Water Security for the ACT and Region

Recommendations to ACT Government

July 2007

ACTEW CORPORATION

WATER security program
safe • secure • sustainable

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ACTEW CORPORATION

Mr Jon Stanhope MLA
Chief Minister
ACT Legislative Assembly
London Circuit
CANBERRA ACT 2601

Ms Katy Gallagher MLA
Deputy Chief Minister
ACT Legislative Assembly
London Circuit
CANBERRA ACT 2601

Dear Chief Minister

Dear Deputy Chief Minister

It is with pleasure that I submit to you ACTEW's recommendations to further secure the ACT and the region's water supply. This report is based on extensive analysis including the significant amount of work completed by ACTEW in 2004 and 2005 as well as extensive updates and additional work completed over the past few months. More than 30 reports support the recommendations contained in this report and will be made available to the public via the ACTEW website and in hard copy.

In our reports to you on *Future Water Options* in 2004 and in 2005, ACTEW made a number of recommendations which were explicitly based on six key assumptions. As we said at that time, we would need to monitor those assumptions to see if there was any significant change and if there was, we would return to you with further recommendations.

As you know, there has been a major change in relation to the key assumption which related to climate change and climate variability. In our earlier reports, based on our most pessimistic approach to the analysis by the CSIRO of the impact of climate change and climate variability, we assumed a 30% reduction in long term average inflows into our dams. In fact, over the period 2001 to 2006, there has been a decline in long term average inflows of 63%, and in 2006, a decline of nearly 90%.

Recent inflows into our storages, while very welcome, do not necessarily mean an end to our difficult situation. Nor should they be seen as in any way justifying any delays to the recommendations in this Report. Our storages have recovered somewhat but they now stand only at 41%, which is the lowest July level during the whole period from 2001 until now. It is true that forecasts are for good rain over coming months, but our experience over the last six years has been that such forecasts are frequently unrealised. In fact, so far in July rainfall has been less than half the average rainfall. In 2006, our storages fell from 51% (10% above the current level) to 39% by the end of the year. If we experienced the same in the second half of this year, we could have less than 30% in our dams and be in Stage 4 Water Restrictions by the end of 2007.

ACTEW Corporation Ltd.
ActewAGL House
Level 9, 221 London Circuit
GPO Box 366 Canberra ACT 2601

Tel. (02) 6248 3111
Fax. (02) 6248 3567

ABN 86 069 381 960

The medium and long term outlook beyond the next few years is what we need to look to and what these recommendations address. The medium and long term outlook is for a significant further deterioration in our long term average inflows from a 30% reduction to almost a 50% reduction. Of greater concern is that the expert advice to us is that we should be prepared for more frequent drought periods that are likely to be longer and drier than we have experienced since 2001.

This leads to the central point of this Report. The key challenge for the medium and long term is to build additional water supply assets that can cope not just with very much reduced long term average inflows into our dams, but with more frequent droughts which are longer and drier than that of 2001-2006, without having to go into high level water restrictions for extended periods.

If we are to have the capability to deal with these longer, drier and more frequent droughts we must have future supply capacity that will be additional to that which we need in years of average or higher than average inflow. The financial cost of this extra capacity is not wasted or premature investment but is essential and justified on the grounds of ensuring water security during these more frequent and more serious drought periods.

We are not alone in taking this cautious approach. Other States are similarly working on the basis that in future water plans must be based on being able to deal with periods of reduced inflows at least as bad as, and more likely worse than, 2001 to 2006. The reason they are taking such an approach is that when it comes to basic services such as energy, and even more in the case of water, it is less costly to take the risk of investing in extra capacity than to take the risk of under-investing and being short of capacity.

Thus we recommend a series of new investments. First, we propose to immediately increase the storage capacity of Cotter Dam to 78 gigalitres. Second in addition to extracting more water from the Murrumbidgee River at the Cotter Pump Station, we recommend we consider doing so from Angle Crossing as well.

In addition to these two recommendations, we believe we must have a new source of water that is largely independent of rainfall in our existing catchments. Therefore we recommend we proceed with either the Tantangera water transfer proposal or to build a water purification plant (either large or small). We need to do more analysis and planning before we can decide between these options and we will advise you in the New Year on which should be implemented in the light of developments. But we believe we should do one of them.

Decisions on prices lie with the Independent Competition and Regulatory Commission. But based on experience, we expect that to enlarge Cotter Dam will add about $70 a year to the water bills of an average ACT household. Adding further pumping from the Murrumbidgee at Angle Crossing will mean about a further $30 a year per household. The next supply option is either the Tantangera transfer, which would add about $50 a year, or the water purification plant, the larger of which would add around about $180 a year, and the smaller, around $100.

So the likely approximate outcome of these recommendations, if all were implemented, is to add somewhere between $150 and $280 a year to the average household bill i.e. about $3 to $5.40 a week.

The decision on these matters, is of course, one for the ACT Government which must balance a range of factors beyond those for which ACTEW has responsibility. From ACTEW's point of view, however, it is necessary to implement all these recommendations as soon as possible if we are to be confident that we will be able to provide water as required into the future without the real risk of prolonged, severe water restrictions, which impose significant economic and social costs on the community and on business. Our strong view is that while we can hope for the best, we must prepare for the worst.

The analysis we have undertaken of the potential of climate change and climate variability based on the work of the CSIRO and other experts may well have implications extending beyond the future of our water supply to encompass other aspects of the ACT's infrastructure, such as the ACT's storm water system. ACTEW would be happy to contribute to any work the ACT Government might decide to undertake on such matters.

ACTEW is of course available to you and your officers if you wish to discuss any of these options.

Yours sincerely

Michael Costello
Managing Director

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The purpose of this report is to review the existing water resources and recommend options to further secure the water supply for the ACT region.

Executive Summary

The key challenge for the medium and long term is to build additional water supply assets that can cope not just with very much reduced long term average inflow into the dams, but with more frequent droughts which are longer and drier than that of 2001-2006, without having to impose high level water restrictions for extended periods.

To have the capability to deal with these longer, drier and more frequent droughts there is a need for future supply capacity that will be additional to that which is needed in years of average of higher than average inflow. The financial cost of this extra capacity is not wasted or premature investment but is essential and justified on the grounds of ensuring water security during these more frequent and more serious drought periods.

The present and immediate future

In 2004/2005 ACTEW presented two reports to the ACT Government outlining options for the future supply of water to the ACT and the surrounding region.

During and since that period, ACTEW, has implemented a series of measures that have provided water to the ACT additional to that which would previously have been available. In particular, ACTEW has undertaken:

- *the building of the Mount Stromlo Water Treatment Plant and the restoration of the Cotter Pump Station which has allowed the use of the Lower Cotter Dam for the first time in decades. This has made available an extra 11 GL (gigalitres) (5% of storage capacity) of water to Canberra's water supply over the last two years. Without this extra water, Canberra water restrictions would have been more severe and prolonged and would have required the introduction of Stage 4 Water Restrictions;*
- *augmentation of the Googong Water Treatment Plant has increased capacity from 180ML/day to 270ML/day thus ensuring that water can be supplied to all of Canberra and Queanbeyan from this source alone;*
- *building of new pumps and pipework has enabled the transfer of excess water from the Cotter River storages to the Googong Reservoir via the Mount Stromlo Water Treatment Plant and the existing water reticulation system when operations and water demand permit (12 GL per year has been transferred);*
- *building a new pumping station at Lower Cotter has enabled the extraction of water from the Murrumbidgee River. This is providing water directly into the water supply via Mount Stromlo Water Treatment Plant and allows the transfer of water from the Murrumbidgee River to the Googong Reservoir via the reticulation system when capacity permits; and*
- *in response to the drought, actions at an estimated cost of around $9.5M, will further enhance the extraction of water from the Murrumbidgee River at the Lower Cotter and will improve the use of recycled water, including:*

- *building a rock weir and additional pipework on the Murrumbidgee River;*
- *improving pump capacity in the Murrumbidgee River;*
- *recommissioning the fifth and sixth pumps at Cotter Pump Station;*
- *increasing the capacity of the Lower Molonglo Water Quality Control Centre recycled water pipeline; and*
- *optimising the North Canberra Water Recycling Scheme.*

If the disastrous conditions of the last six years, especially 2006, were to reoccur after the welcome relief from recent good inflows, there is an emergency plan which is designed to cope with any serious water shortage problems that might emerge over the next two to three years while ACTEW brings on new capacity. This emergency plan has been brought together by the Commonwealth Government and the affected States and Territories. Under this plan, priority will be given to the towns and cities of the Murray Darling Basin over the requirements of irrigation users to draw on reserves of water in the dams of the Snowy Mountains Scheme. In the case of Canberra, this would involve the release of water from Tantangara Dam down the Murrumbidgee River to the Cotter Pump Station, from which it could be pumped in the normal way to the Mount Stromlo Water Treatment Plant.

Before the ACT could get access to such water, the ACT storages would need to be at very low levels requiring stringent Stage 4 Water Restrictions. Encouragingly, however, the heavy snowfalls in the mountains in 2007 mean that water inflows into the Snowy reservoirs later this year will be strong, unlike 2006, and should provide adequate emergency supplies if they were needed in the course of the next few years.

The key challenge for the medium and long term future

Based on the same cautious approach that ACTEW has previously taken to the analysis conducted by CSIRO, but adjusted now for the new data from the last three years, average annual inflows are estimated to be around 105 GL a year to the three main dams. This is a dramatic reduction from average inflows in the past (around 200 GL a year) and a further reduction from the average annual inflows that was assumed based on CSIRO research from the 2005 report (132 GL a year).

The ACT currently needs to abstract 65 to 70 GL a year to meet customer's demand. After taking into account the 30 GL or so normally lost through evaporation, low environmental flows (during drought years) and spills after major storm events this means that about 100 GL must flow into the storages every year.

Therefore, water supply planning should not be based on long term average inflows of 105 GL being available each year. This is because both the CSIRO analysis and the modelling supporting this report show that within that average, there will be droughts both longer and drier than the 2001-2006 drought when flows declined to an average of 71 GL a year and in 2006 to 26 GL. Such droughts are expected to occur with significantly greater frequency than in the past.

Thus the key challenge for the medium and long term is to build additional water supply assets that can cope not just with very much reduced long term average inflow into the dams, but with more frequent droughts which are longer and drier than that of 2001-2006, without having to impose high level water restrictions for extended periods.

To have the capability to deal with these longer, drier and more frequent droughts there is a need for future supply capacity that will be additional to that which is needed in

years of average of higher than average inflow. The financial cost of this extra capacity is not wasted or premature investment but is essential and justified on the grounds of ensuring water security during these more frequent and more serious drought periods.

Criteria for new water supply assets

Choosing new water supply assets to meet this challenge is guided by several criteria:

1. *maximising the use of existing infrastructure, both ACTEW's and others;*
2. *increasing the diversity of sources of water;*
3. *ensuring the availability of one source of water which is not dependent on rainfall in ACTEW's water supply catchments;*
4. *maximising operational flexibility to provide backup capabilities in the event any part of the system is out of operation for whatever reason;*
5. *providing a net economic benefit to the community (this is defined as the gross community benefit expected from any reduced probability of drought restrictions, less the capital and operating costs of implementing that option); and*
6. *optimising outcomes from capital and operational costs and minimising the consequent flow-on cost to consumers.*

Assumptions

The work supporting this report is based upon the six assumptions that underpinned the Future Water Options reports of 2004/2005. These assumptions are that;

- *the Government's water conservation targets will be met;*
- *environmental flows will be delivered according to ACT Government guidelines;*
- *catchment re-growth will respond to bushfires;*
- *the population will continue to grow according to the ACT Government's Spatial Plan;*
- *ACTEW will meet its service obligations to customers; and*
- *projections of climate change and climate variability will occur in line with predictions.*

Five of these assumptions are still valid but the climate change and climate variability assumption has been adjusted based upon the last few years of inflows into storages.

Options

Ten individual supply options have been examined in detail. They include:

- *an enlarged Cotter Dam;*
- *large Tennent Dam;*
- *small Tennent Dam;*
- *increased pumping from the Murrumbidgee River;*

- *water releases from Snowy Hydro's Tantangara Dam;*
- *25 ML/day water purification plant;*
- *50 ML/day water purification plant;*
- *75ML/day water purification plant;*
- *extended non-potable reuse for irrigation purposes; and*
- *bringing forward the Government's Think water, act water per capita water reduction target to 2011.*

ACTEW has examined these options individually and in varying combinations to see which best meets the key challenge.

The proposal for an enlarged Cotter Dam provides the greatest net economic benefit to the community, delivering similar amounts of water to a large Tennent Dam at half the capital cost, at lower risk and bought into operation more quickly. It will make use of existing infrastructure via the pump station at Lower Cotter and the Mount Stromlo Water Treatment Plant. It will draw water from the catchment which is much more reliable in times of drought than the Tennent catchment or for that matter the Googong catchment. It will prevent a large part of potential losses from the environmental flows that cascade down from the current Corin and Bendora dams to the existing small Cotter Dam, and will catch much of the overflow from storm events that the current dams in the Cotter system cannot handle.

The ability to extract more water from the Murrumbidgee River by increasing the amount currently pumped to the Mount Stromlo Water Treatment Plant and/or by pumping from Angle Crossing to the Googong Reservoir would provide additional supply. The Angle Crossing option is particularly attractive because it provides additional supply into Googong Reservoir, which had little or no inflow from 2001 to 2006 and this option does so without requiring water treatment or the risk of operational constraints at the Mount Stromlo Water Treatment Plant. Thus, Angle Crossing provides greater operational flexibility in extracting water from the Murrumbidgee River, it is cheaper than many alternatives and avoids the risk of putting too much reliance on the capacities and operations of the Mount Stromlo Water Treatment Plant.

Which particular Murrumbidgee option is more desirable will depend on further examination of costs but it is highly likely that a combination of the two will be desirable and indeed, necessary.

The combination of an enlarged Cotter Dam and significant increased capacity to take or store water from the Murrumbidgee River will provide assurance in most circumstances of water security long into the future. The average annual household water bill, (based on 250 kilolitres a year) is expected to rise by about around $70 a year for an enlarged Cotter Dam, and by a further $30 a year to extract more water from the Murrumbidgee River at Angle Crossing.

These river based options (and the Tennent Dam option) would however rely entirely on rainfall occurring in the water supply catchments. In prolonged and severe droughts of the kind that now need to be accommodated as a more frequent occurrence in the future, the river options above may not suffice.

There are three options which would provide substantial quantities of water in such circumstances of severe drought:

1. *a desalination plant on the south coast, the cost of which is so high that it is out of contemplation unless the inflows of 2006 (26 GL) were to become the norm.*

2. *water releases from Snowy Hydro's Tantangara Dam which will essentially obtain water from outside the existing ACT catchments and be more reliable than the Tennent Dam. It also provides access to storage of even larger size than Tennent Dam.*
3. *a Water Purification Plant drawing on water from the Lower Molonglo Water Quality Control Centre (LMWQCC).*

ACTEW has also reviewed the option to build the Tennent Dam and is not recommending it at this stage, for the following reasons:

- *Tennent Dam catchment inflows are significantly less reliable than the Cotter and have been impacted substantially more than both the Cotter and Tantangara flows over the last 6 years. From 2001 to 2006, Tennent inflows reduced by 70% compared to a 40% reduction for Cotter and 35% for Tantangara catchments;*
- *a large Tennent Dam (around $300 million) is a more costly option than the enlarged Cotter Dam (around $145 million) but despite its greater storage capacity provides about the same yield;*
- *there are significant issues surrounding the dam's impacts on relocating existing rural lessees, woodlands and threatened bird species and heritage sites; and*
- *it will take longer to build and fill..*

The Tennent Dam site should be retained for future potential use.

<u>The proposal for the Water Purification Scheme</u> entails pumping water from the LMWQCC to a Water Purification Plant. Purified water produced by the plant will be pumped to the Cotter Dam and blends with catchment runoff. From the Cotter Dam the blended water will be pumped to the Mount Stromlo Water Treatment Plant for further treatment, as now occurs for water sourced from the Cotter catchment, where it will then be distributed to residents of Canberra and Queanbeyan through the existing potable water system.

An Independent Expert Panel on Health set up to examine this proposal has reported to the ACT Government. The Expert Panel has concluded that a Water Purification Plant of the kind discussed in this report by ACTEW would meet the high standards required for safe drinking water. The Water Purification Plant is however more expensive than other options, both in capital costs and operating costs. The 50ML/day plant would add at least $180 a year to the annual average household water bill, whereas the 25ML/day plant about $120 each year. During the remainder of 2007 further analysis will be undertaken to investigate whether other methods reduce the very high cost of salt management associated with Water Purification Plant.

<u>The Tantangara transfer</u> would give the ACT guaranteed access to water from the Snowy Mountains Scheme (for example via Tantangara Dam) which is a reservoir of much larger storage capacity (239 GL) than any existing or planned dam in the ACT. The average inflow into this reservoir is 301 GL a year, most of which is allowed to flow immediately down to the Eucumbene Dam.

The Tantangara transfer involves the following main actions:

- *purchasing water from irrigators downstream of the ACT;*
- *storing purchased water in Tantangara Reservoir; and*
- *transporting* that water from Tantangara to the ACT via the Murrumbidgee River.

This proposal has always been very attractive in theory, but as ACTEW advised in the 2004/2005 reports, it involves a high level of legal and political assurance to provide the confidence to rely on such an option. Since the 2004/2005 reports were completed, the nationwide deliberations on water that have taken place in 2007 have produced a more conducive environment in which to discuss these issues. ACTEW is more confident that the ACT can obtain the political and legal assurance needed to proceed.

The capital cost of purchasing the necessary water rights is anticipated to be lower than the capital costs of the Water Purification Plant, but there is a long way to go in commercial negotiations with Snowy Hydro and discussions with the Commonwealth and NSW governments and others, before ACTEW can be confident of securing access to water and obtaining reasonable annual operational costs.

ACTEW considers either of the Tantangara transfer or the Water Purification Scheme is an essential element of any mix of options for the future, because neither is dependent on rainfall in the catchments. On the face of it, the Tantangara transfer has more to recommend, because by purchasing more water rights downstream over the coming decades, ACTEW could access more water from the Tantangara Dam as the population grows. However, until intergovernmental and commercial negotiations are concluded, it is not absolutely clear that the Tantangara transfer is the right option. It is envisaged it will take some six months to complete political, legal and commercial work on Tantangara before a view can be formed on which of these two options is achievable. But, one of them will be essential.

Costs

This report provides the best estimates of costs available at this time. Some of these costs are higher than previously indicated, for example the cost of the Angle Crossing option is higher due to a larger capacity plant being considered with a longer pipeline. The Water Purification Plant costs are also higher due to the need to extract and crystallise salt and the associated high costs for this process. The current construction boom is possibly the largest since the gold rush era and as a result, demand is driving large cost increases across Australia. Some of these increases are very large for equipment, like water pipes. While there is potential for cost increases they are unlikely to significantly affect the ranking of projects to be undertaken.

Each option entails different energy costs. The operating costs presented in this report include a cost for carbon abatement. Once the preferred options have been agreed, ACTEW will determine how it may offset the additional energy to be used. Typically these can be through sequestration, such as planting appropriate trees, or by building renewable generation capacity (mini hydro plants, wind farms, solar power or by the purchase of Green Power).

The water purification process will marginally reduce salt loads discharged into the Murrumbidgee River. The concentration of the brine solution, coupled with the offsite transport and evaporation and/or crystallization of salt are highly energy intensive and are the subject of further investigation. ACTEW is well aware of the ACT's requirements to comply with the Murray Darling Basin's Salinity Management Strategy and will continue to examine ways to reduce salt loads in the ACT.

Recommendations

ACTEW recommends the ACT Government agree that ACTEW should:

1. *immediately commence the detailed planning and construction of an enlarged Cotter Dam to 78 gigalitres capacity;*
2. *add to its capacity and operational flexibility to extract water from the Murrumbidgee River by undertaking the work necessary to proceed to construction of a pumping capability near Angle Crossing, which could also be used to transfer additional flows released from Tantangara Dam if such flows become available;*
3. *obtain additional water from a source not largely dependent on rainfall within the ACT catchments through either;*
    a. *the Tantangara transfer option; or*
    b. *the Water Purification Scheme.*

ACTEW will advise the ACT Government on which option is preferred for the future by December 2007 after determining whether satisfactory legal and commercial arrangements can be made to transfer water to the ACT via the Tantangara Dam, including the establishment of an ACT Water Cap, and after more detailed examination of the Water Purification Scheme, especially further analysis of salt management options;

4. assess how any additional energy used may be offset through measures such as carbon offsets (such as planting of trees) or renewable energy capacity.

1 Introduction

This report investigates and reports on options to further secure Canberra and the capital region's water supply. Recommendations are made on the next steps to ensure a safe, secure and sustainable water supply. The recommendations build on the concept of security through diversity.

1.1 Purpose of this report

The purpose of this report is to review the existing water resources and recommend options to further secure the water supply for Canberra and Queanbeyan. This report continues on from the *Future Water Options* studies by updating water supply security assessments. These previous studies were based on six water planning assumptions and had concluded in 2005 that the region's water supply could be secured until 2023. There has been a fundamental change to one of these assumptions – the impact of climate change and climate variability. This has meant that it was necessary to review water security and the need for diverse supply options. These circumstances meant that options less dependent on rainfall, such as the Tantangara transfer and water purification are now being examined.

Recommendations are made to the ACT Government to further secure water supply.

1.2 Setting the Scene

In April 2004, the ACT Government released: *Think water, act water - a strategy for sustainable water resources management*. The strategy defined actions to achieve sustainability objectives for water use in the ACT out to 2050, including to:

- increase the efficiency of water use; and
- provide a long-term reliable source of water for the ACT and region.

