futurewateroptions

FOR THE ACT REGION IN THE 21ST CENTURY

ACTEW CORPORATION

TENNENT OPTION REPORT

April 2005

THE TENNENT DAM OPTION

A report assessing various alternatives for a new Tennent Dam for future ACT water supply

FINAL

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Context and purpose

When the ACT Government released "Think water, act water – a strategy for sustainable water resource management" in April 2004, a Future Water Options project was established to identify how best to provide a long-term reliable source of water for the ACT region. Three options were selected for detailed assessment:

- *enlargement of the existing Cotter Reservoir;*
- *construction of a new reservoir on the Gudgenby River (the Tennent Reservoir); and;*
- *transfer of water to the ACT from Tantangara Reservoir in NSW on the Murrumbidgee River.*

Within each option a number of alternatives were included, as were combinations of options. This report assesses the Tennent option.

Despite far-reaching action to implement a range of water efficiency measures, designed to reduce per capita mains water consumption by 12 per cent (by 2013) and 25 per cent (by 2025), it seems likely, given present population growth forecasts, that a major new water source will be required. In ACTEW's view, this will be so "unless the ACT is willing to accept the regular occurrence of water restrictions of a severity and frequency unprecedented in planning elsewhere in Australia."

Canberra's water cycle

The amount of water historically available from ACT controlled catchments (that is, excluding water in the Murrumbidgee River as it flows into the southern ACT from NSW) has historically averaged 494 GL per year. Of this, 272 GL are designated as environmental flows, leaving 222 GL potentially available for human consumption. The actual consumption in recent years has averaged about 66 GL, with around half of this (31 GL) being subsequently returned to the Murrumbidgee River after treatment at the Lower Molonglo Water Quality Control Centre.

A further 386 GL per year enters the ACT from the south via the Murrumbidgee River. Thus a total of 845 GL in an average year flows out of the ACT into Burrinjuck Reservoir and beyond, supporting economic activity including the Murrumbidgee Irrigation Area, the towns along or close to the river, and contributing to environmental flow levels.

The ACT is a significant net water exporter to NSW and would remain so if an additional water storage facility were constructed.

Tennent alternatives

The Tennent area has been regarded as a potential water supply source for Canberra since at least the 1960,s[1]*. Provision for the reservoir was included in the National Capital Plan in 1990. The* Think water act water *strategy now requires that the Tennent option be seriously explored and judged against the other selected options.*

The Tennent reservoir catchment (the Naas and Gudgenby Rivers) above the proposed dam site includes a total area of approximately 71,000ha, the bulk of which is used for national park and conservation related purposes. The Tennent catchment is contained within the ACT. Climate and terrain are significantly different in the Naas - Gudgenby catchment to that in the Cotter. With generally

[1] Commonwealth Department of Works for the National Capital Development Commission (1968) *Canberra Water Supply Augmentation,* May 1968

higher elevation but lower rainfall. The area has been utilised for grazing in the past but is now mostly incorporated into Namadgi National Park. The lower catchment where the dam would be sited is still used for grazing.

Four alternatives have recently been considered. Three involve the construction of a dam on the Gudgenby River and one involves construction of a weir on the Murrumbidgee River. The options are:

***Alternative 1** – a 43GL reservoir on the Gudgenby River, at Tennent*

***Alternative 2** – a 76GL reservoir on the Gudgenby River, at Tennent.*

***Alternative 3** – a 159GL reservoir on the Gudgenby River, at Tennent*

***Alternative 4** – a virtual Tennent option using an agreed proportion of Gudgenby River flow (and possibly other unused ACT river flows), but extracted from a site on the Murrumbidgee River at Angle Crossing and pumped to the Googong Reservoir.*

Costs for the reservoir range from $171M to $247M depending on size and Water Treatment Plant (WTP) and pipeline choices. The social and environmental impact of the three dam alternatives would not differ significantly. Existing infrastructure including roads and powerlines in the Naas – Gudgenby valleys would be inundated and require relocation if a reservoir is constructed. Costs for relocation of this infrastructure range from $16.9M to $27.7M depending on the reservoir size.

Water from a new Tennent Reservoir will require treatment. Delivery can be either via a pipeline to the Mount Stromlo WTP or via a new purpose built WTP near the dam site. The second of these would require a pipeline to a location in Tuggeranong.

The "virtual Tennent " option involves a weir and pump station near Angle Crossing on the Murrumbidgee River, with water being pumped via a pipeline to Burra Creek which flows into Googong Reservoir. This infrastructure could be constructed at substantially lesser cost (of the order of $35M) than any of the reservoir alternatives.

In the event that a decision was taken to construct a new Tennent Dam with no other supplements to the water supply system then the full sized dam would be needed to deliver an adequate supply to meet reasonable future needs, based on the hydrological studies that have been completed[2]. This is a costly option and it is more likely that some combination of water supply alternatives would deliver an adequate supply at less cost. The hydrology analysis has indicated that, in combination with other new infrastructure such as a Cotter dam or a virtual Tennent , the small Tennent dam performs adequately. Similarly, the virtual Tennent , could perform adequately if combined with other alternatives.

The small and large dam alternatives and the virtual Tennent option all provide possible solutions to Canberra's water supply options and are assessed in detail through this report.

Planning and approvals – Legislation and Policy Considerations

The statutory framework within which a future water supply option must be planned and implemented involves a complex array of legislation across three tiers of government.

Should a new dam or weir (and associated treatment plants, pump stations and pipelines) be constructed, the principal planning instrument would be a development application submitted under the Land (Planning and Environment) Act to the ACT Planning and Land Authority. This would trigger a number of other legal and administrative processes that would need positive resolution before the Authority could grant approval.

[2] ActewAGL (2005), *ACT Future Water Options Water Resources Modelling report – Volume 1*, April 2005, ACTEW Corp Doc No. 4644.

The virtual Tennent alternative would involve the NSW Government and NSW legislation because it includes a pipeline in NSW. Commonwealth legislation is involved in relation to water supply issues and the provisions of the National Capital Plan as well as possibly heritage and environment matters.

The ACT Government's document, "People, Place, Prosperity", commits the Government to embed sustainability within its decision-making processes. This means recognising the interdependence of social, economic and environmental well-being, the effects of decisions on others, and that meeting today's needs must not be at the expense of future generations. For example, the social impact study (undertaken as part of the Future Water Options project) noted that damage to the ACT, and especially to those at lower income levels, would result if water supply levels and uncertainty inhibited future population growth and employment. This must be balanced against, for example, the values associated with an endangered woodland community that may be partially inundated.

*The ACT "*Economic White Paper*", "*Social Plan*" and "*Spatial Plan*" (collectively the "*Canberra Plan*") state that reliability, availability and quality of supply, along with economy of use and environmental responsibility, are core water-related community values – water use minimisation to the point where it would inhibit natural population growth of Canberra and the region is not contemplated.*

Steps to constructing a Tennent Supply Source

The planning approval process for a reservoir at Tennent will focus around the preparation and submission of a development application that will seek approval for the reservoir itself and for the associated pump station and pipelines, and water treatment plant if there is one. The development application (DA) will include detailed designs for all these facilities. The DA will "trigger" a requirement for an environmental assessment of the proposal to be conducted – a decision on the DA will not be made until the environmental assessment is complete. The DA will also be assessed against the requirements of the Territory Plan and may only be approved if it accords with the requirements of the Plan. There will be a need for a variation to the plan to establish the Naas-Gudgenby catchment as a water supply source.

A decision to proceed with a reservoir will also trigger the need to bring back into public ownership all land in the catchment area. Public ownership of the catchment area is considered to be necessary to maximise the water quality in the reservoir. Currently the valley floor and parts of the catchment are held under leasehold and agistment arrangements; different mechanisms including termination of leases in accordance with withdrawal clauses contained within the leases, termination of agistment arrangements and resumption of leases under the Lands Acquisition Act would be employed.

The virtual Tennent option will require the preparation and submission of a DA and will also require an amendment to the Territory Plan and it is likely that an amendment to the National Capital Plan will also be required to allow construction of a weir. For all alternatives an application will need to be made for a new abstraction license pursuant to the Water Resources Act.

The planning and environmental assessment processes under all Tennent alternatives would involve referrals to a range of Act Government agencies, the Commonwealth and, for the virtual Tennent pipeline, the NSW Government and Queanbeyan City Council.

Water resources and quality

A total of 92.8GL per annum has historically been available from the Tennent catchment. Hydrological modelling, which includes allowances for "worst ever" drought scenarios and climate change, predicts that this will reduce to 51.15Gl per annum in future years. This is still more than sufficient to supply all of the Tennent reservoir options including the large reservoir.

The opportunity exists at Tennent to establish a catchment that is virtually pristine. Implementation of a reservoir would include removal of all agricultural and residential uses in the catchment and

extension of the Namadgi National Park boundary to the foreshore, as is currently the case with the Corin and Bendora catchments. This, combined with a treatment plant, will produce water qualities that will meet or exceed all applicable standards.

The virtual Tennent option involves extraction of water directly from the Murrumbidgee River that would be of sub optimal quality. The water will be piped to Googong reservoir where it will undergo a period of detention and then treatment before consumption. This water will then also meet or exceed all relevant standards.

Climate change

CSIRO, in a recent report for ACTEW Corporation, has predicted that likely changes to the region's climate in coming decades – temperature, rainfall and evaporation – have the potential to reduce water yields relative to historic patterns, by up to 20 percent by 2030 and by up to 50 per cent by 2070. At the same time, per capita demand could rise in response to the warmer temperatures by up to 5 and 16 percent by 2030 and 2070 respectively. Such projections have serious implications for future water supply decisions and have been factored into the calculations and hydrological modelling that underpin the findings of this report.

Water Supply Outcomes from Tennent Alternatives

The term "water supply reliability" means having sufficient water in storage to supply the ACT and region's urban areas without the risk of running out of water.

Water restrictions may need to be imposed in prolonged droughts so that consumption is reduced. ACTEW has determined that a "reliable water supply" means that water restrictions might be expected to be imposed up to 5 per cent of the time. This implies restrictions of some sort (stage 1 or 2) for about one summer every five years, or perhaps one full year every twenty years . Stage 3, where sprinklers are not permitted, would occur about one summer every 25 years. Ideally, stage 4 or 5 restrictions would never be required, but they may be needed in an absolutly catastrophic drought. A corollary of this definition is that the water supply system would be said to be "failing" if restrictions need to be imposed more frequently.

The point at which failure occurs is dependent on both the available supply of water and the demand for usage. Demand will increase over time as the population grows, moderated by the achievement of demand efficiency targets set by the Government. The point at which a particular option will fail is therefore dependent on the rate at which the population grows. For precautionary water supply planning purposes, the ACT Government's "high" population forecast, which assumes a total Canberra – Queanbeyan population of 500,000 persons by 2032, has been adopted.

Calculation of the population level at which the various options will fail has involved a sophisticated hydrology model. [3] *The model has been tailor-made for Canberra conditions and is leading edge for water supply planning in Australia. It predicts the response of the existing and possible future water storages to long sequences of rainfall, stream flow, temperature, water conservation and water demand scenarios. The small and large Tennent Dams options and the Virtual tennent Option remain viable options for future supply depending on future water demand.*

Infrastructure

Engineering studies have indicated that the proposed site for Tennent Dam –3km upstream from the Murrumbidgee confluence with the Gudgenby River – is suitable. The dam would be roller compacted concrete and the crest level for the large dam alternative would be 76 m above the riverbed level, the

[3] ActewAGL (2005), *ACT Future Water Options Water Resources Modelling report – Volume 1*, April 2005, ACTEW Corp Doc No. 4644.

small dam would be 61m above river level. The construction period would be 20 months, with the majority of material coming from a nearby quarry site, immediately upstream.

Infrastructure issues associated with the virtual Tennent option are of a much smaller scale than for the reservoir. They include the construction of a weir on the Murrumbidgee River as well as pumping and pipe infrastructure to transport the water to Burra Creek. The weir need only be 1 – 2m deep.

The Natural Environment

A number of technical reports have reviewed the future water options against relevant environmental considerations. Implementation of any of the options or alternatives would require a detailed assessment of the environmental impacts of the proposal; this would be completed following the selection of a preferred option and the development of firm design concept plans. The work completed to date has been aimed at determining whether or not the natural environment issues associated with any of the options were of such significance that the option should be discarded without further investigation. The conclusion has been that there are no insurmountable issues related to the natural environment for any of the options and alternatives under consideration. Key findings related specifically to the Tennent option are as follows:

The reservoir alternatives

- *Sedimentation patterns in the river will inevitably change; the degree of change and the resultant impact is not likely to be problematic.*
- *Requirement for provision of fish passage is considered unlikely.*
- *Construction impact on downstream environments will require careful management.*
- *Impacts of water harvesting will reduce flows and capacity to scour accumulated sediments in downstream rivers. This is considered a moderate impact.*
- *A minor impact will be the inundation of Mountain Galaxia spawning habitat in the Gudgenby River and Honeysuckle Creek.*
- *A reservoir will facilitate significant increase in the salmonid population upstream of the dam and subsequent decrease in Mountain Galaxias population, this is rated as a moderate impact.*
- *It will be important to establish a monitoring program that will allow alterations to be made to operational criteria should this become necessary.*
- *Reservoirs should include measures to mitigate the downstream effects on the aquatic biota, such as installing a multi-level off-take to prevent cold water pollution.*
- *All three reservoir alternatives will result in the inundation of a large area of Yellow Box Red Gum Grassy Woodland which is an endangered ecological community; some areas of woodland not inundated will be fragmented. The affected areas include 235 ha of partially modified Box/Gum Grassy Woodland and 199 ha of moderately modified Woodland.*
- *Between 2.07 and 2.85 ha of roadside vegetation (Naas and Angle Crossing Roads) comprising mostly secondary grassland will also be removed.*
- *A number of non-endangered vegetation types will also be removed, including about 4.29 ha of Callitris woodland along steep valley walls at the proposed dam wall construction site.*

The loss of woodland is the most significant of the above impacts. Substantial tracts of land in the Naas and Gudgenby valleys above the inundation area that are classified as Yellow Box Red Gum Grassy Woodland under Action Plan 27 are currently within rural leases. These would be returned to public ownership and it is most likely that the Namadgi boundaries would be extended to encompass this land. Advice from Environment ACT has indicated this would allow the woodland to recover to a more natural state and may be considered to outweigh the impact of inundating the areas of woodland in the lower catchment.

The key impacts of the various Murrumbidgee River weir options are as follows:

- *potential transfer of alien fish species (Oriental Weatherloach and Carp) from Murrumbidgee River to Googong Reservoir (Moderate impact);*
- *there will be a requirement for provision of fish passage (Minor impact) at the weir;*
- *potential impacts of weir construction and maintenance on downstream environments (Minor impact); and*
- *impacts of water harvesting on downstream habitats in the Murrumbidgee (reduced flows and reduced capacity to scour accumulated sediments) (Minor impact).*

All of these impacts are considered to be manageable with appropriate design, construction and management techniques.

Indigenous Heritage

The area that would be inundated by the proposed Tennent Reservoir has been examined by Navin Officer who have prepared a report on the heritage aspects of the future water options[4]. 16 recorded sites may be impacted in the vicinity of the inundation and construction site areas and it would be necessary to conduct a more comprehensive survey of the entire affected area prior to a decision to proceed with a reservoir. Navin Officer predict a medium to high probability that sites will be found and that "the most likely site types ….. are small, low density artefact scatters, isolated finds, stone arrangements and possibly art sites".

Some of the pipeline alternatives for both the reservoir (to Stromlo and to Tuggeranong) and the virtual Tennent alternatives (Tharwa to Googong reservoir) were also examined by Navin Officer. In each case they found a number of sites that may be affected by pipeline construction. And again, it is considered that none would be of sufficient significance to preclude any of the proposed pipelines. Navin Officer did not examine the Angle Crossing to Burra alignment but, whilst a detailed alignment survey would be required, it is considered unlikely that any sites would be discovered that would preclude construction of this alternative.

Aboriginal groups that were consulted noted that the Tennent Reservoir Option is likely to have a high impact on Aboriginal archaeological sites and their cultural values, and is not therefore their preferred option. All three ACT Aboriginal groups noted that consultation with local Aboriginal groups must be an integral component of all further stages of assessment of the options. The weir alternatives were not examined by Aboriginal representative groups or by the consultant archaeologists. More detailed work on these sites would be needed if any were to be selected as a preferred option.

Block 92 Tennent is a former Travelling Stock Reserve and has been included in a Native Title Claim.[5] ACT Government policy would probably require that the claimants be consulted and advised if the

[4] Navin Officer Heritage Consultants (2005), *Cultural Heritage Assessment*, April 2005, ACTEW Corp Doc No. 4651.
[5] KMR Consulting (2005), *Land Ownership Study*, April 2005, ACTEW Corp Doc No. 4652.

Tennent option was to proceed. There are no outstanding native title claims within the areas that would be inundated by the virtual Tennent alternatives.

European Heritage

There are 34 recorded non-Aboriginal sites, generally of minor significance, that will be directly impacted by the inundation area and the proposed construction site for Tennent Dam. It is also possible that a further 66 recorded sites in the vicinity of the inundation and construction site areas may be impacted during construction. None of the recorded sites are listed on the ACT Heritage Register and their presence would not preclude the construction of a reservoir.

Several of these sites, including those that will be inundated, are occupied farm homesteads and have strong family associations.

Several of the Tennent pipeline alternatives have also been examined by Navin Officer and whilst more detailed work would be required prior to a decision to proceed with any particular alternative it is most unlikely that a viable alignment could not be found.

Recreation & Amenity

Following the January 2003 bushfires a Recreation Strategy[6] for the Natural Areas of the ACT has been prepared and released by the Act Government as an interim document

The interim strategy provides "key directions" which highlight significant valley recreation resources that relate to the Tennent Reservoir option. These include:

- *the Orroral Valley, a significant access point for day and overnight visitors to Namadgi;*
- *the Boboyan (and Naas/Gudgenby) Valley includes the Boboyan Road, the main thoroughfare through the park;*
- *upper Naas—Mount Clear with a particular focus on horse riding and the redevelopment/relocation of the bicentennial national trail;*
- *Tharwa and the Tharwa precinct is an important location for tourists and the local community in terms of the art, craft and café opportunities; and*
- *Angle Crossing is a very low use area although use is increasing.*

For water quality and health reasons the functions of the water storages would be limited to passive activities such as landscape appreciation and picnicking, from limited locations. Water contact activities including swimming, boating and fishing would be prohibited.

The appearance of the landscape in the Naas/Gudgenby valley would be dramatically altered if a reservoir were constructed. Careful design of the new Naas/Boboyan road that would be required along the western side of the reservoir could enhance the visitors aesthetic experience.

Public Health

*The ACT Water Resources Management Plan, collectively encompassed by "*Think water, act water*"[7] clearly sets out the need to "ensure water supply and management practices are consistent with protecting public health".*

This means that a new water supply at Tennent would be managed, as for existing supplies, with public health as the principal consideration. The water quality outcomes likely to be achieved at all of

[6] Janet Mackay, Planning for People (2004), *Interim Recreation Strategy for the Natural Areas of the ACT*, Prepared for Environment ACT, April 2004.
[7] ACT Government (2004), *Think water, act water,* op cit, April 2004.

the Tennent alternatives have been found[8] to be well within the range that is able to be utilised for human consumption, with appropriate treatment.

To the extent that a Tennent supply would provide Canberra with a third major water supply source in addition to the current two (the Cotter and Googong catchments) then it will add to the security of the water supply. The health benefits of this would be realised if serious contamination were to occur in either or both of the other two sources.

Energy and Greenhouse Gas Emissions

ACTEW has commissioned an assessment of the energy implications of each of the options.[9] This study examined a range of greenhouse impacts of reservoir construction including the embodied energy costs of dam construction, gas releases due to decomposition of organic matter in reservoirs, the positive impacts of mini hydro power stations and the positive impacts of improved watering opportunities and therefore vegetation growth in the urban area, and the like. The general conclusion of this investigation was that the analysis relied on a number of substantial assumptions and with the present state of knowledge it has not been possible to accurately asses the true greenhouse impact of the differing alternatives in such a way as to allow meaningful comparisons.

Rural Leasehold

The residents of the Naas and Gudgenby valleys will be seriously affected if a decision is made to proceed with a Tennent reservoir as residential and agricultural activity would be precluded from the catchment. Inclusion of the existing rural lessees in the planning and analysis process has been given a high priority in an endeavor to ensure that they are as fully informed as possible as work progresses.

A key issue for the Tennent reservoir proposal is the impact of the ongoing uncertainty and, if it is built, the reservoir itself, on the valley residents. The proposal affects 14 rural holdings[10].

Some of the leases that would be subject to acquisition are either short term or include clauses ("land withdrawal clauses") providing for the withdrawal of the lease should the land be required by the Government. Although the residents have therefore been aware of the possibility of a reservoir for a long time, they nevertheless have strong links with the land and in some cases occupation has been multi generational. Some of the leases are for longer terms and have renewal rights. These would be resumed under the Lands Acquisition Act.

For many years the reservoir proposal has remained unconfirmed. An outcome of this current process should be the removal of this uncertainty, one way or the other.

A decision to not ever proceed with a reservoir would clearly be welcomed by the residents; a decision to not proceed within a specified and lengthy timeframe would be of substantial benefit.

A decision to proceed with a reservoir in the short term would obviously impact heavily on the valley residents. An appropriate level of counseling support in addition to the statutory requirements for compensation will be necessary should this eventuate.

In the event that a decision is made to continue to reserve the site for a reservoir but to not proceed with construction in the short term then a scenario whereby leases are issued for as long a term as possible, for example 30 or 50 years, but without automatic renewal rights is proposed. This system provides for sufficient security of tenure for the lessee to commit financial and other resources to sound land management and agricultural practices, maximising the potential of the land whilst at the same time protecting the community interest in the dam site.

[8] ActewAGL (2005), *Tennent Option Water Quality Report*, April 2005, ACTEW Corp Doc No. 4662.
[9] ActewAGL (2005), *Greenhouse Gas Emissions,* April 2005, ACTEW Corp Doc No. 4670
[10] KMR Consulting (2005), *Land Ownership Study*, April 2005, ACTEW Corp Doc No. 4652.

Economic Framework

The economic framework for assessing the various future water options involves quantifying the benefits (measured as the value of having less time under water restrictions) and costs (both construction and operational), all discounted back to a net present value, and measured against a "do nothing" option.

Water restrictions impose costs on households, businesses, recreation facilities, tourism, monitoring and compliance, ACTEW, and the ACT Government. Costs to households range between $20 and $36 million per year for stage 3 restrictions, rising to $40-77 million for stage 5 restrictions. In total, the costs of spending one year in restrictions is $60 million for stage 3 restrictions, and $163 million for stage 5 restrictions. The "benefits" of each water option are then calculated by relating these costs to the extent to which it reduces the expected time in restrictions in future, relative to the baseline scenario.

Of the several Tennent alternatives, the Virtual Tennent plus Cotter dam is the preferred option (of a total of nine modelled), a Tantangara tunnel option ranks second. The large Tennent Dam on its own ranks about equal third with the Virtual Tennent on its own; the small Tennent dam ranks relatively poorly.

The Cotter plus large Tennent, while it produces the most water storage, is ranked last because of what today appears to be a prohibitive cost.

Risk assessment

The risk assessment conducted as part of the Future Water Options project involved the standard approach of determining the degree of risk – multiplying the likelihood of an event occurring by its consequence. This involved assessing inherent risks, as well as residual risks once control actions have been identified.

For the Tennent dam alternatives the risks relate to possible ecological impacts, delay in implementation and financial overruns. There are also hazards inherent in major infrastructure construction and operation. The risks associated with the virtual Tennent alternative are at a lower level as the timing is more certain, financial commitments are at a much lower level and ecological impacts are less.

With the implementation of adequate control measures the risks associated with the all the Tennent alternatives are considered to be manageable and would not preclude a decision to proceed.

Sustainability

A sustainability analysis conducted for the Future Water Options project used "triple bottom line" or TBL (environmental, social and economic) assessments similar to those used by other water agencies in Australia and overseas.

An initial set of environmental, social and economic criteria for the sustainability assessment was developed in scoping workshops involving project team members, specialist consultants and representatives of government agencies. The draft criteria were refined after discussions with the ACT Office of Sustainability and the Sustainability Expert Reference Group. To add rigour, the refined list was evaluated by interested members of the community and community groups in four workshops held in November 2004. The Institute for Sustainable Futures then reviewed these criteria to include best practice examples from sources such as CSIRO and the Institute's own experience.

Finally, the project team refined the list to ensure it incorporated the criteria the community had ranked as most important and that they corresponded to ACTEW and ACT strategy and policy documents

such as 'People, Place, Prosperity*', and the* ACT Water Strategy Think water act water*, to ensure alignment with Government sustainability goals.*

Three sustainability assessment workshops were then conducted with members of the Future Water Options Project Team, representatives of ACT Government Agencies and interested community stakeholders.

The preferences and rankings developed in the sustainability workshops reflect the views of a small number of participants of generally informed people. The community has not been surveyed as a whole for the TBL assessment and it would, of course, be impossible to obtain a single answer that represents the views of "the community".

The results of the sustainability assessment at the three workshops showed that there is a range of views as to the best option. No single option was favoured in all workshops although, overall, there was a slight preference for the Cotter option. The Tennent options ranked highly in one workshop and poorly in another. Similarly, the Tantangara options ranked highly in one workshop and poorly in others.

With regard to the Tennent alternatives that are the subject of this report – the small and large Tennent dams and the virtual Tennent – the findings of the sustainability assessment workshops are also ambiguous. The table below summarises the position:

Tennent Alternative	Overall Sustainability Ranking (out of 6 alternatives) by:		
	New Water Options Project Team	Community Representatives	ACT Government Agency Representatives
Large Tennent dam	6	2	1
Small Tennent dam	5	3	3
Virtual Tennent	4	6	6

This data in itself does not provide a sound basis for a decision between these alternatives. It is clear that some sectors of the community place a greater weighting on dollar costs and other sectors on environmental and social impacts. A consistent theme is the need for a reliable water supply. In this context it is apparent that all three alternatives should be carried forward for consideration for either a stand-alone solution or in combination with alternatives discussed under the Cotter and Tantangara Option investigations.

1 Introduction

1.1 Purpose of Report

In April 2004, the ACT Government released *Think water, Act Water - a strategy for sustainable water resources management*[11]*.* This strategy defined actions to achieve sustainability objectives for water use in the ACT to 2050*. Future Water Options* was initiated to respond to an objective in this strategy:

"to provide a long-term reliable source of water for the ACT region".

Already nearly 30 possible options for boosting Canberra's water supply have been investigated in a report[12] commissioned by ACTEW for *Think water, Act water.* The report identified three options, recommended for more detailed assessment:

- enlargement of the existing Cotter Reservoir,
- construction of a new reservoir on the Gudgenby River (the Tennent Reservoir), and
- transfer of water to the ACT from Tantangara Reservoir on the Murrumbidgee River in NSW.

Within each option, several alternatives were also analysed, and a number of other options were discarded (see section 1.4 below).

As part of the *Think water, act water*, the *Future Water Options* project is to develop these three options and provide recommendations on a new water source for the ACT region.

This report assesses the Tennent Reservoir, option. Companion reports assess the other two options and a summary report provides a final recommendation to the ACT Government on new water sources for the ACT[13].

1.2 Water Supply in the ACT

Two catchments currently supply Canberra's water (see Figure 1.1) as follows:

- the Cotter catchment with three storage reservoirs (Cotter, Bendora and Corin) and Mt Stromlo Water Treatment Plant (WTP) supplies about 60 per cent of Canberra-Queanbeyan's water needs; and
- the Googong Reservoir and WTP supplies the rest.

Historically, water supply has been managed to maximise use of Bendora and Corin Reservoirs in the Cotter catchment. Water from the Bendora reservoir (fed by the Corin reservoir) can be delivered by gravity through the Bendora Gravity Main to the Stromlo WTP and has required only disinfection and fluoride addition before reticulation to Canberra's consumers.

The high water quality was due to the protected nature of its catchment in the Namadgi National Park. Not having to pump the water cuts down energy costs; indeed the availability of some residual energy

[11] ACT Government (2004), *Think water, act water*, Vol 1 "Strategy for sustainable water resource management in the ACT;" April 2004 ;Vol 2 "Explanatory document;" Vol 3 "State of the ACT's water resources and catchments," April 2004.
[12] ActewAGL (2004), *Options for the Next ACT Water Source*, report for ACTEW Corporation by Technical and Consulting Services Branch, ACTEWAGL Water Division, April 2004.
[13] ACTEW Corporation (2005) Future Water Options for the ACT Region – Implementation Plan: A strategy to increase the ACT's water storage, April 2005.

can be used to generate hydroelectricity. This minimises water production costs while yielding environmental gains through greenhouse gas reductions and renewable energy production.

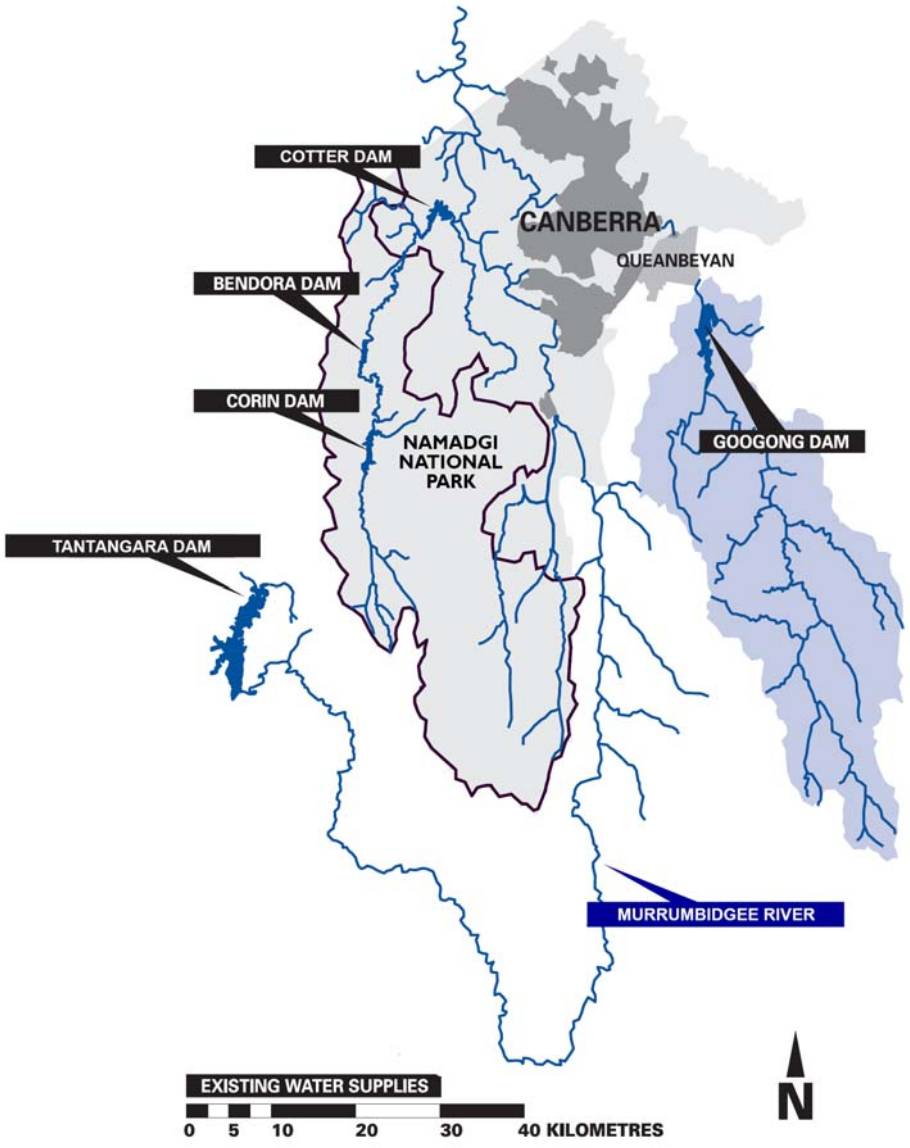


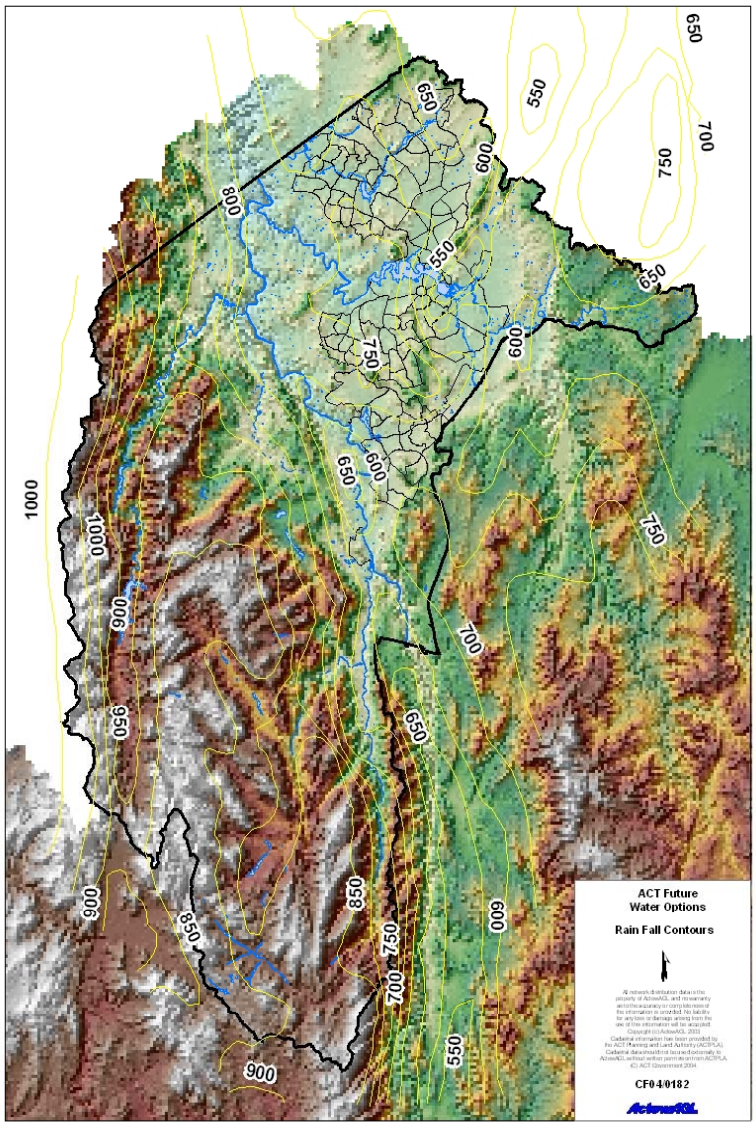
Figure 1.1: Canberra's water supply

Cotter reservoir has not been used for water supply for the past 20 years for several reasons. The water quality from the lower part of the Cotter catchment was poor due to turbidity, in turn mainly a consequence of erodable soils, historic forestry practices and associated forestry infrastructure. Prior to a new water treatment plant, there was no facility available to treat this water. In addition, the need to elevate the water more than 150 m to Mt Stromlo and the small capacity of the storage reduced its attractiveness.

