Australian Government

National Land & Water Resources Audit

An initiative of the Australian Government

NUTRIENTS IN AQUATIC ENVIRONMENTS

INDICATOR HEADING

Phosphorus

INDICATOR PROTOCOL

Total phosphorus + flow leaving a sub–catchment or whole catchment

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Endorsed

This protocol has been endorsed by the National Land and Water Resources Audit Advisory Council. Version 1 – June 2008. The indicators will need to be further developed as identified within the protocol.

www.nlwra.gov.au

Status of indicator agreement

The National Land & Water Resources Audit (the Audit) coordinates the collation of data to support reporting on natural resource condition required under the National NRM Monitoring and Evaluation Framework (National M&E Framework).

The National M&E Framework identifies three requirements for monitoring natural resource condition:

- a set of resource condition indicators to measure progress toward the agreed national outcomes on a medium and long term basis
- a set of indicators for monitoring community and social processes relevant to or affected by NRM programs, as well as measures of the adoption of sustainable development and production techniques
- contextual data pertinent to the indicator being considered.

The Audit Advisory Council has agreed to a process for achieving a practical set of indicators under the National Monitoring and Evaluation Framework.

This process is to:

- obtain on-going **recommendations** from the relevant **National Coordination Committees** for each thematic area (including "Matters for Target") on appropriate indicators, protocols and information needs
- seek **endorsement** from the **Audit Advisory Council** that the indicators and protocols can be implemented at the national, state / territory and regional levels
- seek **agreement** from the Natural Resource Policies and Programs Committee (**NRPPC)** (or the Marine and Coastal Committee –**MACC**- for Estuarine, Coastal and Marine) that the indicators will be used and promoted by jurisdictions to underpin evaluations of NRM initiatives.

The NRPPC and MACC report to the Natural Resource Management Ministerial Council (NRMMC).

Indicator protocol: Phosphorus in aquatic environments

Matter for target:

Nutrients in aquatic environments.

Indicator heading:

Nutrients in aquatic environments: phosphorus.

Indicator name:

Total phosphorus + flow leaving a sub-catchment or whole catchment.

1. Definition

Total phosphorus in the aquatic environment measures the concentration (in µg/L) of all phosphorus in the sample, the molecular form of which is dependent upon whether the sampled system is marine, estuarine, riverine or wetland. Total phosphorus (TP) is the sum of the concentrations of all forms of phosphorus expressed as µg/L present in the water, including those that are not immediately available for biological uptake.

It may be useful or appropriate to measure particular components of TP, particularly in some environments:

- **Wetland and estuarine systems**: filterable reactive phosphorus (FRP) is the concentration of phosphorus in (µg/L) remaining as phosphate (PO_4^{-3}) in the water after filtration of the water sample through a standard 0.45 micron membrane filter paper.

2. Rationale

2.1 Why do we want to know it?

Phosphorus is an essential element required by animals and plants and high levels of phosphorus can be an important contributor to eutrophication – especially in freshwater and estuarine systems. Symptoms of eutrophication may include algal blooms and seagrass decline.

Phosphorus in aquatic systems is generally partitioned into particulate (organic and sediment-bound) and dissolved fractions. Dissolved phosphorus (measured as FRP) is found in the form of phosphate ions (H_2PO, HPO^{2-}) and may be readily taken up by aquatic plants and micro-organisms.

Particulate phosphorus enters stream channels primarily through riparian litter fall, soil erosion and sediment transport. The concentration and load of particulate and dissolved forms of phosphorus in waterways reflect the stresses imposed by land uses and land practices in the catchment.

2.2 Context in which it has been measured with regard to national, state and regional resource management programs

TP is a primary water quality indicator because:

- phosphorus may limit or can boost aquatic primary production (e.g. algal bloom) in rivers and estuarine systems in which they are found, at least for some part of the year;
- it represents the maximum amount of phosphorus that may become available for biological uptake;
- when coupled with streamflow it can be used to estimate the export rates of phosphorus in receiving estuary systems; and
- it is often routinely sampled as part of most monitoring programs in Australia.

FRP is an important water quality indicator for **wetlands and estuarine systems** because:

- in these systems, the availability of soluble phosphorus may limit primary production and excessive levels may cause eutrophication;
- chemical analysis for FRP is relatively easy to undertake (whereas the method for analysing for TP requires the handling of hazardous chemicals and is best undertaken in specialised laboratories); and
- where system phosphorus processing is understood and sources are known, long-term increases in FRP may provide an early warning indicator of pending ecological disturbances, such as that arising from nutrient enrichment.

