Wallis Myall Karuah

Waterway & Catchment REPORT 2016

MidCoast Council

NSW Government Office of Environment & Heritage

NSW Government Local Land Services Hunter

Karuah Great Lakes Landcare

MidCoast Council 2016 Waterway and Catchment Report
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Introduction

The Great Lakes region depends heavily on the health of local waterways and their catchments. The waterways form the basis of the region's economy (supporting tourism and primary production), contribute to our way of life and provide habitat for extraordinary biological systems. The region's catchments are under continued pressure from pollution and impacts associated with catchment land use, development and tourism. If unmanaged this has the potential to result in a decline in the health of our waterways.

All our local waterways are critically susceptible to environmental pressures; a Hepatitis A event in oysters in Wallis Lake in 1997, reoccurring blue-green algae in Myall Lakes and episodic fish kills are all examples of what can go wrong.

This report has been presented to accompany the 2016 Waterway and Catchment Report Card, it provides the technical information on how the Report Card scores were calculated as well as providing more detail on the results. A summary of the management responses undertaken in each estuary to address water quality are also presented here.

The goal for our waterways is to maintain or improve their condition in order to protect biological diversity and maintain ecological processes.

Water quality - ecological health

Good management of our catchments and estuaries requires understanding of how they work, predictions about future conditions and informed choice about actions to get the outcome the community wants. The former Great Lakes Council (now MidCoast Council) and Office of Environment and Heritage (OEH) have worked together to put these principles into action. International best practice suggests that research, modelling, management and monitoring should all use the measures of condition and success. OEH research allowed the development of a solid understanding of the impacts of catchment activities on estuary health. It also concluded that abundance of algae and water clarity would be good indicators for the future. Council used the scientific understanding to form the Water Quality Improvement Plan in 2009, which was designed to achieve a number of specific outcomes, expressed in terms of water clarity and algal abundance. Progress towards these outcomes has been measured using the same measures in the annual report cards.

Since 2008, OEH have undertaken an ecological health monitoring program in Wallis Lake as part of the state-wide Monitoring, Evaluation and Reporting Strategy (MER). As part of the Strategy, Wallis Lake was selected as one of seven estuaries across the state to be sampled each year to track inter-annual variability in two ecological health indicators; chlorophyll a (the amount of algae) and turbidity (the amount of sediment).

Since 2011 Great Lakes Council (now MidCoast Council), in cooperation with state and federal agencies, has ensured that the program has been expanded to cover other key sites across the Great Lakes Region of the MidCoast Local Government Area (LGA). The OEH have provided an independent scientific evaluation on the ecological health of Wallis Lake, Karuah River and Estuary, as well as Myall Lake and the Bombah Broadwater in the Myall Lakes.

This year the report card moves the focus from the estuaries alone, to the rivers in the catchments that flow into them. This requires us to measure a wider range of indicators that reflect the pathways of impact within the catchment. Catchment results will be presented in the report card every 5-10 years.

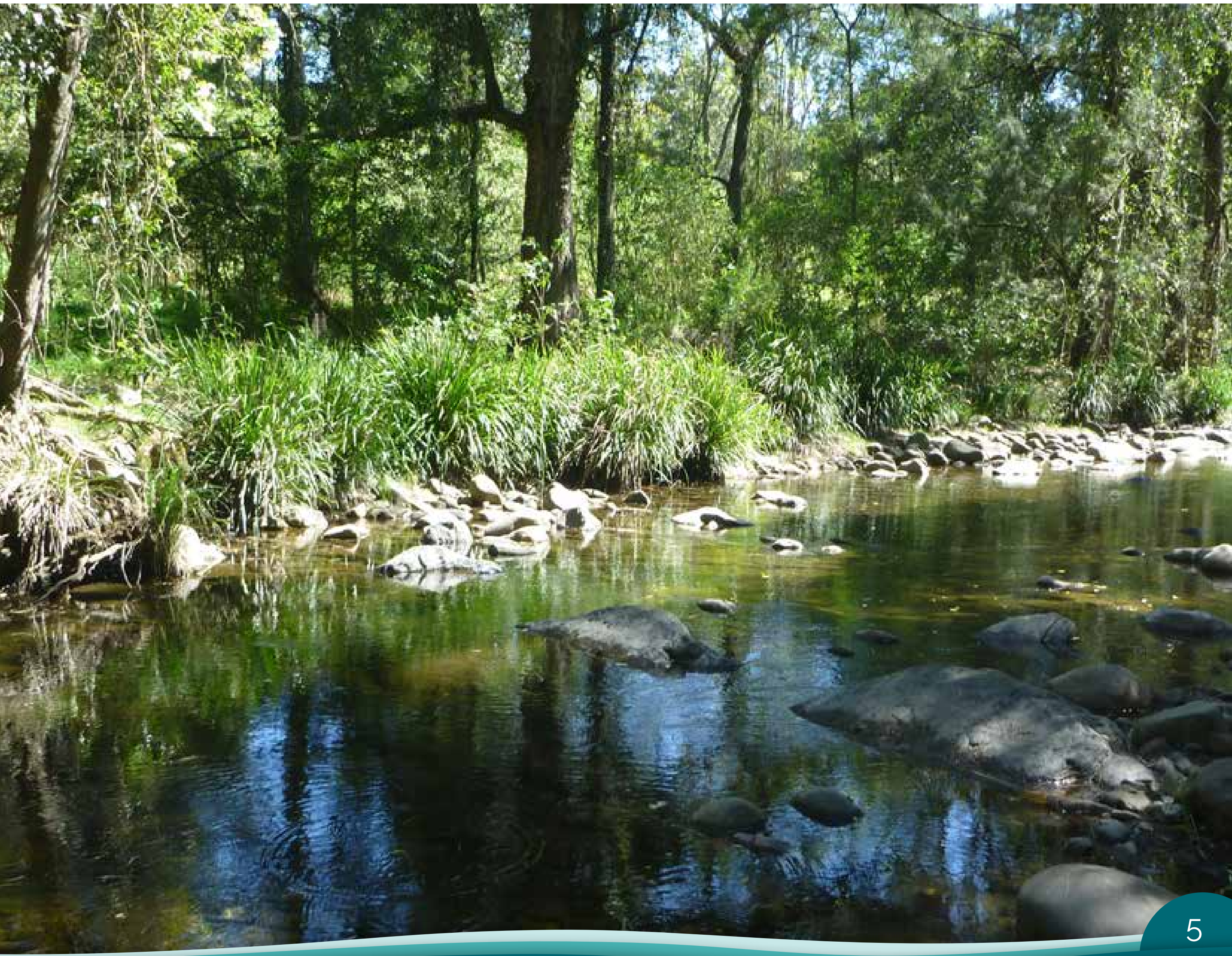
Ecological health does not refer to environmental health issues such as drinking water quality, safety for swimming, heavy metal contamination, disease, bacteria, viruses or our ability to harvest shellfish or fish.

Ecological health results presented in easy to understand Report Card

The results of ecological health monitoring have been presented in a Catchment and Waterways Report Card (see Appendix) which grades the health of the waterways in a similar way to school Report Cards, with a grade ranging from A (excellent) to F (very poor).

The information provided below includes the background details for the Report Card including the objectives, methods and a detailed description of the results.

Figure 1: Upper Karuah



Introduction

Report Card objectives

The objectives for the Report Card are:

1. To report on ecological health.
2. To track progress on management actions.

These objectives are specifically achieved by providing information to:

- Assist in the current and ongoing protection of "high conservation" areas that currently provide substantial water quality and biodiversity benefits to the rivers and estuaries.
- Guide and report on the remediation of areas that have high pollutant loads and highlight areas that may require further action.
- Help protect all areas of Wallis, Smith and Myall Lakes and the Karuah River against further declines in water quality.

In addition to the ecological results, management actions being undertaken in the catchments are also presented in this report. These management actions have been developed to target specific environmental values which Council and the community have determined as important to the region.

Environmental values

The environmental values that management actions in the catchment are aiming to achieve are:

1. Minimal algal growth.
2. Minimal sediment inputs and maximum clarity.
3. Intact aquatic habitats like seagrass, macrophyte and riparian vegetation.

Figure 2: Clear waters with minimal algal growth and maximum clarity support key habitats such as seagrass

Methods

Catchment health assessment

Development of Report Card grades

The catchment monitoring program has assessed the ecological health of streams in the Karuah, Branch, Myall, Wallamba, Coolongolook, Wang Wauk and Wallingat Catchments. These are divided into upper and mid catchment, and there are a number of steps taken to determine the score for each zone and subsequent Report Card grade:

1. Selecting the indicators.
2. Identifying the trigger levels.
3. Collecting the data.
4. Calculating the zone score.
5. Allocating the Report Card grade.

Selecting the indicators

In order to meet the objectives of the Report Card, indicators must report on ecological health, be able to report on the outcomes of management actions, and be repeatable so that we can identify changes over time.

The indicators are selected to show pathways of impact from the activity or fundamental cause (e.g. road construction, intensive agriculture, urban development) through to the stressors that are the changes to the environment that result from the activity and lead to ecological harm and ultimately to the ecological impact or response.

Activity

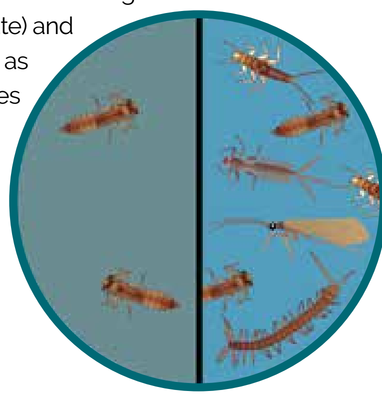
is the fundamental cause (e.g. road building, intensive agriculture, urban development, stock trampling)

Stressors

are changes to the environment that result from the activity and can lead to ecological harm. These measures are focused on likely inputs from known activities and may be affecting instream and downstream ecological condition.

Ecological impacts

Ecological condition grades are a combination of river bug (macroinvertebrate) and algae (measured as chlorophyll) scores



Methods

Stressor indicators

Nutrients - all forms of nitrogen and phosphorus in the waters. High concentrations of nutrients (nitrogen, NOx, ammonia, phosphorus and phosphate) in the water indicate either a diffuse source such as farming fertilisers, or point sources such as sewerage entering the stream.

Turbidity - Sediments in the water and loss of clarity. Sediment can enter the stream from gravel roads, (especially where they cross a stream), from farm runoff and from surrounding landscapes when the riparian zone (area of land adjoining the river) has been cleared. High levels of turbidity impact fish and bugs because it clogs their breathing gills and reduces visibility for feeding.

Electrical conductivity (salinity) - Saltiness of freshwater. High electrical conductivity indicates salinity, which could be from over-use of fertilisers or could be formed naturally from catchment geology.

These three indicators, when analysed together, provide a snapshot of the water quality in a stream.

Riparian condition (the condition of the land beside the stream, in particular vegetation) -The condition of the riparian zone is very important to stream ecological health. Ground cover in this zone helps to prevent sediment and nutrients from entering the stream. Trees and shrubs provide shading, leaf litter and fallen branches which contribute to the in-stream habitat. Healthy riparian vegetation will also reduce bank erosion by binding the soil with their roots.

Reach condition (the condition of in-stream habitat) In the channel the habitat provided by fallen trees and snags as well as cobbles and boulders is very important to fish and bugs. A sediment slug moving down a river can rapidly decrease the available habitat, smothering the spaces between the cobbles and reducing the availability of food resources. Sediment slugs can result from bank erosion or from sediment entering the stream in overland flow.

Ecological indicators (impacts)

River bugs or macroinvertebrates are the basis of the river food chains and are effective indicators of changes to river health. The Australian River Assessment (AUSRIVAS) was developed by the federal government in collaboration with all state governments. AUSRIVAS protocols provide a standard method for sampling and analysing assemblages of bugs. The analysis compares the bugs collected from a site with the bugs that have been collected from similar sites in minimally disturbed catchments. The results tell us how good the ecological condition of the stream has been at the site over the previous weeks or months.

Algae (measured as chlorophyll) The concentration of chlorophyll a in the water tells us about the amount of algae present; algal blooms are usually a response to high nutrient concentrations.

Identifying the trigger levels

A healthy ecosystem refers to a system which has normal ranges of diversity and function. These 'normal' ranges have been established from extensive monitoring of waters across New South Wales. To establish these ranges, sites that represent a variety of ecological conditions from pristine (reference) sites to highly degraded have been sampled over a number of years. The data for pristine (reference) sites have been used to establish the trigger values which are fundamental for ranking the ecological health of a site.

A trigger value is the value which indicates that a variable is outside the 'normal range' and could trigger further investigation. In our context, we have used the trigger value to indicate conditions which are not desirable for continued waterway health.

The Australian and New Zealand Environment Conservation Council (ANZECC) published revised Australian and New Zealand guidelines for fresh and marine water quality in 2000. These Guidelines provide trigger levels for concentrations of nutrients, turbidity, electrical conductivity and chlorophyll a in lowland east flowing rivers of NSW.

The AUSRIVAS method of assessment provides a score for the bug assemblages collected from each site, which is calculated by comparing the bugs collected from a site with bugs collected from reference sites with similar physical and chemical characteristics, this is termed the observed/expected score.

The riparian zone and in-channel assessments follow the OEH method of scoring for qualities such as the presence or absence of trees, shrubs, groundcover, weeds, rubbish, sediment and erosion. Trigger levels are based on the percentile of highest possible score.

Collecting the data

A total of 29 creek reaches were sampled in spring and autumn. At each site staff:

- collected water samples for analyses of nutrients, chlorophyll a and total suspended solids;
- used a calibrated water quality meter to measure water temperature, pH, conductivity, turbidity and dissolved oxygen;
- used field titration to measure alkalinity;
- collected aquatic macroinvertebrates in accordance with AUSRIVAS protocols;
- photographed each stream reach;
- described local land use and visible condition of stream habitat;
- described the geomorphological condition of each reach; and
- assessed the condition of the riparian zone vegetation.

In-situ water quality sampling

Water temperature, pH, dissolved oxygen, conductivity and turbidity were determined in the field using a calibrated Horiba multi-parameter water quality meter at all sites. Alkalinity was measured in the field using CHEMetrics Total Alkalinity test kits.

Nutrients and Total Suspended Solids

Water samples were collected at all sites for the determination of total nitrogen (TN), total phosphorus (TP), ammonia (NH_3-N), nitrates/nitrites (NO_x)), phosphate (PO_4), dissolved organic N & P, particulate N & P and total suspended solids (TSS).

Water samples for the measurement of TSS were collected in 1L PET bottles. These samples were kept cool and away from light while being transported to the laboratory, where they were stored in a cool room at 4°C. TSS analysis was conducted in-house using the standard operating procedures of the OEH Environmental Forensic and Analytical Science (EFAS) laboratory.

Samples for measurement of nutrients were collected in 30ml Sarstedt centrifuge tubes. At each site a disposable syringe was used to collect stream water and fill 3 tubes, one unfiltered and two filtered through a 0.45µm cellulose acetate filter. All containers were placed into a freezer in the vehicle. Samples were processed using flow injection analysis and standard methods.

Chlorophyll a

A 110ml water sample was taken from the creek and filtered in the field through a 0.45 µm glass filter. The filter paper was frozen and returned to the laboratory for analysis of Chlorophyll a concentration using the standard operating procedures of the OEH Environmental Forensic and Analytical Science (EFAS) laboratory.

Macroinvertebrates (bugs)

The sampling method followed the protocols for AUSRIVAS riverine edge and riffle habitats (Turak et al 2004), which are available at http://ausrivas.ewater.com.au/. Macroinvertebrate samples were collected into a 0.25mm mesh sweep net. The samples were placed into a white tray and a representative selection of each taxa was picked out using forceps and placed into a jar of ethanol for transport to the laboratory. This live sorting of macroinvertebrate samples was carried out by experienced operators for a minimum of 40 minutes per sample. This method is used so that the NSW AUSRIVAS model can be applied to the data.

The macroinvertebrates from the samples were identified to family level using a dissecting stereo microscope. Identifications are according to standard keys (see http://ausrivas.ewater.com.au/ausrivas/index.php/taxonomy).

Riparian and in-channel assessment

At each stream site a 100m reach is assessed for riparian condition and geomorphologic condition. Attributes used for the assessment were:

- Riparian condition - longitudinal continuity of riparian vegetation, width at narrowest point, % disturbance by tracks or clearing, % canopy cover, % shrub layer and % ground cover.
- Riparian nativeness - % cover of canopy, shrub layer and ground layer that are native species.
- Riparian diversity - the number of native species at each stratum.
- Riparian habitat - mature trees with hollows, logs, leaf litter, native regeneration, rubbish presence and invasive weed presence in riparian zone.
- Geomorphic condition - aquatic habitats present in channel, channel form, sedimentation, bank erosion, % habitat embedded, algae and rubbish presence.

Methods

Calculating the site score

The ecological condition of the 29 streams in the study is represented using a condition index. Condition scores are calculated for seven separate aspects of stream health: nutrients, turbidity, salinity, algae, macroinvertebrate (bug) community, riparian condition and in-channel condition. A score of between 1 and 5 representing ecological health is allocated for each of these indices.

Scoring category	System condition
1	Excellent
2	Good
3	Fair
4	Poor
5	Very poor

The condition scores for each site are calculated in the following way.

Nutrients, turbidity, salinity and algae

The ANZECC guidelines provide for two states, compliance and non-compliance. To compare site water quality non-compliance over both sampling times (spring and autumn) and to convert these to index scores that calculated the frequence and distance of non-compliance for each site, the following method was used. This method was developed for NSW Estuarine MER (Scanes, Wright, Brennan, & Potts, 2012), and was used to assess condition along an ecological gradient from good to poor.

Step 1. Calculate the non-compliance score: each site was sampled twice, in spring 2015 and autumn 2016. For water quality parameters with an ANZECC guideline trigger value, the proportion of times that each site exceeded the trigger value is calculated.

