Water Resources Environmental Flow Guidelines 2013

Disallowable Instrument DI2013-44

made under the

Water Resources Act 2007, section 12 (Environmental Flow Guidelines)

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1 Name of instrument

This instrument is the *Water Resources Environmental Flow Guidelines 2013.*

2 Commencement

This instrument commences on the day after it is notified.

3 Notification

Notice is hereby given that under section 12 of the *Water Resources Act 2007* the Australian Capital Territory Environmental Flow Guidelines 2013 at Attachment A are approved.

4 Revocation

DI 2006-13 notified on the legislation register on 6 February 2006 is revoked.

Simon Corbell MLA
Minister for the Environment and Sustainable Development
15 April 2013

Australian Capital Territory

Environmental Flow Guidelines

(2013)

Executive summary

The Environmental Flow Guidelines are an instrument under the *Water Resources Act 2007* that set out the environmental flow requirements needed to maintain aquatic ecosystems. The Guidelines have been developed using the most up to date scientific information available, and will be used with Water Resource Management Planning instruments, Water Sharing Plan and Water Management Areas to manage ACT water resources. Environmental flows, for the purposes of the *Water Resources Act 2007*, are specified in Table 3 of Section 5 for each ecosystem category and each specific reach. The Environmental Flow Guidelines apply to all rivers, streams, lakes and ponds in the ACT. The 2013 Environmental Flow Guidelines replace the 2006 Environmental Flow Guidelines.

Purpose of environmental flows

Environmental flows are the flows of water in our streams, rivers and impoundments that are necessary to maintain aquatic ecosystems.

We rely on our waterways for a range of functions including biodiversity and conservation, irrigation and domestic water supply. Waterways need to be healthy to provide these functions. The natural flows in ACT streams are highly variable. Rivers and streams naturally have periods of both very low and very high flows. Flows in our streams also vary seasonally with the higher flows usually occurring in the spring months. The Environmental Flow Guidelines need to identify those components of flow from this variable flow regime necessary to maintain stream health. One way to do this is to specify environmental flows that mimic the flows that would occur naturally. In more heavily used systems such as water supply catchments it may be necessary to protect specific components of the flow regime to keep aquatic ecosystems healthy. In highly modified ecosystems, the environmental flows needed to ensure critical processes occur and provide habitat, may be very different to the natural flow regime that occurred before development.

Components of environmental flows

To account for natural variability, the Environmental Flow Guidelines include protection of particular components of the natural flow. These are:

- base flow;
- small floods (riffle maintenance flows);
- larger floods (pool or channel maintenance flows);
- special purpose flows; and
- impoundment drawdown level.

The base flow is the flow component contributed mostly by groundwater, and is the minimal volume of water that the stream needs to support the fish, plants, insects, and protect water quality. The volume of the base flow is determined for each month for each stretch of stream or river.

The purpose of the small and larger floods, termed riffle, pool, and channel maintenance flows, is to move out sediment deposits and maintain channel form. The movement of sediment is important for maintaining healthy aquatic ecosystems. Riffles are the shallow fast flowing sections of the river. The riffle maintenance flows scour out fine sediment that accumulates in riffles, damaging these habitats for fish, water plants and other aquatic life. The pool and channel maintenance flows scour sediment from pools and ensure the river maintains its natural channel form.

Special purpose flows are flows designed for a particular ecological need, for example the flow needed to encourage breeding of a species of fish, or to protect habitat of a frog species. The Guidelines make provision for special purpose flows should they be identified. However no special purpose flows are currently specified in the Guidelines.

Impoundment drawdown levels are the levels that a reservoir, lake or pond needs to be kept within, so that impacts on macrophytes, sediment processes and water quality do not result in adverse changes to the state of the ecosystem. Static impoundment levels can result in a limited fragile ecosystem dominated by a few species of flora and fauna even though the biomass can be high. Excessive fluctuations in impoundment levels can result in a denuded barren water body that supports little biomass and low biodiversity.

How environmental flows are provided

In the ACT environmental flows are provided in one of two ways: either by releases or spills from dams, or by putting restrictions on the volume of water that can be abstracted from a water management area. In the ACT the volume of water available for abstraction within each water management area is limited to the volume remaining after environmental flow volumes have been provided. Abstraction rules are also applied to ensure that licensed abstractors do not impact on waterways during critical flow events such as very low flows, flooding flows or cause excessive drawdown levels.

Ecological objectives for environmental flows

Setting ecological objectives for waterways allows specific ecological values to be protected by components of the environmental flow regime. In addition, ecological objectives can be used to assess the effectiveness of environmental flows, and the information used to refine the Guidelines.

The ecological objectives and indicators of these objectives identified in the Guidelines are based on the Territory Plan, ACT legislation, Commonwealth threatened species legislation, ACT Government policies and knowledge gained from research. As an example, an ecological objective for the Cotter River reach between Bendora Dam and Cotter Dam is to maintain populations of the endangered fish species Macquarie Perch. An indicator of success in meeting this objective is that more than 40 fish are captured in a standard monitoring effort.

Environmental flows in water supply catchments

In the water supply catchments a balance between environmental needs and consumptive needs has to be made in the Guidelines to ensure that there is adequate supply of water for domestic consumption. At the same time, there is a requirement to maintain the health of the rivers, and in particular to protect the two endangered fish species that live in the Cotter River. The environmental flows that are recommended for the water supply catchments are based on the extensive information about environmental flows in the Cotter River. Flows specified for these catchments are the minimal requirement for healthy aquatic ecosystems, while ensuring that both water supply and conservation objectives can be met. This approach is appropriate for these catchments as the intensive monitoring of the system allows adaptive management to be implemented if adverse effects are detected.

Special rules for drought periods have also been specified for these catchments. The Guidelines recognise that during dry times when the urban population faces water restrictions, it is appropriate that environmental flows also be reduced.

Environmental flows in urban catchments

Urbanisation has caused considerable modification to the streams flowing through urban areas. The increase in impervious surfaces, including roads, roofs and car parks, has caused a higher rate of runoff than occurred naturally. In addition urban watering has led to many urban streams now having unnatural permanent flow. Increased flows in urban streams can stress aquatic ecosystems. For urban streams, the Guidelines identify the natural baseflow and channel maintenance flow that should be protected, and recommends that the additional runoff from urban development be made available for abstraction. This serves the dual purpose of protecting streams from the effects of frequent short duration high flows, and allows more use of second-class water in the urban area.

Environmental flows in other catchments

Environmental flow requirements are also set for streams in natural ecosystems, such as those within Namadgi National Park and Tidbinbilla Nature Reserve, and in modified ecosystems in rural ACT. The Guidelines for these systems are designed to protect the base flow and also protect most of the volume of flood flows that are necessary to maintain the channel form. In these catchments limiting the quantity of water that can be abstracted protects environmental flows.

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1 INTRODUCTION

1.1 Background

Increasing demands for the allocation of water for off-stream uses has resulted in substantial changes in the streamflow regimes in many streams across Australia. These changes in streamflow have contributed to major impacts on aquatic habitats and ecology. In some Australian streams, allocation of water for off-stream uses can exceed total flow resulting in patterns of flow that reflect the rights of water users rather than the requirements of the streams and their ecological processes. Consumptive uses are often given priority, as water rights, entitlements, and licences have legal and commercial status. With the growing use of market forces as the basis of resource allocation, there is a need to ensure that environmental quality and ecological requirements are not disadvantaged.

Over the past decade there has been an acceptance of the need to give explicit recognition to environmental flow needs through the establishment of water entitlements for the environment. Similarly, it is accepted that there is a relationship between surface and ground water and that ground water abstraction will impact on base flows of surface streams. These environmental entitlements should be based on the best available scientific information, to protect the health and viability of the river systems and groundwater basins.

Many aquatic ecosystems in the ACT are modified as a result of changes in land use, changes to river channels and floodplains, streamflow diversion, discharges to streams, introduction of flora and fauna, and recreational fishing. Some of these systems, particularly urban lakes and streams, have been so modified that they have been categorised as *created ecosystems* and as such are highly valued in their own right. Other aquatic ecosystems are in a condition close to that prior to European settlement.

Depending on the condition of a stream and the environmental values specified for that stream, the planning and management issues in respect to environmental flows vary from:

- managing streamflow diversion and discharges so as to maintain the current status of the aquatic ecosystems; to
- managing streamflow diversion and discharges so as to restore aquatic ecosystems to a standard to meet the community's environmental values.

It should be recognised that the guidelines for environmental flows in this document are based upon the best scientific knowledge available at the time they were drafted. The determination of environmental flows is an active research field and this document will be refined and amended as the knowledge base grows.

1.2 Purpose of the guidelines

These Guidelines are a statutory instrument to be used when determining volumes in the Water Sharing Plan and in the regulation of water abstraction. Environmental flows, for the purposes of the *Water Resources Act 2007*, with respect to each ecosystem category and specific reaches within are specified in Table 3 of Section 5.

1.3 National responsibilities

The *Intergovernmental Agreement on the Environment (1992)* sets out clear guidance on land use decision and approval processes to ensure development is ecologically sustainable. *The National Strategy for Ecologically Sustainable Development (1992)* sets the goal of Ecologically Sustainable Development (ESD) as 'development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends'. When applied to ecosystems this core objective is expressed as 'protection of biological diversity and the maintenance of essential ecological processes and life support systems'. These guidelines have been prepared with these principles in mind.

In line with the ESD precautionary principle, the ACT environmental flow guidelines are conservative and may need to be reassessed in light of further knowledge and experience. In water supply catchments a smaller safety margin is accepted on the basis of our better understanding of such streams, and in recognition of the importance of the water supply function of these catchments.

The ACT is also party to the 1994 and 1995 Competition Policy and related reforms agreements. These include the COAG agreement on the strategic framework for the efficient and sustainable reform of the Australian water industry. Amongst other things, this requires the setting of environmental flow requirements based on the best available scientific advice. The 2004 National Water Initiative confirms this requirement.

1.4 Statutory basis for environmental flows in the ACT

1.4.1 Water Resources Act

The preparation of environmental flow guidelines is a requirement of the *Water Resources Act 2007.* This Act has the objectives of:

- ensuring the use and management of water resources to sustain the physical, economic and social wellbeing of the people of the Territory, while protecting the ecosystems that depend on those resources;
- protection of waterways and aquifers from damage and, where possible, to reverse damage that has already occurred; and
- ensuring that water resources are able to meet the reasonably foreseeable needs of future generations.

To achieve these objectives the *Water Resources Act 2007 (The Act)* requires that Environmental Flow Guidelines be prepared to set out the flows necessary to maintain aquatic ecosystems in ACT waterways. The Act also requires the determination of areas (Water Management Areas) for managing the water resources of the ACT and requires that the amount of water available for taking from each area is determined. The Act further provides that the Environment Protection Authority may license the taking of both surface and groundwater from areas as provided for by the Water Sharing Plan and the Environmental Flow Guidelines.

1.4.2 Territory Plan

Implementation of the *Water Resources Act 2007* needs to be consistent with the Territory Plan. Three types of water use catchments are identified in the Territory Plan (Section 11.8 Water use and catchment general code); 'conservation', 'water supply', and 'drainage and open space'. These uses have been designated as the primary uses for the waterbodies within these types of catchment.

Within each of these catchments, secondary use values are also specified and include provision of recreational amenity, supply of potable or second class water, provision of aquatic habitat, and remediation of low quality urban stormwater (Section 11.8 of the Plan). Where several secondary uses are specified for a water body, that water body is to be managed to achieve the use with the most stringent requirements, so that other uses are not compromised by relaxation of standards.

Under the general principles and policies, the Territory Plan requires that planning be guided by the principles of ecological sustainability and exclude catchment land and water uses which impact on the sustainability of identified environmental or water use values. It is therefore necessary that appropriate flows be provided to protect the environmental and use values of ACT water bodies.

The Territory Plan explicitly requires that environmental flows be maintained to ensure that the stream flow and quality of discharges from all catchments protect environmental values of downstream waters. Four policies are elaborated to achieve this objective:

- land use and management practice shall be cognisant of streamflow and water quality impacts downstream;
- stream-flow diversions shall be restricted to authorised diversions;
- lake and reservoir releases shall be consistent with the protection of downstream ecology and water uses; and
- groundwater abstraction shall be consistent with authorised abstraction.

Implementing these policies necessitates defining quantitative environmental flow guidelines for all streams, rivers, lakes, and aquifers in the ACT and the control of abstraction of the volumes not required by the environment.

1.4.3 Supporting legislation and strategies

The objectives of the Territory Plan and the *Water Resources Act 2007* are supported and complemented by the provisions and strategies contained in the *Environment Protection Act 1997,* the *Nature Conservation Act 1980* and the ACT Nature Conservation Strategy 1998. The *Environment Protection Act 1997* provides support by the enforcement of water quality and chemical use standards. The *Nature Conservation Act* and ACT Nature Conservation Strategy support the conservation of native species, communities and habitats essential to the protection of the wellbeing of aquatic habitats.

The Environmental Flow Guidelines will also be complemented by Action Plan 29, 'Ribbons of Life' the Aquatic Species and Riparian Zone Conservation Strategy. The Strategy guides conservation and recovery of aquatic and riparian species in natural water systems.