As part of the development of the *Think water, act water strategy*, ACTEW produced an evaluation report in 2004: *Options for the next ACT water source*, which identified nearly 30 possible options for a long-term reliable water source for the ACT. That report identified three principal options for more detailed assessment:

- enlarging the existing Cotter Dam;
- building a new dam on the Gudgenby River (the Tennent Dam); and
- transferring water from Tantangara Dam in NSW to the ACT.

Also in 2004, ACTEW's report *An Assessment of the Need to Increase the ACT's Water Storage* concluded that unless the ACT community was prepared to accept water restrictions to recur regularly, the ACT would need additional water supply sooner than previously expected.

ACTEW's *Future Water Options* projects examined the three principal options in detail and recommended a preferred approach for additional water supply to the ACT Government. The report, *Future Water Options for the ACT Region - Implementation Plan: A Recommended Strategy to Increase the ACT's Water Supply*, outlines the strengths and weaknesses of various options for additional water supply.

The report concluded with recommendations for:

- immediate implementation of pumping from the Murrumbidgee River to the ACT water supply, identifying a transfer pipeline from the river near Angle Crossing to Googong Reservoir;
- further study on the longer-term options:

  Enlarging Cotter Dam to 78 GL,
  Constructing a dam on the Gudgenby River near Mount Tennent,
  Releasing water from Tantangara Dam in NSW to the Murrumbidgee River; and
- annual assessment of water planning assumptions and security of supply.

The *Implementation Plan* also identified an additional and lower-cost option to transfer excess water from the Cotter River storages to Googong Reservoir. Water was to be transferred via the Mount Stromlo Water Treatment Plant and the existing water distribution system. Implementation of this option – known as the *Cotter Googong Bulk Transfer* – commenced in 2005 and has proved successful in transferring up to 12 GL per year. Further analysis has found that the construction of the Murrumbidgee River pump station at Lower Cotter (instead of Angle Crossing) was predicted to have very similar performance to pumping from the Murrumbidgee River at Angle Crossing but at a lower cost. This option has also been implemented.

The Cotter Dam and Cotter Pump Station were progressively re-introduced into operation as part of the supply system in 2005. A new 80 ML/day pump station was built in the Murrumbidgee River and is now pumping water to the Mount Stromlo Water Treatment Plant.

ACTEW observed that "Analysis comparing the runoff into Googong reservoir with flows in similar sized catchments for the Gudgenby River (near the location of the Tennent Dam option) and the Molonglo River at the ACT border, showed that similar very low runoff has been experienced in all three catchments" (ACTEW 2006). This had serious implications on the viability of any Tennent Dam option if it continued. While the Cotter River flows reduced, these were not to the same extent as in the other catchments.

ACTEW has committed to a variety of measures which can be implemented quickly and provide additional water to supplement supplies in the continuing drought and impending Stage 4 Water Restrictions. These measures will cost up to $9.5 million and include the following:

- Murrumbidgee River Pump Station;
- Murrumbidgee River spare pumps;
- Cotter Pump Station;
- Lower Molonglo Water Quality Control Centre (LMWQCC) recycled water pipeline; and
- North Canberra Water Recycling Scheme optimisation.

The basis of the drought contingency program is to maximise use of existing water sources, primarily the Murrumbidgee River and Cotter Reservoir, through minor works and adjustments of operational procedures. More detail is provided in **Appendix A**. In addition, further expansion of the North Canberra Water Recycling Scheme is being explored.

Water2WATER was ACTEW's proposal to help further secure the ACT's water supply by purifying Canberra's used water and adding this to the Cotter Reservoir which would also be enlarged. ACTEW's Water Security Program is the umbrella for the range of water supply and demand measures that are already in place, under development or consideration for the ACT.

1.3 A Fundamental Change in Assumptions

In April 2005, ACTEW's *Future Water Options* studies, were based on the following six key assumptions:

1. climate variability and climate change;
2. impact of bushfires on inflows to ACT reservoirs;
3. future population growth in Canberra and Queanbeyan and the possibility of servicing additional areas in NSW;
4. reduction targets in per capita water use set by the ACT Government in *Think Water, Act Water*;
5. environmental flow requirements; and
6. acceptable levels for the duration, frequency and severity of water restrictions during times of drought.

ACTEW took a conservative approach by assuming that 2030 climate had already occurred. Whilst modelling of climate and likely future demand are tools to assist in predicting supply augmentation, the recent climate fluctuation indicate how difficult it is to respond to climate variability. Low storage levels and the prolonged period of restrictions highlight the uncertainty when predicting future water requirements. As such, it is prudent to obtain greater certainty in the amount of water available for consumption by creating more supply than these models suggest will be required.

There is increasing evidence that the recent climatic patterns have resulted in significant declines in inflows which may now occur more frequently and with greater variability (see Figure 1.1). On average, inflows have averaged about 200 GL over the past 100 years or so.

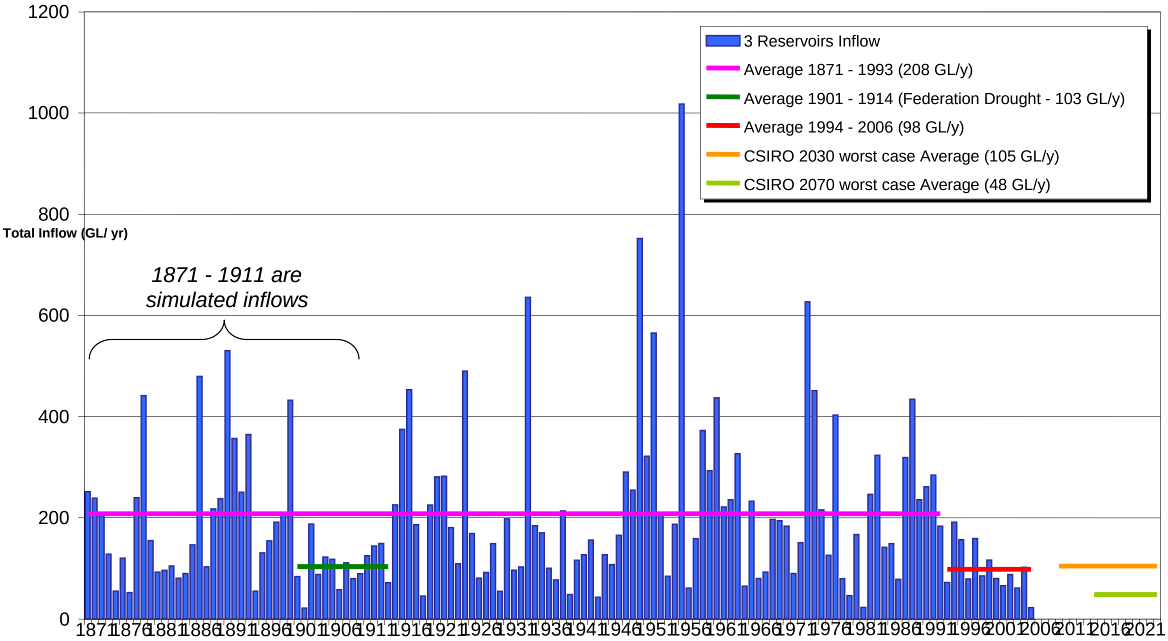


Figure 1.1: Corin, Bendora and Googong Dam Inflows 1871-2006

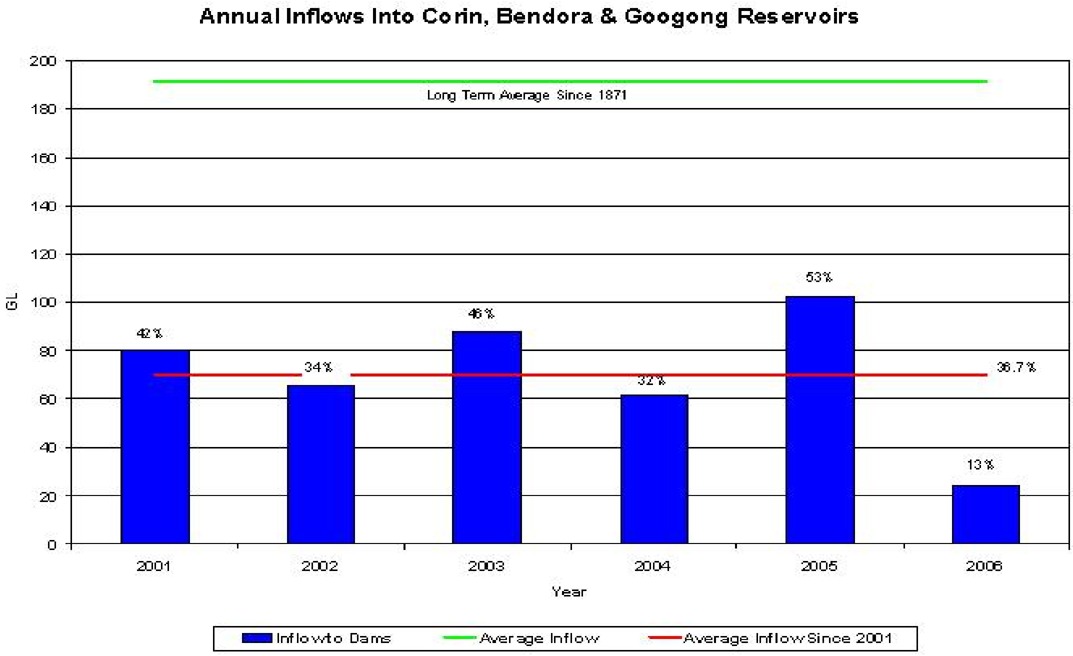


Figure 1.2: Annual inflows into Corin, Bendora and Googong Reservoirs

Inflows over the past six years have averaged about 71 GL, only 26 GL in 2006 and inflows for the first six months of 2007 are again well below average. This drought has resulted in significant water restrictions being imposed in Canberra and Queanbeyan.

Based upon work by the CSIRO (2003), the climate assumptions used in previous *Future Water Options* studies predicted that the 2030 climate change scenario for the ACT region had already occurred – a reduction of 30% in inflows.

The ACT has recently experienced inflows reduced by more than 60% (see Figure 1.2). It is possible the current situation is a temporary decline, even if the chance of this continuing is small, ACTEW must plan for this small eventuality – it is more beneficial to plan for the worst scenario and implement new infrastructure that is seldom used than to have ongoing restrictions and low water supplies.

> The Perth experience shows that we shouldn't assume the weather pattern will return to 'normal'. Between 1911 and 1974, inflows into Perth's water storages were on average 338 GL a year. From 1975 to 1996 they fell to 177 GL a year. And from 1997 to 2003 they had fallen to 114 GL a year, a 66% decline. And in 2006, they suffered a 90% decline in inflows, even worse than in the ACT.
>
> The reasons for this decline are unclear and after thirty years the situation persists. As a consequence, Perth recently commenced operation of a seawater desalination plant, and is now planning a second.
>
> We can not predict the beginning and end to a drought, but we can plan for a scenario of continued low inflows.

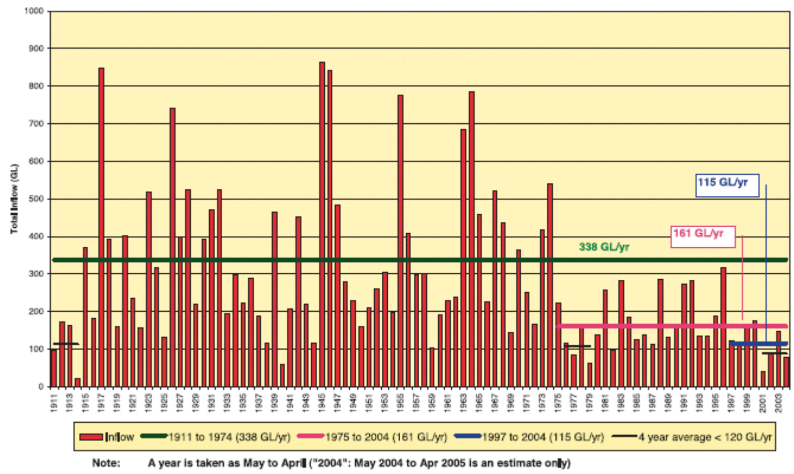


Figure 1.3: Perth inflow data

The following diagrams, provided by Sydney Water, indicate that the hydrological oscillations (or variability in inflows), in Australia are much more variable than those observed in Europe and also that variability is different across Australia. Canberra's variability is greater than that of Sydney. In the past, in Australia, dams were built much larger than would be expected in less variable climates, such as those found in Europe. This is how sufficient supply can be provided during most droughts.

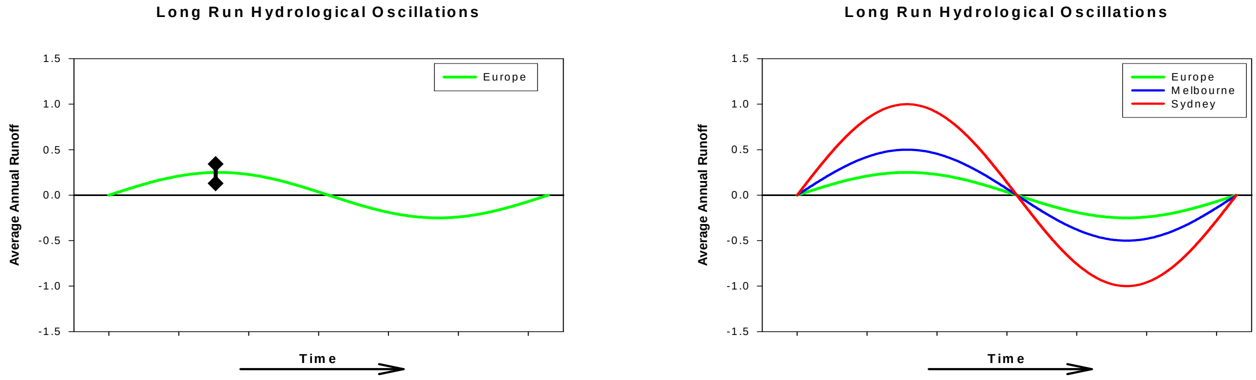


Figure 1.4: Long run hydrological oscillations – Europe and Australia

In recent times and perhaps as a result of climate change, the variability in the inflows has increased and this is shown schematically below. This means that there is a shortfall in storage during longer and prolonged droughts and that any additional supply built to meet this additional variability, for example a dam, a desalination plant or a water purification plant would only be required to operate during these periods of prolonged drought.

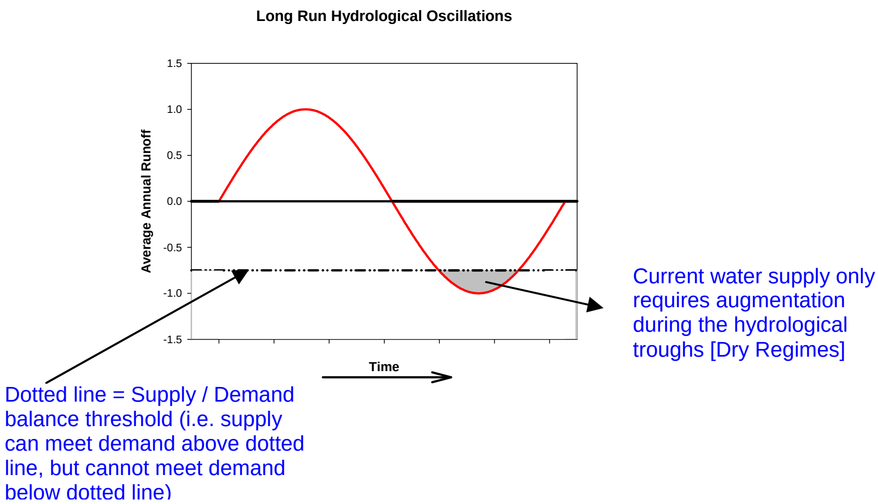


Figure 1.5: Long run hydrological oscillations

1.4 Water Management in the ACT

ACTEW's water supply infrastructure consists of three dams on the Cotter River, Corin (71 GL capacity), Bendora (11 GL capacity) and Lower Cotter (4 GL capacity). Water is transferred from these storages to the Mount Stromlo Water Treatment Plant before distribution to Canberra and Queanbeyan. In addition, water can be transferred from Googong Reservoir (121 GL capacity), treated at Googong Water Treatment Plant and then distributed to the city. Most wastewater is treated at the LMWQCC. A small amount of wastewater is also treated at the Fyshwick Sewage Treatment Plant and then treated to a higher level and used to irrigate local ovals. Reuse of treated wastewater also occurs at a vineyard and golf course in Holt as well as local irrigation at Southwell Park in Lyneham. In all, some 210 hectares (ha) are irrigated, about 8% of the wastewater produced. Further details of water management are provided in **Appendix B**.

1.4.1 Future Water Demand Projections

The demand for water in the future has been estimated by computer modelling. This modelling takes into account recent climate, future climate predictions, population growth, environmental flow requirements. It also assumes that the ACT Government's target of 25% reduction in per capita water use will be met, to estimate a future demand for water. Adopting the prudent planning population growth and climate scenario gives the estimations of future water demand shown below (ACTEW 2005). As a sensitivity analysis, dry and extremely dry predictions are also included. Dry future climate represents conditions that are similar to those experienced over the past 5 years, whereas extremely dry future climate approximates conditions observed in 2006.

Table 1.1: Future water demand

Annual water demand	2007*	2012	2017	2022	2027
	(GL / year)				
Average future climate	65.5	67.3	68.0	68.1	71.8
Dry future climate	68.2	68.9	70.3	69.2	74.8
Extreme dry future climate	68.6	72.8	72.8	72.2	75.6

Notes: * represents estimated demand for water, current consumption is 53.5 GL due to water restrictions applied in current drought.

Figure 1.6 shows the average water demand (shaded green) is relatively constant until 2023 – as the impact of population growth is approximately offset by achieving the ACT Government's demand reduction targets. Beyond 2023, demand is predicted to increase in proportion to population growth. The red and orange shading represents the higher demands expected during "extremely dry" and "dry" climate scenarios. The extremely dry climate scenario is similar to that of 2006. The dry climate scenario is similar to that experienced in the ACT region during the recent drought – the period from 2001 to 2006.

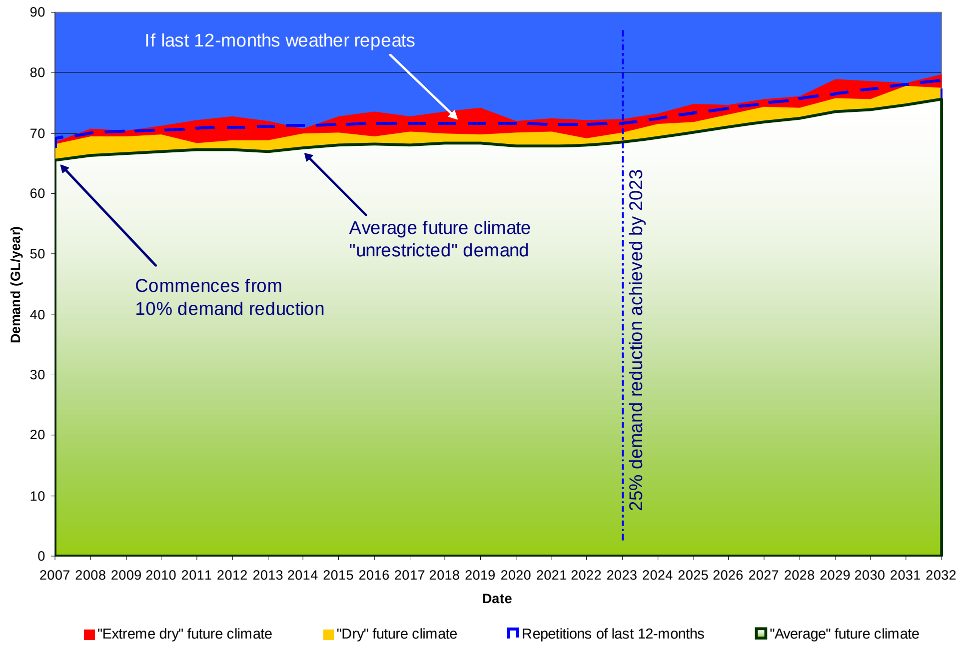


Figure 1.6: ACT's future water demand

2 Future Water Options

In response to the recent reduction in inflows, caused by either changes to climate variability, and/or climate change, it is necessary to urgently review the future water supply options. This is because there has been a significant change in the assumptions that supported the previous *Future Water Options* studies. While it may only be a small chance that these reduced inflows become the new norm, ACTEW cannot afford to take that risk – even if it may be perceived as a small risk. A review has been undertaken of all the previous water supply options.

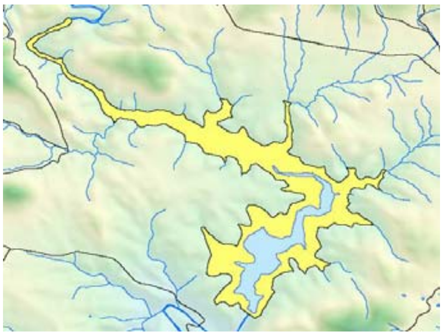
The options reviewed include:

- enlarged Cotter Dam;
- Tennent Dam;
- Tantangara transfer;
- Angle Crossing option;
- seawater option;
- groundwater options;
- water purification scheme;
- non-potable use;
- stormwater;
- rainwater tanks;
- greywater use;
- accelerated demand management;
- cloud seeding; and
- Watermining ™.

These options are discussed below. More detailed information is provided in **Appendix C** and also in ACTEW's *Options for the Next ACT Water Source* report and the *Future Water Options* series of reports (see the Reference section at the end of this report).

