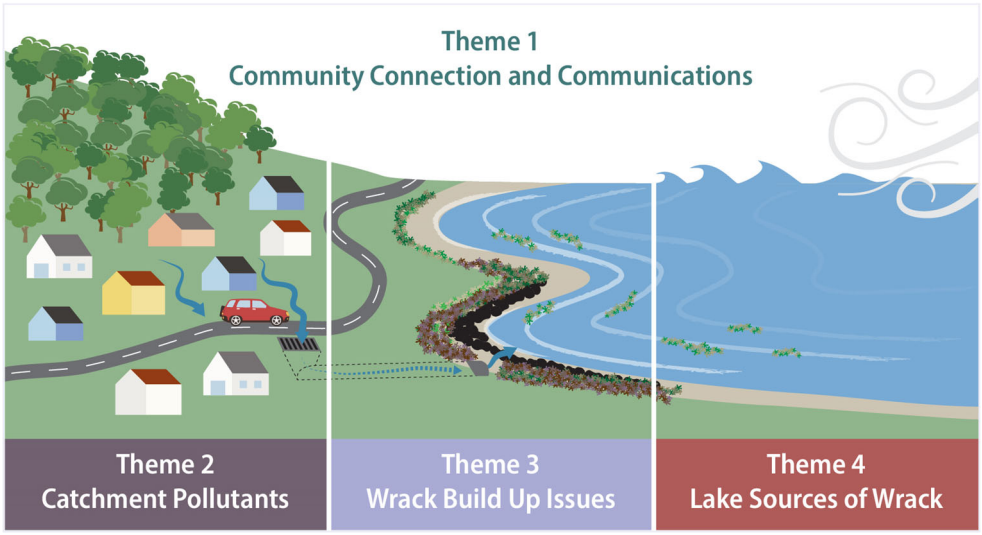

Figure 17 The Wrack Management Strategy approach is based on four main management themes

4.6 Establishing Priority Locations for action

To ensure the strategy remains targeted and less reactive, Priority Locations across the three lakes were identified to enable more efficient wrack collection planning and focussed actions throughout the year. Priority Locations within the estuary were selected as those of high priority for ongoing seasonal scheduled collection operations which represents a move away from the current method of responding to community complaints and requests.

To select Priority Locations, known seasonal wrack accumulation areas, collection accessibility constraints and community usage areas (along with other data) were analysed along with past community requests and known locations requiring clearing. These have been identified using the following resources:

- discussions with Council staff responsible for wrack management,
- the wrack management contractor,
- the community through the Community and Stakeholder Reference Group (CSRG) Workshops,
- the literature review and the locations identified by previous research and investigation,
- Scanes and Ferguson (2013) report (particularly seasonal wrack accumulation locations), and
- Council data collection for macroalgal blooms.

Previous studies (and the current Fisheries Permit) have identified wrack reserves where no collection can be undertaken within certain specified distances to allow for natural deposition and breakdown of wrack. These areas are, within 100m of the HAT (Highest Astronomical Tide) at Colongra Nature Reserve, Munmorah State Conservation Area, Budgewoi Sandmass, Wyrrabalong National Park, Tuggerah Nature Reserve and Terilbah Nature Reserve (western shoreline only).

In addition, wrack collection should not occur over any significant environmental assets or cultural or heritage sites. For example, no collection should damage or adversely affecting seagrass beds, saltmarsh areas, areas with Aboriginal recorded Aboriginal heritage sites (i.e. near Wyongah and Chittaway Point).

Discussions with the collection contractor identified locations around the estuary where collection is physically constrained by various shoreline formations including rocky areas, boat ramps, jetties, very shallow extents in the nearshore zone, and locations where seagrass beds and shoreline reeds such as Phragmites impede access.

All this information was combined to ascertain the key Priority Locations. 13 Priority Locations have been selected for the Strategy, and these are listed in Table 3 and mapped along with wrack reserves and collection constraints in Figure 18 and Figure 19.

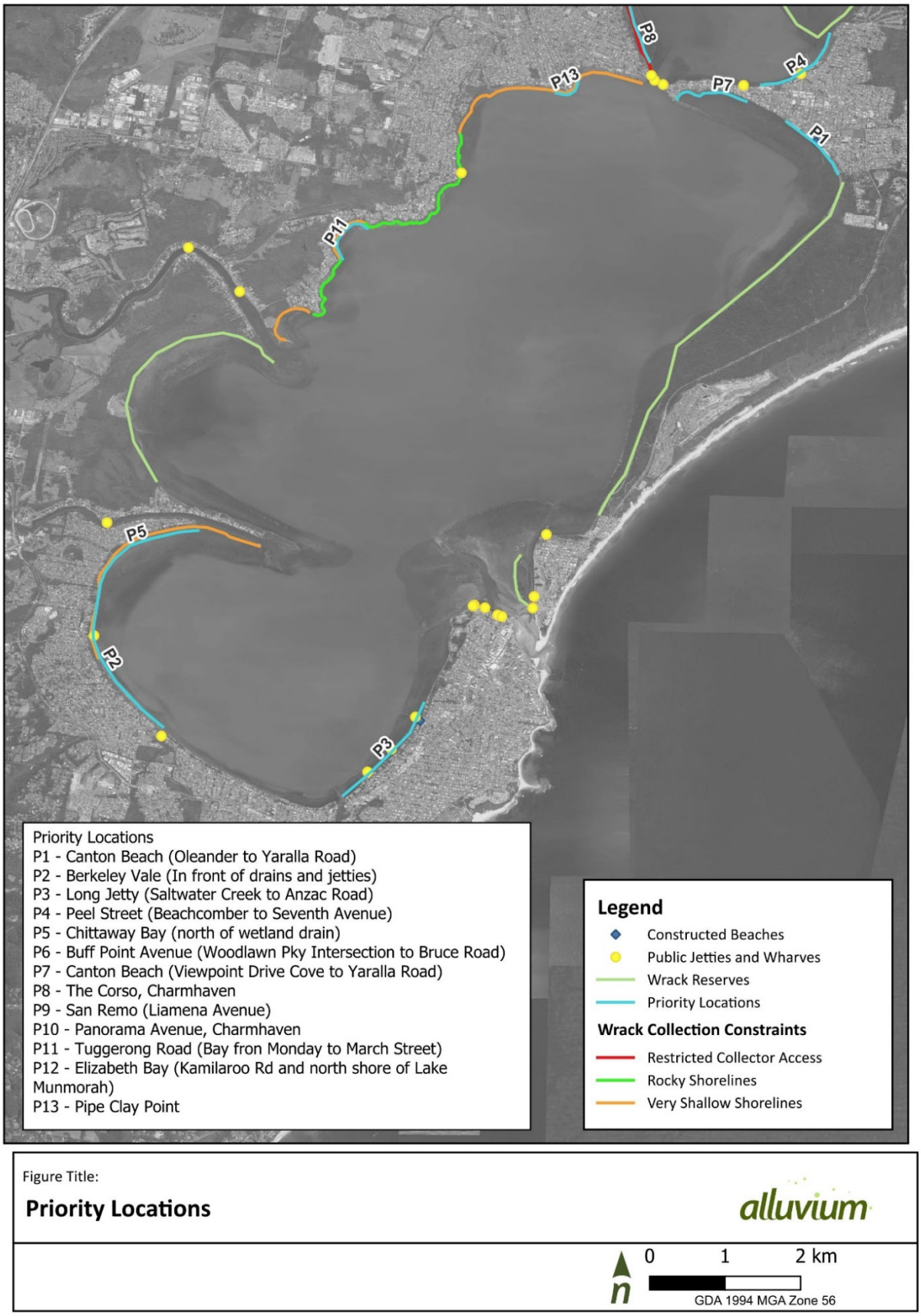

Figure 18 Priority Locations for wrack collection under the strategy acknowledging the shorelines with physical constraints on wrack collection and access– Tuggerah Lake

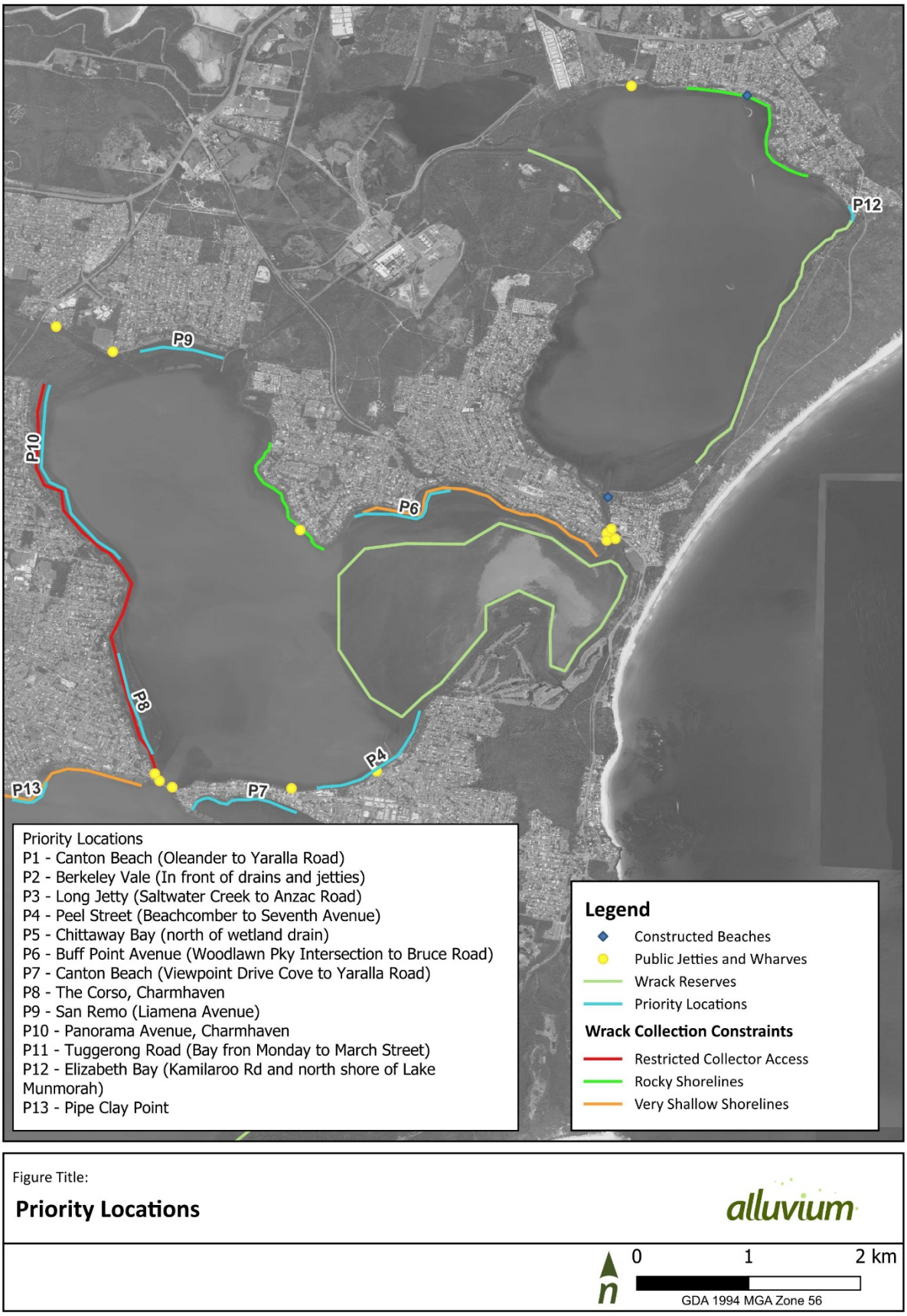

Figure 19 Priority Locations for wrack collection under the strategy acknowledging the shorelines with physical constraints on wrack collection and access – Budgewoi Lake and Lake Munmorah

4.6.1 Seasonal difference in wrack collection

When seasonal wrack accumulation areas are combined with the map showing constraints for collection (because of accessibility, rocky shorelines, very shallow waters, wrack reserves), a seasonal collection schedule for the Priority Locations emerges (Table 2).

Scheduling of collection at priority sites has been generated from both the community input at the project workshops along with macroalgal bloom information and shoreline constraints for machinery collection operations. It has also taken into consideration mapped stormwater drainage outlets, and areas of recreational use. Water levels and wind speed and direction also limit wrack collection operations.

Scheduling of wrack collection at each location was reached through:

- Discussion with the Community and Stakeholder Reference Group,
- the timing required to collect the type of wrack (deep water for just-shed seagrass wrack, macroalgal blooms, onshore/nearshore wrack),
- constraints for collection (such as water level restrictions/depth, rocky shorelines, access problems, garfish breeding season),
- permit restrictions, and
- seasonal projected accumulations because of prevailing wind/wave action.

The schedule outlines when different types of wrack collection should occur throughout the year, however with seasonal variation, the changes between collection types may start earlier, and finish later than the schedule depicts if shedding evidence is apparent. The deployment of Council drones is encouraged to identify shedding as it occurs so that the annual schedule can be adapted to the conditions.

Different collection techniques are required for different Priority Locations depending on the site characteristics. It is not intended that all wrack from all the Priority Locations areas be collected during the same period. Variable factors such as prevailing weather, wind and wave action, wrack build up intensity, flowering times, requests from other locations where an accumulation has occurred. will largely determine the day-to-day operations.

The type of collection suggested for each of the Priority Locations is outlined in Table 2. The method of collection refers to ‘deep water’ where marine collection equipment (wrack collection machinery) currently operates, and nearshore areas where a Truxor or Mobitrak or similarly designed machine may operate or where collection can be completed by hand with groups of volunteers or paid contractors, the permit details of which are yet to be confirmed with Fisheries.

Collecting from the deeper waters as a priority is intended to reduce the amount of wrack that accumulates in nearshore and onshore areas where impacts on the ecosystem of the estuary are greatest through decreased water quality.

Table 2 Seasonal collection schedule with Priority Locations

Tuggerah Lakes Wrack Management Strategy - Proposed Collection Schedule													
Priority	**Location**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
1	Canton Beach (Oleander St to Yaralla Rd)	XXX	XXX								XXX	XXX	XXX
2	Berkeley vale- In front of Drains and Jetties (Blenheim Ave to Tumbi Creek)	XXX	XXX								XXX	XXX	XXX
3	Long Jetty (Saltwater Creek to Anzac Rd)	XXX	XXX								XXX	XXX	XXX
4	Peel Street (Beachcomber to Toukley Bridge)	XXX	XXX								XXX	XXX	XXX
5	Chittaway Bay – north of wetland drain (Blenheim Ave to end of Kalua Dr- all inlets)	XXX	XXX								XXX	XXX	XXX
6	Buff Point Avenue (Woodlawn Pkwy intersection to Kobada Ave)	XXX	XXX								XXX	XXX	XXX
7	Canton Beach- (Viewpoint Dr Cove to Yaralla Rd)	XXX	XXX								XXX	XXX	XXX
8	The Corso, Charmhaven	XXX	XXX								XXX	XXX	XXX
9	San Remo towards Buff Point	XXX	XXX								XXX	XXX	XXX
10	Panorama Avenue, Charmhaven	XXX	XXX								XXX	XXX	XXX
11	Tuggerawong Road- bay from Monday Stto March Street	XXX	XXX								XXX	XXX	XXX
12	Elizabeth Bay Beach/ Kamilaroo Rd / northern shore Lake Munmorah	XXX	XXX								XXX	XXX	XXX
13	Pipe Clay Point - Dalnott Reserve to Lett Street (service when photos evident build up)	XXX	XXX								XXX	XXX	XXX
	Karagi Point Reserve, North Entrance (little tern habitat check)												
	Additional locations as needed	XXX	XXX								XXX	XXX	XXX
	Boat ramps -Picnic Point/Saltwater Creek/ Wyongah/ Canton Beach/Peel Street/Gorokan/SaltRemo/Buff Point/ Elizabeth Bay/ Lake Munmorah (inspection and service when required)	XXX	XXX								XXX	XXX	XXX

Seagrass and algal wrack most likely to accumulate due to prevailing conditions

No scheduled timing for collection – inspections required

XXX – Permit restricts collection from the middle of the lake because of garfish breeding October to February.

