water

Water Quality and River Flow Interim Environmental Objectives

Guidelines for River, Groundwater and Water Management Committees

Clyde River and Jervis Bay Catchments

How to use these guidelines

1 Background

Tells you why the NSW Government has proposed interim water quality and river flow objectives, how it developed them, and what will be done to achieve them.

2 Community comment on the proposed objectives

Reports back on the community's comments on the proposed objectives for this catchment and lists the major river health issues raised.

3 Interim water quality and river flow objectives for the catchment

Lists the interim water quality and river flow objectives that apply specifically to this catchment. Use the map to guide you as you read.

4 Interim water quality objectives explained

Explains all the water quality objectives used in Section 3 and includes the indicators and numerical criteria applying to each objective.

5 Interim river flow objectives explained

Explains the river flow objectives used in Section 3.

Bibliography

A list of documents referred to in these guidelines, and for further reading.

Glossary

Some definitions you may find useful.

Catchment map and catchment at a glance

Show this catchment in detail and each of the areas where the separate sets of objectives described in Section 3 apply.

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Guidelines for River, Groundwater and Water Management Committees

Clyde River and Jervis Bay Catchments

These guidelines should be read in conjunction with the Support Package for River, Groundwater and Water Management Committees

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Environment Protection Authority
59–61 Goulburn Street
PO Box A290
Sydney South 1232
Phone: (02) 9995 5000 (switchboard)
Phone: 131 555 (information & publications requests)
Fax: (02) 9995 5999

E-mail: info@epa.nsw.gov.au
Web: www.epa.nsw.gov.au

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From the Minister for the Environment

Healthy and clean rivers, beaches and harbours are fundamental to the Australian way of life. The NSW Government has made water an essential element of its wide-ranging reform agenda. As part of a comprehensive Water Reform Package announced in August 1997, the Government agreed to develop water quality and river flow objectives for all intra-state rivers.

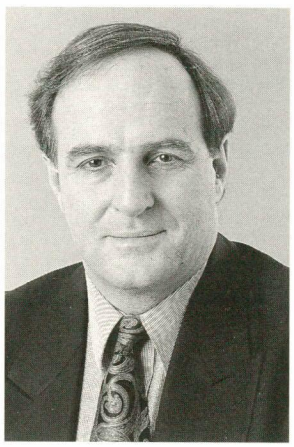
NSW is the first state to propose environmental objectives for all our rivers and the Government is proud of the pioneering work that has been done to develop these tools within the framework of the National Water Quality Management Strategy.

With the publication of these guidelines I am pleased to release interim water quality and river flow objectives for catchments across NSW. The objectives identify the broad goals to achieve long-term river health, maintain biodiversity and secure a sustainable water resource for communities and industries dependent on water of a certain quality. They will guide river, groundwater and water management committees as they develop their management plans.

The guidelines also contain information that will help all of us to better understand the impact of our activities on river health and suggest ways we can all work to achieve cleaner and more natural waterways.

The objectives were developed after consulting with the community across NSW from November 1997 to May 1998 and receiving further feedback from catchment management committees and established river management committees. The advice received during this extensive and, at times, controversial consultation program resulted in significant changes to the original proposals. The recommended objectives now more closely reflect the views of each catchment community.

I urge river and water management committees to use these locally developed targets to develop plans for the immediate and long-term action needed to improve the health of our rivers.



BOB DEBUS

Guiding principles for interim water quality and river flow objectives

The guiding principles for water quality and river flow management are:

- Adapt environmental objectives and river management over time to provide for adjustments based on expanding knowledge, river health monitoring, and changing community and economic values.
- Ensure a catchment focus by tailoring river health provisions to provide the most cost–effective and practical mix of solutions to meet the individual needs of each river system and catchment.
- Recognise the important links between river flows and water quality.
- Consider social and economic impacts.
- Provide water for the environment based on mimicking natural flow regimes as much as possible.
- Protect water quality, river flow regimes and riverine ecosystems that have not been seriously affected by human activities.
- Substantially rehabilitate highly stressed rivers.
- Consider interactions between ground and surface waters for both water quality and quantity.
- New or enlarged instream structures may be undesirable. Such proposals must show that they would provide clear benefits that would outweigh adverse environmental impacts (both at the site and elsewhere, such as downstream), and there are no alternatives.

Contents

1 Background

Why is the NSW Government providing guidelines on interim environmental objectives?

The NSW Government has brought in wide-ranging reforms to ensure the long-term health of all our waterways. We need action now for a healthy future for both our environment and our economy.

Environmental problems are widespread in our coastal river systems and estuaries. These include sewer overflows and leaks, stormwater, excessive nutrient inputs, algal blooms, acid sulfate soils and declining fish populations.

The community and Government have taken important steps towards attaining healthier rivers. Much has been achieved. By having clearly defined, consistent objectives, we will be able to better focus current actions and to plan for new ones.

The Government has already put in place a $3 billion Waterways Program to clean up sewage and stormwater in urban areas. Many of its water reforms have been implemented, including introducing a better balance in the sharing of water between users and the environment, coordinating water monitoring programs, and assessing the stress on rivers and aquifers. The Department of Land and Water Conservation has published detailed material on all the reforms.

Improving water quality and flow regimes are prime objectives for healthier waterways. Establishing these objectives is a major undertaking if we are to cover all NSW rivers and estuaries and develop and implement mechanisms to achieve the objectives. To meet this challenge, the Government has a complementary, two-part process for developing environmental objectives. One part involves providing interim environmental objectives to guide early river management planning and action. The other involves independent inquiries by the Healthy Rivers Commission in individual catchments to recommend longer term environmental objectives and practical strategies to achieve them.

What are water quality and river flow objectives?

The interim water quality and river flow objectives set out in these pages have been developed to guide plans and actions to achieve healthy waterways.

Up to eleven *interim water quality objectives* apply. Each is based on providing the right water quality for the environment and the different uses people have for water. The objectives are based on measurable environmental values for protecting aquatic ecosystems, recreation, visual amenity, drinking water and agricultural water. Section 4 gives a more detailed explanation of how to use water quality objectives.

The twelve coastal *interim river flow objectives* deal with the way water moves down rivers and streams. Each objective aims to improve river health by recognising the importance of natural river flow patterns. The objectives are based on achieving improved environmental results from managing the riverine system. Section 5 gives more detail.

How are these guidelines to be used?

These guidelines on interim environmental objectives are intended mainly for river, water and groundwater committees to consider and include in their water management plans. The committees are responsible for developing the river flow, water quality and groundwater action plans needed to achieve the agreed environmental objectives. The committees have the opportunity to recommend revision, refinement and expansion of the interim objectives to ensure the long-term health of the waterways in their catchment. Any fundamental change will need the NSW Government's approval through the Minister for the Environment and the Minister for Land and Water Conservation.

By integrating the objectives into the planning activities of water management committees, water management plans will help the community to achieve an acceptable balance between environmental, social and economic needs. These plans will ultimately be the basis for managing water resources for NSW rivers and groundwater systems. The plans are subject to Government approval, and progress will be audited.

The Government's existing river health programs already contribute to achieving river flow and water quality objectives. Similarly, individuals, communities and local government are currently taking action to achieve healthy rivers. All these groups will carry on with those programs and activities, which will be coordinated with actions identified in water management plans.

How long do the interim environmental objectives apply?

Interim environmental objectives will apply until the NSW Government either:

- adopts the longer-term objectives resulting from Healthy Rivers Commission recommendations, or
- approves a water management plan for the catchment through the Minister for Land and Water Conservation and the Minister for the Environment. In this case, the environmental objectives would apply for the duration of the plan, subject to review and audit.

Developing the guidelines

In late 1997, the NSW Government released discussion papers, the *Proposed Interim Environmental Objectives for NSW Waters* (EPA 1997), as the basis for a six-month community consultation. The papers gave options for interim river flow and water quality objectives in each catchment, including broad economic evaluations, as a basis for discussion.

Seeking the opinions of communities was essential. More than fifty community discussion meetings and nine special Aboriginal community meetings were held. These were attended by more than 4000 people. The Government received 810 written submissions, and river and catchment management committees gave valuable feedback on the draft objectives.

These guidelines summarise the community's views about the Clyde River and Jervis Bay catchments.

2 Community comment on the proposed objectives

Overview

Two community discussion meetings attended by a total of more than 70 people were held in Batemans Bay and Sussex Inlet; a meeting of Aboriginal people was held at Narooma (attended by representatives of many of the south coast Aboriginal communities) and several written submissions were received. The issues raised and comments made will be considered by the local water management committee when developing management plans.

At this stage, the NSW Government is committed to action through existing programs (see end of this section). Future priorities will be finalised when a water management plan is approved by the Minister for Land and Water Conservation and the Minister for the Environment. Water management committees need to balance environmental, social and economic issues when developing their plans, to avoid unacceptable consequences at the local level.

Water quality and value of the resource

The catchment community supported all the proposed environmental values and the objectives needed to sustain these values. Of particular significance were a healthy aquatic ecology (protection of aquatic ecosystems), safe swimming (primary contact recreation), water looking pleasant and clean (visual amenity), being able to drink the water after some treatment (drinking water supply) and being able to irrigate with water of a quality suited to the crops grown (irrigation water supply).

Most comments indicated a high level of community support for having healthy catchments. Good quality water and sufficient flows were thought to be important—both from a resource point of view, and because of the feelings of attachment and well-being associated with knowing the catchment was healthy.

The community recognised that the benefits of a healthy ecosystem included:

- continuation of a desirable lifestyle, including protection of human health
- maintenance of the undeveloped nature of local catchments with the opportunity for the 'isolation experience' this provides
- continued sustainability of local water-dependent industries such as tourism, recreation, fishing and oyster-growing, with the consequent support of local employment opportunities.

The costs identified for delivering the desired level of ecosystem protection included:

- restrictions on development (although this was seen as being both positive as well as negative)
- possible reductions in the amount of water available for irrigation
- financial costs involved in reversing some of the existing environmental degradation.

It was generally felt that the benefits would outweigh the costs, particularly in the long term.

River flows

The responses indicated that the community thought that the most important river flow issues were:

- low flows or lack of flow
- the connection between inundation from the river or estuary and the viability of adjoining wetlands,

and the need to:

- sustain groundwater quality and quantity
- retain some natural variability in the flow regime
- minimise the impact of instream structures
- protect the estuary.

People concerned about the state of the estuarine lagoons wanted upstream extraction to be limited at times of low or no flows.

Major issues

The process of developing the objectives identified several major issues that could need progressive action to achieve healthy and viable Clyde River and Jervis Bay catchments. Comment on some of these is included in Section 3, as part of the supporting information for the recommended objectives.

Major issues identified were the need to:

- protect the estuarine environments from adverse impacts on water quality, including the effects of drainage from acid sulfate soils. This was

considered a major goal in protecting the local oyster-farming, fishing and tourism industries.