The Cotter catchment receives the highest rainfall, particularly the section above Bendora Dam in the Brindabella Mountains (approximately 950 mm per annum, compared with 600 mm at Canberra Airport).

In the January 2003 bushfires, the Cotter catchment was severely burnt, resulting in long term water quality damage until vegetation regenerates and exposed soils stablise once again. Post bushfire storms washed large amounts of sediment into the Bendora and Corin Dams, demonstrating that the entire Cotter catchment would require water treatment in future. Accordingly, ACTEW commissioned a water treatment plant at Stromlo with a capacity to purify 250 ML per day; this facility became operational in late 2004.

Figure 1.2 ACT Region Rainfall



Googong Reservoir lies about 20 kilometres southeast of Canberra on the Queanbeyan River.[14] The Queanbeyan River water flows through forests, grazing land, and rural residential areas and requires significant treatment for water supply. Although it is triple the size of the Cotter catchment, the Googong catchment receives much less rainfall (650 mm) and has higher evaporation, so its yield is less than the Cotter catchment. The Googong WTP, which processes water before distribution, has recently been upgraded from 180 ML per day to 270 ML per day. Googong water must be pumped 50 metres to the Googong WTP and fully treated before distribution. Treatment and pumping costs mean that water from Googong reservoir is significantly more expensive to supply than Cotter water.

Historically, water from ACT controlled catchments (that is, excluding water in the Murrumbidgee River as it flows into southern ACT from NSW) has averaged 494 GL annually.[15] Of this, 272 GL is designated by the Environmental Flow Guidelines as environmental flows (see section 4.2), leaving 222 GL potentially available for human consumption. The actual consumption in

[14] Under the Seat of *Government Acceptance Act 1909*, the Commonwealth was granted the rights to use water from the Molonglo and Queanbeyan Rivers for Canberra's water supply.
[15] ACT Government (2004) *Think water, act water*, Vol 1, op cit, p 21. April 2004.

recent years has averaged about 63 GL, with around half this (31 GL) being subsequently returned to the Murrumbidgee River after treatment at the Lower Molonglo Water Quality Control Centre.

A further 386 GL per year enters the ACT from the south via the Murrumbidgee River; this water is not used by the ACT and flows along the Murrumbidgee to the north and back into NSW. A total of 845 GL in an average year flows out of the ACT into Burrinjuck Dam, supporting downstream economic activity including the Murrumbidgee Irrigation Area, the towns along or close to the river, and contributing to environmental flows.

These water flow data are based on historical stream flow records collected over time across the catchments. The hydrological modelling discussed in Chapter 4, and used as a basis for determining future water needs, has shown that when factors such as allowance for worst possible drought events and climate change are taken into account, future water flows are likely to be reduced.

In broad terms, the main water aggregates for the ACT are depicted diagrammatically in

Figure 1.3.

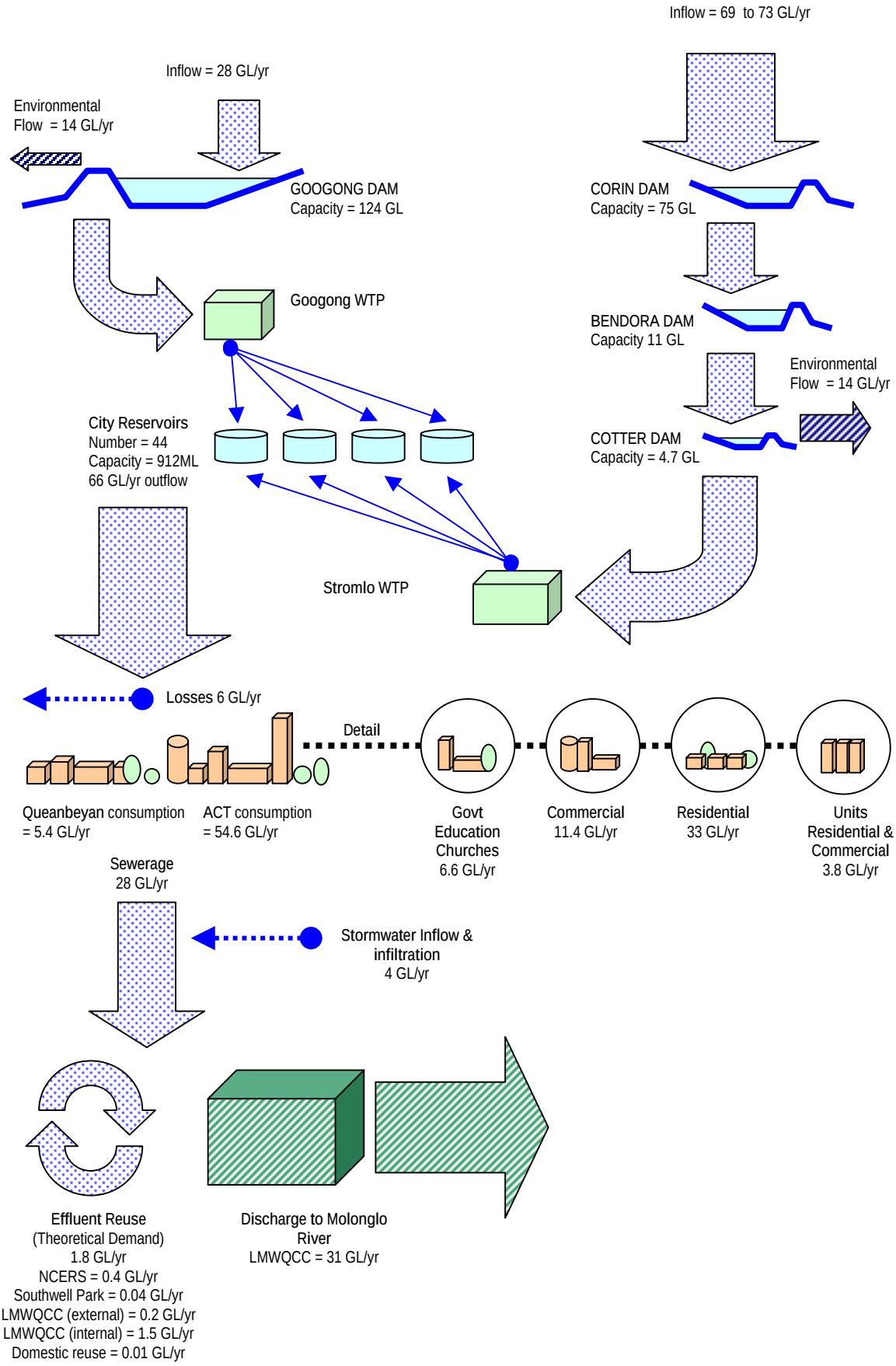


Figure 1.3: The ACT's water cycle

1.3 Think water act water Context

Think water, act water – a strategy for sustainable water resources management was released on 28 April 2004. It followed extensive community involvement and input from experts. Think water, act water constitutes the ACT's Water Resources Management Plan, pursuant to the Water Resources Act 1988, and supercedes a previous version published in August 1999. Think water, act water is designed to achieve the following objectives:

- provide a long-term, reliable source of water for the ACT and region;
- increase the efficiency of water usage;
- promote development and implementation of an integrated regional approach to ACT/New South Wales cross-border water supply and management;
- protect the water quality in ACT rivers, lakes and aquifers, so as to maintain and enhance environmental, amenity, recreational and designated use values and to protect the health of people in the ACT and down river;
- facilitate the incorporation of water sensitive urban design principles into urban, commercial and industrial development; and
- promote and provide for community involvement and partnership in the management of the ACT Water Resources Strategy.

Future water resource management depends on:

- population growth and per capita demand;
- the continuing impact of 2003 bushfire damage;
- climate change; and
- 'urban water cycle' management.

Future water demands could be satisfied by:

- increasing water supplies from existing or proposed reservoirs or other sources;
- reducing per capita mains water use; or
- a combination of both.

The most cost effective and sustainable short-term option is first to implement water efficiency measures. The ACT Government has set targets to reduce per capita mains water consumption by 12 per cent by 2013 and 25 per cent by 2023. These targets could be achieved through:

- water efficiency actions;
- sustainable water recycling;
- enhanced use of stormwater and rainwater; and
- an increase in the use of reclaimed water from the present 5 per cent to 20 per cent.

Even with these efficiencies taken into account, it seems most likely that, given current official forecasts of population growth, a new major water source will still be required unless long periods of restrictions are acceptable. This was confirmed with the release in December 2004 of a report by ACTEW Corporation which concluded that:

> "Unless the ACT is willing to accept the regular recurrence of water restrictions of a severity and frequency unprecedented in planning elsewhere in Australia, then additional water storage will be needed in the ACT."

This report and its companions analysing other water storage options for the ACT, takes the next step in the *Think water, act water* strategy and examines one of the options for future supply. The Tennent reservoir option directly satisfies the need for increased water supply. The Tennent catchment has been regarded as a potential water supply source for Canberra since at least the 1960,s[16]. This position was confirmed as Government policy with the inclusion of provision for the reservoir in the National Capital Plan in 1990. The *Think water act water* strategy now requires that the Tennent option be seriously explored and judged against the other selected options. Tennent was identified for further investigation following an exhaustive review of over thirty possibilities as discussed below.

1.4 Study of Future Water Options

ACTEWAGL's *Options* report 2004 identified new water supply options as well as contingency planning for a continuing drought.[17] It re-assessed previously proposed schemes and developed new options in a three-staged approach illustrated in Figure 1.2.

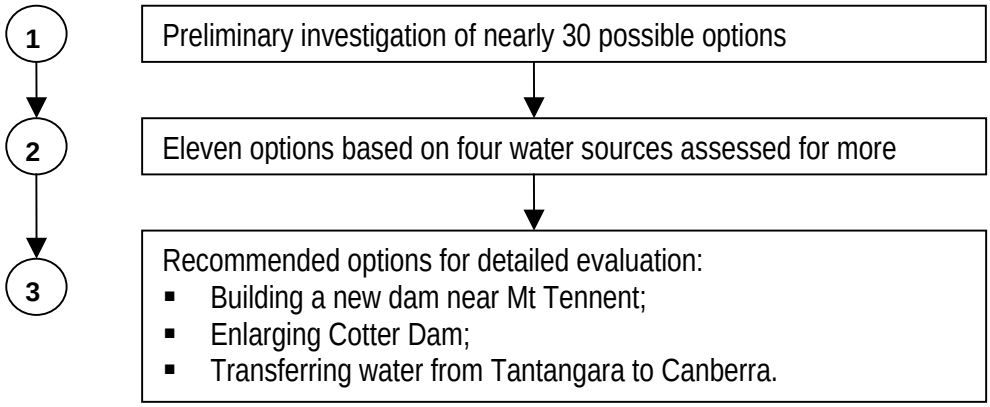


Figure 1.2: Assessing Options For The Next ACT Water Source

Following preliminary investigation, eleven alternatives were short-listed covering the three main options of Tennent, Cotter, and Tantangara. Figure 1.3 shows the location of the three main water supply options and the initial conclusions of the *Options* report with respect to each of these options were:

- "1. Whilst Tennent Reservoir has a large capital cost, it would provide significant storage and the options of feeding water to either a new water treatment plant at Tuggeranong or to the new Stromlo treatment plant.
- 2. Enlarging Cotter Reservoir also has a number of advantages that should be examined in detail. These include that it is an existing dam which would be enlarged, it is in a high rainfall catchment area, and the river is already regulated.

[16] Commonwealth Department of Works for the National Capital Development Commission (1968) *Canberra Water Supply Augmentation,* May 1968.
[17] ActewAGL (2004), *Options for the Next ACT Water Source*, report for ACTEW Corporation by Technical and Consulting Services Branch, ACTEWAGL Water Division, April 2004. Op cit.

- 3. The Tantangara option is attractive enough to warrant further investigation. From an engineering perspective the Yaouk Valley pipeline route, discharging into Porcupine Creek, should be examined in more detail. The other three pipeline options could be discarded because of their high operating cost (pumped option) or capital cost (tunnel option), but further examination of the social and environmental factors need to be considered."

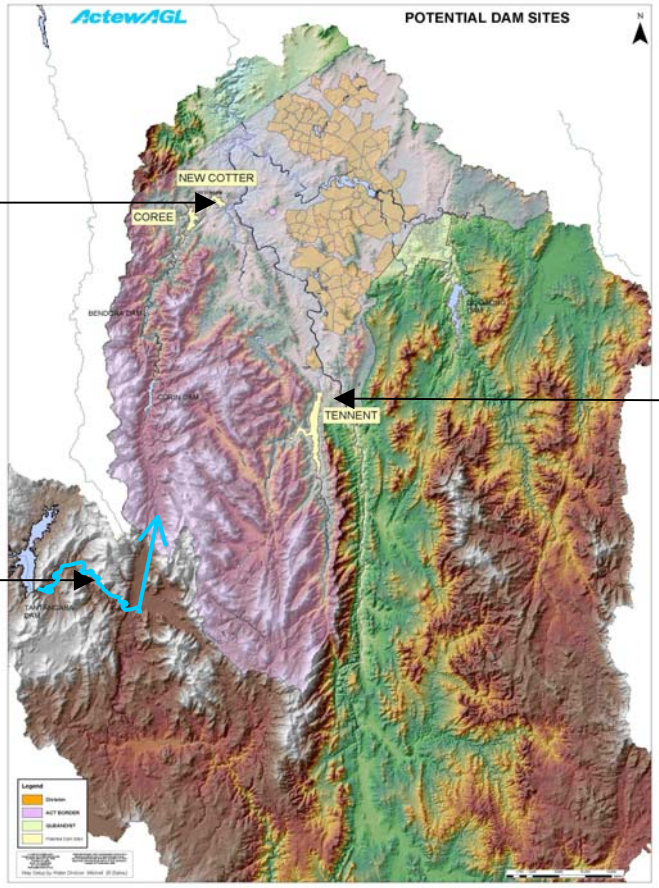


Figure 1.3: Options For The Next ACT Water Source - Main Supply Options

Other water sources that were assessed as part of the *Options* report, but then discarded (for reasons set out in the *Options* report), include:

- a water farm (advanced effluent treatment);
- cross border supplies (other than Tantangara);
- groundwater;
- stormwater reuse;
- using existing urban lakes to supplement supply;
- enlarging other existing storages in the ACT;
- raising spillways on existing storages thus increasing effective capacity;
- transferring water from existing storages in NSW;

- potential dam sites within the ACT; and
- potential dam sites in NSW near the ACT.

As the analysis became more focused and comprehensive, including in terms of the timetable for providing additional water for ACT consumers, additional variants to the initial eleven were assessed. Table 1.1 provides a summary of the 25 variants.

Table 1.1: Summary of new water supply option alternatives

		Option	Alternative	Variant	Features
Cotter	1	Cotter 78 GL			Large new dam over existing Cotter Dam. Capacity of 180 ML per day, pumped to Stromlo WTP
	2	Cotter 45 GL			New dam over existing Cotter dam. Capacity of 180 ML per day, pumped to Stromlo WTP
	3	Cotter 5 GL			The existing dam, with additional capture of Bendora Reservoir environmental flows.
	4	Coree			Large new reservoir at Coree, alternative to new Cotter Dam options
Tennent	5	Tennent 159 GL	Pipe to Stromlo WTP		Large new Tennent Reservoir
	6		WTP at Tennent and pipe to Tuggeranong mains supply		
	7	Tennent 78 GL	Pipe to Stromlo WTP		Medium new Tennent Reservoir
	8		WTP at Tennent and pipe to Tuggeranong mains supply		
	9	Tennent 45 GL	Pipe to Stromlo WTP		Relatively small new Tennent Reservoir
	10		WTP at Tennent and pipe to Tuggeranong mains supply		
	11	Tennent virtual Tennent	Weir at Angle Crossing	Pipe from Angle Crossing to Burra Creek (thence gravity flow to Googong Reservoir)	Water pumped from Murrumbidgee River weir at Angle Crossing, 60 ML per day. Abstraction rate equal to agreed proportion of Gudgenby River flow (which replaces the water taken from Murrumbidgee River)
	12			Pipe from Angle Crossing to Googong Reservoir	As for 11
	13		Weir at Tharwa	Pipe from Angle Crossing to Burra Creek (thence gravity flow to Googong Reservoir)	As for 11 but weir at Tharwa, pipe to Angle Crossing.
	14			Pipe from Angle Crossing to Googong Reservoir	As for 11 but weir at Tharwa, pipe to Angle Crossing
Tantangara	15	Tantangara 20 km tunnel			Water from Tantangara Reservoir into Murrumbidgee River then through a tunnel into Cotter River above Corin Reservoir.

	16	Tantangara 20 km pipeline			Release water from Tantangara Reservoir via pipeline to Cotter River above Corin Reservoir
	17	Tantangara 10 km tunnel plus pipe			Combination of 15 and 16
	18	Tantangara flow down river to ACT	Weir at Angle Crossing	Pipe from Angle Crossing to Burra Creek (thence gravity flow to Googong Reservoir)	Water stored at Tantangara Reservoir, released as required, pumped from Murrumbidgee River to Googong Reservoir
	19			Pipe from Angle Crossing to Googong Reservoir	As for 18
	20		Weir at Tharwa	Pipe from Angle Crossing to Burra Creek (thence gravity flow to Googong Reservoir)	As for 18
	21			Pipe from Angle Crossing to Googong Reservoir	As for 18
	22		Same as drought contingency Scheme	Pump directly from Murrumbidgee River	Pumping from Murrumbidgee River at Cotter pump station to Stromlo WTP (either purchased Murrumbidgee River water or proportion of Gudgenby River flow as per 11)
	23			Construct weir and pump from weir	As for 22
Other	24	Drought contingency Scheme	Pump directly from River using ACT owned water (i.e. not from Tantangara)		Pumping from Murrumbidgee River at Cotter pump station to Stromlo WTP (either purchased Murrumbidgee River water or proportion of Gudgenby River flow as per 11)
	25		Construct weir and pump from weir		As for 24

1.5 Study Procedure

The approach taken to this phase of the future water options study has been to:

- conduct a set of wide-ranging, comprehensive and robust technical studies and consultations into all relevant aspects of each of the three options under investigation;
- investigate and report on the need for, and likely timing of, a new ACT water supply – this was ACTEW Corporation's December 2004 report[18];
- prepare a report on each of the three options under investigation, drawing on the results of the technical and consultation work and objectively setting out all aspects of the option; this report constitutes the Tennent option report; and
- prepare a combined report that summarises the costs, benefits and impacts of each option so that they can be compared and contrasted, leading to the selection of the recommended option, or combinations of options.

The technical studies that have provided input to this part of the work include the following reports:

[18] ACTEW Corporation (2004), op cit.

- Fish Impact Study, by Environment ACT;
- Murrumbidgee Transmission Losses Report, by Marsden Jacob Associates;
- Ecological Risk Assessment, by the CRC for Freshwater Ecology;
- Aquatic Ecology, by the CRC for Freshwater Ecology;
- Flora and Fauna, by Biosis Research;
- Cultural Heritage, by Navin Officer;
- Land Ownership, by KMR Consulting and Guildin Consultants;
- Catchment and Landscape Analysis, by Ecowise Environmental/Barry Starr;
- Water Quality (six studies), by ActewAGL/Ecowise Environmental;
- Technical Advice on ACT Reservoir Recreational Water Use Options, by ActewAGL and Treatment/Water Futures;
- Infrastructure Reports, by GHD and SMEC;
- Geotechnical Investigation, by Coffey Geosciences;
- Social Impact Analysis, by Tania Parkes/Ernst and Young;
- Economic Impact, by the Centre for International Economics;
- Hydrology, by ActewAGL;
- Greenhouse Gas Emissions, by ActewAGL;
- Consultation Framework, by Purdon and Associates, Clarity Communications and Swell Design;
- Community Values and Sustainability Assessment, by Consulting Environmental Engineers; and
- Sustainability Assessment, by the Institute of Sustainable Futures/University of Technology, Sydney.

These technical studies are summarised and cited as appropriate throughout this report.

1.6 Contents of Report

The next chapter provides background description of the Tennent catchment, including its past history, the alternatives examined within the overall Tennent option, including the "virtual Tennent " alternative. Other infrastructure requirements, such as roads and power lines, associated with the alternatives are also discussed.

Chapter 3 contains background material on the planning process that will need to be followed in respect of the Tennent alternatives, in the ACT, NSW and nationally. The specific legislative instruments are described and an assessment provided of what would be required under each piece of legislation in terms of approvals and analysis. Canberra's broader planning policies, starting with the approach to sustainability *People, Place, Prosperity* and the *Social Plan, Spatial Plan,* and *Economic White Paper,* are outlined.

Chapter 4 describes aspects of water resource use: historic river flows in the Tennent catchment, potential yields, environmental flows, water quality, climate change, and other variables. The final section indicates the expected water supply outcomes from the Tennent alternatives.

Chapter 5 summarises the geotechnical and engineering report. The dam site is described, as is the construction procedure, timelines and operation of the dam and virtual Tennent alternatives.

Chapter 6 contains detailed information on a range of environmental factors relevant to Tennent alternatives. These include changes in river flows and ecological risk assessment, sediment transport, the effect of the dam on the riverine habitat, fish, aquatic ecology, and terrestrial flora and fauna.

Chapter 7 considers the human environment, covering such aspects as cultural heritage, recreation, amenity, public health, energy and greenhouse gas emissions and the effects on leaseholders.

In Chapter 8, the results of a comprehensive economic benefit cost study are reported. The economic framework is described, where the benefits from building a new water storage are measured in terms of willingness to pay – variously by households, businesses and other users – in order to avoid (or lessen the prevalence of) water restrictions.

Chapter 9 presents the results of a technical risk assessment of selected alternatives and Chapter 10 presents the results of a sustainability assessment.

2 Tennent Option Alternatives

2.1 Description and History of the Region

The Tennent catchment above the proposed dam site includes a total area of approximately 70,647ha, the bulk of which is used for national park and conservation related purposes. A proportion is devoted to agriculture and a very small area is devoted to forestry (this is subject to review as the Ingledene Forest was destroyed in the January 2003 Fires). Another area of forestry, Boboyan Pines, has been cleared and is being converted back to national park uses. Catchment land use is summarised in Table 2.1 below. These land uses have placed no significant demand on water resources in the catchment and there are no substantial water storages. There are a number of farm dams within the agricultural areas but these are of no significance relative to the total catchment and urban water supply needs.

The Tennent catchment is located in the south east of the ACT (Figure 2.1). The catchment extends from just south of Tharwa and forms the southern boundary with New South Wales. It is completely contained within the ACT.

The catchment has three components described in Table 2.1 below:

Table 2.1 Tennent Catchments and Land Use

Catchment	Area (ha)	Landuse		
		Rural	Conservation	Forestry
Naas (Naas River above Gudgenby River Junction)	28,927	20%	80%	0%
Gudgenby (Gudgenby River above Naas River Junction)	37,216	30%	70%	0%
Mount Tennent sub catchment (Gudgenby River below Naas Junction)	2,252 (note 1)	69%	28%	3%
Total	68395	28.4%	72.4%	0.2%

Source: *Think water act water*, ACT Government April 2004, vol 3.
Note 1: The Mount Tennent sub catchment includes several creeks draining separately to the Gudgenby River. Only about half of the catchment is upstream of the dam site and included in these calculations.

The Naas and Gudgenby rivers flow predominantly through the forests of the Namadgi National Park. The catchment is mountainous and the water quality is high. River flats and swamps occur along the major streams. The diverse aquatic communities and natural riverbank vegetation mean that the rivers in Namadgi National Park are of high ecological value.

Soils on the steeper slopes in Namadgi National Park tend to be shallow and stony. Sandy topsoil and clay subsoil is typical on the lower slopes while deep alluvium is found on the flats.

The rural part of the catchment is undulating to hilly with a mixture of improved and native pasture and scattered trees. Topsoils are sandy and subsoils are thick clay. Land management practices have resulted in some sheet and gully erosion and stream bank erosion.

Climate and terrain are significantly different in the Naas - Gudgenby catchment to that in the Cotter. Elevation ranges from 600 to 1,780 m, with the highest peaks being on the western side adjacent to the Cotter catchment. Some of the valleys falling from the western range are broad and flat with a sharp break in slope to the surrounding ranges. Undulating terrain and gently sloping valleys occur in the lower parts of the catchment to the east and particularly north-east. Rainfall ranges from 960 down

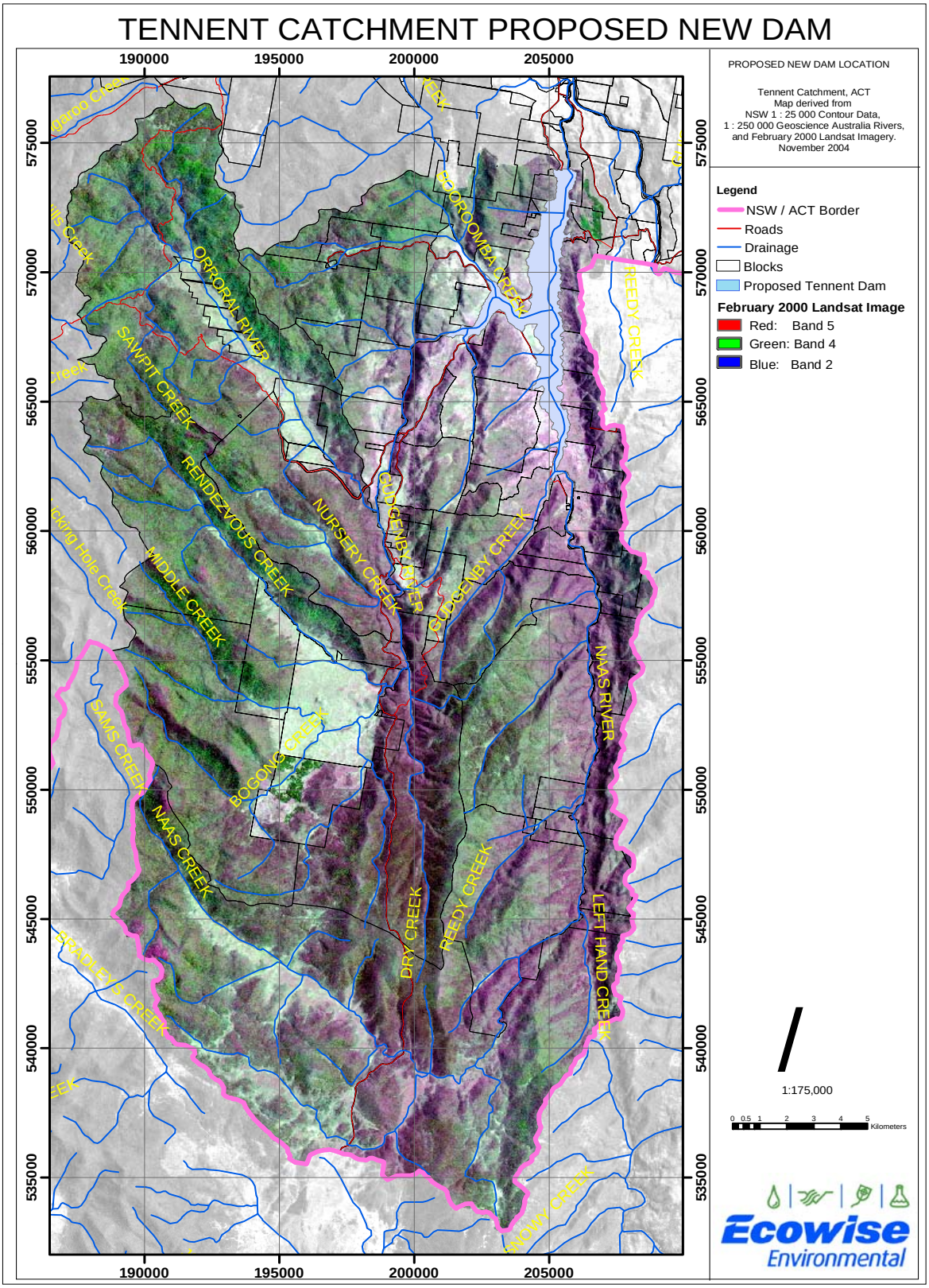


Figure 2.1: Tennent Catchment

to 550 millimetres (mm) with higher elevations to the north-west having the highest rainfall. Most rainfall across the catchment is between 700 to 800 mm with a sharp drop in rainfall just south of the former Boboyan pine plantation.

Historically, this area has been used for grazing since the 1830's with most intense grazing activity in the lower reaches of the catchment, the Orroral valley, Gudgenby station, and along Naas Creek. The more rugged terrain has been used for light grazing on an intermittent basis. Following the dedication of the park, grazing within its boundaries was no longer permitted and was progressively withdrawn, with the last stock exiting in 1989. Grazing is now only practiced in the lower parts of the Naas - Gudgenby catchment.

No mining activity has been documented within the catchment. However, there is evidence of exploration being conducted since the 1800's until the majority of the area became part of the Namadgi National Park. The earliest documented evidence of exploration was the Rev. W. B. Clarke in 1851 or 1852 who identified a gold locality near the Murrumbidgee immediately adjacent to the Naas catchment. Minor gravel pits and quarry sites have been developed for construction and service of the existing roads, tracks and other infrastructure.

More recent activities have included the Boboyan and Ingledene Pine Plantations and the Honeysuckle Creek and Orroral Tracking Stations. The Boboyan Plantation has been completely cleared of pine and is being reincorporated into the national park. The future of the Ingledene Plantation - that slightly overlaps into the catchment in the north east - is still uncertain after its destruction during the 2003 bushfires. Both tracking stations have been closed and their infrastructure mostly removed. Their functions have been consolidated with the Tidbinbilla Tracking Station within the Cotter Catchment.

2.2 Possible Dam and Virtual Tennent Alternatives

The Naas - Gudgenby catchment has long been identified as a potential future water supply for Canberra. Four alternatives have recently been considered. Three involve the construction of a dam on the Gudgenby River and one that involves construction of a weir on the Murrumbidgee River. The options are:

- **Alternative 1** – a 43GL reservoir on the Gudgenby River, at Tennent
- **Alternative 2** – a 76GL reservoir on the Gudgenby River, at Tennent.
- **Alternative 3** – a 159GL reservoir on the Gudgenby River, at Tennent
- **Alternative 4** – a virtual Tennent option using an agreed proportion of Gudgenby River flow (and possibly other unused ACT river flows), but extracted from a site on the Murrumbidgee River. This site could be near the Cotter Pump Station, in which case the water would be pumped to the new Stromlo WTP. Alternatively, the site could be near Tharwa (downstream of the Gudgenby confluence) or in the vicinity of Angle Crossing in which cases the water would be pumped to the Googong Reservoir.

2.3 The Dam Alternatives

The Tennent dam site is located on the Gudgenby River just south of Mt Tennent, at a point where the river travels through a deep narrow gorge. This short section of gorge is the only location in the catchment that would be suitable for a dam of any significant size. This was confirmed in a report in

1968[19] and reiterated in the National Capital Plan. The National Capital Plan[20] sets out requirements for "Namadgi National Park and Adjacent Areas" that include a dam on the Gudgenby River at the Tennent site. The dam site is 4.5 km south of the village of Tharwa, and 3 km from the junction of the Gudgenby and Murrumbidgee Rivers.

The largest of the three dam alternatives would have a full supply level at RL 655 m (655 metres above sea level). A concept design for the dam is shown in Figure 2.2.

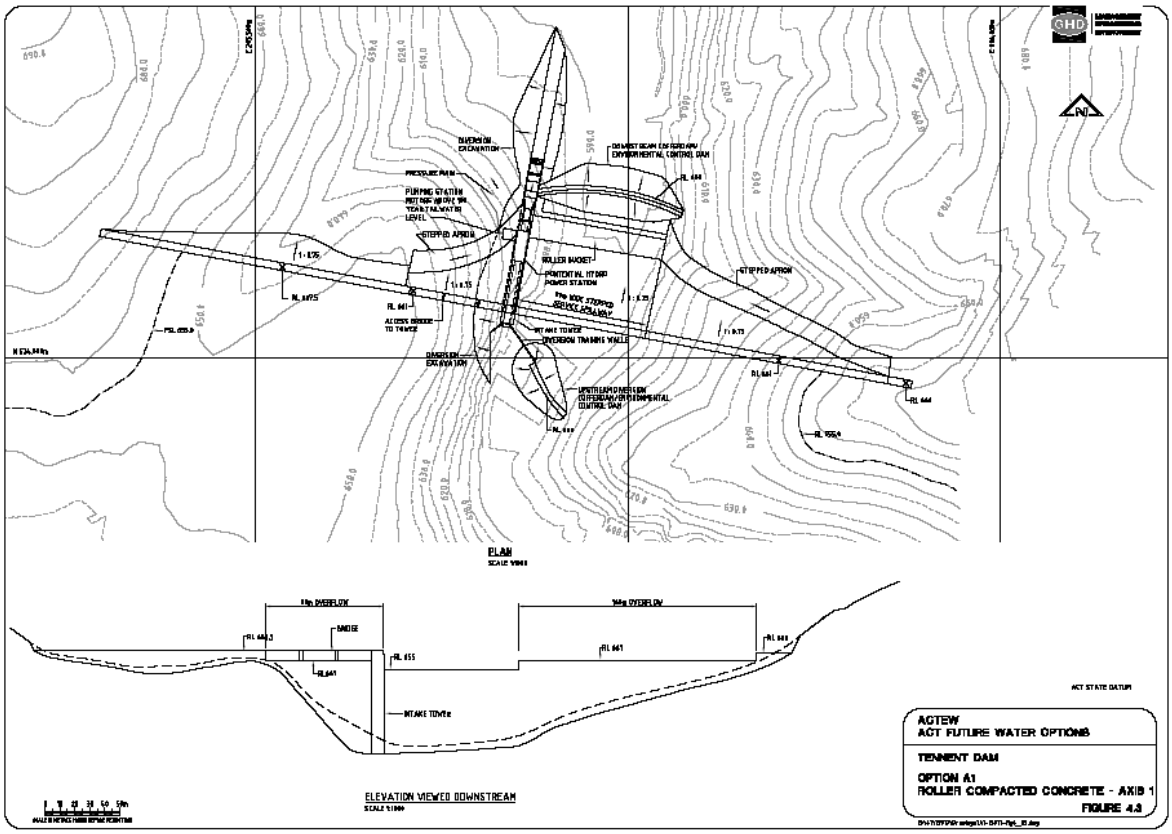


Figure 2.2 Tennent Dam at RL 655

This would inundate the Gudgenby River valley for a distance of approximately 9 km reaching the foot of Fitz's hill and a short distance up the Booroomba Creek valley. It would also inundate 8 km of the Naas River Valley (see Figure 2.3).The total area inundated would be about 1125 ha with a storage capacity of 159,000 ML. The land that would be inundated is largely developed for agricultural use, predominantly grazing and crops. Several homesteads are within the inundation area and there is archaeological evidence of European occupation from about 1820. Pre historical use of the area by aboriginal groups is apparent from some known artefact scatters. Initial assessments indicate that aboriginal use of the valleys was transient. More research would be needed to accurately identify aboriginal site locations[21].