Table 3 Priority Locations, identification, reasons, and community prioritisation for ongoing annual collection of seagrass and macroalgal wrack

Prioritised Location No.	Location identification	Reason for prioritisation	Method of Collection	Timing
P1	Canton Beach (Oleander to Yaralla Roads)	Identified by community as seasonal business area, high value tourism and recreational use area. Noted key tourist site. Large beach wrack accumulation. Some rocky shorelines.	Deep water and Nearshore areas	Prior to School and other Public Holidays
P2	Berkeley Vale in front of drains and jetties (Blenheim Rd to Tumbi Creek) Rocky Point	Identified by community as a high value boating and recreation area for Tuggerah Lake. Wrack disturbs operation of stormwater drains adding to decoupling. Macroalgae at 50% or 75% likelihood of annual bloom in nearshore areas.	Deep water Nearshore areas	August/ September June/ July/ August/ September
P3	Long Jetty (Saltwater Creek to Anzac Road)	Identified by community as a high value boating and recreation area for Tuggerah Lake. 50-75% likelihood of medium to heavy annual macroalgae blooms. Stormwater point-of-entry.	Deep water Nearshore areas	Before monthly markets August/ September July/ August
P4	Peel Street (Beachcomber Rd to Seventh Avenue)	Identified by community as a high value tourist and recreation area for Budgewoi Lake. Macroalgae and seagrass accumulation in high public use area.	Nearshore	August-November July-August
P5	Chittaway Bay – north of wetland drain Blenheim to end of Kalua Drive – all inlets	Identified by community as a high value boating and recreation area for Tuggerah Lake. Very shallow shorelines with 75% likelihood of heavy macroalgal bloom annually in nearshore location.	Deep water Nearshore	June/ July/ August/ September December/ January/ February
P6	Buff Point Avenue (Woodland Parkway intersection to Bruce Road)	Identified by community as a high value boating and recreation area for Budgewoi Lake. Not tourist location. MS black ooze noted.	Nearshore areas Deep water	February March-June

Prioritised Location No.	Location identification	Reason for prioritisation	Method of Collection	Timing
		Very shallow shorelines.		
P7	Canton Beach – Viewpoint Drive to Yaralla Road	High public use area.		
P8	The Corso, Charmhaven			
P9	San Remo - Liamena Avenue	Identified by community as a high value boating and recreation area for Budgewoi Lake. Saltmarsh identified in location – restricted access.	Nearshore areas	February-June
P10	Panorama Avenue, Charmhaven			
P11	Tuggerawong Road – bay from Monday to March Streets	Always built up on shoreline		Prior to holiday peak times
P12	Elizabeth Bay/ Kamilaroo Avenue			
	Additional locations as needed	Response to conditions in the estuary		As required
	Boat ramps -Picnic Point/Saltwater Creek/ Wyongah/ Canton Beach/Peel Street/ Gorokan/ San Remo/ Buff Point/ Elizabeth Bay/ Lake Munmorah			
P13	Pipe Clay Point - Dalnott Reserve to Lett Street			

*Measure of success refers to success of collection at priority location, measures of success of the Strategy implementation and achievement of targets are outlined in the standalone Monitoring and Evaluation Program.

4.6.2 Foreshore access

Wracks collection in all three lakes is constrained by the available access points and mooring locations that enable equipment to enter the estuary and transport wrack to the onshore drying pad locations. Vessel travel to collection points within the lakes can be large so the proximity of access points and mooring points is integral to operations.

Shoreline access points for the shallow water collection by various wrack collection plant and machinery have been mapped in Figure 20 to Figure 21. The maps show recreation reserves (green) along the foreshore, along with other reserves, properties, and property zonings. These access points are public and can also be used for groups of people collecting by hand.

These access points connect to the estuary from the nearest street. Limited access has been identified in some areas especially for the western shoreline of Budgewoi Lake which is also highlighted as a Priority Location in parts with restricted machinery access and very shallow and/or rocky waters and shoreline. These access points have been identified through the NSW Planning Portal Spatial Viewer and have not been ground-truthed.

Access points to the Priority Locations in Lake Munmorah and Budgewoi Lake are described in Table 4 along with the locations of the drying pads. The locations within Lake Munmorah (Figure 20) and Budgewoi Lake (Figure 21)are shown on maps taken from the NSW Planning spatial portal showing foreshore reserves (in green and brown), with Priority Locations as red markers and drying pads as black markers.

Table 4 Priority Locations and access points Lake Munmorah and Budgewoi Lake

PRIORITY LOCATION	Description of nearby access points
P4	Osborne Park, Peel Street
	Easement between 72 & 74 Leonard Avenue
P6	Green Point Reserve off end of Buff Point Avenue
	End of Woodland Parkway
	End of Bruce Road
	Drying Pad: Buff Point- Access via reserve on Woodland Parkway
P8	Hillary Park access off The Corso at the end of Avonlea Avenue
	End of Suncrest Parade between 77 and 79
P9	Easement between 10 & 12, 30 & 32, 72 & 74, 104 & 106 to John Pete Howard Reserve off Liamena Avenue
	End of Emu Drive
P10	Brandon Close Reserve off end of Brandon Close off Diamond Head Drive
	Easement off Diamond Head Drive between 102 and 104
	End of Diamond Head Drive (east) into Budgewoi Point Reserve
P12	Colongra Bay Road into foreshore reserve (off Kamilaroo Avenue), a drying pad is located here also
	McCulloch Reserve easements from Anita Avenue between 108 & 110, 120 & 122, 130 & 132, 140 & 142
	Tom Burke Reserve easements off end of Queens Road, between 74 & 76, end of Diane Avenue, between 56 & 58, 48A & 50, and 24 & 26 Anita Avenue

PRIORITY LOCATION	Description of nearby access points
	Reserve at the end of Andrew Street, and Greenacre Avenue, Elizabeth Bay
	Drying Pad: Kamilaroo Avenue, Lake Munmorah, Lane access way to foreshore opposite mobile home village/caravan park
	Drying Pad: Natuna Avenue, Budgewoi West of toilet block on foreshore
	Drying Pad: Mimosa Road, Budgewoi behind Landcare site on foreshore

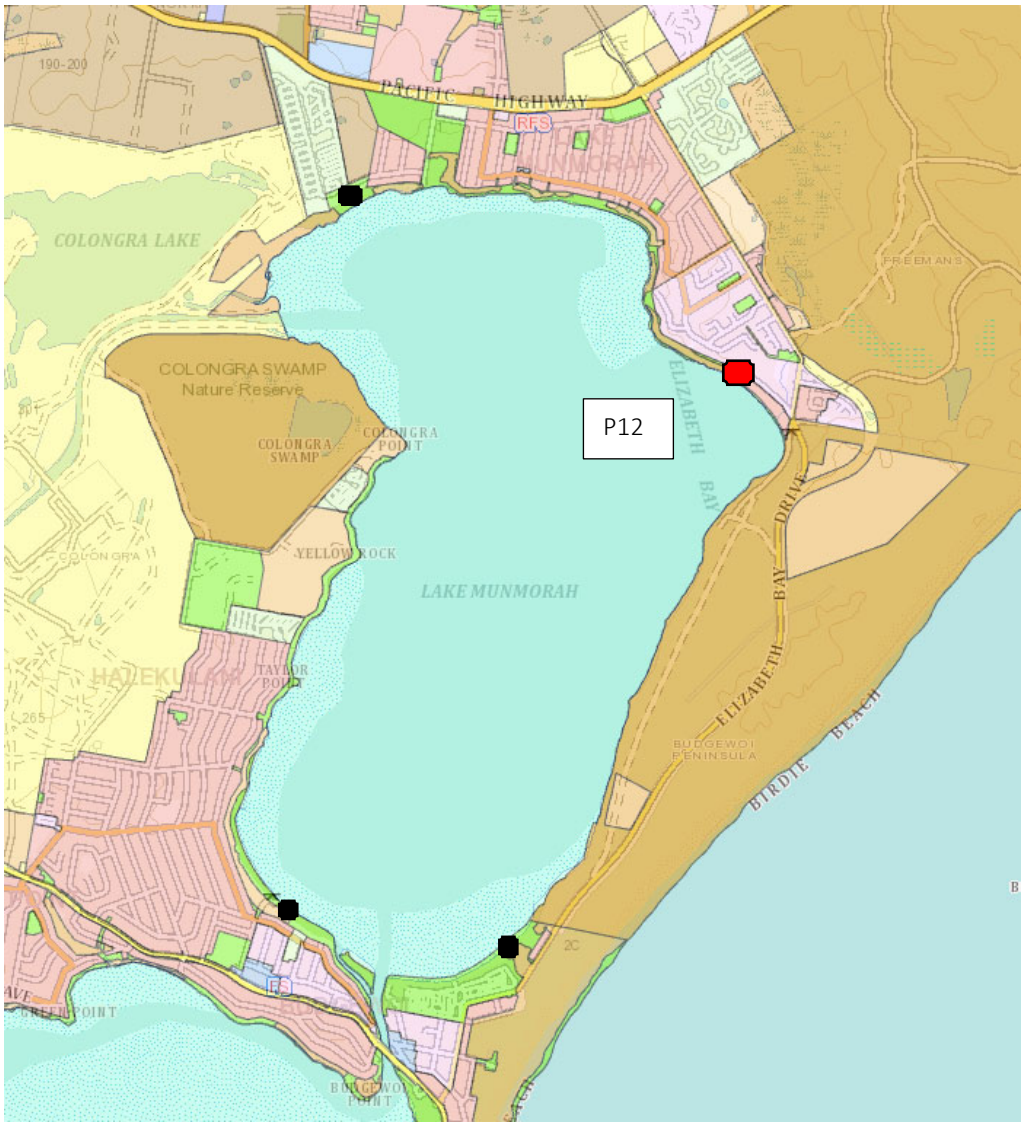

Figure 20 Lake Munmorah showing Priority Location, access points (green) via Recreation Reserves (NSW Planning 2023), and location of drying pads (black dots)

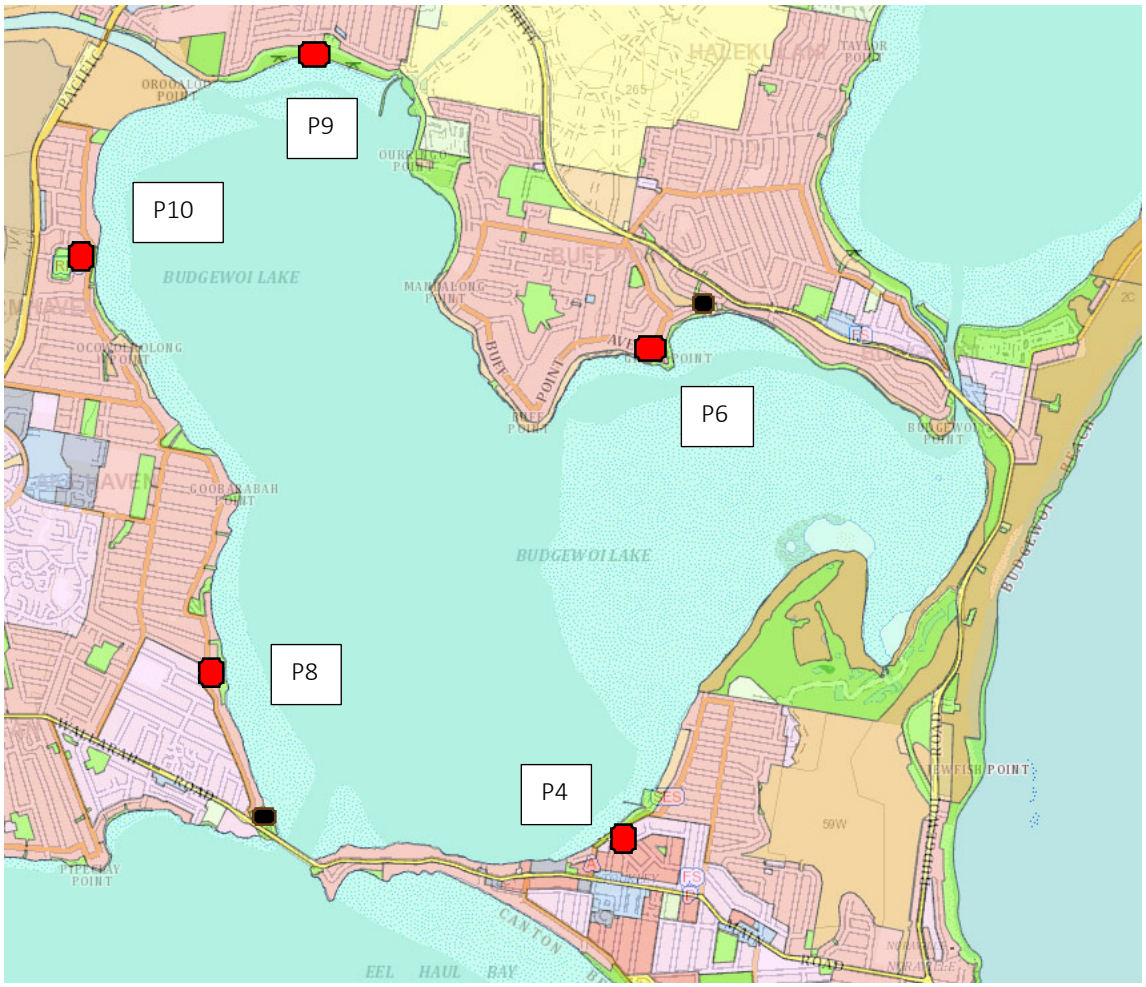

Figure 21 Budgewoi Lake showing access points (green) to Priority Locations (red dots) via Recreation Reserves (NSW Planning 2023) and drying pad locations (black dots)

Access points to the Priority Locations in Tuggerah Lake are described in Table 5 along with the locations of the drying pads. The locations within Tuggerah Lake are shown on maps taken from the NSW Planning spatial portal showing foreshore reserves (in green and brown), with Priority Locations as red markers and drying pads as black markers (Figure 22 and Figure 23).

