

Chapter 6

Ecosystem Health

Key Points

Indicator	Status of Indicator
6.1 Ecosystem water quality	<p>The percentage of locations where water quality parameters exceeded ANZECC guideline values for aquatic ecosystem protection was higher in the 2007 Audit period than in the 2005 Audit period, for 7 out of the 12 parameters tested.</p> <p>The number of locations exceeding ANZECC water quality guidelines has increased for physical and toxicant parameters, and remained high for nutrient parameters compared to the 2005 Audit period.</p>
6.2 Macroinvertebrates	<p>There are fewer sampled locations with 'similar to reference' ratings compared to the 2005 Audit period. Macroinvertebrate assemblages at 39 per cent of the sampled locations in the Catchment were found to be 'significantly impaired' and 2 per cent of all sampled locations had a 'severely impaired' rating.</p>
6.3 Fish	<p>The invasion of introduced fish species is problematic throughout the Catchment and may indicate a moderate level of disturbance to native species, flows or riparian vegetation structure.</p> <p>The Wollondilly, Mulwaree and Jenolan Rivers may be in a disturbed condition.</p>
6.4 Riparian vegetation	<p>Riparian zones outside the Special Areas are likely to be under variable pressure due to little to no standing vegetation cover, stock access, and the presence of exotic species.</p>
6.5 Native vegetation	<p>Native vegetation covers approximately 50 per cent of the Catchment.</p> <p>Approved land clearances remained low during the 2007 Audit period.</p>

Healthy and intact natural ecosystems play a crucial role in maintaining water quality as they provide processes that help purify water, and mitigate the effects of drought and flood. An overall picture of the ecological health of a catchment can be achieved using tools such as water quality assessment, habitat descriptions, biological monitoring and flow characterisation (Qld DNRM, 2001). Ecosystem health assessment has become more ecologically based in recent years with biological measures such as ecosystem structure and species diversity having been added to traditional physico-chemical water quality analysis to provide a more comprehensive picture of the condition of catchment health (Qld DNRM, 2001). This audit examines:

- traditional ecosystem water quality parameters
- aquatic communities, namely macroinvertebrate and fish communities
- terrestrial ecosystems of riparian and native vegetation communities.

Pressures in the Catchment

Sydney's drinking water supply is managed using a multiple barrier approach to control risks to water quality, including catchment management, storage management, delivery system management and treatment systems (SCA, 2005b). Natural systems in the Catchment and around storages contribute to this multiple barrier approach by reducing risks to water quality.

Many water supply authorities have tried to secure ecosystem processes by closing off, or in some way protecting, the hydrological catchments of their storages. The SCA has taken a similar approach through the Special Areas which comprise 370,000 hectares, or about a quarter of the total Catchment area. Special Areas are tracts of largely native vegetation in good condition around water storages and lands containing the SCA's canals and pipelines. The Special Areas are particularly important as part of the multiple barrier approach to protecting water quality. They act as a buffer against nutrients and other pollutants for ecosystems that in reasonably good condition and are near storages and bulk water off-take points. These barriers appear effective under low and moderate flow conditions when water can take several years to travel between the outer catchment and the dam wall. However, under periods of high flow, the barrier effect of the storage breaks down and the capacity of the ecosystem in the remainder of the Catchment becomes critically important. This capacity is strongly dependent on the integrity and health of the ecosystems across the entire Catchment. Pressures on ecosystem health therefore need to be managed across the entire Catchment.

Ecosystem health is affected by a number of natural and human induced pressures. Natural pressure on ecosystem health and condition include fire, flood and drought. The primary human induced pressures on ecosystem health in the Catchment are water demand and management (Chapter 4), land-use change and land management (Chapter 5). These human-induced pressures can directly disturb or destroy ecosystems, as well as indirectly affect ecosystem processes through impacts on water quality, flow regimes, and biodiversity.

Aquatic ecosystem health is a function of many factors including water quality, community structure and diversity (for example, macroinvertebrates and fish), and the extent and condition of riparian and native vegetation in the Catchment. All these factors contribute to the ability of aquatic ecosystems to support and maintain a balanced, integrated and adaptive biological system (CRCFE, 2002).

Chemical, nutrient and cold water pollution are some of the possible threats to aquatic ecosystems caused by human practices and land uses. Clearing of native vegetation and riparian zones can also affect land condition, biodiversity and runoff volumes which ultimately impact upon water quality and aquatic ecosystem processes. Riparian vegetation is particularly crucial for water quality and aquatic ecosystem processes, and also provides habitat for terrestrial fauna. Managing native vegetation clearing, particularly in riparian areas, is therefore important to maintaining ecosystem health.

The presence of exotic fauna is also a pressure on ecosystem health in the Catchment, with exotic species causing physical damage to soil and vegetation, and preying on native species and disrupting natural ecosystem processes. Exotic plant species can also affect ecological processes in vegetation communities.

State of the Catchment

6.1 Ecosystem water quality

Background

Healthy ecosystems generate and maintain good water quality. This audit examines 12 water quality parameters that signal whether the pressures in the Catchment are impacting on water quality required to maintain aquatic ecosystems. These parameters are assessed against the guideline values for ecosystem health in the Australian and New Zealand Environmental Conservation Council (ANZECC) and Agricultural and Resource Management Council of Australia and New Zealand (ARMCANZ) guidelines (2000) (the ANZECC guidelines).

The ANZECC guidelines are split into ecosystem types. The ecosystem types present in the Catchment are upland rivers (>150m altitude) and lakes and reservoirs. Each sampled site in the Catchment is split into either an upland river or lake and reservoir site and assessed against that guideline (Table 6 and 7 in Appendix C). The ANZECC approach also allows for the use of alternative guideline values where locally available data suggest that is appropriate. The Auditor has applied an alternative value for turbidity based on historical data collected in the Catchment by the EPA (now part of DECC). The guideline value for total aluminium was based on trigger values applied to slightly – moderately disturbed systems, and the guideline value for total Iron was based on the Canadian guideline level, as insufficient data for Australia is available (ANZECC & ARMCANZ 2000). The advantages of using the ANZECC guidelines and its associated approach are that it provides a quick methodology that identifies areas for further investigation. There are, however, limitations in that the ANZECC numbers are trigger values that suggest investigation of exceedences are necessary and not that exceedences mean that an ecosystem is unhealthy.

Changes in ecosystem health over previous Audit periods are also assessed. The auditor used the same classifications as the 2003 and 2005 Audits to provide a visual representation of ecosystem water quality across the Catchment during the 2007 Audit period (Map 6.1). In the Audit classification system, the 12 parameters were combined into the following four groups:

- Physical – Turbidity (NTU), pH and Conductivity ($\mu\text{S}/\text{cm}$)
- Toxicants – Total Aluminium (Al) (mg/L) and Total Iron (Fe) (mg/L)
- Nutrients – Total nitrogen ($\mu\text{g}/\text{L}$), Total phosphorus ($\mu\text{g}/\text{L}$), Oxidised nitrogen ($\mu\text{g}/\text{L}$), Ammonia ($\mu\text{g}/\text{L}$) and Filtered phosphorus ($\mu\text{g}/\text{L}$)
- Chlorophyll- a ($\mu\text{g}/\text{L}$) and Dissolved Oxygen (%).

The parameter with the highest level of exceedence within a group then determined the rating for that group. The group ratings are:

- ‘very Poor’ when one or more parameters exceeded the guidelines in more than 75 per cent of samples
- ‘poor’ when one or more parameters exceeded the guidelines in 50 – 75 per cent of samples
- ‘fair’ when one or more parameters exceeded the guidelines in 25 – 50 per cent of samples
- ‘good’ when less than 25 per cent of samples for all parameters exceeded the guidelines.

Findings

Individual parameters

The percentage of sites with water quality samples that exceeded ANZECC guidelines increased for seven out of the 12 parameters during the 2007 Audit period (Figure 6.1).

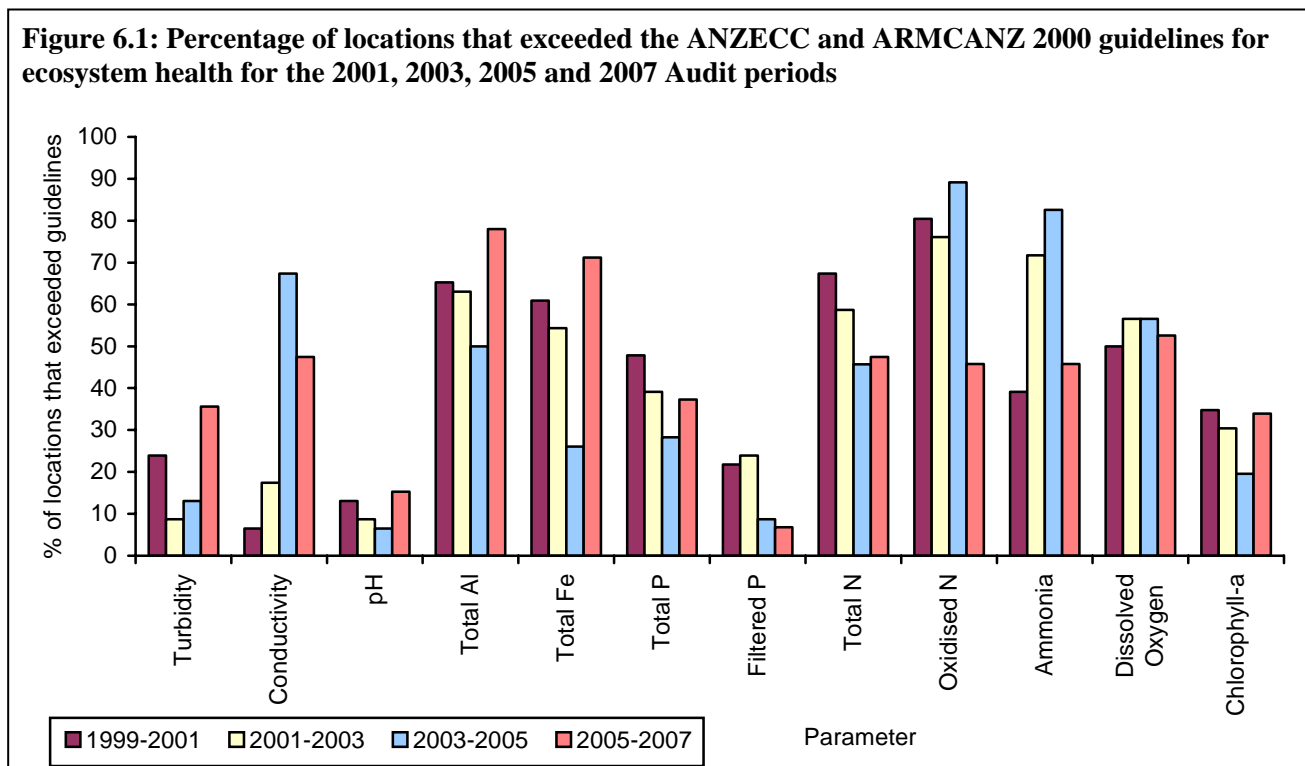
The greatest increases were for Total Aluminium and Total Iron, which increased from 50 and 26 per cent of sites exceeding ANZECC guidelines for these parameters, to 78 and 71 per cent of sites respectively. During the 2005 Audit period these two parameters showed the largest decreases.

Other parameters for which ANZECC guidelines were exceeded at a greater percentage of sites during the 2007 Audit period include Turbidity, pH, Total Phosphorus, Total Nitrogen, and Chlorophyll-a (Figure 6.1).

There was a decrease in the percentage of sites with water quality samples exceeding ANZECC guidelines for five of the 12 parameters during the 2007 Audit period (Figure 6.1).

The largest decreases were for Oxidised Nitrogen, Ammonia and Conductivity. The percentage of sites where water quality samples exceeded ANZECC guidelines for Oxidised Nitrogen almost halved, from 89 per cent of locations during the 2005 Audit period, to 46 per cent in the 2007 Audit period. The percentage of sites exceeding ANZECC guidelines for Ammonia dropped from 83 per cent in the 2005 Audit period, to 46 per cent in the 2007 Audit period. Exceedences of ANZECC guidelines for Conductivity decreased during the 2007 Audit period, however, this parameter showed the largest increase between the 2003 and 2005 Audit periods.

There was also a decrease in exceedences of Filtered Phosphorus and Dissolved Oxygen guidelines. Exceedences at individual sites can be seen in Table 6 and 7 in Appendix C.