1.4.4 National waters

These Guidelines include environmental flows for the Molonglo River downstream of Scrivener Dam and drawdown limits for Lake Burley Griffin. Lake Burley Griffin remains under the control of the Commonwealth and is managed by the National Capital Authority. Environmental flows for Lake Burley Griffin are recommended given the ACT's responsibility to protect ACT water resources upstream of Lake Burley Griffin including the Jerrabomberra Wetlands and the Molonglo River, as well as the Molonglo River downstream of Lake Burley Griffin. The role of these Guidelines are explicitly recognised in the Commonwealth's management of Lake Burley Griffin (National Capital Authority 2005). The Guidelines therefore specify environmental flows for all waterways lying within the ACT.

1.4.5 Paramount rights to Queanbeyan and Molonglo waters

By the Agreement between the Commonwealth and NSW for the surrender of territory by NSW for the Seat of Government, the Commonwealth gained paramount rights to the waters of the Queanbeyan and Molonglo Rivers and their tributaries (in NSW) for all the purposes of the Territory *(Seat of Government Acceptance Act 1909).* The Commonwealth has developed the waters of the Queanbeyan River for the purposes of urban water supply for the ACT through the construction of the Googong Dam. Through the Commonwealth *Canberra Water Supply (Googong Dam) Act 1974*, the Territory Executive exercises the rights to the waters of the Googong Dam Area and this includes any necessary releases from the Googong Dam. *The Canberra Water Supply (Googong Dam) Act 1974* also requires that environmental needs be taken into account in water resources management.

While the only NSW waters yet developed for ACT urban water supply are those entering Googong Reservoir, the remaining waters over which the Commonwealth has paramount rights (that is, the Molonglo River upstream of the ACT and Jerrabomberra Creek upstream of the ACT) are important for other ACT purposes, including the protection of aquatic ecosystems in the ACT. Without appropriate environmental flows entering the ACT from the Molonglo River and Jerrabomberra Creek the ACT may not be able to ensure appropriate environmental flows in these waterways in the ACT and further downstream in NSW. The determination and maintenance of flow requirements in these waters to protect environmental values is the responsibility of NSW, which is currently in the process of addressing this issue. However, to ensure protection of the Commonwealth's paramount rights to these waters under the *Seat of Government Acceptance Act 1909* for the purposes of the Territory, it is expected that water use be limited to that necessary to support stock and domestic purposes for traditional grazing enterprises and associated long established rural villages (or equivalent use). This is expected to ensure that adequate environmental flows into the ACT are maintained.

In this context, these guidelines only specify the environmental flows in NSW immediately downstream of Googong Dam as these flows are under the direct control of the ACT through regulation of releases.

At the time of development of these Guidelines NSW had not yet established environmental flows requirements in streams upstream and downstream of the ACT. The ACT ensures that environmental flow requirements in the rivers it has responsibility for are met by flows under the control of the ACT, principally water running off ACT land.

1.5 Review of the guidelines

Actual flows and their effect on stream structure and ecology will be the subject of an ongoing monitoring and evaluation program. Recommendations for monitoring and evaluation are provided in Section 6 Monitoring and Assessment. The program will be used to evaluate the effectiveness of the Guidelines. The first guidelines were published in 1999 and were reviewed after 5 years. The changes to the original guidelines focussed mainly on the setting of environmental objectives and adjustments to the flows in water supply catchments. Changes to the 2006 Guidelines provided a framework for accommodating climate change and aspects relating to updated water supply infrastructure. The Guidelines will be reviewed after a further five years of operation to determine if the ecological objectives specified are the most appropriate, and the environmental flows required achieve those objectives. The review may be conducted earlier if evidence indicates it is warranted.

2 DETERMINATION OF ENVIRONMENTAL FLOWS

2.1 Basis for determination of environmental flows

The concept of environmental flow is based on the recognition that aquatic ecosystems are adapted to natural flow conditions and modification of the flow regime will impact on the ecosystem. Additionally, the geomorphological structure of streams is largely determined by the flow regime, with flow-on effects on stream biota through changes to substrate type and available habitat. Flow regime refers not only to the quantity of water but also to the variability of flow and incidence of flood and low flow events. For long term viability of some ecosystems there may be a need for periods of low flow.

In practice it may be difficult to determine the effect of an 'environmental flow' component in isolation from other factors such as water quality. The environmental flows have been determined by relating the Territory Plan requirements to protect specific aquatic ecosystems with the scientific basis for sustaining significant ecosystems or species.

2.1.1 Advice on changes to guidelines

As part of the review of the 2006 Guidelines, assessment of the performance of the Guidelines and advice on potential changes was received from eminent aquatic ecologist Professor Terry Hillman. Professor Hillman's recommendations' are summarised below.

Recommendation 1. In the event that the delivery of environmental flows remains a challenge in the immediate future, specific investigations should be aimed at assessing the state of resilience of native fish populations (incl. age structure and recruitment) and selected macroinvertebrates with a view to determining the need and nature of special flow arrangements.

Recommendation 2. *H*ydrological data should be compiled in a form and timely manner that permits water managers to monitor progress towards compliance with the Guideline's flow rules and adapt management practise accordingly. This material should be available for audit in line with Government practise and consideration should be given to providing a summary report of compliance with the Guideline's flow rules annually as part of the ACT Water Report.

Recommendation 3. The performance monitoring program should be assessed with a view to more closely aligning it with the Ecological Objectives and proposed indicators set out in the Guidelines. This should lead to concise summary reports of performance data against ecological objectives in the annual ACT Water Report.

Recommendation 4. Consideration should be given to developing a program that investigates sediment dynamics in ACT streams, particularly deposition of sediment in key areas including known breeding habitats for native fish. This will lead to the establishment of a long term monitoring program.

Recommendation 5 . Compliance and performance monitoring should be undertaken to close the adaptive management cycle for urban lake drawdown and macrophyte maintenance. Where the volume of water potentially warrants the work, specific studies should be carried out that maps the bathymetry of a lake and the distribution of macrophytes and, on the basis of conceptual models describing the provision of human (including water supply) and ecological services by the lake ecosystem, develop a hydrological management plan that optimises those services. Execution of that management plan, and appropriate monitoring and evaluation, should, in time, form the basis of revised environmental flow recommendations for that system.

2.2 Economic and social issues

The primary purpose of Environmental Flows is to maintain aquatic ecosystems, however, the social, and economic consequences of the Environmental Flow Guidelines are also taken into account through two approaches. Firstly, the Guidelines recognise that there are different social and economic factors associated with the three types of water use catchments identified in the Territory Plan:

- Conservation;
- Water Supply; and
- Drainage and Open Space.

The Territory Plan policies for these catchments identify different social and economic values and priorities for these catchments. The Guidelines take account of these priorities in setting environmental flow requirements. For example, in Water Supply catchments, the primary value is domestic water supply, and in recognition of this a smaller safety margin for protection of aquatic ecosystems has been adopted to provide greater volumes of water for domestic supply. In Conservation catchments, the priority is on protection of natural resources and more conservative environmental flow guidelines have been set. Additionally, these Guidelines recognise that the economic and social importance of water can vary over time, particularly during periods of drought. The Guidelines accommodate this factor by changes to the environmental flow requirements during times of drought, balanced against the continuing need to also protect aquatic ecosystems during such critical periods.

Provision of environmental flows and protection of aquatic ecosystems and endangered species is a requirement under both ACT and national legislation, and is an obligation under national agreements to which the ACT is a party. With these fundamental obligations, the socio-economic implications of the revised Guidelines are most appropriately assessed by consideration of the changes from the 2006 Guidelines.

Social and economic issues identified through public submissions received during the consultation process have been taken into account in developing the Guidelines.

2.3 Water quality issues

Both water quality and water quantity characteristics have effects on ecosystems, and in some areas these are strongly interrelated. Although these environmental flow guidelines focus on water quantity, some water quality factors should not be ignored in this discussion. In particular, water quality problems can arise when water is released from impoundments to meet downstream environmental flow requirements. Water from the lower layers of deep, stratified reservoirs can have a much lower temperature and oxygen content than surface waters. If this bottom water is released to meet environmental flow requirements, its quality may compromise its value in the maintenance of aquatic ecosystems. For example most native fish species use both water temperature and flow as cues for reproduction, and the temperature of water released to meet an environmental flow requirement may severely disrupt spawning, migrations, and reproductive activity. In catchments where reservoir releases are made to meet environmental flow requirements, the water quality of the release is to match as closely as possible to that of the water flowing into the reservoir.

2.4 Impoundment release structures

Many dams in the ACT were built before environmental flows were identified and may not be best suited to meet the environmental flow requirements of these guidelines. In particular this relates to the temperature and flow variations to mimic natural conditions. Ideally the water released from a reservoir for environmental purposes should match as closely as possible the temperature of the water entering the reservoir or lake. The major water storage structures; Corin, Bendora, Cotter and Googong Dams all have the capacity to release water from a variety of depths and so inflow and release water temperature can be matched. In practice the depth from which water is drawn for environmental flow releases is often determined by the quality requirements for water supply, which are not always the same as the temperature requirements to protect downstream aquatic ecosystems. The current adaptive management process will continue to ensure that infrastructure will be managed so as to comply as closely as possible with the Guidelines.

The Guidelines do not require environmental flow releases from ACT urban lakes and ponds. These water bodies only have the capacity to release water by overtopping, or discharge through a valve at the base of the dam. Water in the bottom of these reservoirs is often of a lower quality and the release of this water would potentially compromise downstream aquatic ecosystems. However, any reductions in streamflow below and caused by the urban dams tend to have been compensated by the increased runoff from the urbanised area. The flows in urban streams downstream of impoundments in the ACT, generally have been at or above the specified baseflow (the 80^{th} percentile flow). The urban dams have been sized relative to their catchment for purposes of attenuating storm peaks and improving water quality so they are full the majority of the time. Medium flow events and floods entering the lake pass through and on down the river. Flows downstream of the lakes are also augmented by increased flows from downstream urbanised tributaries.

Similarly, Scrivener Dam on the Molonglo River, managed by the Commonwealth, does not have a multi-level off-take. Releases can only be made through a valve at the base of the dam, or by opening the dam gates. Under the Commonwealth Water Act 2007 control of Commonwealth water resources (including Lake Burley Griffin) in the ACT will be referred to the ACT Government. Following that referral the National Capital Authority and the ACT Government will together formulate how to meet environmental flow obligations both in Lake Burley Griffin in the Molonglo River downstream, whilst ensuring that Lake Burley Griffin fulfils its functions in the Parliamentary Triangle.

2.5 Augmentation of stream flows

Streamflow in the ACT is augmented above natural flow levels through various processes; urban runoff, water transfers and return to streams of treated wastewater. These changes can be detrimental to aquatic ecosystems.

In urban areas the increased stormwater runoff from roofs and roads can increase flow volume unnaturally and change flow variability, particularly in small streams. Urban runoff can also degrade streams as water is often of a lower quality. At the same time it needs to be recognised that the community values some urban streams because some now flow permanently in contrast to their prior natural condition.

Streams can be used to transfer water between water storages. ACT examples are the reach of the Cotter River between Corin and Bendora Reservoirs and a section of Burra Creek which will be used as a conduit for water abstracted from the Murrumbidgee River for storage in Googong Reservoir. Higher more constant flows can alter ecosystem processes resulting in a changed ecosystem because there is more water in the stream.

Discharge of treated wastewater is the other process that significantly augments river flows. The ACT diverts up to 65 GL a year for urban water supply. Of the amount diverted around 55% is returned to streams as treated wastewater. Downstream of the Queanbeyan and Lower Molonglo sewage treatment works on the Molonglo River there is a significant increase in base flows as a result of the return of treated wastewater to the river. Augmented flows are not necessarily of benefit to the aquatic ecosystems in these streams. Natural ecosystems are not adapted to the constant, high base flows that large sewage treatment plants discharge. In addition, contaminants such as nutrients and salt in the discharged effluent may compromise the value of return flows from sewage treatment plants to rivers.

Where streamflow is unnaturally augmented either by stormwater runoff or by sewage treatment discharge, reuse is encouraged within the sustainable abstraction limit for a subcatchment, so that streamflows more closely approximate those prior to urbanisation. Streamflow augmented by water transfers will need to be managed in a manner to minimise adverse effects and maintain the values of the stream.

2.6 Climate change

The water resources of southern and eastern Australia have been identified as one of our national resources most vulnerable to climate change (Bates 2010). Projected climate change in the coming decades will alter the hydrology of ACT streams in a number of ways which, in turn, may result in fundamental changes in the ecosystems those streams can support either in a pristine state or as modified by human intervention. It may also result in changes to human needs that, particularly combined with potential demographic and land-use changes, may alter the human impact on the ACT’s natural water resources. In sum these changes may alter the efficacy of the current environmental flow program and/or the capacity of the current monitoring program to reflect that efficacy.