Table 5 Priority Locations and access points – Tuggerah Lake

PRIORITY LOCATION	Description of nearby access points
P1	Beach Parade and end of Belbowrie Street
	Canton Beach Holiday Park off Lake Street and Short Street
	Drying Pad: Oleander Street Toukley – on foreshore in Tourist Park
P2	Easements between 183 & 185, 205 & 207, 225 & 227 Lakedge Avenue
	End of Bundilla Parade, end of Panorama Parade, and end of Bluebell Avenue
P3	Long Jetty Foreshore Reserve, Tuggerah Parade
	Drying Pad: Saltwater Park boat ramp, corner of Tuggerah Parade, Long Jetty

PRIORITY LOCATION	Description of nearby access points
P4	Osborne Park, Peel Street
	Easement between 72 & 74 Leonard Avenue
P5	Lakedge Avenue into Chittaway Bay Lions Park
	End of Chittaway Road
	Easements between 97 & 99, 69 & 71, 53 & 55 Aloha Drive
	Easement between 19 & 21 Kalua Drive
	End of Kalua Drive
P6	Green Point Reserve off end of Buff Point Avenue
	End of Woodland Parkway and end of Bruce Road
P7	End of Viewpoint Drive near Toukley Bridge (east) and easement between 31 & 33
	Easement between No.s 57-59 & 61 Main Road
	End Cross Street
	Easement between 1A & 3 Tamar Avenue
	End of Yaralla Road
	Toukley Sailing Club off Moss Avenue to Canton Beach
P8	Hillary Park access off The Corso at the end of Avonlea Avenue
	End of Suncrest Parade between No.s 77 and 79
	Drying Pad: Gorokan – Peace Park near Toukley Bridge and Gorokan Fishing Co-Op
P9	Easements between 10 & 12, 30 & 32, 72 & 74, 104 & 106 to John Pete Howard Reserve off Liamena Avenue
	End of Emu Drive
P11	Easements off Tuggerawong Road between No. 422 and No. 300
	Ends of March Street, February Street, Jensen Road and Monday Street
P14	Pipeclay Point Reserve from end of Howelston Road
	Dalnott Reserve off end of Dalnott Road
	Easement between No. 5 and 7 Brennon Road

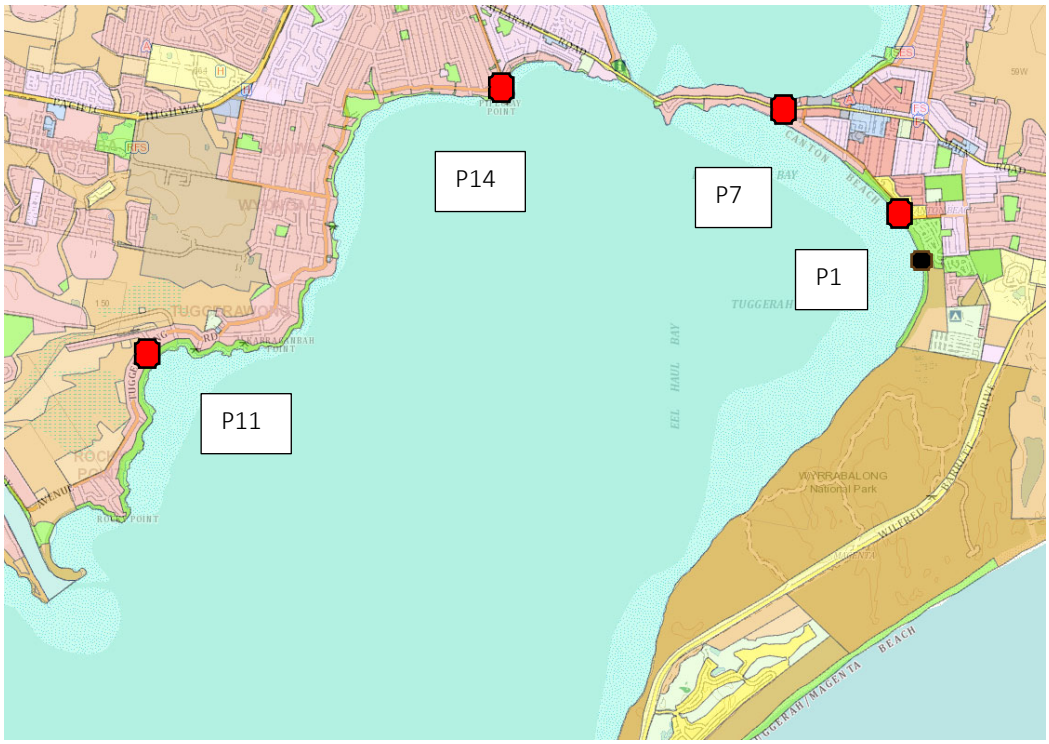

Figure 22 Tuggerah Lake (North) showing Priority Locations, access points (green) via recreation reserves (NSW Planning 2023) and location of drying pad (black dot)

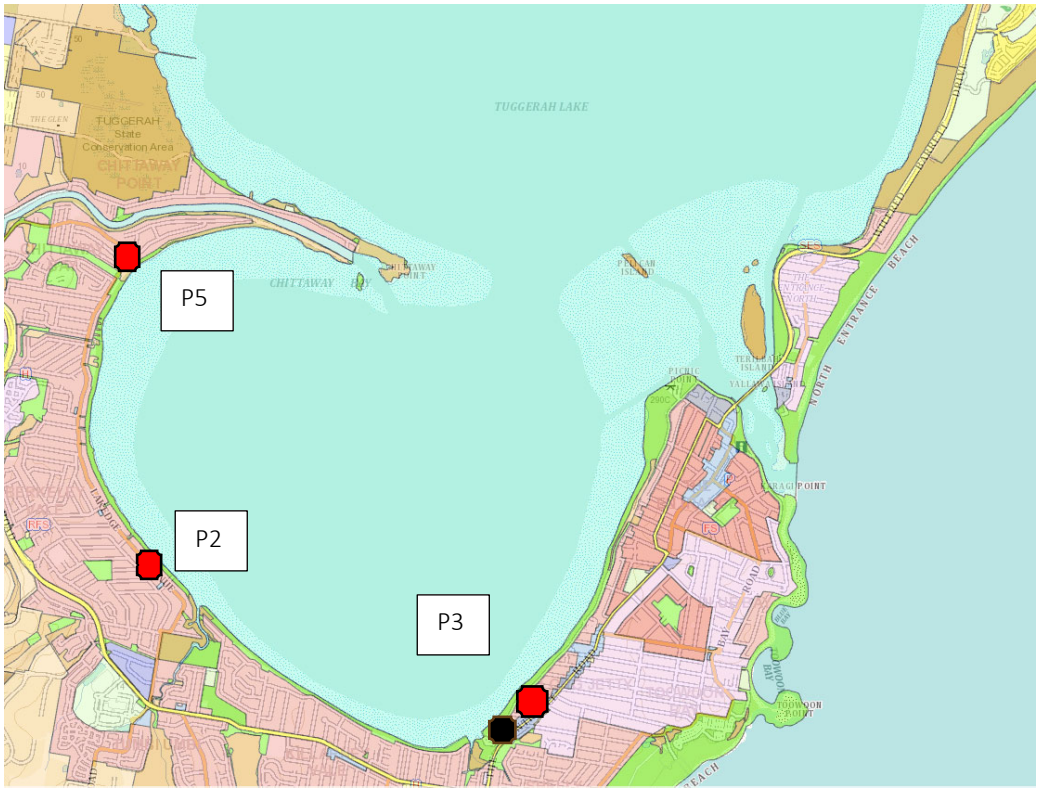

Figure 23 Tuggerah Lake (South) showing Priority Locations, access points (green) via Recreation Reserves (NSW Planning 2023) and location of drying pad (black dot)

4.7 Targets and Actions

This section outlines the targets and actions within each of the four Strategy themes. Targets and actions are summarised in the tables at the beginning of each section with more detail provided in the text below.

Figure 24 **Royal Spoonbill, Tuggerah Lake** (Photo: Trish Chadwick 2023)

4.7.1 Theme 1 – Community Connections

Target for Wrack Management	Actions to achieve Wrack Management Targets	Action Commencement (Year 1 – 10)									
		1	2	3	4	5	6	7	8	9	10
THEME 1 – Community Connections											
Pre-target - Immediately	Establish Tuggerah Lakes Wrack Management Advisory Panel -Delegates to include community members, council staff and, external stakeholders when applicable										
Target 1 - Improve community awareness - within 4 years convert 50% of community complainants to advocates of the wrack management activities.	1.1 – Develop communication plan that will improve the general knowledge of the community about the estuary, seagrass, algae, ooze, and the systems that are in place for both natural and managed areas.										
	1.2 – Install estuary facts interpretive signage at 5 priority collection locations that each relate to estuary issues/features related to wrack processes or wrack management such as wildlife, saltmarsh, ooze, algae.										
	1.3 – Establish a centralised portal for wrack management within Tuggerah Lake.										
	1.4 - Development of information materials for the distribution and communication to the community										
	1.5 – Establish direct communication with lakefront property owners and recreators about wrack										
	1.6 – Identify and liaise with relevant community groups (may include Facebook groups and other groups on social media) with the aim to establish and maintain community links to the centralised portal.										
	1.7 – Investigate and establish community clean up days.										
	1.8- Establish a baseline understanding of the level of community satisfaction/knowledge with wrack management.										
	1.9 – Repeat the community satisfaction social survey and publicise results										

Target for Wrack Management	Actions to achieve Wrack Management Targets	Action Commencement (Year 1 – 10)									
		1	2	3	4	5	6	7	8	9	10
Target 2 – Increase ***state and federal funding for estuary management***	2.1 – Review potential grant funding sources and apply for funding where eligible to implement actions from the Wrack Management Strategy.										

Community Connections

Education and awareness works both ways. Council is tasked with keeping the lines of communication open between the community and the wrack collection operations, and between coordination staff and the community. The community is tasked with keeping Council informed about locations that they believe need prompt attention or where there are other wrack issues developing. Additional ongoing communication is needed between all stakeholders to ensure accurate and up-to-date information is shared, helping to increase awareness and educate all parties about the value of wrack and its management challenges in the region.

Building education and awareness of wrack management issues (within the community, other stakeholders, and Council) can be achieved through direct and indirect communication methods, and through dialogue that occurs during hands-on engagement in wrack management (such as monitoring, collection activities). To be successful, educational strategies will need to be developed for communication and engagement between all parties.

Communication

It will be important for Council to establish and maintain ongoing communication and dissemination of information about wrack issues to the community. This can be achieved through direct contact, informative signage, mailouts, and articles in mainstream and social media, on Council websites and other communication points.

Most of these actions are *one-way* communication. To foster trust and stronger relationships between Council and the community, other approaches can also be considered, including:

- Creating opportunities for *dialogue* (two-way communication) with the community and other stakeholders, such as holding Q&A sessions (e.g., online via Facebook live, or pop-up stalls at local events) to update the community on wrack management and create a space for questions to be asked and answered, and for the community to inform the Council about any concerns or observations of wrack issues. These sessions could include guest presenters to talk about the science or management of wrack in the area.
- Holding communication-focussed workshops to collaborate with the community on developing future education and awareness campaigns (including identifying appropriate communication channels, testing messages, etc.). These workshops provide a perfect opportunity to do critical audience research, and could be run for different audience groups e.g., school students, retirees, etc. The workshops will help Council identify the information/educational needs for each audience group, and the most appropriate channels to communicate with them.
- Identifying and working with local people who are important “hubs” within the community network to become local champions who assist with information sharing between Council and the community (these people may be in addition to the Working Group members, below). People who are well-known, trusted, and well-connected in the community can become important sources of information dissemination. It would be worthwhile holding a workshop (previous point) specifically for these influential people to develop a communication strategy for this group.

Partnerships

Partnerships can be valuable channels for education and raising awareness within the community and beyond. Partnering with community, relevant organisations, and local businesses (especially those connected to tourism or marine activities) can provide support and sponsor wrack management initiatives. These collaborations can help create a positive image for businesses and organisations while contributing to broader environmental education, awareness, and wrack conservation objectives.

Engagement in wrack monitoring and management

Collecting data and other evidence to inform decision-making and raise awareness will be an important mechanism for the Council and community to address wrack management. Involving the community in data collection and monitoring efforts can help increase Council’s and the community’s understanding of the dynamics of seagrass wrack accumulation and its effects on the ecosystem. It can also quickly identify problem areas that need urgent attention.

Citizen science approach

Involving the community in gathering evidence (sometimes referred to as *citizen science*) can also help to improve communication and trust. For example, the University of New South Wales runs a citizen science program called *Coast Snap* (https://www.coastsnap.com/explore/how-it-works), which uses a permanently-installed mobile phone cradle at key locations for passersby to take photos of coastlines in exactly the same position. The photographs are uploaded onto the website and in doing so, researchers and the community can see changes in the coastal environment over time. Locals may be aware there is a Coast Snap station on Marine Parade at The Entrance, and other photos in the Lakes area have also been recorded through this project (see map on Coast Snap website for further details).

Similar phone cradles could be installed around key locations in the Lakes to enable the community to collect data. The cradles could be used to upload photos to the Council website or other location. They may need to ask for the inclusion of data fields to record the quantity and composition of seagrass wrack.

Developing a more consistent approach to monitoring wrack accumulation will help inform decisions about management and responses to wrack in the different areas. This will help build community-generated evidence, which is likely to be accepted by the community and can be used in future communication activities to increase broader awareness of wrack issues in the region. By using a citizen science approach to continuously monitor wrack accumulation (or absence) with the community, Council will be able to demonstrate the effectiveness of management efforts and communicate the outcomes to the community. The successes of this collaborative effort can foster a sense of accomplishment and inspire ongoing commitment to the wrack management strategy.

Other actions that foster increased awareness and education about wrack management issues include:

1. Community-based Cleanup Events: Organising regular community cleanups to remove seagrass wrack from beaches and shorelines. These events can be fun and engaging, involving volunteers, local schools, businesses, and environmental organisations. By involving the community there is a sense of ownership and responsibility for the health of their local environment.
2. Organisation-based Cleanup Events: Partnering with local governments, NGOs, and businesses to organise *large-scale* coastal cleanup events. These efforts not only remove seagrass wrack but also other marine debris, fostering a cleaner and healthier marine environment.
3. Rewards and Recognition: Recognising and rewarding individuals or community groups that actively participate in seagrass wrack management efforts. This recognition can be in the form of awards, certificates, or public appreciation, and can motivate others to participate in future events.

By combining community involvement, effective communication and education, and well-designed management strategies, seagrass wrack management can be successful in safeguarding these vital coastal ecosystems.

Pre- strategy target- Set up Tuggerah Lakes Wrack Management Working Group (TLWWG)

As an immediate action, it was agreed that a group that represents Council and the community be established. It would be titled the Tuggerah Lakes Wrack Management Working Group (TLWMWG) and would function as either as a sub-working group of the existing Catchment to Coast Advisory Committee or as a standalone group consisting of community members.

The main function of the working group would be as the advisory group for actions within the Strategy and the point of contact for Council and community, engaging in the implementation of the actions. This action aligns with a recommendation from the Tuggerah Lakes Expert Panel Report (Glamore et al., 2020) that highly recommended the establishment of a co-ordinating taskforce made up of community and Council to keep the lines of communication open and provide ongoing monitoring and accountability to the operations team, the Council, and the community.

Target 1 - Improve community awareness - within 4 years convert 50% of community complainants to advocates of the wrack management activities.

Action 1.1 - Develop a communication plan that will improve the general knowledge of the community about the estuary, seagrass, algae, ooze, and the systems that are in place for both natural and managed areas.

As the first action, and as a priority, the working group will work with Council to develop a communication plan to improve the general knowledge of the community about the estuary including seagrass, algae, ooze, wrack, fish, biodiversity, catchment contributions, and all the components of the system. The communication plan should include at least the following elements.