Source: SCA 2007

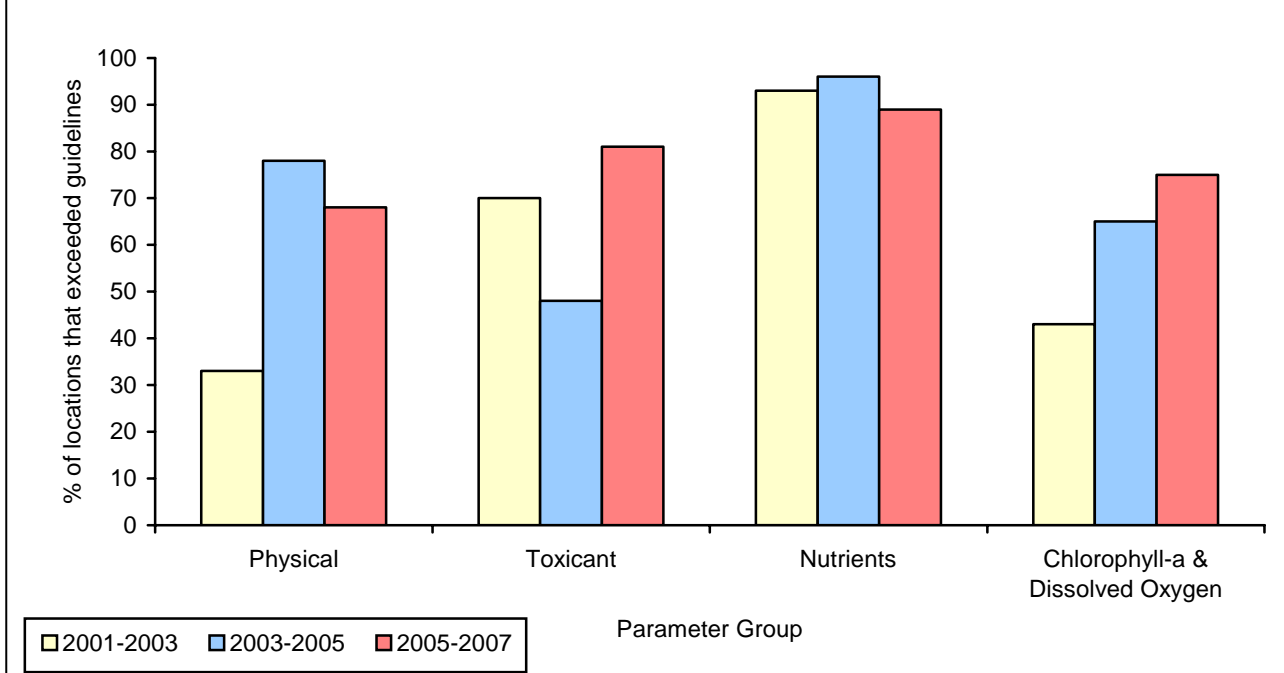
Parameter groups

Guideline exceedences for toxicant and chlorophyll and dissolved oxygen parameter groups increased during the 2007 Audit period (Figure 6.2). The percentage of sites exceeding chlorophyll and dissolved oxygen guidelines has steadily increased since the 2003 Audit period, from 43 to 75 per cent. Toxicant guideline exceedences showed a large increase in the 2007 Audit period, to 81 per cent of sites, despite having decreased from 70 to 48 per cent during the 2005 Audit period (Figure 6.2).

Exceedences of Physical and Nutrient parameter guidelines decreased during the 2007 Audit period (Figure 6.2). Nutrient exceedences have nevertheless remained high, occurring at 89 per cent of sites (Figure 6.2). Seventy-five per cent of sites exceeded Physical parameter guidelines during the 2007 Audit period.

During the 2003 and 2005 Audit periods, it was noted that the majority of the exceedences of water quality guidelines related to the Nutrient parameter group. The majority of exceedences during the 2007 Audit period were still for Nutrients; however the difference between the groups has slightly decreased from the 2005 Audit period. All four parameter groups now have guideline exceedences at more than 60 per cent of sites (Figure 6.2). Trends at individual sites are presented in Table 8 Appendix C.

Figure 6.2: Percentage of locations that exceeded the ANZECC and ARMCANZ 2000 guidelines for ecosystem health parameter groups for the 2001, 2003, 2005 and 2007 Audit periods



Source: SCA 2007

Individual sites

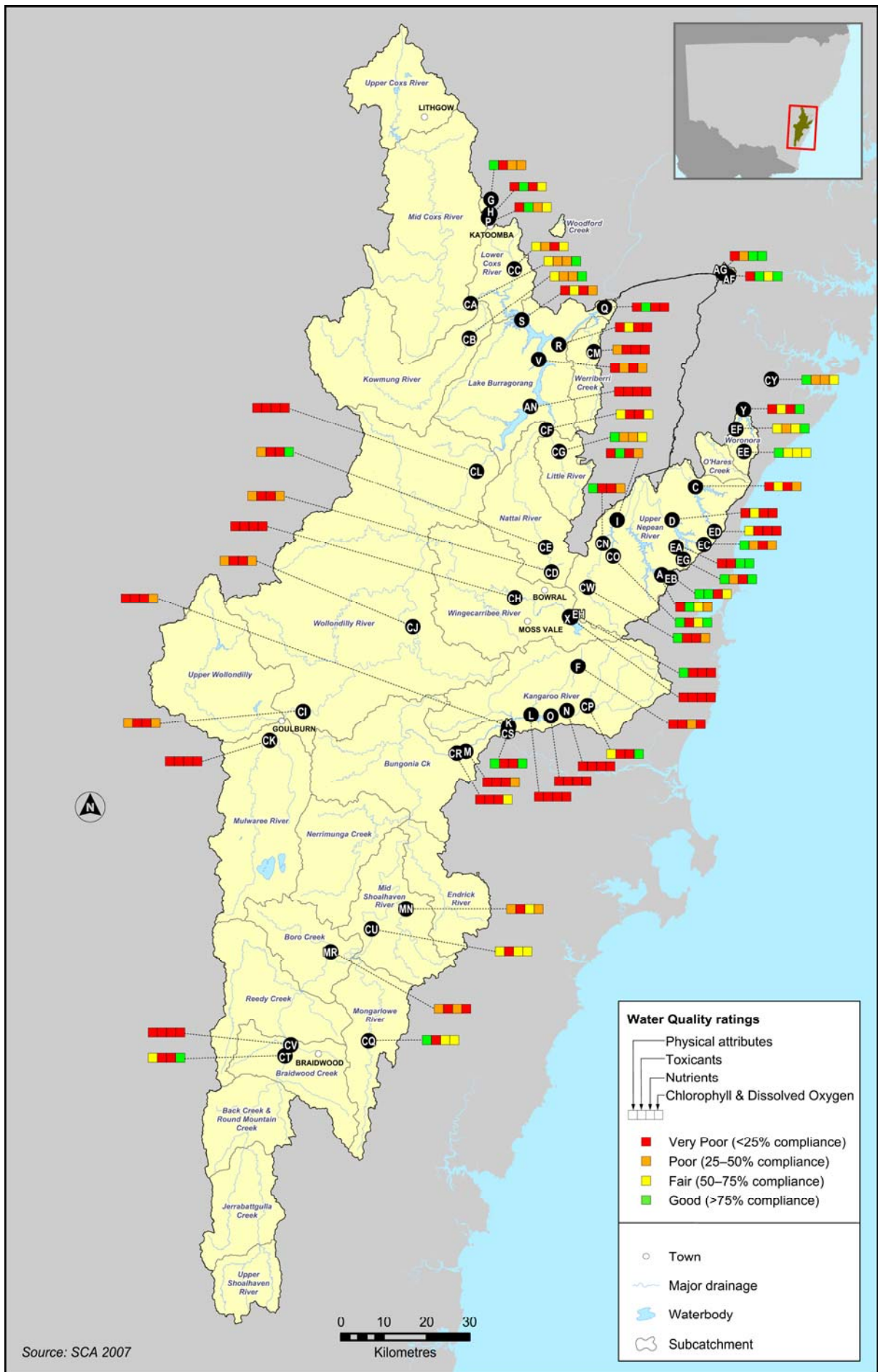
Nine out of 56 sites received ‘very poor’ water quality ratings for all four parameter groups in the 2007 Audit period. These sites were the Wingecarribee River ^(CH*), Gillamatong Creek at Braidwood ^(CV*), Lake Yarrunga in the Kangaroo River (priority) sub-catchment ^(L*, N* & O*), Wollondilly River ^(CL*), Lake Burragorang ^(AN*), Wingecarribee Lake ^(X*) and the Mulwaree River ^(CK*). During the 2005 Audit period, only a single site at Lake Yarrunga ^(L*) rated ‘very poor’ across all four groups.

There were no sites with ‘good’ ratings (less than 25% of samples with exceedences) for all four, or even three of the four parameter groups. Seven sites received ‘good’ ratings for two groups. These were Sandy Creek Inflow ^(EA*), Burke River at inflow to Lake Nepean ^(CO*), Flying Fox Creek No.3 ^(EB*) and Cordeaux River ^(EG*) in the Upper Nepean River sub-catchment, the Shoalhaven River downstream of Tallowa Dam ^(CS*) in the Kangaroo River (priority) sub-catchment, and Lake Prospect ^(AF* & AG*) (Map 6.1).

Waratah Rivulet ^(EE*) in the Woronora River sub-catchment was the only site that did not receive any ‘poor’ or ‘very poor’ ratings during the 2007 Audit period. It had one ‘good’ rating and three ‘fair’ ratings. In the 2005 Audit period, there were four sites with no ‘poor’ or ‘very poor’ ratings.

Five sites had one or two ‘poor’ ratings but no ‘very poor’ ratings. These included the Coxs River at Kelpie Point ^(CA*), Kowmung River at Cedar Ford ^(CB*), Little River at Fireroad ^(CG*), and two sites on the Woronora River ^(EF* & CY*) (Map 6.1).

* See Map 6.1 for locations of sampling sites and Table 10 in Appendix C for explanation of codes.



Map 6.1: Water quality monitoring sites showing the 4 parameter groups and percentage compliance in the Sydney drinking water catchment

Implication

During the 2007 Audit period, nearly 60 per cent of the water quality parameters exceeded ANZECC guideline values at over 40 per cent of locations, compared to 50 per cent of the water quality parameters at over 40 per cent of locations in the 2005 Audit period (Figure 6.1).

Since the 2005 Audit period, the percentage of locations in exceedence of Nutrient parameters has decreased only slightly from very high levels, and the number of locations at which Physical parameters were exceeded has also decreased. Exceedence of Chlorophyll-a and Dissolved Oxygen guidelines have increased, and exceedences for Toxicant parameters have dramatically increased, despite decreasing in the 2005 Audit period.

Oxidised nitrogen exceeded guidelines in 76–98 per cent of locations between 1999 and 2005. During the 2007 Audit period it decreased to 46 per cent. The number of locations at which ammonia levels exceeded guidelines has continually increased from 39 per cent between 1999 and 2001, to 83 per cent of locations during the 2005 Audit period. During the 2007 Audit period, however, it decreased to 46 per cent.

While an appropriate concentration of salts (measured by conductivity) is vital for aquatic plants and animals, salinity beyond the normal range can cause stress or death of aquatic organisms. Highly saline conditions can also affect the availability of nutrients to plant roots, and therefore disturb aquatic plant growth and aquatic ecosystems. During the 2007 Audit period, Streamwatch data from the Coxs River (priority) sub-catchments showed very high conductivity levels ($> 1000 \mu\text{S}/\text{cm}$) in Kangaroo Creek, Sawyer's Swamp Creek, Springvale Creek, Huon Creek, Neubeck's Creek, Coxs River, Pipers Flat Creek and Lamberts Gully Creek. Adverse in-stream biological effects are expected if salinity increases to $1500 \mu\text{S}/\text{cm}$ whereas much lower values around $800 \mu\text{S}/\text{cm}$ may make the water unsuitable for certain agricultural purposes (ANZECC & ARMCANZ, 2000).

The continued exceedence of dissolved oxygen guideline values in more than 50 per cent of locations from the 2003, 2005 and the 2007 Audit may be having a direct impact on aquatic biota. In addition, low dissolved oxygen levels can also cause changes in redox conditions, aiding the release of nutrients and metals from sediments into water.

The increase in turbidity and continued exceedence of dissolved oxygen guideline values may influence the concentration of iron and aluminium and therefore the Toxicant parameter group. There was also an increase in the number of locations exceeding the turbidity guideline. Metals may be adsorbed onto suspended solids (measured by turbidity) and be transported into waterways. The increases in the concentration of iron and aluminium may also indicate a greater influence of groundwater intrusions dominating low flows.

The SCA's water quality monitoring program is largely in the north-east region of the Catchment. There were 10 new sites in the 2007 Audit period. However, none of these new sites were in a sub-catchment that had no monitoring sites in previous Audit periods. There are several sub-catchments with few or no monitoring sites where water quality could be expected to be under stress. A number of the priority sub-catchments have only one or two water quality monitoring sites, and the priority sub-catchments of the Upper Wollondilly River and Upper Coxs River have no water quality monitoring sites. The current SCA water quality monitoring program does not give a comprehensive picture of water quality throughout the Catchment. The Streamwatch data from the Coxs River sub-catchments reinforces the need for more water quality monitoring sites.

Declining water quality is of concern and the Auditor recommends that SCA investigate the causes for this decline. The Auditor believes that this may not be simply related to drought conditions experienced during the 2007 Audit period, since similar conditions prevailed during the 2005 Audit period. It is important to understand the drivers of decreasing water quality. See Recommendation 7.

6.2 Macroinvertebrates

Background

'River health' is a concept that goes beyond suitability of water for particular uses and integrates a range of ecosystem values and functions. Macroinvertebrate assemblages integrate many aspects of the 'health' of streams and rivers, complementing the more traditional assessments of water quality.

Macroinvertebrates are typically visible with the naked eye and exist in a variety of habitats in streams, lakes and wetlands. Of all biological communities used to assess health, macroinvertebrate assemblages are most widely used, as they are abundant and diverse, sensitive to changes in water quality, flow regime and habitat conditions and they allow detection of impacts some time after the impact has occurred (Qld DNRM, 2001). Additionally, there is reasonably good taxonomic knowledge of freshwater macroinvertebrates, and they are relatively easy to collect.

The AusRivAS system is widely practised and supported for use in environmental audits by independent studies (SCA, 1999) and national water monitoring programs. The AusRivAS sampling protocols were developed as part of the National River Health Program's Australia-wide Assessment of River Health. Since 1994, more than 1500 reference sites across Australia have been sampled to build predictive models to interpret field sampling results. The AusRivAS system generates river health assessments by predicting the macroinvertebrates that would be present (expected) and compares this with the macroinvertebrates collected (observed) to create an index of health. The lower the observed/expected value, the more impaired the macroinvertebrate assemblage. The SCA is required by its Operating Licence to report annually on macroinvertebrate assemblages in Catchment waterways. The macroinvertebrate sampling is carried out in Spring, therefore the Spring 2007 AusRivAS data was unavailable for this audit.

This audit presents the 2001 to 2006 Spring AusRivAS scores at 73 sampling locations. Additional data was provided by the Sustainable Rivers Audit (SRA). The SRA is an audit of the health of the rivers within NSW, which uses the AusRivAS sampling method for its macroinvertebrate indicator. Thus the SRA data from sites in the Catchment was able to be combined with the data provided by the SCA.