> *Non-compliance = number of samples non-compliant with trigger level divided by the total number of samples.*

Step 2. Calculate the Worst Expected Value: to calculate how far each sample exceedence was from the trigger value we developed the Worst Expected Value (WEV) based on the data from all of the sites. We set the WEV to be the 98th percentile, so that the majority of the data would fall below it. This means that any measured water quality values that fall at or below the trigger level score 0, and any measured values that fall above the 98th percentile score 1. The next step is to grade all of the values in between these two extremes.

Step 3. Calculate the distance score: the distance score is calculated as the mean distance from the trigger of all non-compliant values.

> *Distance of each non-compliant value = (measured value – trigger value) / (WEV – trigger value).*

Step 4. Calculate site condition score: the non-compliance and distance scores were combined to arrive at a site condition score for each water quality parameter. The Estuaries MER (Scanes, Wright, Brennan, & Potts, 2012) determined that the geometric mean of both scores should be used, as it is more statistically accurate because the distance score is conditional on being above the guideline.

> *Condition Score for water quality indicator = √ (non-compliance x distance score).*

Methods

Step 5. Convert condition score to index: the condition score provides a number between 0 and 1. To convert the condition scores to the Creek MER categories we divided the score equally.

Excellent	0-0.2
Good	>0.2 – 0.4
Fair	>0.4 – 0.6
Poor	>0.6 – 0.8
Very poor	>0.8

Macroinvertebrates (bugs)

The AUSRIVAS method of assessment provides a score for each site bug assemblage and converts these scores into grades.

Band X	more bug groups collected than expected to be present. Score > 1.17
Band A	number of bug groups collected is similar to those expected to be present. Score 0.83 - 1.17
Band B	number of bug groups collected is less than those expected to be present. Score 0.49 to 0.82
Band C	number of bug groups is significantly less than those expected to be present. Score 0.15 – 0.48
Band D	very few of the expected bug groups collected. Score 0.0 – 0.14

Riparian and in-channel assessment

Each site was assigned a score for the attributes described above. A total of the value indicator scores was then calculated for riparian, in-stream and special features and scaled.

Excellent	>80% of the total possible score
Good	61 – 80% of the total possible score
Fair	41 – 60% of the total possible score
Poor	21 – 40% of the total possible score
Very poor	0 – 20% of the total possible score

Calculating site scores

Using the above analyses each site is scored between 1 and 5 for the pressure indicators nutrients, turbidity, salinity, riparian and reach, and for the response indicators bugs and algae.

Allocating the report card grade

In each catchment zone (upper or mid) there is between one and four sites. The bug and algae scores for these groups of sites were averaged and rounded up to a whole number to provide the ecological score for each zone. The site scores were averaged and rounded up to provide a zone score for nutrients, turbidity, salinity, riparian and reach.

Methods

Estuary health assessment

Development of Report Card grades

The monitoring program has assessed the ecological health of Wallis and Myall Lakes as well as the Karuah River Estuary. There are a number of steps taken to determine the score for each zone and subsequent Report Card grade:

1. Selecting the indicators.
2. Identifying the trigger levels.
3. Collecting the data.
4. Calculating the zone score.
5. Allocating the Report Card grade.

Selecting the indicators

In order to meet the objectives of the Report Card, indicators must report on ecological health but also be able to report on the outcomes of management actions. The management actions are linked to the environmental values set for the region (listed above), and the indicators selected have been shown to be responsive to catchment management actions.

There are many different estuary reporting programs world-wide, with indicators specifically chosen to suit local conditions or issues.

Chlorophyll and turbidity are commonly used as they are proven to be very informative and responsive indicators, see Table 1.

Algal growth can be measured by assessing chlorophyll a levels in the water and sediment inputs are assessed by measuring the turbidity. These indicators are easy to measure and directly relate to the environmental values.

While the extent of seagrass beds, macrophytes and riparian vegetation are not currently measured, low chlorophyll and turbidity levels are necessary to ensure healthy habitats. Expansion of the program in the future is likely to include assessment of these habitats.

Methods

Table 1: Indicators used in various estuarine monitoring programs

Monitoring Program	Chlorophyll a	Turbidity	Dissolved Oxygen	Nutrients	Riparian vegetation	Seagrass	Other critical habitats (e.g coral)
South East Queensland Ecosystem Health Monitoring Program	✓	✓	✓	✓	✓	✓	✓
Chesapeake Bay EcoCheck program	✓	✓	✓			✓	✓
Northern Rivers CMA Ecohealth	✓	✓	✓		✓		
New South Wales Monitoring, Evaluation and Reporting Program *	✓	✓	F		F	✓	
Great Lakes Council Report Card (this program)	✓	✓	F		F	F	

F - future

* New South Wales Monitoring, Evaluation and Reporting Program also samples fish in a limited number of sites

The New South Wales Monitoring, Evaluation and Reporting Program, concluded that measurement of chlorophyll a and turbidity provides an effective measure of the short-term response of estuary health to management actions. Seagrass and other macrophytes provide a long-term integration of estuary health.

Dissolved oxygen has been widely used as an indicator of the amount of oxygen in the water column with many critical aquatic processes dependent on a healthy level and minimal variability. MidCoast Council and the New South Wales Monitoring, Evaluation and Reporting Program both acknowledge that dissolved oxygen is an important variable to measure but have not done so to date, due to logistical reasons. There are plans to include this indicator in future monitoring activities.

Identifying the trigger levels

A healthy ecosystem refers to a system which has normal ranges of diversity and function. These 'normal' ranges have been established from extensive monitoring of estuaries across New South Wales. To establish these ranges, sites that represent a variety of ecological conditions from pristine (reference) sites to highly degraded have been sampled over a number of years. The data for pristine (reference) sites have been used to establish the trigger values which are fundamental for ranking the ecological health of a site.

A trigger value is the value which indicates that a variable is outside the 'normal range' and could trigger further investigation. In our context, we have used the trigger value to indicate conditions which are not desirable for continued waterway health.

Methods

A trigger value is specific to different types of estuary. In this study, Wallis Lake, Pipers Creek, Charlotte Bay, Bombah Broadwater and Myall Lake were all classified as 'Lakes' and Wallamba River, Karuah Estuary and the Lower Myall River as a 'River estuary' (Roper et al. 2011).

Table 2: Trigger Values for NSW Estuaries (from Roper et al. 2011)

	Turbidity (NTU)	Chlorophyll (µg/L)
Lake	6.7	2.5
River estuary (mid)	1.9	2.2

Algae

Algae or microscopic plants are always present in waterways but if conditions change and are suited to algal growth, blooms can occur. Blooms may occur if there is a lot of nutrients in the water which can come from urban stormwater, fertiliser runoff from farms and gardens and seepage from septic tanks. Algal blooms can reduce the amount of light reaching seagrass beds limiting their growth. When blooms of algae die and start to decay, the resulting bacterial activity can reduce oxygen concentrations in the water column, possibly leading to fish kills.

Chlorophyll a

Chlorophyll a is a pigment found in plants and is an essential molecule for the process of photosynthesis (the conversion of light energy to chemical energy resulting in the consumption of carbon dioxide and the production of oxygen and sugars). In estuarine and marine waterways, chlorophyll a is present in phytoplankton such as cyanobacteria, diatoms and dinoflagellates. Because chlorophyll a occurs in all phytoplankton it is commonly used as a measure of phytoplankton biomass (EHMP 2008).

Collecting the data

The Great Lakes region has been divided up into ten reporting zones. A zone is actually a broad area within the estuary rather than a discrete point (see maps in Results Section) and may be represented by a single sample or by multiple samples. Five zones were sampled in Wallis Lake estuary (Wallamba River, Wallamba Cove, Pipers Creek, Wallis Lake and Charlotte Bay). There are three zones in the Karuah River (Branch Estuary, Karuah Estuary) and three zones in the Myall Lakes (Myall Lake, Bombah Broadwater and Lower Myall Estuary).

Samples were collected on six occasions between summer and autumn from December to March. This represents the part of the year when the highest chlorophyll concentrations are expected.

At each of the selected sites, samples were taken in accordance with the New South Wales Monitoring, Evaluation and Reporting protocols which are described in full in Roper et al. (2011). At each of the 'Lake' sites, turbidity was measured using a calibrated probe suspended at a depth of 0.5 metres for five minutes as the boat drifted or was motored (generally covering a distance of at least 300 metres), logging data every 15 seconds. The final value for the 'site' sampled was the average of all the logged data. During the drift, at least five samples of the top 1 metre of the water column were collected and combined in a bucket. At the end of the drift, a single 200 millilitre sample for chlorophyll a analysis was taken from the composite in the bucket.

Methods

Figure 3: Office of Environment and Heritage staff carry out the monitoring of the waterways in the Great Lakes Region

For the river estuary sites, an 'underway sampler' is used to pass water past the probe whilst the boat travels at a regulated speed along a transect upstream from the middle to the upper part of the estuary. The turbidity is calculated as the mean of logged values for the transect. At two sites along the transect, composite water samples are collected for chlorophyll a analysis.

Chlorophyll a samples are immediately filtered (within one hour) under mild vacuum and the filter frozen until analysis. Chlorophyll a is extracted into acetone and chlorophyll a concentration is determined by spectrometry.

Sediment

Sediment from the land can be washed into waterways when it rains. If land is poorly managed, large amounts of sediment can wash into our waterways. Sediment also comes from roads and pathways washing directly into the stormwater and then the estuaries.

Too much sediment in the water reduces the amount of light reaching the bottom and is detrimental to seagrass which require light for growth. Seagrass is critical for the health of estuaries as it provides essential habitat for fish and invertebrates which support bird life and the local tourism and aquaculture industries. Excess amounts of suspended particles can also smother benthic organisms like sponges, irritate the gills of fish and transport contaminants.

Turbidity

Turbidity provides a measure of sediment in the water. It is the measure of light scattering by suspended particles in the water column, providing an indication of the amount of light penetration through the water column (EHMP 2008).

Calculating the zone score

The measured values of all indicators are summarised into one value which can then be compared between different reporting zones.

Two basic calculations have been performed for each zone:

- Non-compliance score – are the indicator values non-compliant with the trigger value?
- Distance from the benchmark score – how far from the trigger value are the indicator values?

The distance measure is a recognition that the trigger values only allow for two possible states, compliant and non-compliant. The distance measure provides for more sensitivity for ecological condition along the gradient from good to poor.

Calculating the non-compliance score
The non-compliance score is simply calculated by taking the number of samples that are above the trigger value as a proportion of the total number of samples taken in the sampling period. The non-compliance score is then expressed as a value between 0 and 1, with 0 equal to none of the values being non-compliant (i.e. all compliant) and 1 equal to all values being non-compliant.

Non-compliance score equals the number of samples non-compliant with trigger value divided by the total number of samples.

Calculating the distance from benchmark score
The distance score has been expressed as a proportion between 0 and 1 to be standardised with the non-compliance score. To do that, the distance score is expressed as a proportion of the worst expected value (WEV) with a score of 0 equal to the benchmark value, and 1 equal to the worst expected value for each of the indicators.

The worst expected value has been determined by examination of a data set for all of New South Wales. The 98th percentile value was selected as the worst expected value Table 1.1.3. In the small number (2%) of circumstances where measured values were greater than worst expected value, the distance measure became 1 (which is the highest possible value).

Table 3: Worst expected value (WEV) for Condition Calculations

	Turbidity WEV (NTU)	Chlorophyll WEV (µg/L)
Lake	20	30
River (mid)	60	30
Lagoon	20	30

Distance of each non-compliant value equals: (measured value - trigger value) / (worst expected value - trigger value).

The distance score is calculated as the mean distance from the trigger of those values that are non-compliant for the reporting period.

Once the non-compliance and distance score have been calculated, the geometric mean of both scores is calculated to arrive at a single score that can be used to assess the condition of each indicator in that zone.

Final score for indicator $= \sqrt{(\text{non-compliance x distance score})}$

The final 'zone score' for each reporting zone is then the simple average of the indicator scores.

Allocating the Report Card Grade

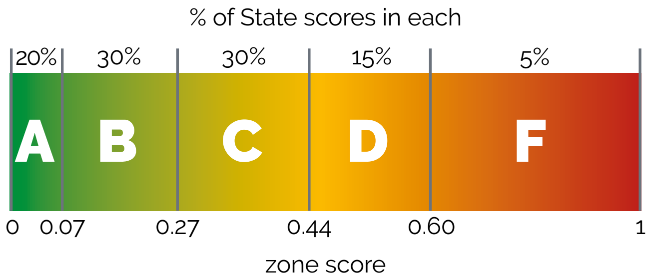
Defining the Report Card grade is an important step in the development of the Report Card. The grade definitions below are linked to the environmental values outlined above and are structured to allow easy comparison between each system and over time.

It is important that the cut-off values for each grade reflect the condition of each zone in comparison to a broader scale of condition across all New South Wales estuaries (i.e. an 'Excellent' grade represents an excellent condition for a New South Wales estuary). To assist with the derivation of cut-offs, scores were calculated for 130 zones across a wide range of New South Wales estuaries using the same triggers and worst expected values as the Great Lakes analyses. Cut-offs were then defined as representing a percentage of the scores for the state (Table 1.1.4). For example, a zone score less than 0.07 defined the 20% of best zone scores in the state and this became our 'Excellent' grade (see Table 1.1.4 for other cut-offs). We did not use a score of 0 as 'Excellent' because, as a consequence of how the trigger values are calculated, we expect that even pristine reference sites will exceed trigger values 20% of the time. The definition of the grades and description are shown in Figure 4.

Table 4: Report Card results, definitions, descriptions and cut-off

Grade	Result	Definition	Description
A	Excellent	All environmental values met (The indicators measured meet all of trigger values for almost all of the year)	The best 20% of scores in the State
B	Good	Most environmental values met (The indicators measured meet all of the trigger values for most of the year)	Next 30% of good scores
C	Fair	Some of the environmental values met (The indicators measured meet some of the trigger values for some of the year)	Middle 30% of scores
D	Poor	Few of the environmental values met (The indicators measured meet few of the trigger values for some of the year)	Next 15% of poorer scores
F	Very Poor	None of the environmental values met (The indicators measured meet none of the trigger values for almost all of the year)	The worst 5% of scores in the State

Figure 4: Relationships between grades, zone scores and state percentiles



Summary of the process for calculating the zone score

In summary, the process for calculating the zone involved:

- Calculating the proportion of time that the measured values of the indicator are above the adopted guideline limits or Trigger Values.
- Calculating the distance/departure from the guidelines for that indicator - the extent the data extends past the trigger value and approaches the worst expected value (WEV) for that indicator.
- Calculating the geometric mean of the non- compliance and distance scores to get a final score for that indicator for each zone.
- Averaging the scores for the two indicators at each site – this gives the 'zone score'.
- Grade the zone based on the zone score as A, B, C, D, F.

Methods

Rainfall results

The amount of rainfall that occurs around the period of sampling for the Report Card (September – March each year) influences the Report Card results. If there is more rain, there is more runoff in the catchment resulting in greater quantities of sediment and nutrients entering our waterways (2011 and 2012 for instance, were particularly wet summers and this was reflected in the sampling data).

This year, 2015-2016 (shown as 2015 on the rainfall graph), rainfall in the sampling period was above average at Forster and relatively similar to the rainfall recorded in 2011 and 2012 (Figure 5). Rainfall at Stroud was average (Figure 6). The average rainfall is clearly shown by the shaded line which represents the average rainfall over the last 70 years.

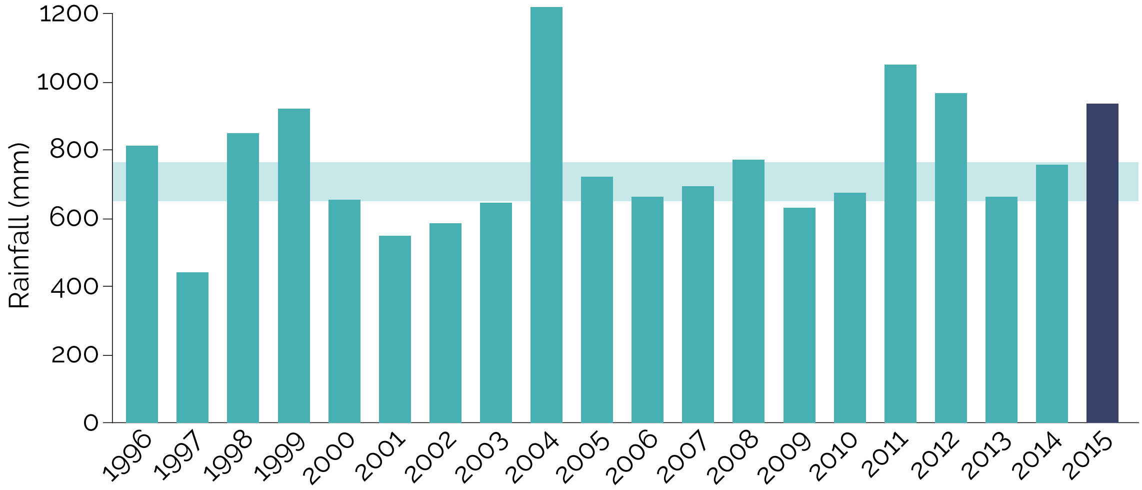


*Figure 5: Data presented includes total rainfall September to March each year, Forster Bureau of Meteorology rainfall station.**

* The rainfall data is taken from the Forster Bureau of Meteorology rainfall station (Tuncurry Marine Rescue) (www.bom.gov.au/climate/data). The same trends were seen in data from Wootton and Bungwahl stations. The shaded line represents the average rainfall over the last 70 years.