- Communication context
- Communication strategy: objective and tactics
    - Identifying target groups – These are groups within the community that will be targeted through the communication strategy
    - Prioritising tactics – to inform, interact with and involve the community
    - Creating cumulative value from tactics – a communication strategy should be designed to make the most from each tactic by releasing the product through multiple platforms and adapted for different target groups.
- Community messages - detailing the messages that will be implicit throughout all of the communication products developed and released through the strategy.
- Action plan – A detailed calendar of planned communication actions with aim of the product, responsibilities, timing/deadlines and estimate hours associated with developing the product.

Action 1.2 – Install interpretive signage at 5 priority collection locations that describe estuary issues/features related to wrack processes or wrack management.

Signage should be erected at the Priority Locations to maximise the reach of the information. Funding for this may be obtained from Council, however, other potential sources of funding can also be sought by the Working Group.

Action 1.3 – Establish a centralised web portal to hold and disseminate wrack management information.

This would take the form of a dedicated webpage for wrack management that houses the Strategy, fact sheets, collection data, monitoring KPIs, operational data etc. The aim is to increase awareness of the existing customer request system (CX platform) which is to remain the main way in which customers lodge wrack collection requests and to encourage community to use it to learn about wrack processes and management (see Theme 3).

Action 1.4 - Development of information materials for the distribution and communication to the community

Information material could take multiple forms but should include, factsheets (e,g, what is wrack, seagrass lifecycle, lake ecological processes, wildlife relating to wrack, the wrack collection process, marine biota reliant on seagrass, what is algae, what is ooze, what is the smell, saltmarsh identification, etc.). The timing of posts or dispersal of information is important and is likely to be most beneficial during the Autumn and Spring shedding of seagrass or when wrack accumulates onshore.

Action 1.5 – Establish direct communication with lakefront property owners and recreators about wrack

To improve their knowledge base, targeted mailouts with the information developed in the previous action. The information should target issues specific to lakefront property owners including the legal limitations regarding the Fisheries restrictions on wrack collection. Communication should also inform them of their local collection points (e.g. skip bins or containers or wrack drying pads) when these are determined by Council. They will be informed about the working group and the centralised portal for community wrack information sharing.

In the past Council has supported collection of wrack that has been gathered by the community and deposited at set collection points. Some interest has been identified from neighbouring households where they have a joint interest in keeping their section of the estuary shoreline in better condition by collecting wrack. To support these and other groups who may be interested, consideration of further wrack collection points has been made.

This education program should also provide information on nutrient and sediment reduction initiatives that lakefront property owners could implement. While most of the nutrients that impact on the water quality of the estuary flows from the catchment (Glamore et al., 2020), there is a significant impact from lakeside properties and those along the inflow creeks and drains. To reduce the amount of nutrients reaching the estuary from adjacent and nearby properties it is recommended that targeted education materials and campaigns be investigated with the aim to initiate stormwater education within the immediate catchment to the estuary.

This might include the use of fertilisers and herbicides, the incorporation of vegetation buffers to trap nutrients before they flow to the Estuary, and continuation of the program that raises awareness of what goes down the drain and where it ends up.

Action 1.6 – Identify and liaise with relevant community groups (may include Facebook groups and other groups on social media) with the aim to establish and maintain community links to the centralised portal.

The Working Group will reach out to other relevant local groups to inform them of the Working Group and the communications portal. Communication will be established allowing the flow of information back and forth between all the groups and community representatives.

Action 1.7 - Investigate and establish community clean up days.

Council in consultation with the Working Group will arrange dates and locations for two community clean up days per year every year at 11 locations starting with those identified in Figure 18 and Figure 19. The Working Group will select alternative locations according to community feedback and requirements. The clean-up days will focus on provision of information around wrack: how to collect, what the limits are, where to dispose of it, what to be careful of with in regards to participants health and safety of the participants and the ecology of the estuary (causing no harm to biota or seagrass), how to report a wrack accumulation using the community portal or other means to suit, how to become involved in Lakecare, how to minimise nutrient input to the estuary.

Action 1.8 - Establish a baseline understanding of the level of community satisfaction/knowledge with wrack management.

Establishing an understanding of the community satisfaction and knowledge with wrack management in the lakes is an important step in tracking progress of the actions within this theme of the strategy. The baseline can be established using a relatively simple social survey that could be mailed or provided by other means and results compiled by the Working Group and shared on the community portal or published in newsletters or local newspapers, and other electronic means. This information forms the basis of the measurable component of this target. The baseline survey should be conducted now with a subsequent survey conducted after 4 years to provide an evaluation of the success of the communications plan and wrack management strategy as a whole.

Action 1.9 – Repeat the community satisfaction social survey and publicise results.

Community satisfaction will be measured again by repeating the social survey at the 4 year mark and at other times as agreed by the Working Group, but at least before the end of the WMS period of 10 years. This information can be used to evaluate and improve the communications plan as needed.

Target 2 – To increase state and federal funding for estuary management

Action 2.1 – Review potential grant funding sources and apply for funding to implement actions from the Wrack Management Strategy.

Council in consultation with the Working Group will seek funding opportunities that relate to wrack management and where eligible will make applications for a minimum of two grants that will reduce wrack or improve wrack management within the first two years after the WMS is adopted by Council.

4.7.2 Theme 2 – Catchment Pollutant Management

Target for Wrack Management	Actions to achieve Wrack Management Targets	Action Commencement (Year 1 – 10)									
		1	2	3	4	5	6	7	8	9	10
THEME 2 – Catchment Pollutant Management											
Target 3 – Manage impacts from nutrients by collecting wrack at high stormwater impacted foreshores	3.1 – Manage wrack in accordance with the Schedule at foreshores with significant stormwater influence within the Priority Locations.										
Target 4 – Investigate techniques to manage impacts of pollutants entering the estuary (collaborative research projects)	4.1 – Investigate collaborative research projects for stormwater treatment systems on foreshore locations (e.g. Australian Research Council, Universities, etc.)										
	4.2 – Trial of novel stormwater treatment methodology/device at one of the Priority Locations										
	4.3 – Investigate collaborative research projects to understand the influence of groundwater on foreshore locations										
	4.4 – Evaluate results and develop action plan with recommendations for implementation.										

Catchment Pollutant Management

Target 3 – Manage impacts from nutrients by collecting wrack at high stormwater impacted foreshores

Action 3.1 – Manage wrack in accordance with the Schedule at foreshores with significant stormwater influence within the Priority Locations.

Collection will be targeted to foreshores, nearshore and deep water where stormwater drains are known to interact adversely with wrack accumulation, in that stormwater (nutrients and sediment) is trapped by accumulated wrack, exacerbating the accumulation of black ooze and associated bad odours.

- Collect wrack at all Priority Locations as part of Theme 3. The existing equipment for collection employed by the contractor are to be continued, the new contract revised and issued, and Priority Locations identified in Figure 18 and Figure 19 along with the Schedule in Table 2 are to form the basis of ongoing collection activities. These activities will require adjustment according to prevailing conditions and high priority 'call outs'.
- Collection and methodology may vary according to water levels with the machinery being able to reach into additional locations when water levels are higher. The prioritisation of collection will be conducted with the contractor and with the Council operations manager in accordance with the Schedule in Table 3 and include some consultation with the Working Group so that information is shared and community remains informed.

Target 4 – Investigate techniques to manage impacts of pollutants entering the estuary (collaborative research projects)

Action 4.1 – Investigate collaborative research projects for stormwater treatment systems on foreshore locations (e.g. Australian Research Council, Universities, etc.)

There are numerous proprietary devices and water sensitive urban design options that are designed to reduce the impact of nutrients and sediments from discharging into receiving environments. A collaboration with research organisations and industry practitioners should be formed to test new devices and techniques and their applicability of different methods for Tuggerah Lakes. This study should be published so that community is aware of ongoing efforts to reduce the impact of catchment pollution in the estuary.

Action 4.2 –Trial of novel stormwater treatment methodology/device at 1 of the Priority Locations

As a result of the literature review in 4.1, a method and or device(s) should be selected to trial at two of the identified Priority Locations that have appropriate stormwater entry points. The relationship with the research organisation can be continued to monitor and evaluate the chosen trial method.

Include monitoring & evaluation program. Monitoring will be based on water quality parameters to be agreed during development of the trial using a before, after, control and impact styler design at the application point of the trial method and or device(s). Details of the monitoring and evaluation, and results of the trail should be publicised and shared across all community portal and group media.

Action 4.3 – Investigate collaborative research projects to understand influence of groundwater on foreshore locations.

A collaboration with research organisations should be formed to better understand the existing sources and locations of groundwater inputs to the estuary and its contribution to wrack build up and black ooze formation. This study should be published so that community is aware of the ongoing efforts into understanding influences around groundwater and wrack sources and its dynamics.

Action 4.4 – Evaluate results and develop action plan with recommendations for implementation.

Evaluation of the results of the trials will inform whether the trialled methods were successful and under which conditions they are best used. Assuming a successful outcome, the best method for the chosen locations that can be used into similar situations will become apparent. From this information, an action plan will be developed that provides details of the successful method, where it was applied, under what conditions, and with what level of success, and a set of requisites for application of the method and or device(s) for other sites. The action plan would involve application of the method or device(s)into other locations to ameliorate or mitigate the impacts of groundwater seepage on wrack accumulation and ooze.

4.7.3 Theme 3 – Management of Wrack Build-up (foreshore)

Target for Wrack Management	Actions to achieve Wrack Management Targets	Action Commencement (Year 1 – 10)									
		1	2	3	4	5	6	7	8	9	10
THEME 3 – Management of wrack build up (nearshore and foreshore)											
Target 5 – Improve the efficiency and reduce the impact from current collection processes.	5.1- Where feasible collect in accordance with the Schedule (Table 2) and Operations Manual including: Priority Locations, timing, and methodology										
	5.2 – Targeted collection at boat ramps and constructed beaches and the locations identified within the Schedule.										
	5.3- Develop drone monitoring program and modify wrack management in accordance with recommendations from evaluation.										
	5.4- Develop real time management decision support tool with built in considerations of water level data, bathymetry, seagrass mapping, wind direction, macroalgae blooms, weather conditions, shoreline, and current collection plant limitations.										
	5.5 – Ascertain baseline ecological health data using the indicators: • Syngnathid and aquatic fauna prevalence and distribution • Monosulfidic Black Ooze prevalence and distribution • Seagrass meadows and their changes (leaf length, m^2 etc) • Turbidity/Chlorophyll a (using existing data and MER program as baseline) • Wrack accumulation (m^2, depth, locations, etc). -Trapped wrack -Beached wrack										
	5.6- Evaluate results of ecological health data and develop action/monitoring plan with recommendations for implementation. Implement the recommendations.										
	5.7- Investigate alternate bins/ wrack drying pads to enhance visual amenity										
Target 6 – Investigate alternate wrack collection methods/machinery	6.1 – Review global market and investigate alternate machinery/ methodologies to access and collect wrack from nearshore zones with an aim to minimise ecological impact.										

Target for Wrack Management	Actions to achieve Wrack Management Targets	Action Commencement (Year 1 – 10)									
		1	2	3	4	5	6	7	8	9	10
	6.2 – Establish collaborative research group (e.g. Uni Newcastle, Dept Planning and Environment) to test new methods of wrack collection, how to prevent or reduce accumulation in certain areas, or how to relocate wrack into areas where collection by machinery can take place in deeper water.										
Target 7 – Establish community group wrack collection program within 2 years	7.1 – Establish volunteer collection pilot program like current Environmental Volunteer Program.										
	7.2 – Investigate collection points/bins (such as skips or other large transportable containers) convenient to Priority Locations for community use.										
Target 8 – Establish network of paid wrack collection groups within 4 years	8.1- Investigate establishing professional paid groups for manual wrack management in areas with limited machinery access (e.g. areas with shallow water levels, rocky shorelines etc.).										
Target 9 – Source ongoing council funding for actions under the WMS	9.1 – Investigate stormwater and environmental levy to fund wrack management.										
	9.2 – Undertake cost benefit analysis for wrack collection plant and equipment to be owned and operated by Council.										
Target 10- Reduce amount of wrack disposed of at waste management facility.	10.1 – Establish trial sites where wrack can be used as an alternative to leaf/garden mulch										

Management of Wrack Build-up (nearshore and foreshore)

Target 5 – Improve the efficiency and reduce the impact from current collection processes

Action 5.1 – Collect wrack from foreshore, nearshore and deep-water areas in accordance with the Schedule (Table 2) and Operations Manual including:
- Priority Locations
- Timing
- Collect relevant data: plant/equipment and methodology utilised, zone in which collection took place, material collected, cubic metres of material collected, , environmental conditions such as lake height and any limitations to collection.

Action 5.2 – Targeted collection at boat ramps and constructed beaches and the locations identified within the Schedule.

Action 5.3 – Develop drone monitoring program and modify wrack management in accordance with recommendations from evaluation.

Develop the best practice usage program and response schedule for drone monitoring of wrack management, wrack accumulation and other recommendations from Action 5.5.

Action 5.4 – Develop real time management decision support tool with built-in considerations of water level data, bathymetry, seagrass mapping, wind direction, macroalgae blooms, weather conditions, shoreline limitations.

Action 5.5 – Develop baseline ecological health data using the indicators:
- Syngnathid and aquatic fauna prevalence and distribution
- Monosulfidic Black Ooze prevalence and distribution
- Seagrass meadows and their changes (leaf length, m^2 etc)
- Turbidity/Chlorophyll a (using existing data and MER program as baseline)
- Wrack accumulation (m^2, depth, locations, etc).
  -Trapped wrack
  -Beached wrack

Action 5.6 – Evaluate results of ecological health data and develop action/monitoring plan with recommendations for implementation.

Based on information collected in Action 5.5, evaluate the baseline health of the estuary at the sampled locations and develop an ongoing monitoring plan. This information can be used to flesh out recommendations for implementation to improve the results into the future.

Action 5.7 – Investigate alternate bins/ wrack drying pads to enhance visual amenity.

Investigate the possible alternatives for wrack collection storage such as bins and drying pads that would be approved relevant agencies such as NSW DPI Fisheries under the current Council Permit, NSW Department of Planning and Environment, NSW Crown Lands and Councils Waste Management department. These may include skip bins, elevated drying platforms, odour screens around existing drying locations, etc.

Target 6 – Investigate alternate wrack collection methods/machinery

Action 6.1 – Review the global market and investigate alternate machinery/ methodology to access nearshore zones and minimise ecological impact.

Technology continues to develop and change. This action is to review the types of equipment and procedures that are being used in other locations around the world and investigate if they're suitable for the conditions in Tuggerah Lakes. The review should include a literature review and interviews with other jurisdictions who use alternate strategies for wrack collection.

Action 6.2 – Establish collaborative research group (e.g. Uni Newcastle, Dept Planning and Environment) to test new methods of wrack collection, how to minimise or prevent accumulation in certain areas, or how to disperse or trap wrack into areas where collection by machinery can take place in deeper water.