Many of the indicators chosen to reflect the achievement of ecological objectives (the performance variables) are based on comparing specific biological observations with the same biological parameters under conditions of zero human hydrological impact – often referred to as “reference condition”. Reference condition can either be observed, by including control sites from pristine streams (e.g. Natural Ecosystems) in the monitoring program, or modelled using best available information. For the ACT the predominant biological assessment method is AUSRIVAS using macroinvertebrates. Reference sites in AUSRIVAS should be Band A with impacted sites being Bands B, C or D. It is reasonable to expect that climate change will affect both pristine and impacted sites – probably differentially – which will result in changes to the 'achievability' of ecological objectives *and* the measurement of progress towards achieving them. Significant response to climate change at reference sites would result in their having a biological condition less than pristine. This could result in one of three responses:

1. Maintain the modelled assemblages as the Ecological Objectives [implying an acceptance that 'pristine' sites are in impaired condition as a result of climate change but an intention to maintain managed sites in the 'historic' reference condition].

2. Accept the altered condition of the 'pristine' sites as the new reference condition and adjust the Ecological Objectives (indicators) accordingly.

3. Modify the models to reflect the post-climate change situation and retain the current indicators.

The third option is probably the most realistic as it acknowledges the reality of climate change but uncouples the flow management response from the response to climate change. It is important to note that there is no need for any of these responses (or to choose a response) unless and until the reference sites score is consistently lower than Band A. This is unlikely in the medium future under moderate climate change considering that:

- Reference sites have remained at or near Band A throughout the recent drought;
- The main monitoring indicator (AUSRIVAS macroinvertebrates) operates at Family level which may mask subtle changes in the macroinvertebrate assemblage; and
- A change of around 9% of total stream flow is not likely to invoke a significant change in AUSRIVAS scores unless it is expressed in substantial changes to some specific aspect of flow (e.g. seasonal pattern, duration of particular events).

Clearly, it would be sensible to continue the current program whilst paying particular attention to the performance of reference sites. To improve the sensitivity of this approach further reference sites might be added to the monitoring program.

If however, extreme climate change effects occur and ecosystems were to decline over time, as drought and other impacts overcome their resilience, and particularly if Natural Ecosystems decline (e.g. their macroinvertebrate communities consistently in 'sub-A' AUSRIVAS band), a more fundamental revision of the objectives within the Guidelines is called for. It may be necessary to review the type of aquatic ecosystems we are aiming to support/reinstate through environmental flow management as well as developing new arrangements that share the significantly depleted resource. This is an extreme response and need be considered only if the monitoring results show it is necessary.

2.7 Groundwater

Aquifers in the ACT fall into two types, aquifers in fractured rock and aquifers in alluvium. Both types of aquifers are relatively shallow and groundwater eventually discharges into lower sections of the catchment's waterways. Both aquifer types can support unique groundwater ecosystems however, at present the ecosystems in the ACT that are recognised as being groundwater dependant are small unregulated streams whose baseflow is primarily supplied by localised groundwater discharge.

Aquifers in alluvium generally have a more direct and rapid connection with surface waters whereas with fractured rock aquifers the connection between surface and groundwater may be less direct. In general, discharge from fractured rock aquifers will occur at the lower parts of the landscape, and the lower reaches of streams in a subcatchment will be the ultimate destination for the groundwater flow. Virtually all water that infiltrates to the groundwater system exits into the streams. Existing work on aquifers in the ACT suggest they are relatively shallow, their boundaries are expected to largely match the topography of the catchments that overlie them, and there is unlikely to be groundwater flow between catchments. Aquifers have low storage and so provide little buffering capacity against a sequence of years with low groundwater recharge. The extraction of groundwater in wet years will have an influence on baseflow in succeeding dry years. Abstraction of groundwater from both types of aquifers will ultimately affect surface water flows in streams. Consequently, the importance of joint consideration of surface and groundwater for water management policies in the ACT is clear.

The proportion of flow in the stream contributed by groundwater (baseflow), depends on the position in the catchment, and varies according to catchment characteristics. The baseflow contribution to streams also varies throughout the year, with baseflow contribution greater during winter and spring. This is a consequence of reduced evapotranspiration in winter and spring and reduced summer recharge. During summer when soil crusts tend to be hydrophobic, higher rainfall intensities generate larger amounts of surface water runoff and less groundwater recharge. Additionally, in dry years stream flow will tend to be dominated by baseflow. In the urban environment the baseflow is supplemented by drainage from garden watering and other activities.

As groundwater in both types of aquifers eventually discharges to streams, these Guidelines limit groundwater abstraction to ensure that there is no impact from groundwater abstractions on aquatic ecosystems. If groundwater abstractions are too high, the baseflow in streams will be significantly reduced. Although aquatic ecosystems are currently adapted to natural low flow and no flow periods, there is a high risk they will be negatively affected by ‘extended’ no flow periods.

2.8 Types of ecosystems

There have been extensive changes to land use in some parts of the ACT resulting in substantial changes to stream flow. Restoration of natural aquatic ecosystems is generally not practical. In recognition of this situation, aquatic ecosystems have been categorised into four broad types, in order to clarify differences in management goals and techniques that can be used to arrive at these goals (Table 1). These ecosystems are based on the water use catchments identified in the Territory Plan.

Different environmental flow requirements have been set for each of the types of ecosystem referred to in Table 1; natural, water supply, modified, and created. These requirements are discussed in detail in Section 3. For the purpose of setting environmental flow requirements major rivers and streams are divided into reaches delineated by major confluences, lakes or reservoirs. This procedure assumes that a degree of homogeneity applies within reaches and acknowledges that there are links between reaches of a river. Specific environmental flow requirements can then be determined for each reach. This procedure is applied to all river reaches.

Table 1: Types of aquatic ecosystems and their location

Category of Aquatic Ecosystem[1]	Description	Management Goal	Water Bodies[2] in this Category
Natural ecosystems (Conservation catchments)	Ecosystems that have persisted in a relatively pristine condition.	Primary goal: maintain aquatic ecosystems in their pristine state, Secondary goals: Range of functions including recreation.	Water bodies in Namadgi National Park, excepting the Cotter River catchment. Water bodies in Tidbinbilla Nature Reserve.
Water supply ecosystems (Water Supply catchments)	Ecosystems in catchments designated to provide the ACT water supply.	Primary goal: provide water supply, Secondary goals: Range of functions including conservation and recreation.	Water bodies in the Cotter River catchment. The Googong Foreshore Area and the Queanbeyan River downstream of Googong Dam.[3]
Modified ecosystems (Conservation catchments)	Ecosystems modified by catchment activities (land use change, discharges) or by changes to the flow regime.	Range of functions including recreation, conservation and irrigation.	All water bodies not included in the other three categories. Includes the Murrumbidgee and Molonglo Rivers, and Lake Burley Griffin.
Created ecosystems (Drainage and Open Space catchments)	Ecosystems in urban lakes, ponds and streams that have developed as a result of urbanisation	Range of functions including recreation, conservation and irrigation.	Water bodies within the urban area excluding the Molonglo River.

[1] Both the terminology used to describe aquatic ecosystems, for environmental flow purposes, and in the Territory Plan are provided. The ecosystems specified in the Territory Plan are in parentheses.

[2] Waterbodies include all streams, rivers, lakes, ponds, reservoirs, and aquifers.

[3] The Queanbeyan River and the Googong Foreshore are not identified as water supply catchments in the Territory Plan, but are considered water supply ecosystems for the purposes of setting environmental flow guidelines.

3 ENVIRONMENTAL FLOW APPROACH ADOPTED

A range of approaches has been used in Australia to establish environmental flow requirements. These include the holistic approach, the building block methodology, expert panel assessments and the habitat analysis model (reviewed by Arthington 1998). Different approaches have differing strengths and weaknesses, and information requirements. The holistic approach has a number of particular strengths:

- it recognises the natural flow regime as a guide to the flow requirements of a system;
- it takes the approach that the flow requirements of a system should be compiled from different flow components meeting different ecological objectives, and that this can be done using field methods, expert advice and using historical data;
- the approach considers the entire aquatic ecosystem rather than a single selected component; and
- it recognises that detailed ecological understanding is not available for many Australian rivers, and that an adaptive management process should be used to refine flow requirements.

Accordingly the holistic approach has been adopted for the setting of environmental flow guidelines in the ACT. This approach works by identifying the essential features of the flow regime, including the natural variability, seasonal variation, floods, and intermittent dry periods (See Figure 1). The influence of the flow components on the ecosystem components is identified, and when more information on flow requirements of particular ecosystem components becomes available e.g. fish spawning and specific flow volumes, it can be readily incorporated into the approach.

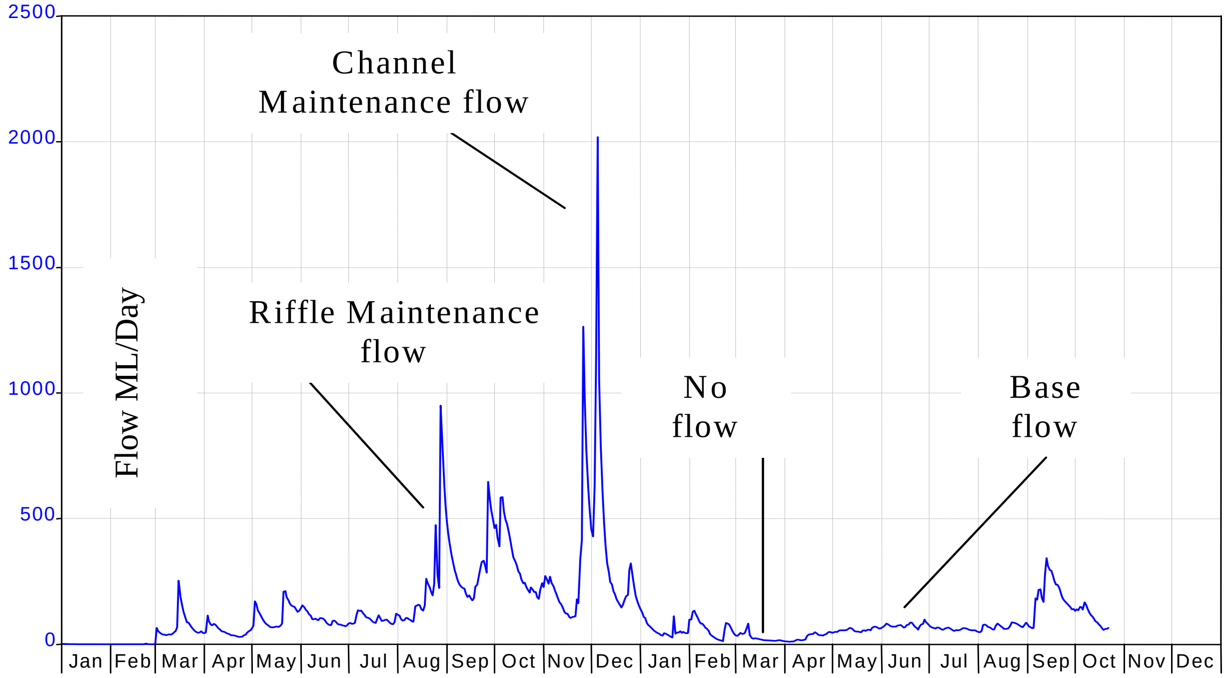


Figure 1: Snapshot of flow at Lobbs Hole on the Murrumbidgee River near the ACT – NSW border Illustrating flow variability and flow elements to be considered in an environmental flow regime.

3.1 Techniques for calculation of flows

For the purpose of these Guidelines, the following methods shall be adopted as the basis for determining flows.

Flow statistics, including percentile flows will be calculated using historical gauging data from stations with a suitable length of record (preferably at least 10 years), and without significant dams or other flow modifications upstream. Flow statistics should be calculated using daily data where possible.

For the Murrumbidgee River in the ACT, flow statistics are calculated from gauged data taken subsequent to construction of the Tantangara Dam. This is an interim approach and may be modified when environmental flow requirements in the Murrumbidgee upstream of the ACT are determined and implemented.

Where an abstraction point or subcatchment boundary is not co-located with a gauging station, the flow at that point can be calculated from the gauged flow of the nearest appropriate station. A catchment area–runoff relationship is used to calculate flow:

$Flow_{req} = Flow_{gauge} \times (A_{req}/A_{gauge})^{0.7}$

Where $Flow_{req}$ is flow at the required point, $Flow_{gauge}$ is flow at the gauging station, A_{req} is the catchment area above the required point, and A_{gauge} is the catchment area above the gauging station.

Rainfall runoff modelling may be used for subcatchments without gauges provided that the modelling approach has been shown to calibrate accurately in subcatchments that have stream gauges.

In water supply sub-catchments in both the Cotter and Queanbeyan river systems an alternative approach, the water balance approach, may be used to determine flow at a point remote from a gauging station. This approach uses data on inflow, outflow, evaporation and abstraction from reservoirs to estimate what natural flow would have occurred in the absence of the reservoir.

3.2 Components of environmental flows

For ACT waterbodies there are particular components that may need to be built into the environmental flow regime for a each river reach or lake. These components are:

- base flows;
- riffle maintenance flows;
- pool maintenance flows;
- channel maintenance flows;
- special purpose flows; and
- impoundment drawdown levels.