- improve controls on stormwater from urban areas. Greater use of filtration and tighter controls on littering were mentioned as possible solutions.
- examine the problem of poor tidal exchange (flushing) in some coastal lagoons. Artificial openings to these lagoons can have positive and negative effects, so need very careful consideration. Some people felt that water diversion from the river within the catchments of these lagoons, especially during low-flow periods, could be accelerating the process of lagoon closure by reducing the volume of water flowing out of the systems. It was suggested that some of these problems could be resolved by better catchment management, leading to improved upstream flows and water quality.
- reduce the ecological impact of water diversions under low-flow conditions. Extraction of water at these times can also move the estuarine saline-water zone upstream, with consequent impacts on irrigators at the downstream ends of river systems.
- minimise the entry of nutrients into the river from fertilisers, from public toilets in areas of high recreational use, and from generally inadequate sewage control. This was mentioned as requiring attention. There were also calls for improved on-site effluent management.
- minimise problems of bank erosion, and consequent sedimentation and navigation problems caused by wash from pleasure-craft. Restrictions on vessel speed were suggested.
- manage stock access to streams. Uncontrolled access was causing increased erosion and elevating the levels of nutrients and bacteria in waters. The associated grazing pressures on riparian zones and creek banks was also a concern.
- improve bushfire management in the interests of protecting public safety, preventing poor-quality runoff and enhancing protection of conservation values
- run community education programs to empower people to take action (e.g. on stormwater) and overcome the fear of change evident in some sections of the community
- give legal force[1] to the objectives, particularly in relation to inappropriate local planning decisions. A related recommendation was to impose tougher conditions on developments, and the subsequent policing of those controls.
- reduce the stress in river systems identified as being under stress
- protect rivers in the catchment that have high conservation value. As a guide, such rivers should not be allowed to further degrade in water quality or flow regime, and may require restoration where they have poor water quality, a changed flow regime and habitat loss or degradation.
- control willows, which are choking streams and causing problems of flooding and erosion
- overcome the effects of erosion and sedimentation from roads and road-building
- protect wetland areas and clear the obstruction to fish passage in areas where this is a problem
- respect Aboriginal spiritual and cultural values associated with rivers, creeks, wetlands and lakes; and traditional Aboriginal management roles in, and uses for, these areas—including as a source of traditional foods that are safe to eat
- allow the catchment community to be actively involved in developing future strategies and actions associated with the interim environmental objectives.

Two water management committees (WMCs) will operate in the Clyde and Jervis Bay catchments to implement the objectives. The Jervis Bay catchment will be covered by the Illawarrra–Shoalhaven WMC and the Clyde River catchment by the South Coast WMC.

Existing programs

Some of the above issues already receive considerable attention and resources. Communities—through Landcare, Rivercare and other programs—are already undertaking important on-the-ground projects. The NSW Government has established and funded programs such as Blue-Green Algae Management, Estuary Management Program, Floodplain Management Program, Wetlands Action, the Country Towns Water Supply

[1] At this stage, the environmental objectives will be in the form of guidelines for planning purposes and are not enforceable.

and Sewerage Program and the NSW Shellfish Quality Assurance Program. At the Commonwealth level, relevant programs are being funded through Landcare and the Natural Heritage Trust.

Where programs such as these are already underway in the catchment, they should be acknowledged and, where possible, incorporated in water and estuary management plans.

3 Interim water quality and river flow objectives for the Clyde River and Jervis Bay catchments

This section gives the interim water quality objectives (WQOs) and the river flow objectives (RFOs) for the Clyde River and Jervis Bay catchments, which should be used by water management committees and others in developing plans and actions affecting river health. The NSW Government seeks further advice from committees and others on refining and expanding these objectives. Only the priority RFOs are listed in this section but committees still need to consider the remaining objectives when developing flow management plans or dealing with particular local river conditions.

Town water supply subcatchments

This category covers subcatchments that typically feed into a town's water supply storage. In many cases, the subcatchment may be declared specially protected to minimise the land-use impacts on water quality.

Map: The objectives apply to streams running through areas coloured light blue on the map.

Water quality objectives

Protection of:


Aquatic ecosystems


Visual amenity


Drinking water—Disinfection only


Drinking water—Clarification and disinfection


Drinking water—Groundwater

River flow objectives


Protect pools in dry times


Protect natural low flows


Protect important rises in water levels


Mimic natural drying in temporary waterways


Maintain natural flow variability


Maintain natural rates of change in water levels


Manage groundwater for ecosystems


Minimise effects of weirs and other structures


Minimise effects of dams on water quality

Supporting information

- This category includes Porters Creek Dam.
- To ensure long-term achievement of these WQOs, existing land-management programs aimed at maintaining or improving drinking water quality should continue and be reviewed.

- Town water supplies will not need to be augmented to meet these objectives. However, if augmentation for other reasons is proposed, appropriate levels of protection of low flows should be determined on a case-by-case basis.
- Local factors include maintaining natural flows from springs (groundwater) and effects of land management on volumes and times of runoff, particularly in droughts; flow needs of ecosystems and people within the area; reliability of town supplies; and needs of ecosystems and people downstream.

Mainly forested areas

Streams in mainly forested areas are often valued for their conservation or recreational values. They often have relatively natural flows and water quality. Many are in national parks or state forests.

Map: The objectives apply to streams running through areas coloured green on the map (state forests, national parks and nature reserves); and through other forested areas, if any are defined locally.

Water quality objectives

Protection of:


Aquatic ecosystems


Visual amenity


Secondary contact recreation


Primary contact recreation


Drinking water at point of supply—Disinfection only


Drinking water at point of supply—Clarification and disinfection


Drinking water at point of supply—Groundwater


Aquatic foods (cooked)

River flow objectives


Protect pools in dry times


Protect natural low flows


Maintain natural flow variability


Manage groundwater for ecosystems


Minimise effects of weirs and other structures

Supporting information

- This category includes Benandarah, Boyne, Kioloa, Termeil, Yadboro, Flat Rock and parts of Mogo state forests, as well as parts of Budawang and Morton national parks. Where these streams have areas of rural land use upstream, these objectives will need to be protected.
- RFO *Manage groundwater for ecosystems* applies in areas of groundwater use.

- While there are few instream barriers in waterways in this category, RFO *Minimise effects of weirs and other structures* is included in case instream structures are proposed in the future.
- There may be locations where Aboriginal communities collect freshwater aquatic foods to be eaten raw. NSW Health recommends against the consumption of raw shellfish harvested on a non-commercial basis and local communities should be made aware of the risks involved.

Waterways affected by urban development

Streams within urban areas that are frequently substantially modified and carry poor quality stormwater. Local communities are, however, often keen to see such streams returned to more natural conditions.

Map: These areas are shown in orange or orange dots on the map.

Water quality objectives

Protection of:

- Aquatic ecosystems
- Visual amenity
- Secondary contact recreation, as a short-term objective, within 5 years
- Primary contact recreation: assess opportunities to achieve as a longer term objective, 10 years or more

River flow objectives

- Mimic natural drying in temporary waterways
- Maintain natural flow variability
- Maintain natural rates of change in water levels
- Manage groundwater for ecosystems
- Minimise effects of weirs and other structures

Supporting information

- This category includes streams around Batemans Bay, Sussex Inlet, Ulladulla, Milton, Huskisson, Vincentia, Durras, Kioloa, Bawley Point, Burrill Lake and some areas around St Georges Basin and Swan Lake.
- In some urban waterways aquatic ecosystems are considerably modified. A return to pristine aquatic ecosystems in these areas is unlikely and impractical. However, water quality conditions for existing ecosystems can be improved greatly for the benefit of local species and broader catchment health. Data from other local aquatic ecosystems of similar type, in areas that are not urbanised, may provide achievable criteria for these modified aquatic ecosystems.

- Existing programs include the Urban Stormwater Management Program, which includes a stormwater education program, the development of stormwater plans and a series of stormwater trust grants. This program has provided $90,000 in funding for the installation of gross pollutant traps at Batemans Bay (to protect a significant natural wetland) and at the Clyde estuary. Another $270,000 has been provided for the installation of gross pollutant traps and litter collecting baskets for Ulladulla harbour and for a community education program aimed at reducing stormwater pollution of the harbour.
- In these catchments, urban development is having significant impacts on estuaries and coastal lakes.
- Impacts on water quality of unsewered areas and stormwater can be significant in various areas throughout the catchment.

Uncontrolled streams

Uncontrolled streams and waterbodies are those that are not in estuaries or in the other categories. Their flow patterns are largely natural but may have been altered to a limited degree.

Map: Uncontrolled streams are shown as blue lines on the map.

Water quality objectives

Protection of:


Aquatic ecosystems


Visual amenity


Secondary contact recreation


Primary contact recreation


Livestock water supply


Irrigation water supply


Homestead water supply


Drinking water at point of supply—Disinfection only


Drinking water at point of supply—Clarification and disinfection


Drinking water at point of supply—Groundwater


Aquatic foods (cooked)

River flow objectives


Protect pools in dry times


Protect natural low flows


Protect important rises in water levels


Maintain wetland and floodplain inundation


Mimic natural drying in temporary waterways


Maintain natural flow variability


Manage groundwater for ecosystems


Minimise effects of weirs and other structures

Supporting information

- Licensed water supply offtake points are at Buckenbowra River (several locations) and Deep Creek Dam (supplies water for Batemans Bay). Particular attention should be paid to maintaining suitable water quality in any areas where town water supplies are drawn from, so that safe supplies can continue to be drawn from these sources and treatment remains effective.
- Many rural dwellers traditionally take drinking water untreated from local streams. There is a widespread community expectation that streams should provide drinking water that does not require disinfection. NSW Health recommends that, at a minimum, all drinking water should be disinfected before consumption. Rural homesteads require good quality water for non-drinking water uses and for drinking with minimal treatment.
- Aboriginal communities indicated their desire to be able to maintain traditional patterns of food gathering. The aquatic foods objective has therefore been included for these waters. Apparently-healthy aquatic foods might inhabit these freshwater streams—but, because of pollution (especially with faecal bacteria) from diffuse sources, these foods might not be suitable for human consumption if eaten raw. NSW Health recommends against the consumption of raw shellfish harvested on a non-commercial basis and local communities should be made aware of the risks involved.
- Community input identified a number of structures on waterways and streams that can affect river flows and water quality. These include: the Burrill causeway, Porters Creek Dam, the weir on Millards Creek above Ulladulla, and Deep Creek Dam.

Estuaries

Being dominated by saline conditions, estuaries have hydraulic and water quality characteristics, and potential problems, that are often very different from those of freshwater systems

Map: Estuaries are coloured purple on the map.

Water quality objectives

Protection of:


Aquatic ecosystems


Visual amenity


Secondary contact recreation


Primary contact recreation


Aquatic foods (cooked) and commercial shellfish production

River flow objectives


Maintain wetland and floodplain inundation


Manage groundwater for ecosystems


Minimise effects of weirs and other structures


Maintain or rehabilitate estuarine processes and habitats

Supporting information

- This category includes Batemans Bay, Tomaga estuary, Durras Lake, Willinga Lake, Meroo Lake, Termeil Lake, Tabourie Lake, Burrill Lake, Narrawallee Inlet, Lake Conjola, Swan Lake and Wollumboola Lake.
- The Clyde River and Conjola–Burrill Lake Shellfish Quality Assurance Programs conduct regular monitoring of estuarine water quality as part of actions to support commercial production of shellfish.
- Parts of the lower estuarine reaches are underlain by potential acid sulfate soils, which should not be disturbed. Dredging and disturbance of bottom sediments (i.e. those below water level) can also have major impacts in these areas for the same reason.