Collaborative research groups that include management organisations, research organisation and industry representatives can apply for funding through the Australian Research Council (e.g. Industry Linkage grants) as well as being eligible for state government research grant initiatives. These alternative methods may include but not be limited to the following investigations:

- microbial breakdown of wrack (identification of the microbes that function to decay the wrack as part of the natural process, and how they may be encouraged to increase in numbers or be introduced as a controlling organism (consultation with CSIRO may be required).
- methods or mechanisms for towing wrack into deeper water where the current equipment can collect. These may include rakes, booms, or chains.
- robotic removal methods or mechanised removal equipment to minimise impacts on the ecology of the estuary and assist with either collection or relocation of wrack to deeper waters for collection.

Target 7 – Establish community group wrack collection program within 2 years

Action 7.1 – Establish volunteer collection pilot program like current Environmental Volunteer Program.

Develop a volunteer wrack collection pilot program like Councils Environmental Volunteer Program management. The initial set up costs would include project planning, WHS and PPE, tools and equipment, plant and trucks for collection, tipping fees (as necessary), permit fees (if required), and Council staff costs for management.

Action 7.2 – Investigate collection points/bins (such as skips or other large transportable containers) convenient to Priority Locations for community use.

As the volunteer program is developed, wrack dumping locations should be establish close to each of the Priority Locations where collection is conducted. Dump locations could take the form of skips or other large transportable containers. Section 4.6.2 describes the access constraints at each of the 11 Priority Locations which will need to be considered in establishing dump locations.

Target 8 – Establish network of paid wrack collection groups within 4 years

Action 8.1 – Investigate the establishment of professional paid groups for manual wrack management in areas with limited machinery access (e.g. areas with shallow water levels, rocky shorelines etc.).

The use of paid groups to collect wrack could be an effective option in areas with limited access for the wrack collection machinery (e.g. areas with shallow water levels, rocky shorelines etc.). Further discussions regarding permit requirements will need to be had with Fisheries about groups like these, especially in relation to collection limits.

Target 9 – Source ongoing council funding for actions under the WMS

Action 9.1 – Investigate stormwater and environmental levy to fund wrack management.

This method of funding for similar environmental management operations has been adopted by many councils and provides a consistent income that may be allocated to wrack management and collection on an ongoing basis.

Currently, the main source of funding for the wrack collection operation is from Council's general revenue. External funding from State Government is only clearly applicable at present through the Coastal Management Program, into which this Strategy will fit. Other sources of funding have been investigated and as recommended in the TLEP report (Glamore et al., 2020) comes back to the introduction of a stormwater levy to enable improvement to the existing catchment sediment and nutrient controls, and an environmental levy to assist with the ongoing costs of maintaining the Estuary. The introduction of both an Environmental Levy and a Stormwater Levy is recommended, however significant due diligence is required which would include:

- Community engagement
- Business case development.

Action 9.2 – Undertake a cost benefit analysis for wrack collection plant and equipment owned and operated by Council.

One of the limitations identified for proactive, strategic, and large-scale wrack collection in the lakes is that there is only one wrack collector operated by the contractor. A cost benefit analysis for the purchase and on-going operation of plant

and equipment needs to be investigated to address this limitation. All parts of the purchase and operation of a wrack plant and equipment would need to be considered including capital cost, as well as ongoing operational costs including staff, materials, repairs, maintenance, and replacement fittings and parts. These costs should be compared to the potential benefits, including amount of additional wrack collection likely, redundancy when one of the collectors is not operational and the efficiency gains of having additional plant and equipment operational during peak wrack collection periods. If it is deemed viable, a business case which includes potential realistic funding options should be prepared for Council.

Target 10 – Reduce amount of wrack disposed of at waste management facility

Action 10.1 – Establish trial sites where wrack can be used as an alternative to leaf/garden mulch

Wrack disposal represents a significant component of the annual wrack management cost to Council. Any reduction in the amount of wrack that is required to be disposed of by paying tipping fees will provide further funds for management that can be used in other activities. A trial should investigate mulching the wrack as an alternative option to dumping.

4.7.4 Theme 4 – Lake Sources of Wrack Management

Target for Wrack Management	Actions to achieve Wrack Management Targets	Action Commencement (Year 1 – 10)									
		1	2	3	4	5	6	7	8	9	10
THEME 4 – Lake Sources of Wrack Management											
Target 11 – Reduce wrack build up in deeper areas of the lake (aims to minimise build-up in nearshore and on beaches)	11.1 – Collect in accordance with Schedule (Table 2) and Operations Manual including: Priority Locations, timing, and methodology										
Target 12 – Investigate options to reduce lake wrack accumulation	12.1 – Investigate boom designs and trial to reduce wrack washing ashore at 2 priority locations										
	12.2 – Investigate methods (including nets) to drag wrack into deeper areas and where feasible trial.										
	12.3 – Investigate the use of floating wetlands or other offshore barriers to reduce wrack build up in the nearshore and foreshore zones.										
Additional Actions for Wrack Management											
Target 13 – Review Wrack Management Strategy	13.1- Review WMS to ensure the program undertaken is current and meeting the needs of community as well as improving the health of Tuggerah Lakes.										
Target 14 – Long-term management aim	14.1 – Consult with and obtain funding and/or financial support from other responsible authorities such as Crown Lands and DPE with the aim to reduce ongoing expenditure resting with Council.										

Lake Sources of Wrack Management

Target 11 – Reduce wrack build up in deeper areas of the lake (before build-up in nearshore and on foreshores)

Action 11.1 – Collect wrack in deeper areas of the lakes in accordance with Schedule and Operations Manual including:
- Priority Locations
- Timing
- Methodology

Collection of wrack from deeper parts of the estuary using the large collection machinery which aims to limit the amount of wrack reaching the nearshore and foreshore where collection may be more difficult depending on the composition of the shoreline, the depth of the shallow waters, and presence of critical habitats or physical barriers.

Target 12 – Investigate options to reduce wrack accumulation

Action 12.1 – Investigate and trial boom designs to prevent wrack washing ashore at two Priority Locations.
Investigate and trial boom designs where permissible and feasible to prevent wrack washing ashore at two of the Priority Locations for example near Buff Point and Viewpoint Dive between the jetties. The trial should concentrate on comparing, contrasting, and trialling different boom designs. It has been found that the booms are ineffective when deployed during periods of high wind and wave action. The wrack is either blown over the boom or driven beneath it. Alternative designs that prevent this require consideration and trialling. It is recommended that further trials of different boom types used across shorter stretches of shoreline, particularly targeting areas where ooze is located, be undertaken. There is also the consideration of groynes or similar structures to deflect flow away from key or highly sensitive areas and thereby also deflect wrack. These option both require further investigation and approval from NSW Fisheries.

Action 12.2 – Investigate and trial methods (including nets) to drag wrack into deeper areas

Investigate methods which may include different net designs, to assist with moving wrack from the foreshore shallows where access is restricted for the collection equipment, into deeper waters where the equipment can operate. Other methods mentioned have included hovercraft platforms to act as anchors either side of nets or booms, and machinery to blow the wrack away from the nearshore zone.

Action 12.3 – Investigate floating wetlands or other offshore barriers to reduce wrack build up in the nearshore and foreshore areas.

Investigate installing offshore floating wetlands, or sills on the foreshore in appropriate locations to trap wrack build up away from nearshore areas so it can't contribute to black ooze formation and other issues. The intent of this action is to trial the creation of areas further offshore to trap or deflect wrack before it reaches the nearshore zone. The priority areas near the shallow shorelines of northeast Tuggerah Lake may be an appropriate trial location. The exact location and method will require investigation with reference to water depth, flow direction, wind/wave direction, and the existing environment. This would need to take place in front of public land or reserved land, not private properties.

Target 13 – Review Wrack Management Strategy

Action 13.1 - Review WMS to ensure the program undertaken is current and meeting the needs of community as well as improving the health of Tuggerah Lakes.

Monitoring of information obtained regarding the Actions within the WMS will be gathered and evaluated in Years 3 and 4, and again in Year 9 or 10. The aim of the review is to assess if the needs of the community are being met and if the health of the estuary is being maintained. Following the assessment, adjustments to the Strategy may be required to improve the outcomes by reviewing the Actions.

Target 14 – Long-term management aim

Action 14.1 - Consult with and obtain funding and/or financial support from other responsible authorities such as Crown Lands and DPE with the aim to reduce ongoing expenditure resting with Council.

The onus is on Council to carry out the wrack management on an ongoing basis, however, this action provides for effort to be made to obtain funding and/or support from other entities such as Crown Lands who hold title to the bed of the lakes and to parts of the foreshore. The NSW government will also be pursued to contribute towards the management of

wrack in the estuary as it is a unique situation state-wide that requires renewal of approvals. There is considerable scope for other levels of government to assist with new approaches, ease of permit renewal, as well as a reduction in the considerable ongoing costs to Council.

4.8 Opportunities to utilise wrack

Another consideration for Council is that there may be real opportunities to utilise the seagrass and algae wrack to produce a commercial product at the same time reducing the impacts of excessive wrack accumulation within the Lakes. Any collection for a commercial purpose would require a separate permit under the *Fisheries Management Act 1991*.

Opportunities were considered in the GHD report (2019) and some are discussed below that would require the development of a business case to fully identify the potential for the effective production of usable biochar or compost by Council or by any other organisation. It is likely that a considerable investment in machinery and equipment would be required at the commencement of such a process given the amount of wrack that is collected.

Biochar

Biochar is a carbon-rich material that is typically prepared from various organic waste (Wang and Wang 2019). Biochar can be used for a multitude of factors such as soil remediation, organic solid waste composting, carbon sequestration, decontamination of water and wastewater as well as soil fertility for agriculture (Wang and Wang 2019). A recent study in Australia investigated the potential of creating biochar from wrack waste to reduce emissions as well as reducing waste entering landfill (Macreadie et al. 2017). The results of this study indicated that the generation of biochar from seagrass wrack creates a commercially viable by-product while also removing the gaseous emissions that are generated by wet decomposing wrack. These studies outline that this type of management practice offers a climate-friendly alternative to the disposal of wrack to landfill, while also providing a resource that council and the community can either use or sell as a product. The types of uses include the following:

- Soil rehabilitation.
- Fuel production.
- Soil conditioner to increase agriculture productivity.
- Organic composting.
- Increase plant productivity.
- Decontamination of water, wastewater, storm water runoff, agricultural runoff (absorbs nutrients, heavy metals, organic pollutants and complex mixtures from environmental matrices).
- Filtering suspended sediments.
- Enhance microbial growth and improve the efficiency of activated sludge treatment and anaerobic sludge treatment.
- Carbon Offsets.

Biochar can simply be made by Council and/or the community by following simple steps such as described below:

1. Dry out wrack, ensure it is not wet before the biochar process.
2. Fill the chosen equipment with the dried wrack. Equipment used to create the biochar could include one of the following - Biochar oven (old oil drum), flame cap trough, kiln, retort, or top-lit updraft gasifier (TLUD)
3. Start the chosen equipment following the instruction manual.
4. Once the equipment is running and a flame is burning, start excluding oxygen by either placing a cover over the fire, covering the fire with soil or placing some more biomass on top of the current pile to keep the oxygen away from the lower levels. Leave it to burn but keep an eye on it.
5. Once all the biomass has been burnt and turned in charcoal, quench the charcoal by tipping liquid over it.
6. Once this done, the charcoal can be crushed if needed to add to compost to charge it with microbial life or it could be added to soil to increase plant productivity.
7. The charcoal can also be left as large clumps as well, depending on your desired use.

Compost

A study by Mainardis et al. (2021) examined different management strategies using a life cycle assessment (LCA) and life cycle costing approach (LCC). As a part of this study, anaerobic digestion (AD), composting, ecological restoration and landfill methods were considered. The study found that all alternative scenarios had lower environmental impacts than landfilling. Specifically, ecological restoration and anaerobic digestion resulted in the best environmental performances, while composting was the most economically favourable scenario. Composting represents a suitable and cheap method for handling and processing accumulated wrack along the foreshore. The biomass collected from the foreshore is typically mixed with a lignocellulosic substrate such as wood chips to the compost (Gibilisco et al. 2020).

Compost can easily be made by Council and/or the community by following the steps below:

1. Collect seagrass wrack from foreshore.
2. Mix the wrack with some form of lignocellulosic substrate (pre-treatment).
3. Add the mixture to the compost bin.
4. Depending on the compost bin, it will need to be rotated every three days to oxygenate the plant material to assist in the decomposition phase.
5. Once the plant material has broken down into a useable resource it can be sold and/or used as a soil conditioner.

This system would likely be at a considerable establishment cost.

Mulch

Organic mulch is another alternative method that could be used as a sustainable way to dispose of wrack accumulation. Organic mulch is effective in conserving soil moisture, suppressing weeds, reducing soil erosion, and buffering drastic changes in soil temperature (Grassi et al. 2014). The accumulated wrack on the foreshore could be used directly as a part of revegetation or restoration projects to supress weeds and retain soil moisture for seedlings.

The current collection process involves dried wrack being transported to a waste management facility where it is combined into mulch and sold to the community.

The NSW Environmental Protection Agency (EPA) provides an exemption (Resource Recovery Exemption under Part 9, Clauses 91 and 92 of the Protection of the Environment Operations (Waste) Regulation 2014) for waste that is or is intended to be applied to land as a soil amendment. Mulch is defined as

> *"…plant material shredded and/or screened to a preferred particle size grading for particular applications. Mulch, by virtue of the nature and source of the plant material, must pose minimal risk of the presence of physical and chemical contaminants.1 Mulch may include urban wood residues and forestry and sawmill residues. Mulch does not include plant material from kerbside waste collections."*

The intent of this Exemption is for use by the person collecting the mulch and the one of the conditions is that it must be applied to the land owned by the person collecting it within 2 weeks of being collected.

Biogas

A study by Mainardis et al. (2021), found that both ecological restoration and anaerobic digestion resulted in the most environmental performances because of biogas production, which could be used as a renewable energy source. Biogas can be used in a combined heat and power (CHP) unit to produce thermal and electric energy need for an anaerobic digesting reactor (Mainardis et al. 2021). This reduces the need to use power from the national electricity grid, thereby reducing costs as well as using a renewable energy source to dispose of the seagrass wrack.

A report produced for the Australian Renewable Energy Agency (ARENA) as part of the Australian Government in 2019 identifies opportunities for biogas in Australia (ARENA 2019). The financial viability of projects is aided by some incentives, however a high level of investment is required. This process is in its infancy in Australia. Revision of the process, policies and viability is recommended in the future.

4.9 Risks to strategy implementation

The Strategy contains targets and actions developed through a review of the current literature relating to the Tuggerah Lakes estuary and from other similar or relevant locations around the world. It has consulted extensively with the CSRG as a source of information and knowledge and has also discussed legislative requirements and permit details with state government officers.

The risks considered to be relevant to this Strategy include:

Funding	Funding is essential to the completion of all the actions to achieve the targets for this Strategy. If funding is not available or sources are not identified, there will be an impact of the level of completion of the actions within the Implementation Plan.
Environmental	Unforeseen and unknown environmental impacts associated with the actions described in the Implementation Plan.
Natural Disasters	Should an unforeseen natural event or events alter the conditions in the estuary so that the implementation of the actions towards the targets is unachievable.
Contractor Availability	There may be a limit to the number of contractors that have appropriate equipment available to carry out the wrack collection requirements.
The unintended consequence of an action	Where there is a chance that something unforeseen results from an action and has consequences that were not considered or predicted or meant to occur.