3.2.1 Base flows

Base flow describes the quantity of water that flows down a waterway in those periods between rainfall events. In the ACT much of the baseflow originates from groundwater seepage into the stream. In the urban environment, the groundwater contribution is augmented by drainage from garden watering and car washing. Downstream of dam walls, stream flow may also be augmented by leakage from the dam, and downstream of sewerage treatment plants, baseflows are significantly augmented by discharge of treated effluent.

Aquatic ecosystems in ACT rivers are assumed to be adapted to periods of low flow or no flow. Such conditions would have occurred before European settlement and still occur in pristine catchments. Ecological understanding indicates that natural low or no flow periods play an important role in maintaining ecosystems, permitting re-colonisation and succession. However, the stresses introduced by low flow periods should not be exacerbated by unnaturally long periods of low or no flow. Ecosystems are particularly sensitive to impact when stressed by low flows and further stress will result in harmful impacts. In addition, ecosystem recovery from low flow stress may be impeded by other cathment stressors such as land use change or point source pollution. Low flows need to be maintained as close to natural low flow levels as possible, by the control of groundwater and surface water abstractions, and by environmental releases.

A critical decision in determination of environmental flow requirements, including base flows, is the time interval over which it is calculated. If a base flow requirement were based on total yearly flow, it would ignore the natural seasonal variability in river flow. ACT flows are naturally higher in winter. Calculation of flows using a smaller time interval (i.e. a week) would better reflect natural variability, but would be impractical for licensing purposes. As a pragmatic compromise, the base flow component of the environmental flow requirement is specified on a monthly basis, calculated using daily flow data.

Selection of a threshold that appropriately defines base flows has generated significant debate. In the *1999 Environmental Flow Guidelines* the 80th percentile flow was accepted as the threshold of base flows based on approaches used in other jurisdictions. The 80th percentile flow is the volume that flows 80% of the time, that is, those commonly occurring (low) levels of flow.

This threshold was considered in the review of the *1999 Guidelines* by the Cooperative Research Centre for Freshwater Ecology (CRCFE) (Ogden *et al* 2004). The CRCFE concluded that protection of low flows, as defined by the 80th percentile flow, had demonstrated benefits for fish and macroinvertebrates in the water supply catchments, and this flow, together with other flow components, could maintain aquatic ecological values with moderate confidence. The Hillman review of the 2006 Guidelines gave further support to the 80th percentile flow giving an appropriate baseflow volume. During the drought various baseflows, below the 80th percentile, were trialled in water supply ecosystems. The monitoring and assessment of those lower baseflows indicated that the 80th percentile flow gives a low risk volume for sustaining ecological processes even though other volumes could be used for similar outcomes albeit with higher risk and requiring more intensive monitoring. Therefore for these Guidelines this measure will be retained for the protection of the base flow in non water supply catchments

Given the importance of groundwater discharge in maintaining base flows in streams, it is not possible to solely rely on controls of surface water abstraction to protect base flow requirements. One of the mechanisms to protect base flow in rivers and streams is to limit abstractions of groundwater to 10% of the annual recharge. Studies have confirmed that limiting abstractions to 10% of the recharge is unlikely to affect the ecology of streams (Barlow *et al* 2005), and causes very little change to the frequency of low flow events (Evans *et al* 2005 and Rassam *et al* 2010). Conversely, increasing abstraction to 20% of the annual recharge was estimated to result in unnaturally low flows 20% of the time (Evans *et al* 2005) and is likely to have a negative effect on aquatic ecosystems (Barlow *et al* 2005). Investigation of the ACT groundwater resources and their effect on stream flows will continue.

Baseflow releases from controlled dams: where baseflow is released from a dam with outlet controls, the baseflow should not be held at a constant discharge for the month. Research and assessment of various baseflow volumes and release regimes in the Cotter River indicate that varying the discharge over a two week period can mitigate some of the effects caused by constant flows. In effect once the monthly volume has been determined, greater ecological benefits can be obtained with fortnightly variations in the rate of release of that monthly volume even though the total monthly volume remains the same.

3.2.2 Flooding flows

Streamflow increases following storm events. These increases in flow are important for the maintenance of aquatic ecosystems and channel structure. Flooding flows are of particular importance in streams downstream of water supply reservoirs. Water supply requirements can drastically change natural flow regimes, causing damage to downstream aquatic communities and changes to stream structure. The Snowy River downstream of Jindabyne Dam is an example of what can happen to a river flow if flooding flows are prevented from passing down a river. Without flooding flows that section of the Snowy River has degraded with pools filling with sand and the shape of the river being dramatically changed through growth of sand bars and the encroachment of riverine vegetation.

Three types of flooding flows have been identified for ACT rivers and streams:

1. **riffle maintenance flows.** These are increases in flow necessary to keep riffles clear of fine surficial sediment;
2. **pool maintenance flows.** These are increases in flow necessary to keep pools clear of sediment.; and
3. **channel maintenance flows.** These are increases in flow necessary for maintenance of the channel structure.

In water supply subcatchments, specific releases can be made to meet flooding flow requirements. The CRCFE recommended during the 2004 review that riffle and pool maintenance flows were required to sustain ecological values.

In other ACT subcatchments without reservoirs, there is not the opportunity to meet flooding flow requirements through specific releases. The approach taken has been to place a limit on abstraction of the volume of water passing down the river in higher flows to ensure that when high volume flows occur, rivers and streams will receive appropriate flooding flows.

In order to ensure that naturally high flows are protected, a limit of 10% of the volume of water above base flow has been set for abstraction. In the previous guidelines, flooding flows were termed flushing flows and were defined as the flood events of 1.5 to 2.5 year annual recurrence interval. These were protected by limiting abstraction in a water management area to 10% of the volume of flows above the 80th percentile (based on annual volumes, not individual events). This threshold was set using the best available scientific advice on the provision of habitat diversity and quality, nutrient and sediment cycling, movement of biota and connectivity between aquatic and terrestrial habitats. The knowledge gained by research on the effects of flushing flows of a range of volumes in the water supply areas indicates that the provision of such volumes of water is a low risk approach. For these Guidelines this measure will be retained for the protection of the channel maintenance flow in non water supply catchments.

Guidelines for protection of flooding flows are in Section 5. The effectiveness of the guidelines for flooding flows will be assessed through monitoring of the flows.

3.2.3 Special purpose flows

Special purpose flows are volumes of water designed to meet specific ecosystem requirements, for example the inundation of a wetland. The ecological requirements for special purpose flows in ACT rivers are not well understood, and no special purpose flows have been identified in these Guidelines. Further ecological research may lead to a need for special purpose flows for such purposes, for example, as maintaining spawning of native fish species or protection of frog habitat in the Cotter River.

3.2.4 Impoundment drawdown levels

Macrophytes in urban lakes are recognised as an important ecological asset. Macrophyte stands are a significant component of aquatic habitat, and their destruction would affect dependent biota and associated ecosystem processes including sedimentation, nutrient cycling and water chemistry. The water levels in lakes, ponds and reservoirs influence the survival and recruitment of submerged and emergent macrophytes. If the water level of urban lakes and ponds is lowered too far below spillway level for a significant period, macrophyte zonation may be significantly changed, compromising the ecological values of those water bodies and their capacity to support other environmental functions. However, water bodies with a water level regime that fluctuates within a reasonable range at the right frequency and seasonality can support a diverse and resilient macrophyte community with beneficial zonation. Stable water levels can result in static and fragile macrophyte communities whilst dramatic water level variations can result in very limited or no macrophyte communities.

In the *2006 Guidelines* a maximum drawdown limit of 0.20m was set for urban lakes to protect macrophytes as an important ecological component of such systems. A drawdown of this extent would expose approximately 2-3m of the lake shoreline and the macrophytes in this zone, which poses low risk to existing macrophytes. Recent research and investigations into drawdown levels in Canberra's urban ponds indicates that a higher drawdown level of up to 0.60m represents a low risk to macrophytes.

There is already a significant demand for use of water from urban waterbodies for such purposes as irrigation of parklands and playing fields, and for irrigation of golf courses. If ponds are drawn down excessively and repeatedly, then the macrophytes may diminish or disappear over time resulting in declining water quality. More flexible drawdown limits than provided by the *2006 Guidelines* can be applied to abstraction activities if they are accompanied by a specific monitoring and assessment program. In the absence of monitoring and assessment, having a precautionary limit of 0.20m on the drawdown level of lakes and ponds is considered to be an effective and efficient approach for the protection of urban lakes or ponds.

3.2.5 Temporary requirements

In any subcatchment, there may be circumstances in which it is necessary to reduce the volume of environmental flows for a limited time. The types of incidents that could trigger the need for reduced flows could be:

- oil spill or other contamination within the catchment requiring the cessation of releases;
- infrastructure failure requiring reduction in flow downstream of a dam;
- landslides affecting water quality; or
- other incidents.

Conversely there may be times when additional environmental flows are identified for ecological purposes. Environmental flow volumes and duration have been determined based on best available science or expert opinion. However, it is possible that, as further understanding is gained, a need for a particular short-term flow component is identified. Examples of increased flows for ecological purposes could include:

- additional riffle or pool maintenance flows following storm events;
- habitat maintenance flows for the Cotter River frog; or
- other ecological requirements.

Flows required to meet both these sorts of requirements are termed temporary requirements. In order for these flows to be implemented, the Environment Protection Authority would need to be satisfied of the need for the change to flows. Temporary requirements are not intended to apply to drought situations, and it is envisaged that changes to flows would apply for a limited period until the incident or situation was resolved.

3.2.6 Water supply drought flows

A water supply drought is a concept describing an abnormally dry period resulting in not enough water for human needs. Urban communities experience a water supply drought when there is insufficient water available in reservoirs for normal domestic consumption. Aquatic ecosystems are adapted to a full range of climatic conditions, including very dry periods. In regulated systems these dry periods can cause additional stress and it is important to minimise additional stress on these systems during such times. Nevertheless, the Guidelines need to reflect the influence of flow requirements on provision of a domestic water supply during dry periods, and do so through three mechanisms. Firstly the Guidelines accommodate seasonal changes in flow by specifying different base flows for each month, calculated using historical data. This approach recognises that there are seasonal differences in river flow in the ACT; higher in winter and spring than in summer. Secondly, during non-drought periods in water supply catchments, the release requirement for base flows is never larger than the reservoir inflow.

Thirdly by recognising that during extended low flow periods, it may be necessary to reduce the environmental releases in water supply catchments in line with domestic measures to reduce water use, and so ensure the ongoing security of the water supply. Water supply drought environmental flows will apply as defined below.

A water supply drought is defined for the purpose of these Guidelines as occurring when the water supply utility initiates temporary water restrictions. The water utility may introduce temporary restrictions in response to low reservoir levels, poor water quality in water supply reservoirs, adverse climate forecasts or other factors judged to be relevant. This approach recognises that the water utility may use a range of information to make a decision about restrictions. The Environment Protection Authority must be satisfied that the restrictions are necessary to ensure water supply security. During a period of a water supply drought, different environmental flow requirements termed water supply drought flows, will apply to ensure security of the ACT water supply. The implementation of permanent water conservation measures will not be considered to be water restrictions for the purposes of these Guidelines.

Water supply drought flows will be applied in two stages, reflecting the stages of water restrictions placed on domestic water consumption:

- Water supply drought flows under stage 1 restrictions
- Water supply drought flows under stage 2 or more severe restrictions

Water supply drought flows only apply to water supply catchments, and have different requirements for each reach within the catchment. Water supply drought flow guidelines are detailed in Section 5.

4 ECOLOGICAL OBJECTIVES FOR ACT AQUATIC ECOSYSTEMS

The purpose of environmental flows is to protect river, stream, lake, and aquifer ecosystems. The setting of ecological objectives allows specific ecological values to be targeted by components of the environmental flow regime. In addition, quantified ecological objectives can be used to assess the effectiveness of environmental flows, and the information can be used to develop an adaptive management approach for environmental flows.

Ecological values may be affected by factors other than environmental flow objectives for different reaches. The ecological objectives and indicators identified in Table 2 below are based on recommendations of the CRCFE (Ogden *et al* 2004), and may be refined based on findings from a monitoring and assessment program (Section 6 Monitoring and Assessment).