An understanding of the relationship between flow and phosphorus concentrations, coupled with phosphorus cycling is critical in order to interpret concentrations and loads in order to make management decisions to protect environmental values. Without this understanding, changes in phosphorus concentrations and loads may be more attributable to variable flow regimes and biological factors rather than any management actions.

In many circumstances, phosphorus is not considered to be a primary water quality indicator in **groundwater** although it can be a useful measure in some situations. For example, in areas with very sandy soils, the use of fertiliser containing water soluble phosphorus may result in increased phosphorus levels in shallow groundwater. Where management actions have been implemented to address this problem, the level of phosphorus in shallow groundwater can be used to measure their effectiveness.

3. Monitoring methodology

3.1 General Guidelines

Consultation with the relevant state and territory agencies that are responsible for the management and monitoring of stream gauging stations is recommended for advice on the measurement of flow. The Australian Hydrographers Association can also be contacted for further information on this issue (see <www.austhydro.tascom.net/branches.html>).

Water quality monitoring is the systematic and careful collection and analysis of samples, in situ observations and measurements with the aim of providing information and knowledge about a body of water and the factors affecting it. A monitoring program is carefully planned, audited and reviewed to ensure its objectives are achieved.

- The primary reference for methods of determining the concentrations of the various forms of phosphorus is the *Standard Methods for the Examination of Water and Wastewater 20th edition* (APHA 1998).

- The National Water Quality Management Strategy (NWQMS) provides the basis for water quality management in Australia. The strategy includes:
    - the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC & ARMCANZ 2000a); and
    - the *Australian Guidelines for Water Quality Monitoring and Reporting* (ANZECC & ARMCANZ 2000b).

These documents can be downloaded from
>http://www.environment.gov.au/water/quality/nwqms/

The preparation of a monitoring program should use or be compatible with NWQMS guidelines and include the steps outlined in *Volume 7 – Australian Guidelines for Water Quality Monitoring and Reporting (2000)*. These steps are summarised below.
(Note: all references relate to ANZECC & ARMCANZ 2000b unless otherwise stated.)

3.2 Data measurement method

All field sample collection, handling, storage and processing should meet established protocols. The field sampling component needs to consider specific data requirements such as measurement parameters, scale and frequency of sampling and the accuracy and precision of the data required. Preservation and storage requirements should be identified. Quality assurance and quality control (QA/QC) issues and procedures should be identified (see below for further information). Occupational health and safety should also be addressed throughout each phase of the monitoring program.

Laboratory analysis should produce accurate and precise data that can meet the requirements of the monitoring program. Selection of analytical methods often depends on the information required by the investigation and the substances to be analysed. There are standard analytical methods for analysing samples from the water column, sediments and biota and many of these have been referenced in the NWQMS monitoring guidelines. Adequate QA/QC procedures should also be developed or used to ensure that the data generated from the analyses are precise, accurate and reliable. Occupational health and safety needs consideration in dealing with laboratory analyses.

TP is measured by photometric means (Molybdenum-Blue method of Murphy and Riley – see APHA 1998). This procedure is somewhat hazardous because of the use of perchloric acid to digest or convert organic and insoluble inorganic phosphorus to soluble forms. An alternative method is provided in APHA (2001). Such analyses should be conducted by laboratories registered with the National Association of Testing Authorities (NATA).

Measuring FRP is fundamentally the same analytical procedure as above, but does not entail the perchloric acid digestion phase. The water sample is filtered prior to analysis, hence only soluble phosphorus (PO_4^{-3}) is measured by colour change with the reagent. Organic forms of phosphorus may be estimated by subtracting FRP from TP.

3.3 Data storage and management

Responsibilities for storing and managing data and information collected, collated and reported by regional groups should be negotiated with the relevant regional and/or state/territory authorities. In principle, however, data should be maintained and be readily accessible for state and national reporting, and stored and managed in accordance with nationally agreed policies and guidelines established by the Spatial Information Council of Australia and New Zealand (ANZLIC). The custodians of these specific datasets would be the relevant authorities at state/territory level.