5 References

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Appendices

Appendix A.1. Summary of scientific literature findings

Appendix A.2 Community input into the Strategy

Appendix A.3 Cost Benefit Analysis

Appendix A.4 Implementation Plan

A.1. Summary of scientific literature findings

A thorough literature review was conducted during the development of this Strategy and is available as a standalone document. The literature review analysed key documents and scientific papers relevant to the Tuggerah Lakes estuary and catchment and wrack management. A summary of the key documents reviewed is provided in the table below.

Timeline for key Tuggerah Lakes reviewed past studies

Name of Report	2006	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Tuggerah Lakes Estuary Management Plan.																
Tuggerah Lakes Wrack Management Strategy.																
Tuggerah Lakes Interim Wrack Harvesting Strategy.																
Tuggerah Lakes Wrack Harvesting Strategy.																
Restoration of Tuggerah Lakes through Improved Water Quality Management.																
An assessment of 'Tuggerah Lakes Restoration Project' as a Shoreline Restoration Strategy.																
Recommendations for Management of Ooze in Tuggerah Lakes.																
Tuggerah Lakes – The Entrance Morphodynamic Modelling.																
Review of Wrack and Algal Collection Program – Final Report for Central Coast Council.																
Tuggerah Lakes Water Quality Independent Expert Panel Review.																
Tuggerah Lakes Estuary Management Plan Summary of Implementation 2008-2020.																
Appendix A – Tuggerah Lakes Coastal Management Program: Community and stakeholder engagement strategy.																
Appendix D – Tuggerah Lakes Coastal Management Program: Environmental Context.																
Tuggerah Lakes Estuary Coastal Management Program Scoping Study.																
Tuggerah Lakes Wrack Collection – Ecological Assessment.																
Tuggerah Lakes Foreshore Condition Assessment Final Report.																
Tuggerah Lakes Estuary Coastal Management Program: Our progress on the recommendations from the Tuggerah Lakes Expert Panel.																

Whilst the standalone literature review outlines the review outcomes in detail, key findings from the literature review stage of the project that have been considered in the development of this Strategy are summarised in the following sections.

A.1.1. Seasonal collection

Seagrass shedding

Seagrass sheds its leaves twice a year in Spring and Autumn as well at other times depending on conditions such as water level, flooding, and other climatic factors. Ferguson and Scanes (2013) identified seasonal wind direction and produced a map of parts of the estuary that were chosen for seasonal wrack collection (Figure 25).

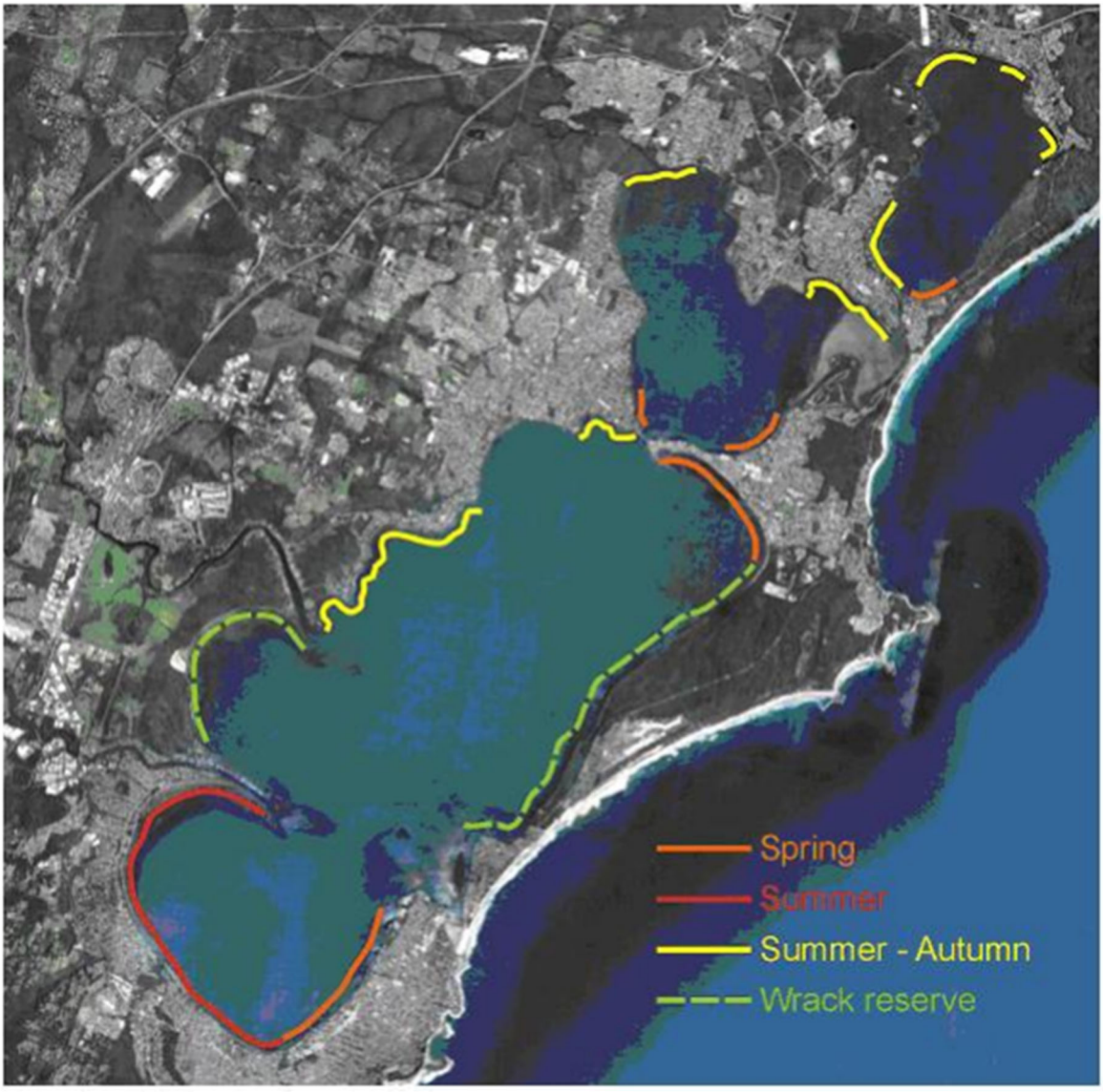

Figure 25 **Areas chosen for seasonal wrack collection** (Ferguson and Scanes, 2013)

Macroalgal blooms

Macroalgal blooms have been recorded throughout the year at all shorelines throughout the estuary but with two peak growth periods highlighted (CCC 2023). While the macroalgal blooms do not persist throughout the year, the variation in occurrence coincides with water levels in the lakes and prolong dry periods, as well as the seasonal development.

Figure 26 indicates areas in red where algal blooms occur in greater than 75% of the years surveyed and where the largest blooms were recorded (CCC 2023). The orange marks indicate areas where algal blooms were detected 50% of the time and were generally nearshore and less extensive that the red areas. While green areas show locations where annual blooms are unlikely to occur and were detected in less than 20% of the years surveyed.

Large persistent macroalgal blooms are noted for Chittaway Bay and Chittaway Point. The bay adjacent to Tuggerah Nature Reserve (where there is restricted access for the contractor), Long Jetty eastern shoreline of Tuggerah Lake, and Budgewoi on the south-western shore of Budgewoi Lake are all noted as most likely to develop algal blooms.

Further records indicate that winter can be a peak growth period for macroalgae and that collection in the highlighted areas where algae is most likely to occur in significant blooms, should be identified and carried out at the earliest possible time by the collection contractor.

An investigation into macroalgal blooms in shallow estuaries by Ivan Valiela et al. (1997) indicates that temperature, light availability, grazing and nutrients (especially nitrogen) are the control mechanisms for algal blooms, while one of the best approaches to remediation is physically removing the macroalgal along with the excess nutrients that caused it. Macroalgae can replace seagrasses at suitable locations such as occur in the estuary at the locations identified below in Figure 26.

In Figure 26, red indicates areas most likely to develop algae bloom with occurrences detected in >75% of the years surveyed. They are also areas where some of the largest blooms were detected. The orange indicates areas where annual blooms were detected approximately 50% of the time and were generally nearshore and less extensive than red areas, and green indicates areas where annual blooms are unlikely to occur, and blooms were detected less than 20% of the time for the years surveyed.

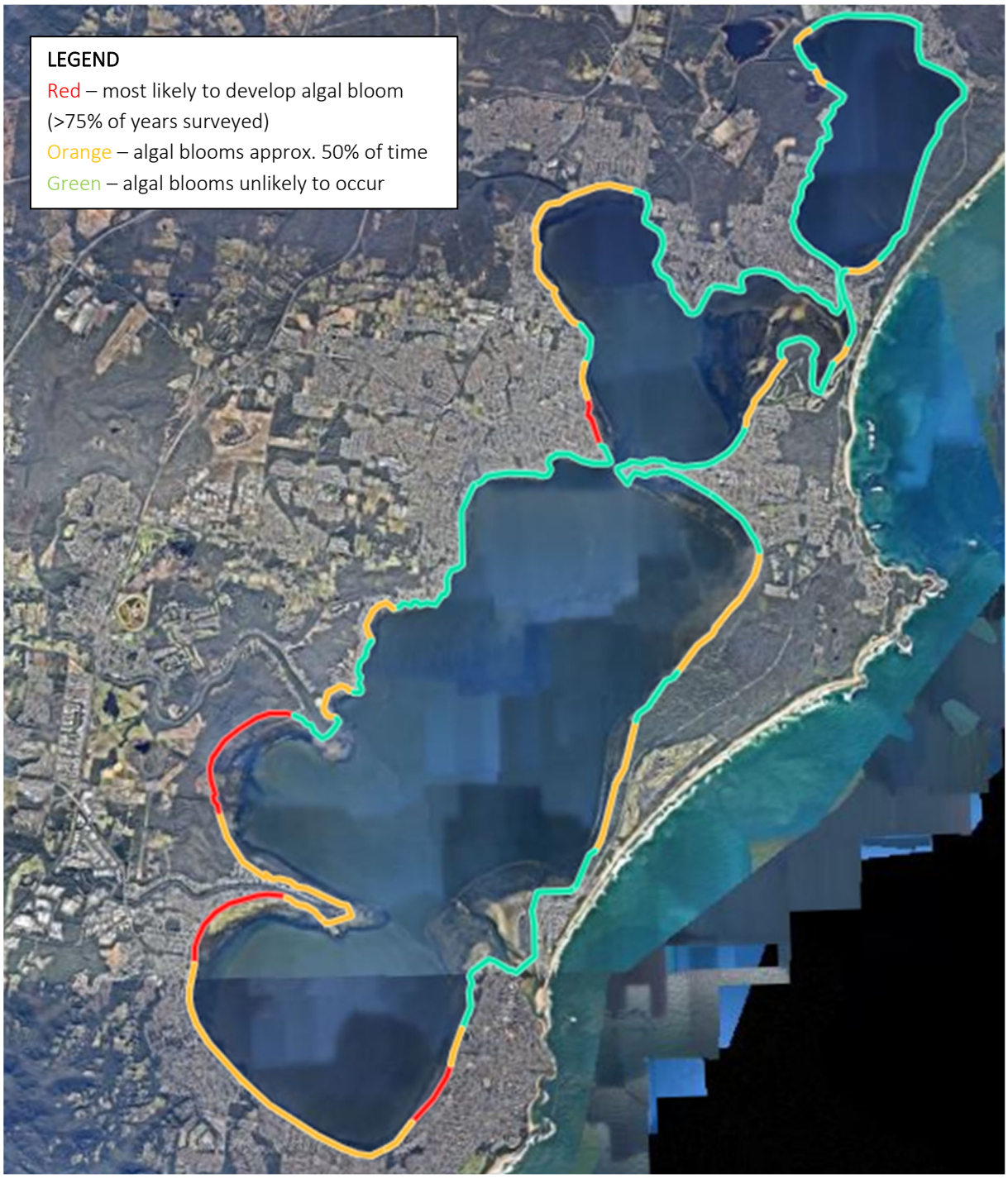

Figure 26 **Summary of macroalgal bloom development risk** (CCC 2023)

A.1.2. Boom trials

Future trials should incorporate these findings and amend the trial to include lessons learned:

- Booms with higher coverage above the water level,
- Booms with beneath the surface barrier in place that is not hazardous to marine life, and
- Shorter lengths of the appropriate booming in priority areas.

A.1.3. Wrack fencing to protect saltmarsh

Wrack fencing intended to restrict excessive amounts of wrack negatively impacting saltmarsh areas was successfully installed, partly on land and partly in the water to > 90cm deep in the wrack accumulation zone for the length of the saltmarsh site. Stormwater outlets were avoided, and fish passage was created with a minimum size of 40x30cm at least 3m apart. This method did not cope with flood conditions. The fence was constructed using the following materials (Pers. Comm. M. Barnett 2023, photo below):

- 2.4m galvanised star posts placed 1.5-2.0m apart,
- 1.8m green or black shade cloth (70% weave),
- 6mm galvanised wire rope with clamping grips,
- Galvanised steel rope,
- Bostitch® Hog ring stapler or compressor-run galvanised hog rings stapler,
- Galvanised Hog ring staples, and
- Heavy duty cable ties.

A.1.4. Bycatch monitoring

The literature review identified that the existing monitoring approach to bycatch is not providing regular results or data that is useful to the ongoing operations of the collection equipment.

Future management should include monitoring of bycatch at collection by the operational staff, at offloading on the shoreline and on storage/drying pads.

A.1.5. Summary of Tuggerah Lakes Expert Panel recommendations

The Tuggerah Lakes Expert Panel (TLEP) made recommendations in the Tuggerah Lakes Water Quality Independent Expert Panel Review (the Review) that included the development of strategic and measurable plans for:

- Dredging,
- Wrack management,

- Nearshore water quality,
- Stormwater management,
- Entrance flood management, and
- Sustainable catchment development.

The Panel's overarching recommendation for a strategic and measurable Wrack Management Strategy and plan included a highly collaborative approach working with community and stakeholders. The key recommendations from the TLEP review involve a whole of catchment approach as detailed in section 4.7 of the Review (Glamore et al., 2020).

Specific recommendations for streambank rehabilitation, stormwater device management, education, address the catchment influences on wrack accumulation. In relation to wrack management, the TLEP supports and commends Council's efforts and recommends:

- a 'Taskforce' be established for a 5-year period with a review after three years to assist in implementation of agreed actions (funded by state government),
- an environmental levy be implemented,
- a stormwater levy also be implemented to audit existing and proposed infrastructure, and
- development of a dredging strategy and plan.