4 Interim water quality objectives explained

This section explains each of the water quality objectives (WQOs). The WQOs for each part of the Clyde River and Jervis Bay catchments are listed in Section 3.

In total, there are eleven WQOS. They provide benchmarks or reference levels to guide water quality planning and management.

Achieving each WQO will mean improving poor water quality or maintaining existing good water quality.

Objectives consist of three parts: *environmental values*, their *indicators* and their *numerical criteria*. For example, if the objective is to protect *secondary contact recreation* (environmental value), we need to keep the *faecal coliform levels* in the water (the indicator) below a *specified number* (the criterion). The objectives comprise community-based environmental values and their associated national criteria. They provide the statewide context for taking this work forward into the water management process. Many catchment management committees have developed more detailed information on WQOs for their rivers.

Refining numerical criteria to account for local conditions

Local water quality varies naturally because of various factors, including the type of land the waters are draining (e.g. soils, slope), or rainfall and runoff patterns (e.g. ephemeral or permanent streams). Different land use and land management practices also affect water quality. Local WQOs must take account of these variations, particularly for the environmental value of aquatic ecosystems.

The indicators and criteria used here are those provided under the National Water Quality Management Strategy. They are listed in the *Australian Water Quality Guidelines for Fresh and Marine Waters* (ANZECC 1992), currently under review. Numerical criteria provide the basis for ascertaining how close current water quality is to meeting desired levels of water quality. Key indicators for each environmental value are listed below. The ANZECC guidelines provide a comprehensive set of indicators and explain how national indicators of water quality may be adapted to establish local reference conditions.

The ANZECC (1992) guidelines need to be adapted to local conditions. Further refinement of the numerical criteria is needed, especially for aquatic ecosystems—and particularly in places, or for issues, requiring priority action. This work will usually be done by government agencies or government agency representatives on water management committees. The committees may recommend local refinements to Government for approval, through the Ministers for the Environment and for Land and Water Conservation.

To establish reference criteria for affected sites, it is best to use least-affected or best-managed reference sites with similar characteristics. In national parks and similar areas, near-pristine sites should be used. Reference sites can be compared with potentially affected sites to help refine management targets.

Information from the National River Health Program (NRHP) provides a starting point for developing local reference water-quality levels in the catchment. These are shown below in the key criteria applying to 'Aquatic ecosystems', under total phosphorus, turbidity and salinity.

Monitoring

State Government agencies, local government, industry and the community are monitoring water in some areas. The State Water Monitoring Coordination Committee is developing a water monitoring strategy that will help to assess progress in achieving the objectives. This process is rationalising and improving the coordination of the monitoring programs and establishing common protocols for those undertaking monitoring for different purposes.

The Department of Land and Water Conservation is coordinating the Integrated Monitoring of Environmental Flows Program, which will result in improved information on the links between river health and flows.

Downstream impacts

Plans and decisions need to recognise that activities and decisions made upstream affect water quality downstream.

Interim water quality objectives

Meeting water quality levels suitable for local ecosystems is generally the basis for protecting the other environmental values, which are the uses people have for water.

Aquatic ecosystems

Maintaining or improving the ecological condition of waterbodies and their riparian zones over the long term

Where the objective applies

- This objective applies to all natural waterways.
- High level protection of aquatic ecosystems applies to waters in and immediately upstream of national parks, nature reserves, state forests, drinking water catchments and high-conservation-value areas. This reflects their largely unmodified aquatic ecosystems, value in providing natural sources of high-quality drinking water, and high levels of recreational use.
- Even in areas greatly affected by human use, continuing improvement is needed towards healthy, diverse aquatic ecosystems.
- Water quality in artificial watercourses (e.g. drainage channels) should ideally be adequate to protect native species that may use them, as well as being adequate for the desired human uses. However, full protection of aquatic ecosystems may not be achievable in the short-term in some artificial watercourses.
- Artificial watercourses should meet the objectives (including protection of aquatic ecosystems) applying to natural waterways at any point where water from the artificial watercourse flows into a natural waterway.

Key indicators and their numerical criteria

The following table summarises the specific water quality indicators and related numerical criteria relevant to monitoring the health of aquatic ecosystems in this catchment.

Aquatic ecosystems	
Indicator	Numerical criteria
Total phosphorus	Site- or region-specific information is needed. • Rivers & estuaries: 10–100 µg/L • Lakes & reservoirs: 5–50 µg/L Understanding the different forms of phosphorus—e.g. the proportion of phosphorus in water that is available for plant growth—is important in managing unfavourable plant/algae responses. Assessment of the NRHP reference sites gives a starting point for developing locally applicable criteria. Typical numbers are 20–50 µg/L. Estuarine studies suggest the same range may apply to the estuary.
Total nitrogen	Site- or region-specific studies are needed. • Rivers & estuaries: 100–750 µg/L • Lakes & reservoirs: 100–500 µg/L Understanding the different forms of nitrogen in waters is important in different management situations, e.g. ANZECC (1992) guidelines provide indicative concentration values for different forms of nitrogen in estuaries. Analysis of water quality data for coastal lakes and estuaries indicates a total nitrogen range of 150–300 µg/L. Based on an assessment of NRHP reference site data and other data on oxidised nitrogen, most of NSW showed a great variation in oxidised nitrogen levels. The NSW south coast and most of the Murray River sites had reasonably low levels, while a region with high levels of oxidised nitrogen could be identified in the central west of NSW.
Chlorophyll-a	Site- or region-specific studies are needed. • Lakes & reservoirs: 2–10 µg/L. • Estuaries & bays: 1–10 µg/L.
Turbidity	Common descriptions: < 5 NTU low turbidity (high clarity); 5–25 NTU medium turbidity; 25–50 NTU high turbidity; > 50 NTU very high turbidity. Site- or region-specific studies are needed. < 10% change in seasonal mean NTU Increases in suspended particulate matter should be limited such that the clarity guidelines are maintained. Data analysis has indicated an interim concentration level for estuaries, also coastal lakes and lagoons, of less than 5 NTU. Local waterbodies may have lower NTU values, which should be maintained (a principle of non-degradation applies). Assessment of the NRHP reference sites gives a starting point for developing locally applicable criteria. Typical numbers are 5–20 NTU in fresh waters with <5 NTU in the Clyde River.
Clarity	For waters deeper than 50% of the euphotic depth, the euphotic depth should not change by more than 10% from an established seasonal norm. In water shallower than 50% of the euphotic depth, the maximum reduction in light at the sediment bed should not exceed 20%.
Salinity (electrical conductivity)	Fresh waters: < 1500 µS/cm. Non-degradation of current levels. Assessment of the NRHP reference sites gives a starting point for developing locally applicable criteria. All reference sites in the catchment: <150 µS/cm.
Dissolved oxygen	> 6 mg/L or 80–90% saturation, being determined over at least 24 hours, and (if possible) over a few days to establish the diurnal range in concentration.
pH	Fresh water range: 6.5–9.0 Changes of more than 0.5 pH units from the natural seasonal maximum or minimum should be investigated. Marine waters: < 0.2 pH unit change.
Temperature	< 2°C increase in natural temperature levels. No current guidelines for acceptable temperature reductions.
Chemical contaminants	See ANZECC (1992) guidelines, section 2.4 for full details. Summary: 'Waters shall be free from pollutants in amounts or combinations that are toxic to humans, animals, plants and other organisms.'

Fringing vegetation of waterbodies	No specific criteria. One aspect where related ANZECC (1992) guidance is given is under *Ecosystem function*: 'In any waterbody, changes that vary the relative importance of detrital and grazing food chains should be minimised. Production-to-respiration ratios should not vary significantly from those of similar, local, unaffected systems.'
Macro-invertebrates	No specific criteria. The species richness of the predominant invertebrate assemblages, as measured by an appropriate biotic index, should not be altered; and impacts that result in significant changes in species composition, compared with those in similar, local, unaffected systems, should not be permitted.
Water plants	No specific criteria. Species richness of the predominant macrophyte assemblages, as measured by an appropriate index, should not be altered; and impacts that result in significant changes in species composition, compared with those in similar, local, unaffected systems, should not be permitted.
Fish	No specific criteria. For biological communities including fish: • Communities should be protected such that the species composition, diversity, and functional organisation remain comparable to that of the natural habitat of the region; and • Impacts that result in significant changes in species composition or diversity should not be permitted.

Supporting information

- The approach to protecting the acquatic ecosystem should consider the range of interacting factors—such as variability of water quality over time, sediment interactions, river flow, local geology, land use, the needs of sensitive habitats, and people's uses for water.
- Assessing ecosystem health also requires using a range of indicators and considering local modifying factors—such as basalt soils that result in naturally higher nutrient levels, or estuary opening patterns that affect water quality. However, information on a full range of indicators may not be available from regular monitoring.
- Although modified, many non-pristine environments contain important aquatic ecosystem. Well-functioning aquatic ecosystems also provide benefits to people using these waters, such as by reducing blue-green algal blooms.
- Nutrient values or concentrations indicate levels at or above which negative algae and plant growth responses have been known to occur, depending on a range of other factors.
- Reducing pollutant loads during rainfall and runoff periods should be a key focus for improving water quality. It is also important in managing longer term impacts, such as sedimentation and polluted sediments.
- The choice of toxicant indicators for use in each management situation is related to known past or current activities. Impacts are detected by measuring water, sediment or biota. Natural sources should also be considered.
- Protecting aquatic ecosystems requires mimicking natural river flow patterns as closely as possible (see Section 5).

Visual amenity

Aesthetic qualities of waters

Where the objective applies

- The objective applies to all waters, particularly those used for aquatic recreation and where scenic qualities are important.

Key indicators and their numerical criteria

Indicators used to monitor visual amenity are summarised in the table.

Visual amenity	
Indicator	Numerical criteria
Visual clarity and colour	Natural visual clarity should not be reduced by more than 20%. Natural hue of the water should not be changed by more than 10 points on the Munsell Scale. The natural reflectance of the water should not be changed by more than 50%.
Surface films and debris	Oils and petrochemicals should not be noticeable as a visible film on the water, nor should they be detectable by odour. Waters should be free from floating debris and litter.
Nuisance organisms	Macrophytes, phytoplankton scums, filamentous algal mats, blue-green algae, sewage fungus and leeches should not be present in unsightly amounts.

Supporting information

- Visual amenity will be improved by protecting acquatic ecosystems and improving stormwater management.
- Visual amenity also needs to be protected to maintain water quality for primary and secondary contact recreation.

Secondary contact recreation

Maintaining or improving water quality for activities such as boating and wading, where there is a low probability of water being swallowed

Where the objective applies

- This objective applies to all waters but may not be achievable for some time in some areas. Section 3 indicates the priority sites for early achievement of the objective in this catchment.
- Secondary contact recreation applies in waterways where communities do not require water quality of a level suited to primary contact recreation, or where primary contact recreation will be possible only in the future.