2.1 Reliance on Catchment Inflows

2.1.1 Cotter Dam

	**Pros** ➢ Existing dam site on Territory land ➢ High Yield at relatively low cost ➢ Minimal environmental impacts **Cons** ➢ Requires pumping ➢ No increase in diversification ➢ Management of endangered fish

As part of the *Future Water Options* studies in 2005, four alternatives involving the Cotter Catchment were under consideration:

- new 68 GL Coree Dam, upstream from the existing Cotter Dam;
- existing dam, plus greater use of environmental flow releases from Bendora Dam;
- enlarged 45 GL Cotter Dam; and
- enlarged 78 GL Cotter Dam.

Coree Dam has been found to be slightly more expensive to construct than an enlarged Cotter Dam as additional concrete is required due to the wider valley. The pump station and pipeline are also more expensive as a new power supply would need to be provided. If Coree were to be built then an enlarged Cotter would not also be built, as water captured by Coree would normally flow into the enlarged Cotter. As an enlarged Cotter is downstream of Coree it has slightly more inflow. Coree is higher in elevation and would have slightly less energy costs when pumping. From a water quality perspective, Coree would have marginally better quality water, but now that the Mount Stromlo Water Treatment Plant has been built, the water from lower Cotter can easily be treated. Coree Dam would likely have a negative impact on fish because it would prevent upstream passage.

The existing Cotter Dam has now been bought back into operation and no significant benefits are obtained through greater use of environmental flow releases from Bendora Dam. The smaller (45 GL) Cotter Dam option was discarded on the basis of hydrological assessment – that is, it did not add sufficiently to future water yield – and also because of a potential fish passage threat to the existing Macquarie Perch population.

The 78 GL Cotter Dam option does not have the same potential fish passage problem and has been further studied since 2005. The existing Cotter Dam has recently been brought back into service now that the poorer quality water can be treated at the upgraded Mount Stromlo Water Treatment Plant. This contributes up to 100 ML per day and Cotter Dam is once again a permanent component of the ACT's water supply system.

The approximate capital cost of the enlarged Cotter Dam is $145 million with an operating cost of around $1million each year. Details on the enlarged Cotter Dam is provided in **Section 3**.

2.1.2 Tennent Dam

	Pros ➢ Diversification through a new catchment ➢ Larger dam **Cons** ➢ Uncertainty of future inflows ➢ Longer timeframe to build and fill ➢ Endangered yellow box woodlands ➢ Leaseholder relocation ➢ Road relocation

One of the options considered as part of the *Future Water Options* project was the construction of the Tennent Dam on the Gudgenby River in the Naas Valley (ACTEW 2005).

The construction of this dam would also require building a new water treatment plant on site or pumping the water to the existing Mount Stromlo Water Treatment Plant.

The proposed dam has a number of complexities that would need further assessment and a long planning lead time before implementation including:

- the Naas Valley has an existing community of rural lessees who would need to be relocated if a dam was built;
- the site has an existing road linking Tharwa with the Boboyan Road, which would need to be entirely relocated;
- the site has areas of Yellow Box Grassy Woodlands, which has national significance. The woodlands is also home to several threatened species of birds; and
- the site has a number of European and Aboriginal Heritage sites that would need to be considered.

The key issue, however, is the uncertainty of the flows in the river system. The Gudgenby River, which would be dammed under the proposal, has long term average flows of about 57 GL per year, compared to 138 GL per year for the Cotter River. Over the last six years Tennent catchment inflows have reduced by 70% compared to 40% in the Cotter Reservoir and 35% for Tantangara reservoir, indicating the Gudgenby flows are much less resilient to drought. In 2006, had the Tennent Dam been in place, the inflows would have been less than 6 GL.

This option is the most expensive dam option currently being considered. Capital cost is estimated at $292 million for a 159 GL dam and annual operating costs would likely be similar or slightly lower than the existing water supply system, with 5 to 10 years to build and fill. ACTEW recommends retaining the Tennent Dam site as a future water supply option. Further reading on the Tennent Dam is provided in ACTEW, 2005c.

2.1.3 Tantangara Transfer

	**Pros** ➢ Provides added diversification ➢ Improves use of Googong Dam ➢ Quick to implement ➢ Cost effective **Cons** ➢ Agreement on an ACT Cap ➢ Changing Snowy Hydro's operating licence ➢ Protracted negotiations

This option was initially evaluated under the *Future Water Options* project (ACTEW 2005d) and has now been further developed. In light of the recent changes to national water management, this option appears to be more promising than it was when last considered by ACTEW in 2004/2005.

The Tantangara water transfer involves the following main actions:

- purchasing water from irrigators downstream of the ACT;
- storing purchased water in Tantangara Reservoir; and

- transporting that water from Tantangara to the ACT.

There are some considerable uncertainties with this option that remain unresolved including:

- having a Murray-Darling Basin Water Cap agreed for the ACT;
- altering Snowy Hydro's operating licence; and
- protracted negations with other parties.

The cost to purchase water is anticipated to be around $38 million. Operating costs will need to be negotiated with Snowy Hydro and others as necessary, but for the purpose of this report is estimated to be around $3.4 million each year. Work is progressing on this option, which is discussed further in **Section 5**.

2.1.4 Angle Crossing Option

	**Pros** ➢ Provides additional diversification ➢ Quick to implement ➢ Cost effective ➢ Improved use of Googong Reservoir **Cons** ➢ Inter-jurisdictional approvals required ➢ Pumping costs

The Angle Crossing option was a primary recommendation of *Future Water Options* in 2005. The scheme involves the installation of a weir and pumps in the Murrumbidgee River at or near Angle Crossing at the southern border of the ACT. Water would be pumped, via a pipeline, from Angle Crossing, under the Monaro Highway, along the road alignment of Williamstone Road to Burra, before being discharged into Burra Creek, inside the Googong catchment boundary, or piped all the way to Googong Reservoir. The Burra Creek route is suited to the lower pumping rates, say less than 60 ML/day. If higher pumping rates were to be chosen then a pipe to Googong Reservoir would be preferred to minimise impacts on Burra Creek.

The recent agreement for a regional approach to water management has helped in obtaining better regional support for this option.

The capacity of the pumps were not determined at the time of *Future Water Options*, but options ranging from 30-60 ML/day were modelled, providing about 10 to 20 GL/year, depending on flows.

The option was postponed, as after further work, it was considered more prudent to abstract water from the Murrumbidgee River via the existing pumps at Lower Cotter and to augment the treatment capacity of Mount Stromlo Water Treatment Plant to treat more river water. Taking water from this point of the Murrumbidgee River also captures flows from the Gudgenby River.

The Tantangara transfer in combination with pumping water from the Murrumbidgee River to Mount Stromlo Water Treatment Plant, provides additional flexibility and capacity by also transferring Murrumbidgee River water to Googong. The capital cost for the Angle Crossing option is around $70 million and operating costs in the order of $2 million per this year (depending on the volume transferred). This option is considered further in **Section 6**.

2.2 Seawater Source

Pros

- Proven technology
- Rainfall independent

Cons

- Higher cost
- Higher energy use
- Inter-jurisdictional approvals

Desalination of seawater to serve Canberra and Queanbeyan was also considered during this review. This option would consist of:

- a seawater reverse osmosis process plant on some 35 hectares;
- the intake and outlet would be located in water depths of approximately 20m offshore to optimise dispersion and intake water quality;
- the plant would have a capacity of 50 ML/day. A one pass reverse osmosis process would be required if the water is to be delivered to the Queanbeyan River. A two pass reverse osmosis process would be required if the water is to be delivered directly to the existing water supply network so as to match existing water quality;
- the intake would draw approximately 140 ML/day to produce 50 ML/day of potable water;
- the plant would be located on the NSW south coast;
- reject water would be discharged to the ocean as is the case in Sydney and Perth;
- a 750 mm diameter pipeline approximately 100 km long, located within road reserves wherever possible, would connect the plant with the existing supply system;
- there would be a main pump station at the plant site and three more along the route; and
- electricity would be sourced from the grid.

Without Commonwealth intervention, under NSW planning laws, the proposal would need to be assessed under the NSW *Environmental Planning and Assessment Act 1979*.

The estimated capital cost of the desalination option would be approximately $1.27 billion and operating cost would be approximately $22 million per year. This estimate includes the additional cost of purchasing Green Power to offset energy use. A 2.5 year to 3 year timeframe will be required to gain approval, construct and commission the plant. For more information see GHD, 2007. This option is not considered appropriate at this point in time.

2.3 Groundwater

	**Pros** ➢ Potentially provides diversification **Cons** ➢ No large aquifers in or near the ACT ➢ Transfer costs to the ACT water network

Groundwater, in the ACT and surrounding NSW, was examined in the *Future Water Options* studies and is still not considered a viable option, for further reading see ACTEW, 2004. Groundwater can provide benefits on a small localised scale and is already being extracted and used at various locations in the ACT.

2.4 Water Purification Scheme

	**Pros** ➢ Less directly dependent on rainfall than a dam ➢ Proven technology ➢ Assist in avoiding restrictions under extremely dry future climate scenarios **Cons** ➢ Higher cost ➢ Higher energy use ➢ May not be used in wetter periods

ACTEW is investigating the advanced technology that already exists to treat used water to a standard safe for human consumption. The proposed Water Purification Plant would use optimum technology to treat water in a planned and controlled manner so the water complies with the national drinking water guidelines and other relevant standards. Membrane filtration and reverse osmosis is the preferred combination of treatment processes that provides a multi-barrier approach to water purification. Membrane filtration uses hollow fibre membranes with fine pores to filter particles and micro-organisms. The membrane surface acts like a screen to retain the micro-organisms; similar to a screen door that retains insects. This step removes microscopic particles, contaminants and pathogens. Reverse osmosis is the process of pushing water through a membrane or filter that traps almost all suspended and dissolved substances and micro-organisms to one side and allows water to come out the other side. The membranes have very small pores, so small that more than 99% of sodium and chloride ions are also removed. This step removes pollutants such as salts, organic compounds and viruses. A further process is installed called ultra violet disinfectant and advanced oxidation. Ultra violet light is used to disinfect water. UV light is effective at destroying micro-organisms such as Giardia and Cryptosporidium and other pathogens. Oxidation destroys chemical compounds. Strong oxidation agents such as hydrogen peroxide remove trace organic constituents. The proposal would also take advantage of nature's own water treatment process by letting the purified water flow into the natural environment.

The cost of this option has decreased in recent years due to technological improvements and greater uptake around the world. The estimated capital cost for a 50ML/day plant is in the order of $220 million to $270 million, depending on the salt treatment technology. Operating costs would be in the order of $18 million per year. Whereas, the estimated capital cost for a 25ML/day plant are in the order of $180 million and operating costs in the order of $10 million per year.

2.5 Stormwater Use

Pros

- Local use of existing storages can be cost effective
- Provides some stormwater control

Cons

- Poor water quality
- Highly variable quantities
- Large storages required
- Cheaper systems are already implemented

Stormwater harvesting is promoted in the ACT Government's *Think water, act water* strategy, as it can assist towards meeting the 25% target reduction of drinking water consumption per person by 2023. It is also factored into the ACT Government's *Waterways: Water Sensitive Urban Design General Code* that target a 40% reduction in drinking water use for all new developments and re-developments. The ACT Government carries out stormwater harvesting from most urban ponds and lakes for use on community parks and ovals. Golf courses, nurseries and other large water users also use stormwater. The ACT Government is currently undertaking the Canberra Integrated Urban Waterways Project with assistance from the Australian Government Water Fund. This project will implement stormwater storage, harvesting and use up to three gigalitres per year by 2015 as well as providing stormwater improvement benefits. A feasibility study is currently underway to determine what level of use is feasible. The project will cost $17 million (excluding ongoing operations, maintenance and monitoring costs).

Stormwater is generated by rainfall events through urban areas and usually comes in large volumes over short time periods. Therefore, there is a requirement to store this water until it is required for use. Ponds and lakes can be used for the storage of stormwater, but if the water levels vary too much, it can have significant impacts on their amenity and aesthetics for the community, fauna and flora. Stormwater is generally of low quality with a high level of pollutants and therefore should only be used for irrigation and have secure backflow prevention measures in place. It is possible to build in mechanisms to divert the first flush and then transport the rest of the stormwater to the surface water storage reservoirs where it is then treated in conjunction with the overall raw water flows. Cost of these schemes is dependant on factors such as existing storage facilities, proximity of irrigation areas and the size of the scheme. There is limited opportunity for citywide stormwater harvesting at significant levels above what is already in place and planned within the Canberra Integrated Urban Waterways Project.

2.6 Rainwater Tanks

Pros

- Supplement existing drinking water use
- Can be used in toilets and laundry
- Reduce stormwater runoff

Cons

- Higher cost
- Rainfall dependent
- Difficult to obtain large enough storage

Rainwater tanks can store runoff from the roof for garden watering and other household uses. They can make a contribution towards reducing the residential water supply demand and are a water conservation measure. The ACT Government's *Rainwater tanks: guidelines for residential properties in Canberra* provides information on this subject. Rainwater tanks are promoted in the ACT Government's *Think water, act water* strategy, as they can assist towards meeting the 25% target reduction of drinking water consumption per person by 2023. The strategy recognises the benefits of installing a rainwater tank in terms of water saving and stormwater reduction. The effectiveness of a tank is increased when the water is used for internal purposes such as toilet flushing and clothes washing as well as garden watering. This provides a way for the tank water to replace drinking water all year round. The ACT Government has provided household rebates for the installation of rainwater tanks to assist the community contribute to water conservation. To be eligible for a rainwater tank rebate, the tank must be plumbed for some internal use, for example to the laundry or toilet. The use of rainwater tanks is also promoted in the ACT Government's *Waterways: water sensitive urban design general code*. The *Think water, act water* strategy states that the cost to install rainwater tanks to existing households (based on a 200 square metre house, with the entire roof connected to a tank and plumbed to the toilet and laundry) would translate into about $4 per kilolitre (kL) for fitting to existing houses. This is compared to the current highest cost of drinking water, being $1.74/kL plus the ACT Government's $0.55/kL Water Abstraction Charge. The *Rainwater tanks: guidelines for residential properties in Canberra* states that a rainwater tank connected to a building with a 150 square metre roof can provide up to 90KL of water per year (assuming the tank water is used for garden, toilet and laundry). Assuming a cost of $3,000 - $5,000 per property for over 110,000 houses, it is estimated that the cost for installing a tank in all households in the ACT would be about $330 million to $550 million for 8 gigalitres per year. Rainwater tanks are also dependent on rainfall thereby reducing the benefit of rainwater tanks during drought periods. There is limited opportunity for citywide rainwater tank use at levels above what is already being put in place. Although rainwater tanks are dependent on rainfall and they can be expensive to install they represent a means to reduce dependence on mains water.

2.7 Greywater Use

Pros

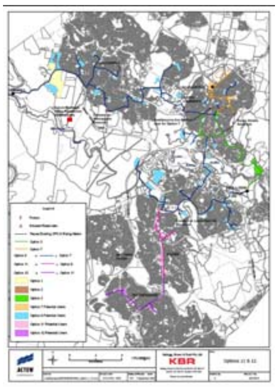
- Replaces drinking water use on gardens
- Reduces sewerage flows (and treatment costs)

Cons

- Higher cost
- Care needed in handling due to potential health issues
- Ongoing maintenance

Greywater is wastewater from hand basins, showers, spas, washing machines, laundries, (and not from the toilet or urinal - which is blackwater). The use of greywater varies from bucketing or siphoning, connecting the outlet drain to a diversion pipe or installing an appropriate greywater treatment system. Greywater use is promoted in the ACT Government's *Think water, act water* strategy, which includes a target to increase reclaimed water from 5% to 20% by 2013. The strategy is continuing to investigate ways to encourage the take-up of greywater use with consideration being given to incentives and rebate schemes. It is also promoted in the ACT Government's *Waterways: water sensitive urban design general code*. Greywater use can replace some drinking water use and contributes to water conservation measures. In addition, it also reduces wastewater flows, which reduces treatment costs and discharge volumes to waterways. Due to poor water quality however, untreated greywater should only be used for irrigation and cannot be stored for more than 24 hours unless an appropriate treatment system is used (ACT Government, 2004). Treated greywater can be used for other purposes. *Think water, act water* states greywater costs approximately $5 per kilolitre, noting this cost is for rebates only (cost to government). The installation of a sophisticated greywater system has been estimated at $10,000 - $15,000 per household. For the ACT's 110,000 properties, it is estimated the proposal would cost in the region of $1.1 billion to $1.6 billion, producing about 14 gigalitres per year (based on figures in the *Greywater: guidelines for residential properties in Canberra*, 2004).

2.8 Other non potable reuse options – large scale irrigation



Pros

- Provides irrigation water during droughts

Cons

- Higher cost
- Disturbance during installation of pipes
- Seasonal use of water

This non-potable reuse option involves extending the existing ACT water reuse schemes for irrigation purposes. This provides additional reuse water for irrigation of open spaces, parks, ovals and golf courses through Central Canberra, Belconnen, Woden and Tuggeranong. This would further reduce the use of potable water by about 3GL each year for a capital cost of more than $100 million. Additional capacity beyond this extension becomes even more expensive.

To implement the scheme, approximately 100 km of pipelines need to be constructed through largely existing urban areas. It also requires several pumping stations to be constructed and connection to decommissioned reservoirs.

The demand for non-potable reuse is mostly limited to seasonal demand during warm and dry periods. It has the advantage of allowing use of sports ovals through periods of drought, but does not reduce the probability that severe restrictions will be required particularly in current and future droughts. The scheme could only be implemented in some parts of the city, meaning that some areas could access playing fields during drought whereas other areas of the city could not. This scheme provides only limited additional flexibility to the water supply system, as it provides non-potable water to limited areas of Canberra only through the summer months. It does not supplement the drinking water supply during years like 2006 and only provides limited offsets to the drinking water supply during periods of water restrictions.

ACTEW continues to examine ways to further expand non-potable reuse where it is viable, including assessment of storage options, seeking suitable winter demand and water pricing.

2.9 Accelerated Demand Management

Pros

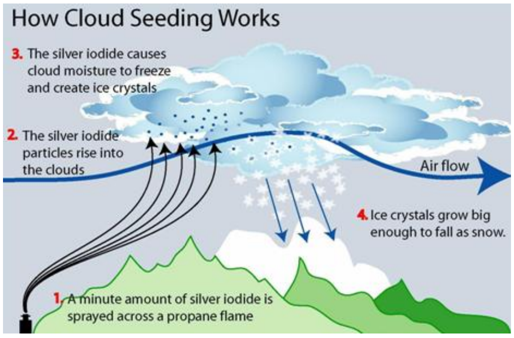
- More efficient use of water
- Fast tracks ACT Government's existing program

Cons

- No additional long-term benefit
- Requires considerable community support

This option requires implementing activities to build on the current ACT Government's demand management (water conservation) program to reach a 20% per capita water consumption reduction by 2011, rather than the government's proposed target of 25% reduction by 2023. This will involve increased technical assistance and financial incentives to: (i) adopt low-flow showerheads, dual flush toilets, internal water audits, water-efficient gardens and leak minimisation; (ii) ensure commercial and business establishments use water efficiently and minimise leaks; and (iii) to install rainwater tanks and grey water recycling systems. Some proposed demand management measures of the Government's 25% reduction are planned for new houses yet to be built, or involve new appliances not yet readily available (ISF, 2003). As these features cannot be brought forward to any significant extent, the full 25% demand reduction is not achievable by 2011; hence this option only examines a 20% reduction. The outcomes of the analysis of this option indicate a short-term advantage with no long-term impact on future demand. The cost of this option is about $150 million. The ranking of this option compared to others indicate this is not a preferred option to provide necessary water security (ActewAGL 2007).

2.10 Cloud Seeding



Pros

- May increase rainfall
- Ongoing research by ACTEW

Cons

- May not increase rainfall
- Uncertain
- Several years to test and prove

Cloud seeding is a form of weather modification which changes the amount or type of precipitation that falls from clouds by dispersing substances into them to serve as cloud condensation or ice nuclei. The usual intent is to increase precipitation, but hail suppression is also practiced. Silver Iodide and dry ice are the most commonly used substances in cloud seeding.

Seeding of clouds requires them to contain liquid water colder than zero degrees Celsius. Introduction of a substance such as Silver Iodide, which has a crystalline structure similar to that of ice, will induce freezing. Clouds can be seeded from the air or ground level.

Snowy Hydro Limited is conducting a six-year research project of winter cloud seeding to assess the feasibility of increasing snow precipitation in the Snowy Mountains. As there have been no cloud seeding studies in the Canberra region, preliminary investigations of seeding types and frequency of suitable atmospheric conditions are required, followed by a four to six year experiment. The correct cloud formations are required for cloud seeding to be successful, therefore research into the types and abundance of clouds over the Canberra water catchment areas needs to be undertaken to determine the usefulness of cloud seeding in the region. ACTEW, ActewAGL and Snowy Hydro are cooperating to understand the potential of cloud seeding for the ACT. A proposal is being developed that builds on the expertise that Snowy Hydro has obtained in the cloud seeding operations to assist with meteorological research into the appropriateness of cloud seeding for the ACT.

While cloud seeding has shown to be effective in altering cloud structure and size and converting cloud water to ice particles, it is more controversial whether cloud seeding increases the amount of precipitation at the ground. Part of the problem is that it is difficult to discern how much precipitation would have occurred had the cloud not been seeded. Nevertheless, there is more credible scientific evidence for the effectiveness of winter cloud seeding over mountains (to produce snow) than there is for seeding warm-season cumuliform (convective) clouds. Cloud seeding essentially makes the wet times wetter and has minimal benefits in dry times. Benefits of cloud seeding will generally only become tangible over a long term period, following a trial period to assess effectiveness.