There are substantial areas of open woodland (Yellow Box Red Gum Grassy Woodland with conservation significance) particularly in the north of the reservoir inundation area. The land surrounding the reservoir area is generally steeper and vegetated with native forest. Virtually all of the

[19] Commonwealth Department of Works for the National Capital Development Commission (1968) *Canberra Water Supply Augmentation,* May 1968.
[20] National Capital Planning Authority (1990), *National Capital Plan*, 1990, as amended, Appendix G.
[21] Navin Officer Heritage Consultants (2005), *Cultural Heritage Assessment*, April 2005, ACTEW Corp Doc No. 4651.

Naas Road south of the reservoir site and parts of the Boboyan, Apollo and Angle Crossing roads are located in the inundation area.

If a dam is constructed at Tennent, then the larger of the three is more economical on a raw dollar cost per GL of water gained as illustrated in Table 2.2 below. It is also notable that the social and environmental impact of the three options would not differ significantly. Agricultural activity and permanent human habitation of the valleys would not be permitted under any option due to water quality impacts. Consequently the impact on rural lessees will be the same under any option.

The most substantial environmental impact will be due to the inundation of areas of Yellow Box Red Gum Grassy Woodland. The degree of inundation and or fragmentation of these communities will be high under all options.

Table 2.2 Tennent Reservoir Alternative Sizes

Reservoir Option	**1**	**2**	**3**
Storage volume (ML)	45,000	76,000	159,000
Wall Height (m above sea level)	640	647	655
Wall height above river bed (m)	61	68	76
Inundated Area (ha)	471	615	1125
Construction and associated cost ($M)(2)	$96.6M	$118.9M	$160.5M
Pipeline/pump station costs (1)	$74.4M – $86.2M	$74.4M – $86.2M	$74.4M – $86.2M
Total cost	$171M - $182M	$193M - $204M	$235M - $247M
Cost per ML of storage ($/ML)	$3800 - $4062	$2543 - $2699	$1432 - $1504
Note 1: Alternatives include pump to Stromlo WTP or Construct a WTP at Tennent and pump to Tuggeranong Note 2: excludes land acquisition costs. Source: *Future Water Options Study, Cotter, Coree and Tennent Options (Engineering) Report December 2004, GHD for ACTEW, P180, as amended*			

Water from a new Tennent Reservoir will require treatment prior to delivery to Canberra households. Delivery can be either via the Mount Stromlo WTP or via a new purpose built WTP that would be constructed near the dam site. The first option would involve construction of a pipeline from Tennent to the Mount Stromlo WTP, ($62.5 M). The second would require a pipeline to a location in Tuggeranong that is suitable for the injection of the new supply into the existing mains system ($32.5 M) and a treatment plant at Tennent ($36 M). The pipeline locations are shown on Figure 2.2. The costs of the two alternatives are only slightly different as shown in Table 2.2.

Selection of a Preferred Tennent Dam option (between the three size alternatives) depends on detailed hydrological analysis to assess water yields, and, an assessment of the costs and benefits. The water yield and the benefit that this would contribute to the Canberra community depends on how the new dam would integrate with supplies from other water sources and this of course depends on what other sources are available. In the event that a decision was taken to construct a new Tennent Dam with no other supplements to the water supply system then the full sized dam would be needed to deliver sufficient supply to meet reasonable future needs, based on the hydrological studies that have been completed[22]. This is a costly option and it is more likely that some combination of water supply alternatives would deliver an adequate supply at less cost. The hydrology analysis has indicated that, in combination with other new infrastructure such as a virtual Tennent , the small Tennent dam performs adequately. The intermediate size dam would perform more strongly but

[22] ActewAGL (2005), *ACT Future Water Options Water Resources Modelling report – Volume 1*, April 2005, ACTEW Corp Doc No. 4644.

obviously at a lesser level than the large option. The large and small alternatives are carried forward for further analysis in this report for simplicity. In the event that a decision was made to proceed with a dam then a more detailed evaluation may lead to a refinement of the actual size.

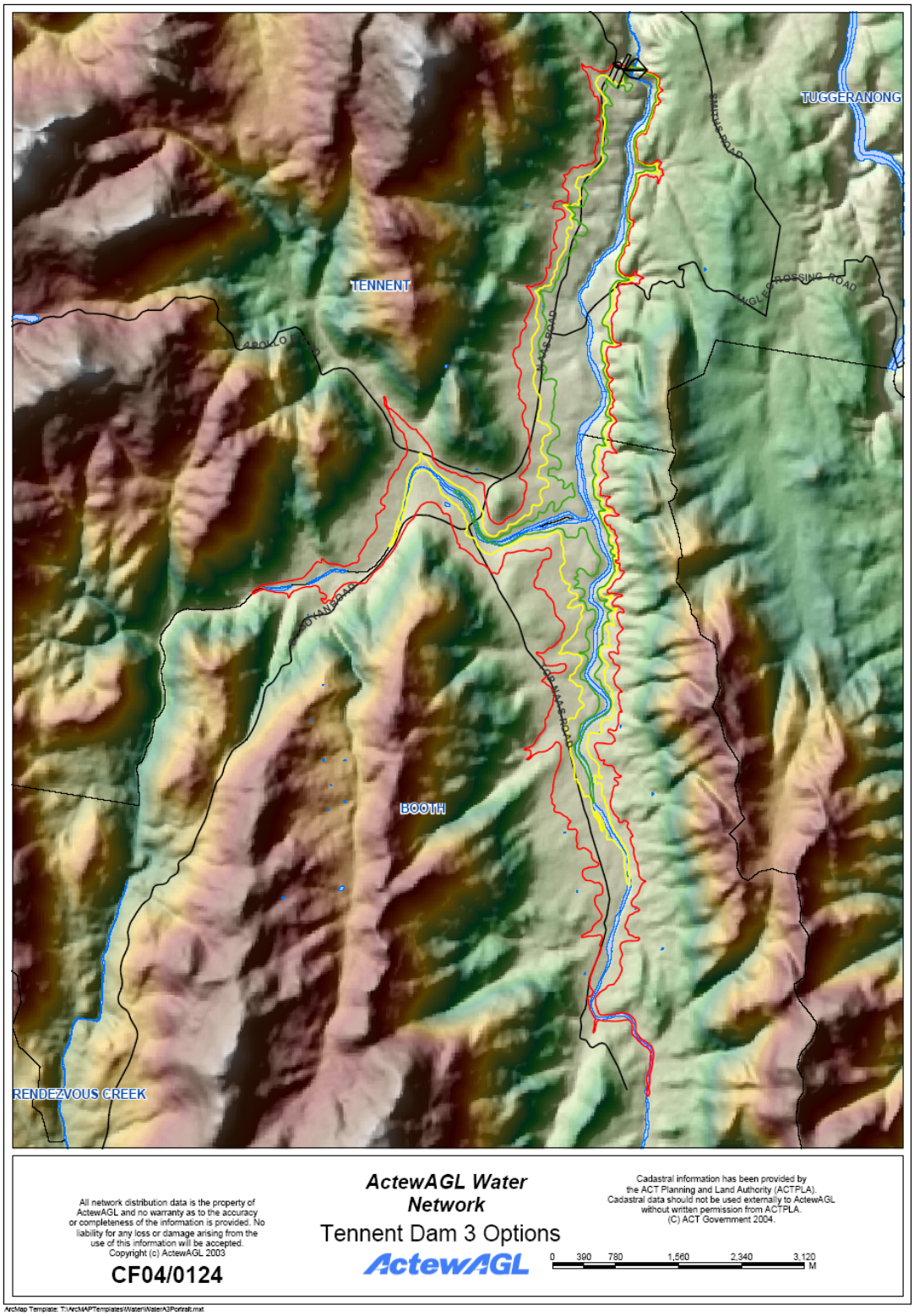


Figure 2.3 Tennent Reservoir Inundation Areas

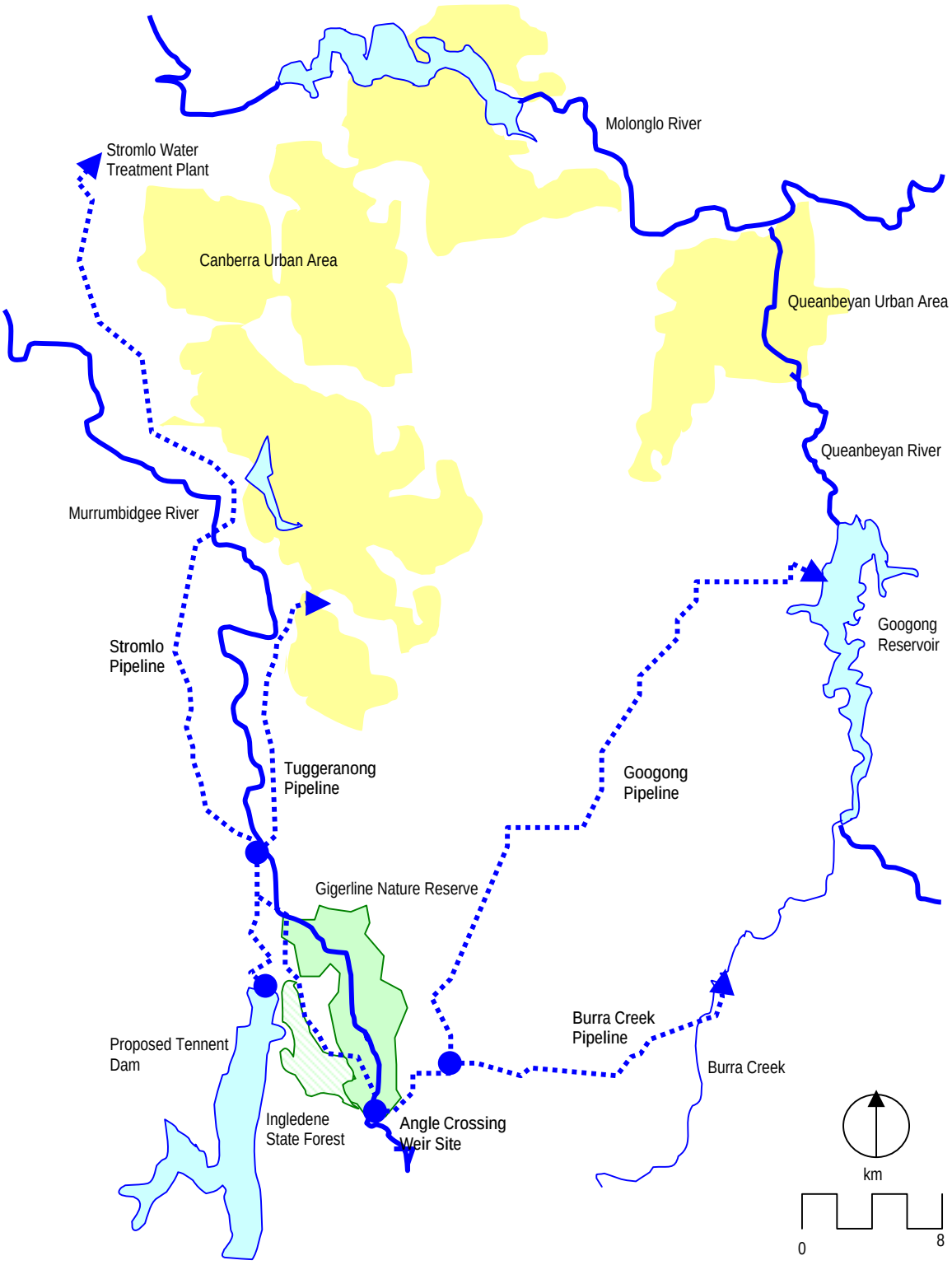


Figure 2.4 Tennent Pipeline and Virtual Tennent alternatives

2.4 Virtual Tennent Alternatives

The long term intention has been that, when population increases warrant it, the Canberra population would be supplied with additional water by the construction of an additional dam (or dams). Construction of a dam has inevitable financial, social and environmental costs and this has led to serious consideration being also given to non – dam options. One of these is referred to as the “virtual Tennent ” option. Under this alternative a weir would be constructed on the Murrumbidgee River from

which water volumes equivalent to that available for abstraction from the ACT controlled tributary streams (Gudgenby, Naas, Tidbinbilla, etc) could be pumped. A weir would be much smaller than a dam with consequently lower financial, social and environmental costs. Three possibilities have been assessed:

- A weir and pump station at Tharwa, 400m upstream from the Tharwa Bridge.
- A weir and pump station at Angle Crossing.
- A pump station and possible weir at the Cotter.

A weir site approximately 150 m upstream from the main Cotter pump station has been identified and assessed as being suitable. Reactivation of the Cotter pump station facility has been approved to provide drought contingency water supply. A capacity of 60 ML/day is potentially available. It is nevertheless considered preferable that water for human use is subject to a period (at least several days) of "detention time" in a reservoir to allow pathogens to die off before treatment. Consequently direct pumping from the river to the treatment plant is not a preferred option for long term supply and this alternative has not been considered further.

The choice between the Angle Crossing and Tharwa locations was reviewed at a meeting convened between ACTEW and Environment ACT in December 2004[23]. The minutes of that meeting indicate that the Tharwa weir site will "definitely have sediment problems". And that there also could be a problem with the Tharwa Bridge as the weir may stop sediments from reaching the bridge; the bridge needs a sediment supply to maintain the integrity of its footings. It was determined that the weir near Angle Crossing would be the best of the two alternatives. In addition to this there would also be a cost penalty with the Tharwa alternative[24] due to increased pipeline length and pumping costs. The Tharwa site has therefore not been considered further.

For the Angle Crossing alternative water would be pumped to Googong Reservoir for storage and subsequent treatment and use. There are two options for piping the water to Googong:

A shorter pipe option delivers the water to Burra Creek above Googong Reservoir. This option could include a tunnel under Gibralton Hill or alternatively follow the Williamsdale Road alignment to the south of the Hill.

A longer option is a pipe delivering the water all the way to the reservoir via the Monaro Highway alignment and the Jerrabomberra Creek Valley.

Both options involve pumping water up and over a range of hills with an elevation of about 830 to 850 m above sea level. The weir locations and pipeline options are illustrated on Figure 2.4.

Preliminary estimates[25] (all assuming 60ML/day capacity) indicate capital costs as shown in Table 2.3.

Table 2.3 Virtual Tennent Alternative Costs Preliminary Estimates

Option	Weir cost	Pump station cost	Power Supply	Pipeline costs	Total cost
Cotter weir:	$2,116,000	$16,025,000	$145,000	$1,320,000	$19,606,000
Tharwa weir & pipe to Googong:	$2,860,000	$8,880,000	$675,000	$36,800,000	$49,215,000
Tharwa weir & pipe to Burra Creek:	$2,860,000	$8,880,000	$675,000	$41,700,000	$54,115,000

[23] Future Water Options Project (2004), Review of Constraints - Aquatic Ecology and Fish Issues, Minutes of Meeting, 1 December 2004.
[24] GHD (2004), *Cotter, Tennent and Coree Options (Engineering) Report*, Dec 2004.
[25] *Ibid*

Option	Weir cost	Pump station cost	Power Supply	Pipeline costs	Total cost
Angle crossing weir & pipe to Googong:	$2,860,000	$8,880,000	$1,135,000	$36,800,000	$49,675,000
Angle crossing weir & pipe to Burra Creek:	$2,860,000	$8,880,000	$1,135,000	$41,700,000(1)	$54,575,000
Note 1: includes directionally drilled pipe @ $21,250,000 Source: *Future Water Options Study, Cotter, Coree and Tennent Options (Engineering) Report December 2004, GHD for ACTEW*					

A review of these costs suggested that the drilled pipe component of the Angle Crossing to Burra Creek alternative should be replaced by a trenched pipeline around rather than through Gibralton Hill. The pipeline cost could be substantially reduced and this then becomes the clearly preferred option on financial grounds. A more detailed assessment of this alternative was then conducted by GHD[26] who reported the following likely costs:

Item Description	Cost ($M)
Angle Crossing Weir	2.9
Intake structure and low lift pumps	1.1
Angle Crossing Booster Pump Station	7.8
Power Supply to Pump Stations	1.4
Sedimentation Tank	1.6
Pipeline to Burra Creek	19.5
Stream Protection and Culvert Upgrading	1.0
TOTAL	35.3

This configuration has been adopted as the preferred virtual Tennent alternative for the purposes of this report.

2.5 Other Infrastructure

Infrastructure in the Naas – Gudgenby valleys that may require relocation if a dam is constructed includes roads, power lines and telephone cables. The Naas and Boboyan roads will be inundated at least in part by all three reservoir options and the largest reservoir results in substantial lengths of both roads requiring relocation. Figure 2.3 shows the roads that would be inundated. Table 2.4 summarises the road requirements for the three options.

Construction of new roads in the water supply catchment and close to the waters edge will require special attention to be paid to runoff and possible contamination problems. Contaminant traps similar to those constructed on the Federal Highway at Lake George will be required.

There will also be a requirement under each of the three reservoir alternatives for the replacement of power lines and telephone cables that will be inundated. The extent of new powerlines and telephone lines required is shown in Table 2.4

[26] GHD (2005) *Future Water Options Study, Option 6: Angle Crossing to Burra Creek 60 ML/day, Report.* Feb 2005.

Table 2.4: Tennent Reservoir Alternatives Other Infrastructure Costs

Reservoir Option	Bitumen Road relocations (m)	Gravel Road Relocations (m)	Length of Bridges Including Elect conduit (m)	Electricity Relocations (aerial line)	Telephone line relocations	Estimated Cost ($M)
RL655	10,150	7,700	2 @ 200m	12.0km	12.4km	27.7
RL647	7,285	2,030	1 @ 200m	8.9km	10.1km	18.9
RL640	5,180	0	1 @ 200m	6.0km	7.7km	16.9
Source: GHD 2004, Tables 29, 33 & 44						

As with the dams themselves this infrastructure will require assessment and approval under a range of legislation discussed in this section. In particular the road alignments are considered to be sensitive as they will traverse relatively undisturbed bushland, in part within the Namadgi National Park, for substantial distances and will be located on relatively steep land.

3 Planning Requirements and Approval Processes

3.1 Statutory Planning and Legislation

The statutory framework within which a future water option must be planned and implemented involves a complex range of legislation of the Commonwealth, NSW, and ACT Governments. Implementation of a preferred option will also be informed and influenced by:

- water resource management policies;
- sustainability strategies, including greenhouse abatement;
- economic, social and spatial dimensions of regional development strategies; and
- environment, land management and development control policies and regimes established to control land use, and manage environmental impacts and water quality.

The responsibilities of the various tiers of government and intergovernmental agreement obligations further delineate the framework within which the *Future Water Options* study has developed. The simultaneous involvement and interaction of Commonwealth, NSW and ACT legislation (especially for the virtual Tennent and Tantangara options) increases the complexity of the planning, investigation, assessment, review and approval processes.

Table 3.1 summarises the main legislative instruments that must be considered with their relevance for the three elements of the various Tennent alternatives highlighted.

Table 3.1: Legislative instruments relevant to the Tennent Alternatives[27]

X – Potentially Relevant XX – Definitely Relevant	**Tennent Reservoir (all sizes)**	**Murrumbidgee Weir (any location)**	**Pipeline Murrumbidgee to ACT border**	**Pipeline ACT border to Googong Reservoir**	**Comment**
Commonwealth					
Seat of Government Acceptance Act 1909 – First Schedule				**XX**	Establishes the 'right' of the ACT to abstract water from the Queanbeyan and Molonglo Rivers in NSW and to build necessary works.
Canberra Water Supply (Googong Dam) Act 1974				**XX**	Authorises building of Googong Dam and pipelines, acquisition of land etc.
ACT Self-Government (Consequential Provisions) Act 1988	**XX**	**XX**	**XX**		Water rights devolved to ACT Government from the Commonwealth.

[27] Adapted from McCann Property and Planning Pty Ltd and ACTEW (2004), *New Water Source for the ACT, Planning and Development Controls*. June 2004.

X – Potentially Relevant XX – Definitely Relevant	Tennent Reservoir (all sizes)	Murrumbidgee Weir (any location)	Pipeline Murrumbidgee to ACT border	Pipeline ACT border to Googong Reservoir	Comment
ACT (Planning and Land Management) Act 1988	**XX**	**X**	**XX**		Establishes National Capital Plan that ensures ACT water supplies are directed to ACT needs, protects catchments, and identifies Tennent Reservoir site.
EPBC Act 1999	**XX**	**X**	**X**	**X**	Provides for management of conservation issues of national significance.
Australian Heritage Commission Act 1975 & Australian Heritage Council Act 2003	**X**	**X**	**X**	**X**	Provides for management of heritage issues of national significance by way of the Register of the National Estate.
Territory					
Land (Planning & Environment) Act 1991	**XX**	**X**	**X**		Establishes the Territory Plan and provides mechanisms for development and environmental assessments. Territory Plan makes provision for Tennent reservoir.
Nature Conservation Act 1980	**XX**	**XX**	**XX**		Provides mechanisms and controls for nature conservation including preparation of threatened and endangered species action plans, the role of the conservator of wildlife. Prohibits construction in certain areas.
Environment Protection Act 1997	**XX**	**XX**	**XX**		Provides mechanisms for pollution control, for example during construction.
Water Resources Act 1998	**XX**	**XX**	**X**	**X**	Provides a framework for management of water in the ACT includes requirements for environmental flows and the preparation of a Water Management Strategy.
Planning and Land Act 2002	**X**	**X**	**X**		Planning Advisory Council advises Planning Authority and Minister on plan variations and major projects.
Heritage Act 2004	**X**	**X**	**X**		Empowers Heritage Council to assess impact of proposals and advise Planning and Land Authority
Lands Acquisition Act	**X**	**X**	**X**		Provides for compulsory acquisition of land needed for public purposes.
NSW					
Environmental Planning and Assessment Act 1979				**XX**	Provides mechanisms for development and environmental assessments.
Protection of Environment Operations Act 1997				**XX**	Provides for the issue of environmental licences.

X – Potentially Relevant XX – Definitely Relevant	Tennent Reservoir (all sizes)	Murrumbidgee Weir (any location)	Pipeline Murrumbidgee to ACT border	Pipeline ACT border to Googong Reservoir	Comment
Wilderness Act 1987					Not applicable to the Tennent alternatives.
National Parks and Wildlife Act 1974					Not applicable to the Tennent alternatives.
Threatened Species Conservation Act 1995				X	Provides for the protection of Threatened Species.
Rural Fires Act 1997				X	Provides for bushfire management, probably of only minor interest.
Fisheries Management Act 1994				X	Provides for the protection of fish resources.
Water Act 1912				X	Provides for the issue of water and infrastructure licences, unlikely to be relevant to the Tennent alternatives.
Land Acquisition (Just Terms Compensation) Act 1991				X	Provides for compulsory acquisition of land needed for public purposes, any required action will need to be implemented cooperatively with NSW.
Murray-Darling Basin Act 1992				X	NSW legislation to enact the Murray-Darling Basin agreement.

3.1.1 Commonwealth water legislation and policy

Canberra's national capital function is supported by Commonwealth legislation, which (among other things) establishes arrangements to secure long-term water supplies.[28] As noted in section 1.2, the legislation creating the ACT provides control over water resources from ACT rivers and streams, exclusive of the Murrumbidgee River, plus the Queanbeyan and Molonglo rivers.

National objectives for improving natural resource management, water distribution, asset management and financial arrangements for the Murray Darling Basin were agreed in 1992, and ratified by the *Murray Darling Basin Act 1993;* subsequent reforms and agreements set parameters that impact on ACT water planning.

The ACT formalised its participation in the Murray Darling Basin initiative in 1998, committing to a cap on water diversions. In consultation with other members of the Murray Darling Basin Commission, the ACT is in the process of quantifying the appropriate cap. The ACT Government has said it will complete a Memorandum of Understanding with the NSW and Commonwealth Governments by the end of 2005 that will include provision for a water cap.

[28] The *Commonwealth Seat of Government Acceptance Act 1909* established paramount water right of the Commonwealth for the purposes of the Territory. NSW retains rights to the reasonable use of the Murrumbidgee River for conservation or irrigation. The *ACT Self Government (Consequential Provisions) Act 1988* transferred water functions to the Territory.

A Murray Darling Basin Water Agreement in 2003 incorporated a five-year strategy for the implementation of water recovery measures, with 500 GL to be set-aside per year for environmental purposes across the Basin. The ACT will contribute $5 million to increase water recovery by 2 GL per annum as part of this agreement.

The Council of Australian Governments (COAG) agreed in June 2004 to a National Water Initiative to achieve environmental outcomes, involving:

- expansion of permanent trading in water entitlements;
- improved water management arrangements;
- more sophisticated, transparent and comprehensive water planning;
- a commitment to address over allocated systems; and
- better and more efficient management of water in urban environments. [29]

The National Water Commission has recently been established, together with an Australian Water Fund.[30] The $2 billion fund will assist projects that improve river flows, encourage on-farm water use efficiency measures, recycle and reuse storm water and grey water, provide more efficient storage facilities (such as underground aquifers), and other initiatives.

Particular implications of Commonwealth water legislation and policy initiatives for the Tennent option are:

- the concurrence of the Murray-Darling Basin Commission may be required for any major additional diversion of water, or establishment of additional storage capacity; and
- the Commonwealth has set a pre-condition – the development of an integrated water supply strategy for the region – before any expansion of regional water supply will be approved. The ACT has established outcomes that it will seek within an integrated regional water supply strategy.[31]

3.1.2 Commonwealth planning legislation and policy

Whilst actual approval for works for any of the Tennent alternatives would be granted by the Territory in accordance with the Land (Planning and Environment) Act, The National Capital Plan[32](NCP) controls the management and future development of land in the Territory; the Territory plan, which is given effect by the Land Act, must be consistent with the NCP. The NCP makes specific provision for a future Tennent reservoir.

The policy position set out in the National Capital Plan is as follows.

> "Run-off in the case of the Gudgenby (Tennent Reservoir) catchment is of a high quality, reflecting the forest and grass character of the catchment, soil stability and limited human activity. Water from Tennent Reservoir would be fed, after treatment, directly into the water distribution system. As some habitation and a wide usage of the catchment for recreation, camping and nature study is proposed, extensive buffer storage and water clarification and disinfection would be required at Tennent Reservoir to ensure adequate protection of public health. The adequacy of this system of protection would be dependent on the maintenance of the high physical and chemical quality of raw water, and on careful control on bacteria discharged in wastewater in the catchment. The

[29] See http://www.pmc.gov.au/nwi/index.cfm
[30] See http://www.aph.gov.au/library/pubs/bd/2004-05/05bd072.htm
[31] ACT Government (2004), *Think water, act water*, Vol 1, op cit, p 38. April 2004.
[32] The *Australian Capital Territory (Planning and Land Management) Act 1988* established the National Capital Authority and National Capital Plan, which sets out special requirements for development in selected areas.

> continuation of rural activities in the Naas and Gudgenby valleys is compatible with the planning intentions in the interim, although ultimately these leases would need to be withdrawn as they would be largely inundated by the reservoir. It would not be appropriate, however, to permit substantial capital development, which to be economically justified, would need to be viable beyond the construction date of the reservoir. In summary, restricted use is possible in the …..Gudgenby catchment" (pending construction of a dam).[33]

Land use policies are defined for the National Capital Open Space System, including the Murrumbidgee River Corridor were the weir alternatives are located. The National Capital Plan does not specifically provide for a virtual Tennent alternative involving a weir on the Murrumbidgee River and use of the Murrumbidgee River water for large scale domestic consumption does not appear to be contemplated by the Plan. Implementation of a weir option would require an amendment to the National Capital Plan. Extraction of water from the river near Angle Crossing may require the site to be identified as a "special development area", or the Murrumbidgee River Corridor Policy Plan to be amended to designate domestic water as a use within the policy designation that applies to the specific site that is selected. Angle Crossing and its immediate vicinity is covered by a "recreation area" specific policy, the surrounding land is a "vegetation restoration area" and land further north is a "nature conservation core area" (the Gigerline nature reserve).

3.1.3 Commonwealth environmental legislation and policy

Under the environmental assessment provisions of the (Commonwealth) *Environment Protection and Biodiversity Conservation Act 1999*, actions that are likely to have a *significant impact* on a matter of national environmental significance are subject to a rigorous assessment and approval process. An "action" includes a project, development, undertaking, activity, or series of activities.

The Act identifies seven matters of national environmental significance, one of which is nationally listed threatened species and ecological communities. As discussed in Chapter 2.0 above, the Yellow Box Red Gum Grassy Woodland ecosystem in the Gudgenby catchment has been nominated for listing as an Endangered Environmental Community under the *Environment Protection and Biodiversity Conservation Act 1999*, and so the provisions of the EPBC Act are expected to apply.

An action will require approval from the Commonwealth Environment Minister if it has, will have, or is likely to have, a significant impact on a species listed in any of the following categories:

- extinct in the wild;
- critically endangered;
- endangered; or
- vulnerable.

Administrative guidelines for determining whether or not an action will fall into the EPBC Act net can be used to assess what is a "significant impact". The guidelines outline criteria affecting significant impacts on critically endangered and endangered species if the proposed action will:

- lead to a long-term decrease in the size of a population;
- reduce the area of occupancy of the species;
- fragment an existing population into two or more populations;
- adversely affect habitat critical to the survival of a species;

[33] Adapted from National Capital Plan, National Capital Planning Authority (1990), *National Capital Plan*, 1990, as amended, Appendix G.: Requirements for Namadgi National Park and Adjacent Areas.

- disrupt the breeding cycle of a population;
- modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline;
- result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species´ habitat[34]; or
- interfere with the recovery of the species.

It would be expected that any of the Tennent alternatives, if proposed for implementation, would be formally referred under the provisions of the Act.

3.1.4 Commonwealth heritage legislation and policy

The *Australian Heritage Council Act 2003* is replacing the *Australian Heritage Commission Act 1975.* The final arrangements with regard to administering the new act have not been completed.

The Murrumbidgee River Corridor within the ACT and specific features within it (e.g. the Cotter Pumping Station) are entered in the Register of the National Estate pursuant to this legislation. Such places or sites cannot be damaged unless there are no feasible or prudent alternatives and Australian Heritage Council advice must be sought before any action that might affect such areas is taken. The virtual Tennent weir alternatives would require clearance under this legislation prior to proceeding.

3.1.5 NSW legislation and policy framework

The Tennent "virtual Tennent " alternatives include the construction of a pipeline from the ACT border near angle crossing to Googong reservoir. This pipeline would be subject to NSW planning and environmental legislation.

The *Environmental Planning and Assessment Act 1979* establishes the development assessment system for NSW. Any major water infrastructure project may be a designated development or an integrated development requiring approval under multiple enactments. It is likely that the pipeline would be classified as an integrated development. (Part 4 of the Act).

- Procedures for environment impact assessment are mandated where a proposal is likely to significantly effect the environment. (Part 5 of the Act).
- Options that impact on the environment in both NSW and the ACT may have to proceed in an integrated and concurrent manner under a formal NSW/ACT agreement covering integrated environmental assessment.

The *Environment Operations Act 1997* allocates responsibilities between the (NSW) Environment Protection Authority, local councils and other public authorities, authorises Protection of the Environment Policies, and establishes licenses for activities that may impact on the environment. Appropriate licenses for the pipelines would be required.

The virtual Tennent option involves the abstraction of water from the Murrumbidgee River but only to the extent that this water is replaced by inflow from ACT controlled catchments, for example Gudgenby. There will therefore be zero net abstraction from the Murrumbidgee and consequently the impact on NSW water resources will be zero. Noting this fact, cross-border water policy issues must also give consideration to the following:

[34] Introducing an invasive species into a habitat may result in that species becoming established. An invasive species may harm a critically endangered or endangered species by direct competition, modification of habitat, or predation.

- NSW and the ACT have a shared interest in management of the resources of the Murrumbidgee River since they underpin current and future regional economic development (ACT Sub Region Planning Strategy 1998).
- The development of a regional Integrated Water Supply Strategy and a Cap on ACT diversions will require inter-governmental agreement and will impact on planning of Future Water Options.
- NSW and the ACT are both stakeholders in the National Water Initiative, and the management of the Murray Darling Basin, setting the framework within which a preferred option for the ACT will be considered.

All of the above legislation is administered at a State Government level, and indeed a pipeline proposal may be declared a "project of state significance", putting the development approval in state rather than local government hands. It will nevertheless be essential that consultation and discussion is held with the local Government Authority (the Queanbeyan City Council) prior to and during the further development of a firm proposal. The Council will have a significant interest in a pipeline alignment, particularly where it utilises local roads and other infrastructure.

3.1.6 ACT legislation and policy framework

The *Water Resources Act 1998* vests to the Territory under Section 13, the right to the use, flow and control of all water of the Territory, and allows:

- the preparation of environmental flow guidelines to maintain aquatic ecosystems (s5) which are supported by subordinate law in the Environmental Flow Guidelines of 27 May 1999;
- subordinate law in the Water Resources Management Plan[35] to describe the water resources of the Territory including the flows required for environmental needs and other water allocations including urban water supply;
- the creation and transfer of water allocations (part 6), licensing water use (Part 7), and permits to construct water control structures (s69);and
- a fee (currently $492.90 per megalitre) to be paid for additional water allocations.