Key indicators and their numerical criteria

Indicators used to monitor water for secondary contact recreation are summarised in the table.

Secondary contact recreation	
Indicator	Numerical criteria
Faecal coliforms	Median bacterial content in fresh and marine waters of < 1000 faecal coliforms per 100 mL, with 4 out of 5 samples < 4000/100 mL (minimum of 5 samples taken at regular intervals not exceeding one month).
Enterococci	Median bacterial content in fresh and marine waters of < 230 enterococci per 100 mL (maximum number in any one sample: 450–700 organisms/100 mL).
Algae & blue-green algae	< 15 000 cells/mL
Nuisance organisms	Use visual amenity guidelines. Large numbers of midges and aquatic worms are undesirable.
Chemical contaminants	Waters containing chemicals that are either toxic or irritating to the skin or mucous membranes are unsuitable for recreation. Toxic substances should not exceed levels given for untreated drinking water.
Visual clarity and colour	Use visual amenity guidelines.
Surface films	Use visual amenity guidelines.

Supporting information

- Water quality tests for faecal coliform bacteria are used to indicate the possible presence of human pathogens. Improved tests and indicators for these are being developed.

Primary contact recreation

Maintaining or improving water quality for activities such as swimming in which there is a high probability of water being swallowed

Where the objective applies

- This objective applies in the immediate future to waters within and immediately upstream of recognised recreation sites. For many other waters this is a long-term objective.
- Secondary contact recreation levels should apply in areas where primary contact recreation, such as swimming, is unlikely to be achieved in the immediate future, owing to pollution.

Key indicators and their numerical criteria

Indicators used to monitor water for primary contact recreation are summarised in the table.

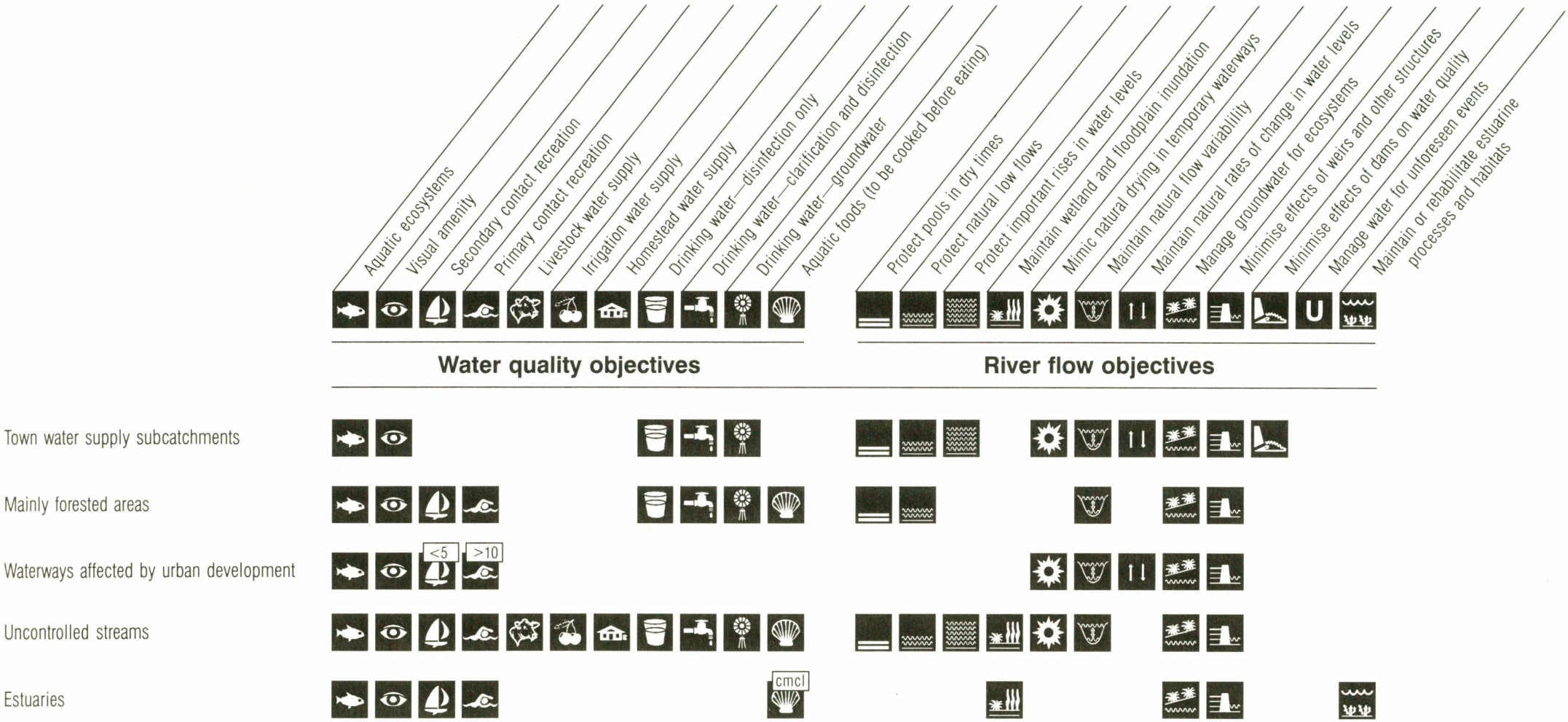
Primary contact recreation	
Indicator	Numerical criteria
Turbidity	A 200 mm-diameter black disc should be able to be sighted horizontally from a distance of more than 1.6 m (approximately 6 NTU).
Faecal coliforms	Median over bathing season of < 150 faecal coliforms per 100 mL, with 4 out of 5 samples < 600/100 mL (minimum of five samples taken at regular intervals not exceeding one month).
Enterococci	Median over bathing season of < 35 enterococci per 100 mL (maximum number in any one sample: 60–100 organisms/100 mL).
Protozoans	Pathogenic free-living protozoans should be absent from bodies of fresh water.
Algae & blue-green algae	< 15 000 cells/mL
Nuisance organisms	Use visual amenity guidelines. Large numbers of midges and aquatic worms are undesirable.
pH	5.0–9.0
Temperature	15–35°C for prolonged exposure.
Chemical contaminants	Waters containing chemicals that are either toxic or irritating to the skin or mucous membranes are unsuitable for recreation. Toxic substances should not exceed levels given for untreated drinking water.
Visual clarity and colour	Use visual amenity guidelines.
Surface films	Use visual amenity guidelines.

Supporting information

- Maintain water quality in all areas where water quality levels for swimming are currently achieved.
- The immediate focus should be on improving swimming water quality at recognised recreation sites, with an emphasis on meeting targets during the bathing season.
- Over the longer term, water quality will need to improve to meet swimming objectives at more locations.
- Bacterial water quality tests are used to indicate the possible presence of human pathogens. Improved tests are being developed.
- Achieving water quality levels that are safe for swimming will also result in safer water quality for non-potable uses in homesteads.

Catchment at a glance

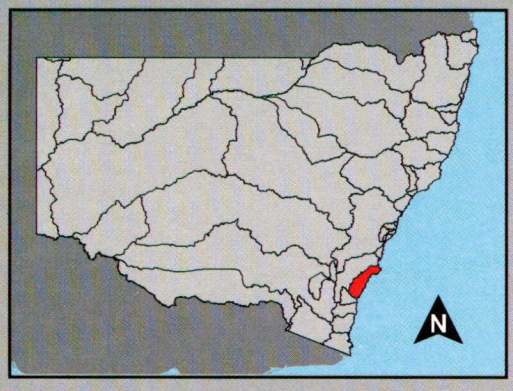
Clyde River and Jervis Bay Catchments



<5 For achievement within 5 years
5-10 For achievement in 5 to 10 years
>10 For achievement in 10 years or more

cmcl Includes commercial shellfish production
wtld Includes wetlands

Clyde River & Jervis Bay Catchments



Lake Wollumboula
Currambene Creek
HUSKISSON
Jervis Bay
VINCENTIA
HYAMS BEACH
St. George's Basin
SUSSEX INLET
Swan Lake
BERRARA
CONJOLA
FISHERMANS PARADISE
Lake Conjola
BENDALONG
CUNJURONG
Porters Creek Dam
River
MILTON
NARRAWALLEE
MOLLYMOOK
ULLADULLA
Clyde
KINGS POINT
Burrill Lake
BURRILL LAKE
Ck
Boyne
Creek
Tabourie Lake
LAKE TABOURIE
Bimberamala
River
Termeil Lake
Meroo Lake
Willinga Lake
TERMEIL
KIOLOA
Currowan
Creek
Clyde
Nelligen
Creek
Durras Lake
DURRAS
Buckenbowra
River
BATEMANS BAY
Batemans Bay
MOGO
Jeremadra
Ck.

0 10 20 30 Kilometres

- Major weirs, storages
- Major storages
- Uncontrolled streams
- Waterways affected by urban development
- Estuaries
- Town water supply subcatchments
- National Parks, Nature Reserves & State Forests
- Mainly forested areas

Prepared by NSW EPA's Remote Sensing / GIS Service

Livestock water supply

Protecting water quality to maximise the production of healthy livestock

Where the objective applies

- This objective applies to all surface and groundwaters used to water stock.

Key indicators and their numerical criteria

Indicators used to monitor water for livestock water supply are summarised in the table.

Livestock water supply	
Indicator	Numerical criteria
Algae & blue-green algae	< 10 000 cells/mL; lower levels may be needed for some algal species.
Salinity (electrical conductivity)	< 3000–9000 µS/cm, depending on the type of livestock and other factors.
Faecal coliforms	Geometric mean: < 1000 faecal coliforms/100 mL, 20% of samples < 5000/100 mL (based on not less than 5 water samples taken per month).
Chemical contaminants	See ANZECC (1992) guidelines, sections 5.2.2 & 5.2.3, and criteria for untreated drinking water.

Supporting information

- Poor water quality can limit livestock productivity.
- This objective is generally attainable if aquatic ecosystems are protected.

Irrigation water supply

Protecting the quality of waters applied to crops and pasture

Where the objective applies

- This objective applies to all current and potential areas of irrigated crops, both small- and large-scale.
- Local requirements for irrigation water quality, such as salinity, apply.

Key indicators and their numerical criteria

Indicators used to monitor water for irrigation water supply are summarised in the table.

Irrigation water supply	
Indicator	Numerical Criteria
Algae & blue-green algae	Should not be visible. No more than low algal levels are desired to protect irrigation equipment.
Salinity (electrical conductivity)	< 280 µS/cm (low-salinity water threshold). 280–800 µS/cm (medium-salinity water threshold).
Faecal coliforms	Geometric mean: < 1000 faecal coliforms/100 mL; 20% of samples < 4000/100 mL (not less than 5 samples taken per month).
pH	4.5–9.0
Chemical contaminants	See ANZECC (1992) guidelines, section 5.1.4.