Table 2: Ecological objectives for ACT aquatic ecosystems

Ecosystem and Reach	Objective	Indicators
Water Supply Catchment Ecosystems		
Corin Dam to Bendora Reservoir	To maintain populations of **Two-Spined Blackfish**	Young of year and year 1+ ages classes comprise >40% of the monitoring catch and, Catch is >80 fish per standard monitoring effort.
	Maintain population numbers and distribution of the **Cotter River Frog**	Extant populations are maintained at current levels.
Bendora Dam to Cotter Reservoir	To maintain populations of **Macquarie Perch**	Young of year and year 1+ ages classes comprise >30% of the monitoring catch, and >40 fish captured per standard monitoring effort.
	To maintain populations of **Two-Spined Blackfish**	Young of year and year 1+ age classes comprise >40% of the monitoring catch, and Catch is >80 fish per standard monitoring effort.
All reaches	To maintain healthy aquatic ecosystems in terms of biota	Macroinvertebrate assemblages are maintained at AUSRIVAS band A level assessed using protocols in the ACT AUSRIVAS sampling and processing manual (http://ausrivas.canberra.edu/au/ausrivas) Non-dominance (<20% cover) of filamentous algae in riffles for 95% of the time. Assessed using standardised collection and processing methods as per Norris *et al* 2004.
	To prevent degradation of riverine habitat through sediment deposition	Sediment deposition is limited to <20% of total depth of pools measured at base flow using techniques as per Ecowise Environmental 2005.
Natural Ecosystems		
All reaches	To maintain healthy aquatic ecosystems in terms of biota see above	Macroinvertebrate assemblages are maintained at AUSRIVAS band A level. Assessed using protocols as per the ACT AUSRIVAS sampling and processing manual (http://ausrivas.canberra.edu/au/ausrivas) Non-dominance (<20% cover) of filamentous algae in riffles for 95% of the time. Assessed using standardised collection and processing methods as per Norris *et al* 2004.

Ecosystem and Reach	Objective	Indicators
	To prevent degradation of riverine habitat through sediment deposition	Sediment deposition is limited to <20% of total depth of pools measured at base flow using techniques per Ecowise Environmental (2005) methods
Modified Ecosystems		
All reaches	To maintain healthy aquatic ecosystems in terms of biota	Macroinvertebrate assemblages are maintained at AUSRIVAS band A level. Assessed using protocols as per the ACT AUSRIVAS sampling and processing manual (http://ausrivas.canberra.edu/au/ausrivas) Non-dominance (<20% cover) of filamentous algae in riffles for 95% of the time. Assessed using standardised collection and processing methods as per Norris *et al* 2004.
	To prevent degradation of riverine habitat through sediment deposition	Sediment deposition is limited to<20% of total depth of pools measured at base flow using techniques per Ecowise Environmental (2005) methods.
	To maintain functional assemblages of macrophytes in urban lakes and ponds	Presence of emergent macrophytes in density and diversity that perform beneficial water quality processes and provide habitat for desired fauna. Submerged macrophytes present and at densities that perform beneficial water quality processes.
Created Ecosystems		
All reaches	To maintain healthy aquatic ecosystems in terms of biota	Macroinvertebrate assemblages are maintained at AUSRIVAS band A level. Assessed using protocols as per the ACT AUSRIVAS sampling and processing manual (http://ausrivas.canberra.edu/au/ausrivas) Non-dominance (<20% cover) of filamentous algae in riffles for 95% of the time. Assessed using standardised collection and processing methods as per Norris *et al* 2004.
	To prevent degradation of riverine habitat through sediment deposition	Sediment deposition is limited to<20% of total depth of pools measured at base flow using techniques per Ecowise Environmental (2005) methods.
	To maintain functional assemblages of macrophytes in urban lakes and ponds	Presence of emergent macrophytes in density and diversity that perform beneficial water quality processes and provide habitat for desired fauna. Submerged macrophytes present and at densities that perform beneficial water quality processes.

5 ENVIRONMENTAL FLOWS FOR PARTICULAR ECOSYSTEMS

Environmental flows have been established for each of the ecosystem types, and for specific reaches within the water supply catchments. The environmental flows are designed to maintain the ecological objectives determined in Section 3. Environmental flows for each ecosystem category and specific reaches within are summarised in Table 3 and discussed in detail in this Section.

Table 3: Summary of Environmental Flow Requirements for the ACT

Flow	Ecosystem Category	Reach	Flow Requirement
Base Flows			
	Water Supply Ecosystems	Above Corin Dam	Maintenance of all natural flows
		Above Googong Dam and any impoundment on the Naas / Gudgenby Rivers	Maintenance of all natural flows except those needed for stock and domestic purposes, and that already provided for at the time these guidelines are listed.
		Below Corin Dam	Maintain 75% of the 80th percentile of the monthly natural inflow, or inflow, whichever is less
		Below Bendora Dam	Maintain 75% of the 80th percentile of the monthly natural inflow, or inflow, whichever is less
		Below Cotter Dam	Maintain an average flow of 15 ML /day
		Below Googong Dam	Maintain an average flow of 10 ML/day or natural inflow which ever is the lesser volume
		Below any impoundment on the Naas / Gudgenby Rivers	Maintain an average flow of 10 ML/day or natural inflow which ever is the lesser volume
	Natural Ecosystems	All reaches in natural ecosystems	Maintain 80th percentile monthly flow in all months. Abstractions may not exceed flow rate.
	Modified Ecosystems	Murrumbidgee River	Maintain 80th percentile monthly flow November – May, and 90th percentile monthly flow June –October inclusive. Abstractions may not exceed flow rate.
		Other reaches in the ACT in modified ecosystems	Maintain 80th percentile monthly flow in all months. Abstractions may not exceed flow rate.
	Created Ecosystems	All reaches in created ecosystems	Maintain 80th percentile monthly flow in all months. Abstractions may not exceed flow rate.
Riffle Maintenance Flows			
	Water Supply Ecosystems	Below Corin Dam	Maintain a flow of 150 ML/Day for 3 consecutive days every 2 months
		Below Bendora Dam	Maintain a flow of 150 ML/Day for 3 consecutive days every 2 months
		Below Cotter Dam	Maintain a flow of 100 ML/Day for 1 day every 2 months
		Below Googong Dam	Maintain a flow of 100 ML/Day for 1 day every 2 months
		Below any impoundment on the Naas / Gudgenby Rivers	Maintain a flow of 100 ML/Day for 1 day every 2 months
	Natural Ecosystems	All reaches in Natural Ecosystems	Riffle maintenance flows are not required
	Modified Ecosystems	All reaches in Modified Ecosystems	Riffle maintenance flows are not required
	Created Ecosystems	All reaches in Created Ecosystems	Riffle maintenance flows are not required
Pool Maintenance Flows			
	Water Supply Ecosystems	Below Corin Dam	Maintain a flow of >550 ML/day for 2 consecutive days between mid-July and mid- October
		Below Bendora Dam	Maintain a flow of >550 ML/day for 2 consecutive days between mid-July and mid- October
		Below Cotter Dam	Not required
		Below Googong Dam	Not required
		Below any impoundment on the Naas / Gudgenby Rivers	Not required
Channel Maintenance Flows			
	Natural Ecosystems	All reaches in Natural Ecosystems	Protect 90% of the volume in events above the 80th percentile from abstraction
	Modified Ecosystems	All reaches in the ACT including the Murrumbidgee	Protect 90% of the volume in events above the 80th percentile from abstraction

Flow	Ecosystem Category	Reach	Flow Requirement
	Created Ecosystems	All reaches in created ecosystems	Protect 90% of the volume in events above the 80^{th} percentile from abstraction
Groundwater Abstraction Limits			
	Water Supply Ecosystems	All Reaches	Groundwater abstraction is limited to 10% of the long term recharge
	Natural Ecosystems	All reaches in natural ecosystems	Groundwater abstraction is limited to 10% of the long term recharge
	Modified Ecosystems	All reaches in the ACT including the Murrumbidgee	Groundwater abstraction is limited to 10% of the long term recharge
	Created Ecosystems	All reaches	Groundwater abstraction is limited to 10% of the long term recharge
Impoundment Drawdown Levels			
	Water Supply Ecosystems	Cotter Reservoir	An adaptive management program will be used to guide drawdown to protect habitat for Macquarie Perch
		All other water supply impoundments	No limits are placed on drawdown levels
	Natural Ecosystems	All natural lakes or ponds	No abstraction is permitted from natural lakes or ponds
		All other impoundments	Drawdown is limited to 0.20m below the spillway[1&2]
	Modified Ecosystems	All impoundments	Drawdown is limited to 0.20m below the spillway[1&2]
	Created Ecosystems	All impoundments	Drawdown is limited to 0.20m below the spillway[1&2]
Drought Flows for Water Supply Ecosystems Stage 1 restrictions			
Base Flows			
		Above Corin Dam	Maintenance of all natural flows
		Above Googong Dam and any impoundment on the Naas / Gudgenby Rivers	Maintenance of all natural flows except those needed for stock and domestic purposes, and that already provided for at the time these guidelines are listed.
		Below Corin Dam	Maintain a flow of 40 ML/day or 75% of the 80^{th} percentile of the monthly natural inflow, or natural inflow whichever is lesser volume
		Below Bendora Dam	Maintain a flow of 40 ML/day or 75% of the 80^{th} percentile of the monthly natural inflow, or natural inflow whichever is the lesser volume
		Below Cotter Dam	Maintain an average flow of 15 ML /day
		Below Googong Dam	Maintain an average flow of 10 ML/day or natural inflow which ever is the lesser volume
		Below any impoundment on the Naas / Gudgenby Rivers	Maintain an average of 10 ML/day or natural inflow which ever is the lesser volume
Riffle Maintenance Flows			
		Below Corin Dam	Maintain a flow of 150 ML/day for 3 consecutive days every 2 months
		Below Bendora Dam	Maintain a flow of 150 ML/day for 3 consecutive days every 2 months
		Below Cotter Dam	Not required
		Below Googong Dam	Not required
		Below any impoundment on the Naas / Gudgenby Rivers	Not required
Pool Maintenance Flows			
		Below Corin Dam	Maintain a flow of >550 ML/day for 2 consecutive days between mid-July and mid- October
		Below Bendora Dam	Maintain a flow of >550 ML/day for 2 consecutive days between mid-July and mid- October
		Below Cotter Dam	Not required
		Below Googong Dam	Not required
		Below any impoundment on the Naas / Gudgenby Rivers	Not required

Flow	Ecosystem Category	Reach	Flow Requirement
Drought Flows for Water Supply Ecosystems Stage 2 restrictions or above			
Base Flows			
		Above Corin Dam	Maintenance of all natural flows
		Above Googong Dam and any impoundment on the Naas / Gudgenby Rivers	Maintenance of all natural flows except those needed for stock and domestic purposes, and that already provided for at the time these guidelines are listed.
		Below Corin Dam	Maintain an average of 20 ML/day
		Below Bendora Dam	Maintain an average of 20 ML/day
		Below Cotter Dam	Maintain an average of 15 ML/day
		Below Googong Dam	Maintain an average of 10 ML/day or inflow which ever is the lesser volume
		Below any impoundment on the Naas / Gudgenby Rivers	Maintain an average of 10 ML/day or natural inflow which ever is less
Riffle Maintenance Flows			
		Below Corin Dam	Maintain a flow of 150 ML/day for 3consecutive days every 2 months
		Below Bendora Dam	Maintain a flow of 150 ML/day for 3 consecutive days every 2 months
		Below Cotter Dam	Not required
		Below Googong Dam	Not required
		Below any impoundment on the Naas / Gudgenby Rivers	Not required
Pool Maintenance Flows			
		Below Corin Dam	Maintain a flow of >550 ML/day for 2 consecutive days between mid-July and mid- October
		Below Bendora Dam	Maintain a flow of >550 ML/day for 2 consecutive days between mid-July and mid- October
		Below Cotter Dam	Not required
		Below Googong Dam	Not required
		Below any impoundment on the Naas / Gudgenby Rivers	Not required

1 For urban lakes and ponds constructed after these guidelines the maximum drawdown as a result of abstraction is 0.20m below spillway level, or a lower level if it can be demonstrated that a pond has been explicitly designed to fulfil its required water quality and ecological functions under the proposed drawdown regime.

2 Drawdown beyond 0.20m as a result of abstraction may occur provided that a specific watering plan, which includes monitoring and contingencies, for that water body is part of the licence to take water.

5.1 Water supply ecosystems

The primary use of waterbodies in water supply catchments is provision of a potable water supply. Although protection of aquatic ecosystems is a designated secondary goal in these areas, the primary function may require substantial drawdown of reservoirs and abstraction from streams. Nevertheless, as a consequence of the protected nature of the Cotter catchment, this system contains valuable aquatic ecosystems. For example, the Cotter River has the highest number of threatened fish species of any river in the ACT or surrounding region.

At present the Cotter River catchment from its headwaters to the wall of the Cotter Dam is the only catchment in this category in the ACT. While the Queanbeyan River is a water supply river for the ACT, regulation of its catchment outside of the Googong Foreshore Area is a matter for NSW. However, the ACT expects NSW's management of the catchment to be consistent with its water supply function as provided for by the *Seat of Government Acceptance Act 1909.* For the Googong Foreshore Area, and for releases from Googong Dam, environmental flow requirements for water supply ecosystems will apply.

If the catchment policy for the Gudgenby/Naas Rivers is changed to that of a water supply catchment in the Territory Plan to allow the use of these rivers for domestic water supply. Then the environmental flow requirements for water supply ecosystems will apply to those reaches and to releases from any future impoundment on these rivers.

In water supply catchments, environmental flows are not expected to mimic natural conditions; if this were the case, there would be a significant reduction in the available volume of potable water supply. An alternative approach has been adopted; identifying ecological values that are expected to be maintained by environmental flows, and the associated flows required. Different types of reaches in water supply ecosystems are identified in order to specify appropriate flows. These reaches are listed in Table 4. Environmental flow requirements for these types of reaches are summarised in Table 3, and are also described below in Table 4.