Any of the future water supply options that sourced water within the ACT or Act controlled catchments would be subject to these provisions.

As noted in section 2.4, the *Environmental Flow Guidelines* set out a methodology for the calculation of environmental flows to be used to support the *Water Resources Act* and the Territory Plan, and as the basis of the *Water Resource Management Plan* for the ACT. The Act requires that environmental flows must be provided for, before any other use.

The *Water Resource Management Plan* determines the allocations available on a sub-catchment basis, taking into account climate, environmental values, land use, streamflow and environmental flow considerations. ACTEW Corporation has a rolling average annual allocation of 62.7 GL limited to the Cotter and Queanbeyan River catchments, and a license which authorises abstractions.[36]

[35] *Think water, act water. Strategy for sustainable water resource management in the ACT* Volume 3, April 2004 is the Water Resource Management Plan presented to the ACT Legislative Assembly, and now a Disallowable Instrument.
[36] Water use in 2003-2004 was 54.4 GL.

Implementation of the preferred option will require adjustments to the management plan, and amendment of allocations and license conditions.[37]

The *Land (Planning and Environment) Act 1991* [ACT] (the Land Act) sets a framework for the assessment and approval (or refusal) of development proposals including infrastructure projects. It includes a number of components.

- It establishes the Territory Plan that in turn determines permissible land uses for land in the Territory (excluding Designated Land covered by the National Capital Plan, see below), and processes for variations to the Plan.
- It specifies procedures for development application approvals, review of decisions, and consultation requirements.
- It provides for referrals to the Heritage Council on matters of heritage significance.
- It establishes procedures and requirements for environmental assessments and inquiries.
- It establishes procedures for land administration, including leasing and land management.

The various proposals for future water supply would come within the definition of a "major utility installation" in the Territory Plan. "Major utility installation" is a use that is able to be permitted within the "mountains and bushland" and "river corridor" land use policy areas of the Territory Plan and consequently the actual construction of the dam and weir options would not in themselves require a variation to the Territory Plan. Appendix 1 of the Territory Plan sets out "water use and catchment policies" that define permitted uses of water within catchment areas. The permitted uses in the Tennent catchment currently do not include use of the water for fully treated bulk supply purposes. Therefore a new reservoir would require an amendment to the Territory Plan Appendix I.

The ACT components of the pipelines associated with the weirs would also be classified as "major utility installations" or "major service conduits" and are also able to be permitted along the proposed alignments. Pipeline alignments traversing NSW would be subject to NSW legislation – see above.

Environmental assessment is subject to part 4 of the Land Act. A Development Application (DA) will be required for the preferred option and this will trigger a mandatory Preliminary Assessment, which would probably lead to a requirement to prepare a full Public Environment Report (PER) or Environmental Impact Statement (EIS) and a formal Inquiry. To date the administration of this part of the Land Act has been such that usually, even for major proposals, only a preliminary assessment (albeit these are sometimes substantial pieces of work) has been required. More recent practice has been to proceed to the further levels of assessment for significant projects. This means that whilst a future water option would probably be subjected to either an EIS or a PER the administration has only minimal experience with these processes. The intent is that, depending on the option that may be selected, this report or one of its companions (which examine Cotter and Tantangara options) will serve as an appropriate document for a Preliminary Assessment and provide a basis for determining further assessment requirements. This is a practical approach that will save both time and money, without any diminution in the rigour of the assessment and approvals process.

Gudgenby, Naas and Tennent sub-catchments have been identified in the National Capital Plan and the Territory Plan as a future water supply catchment. The three sub-catchments are classified in the Territory Plan as conservation (rather than water supply) catchments. This does not preclude their use

[37] Allocations and licences are sub-catchment specific and require detailed analysis.

for water supply purposes but if a decision were made to proceed with a Tennent option it would probably be preferable to vary the Territory Plan to resolve this to ensure maximum clarity.

The Planning and Land Act 2002 sits beside the Land (Planning and Environment) Act. Referral of Territory Plan Variations and major development proposals (such as dams or pipelines) to the Planning and Land Council is mandated by regulations under this Act. The Planning and Land Council is established under the Act to give advice to the Planning Authority and Minister on major planning matters.

The Heritage Act 2004:

- establishes a register for the recognition and conservation of natural and cultural heritage places and objects, including Aboriginal places and objects;
- established the Heritage Council;
- provides for heritage agreements to encourage the conservation of heritage places and objects;
- establishes enforcement and offence provisions to provide greater protection for heritage places and objects;
- provides a system integrated with land planning and development to consider development applications having regard to the heritage significance of places and heritage guidelines.

The Planning and Land Authority must give the Heritage Council a copy of any development application that relates to a place or object registered, or nominated for provisional registration, under this Act. New water supply options would require such a referral.

The Council provides advice to the Planning and Land Authority about the effect of development on heritage issues. The Authority must consider its advice.

It is likely that simultaneous and somewhat overlapping review of the heritage implications will occur pursuant to both Commonwealth and ACT legislation.

The *Nature Conservation Act 1980* provides for the protection and conservation of native animals and plants and for the reservation of areas for these purposes, and for special protection status. Declaration of a threatened fish or invertebrate under the Act confers on it the status of “animal”, meaning that the provisions of the Act also apply. The Yellow Box Red Gum Grassy Woodland areas listed as endangered under the *Nature Conservation Act* are automatically given special protection status.

Permits are required to take, keep, sell or otherwise trade in animals in the ACT. It is also an offence under the Act to disturb or destroy a nest of an animal, which would extend to the destruction of spawning sites of threatened fish. The Act provides for the preparation of Action Plans for the conservation of threatened or endangered species or ecological communities.

There are prohibitions on the Conservator approving certain work in wilderness areas, including Namadgi National Park. *Plans of Management* are developed for public land by the Conservator, approved by the Minister and presented as disallowable instruments to the ACT Legislative Assembly. Any of the future water options will require referral to the Conservator.

The *Environment Protection Act 1997* specifies environmental management and pollution control measures that will impact on detailed design and management, particularly during the construction phase, of a major infrastructure project.

The *Lands Acquisition Act 1994* provides for the compulsory resumption of land for “public purposes”.

The *Independent Competition and Regulatory Commission* is a statutory body set up to regulate prices, access to infrastructure services and other matters in relation to regulated industries. The ICRC will have a role in examining pricing changes generated by increased costs to ACTEW Corporation through the financing of infrastructure required for a preferred option.

3.2 Canberra Planning Policies

- The ACT Government has adopted an overarching policy on sustainability, *People Place Prosperity*[38]*.* The policy is discussed in detail in Chapter 10.0.

Establishing the core values of the Canberra community has been integral to decision-making over the years on Canberra's future direction. These core values have guided the development and coherence of successive iterations of the *Canberra Plan* and its components, the *Social Plan*, *Spatial Plan* and *Economic White Paper*[39]*,* published more recently. The community also had the opportunity in 2003 to express its views about non-urban values, issues and aspirations through the stakeholder consultation process afforded as part of the major post bushfire report, *Shaping Our Territory: Opportunities for Non-Urban ACT*.[40]

The social impact of water supply planning and proposals for securing a new water source, were reviewed for the Future Water Options project team by Tania Parkes Consulting, in conjunction with Ernst and Young.[41] Their report noted that the expression "the Canberra community" extends well beyond the borders of Canberra and the ACT, and beyond its population, because of Canberra's national capital role. The National Capital Authority (NCA) has the role of fostering the national capital interests of the city.

For example, the NCA considers there is a risk to the heritage landscape within the Parliamentary Triangle as a result of both current and potentially escalated water restrictions. It has advised that many of the trees in the heritage landscape are particularly sensitive to longer-term irrigation reduction.[42]

Another important observation of the social impact study was that:

> "The greatest damage to the ACT, and especially those at lower income levels will occur where water supply levels and uncertainty inhibits future population growth in line with Australia's overall population growth and employment opportunities.
>
> High cost government measures such as extensive reticulation of recycled water, high cost regulatory design measures and subsidies for high cost items such as rainwater tanks are also likely to have regressive impact, through least benefit to those on lower incomes and through reducing government financial capacity for providing essential, affordable services."[43]

The *Economic White Paper*, *Social Plan*, and *Spatial Plan* recognise that Canberra's water resources are integral to supporting the community's goals for sustainability. Notably:

- there is an understanding within the *Economic White Paper* of the importance of water for regional economic development;

[38] ACT Government (2003), *People, Place, Prosperity: a policy for sustainability in the ACT*, March 2003.
[39] ACT Government (2003), *The Economic White Paper for the ACT*, December 2003; ACT Government (2004), *Building Our Community: the Canberra Social Plan*, February 2004; ACT Government (2004), *The Canberra Spatial Plan*, March 2004.
[40] Non Urban Study Steering Committee (2003), *Shaping Our Territory – Opportunities for Non Urban ACT,* final report, November 2003.
[41] ACTEW (2005), *Stage 1 Social Impact Appraisal, An overview of the social impact of the Future Water Options Project*, April 2005, ACTEW Corp Doc No. 4657.
[42] *Ibid.*
[43] *Ibid, p ix.*

- there are commitments in the *Social Plan* to ensure that a reliable source of high quality water is maintained; and
- there is recognition in the *Spatial Plan* of water resources management as a key sustainability issue, including a metropolitan urban form that protects existing and future potable water catchment areas and riparian zones and committing the ACT to working with the NSW Government and local councils to ensure coordinated land uses which encourage sustainable development and catchment protection.

Reliability, availability and quality of supply, along with economy in use and environmental responsibility, are thus core water-related community values. They do not suggest that water use minimisation is an overriding goal to the point where it would inhibit natural population growth of Canberra and its region. Neither do they restrict opportunities for livelihood and diversity of activity and participation that underpin the achievement of a fair and equitable society.

3.3 Lease Conditions

All freehold land in the ACT was compulsorily acquired by the early 1970's. The Commonwealth now owns all land in the ACT. Rights to use and occupy land are granted under the leasehold system. Under the provisions of the *Australian Capital Territory (Planning and Land Management) Act 1989* (Commonwealth) the management of the leasehold estate is vested in the Australian Capital Territory Government (the Territory).

Leasehold tenure was adopted so that speculation in undeveloped land could be avoided, and future increases in the value of land remained in the public purse. The leasehold system also has planning advantages. The Government, being responsible for development decisions, can ensure that planning and development policies are implemented in an orderly and efficient manner. Thus, the problems inherent in systems used in other States, such as fragmented development fronts and mismatches between the demand for amenities and their provision, have largely been avoided.

Purchasers or 'owners' of land are granted a lease. The lease document is a form of legal agreement between the government and lessee (land 'owner').

All the land covered at top water level of the Tennent Reservoir option is held under a rural lease or an agistment license, apart from Block 92 Tennent. This block is a former Traveling Stock Route and has been included in a Native Title Claim. Details of the ownership of each block are shown contained in a report on Land Ownership that has been prepared as background to this project.[44]

While the extent of the reservoir foreshore protection area has not yet been determined, it is likely to include most of the areas currently held under rural lease. The foreshore boundary to the east of the reservoir is likely to extend to the ACT border, being the ridgeline in that area. To the west, the foreshores may extend to a point high on the ridgeline, possibly up to the boundary of the Namadgi National Park. The uses for the foreshores will be very restricted and would prevent any major rural use.

If this option proceeds then all rural leases in the Gudgenby and Naas valleys upstream of the dam site would be withdrawn and agistment licenses will be terminated.

[44] KMR Consulting (2005), *Land Ownership Study*, April 2005, ACTEW Corp Doc No. 4652.

3.4 Approvals Processes

In summary the approval processes that would be followed for the Tennent Reservoir options are as follows.

The principal instrument would be a Development Application submitted under the *Land (Planning and Environment) Act 1991* (the Land Act) to the ACT Planning Authority for approval. This would trigger a number of other processes that would need resolution before an approval could be granted by the Planning Authority:

- environmental assessment under Part IV of the Land Act;
- referral to the Conservator of Wildlife in accordance with the provisions of the *Nature Conservation Act 1990;*
- referral to the ACT Heritage Council, in accordance with the *Heritage Act 2004*, the Heritage Council would also take into consideration national heritage interests;
- referral to the National Capital Authority (formally required for the Murrumbidgee Weir options only);
- application for a water abstraction license under the provisions of the *Water Resources Act 1998;*
- referral to the Murray Darling Basin Commission (advisory only, the Commission does not have statutory power and no constraining agreements have as yet been entered into by the ACT Government);
- referral to all relevant ACT Government Agencies (advice only);
- for NSW pipeline options, an application for development under the (NSW) *Environmental Planning and Assessment Act 1979;*
- acquisition of necessary lands would be completed under lease administration processes or by way of NSW and ACT Land Acquisition Legislation;
- referral to the Commonwealth Department of Environment and Heritage for assessment of significant environmental impacts; and
- referral to the Australian Heritage Council for assessment of places listed on the Register of the National Estate.

Several of the above processes, in addition to the development application itself, include provision for community consultation. The practice of the Planning Authority is to ensure that, in addition to statutory requirements for consultation, substantial opportunities are provided for public input to major development proposals.

4 Tennent Water Resources

4.1 Historical River Flows

Volume 3 of *Think water, act water* contains historical data on the river flows and allocation provisions for each of the ACT's catchments. The Tennent dam catchments include the Naas River, the Gudgenby River to the junction with the Naas River, and the Tennent sub catchment, which is the Gudgenby River downstream of the Naas junction to the Murrumbidgee. Only about half of the Tennent sub catchment is upstream of the Tennent dam site. The key data are shown in Table 4.1.[45]

Table 4.1: Historical Annual average flows and water allocations, Tennent Dam catchments

(GL)	Naas	Gudgenby	Tennent (1)	Total
Av annual flow	38.6	50.5	3.7	92.8
Environmental allocation	35.6	48.6	3.4	87.6
Available for use	2.9	4.0	0.26	7.16
Already allocated	0.002	0.026	0	0.028
Provision for allocation	0.05	0.05	0.025	0.125
Reserved	2.9	3.9	0.236	7.036
Note 1: Figures shown here are half the total "Tennent" catchment as this catchment is only partially upstream of the Tennent dam site. Source: ACT Government (2004), *Think water, act water,* Vol 3.				

"Think water act water" is the ACT "Water Resources Management Plan"[46]. Construction of a Tennent Dam would require a revision of the Water Resources Management Plan as virtually all its flow under the current plan is allocated for environmental flows or is currently classified as "reserved". This is because, to date, it has not been used for water supply.

Think water, act water also contains historical data on monthly river flows. For the Tennent Dam catchments the historical average monthly flows are as shown in Table 4.2. The table shows that flow levels have had a clear peak in winter and spring but that flows are maintained all year. The lowest month, March, is a little over one third of the flow of the highest month, September.

Table 4.2: Historical Average monthly river flows in the Tennent dam catchments (GL)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Average Monthly Flow (GL)	5.7	4.5	4.2	7.6	6.0	6.6	9.5	11.0	11.4	11.3	8.7	6.3	92.8
% avge Annual Flow	6	5	5	8	6	7	10	12	12	12	9	7	100%

4.2 Environmental Flows

The *Water Resources Act 1998* requires that Environment ACT produce the Water Resources Management Plan as one component of the management of the ACT's water resources. It specifies

[45] ACT Government (2004), *Think water, act water* Vol 3 "State of the ACT's water resources and catchments," April 2004 pp 30-35.
[46] Refer section 3.1.6 for a discussion on the Water Resources Management Plan and 4.2 for Environmental Flows.

water that is set-aside for environmental flows and then documents how the Government intends to manage the remaining water resources. A key part of the plan is to make provision for water allocations (over a ten year period). Allocations cannot be created or licenses to take water granted unless they are provided for by the plan.

The environmental flow guidelines came into being in 1999. They are defined as the "streamflow necessary to sustain habitats (including channel morphology and substrate), encourage spawning and the migration of fauna species to previously unpopulated habitats, enable the processes upon which succession and biodiversity depend, and maintain the desired nutrient structure within lakes, streams, wetlands and riparian areas."[47]

ACTEW has calculated that the water accounted for by current environmental flows is equivalent to the requirements of 75,000 residents – implying that a new water storage facility will be required somewhat earlier than if the environmental guidelines did not exist.

There are four elements of environmental flows:

- **Low flows** are based on the 80th percentile flows calculated on periods of not more than a month. The 80th percentile flow is the flow that is exceeded 80% of the time. In other words, water flows below the 80th percentile are all required for environmental purposes. The guidelines enable Environment ACT, as the relevant administering agency, to reduce the low flow definition if the water service provider can demonstrate the need for additional supply, but not below the 50th percentile;
- **Flushing flows** are required to ensure that water channel structures and ecological processes dependent on them are maintained. The discharge that has been found to be most critical is the 1 in 1.5 to 2.5 years recurrence interval flood event. In the ACT's rivers, other than water supply catchments, the short duration of high volume flows and a limit on abstraction of 10 per cent of flows above the 80th percentile will ensure that flushing flows occur with this frequency;
- **Special purpose flows** include a requirement for spawning flows in the Cotter River. A flow adequate for spawning has been defined as the 50th percentile monthly flow during the spring months (September, October and November) and the 80th percentile monthly flow for the months of August and December to March inclusive. In two out of every five years, flows are to be at or above the spawning level for each month in the August to March period, regardless of prevailing seasonal conditions. ACTEW would prefer to have this requirement conditional on the previous 12 months flow into Corin Reservoir being in excess of 60 GL;
- **Maintenance of impoundment levels** is required to protect macrophytes. For urban lakes and ponds the maximum drawdown as a result of abstraction is 0.20 m below spillway level.[48]

While most sub-catchments (including the Tennent Dam site catchments) are restricted to having no more than 10 per cent of flows above the 80th percentile abstracted, 'water supply catchments' are able to have 100 per cent of flows above the 80th percentile utilised.

10% of flows above the 80th percentile was selected as a suitable portion of water for abstraction in most sub catchments. This 10% threshold was selected using the then (1999) best available scientific

[47] Environment ACT (1999), *Environment Flow Guidelines*, May 1999, p 3.
[48] ACT Government (2004), *Think water, act water* Vol 3 "State of the ACT's water resources and catchments," April 2004, op cit, p 6.

advice on the provision of habitat diversity and quality, nutrient and sediment cycling, movement of biota and connectivity between aquatic and terrestrial habitats.

For 'Water Supply Catchments' 100% of flows above the 80th percentile are available for abstraction. If the Naas and Gudgenby Rivers were selected as a future water supply source then they would be designated as 'water supply catchments' and, assuming the current regime applies, 100% of the flows above the 80th percentile would be available for storage and use.

The current environmental flow guidelines allow for reduced releases based on 'drought' conditions to ensure security of water supply. 'Drought' is defined for the purpose of the guidelines as occurring when the nine months of the preceding 12 months flows into Corin and Googong were less than the median monthly inflows and the total amount of storage is less than 50%. If these conditions are met, application for 'Drought' flows can be made to the Environment Management Authority (EMA) to reduce releases by a proportion as determined by the EMA on a case by case basis, but not below the 50th percentile flows. If a Tennent dam was introduced into the system then it is expected that this "drought definition" would be reevaluated.

The Environment Management Authority (EMA) of Environment ACT is responsible for establishing and reviewing the environmental flow guidelines. Currently (2004-05) the guidelines are being reviewed and may result in changes. However the final outcomes of this review will not be known before mid 2005. To assess the ability of new water options to meet demand, assumptions have to be made on the environmental flows to be released in the future. Advice was sought from the Environmental Management Authority on potential scenarios for environmental flows for the purposes of assessing the future water options. Three scenarios were identified to provide a realistic basis for assessing the future water options[49]. These are:

Scenario 1 – Current environmental flow guidelines.

Scenario 2 – Preliminary Modified environmental flow guidelines.

Scenario 3 – Modified environmental flow guidelines.

The dam site is located approximately mid way in the Mount Tennent sub catchment and would capture about half of the runoff from that catchment as well as all the runoff from the Naas and Gudgenby rivers upstream of their confluence. The total average annual flow potentially available for capture (based on historical records in "Think water act water") by a dam currently is therefore (from Table 4.1) the sum of the annual flow from the Naas and Gudgenby rivers plus half the Tennent sub catchment flow. This totals 92.8 GL.

Declaration of the catchments as water supply catchments and adjustment of the environmental flow requirements would allow this to be increased dramatically. For example in the Cotter catchment, which is a declared water supply catchment, the total flow is 145.7 GL and 107.5 GL (or 74%) is available for abstraction. 74% of the Tennent inflow would give 68.7 GL per year on average available for extraction.

The potential abstraction from a Virtual Tennent option may be greater as the above figures would include abstraction at a level equivalent to the dam catchment as well as runoff from other ACT creeks and rivers such as Tidbinbilla Creek and Paddys River.

The expected water supply outcomes for these alternatives are discussed in section 4.6 below.

If the dam were constructed then the effect on environmental flow regimes within the catchment would be as follows:

[49] ActewAGL (2004), Environmental Flow Scenarios, Environment ACT personal communication, file note

- the length of the Gudgenby River below the dam site to the Murrumbidgee River (approx 3 km) would have flows maintained at 80th percentile or at levels agreed by the EMA in the current review;
- above the dam site approx 10 km and 8 km of the Gudgenby and Naas rivers respectively would be inundated or periodically inundated; and
- the great bulk of the main streams and tributaries are above the reservoir storage area and would be unaffected.

If the virtual Tennent option were implemented the effect on environmental flows within the Gudgenby and Naas catchments would be nil as the water would be abstracted from the Murrumbidgee (at volumes equivalent to the volumes entering the Murrumbidgee from the ACT controlled rivers and streams. The effect on environmental flows in the Murrumbidgee would be negligible as the volume abstracted is very small compared to the volumes in the River.

4.3 Water Quality

ActewAGL have prepared reports on water quality for the three water supply options, including the Tennent Reservoir and Virtual Tennent alternatives[50]. The focus was to provide projections of key water quality characteristics for the alternatives, specifically from the drinking water supply perspective. The findings were generally positive as discussed below, drawn from the ActewAGL report.

Over the past 20 years, a considerable amount of information has been collected on the water quality of reservoirs and rivers that collectively comprise the Tennent alternatives.

This information indicates that the main factors that influence reservoir water quality appear to be:

- water temperature and dissolved oxygen;
- organic content of the sediment; and
- inflows into the reservoir from rainfall.

As water temperature increases:

- the reservoir becomes stratified with colder (and denser) water at the bottom, and warmer (and less dense) water at the top of the reservoir; and
- sediment microorganisms become more active, and decrease dissolved oxygen concentrations immediately above the sediment. Thus, temperature stratification subsequently results in chemical stratification.

Rainfall, and the subsequent runoff into the reservoir can partly disrupt reservoir stratification as well as introduce suspended material into the water column. Thus rainfall introduces some unpredictability into the otherwise predictable pattern provided by temperature, dissolved oxygen and the organic content of the sediment. The extent of disruption depends on the amount of rainfall runoff, as well as the time of the year and the amount of stratification within the reservoir.

The above factors result in the best reservoir water quality being in the 3 – 6 m level below the reservoir surface. This is because:

- water at the surface can contain significant concentrations of algae, or some floating matter from rainfall runoff; and

[50] ActewAGL (2005), *Tennent Option Water Quality Report*, April 2005, ACTEW Corp Doc No. 4662.

- water in the bottom half of the reservoir can have elevated levels of nutrients and metals, particularly when the reservoir becomes stratified between November and April each year.

Consequently, the ACTEWAGL report focused on water quality trends for the Tennent reservoir at the 3 – 6 m level (for all reservoir sizes).

The report also indicates that the main factor that influences river water quality (relevant to the Virtual Tennent alternatives) appears to be river flows. Low flows result in high numbers of algae and chlorophyll, and high flows result in high levels of turbidity, colour and faecal coliforms.

In a river, the best water quality is at medium flows, or immediately following high flows, during a falling hydrograph.

4.3.1 Tennent Reservoir

Projections of key water quality characteristics indicate that in over 95% of cases, Tennent Reservoir water would be treatable at the new Stromlo treatment plant or at a similar purpose built plant constructed near the dam.

Reservoir destratification may be cost effective at further improving Tennent water quality, especially by reducing the concentration of iron and manganese in the water column.

The future land uses that may be permitted in the catchment would impact on water quality. Permanent residences and agricultural uses are not considered to be desirable and would be prohibited. An analysis of the catchment conducted by Ecowise and Starr[51] in 2004 concluded that existing rural leased lands in both the Naas and Gudgenby catchments would be part of the reservoir foreshore lands and would be acquired. This would be consistent with the Googong foreshore area that generally extends for a minimum of 1.0 km from the waters edge and in places is more than 2.0 km wide.

This would involve the resumption of a number of rural leases and would obviously affect the leaseholders. Details of these impacts are discussed in Section 7.6. The need for this important decision is discussed below.

It is useful to compare the future Tennent catchment with the existing Cotter and Googong catchments that currently provide all of Canberra's water. The Cotter catchment above Bendora dam was, until the 2003 fires, pristine. It is now affected by sedimentation and contamination from runoff but is expected to eventually recover. It provides the highest level of security, from a health perspective, for the city's water supply. The catchment is subject to strict land use controls with no permanent residences and no agricultural activity allowed. Only non vehicle based camping is allowed and numbers are controlled by a permit system. No camping is permitted close to the reservoirs and watercourses.

The immediate foreshore area of the Googong reservoir is protected in a water supply reserve, with similar controls to the Cotter catchment on residential and agricultural uses. Much of the remainder of the catchment is held in private hands and used for agricultural and rural residential purposes. Partly because of the contamination that is already present from these uses some low level recreation is permitted on Googong Reservoir, including boating (electric power only) and fishing, but not swimming. For a major water supply storage this situation is considered to be sub optimal. A study[52] of practices in other Australian cities prepared for ACTEW found that:

[51] Ecowise Environmental and Starr (2005), *Catchment & Landscape Analysis of the Future Water Options for the ACT*, April 2005, ACTEW Corp Doc No. 4656
[52] ActewAGL and Water Futures (2005), *Technical Advice on ACT Reservoir Recreational Water Use Options*, April 2005, ACTEW Corp Doc No. 4671

> "Consistent with the current arrangements for the Cotter catchment reservoirs, all of the most comparable protected catchments permitted no access on their storages or foreshores and no access within defined buffer zones that often extended to the entire hydrological catchments, possibly with the exception of a handful of walking trails several km away from the reservoir
>
> With the exception of the Brisbane and Canberra sources, the comparable impacted catchments did not permit water-based activity and most did not permit activity within a buffer zone that often extended from 1 km (Adelaide) up to 3 km (Sydney) from the reservoir foreshore."

Except for some farming leases in the lower valleys most of the Tennent catchment is similar to the Cotter and mostly pristine as it is also largely in the Namadgi National Park. This also provides the opportunity for a high level management regime to be introduced. If a Tennent reservoir proceeds then it will provide an opportunity to achieve a large volume water supply with the highest level of health security. This opportunity should be taken advantage of (if the reservoir proceeds). This would preclude residential or farming activity, and anything other than passive recreation (e.g. landscape appreciation and picnicking).

Explicit advice from the CRC for Water Quality and Treatment[53] has been that recreation use of a future reservoir should be prohibited. This advice highlighted the fact that, to achieve worlds' best practice in water quality management, several barriers to pathogens are desirable. The CRC stated:

> "The importance of multiple barriers is a fundamental principle of the ADWG (Australian Drinking Water Guidelines) and the World Health Organisation Guidelines for Drinking Water Quality. This is because none of the management interventions available to the water industry are absolutely perfect. Although it may be possible to justify allowing access on the grounds that other barriers, such as filtration, can mitigate those risks, this approach is at odds with the multiple barriers principle. There are many examples of water quality incidents of international significance where the source water has not been protected and the complete reliance on subsequent treatment has proved to be inadequate. We should never be complacent about the emergence of new water quality issues that may not be well understood currently."

This approach is supported, or even required, by the National Capital Plan which, at Part 8.7.3, "Policies for Mountains and Bushlands", states as follows:

> "The Cotter and Gudgenby catchments should be managed to protect the water supply to the National Capital in a manner consistent with their nature conservation values. The quality of water supply in the Cotter catchment is to be assured primarily by controls over catchment uses." (this latter point would presumably also extend to the Gudgenby catchment if it became a water supply source).

The Plan goes on to say:

> "The Tennent area should be planned and managed to protect its long term use as the location for an additional water supply reservoir for the National Capital. Interim use for rural and nature conservation purposes is to be permitted with steeper slopes progressively revegetated to protect and enhance the area's future role as a water supply catchment."

The Territory Plan reflects this position. Appendix I of the Plan sets out water use and catchment policies that, among other things, prescribe allowable activities in catchment areas. Allowable activities in the Gudgenby and Naas valleys are currently as follows:

- domestic water supply;
- stock water supply;
- waterscape (view); and
- aquatic habitat.

[53] Don Bursill CRC for Water Quality and Treatment, Letter to Gary Bickford 15 Dec 2004

If these catchments were developed as a water supply source then a usage regime similar to that which currently applies in the Cotter catchment would presumably be imposed and the stock water supply would become a prohibited use. A variation to the Territory Plan would be required to effect this change.

ACT Forests retains a small leased area within the Tennent catchment, a part the Ingeldene Pine forest that was burnt out in January 2003. Its future is still uncertain. A reservoir foreshore area would also include this forest area. Ongoing management of this area could continue to include commercial forest operations with the proviso that careful management regimes were imposed to ensure water quality protection.

4.3.2 Virtual Tennent – Pumping Murrumbidgee to Stromlo Treatment Plant

The ACTEWAGL report provides projections for key water quality characteristics for Murrumbidgee river water that would be pumped directly to the Stromlo WTP. This water would not have the benefit of a period of detention in a reservoir and its quality would suffer as a result. A period of detention (of several days or more) allows water quality to improve by natural processes including die-off of organisms and settlement of particulates. The report indicates that in about 60% of cases, water abstracted directly from the Murrumbidgee River via the Cotter Pump Station will be treatable by the new Stromlo facility. This is an unacceptably low level. The problem could be resolved by dilution with Bendora Reservoir water in which case this water would be treatable by the new Stromlo facility in over 95% of cases.

4.3.3 Virtual Tennent – Pumping from Angle Crossing to Googong

The ACTEWAGL report has found that in about 95% of cases, water taken from the Murrumbidgee at Angle Crossing and pumped to Googong Reservoir will be treatable by the existing Googong treatment plant. This good quality outcome results from the fact that this alternative involves the delivery of water to the reservoir where it would be diluted with the existing reservoir volume and detained for some time before use.

Reservoir destratification may be cost effective at further improving the quality of the water in Googong reservoir, especially by reducing the concentration of algae in the water column.

4.3.4 Water Quality Conclusions

The ActewAGL report indicates that all of the alternatives that have been under consideration under the Tennent option are feasible from a water quality perspective.

It has been noted that the virtual Tennent alternative involving pumping directly from the Murrumbidgee River to Stromlo Treatment Plant is sub optimal unless the water is diluted with water from the Bendora pipeline. This implies that there is still a higher level of risk, albeit small, in terms of water quality, with this alternative. Given that other feasible alternatives are available this one has not been considered further as a permanent supply solution. It should remain available for drought contingency or other emergency applications.

Maintenance of water quality to the highest possible standard in a future Tennent reservoir would necessitate the removal of all farming and residential activities from the catchment and, in line with this, it has also been concluded that water contact recreational activities should not be permitted.

4.4 Influence of Climate Change

As part of its assessment of the need for a new water storage in the ACT, ACTEW commissioned CSIRO to analyse possible climate changes for Canberra over the next 70 years.[54]

ACTEW commented that

> "with only 90 years of record of ACT climate (available) … the climate (rainfall, evaporation, temperature) records for the ACT (clearly do not) reflect the range of floods and droughts that might be experienced in the future. … The current drought is now the worst on record and would have been difficult to predict even a few years ago. … There are uncertainties in projections and new information continues to give a better understanding of the possible impacts of climate change."[55]

The results of the CSIRO work indicate that there could be significant implications for water yield in the ACT catchments and water demand in the region. Regional temperature, rainfall and potential evaporation projections from global climate models indicate:

- mean annual temperature increases of 0.4 to 1.6 °C by 2030 and 1.0 to 4.8 °C by 2070, with slight seasonal variations;
- temperature increases will change the frequency of extreme temperatures in the ACT region;
- potential evaporation increases resulting from increased temperature, by up to 10 per cent by 2030;
- mean annual rainfall changes by between –9 per cent to +2 per cent by 2030, and –29 per cent to +7 per cent by 2070, the decreases will be largely over winter and spring;
- changes in rainfall will have a significant effect on the frequency of extreme dry and wet years with rainfall effectiveness during wet years reduced by higher evaporation); and
- increased frequency and intensity of extreme rainfall events.

Although the evidence is not definitive, the CSIRO analysis also indicates that atmospheric circulation patterns over the Murrumbidgee Basin have changed over the past 40 years with the following implications:

- there has been a rainfall decline over the ACT region, with lower inter-annual variability since the 1980s and a change in rainfall seasonality (increased winter and decreased summer rainfall); and
- there may be about a 6 - 8 per cent rainfall decrease between 2035 and 2065.

Projections of water yield in the Cotter and Googong catchments and water demand within the ACT indicate:

- decreases in ACT annual run-off of up to 20 per cent in 2030 and 50 per cent by 2070;
- changes in summer/autumn run-off (relative to 1990) of –20 to +5 per cent, and –50 to +10 per cent by 2030 and 2070 respectively;
- changes in winter/spring run-off (relative to 1990) of –20 to –5 per cent and –50 to –10 per cent by 2030 and 2070 respectively.

[54] CSIRO (2003), *Climate Change Projections and the Effects on Water Yield and Water Demand for the Australian Capital Territory*, (ACTEW Corp. Doc. No. 3948).
[55] ACTEW Corporation (2004), *An Assessment of the Need to Increase the ACT's Water Storage*, op cit, pp 6-7. December 2004.

- these projected percentage changes appear higher in the Queanbeyan River catchment than the Cotter River catchment;
- climate change, expressed as an increase in mean temperatures, predicts per capita ACT water demand will increase by 1 to 5 per cent (3 per cent for mid-range scenarios) by 2030 and 1 to 16 per cent (9 per cent for mid-range scenarios) by 2070; and
- climate change, expressed as an increase in the frequency of "hot periods", implies that the increase in demand could be approximately twice this level, 1.4 to 14 per cent by 2030 and 9 to 38 per cent by 2070.