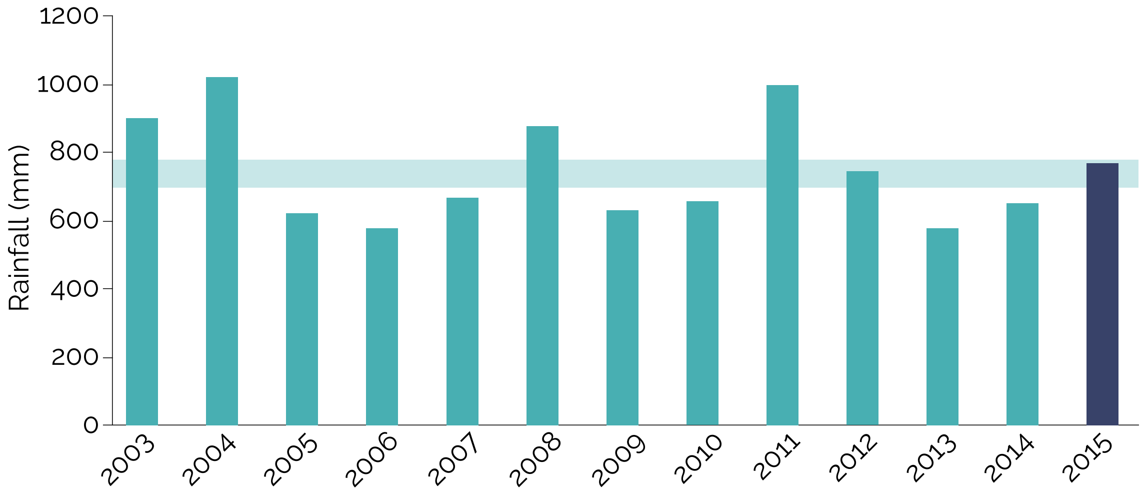


Figure 6: Total summer (Sept to Mar) rainfall at Stroud.

Methods

References

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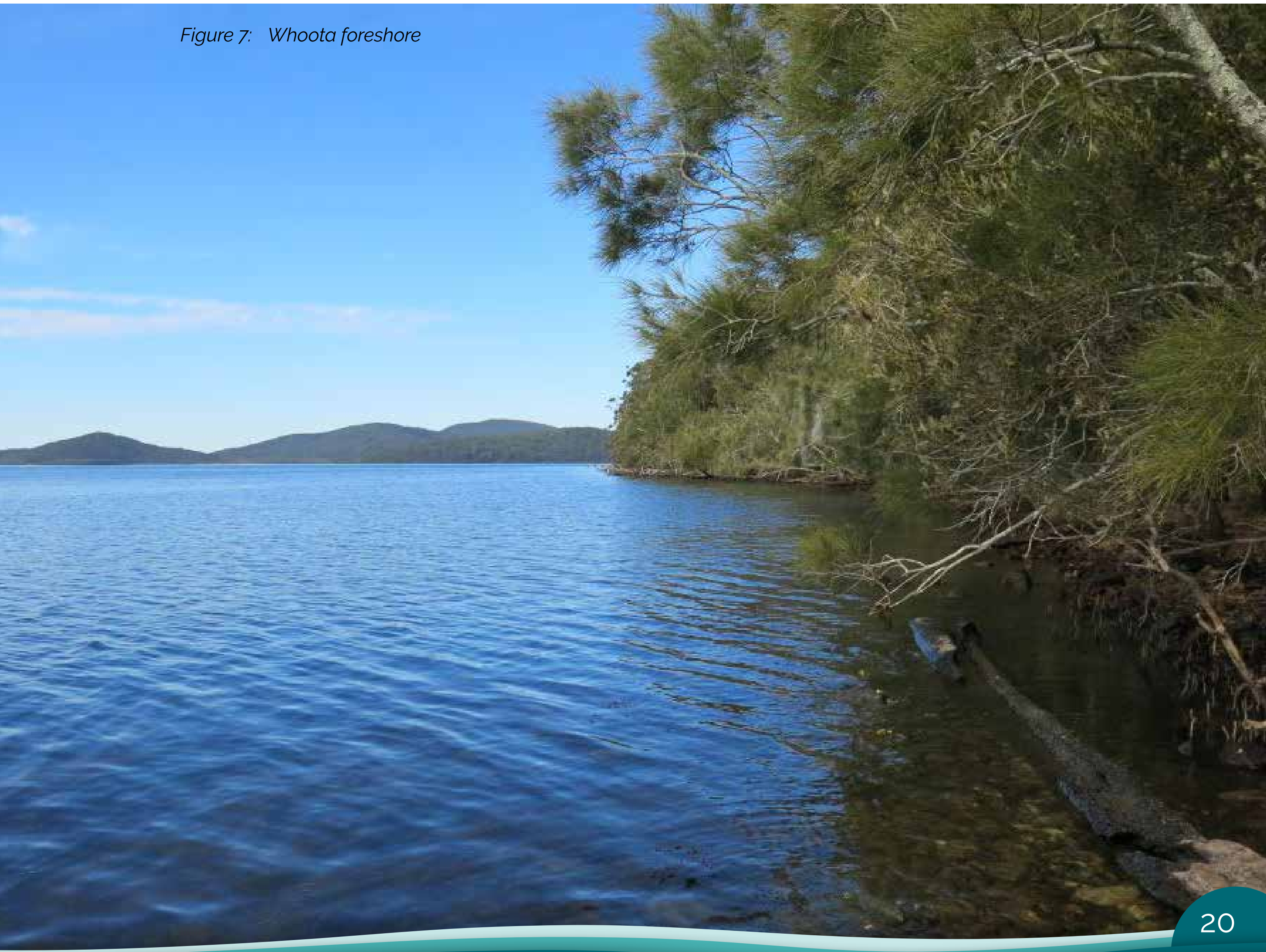
Acknowledgements

The methodology presented here was developed by the Office of Environment and Heritage, Scientific Services Section with input from Hodge Environmental and the International Water Centre.

Figure 7: Whoota foreshore



Karuah River

Catchment description

The Karuah River Catchment is approximately 1460 square kilometres, largely comprised of grazing land, forest and woodland and is sparsely populated, the largest settlements being Karuah (pop.~1000), located at the mouth of the river, and Stroud (pop.~700), located in the centre of the catchment.

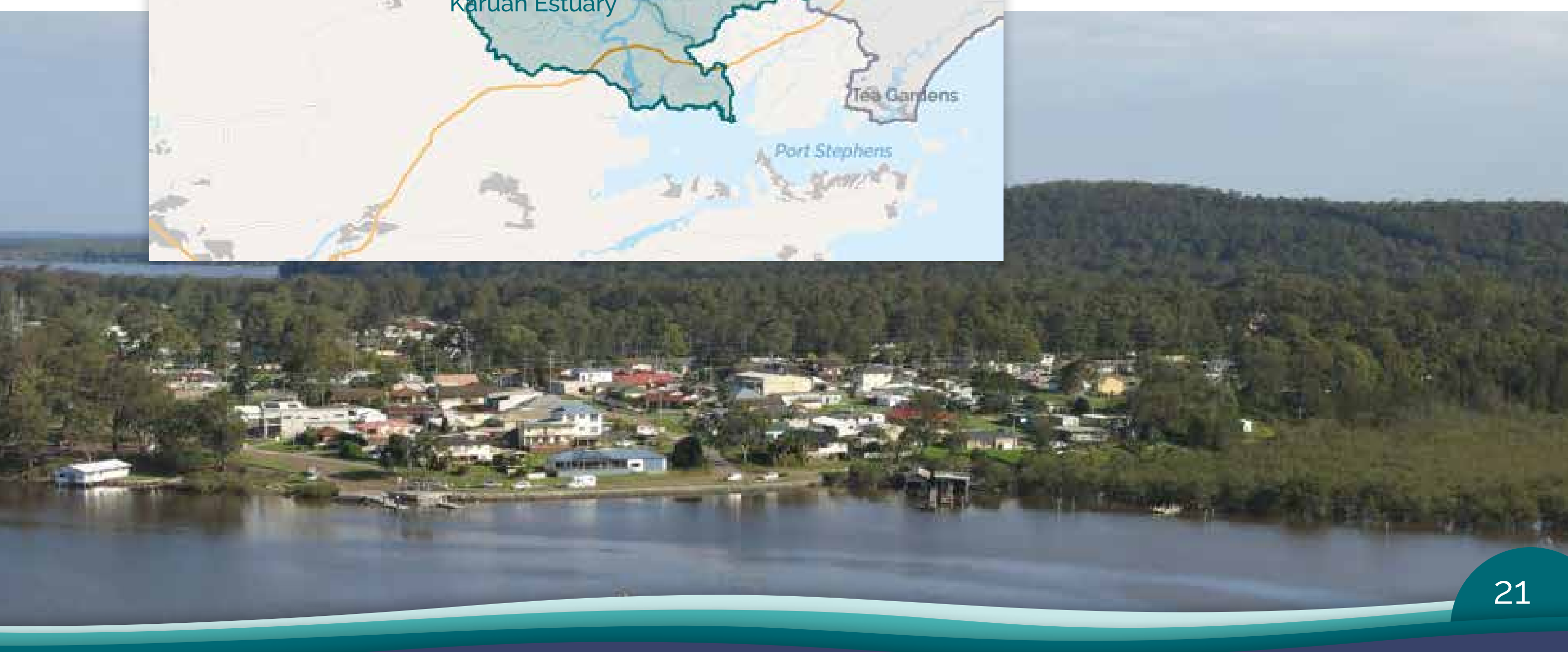
Land use in the Karuah River Catchment has undergone continuous change since European settlement beginning with land clearing for forestry and agriculture from the late 19th century. The landscape today is a mosaic of rural landuse, including forestry, grazing industries, poultry production, mining, aquaculture and rural residential areas.

Trends from past water quality monitoring shows periods of high sediment and nutrient loads within the Karuah River; whilst at the same time displaying a range of in-stream biological diversity. In 2011 the Karuah River estuary and Catchment was assessed as being in a moderate ecological condition, but with some significant threats to the system.

Figure 8: Karuah River Catchment

The Branch is a subcatchment of the wider Karuah River Catchment and is approximately 211 square kilometres. The Branch subcatchment is a mosaic of floodplain environments, with steep ridgelines traversing from the upper catchment through to the tidal zone of the river. The subcatchment is sparsely populated, without any settlements. Landuse is primarily grazing land with some forest and woodland in the upper catchment

Figure 9: Karuah is the largest settlement within the Karuah River Catchment.



Karuah River

Upper Karuah

The Upper Karuah subcatchment extends from Upper Monkerai, Wards River and Terreel south to approximately Stroud Road. The valley floors are generally less than 1 km wide, and are surrounded by steeply sided ridges. The area is sparsely populated with the dominant landuse being conservation (National Parks), forestry and agriculture. Sampling in the Upper Karuah takes place at 4 sites including Upper Monkerai and Mammy Johnsons River.

Mid Karuah

The Mid Karuah subcatchment extends from west of Stroud Road to Booral. Agriculture is the dominant landuse in the Mid Karuah. Sampling in the Mid Karuah takes place at 5 sites between Ramstation Creek and the Karuah River at Booral.

Mid Branch

The Mid Branch subcatchment extends from south of Girvan to the Branch Estuary. Agriculture is the dominant landuse with large areas of the subcatchment cleared for grazing. Some good areas of native vegetation remain, including the Nerong State Forest. Sampling in the Mid Branch subcatchment takes place at 1 location at The Branch Lane.

The Branch Estuary

(referred to as The Branch in the 2014 Report Card)

The tidal zone of The Branch River extends to slightly south of the Branch Lane, and discharges into the wider Karuah Estuary and ultimately into the north western corner of Port Stephens Estuary. The estuary is bounded by substantial areas of mangrove and saltmarsh habitats. The Branch is used as a nursery for juvenile oyster production, whilst landuse within The Branch Estuary is largely grazing lands for beef production and rural lifestyle living.

The Karuah Estuary

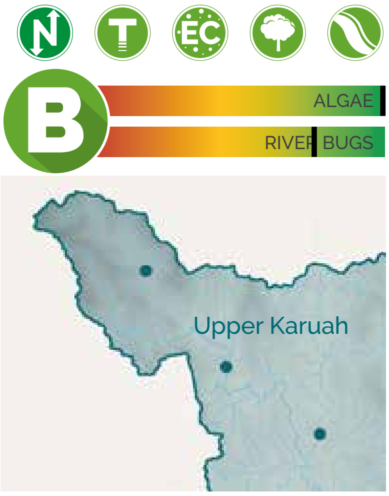
The Karuah Estuary is a priority oyster production area which has suffered periodic water quality issues associated with catchment runoff. The Karuah River estuary discharges into the north western part of Port Stephens, and is the only significant source of sediment to this system. There are substantial areas of mangrove and saltmarsh habitats in the Karuah River estuary, which provide food sources and nursery areas to fish, but only very small areas of seagrass (seagrass extent has decreased by almost 80% between 1985 and 2009). Low light availability, due to high turbidity is the most likely reason for the lack of seagrass in the Karuah River estuary. The extent of saltmarsh over this time has also reduced, while mangrove has increased. Similar to many estuaries in New South Wales it is suggested that mangrove assemblages have increased at the expense of saltmarsh.

The samples for this Report Card have been obtained from three sites within the estuary. These sites were also used for data collection in 2007-2008, 2010-2011, 2011-2012 & 2012-2013. They are:

- Above Allworth (1 site)
- The Karuah River Estuary upstream of the Karuah Bridge between Branch River junction and Allworth (1 site)
- The Branch River (1 site)

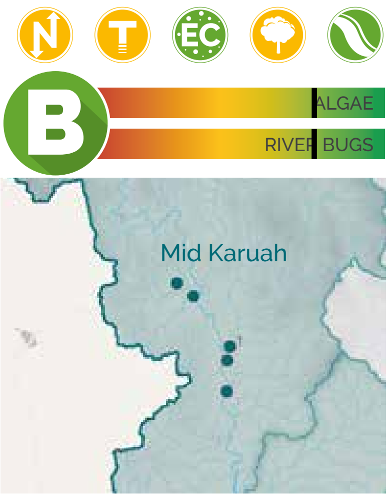
Karuah River

Karuah Catchment Results



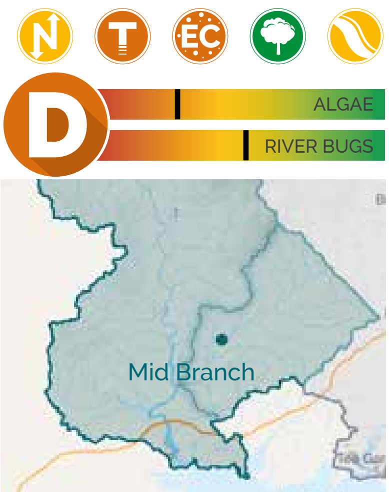
Upper Karuah

In the Upper Karuah Catchment there are large areas of conservation land, the vegetation along the rivers is in good condition and the in-channel habitat is also very good to excellent. Here, stressors from nutrient inputs and salinity were low, and as a result there was very low levels of algae at all sites. Sediment in the water was slightly elevated at two of the four sites, one in spring and one in autumn which suggests that the turbidity is related to flow. The good scores for the other stressors resulted in good scores from the bug assessments.



Mid Karuah

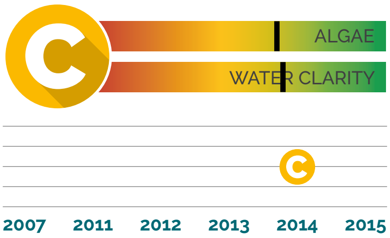
Intensification of land use in the middle reaches of the Karuah corresponds with higher levels of nutrients and sediments and a decrease in the condition of the vegetation along the river. In this zone 4 of the 5 sites had only fair riparian condition, and one site had only fair instream habitat. Nutrient concentrations were fair at one site and poor at another. Turbidity was a problem at two of the five sites and salinity was a problem at one site. As a result of these growing stressors, there were higher levels of algae at two sites and extremely high levels at one site. The bug scores were good to excellent when compared to reference sites, which shows resilience of the bug communities which is aided by the good in-channel habitat. However, the bug assemblages had an increased proportion of pollutant tolerant bugs, which shows that the nutrients and sediment are having some impact.

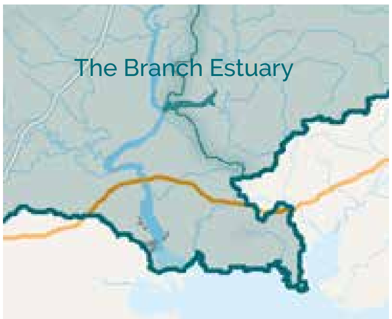


Mid Branch

In the middle part of the Branch Catchment the overall condition was worse than the Mid Karuah. There were very high levels of algae, excessive levels of nutrients and turbidity and poor reach condition. The combined effect of these stressors has impacted the bugs, with bug scores being just fair and the assemblage dominated by pollution tolerant bugs. There were extensive algal blooms at the Mid Branch site in both spring and autumn.