Supporting information

- ANZECC (1992) guidelines recommend salinity criteria for various irrigated crops. For example, medium-salinity water (< 800 µS/cm) is suitable for most types of crops. The impacts of saline water are influenced by soil characteristics, crop tolerance, climate and irrigation practices.
- Long-term effects of irrigation with saline water on soils need to be considered.
- A major consideration for irrigation water supply is the sodium adsorption ratio (SAR), which indicates the level of excess sodium in the water. If the SAR is high, the water may have an adverse effect on soil structure, even though the total water salinity may be low.

- A variety of plant pathogens can be distributed by irrigation water—including nematodes, fungi, viruses and bacteria. However, in the absence of sufficient data, there are no guidelines for controlling plant pathogens.

Homestead water supply

Protecting water quality for domestic use in homesteads, including drinking, cooking and bathing

Where the objective applies

- The objective applies to all homesteads that draw water from surface and groundwaters for domestic needs, including drinking water.
- The NSW Health Department advises that water for domestic use in homesteads should comply with the *Australian Drinking Water Guidelines* (NHMRC & ARMCANZ 1996) at the point of use, regardless of source.

Key indicators and their numerical criteria

Key indicators for drinking water quality at the point of use in the *Australian Drinking Water Guidelines* (NHMRC & ARMCANZ 1996) are set out below. Monitoring should also be considered for health-related parameters of local concern. Communities should refer to the *Australian Drinking Water Guidelines* for information on additional parameters.

Homestead water supply	
Indicator	Numerical criteria
Blue-green algae	No guideline values are set for cyanobacteria in drinking water. In water storages, counts of < 1000 algal cells/mL are of no concern. 1000–2000 algal cells/mL – increase monitoring. > 2000 algal cells/mL – immediate action indicated; seek expert advice.
Turbidity	5 NTU; <1 NTU desirable for effective disinfection; >1 NTU may shield some micro-organisms from disinfection.
Total dissolved solids	< 500 mg/L is regarded as good quality drinking water based on taste. 500–1000 mg/L is acceptable based on taste. >1000 mg/L may be associated with excessive scaling, corrosion and unsatisfactory taste.

Faecal coliforms	0 faecal coliforms per 100 mL (0/100 mL). If micro-organisms are detected in water, advice should be sought from the relevant health authority. See also the Guidelines for Microbiological Quality in relation to Monitoring, Monitoring Frequency and Assessing Perfomance in the *Australian Drinking Water Guidelines* (NHMRC & ARMCANZ 1996).
pH	6.5– 8.5
Chemical contaminants	See Guidelines for Inorganic Chemicals in the *Australian Drinking Water Guidelines* (NHMRC & ARMCANZ 1996).

Supporting information

- For an individual water supply, the emphasis should be on selecting the best quality source water available, and on protecting its quality by the use of barrier systems and maintenance programs. Whatever the source (ground, surface or tank water), householders should assure themselves that the water is safe to drink.
- Information on the quality of surface or groundwater may be available from state and local governments conducting monitoring programs. If not, individuals should consider having the water tested for any key health characteristics identified as being of local concern. Where raw water quality does not meet the requirements of the *Australian Drinking Water Guidelines* (NHMRC & ARMCANZ 1996), a point-of-use device may be needed to treat the water.
- In many cases it will not be possible for water at individual homesteads to comply with the *Australian Drinking Water Guidelines* (NHMRC & ARMCANZ 1996) without some form of treatment. Many homesteads traditionally take drinking water untreated from local streams. Even in pristine areas there are health risks associated with this practice. The Government recommends that drinking water, including water for cooking and bathing, is at least disinfected before use.
- Effective communication and education strategies may be needed to ensure that householders understand that when water is not of a potable quality, precautionary measures should be taken (e.g. avoiding ingestion, boiling drinking water). Such water may be of sufficient quality to be used for washing clothes, gardening, toilet-flushing and other non-potable uses.
- Many homesteads rely on tank water for drinking and cooking. The National Environmental Health Forum Monograph, *Guidance on the Use of Rainwater Tanks* (NEHF 1998) is endorsed by the NSW Health Department and provides useful information on the safe operation of rainwater tanks.

Drinking water

Disinfection only, or

Clarification and disinfection

Groundwater

Refers to the quality of drinking water drawn from the raw surface and groundwater sources before any treatment

Where the objectives apply

- These objectives apply to all current and future licensed offtake points for town water supply and to specific sections of rivers that contribute to drinking water storages or immediately upstream of town water supply offtake points. The objective also applies to subcatchments or groundwaters used for town water supplies.

Key indicators and their numerical criteria

Key indicators in the ANZECC (1992) guidelines for raw water for drinking water supply that is to undergo coarse screening only are listed below. Numerical criteria for algae are drawn from the more recent State Algal Coordinating Committee algal management guidelines (SACC 1996).

Note that a wide range of treatment technologies are available (e.g. coagulation, flocculation, filtration, ion exchange, reverse osmosis, carbon adsorption columns) that enable the production of acceptable drinking water from almost any raw water. The ANZECC (1992) guidelines do not specify criteria for the many types of water quality that could be involved.

Refer to the NSW Groundwater Protection Policy, (DLWC 1998b) for information on the management of groundwater quality.

All drinking water should comply with the *Australian Drinking Water Guidelines* (NHMRC & ARMCANZ 1996) at the point of use. Refer to the Summary in the *Australian Drinking Water Guidelines*.

Drinking water	
Indicator	Numerical criteria
Blue-green algae	< 2000 algal cells/mL – water may be used for potable supply. 2000–15 000 algal cells/mL – may be used for potable supply if regular (at least weekly) toxicity testing is being undertaken and no toxins, tastes or odours are detected. >15 000 algal cells/mL – may not be used for potable supply except with full water treatment, which incorporates filtration and activated carbon. *Source:* Appendix 3, *Implementing the NSW Algal Management Strategy,* (SACC 1996). *Note: New information may soon be available which may lead to a revision of these criteria.*
Turbidity	Site-specific determinant.
Salinity (electrical conductivity)	<1500 µS/cm > 800 µS/cm causes a deterioration in taste.
Faecal coliforms*	0 faecal coliforms per 100 mL (0/100 mL)
Total coliforms*	95% of samples should be 0 coliforms/ 100 mL throughout the year. Up to 10 coliform organisms may be accepted occasionally in 100 mL. Coliform organisms should not be detected in 100 mL in any two consecutive samples.
Dissolved oxygen	> 6.5 mg/L (> 80% saturation)
pH	6.5–8.5
Chemical contaminants	See ANZECC (1992) guidelines, section 4.2.2.

* Values given are ANZECC criteria for raw waters before disinfection or clarification. Raw waters can have concentrations of faecal coliforms above the ANZECC criteria, even in pristine ecosystems. Slightly greater faecal coliform or total coliform contamination, may therefore be acceptable in raw waters that are to be disinfected before delivery to the consumer. (Faecal coliform criteria used in Victoria have suggested that for raw waters requiring only low-level treatment, natural background levels of 95% of samples should have <10 faecal coliforms/100 mL. For high-level treatment, 95% of samples should have <100 faecal coliforms/100 mL.) For a full discussion of drinking water system management and criteria, see the *Australian Drinking Water Guidelines* (NHMRC & ARMCANZ 1996).

Supporting information

- The focus is on improving the quality of raw drinking water sources to protect public health and minimise treatment costs. In some cases, this will require controlling or removing pollutants from dedicated drinking water subcatchments, from upstream of river offtakes and from groundwater systems used for drinking water.
- Protection of zones upstream of raw water or reservoir inlets is essential, but may be feasible only over limited distances. The location and size of offtake zones will need to be defined based on further local community consultation. Upstream conditions will also need to be considered (e.g. existing land use, pollutant sources, climatic and river flow factors).
- The existence of an offtake zone acts as an indication of the need to protect drinking water at the point of supply and to identify upstream threats to those supplies.
- Some waterbodies used as a raw drinking water source may provide water of high quality that needs only disinfection before use. These waterbodies should be regarded as having a high environmental value and should be protected.
- Many town water supplies rely on pumping groundwater from aquifers or river alluvium.
- Water quality tests for faecal coliform bacteria are used as an indicator of the possible presence of human pathogens. Improved tests are being developed.
- Note that the National Health and Medical Research Council is currently considering the introduction of criteria for *Cryptosporidium* and *Giardia*.

Aquatic foods (cooked)

Refers to protecting water quality for safe consumption of foods taken from natural waterbodies.

(In the *Australian Water Quality Guidelines for Fresh and Marine Waters* (ANZECC 1992), this environmental value is called Human Consumers of Fish, Crustacea & Shellfish.)

Where the objective applies

- The objective applies to all waters where aquatic foods are taken for commercial or non-commercial harvesting.

Key indicators and their numerical criteria

Indicators of water quality listed in ANZECC (1992) guidelines to monitor safe eating of aquatic foods are summarised in the following table.

Aquatic foods	
Indicator	Numerical criteria
Algae & blue-green algae	No guideline is directly applicable, but toxins present in blue-green algae may accumulate in other aquatic organisms.
Faecal coliforms	Median faecal coliform bacterial concentration should not exceed 14 MPN/100mL; <10% of samples to be >43 MPN/100 mL i.e. most probable number of organisms in 100 mL, if eaten raw. Under the NSW Shellfish Quality Assurance Program (NSW SQAP), water for shellfish culture should have a medial faecal coliform level of 14 faecal coliforms/100mL. These guidelines are applicable for direct harvest and sale of shellfish. The NSW SQAP has identified this standard as a target for all shellfish culture waters in NSW.
Chemical contaminants	Where criteria for ecosystem protection given in section 2.1 of the ANZECC (1992) guidelines do not provide adequate protection for the human consumer, refer to criteria provided in section 2.5, table 2.11. Tainting substances that may affect the palatability of the food sources are summarised in ANZECC (1992) guidelines, table 2.12.

Note: More detailed information on bacterial standards relevant to commercial shellfish production is available from the NSW Shellfish Quality Assurance Program. Water quality guidelines specified under the Australian Shellfish Sanitation Program and the National Shellfish Sanitation Program, USA, have been adopted.