The Tennent catchments are mid-way between the Cotter and Googong areas and may be expected to be subject to the same type and magnitude of change as the other catchments.

4.5 Influence of Other Variables

Catastrophic events, such as bushfires or major infrastructure failures, could affect both the water quality within a future Tennent Reservoir and downstream flows, or flows in the Murrumbidgee being harvested under a Virtual Tennent alternative. Additionally, catastrophic failure in other elements of Canberra's water supply, including pipe, pump and treatment systems, could impact on the ability of Tennent Reservoir to deliver its allocation to the supply network.

The possibility of deliberate sabotage for terrorist or other reasons also exists and is difficult to guard against. To the extent that it has been possible to do so the selection of a preferred option for Canberra's future water supply has taken into account all levels of risk associated with the various options. A risk assessment of selected options is included in Section 9 of this report.

4.6 Water Supply Outcomes for Tennent Alternatives

4.6.1 Water Supply Reliability

Water supply reliability is clearly an important consideration in the selection of a preferred future water option. While guaranteeing unlimited supply is technically possible, it would be financially prohibitive. In practice the objective must be to achieve reasonable water availability within reasonable financial, environmental and social cost parameters, with the proviso that a certain minimum supply must be guaranteed at all times.

The term "water supply reliability" means having sufficient water in storage to supply the ACT and region's urban areas without the risk of running out of water. As the water supplier, ACTEW must be able to provide customers with water for reasonable household and commercial use, and to maintain public parks and gardens in reasonable condition.

Water restrictions may need to be imposed in prolonged droughts so that consumption is reduced. ACTEW has determined that a "reliable water supply" means that water restrictions might be expected to be imposed up to 5 per cent of the time. This implies restrictions of some sort (stage 1 or 2) for about one summer every five years, or perhaps one full year every twenty years . Stage 3, where sprinklers are not permitted, would occur about one summer every 25 years. Ideally, stage 4 or 5 restrictions would never be required, but they may be needed in an absolutly catastrophic drought. A corollary of this definition is that the water supply system would be said to be "failing" if restrictions need to be imposed more frequently.

4.6.2 Population Growth and Other Assumptions

The task of this water supply options project is to select an option (or a combination of options) that will ensure that system failure does not occur.

The point at which failure occurs is dependent on both the available supply of water and the demand for usage. Demand will increase over time as the population grows, moderated by the achievement of demand efficiency targets set by the Government (12 per cent reduction in per capita consumption by 2013 and 25 per cent by 2023). The point at which a particular option will fail is therefore dependent on the rate at which the population grows.

For precautionary water supply planning purposes, the ACT Government's "high" population forecast, which assumes a total Canberra – Queanbeyan population of 500,000 persons by 2032, has been adopted.

Calculation of the population level at which the various options will fail has involved a sophisticated hydrology model. [56] The model has been tailor-made for Canberra conditions and is leading edge for water supply planning in Australia. It predicts the response of the existing and possible future water storages to long sequences of rainfall, stream flow, temperature, water conservation and water demand scenarios.

Because existing rainfall and stream flow records for the catchments are available for only a relatively short period (a maximum of 130 years), which may not be representative of longer term climatic conditions, the model uses a 10,000 year synthetic record to examine in more detail the effects of climatic variability and possible climatic change scenarios. This approach has found, for example, that whilst the current drought is certainly severe and possibly the "worst on record", it may not be the "worst ever". The modeling suggests droughts have occurred in the past that were twice as bad as the current drought, lasting longer or being more severe. Such extreme events may be expected to occur in the future, albeit only very rarely, and must be provided for in the planning process.

The modeling assumes, in line with CSIRO research discussed above, that a substantial climate change has occurred and will continue. It projects that the water resources thought to be available to the ACT when the *Think water, act water* reports were published may have been optimistic. They were based on stream flow data from gauging stations throughout the ACT that in some cases extended over long periods but did not encompass a "worst ever" drought event, yet did apparently include some reasonably heavy rainfall periods. The modeling has calculated lower catchment inflow levels than those in *Think water, act water*. This approach may turn out to be overly conservative but it is considered prudent for major infrastructure planning purposes.

The modelling has indicated that the water resources thought to be available to the ACT when the "Think water act water" reports were published[57] were optimistic. They were based on streamflow data from gauging stations throughout the ACT that in some cases extended over long periods but did not encompass a "worst ever" drought event and did apparently include some reasonably heavy rainfall periods. The modelling has calculated lower catchment inflow levels than those in "Think water act water". This approach may be overly conservative but is considered prudent for major infrastructure planning purposes.

Canberra's water supply is sourced from local rivers and streams. These waterways are a vital part of the natural environment and need to continue to function as elements in natural ecological systems. The concept of environmental flows (discussed in Section 4.2 above) has been developed to ensure

[56] ACTEW (2004) Op Cit
[57] ACT Government (2004), *Think water, act water* Vol 3 "State of the ACT's water resources and catchments," April 2004.

that a minimum amount of flow is maintained in rivers and streams to ensure that they remain ecologically "healthy". It generally requires that flows be maintained at a minimum 85th percentile of natural levels. This means that certain volumes of water must be constantly released from all dams whenever they are not overtopping. The volumes involved can be substantial and obviously reduce the amount of water remaining in the dams and available for use. Environment ACT is currently reviewing the environmental flow regime in consultation with relevant parties, including ACTEW. Environment ACT has foreshadowed the possibility that the flow levels may be modified and in some cases reduced. The modeling has assessed water supply outcomes under the current environmental flow regime and, in addition, modeling runs have been conducted for the various options under a modified environmental flow regime agreed by Environment ACT for this purpose.

4.6.3 Analysis of the Options

The water supply options study initially focused on three options for future water supply – Cotter, Tennent and Tantangara. Closer examination of these options has revealed that within them there are a range of sub options and combinations of alternatives. The possibility of a "virtual Tennent " (pumping from a weir on the Murrumbidgee to Googong Dam) has also been identified. In all some 26 alternatives and combinations have been identified and analysed.

The outcome of the modelling analysis is best presented by identifying the population level at which the system being analysed will reach the system failure point discussed above. Assuming a given population growth rate one can then calculate the year in which system failure will occur. This is the year beyond which it is likely that restrictions will be imposed for more than 5% of the time.

All other things being equal, the best option will be the one where system failure occurs furthest into the future (following which further infrastructure will be required), or not at all. In reality other factors must also be considered in the selection of a "best" option including risk, economics and sustainability. These are discussed elsewhere in this report.

With the introduction of environmental flows, assessment of climate change and climatic variability, and the impact of post bushfire vegetation recovery on water runoff, factors that were not contemplated prior to the 1990's, the existing water supply system would technically have reached failure point in 1999[58]. This is perhaps borne out by the extraordinarily long current restriction period, although this has been exacerbated by the impacts of the bushfires on the Cotter catchment.

The relative outcomes of the hydrology analysis expressed in terms of projected failure points, are set out in the diagram below. The small and large Tennent Dams options and the Virtual tennent Option remain viable options for future supply depending on future water demand.

[58] ActewAGL (2005), ACT Future Water Options Water Resources Modelling report – Volume 1, April 2005, ACTEW Corp Doc No. 4644

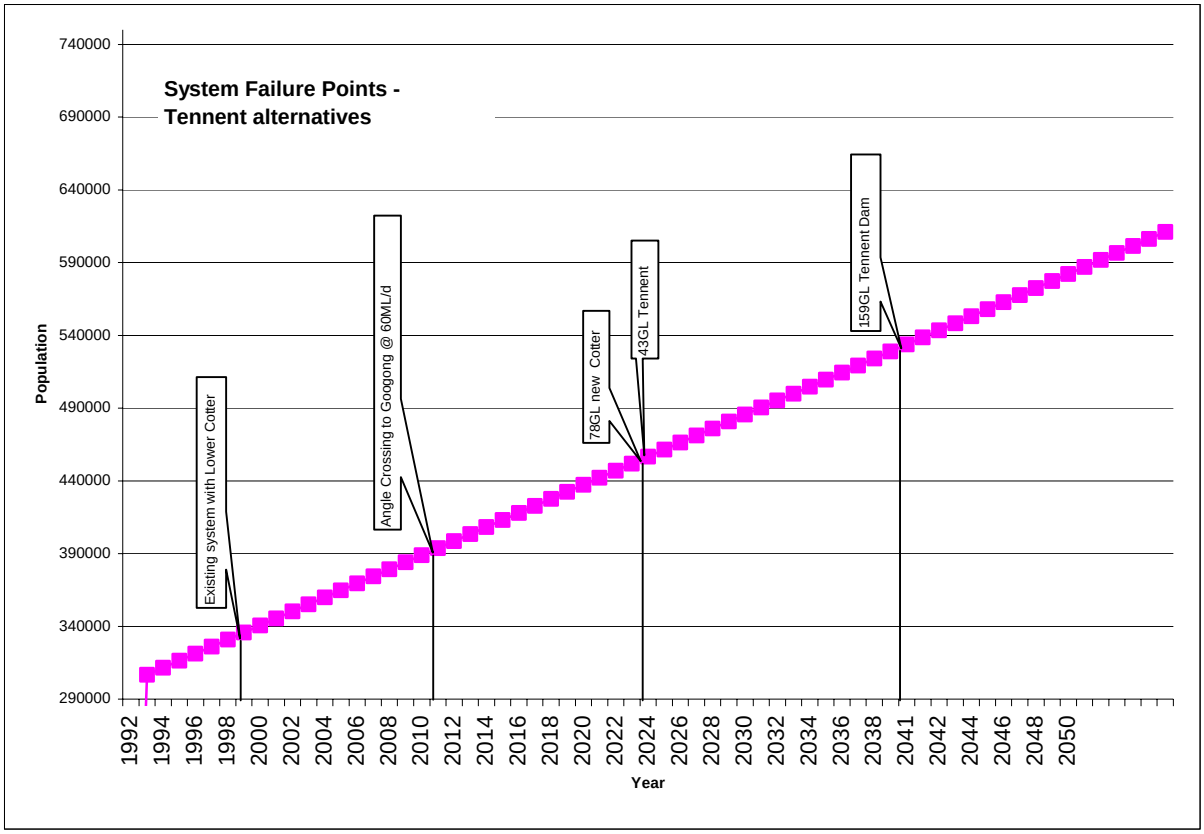


Figure 4.1 System Failure Points

* Note – The graph above shows the relative ranking of options to meet a reliability of supply for no more than 10 per cent time in restrictions. To achieve a reliability of supply of no more than 5 per cent time in restrictions, the line above would shift to the left, maintaining the same relative ranking

Of the three Tennent options, the large dam is the only one that will adequately deliver a reliable water supply for a reasonable period into the future and consequently, of these three, it must be preferred. It is likely however that a combination of other options can also deliver an acceptable or better result and at lower cost. These combinations could include one of the other two Tennent alternatives.

The failure point of the 78 GL Cotter dam is also shown. This is included to illustrate the relative performance and the fact that size is not the only consideration. The failure point of the small Tennent dam (43 GL) and the 78 GL Cotter option are the same even though Cotter is almost twice the capacity of Tennent. This reflects the differences between the catchments and the complexity of the modelling. The Cotter catchment already supplies two large dams thereby reducing the volume of water available for a new dam, whilst the entire Gudgenby – Naas catchment runoff is available to a Tennent dam. This highlights the need to look beyond simplistic considerations of dam size when comparing the various options and alternatives. Of course other factors must also be taken into account in a final decision as well; for example the small Tennent dam is considerably more costly than the Cotter dam.

5 Infrastructure

5.1 Principal Infrastructure Considerations

Key questions with any future water supply proposal are “can it be built?’ and “how will it work”. For example, dams are massive engineering structures that must be located on sites that are geologically stable. Construction considerations, for example where the dam construction material will be sourced from are also important. These issues have been considered by GHD[59],[60] to confirm the viability, from an engineering perspective, of the Tennent options and alternatives. They are summarised below for the large Tennent dam as well as for the virtual Tennent option involving pumping from a weir at Angle Crossing to the Googong Reservoir via Burra Creek. The small Tennent reservoir option, not discussed here, has the same characteristics as the large reservoir; the only difference being that the dam itself and therefore the storage capacity and inundation area is smaller. The impacts of a smaller dam, particularly environmental (flooding of woodland habitat), and social (relocation of all catchment lessees) would be similar to the large dam.

5.2 Large Tennent Dam - 159 GL

5.2.1 Site and Geotechnical Conditions

GHD report that the foundation is considered to be adequate for the construction of the proposed dam. In addition, the foundation appears to be of very low permeability including the shear zone on the right embankment.

There is a considerable amount of investigative work that has been undertaken in relation to this site, however GHD recommend that it would still be prudent to carry out further investigation of the upper right abutment at the detailed design stage.

The site is about 1.5 km west of the Murrumbidgee Fault, a major north-south trending fault zone. A parallel shear zone exists in the vicinity of the right abutment of the dam site, which is considered to be a collection of smaller shears. Additional effort will be required on foundation treatment in this shear zone area. This will comprise additional local excavation, concrete backfill and possibly grouting and drainage work.

5.2.2 Development Description

The 159 GL Tennent dam option (refer to Figures 2.2, 2.3, & 2.4) has a full supply level of RL 655 resulting in a dam height approximately 76 metres above the river bed level. The new dam will be of roller compacted concrete construction and located just downstream from a sharp “S” shaped bend in the Gudgenby River where the river flows through a steep sided relatively narrow gorge. A multi-level intake tower with separate inlets for water supply and environmental releases (due to their differing requirements) will be located on the upstream face of the dam.

The spillway arrangement involves an ungated service spillway to accommodate more frequent floods, with dam crest overflow occurring for very large and low probability floods.

The Tennent dam may supply either to the Stromlo WTP or via a new WTP located near the dam to the Canberra water supply system in south Tuggeranong.

[59] GHD (2004) *Cotter, Tennent and Coree Options (Engineering) Report*, Dec 2004.
[60] GHD (2005) *Future Water Options Study Options Summary Report*. Feb 2005.

The supply to Stromlo involves a major pumping station with a duty of 180 ML/d at 186 m head and a 30.1 km long 1250 mm diameter mild steel cement lined pipeline. The supply to south Tuggeranong comprises two pumping stations, a WTP and a 1250 mm diameter mild steel cement lined pipeline 15.1 km in length to a connection point at the intersection of Johnson Drive and Ashley Drive. The pump stations have duties of 180 ML/d (2,083 L/s) @ 96 and 56 metres head respectively.

5.2.3 Construction Procedure

A construction period of approximately 20 months will be required for this option, of which 18 months is required for the reservoir. The controlling factor is the construction of the pump station(s), primarily due to the long lead time on the supply of the large pumps, motors and valves.

A key construction constraint will be the limited load capacities of bridges accessing the site. In particular the Murrumbidgee River bridge (load limited) at Tharwa and the Cotter River bridge (load limited and geometry constraint) both limit construction traffic able to access site.

The new Tennent dam will be constructed using 370,000 m3 of roller compacted concrete (RCC). RCC dams are gravity dams constructed in layers using a low cementitious concrete mix. Each layer of concrete is spread by a dozer and compacted by smooth drum roller. A typical layer thickness is 300 mm.

One of the major benefits of RCC in this instance is its ability to deal with river diversion during construction, requiring only a small cofferdam and reinforced concrete culvert built into the RCC structure. Once capacity of the 4 m by 4 m culvert is exceeded, flood flows would spill over the dam, causing minimal damage to the structure. Construction could then recommence after cleanup.

Construction materials will largely be sourced from a quarry to be established on the left bank of the Gudgenby River, 250 metres upstream of the dam. This is expected to be able to provide 75% of the fine aggregate for RCC, 100% of the fine aggregate for concrete and the entire coarse aggregate requirement. Cement, flyash and 25% of the fine aggregate requirement for RCC will need to be imported.

It is proposed that the bulk of the construction facilities will be located approximately 150 metres upstream of the left abutment of the dam, relatively close to the quarry.

The pipeline to Stromlo (Figure 2.4) will pass to the west of Tharwa village, and pass between the Canberra Nature Park and Bullen Range Nature Reserves. The route to south Tuggeranong will cross the Murrumbidgee River upstream of the road bridge at Tharwa, then travel around the western perimeter of Gordon and Woodcock Drive onto Johnson Drive.

Construction of the reservoir will require clearing of the 1,125 ha storage area, and relocation of services including roads, electricity and communications.

5.2.4 Operations

The supply to Stromlo involves pumping in 60 ML/d stages up to a maximum of 180 ML/d at 186 m head. Because the high point in the pipeline is at Stromlo, the system hydraulics are not overly complicated and surge pressure vessels located at the pumping station will address surge pressures.

The supply to south Tuggeranong comprises a two stage pumping arrangement and water treatment plant. The first pumping station lifts the flow to a water treatment plant located on a knoll located 0.5 km downstream of the left abutment. The water treatment plant's hydraulics operate under gravity from the plant inlet through to the clear water storage. The main from the WTP to its connection point has been sized to operate under gravity for flows up to 90 ML/d. A booster pump station assists flows greater than 90 ML/d up to a maximum of 180 ML/d.

5.3 The "Virtual Tennent ": Angle Crossing to Googong

5.3.1 Site and Geotechnical Conditions

GHD consultants have assessed[61] the site for a weir on the Murrumbidgee River at Angle Crossing and consider it to be generally suitable. The geotechnical issues associated with a weir are not as significant as for a dam.

The potential for scouring of Burra Creek downstream of the discharge point also requires investigation and assessment of associated costs to prevent erosion.

5.3.2 Development Description

This option comprises a weir located on the Murrumbidgee River at Angle Crossing, an intake wet well pump station, major booster pump station and pipeline to Burra Creek from whence the flow will gravitate into the Googong Reservoir storage.

The weir will be a mass concrete gravity structure with a central "low flow" channel/fish ladder arrangement. The fish ladder will occupy one-third of the river width and be sloped at 1 on 30 to the horizontal. It will be formed using mass concrete surfaced with variably sized rocks set into concrete. The intent is to provide a "riffle" type surface typical of natural river channels.

An intake similar to that being constructed as the Emergency Pump Station on the Murrumbidgee River at Cotter is proposed to extract the flow into a wet well with submersible pumps to lift the flow to the major pump station located above the Q100 flood level.

The major pump station, with a maximum capacity of 60 ML/d, will pump via a 15 km long 800 mm diameter mild steel cement lined pipeline to its discharge point into Burra Creek. The pipeline will include surge vessels and break tanks to deal with the difficult system hydraulics.

5.3.3 Construction Procedure

A construction period of approximately 20 months will be required for this option. The controlling factor is the construction of the pump station(s), primarily due to the long lead time on the supply of the large pumps, motors and valves.

The river will require diversion during construction. It is likely that the weir would be constructed in two halves, with construction of the first stage being completed on one abutment and the river would then be diverted through the first stage work while the remainder of the construction was completed. An upstream and downstream cofferdam will be required to allow construction in the dry. These would also serve as environmental control dams during the construction works.

The weir will be constructed using mass concrete. This will be reinforced where necessary. For the volume of concrete involved, it is likely that contractors would choose to use readily imported mixed concrete than establish a batch plant on site.

Drilling of the pipeline through Gibraltar Hill was considered but found to be overly expensive. Accordingly, the pipeline will be trenched along its entire length including along Williamsdale Road where it passes over a saddle at RL 860, 260 metres above the source point.

[61] GHD (2005) *Future Water Options Study, Option 6: Angle Crossing to Burra Creek 60 ML/day, Report.* Feb 2005

5.3.4 Operations

The intake located on the Murrumbidgee River at Angle Crossing will be a wet well arrangement equipped with submersible pumps to lift the flow to the booster pump station that will be located at top of bank and above the Q100 flood level.

Apart from the booster pump station operating in series with the wet well pumps, the system's hydraulics are complicated by the high point located part way along the pipeline on the saddle adjacent Gibraltar Hill at RL 860. This results in a static lift of 260 metres, and with friction losses results in a head of approximately 300 metres, which is significant.

Break tanks and surge vessels are required. The purpose of the break tanks, located at the high point, is to break the hydraulic grade line thus preventing collapse of the pipeline due to negative pressures experienced during operation and in particular when flow ceases. The surge vessels will be required to deal with transient pressures experienced during pump start and stop.

The discharge into Burra Creek will need to be controlled such that it doesn't combine with storm flow and exceed the carrying capacity of the creek and result in flooding of surrounding areas.

Evaporation and transmission losses will occur during transfer through Burra Creek and storage in the Googong Reservoir storage.

6 Environmental Considerations

6.1 Changes in Sediment Transport

Rivers generally, and this is the case in the ACT, carry very substantial loads of eroded material from upstream catchment areas which is deposited as sediment downstream. Possible changes in sedimentation patterns are a common consequence of the construction of water impoundments such as dams or weirs. Sedimentation impacts have been assessed by the University of Canberra[62] for the various Tennent alternatives.

6.1.1 Dam Alternatives

The three Tennent reservoir options all involve constructing a dam on the Gudgenby River. All Tennent Reservoir alternatives will result in significantly reduced flows immediately below where the dam is proposed. The dam itself will trap all incoming bedload and much of the fine sediment. Reductions in load are likely to offset reductions in sediment transport capacity affecting bed accumulation and there may be little net change in the downstream reach. Minor silting could occur, this would depend on the operation of the reservoir.

Changes in flow in downstream reaches of the Murrumbidgee River are relatively small and as such there would not be expected to be much of a change in sediment transport capacity or bedload transport rates for reaches with sand accumulation.

6.1.2 Virtual Tennent alternatives

The virtual Tennent option will involve construction of a weir on the Murrumbidgee River. The main geomorphic issue with constructing weirs on the Murrumbidgee, at Angle Crossing, Tharwa or Cotter, is that they may trap bedload sediment. The bedload transport rate in this region of the Murrumbidgee River is in the order of 100,000 – 150,000 tons per year. This could completely fill a weir pool in a large event, or over several years. It is also understood that a substantial sediment load is required at Tharwa bridge to maintain the integrity of the pier foundations and that a weir just upstream may reduce the sediment supply.[63]

Bedload sediment supply to the weir must be considered in siting any weir alternatives. Design options exist that allow bedload to be transported through the weir pool, and for the weir pool to be self-flushing at high flow.

Monitoring and modelling of the reach-scale hydraulics and bedload transport and deposition rates may be needed prior to finalising a site. A preliminary analysis of channel gradient indicates that the Tharwa reach has lower gradient, and is more prone to deposition, than the Angle crossing or Cotter reaches.

6.1.3 Burra Creek discharge

The current mean-annual discharge of Burra Creek is estimated to be in the order of 9 GL/y. Assuming the proposal is to discharge 11 GL/y into this creek, this represents an approximate doubling of the mean-annual discharge. The proposed water supply discharge would also reduce the

[62] Water Research Centre, University of Canberra (2005), *Aquatic Ecology Study*, April 2005, ACTEW Corp Doc No. 4682.
[63] Future Water Options Project, Review of Constraints - Aquatic Ecology and Fish Issues, Minutes of Meeting on, 1 December 2004.

variability in discharge. Increased bank erosion is an expected response to this increased discharge volume and reduced variability. The erosion may be most active in areas of erodable soils, and poor riparian vegetation. Ameliorative measures including bank stabilization will need to be investigated and may be required.

6.2 Effects on Fish and Crayfish

6.2.1 Current situation

The Wildlife Research and Monitoring Unit of Environment ACT has provided detailed advice on the impacts of future water supply options on fish and crayfish populations.[64] There are few published studies on the fish fauna of the Naas-Gudgenby catchment that can be considered primary sources of information. The earliest record relating to fish in the Naas-Gudgenby is by Gale (1927) who reported the introduction in 1888 of Brown Trout, Redfin Perch and Russian Carp (probably Goldfish) into the Queanbeyan, Naas, Molonglo and Cotter rivers. Other later studies during the 1970's, 1980's and 1990's have provided a basis for an assessment of the likely impact on fish ecology. Similarly there have been no systematic collections of crayfish in the Naas-Gudgenby catchment, with only ad-hoc and anecdotal information available from a number of studies in the 1980's and 1990's and in 2000 and 2002.

The Naas-Gudgenby catchment effectively has a single fish community comprising three fish species, with the addition of a few vagrants or new invaders in the lower reaches of the Gudgenby system. A survey in 1981 of long time anglers produced anecdotal recollections of three additional native species that were possibly present in the Naas-Gudgenby; Silver Perch, Macquarie Perch and Blackfish.

There is only a single native fish species (Mountain Galaxias) now known to be present in the catchment upstream of the proposed dam site (see Table 6.1). This species is widespread throughout the catchment and is particularly abundant where trout species are absent or in low abundance. Rainbow and Brown Trout, Carp and Eastern Gambusia, all introduced species, are all present upstream of the dam site either in the rivers or in farm dams.

The native fish fauna in the Gudgenby River downstream of the proposed Tennent reservoir site has few additional species recorded to those from the upstream catchment (see Table 6.1). Murray Cod, Golden Perch and Macquarie Perch have all been recorded from the Tharwa Sandwash area, and prior to 1850 would have been expected to be a regular component of the fish fauna of the lower Gudgenby River. The severe floods of 1851 and 1852 resulted in extreme amounts of sediment being deposited in the Lanyon-Tharwa reach of the Murrumbidgee River, and also presumably in the lower Gudgenby. These and other flood events around that time resulted in changes to the river channel. The nature of the Lanyon-Tharwa reach of the Murrumbidgee changed from being a series of deep holes to that of a sand-filled, shallow stream. This meant that by the 1890's the Murrumbidgee River at Lanyon had attained its current form of a flat, shallow sandy river (Lintermans 2004a). The sand-slug below Tharwa Bridge is considered to act as a barrier to fish movement and it is assumed the sand-impacted reach in the Gudgenby River immediately above its confluence with the Murrumbidgee is acting in the same way.

This would explain why fish species that are present in the Murrumbidgee (Golden Perch, Murray Cod) have not been recorded from the lower Gudgenby in recent years.

There are only three crayfish species confirmed from the Naas-Gudgenby catchment, with another two species suspected of occurring (Table 6.1). The yabby is widespread in the lower and mid-altitude

[64] Lintermans (2004), *Review of potential impacts on fish and crayfish of future water supply options for the ACT: Stage 1* December 2004.

reaches of the catchment. Muray River Crayfish are only known from two unconfirmed reports. The Spiny Crayfish is known from the Orroral River and Naas Creek but there have been no systematic surveys for freshwater crayfish in the ACT, and they are probably more widespread than this. Similarly, the Burrowing crayfish has not been recorded from the Naas-Gudgenby system, but it has not been the subject of a survey. The newly described spiny crayfish *Euastacus rieki* is likely to be present in the montane areas of the catchment, but has not been the subject of a survey.

Table 6.1: Fish and Crayfish Species

Species		**Native / alien**	**Catchment upstream of dam site**	**Gudgenby River downstream of dam site**	**Murrumbidgee River from Point Hut Crossing to Gudgenby confluence**
Finfish					
Mountain Galaxias	*Galaxias olidus*	native	✓	✓	✓
Rainbow Trout	*Oncorhynchus mykiss*	alien	✓	✓	✓
Brown Trout	*Salmo trutta*	alien	✓	✓	✓
Carp	*Cyprinus carpio*	alien		✓	✓
Eastern Gambusia	*Gambusia holbrooki*	alien	✓1	✓	✓
Oriental Weatherloach	*Misgurnus anguillicaudatus*	alien		✓	✓*
Golden Perch	*Macquaria ambigua*	native		#	✓
Murray Cod	*Maccullochella peelii*	native		#	✓
Redfin Perch	*Perca fluviatilis*	alien		✓	✓
Western Carp Gudgeon	*Hypseleotris klunzingeri*	native			✓
Goldfish	*Carassius auratus*	alien		✓	✓
Trout Cod	*Maccullochella macquariensis*	native			✓
Macquarie Perch	*Macquaria australasica*	native			✓
Australian Smelt	*Retropinna semoni*	native			✓
Crayfish					
Murray Crayfish	*Euastacus armatus*	native		✓	✓
spiny crayfish	*Euastacus crassus*	native	✓		
Yabby	*Cherax destructor*	native	✓	✓	✓
Burrowing crayfish	*Engaeus cymus*	native	✓*	✓*	
spiny crayfish	*Euastacus riekii*	native	✓*		
✓* = expected to be present; # = expected to be rare vagrants; ✓1 = only present in isolated farm dams					

6.2.2 Endangered and threatened species and communities

There are no threatened species known from the catchment upstream of the proposed reservoir site. There have been occasional records of Murray River Crayfish from the Gudgenby River downstream of the reservoir site, but these are thought to represent rare vagrants from the Murrumbidgee River. All other threatened fish species associated with the Tennent proposals are from the Murrumbidgee.

Table 6.2: Conservation status of selected fish and crayfish from the Naas-Gudgenby and Lanyon-Tharwa reach of the Murrumbidgee River under NSW, ACT, National (EPBC and ASFB) and International listings

Species	ACT	NSW	National		International
	Nature Conservation Act 1980	Fisheries Management Act 1994	ASFB listing (2003)	EPBC Act 1999	IUCN Redlist (2004)
Macquarie perch	Endangered	Vulnerable	Endangered	Endangered	Data Deficient
Murray Cod				Vulnerable	
Trout Cod	Endangered	Endangered	Critically Endangered	Endangered	Endangered
Murray River Crayfish	Vulnerable				Vulnerable
Spiny crayfish, *Euastacus crassus*	Protected invertebrate				Endangered
Spiny crayfish, *Euastacus rieki*	Protected invertebrate				
ASFB = Australian Society for Fish Biology					

As would be expected from a much larger river system, the fish fauna in the Murrumbidgee River in the Lanyon-Tharwa reach includes most of the fish species known from the ACT, some of which have conservation status (Table 6.2). The only significant omissions are the Two-spined Blackfish (which is now only found in the Cotter catchment) and Silver Perch (which is not reliably known upstream of Kambah Pool).

6.2.3 Fish Migration

The introduction of a dam at the gorge location on the Gudgenby River would have negligible impact on any migration patterns of fish or crayfish species. The gorge itself already provides a barrier to movement. Crayfish species do not move significant distances and the only significant native fish species (Galaxia) are not migratory. Consequently there would not be a need for any fish passage facilities to be built into a Tennent Dam.

Several of the species found in the Murrumbidgee River are known to move substantial distances up and down river, and species such as perch rely on downstream movement of eggs for reproduction and species dispersal. Mechanisms to allow these movements to continue would be required in any weirs constructed on the Murrumbidgee. The proposed weir designs discussed in Section 2 of this report include appropriate facilities.

6.2.4 Impacts on Fish and Crayfish

The impacts on fish and crayfish of a reservoir (of any size) are summarised as follows:[65]

- may be a requirement for provision of fish passage (but considered unlikely) as this is a dam on a previously unregulated catchment (Minor impact);
- potential impacts of construction of downstream environments (Gudgenby and Murrumbidgee rivers) (Moderate impact);
- impacts of water harvesting on downstream habitats in the Murrumbidgee (reduced flows and capacity to scour accumulated sediments) (Moderate impact);
- dam construction is a probable stimulus for the development of a recreational fishery on the reservoir, resulting in the likely introduction and establishment of alien species such as Carp and Redfin Perch (Moderate impact only if fishing is permitted);
- reservoir will destroy (inundate) Mountain Galaxias spawning habitat in the Gudgenby River and Honeysuckle Creek (Minor impact); and
- reservoir will facilitate significant increase in the salmonid population upstream of the upstream catchment and subsequent decrease in Mountain Galaxias population (Moderate).

The impacts of the various Murrumbidgee River weir options are as follows:[66]

- potential transfer of alien fish species (Oriental Weatherloach and Carp) from Murrumbidgee River to Googong Reservoir (Moderate impact);
- will be a requirement for provision of fish passage (Minor impact);
- potential impacts of weir construction and maintenance on downstream environments (Minor impact); and
- impacts of water harvesting on downstream habitats in the Murrumbidgee (reduced flows and reduced capacity to scour accumulated sediments) (Minor impact).

6.2.5 Further Design and Investigation

Whilst there are some gaps in available knowledge on the probable impacts of the various Tennent alternatives on fish and crayfish none of these are such as to preclude a decision to proceed to further detailed design and investigation work. Whilst the possibility does exist, it is thought that further investigation is most unlikely to uncover any material that would preclude any of the Tennent alternatives. The knowledge gaps include:

- there is little knowledge of the composition or dynamics of the fish community in the lower Gudgenby River;
- the predicted expansion of the trout population (following reservoir establishment) and their impacts on the Mountain Galaxias need monitoring;
- the impacts of reduced stream flows on sedimentation at the Gudgenby/Murrumbidgee confluence need investigating;

[65] Lintermans (2004), *Review of potential impacts on fish and crayfish of future water supply options for the ACT: Stage 1* December 2004.

[66] Lintermans (2004), *Review of potential impacts on fish and crayfish of future water supply options for the ACT: Stage 1* December 2004.

- the impacts of reduced stream flow on sedimentation in the Lanyon-Tharwa reach require investigation, with the maintenance/restoration of pool habitats a priority;
- the construction of a fishway on the Murrumbidgee weir would require the establishment of a short-term monitoring program to establish the efficacy of the fishway for all species and under varying flows;
- the establishment of a recreational fishery in Tennent Reservoir would require a monitoring program to detect alien invasions of pest species; and
- trials are required of fish screens to prevent transfer of unwanted species between water bodies (e.g. for a pipeline connection to Burra Creek/Googong).

6.3 Effects on Aquatic Ecology

A review of aquatic ecology in the Gudgenby/Naas River catchments has been undertaken by the Water Research Centre of the University of Canberra.[67] The report is comprehensive and, as well as focusing on factors specific to the three water supply options and the alternatives within these, contains a detailed literature review of relevant, mainly broader, aquatic ecology issues.

The Water Research Centre report follows the approach of the National Land and Water Resources Audit and the Murray-Darling Basin Sustainable Rivers Audit, evaluating the major components of the aquatic ecosystems (Figure 6.1). The following elements were included: hydrology, habitat, water quality, and aquatic biota. Where possible, assessments were made relative to a reference condition, that is, measuring change, rather than just providing values. This enables some evaluation of the change to ecological condition that may occur because of the proposed developments.

The report assesses the Tennent Reservoir option including the three dam size alternatives as well as the virtual Tennent option including three alternative weir sites, with two of these involving a pipeline link to Googong reservoir via Burra creek.