3.4 Data analysis and interpretation

Data analysis is a fundamental component of the monitoring program. It should be appropriate to meet the stated objectives. A suite of statistical analysis techniques and packages that ranges from descriptive statistics (e.g. mean and median), analysis of variance through to regression and multivariate type analyses is available for undertaking data analysis. The type of analysis required will be determined by the objectives of the monitoring program and may be limited by the data collected. While not an exhaustive reference, the NWQMS monitoring guidelines provides guidance on the use of common statistical methods. Complex studies may require advice from a professional statistician who should be engaged from the beginning of the design phase of the monitoring program.

3.5 Reliability, validity and quality assurance

Quality assurance and quality control (QA/QC) procedures are essential components of all phases of the monitoring program. They help to anticipate and avoid likely errors and problems and ensure that the data collected are of a known quality.

QA is the implementation of checks on the success of the quality control and includes managerial activities, staff training, data validation, and audits of laboratory and data analysis and management (Table 1; ANZECC & ARMCANZ 2000b; NCSU 2000).

QC is the implementation of procedures to maximise the integrity of monitoring data and includes procedures for proper collection, handling and storage of samples, replicate samples, inspection and calibration of equipment, analysis of blank or spiked samples and use of standards or reference materials (ANZECC & ARMCANZ 2000b; NCSU 2000). To control or minimise sampling and processing errors a QA/QC protocol should be developed and used for each component of the monitoring program. Common QA and QC activities are outlined below.

Table 1. Common quality assurance and quality control activities.

Quality assurance activities	Quality control activities
• Assignment of roles and responsibilities • Determination of the number of samples required to obtain data at a certain confidence level • Tracking sample custody from field to analysis • Development of data quality objectives • Auditing field and laboratory operations • Maintenance of accurate records • Training of personnel in sampling techniques and equipment use	• Duplicate samples • Analysis of blank and spike samples • Using replicate samples • Regular calibration of equipment • Inspection of reagents

3.6 Metadata

Metadata statements should be consistent with current ANZLIC guidelines - see http://www.anzlic.org.au/policies.html (click Metadata protocol and standard metadata profile [PDF: 99pp, 705kb]). The ANZLIC standard now uses a profile of the international ISO 19115/ANZS19115 standard.
http://www.osdm.gov.au/osdm/docs/resources/mwg_aus_gov_profile.pdf)

4. Reporting / information products

4.1 Proposed responsibilities.

When targets are set as part of the planning process it is also necessary to ensure that effective monitoring arrangements will be available. This does not mean that the regional body setting the target has to undertake the actual monitoring itself although it could choose to do so. In many cases the most cost-effective and efficient option will be to use existing monitoring programs being undertaken by state or territory agencies or similar bodies. Consideration should be given to who will have responsibility for the following activities:

- data collection;
- data collation;
- data analysis and interpretation;
- generation of reporting products; and
- data storage and management.

4.2 Products

Reporting requirements to meet the National Monitoring and Evaluation Framework have been recommended by the Executive Steering Committee for Australian Water Resources Information. They fall into three main categories,

1. National – information presenting a national (whole of Australia) viewpoint.
2. Regional / Catchment – information presenting regional or catchment viewpoints.
3. Point – information presented from a specific point (recording station).

Development of national products based on a collation of state/territory datasets will require consultation with relevant state/territory-based authorities to address issues of cross-border difference and other issues, in order to develop a uniform and seamless dataset.

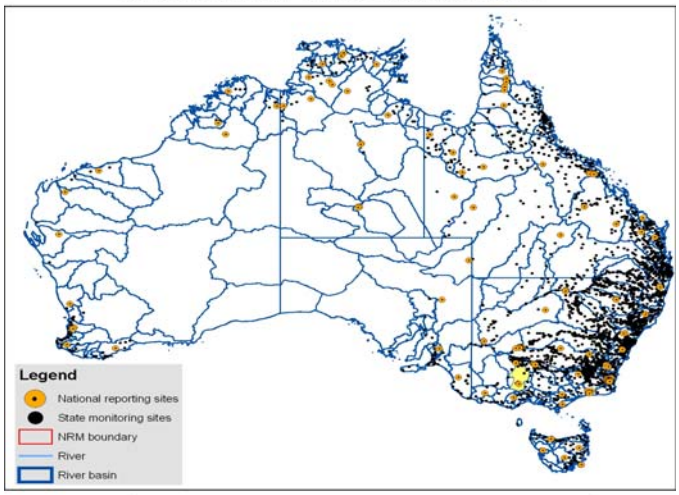
4.2.1 National

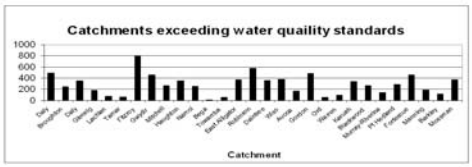
It is recommended that the following National products be made available annually:

- Locations (map and / or table) of all monitoring site locations (representing a part of the monitoring infrastructure);
- Locations (map and / or table) of active sites and metadata statements regarding the period of monitoring of data relevant to this indicator; and
- Locations of sites that will be used to monitor (actual or modelled) end of valley or end of catchment export rates (National M and E sites). Note that each river site has an associated catchment upstream of the site – and the amount of nutrient passing that point could be considered as “leaving the catchment”. To assess overall nutrient export from a river basin (multiple catchment) estimations using modelling may be required.
- National maps indicating total export rate for regions and or catchments and exceedance of any specified levels/targets or water quality guidelines (NLWRA 2000). Jurisdictions and regions will identify those points at which targets are being set. Reporting period should be negotiated with jurisdictions to take into account priority areas and capability.

Examples of the types of products recommended for development for reporting under the National Monitoring and Evaluation Framework are identified in the following figures.

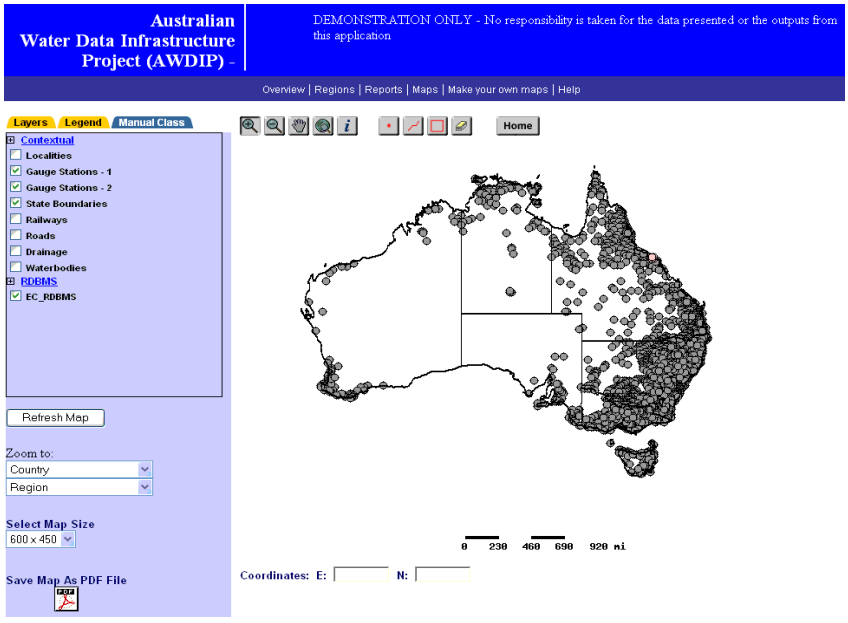
National Information

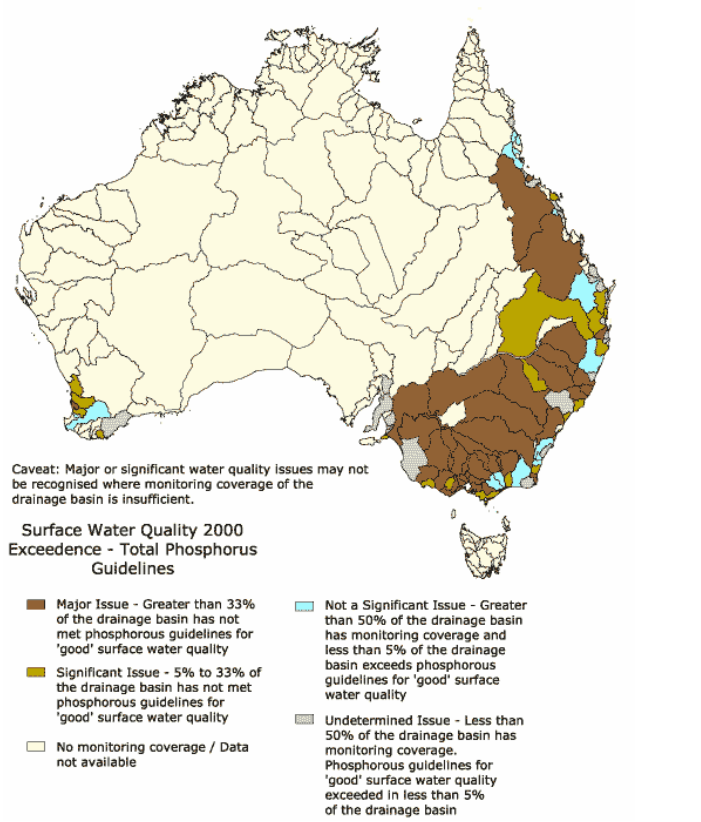




Text box

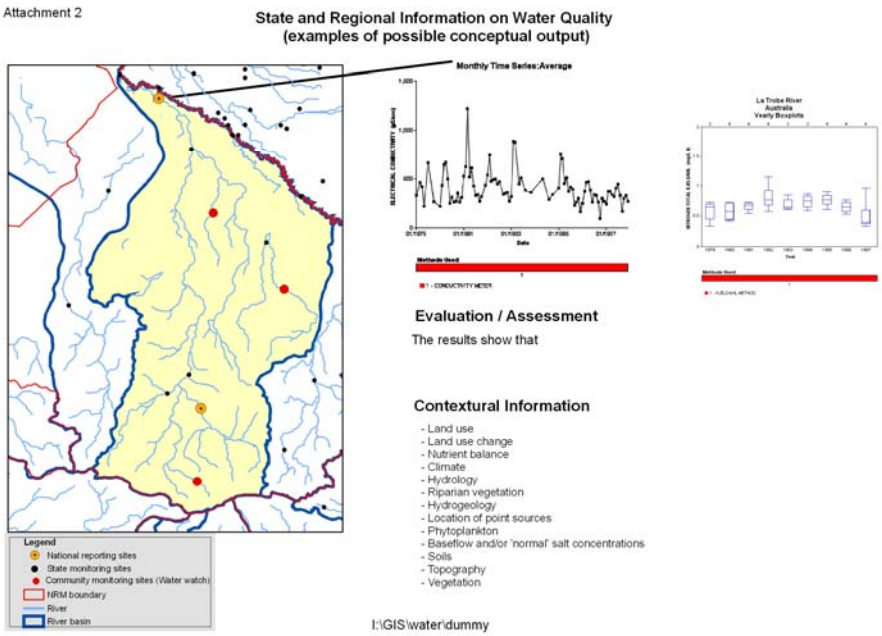
Australia's estimated total water supply in 1996/97 was 80,363 Gigalitres (GL) - of this supply 85% was "self extracted", 14% as mains supply, and <1% as effluent reuse. In addition, some 49,480 GL was supplied as regulated discharge (ABS Water Account, 2000).