Supporting information

- Indicators and criteria relevant to protecting the growth and reproduction of fish, crustaceans and shellfish are generally those discussed under WQO *Aquatic ecosystems* (see the beginning of Section 4).
- There is a need to identify all aquatic food sources to ensure that appropriate management is in place to protect the human consumer.
- The condition of the waterway must be suitable for both individual species and their habitats and must protect consumers from chemical contaminants that may accumulate in the tissues of aquatic foods or from human pathogens. Many waterways in NSW produce aquatic foods that are suitable for eating after cooking.
- NSW Health should be consulted about issues that have a direct public health impact and concerns about the safety of aquatic foods should be brought to the attention of local Public Health Units.
- The potential for members of the public, including those in Aboriginal communities, who gather shellfish for subsistence or non-commercial purposes to be exposed to pathogens by eating raw shellfish needs to be considered.
- NSW Health recommends against the consumption of raw shellfish harvested on a non-commercial basis. All such shellfish should be thoroughly cooked to kill pathogens and minimise the risk of food poisoning. Cooking cannot remove algal toxins or chemical contaminants.
- The potential presence of microbial pathogens (faecal bacteria, viruses, *Cryptosporidium*), algal and biotoxins and chemical contaminants needs to be considered when assessing the risks associated with shellfish consumption.
- Commercial shellfish production requires good water quality. Estuarine water quality and shellfish monitoring for indicators of faecal pollution are of paramount importance in assuring shellfish quality and public health. In addition, an understanding of the catchment and actual and potential pollution sources that may impact on the water quality is essential.
- The NSW Shellfish Quality Assurance Program aims to ensure that shellfish are taken from estuarine water to be sold for human consumption only if:
  - the shellfish meet the quality standards specified in or under the program; and
  - those waters meet the environmental standards specified.
- NSW Shellfish Quality Assurance Program has surveyed each estuary in NSW and mapped actual and potential pollution sources. On the basis of this information, a strategic sampling program, incorporating routine and event sampling, has been implemented in each of the 30 estuaries where commercial shellfish production occurs in NSW.
- The NSW Shellfish Quality Assurance Program monitors all sampling results, has established harvest criteria for shellfish, monitors shellfish post-depuration (quality control), instigates formal closures of areas to shellfish harvesting under adverse conditions and is responsible for re-opening estuaries to shellfish harvesting when conditions are appropriate.
- Water quality tests for faecal coliform bacteria are used as an indicator of the possible presence of human pathogens. Improved tests are being developed.

Industrial water supplies

The high economic value of water taken from rivers and lakes for use by industry needs recognition in water quality planning and management. It has been identified as an important environmental value through community consultation. *Australian Water Quality Guidelines for Fresh and Marine Waters* (ANZECC 1992) provides guidance on the water quality needed for various industries.

As industry water supply needs are diverse, relevant water quality criteria are not summarised here. Sources of water used for industry invariably have other environmental values, which mostly need water of a higher quality than that needed by industry. Further, individual industries are more prepared to monitor and treat the available water resources to meet their own needs.

5 Interim river flow objectives explained

This section explains each of the interim river flow objectives (RFOs). The RFOs for each part of the Clyde River and Jervis Bay catchments are listed in Section 3.

In total, there are twelve coastal river flow objectives, each dealing with a critical element of natural river flows and estuarine processes.

Flow patterns in many rivers have been significantly altered and will not return to natural flow regimes. The NSW Government is not attempting to restore completely natural flow patterns where the community benefits significantly from altered flow patterns. Communities and the Government have identified important areas where we can make adjustments to maintain or improve river health while continuing to benefit from water use.

Water management plans (WMPs) will contain integrated actions and timeframes to achieve objectives and implement identified actions in consultation with the community. Different approaches and outcomes will apply across different parts of the catchment.

Recommending variations to objectives

Water management committees (WMCs) may recommend alternative or additional actions and refinements to numerical targets.

Protect pools in dry times

Protect natural water levels in pools of creeks and rivers and wetlands during periods of no flows

During dry times, some streams stop flowing and form pools. Pools and wetlands are refuges for aquatic plants and animals. Pumping water from these areas can make it more difficult for many species to recover after a drought.

Measures to achieve objective

- There should be no water extraction from streams or wetlands in periods of no flow.
- If conditions on water licences do not provide for meeting this objective, priority goes to implementing it by actions appropriate to local circumstances.

Supporting information

- Along with social and economic considerations, the Department of Land and Water Conservation and the WMCs need to define when and how to protect specific pools:
  - — in natural wetlands with licensed pumps
  - — in streams where water flows under the sediment surface
  - — where these pools have become deeper or shallower.
- Where water extraction for stock and domestic use is high (e.g. in rural subdivisions surrounding large urban centres), WMCs may seek community views and recommend actions to protect the environment in periods of no flow.

Protect natural low flows

Protect natural low flows

Water extraction and storage are high in dry times and impose long artificial droughts that increase the stress on aquatic plants and animals.

Measures to achieve objective

- Share low flows between the environment and water users and fully protect all very low natural flows.
  - — Very low flows: defined as flows below the level naturally exceeded on 95% of all days with flow.
  - — Low flows: defined as flows below the level naturally exceeded on 80% of all days with flow.
- Unless environmental, social and economic evaluations give an appropriate alternative, the following limits on water extraction apply:
  - — Environmental share in high-conservation-value streams: to be all or most of very low flows. There should be no increase in extraction of low flows.
  - — Environmental share in other streams: to be all of very low flows; and 50%–70% of daily low levels.
- New or transferred licences should not allow extraction during low flows below the 80th percentile.
- In streams with little water use, or with important conservation values, minimise risks to ecosystems during low flows.
- Review management of town water supplies to assess whether changes may help achieve the objective without significantly affecting reliability.

Supporting information

- Management plans for waterways need to identify actions to achieve targets for each stream that will balance local environmental, social and economic considerations. Based on such assessments, WMCs may recommend amended targets to the Minister for the Environment and the Minister for Land and Water Conservation.
- In streams where extraction currently exceeds 50% of low flow, WMCs will need to find means to achieve targets, in consultation with water licence holders and others affected. Where extraction is currently less than 30% of low flow, it should not be allowed to exceed 30%.
- Town water supplies will not need to be augmented to meet this objective. If augmentation is proposed for other reasons, appropriate levels of protection of low flows should be determined on a case-by-case basis.
- In urban streams, the changes made to the natural low-flow regime are generally unknown. Streams may be wetter than natural because of garden watering in the catchment. Alternatively, if inputs to groundwater are reduced, streams could be drier than natural during dry times. Site-specific studies and comparison with undeveloped streams would be needed to determine the amount of change.

Protect important rises in water levels

Protect or restore a proportion of moderate flows ('freshes') and high flows

Rain causes peaks in river flows. This 'pulsing' of flows, and their duration, may trigger migration of animals and reproduction of plants and animals; provide over-bank flows to wetlands and floodplains; shape the river channel; and control water quality and nutrients. Water storage and extraction can alter or remove freshes, inhibiting these vital processes. The height, duration, season and frequency of higher flows are all important.

Measures to achieve objective

- Unless local information suggests appropriate alternative targets, use the following limits on extraction:
  - — No extraction of more than 30–50% of moderate to high flows on a daily basis. (This means that, for each stream, the WMC should recommend an appropriate limit on the proportion of flows that may be extracted whenever flows are greater than the level that would naturally be exceeded on 80% of all days with flow. For some streams this limit may be 30%; for other streams it may be as high as 50%.)
  - — No increase in extractions from high-conservation streams.
- Where use exceeds the above limit, develop appropriate ways of limiting the volume or controlling the timing of extraction.
- In areas of new development, ensure that stormwater is managed in such a way that there is no increase in the height or flow rate of high flows.
- In areas of existing development, explore opportunities for improving stormwater management to mitigate flooding.

Supporting information

- These targets are currently being met in many streams, particularly those with low water extraction.
- Management plans need to include appropriate actions to achieve this objective that will balance environmental, economic and social considerations. WMCs may recommend variations from targets, if there is a demonstrated need.
- High flows may cause flooding, which is a significant community concern. Mitigation requires both better stormwater management (increased detention and infiltration) and planning to avoid the problem (relocating houses and infrastructure from flood prone areas and preventing new development in these areas.
- Adequate management of stormwater is easier in new developments. It may be costly and more difficult to retrofit in existing developed areas.
- All councils in this catchment are required to develop stormwater management plans under the Urban Stormwater Management Program.

Maintain wetland and floodplain inundation

Maintain or restore the natural inundation patterns and distribution of floodwaters supporting natural wetland and floodplain ecosystems

Floodplain and wetland ecosystems develop in response to flow patterns and the nature of the landscape between the river and the wetlands or floodplains. Floodplain works can change the flooding patterns, which will then lead to changes in habitat and vegetation. These changes can be expected to reduce or change the diversity and abundance (or both) of species in the ecosystem. In particular, they can lead to reduced numbers of native fish and to water quality problems.

Measures to achieve objective

- In management plans and actions for waterways, include strategies to:
  - — maintain, restore or mimic natural inundation and drying patterns in natural and semi-natural wetlands and remaining native floodplain ecosystems
  - — ensure adequate access for native fish to and from floodplain wetlands.
- Flooding patterns should not be altered without proper environment assessment.

Supporting information

- This objective needs to be implemented in only a few locations.
- Maintaining wetlands and floodplains will improve water quality and reduce downstream flooding.
- Property protection issues need to be taken into account.

Mimic natural drying in temporary waterways

Mimic the natural frequency, duration and seasonal nature of drying periods in naturally temporary waterways

In urban areas, the preponderance of hard-surfacing (e.g. paved or concreted areas) and garden-watering can cause streams and wetlands to be 'wetter' than natural. In streams and wetlands that would dry out naturally if these impacts were absent, this can create problems in maintaining habitat and vegetation, nutrient cycling, and signals for breeding. It can also lead to a high watertable and associated salinity problems. Natural wetting and drying cycles produce diversity of habitat and, therefore, high species diversity.

Measures to achieve objective

- Identify any streams where unnatural flows have greatly reduced drying-out periods. Assess the potential short- and long-term environmental, economic and social effects of this change, and of possible management alternatives.
- Decide what (if any) action is appropriate to implement this objective in streams and wetlands on a case-by-case basis, after giving due consideration to local views.

Supporting information

- This objective is being met in most or all the streams.
- There are few streams where drying periods differ significantly from natural conditions. In urban streams, the change to the natural low-flow regime is generally unknown. Streams may be wetter than natural because of watering in the catchment; alternatively, if inputs to groundwater are reduced, streams could be drier than natural during drying times. Site-specific studies and comparison with undeveloped streams would be needed to determine the change.

Maintain natural flow variability

Maintain or mimic natural flow variability in all streams

Australia's rainfall and river flows are naturally variable. The way we currently store and divert river water can reduce natural pulsing of water down rivers and maintain artificially high or stable river heights. In urban areas and other places where the ability of the land to absorb or detain rainfall is reduced, more water runs off rapidly, so water levels will rise higher. These changes often create problems with streambank stability, biodiversity and signals for breeding and migration.

Measures to achieve objective

- Identify streams with unnatural flow variability and develop actions to mimic natural variability.
- Identify streams or development proposals with potential to have or cause flow variability problems, and take early action.

Supporting information

- Changes in variability occur mainly in controlled rivers, but may occur in certain locations or situations in other streams, such as in urban streams. In these areas, the objective should be addresses through stormwater management plans.
- This objective may also affect the achievement of water quality objectives.
- This objective is being met in most or all streams in this catchment.

Maintain natural rates of change in water levels

Maintain rates of rise and fall of river heights within natural bounds

Unnaturally fast changes in water level can occur in creeks with hard-surfaced catchments (such as in urban areas) or in streams that receive large releases from dams too quickly. If water levels fall too fast, water does not drain properly from riverbanks and they may collapse. Migration of aquatic animals may also be restricted by such sudden falls in river height. Very fast increases in flow and stream height can endanger people or aquatic organisms and contribute to bank erosion.

Measures to achieve objective

- Identify locations where water levels often rise or fall faster than they would naturally. Identify the reasons (in urban areas, usually the result of increases hard-surfacing) and impacts. Remedial action requires case-by-case assessment.
- Identify potential problems and take early action.