2.11 Watermining TM

	**Pros** ➢ Reduces drinking water demand ➢ Further locations being investigated **Cons** ➢ Higher cost ➢ Seasonal use ➢ Not a major supply option

Watermining TM is a process by which wastewater is taken from a sewer and treated for reuse in the local vicinity, such as for irrigating ovals, parks and playing fields. ACTEW currently operates a Watermining TM scheme at Southwell Park, which was commissioned in 1995 as a demonstration facility of new technology. This scheme supplies irrigation water for the adjacent Southwell Park playing fields. In 2005, ACTEW investigated localised watermining opportunities for the ACT including Watermining TM schemes in Kambah, Stirling, Isabella Plains, Condor, Melba and Charnwood. Investigations highlighted that watermining schemes were expensive and even if maximised across the ACT at a localised scale, provided little benefit to the overall security of ACT water supply. ACTEW is now developing a feasibility report on watermining opportunities and constraints for individual sites within the ACT. This study is looking at smaller scale plants than previously considered. Although Watermining TM may have opportunities to benefit individual sites in the ACT, it does not have the potential to provide sufficient water at a reasonable cost to meet the security required for current and future droughts.

2.12 Evaporation Control on Reservoirs

ACTEW has investigated techniques for reducing evaporation from the water supply reservoirs. None of the options examined provided a cost effective solution. The options were only suitable for the smaller reservoirs, Bendora and Cotter, which have relatively insignificant evaporation losses compared to Googong and Corin reservoirs. ACTEW will continue to review new products and techniques that become available.

2.13 Preferred Options

Of all the above options, the following are considered as future supply options:

- Angle Crossing;
- enlarged Cotter Dam;
- water purification;
- Tantangara transfer; and
- Tennent Dam be retained as a longer term option.

Many of the other options have a role to play in either reducing the demand for water or providing some additional supply.

3 Cotter Dam Enlargement

3.1 Description of Proposal

Construction of an enlarged dam on the Cotter River, to be sited downstream of the existing dam, is an option for the future water supply of Canberra. The assessment of the Cotter Dam enlargement option was reported in *The Cotter Dam Option* (ACTEW 2005). Following this report, further studies into the technical, cost, environmental and other aspects of the provision of a larger reservoir have been ongoing. Geotechnical investigations commenced at the site in March 2007. Technically, the option to construct a dam has been taken to a pre-feasibility level (GHD 2005). Construction of the dam would add 74 GL to the storage capacity in the ACT. Water from the reservoir would gravitate to the Cotter Pump Station where it would be pumped to the Mount Stromlo Water Treatment Plant before distribution. The extra volume of water to be pumped will require the station to be extended by installation of two more pumps.

3.2 Description and History of the Area

The Cotter River catchment is approximately 48,200 ha (or 482 km^2) situated on the western extremity of the ACT. The Cotter River flows in a northerly direction before joining the Murrumbidgee River, its path largely determined by the Cotter fault, a high angle reverse fault extending for about 40 km. The catchment is bound by the Tidbinbilla Range in the east and the Brindabella Range in the west. Downstream, the river flows in a narrow valley, whereas upstream from Kangaroo Creek, the valley is wider. From the existing Cotter Dam, the catchment extends for about 55 km in a southerly direction and averages about 13 km in width, see Figure 3.1.

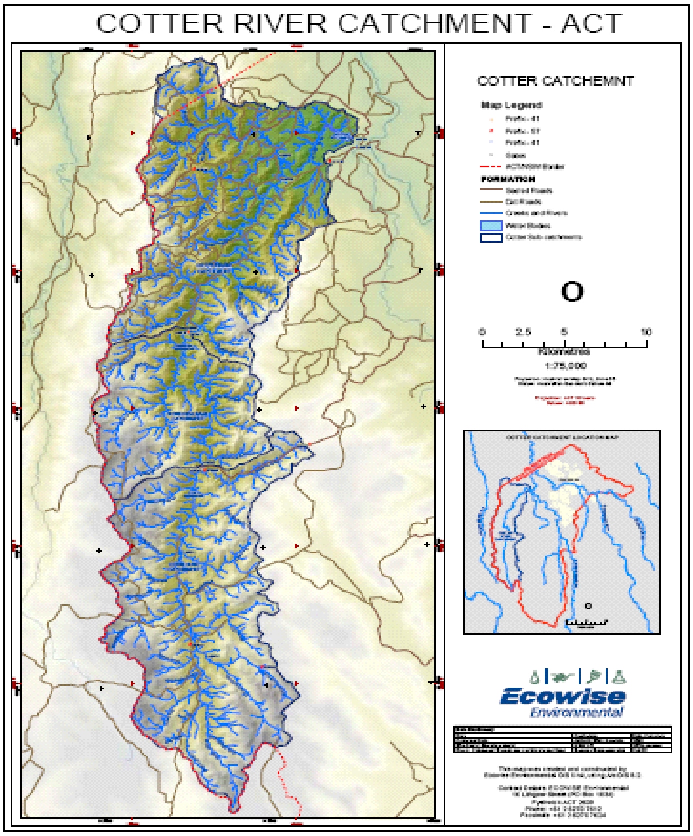


Figure 3.1: Cotter River Catchment

The lowest point of the catchment where the Cotter River joins the Murrumbidgee River is 500 m above sea level. It rises to an elevation of about 1900 m at Mount Bimberi. Over half the catchment is located within the Namadgi National Park. The upper Cotter Catchment (above Corin Dam) is rugged and virtually unmodified by human activity. There is some localised soil erosion along tracks and firebreaks. Native fauna is abundant and recreation is limited to protect water quality.

The lower section of the catchment, near Cotter reservoir, previously contained large areas of pine plantations. The remnants of these plantations have been cleared since the bushfires and a replanting program of mostly native vegetation is underway. The terrain of the lower catchment is hilly with some steep slopes. Sandy topsoils overlay thick clay subsoils and there is some localised soil erosion from logged areas, tracks and firebreaks. The catchment comprises sharply dissected terrain with a mixture of sub-alpine, wet and dry sclerophyll forests, perched swamps and valley floor grasslands. Climate and terrain have a dominating influence on the hydrology of the catchment: higher elevations are associated with increased rainfall, wetter forests – except on ridge tops – and lower temperatures. Away from valley floor systems, the terrain is precipitous with slopes averaging more than 20 degrees.

Apart from water supply, other land uses within the catchment over the years have included grazing, forestry, mining and recreational activities. Clearing of parts of the catchment for pasture development occurred; however, due to the fragile soils, overgrazing and introduced rabbits, major erosion soon followed. There has been virtually no grazing within the total catchment since its acquisition by the Commonwealth. Prospecting and mining for precious minerals was initiated in the late 1800s via shallow pits and trenches at Mount Blundell. Exploration identified lead and zinc with minor copper deposits. Extraction activities occurred spasmodically until the late 1920s. Quarrying occurred during the construction of the Corin Dam adjacent to the existing dam wall. Minor gravel pits were also created for construction and servicing of the existing roads and tracks. Softwood pine plantation developments were introduced to the northern parts of the catchment, around Cotter Dam, as a response to soil erosion. The initial plantings occurred during 1926 and planting extended throughout the Uriarra and Pierces Creek areas. Selective hardwood logging of Alpine Ash and Brown Barrel in the northern catchment from around Piccadilly Circus to Mount Franklin, above Bendora Dam, occurred in the periods 1930 to 1938 and 1947 to 1967. Recreation is mostly limited to the lower catchment and along the Brindabella range as far south as Mount Ginini. Recreation activities include pleasure driving, trail bike riding, picnicking, snow sight seeing, skiing, and bushwalking, with much of the upper catchment restricted to walking. Camping occurs to a minor degree, subject to permits being obtained. The catchment is used extensively for research, including vegetation, fauna, fire ecology, nutrient cycling, hydrological and water quality studies.

3.3 Existing Water Storages in the Cotter Catchment

The existing Cotter Dam site was the most suitable of six sites on the Cotter River selected by surveyors in 1908 for storing Canberra's water supply. The dam was completed in 1915, when it was designed to serve a population of 25,000; in 1951 the wall was raised by 7.5 m. Cotter Dam provided Canberra's water until 1961 when the Bendora Dam was constructed. In the 1960s and 1970s, Canberra's population was increasing at an annual rate of 12 per cent and so the Corin and Googong dams were constructed in quick succession. Corin Dam, another of the short listed sites from 1908, was selected for construction in late 1963 and filling commenced in April 1968, five months ahead of schedule. This short lead-time reflected the clear need for enhanced storage facilities at this time.

Following construction of Bendora Dam in 1961, the benefits of having a gravity main to the city (feasible because of Bendora's elevation) became increasingly apparent. The cost of maintaining and operating the Cotter Pumping Station continued to rise, while it struggled to meet peak demands due to Canberra's growing population. Accordingly, a 20 km long, 1500 mm diameter pipeline was commissioned in 1968 with a capacity to deliver 320 ML of water to

Canberra each day, nearly equivalent to Canberra's mid summer maximum (350 ML) and well above the average daily consumption of around 180 ML.

3.4 Planning, Environment and Heritage Considerations

In 2005, ACTEW initially examined four alternatives involving the Cotter Catchment. The preferred option was to construct an enlarged 78 GL Cotter Dam (ACTEW 2005b). A review of this previous work, indicates this is still the preferred approach for Cotter *Future Water Options Review* (ACTEW, 2007).

Should a dam be constructed, the principal planning instrument would be a development application submitted under the *Land Planning and Environment Act* (1997) to the ACT Planning and Land Authority. This would trigger a number of other processes and will need positive resolution before the Authority could grant approval. Alternatively, the government could invoke special purpose legislation. The Commonwealth would also be involved due to the *Environment Protection and Biodiversity Conservation Act* (1999) provisions. The ACT Government's document, *People Place Prosperity* (2003), 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.

There are no privately held leases in the catchments affected by enlargement of the Cotter Dam – all is unleased Territory land and no variation to the Territory Plan would be required. Four categories of land, as defined by the Territory Plan, are involved: water feature, plantation forestry, mountains and bushlands, and river corridors. A "major utility installation" (such as a dam) is permitted in each of these categories.

Turbidity has been a problem with the Cotter reservoir water for many years, reflecting the fragile soils in the catchment, especially in the Pierces Creek area and subsequent sediment discharge. As water temperatures increase during the summer months, the reservoir becomes stratified, with warmer (less dense) water at the top. Sediment micro-organisms become more active, decreasing dissolved oxygen that in turn releases nutrients (such as nitrogen and phosphorus) and metals (iron and manganese) into the water column. Nutrients can result in algal blooms, while metals lead to water discoloration. Around April-May, surface water temperatures cool quickly and the cooler heavier surface water sinks to the bottom, distributing the previously released material throughout the reservoir. In response, mechanical de-stratification of the reservoir has been implemented. Key water quality characteristics are now treatable by the recently upgraded Mount Stromlo Water Treatment Plant.

There are two endangered fish species in the streams of the Cotter Catchment that are potentially affected by an enlarged Cotter Dam: Macquarie Perch and Trout Cod. Cotter Dam enlargement has a relatively low impact on fish because it provides opportunities for active enhancement of threatened fish habitats and populations. However, an enlarged dam could require operating rules to minimise potential impacts on threatened fish. There are no threatened plant species that would be affected by Cotter Dam enlargement and the potential occurrence of significant animal species is low.

There do not appear to be any major Aboriginal cultural heritage constraints to the Cotter Dam enlargement option. The existing Cotter Dam appears on the Register of the National Estate and would be flooded by an enlarged Cotter Dam; other registered sites (the Cotter Pumping Station, the Upper Cotter Catchment, the Murrumbidgee corridor and the Murrumbidgee River) would be largely unaffected. There are increasing demands for recreational use at the Cotter precinct and in the catchment (including a wider range of recreation pursuits), issues that have been addressed in work commissioned by the Shaping Our Territory Working Group and elsewhere. For more reading on the work associated with the short listing of the Cotter Dam options see ACTEW 2004, ACTEW 2005b and ACTEW 2007.

The likely planning timeframe for this project is in the order of 36 months, based on a 16 month period for environmental impact assessment and planning approvals, followed by a 20 month construction period.

3.5 Proposed Enlarged Cotter Dam and Associated Infrastructure

Preliminary geological and geotechnical studies have indicated that the proposed site for enlarged Cotter Dam is suitable. Recent engineering comparative studies of possible construction methods have led to the selection of a Roller Compacted Concrete type construction for the enlarged dam. The enlarged Cotter Dam is planned to be a 78 m high with a two stage spillway. The dam crest level would be 50 m higher than the existing dam and 76 m above the riverbed level. Two saddle dams would also be required in lower saddles of the reservoir catchment to hold water back and deliver the maximum dam capacity of 78 GL.

Diversion of river flows during construction would be through a four metre conduit to be plugged at the end of the construction period.

The outlet works would include a wet well intake tower attached to the upstream wall of the dam with provision for water to be drawn from different levels in the reservoir. The outlet pipes would feed water to the Cotter Pump Station. A new pipeline would cross under the Murrumbidgee River to near the existing Cotter Pump Station. There may be a need to construct a new pump station or perhaps modifying the existing Cotter Pump Station.

A small amount of hydropower generation could be possible utilising environmental flows.

The construction period would be about 20 months, with the majority of material coming from a nearby quarry site. Suitable environmental controls would be implemented during construction, the main risks being sediment discharge and alkaline water from the dam wall.

The dam would supply up to 180 ML per day to the Mount Stromlo Water Treatment Plant.

3.6 Cost Estimate

The cost of the dam was estimated in 2005 and again, by two consultants, in 2007. The 2007 cost estimate is approximately $119 million for the dam and associated works. Allowances of $4 million have been made for clearing and site preparation, $2 million for pipelines, $15 million for the pump station and $5 million for miscellaneous works, giving a total cost of approximately $145 million.

4 Water Purification Scheme

4.1 Description of Proposal

The proposal is to pump water from the LMWQCC to a Water Purification Plant. Purified water produced by the plant would be pumped to the discharge location (possibly through a constructed wetland) into a water course which flows into the Cotter Reservoir and blend with catchment runoff. From the Cotter Reservoir, the blended water would be pumped to the Mount Stromlo Water Treatment Plant for further treatment where it would be distributed to the residents of Canberra and Queanbeyan through the existing potable water system.

4.2 Water Purification Plant

4.2.1 Location of the Plant

A number of locations for the plant were considered but the preferred site is at the existing LMWQCC. A suitable location exists at this site for a plant of up to 75 ML/day capacity. This site would be located on the eastern side of the LMWQCC Maintenance Building. The area is relatively clear of trees, is relatively flat and has only minimal impact on locally identified fauna of concern, the pink tailed worm-lizard. Locating the plant at this site has a number of advantages over alternative locations:

- the site is easily accessible from Stockdill Drive for construction traffic initially and visitors and plant deliveries once the plant is complete;
- the plant would be the first building encountered the public when they arrive at the site;
- the site can be visually separated from the LMWQCC by suitable tree plantings; and
- the close access to the LMWQCC will be advantageous for personnel management and common facilities may be able to be utilised (i.e. chemical handling systems, operations, maintenance and administration facilities, etc).

4.2.2 Capacity and Staging

The plant would occupy an area of approximately three ha. Three plant sizes have been considered: a 25 ML/day, 50 ML/day and 75 ML/day. The development of the Water Purification Scheme, including brine treatment, may be undertaken as three 25 ML/day stages (each comprising three trains of approximately 8 ML/day capacity). Because of the establishment nature of the first stage, it would be the most costly.

It is considered the current upper limit capacity is approximately 50 ML/day based on existing inflows to LMWQCC.

The establishment infrastructure which would be critical for all stages include:

- bulk earthworks;
- drainage;
- roadwork’s;
- landscaping;
- core services (power, water, sewerage, etc);

- plant laboratory and refrigerated sample storage area;
- staff facilities; and
- chemical storage.

4.2.3 Treatment Process

The dual membrane process (membrane filtration and reverse osmosis) with advanced oxidation using ultraviolet irradiation (UV) and hydrogen peroxide is the preferred treatment train for the Water Purification Plant. Coupled with the Water Purification Plant will be a pre-treatment denitrification facility at LMWQCC.

The Water Purification Scheme would consist of:

- equalisation tank;
- denitrifying filter;
- membrane filtration feed tank;
- microstrainers;
- membrane filtration;
- reverse osmosis;
- advanced oxidation;
- carbon dioxide stripping;
- product water storage; and
- wetland (possible).

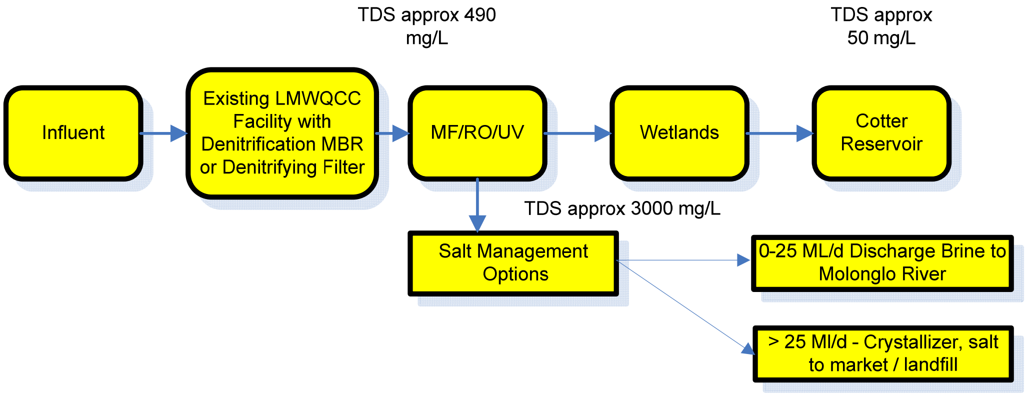


Figure 4.1: Proposed treatment process

The dual membrane plant and brine treatment process will produce a 10% reject brine stream for further treatment. This high overall recovery of water (90%) is made possible through the use of single pass three stage reverse osmosis process and the addition of the purified water from the brine stream.

Extensive water quality monitoring is yet to be undertaken on the LMWQCC effluent. The target water quality to be achieved by the Water Purification Plant has been derived from other similar operating plants around the world. Extensive further review of water quality targets is required to determine health risks associated with detected substances in the LMWQCC water and the efficacy of the proposed processes for the Water Purification Plant in their removal. A sampling and monitoring program is under development. The expected final water quality would be: (some parameters only).

Table 4.1: Product Water Quality for Dual Membrane Process

Parameter	Unit	Inlet Water (Average)	Target Product Water Quality
Dissolved solids – mainly salt	mg/L	490	<50
pH		7.7	7 - 7.5
Total Nitrogen	mg/L	15	0.7 *
Total Phosphorus	mg/L	0.2	<0.05 *
Total Organic Carbon	mg/L	4	<0.1
Giardia & Cryptosporidium	Cells/L	Unknown +	Below detection
Viruses and Bacteria	Number per 100mL	Unknown +	Below detection
Endocrine disrupting compounds**	nano-g/L	Detected ++	Below detection
NDMA	nano-g/L	Not detected +++	<10

* Total Nitrogen and Total Phosphorus targets are based on existing water quality in the Cotter Reservoir. Additional review will be required on these parameters.

+ Limited samples have been collected. At this stage no detections

++ Detected, however limited samples have been collected and analysed

+++ Analyses undertaken to date had limit of detection of 100 nano-g/L

Further natural treatment could occur in the wetland (if incorporated) and the Cotter Catchment and reservoir prior to pumping to the Mount Stromlo Water Treatment Plant for final treatment before distribution to the city. Because of the many treatment barriers the treatment concept is referred to as a multiple barrier approach.

The dual membrane technology is one of the most common for this application and similar to that used for the Singapore NEWater plants, the Orange County Groundwater Replenishment Program in California, the USA and has been adopted for the Western Corridor Project in South East Queensland.

Reverse osmosis provides a barrier for most chemicals. Salt is removed from the water and this will reduce the overall salt load from the LMWQCC discharges to the Murrumbidgee River if the brine stream is not returned to the LMWQCC outfall. Whilst this can be considered an advantage it also poses the difficulty of disposal. This is discussed below in the **Section 4.4**.

4.2.4 Equalisation Tank

The wastewater flow to the LMWQCC has both seasonal and daily variations. To operate the Water Purification Plant at 25 ML/day, a flow equalisation storage tank may be required. For plants with a capacity of 50 ML/day or higher, an equalisation tank is required. Tertiary effluent from LMWQCC filters will be taken from the inlet of the chlorine contact tank, prior to chlorination, and diverted to the equalisation tank (if required). Stored water will be pumped to the inlet of the denitrification filter.

4.2.5 Denitrifying Filter

The feed water to the Water Purification Plant must receive additional denitrification prior to the reverse osmosis process in order to achieve the target total nitrogen levels for discharge to the

Cotter Catchment. This will be achieved using a denitrifying filter comprising a deep bed of uniformly graded filter media (sand). Water flows through the filter bed and is dosed with methanol (a carbon source for micro-organisms). Denitrifying micro-organisms are seeded into this process and grow on the filter media converting dissolved nitrates in the water to nitrogen gas which is then lost to the atmosphere. The filter is regularly backwashed to remove excess biological growth. Backwash water is returned to the LMWQCC plant for reprocessing. The denitrified water then passes to the micro-strainers. Water leaving the denitrifying filter is dosed with chemicals (ammonia and sodium hypochlorite) to form chloramines. Chloramination prevents biological growth in the microfiltration feed tank and on the surface of downstream process equipment.

4.2.6 Membrane Filtration Feed Tank

The feed tank is located immediately before the membrane system. Its main function is to provide buffering storage capacity between systems to even out flow variations and to allow maintenance to be carried out without interrupting the downstream processes.

4.2.7 Micro-strainers

The micro-strainers are required to protect the downstream membranes from fouling by foreign materials such as hair, fibre, and other particles that may impair their performance or damage membrane fibres.