The SCA macroinvertebrate monitoring program uses two core sites and one roaming site in each sub-catchment, to allow both trend analysis at fixed sites over time and a wider area of the Catchment to be monitored through the roaming sites. Hence the status of macroinvertebrate assemblages in the Catchment is discussed here in two sections. First, the trends over the years between 2001 and 2007 at the core sampling sites are described, and then a snapshot of each sub-catchment in the 2007 Audit period is presented, using the data from both the core and the roaming sites, as well as from the DECC SRA program.

Findings

Core sites – trends over time

During Spring 2006, the macroinvertebrate assemblages at 39 per cent of the sampled locations in the Catchment were significantly impaired, and 2 per cent of all sampled locations had severely impaired ratings. Thus over 40 per cent of sites in the Catchment had impaired macroinvertebrate assemblages (Map 6.2). Overall, between the 2001 Spring sampling and the 2006 Spring sampling:

- locations richer than reference decreased slightly, from 10 per cent in 2001 to 6 per cent in 2006
- locations with a similar to reference rating decreased, from 63 per cent in 2001, to 53 per cent in 2006
- locations with a significantly impaired rating have increased, from 23 per cent in 2001, to 39 per cent in 2006
- severely impaired locations have decreased slightly from 5 per cent in 2001, to 2 per cent in 2006.

Mulwaree River at the Towers ^(MI*) received an AusRivAS health rating of severely impaired during Spring 2006. It also received a severely impaired rating in Spring 2002, however the site had improved to reference condition in 2003, but has since deteriorated.

Woronora River at the Needles ^(MT*) was rated as severely impaired in Spring 2004 and 2005, but had improved slightly to significantly impaired in Spring 2006.

The Upper Tarlo River at Tarlo ^(MB*) also had a severely impaired rating in Spring 2004, but improved slightly to receive a significantly impaired rating in 2005 and 2006.

Werriberri Creek at the Oaks ^(OE*) had a significantly impaired macroinvertebrate assemblage in 2004, which subsequently improved to significantly impaired in 2005, and then to reference condition in Spring 2006 (Map 6.2).

Jacqua Creek at Lumley Rd ^(NZ*) received an AusRivAS health rating of severely impaired during Spring 2003. It improved to significantly impaired in Spring 2004, to reference condition in Spring 2005, then worsened to significantly impaired again in Spring 2006 (Map 6.2).

The Wingecarribee River at Berrima ^(ON*) received a severely impaired rating in 2001, and has received significantly impaired ratings in every year since.

Yosemite Creek upstream of Minnihaha Falls ^(NS*) received a severely impaired rating in 2002, but has moved back and forth between reference condition and significantly impaired ratings since. In 2006 it was significantly impaired (Map 6.2).

Kedumba River at Scenic Railway ^(NT*) received two severely impaired ratings in 2001 and 2002, but has not been sampled since. Thus no inferences can be drawn about the current state of the macroinvertebrate community in the Kedumba River, or whether it has improved or worsened in the intervening period.

Overall, eight sites have received consistently poor ratings (no more than a single rating at similar or greater than reference condition) across the 2001-2006 sampling periods. These were Gillamatong Creek at Braidwood ^(MS*), Bungonia Creek at Bungonia ^(OT*), Tonalli River upstream of Basin Creek ^(MU*), Blue Gum Creek along fire trail W41 ^(MW*), Mulwaree River at the Towers ^(MI*), Wingecarribee River at Berrima ^(ON*), Upper Tarlo River at Tarlo ^(MB*), and Woronora River at the Needles ^(MT*) (Map 6.2).

Twelve sites have received a consistently good (similar to or richer than reference) AusRivAS health rating across the 2001-2006 sampling periods. These include Shoalhaven River at Farrington Crossing ^(NG*), Titringo Creek at High Forest ^(OU*), Boggy Creek upstream of Shoalhaven River ^(NA*), Kangaroo River at Hampton Bridge ^(ML*), Mongarlowe River at Monga ^(OI*), Shoalhaven River at Yarra Glen ^(MY*), Kowmung River at Cedar Ford ^(MD*), Little River at Fire Trail W41 ^(MX*), Kedumba River at Kedumba Crossing ^(ME*), Coxs River at Kelpie Point ^(MC*), Nattai River at the Craggs ^(MF*), and Coxs River at Lidsdale ^(OV*) (Map 6.2).

Richer than reference ratings between Spring 2001 and Spring 2004 were recorded at Jerrabuttgulla Creek at Warragandra ^(NB*), Corang River at Meangora ^(MN*), Mongarlowe River at Monga ^(OI*), Shoalhaven River at Yarra Glen ^(MY*), Kowmung River at Kowmung fire trail ^(NE*), Coxs River at Kelpie Point ^(MC*) and Wollondilly River at Goonagulla ^(NK*) (Map 6.2). Kowmung River at Kowmung fire trail ^(NE*) was the only site which retained its richer than reference rating (from Spring 2004) through to Spring 2006.

In Spring 2005 and 2006, new richer than reference ratings were recorded at Nepean River at Maguires Crossing ^(NJ*), Kangaroo River at Hampton Bridge ^(ML*), Currumbene Creek at Krawaree Road Crossing ^(OL*), and Waratah Rivulet at Flatrock Crossing ^(OJ*) (Map 6.2).

A number of locations with a health rating of significantly and severely impaired macroinvertebrate assemblages in Spring 2007 also exceeded ANZECC (2000) guidelines in 3 or 4 groups of physico-chemical water quality (Maps 6.1 and 6.2). These locations include Woronora River at the Needles ^(CY-MT), Shoalhaven River at Fossickers Flat ^(CR-MP), Nattai River at Smallwood's Crossing ^(CF-MG), and Gillamatong Creek at Braidwood ^(CV-MS) (Maps 6.1 and 6.2).

Woronora River at the Needles has declined in AusRivAS health, from similar to reference in 2003, to significantly or severely impaired between 2004 to 2006. It has also declined in water quality compared to the 2005 Audit period for 3 out of 4 water quality parameter groups.

Shoalhaven River at Fossicker's Flat has similarly declined in AusRivAS health ratings, from similar to reference condition in 2004, to significantly impaired in both 2005 and 2006. The site has also experienced a concurrent decrease in water quality in 3 out of 4 water quality parameter groups since the 2005 Audit period (Maps 6.1 and 6.2).

* See Map 6.2 for macroinvertebrate sampling locations and Table 10 in Appendix C for explanation of codes.

The Nattai River at Smallwood's Crossing has maintained its high exceedences of water quality guidelines across all four parameters, and has declined in AusRivAS health ratings from similar to reference condition in 2004, to significantly impaired in both 2005 and 2006 (Maps 6.1 and 6.2).

Gillamatong Creek at Braidwood has remained in a similar state to the 2005 Audit period, with both high percentages of exceedences in water quality guidelines, and a continued AusRivAS health rating of significantly impaired (Maps 6.1 and 6.2).

Core and roaming sites – current state of the catchment within the 2007 Audit period

During the 2007 Audit period, four sub-catchments had good AusRivAS health ratings (all ratings either similar to or richer than reference condition) at both of their core sites, as well as at their roaming sites. These were Back and Round Mountain Creeks, Jerrabattagulla Creek, Upper Nepean River and Upper Shoalhaven River sub-catchments (Table 9 in Appendix C).

Four sub-catchments rated poorly across their core and roaming sites (with no more than a single similar to reference condition rating) during the 2007 Audit period. These were Boro Creek, Braidwood Creek, Lake Burragorang and Little River sub-catchments (Table 9 in Appendix C).

Twelve out of the 28 sub-catchments received at least one severely impaired AusRivAS health rating during the 2007 Audit period. Sub-catchments with a single severely impaired rating included Boro Creek, Braidwood Creek, Bungonia Creek, Endrick River, Mulwaree River (priority), Nerrimunga River, Upper Wollondilly River (priority), Werriberri Creek (priority), Wingecarribee River (priority), Wollondilly River (priority) and Woronora River sub-catchments. The Lower Coxs River (priority) sub-catchment received two severely impaired ratings in the 2007 Audit period, these were at two roaming sites, Jamison Creek at Dalrymple Ave ^(PM*), and Spring Creek at Kedumba Valley Road ^(PN*) (Table 9 in Appendix C).

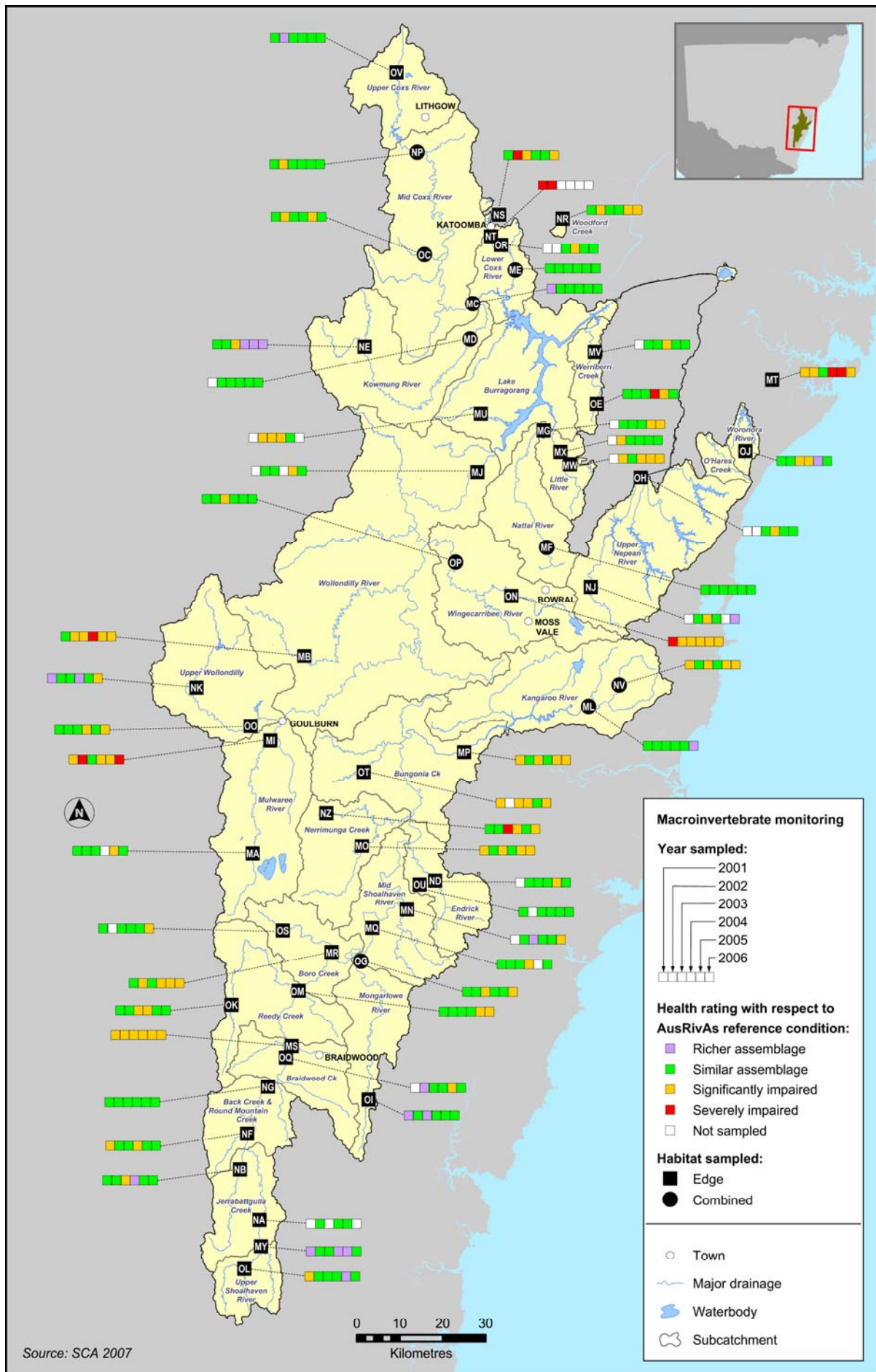
In the Woronora River and Mulwaree River (priority) sub-catchments, the severely impaired ratings occurred at core sites. In the other 11 sub-catchments which received severely impaired AusRivAS health ratings in the 2007 Audit period, those ratings occurred at roaming sites. This reinforces the importance of the use of roaming sites, as they provide a more complete assessment of the health of macroinvertebrate communities across the whole sub-catchment. Without these roaming sites these sub-catchments may have appeared to be in better health than they perhaps are.

Implication

In Spring 2006, the macroinvertebrate assemblages at 39 per cent of the sampled locations were either significantly or severely impaired, and 2 per cent of sites were severely impaired. In Spring 2004 these figures were 33 per cent and 6 per cent respectively. Whilst it may appear that in the short term there has been relatively little change, over the longer term the general trend is that the AusRivAS macroinvertebrate health ratings have declined since 2001. In Spring 2001, only 23 per cent of sites had severely impaired macroinvertebrate assemblages, whilst 5 per cent had significantly impaired assemblages. While this suggests overall diminishing health, it is unclear whether this is due to deteriorating water quality or drought conditions.

Sites with a richer than reference rating can occur because of either a naturally high biodiversity, or an impact such as mild nutrient enrichment (Barmuta *et al.* 2002). Thirteen sub-catchments had at least one 'richer than reference' rating between Spring 2001 and Spring 2007. All 'richer than reference' locations from the Spring 2004 sampling were adjacent or close to pasture land (see Map 5.1 for land use), although there is no water quality monitoring at these locations to assist with the interpretation. Follow up macroinvertebrate monitoring should be considered at all these locations to determine whether the AusRivAS health rating results from natural processes or human induced impacts.

The spatial coverage of macroinvertebrate monitoring across the Catchment is generally better than for the water quality monitoring assessed in Section 6.1, as more sub-catchments are monitored. The data reflected the wide range of states of macroinvertebrate assemblages across sub-catchments. The inclusion of annual roaming sampling sites allows a wider area of each sub-catchment to be monitored over time. However, it can also result in locations where impacts on macroinvertebrate are detected on one sampling year not being monitored in subsequent years. It is suggested that the causes of the decrease in stream health as measured by macroinvertebrates be investigated and that follow-up sampling at sites with high macroinvertebrate impairment ratings be done to aid in longer term analysis (see Recommendation 7). This will provide greater confidence in management responses to macroinvertebrate health ratings.