Karuah River

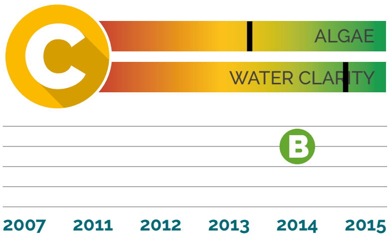




The Branch Estuary

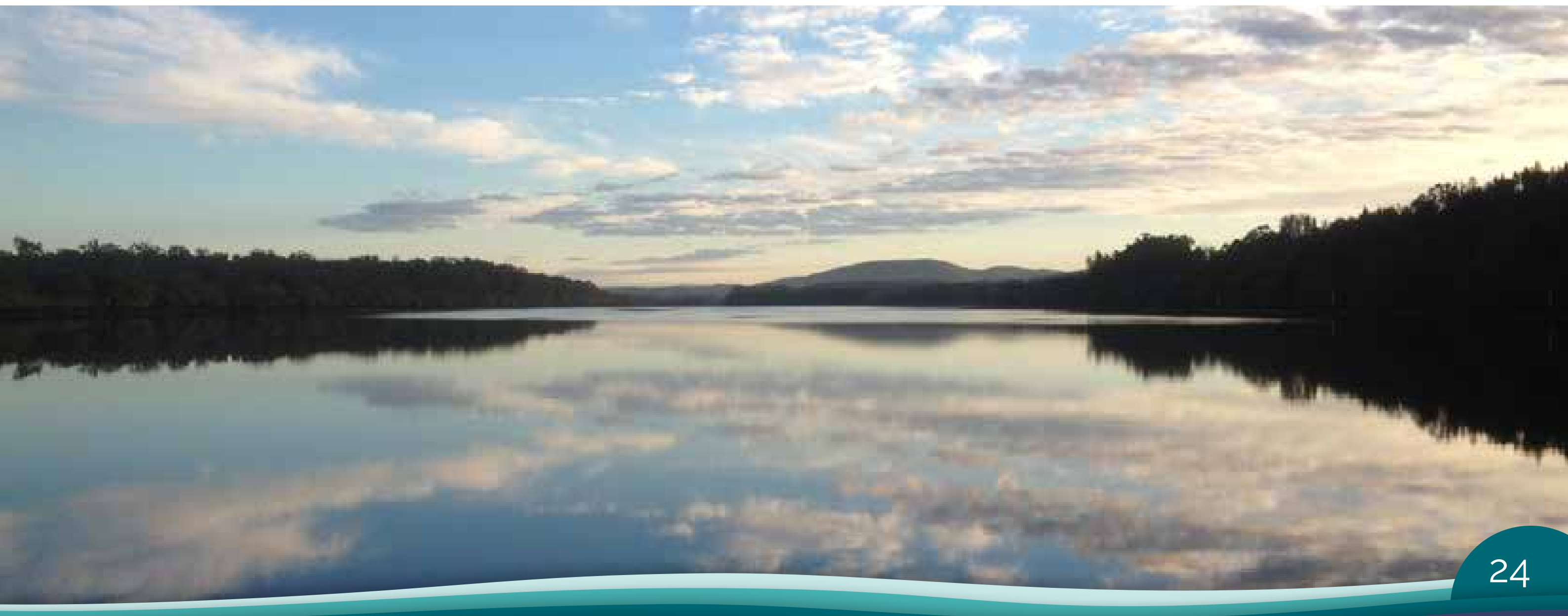
(referred to as The Branch in the 2014 Report Card)

In the Branch Estuary, results were a 'fair' C grade, the same as what was last recorded in 2014. The apparent improvement in ecological health when compared to the Mid Branch Catchment score, is more likely a reflection of dilution from other sources rather than an 'actual' improvement.



Karuah Estuary

The overall 'C' grade for the Karuah Estuary are similar to those recorded in 2012 but this year's score represents a decline in health from the results from 2014. High levels of algae and sediments in the Karuah estuary were influenced by the stress being put on the middle parts of the catchment. Results clearly show the strong connection between catchment land use and estuary health.



Myall Lakes

Catchment description

The Myall Lakes Catchment covers 440 square kilometres. Its major tributary is the Myall River, whose headwaters extend to Craven Nature Reserve and the Kyle Range. The catchment is largely occupied by agricultural land, with forestry and protected vegetation in the steeper areas and a small amount of urban land in the townships of Bulahdelah and the well-known tourist destinations of Tea Gardens-Hawks Nest.

Figure 10: Myall Lake Catchment

The Myall Lakes and Myall River in particular are part of a large tourism and recreation industry which includes Myall Lakes National Park, one of New South Wales' most visited National Parks with estimated annual visitor numbers of 250,000.

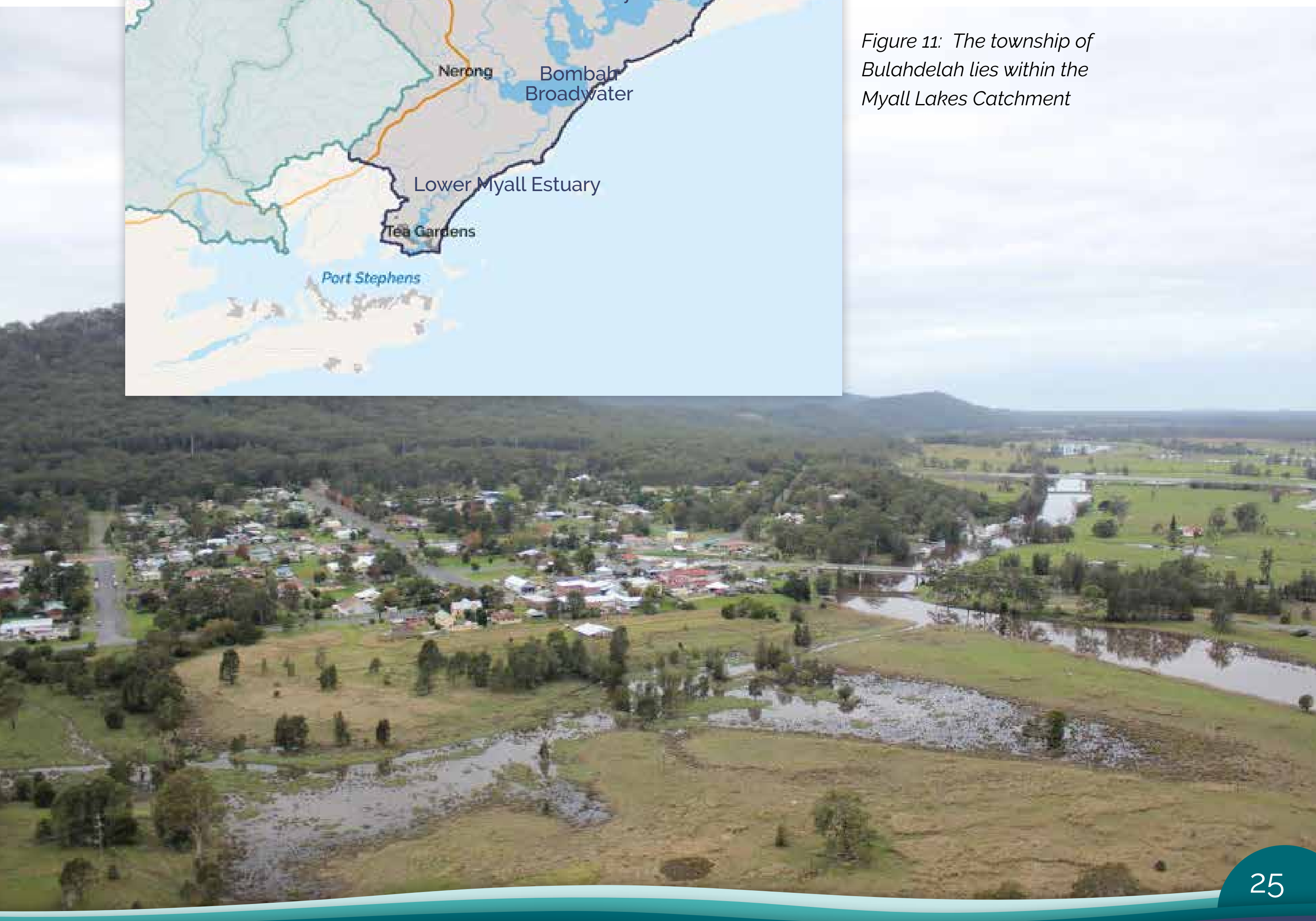


Figure 11: The township of Bulahdelah lies within the Myall Lakes Catchment

Myall Lakes

Upper Myall

The Upper Myall subcatchment extends from the upper reaches at Warranulla to south of Markwell. The dominant landuse is agriculture however, there are extensive areas of National Park and State Forest. Sampling in the Upper Myall takes place at 4 sites between Warranulla and Deep Creek at Markwell.

Mid Myall

The Mid Myall subcatchment extends from north of Bulahdelah to the Bombah Broadwater within the Myall Lakes National Park. Grazing is the dominant landuse around Bulahdelah with much of the area cleared for pasture. In the lower reaches, the land is well forested and includes a large area of National Park. Sampling in the Mid Myall takes place at Battles Bridge on Markwell Road and Old Inn Road at Crawford River.

Bombah Broadwater and Myall Lake

The Bombah Broadwater and Myall Lake are part of the Myall Lakes system which is comprised of four linearly connected brackish to freshwater basins: Myall Lake, Two Mile Lake, Boolambayte Lake and the Bombah Broadwater. The Myall Lakes National Park surrounds the lakes and is listed as a Ramsar wetland of international importance.

While the Bombah Broadwater itself is surrounded by National Park, it receives the majority of its inflow from the Upper Myall River and Crawford River Catchments. Samples were taken from three sites in the Bombah Broadwater and were combined to give an overall score for the health of the system.

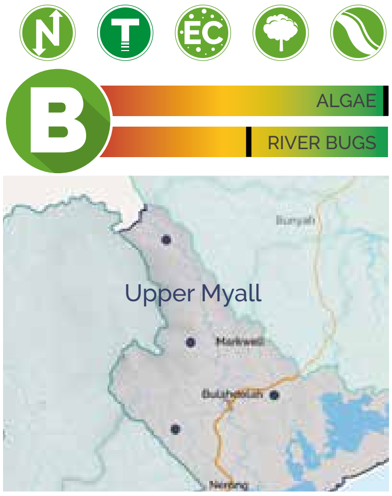
Myall Lake is directly influenced by a small fringing catchment. During times of high rainfall however, water from the Broadwater (and therefore the Upper Myall River and Crawford River Catchments) influences Myall Lake by carrying with it nutrients and algae. Samples were taken from two sites in Myall Lake and were combined to give an overall score for the health of the system.

Lower Myall Estuary (referred to as Myall River in previous Report Cards)

The Lower Myall Estuary near Tea Gardens is the mouth of the Lower Myall River and is situated in an area of highly mobile sand features. The river discharges into the moderately sheltered waters of Port Stephens but the river entrance is exposed to swell from the south-east coming through the entrance of the Port. The Lower Myall Estuary receives water from the urban area of Tea Gardens and Hawks Nest and is strongly influenced by the waters of the Bombah Broadwater following rainfall.

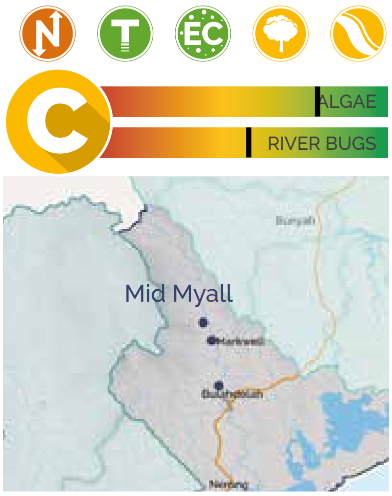
Myall Lakes

Myall Lake Catchment Results



Upper Myall

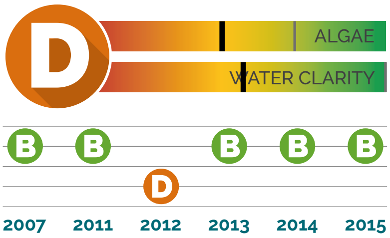
The condition of vegetation along the upper Myall River is good at three of the four sites in the catchment and fair at one site. In-channel habitat was good to excellent at all sites. Stressors such as nutrients, salinity and turbidity were low resulting in low algal levels. As a result of the good conditions the bugs scores were good, with the exception of one site where a "blackwater" event affected the bug assemblage. "Blackwater" events are caused by breakdown of a large amount of leaf litter in the stream, which depletes the water of oxygen. These occur naturally, usually following a rain event that washes the leaves into the stream.



Mid Myall

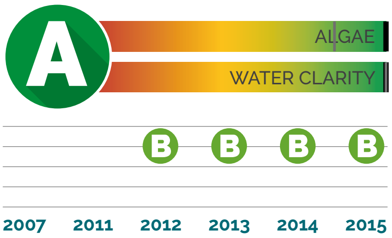
Ecological health deteriorated markedly in the middle reaches of the Myall where land use intensifies. All three sites in this zone had high levels of nutrients and at one site this has resulted in very high algal levels. Turbidity was a problem at one site, and all sites had declining condition of vegetation along the river. Reach condition was degraded at one site where cattle access has caused severe bank erosion. As a result of the increased pressures the bug scores were only good to fair, however, at this time resilience of the bug communities is still evident.

Myall Lakes



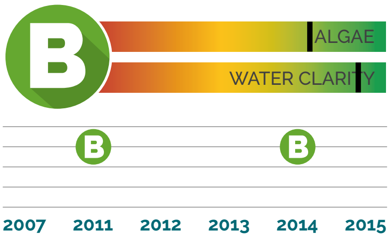
Bombah Broadwater

The average conditions recorded upstream in the Mid Myall Catchment were reflected in the results in the Broadwater where the overall grade was a 'D'. The last time the Broadwater received a 'D' grade was in 2012 when high rainfall conditions in the catchment were similar. This year's results are strongly influenced by both high algal levels and sediments.



Myall Lake

Scores in the Myall Lake were excellent receiving an 'A' grade for the first time since sampling commenced in 2007. These results reflect the limited catchment inputs from the surrounding Myall Lakes National Park.



Lower Myall Estuary (Myall River)

At Tea Gardens, the overall grade in the Myall Estuary was good, the same score as was recorded in previous years. This year however, algal abundances were higher than desired. Just as the Myall Catchment influences the ecological condition of the Broadwater the algal scores were mostly a consequence of algae being carried downstream from the Broadwater. These higher than desired algal levels were balanced by good turbidity scores.

Wallis Lake

Catchment description

The Wallis Lake Catchment extends over 1400 square kilometres. This catchment includes the region's major urban centre of Forster-Tuncurry.

Wallis Lake is one of the most significant producers of Sydney Rock Oysters in Australia and is also central to the local tourism industry, valued at over $315m per year. The lake is one of New South Wales' top three producing estuarine fisheries and is utilised extensively for recreation including boating, fishing and swimming.

Figure 12: Wallis Lake Catchment

The Wallis Lake Catchment contains habitat for threatened and international migratory species and contains 35% of the seagrass beds of New South Wales, as well as the second largest representation of saltmarsh in the State.

Figure 13: High quality Saltmarsh, Mangroves and Swamp Oak forest on Minimbah Creek within the Wallis Lake Catchment.

Wallis Lake

Upper Wallamba

The Upper Wallamba subcatchment covers an area from Dyers Crossing to the Upper Wallamba River extending to the watershed of the Wallamba River valley. The area is dominated by hilly terrain, rising to elevations of 3–400m in the westernmost areas. The subcatchment has been extensively cleared with agriculture the dominant land use. There is a high risk of sheet and gully erosion in large parts of the catchment. Sampling in the Upper Wallamba takes place at 3 sites, the Wallamba River at Karkatt, Firefly Creek and Khoribakh Creek at Dyers Crossing.

Mid Wallamba

The Mid Wallamba subcatchment covers the area east of Dyers Crossing to west of Failford. The dominant land use in the Mid Wallamba is agriculture and almost 70% of the land has been cleared. Sampling in the Mid Wallamba subcatchment takes place at 3 sites, Wallamba Creek at Wellers Lane, Nabiac Creek and Bungwahl Creek upstream of Possum Brush Road.

Coolongolook / Wang Wauk

Two subcatchments feed into the Coolongolook Estuary, the Coolongolook and Wang Wauk. For the purposes of sampling, sites from these two subcatchments have been combined as the landuse in these subcatchments are similar.

Upper Coolongolook / Wang Wauk

The Upper Coolongolook / Wang Wauk subcatchment is located in the south west of the Wallis Lake Catchment and includes the rural villages of Wootton and Coolongolook. Large areas of the catchment are under forest, while unimproved pasture accounts for almost 50% of the total land area and contributes most of the pollutant exports. River flats have generally been cleared with steep country retaining forest cover. Riparian vegetation has been retained along creek lines, although the width at many sites has been greatly reduced. All lands in the catchment are on erodible soils. Sampling in the Upper Coolongolook / Wang Wauk takes place at 2 sites, one in the Coolongolook subatchment and one in the upper Wang Wauk.

Mid Coolongolook / Wang Wauk

The mid Coolongolook / Wang Wauk subcatchment extends from Bunyah Creek to the Coolongolook Estuary. All lands in the subcatchment are on erodible soils. Unimproved pasture accounts for almost 50% of the total land area. Sampling in the Mid Coolongolook / Wang Wauk takes place at 4 sites in the Mid Wang Wauk subatchment.

Upper Wallingat

The Upper Wallingat subcatchment remains the least modified of all Wallis lake subcatchments. Over 70% of the Upper Wallingat is forested, being either private, State Forest or National Park, with the remaining land comprised of unimproved pasture, unpaved roads and small areas of improved pasture and rural residential land. Sampling in the Upper Wallingat subcatchment takes place at 1 site on Sugar Creek.

Wallis Lake

Mid Wallamba Estuary

The Mid Wallamba Estuary subcatchment covers almost one third of the Wallis Lake Catchment (550 km^2). The catchment is one of the most modified subcatchments in Wallis Lake. Agriculture is the dominant land use in the Wallamba Catchment. The Mid Wallamba Estuary faces additional localised pressures from the erosion and collapse of stream banks due to its popularity for water sports over the summer period.

The water quality sampling occurs in the estuarine reaches of the river from Wallamba Island to Failford.

Wallamba Cove

Wallamba Cove receives runoff from part of the urban catchment in Tuncurry. The rainfall that once infiltrated into the ground through native vegetation now meets impervious surfaces (roofs, roads and footpaths) and runs directly into stormwater drains and into Wallamba Cove. This stormwater runoff carries with it pollutants such as sediments and nutrients from houses, lawns, pets and the like.