[67] Water Research Centre, University of Canberra (2005), *Aquatic Ecology Study*, April 2005, ACTEW Corp Doc No. 4682.

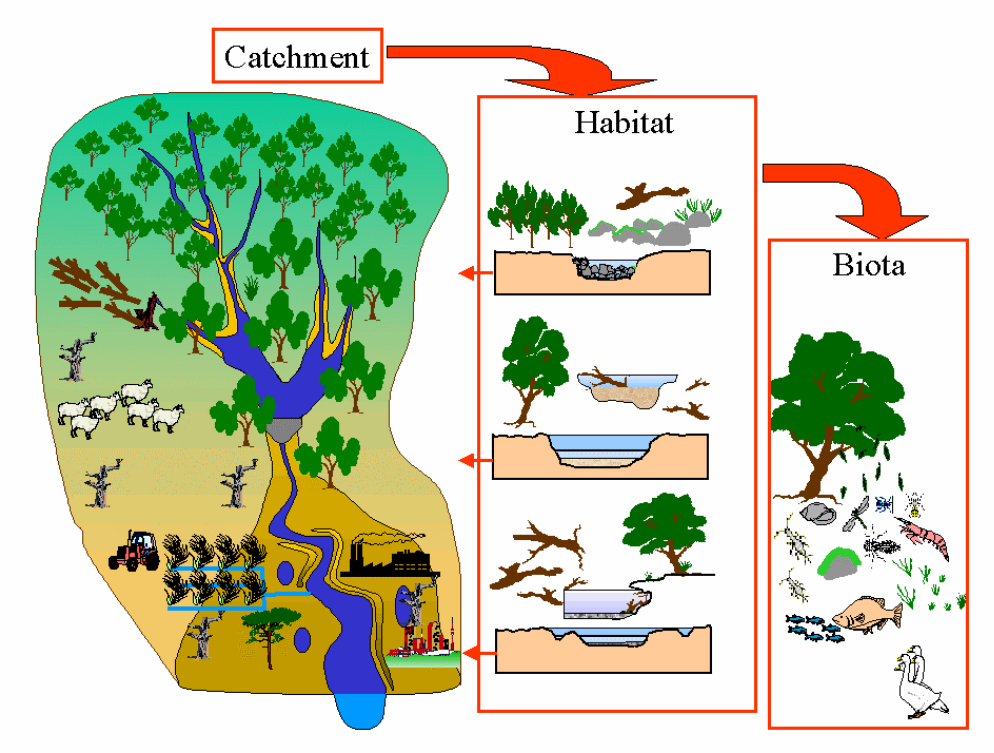


Figure 6.1 Model of factors related to river condition

6.3.1 Water resource Audits of Gudgenby and Naas Rivers

The results of FNARH surveys[68] that were undertaken on the Gudgenby and Naas Rivers are detailed in the CRC report. Most sites on the Gudgenby and Naas Rivers have previously been assessed as equivalent to reference condition (i.e. relatively ecologically healthy), however, there are several sites that show significant impairment. In particular, the site of the proposed Tennent Reservoir is impacted by rural landuse, with cattle access to the stream, sedimentation and willow infestation.

Sites previously sampled for macroinvertebrates on Burra Creek have been assessed as equivalent to reference condition.

6.3.2 River Flow effects

Construction of a dam on the Gudgenby River will impact on downstream water quality and change flow and sediment regimes. The dam will also create a barrier to macroinvertebrate upstream and downstream movement and dispersal. This is likely to impair macroinvertebrate communities.

The University of Canberra has examined the likely impacts on river flows downstream of the Tennant dam site under alternative scenarios of maximum water use to meet demand or a limitation of use to a static level of 11 GL/year. Both scenarios assume a minimum environmental flow is maintained at the 80th percentile level.

[68] In 1992 the Australian Federal Government initiated a nationwide program of biological assessment of river health. In the ACT, the First National Assessment of River Health (FNARH), previously called the Monitoring River Health Initiative (MRHI), was coordinated by the Cooperative Research Centre for Freshwater Ecology (CRCFE). Under the MRHI, the Australian River Assessment System (AUSRIVAS) predictive models for the biological assessment of river health were developed.

It is clear from the hydrologic analyses of the three reservoir options that if the reservoirs are operated to maximise the water available for consumptive use, rather than to supply a static demand, then the likely impact on the aquatic ecosystems will increase. The impact will be on the length of the Gudgenby River downstream of the dam site and upstream of the Murrumbidgee confluence. This reach is only about 3 km in length and is largely farmland. It does not have high ecological significance.

The impact on the Murrumbidgee River of alterations to the flow regime of the Gudgenby River will be negligible due to the great difference in the relative volumes of the two rivers. Natural mean annual flows in the Murrumbidgee are in the order of 460 – 500 GL/yr.

Water abstracted from a Tennent Reservoir (or via the virtual Tennent alternative) will be input to the Canberra water supply system. Currently about half the water input to Canberra is output via the Lower Molonglo Water Quality Control Centre (LMWQCC) to the Murrumbidgee via the lower reach of the Molonglo River. Consequently one result of the Tennent option will be an increase in the flow volume below the LMWQCC of, say, 6 GL/yr.

The potential effect on the aquatic ecosystems during the filling cycle of the reservoir also warrants consideration. There will be a tradeoff between the time taken to fill the reservoir and the impact on the aquatic ecosystem. The reservoir will be filled the quickest if only the minimum environmental flow requirement (currently the 80 percentile of natural flows) is released from the reservoir, and the rest of the inflows captured. Even under this scenario, for average inflows it will take at least fourteen months to fill the 43 GL reservoir and 23 months to fill the 76 GL reservoir and 48 months to fill the 159 GL reservoir. However, this pattern of constant low flow release is likely to have detrimental effects on the aquatic biota that rely heavily on the seasonality of the flows.

Once the reservoir is full, there will be additional impacts on the aquatic ecology caused by the alteration to the inflow hydrographs caused by the altered reservoir operation.

The current mean-annual discharge of Burra Creek is estimated to be in the order of 9 GL/y. Assuming the proposal under the virtual Tennent alternative is to discharge 11 GL/y into this creek (i.e about half of the theoretical capacity of the proposed 60ML/day pump), this represents a doubling of the mean-annual discharge. The proposed water supply discharge would also reduce the variability in discharge. Increased bank erosion is an expected response to this increased discharge volume and reduced variability.

6.3.3 Biota

Construction of any of the three Tennent reservoir alternatives will flood considerable areas of existing aquatic habitat, both in the bed of the river, and in adjacent riparian areas.

Amphibians

The construction of Tennent dam (at any of the three alternative size options) poses a moderate risk to amphibian populations[69]. This proposal will flood considerable areas of existing amphibian habitat, both in the bed of the river, and in adjacent riparian areas. The main species affected will be the Rocky Stream Frog, the Eastern Banjo Frog and the Common Eastern Froglet. These are common species in the ACT region.

[69] Water Research Centre, University of Canberra (2005), *Aquatic Ecology Study*, April 2005, ACTEW Corp Doc No. 4682.

Other riverine species such as the Eastern Water Dragon and Heatwole's Water Skink occur within the reservoir site gorge. These are common species in the ACT and region. It is very likely that the vulnerable Rosenberg's Monitor may also occur in this area.

Pumping water from the Murrumbidgee River (the virtual Tennent alternative) poses a low risk to amphibian populations. This option will reduce water flow downstream of the off-take, however, the comparatively small proportion of the river flow to be extracted is unlikely to affect amphibian populations associated with the river corridor. Provided normal peak flows still occur during the wetter parts of the year habitat condition for frogs should be maintained in the bed of the river.

If water is pumped to Burra Creek, it will result in increased stream flows during summer, and significant rises in water level and velocity at times when amphibians may be breeding. It may result in flushes of cold water downstream of the water entry point. During late spring and summer, when frogs may be breeding in the stream, maintenance of a higher flow is likely to influence adult frogs and tadpoles. The calling sites used by male frogs, such as overhanging vegetation and boulders in the streambed, may be submerged and it may be difficult for frogs to find suitable oviposition sites because of the high flow. If flow is maintained at a much higher-level, tadpoles and eggs may be swept downstream. By contrast, the impact of the increased water flow at times of peak flow, or high water levels, is likely to have a fairly limited impact on amphibians. At this time, frogs and tadpoles have already sought refuge from the high flows.

Mammals – Platypus

Platypuses have been recorded at several locations on the Gudgenby River, but further upstream than the proposed Tennent Dam site. There have been records from Rocky Crossing, Middle Creek and Gudgenby Station; it is likely that platypus would be distributed throughout the river system. They have been recorded infrequently from the Naas River; probably as a result of poor survey effort rather than low abundance. Platypuses are also known from Tharwa Sandwash, just upstream of the junction of the Murrumbidgee and the Gudgenby Rivers. Construction of Tennent Reservoir may affect platypus populations through changes to benthic food availability, and flooding upstream areas. Cold-water releases from the reservoir may impose additional stress on animals inhabiting waters downstream.

Wetlands

There will be no direct impacts on wetlands from the Tennent alternatives, however, construction of a dam will isolate the upstream wetlands from the Murrumbidgee River.

Nationally important wetlands that may be affected by fragmentation are Rock Flats, Upper Naas Creek, and Nursery Swamp. The effects of fragmentation are likely to be the same, regardless of reservoir capacity. The advantage of the virtual Tennent option is that the effects of fragmentation may be less.

Riparian Effects

The riparian vegetation in the Gudgenby River is currently showing impairment because of the 2003 bushfires. Substantial lengths of riparian habitat would be affected by flooding at the site of the Tennent Reservoir, and there may also be downstream effects introduced because of the barrier to drifting plant material. The areas that would be inundated are largely farmland with stock access to the River, consequently they have relatively low value as riparian zones.

6.3.4 Aquatic Ecology impacts

Construction of a dam on the Gudgenby River would convert a free-flowing river to reservoir habitat. This would increase isolation through both the immediate loss of habitat area and fragmentation of

native populations of aquatic fauna and flora. Protection of unregulated small streams and upper reaches should become a priority given the crisis facing the biodiversity of river systems.

The point has been made that the Tennent dam would be the first dam on a currently unregulated river system. The value of such a system is perceived to be significant by some. The environmental investigations discussed in this report have shown that the impact on the river system is minimal. It is noted that the dam location is near the lower end of the Naas Gudgenby catchment and that the length of river to be inundated has been substantially impacted by agriculture.

The virtual Tennent option poses less threats than the other Tennent options because there are less construction impacts, less of a barrier to fish and macroinvertebrate passage, and less risk to aquatic fauna because this option avoids flooding large areas of existing habitat, both in the bed of the river, and in adjacent riparian areas. This option would require building a small (2-3 m high) weir on the Murrumbidgee River. Given the proposed size of the weir, it is unlikely to interrupt the supply of bedload to downstream reaches enough for sediment starvation to be a problem, although some scouring of existing sand deposits, may occur. If water is pumped to Burra Creek, rather than directly to Googong Reservoir, this will double the mean-annual discharge, increase bank erosion and impact aquatic biota. Burra Creek is already impaired by agricultural landuse, with less conservation concerns than those surrounding increased discharge to Porcupine Creek which is discussed as part of the Tantangara option.

The University of Canberra study makes the following key points with respect to impacts on the aquatic environment across the various Tennent alternatives:

- Environmental impacts during construction may be mitigated with proper planning and implementation of best management practices. During construction water would need to be controlled and provisions for runoff and erosion control would need to be developed and implemented. A spill control plan may be needed to control any construction-related fuels, lubricants, and other materials.
- For any of the chosen options, it is important to establish a monitoring program that will allow alterations to be made to operational criteria, such that particularly harmful impacts may be reduced, should this become necessary. This also emphasises the need for flexible design in operational criteria.
- Construction of dams should include measures to mitigate the downstream effects on the aquatic biota, such as installing a multi-level off-take to prevent cold water pollution; providing large enough outlets for environmental flows; and providing fish passage where appropriate.
- Any implemented regime of flows should be viewed as an interim condition, to be revised once substantial knowledge is gained through ensuing scientific research and monitoring. This is a fundamentally important feature of any adaptive stream management strategy.
- The common occurrence of aquatic biota, such as the platypus, throughout much of the ACT is not a sign that we should be complacent. Careful management and strategies that prevent further degradation of stream habitat will be important in ensuring that these species do not become a conservation problem.
- Alternative strategies for water supply and management that avoid the construction of dams or weirs may have less impact on aquatic ecosystems than options that create a barrier to movement and dispersal of aquatic biota.

6.4 Effects on Terrestrial Flora and Fauna

An assessment of impacts on flora and fauna of potential future water options was conducted for the *Future Water Options Project* team by Biosis Research.[70] The purpose was to establish whether there is any major impediment to implementation due to significant flora and fauna issues. The study:

- reviewed existing literature;
- undertook a field assessment of all significant flora, fauna and vegetation;
- identified threatened species, or species habitat, that may be impacted by the proposed Tennent Reservoir, against the requirements of the *Nature Conservation Act 1980* and the (Commonwealth) *Environment Protection and Biodiversity Conservation Act 1999*; and
- detailed issues needing further examination via a preliminary assessment or full environmental impact assessment.

At the time of survey the condition and cover abundance of native vegetation within the study area was influenced by the 2003 bushfires. Recovery rates across the study area varied markedly depending on the type of vegetation affected A general observation was that native plant regeneration was in a range of advanced stages. The small area of burnt out pine forest was not regenerating.

6.4.1 Flora at the Tennent Site

Degraded Tablelands Dry Tussock Grasslands

The lower valleys, through which the Gudgenby and Naas Rivers flow, contain mainly altered grassland vegetation. The majority of these grasslands are used as non-native pasture to support sheep and cattle grazing. The proportions of exotic species present in the grasslands varied from locally dominant to moderately frequent.

In general, the grasslands in the Tennent reservoir study area are in poor to moderate condition, as a result of long-term grazing. Small patches of grassland in the study area may have some affinity with the ecologically endangered community 'Natural Temperate Grasslands', but are more likely to constitute secondary grassland, and therefore, part of the Yellow Box Red Gum Grassy Woodland, which are discussed below.

Yellow Box-Red Gum Woodland

The vegetation on the slopes in the Tennent study area is woodland vegetation, with Eucalyptus melliodora as the dominant canopy species. Several other eucalypt species occurred infrequently and some individuals of the exotic Cinnamomum camphora were recorded. The understorey in most areas was affected by grazing activities. Frequency and abundance of exotic species varies substantially, and generally the Eucalyptus melliodora woodland is in poor to moderate condition.

Secondary grassland (remnants of Eucalyptus melliodora woodland) also occur along roadsides, particularly along Naas Road. These remnants are in poor to moderate condition.

The Eucalyptus melliodora woodland in the study area forms part of the Endangered Ecological Community which is discussed below.

[70] Biosis Research (2005), *Terrestrial Flora and Fauna and Vegetation Study*, April 2005, ACTEW Corp Doc No. 4649.

Murrumbidgee Nortons Box Callitris Woodland

On the relatively steep slopes in the northern section of the study area (near the proposed dam wall), the vegetation consists of forest with a canopy of Callitris endlicheri. This vegetation was severely affected by the 2003 bushfires, with the majority of the trees and understorey killed by the fire. At the time of survey, natural regeneration was occurring in the canopy, shrub and understorey strata. Many understorey species were present only as seedlings.

The Callitris endlicheri forest was in moderate condition, with relatively low abundance of exotic species and natural structure present despite the fires. This vegetation community is not consistent with any Endangered Ecological Communities listed on the EPBC or Nature Conservation Acts.

Slopes and Tablelands Riparian She-oak Woodland

The vegetation along the Gudgenby River is in relatively poor condition, with many exotic species present in the tree, shrub and ground strata. This vegetation is not consistent with any Endangered Ecological Communities listed on the EPBC and/or Nature Conservation Acts.

6.4.2 Endangered Ecological Communities

Natural Temperate Grassland

Natural Temperate Grassland is listed as an Endangered Ecological Community on the Commonwealth EPBC Act and the ACT Nature Conservation Act. The grasslands in the study area were not identified as part of the community in the Action Plan for Natural Temperate Grassland prepared by the ACT Conservator of Flora and Fauna. The grasslands in the Naas and Gudgenby Valleys occur at elevations of between about 600 and 700 m. The Action Plan for Natural Temperate Grasslands states that 'in the ACT, natural temperate grasslands occur below 625 m elevation'. The grasslands in the study area occur above 600 m elevation, are considered secondary grasslands and contain a high proportion of exotic species.

Yellow Box Red Gum Grassy Woodland

This Endangered Ecological Community is listed under the ACT Nature Conservation Act and is nominated for listing under the Commonwealth EPBC Act.

Some areas of Yellow Box Red Gum Woodland in the study area are consistent with the criteria for Yellow Box Red Gum Grassy Woodland. This community has been previously identified as occurring in the study area by Environment ACT, as shown on the INCP mapping database[71] . It is now included as a part of the endangered community covered by Action Plan No. 27[72].

It is estimated that about 2,946 ha of variable quality Yellow Box Red Gum Grassy Woodland (refer to Figure 6.2) occurs within the study area and in the vicinity, but a more detailed field assessment would be required to verify the existing mapping and facilitate a more precise estimate. An assessment of impact of the proposal on this community is given below.

[71] www.incp.environment.gov.au
[72] Environment ACT (2004), *Woodlands for Wildlife: ACT Lowland Woodland Conservation Strategy*, March 2004.

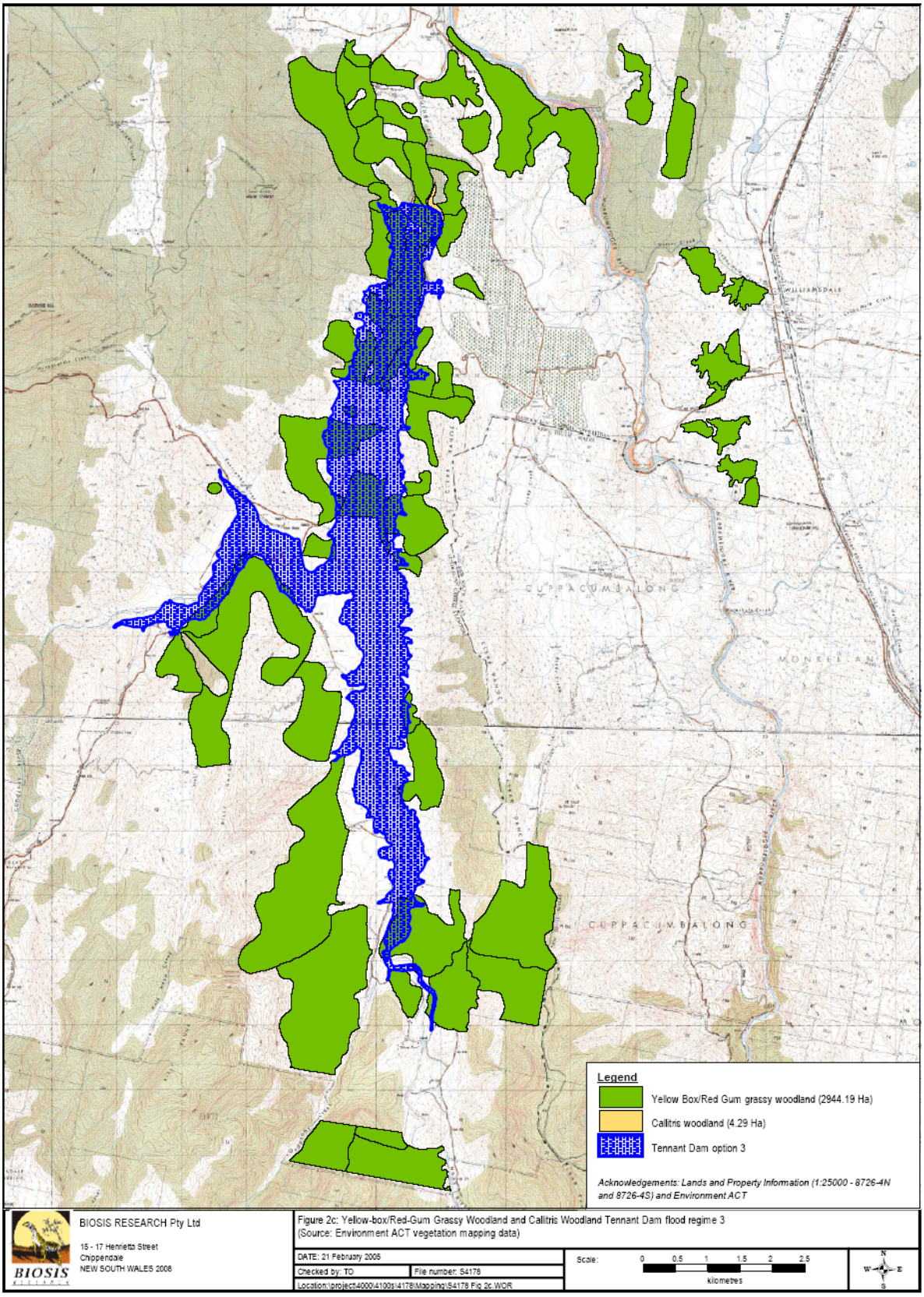


Figure 6.2 Tennent reservoir Site Woodlands

6.4.3 Significant plant species

A total of 64 dominant plant species were recorded from the study area, including 13 exotic species.

One threatened species, Swainsona sericea, which is listed as Vulnerable under the NSW Threatened Species Conservation Act, was recorded during the Biosis survey. Approximately six individuals were recorded within the study area, east of the Gudgenby River. Additional surveys would be required to determine the wider distribution and abundance of this species. The NSW Department of

Environment and Conservation Atlas of NSW Wildlife contains five records of this species occurring in NSW, near Michelago approximately 5 km to the east of the study area.

Eight threatened plant species listed on the EPBC, Nature Conservation and/or TSC Acts (Table 6.3) have been previously recorded within the vicinity of the study area. In addition to Swainsona sericea, six other threatened species have the potential to occur within the study area.

Table 6.3. Potential occurrence of threatened plant species, Tennent Reservoir area.

Species	NC Act	TSC Act	EPBC Act	Habitat requirements	Likely to occur in study area?
Calotis glandulosa	-	V	V	Grows in grassland and sclerophyll forest at higher altitude, from Eden to Dubbo area (Harden 1992).	Possible, in grassland vegetation in study area.
Gentiana baeuerlenii	E	E	E	Known from one location in the Orroral Valley in the Namadgi National Park. The orchid, *Spiranthes sinensis*, the herb, *Ranunculus pimpinellifolius* and the grass *Hemarthria uncinata* were found in association with the herb and this group of more widespread species may be indicators for other potential sites (Environment ACT Factsheet No. 5).	No, associated species not recorded in study area.
Muehlenbeckia tuggeranong	E	-	E	Known only from the flood terraces on the eastern bank of the Murrumbidgee R., near Tuggeranong, ACT (Harden 2000).	Potential habitat in study area.
Prasophyllum petilum	E	E	E	Grows in patchy woodland in fertile soils (Harden 1993). The ACT habitat is grassland dominated by Kangaroo Grass (*Themeda triandra*) in remnant *Eucalyptus melliodora - E. blakelyi* woodland (Environment ACT Factsheet No. 4). Known from only two locations-near Boorowa in NSW and in a 0.5 ha site in the cemetery at Hall, ACT (Environment ACT Factsheet No. 4).	Yes, habitat in grassland and woodland within study area.
Rutidosis leptorrhynchoides	E	E	E	Occurs in the ACT and Monaro region where it grows in grassland and woodland (Harden 1992). This species flowers mostly in summer (Harden 1992).	Yes, habitat in grassland and woodland within study area.
Swainsona recta	E	E	E	Grassland and open woodland, often on stony hillsides (Harden 1991).	Yes, habitat in grassland and woodland in study area.
Swainsona sericea	-	V	-	Grows in grassland and eucalypt woodland, sometimes with Callitris species; widespread (Harden 2002).	Yes, habitat in study area.
Thesium australe	-	V	V	Grows in grassland or woodland, often in reservoirp sites; widespread but rare (Harden 1992).	Yes, habitat in grassland and woodland within study area.

Key: V = Vulnerable; E = Endangered

Source: T O'Sullivan and E Gorrod (2004), *Terrestrial Flora, Fauna and Vegetation Study*, prepared by Biosis Research Pty Ltd for ACTEW Corporation and the Future Water Options Project Team, December 2004.

6.4.4 Fauna and Fauna Habitats at Tennent

A total of 66 animal species were recorded within the Tennent Reservoir study area by Biosis, including four frog, four reptile, 48 bird and 11 mammal species.

Despite widespread changes to habitat (including altered vegetation assemblages and structures, reduced extent and connectivity) there are potential opportunities, although variable, for rare and threatened species to occur (see Table 6.4).

Upstream from the proposed dam wall site, the Gudgenby River cuts though a steep valley which is lined by Callitris endlicheri woodland on the relatively steeper sections with exposed rock, which is incised at various intervals with shallow gullies. The north-western and western aspects provide suitable shelter and basking sites for a range of rock-dwelling reptiles, including the Eastern Brown Snake, Jacky Lizard and Eastern Blue-tongue Lizard.

Most of the lower Naas Valley has been cleared of native vegetation and converted to pasture, with local vegetation remnants restricted to scattered trees, secondary grassland and roadside strips within the valley and lower slopes. The area is currently grazed by mobs of Eastern Grey Kangaroo, Common Wallaroo and domestic stock. At a broad scale, fauna habitats in the study area correspond to the compositional and structural features of vegetation types outlined above. Finer scale habitat features on and near the study area include rock outcrops along the ridgelines, spurs and knolls, tree hollows, hollow logs and creek and riparian habitats. Surrounding slopes provide better habitat components and connectivity, particularly east of the Gudgenby River and to the west of Mount Tennent. Habitat fragments and isolated trees may form part of a weak network of local habitat linkages across the Naas Valley, but for the most part connectivity is poor.

A small patch of degraded woodland perched on a rocky outcrop east of the Naas Road and Apollo Road intersection provides a range of habitat opportunities, including rock outcrops and hollow-bearing trees. This area provides suitable but isolated habitat for less common ground dwelling and fossorial reptiles such as the Spotted Skink, Blind Snake and Olive Legless Lizard. Bird activity is noticeably greater in this area with 14 species of bird recorded, including the locally rare White-winged Triller and Brown Treecreeper. This rocky outcrop is above the high water mark of the large reservoir alternative. Bird diversity was also greater along the western and eastern margins of the Naas Valley, and correlated to areas of intact woodland of the slopes.

Significant Animal Species

Three threatened species scheduled under the ACT Nature Conservation Act and/or the NSW Threatened Species Conservation Act were recorded north of the Gudgenby and Naas River confluence. These included the White-winged Triller, Brown Treecreeper and Speckled Warbler. Two less common species were the Jacky Winter and Spotted Quail Thrush.

Three threatened reptile species, the Pink-tailed Worm Lizard, Striped Legless Lizard and Grassland Earless Dragon, have not been previously recorded from study area. The vegetation of the study area was not entirely consistent with the habitat requirements of these species. Due to the past disturbances and structural changes across the study area it is considered unlikely that these reptile species would occur. There is also the possibility that the historic distribution of these species did not extend into the study area.

Some of the species that may use parts of the study area on a temporary or transient basis, particularly migratory or highly mobile species, include various microbat species, Swift Parrot, Dusky Woodswallow and Regent Honeyeater. Rare woodland birds such as the Diamond Firetail, Hooded Robin and Speckled Warbler might also occupy local woodland and associated grassland habitats on a more permanent basis, but were not detected during the survey period.

The Diamond Firetail is mostly sedentary, with some populations showing local movements at times, and are restricted to woodland habitats. The Hooded Robin also inhabits woodland, but its range extends westward into shrublands of semi-arid NSW. Local populations and family groups of both species may be dependent, to some degree, on the woodland resources within the study area. These species may undertake local movements and groups may also occupy adjacent woodland and grassy woodland habitats from time to time. Potential habitat for these bird species is likely to be negatively impacted by the removal of remnant woodland and associated grasslands.

Given that some of these species are restricted in range and occur as isolated populations, it is likely that the loss of known and potential habitat from the study area could result in viable local populations being placed at risk of extinction.

Table 6.4. Potential occurrence of rare and threatened animal species, Tennent Reservoir area.

Common Name	NC Act	TSC Act	EPBC Act	Habitat Opportunities within Option 3
Invertebrates				
Golden Sun Moth	E	E	CE	No
Perunga Grasshopper	V			Possible
Amphibians				
Giant Burrowing Frog		V	V	Unlikely
Reptiles				
Striped Legless Lizard	V	V	V	No
Grassland Earless Dragon	E	E	E	No
Heath Monitor		V		Possible.
Birds				
Glossy-black Cockatoo		V		Possible
Brown Treecreeper	V	V		Recorded
Varied Sittella	V			May occur in native forest/woodland
Latham's Snipe			M	May occasionally occur in reed beds along the shallow margins of Gudgenby River
Painted Honeyeater	V	V		May occur in native woodlands
White-bellied Sea-Eagle			M	May occasionally forage along the Gudgenby River
White-throated Needletail			M	Yes above ranges to the E and W
White-winged Triller	V			Recorded
Swift Parrot	V	E	E/M	May occur in native forest/woodland
Hooded Robin	V	V		May occur in remnant grassy woodlands
Satin Flycatcher			M	May occur in native forest/woodland
Powerful Owl		V		Parts of the upper Naas Valley may comprise part of a local pairs home range

Common Name	NC Act	TSC Act	EPBC Act	Habitat Opportunities within Option 3
Superb Parrot	V	V	V	Unlikely
Rufous Fantail			M	May occur in native forest/woodland
Australian Painted Snipe			V	May occasionally occur in reed beds along shallow margins of Gudgenby River
Painted Snipe		V	M	May occasionally occur in reed beds along shallow margins of Gudgenby River
Diamond Firetail		V		May occur in remnant grassy woodlands
Regent Honeyeater	E	E	E/M	May occur in native forest/woodland
Mammals				
Spotted-tailed Quoll	V	V	V	May occur in native forest/woodland particularly along the western and southern margins of the study area.
Brush-tailed Rock-wallaby	E	V	V	Not in study area. Evidence of previous occurrence at Mt Tennent and Clear Range to the east (Ormay 1997)
Koala		V		Unlikely
Eastern Long-eared Bat		V	V	Possible
Brush-tailed Phascogale		V		Possible in forest areas

Key: V = Vulnerable; E = Endangered

Adapted from: T O'Sullivan and E Gorrod (2004), *Terrestrial Flora, Fauna and Vegetation Study*, prepared by Biosis Research Pty Ltd for ACTEW Corporation and the Future Water Options Project, Dec 2004.

The virtual Tennent (Murrumbidgee weir) alternatives at Angle Crossing, Tharwa and Cotter were not assessed as part of the detailed survey discussed above. The "footprint" of the weir structures and associated pipelines is relatively small (the pipes are most likely to be buried). It is believed that these facilities could be constructed without unacceptable impacts on flora or fauna although this would be subject to detailed site assessment if a decision was made to proceed with these.

6.4.5 Potential Impacts on Flora and Fauna

The construction of a reservoir would have a number of impacts on plants and animals and their habitats within the study area[73]. A Tennent reservoir would have a direct effect on the landscape by replacing existing riparian, gully, pasture, secondary grassland and woodland habitats with a lacustrine habitat. The development footprint (including the flooded area, dam wall and road construction) would cover a maximum of 1339 ha and remove up to 434 ha of variable remnant Yellow Box Red Gum Grassy woodland (Endangered Ecological Community), which includes:

- 235 ha of partially modified Box/Gum Grassy woodland; and,
- 199 ha of moderately modified Box/Gum Grassy woodland.

Between 2.07 and 2.85 ha of roadside vegetation (Naas and Angle Crossing Roads) comprising mostly secondary grassland will also be removed.

[73] Biosis Research (2005), *Terrestrial Flora and Fauna and Vegetation Study*, April 2005, ACTEW Corp Doc No. 4649.

A number of non-endangered vegetation types will also be removed, including about 4.29 ha of *Callitris* woodland along steep valley walls at the proposed dam wall construction site.

The Tennent Reservoir will convert existing terrestrial (much of which is pasture) and riverine habitats to a lake. It will also increase gaps between native vegetation either side of the Gudgenby and Naas Rivers and remove movement linkages for woodland fauna species. Potential habitat for up to six threatened plant species listed under the Commonwealth Environment Protection and Biodiversity Conservation Act, the ACT Nature Conservation Act and the NSW Threatened Species Conservations Act would be affected by the implementation of the reservoir.

The removal of up to 439 ha of woodland and secondary grassland habitat would have a significant local impact on the local occurrence of rare and threatened woodland birds.

A detailed environmental impact assessment, meeting the requirements set by the Land (Planning and Environment) Act would be required prior to any decision to proceed with this proposal.

The assessment would review the total impact of the reservoir including the withdrawal of all agricultural activity from the catchment. Substantial tracts of land in the Naas and Gudgenby valleys above the inundation area that are classified as Yellow Box Red Gum Grassy woodland under Action Plan 27 are currently within rural leases. These would be returned to public ownership and it is most likely that the Namadgi National Park boundaries would be extended to encompass this land. Advice from Environment ACT[74] has indicated that this would be consistent with the ACT Lowland Woodland Conservation Strategy adopted by the ACT Government in April 2004. This would allow the woodland to recover to a more natural state and may be considered to outweigh the impact of inundating the areas of woodland in the lower catchment.

[74] David Shorthouse, Manager, Wildlife Research and Monitoring, Environment ACT, email, 18/02/2005

7 Human Environment

7.1 Heritage

7.1.1 Indigenous Heritage

The area that would be inundated by the proposed Tennent Reservoir is large and has not been subjected to detailed archaeological survey. Various surveys of parts of the area have been conducted and these have been examined by Navin Officer who have prepared a report on the heritage aspects of the future water options[75]. They have found that no recorded Aboriginal sites would be directly impacted by the inundation area and the proposed construction site for Tennent Reservoir. However, it is possible that 16 recorded sites may be impacted in the vicinity of the inundation and construction site areas due to the creation of roads and/or other ancillary works required during construction. Details of the sites that would be directly impacted, and those additional sites which may be impacted, are provided in the Navin Officer report. Prior to any action that would disturb these sites they will require detailed assessment. It is considered unlikely that any would be found to be of such significance as to preclude a reservoir project.