A.1.6. Future Management Options

The Review (Glamore et al., 2020) as a key background document makes recommendations towards the following:

- Communication re-set – government and community (Chapter 2)
- No permanent ocean entrance for water quality purposes (Chapter 3)
- Council existing work continues, to recouple the fringing seagrass area with the deeper zones to improve water exchange (Chapter 4)
- Stormwater or environmental levy to be used to maintain the stormwater inflows (Chapter 5)
- Future development in the catchment – design and constraints (Chapter 6)

The overarching recommendations described in Section 6.2 of the Review (Glamore et al., 2020) include:

- Establishment of a ***Catchment Coordinator Taskforce*** for a 5-year period to assist with implementation
- Environmental levy to maintain the response
- Stormwater levy to audit existing and proposed design and infrastructure
- Develop dredging management strategy for the Entrance channel (currently underway)
- Establish a working group to set criteria to guide options and actions, oversee pilots and investigations, and monitor ongoing works
- Entrance dredging and consideration of second entrance – ongoing and underway
- Water quality and ecological recommendations:
    - Redirect stormwater into rivers and creeks to alleviate nearshore eutrophication where possible
    - Large-scale re-engineering of shorelines
    - implementation of strategic wrack collection
        - *science-driven to adapt to wind-driven transport with focus on locations where wrack collection would improve nearshore circulation (by removing offshore wrack barriers)*
        - *allow wrack to remain in areas where aerobic drying can occur*
        - *need to increase wrack collection capacity – machinery upgrade, methodologies for shallower waters, etc.*
- Wetland rehabilitation

- Further studies to quantify importance of groundwater nutrient inputs to the nearshore zone
    - If found important, strategies such as use of bioreactors should be investigated for feasibility
- Ongoing monitoring and adaptive management
- Community education and engagement
- Visual products
- Funding and implementation
- Planning
- Opportunities – for future planning, development, retro-fitting within the catchment.

This Strategy focuses on the recommendations from the Review around water quality and ecological concerns, with further focus on implementing strategic wrack harvesting.

A.1.6.1. Science-driven considerations

The Review recommends using the evidence base developed by DPIE for strategic wrack harvesting (Swanson, 2013). The three recommendations for wrack harvesting are:

- Strategic harvest of offshore accumulations:

Wrack accumulations can be trapped by emergent seagrass beds that act as a barrier to water currents and flow in the nearshore. There is little mixing of the waters between nearshore and lake basin areas where this occurs. This is a major contributing factor to poor water quality and ooze in the nearshore. Seasonal strategic wrack collection is recommended to improve water quality in the nearshore and reduce ooze by improving water flow and mixing. It might be as a supplement to ongoing reactionary collection from public foreshores with high amenity value.

Wrack collection must minimise secondary effects such as damage to living seagrass, disturbance of ooze and oozey sediments, damage to fringing saltmarsh.

- Sensitive harvest of wrack from nearshore areas

The NSW government (then Office of Environment and Heritage) proposed new techniques for trial and investigation:

- Movement of trapped wrack onto shore where conditions permit, and
- Skimming wrack from shallow to deeper waters where the collection equipment can collect it.
- Community harvest for Council collection

Aim to reinstate the community collection policy through education and involvement. Help community to increase the ‘ownership’ of the Lakes and improve the condition of the nearshore zone in front of privately owned land.

A.1.6.2. Locations where wrack can remain

Priority Locations have been established where wrack is to remain in place. These are identified as ‘wrack reserves’ and included parks, saltmarsh, reserves, and areas where natural vegetation is present on the lake shore. This recommendation has been undertaken. Wrack can also remain in place where there is no housing development and where there are no direct stormwater inflows.

A.1.6.3. Increase wrack collection capacity

The capacity to collect wrack is limited because of the availability of the appropriate equipment and machinery. An increase in the available equipment could be achieved by Council purchasing their own equipment and sourcing other contractors to supplement the ongoing seasonal strategic collection of wrack at peak times. These options require further and ongoing consideration.

A.1.6.4. Education and awareness

It is imperative that community knows the natural process of wrack production and is aware of the limitations that exist around collection of the excessive wrack accumulations that are such a negative impact on the estuary.

A.2. Community input into the Strategy

A.2.1. Community and Stakeholder Reference Group Workshops

A central activity in the development of this Strategy was the formation and engagement with a Community and Stakeholder Reference Group (CSRG) that was established to contribute to the content of the Strategy. The CSRG was comprised of 15 community participants selected via an Expression of Interest process to ensure diversity amongst participants and to incorporate the views of the whole community. Participation in the CSRG was also received from NSW Department of Planning and Environment and NSW DPI Fisheries, and requests for attendance and/or input from Crown Lands, commercial fishing groups, sailing clubs, and the local traditional owner groups were made.

A series of three extensive and highly collaborative workshops were held in person with the CSRG with the aim of ensuring comprehensive community input to the Strategy occurred. The workshops covered a range of aspects including the current state and issues, management options and approaches, key responsibilities, action permissibility and prioritising wrack management actions. A summary of each of the workshop outcomes is provided in the following sections.

The community-driven targets identified in the CSRG Workshops form part of the final Strategy and are incorporated where appropriate with the targets identified by other stakeholders, Council, and the needs of the environment.

A.2.1.1. Workshop #1

The first workshop was held at Wyong on 14th June 2023 and commenced with an information session about seagrass and the conditions in the Tuggerah Lakes estuary. Following that, participants were asked to provide their thoughts about the main issues around the Lakes in terms of developing the Wrack Management Strategy.

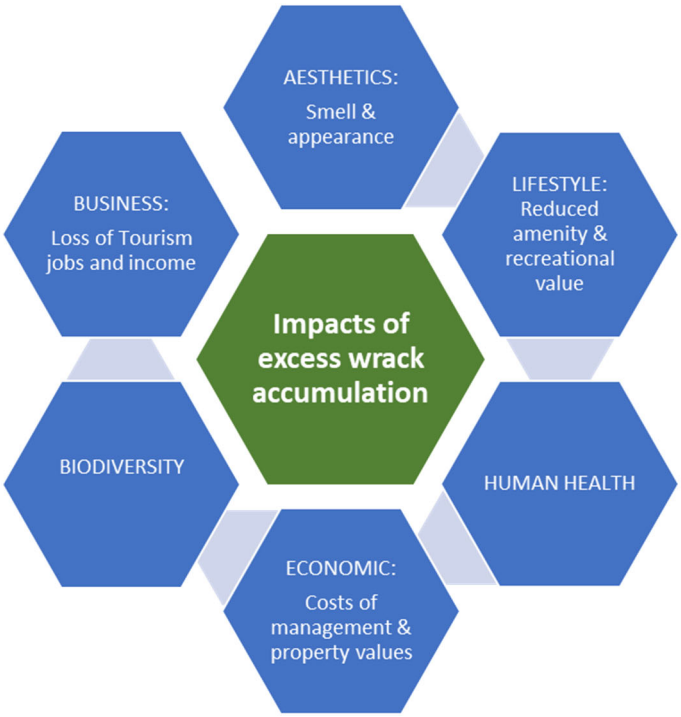

Figure 27 Key issues with excess wrack accumulation in Tuggerah Lakes – results from Community Workshop 1

The main issues were identified as shown in Figure 27 as:

Aesthetics: the unhealthy appearance of the Lakes where wrack and ooze appear, and the associated smell.

Business: the loss of tourism income, associated employment and income, low level of return visitors.

Biodiversity: appearance of dead fish, birds, reduction in observed wildlife, depleted fish stocks.

Economic: the cost of management and the decrease in property values.

Human health: the odour, the condition of the Lakes, the perception of not being able to help a very sick system, depression, and anxiety levels. Occasional Council warnings not to swim because of water quality.

Lifestyle: reduced amenity value including inability to paddle, canoe, kayak, swim, enjoy the Lakes.

The workshop participants were asked to identify Priority Locations, in general and specifically. These are shown in Figure 28. The Priority Locations have been mapped against the operational collection constraints (such as rocky shorelines and shallow waters).

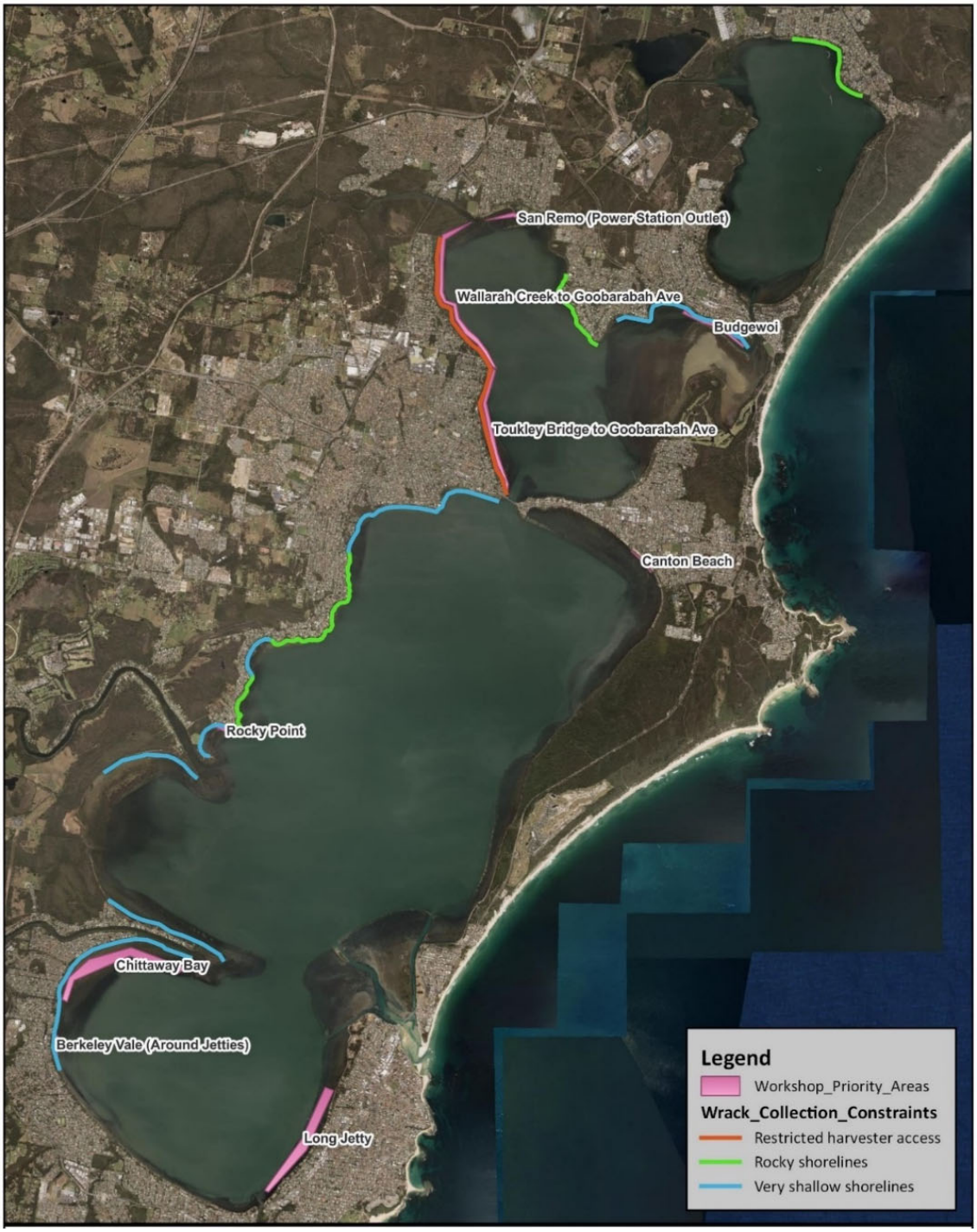

Figure 28 Priority Locations for wrack collection in Tuggerah Lakes as identified in Community Workshop 1

A.2.1.2. Workshop #2

The second workshop was held at the same location at Wyong Council on 5th July 2023.

This session aimed to identify the management targets that the group would like to see form the basis of the WMS. The actions to reach or work towards the targets below are listed in detail in the Implementation Plan (Appendix A.2.). Targets have been listed for immediate action, that is prior to the commencement of the Wrack Management Strategy, during the period when the Strategy has been adopted by Council and is being considered by State Government under

the Coastal Management Act. Targets are then set up for within the first four years and for the remaining six years of the Strategy.

The targets are summarised below:

Immediately

Immediately establish **Lake Wrack Management Working Group** to provide oversight and communication point between council and community with regards to wrack management operations, further investigations, scheduling, etc.

Years 1 – 4

Theme 1 – Communications.

Interpretive signage incorporated into key locations to provide education and awareness to community.

Community satisfaction, knowledge and understanding baseline data collected in Year 1.

Point of contact identified for community to contact Council regarding wrack accumulation and Priority Locations.

Within four years convert 50% of community complainants into advocates.

Lake Wrack Management Working Group continues to operate.

Theme 2 – Source

Ten key locations identified to collect sediment and nutrients before they enter the estuary.

Reduced nutrients entering the estuary from the catchment measured at 2 key locations.

New developments incorporate WSUD and nutrient capture devices at the planning stage.

Theme 3 – Accumulation

Accumulation of seagrass and algae wrack reduced at 10 key locations within 4 years of commencement of the Strategy.

Reconfigure shorelines at 5 locations to allow seagrass wrack to 'leave' the estuary by wind/wave action within 4 years.

At least two pilot studies commenced within the Year 1 to Year 4 period – e.g. boom designs/styles and boom locations.

Theme 4 – Collection

Annual collection schedule published for whole community.

LakeCare established and operating at 2 locations.

Establish baseline level of impact from current collection equipment by assessment of shoreline impacts and bycatch monitoring.

Results of pilot studies incorporated into ongoing Wrack Management implementation.

Years 5 – 10

At least two further pilot studies completed within the Year 5 to Year 10 period.

Theme 1 – Communications.

Community satisfaction surveyed again at Year 4 and Year 8, and results publicised.

Lake Wrack Management Working Group continues to operate.

Point of contact satisfactory according to further community survey.

Theme 2 – Source

Ten key locations identified in first 4 years, monitored for impacts on WQ, wrack, algae and ooze.

Reduced nutrients entering the estuary from the catchment measured at 2 further locations.

New developments continue to incorporate WSUD and nutrient capture devices at the planning stage.

Theme 3 – Accumulation

Results of boom pilots incorporated into ongoing collection for at least 4 sites so as to manage accumulation.

Results from ongoing monitoring guide future practices to manage accumulation of wrack at 10 key locations.

Theme 4 – Collection

LakeCare established and operating at 8 more locations.

Ability to collect from previously constrained areas improved through improvements to booming and shoreline configurations at trial locations.

Annual wrack collection schedule published.

Results from ongoing monitoring guide future collection practices.

A.2.1.3. Workshop #3

Workshop 3 was held at Wyong on 26th July 2023. The Draft WMS targets and actions developed from the community input during the earlier workshops were presented to the group at this session and feedback was recorded. Amendments and changes were made to the targets and actions as requested by the Workshop group based on the framework shown below:

Theme 1 – Community connection	Theme 2 – Catchment pollutants	Theme 3 – Wrack build up issues	Theme 4 – Lake sources of wrack
Issues requiring inclusion in the wrack management strategy			
Little community involvement	Sediment and nutrient pollution	Accumulation on economically valuable shorelines	Wrack rafts accumulating in lake
No enforcement	Stormwater entering lakes contributing to ooze	Contractor collection efficiency	Wind fetch
Little understanding of the issue		Weather and water levels	

The final community Targets and Actions were honed and adjusted so that the results, under the four Themes identified in Workshop #2, became those which have been included in the Implementation Plan in Appendix A.4. The Community Targets are:

Pre-target - Immediately

Target 1 - Improve community awareness - within 4 years convert 50% of community complainants to advocates

Target 2 – To increase state and federal funding for lake management

Target 3 – Manage impacts from nutrients by collecting wrack at high stormwater impacted foreshores

Target 4 – Investigate techniques to manage impacts of pollutants entering the estuary (collaborative research projects)

Target 5 – Improve/reduce the impact from current collection processes

Target 6 – Investigate alternate wrack collection methods/machinery

Target 7 – Establish community group wrack collection program within 4 years

Target 8 – Establish network of paid wrack collection groups within 4 years

Target 9 – Source ongoing council funding for actions under the WMS

Target 10 – Reduce wrack build up in deeper areas of the lake (before build up in nearshore and on beaches)

Target 11 – Investigate options to reduce lake wrack accumulation

A.2.2. Community Drop-in Sessions

Four community drop-in sessions were held across the estuary at the following locations on 5th and 6th October 2023 at the following locations:

- Saltwater Creek Reserve, Tuggerah Parade, Long Jetty,
- Tuesday Street, Tuggerawong,
- Beach Parade, Canton Beach, and
- Edgewater Park, Narambi Road, Buff Point.