There are two water quality sampling sites one at the entrance of Wallamba Cove and one at the exit into Wallis Lake.

Pipers Creek

The majority of the Forster township is located in Pipers Creek Catchment. The rainfall that once infiltrated into the ground through native vegetation now meets impervious surfaces (roofs, roads and footpaths) and runs directly into stormwater drains and Pipers Creek. This stormwater runoff carries with it pollutants such as sediments and nutrients from houses, lawns, pets and the like. In the past, Pipers Creek and Pipers Bay have experienced large algal blooms and shown signs of poor ecological health. Following large rainfall events, the water from Pipers Creek and Pipers Bay can reach Wallis Lake and Charlotte Bay areas. Reducing the impacts of stormwater from the Pipers Bay Catchment therefore has benefits across the whole of Wallis Lake.

The samples for this Report Card are taken next to Big Island adjacent to Forster Keys.

Wallis Lake

Wallis Lake is in the centre of the estuary and receives runoff from a narrow catchment immediately surrounding the lake. Adjoining areas directly influencing Wallis Lake include Coomba Park, Green Point and the rural residential land on the western side of Wallis Lake. During large rainfall events, water from the major rivers and the Pipers Creek Catchment flow into this area carrying pollutants with it.

Sampling in Wallis Lake takes place in the centre of the estuary between Yahoo Island in the north and Earps Island in the south.

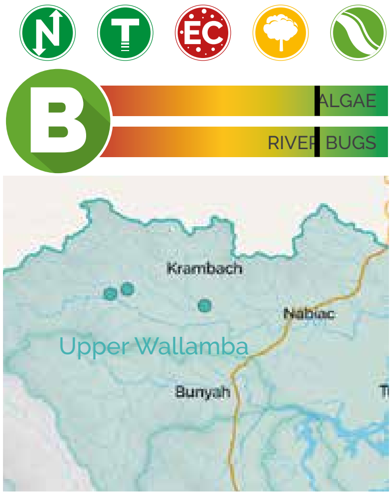
Charlotte Bay

Charlotte Bay covers the southern most part of the Wallis Lake Estuary. There is limited mixing between the northern and southern parts of Wallis Lake, therefore the condition of this area is influenced mainly by the surrounding catchment. The catchment is largely vegetated with a small amount of residential, commercial and rural residential land.

Sample collection in Charlotte Bay occurs in the middle of the water body south of Earps Island.

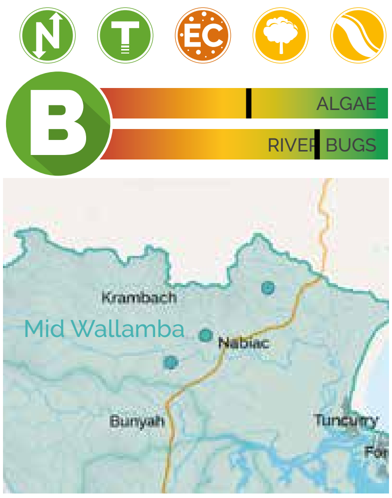
Wallis Lake

Wallis Lake Catchment Results



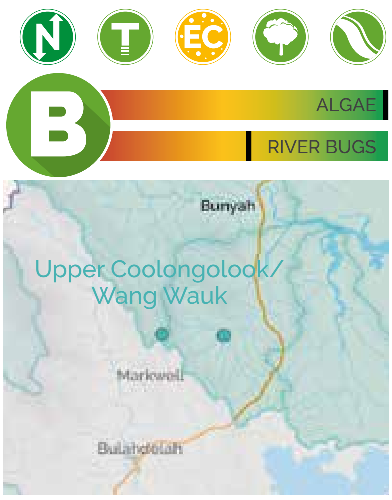
Upper Wallamba

The Wallamba has a long history of agriculture with less intense land use in the steep upper reaches of the catchment. The condition of the riparian zone was good at two of the sites and only fair at the third site. In-channel habitat was good at all three sites. Nutrient and turbidity levels were very good, which meant that the bug community score was good and the levels of algae were low. Salinity was much higher than expected at all three sites; further work is needed to see if this is a result of the local geology or from human activity.



Mid Wallamba

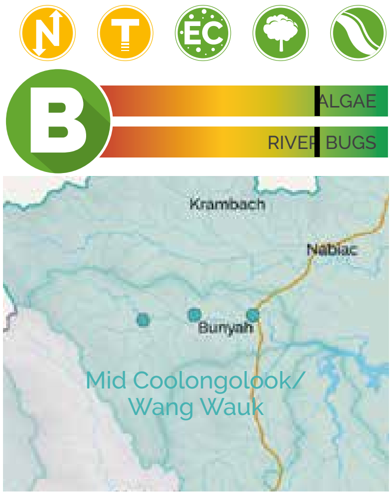
River health declined at all three sites in the middle reaches of the Wallamba Catchment, there were increased nutrient levels and in response some increase in algae which was very high at one site. Salinity remained high in the middle of the catchment. The riparian and in-channel condition was just fair to good indicating pressures on the streams from intense land use. Despite these declining conditions the bug communities showed great resilience, with scores of good to excellent.



Upper Coolongolook/ Wang Wauk

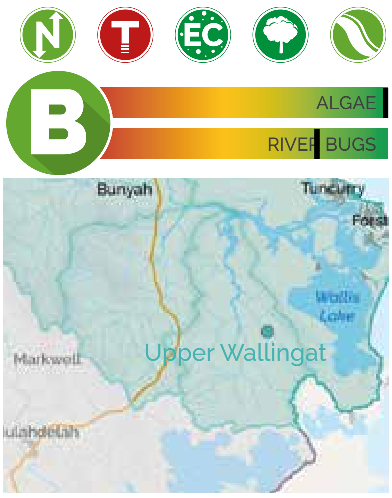
In the upper parts of the catchment salinity levels were high at one site and normal at the other. Low nutrient levels at both sites meant that the algal levels were also low. Riparian and in-channel condition were good to excellent. Bug scores were good at one site and only fair at the other, a response to a natural "blackwater" event.

Wallis Lake



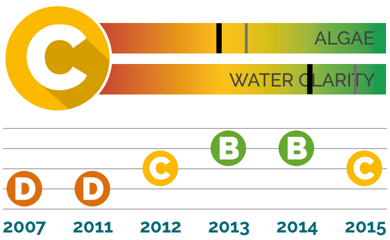
Mid Coolongolook/ Wang Wauk

The middle reaches of the catchment were in good ecological condition, with bugs, algae, riparian and in-channel assessments all resulting in scores of good or excellent. Salinity was elevated at one of the three sites. Nutrients were elevated at one site and turbidity were elevated at another site, however, the system appears to be quite resilient. The elevated nutrient levels could have implications for the estuary.



Upper Wallingat

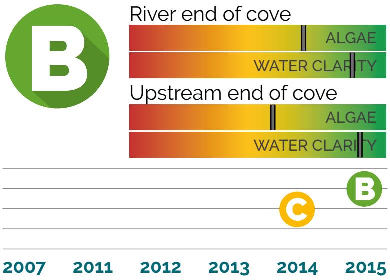
One site was sampled in the Wallingat Catchment and it had very low levels of algae and good bug communities. The riparian and in-channel conditions were good, nutrient levels were good, and salinity was very low. The stressor at the site was very high turbidity, which is most probably caused by runoff from the unsealed road.



Mid Wallamba Estuary

In the Wallamba Estuary, the overall condition was a 'C' grade, the same as the score recorded in 2015. High levels of algae were recorded, reflecting the large amounts recorded in the Mid Wallamba Catchment. Results show there are still significant problems with nutrients from catchment activities in the Wallamba.

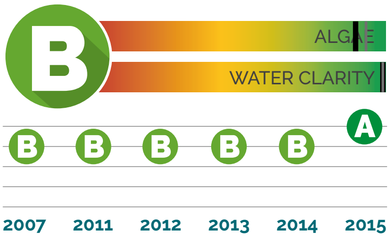
Wallis Lake



Wallamba Cove

In Wallamba Cove, there was a difference in health between the site near the river and the upstream site. The difference is mainly driven by algae. At the upstream site there were high levels of algae, all samples exceeded the trigger, by 6 to 33% of the worst value. Turbidity criteria were also exceeded in half of samples, but generally by only a small amount. This information shows clearly that urban runoff is having a large effect in Wallamba Cove, but that effect is somewhat diluted at the downstream end by mixing with the Wallamba River. This year the grade dropped from excellent in 2015 to good, most probably a consequence of the extreme wet weather experienced in January 2016.

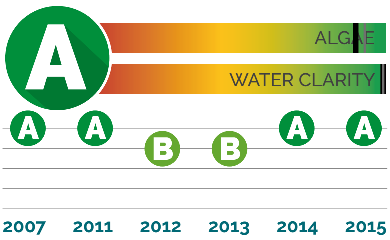
Results show that estuary health in the Cove requires improvement, the chlorophyll data show that targeted work on managing nutrients in the catchment is the highest priority.



Pipers Creek

The ecological health in Pipers Creek dropped back one grade to good from the excellent grade received in 2015. These results were most probably a consequence of the extreme wet weather experienced in January 2016. Consistent with previous years, the waters in Pipers Creek remained clear. The nutrient loads from the urban catchment of Forster during the wet weather have resulted in good algal levels, but they were high enough to result in an overall 'B' grade.

Ecological health in Pipers Creek is strongly influenced by inputs from the large urban catchment. Control of nutrients from houses, lawns and pets, that can wash into the creek through stormwater, is more difficult in rainstorms.

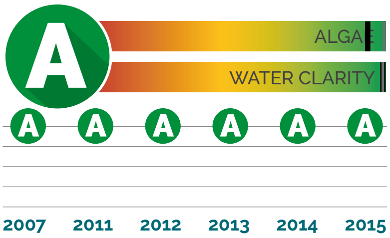


Wallis Lake

Ecological health was excellent this year, maintaining the excellent 'A' grade from the previous two years. The amount of algal growth remained very low. The above average rainfall experienced during the sampling period meant that chlorophyll samples exceeded the trigger value in one third of samples but the size of the exceedances was small. This probably reflects the on-going work to reduce runoff of nutrients from the catchment.

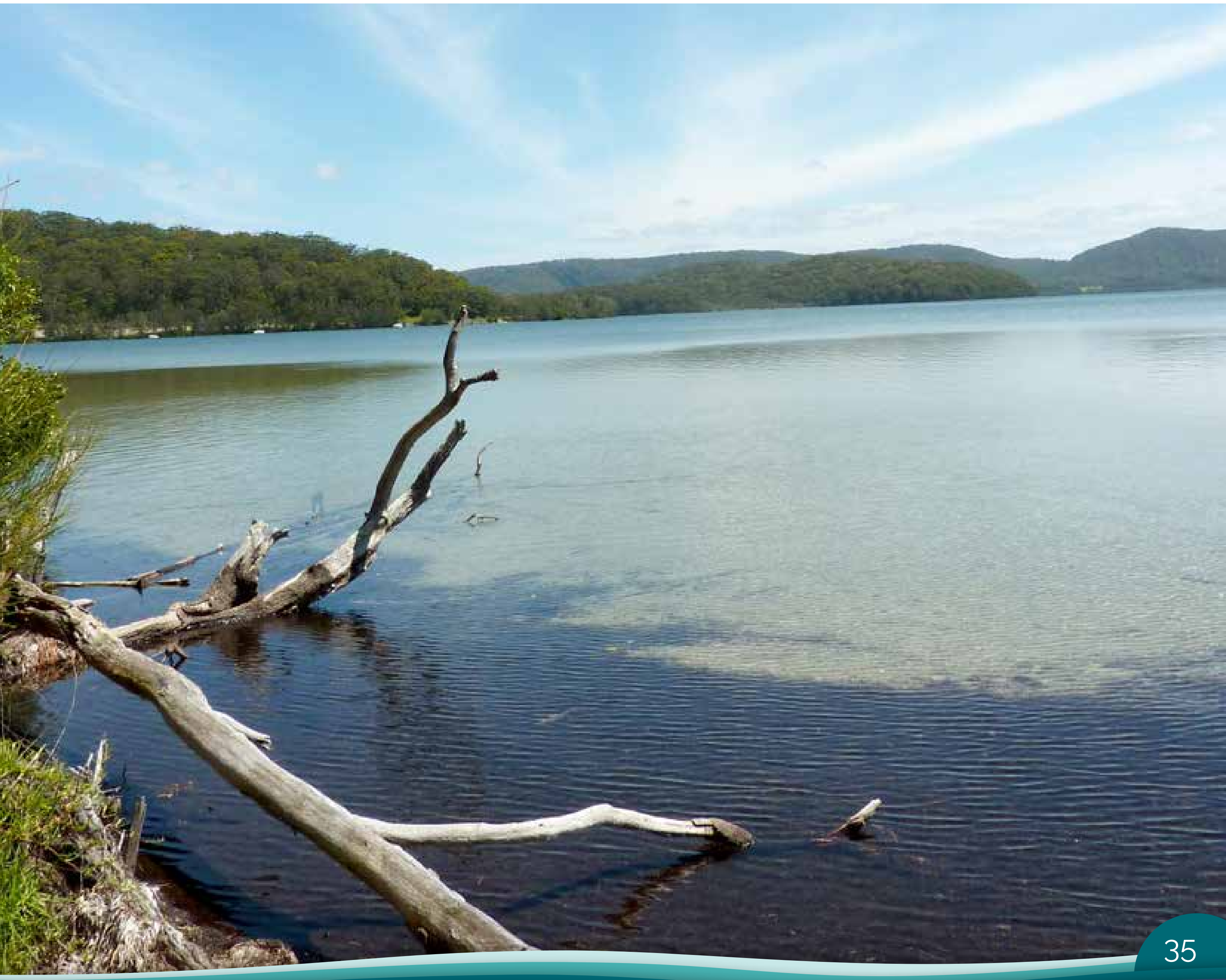
All turbidity samples remained below trigger values meaning the waters are very clear, allowing plenty of light to penetrate the water, this means that seagrasses can survive to greater depths and maintain a large area of coverage.

Wallis Lake



Charlotte Bay

Ecological health remained excellent in Charlotte Bay, despite the above average rainfall. Algal growth was at very low levels, exceeding trigger values in just 15% of samples. Water clarity was excellent with no exceedances.



Management Actions

LGA wide

Landcare and Sustainability Groups

The Great Lakes Sustainable Farming Program was a collaborative project between the previous Great Lakes & Greater Taree City Council's (now MidCoast Council), Karuah & Great Lakes Landcare, and the Hunter Central Rivers Catchment Management Authority (now Hunter Local Land Services). The aims of the program were to facilitate sustainable and productive land use across the Great Lakes Catchments.

The program focused on educating landholders in best practice sustainable land management and to engage and build landholders' knowledge of the environment, its protection and restoration. Landholder skills and knowledge were developed through 'participatory action learning' and empowering landholders to teach other landholders.

During the program several sustainable farming groups were established. Some groups were not soley focused on farming issues but branched out to include sustainable living and farm biodiversity (primarily the Land for Wildlife Program).

In addition to these localised sustainable farming groups, the Sustainable Farming Program incorporated a number of professional workshops, on-farm trials and 'Best Practice Demonstration Farms.

The Great Lakes Sustainable Farming Program was funded through 'Caring for our Country' grants secured in 2008 and 2010, with the most recent grant concluding in June 2013. A number of the sustainable farming groups have become independent entities with many of them signing up to become subgroups of Karuah & Great Lakes Landcare.

Over the past year, Karuah & Great Lakes Landcare subgroups have held a number of interesting sessions and field days including: Giant Parramatta Grass biological control, DIY biological supplements, soil health, permaculture, regeneration projects in riparian landscapes and the use of drones for farm planning. Sustainable farming practices and capacity building in the catchment continue to be supported by Karuah & Great Lakes Landcare and MidCoast Council. In 2015, a Memorandum of Understanding to facilitate future partnership projects and funding applications was formally adopted by Karuah & Great Lakes Landcare and Council.

Urban engagement - sustainable gardening

During the Sustainable Farming program, a program aimed at urban residents to achieve similar land management and water quality goals, but at an urban audience was also trialled. The concept of 'sustainable gardening' was seen as an excellent framework for Council to engage with residents regarding urban impacts on water quality.

Over 12 months in 2012, participants were led through a series of workshops and outdoor training sessions with local gardening experts. The objectives of the program were to work with urban residents to help them to reduce their individual impact on water quality by taking actions in their garden to reduce nutrient application, utilise water and hold water in their soil so that it would not runoff into our waterways. Many actions to achieve this objective have been undertaken by participants including composting, worm farming, mulching and establishing gardens. Numerous participants indicated that being involved in the Program gave them the confidence to 'have a go' and become more relaxed about learning by doing.

In 2014, the sustainable gardening group became a sub-group of Karuah & Great Lakes Landcare.

Management Actions

Land for wildlife

Land for Wildlife (LFW) is a national voluntary registration scheme for landowners who manage areas of their property for biodiversity and wildlife habitat. The program encourages and assists landholders to include nature conservation in their land management objectives. The LFW program is free to join, it is not legally binding and registration does not change the legal status of a property.

MidCoast Council and Karuah & Great Lakes Landcare are partners in delivering the LFW program in our area. Karuah & Great Lakes Landcare volunteers and MidCoast Council staff help identify and assess wildlife habitats on private lands and their connectivity across the landscape, enabling registration with the program. To date 33 properties across the Local Government Area (LGA) have registered with LFW. Karuah & Great Lakes Landcare purchased two motion-sensing cameras that are available to loan through the program so landholders can record animal movements on their land. The camera loans scheme has been highly utilised throughout 2015/16 with some interesting wildlife sightings observed.

Two LFW "Know your Bush" field days were held in 2016 at Durness Station at Tea Gardens and Wootton, with a focus on the value of bushland in maintaining healthy catchments and supporting agriculture. Many of the objectives of the sustainable farming program have been incorporated into MidCoast Council and Karuah & Great Lakes Landcare's support of the Land for Wildlife program.