4.2.8 Membrane Filtration

The purpose of the membrane filtration system (either microfiltration or ultrafiltration) is to remove sub-micron particles including bacteria, large colloids and other suspended solids to improve the performance of the downstream reverse osmosis process, by reducing fouling and minimising the chemical cleaning requirements. The membrane filtration system is made up of microporous membranes with typical pore sizes ranging from about 0.2 down to 0.04 microns (µm, 10^{-6}m). Studies indicate that 99.99% removal of Giardia cysts and Cryptosporidium oocysts can be readily achieved in a properly maintained membrane system. Viruses, however, are more likely to pass this barrier due to their small size. Membrane systems require regular cleaning to maintain economic performance. Clean-in-place systems will be provided. These are automated to safeguard the membranes and simplify plant operation. Capability will exist to divert water from the membrane filtration process to the inlet of LMWQCC if water quality is compromised.

4.2.9 Reverse Osmosis

A storage tank to store the membrane filtration water will be provided to balance flows between the multiple batch microfiltration process and the continuous reverse osmosis process. Oxidation-Reduction potential of the water is monitored and sodium bisulphite or sulphur dioxide is dosed to ensure that no free chlorine can be introduced to the reverse osmosis membranes. The name reverse osmosis derives from the fact that pressure is used to oppose the natural process of osmosis, as used by cellular organisms to absorb and transport water. The process utilises membranes with the ability to reject dissolved solids including ionised salts and organic molecules of relatively low molecular weight. The mechanism of reverse osmosis is size exclusion, or sieving, in the angstrom size range, and also by chemical interactions at the molecular level. Thus, greater than 99% of sodium ions are rejected, while water and some other small molecules can pass through into the water produced. Large molecules and pathogens, such as viruses and oocysts, show minimum 99.9999% removal in a properly maintained system. Pharmaceutical and estrogenic hormone removal from water generally indicates no quantifiable detections. Reverse osmosis membranes are also effective in reducing disinfection-by-products. Reverse osmosis has been in use for 40 years and is a mature technology. The reverse osmosis system will likely be a three stage system with the concentrate from the first stage being processed by a second set of membranes and the concentrate from the second stage being processed by a third set of membranes. This will produce a water quality with a total dissolved solids level of less than 50 mg/L. The extracted salts will be treated further or returned to LMWQCC for discharge. Capability will exist to divert water from the reverse osmosis processes to the inlet of LMWQCC if water quality is considered compromised.

4.2.10 Advanced Oxidation

The water from the reverse osmosis process will be subjected to an advanced oxidation process. Advanced oxidation processes make use of chemical oxidants to remove both organic and oxidisable inorganic compounds. The processes can oxidise organic compounds to carbon dioxide and water and oxides of other elements, termed “mineralisation”. It is proposed to use intense ultraviolet radiation in combination with hydrogen peroxide. When properly operated and maintained this ensures the destruction of complex organic molecules and minimises the potential for disinfection by-product formation. Capability will exist to divert water from the advanced oxidation processes to the inlet of LMWQCC if water quality is considered compromised.

4.2.11 Carbon Dioxide Stripping

After UV disinfection, the water will be passed through a packed-tower with counter-current air flow to strip dissolved carbon dioxide from the water.

4.2.12 Product Water Storage

Final purified water will be provided stored to enable on line monitoring of water quality and flow balancing prior to pumping to the Cotter Catchment.

4.2.13 Purified Water Pumping to the Cotter Catchment

Purified water from the product water storage will be pumped to the Cotter Catchment via a buried pipeline. The pipeline, approximately 10km in length, will cross the Molonglo River to the west of LMWQCC and then approximately follow the alignment of Uriarra Road to the Cotter Catchment boundary near Bullock Paddock Flat. Water could discharge from the pipeline to a wetland facility.

4.2.14 Wetlands

The primary function of a wetland facility is to stabilise the temperature of the purified water prior to release to the Cotter Reservoir, minimising the differential in water temperature between the purified water and the Cotter Reservoir. In addition the wetland would provide an additional barrier of natural treatment processes for removal of trace amounts of organic materials and provide further polishing of removal of nitrates from the water. The wetland area is estimated to be in the order of 10-20 hectares for a 25ML/day plant.

4.3 Commissioning Phase

A key focus for the scheme will be commissioning an extensive proving period for the plant prior to supply of the first water Cotter Catchment. A commissioning plan for the Water Purification

Plant will be developed during the design and construction period. Prior to commissioning, each individual process and equipment elements will need to meet performance and operational requirements. During commissioning the plant will be operated over the full range of its operating specification to demonstrate reliable operation and that it meets water quality performance measures. During this period treated water would be diverted to the LMWQCC. Only after successfully meeting the requirements of the commissioning plan will the plant commence delivery of water to the Cotter Catchment.

4.4 Brine Management and Disposal

The dual membrane plant will produce a brine (salt solution) reject stream. Approximately 10 tonnes per day (dry weight) of salt will be produced by the 25 ML/day plant. It is likely this could be returned with effluent from LMWQCC to the Molonglo River with minimal environmental impact. If this was not done, or a plant larger than 25 ML/day was commissioned then other treatment processes might be required; options include:

- physical/chemical treatment at the site to reduce the water content followed by

  further drying using evaporation ponds and natural drying or mechanical misters; and

  pumping the brine waste to the coast for ocean/estuary disposal; or

- physical/chemical treatment at the site to produce a solid salt product followed by:

  landfilling of solid salt product;

  disposal of solid salt product to the ocean via an existing sewage treatment plant outfall; and

  beneficial reuse in industry.

All options involving the concentration of the brine solution, coupled with offsite transport and evaporation and/or crystallisation of salt, are highly energy intensive. Further investigations are required to determine the optimum brine management procedure.

4.5 Energy

The proposed Water Purification Scheme will require an increase in electrical power supply to the LMWQCC site. The upgrade will require approximately 9.4 MW of load for a 50 ML/day dual membrane plant, including power for delivery of the water to the wetlands or Cotter Catchment (estimated to be in the order of 2 MW). This assumes that brine management consists of the release of brine solution to the Molonglo River for the first 25 ML/day of capacity and for Zero Liquid Discharge to produce a dry salt product from the remaining 25 ML/day capacity.

4.6 Cost Estimates

The estimated capital costs for the 25 ML/day, 50 ML/day and 75 ML/day dual membrane plants are shown in the table below. Estimated costs include costs for the denitrification facility, pump station and pipeline for transfer of water to the Cotter Catchment and for a wetland facility sized for temperature stabilisation. All estimates include an allowance of $10 million for the upgrade of the power supply to LMWQCC. Further work will be undertaken during 2007 to identify if the high cost of salt management can be reduced through examining other options.

Table 4.2: Capital Cost Estimate

Plant Capacity	Capital Cost $M	Comments
25 ML/day Plant	181	Brine discharge to river
25 ML/day Plant	225	Brine crystallisation
50 ML/day Plant	230	Brine discharge to river
50 ML/day Plant	274	Brine discharge to river for first 25 ML/day and brine crystallisation for brine from the remaining 25 ML/day
75 ML/day Plant	285*	Brine discharge to river
75 ML/day Plant	367*	Brine discharge to river for first 25 ML/day and brine crystallisation for brine from the remaining 50 ML/day

* 25 & 50 ML/day capacity plants based on 750 diameter pipeline. 75 ML/day plant based on 900 diameter pipeline
Note: All estimates include an allowance of $10 million for the upgrade of the power supply to LMWQCC

4.7 Hazard Analysis and Critical Control Point (HACCP) Plan

In implementing the proposed Water Purification Plant a third party certified Hazard Analysis and Critical Control Point (HACCP) plan would be implemented. The HACCP plan will be based on the 12 elements of the draft Australian Guidelines for Recycled Water – Augmentation of Potable Supplies and equivalent Framework for Management of drinking water detailed in the Australian Drinking Water Guidelines (2004).

At present the water supply for Canberra is covered by a HACCP plan covering the collection of water in catchments, water treatment plants and through to water delivery to customers' taps. This plan is now being reviewed and updated to cover the sewerage collection and existing treatment systems (including existing effluent reuse projects). A critical element of the HACCP plan now under review and development relates to the assessment of the sewerage collection system, with particular focus on trade and industrial waste discharges to the sewer network and the identification of critical control points within this system. The early objectives of this work are to gain greater knowledge of trade and industrial waste discharges to the sewer network, to undertake detailed risk assessment on these and to commence early water monitoring at these control points. A HACCP plan for the water purification scheme would include the following elements:

- detailed and regular risk assessments;
- sample and Monitoring Programs;
- operations and Maintenance Management System Development and Documentation;
- systems Management and Operator Training; and
- process Monitoring during Operation.

An outline of these elements is provided in **Appendix D**.

4.8 Expert Auditing and Advisory Panel

ACTEW plans to establish an Expert Auditing and Advisory Panel for the Water Purification Scheme along similar lines with those established by the Singapore Public Utilities Board, the Orange County Water District and the Western Corridor project in Queensland. The membership of the Panel will be established from external experts. The Panel would be established prior to commencement of detailed design and have the following key roles:

- to advise ACTEW on key process design selection issues, including water quality objectives, process selection, etc;
- to advise on the design and construction development and pilot/demonstration plant performance information, including commenting on key design modifications;
- to advise on the commissioning plans and sampling programs, including results from these programs;
- to advise on acceptance of the plant at the end of the commissioning period;
- to undertake regular 3-6 monthly reviews of the plant's performance, including operations and maintenance plans and non conformance reports and monitoring program data and independently report on these to the ACTEW Managing Director, Chairman and the Chief Health Officer; and
- to provide a source of expert advice and information on the international development of indirect potable use water technologies and of key issues arising in the use of indirect potable use water technologies from a public health perspective.

5 Tantangara Transfer

5.1 Description of the Proposal

Several Tantangara water transfer options were assessed as a part of the *Future Water Options* reports published in 2005 (ACTEW, 2005d). The Tantangara water transfer involves the following main actions:

- purchasing water from irrigators downstream of the ACT;
- storing purchased water in Tantangara Reservoir (or Eucumbene Reservoir); and
- transporting that water from Tantangara to the ACT.

Under this option, ACT would buy water from irrigators in New South Wales, Victoria or South Australia and entering into a commercial agreement with Snowy Hydro for storage and transfer of water to the ACT. In effect the ACT would lease access to Snowy Hydro assets rather than building new structures. When ACT needed water, Tantangara Dam releases would flow down the Murrumbidgee River for transfer to the ACT via pipes and tunnels about 20 to 30 km to Corin Reservoir or via a pipe to Googong Reservoir near Angle Crossing, 100 km downstream.

5.2 Alternatives

Previous studies show that most of the proposed tunnel and pipe alternatives could severely affect the environment through discharges of water at the top of the Cotter Catchment – a significant wilderness area. Heritage values in some of the region's more culturally sensitive areas would also be at risk. Social and amenity values could be compromised by many of the pipe and tunnel alternatives where pipelines and infrastructure intruded into highly valued public and private lands.

These considerations result in the "long tunnel" and "Murrumbidgee River flow" as the final two alternatives examined (ACTEW, 2005d). In the first alternative, a 20km-long tunnel would link the Murrumbidgee River just outside Kosciuszko National Park, to the Cotter River, three kilometres upstream from Corin Reservoir's headwaters. Water flowing down the tunnel could power a hydro plant at the Cotter end to offset costs. The second alternative previously examined is a pipeline connecting the Murrumbidgee River to Googong Reservoir. This alternative has comparatively lower risks and represents the most effective alternative of the Tantangara transfer.

The Tantangara transfer would require approvals and consent processes that include NSW, Victoria, ACT and Commonwealth jurisdictions. Local, state and federal laws, regulations, policies, and protocols would apply to environmental, heritage, land use, and economic elements in construction and operation. These would likely include participation within the Murray Darling Basin Water Cap, its associated trading scheme and operating rules that govern the Cap. Documentation and approval processes would accompany an environmental impact assessment that could be coordinated between jurisdictions complimented by integrated approvals and their attached conditions. Sustainability concepts embedded within these assessment and approval processes also feature in ACTEW's corporate controls and legal obligations. It is possible these negotiations could take considerable time.

There are two possible water-trading processes for the Tantangara water transfer. In the first process, purchased NSW water could be stored in Tantangara Dam for release to the ACT by

Snowy Hydro. This involves some risks because the water is largely controlled by NSW and cannot be guaranteed for delivery to ACT, unless appropriate arrangements can be formalised. Alternatively, the Territory's participation in the Cap would enable it to purchase Cap Water for the ACT. This lowers the sovereignty risk by transferring Cap Water control from NSW to the ACT. Nevertheless, neither process can absolutely guarantee water delivery because in an extreme drought the ACT would share water entitlements with other licence holders.

ACTEW can purchase (and hold) NSW water entitlements from downstream users in the following ways:

- purchase entitlements via a water broker;
- purchase an irrigation property with its attached water entitlement;
- purchase by electronic exchanges; and
- bilateral negotiation.

If ACT participated in the Murray Darling Basin Cap it could purchase Cap Water from a variety of NSW, Victorian or South Australian sources. The Territory could then transfer that water right and permanently hold the water rights under ACT control. In other words, the purchase would be in addition to the ACT Cap while reducing the seller's Cap. Subject to negotiation with NSW and Snowy Hydro, this water could be stored within the Tantangara reservoir but negotiations for storage and release may be subject to a NSW environmental flows strategy. An ACTEW purchase of a NSW general security water entitlement may need conversion to a high security entitlement to give greater security of delivery. Converting entitlements and their respective conversion rates are subject to:

- NSW Government and Minister's approval of conversion rates for water trading;
- If conversion to ACT Cap Water then:
  a. ACT ratification of the National Water Initiative under a proposed trading regime; and
  b. participation by ACT in the Murray Darling Basin Cap to convert NSW entitlements to ACT entitlements under a proposed trading regime, would be also required.

If the ACT participated in the Cap through a proposed trading regime the conversion rates would be determined through endorsed schedules of the Murray Darling Basin Agreement. It is possible that even with high security entitlements under ACT control the Territory may not have complete access to its water. This situation could occur when extreme drought conditions left a shortfall of high security water to be spread amongst competing high security users – as is the situation in 2007. Under this situation, water access would be rationed between users. The NSW Minister currently must approve a water transfer from the lower Murrumbidgee (covered by the Murrumbidgee Water Sharing Plan) to Tantangara Reservoir because it lies outside the Water Sharing Plan boundary. NSW controls water entitlement volumes in Snowy catchments but Snowy Hydro has obligations and rights in the collection, storage and timing of water releases. Under the Corporatisation Act, Snowy Hydro must consider requests for water but Snowy Hydro must also release a minimum 1,026 GL annually for the Murrumbidgee (via the Tumut River). Snowy Hydro may also release discretionary volumes (above target water) averaging about 254 GL per year.

Under the Snowy Hydro Corporatisation Act 1997 [NSW] extractive entitlements to water stored in the Snowy Scheme can only be granted by the NSW Water Ministerial Corporation. The Act enables Snowy Hydro to charge a fee for taking extractive water that can either be negotiated with the extractor or determined by the NSW Water Ministerial Corporation. The key negotiating issue for the ACT is the opportunity cost of foregone electricity from:

- water taken (volumes);
- whether the water is below or above target water;
- impacts on Tantangara Dam operations particularly in relation to spills and losses;
- the value of Snowy Hydro's power in the National Electricity Market (NEM) or in contracts with distributors and other NEM parties; and
- value of renewable energy certificates for that part of Snowy Hydro's generation eligible under the Renewable Energy (Electricity) Act.

Final negotiations and agreements involving Snowy Hydro and NSW would need to consider factors such as off-take arrangements, pipeline design, identified risks and liability.

5.3 Water Resources and Quality

Around 300 GL average yearly flow is potentially available from Tantangara Reservoir. Nearly all of this supply is currently diverted to Lake Eucumbene for Snowy Hydro operations. Hydrological modelling indicates that releases for ACT would occur on average about three to four years each decade. Water quality within Tantangara Reservoir is reasonably high. The catchments' location within Kosciusko National Park provides high water security. A common comment is that Tantangara water would not be available when needed. Over the past several years, irrigators have received some if not all of their allocations. 2007 is the first year where no allocation is contemplated. So even in tough times some water will be available to top up ACT storages and in many years ACTEW will not want to call on any water as ACT storages will have sufficient water.

5.4 Cost Estimates

It is estimated that about $38 million may be spent on purchasing water rights from irrigators in the market but the operating costs will depend upon the agreed commercial arrangements with Snowy Hydro and others as necessary. For the purpose of this report, it is assumed the operating costs would be around $3.4 million each year.

5.5 Conclusions

The Tantangara transfer's main advantage is the lease of existing dams at relatively low cost but the main disadvantage remains one of sovereignty and risk, that is Tantangara water is currently controlled by NSW and Snowy Hydro. The main considerations around this option are still the complexity of the agreements that need to be made, some of which are not in the control of ACTEW or the ACT Government. These complexities mean that considerable time may be required for negotiations. The main risks revolve around the agreement to the ACT Cap and the variations to the Snowy Hydro operating licence. Of the Tantangara alternatives, the proposed Murrumbidgee River flow has comparatively low environmental, social, and heritage impacts, potentially higher environmental benefits and superior flexibility that makes it better value for money. The Tantangara transfer should continue to be pursued with the relevant jurisdictions and authorities over the remainder of 2007.

6 Angle Crossing

6.1 Description of Proposal

Murrumbidgee River water would be pumped from near Angle Crossing via a pipeline to Burra Creek from where it runs by gravity into Googong Reservoir. An alternative is to run the pipeline all the way through to reservoir. The facility has the potential to pump in the order of 100 ML/day or more from the Murrumbidgee River, although its actual pumping rate will depend on flows, extraction rules and pumping protocols.

The Angle Crossing option has undergone considerable analysis (ACTEW, 2005c) but no extraction site has been chosen and the exact pipeline route is yet to be determined, although discussions with Palerang Shire Council indicate a preference for locating the pipe in the road reserve of Williamsdale Rd. The project is feasible from an engineering perspective, there has been independent corroboration of the likely capital cost and regulatory and administrative issues are manageable.

The Angle Crossing option does not require further modifications or additions to the Googong water treatment system as the present level of risk is approximately equal to the water quality levels currently experienced in the Googong system (Water Futures, 2006).

A predictive terrestrial flora and fauna analysis has been undertaken and whilst there is evidence of Aprasis (Pink Tailed Worm Lizard) it not considered an impediment to the program. The proposal of siting the pipeline in the road reserve raises issues of remnant vegetation, common in rural areas. Many significant trees exist in the road reserve which would need to be considered.

Minimum flows in the Murrumbidgee River would need to be maintained which would influence the pumping regime.

Consultation with local residents raised concern about disruptions and road closures during construction. These concerns would need to be addressed. Given that Googong is a populated catchment, consideration would need to be given to discharge points from the proposed pipeline route.

6.2 Planning and Construction

To deliver this proposal would require the following:

- engagement of a consulting engineer and project planner to carry out all design works and preliminary investigations. This will include the identification of the preferred route based on engineering issues, flora, fauna and heritage issues, land owner assessment, and a detailed, construction standard design of the weir, pump station and pipeline;
- negotiation with the NSW Government agencies, the Palerang Shire Council and ACT Government agencies concerning relevant approvals and environmental assessments;
- preparation of appropriate environmental assessment documentation, lodgement of a development application in accordance with ACT and NSW planning statutory requirements. It is likely that up to 12 months will be required to prepare and have approved all necessary documentation; and

- A construction period of up to 20 months is envisaged. Mechanisms for compressing this timeframe, including early ordering of pipe, will be investigated.

Given the above, a likely timeframe from commencement to completion of the Angle Crossing option is approximately two to three years.

6.3 Previous Consideration

ACTEW previously recommended to the ACT Government that planning commence for the Angle Crossing project. ACTEW further advised that a similar outcome could be achieved more quickly by pumping water from the Murrumbidgee River near the Cotter Pump Station so deferring the need for pumping at Angle Crossing. This facility is now in operation, pumping up to 50 ML per day during mid 2007, with pumping capacity now being upgraded to 100 ML per day.

7 Community Consultation

This section summarises the outcomes of the three-month *Water2WATER* community consultation program conducted by ACTEW from March 22 to June 22, 2007. The community consultation program was undertaken to provide the ACT Government with an informed view regarding community attitudes toward the *Water2WATER* proposal as well as other options for the future water supply. The focus of the consultation was on the *Water2WATER* proposal.

7.1 Water2WATER Proposal

Water2WATER was ACTEW's proposal to help further secure the ACT's water supply by purifying Canberra's used water and adding this to the Cotter Reservoir which would also be enlarged. The proposal was developed due to the severe water shortages in the ACT, following near record low inflows to reservoirs in recent years. In 2006 inflows were about 10% of the long term average. The ACT Government requested ACTEW to undertake a community consultation program whilst technical studies for securing the ACT's water supply were completed. The consultation program focused on the ACT and Queanbeyan communities' views and issues related to the Water Purification Scheme and the enlargement of the Cotter Dam. A separate Community Consultation report will be submitted to the ACT Government (ACTEW, 2007).

7.2 Consultation Tools

ACTEW collected views through surveys, the *Water2WATER* Project Office, community meetings and forums, stakeholder meetings, local events and shopping centre displays and via the *Water2WATER* website.

The ACT Government established an Expert Panel on Health, which was Chaired by Emeritus Professor Ian Falconer AO, Hon Visiting Fellow, Pharmacology, Faculty of Medical Sciences, University of Adelaide, Senior Consultant, Cooperative Research Centre for Water Quality and Treatment, and Vice President, Conservation Council of SE Region and ACT.

The Expert Panel was briefed on the community consultation strategy and sent an observer to several of the key activities such as the community forums and community briefings.

7.3 Key issues

During the community consultation program, six key issue areas emerged from the community, each containing a number of sub issues. Two categories emerged: primary issues defined as those that were consistently raised across a number of the tools and secondary issues defined as those that were raised less frequently.