It would also be necessary to conduct a more comprehensive survey of the entire affected area prior to a decision to proceed with a reservoir. Navin Officer have included in their report a gap analysis which provides predictive advice on the likely outcomes of such a survey. Based on an assessment of the landscape characteristics and other physical features, and comparing this with the locational characteristics of known sites throughout the region they predict that *"the most likely site types to be found in the Tennent study area are small, low density artefact scatters, isolated finds, stone arrangements and possibly art sites. As the area has been identified as being used for local occupation by small groups of people for reasons connected with ornamented (art and stone arrangement) sites, it is considered a medium to high probability that these types of sites will be located in the area"*.

Some of the pipeline alternatives for both the reservoir (to Stromlo and to Tuggeranong) and the virtual Tennent option (Tharwa to Googong reservoir) were also examined by Navin Officer. In each case they found a number of sites that may be affected by pipeline construction. Again, it is considered that none would be of sufficient significance to preclude any of the proposed pipelines. Pipelines can be deviated where necessary to avoid significant sites although this is considered unlikely to be required. Detailed surveys of the proposed alignments would be required prior to any decision to proceed. Navin Officer did not examine the Angle Crossing to Burra alignment as the possibility of this alternative had not been raised when their work was commissioned. Whilst a detailed alignment survey would be required it is considered unlikely that any sites would be discovered on this alignment that would preclude construction of this alternative should it be selected.

The three Aboriginal community groups who have an interest in cultural heritage issues within the ACT and who are registered with the ACT Heritage Unit were consulted about each of the three options.

Representatives from the Ngunnawal ACT and District Indigenous Peoples Association based at Yass, the Ngunnawal Elders Council Incorporated/Ngunnawal Local Aboriginal Land Council based at Queanbeyan and the Buru Ngunawal Aboriginal Corporation based at Dunlop, ACT indicated that, superficially, there did not appear to be any major Aboriginal cultural heritage constraints to the Tennent Reservoir options. They noted that there was insufficient information available for them to

[75] Navin Officer Heritage Consultants (2005), *Cultural Heritage Assessment*, April 2005, ACTEW Corp Doc No. 4651.

make considered, detailed comments, and reserved their right to comment further when additional, more specific, information becomes available on a preferred option.

Both Aboriginal groups that provided detailed comment noted that the Tennent Reservoir option is likely to have a high impact on Aboriginal archaeological sites and their cultural values, and is not therefore a preferred option.

All three ACT Aboriginal groups noted that consultation with local Aboriginal groups must be an integral component of all further stages of assessment of the options.

The Tharwa, Angle Crossing and Cotter weir alternatives were not examined by Aboriginal representative groups or by the consultant archaeologists. More detailed work on these sites would be needed also if any were to be selected as a preferred option.

Namadgi National Park is currently administered by a Board of Management that includes representatives of local Aboriginal groups, in recognition of their prior ownership of the land. It is possible that, were a Tennent Reservoir option to proceed, the boundaries of the national park could be extended to encompass upstream, and perhaps also the foreshore areas, of the reservoir. This would extend the role of the Board of Management and, inter alia, the representatives of the Aboriginal groups.

Block 92 Tennent is a former Travelling Stock Reserve and has been included in a Native Title Claim.[76] Advice from the Government Solicitor's Office is that while the land might be capable of being subject to a claim, and a claim has been made, that claim has not been registered with the Native Title Registry. There is no legal entitlement of the claimants to the land. General ACT Government policy would probably require that the claimants be consulted and advised if the Tennent option was to proceed. The "Wik" amendments to the Commonwealth native title legislation made provision for Government infrastructure to be erected on land the subject to a native title claim and, although not a legal requirement, the Government could consider an ex gratia compensation payment to the Claimants. The Government Solicitor's Office also advised that there were prospects that the claim, which is an ambit one, might be withdrawn. This would lift any political or general policy requirement to deal at all with the current claimants.

There are no outstanding native title claims within the areas that would be inundated by the virtual Tennent weir alternatives.

7.1.2 European Heritage

The majority of non-Aboriginal archaeological knowledge relevant to the Tennent options results from a survey undertaken by Winston-Gregson of a proposed National Park at Gudgenby in 1978[77]. Winston-Gregson identified several huts/homesteads and ancillary structures (stockyards, woolsheds, gear-sheds and fences), and track-ways (bridlepaths, dray routes, stock routes, public roads and fire trails).

This and other surveys conducted within the Tennent option have covered:

- 1 km either side of the Murrumbidgee River Corridor;
- the majority of the valley contexts at Rendezvous Creek, Tennent, Glendale, Naas Creek and Grassy Creek;
- fire and bridle trails; and

[76] KMR Consulting (2005), *Land Ownership Study*, April 2005, ACTEW Corp Doc No. 4652.
[77] Discussed in detail in Navin Officer, Navin Officer Heritage Consultants (2005), *Cultural Heritage Assessment*, April 2005, ACTEW Corp Doc No. 4651.

- exposed ridge crests.

There are 34 recorded non-Aboriginal sites that would be directly impacted by the inundation area and the proposed construction site for the large Tennent Reservoir. In addition, it is also possible that a further 66 recorded sites in the vicinity of the inundation and construction site areas may be impacted due to the creation of roads or other ancillary works required during construction. Details of the sites that would be directly impacted, and those additional sites that may be impacted, are provided in the Navin Officer report. None of the recorded sites are listed on the ACT Heritage Register and their presence would not preclude the construction of a reservoir.

It is important to note that several of the homesteads are occupied farm homesteads and some of these have strong family associations.

Several of the Tennent pipeline alternatives have also been examined by Navin Officer and whilst more detailed work would be required prior to a decision to proceed with any particular alternative it is most unlikely that a viable alignment could not be found.

7.2 Recreation

Following the January 2003 bushfires a Recreation Strategy[78] for the Natural Areas of the ACT has been prepared and released by the Act Government as an Interim document whilst a range of other significant planning and consultation processes are underway which will greatly influence the final strategy. This strategy is a secondary document to Plans of Management, the Territory Plan, and the Shaping Our Territory Report and the Implementation Studies which have been commissioned as a result of the Shaping Our Territory study. Key studies that are ongoing include:

- Namadgi Plan of Management review;
- Tidbinbilla Nature Reserve Business Case and Masterplan;
- Cotter Precinct Masterplan; and
- other Shaping Our Territory Planning includes five studies into identified areas, Tidbinbilla/Block 60, Cotter Precinct, Rural Villages, Stromlo/Deeks Forest and the International Arboretum. Each of these master planning exercises will greatly impact on the Recreation Strategy.

At this stage the interim strategy provides “key directions” for a number of recreation resources that relate to the Tennent Reservoir option. These are:

- The Orroral Valley, a significant access point for day and overnight visitors to Namadgi as a destination and as a trailhead. This area is appropriate to ongoing use for a range of recreational activities. The Orroral Ridge, above the valley, is an important area for walking, climbing and camping.

Reinstatement of the Boboyan Road, if inundated by a reservoir, would be essential to meet this objective

- The Boboyan (and Naas/Gudgenby) Valley includes the Boboyan Road, the main thoroughfare through the park, and the Old Boboyan Road. A range of recreational opportunities are provided in this area and additional uses can be provided for.

The importance of the road for recreational access is highlighted.

[78] Janet Mackay, Planning for People (2004), *Interim Recreation Strategy for the Natural Areas of the ACT*, Prepared for Environment ACT, April 2004.

- Upper Naas—Mount Clear – with a particular focus on horse riding and the redevelopment/relocation of the bicentennial national trail.

Substantial lengths of the existing trail would be inundated by the Tennent reservoir and would need to be reinstated. A possible alignment would be along the western edge of the Naas valley arm of the reservoir, to link with the new Boboyan Road. Access and camping in this area would be problematical for water quality reasons. Alternative alignments through more sensitive parts of the National Park may also prove difficult.

- Tharwa Bridge is an area of high importance to the local community. As a key point on Tourist Route 5 and highly visible from the Tharwa Bridge, appropriate site management is essential. The Tharwa precinct is an important location for tourists and the local community in terms of the art, craft and café opportunities.

A weir at Tharwa, if constructed, should be located upstream of the intensive activity area around the bridge and the design should be compatible with the historic precinct.

- Angle Crossing is a very low use area although use is increasing with rural development in the Royalla area. The implementation of simple day use facilities will enable people to enjoy this site.

A water supply weir should preferably be located away from the swimming area (for water quality reasons), which is immediately upstream of the road crossing so that the recreation activity can continue and grow.

The scale and demographics of anticipated growth in the Canberra population means that there is a need for a broad range of recreation opportunities from the more remote settings with opportunities for adventure activities, through to developed sites with opportunities for more passive recreation and facilities for disabled people. A future Tennent reservoir (or to a lesser extent any of the proposed weirs) could provide some contribution to the development of recreation facilities to meet this growing community need. For water quality and health reasons (discussed in Section 4.3 above) the functions of the water storages would be limited to passive activities such as landscape appreciation and picnicking, from limited locations. Water contact activities including swimming, boating and fishing would be prohibited.

The proximity of Tennent Reservoir to Namadgi National Park is likely to enhance the attractiveness of both. In 2001/02 Namadgi accommodated a total of 154,452 visitors[79], with the added attraction of a major water feature in the vicinity this number would be expected to increase. Actual volumes would be dependent on the management regimes and uses permitted on the reservoir and foreshore areas.

7.3 Amenity

The visual amenity of the landscape in the Naas/Gudgenby valley would be dramatically altered if a dam were constructed. The larger reservoir alternative would result in the inundation of the whole valley floor; the current view from the Naas/Boboyan Road over cleared farmland would be replaced by a view over a body of water. Depending on the management regime adopted for use of reservoir water the waters edge would periodically consist of a cleared zone as water levels fluctuate up and down. Views over water bodies are usually considered to be aesthetically pleasing and this would be the case with the Tennent reservoir. The aesthetic appeal would be enhanced by the 'framing' of the water body by the high ridgelines on either side. Careful design of the new Naas/Boboyan Road that would be required along the western side of the reservoir could enhance the visitors aesthetic experience.

[79] Janet Mackay, Planning for People (2004), *Interim Recreation Strategy for the Natural Areas of the ACT*, Prepared for Environment ACT, April 2004.

The dam itself, located within a narrow deep gorge would be visible from the road and from areas downstream. It would be framed by the mountains on either side and with attention to design detail could have the appearance of an (albeit large) element within the valley rather than dominating the local landscape.

7.4 Public Health

The ACT Water Resources Management Plan, collectively encompassed by "Think water, act water"[80] clearly sets out the need to "Ensure water supply and management practices are consistent with protecting public health". This is consistent with the array of Commonwealth and ACT Legislation that governs the management of ACT water supplies[81]. Taken together the legislation requires[82]:

- a triple bottom line (environment, economic and social) approach be used in decision-making;
- that water management occur within an ecologically sustainable, healthy, attractive, safe and efficient environment, ensuring provision for the needs of future generations;
- the reduction of source pollution be promoted;
- water quality protection generally receive higher priority than recreational access;
- waterways and aquifers be protected from damage; and
- secondary uses of designated catchments be permitted provided they do not compromise primary environmental values as water supply catchments. [83]

This means that a new water supply at Tennent would be managed, as for existing supplies, with public health as the principal consideration. The water quality outcomes likely to be achieved at all of the Tennent alternatives have been found[84](see section 4.3) to be well within the range that is able to be utilised for human consumption, with appropriate treatment. Human access to the catchment will need to be carefully managed, in order to keep microbiological contamination at a low level. The management of such access will be particularly important for future recreational opportunities and facilities near Cotter Reservoir.

In the ACT, drinking water management follows the requirements of the following two key documents:

ACT Department of Health and Community Care (2000). Drinking Water Quality Code of Practice.

National Health and Medical Research Council and Agriculture and Resource Management Council of Australia and New Zealand (1996). Australian Drinking Water Guidelines.

These document emphasise the importance of a catchment to consumer approach, and the need to retain multiple barriers to prevent the transmission of microbiological or chemical contaminants.

To the extent that a Tennent supply would provide Canberra with a third major water supply source in addition to the current two (the Cotter and Googong catchments) then it will add to the security of the water supply. The health benefits of this would be realised if serious contamination were to occur in either or both of the other two sources.

[80] ACT Government (2004), *Think water, act water,* op cit, April 2004.
[81] see for example: McCann Property and Planning Pty Ltd and ACTEW (2004), *New Water Source for the ACT, Planning and Development Controls*. June 2004.
[82] adapted from Don Bursill (2005), Peer Review of "Technical Advice on ACT Reservoir Recreational Water Use Options, January 2005.
[83] ActewAGL and Water Futures (2005), Technical Advice on ACT Reservoir Recreational Water Use Options, April 2005, ACTEW Corp Doc No. 4671.
[84] ActewAGL (2005), *Tennent Option Water Quality Report*, April 2005, ACTEW Corp Doc No. 4662.

An important health consideration for the Tennent reservoir proposal is the impact of the proposal and, if it is built, the dam itself, on the psychological health of the valley residents. This is discussed in more detail in Section 7.6 below.

A more widespread public health issue is the stress and anxiety that suburban residents suffer during prolonged periods of drought, and accompanying water shortages and restrictions. The time required to water established and valuable gardens by hand during higher level restrictions, can be significant, encroaching into the available time for other pursuits. The possible loss of plants is also an issue. It is partly for this reason that ACTEW has reliability explicitly in its charter of service delivery.

7.5 Energy and Greenhouse Gas Emissions

The ACT Government has, as a guiding objective, the prudent use of resources.[85] This includes the minimisation of energy consumption and greenhouse gas emissions. Accordingly, as part of the evaluation of future water options, ACTEW commissioned an assessment of the energy implications of each of the options.[86]

A new water storage reservoir consumes energy and produces greenhouse gas emissions in three ways:

- construction energy and embodied energy of the materials used;
- energy and chemicals used in the operation of the system following construction; and
- decomposition of organic matter within reservoirs, both aerobic (where oxygen is readily available, and carbon dioxide is released) and anaerobic (where oxygen is absent and methane is released, methane having about 20 times the greenhouse impact of carbon dioxide).

All reservoirs (as well as natural lakes) release some greenhouse gases. The scale reflects:

- the amount of uncleared vegetation allowed to remain in a reservoir after the construction and flooding process;
- the amount of nutrients and organic matter entering the reservoir as catchment run-off after construction;
- the organic content of sediment;
- the depth of the reservoir;
- the temperature of the water; and
- the dissolved oxygen in the water column and at the sediment surface, which will determine whether carbon is decomposed aerobically or anaerobically.

Various management procedures can significantly reduce emissions, for example:

- removing trees and other large organic material during construction;
- maintaining good catchment health, thereby reducing organic material run-off; and
- destratifying the reservoir during warmer months to promote aerobic decomposition.

[85] ACT Government, Office of Sustainability (2003) *People Place Prosperity: a Policy for Sustainability in the ACT*. 2003.
[86] ActewAGL (2005), *Greenhouse Gas Emissions,* April 2005, ACTEW Corp Doc No. 4670

Energy is used during construction of any large infrastructure project, and is influenced by factors including:

- sourcing of materials: materials sourced locally tend to use less transport energy than those sourced from further away;
- the transport mode: mass transport options, such as rail, tend to use less transport energy than more tailor made options;
- the existence of waste minimisation programs on the construction site; and
- the balance of cut and fill: avoiding the import or export of soil will decrease the amount of transportation energy.

In addition, tunnelling options requiring blasting and drilling will use more energy than the construction of reservoirs, which in turn will use more energy than pipelines. The precise quantification of these construction energy costs is difficult and accurate estimates have not been able to be calculated.

Embodied energy is the amount of energy used to make a particular piece of material. Once again, quantification is difficult, given there can be large differences in:

- transport distances for raw materials;
- energy used on site for building or assembling;
- upstream energy inputs for manufacturing the material; and
- recycling of materials after their intended use.

In addition, the direct conversion of embodied energy into greenhouse gas emissions (in terms of carbon dioxide equivalent) depends on upstream energy sources, such as coal-fired power stations or hydro-power, and whether methane was incorporated.

Against this background, the following calculations were made for the enlarged Tennent Reservoir option:

- embodied energy: 3,100 tonnes per year as CO_2 equivalent (assuming a 100 year life);
- operating energy: 23,000 tonnes per year as CO_2 equivalent;
- sediment releases (based on overseas data): 440 tonnes per year as CO_2 equivalent (assuming best management practices are employed); and
- a total of 167 tonnes per year (CO_2 equivalent) per GL of reservoir capacity.

Measured on a CO_2 equivalent per GL stored the large Tennent Reservoir option ranks highest (best) of the various new water supply options. This reflects high energy consumption in other activities such as tunnelling for some of the Tantangara options or high pumping costs for the virtual Tennet alternative pumping to Googong. The calculations have not factored in some elements of these proposals such as mini hydro power stations that would have a mitigating effect.

Energy estimates require further investigation to make a reliable comparison between options. The absence of virtual Tennent possible hydropower contributions to renewable energy has already been discussed but the use of existing reservoirs (at Tantangara and Corin) and their embodied energy also requires further consideration.

Finally, the beneficial greenhouse effects of a reliable water supply to Canberra's parks, gardens, and streetscape and their consequent microclimate effects are significant. Energy savings from these microclimate effects (through reduced air-conditioning and cooling) – and the threat to them from frequent water restrictions – should be considered when comparing greenhouse gas emissions.

A recently published Tree Management and Protection Policy for the ACT noted, as some of the benefits of a well tree-ed and shady landscape, the fact that:

- urban trees mitigate the impact of human-induced urban heat islands, and reduce pollution (through the absorption of ozone, sulphur dioxide and nitrogen dioxide, the interception of particulate matter, and the release of oxygen);
- trees lower urban temperatures and reduce the rate of ozone formation;
- urban trees in car parks help lower the temperature of parked vehicles and reduce vehicle hydrocarbon emission;
- tree shade over roads protects weathering and reduces the need for frequent road sealing;
- urban trees reduce greenhouse gases (by storing carbon); and
- shading, wind shielding, evapo-transpirative cooling of air temperatures and modification of solar radiation reduce energy consumption for summer air conditioning and winter heating – saving energy costs, reducing carbon dioxide emissions and power utility investments.[87]

These effects have not been quantified, although the impact of public area street trees that have died due to water restrictions has been factored in to the benefit cost analysis discussed in the next chapter.

7.6 Crown Leaseholders

The residents of the Naas and Gudgenby valleys would be seriously affected if a decision is made to proceed with a Tennent reservoir. Section 4.3 of this report refers to the water quality and health implications of the reservoir proposal and concludes that, if a reservoir proceeds, then residential and agricultural activity will be precluded from the catchment. Consultation with the existing rural lessees as the planning and analysis process proceeds has been given a high priority in an endeavor to ensure that they are as fully informed as possible as work progresses. A presentation was given to residents of the Naas Valley on Saturday, 23 October 2004. The meeting was well attended with all lessees in the area being represented. The issues that were raised[88] are set out in the table below, together with a response for each issue:

Table 7.1 Leaseholder Issues

Issues raised	Response
Costs of any reservoir must include the associated relocation of infrastructure, pipelines and treatment plants. The costs as proposed by the Liberal Party pre-election were rejected as being too low.	The ACT liberal party "Policy Statement 2004 Water Security" stated that a Tennent reservoir would cost $140-$150m. material in section 2 of this report indicates that the full cost would be of the order of $250M
Assurances were sought that appropriate studies were conducted to ensure that a reservoir in the area would fill. Local knowledge indicates very low flows in the Naas and Gudgenby Rivers and a natural fault in the area	The appropriate studies have been conducted and are reported on in this report. A number of relevant technical reports are listed in Appendix ??????
Concerns expressed that even if the Tennent option is not chosen that it will still be considered in the future. This has an impact on the terms of their	This issue is addressed in below. The need for certainty is recognised and the impact of uncertainty on, for example, land management decision making, is recognised.

[87] Environment ACT (2001), *A Tree Management and Protection Policy for the ACT*, September 2001.
[88] Future Water Options Working Group (2004), Monthly Report, October 2004 DM3902

leases, land values and the level of improvements they will commit to. It also affects land management practices. They feel the issue will never go away.	
Concerns that even if a small option is progressed, this will affect rural activities in the catchment. Also fear that there will be a push to have the remaining area incorporated in the NNP. Very critical of EACT's land management practices	All options have similar environmental impact. Farming activities within the Naas and Gudgenby valleys would be precluded by all options.(See Section 4.3)
Opinion that there is a conflict of interest in ACTEW carrying out this study. Sought to clarify if ACTEW would be deciding upon a preferred option and recommending this to ACT Government. Questioned whether the ACT Government would not accept ACTEW's advice	The final decision on a new water storage for the ACT, if any, will be made by the ACT Government. ACTEW provides technical advice to Government to assist the decision making process. ACTEW makes every effort to ensure that the advice is unbiased and technically correct. This includes the use of independent experts and commissioning independent peer review of key pieces of work.
Assurances sought that ACTEW were not progressing another water source in order to increase revenue by providing water to interstate customers	ACTEW currently supplies water to Queanbeyan and this will increase as Queanbeyan grows. ACTEW may in future supply water to other parts of the region, noting that water should be managed as a regional resource.
Assurances sought that the Tennent option would not be favoured due to the advantage of it opening up an additional catchment. A balanced and even consideration of all issues was requested	There are some advantages in terms of supply security in utilising a third catchment for Canberras' water supply. This advantage of the Tennent option will be weighed against the other advantages and disadvantages of Tennent and the other options.

A key issue for the Tennent Reservoir proposal is the impact of the ongoing uncertainty and, if it is built, the reservoir itself, on the valley residents. The proposal affects 14 rural holdings[89] and would require the relocation of 11 families that in some cases occupy two or three households. The inundation area covers virtually all the relatively flat land in the two valleys and would render broadacre agricultural activity impossible. The areas of land affected are summarised as follows:

Table 7.2: Rural Lease tenure Arrangements

Land held under long term lease requiring acquisition under the lands Acquisition Act	2031ha
Land held under quarterly lease or similar arrangement or longer term lease with withdrawal clause in lease, acquisition would require compensation for lessee owned improvements	2898ha
Land held under agistment licenses, Territory owned, acquisition not required	3418ha
One house site held under license.	0.5ha

Of the total 8347 ha currently occupied about 1400 ha is located on the valley floors and is reasonably level and cleared; this would be regarded as viable and in parts good quality agricultural land. It is good for grazing with a reliable rainfall and good soil fertility. The balance is steep or very steep terrain and generally timbered with limited grazing potential.

Some of the leases that would be subject to resumption are either short term or include clauses ("land withdrawal clauses") providing for the withdrawal of all or part of the land from the lease should the land be required by the Government (e.g. for a reservoir). The residents have therefore been aware of the possibility of a reservoir for a long time; they nevertheless have strong links with the land and in some cases occupation has been multi generational. Some of the leases are for longer terms (25 years), do not include withdrawal clauses and have renewal rights under Section 171A of the Land Act.

[89] KMR Consulting (2005), *Land Ownership Study*, April 2005, ACTEW Corp Doc No. 4652.

An issue that already exists is the uncertainty that has long been a feature of life in the two valleys. For many years the reservoir proposal has remained unconfirmed. The difficulty that this will have brought to major life decisions for the residents will inevitably have caused stress. It is noted that all residents have been obviously free to sell up and relocate to a more certain future elsewhere at any time. Presumably, and not unreasonably, they have not done this because their strong association with the land and the quality of the lifestyle that the valley offers has been such that they have been reluctant to take this final step until they are absolutely certain that it is unavoidable. An outcome of this current process should be the removal of this uncertainty, one way or the other.

A decision to not ever proceed with a reservoir would clearly be welcomed by the residents; a decision to not proceed within a specified and lengthy timeframe (e.g. not for at least thirty years with another water supply option being implemented first) would be of substantial benefit.

A decision to proceed with a reservoir in the short term would obviously impact heavily on the valley residents. An appropriate level of counseling support in addition to the statutory requirements for compensation will be necessary should this eventuate.

In the event that a decision is made to continue to reserve the site for a reservoir but to not proceed with construction in the short term then all possible steps should be taken to provide the rural lessees with as much certainty into the future as is reasonably possible. A possible scenario would be as follows:

- Confirm a deferral timeframe, i.e. a period of say 30 or 50 years during which there is reasonable confidence that a Tennent Reservoir will not be required.
- Issue leases to all existing short term lessees in accordance with the provisions established by the Rural Lease Policy[90] modified as necessary by reservoir requirements. Many of the provisions established by this policy may need to be reviewed on the basis of Government decisions on the future water options.

Consideration should be given to the following leasing options in the dam affected area:

- A fixed term, equivalent to the deferral time as discussed above, with the grant of further leases to be assessed at the appropriate time.
- No land withdrawal provisions within the lease.
- Provision for a review of the lease at a fixed time before expiry (say 10 years). At this time the Government would be obliged to decide whether or not the land would be required for a reservoir on expiry of the lease. If a reservoir is imminent then the lessee would be notified that a further lease would not be granted in view of the land being required for a public purpose. Temporary occupancy arrangements could be considered.
- If a reservoir is not imminent then a further lease would be considered for another period equivalent to a new “deferral timeframe”. Again this would need to be for a substantial period, say 30 to 50 years, no withdrawal clause or automatic renewal rights.
- This system of “rolling” renewals would continue indefinitely until a dam is required.

This system provides for sufficient security of tenure for the lessee to commit financial and other resources to sound land management and agricultural practices, maximising the potential of the land. This is a benefit to the environment and to the economy. It also provides for periodic opportunities for

[90] ACT Government “Farming in the ACT”, 1999

the Government to resume the land at minimal cost and within a timeframe compatible with planning for an infrastructure item of this magnitude. The opportunity would also always be open to the Government to acquire leases under the *Lands Acquisition Act 1994* for reservoir purposes if a need arose earlier than expected. In this case acquisition costs would be expected to be reduced compared to "normal" ACT leases (which are 99 years and renewable) because the acquisition cost would be calculated on the balance of the term of relatively short term non renewable leases.

8 Economic Implications

8.1 Economic Framework

The Centre for International Economics (CIE) undertook a benefit cost analysis of future water options, using data and key assumptions provided by the *Future Water Options Project* team.[91] Each future water option produces benefits in terms of a lower likelihood of restrictions than "do nothing", and hence a lower cost of restrictions. The basis of the benefit cost analysis is to compare the reduction in the expected costs of restrictions associated with a new water option (the benefit side of the equation) with the costs (both construction and operational) of providing it.

Behind this relatively simple economic framework, a number of quite complex variables need to be taken into account, for example:

- the stage of restrictions (there are five stages, each with a different target for reduction in water demand);
- impact of restrictions on different categories of water user;
- timing issues, requiring the discounting of future costs and benefits back to the present using an agreed discount rate (5 per cent real), to produce a net present value which can then be compared across different options; in addition a crucial timing consideration is the time at which a new water storage facility would be constructed;
- cost components, including construction costs, environmental costs and social costs, associated with each future water option; and
- the make-up of the do nothing options, including population growth, income growth, climate change, and demand management.

The outcome of the benefit cost analysis is to identify the option with the highest net present value (of benefits less costs).

Seven main costs of water restrictions have been identified:

- cost to households of dealing with restrictions;
- cost to business and industry of restrictions, including lost surpluses from plant based industries;
- cost of changed outside recreation options as a result of restrictions affecting parks and playing fields;
- cost of reduced outside tourism to the ACT resulting from restrictions affecting attractions such as Floriade, plus the impact on the urban environment such as street trees;
- cost of monitoring and enforcing restrictions;
- impact on ACTEW profits from reduced water sales; and
- impact on the ACT Government from reduced water extraction charge revenue while incurring fixed costs for water related activities.[92]

[91] Centre for International Economics (2005), *Economic benefit-cost analysis of new water supply options*, April 2005, ACTEW Corp Doc No. 4674.
[92] *Ibid*, p 6.

The starting point is two "do nothing" options, one based on medium population growth and one described as the prudent planning scenario. Under the medium growth scenario, Canberra's population would grow according to the medium projections of the ACT Demographer, demand management would result in a 12 per cent per capita reduction in water use by 2013, existing environmental flow assumptions apply and climate change is as predicted by CSIRO. Under the prudent planning scenario, population is assumed to grow according to the high projections by the ACT Demographer, while demand management would result in a 25 per cent per capita reduction in water use by 2025.

8.2 Costs to Households

Households are the main users of water in the ACT (see) and bear a significant proportion of the cost of water restrictions. Almost 90 per cent of ACT households have a garden, a figure that has not changed significantly over time.

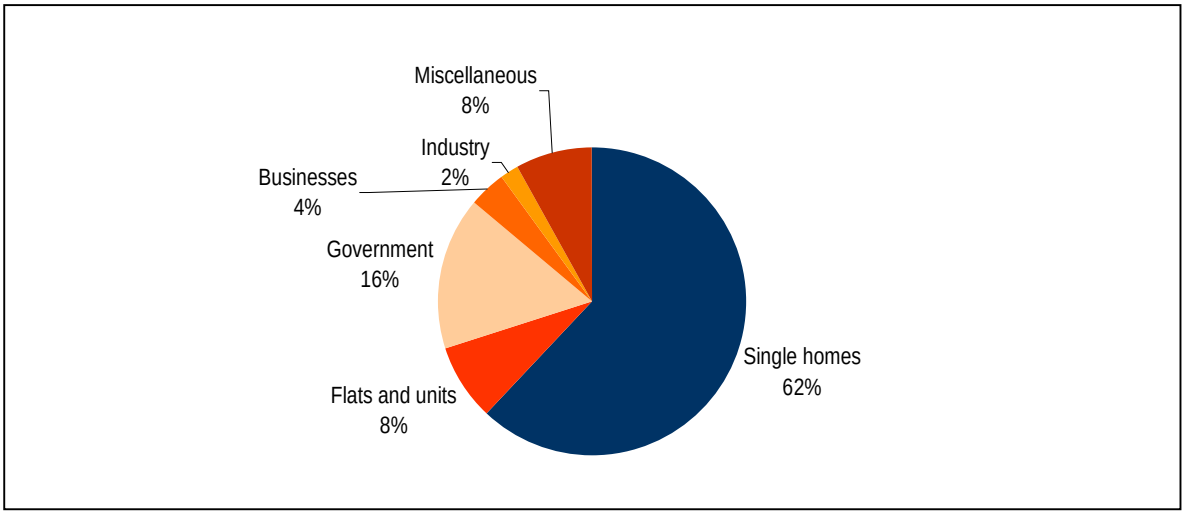


Figure 8.1: Water use in the ACT[93]

While, in theory, households could offset most of the impact of the way water restrictions are currently applied (eg by engaging sufficient numbers of "volunteers" to use many hoses), in practice restrictions limit water use and dictate behavioural change. Householders' costs of water restrictions include the inconvenience (and time taken) of hand-watering gardens, the cost of restoring gardens after restrictions have been lifted, and the cost of installing rainwater tanks or water efficient devices to "live with" restrictions. To estimate these costs, it is necessary to quantify householders' willingness to pay to obtain a reliable supply of water, free from restrictions on its use.

Household demand for water reflects several factors, not least its price. Some uses (for example, cooking and personal hygiene) are relatively insensitive to price (referred to as inelastic demand), whereas others (such as outdoor use) are more price sensitive (more demand elastic). The latter uses comprise around 55 per cent of total household water use, as shown in Figure 8.2.

Other factors relevant to household water demand include the number of people in the household, property size, weather conditions, existing appliances and investments (dishwashers, spas, swimming pools, lawns etc), the cost of changing over to appliances that use less water, the cost and availability of grey water recycling systems, and so on.

[93] Source: Centre for International Economics (2005), *Economic benefit-cost analysis of new water supply options*, April 2005, ACTEW Corp Doc No. 4674.

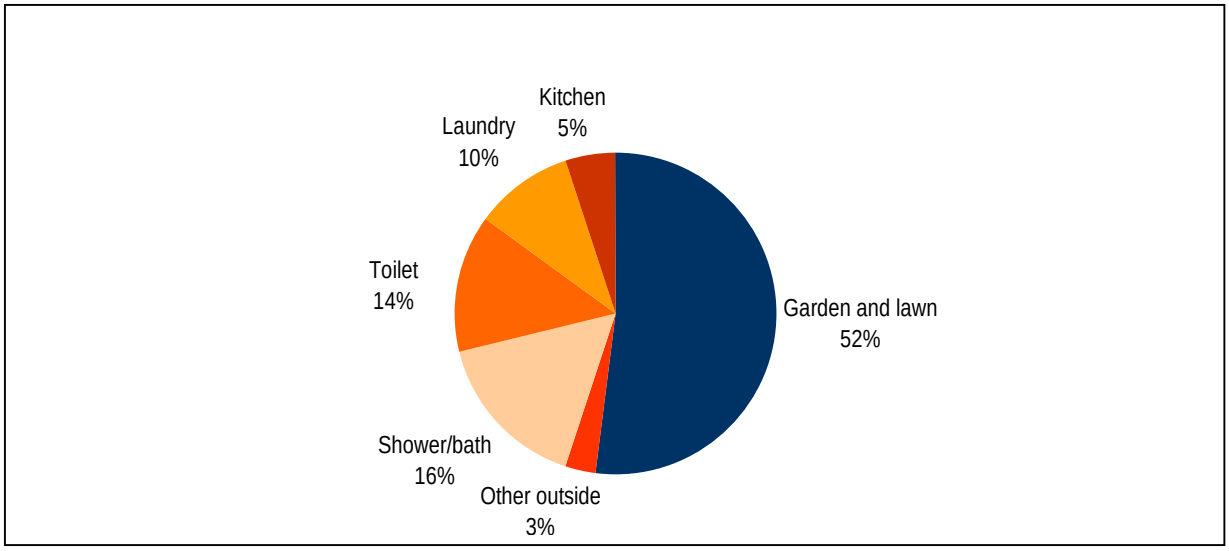


Figure 8.2: ACT Household Use of Water[94]

The ACT has employed a mix of price-based and quantity-based measures, along with community education programs, in an attempt to influence water demand. The Government provides subsidies for the installation of water saving appliances, and the basis of water pricing has been modified over time to reflect user pays principles more closely[95]. In addition, consumer preferences change over time, with factors such as an increase in higher density/apartment living, individual responses to the recent water restrictions (such as replacing exotic garden plants with natives), and the wider availability of water saving technology, being examples.