Table 4: Water Supply Reaches

Reach Type	River	Reach
Reaches above all impoundments	Cotter River	Above Corin Reservoir
	Queanbeyan River	Above Googong Reservoir
	The Naas and Gudgenby Rivers[1]	
Reaches between impoundments used as a conduit for water supply	Cotter River	Between Corin Dam and Bendora Dam
	Cotter River	Between Bendora Dam and Cotter Dam
Reaches below impoundments not used as a conduit for water supply	Cotter River	Below Cotter Dam
	Queanbeyan River	Below Googong Dam
	The Gudgenby River[1]	

[1] If in the future the Gudgenby/Naas subcatchments are designated as water supply catchments in the Territory Plan to enable the abstraction of water for domestic supply.

5.1.1 Reaches above all impoundments

Above Corin

Ecological objectives
To maintain healthy aquatic ecosystems in all natural ecosystems.

The reach above Corin dam is unregulated and has a natural flow regime and high conservation value. Within this region there is to be no interruption to natural flows to achieve both conservation and water supply objectives.

Other reaches above all impoundments

Ecological objectives
To maintain healthy aquatic ecosystems in all natural ecosystems.

Should the Naas and Gudgenby subcatchments be designated as water supply catchments, there should be no interruption to inflows except that necessary for stock and domestic purposes (as provided by the *Water Resources Act 1998*) and that already provided for at the time these guidelines are listed.

For the Googong, Tinderry and Burra subcatchments there should be no abstraction of inflows except that necessary for stock and domestic purposes and that already provided for at the time these guidelines are listed. While the ACT has no statutory responsibility for management of the Googong Reservoir catchment to ensure compliance with the *Seat of Government Acceptance Act 1909,* the ACT considers that any abstraction of natural flows should not be greater than that necessary to support best practice traditional grazing enterprises.

5.1.2 Reaches between impoundments used as a conduit for water supply

Between Corin and Bendora Dams and between Bendora and Cotter Dams

Ecological objectives
The ecological objectives for the reaches between Corin Dam and Bendora Dam and between Bendora Dam and Cotter Dam are:

- to maintain populations of **Macquarie Perch** between Bendora Dam and Cotter Dam;
- to maintain populations of **Two-Spined Blackfish** between Corin Dam and Cotter Dam; and
- to maintain healthy ecosystems in the Cotter River catchment between Corin Dam and Cotter Dam.

The approach taken has been to base guidelines on the flow requirements that maintain these ecological objectives with a minimum safety standard.

Base flows
In all months in all years the defined base flow is to be protected. The base flow is defined as 75% of the 80th percentile of water flowing into the reservoir or the inflow, which ever is less. That is, flows entering the reservoir, up to and including 75% of the 80th percentile are to be released. This volume does not easily translate to a fixed percentile; depending on the reach and the month this equates to a volume between the 85th and 90th percentile.

The base flow volume required has been determined from experience with environmental releases in the Cotter. Where baseflow is released from a dam with outlet controls the baseflow should not be held at a constant discharge for the month. Research and assessment of various baseflow volumes and release regimes in the Cotter River indicate that varying the discharge over a two week period can mitigate some of the effects caused by low constant flows. In effect once the monthly volume has been determined, greater ecological benefits can be obtained with fortnightly variations in the rate of release of that monthly volume even though the total monthly volume remains the same.

Riffle maintenance flow
In the water supply catchments riffle maintenance flows are not designed to mimic natural flows; they are specified to achieve ecological outcomes. As such, regular riffle maintenance flows are required instead of irregular flows as would occur naturally.

A riffle maintenance flow of 150 ML/Day for three consecutive days is to occur every two months. Riffle maintenance flows can be met by a sufficient volume of water flowing over the dam spillway, a release through the dam valves or a combination of these sources. Each time a riffle maintenance flow occurs, either by spill or by release, the next flush is required within the next two months +/- 1 week.

The riffle maintenance flow has been determined from the monitoring of riffle condition in the Cotter River before and after a series of experimental riffle maintenance flows. The effect of the riffle maintenance flows on the identified ecological objectives and indicators will continue to be monitored and assessed.

It is recognised that on occasions there may be significant volumes of water flowing over the dam spillway. If such a flow occurs of a volume and duration equal to the required riffle maintenance flow, it will be considered to be a riffle maintenance flow and the next riffle maintenance flow will not be required for two months +/- 1 week.

Below both Bendora and Corin Dams, the riffle maintenance flow is to be measured at the gauging station below the dam wall. If additional gauging stations are installed in the reaches below either dam, or additional information provided, the point at which the riffle maintenance flow is measured may be changed if it can be demonstrated that any changes still ensure that the riffle maintenance function of the flows is being achieved

Pool maintenance flow
A pool maintenance flow of a volume of >550 ML/day for two consecutive days is to be provided between mid July and mid October. Three sources of water may comprise a pool maintenance flow; tributary inflows, water flowing over the dam spillway or releases from the dam.

It is recognised that there may not be the infrastructure capacity to safely release the full pool maintenance volume and that the volume may need to be implemented by making a dam release in conjunction with a tributary inflows or dam overtopping.

If the pool maintenance flow is met solely by tributary inflows, then this flow will not be considered a riffle maintenance flow as experience has shown that during the falling leg of an event of this size, significant sediment can be deposited in riffle areas.

If the pool maintenance flow has been augmented by water flowing over the dam spillway or releases from the dam, then this flow will also be considered to be a riffle maintenance flow.

Below Bendora Dam, the pool maintenance flow is to be measured at Vanities Crossing gauging station, and below Corin dam, the flow is to be measured at the gauging station below the dam wall. If additional gauging stations are installed in the reaches below either dam, the point at which the pool maintenance flow is measured may be changed if it can be demonstrated that any changes still ensure that the pool maintenance function of the flows is being achieved.

Drought flows - stage 1 restrictions
During a defined water supply drought the following flow requirements apply for the reaches between Corin Dam and Bendora Reservoir, and between Bendora Dam and Cotter Reservoir.

Under stage 1 restrictions the domestic water supply is under threat and a reduction in environmental flow requirements is appropriate to protect supply security while still protecting ecosystem values.

The base flow requirement is an average of 40 ML/day, or 75% of the 80th percentile, or natural inflow, whichever is the lesser volume. It is anticipated that licensing requirements will ensure a scheme of variable low flow releases around the average of the daily base flow.

Riffle maintenance and pool maintenance flows remain the same as for non-drought periods.

Drought flows - stage 2 or more severe restrictions
Under stage 2 or more severe restrictions the domestic water supply is under significant threat and a significant reduction in environmental flow requirements is appropriate to protect supply security. This reduced flow regime poses an increased risk of degradation to the aquatic ecosystem; the river would be expected to recover from a short-term reduction in flow of this magnitude, but a long term reduction would result in degradation.

The base flow requirement is an average 20 ML/day. The licensing requirements will ensure a scheme of variable low flow releases around the average of the daily base flow.

Riffle maintenance and pool maintenance flows remain the same as for non-drought periods.

5.1.3 Reaches below all impoundments

Below Cotter Dam
Below Googong Dam

Ecological objectives
The ecological objectives for the reaches below impoundments are:

- to maintain populations of **Macquarie Perch** below Cotter Dam;
- to maintain healthy aquatic ecosystems below Cotter Dam;
- to maintain healthy aquatic ecosystems below Googong Dam; and

Base flows
Below Cotter 15 ML/day
Below Googong 10 ML/day or inflow whichever is less

The base flows below the bottom impoundments in the water supply catchments are specified as minimum channel wetting volumes in recognition that these reservoirs are the final capture point for domestic supply. A channel wetting volume is the flow that covers a reasonable proportion of a specified riffle, allowing adequate habitat for periphyton, macroinvertebrates, and fish to be wetted at all times. Channel wetting flows were established by an ‘expert panel’ approach and have been validated by specific research and monitoring on base flow volumes in each reach. A higher base flow is specified for the section of the Cotter River below Cotter Dam in recognition that this reach provides connectivity between the Murrumbidgee River and Paddys River.

Riffle maintenance flow
In the water supply catchments riffle maintenance flows are not designed to mimic natural flows, rather they are managed for specific ecological outcomes. As such, regular riffle maintenance flows are required instead of irregular flows as would occur naturally.

A riffle maintenance flow of a volume of 100 ML/day for one day is to occur every two months. Each time a riffle maintenance flow occurs either by spill, or by release, the next flush must occur two months +/- 1 week after the last riffle maintenance flow.

Pool maintenance flow
No pool maintenance flows are specified for reaches below final impoundments. If further monitoring and assessment determine the need for pool maintenance flows, they can be provided as a temporary requirement.

Drought flows – all levels of restriction
During a defined drought the following flow requirements apply below Cotter Dam and Googong Dam, for all levels of water restrictions. The base flow below Cotter Dam will be15 ML/day. The base flow below Googong will be 10 ML/day or natural inflow whichever is less.

Riffle or pool maintenance flows for these reaches are not required during drought. If further monitoring and assessment determine the need for riffle or pool maintenance flows, they can be provided as a temporary requirement.

5.1.4 Requirements applying to all water supply ecosystems

Impoundment drawdown levels
Guidelines will be established to control the drawdown of the Cotter Reservoir to protect habitat for Macquarie Perch. Between the late 1960s and 2004 the Cotter Reservoir was not an active part of the ACT

water supply, and so drawdown was not an issue. The only successfully breeding ACT population of the endangered Macquarie Perch lives principally in the Cotter Reservoir and the Cotter River upstream of the reservoir. The Cotter Reservoir population is reliant on the emergent macrophytes and boulder piles around the margins of the reservoir as its main habitat. The construction of the enlarged Cotter Dam will completely change the nature and extent of potential habitat for the Macquarie Perch and as such large amounts of artificial habitat will be placed in the new reservoir. The Reservoir will be operated in such a manner that fish habitat is available and safe connectivity with the Cotter River is provided during fish spawning periods. Drawdown limits are not set for other water supply reservoirs.

Water quality

Reservoir releases to meet environmental flow requirements should be of a water quality similar to that of natural inflows as far as possible. Of particular concern are water temperature and dissolved oxygen. Water from the lower layers of deep, stratified reservoirs can have a much lower temperature and oxygen content than surface waters. If this bottom water is released to meet environmental flow requirements, water quality may compromise the value of the release for the maintenance of aquatic ecosystems. For example most native fish species use both water temperature and flow as cues for reproduction, and a cold-water release may severely disrupt spawning migrations and reproductive activity.

Another issue that has arisen is the release of turbid water from ACT reservoirs. Normally reservoirs act to trap sediment and releases have lower sediment levels than inflows. In some situations a layer of highly turbid water has persisted in ACT reservoirs with the potential to compromise the quality of the entire reservoir when bottom waters mixed with surface layers during winter. It may be desirable from a water supply perspective to release this turbid water. Such releases need to be managed to protect downstream ecological values. Water with high turbidity can reduce the abundance and diversity of macroinvertebrates. To minimise the potential impact of turbid releases, clean water releases may be required before and after a turbid release to protect aquatic ecosystems downstream.

Water quality issues can also arise when flows remain at a steady low volume. For example, constant low flows cause periphyton to accumulate in thick layers, trapping sediment and organic matter that can degrade water quality by lowering dissolved oxygen levels and changing pH levels (Stevenson 1996). To minimise this effect base flow releases should be varied by as much as 50% around the recommended volume.

Implementation of environmental flows

Environmental flows below impoundments are implemented through a combination of releases and water flowing over the dam spillway. Water released to achieve environmental flow requirements should be at a temperature approximating as closely as possible that of inflow water. If inflow water temperature is unknown, it should be assumed to be the same as surface water in the reservoir. Where the flow requirement is based on a flow percentile, percentiles should be calculated on a monthly basis but the volume so determined should be released in a manner to include short-term variability.

5.2 Natural ecosystems

Water bodies in the natural ecosystem category include those within Namadgi National Park excepting the Cotter River Catchment, and those within Tidbinbilla Nature Reserve. These are ecosystems that have persisted in a relatively natural state from a period prior to European settlement. The primary management goal for these ecosystems is the conservation of their natural state, and these ecosystems are secondarily managed for recreation and other purposes.

Ecological objective

- To maintain healthy aquatic ecosystems in all natural ecosystems.

Base flows

In all months in all years the base flow is to be protected. The base flow is defined as the 80th percentile of flows. In addition, abstractions of surface water may never exceed the flow rate. Abstraction of groundwater is limited to 10% of the recharge rate to protect base flow.

Flooding flows

Flooding flows, particularly channel maintenance flows, are to be protected by restricting abstraction in water management areas to 10% of the flow volume above the 80th percentile. The discharge most critical at determining the width, depth and meander frequency of channels is the 1.5 to 2.5 year annual recurrence interval flood event.

Specific conditions that can be placed on licenced abstracters in relation to infrastructure limitations will also ensure that flooding flows of this magnitude are protected.

Impoundment drawdown levels
No abstraction is permitted from natural lakes and ponds.

Implementation
Environmental flows are to be maintained through restrictions on abstractions as detailed above.