Map 6.2: Macroinvertebrate AusRivAS health rating for Spring 2001 to Spring 2006 in the Sydney drinking water catchment

Only four sub-catchments received similar to or better than reference condition ratings at all sampling sites in the Catchment. Four sub-catchments had mostly significantly or severely impaired ratings at all sites, and almost half of all sub-catchments received at least one severely impaired AusRivAS health rating.

In addition to follow-up macroinvertebrate monitoring, the integration of macroinvertebrate and water quality monitoring in the Catchment would be beneficial to provide capacity for a more comprehensive assessment of Catchment condition integrating across a number of indicators, and interpretation of results (see 2005 Recommendation 3). Such integration may also enable more focused management responses to identified changes in the condition of macroinvertebrate assemblages. See Recommendations 8 and 9.

Recommendation 7: The SCA should investigate the reasons and drivers for declines in both water quality and macroinvertebrate health in those sub-catchments where declines have been documented.

Recommendation 8: The SCA should review its water quality and macroinvertebrate monitoring program to ensure that appropriate integrated ecosystem monitoring is undertaken in all sub-catchments.

Recommendation 9: The SCA should undertake follow-up monitoring at macroinvertebrate monitoring locations that have significantly impaired or severely impaired AusRivAS ratings.

6.3 Fish

Background

The abundance and diversity of many native fish and crustacean species has declined in most regions of Australia since European settlement. The natural range of about one third of native inland-water fish has been significantly reduced. Continued pressures from habitat modification, introduced pests, pollution and harvesting continue to affect native fish species and fish communities. Fish populations in the Catchment are also likely to have been especially impacted by the modification of river flows and physical barriers caused by dams and weirs, the temperature of water released from dams, and competition with exotic fish species.

Dams and weirs modify and disrupt natural flows of rivers and streams by collecting variable flows and then releasing constant or regulated water-flows downstream. The modification of flows can affect a wide range of aquatic organisms, including fish, potentially reducing the species diversity and increasing the success of introduced species (Gehrke and Harris, 2001).

Water released from dams is also often colder than downstream flow, especially if the dam has a bottom valve off-take. Cold water pollution can affect fish growth and survival and can potentially limit the distribution of fish within rivers to warmer areas (NSW Fisheries, 2003).

Dams, weirs, and many types of in-stream works also act as significant barriers to fish passage, reducing the abundance and diversity of fish throughout a river system (CRCFE, 2000). Physical barriers prevent the upstream and downstream passage of migratory fish, and inhibit access of fish to other areas of rivers over shorter distances.

This indicator remains highly relevant as a measure of ecosystem health, as fish interact on many trophic levels and are sensitive to many kinds of human disturbance. Fish are also considered useful for environmental assessments due to their mobility and longevity. The abundance of fish individuals and species can decrease in areas with degraded riparian vegetation and poor water quality (Growth *et al.* 1998).

A significant amount of new data has become available since the 2005 Audit. The DPI has conducted several separate monitoring programs and provided the data to the audit.

This audit examines:

- numbers and proportions of native and exotic fish species present within each sampled water body
- cold water pollution
- barriers to fish migration.

Findings

There are five sets of localised data collected by the DPI Aquatic Ecosystems Unit during the 2007 Audit period. These include:

- Research into the distribution and critical habitat of the threatened Macquarie perch between August 2006 and May 2007, funded by H-N CMA
- A state-wide assessment of the diversity, distribution and abundance of fish in NSW rivers in October 2006
- Assessment of the fish community above and below Pheasants Nest weir in August and September 2006 and March 2007 prior to the proposed raising of the height of the weir
- Assessment of the fish community in the Shoalhaven River catchment prior to the proposed construction of a fishway on Tallowa Dam in November and December 2005
- Research into the distribution of the introduced redfin perch in the Wollondilly Catchment in May and June 2007, funded by H-N CMA.

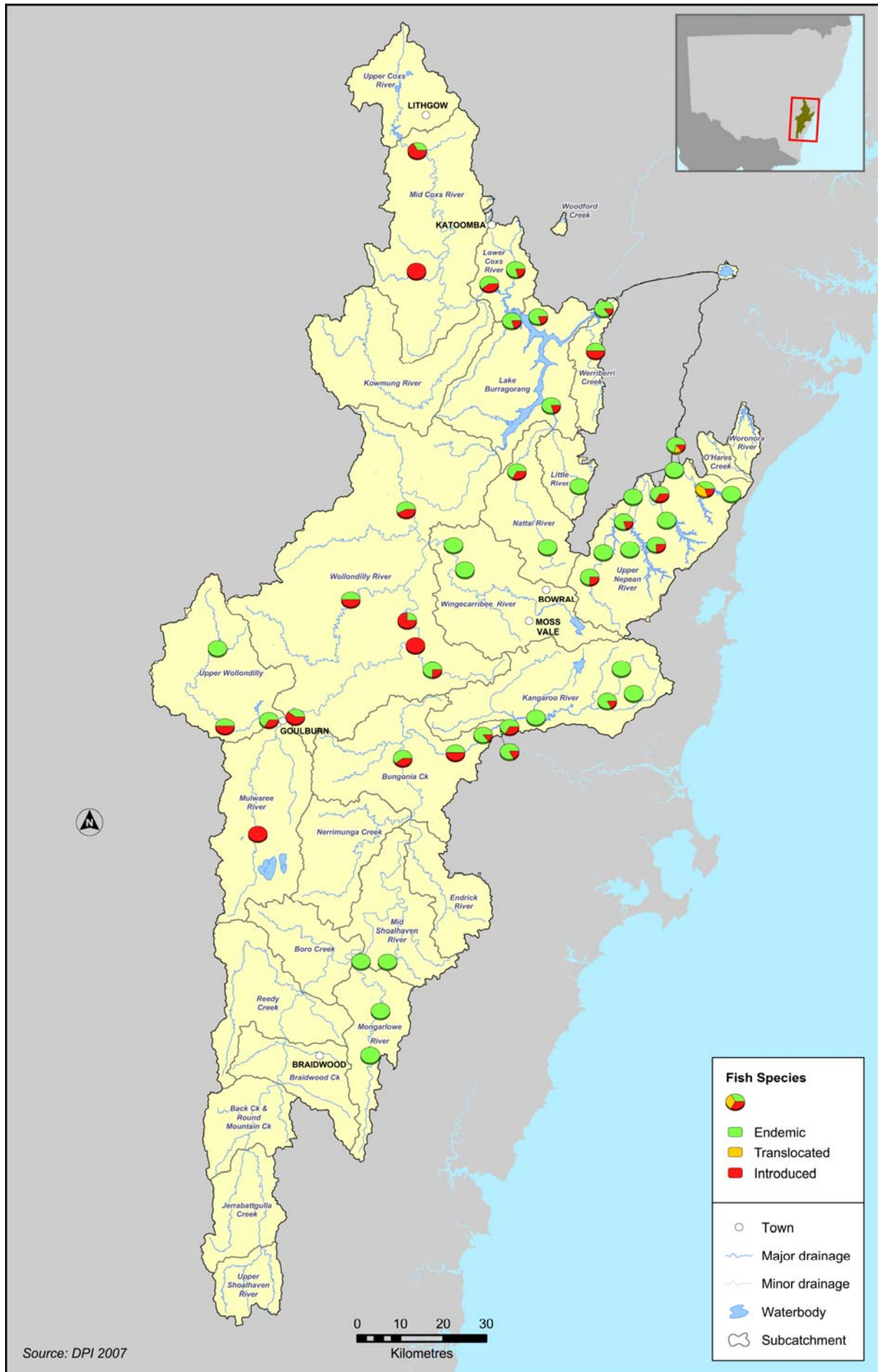
During the 2007 Audit period, 49 sites within 27 water bodies were sampled using a combination of electrofishing and bait trapping sampling techniques (Map 6.3 and Figure 6.3). A total of 6183 fish representing 22 species were captured (Table 6.1). Thirteen species of fish are endemic to the Catchment, two species have been translocated into the area from the Murray-Darling basin and seven species have been introduced from overseas.

Table 6.1: Fish species recorded in the Catchment during the 2007 Audit period.

Family	Scientific name	Common name	Status
Anguillidae	<i>Anguilla australis</i>	Shortfinned eel	Endemic
	<i>Anguilla reinhardtii</i>	Longfinned eel	Endemic
Cobitidae	<i>Misgurnus anguillicaudatus</i>	Oriental weatherloach	Introduced
Cyprinidae	<i>Carassius auratus</i>	Goldfish	Introduced
	<i>Cyprinus carpio</i>	Common carp	Introduced
Eleotridae	<i>Gobiomorphus australis</i>	Striped gudgeon	Endemic
	<i>Gobiomorphus coxii</i>	Cox's gudgeon	Endemic
	<i>Hypseleotris klunzingeri</i>	Western carp gudgeon	Endemic
	<i>Hypseleotris spp.</i>	Unidentified gudgeon	Endemic
	<i>Philypnodon grandiceps</i>	Flathead gudgeon	Endemic
	<i>Philypnodon macrostomus*</i>	Dwarf flathead gudgeon	Endemic
Galaxiidae	<i>Galaxias brevipinnis</i>	Climbing galaxias	Endemic
	<i>Galaxias olidus</i>	Mountain galaxias	Endemic
Percichthyidae	<i>Maccullochella peelii</i>	Murray cod	Translocated
	<i>Maccullochella sp.</i>	Unidentified cod	Translocated
	<i>Macquaria australasica</i>	Macquarie perch	Endemic, endangered
	<i>Macquaria novemaculeata</i>	Australian bass	Endemic
Percidae	<i>Perca fluviatilis</i>	Redfin perch	Introduced
Plotosidae	<i>Tandanus tandanus</i>	Freshwater catfish	Endemic
Poeciliidae	<i>Gambusia holbrooki</i>	Eastern gambusia	Introduced
Retropinnidae	<i>Retropinna semoni</i>	Australian smelt	Endemic
Salmonidae	<i>Oncorhynchus mykiss</i>	Rainbow trout	Introduced
	<i>Salmo trutta</i>	Brown trout	Introduced
Terapontidae	<i>Bidyanus bidyanus</i>	Silver perch	Translocated

Source: DPI 2007.

Notes: * previously *Philypnodon* sp.1

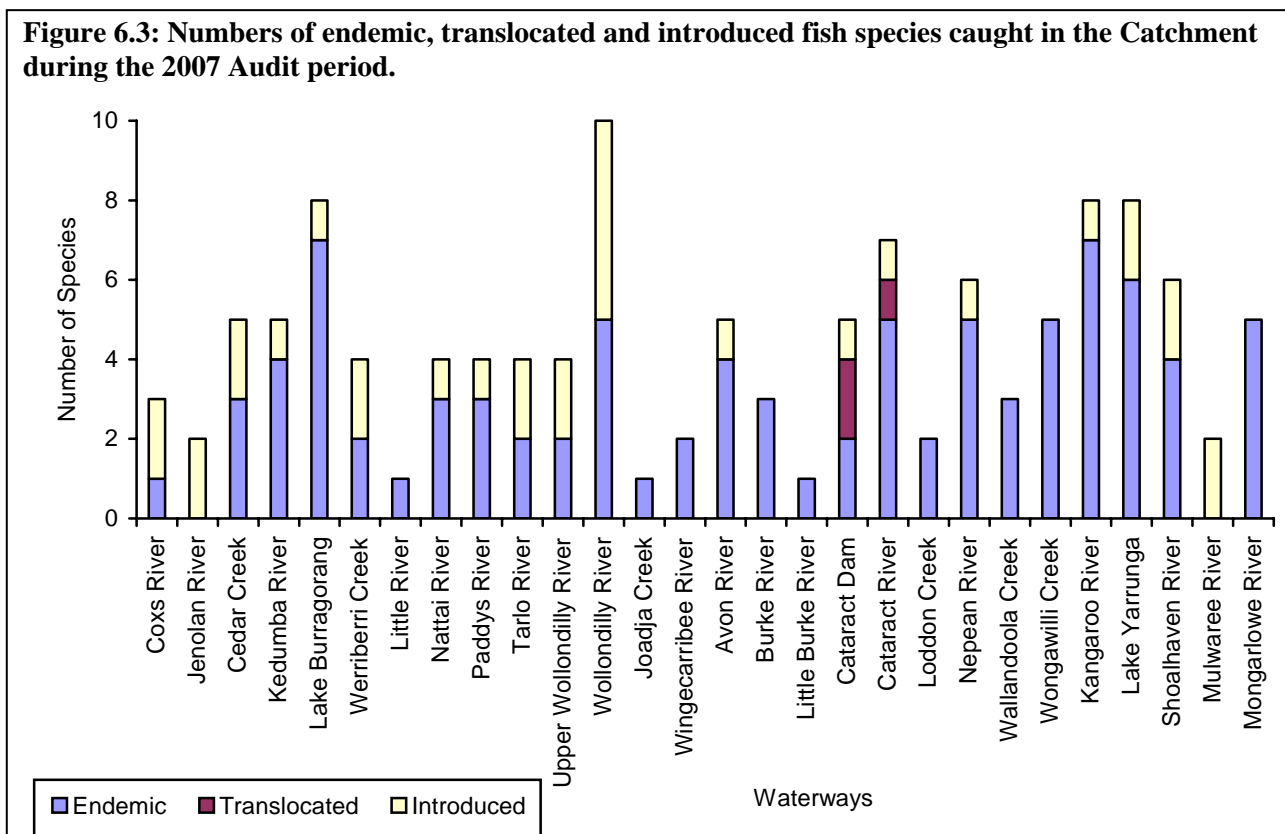


Map 6.3: Endemic, introduced and translocated fish species in the Sydney drinking water catchment

Direct comparisons of these catch data are restricted as they are derived from a number of projects in which sampling effort varied considerably among water bodies. It is noteworthy however, that introduced species were captured in 18 of the 27 water bodies (67 per cent), with the Wollondilly River having the greatest number (five) of these species (Map 6.3 and Figure 6.3). The largest number of introduced species at any other site was only two, suggesting that the Wollondilly River figure is comparatively high. Similarly, in both the Jenolan (Mid Cocks River (priority) sub-catchment) and Mulwaree Rivers, only two species were captured, both of which were introduced (Figure 6.3).