The CIE report discussed an earlier study undertaken for ACTEW Corporation and ActewAGL by NERA and ACNielsen that examined households' willingness to pay for reliability of water supply.[96] While the study was not specifically targeted at future water supply options, and was conducted before participants had had extensive experience in dealing with water restrictions – after which arguably their willingness to pay for water reliability and avoid the inconvenience of restrictions may well have increased further – it provides useful information about the costs that restrictions impose on households. A total of 211 Canberra households participated in the survey, conducted in March 2003, that is, just after the January 2003 bushfires. At this time stage 1 restrictions (sprinklers to be used only between 6pm and 8am) were in place.

The results indicated that:

- respondents were only willing to pay to avoid restrictions that were stage 3 or above, that lasted all year and that applied every day;
- on average, households were willing to pay $237 (31 per cent of the average water and sewerage bill) to reduce the frequency of these restrictions from every year to never; and
- respondents were not willing to pay to avoid brown lawns in public areas.

[94] Source: Centre for International Economics (2005), *Economic benefit-cost analysis of new water supply options*, April 2005, ACTEW Corp Doc No. 4674.
[95] Prior to 1991-92 households had a "free" allowance of 455kl and were charged for water use above this; between 1991-92 and 1993-94 the free allowance was 350kl. Since 1994-95, the free allowance has been 1kl, with usage up to 350kl being charged at 28c per kl, and 64c per kl above it. An assessment showed that many households, especially among middle-class households in older established suburbs, reduced water usage (there were no restrictions operating at the time) from 350kl to 300kl. See Centre for International Economics (2005), *Economic benefit-cost analysis of new water supply options*, April 2005, ACTEW Corp Doc No. 4674.
[96] NERA and ACNielson Research (2003), *Willingness to Pay Research Study,* a report for ACTEW Corporation and ActewAGL, September 2003.

The CIE study also noted the results of the community consultation meetings, conducted as part of the Future Water Options project, in which participants were asked explicitly how much they would be prepared to pay to reduce the frequency of water restrictions. Twenty-eight per cent said nothing, and that they were happy with restrictions one year in six; 28 per cent said $40 per year to reduce the frequency from one year in six to one year in 12; 23 per cent said $80 per year to reduce the frequency from one year in six to one year in 25, and 21 per cent said $150 per cent to reduce the frequency from one year in six to one year in 70.

These answers are equivalent to saying the cost of restrictions is $480 (for the $40 willingness to pay group), $632 (for the $80 willingness to pay group), and $984 (for the $150 willingness to pay group), or $486 on average per household (inclusive of the 28 per cent who were not willing to pay to have the frequency of restrictions lessened).

From this study and other data and analyses, CIE produced a range of estimates for household costs of water restrictions, reproduced in Table 8.1. These data are in turn used in the calculations reported below.

Table 8.1: Estimates of household cost of water restrictions (based on 2005 prices and incomes)

	Lower estimates	Higher estimates
Per household estimates	$	$
Stage 1	18	24
Stage 2	80	118
Stage 3	198	360
Stage 4	224	411
Stage 5	396	769
Average for stage 3 and above	273	513

Source: CIE estimates based on water use data, a range of elasticity estimates and NERA/AC Neilson

In aggregate household terms, the cost of stage 3 restrictions ranges between $20 and $36 million, rising to $40 - $77 million for stage 5 restrictions.

8.3 Other Costs of Restrictions

There are at least two effects of water restrictions on commercial and industrial activities in the ACT: the effects on businesses that use water themselves, and reduced sales by firms that sell products that require water for their ultimate use.[97]

As to the first category, the CIE's economy-wide model of the ACT/Queanbeyan region assessed the cost of stage 3 and above water restrictions per average commercial water user at $1560, a broadly similar figure to the NERA/AC Nielsen's willingness to pay estimate for commercial customers of $1104.

The second category includes nurseries and businesses selling lawn, and other water intensive products. The overall effect here is complex, both because demand for native or water hardy plants

[97] A possible third effect – reduced demand for goods and services because people are hand watering when they could be eating at restaurants, going to the movies etc – has not been taken into account in the CIE analysis. Tracing out the full effects of restrictions is complex, for example, the ACT economy may receive a boost to the extent that fewer residents choose to go to the coast at weekends because they are staying at home to keep their gardens alive. And so on.

may increase, and that consumers who do not spend money on these products will tend to spend similar amounts elsewhere, with similar overall output, employment and consumption effects. In the case of nurseries, the capital tied up in existing stocks of plants for which demand has declined cannot easily be transformed to other plants. In addition there is evidence of significant sales declines by nurseries due to the existing stage 3 restrictions. Taking these factors into account, the cost estimate of stage 3 restrictions on nursery businesses was put at $2.9 million, rising to $8.6 million for stage 5 restrictions.[98]

The cost of water restrictions on recreation activities was estimated by noting that ACT residents spend around 164 hours per year on outdoor recreation, an implicit value of around $1600. Assuming that 15 per cent of this time needs to be reallocated under stage 3 restrictions, and adding a cost to restore the recreation activities after restrictions have been lifted, produces a total cost estimate of $8 million for stage 3 restrictions, rising to $21 million for stage 5 restrictions.

The impact of water restrictions on tourism in the ACT is difficult to determine, although tourism is a major activity, contributing about $690 million to the ACT's gross state product each year. The CIE's assumption is that stage 5 water restrictions would reduce tourism by 10 per cent, relative to what it otherwise would be, implying a $31 million reduction in real household welfare, using the economy-wide model.

There is anecdotal evidence that some of the existing decline in tourism numbers to the ACT is in response to the combined impact of drought and water restrictions. However, there is no hard quantitative evidence to support this and CIE has not factored it into its calculations.

As noted in section 7.5, the benefits of Canberra's "garden city" status, especially the impacts of street trees and other trees in the urban environment, are significant. Canberra Urban Parks and Places has estimated that around half of the 6000 street trees lost as a result of the drought, could have been saved in the absence of water restrictions.[99] Attributing a conservative value of $1000 for each tree, including the cost of its removal, the cost of stage 3 restrictions on street trees is $3 million.[100]

The imposition of water restrictions imposes a range of transactions costs, such as advertising material to inform the community, monitoring compliance with restrictions, and prosecuting breaches. These costs have been estimated at $1.8 million for stage 3 restrictions.

Stage 3 restrictions have been estimated to reduce ACTEW's profits by $3.8 million, rising to $8.4 million at stage 5, and the ACT Government will experience an additional revenue loss of $1.3 million at stage 3, rising to $2.9 million at stage 5.

8.4 Overall Costs

The total costs of restrictions for stages 3 and 5, drawing together the material from the previous two sections, and assuming one year in restrictions at the stage indicated, are as shown in Table 8.2. The estimates for 2055 are based on assumed population and income growth, expressed in today's dollar terms.

[98] These estimates drew in part on confidential sales data from a number of representative nurseries.
[99] This section has been assisted by discussions with staff of Canberra Urban Parks and Places, part of the Department of Urban Services.
[100] There is an established methodology that values such specimen trees, with outstanding examples being attributed a value of up to $100,000 each in some circumstances.

Table 8.2: Total costs of spending one year in restrictions ($ million)

Category of cost	Stage 3	Stage 5
Household (upper estimate)	36.2	76.7
Commercial	6.3	13.1
Recreation	8.0	20.8
Tourism/street trees	3.0	37.0
Transactions costs	1.8	3.6
ACTEW profits	3.8	8.4
ACT Government	1.3	2.9
Total	60.3	162.8
Projected to 2055 (2005 $s)	157.6	428.9
Source: CIE analysis.		

Under either of the do nothing options, the probability of water restrictions increases over time in line with population growth and water demand, net of demand management efficiencies. With the medium growth scenario, the expected time in restrictions rises from 26 per cent now, to 54 per cent by 2055, with around 15 per cent of the time being in stage 3 restrictions or above, as shown in Figure 8.3. Under the prudent planning scenario, the proportion of time in restrictions hits 100 percent by 2043; by 2055 the probability of stage 3 restrictions or above is 50 per cent, as shown in Figure 8.4.

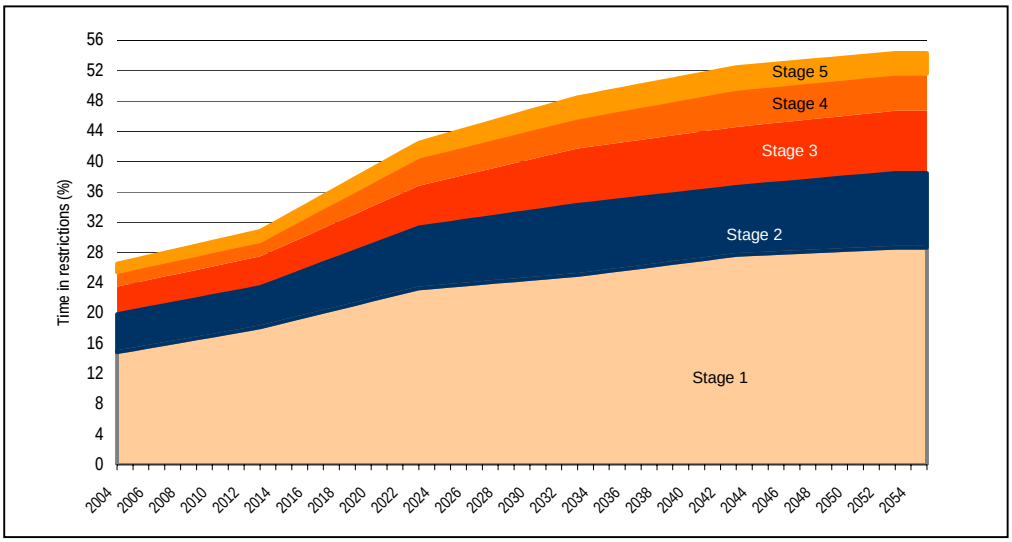


Figure 8.3: Cumulative time in restrictions (medium growth scenario)

In order to estimate the costs of restrictions in the do nothing options, the cost data associated with restrictions need to be multiplied by the expected time in restrictions. This is shown in Figure 8.5 for the medium growth option and Figure 8.6 for the prudent planning option.

In the medium growth scenario, the total expected cost of restrictions increases from $7 million in 2005 to $42 million by 2055, with most arising because of stagee 3 or above restrictions. In line with the much higher expected time in restrictions associated with the prudent planning scenario, the expected costs are also much higher, rising to $170 million by 2055, with the bulk being associated with stage 4 or 5 water restrictions.

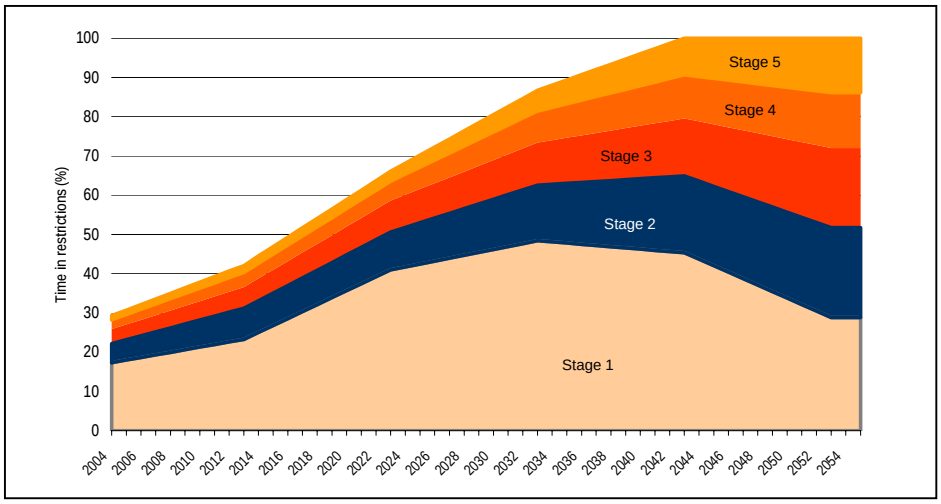


Figure 8.4: Cumulative time in restrictions (prudent planning scenario)

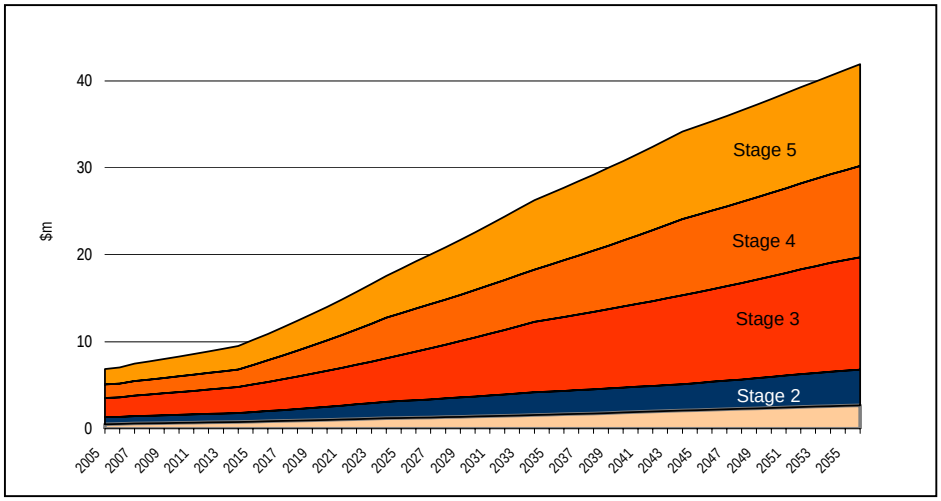


Figure 8.5: Expected cost of restrictions, medium growth scenario

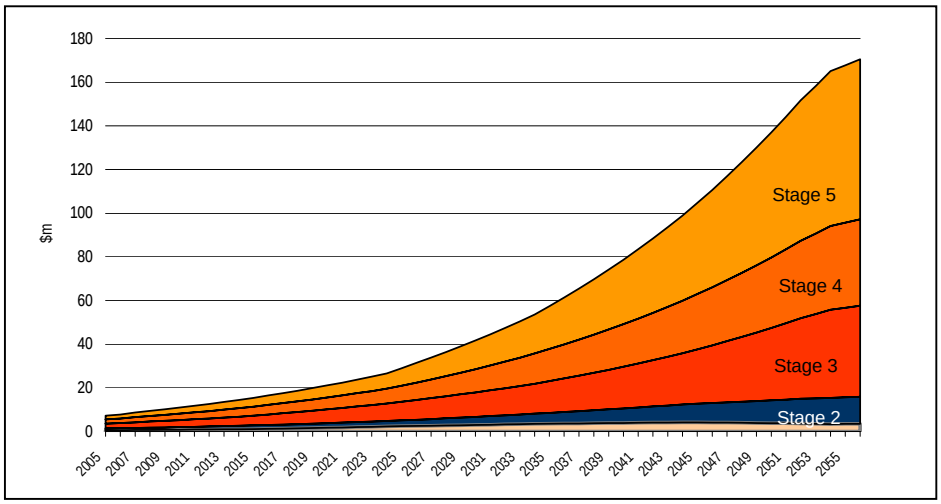


Figure 8.6: Expected cost of restrictions, prudent planning scenario

8.5 Implications for Tennent Alternatives

The performance of each water supply option can be measured by the extent to which it decreases the expected time at each stage of restrictions relative to the do nothing options. In other words, the "benefits" of each option is equivalent to the reduction of costs as discussed in previous sections.

As far as the Tennent alternatives are concerned, CIE modeled six configurations: 43 GL Tennent Dam on its own, 159 GL Tennent Dam on its own, the virtual Tennent option on its own, the virtual Tennent plus Cotter dam, the virtual Tennent plus small Tennent dam and the large Tennent plus Cotter dam. Other alternatives not involving Tennent were also modeled. The results relating to the Tennent alternatives are in Table 8.3 which shows the percentage point reduction of expected time in restrictions, at the stages specified, and for the years out to 2050. CIE modelling included both a "prudent planning" scenario and a "medium growth" scenario. Only the "prudent planning" scenario results are included in Table 8.3 for simplicity.[101]

Table 8.3: Performance of Tennent alternatives, relative to do nothing options (percentage point reduction of expected time in restrictions)

Alternative	Level of restrictions	2010	2020	2030	2040	2050
Tennent 43GL	All levels	20	35	39	11	0
	Stage 3 & above	6	10	14	18	19
Tennent 159GL	All levels	31	50	62	63	50
	Stage 3 & above	8	12	18	25	34
Virtual Tennent	All levels	18	34	38	11	0
	Stage 3 & above	6	9	13	14	13
Virtual Tennent + Cotter	All levels	32	52	65	67	56
	Stage 3 & above	8	13	18	26	35
Virtual + Small Tennent	All levels	20	34	38	11	0
	Stage 3 & above	6	9	13	18	22
Large Tennent + Cotter	All levels	35	55	72	78	71
	Stage 3 & above	9	13	20	28	38

Source: CIE analysis

The costs associated with the Tennent alternatives are shown in Table 8.4. Thus for the small 43 GL dam alone, there is the capital cost ($185 million – see Chapter 5), an allowance for environmental management ($4 million) and annual operational (including energy) costs ($2.8 million). These costs are then brought back to a net present value (using a 5 per cent real discount rate), resulting in $209 million.[102] The equivalent figure for the large Tennent plus Cotter dam alternative is $396M.

[101] Centre for International Economics (2005), *Economic benefit-cost analysis of new water supply options*, April 2005, ACTEW Corp Doc No. 4674.
[102] Assuming capital costs are incurred in 2007 and 2008, environmental costs are incurred over the four years 2007 – 2010 and operational costs commence in 2010.

Table 8.4: Costs of Tennent alternatives ($m)

Option	Capex	Environmental Managementt	Annual costs	Present Value of costs (in 2005)
Tennent 43GL	185	4	2.8	209
Tennent 159GL	250	3	3.2	270
Virtual Tennent	40	2	2.1	65
Virtual Tennent + Cotter	160	7	3.5	192
Virtual + Small Tennent	225	5	4.9	274
Large Tennent + Cotter	370	8	4.6	396

The CIE report then calculates the net benefits associated with each of the alternatives analysed. The data assume the "best" timing to build the various dams, noting that delaying construction until demand warrants it provides a better outcome because of the way the discounting (net present value) arithmetic operates on up front capital costs versus delayed benefits from reduced time in restrictions. The results for the Tennent alternatives are shown in the table below.

Table 8.5: Net benefits associated with Tennent and other alternatives, prudent planning scenario ($m)

	Option	Net benefits	Ranking
Tennent Alternatives	Tennent 43GL	129	5
	Tennent 159GL	214	3B
	Virtual Tennent	217	3A
	Virtual Tennent + Cotter	290	1
	Virtual + Small Tennent	88	6
	Large Tennent + Cotter	168	4
Other alternatives	Tantangara tunnel	286	2
	Tantangara down river	200	3D
	Cotter 78GL	205	3C

Cotter plus virtual Tennent is the preferred option under the prudent planning baseline, it comes second under the medium growth baseline discussed in the CIE report but it remains the preferred option under a combined baseline. The large Tennent dam by itself ranks either fourth but is very similar to virtual Tennent , the Cotter dam by itself and the Tantangara river alternatives. The small Tennent dam, either alone or combined with the virtual Tennent, ranks poorly.

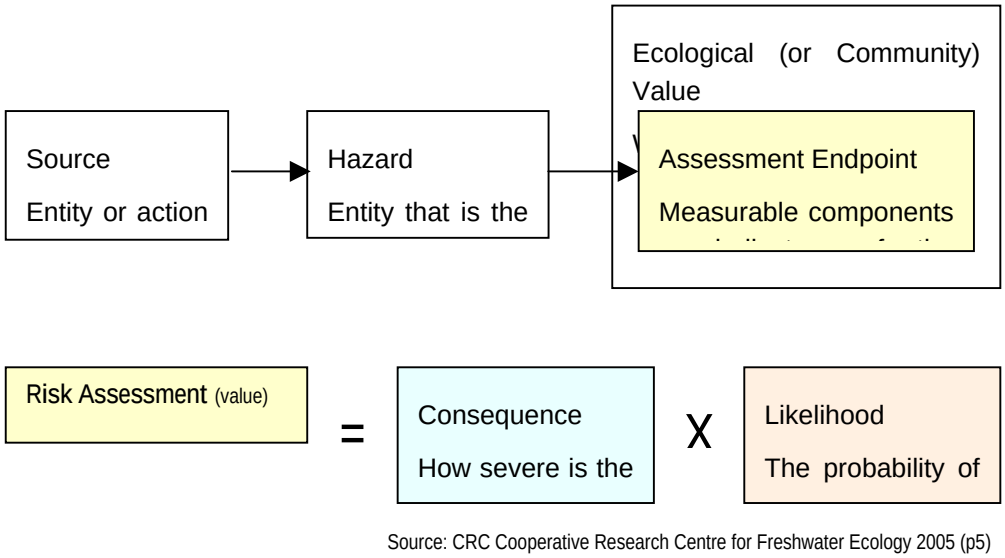
Various sensitivity tests – higher discount rate, lower/higher economic growth, and lower estimates of household costs of water restrictions – do not greatly change the ranking of options. Cotter plus virtual Tennent is ranked first or second in all cases (virtual Tennent alone ranks ahead of it in some circumstances). These results, discussed in more detail in the CIE report, indicate that the rankings are fairly robust against changes in key model assumptions.

Finally, the CIE report describes changes to the outcomes of the model when modified environmental flow assumptions are used. The values for net benefits decline somewhat in each case – because more water presently required for environmental flows would be available for potable water consumption, thus implying a reduced need for additional water storage – but the rankings remain largely unchanged. Virtual Tennent plus Cotter remains the preferred option.

9 Risk Assessment

The risk assessment process employed workshops to identify and measure of the degree of risk by multiplying the ***likelihood*** of an event occurring and the ***consequence*** of the event. The approach was adapted from the Australian Risk Management Guidelines (AS/NZS 4360) and the US Environment Protection Agency framework.

Despite its subjectivity, this approach provides reasonable risk analyses when experienced workshop participants provide knowledge on the risk events and their characteristics. Figure 8.1 below shows the approach.



Source: CRC Cooperative Research Centre for Freshwater Ecology 2005 (p5)

Figure 8.1 Risk Assessment Approach

9.1 Risk Assessment Results

The risk assessment process, when applied to the preferred Tennent alternatives identified potential risk sources should those alternatives be implemented. Those risk sources that pose the greatest level of risk for the Tennent options are listed below and discussed in more detail in the risk assessment report[103].

The major risk sources are:

Small Tennent Reservoir

very high risk that the reliability of supply would not be sufficient to avoid an occasional need for stage 4 or 5 restrictions and frequent need for stage 3 restrictions;

very high risk that a road through the catchment may impact water quality;

very high risk that recreational use of the reservoir foreshore could impact water quality; and

very high risk that delays during the approval process could lead to several more years with occasional need for stage 4 or 5 restrictions and frequent need for stage 3 restrictions.

[103] URS and ACTEW (2005), *Future Water Options Risk Assessment*, April 2005, ACTEW Corp Doc No. 4650.

Large Tennent Option

Extreme risk of over capitalisation and consequent investment redundancy;

Very high risk that a road through the catchment may impact water quality;

Very high risk that recreational use of the reservoir foreshore could impact water quality; and

Very high risk that delays during the approval process could lead to several more years with occasional need for stage 4 or 5 restrictions and frequent need for stage 3 restrictions.

Virtual Tennent Option (Angle Crossing to Googong via Burra Creek)

Extreme risk that that the reliability of supply would not be sufficient to avoid an occasional need for stage 4 or 5 restrictions and frequent need for stage 3 restrictions.

9.2 Control Measures

The risk that the reliability of supply provided by the small Tennent or virtual Tennent options would lead to an unacceptable amount of time in stage 3 restrictions or worse, can be mitigated by implementing either of these options in combination with other intermediate supply options.

The other major risks would require intensive planning and implementation of catchment management practices and development of a recreation management plan. Risks related to delays to approvals processes can be mitigated by ensuring that project management procedure recognises and addresses this issue.

With the implementation of adequate control measures the risks associated with any of the above alternatives are considered to be manageable and would not preclude a decision to proceed with the one of these alternatives, noting that selection of either the small dam or the virtual Tennent implies the concurrent selection of a second supply source.

10 Sustainability Assessment

10.1 Sustainability Framework

The concept of sustainability:

- recognises that effective environmental solutions must achieve a balance with economic and social issues;
- reflects ecologically sustainable development as defined in the *1992 National Strategy for Ecologically Sustainable* Development: "ecologically sustainable development is development which aims to meet the needs of Australians today, while conserving our ecosystems for the benefit of future generations"; and
- means maintaining or enhancing total resources without reducing any one type of natural, human, social, physical or financial capital below a point of irreversibility.

ACTEW's objectives now include ecologically sustainable development principles:

- the precautionary principle, whereby a lack of scientific certainty should not be used to postpone taking action to prevent environmental degradation;
- the inter-generational equity principle, whereby the present generation should ensure health diversity and productivity of the environment for the benefit of future generations;
- conservation of biological diversity and ecological integrity; and
- improved valuation and pricing of environmental resources.

10.1.1 Environmental, Social and Economic Parameters

Analyses conducted for the *Future Water Options Project* used "triple bottom line" or TBL (environmental, social and economic) assessments similar to those used by other water agencies in Australia and overseas.

The assessment criteria were developed from the eleven core sustainability dimensions set out by the ACT Office of Sustainability in the document: People Place Prosperity. From these, twelve sustainability criteria were developed with expert input, and in consultation with the community, for the evaluation of the future water options.

The 12 assessment criteria include 4 relating to each of environmental, social and economic factors, and are set out in Table 10.1. The assessment criteria are designed so that:

- there is equal consideration of economic, environmental and social factors;
- they represent the key issues involved in the comparison of Future Water Options as identified in public and agency consultation, can be measured for the different options, and cover the sustainability areas to ensure proper account is being taken of all factors to achieve objectives;
- they are able to show a difference for the various options;
- they do not overlap, in order to avoid the problems of double counting;
- they reflect local, regional, basin-wide, national and worldwide concerns and interests; and
- they provide a direct measure of inter-generational equity.

Table 10.1: Sustainability Criteria for Evaluation of Future Water Options

Criteria	Sector
Effect on aquatic ecology	Environment
Effect on terrestrial ecology	Environment
Greenhouse gas emissions	Environment
Intrinsic value	Environment
Risk to public health	Social
Heritage and cultural values	Social
Landscape and amenity values	Social
Recreational opportunities	Social
Cost and affordability	Economic
Reliability	Economic
Employment creation	Economic
Distribution of costs and benefits	Economic

An initial set of environmental, social and economic criteria for the sustainability assessment was developed in scoping workshops involving project team members, specialist consultants and representatives of government agencies. The draft criteria were refined after discussions with the ACT Office of Sustainability and the Sustainability Expert Reference Group. To add rigour, the refined list was evaluated by interested members of the community and community groups in four workshops held in November 2004. The Institute for Sustainable Futures then reviewed these criteria to include best practice examples from sources such as CSIRO and the Institute's own experience.

Finally, the project team refined the list to ensure it incorporated the criteria the community had ranked as most important and that they corresponded to ACTEW and ACT strategy and policy documents such as '*People, Place, Prosperity*', and the *ACT Water Strategy Think water act water*, to ensure alignment with Government sustainability goals.

10.1.2 Assessment Procedure

The procedure followed to assess the various options was as follows:

A summary of the key environmental, social and economic issues relating to the construction and operation of each of the six options being assessed was prepared by the environment manager, planning manager and an independent third party, summarising the findings of the specialist consultants.

A sheet was then prepared, summarising the key issues for each of the options, and with a column for scoring the option in the sustainability assessment workshops. The effects, levels or attributes of the options with respect to each criterion were described quantitatively.

At the workshops, the criteria were discussed sequentially, with the key information being read first, then questions from the participants of the appropriate specialist manager and then discussion in the workshop;

Workshop participants then scored each option for each criterion in turn, using an eleven point scale: - 5 (worst) to 0 (no change) to +5 (best).

After each of the three groups of four criteria (environmental, social or economic) had been scored, participants weighted the criteria (so that the sum of the weights for each group of criteria added to 30). The weighting is a judgment of 'how important each criteria is relative to the others';

The average score for each criterion and the average weighting were then calculated.

The average scores were multiplied by the average weightings to derive the normalised average score for each group of criteria, and the rank of the options calculated for each group of criteria (the option with the highest normalised average score was ranked first, and so on); and

The overall rank of the options was derived by calculating the normalised average score for all 12 criteria.

10.2 Results from Project Team Workshop

The first Sustainability Assessment Workshop involved the project team, as it was considered that members would have a good understanding of the characteristics and issues relating to the options and could provide comment on the documentation of issues as well as 'test run' the scoring and weighting procedure. There were 12 project team members present, and the workshop was run by an independent facilitator. The rankings for the three groups of criteria and the overall ranking for the options are shown in Table 10.2.

Table 3-2: Sustainability Ranking of Major Options by Project Team

Option	Overall ranking	Environment	Social	Economic
Large Cotter Dam	1	1	2	4
Tantangara – via river	2	3	1	3
Tantangara tunnel	3	5	3	1
Virtual Tennent Dam	4	2	4	2
Small Tennent Dam	5	4	5	5
Large Tennent Dam	6	6	6	6

The outcome was that the Cotter option was ranked best on the basis of least environmental impacts, and little social impact. These considerations outweighed the lower ranking of the Cotter option in terms of economic criteria.

10.3 Results from Community Perspective

The second Sustainability Assessment Workshop involved 12 community representatives, three from each of four groups (Conservation Council, Engineers Australia, commercial interests and 'concerned citizens'). These representatives had each attended a briefing on the project and the exhibition of the options, so were informed about the options and their implications. However, these persons should not necessarily be seen as representing the whole community.

The results were somewhat bi-polar, with half clearly favouring the large Tennent option and the other half clearly favouring the Tantangara via the river option. Nonetheless, the procedure of averaging scores and weights mutes these clear preferences, leading to the overall rankings as shown in Table 10.3.

Table 10.3: Sustainability Ranking of Options by Community Representatives

Option	Overall ranking	Environment	Social	Economic
Large Cotter Dam	1	1	3	4
Large Tennent Dam	2	4	1	1
Small Tennent Dam	3	5	2	3
Tantangara – via river	4	2	5	6
Tantangara tunnel	5	6	4	5
Virtual Tennent Dam	6	3	6	2

The outcome was that the Cotter option was ranked best on the basis of least environmental impacts, and this outweighed the lower social and economic rankings for this option. The Tennent options also were ranked highly, and the high volume of water available from these options was seen by most participants to have major social and economic value. The perception of the social value reflected a view about the importance of water in the urban environment that was considered by some participants to offset concerns about the effects on existing leaseholders in the Gudgenby/Naas valley. On the other hand, most participants saw the Tennent options as having greater environmental effects than the other options.

The Tantangara options ranked poorly (despite recognition of the environmental benefits of releasing water to flow down the Murrumbidgee River). This was also found to be the case in the public exhibition of options, where ACT residents were very uneasy about relying on NSW for the long term supply of water, while NSW residents wanted the ACT to 'leave NSW water alone' or in any event to use only ACT water resources.

10.4 Agency Perspectives

The third Sustainability Assessment Workshop involved mostly representatives of ACT government agencies, as it was considered that they also would have a good understanding of the characteristics and issues relating to the options. There was extensive discussion on the merits of the various options in this workshop, and additional presentations were given by the environment manager and the planning manager to clarify some issues. The rankings for the three groups of criteria and the overall ranking for the options are shown in Table 10.4.

Table 10.4: Sustainability Ranking of Options by ACT Agency Representatives

Option	Overall ranking	Environment	Social	Economic
Large Tennent Dam	1	1	1	1
Large Cotter Dam	2	2	2	2
Small Tennent Dam	3	3	4	3
Tantangara tunnel	4	6	3	4
Tantangara – via river	5	4	5	6
Virtual Tennent Dam	6	5	6	5

The outcome was that the large Tennent option was ranked best. The Cotter option was also well regarded. Most participants saw the Tantangara options as having a lower benefit than additional storage of water in the ACT.

10.5 Overall Assessment

The preferences and rankings developed in the sustainability workshops reflect the views of a small number of participants of generally informed people. The community has not been surveyed as a whole for the TBL assessment and it would, of course, be impossible to obtain a single answer that represents the views of "the community".

Nonetheless, the results of the sustainability assessment at the three workshops showed that there is a range of views as to the best option. No single option was favoured in all workshops although, overall, there was a slight preference for the Cotter option. The Tennent options ranked highly in one workshop and poorly in another. Similarly, the Tantangara options ranked highly in one workshop and poorly in others.

With regard to the Tennent alternatives that are the subject of this report – the small and large Tennent dams and the virtual Tennent – the findings of the sustainability assessment are also ambiguous. Table 10.5 summarises the position:

Table 10.5: Summary of Tennent Alternatives Sustainability Rankings

Tennent Alternative	Overall Sustainability Ranking (out of 6 alternatives) by:		
	New Water Options Project Team	Community Representatives	ACT Government Agency Representatives
Large Tennent dam	6	2	1
Small Tennent dam	5	3	3
Virtual Tennent	4	6	6
Data from Tables 10.2-4 above			

This data in itself does not provide a sound basis for a decision between these alternatives. It is clear that some sectors of the community place a greater weighting on dollar costs and other sectors on environmental and social impacts. A consistent theme is the need for a reliable water supply. In this context it is apparent that all three alternatives should be carried forward for consideration either a stand-alone solutions or in combination with alternatives discussed under the Cotter and Tantangara option investigations.

11 Abbreviations

°C	degress Celsius
µg/L	Microgram per liter (equivalent to parts per billion (ppb) or one millionth of a gram per litre)
ACT	Australian Captial Territory
CFU	colony forming units
CRC	Cooperative Research Centre
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DA	Development Application
EIS	Environmental Impact Statement
EMA	Environment Management Authority
EPBC	Environment Protection and Biodiversity Conservation
GL	Gigalitres (1 gigalitre = 1 000 000 000 litres)
GL/yr	Gigalitres per year
ha	hectares (equals 10,000 square meters)
ICRC	Independent Competition and Regulatory Commission
km	kilometres
km2	square kilometres (equal to one million square meters (m2), 100 hectares (ha))
kW	kilowatts (1,000 watts)
kWh	kilowatt hours (1,000 watts for one hour)
m	metres
m3	cubic metres
mg/L	milligrams per litre
ML	Megalitres (1 megalitre = 1 000 000 litres)
mL	millilitre
ML/day	Megalitres per day
mm	millimetres
Mt	Mount
NCA	National Capital Authority
NCP	National Capital Plan
NSW	New South Wales
NTU	Nephelometric Turbidity Units
Pt-Co	platinum-cobalt units
WTP	Water Treatment Plant

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