Figure 14: Mark Graham from the Nature Conservation Council during one of the recent Land For Wildlife "Know Your Bush" workshops.

Management Actions

Protection from development and re-development

Council has focused on protecting all waterways in the LGA through its application of water quality targets for development and re-development. These water quality targets are incorporated into the Great Lakes Development Control Plan. For new developments (greenfield sites) water quality targets ensure that there is a neutral or beneficial effect on water quality which means nutrients are not allowed to increase above current levels. To achieve this, developers are required to present a stormwater strategy including measures such as installing raingardens and rainwater tanks.

Since the Water Sensitive Design chapter of the Development Control Plan was adopted, 30 subdivisions ranging from 2 lot to 81 lots have been approved.

Small scale infill development including individual houses and dual occupancies are included in the development control plan providing further protection from nutrient and sediment inputs to our waterways. Since the Water Sensitive Design chapter of the Development Control Plan commenced in 2012, 250 individual houses, 32 dual occupancies / multiple dwellings have been required to address water sensitive design. It is estimated that by constructing raingardens, swales and including rainwater tanks on these small scale developments we have stopped 105 kilograms of total nitrogen, and 8.5 kilograms of total phosphorus being deposited in our waterways each year. This is the equivalent of keeping 500, 17.5 kilograms bags of dynamic lifter out of our waterways annually. In addition to the nutrient reductions, it is estimated that 2.5 tons of Total Suspended Sediments are intercepted by these water quality treatments each year.

These figures are considered to be conservative as additional nutrient and sediment removal will be achieved on the 57 commercial developments where the Water Sensitive Design chapter of the Development Control Plan was also applied.

Management of aquatic weeds

High priority noxious aquatic weed management remains a focus for Council with Cabomba and Salvinia infestations impacting the Wallis Lake Catchment being monitored and managed where required under an integrated weed management program.

All known historic Cabomba infestations targeted for management during a two-year federally funded Cabomba eradication project have been recently assessed. Two areas have shown preliminary stages of re-establishment of the submerged weed which are scheduled for re treatment in the 2016 summer period.

Several scattered sites are being monitored and managed for Salvinia using a combination of controls including chemical, physical and biological treatments governed by site specific conditions.

Figure 15: Plants are an excellent indicator of water quality. Aquatic weeds can quickly dominate and clog nutrient rich waters.

Management Actions

Wallis Lake

Protection and rehabilitation of key habitats

Council has acquired and rehabilitated 1,079 hectares of wetlands at Darawakh, Pipers Creek Catchment, Minimbah and Lower Wallamba / North Tuncurry to protect water quality and biodiversity. The acquired landscapes are protected as Community Land under the Local Government Act, zoned for Environmental Protection in the Great Lakes Local Environmental Plan. Further, Council actively protects and restores the landscapes by direct and targeted actions, as funding permits.

Council has also restored pre-disturbance hydrology to over 90% of the Darawakh Creek/ Frogalla Swamp through the infilling or decommissioning of 22.2 kilometres of artificial drains and removal of 1.5 kilometres of artificial levees to remediate a significant acid sulfate floodplain wetland system. Monitoring has indicated that the works are having measurable success regarding the protection of the Lower Wallamba River from toxic acid and metal discharges. Further, there has been substantial biodiversity outcomes associated with the program.

Figure 16: Darawakh Wetland

Bank stabilisation

A total of 6.5 kilometres of the Wallamba River has been stabilised with rock protection and 10, 170 native plants have been planted. Ongoing bush regeneration and maintenance conserves 10.9 kilometres of streambank.

Rock walls that allow establishment of mangroves have been constructed to reduce bank erosion.

The Wallamba River is exposed to severe bank erosion due to past vegetation clearance, ongoing cattle grazing and wash from boats. Monitoring from MidCoast Council has indicated an erosion rate of up to 1 metre per year along 12 kilometres of river.

Sedimentation downstream is impacting on the health of the Wallis Lake oyster and fishing industry contributing to turbidity levels, and in turn, affecting the Report Card scores. Sedimentation directly affects oyster leases and turbidity reduces the depth at which seagrass will grow, thus reducing fish habitat.

The Wallamba River Memorandum of Understanding (MOU) brokered an innovative agreement to the management and remediation of these significant riverbank erosion issues affecting the banks of the lower Wallamba River. The MOU was amended in 2010 to address the increasing impact of wash from wake enhancing activities.

The MOU amendments were negotiated with key stakeholders including caravan park businesses, landholders, waterway users and government agencies. Importantly, the amendments provide a designated area for wakeboarding and other wake enhancing activities within Wallis Lake in an area on the western side of Wallis Island and maintains the existing ski zone within the Wallamba River.

It enacted responsibilities on land management agencies and river users to adopt actions and protocols to care for and restore the riverbank landscape to maintain the health of the river and its responsibilities including management of the riparian zone, protection and restoration of the downstream estuary and consider and manage aquatic habitat. MidCoast Council, with the support of other land management agencies, has been implementing activities that relate to riverbank protection and stabilisation and associated riparian enhancement. Outputs have included installation of 6.5 kilometres of riverbank armouring (rock fillets/revetment), enhancement and re-establishment of riparian vegetation and mangroves, and stock exclusion fencing.

Figure 17: Rock fillets along the Wallamba River

Erosion control

Since 2008 the New South Wales National Parks and Wildlife Service have undertaken a local program of track rationalisation and rehabilitation in National Parks to reduce erosion and sediment reaching lakes and waterways. In total, 10 kilometres of roads and trails have been closed, rehabilitated and maintained to reduce erosion and sedimentation in the Wallis Lakes Catchment.

Sites for rehabilitation were identified based on the steepness, level of erosion and their location in the catchment. To rehabilitate the roads trails were re-shaped to match the contour of the land, where possible the natural drainage was reinstated and erosion and sediment controls were put in place to reduce sediment transport.

Staff were trained in best practice erosion and sediment control to assist with future management of gravel roads.

In the areas where the roads were closed, signs, gates and bollards were constructed, trees were left across the track and the surface of the land was roughened to promote vegetation growth. These areas have begun to revegetate naturally.

Council has undertaken a number of erosion control projects along gravel roadsides at river and creek crossings in an effort to reduce the amount of sediment entering our waterways. During the 2015-16 period, two roadside erosion control projects at river crossings in the Upper Wallamba subcatchment, one on Wallanbah Road at Firefly and the other on Dargavilles Road at Nabiac were completed.

This involved the stabilisation of gully erosion, the removal of excess sediment from table & mitre drains and the construction of rock check dams. These structures work by slowing down the speed of the water flowing along the table drains and allowing the sediment to drop out of suspension before being washed into the river. The works have also involved the cleaning out of culverts that had become clogged with sediment and no longer functioned as they should, leading to damage of the road surface. One site required the complete rebuild of the drainage line which had become severely eroded over many years, contributing tonnes of sediment to the waterway.

Council has also undertaken the sealing of a number of rural roads during 2015/16 through Council's Rural Road Construction Program. This has included a 1.3km section of Wattley Hill Road at Wootton, 0.8km of Willina Road at Coolongolook and a section of Cowper Street at Nabiac.

Bush rehabilitation

Wallamba Catchment

Nabiac Landcare has been working on regeneration programs in the Nabiac area for over 20 years. The main focus of the group's work in the past has been the regeneration of a six hectare area of river flat sclerophyll forest at Bullock Wharf on the Wallamba River. In 2015-2016, the group have also continued regeneration works along Woosters Creek at Lilly Pilly Bend in Nabiac village. This ephemeral creek contains remnant riparian vegetation, with large stands of Waterhousea floribunda that is under threat from dense infestations of small-leaved privet and lantana.

Additionally, the group routinely visits the site at Bullock Wharf to manage new weed incursions and maintain the area.

The group completed 3178 hours in 2015-16; and planted 92 tubestock.

Wallis Lake

Two volunteer bush regeneration groups work on a variety of vegetation types and weeds in Forster. At the southern end of Little Street, a single volunteer maintains a small (0.4 hectare) public reserve containing remnant floodplain rainforest and important SEPP14 wetland (saltmarsh) on Wallis Lake foreshore. The area was overrun with woody weeds, such as lantana and senna, but also contains vine weeds such as climbing asparagus and morning glory. Native vines are also present, and in this highly disturbed landscape, are overgrowing old growth rainforest trees. Ongoing support is needed to complete meaningful restoration of the site.

The Community Garden volunteers at Pennington Creek, Forster continue to maintain the banks of the creek, when they can spare time away from their vegetable plots. The volunteers clean up rubbish, as well as removing weeds. Woody weeds such as lantana, senna, camphor laurel and date palms once dominated the site, but volunteers are now into the maintenance phase for these species. The ongoing challenge for the group is to manage the more persistent weeds such as asparagus weeds, madeira vine, fishbone fern and invasive grasses from dominating the creek banks.

Council's weeds crew have completed several treatments of weeds on the southern bank of the creek; removing mature date palms, mature camphor laurels, as well as treating fishbone fern and asparagus on the creek bank.

The site includes mangroves, old-growth remnant rainforest trees, sclerophyll species, as well as natives planted to help out compete the weeds.

A small group of volunteers have achieved excellent results along the banks of Muddy Creek in

Tuncurry. The group has been actively managing weeds along the small urban creek since 2010. They initially removed large amounts of Lantana and Senna, but have had to treat a plethora of garden escapes, such as Broad-leaved Pepper Tree, Coral Berry, various palms, as well as truck loads of Ground Asparagus and Coastal Morning Glory.

Figure 18: Muddy Creek volunteer, Ed working on the removal of garden escapes from the site in March 2016.

Four volunteer groups are actively regenerating their local bushland reserves in the Wallis Catchment. Green Point Coastcare has been meeting weekly since 1996 to reduce weeds along the foreshore of Wallis Lake. Their initial work involved clearing vast tracts of lantana and bitou bush, now the remaining four members are tackling vine weeds, asparagus fern and invasive grasses. In 2015/16, the group have contributed 414 hours and planted 910 seedlings. The group mainly focus on a 2 hectare area that has casuarinas fringing the lake's edge, with rainforest and eucalypt canopy in some areas.

Three volunteer groups are active at Coomba Park. One group, with six volunteers, works on a 3 hectare site at Coomba Aquatic Gardens. This area contains a sclerophyll forest on the headland point, and a large area of saltmarsh with mangroves fringing the lake. The site was heavily infested with Lantana when the group commenced in 1994.

The woody weeds (lantana and senna) are mostly under control. However, vine weeds (passionfruit, morning glory) and garden escapees are proving more problematic in the long-term management of the area. In 2015-16, the group planted 120 seedlings and completed 591 hours at the site.

The Coomba Foreshore group has 12 members who meet weekly to work in a 1.5 kilometre long foreshore reserve that contains both sclerophyll forest and saltmarsh. Woody weeds, such as lantana and senna have been systematically removed, and the group is now working on asparagus weeds (ground and climbing), vine weeds, including morning glory, madeira vine, moth vine and passionfruit vines (two species). Garden escapees and grass weeds are also a problem at this site. The group works in a 7 hectare area on Wallis Lake, and 2015-16 completed 959 hours.

Management Actions

The third site contains a 9 hectare area of saltmarsh on Burraneer Road, and is maintained by a single volunteer.

Funding from the Environmental Special Rate continues to support volunteers in the Wallis Catchment, with mentoring and extension bush regeneration works by contractors.

Charlotte Bay

Two volunteers meet irregularly at the wetland behind the Community Hall at Pacific Palms. The group commenced in 2009 on the 4 hectare site, which contains a mixture of saltmarsh species, old-growth mangroves and orchid-bearing casuarinas; as well as dense stands of cabbage-tree palms, grey gums and swamp mahoganies. Over a six year period of consistent regeneration works, the wetland has been converted from a weed dominated understorey, to a healthy mix of wetland reeds and rushes, and various rainforest understorey species. Funding from the Environmental Special Rate continued in 2015-16, enabling further expansion of regeneration works in the foreshore reserve to the south of the site. This work has focused on priority weed species such as ground asparagus, lantana and coastal morning glory.

The site is a natural wetland, doing vital work in filtering water coming off the adjacent village and infrastructure. The removal of weeds at this site has seen a proliferation of native rushes and sedges, and subsequently improved functioning of this important natural system. During early 2016, regenerators discovered the endangered Syzygium paniculatum growing under a dense Cissus curtain on the site, adding further value to this unique ecosystem.

Water Sensitive Urban Design

Over the past five years MidCoast Council have been building water quality gardens in the Pipers Creek Catchment to filter the sediments and nutrients out of the stormwater prior to flowing out into Wallis Lake. Six gardens have been built in the Palms Estate drainage reserve between Kularoo Drive and the Southern Parkway in Forster. An additional garden was built out the front of Council on Breese Parade as a demonstration, filtering water from the road, further protecting Pipers Creek. In 2013, another water quality garden was constructed at the Forster campus of Great Lakes College. The construction of the ninth water quality garden on the corner of Pipers Bay Drive and Tahiti Avenue, Forster was completed in August 2014. The number of gardens constructed now totals nine. The water quality gardens work by slowing down the stormwater so that large particles like soil drop out of suspension. The water then flows over a planted area and the microscopic alga (biofilms) which grow on the plant roots remove the nutrient nitrogen. The sandy loam soil that the plants grow in also acts as an additional filter removing other pollutants like heavy metals, petrochemicals and phosphorus. The water that then flows into the stormwater drain is cleaner prior to flowing into Wallis Lake.

Figure 19: Pipers Bay Drive water quality garden

Management Actions

Great Lakes College: incorporating local water quality issues into the curriculum

In 2012-2013 Council worked with Great Lakes College Forster Campus to design a program to embed local water quality and catchment issues into the geography curriculum for Years 7-10. Council, in cooperation with MidCoast Water, has continued to work with Great Lakes College to run a twice-annual field day with Year 10 Geography students.

To date, over 400 students have learnt about catchment management, threats to water quality in natural areas and water quality improvement gardens through these field days. Class room theory lessons are combined with a specially- designed catchment trailer, dip-netting for macro-invertebrates in the lake and undertaking water quality monitoring in Pipers Creek.

Great Lakes College have begun water quality monitoring at their school site with the Waterwatch program, and have also constructed a water quality improvement garden on-campus for water quality outcomes, and as a practical demonstration of the types of actions that can be taken to improve water quality in urban catchments.

Figure 20: Great Lakes College

Management Actions

Myall Lakes

Erosion control

In an effort to reduce erosion and sedimentation in the Myall Lakes Catchment, the New South Wales National Parks Service have rehabilitated, maintained or closed 59 kilometres in the Myall Lakes Catchment since 2008. Outside of the National Park, erosion hot spots on gravel roads in the catchment have begun to be addressed. On Old Inn Road a concrete causeway was constructed across the Wild Cattle Creek along with sealing of the road on the approaches to the creek combined with geo-fabric and rock lining of the table drain significantly reducing sediment loads and turbidity to the creek. In 2015/16, a 1.1km unsealed section of Bombah Point Road at Bulahdelah was sealed through Council's Rural Road Construction Program.

Bush Rehabilitation

Volunteers in Hawks Nest, known as 'the Bitou Busters', 38 members completed 234 hours at various sites in Hawks Nest, including Winda Woppa, Bennetts Beach and Jimmies Beach. Weeds of concern at all sites include asparagus weeds, polygala, coastal morning glory, lantana and bitou. Grant funding from the Environmental Trust has employed contract bush regenerators to complete additional works across the Hawks Nest landscape, complimenting volunteer efforts in the area.

A significant population of the endangered Magenta Lilly Pilly (Syzygium paniculatum) has also been recorded in the area, as well as several sightings of Powerful Owl families.

Figure 22: Trail in Myall Lakes

Figure 21: Volunteers completing the painstaking follow-up weeding on Ground Asparagus at Bennetts Beach, Hawks Nest.

Management Actions

Management of aquatic weeds

Aquatic weeds were monitored and treated along 46 kilometres of stream bank in the Myall Catchment. The ongoing monitoring program has revealed significant reductions in densities and occurrences of the target weed Parrots Feather.

One and a half hectares of Alligator Weed received multiple treatments at the obsolete landfill area contained within Tea Gardens Waste Management Centre. This newly discovered infestation is currently being managed under an intensive, ongoing, integrated weed management program.

One and a half hectares of Salvinia infested water bodies were treated at Tea Gardens. These works are a continuation of an integrated program for the wetland's management focusing on water retention ponds in the area. The main pond infestation has been reduced to >0.1% with monitoring and hand removal efforts ongoing.

Monitoring has revealed no sign of Salvinia in the main water body since January 2014. The use of biological controls and a containment barrier in the creek adjacent to the pond is maintaining weed densities and the eradication program will extend to this area in subsequent years as funds permit.

One hectare of land has been treated for Longleaf Willow Primrose and the integrated management program for Longleaf Willow Primrose in drainage areas of Tea Gardens is ongoing.

Land and water on private properties along 8 kilometres of Lewis Creek at Girvan has been under an intensive management program headed by MidCoast Council. Council has been coordinating the program due to the importance of the weed, complexities with effective management and spread of this highly invasive species. Since 2007, the infestation areas have undergone regular inspections, monitoring and an integrated treatment program aiming at suppression leading to eradication. This program has been highly effective seeing a reduction in excess of 90% of the plants above and below ground vegetative biomass.

Protection and rehabilitation of key habitats

The Water Quality Improvement Plan recognised the critical role that wetland protection and restoration plays in the maintenance and improvement of water quality and aquatic health. Functional floodplain wetlands are particularly important in the protection of receiving waterways from catchment runoff. Given that algae concentrations remain an issue in the Myall Lakes system, it is important that Myall River Floodplain wetland systems are appropriately protected and managed.