Conversely, a high species diversity and largely endemic species composition is suggestive of a relatively pristine condition. Both Wongawilli Creek (Upper Nepean River sub-catchment) and the Mongarlowe River showed a comparatively high species richness of five species each, and at both sites all species were endemic (Figure 6.3). The Kangaroo River, Lake Burragorang and Lake Yarrunga (Kangaroo River (priority) sub-catchment) all had higher species richness, at eight species each, however these sites also had at least one introduced species (one at Kangaroo River and Lake Burragorang, two at Lake Yarrunga) (Figure 6.3).

Other water bodies where only endemic species were caught include the Burke River (Upper Nepean River sub-catchment), Joadja Creek (Wingecarribee River (priority) sub-catchment), Little Burke River (Upper Nepean River sub-catchment), Little River, Loddon Creek (Upper Nepean River sub-catchment), Wallandoola Creek (Upper Nepean River sub-catchment), and the Wingecarribee River. It should be noted however that at these sites only one to three species were caught in total (Figure 6.3). Additionally, as sampling effort varied across water bodies it is difficult to compare species richness or composition across sites.



Source: DPI 2007

The Macquarie perch is listed as a vulnerable species under the NSW *Fisheries Management Act 1994* and has been recorded from the Mongarlowe River, Cocks River, Kowmung River, Little River, Warragamba Dam (Lake Burragorang sub-catchment), Nepean, Avon, Cordeaux and Cataract Dams (all in the Upper Nepean River sub-catchment), and in the lower Nepean and Cataract River below the storages (also in the Upper Nepean River sub-catchment). The DPI surveyed for the presence of Macquarie perch at 24 locations in the Catchment between August 2006 and May 2007. The species was captured at five of these locations including the Loddon Arm of Cataract Dam, Wongawilli Creek, Loddon Creek above the Loddon Falls (all in the Upper Nepean River sub-catchment), Kedumba River at Kedumba Crossing (Lower Cocks River

(priority) sub-catchment), and Cataract River at Jordans Pass (Upper Nepean River sub-catchment). A total of 336 Macquarie perch were caught, 306 of which came from Cataract Dam.

Sites where high numbers of native species were caught include the Kangaroo River, where the majority of the catch was Australian Smelt (*Retropinna semoni*), the Nattai River, where the catch was largely mountain galaxias (*Galaxias olidus*), and Lake Yarrunga (in the Kangaroo River (priority) sub-catchment), which had mostly endemic species and a catch dominated by Australian smelt (*Retropinna semoni*) and flathead gudgeon (*Philypnodon grandiceps*).

Carp (*Cyprinus carpio*) is a noxious species in a number of Australian states. The DPI is currently undertaking research into the comparative age, sex and genetic analysis of carp populations. Carp were present in the Kangaroo River, Lake Yarrunga (Kangaroo River (priority) sub-catchment), Lake Burragorang, Shoalhaven River (in the Bungonia Creek sub-catchment) and the Wollondilly River.

The mosquito fish (*Gambusia holbrooki*) is a major pest species in the freshwaters of eastern New South Wales. Mosquito fish were the most numerous fish species caught in the Avon River (in the Upper Nepean River sub-catchment). Mosquito fish have been associated with the decline of abundance or range of 35 fish species worldwide, including Australian native species such as gudgeon, hardyheads and some rainbow fish (NPWS, 2003).

In the Wollondilly River, as previously mentioned, a large proportion of the catch was introduced. The majority of these fish were goldfish (*Carassius auratus*), although redfin perch (*Perca fluviatilis*) were also present. The redfin perch is an introduced species implicated in the decline of Australian freshwater fish including the vulnerable Macquarie perch. It was first detected in the Wollondilly River in May 2006 during the Macquarie perch surveys. Redfin perch are likely to disperse downstream into Warragamba Dam and may impact on the endemic aquatic fauna including the vulnerable Macquarie perch (See Redfin Perch Case Study).

In Cedar Creek (in the Lower Coxs River (priority) sub-catchment), a large number of Oriental Weatherloach (*Misgurnus anguillicaudatus*) were caught. Interestingly, the data suggests that different introduced species may dominate within different water bodies. This emphasises the need for targeted programs as no single pest reduction program is likely to be suitable to combat all exotics across all waterways.

Cold water pollution

The SCA monitors the temperature of water releases at a number of sites downstream of dams. During 2003 and 2004 the SCA monitored water temperature downstream of Woronora, Warragamba and Tallowa Dams. There was little difference between the median annual temperatures upstream and downstream of Woronora Dam. There were inconclusive results for releases from the Warragamba Dam due to confounding factors and variable results. Releases from Tallowa Dam were found to cause a decrease in Shoalhaven River temperatures with median annual water temperatures above Tallowa Dam ranging from 15°C to 21°C and median downstream temperatures of 14.6°C. Temperatures 10 degrees below ambient have been shown to have negative effects on some fish species and other organisms (NSW Fisheries, 2003).

The Tallowa Dam Aeration Project commenced on 31 October 2005. In order to measure the effectiveness of the aeration, sampling sites were established and probes that constantly measure temperature and dissolved oxygen were installed near the dam wall. The installation of the aerator has created mixing between the deeper, colder water and the warmer surface water, increasing the temperature of released water by 10°C. Similarly dissolved oxygen contents within the deeper section of the lake were found to be significantly higher in January 2006 than they were for the corresponding month in previous years (SCA, 2006a).

Disruption to fish passage

In south-eastern Australia, approximately half of all fish species migrate as part of their life cycle (NSW Fisheries, 2003). In-stream structures such as weirs, causeways and bed-control structures can prevent fish movement and migration, and cause disturbance to stream habitat that allows generalist exotic species to thrive where specialist natives cannot. The SCA confirmed the presence of 68 weirs in the Catchment. None of these weirs were found to provide effective fish passage.

The State Government agencies responsible for the health of rivers have recognised that there needs to be modification of barriers to improve fish passage as part of the program to deliver environmental flows.

DPI has recently undertaken several statewide projects that relate to fish passage, including two Environmental Trust-funded projects within the Hawkesbury Nepean and Shoalhaven River catchments. One project included a review of waterway crossings requiring fish passage remediation. The second project built on the outcomes of the NSW Initial Weir Review by undertaking detailed reviews of 80 high-priority fish passage barriers in NSW.

The study identified 35 barriers to fish passage which it classified as medium to high priority sites for remedial action in the Catchment. Three weirs in the Catchment were identified as high priority sites for remediation works; these were Mongarlowe Weir, Kangaroo River Weir and Braidwood Weir. The study also identified 18 medium and 14 high priority other structures that were acting as barriers to fish passage (mostly causeways), and made specific recommendations for each about appropriate remediation measures.

During the 2007 Audit period, a fishway was built on Black Bob's Creek (a DPI site of medium priority remediation work), which was undertaken in conjunction with other works to stabilise banks and improve instream habitat (Figure 6.4).

SCA continues to develop works to improve fish passage at Tallowa Dam. It is anticipated that works will be completed by December 2008.



Figure 6.4: Black Bobs Creek fishway and bank stabilisation works

Source: DECC 2007

Implication

In order to draw conclusions about the state of the fish populations in these water bodies, a unified sampling program needs to take place. Consistent sampling effort combined with baseline information for comparison would allow more conclusive assessment of the state of fish populations in the Catchment.

Introduced species can have devastating impacts on the endemic aquatic fauna. Introduced species often thrive in degraded habitats and hence may indicate that the Wollondilly River is in a disturbed condition. The newly available information about fish populations throughout the Catchment suggest that the invasion of exotic species is problematic, and may indicate a moderate level of disturbance to native species, flows or riparian vegetation structure in those areas where species diversity is low, and/or where a greater proportion of the species composition is introduced. The 2007 data suggests that the Wollondilly, Mulwaree and Jenolan Rivers may be in a disturbed condition.

Conversely, Wongawilli Creek, Mongarlowe River, Kangaroo River, Lake Burratorang and Lake Yarrunga all appear to be in relatively good condition. A more accurate assessment of the health of these water bodies would be possible with directly comparable information about expected species diversity and species composition in similar water bodies when healthy.

The large proportion of exotic fish species present throughout the Catchment was highlighted in the 2003 Audit Report as a priority and a number of management options discussed including managing the health of

riparian areas, and direct removal of exotic species through initiatives such as the ‘daughterless carp’ program. The 2003 Audit Report also suggested that management initiatives be prioritised to infested areas, particularly in storages and inflows to storages.

Case Study – The introduced pest fish: Redfin perch (*Perca fluviatilis*)

The Redfin perch (*Perca fluviatilis*), also known as European perch, Eurasian perch, and English perch, is a medium-sized freshwater fish native to northern Europe. Redfin were first introduced to Australia in the 1860s for angling, and are now widespread across much of southern Australia. Their distribution seems to be limited by an upper water temperature of around 31°C and they are rarely found in fast waters or high altitude areas.



Figure 6.5: Redfin perch (*Perca fluviatilis*)

Source: Günther Schmida.

Redfin are popular with some anglers because of their fighting qualities and taste. However, they often form very dense populations containing large numbers of stunted fish which are of poor angling quality. They are also voracious predators of other fish, preying on small fish as well as the eggs and fry of larger fish such as trout and native perch. This predation can seriously affect recreational fisheries for these species. Redfin may also devastate native fish populations by spreading disease (Epizootic Haematopoietic Necrosis). For these reasons, redfin are considered a serious pest in NSW.

In 2006 the NSW Department of Primary Industries (DPI) discovered new populations of redfin in the Wollondilly River (priority) sub-catchment. This area, which was previously free of redfin, supports some of the last known NSW

populations of threatened native Macquarie perch. The recently discovered populations of redfin appear to have been introduced either deliberately or accidentally through contaminated batches of fish for stocking.

DPI is undertaking specific surveys to document the distribution, spread and abundance of redfin in the Wollondilly River (priority) sub-catchment and throughout other areas of NSW. A range of options has been considered for targeted control and/or containment of redfin to limit the impacts on threatened species. However, as with all pest fish in open waterways, it currently appears to be extremely difficult to eradicate redfin populations or prevent natural dispersal to new areas.

The Hawkesbury-Nepean CMA is funding a DPI project to look at options for excluding redfin from Macquarie perch habitats in the Wollondilly River (priority) sub-catchment and associated waterways including Warragamba Dam. DPI and the University of Sydney are jointly studying the disease carried by redfin in NSW and its impacts on native species. In addition, DPI has commenced an awareness raising campaign to alert anglers to the problems this fish can cause. The campaign has involved producing an educational poster that has been sent to all NSW fishing licence agents and recreational fishing clubs throughout NSW.

Source: DPI 2007

Future directions

A fish monitoring program that is integrated over the entire Catchment, and hence uses the same methods and amount of sampling effort per site, would provide information about the numbers of species and total numbers of fish caught at each site. Monitoring over time in this way would allow, for example, assessment of the impacts of control programs on exotic species, which would likely be measured in a reduction in the numbers of exotic fish present, rather than the number of species.

As indicated in the background of this chapter, fish interact on many trophic levels. They are mobile and have a lifespan which enables fish populations to be used to assess changes in ecosystem health over time. Integration with monitoring programs for water quality, macroinvertebrates and riparian vegetation, a fish monitoring program is likely to provide greater knowledge of Catchment health, and provide greater confidence that management responses address identified ecosystem health concerns.

The 2005 Audit recommended that sampling of fish at designated sites should be carried out approximately every 3 years to determine the status of, and changes in, the composition of fish communities and to measure the success of any exotic fish control initiatives. This timeframe is consistent with that used in the Sustainable Rivers Audit. It is recommended that the SCA liaise with the DPI to discuss the scope of fish monitoring in the Catchment with a view to ensuring that comprehensive data become available in future (see 2005 Recommendation 24). In addition the SCA should liaise closely with the DPI during 2007/08 to ensure that any fish monitoring planned under the NSW Monitoring, Evaluation and Reporting Strategy is integrated with monitoring programs in the Catchment. The 2007 Audit has received improved data on fish populations, and notes the progress since the 2005 recommendation was made.

The auditor believes that fish monitoring could be part of a future integrated catchment-wide monitoring program (see 2005 Recommendation 3).

6.4 Riparian vegetation

Background

Riparian zones typically consist of vegetated corridors adjacent to stream channels where the vegetation is influenced by the water. These areas can be effective barriers to pollution from land-based activities, including agriculture and urbanisation. The riparian zone also contributes to ecosystem health by providing shade, stabilising banks, minimising erosion, limiting downstream flooding, supporting fisheries, taking up and storing nutrients and contaminants and by providing habitat for a range of species.

Riparian zones are often the most fertile part of the landscape and are subject to many pressures from land management practice, land-use change and human activities. The primary pressures on riparian vegetation are removal of riparian vegetation, introduced plant species (eg. willows) and stock access. Willows are listed as a weed of national significance.

This Audit focuses on the extent and condition of riparian vegetation in the Catchment. The Audit also reports on the area of vegetation cleared in the riparian zone during the audit period, and provides information on restoration and protection programs in Actions and Responses.

Findings

The SCA estimated there is 81,125 ha of riparian zone in the Catchment of which native vegetation covers 54,787 ha and 23,806 ha is pasture (SCA, 2003a). The SCA estimates that 38,753 km (48 per cent) of watercourse in the Catchment is presently being, or has the potential to be, accessed by stock. This has increased since 2005, when 38 per cent of the riparian zone in the Catchment was reported as accessible to stock.