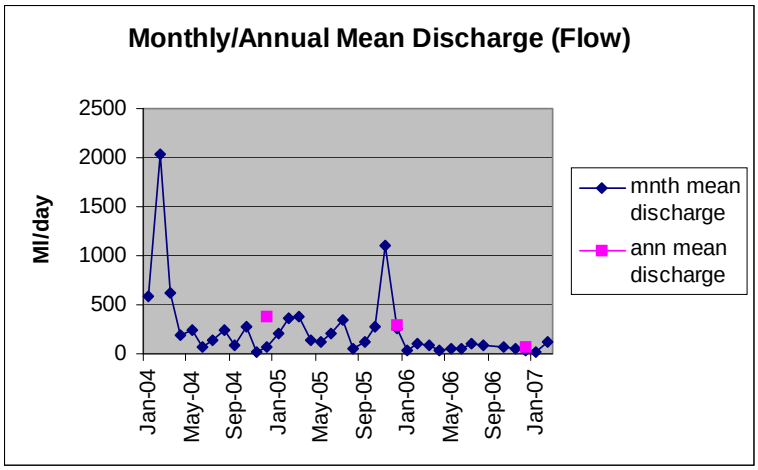
4.2.2 Regional/Catchment

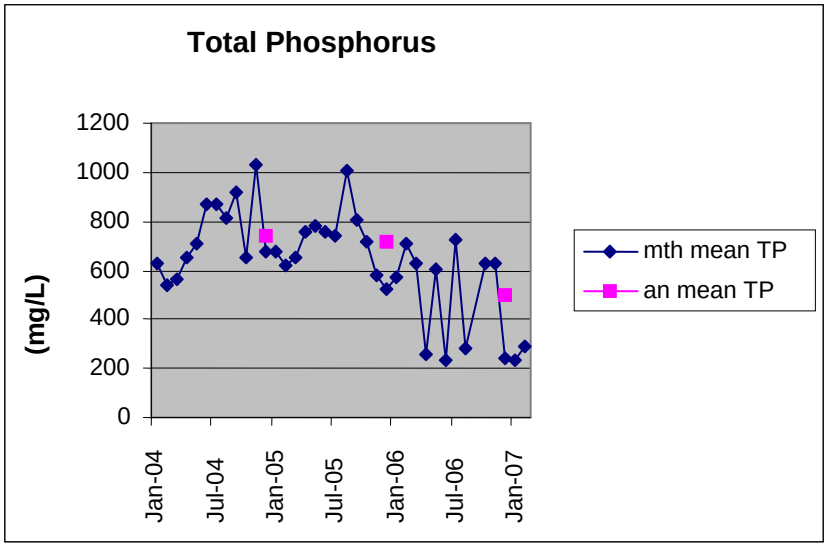
Regional products need to clearly identify the catchment or sub-catchment for reporting and will include regional summaries tailored closely to the type of region. Note that for reporting under the NMEF, there needs to be a sampling point or a modeled point that can be used to identify total nutrient leaving a catchment.



4.2.3 Point

Information that could be presented that would be useful for reporting under the NMEF would be monthly and annual mead discharge as information related to flow. Annual reporting - on a moving five year average – would be considered adequate. Whilst the capacity to report depends on the type of data recording station and the frequency of collection, the aspiration aim would be to be able to report monthly.





4.3 Confidentiality

The majority of this data should be publicly available and would therefore have no confidentiality risk. Maintenance of data which does carry a confidentiality risk will be the responsibility of the custodian of the data (e.g. the relevant management authority at state/territory level responsible for monitoring and reporting water information) and would only be made available under licence.

4.4 Data access and storage

Currently data is available from jurisdictionally managed databases. The Australian Water Data Infrastructure (AWDI) is a framework for accessing a network of distributed hydrological databases. The framework will enable on-line access to data sets via a network of distributed jurisdictional databases. This technology will be available to emerging water information systems as they become operational (for example the Australian Water Resources Information System proposed by the National Water Commission and being implemented by the Bureau of Meteorology).

It is proposed that National information be made available via the AWRIS and that it be reported with other indicator information under the National Monitoring and Evaluation Framework through the Australian Natural Resources Atlas (Australia's Resources Online - ARO). The National Land and Water Resources Audit has developed ARO is an internet application which will provide access to national collations of the most up-to-date

information to support reporting on the condition and trend of Australia's natural resources.

The National Water Commission has developed specifications for a set of tools that will access information published through a distributed water data infrastructure to deliver future water resource assessments. The Australian Water Resources Information System will be further developed and maintained by the Bureau of Meteorology into an integrated national water information system, including river flows, groundwater levels, reservoir storage, water quality, water use, water entitlements, water allocation announcements and water trades. AWRIS will be used to deliver annual national water resource assessments and an annual national water account. It will also enable public queries on the state of Australia's water resources at any time.

5. Future development

This indicator will need to be reviewed as legislative needs and policies develop, particularly related to the future development of the AWRIS and the water information standards being developed by the Bureau of Meterology.

6. Links to other indicators

This indicator is also relevant to river condition and wetland ecosystem condition because water quality is a component of the measure of condition of these environments.

7. Further information

Australian and New Zealand Environment and Conservation Council & Agriculture and Resource Management Council of Australia and New Zealand (ANZECC & ARMCANZ). 1994, *Policies and Principles: A Reference Document*, National Water Quality Management Strategy Paper No. 2, ANZECC & ARMCANZ, Canberra.

—— 2000a, *The Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. National Water Quality Management Strategy Paper No 4, ANZECC & ARMCANZ, Canberra, <www.ea.gov.au/water/quality/nwqms/index.html>.

—— 2000b, *Australian Guidelines for Water Quality Monitoring and Reporting*. National Water Quality Management Strategy Paper No 7, ANZECC & ARMCANZ, Canberra, <www.ea.gov.au/water/quality/nwqms/index.html>.

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