One example of a floodplain wetland restoration project is the acquisition and restoration of the Bulahdelah Plain Wetland. This 366 hectare area is located on the Myall River Floodplain above the Myall Lakes Ramsar site. It was acquired by Great Lakes Council (now MidCoast Council) with support from the New South Wales Estuary Grants and the Hunter Central Rivers Catchment Management Authority (now Hunter Local Land Services). The public acquisition of this wetland system has ensured that the important ecosystem services functions are protected against changed or intensified private land use. Further, the wetland is being actively restored so that ecosystem services functions are improved. Council has benefitted from the funding support of the Commonwealth Biodiversity Fund, New South Wales Environmental Trust and New South Wales Estuary Grants programs and is revegetating previously cleared areas of the land, controlling weeds and feral animals and excluding stock.

The works will safeguard downstream waterways and will conserve an important area of habitat for significant biodiversity, including threatened species and endangered ecological communities.

In addition, Council has become Trust Manager for the Crown Foreshore Reserve adjoining the Bulahdelah Plain Wetland Reserve and has commenced management interventions to harness ecosystem benefits and protect the natural environment. Works undertaken in 2015-16 included the establishment of 2.3 kilometres of stock-exclusion fencing and over 4.7 hectares of revegetation plantings in currently cleared areas. These works will increase the protection of the Myall Lakes system.

Finally, MidCoast Council has worked with a nearby landholder to facilitate the permanent private conservation of over 200 hectares of naturally-vegetated land. This outcome was achieved through the use of Council's development-incentives for conservation clause in the Local Environmental Plan. This is a substantial positive outcome for local water quality and biodiversity.

Lower Myall

Council is a strategic partner in a project to establish connected habitat corridors and preserve and restore native vegetation at Durness Station, Tea Gardens. The Durness – Borland Landcare Corridor project involves the establishment of corridors of native vegetation linking the northern foreshores of Port Stephens with habitats in Nerong State Forest and Myall Lakes National Park.

The corridors protect 92 hectares of land, which contains 20 hectares of remnant native vegetation. The remaining 72 hectares of land in the protected corridors is being revegetated by the establishment of environmental plantings. Over 65,000 native plants have been established in these corridor areas, to restore functional native vegetation to previously cleared areas. The project is associated with the establishment of stock exclusion fencing and riparian restoration on the trunk and tributaries of Kore Kore Creek as well as the remediation of active gully and sheet erosion sites and un-vegetated steep lands. This will deliver significant water quality benefits to Kore Kore Creek, Monkey Jacket Creek and the lower Port Stephens estuary.

The project is being delivered as part of a major re-development of the agricultural production system on Durness Station to ensure greater sustainability including the establishment of a rotational grazing system and farm-scale offstream watering network. The project site will be utilised for education and awareness activities.

The Durness – Borland Landcare Corridor is being delivered by Landcare Australia Ltd and the landowner with funding provided by a bequest from the estate of the late Raymond Borland. Council and Hunter Local Land Services are significant contributing partners. As a further contribution to this project, Council has acquired and conserved 122 hectares of land to protect water quality and biodiversity in the Kore Kore Creek Catchment. This land is a core conservation node and protects a landscape important for water quality protection. Beneficial, low-intensity uses are being developed in the Kore Kore Conservation Reserve, including walking trails and signage to encourage stewardship and awareness. The Kore Kore Conservation Area has been subject to primary and follow-up weed controls, wild dog and fox controls, enhancement of track conditions and erection of nesting boxes to enhance the condition and function of the native vegetation of the land. Restoration and enhancement efforts of the Reserve are being directed by a Restoration Management Plan.

Management Actions

Karuah River

Karuah River Catchment Management Plan

Initial implementation of the Karuah River Catchment Management plan has continued during 2015-2016. As reflected in this year's report card results, the headwaters of the Karuah River are in excellent condition, with large areas of intact terrestrial and riparian habitat. In partnership with local community members in the upper catchment, a program is in place to protect high-quality reaches of the river, to restore riparian habitat in degraded reaches of the river and to increase overall community understanding and participation in riparian restoration.

A priority identified by both the Catchment Management Plan and water quality monitoring is to reduce nutrient pressures on the river and estuary. In collaboration with industry a best management practice program has been established. The aim is to develop locally relevant infrastructure and farm management practices which are economically viable to reduce pressures on catchment health.

Actions in the Karuah River Catchment also include a range of field days and workshops to improve awareness and understanding of catchment management principles. Some examples of activities during 2015-16 include Hotspots fire and biodiversity workshop, understanding soils, and primary schools in the district learning about catchments at the Stroud Show.

Erosion control

To reduce erosion and sediment in the Karuah Catchment, the New South Wales National Parks and Wildlife Service have undertaken a program of track rationalisation and rehabilitation. To date, a total of 99 kilometres of roads and trails have been rehabilitated, maintained or closed to reduce erosion and sedimentation works in the catchment. In 2015/16, unsealed sections of Hinton Street and Wye Street at Stroud were sealed by Council. This will help to reduce sedimentation inputs to Mill Creek and the Karuah River.

Management of aquatic weeds

The Noxious Aquatic weed, Water Hyacinth, is impacting tens of hectares of known water bodies on dozens of private properties in many localities throughout the floodplains of the Karuah Catchment, including Nooroo, Stroud Road, Washpool, Stroud, Booral and Allworth. Council and private land managers have been undertaking adhoc controls to manage this weed in various areas for many years, however a problem such as this requires an ongoing large scale coordinated approach to truly be effective. Due to many complexities the effectiveness of biological controls are limited.

Into the future, Council intends to form a partnership with effected land holders and seek external funding to implement a long term control strategy to assist landholder manage the problem. Water Hyacinth may rapidly take over an entire waterway and its large reproductive capacity can cause annual re-infestation thus making ongoing control necessary. There are new 'off label' permits available for the use of certain herbicides to effectively treat Water Hyacinth on waterbodies. Land managers should contact Councils Noxious Weeds Coordinator for management advice.

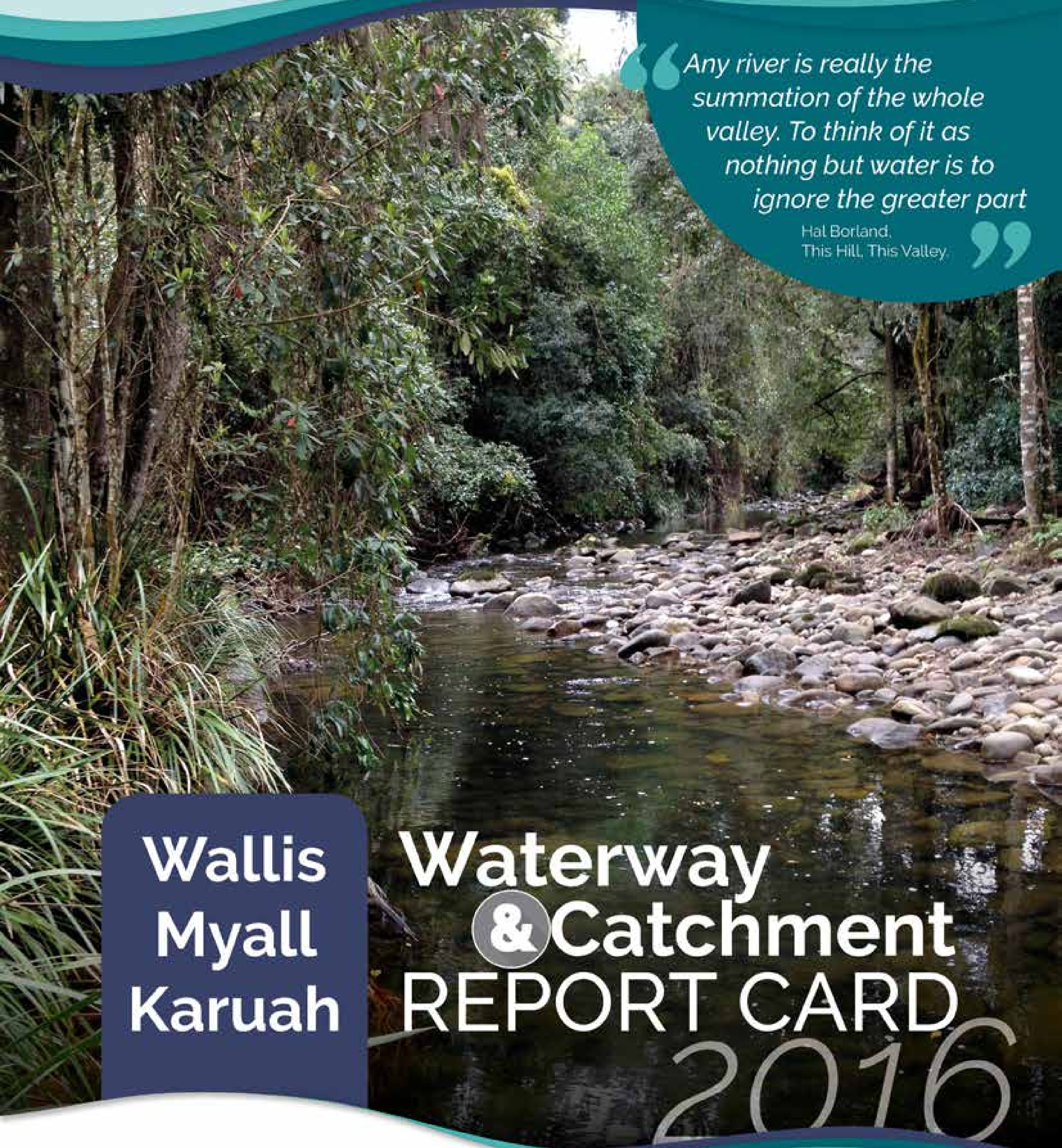
Management Actions

The Branch subcatchment

Action within The Branch subcatchment has focused on understanding and addressing poor water quality within The Branch. This has included undertaking a landscape risk assessment in partnership with Hunter Local Land Services in order to identify hotspot locations in which to target on-ground water quality actions.

There are extensive wetland systems with the estuarine zone of The Branch subcatchment. A program has been in place to improve awareness of the value of wetlands in the landscape and to reduce pressures which are presently impacting wetland health and functioning.

Figure 23: Wetlands Management workshop at The Branch.



> *Any river is really the summation of the whole valley. To think of it as nothing but water is to ignore the greater part*
>
> Hal Borland,
> This Hill, This Valley.

Wallis Myall Karuah

Waterway & Catchment REPORT CARD 2016

MidCoast Council

Office of Environment & Heritage

Local Land Services Hunter

Karuah Great Lakes Landcare

MidCoast Council water quality improvement projects are made possible by the Environmental Special Rate

Karuah Ca

In the upper Karuah Catchment s
sediment were low to very low re
for river bugs.

Higher levels of nutrients and sec
the vegetation along the river con
in the middle reaches of the Karu
however, river bug communities

The Karuah
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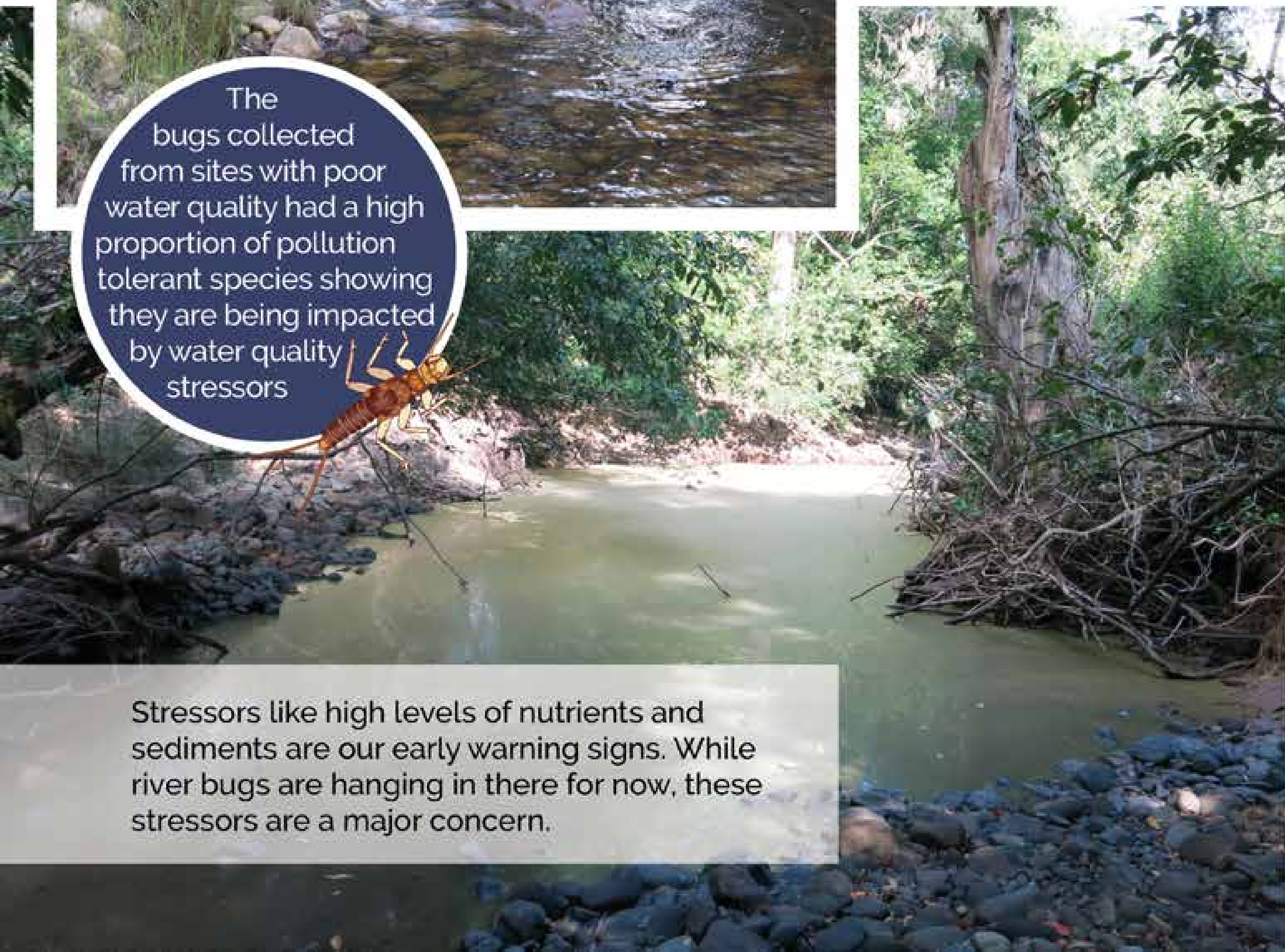
Many of the activities in our catchments are having unintended negative consequences for water quality and ecological condition of our waterways.



The bugs collected from sites with poor water quality had a high proportion of pollution tolerant species showing they are being impacted by water quality stressors

Stressors like high levels of nutrients and sediments are our early warning signs. While river bugs are hanging in there for now, these stressors are a major concern.

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Score

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tressors from nutrient inputs, salinity and
sulting in low algal levels and good scores

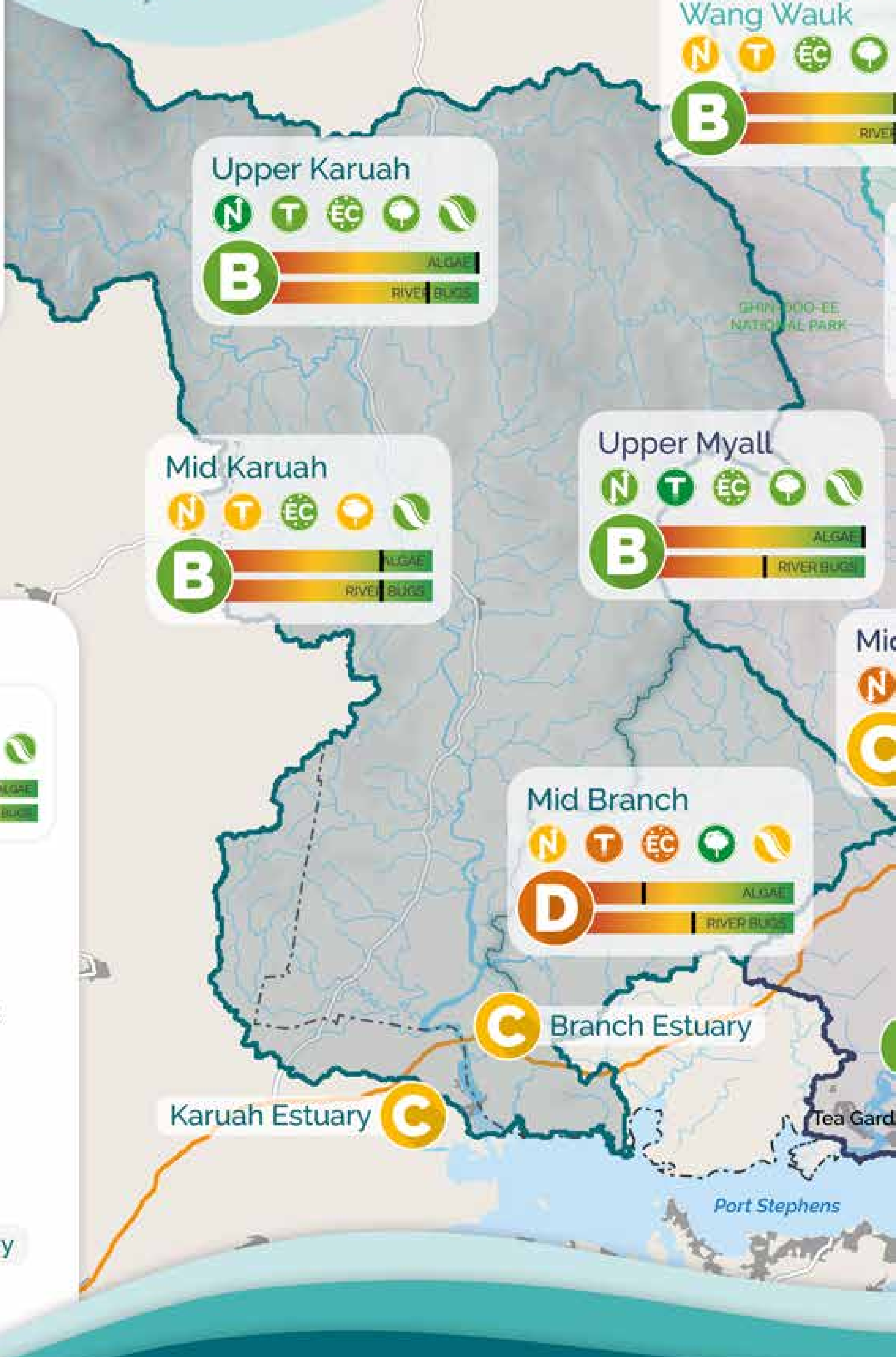
diments and a decrease in the condition of
responded with intensification of land use
ah. There was an increase in algal levels;
remained in good condition.