The SCA has remapped the riparian zone index using 2006 Landsat imagery across the Catchment and prioritised assessment of sites for the Riparian Management and Assistance Program. The focus for 2007 Audit period was on the:

- Upper Werriberri Creek (2 ha treated in 2005-06) in the Werriberri Creek (priority) sub-catchment
- Paddy's River, Uringall Creek and Long Swamp Creek in Wollondilly River (priority) sub-catchment

- Coxs River from Kanimbla to Blue Mountains National Park, Cullenbenbong Creek (14 ha treated in 2005-06) and Ganbenang Creek (7 ha treated in 2005-06) in Mid Coxs River (priority) sub-catchment
- Barrengarry Creek (52 ha treated in 2005-06) and Brogers Creek (56 ha treated in 2005-06) in the Kangaroo River (priority) sub-catchment.

The SCA has completed 39 km of weed management in riparian zones throughout the Catchment, the SR CMA has completed 20 km, the H-N CMA has completed 73.5 km under its River Restoration Project, and a further 1,904 ha have been treated for weeds through the Wetland Management Program. DECC has treated a further 200.7 km, in Special Areas and National Parks.

Willows are a primary pressure on the health of the riparian zone in many sub-catchments. The SCA has treated 1,590 ha of willow infestations during the 2007 Audit period, and the H-N CMA has treated an additional stretch of 1.2 km of riparian zone for willow infestation.

Fencing of watercourses restricts stock access and hence limits degradation of river banks and removal of riparian vegetation. The SCA has fenced 45.3 km of riparian land, the SR CMA 28.5 km and H-N CMA 5,073 km of riparian zone in the Catchment.

In efforts to improve the quality of riparian zones throughout the Catchment, the H-N CMA has planted 110,192 trees, and the SR CMA has completed 3 km of revegetation as well as a further 70 ha. Fifty-nine km of direct seeding was also completed by H-N CMA. The SR CMA has completed 71.19 km and 92 ha of rehabilitation, the H-N CMA has completed 585 ha of rehabilitation, and DECC has completed 21.2 km of rehabilitation of riparian vegetation.

The SR CMA has completed works to stabilise both stream beds and banks at 13 sites and along 45.9 km of riparian zone. The H-N CMA has completed similar works along 80 km of riparian land and at 19 sites.

Forty two off-stream watering sites for stock have been installed by the SR CMA, and 51 by the H-N CMA. These provide alternative water sources for stock which previously had access to stream banks, and this work is often partnered with programs to fence out stock.

The SCA have developed a riparian zone index to measure the proportion of standing vegetation (with no discrimination between native and exotics) in the riparian zones in the Catchment. Based on this index, riparian zones in National Parks and Special Areas have a good proportion of standing vegetation, while the Mulwaree River (priority), Upper Wollondilly River (priority), Braidwood Creek and Reedy Creek sub-catchments have little or no standing vegetation cover along riparian zones.

The SCA funded a Synoptic Biodiversity Survey in 2001, carried out by the CRC for Freshwater Ecology. This study found that three (7.5 per cent) sites had less than 25 per cent cover of native species. These three sites were located in urban areas at Lithgow, Bowral and Goulburn. Fifteen of the 40 sites (37.5 per cent) had 25–50 per cent native species in the riparian zone, many of which were in the priority sub-catchments of Upper Coxs River, Mid Coxs River, Wingecarribee River, Wollondilly River, Upper Wollondilly River and Mulwaree River. The Reedy Creek, Braidwood Creek, Back and Round Mountain Creeks and Jerrabattagula Creek sub-catchment also had sites with 25–50 per cent native species. Seven sites (17.5 per cent) had more than 75 per cent of native species in the riparian zone, and these sites are located in the Nattai River, Woronora River, Nerrimunga River, Mongarlowe River and Upper Shoalhaven River sub-catchments.

Implication

There are riparian areas in the Catchment with good proportions of standing vegetation and native vegetation cover, particularly in the Special Areas and National Parks. However, there are also riparian zones in the Catchment that are likely to be under a variety of pressures, from little to no standing vegetation cover, areas of pasture, stock access, and the presence of exotic species. These conditions can threaten ecosystem health and water quality.

Healthy riparian zones assist in maintaining the health of rivers and streams in the Catchment, acting as the first of the multiple barriers that protect drinking water quality. Riparian zones are particularly important for water quality in areas where the adjacent land is subject to activities such as agricultural or urban land use.

The Mulwaree River (priority), Upper Wollondilly River (priority), Braidwood Creek and Reedy Creek sub-catchments have little or no standing vegetation cover along riparian zones as shown by the SCA's Riparian Zone Index. Water quality and ecosystem health is potentially at risk in these sub-catchments.

Weed removal along riparian zones, such as willow elimination, can cause disturbance in the riparian zone and can lead to erosion and water quality impacts. Management of weed removal sites in the riparian zone should include follow up measures to prevent secondary impacts.

Future directions

It was recommended in the 2005 Audit report that integrated ecosystem monitoring program including riparian vegetation should be investigated (see 2005 Recommendation 3).

The SCA, CMAs and Councils all have programs which outline a number of on-ground works to protect and rehabilitate riparian zones. Future on-ground rehabilitation works should be targeted in the Mulwaree River (priority), Upper Wollondilly River (priority), Braidwood Creek and Reedy Creek sub-catchments, as these sub-catchments have little or no standing vegetation in the riparian zone.

There are many programs for restoration and rehabilitation of riparian zones, which are all likely to contribute to an improvement in the health of riparian zones and provide improved protection of water quality. While records are maintained by relevant agencies and organisations about individual programs for riparian management, there does not appear to be a systematic use of measures to record the extent of this work. The Auditor is therefore not able to report on the location of riparian restoration and rehabilitation across the Catchment. This information should be collected systematically across the Catchment to enable better information for both future audits and development and co-ordination of management decisions (see Recommendation 12, regarding systematic databasing of spatial data).

6.5 Native vegetation

Background

Native vegetation in the Catchment is important for maintaining the health of individual species of flora and fauna, ecosystem process and genetic diversity. The degradation or clearing of native vegetation can impact on critical ecosystem services such as the improvement of water quality, nutrient recycling and the provision of resources such as food and fibre. Impacts on native vegetation can also induce soil salinity and acidity, soil erosion, loss of nutrients, changes to flow regimes and climate change. The presence of exotic weed species can affect the condition of native vegetation and the extent to which it can provide habitat. The rate of biodiversity loss accelerates dramatically when a vegetation community declines below approximately 30 per cent of its original area.

Relevant weeds of national significance in the Catchment are blackberry, gorse, lantana and serrated tussock (Figure 6.6).



Figure 6.6: Serrated tussock in the Wingecarribee River (priority) sub-catchment.

Source: DECC 2007

Native vegetation mapping (Map 6.4) in the outer Catchment was undertaken during the 2005 Audit period by the former DIPNR. There are small areas in the Upper Cocks River (priority), Kowmung River and Upper Wollondilly River (priority) sub-catchments which are currently being mapped.

This audit examines the extent and condition of native vegetation in the Catchment, as well as the:

- area of vegetation protected in National Parks and Reserves
- area of weeds removed
- area revegetated and rehabilitated
- area of native vegetation cleared.

Findings

During the 2007 Audit period DECC acquired a total of 1,373 ha in the Catchment, including land in the Blue Mountains National Park, Burragorang State Conservation Area, Morton National Park and Nattai National Park.

The major outcomes of programs to treat weed infestations and improve native vegetation condition are outlined below:

- The SCA has treated an estimated 88,917 ha of serrated tussock and 4,825 ha of blackberry in the Catchment during the 2007 Audit period. The SR CMA has completed 165 ha of weed removal, the H-N CMA reported the treatment of 373 ha, and DECC has treated a further 468 ha. Other weeds that have been targeted by SCA are Cootamundra wattle, broom, privet and pampas grass.
- The SR CMA has fenced 8.5 ha of land, revegetated 40.3 ha, and undertaken the rehabilitation of 2,167 ha of native vegetation. The H-N CMA has planted 65,580 native trees, completed 96 km of direct seeding, and rehabilitated 1,075 ha of native vegetation.
- Native vegetation covered approximately 50 per cent of the Catchment in the 2005 Audit period, based on the 2005 mapping. The Kowmung River, Lower Cocks River (priority), Lake Burragorang, Little River, Nattai River, Woronora River, O'Hares Creek, Upper Nepean River and Upper Shoalhaven River sub-catchments have a large percentage of native vegetation cover (>80 per cent). The sub-catchments with the lowest percentage of native vegetation cover (<20 per cent) are the Upper Wollondilly River (priority) and Mulwaree River (priority) (Map 6.4).
- Approvals under the *Native Vegetation Act 2003* (formerly the *Native Vegetation Conservation Act 1997*) were granted for the removal of 20.2 ha of native vegetation in the Catchment during the 2007 Audit period. This is less than the 30.96 ha cleared in the 2005 Audit period, and far less than the 728.76 ha of native vegetation removed from the Braidwood district alone during the 2003 Audit period.

During the 2007 Audit period, SCA created a series of vegetation indices to measure changes in vegetation condition over time. Mapping of the entire Catchment has not yet been completed.

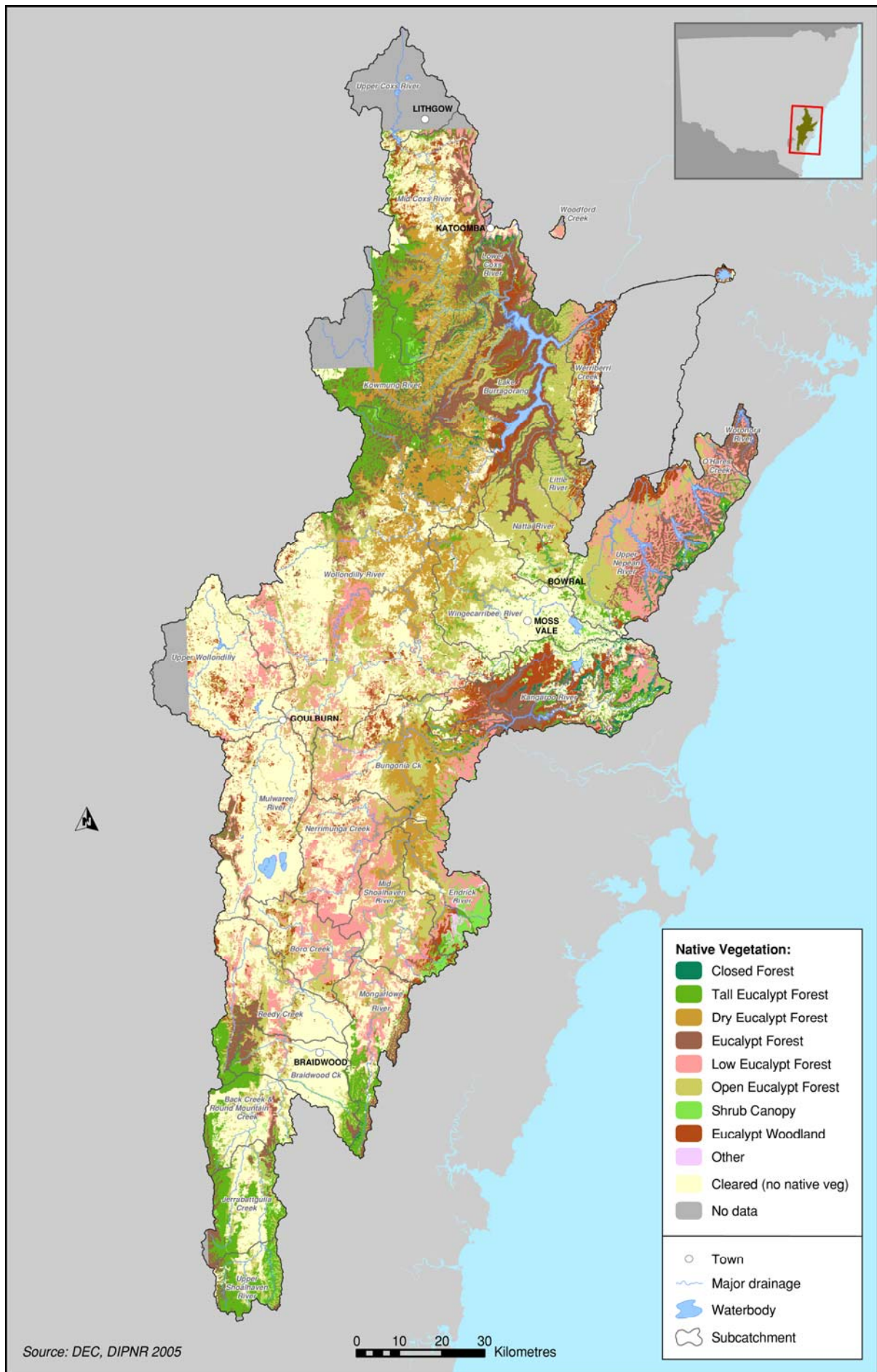
Restoration and protection programs are detailed in Actions and Response section of this chapter.

Implication

The area of native vegetation cleared with approval under the *Native Vegetation Act 2003* has remained low compared with the 2005 Audit period, which was a reduction from the amount of native vegetation cleared during the 2003 Audit period. This is a continued positive outcome for ecosystem health and protection of water quality in the Catchment.

The lowest percentage of native vegetation cover in 2005 was in the Upper Wollondilly River (priority) and Mulwaree River (priority) sub-catchments. The low percentage cover of native vegetation in these sub-catchments may put water quality and ecosystem health at risk.

Some areas of the Catchment play a particularly important role in preventing pollutants entering the water supply and proper management and ongoing monitoring of vegetation within these areas is clearly important in maintaining water quality and quantity. These areas include those in immediate proximity to the water storages, riverine corridors (over 18°) and flood prone lands.



Map 6.4: Native vegetation in the Sydney drinking water catchment

Future directions

Vegetation mapping is being addressed in the Catchment, however, the condition of that vegetation is still to be mapped outside of the Special Areas. Therefore, action on Recommendation 25 from the 2005 Audit report regarding the need for vegetation condition mapping needs to continue.