Water quality
Water quality issues can arise when flows remain at a steady low volume. For example, constant low flows cause periphyton to accumulate in thick layers, trapping sediment and organic matter that can degrade water quality by lowering dissolved oxygen levels and changing pH levels (Stevenson 1996). To minimise this impact, abstractions should allow natural flow variability to be maintained.

5.3 Modified ecosystems

Rivers, lakes and streams in the modified ecosystem category include those water bodies outside Namadgi National Park, Tidbinbilla Nature Reserve and the Canberra urban area. Lake Burley Griffin, the Molonglo River, and the Queanbeyan River above Googong Reservoir are also considered modified ecosystems. These ecosystems have been modified by catchment activities including landscape change, and modifications to the natural flow regime.

In modified ecosystems, the Guidelines seek to maintain modified ecosystems in as natural a state as possible through management of flows and abstraction. To achieve these management goals three groups of modified ecosystems have been identified:

- Murrumbidgee River;
- other ACT reaches including the Molonglo, Naas and Gudgenby (unless designated as water supply catchments under the Territory Plan); and
- reaches in NSW over which the Commonwealth has paramount rights to the water other than those in the Queanbeyan River catchment;

Ecological objective

- To maintain healthy aquatic ecosystems.

5.3.1 Murrumbidgee River environmental flows

There are currently no environmental flow rules implemented in the NSW section of the Murrumbidgee above the ACT, however, some environmental releases are made in accord with recommendations by the Snowy Scientific Committee. With the uncertainties as to what or when NSW will establish environmental flows upstream or downstream of the ACT, the ACT must continue to manage the water it controls responsibly. The ACT ensures that environmental flow requirements in the rivers for which it has responsibility are met by flows under the control of the ACT. In consequence, environmental flows from NSW upstream are likely to pass through the ACT unaffected by activity in the ACT as they are not targeted or accounted for in ACT planning.

Base flows
In all months in all years the base flow is to be protected. The base flow is defined as the 80^{th} percentile of stream flow in the months November to May inclusive, and the 90^{th} percentile of stream flow in the months June to October inclusive. In addition, abstractions of surface water may never exceed the flow rate. Abstraction of groundwater is limited to 10% of the recharge rate to protect base flow.

Base flows requirements in the Murrumbidgee recognise that the Murrumbidgee has become an important source of water for contingency domestic water supply, and will become an ongoing source of domestic supply. Within this large river, lower base flows can be accepted in the wetter months of the year without significantly compromising the processes supporting aquatic ecosystems. In the winter months the absolute volumes are greater and consequently a 90th percentile flow will still ensure that key riffle habitat is inundated and connectivity is provided. The information supporting this approach for a differing percentile for summer/winter flows in certain systems is from research and experience in Victoria (Department for Natural Resources and Environment 2002).

Flooding flows

Flooding flows, particularly channel maintenance flows, are protected by restricting abstraction activities to ensure that abstraction does not affect the frequency of channel maintenance events. The discharge most critical at determining the width, depth and meander frequency of channels is the 1.5 to 2.5 year annual recurrence interval flood event. A restriction of abstraction to flows below that threshold or a restriction on the rate of abstraction that can occur during those events, will ensure that channel maintenance flows occur at appropriate frequencies.

5.3.2 Other reaches in the ACT

This group includes the Naas and Gudgenby Rivers, and the Molonglo River including Lake Burley Griffin.

Base flows

In all months in all years the defined base flow is to be protected. The base flow is defined as the 80th percentile of stream flow unless another baseflow regime is identified through specific assessment. In addition, abstractions of surface water may never exceed the flow rate. Abstraction of groundwater is limited to 10% of the recharge rate to protect base flow.

Flooding flows

Flooding flows, particularly channel maintenance flows, are to be protected by restricting abstraction in water management areas to 10% of the flow volume above the 80th percentile. The discharge most critical at determining the width, depth and meander frequency of channels is the 1.5 to 2.5 year annual recurrence interval flood event.

Specific conditions that can be placed on licenced abstracters in relation to infrastructure limitations will also ensure that flooding flows of this magnitude are protected.

5.3.3 NSW reaches

This group of reaches includes waters in NSW, over which the Commonwealth has paramount rights to water for all the purposes of the Territory as a result of the Commonwealth *Seat of Government Acceptance Act 1909*. It includes the Queanbeyan River and its tributaries above Googong Dam, and the Molonglo River and its tributaries in NSW including Jerrabomberra Creek. Waters from the Queanbeyan River and tributaries entering the Googong Dam Area have been specifically developed for urban water supply purposes by the Googong Dam and associated infrastructure. Waters from the remaining NSW reaches in this category are important for existing or future Territory purposes (as previously identified). The determination and maintenance of flow requirements in these waters to protect environmental values is the responsibility of NSW which has yet to specifically address this issue in these waters. However, to ensure protection of the Commonwealth rights to water under the *Seat of Government Acceptance Act 1909* for all the purposes of the Territory, it is expected that water use be limited to that necessary to support stock and domestic purposes for traditional grazing enterprises and associated long established rural villages (or equivalent use). This is expected to ensure that adequate environmental flows into the ACT are maintained.

5.3.4 Requirements applying to all modified ecosystems

Impoundment drawdown levels

Ponds and lakes sustain aquatic ecosystems within the waterbody, and protect downstream waters by removing pollutants. An integral component of pond ecosystems is the zone of macrophytes around the margin. Macrophytes provide habitat, stabilise and protect margins from wave action and assist with removal of pollutants. Macrophytes and their associated ecosystem components can be affected if a pond is drawn down too far or for too long, compromising the ecological function of the pond. For this reason drawdown limits are set for urban lakes and ponds.

For urban lakes and ponds that were constructed before the year 2000 the nominal drawdown as a result of abstraction is 0.20m below spillway level. This level of drawdown would result in the lake margins retreating approximately 2 metres in most areas as pond design guidelines require edges to be sloped at approximately 1 in 10 for stability, safety and public health reasons. This drawdown limit had been established on the basis that those existing lakes and ponds had been designed to fulfil their ecological functions at operating at close to full supply level. Historically it is noted that water level variations without abstraction have been greater than 0.20m. Research on Canberra's lakes and ponds indicates that drawdown to 0.60m is the upper limit without the risk of adverse ecological effects increasing significantly. Therefore the drawdown caused by abstraction, of lakes and ponds constructed before 2000 can only exceed 0.20m if the activity is covered by intensive management and monitoring. For minor abstraction activities from lakes and ponds where management/monitoring programs are uneconomical a drawdown of 0.20m provides an efficient and safe limit.

For urban lakes and ponds constructed after 2000 the maximum drawdown as a result of abstraction is 0.20m below spillway level, or a lower level if it can be demonstrated that a pond has been explicitly designed to fulfil its required water quality and ecological functions under the proposed drawdown regime. As with other guidelines, there will be a need to monitor the effect of this guideline on lake and pond macrophytes and fish populations of stocked lakes over time.

Implementation
Control of abstraction is seen as the appropriate mechanism for achieving environmental flows for these types of ecosystems. Total abstractions are limited to the volume determined by these Guidelines, and detailed in the Water Resource Management Plan. During low flow periods licensees would not be permitted to withdraw their entitlement except for stock and domestic purposes (as provided by the *Water Resources Act 2007)*. Conversely, during normal or high flow periods abstraction of stormwater can play a significant role in improving the ecological values of modified ecosystems, as detailed in Section 2.5.

The Guidelines do not require releases from lakes and ponds in modified ecosystems to maintain environmental flows in downstream waters. The environmental flow requirements of the streams downstream of impoundments are met through a combination of dam maintenance releases and water passing over the spillway. Although these waterbodies are commonly used for irrigation, this loss of water is compensated by the augmented runoff coming from urban catchments.

Urban impoundments generally only have the capacity to release water by overtopping, or by discharge through a valve at the base of the dam. Water in the bottom of these reservoirs can be of a lower quality such that release of this water would potentially compromise downstream aquatic ecosystems. It is recommended that new dams be fitted with release structures that allow water released from the dam to be at temperatures that reflect natural inflow temperature.

The lake and pond water level requirement will be met principally by controls on abstraction. Abstraction from lakes and ponds will be permitted only if the water level was above the drawdown specified in these Guidelines or in a watering plan developed for the specific waterbody.

Under the Commonwealth Water Act 2007, control of Commonwealth water resources (including Lake Burley Griffin) in the ACT will be referred to the ACT Government. Following that referral, the National Capital Authority and the ACT Government will together formulate how to meet environmental flow obligations. The obligations include water in Lake Burley Griffin in the Molonglo River downstream, whilst ensuring that Lake Burley Griffin fulfils its functions in the Parliamentary Triangle.

5.4 Created ecosystems

All streams, lakes and ponds within the urban area excluding the Molonglo River fall into this category. There have been considerable changes to urban waterbodies as a result of urbanisation. Prior to European settlement, streams in the now urbanised part of the ACT, with the exception of the Molonglo River, flowed only intermittently. Streams took the form of 'chains of ponds' where the stream was a set of ponds joined by a poorly defined streambed. Initially through land clearing, and more recently through the presence of impervious surfaces in urban areas, the urban streams now receive flows that exceed natural flows. Additionally, urban stormwater can contain large quantities of sediment, nutrients and pollutants.

In recent years, there has been significant community support for restoring urban streams to a more natural condition. Introduction of water sensitive urban design in Canberra has led to installation of features such as ponds, rain gardens, pervious pavements, bioswales and stormwater drains as more natural waterways and on-site detention of stormwater.

These Guidelines recommend that flows in urban streams be restored to natural flow regimes as far as practicable, while recognising that it is unlikely that streams will return to the pre-development ‘chain of ponds’ condition.

Ecological objectives

- For all created ecosystems the ecological objective of environmental flows is to maintain a range of healthy aquatic ecosystems.

Base flows

In all months in all years the base flow is to be protected. The base flow is defined as the modelled natural 80^{th} percentile of stream flow. In addition, abstractions of surface water may never exceed the flow rate. Abstraction of groundwater is limited to 10% of the recharge rate to protect base flow.

Flooding flows

Flooding flows, particularly channel maintenance flows, are to be protected by restricting abstraction in water management areas to 10% of the flow volume above the 80^{th} percentile. The discharge most critical at determining the width, depth and meander frequency of channels is the 1.5 to 2.5 year annual recurrence interval flood event.

Specific conditions that can be placed on licensed abstracters in relation to infrastructure limitations will also ensure that flooding flows of this magnitude are protected.

Impoundment drawdown levels

For urban lakes and ponds that were constructed before the year 2000 the drawdown as a result of abstraction is 0.20m below spillway level. This level of drawdown would result in the lake margins retreating approximately 2 metres in most areas as pond design guidelines require edges to be sloped at approximately 1 in 10 for stability, safety and public health reasons. This drawdown limit had been set on the basis that those existing lakes and ponds would fulfil their ecological functions at operating at close to full supply level. Historically it is noted that water level variations without abstraction have been greater than 0.20m. Research on Canberra’s lakes and ponds indicates that drawdown to 0.60m is the upper limit without the risk of adverse ecological effects increasing significantly. Therefore the drawdown caused by abstraction, of lakes and ponds constructed before 2000 can only exceed 0.20m if the activity is covered by intensive management and monitoring. For minor abstraction activities from lakes and ponds, where management/monitoring programs are uneconomical, a drawdown of 0.20m provides an efficient and safe limit.

For urban lakes and ponds constructed after 2000 the maximum drawdown as a result of abstraction is 0.20m below spillway level, or a lower level if it can be demonstrated that a pond has been explicitly designed to fulfil its required water quality and ecological functions under the proposed drawdown regime. As with other guidelines, there will be a need to monitor the effect of this guideline on lake and pond macrophytes and fish populations of stocked lakes over time.

Implementation

Control of abstraction is seen as the appropriate mechanism for achieving guideline environmental flows for these types of ecosystems. Total abstractions are limited to the volume determined by these Guidelines, and detailed in the Water Sharing Plan. During low flow periods licensees would not be permitted to withdraw their entitlement except for stock and domestic purposes (as provided by the *Water Resources Act 2007*). Conversely, during normal or high flow periods, abstraction of stormwater can play a significant role in improving the ecological values of created ecosystems, as detailed in Section 2.5.

The Guidelines do not require releases from lakes and ponds in modified ecosystems to maintain environmental flows in downstream waters. The environmental flow requirements of the streams downstream of impoundments are met through a combination of dam maintenance releases and water passing over the spillway. Although these waterbodies are commonly used for irrigation, this loss of water is compensated by the augmented runoff coming from urban catchments.

These impoundments generally only have the capacity to release water by overtopping, or by discharge through a valve at the base of the dam. Water in the bottom of these reservoirs can be of a lower quality such that release of this water would potentially compromise downstream aquatic ecosystems. It is recommended that new dams be fitted with release structures that allow water released from the dam to be at temperatures that reflect natural inflow temperature.

The lake and pond water level requirement will be met principally by controls on abstraction. Abstraction from lakes and ponds would be permitted only if the water level were above the drawdown specified in these Guidelines or was occurring with an associated monitoring regime within an adaptive management framework.