Estuary results were only 'fair' this was
d by the higher levels of nutrients,
nents and deteriorating vegetation
ndition in the Mid Karauh Catchment.

Overall condition in the Branch was poor,
considerably worse than the Mid Karuah.
Ecological health in the Branch Estuary
appears to be better than the Branch
Catchment; however, this is a reflection
of dilution from other sources rather than
an 'actual' improvement.

Rivers

run through our history and folklore, and link us as a people. They nourish and refresh us and provide a home for dazzling varieties of fish and wildlife and trees and plants of every sort.



chment score key

ors: Changes to the
nment that can lead
logical harm.

ll grade: Ecological
ion, a combination of
ug and algae scores.

Catchment

B

ALGAE

RIVER BUGS

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Stressor measures

- Nutrients
- Turbidity
- Electrical conductivity (saltiness)
- Riparian condition
- Reach condition

uary score key

ll grade: Ecological
ion, a combination of
and water clarity scores.

B Estuary

ore details see Waterway and Catchment
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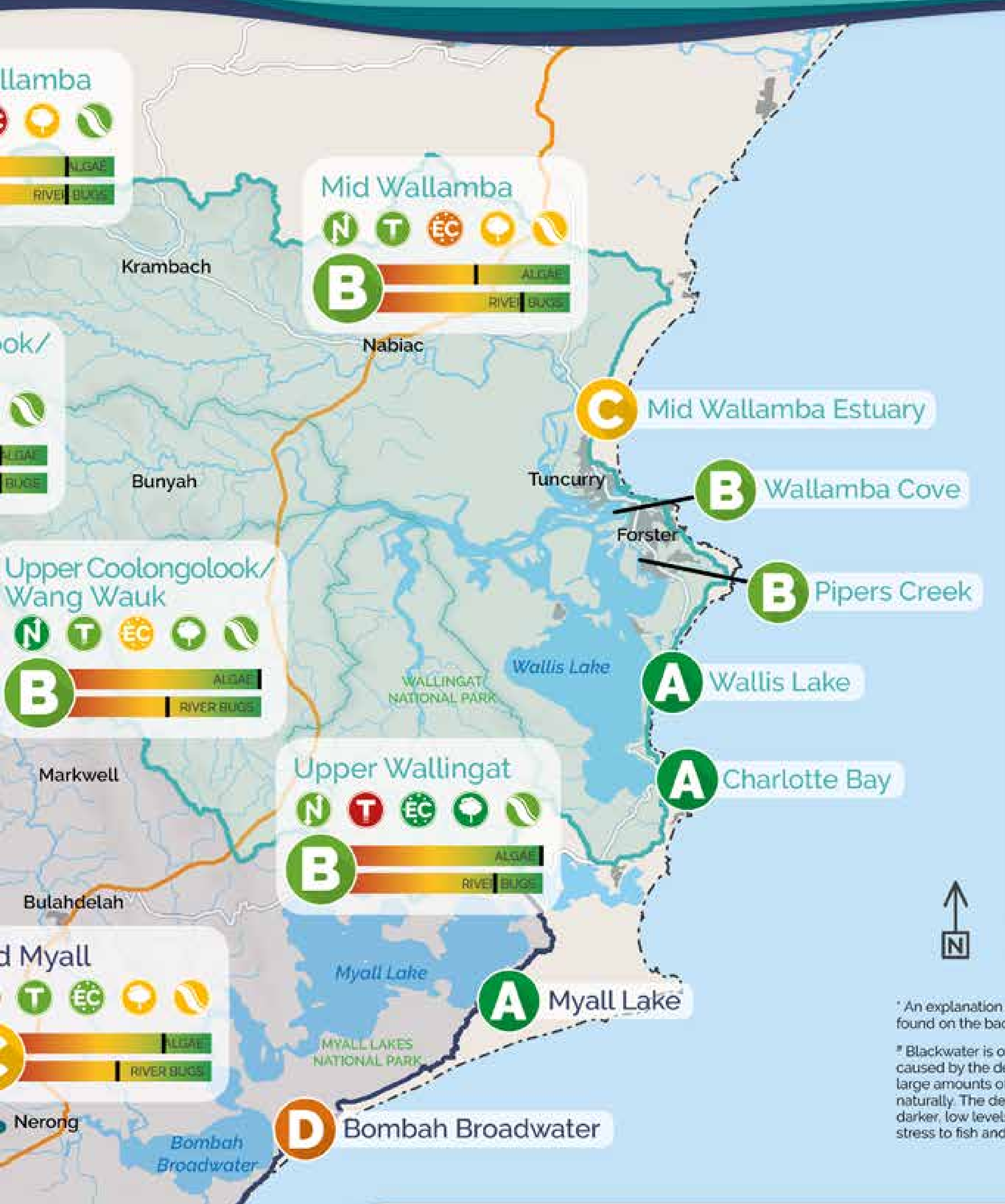

Wallis
Catchm

Wallamba Cat

The upper Wallamba ecological condition very low nutrient and The condition of vege was also only 'fair' inc being placed on the r expected; further wo or from human activit

The overall ecologica remained the same a and instream reach c increased placing ad

High levels of algae w the overall grade. Incr Wallamba Catchment

Coolongolook

In the upper parts of t levels were low. River "blackwater#" event n nutrients and sedime

Nutrient and sedimen Coolongolook/Wang

Wallingat Catc

One site was sample levels of algae and g levels were recorded site which receives ru

* An explanation of reach condition can be found on the back page

Blackwater is oxygen-depleted water caused by the decay of organic matter such as large amounts of leaf litter. Blackwater occurs naturally. The decay process makes the water darker, low levels of dissolved oxygen cause stress to fish and water bugs

Myall Catchment

Ecological condition of the upper Myall was good. The river bug score was only fair because of a natural blackwater event.

In the middle of the Myall Catchment, high levels of nutrients, declining condition of vegetation along the river and declining reach condition* resulted in increased algal levels. There was no blackwater event# in the mid Myall, the river bug score was associated with nutrient enrichment.

These results were reflected in the Broadwater where overall ecological condition was poor, high algae and sediment levels were recorded.

At Tea Gardens, algal abundances were higher than desired and this was mostly a consequence of algae being carried downstream from the Broadwater.

Lake
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was in good
corresponding with
sediment levels.
etation along the river
dicating there is some stress
river. Salinity was much higher than
rk is needed to see if this is a result of the local geology
ty.

al condition in the middle reaches of the Wallamba
s the upper Wallamba; however, algal levels increased
ondition declined*. Nutrients and sediment levels
ditional stress on the system.

ere recorded in the Wallamba Estuary strongly influencing
easing levels of nutrients and sediment recorded in the Mid
would have influenced the algae results.

/Wang Wauk Catchment

he Coolongolook/Wang Wauk Catchment, algal
bug scores were only fair; but this was due to a natural
ot pollution. These results corresponded with very low
nts.

t scores were only fair in the middle reaches of the
Wauk, algal levels and the river bug scores were good.

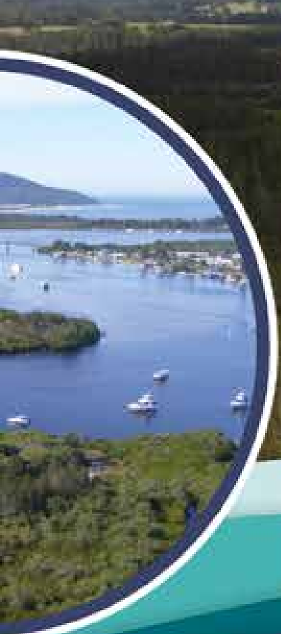
chment

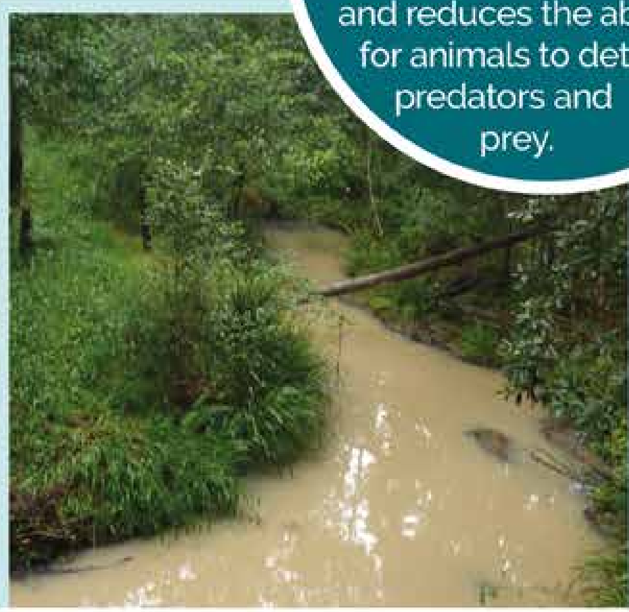
d in the upper Wallingat Catchment and it had very low
ood river bug communities. Extremely high sediment
were thought to be a factor of the particular sampling
unoff from unsealed roads and had very low flow.

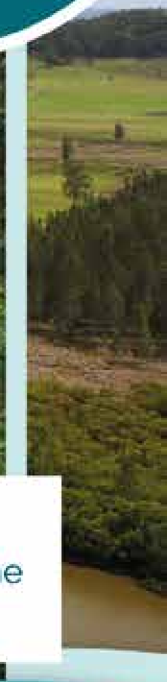
Algae blooms occur in pools and slow flowing reaches. In faster flowing waters the impacts show up downstream in our lakes and estuaries.

The headwaters are typically preserved in excellent condition where there are large areas of conservation and intact riparian zones. As land use intensifies, pressures on the system increase and ecological health and water quality decline.

Excessive sediment in waterways has multiple impacts. It smothers habitat, reduces plant growth, clogs the gills of fish and macroinvertebrates and reduces the ability for animals to detect predators and prey.

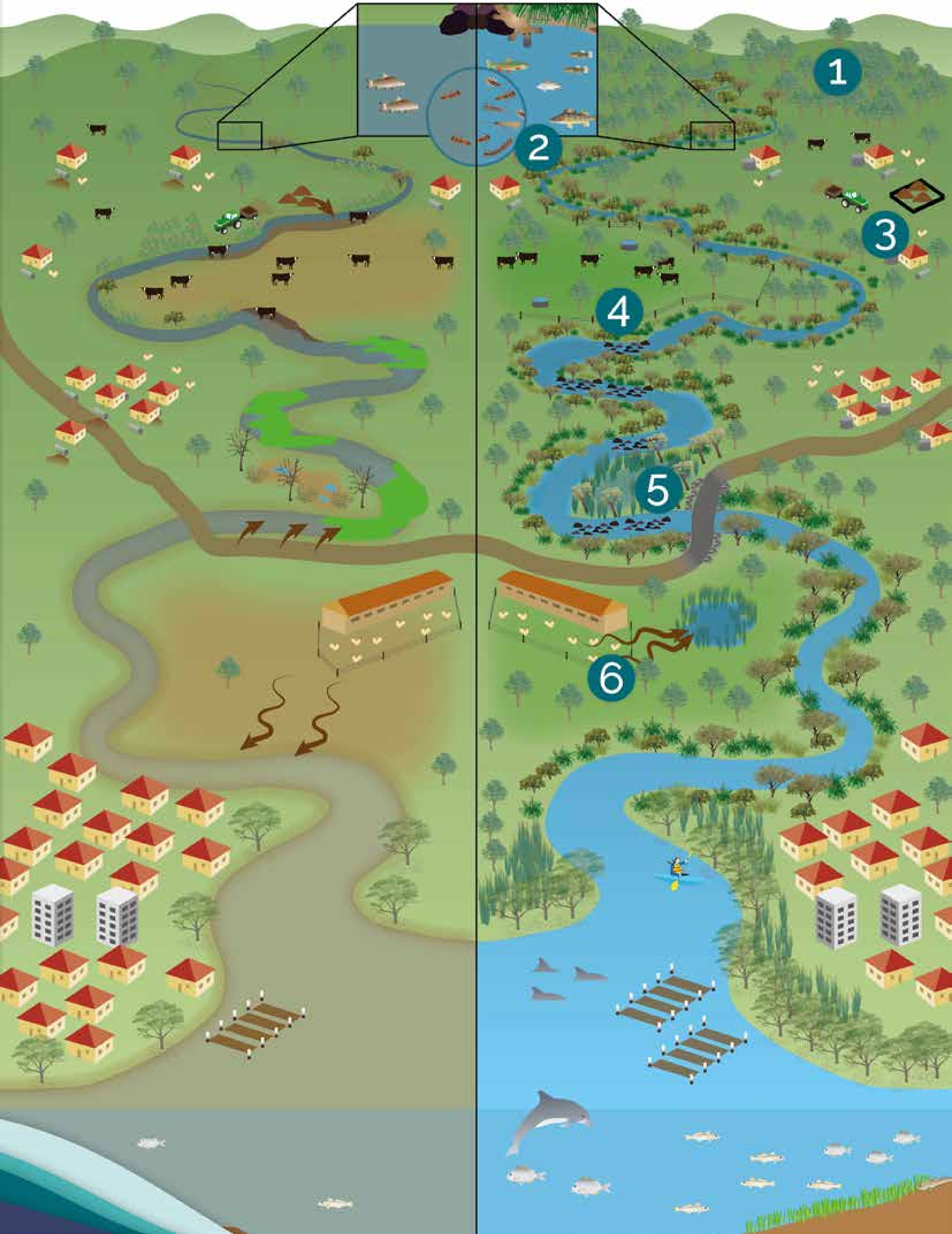






Some stressors have immediate impacts on stream ecological health, but others can be transported downstream all the way to the estuary, where they accumulate and change estuary condition.

Where would you rather be?



Enhance farm profitability and cattle health while improving waterway health

Features of a healthy catchment

1. Vegetation on steep slopes reduces erosion
2. River life is abundant and diverse
3. Fertilizer is applied and stored away from waterways
4. Stock is out of waterways and wetlands
5. River vegetation is healthy
6. Productive pastures with high ground cover

Did you know?

- Stock can lose up to ½ kg/day when drinking muddy water
- Nitrogen not taken up by the plant 0-14 days after application is lost to the environment and to your 'back pocket'
- To promote optimal plant uptake and growth, when using nitrogen fertilisers, apply them the day you move stock out of the paddock.
- Even without planting, fencing off streams can reduce faecal coliforms by 35%
- Nutrients applied in excess of plant needs, achieves minimal additional pasture yield
- Wetlands are like the kidneys of the landscape; they clean our water, slow the flow of water and reduce flood peaks.
- Small amounts of fertiliser applied more regularly will yield greater pasture productivity than a single large annual application.

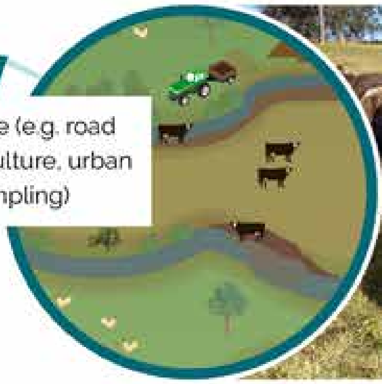
Pathways of impact

Learning from the science

This year the report card moves the focus from the estuaries alone, to the rivers in the catchments that flow into them. This requires us to measure a wider range of indicators. Indicators are selected to show pathways of impact. Catchment results will be presented in a report card every 5-10 years

Activity

is the fundamental cause (e.g. road building, intensive agriculture, urban development, stock trampling)



Stressors

are changes to the environment that result from the activity and can lead to ecological harm. These measures are focused on likely inputs from known activities and may be affecting instream and downstream ecological condition.

- N Nutrients - all forms of nitrogen and phosphorus in the waters
- T Turbidity - sediments in the water and loss of clarity
- EC Electrical conductivity - increasing saltiness of freshwaters
- Riparian condition - the type and condition of vegetation on stream banks
- Reach condition - the condition of banks and variety of instream habitats

Ecological impacts

Ecological condition grades are a combination of river bug and algae scores

River bugs or macroinvertebrates are the basis of river food chains and are effective indicators of changes to river health. Different types of bugs respond to different stressors (e.g water quality, density and condition of vegetation along the rivers, bank condition, instream habitat) and can help us understand how stressed our catchments are.

Algae (also known as chlorophyll) can grow excessively with high levels of nutrient inputs. The way this is expressed in rivers is mostly determined by flow. In pools and slow flowing reaches, microscopic algae can bloom and can be measured as chlorophyll in the water. In faster flowing waters the microscopic algae are washed away and rarely show up in water samples, instead we tend to see growth of visible algal scums on rocks, timber and other hard surfaces.

Details on the report card methods and more information on results are available at http://midcoast.greatlakes.nsw.gov.au/Environment/The-Big-Picture