The two primary issues identified were health and planning/other options and the secondary issues identified were cost, environment, quality assurance and government transparency. The following table demonstrates the community's issues of concern and the consultation methods where these issues were identified.

Table 7.1: Summary of issues of concern to the community

Key issues	Random telephone	On-Line survey	Community brief	Stakeholder brief	Community forum	Shopping centres/events	Email	Telephone	Mail	Feedback Forms
Health	x	x	x	x	x	x	x	x	x	x
Removal of hormones, viruses, diseases, pharmaceuticals	x	x	x		x	x	x	x	x	x
Wastes from hospitals		x								x
Drinking sewage, bodily fluids							x	x		x
Planning /other options	x	x	x		x	x	x	x	x	x
Build Tennent Dam		x	x		x	x	x	x	x	x
Demand management	x		x		x					
Rainwater tanks	x					x	x			x
Explore more options					x					
Grey water usage		x				x	x			
Environmental flows		x			x		x	x	x	
Seek water from Tantangara Dam					x					
Desalination		x				x	x	x		
Storm water usage		x			x					x
Too much emphasis on W2W					x					
Timing – urgency to do it now		x					x	x		x
Consideration of population growth			x							
Separate pipes							x			x
Environment		x	x	x	x	x	x	x	x	
Energy required		x				x				
Climate change/global warming		x	x		x	x				
Disposal of salt			x							
Contamination of catchment							x	x	x	
Cost		x	x		x	x				
Increased water prices						x	x	x	x	x

Key issues	Random telephone	On-Line survey	Community brief	Stakeholder brief	Community forum	Shopping centres/events	Email	Telephone	Mail	Feedback Forms
More expensive than other options					x	x	x	x	x	
Quality assurance	x	x				x				
Technical failure	x		x			x	x	x	x	x
Safety standards	x	x								
Human error in operations and maintenance	x				x					
Government transparency		x			x					
Community consultation/education program			x		x		x	x	x	
ACTEW conflict of interest					x					
Govt made up its mind		x								
More information							x	x		
Lack of trust							x			

7.4 Consultation Outcomes

The following are key outcomes of the consultation:

- A Random Telephone Survey, the only statistically valid representation of the community's perceptions, demonstrated that 75% of the community was positive (53%) or conditionally positive (22%) towards the *Water2WATER* proposal.
- More than 3700 direct contacts were made with the project during the consultation period. In addition ACTEW reached the wider community through advertising, the *Water2WATER* website and media coverage.
- The majority of people in contact with the project were positive or conditionally positive about the project. Where they had concerns, these were about health aspects and a desire to see better planning for water security in the ACT.
- There is not widespread community outrage regarding the *Water2WATER* proposal.
- There are some individuals and groups (approximately 820 contacts), particularly those actively involved through community forums, the online survey, telephone, email, and mail, who expressed dissatisfaction with the water purification component of the *Water2WATER* proposal. Their six major issues were:

  health with a focus on removal of drugs and hormones;
  investigation and communication of all water supply/security options;
  environmental factors, particularly energy usage;

cost to the end user;
quality assurance/monitoring; and
community confidence in ACT Government and ACTEW.

- A significant number of individuals and groups (approximately 2300 contacts), typically those who were passively involved through community and stakeholder briefings, shopping centre displays and events, were conditionally supportive of the *Water2WATER* proposal. Where they had concerns, these were similar to the smaller group (approximately 820 contacts).
- There were 620 contacts by people who were neither positive nor negative about the *Water2WATER* proposal; these were classified as neutral.
- There are no significant differences between the ACT and Queanbeyan communities' attitudes toward the *Water2WATER* proposal.

In summary, the ACT and Queanbeyan communities appear to be open to the *Water2WATER* project proceeding, provided the following conditions are met:

- ensuring an adequate response to six major issues raised during the consultation; and
- ensuring that a robust consultation process is a core function of any future planning and approvals process that includes all stakeholder groups.

8 Analysis of Options

8.1 Climate and Hydrology

Planning for future water supply security is always uncertain, even more so under conditions where more variability is likely in future climate. The ACT has 133 years of recorded climate data, which covers three major droughts including the present drought. For this report, three climate scenarios have been examined.

Scenario 1: Consistent with the approach taken in the *Future Water Options* reports, including CSIRO climate change predictions, future climate change impacts were simulated by extending the 133 years of observed weather by standard hydrological processes and adjusting this by CSIRO's most pessimistic climate projection for ACT in the year 2030 (Bates et al, 2003);

Scenario 2: repetition of the last six-years of the current drought; and

Scenario 3: repetition of 2006 climate.

The Scenario 1 climate projection approach is similar to that taken in the *Future Water Options* series of reports and includes more frequent and more severe droughts than ACT has experienced to date, however, this review includes two significant differences: (i) Googong Dam modelled inflows are reduced to reflect the recently observed low inflows, and (ii) modelling commences at the low water storage levels of April 2007. On average, this future climate reproduces the observed ACT climate of the last 10 years. This represents an almost 50% reduction from the long-term average dam inflows. Increases in climate variability are a feature of the future climate predictions. The climate of the past six years represents about a 60% decline in inflows to the storages, whereas the 2006 climate represents ongoing annual inflows in the order of 26 GL.

The analysis carried out (ActewAGL 2007) indicated that no individual option would provide full recovery from the current drought under the average future climate conditions until around 2014. Even the best combination of options for drought recovery is likely to take at least until around 2012 to reduce the probability of drought restrictions to acceptable levels. In conjunction with an enlarged Cotter Dam, a variety of combinations of options has been examined including the *Water2WATER* combinations, pumping from Murrumbidgee River to Googong Reservoir storage (the Angle Crossing option) and transfer of water into Tantangara Reservoir then to the ACT.

8.2 Economic Benefit Approach

The net economic benefit approach follows from the underlying philosophy of the WSAA approach (Erlanger P and Neal B 2005). This approach was applied in the *Future Water Options* report (CIE, 2005) that has been updated (CIE, 2007). The net economic benefit of implementing each scenario is calculated by deducting the capital and operating costs of each supply option from the gross economic benefit to the community arising from any reduced time in drought restrictions. This approach was applied to the future climate scenario 1. The other climate scenarios are presented in terms of storage recovery.

8.3 Gross economic benefits

In the *Future Water Options* project, the annual cost of time in each level of drought restrictions was estimated from various sources; including international research of similar economic studies, an ACT choice modelling study undertaken in 1997 and an ACTEW willingness-to-pay survey undertaken in 2003 (CIE, 2005). These estimates are updated in this study to take into account the introduction of the Permanent Water Conservation Measures, the new drought restriction scheme and to reflect current prices and incomes. In addition, an adjustment was made to improve the calculation of the total cost of restrictions to reflect a *"risk aversion to Stage 4 restrictions"*. In the *Future Water Options* project, the total cost of restrictions under a particular option was taken to be equal to the probability of each stage of restrictions multiplied by the cost of that stage of restrictions and summed across all stages. This essentially assumed that the community was *"risk neutral"* with regards to the probabilities of different types of restrictions.

Because Stage 4 is considerably more severe than lesser stages and is indicative of supply insecurity, there is a strong view that Level 4 restrictions should only be applied in exceptional circumstances. To reflect this view, a risk aversion factor is applied to the Stage 4 component of the total cost of restrictions. This factor, estimated at 3.5, is multiplied by the cost of Stage 4 restrictions. The effect of this change is to provide increased economic benefits from options that are more effective at reducing the probability of Stage 4 restrictions. The costs of restrictions for the non-potable reuse option have been adjusted downwards by a small amount to reflect the impact of maintaining recreational opportunities in ACT parks and sports fields.

Table 8.1: Estimated community costs of restrictions for 2007

Drought Restriction Stage	Cost of Restrictions for 2007
Stage 1	\$5.6 M
Stage 2	\$44.9 M
Stage 3	\$62.1 M
Stage 4	\$139.6 M
Effective Stage 4 (adjusted by 3.5)	\$488.5 M

8.4 Capital and Operating Costs

The benefits of each option are generally associated with cost penalties comprising new capital costs and ongoing operating costs – i.e. energy costs for pumping, water treatment costs and other miscellaneous operating costs. These capital and operating costs are estimated based on historical data and current prices, however costs associated with environmental impacts are often much more difficult to quantify. While environmental impacts are considered they have not been costed in this assessment. The costs associated with non-infrastructure options, such as the Tantangara transfer, are related to the annual opportunity costs of that option over the planning period and converted back to an equivalent capital cost. Model predictions of supply sources and unit operating costs are used to estimate the operating cost for each option. Further reading on the economic analysis can be found in CIE 2007 and ActewAGL 2007.

8.5 Future Water Demand

If future climate was similar to 2006, the unrestricted demand for water (i.e. free of drought restrictions) will continue at just above 70 GL/yr. The red shaded area shows an estimate of climate similar to 2006, whereas the orange shows climate similar to that of the past six years.

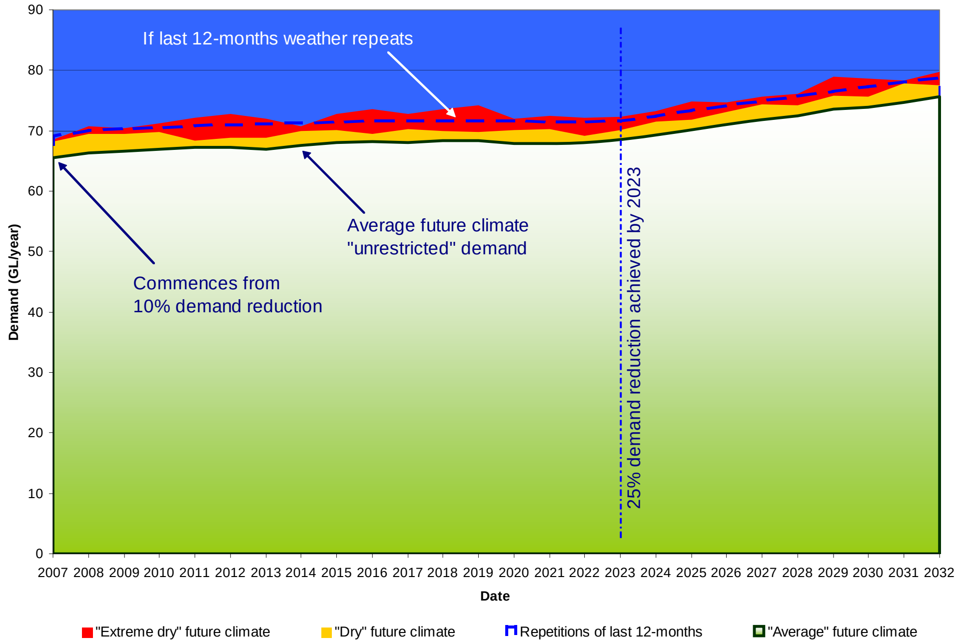


Figure 8:1: Future Water Demand

8.6 Basis of Comparison of Options

Ten individual options have been examined including an enlarged Cotter Dam, a large Tennent Dam, a smaller Tennent Dam, increased pumping from the Murrumbidgee River, water releases from Snowy Hydro's Tantangara Dam, three sizes of a water purification plant scheme, extended non-potable reuse for irrigation purposes and bringing forward most of the Government's *Think Water Act Water* consumption reduction target to 2011.

Option performance has been assessed by two primary indicators:

- the probability that drought restrictions will be needed in the future, and
- the net economic benefit to the community.

Net economic benefits are the gross community benefits expected from any reduced probability of drought restrictions, less the capital and operating costs of implementing that option. The costs of restrictions are quantified following review of similar economic assessments (CIE, 2005; ActewAGL, 2007). Other performance considerations include: the average increase in household water bills, the level of greenhouse gas emissions and future storage predictions.

8.7 Results for Climate Scenario 1

Modelling of the individual options reveals that if only one option was implemented, then recovery from the current drought is likely to be protracted to around 2014. More than one option should therefore be implemented. The 50 ML/day water purification plant by itself achieves and sustains an acceptably low probability of Stage 4 restrictions; however the performance of the 25 ML/day water purification plant is lower.

An enlarged Cotter Dam provides the greatest net economic benefit, more than a Tennent Dam, and is more able to maintain a positive benefit under future climate conditions. Earlier assessments also show the Tennent Dam has greater potential for impediment due to planning, environmental, social and community issues than an enlarged Cotter Dam. The Tennent catchment has been observed to be less resilient in maintaining river flows during the current drought than the Cotter Catchment (see Figure 8.2).

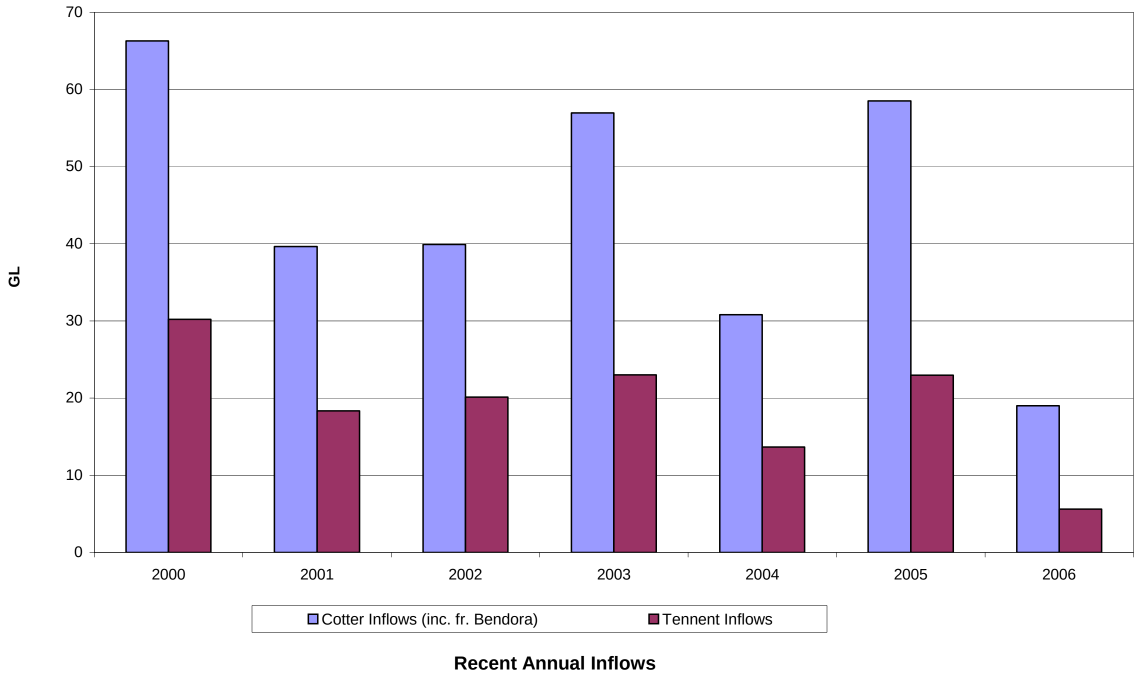


Figure 8.2: Annual inflows to Cotter and Tennent

In summary, enlarging Cotter Dam is preferred because it delivers similar performance with much lower cost and lower risk.

8.7.1 Combinations of Options under Climate Scenario 1

Eight combinations of *Future Water Options* have been examined. All combinations are based on an enlarged Cotter Dam, in combination with the water purification plant (either 25 ML/day or 50 ML/day) and/or with increased pumping from the Murrumbidgee River at Lower Cotter or Angle Crossing, with and without Tantangara Dam releases.

Combining an enlarged Cotter Dam with the larger water purification plant reduces time spent in restrictions; but although its net economic benefit remains positive, it is reduced from that of the Cotter Dam alone. Under this climate scenario, combining the enlarged Cotter Dam with a 70 ML/day increase in pumping from the Murrumbidgee River at Angle Crossing to Googong Reservoir, with the 80 ML/day at Cotter, further reduces the time spent in restrictions. Adding to this the Tantangara transfer provides further reduced time in restrictions (see Figure 8.3). A summary of the options is provided in **Appendix D**.

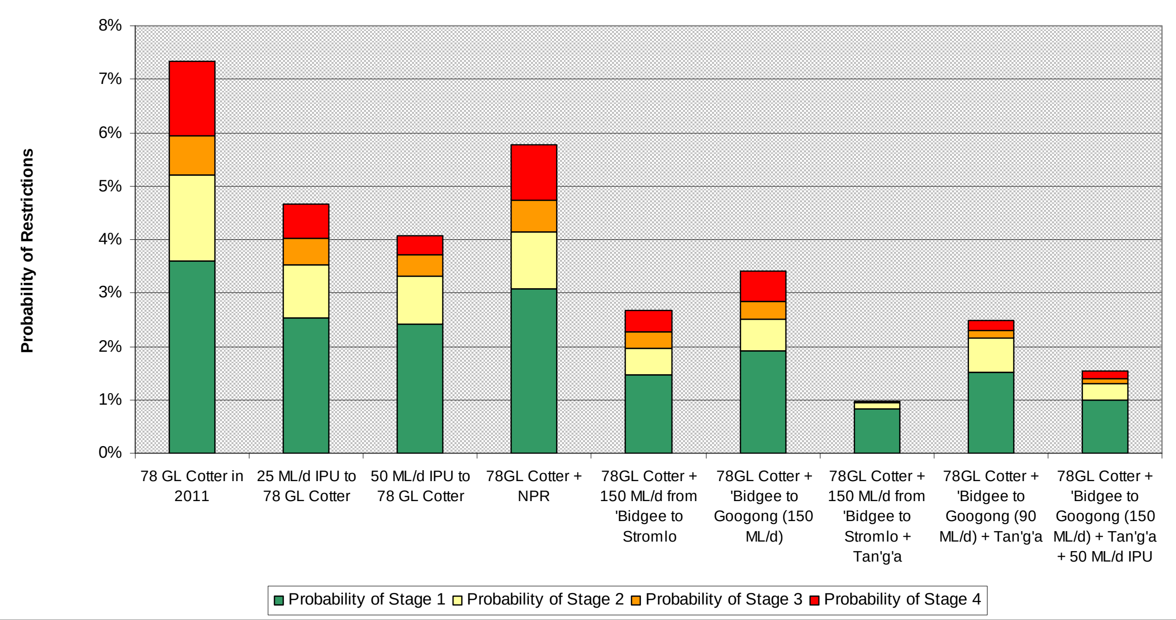


Figure 8.3: Combined options - overall probability of restrictions

Observation and modelling shows there is sufficient water flowing down the Murrumbidgee River to make the increased Murrumbidgee River pumping options feasible, assuming 2030 climate. Adding Tantangara releases can provide Murrumbidgee River pumping with even greater security of supply through more severe periods of drought. However, this lowers the net economic benefit (see Figure 8.4). The Tantangara option is still under development and has potential for improved performance.

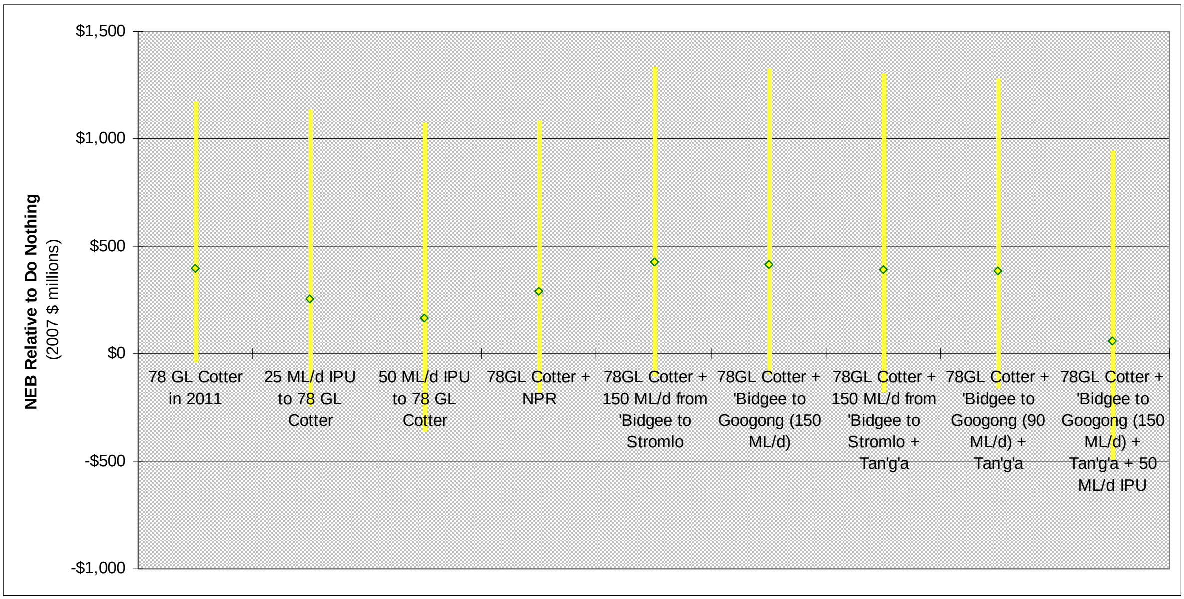


Figure 8.4: Net economic benefit confidence limits for climate scenario 1.

8.7.2 Increases to Water Bills

The average annual household water bill (based on 250 KL per year) is expected to increase by around $70 per year for an enlarged Cotter Dam or $100 per year if Murrumbidgee River pumping is included. This compares with an increase of around $250 per year for an enlarged Cotter Dam combined with the 50ML/day water purification plant.

8.8 Scenario 2: Repetition of the Last Six Years Climate

The increase in variability in the ACT's climate is becoming difficult to predict and model. In light of the significant changes in inflows during the last six years, modelling has also been carried out to ascertain what additional infrastructure might be needed if the future climate was similar. In the event the last six-years of the current drought represents the future changed ACT climate, there is still expected to be sufficient water available to further secure ACT's water supply. In this climate analysis, storage levels recover over time. All options, except "do nothing", result in avoiding restrictions for the duration of the analysis – until 2032 (see Figure 8.5).