Supporting information

- Local observations, such as bank erosion, may indicate a need for action.
- In urban streams, solutions may require increasing on-site detention or infiltration.

Manage groundwater for ecosystems

Maintain groundwater within natural levels and variability, critical to surface flows and ecosystems

Some shallow groundwaters are directly linked to flows in streams and wetlands. They may provide base flows in rivers during dry periods and may be primary sources of water for wetland, floodplain and riparian vegetation. Also, serious depletion of grounwater in dry times may lead to unnatural recharge of groundwater from surface waters during the next flow event. Lowering groundwater in many coastal areas may expose acid sulfate soils, which—in many coastal areas—may contribute to soild and water quality problems. Lowering groundwater levels may cause seawater to intrude into aquifers and wetland soils that previously held fresh water.

Measures to achieve objective

- Implement the State Groundwater Policy (DLWC 1997a, 1998b).
- Identify any streams or ecosystems that may depend on high groundwater levels, and assess whether impacts on these may be caused by changed recharge rates or excessive pumping.
- Identify areas where groundwater may be rising and likely to threaten ecosystems or surface water quality.
- Identify long-term trends or changes in groundwater levels that are likely to threaten ecosystems or the quality of ground- or surface-water.
- Determine appropriate action to keep changes in groundwater level within acceptable bounds.

Supporting information

- WMCs should identify areas and actions needed, particularly where there are threatened ecosystems.
- This objective also covers areas of acid sulfate soils, where draining can mobilise acid and toxic metals, affecting surface ecosystems.

Minimise effects of weirs and other structures

Minimise the impact of instream structures

Most instream structures (e.g. weirs) convert flowing water to still water, thus altering habitat and increasing the risk of algal blooms or other water quality problems. Barriers restrict the passage of plant propagules (e.g. seeds) and animals.

Measures to achieve objective

- Implement the NSW Weirs Policy (DLWC 1997b).
- Identify and take action to reduce the impact on native fauna of other structures that impede movement of water—e.g. floodgates, tidal barriers.

Supporting information

- The NSW Weirs Policy (DLWC 1997b) and weir review process will help set priorities and assess management options.

Minimise effects of dams on water quality

Minimise downstream water quality impacts of storage releases

Many dams release water from the bottom of reservoirs where temperatures and dissolved oxygen are low and nutrient concentrations are high. These differences in water quality can affect the river downstream for hundreds of kilometres. For instance, many native fish will not breed in colder water.

Measures to achieve objective

- Determine whether water quality from dam releases limits achieving WQOs in unregulated streams and develop appropriate actions.

Supporting information

- WMPs need consider this objective only in relation to those streams with dams or large weirs.

Make water available for unforeseen events

Ensure river flow management provides for contingencies

River systems can sometimes be affected by unforeseen or irregular events—such as algal blooms or the start of bird-breeding seasons. As river flows are a major determinant of many of these processes, we can sometimes alleviate a water-quality or environmental problem by better managing river flows.

Measures to achieve objective

- Current water licence conditions enable pumping to be suspended in the rare event that this may be necessary. WMPs should identify potential situations when such action may be warranted, as well as the steps to be taken to manage flows at these times.

Supporting information

- Protecting or mimicking elements of a natural flow regime is preferable to making water available for unforeseen events.
- Management plans need consider this objective only in relation to streams with significant water extraction or dams from which releases can be made.

Maintain or rehabilitate estuarine processes and habitats

Maintain or rehabilitate estaurine processes and habitats

Coastal lagoons, estuaries and river mouths often change naturally in response to storms or tides. Flood-mitigation structures, weirs and other works also affect estuaries by limiting tidal flow, changing salinity conditions or altering water levels. Development of estuarine areas can also disturb acid sulfate soil deposits, which may release large amounts of sulfuric acid and toxic metals into the estuarine environment.

Upstream management of rivers also affects estuaries and lagoons. Stormwater carries nutrients, organic matter and sediments. Scouring as a result of flooding can affect the opening and closing of river mouths. Reduced freshes and flooding in estuaries severely depletes food sources for estuarine species. These effects can contribute to a decline in the number and abundance of species that use estuaries as habitat, nursery grounds or both.

Measures to achieve objective

- Adequate environmental assessment is necessary to determine the optimal opening regime of coastal lagoons and lakes. Management in the longer term should require planning to reduce the risk of flooding, and management of catchment activities to improve water quality.
- Dredging beyond the minimum needed to maintain navigation channels should be subject to environmental assessment before being allowed to proceed.
- Minimise draining or disturbance of areas of potential acid sulfate soils.
- Protect fish habitats—such as protected areas, seagrass beds and mangroves—from pollution and increased sedimentation or erosion. Polluted sites should be rehabilitated.
- Ensure that water-based activities have minimal impact on fish habitat.
- Deal with other processes affecting (or potentially affecting) estuary health—e.g. where increased urbanisation is proposed, ensure that impacts are avoided or minimised.

Supporting information

- Dredging or drainage could expose acid sulfate soils. As treatment of acid sulfate soils is expensive and relatively untested, the priority is to minimise exposure of these soils.
- Marinas and extensive moorings may affect water circulation patterns or aquatic habitats. This may expose acid sulfate soils and contaminated sediments, and affect the water quality and tidal flows generally.

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Glossary

Acid sulfate soils: include *actual acid sulfate soils* and *potential acid sulfate soils*. Actual and potential acid sulfate soils are often found in the same soil profile, with actual acid sulfate soils generally overlying potential acid sulfate soil horizons.

- actual acid sulfate soils: are soils containing highly acidic soil horizons or layers resulting from the aeration of soil materials that are rich in iron sulfides, primarily sulfide. This oxidation produces hydrogen ions in excess of the sediment's capacity to neutralise the acidity resulting in soils of pH of 4 or less when measured in dry season conditions. These soils can usually be identified by the presence of pale yellow mottles and coatings of jarosite.
- potential acid sulfate soils: are soils which contain iron sulfides or sulfidic material which have not been exposed to air and oxidised. The field pH of these soils in their undisturbed state is pH 4 or more and may be neutral or slightly alkaline. However, they pose a considerable environmental risk when disturbed, as they will become severely acid when exposed to air and oxidised.

Alien species: *See* Introduced species.

Allocation: The volume of water a licence holder is entitled to extract during a year, subject to licence conditions and availability. Currently, only licence holders on regulated rivers supplied by irrigation dams have an allocation. (*See also* Off-allocation flows)

Allocation reliability: The long-term probability (over wet, dry and average years) of irrigators with 'normal security' water allocations being able to get a certain proportion of their nominal allocation by a specified date.

Alluvial aquifer/groundwater: Groundwater (or sub-surface water) contained in the alluvial deposits near a river. It is usually directly connected to the river and therefore its level is closely related to river levels. Alluvial aquifers can be recharged directly from the river under high-flow conditions. Under low-flow conditions, alluvial aquifers can provide base flow in the river channel.

Anabranch: A stream that leaves the main stream and re-joins it further down.

Anoxic: Containing low levels of oxygen.

ANZECC: Australian and New Zealand Environment and Conservation Council.

Aquifer: An underground layer of soil, rock or gravel able to hold and transmit water. Bores, spear-points and wells are used to obtain water from aquifers.

ARMCANZ: Agriculture and Resource Management Council of Australia and New Zealand.

Bank slumping: The falling or slumping of a riverbank into the river. May occur due to removal of riparian vegetation, erosion or bank destabilisation. The term is used here to denote slumping resulting from a rapid decrease in river height, in which water drains more quickly from the river than it does from the banks, which then collapse under their own weight.

Billabong: A backwater channel, often formed by a cut-off river bend, that forms a lagoon or pool when river levels fall.

Billion: a thousand million.

Bioaccumulate: The process by which chemical substances are taken up by living things and retained and concentrated as they move up through the food chain.

Biodiversity (biological diversity): The variety of all life forms, comprising genetic diversity (within species), species diversity and ecosystem diversity.

Biota: All living things, including micro-organisms, plants and animals.

Blue-green algae (cyanobacteria): Naturally occurring, microscopic, primitive photosynthetic bacteria. Under certain conditions (including high nutrients, warm still water, strong sunlight into the water) they can bloom into a dense and visible growth and may become toxic.

Cap: A limit on the amount of water that may be diverted from the river for human uses, e.g. the Murray–Darling Basin Ministerial Council announced a cap on water use in the Murray–Darling Basin in 1995.

Catchment: The area of land drained by a river and its tributaries.

Channel capacity: The volume of water that can pass along the river channel at a certain point without spilling over the tops of the banks.

Confluence: The place where two or more streams flow together.

Contingency allowance: A volume of water reserved in a supply dam for release if and when needed for ecological and/or water quality reasons. For example, a release may be required to maintain water levels in a wetland to enable waterbirds to complete breeding, or to flush away an algal bloom.

Controlled streams: Streams where flow is usually controlled by upstream dams or diversion works, resulting in major changes to the natural flow patterns. These include regulated streams as defined in the *NSW Water Act 1912*, where water is released from storage to meet downstream irrigation needs.

Criteria: The recommended water quality limits for protecting water uses and values, derived from the evaluation of scientific data. Under the NWQMS, ANZECC criteria are the national reference levels.

Crustaceans: Invertebrate animals that have segmented legs and hard shells, e.g. crabs, yabbies, prawns.

Deoxygenated: With most or all oxygen removed. Water becomes deoxygenated (i.e. loses its dissolved oxygen) for a number of reasons including stagnation, eutrophication and rising temperatures.

De-snagging: The removal of fallen trees and dead branches from a watercourse.

Diatom: A type of very small algae that can be used as an indicator of water quality.

Dissolved oxygen: Oxygen in the water (which may be used by aquatic animals).

DLWC: NSW Department of Land and Water Conservation.

Draw-down(s): Volumes of water released or extracted from a pool or dam, thereby lowering the water level.

Dryland salinity: *See* Salinity.

Ecosystem: Any system in which living organisms and their immediate physical, chemical and biological environment are interactive and interdependent. Examples are ponds, forests and wetlands.

Effluent creek: A creek that leaves a watercourse and does not return to it (the opposite of a tributary). ('Effluent' in this sense has nothing to do with pollution.)

Electrical conductivity (or EC units): A measure of the ability of water to conduct an electric current between electrodes placed in the water; the value obtained relates to the nature and amount of salts present.

Environment: The *Protection of the Environment Administration Act 1991* sets out a meaning of 'environment' as: 'Components of the earth, including:
(a) land, air and water
(b) any layer of the atmosphere
(c) any organic or inorganic matter and any living organism
(d) human-made or modified structures and areas, and includes interacting natural ecosystems that include components referred to in (a)–(c).'

Environmental flows: Flows, or characteristics of the flow pattern, that are either protected or created for an environmental purpose.

Environmental impact statement: A document which describes a proposed development or activity, predicts the possible or certain effects of the activity on the environment, and outlines safeguards to mitigate or control environmentally damaging effects.

Environmental standard: A quantifiable characteristic of the environment against which environmental quality may be assessed.

Environmental valuation: Technique employed to estimate the worth of an environmental resource from the perspective of society as a whole in the absence of prices.