In summary, the comments from community regarding wrack included:

- Blockage of Tumbi Creek by wrack at the mouth
- Lack of boating access because of ooze
- Commercial fisheries damage seagrass which contributes to amount in foreshore
- Prawn Beach Lane off Tuggerawong Road – unusable any more
- Contractors seen as not efficient, sometimes damaging shorelines, pipes, etc.
- Flooding a constant concern
- Conserve the seagrass and the biodiversity especially wildlife
- Take wharves out past the foreshore to provide better community access
- Maintain Canton Beach as a high priority tourism drawcard
- The stench from drying pads – timing could be better to suit holiday periods
- Trials of other methods strongly supported by some
- Use tractor and hopper on beaches
- Smell near Buff Point, rocky shores and poor collection practices

Some commented that wrack was not really an issue at their location which others were incensed about the amount of wrack built up continually and not cleared. Some saw the contractors as great and very helpful while others were sure they were inefficient and ineffective and damaged the foreshore areas.

A.2.3. Social Pinpoint

In June 2020, Council set up mysocialpinpoint.com/wrack-management-strategy to facilitate comment from the CSRG including photographs about the estuary and the current wrack management operation. Some example comments and photographs are included below. [Please note all comments and photographs are anonymous.]

Damage to foreshore sediments by collection equipment on the north shore of Budgewoi Lake (Photo 1). An algal bloom shown at Chittaway Bay (Photo 2).

The question of whether the Common Reed (*Phragmites australis*) should be removed or encouraged from the shores around the estuary was raised on social pinpoint. This plant absorbs nutrients and provides shoreline protection from wave and storm surge, however, it can become invasive and act as a barrier to seagrass wrack being able to blow out of the water (Photo 4).

Photo 1 Sediment disturbed by shoreline wrack collection equipment

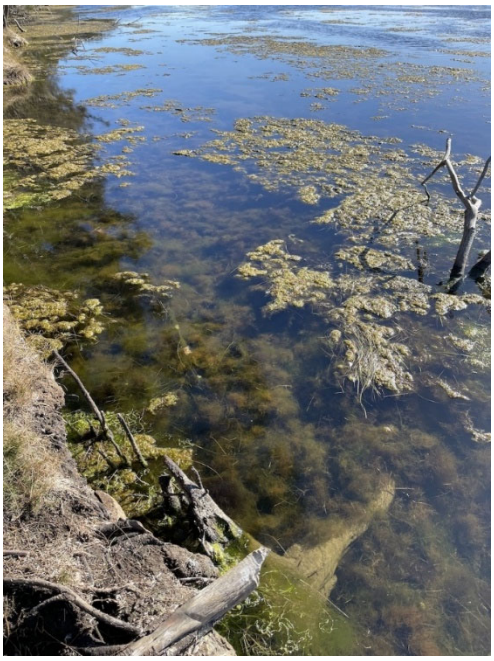

Photo 2 Algal bloom at Chittaway Point in central Tuggerah Lake

Photo 3 Northern shore of Tuggerah Lake showing *Phragmites australis* growth

**All photos from social pinpoint.*

A.3. Cost benefit analysis

This is reproduced from the Tuggerah Lakes Wrack Management Strategy - Literature Review (2023) prepared by Alluvium Consulting Australia.

The GHD Report (2019) carried out an analysis of Council collection expenses for 2018/19 which amounted to $1.15million. The Report estimated that 2019/20 costs with an allowance for increased wrack and CPI would be in the vicinity of $1.31million.

The GHD Report (2019) provided an analysis of Council's expenses for 2018/19 financial year of $1.15 million which included internal plant hire fees (from Council's Plant and Fleet division) for the wrack and algae collector, mobile boat trailer and 12tf alloy punt (2017-2019). Council budgeted for 2019/20 of $1.31 million included increased costs for:

- $450,000 for tipping fees,
- $470,000 contractors, and
- $390,000 hire costs, overheads, and salaries.

Actual costs for the 2020/21 financial year were $830,112 as provided below:

- $126,000 tipping fees,
- $58,850 land improvement costs (depreciation of wrack pads, ramps and moorings),
- $62,500 plant, fleet, licences, and mooring fees
- $168,500 current staff and overheads
- $414,262 contractor costs

The AES contract commenced in 2019 and was valued at $1,557,000 over the initial three years. The optional extension was taken up at a cost of $1,140,000 and will be completed in August 2024. The total contract value of $2,697,000 over five years amounts to an average $539,400 per year across that period.

A cost benefit analysis has been completed with regards to ongoing contractor costs compared to the costs to Council of purchasing equipment and employing operational staff. It would be necessary to continue engagement of contractors on a different basis, to assist with regular collection and particularly with times where accumulation is extreme. There may be practical difficulties with an arrangement like this as AES has dedicated its operations to the Tuggerah Lakes and, if not engaged on a similar contract, it would be necessary to find alternative engagement for the equipment to maintain business operations. At present, there do not seem to be other similar contractors available.

The potential costs involved with purchasing equipment must also include the required modifications and approvals through Fisheries and also for marine vessels through Department of Transport NSW maritime services. The ongoing costs of maintenance and servicing, the costs associated with the spasmodic time allocations of staff to use the equipment, the requirement to have two staff on any operating equipment, all add up to much more than an initial outlay.

An estimate of the potential costs has been compiled in the table below. Estimates are based on the report by GHD (2019) and on information provided by Council. An allowance for inflation from 2020/21 costs (GHD 2019) has also been made of 14% across two years (ABS 2023).

COST ESTIMATE (including CPI increase)	Initial Cost	Per Year (estimate)
Purchase equipment – Mobitrac & fittings (bucket, rake, mesh, etc) completed by Council's Plant and Fleet Division (market estimate)	$350-500,000	
Ongoing permanent hire (internal) of wrack and algae collector, Truxor, tender vessel and/or punt, 4x4 ute and/or truck, 3-way tipping trailer and other plant and equipment as required		$444,600
Existing staff		$192,000
Additional operational staff (based on 1x Level 1 crew leader, 1x Level 2 crew member) plus on costs at 42.5%		$225,000
Tipping fees		$144,000
Licensing, mooring, external plant hire and permit fees		$71,250
Repairs, Maintenance & ongoing running costs (based on 10% of cost)		$50,000

Contractor costs over the last five-year period have been $476,000 (based Council estimate for 2022-23) with the whole 5-year contract 2019-2024 totalling $2,697,000. Over a 10-year period, the cost for Council to procure and operate in a similar nature equates to double the contract sum (including a nominal increase of 15%), which is an estimate of over $6 million.

Compared to the existing contract and allowing for a 14% CPI increase on the last contract, the expected contract for 2024 to 2027 would be in the vicinity of $542,000 per year.

The benefits of continuing with a Contractor-based system for the ongoing collection of seagrass wrack and algae include:

- No initial outlay required,
- Ongoing maintenance and upgrades to machinery form part of the contract and are not Council responsibility,
- Risks associated with damage to equipment and ongoing repairs, sit with the Contractor, and
- Associated costs for insurance, registration, maintenance, etc. remain with the Contractor.

The only obvious benefit from Council owning their own equipment and employing dedicated staff would be the ability to increase collection at times when it is needed if the Contractor was available to assist.

A.4. Implementation Plan

Target for Wrack Management	Actions to achieve Wrack Management Targets	Action Commencement (Year 1 – 10)										COST ESTIMATE	Additional comments / notes
		1	2	3	4	5	6	7	8	9	10		
THEME 1 – Community Connections													
Pre-target- Immediately	Establish Tuggerah Lakes Wrack Management Working Group -Delegates to include community members, council staff and, external stakeholders when applicable												
Target 1- Improve community awareness - within 4 years convert 50% of community complainants to advocates	1.1 – Develop communication plan that will improve the general knowledge of the community about the estuary, seagrass, algae, ooze, and the systems that are in place for both natural and managed areas.												
	1.2 – Install estuary facts interpretive signage at 5 priority collection locations that each relate to estuary issues/features related to wrack processes or wrack management such as wildlife, saltmarsh, ooze, algae.											$1,200 for each with Council to instal within works program – total estimate $6,000	
	1.3 – Establish a centralised portal for wrack management within Tuggerah Lake.												
	1.4- Development of information materials and distribute/communicate them to the community, timing of posts to align with Autumn and Spring shedding) (e.g. factsheets (what is wrack, seagrass lifecycle, ecological processes, wildlife relating to wrack, wrack collection process, marine biota reliant on seagrass, what is algae, what is ooze, what is the smell, saltmarsh identification, etc.)											$10-15,000 for printing etc.	
	1.5 – Establish direct communication to lakefront property owners and recreators about wrack (e.g. fact sheets, mail outs, web publications, etc.)											$2,000 each for mail outs	
	1.6 – Identify and liaise with relevant community groups (may include Facebook groups) with the aim to establish links to the centralised portal												
	1.7 – Investigate and establish community clean up days.											$3,000 per day for event	
	1.8- Establish baseline of community satisfaction/knowledge with wrack management (social survey) results shared with public.											Materials and mailing costs $5,000 to the larger community	
	1.9 – Re-do community satisfaction social survey and publicise results											Materials and mailing costs $5,000 to the larger community	
Target 2 – To increase state and federal funding for lake management	2.1 – Review potential grant funding sources and apply for funding to implement actions from the Wrack Management Strategy												
THEME 2 – Catchment Pollutant Management													
Target 3 – Manage impacts from nutrients by collecting wrack at high stormwater impacted foreshores	3.1 – Manage wrack in accordance with the Schedule at foreshores with significant stormwater influence within the Priority Locations.												
Target 4 – Investigate techniques to manage impacts of pollutants entering the estuary (collaborative research projects)	4.1 – Investigate collaborative research projects for stormwater treatment systems on foreshore locations (e.g. Australian Research Council, Universities, etc.)												
	4.2 – Investigate trial of novel stormwater treatment methodology/device at 1 of the Priority Locations - Include monitoring program (sediment/nutrient before-after-control-impact design)												

Target for Wrack Management	Actions to achieve Wrack Management Targets	Action Commencement (Year 1 – 10)										COST ESTIMATE	Additional comments / notes
		1	2	3	4	5	6	7	8	9	10		
	4.3 – Investigate collaborative research projects for groundwater treatment systems on foreshore locations (e.g. Australian Research Council, Universities, etc.)												
	4.4 – Investigate trial of novel groundwater treatment methodology/device at 1 of the Priority Locations - Include monitoring program (sediment/nutrient before-after-control-impact design)												
	4.5 – Evaluate results and develop action plan with recommendations for implementation.												
THEME 3 – Management of wrack build up (nearshore and foreshore)													
Target 5 – Improve the efficiency and reduce the impact from current collection processes.	5.1- Collect in accordance with Schedule and Operations Manual including: - Locations - Timing - Methodology												
	5.2 – Responsive collection at boat ramps and constructed beaches and the locations identified within the Schedule.												
	5.3- Develop real time management decision support tool with built in considerations of water level data, bathymetry, seagrass mapping, wind direction, macroalgae blooms, weather conditions, shoreline limitations.												
	5.4 – Ascertain baseline ecological health data using the indicators: • Sygnathid and aquatic fauna prevalence and distribution • Monosulfidic Black Ooze prevalence and distribution • Seagrass meadows and their changes (leaf length, m^2 etc) • Turbidity/Chlorophyll a (using existing data and MER program as baseline) • Wrack accumulation (m^2, depth, locations, etc). -Trapped wrack -Beached wrack											$25-30,000 (possibly annually) if outsourced from Council and depending on requirements	
	5.5- Evaluate results of ecological health data and develop action/monitoring plan with recommendations for implementation.												
	5.6- Implement ecological health action/monitoring plan												
	5.7- Develop drone monitoring program and modify wrack management in accordance with recommendations from evaluation.												
	5.8- Investigate alternate bins/ wrack drying pads to enhance visual amenity												
Target 6 – Investigate alternate wrack collection methods/machinery	6.1 – Review global and investigate alternate machinery/ methodology to access nearshore zones and eliminate ecological impact.												
	6.2 – Establish collaborative research group (e.g. Uni Newcastle, Dept Planning and Environment) to test new methods of wrack collection, how to prevent accumulation in certain areas, or how to disperse wrack into areas where collection by machinery can take place in deeper water.												
Target 7 – Establish community group wrack collection program within 2 years	7.1 – Establish volunteer collection pilot program similar to current Environmental Volunteer Program.												

Target for Wrack Management	Actions to achieve Wrack Management Targets	Action Commencement (Year 1 – 10)										COST ESTIMATE	Additional comments / notes
		1	2	3	4	5	6	7	8	9	10		
	7.2 – Investigate collection points/bins (such as skips or other large transportable containers) convenient to Priority Locations for community use.												
Target 8 – Establish network of paid wrack collection groups within 4 years	8.1- Investigate establishing professional paid groups for manual wrack management in areas with limited machinery access (e.g. areas with shallow water levels, rocky shorelines etc.).												
Target 9 – Source ongoing council funding for actions under the WMS	9.1 – Investigate stormwater and environmental levy to fund wrack management. This would include: - Community engagement - Business case development												
	9.2 – Undertake cost benefit analysis for a wrack collection plant and equipment owned and operated by Council. If viable, prepare a business case which includes potential realistic funding options.												
Target 10- Reduce amount of wrack disposed of at waste management facility.	10.1 – Establish trial sites where wrack can be used as an alternative to leaf/garden mulch (eg around trees, rehabilitation/ amelioration sites). - Expand to additional areas if applicable.												
THEME 4 – Lake Sources of Wrack Management													
Target 11 – Reduce wrack build up in deeper areas of the lake (before build-up in nearshore and on beaches)	**11.1 –** Collect in accordance with Schedule and Operations Manual including: - Locations - Timing - Methodology												
Target 12 – Investigate options to reduce lake wrack accumulation	12.1 – Investigate and trial boom designs to prevent wrack washing ashore at 2 Priority Locations e.g. Buff Point, Viewpoint St between jetties												
	12.2 – Investigate and trial methods (including nets) to drag wrack into deeper areas for collection – priority areas 'very shallow shorelines' north-east Tuggerah Lake.												
	12.3 – Investigate floating wetlands or other offshore barriers to manage wrack build up and nutrient/groundwater impacts in nearshore areas.												
Additional Actions for Wrack Management													
Target 13 – Review Wrack Management Strategy	13.1- Review WMS to ensure the program undertaken is current and meeting the needs of community as well as improving the health of Tuggerah Lakes.												
Target 14 – Long-term management aim	14.1 – Consult with and obtain funding and/or financial support from other responsible authorities such as Crown Lands and DPE with the aim to reduce ongoing expenditure resting with Council.