This modelling also shows (see pale blue and yellow lines) increased pumping from the Murrumbidgee River speeds drought recovery and keeps storages at the highest level. It also shows how the Tantangara transfer, when teamed with increased Murrumbidgee pumping, is the best performing option in the early stages of recovery, assuming it can be implemented in the timeframe assumed in the modelling. This analysis reinforces the need to increase pumping from the Murrumbidgee River at the Cotter Pump Station and/or with the Angle Crossing option including the Tantangara transfer. The analysis also suggests that if the Tantangara transfer cannot be delivered then the water purification plant provides improved performance over the enlarged Cotter Dam only (see the dark blue line in Figure 8.5).

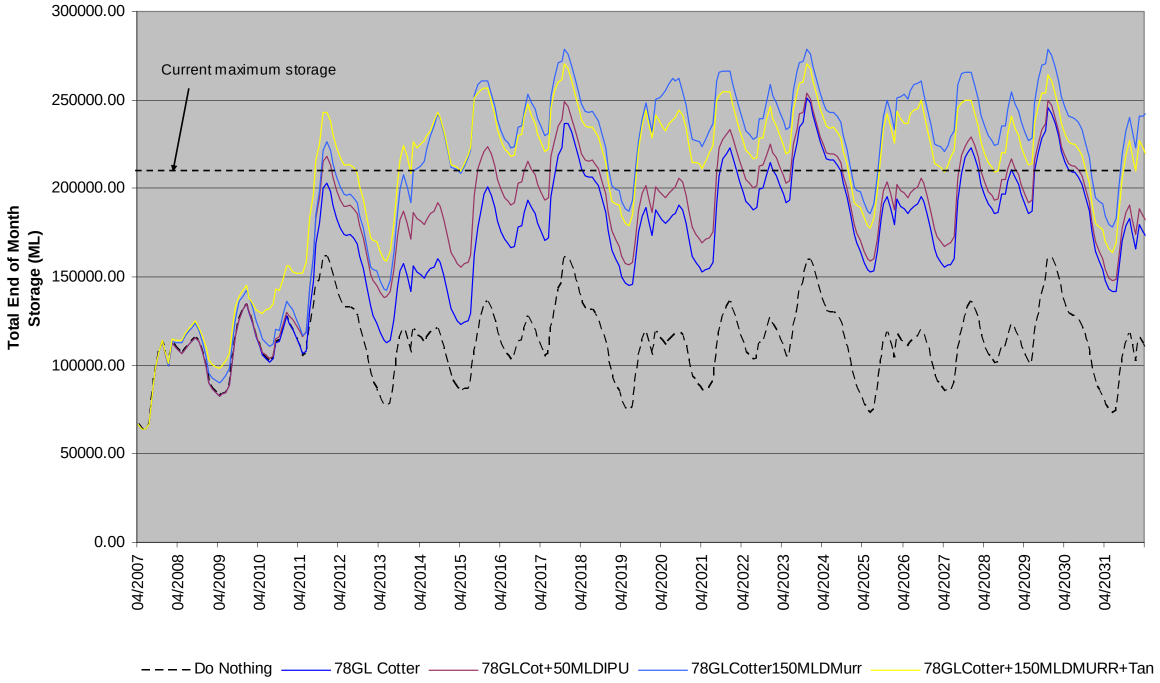


Figure 8.5: Predicted storage levels if the last six-years of drought continues

8.9 Scenario 3: Repetition of 2006 Climate

If the climate experienced in 2006 is typical of the future ACT climate, permanent Stage 4 restrictions are expected unless all feasible options – enlarged Cotter Dam, the large water purification plant, increased Murrumbidgee River pumping and Tantangara Dam releases are implemented as soon as practical. Even then it will take some years before restrictions are no longer required (shown by the yellow and pink lines in Figure 8.6). This also shows that the water purification plant provides the better performance in the longer term by maintaining a higher level of storage (see the pink line in Figure 8.6).

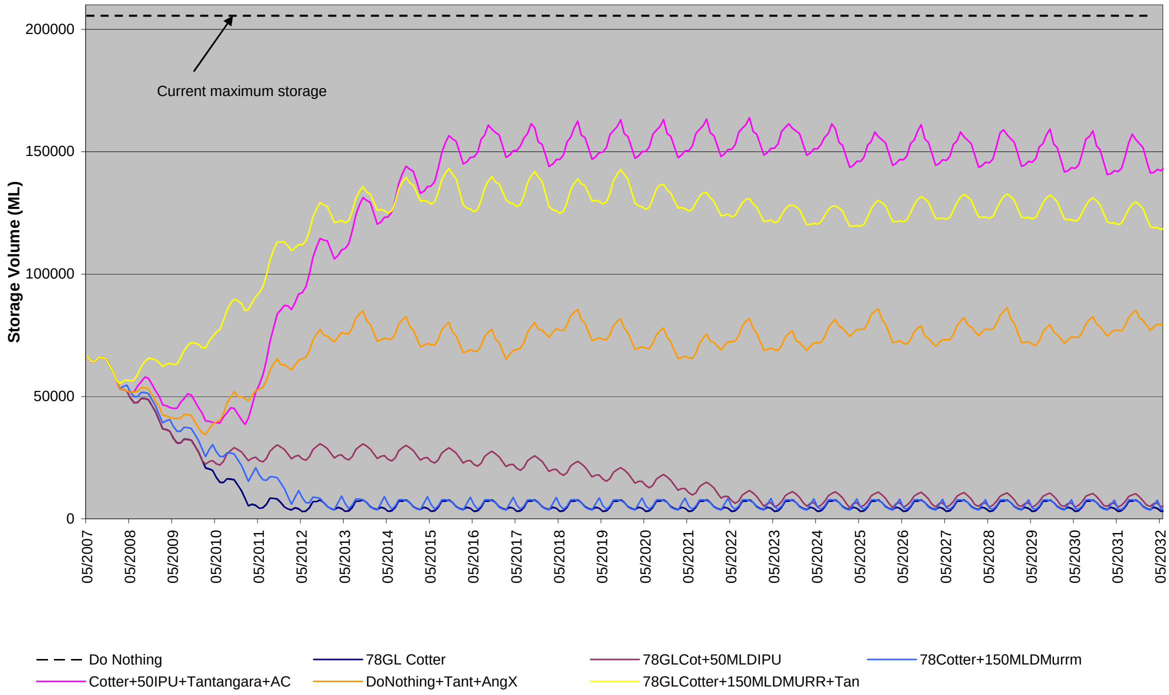


Figure 8.6: Predicted storage levels if the last 12-months of drought continues

If the options proposed above are implemented and can all be made to work as modelled, then Canberra could remain out of restrictions, even if 2006 weather is continuously repeated (see Figure 8.7).

In the longer-term, additional options such as Tennent Dam or other yet to be considered options will be required to ensure water supply security.

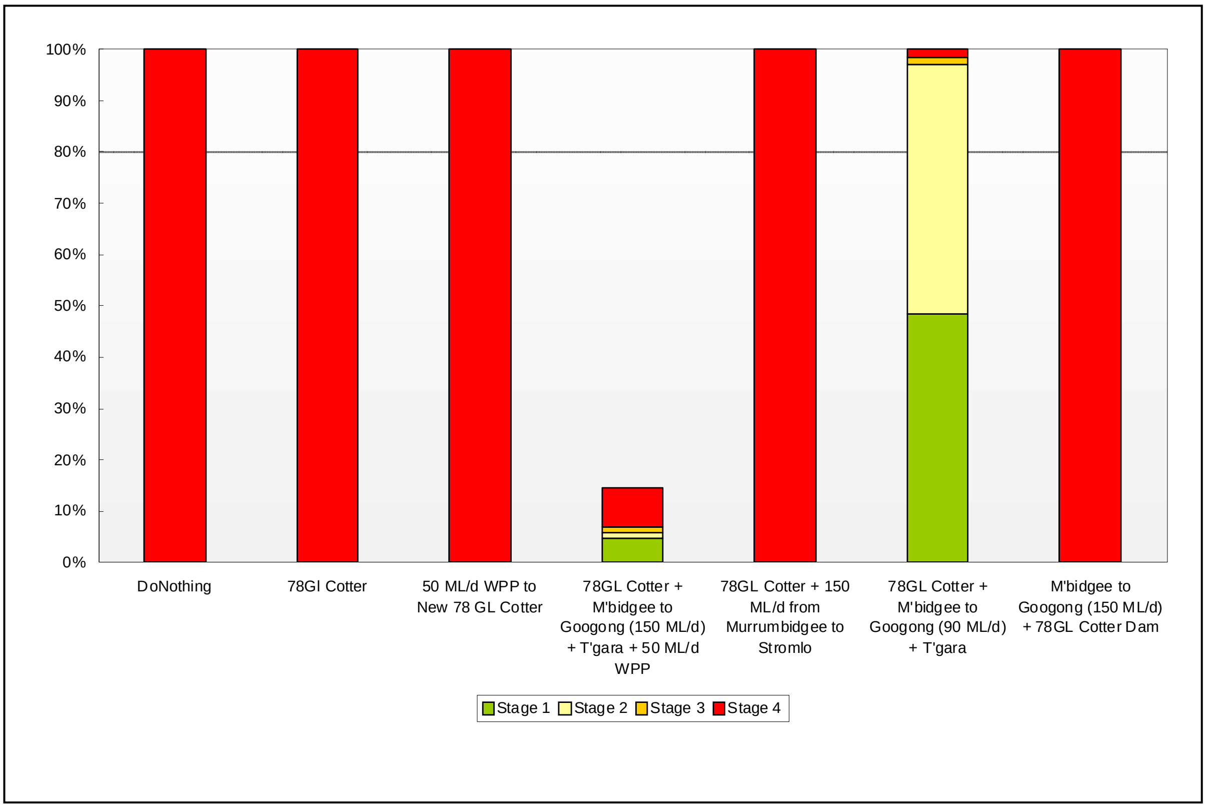


Figure 8.7: Time in restrictions under repeated 2006 climate

8.10 Green House Gas Offsets

All of the projects being considered in this report, together with recent structures that have been built will contribute to increased green house gas emissions. Typically, water utilities are taking the approach to examine ways to offset such emissions. ACTEW, too, is examining these options. Typically green house gas offsets can be through sequestration, such as planting appropriate trees to store carbon. Building new renewable generation capacity such as wind farms or solar power or by the purchase of Green Power are some of the options available. Once the preferred options have been agreed by the ACT Government, ACTEW will determine how to offset the increase in green house gases.

Green energy is produced from clean, renewable sources that don't harm the environment. It's more expensive than energy from fossil fuel alternatives, but fossil fuel energy doesn't take into account such hidden costs as resource depletion, pollution and the impact on climate change. Green energy is renewable energy from sources that cannot be depleted or can be replaced such as wind, solar, biomass and hydro. Renewable sources such as these will always be available and are essentially non-polluting.

Reducing greenhouse gas emissions is an important part of actions taken by businesses to improve environmental performance. Planting trees or investing in forest sink emission offsets can be an effective way to reduce emissions of greenhouse gases into the atmosphere, while potentially contributing to Australia's other environmental and economic goals. Trees and other plants take up (sequester) carbon dioxide from the atmosphere as they grow, through the process of photosynthesis. This decreases the concentration of CO_2 in the atmosphere and helps reduce the greenhouse effect. Trees use the sequestered carbon to grow leaves, stems, bark and roots. Where a forest sink is established as an emissions offset, the amount of carbon sequestered over time needs to be estimated. Australia's national approach to carbon accounting for forest sinks involves estimating annually the amount of carbon added to, or lost from, a forest's carbon stocks. Predictions of carbon sink performance can be developed before a forest is established or while it is growing (Commonwealth of Australia, 2006).

The operating costs presented in this report include a carbon abatement cost rising from $10 per tonne in 2007 to $30 per tonne over 30 years.

9 Statutory Planning and Legislation

The Planning and Development Bill was introduced to the ACT Legislative Assembly in December 2006. ACTPLA is currently working towards an implementation date of late 2007, however there is a possibility that this could spill into early 2008. Associated with the new Act are a series of schedules and regulations that have not yet been drafted. It is expected that recommendations from this report will be assessed under the new Act. Development applications lodged under the current Land Planning and Environment Act (before the new Act is implemented) would be assessed under the old Act. Alternatively, the ACT Government may choose to enact a piece of specific purpose legislation once recommendations are agreed.

9.1 Commonwealth Legislation and Policy

The two components of *Water2WATER* will trigger the requirement for a referral to the Commonwealth Minister for Environment and Water Resources under the EPBC Act. The trigger is brought about by the potential to impact upon two endangered fish species (Trout Cod and Macquarie Perch) that live in the Cotter Reservoir and the potential to impact on items that are listed on the Register of the National Estate (Cotter Pump Station and precinct and Murrumbidgee River corridor).

9.2 Approvals Processes

The required approval process for new infrastructure is assumed to occur under the proposed Planning and Development Bill 2006. Development Applications under the new Act are assessed in one of three streams, Code, Merit or Impact. The Impact Track stream applies to proposals that are:

- listed in a Development Table in the Territory Plan as requiring impact assessment, or
- proposals that would trigger an EIS (Schedule 4, includes a major dam and any proposal with the potential to have a significant impact on a domestic water supply catchment or a water use purpose mentioned in the Territory Plan), or
- projects that are not foreseen in the Development Table, or
- if the Planning Minister, or the Minister for Public Health make a declaration that the Impact Track applies.

It is believed that the projects recommended in this report would be assessed under the Impact Track. All projects assessed under the impact track require an EIS (s126), unless specifically exempted by the Minister. Any Development Application will be referred to Environment ACT, TAMS, the Conservator of Flora and Fauna, ACT Health, Emergency Services Authority and ActewAGL. In addition, applications that may affect a place listed on the Heritage Register will be referred to the Heritage Council and applications on unleased land will be referred to the land custodian.

9.3 Timing and Further Studies

There are certain technical issues that will have to be addressed during the approval process. The accepted method to address such issues is to commission specific studies into technical aspects. For the enlarged Cotter Dam project desktop studies have already been completed on subjects including Cultural Heritage, Fish Impacts, Flora and Fauna, Catchment and Landscape Analysis, and Social Impacts. This body of work provides references and also the confidence that there are no critical constraints on the project proceeding. Similar background work has not been completed for the Water Purification Plant or the Tantangara transfer option and will need to be carried out if the proposal proceeds.

10 Conclusions

Climate change predictions indicate that the climate will become more variable – droughts are likely to be longer and more severe, storms and flood events are likely to increase and temperatures will continue to rise. The magnitude of the increase in variability is unknown. These conditions indicate that further investment in water infrastructure is required to address these changes in climate, but it also indicates that dams are likely to spill more often and new infrastructure designed to meet longer droughts will not be in use for periods when rainfall is high. The reduction in inflows leads to the conclusion that a water source that is less dependent on rainfall in the ACT's (and Googong) catchments should by added to the water supply. The three options available are desalination, a water purification plant or the Tantangara water transfer. While we can hope for the best, ACTEW must prepare for the worst. Once operational and on the basis of current information, the measures recommended in this report should avoid the need to impose Stage 3 restrictions.

Since 2005, ACTEW has built new structures to increase the reliability of supply. New pumps and pipework transfer excess water from the Cotter River storages to Googong Reservoir. About 12 GL of water can be transferred each year via the Mount Stromlo Water Treatment Plant and existing water distribution system. The construction of the Murrumbidgee River pump station at Lower Cotter (instead of Angle Crossing) was predicted to have similar performance to pumping at Angle Crossing but at a lower cost. A new 80 ML/day pump station has been built in the Murrumbidgee River and is now pumping water to the Mount Stromlo Water Treatment Plant. It is planned to further increase pumping capacity from the Murrumbidgee River at Lower Cotter. The Cotter Dam and Cotter Pump Station have been progressively re-introduced into operation as part of the supply system.

The ACT has 133 years of weather data, which covers three major droughts including the current drought. This review uses three climate scenarios to model future water demand and availability:

- *future climate* simulated by extending the 133 years of observed weather by standard hydrological processes and adjusting this by CSIRO's most pessimistic climate projection for the ACT in the year 2030;
- repetition of the last six-years of the current drought; and
- repetition of the 2006 inflows to the storages.

65 to 70GL of water will be needed each year to supply the ACT and Queanbeyan without restrictions until 2023 assuming the Government's water conservation targets are also met.

Ten individual supply options have been examined in detail, including an enlarged Cotter Dam, a large Tennent Dam, a smaller Tennent Dam, increased pumping from the Murrumbidgee River, water releases from Snowy Hydro's Tantangara Dam, three different sized water purification plants, extended non-potable reuse for irrigation purposes and bringing forward most of the Government's *Think Water Act Water* per capita water reduction target to 2011. Modelling of the individual options reveals that if only one option is implemented, recovery from the current drought is likely to be protracted unless there is a return to average rainfall conditions. The performance of the individual options and various combinations are assessed by two indicators:

- the probability of drought restrictions in the future; and

- net economic benefit to the community.

Net economic benefits are the gross community benefits expected from any reduced probability of drought restrictions, less the capital and operating costs of implementing that option.

The results of the modelling under the future climate scenario indicate that an enlarged Cotter Dam provides the greatest net economic benefit because it delivers similar performance to a large Tennent Dam with lower cost and lower risk. Combining the enlarged Cotter Dam with increased pumping from the Murrumbidgee River (up to 150 ML/day) to the Mount Stromlo Water Treatment Plant and at Angle Crossing to Googong Reservoir provides the benefits of more flexibility and greater diversity of supply.

The average annual household water bill (based on 250 KL per year) is expected to increase by around $70 per year for an enlarged Cotter Dam or $100 per year if increased Murrumbidgee River pumping is included. An increase of around $250 per year is predicted for an enlarged Cotter Dam combined with the larger water purification plant. The water purification plant provides little additional benefit under the future climate scenario, but provides additional benefits if climate similar to the recent past is repeated.

If the last six-years of the current drought is representative of the future ACT climate, storage levels are expected to recover if new water supply combinations are implemented. The modelling shows that increased pumping from the Murrumbidgee River speeds drought recovery. The Tantangara transfer, when combined with increased Murrumbidgee River pumping, is the best performing option in the early stages of drought recovery. This analysis reinforces the need to continue with the current pumping from the Murrumbidgee River at the Cotter Pump Station but also add the Angle Crossing option and Tantangara transfer. If the Tantangara transfer cannot be delivered then the water purification plant provides improved performance when added to an enlarged Cotter Dam.

If the climate experienced in 2006 is typical of the future ACT climate, permanent Stage four restrictions are expected unless all feasible options – enlarged Cotter Dam, the large water purification plant, increased Murrumbidgee River pumping at the Cotter and to Googong Reservoir as well as Tantangara releases are implemented as soon as practical. The water purification plant provides better performance in the longer term by maintaining a higher level of storage. Under this scenario and in the longer term options such as the Tennent Dam would be required to ensure water supply security.

While the implementation of additional supply measures may mean capital is invested in structures that are seldom used, this was also the case when Googong Dam was built. The measures recommended in this report, if implemented, will give greater diversity in the sources of water and thereby increasing security. It will mean an increase in the use of the Cotter Catchment and also supplementing water supplies into Googong Reservoir. Even then, the ACT will remain a net exporter of water to NSW. Any new diversions of water to the ACT would be delivered within an ACT Water Cap once agreed with other jurisdictions.

The recommendations in this report are prudent if the cost of restrictions to the regional economy and the concerns of the community were to be addressed – this ‘belts and braces’ approach needs to be adopted.

11 Recommendations

ACTEW recommends the ACT Government agree that ACTEW should:

1. immediately commence the detailed planning and construction of an enlarged Cotter Dam to 78 gigalitres capacity;
2. add to its capacity and operational flexibility to extract water from the Murrumbidgee River by undertaking the work necessary to proceed to construction of a pumping capability near Angle Crossing, which could also be used to transfer additional flows released from Tantangara Dam if such flows become available;
3. obtain additional water from a source not largely dependent on rainfall within the ACT catchments through either;
    a. the Tantangara transfer option; or
    b. the Water Purification Scheme.

ACTEW will advise the ACT Government on which option is preferred for the future by December 2007 after determining whether satisfactory legal and commercial arrangements can be made to transfer water to the ACT via the Tantangara Dam, including the establishment of an ACT Water Cap, and after more detailed examination of the Water Purification Scheme, especially further analysis of salt management options;

4. assess how any additional energy used may be offset through measures such as carbon offsets (such as planting of trees) or renewable energy capacity.

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APPENDICES

Appendix A – Drought Contingency Measures

Murrumbidgee Pump Station

The Murrumbidgee pump station was constructed in 2004 as a drought contingency measure. Water is transferred to the Cotter Pump Station, where it is pumped to the Mount Stromlo WTP. Its capacity is 40 ML/day with two Cotter pumps operating. Installation of a rock weir within the river will improve ability to access Murrumbidgee water. The project is estimated to cost $1.5m.

Cotter Pump Station

Temporary recommissioning of two additional pumps in the Cotter Pump Station has increased reliability to allow pumping from Murrumbidgee and Cotter up to approximately 75 ML/day. A fifth pump at Cotter Pump Station is being recommissioned and a sixth pump may be brought back to operational condition following investigations. This would further increase the reliability of the Cotter Pump Station, and allow time for the full refurbishment of the pumps currently in use, under the CGBT 2 project. The cost to temporarily recommission a fifth and sixth pump is estimated at approximately $1.5m. With an upgraded power supply, six pumps operating full time at Cotter would be able to supply approximately 150 ML/day. ACTEW is reviewing the capability of Mount Stromlo WTP to effectively treat Cotter and Murrumbidgee at higher flow rates.