Environmental value: A particular value or use of the environment that is conducive to public welfare, safety or health, and which requires protection.

Ephemeral: Temporary or intermittent, for instance a creek or wetland that dries up periodically.

Escherichia (*E.*) *coli*: A type of faecal coliform bacteria (see below) which is found in large

numbers in the faeces of humans and other mammals. It serves as a reliable indicator of recent faecal contamination of water.

Estuary: The part of a river in which water levels are affected by sea tides, and where fresh water and salt water mix.

Euphotic depth/zone: The lit region of a body of surface water. This extends from the surface down to the deepest level at which there is sufficient light for photosynthesis to occur.

Eutrophication: Excessive levels of aquatic plant growth (including algae) resulting from raised levels of nutrients and other factors.

Extraction: Water taken from rivers for off-stream use or for consumption.

Faecal coliform: A type of bacteria found in faecal material of humans and other mammals. Faecal coliforms themselves generally do not make people sick. High levels indicate that water is likely to contain other micro-organisms that make people sick.

Fish ladder or fishway: A structure designed to enable fish to move over a physical barrier (dam or weir) in a waterway.

Flood channel: A natural channel in a floodplain, which carries flowing water only during a flood.

Floodplain: Flat land beside a river that is inundated when the river overflows its banks during a flood.

Floodrunners: Channels that run with water only during floods and very high flows.

Floods: Flows that are high enough at their peak to overrun river banks or cause flow through high-level anabranches, floodrunners or to wetlands.

Flow regime: The pattern of flow in a river which can be described in terms of quantity, frequency, duration and seasonal nature of water flows.

Freshes: Flows that produce a substantial rise in river height for a short period, but which do not overrun the river banks or inundate areas of land.

GMC: Groundwater Management Committee.

Great Artesian Basin: A vast, very deep store of underground water below much of the drier regions of eastern Australia.

Groundwater: Underground water filling the voids in rocks; water in the zone of saturation in the earth's crust.

Habitat: The type of environment in which a given animal or plant lives and grows, including physical and biological conditions.

Hard-surfacing: A hard, generally impermeable surface placed over soil—e.g. concrete or bitumen.

Headwaters: The small streams on the higher ground of a catchment, which flow into a river.

High flows: Higher than normal flows, which occupy much of the river channel or which overrun banks. In these guidelines, high flows in the middle and lower reaches of rivers are those that are greater than the level that long-term records indicate would naturally be exceeded 30% of the time (i.e. the 30th percentile).

High-security water use: Licensed entitlement to a more secure water supply than under normal-security licences, e.g. for horticulture and town water supplies.

Hydrographic shape: Describes the flow pattern of water, for example, after a short storm or runoff from prolonged rain.

Hydrology: The study of the distribution and movement of water.

Indicator (e.g. water quality, biological, ecological): Any physical, chemical or biological characteristic used as a measure of environmental quality.

Introduced species: Species of plants or animals that are not native to Australia (also referred to as exotic or alien species).

Invertebrates: Animals without backbones, including worms, insects, shrimps, crabs, snails, shellfish and zooplankton. Macroinvertebrates are large enough to be seen without the aid of magnification; microinvertebrates need to be viewed through a microscope.

Irrigation salinity: *See* Salinity.

Levee: A constructed embankment to prevent a river overflowing.

Low flows: Flows that occupy only a small portion of the river channel. Low flows would normally occur when there is little contribution to the river from rainfall events. For the purposes of the river flow

objectives, the low flow is defined as the flow which occurs less than 20% of the total time that the river is flowing.

Macrophyte: A plant large enough to be seen without the aid of a microscope.

Median: The median is the middle value in a data set ranked from lowest to highest.

Megalitre (ML): One million litres (one Olympic swimming pool is approximately 2 ML).

Microbiological quality: In these guidelines, refers to the quality of water in terms of the level of disease-causing organisms it contains.

Multi-level offtake: An offtake structure within a dam, which can take water from various depths, rather than just one. For instance, if the offtake is only at the bottom of the dam, releases of water may be cold, deoxygenated and nutrient-rich. A multi-level offtake allows releases to be made from upper layers where water quality is often better.

Natural flow regime: The likely pattern of flow before European settlement in Australia. In these guidelines, natural flow regime refers to the flow patterns without any regulation or extraction of water.

NHMRC: National Health and Medical Research Council.

Non-point source pollution: *See* Point-source pollution.

NRHP: National River Health Program.

NTU: Nephelometric turbidity unit (a unit of measurement for turbidity).

Nutrients: Nutritional substances. Unnaturally high levels of nutrients, such as in a river below a sewage treatment plant, can encourage abnormally fast and prolific growth of algae in the water, or weed growth in the bush.

NWQMS: National Water Quality Management Strategy. A joint initiative of the state and federal governments, to pursue sustainable use of the nation's water resources by protecting and enhancing their quality while maintaining economic and social development.

Off-allocation flows: Water that has not been released from storage, but comes from dam spills and/or inflows from tributaries below the dam. Licence holders are permitted to extract water from these flows but water so extracted is not debited against their allocation.

Off-allocation period: When access to flows (dam spills or tributary inflows downstream of dams) is permitted by licence holders without debit against their allocated volume. The DLWC announces the start of an off-allocation period, usually when flows are greater than are needed to meet on-allocation orders.

Offtake structure: A structure or point of diversion for water transfer. For instance, water is released from a dam via an offtake structure (*see also* multi-level offtake).

On-allocation: Water ordered by a licence holder and which will be debited against their actual allocation.

Pathogen: Disease-causing organism.

Percentile: In these guidelines, usually refers to flow duration curves. The horizontal scale of the graph is divided from 0 to 100 percentiles (or per cent of time), while the vertical scale is flow rate (often in ML/day). For example, when looking at flow rates, the 90th percentile is the daily rate that is exceeded on 90% of days at a specific location. If the 90th percentile is 13 ML/day, then the stream flow would be *higher* than 13 ML/day for 329 days per year, and *lower* for 36 days per year.

Point-source pollution: A single, identifiable source of pollution, such as a drain from an industrial site or sewage treatment plant (as opposed to non point-source or diffuse-source pollution—coming from many small sources over a large area).

Potable water: Water fit for human consumption.

Propagules: Parts of a plant (such as seeds, roots or stems) from which new plants can germinate.

Precautionary principle: The principle that the lack of scientific certainty should not be a reason to postpone preventive measures to avert threats of serious or irreversible environmental damage.

Pulsing supply: A strategy to reintroduce variability to releases of water from dams; introducing pulses of flow below dams allows a more natural flow pattern.

Ramsar Wetlands: Wetlands of international importance listed under the Ramsar Convention. To be put on the register, a wetland has to fulfil certain criteria—such as being important to the

survival of migratory birds or endangered plant and animal species.

Raw water: Surface or groundwater that has received no treatment to make it suitable for drinking.

Recharge: Water that infiltrates through the soil surface to the watertable.

Recharge in-take bed: Areas like sandstone hills or gravelly river banks, which prolonged rainfall or high flows seep through to refill an underground waterbody.

Regulated: A river or creek where water is released from storage to meet diversion requirements downstream.

Regulator: A structure used to control the flow of water, for example, diverting water away from the main channel down an effluent creek.

Riffle: A shallow area of the river in which water flows rapidly over stones or gravel.

Riparian zone: The area along the bank of a river or a stream, which often has water-dependent vegetation.

River alluvium: Material deposited by a flood.

RMC: River Management Committee.

Sag: 'Dissolved oxygen sag'—a section of the river where dissolved oxygen levels are depleted, often below a pollution source.

Salinity: The concentration of salts in soil or water, including sodium chloride (NaCl). Dryland salinity is caused by clearing deep-rooted vegetation on areas of saline watertables. The uptake of water by plants is reduced, allowing the watertable with soluble salts to rise, killing plants and creating bare areas prone to erosion. Irrigation salinity occurs when irrigation raises the watertable, bringing high concentration of salt within root zones of plants, killing and stunting vegetation. It results from applying more water than can be used by the crop and by clearing of deep-rooted vegetation such as trees. Urban salinity is when rising watertables cause damage to infrastructure such as roads, underground pipes, houses and gardens. Urban salinity has been identified in NSW in 26 inland towns and in western Sydney.

Spear-point: A shallow bore inserted in soft sediments to draw up water.

State Environmental Planning Policy (SEPP) 14: NSW Government policy to ensure that the coastal wetlands are preserved and protected; prepared under the *Environmental Planning and Assessment Act 1979*.

Stressed river: Assessment made by the Department of Land and Water Conservation that determines appropriate management strategies for water allocation and flow management in uncontrolled streams. A classification based on environmental and water-use criteria.

Stratification: Distinct layers of water in a dam or weir pool, formed when there is little movement to cause intermixing—usually in summer when deeper layers of water become cold and deoxygenated. These changes may, in turn, induce other water quality changes.

Surface water: Water on the surface of the land, for example in rivers, creeks, lakes and dams.

Suspended solids: The smaller, lighter material such as clay, silt and fine sand carried in suspension in water.

Sustainable: (As applied to water resource management.) Management that will meet current needs while conserving natural ecosystems so they can also meet future needs.

Target (water quality): A level of water quality to be achieved in a specified time frame as a step towards the desired long-term objectives. It is derived from comparing available water quality data/information with the water quality objectives, and considers social and economic factors.

Top-release (of water): Better-quality water released from the top layers of a dam.

Tributary: A river or creek that flows into a larger river.

Turbidity: A measure of the amount of the light-scattering properties of water. It indicates how much silt, algae and other material is suspended in water. Highly turbid waters may look muddy, stain clothes, block irrigation sprays and pipes or harm aquatic organisms.

Uncontrolled streams: Streams that are largely free of structures that control flow, such as major dams.

Urban salinity: *See* Salinity.

Variability: The likelihood of variation or change. High variability of river flows means that stream height at any one place can change substantially over time. Variability is determined by catchment size, number of tributaries, slope and climate. Overall, Australia has extremely variable rainfall and river flows. River management for consumptive uses has decreased variability.

Watertable: The upper surface of a groundwaterbody.

Water quality goal: A desired water quality outcome to help develop strategies for managing human activities that may affect the environment. Under the NWQMS, a chosen suite of environmental values for a catchment would constitute the water quality goals for that catchment.

Water quality objective: Numerical concentration limits or requirements established to support and protect the designated environmental values of water at a specified site. Under the NWQMS, they are the locally established benchmarks for water quality derived from the *Australian Water Quality Guidelines for Fresh and Marine Waters* (ANZECC 1992).

Weir pools: The water held back by a weir, forming a still pool. Where the land is very flat, such as in western NSW, a weir can cause very long pools to form. For example, Maude Weir on the Murrumbidgee River is 6 m high and creates a weir pool 35 km long.

Wetland: Land inundated with temporary or permanent water that is usually slow moving or stationary, shallow, can be fresh, brackish or saline, and where the inundation affects the plant and animal communities and the type and productivity of soil.

WMC: Water Management Committee.

WMP: Water Management Plan.

water

Water Quality and River Flow
Interim Environmental Objectives