6 MONITORING AND ASSESSMENT

A monitoring and assessment program is needed to confirm the flow requirements of local aquatic biota and ecological processes, and to determine if the indicators and ecological objectives nominated in the guidelines are the most appropriate for individual water bodies. Using this information to refine the environmental flows is integral to the holistic approach used to develop these guidelines.

Understanding the environmental flow requirements for rivers in the ACT, as elsewhere in Australia, is not a straightforward task. In Australia, we cannot rely on understanding gained from the very different northern hemisphere ecosystems. Australian streams have much more variable flow regimes than those in most other regions of the world. Understanding the effect of daily, seasonal, and event based flow variability to the long-term health of aquatic ecosystems is of great importance, but also presents a significant challenge. There is a considerable amount of research currently being undertaken into environmental flows in the Australian context, including work being conducted locally. The monitoring and assessment program will continue to build on this work.

The monitoring and assessment program will also review the appropriateness of the ecological objectives and indicators identified in Section 4, and evaluate the effectiveness of the environmental flows in maintaining these ecological objectives. In part, this assessment process will be based on a continuation of the licence based monitoring that occurs in water supply catchments, and on the ongoing biological and water quality monitoring program in other catchments. However, there are also knowledge gaps that are not covered by these programs, and additional research will need to occur if we to evaluate the effectiveness of these guidelines.

It is recommended that the additional research required should be a collaborative effort with other agencies to consolidate research and monitoring requirements and available resources. The information gained from the monitoring programs, and additional research should be reviewed on a regular basis, and the findings used to guide adjustments to the different environmental flows, ecological objectives, and ecological indicators. This program will also allow us to refine our understanding of flow – biota relationships.
As a guide for developing a comprehensive environmental flows monitoring and assessment program, a framework has been adapted from Cottingham *et al* (2004) *Environmental Flows Monitoring and Assessment Framework.* The framework can be applied to each of the different environmental flow requirements and ecological objectives, and is outlined below. The specific monitoring requirements and research needs for each ecosystem type, and generic flow components are outlined in more detail in the following section.

1. Define the information needed for each ecosystem and environmental flow component, over appropriate temporal and spatial scales.
2. Define the conceptual understanding of flow-ecology relationships and the questions to be tested as formalised as ecological objectives as in Section 4.
3. Select the ecological indicators to be tested as defined in Section 4
4. Determine the study design, accounting for the specific flows, and ecological objectives and indicators and location within each ecosystem, guided by the decision framework in Cottingham *et al* 2004
5. Optimise study design for the size of the ecological response to be detected, and the temporal and spatial extent of the sampling design.
6. Implement the study design, and
7. Assess whether the environmental flows have met the specific objectives and review the conceptual understanding and hypothesis, and feed this back into the adaptive management process.

6.1 Applying the framework to the different ecosystems and flow components

6.1.1 Water supply

In the water supply catchments, the significant research that has taken place during 2000-2010 (for example, Chester 2003; Norris *et al* 2004; more in here) has enabled environmental flows to be better targeted to achieve specific ecological outcomes. Given the extensive datasets that have now built over time, further work is needed to formulate general relationships between flow and flow responses in terms of the various ecological indicators of river health. The determination of such relationship will improve predictive ability for managing environmental flow releases under changing environmental circumstances. Monitoring of flows and the ecological indicators will continue and be used to refine environmental flows.

Further information is particularly needed regarding the flows needed to enhance Macquarie Perch and Two-Spined Blackfish populations, including requirements for spawning and survivorship of young of the year. Understanding these relationships will assist in adapting environmental flows to protect these threatened fishes, and to evaluate the suitability of the fish based ecological indicators. In addition, there is a need for a research and monitoring program for the locally rare Cotter River Frog (*Litoria nudidigitus)*, of which the local spotted form is unique. Further knowledge is required to establish the distribution and breeding requirements of this species in relation to flows. Understanding the distribution of the Cotter River frog will assist in assessing the Cotter River Frog as an ecological indicator for environmental flow objectives, and in adapting environmental flows towards maintaining the population.

6.1.2 Modified and created ecosystems

The CRCFE review of the 1999 Guidelines and the Hillman review of the 2006 Guidelines indicated a need for a monitoring and research program in the modified and created ecosystems to assess the effectiveness of the environmental flows. The environmental flows monitoring and assessment approach outlined by Cottingham *et al* 2004 assumes that the role of the environmental flow in maintaining or improving the ecological condition of the river has been identified. This is not the case for most aquatic ecosystems.

The evaluation of environmental flows outside the water supply catchments is not a straightforward process as streams can be affected by many impacts, for example; flow regulation, water quality degradation, riparian vegetation change and land use change. The environmental flows research challenge is to disentangle these confounded effects so that the effectiveness of the environmental flow regime can be assessed. A research program has not yet been developed, but areas recommended for consideration are;

- Investigation of the effectiveness of the base flows and flooding flows at protecting ecological objectives
- Review of the appropriateness of the ecological indicators in representing ecological outcomes.
- Refinement and elaboration of ecological objectives being maintained by environmental flows.
- Evaluation of the effectiveness of the drawdown limit of urban lakes and ponds at protecting their aquatic ecosystems.

6.1.3 Groundwater

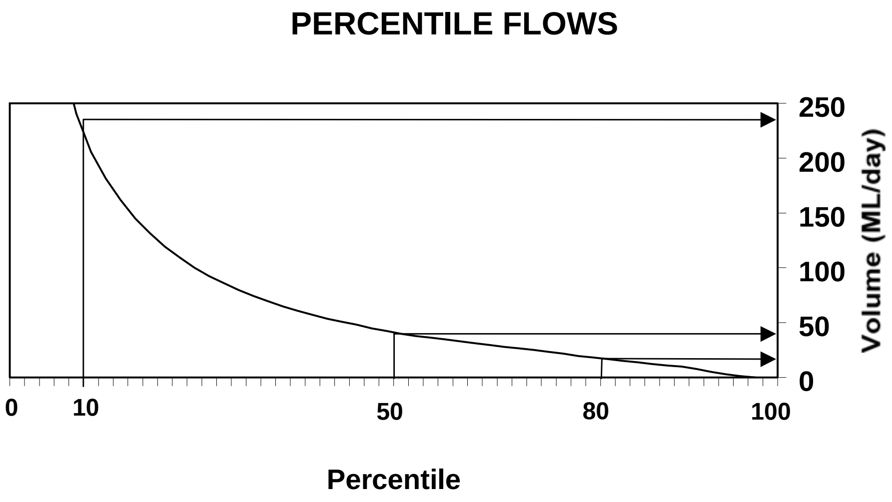
Groundwater discharge is important in maintaining base flows in streams, it is not possible to rely solely on controls on surface water abstraction to protect base flow requirements. Recent investigations have reported that increasing groundwater abstractions above 10% of the volume of long term recharge are likely to increase the periods of low flow in rivers (Evans *et al* 2005 and Rassam *et al* 2010) and this is likely to have a negative effect on biota (Barlow *et al* 2005). We know from the literature that such changes will affect macroinvertebrates, but it is likely that other components including fish, macrophytes, and algae will also be affected. The investigations were desktop studies, and further on-ground research has been put in place to assist in the management of this resource. A program monitoring groundwater levels and rainfall recharge rates is in place throughout areas where groundwater use is highest. Data will soon be available to quantify groundwater processes and assessment of safe groundwater volumes for abstraction can then be performed.

6.1.4 Base flows

In the 1999 Environmental Flow Guidelines, the base flow was defined as the 80th percentile flow. This level of protection was based on a review of the various methods for defining base flows. The CRCFE review of the 1999 Environmental Flow Guidelines found that this level of protection has been able to sustain ecological processes in the water supply catchments, but there was insufficient evidence to assess the effectiveness in other ecosystems. The monitoring and assessment program should assess the effectiveness of the 80th percentile flow rule at protecting ecological objectives. The Hillman review of the 2006 Guidelines gave further support to the 80th percentile flow, giving an appropriate baseflow volume. During the drought various baseflows, less than the 80th percentile, were trialled in water supply ecosystems. The monitoring and assessment of those lower baseflows indicates that the 80th percentile flow provides a low risk volume for sustaining ecological processes.

GLOSSARY

Abstracter	An abstracter is a person or corporation that abstracts water from a waterway, impoundment or bore.
Abstraction	Abstraction refers to the removal of water from a natural waterway, impoundment or bore, and includes diversion of water.
Adaptive Management	Adaptive management is the systematic process of continually improving management policies and practices by learning from the outcomes of operational programs.
Aquatic Ecosystem	For the purposes of these guidelines, an aquatic ecosystem is an ecosystem in a river stream, lake or pond bounded by the riparian zone.
Aquifer	An aquifer is a layer of rock or soil that is permeable and has the capacity to contain groundwater.
Augmentation	The addition of water to a stream or aquifer, from an anthropogenic process.
Base flow	Base flow is the flow in a waterway that occurs between runoff events. For ACT streams most base flow is a result of seepage of groundwater into the channel.
Biota	Biota is a general term describing the animal or plant life of an area.
Channel Maintenance Flows	Channel maintenance flows are flows necessary for maintenance of the channel structure
Created Ecosystem	A created ecosystem is an aquatic ecosystem that has been significantly altered by human activity.
Discharge	Discharge refers to the release of water from a detention structure into a waterway.
Diversion	See abstraction. Note that for licensing or allocation purposes, abstraction and diversion may differ but for impacts on ecosystems the terms are effectively the same.
Drawdown	Drawdown is the extent to which the level of an impoundment has been "drawn down" below the full supply level.
Ecosystem	An ecosystem is a biological community of interacting organisms and their physical environment.
Ephemeral Streams	Ephemeral streams are waterways that do not flow continuously. That is, they tend to flow for a relatively short period of time, usually only days or weeks, after a storm event.
Flooding Flows	Flooding Flows are flows of water after storm events.
Flow Regime	Flow regime describes the pattern of flow that occurs in a stream and will include such components as low flows and flood events.
Flushing Flows	Flushing Flows are flows resulting from storm events or specific releases from impoundments, and typically comprise high flow rates of a relatively short duration that mobilise sediments and change other instream physical and chemical processes.
Fractured Rock Aquifer	A fractured rock aquifer is an aquifer in which groundwater is stored in cracks and joints in the bedrock, and not within the rock itself. Fractured rock aquifers tend to contain smaller volumes of water than alluvial or consolidated aquifers and transmit the water slowly.
Macrophytes	Macrophytes are large water plants. Emergent macrophytes are plants that are rooted in the riverbeds or lakebeds, and protrude through the water surface. Submerged macrophytes are plants that are rooted in the riverbeds or lakebeds, but may have both aquatic and aerial adapted stems, leaves and reproductive parts.
Modified Ecosystem	In the context of this document a modified ecosystem is an aquatic ecosystem that has been somewhat altered by direct or indirect human influence.
Multi-level Off-takes	Multi-level Off-takes are structures that allow the release of a controlled quantity of water from a variety of depths in an impoundment thus allowing water of a particular quality i.e. temperature to be released or diverted.
Natural Ecosystem	A natural ecosystem is an aquatic ecosystem in which there has been minimal human impact.
Percentile	A percentile is a value between 0 and 100 that indicates the proportion of

	measurements that fall above the percentile value. In this document the range of stream flows are expressed in percentiles. The 80th percentile flow is the flow that is exceeded 80% of the time. That is, it is those commonly occurring (low) levels of flow. The 50th percentile, or median is that flow that is exceeded only half of the time. Percentile flows are represented graphically in Figure 2.  **Figure 2**: A graphical representation of percentile flows
Pool Maintenance Flows	Pool Maintenance flows are flows of water necessary to keep pools clear of sediment.
Riffle Maintenance Flows	Riffle maintenance flows are flows of water, necessary to keep riffles clear of fine sediment but does not break up an armoured layer if one has formed in the riffle.
Riparian Vegetation	Riparian vegetation is vegetation growing on the banks of streams or rivers that is influenced by its proximity to a body of water.
Special Purpose Flows	A special purpose flow refers to a particular flow regime that is required to meet a specified purpose. For example, some fish require a relatively unique flow regime, in terms of flow and temperature, before spawning is initiated.
Stratified Reservoir	A reservoir becomes stratified when the water forms a layered structure, each layer having a distinct temperature and water quality.
Stressed Stream	A stressed stream is a stream that has endured a prolonged period of low flow. These conditions are often detrimental to stream health in the short term yet are a necessary component of the flow regime because they improve the resistance of local organisms to periods of low flow or drought conditions. A stressed stream may also refer to a stream that is suffering from pollution.
Sustainable Yield	Sustainable yield refers to the quantity of water that may be diverted without having an adverse effect on dependent ecosystems.
Urban Lake or Pond	Water Features listed in the Territory Plan defined as public land (unless specifically excluded). Generally an urban lake or pond is an impoundment that was constructed for the purposes of minimisation of peak storm flows, pollution control and recreation. The impoundment is connected to the stormwater system, does not occur on private property and does not include the Jerrabomberra Wetlands.
Water Supply Ecosystem	A water supply ecosystem is an ecosystem in a catchment primarily used for water supply.
Water Use Restrictions	Water use restrictions are defined in regulations made under the Utilities Act.

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