LMWQCC Recycled Water Pipeline

The pipeline from LMWQCC to provide recycled water to the golf course and winery in Holt needs to be replaced. A recycled water filling point will be constructed to provide a non-potable water source for tankers. Concept design work is complete and final design and planning approval is underway. It is anticipated that the project will take 6 months to complete at a cost of about $2m.

North Canberra Water Reuse Scheme (NCWRS)

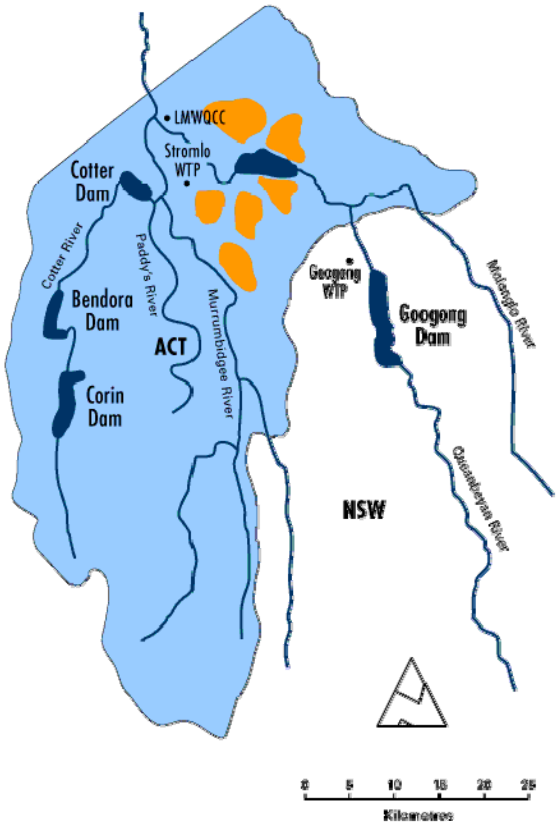
Following a review of the NCWRS in 2006, measures were identified to optimize the performance of the scheme. Additional membrane cartridges are to be installed at Fyshwick to increase the treatment capacity from 20L/s to 40L/s. Operations will be further optimised through some minor works and further improvements to operational procedures. These actions would enable the existing system to be more efficient by reducing potable water top-up to the scheme during summer, by about 100-150 ML/yr. A filling point will also be constructed at Fyshwick to allow customers to access water via tankers. ACTEW is pursuing this project as a priority for this summer. The initial estimate for these works is $2m.

Expansion of NCWRS

To expand NCWRS and connect more customers, additional inflow to the scheme is needed. These could be sourced from either redirecting an existing catchment (such as Kingston) or connecting the Queanbeyan Sewage Treatment Plant outflows through to Fyshwick. ACTEW reviewed the potential to expand NCWRS by sourcing effluent from the Queanbeyan STP in 2006 as part of its investigations into proposals for National Water Commission funding submitted in May 2006. The expanded scheme includes supply to the Parliamentary Triangle, Manuka Oval, Federal Golf Course and other sites. A conservative program was developed at that time showing that these works, and connection of additional customers in north and south Canberra, would take about 3-4 years to complete at a cost of about $30m. ACTEW has is reviewing this project and further refining options for expansion with the drought worsening and the impending Stage 4 Water Restrictions.

Appendix B – Water Management

The construction of Canberra's first dam at the Lower Cotter started in 1912 and became operational in 1918. It had an original capacity of about 1.8 Gigalitres and between 1949 and 1951 the dam wall was raised to 31 metres, providing the present day storage of 3.85 Gigalitres The Bendora Dam was constructed between 1958 and 1961, providing a storage capacity of 11.5 Gigalitres. Corin Dam was completed in 1968 and provides a further 70.09 Gigalitres of water storage.



Canberra experienced a drought during 1965 to 1969 that emptied Corin Dam. Water restrictions were imposed during the first half of 1968. Water was released from the Tantangara Reservoir to provide additional supplies. The water was pumped from the Murrumbidgee River at the Cotter into Cotter Dam and from there to Mount Stromlo Treatment Plant.

The Mount Stromlo Water Treatment Plant was completed in June 1967, enabling the treatment of the water before distribution to Canberra and Queanbeyan. This plant has been recently upgraded to treat poorer water quality problems arising from the 2003 bushfires. The water treatment plant has a production capacity of 250 megalitres (million litres) a day. The treatment process involves the following steps:

- coagulation and flocculation
- optional dissolved air flotation
- dissolved air flotation and filtration or direct filtration
- disinfection by chlorination
- pH adjustment and stabilisation with lime and carbon dioxide
- fluoridation by sodium silico fluoride.

Under the *Seat of Government Acceptance Act 1909* the Commonwealth was granted the rights to the waters of the Molonglo and Queanbeyan rivers for the purposes of water supply. Googong Dam on the Queanbeyan River was completed in 1978 providing water storage for 125 Gigalitres.

The Cotter Catchment with three storage dams supplies about 60 per cent of the Canberra-Queanbeyan water needs, distributed through the Mount Stromlo Water Treatment Plant. The Googong Reservoir and Water Treatment Plant provides the remainder. Since May 2007 water is also supplied from the Murrumbidgee river.

The Lower Molonglo Water Quality Control Centre (LMWQCC) is the main wastewater treatment facility for Canberra and is the largest inland treatment centre in Australia. Located one kilometre upstream from the junction of the Murrumbidgee and Molonglo rivers. LMWQCC treats more than 90 million litres of Canberra's wastewater each day. The process includes physical, chemical, and biological treatment processes before the water is discharged into the

Molonglo River. Some wastewater from the industrial area of Fyshwick and adjacent suburbs is treated at the Fyshwick Sewage Treatment Plant for local recycling. The North Canberra Water Reuse Facility (NCWRF) was brought online in 2005 to filter used water through an ultrafiltration treatment process from the Fyshwick Sewage Treatment Plant to supply irrigation water for fields in North Canberra. The filtered effluent flows into a balance tank from which it is pumped into the Lower Russell Reservoir, which supplies the irrigation water for various sites including ovals, playing fields and a golf course. The scheme is monitored and controlled remotely at LMWQCC.

The Southwell Park Watermining ™ facility recycles wastewater by extracting wastewater from a sewer, treats the water to a high standard, and provides recycled water for local use in irrigation of the local Southwell Park fields. Protecting the health of the public has been a major consideration in the design and operation of the Watermining ™ facility.

Appendix C – Possible Supply Options

The initial *Future Water Options* studies identified a number of possible supply options for the ACT not being considered further. Following is a summary of those options and more detail can be found in ACTEW's Options report (ACTEW, 2004).

Water Farm

This concept proposed transferring effluent from the Lower Molonglo Water Quality Control Centre (WQCC) to an advanced water reclamation plant before being transferred to a service reservoir or into a water pipeline upstream of the Mount Stromlo Water Treatment Plant.

An independent report of this option by IBL Solutions assessed preliminary indicative capital and operating costs for reuse schemes with capacities of 45 ML/day and 90 ML/day. The costing included the construction of an advanced water reclamation plant at the Lower Molonglo WQCC and the transfer of the reclaimed water to a raw water reservoir, such as the Cotter Dam (this being possible with the Stromlo WTP now being built). The capital costs of the Water Farm were about $94m for a 45 ML/day facility and $150m for a 90 ML/day facility, with estimated annual operating costs of $6m and $12m respectively.

The study by IBL Solutions also examined overseas experiences, including Singapore where a water reclamation plant has recently been installed. It was found that planned indirect potable reuse is a viable means of augmenting a community's water supply but only after other means have been exhausted. One of the issues is the significant ongoing cost of monitoring, to ensure long-term peace of mind for the community about the reuse of such water.

This option has been further refined since it was examined under the *Future Water Options* project and new and better technologies are now available together with lower costs. While the original concept of the Water Farm is still not considered viable a better configuration of the original proposal is now presented in this report as the *Water2WATER* option.

Cross Border Water Options

Many options were investigated in a preliminary way such as transferring water from the Burrinjuck and Blowering dams, and a dam on the Goodradigbee River with a tunnel to the Cotter River. In addition, further NSW dam sites were considered in a 1968 report for the National Capital Development Commission. All these other options still have significant environmental (water transfers between catchments, new dams, etc) and/or economic (pumping from Burrinjuck/Blowering) and/or water quality constraints that make them far less viable than the recommended options.

Riverlea Dam

A potential site for a water supply dam exists on Paddys River south west of Black Hill. With a top water level of 650 metres the dam has storage capacity for 115 Gigalitres with a potential yield to support a population of an additional 100,000 people based on the current demand pattern. The dam would consist of an earth and rock fill embankment of about 80 metres. The catchment is open to a significant amount of agricultural development mainly grazing and the water quality of the stored water would be such that full water treatment would be required before the water could be distributed to Canberra and Queanbeyan. The stored water level would pose a number of issues due to the flooding of the Tidbinbilla Deep Space Tracking Station and the need for major road reconstruction if north-south travel in the valley was to be maintained along Paddys River Road. Other major constraints include:

- the Riverlea proposal has previously been rejected, and so is not designated as a potential dam site in the National Capital Plan. Hence planning approval would be difficult, and include the resumption of leased land; and
- the dam site would require a long dam embankment (i.e. more cost per GL stored) making it less attractive than other options.

Given these constraints Riverlea Dam has not been short listed.

Welcome Reef Dam

Sharing the cost and water from Sydney Water's Welcome Reef Dam was one of the options considered in the 1994 *ACT Future Water Supply Strategy*.

Holding five times the volume of Sydney Harbour, this dam on the Upper Shoalhaven River was to be the 'final solution' for Sydney's water supply. Construction was to begin in 2002 and end in 2005. The proposed dam would have covered more than 15,300 ha extending from a point 10 km north-west of Braidwood to 28 km north on the Shoalhaven River. It would also have flooded large areas on the lower Mongarlowe River and Boro Creek. Water from the Mongarlowe and Shoalhaven Rivers would be transferred to the Wollondilly River and flow to Warraamba Dam. Flows downstream to the Shoalhaven would have been reduced by half.

The proposal was unpopular with some groups and a strong coalition of farmers, fishermen, canoeists and conservationists formed the Coalition Against Welcome Reef Dam. The NSW Government has now permanently deferred plans for a dam at Welcome Reef on the Shoalhaven River with the creation of the Welcome Reef Nature Reserve. Hence this option is no longer viable.

Carwoola Dam – Molonglo river

Under the *Seat of Government Act* the Federal Government has paramount rights to the waters of the Molonglo and Queanbeyan rivers for the purposes of water supply to the ACT. This allowed the construction of Googong Dam and also led to many investigations of the Molonglo river.

Several dam sites on the Molonglo river have been considered in the past, including Carwoola and Burbong (where the King's Highway crosses the Molonglo River). The Carwoola site was the preferred site in the 1963 report. All sites on the Molonglo river suffer from the risk of contamination from the mine tailings dam at Captains Flat. For this reason the Carwoola site has not been short listed.

Enlarged Corin Dam

Corin Dam has been the principal water supply storage dam for Canberra and Queanbeyan since its construction was completed in 1968. It is estimated that a rise in the embankment height of 5 metres would raise the storage volume to approximately 92 Gigalitres, a significant increase in storage. However, construction of the dam is impractical because much of the rock surrounding the dam lies on the Cotter Fault and is crushed and weak. The spillway currently lies on a band of strong rock but would be moved onto much weaker rock if the dam was raised. There is no other suitable location for a spillway. Corin is considered a high hazard dam because failure would result in the failure of the Bendora and Cotter dams downstream. This could lead to loss of life and have a severe impact upon Canberra's water supply. Therefore, as raising of the dam will be technically difficult due to the Cotter fault and associated ground conditions around the spillway, and the potential to increase the hazard rating of the dam, an enlarged Corin Dam has not been considered further.

Enlarged Bendora Dam

Bendora Dam is a double curvature concrete arch dam rather than an embankment. As such it is not possible to raise the height of the dam wall but it would be possible to increase the top water level by placing a gate, such as a rubber dam or fuse plug, between the top of the spillway and the bridge that passes above the spillway. This would increase the dam height by 4.56 metres, increasing the storage capacity by 2.7 Gigalitres to 13.4 Gigalitres. However, Bendora is considered to be a high hazard structure because of its importance to the water supply of Canberra and Queanbeyan. Stability of the right abutment is critical to the stability of the dam. Rock in this area is layered, with bedding planes of low friction angle oriented at 25 degrees towards the river. Anchoring was put in place during construction of the dam but has now passed its normal service life. Movement of the rock in this area is continuously monitored to identify signs of potential failure. As the load on the abutment would be increased by increasing the storage volume, a raise in top water level would increase the probability of dam failure. Such risk may be acceptable but would need to be studied in detail before this option could proceed. It has not been considered by because there were better options to consider further. The cost of the "fuse plug" option (see below for more about "fuse plugs") would be around $4m. Although it could be done relatively quickly, it would not provide much additional storage, hence it has not been investigated further.

Enlarged Googong Dam

Water from Googong Dam requires full treatment and must be pumped before use in Canberra and Queanbeyan. Consequently, the water from Googong costs ten times more to produce than water from Bendora Dam. Googong Dam is a 66 metres high earth-rockfill embankment with a storage capacity of 125 Gigalitres, with a top water level of 663 metres AHD. It is estimated that raising the top water level of the dam by 10 metres would close to double the storage volume (to about 217 Gigalitres). However, the increase in yield (i.e. the dam's capacity to continue supply through a drought) would be much more modest, more like 25 per cent. In the 1963[1] and 1968[2] reports that were the genesis for the construction of Googong Dam, it is clear that the dam height was chosen on economic not structural grounds, confirming the view that it would be possible to raise the dam wall and spillway. This option would involve:

- raising the main dam wall, the coffer dam wall intake tower and the spillway by 10 metres each;
- moving the river discharge pipework (that would be buried by the enlarged dam); and
- constructing a new spillway.

The dam is considered to be a high hazard structure because failure would lead to significant loss of life and economic loss in both Queanbeyan and Canberra. The dam currently meets the most stringent NSW Dam Safety Committee guidelines. Raising of the dam is unlikely to significantly increase the probability of dam failure, however, should there be a dam failure, the consequences of it would be exacerbated – a higher water level would lead to a larger area of destruction from the downstream flood. Whilst the storage would be nearly doubled, the yield would only increased by around 25 per cent and the cost of supply for this additional yield is far above that for any of the options carried forward and this option is not considered further.

Raising Googong spillway – "fuse plug"

1[1]Department of Works, *Report on Proposed New Storage Canberra Water Supply*
2 Department of Works, *Report Canberra Water Supply Augmentation*

Many dams around the world are having their spillway levels raised by the use of collapsible "fuse plug". The principle behind this technology is that spillways are designed to take the maximum possible flood without the dam itself overtopping. But the vast majority (maybe all) floods do not reach this height. Hence the spillways are raised by a technique that allows the additional height of the spillway to be washed away should a huge flood does eventuate. A fuse plug can be as simple as sand, or rubber, or steel weirs. All are designed to wash away in the event of a major flood. Should it wash away it makes very little difference to the size of the flood downstream of the dam. This approach has been taken with the Warragamba Dam in Sydney, and the Lyell Dam in Tasmania, among many others throughout the world. If applied at Googong the spillway could be raised by 3 metres for around $4m. This would increase the volume from 125 Gigalitres to around 145 Gigalitres but does not increase the yield by much (yield being a measure of a particular dam's supply through a drought). This option has not been considered in detail as it does not produce enough extra yield to be considered as a "next source", but is more a refinement of an existing source.

Appendix D – Water Purification Plant Draft Operational Program

Detailed and Regular Risk Assessments

Risk assessments will be an integral part of the design development, commissioning and on-going operation, maintenance and management of the water purification plant. All risk assessment will be undertaken on the basis is the AS/NZS 4360:2004 – Risk Management, the ADWG 2004 'Frameworks for Management of Drinking Water Quality' and the Australian Guideline for Water Recycling 'Frameworks for Management of Recycled Water Quality and Use' and other appropriate risk assessment tools for public health risk management. Regular re-assessment of risks and review of identified risks will be undertaken. Risk registers will be reviewed by independent auditors.

Sample and Monitoring Programs

A second key element the HACCP plan on which early planning has commenced is the development of a sampling and monitoring program (SAMP) covering the critical control points.

To-date ACTEW has undertaken a detailed review of current national and international water quality guidelines relating to recycled water; reviewed sampling and monitoring programs in use in Singapore, Orange County CA and Namibia and developed an initial baseline monitoring program. This is program has been peer reviewed by Professor Tony Priestly, Deputy CEO of the CRC Water quality & Treatment and member of the Western Corridor (Qld) expert advisory panel.

Together with ACT Health and the Environment and Heritage Unit (TAMS), ACTEW plan to take first samples for analysis based on the Singapore NEWater SAMP in the coming weeks and then extend this to cover a wider range of analytes based on the ACTEW review. This early monitoring will cover in excess of 200 analytes.

The SAMP will initially be very intense, peaking during the commissioning and first water delivery periods and then be on going with the operation of the plant.

Operations and Maintenance Management System Development and Documentation

As part of the water purification plant development contract there will be a requirement for the development of a comprehensive documentation of operation and maintenance procedures and plans for the plant, including emergency management plans. These will link with the training program detailed below.

Systems Management and Operator Training

As part of implementing the water purification plant a broader and more focused competency based training program for all management, operations and maintenance staff will be implemented to ensure all staff are fully competent and aware of their responsibilities in operating the water and sewerage networks prior to the water purification plant being commissioned and into production.

This program will be based to an extent on programs implemented overseas and being developed for implementation in Australia in locations where indirect potable water use is practiced. Part of this program will be implemented as part of the Water Purification Plant development contract.

Part of this skills development will take place during the pre-commissioning and commissioning period of the plant during which time the operators and maintainers will work under the direction of an experienced membrane plant commissioning engineer. This guided management period may be extended post commissioning.

Process Monitoring during Operation

Due to the time taken in obtaining water information from the SAMP detailed above, rapid real-time or near real-time monitoring of the plant will be a priority coupled with detailed standard operations response procedures for out of specification performance or operation.

For any advanced water treatment technology such as a dual membrane MF/RO plant, on-line instrumentation plays an important role in continuously monitoring the integrity of the process to ensure that the product water quality is always meets specifications. Instrumentation can be incorporated both on the main process streams and on individual membrane skids to detect any changes in performance.

Typical on-line instrumentation used at other facilities and that will be considered for the water purification plant includes;

- Inlet feed water to MF/UF membranes – Turbidity is typically measured to monitor the quality of the water onto the membranes. Since chloramination is often used to protect the membranes from fouling, a combination of combined chlorine, free chlorine and ammonia can be measured to both ensure ongoing dosing and protect the membranes against free chlorine residual.
- On each MF/UF skid – A programme of membrane integrity testing (such as pressure decay testing) is used to regularly check the integrity of the membranes, and the trans membrane pressure (TMP) is monitored to indicate the need for initiation of membrane cleaning cycles. (For TMP, the feed and filtrate pressure, temperature and filtrate flow are measured).
- Permeate from each MF/UF skid – Depending on the membrane configuration, turbidity is typically used on the permeate line from each skid. Particle counters could also be used on each train to detect any particulate material although this is uncommon.
- Main MF/UF permeate stream (RO feed water) – Turbidity is monitored continuously (Hach laser method) with the permeate expected to be less than 0.1 NTU. A particle counter could also be employed to detect any particulate breakthrough although this is uncommon. Online electrical conductivity (EC) is often measured to represent the dissolved salts being applied to the RO membranes. Since most RO membranes have a very low tolerance to free chlorine, oxidation/reduction potential (ORP) is typically monitored to indicate the absence of free chlorine to ensure that the RO membranes do not get damaged. The Silt density index (SDI) is measured as an indication of the fouling potential on the membrane and pH is also measured.
- On each RO skid – Feed and permeate pressure is measured across each Stage of RO membranes to indicate fouling on the membranes and the net pressure required to pass permeate across the membrane. The pressure, EC and flow of the concentrate are also measured to provide a mass balance over the process.
- Permeate from each RO skid – Electrical conductivity is often measured to determine the dissolved salts rejection across the RO membranes. On-line total organic carbon (TOC) can be used to detect the combined remaining carbonaceous material in the RO permeate. Other on-line monitoring includes pressure (upstream of any stage where permeate backpressure is being used), and water temperature.

- Combined RO permeate – As for individual skids, electrical conductivity is used to reflect the remaining dissolved salts. On-line TOC (Sievers unit) is used to detect the combined remaining carbonaceous material in the RO permeate. The pH of the water is also measured to indicate the need for neutralisation/adjustment before discharge.

For processes with advanced oxidation, on-line UV transmissivity can also be used as an indication of how well the organic material has been removed from the water.

Whilst all of this on-line instrumentation contributes to the overall confidence in the integrity of the membrane performance, the concentration of impurities in the RO permeate is so low that most on-line instruments do not have the range and provide the necessary degree of accuracy to measure changes in the effluent quality. However, a TOC analyser on the RO permeate can accurately measure very low concentrations of organic compounds and as such the on-line TOC can be used as an indicator as to whether the product water will meet specification. At the NEWater plants in Singapore, online TOC is continuously monitored and if the TOC rises above a pre-determined limit (typically around 100 ppb), product water discharge off site is discontinued immediately and the permeate is recycled back to the head of the plant until the cause of the high reading has been determined and remedied, and the permeate is back within the required specification. A similar approach will be adopted for the water purification plant at LMWQCC. The design incorporates two parallel product water tanks, such that one tank will be filling while the contents of the other tank is being pumped to the catchment. If the TOC analyser measures a concentration in the permeate exceeding the pre-determined limit, the contents of the product tank currently being filled would be emptied back to the head of the plant and permeate recycled until the problem is rectified.

In summary, state of the art instrumentation will be used at the water purification plant to continuously measure the integrity of the process and ensure that only product water that meets specification will be transferred to the catchment.