All on-ground works being undertaken in the Catchment to revegetate and rehabilitate native vegetation should be integrated and a spatial database of location, type and area of works created and maintained (see Recommendation 12). The auditor notes that progress is being made on the use of spatial database by agencies such as the CMAs in their operations in the Catchment, and encourages their ongoing development and use.

Actions and Response

Response to issue

There are many responses to the degradation of ecosystem health including programs to reduce the impacts of pollution (Chapter 3), new water management rules under statutory water sharing plans (Chapter 4) and programs to improve land management (Chapter 5). In addition there are specific responses to the degradation of ecosystem health, including programs to:

- *monitor and maintain ecosystem water quality*
- *monitor and maintain macroinvertebrate communities*
- *maintain and enhance native fish communities*
- *maintain and enhance riparian zones*
- *maintain and enhance native vegetation.*

In 2006, the NSW Government released the NSW State Plan. The plan sets five areas of activity including the Environment for Living. Within the Environment for Living activity area there is a *Better outcomes for native vegetation, biodiversity, land, rivers, and coastal waterways* result area. Below are listed the targets under this result area of the NSW State Plan that are relevant to the audit (NSW Government, 2006a).

Targets

- biodiversity – by 2015 there is an increase in native vegetation extent and an improvement in native vegetation condition
- water – by 2015 there is an improvement in the condition of riverine ecosystems

Actions

- implementing the Catchment Action Plans of the CMAs
- actively managing weeds, fire and pests on national parks, reserves and crown land
- providing incentives to landholders for improved management through stewardship programs, native vegetation offsets and CMA incentives schemes to deliver state-wide and regional targets

New directions

- building and managing a comprehensive, adequate and representative reserve system which includes terrestrial parks to protect the state's unique biodiversity from current and future pressures.
- promoting voluntary conservation on private land and linking areas of prime habitat with corridors to mitigate the impacts of climate change.
- targeting resources to manage priority weeds in key locations through a NSW Invasive Species Plan
- support industry to increase adoption of low impact conservation farming systems such as minimum till, water efficient technology and uptake of R&D which impacts positively on the environment
- encourage the expansion of forest plantations for carbon sequestration, mine site rehabilitation, other environmental benefits and future timber supply.

Programs to monitor and maintain ecosystem water quality and macroinvertebrates communities

The SCA has both a **Water Quality Monitoring Program (WQMP)** and a **Macroinvertebrate Monitoring Program (MMP)**. The purpose of the WQMP is to understand the threats to water quality throughout the delivery system, including rivers and reservoirs, as well as showing long term trends (SCA, 2005c).

The aim of the WQMP is to:

- provide early warning of possible contaminants in the water to help protect the health of approximately four million consumers
- ensure that the untreated bulk water delivered to its wholesale customers such as Sydney Water Corporation is of an appropriate quality
- identify and target possible sources of contamination in the Catchment and storages
- identify emerging water quality issues and address them in forward planning.

The aim of the MMP is to (SCA, 2006d):

- determine ecosystem health through an assessment of aquatic macroinvertebrate communities at 27 SCA sub-catchments
- detect change in ecological health within the sub-catchments
- provide a reporting mechanism on the state of the catchments' aquatic ecosystems.

The purpose of the SCA's **Water Quality Risk Management Framework (WQRMF)** is to address risks to bulk raw water quality in the SCA supply systems. It identifies hazards to bulk raw water quality and assesses the risk of events that cause these hazards. The Framework also identifies and evaluates the controls to be used in dealing with the hazards throughout the SCA system (SCA, 2005b).

The **Streamwatch Program** is a community/school-based assessment of water quality and macroinvertebrates in local streams. The SCA supports 40 Streamwatch groups who collect water quality data from approximately 80 sites. In 2005-06 two more groups joined the program. Streamwatch groups help their broader communities to identify and act on local water quality issues.

The H-N CMA's **Hawkesbury-Nepean River Health Strategy (RHS)** provides a framework for identifying the priorities for action that will help achieve the state-wide targets for water. The RHS applies a systematic approach to identifying the values and threats of each river reach and then appropriate management actions (H-N CMA, 2007).

Programs to maintain and enhance native fish communities

The DPI carried out the following relevant programs for fish management:

- research into the distribution and critical habitat of the threatened Macquarie perch between August 2006 and May 2007
- a state-wide assessment of the diversity, distribution and abundance of fish in NSW rivers in October 2006
- assessment of the fish community above and below Pheasants Nest weir in August and September 2006 and March 2007 prior to the proposed raising of the height of the weir
- assessment of the fish community in the Shoalhaven River catchment prior to the proposed construction of a fishway on Tallowa Dam in November and December 2005
- research into the distribution of the introduced redfin perch in the Wollondilly Catchment in May and June 2007.

In 2006, DPI published reports on the outcomes of their **NSW Detailed Weir Review** and **NSW Road Crossing Review Projects** (DPI, 2006d, 2006e, 2006f). The **NSW Detailed Weir Review Project** built on the outcomes of the NSW Initial Weir Review (NSW, Fisheries, 2002) by undertaking detailed reviews for high-priority structures within the thirteen catchments of NSW. The review aims to facilitate future on-ground works by addressing the social, ecological, cultural and logistical issues that surround the modification of existing barriers. The primary objectives of the project were to:

- Identify high priority weir structures within each CMA region that have a major impact on fish passage and aquatic habitat condition
- Assess high priority weirs by reviewing social, ecological, cultural and logistical issues that are associated with each structure
- Rank high priority weirs within each CMA region
- Recommend remediation options to improve fish passage at each weir structure.

The **NSW Road Crossing Review Project** was developed to identify and prioritise waterway crossings for remediation action in all coastal-draining catchments of NSW (DPI, 2006d, 2006e). The primary objectives and outcomes of the project were to:

- identify and assess the impacts of road crossings on aquatic habitat
- complete a field inventory of road crossing obstructions and identify other environmental impacts on aquatic habitat associated with road crossings
- develop an aquatic habitat management database and establish environmental auditing protocols for assessing road crossings
- demonstrate options for remediation and improved management of road crossings
- encourage remediation of priority sites with structure owners, and promote ‘fish-friendly’ principles for application in future instream works
- establishment of remediation demonstration sites at two key road crossing sites
- increase awareness of the importance of fish passage and aquatic habitat management for road management authorities and the broader community.

Following on from the above review projects DPI began the **Bringing Back the Fish Project** in partnership with the H-N CMA, in June 2006. The project aims to remediate priority fish passage barriers by implementing on-ground works at weirs, road crossings and floodgates. To date, three road crossings on Black Bob’s Creek have been modified to provide for fish passage.

DPI also produced a factsheet in 2006 outlining the **‘Fish in Farm Dams’**. This document encourages the use of native fish and plants in farm dams and also identifies undesirable and pest fish species.

During the 2007 Audit period, a biodiversity partnership project between H-N CMA and DPI into **Macquaire perch habitat protection** (redfin exclusion) was initiated to investigate options for controlling redfin which was discovered in the Wollondilly River in early 2006.

New infrastructure is being built at Tallowa Dam to allow native fish passage and to improve the temperature of water released from the dam. The SCA continues to investigate a \$7 million fishway and multi-level offtake point at Tallowa Dam. The fishway would enable migratory fish species to access the Shoalhaven and Kangaroo rivers, upstream of the 42 metre high dam wall at Tallowa. The SCA’s **Tallowa Dam Aeration Project** is improving the temperature of the water released from the dam by mixing the deeper, colder water with the warmer surface water, increasing the temperature of the release water by 10°C. Similarly, the dissolved oxygen contents in the deeper section of the lake were significantly higher in January 2006 than for the corresponding month in previous years.

In November 2001, the removal of large woody debris from NSW rivers and streams was listed as a key threatening process (KTP) under the *Fisheries Management Act 1994*. In June 2005, DPI produced a factsheet on the Removal of Large Woody Debris from NSW Rivers and Streams. The factsheet provides information on why large woody debris is important for native fish, which fish species are affected and the steps in producing a threat abatement plan.

Programs to maintain and enhance riparian zones

The SCA’s **Healthy Catchment Program** includes a **Riparian Strategy** to improve the condition of riparian zones in the Catchment. The Strategy requires identification of the condition of the riparian zone within the Catchment and provides for grants and assistance schemes, education programs and regulatory processes in consultation with appropriate authorities (SCA, 2006c).

The SCA’s **Riparian Management Assistance Program (RMAP)** under the SCA’s Riparian Strategy provides financial assistance to property owners in priority stream catchments of Brogers and Barrengarry

Creek (Kangaroo River sub-catchment), Cullenbenbong and Ganbenang creeks (Mid Cocks River sub-catchment), Uringalla, Paddys River and Long Swamp (Wollondilly River sub-catchment) and Upper Werriberri Creek to maintain and improve the management of riparian zones for water quality. The **RMAP** granted 27 applications in 2005-06 with a total value \$909,156. The works completed will minimise stock access along 35km of streams and gullies and over 23,000 trees have been planted to improve vegetation cover and bank stability.

The SCA has developed a method to map the extent of willows using multi-seasonal SPOT5 satellite imagery. The SCA and others intend to use this information to prioritise work under the **Riparian Management Assistance Program**.

The SCA's **Catchment Protection and Improvements grants for community groups** funded a number of projects to improve riparian vegetation, including:

- Berrima Bushcare Group
- Kangaroo Valley Environment Group
- Sydney Bushwalkers Association
- Kangaroo Valley Environment Group – riparian restoration of Village Gully
- Wingecarribee Landcare and Bushcare Network inc – revegetate riparian zone on Wingecarribee River west of Bong Bong Bridge, Moss Vale
- Restoration works on Iron Mines Creek to Gibbergunyah Creek by Wingecarribee Council, funded by Sydney Catchment Authority, Catchment Protection and Improvements Grants and the Wingecarribee Council's Environmental Levy.

During the 2007 Audit period, the SCA completed two riparian projects in the Cocks River sub-catchments. An area of Farmer's Creek was fenced, a stock crossing and stock water supply were built and the riparian area was replanted. The removal of 45 ha of willows and woody weeds was also completed between Jill's Crossing and the Blue Mountains National Park boundary, upstream of Warragamba Dam.

The H-N CMA's **River Health Program** recognises that the Hawkesbury–Nepean is a river of national significance and that its improved functioning is essential to the ability of the river to continue to deliver the many benefits it gives to a large number of Australians. It aims to provide funding for landholders and local government as the key partners in delivering on-ground action to positively influence the health of this river system.

The **River Restoration Project** under the H-N CMA's River Health Program provides funding for landholders to undertake activities to maintain and improve riparian area, instream habitat, riverine wetlands and bank stability. This project builds on two previous programs the **Hawkesbury–Nepean Riverbank Management Program** and **Warragamba Riparian Program**. The Hawkesbury-Nepean River Health Strategy links closely with the River Restoration Project and helps to identify priority management issues and locations for river restoration activities to maximise environmental outcomes. Landholders can apply for grants up to \$15 000; and larger projects will also be considered under the River Restoration Project when a significant environmental outcome is clearly evident.

Wingecarribee Council was awarded funding during the 2007 Audit period through H-N CMA to complete the Berrima School to Wingecarribee River Restoration Project.

Wollondilly Shire Council has a number of riparian improvement programs including the Werriberri Creek Riparian improvement project and the Wattle Creek and Myrtle Creek Privet removal projects.

The SR CMA **Shaolhaven-Illawarra Riparian Rehabilitation Project**, involves the development of Voluntary Conservation Agreements with landowners. The project's on-ground aims are to fence off and conserve riparian vegetation, revegetate riverbanks, control weeds, stabilise streambeds and establish off-stream watering points.

Programs to maintain and enhance native vegetation

Actions to maintain and enhance native vegetation include formally protecting high value conservation areas, minimising clearing, removing weed infestation and revegetating cleared areas to restore biodiversity values.

The Australian Government **Envirofund** is the local action component of the Australian Government's \$3 billion Natural Heritage Trust. It helps communities undertake local projects aimed at conserving biodiversity and promoting sustainable resource use. Community groups and individuals can apply for grants of up to \$50,000 to carry out on-ground and other actions to target local problems.

During the 2007 Audit period, Wingecarribee Council completed works on the southern slope of Mount Gibraltar, funded through the **Envirofund** Grants program.

Programs to protect high conservation areas

A number of **nationally threatened species and ecological communities** under the *Environment Protection and Biodiversity Conservation Act 1999* are located in the Catchment. These include White Box – Yellow Box – Blakely's Red Gum grassy woodlands and derived grasslands, Temperate Highland Peat Swamps on Sandstone and Turpentine-Ironbark Forest of the Sydney Basin Bioregion. Funding is available for projects to recover threatened species and ecological communities under the Threatened Species Network Community grants and Envirofund grants.

DECC administers a number of mechanisms that enable landholders to formally protect conservation value, including native vegetation. These mechanisms are:

- voluntary conservation agreements (VCAs) which are a permanent legal protection for the property's special features, through an agreement between the landholder and the Minister for the Environment
- wildlife refuges, where specified land is legally declared a wildlife refuge, and the terms of the agreement can be changed over time
- land for wildlife, where information is provided to landholders to help conserve the bushland.

Other initiatives such as the SR CMA **Southern Rivers Bush Incentives Program** provide funding to landholders to support them in managing priority native vegetation for conservation purposes. The H-N CMA **Bushland Conservation Project** aims to maintain and improve native vegetation including native grasslands, woodlands and forests that are not directly associated with waterways. Funding is available for landholders in the rural local government areas (LGAs) of the Catchment: Wollondilly, Wingecarribee, Goulburn–Mulwaree, Upper Lachlan Shire, Greater Lithgow, Oberon and Blue Mountains. Priority funding will be offered to projects that target endangered ecological communities, threatened species habitat and regionally significant vegetation communities as indicated in the Catchment Action Plans.

The SR CMA has also implemented in the 2007 Audit period, a comprehensive **voluntary biodiversity conservation scheme** for south-east NSW, as well as projects to protect biodiversity in the southern part of the Catchment and revegetation of the Braidwood Granites.

Programs to manage vegetation clearing

The *Native Vegetation Act 2003* sets a legal framework for ending broadscale clearing unless it improves or maintains environmental outcomes, encouraging revegetation and rehabilitation of land with native vegetation, and rewarding farmers for good land management. Landholders seeking to clear native vegetation are now required to either submit a development application, or enter into a legally binding agreement with the local CMA called a Property Vegetation Plan. This plan outlines the planned clearing of native vegetation on a property for up to 15 years.

Weed control programs

On 1 March 2006, the amended *Noxious Weeds Act 1993* came into force (via *Noxious Weeds Amendment Act 2005*). There have been a wide variety of changes in the new Act that will have an impact on local government, as both a land manager and as the Local Control Authority.

The objects of this Act are:

- to reduce the negative impact of weeds on the economy, community and environment of this State by establishing control mechanisms to:
 - prevent the establishment in this State of significant new weeds
 - restrict the spread in this State of existing significant weeds
 - reduce the area in this State of existing significant weeds
- to provide for the monitoring of and reporting on the effectiveness of the management of weeds in this State.

The **Australian Weeds Strategy** provides a framework to establish consistent guidance for all parties, and identifies priorities for weed management across the nation with the aim of minimising the impact of weeds on Australia's environmental, economic and social assets. The Australian Weeds Strategy emphasises the importance of preventing new weeds from establishing themselves in the area and the need to respond quickly to incursions.

A central component of the strategy is the identification of **Weeds of National Significance** and the resultant coordinated actions across all States and Territories. Relevant weeds of national significance within the Catchment are Blackberry, Gorse, Lantana, Serrated Tussock and Willows. A Strategic Plan and a Weed Management Guide has been developed for each of the weeds of National Significance in the Catchment. The weed management guides outline the identification of the weed and the best ways to manage the weeds.

The **National Weed Awareness Action Plan** focuses on improving awareness as a prerequisite to achieving acceptable long-term management of weeds. Increased awareness depends on participation by landowners, land managers, industry, the wider community and local, state and Australian governments. The goal is a targeted, well-resourced and consistent national weed awareness program that increases community and whole-of-government understanding of the weed crisis.

A **National Weed Spread Prevention Action Plan** (currently being developed) will establish a framework to prevent weed spread. The draft objectives are to identify and address all pathways for weed spread; achieve national consistency in weed spread prevention; minimise the spread of weeds by human agency; and meet the requirements of the National Weeds Strategy.

The **NSW Weeds Strategy** defines the major objectives and activities required to achieve a sustainable reduction of weeds in New South Wales. It explains ways stakeholders can improve the effectiveness and coordination of the fight against weeds. The strategy is linked to: the National Weed Strategy; weeds strategies in other states; and weed control and other environmental plans by local government, government and private landholders.

The **NSW Invasive Species Plan 2007-2015** is being developed in line with the **NSW State Plan**, will replace the current **NSW Weeds Strategy**, and will incorporate the management of weeds, vertebrate pests, invertebrate pests and freshwater and marine aquatic pests. It will provide a comprehensive set of objectives with key priority actions to deliver measurable outcomes in invasive species management in NSW.

Crown Lands Office is also involved in the development of regional weed management plans, the federal weeds of National Significance initiative and Recovery Plans for Threatened Native Species.

The SCA's **Pest and Weed Control Program for Special Areas** focuses on the control of blackberry, serrated tussock, pampas, willows and privet in the Special Areas. In addition to this program there is a **Pest and Weed Management Operational Plan Warragamba and Blue Mountains Special Areas 2004 -2009** which is the basis for all pest and weed control planning in the Blue Mountains and Warragamba Special Areas. In response to a severe infestation of privet beside the Kangaroo River, including the entire foreshore of Lake Yarrunga, the Shoalhaven Special Area Privet Management Project was commenced in 2006. The Shoalhaven City Council is contracted to remove the privet. Approximately 40 per cent of the primary privet control work has been completed.

The SCA also has a **Wingecarribee Swamp and Special Area Plan of Management 2007 (WSSAPoM)** which establishes management targets in order to reach a longer term vision. The management targets include water quality, ecosystem management and pests and weeds. The SCA will continue to implement the Draft Pest and Weed Management Plan for the Wingecarribee Swamp. As part of this Plan the SCA has implemented a **Wingecarribee Swamp weed control program**. The program aims to achieve sustainable management of willows and blackberry within four years. Significant progress has been made against the deepest weed infestations (SCA, 2007d).

Case Study – Weeds in the Wingecarribee Swamp

Wingecarribee Swamp is the largest upland peat swamp in mainland Australia. The swamp previously played an important role in filtering the runoff entering Wingecarribee Reservoir from the surrounding 4000 hectare rural catchment area. It also held significant biodiversity and conservation values, as it was home to a number of complex vegetation types, habitats, species and communities listed under the *Threatened Species Conservation Act 1995* (TSC Act).

The swamp was first mined for peat in the 1960s. Operations were finally halted in 1998, in response to loud opposition voiced in support of the ecological and archaeological values of the area. This halt came too late for the swamp however, which suffered a massive structural failure and collapsed during heavy rains in August 1998. Large volumes of peat flowed into Wingecarribee Reservoir, temporarily impacting on the quality of water stored there. A channel formed down the centre of the swamp during the collapse, which has compromised the water-filtering role previously played by the swamp.

The Wingecarribee Swamp and Special Areas Plan of Management 2007 provides for the mitigation of some of the worst current threats to the ecology of the swamp. These include the widespread invasion of weeds such as willow and blackberry, which threaten ecosystem biodiversity and compete with native species.

An estimated 1 million willows now infest the swamp. The 2007 Audit Team inspected the swamp, and observed the extent of the infestation.



The SCA has allocated significant resources to a four-year weed control program over the entire area of Wingecarribee Swamp. The first year of the program has been deemed a considerable success, with weed control contractors able to work effectively in the difficult swamp terrain. Extensive areas of the largest willow monocultures in the swamp are now controlled. There have been no recorded spills or environmental incidents caused by the weed control activities, and monitoring has not detected any pesticides in the adjacent waters since the program commenced. The success to date increases the SCA's confidence that willow and blackberry populations in Wingecarribee Swamp can be managed, if not eradicated.

Figure 6.7: Wingecarribee Swamp with young willows in the background

Source: DECC 2007

Land and Water Australia produced a **River and Riparian Land Management Technical Guideline for Controlling Willows along Australian Rivers** (Land and Water, 2006). This guide provides information about willows and their management. Willow sawfly (*Nematus oligospilus*) has recently arrived in Australia and may be a potential biological control for willows. Willow Sawfly larvae feed on willow leaves and can completely defoliate large willow trees and cause tree death as a result of several defoliation events over a period of two or more seasons (VIC DPI, 2006).

Other initiatives to combat weeds in the Catchment are:

- The **Shoalhaven Corridor Weed Management Plan** directs annual riparian weed control activities around Tallowa Dam, Kimberley Park and the Kangaroo River arm of the Shoalhaven system in Morton National Park
- SR CMA's **Broom Management Program** focuses on the control and eradication of broom and other weeds from the Shoalhaven River and its tributaries

- As part of the H-N CMA's biodiversity partnership project the H-N CMA and DPI are developing a **Catchment Weeds Strategy** following extensive consultation with stakeholders
- Roadside weed control works by the Upper Lachlan Council have continued to be focused on the control of serrated tussock and African lovegrass in the Taralga areas
- Goulburn Mulwaree Council began blackberry spraying during the 2007 Audit period along the Wollondilly and Mulwaree rivers
- The HN CMA has prepared a gorse strategy and offered funding to assist landholders to control gorse.

Native vegetation management programs

Property Vegetation Plans (PVPs) are a negotiated process between the CMA and the landowner. An officer from the CMA will carry out field surveys over the proposed clearing and offset areas to determine their environmental values. The data is then entered into the PVP assessment tool and the environmental values before and after clearing determined. As well as approving clearing, PVPs can also be used to identify areas of regrowth vegetation on a property, giving landowners greater security to plan and invest.

CSIRO developed a handbook in 2007, entitled **Motivating Change in the Catchment**. It is a guide to revegetation design and incentives for catchment management bodies, which is intended to be used by catchment managers as a guide to assessing whether or not and what type of incentive program is appropriate for biodiversity enhancement in their catchment (CSIRO, 2007c).

Revegetating the Braidwood Granites and Upper Shoalhaven Project was carried out by SR CMA during the 2007 Audit period. The Braidwood Granite Basin comprises approximately 40,000 ha of extensively cleared farmland, with less than 100 ha of remnant bushland. Much of the country is highly susceptible to wind erosion, particularly during dry periods. This project aims to re-establish native vegetation across the granite basin.

The SCA's **Catchment Protection and Improvements grants for community groups** funded a number of projects to improve vegetation, including:

- Casurina Gully – Chinamans Creek Bushcare Group – stabilisation of Forty Foot Falls
- Gibbergunyah Creek Bushcare Group – weed control to improve water quality of Gibbergunyah Creek
- Kedumba Creek Bushcare – rehabilitate bushland above creek and repairing stormwater controls
- Moss Vale Landcare Group – weed control and removal, and rehabilitation of Whites Creek
- Mt Alexandra Reserve Bush care Group – Bush regeneration along Iron Mines Creek
- Mt Gibraltar Landcare and Bushcare – removal of primary weeds at Mount Gibraltar Reserve
- National Trust of Australia – Regeneration works in bushland section of Everglades Gardens at Leura
- Nerriga Landcare Group – to protect the Corand Callitris Pine and vegetation by installing a fence to create a vegetative buffer along the Corang River.

Local councils undertake or facilitate many on-ground works for restoring and maintaining native vegetation in the Catchment. A few examples follow.

- Shoalhaven City Council has undertaken extensive privet control throughout the catchments of the Kangaroo River and its tributaries. This work has been funded through SR CMA and SCA. During the period from July 2005 to June 2007, this project undertook major works along Brogers Creek, Barrengarry Creek and Lake Yarrunga.
- Taralga Landcare group received \$11,507 funding from Round 1 of the Australian Government's Community Water Grants to remove willows from Woolshed Creek, revegetate three hectares with native species, and increase the size of a water storage pond.
- A new Tarago and District Landcare group formed in November 2006 and is the first landcare group in the headwaters of the Hawkesbury-Nepean catchment. The group aims to address local weed problems, pest animal control, education and sustainable agricultural practices. The group's first projects include planting at Crisps Creek Woodlawn mining site; and rehabilitating the banks of the creek of the recreation reserve in Tarago.

- Gorse Eradication Program continued throughout the Coxs River Catchment to ensure that control was carried out on all mapped infestations on public lands and 80-90 per cent of mapped infestation on private lands.
- Over 500 trees and shrubs were planted throughout the Farmers Creek, Lake Pillans, and the Lithgow township as part of the 'Greening Lithgow Program' in partnership with Lithgow Tidy Towns and Lithgow Oberon Landcare Association.
- \$6,000 of weed control carried out on broom, pussy willow, gorse and serrated tussock as part of the 'Weed Resilient Landscapes Program' in partnership with the DPI.
- Mt Gibraltar Landcare/Bushcare group – 10-year anniversary of volunteers working to restore this 120 hectare bushland reserve. In 2005-06, the group undertook 1,500 volunteer hours and since 1993 have received \$470,000 in funding to undertake a project worth \$850,000.
- Moss Vale Landcare Group undertook restoration of riparian zone of Whites Creek including 1,000 volunteer hours in 2005-06 with \$44,000 funding.
- Wingecarribee Council was awarded funding during the 2007 Audit period through the SCA, Catchment Protection and Improvements Grants, to complete bushland restoration in the Berrima Weir Reserve.

Landcare and Bushcare groups operate in the Catchment, undertaking work to protect and restore native vegetation. The **Mt Kanimbla Landcare Group** has planted 20,000 native trees during the 2007 Audit period, as part of an effort to establish wildlife corridors connecting the Kanimbla Valley to the Coxs River. Wingecarribee Council set up two new Bushcare Group in Moss Vale and Welby Tip Site in the Catchment.

The Blue Mountains City Council Environment Levy provides funding to spend specifically on additional environmental protection and natural resource management projects within the Blue Mountains local government area. A number of projects have been funded from the Environmental Levy including:

- **New Bushcare Groups** - The Medlow Bath Bushcare group were established, additional training opportunities for bushcare groups were provided and biodiversity workshops have been conducted.
- **Comprehensive Bush Regeneration** – aims to provide a healthy resilient bushland protecting the head of catchments throughout the Blue Mountains and creekline restoration. During the 2007 Audit period gorse was removed from creek banks at Pope's Glen, Blackheath and control of broom and blackberry at Upper Kedumba Creek, Katoomba were carried out.
- **Habitat Conservation Network** - The network provides high-level technical and material support to landowners achieving significant conservation outcomes. Objectives are improved weed control on non-council managed land, improved protection of bushland on non-council managed land and improved protection of endangered ecological communities and other significant vegetation. To date there are 17 Habitat Conservation Network participants.

Local Provenance Seed Strategy – CMAs and local government have a strategy that all regeneration work should use species of local provenance. Local provenance refers to seed collected from natural populations growing in the same vegetation community and position in the landscape within a reasonable (closest possible) distance of the area being restored.

Gaps in the response

The monitoring of ecosystem water quality, macroinvertebrate and fish communities provide useful information about the state of the Catchment. Actions that respond to and investigate reduced water quality and impaired macroinvertebrate and fish communities now need to be developed and implemented based on this monitoring information.

There are many programs for the restoration of riparian and native vegetation which contribute to improved ecosystem health. These programs need to be coordinated across the Catchment to ensure priority areas are targeted for funding and on-ground works. Spatial data on the extent of native vegetation and weeds and the location of rehabilitation and revegetation works in riparian and other areas of the Catchment need to be available and accessible to all land managers. See Recommendation 12.